Ensemble Forecast Visualization and Verification in Python

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Overview

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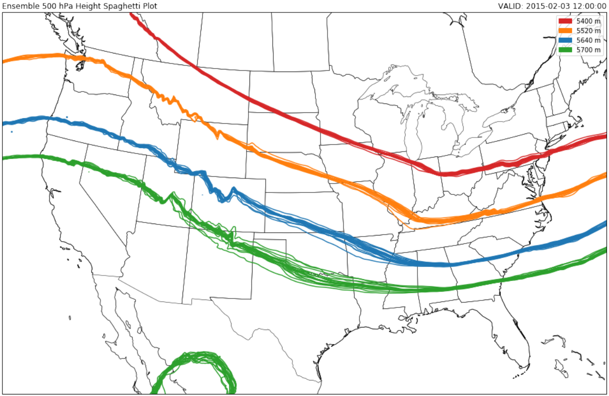
Examples and Data Repository

https://github.com/tjwixtrom/workshop2018

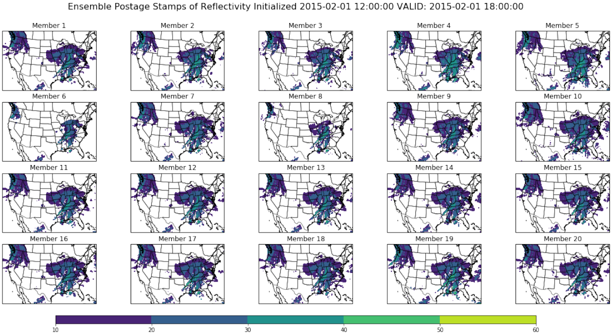
Spaghetti Plots and Postage Stamps

Spaghetti plots and postage stamp plots are both concise, simple methods of viewing all members in a ensemble on the same plot. Spaghetti plots are generally used for contoured fields (e.g. 500 hPa geopotential height) while postage stamps are more commonly reserved for shaded fields (e.g. simulated reflectivity).

Spaghetti Plots and Postage Stamps



Spaghetti Plots and Postage Stamps



Spaghetti Plots and Postage Stamps

Advantages

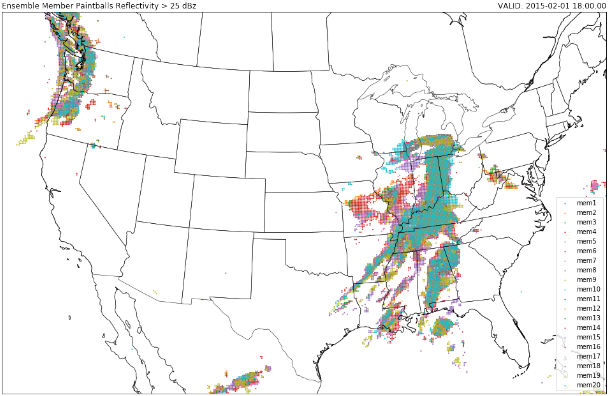
- Displays information from each individual member
- Full location and magnitude of each field is plotted
- Simple to interpret

Disadvantages

- Can be very busy
- Becomes increasingly hard to interpret as spread increases
- Easy to miss small differences among members (esp. postage stamps)

Paintball Plots

Paintball plots are plots where individual points greater than a specified threshold (e.g. simulated reflectivity $\geq$ 40 dBZ) are plotted, color-coded by ensemble member.



Paintball Plots

Advantages

- Easy to quickly see spatial variations among individual member solutions
- Plot remains relatively uncluttered, even for ensembles with many members

Disadvantages

- Very little information regarding variations in intensity
- Thresholds are arbitrary and may not be best for all cases

Probability Plots

If an ensemble contains a sufficient number of members and sufficient spread, probabilities of event occurence can be calculated based on the individual members. This is done at a single point with the following method (Schwartz and Sobash, 2017):

Ensemble Probability

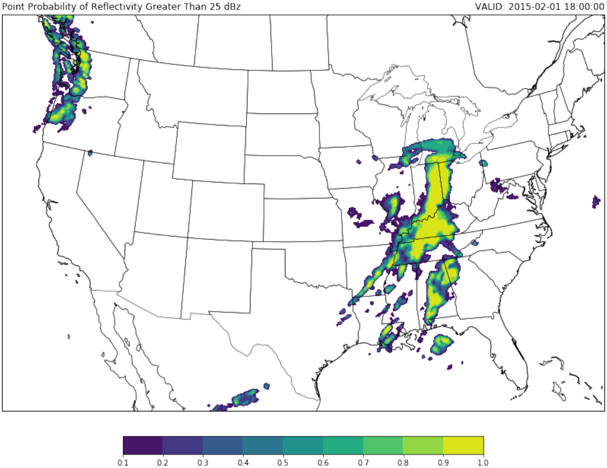
- Define threshold for field
- Define the binary probability (BP) at each point

$$BP(q)_{ij} = \begin{cases} 1 & f_{ij} \geq q \\ 0 & f_{ij} < q \end{cases} \quad (1)$$

- Take average of member binary probabilities to define ensemble probability (EP) for each point

$$EP(q)_i = \frac{1}{N} \sum_{j=1}^{N} BP_{ij} \quad (2)$$

Ensemble Probability



Neighborhood Ensemble Probability

Since the ensemble probability is defined for only a single point and does not account for spatial differences in member solutions, the Neighborhood Ensemble Probability (NEP) can be defined as the probability of even occurence within a specified radius of any point (Schwartz and Sobash, 2017).

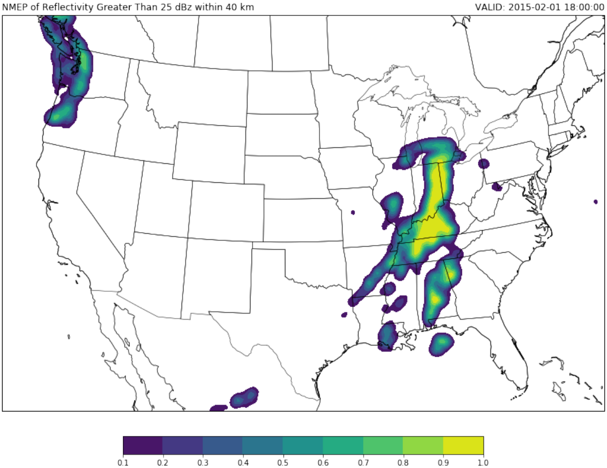
Neighborhood Ensemble Probability

To calculate the NMEP for a given field and threshold q:

- Begin by calculating the EP at each point
- Find all points within specified radius and calculate mean of EP

$$NEP(q)_i = \frac{1}{N_b} \sum_{j=1}^{N_b} EP_{ij} \tag{3}$$

Neighborhood Ensemble Probability



Probability Plots

Advantages

- Probabilistic forecasts of specific events
- Quickly shows ensemble confidence
- Relatively simple to interpret

Disadvantages

- Probabilities are often too high due to low model spread
- Assumes that all member solutions are equally likely
- Limited information regarding member differences in intensity and location

Verification

There are many verification metrics available which can be placed into three categories:

- Grid-point (Wolff et al., 2014)
- Object-based (Davis et al., 2006)
- Neighborhood approaches (Schwartz and Sobash, 2017)

One very simple approach that is often used in the Root Mean Square Error (RMSE).

Root Mean Square Error

The Root Mean Square Error is defined as:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2} \tag{4}$$

- Measure of mean magnitude of forecast error
- Same units as forecast value
- Simple to compute and interpret
- Useful for comparing two models, multiple members, etc.
- Holmes (2000)

Summary

Plot Type	Best For
Spaghetti Plots and Postage Stamps	Individual members, spread, range of solutions
Paintballs	Differences in member spatial distribution
Probability	Likelihood of event occurence

Examples

1. Open terminal
2. Navigate to `workshop2018` folder
3. "`source activate workshop`" for mac users, "`activate workshop`" for windows users
4. Type "`jupyter lab`"

References

Davis, C., B. Brown, and R. Bullock, 2006: Object-Based Verification of Precipitation Forecasts. Part I: Methodology and Application to Mesoscale Rain Areas. *Mon. Weather Rev.*, **134 (7)**, 1772–1784.

Holmes, S., 2000: RMS Error. URL statweb.stanford.edu/~susan/courses/s60/split/node60.html.

Schwartz, C. S., and R. A. Sobash, 2017: Generating Probabilistic Forecasts from Convection-Allowing Ensembles Using Neighborhood Approaches: A Review and Recommendations. *Mon. Weather Rev.*, **145 (9)**, 3397–3418.

Wolff, J. K., M. Harrold, T. Fowler, J. H. Gotway, L. Nance, and B. G. Brown, 2014: Beyond the Basics: Evaluating Model-Based Precipitation Forecasts Using Traditional, Spatial, and Object-Based Methods. *Weather Forecast.*, **29 (6)**, 1451–1472.