Using Model Climatology to Develop a Confidence Metric for Operational Forecasting

Taylor S. Mandelbaum[1], Brian A. Colle[1], Trevor Alcott[2]

[1]School of Marine and Atmospheric Sciences, Stony Brook University, [2]Earth Systems Research Laboratory, Global Systems Division

Motivation

- Ensemble forecasting is used to help quantify and communicate uncertainty (spread).
- Tools such as the ensemble situational awareness table[1] help communicate the magnitude of anomalies in reference to a model climatology (M-Climate), but there isn't a method to communicate magnitude of uncertainty.

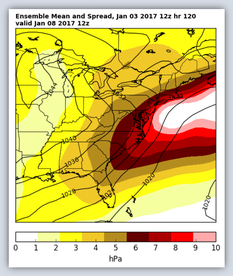


Fig. 1: GEFS Jan 03 2017 12z MSLP ens mean and spread, valid January 08 2017 12z (120hr)

- **Can we use ensemble mean and spread M-Climate to determine how anomalous the spread may be in reference to events of similar magnitude?**

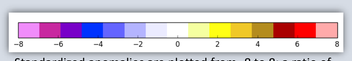
Methods

- Ens mean M-Climate consisting of 30 years (Nov 1985-Mar 2015) and forecast hours 0-168 is used to subset a new spread M-Climate based on ens mean standardized anomaly.
- Standardized spread anomaly,

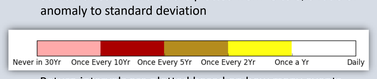
$$\frac{F - C_{s_m}}{\sigma_{s_m}}$$

where F is forecast spread, C_{sm} is modified spread climatology, and σ_{sm} is standard deviation of the climatology, shows where the spread lies with respect to the mean of the modified climatology.

- Return intervals are created based on the number of spread cases in the distribution of equal or greater magnitude, then divided by the record length (30 years).



Standardized anomalies are plotted from -8 to 8; a ratio of anomaly to standard deviation



Return intervals are plotted based on how many events occur of equal or greater spread in the climatology. Salmon is 0-3 events, red 3-6, brown 6-15, yellow 15-30, white 30+

Load in Data

M-Climate ensemble mean and spread from Nov 21-Mar 10 1985-2015 (30 years). Forecast ensemble mean and spread used to determine standardized anomalies to subset a new spread M-Climate

Subset new M-Climate

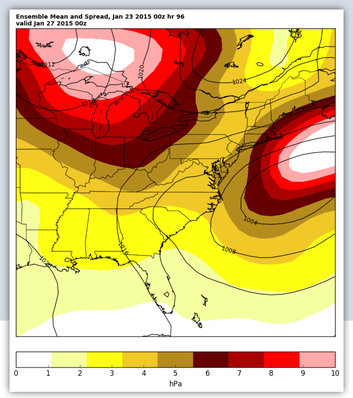
If M-Climate ensemble mean standardized anomaly is within 1 σ of forecast's, append spread value of M-Climate data point into new spread climatology (creating a distribution of spread values). Take average of each grid point to create a subset spread M-Climate

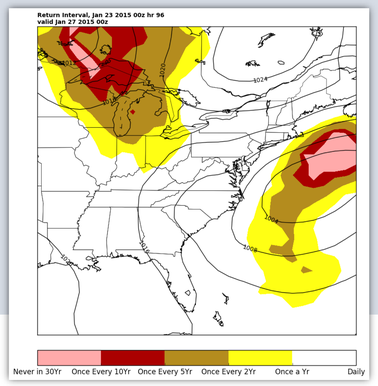
Output Plots

Standardized spread anomaly plot determines departure from climatological mean

Return interval plot relates the forecast spread to the rate of equal or greater magnitude spread values that appear in modified M-Climate

Case 1: Jan 26-27, 2015 East Coast Blizzard





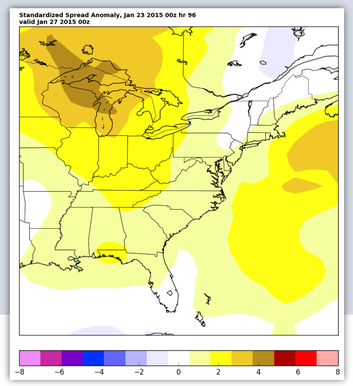
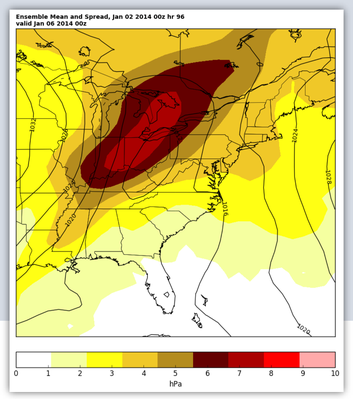
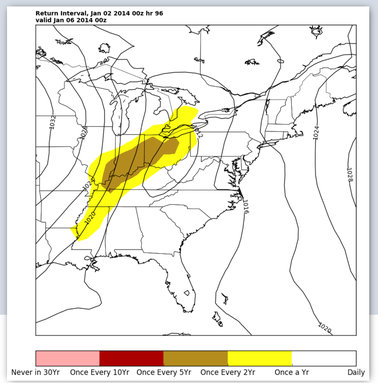


Fig.2: Forecast taken from the GEFS retrospective run, Jan 23 2015 (96h forecast); the GEFS ensemble mean and spread valid 00z Jan 27 2015 (left). Spread return interval of similar magnitude ensemble mean MSLP anomalies (center). Standardized spread anomaly of similar magnitude ensemble mean MSLP anomalies (right).

Case 2: January 6, 2014 Northeast Snow Event





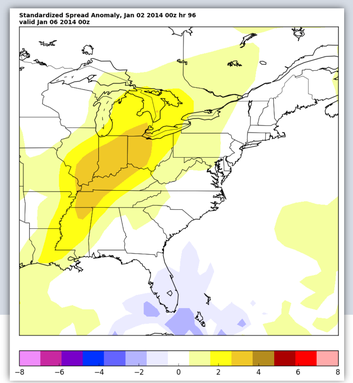


Fig.3: Forecast taken from the GEFS retrospective run, Jan 2 2014 (96h forecast); the GEFS ensemble mean and spread valid 00z Jan 6 2014 (left). Spread return interval of similar magnitude ensemble mean MSLP anomalies (center). Standardized spread anomaly of similar magnitude ensemble mean MSLP anomalies (right).

Discussion

- Spread is inherently a non-normal distribution due to extreme events. Methods such as using percentiles can provide a more detailed context for a forecaster.
- An analysis of dprog/dt, or how the model uncertainty changes over time, can be performed using this method (must be wary of underdispersion, clustering using the ensemble mean).

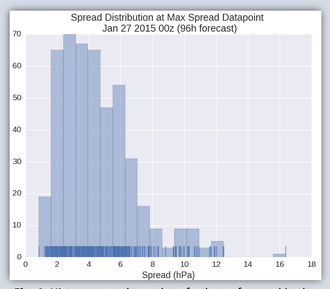


Fig. 4: Histogram and rug plot of values of spread in the DJF M-Climate within 1σ of the maximum spread grid point, Jan 23, 2015 00z 96h forecast, valid Jan 27, 2015 00z. The spread value at this grid point is 12.01 hPa.

- The tool is not intended to provide a conclusive analysis of uncertainty (only as good as the model performs).
- Other variables have been tested (surface temperature and 500 heights).

Summary/Future Work

- The tool can be used to help assess the uncertainty (or confidence) of an event relative to events of similar anomaly.
- More variables (PWAT, 700 RH, 850 winds, 850 temp) will be added and analyzed.
- More robust quantitative and statistical analysis of methods will be performed.
- A webpage with real time updates and maps is on the way.
- More questions? Send an email to taylor.mandelbaum@stonybrook.edu

References

[1]Ensemble Situational Awareness Table, (http://ssd.wrh.noaa.gov/satable/)

Hamill, T. M., G.T. Bates, J. S. Whitaker, D. R. Murray, M. Fiorino, T. J. Galarneau, Y. Zhu, and W. Lapenta, 2013: NOAA's Second Generation Global Medium Range Ensemble Forecast Dataset. Bull. Amer. Meteor. Soc., 94, 15531565.

Anticipating a Rare Event Utilizing Forecast Anomalies and a Situational Awareness Display, The Western U.S. Storms of 18–23 January 2010. Randy Graham, Trevor Alcott, Nanette Hosenfeld, and Richard Grumm. Bull. Amer. Meteor. Soc. BAMS-D-11-00181.1

Stony Brook University
School of Marine and Atmospheric Sciences