Draft Modeling Protocol

Procedures for Modeling 8-Hour Ozone Concentrations in the Baton Rouge 5-Parish Area

Prepared by

Air Quality Assessment Division
Office of Environmental Assessment
Louisiana Department of Environmental Quality
602 North Fifth Street
Baton Rouge, Louisiana 70802

15 September 2006

TABLE OF CONTENTS

Page

APPENDICES

TABLES

FIGURES

1.0 INTRODUCTION

1.1 Overview

This report constitutes the Air Quality Modeling Protocol for the Baton Rouge 5-Parish 8-hour ozone modeling analysis in support of 8-hour ozone attainment demonstration modeling of the Baton Rouge area. It describes the overall modeling activities to be performed by the Louisiana Department of Environmental Quality (LDEQ) in order to demonstrate attainment of the 8-hour ozone standard in Baton Rouge and other areas in Louisiana.

A comprehensive modeling protocol for an 8-hour ozone SIP attainment demonstration study consists of many elements. Its main function is to serve as a means for planning and communicating how a modeled attainment demonstration will be performed before it occurs. The protocol guides the technical details of a modeling study and provides a formal framework within which the scientific assumptions, operational details, commitments and expectations of the various participants can be set forth explicitly and means for resolution of potential differences of technical and policy opinion can be worked out openly and within prescribed time and budget constraints.

As noted in the U.S. Environmental Protection Agency's (EPA) 8-hour ozone modeling guidance, the modeling protocol serves several important functions (EPA, 2005a):

- Identify the assistance available to the LDEQ (the lead agency) to undertake and evaluate the analysis needed to support a defensible attainment demonstration;
- Identify how communication will occur among States/Tribes and stakeholders to develop a consensus on various issues;
- Describe the review process applied to key steps in the demonstration; and
- Describe how changes in methods and procedures or in the protocol itself will be agreed upon and communicated with stakeholders and the appropriate U.S. EPA regional Office.

1.2 Study Background

The main goal of the Baton Rouge 8-Hour Ozone Attainment Demonstration Study is to develop the photochemical modeling data bases and associated analysis tools needed to reliably simulate the processes responsible for 8-hour ozone exceedances in the Baton Rouge region and the evaluation of realistic emissions reduction strategies for inclusion in the Baton Rouge 8-hour ozone SIP.

Based on measured ozone data from 2001-2003, the EPA designated the Baton Rouge 5-Parish area as a Marginal 8-hour ozone nonattainment area. Although EPA does not require a modeled attainment demonstration for Marginal nonattainment areas, the Baton Rouge area has experienced high ozone conditions in 2005 and to date in 2006 and will not attain the 8-hour ozone standard in 2006 to meet the June 15, 2007 attainment date for Marginal areas. The Baton Rouge area will likely face a "bump-up" to the Moderate classification with an attainment date of June 15, 2010. With the Moderate classification, a modeled attainment demonstration must be submitted to the EPA.

1.3 Lead Agency and Principal Participants

The Louisiana Department of Environmental Quality (LDEQ) Office of Environmental Assessment, Air Quality Assessment Division is the lead agency in the development of the Baton Rouge 8-hour ozone SIP. EPA Region 6 in Dallas, Texas is the local regional EPA office that will take the lead in the approval process for the Baton Rouge 8-hour ozone SIP. The LDEQ has contracted with ENVIRON International Corporation to assist them in the 8-hour ozone attainment modeling demonstration.

1.4 Related Regional Modeling Studies

The Baton Rouge 8-hour Ozone Study draws from several urban- and regional scale emissions, photochemical, PM, and visibility modeling efforts performed in the central states and across the United States. The procedures used in these previous studies provide a guide to the modeling and QA approach for the Baton Rouge study.

1.4.1 Related Regional Regulatory Air Quality Studies

There are several related regulatory air issues that have direct relevance to the Baton Rouge 8-hour ozone attainment demonstration SIP. These issues include, but are not limited to, the following:

Clean Air Interstate Rule (CAIR): The State of Louisiana is part of the CAIR controls for both ozone and $PM_{2.5}$. EPA determined that Louisiana contributed significantly to downwind 8-hour ozone nonattainment in Galveston, Harris and Jefferson Counties, Texas (EPA. 2005b). EPA also determined that Louisiana also contributed significantly to downwind $PM_{2.5}$ nonattainment in Jefferson and Russell Counties, Alabama. Accordingly, Louisiana will be subject to the NOx and SO2 emission control requirements under both the ozone and $PM_{2.5}$ provisions of the CAIR. The CAIR determined which states contributed significantly to downwind $PM_{2.5}$ and ozone nonattainment using the CMAQ and CAMx models, respectively.

Clean Air Mercury Rule (CAMR): Louisiana Electrical Generating Units (EGU) are subject to the requirements of the Clean Air Mercury Rule (CAMR).

Clean Air Visibility Rule (CAVR): The Clean Air Visibility Rule (CAVR) requires specific sources that are shown to reasonably contribute to visibility impairment at a Class I area to install Best Available Retrofit Technology (BART). The BART requirements apply to sources built between 1962 and 1977 that have the potential to emit 250 tons per year (TPY) of a visibility impairing pollutants (SO2, NOx, PM and/or VOC) and are one of 26 specific source categories. EPA has published guidelines for the BART component of the CAVR (EPA, 2005c). In November 2002, the LDEQ distributed a survey and based on that survey published a list of potentially BART-eligible sources (see: http://www.deq.louisiana.gov/portal/Portals/0/AirQualityAssessment/BART%20eligible%20sources.pdf).

1.4.2 Related Local Air Quality Planning Efforts

There are several ozone air quality planning efforts in the central states that are related to the Baton Rouge 8-hour ozone study, either by their proximity so they may affect transport into the area or they may contain air quality control measures that may be of interest. Below we summarize many of these efforts, including 8-hour ozone Early Action Compact (EAC) State Implementation Plans (SIPs) that were submitted to EPA in December 2004 as well as ongoing 8-hour ozone planning in nearby nonattainment areas.

Houston/Galveston/Brazoria Area (HGB) Ozone Attainment: The HGB has been the subject of several ozone modeling efforts. During summer of 2000 a massive air quality field study was performed (TexAQS2000) that was used to develop a photochemical modeling database from August-September 2000. The Texas Commission on Environmental Quality (TCEQ) is currently developing enhanced ozone modeling databases in preparation for the HGB 8-hour ozone SIP due June 2007. The TCEQ is using the MM5/EPS/CAMx modeling system for their ozone attainment demonstration modeling. Details on the TCEQ HGB ozone modeling activities can be found on their website (see: http://www.tceq.state.tx.us/nav/eq/sip.html).

Beaumont/Port-Arthur (BPA) Ozone Attainment: In September 2005, the TCEQ approved adoption of an 8-hour ozone attainment demonstration SIP for the BPA nonattainment area. Ozone nonattainment problems in the Houston and Beaumont areas are linked by their proximity and the complex meteorological patterns along the Gulf Coast. TCEQ uses the same MM5/EPS/CAMx ozone-modeling databases for both BPA and HGB and was able to develop BPA control strategies that demonstrate attainment by 2007.

Dallas/Fort-Worth (DFW) Ozone Attainment: The TCEQ is developing an 8-hour ozone SIP for the DFW area (see: http://www.tceq.state.tx.us/implementation/air/sip/dfw.html) and plans to propose the SIP for adoption in late 2006. The DFW SIP will be one of the first 8-hour ozone plans for a major metropolitan area to come before EPA and the TCEQ is working closely with EPA's regional office and OAQPS to establish the procedures for modeling and attainment demonstrations. TCEQ is using the MM5/EPS/CAMx modeling system for the DFW 8-hour ozone SIP.

St. Louis Ozone Attainment: The Missouri Department of Natural Resources (MDNR) and the Illinois Environmental Projection Agency (IEPA) are jointly developing an 8-hour ozone SIP for the St. Louis region. Link-based on-road mobile source emissions are being developed for the greater St. Louis area, with regional emissions obtained from the CENRAP effort. MDNR/IEPA are using the MM5/SMOKE/CAMx modeling system for the St. Louis 8-hour ozone SIP.

Texas 8-Hour Ozone EAC SIPs: Several of the Texas Near Nonattainment Areas (NNAs) submitted 8-hour ozone EAC SIPs in December 2004. These areas include Northeast Texas (Tyler-Longview), San Antonio and Austin. The MM5/EPS/CAMx modeling system was used in each of these EAC SIPs (see: http://www.tceq.state.tx.us/implementation/air/sip/sipplans.html).

EAC Study in Four Corners New Mexico: An ozone photochemical modeling attainment demonstration was carried out as part of the San Juan EAC Study. A state-of-science air quality modeling system (EPS/MM5/CAMx) was applied to four ozone episodes during a fifty (50) day long summer ozone period over the Four Corners/San Juan Basin region. Nested meteorological and photochemical model simulations were performed consistent with draft EPA guidance. Results were integrated into an 8-hour ozone EAC SIP submitted and approved by EPA.

EAC Study in Denver Front Range Region: 8-hour ozone photochemical modeling attainment demonstration was conducted as part of the Denver-Front Range EAC Study. A state-of-science air quality modeling system (EPS/MM5/CAMx) was applied for several ozone episodes during the summer of 2002 and 2003 over the central Colorado region. Nested meteorological and photochemical model simulations were performed consistent with draft EPA guidance. Grid resolution of 36/12/4/1.33 km was used in the study, although the final SIP attainment demonstration was based on 36/12/4 km modeling that was submitted and approved by EPA.

Oklahoma 8-Hour Ozone EAC SIP: The Oklahoma Department of Environmental Quality (ODEQ) developed an 8-hour ozone EAC SIP. The ODEQ meteorological, emissions and photochemical modeling support for their 8-hour ozone EAC SIP used the EPS/MM5/CAMx modeling system (Morris et al., 2005d). Initially, a 1995 photochemical modeling database for Dallas-Fort Worth 1-hour SIP modeling was adapted for simulating ozone in the Tulsa and Oklahoma City areas. More recently, ENVIRON performed the necessary meteorological, emissions and photochemical modeling needed to develop an 8-hour ozone EAC SIP for Tulsa and Oklahoma City. The MM5 meteorological, EPS emissions and CAMx photochemical models were used to simulate an all new August 1999 episode. Link-based VMT data for the Tulsa and Oklahoma City were used along with MOBILE6 to generate on-road mobile source emissions. GLOBEIS was used to generate biogenic emissions. 1999 Base Case and sensitivity simulations were performed along with 2007 Base Case, sensitivity and control strategy simulations. The Ozone Source Apportionment Technology (OSAT) was used to guide the selection of effective control strategies. The results were documented in a Technical Support Document (TSD) that was submitted by ODEQ with their 8-hour EAC SIP to EPA Region VI in December 2004.

Peninsular Florida 8-hour Ozone Attainment Study: The objectives of the Peninsular Florida Ozone Study (PFOS) included: (1) set up and evaluate advanced emissions, meteorological, and photochemical modeling tools for up to nine (9) 8-hour ozone episodes affecting the Tampa, Orlando and Jacksonville areas (3 episodes per area), (2) examine potential emissions control strategies that will attain and/or maintain the new 8-hour standard in the region, and (3) assist in the development of the technical analyses supporting a "weight of evidence" attainment demonstration that can be used by the Florida Department of Environmental Protection for regulatory decision-making and in developing its SIP submittal to the EPA.

1.4.3 $PM_{2.5}$ and Regional Haze SIP Studies

Five Regional Planning Organizations (RPOs) are performing regional photochemical ozone and PM modeling to support the development of regional haze SIPs due December 2007 that may become the regional component of 8-hour ozone SIPs and $PM_{2.5}$ SIPs due June 2007 and April 2007, respectively. Of particular relevance are the activities of the Central Regional Air Planning Association (CENRAP) RPO that covers the central states, including Louisiana.

Big Bend Regional Aerosol and Visibility Observational Study (BRAVO): The BRAVO study examined the causes and sources of regional haze at the Big Bend National Park, the most southwesterly Class I area in the CENRAP states. It performed data collection activities, modeling and used numerous techniques to estimate PM source apportionment (Pitchford et al., 2004).

CENRAP Scoping Study: CENRAP commissioned a scoping study to identify the causes of visibility impairment at Class I areas in the CENRAP states and to identify the analytical tools that are available to investigate regional haze (Green et al., 2002).

CENRAP Ammonia Emissions Inventory Study: CENRAP sponsored a study to develop an improved ammonia emissions inventory for the CENRAP states (Coe and Reid, 2003).

CENRAP Agricultural and Prescribed Burns Study: In this study improved emissions inventories for prescribed burns and agricultural burning were developed for the CENRAP states (Reid et al., 2004a).

Evaluation of CMAQ and CAMx Models Over the CENRAP States for Three Episodes: CMAQ and CAMx model simulations of January 2002, July 1999 and July 2001 episodes were evaluated using measurement data in the CENRAP states (Tonnesen and Morris, 2004).

Development of Enhanced Mobile Source and Agricultural Dust Emissions for CENRAP: This study developed on-road and non-road mobile source and agricultural dust emission inventories for the CENRAP states (Reid et al., 2004b).

Development of 2002 Base Case Modeling Inventory for CENRAP: CENRAP sponsored this study to prepare a 2002 Base Case emissions inventory for the CENRAP states that can be used in emissions and photochemical modeling of the 2002 annual period (Strait, Roe and Vukovich, 2004).

Preliminary PM and Visibility Modeling for CENRAP: Under this study preliminary regional PM and visibility modeling was conducted focused on the CENRAP region using the CMAQ and CAMx models (Pun, Chen and Seigneur, 2004).

CENRAP 2002 Annual Modeling: CENRAP is performing annual modeling for 2002 on a 36-km grid covering the continental U.S. and potentially a 12-km grid covering the central states. The CENRAP 2002 annual modeling has prepared a Modeling Protocol (ENVIRON and UCR, 2004) and a Quality Assurance Project Plan (QAPP; Morris and Tonnesen, 2006). CENRAP is using the MM5 meteorological and SMOKE emissions modeling systems and two air quality models, CMAQ and CAMx. A preliminary 2002 base case modeling and model performance evaluation report has been prepared (Morris et al., 2005c). Revised 2002 base case modeling and 2018 future-year modeling along with visibility projections have also been carried out that are available on the project website (http://pah.cert.ucr.edu/aqm/cenrap/index.shtml).

VISTAS Phase I Model Sensitivity and Evaluation Study: This study, sponsored by VISTAS, performed extensive model sensitivity testing and evaluation analysis using the CMAQ and CAMx models and three episodes, January 2002; July 1999 and July 2001 (Morris et al., 2004a).

WRAP Section 309 SIP/TIP Modeling Analysis: The WRAP performed a study to generate the necessary modeling data needed to develop Section 309 SIP/TIP for states that opt-in to this program (Tonnesen et al., 2003).

VISTAS Phase II 2002 Annual Modeling: VISTAS is performing annual modeling of 2002 using a continental US 36-km domain and eastern US 12-km domain with attendant model evaluation and sensitivity analysis (Morris et al., 2004b).

Many of the above studies are providing data (e.g., emissions) and/or modeling tools that may be used in this study. Consequently, the quality assurance (QA) and quality control (QC) procedures employed are directly relevant to this Modeling Protocol. Others are companion modeling studies (e.g., BRAVO, VISTAS and WRAP) that provide information used in the development of this Modeling Protocol (see, for example, ENVIRON and UCR, 2004).

1.5 Overview of Modeling Approach

The Baton Rouge 8-Hour Ozone Modeling Study includes episodic emissions, meteorological and ozone simulations using a nested 36/12/4 km grid with the 4-km grid focused on southern Louisiana and the immediate Gulf coast area.

1.5.1 Ozone Episode Selection

Episode selection is an important component of an 8-hour ozone attainment demonstration. EPA guidance recommends that at least 10 days be used to project 8-hour ozone Design Values at each critical monitor, with 5 days being an absolute minimum.

1.5.1.1 EPA Guidance for Episode Selection

EPA's current guidance on 8-hour ozone modeling (EPA, 2005a) identifies specific criteria to consider when selecting one or more episodes for use in demonstrating attainment of the 8-hour ozone National Ambient Air Quality Standard (NAAQS). This guidance builds off the 1-hour ozone modeling guidance (EPA, 1991) in selecting multiple episodes representing diverse meteorological conditions that result in ozone exceedances in the region under study:

- A variety of meteorological conditions should be covered, this includes the types of meteorological conditions that produce 8-hour ozone exceedances in the Baton Rouge 5-Parish area;
- To the extent possible, the modeling data base should include days for which extensive data bases (i.e. beyond routine aerometric and emissions monitoring) are available; and
- Sufficient days should be available such that relative reduction factors (RRFs) can be based on several (i.e., $\geq$ 10) days with at least 5 days being the absolute minimum.

EPA also lists several “other considerations” to bear in mind when choosing potential 8-hour ozone episodes including:

- Choose periods which have already been modeled;
- Choose periods which are drawn from the years upon which the current Design Values are based;
- Include weekend days among those chosen; and
- Choose modeling periods that meet as many episode selection criteria as possible in the maximum number of nonattainment areas as possible.

1.5.1.2 Selection of Baton Rouge Ozone Modeling Episodes

The preliminary draft Modeling Protocol used CART analysis of air quality and meteorological data from 1996-2004 to classify days in Baton Rouge according to meteorological and aerometric conditions (ICF, 2005). Five CART bins were associated with 8-hour ozone exceedances. Based on the CART analysis, four episodes were identified for modeling.

In this Modeling Protocol we analyzed ozone air quality data from 2000-2005 to rank candidate episodes for modeling. Starting with 15 candidate episodes, the top seven were ranked for appropriateness using criteria in EPA’s guidance (EPA, 2005a) and other criteria. This analysis is discussed in Chapter 3.

Additional analysis of the seven highest ranked episodes was conducted to find the optimal subset for 8-hour ozone modeling of Baton Rouge. In particular, analysis of the air quality and meteorological conditions of each of the candidate episodes was conducted along with the development of a conceptual model that explains each 8-hour exceedance.

1.5.2 Model Selection

Details on the rationale for model selection are provided in Section 2. The MM5 prognostic meteorological model was selected for the Baton Rouge ozone modeling using a 36/12/4 km resolution grid, with the 4-km grid covering Louisiana and the immediate Gulf coast region. Emissions modeling is being performed using the EPS emissions processor. The CAMx photochemical grid model, which supports two-way grid nesting and subgrid-scale Plume-in-Grid, will also be used. This is the same EPS/MM5/CAMx modeling system used in many recent 8-hour ozone EAC SIPs that have been already approved by EPA. It is also the same systems used in current 8-hour SIP studies in nearby states to be submitted in mid-2007.

1.5.3 Emissions Input Preparation and QA/QC

Quality assurance (QA) and quality control (QC) on the emissions datasets are some of the most critical steps in performing air quality modeling studies. Because emissions processing is tedious, time consuming and involves complex manipulation of many different types of large data sets, errors are frequently made in emissions processing and, if rigorous QA measures are not in place, these errors may remain undetected. The Baton Rouge 8-Hour Ozone Modeling Study will perform a multistep emissions QA/QC approach. This includes the initial emissions QA/QC by the LDEQ as the data are acquired, as well as QA/QC by the LDEQ and potentially others on the modeling team as the dataset is processed and made available for modeling. This multi-step process with separate groups involved in the QA/QC of the emissions is designed to detect and correct errors prior to the air quality model simulations.

QA/QC performed as part of the emissions processing includes:

EPA Input Screening Error Checking Algorithms: Although the EPS emissions model used for emissions processing contains internal error checking and flagging, some additional input error checking algorithms, like those used with the EMS and SMOKE emission models, may be considered to screen the data and identify potential emission input errors. Additionally, EPA has issued a revised stack QA and augmentation procedures memorandum that will be used to identify and augment any outlying stacks.

EPS Error Messages: EPS provides various cautionary or warning messages during the emissions processing. The EPS output will be reviewed for error messages. An archive of the log files will be maintained so that the error messages can be reviewed at a later date if necessary.

EPS Emissions Summaries: QA functions built into the EPS processing system will be used to provide summaries of processed emissions as daily totals according to species, source category and county and state boundaries. These summaries will then be compared with summary data prepared for the pre-processed emissions, e.g., state and county totals for emissions from the augmented emissions data.

After the CAMx-ready emission inputs have been prepared, additional emissions QA/QC will be performed as appropriate, such as:

Spatial Summary: Sum the emissions for all 24 hours to prepare a PAVE plot showing the spatial distribution of daily total emissions. In our base case simulations these plots will be presented as tons per day. The 5 emission categories typically used are biogenic, on-road mobile, non-road mobile, other low-level anthropogenic and point sources (fires are also analyzed separately when available). If possible, separate spatial QA plots will be generated for low-level and elevated point sources. The objective of this step is to identify errors in the spatial distribution of emissions.

Short Term Temporal Summary: The total domain emissions for each hour will be accumulated and time series plots prepared by source category that display the diurnal variation in total hourly emissions. The objective of this step is to identify errors in temporal profiles.

Control Strategy Spatial Displays: Spatial summary plots of the daily total emissions differences between a control strategy and base case emissions scenarios will be generated. These plots can be used to immediately identify a problem in a control strategy. For example, if a state's NOx emissions control strategy is being analyzed and there are changes in emissions for other pollutants or for NOx outside of the Baton Rouge area, problems in emissions processing can be identified prior to the air quality model simulation.

The emissions QA/QC displays will be made available to study participants including EPA for review.

1.5.4 Meteorology Input Preparation and QA/QC

MM5 modeling of the selected episodes will include QA/QC and evaluation of the meteorological fields. In addition, the modeling team will also perform some QA/QC of the meteorological data to assure that it has been transferred correctly, to obtain an assessment of the quality of the data, and to assist in the interpretation of the air quality modeling results.

The Baton Rouge modeling team will perform the following QA/QC of the MM5 meteorological fields developed for the study:

- Analyses of the various observational input and evaluation data sets to assure that they have been transferred correctly;
- Verification that correct configuration and science options are used in compiling and running each module in the MM5 modeling systems (TERRAIN, REGRID, RAWINS, INTERPF, etc.);
- Evaluation of the MM5 fields using the METSTAT program and the comparison of model performance statistics against performance benchmarks (see for example the CENRAP MM5 evaluation at: http://pah.cert.ucr.edu/aqm/cenrap/ppt_files/CENRAP_VISTAS_WRAP_2002_36km_MM5_eval.ppt);
- Evaluation of upper-air MM5 meteorological estimates by comparison to upper-air observations and satellite images;
- Evaluation of MM5 precipitation patterns and intensity against radar and rain-gauge analyses available from the Climatic Prediction Center;
- Comparison of the Baton Rouge MM5 simulation with those generated by CENRAP, WRAP, VISTAS, TCEQ and others;
- Generation of the CAMx-ready inputs with the MM5CAMx processor, and review of summary statistics generated by that program;
- Backup and archiving of critical model input/output data.

1.5.5 Air Quality Modeling Input Preparation and QA/QC

Key aspects of QA for the CAMx input and output data include the following:

- Verification that correct configuration and science options are used in compiling and running each module in the CAMx modeling systems, where these include the MM5CAMx, TUV, landuse, and initial/boundary condition processors;
- Evaluation of CAMx results to verify that model output is reasonable and consistent with general expectations;
- Processing and QA of ambient monitoring data for use in the model performance evaluation;
- Evaluation of the CAMx results against concurrent observations and various other CAMx simulations;
- Backup and archiving of critical model input data.

The most critical elements for CAMx simulations are the QA/QC of the meteorological and emissions input files, which are discussed above. The major QA issue specifically associated with the air quality model simulations is verification that the correct science options were specified in the model itself and that the correct input files were used when running the model.

The Baton Rouge Modeling team will also perform a post-processing QA of the CAMx output files similar to that described for the emissions processing. Animated graphic files will be generated using PAVE that can be viewed to search for unexpected patterns in the CAMx output files. In the case of model sensitivity studies, the animated graphic files will be prepared as difference plots for the sensitivity case minus the base case. Often, errors in the emissions inputs can be discovered by viewing the animations. Finally, daily maximum 1-hour and 8-hour ozone plots with superimposed observations will be produced for each day of the CAMx simulations. This will provide a summary that can be useful for quickly comparing various model simulations.

The Model Performance Evaluation (MPE) is a multi-step process using several different techniques:

ENVIRON Analysis Tools: ENVIRON has developed ozone performance statistical techniques, "Soccer Plots", time series plots, spatial maps and other summary plots that displays model performance across networks, episodes, species, models and sensitivity tests and compare them against performance goals. These tools can interface with Excel® to generate scatter plots and time series plots. It can also interface with SURFER® to generate spatial maps of model performance. ENVIRON has also developed software to generate 8-hour performance metrics and displays as recommended in EPA's preliminary draft 8-hour ozone modeling guidance (EPA, 1999) that analyze predicted and observed daily maximum 8-hour ozone concentrations near each monitor.

UCR Analysis Tools: The University of California at Riverside (UCR) has developed Analysis Tools that are used extensively in the CENRAP, VISTAS, and WRAP regional haze studies. Graphics are automatically generated using gnuplot and the software generates: (a) tabular statistical measures; (b) time Series Plots; and (c) scatter Plots by all sites and all days, all days for one site, and all sites for one day.

The evaluation of the CAMx base case simulations will use the appropriate analysis tools listed above to take advantage of their different descriptive and complimentary nature. The use of multiple model evaluation tools is also a useful QA/QC procedure to assure that errors are not introduced in the model evaluation process. Statistical performance measures for ozone, ozone precursors, and products species will be calculated to the extent allowed by the Baton Rouge ambient monitoring network database.

1.5.6 Proposed Model Performance Goals

The issue of model performance goals for 8-hour ozone concentrations is an area of ongoing research and debate. For 1-hour ozone modeling, EPA has established performance goals for unpaired peak performance, mean normalized bias (MNB) and mean normalized gross error (MNGE) of <±20%, <±15% and <35%, respectively (EPA, 1991). The EPA 8-hour ozone modeling guidance stresses performing corroborative and confirmatory analysis to assure that the model is working correctly (EPA, 2005a). EPA's draft 8-hour ozone modeling guidance included comparisons of predicted and observed daily maximum ozone concentrations near the monitor with a <±20% performance goal (EPA, 1999), however this goal was dropped from the final guidance (EPA, 2005a). However, it is still a useful metric. In evaluating the ozone and precursor model performance for the Baton Rouge 8-hour ozone episodes, many performance measures and displays will be used to elucidate model performance and maximize the probability of uncovering potential problems that can be corrected in the final runs.

1.5.7 Diagnostic and Sensitivity Studies

Rarely does a modeling team find that the first simulation satisfactorily meets all (or even most) model performance expectations. Indeed, our experience has been that initial simulations that "look very good", usually do so as the result of compensating errors. The norm is to engage in a logical, documented process of model performance improvement wherein a variety of diagnostic probing tools and sensitivity testing methods are used to identify, analyze, and then attempt to remove the causes of inadequate model performance. This is invariably one of the most technically challenging and time consuming phase of a modeling study. The CAMx model base case simulations will present some performance challenges that may necessitate focused diagnostic and sensitivity testing in order for them to be resolved. Below we identify the types of diagnostic and sensitivity testing methods that might be employed in diagnosing inadequate model performance and devising appropriate methods for improving the model response.

1.5.7.1 Traditional Sensitivity Testing

Model sensitivity experiments are useful in three distinct phases or "levels" of an air quality modeling study and all will be used as appropriate in the Baton Rouge ozone modeling. These levels are:

Level I: Model algorithm evaluation and configuration testing;

Level II: Model performance testing, uncertainty analysis and compensatory error diagnosis; and

Level III: Investigation of model output response (e.g., ozone, aerosol, deposition) to changes in precursors as part of emissions control scenario analyses.

Most of the Level I sensitivity tests with CAMx have already been completed by the model developers (e.g., see www.camx.com) and others (e.g., the RPOs). However, given the open community nature of the CAMx model, the frequent science updates to the model and supporting databases, it is possible that some additional configuration sensitivity testing will be necessary.

Potential Level II sensitivity analyses might be helpful in accomplishing the following tasks:

- To reveal internal inconsistencies in the model;
- To provide a basis for compensatory error analysis;
- To reveal the parameters (or inputs) that dominate (or do not dominate) the model's operation;
- To reveal propagation of errors through the model; and
- To provide guidance for model refinement and data collection programs.

At this time, it is not possible to identify one or more Level II sensitivity runs that might be needed to establish a reliable CAMx base case. The merits of performing Level II sensitivity testing will depend upon whether performance problems are encountered in the operational evaluation. Also, the number of tests possible, should performance difficulties arise, will be limited by resources and schedule. Thus, at this juncture, one cannot be overly prescriptive on the number and emphasis of sensitivity runs that may ultimately be desirable. However, from past experience with CMAQ, CAMx, UAM and other models, it is possible to identify examples of sensitivity runs could be useful in model performance improvement exercises with the CAMx Baton Rouge modeling databases. These include:

- Alternative vertical mixing rates and minimum vertical diffusion coefficient;
- Modified biogenic emissions estimates;
- Modified on-road motor vehicle emissions;
- Modified air quality model vertical grid structure;
- Higher resolution horizontal grid;
- Modified boundary conditions;
- Modified fire emissions; and
- Modified EGU emissions.

If desired, Process Analysis outputs can be included in these Level II diagnostic sensitivity simulations in order to provide insight into why the model responds in a particular way to each input modification. Other "Probing Tools" available in CAMx such as the Decoupled Direct Method (DDM) and Ozone Source Apportionment Technology (OSAT) may also be useful diagnostic tools to identify model performance issues. Again, the number, complexity, and importance of these types of traditional sensitivity simulations can only be determined once the initial CAMx base case simulations are executed.

Level III sensitivity analyses have two main purposes. First, they facilitate the emissions control scenario identification and evaluation processes. Today, four complimentary sensitivity "Probing Tools" can be used in the CAMx photochemical model:

- Traditional or "brute force" testing;
- The Decoupled Direct Method (DDM);
- Ozone Source Apportionment Technology (OSAT); and
- Process Analysis (PA).

Each method has its strengths and weaknesses and they will be employed where needed and as resources are available. The second purpose of Level III sensitivity analyses is to help quantify the estimated reliability of the air quality model in simulating the atmosphere's response to significant emissions changes.

Based on experience in other regional studies, examples of Level III annual sensitivity runs for Baton Rouge ozone analysis include:

- Ozone sensitivities to total VOC, NOx, CO and other emissions;
- Ozone sensitivities to elevated point source NO_x emissions;
- Ozone sensitivity to NO_x and VOC emissions from specific source categories such as on-road and non-road mobile sources, area sources and biogenic sources.

The need to perform sensitivity experimentation (Levels I, II, or III) will depend on the outcome of the initial Baton Rouge ozone operational performance evaluations. If such a need arises, the ability to actually carry out selected sensitivity and/or diagnostic experiments will hinge on the availability of resources and sufficient time to carry out the analyses. Clearly, selection of the specific analysis method will depend upon the nature of the technical question(s) being addressed at the time.

1.5.7.2 Diagnostic Tests

A rich variety of diagnostic probing tools are available for investigating model performance issues and devising appropriate means for improving the model and/or its inputs. In the previously section we introduced the suite of "Probing Tools" available for use in the CAMx modeling system. Where the need exists (i.e., if performance problems are encountered) and assuming the Baton Rouge modeling study elects to use probing tool applications, these techniques could be employed as appropriate to assist in the model performance improvement efforts associated with the Baton Rouge ozone base case development. Here we describe an additional diagnostic method – indicator species and species ratios – that is potentially useful not only in model performance improvement activities but also in judging the models reliability in estimating the impacts on air quality from future emissions. If, during the conducting of the Baton Rouge ozone simulations the application of indicator species and species ratio techniques would be beneficial to the study, it would be explored for inclusion in the study.

Beginning in the mid 1990s, considerable interest arose in the calculation of indicator species and species ratios as a means of diagnosing photochemical model performance and in assessing model credibility in estimating the effects of emissions changes. Major contributions to the development and refinement of this general diagnostic method over the past decade have been made many scientists including Milford et al., (1994), Sillman (1995, 1999), Sillman et al., (1997), Blanchard (2000), Blanchard and Fairley (2001), and Arnold et al., (2003).

Recent analytical and numerical modeling studies have demonstrated how the use of ambient data and indicator species ratios can be used to corroborate the future year control strategy estimates of Eulerian air quality models. Blanchard et al., (1999), for example used data from environmental (i.e., smog) chambers and photochemical models to devise a method for evaluating the 1-hour ozone predictions of models due to changes in precursor NOx and VOC emissions. Reynolds et al., (2003) followed up this analysis, augmented with process analysis, to assess the reliability of SAQM photochemical model estimate of 8-hour ozone to precursor emissions cutbacks. These researchers used three indicator ratios (or diagnostic "probes") to quantify the model's response to input changes:

- The ozone response surface probe [O_3/NO_x];
- The chemical aging probe [NO_z/NO_y]; and
- The ozone production efficiency probe [O_3/NO_z].

By closely examining the CMAQ's response to key input changes, properly focused in time and spatial location, Arnold et al., (2003) were able to show not only good agreement with measurements but also convincingly demonstrated the utility of the method for diagnosing model performance in a variety of ways.

1.5.8 Weight of Evidence Analyses

EPA's guidance recommends three general types of "weight of evidence" analyses in support of the attainment demonstration: (a) use of air quality model output, (b) examination of air quality and emissions trends, and (c) the use of corroborative modeling such as observation-based (OBM) or observation-driven (OBD) models. Use of these methods in conjunction with the CAMx modeling could significantly strengthen the credibility and reliability of the modeling available to the states for their subsequent use. The exact details of the weight of evidence (WOE) analyses must wait until the Baton Rouge ozone modeling study evolves further. It is premature to prescribe which, if any of the WOE analyses would be performed since the model's level of performance for the Baton Rouge ozone modeling episodes is obviously not known at this time and the level of the future-year projected 8-hour ozone Design Values are also not known at this time. EPA requires a WOE analysis, and we believe it is always a good idea to perform WOE analysis to corroborate the modeled attainment demonstration. Below are thoughts regarding what would likely be considered as part of the WOE analyses.

Use of Emissions and Air Quality Trends: Emissions and air quality trend analysis is always an important component of a WOE analysis. When combined with meteorological analysis of the yearly ozone formation potential, it can be used to determine whether actual trends can corroborate the model projected determination of whether future-year air quality goals are achieved.

Use of Corroborative Observational Modeling: While regulatory modeling studies for ozone attainment demonstrations have traditionally relied upon photochemical models to evaluate ozone control strategies, there has recently been growing emphasis on the use of data-driven models to corroborate the findings of air quality models. As noted, EPA's guidance (EPA, 2005a) now encourages the use of such observation-based or observation-driven models (OBMs/ODMs). The merits of using these techniques will be considered as supportive weight of evidence. While the OBD/OBM models cannot predict future year air quality levels, they do provide useful corroborative information on the extent to which ozone formation in specific subregions may be VOC-limited or NOx-limited, for example. Information of this type, together with results of DDM, PA and OSAT as well as traditional "brute-force" sensitivity simulations, can be extremely helpful in postulating emissions control scenarios since it helps focus on which pollutant(s) to control.

Other WOE Analysis: EPA's 8-hour ozone guidance (EPA, 2005a) lists additional analysis that can be performed as part of the WOE including analysis of other studies, use of alternative models and the calculations of alternative model statistics. The use of all of these other techniques will be explored as appropriate.

1.5.9 Assessing Model Reliability in Estimating the Effects of Emissions Changes

EPA identifies three methods (e.g., EPA, 2001, pg. 228) potentially useful in quantifying a model's reliability in predicting air quality response to changes in model inputs, e.g., emissions. These include:

- Examination of conditions for which substantial changes in (accurately estimated) emissions occur;
- Retrospective modeling, that is, modeling before and after historical significant changes in emissions to assess whether the observed air pollution changes are adequately simulated; and
- Use of predicted and observed ratios of "chemical indicator species".

We note that in some urban-scale analyses, the use of weekday/weekend information has been helpful in assessing the model's response to emissions changes. Such analysis should be examined to determine whether it is appropriate for the Baton Rouge area.

The use of indicator species and ratios offers some promise, and was described earlier in Section 1.5.7.2. The first two methods have actually been considered for over 15 years and were the subject of intensive investigations in the early 1990s in Southern California in studies sponsored by the South Coast Air Quality Management District (Tesche, 1991) and the American Petroleum Institute (Reynolds et al., 1996). To date, neither method has proven useful largely because of the great difficulty in developing historical emissions inventories of sufficient quality to make such an analysis credible and the difficulties in removing the influences of different meteorological conditions such that the modeling signal reflects only the model's response to emissions changes. It is difficult enough to construct reliable emissions inventories using today's modeling technology let alone construct retrospective inventories 5-10 years ago prior to the implementation of significant emissions control programs or major land use changes.

1.5.10 Future Year Control Strategy Modeling

Future-year modeling for ozone will be performed for 2009. The Baton Rouge area is currently designated as a Marginal 8-hour ozone nonattainment area and must attain the 8-hour ozone standard by the end of 2006 to meet the June 15, 2007 attainment date. Given the high ozone conditions of 2005 and to date in 2006, the Baton Rouge area will not attain the 8-hour ozone standard in 2006 and will likely bump-up to the Moderate classification with an attainment date of June 15, 2010. Therefore, future year modeling for a 2009 attainment year must be performed. The 2002 baseline emissions will be projected as needed to the modeling episodes being considered (from 2000-2005) and for the future-year 2009, assuming growth and currently on-the-book (OTB) controls.

1.5.11 Future Year Ozone Attainment Demonstration

The Baton Rouge modeling results will be used to demonstrate attainment of the 8-hour ozone NAAQS. The procedures to be used to demonstrate attainment of the ozone NAAQS will follow EPA guidance. Guidance for procedures for demonstrating attainment of the 8-hour ozone standard have been finalized (EPA, 2005a). These procedures use the modeling results in a relative fashion to scale the observed 8-hour ozone Design Values using Relative Reduction Factors (RRFs). RRFs are the ratio of the future-year to current-year modeling results and are used to scale the current-year 8-hour ozone Design Values to project future-year Design Values that are compared against the 8-hour ozone NAAQS to determine whether attainment has been demonstrated. Section 8 of this Protocol provides more details on the 8-hour ozone attainment demonstration modeling approach.

1.6 Project Participants and Contacts

The Louisiana Department of Environmental Quality (LDEQ) is the lead agency in the development of the Baton Rouge 8-hour ozone SIP. They will work closely with EPA Region 6 in the SIP development, including the sharing of interim results as they become available. LDEQ will also work with local agencies and stakeholders in the Baton Rouge SIP development, where stakeholders include environmental groups and industry. To date the LDEQ has enlisted the assistance of two contractors to assist them in the Baton Rouge SIP development: ICF Consulting, who prepared a preliminary 8-hour ozone Modeling Protocol (ICF, 2005); and ENVIRON International Corporation, who assisted the LDEQ in the preparation of this Modeling Protocol. Key LDEQ representatives to contact regarding the technical work are:

Jennifer Mouton: Env. Scientist Manager, Engineering Support	(225) 219-3427
Patrick Pakunpanya: Env. Chemical Specialist Staff	(225) 219-3428
Maurice Oubre: Env. Chemical Specialist Staff	(225) 219-3434

1.7 Communication

Frequent communication between the LDEQ and EPA, and the LDEQ contractors as needed, is anticipated. These communications will include e-mails, conference calls and face-to-face meetings. The LDEQ envisions that interim products will be reviewed by EPA and others as they become available so that comments can be received during the study to allow for corrective action as necessary. These interim deliverables would include, but not be limited to, preliminary MM5 evaluation, preliminary current and future-year emissions assumptions and results, and preliminary CAMx model performance evaluation.

1.8 Preliminary Modeling Protocol and Response to EPA Comments

Under contract to the LDEQ, a preliminary draft Modeling Protocol for simulating 8-hour ozone concentrations in the Baton Rouge area was prepared (ICF, 2005). EPA Region 6 provided comments on the Baton Rouge preliminary draft Modeling Protocol (Diggs, 2005). This revised draft Modeling Protocol addresses almost all of EPA's comments on the preliminary draft Modeling Protocol. There are several significant improvements and updates to the technical approach as follows:

- Use of the more current Comprehensive Air quality Model with extensions (CAMx; ENVIRON, 2006) over Version V of the Urban Airshed Model (UAM-V; Morris et al., 1991). CAMx allows the use of advanced features such as CB or SAPRC chemistry, advanced Plume-in-Grid (PiG) sub-modules, and a suite of "Probing Tools";
- Update of the Emissions Processing System from Version 2.5 (EPS2.5) to Version 3 (EPS3);
- Expansion of the modeling domains to be truly regional in nature as has been recommended in recent 8-hour ozone EAC SIP modeling (e.g., Oklahoma), 8-hour ozone modeling for Texas and Regional Haze modeling;
- Other refinements based on recent advances in modeling and comments from EPA and others.

Below we address each of the EPA comments (Diggs, 2005) on the preliminary draft Modeling Protocol (ICF, 2005):

<u>Chapter 1</u>

<u>Technical Issues Brought up with EPA</u>: EPA raised a concern that any technical issues encountered would be resolved by the contractor and LDEQ without EPA involvement. It was always the intent of the LDEQ to work with the EPA in the development of the Baton Rouge 8-hour ozone attainment plan and the LDEQ will bring up any issues with EPA as part of their resolution. This is made clearer in the current draft Modeling Protocol.

<u>One Report at End of Modeling</u>: The preliminary draft Modeling Protocol indicates that only one report is planned at the end of the modeling. Although the intent to have one

report at the end of the project to serve as the Technical Support Document (TSD) for the Baton Rouge 8-hour ozone SIP, there will be numerous interim work products that will be available for EPA to review as the LDEQ works with their contractors and EPA in the development of the SIP.

Chapter 2

Description of CB-V: EPA noted that the Attachment describing the CB-V chemical mechanism was not attached to the preliminary draft Modeling Protocol as indicated on page 2-4 item #5. A description of the CB-V chemical mechanism is available at: http://www.uamv.com/members/documents/CB5_SAI_Memo_021204.doc. However, in this updated Protocol we no longer propose to use CB-V.

Use of SAPRC Chemistry: EPA suggested that the SAPRC chemistry may be a better choice over the CB chemistry since it has been shown to have better treatment of Highly Reactive VOC (HRVOC) compounds in Houston. This issue is addressed in this revised draft Modeling Protocol. The switch from the UAM-V to CAMx models allows for an investigation into the use of both the CB and SAPRC chemical mechanisms. We propose that this issue be addressed with sensitivity tests.

Chapter 3

Sufficient Days for 8-Hour Ozone Attainment Test: EPA raised concerns that since just the peak 8-hour ozone concentrations are given for each day then they can not determine whether there will be sufficient days to perform a reliable 8-hour ozone attainment demonstration at each key monitor. EPA guidance recommends at least 10 days with base case ozone above 70 ppb (above 85 ppb preferred) with 5 days an absolute minimum. In the revised draft Modeling Protocol we have provided daily maximum 8-hour ozone concentrations from all monitors for the 6-year period of 2000-2005 as Appendix B; and for the proposed episode days in Chapter 3 we list ozone for all Baton Rouge monitors.

Chapter 4

Size of Modeling Domain: EPA was concerned that the modeling domain is too small and doesn't reflect the recent findings from the Oklahoma EAC modeling (Morris et al., 2005d) that found benefits from increasing the size of the modeling domain. The proposed 36/12/4 km modeling domains have been revised substantially (see Chapter 4) with the 36-km domain extending north of Chicago and the 12-km domain extended north and east to include many of the major sources in the Ohio River Valley.

Move the 4-km Southern Boundary Further South: EPA also commented that the southern boundary should be moved further south to minimize effects of the shoreline and land cover changes near the 4-km and 12-km grid boundaries. As seen in Chapter 4, the 4-km boundary for the MM5 modeling is now far south of the Coastline to minimize these effects.

Use of CEM Data: EPA was unclear on how the CEM data would be used. Day-specific hourly CEM data will be used for Electrical Generating Units (EGU) for the Baton Rouge modeling episodes for the actual base case simulations that are used in the model performance evaluation. For projecting future-year 8-hour ozone Design Values, representative average emissions for EGUs will be used for the baseline period under analysis (e.g., 2000-2005).

Use of Plume-in-Grid Treatment: EPA was unclear what sources would be treated with the Plume-in-Grid (PiG) module, whether the PiG module included full chemistry and whether HRVOC sources would be treated with the PiG. With the switch to the CAMx model, the Incremental Reactive Organic Nitrogen (IRON) Plume-in-Grid (PiG) can be used that includes full photochemistry. IRON PiG has been used successfully to simulate HRVOC sources in the Houston Galveston Brazoria (HGB) area. If HRVOC emissions can be characterized in the Baton Rouge area, they can be treated with the IRON PiG.

Self Generating Boundary Conditions: EPA requested more information on how the self-generating boundary conditions (BCs) will be used and why only modeled values at midnight are used. With the expansion of the 36-km modeling domain to include the eastern U.S. the importance of BCs has been reduced substantially. The new draft Modeling Protocol does not propose to use self-generating BCs.

MM5 Model Configuration: EPA desired clarification on the physics options in MM5 and objects to the specification of a simple ice and stable precipitation scheme in the 4-km fine grid as it would not account for convective mixing. The definition of the physics options to be used in MM5 is clearer in this revised draft Modeling Protocol (see Chapter 5, especially Table 5-1). In particular, we are proposing to use the Reisner II mixed phase explicit microphysics in all three grids (36/12/4 km) and the Kain Fritsch II subgrid-scale cumulus parameterization in the 36/12 km grids.

Use of 108-km Grid for MM5: EPA objected to the use of a 108-km MM5 grid to drive the 36-km MM5 grid when the EDAS data driving it are at 40-km resolution. We agree with EPA and have dropped the 108-km grid in this revised draft Modeling Protocol so that the 40-km EDAS data will be used as ICs, BCs and nudging fields directly with the MM5 36-km grid simulation.

Number of vertical levels: EPA stated that 25-30 vertical levels for MM5 may not be sufficient. In the current Modeling Protocol we have increased the number of vertical layers for the MM5 modeling and are expecting to use 34 vertical layers based on CENRAP modeling.

Use of the MRF PBL scheme: EPA expressed concerns with using the MRF PBL scheme as it has overestimated PBL heights in the past. In this revised Modeling Protocol we are proposing to use the PX/ACM LSM/PBL scheme in MM5 and evaluate the NOAH/ETA scheme suggested by EPA as a sensitivity test.

MM5 Spin-up Time Insufficient: EPA noted that the 5 hour spin-up time for MM5 before using the data for photochemical modeling may be insufficient to eliminate the effects of the ICs and suggests that a 12-24 hour spin-up may be more appropriate. Based upon the modeling team's experience, 5 hours should be sufficient spin-up time given that MM5 will use the EDAS to provide initial and boundary conditions, and will use EDAS in the FDDA component. Also note that the effective MM5 spin-up time before the first photochemical modeling episode day will be ~10 days, due to the need to run the photochemical model through a similar 10 day spin-up period to initialize the 36-km grid and completely eliminate the effects of the ICs on the simulated ozone concentrations.

MM5 Model Evaluation Procedures Lacking: EPA requested more detail on the MM5 model performance evaluation. This is provided in Chapter 5 of this draft Modeling Protocol.

Boundary Conditions Procedures: EPA was concerned about the procedures proposed for self generating boundary conditions (BCs) and suggests it may be more appropriate to use results from a global scale model such as GEOS-CHEMN or MOZART. In this draft Modeling Protocol we are proposing to use BCs from the CENRAP RPO annual 2002 simulations of the continental US at 36-km resolution. This will provide better resolution than the global models that are frequently run with 4 to 5 degree grid cell resolution (~400-500 km). For episodes from 2002 we would use day-specific hourly BCs from the CENRAP 36-km simulations. For episodes outside of 2002 we would use monthly average diurnally varying values from the CENRAP 2002 simulation.

Chapter 6

Clarification of Model Evaluation Metrics and Displays: EPA requested that there be more details on the displays, metrics and analysis that will be used in the modeling evaluation. This revised draft Modeling Protocol devotes Chapter 6 to the ozone model performance evaluation, which provides such details.

Chapter 7

Reporting on all Diagnostic Simulations: EPA requested that all modifications and adjustments to the model inputs and models as a result of the diagnostic tests be reported to LDEQ and EPA for review and comment. This was always our intent and it is made more explicit in this Modeling Protocol.

Chapter 9

Calculation of Daily RRF Values at Each Monitor: EPA requested that daily RRF values be calculated at each monitor to elucidate the understanding of the model response. This is easy to do and will be performed and reported on in the course of the modeling analysis.

General

More Information on Episode Selection: EPA requested that more information be provided on episode selection, and that EPA be allowed to provide additional comments as the information provided in the preliminary Modeling Protocol was insufficient to provide substantive comments. Additional information on episode selection is provided in this Modeling Protocol. In particular, we provide more complete information on the ozone levels at all monitors for the candidate episodes and rank seven candidate episodes for modeling.

New EPA 8-Hour Ozone Modeling Guidance: EPA notes in their comments that final 8-hour ozone modeling guidance is forthcoming. This guidance was finalized in October 2005 (EPA, 2005a) and its contents have been incorporated in this draft Modeling Protocol.

2.0 MODEL SELECTION

This section introduces the models to be used in the Baton Rouge 8-hour ozone modeling study. The selection methodology presented in this chapter rigorously adheres to EPA's guidance for regulatory modeling in support of ozone attainment demonstrations (EPA, 2005a). Unlike previous ozone modeling guidance, the agency now recommends that models be selected for SIP studies on a "case-by-case" basis with appropriate consideration being given to the candidate models:

- Technical formulation, capabilities and features;
- Pertinent peer-review and performance evaluation history;
- Public availability; and
- Demonstrated success in similar regulatory applications.

All of these considerations should be examined for each class of models to be used (e.g., emissions, meteorological, and photochemical) in part because EPA no longer recommends a specific model or suite of photochemical models for regulatory application as it did fifteen years ago (EPA, 1991). After identifying the models we believe are best suited to the requirements of the Baton Rouge 8-hour ozone SIP modeling study, the justification for their selection is discussed. The actual science configurations recommended for each model in this study are introduced in Chapter 5.

EPA's new guidance on model selection and justification requires a substantial effort to document the past evaluation studies, peer-reviews and application efforts associated with the models recommended for use. Many of the relevant citations are presented in the References section of this protocol.

2.1 Regulatory Context for Model Selection

A comprehensive modeling protocol for the Baton Rouge 8-hour ozone attainment demonstration study consists of many elements. Its main function is to serve as a means for planning and communicating how a modeled attainment demonstration will be performed *before* it occurs (EPA, 1999). The protocol guides the technical details of a modeling study and provides a formal framework within which the scientific assumptions, operational details, commitments and expectations of the various participants can be set forth explicitly and means for resolution of potential differences of technical and policy opinion can be worked out openly and within prescribed time and budget constraints.

The modeling protocols for regulatory applications all too often fall short of providing sufficient detail in the description of the modeling assumptions and procedures to be employed (Roth et al., 2005). They are seldom updated as the modeling program ensues, notwithstanding declarations that they are "living documents". Part of the reason for this is that resource and schedule limitations necessitate greater emphasis on performing the modeling studies satisfactorily and on time and in addressing unexpected challenges that invariably arise; refining the protocol becomes a lower priority. As the cognizant State agency, the LDEQ has the responsibility for updating relevant portions of this chapter of the protocol as new information is gained relative to the suitability of the models recommended for use in Baton Rouge.

2.1.1 Summary of Recommended Models

To develop new 8-hour ozone modeling episodes for the Baton Rouge 5-Parish area, the following state-of-science regional meteorological, emissions and air quality models will be used. The science features of these models and the justification for their selection are given later in this section. For the Baton Rouge 8-hour ozone modeling, we propose to use the MM5/EPS3/CAMx modeling system. This is the same modeling system that is being used to address ozone issues in Texas (e.g., HGB and DFW) and was also used in several recent 8-hour ozone EAC SIPs that have been approved by EPA (e.g., Denver, Texas NAAs, Oklahoma and New Mexico).

> MM5: The Fifth Generation Pennsylvania State University (PSU) National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5) is a nonhydrostatic, prognostic meteorological model routinely used for urban- and regional-scale photochemical, fine particulate, and regional haze regulatory modeling studies (Dudhia, 1993; Seaman, 2000). Developed in the 1970s, the MM5 modeling system maintains its status as a state-of-the-science model through enhancements provided by a broad user community worldwide (Stauffer and Seaman, 1990; Xiu and Pleim, 2000; Byun et al., 2005a,b). MM5 is used nearly exclusively for regulatory air quality applications in the U.S. In recent years, the modeling system has been successfully applied in continental scale annual simulations.
>
> EPS3: The Emissions Processing System Version 3 (EPS3) is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, nonroad, area, point, fire, biogenic and other emission sources for photochemical grid models. The EPS3 is an extension of the EPS2.5, which the LDEQ has used in the past, and incorporates several new features, including better quality assurance (QA), and is more computationally efficient. EPS3 is used primarily to process county level emissions to the photochemical model grid and species at an hourly time scale and is also used to process point source emissions. Day-specific biogenic emissions will be generated using the GLOBEIS model.
>
> CAMx: The Comprehensive Air quality Model with Extensions (CAMx) is a state-of-science "One-Atmosphere" photochemical grid model capable of addressing ozone, particulate matter (PM), visibility and acid deposition at regional scale for periods up to one year (ENVIRON, 2006). CAMx is a publicly available open-source computer modeling system for the integrated assessment of gaseous and particulate air pollution. Built on today's understanding that air quality issues are complex, interrelated, and reach beyond the urban scale, CAMx is designed to (a) simulate air quality over many geographic scales, (b) treat a wide variety of inert and chemically active pollutants including ozone, inorganic and organic $PM_{2.5}$ and PM_{10} and mercury and toxics, (c) provide source-receptor, sensitivity, and process analyses and (d) be computationally efficient and easy to use. The U.S. EPA has approved the use of CAMx for numerous ozone and PM State Implementation Plans throughout the U.S., and has used this model

to evaluate regional mitigation strategies including those for most recent regional rules (e.g., CAIR, NOx SIP Call, etc.).

2.2 Details of the Recommended Models

Further details of the models we propose for use in the Baton Rouge 8-hour ozone modeling effort are described below. More information on these models may be obtained from the VISTAS, CENRAP, and Houston-Galveston-Beaumont modeling protocols (Morris et al., 2004a,b; Tesche et al., 2005b) and the literature references cited therein.

2.2.1 The MM5 Meteorological Model

The non-hydrostatic MM5 model (Dudhia, 1993; Grell et al., 1994) is a three-dimensional, limited-area, primitive equation, prognostic model that has been used widely in regional air quality model applications (Seaman, 2000). The basic model has been under continuous development, improvement, testing and open peer-review for more than 20 years (Anthes and Warner, 1978; Anthes et al., 1977) and has been used world-wide by hundreds of scientists for a variety of mesoscale studies, including cyclogenesis, polar lows, cold-air damming, coastal fronts, severe thunderstorms, tropical storms, subtropical easterly jets, mesoscale convective complexes, desert mixed layers, urban-scale modeling, air quality studies, frontal weather, lake-effect snows, sea-breezes, orographically induced flows, and operational mesoscale forecasting.

MM5 is based on the prognostic equations for three-dimensional wind components (u, v, and w), temperature (T), water vapor mixing ratio (q_v), and the perturbation pressure (p'). Use of a constant reference-state pressure increases the accuracy of the calculations in the vicinity of steep terrain. The model uses an efficient semi-implicit temporal integration scheme and has a nested-grid capability that can use up to ten different domains of arbitrary horizontal and vertical resolution. The interfaces of the nested grids can be either one-way or two-way interactive. The model is also capable of using a hydrostatic option, if desired, for coarse-grid applications.

MM5 uses a terrain-following non-dimensionalized pressure, or "sigma", vertical coordinate similar to that used in many operational and research models. In the non-hydrostatic MM5 (Dudhia, 1993), the sigma levels are defined according to the initial hydrostatically-balanced reference state so that the sigma levels are also time-invariant. The gridded meteorological fields produced by MM5 are directly compatible with the input requirements of “one atmosphere” air-quality models using this coordinate (e.g., CMAQ and CAMx). MM5 fields can be easily used in other regional air quality models with different coordinate systems (e.g., CAMx) by performing a vertical interpolation, followed by a mass-conservation re-adjustment.

Distinct planetary boundary layer (PBL) parameterizations are available for air-quality applications, all of which represent sub-grid-scale turbulent fluxes of heat, moisture and momentum. These parameterizations employ various surface energy budget equations to estimate ground temperature (T_g), based on the insolation, atmospheric path length, water vapor, cloud cover and longwave radiation. The surface physical properties of albedo, roughness length, moisture availability, emissivity and thermal inertia are either defined as functions of land-use for numerous categories via a look-up table, or are provided as input fields from various terrestrial and large-scale analysis datasets.

Initial and lateral boundary conditions are specified from mesoscale three-dimensional analyses developed at 3-hour intervals on the outermost grid mesh selected by the user. Additional surface fields are also available at three-hour intervals. A Cressman-based technique is used to include standard surface and radiosonde observations into the analyses to improve local mesoscale representations. The lateral boundary data are introduced into MM5 using a relaxation technique applied in the outermost five rows and columns of the most coarse grid domain.

A major feature of the MM5 is its use of state-of-science methods for Four Dimensional Data Assimilation (FDDA). The theory underlying this approach and details on how it has been applied in a variety of applications throughout the country are described in depth elsewhere (Stauffer and Seaman, 1990, 1996; Seaman et al., 1992, 1995, 1996).

Results of detailed performance evaluations of the MM5 modeling system in regulatory air quality application studies have been widely reported in the literature (e.g., Emery et al., 1999; Tesche and McNally, 1996b,1997c, 1999, 2001; Sistla et al., 2001;Nielsen-Gammon, et al., 2005; Olerud and Sims, 2004a,b) and many have involved comparisons with other prognostic models such as RAMS. The MM5 enjoys a far richer application history in regulatory modeling studies compared with RAMS or other models. Furthermore, in evaluations of these models in over 60 recent regional scale air quality application studies since 1995, it has generally been found that MM5 model tends to produce somewhat better photochemical model inputs than alternative models (Tesche et al., 2002).

2.2.2 The EPS3 Emissions Modeling System

Emissions modeling for Baton Rouge will be performed primarily with the Emissions Preprocessor System 3.0 (EPS3). The Emissions Preprocessor System 2.0 prototype was originally developed at ICF Consulting/Systems Applications International (ICF/SAI; EPA, 1990). As with most "emissions models", EPS is principally an emission processing system, and not a true emissions modeling system from which emissions estimates are simulated from "first principles." This means that, with the exception of biogenic sources, its purpose is to provide an efficient, modern tool for converting emissions inventory data into the formatted emission files required by an air quality simulation model. EPS3 consists of a series of FORTRAN modules that perform the intensive data manipulations required to incorporate spatial, temporal, and chemical resolution into an emissions inventory used for photochemical modeling.

EPS was originally designed to provide emission modelers with a cohesive set of FORTRAN programs that allowed flexibility in processing, minimal setup requirements, ease of use, and informative output reports to enhance quality assurance and support technical reports. The processing is flexible because the steps of temporal projection, controls, chemical speciation, temporal allocation, and spatial allocation are separated into independent programs that share a consistent internal file format that allows emissions data to be passed from one module to another. The flexibility of EPS provides the users with both a "turn-the-crank" system for generating modeling inventories, and a means for the discriminating user to implement detailed, locally available data such as source-specific speciation, temporal information, and episode specific emissions. It provides for processing large sets of similarly formatted data (large national datasets) or processing individual sources separately (a single production facility reviewing control strategies). EPS3 supports area, mobile, both on-road and off-road, and point source emissions processing. The results from these processing categories are merged together at a final stage of processing.

EPS has been available since the 1990 release of the UAM modeling system (Morris and Myers, 1990), and it has been used for emissions processing in numerous regional air quality modeling applications throughout the world. In 2004, EPS3 was redesigned and improved by ENVIRON for TCEQ in support of their SIP efforts. The primary purposes of the EPS3 redesign were to: (a) generalize the output report writing routines and allow user selections of output tables, (b) optimize the code structure to eliminate outdated and never used functions, (c) define an easy method for user-specified criteria and model species, (d) increase the field sizes for character identifiers to support the NIF data, (e) enhance the spatial allocation routines to allow for secondary and tertiary surrogates to be defined and used in cases where the primary surrogate assignments would result in a loss of total emissions, and (f) provide a single module to merge elevated point source files and support plume-in-grid (PiG) treatment of point sources. Since the user can now specify the emission inventory criteria pollutants as well as the modeling lumped compounds, any chemical mechanism can be used in EPS3 as long as the appropriate input data are supplied.

Notable features of EPS3 from an applications standpoint include: (a) improved control strategy processing by providing additional modules (low level and elevated) to maintain the detailed information that is required for control applications on the speciated, temporally and spatially allocated emissions, (b) FORTRAN is the only software required to run EPS3, although some input file preparation may require other software, (c) additional EPS3 programs provide more flexibility than earlier versions, (d) improved data file formats, (e) enhanced quality assurance, (f) improved emissions reporting and QA capabilities, (g) improved temporal allocation, and (h) the source code is distributed with example test cases to allow project specific enhancements.

Continuing model development activities with EPS3 now occur at ENVIRON. EPS3, released in February 2006, is the version that will be used for the various Baton Rouge model runs.

2.2.3 The CAMx Regional Photochemical Model

The Comprehensive Air quality Model with Extensions (CAMx) is a publicly available (www.camx.com) three-dimensional multi-scale photochemical/aerosol grid modeling system that is developed and maintained by ENVIRON International Corporation. CAMx was developed with all new code during the late 1990s using modern and modular coding practices. This has made the model an ideal platform to treat a variety of air quality issues including ozone, particulate matter (PM), visibility, acid deposition, and air toxics. The flexible CAMx framework has also made it a convenient and robust host model for the implementation of a variety of mass balance and sensitivity analysis techniques including Process Analysis (IRR, IPR, and CPA), Decoupled Direct Method (DDM), and the Ozone/PM Source Apportionment Technology (OSAT/PSAT). Designed originally to address multiscale ozone issues from the urban- to regional-scale, CAMx has been widely used in recent years by a variety regulatory agencies for 1-hour and 8-hour ozone SIP modeling studies. Key attributes of the CAMx model for simulating gas-phase chemistry include the following:

- Two-way grid nesting that supports multiple levels of fully interactive grid nesting (e.g., 36/12/4/1.33 km);
- CB4 or SAPRC99 chemical mechanisms;
- Two chemical solvers, the CAMx Chemical Mechanism Compiler (CMC) Fast Solver or the highly accurate Implicit Explicit Hybrid (IEH) solver;
- Multiple numerical algorithms for horizontal transport including the Piecewise Parabolic Method (PPM) and Bott advection solvers;
- Subgrid-scale Plume-in-Grid (PiG) algorithm to treat the near-source plume dynamics and chemistry from large NOx and VOC point source plumes;
- Ability to interface with a variety of meteorological models including the MM5, WRF and RAMS prognostic hydrostatic meteorological models and the CALMET diagnostic meteorological model (others also compatible);
- The Ozone Source Apportionment Technology (OSAT) that identifies the ozone contribution due to geographic source regions and source categories (e.g., mobile, point, biogenic, etc.); and
- The Decoupled Direct Method (DDM) sensitivity method is implemented for emissions and IC/BC to obtain first-order sensitivity coefficients for all gas-phase species.

Culminating from extensive model development efforts at ENVIRON and other participating groups, the CAMx v4.2 was released on 13 July 2005 as a truly “One-Atmosphere” model that rigorously integrates the gas-phase ozone chemistry with the simulation of primary and secondary fine and coarse aerosols. This extension of CAMx to treat PM involved the addition of several science modules to represent important physical processes for aerosols. Noteworthy among these are:

- Two separate treatments of PM: Mechanism 4 (CF) uses two static size sections and science modules comparable to CMAQ (e.g., RADM aqueous-phase chemistry and ISORROPIA equilibrium); and Mechanism 4 (CMU) uses a multi-section “full-science” approach using aerosol modules developed at Carnegie Mellon University (CMU).
- The size distribution in the CMU approach is represented using the Multi-component Aerosol Dynamics Model (MADM), which uses a sectional approach to represent the aerosol particle size distribution (Pilinis et al., 2000). MADM treats the effects of condensation/evaporation, coagulation and nucleation upon the particle size distribution.
- Inorganic aerosol thermodynamics can be represented using ISORROPIA (Nenes et al, 1998; 1999) equilibrium approach within MADM, or a fully dynamic or hybrid approach can also be used.

- Secondary organic aerosol thermodynamics are represented using the semi-volatile scheme of Strader and co-workers (1999).
- Aqueous-phase chemical reactions are modeled either using the RADM module (like CMAQ) or the Variable Size-Resolution Model (VRSM) of Fahey and Pandis (2001), which automatically determines whether water droplets can be represented by a single "bulk" droplet-size mode or whether it is necessary to use fine and coarse droplet-size modes to account for the different pH effects on sulfate formation.
- The PM Source Apportionment Technology (PSAT) "Probing Tool" can separately track PM source apportionment for SO4/NO3/NH4, SOA, Primary PM and Hg families of tracers.

In 2006 ENVIRON released CAMx v4.31 that is the most current (May 2006) version of CAMx available on the website (www.camx.com). Version 4.31 includes several improvements geared mainly toward improved PM simulations. Version 4.40 is currently under development to expand PSAT for use with the PiG sub-module. Either version 4.31 or 4.40 will be used in the Baton Rouge 8-hour Ozone Study.

2.3 Justification for Model Selection

2.3.1 MM5

The most commonly used prognostic meteorological models to support air quality modeling are the MM5 and the Regional Atmospheric Modeling System (RAMS). The new Weather Research Forecast (WRF) model shows promise as a meteorological driver for air quality models, but it needs further demonstration before it can be used in a regulatory modeling study. A number of recent studies inter-compare the theoretical formulations and operational features of the MM5 and RAMS models and evaluate their performance capabilities under a range of atmospheric conditions. There have also been a number of studies involving "side-by-side" comparative performance evaluations of MM5 and RAMS for the OTAG and LMOS episodes. Consistent with these evaluation studies, the MM5 is recommended as the prognostic meteorological modeling component for the Baton Rouge study for the following reasons:

- All of the available state-of-science regional photochemical models identified in EPA's 8-hour modeling guidance can be operated without difficulty using inputs supplied by the MM5; however, some ozone models such as MAQSIP and Models-3/CMAQ cannot be run easily with the RAMS polar stereographic map projection. In some cases, costly software development would be needed to allow this coupling between RAMS and certain air quality models.
- In recent scientific model inter-comparisons examining over sixty air quality applications across the country, the MM5 model was found to perform somewhat better than RAMS, particularly for surface and aloft winds and surface temperatures.
- The MM5 model has a far richer application history in regulatory ozone modeling studies compared with RAMS. While RAM's principal air quality applications have been in OTAG and SAMI, the MM5 has been employed in a much wider range of regional studies including CAIR, CAMR, SAMI, NARSTO, SARMAP, SCOS,

SCAQS, VISTAS, MANE-VU, CENRAP, MRPO, and WRAP as well as in a number of urban-scale SIP applications (e.g., Pittsburgh, Cincinnati, San Juan, Kansas City, St. Louis, Denver, Tulsa, Houston, Dallas, Central California, Phoenix, Boise, etc.).

- While MM5 and RAMS meteorological models have been used for air quality modeling in different urban and regional-scale studies, in most regulatory ozone applications the MM5 model has been the preferred system.

2.3.2 EPS3

The EPS3 modeling system is recommended as the emissions model for the Baton Rouge 8-hour ozone modeling study for the following reasons:

- EPS3 is a mature, thoroughly-tested emissions modeling system having been employed by a wide variety of governmental, commercial, academic, and private users in numerous regions throughout the U.S. and abroad.
- The LDEQ has considerable experience with EPS, most notable with EPS2.5, and the additional features in EPS3 (better reporting QA and computational efficiency) will be mostly transparent in its application.
- EPS3 is being used by the TCEQ for their ozone modeling (e.g., HGA, BPA and DFW) that can be leveraged for the Louisiana emissions modeling.
- EPS3 does not require any special software (e.g., SAS) or libraries (e.g., I/O API) like other emissions modeling systems (e.g., EMS, SMOKE, and CONCEPT).
- All of the required emissions data sets needed to construct EPS3 input files for Baton Rouge are readily available from LDEQ, TCEQ, EPA, CENRAP, the MRPO and/or VISTAS.
- EPS3 provides several quality assurance and error checking routines, thereby allowing the study team to perform an independent verification of the base year and future year emissions inventories developed for this project.

2.3.3 CAMx

During the NARSTO Critical Tropospheric Ozone Assessment, two major reviews of photochemical modeling were performed. Russell and Dennis (2000) compared the scientific and operational features of essentially all current recent Eulerian photochemical models in use up to that time. In parallel, Roth et al. (1998, 2005) reviewed more than twenty regulatory applications of photochemical models in the U.S. and Canada. From these reviews, and the modeling team's experience with each of these models, we recommend CAMx as the ozone modeling tool for the Baton Rouge study for the following reasons:

- CAMx is a state-of-science "one-atmosphere" model;
- CAMx has undergone extensive successful testing by a variety of groups for nearly a decade.
- CAMx is unique among state-of-science "one-atmosphere" air quality models in its ability to offer ozone and particulate source apportionment technology (OSAT, PSAT), Process Analysis, and the DDM sensitivity analysis scheme.

- CAMx is relied upon almost exclusively by TCEQ as the air quality model for SIP applications in Texas, and other regulatory agencies including the EPA have relied on the model to support for regulatory decision making (e.g., CAIR, NOx SIP Call, etc.).
- CAMx has been used in most 8-hour ozone SIP modeling to date submitted to EPA (e.g., Oklahoma, New Mexico, Denver, San Antonio, Austin and East Texas 8-hour ozone EAC SIPs).
- CAMx is a public-domain model, available free of charge, without restriction (www.camx.com).

2.4 Model Limitations

All mathematical models possess inherent limitations owing to the necessary simplifications and approximations made in formulating the governing equations, implementing them for numerical solution on fast computers, and in supplying them with input data sets and parameters that are themselves approximations of the full state of the atmosphere and emission processes. Below, we list the more important limitations of the various modeling systems to be employed in the Baton Rouge study.

2.4.1 MM5

In VISTAS (Morris et al., 2004a,b), four different configurations of the MM5 Land Soil Model (LSM) and Planetary Boundary Layer (PBL) were evaluated. Depending on the meteorological variable (e.g., winds, temperature, moisture) and location (e.g., mountains, coastal, east, west), different LSM_PBL configurations performed better. For VISTAS, the Pleim-Xiu PBL scheme (Xiu and Pleim, 2000) was selected because it was consistently the top performing configuration across the VISTAS. However, detailed research in Houston by UH/IMAQS (Byun et al., 2005a,b) have revealed that their modified MRF PBL scheme appears to better match the local meteorological conditions of the study region. The proper treatment of vertical turbulent mixing and the estimate of the PBL heights are among the important current science limitations in the model.

2.4.2 EPS3

All emissions modeling systems have uncertainties and limitations. Foremost among these are the initial emissions estimates provided as input to the emissions models. However, even with exact emission estimates as inputs (an unlikely event) the emissions models still have numerous limitations just because of the shear volume of data that needs to be characterized and processed and the limited amount of data available to make the characterization:

Spatial Allocation: Emissions modeling system use surrogate distributions to spatially distribute county-level emissions. For example agricultural land use category would be used to spatially distribute agricultural equipment emissions, population may be used for a variety of home related emissions (e.g., home heating, aerosol sprays, etc.). The accuracy of these surrogate distributions will likely vary by source category.

Temporal Allocation: The allocation of annual average emissions to months and across the diurnal cycle use typical distributions by source category. The accuracy of these temporal allocations vary by source type within broader categories (e.g., heavy-duty diesel vs. light duty gas within the on-road category). They may also vary over different days. For example, the Saturday temporal distribution of mobile sources emissions may be quite different on days when the LSU Tigers have a home football game from a typical Saturday emissions.

Chemical Speciation: Emission models need to chemically speciate the VOC emissions into the photochemical mechanism (e.g., CB4) used in the photochemical grid model based on industrial codes. There is actually a limited number of speciation profiles and individual source tests have not been conducted for all different types of sources; consequently speciation profiles are assigned to "similar" sources that have source profile measurements.

Emission Projections: Projecting emissions introduces probably the largest layer of uncertainty. Emission projections include growing emissions from a current (e.g., 2002) to future (e.g., 2009) year and then the application of any appropriate controls. Both of these steps are characterized by potentially huge limitations. For example, the fact that Baton Rouge about doubled its population in 2005 was not forecast in any past growth scenarios.

2.4.3 CAMx

Like all air quality models, there are a number of conceptual, physical, chemical, computational and operational challenges that CAMx model developers and the user community face to one extent or another. One current limitation is the treatment of vertical turbulent mixing where there are alternative means for estimating the time and space variation in turbulent mixing. Another common drawback of CAMx are the extensive emissions, meteorological and IC/BC inputs needed to operate the model. Treatment of clouds and wet deposition is an area of current research that needs to be updated. A practical limitation of CAMx is the computational requirements, including the need of significant disk space

None of the current limitations identified in the MM5, EPS and CAMx models render any of these models inappropriate for their use in this study, and are in fact common to all current models available for this type of application. However, such limitations need to be recognized and accounted for in the interpretation of the modeling results

2.5 Model Input Requirements

Each of the modeling system components has significant data base requirements. These data needs fall into two categories: those required for model setup and operation, and those required for model evaluation and testing. Below, we identify the main input data base requirements for the meteorological, emissions, and air quality models. Details on the sources of the required data and how they will be used to construct model inputs are discussed in Chapter 5.

2.5.1 MM5

The databases required to set up, exercise, and evaluate the MM5 model consist of various fixed and variable inputs including: (a) topography, (b) vegetation type, (c) land use, (d) atmospheric data, (e) water temperature, (f) clouds and precipitation; and (g) multi-Scale FDDA data. Much of this data is available from the NCAR website.

2.5.2 EPS3

The databases required to set up and operate EPS3 for the Baton Rouge episodes are as follows (a) area source emissions in AMS format, (b) nonroad source emissions in AMS format, (c) stationary point source emissions in AFS format, (d) CEM emissions, day specific, (e) wildfire emissions, day specific, (f) on-road motor vehicle VMT and activity data, and (g) MOBILE6.2 input parameters. Also required are data files specific for temporal allocation, spatial allocation, and chemical speciation.

2.5.3 CAMx

Major CAMx model inputs include: (a) three-dimensional hourly meteorological fields generated by MM5 via the MM5CAMx interface tool, (b) three-dimensional hourly emissions generated by EPS, (c) initial conditions and boundary conditions (IC/BC), (d) photolysis rates look up table, (e) albedo/haze/ozone Column input file, and (f) land use.

2.6 Summary of Model Selection and Justification

In summary, the MM5, EPS3 and CAMx regional models are recommended for use in the Baton Rouge 8-hour ozone modeling study. In this chapter, we have introduced the models in the context of the current state-of-science in emissions, meteorological, and photochemical modeling and have provided brief technical summaries of each one. In addition, we have presented the rationale underpinning the selection of this specific suite of models for the Baton Rouge photochemical modeling study.

We conclude the model selection discussion by presenting in Tables 2-1 through 2-4 the six (6) criteria set forth in EPA's draft 8-hour modeling guidance (EPA, 2005a) for determining whether a candidate model is *appropriate* for use in an ozone attainment demonstration study. Associated with each of the six criteria are the reasons why we believe the three models selected are indeed suitable candidates for this application. Tables 2-5 through 2-8 list the five (5) criteria that EPA has established for actually *justifying* the use of a model in the proposed study. Collectively, the information presented in Tables 2-1 though 2-8 supports our recommendation that the MM5, EPS3 and CAMx models are logical choices given the specific technical, regulatory, and resource aspects of the Baton Rouge 8-hour ozone modeling study.

2.7 Availability of Model Codes, Analysis Tools and Related Software

The source codes, user's guides, analysis tools, documentation and related software for all models used in this study are publicly available. These models and their pre- and post-processor programs and test data bases may be obtained from the following:

MM5:	http://www.mmm.ucar.edu/mm5/overview.html
EPS3:	Contact ENVIRON International Corporation (camx@environ.org)
CAMx:	http://www.camx.com

Table 2-1. Factors qualifying MM5 for use in the Baton Rouge ozone modeling study.

Consideration	Qualification
The model has received a scientific peer review.	Formal scientific reviews of the MM5 model have been widely carried out in the U.S. and abroad over the past 20 years. Examples include Pielke (1984); Emery et al., (1999, 2001); Barchet and Dennis (1990); Tesche and McNally (1993e,f); Pielke and Pierce (1994); and Seaman (1995, 2000, 2005). More than one hundred governmental, academic, industrial and private modeling groups in the U.S. and abroad have reviewed the model code as part of training, model set-up, exercise, and quality assurance activities.
The model can be demonstrated to be applicable to the problem on a theoretical basis.	By design, MM5 explicitly or implicitly represents the various physical and microphysical processes relevant to the prediction of mesoscale atmospheric phenomena. The model has been used world-wide by hundreds of scientists for a variety of mesoscale studies, including cyclogenesis, polar lows, cold-air damming, coastal fronts, severe thunderstorms, tropical storms, subtropical easterly jets, mesoscale convective complexes, desert mixed layers, urban-scale modeling, air quality studies, frontal weather, lake-effect snows, sea-breezes, orographically induced flows, and operational mesoscale forecasting. The features and capabilities of the MM5 modeling system are consistent with the application on a combined urban- and regional-scale, as required in the Baton Rouge study.
Date bases needed to perform the analysis are available and adequate.	The surface and upper air meteorological data required to exercise and evaluate MM5 are available routinely from the National Weather Service. Large-scale databases needed for model initialization and boundary conditions are available from the National Center for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR). These data sets include surface and aloft wind speed, wind direction, temperature, moisture, and pressure. Hourly surface data for model evaluation are available from many "Class I" airports, i.e., larger-volume civil and military airports operating 24-hour per day. The standard set of upper air data are provided by rawinsonde soundings launched by the NWS every 12 hours from numerous sites across the continent. In addition, NOAA/NCAR operate continuous hourly RADAR profiler sites that report upper-air meteorological measurements at approximately 30 sites throughout the central U.S. Model inputs will be prepared following the guidelines recommended by the model developers and the adequacy of the input data bases will be assessed as part of the MM5 model performance evaluation.
Available past appropriate performance evaluations have shown the model is not biased toward underprediction.	A number of studies have examined the theoretical formulation and operational features of the MM5 model (Mass and Kuo, 1998; Seaman, 1995, 1996; Pielke and Pearce, 1994), the performance of the model under a range of atmospheric conditions (e.g., Cox et al., 1998; Hanna et. al., 1998; Seaman et al., 1992, 1995, 1996), and the performance of the model when compared with other models (e.g., RAMS) for various regional modeling episodes including the OTAG and LMOS episodes (Tesche and McNally, 1996b; Tesche et. al., 1997a; Tesche et al., 1999a). No significant, unexplained bias in the model's estimates of state variables has been encountered. MM5 is one of two state-of-science mesoscale prognostic meteorological models actively used in the U.S. and abroad as input to regional photochemical dispersion and emissions models. The MM5 model has been used extensively in Texas in support of the 1-hr ozone SIPs (Nielson-Gammon, 2001, 2002; Nielson-Gammon et al., 2005a,b; Fan et al., 2005).
A protocol on methods and procedures to be followed has been established.	The protocol is outlined in this document. The MM5 modeling will be performed in a manner that is consistent with established practice and EPA guidelines regarding air quality modeling related to the 8-hr ozone standard.
The developer of the model must be willing to make the source code available to users for free or for a reasonable cost, and the model cannot otherwise be proprietary.	MM5 has been in the public domain since its original development in the early 1980s. Free copies of the source code, user's guide, and test model inputs can be obtained from the National Center for Atmospheric Research, the Pennsylvania State University, and the U.S. EPA Office of Research and Development. Copies of ancillary data sets and model applications and evaluation software are available from various governmental agencies (e.g., the California Air Resources Board), academic institutions, National Laboratories, and consulting firms.

Table 2-2. Factors qualifying EPS for use in the Baton Rouge ozone modeling study.

Consideration	Qualification
The model has received scientific peer review.	A formal scientific review of the EPS modeling system has been continuous since its first release as part of the UAM modeling system in 1990 (Morris and Myers, 1990). Numerous governmental, educational and private modeling groups in the U.S. and abroad have engaged in ongoing review, testing, and evaluation of the EPS model code as part of training, model set-up, exercise, and quality assurance activities. In particular, the TCEQ has performed extensive testing and peer-review of the EPS3 modeling system (e.g., http://www.tceq.state.tx.us/assets/public/implementation/air/am/committees/pmt_dfw/20050505/20050505-JimMacKay-EI_Modeling_AreaNR_DFW.pdf).
The model can be demonstrated to be applicable to the problem on a theoretical basis.	The EPS3 modeling system was explicitly designed to treat all categories of anthropogenic and biogenic emissions source in a modeling framework suitable for input to episodic Eulerian photochemical dispersion models. The model provides hourly resolved, gridded, chemically speciatiated, and source category specific emissions estimates for the important known precursors of photochemically produced ozone. EPS3 is one of three state-of-science regional emissions models actively used in the U.S. and abroad. The features and capabilities of the EPS3 modeling system are consistent with the application on a combined urban- and regional-scale, as required in the Baton Rouge modeling study.
Date bases needed to perform the analysis are available and adequate.	Key input data bases to the EPS3 modeling system (e.g., point, area, and motor-vehicle sources plus biogenic sources, are readily available from the LDEQ, TCEQ, CENRAP, VISTAS, MRPO, or EPA. Model inputs will be prepared following published User's Guidelines, the development of the TCEQ, CENRAP, and VISTAS regional inventories, and those used by EPA in the development of the CAIR modeling. The adequacy of the input data bases developed by these various sources will be assessed as part of the EPS QA process.
Available past appropriate performance evaluations have shown the model is not biased toward underprediction.	There are very limited data sets with which to verify emissions models. Major point source emissions estimates are commonly based on continuous emissions monitoring (CEM). On road motor vehicle emissions estimates are based on the EPA MOBILE6. Non-road mobile sources emissions are based on EPA's NONROAD model.
A protocol on methods and procedures to be followed has been established.	The protocol is outlined in this document. The EPS3 modeling will be performed in a manner that is consistent with established practice and EPA guidelines regarding air quality modeling related to the 8-hr ozone standard.
The developer of the model must be willing to make the source code available to users for free or for a reasonable cost, and the model cannot otherwise be proprietary.	EPS has been in the public domain since its original development under EPA contract in the late 1980s that was provided to States and then made available on EPA's Model Clearing House website (http://www.epa.gov/scram001/) with the release of the UAM Modeling System in 1990 (Morris and Myers, 1990). Copies of the current EPS3 source code can be obtained from ENVIRON International Corporation at no cost (camx@environ.org).

Table 2-3. Factors qualifying CAMx for use in the Baton Rouge ozone modeling study.

Consideration	Qualification
The model has received a scientific peer review.	Formal scientific reviews of the CAMx model have been widely carried out since the model was first introduced in the mid 1990s (Russell and Dennis, 2000; Roth et al., 2005). Literally dozens of governmental, academic, industrial and private modeling groups have reviewed the model code as part of training, model set-up, performance evaluations, regulatory applications, and quality assurance activities.
The model can be demonstrated to be applicable to the problem on a theoretical basis.	The CAMx modeling system represents either explicitly or implicitly the physical and chemical processes that are currently known to influence the formation and transport of ozone as well as the emissions, chemical transformation, and dispersion of ozone precursor pollutants. The features and capabilities of the CAMx modeling system are consistent with the application on a combined urban- and regional-scale, as required in the Baton Rouge study.
Date bases needed to perform the analysis are available and adequate.	The CAMx modeling system requires several different types of input data including land use, topographic, air quality, meteorological, and demographic. All of these data sets are routinely available from state or federal agencies. Model inputs will be prepared following EPA guidelines and the adequacy of the input data bases will be assessed as part of the CAMx model performance evaluation.
Available past appropriate performance evaluations have shown the model is not biased toward underprediction.	The CAMx modeling system has undergone extensive third party review and performance testing and many prior evaluations and applications. Examples of recent model performance evaluations with CAMx are cited in the references section. Collectively, these evaluation studies do not reveal the presence of significant, unexplained underestimation bias for ground-level ozone concentrations.
A protocol on methods and procedures to be followed has been established.	The protocol is outlined in this document. The CAMx modeling will be performed in a manner that is consistent with established practice and EPA guidelines regarding air quality modeling related to the 8-hr ozone standard.
The developer of the model must be willing to make the source code available to users for free or for a reasonable cost, and the model cannot otherwise be proprietary.	CAMx has been in the public domain since its original development in the mid 1990s. Free copies of the source code, user's guide, and test model inputs can be obtained from the model developer's website at www.camx.com. Copies of ancillary data sets and model applications and evaluation software are available not only from the model developer (ENVIRON International) but also from various governmental agencies (e.g., TCEQ), academic institutions, and consulting firms.

Table 2-4. Factors justifying MM5 as the meteorological model for the Baton Rouge ozone modeling study.

Consideration	Rationale for Selection
Nature of air quality problem leading to non-attainment of the ozone NAAQS should first be assessed, and the selected model should have the attributes and capabilities consistent with the perceived nature of the problem.	The MM5 modeling system is expected to allow a physically realistic, dynamically consistent simulation of the circulations over the Baton Rouge study area as well as other mesoscale features including convergence zones, cumulus convection, and so on. The nested grid feature of MM5 will directly support the urban- to regional-scale nesting schemes in CAMx.
Availability, documentation and past performance should be satisfactory.	The MM5 modeling system is publicly available and has been regularly used in support of CAMx modeling studies across the country. It has also been successfully used for several air quality studies in the U.S. including the SCAQS, SCOS, and SARMAP studies. It has been used in 1-hr ozone attainment demonstrations in the Pittsburgh-Beaver Valley and Cincinnati-Hamilton areas, numerous 8-hr ozone EAC studies (e.g., Denver/Northern Front Range EAC, the Kansas City/Missouri region). MM5 is the model used in all of the RPO studies currently being performed for Regional Haze. Versions of the MM5 have been used for the past 20 years in support of a variety of mesoscale research projects. Results of numerous model evaluation studies with the MM5 reveal that the model performs as well or better than any other mesoscale, applications-oriented, public domain model (Seaman, 2000, 2005).
Relevant experience of available staff and contractors should be consistent with choice of a model.	The MM5 modeling will be performed by the LDEQ assisted by their contractors who are thoroughly knowledgeable of the use of the model for mesoscale research applications as well as in regulatory photochemical modeling studies.
Time and resource constraints may be considered.	Use of the MM5 model is consistent with the Baton Rouge 8-hour ozone SIP development schedule.
Consistency of the model with what was used in adjacent regional applications should be considered.	MM5 has been applied in several photochemical modeling studies (e.g., Denver EAC study, CRC Comparative Model Evaluation Study in Lower Lake Michigan, the SARMAP study in California, various stakeholder studies participating in the OTAG, EPA NOx SIP Call, and EPA Tier II/Sulfur modeling analyses, the Pittsburgh-Beaver Valley SIP, the Cincinnati-Hamilton SIP, and in a half dozen other regional ozone modeling studies.) The system was successfully applied in the Peninsular Florida 8-hr Ozone Study, the Kansas City/Missouri 8-hr ozone modeling study and recent 8-hr ozone studies in Texas and Oklahoma. MM5 was also recently used for regional-scale modeling of the southeastern U.S., with emphasis on Atlanta, Birmingham, and the eastern Gulf Coast. It was used for the Gulf Coast Ozone Study and ATMOS.

Table 2-5. Factors justifying EPS3 as the emissions model for the Baton Rouge ozone modeling study.

Consideration	Rationale for Selection
Nature of air quality problem leading to non-attainment of the ozone NAAQS should first be assessed, and the selected model should have the attributes and capabilities consistent with the perceived nature of the problem.	EPS3 is designed for the preparation of detailed urban- and regional-scale photochemical modeling inventories such as are required for the Baton Rouge study. ENVIRON's GloBEIS model is state-of-science model widely recommended for use in estimating biogenic emissions, which are expected to play an important role in ozone formation in the study area. MOBILE6.2 is the current operational version of EPA's model for on-road mobile sources and is included in the EPS system. Use of MOBILE6.2 facilitates the use of county-level estimates of vehicles miles traveled (VMT) and detailed surface temperature.
Availability, documentation and past performance should be satisfactory.	EPS3, GloBEIS, and MOBILE6.2 are publicly available at no charge from the U.S. EPA or ENVIRON. These models have been successfully used in a variety of regional modeling studies including TCEQ 1-hour ozone attainment studies, several 8-hour ozone EAC SIPs, OTAG, SAMI, the EPA NOx SIP Call, CAIR, CAMR and CAVR.
Relevant experience of available staff and contractors should be consistent with choice of a model.	The emissions modeling tasks in the Baton Rouge study will be performed by LDEQ and their contractors all of who have substantial experience in using the model.
Time and resource constraints may be considered.	Use of the EPS3, GloBEIS, and MOBILE6.2 models is consistent with the Baton Rouge project schedule.
Consistency of the model with what was used in adjacent regional applications should be considered.	EPS3, GloBEIS, and MOBILE6.2 models (or their predecessors) have been applied in several recent photochemical modeling studies including the OTAG modeling, the EPA NOx SIP Call, the EPA Tier II/Sulfur modeling analysis, the SAMI regional modeling study, various 8-hour ozone EAC SIPs, and in more than a dozen other regional ozone modeling studies.

Table 2-6. Factors justifying CAMx as the photochemical model for the Baton Rouge ozone modeling study.

Consideration	Rationale for Selection
Nature of air quality problem leading to non-attainment of the ozone NAAQS should first be assessed, and the selected model should have the attributes and capabilities consistent with the perceived nature of the problem.	Based on an analysis of the observed 1-hr and 8-hr ozone data and review of climatological data sets in Louisiana, the potential 8-hr ozone nonattainment problems in the region include both regional and local components and is sometimes strongly influenced by the complex coastal meteorology of the region. The CAMx photochemical modeling system is well suited for this application in that its urban- and regional-scale grid nesting scheme appropriately addresses the various time and space scales relevant to the mesoscale processes involved in 8-hr ozone episodes. Utilizing meteorological inputs from a nested prognostic model (MM5), CAMx can directly simulate the local processes involved in 8-hr ozone problems together with the influence of imported ozone and precursor species from upwind (regional-scale) source regions. The use of detailed meteorological inputs and grid nesting will allow proper treatment of the gulf breeze, convective circulations, vertical mixing and cloud processes. The process-analysis, ozone source apportionment, and direct decoupled sensitivity analysis algorithms (DDM) in CAMx will allow a more rigorous evaluation of model performance and aid in diagnostic analysis.
Availability, documentation and past performance should be satisfactory.	The CAMx modeling system is publicly available at no cost. Full user documentation can be obtained from the website: www.camx.com. The CAMx model has been widely evaluated by numerous groups in the U.S. The model has undergone extensive successful testing by a variety of groups (see, for example, Lurmann and Kumar, 1997; McNally and Tesche, 1998a, McNally et al., 1998a-c; Tesche and McNally, 1998a; Tesche et al., 1998c,e,f). Model performance for ozone has consistently been comparable to or better than that of other contemporary model such as the CMAQ, UAM-V, SAQM, and URM.
Relevant experience of available staff and contractors should be consistent with choice of a model.	The CAMx modeling will be performed by the LDEQ with technical support from their contractors who are thoroughly knowledgeable of the use of the model for regulatory photochemical modeling studies. The LDEQ contracting team includes the developers of the CAMx model and personnel with over 25 years experience in photochemical grid-modeling.
Time and resource constraints may be considered.	Use of the CAMx model is consistent with the Baton Rouge 8-hour ozone project schedule.
Consistency of the model with what was used in adjacent regional applications should be considered.	CAMx has been applied in several recent photochemical modeling studies including the CRC Comparative Model Evaluation Study in Lower Lake Michigan (Tesche et al., 2000), the OTAG, EPA NOx SIP Call, and EPA Tier II/Sulfur modeling analyses, Clean Air Interstate Rule, Texas 1-hour ozone SIPs and several 8-hour ozone EAC SIPs.

3.0 EPISODE SELECTION

3.1 Overview of EPA Guidance

EPA 8-hour modeling guidance (EPA, 2005a) contains recommendations for selecting modeling episodes, while also referencing EPA's 1-hour ozone modeling guidance for episode selection (EPA, 1991).

3.1.1 Primary Criteria

EPA's guidance on 8-hour ozone modeling (EPA, 2005a) identifies specific criteria to consider when selecting one or more episodes for use in demonstrating attainment of the 8-hour ozone National Ambient Air Quality Standard (NAAQS). The 8-hour ozone guidance builds off the 1-hour ozone guidance in selecting multiple episodes representing diverse meteorological conditions that result in ozone exceedances in the region under study, and includes the following criteria:

- A variety of meteorological conditions should be covered, including the types of meteorological conditions that produce 8-hour ozone exceedances in the Baton Rouge 5-Parish area;
- To the extent possible, the modeling data base should include days for which extensive data bases (i.e. beyond routine aerometric and emissions monitoring) are available; and
- Sufficient days should be available such that relative reduction factors (RRFs) can be based on several (i.e., $\geq$ 10) days with at least 5 days being the absolute minimum.

3.1.2 Secondary Criteria

EPA also lists several "other considerations" to bear in mind when choosing potential 8-hour ozone haze episodes including:

- Choose periods which have already been modeled;
- Choose periods which are drawn from the years upon which the current Design Values are based;
- Include weekend days among those chosen; and
- Choose modeling periods that meet as many episode selection criteria as possible in the maximum number of nonattainment areas as possible.

3.1.3 Methods Commonly Used to Identify Candidate Episode

There are several methods used to identify optimal episodes for 8-hour ozone modeling that include all pertinent meteorological conditions that lead to ozone exceedance in a nonattainment area. Some of these methods include:

Classification and Regression Tree (CART) Analysis: to classify days according to meteorological and air quality conditions.

Cluster Analysis: to group episodes by meteorological and air quality conditions.

The preliminary draft Modeling Protocol for 8-hour ozone modeling of Baton Rouge (ICF, 2005) performed CART analysis to help select modeling episodes. Although LDEQ funded the CART analysis in the preliminary draft Modeling Protocol, the insertion of copyright statements in the preliminary draft Modeling Protocol means the text can not be reproduced in this draft Modeling Protocol. Thus, the approach is simply paraphrased here and the CART results are used to help corroborate our final episode selection priorities. The reader is referred to the preliminary draft Modeling Protocol for more details (ICF, 2005).

3.1.4 Summary of CART Analysis

CART was applied separately to Baton Rouge, New Orleans, Lake Charles and Shreveport. Surface ozone data from the AIRS database and surface and upper-air meteorological observations from 1996-2004 were extracted and used in the CART analysis. CART identified 5 bins associated with 8-hour ozone exceedances. Using the CART analysis the candidate episodes were reviewed and ranked according to how each was:

- Representative of the range of meteorological conditions that are most frequently associated with elevated 8-hour ozone occurrences; and
- Representative of the observed 8-hour ozone Design Values (defined as within 10 ppb).

Two additional considerations were factored into the CART-derived episode selection analysis:

- Many of the Baton Rouge 8-hour exceedance episodes are one-day events. In order to obtain sufficient days for performing an attainment demonstration there was a preference for multi-day episodes; and
- Episode selection was limited to the years 2000-2004 with a preference for 2002-2004 to be more current.

Using these criteria and the CART results, the preliminary draft Modeling Protocol recommended four ozone episodes from (2002 -2004) for Baton Rouge 8-hour ozone modeling.

3.2 Selection of Baton Rouge 8-hour Ozone Modeling Episodes

The CART episode selection analysis in the preliminary Modeling Protocol could not be used directly in the episode selection analysis in this draft Modeling Protocol because of its proprietary nature and, as pointed out by EPA (Diggs, 2005), it did not address whether the selected episodes included sufficient elevated ozone exceedance days at each key ozone monitor to satisfy EPA’s minimal data requirements for attainment demonstration modeling. EPA guidance recommends at least 10 modeling days be used in the attainment demonstration analysis, with a 5 day absolute minimum (EPA, 2005a). These modeling days are preferred to have base case modeled 8-hour ozone concentrations near the monitor of 85 ppb or higher, with a 70 ppb absolute minimum.

Below we prioritize the ranking of the Baton Rouge episodes using a different approach than used in the preliminary draft Modeling Protocol. Here we focus on selecting episodes that maximize the potential number of exceedance and elevated 8-hour ozone concentration days across the key monitors in the Baton Rouge area. We then compare the ranked list of proposed Baton Rouge episodes with the CART analysis to assure that we have captured all key ozone exceedance day classifications.

3.2.1 Key Baton Rouge Ozone Monitors

Table 3-1 displays the yearly fourth highest 8-hour concentration at each of the Baton Rouge monitors from 1998 to 2002, and their 8-hour ozone Design Values (DV) from 1998 to 2005; i.e., the running three-year average of the fourth highest values. The locations of the monitors are shown in Figure 3-1. In general, there has been a substantial improvement in the number of violating ozone monitors in the Baton Rouge area over the last 8 years. The year 2000 8-hour DV exceeded the 8-hour ozone standard at all 10 ozone monitors in the Baton Rouge area. In 2001, 9 of the 10 ozone monitors in Baton Rouge area violated the 8-hour ozone standard. By the year 2002, less than half (4 of 10) of the Baton Rouge monitors were still violating the 8-hour ozone standard (Baker, LSU, Port Allen and Carville) with DVs just barely above (85-86 ppb) the 8-hour ozone standard (85 ppb). It should be noted that these monitors are aligned in a north-south direction and lie along the river where chemical plants and refineries are also present (Figure 3-1). By 2003, only the LSU monitor (86 ppb) still violated the 8-hour ozone standard, although the Baker, Capitol, Port Allen and Carville monitors were within 1-2 ppb of violating the standard (83-84 ppb). The summer of 2004 saw some worsening in 8-hour ozone at the LSU and Baker monitors with violations of 89 and 86 ppb, respectively, and slight improvements at Port Allen (83 ppb), Carville (83 ppb) and Capitol monitors (80 ppb). 2005 was the worst ozone year in the Baton Rouge area in a half decade resulting in four ozone monitors violating the 8-hour ozone standard (Baker, LSU, Port Allen and Carville). In fact, the 2005 8-hour ozone DV at LSU (96 ppb) matches the highest DV over the last 5 years (2000 DV at LSU), whereas the violations at the other three monitors in 2005 are only 1-2 ppb above the standard (85-87 ppb).

Based on the measured ozone air quality over the last 7 years, the LSU monitor is the most critical, followed by the Baker, Carville and Port Allen monitors. These are the four ozone monitors where it will be imperative to select episodes with sufficient number of modeling days ($\geq$ 10) so that a robust attainment demonstration can be performed. The 8-hour ozone DVs at several of the other Baton Rouge monitors are in the 80-83 ppb range so are close to the standard and need to have sufficient days to be included in the attainment demonstration. However, unlike the four primary monitors that are currently violating the 8-hour ozone standard, these sites have not recorded a violation of the 8-hour ozone standard since 2001.

3.2.2 Episode Selection Approach

We focus our episode selection to periods that occurred over the last 6 years (2000-2005). Many of the recent 8-hour ozone exceedance days in Baton Rouge occur over one day and many

Table 3-1. 8-hour ozone Design Values for the years 1998-2005 and fourth highest 8-hour ozone concentrations for 1998-2002 at monitors in the Baton Rouge 5-Parish area.

Monitor	1998 (4th High)	1999 (4th High)	2000 (4th High)	98-00 (DV)	2001 (4th High)	99-01 (DV)	2002 (4th Hi)	00-02 (DV)	01-03 (DV)	02-04 (DV)	03-05 (DV)
Baker	90	100	92	**94**	81	**91**	83	**85**	84	**86**	**87**
Capitol	87	86	88	**87**	81	**85**	79	82	83	80	81
LSU	100	88	100	**96**	82	**90**	78	**86**	**86**	**89**	**96**
Pride	87	88	86	**87**	78	84	75	79	78	79	82
Port Allen	81	90	93	**88**	84	**88**	80	**85**	84	83	**85**
B Plaq	85	89	90	**88**	79	**86**	73	80	77	76	79
Carville	91	86	96	**91**	88	**90**	75	**86**	84	83	**86**
G Tete	85	86	93	**88**	79	**85**	74	82	79	78	83
Dutchtown	90	85	98	**91**	75	**86**	75	82	77	79	80
F Settle	86	86	101	**91**	76	**88**	75	84	77	77	78
# Violating				10		9		4	1	2	4

Figure 3-1. Locations of Baton Rouge ozone monitors.

times at just one monitor. Like the Houston Galveston Brazoria (HGB) area, Baton Rouge is home to several chemical plants and refinery facilities that may, on occasion, release Highly Reactive Volatile Organic Compound (HRVOC) emissions. These HRVOC emissions can produce plumes with rapid rise in ozone formation and highly localized ozone exceedances that may only impact one or two monitors for an hour or two. Although any Baton Rouge ozone attainment plan must address the effects of HRVOCs, selecting episodes based on the isolated ozone impacts of the difficult-to-characterize HRVOC emissions would be a poor use of limited resources.

The primary objective of the Baton Rouge episode selection is to select periods that span the range of conditions that produce 8-hour ozone exceedances in Baton Rouge, include sufficient number of days at the key ozone monitors to conduct a robust attainment demonstration, while minimizing the number of episodes modeled due to resource limitations. Recent modeling by the Regional Planning Organizations (RPOs) found that 10-15 days are required to completely eliminate the effects of Initial Concentrations (ICs) in regional-scale domains, like the 36-km grid proposed for Baton Rouge. Thus, we are proposing to use a 10 day initialization period for the 36-km regional domain. This sets a high priority to select modeling episodes that maximize the number of high ozone days at all of the key monitoring sites (i.e., multiday episodes).

Appendix B lists tables of daily maximum 8-hour ozone concentrations at the 10 Baton Rouge area monitoring sites during the ozone season (May-October) over the last 6 years (2000-2005). For each day and monitoring site, the daily maximum 8-hour ozone concentrations are color coded for high ozone days as follows:

Red for 8-hour ozone exceedances (≥ 85 ppb);
Orange for 8-hour ozone ≥ 80 ppb but < 85 ppb;
Yellow for 8-hour ozone ≥ 75 ppb but < 80 ppb; and
Light Green for 8-hour ozone ≥ 70 ppb but < 75 ppb.

In selecting candidate ozone modeling episodes we used the following general initial guidance to try and pick episodes with multiple exceedance days at multiple monitors:

1. Select candidate episodes that have at least two exceedance days within a week;
2. Select episodes with exceedances at multiple monitors; and
3. Ignore episodes after August 2005 (post-Hurricane Katrina) because of major shifts in local emission patterns.

Examining the observed 8-hour ozone data in Appendix B and using the general criteria above, we identified 15 candidate ozone episodes from 2000–2005 as listed in Table 3-2. One exception to the criteria listed above was July 18, 2003, a one-day episode. This one day episode was included as a candidate due to having exceedances at four monitors, and near exceedances at two other monitors, with the highest severity of any single 8-hour ozone exceedance day since the extreme events in 2000.

For each of the 15 candidate episodes, Table 3-2 lists the following information:

- Number of days in the episode;
- Number of 8-hour ozone exceedance days;
- Number of monitors with exceedances;
- Number of days with 3 or more monitors measuring exceedances;
- Number of monitor-exceedance days during the episode;
- Number of monitor-days greater or equal to 80 ppb; and
- Number of monitor-days greater or equal to 70 ppb.

Table 3-2. Summary of candidate 8-hour ozone modeling episodes from 2000-2005 for the Baton Rouge 5-Parish area.

Candidate Episode	# Days	# Exceed Days	# Exceed Monitors	# Exceed Days ≥ 3 Mon	# Exceed Mon-Days	# > 80 ppb Mon-Days	# > 70 ppb Mon-Days
July 4-27, 2000	24	12	9	6	37	62	100
August 11 – Sep 5, 2000	26	14	10	10	55	77	136
May 12-15, 2001	4	2	4	0	4	5	13
August 21-25, 2001	5	3	6	2	10	15	28
September 11-15, 2002	5	2	5	1	6	12	26
April 12-18, 2003	7	3	3	0	4	13	36
April 27-30, 2003	4	3	5	1	7	11	26
May 19-30, 2003	12	4	5	1	8	16	44
July 18, 2003	1	1	4	1	4	6	6
September 17-20, 2003	4	2	6	2	8	11	22
October 4-6, 2003	3	2	9	2	14	18	22
May 4-9, 2004	6	4	3	0	5	15	40
August 16-18, 2004	3	2	4	0	4	11	16
September 28-30, 2004	3	2	5	1	5	9	22
May 22-28, 2005	7	5	7	2	14	23	46

These air quality metrics allow for an assessment of the frequency and duration of the ozone exceedances and associated ozone concentrations, as well as how wide-spread the high ozone was during each of the candidate episodes.

Table 3-3 lists the peak daily maximum 8-hour ozone concentration that occurred during each of the candidate episodes, along with the 8-hour ozone Design Values from 2000-2002, 2001-2003, 2002-2004 and 2003-2005. This table provides an indication of the number of monitors with exceedances of the 8-hour ozone NAAQS and the magnitude of the exceedance events. One goal that has been used in the past to select episodes is to choose days with the observed ozone near the 8-hour ozone DVs (e.g., within ±10 ppb). However, this can be misleading and screen out perfectly good episodes, especially in areas like Baton Rouge with HRVOCs. For example, just because the July 18, 2003 episode has the highest observed 8-hour ozone of all recent episodes does not make it a good candidate. In fact, the severity of the 8-hour ozone exceedances on July 18, 2003 plus the fact it is a one-day episode make it a poor choice according to the guidance. As noted previously, the isolated HRVOC emission events are difficult to characterize and may result in an increase in the observed 8-hour ozone by >10 ppb resulting in it exceeding the ±10 ppb DV criteria. However, without HRVOCs in the model it would predict levels near the DV and be a representative episode according to the guidance. Although HRVOC emissions must be addressed in the Baton Rouge 8-hour ozone attainment plan, it is unlikely that historical emissions will be well characterized for all of the episode days.

Finally, Table 3-4 lists the number of days during each of the 15 candidate episodes that the observed ozone is 70 ppb or higher at each of the monitors. Since a modeled base case 70 ppb level is the absolute minimum cut-off for using the modeling results in the attainment demonstration, this table provides an indication of the potential for each episode to contribute days toward the attainment demonstration approach at each ozone monitor.

3.2.3 Prioritization of Candidate Modeling Episodes

Analyzing the frequency, magnitude and duration of the 8-hour ozone exceedances and elevated ozone concentrations in the Baton Rouge area from 2000-2005 and accounting for:

- Maximizing the number of exceedance and high ozone days at the four key ozone monitors (LSU, Baker, Carville and Port Allen) as well as high ozone days for the secondary monitors (Grosse Tete, Pride, Capitol, Bayou Plaquemine, Dutchtown and French Settlement);
- Minimizing the number of total modeling days;
- Selecting episodes from different times of year; and
- Having a preference for more recent episodes (e.g., from the 2003-2005 Design Value cycle),

we have prioritized the candidate Baton Rouge ozone modeling episodes as follows (days of week with exceedances in parentheses):

Table 3-3. Observed 8-hour ozone Design Values and peak 8-hour ozone concentrations (ppb) for the candidate 8-hour ozone episodes for the Baton Rouge area.

	Obs 8-hr Design Value				Jul	Aug	May	Aug	Sep	Apr1	Apr2	May	Jul	Sep	Oct	May	Aug	Sep	Sep
	2002	*2003*	*2004*	*2005*	'00	'00	'01	'01	'02	'03	'03	'03	'03	'03	'03	'04	'04	'04	'05
Capitol	*82*	*83*	*80*	*81*	101	110	78	95	103	76	76	83	115	87	94	74	81	88	86
Baker	*85*	*84*	*86*	*87*	86	115	69	87	82	92	88	88	83	100	114	96	94	79	97
BPlaquem	*80*	*77*	*76*	*79*	96	89	67	85	93	81	106	82	56	92	89	81	71	75	82
LSU	*86*	*86*	*89*	*96*	115	121	82	90	106	79	79	87	120	105	108	82	101	111	99
Carville	*86*	*84*	*83*	*86*	100	97	88	89	90	79	98	94	87	85	106	91	84	97	83
Dutchtown	*82*	*77*	*79*	*80*	99	109	78	75	82	77	83	73	83	75	89	84	84	86	87
F Settle	*84*	*77*	*77*	*78*	105	117	86	73	87	87	76	83	65	68	82	81	83	68	81
G Tete	*82*	*79*	*78*	*83*	106	99	89	81	74	77	91	85	-	74	92	83	87	85	97
P Allen	*85*	*84*	*83*	*85*	93	114	68	105	83	82	86	90	109	86	109	82	83	84	98
Pride	*79*	*78*	*79*	*82*	84	100	85	71	91	93	72	83	64	53	97	90	93	74	97

Table 3-4. Number of days daily maximum 8-hour ozone concentrations was 70 ppb or higher at each Baton Rouge monitor and for the candidate 8-hour ozone episodes.

Monitoring	Jul	Aug	May	Aug	Sep	Apr1	Apr2	May	Jul	Sep	Oct	May	Aug	Sep	Sep
Site	**'00**	**'00**	**'01**	**'01**	**'02**	**'03**	**'03**	**'03**	**"03**	**'03**	**'03**	**'04**	**'04**	**'04**	**'05**
Capitol	11	13	3	4	3	3	2	3	1	2	2	3	2	1	3
Baker	8	15	0	3	3	5	3	4	1	3	3	6	2	3	5
BPlaquem	11	14	0	3	2	5	3	5	0	2	2	2	2	3	4
LSU	12	15	1	4	3	4	3	6	1	4	2	5	2	3	7
Carville	10	16	3	3	3	4	3	6	1	4	3	4	2	3	3
Dutchtown	9	13	2	2	2	1	1	1	1	2	2	4	1	2	4
F Settle	13	16	2	1	3	5	2	4	0	0	2	4	1	0	6
G Tete	11	15	1	3	3	2	2	6	0	2	2	2	1	3	6
P Allen	8	14	0	4	3	4	4	5	1	3	2	5	2	2	3
Pride	5	5	1	1	1	4	3	4	0	0	2	5	1	2	5

1. May 22-28, 2005 (Su, W, Th, F, Sa)
2. May 19-30, 2003 (M, Sa, W, Th)
3. September 28-30, 2004 (W, Th)
4. April 12-30, 2003 [combine two episodes] (Su, M, F, Su, M, Tu)
5. October 4-6, 2003 (Sa, Su)
6. May 4-9, 2004 (Tu, W, Th, Sa)
7. August 11 – September 5, 2000 (F, Su, Th, F, Sa, Su, M, F, Sa, W, Th, F, Sa, Su)

We have included the extensive episode in August-September 2000 for several reasons: (a) it is the last multi-week period experienced in Baton Rouge with 8-hour ozone exceedances at many sites per day, and with high 8-hour ozone routinely topping 100 ppb at multiple sites and days; (b) it was a regional ozone episode, with high concentrations measured throughout the Gulf Coast region, including Houston/Galveston and Beaumont/Port Arthur; and (c) the modeling team may be able to take advantage of the extensive modeling database and products developed by the TCEQ (and others). However, the fact that no such extreme conditions have since been recorded in Baton Rouge is considered to be a major disadvantage because this episode may now be unrepresentative of the later episodic conditions upon which the current 8-hour ozone status is based. Nevertheless, this episode could help to bolster the number of high 8-hour ozone days needed for the attainment demonstration.

Not all of the episodes listed above will need to be modeled. In fact, some may have redundant characteristics. Four of the later episodes alone have a good mixture of weekdays and weekend days. Further analysis of the meteorological conditions is needed to characterize the episode days and assure that we have maximized the types of meteorological conditions that generate adverse ozone conditions in the Baton Rouge area.

3.2.4 Further Analysis of Five Candidate Episodes

In this section, we perform further analysis of the ranked candidate episodes to determine the number of potential days available for the attainment demonstration, and to classify the episodes according to the CART analysis performed previously, where available.

Table 3-5 lists the number of days the observed 8-hour ozone concentrations were greater than or equal to 70 ppb and 85 ppb for the top six (recent) ranked episodes, and the total number of days across the highest ranked episodes. These days are important because EPA guidance prefers using modeled ozone days with base case ozone concentrations near the monitor that are 85 ppb or higher in the attainment demonstration. In the event there are less than 10 days with such modeled ozone greater or equal to 85 ppb, then the minimum threshold is reduced by 1 ppb with a floor at 70 ppb until 10 days are obtained. If the 70 ppb floor is reached, but there are at least 5 or more days, the attainment demonstration may still proceed. However, if there are less than 5 days, EPA discourages proceeding with the modeling if this occurs at a key monitor in the nonattainment area. It is recognized that some monitors in nonattainment areas may be primarily upwind and rarely exceed the ozone NAAQS, in which case the number of days needed in the attainment demonstration is more lax.

Although the data in Table 3-5 are based on observed 8-hour ozone concentrations, and not modeled values near the monitor, it gives some indication of the number of days that will be

Table 3-5a. Number of observed ozone days ≥ 70 ppb for the top six ranked candidate episode and total days across highest ranked episodes.

Rank	1	2	3	4	5	6	Total Days		
Monitoring Site	May '05	May '03	Sep '04	Apr '03	Oct '03	May '04	1-3	1-4	1-6
Capitol	3	3	1	5	2	3	7	12	17
Baker	5	4	3	9	3	6	12	21	30
BPlaquem	4	5	3	7	2	2	12	19	23
LSU	7	6	3	7	2	5	16	23	30
Carville	3	6	3	7	3	4	12	26	33
Dutchtown	4	1	2	2	2	4	7	9	15
F Settle	6	4	0	7	2	4	10	17	23
G Tete	6	6	3	4	2	2	15	19	23
P Allen	3	5	2	8	2	5	10	18	25
Pride	5	4	2	7	2	5	11	18	25
Total 4 Key Sites	18	21	11	31	9	20	50	88	118

Table 3-5b. Number of observed ozone days ≥ 85 ppb for the top six ranked candidate episode and total days across highest ranked episodes.

Rank	1	2	3	4	5	6	Total Days		
Monitoring Site	May '05	May '03	Sep '04	Apr '03	Oct '03	May '04	1-3	1-4	1-6
Capitol	1	0	1	0	2	0	2	2	4
Baker	2	1	0	4	2	3	3	7	12
BPlaquem	0	0	0	1	1	0	0	1	2
LSU	2	1	1	0	2	0	4	4	6
Carville	0	4	1	2	2	1	5	7	10
Dutchtown	1	0	1	0	1	0	2	2	3
F Settle	0	0	0	1	0	0	0	1	1
G Tete	4	1	1	1	2	0	6	7	9
P Allen	2	1	0	1	1	0	3	4	5
Pride	2	0	0	1	1	1	2	3	5
Total 4 Key Sites	6	7	2	7	7	4	15	22	33

available when modeling one, two, three, etc. episodes. With the 70 ppb threshold, there are at least 10 days with observed ozone ≥70 ppb at the four key monitors using the first three ranked episodes. There are 18–26 observed ozone days ≥70 ppb during the top 4 ranked episodes at the four key monitors. But there are only 3–5 days at these four monitors for which the observed ozone is 85 ppb or higher for the first 3 ranked episodes. Even with all top 6 ranked episodes, there are only 5–12 days when the observed ozone is ≥85 ppb at the Baker, LSU, Carville and Port Allen key monitors. Thus, it appears we will likely achieve ~10 modeling days with ozone above the 70 ppb threshold for the key monitors, but the likelihood of obtaining 10 days at all the key monitors with ozone ≥85 ppb is unlikely with only these 6 recent episodes.

With the addition of the August-September 2000 episode to the top three episodes, the number of days above 70 ppb increases to 24–31 at the four key monitors, and up to 9-12 days above 85 ppb. Therefore, it may be necessary to include this older episode in order to maintain a high number of exceedance days for the attainment demonstration.

The CART analysis presented in the preliminary draft Modeling Protocol provided characterization of 4 of the 7 ranked episodes above (May 2005, October 2003, and August-September 2000 were not included). The CART analysis identified 5 main bins of 8-hour ozone exceedance days. These bins and their relative importance are as follows:

- Bin 10 (22%)
- Bin 20 (24%)
- Bin 25 (33%)
- Bin 27 (10%)
- Bin 35 (11%)

Table 3-6 displays the CART classification for the 4 ranked episodes for which data are available. CART bins 27 and 35 are not represented by these four episodes (but may be by the May 2005 or October 2003 episodes). These 2 CART bins are the least frequent representing only 21% of the exceedance days classified by all 5 bins.

Table 3-6. CART Bins for 4 ranked episodes for which data are available (Source: ICF, 2005).

Rank	Episode	CART Bins for Exceedance Days
3	April 2003	10, 18, 18, 25, 25
1	May 2003	6, 27, 28
6	May 2004	6, 10, 19, 20, 25
2	September 2004	29, 31

The CART analysis confirms that three of the top-ranked episodes encompass most of the CART bins (65% of days) that include ozone exceedances in Baton Rouge to represent a mixture of meteorological conditions.

It is worth analyzing the differences between the ranked episodes and the recommended episodes from the CART analysis (ICF, 2005). The final four recommended episodes in the preliminary draft Modeling Protocol were ranked second (May 2003), third (September 2004), sixth (May 2004) and unranked (August 2004) in the current analysis. The August 2004 episode that was unranked in the current analysis consisted of only two days of exceedances. It included CART bins 10 and 27, both of which are covered by other episode days.

3.3 Conceptual Model and Aerometric Conditions of each Episode

The next step in the episode selection process is the characterization of the meteorological conditions and air quality, and the development of conceptual models, for each of the candidate ozone episodes. Based on these results, we select the final Baton Rouge ozone episodes for modeling.

3.3.1 May 22-28, 2005

Eight-hour exceedance days during this period included:

May 22 (Sunday)
May 25 (Wednesday)
May 26 (Thursday)
May 27 (Friday)
May 28 (Saturday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-2a) and the other monitors (Figure 3-2b). Among the key monitors on the highest ozone days (May 22 and 27), the Baker site records the highest ozone, with LSU and Port Allen about 10 ppb lower. Carville consistently records the lowest ozone of these sites on the highest days, but the highest ozone on the low-ozone days, indicating consistent day-to-day ozone levels through the period. The highest 1-hour ozone recorded during this period occurred on May 27 at Pride (127 ppb). Grande Tete was the only site to peak above 86 ppb on May 25 (113 ppb), indicating a possible Transient High Ozone Event (THOE) or Rapid Ozone Formation Event (ROFE) since that peak was reached after a 30 ppb rise over 2 hours. Ozone at all other sites show consistent patterns day-to-day.

Meteorological conditions in the south-central U.S. during this episode were influenced by an expansive upper-level high pressure system located over the southwest U.S. and vigorous low pressure systems moving eastward across the northern tier states. This pattern induced light to moderate northerly aloft winds over Louisiana from May 23-26, until on May 27 a deep expansive low over the Great Lakes pushed the jet stream southward and strengthened upper-level winds in the area to moderate westerly. At the surface, low-pressure systems passing over the Great Lakes generated cold frontal systems that slowly moved southward from the central Plains toward the Gulf Coast. The first front moved into Louisiana on May 25 and dissipated over the next two days just south of the coastline; the second front entered the area on May 28 as a stationary system. A broad flat surface high pressure area was maintained over the central Gulf Coast through the duration of the episode. Surface winds along the Gulf Coast responded mainly to the weak frontal systems: winds began moderate easterly on May 23, then turned to weak westerly through May 24; then turned back easterly with the passage of the weak cold front on May 25, after which winds lightened and became calm and variable through May 28. The only widespread cloudiness and precipitation in Louisiana during the episode occurred during frontal passage on May 25, and late on May 28. Ubiquitous high pressure and light wind conditions caused many reports of morning fog and haze throughout the period.

Daily maximum temperatures started in the mid-90's and lowered to the low-90's through May 26; afterward, temperatures were further modified by the cooler northern continental airmass following the frontal passage on the 25th, with temperatures in the high 80's for the remainder of the period. Similarly, humid conditions prevailed early in the period with dewpoint temperatures in the low 70's until the drier airmass arrived on the 26th, when dewpoints moderated to the low- to mid-60s.

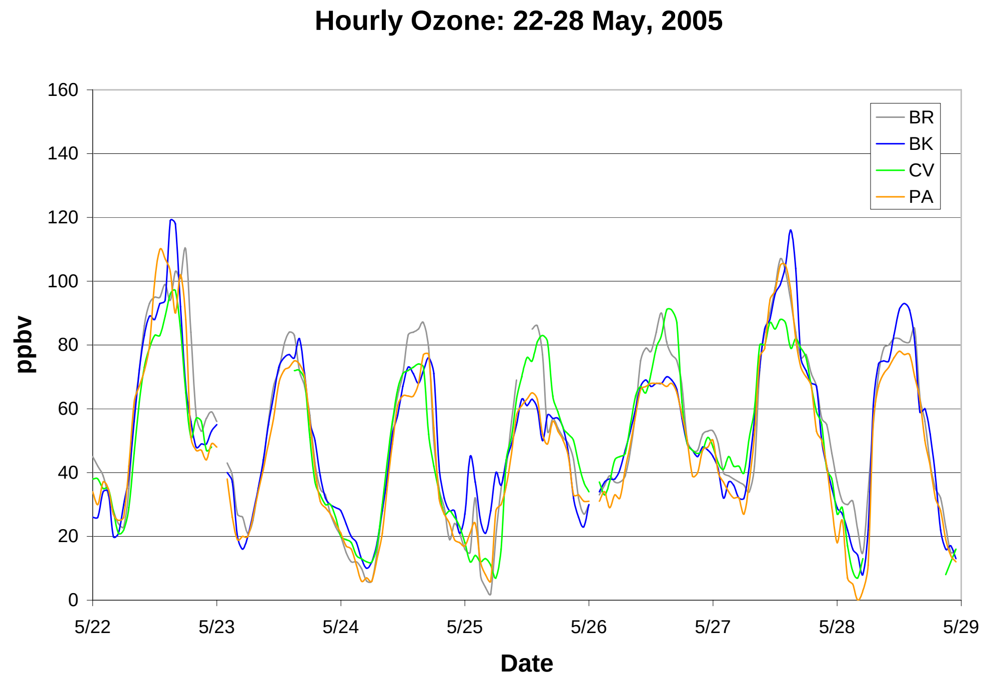


Figure 3-2a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

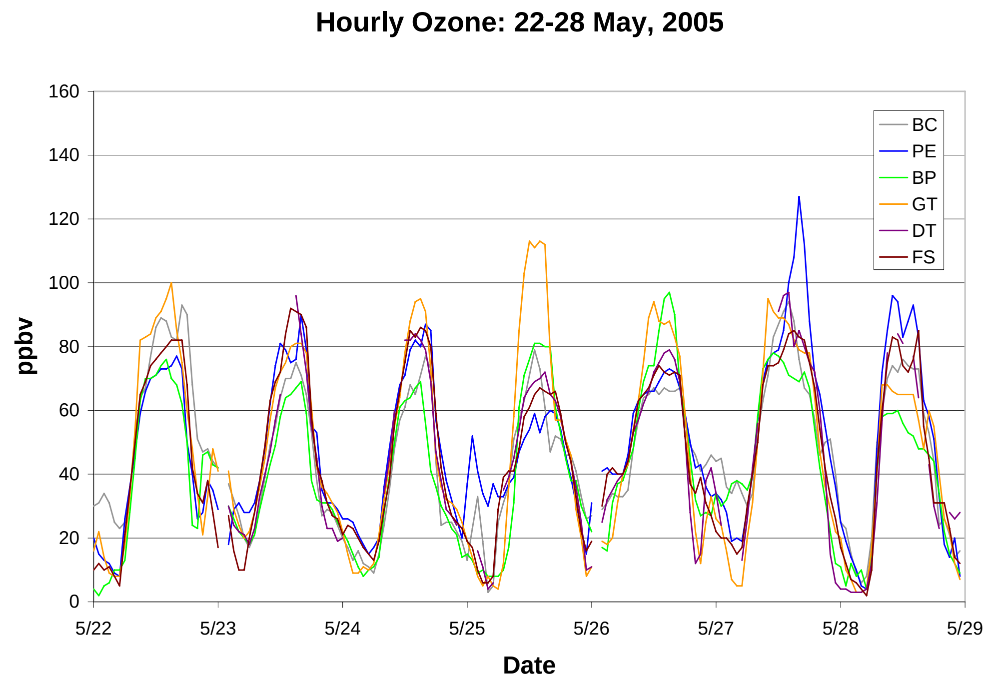


Figure 3-2b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-3. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-4. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

Wind speeds indicate a wide range of variation among the monitoring sites, with daytime maximum winds reaching 8-10 mph on many days (with a peak of 13 mph late on May 28), while minimum speeds remained within 2-4 mph. On average, winds ranged from 2 to 6 mph, which is consistent with light wind conditions under stagnant high pressure regimes. Temperatures also show a large range of variation among the monitoring sites over the entire diurnal period of each day. The temperature pattern over the episode shows the warmest period between May 22-24, followed by up to a 5C (9F) cooling afterwards. The wind rose shows the two major wind regimes as described above: a westerly component (early period) and an easterly component (later period). Near-calm winds (0-2 mph) occur ~25% of the time, mostly during the easterly period. Light winds dominate the statistics, with nearly 70% of the speeds less than 4 mph. Winds greater than 6 mph were observed just ~7% of the time.

Back trajectories show a large degree of shear among the various levels tracked, as evidenced by the deviating trajectory paths at each level. Up through May 26, back trajectories suggest very long fetches to the north, following the Mississippi River Valley as far back as Illinois. Also note the extreme degree of sinking air (subsidence) over this period, especially for the parcel that ends at the surface in Baton Rouge. This indicates very strong sinking motion associated with a deep high pressure circulation, which would also suggest very strong suppression of vertical mixing throughout the central U.S. A good case could be made for a large component of regional transport into the Gulf States. The entire trajectory pattern changes after May 26, where the shorter trajectories indicate much weaker winds with no evidence of subsidence. Back trajectories extend eastward or offshore from the coast. Mush less regional transport would be expected on these days, even though some of the most widespread and highest ozone is recorded on May 27 in Baton Rouge. This episode presents an interesting couple of two very different prevailing weather conditions and transport regimes.

3.3.2 May 19-30, 2003

Eight-hour exceedance days during this period included:

May 19 (Monday)
May 24 (Saturday)
May 28 (Wednesday)
May 29 (Thursday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-5a) and the other monitors (Figure 3-5b). Among the four key monitors, Carville is consistently the peak site by 10-20 ppb. A possible Transient THOE/ROFE may have occurred on May 24 at Carville, and again on May 30 at Baker and Carville. All other monitors show consistent ozone patterns day-to-day.

Wind Speed (mph) Time Series : May 2005 Episode

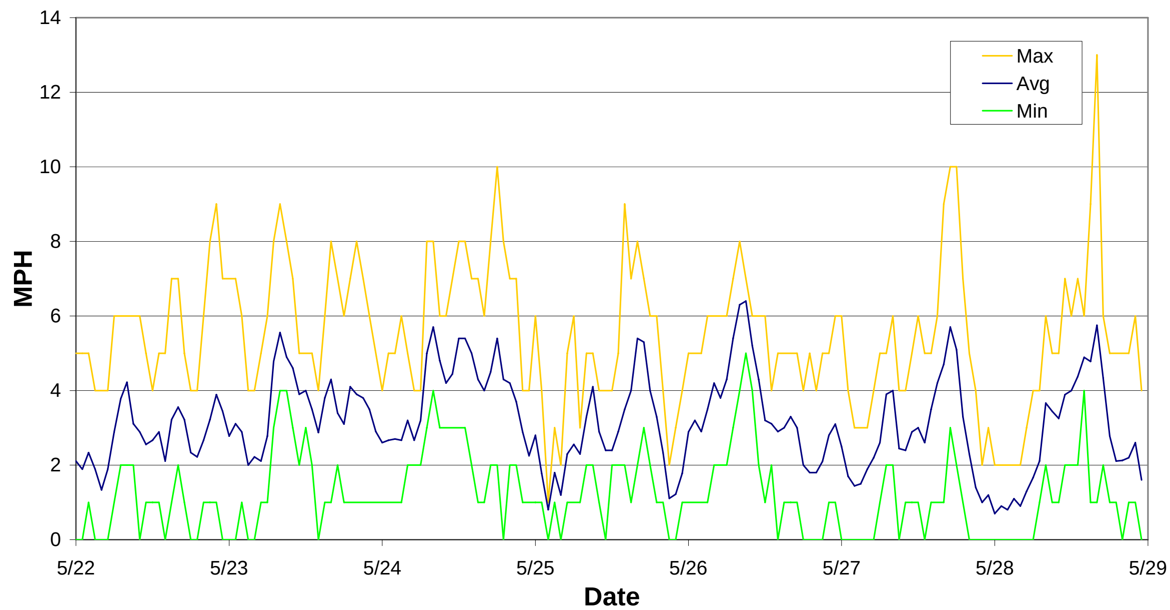


Figure 3-3a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

Temperature Time Series : May 2005 Episode

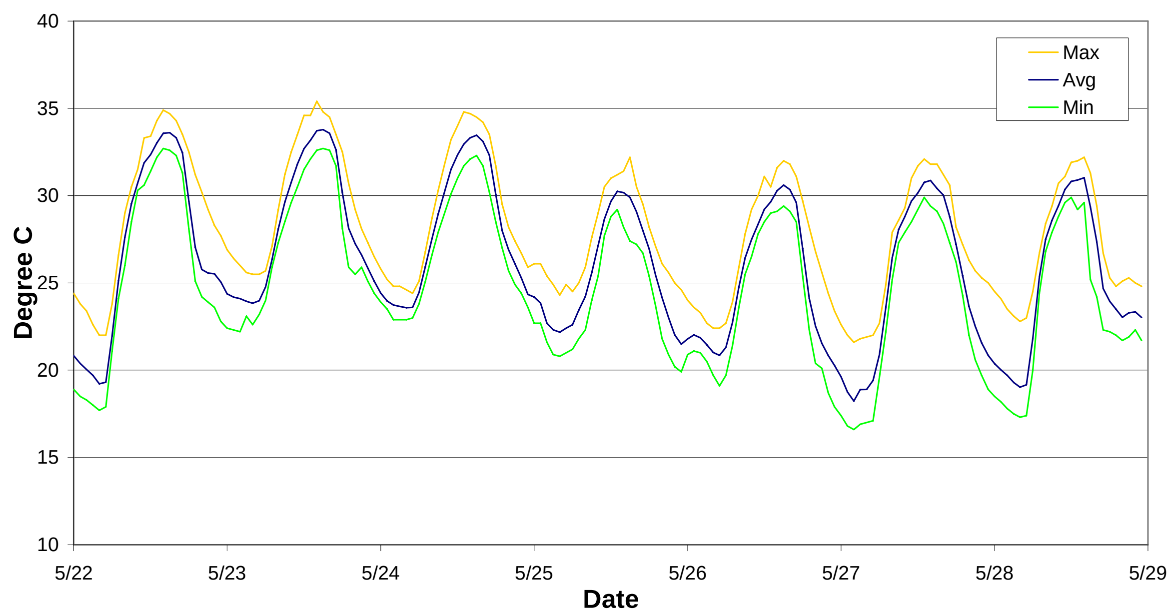


Figure 3-3b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

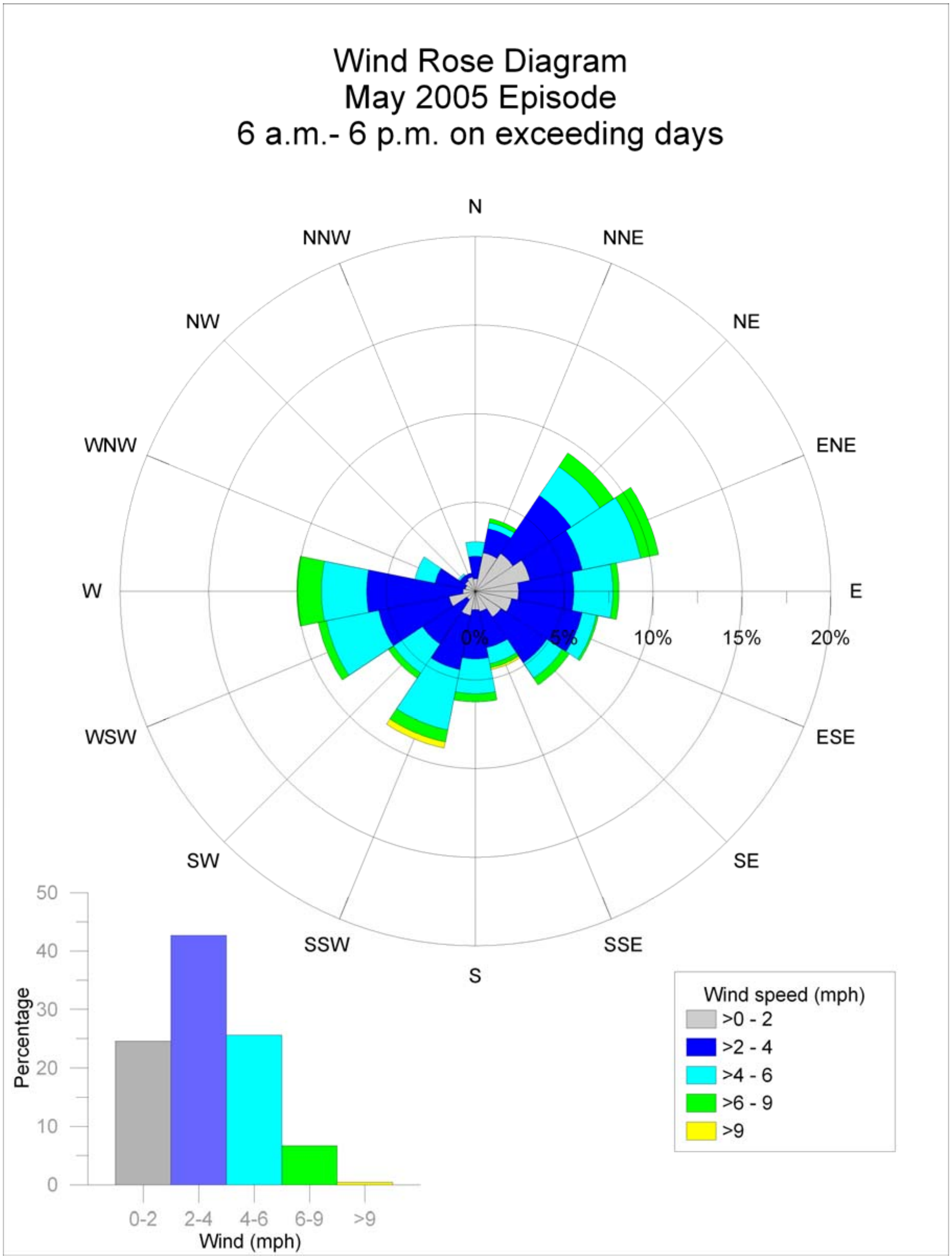


Figure 3-4. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

Hourly Ozone: 19-30 May, 2003

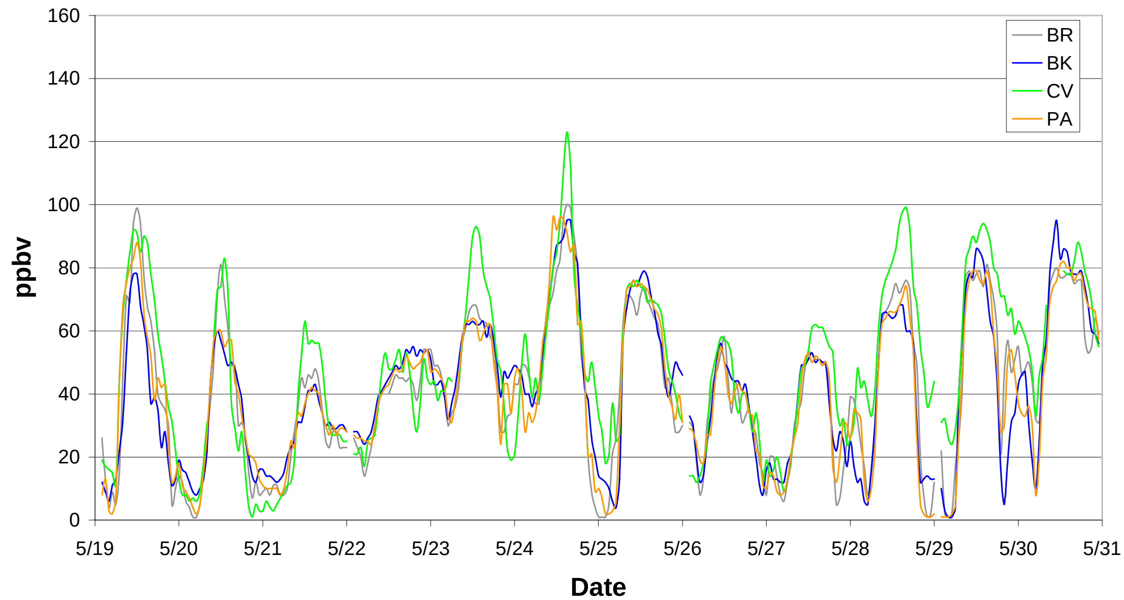


Figure 3-5a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

Hourly Ozone: 19-30 May, 2003

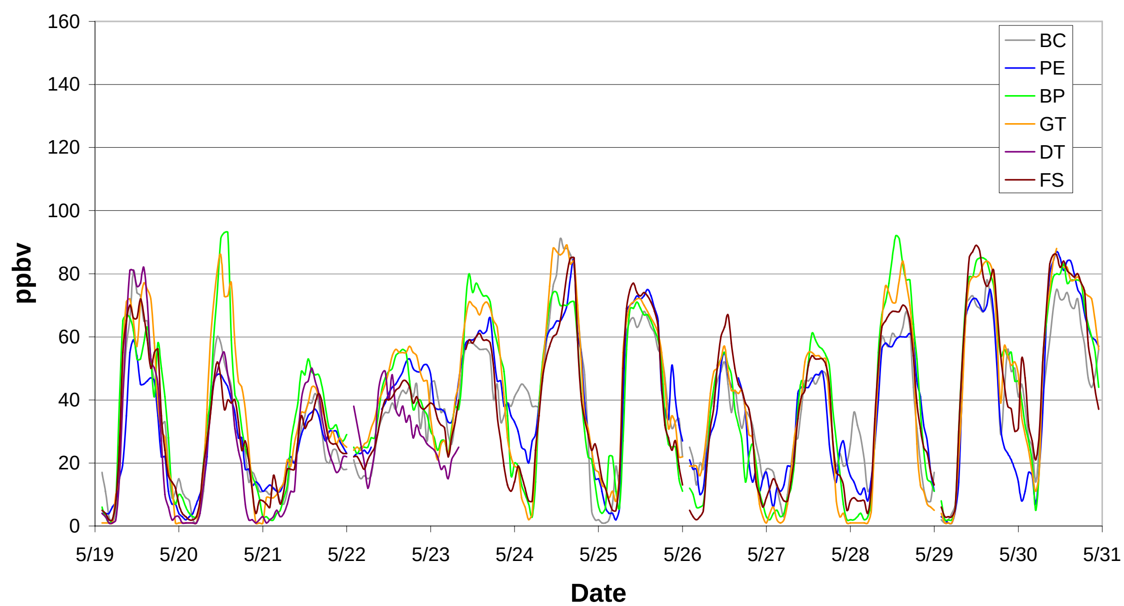


Figure 3-5b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

Meteorological conditions in the south-central U.S. during this episode were influenced by the modulation of a relatively weak upper-level low and associated stationary trough over the eastern U.S. This modulation was caused by the passing of several vigorous short waves across the continent. Each exceedance day represented a waning of the strength of the upper-level trough and winds, while multi-day periods between each exceedance day were associated with a strengthening of the upper-level trough. At the surface, this modulation influenced the passing of weak frontal systems from the north during low ozone days, which brought widespread cloud cover and precipitation. These were followed by high pressure, calm/light surface winds, and clear skies on intervening high ozone days. Additionally, temperatures on exceedance days were consistently in the mid-80's to low 90's, while non-exceedance days were limited to the high 70's to mid 80's. This period was generally characterized by humid conditions, with dewpoint temperatures in the high 60's to low 70's. Morning fog was reported at many sites throughout the Gulf States.

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-6. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-7. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

Wind speeds indicate a wide range of variation among the monitoring sites, with daytime maximum winds reaching 8-10 mph on some days, while minimum speeds remained within 2-4 mph. On average, winds ranged from 2 to 6 mph, which is consistent with light wind conditions under stagnant high pressure regimes. Temperatures also show a large range of variation among the monitoring sites over the entire diurnal period of each day. This was a rather consistently warm period, except for May 27 during the passage of a cold front. The wind rose indicates mostly westerly to northerly daytime winds with light speeds in the 2-6 mph range during exceedance days. Near calm winds contribute about 23% of the observations. Winds greater than 6 mph were observed just 10% of the time.

Back trajectories indicate very stagnant conditions leading up to May 19 (the first exceedance day of the period), with trajectories reaching back to northern Louisiana and east Texas 48 hours prior. Note the curious and rather extreme upward vertical motion (as diagnosed by the EDAS) for parcels ending at 1000 and 2000 m altitude over Baton Rouge. Such upward vertical motion would not be expected during ozone events, so the phenomena driving this motion should be investigated further. On May 24, 28, and 29, back trajectories appear more typical of ozone events in the south-central U.S., with origins several states to the north and anti-cyclonic curvature. Even so, upward motion is diagnosed over the previous 24 hours for two of these later exceedance days. Regional transport into Baton Rouge would be expected during these later three days.

Hourly Wind Speed: 19-30 May 2003

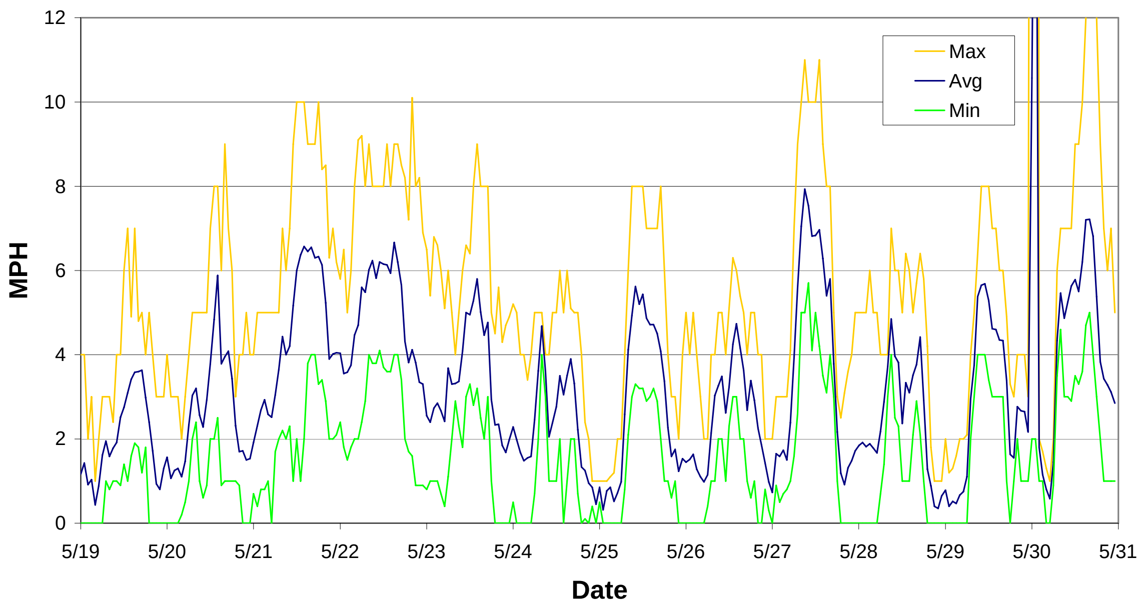


Figure 3-6a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors. The extreme winds on May 30 are likely erroneous.

Hourly Temperature: 19-30 May 2003

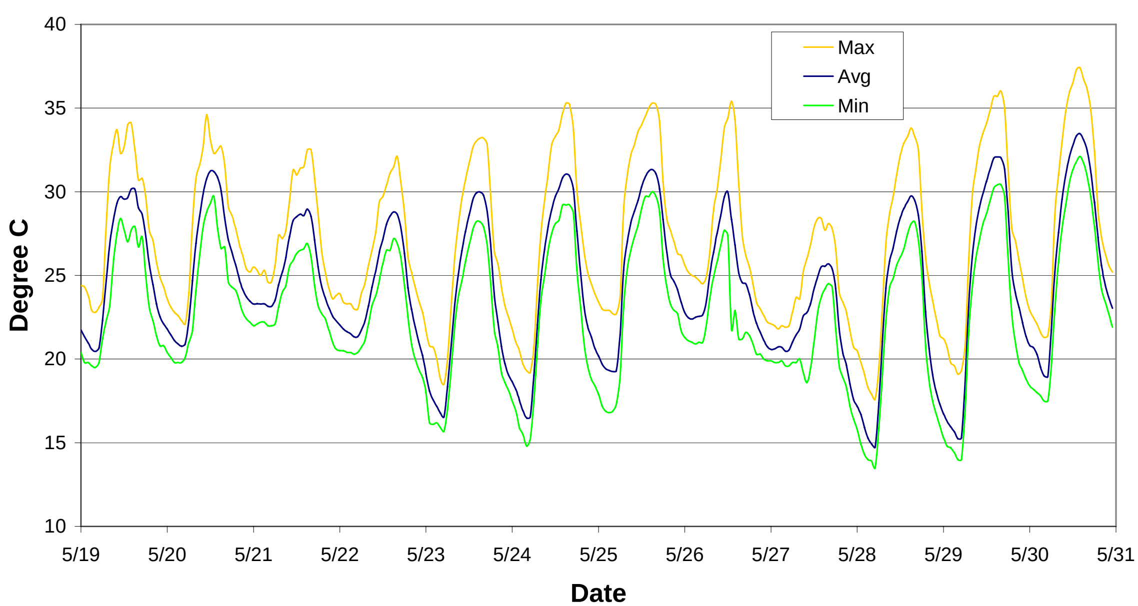


Figure 3-6b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

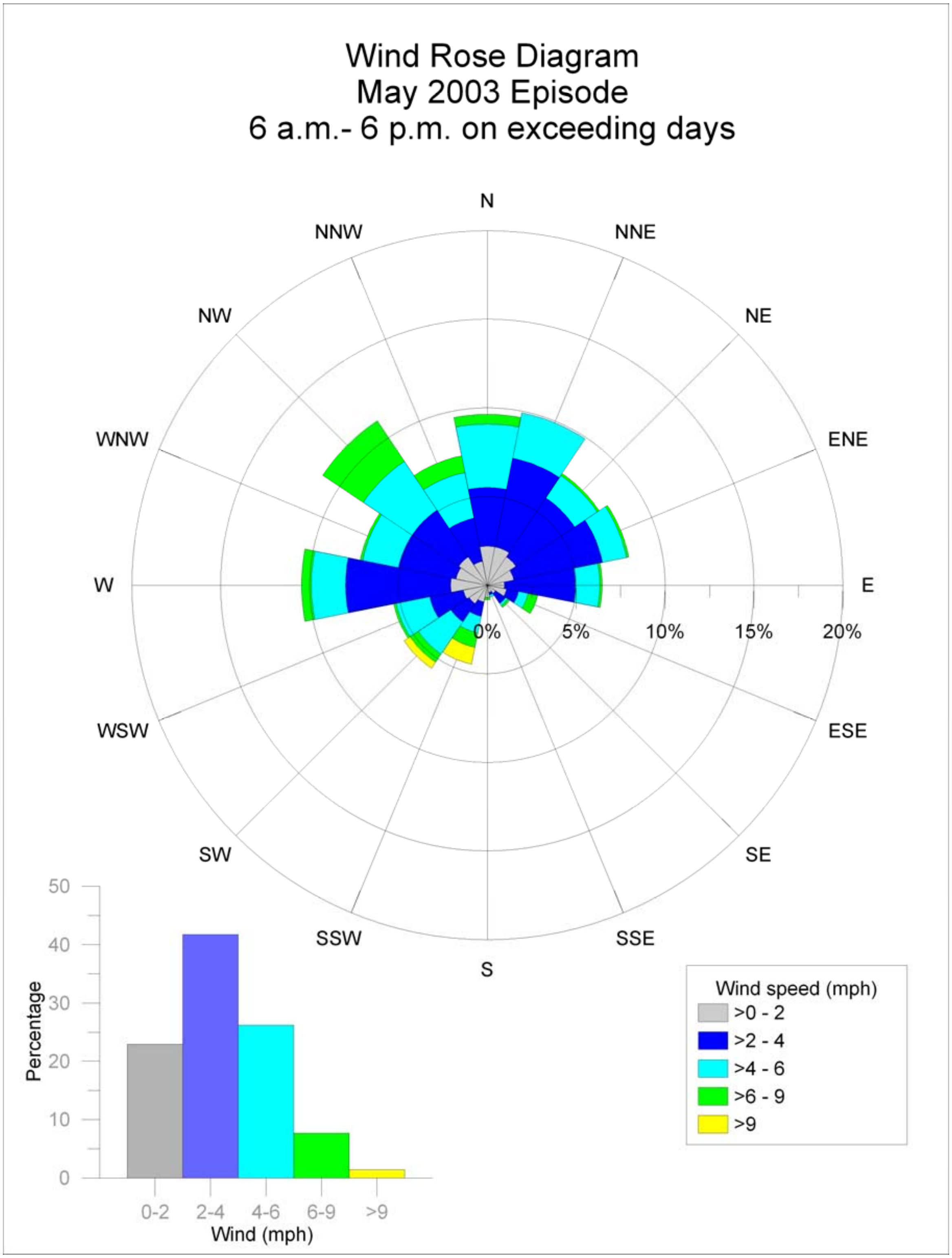


Figure 3-7. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

3.3.3 September 28-30, 2004

Eight-hour exceedance days during this episode included:

September 29 (Wednesday)
September 30 (Thursday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-8a) and the other monitors (Figure 3-8b). Among the four key monitors, Carville and LSU rise well above the other two on September 28 and 29, while ozone peaks at all sites are quite similar on September 30. A case might be made for a possible THOE on September 29, when Carville and LSU record peaks that are 40 and 60 ppb higher than the other sites, respectively. The Capitol and Dutchtown sites record a similar pattern (Figure 3-8b). The peak timing offsets among these sites suggest the southward transport of an ozone cloud. All other monitors show consistent ozone patterns day-to-day.

Meteorological conditions in the south-central U.S. during this episode were characteristic of quiet early fall conditions. Upper air patterns were zonal (west-to-east flow) but generally weak. On September 28, tropical depression "Jeane" was moving north over the Carolinas, having been downgraded from a tropical storm a day earlier. Ozone conditions were primarily driven by surface patterns, which were dominated by a strong high pressure system that extended into the south-central U.S. following a frontal system that passed through on September 28. Surface winds remained calm or light/variable through the period, and skies were clear. Maximum daily temperatures only reached the mid 80's. Humidity levels were moderate, with dewpoints typically in the low 60s.

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-9. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-10. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

This episode is characterized by weak winds at the surface. Wind speeds remained very light on the exceedance days, with maxima only reaching 6-8 mph. A large variation among the monitoring sites is seen by the difference between minimum and maximum speeds.

Temperatures were moderate and consistent day-to-day; a wide spread of temperature is also seen among the monitors, especially in the nighttime hours. The wind rose indicates a high frequency of calm to light winds (68% in the 0-4 mph range), mostly from the northwest and secondarily from the east. Winds between 4-6 mph comprise the remaining 23% frequency, with <10% frequency of winds above 6 mph.

Hourly Ozone: 28-30 September, 2004

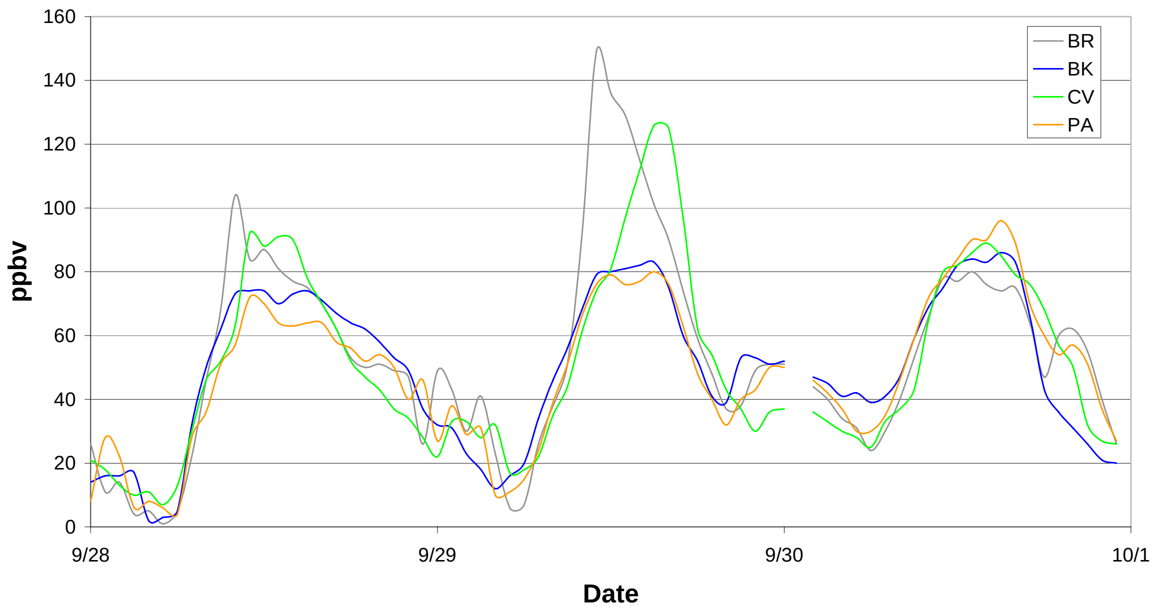


Figure 3-8a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

Hourly Ozone: 28-30 September, 2004

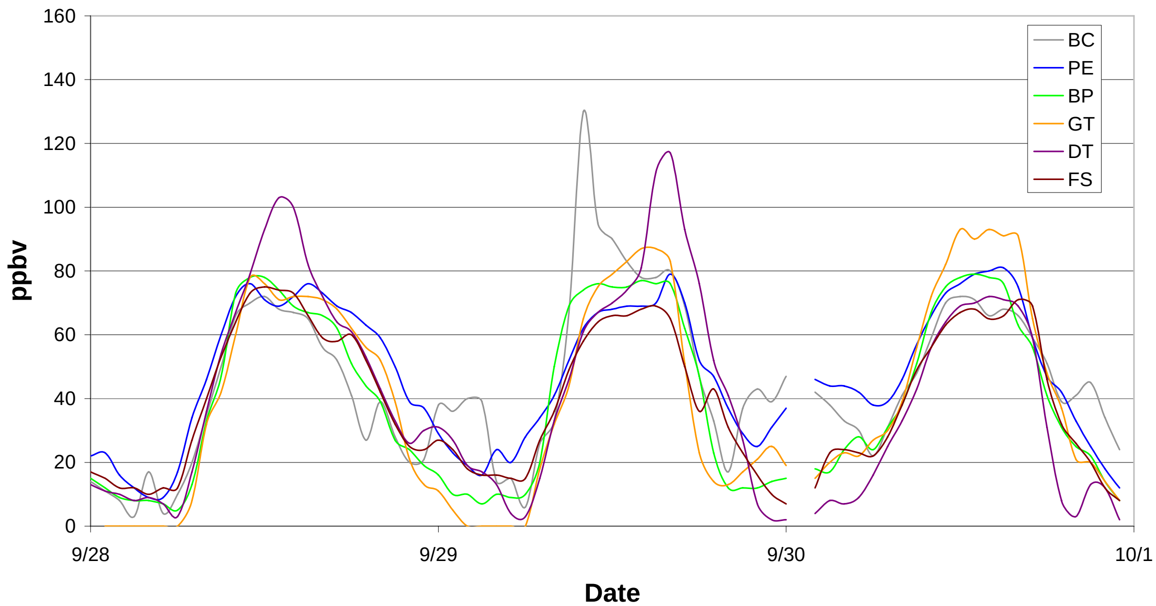


Figure 3-8b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

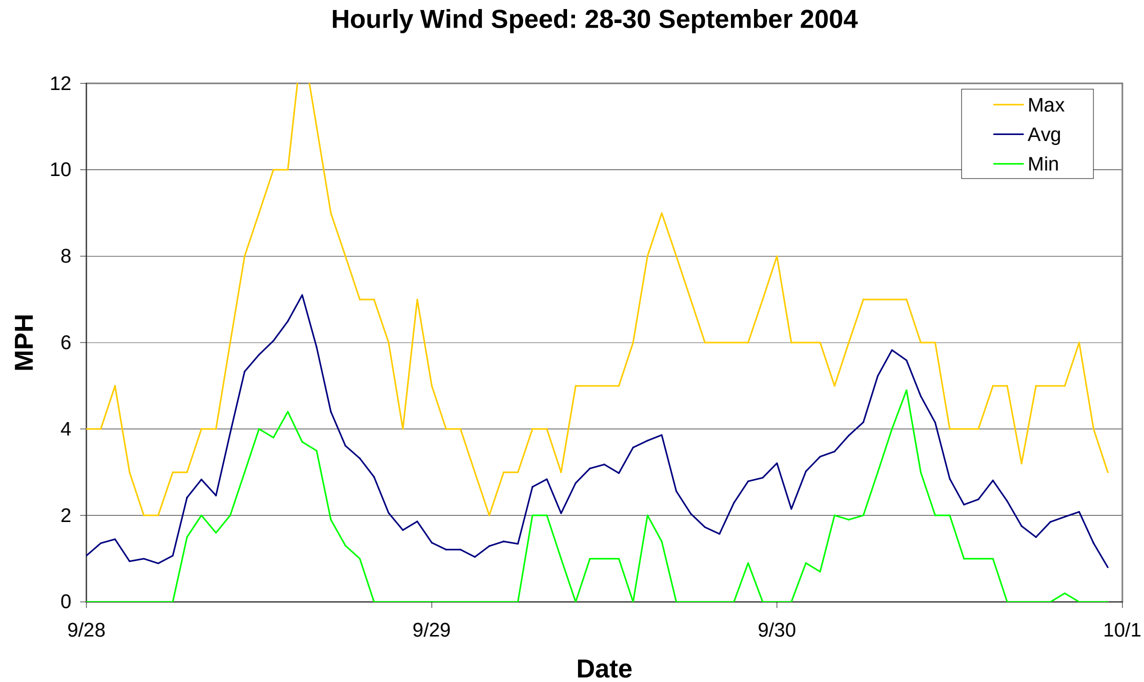


Figure 3-9a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

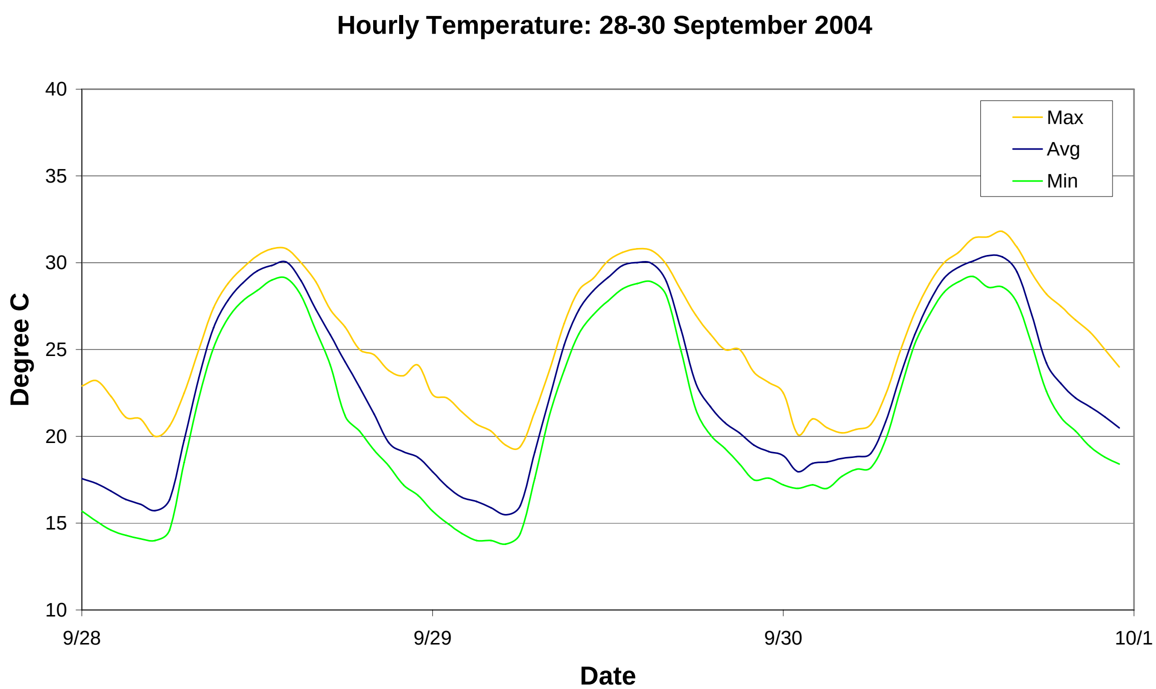


Figure 3-9b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

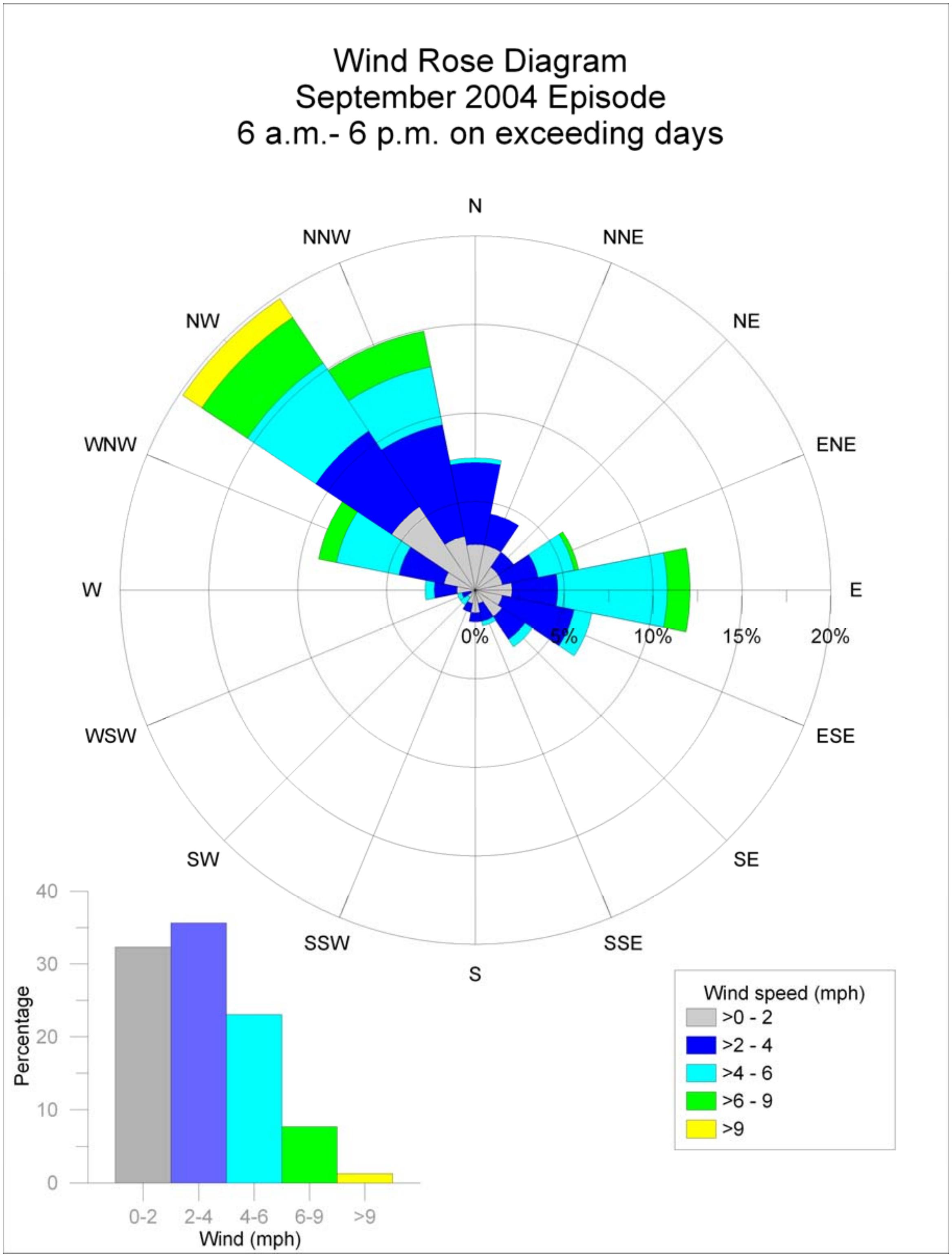


Figure 3-10. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

The EDAS back trajectories suggest long range transport from the north, extending as far back as Illinois over the 48 hours prior to the first exceedance day (September 29). Trajectories shorten for September 30 as the regional winds calm, but near-surface trajectories continue to reach back into Tennessee. Regional transport into Baton Rouge would be expected during this episode.

3.3.4 April 12-30, 2003

Eight-hour exceedance days during this combined period included:

April 13 (Sunday)
April 14 (Monday)
April 18 (Friday)
April 27 (Sunday)
April 28 (Monday)
April 29 (Tuesday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-11a) and the other monitors (Figure 3-11b). Ozone patterns at all monitors are consistent over much of the period, except for excursions at Baker and Carville on April 18 and 27, respectively. The Carville peak on April 27 may indicate a THOE given that it is ~40 ppb higher than the highest peaks among the other sites.

This mid-spring period represents three distinct exceedance episodes separated by extensive cooler, breezier conditions that were associated with weather events. The first three exceedance days are separated from the final three days by more than one week of widespread precipitation. It may be advantageous to model this period as two individual periods.

Meteorological conditions in the south-central U.S. during this episode were quite variable, which would be expected of weather during the mid-spring. During the first two exceedance days, upper-air meteorology was dominated by the expansion of a broad, strong ridge that eventually covered the eastern two-thirds of the country following the exit of a vigorous trough eastward over the Atlantic. At the surface, the south-central U.S. was under the influence of strong high pressure, which led to calm or light/variable winds and clear skies. Maximum temperatures only reached the low 80's. Humidity was rather low, with dewpoints in the 40s to mid-50s. During the intervening days to April 18, a vigorous upper-level short wave induced a surface low pressure system over the central Plains States with some weak frontal systems moving into the south-central U.S. Surface winds along the Gulf Coast increased from the south ahead of the front, and temperatures cooled. However, the period remained dry in Louisiana. On April 18, calm conditions prevailed with the re-establishment of high pressure at the surface and aloft. Maximum temperatures reached the mid-80's.

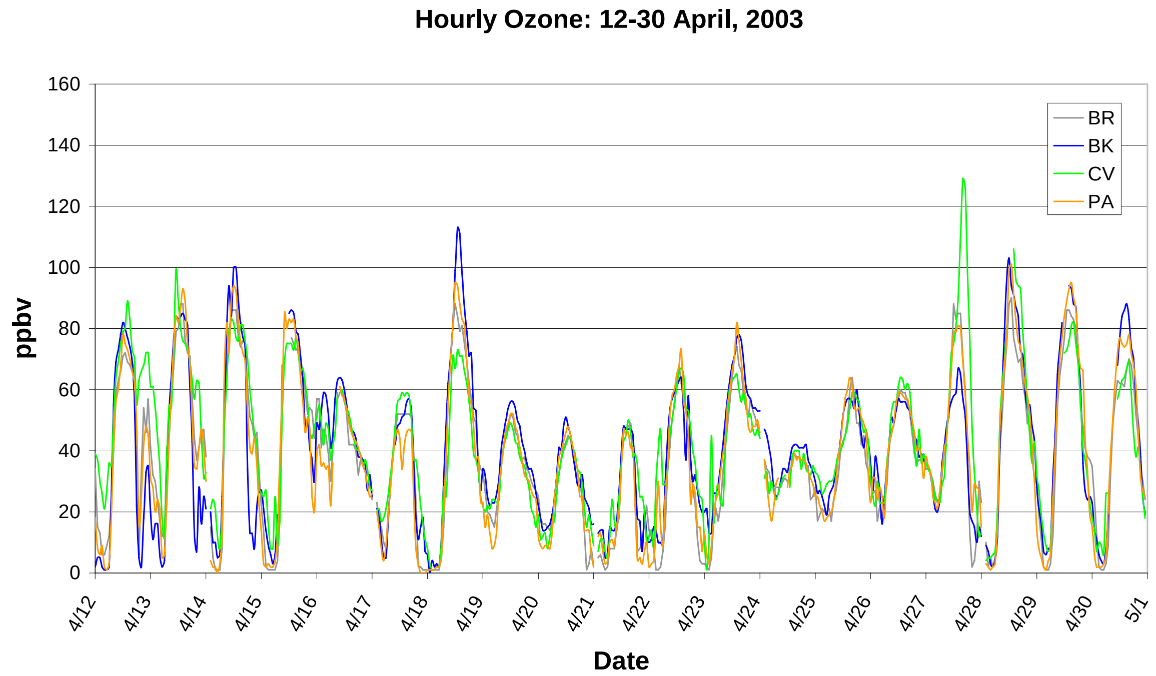


Figure 3-11a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

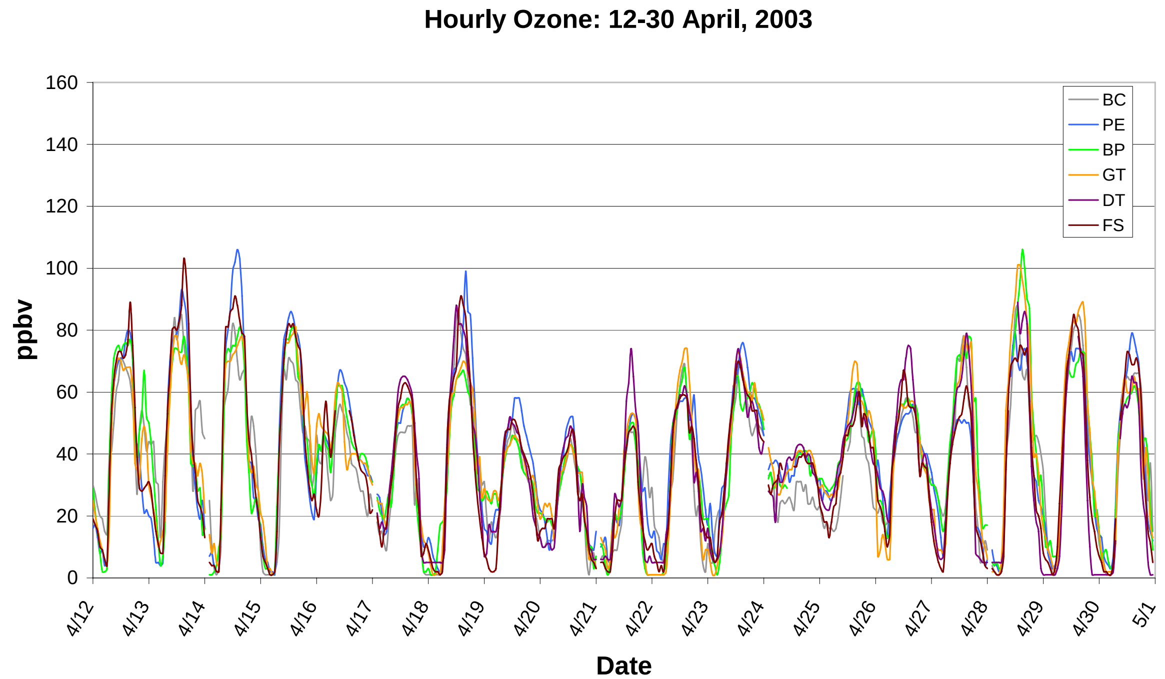


Figure 3-11b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

Subsequent to over one week of poor weather, a broad, low-amplitude ridge was once again established over the central U.S. on April 26. Over the next few days, this ridge broadened to cover the entire U.S., bringing weak zonal flow aloft. At the surface, strong high pressure built in over the eastern U.S., extending a ridge southward over all the Gulf Coast states. Surface winds remained calm or light/variable through the last three exceedance days, with dry clear skies. Maximum temperatures increased into the low 80's. Humidity also increased from low dewpoints on April 27 to moderate dewpoints (low 60's) by the last day.

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-12. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-13. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

Given the large range of weather patterns over this period, the wind speeds at the Baton Rouge monitors indicate a wide range of variability, and much stronger winds than have been described for previous episodes. However, one can identify the three elevated ozone periods in Figure 3-12a by their suppressed wind speeds. Again, a wide variation of winds is measured by the monitors, even on exceedance days. The cooler, drier mid-spring conditions led to moderate but consistent peak temperatures each day and rather low minimum temperatures for ozone episodes in this area. A consistently large variation in temperature is exhibited among the sites over all hours of the day.

The wind rose for exceedance days shows a predominance of calm to light winds up to 4 mph (65%), with a bi-modal direction distribution from the southeast and northwest. The mild speeds of 4-9 mph tended to be southerly through southeasterly.

Back trajectories for the first set of exceedance days (April 13-14) show marked anti-cyclonic curvature and downward velocities associated with flow around a strong high pressure area. This is typical of subsidence that can establish strong static stability, stagnation conditions, and shallow boundary layers, all of which are commonly seen during ozone episodes. The trajectories are rather short, indicating weak flow from the north, originating one state away 48 hour prior. On the middle exceedance day (April 18), back trajectories indicate much stronger flow from the northwest, with trajectories originating Oklahoma, Kansas, and Colorado. However, strong subsidence is also present during this time. Over the last three exceedance days (April 27-30), an interesting dynamical situation is shown. Trajectories shift from strong northerly flow, to more moderate easterly flow along the Gulf Coast. All three sets of trajectories indicate anti-cyclonic curvature (suggesting winds around high pressure), but upward velocity is diagnosed, especially for the mid-layer trajectory. Important dynamical influences are present during the entire April 2003 period, although long-range pollutant transport may not be so important during this time as no consistent transport corridors are established for more than a day or two.

Hourly Wind Speed: 12-30 April 2003

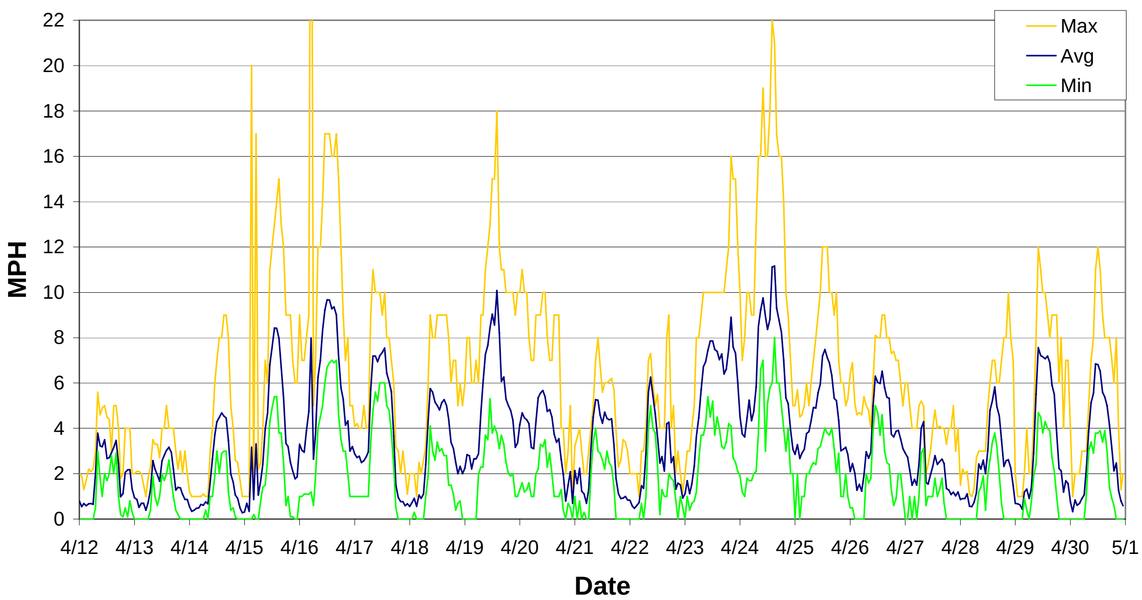


Figure 3-12a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

Hourly Temperature: 12-30 April 2003

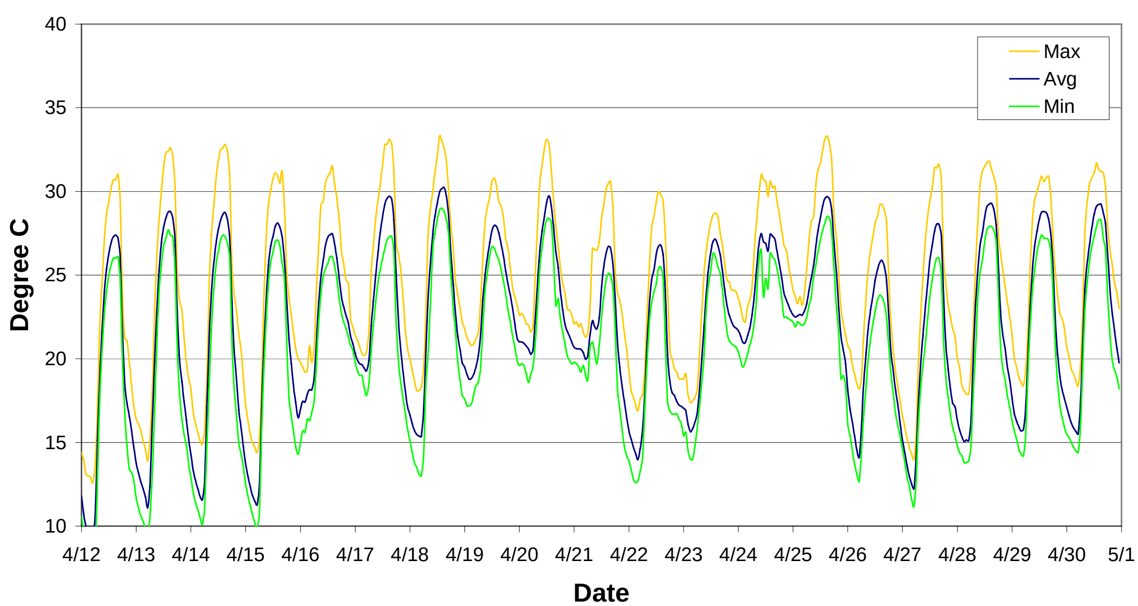


Figure 3-12b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

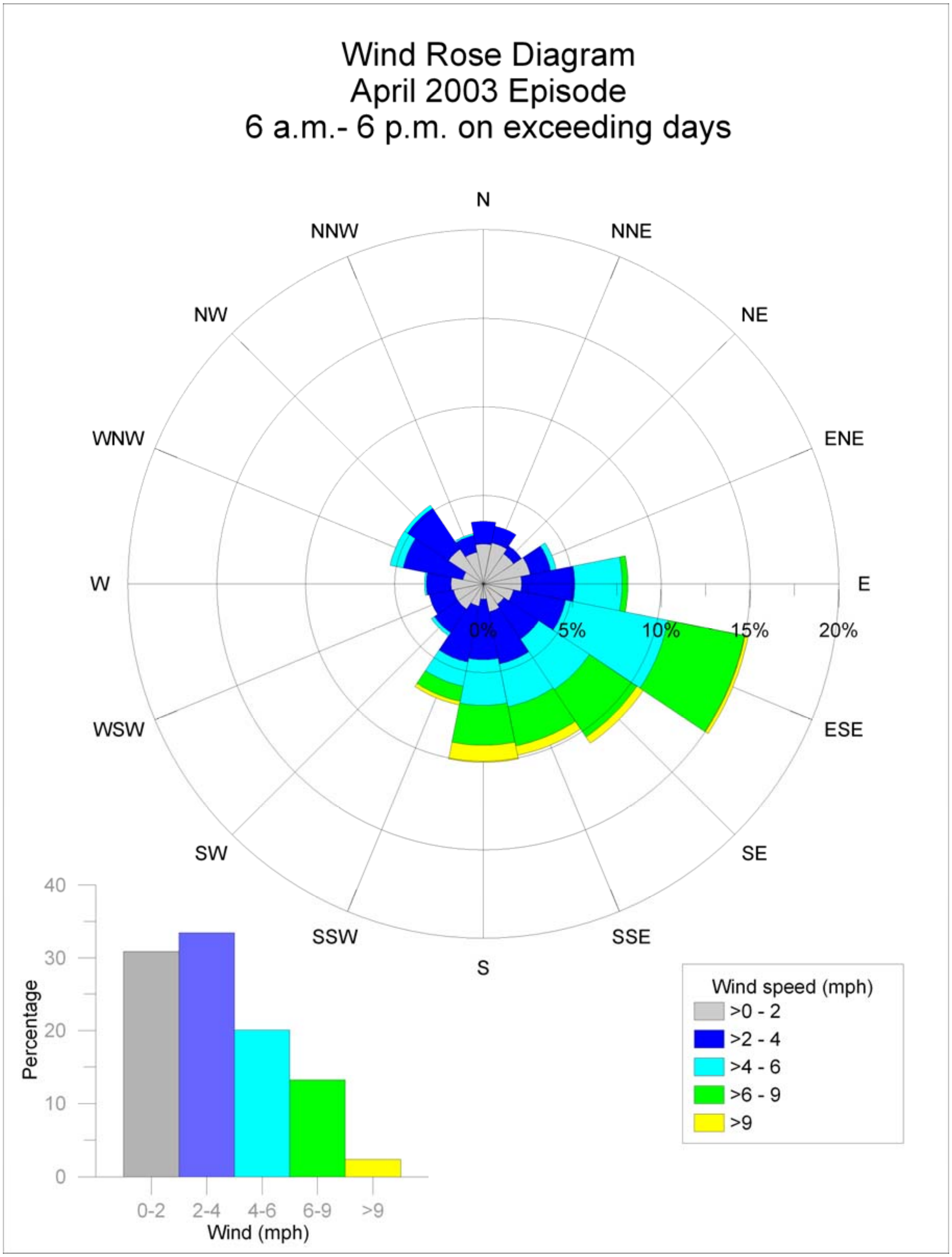


Figure 3-13. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

3.3.5 October 4-6, 2003

Eight-hour exceedance days during this episode included:

October 4 (Saturday)
October 5 (Sunday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-14a) and the other monitors (Figure 3-14b). Peak ozone is quite high over all monitors, with most reaching 100 ppb or more. Among the four key monitors, the LSU and Baker monitors reach the highest levels of nearly 140 ppb, which is 20 ppb above all others. A case might be made for a ROFE at LSU on October 4, but given the high ozone at all monitors, and the high ozone over several afternoon hours at LSU, it would be difficult to attribute this to a single emissions event.

Meteorological conditions during this episode were influenced by the eastward propagation of a very high-amplitude and deep trough/ridge system over the continent. Most of the energy between these two systems remained well to the north of the Gulf Coast; fairly weak zonal flow was dominant over the southern states. On October 4, a long cold front extended southward from a large low pressure system over the northeast U.S., back into Texas. This slowly propagated southward, and by October 6 was a weak stationary front along the Gulf Coast that brought widespread precipitation to the area. South of this front, a surface high pressure ridge nosed westward from Georgia back into Louisiana, bringing calm to light/variable winds, clear conditions, and maximum temperatures in the mid-80’s on October 4 and 5. With the evolving front/ridge system, humidity varied over these three days, with the lowest values on October 5 (high 50s) and high values on October 6 (high 60s) associated with the increased cloudiness.

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-15. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-16. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

Wind speeds among the Baton rough monitors were exceptionally low during this episode. Peak winds barely reached 5 mph, while the average speed ranged from 1 to 2 mph on the exceedance days. Daily maximum temperatures were consistent day-to-day, but the increasing minimum temperatures reveal the build up of humidity under the stagnant conditions. Not surprisingly, the wind rose exhibits a dominance of calm winds (60%) and the lack of speeds greater than 4 mph (~5%). Directions are skewed toward the east, with fairly even distribution from southeast through northeast. The highest speeds are associated with southeasterly flow.

Trajectory plots also demonstrate the high degree of stagnation during this event. On both exceedance days, recirculation patterns cause the back trajectories to remain within the state of Louisiana at all three altitudes. Some subsidence is suggested. This ozone episode would appear to be generated by local emissions only.

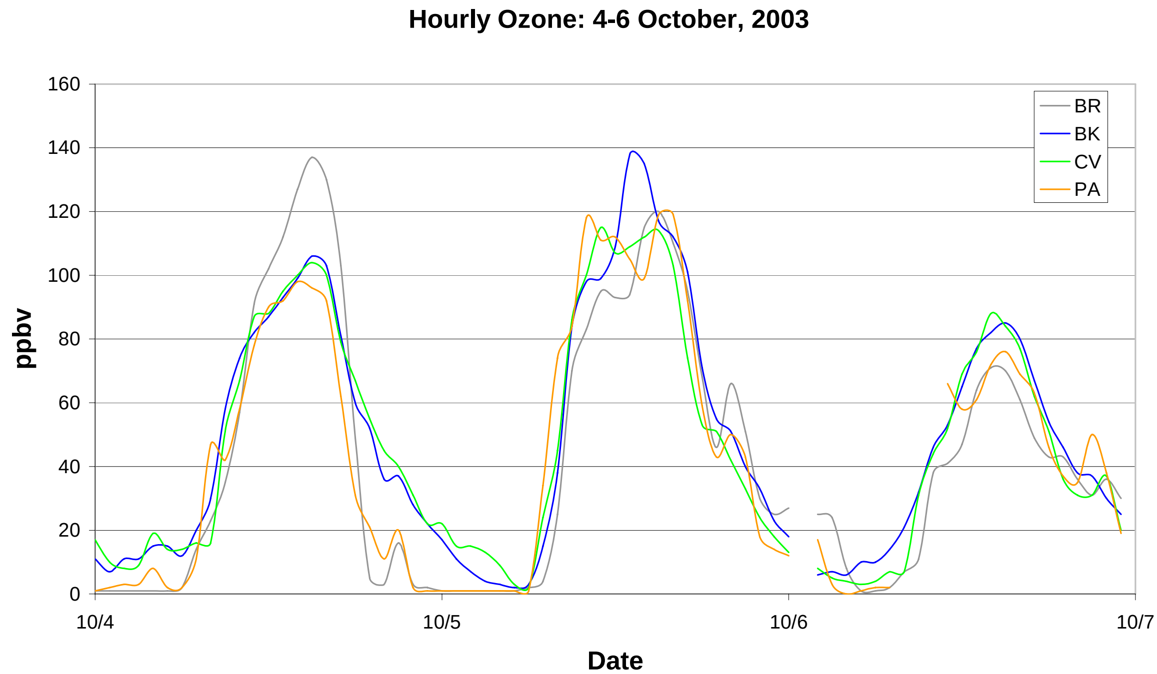


Figure 3-14a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

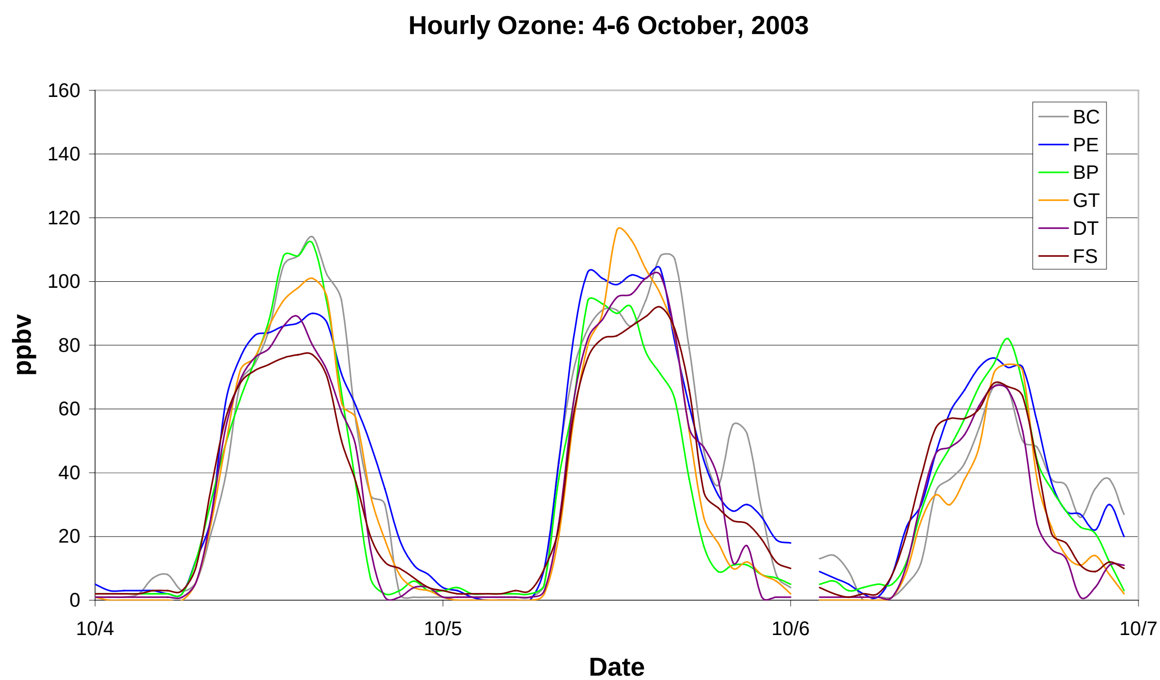


Figure 3-14b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

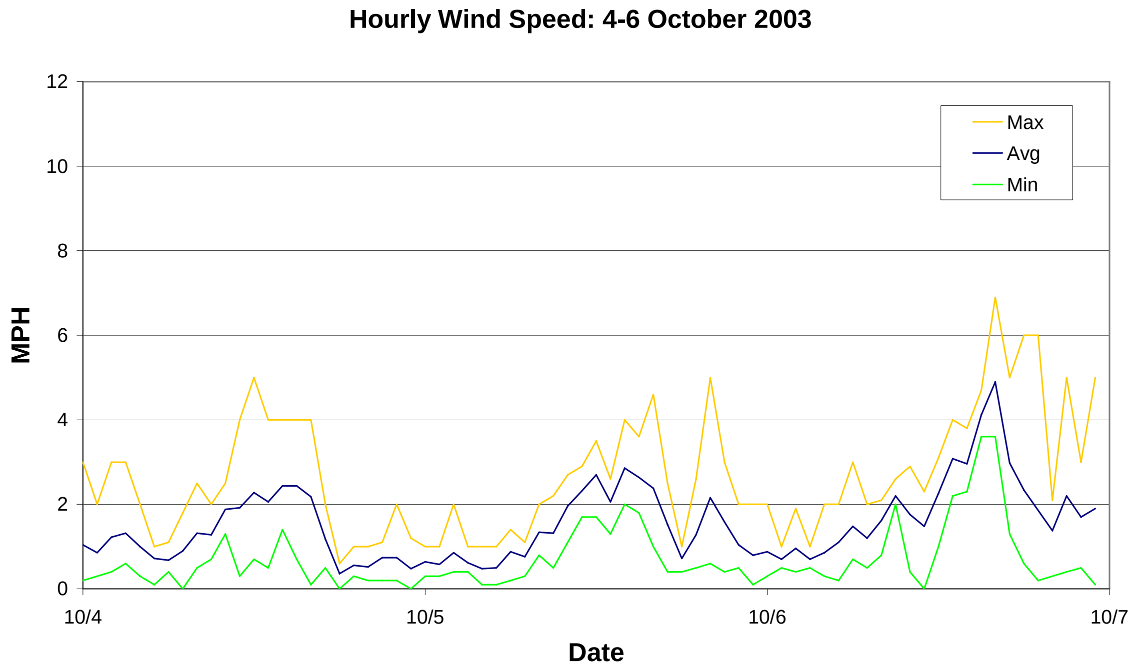


Figure 3-15a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

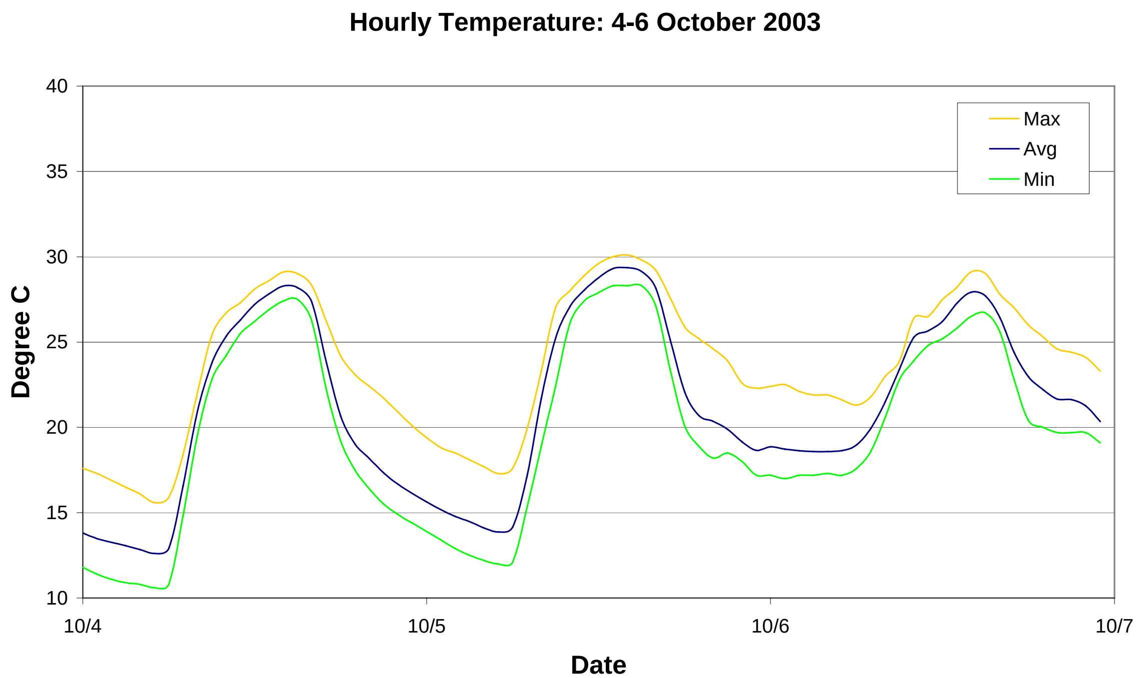


Figure 3-15b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

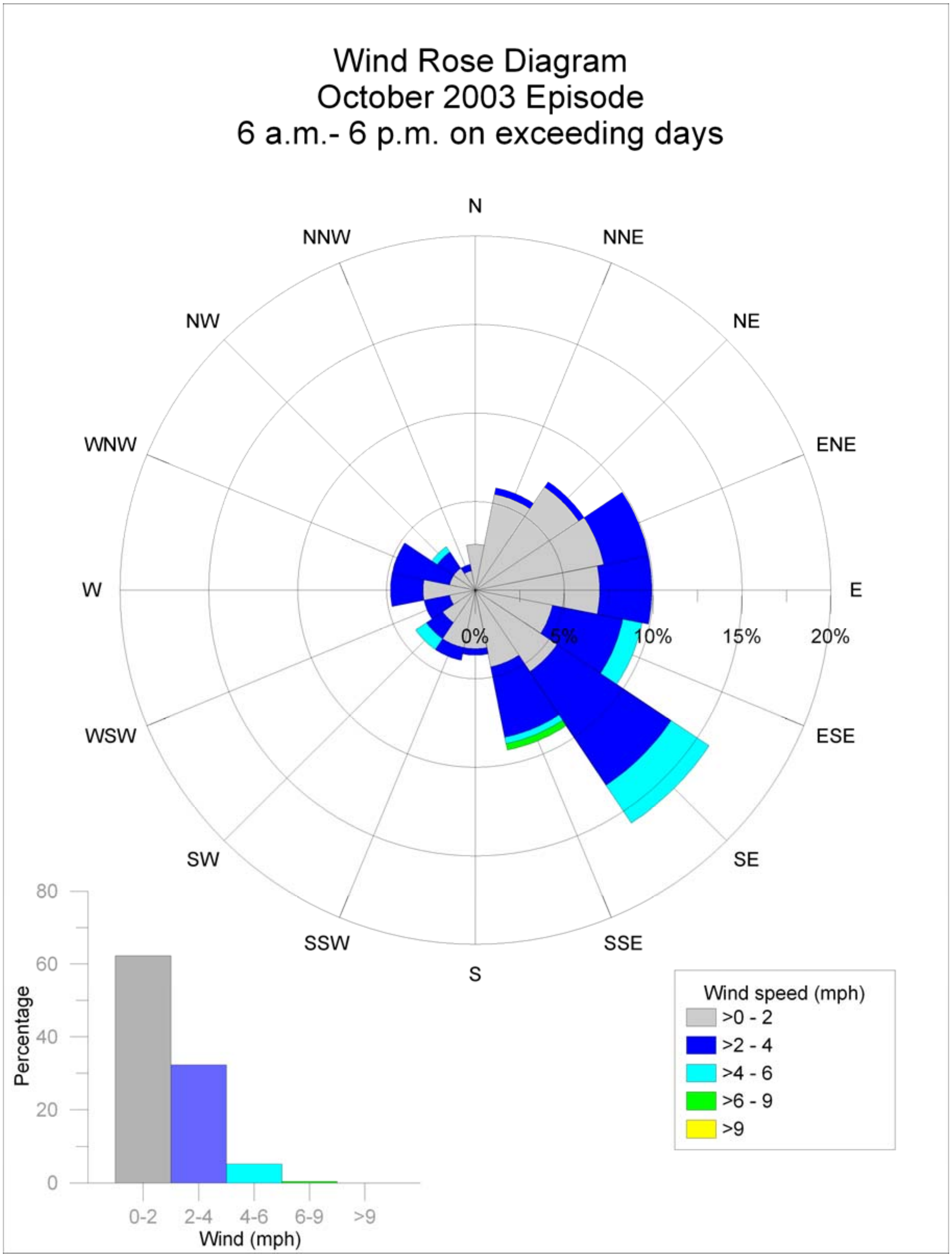


Figure 3-16. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

3.3.6 May 4-9, 2004

Eight-hour exceedance days during this episode included:

May 4 (Tuesday)
May 5 (Wednesday)
May 6 (Thursday)
May 8 (Saturday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-17a) and the other monitors (Figure 3-17b). Daily peak ozone is fairly consistent among the ozone monitors, although Baker is consistently 10-20 ppb higher than the other four key monitors during the middle of the period. Among the other monitors, time shifts in the peaks between southern and northern monitors suggest ozone transport from the north on the first few days, shifting to transport from south to north on the latter days. The data in these figures do not indicate an obvious THOE or ROFE during this period.

Meteorological conditions in the south-central U.S. during this episode were dominated by the existence of a very broad, low-amplitude ridge over most of the continent. Conditions in the Gulf States were modulated by a weak trapped low pressure center and trough aloft that started over Mexico and slowly drifted over the south-central U.S. during the period. Flow patterns remained quite weak aloft, changing from zonal early on, to disorganized at the midpoint, to southerly by the end. During the entire period, a surface high pressure system over the southeast U.S. expanded, shifted westward, waned, and finally moved out over the Atlantic by May 9. This caused calm to light/variable winds over the region for most days, with increasing southerly flow off the Gulf during the final day. Skies remained clear on all days except the intervening non-exceedance day of May 7 and the last day, when some light precipitation fell in Louisiana. Interestingly, maximum temperatures started in the high 70's on May 4 (an exceedance day), and slowly increased to the mid-80's by May 9. Humidity started low (dewpoints in the mid 50s) and increased through the period to moderate levels (low- to mid-60's).

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-18. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-19. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

A regular diurnal pattern of winds speed set up over this period, with average daytime ranges from 1 mph in the morning to 5 mph in the afternoon. Like other episode, a wide range of speeds was measured by the network each hour, as indicated by the span between minimum and maximum speeds. However, the overall pattern indicates quiescent conditions. Temperature trended slowly upward during the period from rather mild conditions on the first day, to warm conditions over the last couple days. Like other episodes, a wide range of temperature was seen among the monitors, mostly in the early morning hours.

Hourly Ozone: 4-9 May, 2004

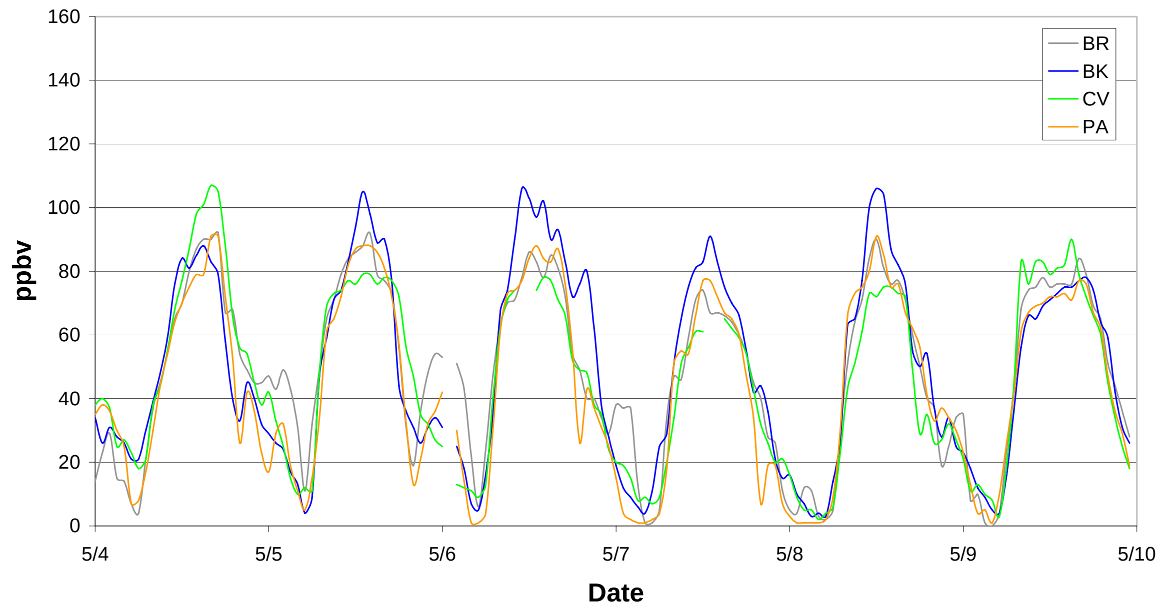


Figure 3-17a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

Hourly Ozone: 4-9 May, 2004

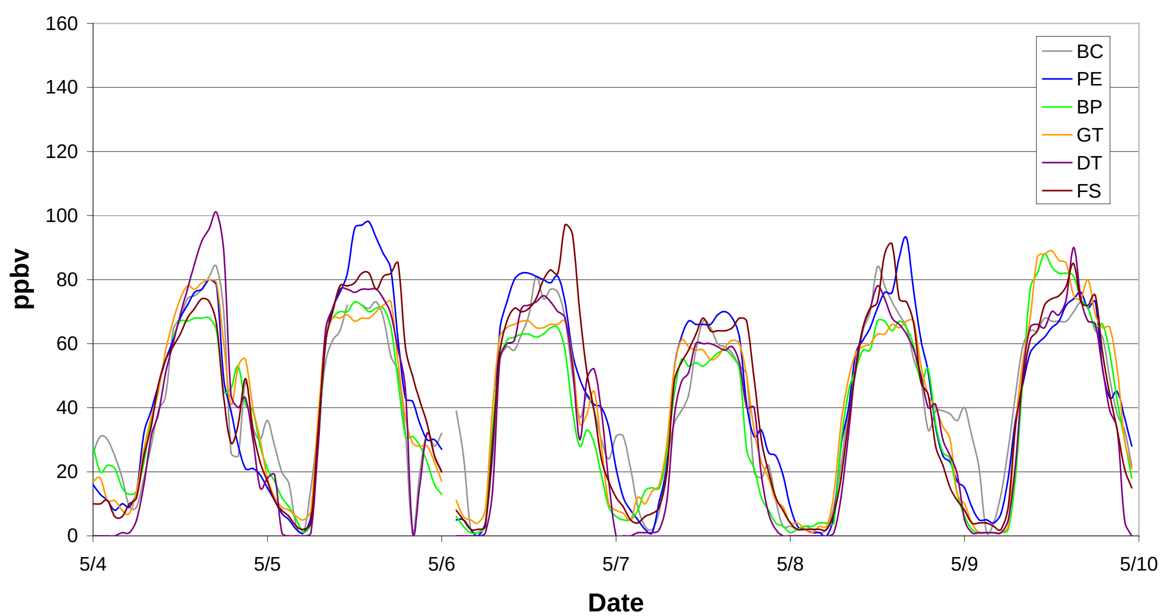


Figure 3-17b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

Hourly Wind Speed: 4-9 May 2004

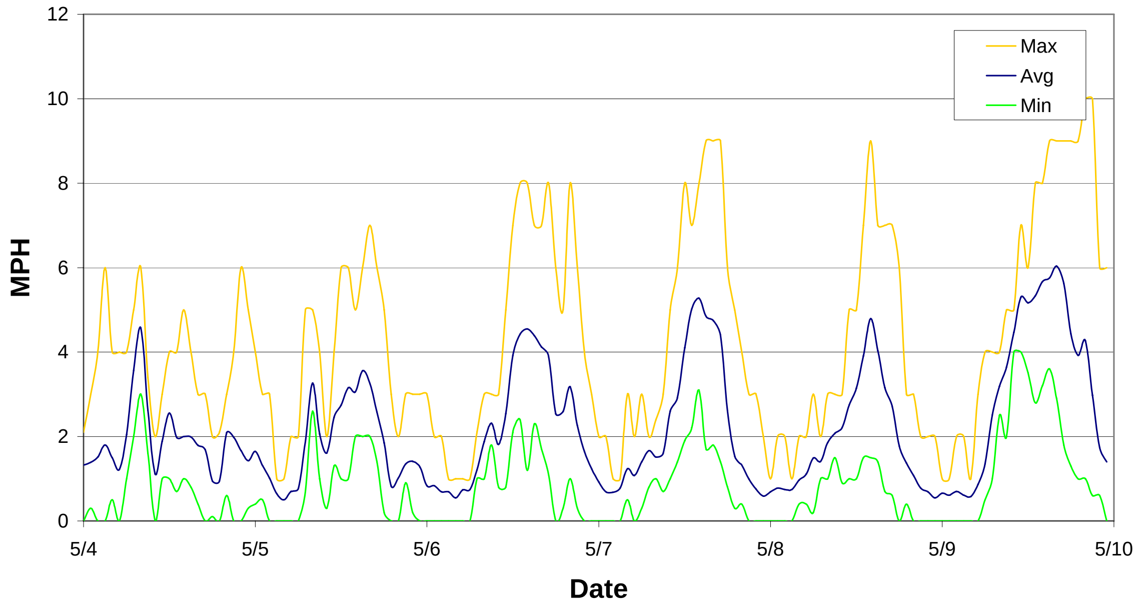


Figure 3-18a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

Hourly Temperature: 4-9 May 2004

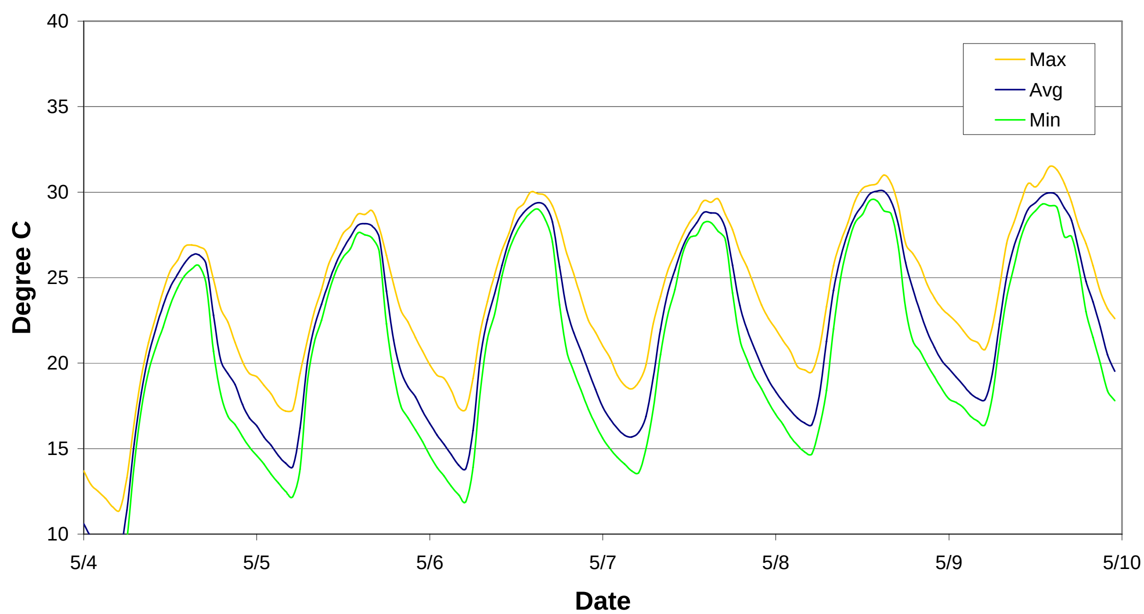


Figure 3-18b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

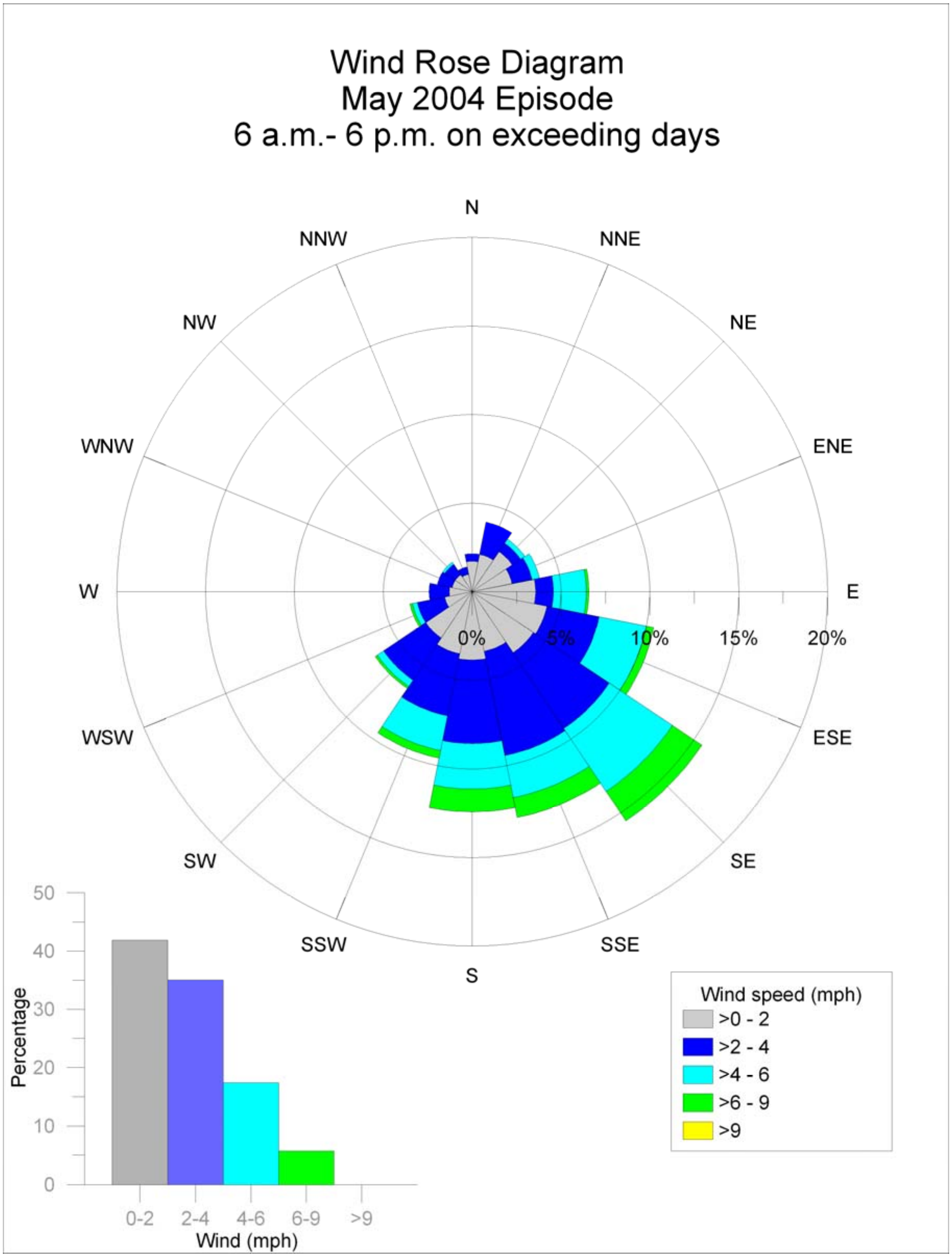


Figure 3-19. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

The wind rose indicates a dominance of calm conditions (>40%), while light winds < 4 mph make up an additional 35% of the distribution. Directions were skewed toward the southwest through southeast quadrants for all speed ranges.

Back trajectories for this episode exhibit strong anti-cyclonic curvature and downward motion associated with flow around a strong high pressure system. The daily shift of high pressure from the south-central U.S. to the south-east U.S. and Atlantic is indicated by the eastward shift of trajectories each day. Only on the last day is there evidence of upward motion, as the trajectories show an onshore component from the eastern Gulf with the approach of a weather system to the northwest. Long range ozone transport might have been operative early in the episode, but most near-surface trajectories show on-shore (northward) airflow on later days. If continental pollutants were transported aloft over the Gulf during this time, then there could be a mechanism for transport impacts on later days of the episode if sufficiently deep mixing occurs over Louisiana.

3.3.7 August 11 – September 5, 2000

Eight-hour exceedance days during this episode included:

August 11 (Friday)
August 13 (Sunday)
August 17 (Thursday)
August 18 (Friday)
August 19 (Saturday)
August 20 (Sunday)
August 21 (Monday)
August 25 (Friday)
August 26 (Saturday)
August 30 (Wednesday)
August 31 (Thursday)
September 1 (Friday)
September 2 (Saturday)
September 3 (Sunday)

Hourly ozone for the period is shown for the four key ozone monitors (Figure 3-20a) and the other monitors (Figure 3-20b). This episode was the last extreme multi-week pollution episode in Baton Rouge. On most days, consistent peak ozone concentrations were measured among all the sites, however some severe short-lived peaks stand out: LSU, Port Allen and Capitol on August 11 (140-160 ppb); Dutchtown on August 18 (130 ppb); LSU, Carville, and Port Allen on August 21 (120-130 ppb); and Baker and Port Allen on August 31 (120-150 ppb).

Hourly average, maximum, and minimum wind speeds and temperature time series among all LDEQ Baton Rouge monitoring sites are displayed in Figure 3-21. A wind rose of the hourly daytime (6 AM to 6 PM) wind speed and direction distribution on exceedance days during this episode is shown in Figure 3-22. Forty-eight hour backward trajectories ending at Baton Rouge at 3 PM on each exceedance day of this episode are shown in Appendix C.

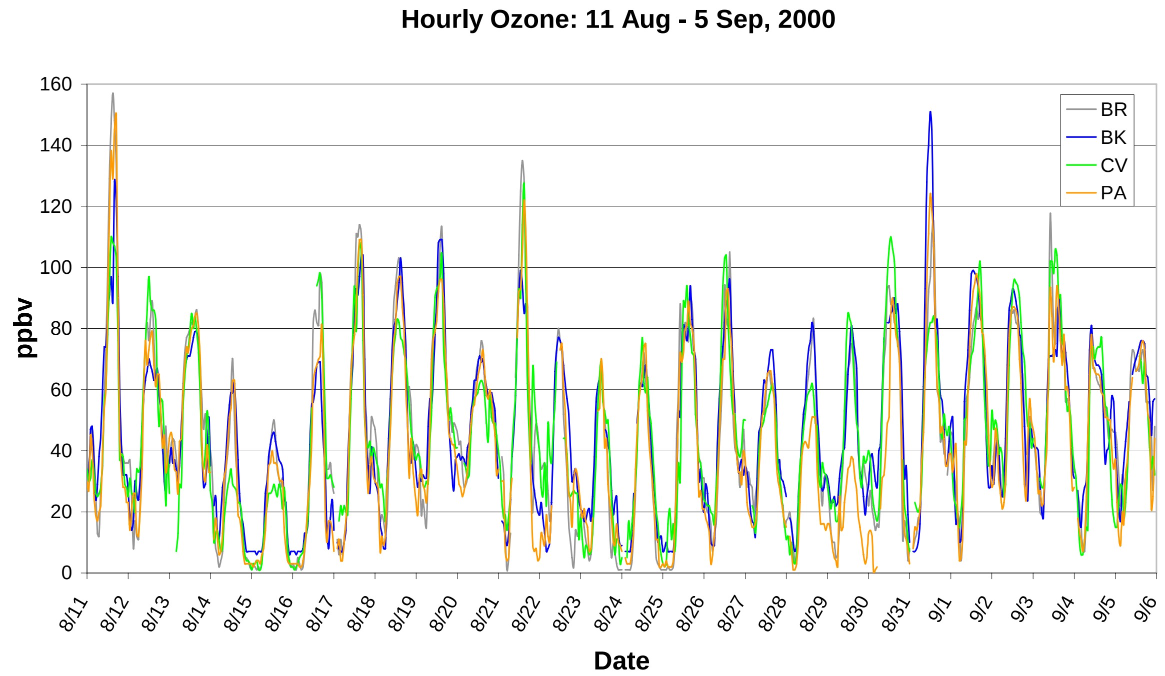


Figure 3-20a. Hourly ozone (ppb) at the four key Baton Rouge monitors: LSU (BR), Baker (BK), Carville (CV), and Port Allen (PA).

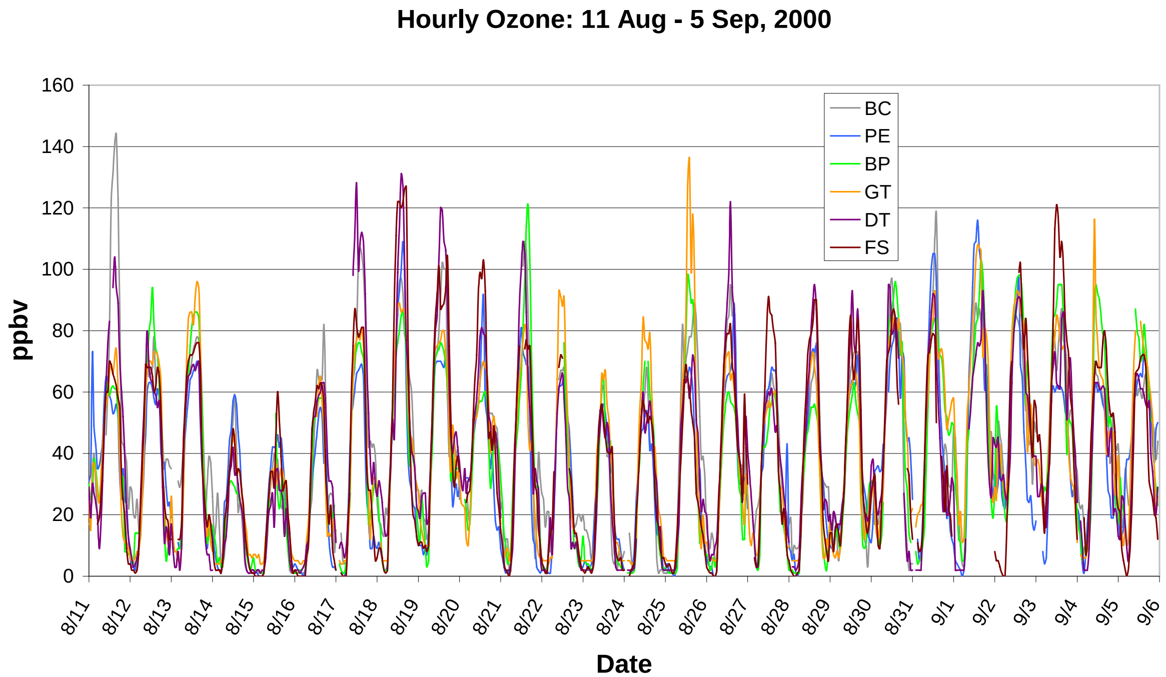


Figure 3-20b. Hourly ozone (ppb) at the other Baton Rouge monitors: Capitol (BC), Pride (PE), Bayou Plaquemine (BP), Grosse Tete (GT), Dutchtown (DT), and French Settlement (FS).

Hourly Wind Speed: 11 Aug - 5 Sep 2000

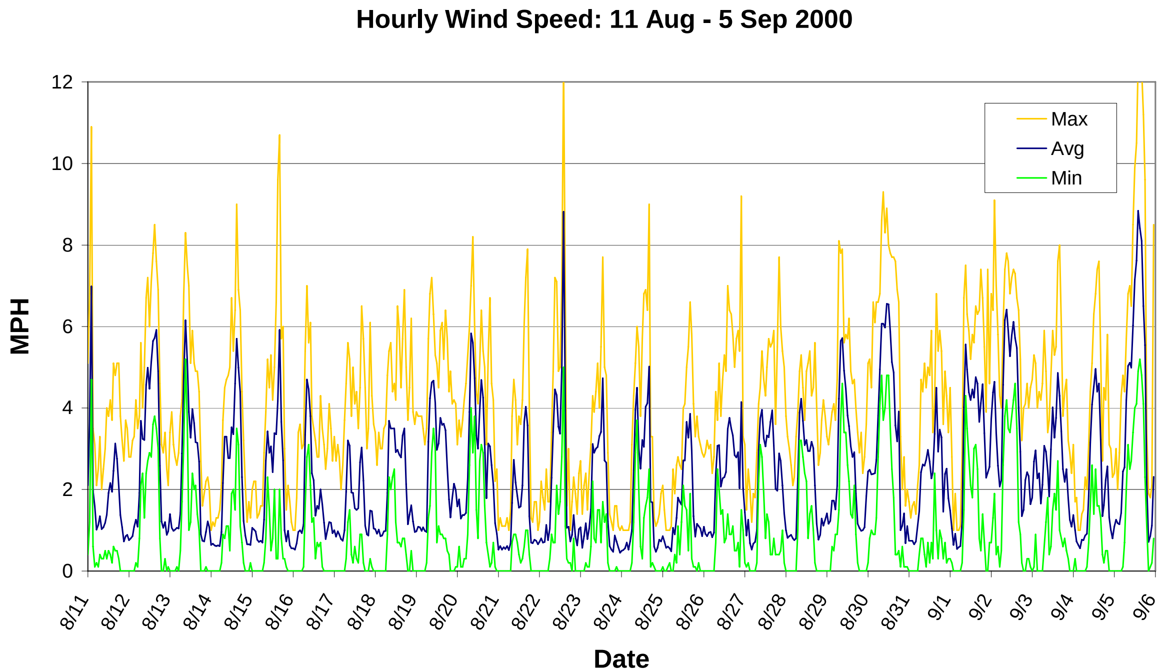


Figure 3-21a. Average, maximum, and minimum hourly wind speed (mph) among the Baton Rouge monitors.

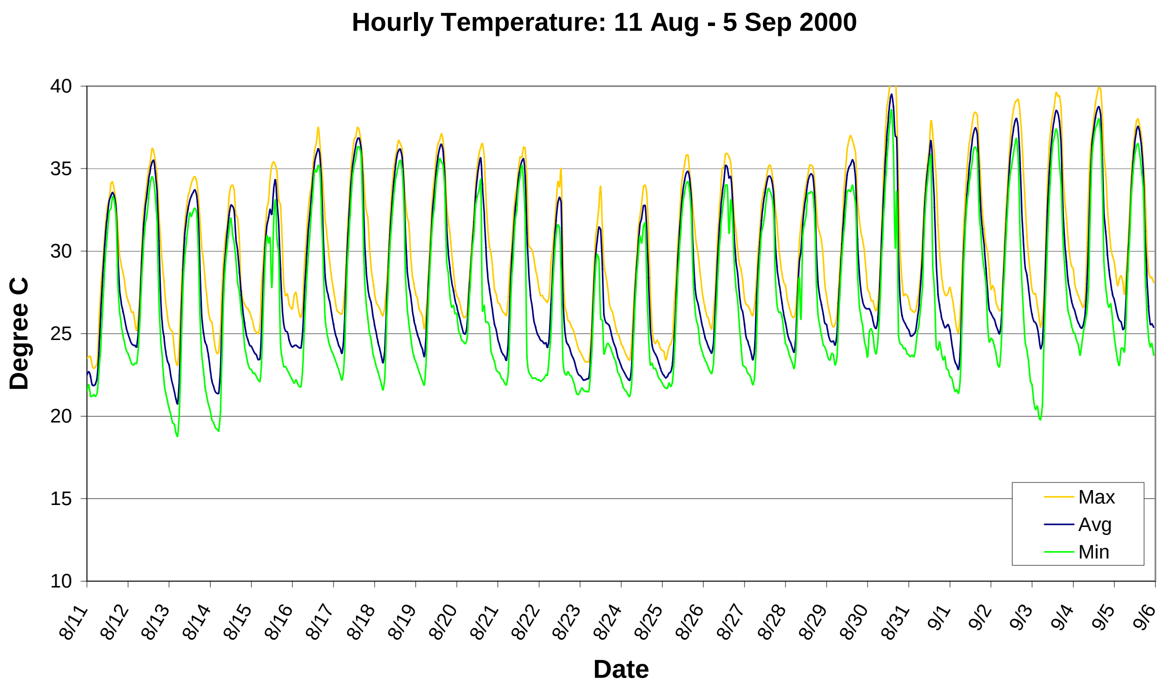


Figure 3-21b. Average, maximum, and minimum hourly temperature (C) among the Baton Rouge monitors.

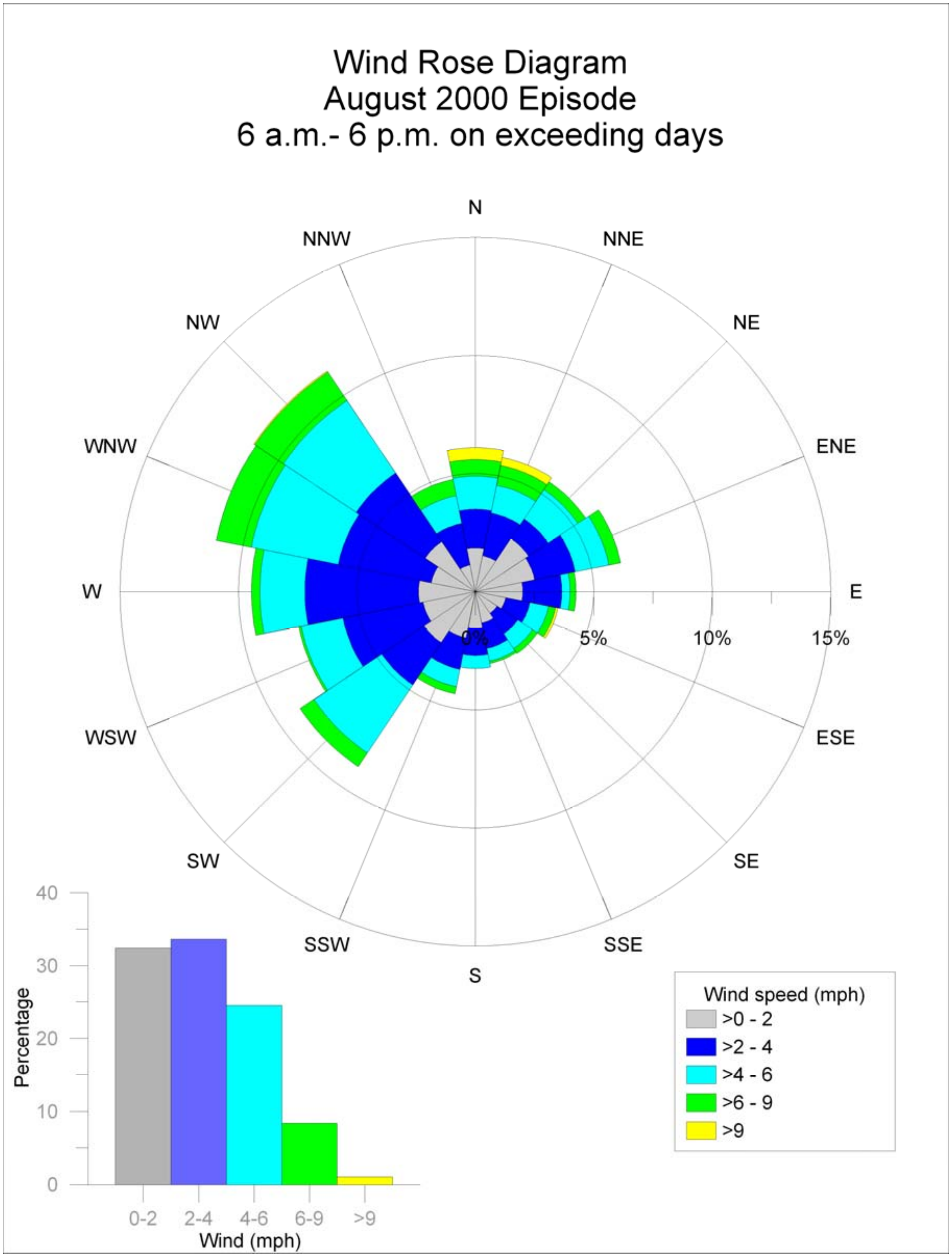


Figure 3-22. Wind rose based on hourly wind speed/direction data from all Baton Rouge monitors between 6 AM and 6 PM on exceedance days.

Wind speeds were consistently light during the entire period, averaging 1-5 mph, with only occasional afternoon peak winds reaching 10 mph at the maximum site. Minimum afternoon winds rarely exceeded 3 mph among the Baton Rouge sites. Daily temperatures were quite warm over the month as well, and reached up to 40 C (104 F) during the first days of September. As seen for other episodes, there was a wide range of temperatures among the monitoring sites each hour, especially in the early morning. Conditions were also rather humid, as evidenced by the very high daily minimum average temperatures of 25 C (77 F).

The wind rose exhibits a fairly consistent speed distribution in the 0 to 6 mph range (covering 90% of total observations), and the frequency of higher speeds is significantly less. The directions are weighted toward the western quadrants, which are associated with the highest speeds, while the northeast direction comprises a secondary maximum. Little wind direction observations were measured from the south through the east.

The back trajectories indicate a wide range of transport routes, which would be expected given the large number of exceedance days during this episode. However, anti-cyclonic curvature around high pressure systems is a common trait among most trajectory plots. There are certain days that show marked stagnation, as the trajectories re-circulate within a very short distance over 48 hours, while others indicate the potential of long range transport from the upper Midwest, Ohio Valley, and the southeast U.S. Despite the consistent local wind and temperature conditions measured in Baton Rouge over August and early September 2000, it is clear from these plots that a variety of regional transport conditions exist.

4.0 MODELING DOMAINS AND DATA AVAILABILITY

This chapter summarizes the model domain definitions for the Baton Rouge 8-hour ozone modeling, including the domain coverage, resolution, map projection, and nesting schemes for the high resolution sub-domains. It also discusses the emissions and aerometric data available from various State and federal agencies for use in model input preparation and performance testing.

4.1 Horizontal Modeling Domain

The 36-km eastern United States (U.S.) horizontal domain for CAMx and EPS will be identical to what is used by the TCEQ in their current 8-hour ozone modeling. This 36-km modeling domain was also selected by the Oklahoma DEQ for their 8-hour ozone EAC SIP modeling after evaluating the effects of the size of the 36-km regional modeling domain on their 8-hour ozone impacts in Tulsa and Oklahoma City (Morris et al., 2005d). Through 2004, both TCEQ and ODEQ were initially using a smaller regional 36-km domain (although much larger than the 36-km domain proposed in the preliminary draft Modeling Protocol for Baton Rouge 8-hour ozone modeling; ICF, 2005). However, when they performed ozone source apportionment modeling on their original 36-km domain they found a larger than expected contribution from the lateral boundary conditions. Thus, the TCEQ and ODEQ expanded the 36-km modeling domain, which not only reduced the influence of the boundary conditions but also allowed them to account for the benefits of the large NOx controls in the Midwest due to the NOx SIP Call on transported ozone into Texas and Oklahoma.

The Baton Rouge CAMx/EPS 12-km modeling domain is defined to include the Gulf States and most of the Ohio River Valley source region; the new proposed 12-km modeling domain is also larger than the original 36-km domain in the preliminary draft Modeling Protocol. The 4-km modeling domain covers the southern half of Louisiana and the immediate Gulf coastline, and includes the Houston-Galveston and Beaumont-Port Arthur areas in Texas eastward across Mobile Bay to about Pensacola, Florida.

The CAMx air quality and EPS emissions 36/12/4 km modeling domains are aligned within the MM5 domains. The MM5 modeling domains are offset (larger) from the CAMx/EPS modeling domains by 6 grid cells in each direction. Figure 4-1 displays the nested 36/12/4 km domains proposed to be used in the Baton Rouge 8-hour ozone modeling analysis; the MM5 domains are the outer solid lines, whereas the CAMx/EPS domains are the dotted lines. These grids are based on a Lambert Conformal Projection (LCP) using the same projection as adopted for Texas and Oklahoma. The LCP is defined by the projection parameters listed in Table 4-1.

There is a possibility of boundary noise effects resulting from boundary conditions coming into dynamic balance with MM5's algorithms. The larger MM5 domain is designed to sequester such errors from the air quality simulation. The buffer region used here exceeds the EPA suggestion of at least 5 grid cell buffer at each boundary. A similar 6 cell buffer is used around the CAMx boundaries for the 12-km and 4-km domains.

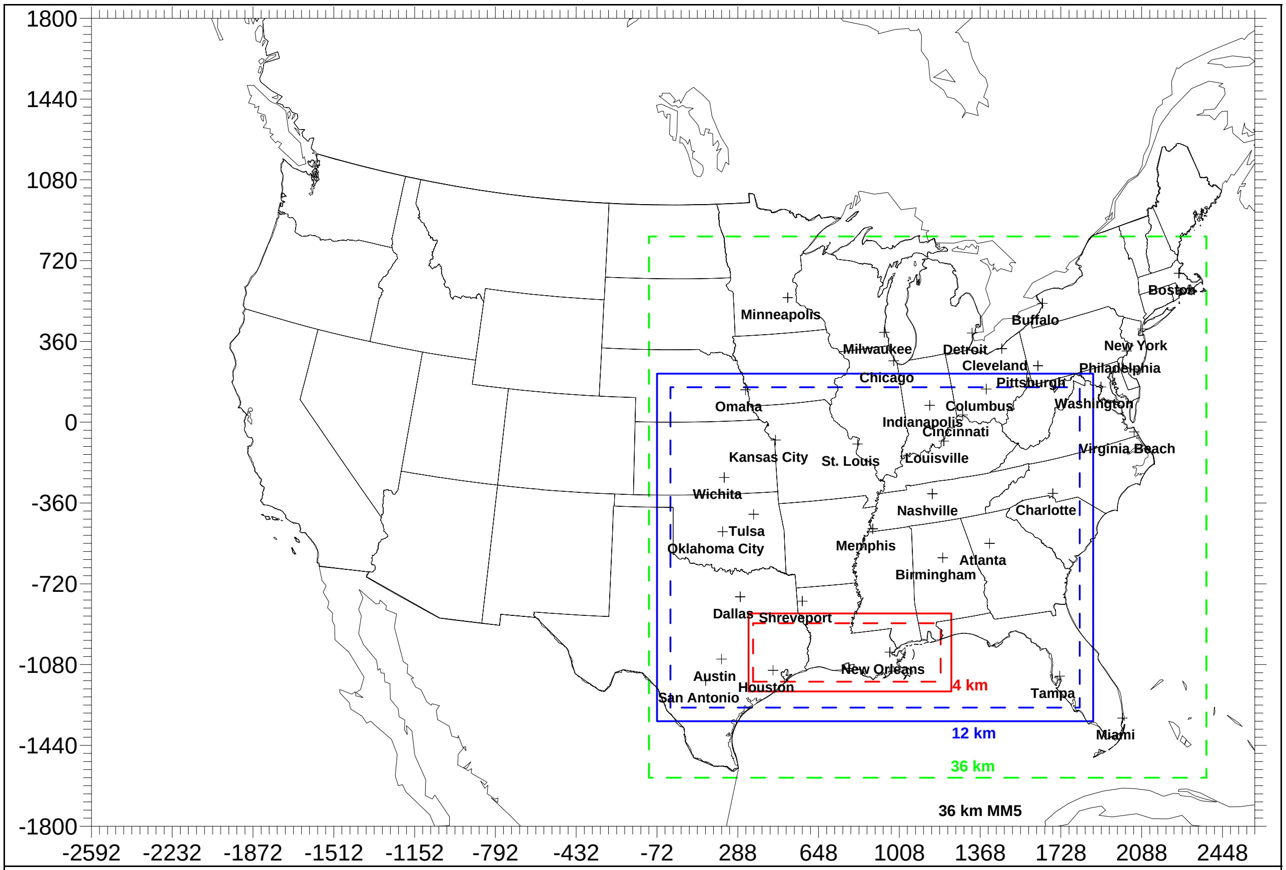


Figure 4-1a. Nested 36/12/4 km modeling domains for the Baton Rouge 8-hour ozone modeling study. Dotted line domains are for CAMx/EPS that are nested in the MM5 solid line domains.

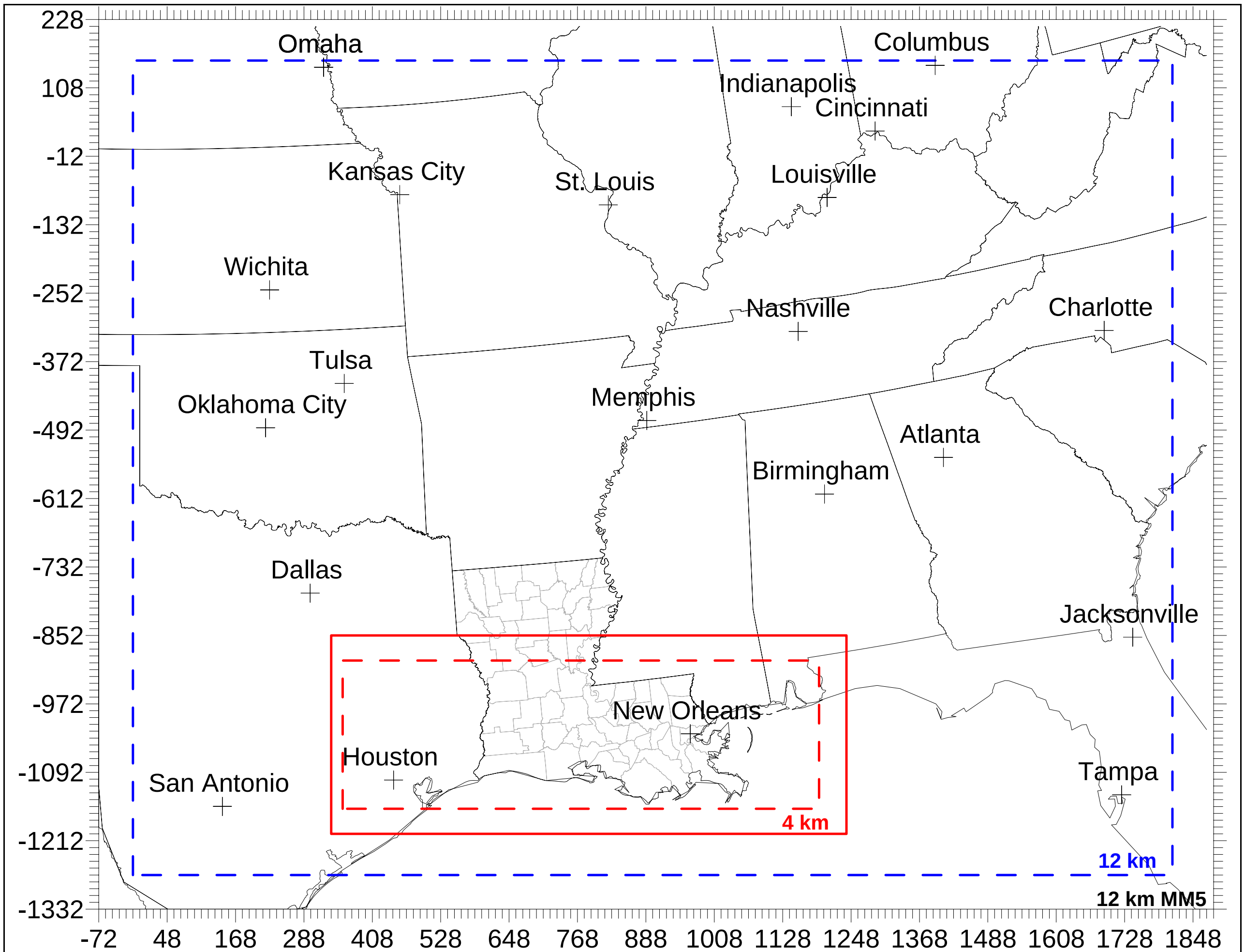


Figure 4-1b. Nested 12/4 km modeling domains for the Baton Rouge 8-hour ozone modeling study. Dotted line domains are for CAMx/EPS that are nested in the MM5 solid line domains.

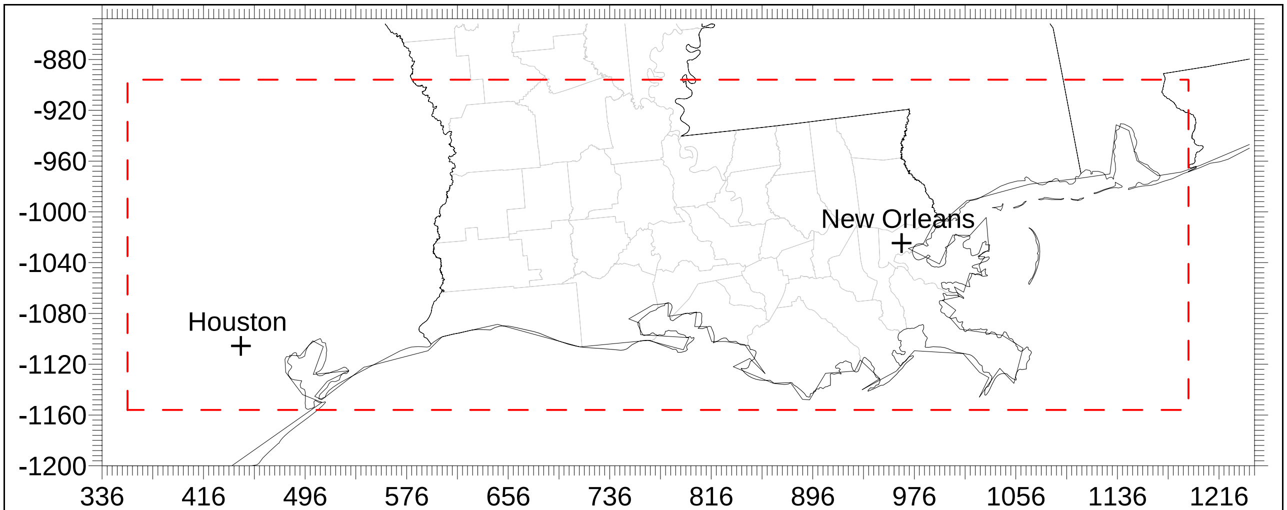


Figure 4-1c. 4-km Louisiana modeling domain for the Baton Rouge 8-hour ozone modeling study. Red dotted line domain is for CAMx/EPS that are nested in the MM5 domain.

Table 4-1. Lambert Conformal Projection (LCP) definition for the Baton Rouge 36/12/4 km modeling grid.

Parameter	Value
Projection	Lambert-Conformal
1st True Latitude	30 degrees N
2nd True Latitude	60 degrees N
Central Longitude	100 degrees W
Central Latitude	40 degrees N

Table 4-2. Grid definitions for MM5, EPS and CAMx.

MODEL	COLUMNS DOT(CROSS)	ROWS DOT(CROSS)	XORIGIN (KM)	YORIGIN (KM)
MM5				
36 km grid	145 (144)	101 (100)	-2592.0	-1800.0
12 km grid	163 (162)	130 (129)	-72.0	-1332.0
4 km grid	227 (226)	88 (87)	336.0	-1200.0
EPS/CAMx				
36 km grid	(69)	(67)	-108.0	-1584.0
12 km grid	(152)	(119)	-12.0	-1272.0
4 km grid	(209)	(65)	356.0	-1156.0

Table 4-2 lists the number of rows and columns and the definition of the X and Y origin (i.e., the southwest corner) for the 36/12/4 km domains to be used by MM5, EPS and CAMx. In Table 4-2 "Dot" refers to the grid mesh defined at the vertices of the grid cells while "Cross" refers to the grid mesh defined by the grid cell centers. Thus, the dimension of the dot mesh is equal to the cross mesh plus one.

4.2 Vertical Modeling Domain

The CAMx vertical structure is primarily defined by the vertical grid used in the MM5 modeling. The MM5 model employs a terrain following coordinate system defined by pressure, using multiple layers that extend from the surface to 100 mb (approximately 15 km AGL). A layer averaging scheme is adopted for CAMx simulations to reduce the air quality computational time. The effects of layer averaging were evaluated by WRAP and VISTAS and found to have a relatively minor effect on the model performance metrics when both 34 layer and 19 layer CMAQ model simulations were compared to ambient monitoring data (Morris et al., 2004a). For the Baton Rouge ozone modeling, 16 vertical layers will be used. Table 4-3 lists the mapping from the MM5 vertical layer structure to the CAMx vertical layers. This MM5 structure was taken from the CENRAP configuration and the CAMx structure is also being used in the St. Louis 8-hour ozone modeling.

Table 4-3. Vertical layer definition for MM5 simulations (left most columns), and approach for reducing CAMx layers by collapsing multiple MM5 layers (right columns). Configuration is based upon the CENRAP visibility and St. Louis 8-hour ozone modeling applications.

MM5					CMAQ/CAMx			
Layer	Sigma	Pres (mb)	Height (m)	Depth (m)	Layer	Pres (mb)	Height (m)	Depth (m)
34 (top)	**0.000**	**100**	**18123**	**2856**	**16**	**100**	**18123**	**7987**
33	0.050	145	15267	2097				
32	0.100	190	13170	1659				
31	0.150	235	11510	1374				
30	**0.200**	**280**	**10136**	**1173**	**15**	**280**	**10136**	**3106**
39	0.250	325	8963	1024				
28	0.300	370	7938	909				
27	**0.350**	**415**	**7030**	**817**	**14**	**415**	**7030**	**2866**
26	0.400	460	6213	742				
25	0.450	505	5471	680				
24	0.500	550	4791	627				
23	**0.550**	**595**	**4163**	**582**	**13**	**595**	**4163**	**1635**
22	0.600	640	3581	543				
21	0.650	685	3038	509				
20	**0.700**	**730**	**2528**	**386**	**12**	**730**	**2528**	**664**
19	0.740	766	2142	278				
18	**0.770**	**793**	**1864**	**269**	**11**	**793**	**1864**	**443**
17	0.800	820	1596	174				
16	**0.820**	**838**	**1421**	**171**	**10**	**838**	**1421**	**338**
15	0.840	856	1251	167				
14	**0.860**	**874**	**1083**	**164**	**9**	**874**	**1083**	**324**
13	0.880	892	920	161				
12	**0.900**	**910**	**759**	**79**	**8**	**910**	**759**	**158**
11	0.910	919	680	78				
10	**0.920**	**928**	**601**	**78**	**7**	**928**	**601**	**155**
9	0.930	937	524	77				
8	**0.940**	**946**	**447**	**76**	**6**	**946**	**447**	**152**
7	0.950	955	371	75				
6	**0.960**	**964**	**295**	**75**	**5**	**964**	**295**	**149**
5	0.970	973	220	74				
4	**0.980**	**982**	**146**	**37**	**4**	**982**	**146**	**37**
3	**0.985**	**987**	**109**	**37**	**3**	**987**	**109**	**37**
2	**0.990**	**991**	**73**	**36**	**2**	**991**	**73**	**36**
1	**0.995**	**996**	**36**	**36**	**1**	**996**	**36**	**36**
0 (ground)	**1.000**	**1000**	**0**	**0**	**0**	**0**	**0**	**0**

4.3 Data Availability

The CAMx modeling systems requires emissions, meteorology, surface characteristics, initial and boundary conditions (IC/BC), and ozone column data for defining the inputs.

4.3.1 Emissions Data

The base year emissions inventory for ozone modeling will be based upon the revised 2002 emissions developed by the CENRAP emission inventory contractor (Strait, Roe and Vukovich, 2004) and by the Texas Commission on Environmental Quality (TCEQ). Emissions for the non-CENRAP states, Mexico and Canada will be based on the latest available inventories that are being used by MRPO, WRAP and VISTAS. These emissions will be augmented by local emissions data for the Baton Rouge 5-Parish area and for Louisiana as available. They will be projected to the base year of the Baton Rouge episodes being modeled. For purposes of air quality model performance evaluation, actual day-specific hourly NOx and SO2 emissions for Electrical Generating Units (EGU) and other large stationary sources that have Continuous Emissions Monitoring (CEM) systems will be used. If appropriate and as data are available, day-specific fire activity data will be also be used in the base case simulations used for model evaluation. For strategy and future year emission runs, "typical year" emissions for these categories will be processed for the base and future years.

As necessary, all emissions will be converted to Area Mobile Source (AMS) and AIRS Facility System (AFS) format and the data will be processed for air quality modeling using Version 3 of the Emissions Processing System (EPS3). Included in these runs will be the temporal and speciation profiles and cross-reference data provided with EPS3, augmented with any recommended and approved emission profile data obtained from EPA, or prepared by the study team prior to initial emissions modeling. Spatial allocation of the emissions will be based on profiles and allocation factors developed for the modeling grid. Additional description of emissions processing is described in Chapter 5 and emissions QA is described in Appendix A.

4.3.2 Air Quality

Data from ambient monitoring networks for gas species are used in the model performance evaluation. Table 4-4 summarizes ambient gaseous and PM monitoring networks.

4.3.3 Ozone Column Data

Additional data used in the air quality modeling include ozone column data from the Total Ozone Mapping Spectrometer (TOMS) satellite platform. TOMS data are available for 24-hour average time periods, and are obtained from http://toms.gsfc.nasa.gov/eptoms/ep.html. The TOMS data are used in the CAMx (TUV) radiation models to calculate photolysis rates. Frequently TOMS ozone column data are missing for extended periods so data needs to be filled. The CAMx TUV processor allows for the use of episode average data. If there are large periods of missing TOMS data during a Baton Rouge modeling episode, then we may use monthly or episode average TOMS data and ignore the missing data.

Table 4-4. Overview of ambient data monitoring networks. The EPA AQS/AIRS and PAMS networks are of particular relevance to the Baton Rouge ozone study.

Monitoring Network	Chemical Species Measured	Sampling Period	Data Availability/Source
The Interagency Monitoring of Protected Visual Environments (**IMPROVE**)	Speciated PM_{25} and PM_{10} (see species mappings)	1 in 3 days; 24 hr average	http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm
Clean Air Status and Trends Network (**CASTNET**)	Speciated PM_{25}, Ozone (see species mappings)	Approximately 1-week average	http://www.epa.gov/castnet/data.html
National Atmospheric Deposition Program (**NADP**)	Wet deposition (hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium)), Mercury	1-week average	http://nadp.sws.uiuc.edu/
Air Quality System (**AQS**) or Aerometric Information Retrieval System (**AIRS**)	CO, NO2, O3, SO2, PM_{25}, PM_{10}, Pb	Typically hourly average	http://www.epa.gov/air/data/
Speciation Trends Network (**STN**)	Speciated PM	24-hour average	http://www.epa.gov/ttn/amtic/amticpm.html
Southeastern Aerosol Research and Characterization (**SEARCH**) (Southeastern US only)	24-hr PM25 (FRM Mass, OC, BC, SO4, NO3, NH4, Elem.); 24-hr PM coarse (SO4, NO3, NH4, elements); Hourly $PM_{2.5}$ (Mass, SO4, NO3, NH4, EC, TC); Hourly gases (O3, NO, NO2, NOy, HNO3, SO2, CO)	Hourly or 24-hour average, depending on parameter.	Electric Power Research Institute (EPRI), Southern Company, and other companies. http://www.atmospheric-research.com
EPA Particulate Matter Supersites(Includes St. Louis, Pittsburgh, Baltimore, Atlanta and New York in the Baton Rouge modeling domain)	Speciated PM25		http://www.epa.gov/ttn/amtic/supersites.html
Photochemical Assessment Monitoring Stations (**PAMS**)	Varies for each of 4 station types.		http://www.epa.gov/ttn/amtic/pamsmain.html
National Park Service Gaseous Pollutant Monitoring Network	Acid deposition (Dry; SO4, NO3, HNO3, NH4, SO2), O3, meteorological data	Hourly	http://www2.nature.nps.gov/ard/gas/netdata1.htm

4.3.4 Meteorological Data

Meteorological data are being generated using the MM5 prognostic meteorological model. Episodic MM5 runs will be performed on the 36/12/4 km domains. Initialization days prior to the Baton Rouge episode will be run on the 36-km grid for 10 days, 12-km grid for 3 days and 4-km grid for 1 day prior to the start of the Baton Rouge ozone episodes. The MM5 model will be started approximately 12 hours prior to the first hour that the data will be used by CAMx/EPS.

4.3.5 Initial and Boundary Conditions Data

For the Baton Rouge ozone simulations we will use a 10-day initialization period on the 36-km grid to eliminate the contribution of initial concentrations. Clean initial conditions (ICs) will be used at the start of the 10-day initialization period. CAMx boundary conditions (BCs) will be based on results from the 2002 CENRAP base case simulation, processed to diurnally-varying monthly averages.

5.0 MODEL INPUT PREPARATION PROCEDURES

This section describes the procedures to be used in developing the meteorological, emissions, and air quality inputs to the CAMx model for the Baton Rouge 8-hour ozone modeling episodes on the 36/12/4 km grids. The development of the CAMx meteorological and emissions inputs are discussed together with the science options recommended for MM5 and CAMx models. The procedures for developing the initial and boundary conditions and photolysis rates inputs are also discussed along with the model application procedures.

The procedures set forth here are consistent with EPA guidance (e.g., EPA, 1991; 1999; 2005a), other recent 8-hour ozone modeling studies conducted for various State and local agencies using these or other state-of-science modeling tools (see, for example, Tesche et al., 2003a,b,c; Morris et al., 2004a,b; Tesche et al., 2005a), as well as the methods used by EPA in support of the recent Clean Air Interstate Rule (EPA, 2005b) and the Clean Air Mercury Rule (EPA, 2005c).

5.1 Meteorological Inputs

5.1.1 MM5 Model Science Configuration

The MM5 model configuration will be based on recent modeling research and sensitivity testing carried out with the MM5 in Texas (Byun et al., 2005a,b), work at the Iowa Department of Natural Resources (Johnson, 2004), Olerud and co-workers with the VISTAS program (Olerud and Sims, 2004, Abraczinskas et al., 2004), WRAP MM5 modeling (Kemball-Cook et al., 2004) and MM5 modeling to support 8-hour ozone EAC SIP development in Texas, Oklahoma, New Mexico and Colorado (see Table 5-1 for additional details),.

5.1.2 MM5 Input Data Preparation Procedures

A brief summary of the MM5 input data preparation procedures we will use are listed below and provided in Table 5-1.

Model Selection: The current version of the non-hydrostatic MM5 (version 3.7) will be used. The MM5 TERRAIN, PREGRID/REGRID, RAWINS/little_r, and INTERPF processors will be used to develop model inputs.

Horizontal Domain Definition: The computational domain on which MM5 will be applied will be sufficiently sized to accommodate the air quality and emissions modeling grids as defined in Figure 4-1 and Tables 4-1 and 4-2. The MM5 36/12/4 km domains are defined with a 6 grid cell buffer in all directions from the air quality modeling domains.

Vertical Domain Definition: The MM5 modeling will employ 34 vertical layers with an approximately 36 meter deep surface layer, based upon the configuration used in the CENRAP modeling. The MM5 vertical domain is presented in both sigma and height coordinates in Table 4-3.

Topographic Inputs: Topographic information for the MM5 will be developed using the NCAR and the U.S. Geological Survey (USGS) terrain databases. The 36-km grid will be

Table 5-1. MM5 (Version 3.7) model configuration.

Science Options	Configuration	Details
Model Code	MM5 version 3.7 (MPP) -- 23 Dec '04 Release	Dudhia (1993), Grell et al., (1994)
Horizontal Grid Mesh	36/12/4 km	
36 km grid	145 x 101 cells	Cross Points (add one for dot points)
12 km grid	163 x 130 cells	
4 km grid	227 x 88 cells	
Vertical Grid Mesh	34 Layers; Surface layer ~ 35 m deep	Vertically varying; sigma pressure coordinate
Domain Depth	Surface to ~15 km AGL	Top defined by 100 mb
Grid Interaction	Feedback	Two-way nesting with feedback
Initialization	EDAS	Eta Data Assimilation System
Boundary Conditions	EDAS	40 km resolution
Microphysics	Mixed Phase Moisture Scheme	Reisner II in 36/12/4 km grids
Cumulus Scheme	Kain-Fritsch 2 subgrid scale cumulus	36/12 km grids only
Planetary Boundary Layer	ACM	Asymmetric Convective Mixing with PX LSM
Radiation	RRTM	Rapid Radiative Transfer Model
Vegetation & Land Use	USGS	24 Category Scheme
36 km grid	10 min (~18 km) global data	Geophysical Data Center
12 km grid	5 min (~9 km) global data	Geophysical Data Center
4 km grid	High-Resolution (30 sec)	NCAR
Land Surface Model	Pleim-Xiu LSM (ISOIL = 3)	Soil moisture from EDAS fields, not PX module
Topographic Input		
36/12/4 km grid	Updated NCAR/PSU data bases	Supplied with MM5
Shallow Convection	None	
Sea Surface Temperature	EDAS skin temperature	Spatially varying
4D Data Assimilation		
36 km grid	Analysis nudging wind, temp and moisture above PBL, only wind below PBL	Wind, temp coeff = 2.5x10-4; mixing ratio coeff = 1x10-5
12 km grid	Analysis nudging wind, temp and moisture above PBL, only wind below PBL	Wind, temp coeff = 2.5x10-4; mixing ratio coeff = 1x10-5
4 km grid	Analysis nudging wind, temp and moisture above PBL, only wind below PBL. Surface wind observation nudging.	Wind, temp coeff = 2.5x10-4; mixing ratio coeff = 1x10-5
Spin-up	Spin-up time typically ~12 hrs	Spin-up prior to ozone episode simulation

based the 10 min (~18 km) Geophysical Data Center global data. The 12-km grid will be developed from the 5 min (~9 km) Geophysical Data Center global data, whereas the 4-km terrain heights will be based on 30 second data (~1 km resolution). Terrain data will be interpolated to the model grid using the TERRAIN pre-processor.

Vegetation Type and Land Use Inputs: Vegetation type and land use information will be developed for the 36/12/4 km grids using the most recently released NCAR/PSU databases provided with the MM5 distribution. Standard MM5 surface characteristics corresponding to each land use category will be employed.

Atmospheric Data Inputs: Initialization, boundary conditions and FDDA nudging fields will be based on the 40 km Eta Data Assimilation System (EDAS) fields.

Water Temperature Inputs: The EDAS "skin temperature" field will be used for water temperature inputs.

FDDA Data Assimilation: Standard FDDA data assimilation techniques will be used in this study (see, for example, Byun et al., 2005a; Nielson-Gammon et al., 2005; Olerud and Simms, 2004a,b;and Gao et al., 2000; Kemball-Cook et al., 2005). The MM5 simulations will use the three-dimensional analysis-nudging technique where the predictions are nudged toward a field prepared by regridding the EDAS. For these simulations a nudging coefficient of 2.5×10^{-4} will be used for winds and temperature and 1×10^{-5} for mixing ratio on the 36/12/4 km grids. Thermodynamic variables will *not* be nudged within the boundary layer (i.e., only winds will be nudged within the PBL). In the 4-km grid, surface observation nudging will be performed for winds.

Physics Options: The MM5 model physics to be used in the MM5 simulations will be as follows:

- Kain Fritsch II cumulus parameterization;
- ACM PBL that is compatible with the PX LSM;
- Plein-Xiu (P-X) Land Surface Model;
- Reisner II Mixed Ice Moisture Scheme; and
- RRTM Atmospheric Radiation Scheme.

Sensitivity tests will be conducted to evaluate alternative MM5 physics options for one or more of the Baton Rouge episodes. For example, the Eta PBL and NOAH/OSU LSM schemes will be evaluated as an alternative to the PX/ACM LSM/PBL scheme.

5.1.3 MM5CAMx Reformatting Methodology

The MM5CAMx processor maps MM5 meteorological fields to the format required by CAMx. It also calculates turbulent vertical exchange coefficients (Kz) that define the rate and depth of vertical mixing in CAMx. Steps in the MM5CAMx processing include:

- Reading in meteorological model output files;
- Extracting meteorological data for CAMx domain;

- Collapsing meteorological data if coarser vertical resolution data is requested in CAMx than used in MM5;
- Computing vertical diffusivities (Kz) using three options available to the user;

When feasible it is desirable to use the same layer structure in the air quality model as in the MM5 to prevent errors associated with averaging layer data, and to maintain consistency between data produced by the meteorological model and those used by the chemistry-transport model. However, vertical layer collapsing is typically used to reduce computational costs associated with using large number of vertical layers. Further details on the CAMx modeling domain definitions were provided in Chapter 4 (Table 4-3).

Two sets of vertical turbulent diffusivity options will be invoked in MM5CAMx from the MM5 ACM/P-X runs: (a) the O'Brien scheme (OB70), and (b) the CMAQ scheme. A third option (the TKE method) could also be invoked for the MM5 Eta run. MM5CAMx will be operated initially with a 0.1 m^2/s minimum K_V (Kz_min) value.

5.1.4 Treatment of Minimum K_V

The minimum K_V value (Kz_min) is an area of ongoing investigation by the CAMx model developers and the scientific user community (e.g., CMAQ developers). EPA initially recommended a 1.0 m^2/s Kz_min for CMAQ modeling. However in their ozone forecasting, EPA uses Kz_min values of 0.1 to 2.0 m^2/s depending on the amount of urban land use present. To maximize flexibility we will process the MM5 data using MM5CAMx using a 0.1 m^2/s Kz_min and then test other Kz_min values (e.g., 1.0 m^2/s). The CAMx modeling system contains a utility that produces enhanced minimum Kz (Kz_min) values near the surface to account for increased mixing due to roughness and the urban heat island. The selection of the Kz profiles (O'Brien or CMAQ) and Kz_min approach will be based on the latest thinking, CAMx sensitivity tests and model performance.

5.2 Emission Inputs

5.2.1 Available Emissions Inventory Datasets

The emissions inventories developed for the Baton Rouge 8-hour ozone modeling study will be based on the latest 2002 emissions database, as updated by States and the RPOs, augmented by local emission inventories for the Baton Rouge area, local traffic demand model (TDM) output for on-road mobile sources in Baton Rouge, and day-specific emissions for sources with Continuous Emissions Monitoring (CEM) systems (e.g., Electrical Generating Units, EGUs). The year 2002 is the latest emissions year with complete emissions inventories for all states.

The base year emissions inventory for the Baton Rouge ozone modeling will be derived from the revised 2002 base case emissions developed by CENRAP emission inventory (EI) contractors (Strait, Roe and Vukovich, 2004). Non-CENRAP state emissions will be based on inventories supplied by the other RPOs (e.g., MRPO and VISTAS) that were developed to be representative of the 2002 year. These emissions will be projected to the base year of the various Baton Rouge ozone episodes (see Chapter 3).

Local emissions within the 5-Parish Baton Rouge area will be updated with data from local sources as available. Link-based Vehicle Miles Traveled (VMT) data will be used along with the EPA MOBILE6 model to generate on-road mobile source emissions within the Baton Rouge area.

Biogenic emissions will be day-specific and based the MM5 model-derived temperatures using the GloBEIS biogenic emissions model. MM5 temperature fields will be reviewed and statistically analyzed for the presence of any daytime temperature bias. If a significant bias exists that cannot be removed through any re-configuration of the model, an alternative means of providing gridded temperature fields from observational analyses will be developed.

For model evaluation, day-specific hourly CEM emissions will be used for large stationary source point sources where available (e.g., EGUs). For the base year projection inventory and future year emission runs, "typical year" emissions for these large stationary sources will be processed.

These emissions will be converted to the Area Mobile Sources (AMS) and AIRS Facility System (AFS) formats used by the EPS emissions model.

5.2.2 Development of CAMx-Ready Episodic Emissions Inventories

CAMx-ready emissions will be generated by the EPS3 suite of programs. Table 5-2 summarizes the EPS3 configuration to be used.

Emissions inventory development for episodic 8-hour ozone modeling must address several source categories including: (a) stationary point sources, (b) area sources, (c) on-road mobile sources, (d) non-road mobile sources, and (e) biogenic sources. For this analysis, these estimates must be developed to support the episodes being modeled (see Chapter 3).

Development of an emissions inventory customized for the Baton Rouge 5-Parish area requires a merging of: (a) the most recent *pertinent* regional inventory and (b) available high-resolution, locale-specific emissions estimated by local, state, and regional agencies in the region. Local air regulatory and transportation planning agencies are generally the best sources of domain-specific activity and control factors to use in developing the base year emissions. Often, these local emissions data sets come from a variety of sources, frequently in different formats. Contacts with CENRAP's emission inventory contractors, other RPOs, and the U.S. EPA will be established and formal requests made for inventory corrections, updates and ancillary data pertinent to the modeling of emissions in their jurisdictions. Where feasible these updated emissions data sets will be acquired and will be used to create day-specific modeling inventories for the Baton Rouge area for each of the ozone episodes to be modeled.

CAMx requires two emission input files: (1) low level gridded emissions that are emitted directly into the first layer of the model from sources at the surface with little or no plume rise; and (2) elevated point sources (stacks) with plume rise calculated from stack parameters and meteorological conditions. Hour emissions are required for NO, NO2, CO, several classes of VOCs and other pollutants as available. The VOC classes used will depend upon the chemical mechanism selected. Although the CB4 chemical mechanism has been used in most recent 8-hour ozone EAC SIPs and by the RPOs for their regional modeling, indications from the HGB modeling suggest that the effects of HRVOC emissions on ozone formation may be better simulated using the SPARC chemical

Table 5-2. EPS (Version 3) configuration.

Emissions Component	Configuration	Details
Model Code	EPS Version 3	
Horizontal Grid Mesh	36/12/4 km	
36 km grid	69 x 67 cells	
12 km grid	152 x 119 cells	
4 km grid	209 x 65	
Area Source Emissions	CENRAP/VISTAS/MRPO/LDEQ	
On-Road Mobile Sources	CENRAP/VISTAS/MRPO/LDEQ Baton Rouge TDM, MOBILE6	
Point Sources	CENRAP/VISTAS/MRPO/LDEQ CEM day-specific for EGUs	
Off-Road Mobile Sources	CENRAP/VISTAS/MRPO/LDEQ EPA NONROAD model	
Emissions Data Sources		
	2002 Base B CENRAP States	
	2002 Base K MRPO States	
	2002 Base G VISTAS States	
	2002 TDM VMT for BTR	
	2002-2005 LDEQ Data	
Biogenic Sources	GloBEIS	
Temporal Adjustments	Seasonal, day, hour	Based on latest collected information
Chemical Speciation	Revised CB4 Chemical Speciation SAPRC Speciation (optional)	EPA study
Gridding	Spatial Surrogates based on landuse	
Growth and Controls	TBD	
Quality Assurance	QA Tools in EPS; PAVE plots	

mechanism. Given that HRVOC emissions may also be important for many of the Baton Rouge ozone exceedance days, use of the SAPRC chemical mechanism will be considered.

5.2.2.1 Episodic On-Road Mobile Source Emissions

The inputs needed to perform on-road mobile sources modeling for the Baton Rouge episodes on the 36/12/4 km grids include the county-level vehicle miles traveled (VMT) for the entire modeling domain (36-km grid) and the link-based VMT for the urbanized portion of the Baton Rouge area. In addition to the link-based VMT data, GIS-based data specifying the locations of the links from transportation modeling will be required. Vehicle class-specific speciation and temporal profiles will be taken from EPS3 default files, unless additional information can be accessed for this study.

As noted previously, much of the data necessary for this task are currently available from the Regional Planning Organizations (RPOs). County-level VMT and MOBILE6 input files are available for the CENRAP, WRAP, VISTAS and Midwest RPO (MRPO). The starting point for the on-road mobile source emissions modeling would be the most current CENRAP mobile source emissions inventory. The VMT data for the regional grids (36 and 12 km) would be projected to the base year(s) of the Baton Rouge episodes.

For the finer scale 4-km grid, link-based VMT data from a TDM will be used along with the EPA MOBILE6 model and MM5 temperatures to generate gridded day-specific on-road mobile source emissions. Again, if a significant temperature bias exists that cannot be removed through any re-configuration of MM5, an alternative means of providing gridded temperature fields from observational analyses will be developed. Whereas the on-network emissions estimates are spatially allocated based on link location and subsequently summed to the grid cell level, the off-network emissions estimates are spatially allocated based on a combination of the FHWA version 2.0 highway networks and population. For the Baton Rouge 36/12 km modeling, no link-based data will be used.

The EPA MOBILE6, interfaced with EPS3, will be used to develop the base year on-road mobile source emissions estimates for CO, NOx, PM, and VOC emissions. The MOBILE6 parameters, vehicle fleet descriptions, and VMT estimates will be combined with gridded, episode-specific temperature data to calculate the gridded, temporal emission estimates. The MOBILE6 emissions factors are based on episode-specific temperatures predicted by the meteorological model. Further, the MOBILE6 emissions factors model accounts for the following:

- Weekly average minimum/maximum temperatures;
- Facility speeds;
- Locale-specific inspection/maintenance (I/M) control programs, if any;
- Adjustments for running losses;
- Splitting of evaporative and exhaust emissions into separate source categories;
- VMT, fleet turnover, and changes in fuel composition and Reid vapor pressure (RVP).

The primary input to MOBILE6 is the MOBILE shell file. The MOBILE shell contains the various options (e.g. type of inspection and maintenance program in effect, type of oxygenated fuel program in effect, alternative vehicle mix profiles, RVP of in-use fuel, operating mode) that direct the calculation of the MOBILE6 emissions factors.

5.2.2.2 Episodic Biogenic Source Emissions

Biogenic emissions will be generated using the GloBEIS biogenic emissions model. GloBEIS uses high resolution GIS data on plant types and biomass loadings, MM5 or objectively-analyzed surface temperature fields, and solar radiation (modeled or satellite-derived) to develop hourly emissions for biogenic species on the 36/12/4 km grids. GloBEIS generates gridded, speciated, temporally allocated emission files.

5.2.2.3 Point Source Emissions

Point source emissions will be taken from the 2002 RPO database updated with any local information for the Baton Rouge area. These emissions will be projected to the base year of the Baton Rouge episode as needed. The locations of the point sources will be converted to the LCP coordinate system used in the modeling. They will be processed by EPS to generate the temporally varying (i.e., day-of-week and hour-of-day) speciated emissions needed by CAMx, using standard EPS default profiles by source category.

For large point sources with CEM data, the hourly CEM data for the episode periods will be processed and used as input for the current year actual base case simulations. However, for the ozone projections we will use the average current year emissions from these sources.

5.2.2.4 Area and Non-Road Source Emissions

County level area source emissions will be taken from the RPO 2002 emissions inventory augmented with any local data and projected tom the Baton Rouge episode years(s). The area sources will be spatial allocated to the grid using an appropriate surrogate distribution (e.g., population for home heating, etc.). The area sources will be temporally allocated by month and by hour of day using the EPS default source-specific temporal allocation factors. Non-road mobile source emissions will be calculated using EPA's NONROAD model to generate county-level emissions. Local data regarding equipment usage will be used to update the data in the NONROAD model as available. The non-road mobile source emissions will be spatially allocated to the grid using an appropriate surrogate distribution (airport locations for aircraft and airport related emissions, railways for locomotive emissions, agricultural land use category for agricultural equipment, etc.). The EPS source-specific temporal and speciation allocation profiles will be used.

5.2.2.5 Wildfires, Prescribed Burns, Agricultural Burns

If there are indications of any fires present near the Baton Rouge area, or within the south-central U.S., during any of the episodes they will be accounted for in the model as information is available.

5.2.2.6 QA/QC and Emissions Merging

The emissions will be processed by major source category in several different "streams", including area sources, on-road mobile sources, non-road mobile sources, biogenic sources, non-CEM point sources, CEM sources using day-specific hourly emissions, CEM sources using average emissions and, as available, emissions from fires. Separate Quality Assurance (QA) and Quality Control (QC) will be performed for each stream of emissions processing and in each step. EPS3 includes advanced quality assurance features that includes error logs when emissions are dropped or added. In addition, we will generate visual displays that include:

- Spatial plots of the hourly emissions for each major species (e.g., NOx, VOC, some speciated VOC and CO);
- Vertical average emissions plots for major species and each of the grids;
- Diurnal plots of total emissions by major species; and
- Summary tables of emissions for major species for each grid and by major source category.

This QA information will be examined against the original point and area source data and summarized in an overall QA/QC assessment.

Scripts to perform the emissions merging of the appropriate biogenic, on-road, non-road, area, low-level, fire, and point emission files will be written to generate the CAMx-ready two-dimensional day-specific hourly speciated gridded emission inputs. The point source and, as available elevated fire, emissions would be processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

The resultant CAMx model-ready emissions will be subjected to a final QA using spatial maps, vertical plots and diurnal plots to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

5.2.3 Use of the Plume-in-Grid (PiG) Subgrid-Scale Plume Treatment

The Plume-in-Grid (PiG) sub-model treats the early plume chemistry and dynamics of emissions from point sources and then releases the emissions into the grid model farther downwind at such time that the plume is adequately resolved by the grid. There are currently two PiG options in the CAMx model:

- GREASD PiG: treats the early plume dynamics and inorganic NOx chemistry, and releases the emissions from the PiG to the grid model when organic chemistry starts being important; and
- IRON PiG: treats the full CB4 or SAPRC chemistry at all downwind distances.

The GREASD PiG was designed for large NOx point source plumes, where the early evolution of the plume is dominated by NOx and inorganic chemistry. Because of the high NOx in these plumes, the mass they carry are typically released to the grid model at the time that organic chemistry becomes important.

The IRON PiG uses full chemistry and is appropriate for both NOx and VOC plumes. If the PiG is to be used for HRVOC emissions, then the IRON PiG would be the appropriate choice. Currently the CAMx model can only use one PiG module in each run (i.e., it cannot run point source X with GREASD PiG and point source Y with IRON PiG in the same run).

Large NOx plumes, and potentially HRVOC sources as characterized in the inventory, will be selected for treatment by the subgrid-scale PiG module. The selection of which sources to be treated by the PiG module will be made after a review of the inventory. Tests will likely be conducted to determine the sensitivity of the ozone estimates in the Baton Rouge area to the use of the different PiG modules, as well as use of ultra-high resolution (~1 km) flexi-nests applied over the locations of HRVOC sources.

5.2.4 Products of the Emissions Inventory Development Process

In addition to the CAMx-ready input files generated for each hour of all days modeled in the Baton Rouge episodes, a number of quality assurance (QA) files will be prepared and used to check for gross errors in the emissions inputs. Importing the model-ready emissions into PAVE and looking at both the spatial and temporal distribution of the emission provides insight into the quality and accuracy of the emissions inputs.

- Visualizing the model-ready emissions with the scale of the plots set to a very low value, we can determine whether there are areas omitted from the raw inventory or if emissions sources are erroneously located in water cells;
- Spot-checking the holiday emissions files to confirm that they are temporally allocated like Sundays;
- Producing pie charts emission summaries that highlight the contribution of each emissions source component (e.g. nonroad mobile);
- Normalizing the emissions by population for each state will illustrate where the inventories may be deficient and provide a reality check of the inventories.

State inventory summaries prepared prior to the emissions processing will be used to compare against EPS output report totals generated after each major step of the emissions generation process. To check the chemical speciation of the emissions to CB-IV and/or SAPRC species, we will compare reports generated with EPS to target these specific areas of the processing. For speciation, the inventory state import totals will be compared against the same state totals with the speciation matrix applied. These reports will be generated for a representative weekday in each of the episodes for each of these selected states.

The quantitative QA analyses often reveal significant deficiencies in the input data or the model setup. It may become necessary to tailor these procedures to track down the source of each major problem. As such, one can only outline the basic quantitative QA steps that we will perform in an attempt to reveal the underlying problems with the inventories or processing. Following are some of the reports that may be generated to review the processed emissions:

- State and county inventory totals for each source category.
- State and county totals after spatial allocation for each source category.
- State and county totals by day after temporal allocation for each source category for representative days.
- State and county totals by model species after chemical speciation for each source category.
- State and county model-ready totals (after spatial allocation, temporal allocation, and chemical speciation) for each source category and for all source categories combined.
- If elevated source selection is chosen by user, the report indicating which sources have been selected as elevated and plume-in-grid will be included.
- Totals by source category code (SCC) from the inventory for area, mobile, and point sources.

- Totals by state and SCC from the inventory for area, mobile, and point sources.
- Totals by county and SCC from the inventory for area, mobile, and point sources.
- Totals by SCC and spatial surrogates code for area and mobile sources.
- Totals by speciation profile code for area, mobile, and point sources.
- Totals by speciation profile code and SCC for area, mobile, and point sources.
- Totals by monthly temporal profile code for area, mobile, and point sources.
- Totals by monthly temporal profile code and SCC for area, mobile, and point sources.
- Totals by weekly temporal profile code for area, mobile, and point sources.
- Totals by weekly temporal profile code and SCC for area, mobile, and point sources.
- Totals by diurnal temporal profile code for area, mobile, and point sources.
- Totals by diurnal temporal profile code and SCC for area, mobile, and point sources.
- PAVE plots of gridded inventory pollutants for all pollutants for area, mobile, and point sources.

5.2.5 Future-Year Emissions Modeling

Future-year emission inputs will be generated by EPS by projecting the current year (e.g., 2002) inventory using growth and control factors. Because of the unusual nature of growth in Baton Rouge due to Hurricane Katrina (doubled population in a year), standard growth assumptions may not be applicable. This is an area that will be studied in more detail as the Baton Rouge 8-hour ozone study progresses.

5.3 Photochemical Modeling Inputs

5.3.1 CAMx Science Configuration and Input Configuration

This section describes the model configuration and science options to be used in the Baton Rouge 8-hour ozone modeling effort. Table 5-3 summarizes the CAMx configuration to be used. The latest version of CAMx (either v4.31 or v4.40) will be used in the Baton Rouge modeling.

As indicated in the CAMx model setup defined in Table 5-3, three grids will be employed in which 12- and 4-km nests will be introduced into the simulation over the 10-day spinup period prior to the first day of each episode (see below). All grids will be run together in 2-way interactive mode (as opposed to 1-way mode as employed in CMAQ). The PPM advection solver will be used along with the spatially varying (Smagorinsky) horizontal diffusion approach. K-theory will be used for vertical diffusion.

Initially, the CB-IV gas-phase chemical mechanism is selected because it has been widely used by most recent 8-hour ozone EAC SIPs as well as by the RPOs (e.g., CENRAP, MRPO, VISTAS, etc.). However, recent modeling in the Houston Galveston Brazoria (HGB) area has indicated that a better representation of the effects of HRVOC emissions may be obtained using the SAPRC99 chemical mechanism. Thus, the modeling team will also evaluate the suitability and advantages of modeling using the SAPRC chemistry.

Meteorological Inputs: The MM5-derived meteorological fields will be prepared CAMx using MM5CAMx. Several alternative vertical diffusivity options will be generated for CAMx input and evaluated in sensitivity tests, as described earlier.

Initial/Boundary Conditions: The initial and boundary conditions will be derived from the CENRAP RPO regional modeling for the calendar year 2002 on the RPO continental US 36-km grid. For Baton Rouge episodes from 2002, the CAMx initial concentrations (ICs) and boundary conditions (BCs) would be day-specific and hourly from the CENRAP 2002 Base Case CAMx simulation. For Baton Rouge episodes outside of the 2002 year, monthly average diurnal profiles would be constructed.

Photolysis Rates: The modeling team will prepare the photolysis inputs as well as albedo/haze/ozone/snow inputs for CAMx based on Total Ozone Mapping Spectrometer (TOMS) data. For CAMx the TUV processor will be used. If there are periods of more than a couple of days where daily TOMS data are unavailable, monthly average TOMS data will be used.

Landuse: The team will generate landuse fields based on USGS GIRAS data using tools provided by the LDEQ contractors.

Spin-Up Initialization: RPO modeling for large 36-km domains, like that proposed for the Baton Rouge modeling, has shown that 10-15 days of spin up is needed to eliminate the influences of initial concentrations. For the Baton Rouge episodes we also proposed to use 10 days of spin up for the 36-km domain, invoking the higher resolution grids near the start of the ozone episodes as follows:

- 36 km grid: 10 days of initialization;
- 36/12 km grid: 3 days of initialization;
- 36/12/4 km grid: 1 day of initialization.

Table 5-3. CAMx (Version 4.3 or 4.4) model configuration.

Science Options	Configuration	Details
Model Code	CAMx (v4.31) – April 2006 Release	see: www.camx.com; potentially v4.40
Horizontal Grid Mesh	36/12/4 km	
36 km grid	69 x 67 cells	
12 km grid	152 x 119 cells	
4 km grid	209 x 65	
Vertical Grid Mesh	16 vertical layers, defined by MM5	Layer 1 thickness ~ 35 m
Grid Interaction	Two-way nesting	
Initial Conditions	Default – 10 day spin-up on 36 km grid	Clean EPA default conditions
Boundary Conditions	Hourly day-specific for 2002 episodes; monthly average diurnally varying for other years	Based on CENRAP 2002 Base Case simulation
Emissions		
Baseline Emissions Processing	EPS3	
Sub-grid-scale Plumes	Plume-in-Grid for major NOx sources and potentially HRVOC sources	GREASD-PiG NOx chemistry plume model, IRON-PiG full chemistry plume model
Chemistry		
Gas Phase Chemistry	CBM-IV with isoprene and NOx updates SAPRC chemistry as option	Gery et al., (1989). Includes re-nitrification reactions
Meteorological Processor	MM5CAMx	Compatible with CAMx v4.3
Horizontal Diffusion	Spatially varying	K-theory with Kh grid size dependence
Vertical Diffusion	Kv (O'Brien '70, CMAQ, TKE methods)	Sensitivity tests to Kz methods
Diffusivity Lower Limit	Kz-min = 0.1 to 1.0 m^2/s	Run MM5CAMx with Kz_min = 0.1 m^2/s; sensitivity tests for Kz_min
Deposition Schemes		
Dry Deposition	Wesley resistance scheme	Wesley (1989)
Wet Deposition	CAMx-specific formulation	rain/snow/graupel
Numerics		
Gas Phase Chemistry Solver	Chemical Mechanism Compiler-- Fast Solver	ENVIRON (2004)
Vertical Advection Scheme	Fully implicit scheme	
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	
Integration Time Step	Wind speed dependent	~0.5-1 min (4-km), 1-5 min (12-km), 5-15 min (36-km)

6.0 OZONE MODEL PERFORMANCE EVALUATION

This chapter describes the model performance evaluation from which to establish reliable CAMx 8-hour ozone modeling for the Baton Rouge 5-Parish area. In general terms, this process consists of the following cycle:

- Exercise the modeling system for the base case, attempting to replicate the time and space behavior of the observed 1-hour and 8-hour ozone concentration fields as well as concentrations of precursor and product species;
- Evaluate the model's fidelity in simulating ozone and precursor/product species using a two-step process consisting of: (a) an initial "screening model performance evaluation" (SMPE) process, and if the modeling results pass the screening analysis, (b) a "refined model performance evaluation" (RMPE) consisting of progressively more stressful testing procedures involving multi-species, multi-scale surface and aloft model performance evaluation (MPE);
- Identify sources of error and/or compensating biases, through evaluation of preprocessor models (MM5, EPS), air quality model inputs, concentrations aloft, mass budgets and conservation, process analysis, etc;
- Through a documented process of diagnostic and sensitivity investigation, pinpoint and correct the performance problems via model refinement, additional data collection and/or analysis, or theoretical considerations;
- Re-run the model for the base case and re-evaluate performance until adequate, justifiable performance is achieved, or time and/or resources are expended, or the episode is declared unsuited for further use based on documented performance problems.

To an extent, some or all of these steps will be taken by the LDEQ modeling team for each of the Baton Rouge ozone episodes, ideally culminating in a suite of episodes demonstrated to exhibit sufficiently minimal bias and error that they may be used reliably to evaluate 8-hour ozone control strategies and to perform an 8-hour ozone attainment demonstration. In the following subsection, we briefly identify the steps that will be taken by the LDEQ modeling team in constructing and evaluating the CAMx base cases for 8-hour ozone SIP development in Baton Rouge.

6.1 Establishing Base Case CAMx Simulations for Baton Rouge Episodes

6.1.1 Setting Up and Exercising CAMx Base Cases

The LDEQ modeling team will select the final model configurations for the CAMx base case simulations for each episode (see Chapter 5). The modeling team will define the recommended final model configurations based on results from the initial configuration (see Tables 5-1 through 5-4) and the following factors:

- Model performance obtained using the initial model configurations and input data;
- Model performance for base case sensitivity tests;
- The modeling team's knowledge of the CAMx model configurations and associated attributes;

- Experience performing sensitivity tests and model performance evaluation for CENRAP, VISTAS, MRPO, WRAP and numerous other studies including ozone SIP and EAC studies; and
- Comments from EPA and other participants.

The objective in identifying optimum model configurations is to obtain the best performance for the right reasons consistent with sound science and EPA guidance. Sometimes, decisions must be made that trade off better/poorer model performance for one pollutant against another, or for one episode against another. These factors will be considered and potential issues discussed among the LDEQ modeling team, EPA and others. Based on the analysis and comments from EPA and other interested parties, the LDEQ modeling team will select the final ozone model configurations.

6.1.2 Use of Sensitivity, Source Apportionment, and Related Diagnostic Probing Tools

The Baton Rouge ozone study may utilize several diagnostic and probing tools to further test and understand the CAMx base case ozone simulations. The use of these tools is discussed below.

Traditional Sensitivity Testing: Traditional sensitivity testing may be performed using the CAMx model. Once each model is operating properly for each base case, sensitivity runs may be performed to explore response to emissions changes as well as changes in key input parameters. These sensitivity runs serve two purposes:

- Aid in helping to define appropriate emissions control scenarios; and
- Provide episode-specific model uncertainty information that may be used later in "Weight of Evidence" analyses in support of the 8-hour ozone attainment demonstration.

Ozone Source Apportionment: Focused use of ozone source apportionment technology (OSAT) for selected episodes may be employed to better understand model response and to aid in the design of control strategies. The value of source apportionment modeling for subsequent stages of the Baton Rouge modeling study is that these calculations will help to:

- Assess the contribution of sources in the Louisiana region and surrounding states to ozone concentrations at key Baton Rouge receptor locations; and
- Identify the particular source categories that may contribute the most to elevated 8-hour ozone concentrations at various nonattainment monitors.

DDM Sensitivity Modeling: Another type of sensitivity that may be performed entails the use of the Direct Decoupled Method (DDM) technology in CAMx. For one or more episodes, DDM may be set up and exercised to produce a numerically intensive, direct sensitivity/uncertainty analysis. DDM can provide information on the sensitivity of ozone to model inputs (e.g., IC, BC, specific emissions). For example, it was used in the HGB area to identify where locations of potential HRVOC emissions would be that could explain the rapid rise in ozone at a particular time and location (i.e., assuming that VOC emissions are missing from the inventory, what emissions locations would best explain observed high ozone levels?).

Process Analysis: Process Analysis is a tool in CAMx to extract additional information about the various physical and chemical processes in the model that produced the ozone concentrations. Information on VOC-limited versus NOx-limited ozone formation, importance of local production versus entrainment of ozone aloft and identification of the contributions of individual VOC species to ozone formation (e.g., HRVOCs) are the types of information that can be obtained with Process Analysis. It can be a powerful tool for diagnosing the causes of poor model performance.

6.2 Evaluation of CAMx Base Cases for the Baton Rouge Episodes

This section describes the procedures for evaluating the performance of the meteorological and photochemical models using the available aerometric data sets for the Baton Rouge ozone episodes.

6.2.1 Overview

Model performance evaluation (MPE) is the process of testing a model's ability to accurately estimate observed atmospheric properties over a range of synoptic and geophysical conditions. When conducted thoughtfully and thoroughly, the process focuses and directs the continuing cycle of model development, data collection, model testing, diagnostic analysis, refinement, and re-testing. Below we summarize the philosophy and objectives that will govern the evaluation of the MM5 and CAMx models for the Baton Rouge 8-hour ozone application. Specific evaluation methods are identified that will be employed to judge the suitability of the meteorological and air quality models for regulatory applications, using common statistical measures and graphical procedures to elucidate model performance. This evaluation plan conforms to the procedures recommended by the EPA (1991; 1999; 2005a) for 1-hour and 8-hour ozone attainment demonstration modeling.

We begin by establishing a framework for assessing whether the EPS/MM5/CAMx modeling system (i.e., the emissions, meteorological and dispersion models and their supporting data sets) perform with sufficient reliability to justify their use in developing 8-hour ozone control strategies for the Baton Rouge nonattainment area. The models' reliability will be assessed given consideration to the following principals:

The Model Should be Viewed as a System: When we refer to evaluating a "model", we mean this in the broad sense. This includes not only the CAMx photochemical model, but its various components: companion preprocessor models (i.e., the EPS emissions and the MM5 meteorological models), the supporting aerometric and emissions data base, and any other related analytical and numerical procedures used to produce modeling results. A principal emphasis in the model testing process is to identify and correct flawed model components;

Model Acceptance is a Continuing Process of Non-Rejection: Over-reliance on explicit or implied model "acceptance" criteria should be avoided for the reasons identified by Roth et al. (2005). This includes EPA's ozone performance goals (EPA, 1991). Models should be accepted gradually as a consequence of successive non-rejections. Over time, confidence in a model builds as it is exercised in a number of different applications (hopefully involving stressful performance testing) without encountering major or fatal flaws that cause the model to be rejected;

Criteria for Judging Model Performance Must Remain Flexible: The criteria for judging the acceptability of model performance should remain flexible, recognizing the challenging requirement of the Baton Rouge region; and

Previous Experience Used as a Guide: Previous photochemical modeling experience serves as a primary guide for judging model acceptability. Interpretation of the CAMx modeling results for each episode, against the backdrop of previous modeling experience, will aid in identifying potential performance problems and suggest whether the model should be tested further or rejected.

A rigorous ozone model evaluation in typical regulatory applications consists of two components. The *operational evaluation* entails an assessment of the model's ability to correctly estimate surface meteorological or air quality variables largely independent of whether the actual process descriptions in the model are accurate. The operational evaluation essentially tests whether the predicted surface meteorological and air quality fields are reasonable, consistent and agree adequately with routinely available observations. In this study, the operational evaluations focus on the various model's reliability in reproducing hourly-average surface wind speed, wind direction, temperature, mixing ratio and ozone concentrations across the 4-km Louisiana domain with particular emphasis on the Baton Rouge area.

The *scientific evaluation* addresses the realism of the meteorological and air quality processes simulated by the models through testing the model as an entire system (i.e., not merely focusing on surface wind, temperature or ozone predictions) as well as its component parts. The scientific evaluation seeks to determine whether the model's behavior, in the aggregate and in its component modules, is consistent with prevailing theory, knowledge of physical processes, and observations. The main objective is to reveal the presence of bias and internal (compensating) errors in the model that, unless discovered and rectified or at least quantified, may lead to erroneous or fundamentally incorrect decisions based on model usage. Ideally, the scientific evaluation consists of a series of diagnostic and mechanistic tests aimed at: (a) examining the existence of compensatory errors, (b) determining the causes of failure of a flawed model, (c) stressing a model to ensure failure if indeed the model is flawed, and (d) providing additional insight into model performance beyond that supplied through routine, operational evaluation procedures.

Practically, a rigorous scientific evaluation is seldom feasible due to the absence of the specific measurements needed to test the process modules (e.g., soil moisture, Reynold's stress measurements, PBL heights, trace gas species, and so on). Accordingly, the overall model performance evaluation in this study is constrained mainly to operational testing of the MM5 models' primary meteorological outputs (i.e., wind speed, wind direction, temperature, and moisture) and the CAMx model's predictions of ozone, NOx, CO and potentially VOC. However, some components of the scientific evaluation of the air quality model are possible through examination of ground-level and aloft primary and product species and species ratios. In addition, corroborative analyses involving joint analysis of emissions inventory estimates, air quality model predictions and ambient measurements adds to the scientific evaluation.

6.2.2 Meteorological Model Evaluation Methodology

Meteorological inputs required by the CAMx model include hourly estimates of the three-dimensional distribution of winds, temperatures, mixing ratio, pressure, clouds, and precipitation, and other physical parameters or diagnosed quantities such as turbulent mixing rates (i.e., eddy diffusivities) and planetary boundary layer heights. Accordingly, the objective of the MM5 performance evaluation is to assess the adequacy of the surface and aloft meteorological fields for the Baton Rouge ozone modeling episodes.

6.2.2.1 Components of the Baton Rouge MM5 Evaluation

The MM5 modeling system is well-established with a rich development and refinement history spanning more than two decades (Seaman, 2000). The model has seen extensive use worldwide by many agencies, consultants, university scientists and research groups. Thus, the current version of the model, as well as its predecessor versions, has been extensively "peer-reviewed" and considerable algorithm development and module testing has been carried out with all of the important process components. Given that the MM5 model code and algorithms have already undergone significant peer review, performance testing of the MM5 model in this study will be focused on an operational evaluation.

Typically, the scope of the scientific evaluation is limited by the availability of special meteorological observations (radar profiler winds, turbulence measurements, PBL heights, precipitation and radiation measurements, inert tracer diffusion experiments, and so on). Unfortunately, since these types of measurements may be limited over Baton Rouge during the modeling episodes, a meaningful scientific evaluation of the MM5 may not be possible in this study. However, if the operational evaluation presented in subsequent chapters is performed thoroughly, they are expected to be sufficient to serve as the basis for judging whether the model is operating with sufficient reliability over the Baton Rouge domain to be used in the photochemical modeling portion of this study.

6.2.2.2 Data Supporting Model Evaluation

Hourly surface observations will be obtained from the National Center for Atmospheric Research and other sources to support the evaluation of MM5 near-surface temperature, water vapor, and wind speed fields. The specific NCAR data set used for this purpose is DS472.0 which is the hourly airways surface data. The primary data set available for comparing model performance aloft is the NOAA Forecast Systems Lab and National Climatic Data Center's

Radiosonde Data of North America. These data sets will be collected in performing the Baton Rouge MM5 model evaluation.

6.2.2.3 Evaluation Tools

The primary tool used for evaluating the MM5 model in air quality modeling study is the METSTAT program developed by ENVIRON. METSTAT calculates a suite of model performance statistics using surface wind speed, wind direction, temperature and water vapor mixing ratio for use specified subdomains. Tables 6-1 and 6-2 list some of the model performance evaluation metrics to be used in evaluating the MM5 model. We will use both regional as well as local subdomains in the METSTAT analysis. Region domains would include those used by CENRAP, WRAP and others so that the Baton Rouge MM5 performance can be compared with other MM5 performance in the same subdomains to help put the results into context and against meteorological model performance benchmarks (Emery, Tai and Yarwood, 2001). Local domains would include the Baton Rouge area and possibly even more refined subdomains. The evaluation of the MM5 aloft meteorological estimates with upper-air observations would be accomplished using the RAOBS program developed by the State of Iowa. Additional comparisons of the spatial patterns of precipitation and clouds may also be made using satellite and radar-based data, but these are usually less important for ozone episodes.

6.2.3 Photochemical Model Evaluation Methodology

The CAMx performance evaluations will follow the procedures recommended in the EPA photochemical modeling guidance documents (EPA, 1991; 1999; 2005a). The evaluation will be carried out in two sequential phases, beginning with the simplest comparisons of modeled and observed ground-level ozone concentrations, progressing to potentially more illuminating analyses if necessary (e.g., examination of precursor and product species, comparisons of pollutant ratios and groupings). That is, the specific two-step ozone evaluation process is:

- An initial "screening model performance evaluation" (SMPE) process, and if the modeling results pass the screening analysis;
- A "refined model performance evaluation" (RMPE) consisting of progressively more stressful testing procedure involving multi-species, multi-scale surface and aloft MPE;

We describe below how this evaluation will be conducted. The formal procedures outlined in EPA recent 8-hour modeling guidance will be used to evaluate CAMx for all of the Baton Rouge modeling episodes. The LDEQ modeling team will consider all six means for assessing photochemical model performance as specified in the draft guidance are as follows:

- Use of computer generated graphics;
- Use of ozone metrics in statistical comparisons;
- Comparison of predicted and observed precursor emissions or species concentrations;
- Comparison of observed and predicted ratios of indicator species;
- Comparison of predicted source category contribution factors with estimates obtained using observational models; and
- Use of retrospective analyses in which air quality differences predicted by the model are compared with observed trends.

Obviously, a comprehensive measurement database for ozone and precursors from an extensive monitoring network is needed to support all six of these analyses. This may not be possible with the current air quality data collected in the Baton Rouge area, particularly in regards to precursor measurements, since no intensive field measurements were conducted in this area during the proposed episode periods. However, there are up to three PAMS monitoring sites in Baton

Rouge that collect speciated VOC, NOx, ozone and other species that would potentially assist in the model evaluation. Therefore, the evaluation approach will consist of a blend of those points above and the steps outlined below. To the extent possible, each of the performance procedures described by EPA's 8-hour guidance will be addressed, and at a minimum, an explanation of why certain components cannot be fulfilled will be provided.

Initial screening of the CAMx base case ozone predictions (i.e., the SMPE) will be performed for each episode in an attempt to identify obviously flawed model simulations and to implement improvements to the model input files in a logical, defensible manner. The screening SMPE will employ some of the more appropriate ozone performance statistics and plots listed in Table 6-3. Examples of the types of graphical displays that may be helpful in the SMPE include the following for both 1-hour and 8-hour ozone concentrations:

- Spatial mean ozone time series plots;
- Ozone time series plots;
- Ground-level ozone isopleths;
- Ozone concentration scatterplots;
- Bias and error stratified by concentration; and
- Bias and error stratified by time.

Experience in photochemical modeling is the best basis upon which to identify obviously flawed simulation results. Efforts to improve photochemical model performance, where necessary and warranted (i.e., to reduce the discrepancies between model estimates and observations), should be based on sound scientific principles. A "curve-fitting" or "tuning" activity is to be avoided.

The following principals will govern the model performance improvement process (to the fullest extent possible given the project schedule):

- Any significant changes to the model or its inputs must be documented and discussed with key participants (e.g., EPA);
- Any significant changes to the model or its inputs must be supported by scientific evidence, analysis of new data, or by re-analysis of the existing data where errors or misjudgments may have occurred; and
- All significant changes to the model or its inputs should be reviewed by the project sponsors and/or other advisory group(s).

If the initial screening of the CAMx ozone results does not reveal obvious flaws, the refined model performance evaluation will be carried out. If the SMPE is not passed, further model diagnosis and quality assurance of the input files and related model performance improvement analyses will be performed. That is, the full refined model performance evaluation will not be carried out on obviously flawed model simulations as it would be wasteful of project resources and schedule.

Assuming the SMPE is passed, the formal operational evaluation in the RMPE will commence. First, the graphical displays utilized previously for ozone may be generated for NOx, VOC, and key product species (e.g., HNOx, PAN) as available. Note that model performance for VOC and many product species may be limited since there is a limited quantity of relevant ambient measurements collected in the Baton Rouge area (up to 3 PAMS sites). But even so, the graphical displays for ozone precursor and product species will be examined for obvious flaws that may be readily apparent even in the absence of measurements. Should these be detected, the model diagnosis and performance improvement efforts may be needed to fully identify, correct (if possible) and document the noted problems. Table 6-4 lists performance evaluation techniques for a RMPE.

Second, diagnostic analysis and testing, including a limited number of model sensitivity and/or uncertainty simulations, may be performed to help elucidate model performance and response to changes in key inputs. Sensitivity analysis, often an important component of the evaluation process, will be performed to aid in understanding the air quality model's response to key input parameter uncertainties. They provide evidence that the model is responding as expected relative to local understanding of the conditions leading to high ozone (i.e., conceptual models). The extent to which sensitivity simulations with CAMx will be needed can only be assessed after the initial model evaluations are performed. With the advent more sophisticated one-atmosphere models, certain sensitivity runs historically carried out older models (e.g., UAM family) are no longer feasible, needed, or appropriate (e.g., zero IC/BC or zero-emissions runs). Other, more insightful and physically meaningful experiments are used (e.g., NOx and VOC emission changes, vertical eddy diffusivity and grid changes, alternative chemistry mechanisms, etc.). Emission sensitivity tests are particularly relevant as they provide: (1) a reality check that the model is responding as expected; (2) information on which emission source components are important; and (3) initial quantification of potential impacts of controls.

An important issue specific to Baton Rouge is the role of HRVOC releases in generating very high ozone concentrations at specific downwind monitors. To the extent that observations indicate a potential HRVOC impact, and that HRVOC event emission data are available, diagnostic and sensitivity tests will be designed using the CAMx PiG capabilities to explicitly model such plumes. Additionally, the PiG simulations may be compared to ultra-high resolution (~1 km grid spacing) flexi-nests located over the local sources and monitors to allow CAMx to explicitly model such HRVOC plumes on the grid system.

Sensitivity experiments will be conduced as part of the CAMx model performance evaluation analysis as appropriate. The potential need for and nature of these simulations would be discussed among the LDEQ modeling team and the EPA after the operational evaluation results have been reviewed.

6.2.4 Available Aerometric Data for the Evaluations

Limited concentration measurements and meteorological parameters are available for the Baton Rouge area. These will be used to the fullest extent possible in the evaluation of the MM5 and CAMx models. Examples of available air quality data available for the evaluation are summarized as follows:

AIRS Surface Air Quality Data: Data files containing hourly-averaged concentration measurements at a wide variety of state and EPA monitoring networks are available in the AIRS/AQS database. These data sets will be reformatted for use in the model evaluation software. Typical surface measurements at the ground level routine AIRS monitoring stations include ozone, NO_2, NO_x and CO.

<u>PAMS Surface Air Quality Data</u>: Up to three Photochemical Assessment Monitoring Sites (PAMS) have been operating in the Baton Rouge area. These PAMS sites are co-located with the Capitol, Pride and B. Plaq sites discussed in Chapter 3 (see Figure 3-1). PAMS sites collect ozone, speciated VOC, NOy and other parameters. The availability of the PAMS data will depend on the episodes selected.

<u>Private Monitoring Networks</u>: There may be air quality measurements collected by industrial sources in the area. These are typically difficult to acquire and may have sampling issues.

Table 6-1. Statistical measures and graphical displays used in the MM5 operational evaluation.

Statistical Measure	Graphical Display
Surface Winds (m/s)	
Vector mean observed wind speed	Vector mean modeled and observed wind speeds as a function of time
Vector mean predicted wind speed	Scalar mean modeled and observed wind speeds as a function of time
Scalar mean observed wind speed	Modeled and observed mean wind directions as a function of time
Scalar mean predicted wind speed	Modeled and observed standard deviations in wind speed as a function of time
Mean observed wind direction	RMSE, $RMSE_s$, and $RMSE_u$ errors as a function of time
Mean predicted wind direction	Index of Agreement as a function of time
Standard deviation of observed wind speeds	Surface wind vector plots of modeled and observed winds every 3-hrs
Standard deviation of predicted wind speeds	Upper level wind vector plots every 3-hrs
Standard deviation of observed wind directions	
Standard deviation of predicted wind directions	
Total RMSE error in wind speeds	
Systematic RMSE error in wind speeds	
Unsystematic RMSE error in wind speeds	
Index of Agreement (I) in wind speeds	
$SKILL_E$ skill scores for surface wind speeds	
SKILLvar skill scores for surface wind speeds	

Table 6-1 (continued). Statistical measures and graphical displays used in the MM5 operational evaluation.

Statistical Measure	Graphical Display
Surface Temperatures (Deg-C)	
Maximum region-wide observed surface temperature	Normalized bias in surface temperature estimates as a function of time
Maximum region-wide predicted surface temperature	Normalized error in surface temperature estimates as a function of time
Normalized bias in hourly surface temperature	Scatterplot of hourly observed and modeled surface temperatures
Mean bias in hourly surface temperature	Scatterplot of daily maximum observed and modeled surface temperatures
Normalized gross error in hourly surface temperature	Standard deviation of modeled and observed surface temperatures as a function of time
Mean gross error in hourly surface temperature	Spatial mean of hourly modeled and observed surface temperatures as a function of time
Average accuracy of daily maximum temperature estimates over all stations	Isopleths of hourly ground level temperatures every 3-hr
Variance in hourly temperature estimates	Time series of modeled and observed hourly temperatures as selected stations
Surface Mixing Ratio (G/kg)	
Maximum region-wide observed mixing ratio	Normalized bias in surface mixing ratio estimates as a function of time
Maximum region-wide predicted mixing ratio	Normalized error in surface mixing ratio estimates as a function of time
Normalized bias in hourly mixing ratio	Scatterplot of hourly observed and modeled surface mixing ratios
Mean bias in hourly mixing ratio	Scatterplot of daily maximum observed and modeled surface mixing ratios
Normalized gross error in hourly mixing ratio	Standard deviation of modeled and observed surface mixing ratios as a function of time
Mean gross error in hourly mixing ratio	Spatial mean of hourly modeled and observed surface mixing ratios as a function of time
Average accuracy of daily maximum mixing ratio	Isopleths of hourly ground level mixing ratios every 3-hr
Variance in hourly mixing ratio estimates	Time series of modeled and observed hourly mixing ratios at selected stations

Table 6-2. Statistical measures and graphical displays used in the MM5 scientific evaluation. (measures and displays developed for each simulation day).

Statistical Measure	Graphical Display
Aloft Winds (m/s)	
Vertically averaged mean observed and predicted wind speed aloft for each sounding	Vertical profiles of modeled and observed horizontal winds at each NWS sounding location and at each NOAA continuous upper-air profiler location in the 36, 12, and 4-km grid.
Vertically averaged mean observed and predicted wind direction aloft for each sounding	
Aloft Temperatures (Deg-C)	
Vertically averaged mean temperature observations aloft for each sounding	Vertical profiles of modeled and observed temperatures at each sounding location
Vertically averaged mean temperature predictions aloft for each sounding	

Table 6-3. Statistical measures and graphical displays for 1-hour and 8-hour ozone concentrations to be used in the screening model performance evaluation (SMPE) of CAMx surface ozone concentrations.

Statistical Measure on 36/12/4 km grids	Graphical Display on all grids
Maximum observed concentration	Modeled and observed spatial mean concentrations as a function of time
Maximum modeled concentration	Measures of peak estimation accuracy (A_{TS}, A_T, A_S, A_U, A)
Maximum modeled concentration at a monitoring station	Normalized bias as a function of time
Ratio of maximum modeled to observed concentrations	Normalized gross error as a function of time
Accuracy of peak estimation (paired in time and space)	Normalized bias as a function of concentration level
Accuracy of peak estimation (unpaired in time and space)	Normalized gross error as a function of concentration level
Average accuracy over all stations	Scatterplot of hourly concentration pairs
Normalized bias in hourly concentrations	Scatterplot of daily maximum concentration pairs
Mean bias in hourly concentrations	Quartile plots of hourly species concentrations
Normalized gross error in hourly concentrations	Daily maximum ground-level concentration isopleths
Mean gross error in hourly concentrations	
Variance in hourly concentrations	

Table 6-4. Statistical measures and graphical displays for 1-hour and 8-hour ozone, VOCs, NOx, and indicator species and indicator species Ratios to be used in the refined model performance evaluation (RMPE) involving multi-species, multi-scale evaluation of CAMx surface and aloft concentrations.

Statistical Measure on 36/12/4 km grids	Graphical Display on all grids
Maximum observed concentration	Modeled and observed spatial mean concentrations as a function of time
Maximum modeled concentration	Measures of peak estimation accuracy (A_{TS}, A_T, A_S, A_U, A)
Maximum modeled concentration at a monitoring station	Normalized bias as a function of time
Ratio of maximum modeled to observed concentrations	Normalized gross error as a function of time
Accuracy of peak estimation (paired in time and space)	Normalized bias as a function of concentration level
Accuracy of peak estimation (unpaired in time and space)	Normalized gross error as a function of concentration level
Average accuracy over all stations	Scatterplot of hourly concentration pairs
Normalized bias in hourly concentrations	Scatterplot of daily maximum concentration pairs
Mean bias in hourly concentrations	Quartile plots of hourly species concentrations
Normalized gross error in hourly concentrations	Daily maximum ground-level concentration isopleths
Mean gross error in hourly concentrations	
Variance in hourly concentrations	
Mean, maximum, minimum, standard deviation, bias and error of observed and modeled aloft concentrations (e.g., ozone, NO_x) along individual aircraft paths	Modeled and observed time series of ozone and NO_x concentrations along individual aircraft flight paths

7.0 FUTURE YEAR MODELING

This chapter discusses the future year modeling procedures to be performed by the LDEQ modeling team for the Baton Rouge ozone episodes that are shown to be performing adequately for use in 8-hour ozone attainment demonstration modeling.

7.1 Future Year to be Simulated

Baton Rouge is currently designated a Marginal 8-hour ozone nonattainment area and so is required to achieve attainment by 2007. This means that the measured 8-hour ozone Design Values for the 2005-2007 period must all be less that 85 ppb. For modeling future-year attainment EPA guidance recommends that the mid-year from the 3-year Design Value attainment determination period be used which would be 2006.

However, given the higher ozone measurements in recent years, Baton Rouge will not attain the 8-hour ozone standard by 2007. With a fourth highest 8-hour ozone standard at the LSU monitor in 2005 of 98 ppb, the fourth highest values at this monitor would have had to average 78 ppb for 2006 and 2007; measurements so far in 2006 show that this will not be possible. The next milestone 8-hour ozone attainment year is 2010, which will require that a 2009 future-year be modeled to ensure that the area fully attains by 2010.

7.2 Future Year Growth and Controls

Several RPOs, including CENRAP, VISTAS, WRAP and the MRPO, are refining future year modeling inventories for 2009, 2012, and 2018 (Stella, 2004, 2005). EPA has developed future year inventories for 2010 and 2015 as part of their CAIR/CAMx analysis. The Texas Commission on Environmental Quality (TCEQ) has also developed future-year modeling inventories for their DFW and HGB ozone attainment efforts. Since the 36/12/4 km Baton Rouge modeling domain encompasses the inventories of several of these groups, projections developed by the RPOs, EPA and TCEQ may be the most appropriate starting point for use in future year modeling for the Baton Rouge modeling analysis region. These projections will cover the area, point, nonroad, and motor vehicle source categories. The LDEQ modeling team will review the appropriate datasets, with special attention to the 36/12/4 km Baton Rouge modeling domain, as these data become available.

Within Baton Rouge itself, developing growth factors will be particularly challenging. Over the past year the population of Baton Rouge has approximately doubled in size due to the displacement of population from the Gulf Coast (e.g., New Orleans) caused by Hurricane Katrina, an event not forecast by current growth techniques (e.g., used by RPOs and EPA). This is an area of ongoing research that will have to be worked out during the course of the study with consultation among the LDEQ modeling team, local agencies, EPA and others.

7.2.1 Regional Growth and Control Factors

Coordinating with the CENRAP, MRPO, VISTAS, WRAP, MANE-VU, TCEQ and EPA, the modeling team will review and refine national and regional growth factors, MOBILE6 input files, and control program reduction estimates that are consistent with Baton Rouge's definition of the future year 2009 base case for the attainment demonstration.

The files prepared will include all federally promulgated rules for the 36-km regional-scale domain and will be largely based on data prepared by the RPOs (e.g., MRPO and VISTAS), States (e.g., Texas) and EPA. This information is based on the latest publicly available information from EPA's federal rulemaking process and at the time of this writing are deemed to be the most recent information available on the topic. Each reviewed rule and regulation found applicable to the eastern U.S. modeling domain relevant to ozone abatement or visibility impairment will be documented with cite, geographic coverage, source categories of impact, and associated and expected emission reduction potential. Additional synchronization with EPA and CENRAP's sister RPOs will be conducted to ensure consistent, if not comparable, application of these programs.

Using summary files prepared to present this information in an easily reviewable format, the modeling team will contact individually identified or otherwise interested regional representatives to solicit comment on the originally presented growth and control factors. Upon review and comment of these factors, the team will revise the regional growth and control factors consistent with the comments collected. The control factor lists will then be compared to the base year emission inventory to determine which, if any, of these programs may already be accounted for in the emission estimates. The factors will be converted to create a complete set of EPS growth and control packets allowing the generation of future year controlled emissions.

7.2.2 Local Growth and Control Factors

As noted above, the development of the Baton Rouge local growth and control factors will be particular challenging. Standard projection techniques that are used for other nonattainment areas (e.g., Economic Growth Analysis System, EGAS) are inappropriate for the Baton Rouge area, which has experienced very atypical growth patterns over the last year. The LDEQ modeling team will work with state and local agencies and EPA to develop appropriate and representative growth projections and control factors for the Baton Rouge area.

7.3 Future Model–Ready Emissions Inventory Development and QA

Future year emissions will be processed into the gridded speciated hourly three-dimensional emissions inputs for the CAMx photochemical model using the EPS3 emissions model. The same biogenic emissions as used in the Baton Rouge base year modeling will be used for the future-year modeling. This assumes that the same land use and biomass distribution as used in the base case emissions would exist in the future-year emission scenarios. The effects of changes in Baton Rouge landuse (growth), agriculture, deforestation, etc. between the current and future-year would not be included. If future-year travel demand model (TDM) link-based VMT data are available they will be used to generate on-road mobile source emissions for the future year. Typical-year EGU and fire emissions (if fires were included in the base year emissions scenario) would also be used in the future-year.

Similar QA/QC will be performed on the future year model-ready emissions inventories as were utilized in checking the base year datasets. Standard inventory assessment methods will be employed to generate the future year emissions data including, but not limited to: (a) visualizing the model-ready emissions graphically, (b) spot-checking the holiday emissions files to confirm that they are temporally allocated like Sundays. (c) producing pie charts emission summaries for each source category, (d) normalizing the emissions by population for each state to reveal where the future year inventories may be suspect and (e) spot-checks of the vertical allocation of point sources using PAVE. The additional QA analyses and reports that we may find particularly useful for the future year emissions files are given in Section 5.2.4.

7.4 Future Year Baseline Air Quality Simulations

The Baton Rouge future-year modeling will use the MM5 meteorological conditions developed for the Baton Rouge ozone episodes. That is, the meteorological conditions for the future-year are assumed to be the same as for base year ozone episodes. This will allow for the comparison of the changes in 8-hour ozone concentrations in the study area from the current to future-year due to changes in emissions only. This means that the effects of inter-annual variability, land use variations and climatic variations will not be accounted for in the future-year meteorological inputs. Several other decisions concerning the future-year to be modeled, model(s) to be used, and modifications to the model inputs to reflect future years, need to be made, as described below.

7.4.1 Future-Year Initial and Boundary Conditions

The same initial conditions as used in the base year would be used in the future-year modeling. Because a 10 day spin up period is being used, initial conditions should have minimal if any influence on the model estimated concentrations.

The base year boundary conditions will be developed from the CENRAP 2002 base case simulation on the national RPO 36-km grid (see Section 5.3.1). If appropriate similar future-year simulations are also available, then they will be processed the same way as the base year. Otherwise, the 2002 boundary conditions will be held constant for the future-year modeling.

7.4.2 Other Future-Year Modeling Inputs

All other future-year CAMx modeling inputs will be identical to the base year simulation, including meteorology, photolysis rates, landuse, and other inputs.

7.5 Emissions Sensitivity Experiments

Model sensitivity experiments are a vital and mandatory component of an 8-hour ozone SIP attainment demonstration analysis – both for the base case performance assessment (see Chapter 6) as well as in the future year control strategy assessment and uncertainty analysis.

Turning specifically to the future year assessments, sensitivity analyses are designed to facilitate the emissions control scenario identification and evaluation process. Today, four complimentary "Probing Tools" can be used in the CAMx regional photochemical model. These methods include: (a) traditional or "brute force" testing, (b) the direct decoupled method (DDM), (c) Ozone Source Apportionment Technology (OSAT), and (d) Process Analysis (PA). The LDEQ modeling team may use at least two types of emissions sensitivity testing methods with the CAMx future year simulations.

Traditional Sensitivity Testing: The LDEQ modeling team may perform numerous sensitivity runs to explore response to emissions changes as well as changes in key input parameters. Typically, these sensitivity runs entail scalar reductions to key categories of anthropogenic emissions (e.g., 20% reduction in on-road motor vehicle emissions, 20% reduction in emissions from elevated point sources, 20% reduction in architectural coating VOC emissions, etc.). These sensitivity runs serve two purposes. They: (a) aid in helping to define more refined emissions control scenarios, and (b) they provide episode-specific model uncertainty information that may be used later in the "Weight of Evidence" analyses in support of the 8-hour ozone attainment demonstrations.

DDM Sensitivity Modeling: Another type of sensitivity modeling entails the use of the Direct Decoupled Method (DDM) technology in CAMx. For one or more episodes, the DDM algorithm may be exercised to produce a numerically intensive, direct sensitivity/uncertainty analysis. These future year DDM sensitivity simulations are an adjunct to the brute force runs and also help to design future year, realistic ozone control strategies, as needed, for the Baton Rouge region.

Ozone Source Apportionment: With CAMx, focused use of ozone source apportionment technology (OSAT) for selected future-year episodes may be employed to better understand model response and to aid in the design of control strategies. The value of source apportionment modeling for subsequent stages of the Baton Rouge modeling study is that these calculations will help to: (a) assess the contribution of sources in the Louisiana region and surrounding states to ozone concentrations in key receptor areas in the Baton Rouge area, and (b) identify the particular source categories that may contribute the most to future-year elevated 8-hour ozone concentrations at various nonattainment monitors.

7.6 Control Strategy Development, Testing and Analysis

The general approach to be followed in assessing whether the Baton Rouge region is likely to be in attainment of the 8-hour ozone standard or whether and to what extent additional VOC and NOx emissions reductions will be required to achieve attainment will be consistent with the methodologies stipulated in EPA's recent 8-hour ozone modeling guidance (EPA, 2005a). The procedure to be followed in performing the ozone attainment demonstrations is discussed in Chapter 8. The main theme of this approach is to use the model in a relative sense through model-derived site-specific relative reduction factors (RRFs) that are used to scale the observed 8-hour ozone Design Values (DVs).

The CAMx 2009 future-year 8-hour ozone simulations will reveal the extent to which further emissions reductions are needed in the region to provide for attainment of the 8-hour ozone NAAQS by 2010. Should ozone violations be projected in the region in the future year simulation, the severity, location, and spatial extent of the modeled exceedances will be studied in order to postulate candidate emissions reductions strategies within and upwind of the nonattainment area. That is, should the future year modeling reveal a nonattainment problem, then an attainment demonstration analysis will be performed that will include the 8-hour ozone modeled attainment test, specific screening analysis and supplemental corroborative analyses set forth in the EPA guidance. These attainment demonstration procedures for ozone are described in detail in the following Chapter 8.

It is difficult when a modeling study protocol is first prepared to specify precisely the nature of the future year local and regional ozone control scenarios that may be required; indeed, the application of existing and mandated regional and local controls “on the books” and “on the way” (e.g., the effects of the Clean Air Interstate Rule) will potentially and dramatically change the current attainment picture in the region.

8.0 OZONE ATTAINMENT DEMONSTRATION

The ultimate objective of the Baton Rouge modeling study is the development of modeling databases that can be used to define emissions control strategies that demonstrate future-year attainment of the 8-hour ozone National Ambient Air Quality Standard (NAAQS). This section describes the procedures for demonstrating future-year attainment of 8-hour ozone NAAQS.

8.1 Ozone Weight of Evidence Analyses

A central theme of EPA's 8-hour ozone modeling guidance document is the use of supporting corroborative analyses to bolster confidence that the selected control plan will in fact achieve attainment in the future-year (EPA, 2005a). This corroborative analysis is part of the Weight of Evidence (WOE) used in a State Implementation Plan (SIP) to support the final control plan selection. Details of the WOE and types of corroborative analysis that can be used in an ozone attainment demonstration have been discussed earlier in Chapter 1.

8.2 8-Hour Ozone Attainment Demonstration Procedures

The procedures for performing a modeled ozone attainment demonstration are outlined in EPA's 8-hour ozone modeling guidance (EPA, 2005a). These procedures involve the use of the model in a relative sense to scale the observed site-specific 8-hour ozone Design Values based on the relative changes in the modeled 8-hour ozone concentration between the current-year (e.g., 2002-2005) and 2009 future-year. The model-derived scaling factors are called Relative Reduction Factors (RRFs). The general procedures are as follows:

- Start with the average of three 3-year periods of 8-hour ozone Design Values centered on either 2002 or 2003 (i.e., average either of the 2000-2002, 2001-2003 and 2002-2004 8-hour ozone Design Values at each ozone monitor in Baton Rouge, or average the three years of 2001-2003, 2002-2004 and 2003-2005, to be determined with consultation with EPA);
- Perform base year modeling on the 36/12/4 km grid for the selected Baton Rouge ozone episodes;
- Perform 2009 future-year base case and control strategy modeling on the 36/12/4 km grid for the ozone episodes;
- Develop RRFs, defined as the ratio of the average of 8-hour daily maximum ozone concentrations "near" each monitor for the future year emission scenarios and the base year for all ozone values above a "threshold" value:
  - Here, "near" the monitor is defined as a 3x3 or 5x5 array of 4-km grid cells centered on the ozone monitor (as much as a 7x7 array is recommended, but the monitoring sites are grouped rather closely in Baton Rouge, necessitating the need for a smaller number of grid cells to avoid overlap with other monitors);
  - EPA's 8-hour ozone guidance specifies that RRFs should be calculated using all days with base-year ozone concentrations near the monitor greater or equal to 85

ppb, and also recommends that at least 10 modeling days should be included – these two recommendations may be in conflict:

- In the event that there are less than 10 modeling days with base year daily maximum 8-hour ozone concentrations near the monitor $\geq$ 85 ppb threshold then:
  - The threshold is successively reduced by 1 ppb (e.g., 84 ppb, 83 ppb, etc.) until 10 modeling days are obtained; or
  - A 70 ppb threshold floor is imposed;
- If there are still less than 10 days upon reaching the 70 ppb threshold then:
  - If there are 5 or more days, proceed with the attainment demonstration but the results should be analyzed carefully to be sure no single day is producing unusual model signals; or
  - If there are less than 5 days EPA Region 6 will be contacted for advice;

- Apply the modeled-derived RRFs to the three-year average of observed 8-hour ozone Design Values at each ozone monitor to obtain a projected future year 8-hour ozone Design Value;
- Compare the projected 8-hour ozone at each monitor with the 8-hour ozone standard, where if all projected 8-hour ozone values are 84.9 ppb or lower then attainment has been demonstrated;
- Even if the modeled future-year 8-hour ozone Design Value is 85 ppb or higher, a WOE attainment demonstration may be possible using supportive, corroborative and additional analysis:
  - o In fact, EPA recommends that the WOE analysis be conducted with projected 8-hour ozone Design Values in the 82 to 87 ppb range;
  - o EPA notes that for projected 8-hour ozone Design Values of 88 ppb or higher no amount of supportive information would likely be convincing for an attainment demonstration.

REFERENCES

Abraczinskas, M., D.T. Olerud, and A.P. Sims. 2004. Characterizing annual meteorological modeling performance for visibility improvement strategy modeling in the southeastern U.S. *13th AMS Joint Conf. on Applications of Air Pollution Meteorology with the Air & Waste Manage. Assoc.* American Meteoro. Society, Vancouver, BC.

Anthes, R.A. 1977. "A Cumulus Parameterization Scheme Utilizing a One-Dimensional Cloud Model", *Mon. Wea. Rev.*, Vol. 105, pp. 270-286.

Anthes, R.A. and T.T. Warner. 1978. "The Development of Mesoscale Models Suitable for Air Pollution and Other Mesometeorological Studies", *Mon. Wea. Rev.*, Vol. 106, pp, 1045-1078.

Arnold, J.R., R.L. Dennis, and G.S. Tonnesen. 2003. "Diagnostic Evaluation of Numerical Air Quality Models with Specialized Ambient Observations: Testing the Community Multiscale Air Quality Modeling System (CMAQ) at Selected SOS 95 Ground Sites", *Atmos. Environ.*, Vol. 37, pp. 1185-1198.

Barchet, W.R., and R.L. Dennis. 1990. "ANAPAP Model Evaluation, Volume 1: Protocol", prepared for the U.S. Environmental Protection Agency, prepared by Battelle Pacific Northwest Laboratories, Richland, WA.

Byun, D. W., et al. 2005a. "Parallel Computation of the Air Quality Forecasting System for Eastern Texas", prepared by the Institute for Multidimensional Air Quality Studies (IMAQS)-University of Houston, April.

Byun, D. W., et al. 2005b. "Development and Operational Evaluation of the Eastern Texas Air Quality (ETAQ) Forecasting System Based on MM5/SMOKE/CMAQ", presented at the 4th Annual CMAS Models-3 User's Conference, University of North Carolina, Chapel Hill, NC. 26-28. http://cf.cmascenter.org/html/2005_conference/conf_agenda.cfm

Coe D. and S. Reid. 2003. "Research and Development of Ammonia Emission Inventories for the Central States regional Air Planning Association". Final Report. Sonoma Technology, Inc. (STI). October 30.

Diggs T.H. 2005. U.S. Environmental Agency (EPA) Region 6 Detailed Comments on the Draft Modeling Protocol for the Baton Rouge Area. Letter from Thomas H. Diggs, Chief Air Planning Section, U.S. EPA Region 6 to Mr. Chris Roberie, Administrator, Air Quality Assessment Division, Louisiana Department of Environmental Quality, Baton Rouge, LA. July 29.

Dudhia, J. 1993. "A Non-hydrostatic Version of the Penn State/NCAR Mesoscale Model: Validation Tests and Simulation of an Atlantic Cyclone and Cold Front", *Mon. Wea. Rev.*, Vol. 121. pp. 1493-1513.

Emery, C. et al. 1999. "Ozone Modeling for the Kansas City Nonattainment Area: Final Protocol", prepared for the Kansas Department of Health and Environment, prepared by ENVIRON International Corporation and Alpine Geophysics.

Emery, C., E. Tai, and G. Yarwood. 2001. "Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Episodes", report to the Texas Natural Resources Conservation Commission, prepared by ENVIRON, International Corp, Novato, CA.

ENVIRON. 2004. User's Guide – Comprehensive Air-quality Model with extensions, Version 4.10s. ENVIRON International Corporation, Novato, California. (http://www.camx.com).

ENVIRON and UCR. 2004. "Modeling Protocol for the CENRAP 2002 Annual Emissions and Air Quality Modeling." ENVIRON International Corporation and University of California at Riverside. November 19.

ENVIRON. 2006. User's Guide – Comprehensive Air Quality Model with Extensions – Version 4.30. ENVIRON International Corporation, Novato, California (www.camx.com). February.

EPA. 1990. Users Guide for the Urban Airshed Model, Volume IV: User's Manual for the Emissions Preprocessor System, Version 2.0, Part A: Core Fortran System. U.S. Environmental Protection Agency, Research Triangle Part, NC.

EPA. 1991. "Guidance for Regulatory Application of the Urban Airshed Model (UAM), "Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C.

EPA. 1999. "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS". Draft (May 1999), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C

EPA. 2001. "Guidance Demonstrating Attainment Air Quality Goals for $PM_{2.5}$ and Regional Haze". Draft Final (17 February 2005), U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C.

EPA. 2001. "Guidance for Demonstrating Attainment of Air Quality Goals for $PM_{2.5}$ and Regional Haze", Draft Report, U.S. Environmental Protection Agency, Research Triangle Park, NC.

EPA. 2005a. Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS -- Final. U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C. October.

EPA. 2005b. Technical Support Document for the Final Clean Air Interstate Rule – Air Quality Modeling. U.S. Environmental Protection Agency, Office of Air Quality and Planning Standards, Research Triangle Park, North Carolina, 27711. March.

EPA. 2005c. "Regional Haze Regulations and Guidelines for Best Available Technology (BART) Determinations". Fed. Reg./Vol. 70, No. 128/Wed. July 6, 2005, Rules and Regulations, pp. 39104-39172. 40 CFR Part 51, FRL-7925-9, RIN AJ31.

Fahey, K.M., and S.N. Pandis. 2001. Optimizing model performance: variable size reduction in cloud chemistry modeling. *Atmos. Environ*. Vol. 35, pp. 4471-4478.

Gery, M. W., G.Z. Whitten, J.P. Killus, and M.C. Dodge. 1989. A photochemical mechanism for urban and regional-scale computer modeling. *J. Geophys. Res.* 94, 12925-12956.

Green M., J. Watson, H. Kuhns, R. Morris, A. Pollack, P. Fields and M. Wolf. 2002. "A Scoping Study for Haze in the CENRAP Region". Final Report. Desert Research Institute (DRI), EBVIRON and ERG. December 18.

Grell, G. A., J. Dudhia, and D. R. Stauffer. 1994. "A Description of the Fifth Generation Penn State/NCAR Mesoscale Model (MM5). NCAR Tech. Note, NCAR TN-398-STR, 138 pp.

Gao, Y.-R., Y.-H. Kuo, J. Dudhia, and D.B. Barsons. 2000. Four-dimensional variational data assimilation of heterogeneous mesoscale observations for a strong convective case. Mon. Wea. Rev., 128, 619-643.

ICF. 2005. 8-Hour Modeling Analysis for the Baton Rouge 5-Parish Area – Draft Technical Protocol. ICF Consulting, Systems Applications International, LLC, 101 Lucas Valley Road, Suite 260, San Rafael, CA 94903. June 14.

Johnson, M. 2004. "Annual 2002 MM5 v363 Simulation Evaluation." Iowa Department of natural Resources, Air Quality Bureau. November. (Available at www.ladco.org/tech/photo/present/mm5v363_eval.pdf).

Kemball-Cook, S. Y Jia, C. Emery, R. Morris, Z. Wang, G. Tonnesen. 2004. 2002 Annual MM5 Simulation to Support WRAP CMAQ Visibility Modeling for the Section 308 SIP/TIP: MM5 Sensitivity Simulations to Identify a More Optimal MM5 Configuration for Simulating Meteorology in the Western United States. Prepared for the Western Regional Air Partnership, by ENVIRON International Corporation and UC Riverside, CE-CERT. December 20, 2004.

Morris, R. E. and T. C. Myers. 1990. "User's Guide for the Urban Airshed Model. Volume I: User's Manual for UAM (CB-IV)" prepared for the U.S. Environmental Protection Agency (EPA-450/4-90-007a), Systems Applications International, San Rafael, CA.

Morris, R. E., M. A. Yocke, T. C. Myers, and R. C. Kessler. 1991. "Development and Testing of a Nested-Grid Version of the Urban Airshed Model UAM-V" paper presented at the Air and Waste Management Association Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R.E., B. Koo, S. Lau, T.W. Tesche, D. McNally, C. Loomis, G. Stella, G. Tonnesen and Z. Wang. 2004. "VISTAS Emissions and Air Quality Modeling – Phase I Task 4cd Report: Model Performance Evaluation and Model Sensitivity Tests for Three Phase I Episodes", prepared for the VISTAS Technical Analysis Committee, prepared by ENVIRON International Corporation, Alpine Geophysics, LLC, and the University of California, Riverside (CE-CERT).

Morris, R.E., D. McNally, T. Tesche, G. Tonnesen, J. Boylan and P. Brewer. 2004. "Regional Haze Modeling over the VISTAS States: Preliminary Verification of Models-3/CMAQ for the 2002 Annual Period." Presented at AWMA Visibility Conference, Asheville, North Carolina. October.

Morris, R.E., A. Hoats, S. Lau, B. Koo, G. Tonnesen, C-J. Jung and M. Omary. 2005c. Air Quality Modeling Analysis for CENRAP – Preliminary 2002 Base Case CMAQ and CAMx Modeling of the Continental US 36 km Domain and Model Performance Evaluation. ENVIRON International Corporation, Novato, CA. April.

Morris R.E., E. Tai, Y. Jia and M. Jimenez. 2005d. Photochemical Modeling of the Tulsa and Oklahoma City 8-Hour Ozone Early Action Compact (EAC) State Implementation Plan (SIP) – Technical Support Document. ENVIRON International Corporation, Novato, California. March 28.

Morris R.E. and G. Tonnesen. 2006. Quality Assurance Project Plan (Draft) for Central Regional Air Partnership (CENRAP) Emissions and Air Quality Modeling – Revision 3. ENVIRON International Corporation, Novato, California. March 29.

Nenes, A., C. Pininis, and S.N. Pandis. 1998. ISORROPIA: A New Thermodynamic Model for Multiphase Multicomponent Inorganic Aerosols. *Aquatic Geochemistry*, **4**, 123-152.

Nenes, A., C. Pininis, and S.N. Pandis. 1998. Continued Development and Testing of a New Thermodynamic Module for Urban and Regional Air Quality Models. *Atmos. Environ.*, **33**, 1533-1560.

Nielsen-Gammon, J. W., R.T. McNider, A.B. White, W. Angevin, and K. Nnupp. 2005. Mesoscale model performance with assimilation of wind profiler data: Sensitivity to assimilation parameters and network configuration. *J. Appl. Meteorol*,. (in press).

Olerud, D. and A. Sims. 2004a. "Protocol for Annual MM5 Sensitivity Modeling in Support of VISTAS (Visibility Improvement - State and Tribal Association)] VISTAS Task 3a deliverable". Available from Mike Abraczinskas, Meteorologist, NC Division of Air Quality, 1641 Mail Service Center, Raleigh, NC 27699-1641

Olerud, D. and A. Sims. 2004b. MM5 2002 Modeling in Support of VISTAS (Visibility Improvement – State and Tribal Association). Baron Advanced Meteorological Systems, LLC, Research Triangle Park, NC. (http://www.baronams.com/projects/VISTAS/).

Pilinis, C., K.P. Capaldo, A. Nenes, and S.N. Pandis. 2000. "MADM - A new multicomponent aerosol dynamics model." *Aerosol Sci. Tech.*, Vol. 32(5), pp. 482-502. 2000.

Pitchford, M.L., I. Tombach, M. Barna, K. Gebhart, M. Green, E. Knipping, N. Kumar, W. Malm, B. Pun, N. Schichtel and C. Seigneur. 2004. "Big Bend Aerosol and Visibility Study". Final Report. September.

Pun B., S-Y. Chen and C. Seigneur. 2004. "CENRAP Model Simulations and Performance Evaluations". Atmospheric and Environmental Research, Inc. (AER). August.

Reid S., S. Brown, D. Sullivan, H. Arkinson, T. Funk, and P. Stiefer. 2004a. "Research and Development of Planned Burning Emission Inventories for the Central States Regional Air Planning Association". Final Report. Sonoma Technology, Inc. (STI). July 30.

Reid, S., D. Sullivan, B. Penfold, T. Funk, T. Tamura, P. Stiefer, S. Raffuse and H. Arkinson. 2004. "Emission Inventory Development for Mobile Sources and Agricultural Dust Sources form the Central States". Final Report. Sonoma Technology, Inc. (STI). September 22.

Reynolds, S. D., C.L., Blanchard, S.D., Ziman. 2003. Understanding the effectiveness of precursor reductions in lowering 8-hr ozone concentrations. Journal of the Air & Waste Manage. Association, 53, 195-205.

Roth, P.M., S.D. Reynolds, and T.W. Tesche. 2005. Air quality modeling and decisions for ozone reduction strategies. *Journal of the Air & Waste Manage. Association,* **56**, 1-16.

Russell, A.G., and R.L. Dennis. 2000. "NARSTO Critical Review of Photochemical Models and Modeling", *Atmos. Environ.*, Vol. 34, No. 12-14, pp. 2283-2324.

Seaman, N.L. 1995. "Status of Meteorological Pre-Processors for Air Quality Modeling", *International Conf. On Particulate Matter*, Air and Waste Mgt. Assn., Pittsburgh, PA.

Seaman, N.L. 1995. "Status of Meteorological Pre-Processors for Air Quality Modeling", *International Conf. On Particulate Matter*, Air and Waste Mgt. Assn., Pittsburgh, PA.

Seaman, N.L. 1996. "Study of Meteorological Variables Needed in Air-Quality Modeling', Annual Progress Report prepared for the Coordinating Research Council (CRC), Interim Report, Project A-11, prepared by the Department of Meteorology, Penn State University, State College, PA.

Seaman, N.L. 2000. "Meteorological Modeling for Air Quality Assessments", *Atmos. Environ.*, Vol. 34, No. 12-14, 2231-2260.

Seaman, N. L., and D. R. Stauffer. 1996. "SARMAP Meteorological Model Final Report", prepared for the San Joaquin Valleywide Air Pollution Study Agency, prepared by the Department of Meteorology, Pennsylvania State University, University Park, PA.

Seaman, N.L., D.R. Stauffer, and T.W. Tesche. 1992. "The SARMAP Meteorological Model: A Four-Dimensional Data Assimilation Technique Used to Simulate Mesobeta-Scale Meteorology During a High-Ozone Episode in California", International Specialty Conference on Tropospheric Ozone Nonattainment and Design Value Issues, U.S. EPA/AWMA, 27-30 October, Boston, MA.

Seaman, N.L., D.R. Stauffer, and L.M. Lario. 1995. "A MultiScale Four-Dimensional Data Assimilation System Applied to the San Joaquin Valley During SARMAP. Part I: Modeling Design and Basic Performance Characteristics", *J. Appl. Meteo.*, Vol. 34, pp. 1739-1761.

Seaman, N.L., D.R. Stauffer, and D.E. McNally. 1996. "Application of the MM5-FDDA Meteorological Model to the Southern California SCAQS-1997 Domain: Preliminary Test Using the SCAQS August 1987 Case", Ninth Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society, 28 January-2 February, Atlanta, GA.

Sistla, G., W. Hao, J-Y Ku, G. Kallos, K. Zhang, H. Mao, and S.T. Rao. 2001. An operational evaluation of two regional-sale ozone air quality modeling systems over the eastern United States. *Bull. Amer. Meteorological Soc.*, **82**, (5), 945-964.

Stauffer, D.R. and N.L. Seaman. 1990. "Use of Four-Dimensional Data Assimilation in a Limited-Area Mesoscale Model. Part I: Experiments with Synoptic Data". *Mon. Wea. Rev.*, **118**, 1250-1277.

Strader, R., F.W. Lurmann and S.N. Pandis. 1999. "Evaluation of secondary organic aerosol formation in winter." *Atmos. Environ*. Vol. 33, pp. 4849-4864.

Strait, R., S. Roe and J. Vukovich. 2004. "2002 Base Case Modeling Inventory – Work Plan." E.H. Pechan and Associates, Inc. Durham, North Carolina. July 30.

Tesche, T.W., and D.E. McNally. 1993a. "Operational Evaluation of the CAL-RAMS Meteorological Model for LMOS Episode 1: 26-28 June 1991", prepared for the Lake Michigan Air Directors Consortium, prepared by Alpine Geophysics, LLC, Crested Butte, CO.

Tesche, T.W. and D.E. McNally. 1996b. "Superregional Ozone Modeling and Analysis Study C Phase II: Work Element 5 Technical Report: Comparative Evaluation of the MM5 and RAMS Models for the July 1991 OTAG Episode", prepared for the Midwest Ozone Group, prepared by Alpine Geophysics, LLC, Ft. Wright, KY.

Tesche, T.W., et al. 2002. "Operational Evaluation of the MM5 Meteorological Model over the Continental United States: Protocol for Annual and Episodic Evaluation", prepared for the U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, prepared by Alpine Geophysics, LLC, Ft. Wright, KY.

Tesche, T.W., and H.E. Jeffries. 2002. "Findings From BCCA-AG Science Studies", prepared for the Business Coalition for Clean Air- Appeals Group, (2002), prepared by Alpine Geophysics, LLC, Ft. Wright, KY.

Tesche, T.W., R.E. Morris, G. Tonnesen, D.E. McNally, J. Boylan, and P. Brewer. 2005a . CMAQ/CAMx Annual 2002 Performance Evaluation over the Eastern U.S. *Atmospheric Environment* (in press).

Tesche, T.W., D.E. McNally, C.F. Loomis, G.M. Stella, and J.G. Wilkinson. 2005b. "Modeling Support for the Houston 8-hr Ozone Attainment Demonstration: 8-Hr Ozone Modeling Protocol", prepared for the Houston 8-hr Ozone Coalition and the Texas Commission on Air Quality, prepared by Alpine Geophysics, LLC, Ft. Wright, KY.

Tonnesen, G., R.E. Morris, J. Vimont, M. Uhl, K. Briggs and T. Moore. 2003. "The WRAP Regional Modeling Center – Application and Evaluation of Regional Visibility Models." Presented at AWMA Annual Meeting and Exhibition. June.

Wesely, M.L. 1989. Parameterization of Surface Resistances to Gaseous Dry Deposition in Regional-Scale Numerical Models. *Atmos. Environ.*, **23**, 1293-1304.

Xiu, A. and J.E. Pleim. 2000. Development of a land surface model. Part I: application in a mesoscale meteorology model. *J. App. Met.*, **40**, pp. 192-209.

APPENDIX A

Quality Assurance Project Plan

A.0 QUALITY ASSURANCE PROJECT PLAN

In this appendix we discuss the quality assurance procedures that will be used in the Baton Rouge 8-hour ozone modeling study. These procedures follow EPA's recommendations for a Quality Assurance Project Plan (QAPP).

A.1 Quality Assurance Objectives

In December 2002, the USEPA publish extensive guidance on developing a Quality Assurance Project Plan (QAPP) for modeling studies (EPA, 2002). The objective of a QAPP is to ensure that a modeling study is scientifically sound, robust, and defensible. The new EPA guidance suggests that a QAPP should include the following elements:

- A systematic planning process including identification of assessments and related performance criteria;
- Peer reviewed theory and equations;
- A carefully designed life-cycle development process that minimizes errors;
- Clear documentation of assumptions, theory, and parameterization that is detailed enough so others can fully understand the model output;
- Input data and parameters that are accurate and appropriate for the problem;
- Output data that can be used to help inform decision making; and
- Documentation of any changes from the original quality assurance plan.

Moreover, the EPA guidance specifies that different levels of QAPP may be required depending on the intended application of the model, with a modeling study designed for regulatory purposes requiring the highest level of quality assurance. The QAPP also provides a valuable resource for project management. It can be used to document data sources and assumptions used in the modeling study, and it can be used to guide project personnel through the data processing and model application process to ensure that choices are consistent with the project objectives.

The guidance document also addresses model development, coding and selection of models, and model performance requirements. For the Baton Rouge ozone study, the LDEQ is using existing models (MM5, EPS and CAMx) with a demonstrated past history of successful application throughout the U.S. and abroad; LDEQ has no current plans for model development activities. Thus, our QAPP focuses primarily on documenting data sources and QA of data processing performed by the modeling team. QA objectives for specific aspects of the project are discussed below, and these will be incorporated into a QAPP that conforms to the EPA guidance documents for modeling studies (e.g., EPA, 1991; 1999; 2005a).

A.2 QA for the Baton Rouge 8-hour Ozone Modeling

The Baton Rouge modeling study will use emissions data sets provided by the RPOs, States, and EPA, and will generate MM5 meteorological data for the Baton Rouge 8-hour ozone modeling episodes. Closely integrated with the episodic meteorological, emissions and air quality modeling will be ongoing project management, technical review, and QA activities performed under the guidance of the LDEQ technical staff. Complementing the data acquisition, modeling input development activities, and project management activities, the following QA activities/functions will be performed, consistent with this QAPP and the study Modeling Protocol.

A.2.1 Data Gatekeeping

The modeling team will receive emissions, meteorological, and air quality data from the RPOs, States, EPA and others. As a first line of QA, the LDEQ modeling team will perform a gatekeeping function to assure: (a) that the emissions, meteorological and air quality data provided to the modeling team have been received correctly from their original data repositories, (b) that the data have been evaluated for quality and consistency, and (c) that the data received have been properly documented and logged. Separate air quality, meteorological and emissions gatekeeper functions by the LDEQ modeling team are defined below.

Air Quality Data Gatekeeper: An Air Quality Data Gatekeeper appointed by the LDEQ is responsible for obtaining and reviewing air quality data as appropriate for model input development and model performance evaluation and for assuring that the quality of all air quality data obtained are consistent with the approved QAPP. The LDEQ air quality data gatekeeper is responsible for providing documentation of the quality of the aerometric data sets to be used by the modeling team in preparing inputs for CAMx for all modeling runs and for the various simulation performance evaluations.

Meteorological Gatekeeper: The LDEQ will appoint a Meteorological Gatekeeper who will be responsible for obtaining and/or developing the meteorological data used to exercise the MM5 model and to develop emissions and air quality model inputs for the CAMx simulations of the Baton Rouge 8-hour ozone modeling episodes. The meteorological gatekeeper function also performs data quality checks as approved in the QAPP, together with the appropriate documentation of model performance evaluation activities.

Emissions Gatekeeper: The Emissions Gatekeeper is responsible for obtaining the emissions inventory data to be used in the Baton Rouge modeling study to support episodic current and future year modeling and recommend sources of emissions data to be used. The emissions gatekeeper assures quality of all emissions data received are consistent with the approved QAPP, and develops all emissions modeling files to support the modeling runs.

Data Management Gatekeeper: The LDEQ is responsible for maintaining a modeling website and or ftp site including posting modeling input and output files, reports, interpretation of results, and other documents developed the modeling team. This includes, for example, the storage of model inputs and outputs for annual (and episodic) runs and the transfer (via fire wire or alternative media) of electronic files to EPA, other participants, and stakeholders. The timely and continuous involvement of the EPA in the development of the Baton Rouge 8-hour ozone attainment plan is an important component of the study.

A.2.2 Emissions QA/QC

Emissions Quality Assurance (QA) and Quality Control (QC) are some of the most critical steps in performing air quality modeling studies. Because emissions processing is tedious, time consuming and involves complex manipulation of many different types of large data sets, errors are frequently made in emissions processing and, if rigorous QA measures are not in place, these errors may remain undetected. The LDEQ emissions gatekeeper will perform a multistep emissions QA/QC approach. This includes the initial emissions QA/QC as described above, as well as QA/QC by the modeling team. The team's QA/QC will occur largely during the processing of emissions, followed by additional QA/QC by the air quality modelers of the final CAMx-ready emissions. This multistep process with separate groups involved in the QA/QC of the emissions is designed to detect and correct errors prior to the air quality model simulations.

Emissions QA/QC performed as part of the emissions modeling includes:

EPA Input Screening Error Checking Algorithms: Although the EPS emissions model will be used for emissions processing and contains numerous internal QA/QC checks and reporting, some additional input error checking algorithms like those used with the EMS and SMOKE emission models may be considered to screen the data and identify potential emission input errors. Additionally, EPA has issued a revised stack QA and augmentation procedures memorandum that will be used to identify and augment any outlying stacks.

EPS Error Messages: EPS provides various cautionary or warning messages during the emissions processing. The user may redirect the EPS output to log files and review the log files for serious error messages. An archive of the log files will be maintained so that the error messages can be reviewed at a later date if necessary.

EPS Emissions Summaries: QA functions built into the EPS emissions processing system will be used to provide summaries of processed emissions as daily totals according to species, source category and county and state boundaries. These summaries will then be compared with summary data prepared for the pre-processed emissions (e.g., state and county totals for emissions from the augmented emissions data).

After the CAMx-ready emission inputs have been prepared, additional emissions QA/QC will be performed as appropriate, such as:

Spatial Summary: Emissions are summed for each major source category and for all 24 hours and used to prepare PAVE plots showing the daily total emissions spatial distribution. In our base case simulations these plots will be presented as tons per day. The 5 emission categories typically used are biogenic, on-road mobile, non-road mobile, area and point sources. If possible, separate spatial QA plots will be generated for low-level and elevated point sources. The objective of this step is to identify errors in spatial distribution of emissions. In addition, daily summary plots are prepared for the total emissions summed across all source categories

Short Term Temporal Summary: The total domain emissions for each hour will be accumulated and time series plots prepared by source category that display the diurnal variation in total hourly emissions. The objective of this step is to identify errors in temporal profiles.

Long Term Temporal Summary: The total domain emissions for each day will be accumulated and displayed as time series plots that show the daily total emissions across the domain as a function of time. The objective of this step is to identify particular days for which emissions appear to be inconsistent with other days for no reason (e.g., not a weekend) and compare against the general trend (make sure weekday, Saturday and Sundays are represented correctly and any major holiday's emissions looks like a weekend day).

Control Strategy Spatial Displays: Spatial summary plots of the daily total emissions differences between a control strategy and base case emissions scenarios will be generated. These plots can be used to immediately identify a problem in a control strategy. For example, if a state's NOx control strategy is being analyzed and there are changes in emissions for other pollutants, or for NOx outside of the Baton Rouge area, problems in emissions processing can be identified prior to the air quality model simulation.

The emissions QA/QC displays will be made available to study participants for review through a project website or ftp download.

A.2.3 Meteorology QA/QC

The LDEQ modeling team will conduct QA/QC and evaluation of the meteorological fields. These evaluations will include the following:

- Evaluation of the MM5 surface winds, temperatures and mixing ratio estimates against surface observations using the METSTAT program. METSTAT evaluation will be performed on a regional as well as subregional basis. Results would be compared against MM5 model performance benchmarks and other studies (e.g., see: http://pah.cert.ucr.edu/aqm/cenrap/ppt_files/CENRAP_VISTAS_WRAP_2002_36km_MM5_eval.ppt);
- Evaluation of MM5 vertical wind, temperature and moisture (dew point) profiles at times and locations of upper-air measurements using the RAOBS program;
- Evaluation of MM5 modeled versus observed clouds using satellite data;
- Evaluation of MM5 modeled versus observed precipitation;
- Visualization of the modeled mixing height (PBL) fields;
- Processing of the MM5 fields using MM5CAMx for the 36/12/4 km grids using multiple vertical diffusivity options:
  - O'Brien Kz profile;
  - CMAQ Kz profile;
  - TKE Kz profile (subject to MM5 boundary layer configuration); and
  - Kz_min patches at 0.1 and 1.0 m^2/s.

In addition, the study team will also perform some QA/QC of the meteorological data to assure that it has been transferred correctly, to obtain an assessment of the quality of the data, and to assist in the interpretation of the air quality modeling results:

- Analyses of the MM5 data to assure that it have been transferred correctly.
- Displays of the CAMx-ready meteorological fields.

- Visualization of the mixing heights using METPAVE.

A.2.4 Air Quality Modeling QA/QC

Key aspects of QA for the CAMx input and output data include the following:

- Verifying that the correct configuration and science options are used in running each program in the CAMx modeling system, including MM5CAMx, TUV, CAMx, and the CMAQ-to-CAMx emissions and IC/BC processors;
- Verifying that correct input data sets are used when running each model;
- Evaluating CAMx results to verify that model output is reasonable and consistent with general expectations;
- Processing and checking ambient monitoring data for use in the model performance evaluation;
- Evaluating the CAMx results against concurrent observations and each other;
- Backup and archiving of critical model input data.

The most critical element for CAMx simulations is the QA/QC of the meteorological and emissions input files, which is discussed above. The major QA issue specifically associated with the air quality model simulations is verification that the correct science options were specified in the model itself and that the correct input files were used when running the model. CAMx modeling employs a system of naming conventions using environment variables in the compile and run scripts that guarantee that correct inputs and science options are used. A redundant naming system is employed so that the names of key science options or inputs are included in the name of the CAMx executable program, in the name of the CAMx output files, and in the name of the directory in which the files are located. This is accomplished by using the environment variables in the scripts to specify the names and locations of key input files.

A second key QA procedure is to never "recycle" run scripts, i.e., it is best to preserve the original runs scripts and directory structure that were used in performing a model simulation.

The LDEQ modeling team will also perform a post-processing QA of the CAMx output files similar to that described for the emissions processing. Animated GIF files will be generated using PAVE to search for unexpected patterns in the CAMx output files. In the case of model sensitivity studies, the animated GIFs will be prepared as difference plots for the sensitivity case minus the base case. Often, errors in the emissions inputs can be discovered by viewing the animated GIFs. Finally, daily maximum 1-hour and 8-hour ozone plots will be produced for each day of the CAMx simulation. This will provide a summary that can be useful for quickly comparing various model simulations.

A.3 Overview of Data Flow and Quality Assurance Process

The modeling team will receive different types of data from various sources that have performed their own QA and QC. Whenever data are received by the modeling team, resources permitting, it will first be subjected to a QA check by the cognizant team member to assess the accuracy and quality of the data. Where appropriate, a summary presentation on the QA check may be developed. If any problems are identified with the data, the provider of the data will be contacted and asked to correct the data. The data are then used in the modeling and resultant output (e.g., model-ready emissions or meteorological files), and are then subjected to another round of QA to assure the integrity of the data is retained.

After the model-ready inputs have been developed and subjected to QA/QC, the CAMx model will be applied using Base Case emissions and the modeling results will be subjected to a model performance evaluation. The model performance evaluation (MPE) represents an extensive QA effort and is one of the most time consuming components of the study. EPA has developed guidance for 1-hour (EPA, 1991) and 8-hour (EPA, 1999; 2005a) ozone modeling. The EPA 1-hour ozone modeling guidance contained specific performance goals that were required to be met for SIP modeling. The EPA 8-hour ozone modeling guidance adopts the 1-hour ozone performance goals, but stresses a more holistic model performance evaluation that examines corroborate and alternative techniques to verify model performance, in additional to performance statistics and goals. The Baton Rouge 8-hour ozone modeling study will examine multiple approaches to assess model performance including:

ENVIRON Analysis Tools: ENVIRON has developed various model evaluation tools and display approaches for assessing model performance. These tools generally extract model performance information from the model on a Linux computer and write out information that can be loaded into Windows-based display programs. These tools will generate:

- Time series plots of predicted and observed ozone and precursors (e.g., NOx, CO, etc.) at and near monitoring sites;
- Scatter plots of predicted and observed concentrations;
- Spatial plots of modeled daily maximum 1-hour and 8-hour ozone concentrations with superimposed observations;
- Summary model performance statistical measures by subregions.

UCR Analysis Tools: The University of California at Riverside (UCR) Analysis Tools are used extensively in the CENRAP, VISTAS, and WRAP regional haze studies. Graphics are automatically generated using gnuplot and the software generates: (a) tabular statistical measures; (b) time Series Plots; and (c) scatter plots by all sites and all days, all days for one site, and all sites for one day. The advantages of these tools are that they can generate numerous performance displays on the Linux computer for fast turn around, and they provide quick QA/QC.

The evaluation of the CAMx base case simulations will employ the appropriate analysis tools listed above to take advantage of their different descriptive and complimentary nature. The use of multiple model evaluation tools is also a useful QA/QC procedure to assure that errors are not introduced in the model evaluation process. CAMx model performance evaluation statistical measures for ozone, ozone precursors, and products species will be calculated to the extent allowed by the Baton Rouge ambient monitoring network data base. More details on the ozone model performance evaluation are provided in Chapter 6.

APPENDIX B

Daily Maximum 8-Hour Ozone Concentrations (ppb)
in the Baton Rouge 5-Parish Area for
2000 - 2005

2000

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	71	52	53	57	46	55	47	42	39	41	31	32	49	56	68	95	77	53	44	38	52	65	42	30	35	35	32	40	69	74	73
Capitol	52	39	38	42	28	36	34	30	29	30	19	18	38	52	76	74	61	39	34	27	46	54	34	17	19	17	21	25	64	72	58
LSU	57	53	52	57	39	48	47	41	42	43	30	29	52	65	92	89	78	55	44	40	59	68	48	31	32	31	31	37	80	91	75
B Plaq	66	52	47	54	37	40	41	36	38	36	24	25	55	68	86	80	69	53	40	35	56	61	44	28	25	25	28	28	75	93	74
Carville	63	50	48	55	37	43	42	36	38	39	25	26	63	65	97	81	70	50	40	38	55	64	44	28	26	26	28	29	78	90	71
D'town	59	51	34	52	38	43	43	34	38	39	27	25	48	57	78	80	72	50	42	37	58	74	38	29	26	27	27	28	79	72	62
F Settle	66	53	41	58	40	53	49	41	42	50	32	29	44	60	75	101	76	51	48	34	62	82	37	33	31	31	31	37	64	74	69
G Tete	58	48	46	50	36	40	39	34	36	37	27	28	49	60	81	76	67	50	40	35	53	63	44	29	29	27	28	38	68	84	74
P Allen	61	50	51	54	39	47	44	36	36	35	26	27	49	58	77	83	71	51	40	38	56	63	42	27	33	31	31	37	73	78	74
Pride	65	54	42	58	41	48	48	45	48	47	36	36	49	56	63	104	84	61	56	38	55	67	46	32	44	37	40	41	62	68	68

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	79	81	58	36	30	55	69	76	52	79	69	67	53	32	32	22	25	37	37	33	31	35	50	53	47	38	52	39	41	61
Capitol	68	52	51	26	18	45	69	65	32	69	58	52	41	19	19	9	13	19	18	15	17	28	46	43	42	25	40	34	39	52
LSU	83	67	64	37	29	56	92	79	48	84	73	64	47	29	28	19	21	26	24	28	29	37	56	50	55	39	60	40	32	56
B Plaq	62	44	45	28	24	72	97	87	38	64	68	70	45	25	24	19	22	25	23	24	26	37	41	48	37	36	40	36	41	44
Carville	59	48	55	27	27	59	86	82	35	68	69	62	47	26	29	21	22	25	26	26	28	40	53	45	47	35	50	36	39	48
D'town	63	60	60	29	21	44	70	75	30	72	62	52	43	24	26	15	20	25	22	26	28	40	61	48	56	33	47	42	43	54
F Settle	74	48	68	38	24	55	72	83	44	76	66	54	50	28	30	22	24	32	29	31	32	51	81	60	56	37	49	51	50	60
G Tete	80	42	53	31	24	63	87	93	40	79	84	82	49	29	30	24	23	29	27	28	29	38	46	50	39	34	45	37	39	51
P Allen	83	74	60	35	27	56	74	82	50	81	71	57	50	30	27	21	22	29	26	29	27	33	52	53	48	35	54	40	46	55
Pride	72	65	58	43	30	54	67	72	51	65	58	65	62	33	37	24	24	35	34	30	32	32	56	55	53	37	51	41	44	48

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	37	32	68	66	80	68	62	59	66	39	39	43	49	57	84	83	59	55	50	73	76	67	48	59	74	88	86	56	39	44	43
Capitol	37	31	63	66	87	76	72	70	64	34	41	55	52	60	91	84	55	56	60	85	83	69	50	68	82	101	79	61	33	42	38
LSU	41	34	62	74	93	89	84	84	65	36	47	57	54	63	100	86	52	59	61	88	82	68	55	73	91	115	81	39	35	43	43
B Plaq	28	24	52	70	75	96	80	86	53	31	22	50	45	51	76	74	45	46	51	77	70	51	48	62	84	90	49	38	32	38	34
Carville	35	28	52	69	78	100	95	79	54	34	32	51	48	58	93	74	46	50	47	80	75	55	52	76	85	93	57	53	32	40	35
D'town	37	32	54	67	73	81	80	58	57	39	36	56	58	64	96	83	47	56	48	90	77	64	46	69	80	99	64	52	34	45	34
F Settle	40	37	61	64	92	63	64	60	70	55	53	65	75	78	99	105	60	76	64	100	87	73	41	59	77	91	72	67	41	51	40
G Tete	34	31	55	86	79	80	70	78	61	34	46	55	53	59	88	84	57	57	57	78	80	65	51	65	84	106	64	33	35	42	40
P Allen	39	39	67	69	89	70	69	69	67	38	36	54	49	56	91	85	62	57	53	60	78	69	48	66	79	93	82	59	36	44	40
Pride	34	28	58	60	68	65	63	60	68	47	42	52	55	69	79	82	68	64	56	84	72	69	47	57	65	81	66	61	36	39	43

Aug	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	57	51	41	53	49	48	73	32	64	63	97	65	74	51	40	59	89	87	91	66	83	69	52	60	80	80	65	69	66	85	115
Capitol	54	45	31	49	44	56	60	25	55	60	110	65	72	40	32	61	88	83	85	61	87	60	47	52	78	76	58	62	65	84	88
LSU	59	47	37	60	48	58	72	31	55	69	121	75	81	53	39	80	95	91	90	66	106	65	51	58	81	76	59	65	64	84	88
B Plaq	42	36	31	40	37	35	45	28	28	48	60	76	79	30	30	51	70	76	71	56	88	41	48	59	82	55	52	51	54	85	77
Carville	43	37	33	44	39	39	55	28	33	60	92	83	77	45	27	83	86	76	86	59	89	50	54	61	79	79	55	55	69	97	77
D'town	42	37	27	48	49	47	52	27	46	65	87	64	66	31	27	57	109	98	101	69	84	52	45	51	63	87	55	74	75	83	74
F Settle	47	43	38	61	60	63	53	27	61	54	63	66	72	37	40	57	77	117	92	85	73	45	46	51	56	71	77	78	73	74	71
G Tete	52	41	35	43	43	39	55	30	33	50	65	70	86	37	33	54	74	83	75	62	65	73	55	70	99	64	55	62	59	79	78
P Allen	53	49	39	54	49	51	66	31	60	68	114	70	79	47	34	64	89	84	85	64	99	54	54	59	78	74	60	46	31	72	95
Pride	61	50	42	69	54	60	52	36	47	50	58	60	64	48	41	45	63	86	68	62	68	58	48	47	61	68	62	64	61	75	86

Sept	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	92	86	75	70	72	59	37	30	22	32	47	39	36	51	70	64	67	81	59	38	29	27	28	30	29	30	46	57	62	49
Capitol	81	77	77	62	61	48	29	20	11	21	32	28	23	33	65	59	61	81	43	24	16	15	19	22	14	25	47	56	61	49
LSU	82	79	87	65	69	50	30	21	16	26	38	32	23	38	74	61	63	85	45	26	17	18	19	24	18	26	48	55	61	50
B Plaq	85	89	86	83	77	48	30	16	14	20	39	22	30	41	76	70	68	84	36	23	27	16	19	21	23	31	58	65	72	54
Carville	82	88	96	72	64	48	41	30	19	32	40	28	34	51	81	73	68	80	45	28	29	21	23	25	23	31	61	63	63	49
D'town	75	81	71	60	60	38	33	22	14	31	29	26	25	36	62	59	60	70	38	28	17	19	22	24	20	24	44	55	53	44
F Settle	86	103	71	66	70	44	34	21	21	28	33	33	33	39	64	64	65	75	46	33	24	20	24	30	20	27	50	61	58	51
G Tete	93	86	77	74	75	53	34	23	21	26	44	31	31	42	71	63	64	83	45	28	34	23	24	26	26	31	52	60	66	58
P Allen	89	79	81	66	69	46	33	23	13	26	42	35	28	38	67	62	65	83	53	28	18	20	21	23	23	28	48	58	65	52
Pride	100	77	60	57	65	50	32	23	19	24	36	35	25	48	65	58	59	71	48	36	23	23	31	27	21	29	49	59	61	46

Oct	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	43	49	53	56	39	26	34	29	26	39	52	61	70	69	60	53	35	38	52	59	67	49	61	68	55	62	56	65	77	71	69
Capitol	41	44	45	51	34	19	31	26	23	37	52	61	60	63	70	46	38	36	56	68	66	45	57	63	52	61	45	69	71	61	56
LSU	44	47	34	54	37	16	32	27	23	35	51	60	61	63	70	48	41	40	58	76	68	47	59	63	54	59	37	70	73	61	60
B Plaq	54	51	60	44	23	20	36	29	25	35	56	62	69	56	54	47	21	39	62	65	66	47	63	67	55	31	51	65	64	61	56
Carville	51	51	55	46	23	24	35	30	28	39	58	63	69	58	67	50	41	48	60	72	64	44	63	63	54	58	44	73	70	63	61
D'town	42	42	42	45	20	19	33	28	25	33	50	58	61	64	60	50	45	42	50	69	63	40	55	56	53	51	35	68	71	59	59
F Settle	42	48	49	60	28	26	38	32	28	41	59	68	70	61	56	58	51	45	59	69	69	48	69	71	58	68	44	66	81	77	79
G Tete	54	52	61	49	26	26	36	29	29	41	57	68	68	59	61	51	41	44	58	63	74	51	61	68	61	60	53	76	69	66	57
P Allen	45	52	52	59	34	22	36	30	26	41	54	65	67	69	74	50	38	40	55	65	71	49	61	71	57	66	54	75	78	70	68
Pride	40	46	50	51	32	26	35	30	26	39	50	64	68	59	52	59	41	40	60	59	62	45	62	63	59	56	48	61	75	70	59

2001

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	63	55	53	60	56	65	73	48	65	64	48	61	53	66	69	48	47	39	37	34	38	45	73	60	51	72	50	31	39	28	21
Capitol	62	35	0	57	52	61	64	45	56	63	40	71	59	78	72	52	43	35	33	30	32	44	67	56	56	63	49	27	34	25	10
LSU	59	49	48	54	50	54	61	41	54	62	37	68	56	82	69	47	46	34	34	31	36	45	67	59	57	61	48	31	35	28	16
B Plaq	48	41	48	48	47	47	51	50	48	54	38	55	55	67	64	42	44	32	31	28	32	45	62	53	67	53	43	27	29	23	13
Carville	58	48	53	55	49	53	59	49	55	64	46	74	65	88	73	52	51	39	38	34	38	54	69	60	67	65	50	30	32	22	17
D'town	55	49	49	52	48	53	59	44	54	62	41	69	56	71	78	51	52	39	41	39	39	45	73	65	65	75	50	29	43	30	16
F Settle	61	54	52	58	53	57	69	49	57	63	50	58	58	70	86	59	52	41	44	40	39	46	78	64	60	77	54	31	47	35	19
G Tete	61	46	54	56	49	50	44	55	52	65	43	55	58	89	68	46	45	35	34	31	34	45	70	56	62	56	45	29	34	23	15
P Allen	62	51	49	58	51	58	63	42	56	63	44	64	54	66	68	46	45	37	35	33	36	44	70	54	54	63	52	28	37	24	12
Pride	57	57	50	55	57	59	68	47	58	61	51	50	53	63	85	62	60	52	41	41	46	46	78	68	52	78	66	33	52	47	26

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	53	38	27	28	25	23	24	19	20	23	30	80	35	27	59	53	62	69	55	44	28	45	56	63	72	72	53	43	58	48
Capitol	48	28	21	18	15	16	18	12	13	21	37	64	29	15	45	64	66	73	61	46	25	46	59	64	68	63	40	40	50	51
LSU	49	28	24	23	19	16	17	12	12	20	32	58	30	17	53	59	60	65	57	43	26	44	58	64	69	61	41	36	48	44
B Plaq	49	23	19	21	19	23	21	13	15	22	30	37	26	18	41	49	64	65	49	36	21	46	70	70	85	52	40	42	45	40
Carville	39	31	24	23	19	26	22	18	20	26	25	0	14	21	45	70	69	71	60	46	26	53	67	70	86	57	46	50	51	43
D'town	66	32	25	22	20	20	20	12	18	27	53	60	28	22	59	68	65	63	59	53	28	59	58	65	74	56	45	61	49	47
F Settle	68	37	26	25	27	26	24	20	16	26	57	59	26	25	51	50	66	67	56	61	33	50	59	64	71	65	45	52	73	48
G Tete	54	28	22	22	20	19	20	16	13	18	28	45	27	18	40	50	60	67	59	37	24	44	59	71	79	59	34	36	40	35
P Allen	48	31	22	22	16	13	16	8	13	17	28	66	26	23	56	55	61	70	55	41	27	41	55	61	69	66	42	37	52	45
Pride	53	43	37	29	28	24	27	19	24	21	28	64	36	30	59	50	62	64	52	48	33	46	55	59	66	68	27	35	72	42

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	62	39	49	46	43	62	76	46	41	42	50	50	47	55	62	66	70	52	81	39	53	48	56	58	58	23	26	45	26	26	34
Capitol	54	40	45	44	44	52	78	56	47	46	54	46	43	59	74	66	69	53	75	40	58	49	58	61	53	19	20	31	25	24	40
LSU	51	41	44	37	38	49	66	49	43	39	48	42	38	59	77	63	69	52	68	36	53	46	55	61	55	23	19	26	23	23	34
B Plaq	51	48	47	32	49	46	58	42	42	44	51	39	35	79	98	40	78	74	53	28	51	57	63	74	63	24	20	23	19	22	23
Carville	59	50	47	35	43	59	61	55	52	50	51	46	44	67	88	60	79	69	67	31	60	51	60	72	58	26	24	24	23	26	37
D'town	46	33	45	43	47	64	63	65	59	58	54	44	50	54	63	62	60	58	58	35	58	45	53	51	48	23	23	25	23	26	47
F Settle	48	35	41	47	52	60	64	61	61	66	62	47	59	56	64	64	59	57	71	51	52	46	57	58	45	22	24	28	25	39	61
G Tete	52	52	49	35	42	45	69	39	41	39	48	35	35	61	79	50	78	55	53	28	44	54	52	60	56	21	19	19	18	20	27
P Allen	59	39	41	39	30	50	81	41	36	39	45	45	39	52	63	61	66	47	72	36	55	44	57	59	58	20	23	34	25	22	35
Pride	46	35	36	55	42	51	60	62	51	48	54	52	48	53	56	54	57	46	67	36	45	42	52	51	56	26	30	47	29	31	40

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	43	44	56	59	52	39	26	14	24	27	36	22	24	36	65	35	33	38	29	51	64	55	82	87	81	36	37	58	21	24	15
Capitol	44	42	51	65	56	53	16	6	22	22	28	21	22	35	61	35	36	36	28	59	95	57	79	90	71	34	29	36	14	20	13
LSU	46	43	51	63	59	50	23	15	28	24	29	21	26	36	65	39	36	36	27	60	90	61	82	85	71	31	28	35	13	21	15
B Plaq	41	37	49	63	53	43	14	10	20	21	23	18	19	48	50	33	36	28	23	44	77	73	85	65	46	24	24	30	17	22	12
Carville	45	42	59	68	62	48	20	15	24	22	25	21	24	41	52	37	37	32	29	57	89	66	88	78	58	29	31	32	19	29	19
D'town	40	36	47	57	54	40	19	8	24	23	25	19	18	34	51	39	43	35	31	64	54	55	75	72	58	28	31	24	13	24	12
F Settle	38	42	52	61	52	35	23	15	32	31	26	20	20	32	55	38	55	37	33	52	52	58	73	63	62	34	31	37	19	28	20
G Tete	46	44	52	61	55	53	19	13	14	23	24	17	20	34	47	32	28	25	20	34	74	55	81	78	40	21	21	26	14	22	8
P Allen	44	42	54	61	54	50	21	9	20	26	28	21	21	34	64	32	31	34	26	53	94	54	84	105	70	30	31	43	14	21	12
Pride	36	40	52	57	48	34	33	15	27	31	36	18	30	29	51	41	42	31	27	39	48	49	71	64	61	29	39	53	22	26	12

September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	24	20	26	24	47	61	23	17	32	34	42	33	39	64	62	87	55	58	27	41	51	60	61	46	40	46	53	58	54	56
Capitol	15	16	20	21	42	43	14	10	27	34	45	32	40	62	71	93	62	49	29	46	53	77	81	43	38	46	54	57	56	57
LSU	15	18	20	22	45	31	16	14	30	37	49	33	38	63	73	87	61	45	27	41	54	70	76	49	37	46	54	58	55	56
B Plaq	14	19	17	22	27	27	16	17	26	47	54	41	42	66	76	64	57	47	24	41	65	73	60	54	46	52	59	63	62	59
Carville	17	18	20	24	38	36	17	19	29	40	54	34	43	64	88	72	61	55	33	51	60	77	67	60	48	56	63	66	63	61
D'town	15	15	19	24	34	39	13	15	25	32	41	29	35	52	63	80	60	55	31	46	48	57	58	47	42	42	49	55	55	53
F Settle	13	18	21	28	30	47	22	16	25	35	42	33	39	56	57	68	65	55	26	49	51	59	52	48	43	48	53	60	57	54
G Tete	14	16	15	17	30	32	15	15	23	34	43	30	37	58	66	60	51	44	23	41	59	70	61	43	38	45	53	57	54	52
P Allen	20	16	21	21	30	43	16	12	29	32	42	31	38	63	63	82	55	52	27	38	53	73	67	46	37	45	52	56	54	56
Pride	21	22	23	36	43	40	26	19	28	35	44	33	38	65	59	76	66	57	27	39	45	54	49	47	41	44	56	59	54	55

October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	48	72	76	63	31	19	39	53	39	33	28	27	42	33	54	35	40	41	58	72	35	33	31	24	40	38	38	36	44	50	54
Capitol	48	67	61	57	29	17	39	48	36	31	21	22	30	34	47	29	38	35	53	65	35	30	24	21	34	36	37	37	42	48	44
LSU	53	68	65	59	27	15	38	51	36	32	27	25	32	34	47	32	38	36	53	58	35	28	25	24	36	37	37	35	38	46	45
B Plaq	59	72	59	50	31	17	42	53	35	32	28	27	38	36	45	37	40	39	53	52	37	32	29	26	41	42	41	39	47	50	44
Carville	61	80	65	36	32	24	44	51	34	31	25	31	39	40	45	38	44	43	59	64	40	33	31	25	43	45	43	40	47	51	49
D'town	51	69	59	52	33	16	37	46	34	26	28	27	34	30	42	30	34	26	50	51	31	28	31	24	33	34	36	33	37	41	40
F Settle	53	71	65	59	34	18	38	48	38	35	31	30	39	32	48	34	38	43	48	48	38	37	39	27	32	39	39	35	44	45	51
G Tete	49	70	57	59	28	11	37	51	35	26	23	22	35	31	42	31	38	28	47	49	36	24	27	23	37	36	36	34	40	51	44
P Allen	51	67	70	60	30	17	38	52	37	28	25	20	35	32	49	33	38	29	52	88	33	30	27	23	27	34	38	37	44	48	52
Pride	50	67	66	59	29	18	36	47	35	32	32	25	43	33	45	35	39	37	57	54	31	27	37	26	40	38	38	34	43	22	48

2002

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	48	38	38	33	66	40	45	42	45	59	52	41	33	57	80	59	31	44	56	**67**	**68**	83	92	74	76	**67**	80	72	**65**	51	54
Capitol	42	34	32	33	54	31	34	32	42	56	44	35	27	53	71	48	24	34	52	61	63	73	78	57	60	72	70	58	56	30	48
LSU	38	31	31	33	55	31	34	34	38	58	44	35	28	52	**69**	47	26	38	52	62	**65**	75	79	60	59	64	71	55	59	39	48
B Plaque	42	32	29	29	36	29	33	33	38	42	38	31	32	60	61	48	30	39	54	63	**68**	73	72	47	48	64	60	47	52	35	40
Carville	44	33	31	32	46	31	34	33	39	52	42	33	34	60	**66**	47	29	41	54	**65**	**68**	73	75	52	54	63	70	56	59	36	45
D'town	46	35	33	32	46	33	38	36	39	51	44	36	29	53	**65**	43	31	36	49	58	62	**67**	73	52	53	53	**69**	59	64	32	55
F Settle	48	38	35	36	50	34	40	39	42	47	45	36	33	57	**69**	58	31	37	53	62	**65**	73	78	59	56	54	73	59	64	42	50
G Tete	41	29	28	25	37	28	31	30	36	49	35	28	26	53	**68**	42	23	0	0	54	62	71	77	50	50	**69**	71	42	53	44	49
P Allen	45	38	36	33	58	35	40	39	46	60	46	39	32	54	74	52	29	42	54	45	64	75	80	63	**65**	72	74	63	52	41	49
Pride	54	47	45	40	41	41	48	42	60	49	45	43	31	51	73	59	32	41	54	62	64	**68**	84	60	56	51	59	62	**67**	47	44

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	52	92	55	62	47	40	54	53	37	44	64	85	73	60	**66**	70	63	63	46	30	**65**	61	43	56	56	28	24	22	46	40
Capitol	60	79	36	41	39	40	61	43	37	33	57	**69**	**68**	54	**67**	62	60	57	43	27	57	56	42	36	46	14	11	12	42	38
LSU	**69**	79	38	44	46	47	64	44	37	35	58	**68**	64	57	**68**	64	61	55	46	32	59	56	43	42	46	20	17	14	40	38
B Plaque	54	43	27	32	35	54	54	29	37	26	63	52	40	51	**69**	47	61	59	34	38	63	58	40	37	34	28	18	17	24	55
Carville	59	**66**	32	37	44	43	63	33	38	33	63	57	56	55	72	56	61	60	36	37	58	56	39	41	36	28	19	18	28	58
D'town	44	**67**	34	41	41	33	48	33	36	36	51	57	**69**	63	72	57	58	53	41	29	54	53	34	42	37	17	12	13	30	45
F Settle	44	**67**	41	52	39	34	45	41	32	47	56	60	63	**67**	**66**	59	64	56	48	37	59	55	38	26	44	28	18	17	54	34
G Tete	60	46	28	33	49	49	64	28	42	30	76	**67**	43	57	**68**	56	61	70	38	43	61	57	42	44	39	27	19	15	24	56
P Allen	57	78	41	47	43	37	59	46	36	34	63	82	62	54	**65**	63	59	59	45	35	56	55	41	45	44	18	16	16	43	38
Pride	39	60	54	47	39	35	46	60	26	44	58	48	79	57	59	60	56	56	44	34	60	54	39	44	42	25	21	16	35	25

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	58	36	41	35	46	57	**65**	52	42	50	64	73	49	45	24	31	51	64	56	51	51	57	49	58	51	47	33	36	23	21	35
Capitol	33	20	25	33	35	56	**65**	45	31	41	64	74	44	40	21	25	47	80	62	56	52	52	41	56	48	37	31	28	17	17	32
LSU	40	26	27	35	37	58	**66**	45	33	49	62	**68**	45	40	22	27	40	78	**66**	54	53	53	42	60	43	39	31	28	20	19	32
B Plaque	37	25	18	28	33	56	59	41	32	48	50	53	39	29	21	22	28	52	42	35	37	44	44	44	43	27	25	22	18	14	28
Carville	38	28	20	38	37	56	58	42	33	58	59	77	44	32	22	21	33	70	56	42	44	52	58	58	50	30	26	19	18	18	29
D'town	33	28	22	35	37	50	50	39	26	28	0	0	45	32	22	26	50	77	85	61	62	57	61	58	52	35	29	27	13	13	29
F Settle	36	34	29	38	45	58	54	44	35	41	56	72	51	37	24	29	67	58	72	71	**68**	62	59	**67**	**65**	39	35	31	25	22	43
G Tete	42	26	22	29	35	55	78	48	37	45	58	54	37	37	19	21	27	45	45	37	48	52	45	55	46	33	22	22	18	18	26
P Allen	53	26	26	31	37	54	**65**	43	39	43	63	**68**	44	42	22	25	39	**67**	57	49	51	50	38	58	47	42	32	33	19	19	30
Pride	47	34	31	25	39	50	52	45	32	38	51	58	52	42	28	35	75	57	**66**	63	59	52	44	50	55	52	45	42	33	25	50

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	39	46	63	49	34	31	53	**67**	**66**	61	53	42	36	23	21	34	42	65	45	46	**65**	34	33	35	42	49	55	56	59	50	45
Capitol	42	48	**65**	48	33	20	54	70	63	59	50	38	30	16	15	24	30	67	37	51	**65**	19	24	38	43	50	62	57	58	51	44
LSU	44	50	64	47	35	25	56	**68**	62	58	49	40	32	22	18	24	29	65	41	55	58	23	24	36	44	57	**65**	60	61	50	43
B Plaque	34	48	**67**	48	34	32	60	53	73	61	36	33	29	21	21	22	23	27	27	54	54	23	21	27	42	41	**65**	**66**	70	53	42
Carville	38	50	64	45	36	34	55	52	**68**	57	41	34	29	24	19	21	23	33	38	52	52	25	25	32	45	62	70	62	64	51	39
D'town	46	39	58	43	44	35	47	58	60	54	39	37	34	25	26	21	28	55	42	49	46	16	28	54	45	48	56	55	56	43	38
F Settle	45	44	61	45	42	41	49	50	62	59	41	42	37	25	26	23	28	45	42	53	52	22	30	52	52	48	51	58	62	48	41
G Tete	33	49	58	49	28	22	56	62	62	54	35	34	29	17	17	22	21	21	26	**68**	61	24	22	27	36	40	49	52	57	61	44
P Allen	42	43	63	48	31	24	47	72	**65**	62	55	38	33	21	22	26	33	**69**	35	50	73	17	12	37	40	48	**65**	62	64	53	45
Pride	41	48	59	47	36	36	48	58	62	57	39	43	37	28	24	29	36	55	52	39	52	31	42	52	40	45	49	60	58	46	43

September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	32	33	32	31	44	52	35	37	41	52	77	70	43	41	82	71	43	32	31	20	51	27	42	45	28	24	34	7	0	29
Capitol	33	29	24	26	42	28	30	32	40	46	103	73	38	46	80	58	29	22	24	15	37	26	39	41	26	21	38	40	50	30
LSU	33	29	23	25	41	29	29	32	38	48	106	74	36	47	75	45	31	23	25	18	35	26	38	41	26	21	40	40	50	31
B Plaque	31	30	23	29	36	29	26	33	46	49	93	82	38	42	**68**	32	31	24	25	20	24	26	42	34	26	21	37	44	50	31
Carville	27	29	26	31	40	31	27	32	42	46	90	78	32	45	74	35	26	23	24	21	24	23	39	41	27	21	43	41	49	29
D'town	26	27	23	22	40	26	26	28	40	41	75	**66**	32	49	82	38	28	21	30	21	27	20	34	37	24	20	45	36	43	26
F Settle	28	28	30	36	50	34	32	36	44	50	77	75	41	45	87	58	38	23	30	27	34	26	42	44	30	24	36	41	50	42
G Tete	37	32	27	26	37	31	27	30	41	53	74	73	45	43	71	41	27	19	24	17	27	24	37	36	24	20	36	43	56	34
P Allen	33	31	25	22	49	37	32	34	43	48	83	77	35	46	82	60	33	29	30	22	42	28	41	42	29	24	37	41	51	37
Pride	29	29	28	30	39	5	0	0	25	47	**65**	**66**	34	35	91	73	38	33	34	24	34	27	43	45	29	25	35	34	44	38

October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baker	39	35	27	32	36	36	25	33	25	29	15	50	39	30	42	49	31	65	50	26	18	29	29	28	11	26	16	14	16	34	34
Capitol	34	31	26	27	38	46	27	34	15	21	18	56	38	28	41	49	47	56	46	20	14	21	21	21	6	21	11	8	10	33	32
LSU	30	26	28	31	42	44	29	31	16	25	17	53	36	29	41	51	47	53	46	23	16	20	17	21	9	16	9	13	13	35	32
B Plaque	43	31	28	31	26	23	29	35	23	27	25	41	40	33	45	50	53	57	48	28	22	23	25	22	18	19	12	16	20	44	40
Carville	39	28	27	28	32	28	33	37	21	24	20	51	38	32	40	53	59	55	45	31	23	22	26	24	15	19	10	15	17	42	38
D'town	34	25	22	22	31	28	28	28	11	21	19	56	34	27	36	52	49	54	49	26	25	18	19	21	9	15	8	12	11	34	32
F Settle	37	32	31	31	28	42	32	35	28	29	22	55	39	32	34	53	51	59	51	32	33	30	25	27	18	21	14	17	20	41	38
G Tete	39	31	22	24	22	23	24	37	22	32	20	47	38	33	45	42	47	58	49	21	15	24	21	27	17	19	12	17	21	38	35
P Allen	40	36	29	34	38	45	29	36	19	28	16	56	39	30	42	50	53	63	50	24	17	26	28	24	10	24	14	16	14	37	34
Pride	31	31	28	32	23	47	25	31	26	28	19	35	39	30	41	48	49	63	52	25	21	26	30	26	14	23	16	18	19	36	36

2003

April	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baker	61	49	46	44	31	26	37	44	39	51	57	75	80	88	81	57	51	92	53	43	42	57	70	57	55	54	58	88	86	81
Capitol	50	36	36	32	22	19	28	33	29	47	53	64	76	70	65	48	46	73	44	37	40	55	60	49	51	52	64	71	76	64
LSU	58	47	44	31	23	25	33	35	34	50	56	68	78	79	73	56	51	78	49	39	41	57	64	52	52	56	74	76	79	64
B Plaque	63	52	48	43	28	28	45	36	44	63	70	77	78	81	81	62	58	67	46	43	50	68	65	48	63	58	78	106	73	62
Carville	59	45	41	42	26	23	29	32	38	54	64	77	79	79	73	55	56	67	44	40	41	59	60	50	53	60	98	91	76	63
D'town	61	50	44	43	24	26	18	0	0	0	0	0	0	0	0	0	61	77	47	43	54	56	63	49	54	66	66	83	49	58
F Settle	59	51	45	44	27	26	41	42	34	54	64	75	87	84	77	48	58	77	48	41	40	55	63	52	52	58	54	72	76	68
G Tete	59	43	45	43	27	25	35	35	39	54	62	68	71	73	77	53	54	66	46	38	44	64	65	57	60	55	69	91	83	62
P Allen	60	48	45	42	26	26	30	37	34	49	55	69	81	82	79	54	44	82	47	42	37	60	68	51	57	56	71	84	86	74
Pride	63	52	53	51	31	30	40	44	35	58	60	73	82	93	80	60	53	79	53	44	46	56	68	56	59	52	49	72	72	70

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	39	43	36	26	23	19	23	24	23	26	28	47	55	39	30	28	26	58	67	48	36	42	57	83	65	44	46	61	72	72	61
Baker	46	50	44	32	31	27	32	35	32	32	27	51	63	46	35	40	28	59	63	52	37	53	62	88	74	48	50	65	77	84	71
B Plaq	42	46	37	28	26	21	26	25	26	26	33	53	74	56	31	30	27	63	61	69	47	52	74	71	67	47	54	82	82	79	66
LSU	42	47	34	26	27	22	28	27	26	27	30	50	62	45	32	32	27	62	80	59	43	46	64	87	70	46	50	72	78	77	66
Carville	48	50	35	27	26	22	27	26	26	26	34	52	72	48	37	32	29	70	86	61	54	50	80	94	73	51	58	88	89		71
D'town	42	47	34	26	26	23	27	26	25	25	35	40	52	34	34	31	28	64	73	45	41	42	30	26	19	14	19	20			55
F Settle	51	54	42	29	29	26	28	29		28	38	47	53	39	38	33	31	67	65	42	36	43	59	71	73	55	50	68	83	83	73
G Tete	42	49	38	29	29	23	29	26	27	28	32	59	78	60	32	32	27	60	70	72	39	55	69	85	69	48	52	75	81	82	68
P Allen	44	42	41	29	28	25	29	30	29	29	29	52	63	44	28	35	27	60	75	54	38	51	62	90	74	45	50	67	76	79	68
Pride	52	58	44	32	30	22	29			30	25	45	46	41	37	39	28	56	50	43	33	51	61	70	72	50	46	59	71	83	69

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol	63	31	17	45	45	27	52	61	76	34	28	21	24	25	23	29	28	46	29	20	29	41	68	51	33	43	31	36	24	19
Baker	71	36	28	49	56	33	50	61	86	40	34	38	31	28	30	34	38	44	37	39	43	45	87	59	40	46		36	30	25
B Plaq	59	30	23	53	54	28	48	59	61	33	28	23	26	26	24	32	44		25	23	26	49	42	32	28	27	31	55	26	21
LSU	65	33	24	51	47	33	53	63	75	42	31	26	26	26	24	30	31	49	33	18	32	52	80	55	37	46		39	27	20
Carville	64	34	28	55	57	34	56	71	75	44	27	24	27	27	25	36	49	65	36	28	25	44	54	36	32	37		43	27	24
D'town	55			30	36	23	49	57	77		31	21	29	27	23		34	63		24	26	31	55	42	40	42		39	25	
F Settle	74	37	33	50	56	34	61	81	99	31	36	26	31	29	25	30		58	45	26	30	74	57	40	48	50	43	39	30	25
G Tete	60	33	31	58	53	32	49	59	66	36	28		24	23	26	34	46	42	30	26	26	44	58					98	69	
P Allen	70		26	46		32	50	63	90	43	31	25	28	27	26	35	35	42	31	31	34	47	73	67		40	30	36	27	22
Pride	71	38	31	40	46	56	44	56	79	37	38		41	37	33	36	35	59	36	40	28	38	53	58	45	50				

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	28	58	48	24	16	27	31	35	27	20	17	39	46		28	58	29	115	53	46	34	23	30	50	51	46	69	43	44	32	20
Baker	32	64	56	32	24	35	37	58		26	24	43	47	34		54	37	83	59	50	44	30	38	55	68	51	53	44	52	38	29
B Plaq	29	37	30	23	20	22	38	28	22	21	21	52	40	26	27	29	31	56	49	46	31	25	35		44	33	58	35	43	27	23
LSU	32	60	51	26	19	30	34		30	25	22	50	45	27	33	65	33	120	57	50	36	27	37	59	58	48	91	47	48	33	28
Carville	33	46	36	26	20	23	39		26	23	24	59	39	23	25	43	48	87	51	47	34	29	39	58	53	44	66	53	48		26
D'town	40	63	36	21	18	21	27	28	30	25	27	46	34	25		52	38	83	51	46	33	25	36	39	55	39	51	52	46	32	24
F Settle	56	65	36	28	23	29	29	32	33	33	34	45	36	31	39	33	34	65	58	57	42	27	38		57	38	54	65	52	40	29
G Tete			37	25	19	28	46	35	22	19	23	46	45	31	26	26								61	43	34	37	42	43	34	24
P Allen	29	54	51	27	19	29	36	49	29	21	20	43	52	30		53		109	57	47	34	26	31	59	58	47	69	43	46	32	25
Pride		57	53	36	26	34	35	55	50	33	29	43	46	38	42			64	66	61	62	39	40	53	63	46	45	59	65	47	37

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	32	31	27	24	26	30	47	52	60	51		49	37	27	33	42	44	89	51		49	41	42	36	34	41	37	37	40	19	21
Baker	41	36	30	31	33	33	55	58	62	59	76	62	48	29	33	39	49	76	62	57	53	45	39	41	42	64	65	51	52	25	28
B Plaq	30	25	24	25	26	25	49	66	64	74	55	49	36	34	34	50	49	57	45	39	45	49	49	47	48	30	45	31	43	20	21
LSU	34	34	30	27	32	34	53	62	67	64	66	57	45	28	39	52	56	89	59	52	53	45	52	42	39	47	48	41	46	22	25
Carville	32	28	24	27	29	26	28	72	73	65		61	40	35	36	51	62	58	68	65	55	50	57	42	44	36	49	33	42	21	19
D'town	35	31	28	28	35	27	55	56	72	54	84	49	35	27	30	33	45	71	59	50	49	37	33	35	32	36	42	32	34	19	21
F Settle	41	36	38	36	41	34	58	59	56	55	62	52	42	34	35	34	47	54	73	56	55	40	36	38	34	54	43	43	35	22	25
G Tete	30	27	27	25	29	32	48	59	55	61	46	52	40	35	37	48	49	66	50	52		55	41	41	42	40	60	32	52	18	21
P Allen	34	32	27	26	26	30	47	54	61	57	66	58	48	28	33	40	50	113	54	46	55	50	43	41		48	57	44	48	22	25
Pride							22	59	57	59	70	52	50	25	31	31	50	61	54	63	48	39	33	37	40	51	49	44	39	24	24

September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol	24	39	53	24	45	58	33	53	53	49	42	27	20	49	42	52	59	73	87	66	39	31	47	56	50	46	50	40	37	47
Baker	40	64	53	31	51	58	38	56	69	58	49	43	37	51	47	56	62	100	85	72	40	39	54	60	55	54	51	48	44	53
B Plaq	21	32	56	26	57	60	59	30	48	56	37	38	27	71	57	64	76	69	92	64	23		60	58	64	38	57	46	42	53
LSU	28	41	64	31	55	68	39	57	59	52	45	31	25	56	48	58	72	81	105	70	37	36	52	58	56	51	62	45	40	50
Carville	23	35	76	48	63	88	49	62	53	61	41	38	28	60	56	68	80	85	83	70	36	43	60	66	64	43	57	49	48	59
D'town	21	36	49	44	45	73	36	49	48	47	45	30	28	45	43	55	58	75	74	60	25	32	48	54	50	39	40	41	36	47
F Settle	26	44	44	32	48	57	38	55	57	52	54	43	35	47	47	60	63	68	65	65	31	37	53	60	54	47	38	45	41	52
G Tete	20	30	39	26	49	61	40	58	53	59	39	36	27	56	47	62	65	74	71	68	23	35	57	64	59	40	43	45	40	52
P Allen	27	46	48	24	49	59	35	53	62	55	48	37	26	51	44	54	60	86	86	71	52	34	50	60		48	49	45	41	52
Pride	29	53	43	32	52	56	32	49	64	51	55	43	38	48	47	53	40	53	34	46	32	39	54	58	57	40	48	47	46	52

2003 (Continued)

October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	54	43	61	**94**	**93**	51	47	35	17	22	27	32	34	32	42	51		44	47	57	52	54	54	56	38	19	18	38	50	37	40
Baker	60	52	**66**	**91**	**114**	70	60	42		31	31	37	42	42	50	63	49	48	50	57	54	61	75	78	51	25	28	43	62	51	55
B Plaq	61	49	**65**	**89**	80	60	54	40	26	22	26	36	46	41	44	54	47	50	50	55	61	58		55	47	22	22	44	58	44	50
LSU	60	48	**67**	**108**	**101**	56	53	41		23	28	35	42	38			42	48	51	12	58	58		64	43	22	21	39	60	43	43
Carville	**67**	56	**69**	**90**	**106**	70	61	46	30	29	29	39	51	43	49	63	49	53	56	71	74	**68**	74	73	47	25	24	36			
D'town	54	44	60	76	**89**	53	44	34	25		24	31	35	41	43		45	44	48	51		62	63	**67**	39	25	17	42	58	48	45
F Settle	61	48	55	71	82	59	45	39	33	34	29	35	38	44	47	61		47	50	53	62	**66**	58	76	51	31	25		62	50	55
G Tete	53		64	**86**	**92**	51	57	44	23	25	27	36	45	40	47	56	47	49	51	73	62	58	**66**	56	46	19	22	46	59	46	52
P Allen	57	48	**68**	83	**109**		59	42	21	25	27	34	40	37	49	61	42	46	48	60	53	55	62	**69**	42	18	20	38	59	49	50
Pride	61	49	62	83	**97**	**65**	48	36	26	29	31	36	37	46	48		49	50	49	54	56	**65**	64	**92**	54	28	28	40	74	52	47

2004

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	23	38	44	74	69	71	59	70	68	44	29	28	27	28	28	31	28	19	34	47	38	41	33	31	38	35	31	33	22	19	39
Baker	32	44	53	79	89	96	78	87	74	53	39	40	38	35	35	37	39	27	50	59	55	53	38	32	42	41	39	37	28	26	44
B Plaquen	31	40	51	66	71	63	55	63	81	46	36	37	38	33	39	28	32	24	33	42	40	42	33	32	39	39	35	36	23	20	42
LSU	29	42	53	81	82	79	66	77	77	49	36	27	33	33	35	35	37	27	43	53	45	46	36	34	42	41	38	38	25	23	45
Carville	31	41	56	91	77	74	61	69	82	46	35	36	34	32	40	31	35	21	38	49	45	46	34	36	43	43	40	42	26	22	44
D'town	28	33	50	84	76	70	58	68	72	43	26	26		28	29	28	28	17	36	45	44	46	34	35	45	45	40	41	26	21	40
F Settleme	34	37	51	66	81	81	65	75	76	46	36	37	33	34	31	41	40	25	41	57	48	48	34	35	45	44	41	41	28	24	43
G Tete	32	46	53	74	69	66	58	64	83	50	37	37	33	35	37	35	34	29	38		43	46	35	32	40	38	39	38	26	24	44
P Allen	27	42	48	78	82	82	67	78	73	47	34	32	33	32	30	35	34	25	42		49	48	38	32	43	41	37	36	25	22	42
Pride	33	44	54	71	90	81	67	76	70	35	35	39	37	35	34	36	38	27	43	58	57	51	49	46	57	46	43	42	31	26	38

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol	35	26	43	49	58	26	23	26	38	29	25	37	38	19	33	15	25	32	42	57	36	20	36	21	18	30	17	19	24	22
Baker	41	36	45	52	69	31	35	35	53	43	29	36	52	26	39	20	27	33	40	55	45	32	34	28	22	40	24	29	39	38
B Plaquen	37	25	33	43	46	27	24	25	29	26	25		25	23	35	17		24	41	63	35	18	29	25	26	31	20	20	26	23
LSU	39	32	47	58	65	30	25	33	43	32	30	39	44	24	37	19	28	33	53	77				23	22	36	21	23	26	30
Carville	49	32	40	62	54	30			35	30	27	29	32	24	34	20	25	29	67	85	49	22	44	28	28	35	23	22	26	26
D'town	40	28	42	65	55	31	19	23	36	30	31	33	33	16	35	19	27	42	63	69	53	20	42	24	23	29	22	21	21	24
F Settleme	44	31	50	59	53		25	30	45	33	36	35	38	21	35	22	31	57	41	43	46	22	36	14	21	29	22	26	24	31
G Tete	42	28		52	52	27	26	32	37	28	28	28	36	28	37	23	25	33	41	52	45	25	28	24	26	41	24	27	34	25
P Allen	42	31	43	55	64	30	26	32	46	37	26	27	13	14	36	19	24	29	44	54	35	24	42	23	22	38	20	25	42	27
Pride	37	41	46	48			27	15	96	44	37	36	39	22	48	25	37	39	33	38	52	34	27	23	22	32	24	34	30	34

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	19	25	27	26	31	24	21	23	32	35	53		49	41	76		38	47	46	71	45	34	46	54	43	39	39	56	53	48	61
Baker	34	29	33	30	36				43	45	71	41	48	48	71	62	39	52	46	78	55	40	54	50	48	41	38	60	63	47	56
B Plaquen	24	22	23	26	22	23	23	30	31	29	33	36	34	51	71	49	46	41	57	66		30	43	77	48	51	40	46	46	32	71
LSU	24	33	30	30	29	29	29	32	42	40	53	45	57	58	99	69	46	60	62	81	59	40	54	61	49	49	45	63	61	53	74
Carville		26	25	28	25	27	24	34	34		36	50	54	69	87	50	50	52	72	77	51		57	63	47	63	53	56	53	44	44
Dutchtown	24	24	25	31	26	28	26		34	29	41	44	49	52	59	53	52	56	48	64	41		53	48	40	49	51	63	54	53	34
F Settleme	30	29	29	38	31	29	38	32	39	31	31	50	38	43	53	54	47	56	46	61	48		45	43	39	38	48	68	60	52	31
G Tete	22	22	28	25	23	28	25	28	31	34	36	37	40	46	72	64	40	47	48	63	39	32	42	54	52	41	38	47	45	35	59
P Allen	24	7	10	11	11	9	8	25	36	47	80		51	49	74	65	39	52	48	82	50	40	49	53	49	36	38	58	55	48	64
Pride	30	49	34	37	40	38	33	32	46	30	51	32	41	45	47	73	34	44	43	56	54	44	42	42	43	36	35	62		50	52

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	48	40	47	72	59	40	57	51	39	50	71	45	38	41	48	57	81	73	32	15	38	24	27	25	27	27	45	73	50	37	48
Baker	40	41	48	76	67	45	59	55	43	49	80	51	44	44	52	61	83	94	43	21	39	26	27	30	34	38	51	71	47	41	46
B Plaquen	50	69	67	64	64	45	65	51	48	51	50	37	46	46	54	70	71	63	22	17	27	22	21	20	21	23	50	56	44	51	61
LSU	57		61	91	72	49	68	61		60		50	46	46	55	67	101	79	40	21	42	28			28	28	50	75	53	45	63
Carville	53	62	67	82	65	54	65	53	50		58	42	48	48	55	65	84	76	39	21	27	28	27	24	24	27	58	60	54	43	66
Dutchtown	41	58	49	81	69	42	54	46	43	67	59	31		44	50	56	68	84	26	20	30	27	25	23	20	30	44	51	52	28	53
F Settleme	39	42	50	64	71	46	58	48	44	44	45	32	45	45	51	60	65	83	40	22	35	30	29	30	23	33	48	42	46	30	41
G Tete	55	50	66	64	65	44	68	57	48	52	55		44	44	51	62	87	64	26	18	39			23	20	24	58	64	45	42	57
P Allen	47	44	50	71	67	43	60	53	42	49	79	47	42	43	51	59	83	83	36	17	39	25	25	27	29	31		74	52	39	49
Pride	36	40	48	58	73	45	54	52	39	42	42	43	44	43	51	56	63	93	46	24	39	28	48	36	30	38	46	51	44		41

Septembe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol	55	59	27	31	45	34	44	60	56	55	52	30	29	30	23	30	64	56	49	47	41	39	32	41	61	56	55	65	88	66
Baker	55	63	35	33	47	36	46	56	51	57	53	30	36	34	26	34	67	58	52	55	48	46	37	49	67	61	61	72	76	79
B Plaquen	61	52	28	31	59	46	41	59	54	58	62	27	36	35	26	31	54	69	65	54	44	42	33	37	55	62	61	71	75	72
LSU	63	66	29	35	52	40	51	70	66	64	60	29	32	33	25	35	71	64	56	52	44	42	33	44	68	63	66	81	111	74
Carville	65	67	38	35	50	43	55	71	57	62	58	32	33	36	27	36	73	65	59	51	45	43	34	40	62	64	74	79	97	81
Dutchtown	45	49		28	43	33	59	70	43	49	50	26	31	34	24	39	78	54	50	44	39	38	31	38	52	57	64	83	86	66
F Settleme	45	47	23	29	43	30	40	47	43	51	50	27	30	34	24	33	68	54	48	49	41	40	33	45	57	58	59	68	63	66
G Tete	62	64	40	38	50	42			67	75	63	27	34	37											67	63	63	71	76	85
P Allen	54	67	31	31	48	36	42	57	58	60	56	30	35	33	26	30	67	59	51	52	44	45	35	48	61	60	55	64	74	84
Pride	49	49	31	29	43	35	46	45	46	51	51	29			24	25	60	58	51	52	44	44	34	42	67	61	63	72	69	74

October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	50	40	63	63	41	49	28	29	32	32		33	42	23	43	46	37	24	13	19	23	43	24	17	27	32	39	46	30	33	27
Baker	61	41	54	64		51	34	37	36	37	39	35	48	32	46	57	43	26	16	26	28	66	29	22	32	49	52	62	41	37	33
B Plaquen	46	38	57	49	46	45	27	35	32	29	41	37	52	27	47	48	39	24	17	22	21	30	25	21	31	32	37	42	34	37	
LSU	54	50	73	71	48	54	32	35	37	35	41	38	51	26	50	54	43	28	17	22	28	52	27	20	33	36	45	52	38	37	
Carville		55	70	52	46	44	26	33	29	30	39		54	22	50	52	42	26		25		44	27	24	37	37	40	52	36	42	30
Dutchtown	50	56	68					27	27	28	43	41	51	28	50	49	41	26	18	29			29	25			40	47	38	43	
F Settleme	54	56	49	48	42	53	33	45	39	35	41	41	53	28	49	53	45	31	18	27	35	47	28	29	43	46	50	56	41	44	
G Tete	55	40	55	61					33	31	23	38	52	30	49	55	44	30	18	25	29	38	28	21	33	37	37	45	40	39	
P Allen	53	42	57	85	46	57	33	33	33	34	36	33	46	26	44	51	41	23	14	21	22	50	25	16	27	40	43	51	36	32	29
Pride	69	43	49	53	40	52	35	37	35	36	41	37	51	36	47	60	46	28	19	31	32	48	32	21	37	52	46	54	44	41	34

2005

May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	48	54	50	46	52	61	64	65	43	64	56	59	53	50	48	59	55	49	51	44	55	86	65	65	63	66	82	72	27	37	30
Baker	52	59	55	51	59	66	77	78	51	77	73	67	61	61	52	62	68	65	72	52	58	97	72	70	59	68	96	83	37	43	37
B Plaquemi	51	62	59	50	59	73	57	55	41	46	43	53	55	40	57	70	60	38	39	44	62	70	59	59	74	82	74	56	23	37	35
LSU	53	61		51	60	72	71	74	49	69	64	69	56	55	53	73	61	58	58	46	68	99	73	76	71	80	92	80	32	42	35
Carville	61	64	62	56	64	79	63	62	48	70	50	66	58	51	59	77	60	47	50					67	74	79	83		22	40	43
Dutchtown	10		54	47		67	65			65	53	70	54	53	51	63	51	53	54	51	68			77	66	72	87	76	28	40	34
F Settleme	51	59	56	52	63	68	72	65	55	55	62	59	61	53	50	61	56	63	58	55	59	78	81	77	63	70	80	76	29	35	32
G Tete	56	69	62	54	65	76	67	66	49	68	53	75	66	42	81		72	47	48	53	71	89	74	80	97	85	86	65	32	43	44
P Allen	48	55	52	46	54	64	66	69	43	81	62	64	58	55	49	60	61	54	58	46	56	98	68	66	58	67	92	74	28	39	33
Pride	52	60	56	52	60	64	73	69	47	53	65	57	62	56	50	60	64	58	67	53	57	72	77	76	56	69	97	87	31	41	37

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol	29	50	56	40	31	23	40	34	46		23	90	50	35	48	64	39	51	60	53	60	60	69	64	60	59	76	53	37	50
Baker	31	50	74	50	34	29	48	39	55	46	24	87	57	35	57	68	41	47	64	58	66	70	68	66	65	65	77	65		55
B Plaquemi	27	45	47	33	26		30	32		47	31	50	36	27	42	61	39	49	70	67	68	67	75	83	67	67	81	63	48	41
LSU	33	57	63	44	36	27	48	37	52	46	26	98	58	41	53	74	44	61	68	63	70	72	81	84	71	69	98	65	46	
Carville	34	67	55	40	30	23	38	34	58							67		58	61	59	62	63	80	75	63	59	84	55	41	52
Dutchtown		64	61	40	33	17	51	47		38	24	93	45	57	54	72	53	49	59	56	55	58	70	72	61	59	69	49	32	62
F Settleme	40	72	62	43	37	24	56	47	54	42	24	53	40	54	64	59	54	47	63	62	59	63	65	70	65	58	66	50	34	66
G Tete	34	58	57	45	37	29	38	37	59	49	31	54	37	33	50	69	43	56	74	65	79	88	74		79	74	76	81	60	
P Allen	28	49	63	43	32	26	41	32	47	43	22	72	44	34	49	65	42	50	60	54	62	64		65	61	61	77	56	39	52
Pride	31	48	80	53	32	24	52	37	40	44	23	50	48	43	48		43	44	62	56	61	65	57	60	59	62	75	57	35	48

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	37	45	61	25	26	33	59	55	46	26	34	30	24	14	23	16	24	43	31	36	73	70	64	42	51	71	39	39	43	39	45
Baker	41	46	61	36	29	34	75	62	44	26	36	37	29	18	32	25	33	50	37	45	56	55	67	44	58	77	46	42	46	43	45
B Plaquemi	29	45	36	20	26	28	43	42	46	27	36	27								28	69	73	52	41	70	52	30	38	40	45	50
LSU	42	52	70	30		36	67	63	52	28	37				27	20	26	51	36	43	89	95	80	51	61	82	47		47	46	57
Carville	28	45	47	21	27	33	45	43	44	26	36	29	23	23	24	17	20		32	37	61	76	78	54	72	62	42	47	55	51	56
Dutchtown		57	47	27	25			45	42	23	41		25		28	19	23	45	30	37	56	62	65	59	57	71	44	52	58	42	47
F Settleme	37	53	44	22	24	34	58	45	45	24	49	38	29	29	31	20	26	42	30	38	39	47	58	45	53	62	50	61	55	39	45
G Tete	44	53	47	23	34	31	54	49	57	24	40	32	28	23	26	20	23	60	43	48	83	63	61	47	68	58	46	45	42	50	65
P Allen	37	46	60	28	26	29	67	54	43	27	34	30	26	17	26	19	26	36	33	42	62	55	61	46	53	73	39	38	40	40	48
Pride	56		57	34	24	26	53	73	42	25	41	39	31	22	37	28	29	33	32	40		44	57	41	53	102	49	39	42	41	39

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	61	58	37	39	41	39	61	58	58	55	35	68	55	34	36	61	52	47	43	44	32	65	68	53	42	46	41	33	23	39	67
Baker	68	59	47	40	45	42	67	61	61	61	37	63	85	45	50	58	57	51	60	48	36	50	67	61	52	52	44	39	26	43	71
B Plaquemi	49	60	40	53	54	50	52	43	52	45	35	65	42	22		65	52	43	29	27	31	80	62	69	46	68	52	30		35	55
LSU	64	74	55	48	49	44	67	70	67	58	46	84	63	37	49	87		52	49	50				64	45	55	46	36		41	78
Carville	56	71	49	51	48	46	71	62	64	56	40	71	46	26	41	106	57	48	36	41	34	90	89	55	49	57	46	33		39	70
Dutchtown		48	49	43	42	41	75	72	84	68		63	54	29	41	79	72	61	43	57	44	70	74	51	44	50	43	28	26	51	78
F Settleme	67	47	45	43	45	42	56	57	89	64	43	57	57	31	42	58	67	63	43	40	38	50	65	51	39	50	45	29			
G Tete	60	65	47	51	51	47	58	54	61	50	43	71	47	28	37	63	61	49	35	33	36	70	68	74	56	61	52	40	26	47	66
P Allen	60	67	53		42	39	62	58	58	54	37	69	65	36	41	57	53	48	50	38	36	56	70	59	49	51	42	38			66
Pride	51	49	43	41	43	41	58	50	61	56	39	53	84	49	41	50	67	64	68	50	35	49	60	57	58	49	44	33			

September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capitol		59	54	64	57	50	41	51		81	63	60	67	43	32	26	42	58	69	48	56	36	21	31	26			57	37	57
Baker	45	65	59	68	63	58	47	57	57	73	71	70	84	39	35	34	47	67	71	54	63	40	27		27			58	43	59
B Plaquemi	62	65	62	77	62	58	50		70	62	74	57	54	35	34	28	36	39	83	61	67	37	25		32	29	75	83	63	58
LSU	54	70	62	72	63	57	48	60	72	82	70	71	77	53	37	28	49	66	88	61	64	38	25	36	30	38	63		55	63
Carville	53	66	61	73	58	59	51		69	74	75	71	68	39	37	28	35	52		65			23		28	31	58	76	53	63
Dutchtown	51	62	58	68	56	55	46	62	60	66	69	61		46		33	45	54	59	52	57	32	24	35	26	35	49	60	45	46
F Settlement		65	59	67	60	54	48	63	61	61	66	55	73	51	49	40	48	47	59	53	61	35	21		27	46	50	62	47	43
G Tete	57	74	65	73	62	64	61		71	77	74	64	57	35	33	32	41	37	101	58	75	46			22	41	62	76		60
P Allen	45	63	56	67	62	54	46	55	58	86	68	70	74	35	32	26	44	61	77	50	58	38	22		27	32	49	67	46	80
Pride															47	34	41	61	58	51	61	36			32	41	40	52	40	45

October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Capitol	35	30	28	39	30	33	30	40	49	46	46	40	43	44	50	55	44	82	71	42	45	36	39	25	29	37	36	34	45	54	38
Baker	42	39	34	42	35	43	41	47	49	49	50	46	47	52	55	56	48	62	80	51	47	39	45	34	35	42	48	45	55	65	55
B Plaquemi	43	36			40	44	39	46	56	59	67	58	66	57	61	65	57	71	81	47	52	42	48	34	40	44	47	41	54	57	45
LSU	42	34	31	40	38	42	39	48	60	55	57	55	54	55	59	64	58	102	92	53	55	43	49	32	38	41	45	42	53	63	51
Carville	41	32	30	39	38	41	38	50	74	61	66	64	61	56	60	63	66	69	80	46	52	42	47		39	43	52	45	55	61	22
Dutchtown	37	29	28	37	34	37	36	47	60	52	55	50	57	51	58	59	55	62	67	49	58	37	44	33	38	44	42	38	50	60	47
F Settleme	42	31	33	41	38	41	39	44	50	54	53	52	59	54	59	58	56	60	72	52	59	39	46	37			46	42	52	63	53
G Tete	50	37			44	46	43	47	56	57	64	53	55	58	59	76	61	69	89	55	58	40	51	34	40	48	46	43	53	62	48
P Allen	41	35	33	47	35	39	39	43	54	51	50	48	50	52	55	61	52	76	95	48	52	41	48	34	33	42	43	40	54	59	48
Pride	35	37	31	36	35	45	43	45	45	45	47	46	47	55	55	56	51	56	70	59	56	43	47	35	40	40	46	42	50	56	

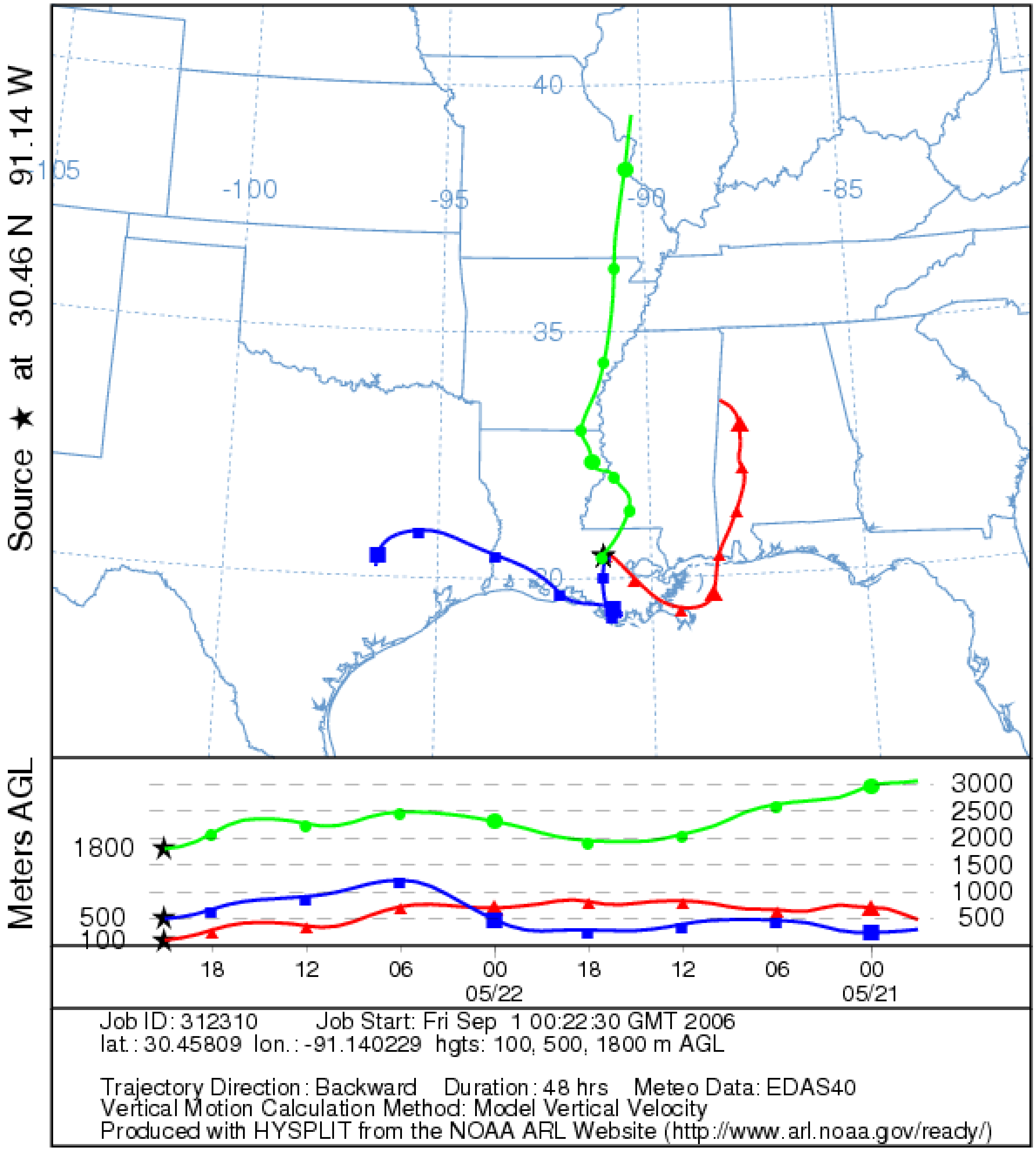
APPENDIX C

48-Hour Backward Trajectories Ending in Baton Rouge
On the Afternoon of Each 8-hour Ozone Exceedance Day
Of the Six Candidate Episodes (Chapter 3)

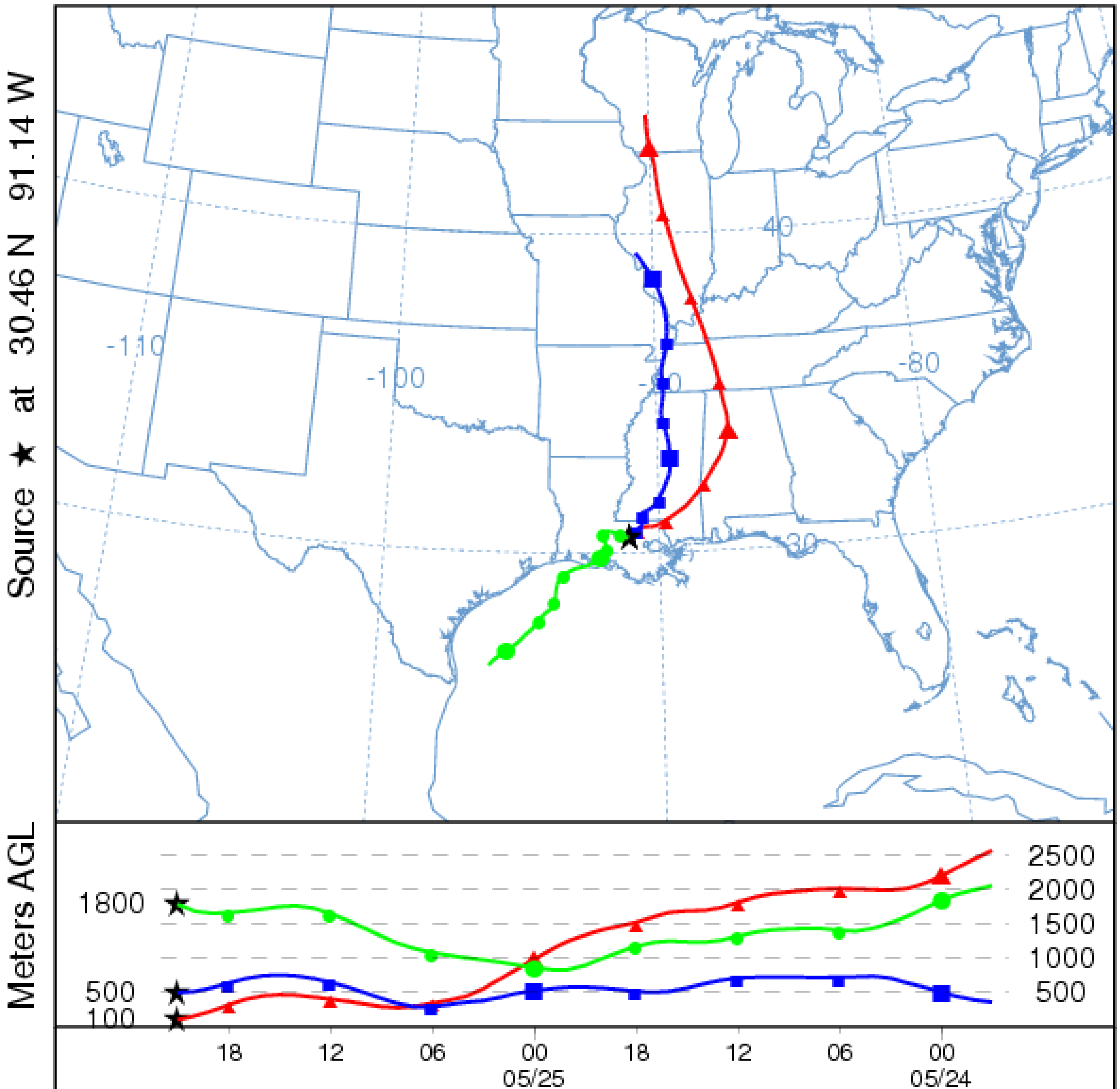
1. May 22-28, 2005
2. May 19-30, 2003
3. September 28-30, 2004
4. April 12-30, 2003
5. October 4-6, 2003
6. May 4-9, 2004
7. August 11 – September 5, 2000

May 22-28, 2005

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 22 May 05
EDAS Meteorological Data



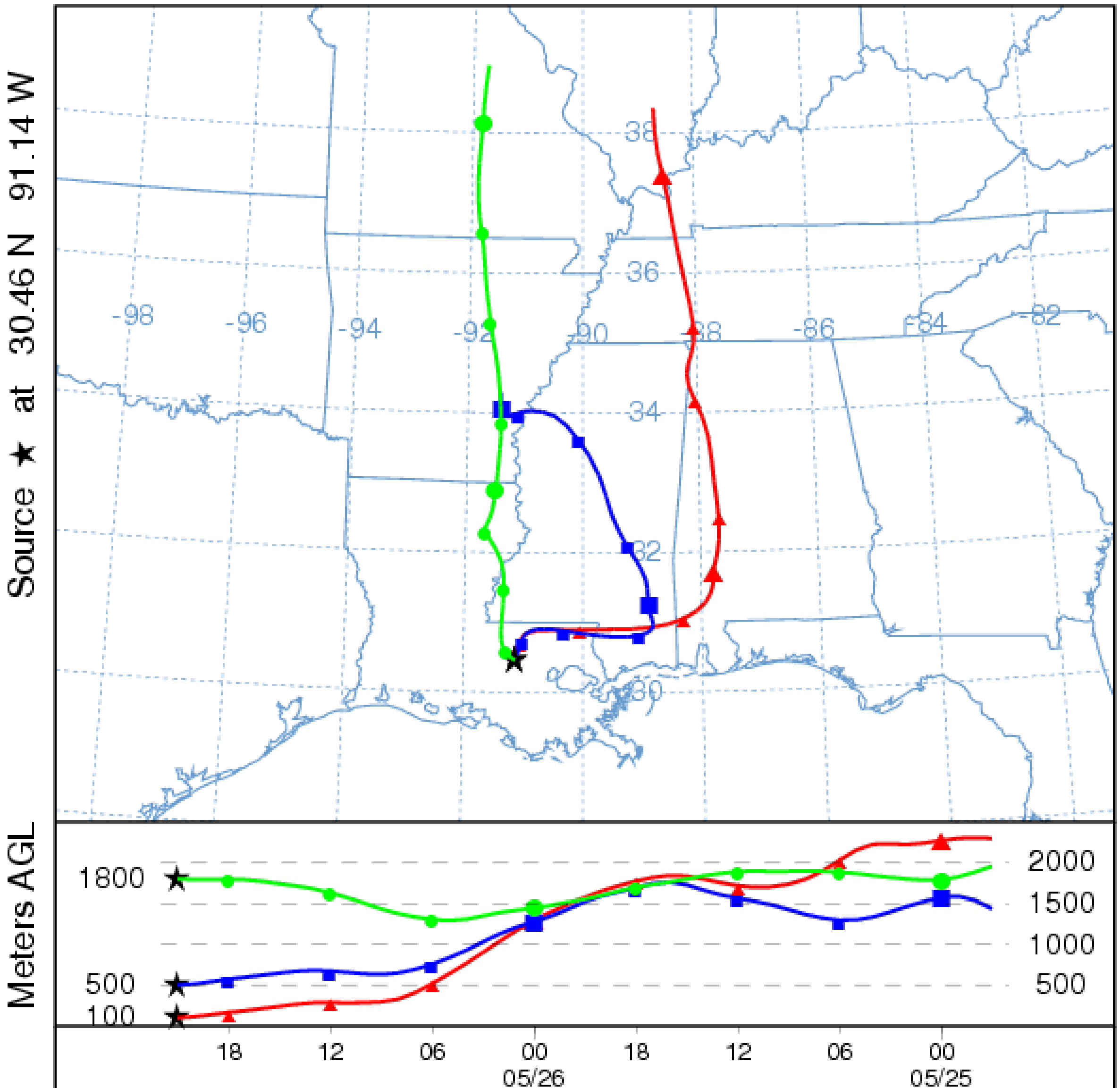
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 25 May 05
EDAS Meteorological Data



Job ID: 312343 Job Start: Fri Sep 1 00:24:41 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 500, 1800 m AGL

Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

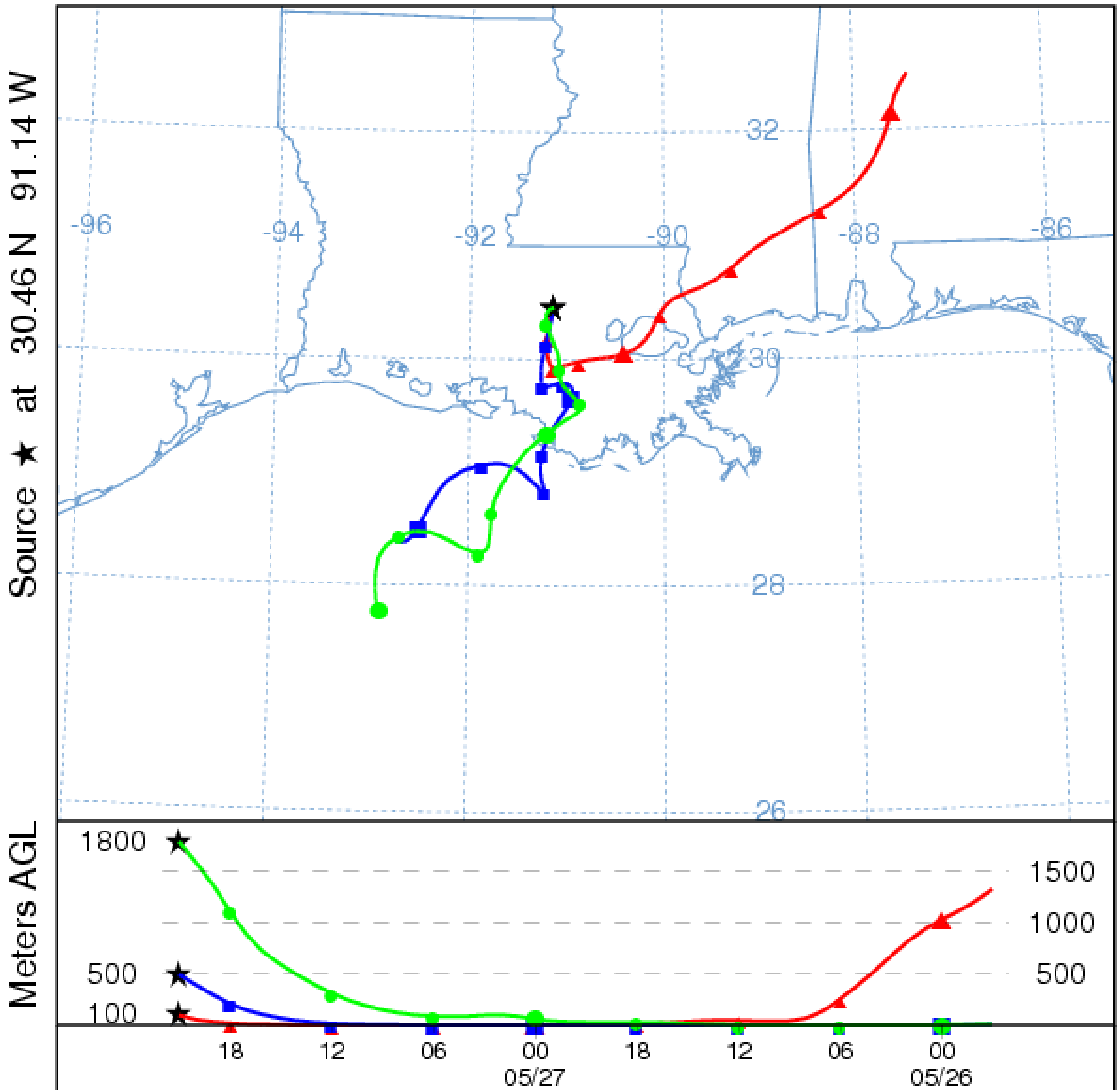
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 26 May 05
EDAS Meteorological Data



Job ID: 312356 Job Start: Fri Sep 1 00:25:19 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 500, 1800 m AGL

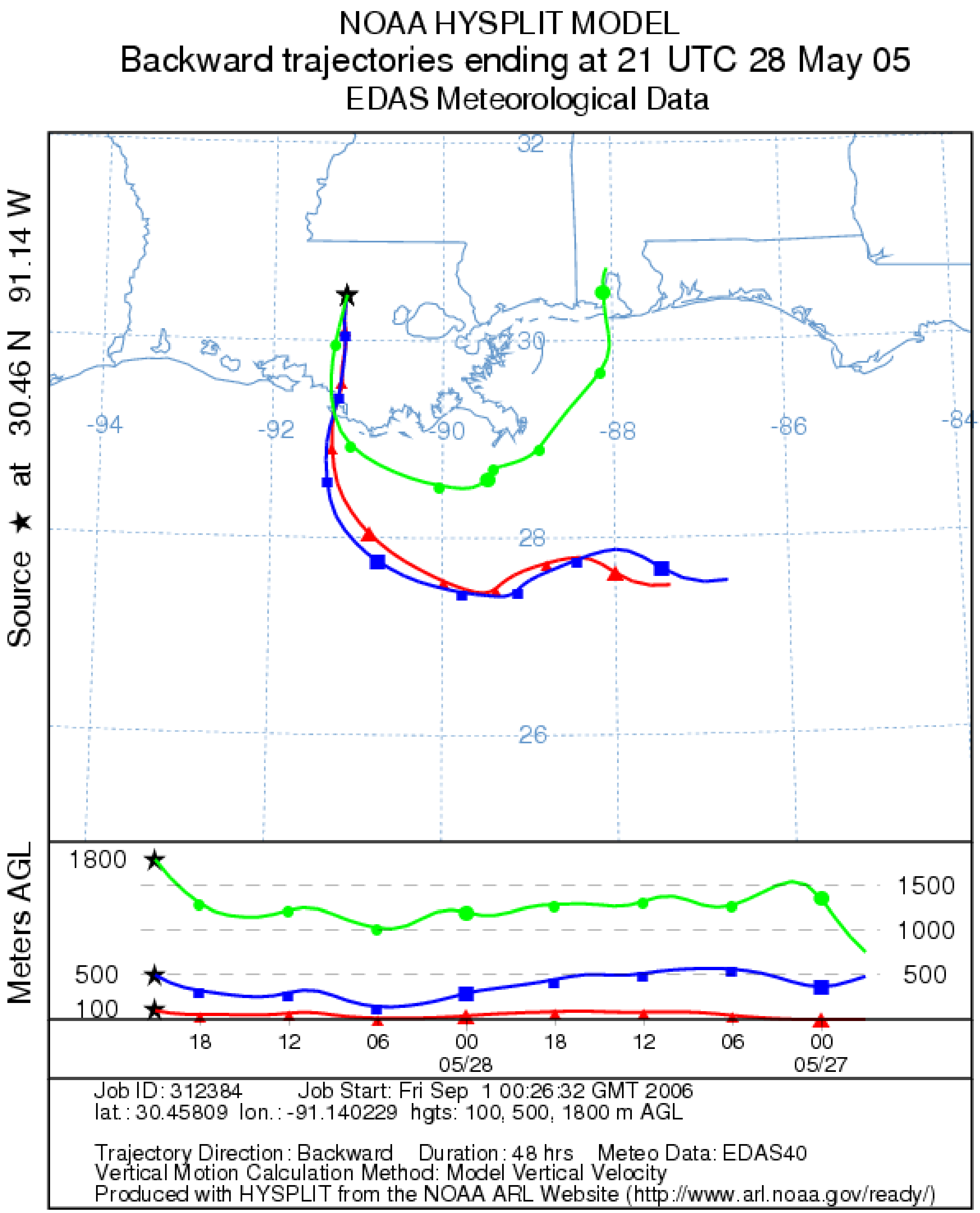
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 27 May 05
EDAS Meteorological Data

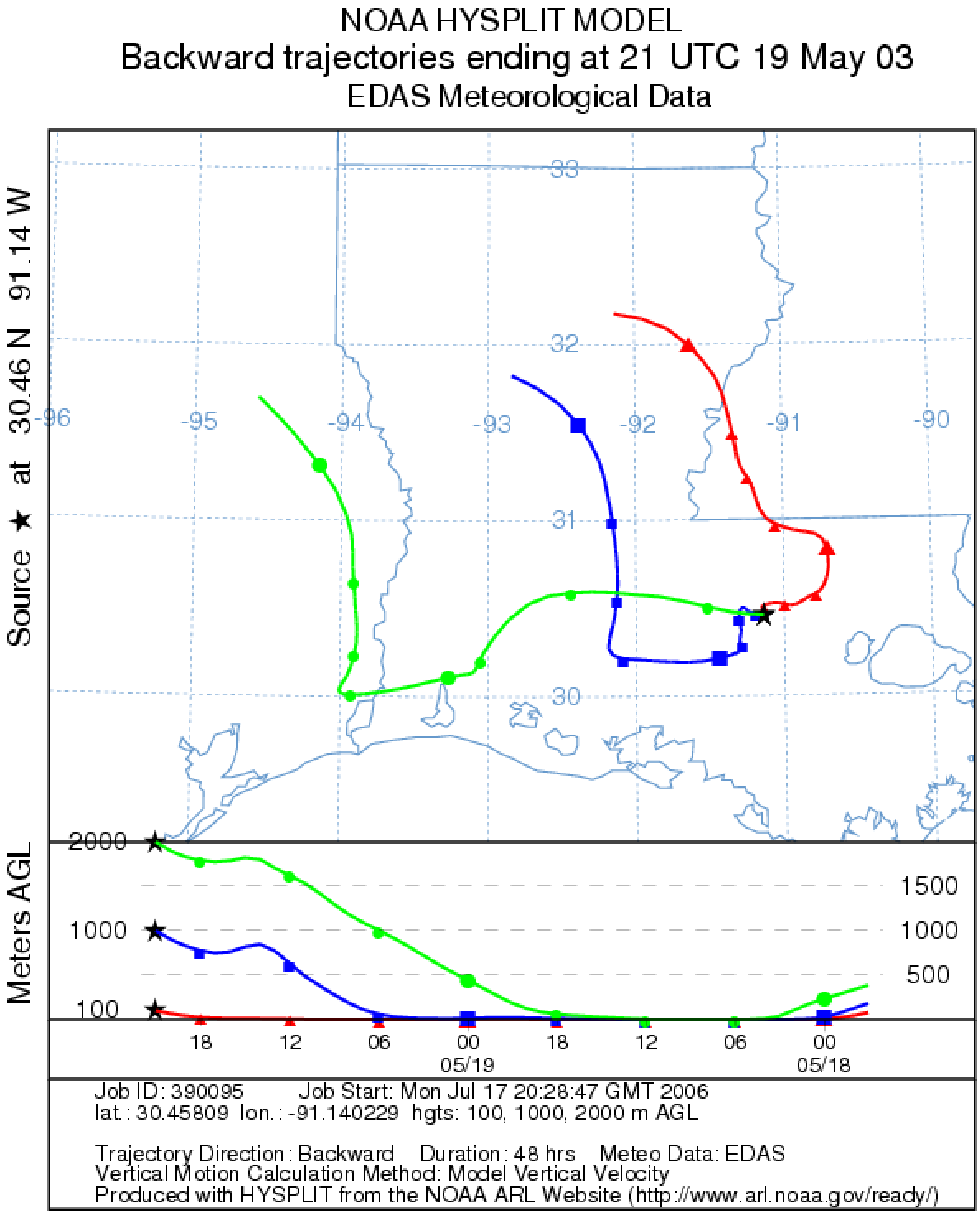


Job ID: 312361 Job Start: Fri Sep 1 00:25:57 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 500, 1800 m AGL

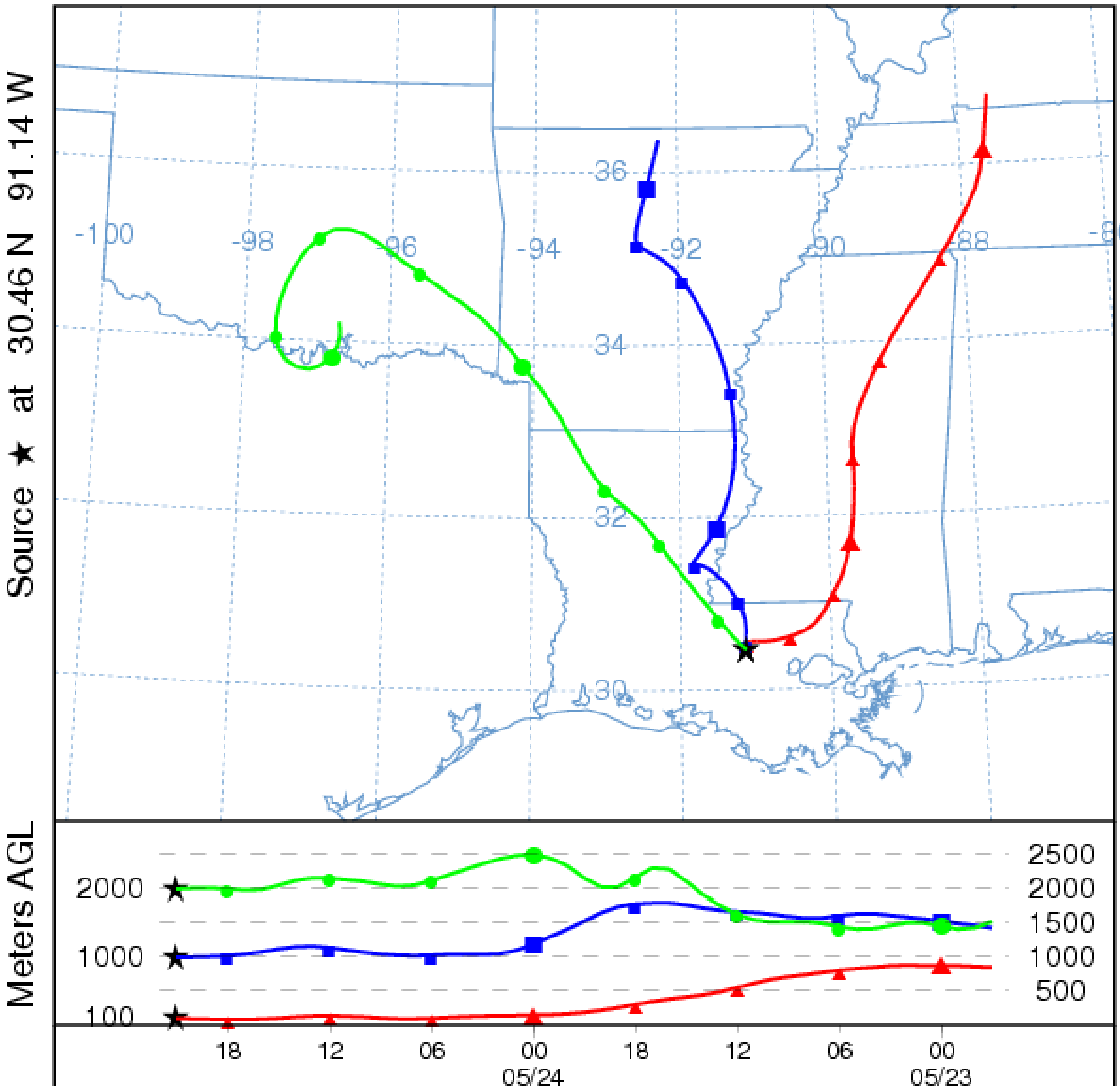
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 28 May 05
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
32
30
28
26
-94
-92
-90
-88
-86
-84
Meters AGL
1800
1500
1000
500
500
100
18
12
06
00
05/28
18
12
06
00
05/27
Job ID: 312384 Job Start: Fri Sep 1 00:26:32 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 500, 1800 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

May 19-30, 2003

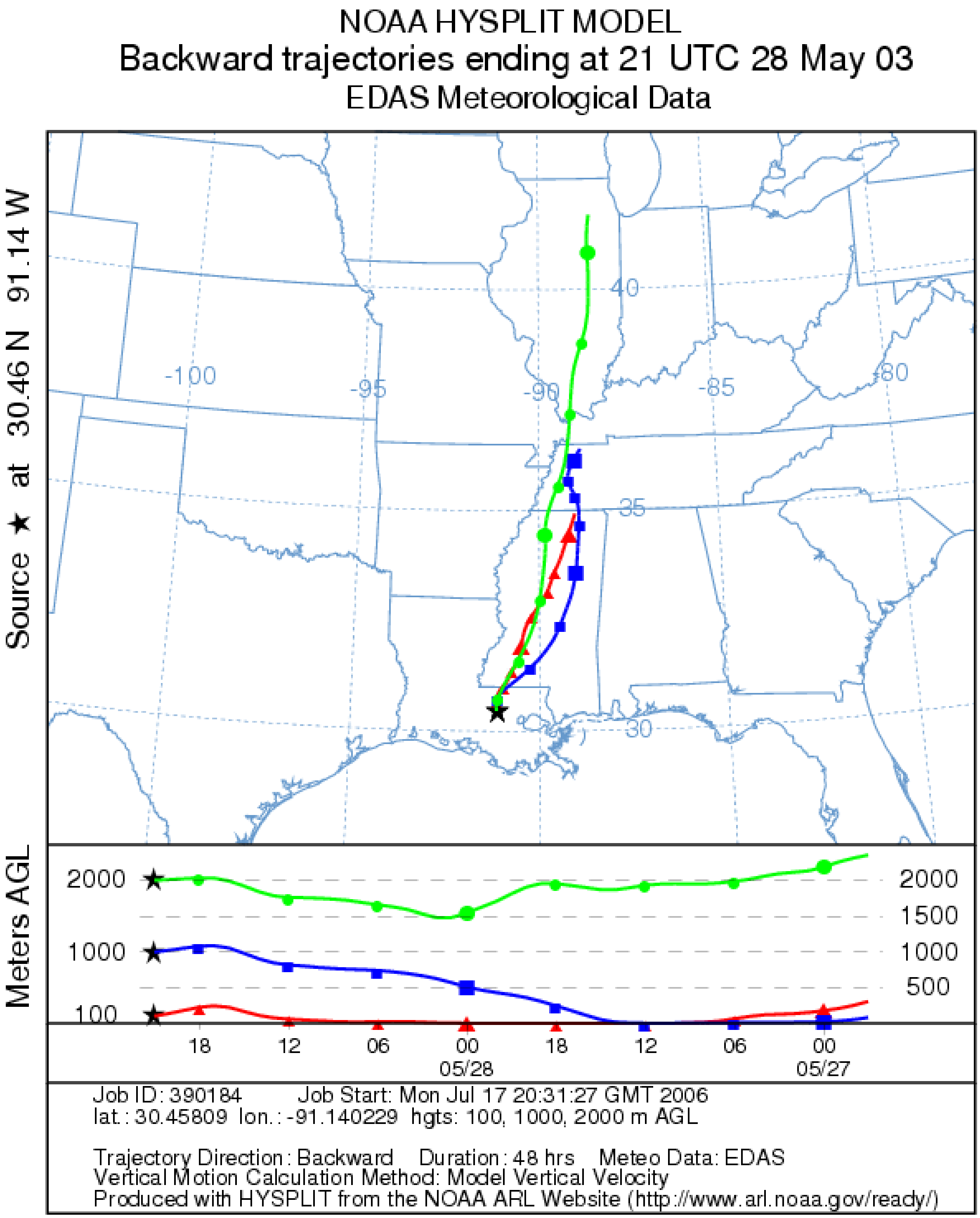


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 24 May 03
EDAS Meteorological Data



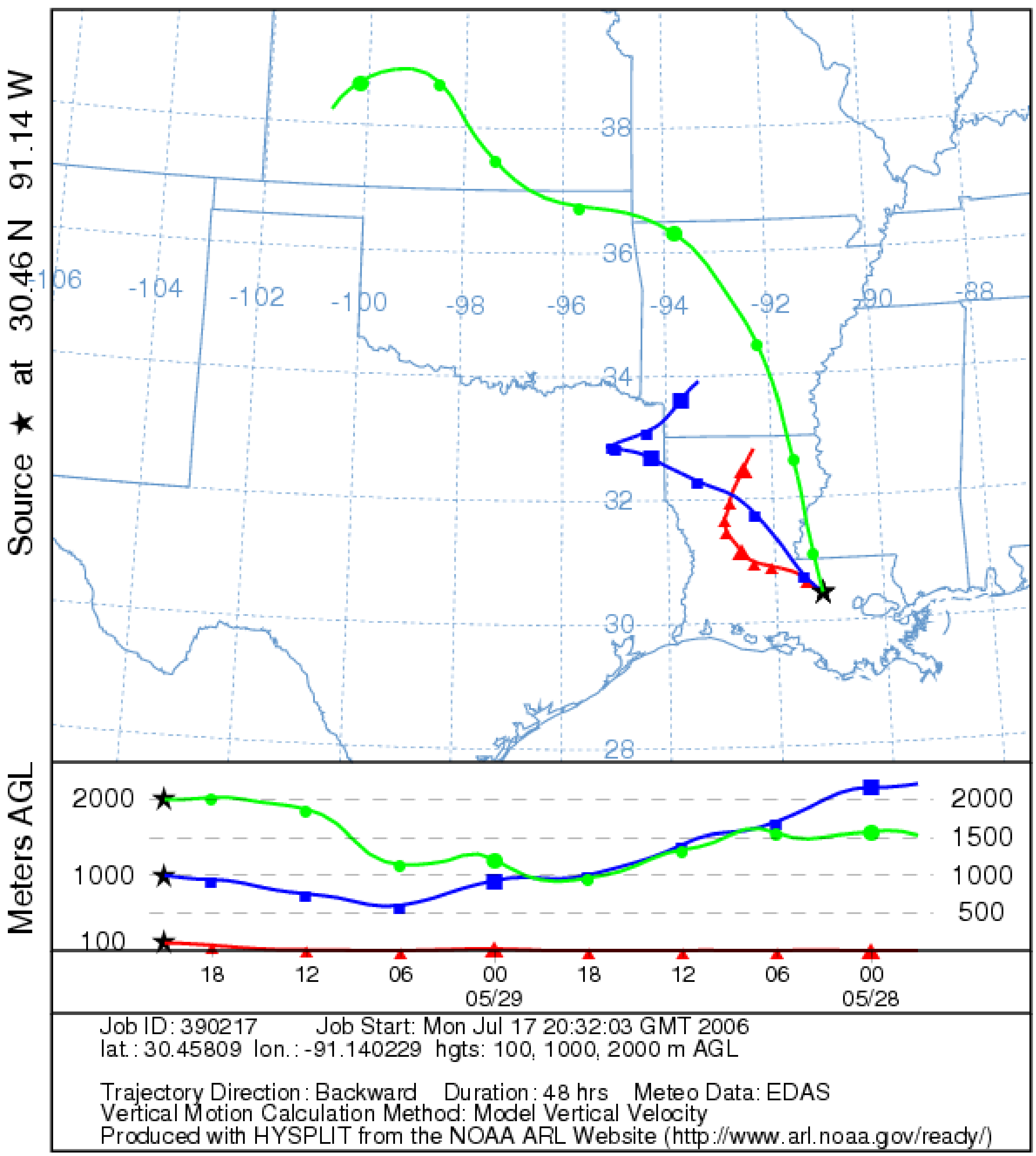
Job ID: 390166 Job Start: Mon Jul 17 20:30:47 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

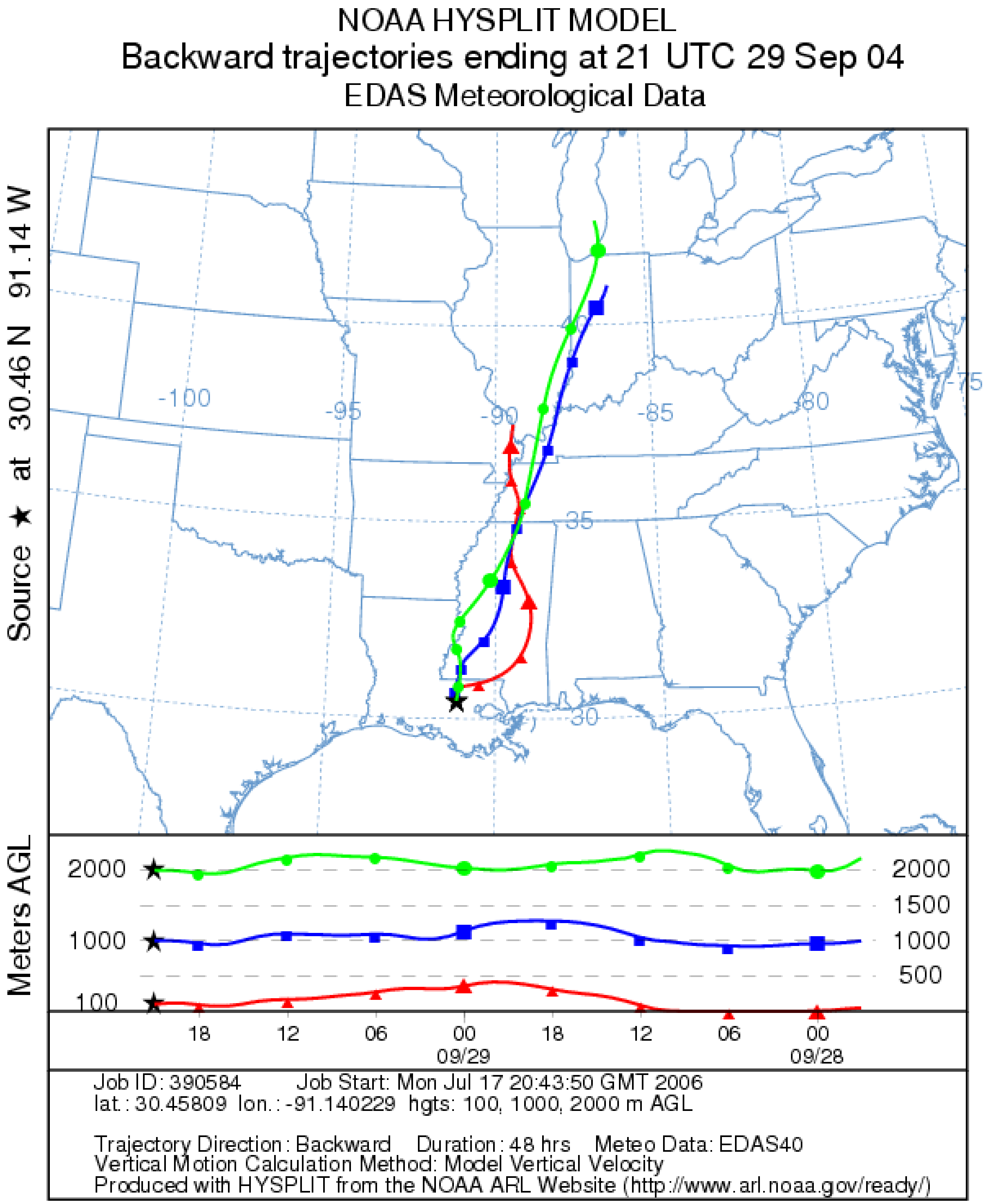


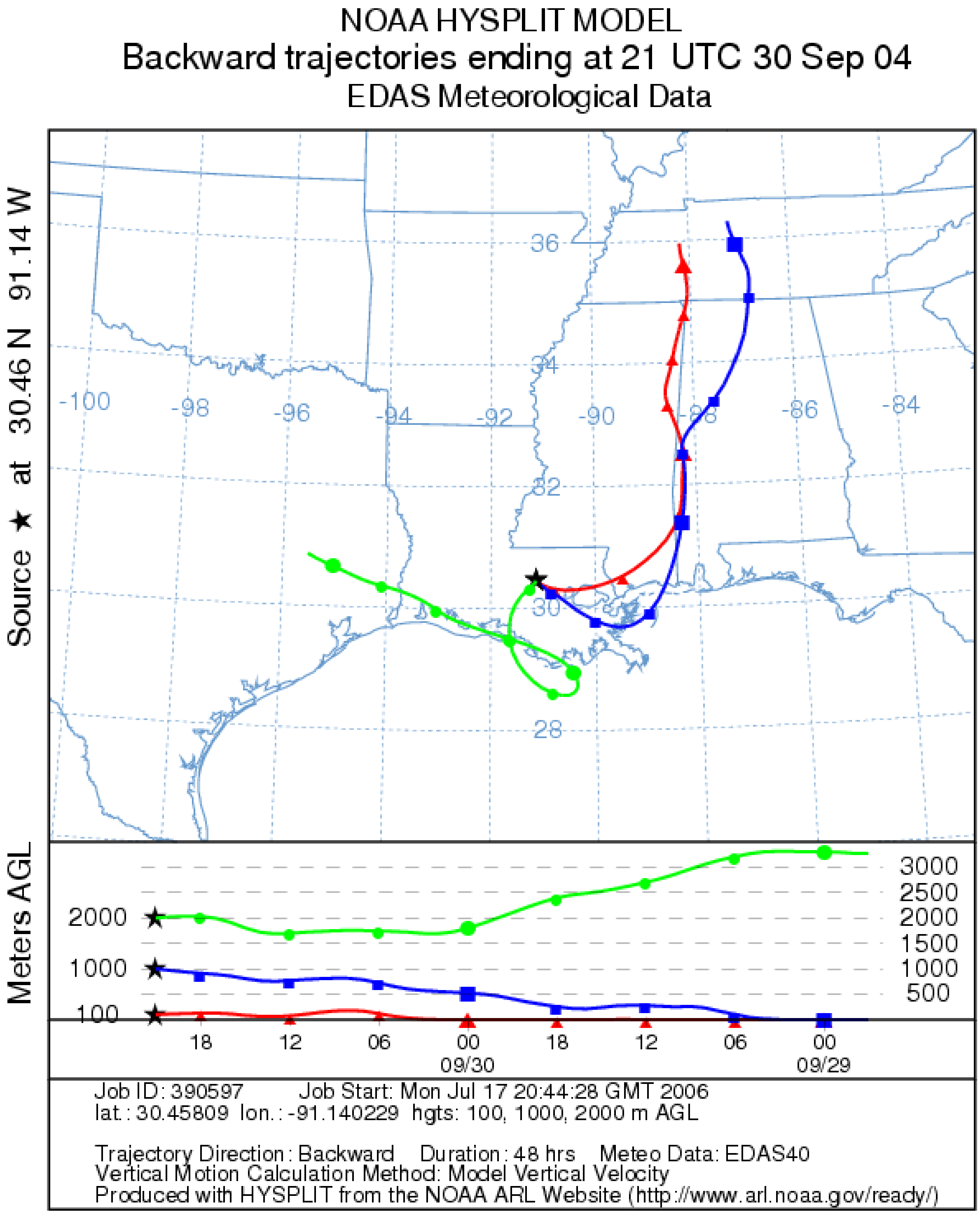
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 28 May 03
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-100
-95
-90
-85
-80
40
35
30
Meters AGL
2000
1500
1000
500
100
18
12
06
00
05/28
18
12
06
00
05/27
Job ID: 390184 Job Start: Mon Jul 17 20:31:27 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 29 May 03
EDAS Meteorological Data

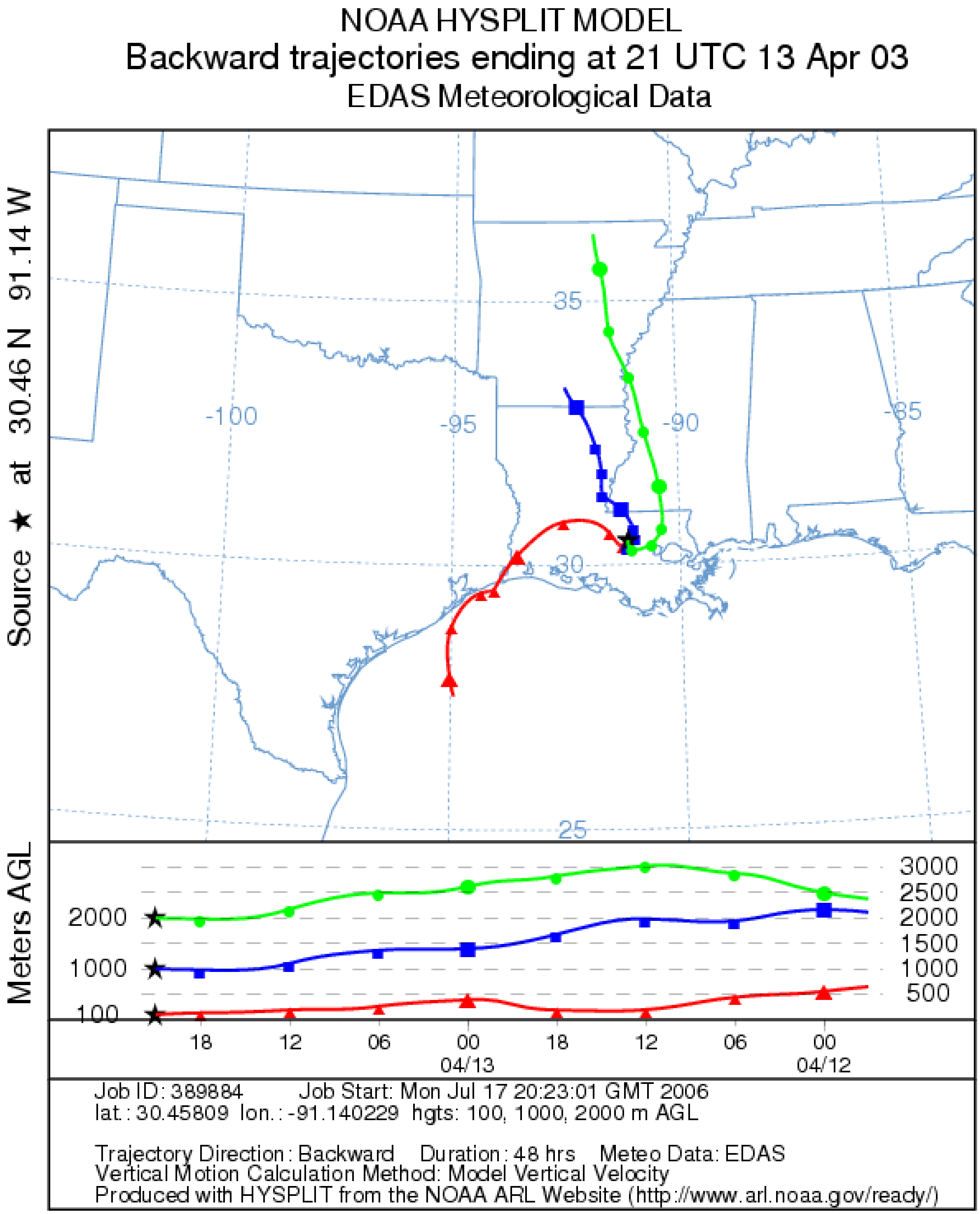


September 28-30, 2004

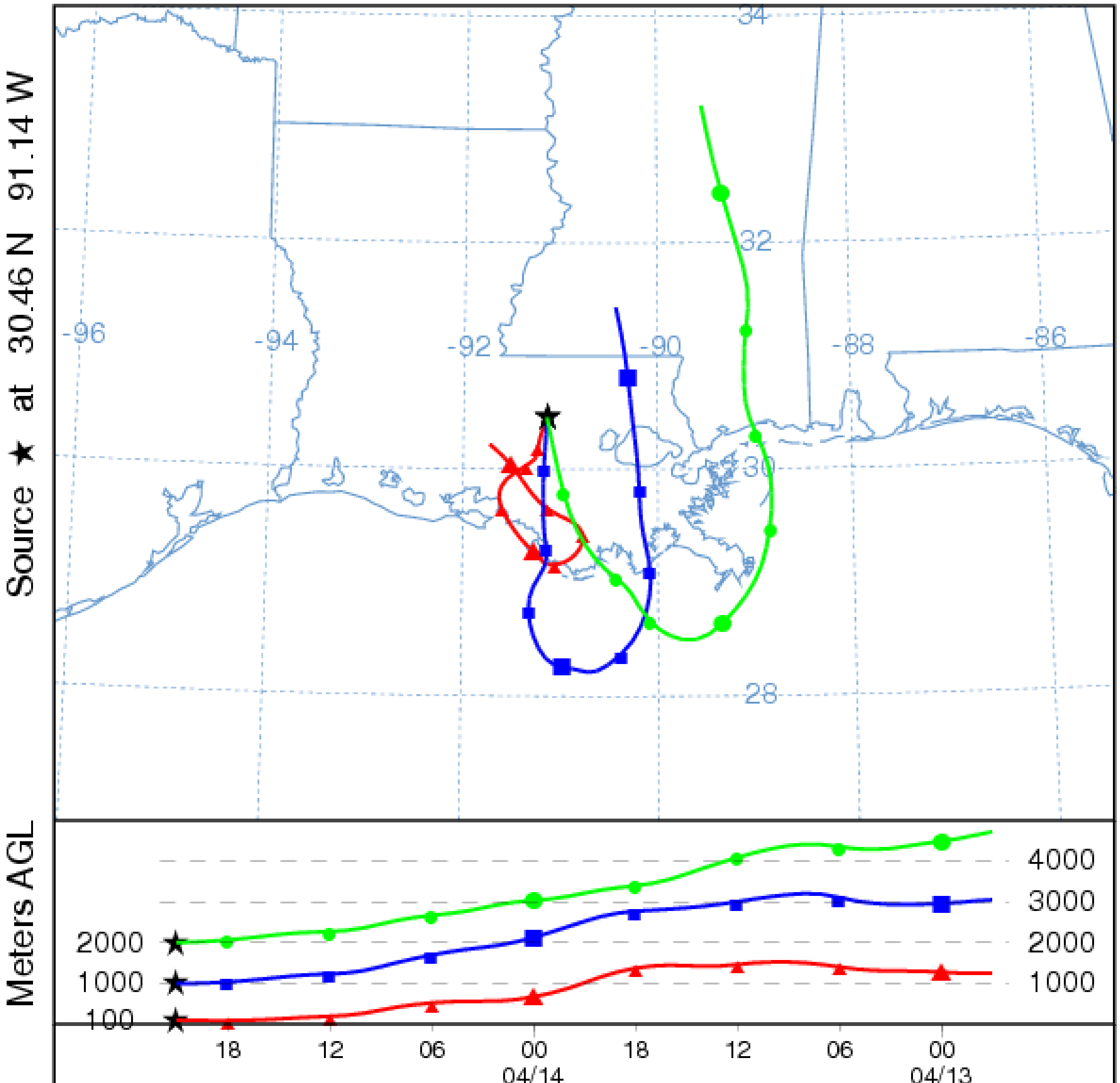



NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 30 Sep 04
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
Meters AGL
Job ID: 390597 Job Start: Mon Jul 17 20:44:28 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

April 12-30, 2003



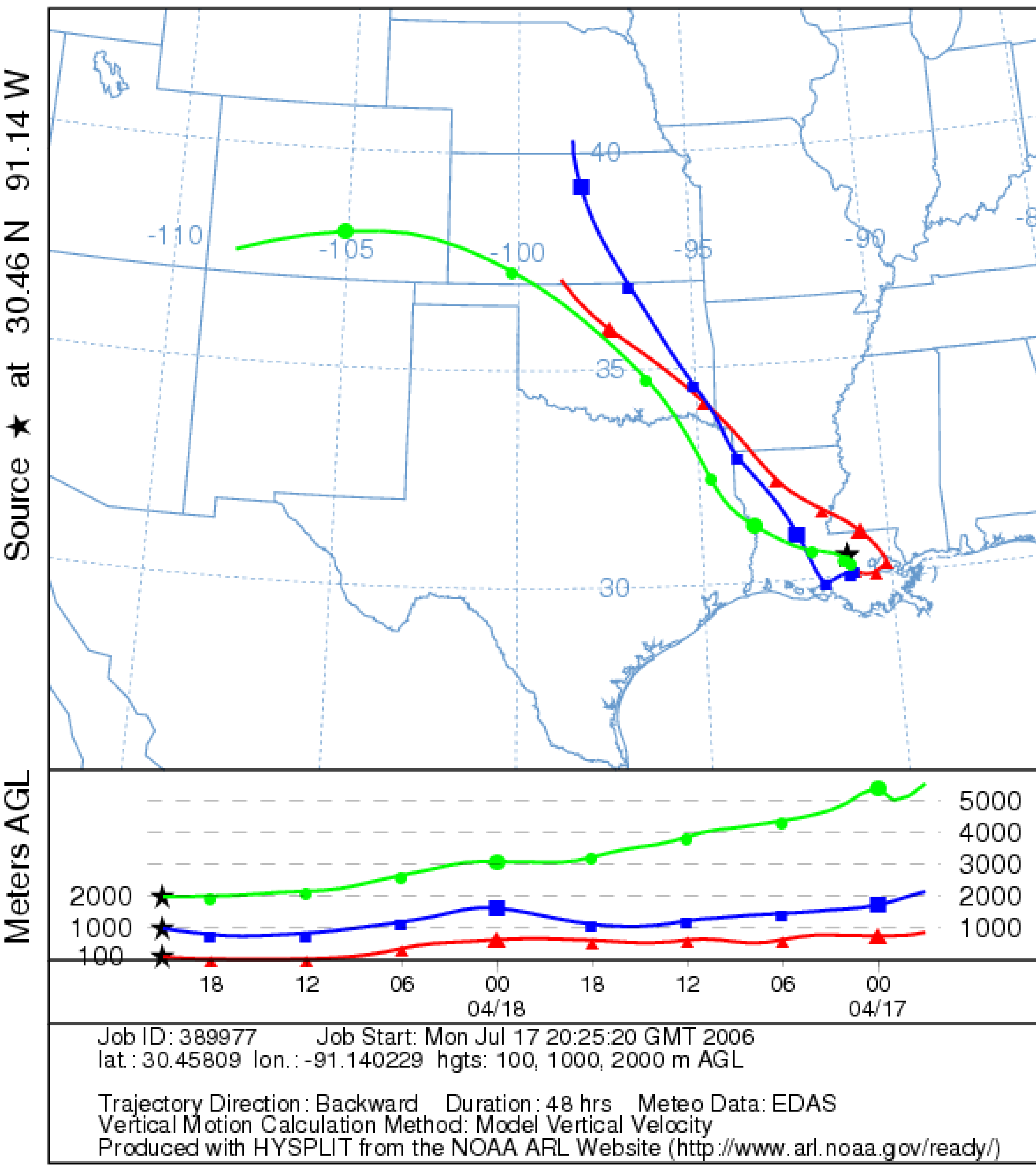
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 14 Apr 03
EDAS Meteorological Data

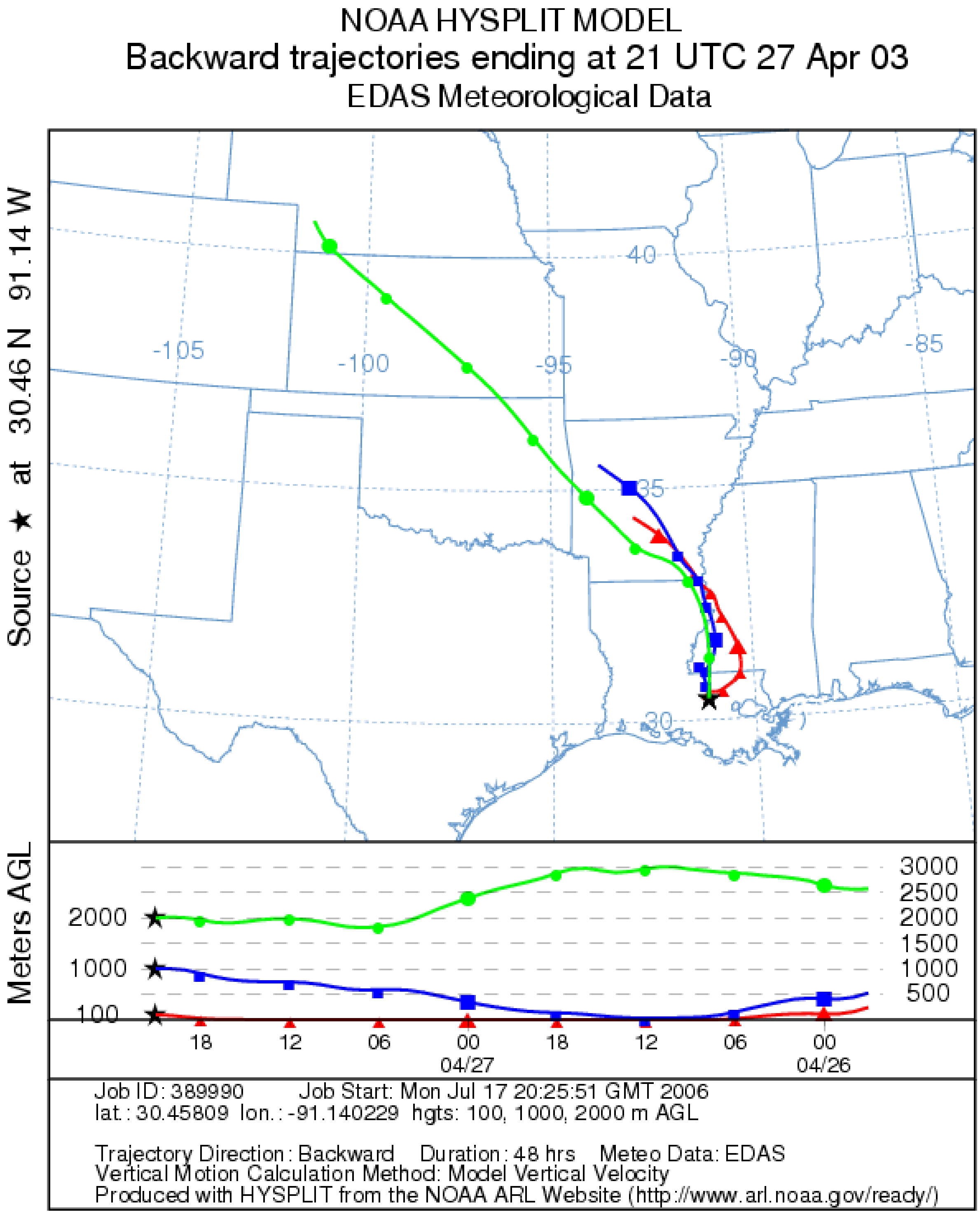


Job ID: 389918 Job Start: Mon Jul 17 20:23:34 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

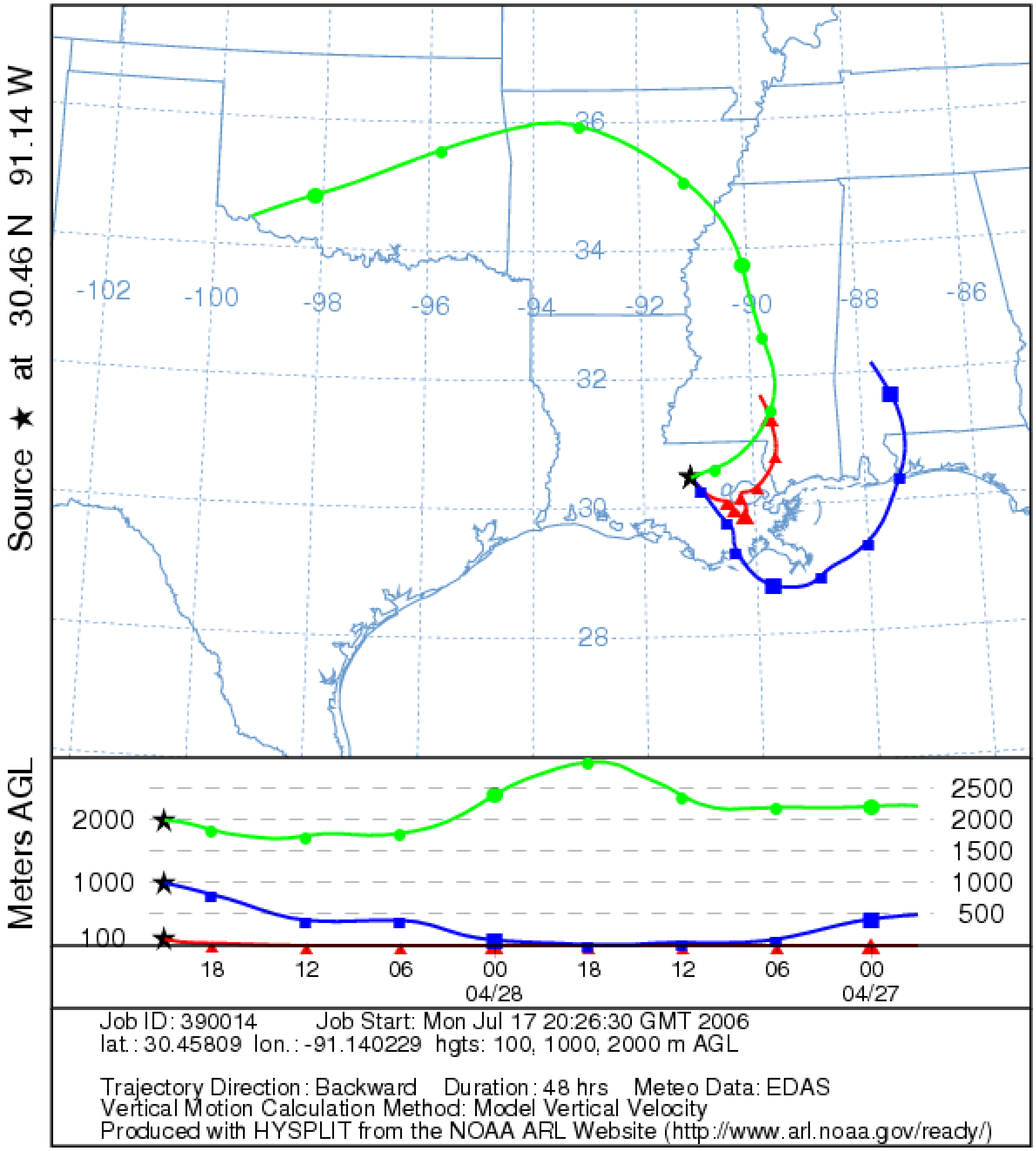
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

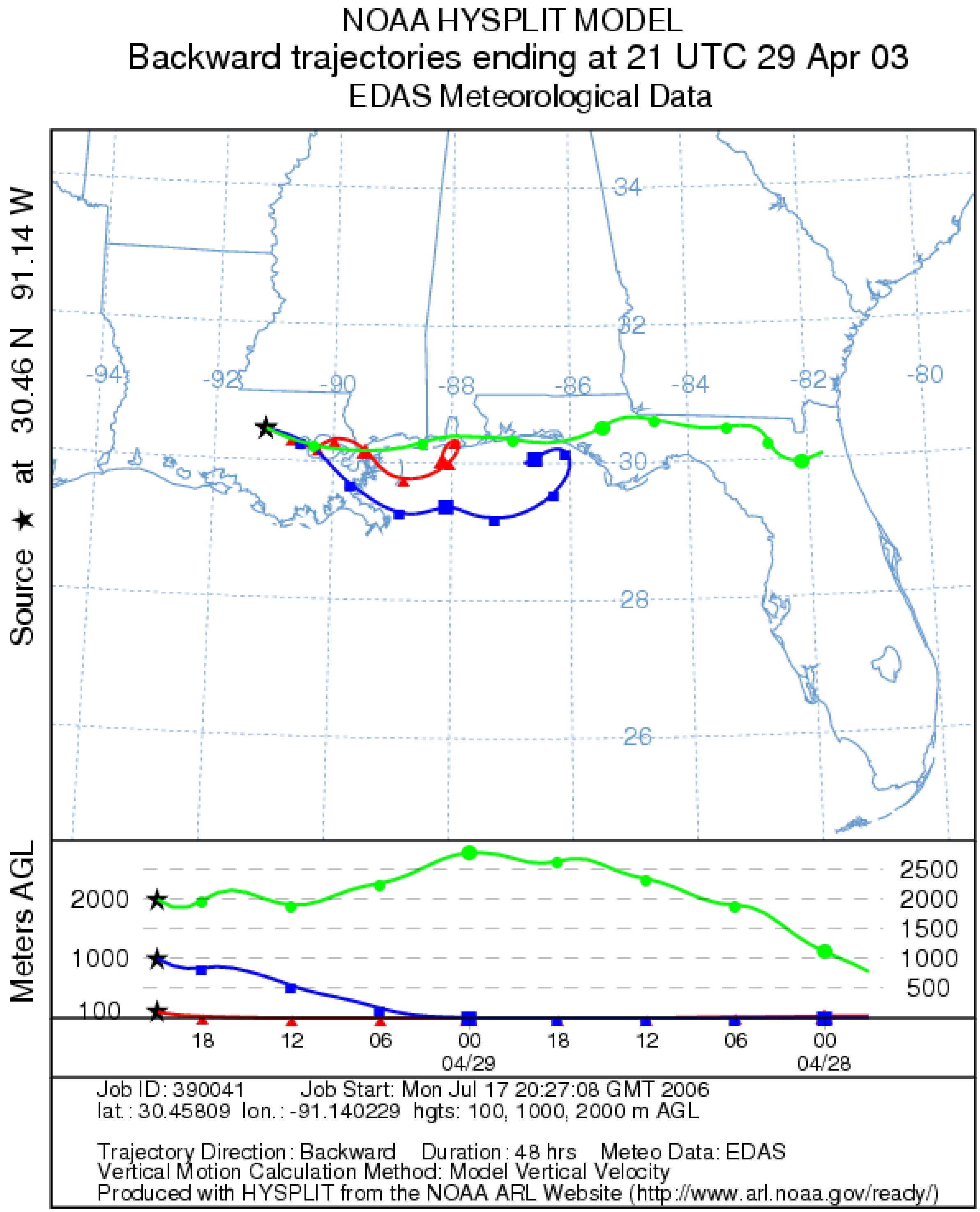
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 18 Apr 03
EDAS Meteorological Data



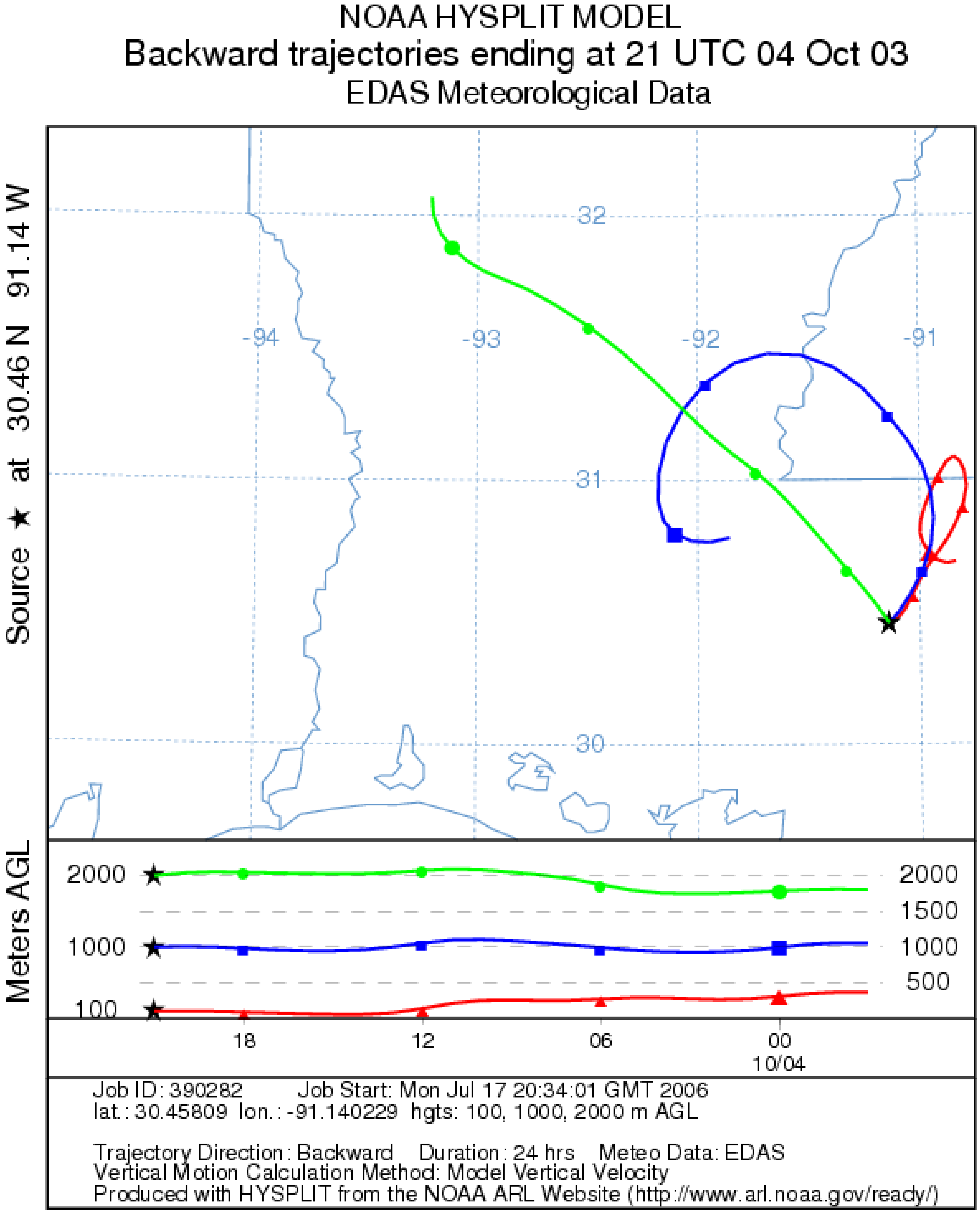

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 27 Apr 03
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-105
-100
-95
-90
-85
40
35
30
Meters AGL
3000
2500
2000
1500
1000
500
100
18
12
06
00
04/27
04/26
Job ID: 389990 Job Start: Mon Jul 17 20:25:51 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

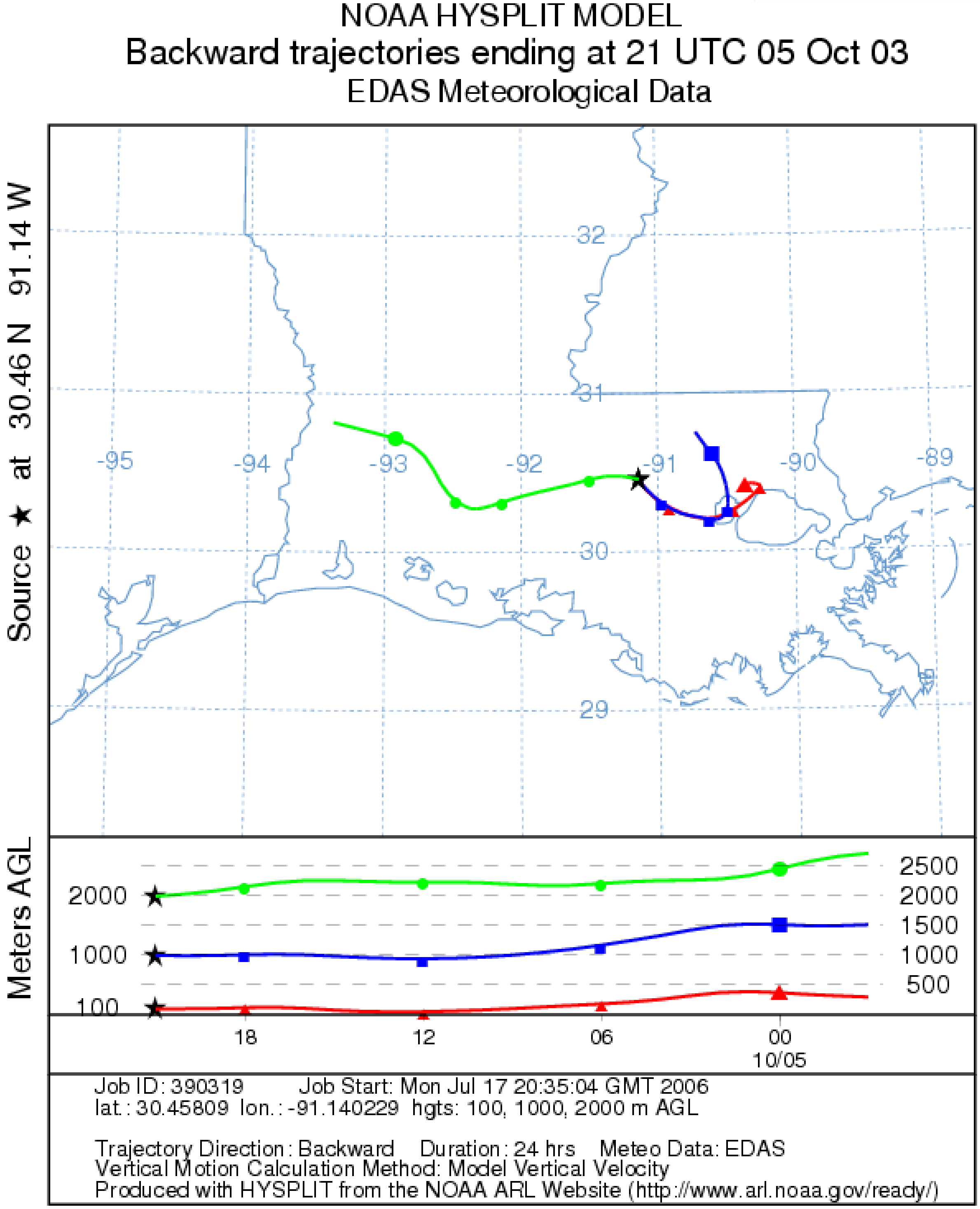
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 28 Apr 03
EDAS Meteorological Data




NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 29 Apr 03
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
34
32
30
28
26
-94
-92
-90
-88
-86
-84
-82
-80
Meters AGL
2000
1000
100
2500
2000
1500
1000
500
18
12
06
00
04/29
18
12
06
00
04/28
Job ID: 390041 Job Start: Mon Jul 17 20:27:08 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

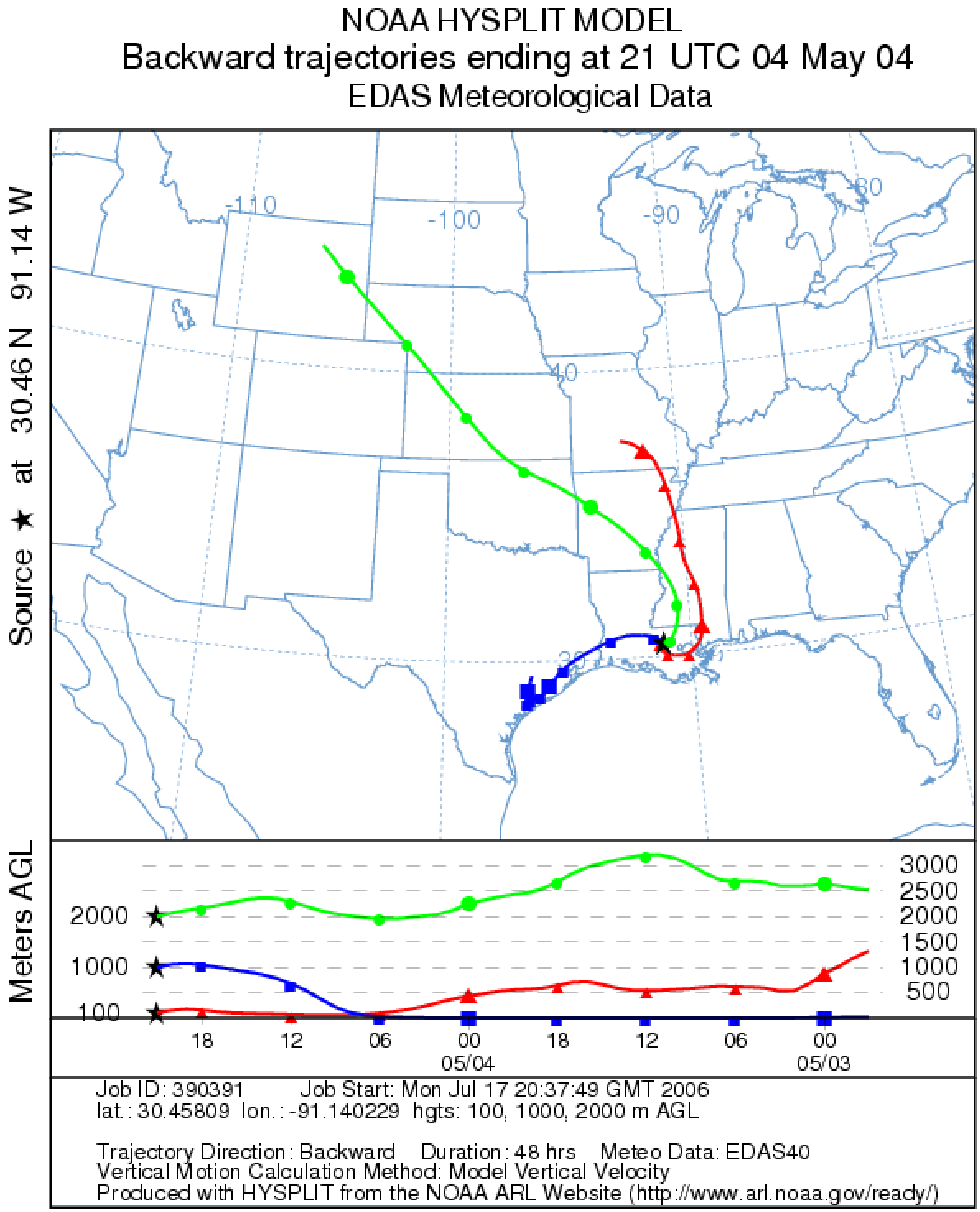
October 4-6, 2003

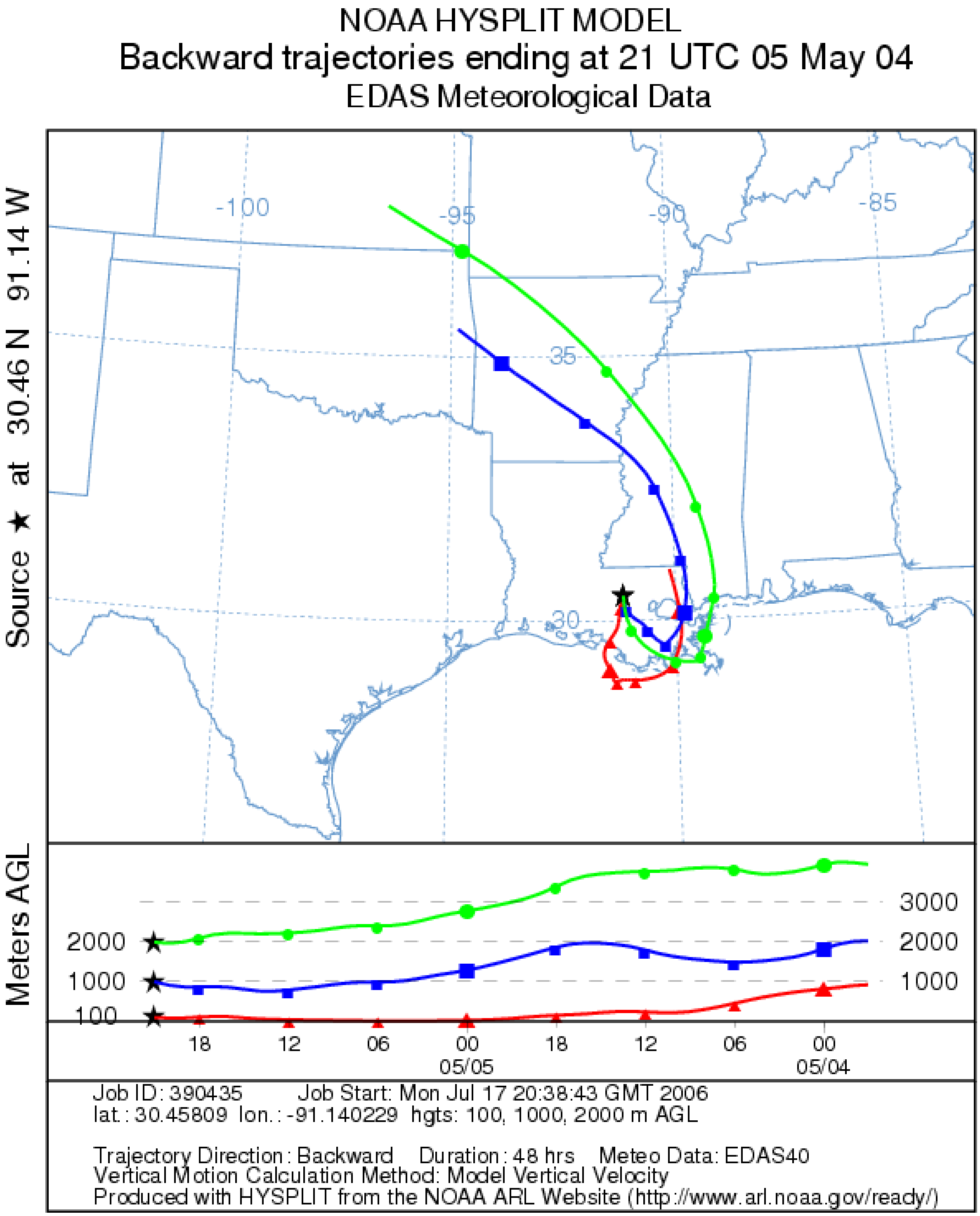


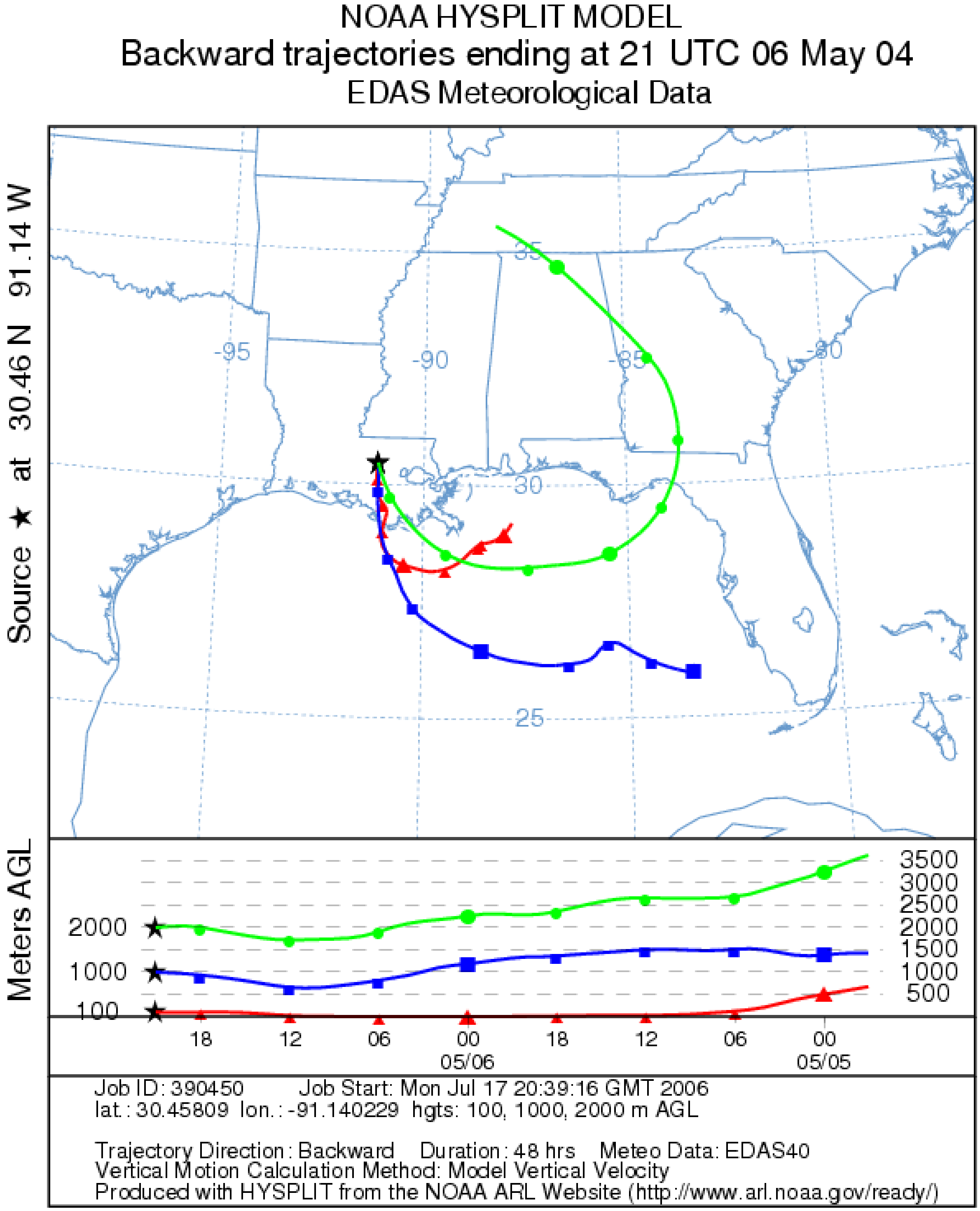


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 05 Oct 03
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
32
31
30
29
-95
-94
-93
-92
-91
-90
-89
Meters AGL
2000
1000
100
2500
2000
1500
1000
500
18
12
06
00
10/05
Job ID: 390319 Job Start: Mon Jul 17 20:35:04 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 24 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

May 4-9, 2004

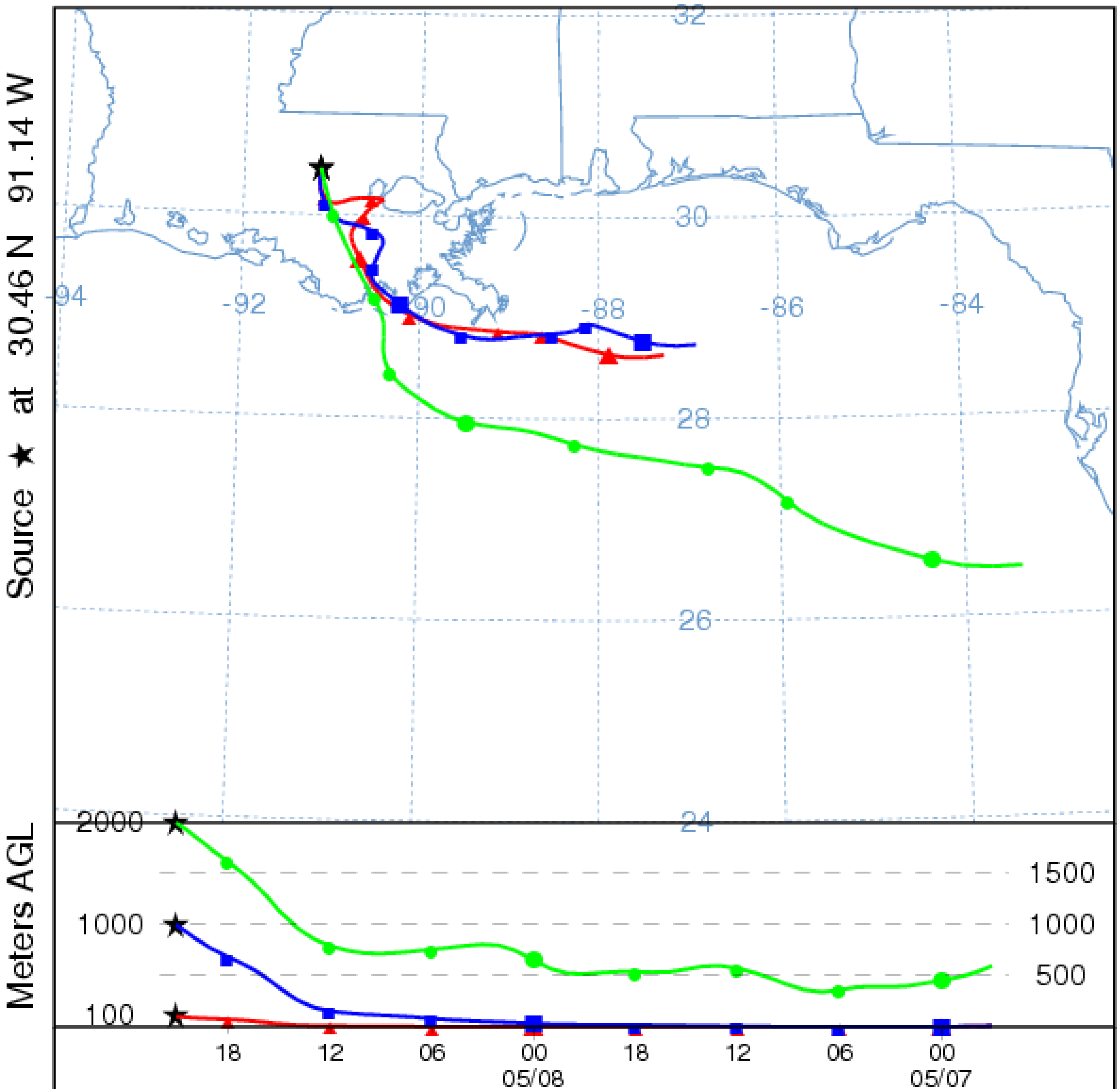

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 04 May 04
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-110
-100
-90
-80
40
30
Meters AGL
2000
1000
100
3000
2500
2000
1500
1000
500
18
12
06
00
05/04
18
12
06
00
05/03
Job ID: 390391 Job Start: Mon Jul 17 20:37:49 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 05 May 04
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-100
-95
-90
-85
35
30
Meters AGL
3000
2000
1000
100
18
12
06
00
05/05
05/04
Job ID: 390435 Job Start: Mon Jul 17 20:38:43 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)



NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 06 May 04
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-95
-90
-85
-80
35
30
25
Meters AGL
2000
1000
100
3500
3000
2500
2000
1500
1000
500
18
12
06
00
05/06
18
12
06
00
05/05
Job ID: 390450 Job Start: Mon Jul 17 20:39:16 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

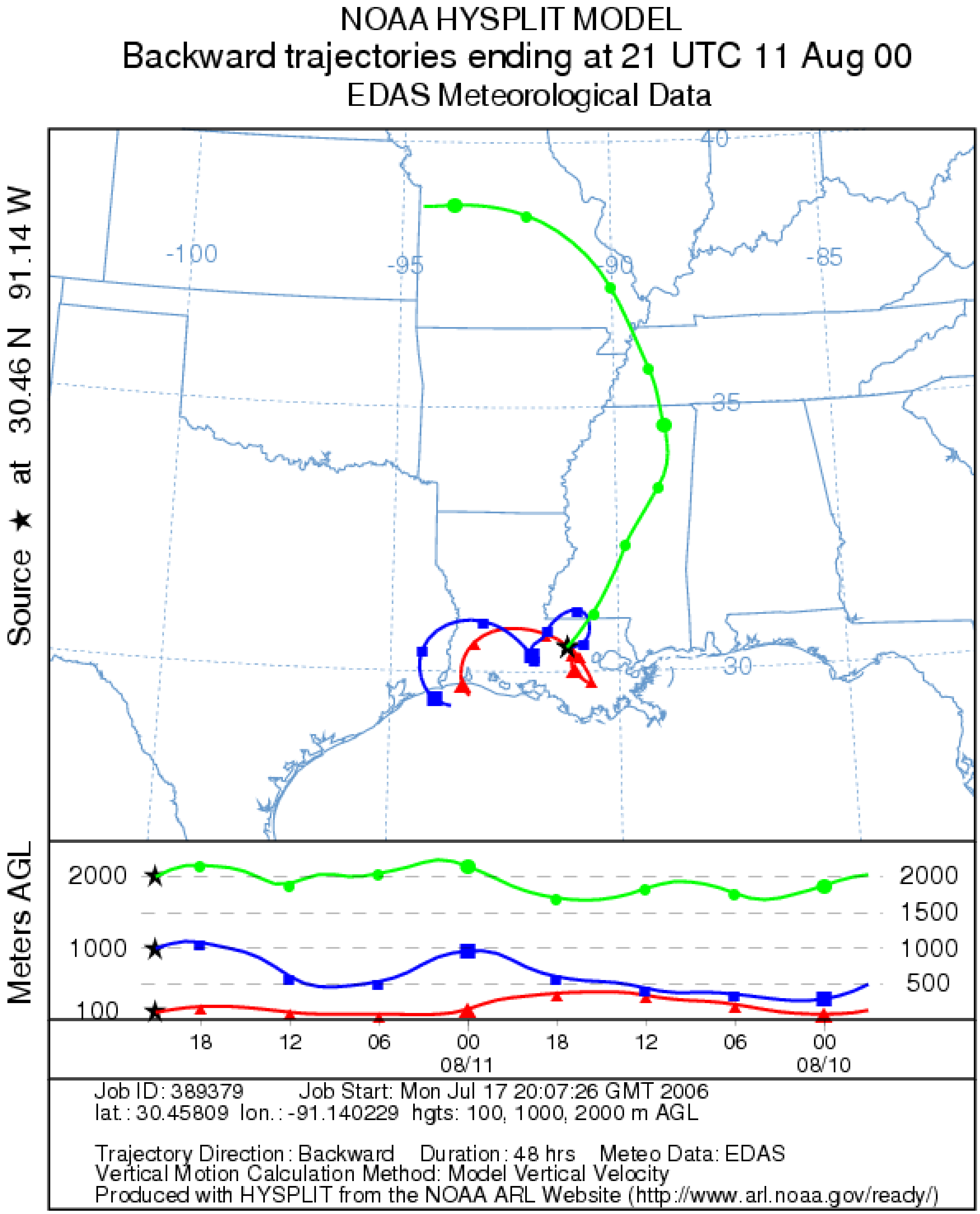
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 08 May 04
EDAS Meteorological Data

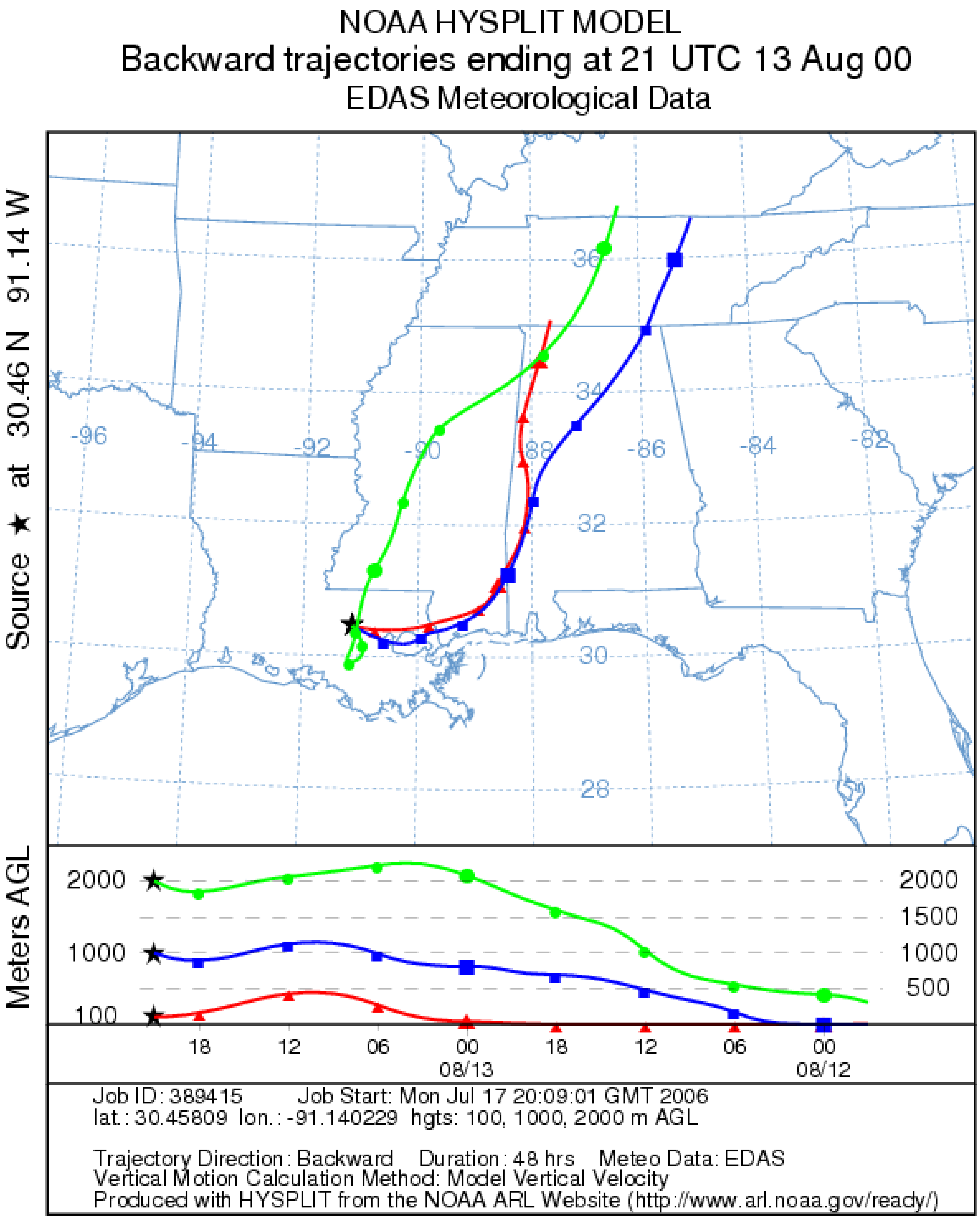


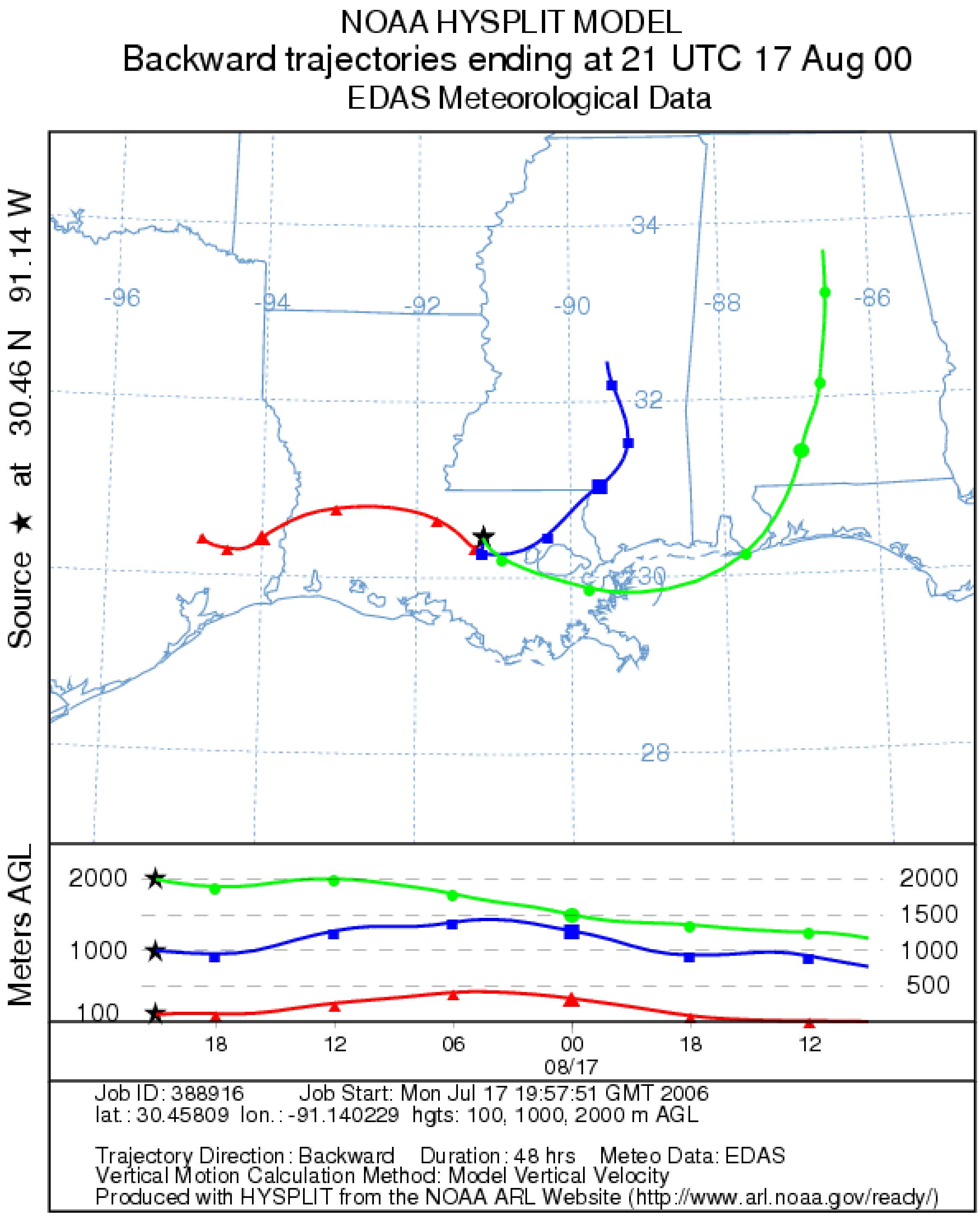
Job ID: 390516 Job Start: Mon Jul 17 20:40:26 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

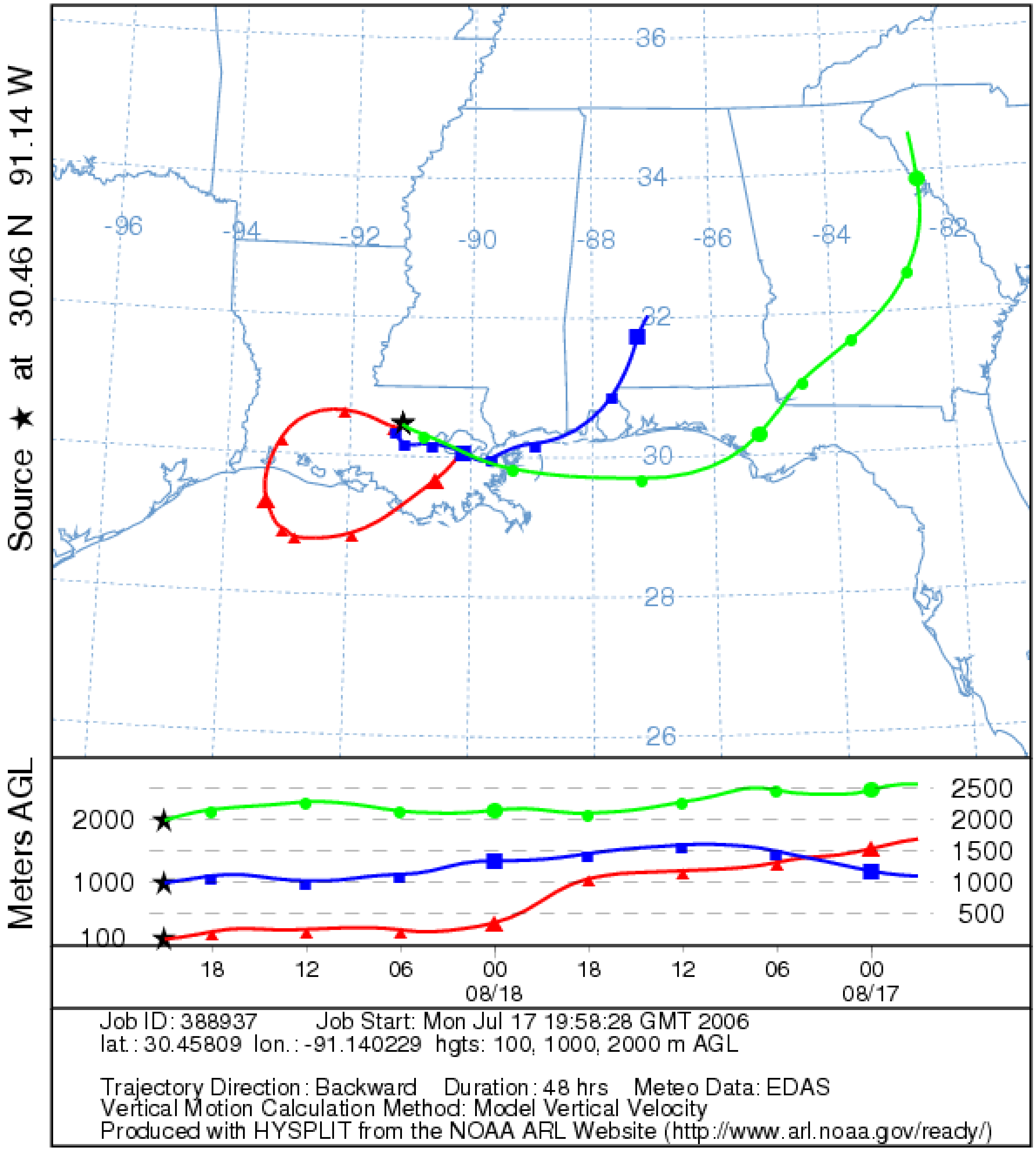
August 11 – September 5, 2000

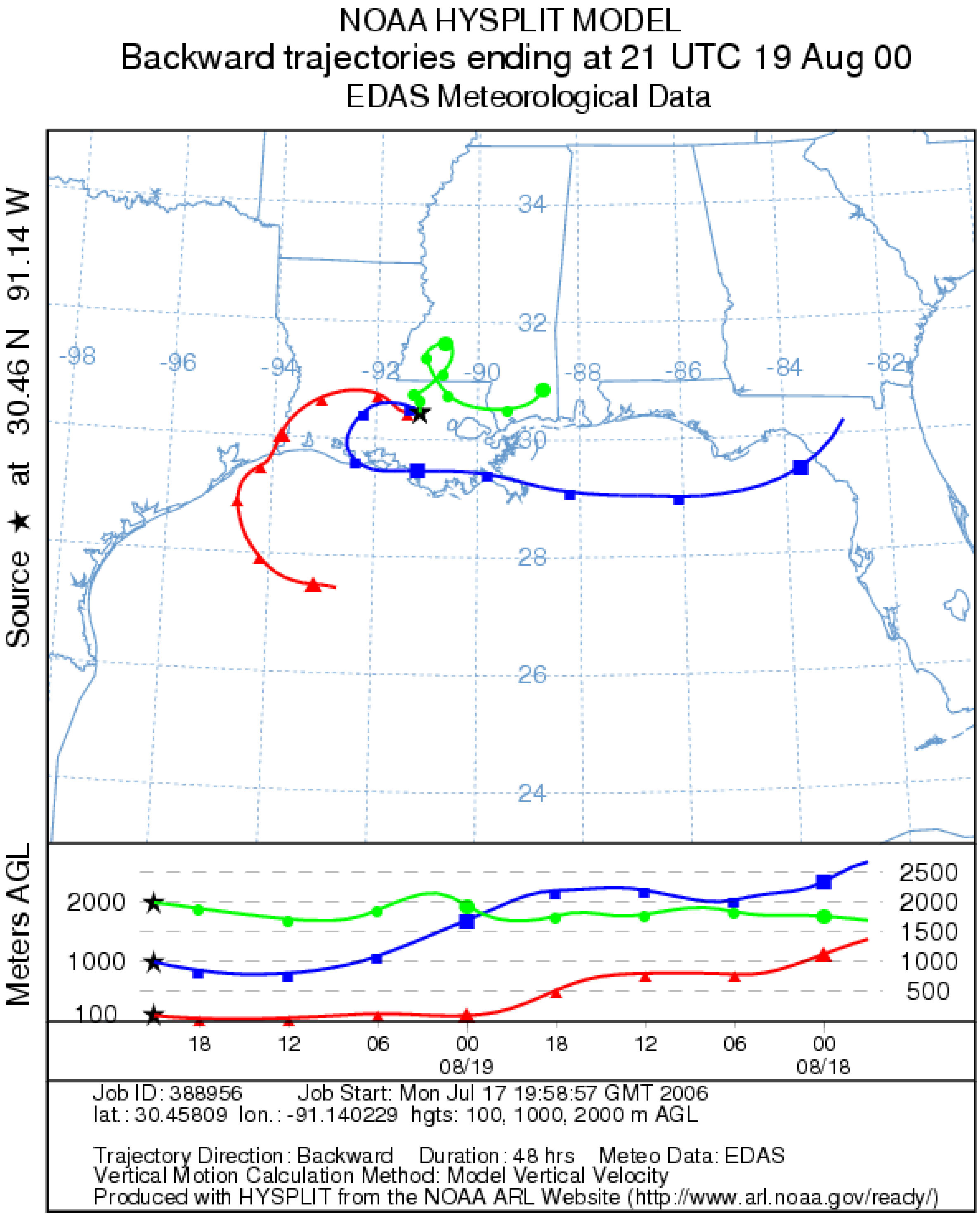



NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 13 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-96
-94
-92
-90
-88
-86
-84
-82
36
34
32
30
28
Meters AGL
2000
1000
100
2000
1500
1000
500
18
12
06
00
08/13
18
12
06
00
08/12
Job ID: 389415 Job Start: Mon Jul 17 20:09:01 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

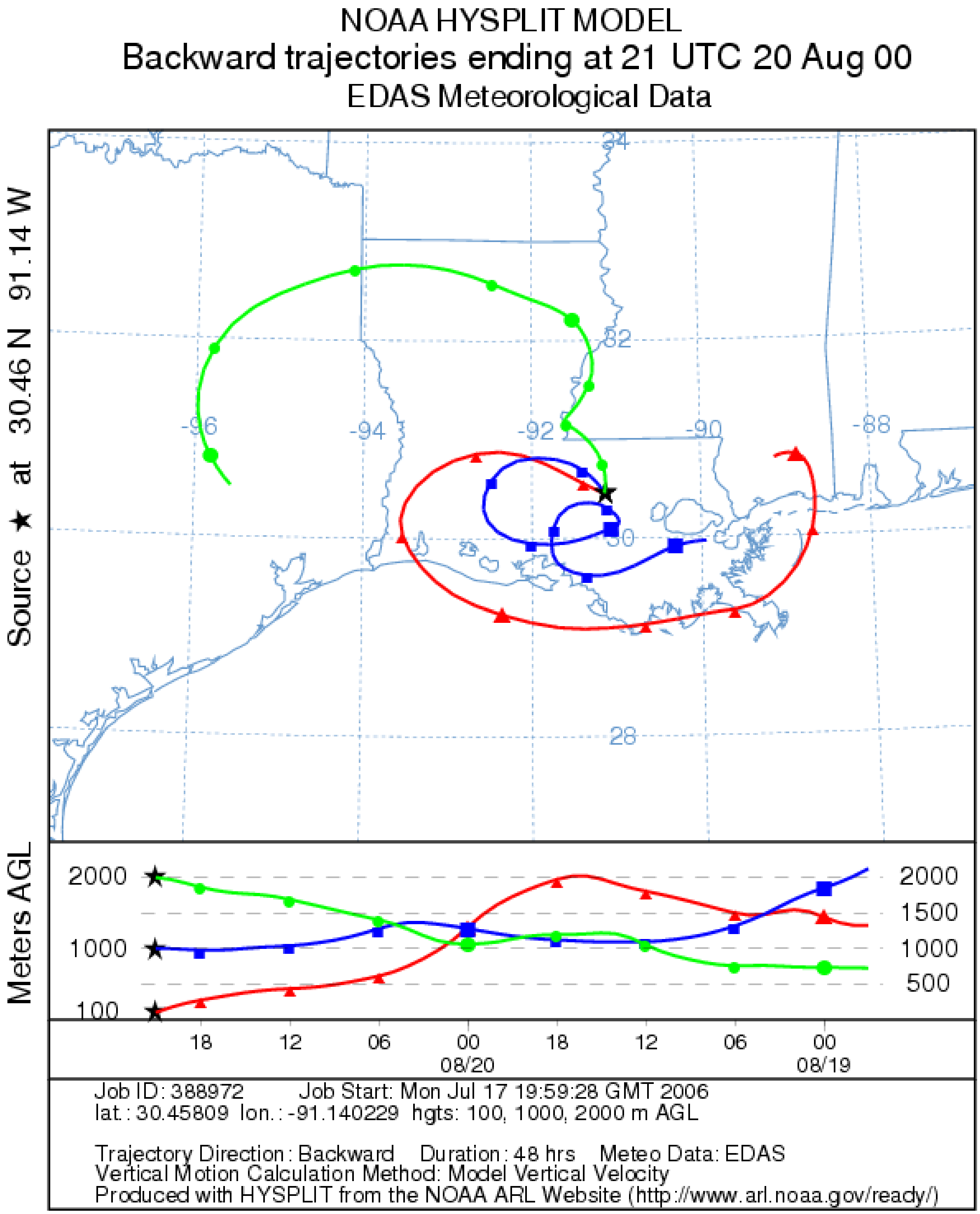

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 17 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-96
-94
-92
-90
-88
-86
34
32
30
28
Meters AGL
2000
1000
100
2000
1500
1000
500
18
12
06
00
08/17
18
12
Job ID: 388916 Job Start: Mon Jul 17 19:57:51 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 18 Aug 00
EDAS Meteorological Data

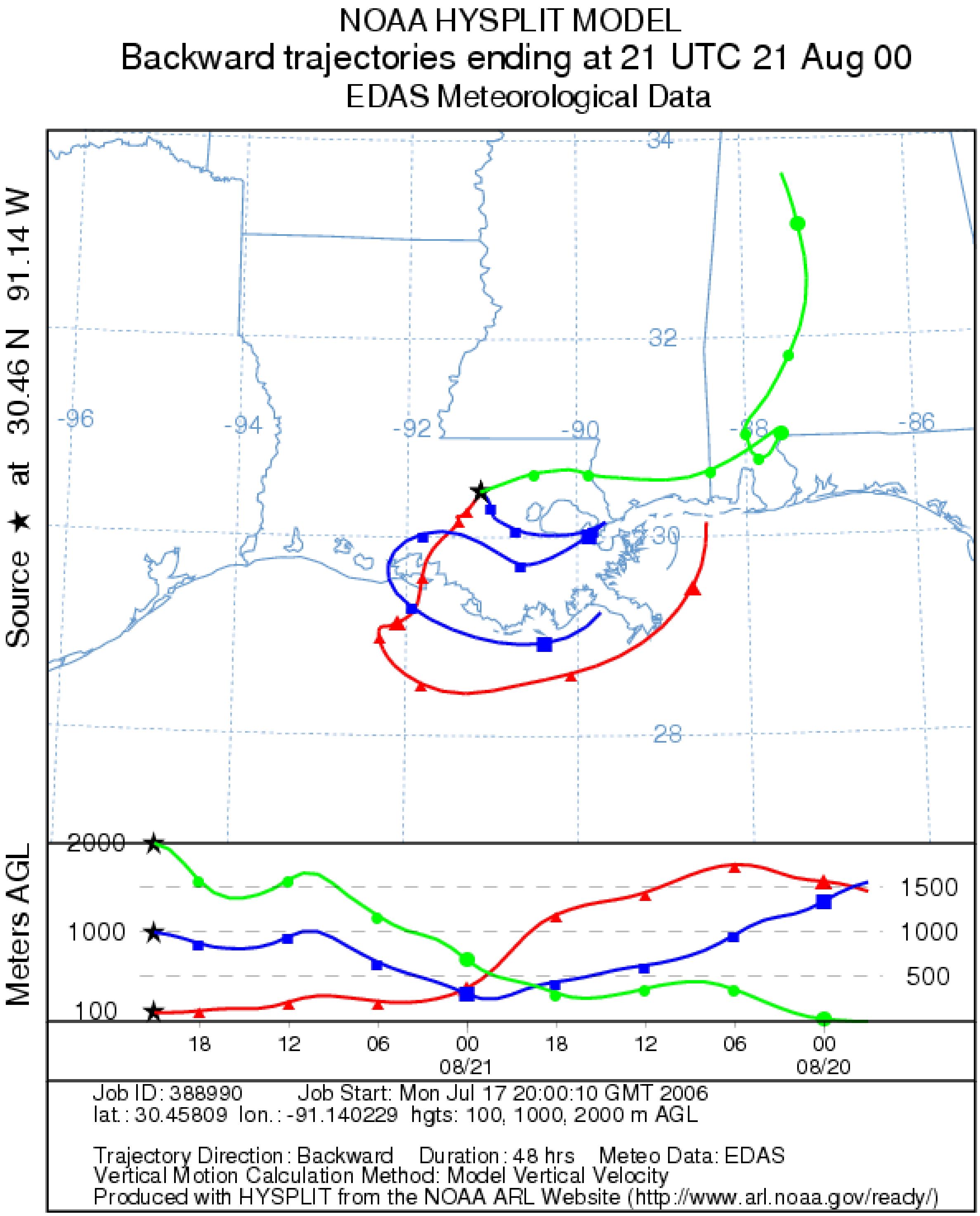




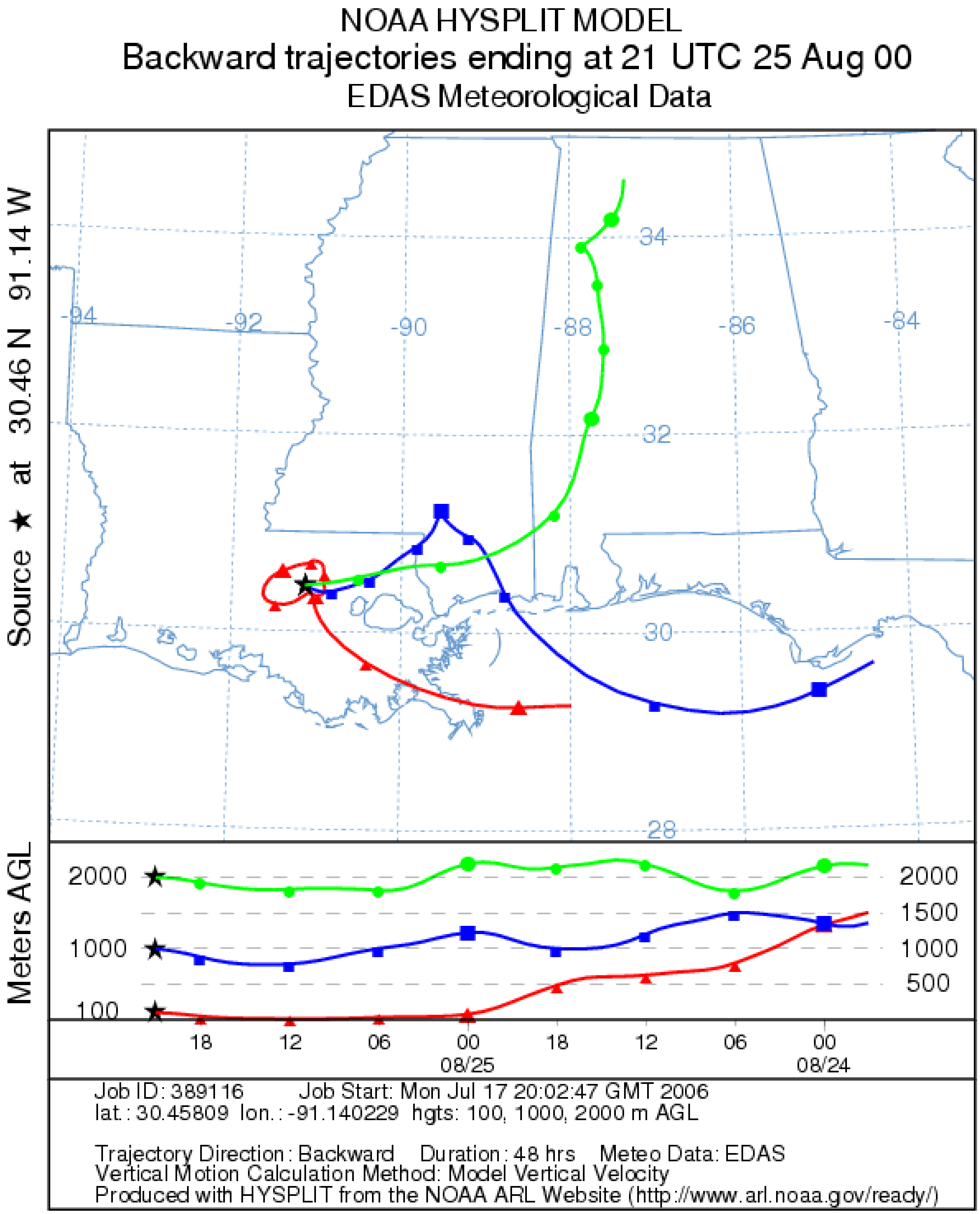
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 19 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
34
32
30
28
26
24
-98
-96
-94
-92
-90
-88
-86
-84
-82
Meters AGL
2000
1000
100
2500
2000
1500
1000
500
18
12
06
00
08/19
18
12
06
00
08/18
Job ID: 388956 Job Start: Mon Jul 17 19:58:57 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)



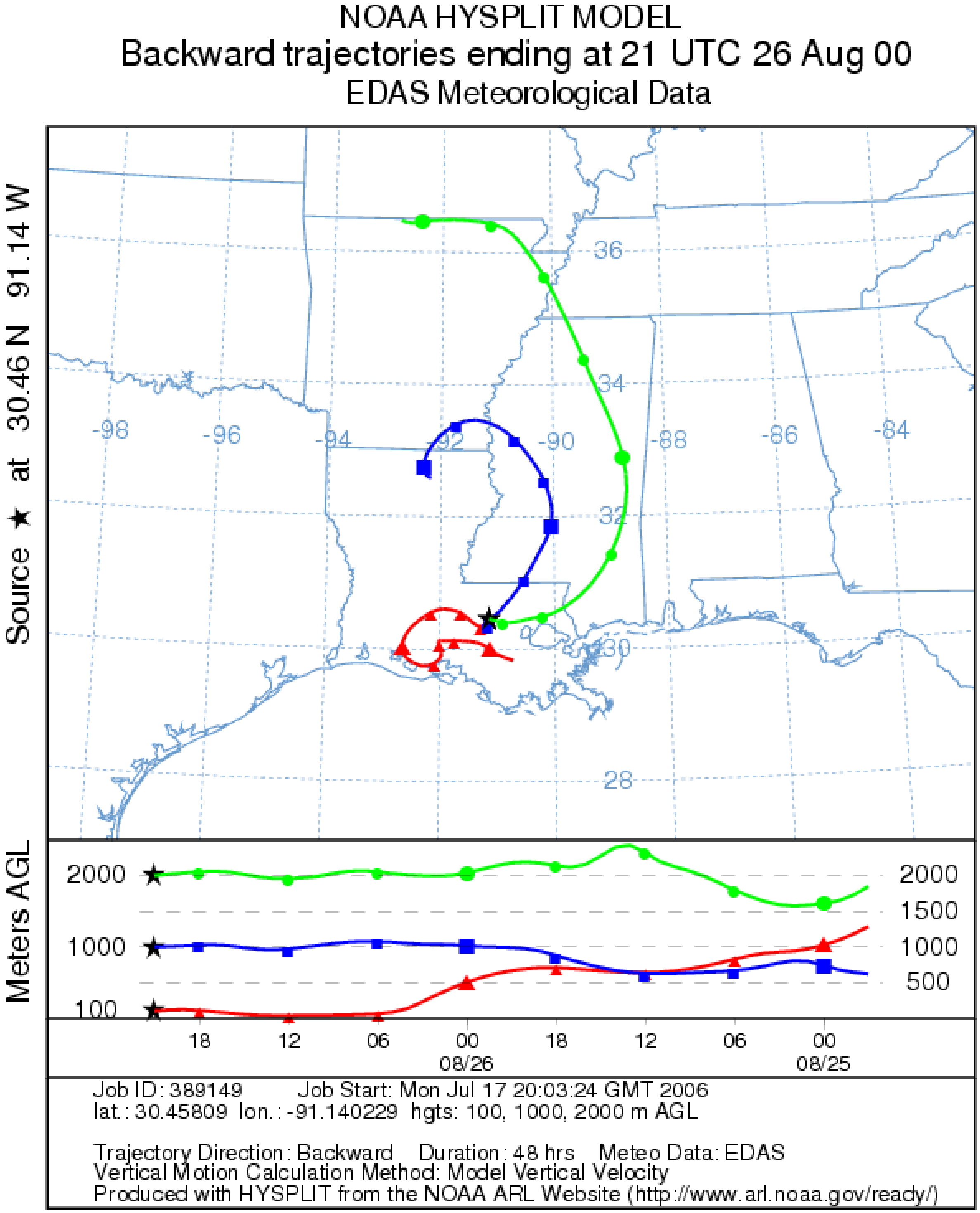
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 20 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
34
32
30
28
-96
-94
-92
-90
-88
Meters AGL
2000
1000
100
2000
1500
1000
500
18
12
06
00
08/20
18
12
06
00
08/19
Job ID: 388972 Job Start: Mon Jul 17 19:59:28 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)



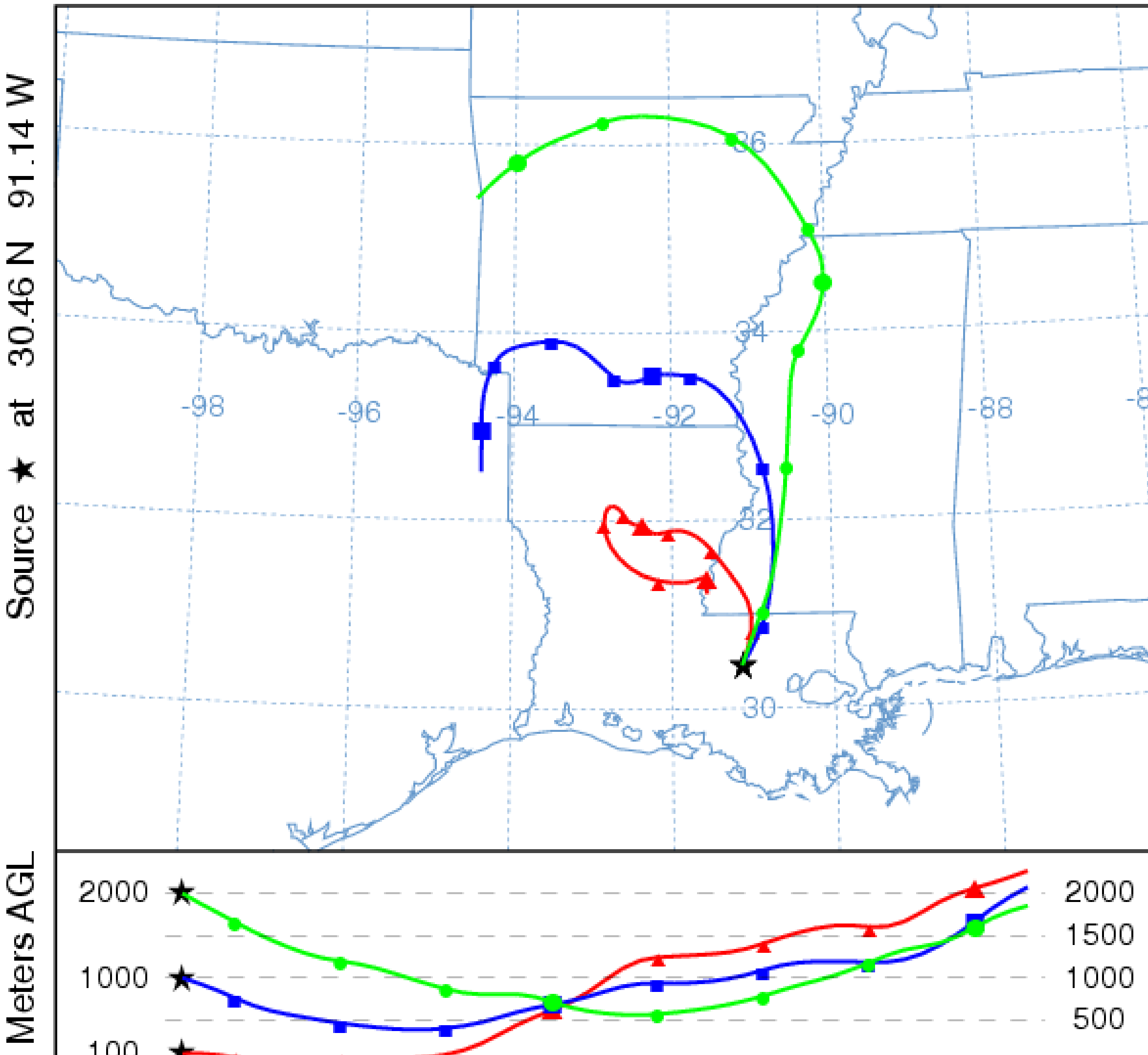
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 21 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
34
32
30
28
-96
-94
-92
-90
-88
-86
Meters AGL
2000
1000
100
1500
1000
500
18
12
06
00
08/21
18
12
06
00
08/20
Job ID: 388990 Job Start: Mon Jul 17 20:00:10 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)



NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 25 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
-94
-92
-90
-88
-86
-84
34
32
30
28
Meters AGL
2000
1500
1000
500
100
18
12
06
00
08/25
18
12
06
00
08/24
Job ID: 389116 Job Start: Mon Jul 17 20:02:47 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 26 Aug 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
Meters AGL
2000
1000
100
1500
500
18
12
06
00
08/26
08/25
-98
-96
-94
-92
-90
-88
-86
-84
36
34
32
30
28
Job ID: 389149 Job Start: Mon Jul 17 20:03:24 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

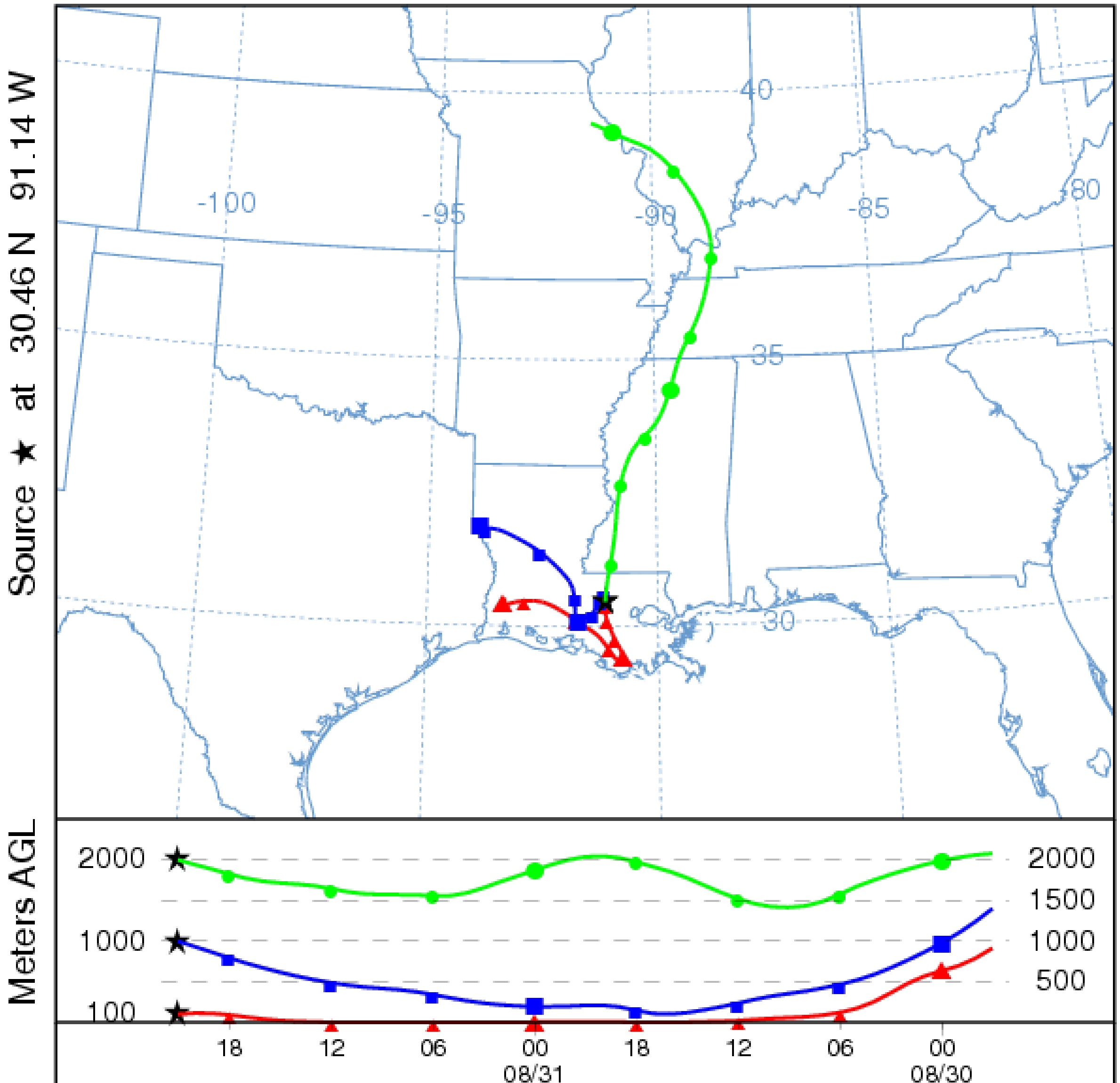
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 30 Aug 00
EDAS Meteorological Data



Job ID: 389314 Job Start: Mon Jul 17 20:05:45 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

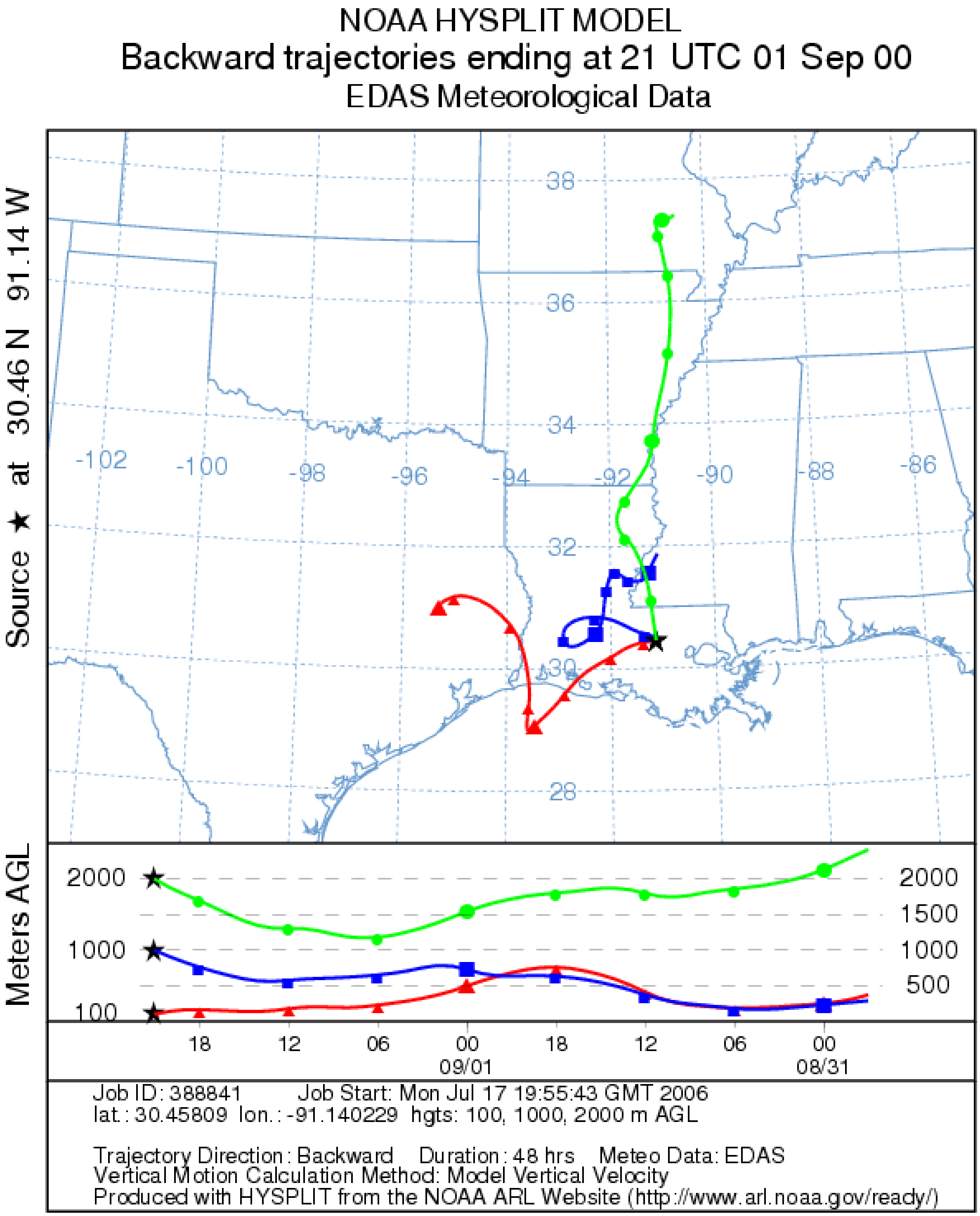
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 31 Aug 00
EDAS Meteorological Data

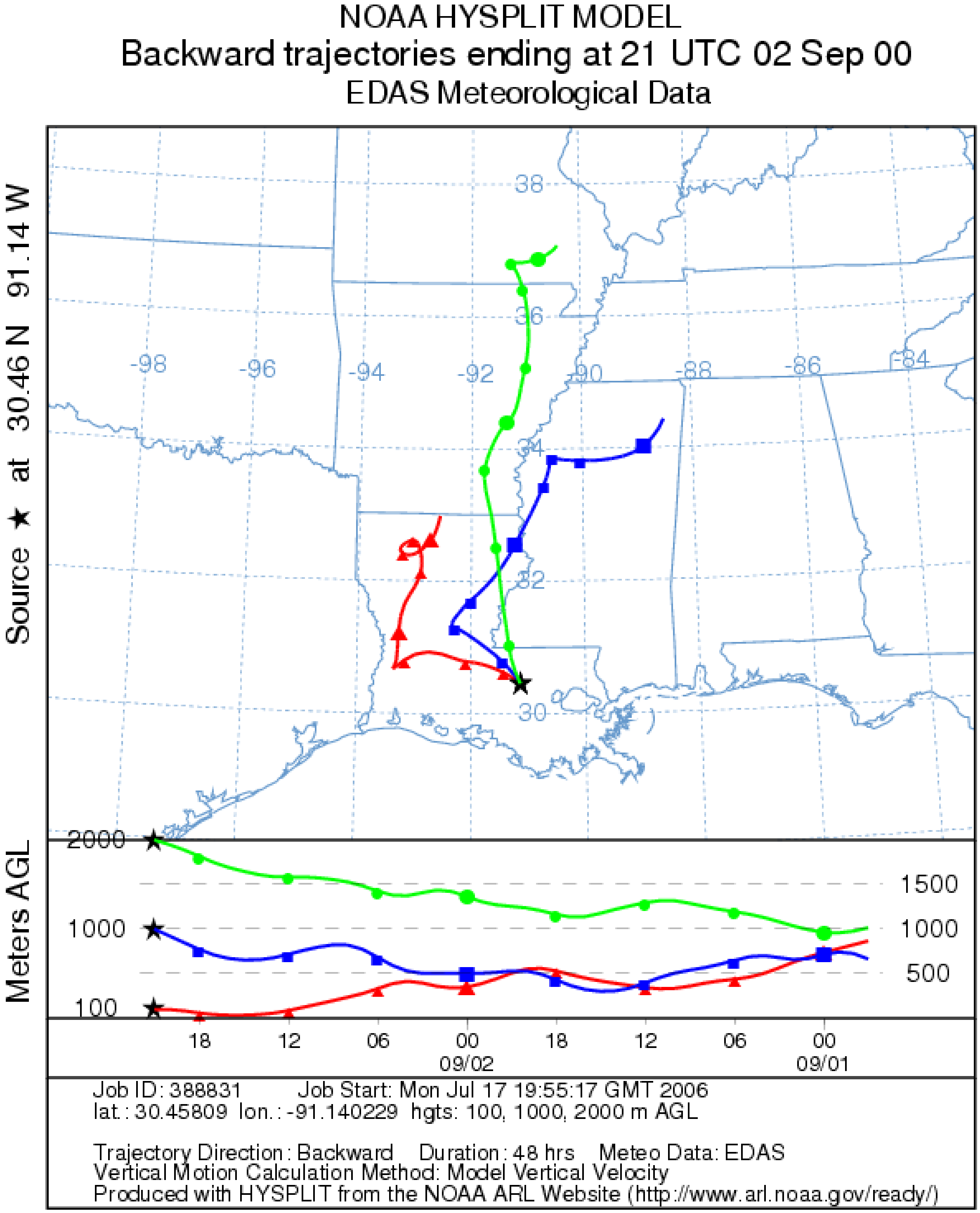


Job ID: 389348 Job Start: Mon Jul 17 20:06:15 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)



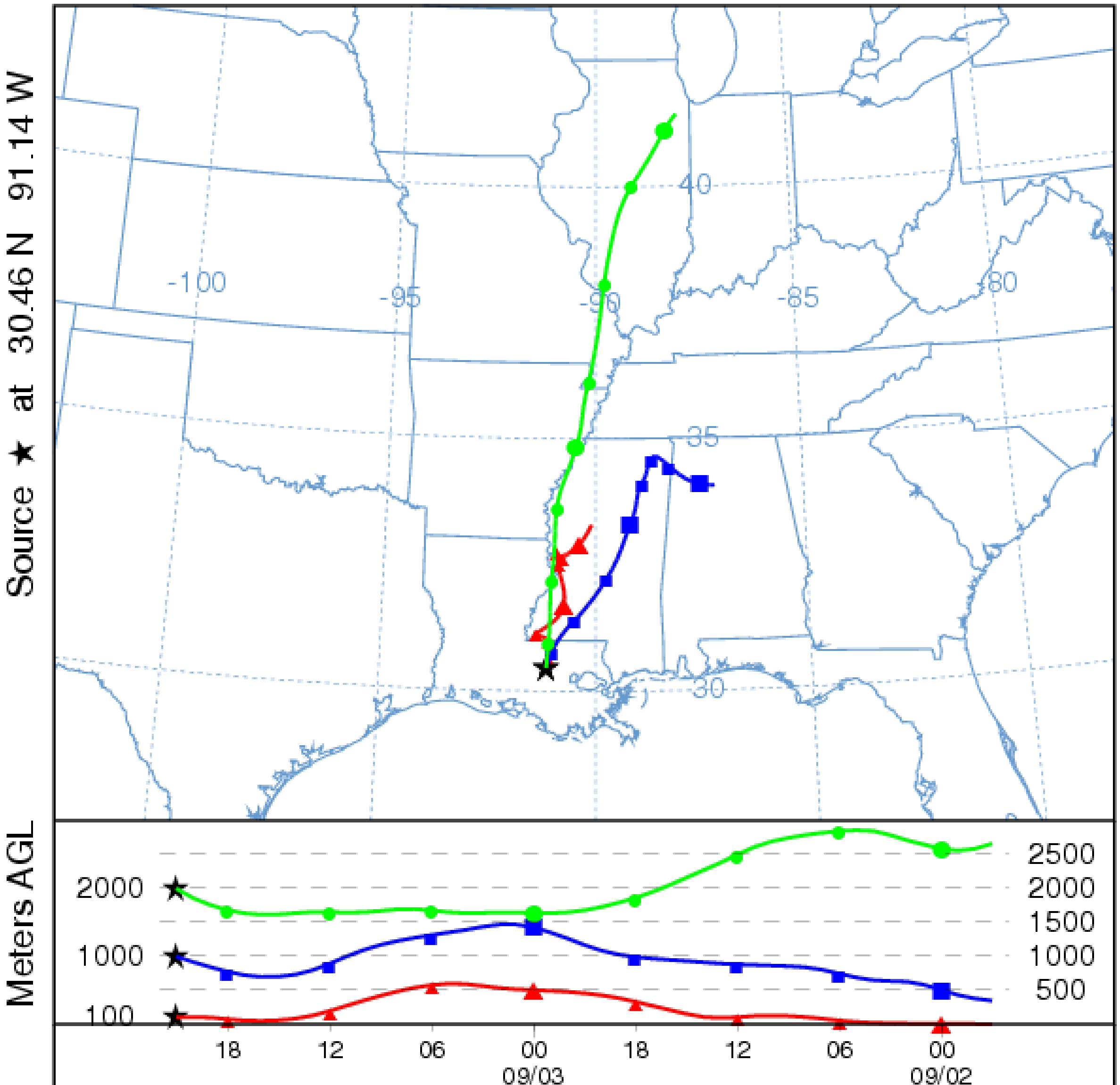
NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 01 Sep 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
38
36
34
32
30
28
-102
-100
-98
-96
-94
-92
-90
-88
-86
Meters AGL
2000
1500
1000
500
100
18
12
06
00
09/01
18
12
06
00
08/31
Job ID: 388841 Job Start: Mon Jul 17 19:55:43 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


NOAA HYSPLIT MODEL
Backward trajectories ending at 21 UTC 02 Sep 00
EDAS Meteorological Data
Source ★ at 30.46 N 91.14 W
Meters AGL
38
36
34
32
30
-98
-96
-94
-92
-90
-88
-86
-84
2000
1000
100
1500
1000
500
18
12
06
00
09/02
18
12
06
00
09/01
Job ID: 388831 Job Start: Mon Jul 17 19:55:17 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL
Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL

Backward trajectories ending at 21 UTC 03 Sep 00

EDAS Meteorological Data



Job ID: 388801 Job Start: Mon Jul 17 19:54:23 GMT 2006
lat.: 30.45809 lon.: -91.140229 hgts: 100, 1000, 2000 m AGL

Trajectory Direction: Backward Duration: 48 hrs Meteo Data: EDAS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)