High-Resolution Rapid Refresh coupled with Smoke (HRRR-Smoke) - experimental smoke forecasting model

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Recent wildfires in the western US highlight the importance of timely and accurate forecasts of air quality and visibility. It is a huge challenge to accurately forecast biomass burning (BB) emissions from rapidly changing wildland fires across the US and surrounding regions, and the transport of smoke near the surface and aloft on local and regional scales.

We present an experimental smoke forecasting system, which leverages the existing Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) numerical weather prediction models running operationally at NOAA/NWS. The RAP domain (13.5 km resolution) covers all of North America, as well as Hawaii and other regions, and a new simulation begins every hour to provide weather forecasting for the next 21-39 hours. The HRRR model is nested within RAP and runs on a very high resolution (3km) domain over CONUS. The RAP model enables simulation of smoke over Alaska, and also provide boundary conditions of smoke to the HRRR domain to account for the impact of smoke transport from Canada and Mexico into CONUS.

We implemented BB emissions and in-line plume rise simulation parameterization in the RAP/HRRR modeling system by ingesting the real-time satellite (Suomi-NPP, NOAA-20 and MODIS Aqua/Terra) fire radiative power (FRP) data. The inline smoke transport modeling structure allows us to take advantage of the RAP/HRRR meteorological input fields, which are updated by the state-of-the-art data assimilation system. Therefore, the frequently updated RAP/HRRR-Smoke system allows us to account for rapidly-changing

BB emissions and weather conditions in smoke forecasting. The rapidly updated forecast products of smoke (near surface and aloft), visibility and other related variables are provided to a wide range of operational users and researchers across the US. These forecast products are evaluated using the available ground particulate matter and satellite based (e.g. VIIRS AOD) measurements for case studies. Here, we discuss some case studies related to smoke transport over complex terrain in the western US, and long-range transport of smoke in the free troposphere. Finally, the use of a coupled meteorology-smoke modeling framework extends our forecasting capabilities further by enabling smoke feedback on meteorological processes. This could help to improve weather forecasting in the future.