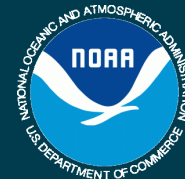# HRRR-Smoke

Research today for better forecasts tomorrow

The experimental High-Resolution Rapid Refresh-Smoke (HRRR-Smoke) is the first numerical weather prediction model in the U.S. that simulates smoke impact on surface visibility and is scheduled to be implemented into operations in 2020. HRRR-Smoke predicts how the weather could impact smoke movement and how much the smoke could reduce visibility and air temperatures.

HRRR-Smoke Facts

What does HRRR-Smoke predict?
- The 3D movement of fire-emitted fine particulate matter (PM2.5 or fire smoke)
- 3D movement of wildfire smoke
- Impact of smoke on the weather
- Impact of weather on smoke

Applications
- Identifies wildfires
- Models smoke dispersion over flat and complex terrain
- Produces visibility forecasts
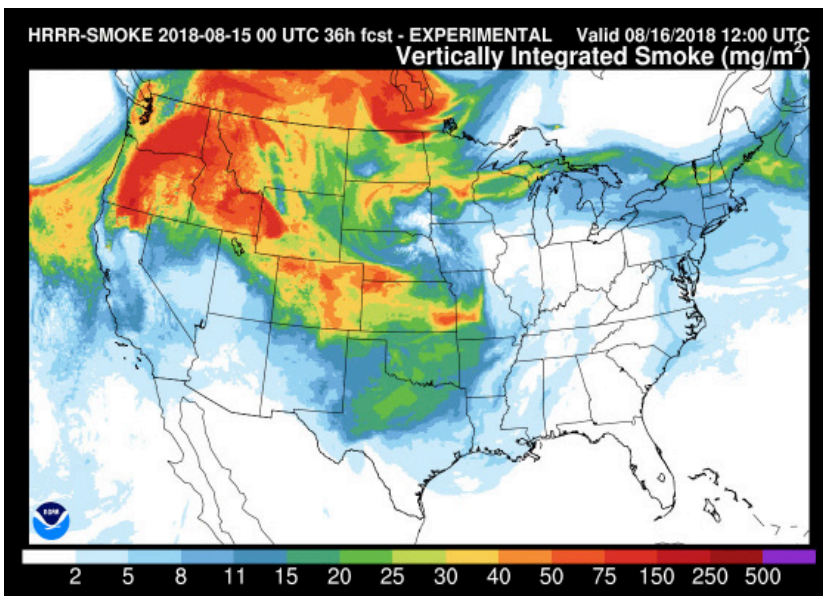- Supports air quality forecasts

Data used
- Weather data from existing NWS operational models and weather observations
- Fire Radiative Power data from NOAA and NASA polar orbiting satellites
- Biomass burning emission estimates and plume rise simulations using FRP

Resolution
- 3km horizontal grid spacing
- 50 vertical levels to about 25km
- Updated every 6 hours
- Forecast lead time is 36 hours

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GSD's HRRR-Smoke model prediction of smoke transport is often used to support air quality and visibility forecasts. This image is from August 16, 2018.

HRRR-Smoke - how does it work?

GSD's HRRR-Smoke module uses Fire Radiative Power (FRP) data from NOAA/NASA satellites. FRP is a measure of the radiant energy released by burning vegetation that is used to detect the location and intensity of wildfires. These measurements are mapped to the HRRR 3km grid and processed to calculate the size of the fires. This information is coupled with weather simulations in the model to create plots of the following:

- **Fire Radiative Power (FRP)** - Shows fire locations and intensities used as input data.
- **Near-Surface Smoke** - Predicts fire-emitted fine particulate matter concentrations at about 8 meters above the ground.
- **Vertically-Integrated Smoke** - Simulates total smoke mass within vertical columns over each model grid cell identifying smoke that may affect visibility and the weather both near the surface and aloft.
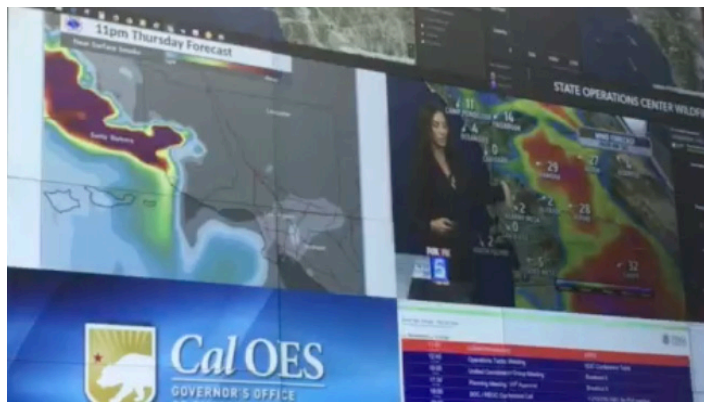
These products complement the experimental 10-meter winds, 1-hour precipitation, 2-meter temperature, and surface visibility products produced by the HRRR-Smoke model.

How HRRR-Smoke is being used

HRRR-Smoke is scheduled to be operational in 2020, but NOAA's NWS forecast offices have been sharing HRRR-Smoke images of how smoke will move downstream from the fires to alert communities sensitive to fine airborne particulates. During wildfire operations, NOAA's NWS Incident Meteorologists use HRRR-Smoke in their briefings to stakeholders including the National Park Service and state and local emergency management offices to help with fire management and aviation decisions. Local and national media outlets are sharing HRRR-Smoke forecasts to illustrate how the smoke is impacting the entire U.S.

HRRR-Smoke is on the situational awareness display at the CalOES State Operations Center.

During the historic wildfires of 2018, the California Office of Emergency Services (CalOES) State Operations Center (SOC) relied on HRRR-Smoke for its wildfire support operations. "Core partners can't be without it here at CalOES SOC," said Bill Rausch, from the NWSFO in Sacramento, CA. HRRR-Smoke model data has also been vital to the Department of Transportation partners working with AMTRAK when they decided to temporarily suspend service in the Ferguson Fire area due to poor visibility and air quality.

HRRR-Smoke and other smoke models

HRRR-Smoke simulates how the weather could impact smoke movement and how much the smoke could reduce visibility and air temperatures. The HYSPLIT model can analyze where a pollutant came from and where it could go using HRRR 3-D winds and turbulence as input. Both HRRR-Smoke and HYSPLIT complement each other to achieve NOAA's mission.

This picture of the smoke plume from the Ferguson fires near Yosemite National Park was taken from an altitude of 25,000 feet on August 5, 2018. Credit: NOAA - Kevin Kelleher

What's next for HRRR-Smoke?

Researchers have been running the experimental HRRR-Smoke in real-time since June 2016. Development will continue until it is implemented into NWS operations in 2020. HRRR-Smoke work is sponsored by the NOAA/NASA Joint Polar Satellite System Program, NOAA Earth Systems Research Laboratory Global Systems Division, FAA, Cooperative Institute for Research in Environmental Sciences (CIRES) and the Cooperative Institute for Research in Environmental Sciences (CIRA).

The NWS frequently shares images of HRRR-Smoke forecasts on social media to illustrate potential areas of concern for visibility and air quality.