HYSPLIT Chemical Applications and Emergency Response

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Chemical Applications and Emergency Response

- The accidental or intentional release of chemical, biological, or nuclear agents can have significant health, safety, national security, economic, and ecological implications.
- We want to understand and predict how, where, and when harmful materials are atmospherically transported and deposited.

Operational NWS HYSPLIT web application

• Used by the Weather Forecasting Offices at the National Weather Service (NWS) for local emergency response.

READY web applications

- Widely used by regulatory and scientific communities.
- We will highlight major enhancements and future plans in this presentation.







Relevance to OAR Strategic Goals

Make Forecasts Better

Design tools and processes to forecast highimpact weather, water, climate, ocean, and ecosystem events

-- OAR Strategy 2020-2026

Transition science that meets users' current and future needs

-- OAR Strategy 2020-2026

Improve weather & climate predictions by increasing our understanding of Planetary Boundary Layer (PBL) processes

-- OAR Implementation Plan 2021-2026



HYSPLIT plume forecast for the April 25, 2019, chemical-spill incident involving ammonia in Chicago



HYSPLIT for NWS Weather Forecast Offices

- Available to NWS Weather Forecast Offices (WFOs) starting in 2007
- Trajectory simulations (forward and backward)
- Dispersion simulations
 - Generic: includes prescribed burns and wildfires.
 - Chemical: integrated in 2013 with CAMEO-ALOHA scenario-based source model from NOAA National Ocean Service (NOS), Office of Response and Restoration (OR&R)
 - Radiological multi-species: for small-scale nuclear accidents^{*}
 - Nuclear: for catastrophic failure of a nuclear power plant*

* in addition to ARL's activities in support of the Washington Regional Specialized Meteorological Center (RSMC).



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Ensemble Forecasts for NWS HYSPLIT

Ensemble forecast (2021) – under testing:

- Based on NOAA's High Resolution Ensemble Forecast (HREF) product.
- HREF has ten ensemble members \rightarrow Ten HYSPLIT runs.
- Results from ten runs are combined for probabilistic forecast.



Using Drone data in NWS HYSPLIT Forecasts

Drone data use (2021) – under testing:

- In collaboration with Weather Forecast Office Morristown, TN
- Weather forecast data used by NWS HYSPLIT have ~3 km resolution
- Drone measurements can provide accurate local weather data
- We built an automated data ingest and assimilation system using Apache NiFi:
 - Periodically checks an ftp site for new data files to download them.
 - O Downloaded files are automatically converted into the HYSPLIT format.
 - O Conversions using HRRR, NAM, etc. and assimilation into WRF \rightarrow 5 simulation choices



NWS-HYSPLIT migrated to the Cloud

Cloud migration (2021):

- In collaboration with NOAA Web Operations Center (WOC)
- Mitigates risk of hardware failures of aging on-premise servers
- *Lift-and-shift* migration:
 - Applications and weather forecast data ingest One of the most complicated migrations that WOC performed.
 - Performed thorough installation tests after provisioning 3 servers.
- Cutover to cloud in July 2021
- Established and documented a *semi-automated installation process*
 - Ansible playbooks and shell scripts to minimize manual execution of commands.
- Standing up a new server on the cloud takes a couple of hours, not months!



Additional NWS HYSPLIT Enhancements

- 2020 Convert full or partial address to location
 No need to find lat-long → reduces data entry time
- **2020** Satellite imagery to locate oil/chemical tanks
 - No need to find lat-long \rightarrow reduces data entry time
- 2020 Local time instead of UTC time in graphical outputsEmergency responders do not need to convert time
- 2019 Chemical plant database for quick pick of source location
 No need to find lat-long → reduces data entry time
- 2018 Mapping routines changed from Flash to Leaflet
- 2017 Increased NAM CONUS 4km Nest to 48 hours of forecast data





+ Ongoing talks with NWS about new potential enhancements, e.g., simulate in situ oil burns



WFO's use NWS HYSPLIT for emergency response





Real-time Environmental Applications and Display System (READY)

- Continuous development since 1997
- Allows users to access and display meteorological data and run HYSPLIT on ARL's web server.
- Backup and Portal for numerous emergency response applications, with differing access depending on level of authorization





Real-time Environmental Applications and Display System (READY)

A wide range of meteorological and modeling services







READY is Extensively Used



- Graph at left shows just the yearly on-line HYSPLIT simulations
- ... and many additional online uses for examining meteorological data
- ... and many more simulations carried out by users after downloading and installing model on their local computers

Publications



A. Stein, R. Draxler, G. Rolph, B. Stunder, M. Cohen, and F. Ngan (2015). NOAA's HYSPLIT Atmospheric Transport and Dispersion Modeling System. *Bulletin of the American Meteorological Society*, 96: 2059 doi: 10.1175/BAMS-D-14-00110.1

G. Rolph, A. Stein, and B. Stunder (2017). Real-time Environmental Applications and Display sYstem: READY. *Envr. Modelling and Software* 95: 210 doi: 10.1016/j.envsoft.2017.06.025



Future Plans

- Continue process of transitioning new capabilities to NWS HYSPLIT operations, e.g., ensemble simulations, drone data assimilation
- > Add *in-situ* oil burn capability
- Reduce technical debt, e.g., transition Perl code to Java
- Cloud friendly architecture use multiple (virtual) machines at a time for ensemble runs
- Enhance wildfire smoke forecasting system, e.g., establish testbed system







New cloud-based implementation of NWS-HYSPLIT for Weather Forecast Offices



US Government main portal: USA.gov

3/19 12:00 PM through 6:00 PM CDT Issued March 19, 2019 11:06 AM CT Smoke Footprint 19 12 00 PM the HYSPLIT forecast smoke plume dispersion (NOAA NWS) @NWSHouston weather.gov/Houstor **HYSPLIT** - 1.0E-11 1/m3 > 1.0E-12 1/m > 1.0E-13 1/m3 simulation of mum: 8.6E-10 1/m3 mum: 5.8E-19 1/m hazmat pollutant (Nov 2019).

Smoke Plume Footprint – Deer Park Fire

Weather Forecast Office

Houston/Galveston, T)

