NWS HYSPLIT atmospheric transport and dispersion modeling

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Understanding and predicting atmospheric transport and dispersion is essential for protecting the health and welfare of the public and emergency response personnel when harmful substances are released into the air in significant quantities. The Federal National Response Framework, approved by the President in January, 2008, assigns to NOAA the responsibility for atmospheric transport and dispersion (ATD) prediction of smoke and radioactive and hazardous materials, maintenance and development of the Hybrid Single Particle Lagrangian Integrated Trajectory model (HYSPLIT) and coordination with the World Meteorological Organization (WMO) on international incidents. NOAA's Air Resources Laboratory (ARL) develops many of NOAA's capabilities for these services.

Needs for ATD or "plume" understanding and tools are continually evolving, driven by demands for more accurate predictions, estimates of uncertainties, finer spatial resolution, easier-to-use tools, and tools to address evolving risks. For instance, in 2008 the GAO[1] recommended that the Secretary of Homeland Security "work with the federal plume modeling community to accelerate research and development to address plume model deficiencies in urban areas and improve federal modeling and assessment capabilities. Such efforts should include improvements to meteorological information, plume models, and data sets to evaluate plume models." NCEP works with ARL's research and development (R&D) to address each of these areas within the HYSPLIT dispersion modeling system.

Currently, the HYSPLIT system is used to provide the following operational atmospheric dispersion products:

- 48-hour wild-fire smoke forecasts from the daily 06 UTC cycle for CONUS, Alaska, and Hawaii driven by the 12 km North American Model (NAM).
- 48-hour dust forecasts from 06 and 12 UTC cycles for CONUS.
- 48-hour volcanic ash forecasts whenever requested by the International Civil Aviation Organization (ICAO)-designated U.S Volcanic Ash Advisory Centers (Washington, DC and Anchorage, AK). This is typically GFS-driven, although other model output can be used.
- 72-hour radiological emergency response plume forecast when requested per the WMO-designated Regional Specialize Meteorological Center (RSMC) arrangements (IAEA or another nation's NMS). This is typically GFS- driven, although other model output can be used.
- 16-hour dispersion forecast for HAZMAT-type (chemical spill, explosion, etc.) incident upon the request of a Weather Forecast Office (WFO), almost always driven by 12-km NAM, though other model output can be used.
- 16-hour dispersion forecasts for HAZMAT-type incidents, driven by 12 km NAM, for about 25 locations run four times a day to support WFOs ("canned" runs).
- 48-hour back-tracking product when requested per the WMO/RSMC arrangements. This is typically GFS-driven, although the NAM can be used.
- HYSPLIT-formatted meteorology files created for input to the above dispersion applications.
  - GFS (1 degree, pressure-level), GDAS (1 degree, pressure-level), NAM (hybrid-level: CONUS, Alaska, Hawaii nest, fire weather nest CONUS nest; and pressure-level: CONUS), and Rapid Analysis and Prediction system (RAP: 20 km, pressure-level).
- HYSPLIT-formatted meteorology files disseminated to ftpprd.ncep.noaa.gov, where they are

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[1]GAO, 2008. First Responders' Ability to Detect and Model Hazardous Releases in Urban Areas is Significantly Limited. GAO-08-180 Homeland Security.

- o Automatically retrieved by the Web Operations Center to operationally support the web-based HYSPLIT interface for NWS WFO (https://www.hysplit.noaa.gov).
- o Automatically retrieved by ARL to support
  - a test of HYSPLIT trajectories-by-email for the NWS Fire Weather program,
  - customers on the ARL REal-time Access and Display sYstem (READY) website (http://ready.arl.noaa.gov/).

For all applications, dispersion is simulated using either the multi- or single-processor version of the same code. The smoke and dust forecast guidance is sent in gridded form to the NOAA/MDL (Model Diagnostics Laboratory) National Display and Graphics System (NDGD) for distribution to forecasters and emergency managers at the individual state level.

RSMC predictions are initiated by the NCEP/SDM (Senior Duty Meteorologist) and distributed to National Forecast Centers via fax. Digital and graphical products are also shared between other nations' RSMCs through a protected ARL (non-operational) web page. Monthly exercises are performed by the SDM with other RSMCs.

The volcanic ash predictions are initiated by NCEP, NESDIS/SAB (Synoptic Analysis Branch), or NWS AAWU (Alaska Aviation Weather Unit) and distributed via World Area Forecast System (WAFS) and made available over the Internet operationally at the Aviation Weather Center (AWC) and non-operationally at ARL and SAB.

The HAZMAT-type output is made available on a secure NCEP server (https://hysplit.ncep.noaa.gov/). NCEP/AWC is able to initiate a HAZMAT-type model run.

In 2016, HYSPLIT was improved to meet the NCEP requirements for volcanic ash product dissemination and NOAA requirements for back-tracking support to the Comprehensive Test Ban Treaty Organization (CTBTO). Improvements were accomplished mainly by upgrading the wet deposition scheme for radiological materials and volcanic ash. The success of the implementation is measured both for quality and timeliness. The threat score should be predicted 0.08 for the 24 hour averaged smoke forecast. Volcanic ash forecasts will be evaluated against satellite derived ash plumes. The ARL DATEM (Data Analysis of Tracer Experiments and Meteorology) database of previous dispersion field experiments is used for RSMC, HAZMAT-type prediction verification.