NCAR | RESEARCH APPLICATIONS LABORATORY

ADVANCED FORECASTING FOR AIR QUALITY

A Global Problem

Air pollution is estimated to cause about 4.2 million premature deaths worldwide and destroys enough crops to feed millions of people every year. Health officials, the general public, and farmers need advance notice when dangerous air-quality levels are on the rise. Researchers and engineers at RAL are dedicated to developing new technologies that directly help decision-makers plan for high-pollution days, and discern which emission sources are responsible for such days.

PREDICTION AND RESEARCH

This work allows meteorologists and local planners to:

- Forecast air quality for cities and rural areas 3 days in advance.
- Project the impact of changes in human activities and climate on future air quality.
- Quantify cross-border transport of air pollution.
- Assess societal impacts of air pollution.

DETAILED FORECASTING SYSTEM

Current air-quality forecasts are limited. They provide a simple single-value prediction and do not specify the prediction uncertainty. They only simplistically tell whether ozone levels will be high or low. Much more detail in the forecast is needed, and, with funding from NASA and NOAA, NCAR and its partners, have developed a new capability to produce 48-hour detailed forecasts of ground-level ozone and fine particulate matter.

Benefits & Impacts

- Short-term, air-quality forecasts
- Future air-quality projections in response to climate change
- Source attribution of specific primary pollutants
- Assess societal impacts of air pollution

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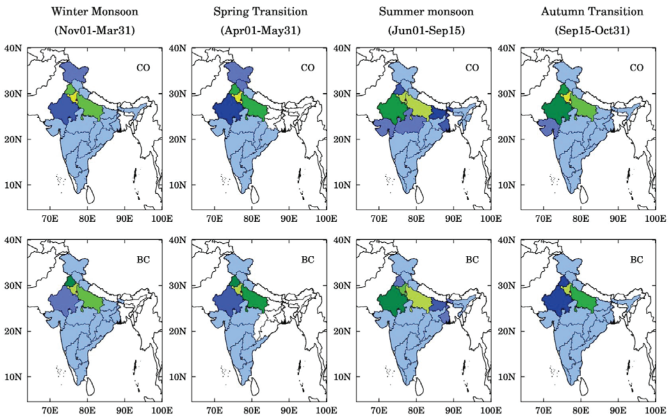
This new forecasting capability combines satellite and in situ observations with state-of-the-art modeling, and generates air-quality forecasts in fine detail. Just as a weather forecast, for example, might warn of an 80% chance of rain in the afternoon, new air-quality forecasts might warn of an 80% chance of high ozone levels during certain times of the day. Such improved forecasts will significantly enhance the decision-making activity in air-quality management. This system has been operational over the USA and is being implemented over New Delhi, India. This system can be easily applied to any part of the world.

FUTURE AIR QUALITY

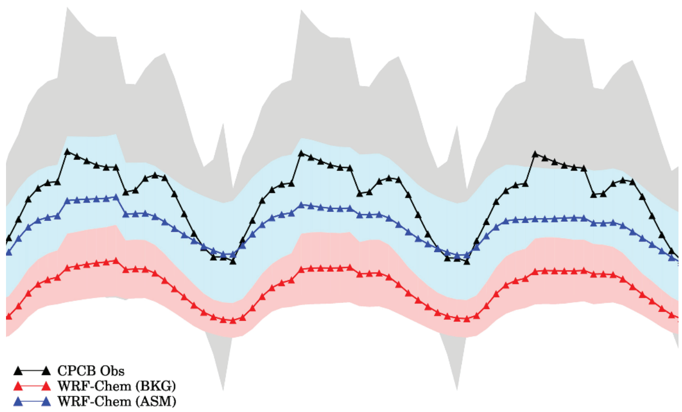
To quantify future changes in air quality, due to changes in future climate and human activities, NCAR has developed a global and regional climate model coupled with chemistry capabilities. These models can be used to examine the impact of different emission scenarios on the air quality of any region of the world. They have been used to predict changes in air quality over the USA and India as far out as mid-century (2050). We project an increased health risk to the South Asian population caused by combined exposure to both extreme heat and air pollution.

CROSS-BORDER TRANSPORT

Depending on the lifespan of any given pollutant, air pollutants can be transported by atmospheric winds from one country to another. Thus, it is crucial to quantify the contribution of such cross-border transport, while designing air-pollution mitigation strategies.



The 2014 spatial distribution of CO (by state [top panel]) and black carbon (bottom panel) levels over four seasons (left to right).



Observed and WRF-Chem forecasted surface $PM_{2.5}$ mass concentrations in Delhi and surrounding regions averaged over 10 October to 19 November 2017. Shaded areas represent standard deviation in average values from observations (grey), BKG (light red), and ASM (light blue) experiments.

NCAR developed a tagged tracer technique to quantify the cross-border contribution to both gaseous (carbon monoxide [CO]) and aerosol (black carbon [BC]) pollutants. Using this technique, the cross-border transport is estimated to contribute up to 30% to wintertime CO pollution, but less than 5% to BC pollution in India, indicating that India needs to partner with neighboring countries to reduce CO pollution. However, it also reveals that the country can control BC pollution. The same technique has been applied to study the contribution of interstate transport to CO and BC pollution within different states of India.

SOCIETAL IMPACTS

NCAR and its partners coupled the chemistry transport models with agricultural production and population datasets to assess the impacts of air pollution on human health and crops. For the Indian region, it has been estimated that surface-ozone pollution destroys enough food to feed about 94 million people, and, along with fine particulate matter, can lead to about 0.9 million premature deaths every year. The economic damage from the health and crop impacts of air pollution in India are estimated to be more than 2 billion USD. Through collaboration with Indian institutions, we estimated that recent Indian policies (tighter vehicular emission standards and subsidized distribution of cleaner cooking fuels) could reduce air pollution-related mortality in India by 11–30%.

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