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Towards Filling the Gap in NOAA's Seamless Suite of Forecast Products; Prospects of "Useful" Predictions for Weeks 3 & 4?

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1. Introduction

In the operational NOAA's seamless suite of weather and climate forecast products that are now issued to the public, there are products on "almost" all time scales ranging from minutes (in the form of alerts and warnings) to seasons and years (as guidance and outlooks). The Climate Prediction Center is responsible for forecast products beyond a week. At present, as can be seen from Fig.1, there are no official forecast products in the weeks 3-4 time frame, sometimes referred to as the 'black hole' in the forecast suite. In fact this "hole" has remained unfilled, even though NWS started issuing 5-day mean forecasts (circa 1940), monthly (early 1950s) and seasonal (early 1970s) climate outlooks a long time ago. In the early 1990s, while analyzing the Dynamical Extended Range Forecast (DERF) experiments' products data at former NMC (now NCEP), Huug van den Dool (1994) showed that there was very little forecast skill in the anomaly correlations of NMC's operational model's forecasts of daily mean 500mb geopotential height during weeks 3-4 (Fig. 2). About fifteen years later in Europe, Weigel *et al.* (2008) showed that the time averaged weeks 3 and 4 temperature forecasts skill remained still low with anomaly correlations hovering only between 0.1 and 0.2 all through the year for Northern/Southern Hemisphere or for Tropics. (Fig. 3).

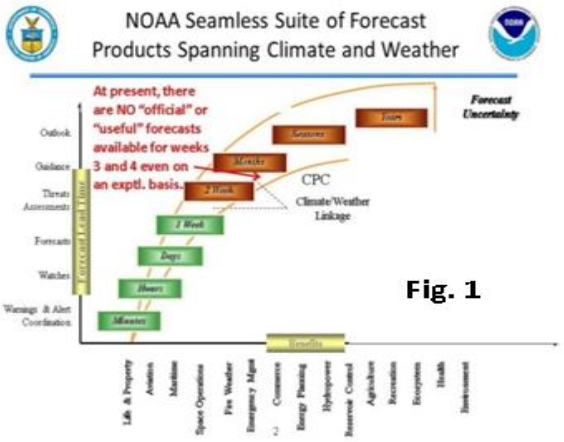

Fig. 1

Then recently at NCEP (Saha *et al.* 2013), a large dataset was created of 45-day forecasts, made 4 times a day (now 16) for about 12 years (1999-2010), using the latest state of the art data assimilation system and coupled ocean-sea ice-atmosphere climate forecast system (CFSv2) model. The schematic is shown in Fig. 4.

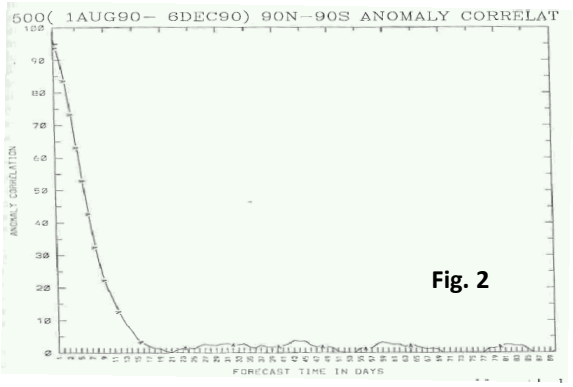

Fig. 2

Using this recent CFSv2 data set, we again evaluated the skill of week 3 (purple) and week 4 (light green) mean forecasts of 500 mb Geopotential height, and it is shown in Fig. 5 for the globe (top panel) and for a rectangular region over the continental US (bottom panel). To place the skill of weeks 3 and 4 in perspective, for comparison purposes, we also show the skill for days 1, 2, 5, wk1P (dys 6-10), and week 2. But weeks 3 and 4 forecasts still remain very low.

So the question becomes, when will the forecast skill of weeks 3-4 time scale improve? Do we just wait and hope the skill improves sometime in the future? Or do we need to think differently about the way we want to issue forecasts or the metrics we use for weeks 3-4 forecasts, since this time period is beyond weather time scale (up to 7-10 days) and less than climate time scale (month-season)?

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While it is clear that for weather time scale, the future state of the atmosphere is sensitive mainly to the initial conditions of the "fast atmosphere", and for the longer climate time scales (month-season) the future climate is sensitive to the initial condition of the "slow ocean" as well as the intermediate land surface components, it is not even clear exactly what to call the weeks 3, and 4. Is it weather or climate?

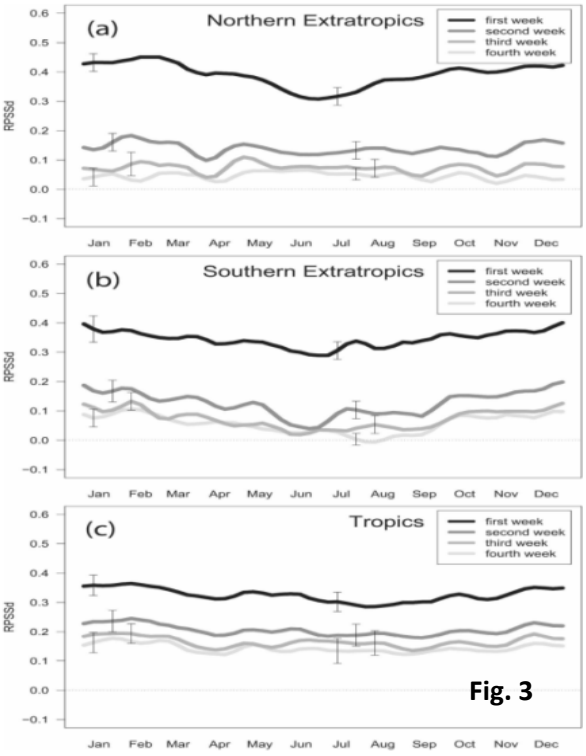

Fig. 3

Also note that the metric that was used in Figs. 2, 3 and 5 is the traditional anomaly correlation coefficient, where the anomalies for weeks 3 and 4 are computed as departures from some long term climatology. That is, we are treating this period as "climate". Is it really climate? Is this really the metric we want to use for this time scale? Is this why our forecast skill score as noted in Figs. 2, 3, and 5 has not improved over the last few decades in spite of the great advances and understanding in weather prediction and climate? Note that the typical weather forecast for tomorrow, the next few days up to a week (up to ten days in weather.com, or in accuweather.com) is NOT anomalies but the actual (total) temperature or precipitation amount.

Since the weeks 3-4 time period is neither weather, nor climate, we need a 'paradigm shift' in the way we look at forecasts for weeks 3 and 4. As this period is "weather-to-climate" transition period, why don't' we look at forecasts of "something new", that is neither the total field (weather) nor anomaly from a traditional long term mean climatology (climate)?

2. Propsal and discussion

I propose that on any given day, while issuing forecasts for weeks 3 and 4, we use terminology such as 'departure' from 'yesterday' or the 'past week's mean average conditions (see Fig. 4), since most likely people will remember how 'yesterday's weather was like, or the immediately previous week's weather was like. Such as, if it was too hot or cold. Was it dry or was it rainy? Is the general public more likely to remember this than some climatology? This kind of information will definitely be 'useful guidance' to the public regarding upcoming weeks 3 and 4 weather/climate conditions, with reference to something they experienced very recently. In Figs. 6 and 7 below, we show respectively the forecast skill score results for Weeks 1P, 2, 3 and 4 for Global 500 mb Heights and T2m respectively.

In Figs. 6 and 7, the top right panel shows results for week 3 forecast and bottom right panel is for week 4 forecast. Also shown for reference and comparison are week 1P (days 6-10) and week 2 forecast in top left and bottom left panels. The different lines are the average skill scores for the 1999-2010 period by different methods.

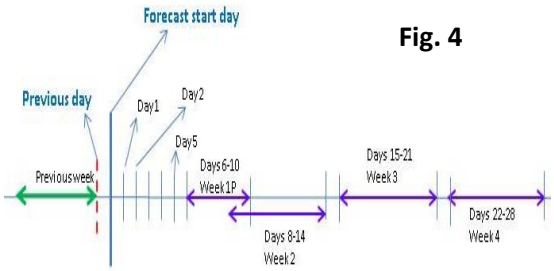

Fig. 4

In each panel, the blue line, all the way at the bottom, corresponding to the traditional anomaly correlation method (cf. Figs. 2, 3, and bottom 2 lines in both panels of Fig. 5), the skill is expectedly low. The yellow/orange line at the top is for the 'null' forecast, where the observed climatology (1999-2010 mean) itself is prescribed as forecast for each appropriate period in years 1999, 2000, … 2010. The black line near the top is the spatial 'correlation' among the full fields (not anomaly).

Here, as expected the skill is high since the fields are dominated by climatology. It is interesting however, that 'on average' using climatology for forecast (yellow line) is better than the black line. The red line is the correlation between the observed (analysis) and the forecast for week 3 (or week4, etc.) after subtracting the "previous 7 day mean" from both the verifying analysis and forecast fields. Note in both Figs. 6 and 7, the distance/difference between the blue and red lines gradually increases as we move farther out from wk1p forecast (top left panel) to week 4 (bottom right) forecast, thus showing how the 'traditional' skill score falls rapidly from wk1p to wk4. One criticism with the red line being so high is the presence of the residual effect of climatology among the correlated fields. To remove this effect from the red line, we further remove the 'climatology difference or tendency', - that is the climatology of the future verifying period minus the climatology of the previous 7 day mean - from the correlated fields. This result is shown in the green curve, which is below the red line. Forecasts for weeks 3-4 mean as departures from 'previous 1-day mean' (purple) are also shown. The correlation skill of the forecasts, if thought of as departures from previous 7-day or 1-day means, is quite high. It is hoped that this kind of guidance will be useful to public and industry alike.

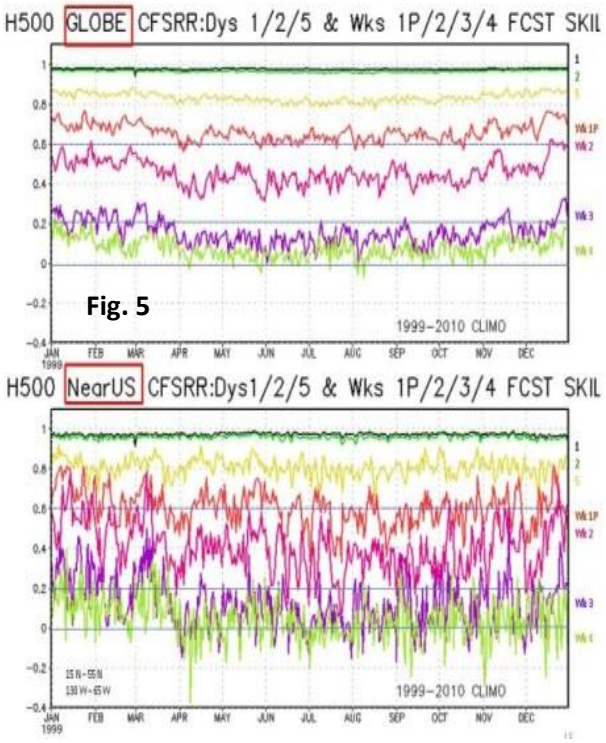

Fig. 5

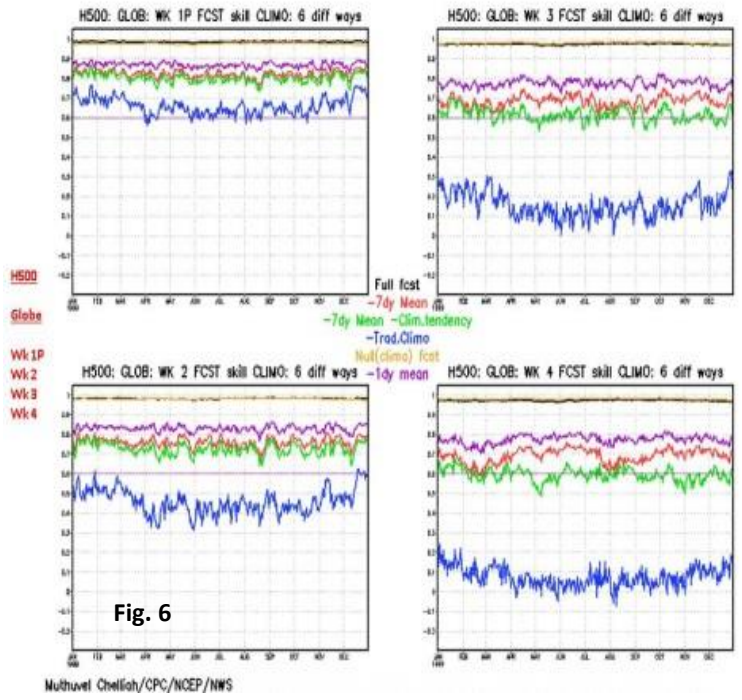

Fig. 6

3. Summary

At present we do not have any official forecast products (or even guidance) in the weeks 3-4 time frame. Based on the traditional anomaly (from a long term climatology) correlation skill metric, the forecast skill of operational models have remained very low (below 0.2) over the past 2-3 decades in spite of great improvements in other weather and climate prediction. Weeks 3-4 period is neither weather nor climate. This study proposes that we think differently about issuing weeks 3-4 forecast guidance to the public. Instead of treating weeks 3-4 as "climate" by evaluating the forecast anomaly as departures from some long term climatology, and then computing the correlations, which stil remains low, it is suggested that we treat the anomalies of weeks 3-4 as departures from most recent 1-day or 7-day means, which people are most likely to remember. In other words, we forecast the 'tendencies'. These tendencies in weeks 3 and 4 have much higher skill (~0.6 or higher) throughout the year even after accounting for and subtracting the "climatology tendency". It is hoped that forecasts for weeks 3-4 presented this way, will be useful to the public and industries alike.

References

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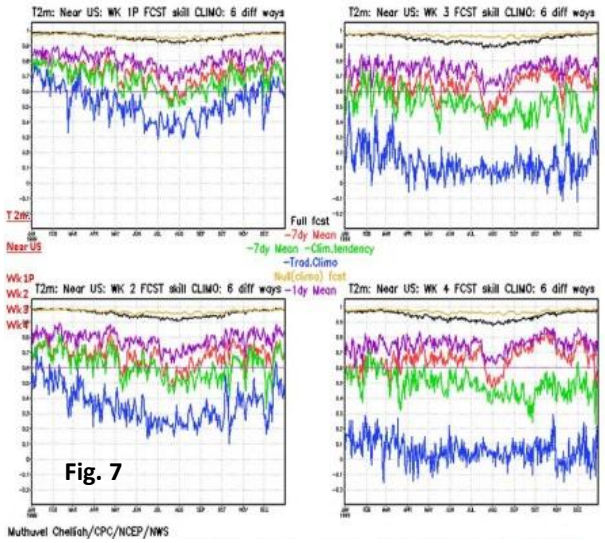

Fig. 7