A History of Volcanic Ash Forecasting at NOAA Air Resources Laboratory

by

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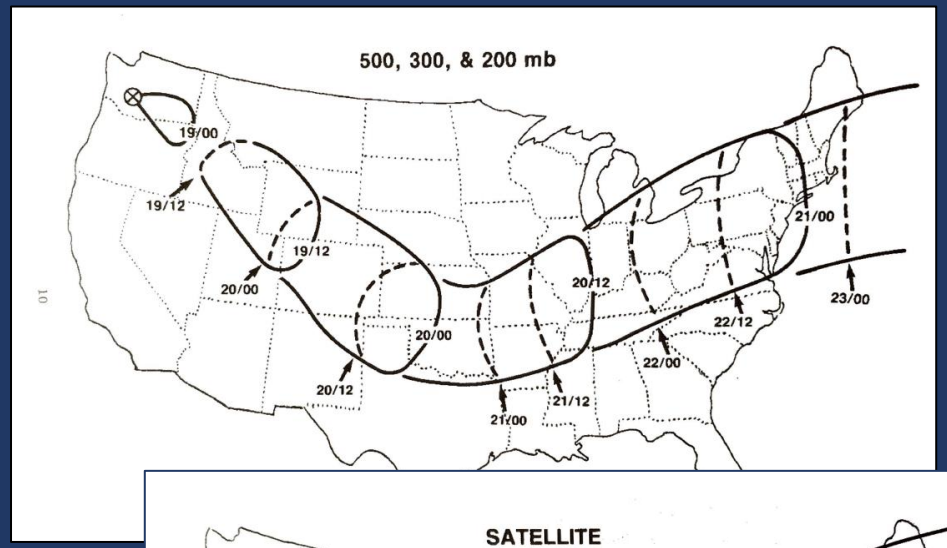
Image: Redoubt on Dec. 18, 1989. (W.M. White/Alaska Volcano Observatory)
https://www.ktoo.org/2020/12/15/on-this-day-in-1989-redoubt-eruption-triggered-seismic-shift-in-alaska-volcano-research

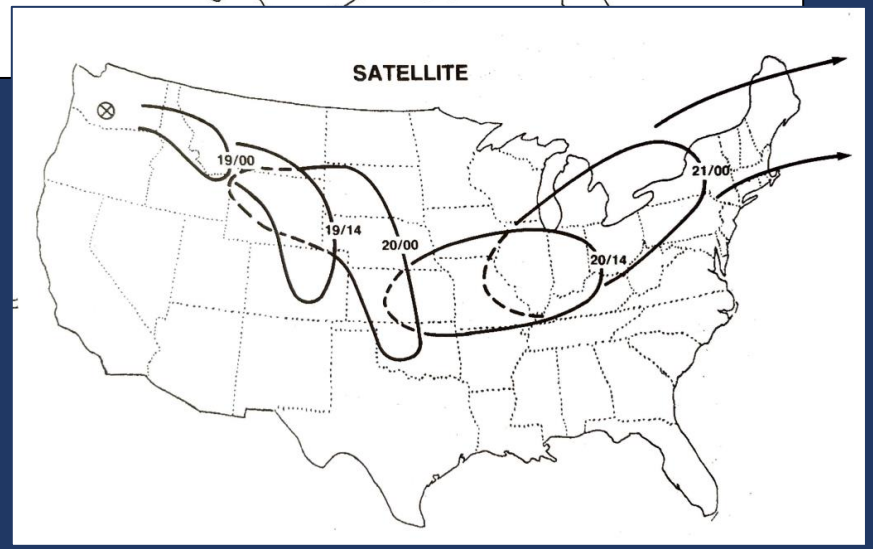
1980s

Mt. St. Helens volcano, Washington state – May 18, 1980

ARL forecast trajectories, text only, on NMC (now NCEP*) computer and faxed

→ **NOAA/FAA Memo. of Understanding (MOU)**





May 19-23, 1980. Top: Composite upper tropospheric trajectories (200, 300, 500 mb). Bottom: Ash cloud position from NOAA satellite imagery.
(Draxler, 1981: Observing and forecasting motions of volcanic emissions shortly after the initial Mt. St. Helens eruptions. NOAA Tech Memo ERL ARL-95)

*NWS National Centers for Environmental Prediction

1980s - 1990

Galunggung volcano, Indonesia – June 24, 1982 -- BA 009

→ **ICAO* International Airways Volcano Watch**

Redoubt volcano, Alaska – December, 1989 – June, 1990

December 15 -- KLM 867

Pilot: Climbing to level 390, we're in a black cloud, heading 130.
Pilot: KLM 867 we have flame out all engines …
Pilot: KLM 867 heavy, we are descending now: we are in a fall!
. . .

*International Civil Aviation Organization

Late 1980s / Early 1990s

Dot-matrix printer graphics

NWP global output on pressure levels, 381 km, 6-hourly

“Silent 700” computer terminal

ARL develops volcanic ash forecast guidance to support safe flight.

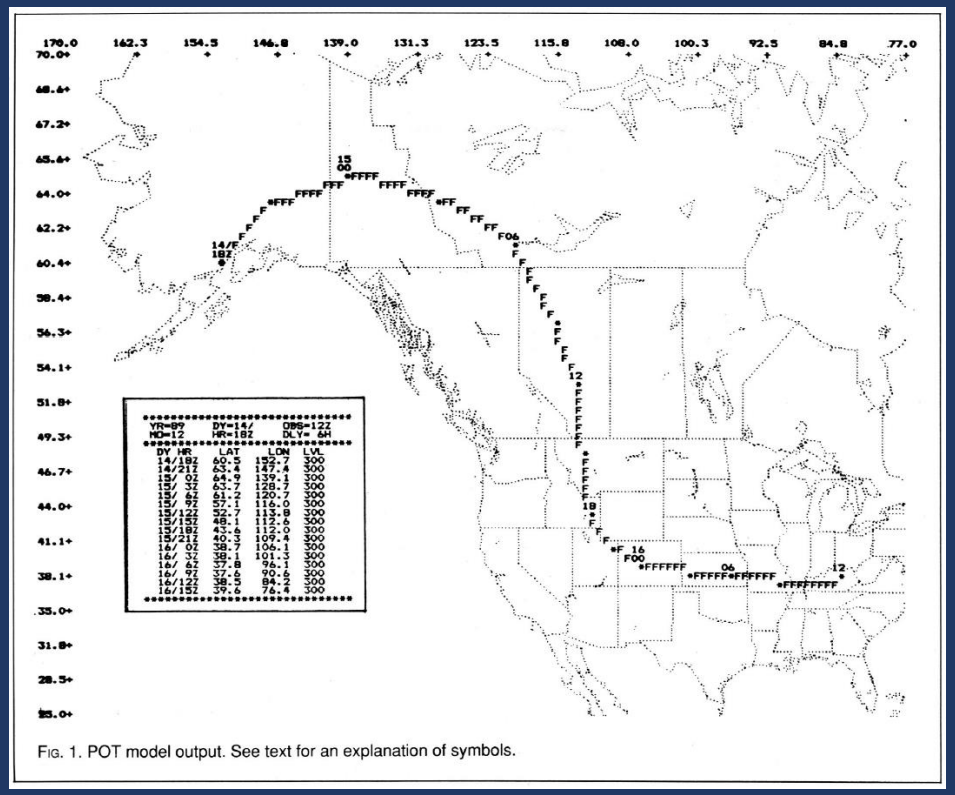


Fig. 1. POT model output. See text for an explanation of symbols.

Heffter, J.L., et al., 1990: Long-range forecast trajectories of volcanic ash from Redoubt volcano eruptions. Bull. Amer. Meteor. Soc. 71(12):1731-1738.

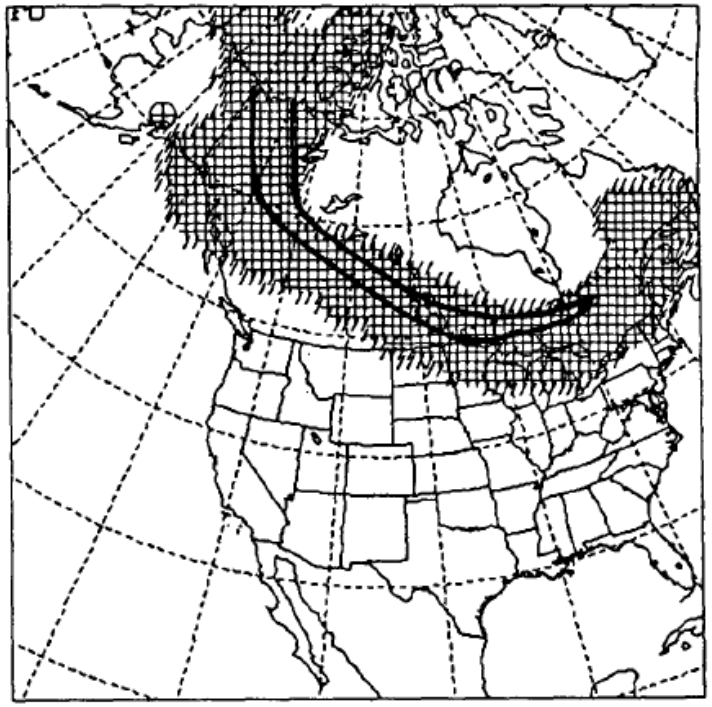
Late 1980s / Early 1990s

ARL developed VAFTAD –
Volcanic Ash Forecast Transport
And Dispersion model

Qualitative output – ash or no ash

Verification with hardcopy
satellite imagery (solid line on figure)

"arlrisc" workstation – pseudo-operational



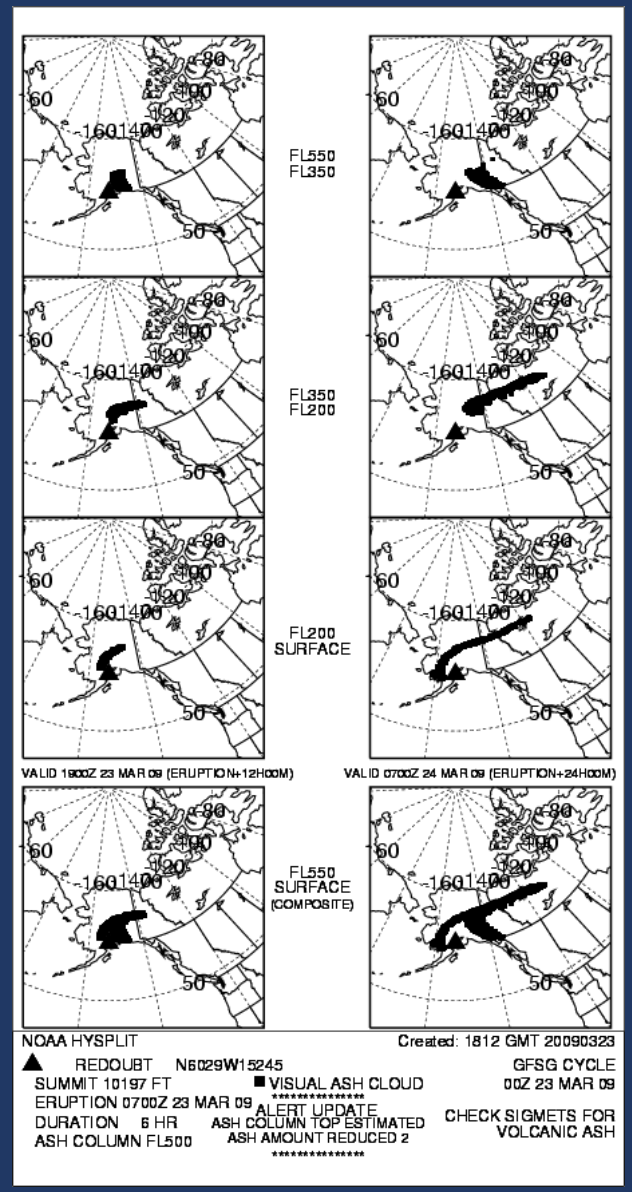
Heffter and Stunder, 1993: Volcanic ash forecast transport and dispersion (VAFTAD) model. Weather and Forecasting 8(4):533-541.

1990s

VAFTAD transferred to NWS/NCEP Operations (R2O – Research-to-Operations)

ICAO – “VAFTAD-format graphic”
avoid ash

OFCM (now ICAMS*)
Volcanic Ash Working Group National Plan



*Interagency Council for Advancing Meteorological Services

2000s

NCEP volcanic ash modeling - HYSPLIT instead of VAFTAD

- VAFTAD look-alike graphic from HYSPLIT (NWS product)
- avoid ash

US Geological Survey (USGS) – Eruption Source Parameters*

relation between eruption height and volume erupted ash

$H = 2.00\ v^{0.241}$

v="dense rock equivalent" (m^3/s) but need "fine ash"

H=plume height (km)

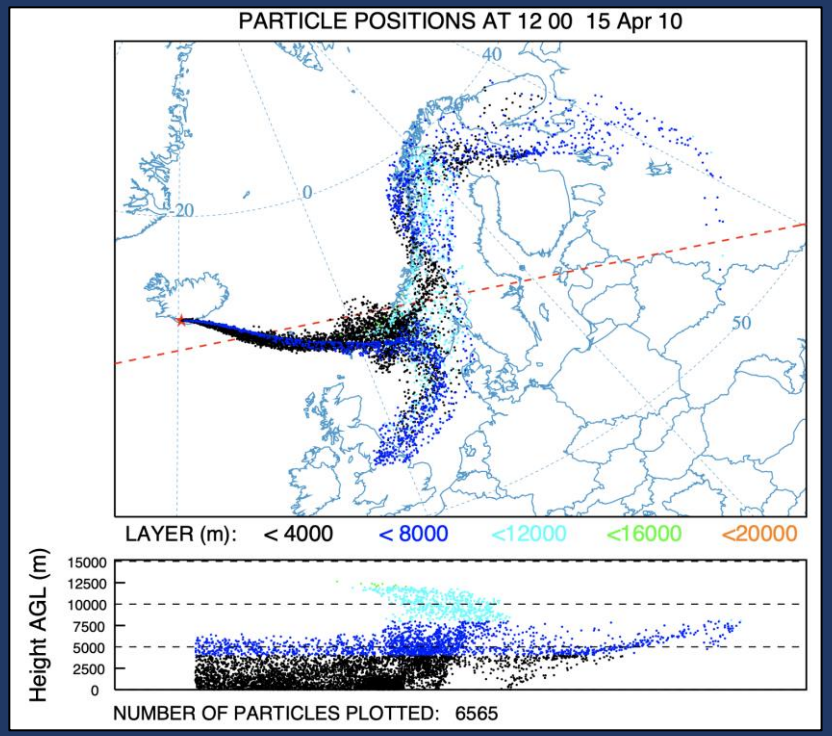
*Mastin, L.G., et al., 2009: A multidisciplinary effort to assign realistic source parameters to models of volcanic ash-cloud transport and dispersion during eruptions, Journal of Volcanology and Geothermal Research, 186:10-21.

2010s

Eyjafjallajökull

- ICAO: risk assessment instead of ash avoidance

- "Quickly" increased NCEP capability
  - Time-varying source
  - Modify particle size distribution
  - Horizontally translate ash footprint

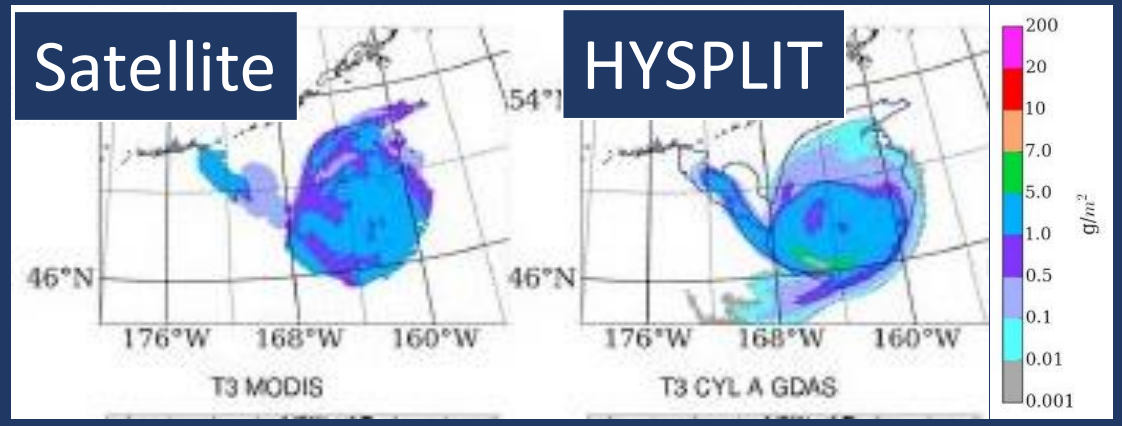


HYSPLIT Eyjafjallajökull snapshot.
HYSPLIT tutorial file xamp16.png
https://www.ready.noaa.gov/documents/Tutorial/html/index.html

2010s

FAA funding for ARL

- research into improving source terms for quantitative forecasts (mass loading) using satellite data

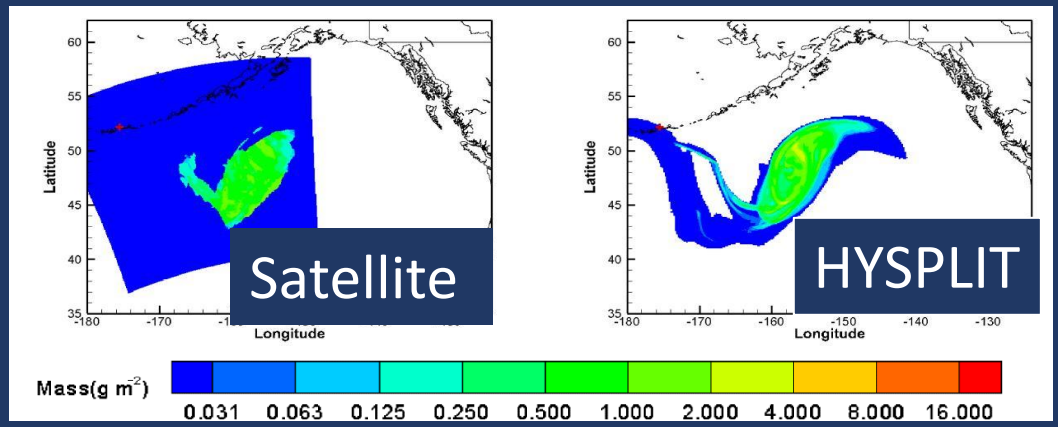


Crawford et al., 2016 (from Fig. 2)
Source – Cylindrical shape

Crawford, A. M., et al., 2016: Initializing HYSPLIT with satellite observations of volcanic ash: A case study of the 2008 Kasatochi eruption, ,J. Geophys. Res.Atmos.,121, 10,786–10,803, doi:10.1002/2016JD024779.

Kasatochi, Alaska, 2008

Chai et al., 2017 (from Fig. 5)
Source from inverse modeling,
(different time period)

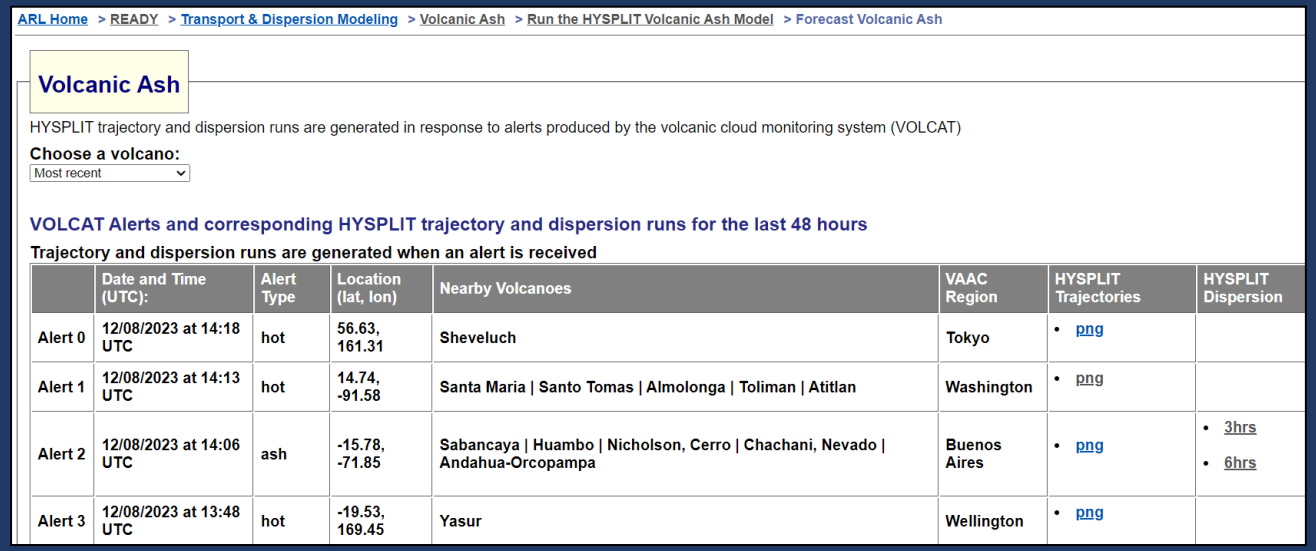


Chai, T., et al., 2017: Improving volcanic ash predictions with the HYSPLIT dispersion model by assimilating MODIS satellite retrievals, Atmos. Chem. Phys., 17, 2865–2879, https://doi.org/10.5194/acp-17-2865-2017.

ARL web early 2020s -

- Posted on ARL web page

Automatically-run HYPSLIT dispersion and trajectories upon receipt of satellite retrievals of ash or a hot spot



ARL Home > READY > Transport & Dispersion Modeling > Volcanic Ash > Run the HYSPLIT Volcanic Ash Model > Forecast Volcanic Ash

Volcanic Ash

HYSPLIT trajectory and dispersion runs are generated in response to alerts produced by the volcanic cloud monitoring system (VOLCAT)

Choose a volcano:

Most recent

VOLCAT Alerts and corresponding HYSPLIT trajectory and dispersion runs for the last 48 hours

Trajectory and dispersion runs are generated when an alert is received

	Date and Time (UTC):	Alert Type	Location (lat, lon)	Nearby Volcanoes	VAAC Region	HYSPLIT Trajectories	HYSPLIT Dispersion
Alert 0	12/08/2023 at 14:18 UTC	hot	56.63, 161.31	Sheveluch	Tokyo	• png	
Alert 1	12/08/2023 at 14:13 UTC	hot	14.74, -91.58	Santa Maria | Santo Tomas | Almolonga | Toliman | Atitlan	Washington	• png	
Alert 2	12/08/2023 at 14:06 UTC	ash	-15.78, -71.85	Sabancaya | Huambo | Nicholson, Cerro | Chachani, Nevado | Andahua-Orcopampa	Buenos Aires	• png	• 3hrs • 6hrs
Alert 3	12/08/2023 at 13:48 UTC	hot	-19.53, 169.45	Yasur	Wellington	• png	

https://www.ready.noaa.gov/hysplitash-bin/autoash.py

- ARL web is ahead of what is at NCEP; Implementation at NCEP takes time
  - Need requirements, coordinate products, testing, approvals, etc.

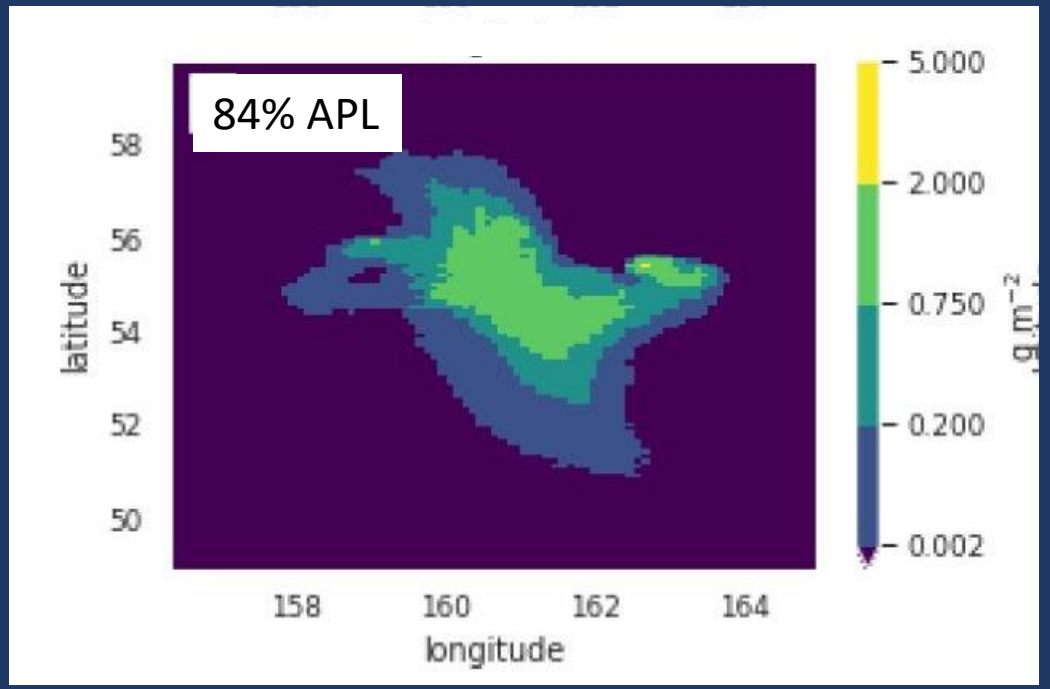
Through the present

NOAA Research funding – NCEP Global Ensemble Forecasts

- Products, verification, bias correction (Crawford et al., 2022)

Leads to new workflow plan

- ingest satellite retrievals
- inverse modeling
- probabilistic products
- probabilistic verification



84% of ensemble members have mass loading < given value

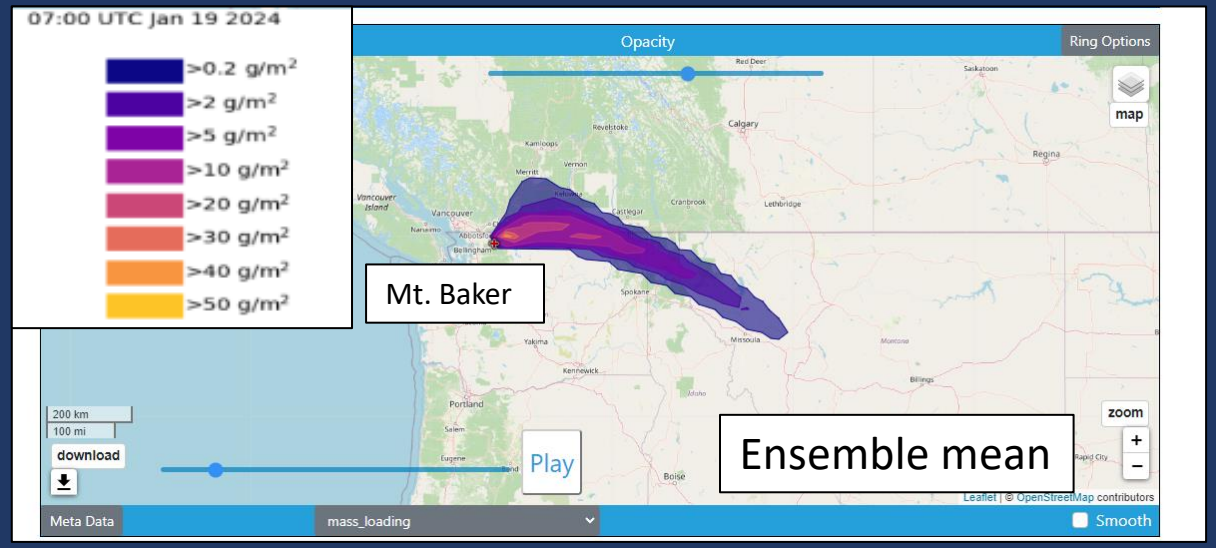
Crawford, A., et al., 2022: Evaluation and Bias Correction of Probabilistic Volcanic Ash Forecasts, Atmos. Chem. Phys., https://doi.org/10.5194/acp-22-13967-2022.

APL = Applied Percentile Level

Conclusion

ARL developed/s VA forecast guidance to support safe flight.

Trajectory text product



- ARL-developed trajectory/dispersion models
- NCEP meteorology models
- Satellite data/analyses
- Pseudo-operations at ARL – NCEP operations (R2O)
- Bureaucracy – requirements and funding