PROVIDING TIMELY PUBLIC ACCESS TO DAILY AIR QUALITY INFORMATION ABOUT BIRMINGHAM, AL AND ITS REGIONAL ENVIRONMENT

Final Report

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This report has been prepared by Prof. Noor Gillani of UAH, with significant inputs from the following Project team members: Samuel Bell (JCDH, Public Outreach other than the EMPACT-Birmingham website), Randy Dillard (JCDH, Local Monitoring), John McHenry (MCNC, Photochemical Forecast Modeling) and William B. Norris (UAH, Information Management). The work of this Project was supported by EPA under EMPACT Metro Grant No: 828583-01-0. We are also grateful to the Regional Planning Commission of Birmingham for the CMAQ grant to sustain the EMPACT-Birmingham website and the photochemical modeling of ozone forecasts during 2003.

EXECUTIVE SUMMARY

Period Covered by the Report: 1 Jan 2001 – 31 Dec 2003
Date of Final Report: 1 May 2004
EPA Agreement Number: R828583
Title: Providing Timely Access to Daily Air Quality Information About Birmingham AL and Its Regional Environment
Investigators: Samuel Bell (PI, JCDH), Randy Dillard (JCDH), Noor V. Gillani (UAH), Christopher Howard (ADEM), John McHenry (MCNC), William B. Norris (UAH)
Institutions: Jefferson CO Dep. of Health (JCDH), AL Dep. of Environmental Management (ADEM), University of AL in Huntsville (UAH)and MCNC Inc.
Research Category: Environmental Monitoring for Public Access and Community Tracking
Project Period: 1 Jan 2001 – 31 Dec 2003

Project Objectives:

The goal of the Project was twofold: (a) to extend the Birmingham local program of air quality monitoring and assessment within a multi-scale, multi-pollutant outlook, using a broader range of pertinent public-domain data products and state-of-the-art modeling tools, with a view to creating a sustainable and transferable national model program; and, (b) to raise public awareness and participation in local air quality management through a program of effective and timely public access to relevant user-friendly information and education.
The specific objectives of the Project within such a goal were as follows:

1. Continue the existing program of air quality monitoring, assessment and public outreach.
2. Create a working partnership of state and local AQ management agencies with expertise at the state university.
3. Extend program focus from mainly ozone to ozone and $PM_{2.5}$.
4. Extend program focus from local only to local and regional, utilizing both observation-based and state-of-the-art model-based information.
5. Extend forecast modeling capability for both meteorology and chemistry, utilizing both statistical modeling and state-of-the-art real-time 3D Eulerian grid modeling.
6. Extend timely and effective public outreach via internet, the news media, and other means.
7. Develop a centralized database management system.
8. Provide for local program sustainability and national program transferability.

Project Approach, Activities and Findings:

EPA's Metro EMPACT program was aimed at promoting local community-based response to the following two requirements in large metropolitan areas for local control measures to meet air quality standards: (a) monitoring and assessment of the ambient levels and emissions of criteria pollutants; and (b) public awareness and timely action aimed at controlling the emissions. Our Project was aimed at these broad goals for the Birmingham ozone non-attainment area (BONA), comprising of Jefferson and Shelby Counties (see Figure 1). The BONA has a population exceeding 800 000, of which about 82% is in Jefferson CO. In 2001, at the commencement of this Project, it was in marginal violation of both the 1-h and 8-h ozone NAAQS, but as of April 2004, soon after the end of this Project, it has been in attainment of the 1-h standard. The local emissions of NOx are dominated by major point sources (more than 2/3) and of VOC by biogenic sources (about 3/4). The BONA is in a region dominated by biogenic VOC emissions, and the regional chemistry of ozone is decidedly NOx-limited. The responsibility of air quality management belongs to JCDH for Jefferson CO, and to ADEM for Shelby CO.

With respect to the key goals of expanding local air quality monitoring/assessment and public outreach, our Project took an innovative approach in two particular respects: expansion of focus from ozone only to ozone and PM2.5, and of outlook from mainly local to one including a regional perspective also. Such expanded focus and outlook are very much evident in the products we produced and brought to the public in very graphical and easily-accessible form in near real time. We also used this Project as an opportunity to bring into our previous partnership between JCDH and ADEM, the participation of Prof. Noor Gillani's group from our State's flagship Atmospheric Science Program at UAH. This partnership has solidified during the project to the distinct benefit of all partners and the State in air quality management. This has been a major contribution of this Project. Dr. Gillani also brought into our program the participation of the air quality modeling group of MCNC of RTP, NC. This collective team made possible a program which has been broad and sophisticated in scope and quality, and very productive in generating very useful products towards meeting our objectives. UAH has served as our science advisor, and has developed our new information management system and the new EMPACT-Birmingham website, which has become the flagship of our Project, and a major contribution to our overall public outreach effort. MCNC performed ozone forecasting based on 3D photochemical grid modeling, while ADEM continued the statistical ozone forecasting, as well as serving as the focal point for issuing the daily ozone forecasts based on all inputs including the statistical and photochemical modeling. JCDH performed the local monitoring and public outreach, as well as coordinating with EPA. The new partnership is in place for joint new ventures in the future.

Figure 1 shows a map of the BONA and surrounding local environment in C. Alabama, along with the 11 routine air quality monitoring stations and the three largest local NOx point sources.

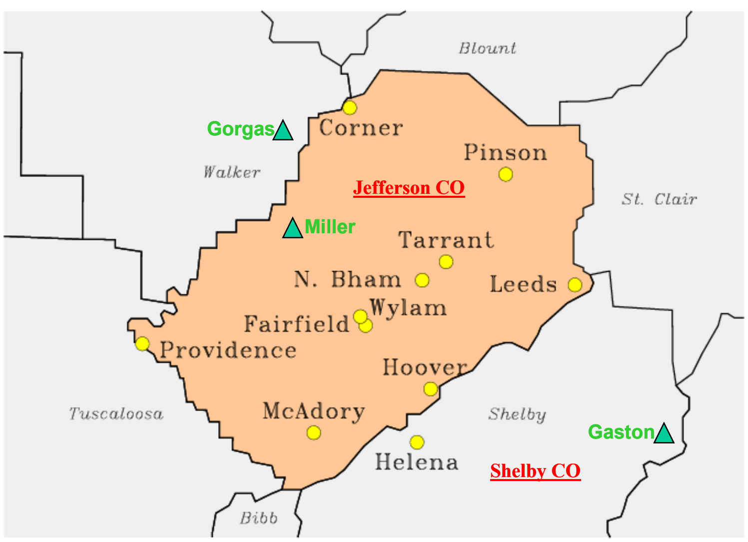

Figure 1. Map of Jefferson and Shelby Counties showing the 11 routine AQ monitoring sites (yellow circles) and the 3 largest NOx point sources (coal-fired power plants, green triangles).

Four sites are core urban sites (Tarrant, N. Birmingham, Wylam and Fairfield), two are suburban (Hoover and Helena), and the remaining five are rural (Pinson, Leeds, McAdory, Providence and Corner). The three power plants emit between 28 000 and 44 000 tons of NOx as NO2. Before the Project, 9 of the 11 sites monitored ozone continuously (all except Leeds and Wylam) and only one site (N. Birmingham) measured PM2.5 continuously. During the Project, ozone monitoring was added to Leeds, while continuous monitoring capability for PM2.5 was added to 7 sites (Wylam, Hoover and the 5 rural sites). In this manner, the continuous monitoring programs of ozone and PM2.5 have been brought to parity (10 ozone sites, 8 PM2.5 sites), with urban, suburban and rural coverage of both. Importantly, both are now monitored at all 5 rural sites which surround the metro area on all sides. This makes it possible for us now to characterize both the upwind inflow of regional secondary pollution from any direction and the downwind outflow, thus making it possible to delineate local and regional impacts to local air quality of ozone and PM2.5. At all 8 continuous PM2.5 sites, we are also collecting 24-h average batch-mode filter samples (FRM) at 1- to 6-day intervals for gravimetric analysis (total mass concentration), and 3 of these sites (N. Birmingham, Wylam and Providence), we are also collecting 24-average samples at 3- to 6-day intervals for detailed speciation (major ions and elements). Furthermore, PM10 is also measured continuously at 2 sites and in batch mode at 8 sites; SO2 (2 sites), NOx (1 site) and CO (1 site) are continuously monitored more sparingly. Our expanded monitoring program is now one of the best in the nation for mid-size cities like Birmingham, and possibly the best for secondary ozone and PM2.5.

Our substantial urban-rural coverage of continuous monitoring also makes it possible for us to weigh the relative importance of local versus regional impact on the local air quality of the regional pollutants (ozone and PM2.5). The location of the 3 large power plants at distances of 40-50 km from downtown is also such as to have substantial impact on urban air quality of ozone and PM2.5, and our local monitoring program is also now adequate for us to discern the specific impact of these power plants on the BONA. In addition, we now have a process in place to generate daily peak ozone contour maps for eastern USA (like the ones available in near real time from EPA-AIRNOW) based on data of ~1430 sites. But importantly, we are also now generating similar maps for PM2.5 (see Fig. 2) using new in-house capability we have developed for this, and we augment such regional mapping of ozone and PM2.5 with satellite (GOES) visible imagery of regional haze and cloudiness. Furthermore, we examine on a daily basis such maps and images for the past four days to maintain on-going awareness not only of the regional pollution picture, but also of its dynamics and potential to impact us in the coming days.

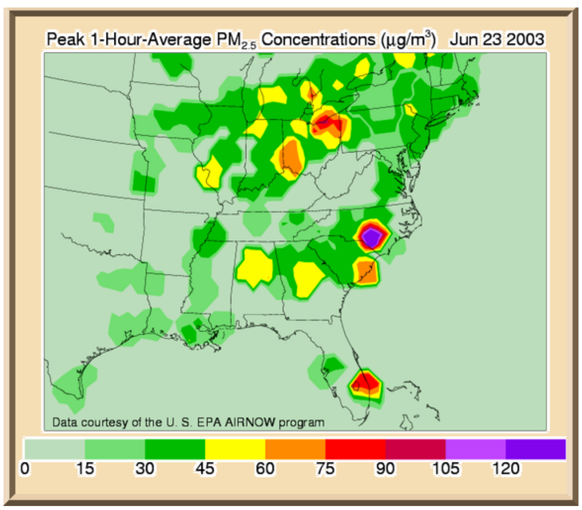

Figure 2. An example of our new capability to generate regional contour maps of PM2.5 in near real time, using EPA-AIRNOW continuous data of 462 sites.

Another major innovation of EMPACT-Birmingham has been in the area of ozone forecasting. Our previous practice for forecasting peak ozone for tomorrow, as is common in most cities, was based on statistical modeling using only local data of meteorological variables (forecast) and peak local measured ozone from yesterday. A major drawback of this method is the presumed implicit unrealistic assumption that local ozone levels remain correlated in time for 48 hours. It ignores the roles of transport and chemistry of tomorrow's impacting airmass over the past two-day period. We have therefore now included twice daily regional 3D photochemical grid modeling in forecast mode (48 hours) in our program. The meteorology is forecast based on

MM5, the emissions based on SMOKE, and the transport-chemistry based on the near-real-time forecast model MAQSIP-RTOFS, which is a sister model of EPA's Model-3/CMAQ. Our experience in this area during the 2001 ozone season was that the local ozone forecasts tended to be consistently excessive. The cause was attributed to two main causes: possible errors in emissions and in the regional photolysis rates, the latter due to errors in the forecast cloud fields. During 2002, improvements in the photolysis calculations improved the forecasts significantly, but such photochemical modeling in forecast mode, while a useful additional input to the forecasting process, is still in infancy.

We have also developed a sophisticated new information management system (IMS) and a highly successful new EMPACT-Birmingham website, both at UAH. The IMS receives numerical data and graphical images in near real time from a variety of sources: continuous local monitoring data from JCDH and ADEM, hourly AIRNOW data of both ozone and PM2.5 from EPA, satellite data from NASA, and photochemical modeling results from MCNC. These data are used not only by UAH in preparing the web products, but also by other partners. The IMS facilitates all these functions, and also maintains appropriate archives on the EMPACT server at UAH. In addition, a variety of software products have been custom-developed to perform the various data processing and management functions, as well as to develop the graphical web products.

A major goal of our Project was aimed at expanding public outreach. The new website is one of several vehicles of public outreach. The other vehicles include the local media, which have been very cooperative, educational programs with local educational institutions, and collaboration with other stakeholders in the form of the Alabama Partners for Clean Air. JCDH determines the daily air quality index and the daily PM2.5 forecast, while ADEM develops the daily ozone forecasts. Both of these are displayed on the EMPACT website as well as communicated to the other stakeholders and to the public via the media. In partnership with the Southern Environment Center of Birmingham Southern College and the Macwane Science Center of Birmingham (through the Globe program), JCDH has developed an ozone monitoring program in all 11 BONA school districts, which provides opportunities to the students to participate in ozone monitoring as well as various levels of research.

The most successful product of this Project is probably the new EMPACT-Birmingham website. The web site (http://vortex.nsstc.uah.edu/empact_bhm/) resides on the UAH web server (VORTEX), but can be accessed through links from both the JCDH and ADEM website. It provides user-friendly near real time access to graphical information based on the local monitoring data as well as regional information about ozone and PM2.5 from EPA-AIRNOW, satellite imagery from NASA, and ozone forecast products based both on the statistical modeling of ADEM and the photochemical modeling of MCNC. It also provides links to the JCDH and ADEM sites, as well as to EPA-AIRNOW and other useful sites.

Figure 3 shows the home page of the EMPACT-Birmingham website. It is graphical and attractive, and clearly highlights the local-regional emphasis of the coverage. It also provides easy passage to a variety of information at the click of a button --- the air quality index (at the JCDH site), the ozone forecast (at the ADEM sites), local data, regional data, Project Reports, and links to other websites, etc. Such easy navigation is facilitated from any web page to any other web page in very easy fashion. The local data to be viewed can be selected easily by monitoring site (individual or all), monitored species (ozone, PM2.5, PM10, SO2, etc.), temporal

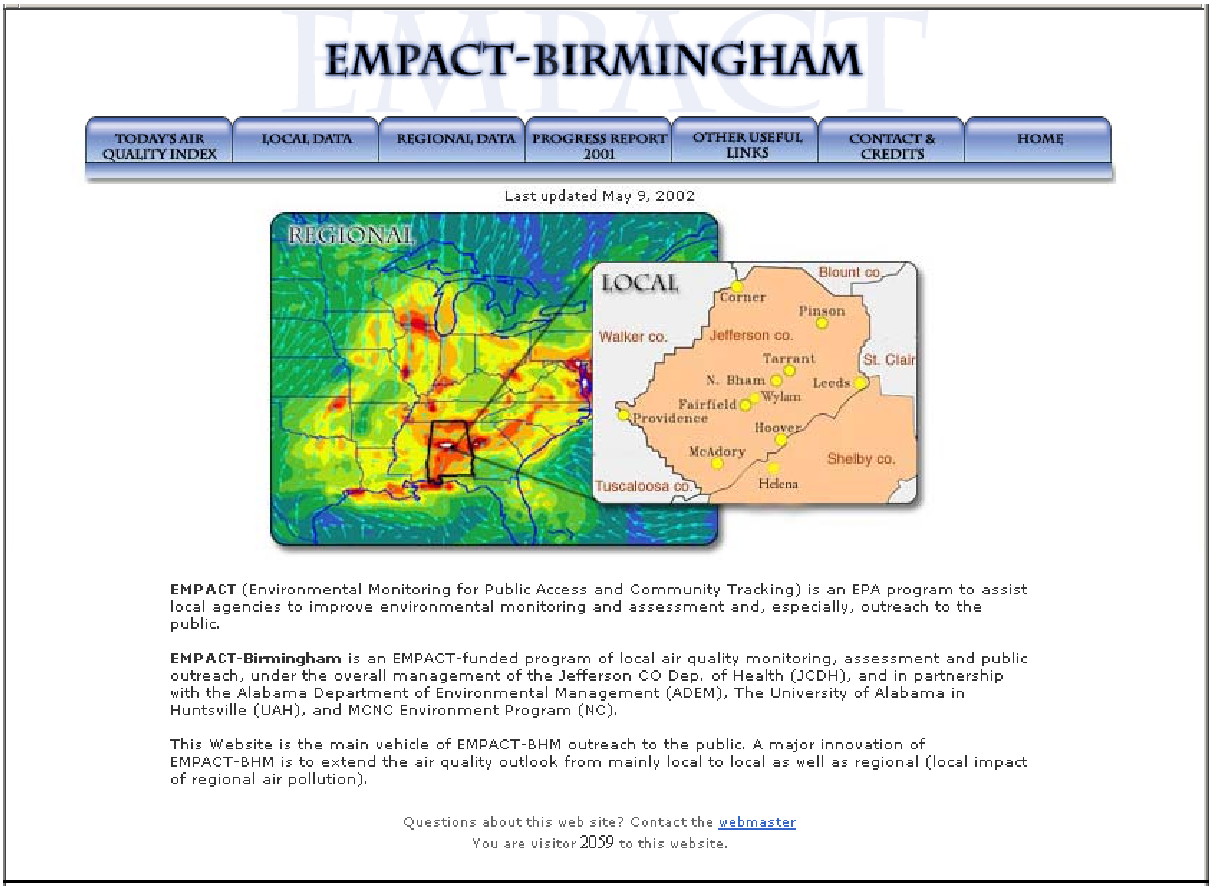

Figure 3. The Home page of the EMPACT-Birmingham website.

resolution (1-h, 8-h, 24-h averages, etc.), in AQI or engineering units, and may be viewed as color-coded temporal plots (time series of hourly data or more averaged data updated every hour) or spatial distribution plots. The regional data can be of peak daily ozone (observed or forecast) or peak daily PM2.5 (observed) in the form of eastern USA contour maps (e.g., Fig. 2), or of daily satellite imagery at noon. The observed information is presented for the past four days (four plots) so that the multi-day regional dynamics of the displayed information can also be inferred.

Our Final Report contains a detailed description of the website and its contents and method of navigation within it. The Report is also quite detailed for all other components of the Project. It also demonstrates that we have developed the necessary on-going support to sustain the Project indefinitely. We are also most open to providing assistance to any state-local agency entities in other states wishing to replicate a similar program in their states.

We have also included two recommendations in the Final Report. They both pertain to use of the rich database and products being generated by the Project. One pertains to enhancing the statistical forecasting approach by including the role of 48-hour transport in it, through use of measured ozone in the impacting airmass at originating upwind locations, rather than using local values; the other pertains to utilizing the local monitoring data (urban and rural) in conjunction with lagrangian reactive plume modeling and forecast meteorology to predict and characterize the next-day ozone impact of the nearby power plants on the urban area.

Table of Contents

1. INTRODUCTION

Of the six criteria pollutants regulated by EPA (SO_2, NO_x, CO, Pb, O_3 and PM), the first four, and PM_{10}, are mostly primary emissions, while O_3 and $PM_{2.5}$ are largely secondary pollutants. Because of their secondary nature and relatively long atmospheric residence times, O_3 and $PM_{2.5}$ have the greatest potential to transport and distribute regionally, and are therefore harder to control by local control measures only. Also, the chemistry of their secondary formations is intertwined (the photochemical smog mechanism involving many of the same precursor and intermediate species), and there is often close correlation between episodes of these two pollutants. In terms of harmful effects of the criteria pollutants at ambient levels, these two pollutants are also of the greatest concern. Violations of the NAAQS are also most common for these two pollutants, especially non-attainment of ozone standards. For this reason, ozone mitigation strategies have, in the past received the greatest attention, although increasing attention is now being paid to $PM_{2.5}$ also. There is much justification to pay joint attention to these two pollutants, with not only a local perspective, but also a regional perspective.

Local control measures to meet air quality standards require, first of all, monitoring and assessment of the ambient levels and emissions of the pollutants, and then of public awareness and timely action aimed at controlling the emissions. Metro EMPACT was an EPA program aimed, above all, at promoting local community-based response to these two requirements in large metropolitan areas, particularly those in non-attainment of the NAAQS (the Metro EMPACT program has now been discontinued by EPA). Typically, the focus of local agencies has been largely on routine local monitoring of pollutant ambient concentrations, and on application of relatively simple forecast modeling and alerts based on them to raise public awareness and response. The EMPACT program tried to provide strong incentive for local agencies to form partnerships with local universities with strength in air quality studies and sophisticated modeling capabilities, in order to meet the EMPACT objectives. Under EMPACT sponsorship, a very successful national program was also created for ozone monitoring and timely graphical products generation suitable for use by the general public (EPA, 1999).

This report is the Final Report of a Metro EMPACT grant from EPA to a team headed by the Jefferson County (AL) Department of Health (JCDH), targeted at the Birmingham AL ozone non-attainment area (BONA). Prior to this Project, the air quality monitoring-assessment-outreach program for the BONA had significant limitations: there was no significant collaboration between state and local environmental regulatory agencies in Alabama, on the one hand, and state universities with expertise in air quality studies, on the other; the local air quality monitoring program in Birmingham (the largest metropolitan area in the state, then in violation of both the 1-h and 8-h ozone standards) was focused mostly on ozone with a very local perspective; ozone forecasting was limited to statistical forecasting based on local information only; and, public outreach was quite limited, particularly in relation to the general public. Our Project was aimed at taking innovative actions in all these areas, as follows:

- creation of a solid partnership between state and local regulatory agencies and an outstanding air quality studies program at our state university in Huntsville, AL;
- expansion of the monitoring-assessment-outreach program from mainly ozone to ozone *and aerosol*;
- shift in emphasis in assessment from local only to local *and regional* contributions to local ozone and aerosol;

- expansion of forecast modeling to include application, in forecast mode, of sophisticated 3D Eulerian grid models, both meteorological and photochemical;
- generation of a broad range of graphical products aimed at the general public, made publicly accessible in a very timely manner, over Internet and in the news media;
- development and centralization of a database management process.

Our EMPACT program (2001 -) has been centered on the metropolitan area of Birmingham, AL, but also provides simultaneous broad regional perspective. In Alabama, at the outset of this program (2001), the Birmingham metropolitan area was the only locality in Alabama which was in violation of the ozone NAAQS. Specifically, it was designated to be in marginal violation of both the 1-h and 8-h ozone standards. The city of Birmingham is in Jefferson CO, but its suburbs are rapidly spreading into nearby Shelby CO. The two counties together comprise the BONA. From 1990 to 1998, the population of Jefferson CO increased by about 1% to 660 000, while that of Shelby CO grew about 42% to 141 000; the total daily vehicle miles travelled in the two counties was estimated at about 25 million for 1997 (ADEM, personal communication). In 1996, point-source emissions of NO_x for the BONA were estimated at more than twice the non-point-source emissions; about ¾ of the VOC emissions were estimated to be biogenic, with 80% of the anthropogenic emissions being from area and mobile sources. In terms of summertime air quality, Birmingham was quite representative of large southeastern cities with substantial contribution from biogenic VOC emissions, a regional environment characterized by NO_x-limited chemistry (SOS 1995), and significant two-way urban-regional interactions, with regional inflow of reactive VOC as well as preformed ozone and aerosols, and outflow of locally-emitted SO2 and NO_x into a NO_x-starved regional environment.

The BONA includes two counties --- Jefferson (in which downtown Birmingham is located) and Shelby (see Figure 1; all figures are at the end of the text of the Report narrative). The Jefferson County Department of Health (JCDH, the primary contractor of this Project) is the local organization charged with the air quality (AQ) management responsibilities (monitoring, assessment, regulation, public outreach) for Jefferson Co., while the AL Department of Environmental Management (ADEM) has the corresponding responsibility for Shelby Co. Most of the local population is in Jefferson Co., although Shelby Co. is growing rapidly. This Project has been a joint effort between JCDH, ADEM and the University of AL in Huntsville (UAH), with subcontractual support also from industry (MCNC[*] of Research Triangle Park, NC).

The Project period was originally for two years (2001 and 2002), but was extended (no-cost extension) for one more year (2003) mainly to test Project sustainability without EMPACT financial support.

[*] The members of MCNC who participated in EMPACT-Birmingham have now moved to Baron Advanced Meteorology Systems (BAMS), also in Research Triangle Park, NC.

2. PROJECT OBJECTIVES

2.1 Project Goal : was to extend the Birmingham local program of air quality monitoring and assessment within a multiscale, multi-pollutant outlook, using a broader range of pertinent public-domain data products and state-of-the-art modeling tools, with a view to creating a sustainable and transferable national model program; and, to raise public awareness and participation in local air quality management through a program of effective and timely public access to relevant user-friendly information and education.

2.2 Specific Project Objectives:

1. Continue the existing program of air quality monitoring, assessment and public outreach.
2. Create a working partnership of state and local AQ management agencies with expertise at the state university.
3. Extend program focus from mainly ozone to ozone and $PM_{2.5}$.
4. Extend program focus from local only to local and regional, utilizing both observation-based and state-of-the-art model-based information.
5. Extend forecast modeling capability for both meteorology and chemistry, utilizing both statistical modeling and state-of-the-art real-time 3D Eulerian grid modeling.
6. Extend timely and effective public outreach via Internet, the news media, and other means.
7. Develop a centralized database management system.
8. Provide for local program sustainability and national program transferability.

A basic premise of our program has been that the public has the right to know and influence the quality of air they breathe daily in metropolitan areas such as Birmingham, and that the local agencies assigned to the task of air quality monitoring and protection have the responsibility to utilize the best available know-how and technology to perform their task, and to inform, involve and protect the public as fully as possible. It is well established that ozone and aerosols can have serious health effects on susceptible segments of the public, as well as costly secondary harmful effects on private and public property. The public has a need to be aware of the relationship between ambient air quality and public welfare at the time scales at which such damage can occur. Such time scales, as implied by the NAAQS, are both short-term (e.g., 1-h, 8-h, 24-h) and longer-term (e.g., annual). The program was to be aimed at providing the public informative and timely alerts during episodes, reassurances during clean conditions, and awareness and education about local as well as larger scale conditions at all times.

3. APPROACH AND ACTIVITIES

At the outset of this Project, the air quality management program in the Birmingham ONA included mainly of the following: limited monitoring of the criteria pollutants by JCDH/ADEM; data preparation and exchange with EPA (AIRNOW) by both ADEM (Shelby CO) and JCDH (Jefferson CO); daily statistical ozone forecast modeling for BONA during the ozone season by ADEM (based on local monitoring data only), as well as some post-facto MOBILE5 and UAM airshed model-ing by ADEM for assessment studies; public outreach in the form of the Ozone Monitoring Program conducted at local public school districts in BONA by JCDH in partnership with the Southern Environmental Center of Birmingham-Southern College, and the Ozone Action Program of AL Partners for Clean Air, a local consortium of which JCDH is a member, aimed at promotion of outreach to the stakeholders, including government, business, the media and religious/civic-social/educational sectors. The goal of the upgraded program under EMPACT was to sustain, enhance and add to these activities within the context of the specific objectives stated in Sec. 2. In what follows, we summarize our approach to achieve each of those objectives, and the progress in each case during the Project period.

3.1 Task 1: Continuation of the Pre-existing Program.

The pre-existing program of air quality (AQ) management for the BONA of Jefferson and Shelby Counties (see Fig. 1), consisting of the following, was continued during 2001-2003:

- Continuous AQ monitoring -- ozone (9 sites), CO (1 site), SO_2 (2 sites), NO_x (1 site) and $PM_{2.5}$ (1 site);
- 24-hour average batch-mode sampling of $PM_{2.5}$ (every day at 2 sites and every three days at 5 sites, with speciation every three days at N. Birmingham and every 6 days at Wylam and Providence), and of PM10 (every six days at 3 sites);
- Daily ozone forecasting based on statistical modeling only, using local input variables only;
- Public outreach involving local educational programs and sharing daily ozone forecasts with selected stakeholders.

The Monitoring Program: Figure 1 shows a map of Jefferson CO and surroundings, including Shelby CO, and the locations of the 11 routine monitoring sites for criteria pollutants: 10 of the 11 sites are in Jefferson CO and one (Helena) is in Shelby CO just across the border; four sites are core urban sites (Tarrant, N. Birmingham, Wylam and Fairfield), two are suburban (Hoover and Helena), and the remaining five are rural (Corner, Pinson, Leeds, McAdory and Providence). In addition, from time to time, JCDH and ADEM also commission additional special sites for supplementary monitoring. We shall limit ourselves here to the 11 routine sites only, which were part of the core EMPACT program. Table 1 provides a summary of the various species monitored at each of these sites, with the letter O in any cell representing original or pre-existing activity at the commencement of this Project, and N indicating new activity initiated during the course of the Project (2001, 2002, 2003). Observe that only ozone was originally monitored continuously at both urban and rural sites (ozone monitored at all sites except Wylam, which has always been more of a PM monitoring site); *rural* monitoring of PM2.5 was only in batch-mode (24-h average) every 3 days, by FRM (total mass concentration only), at four sites, and for speciation (STN) every 6 days at one site only (Providence). The only other rural monitoring was of hi-vol PM10 (total mass concentration) at Leeds every 6 days. Continuous PM monitoring was at one site only for PM2.5 (N. Birmingham) and two sites for PM10 (N. Birmingham and Wylam). Only Fairfield monitored SO2 and CO, and only Helena monitored NOx. All of this original monitoring was sustained throughout the Project period.

All monitors were and are EPA-approved, and maintained and operated in accordance with appropriate EPA guidelines. The continuous monitors in the network (including ozone) were (and are) linked to a central server which polled the data several times daily, performed QA, and transfered them to EPA's AIRS Data Collection Center (DCC). The DCC performed its own QA and processing and made the data available at both station level and in gridded form ready for contour mapping.

***The Ozone Forecasting Program*:** The original approach of ozone forecasting (by ADEM) was by the common practice of statistical modeling, i.e., to use statistical linear regressions between the forecast variable (tomorrow's peak ozone at a given site) and certain "independent" variables, mostly meteorological, but usually also the last available peak daily observed ozone (yesterday's) at a monitoring site. In this procedure, the meteorological variables used are tomorrow's forecasts of high/low temperatures, average RH/cloud-cover/wind-speed (at the monitoring site) from 0600 to 1500, and the difference between the surface and 900 mb temperatures. ADEM uses NWS forecasts, forecasts by synoptic scale grid models (the NWS Nested Grid Model, NGM, the ETA model, and the Aviation model), as well as case-by-case judgement to infer the forecast values of the above met variables. The main problem with this approach is, of course, the indefensible assumption that the local air quality is locally persistent for two days to the extent that local peak ozone will remain highly correlated for 48 hours. A more defensible assumption is that tomorrow's local peak ozone will be correlated with the ozone concentration yesterday at the upwind location of the airmass which will arrive here tomorrow. To do this, one must use the regional forecast grid-model wind fields to calculate 48-hour back-trajectories from the local site, and use the observed ozone information nearest to the upwind location at the past time. But there is a problem with this approach also, for it neglects the fact that the ozone levels will change along the 2-day trajectory by a wide range of physical and chemical processes (e.g., dispersion and chemistry). To address this problem fully, one must resort to application of a regional 3D grid model including both transport and chemistry, and this too, in near-real-time forecast mode. That is a tall order, which is why this is hardly ever done. Comprehensive 3D Eulerian grid models such as EPA's new multiscale (urban-regional), multi-pollutant (gases and aerosols) Models-3 are complex enough for application even for a past period, let alone in forecast mode. In our Project, the statistical modeling was continued as before, and we also performed 3D photochemical forecast grid-modeling in the Project.

***The Public Outreach Program*:** The Birmingham ONA was designated in violation of the 1-h ozone standard in 1991, and remained so until April 2004, when it was declared in attainment of the 1-hour standard, but in violation of the new 8-hour standard. Perhaps the public outreach of this Project played a positive role. The sites which are most prone to exceedance are Hoover and Helena. During 1996-98, JCDH placed considerable emphasis on raising public awareness on the ozone issue, because scientific surveys had revealed the need for community education. Since 1999, emphasis in public outreach efforts had shifted more toward action --- informed individual and collective actions by the public to abate the ozone pollution. The Southern

Environmental Center (SEC) of Birmingham-Southern College is one of the premier centers of its type in the nation. An ongoing partnership with the college had been in existence for several years. Air quality issues have been important aspects of the Center's educational program. The SEC was already partnering with JCDH to expand the Ozone Monitoring Project, which had been incorporated into all 11 public school districts of the two-county BONA. This project, with its Eco Badge® Smog Patrol™ Kits, was applicable to K-12 students in all disciplines, and teachers and students with all levels of technical ability. Entry-level project participation involved basic monitoring of classroom ozone levels; exploratory level participation involved additional monitoring of ozone levels outside the classroom and more sophisticated manipulation and analysis of data; research level participation involved independent research based on the basic protocol of the project, possibly involving collaboration with other schools and presentation of research results in some format. Teachers and students could collect data for in-depth research projects, as well as yearly and long-term studies. The project was supported with lesson plans (teacher guides) from "Let's Clean the Air About Air (Pollution, That Is)." Appropriate levels of the teacher guides were targeted at elementary schools, middle schools, high schools, and colleges (if required). Methodology also included the possibility of a "Cybermarch" program, a year-round air-monitoring program on the Internet, an innovative network science project developed by Vistanomics, Inc. of California, in which students monitor ground-level ozone and then share their data over the Internet.

JCDH also participated in the Ozone Action Program of AL Partners for Clean Air (APCA), a local consortium aimed at promotion of outreach to the stakeholders, including government, business, media and religious/civic-social/educational sectors. During the EMPACT Project, we continued supporting and participating in all these programs, and expanded the outreach program dramatically by way of our new EMPACT-Birmingham website, as will be shown later.

3.2 Task 2: Creation of a Working Partnership Between JCDH, ADEM and UAH

At the beginning of the Project, there was a good working relationship between JCDH and ADEM, but we had not capitalized on the existing strength in air quality studies and research at Alabama's only university-based Atmospheric Science Program at the University of Alabama in Huntsville (UAH). This Program is recognized as one of the best in the nation. As a result of EMPACT-Birmingham, a very solid partnership has been created with strong UAH participation by the group of Professor Noor Gillani, who has been active in Air Quality Research for the past 30 years. During much of that time, he has also worked closely with scientists at EPA's Atmospheric Science Modeling Program at the National Exposure Research Lab in Research Triangle Park, NC, and its predecessors. Dr. Gillani has provided us with a strong science interface: he was instrumental in suggesting the expansion of our AQ program to include more emphasis on PM2.5, on the synergy between the ozone and PM2.5 formation systems, and on regional outlook also. He brought the MCNC regional forecasting group into our team to expand our capability to include 3D urban-regional grid modeling, both meteorological and photochemical, in forecast mode. And above all, his group developed the EMPACT-Birmingham website, which has become the cornerstone of our public outreach effort and the flagship of EMPACT-Birmingham. UAH has also developed our centralized database management program. The UAH participation has also opened up possibilities for us to perform some genuinely meaningful assessments and pollution prevention studies in the future using our very rich ozone-PM2.5 monitoring database and UAH's solid multiscale, multi-pollutant modeling capabilities. The group possesses special strength in meteorological and air quality modeling and diagnostic analyses at spatial-temporal scales ranging from LES (Large Eddy Simulation) to regional, as well as in the application of satellite data in model assimilation, inputs and evaluations. We are in the process of extending this partnership to air toxics monitoring and assessments, including development of innovative instrumentation for continuous monitoring of air toxics (both gases and aerosols). We are indeed grateful to the EMPACT support of EPA to make this most valuable partnership evolve. It is surely in the best interests of all the partners, including JCDH, the state of Alabama and EPA.

3.3 Task 3: Expansion of Program Focus From Mainly Ozone to Ozone and PM

To date, this has happened mainly in the form of expanded monitoring to include a substantial PM2.5 program, and use of EPA's national PM2.5 database to locally generate regional PM2.5 contour maps like the AIRNOW maps for ozone. These two features are described below.

Table 1 summarizes not only the scope of the monitoring program for the BONA before the EMPACT Project, but also the scope at the end of the project period (current). All cells in the Table marked "N" indicate new addition to the monitoring program during the Project. The most notable expansion has been in the monitoring of PM, both PM2.5 and PM10. Before EMPACT, there was only one continuous PM2.5 monitor, at the urban site at N. Birmingham. During EMPACT, seven more continuous PM2.5 monitors (Rupprecht & Patashnick Model 1400ab TEOM [Tapered Element Oscillating Microbalance] with the Sharp Cut Cyclone [SCC] operated at 50 C) were added to the local network, four of them being purchased from EMPACT funding. In this upgraded monitoring network, 7 of the 8 continuous PM2.5 sites are now co-located with 7 of the 9 ozone sites, with urban, suburban and rural coverage. These continuous monitors can now provide detailed spatial and temporal coverage (including diurnal variability) of both of these secondary correlated pollutants. Birmingham now generates one of the best databases of both ozone and PM2.5 of all cities of its size in the nation. In addition to the continuous monitoring of PM2.5, there is also an extensive batch-mode filter sampling program for periodic 24-hour-average sampling: 8 of the 11 monitoring stations collect such samples, either FRM samples for total mass concentration (8 sites, daily sampling at 2 sites, sampling every 3 days at 5 sites, and every 6 days at Leeds), or STN samples for speciation every 3 days at N. Birmingham, and every 6 days at Wylam in the urban core and Providence in the rural background. As for PM10, 2 sites have continuous monitoring (N. Birmingham and Wylam), 8 sites have Low-vol FRM sampling every 6 days, and 3 sites have Hi-Vol FRM sampling every 6 days.

All of the filter samples from the network are equilibrated and weighed in JCDH's state-of-the-art filter weighing laboratory that includes the MTL (Measurement Technology Lab) room control and gravimetric data management software. In addition, the JCDH PM Laboratory is one of the few laboratories in the country to have one of MTL's Automated Filter Weighing Systems. This system automatically weighs each filter three times, averages the results, and reweighs each filter again three times and averages the results for comparison to the initial weighing average. This same procedure is performed on the filters prior to and after the completion of the sampling. Lab filter blanks and field filter blanks are also used in the QA process.

Samples from the three PM2.5 Speciation Trends Network (STN) monitors (at the North Birmingham, Wylam, and Providence sites) are analyzed for total mass, sulfates, nitrates, ammonium, elemental carbon, organic carbon, and approximately 30 to 40 crustal elements by Research Triangle Institute (RTI) in Research Triangle Park, North Carolina.

For quality assurance (QA) purposes, flowchecks are performed monthly on all of the STN monitors by the operators and flow audits are performed quarterly by the QA Coordinator using a different audit flow device than that of the operator. Field blanks and trip blanks furnished by RTI are also used in the QA process. In addition, RTI also performs extensive in house laboratory QA procedures. The STN PM2.5 mass data is also compared to the 24-hour midnight-to-midnight-average FRM PM2.5 mass data for an additional QA check. As for the QA of continuous PM2.5 data, a flow check is performed on every monitor once each month for precision, and an accuracy audit is performed on every monitor each quarter by the QA Coordinator using a different audit flow device than that of the operator. In addition, the internal instrument flow is checked two or three times per week, a leak check is performed once each month, and the 24-hour midnight-to-midnight-averages are compared to those of the filter-based PM2.5 FRM samplers.

The current monitoring network also includes more limited monitoring of SO2 (2 sites, with a new Thermo Electron Model 43C analyzer for SO2 at the Fairfield site), and NOx and CO at one site each. The Helena data (ozone, SO2, NOx) are processed and managed by ADEM, and also directly delivered to EPA by ADEM.

As will be discussed under the next Task, we also maintain awareness of the multi-day regional distribution and dynamics of the ozone and PM2.5 observed fields based on the AIRNOW (EPA's AQ System) database. The purpose of this is to distinguish between local and regional impacts to local air quality.

3.4 Task 4: Extension of Program Outlook from Local Only to Local *and* Regional

In most local urban AQ management programs, the focus is limited to local monitoring and assessments. Especially for secondary regional pollutants like ozone and PM2.5, this is short-sighted, as regional imported pollution can frequently play a pivotal role in local violations, especially in eastern USA. In our EMPACT program, we took a number of steps to include the regional awareness in our program. In the monitoring network, we expanded the continuous PM2.5 monitoring such that we now have 5 rural sites located in the periphery of the BONA on all sides of the urban core. In this manner, we can delineate the upwind inflow AQ as well as the downwind outflow AQ, so that from the difference between the two, we can assess the relative local and regional contributions to the local AQ of ozone and PM2.5 in a continuous timeframe. The utility of this is not only limited to such delineation of the impact of far sources, but also of the three largest NOx point sources (power plants) in the vicinity of the BONA --- Miller and Gaston about 40 to 50 km to the NW of downtown Birmingham, and Gorgas about an equal distance to the east (see Figure 1). These are large enough coal-fired power plants (28 000 to 44 000 tons of NOx emissions as NO2 in 1998) to have a major impact on Birmingham AQ, and far enough from downtown Birmingham to carry substantial secondary ozone and PM2.5 in their plumes upon urban impact when the wind direction is appropriate. Birmingham now possesses an outstanding database of surface monitoring to assess the local-regional character of local AQ, with information also about whether the imported contribution is from the neighboring large power plants or of truly regional origin.

Such capability is also independent of the mesoscale wind direction, since our rural sites are located in all four directions from the city. But the local monitoring data cannot tell us anything about the origin of the impacting regional airmasses, nor warn us in advance when such impact is likely to occur. To maintain that kind of *a priori* awareness, we initiated a process based on utilization of the national AIRNOW database of EPA for both ozone and PM2.5. As a result of past EMPACT projects, AIRNOW developed the capability to generate regional daily peak ozone concentration contour maps for the past day. We have extended that capability to generate our own contour maps of ozone and PM2.5. With this capability, we can generate such maps for any past hour. Our practice is to isolate the daily peak hourly concentrations of both ozone and PM2.5 each day (based on continuous measurements) and to archive this information. Figure 2 shows the distribution of the 1430 sites in the eastern USA reporting hourly ozone data and the 462 sites reporting hourly PM2.5 data to EPA. Based on such information, we generate the regional contour maps of peak daily ozone and PM2.5 every day for eastern USA, and save the maps of the last 4 days on-line. Based on the last four days of such information, it is possible to identify episodes of regional haze from such regional maps, and by examination of such plots for four consecutive days, it is also possible to discern the regional transport of such haze episodes. In this manner, we can maintain an *a priori* awareness of any such episode heading our way. Such graphical regional information, along with the local monitoring information, is available on our EMPACT-Birmingham website to be discussed in Section 3.6. The website also displays the noon maps for SE USA of GOES visible satellite imagery for the past four days to provide visible depiction of regional haze and cloudiness.

As mentioned before, our pre-EMPACT program of ozone forecasting was based on statistical modeling based on local information only. This ignores the role of regional transport and chemistry which can play critical roles in determining local impacts of ozone and PM2.5. As part of EMPACT-Birmingham, we also initiated the practice of twice-daily regional 3D meteorological and photochemical forecast modeling extending into the future up to 48 hours. Section 3.5 describes the new regional 3D forecast modeling effort including the role of regional transport and chemistry.

3.5 Task 5: Ozone Forecasting Based on 3D Meteorological and Photochemical Grid Modeling

3.5.1 Introduction

This section summarizes the work completed by MCNC under EPA EMPACT Grant #R828583 for the first of its two-year performance period.

The report is structured into four sections. Section 1 provides an overview of the objective/tasks and the status of deliverable items for years 1 and 2. In section 2, the MAQSIP-RT forecast runs and evaluation are discussed based on year 1 results. Section 3 provides a concluding discussion, followed by figures in section 4.

3.5.1.1 Year 1 Objective and Tasks

MCNC's principal objective for Year 1 of the grant was to support the timely communication of air quality forecast information to the public in Jefferson County by conducting forecast runs using a real-time ozone forecast system.

As a subcontractor to the Jefferson County Dept. of Health, MCNC undertook five main tasks in order to achieve this objective. These tasks were identified as:

- Deploy an operational real-time ozone forecast system (RTOFS) using new model grids consistent with forecaster needs in and near Jefferson County, Alabama.
- Implement a forecast product delivery mechanism to enable ADEM forecasters and the EMPACT-Birmingham website to obtain, utilize, and evaluate forecast maps.
- Conduct twice-daily forecast runs of the RTOFS on MCNC host computers.
- Provide MM5 forecast model datasets for input to ADEM statistical forecast model(s).
- Archive model output data and conduct a post-season forecast evaluation to assess performance and inform improvements.

3.5.1.2 Year 1 Task Status

Table 1 shows the status of the five tasks as of April 26, 2004.

Table 3.5.1. Year 1 Task and Deliverable Status

	Task 1: Deployment	Task 2: Delivery Mechanism	Task 3: Conduct Forecast Runs	Task 4: Provide MM5 Data	Task 5:Archive and Evaluate
Status	Complete	Complete	Complete	Not Utilized	Complete

In the deployment phase, the three computational models which serve as the RTOFS core were configured to compute forecasts on new grids consistent with JCHD needs. The three models include the MM5V3.4 mesoscale meteorological model, the SMOKE V1.3 emissions processing/modeling system, and the MAQSIP-RT real-time photochemical forecast model.

Figure 3 shows the new grids, which included a 15km-scale SE US grid (grid 002, Figure 3) and a 5km-scale grid (grid 003) centered on Jefferson County. The grid scale was chosen as the highest resolution possible for the computational resources available. The MM5 domains were chosen first, and then the SMOKE and MAQSIP-RT domains were chosen as "windowed" portions of the MM5 domain (grid 001). The MM5 domains are shown in Figure 3, with the outermost resolution (grid 001) at 45km.

In addition to the new grids, updates were made to both the emissions inventories and models used. The EPA NET-99 inventory was implemented as the basis for computing point, area, and mobile source emissions throughout the SE, including Jefferson County. In addition, biogenic emissions were forecast using the BEIS-3 emissions model. We were not able to obtain useful local updates to emissions databases from JCHD, however.
MAQSIP-RT is a photochemical model that has been specifically optimized for real-time forecasting. It is a close "cousin" of EPA's Models-3/CMAQ, having been co-developed during the mid-1990's with CMAQ. The primary differences between the real-time, or "RT" version of the model, and the publicly available version of the model include:

- The solver/driver and all sub-modules have been fully optimized for fast performance on scalar/shared-memory computers.
- The full KF (Kain-Fritsch), shallow convection, and resolved cloud chemistry sub-modules are included, and used.
- MAQSIP-RT reads MM5 output files directly written by the MCPL sub-module implemented in MM5, obviating the need for any meteorological data pre-processing.
- The RADM 11-category land-use dry deposition module is incorporated directly.
- A top boundary condition is implemented whereby monthly mean observed 100mb ozone is utilized to simulate stratospheric re-supply of ozone near model top.
- Realistic monthly mean observed ozone sidewall boundary conditions are used on the outer domain.

In order to provide forecast information, a password protected website (http://emc.mcnc.org/projects/SECMEP/index.html) was developed at MCNC to host both animated and static forecast maps. The primary forecast product was designed to depict both peak 1-hour and peak 8-hour average ozone forecasts at three resolutions: 45km, 15km and 5km. The maps were designed to correspond with the EPA color-differentiated alert codes: green, yellow, orange, red, and purple. The Air Quality Index was calculated from ozone alone and thus a 1:1 correspondence exists between the color codes and forecast parts-per-billion (ppb). Thus, on the maps, PPB were displayed by color code. Example maps are shown in Figures 5a, 6a, and 7a.

Actual forecast runs were targeted to begin July 1, but, due to delays in obtaining upgraded computer resources, actual forecasts began in late July. Forecasts were run twice daily, with the highest resolution (5km) being a same-day forecast available in the early morning hours. Both the 45km (48-hour forecast) and the 15km (24-hour forecast) runs were conducted twice daily, beginning at 00z and 12z respectively. Delivery of the daytime run graphical products was achieved by about 1PM EDT, the production deadline for forecaster usability on the 12z cycle. The 00z forecasts were consistently available by about 3AM.

An FTP gateway was configured at MCNC to allow download of MM5 forecast data for input into a statistical model at ADEM. However, due to workload constraints, this was not activated during Year 1.

As noted, production forecasts began in late July. Forecasts were run through the end of October, typically the end of the ozone season in the southern US. All forecast datasets were archived on the MCNC-North Carolina Supercomputing Center Data Migration Facility. Further, an evaluation of the 15km grid forecasts for the month of August was completed. This evaluation was posted to the RTOFS Website. Results will be discussed below.

3.5.1.3 Year 2 Objective and Task

MCNC's principal objective for Year 2 of the grant was to continue to run the forecast system developed in Year 1 of the grant, while transferring forecast system technology to enable local forecast modeling to occur in Alabama.

As a subcontractor to the Jefferson County Dept. of Health, MCNC undertook two main tasks in order to achieve this objective. These tasks were identified as:

- Implement the MAQSIP-RT model on a dual-processor Linux-based PC system accessible to ADEM.
- Provide operational forecast output from the system to UAH through the EMPACT-Birmingham Website developed in Year 1, by continuing to run the system at MCNC twice-daily.

3.5.1.4 Year 2 Task Status

Table 2. Year 2 Task and Deliverable Status

	Task 1: Tech Transfer	Task 2: Forecast Model Run Continuation
Status	Complete	Complete

Production forecasts began on May 1 of Year 2 and continued throughout the ozone forecast season, ending on September 30. Following that, MAQSIP-RT source code and build scripts were ported to a computer housed at UAH. MAQSIP-RT was successfully built under Linux and demonstration runs were conducted.

3.5.2 Year 1 MAQSIP-RT Forecast Results: 15km Grid

3.5.2.1 Qualitative Forecast Results (Year 1 description)

Feedback from ADEM forecast personnel, beginning about 2 weeks into the forecast production period, suggested that MAQSIP-RT tended to overforecast ozone in the Birmingham area. In addition, forecasters in east Tennessee and North Carolina both noted the same trend on many days in August. We find that such forecaster feedback is vital in developing an initial understanding of model trends that may be useful in incorporating future improvements.

3.5.2.2 Quantitative Forecast Results

Figures 4a, 4b, and 4c show time-series of daily peak 1-hour and 8-hour-average ozone forecast versus observed peak-averages for the month of August. Three representative monitors in Jefferson County are shown; additional plots are available on the project Website. All three reveal the overforecast difficulty noted by the forecasters, this being particularly evident for the Fairfield monitor (Figure 4a: note that MAQSIP-RT gridded forecast data was bilinearly interpolated to the monitor lat/lon before plotting, and that monitor data was obtained from EPA AIRNOW.)

It is interesting that for both the Mtn. Brook and Tarrant City monitors, the ozone forecast *trends* track reasonably well with the observed trends, despite the high bias. This is also the case, though more weakly so, for the Fairfield monitor.

The next series of plots, Figures 5,6, and 7, examine three representative days during the August forecast period. Figures 5a (5b, 5c) show spatial plots of the 15km forecasts versus monitor observations for Aug 3rd (17th , 23rd). Though on the 3rd, the forecast represents what occurred in Alabama and NC reasonably well, most of the state of Tennessee is overforecast by one color code (yellow instead of green). Figure 5b is a scatter plot of forecast versus observed daily max 8-h segregated by monitor location. The two lines represent a 25% bound either side of the 1:1 line. It is seen that the rural monitors are more well-scattered with the exception of a cluster of overforecasts near 80-85PPB. Both the urban and suburban monitors show overforecasts at a wider concentration range on this day.

Aug 17th represents a clean day, code green throughout most of the 15km grid. However, it is seen (Fig. 6a) that MAQSIP-RT forecast code yellow or higher throughout much of a band stretching from Birmingham through Atlanta and NE into West/Central NC. The scatter plot (Fig. 6b) reveals the characteristics of the overforecast. Unlike the 3rd, the overforecast on this day is of higher relative magnitude at the rural sites than at the urban or suburban.

Finally, Aug 23rd represents a day in which MAQSIP-RT provided relatively good guidance to the forecasters. The spatial pattern (Fig. 7a) is quite well-represented throughout the SE, and the scatter plot (Fig. 7b) shows just a handful of monitor locations at which MAQSIP-RT forecast greater than 25% more ozone than occurred.

Examination of the all of the August data suggests that, like the results from the 23rd, MAQSIP-RT performed reasonably well on days that were favorable for ozone formation. Using a 60PPB observation cutoff, the normalized bias for MAQSIP-RT for peak 1-hour O3 forecasts is presented in Figure 8a. Such a data cutoff is routinely used in judging the performance of photochemical models such as MAQSIP-RT for State Implementation Planning. The normalized bias is computed as the average difference of the observed minus the forecast ozone divided by the observed ozone, all multiplied by 100%. For low ozone values, this can be somewhat misleading: an observation of 10PPB and a forecast of 25PPB would both be code green but would yield a normalized bias of negative 150%, whereas a forecast of 105PPB and an observation of 90PPB (still a 15PPB difference) would yield a forecast of red, an observation of orange, and a bias of negative 16%. The latter bias would be much smaller, but the forecast error more significant.

The normalized bias for *all* peak 1-hour average observations (0 PPB cutoff) is shown in Figure 8b. Taking into account the above caution, it can be seen that when the lower peak observations are included, the high-bias increases substantially. This suggests that on many clean to near-clean days, MAQSIP forecasts code yellow or above. This would yield a relatively high false alarm rate, which is an undesirable feature of a forecast model.

Work is proceeding on understanding the possible causes of the high bias in the SE US. We believe that two mechanisms may be involved: emissions and clouds. Examination of satellite data suggests that MAQSIP-RT may under-represent the attenuating effect of thin-to-moderate cloud cover on the photon flux in the visible and UV bands responsible for photochemistry. This may make the model "too hot" on these types of days, which were pervasive in the SE this past August. Also, examination of the spatial patterns of the ozone biases suggests a larger high-bias in the Birmingham-Atlanta-Charlotte-Raleigh corridor, and thus emissions inventories need to be investigated. Based on these observations, we made some updates to the photolysis rate calculations during the 2002 summer forecast simulations, which resulted in some improvement in performance. These results are discussed in our paper (McHenry and Coats, 2003) included in the Appendix.

3.5.3 Conclusions

This technical memorandum has summarized the work completed by MCNC under EPA EMPACT grant #R828583 for its two-year performance period. The principal objective, to provide the Jefferson County Dept. of Health with numerical ozone forecast guidance through an RTOFS, has been achieved. During the summer of 2003 and again in 2004, the model has been (will be) used as an integral part of the forecasting tools available to ADEM. The MAQSIP photochemical runs provided another valuable tool to be used when evaluating present day ozone levels, forecasted meteorology and statistical equation output. Several times over the ozone seasons, the modeling results were used as the final impetus for issuing an alert, and model performance across the season, when compared to actual data, improved greatly with each new season. Overall, ADEM was very pleased with the modeling simulations and found MAQSIP to be a valuable part of our forecasting program.

3.6 Task 6: Timely and Effective Public Outreach via Internet, News Media, and Other Means

This was the principal objective of this Project, and we believe we have been very successful in it. Prior to our EMPACT grant, a primary agent for public outreach was the daily ozone forecasting performed by ADEM meteorologists. In addition, public outreach involved local educational programs, especially at schools, which included sharing of daily forecasts with the selected stakeholders. Early efforts at providing on-site ozone monitoring at schools were limited and "primitive," especially because there were no ways to compare real-time monitored results at schools with real-time ozone monitored values at the EPA-approved ozone sites in the Birmingham area. JCDH spearheaded ozone monitoring efforts among a few of the organizations of the Alabama Partners for Clean Air (APCA) to provide ozone monitoring to students. These organizations included the Southern Environmental Center at Birmingham-Southern College and Ruffner Mountain Nature Center.

From these earlier beginnings, our EMPACT grant has allowed us to advance with much greater scientific information into the classroom (both indoor and outdoor classrooms). Teachers and students now have been allowed the opportunities to compare their own locally monitored ozone concentrations with those of JCDH in the Birmingham area, as well as others throughout EPA's extensive AIRNOW network.

Our focus and flagship activity in the area of public outreach has been the ongoing development of the EMPACT-Birmingham website at UAH, which can be readily accessed from the websites of JCDH and ADEM. This website will be described in detail shortly. Following approval by the EPA of our EMPACT grant, a public outreach campaign was waged, after being launched in conjunction with a press release to promote the Birmingham EMPACT program. Local media services have been extremely supportive of getting news about air quality to the public (especially noteworthy are *The Birmingham News*, *The Birmingham Post-Herald*, local television meteorologists from NBC, ABC, and FOX6 affiliates, and WBHM Radio affiliate of National Public Radio).

The developmental work continues for this ever-expanding web site, which was opened to the public during the 2002 ozone season. Stakeholders in the local ozone action program, especially the Alabama Partners for Clean Air (APCA), have also helped to provide "timely public access to air quality information." Educational programs have been numerous and have targeted outreach programs to the one hundred neighborhood associations in Birmingham, to many public and private schools, as well as colleges and universities, and to many civic-social, business, and environmental groups. Several thousand people have benefited from presentations focusing on the ozone and air quality issues in the Birmingham area. The EMPACT website is a source of pride as it provides near real-time public access to pollutant concentrations at our monitoring sites in the Birmingham area. It has proved especially beneficial this past year (2003-2004) as JCDH and other APCA partners are now utilizing wireless technology to take the website into presentations before the public. More recent partnering with the GLOBE program (Global Observations To Benefit the Environment) has allowed for more in-depth use of our EMPACT website with teachers and students in the Birmingham area who are pursuing air quality studies to understand more about the complex interconnections between meteorology and pollution caused by humankind.

In 2004 the Birmingham area was designated by the EPA as attainment of the 1-hour ozone NAAQS, following the conclusion of the 2001-2003 ozone seasons (EPA’s effective date was April 12, 2004). However, three days later on April 15, 2004, the area (Jefferson and Shelby Counties) was designated non-attainment of the stricter 8-hour ozone NAAQS. As a result, the website will continue to play a dynamic role in providing timely public access to air quality information. Ozone will continue to be one of several pollutants to be tracked via our EMPACT site. Finally, the Birmingham area (at least Jefferson County) will be designated by the EPA as being in non-attainment of the PM2.5 NAAQS in December 2004 or early 2005. The importance of our EMPACT site cannot be emphasized enough in terms of providing timely and effective public access to useful information about air quality for the Birmingham area.

3.6.1 Description of the EMPACT-Birmingham Website

This website was developed during 2001 at UAH under the leadership of Professor Gillani. Critical roles have also been played by his team-members William “Benjie” Norris, the chief software and data specialist, and Ms. Jennifer Geary, the graphics designer. All software development, data exchange with outside organizations, data processing and graphics generation related to the website products are performed on the EMPACT PC-server at UAH, purchased from EMPACT funds. The EMPACT database also resides on this hardware system. The website itself resides on the UAH web server (VORTEX).

The website integrates all the objectives of the Project. Its contents include local as well as regional information, monitoring data as well model simulations and satellite data, with focus on ozone and PM2.5. It is highly user-friendly and very graphical, providing the user a great deal of flexibility in accessing a variety of information with great ease. At this time, it is most developed in the function of data navigation in graphical form, and the data are updated every hour, hence near-real-time. In the future, we wish to further evolve it in the direction of online interactive education of the public in the basics of air quality. We now begin the description of the website itself.

The URL of the website is http://vortex.nsstc.uah.edu/empact_bhm/. Figure 9 shows the home page of the EMPACT-Birmingham website. It is a colorful, catchy page and immediately shows the regional-local dichotomy in the central graphic image. At the bottom of the image is the basic definition of EPA's EMPACT program and of EMPACT-Birmingham. Above the image are the main navigational buttons (blue), which remain atop every web page, so that one can easily move to any part of the website from whatever current position. The buttons are as follows:

- "Today's Air Quality Index" takes one to the JCDH website and information related to AQI;
- "Local data" opens up the world of the near-real-time local monitoring data of the BONA;
- "Regional Data" does the same for information pertaining to the eastern USA region;
- "Progress Reports" is for the user interested in the detailed information in Project reports;
- "Other Useful Links" opens the world of EPA, JCDH, ADEM, and many other useful sites;
- "Contact & Credits" recognizes the site developers and managers who can help, if needed;
- "Home" returns one to the Home Page.

The graphic image on the Home Page is for aesthetics and to highlight the essence of the site. The navigation to the rest of the site is via the buttons. So let us take a trip through the site, one button at a time.

Press the "Today's Air Quality Index" button and you are transported to the JCDH Home Page, shown in Figure 10. In the top left corner is the bar chart of today's near-real-time AQI, and below that is the link back to the EMPACT-BHM Home Page. It is via this latter link that the JCDH public reaches the EMPACT-Birmingham website. There is also a similar link to the EMPACT website from the ADEM website. Above the AQI bar on the JCDH home page is the link to "Air Quality Index", which transports one to the contents of Figure 11 providing much more detailed information related to AQI in tabular form. The top table gives the numerical value of the current AQI, identifies the pollutant responsible for it, and also provides a forecast of tomorrow's AQI. The next table provides the pollutant-specific AQI and related concentration and the monitoring site with this highest level. The information is hourly, based on the continuous data for ozone, PM2.5, PM10, SO2 and CO. The next table relates the AQI descriptive classes with their corresponding numerical ranges, and the final Table defines the primary NAAQS for these pollutants. Following the tables are two related links, one to tomorrow's ADEM-forecasted ozone AQI (Figure 12), and the other to educational information about the AQI as contained in the EPA website (Figure 13). The ADEM ozone forecast page (Figure 12) is for the whole state of Alabama, and provides the ozone-AQI forecasts for the BONA as well as for the Mobile and Huntsville-Decatur areas. These are the three in-state areas for which ADEM produces daily ozone forecasts. Figure 13 shows the leading page about the AQI in EPA's AIRNOW website. Here, the user can self-navigate through the variety of educational information contained in the AIRNOW website. Now back to the EMPACT-BHM Home Page and on to the next button.

Through the "Local Data" button, we arrive at the local monitoring data of the 11 measurement sites shown in Figure 1. This is a busy page, and a gateway to a broad variety of local as well as bi-state (AL and MS) observational information in graphical form. The local information is available in spatial or temporal form. Let us first explore the temporal realm, based on the continuously measured data. There are two choices: one can examine the data by individual site or for all sites together. In the top left, under the header "Spatial Maps", is a map of the 11 local sites. By clicking on the yellow circle for any single site, one goes to the kind of information contained in Figure 15. In the lower part of the Figure, for compaction, we have included two plots of the past 24-hour time series of the 1-h (left, hourly-average data) and 8-h (right, 8-h running average based on hourly data) ozone data, but when the user arrives to this page, there is only one plot, that of the 1-h average data (left). The page also contains the matrix on top, from which one can choose to access similar individual-site (any site can be chosen from the top row) temporal plots by species and temporal resolution (left column) of --- ozone (1-h or 8-h), PM-10 (1-h, 24-h), PM2.5 (1-h or 24-h), and SO2 (1-h or 24-h). The dots in the cells of the matrix indicate data availability (no dot, no data); the color coding of the dots simply distinguishes the one site in Shelby CO (Helena, brown) from the remaining sites in Jefferson CO (blue). By clicking on any dot, one is taken to the corresponding plot of the chosen species, temporal resolution and site. By clicking on the "Local Data" blue button at the top, one is returned to the Local Data page (Fig. 14). To get the temporal data of all sites on the same plot, one uses the buttons on the lower left panel of the Local Data page. There are four buttons --- for ozone, PM2.5, PM-10 and SO2. By clicking on the button for any of these species, one sees a 24-h temporal (time series) plot of all sites, as in Figure 16 for ozone. Again, for compaction, we have included two plots, for 1-h and 8-h ozone (the actual web page has only one plot). Between the top blue buttons and the plots is the link to choose, from this page, any of the four species. The ozone plots show ten traces of data from the ten ozone sites, color coded by site, as defined in the legend in the upper left of the plot.

Now we turn our attention to viewing spatial plots of the measured concentrations at the 11 sites. We go back to the "Local data" page (Fig. 14). The spatial plots are like the one in Figure 1, with the filling color in each site circle representing the AQI or concentration class. The choice of species and temporal resolution for the plot wanted can be made from the colored buttons in the upper right (below the home-page blue buttons). Under the header of each species, the buttons show the temporal resolutions (and units, e.g., AQI class or ppb class) of choice. In Figure 17, again for compaction, we have included two plots instead of the normal one, here for 1-h ozone (AQI and ppb classes). In each plot, the color coding for each site is defined in the legend to the upper left of the plot. Above the plots are the links to all the other available choices (same as available via the corresponding buttons in Fig. 14). Thus, once one enters the temporal or spatial realm, one can continue to navigate through all the available choices of that realm without necessarily going back to the Local Data page to make a new choice. One must go back to the Local Data page only to change the realm (spatial or temporal). In the Local data page, we also have the choice to access a bi-state (AL-MS) contour plot of near-real-time or archived 1-h ozone based on AIRNOW data. This information is not locally generated, but is imported from EPA's AIRNOW site. By clicking on the choice to do the bi-state ozone plot, one is taken to a link such as in the upper half of Figure 18. That step-by-step instruction path permits one to choose (from the EPA site) the day and hour for which the contour plot is wished. The bottom of the figure shows the result for June 12 2002 (the plot was made on that day based on current data at 3:40 pm). So now, we have an idea of the type of local data products one can access. We now turn attention to the available "Regional Data" by clicking on that primary blue button at the top.

We arrive at the content of Figure 19, which shows a regional (eastern USA) contour plot (generic). On the map are rectangular headers for ozone, PM2.5 and Satellite Imagery. Under ozone, we have a finer selection of "measured" or "forecast" information. Figure 20 shows an example of the type of graphic product that was seen by clicking on the Measured Ozone button on 23 April 2004. There are four eastern USA regional contour maps of peak daily ozone for the past four days. Figure 21 shows the same kind of product when the PM2.5 button was clicked. The four-day sequence shows not only the spatial (regional) distribution of the pollutant, but also the four-day dynamics. Let us focus on Figure 21 for now (generated on 27 June 2003). We see two bands of regional haze and their four-day dynamics. During the whole period, Birmingham was under the influence of the lower (more southerly) of the two bands, associated with a high pressure cell, with the haze being rather stagnant and most intense locally on days 1 and 2 and thereafter gradually weakening. In the meanwhile, the upper band was moving relatively rapidly eastward toward the eastern USA coastline and also intensifying with time. By the fourth day, the two bands had become aligned ahead of a strong frontal passage. Combining such information with synoptic weather maps (pressure, winds, precipitation, etc.) and satellite imagery (Figure 22, not for the same period), one can formulate a good sense of the regional pollution picture in a dynamic sense, and maintain an awareness of how the local conditions are likely to be influenced by regional episodic pollution. Figure 22 shows a sample of four days of GOES satellite imagery such as can be retrieved by clicking on the "Satellite Imagery" button on the "Regional Data" page. Actually, the links are to such a map for a single day, with options to get any of the four days. Such a sequence contains visible satellite information of regional cloudiness and regional haze, and augments the other regional information to maintain awareness of potential regional impacts on local air quality ahead of time.

The above regional information products are all based on *in situ* or remotely-sensed observational data. We also have access to regional products from our regional 3D photochemical modeling in forecast mode. Figures 23 and 24 show that kind of information accessed by clicking on the Forecast button under OZONE on the Regional Data page (Fig. 19). The two plots are, respectively, of 1-h and 8-h average peak forecast ozone for 23 June 2003 (1600 CDT). In the summer of 2002, we had a broader choice of such products to choose from, and such choice was summarized in the "options" listed in the upper part of each page. The choices include forecasts for today or tomorrow, and for each, peak 1-h or 8-h ozone contours. In 2002, we also performed the simulations in three nested domains (see Fig. 3), with 45-, 15- and 5-km spatial (horizontal) grid resolution, and had the choice to select simulation products from any of the three grids and grid resolutions. The plots in Figures 23 and 24 are for the coarsest (45-km resolution). Such products are used by ADEM, along with the results of their statistical forecasting, in the final forecasting issued to the stakeholders. The MAQSIP photochemical runs provided another valuable tool to be used when evaluating present day ozone levels, forecasted meteorology and statistical equation output. Several times over the ozone seasons, the modeling results were used as the final impetus for issuing an alert, and model performance across the season, when compared to actual data, improved greatly with each new season. Overall, ADEM was very pleased with the modeling simulations and found MAQSIP to be a valuable part of our forecasting program.

This completes the description of the website. The site is clearly the single most outstanding feature of our program and has already been used extensively by a wide range of stakeholders and the general public. It has proven to be quite popular with the whole range of users and we expect its functionality and popularity to grow with time. It is a great asset to our whole AQ management program and is a product that EMPACT and EPA can be very proud of, as we are. We also believe that our contour map product for PM2.5 has similar potential to that of the AIRNOW ozone product at the regional scale.

3.7 Task 7: Development of the Centralized Information Management System of EMPACT-Birmingham

3.7.1 Introduction

ADEM and JCDH maintain 21 continuous monitors at eleven sites in the Greater Birmingham metropolitan area of Jefferson and Shelby Counties. JCDH operates and maintains nine ozone monitors, two PM_{10} and eight $PM_{2.5}$ monitors, and one SO_2 monitor in Jefferson County. ADEM operates and maintains an ozone monitor in Shelby County. Observations from these monitors are automatically polled and transferred to the EPA Data Collection Center (DCC) as a part of the Automatic Data Transfer System (ADTS). These data are also made available to the University of Alabama in Huntsville (UAH) where they are processed into graphical form for public access through the EMPACT-Birmingham website on the World Wide Web. Regional ozone and particulate data are retrieved from the EPA DCC, and satellite data from NASA, for presentation on the web. The regional data provide a broader context in which the data of the Greater Birmingham area can be interpreted. Finally, during the ozone season, ozone forecasts produced by a photochemical model are downloaded from Baron Advanced Meteorological Systems (BAMS, formerly MCNC) and made web-accessible. The purpose of this section is to describe the origin, transfer, processing, and storage of the data, and the database management infrastructure and process.

3.7.2 Data Owners and the Data Flow Process

Figure 25 shows the organizations that participate in the data-management system and how the data flow between them. The data-flow paths in the figure are numbered for reference. The hub of the system is a Linux-based computer (purchased from EMPACT funding and named "EMPACT") that resides at UAH and is operated and maintained by UAH. The computer's main role is to ingest data from a variety of sources, use the data to create graphical products, and upload the products for public viewing on the EMPACT-Birmingham web site. The web site resides on the UAH web server ("VORTEX"). The disk space on the computer acts as the repository for any data not already routinely archived by other participating organizations.

Products available on the web page are derived from both surface observations of pollutants (JCDH, ADEM, EPA), meteorological forecasts (NOAA), satellite observations (NASA), and a photochemical model (BAMS). The sources of these data contribute to the development of these products but are behind-the-scenes participants. Data required by BAMS and UAH from the above government agencies are routinely downloaded from publicly available ftp or http sites operated and maintained by these agencies.

NOAA supplies (data-flow path 1) meteorological observations and meteorological model output to BAMS. On a 12-hour cycle ETA model output and EDAS analyses become available to BAMS for initializing and nudging the meteorological model component (MM5) of the Real-Time Ozone Forecast System (RTOFS). BAMS also partially initializes the ozone fields of RTOFS with the previous day's ozone observations, which are downloaded (2) from the EPA DCC. When the forecast products are ready, UAH uploads them (3) from BAMS. UAH ingests (4) a satellite image of the southeastern United States each day at about noon. UAH receives (5) current surface ozone, particulate-matter, and SO_2 concentrations for Jefferson Country from JCDH every hour. UAH also receives (7) concentration data from the remaining continuous monitoring sites in the State from ADEM. However, only the data from the Shelby County ozone site is used for this project. While JCDH and ADEM are transmitting these data to UAH, they are also transmitting them (6 and 8) to the EPA DCC. Each morning at about 10:45 local time, UAH downloads (9) all available ozone and PM2.5 data from the EPA DCC. These data are used to construct regional contour plots of these two pollutants for the past four days using software generated at UAH. When UAH has processed the data it receives and has created graphical images from them, the data and several of the web-page products are archived (10), and the images are uploaded (11) to the UAH web server for presentation on the Birmingham EMPACT web site. The site provides a form whereby users can enter dates and times of a pollutant of interest and can retrieve the corresponding concentration image, if it is available.

3.7.3 Data Collection Methods

All surface observations of pollutants in the Greater Birmingham area reported on the Birmingham EMPACT web site are obtained from commercially available continuous monitors that are polled hourly. The operation and maintenance of the monitors are governed by ADEM and EPA monitoring documents. Data polling and data uploading to the EPA DCC and to the UAH computer are handled by ADTS software and conform to ADTS specifications.

3.7.4 Data Storage and Retrieval

Storage and retrieval of the project data occur at several locations depending on the nature of the data. Surface and upper-air weather observations are archived at NOAA's National Climatological Data Center in Asheville, North Carolina. Satellite images are archived at a number of NASA sites including the National Space Science and Technology Center in Huntsville, Alabama. Ozone and particle concentrations for the greater Birmingham area are stored at UAH as well as in the EPA DCC. BAMS archives its RTOFS ozone forecasts for the duration of this project so that they can be evaluated against ozone observations. As a rule graphical products will not be archived by the UAH computer if they can be readily regenerated from archived observations. However, images displaying the hourly concentrations of ozone at all sites for the previous 24 hours are archived. The same is true for the corresponding images of particulate and SO_2 concentrations.

3.7.5 Data Delivery System

The primary vehicle for delivering information to the public is the Birmingham EMPACT web site, located on the UAH web server. One of the advantages of a web page is that it can not only be consulted directly by the public but can be linked to other web sites in which the public is likely to be interested and thus provides a multiplier effect in the dissemination of information. The ADEM site, the JCDH site, the EPA EMPACT site, and the EPA AIRNOW site are among the useful links available from the Birmingham EMPACT site.

3.8 Task 8: Project Sustainability and Transferability

The EMAPCT-Birmingham Project is fully institutionalized and sustainable. It is also dynamic in that it continues to evolve in response to practical needs of the beneficiaries, including JCDH, ADEM and the public. The essential hardware and software needed to sustain it (mainly the monitoring and the website) are in place. A strong and very efficiently operational team also exists now to provide the necessary technical human resource for Project sustenance. The JCDH team performs the local monitoring within Jefferson CO, while ADEM performs that function in Shelby CO. The funding for these functions is part of the base funding of these organizations, with contributions from EPA. The JCDH team also handles the local public outreach function with the local media, schools and other stakeholders. The UAH team is in charge of the design, development and maintenance of the EMPACT-Birmingham website and the EMPACT DBMS system. UAH also drives the science components of the Project including future data analyses and interpretations. As such UAH oversees the participation of the BAMS photochemical forecast modeling team. It is our intent over time to internalize the forecast grid modeling functions at UAH so that the entire Project is carried out in-State. The human resource needed to sustain this Project is in place, trained and routinely delivering.

The major question mark pertaining to Project sustenance has to do with long-term base funding. We do not have that in place. We requested from EPA a no-cost extension of the Project period by one year to test out the funding scenario beyond the timeframe of EPA-EMPACT funding (2001 and 2002). During that year (2003), JCDH and ADEM continued their monitoring and chemical analysis responsibilities with internal-external funding, including non-EMPACT EPA funding. These resources appear to be long-term and reliable. JCDH was also able to generate funding, via the Birmingham Regional Planning Commission, from DOT's Congestion Mitigation Air Quality (CMAQ) program (80%), and JCDH matching funds (20%), to fund the continued participation of UAH (mainly to maintain and further develop the website) and of BAMS (to continue providing the photochemical model ozone forecasts). All the external funding to continue the EMPACT-Birmingham project during 2004 is also in place. At least for now, it appears that the Project has impressed local-federal agencies sufficiently that it is likely to continue and evolve. The website has functioned very well during 2003 and has even been upgraded as dynamically necessary. For example, a a new PM2.5 continuous monitor was installed during 2003 at the Leeds site, and we had to make software changes related to the website and to the DBMS to accommodate the new data and their timely display in the website. The JCDH scientists also suggested that we include color-coded bars showing the AQI classes alongside the vertical concentration axes on all local temporal plots. The necessary changes to the software were made to accommodate such an upgrade. We have also facilitated for ADEM to get near real time numerical data of the Shelby CO (Helena) monitoring program directly out of our database more easily than it is for them to get it from their own monitoring arm. Occasionally, web users (mainly the monitoring people at JCDH) detect some error in the website and report to us, and we react to make the necessary changes to correct it. So, UAH maintains the DBMS and the website in an on-going manner, making upgrades as necessary.

As far as Project transferability beyond AL is concerned, we believe that the Project process is well documented, as in this Report, for other state-local agencies to become fully aware of the Project functions and benefits. We would be happy to help other state-local agency personnel as much as we can in technology transfer to create an equivalent project in their domains. It would be very beneficial if the first such technology transfer trial effort happened under EPA aegis.

4. **RECOMMENDATIONS**

Our principal recommendations are in the area of technical assessments based on the rich EMPACT-Birmingham database.

We have generated and archived a fantastic database of local-regional information pertinent to the AQ of Birmingham. Mostly, this database is being wasted, and the same is true in most other metro areas. We believe that an assessment program needs to be created to demonstrate the utility of this database towards AQ management and improving the chances for ozone and PM2.5 attainment. We give two examples here of how this may be done:

(1) It is possible to improve on the current practice of statistical forecast modeling significantly at relatively much lower cost than the regional 3d photochemical modeling, which is an evolving science whose attainment of solid reliability and institutionalization nationwide is still several years into the future. The improvement we are alluding to would be to include the role of transport, if not of chemistry during the forward forecasting period. Let us say that we want to generate an ozone forecast 48 hours ahead.

Clearly, it is most unlikely most times that the local AQ will remain static for that period. Therefore, the use of today's local ozone concentration as an independent variable in the statistical regression formula to forecast the local ozone concentration 48 hours into the future is without good basis. It would be much more defensible to use the value of the ozone concentration at the upwind location of the same airmass 48 hours in the past as the independent variable in the regression analysis. To do this, we must construct a 48-hour back trajectory using forecast wind-field (a routine product from on-going met forecasting), and use the ozone concentration there at that time generated from spatial interpolation from the rich database of EPA-AIRNOW. Calculation of the back-trajectory is a fairly simple task with operational trajectory models (e.g., NOAA's HYSPLIT). Once such upwind concentration information is generated, it should be plugged into a revised regression formula derived using such upwind information. The derivation of such a formula requires some statistical analyses of sufficient amount of data from the past. We believe that such an enhancement of the statistical modeling method would significantly improve the accuracy of the forecast. Also, the procedure developed can easily be replicated throughout the country.

(2) It is well enough recognized now that the contribution of ozone production in large coal-fired power plants within a mesoscale distance (< 100 km, say) of a large metro area can, in the event of direct impact, add sufficiently to the regional-background + local-urban contributions, and possibly lead to violation of the 1-h ozone standard, in particular (see for example, Gillani et al., 1998), and possibly also contribute significantly to the 8-h standard violations. Such impacts occur only when the wind direction is appropriate to transport the power plant plume directly over the urban area. Both the likelihood of such transport and the quantitative magnitude (in terms of ppb of ozone) can be forecast, possibly with good accuracy, using available monitoring data and models (including Lagrangian Reactive Plume Models). This is a relatively simpler procedure than the application of a full-blown 3D regional photochemical model in forecast mode. We strongly recommend that such capability for mesoscale forecasting of power plant plume impact on large urban areas be explored. The utility of predicting such impact accurately could have very major benefit for a large number of urban areas with large power plants less than 100 km upwind.

(3)

5. REFERENCES

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Gillani, N.V. et al. (1998). Relative production of ozone and nitrates in urban and rural power plant plumes, I. Composite results based on data from 10 field measurement days, *J. Geophys. Res. (Atmospheres),* **103 (D17)**, 22593 – 22615.

McHenry, J. N. and C. Coats (2003). Improved representation of cloud/actinic flux interaction in multiscale photochemical models, Proc. 83rd Annual Meeting of AMS, Long Beach CA, 9-13 Feb. 2003.

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TABLE 1

EMPACT-Birminghm : Monitoring Program --- Original and New*

	Monitoring Sites	Ozone	PM2.5			PM10			SO2	NOx	CO
			Continuous	FRM**	STN**	Continuous	FRM	Hi-Vol**			
1	Corner	O	N	O (3d)			N (6d)				
2	Fairfield	O						O (6d)	O/N***		O
3	Helena	O							O	O	
4	Hoover	O	N	O (3d)			N (6d)				
5	Leeds	N	N	N (6d)			N (6d)	O (6d)			
6	McAdory	O	N	O (3d)			N (6d)				
7	N. Birmingham	O	O	O (daily)	O(3d)	O	N (6d)				
8	Pinson	O	N	O (3d)			N (6d)				
9	Providence	O	N	O (3d)	O(6d)		N (6d)				
10	Tarrant	O						O (6d)			
11	Wylam		N	O (daily)	O(6d)	O	N (6d)				

* O = original (pre-existing) and N = new (installed during Project)
Ozone, SO2, NOx, CO monitoring continuous; PM2.5,10 continuous or batch-mode (FRM, STN), as indicated

** Frequency of 24-h sampling (e.g., 3d = every three days)
FRM = Federal Registered Method for gravimetric analysis of total mass concentration
STN = Speciation Trends Network sampling for speciation of samples

*** The original monitor was replaced by a new one during the Project

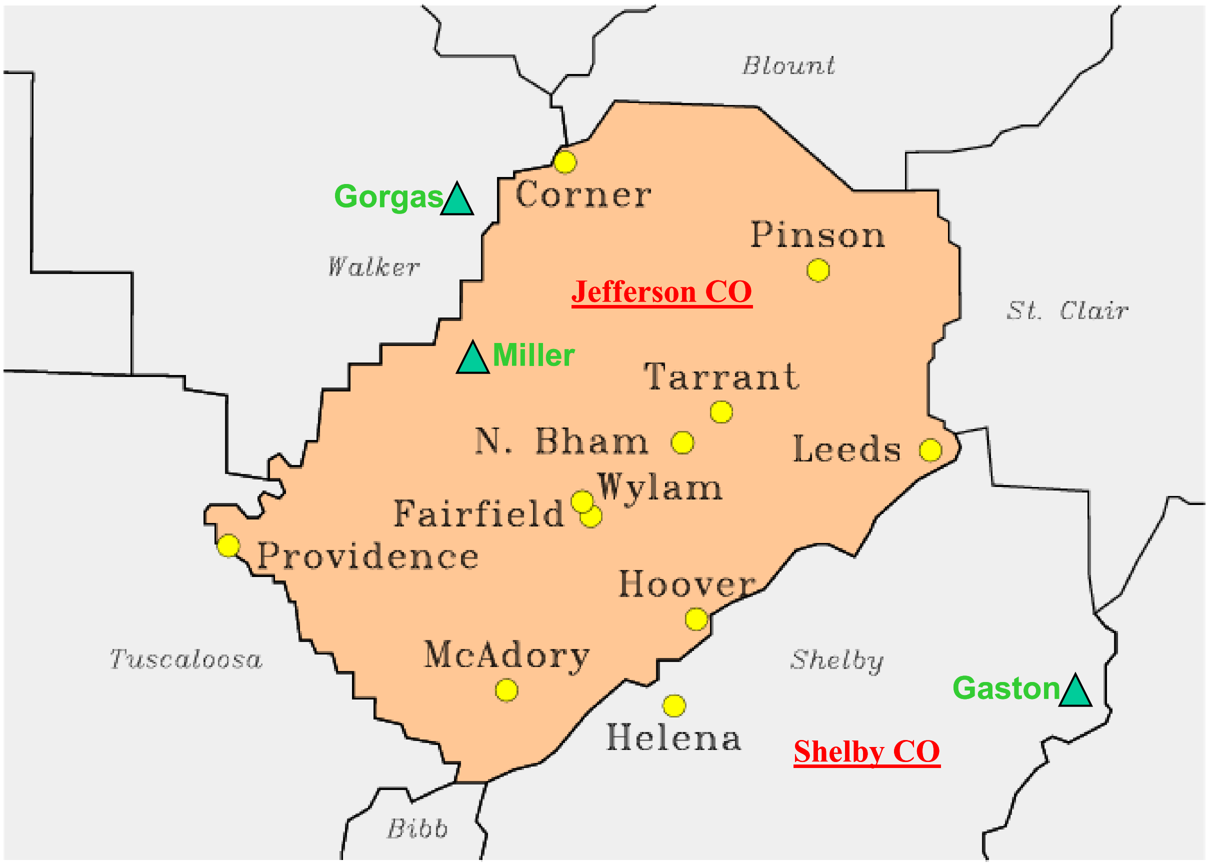


Figure 1. Map of the Birmingham area showing Jefferson and Shelby Counties, the local air quality monitoring sites (circles with yellow shading), and large coal-fired power plants (Gorgas, Miller and Gaston, triangles shaded green).

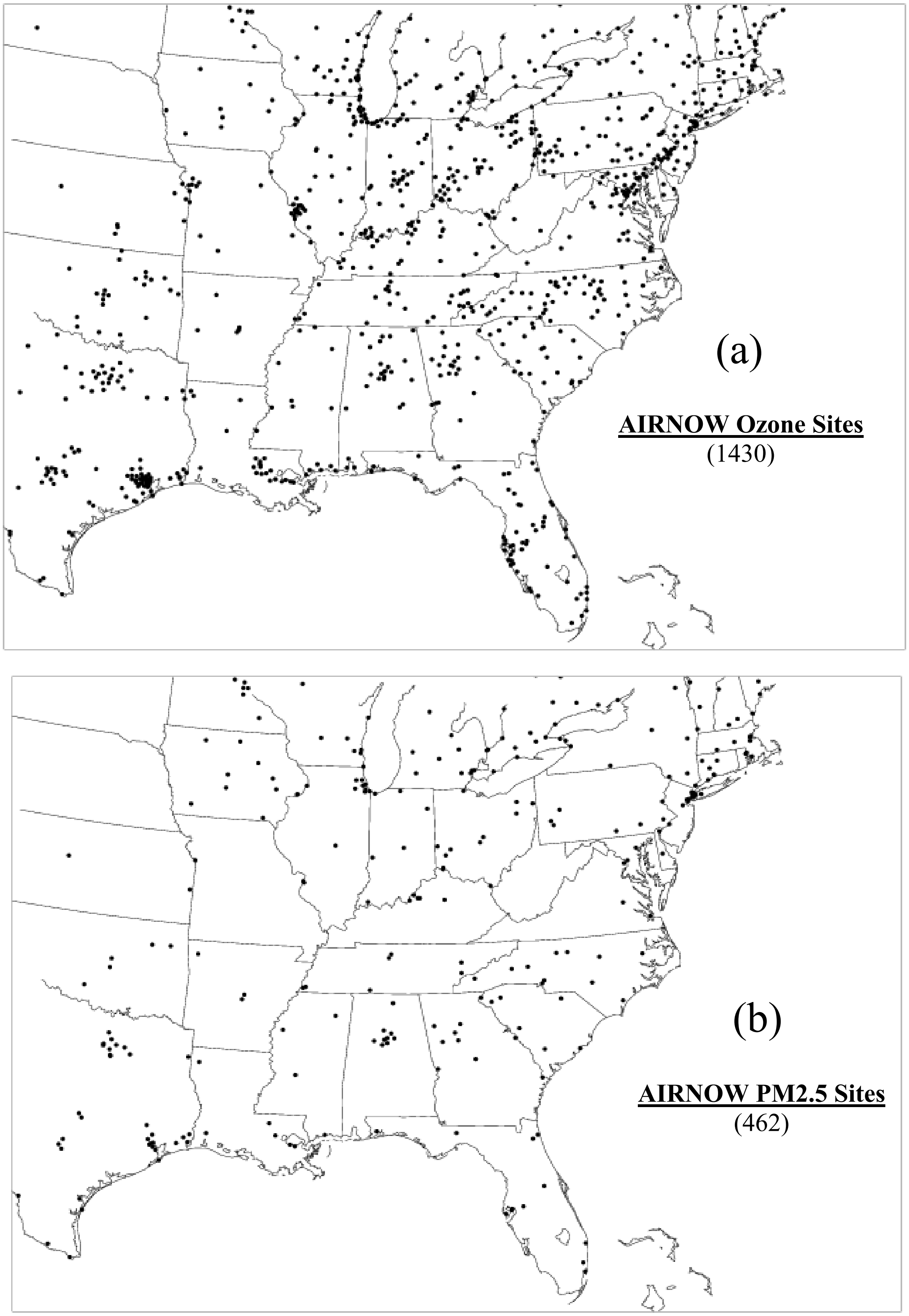


Figure 2. Locations of the EPA-AIRNOW sites in the Eastern USA, for ozone (1430 sites) and for PM2.5 (462 sites).

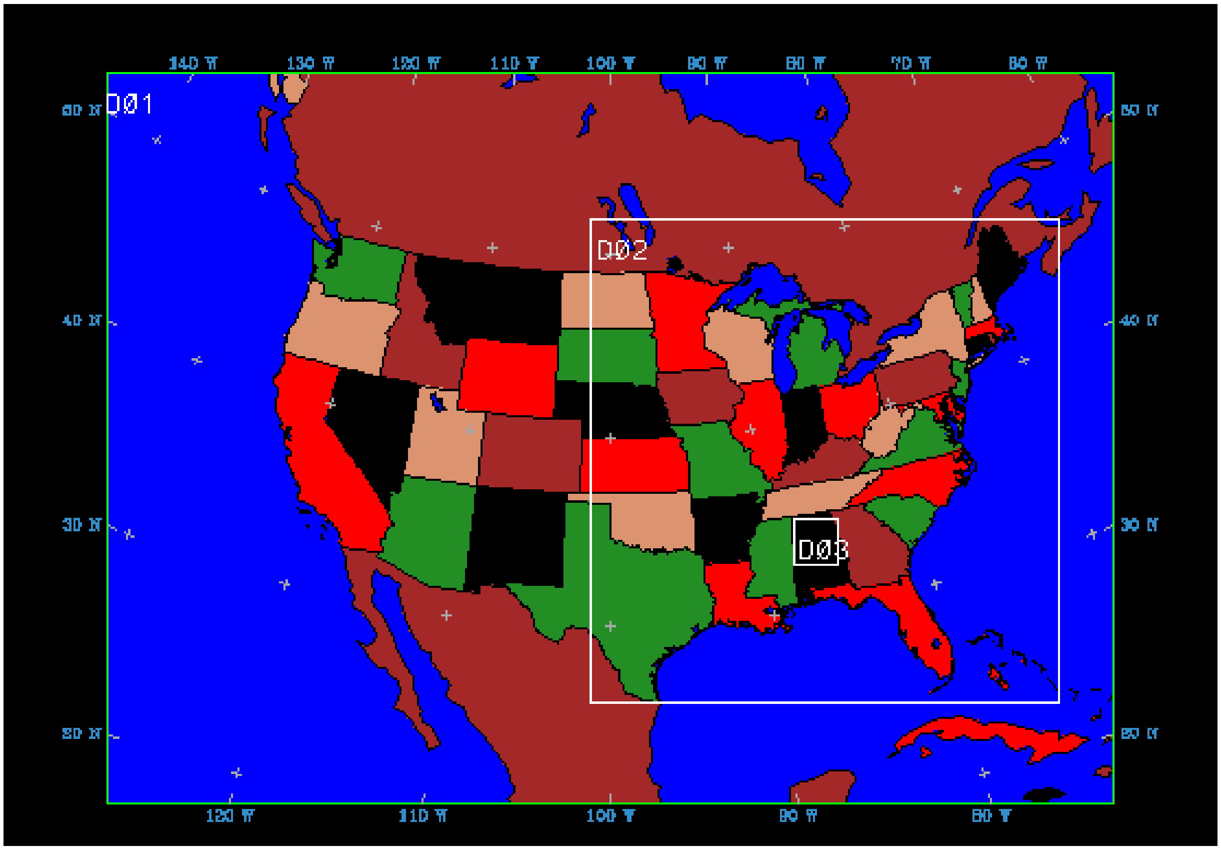
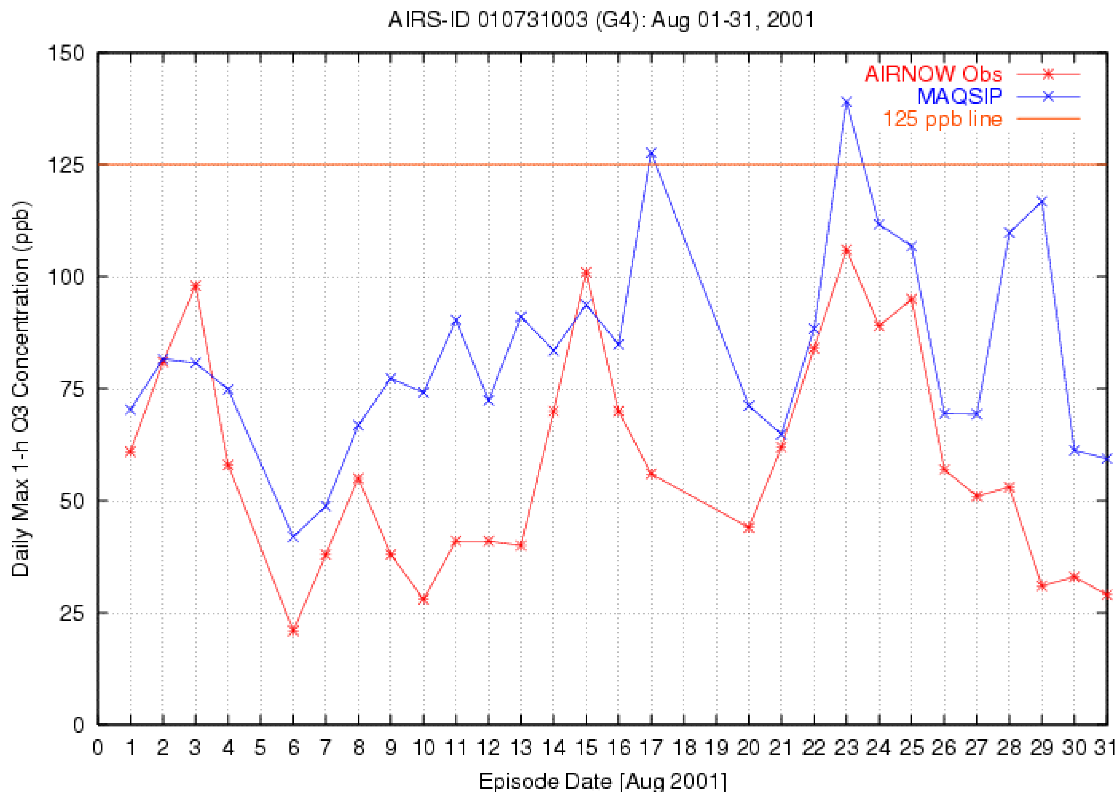


Figure 3. The grids for the EMPACT-Birmingham 3D photochemical ozone forecast grid modeling.
Grid 001 is the outermost whole-US domain with the coarsest (45 km) grid;
Grid 002 is the middle eastern-US domain with the intermediate-resolution (15 km) grid;
Grid 003 is the innermost Birmingham-local domain with the finest (5 km) grid.



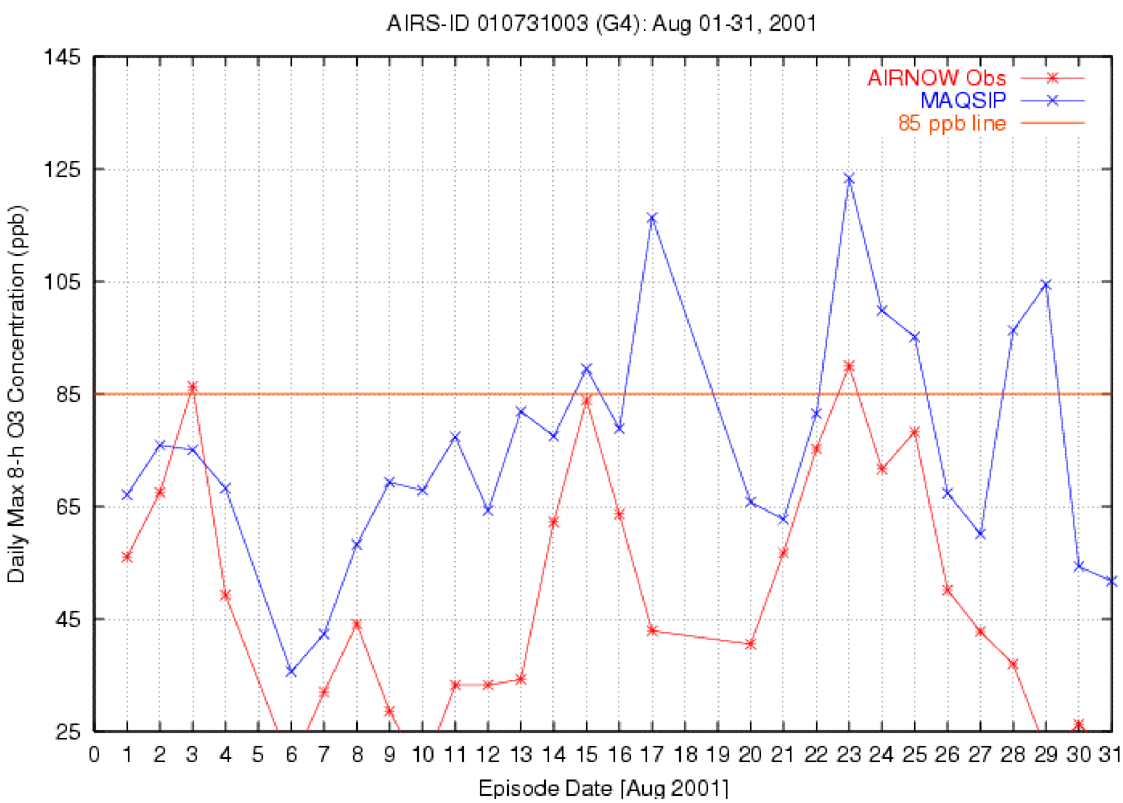
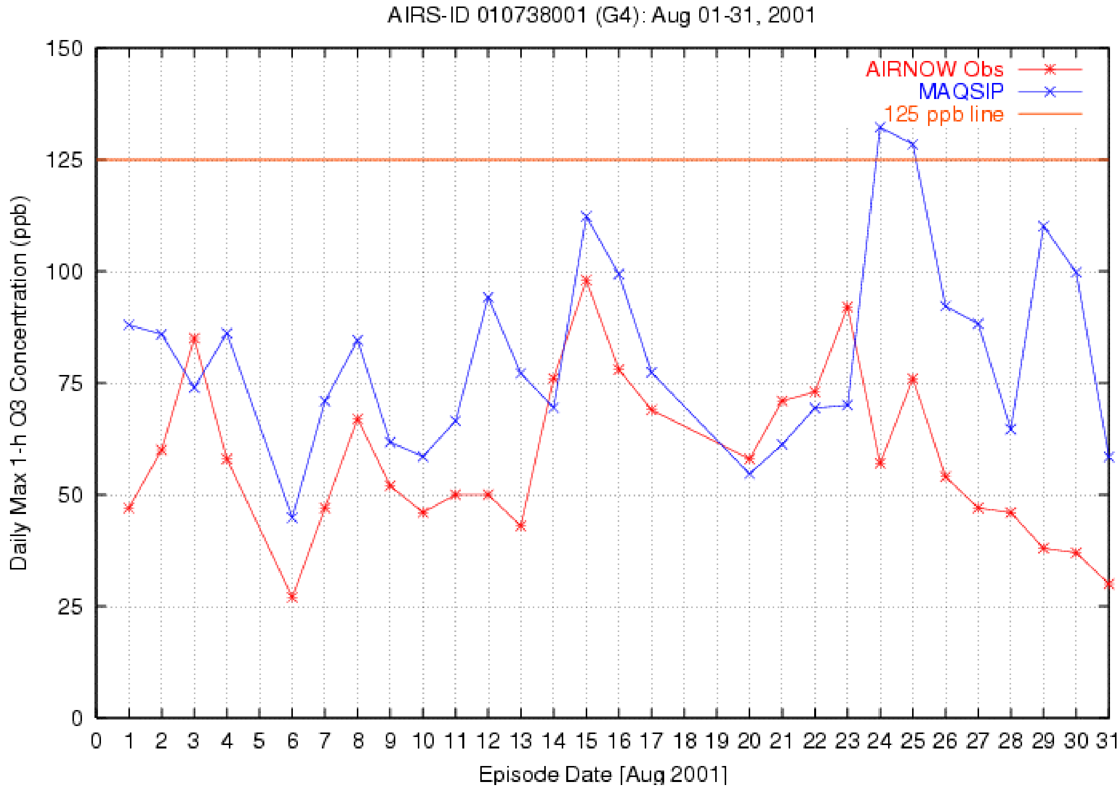


Figure 4a. August 2001 time-series of daily *maximum* 1-hour-ave (top) and 8-hour-ave (bottom) MAQSIP-RT 15km SE grid forecast versus observed ozone for the Fairfield (Jefferson County) monitor.



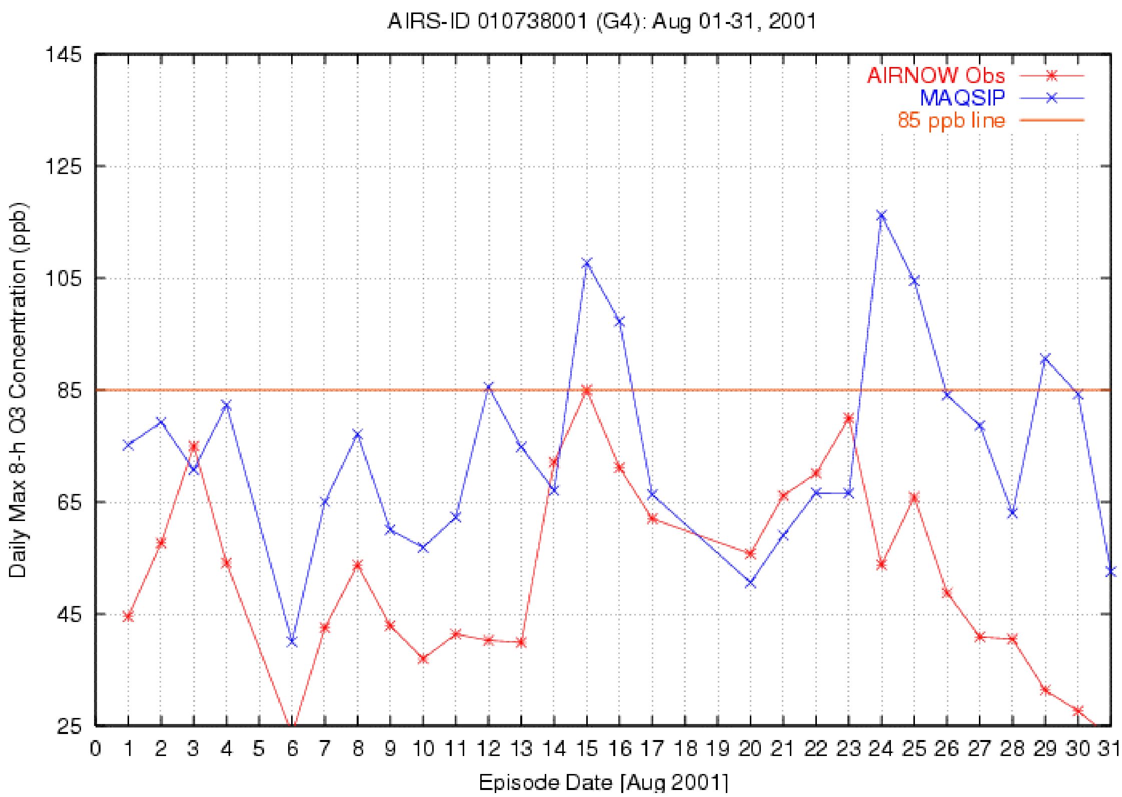
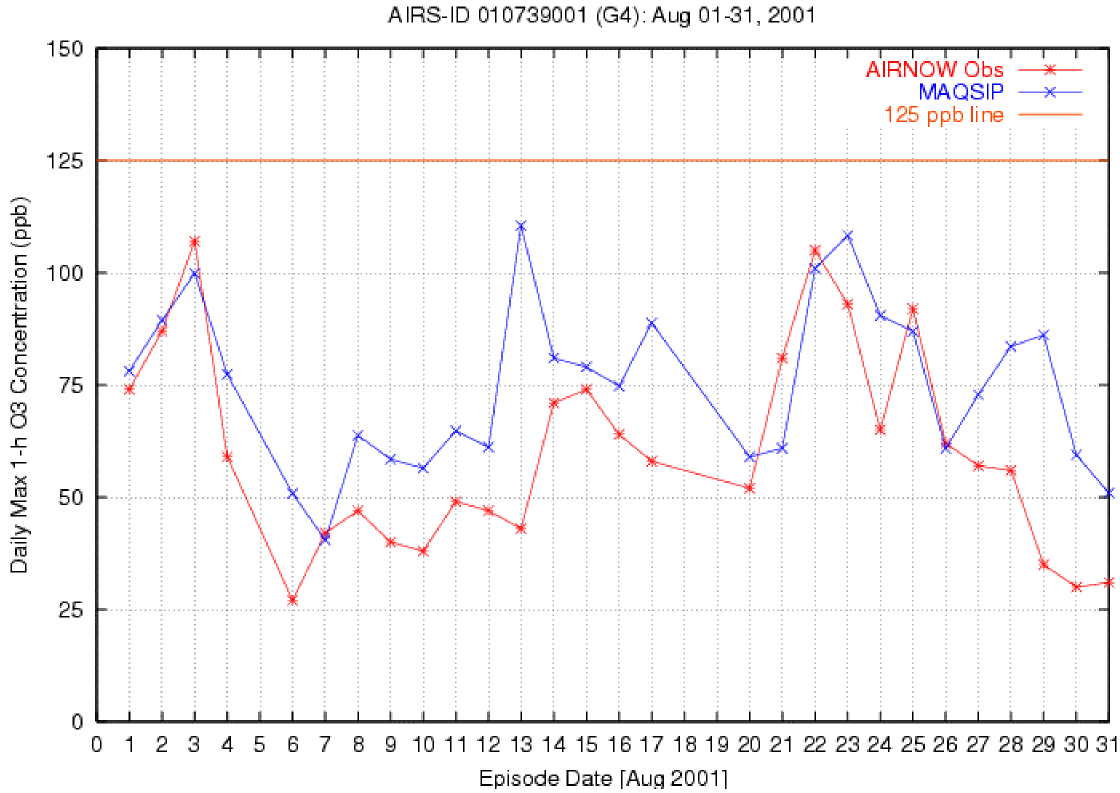


Figure 4b. August 2001 time-series of daily *maximum* 1-hour-ave (top) and 8-hour-ave (bottom) MAQSIP-RT 15km SE grid forecast versus observed ozone for the Mtn. Brook (Jefferson County) monitor.



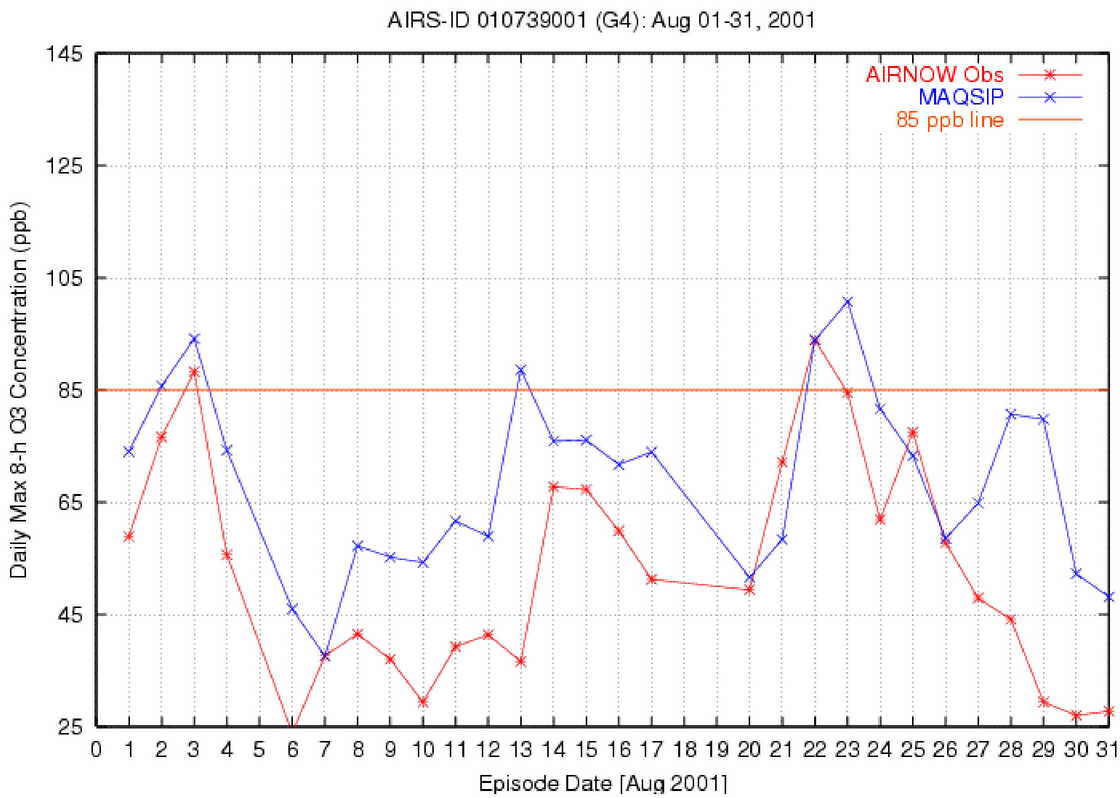
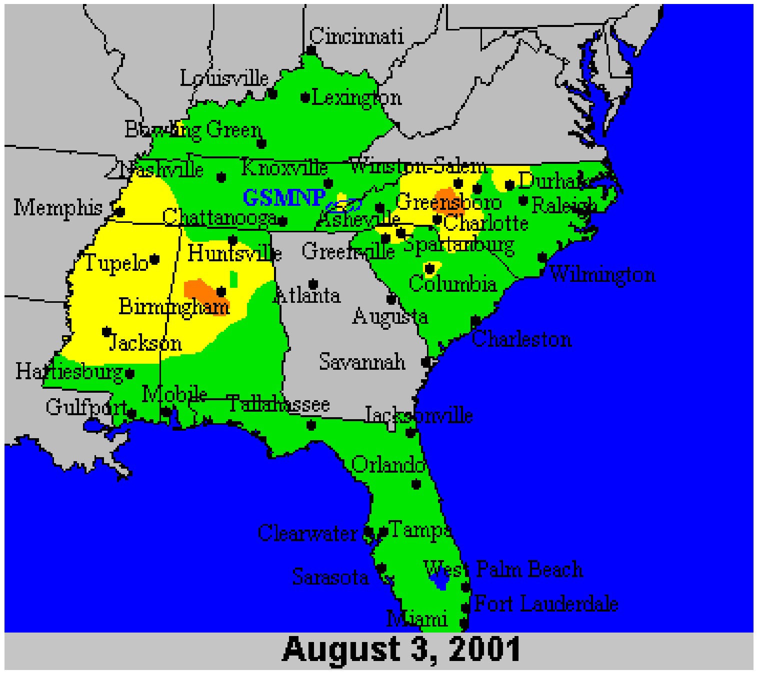


Figure 4c. August 2001 time-series of daily *maximum* 1-hour-ave (top) and 8-hour-ave (bottom) MAQSIP-RT 15km SE grid forecast versus observed ozone for the Tarrant City (Jefferson County) monitor.



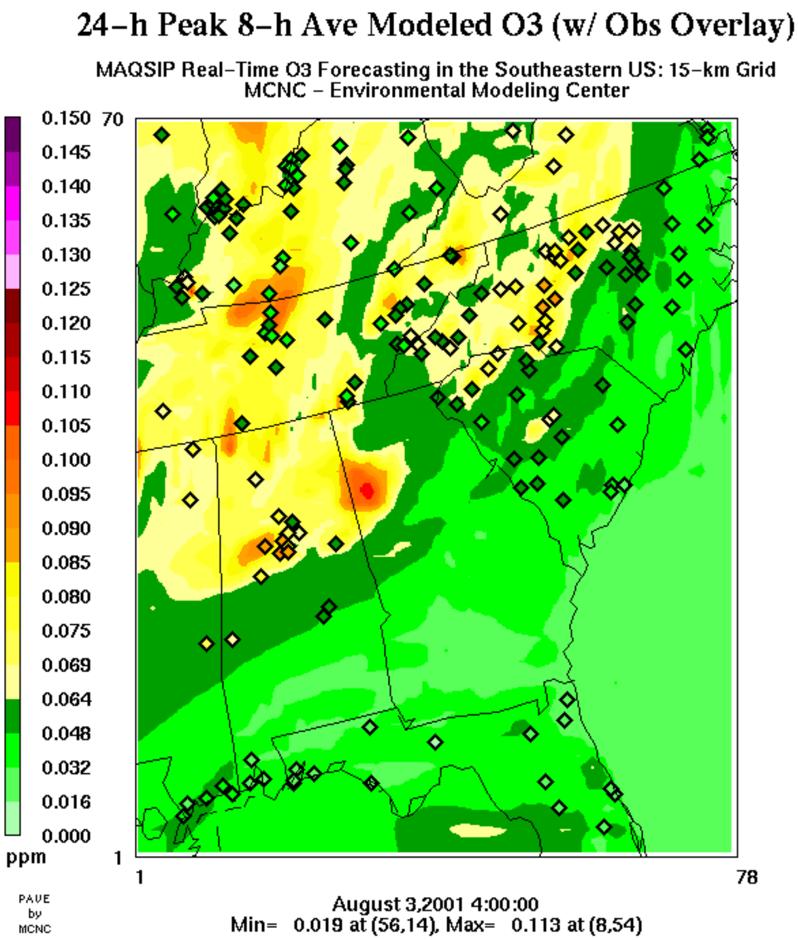


Figure 5a. Observed (top) and 24-hour forecast (bottom) ozone for Aug 3rd, 2001, MAQSIP-RT 15km SE grid. Top panel courtesy EPA.

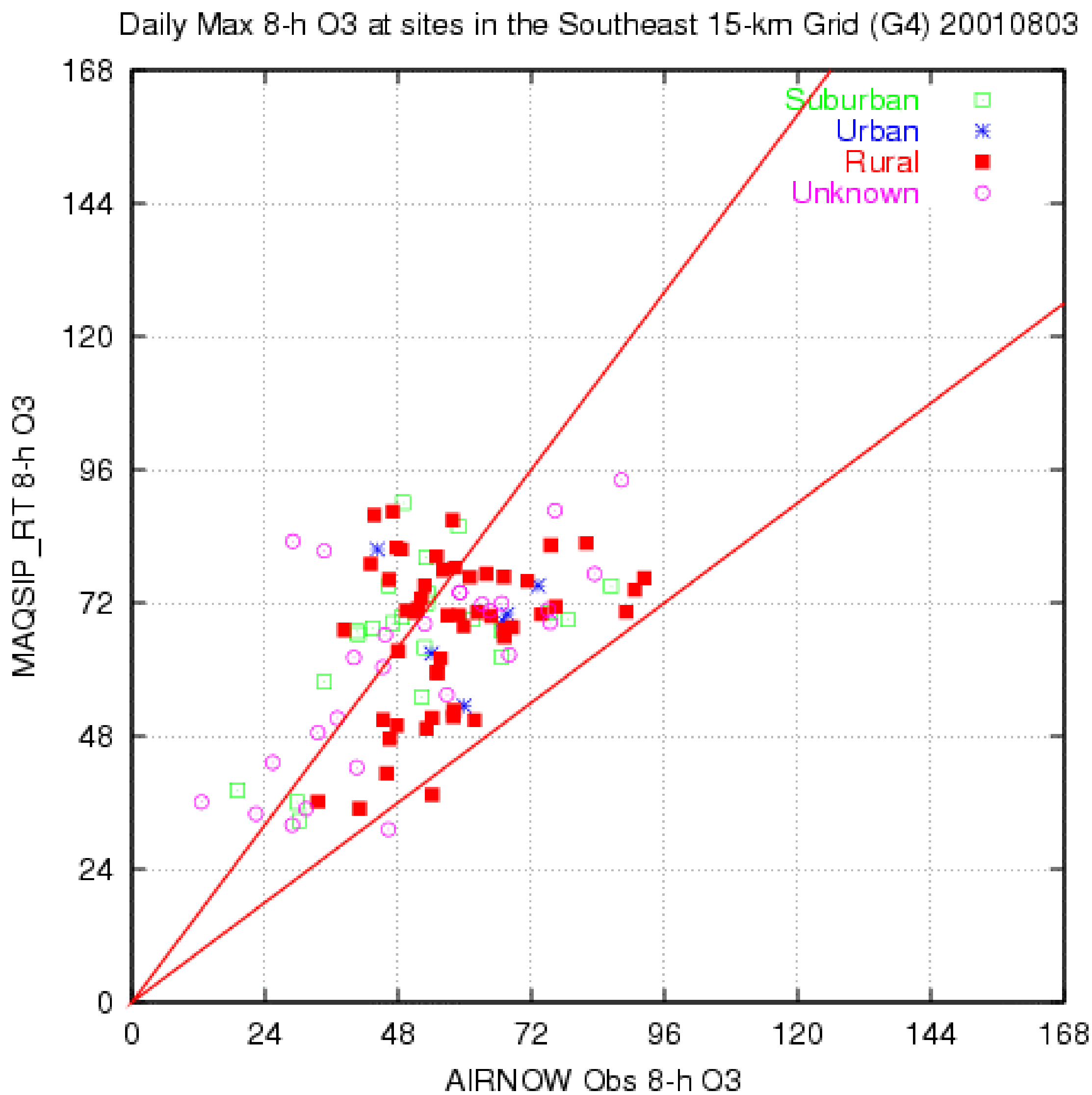


Figure 5b. Scatter plot of 24-hour forecast versus observed ozone for Aug 3rd, 2001, MAQSIP-RT 15km SE grid.

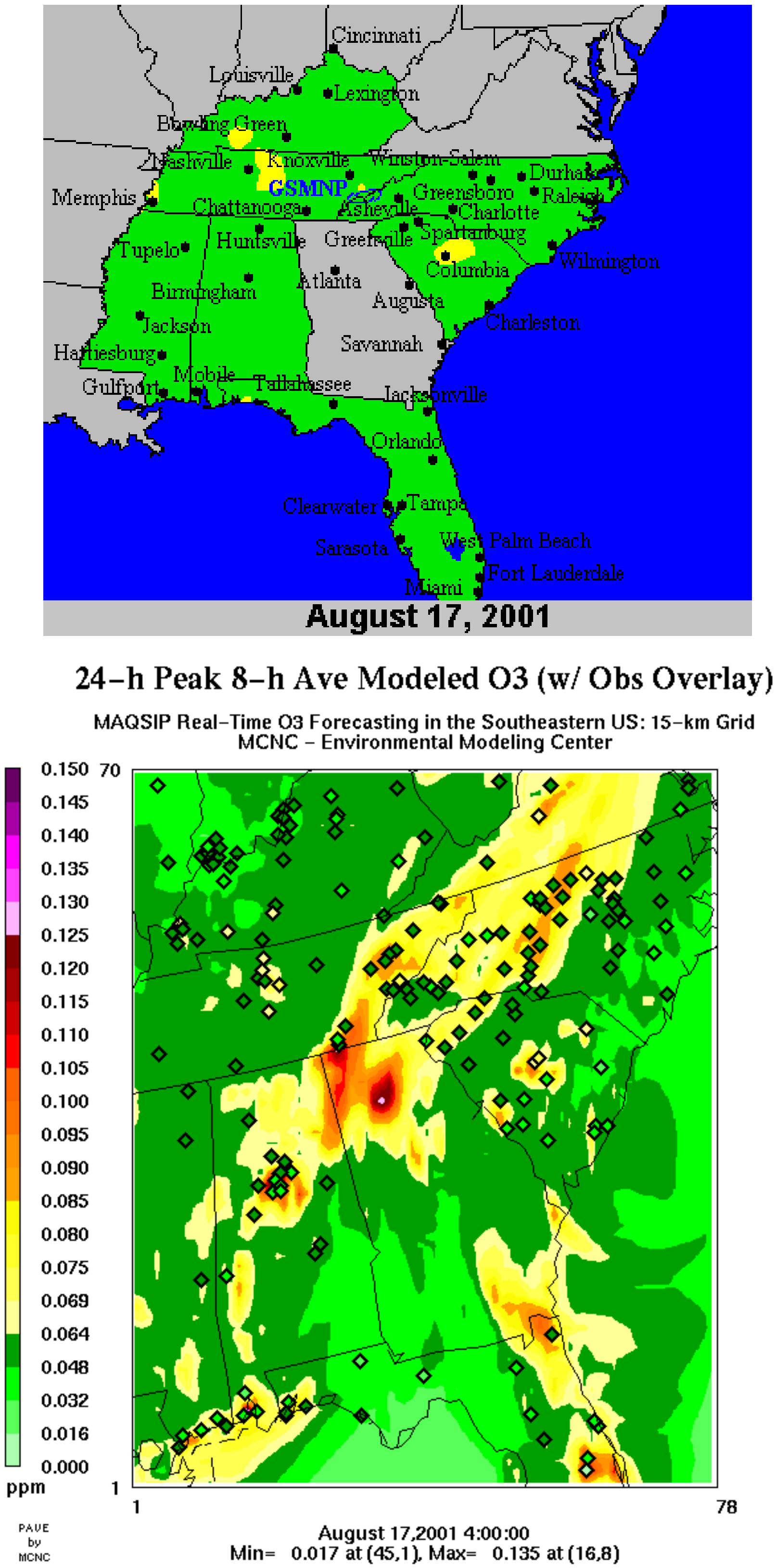


Figure 6a. Observed (top) and 24-hour forecast (bottom) ozone for Aug 17th, 2001, MAQSIP-RT 15km SE grid. Top panel courtesy EPA.

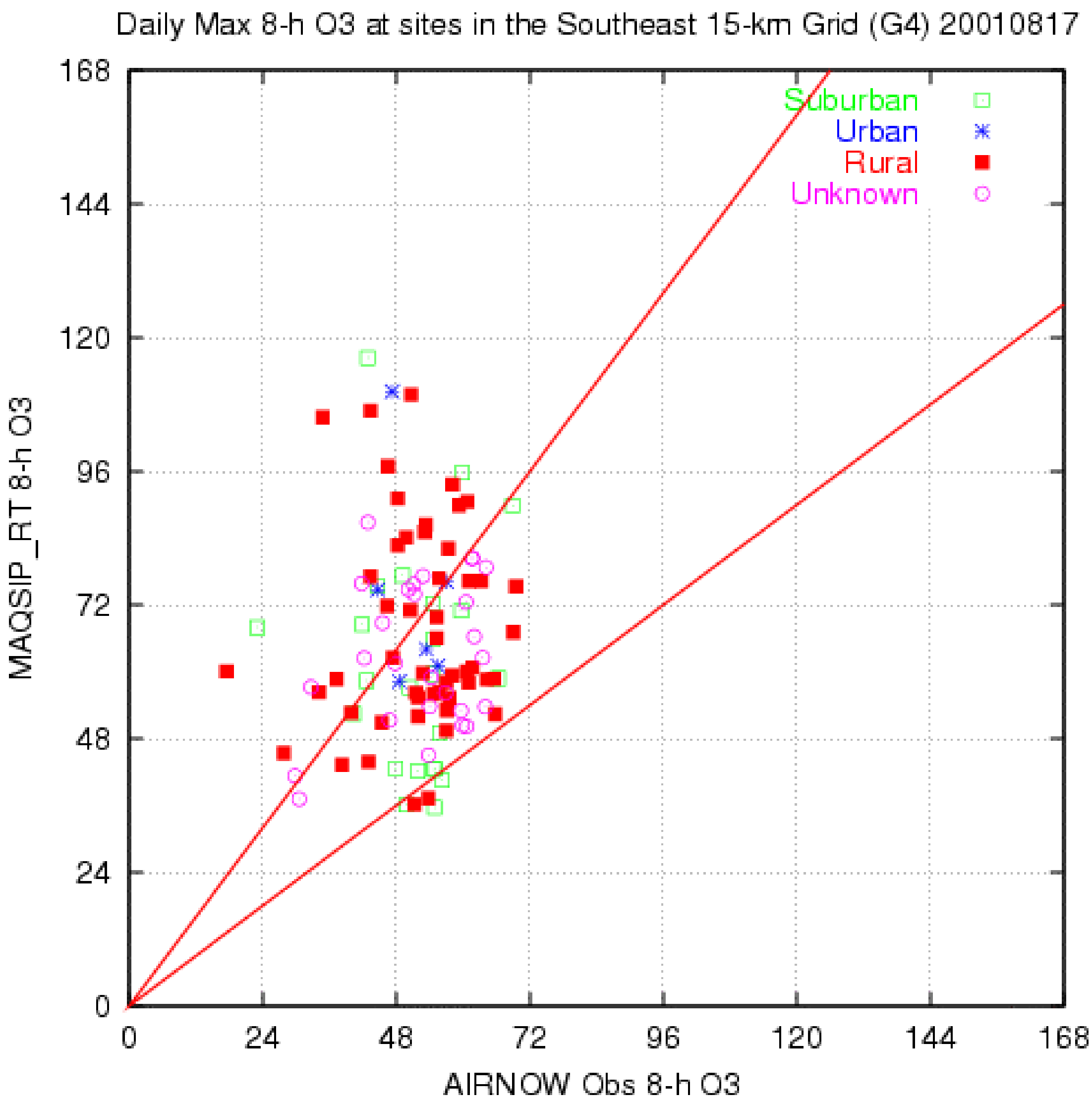


Figure 6b. Scatter plot of 24-hour forecast versus observed ozone for Aug 17th, 2001, MAQSIP-RT 15km SE grid.

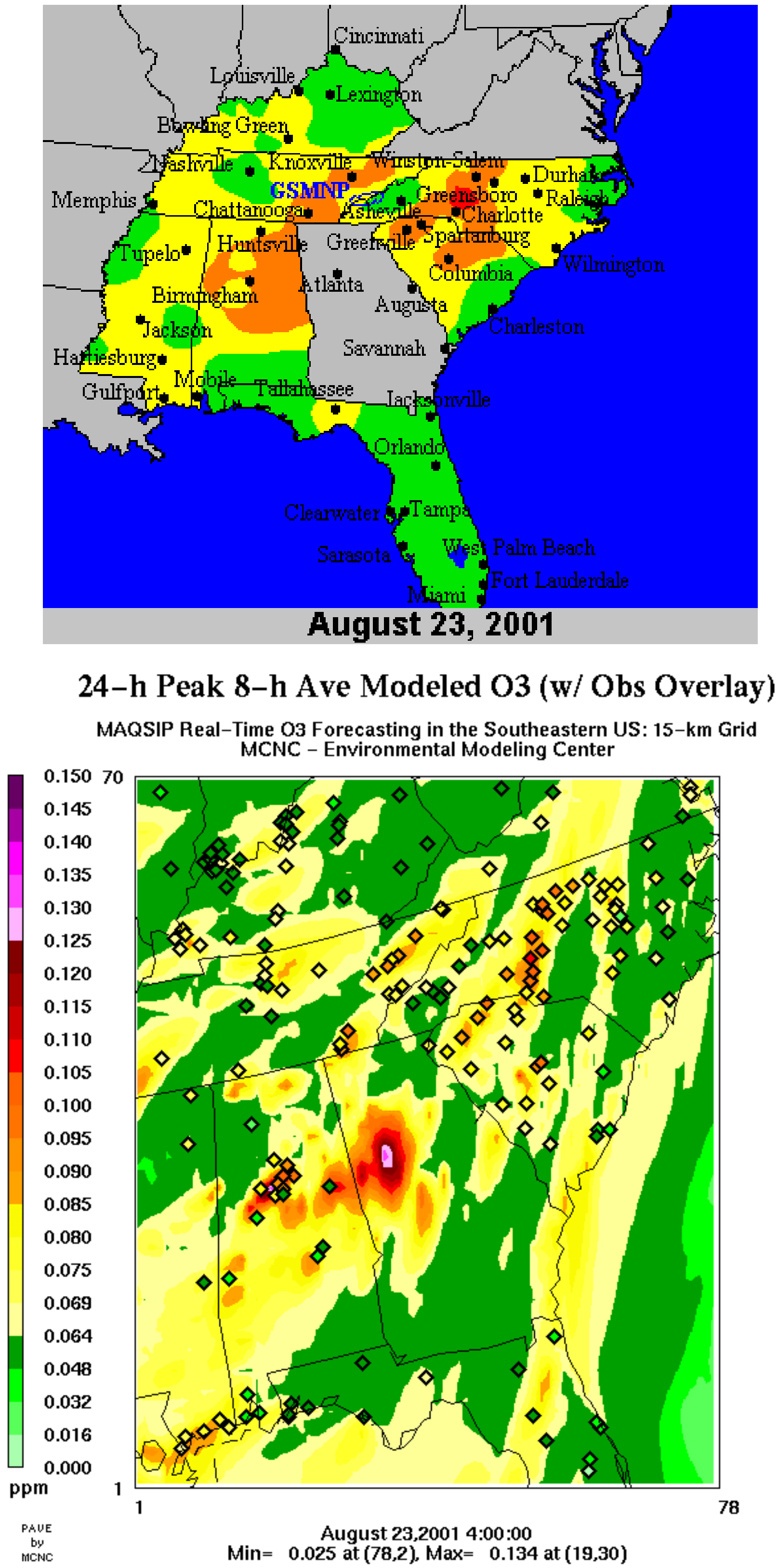


Figure 7a. Observed (top) and 24-hour forecast (bottom) ozone for Aug 23rd, 2001, MAQSIP-RT 15km SE grid. Top panel courtesy EPA.

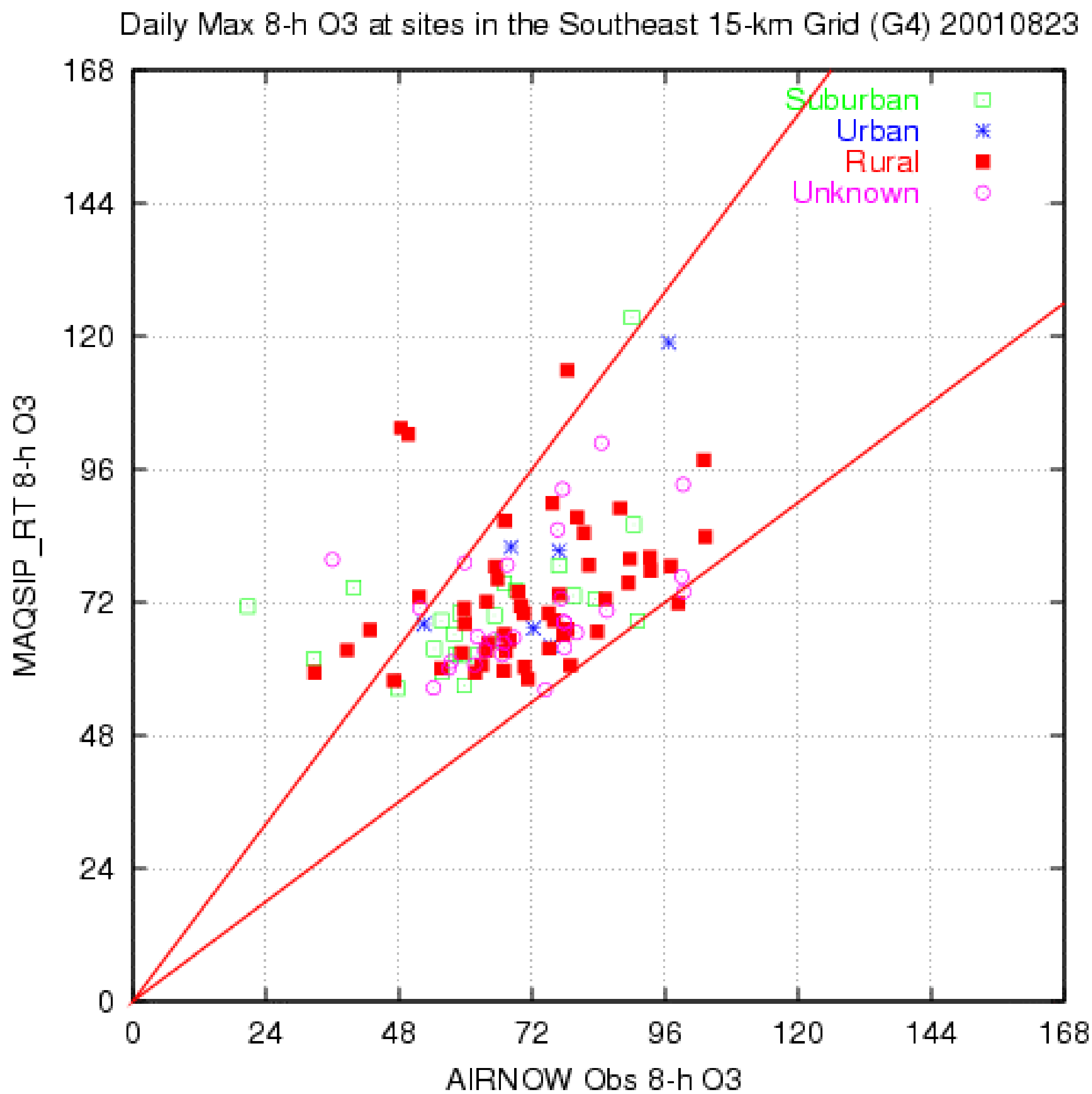


Figure 7b. Scatter plot of 24-hour forecast versus observed ozone for Aug 23rd, 2001, 15km MAQSIP-RT.

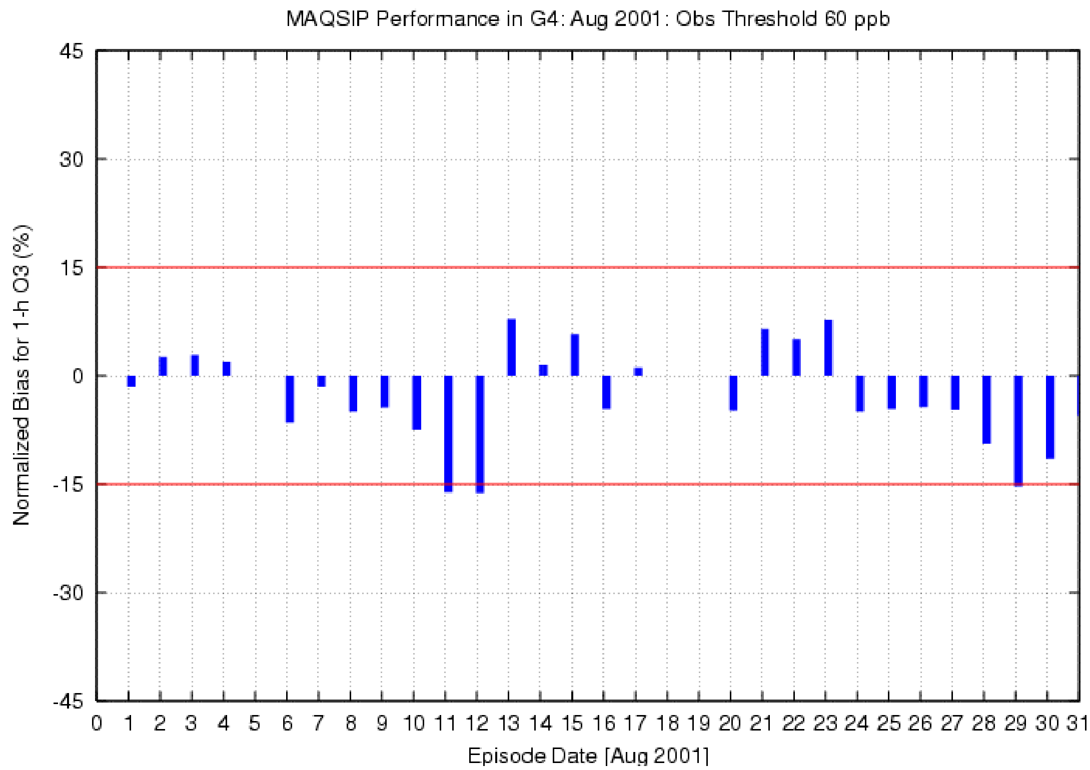


Figure 8a. MAQSIP-RT 24-hour forecast (15km SE grid) normalized bias using 60PPB cutoff.

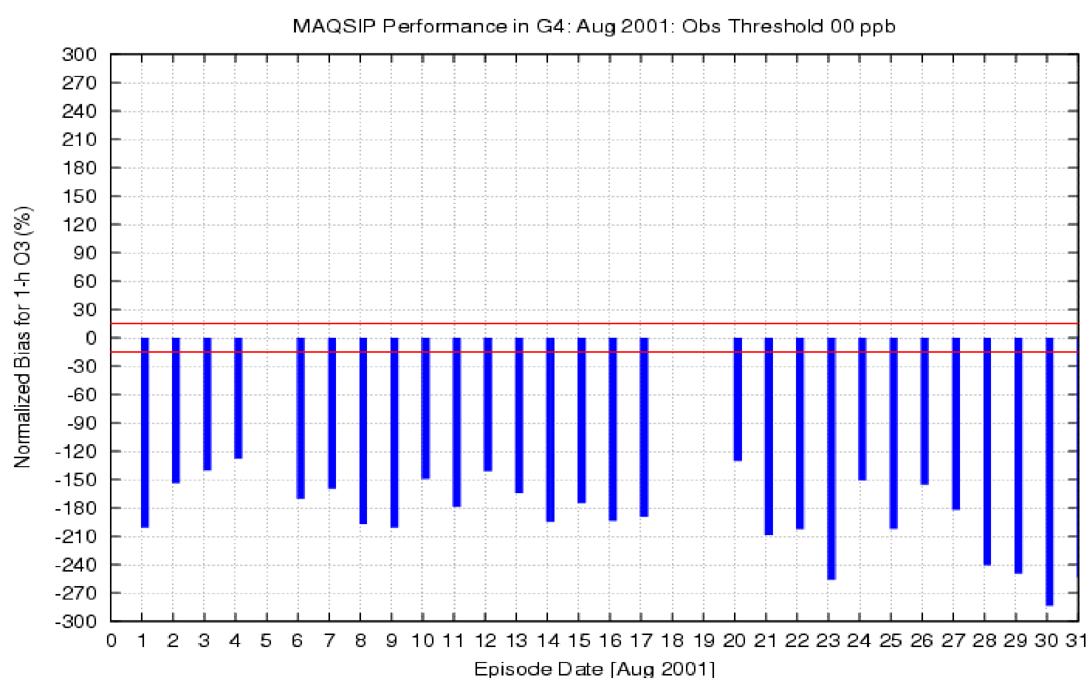


Figure 8b. MAQSIP-RT 24-hour forecast (15km SE grid) normalized bias using 0PPB cutoff.

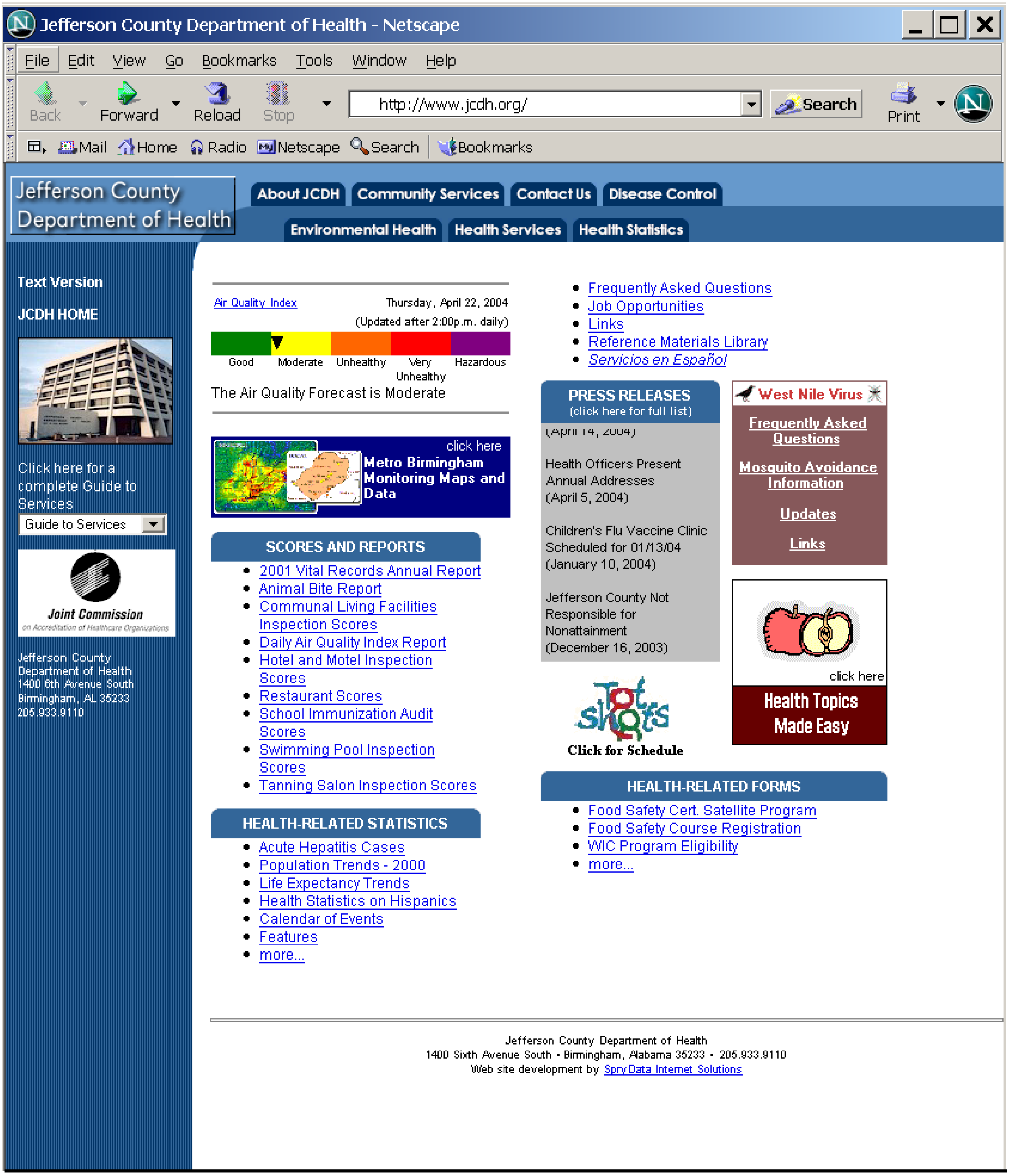


Figure 10. The Home Page of the JCDH website, accessed from the EMPACT_BHM website through the link marked "Today's Air Quality Index". Observe the color-coded AQI bar in the upper left corner of the page. Observe also the link to the EMPACT-BHM website from this JCDH page (just under the AQI bar).

Daily Air Quality Index

JEFFERSON COUNTY DEPARTMENT OF HEALTH
ENVIRONMENTAL HEALTH SERVICES
AIR POLLUTION CONTROL PROGRAM

DAILY AIR QUALITY INDEX

DATE: Thursday, April 22, 2004

COLLECTION PERIOD ENDING DAILY AT: 2:00 PM CDT

Today's Air Quality Information	
Air Quality Index	51
Responsible Pollutant	Particulate Matter 2.5
Air Quality Description	Moderate

Note: The Air Quality Index is not reported on weekends or holidays.

Air Quality Forecast	
Air Quality Forecast Description	Moderate

Maximum Concentrations for Today's Reporting Period			
POLLUTANT	**SITE**	**CONCENTRATION**	**INDEX**
Carbon Monoxide	East Thomas-Finley	0.3 ppm	03
Particulate Matter 10	Wylam	44 ug/m^3	41
Sulfur Dioxide	Fairfield	0.000 ppm	00
Ozone	Leeds/ Providence	(8-hr) 0.046 ppm	36
Particulate Matter 2.5	Wylam	15.5 ug/m^3	51

Pollution Categories	
Air Quality Description	**Index**
GOOD	1-50
MODERATE	51-100
UNHEALTHY	101-200
VERY UNHEALTHY	201-300
HAZARDOUS	301 or above

Daily Primary Standards		
Carbon Monoxide	8 HR Average Concentration Not to Exceed	9 ppm
Particulate Matter 10	24 HR Concentration Not to Exceed	150 ug/m3
Sulfur Dioxide	24 HR concentration Not to Exceed	0.14 ppm
Ozone	1 HR Concentration Not to Exceed or 8 HR Average Concentration Not to Exceed	0.12 ppm 0.08 ppm
Particulate Matter 2.5	24 HR concentration not to exceed	65 ug/m3

Daily Ozone Forecast: http://www.adem.state.al.us/ftproot/air/stateo3.jpg

Air Quality Guide for Ozone: http://www.epa.gov/airnow/aqibroch/aqi.html

Figure 11. AQI link from the Home Page of the JCDH website (or from the EMPACT-BHM website, bottom of Fig.2), providing numerical information related to AQI (current-day and definitional).

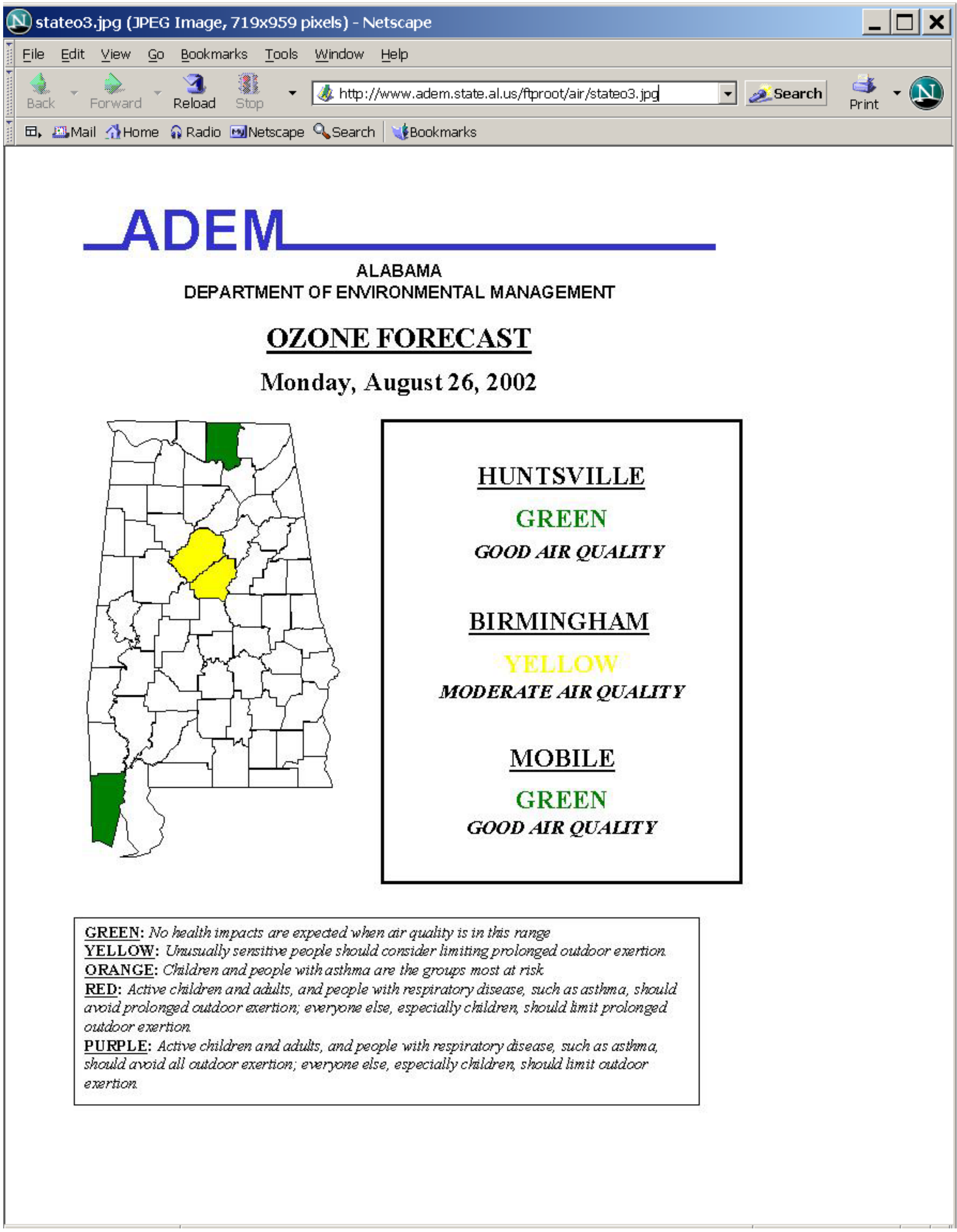


Figure 12. Link to the ADEM 4-county "Daily Ozone Forecast" from the bottom of Figure 4. The four counties (including Jefferson and Shelby Counties, yellow-shaded) and their AQIs are shown for 26 August 2002.

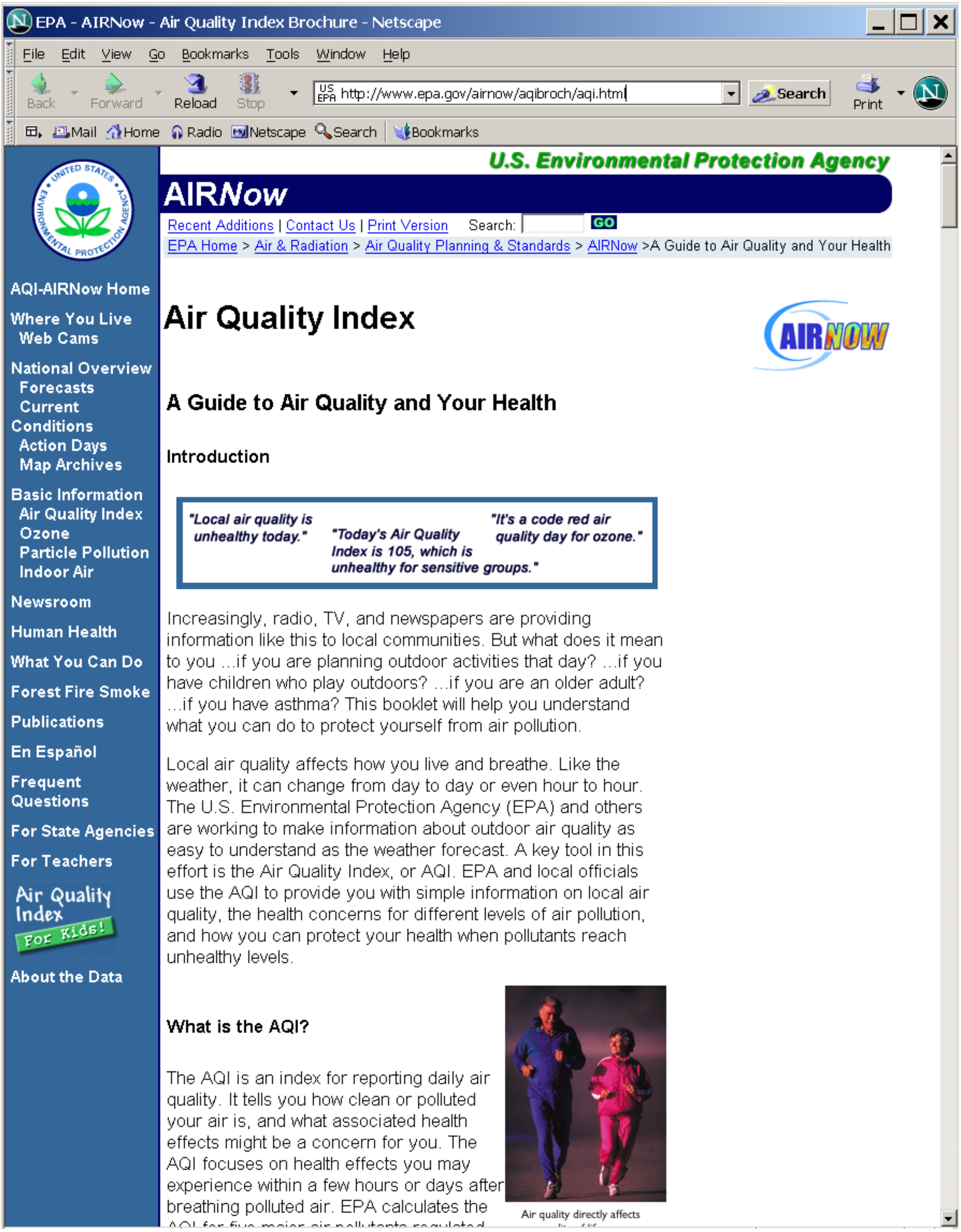


Figure 13. "AQ Guide for Ozone" link to the EPA website, from the bottom of Figure 4.

EMPACT-BIRMINGHAM

TODAY'S AIR QUALITY INDEX | LOCAL DATA | REGIONAL DATA | PROGRESS REPORT 2001 | OTHER USEFUL LINKS | CONTACT & CREDITS | HOME

Instructions for Viewing Archived EPA AIRNOW Ozone Maps for Mississippi/Alabama
May 1, 2002 to the Present

1. Click the following link: http://www.epa.gov/airnow/. After the new page appears, minimize the window so that each page is side by side. Then continue with the instructions.

2. On the AIRNOW page click "Ozone Maps".

3. On the resulting page, click the link "2002 Ozone Season Maps Archive" located just above the map of the United States.

4. Click the light blue (Southeast) area of the US map.

5. On the scroll-down menu labeled "Southeast", scroll down and select "Mississippi/Alabama".

6. Click the button labeled "See Archives".

7. From the leftmost column of the resulting table, find the date of interest, then click in one of the three columns to the right to select:
   a. An animation of 8-hour average ozone levels.
   b. A static map of the highest 1-hour average ozone levels.
   c. A static map of the highest 8-hour average ozone levels.

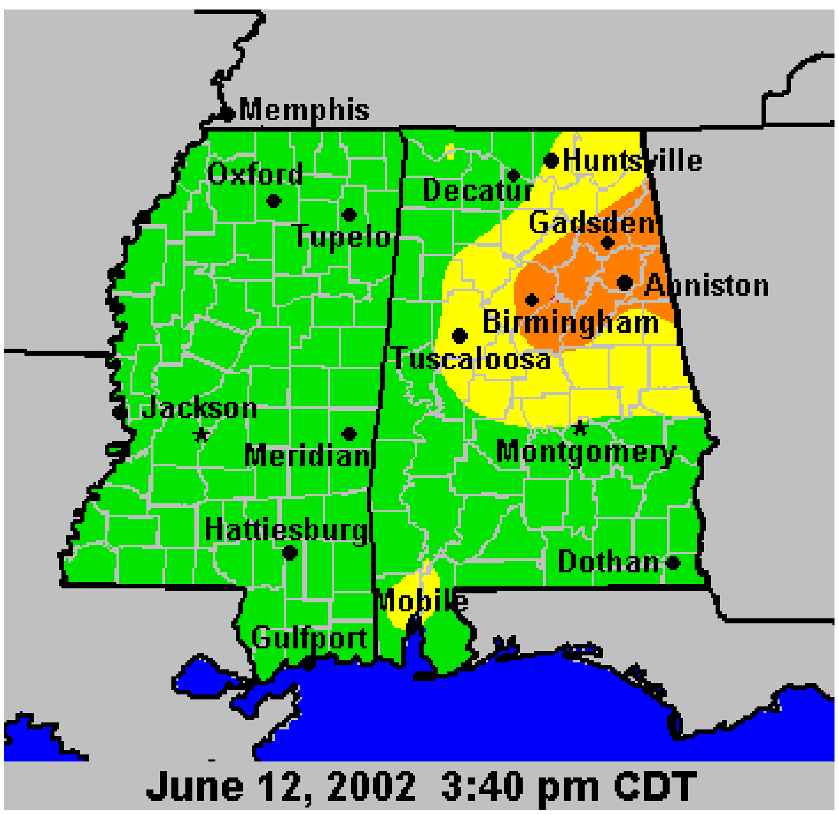


Figure 18. EPA AIRNOW link reached by clicking on the "Bi-state (AL-MS) Archived Ozone Maps" button at the lower right of the "Local Data" page of the EMPACT-BHM webpage, after following the instructions at the top.

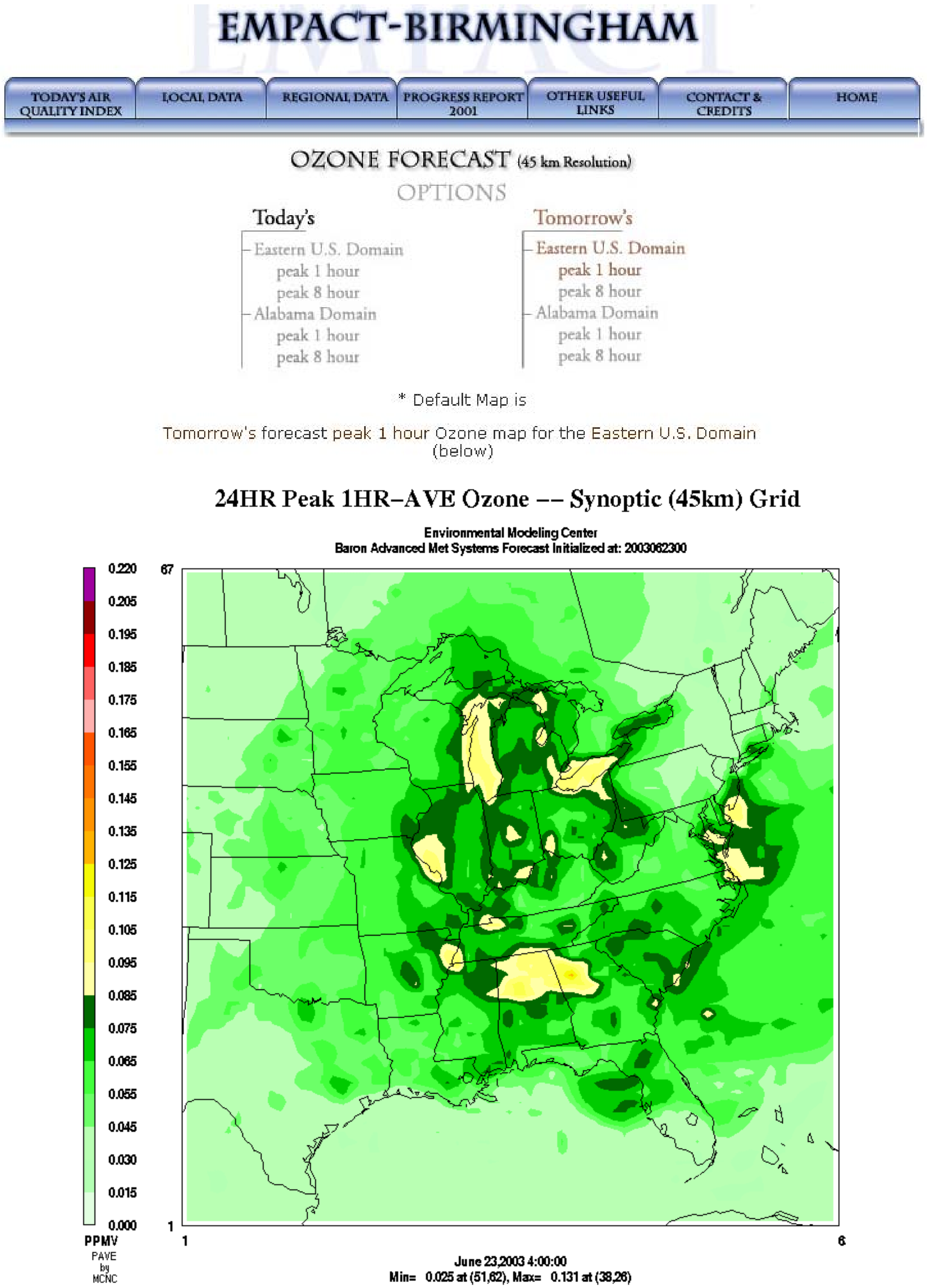


Figure 23. Link to "Ozone – Forecast" from the Regional Data page of the EMPACT-BHM website, showing results of the MAQSIP-RTOFS regional photochemical model simulation of peak hourly ozone for 23 June 2003..

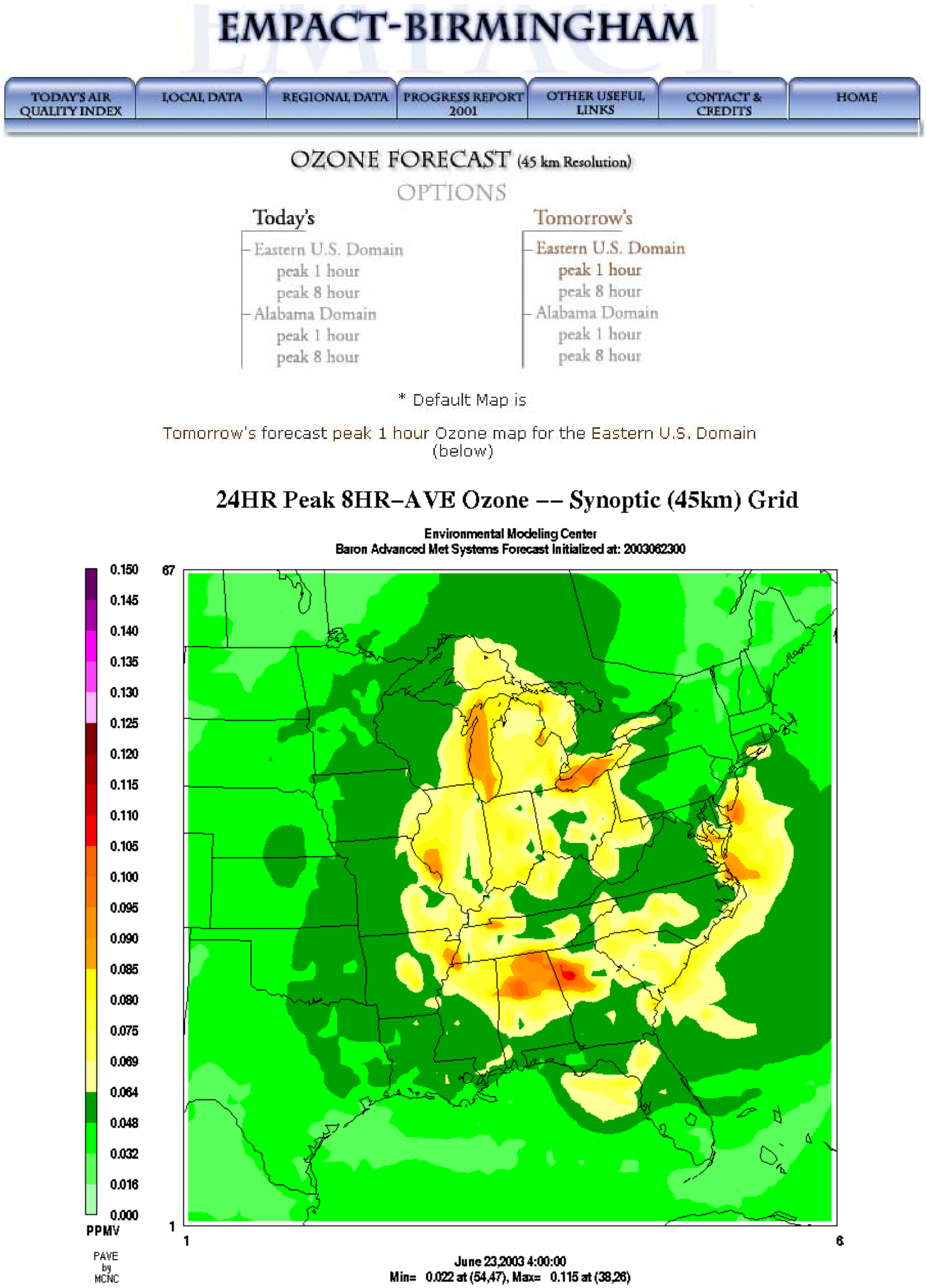


Figure 24. Link to "Ozone – Forecast" from the Regional Data page of the EMPACT-BHM website, showing results of the MAQSIP-RTOFS regional photochemical model simulation of peak 8-hour ozone for 23 June 2003.

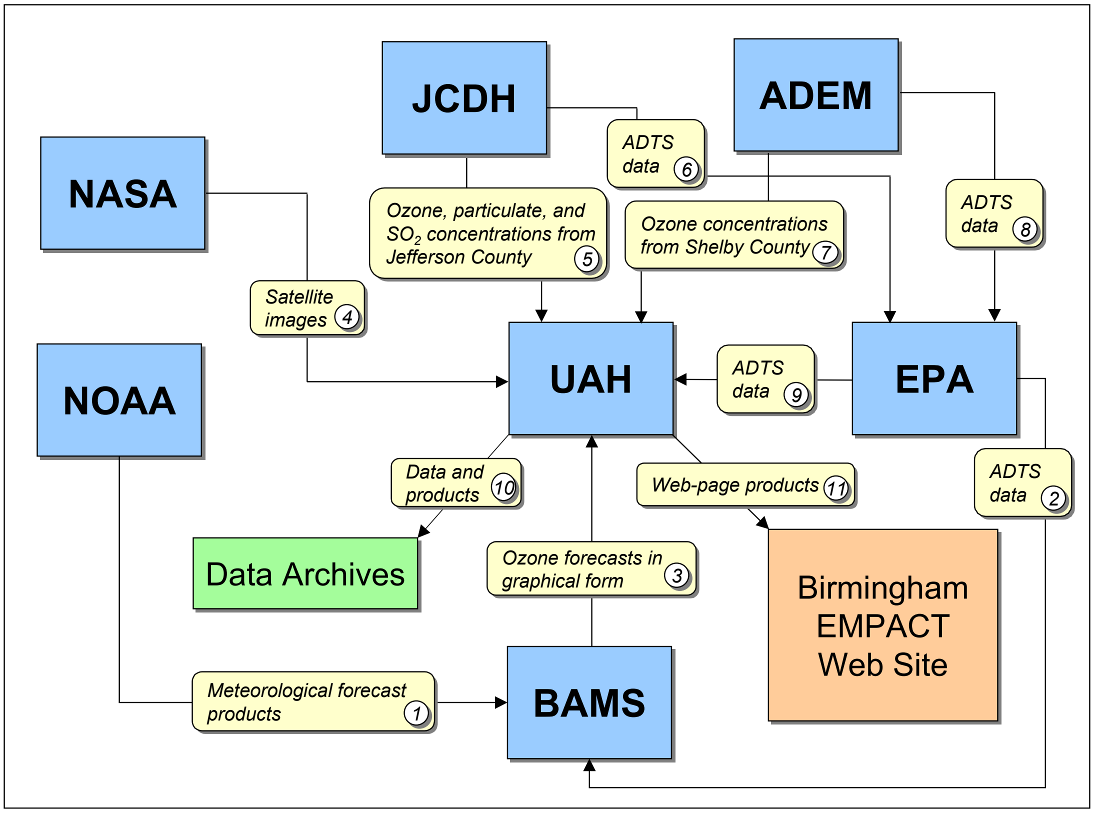
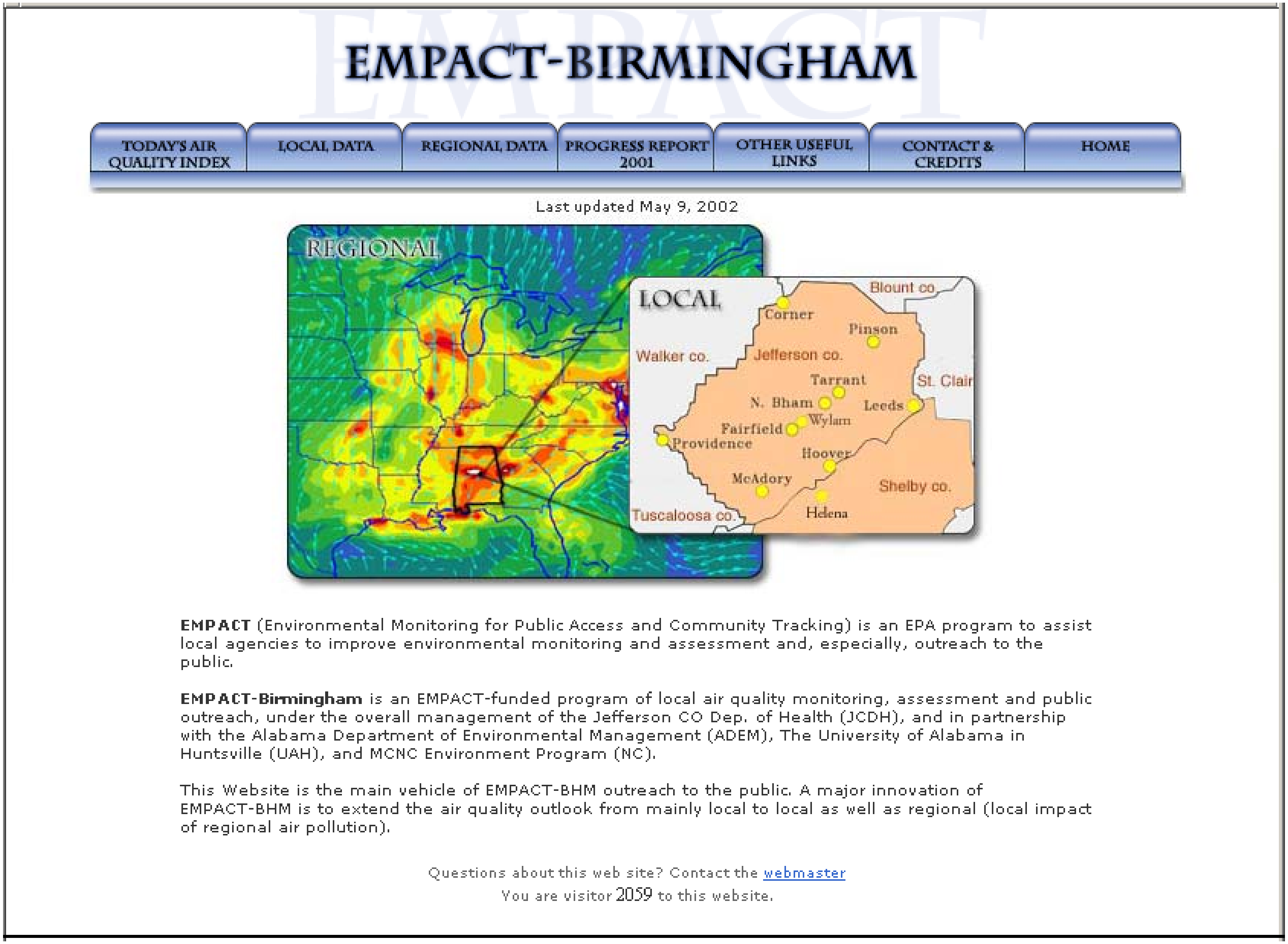


Figure 25. Organizations participating in the Birmingham EMPACT project and the data flow among them.



EMPACT-BIRMINGHAM

TODAY'S AIR QUALITY INDEX | LOCAL DATA | REGIONAL DATA | PROGRESS REPORT 2001 | OTHER USEFUL LINKS | CONTACT & CREDITS | HOME

Last updated May 9, 2002

EMPACT (Environmental Monitoring for Public Access and Community Tracking) is an EPA program to assist local agencies to improve environmental monitoring and assessment and, especially, outreach to the public.

EMPACT-Birmingham is an EMPACT-funded program of local air quality monitoring, assessment and public outreach, under the overall management of the Jefferson CO Dep. of Health (JCDH), and in partnership with the Alabama Department of Environmental Management (ADEM), The University of Alabama in Huntsville (UAH), and MCNC Environment Program (NC).

This Website is the main vehicle of EMPACT-BHM outreach to the public. A major innovation of EMPACT-BHM is to extend the air quality outlook from mainly local to local as well as regional (local impact of regional air pollution).

Questions about this web site? Contact the webmaster
You are visitor 2059 to this website.

Figure 9. The Home Page of the EMPACT-Birmingham Website

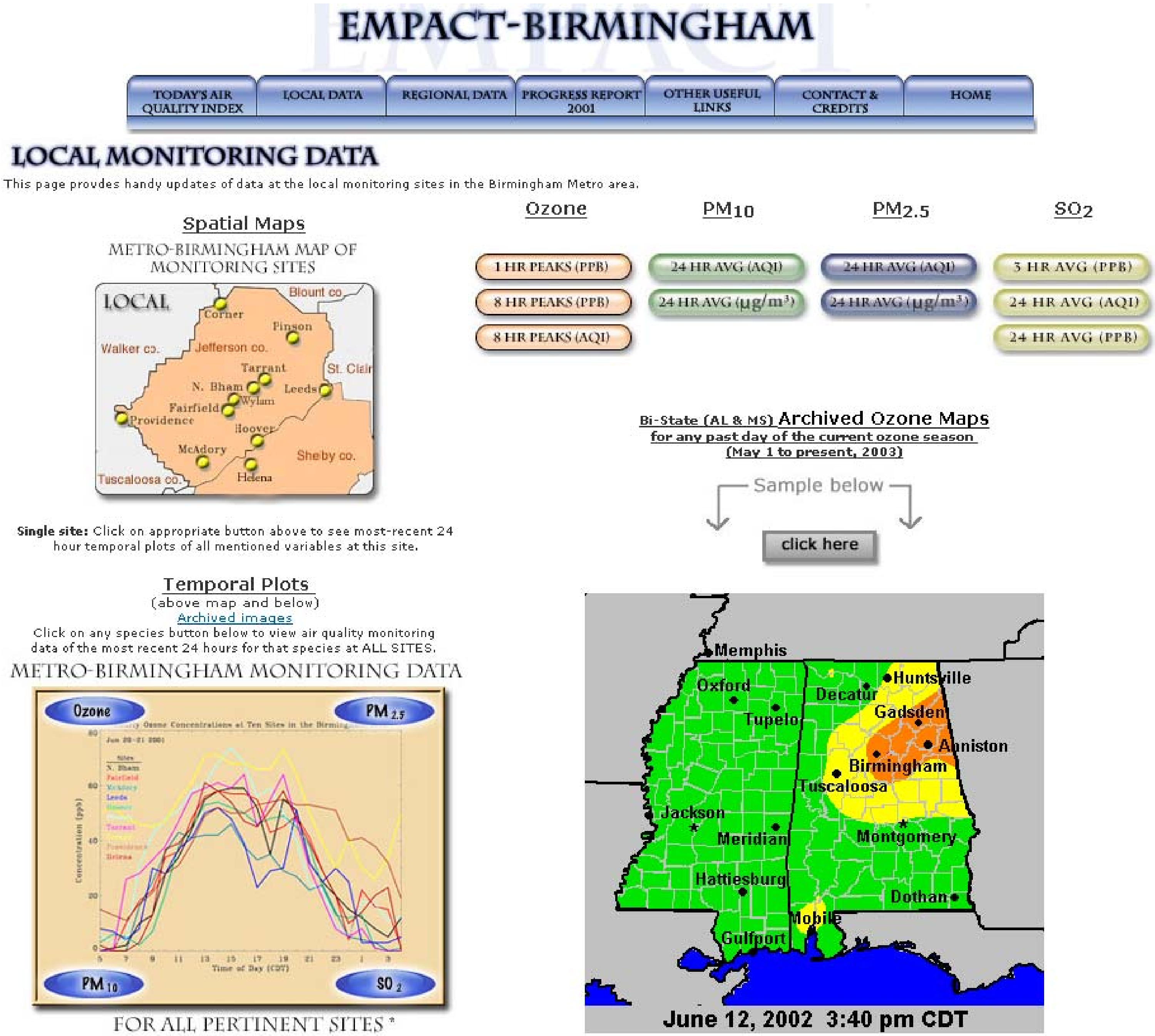


Figure 14. Link reached from the EMPACT-BHM website by clicking on the “Local Data” button.

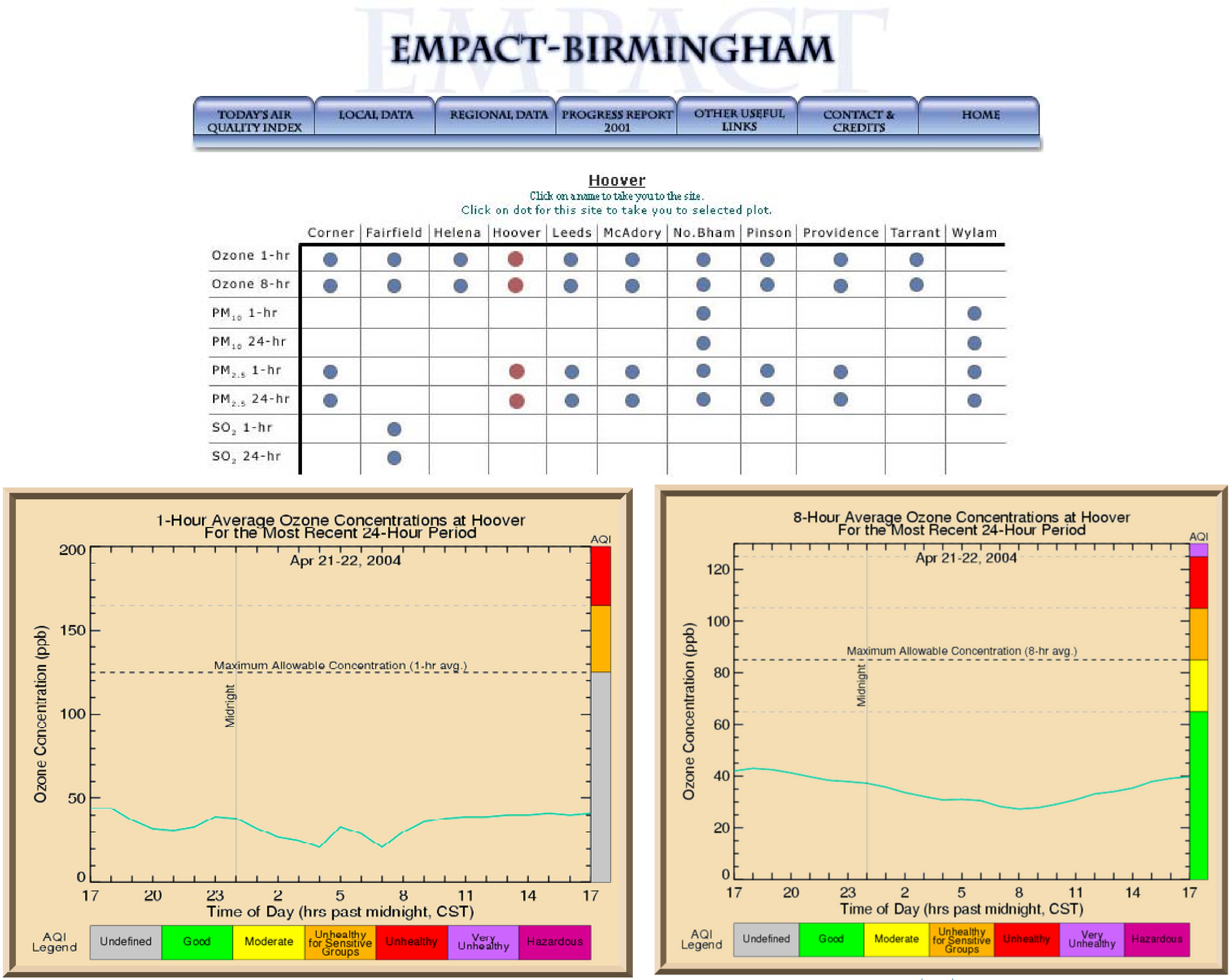


Figure 15. Link reached by clicking on any particular monitoring site location (here, Hoover) on the LOCAL map under the "Spatial Maps" heading on the "Local Data" page of the EMPACT-BHM webpage. From the chart at the top, one can proceed to similar data of any species and site.

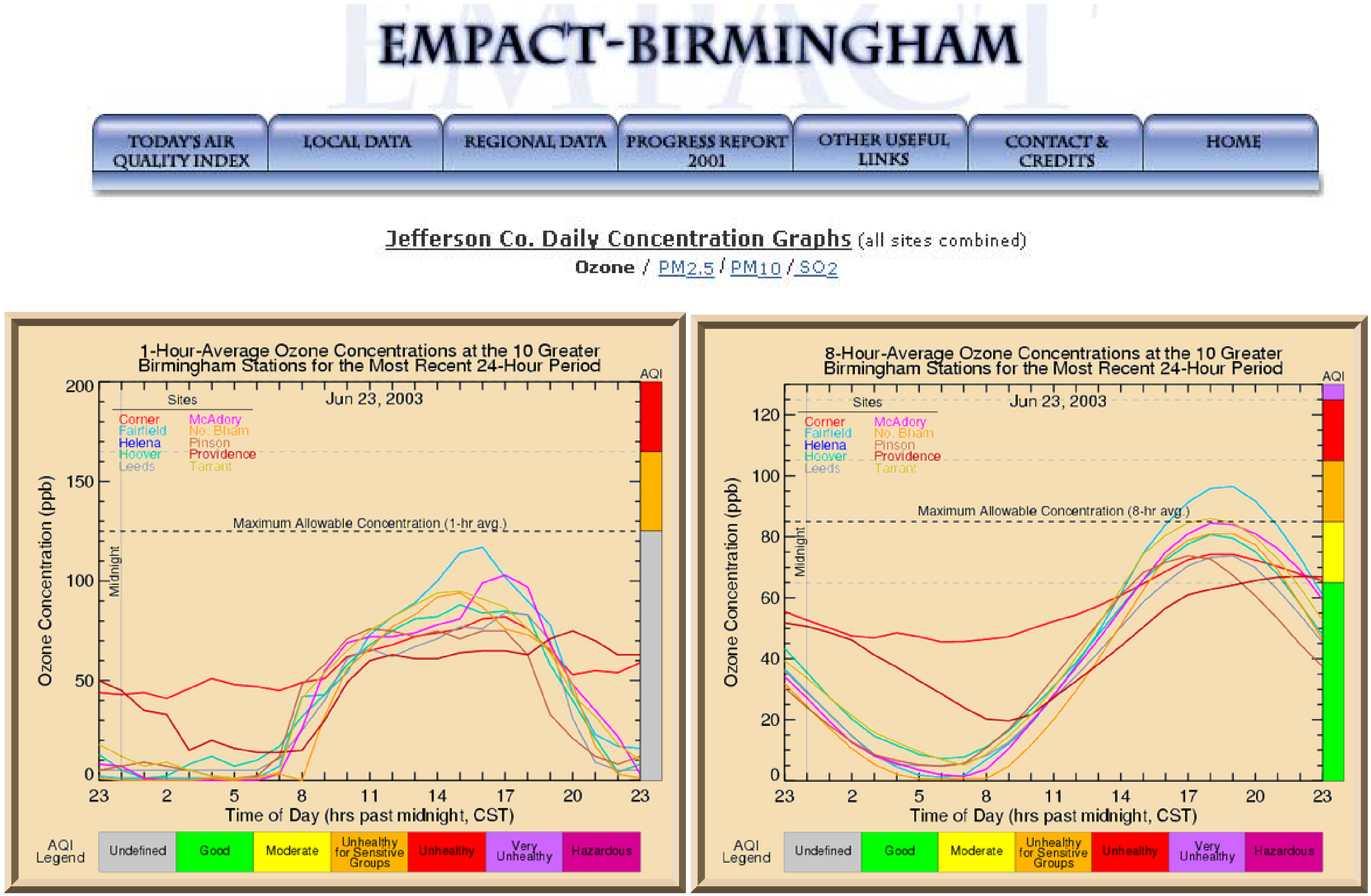


Figure 16. Link reached by clicking on "Ozone" under the "Temporal Plots" heading on the "Local Data" page of the EMPACT-BHM webpage. Similar temporal data plots of all monitoring sites can be reached for other species also, from this page (see links at the top of the plots). The link actually shows a single plot, as selected (here, both AQI and ppb plots of ozone are shown for convenience).

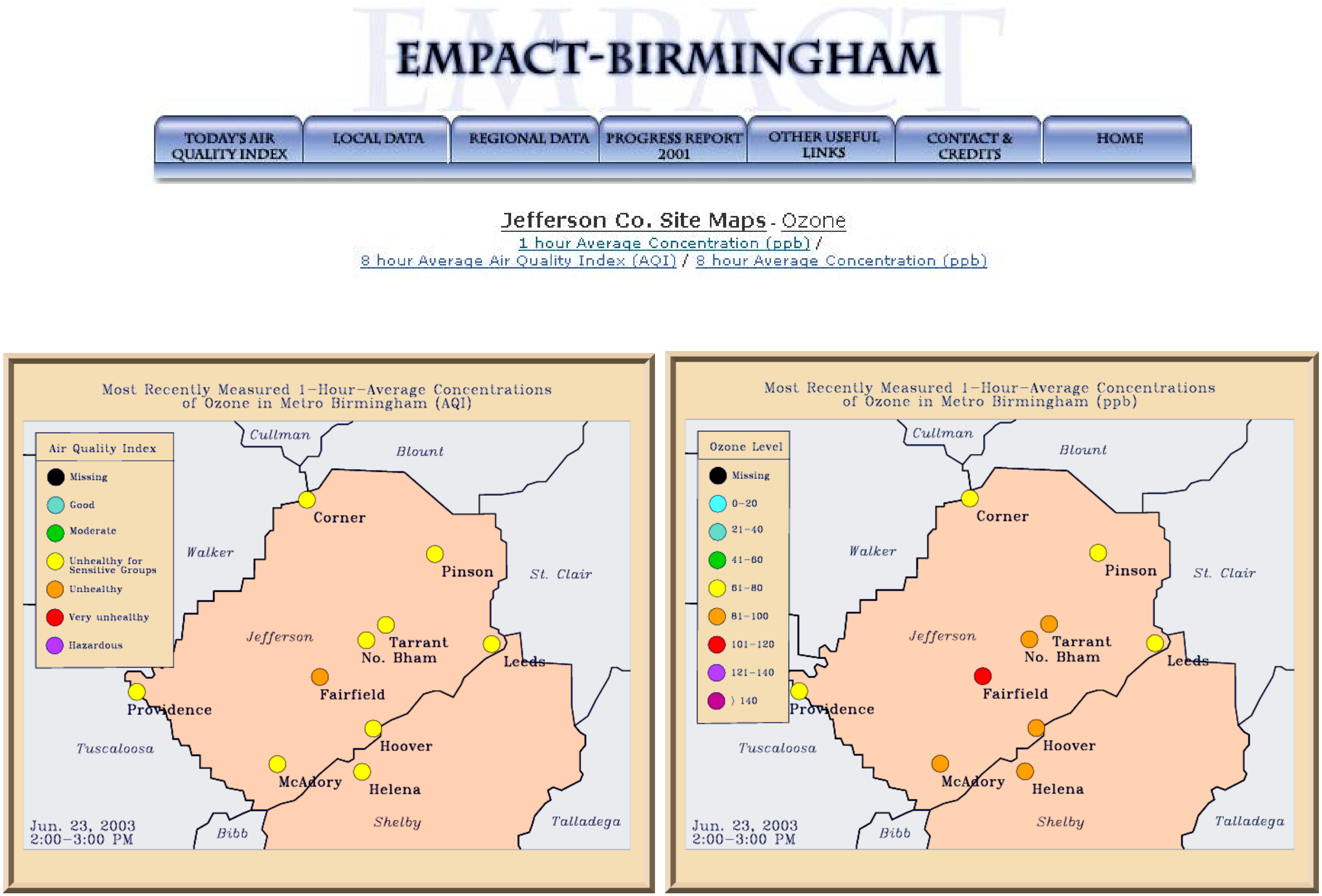


Figure 17. Link reached by clicking on appropriate buttons in the upper right of the "Local Data" page of the EMPACT-BHM webpage. Each button links to one plot (two shown above for convenience) for the selected species, AQI or physical unit, and temporal resolution selected.

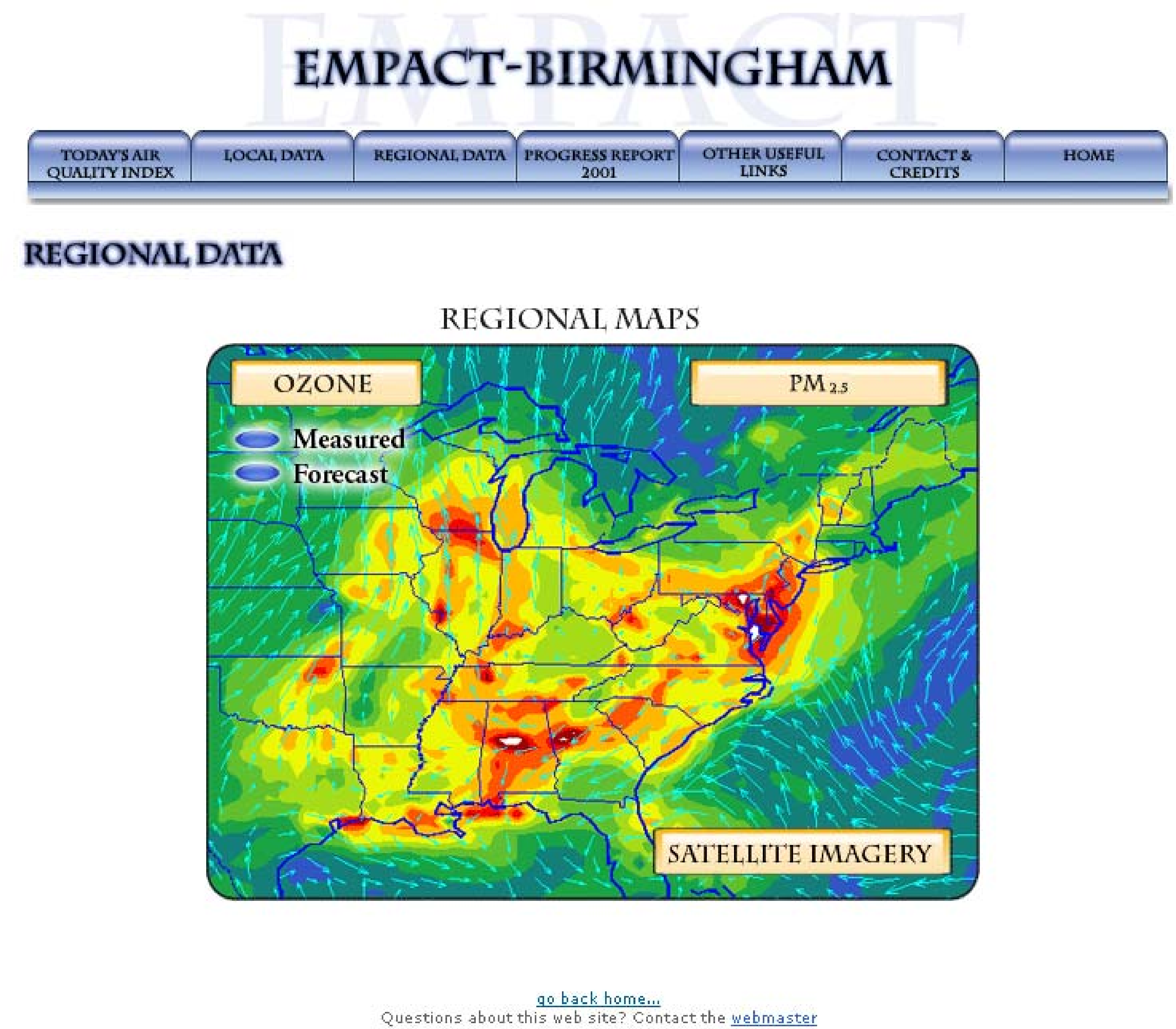


Figure 19. The “Regional Data” page of the EMPACT-BHM website.

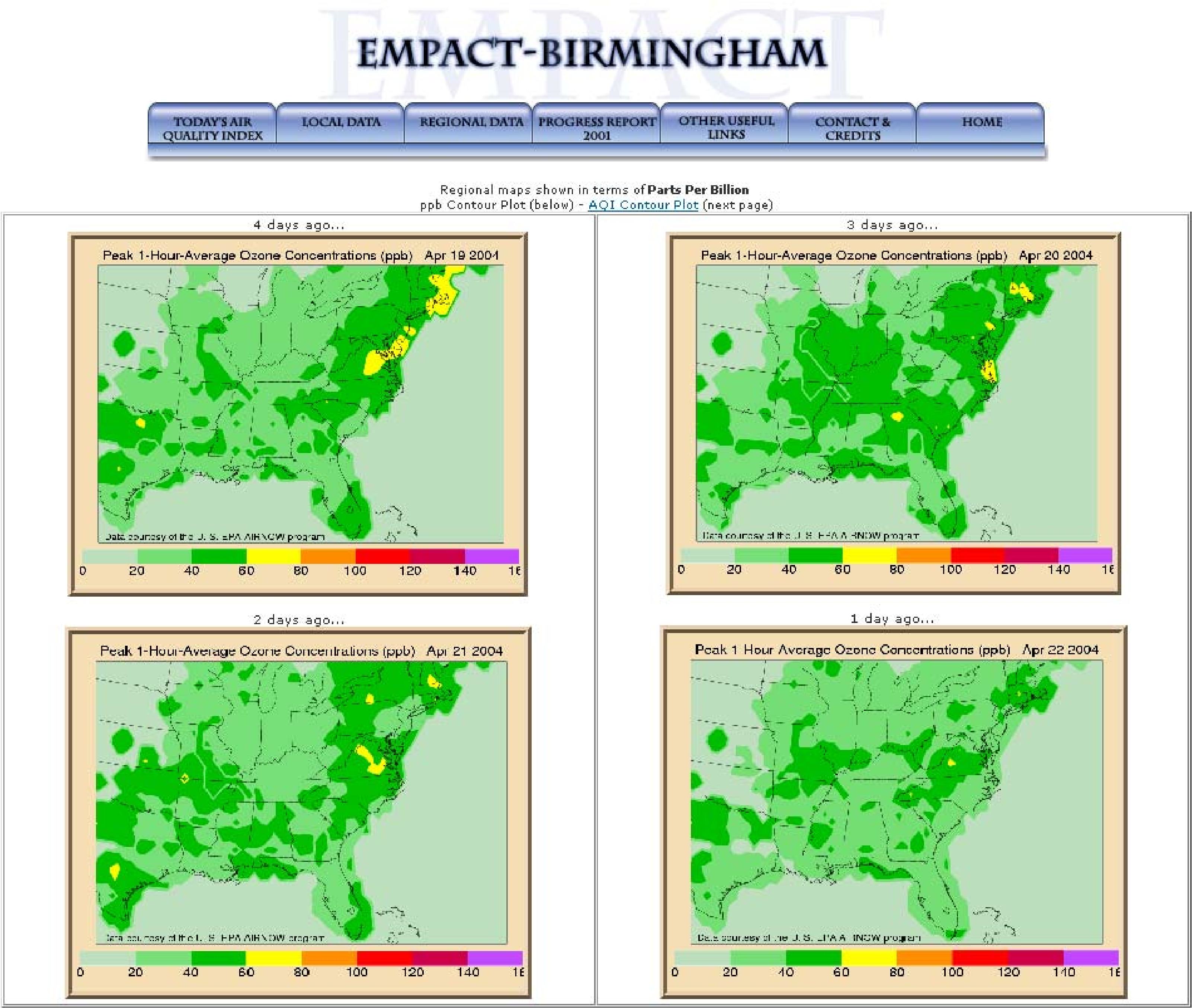


Figure 20. Last 4 days regional ozone isopleths based on EPA-AIRNOW measured data (here, 19-22 April 2004)

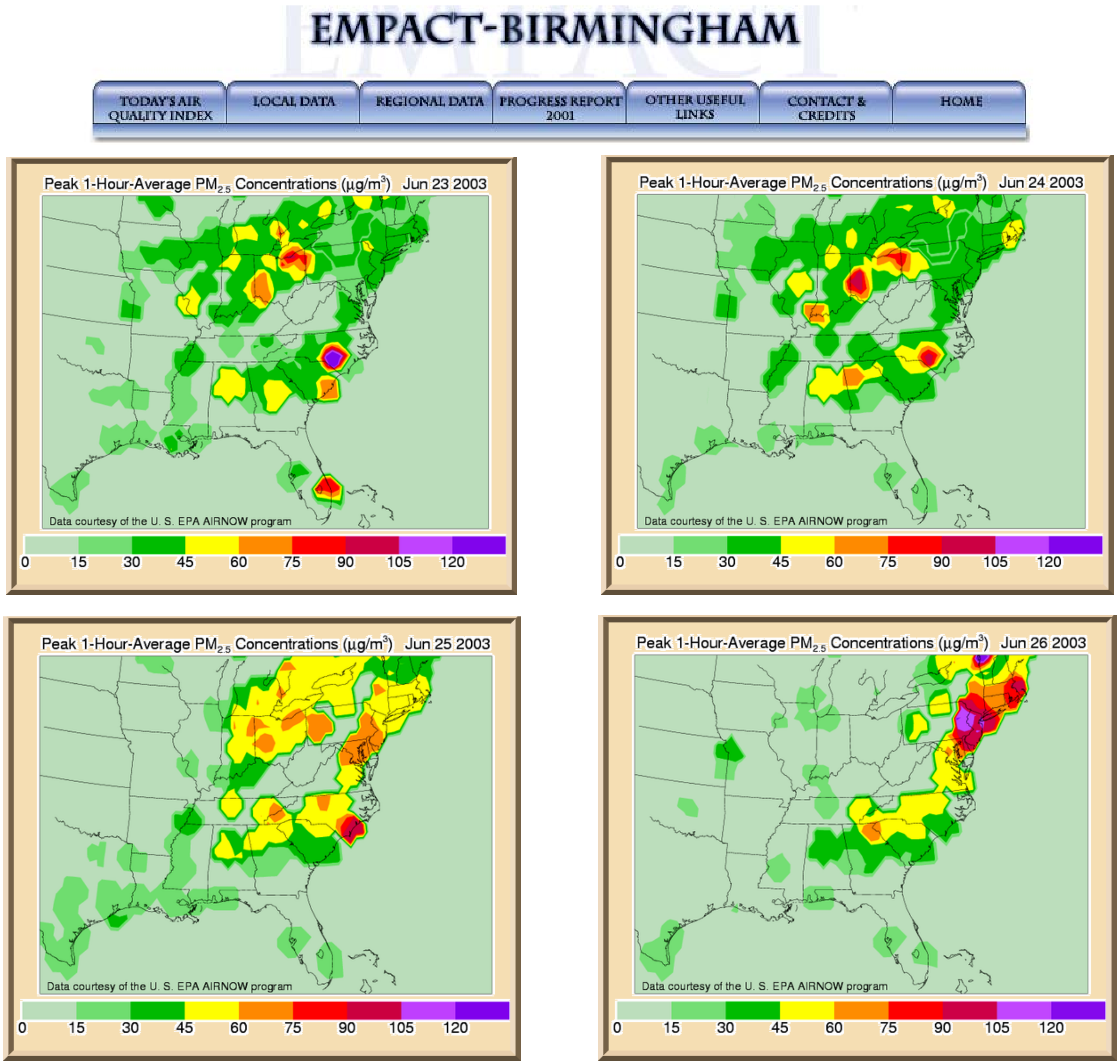


Figure 21. Last 4 days regional PM2.5 isopleths based on EPA-AIRNOW measured data (here, 23-26 June 2003).

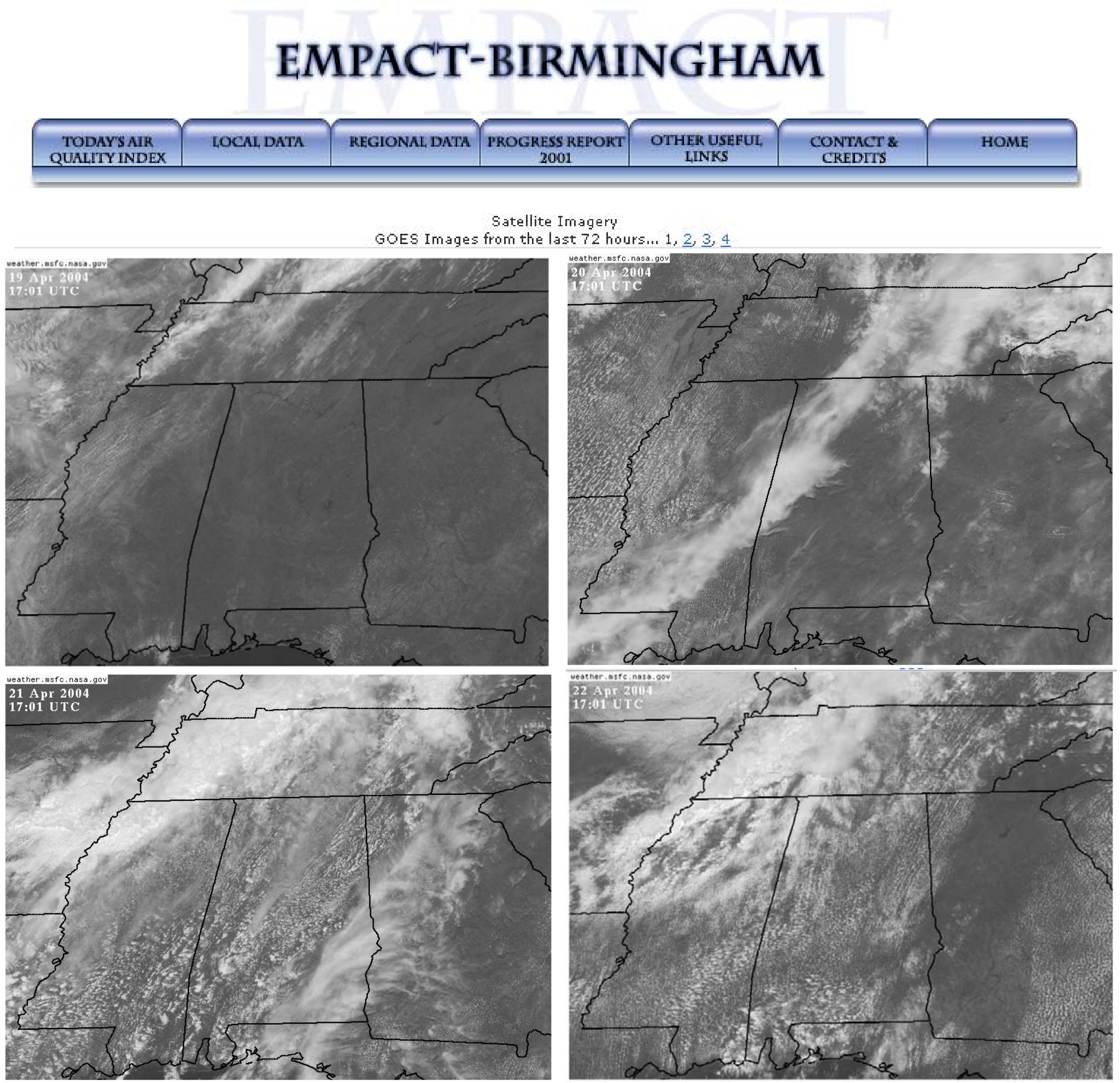


Figure 22. Link to "Satellite Imagery" from the Regional Data page of the EMPACT-BHM website, showing visible GOES imagery at 1701 UTC on the last four days (here, 119-22 April 2004) for SE USA.