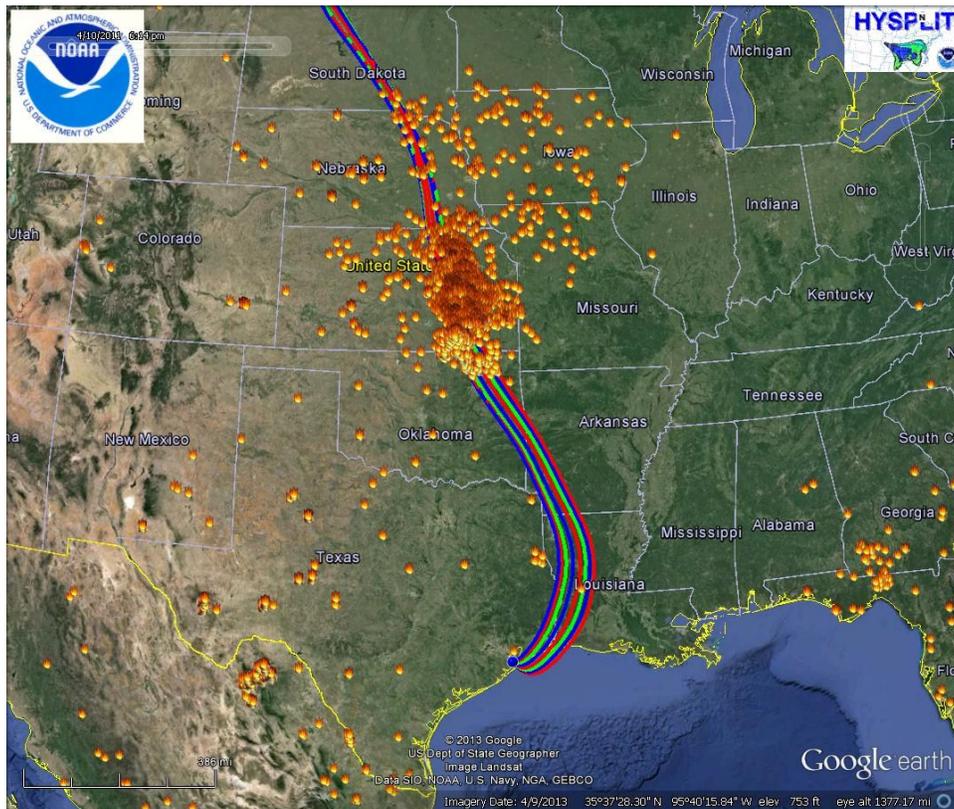


RESOURCES FOR ANALYZING THE IMPACTS OF EXCEPTIONAL EVENTS ON DOWNWIND POLLUTANT LEVELS



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COVER PICTURE

NOAA HYSPLIT trajectories projected backward for 48 hours from Galveston, TX, on April 12, 2011 passed over eastern Kansas the previous day, where numerous grassland fires were actively burning. Daily maximum 8-hour ozone levels above 75 ppb were measured at two sites in eastern Kansas and both exceedances were flagged as exceptional events. Daily maximum 8-hour ozone levels also exceeded 75 ppb at Galveston, Sabine Pass and several other coastal Texas monitoring sites. HYSPLIT trajectories indicate that wind conditions were favorable for transporting ozone precursors or ozone produced in the fire plume from eastern Kansas to southeast Texas.

1.0 INTRODUCTION AND PLACES TO START

This document provides an annotated bibliography of technical resources that may be useful for analyzing the effects of wildland fire exceptional events on downwind ozone levels. The Code of Federal Regulations (40 CFR §50.1(j)) defines an exceptional event as “an event that affects air quality, is not reasonably controllable or preventable, is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and is determined by the Administrator in accordance with 40 CFR §50.14 to be an exceptional event.” Additionally, 40 CFR §50.14 instructs EPA to “exclude data from use in determinations of exceedances and NAAQS violations, where a State demonstrates to EPA's satisfaction that emissions from prescribed fires caused a specific air pollution concentration in excess of one or more national ambient air quality standards at a particular air quality monitoring location...”

The annotated bibliography is organized as follows:

- Section 2 – Wildland Fire Resources
- Section 3 – Meteorological Data Sources
- Section 4 – Meteorological Modeling Sources
- Section 5 – Emissions Information Sources
- Section 6 – Photochemical Modeling Sources
- Section 7 – Ambient Monitoring Data
- Section 8 – Satellite Imagery
- Section 9 – Scientific Literature.

A bibliography of useful resources that overlap these categories and may be good places to begin an analysis of possible exceptional events is given below.

General Resources and Places to Start an Analysis Of a Possible Exceptional Event

1. “Treatment of Data Influenced by Exceptional Events,” modified on June 2, 2014, <http://www.epa.gov/ttn/analysis/exevents.htm>.

This EPA website is periodically updated with announcements and links to new guidance documents and technical resources, including examples of successful exceptional events technical demonstrations.

2. “State of Kansas Exceptional Event Demonstration Package,” November 27, 2012, accessed online at http://www.epa.gov/ttn/analysis/docs/KDHE_ExEvents_final_042011.pdf.

This document provides technical support for declaring that exceedances of the 2008 ozone standard measured in Kansas on four days during April 2011 were caused by grassland fires in eastern Kansas and other wildland fires in Texas and Mexico. The document may serve as a model for an exceptional event technical demonstration and, perhaps, a benchmark for the weight of evidence required for receiving EPA concurrence.

3. “The U.S. Air Quality Weblog,” modified daily, <http://alg.umbc.edu/usaq/>.

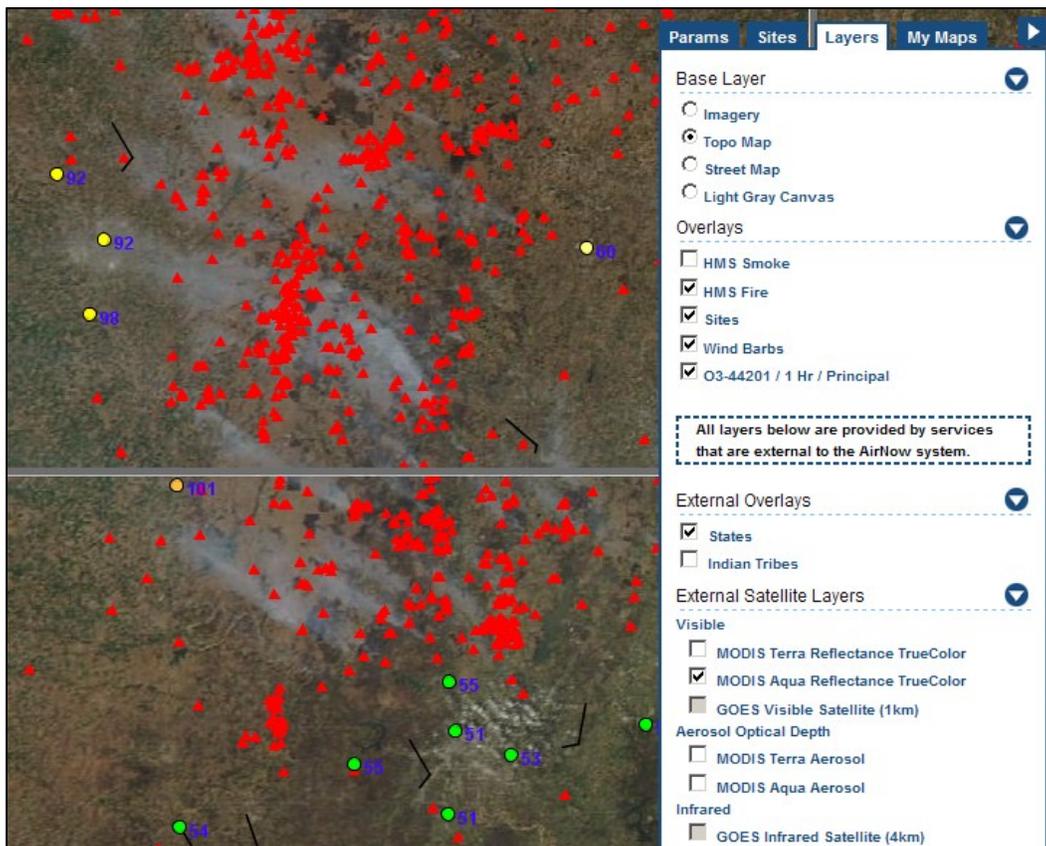
The “U.S. Air Quality Weblog” also known as “the Smog Blog,” is a daily diary of air quality in the U.S. prepared by the staff of the University of Maryland, Baltimore County Atmospheric LIDAR Group. The Smog Blog reports significant, or in other ways interesting, air quality observations and events using a broad assortment graphical images from satellites, ground-based measurements, and models. The website includes a comprehensive list of links to frequently used air quality and meteorological data sources and data analysis tools. Archived postings are available from September 2003 to current. This is an excellent place to start an analysis of possible exceptional events or to just keep informed of current air quality events and applications of online air quality data analysis tools.

4. “AirNow-Tech,” updated hourly, <http://airnowtech.org/>.

This website provides access to preliminary air quality and meteorological data reported to EPA AirNow by federal, state, local, and tribal agencies. The interactive “Navigator” allows registered users to produce maps of current and archived air quality data with optional layers including:

- NOAA HYSPLIT trajectories
- Wind barbs and wind roses from data recorded at surface monitoring sites
- Fire and smoke locations reported by the NOAA Hazard Mapping System (HMS)
- GOES visible and infrared imagery
- MODIS Terra and Aqua true color visible and aerosol optical depth imagery

The example AirNow-Tech product shown below identifies the locations of satellite-detected fires east of Wichita, KS on April 11, 2014, with MODIS Aqua true color surface reflectance showing transport of smoke plumes northwestward from the fires, toward Wichita's ozone monitors. Ozone concentrations for the 1-hour period beginning 2:00 p.m. CST ranged from 92 ppb to 98 ppb in Wichita and reached 101 ppb a little to the south, in Newkirk, OK. Upwind of the fires, near Tulsa, OK, the 2:00 p.m. CST ozone levels ranged from 51 ppb to 55 ppb.



AirNow-Tech map of 1-hour ozone levels for 2:00 p.m. CST on April 11, 2014, with surface wind barbs and satellite-detected fires and smoke plumes

Note that AirNow data are not fully verified or validated and the EPA data use guidelines discourage the use of AirNow data as a substitute for data stored in AQS (EPA's Air Quality System) to formulate or support regulation, ascertain trends, act as guidance, or support any other government or public decision-making.

5. "AERONET Data Synergy Tool," http://aeronet.gsfc.nasa.gov/cgi-bin/bamgomas_interactive.

The AERONET (Aerosol RObotic NETwork) program is an international federation of ground-based remote sensing aerosol networks. The Data Synergy Tool provides access to AERONET data, as well as access to satellite-derived aerosol data products and backward trajectories all from a single web page. Trajectories are calculated using NOAA HYSPLIT and

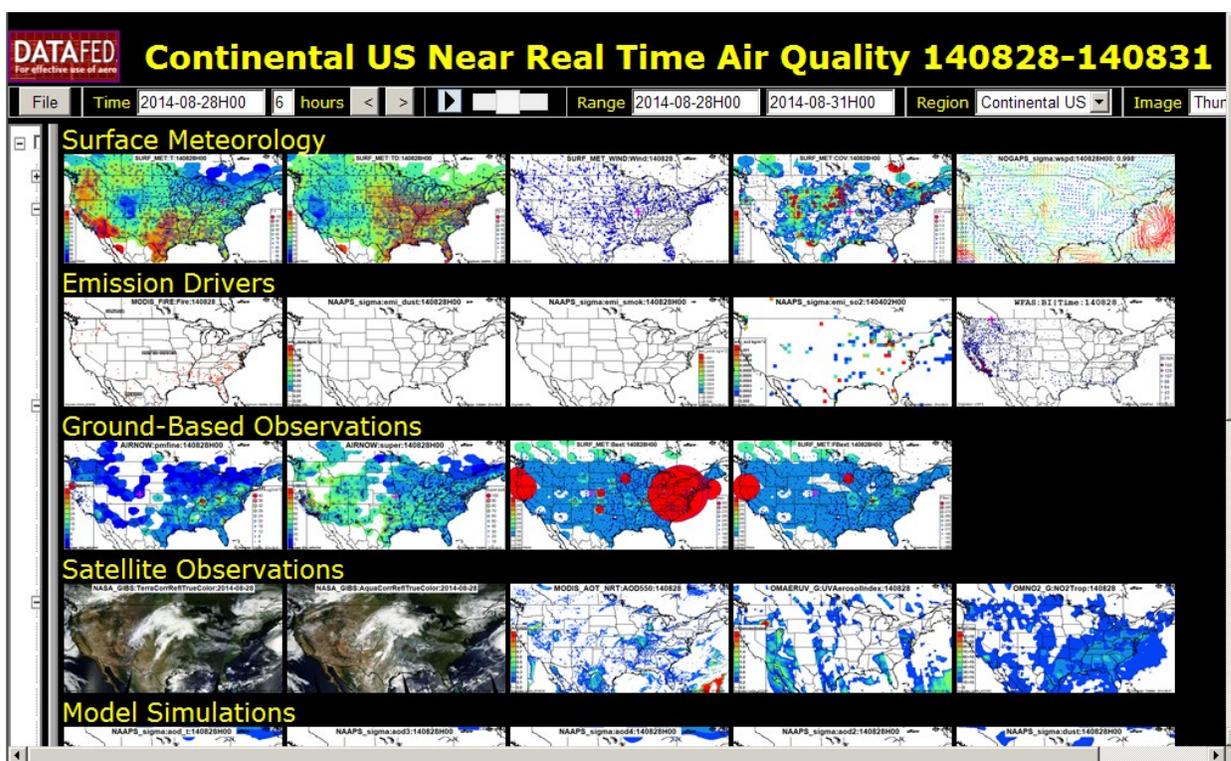
an alternate trajectory model developed by NASA that is based on gridded analysis data from the National Centers for Environmental Prediction (NCEP). Output from both trajectory models may be saved in KML format for displaying in Google Earth. The NASA/NCEP trajectories terminate above the surface at the 950 mb, 850 mb, and 700 mb levels at either 00 UTC or 12 UTC.

6. “Exceptional Air Pollution Event Analysis Community Workspace,”
http://wiki.esipfed.org/index.php/Exceptional_Air_Pollution_Event_Analysis_Community_Workspace.

This website is a community wiki workspace developed to support the analyses of exceptional events flagging and documentation. It contains links to data, data analysis tools, and example case studies.

7. “DataFed Regional Console,”
http://webapps.datafed.net/console.aspx?template=RegionalConsoles/US_NRT.kml.

The DataFed Regional Console displays many data products that are commonly used to analyze exceptional events (e.g., surface meteorological data, emissions, ground-based measurements, satellite data products and model output) all on one dashboard for easy viewing.



Screenshot of the DataFed Regional Console

2.0 WILDLAND FIRE RESOURCES

1. “InciWeb Incident Information Management System,” <http://inciweb.nwcg.gov/>.

InciWeb provides access to descriptive and quantitative information about current and recent wildland fires in the United States including the following essential components of a successful exceptional events demonstration; photographs, maps, the date of origin, incident type (e.g., wildfire), cause (e.g., lightning), location, acreage, and fuel type (e.g., grass). Data are archived for 90 days.

2. “National Interagency Fire Center,” modified daily, <http://www.nifc.gov/index.html>.

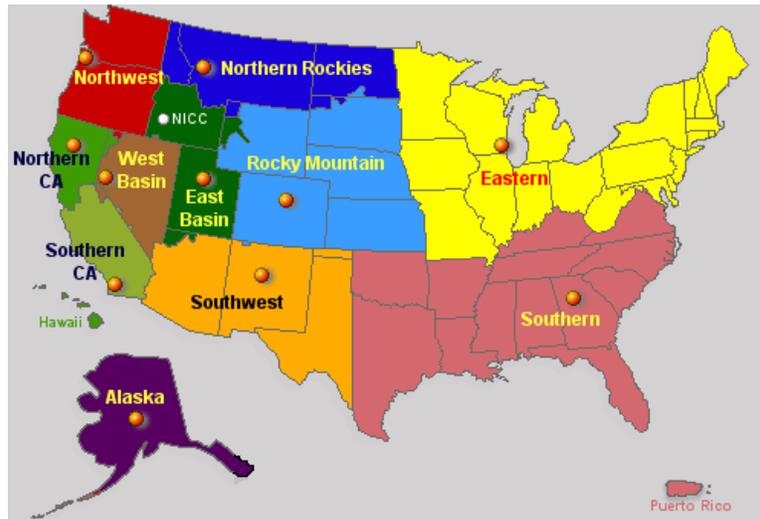
The National Interagency Fire Center (NIFC) website provides access to current and historical fire information, situation reports, and statistics; including a daily report of all active large fires in the United States.

3. “Southern Area Coordinating Center,” <http://gacc.nifc.gov/sacc/index.php>.

The Southern Area Coordinating Center (SACC) website provides access to current fire situation reports, maps of large fires, fire weather, and outlooks for Texas and other south central and southeastern states. The SAAC is one of 11 regional coordinating centers in the United States shown in the figure at the bottom of this page.

4. “National Geographic Area Coordinating Centers Website.” <http://gacc.nifc.gov/index.php>.

The National Geographic Area Coordinating Centers (GACC) website provides access to current fire situation reports, maps of large fires, fire weather and outlooks, year-to-date fire statistics, and historical fire statistics for the United States. The GACC website also provides links to each of the 11 regional coordinating centers, including the SACC.



Map showing the 11 Geographic Area Coordinating Center Locations

3.0 METEOROLOGICAL DATA SOURCES

1. “AirData Download Files,”
http://aqhdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html#Raw.

The EPA AirData Website provides access to files of hourly and daily summary meteorological data for downloading.

2. “National Weather Service,” <http://www.weather.gov/>.

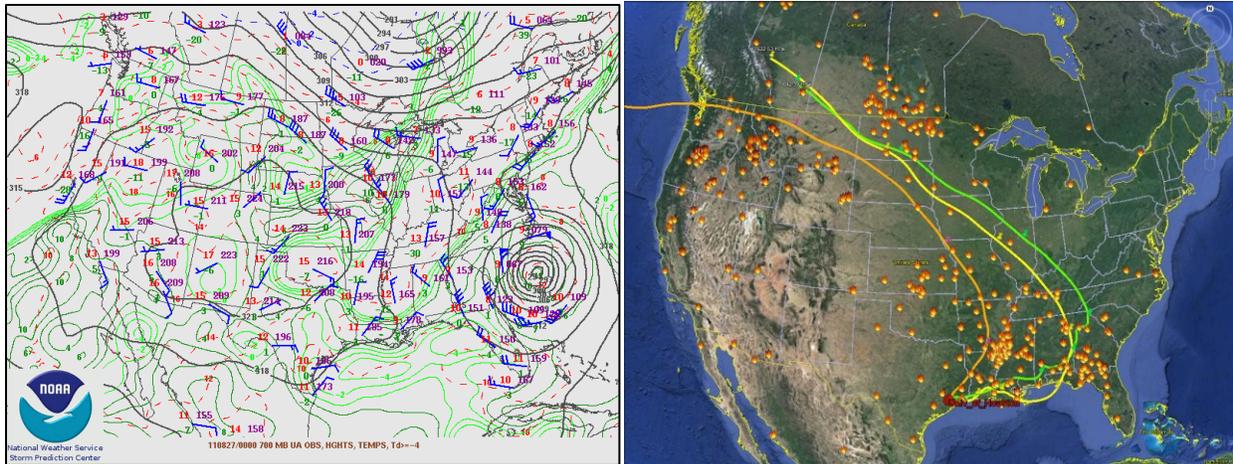
The National Weather Service (NWS) Home Page provides links to current, forecast, and archived weather maps; air quality forecasts; satellite products; and fire weather. Navigation from the NWS Home Page to specific data products is not always intuitive. Direct links to some potentially frequently used data products are given below.

3. “WPC Surface Analysis Archive,” modified daily,
http://www.wpc.ncep.noaa.gov/archives/web_pages/sfc/sfc_archive.php.

The NWS Weather Prediction Center (WPC) surface analysis archive page provides access to surface level weather maps produced at three-hour intervals from March 2006 to current. Alternate access to archived NWS daily weather maps, produce twice each day, is provided at <http://www.wpc.ncep.noaa.gov/dailywxmap/index.html>.

4. “Storm Prediction Center Surface and Upper Air Maps,” modified daily,
<http://www.spc.noaa.gov/obswx/maps/>.

This website provides access to current and archived surface and upper air weather maps from the NWS Storm Prediction Center, including the 700 mb and 850 mb height contours (approximately 3,000 meters and 1,500 meters above ground level, respectively). The weather map shown below (on the left) is the 700 mb height contour map from 0000 UTC on August 27, 2011 (6:00 p.m. CST on August 26, 2011). The closed circulation centered over New Mexico and Colorado was favorable for transporting ozone produced by wildland fires in the northern Rocky Mountains to the Gulf Coast. Note the similarity to the orange colored trajectory in the image on the right (the trajectory furthest to the left). This is the 700 mb NASA/NCEP trajectory projected backward from Houston at 0000 UTC on August 27, 2011. The yellow and green trajectories terminate at the 850 mb and 950 mb, heights, respectively. The trajectories were accessed using the AERONET Data Synergy Tool.



700 mb height contours for 0000 UTC on August 27, 2011 (6:00 p.m. CST on August 26, 2011) and 700 mb (orange/left), 850 mb (yellow/middle), and 950 mb (green/right) trajectories projected back 7 days from Houston. The orange markers are NOAA HMS detected fires.

5. “National Weather Data in KML/KMZ Formats,” <http://www.srh.noaa.gov/gis/kml/>.

This website provides links to current and forecast weather maps in Google Earth formats. Archived data are limited.

6. “NCAR Real-Time Weather,” <http://weather.rap.ucar.edu/>.

This website provides real-time access to surface and upper air weather charts as well as access to visible and infrared satellite imagery from GOES-12 and GOES-10.

7. “NOAA/ESRL Radiosonde Database,” <http://esrl.noaa.gov/raobs/>.

This website provides access to current and archived radiosonde data from around the world.

8. “Atmospheric Soundings,” <http://weather.uwyo.edu/upperair/sounding.html>.

This University of Wyoming Department of Atmospheric Sciences Website is alternate source of radiosonde data.

9. “Cooperative Agency Profilers,” modified daily, <https://madis-data.noaa.gov/cap/index.jsp>.

This website provides access to boundary layer vertical wind profile data from sites throughout the United States, including Houston, Beaumont-Port Arthur, and the Dallas-Fort Worth Area. The following example is for the 24-hour period ending at 0600 UTC on April 13, 2011 (6:00 p.m. CST on April 12, 2011). Northerly to northeasterly winds up to 40 knots were measured at about the 1000 m level were favorable for transporting smoke from eastern Kansas grass fires to the Gulf of Mexico. By noon, the winds in the lower boundary layer had become southerly, bringing the smoke remnants onshore.

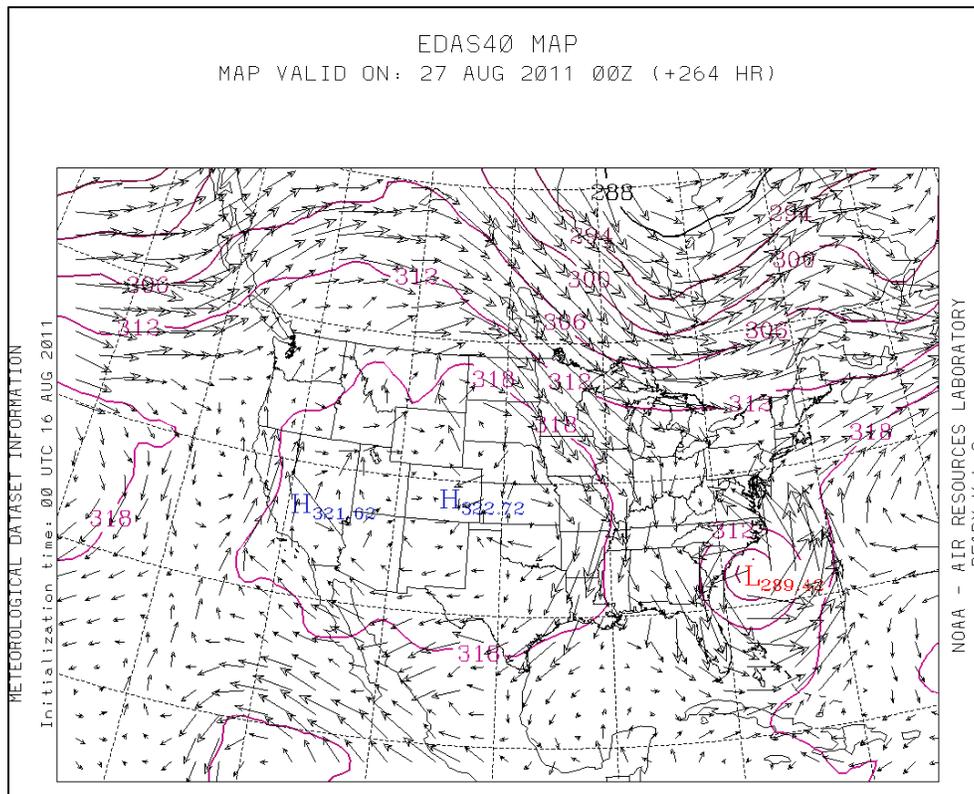
4.0 METEOROLOGICAL MODELING SOURCES

1. "HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model,"
<http://ready.arl.noaa.gov/HYSPLIT.php>.

This interactive website allows users to calculate forward and backward trajectories from anywhere in the world using current, forecasted, or archived gridded meteorological model datasets. Advanced features include trajectory matrices and trajectory ensembles. Output can be saved in GIF, PDF, or KMZ formats.

2. "READY - Real-time Environmental Applications and Display sYstem,"
<http://ready.arl.noaa.gov/index.php>

The READY website provides access to current, forecasted, and archived gridded meteorological model data and charts in three dimensions. The following example chart shows wind vectors at the 700 mb level for 0000 UTC on August 27, 2011 (6:00 p.m. CST on August 26, 2011). The circulation approximately centered over New Mexico and Colorado show the same transport pattern as depicted in the NOAA 700 mb analysis may and back trajectory shown above.



EDAS 40 km grid 700 mb height contours and wind vectors at 0000 UTC on August 27, 2011 (6:00 p.m. CST on August 26, 2011)

3. “Model Analysis and Guidance,” updated hourly, <http://mag.ncep.noaa.gov/>

The NWS National Centers for Environmental Prediction (NCEP) provides access to various observational and experimental numerical weather prediction products, including NAM surface and upper air charts.

4. “Rapid Refresh (RR),” updated hourly, <http://rapidrefresh.noaa.gov/RAP/>.

The NOAA Earth Systems Research Laboratory (ESRL) Rapid Refresh Website provides access to experimental output from the RAP (Rapid Refresh) and HRRR (High Resolution Rapid Refresh) hourly updated weather forecast model/assimilation system. Surface and upper air two-dimensional plots of meteorological variables are given at hourly intervals. Access is also provided to vertical soundings.

5.0 EMISSIONS INFORMATION SOURCES

1. “Atmospheric Composition Remote Sensing and Prediction,” updated daily, <http://www.acd.ucar.edu/acresp/forecast/fire-emissions.shtml>

This website provides access to near real-time fire emissions from the Fire Inventory of NCAR (FINN), based on MODIS Rapid Response fire counts. Emissions data files available at: <http://www.acd.ucar.edu/acresp/dc3/AMADEUS/finn/emis/>. FINN fire emissions for previous years are available from: <http://bai.acd.ucar.edu/Data/fire/>.

2. “Emissions Inventories – AirFire, accessed August 29, 2014” <http://www.airfire.org/emissions/>.

AirFire creates wildland fire emissions inventories through the SmartFire v2 – BlueSky frameworks, both for real-time and retrospective uses. According to the AirFire Website, emissions data download access is under construction. In the interim, data may be obtained directly from Sim Larkin, United States Forest Service at 206.732.7849.

3. “NRL Monterey Aerosol Page – Satellite Analysis,” <http://www.nrlmry.navy.mil/aerosol/#satelliteanalyses>

This website provides current and archived estimates of smoke emissions from fires calculated by the Fire Locating and Modeling of Burning Emissions (FLAMBE) Program.

6.0 SMOKE MODELING AND PHOTOCHEMICAL MODELING SOURCES

1. “NRL/Monterey Aerosol Page,”
<http://www.nrlmry.navy.mil/aerosol/#currentaerosolmodeling> .

The NRL/Monterey Aerosol Page provides access to output images and animated loops from the Navy Aerosol Analysis and Prediction System (NAAPS) Global Aerosol Model simulating smoke, dust, and sulfate aerosol transport.

2. “NOAA Air Quality Forecast Guidance for East Texas,” modified daily,
<http://airquality.weather.gov/sectors/easttexas.php#tabs>.

This website provides daily and hourly forecasts of ozone, smoke, and dust concentrations for east Texas and can be zoomed out for larger regions.

3. “National Weather Service / Weather Prediction Center,”
<http://www.wpc.ncep.noaa.gov/hpcaq/>.

This website provides links to NWS WPC North American CMAQ model output (NAM NEST) for a variety of phenomena associated with air quality and transport forecasts. Boundary layer height, ventilation index, pressure gradient and streamlines are forecast outputs. The page contains links to the model development and references as well as links to other NOAA and NWS air quality forecast products.

4. “Blue Sky Daily Runs,” accessed August 29, 2014, <http://www.airfire.org/data/bluesky-daily/>.

The Blue Sky Daily Runs Website provides access to daily smoke dispersion forecasts developed using satellite-detected fire locations and forecasted meteorology. Archived dispersion forecasts are available since July 9, 2014.

7.0 AMBIENT MONITORING DATA

1. “EPA AirData,” updated on July 11, 2014, <http://www.epa.gov/airdata/>.

The AirData website provides access to graphical and tabulated summaries of ambient monitoring data from the EPA Air Quality System (AQS) database. Data files containing hourly, daily summary, and annual summary data are available for downloading.

2. “AirNow-Tech,” updated hourly, <http://airnowtech.org/>

AirNow-Tech provides registered users access to air monitoring data transmitted by state, local, and tribal air agencies to the EPA AirNow system. Data from AirNow-Tech are not verified or validated. Note that AirNow data are not fully verified or validated and the EPA data

use guidelines discourage the use of AirNow data as a substitute for data stored in AQS (EPA's Air Quality System) to formulate or support regulation, ascertain trends, act as guidance, or support any other government or public decision-making.

3. "Texas Air Monitoring Information System (TAMIS)," <http://www5.tceq.state.tx.us/tamis/index.cfm?fuseaction=home.welcome>.

TAMIS provides access to ambient air and meteorological data collected by the TCEQ and other public and private air monitoring organizations in Texas.

8.0 SATELLITE IMAGERY

1. "Applied Remote Sensing Training (ARSET)," <http://arset.gsfc.nasa.gov/>.

The ARSET website provides links to training and instructional materials related to the use of satellite images and data products in air quality analysis.

2. "Introduction to Remote Sensing and Air Quality Applications," <http://arset.gsfc.nasa.gov/airquality/workshops/texas-2014>.

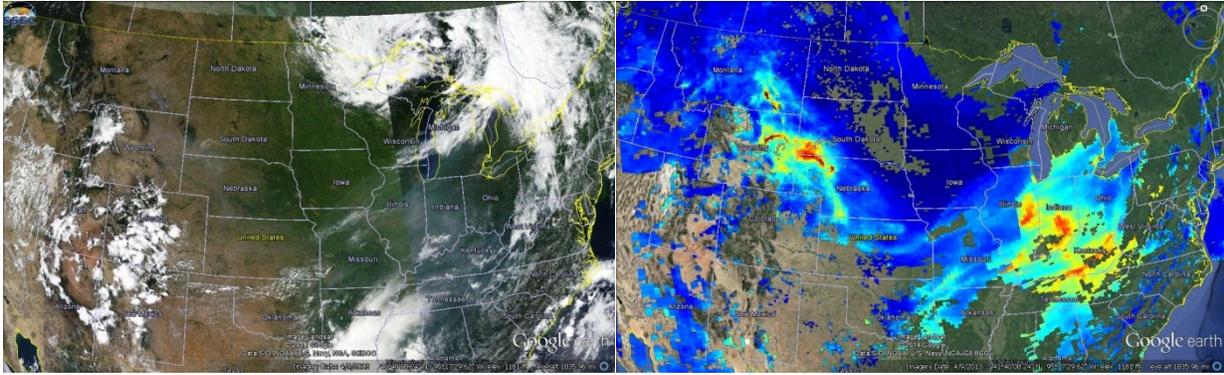
This website provides links to handouts, slide presentations, and other materials used in a training course hosted by TCEQ in February 2014.

3. "MODIS Today: USA Composite," updated twice daily, <http://ge.ssec.wisc.edu/modis-today/>.

The MODIS Today website provides access to MODIS (Moderate Resolution Imaging Spectroradiometer) true color and false color imagery from NASA's Terra and Aqua orbiting satellites for the Continental United States (CONUS). Images may be saved in GIS or KML formats. True color imagery may be useful for detecting smoke plumes or regional haze.

4. "IDEA – Infusing Satellite Data into Environmental Applications," modified daily, <http://www.star.nesdis.noaa.gov/smcd/spb/aq/index.php>.

The IDEA website provides access to MODIS Terra and Aqua, GOES, and VIIRS true color and aerosol optical depth (AOD) imagery in a variety of formats including KML, PNG, and animated GIF (for GOES images, only). The following are MODIS Aqua true color and AOD imagery from MODIS Today and IDEA, respectively, for August 24, 2011.



MODIS Aqua true color and AOD imagery from MODIS Today and IDEA, respectively, for August 24, 2011

5. “CALIPSO LIDAR Browse Images,” http://www-calipso.larc.nasa.gov/products/lidar/browse_images/show_calendar.php.

This website provides access to vertical profiles of clouds and aerosols detected by LIDAR on board the Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observations (CALIPSO) satellite. The imagery may be helpful in the analysis of a possible exceptional event by showing the altitudes and thicknesses of smoke plumes and haze layers and by classifying detected aerosols as smoke or other particle types.

6. “NASA Worldview,” <https://earthdata.nasa.gov/labs/worldview/>

The NASA Worldview website provides near real-time global satellite imagery from over 100 different data products.

7. “Giovanni – Interactive Visualization and Analysis,” <http://disc.sci.gsfc.nasa.gov/giovanni>

Giovanni is a web-based data analysis tool that allows easy and quick visualization and retrieval of satellite imagery from Terra and Aqua MODIS and other remote sensing instruments.

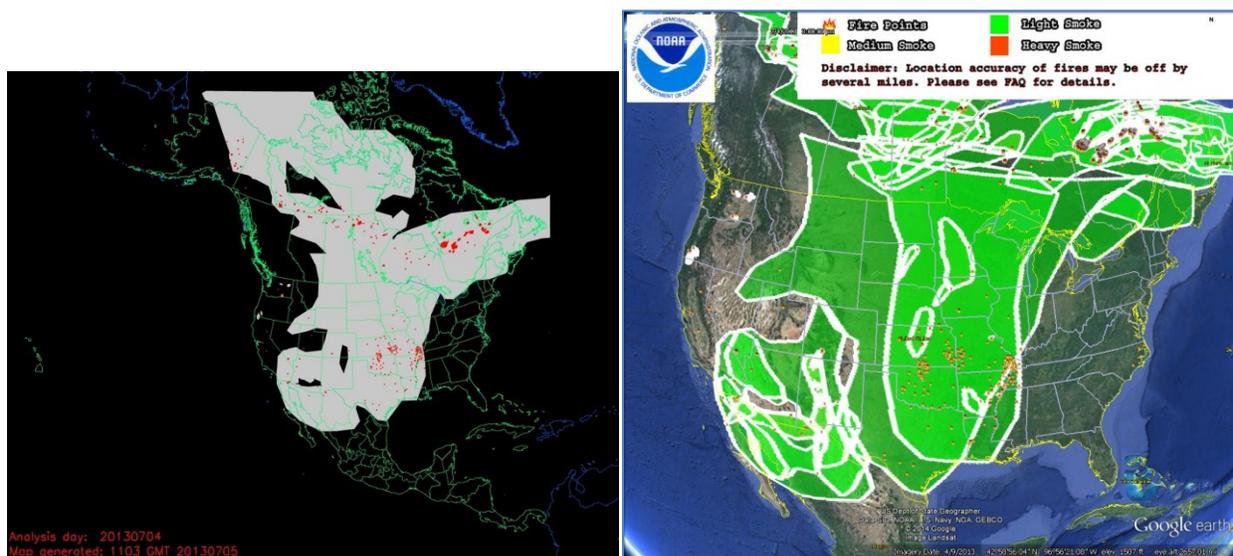
8. “CIMSS Satellite Blog,” <http://cimss.ssec.wisc.edu/goes/blog/archives/8828>.

This University of Wisconsin blog space provides case studies of significant fire and weather events.

9. “NOAA Hazard Mapping System (HMS) Fire and Smoke Product,” modified daily, <http://www.ospo.noaa.gov/Products/land/hms.html>.

This website provides access to current and archived fire and smoke analyses for North America and real-time visible and infrared imagery loops based on data from geostationary and polar orbiting satellites. Fire and smoke analyses are available in GIS format (shown below on the left) and KML format for display in Google Earth (shown below on the right). Archived

images and KML files are accessible only for the most recent 6 months; however, older GIS images can be accessed through AirNow-Tech and older KML files can be retrieved from the NOAA Air Resources Laboratory ftp site (<ftp://arlftp.arlhq.noaa.gov/pub/archives/fires/national/arcweb/>). The images below are from July 4, 2013.



NOAA HMS Fire and Smoke Product for July 4, 2013

10. “NOAA SSD Smoke Text Product,” modified twice daily, http://www.ssd.noaa.gov/PS/FIRE/current_text.html.

The NOAA SSD Smoke Text Product is a description of the smoke observed in satellite imagery, including smoke from active fires and smoke that has become detached from the source and has drifted downwind over the course of a few days. Archived product from 2005 – present is accessible from <http://www.ssd.noaa.gov/PS/FIRE/DATA/SMOKE/>. The following example smoke text product describes the smoke that was reported on July 4, 2013 (shown above).

“The majority of North America is covered by smoke from Alaska east/southeast across Canada and southward across most of the US to northern Mexico. The smoke is being generated by numerous wildfires in the Canadian Northwest Territories, Manitoba, Ontario, and Quebec, as well as wildfires in the western U.S. and Alaska. The smoke was most dense over central and southeast Canada.”

11. “USDA Forest Service Active Fire Mapping Program,” <http://activefiremaps.fs.fed.us/>

This website provides access to true color and false color satellite imagery from Terra MODIS, Aqua MODIS, and VIIRS, as well as current and archived fire data in KML format. Archived KML files may be accessed directly from <http://activefiremaps.fs.fed.us/googleearth.php>.

12. “NOAA GOES Aerosol Smoke Product (GASP),” updated every 30 minutes, <http://www.ssd.noaa.gov/PS/FIRE/GASP/gasp.html>

The GASP product is a retrieval of aerosol optical depth derived from GOES East visible imagery. This product is available at a 30-minute interval and 4 km x 4 km spatial resolution during the sunlit portion of the day.

9.0 SCIENTIFIC LITERATURE

1. “NASA Air Quality Applied Sciences Team,” <http://acmg.seas.harvard.edu/aqast/>.

This website provides links numerous online publications, presentations, newsletters, meeting announcements, etc., dealing with the use of satellite data products in air quality analysis.