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Objective, Temporally and Spatially Skill-Weighted Consolidation of Dynamical Model Forecasts for Week-2 Outlooks

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1. Introduction

The Climate Prediction Center (CPC) currently produces automated extended range probabilistic temperature and precipitation outlooks for the contiguous United States and Alaska on a daily basis. These automated outlooks are the primary source of guidance for CPC's official week-2 manually drawn outlooks during the week and form the basis of the official automated outlooks on weekends. The probabilistic information expressed by these outlooks reflects the chances that the mean temperature (total accumulated precipitation) over the period will fall into the most likely of three classes: above, below, or near normal (median).

By definition, this three class system reflects only a limited representation of the forecast probability distribution as probabilities are available only in reference to the 33rd and 67th percentiles of the climatological distribution. Moreover, these probabilities are currently calculated through a subjective weighting of dynamical and statistical forecasts which was predetermined by the collaborative group of CPC forecasters. These subjective weightings do not take temporal and spatial variations of skill into account.

The week-2 Consolidation Project (CON) was designed, in part, to increase the skill of CPC's automated week-2 probabilistic temperature and precipitation outlooks by objectively weighting input forecast tools through analysis of past skill both temporally and spatially. In this way, the CON tool can more effectively utilize the independent information of each of its component input dynamical forecasts.

Additionally, the CON provides information on a wider spectrum of the forecast probability distribution similar to what is currently available for CPC's seasonal outlooks. Thus, users can have access to the mean temperature or accumulated precipitation values corresponding to the median, tails, or most likely range in the forecast distribution.

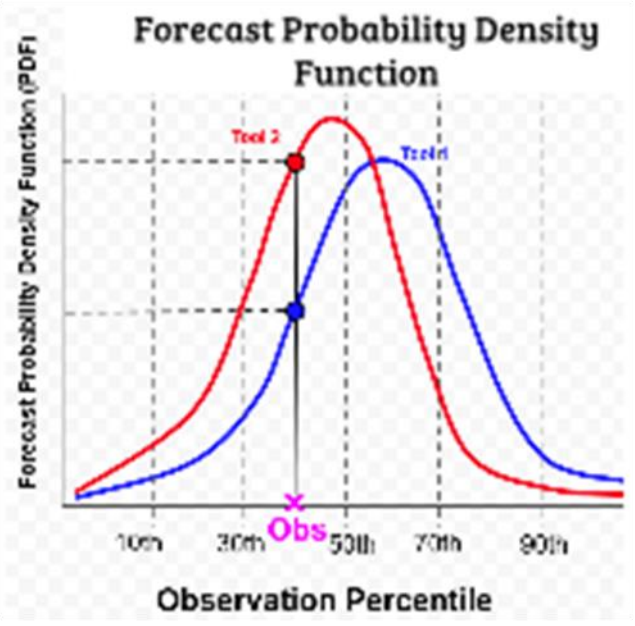

Fig. 1 Example of probability curves for 2 input tools for one day in the evaluation period at a grid point. 'X' marks the percentile that was actually observed that day, and the red and blue circles denotes the estimated probability values at the observation. Tool 2 in this case had the higher "winning" probability, because it was more confident at where the observation verified.

2. Methodology

2.1 Calculation of probability density function values

A probability density estimate is obtained of each of the input forecast tools at the observed percentile for the valid date/location for a range of past dates. These values are compared to determine which tools perform better than others to get weights for the consolidation. Below is a diagram (Fig. 1) showing an example of how two tool probabilities

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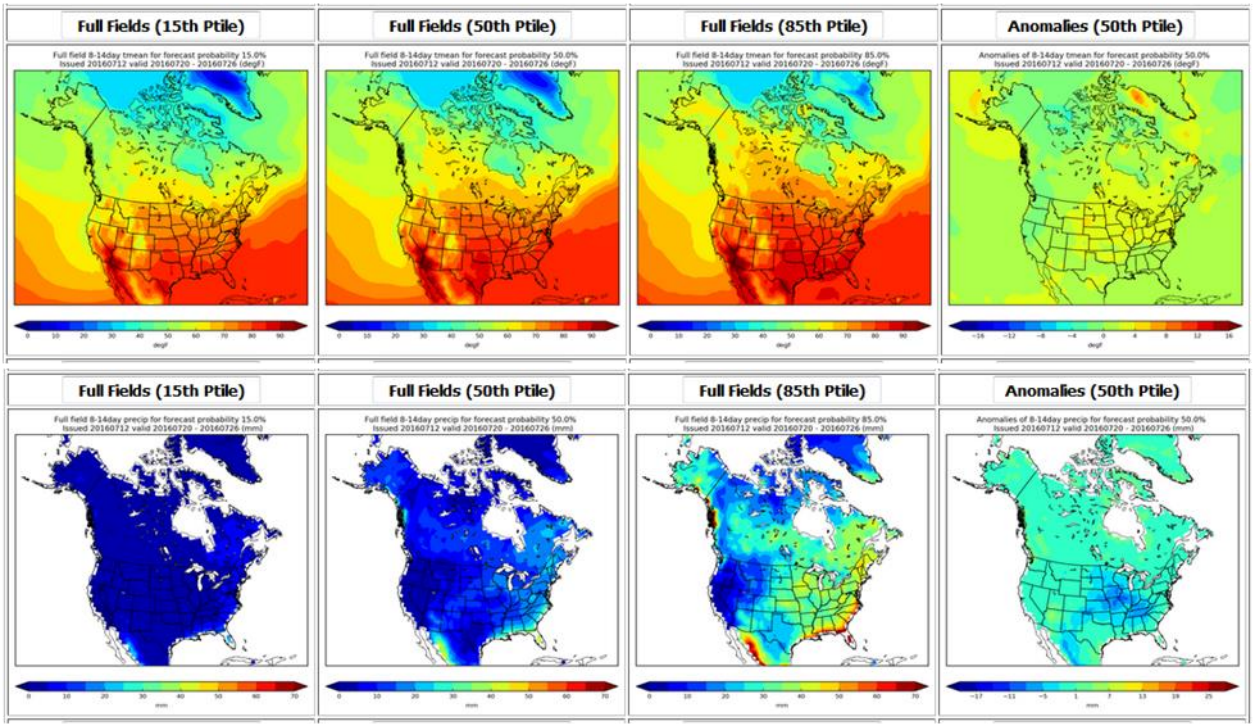

Fig. 2 Temperature (top) and precipitation (bottom) outputs. (See descriptions in Section 3.1 for details.)

would be compared for a specific date/location compared to the observation. This example represents 2 different tools (blue and red curves) of the forecast probabilities in PDF format. The "winning" tool would be Tool 2 in Fig. 1 since the area under the curve surrounding the observed percentile was greater than tool 1. This process is iterated over the entire evaluation period, doing an additive count of how many times each of the tools "win" over the period.

2.2 Weighting procedure

Weights are determined for each 1x1 degree grid point using the accumulated count of which input had the highest PDF value at the observation during the skill evaluation period. The evaluation period contains 135 days in total (90 days from the previous year centered on the forecast center day as well as the last 45 days from the current year). In order to minimize discontinuities, a 9 point smoother is applied to the weights for each grid point. Weights for land (ocean) areas are smoothed with the weights for the surrounding land (ocean) areas.

3. Output

3.1 Full field output

Binary, gridded output files containing full field mean temperature and total precipitation values at 19 probability of exceedance levels are produced on a daily basis. Additionally, maps of the consolidated forecast full field values at the 15th, 50th, and 85th probability of exceedance levels are produced for both mean temperature and accumulated precipitation (first three columns of Fig. 2). Anomaly maps representing the difference between the full field values at the 50th percentile of the forecast distribution and the 50th percentile of the climatological distribution are also provided (last column of Fig. 2).

3.2 Probabilistic output

Binary gridded output files containing the probability of the mean temperature or accumulated precipitation exceeding 19 climatological thresholds are produced on a daily basis. Additionally, graphical maps are produced for forecast tercile probabilities, (top left of Fig. 3), percent weights of each of the input

forecast tools (bottom row of Fig. 3), and climatological percentile values corresponding to the observed mean temperature or total precipitation during the forecast valid period (top right of Fig. 3).

4. Results

Preliminary verification statistics were compiled for the period January 1 - September 1, 2016. For week-2 temperature and precipitation outlooks, the mean Heidke Skill Score (HSS) for the consolidated output surpassed the HSS for all of its inputs. Consolidated temperature (precipitation) HSS was 35.1 (16.0) as compared to input ECMWF Ensemble HSS of 33.3 (13.4) and GEFS HSS of 31.2 (13.8).

5. Conclusions/Next steps

The objective, skill-weighted, week-2 CON tools show promise for providing more skillful first guesses to CPC's manually drawn official weekday forecasts and mostly automated weekend forecasts. In addition, through improvements in skill to CPC's automated guidance, the consolidation tool may increase the skill of the official week two probabilistic outlooks and the efficiency of their production. Moreover, by providing information on a wider spectrum of the forecast probability distributions, the week-2 CON provides information consistent with CPC's current seasonal POE output, which contains similar information. Since the CON POE produces output for a wide spectrum of POE levels, this could aid the forecasters that produce the probabilistic U.S. Hazards Outlook through the identification of the most likely mean temperature and accumulated precipitation ranges as well as the potential for extreme events. The production of weight maps of the input dynamical model forecast tools may also prove useful for the week-2 U.S. Hazards Outlook though the identification of areas of relative skill among the input model forecasts.

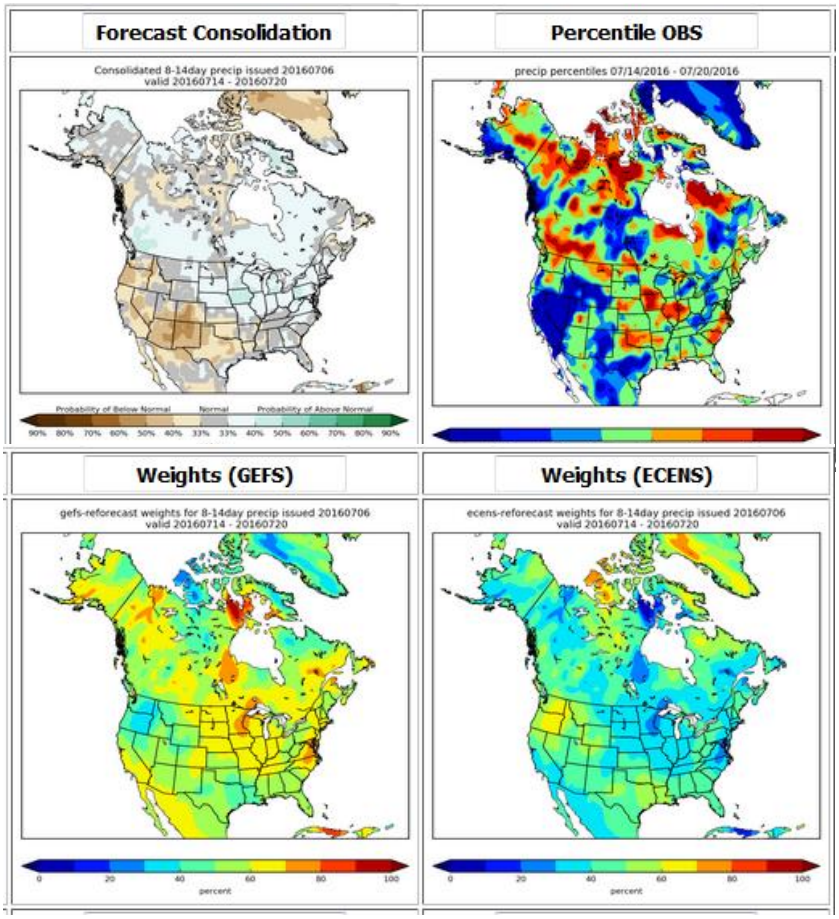

Fig. 3 Tercile Probabilistic Precipitation Output (top left), Percentile Observations (top right), and Weights (bottom row). (See descriptions in Section 3.2 for details.)

Planned future work incorporates inclusion of additional dynamical and statistical tool input as well as a more thorough skill evaluation of the CON output, (including probabilistic measures such as the RPSS and Reliability Diagrams). Future evaluations will also include skill comparisons with additional combination techniques (such as equal weighting).

References

Unger, D.A., H. van ven Dool, E. O'Lenic, D. Collins, 2009: Ensemble regression. *Mon. Wea. Rev.*, **137**, 2365-2379.