06/17/2022

HYSPLIT tutorial supplemental material
For sections 12 and 16

Contact: alice.crawford@noaa.gov
NWP ensemble datasets

• NOAA HREF high resolution ensemble forecast 10 members
• NOAA GEFS global ensemble forecast system 31 members. 0.25 degree.
• ECMWF ERA5 10 member (3h 63 km)
  • https://www.ecmwf.int/en/newsletter/159/meteorology/global-reanalysis-goodbye-era-interim-hello-era5
  • https://github.com/amcz/hysplit_metdata
Comparison of GEFS (thin lines) and GFS 0.25° (Thick line) Near Bezymianny Volcano in Kamchatka Profiles at 10 October 2020 at 21:00 UTC

From Crawford et. al, Evaluation and Bias Correction Probabilistic Volcanic Ash Forecasts
https://doi.org/10.5194/gispheres-2022-290
Preprint. Discussion started: 11 May 2022 © Author(s) 2022. CC BY 4.0 License.
Conprob utility

- Ensemble relative frequency of exceedance that concentration >=
  - 1% of maximum value
  - 10% of maximum value
  - Maximum value

- Also called Agreement in Threshold Level (ATL)

Coefficient of Variation - relative standard deviation – standard deviation divided by mean
ATL Agreement in threshold level – Ensembles relative frequency of exceedance

Probability of concentration exceeding

- Pick a concentration / mass loading threshold.
- Count how many ensemble members are above that threshold at each point.
- Each point becomes number of ensemble members above that threshold divided by total number of ensemble members.
- Values range from 0 to 100%.
- In order to use in risk based assessment, pick a probability threshold to decide which areas should be avoided.

All slides show a small/medium eruption of Bezymianny in Kamchatka in October 2020. HYSPLIT ensemble generated with GEFS and an inversion algorithm to determine source term. 31 members in ensemble.
APL Agreement in Percentile Level – Concentration at percentile

- Pick a probability/frequency threshold, X%.
- Order values at each point from least to greatest and find value for which X% of ensemble members are smaller.
- Each point becomes concentration / mass loading for which X% of ensemble members are less than that value
- Values are in same units as individual ensemble members.
- APL at 50% is the ensemble median which is similar to ensemble mean but less sensitive to outliers.
How are ATL and APL related?

26 members had lower values than the value shown.

VOLCAT (values of 0 to 100%) > 0.2 g/m²

APL (values of g/m²) > 84% frequency

ATL with 16% probability threshold applied (> 5 members exceed 0.2mg/m³)

2-D Dispersion example with toy model

Mean wind 2 m/s in u direction
Instantaneous release of 100 particles from (0,0)
Simplified Number of Particles?

Release 1 kg gram
Consider:
Concentration grid size
Averaging time
Length of time
Minimum detection

1000 particles   Each particle 1g

100 particles   Each particle 10g

10 particles   Each particle 100g
Different numbers of particles representing distribution made up of two Gaussians.
Guassian mixture model may also be used:  [https://www.mdpi.com/2073-4433/11/12/1369](https://www.mdpi.com/2073-4433/11/12/1369)
Example: Fluctuating velocity for 10 particles.

\[ u(t+\Delta t) = R(\Delta t) \ u(t) + \sigma \lambda ( 1-R(\Delta t)^2 )^{0.5} \]

DNS and experiments show turbulent velocity PDF of fluid particles in a turbulent flow is very close to Gaussian.

Velocity autocorrelation is represented well. Velocity is correlated over the Lagrangian time scale. (Time scale of largest scales in flow).
FIGURE 6.24 Schematic illustration of some concepts in ensemble forecasting, plotted in terms of an idealized two-dimensional phase space. The heavy line represents the evolution of the single best analysis of the initial state of the atmosphere, corresponding to the more traditional single deterministic forecast. The dashed lines represent the evolution of individual ensemble members. The ellipse in which they originate represents the probability distribution of initial atmospheric states, which are very close to each other. At the intermediate projection, all the ensemble members are still reasonably similar. By the time of the final projection some of the ensemble members have undergone a regime change, and represent qualitatively different flows. Any of the ensemble members, including the solid line, are plausible trajectories for the evolution of the real atmosphere, and there is no way of knowing in advance which will represent the real atmosphere most closely.

- Stacked emissions example – one particle size.
- Each emission cycle MUST have same number of lines

```
1 h emission cycle
```

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<th>#spnum</th>
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- Emissions of 1.54e7 from 6880 to 7880
- Emissions of 0 from 7880 to 8880
- Emissions of 3.0e9 from 8880 to 9880
- Emissions of 1.22e9 from 9880 to 10880

```
1 h emission cycle
CONTROL file should have 12 location lines
And one species defined.
```

• Stacked emissions example – one particle size.

• Each emission cycle MUST have same number of lines.

This could be setup differently with Emission cycles covering different amounts Of time.

Example – 2 h emission cycles could be setup. Then the two cycles shown here would be combined and there would be 24 lines per emission cycle.

CONTROL file would need 24 location lines.

NUMPAR is number of particles emitted per Emission cycle.

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<th>LON</th>
<th>HGT (m)</th>
<th>RATE (/h)</th>
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</table>
EMIT file for multiple particle sizes

If you have two pollutants defined in your CONTROL file then in the EMTIMES file you need to have one line per pollutant. If one of the pollutants has 0 emissions for that time period then you need to add a dummy line with 0 emissions. See below. For this case you should have 4 start locations and two species defined in the CONTROL file.

The start locations and number of species in the CONTROL file are used to define how big some arrays should be. If the array sizes defined in the CONTROL file are read don’t match what is needed by the information in the EMTIMES file, you will end up with segmentation faults.

### CODE: SELECT ALL

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<tr>
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<th>RECORDS</th>
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Number of lines = Number of location lines in CONTROL file
X Number of species in CONTROL file.

CONTROL file for this run should have 4 locations.