The Impact of New BlueSky Smoke Emission on the NWS Operational HYSPLIT smoke Forecasting

Ho-Chun Huang, Susan O’Neil, Barbara Stunder, Perry Shafran, Jeff McQueen, Mark Ruminiski, Shobha Kondragunta
Jerry Gorline, Jianping Huang, Ariel Stein, Robert Solomon, Ivanka Staurner, Srikheya Upadhyay, Narasimhan Larkin

1. M. Systems Group, Inc. 2. NOAA NWS/National Centers for Environmental Prediction 3. US Forest Service, PWX Research Station 4. NOAA Air Resources Laboratory (ARL) 5. NOAA National Environmental Satellite, Data, and Information Service (NESDIS) 6. NOAA Meteorological Development Laboratory (MDL) 7. NOAA NWS/Office of Science and Technology Integration 7. Syneren Technologies

NWS/HYSPLIT Smoke Forecasting System

The particulates matter (PM) generated from forest fires often severely impact the air quality and human health in the nearby and downstream areas. Wildfires occur randomly and the intensity and location of fire can change with time. It is extremely difficult to model the fire smoke particulate both in spatial and temporal scale.

The National Weather Service uses the HYSPLIT smoke forecasting system (NWS/HYSPLIT smoke) to forecast the smoke concentration resulting from fire (Figure 1). It consists of the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) Hazard Mapping System (HMS) fire and smoke detection system, the emission module of the US Forest Service BlueSky Smoke Modeling Framework (BlueSky), and The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model.

NWS/HYSPLIT smoke is in operational production since 2007. Since then it has been updated regularly to include more advance scientific findings and newly available tools. The latest update (in progress) is the newer version of the BlueSky.

In this study, we will examine the impact of updated BlueSky smoke emissions module on the NWS/HYSPLIT smoke.

Model Components

- **HYSPLIT** is used to calculate the transport, dispersion, and deposition of the emitted fire smoke PM (http://www.arl.noaa.gov/HYSPLIT_info.php). A fix number of particle (a computational mass representing a pollutant) is used to track smoke dispersion that are moved by the mean wind field and spread by a turbulent component.

- The NOAA NESDIS’s HMS fire and smoke detection system (http://www.ospo.noaa.gov/Products/land/hms.html) provides the locations and extents of fires. Experienced analysts inspect satellite imagery (two GOES, five NOAA-AVHRR and NASA EOS Aqua and Terra), identify the location, size and duration of smoke emissions.

- The emissions module of BlueSky (http://www.airfire.org/bluesky) provides the PM emissions and heat from fire smokes based on HMS’s fire locations. In addition, the BlueSky also provides fire gases and PM information to the National Air Quality Forecasting HMS (NAQFC) that uses the Community Multiscale Air Quality (CMAQ) to provide air quality guidance available to state and local air quality forecasters for their daily operation.

**NWS/HYSPLIT smoke** is being updated to use a newer version (v3.5.1) of the BlueSky. The updated BlueSky incorporates the Fuel Characterization System (FCCS) and the Multiscale Air Quality (CMAQ) to provide air quality guidance available to state and local air quality forecasters for their daily operation.

The updated BlueSky also uses an improved fuel consumption model and fire emission production system (FEPS). Current operational BlueSky does not have explicit fuel load map for Alaska region. It uses default fuel load type “Quartz Complex” based on historical Quartz Complex fire in Canada.

The updated BlueSky provides an explicit description of fuel load in Alaska (Table 1). Combined with more fuel load categories and updated emission processing, figure 2 shows the comparison of PM25 emission rates of the fires listed in Table 1 between using operational and updated BlueSky. The explicit fuel load type used by updated BlueSky leads to more realistic PM25 emissions than a single default fuel load type used by the operational BlueSky, i.e., a more heterogeneous strength of fire.

The results of NWS/HYSPLIT smoke simulations on June 26 2015 show a larger column mean smoke PM25 concentration from using updated BlueSky than operational BlueSky (figure 3).

![Figure 1: The Flow Chart of NWS/HYSPLIT smoke forecast](image1)

![Figure 2: The PM25 smoke emission rate for operational BlueSky (PROD) and updated BlueSky (EMC DEV) for selected fires in Table 1](image2)

![Figure 3: The Column mean (1-5000m) PM25 smoke concentration for HYSPLIT smoke with (a) operational BlueSky and (b) updated BlueSky at forecast hours 12 valid on 18Z August 26 2015, respectively.](image3)

![Figure 4: The Canadian fire smoke impacts on the US air quality on June 3. Both NOAA/NESDIS HMS expert analysis (a) and GOES RGB image (b) indicate the smoke plume has been transported from Canada to the upper Midwest and Northeast US (courtesy of Mark Ruminiski). Both operational NWS/HYSPLIT smoke (PROD) and updated BlueSky (EMC DEV) c and f) agree well with the observations and expert analysis both for the column (1-5000m; c and d) and surface layer (0-100m; e and f) mean PM25 concentration. NWS/HYSPLIT smoke with updated BlueSky leads to higher smoke concentration in the US than that of operational NWS/HYSPLIT smoke.](image4)

![Figure 5: Similar to figure 3 except for June 30 2015, but a much stronger smoke intrusion case.](image5)

![Figure 6: The performance verification of NWS/HYSPLIT smoke forecasting over the CONUS using operational (PROD) and updated (EMC DEV) BlueSky (b) is the critical successful index (CSI) of various thresholds over the simulation period. Figures 6b-6c show the daily CSI score of threshold > 1 μg/m³ for 1st and 2nd day forecasts, respectively.](image6)

![Figure 6a: The Column mean (1-5000m) PM25 smoke concentration for HYSPLIT smoke with (a) operational BlueSky and (b) updated BlueSky at forecast hours 12 valid on 18Z August 26 2015, respectively.](image7)

![Figure 6b: The critical successful index (CSI) of various thresholds over the simulation period.](image8)

![Figure 6c: The daily CSI score of threshold > 1 μg/m³ for 1st and 2nd day forecasts, respectively.](image9)