Updates to the HYSPLIT Plume Predictions
Effective 15 July 2013

Synopsis of Changes

- Modifications to the pollutant wet removal processes: spatial interpolation of precipitation field was turned off and both rain and clouds are now required to be in the same grid cell for wet scavenging to occur. This change was prompted by the need to account for differences between the meteorological model's instantaneous transport fields and the time accumulated precipitation fields. In addition, the wet removal coefficients, for both in-cloud and below-cloud scavenging were substantially reduced. These changes were tested and compared with air concentration observations from the Fukushima accident and the changes resulted in the elimination of a factor of ten under-prediction. Changes to the wet removal process may affect all HYSPLIT applications.

- Modifications to the dispersion equations: the equation for the horizontal puff dispersion rate was modified to be more consistent with 3-dimensional particle dispersion. The original puff growth equation contained an extraneous square root of two; hence the horizontal puff growth rate was 1.4 times larger than the 3-D particle growth rate. Both are derived from the same horizontal turbulence coefficient. The smaller puff growth rate should results in slightly higher concentration levels for those simulations that use the horizontal puff assumptions (smoke simulations and certain emergency response applications). In addition, the default vertical mixing parameterization, how the stability profile is converted to a turbulent velocity, was changed to a different set of equations. Testing of the new vertical turbulence parameterization by comparing the model results against several different experiment data showed a marked improvement in model performance. Interactive testing of HYSPLIT against various experiments using different model parameterizations is available from the Air Resources Laboratory web site at http://www.ready.noaa.gov/HYSPLIT_datem.php.

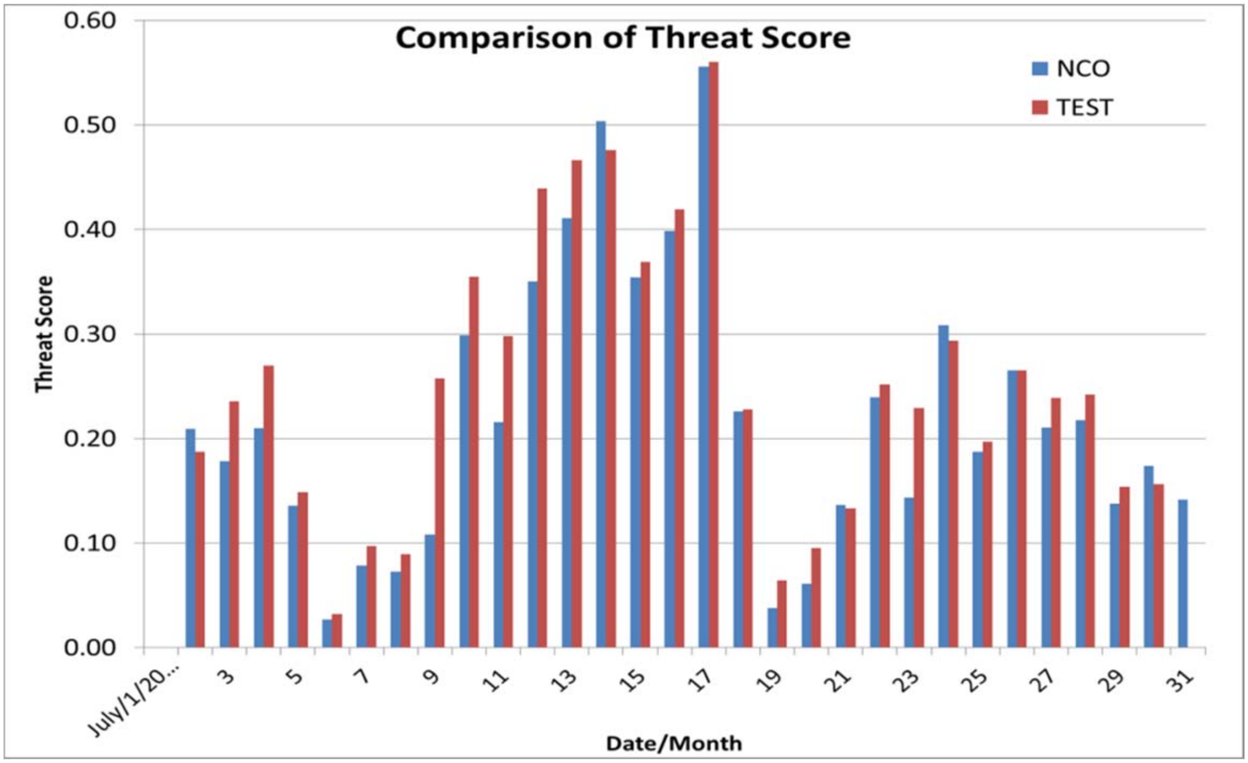
- Treatment of fires for the smoke simulations: based upon extensive testing and comparison with observational data the maximum plume rise limits were relaxed from 0.75 of the PBL depth to 1.25 of the PBL depth. In addition, non-continuous fire emissions in Central America (south of 23^{o}N), such as from prescribed burns were permitted to start up again each day into the 48 hour forecast period. The treatment of non-continuous fires in the CONUS remains unchanged in that they are not included in the forecast period. This modification was prompted by an extensive analysis of repeating fire locations by NESDIS, which showed that CONUS non-continuous fires were more likely to be in a different location the next day than those in Central America. The treatment of continuous fires also remains unchanged, in that they continue to burn into the forecast period.

- There were no explicit changes to the dust forecast except as previously noted to the internal HYSPLIT model physics related to mixing and wet scavenging which applies equally to all applications.

The Smoke Forecast Description

The National Oceanic and Atmospheric Administration's (NOAA) current operational Smoke Forecasting System (SFS) is intended to provide guidance to air quality forecasters and the public for fine particulate matter (<2.5 μm) emitted from large wildfires and agricultural burning, which can elevate particulate concentrations to unhealthful levels. The SFS uses the National Environmental Satellite, Data, and Information Service (NESDIS) Hazard Mapping System (HMS), which is based on satellite imagery, to establish the locations and extents of the fires. The particulate matter emission rate is computed using the emission processing portion of the U.S. Forest Service's BlueSky Framework, which includes a fuel-type database, as well as consumption and emissions models. The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model is used to calculate the transport, dispersion, and deposition of the emitted particulate matter. The current SFS system has been described in detail by Rolph et al. (2009). Subsequently, a more detailed investigation into several case studies using in-situ measurements and satellite data was conducted by Stein et al. (2009). Four multiday forest fire case studies, one covering the continental United States, two in California, and one near the Georgia–Florida border, have been analyzed and not surprisingly, it was found that the model's capability to accurately represent the measured values is highly dependent on the determination of the actual injection height and in particular to whether the smoke injection actually occurred below or above the planetary boundary layer. Further evaluation of these and other case studies suggested that a simple change to the plume rise algorithm would improve the prediction of western U.S. fires, those in more mountainous regions. The plume rise calculation based upon the fire heat release rate was modified to relax the plume rise restriction from 0.75 to 1.25 of the boundary layer (BL) depth during neutral or unstable conditions. This means that in the new SFS version, smoke released during the day may now rise about the boundary layer top. Restrictions during stable conditions remain unchanged (rise limit < 2 x BL depth).

Because of the more numerous changes to the smoke forecast system, more extensive testing was conducted of the changes between the original or upgraded model. Verification of smoke predictions against GOES smoke retrievals were conducted for July 2012. The threat score (area correct divided by the sum of the forecast and observed areas minus the area correct) for the current operational run (NCO – blue) and the new upgraded code (test – red) is shown in the illustration below. The differences between the two simulations are typically 0.05 or less and certainly less than the day-to-day variability which can be as much as 0.10. Although not particularly significant show that the upgraded code has a higher threat score on 24 out of the 30 days in the test period.



References

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