Updates to Operational HYSPLIT Dispersion Predictions
Including
National Air Quality Forecast Capability

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CCB

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Outline

- Review list of HYSPLIT applications
- Scope of changes
- Expected benefits
- Science changes
- Effect of changes
- Examples of new/revised products
- Evaluator feedback and recommendation

HYSPLIT operational applications at NCEP

(what exactly is changed with this upgrade will be described later)

- Smoke
- Dust *(only application with no change)*
- "Canned" (WFO/HAZMAT/lake-effect trajectories)
- "On-demand"
  - Volcanic ash
  - Radiological (RSMC)
  - WFO/HAZMAT (backup to WOC)
- CTBTO (also on-demand, but different job)
- Volcano trajectories
- Convert NWP output to HYSPLIT-format
  - Drive applications at NCEP
  - Drive WFO applications at WOC

Scope of changes

Meteorology

- Replace half-degree GFS on hybrid-levels with quarter-degree
  - Add surface height field
  - Replace specific humidity with relative humidity
  - Note half-degree had vertical velocity prior to GFS upgrade (July 2017). Vertical velocity is computed in HYSPLIT using divergence.

- Add HRRR 3 km sigma-level (hourly cycles, hourly to 18 hours forecast)
- Remove RAP (20 km, 3-hourly cycles)

- NAM hybrid-level file - add CAPE, remove low/middle/high cloud cover (cloud cover not used in HYSPLIT)

- Remove NAM 12 km regional “tiles” (e.g. hysplit.t00z.namsf.NEtile), but the full-CONUS grid remains

Scope of changes

RSMC - Transfer RSMC web page from ARL to NCO (May be de-scoped. Waiting on NCO IDP team.)

CTBTO - parallel job instead of serial

Volcanic ash

- option to use Ganser fall velocity
- add Chiles-Cerro Negro to file listing all volcanoes
- add transfer of ASH_TABLE file to internal NCO server, to aid interpretation of graphics in NAWIPS

WFO/HAZMAT (on-demand) - option to use HRRR

Lake-effect (snow) trajectories – change starting heights

Volcano trajectories – add gifs; transfer gif, kmz, txt to ftpprd/NOMADS

Smoke – minor edit to gif graphics that go to ARL

Scope of changes

Upgrade HYSPLIT (mostly minor changes)

- to ARL SVN r856
  - Revised arl_hysplit library (many library subroutines revised, including fix for RH on hybrid-levels, but otherwise minor changes)
  - Revised executables (minor unless noted)
    - Dispersion and trajectory hycmstd, hycsstd, hytsstd
    - Post-processing gridplot, trajplot, volcplot, con2grib2 (bugfix for couple radionuclides, not Bug 642-Cobalt), concrop (Bug 593),
    - CTBTO con2asc, set4ctbt (for parallel processing (MPMD))
    - Convert meteorology –
      - global2arl (horizontal gridsize)
      - nmmb2arl – add CAPE, remove low, mid, high cloud cover
  - New executable – hrrr2arl
  - Removed executables – rap2arl, xtrctgrid (remove NAM tiles)

Expected benefits

- HRRR and higher resolution GFS drivers provide opportunity for improved dispersion modeling
- Consistency of all NCEP HYSPLIT applications running the same code with improvements/corrections
- Keep up with ARL development of HYSPLIT
- Improved response time for CTBTO back-tracking application

Science changes at NCEP

- Added option for Ganser fall velocity which the New Zealand Volcanic Ash Advisory Center (VAAC) added to HYSPLIT (volcanic ash, largest particles). This option facilitates further testing by the U.S. VAACs.

- Added CAPE to nam/hysplit file for further testing of enhanced vertical mixing

- Corrected virtual temperature calculation when using meteorological datasets on hybrid levels containing RH (gfs0p25)

- Corrected time interpolation for deposition (RSMC)

Science changes

- Option for Ganser fall velocity (volcanic ash, possibly affecting largest

Small effect for NCEP because particles barely large enough to be affected

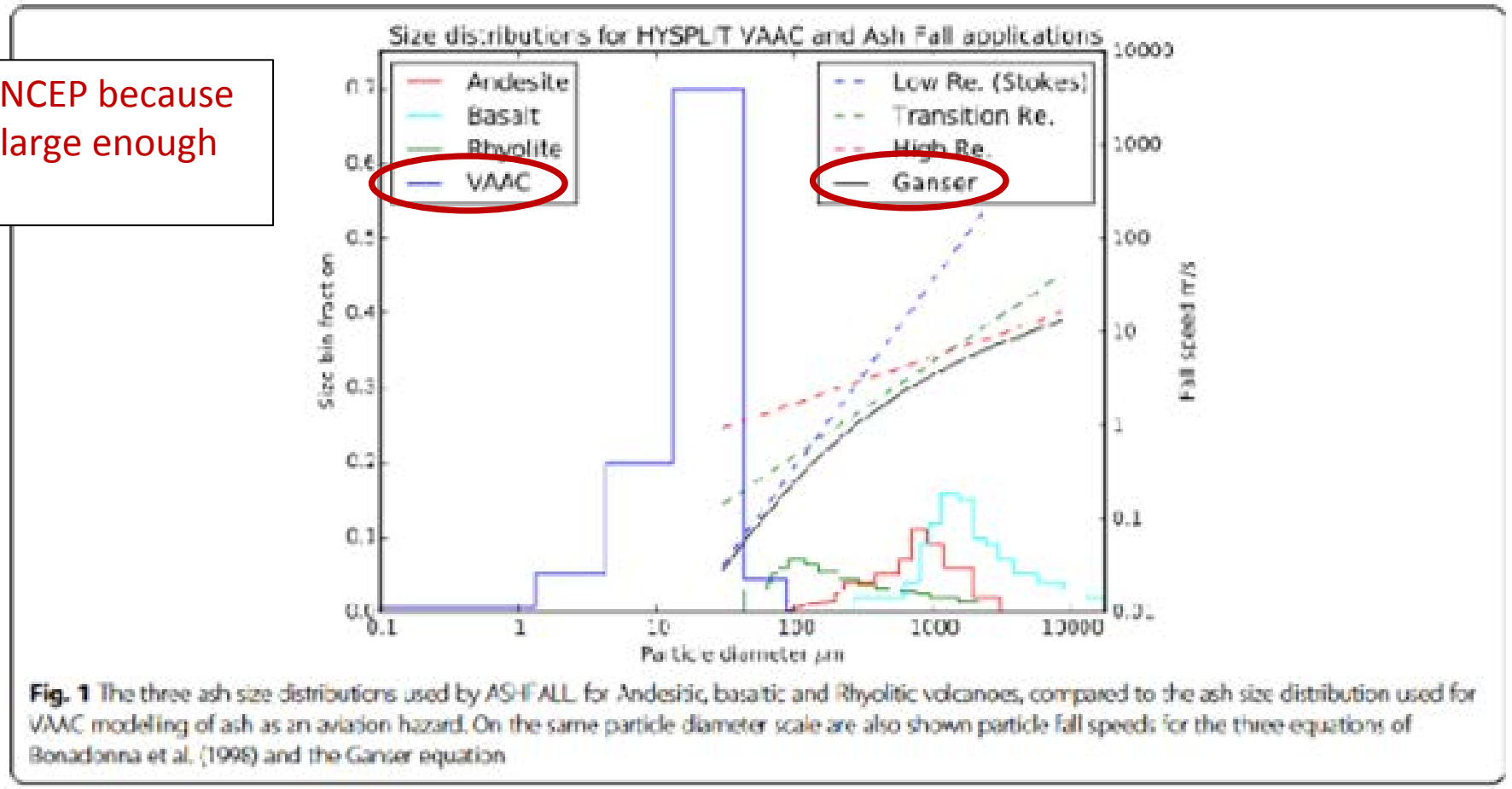


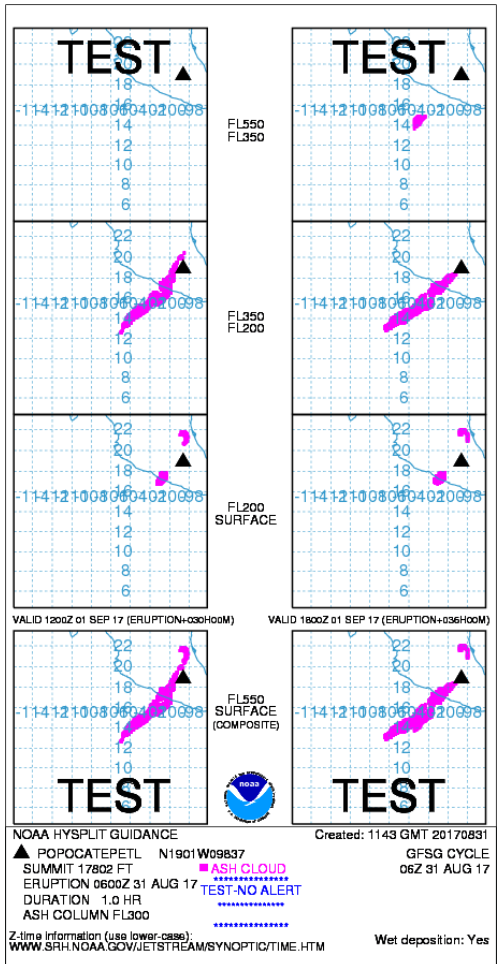
Fig. 1 The three ash size distributions used by ASH FALL for Andesitic, basaltic and Rhyolitic volcanoes, compared to the ash size distribution used for VAAC modeling of ash as an aviation hazard. On the same particle diameter scale are also shown particle fall speeds for the three equations of Bonadonna et al. (1998) and the Ganser equation

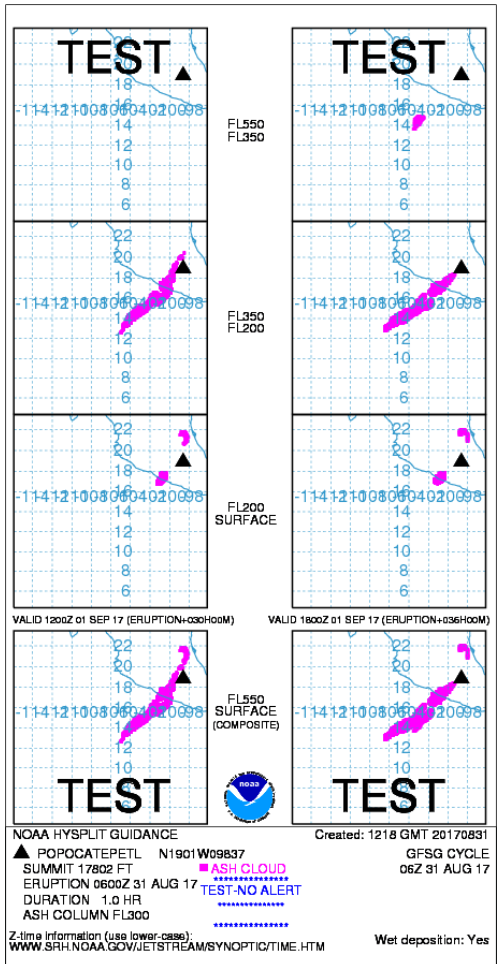
From Hurst, T., and C. Davis (2017): Forecasting volcanic ash deposition using HYSPLIT, *J. Applied Volcanology*, 6.5, DOI 10.1186/s13617-017-0056-7

Effect of science changes (trajectory and dispersion model)

- Confirmed no effect of changes in HYSPLIT dispersion due to updated main code and library
  - ARL “DATEM” (Data Archive of Tracer Experiments and Meteorology) on WCOSS with v7.5 vs. v7.4, same results/statistics
  - Individual cases – smoke, dust, volcanic ash, RSMC, canned, trajectories

Volcanic ash example



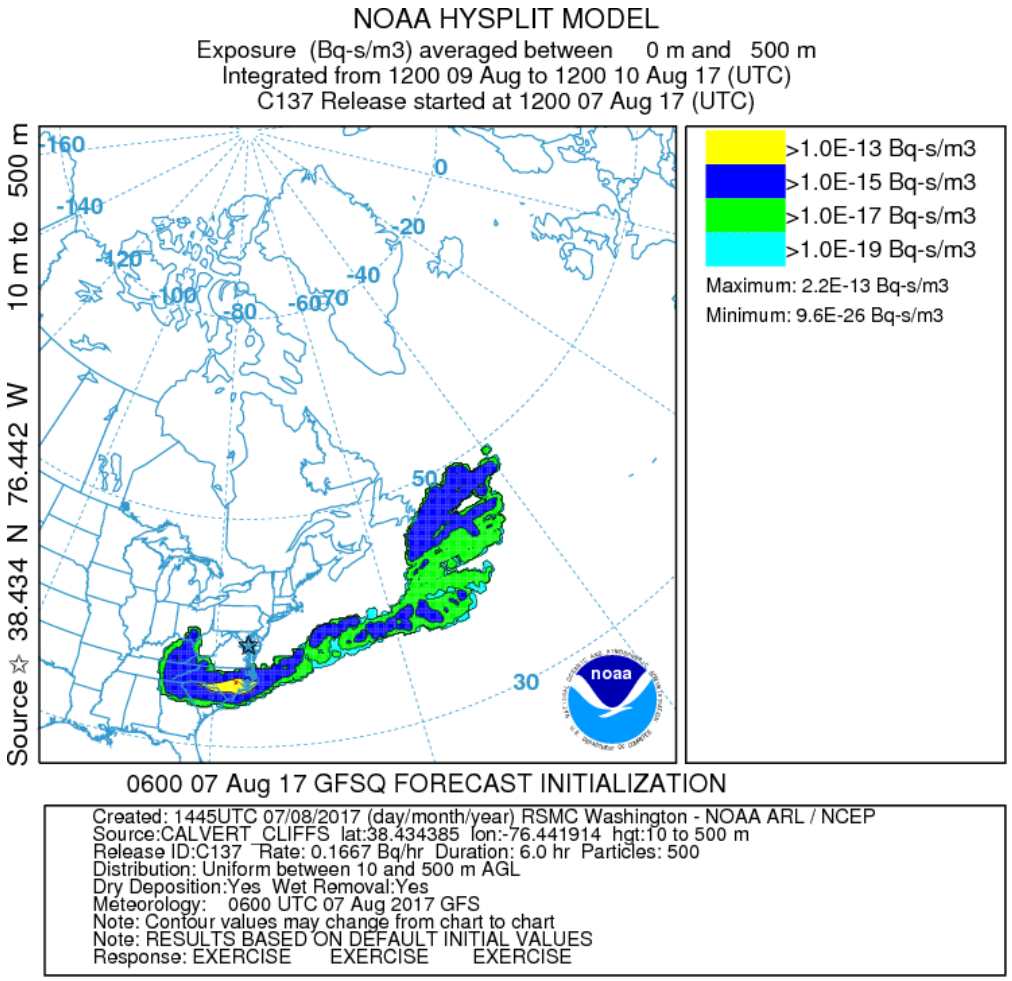


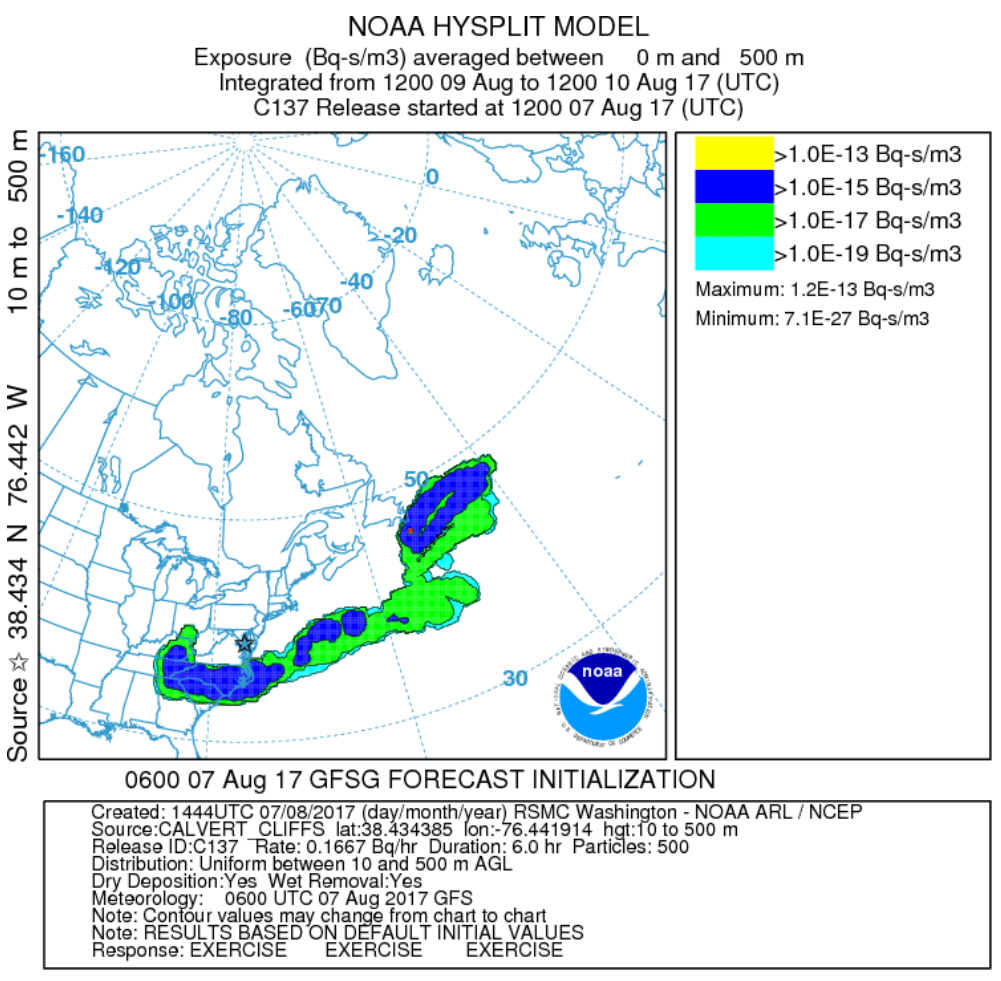
para, one-deg GFS

prod, one-deg GFS

Effect of GFS quarter- instead of half-degree (hybrid levels)

- Some reasonable differences – RSMC - exposure



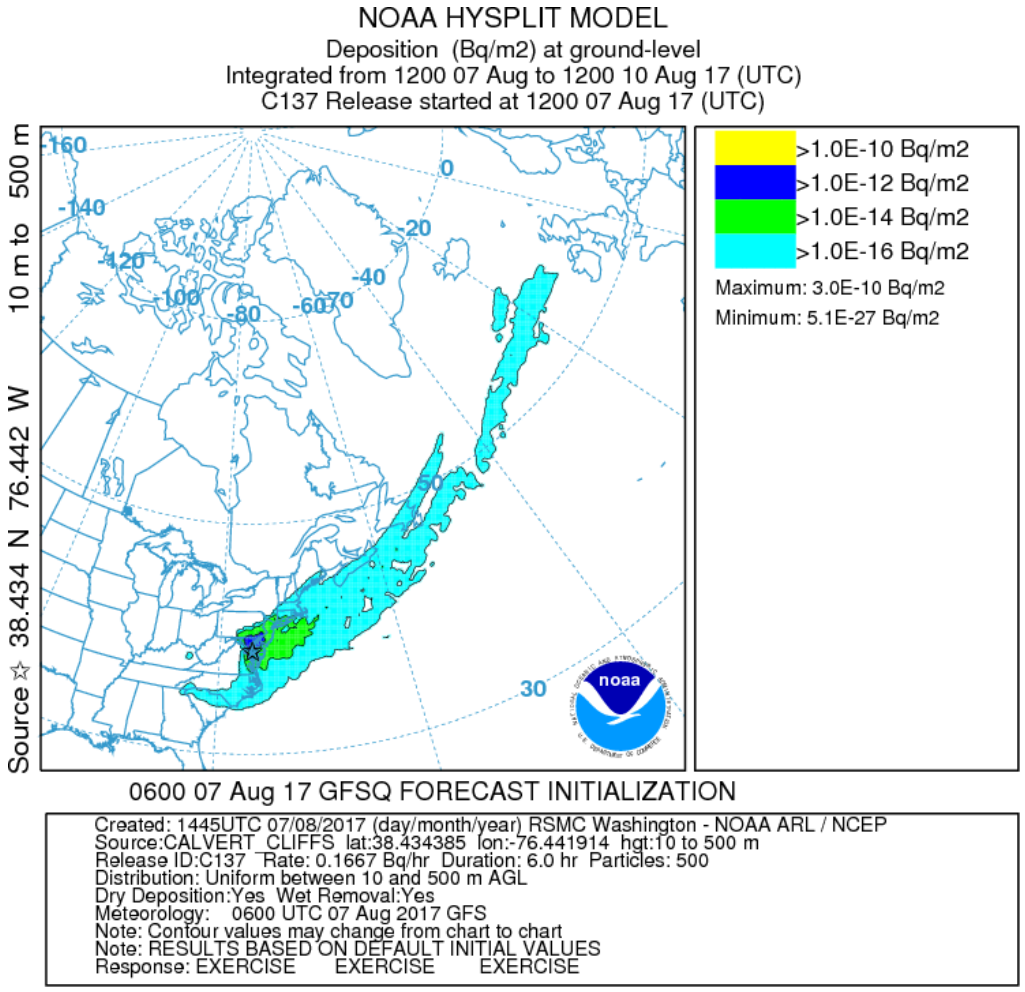


para, quarter-deg

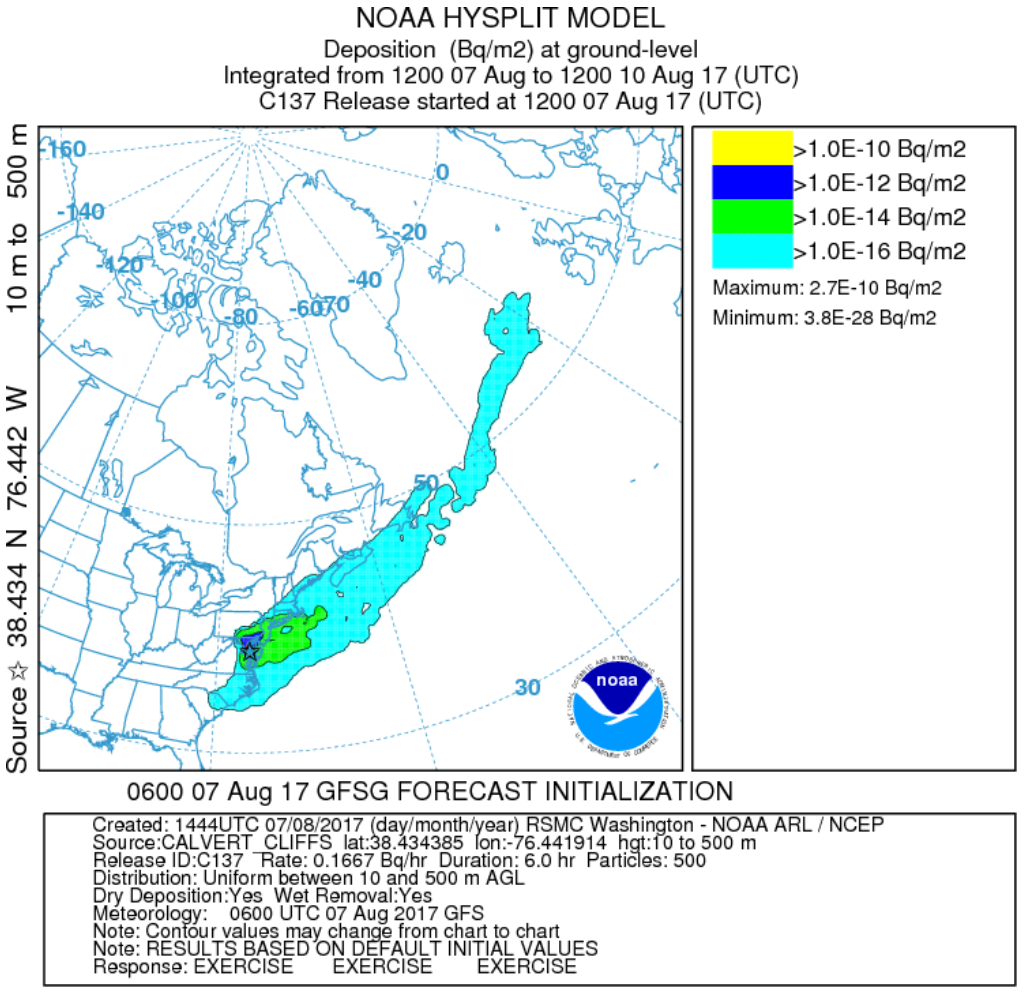
prod, half-deg

Effect of GFS quarter- instead of half-degree

- Some reasonable differences – RSMC - deposition



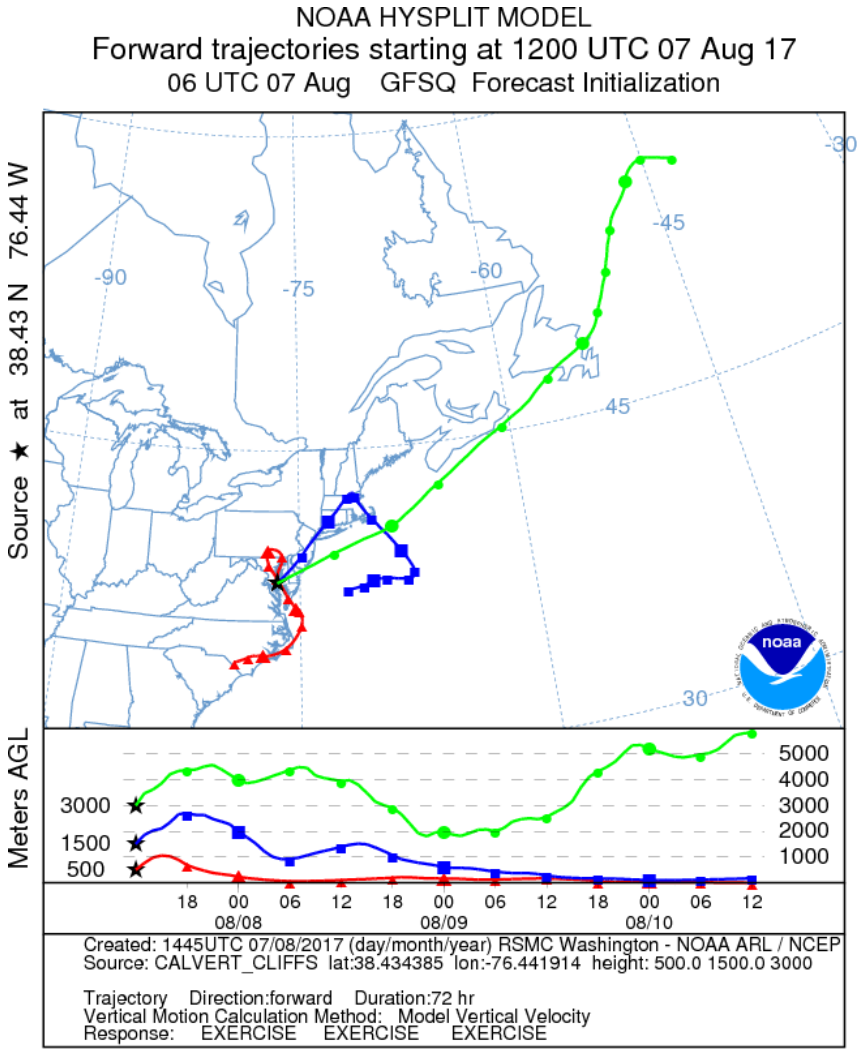
para, quarter-deg



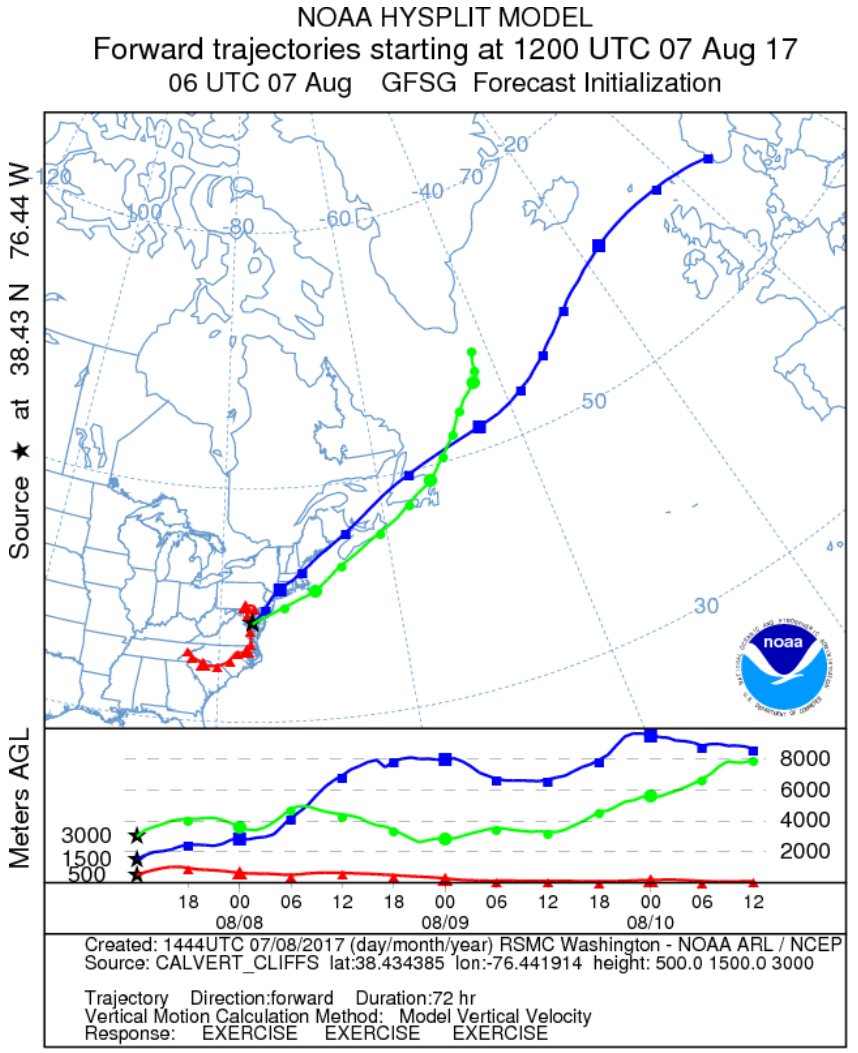
prod, half-deg

Effect of GFS quarter- instead of half-degree

- Some differences, vertical motion, wind shear for this synoptic situation – RSMC - trajectories



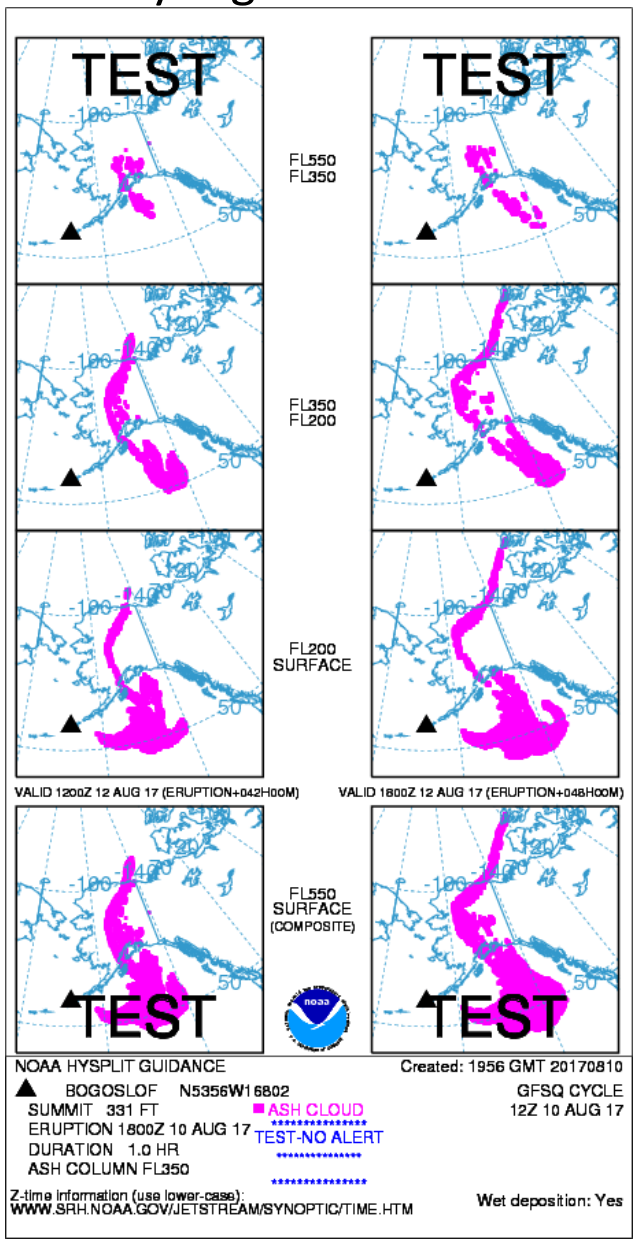
para, quarter-deg

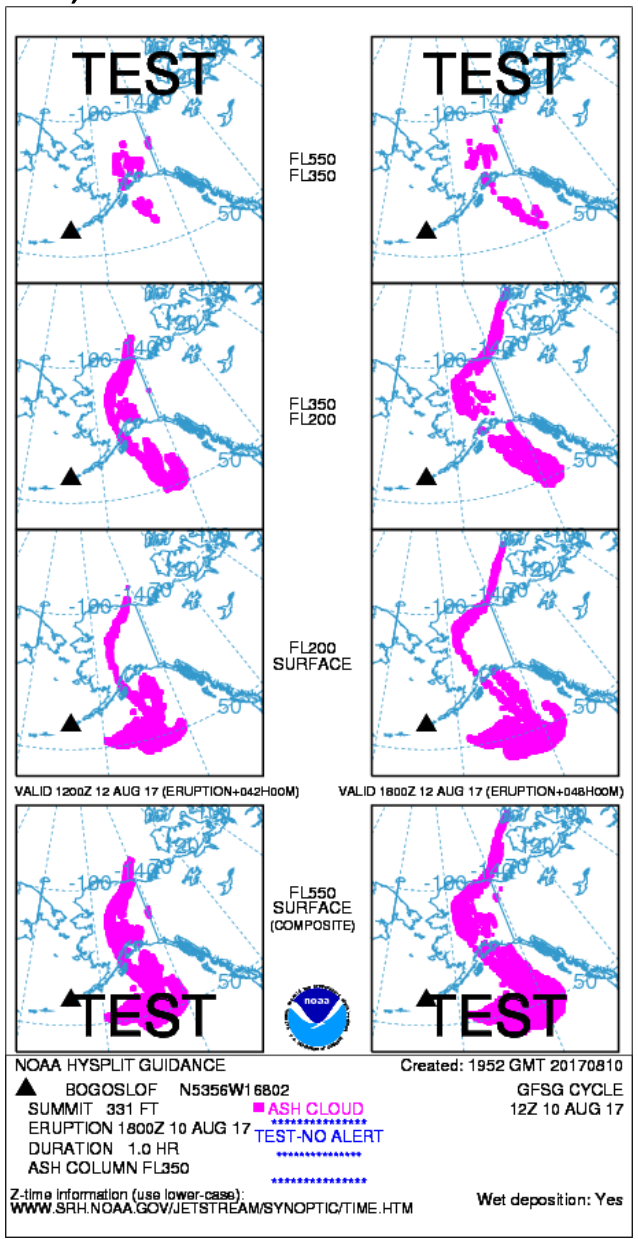


prod, half-deg

Effect of GFS quarter- instead of half-degree

- Some very slight differences here – volcanic ash, Alaska



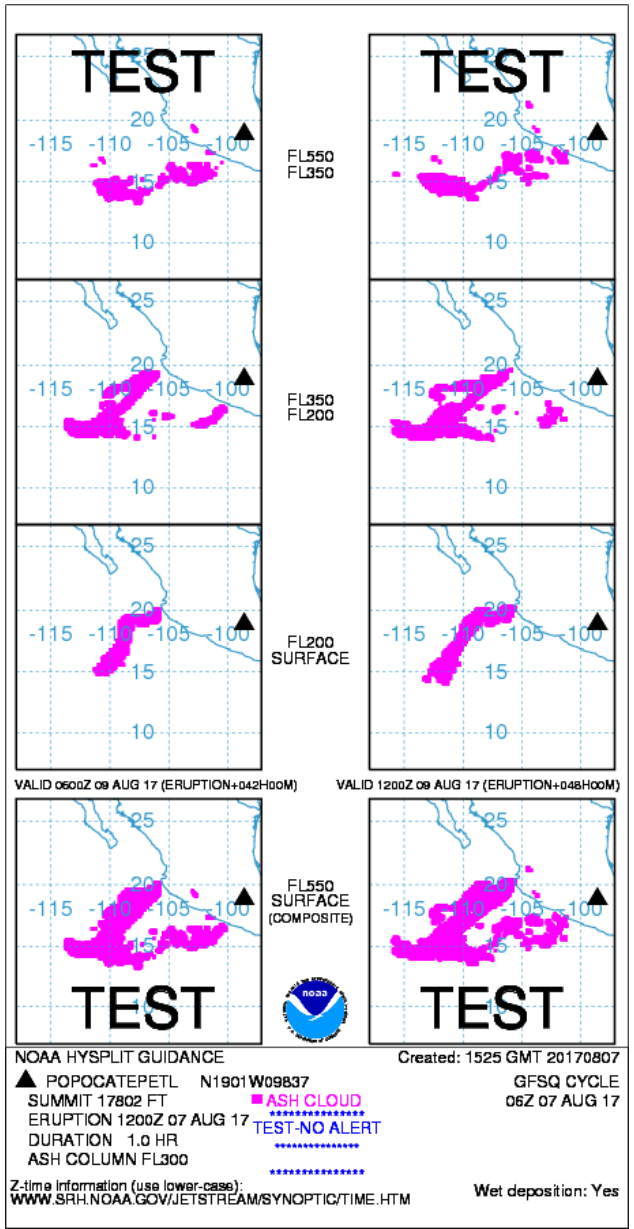


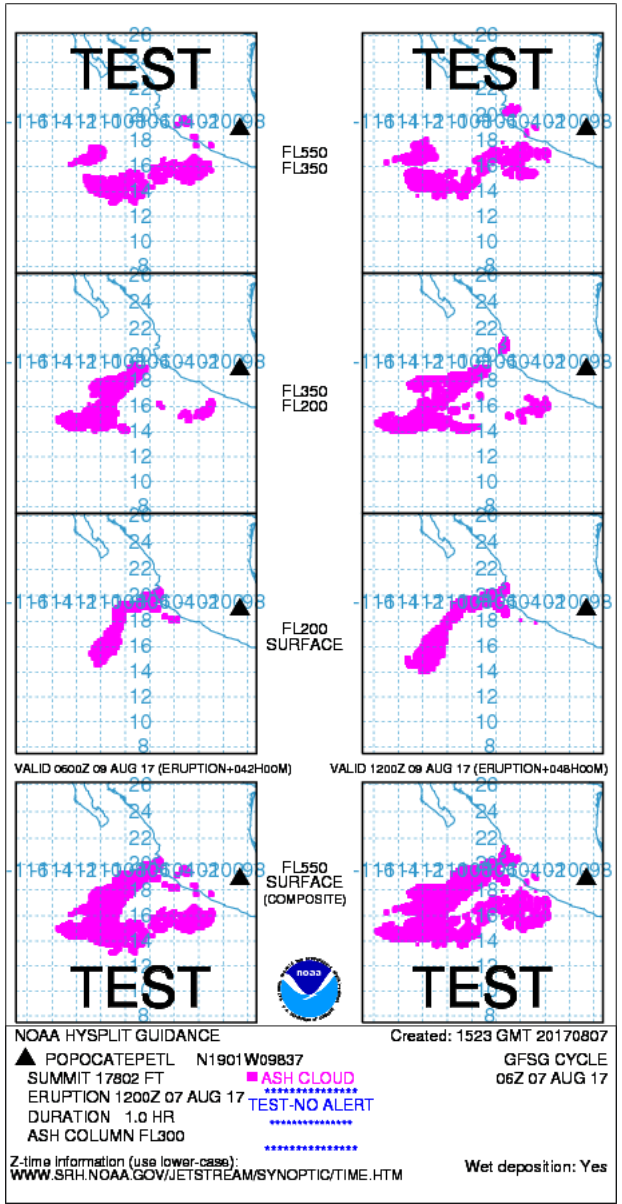
para, quarter-deg

prod, half-deg

Effect of GFS quarter- instead of half-degree

- Some differences here – volcanic ash, Mexico (Washington Volcanic Ash Advisory Center)



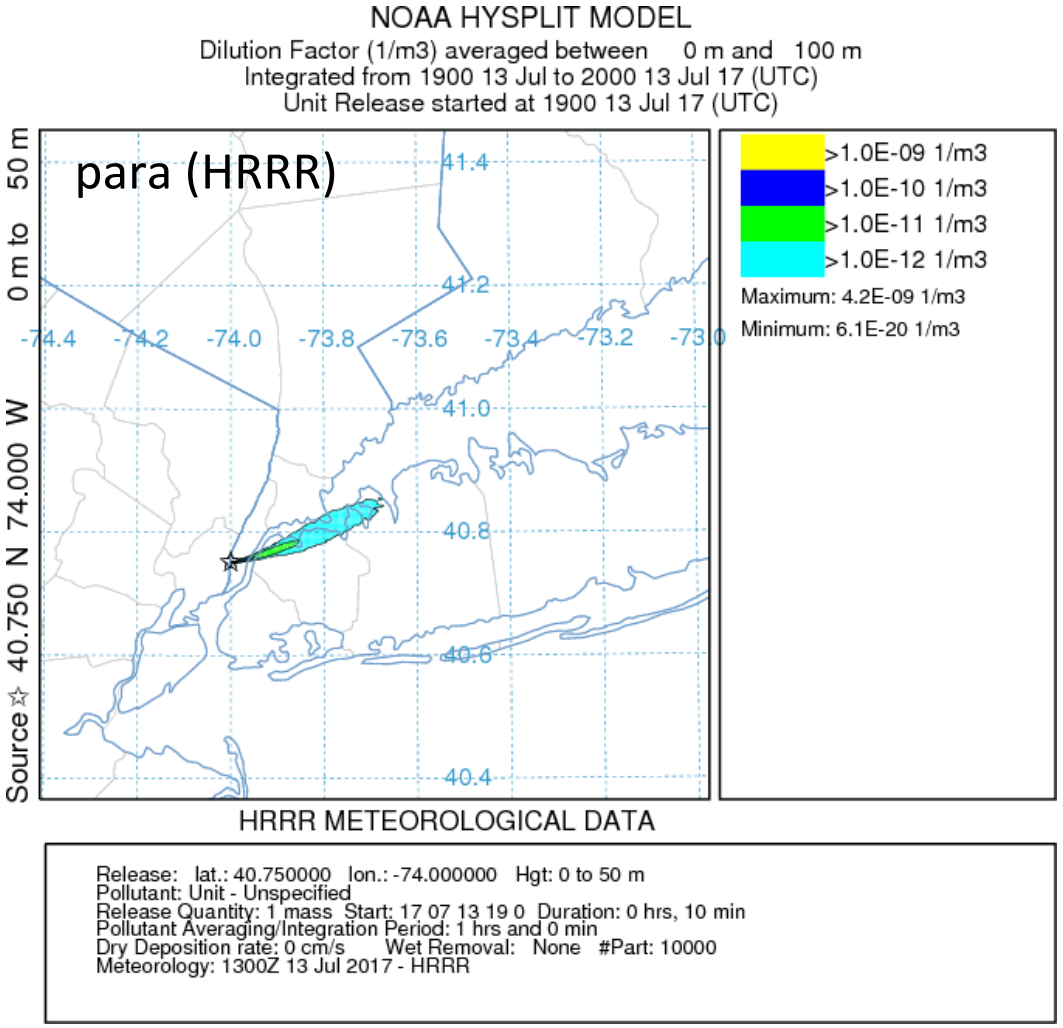


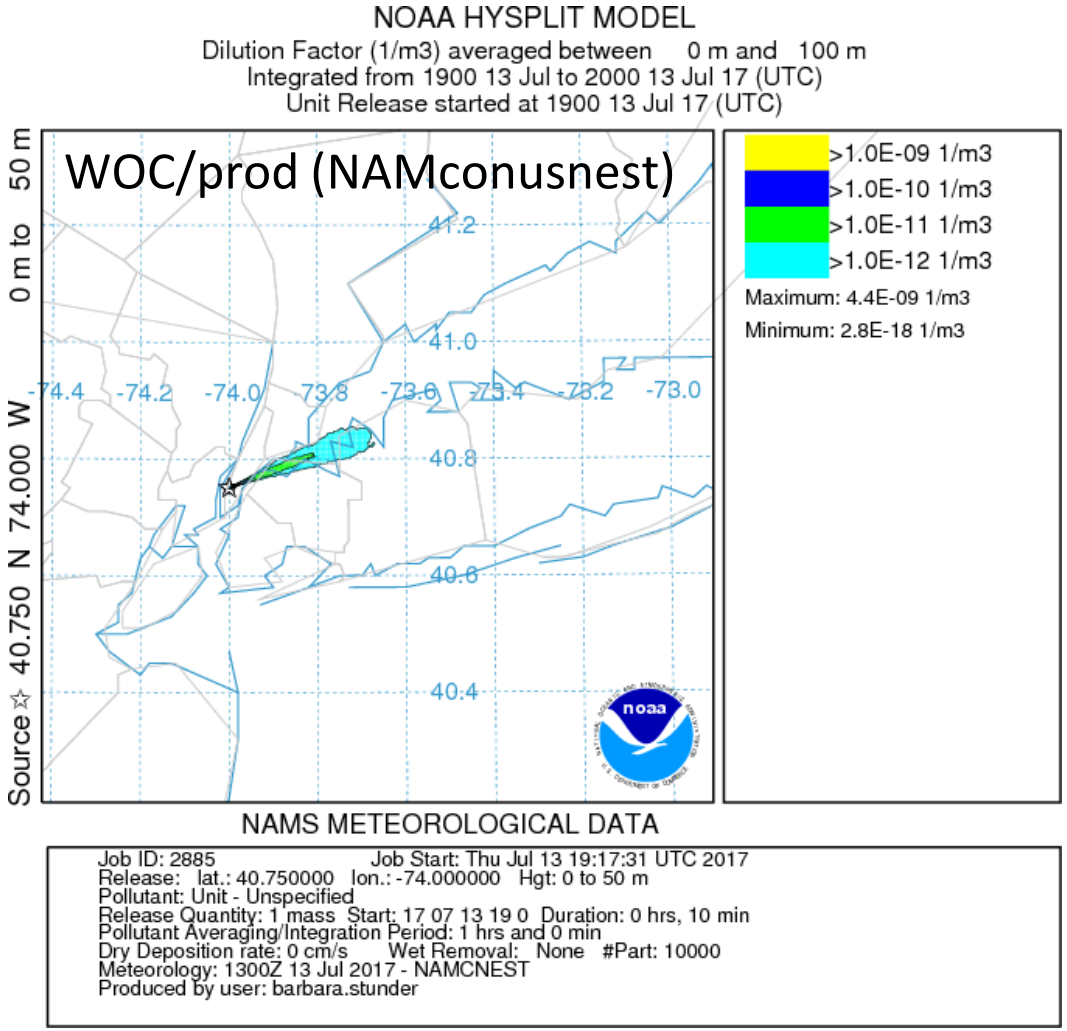
para, quarter-deg

prod, half-deg

Example of new or revised products

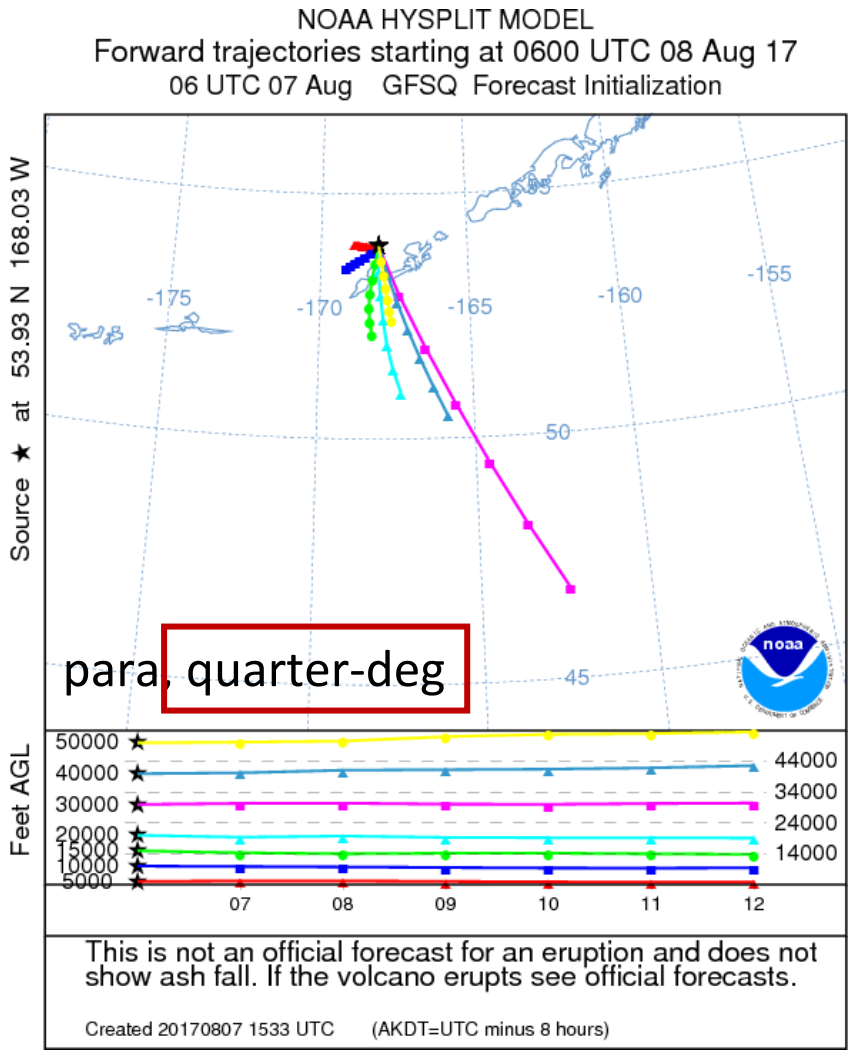
- HRRR vs NAM conusnest, HAZMAT (HRRR new, but similar in this example)
- Alaska volcano trajectories
- Lake-effect trajectories
- Ganser fall velocity

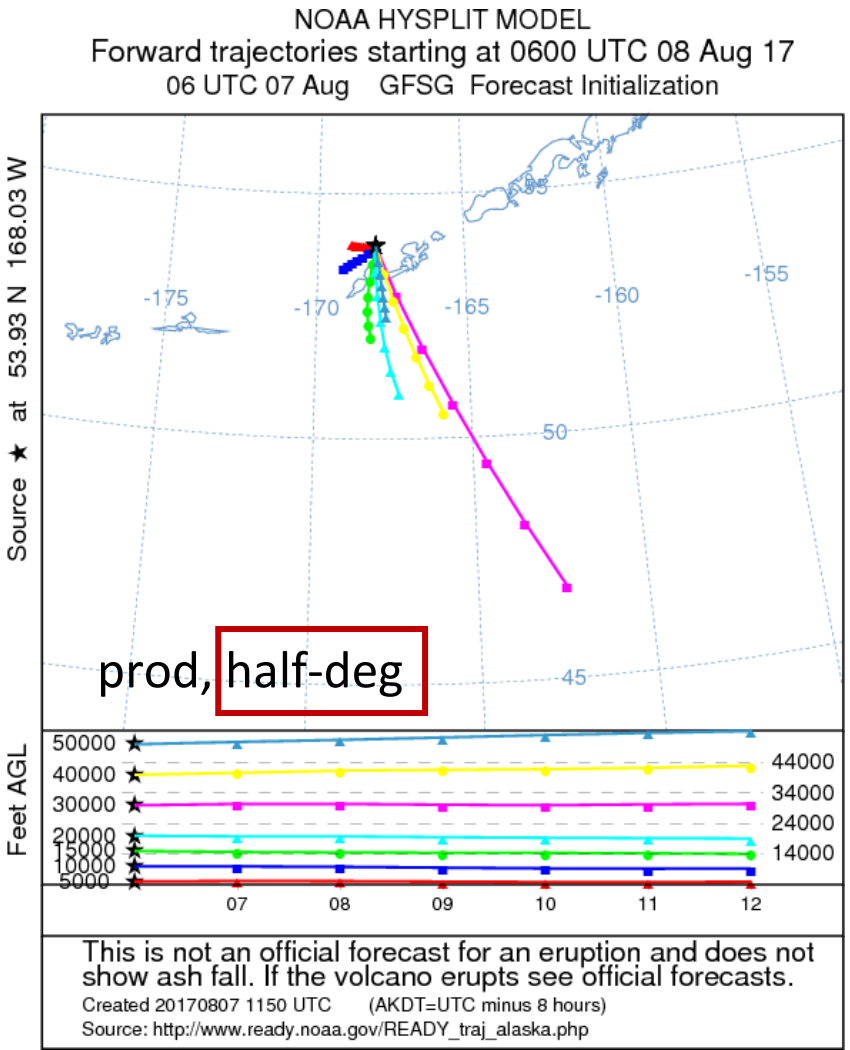




Example of new or revised products

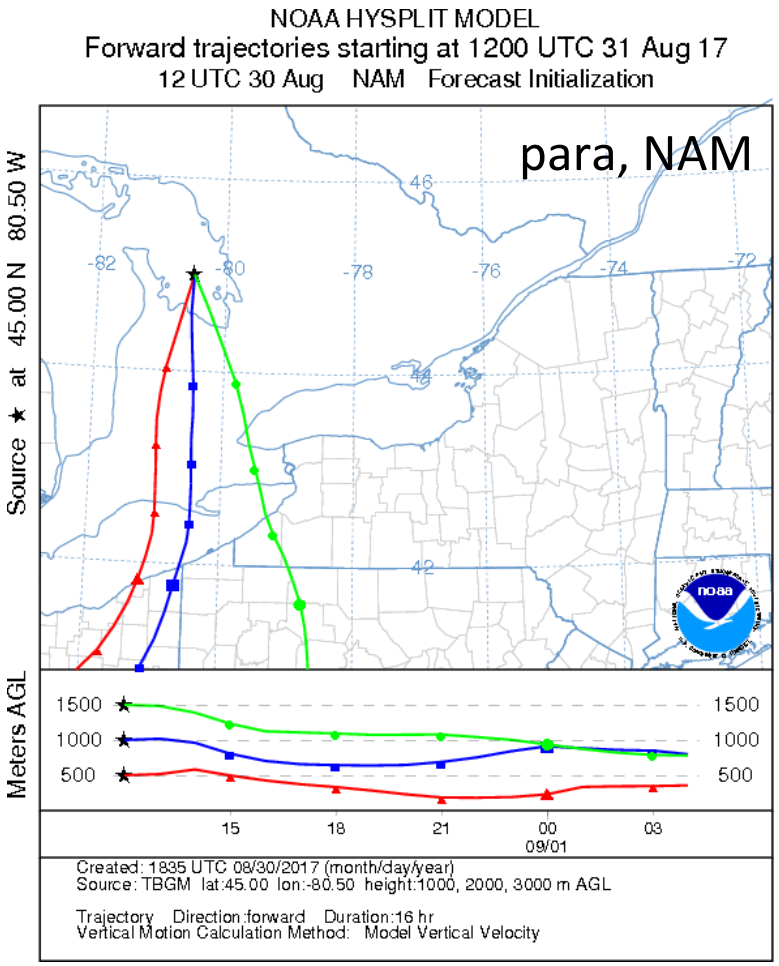
- HRRR vs NAM conusnest, HAZMAT
- Alaska volcano trajectories (similar, except swapped lt. blue and yellow trajs)
- Lake-effect trajectories
- Ganser fall velocity

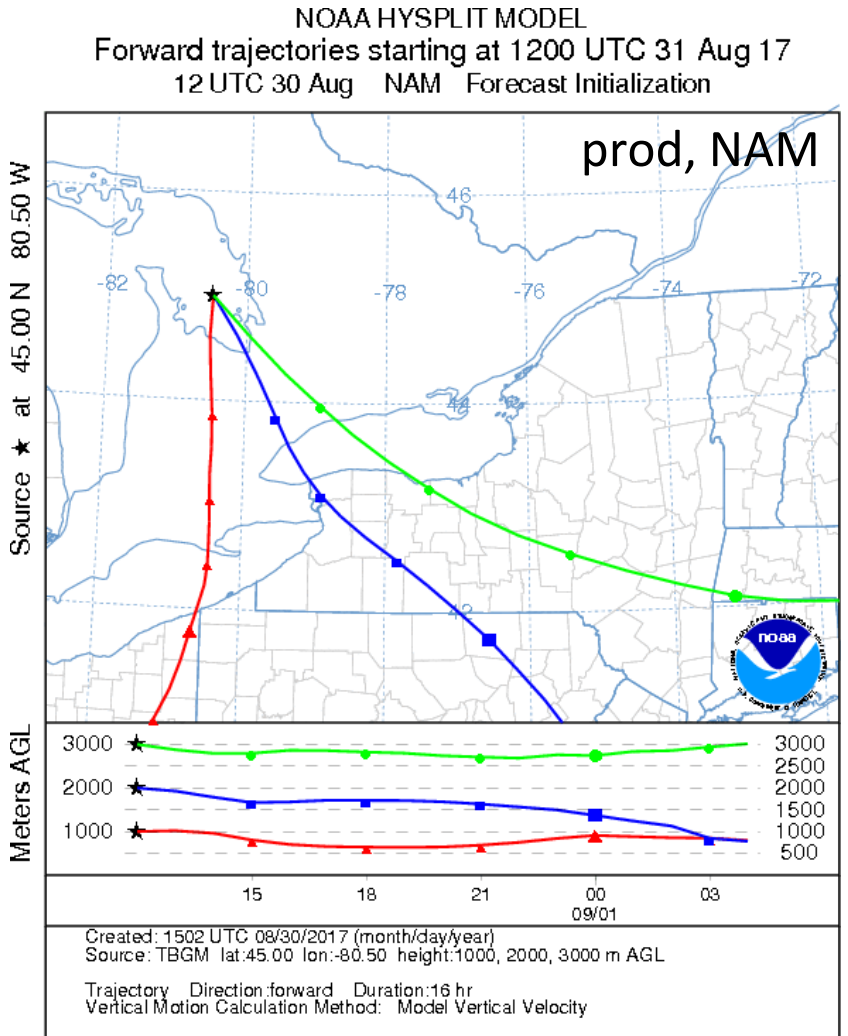




Example of new or revised products

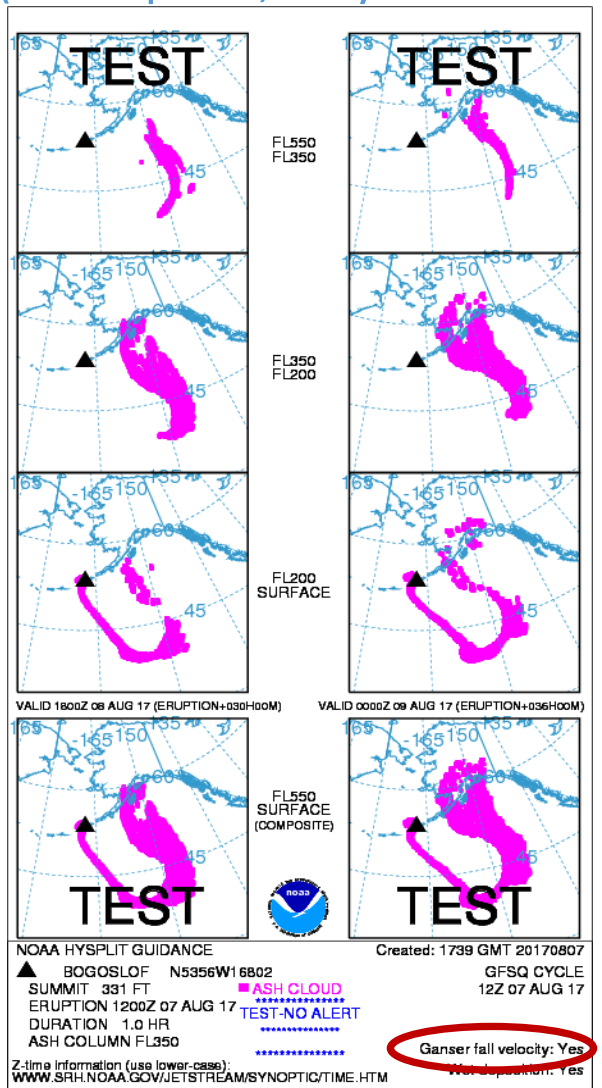
- HRRR vs NAM conusnest, HAZMAT
- Alaska volcano trajectories
- Lake-effect trajectories (blue left =red right, others changed start heights)
- Ganser fall velocity

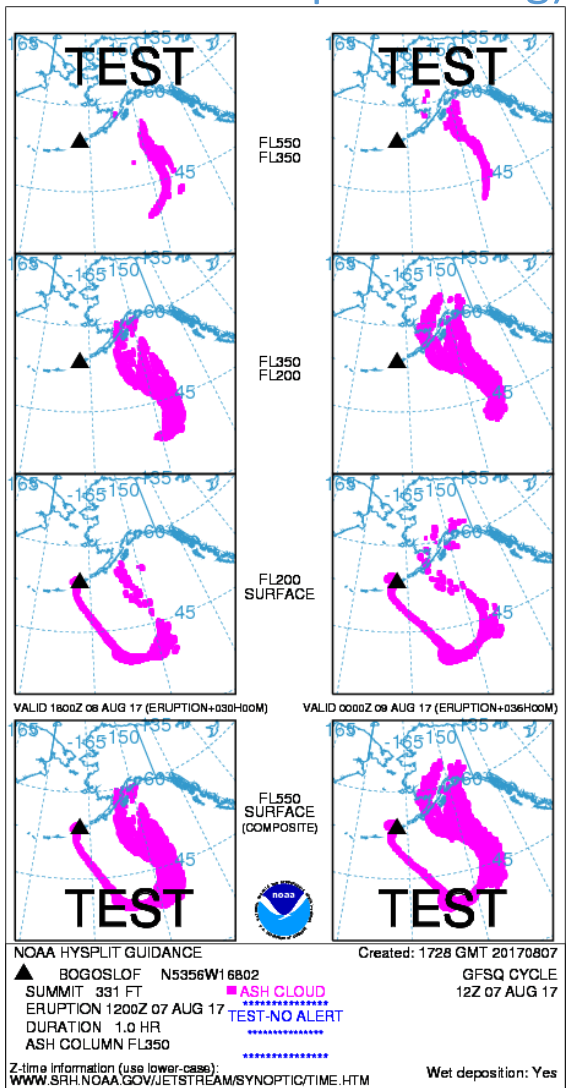




Example of new or revised products

- HRRR vs NAM conusnest, HAZMAT
- Alaska volcano trajectories
- Lake-effect trajectories
- Ganser fall velocity (new option, very small effect, both here GFS-quarter deg)





Evaluator feedback

Central Region

- Are the HYSPLIT Hazmat products with HRRR as a driver more skillful and/or useful to you?
  Yes
- Recommendation:

Implement as proposed.

Eastern Region

- We have no way to quantitatively answer the questions. From a qualitative aspect we believe the additions are useful, but even that is subjective since we have no way of balancing this vs. other priorities that may exist.

Evaluator feedback (cont)

WFO Lake Charles, LA, commenting on the WOC application:

- "You have turned this program into a must use by NWS and this office."
- "I do like the changes that you have made… May I suggest…"
  - Would like to overlay satellite images on HYSPLIT output, and radar and observations.
  - "Would like to see how the plume looks in 3D and move around in 3D."
  - "Would like to see selected sites automatically" run. [Action: ARL and NWS/HQ: Ensure WFOs are aware of the HAZMAT canned runs at pre-defined locations at https://hysplit.ncep.noaa.gov/]
  - "Would like the runs go to a webpage for our users." [Action: ARL and NWS/HQ: Ensure WFOs are aware there is an option on the WOC website that does this.]

Evaluator feedback (cont)

NESDIS/Synoptic Analysis Branch (Washington Volcanic Ash Advisory Center)

- No response on evaluation but added requests for consideration for next upgrade
- Need to be able to run a case where the eruption occurred 84-120 hours ago (e.g. in Kamchatka, Russia) [can do this with GFS/GDAS one-degree, but not quarter-degree]
- Add trajectories to the SDM dispersion run, like the Alaska Volcano Trajectories, but only on-demand.
- In NAWIPS – want to be able to view each “ash reduction” separately as opposed to current single image with multiple contour lines.