SR SSD 2003-08
4/2003

Technical Attachment

Tips for Preserving Meteorological Consistency in Gridded Forecasts

Jeffrey M. Medlin
Weather Forecast Office
Mobile, AL

1. Background and Motivation

Since the introduction of the interactive forecast preparation system (IFPS) into the real-time forecast operations at WFO Mobile in the summer of 2001, the forecast process has seen major readjustment in order to meet new workload demands. By far, the top challenge has been to manage time effectively while simultaneously maintaining the scientific integrity in the forecast process.

For those making gridded forecasts for the first time, the process may appear cumbersome and will certainly result in one spending less time in the actual forecast process and more time performing the mechanics required to generate forecast grids. The key to solving this problem clearly revolves around the individual knowing the difference in model types (i.e., their construct), recent model performances under various situations, and how each model can be used to accomplish the task at hand with respect to populating individual forecast elements as a starting point. Once that has been accomplished, the remaining task is understanding how to best make further edits to individual forecast grids in a manner that is both time-efficient and as scientifically sound as possible.

The purpose of this paper is to provide potentially useful tips for preserving meteorological consistency while making meteorologically sound gridded forecasts. It is felt that a simple statement of these methods may assist surrounding offices as well as our own, and foster further sharing of ideas among offices. These methods have already been proven to provide both in-house guidance to veteran forecasters as well as to serve as a starting point for those making gridded forecasts for the very first time. These methods are merely suggestive, and by no means, is there any advocation that they are the only approach that should be considered.

2. Starting Point and Grid Generation Process Overview

In this section, a general description of the forecast methodologies used to generate various weather element grids is provided. We start our overview of the process of grid generation with a brief discussion on generating weather grids. Once the forecast process has ended (mentally assimilating observed and model data using the forecast funnel approach), the weather grids are first prepared. It is felt that since the weather type and duration affect other variables (temperature, for example) when it occurs, all other forecast elements must conform to the weather grids in space and time. As a result, at WFO Mobile we strive to generate the weather grids first. The beginning and ending time of the weather actually reflects the actual time the weather is expected to start and stop. A simple example would be that if one were forecasting widespread long-duration rainfall tomorrow over a given set of zones, then the surface temperatures should be lowered to remain meteorologically consistent with the resulting opaque cloud cover and the evaporative cooling effects of the rainfall.

Next, 12-hr probability of precipitation (PoP) grids and sky are then generated to fit the weather grids in space and time. Maximum and minimum temperature grids are created next, followed by surface temperatures, surface dewpoint temperatures and surface winds. After one knows the precipitation type, location and timing (all found in the weather grids), one can then focus on generation of the quantitative precipitation forecast. Finally, derived forecast elements (e.g., heat index, wind chill and relative humidity) are then generated using GFE Smart Tools. The next section provides a brief description of the general forecast methodology that is necessary in order to produce each of the required forecast elements.

3. Individual Forecast Elements

After having prepared the weather grids (discussed above):

- **Weather, 12-hr PoP and sky -** *In combination with the weather grids, it is evident that generating these grids has now become the most important part of the forecast process, thus placing emphasis on the role and need of human involvement.* Below are some points to ponder when generating these grids.

  - General strategy - Have one! In most cases, these grids are deeply interrelated. Thus, there should be a direct 1:1 correspondence with the weather grids (except in cases of non-precipitation weather events) through space and time. To begin, very detailed weather grids are drawn which start/stop at the actual hours of expectation. In between, one will find long blocks of "no weather" that may cross several forecast periods. WFO Mobile forecasters make many small zone groupings before running the text formatter. This way, the detail that was previously provided in the graphics is better represented in the text formatters after the averaging process takes place in both space and time (e.g., showers ending by mid-morning for a subset of zones).

  \- **Models** can assist the forecaster by providing the general timing of these events (through population of select model fields). *However, the meteorologist must make the final necessary spatial and temporal adjustments, while more importantly, determining the type and magnitude of these events.*

  - Weather and PoPs - *Our best success in achieving the maximum amount of meteorological consistency comes when the PoPs are derived* <u>*after*</u> *the weather grids have been generated.* This occurs as one carefully draws precipitation areas for a single grid in time, then afterward derives PoPs from the spatial weather contour (e.g., scattered [or chance] precipitation will be assigned 30, 40 or 50%). This action forces the PoP grid to match the weather grid according to assigned weather type. Finally, one is then left with the task of assigning the intended PoPs (e.g., 30, 40 or 50%) to the desired area using the GFE edit area functionality. As a final step for the sake of consistency, the PoPs should be compared to guidance, because eventually the Coded City Forecast (CCF) will be derived from the grids and out to seven days.

- Sky (or percent opaque cloud cover) - *Due to the aforementioned interrelationship between clouds and weather, we assign clouds to match the location and movement of previously assigned weather.* It should be stated there is currently no Smart Tool, and likely never will be, that reasonably forecasts the correct percentage of opaque cloud cover through seven days for all areas at all times. Thus, the forecaster must think through this element in time, applying meteorological consistency when and where necessary, while simultaneously remaining within the bounds of the science and realizing that certain values of percent opaqueness ultimately determines the final sky condition description in the text portion of the Zone Forecast Product (ZFP).

- **Temperatures - (Tmax, Tmin and T) -** As previously mentioned, surface temperatures should consistently reflect the effects of clouds and precipitation. In general, we start the process by forecasting the maximum (**Tmax**) and minimum temperatures (**Tmin**) through time. Next, these grids are copied into the actual (**T**) weather element hour corresponding to when those temperatures are expected to occur. Once copied (e.g., tonight's min temperature occurs at 0800 UTC), we then strive to move (both directions in time) as far away as possible from this point in time until we feel meteorologically uncomfortable proceeding any farther. To further elaborate, perhaps the min temperature remained constant between 08-12 UTC. That represents four additional hours of 1-hr grids which can be legitimately copied into their correct location in time. Interpolation is then used to fill in the time gaps at other points in the diurnal heating and cooling cycle. Before the final interpolation process, for the 1-2 hours surrounding the Tmax and Tmin grids, you may just need to adjust the temperature grids up or down a bit to represent slower and/or more rapid temperature rises or falls. In any event, WFO Mobile has found that filling in the grids with what you can comfortably forecast is better than leaving an interpolation scheme to its "non-meteorological" vices. Additional tips follow.

- Starting point for Tmax and Tmin- Model Output Statistics (or MAV) derived from the Global Forecast System (GFS) is used as a starting point, along with the meso-Eta physical solution 2 m surface temperature over water areas (as the latter retains a more accurate natural thermal gradient compared to the coarser cooler MOS). Keep in mind the lowest layer of the GFS (MRF) is at 1000 mb, not the surface. So, the actual temperatures are likely to be warmer and wind speeds a bit slower. The Nested Grid Model (NGM) MOS has proven to be of little use compared to the MAV due to its lack of MOS sites (used in the interpolation process) and its overall poorer performance when compared to the GFS MOS (MAV).

- MAV MOS versus direct model output - Sometimes the MOS surface heating and cooling curves appear "dampened" when compared to direct physical model output. Cases have recently been found under locally dry deep-layer tropospheric conditions where the MAV MOS (presumably due to this "dampening effect") was found to be too cool for the max temperature and too warm for the min temperature within a 24-hr period. By contrast, the direct model output of the Eta 2 m temperature captured the higher amplitude max and min with more accuracy (even when compared to its own MOS). The most important point is that the direct model output is worth a look under some situations and the key is knowing how models behave under various synoptic conditions within the local forecast area.

- *MatchMOS* - Not long after the above problem was discovered, a GFE application *(MatchMOS*, Barker 2003) was discovered and installed which adjusts MOS point forecasts to a given model's physical solution. This effectively allows the more accurate heating and cooling curves provided by the direct model output to be combined with the MOS for ease of comparison. This could fundamentally serve as a tip-off for when both solutions may need to be blended to ensure the most accurate forecast.

- **Td -** Similar to the above mentioned process, when T = Td, go ahead and copy these grids to where you know they belong (such as near 1000-1200 UTC on most days), especially where the maxima and minima exist, prior to interpolating. Like T, much research is still needed on which model has the lowest mean error for Td by season and by base-state wind regime. We have found recently (March 2003) that the Eta surface dewpoint temperature forecasts appear too moist, while both the GFS physical and its MOS (MAV) exhibit lower MAEs.

- **Wind -**

  - Direction - Model surface (or near-surface) wind directions are just a reflection of the synoptic position of fronts, cyclones and anticyclones within the model. Thus, if you agree with the placement of the aforementioned features in a given model, accepting the wind direction should not be a problem (unless some mesoscale process is at work, but with the exception of topographically based features such as coastlines, that would be difficult to assess days in advance).

  - Speed - Some adjustment of surface (or near-surface) wind magnitudes will likely be needed, especially over the marine area. Again, the best way to solve this problem is to keep up-to-date verification on which model produces the lowest mean absolute wind speed error by season and time of day, and by certain synoptic regimes (e.g., post-frontal).

4. Additional Considerations

Although not explicitly mentioned in Section 3, there is a point in time when a forecaster must exclusively use the GFS (MRF) for generating all forecast grids. In order to maintain further meteorological consistency, WFO Mobile has generally elected to change the Day 5-7 forecast, once a day (on the day shift), unless significant changes in fronts and their precipitation patterns become very evident. There is no shortage of creative efforts - both within the NWS and by the academic and research communities - to manipulate model output and develop Web-based displays and tools to assist with such interpretation. At WFO Mobile we use a "d(PROG)/dt" approach based on MRF

MOS Tmax, Tmin and PoPs trend images located on the Pennsylvania State University Eyewall home page (*http://eyewall.met.psu.edu/*). Using this site, one can easily assess the latest MRF MOS trends at a glance (e.g., warming and moistening or cooling and drying) for specific locations. The latter has direct applicability to operations by serving as a basis for extended range grid edits.

Finally, the author wishes to draw attention to the plethora of Smart Tools and Procedures that have been developed in order to generate derived weather elements. While it is an excellent idea to have a Smart Tool repository (*http://isl715.nws.noaa.gov/STR/printbylang.php3*) as a computer code resource, it is felt that before a certain script is officially adopted locally, it should undergo rigorous regional and local scientific testing to be sure the code is being applied in a manner that is consistent with both the climatology and local meteorology of any given region. Thus, it is advocated that at a minimum, surrounding offices should come to a mutual agreement of which tools to use, especially when surrounding areas of responsibility are similar geographically and topographically.

5. Conclusions

Several useful tips for preserving meteorological consistency while making gridded public forecasts have been presented. It is felt that sharing these may potentially assist surrounding offices, as well as our own. They represent suggestions only, but they have been developed and tested with an eye toward consistency with a sound and scientific forecast process.

6. Acknowledgments and Future Work

The author would like to thank various members of the WFO Mobile forecast staff for providing helpful comments and suggestions that have served to improve both the methods used to prepare routine forecasts and this manuscript. It is the intent of the author to provide such direction in the areas of IFPS marine and fire forecast methodologies in the near future.

7. Reference

Barker, T., 2003: MatchMOSAll, version 1.4. NOAA - National Weather Service Smart Tool Repository, **Application** # 355. *http://isl715.nws.noaa.gov/STR/printbylang.php3*.