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Haze modeling and observation resources at the National Climatic Data Center

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ABSTRACT

NOAA's National Climatic Data Center (NCDC) is a valuable repository of weather and climate data useful for modeling haze in the United States and around the world. Such data are particularly useful for initializing model runs to forecast haze, performing field studies to better understand haze transport and local climatologies, and for understanding micro-climates that affect haze monitoring efforts. NCDC archives *in situ*, satellite, and radar observations as well as model input and output data sets. Haze studies, analyses and modeling will benefit from the data available at NCDC.

BACKGROUND

One of the primary missions of the National Oceanic and Atmospheric Administration (NOAA) is the protection of life and property. This is evident through the emphasis in the National Weather Services on the severe weather watch and warning system. Yet, while air quality (such as particulate matter) may cause as many as 30,000 deaths in the United States per year[1], it was not part of these forecasts. However, that changed in 2002 when the U.S. Congress mandated that NOAA "establish a program to provide operational air quality forecasts and warnings for specific regions of the United States." Since then, NOAA has begun an aggressive program to make these forecasts possible. In doing so, the NWS began an effort to make operational ozone forecasts by September 2004 for the northeastern U.S. and to incorporate forecasts of particulate matter with diameter less than 2.5µm (PM2.5) within 5 years.

As part of NOAA, the National Climatic Data Center (NCDC) in Asheville, NC hopes to participate with NOAA and the research community in this endeavor. From *in situ* and satellite observations to model data, NCDC provides numerous data sources that will benefit the public through its contribution to air quality research and forecasting.

IN SITU DATA RESOURCES

The *in situ* data, much of which are available in near real time, can be used for model initialization and providing atmospheric information to fully understand the climate and weather for the lifetime of a haze outbreak. In particular, the Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS) hourly data from more than 1500 sites around the U.S. are available, with over 250 of the ASOS sites having one-minute time resolution data. The aerosol extinction coefficients measured by the ASOS visibility sensor can provide ground-level aerosol measurements;

and the temperature, cloud, wind, dew point (moisture), visibility, and precipitation data from ASOS and AWOS sites are useful in a variety of ways, such as determining frontal positions, the timing of particulate scouring (e.g., by precipitation), and other local conditions at the observing station. These data, along with similar data from international stations, are available online from NCDC.

The Integrated Surface data set (ISD) has U.S. and global hourly and daily observational data for the past 100 years, with the majority of stations having digital data for the past 20 to 50 years. For finer-scale analyses, NCDC has daily temperature (maximum/minimum) and precipitation data for over 8000 active "Cooperative" observing stations across the U.S., with historical data for some of these stations from as early as the late 1800's to present. NCDC archives U.S. and global upper-air sounding data (from weather balloons and a few rocketsondes), which provide a vertical profile of the atmosphere, including wind, temperature, pressure, and dew point data. Upper-air data are often used to estimate atmospheric stability and the mixing layer height. (To access any of these data (and many other data types), go to: http://cdo.ncdc.noaa.gov/. This system includes a variety of access methods, including a GIS map interface.)

REMOTE SENSING DATA RESOURCES

Satellite data

Satellite data at NCDC can provide information on the location and movement of aerosol plumes. Observations from instruments such as the Solar Backscatter Ultraviolet instrument (SBUV/2), Advanced Very High Resolution Radiometer (AVHRR) and the Imager on the Geostationary Operational Environmental Satellite (GOES) have provided information on the distribution of aerosols in the atmosphere for many years.

In particular, the GOES Aerosol/Smoke Product (GASP) is useful for haze studies, providing aerosol information at high spatial and temporal resolutions. The GASP product operates at the NOAA Center for Satellite Applications and Research retrieving aerosol optical depth over the coterminous U.S. at 30 minute intervals (http://orbit-net.nesdis.noaa.gov/crad3/gasp/RealTime.html). The GASP product is described and validated by Knapp et al.[2,3]. For example, the GASP product was used during the International Consortium for Atmospheric Research on Transport and Transformation (ICARTT) 2004 field campaign to plan aircraft flight paths. While the GASP product is not yet archived at NCDC, the algorithm may be applied to archived geostationary data (e.g., GOES data) thus providing a historical perspective on haze.

Additionally, aerosol retrievals from future NOAA sensors aboard NPOESS will be available through the Comprehensive Large Array-data Stewardship System (CLASS) at: http://www.class.noaa.gov/. The Visible Infrared Imager Radiometer Suite (VIIRS) instrument will have channels similar to MODIS, allowing for aerosol retrievals over land and ocean. In particular, though, the Aerosol Polarimeter Sensor (APS) will provide the most advanced measurements of aerosol from space. The APS is an along track scanning radiometer, that will make observations along the satellite track. The along track scanner will sample an earth location from numerous viewing angles. The spectral and

polarimetric observations at these angles will provide precise retrievals of aerosol size, sphericity and refractive index. These measurements, in addition to ground sensors, will provide some of the most comprehensive data available.

Radar data

The National Weather Service (NWS) network of weather radars, Next Generation Radar (NEXRAD), has been operational for approximately 10 years at many sites in the U.S. and the data are archived at NCDC. Level II products are the base products that consist of reflectivity, Doppler velocity, and spectrum width. Level III products consist of 20 products derived from level II data including reflectivity, rainfall estimates, and storm velocity. Rainfall estimates based on the Weather Surveillance Radar 1988 Doppler (WSR-88D) rainfall algorithm are available in the level III data set for each NEXRAD radar site. Other products, such as storm velocity, vertical integrated liquid and base reflectivity and velocities, are available in the level III data set. The products are available from 1 km x 1° polar to 4 x 4 km^2 Cartesian spatial resolution and from 5 minutes to hourly temporal resolution. Interested users can order level II and level III data from the HPSS Access System (http://has.ncdc.noaa.gov) free of charge.

MODELLING RESOURCES

NOAA Operational Model Archive and Distribution System (NOMADS)

Until recently, there existed no long-term archive for climate and weather models. To address the need for distributed access to Numerical Weather Prediction (NWP) and General Circulation Models (GCM) and data, the NCDC, along with the National Center for Environmental Prediction (NCEP) and the Geophysical Fluid Dynamics Laboratory (GFDL), initiated the infrastructure and model data access project called the NOAA Operational Model Archive and Distribution System (NOMADS). NOMADS archives NOAA operational model forecast output and the Global Data Assimilation System (GDAS) fields used for Global and Regional model start up. The GDAS data set consists of the minimum set necessary to re-generate NCEP analysis and forecast products (model re-start and initialization files).

For air quality models, the highest resolution models have been shown to produce the most accurate derived model parameters or “tracers” such as ozone or liquid water. Therefore, either the GDAS model input fields to initialize local scale (<12km), models for horizontal and vertical mass and motions fields, or model output data can be used to inter-compare local models to regional models. Model output fields include the Global Forecast System (GFS), the Rapid Update Cycle (RUC) model, and the Eta and mesoEta (12km) models. Long-term regional and global model reanalysis data sets are also accessible in a variety of standard formats which could be input into haze transport models (such as the Multiscale Air Quality Simulation Platform). The new North American Regional Reanalysis (NARR), is now being ingested at NCDC. NARR can be used to improve both models and the observations in a hindcast mode, as well as improved air-quality models by model to analysis inter-comparisons. Both Real-Time

(see the NCEP NOMADS: http://nomad1.ncep.noaa.gov/) and retrospective data (see the NCDC NOMADS: http://nomads.ncdc.noaa.gov/) are available through NOMADS.

Education and Research Consortium of the Western Carolinas (ERCWC)

NCDC has a Memorandum of Agreement with the ERCWC which provides NCDC with high performance computing resources in exchange for computer center space, utilities, access to climate databases and technical expertise. The ERCWC has actively pursued obtaining high performance computing capabilities and capacity to support environmental modeling. They are currently in the process of negotiating an agreement with Oak Ridge National Laboratory (ORNL) which will provide the ERCWC access to their high performance computing facility at ORNL. Expectations are that NCDC will be able to leverage this agreement and utilize the vast computing resources at ORNL in the foreseeable future.

National Environmental Modeling and Analysis Center (NEMAC)

NCDC's new partner, NEMAC, is located at the University of North Carolina-Asheville. NEMAC conducts basic and applied environmental modeling research and is working with NCDC to explore applications of environmental modeling in the Southern Appalachians in several areas including air quality, energy efficiency and renewable energy studies.

Currently, regional scale weather models lack the resolution needed to adequately predict local influences to weather in mountainous terrain such as in WNC. NEMAC, in cooperation with the Department of Atmospheric Sciences at UNCA is working to implement the Weather Research and Forecasting (WRF) Model on a regional scale at a resolution that will allow better prediction of small scale phenomenon such as cold-air damming and location of heavy snow events, frontal boundary position, and heavy rain events associated with severe thunderstorms. Fine tuning of this local model will be performed and will include studies to optimize model output results based upon model input initialization and physical parameterizations (microphysics, boundary layer, etc.).

SUMMARY

The National Climatic Data Center has available many untapped resources for haze modeling and observations. Remote sensing applications and model data provide large-scale perspectives while *in situ* observations provide the interpretive data needed to understand haze episodes.

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