Air Resources Laboratory

Air Quality Forecasting Research and Development

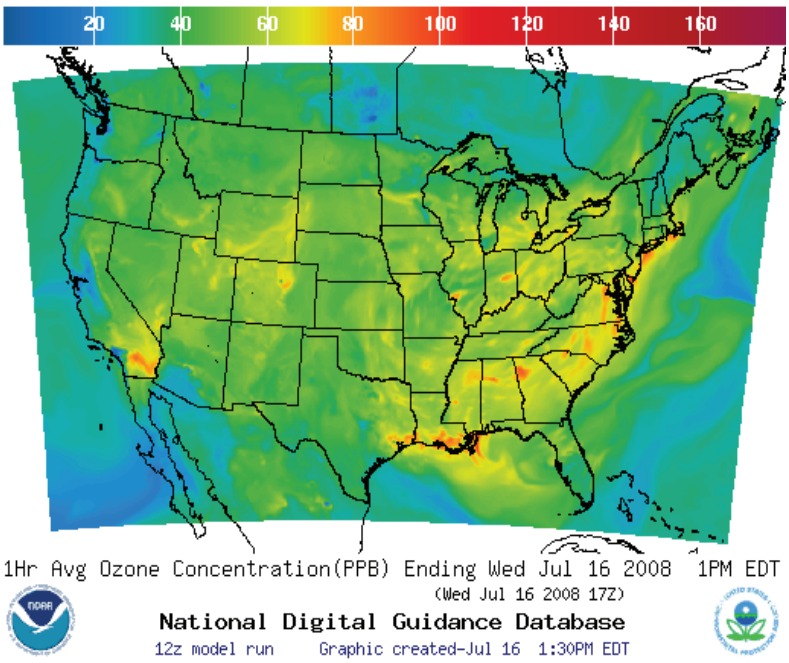
Improving the Performance of Air Quality Forecasting Models to Protect Human Health and the Environment

Elevated levels of ground-level ozone and particulate matter cause respiratory and cardiovascular problems and annually lead to tens of thousands of premature deaths, with costs in the United States of more than $100 billion. Accurate air quality forecasts enable communities to take actions that can reduce the severity of episodes of poor air quality (e.g., encourage people to telecommute or take mass transit instead of driving). They also enable individuals to take protective actions that limit their own exposure to poor air quality, such as limiting exercise or staying indoors.

Los Angeles, California air on clear day (top) and a smoggy day (bottom). Image Credit: California Air Resources Board

What We Do

The Air Resources Laboratory's (ARL) Air Quality Forecasting Research and Development program helps to ensure that forecast models run operationally by NOAA's National Weather Service (NWS) provide consistently high quality forecast products and support air quality planners and managers, air quality forecasters, and the research community. An important component of ARL's work is evaluating and improving computer models used to predict air concentrations of ground-level ozone and fine particulate matter. ARL scientists evaluate the models by performing rigorous comparisons of model predictions with actual atmospheric measurements. Based on the knowledge gained from these evaluations, ARL adds or enhances specific model processes or input data sets to better represent emissions of air pollutants and the physical and chemical complexities that occur in the atmosphere. The continuous model evaluation and improvement cycle conducted by ARL scientists leads to better operational air quality forecast products.



An example map of ground-level O_3 concentrations predicted for the continental U.S. The NWS generates such maps twice daily using an ARL-developed modeling system.

Ground-level Ozone

Ground-level ozone (O_3) is a gas typically produced from other air pollutants reacting in the presence of sunlight. O_3 is a major constituent of smog. Motor vehicle exhaust, power plant and industrial emissions, gasoline vapors, and chemical solvents, as well as natural processes, are sources of the compounds that act to form ground-level O_3. ARL improves the NWS's operational modeling system for short-term (1-2 day) prediction of ground-level O_3. ARL works with scientists in other NOAA laboratories, other federal agencies, and at universities to improve air quality forecast models and to generate data that are necessary to model all of the significant processes that control the concentrations of ground-level O_3.

Particulate Matter

ARL also supports NOAA's goal of predicting atmospheric concentrations of fine particulate matter ($PM_{2.5}$). These tiny particles, which are 2.5 micrometers in diameter or less (or less than 1/30th the width of a human hair), are especially dangerous to human health because they can be inhaled into and accumulate in the respiratory system. $PM_{2.5}$ is emitted directly into the air from

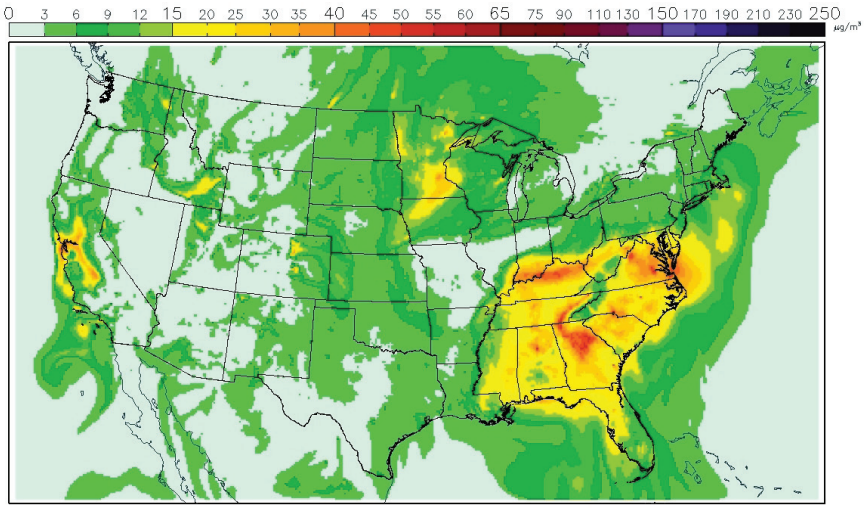
combustion processes (burning of fossil fuels, residential fireplaces, agricultural burning, and fires), volcanic emissions, and windblown dust, but it can also form in the air as a result of chemical reactions.

Although scientific understanding of the origin and fate of $PM_{2.5}$ has advanced rapidly over the last 20 years, the forecasting capabilities of these atmospheric constituents are not as advanced as that of ground-level ozone. This is largely because the physical and chemical processes that govern the concentration of fine particulates in air are much more complex than those that determine ozone concentrations.

ARL is working to improve NOAA's forecast models for $PM_{2.5}$ by incorporating the latest scientific understanding of these processes obtained from field and laboratory measurements and other modeling efforts across the air quality scientific community. An example of this work is the NOAA Smoke Forecasting System (SFS), which integrates NOAA's satellite imagery of the location and extent of the fires, estimates of emissions from fires, and the dispersion simulations from ARL's Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model to produce a daily 48-hour prediction of smoke concentrations. The SFS serves as guidance to air quality forecasters and the public for $PM_{2.5}$ emitted from large wildfires and agricultural burning.

To support a future capability to predict all forms of $PM_{2.5}$, ARL is working on an advanced PM modeling system that will include particles formed in the atmosphere through chemical reactions. ARL is also developing a similar capability for windblown dust.

All of this R&D helps to ensure that the operational forecast models provide consistently high quality forecast products.



Forecast daily mean surface concentrations of $PM_{2.5}$ in ug/m³ for November 17, 2009, from the developmental forecast system. Red, orange, and yellow show the highest concentrations. ARL scientists are working to improve the capabilities of this system in order to provide accurate forecasts of this important atmospheric pollutant.

An example map of surface smoke predicted for the Continental United States. The NWS generates such maps twice daily using an ARL-developed modeling system.

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Operational Air Quality Predictions
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ARL Air Quality R&D
www.arl.noaa.gov/AirQual.php
NOAA Smoke Forecasting System
www.arl.noaa.gov/smoke.php
NOAA's State of the Science Air Quality Fact Sheet
www.arl.noaa.gov/documents/Summaries/AQSOSFactSheetFINAL.pdf

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