Predicting harmful pollutants

Global Ensemble Forecast System - Aerosols

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The Need

Atmospheric aerosols in air pollution and wildfire smoke kill an estimated 4.2 million people each year worldwide. Improved forecasts of air pollutants help the public avoid hospitalizations and premature deaths from respiratory, cardiovascular, and neurological diseases. Advanced models will support local authorities and the public with timely warnings to make decisions to protect health.

The Science

GSL led the development of the **Global Ensemble Forecast System - Aerosols (GEFS-Aerosols)**, an atmospheric composition model that integrates weather and air quality forecasting to produce week-long forecasts of aerosol components including wildfire smoke, soot, organic carbon, particulate sulfate, dust, sea salt, and volcanic ash. The model is able to provide both the weather and aerosol forecast at the same time. It is also capable of predicting the atmospheric impact of volcanic eruptions, which can disperse quantities of ash and other particulates over wide areas. This is NOAA's first operational global forecast that realistically accounts for the geographic distribution of atmospheric aerosols resulting from wildfires, dust storms, and human activity.

GEFS-Aerosols uses the Finite Volume Cubed Sphere (FV3) core. The atmospheric chemistry component of GEFS-Aerosols is based on WRF-Chem, a community modeling system used by thousands of users worldwide. The aerosol modules are based on the NASA Goddard Chemistry Aerosol Radiation and Transport model (GO-CART). Global anthropogenic emission inventories are derived from the Department of Energy's Community Emissions Data System. A new dust emissions algorithm was developed and implemented in GEFS-Aerosols by scientists in ARL. The algorithm significantly improves the model's estimates of dust in the global atmosphere, thereby potentially improving weather and air quality forecasts. The biomass burning plume rise module added in GEFS-Aerosols is from WRF-Chem.
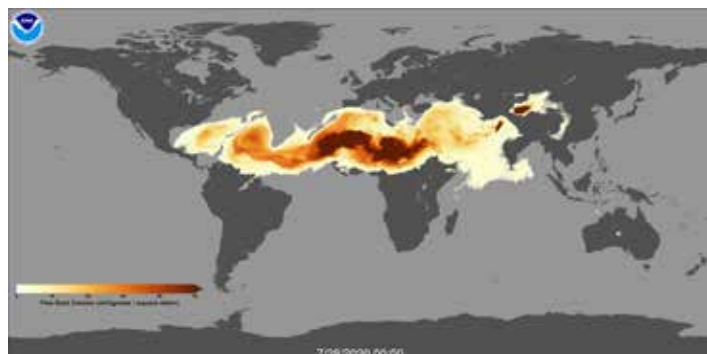
A visualization of the GEFS-Aerosols forecast of Saharan dust carried across the Atlantic Ocean by wind in 2020.
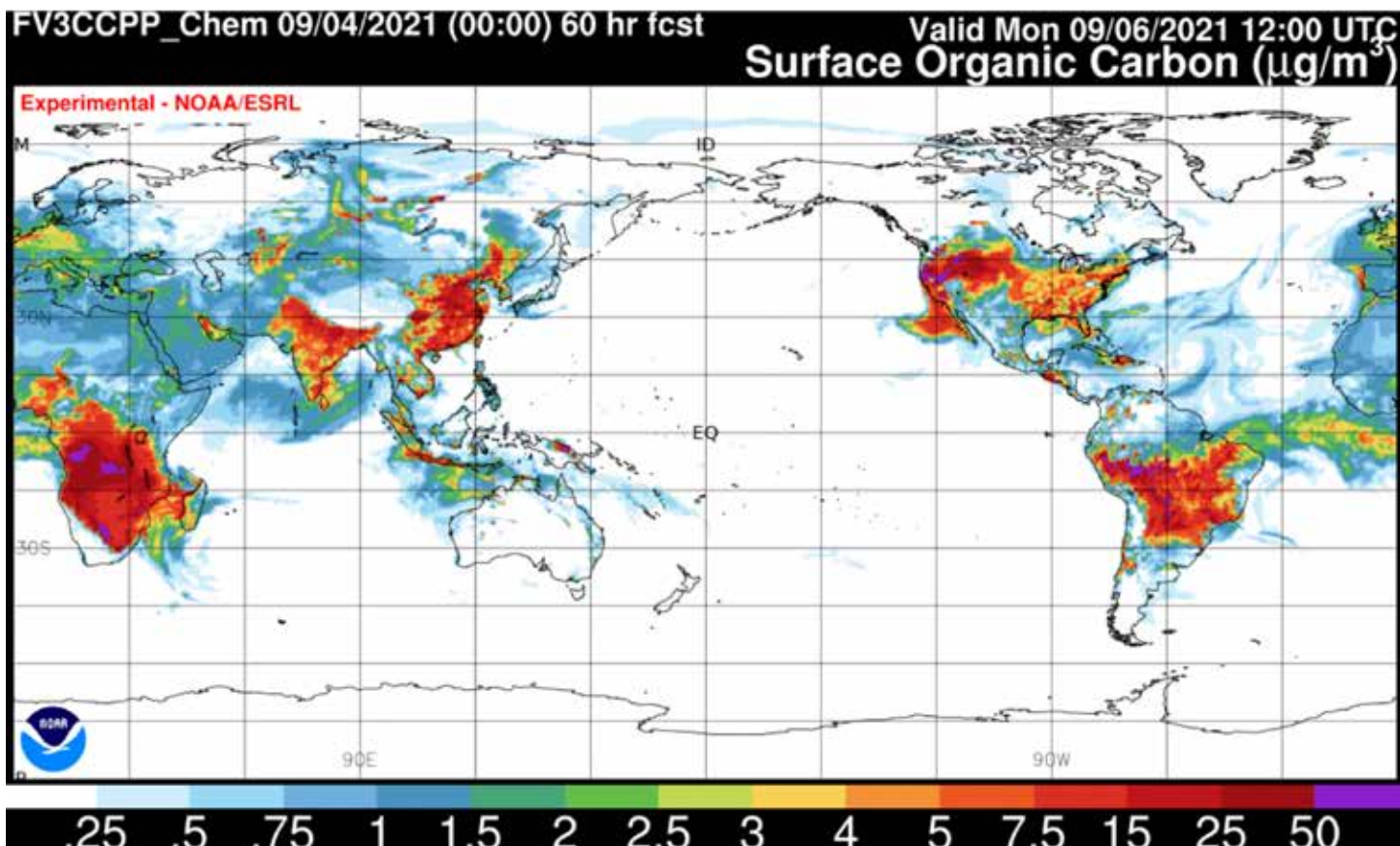
An experimental prediction of organic carbon in the atmosphere at the surface. Areas showing brighter colors identify unhealthy levels of pollution.

Applications

NOAA and other agencies use GEFS-Aerosols to make daily pollution and visibility forecasts for the US and the globe. Improved forecasts of air pollutants help the public avoid hospitalizations and premature deaths from respiratory, cardio-vascular, and neurological diseases. The FAA uses NOAA forecasts of visibility to keep aircraft flying safely by predicting ash from volcanic eruptions and smoke from wildfires. Recently it correctly forecasted the transport of US and Australian wildfire smoke plumes across the oceans and their impact on other continents. GEFS-Aerosols also helps predict the track of enormous dust plumes from the Saharan Desert that lead to persistent haze over the US.

Transitions

GEFS-Aerosols is the culmination of a successful 5-year collaboration and was transitioned into NOAA National Weather Service operations on September 23, 2020.

Metrics

GEFS-Aerosols significantly improves predictions of global aerosol composition and variability when compared with NOAA's previous global forecasts. GEFS-Aerosols has reduced biases (reduction of the global Aerosol Optical Depth bias by 61%), improved correlations (reduced Root Mean Square Error by 35%) and performs on par with other global aerosol forecasts.

Future Work

Advances made in developing GEFS-Aerosols will inform ongoing work on NOAA's next-generation operational air quality forecasts to extend predictions out to sub-seasonal and seasonal timescales. GEFS-Aerosols is a collaborative effort between NOAA's GSL, Chemical Sciences Laboratory, Air Resources Laboratory, the Environmental Modeling Center and NOAA National Environmental Satellite, Data. and Information Service.

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