Recommendations & Comments for the IFPS Science Steering Team (ISST) Regarding How NCEP Centers Should Support WFOs in the Digital Forecast Process

Scope: How should NCEP Centers support WFOs in the digital forecast process.

A) NCEP Overview

Most products issued by WFOs are derived directly from the grids in IFPS and with the recent development of the Graphical Headline Generator (GHG), long fused warnings can now be generated. While these efforts have provided forecasters with better tools and techniques for NWS product generation, there are numerous deficiencies because many products used by forecasters can not be effectively imported into or used in IFPS. This includes NCEP products like MOS, weather outlooks, and medium range guidance. In recent years, NCEP has provided new and experimental products, but few of these new products were designed specifically for use in IFPS. This document will recommend additional improvements that can be made by NCEP, with **the overall recommendation that NCEP begin to provide products that can be used directly in the digital forecast process.**

B) Model Guidance (EMC)

- EMC should produce the best **Analysis of Record** (AoR) grids using all available, quality observational data sets. Analyses should be performed with the same spatial and temporal resolution as the NDFD, and evolving national verification requirements. These grids could also help focus currently limited resources on further IFPS development and reduce the amount of coordination needed between offices. Observations are the legacy of the NWS, and all efforts should be made to begin development of the AoR grids as soon as possible.

- EMC should support WFOs in the production of an **Analysis of the Moment** (AoM) set of grids. These grids would be used to continually update and validate the first period of the forecast. AoM grids should be retained locally for potential use as **persistence grids** and/or to develop **conditional climatology grids**.

    - Efforts to develop the AoM set of grids should leverage regional and local efforts which have already occurred. For example, efforts in Western Region between the University of Utah and WFOs have resulted in a regional analysis of several parameters utilizing all available local

mesonet information. This data is already being used at the local level for rudimentary verification, persistence forecasts, and development of conditional climatologies. A more robust real-time AoM would better support these needs. These grids might also be useful as a first-guess analysis toward the AoR.

- A team comprising field representatives from each region along with NCEP representatives (both modelers and data distributors) should be formed to **identify the optimal *suite* of model guidance** for the support of the watch, warning, advisory program and the digital forecast database within the limited SBN architecture.

    - Due to the procurement of faster supercomputers, a change in the EMC modeling system to the WRF model and continued limitations with the SBN, this is an opportune time to optimize the model data flow to the field in support of the watch/warning/advisory and digital services programs.
    - Rather than relying on WFOs to use valuable resources to subjectively remove model bias from model output and return detail to degraded resolution data sets using crude tools, EMC should examine ways to provide WFOs with bias corrected sensible weather grids that are *directly applicable to IFPS*. For example, providing a Sky grid derived from full resolution bias corrected model output, including output from the cloud model, would be much more valuable than providing every model level relative humidity field at full resolution to forecasters to try to construct a Sky grid themselves using a variety of techniques at the local level. WR realizes that this effort may take years to develop for all IFPS fields, and suggests that Sky and Temperature could be two good choices for initial EMC efforts in this regard.
    - While providing WFOs with model guidance in its native resolution is important, there is likely an optimal mix of lower resolution synoptic scale fields and native resolution surface and near surface fields that would provide the best data for the field, while allowing EMC to also provide IFPS applicable bias corrected sensible weather grids within a limited SBN architecture.
    - EMC should provide useful verification statistics on the accuracy of their model output to enable forecasters to know which models are performing best in *sensible weather* elements.

- EMC should provide **the optimal mix of ensemble data** to the WFOs.

    - EMC should provide a subset of medium range ensemble model fields for ingest into AWIPS. By simply substituting hours 108-192 for the currently available 0-84 hour ensemble data in AWIPS, this need would be supported without negatively impacting the current SBN transmission. If room exists on the SBN, then hours 84-192 would be transmitted to provide offices with the full ensemble period of Days 3.5 through Day 7.

- To support the short range period, a subset of SREF fields should be provided on AWIPS. The team mentioned above could define which fields would be most useful to the field.
- EMC should provide useful ensemble mean sensible weather grids for the direct support of IFPS. Ensemble mean forecasts have been shown to be more reliable for the medium range timeframe, and until probabilistic functionality is added to IFPS, having ensemble mean sensible weather grids provides better guidance to the field and a better service to the public than the one deterministic operational model run currently available.

- EMC should identify the **optimal operational suite order** to provide the best model data to the field, be it raw model output or statistically processed bias corrected sensible weather grids.

  - With the recent purchase of a new supercomputer, this is a good time to reexamine the model suite order and priority. Now that the operational models are being run up to four times a day, the need to have high resolution model data available as quickly as possible for the 0000 and 1200 UTC run times is not as urgent. Additionally, with a digital database that should always be current, this need is also diminished. Testing should be undertaken to identify the benefits and limitations of running the global model prior to the high resolution model. One solution may be to start the global model at the data cut-off time and start the high resolution model soon after allowing them to run in near-parallel, allowing the high resolution model to benefit from the global model boundary conditions.

- EMC should support the WFOs in **running local versions of the WRF mesoscale model** focused on the 00-24 hour time frame.

  - The intent is to improve the Day-1 forecast and keep it well-maintained (especially for impact weather or extreme event situations). The flexibility with utilizing local models to address local issues requiring high resolution data that cannot be supported nationally, such as high resolution fire weather spot forecasts, is important. Additionally, this could also be utilized as a local research and training tool, and allow local offices to partner directly with the research community for further improvements to the WRF model. There is a legitimate role for local modeling, and a role for EMC in support of such an initiative.

C) Storm Prediction Center (SPC)

SPC already produces valuable, graphical, short-range (days 1-3), and probabilistic thunderstorm and severe thunderstorm forecasts. All of these are posted to the SPC website, AWIPS, or both. We believe that given the evolving IFPS and NDFD framework, **all of these current operational products should also be converted to digital form and exported to IFPS.** They could then be used by customers, partners and

even WFOs to add value to their forecasts (i.e., in the case of WFOs, setting minimum probability thresholds for when thunderstorms and convective "heightened wording" hazards such as large hail, damaging winds, or tornadoes should be included in their "Wx" grids).

Given the "state of the science" and taking resource availability into consideration, we do not believe SPC should be tasked to provide long-range (days 4-7) thunderstorm and severe thunderstorm guidance to field offices. On March 8, SPC began to supply a graphical Day 4 through 8 severe thunderstorm forecast, although just for the period as a whole and not the individual 24 hour blocks. Because of this, this new forecast product from SPC does not lend itself well to the IFPS framework at this time, although it clearly serves other planning purposes outside of IFPS.

All SPC convective watches, and updates to those watches, should be easy to convert into digital form. These products are already issued with lat-long coordinates. Once SPC issues a watch or updates a watch, customers and WFOs could use the discrete watch polygon grid to determine where to include heightened wording in their "Wx" and "Hazards" grids.

To summarize, we recommend that SPC provide the following products (already issued by SPC) in digital form to IFPS before the end of this FY or beginning of FY06:

- Day 1 probability of thunder, large hail, damaging wind, and tornado outlooks (issuance time to 12Z following day)
- Day 2 probability of both "general" thunderstorms and "all severe" thunderstorms in one 24 hr time block, 12Z Day 2-12Z Day 3
- Day 3 probability of "all severe" thunderstorms in one 24hr time block 12Z Day 3-12Z Day 4
- In addition to the county-based WCL and WOU products, issue watch polygons and watch polygon updates in digital form (issued as needed, with grid length dependent on the valid watch time). This will allow WFOs with large counties to subdivide watches to smaller zones.

We also propose that since Day 3 severe thunderstorm probabilities are already generated, it is highly desirable that SPC also begin to issue Day 3 probability of "general" thunderstorms. This would naturally be in digital form and would be included in the Day 3 outlook currently issued once a day.

SPC has begun to issue experimental 12-hour probability of thunder outlooks (posted on their website). These are in 12Z-00Z and 00Z-12Z time blocks at Day 1. As soon as these become operational, they should be provided in digital form.

In the next 2-5 years, as the state-of-science advances, we anticipate that SPC's skill will increase in both their Day 2 and 3 forecasts such that probabilities of hail, damaging wind and tornadoes will be generated. **When these, or any other future products, are**

created and become part of the SPC official suite of products, they should be converted into digital form and made available in IFPS.

D) Tropical Prediction Center (TPC)

TPC currently produces short-medium range guidance regarding intensity and track of tropical systems in the Atlantic and east Pacific basins. For example, TPC issues initial wind grids based off their Atlantic tropical cyclone advisory messages (TCMs), through Day 5. WFOs along and near the Gulf and Atlantic coasts then have the option to modify these initial grids based on local terrain effects. Although tropical cyclone strike frequency over the southwest United States is much lower than what occurs along the Gulf and Atlantic coasts of the south and east United States, previous southwest United States tropical cyclones, such as Nora (1997) and Lester (1992), have caused considerable higher elevation wind damage, even hundreds of miles from their point of landfall. Therefore, we recommend that TPC also provides initial wind grid forecasts for eastern Pacific tropical cyclone/storms via the GFE. In conjunction with the wind grid forecast support, strike probability and wave height forecasts should also be provided to field offices via the GFE.

We recommend that TPC (and/or their research partners) strives to provide the field with a GFE-based SmartTool which would allow forecasters to scientifically enhance tropical cyclone associated winds in mountainous terrain and reduce winds in sheltered/valley locations. This SmartTool could then be used by all offices, thus reducing wind forecast discrepancies along WFO boundaries.

In summary, we recommend that TPC provides the following products in digital form to the GFE before the end of the present FY:

- 6-hour surface wind guidance, out to 5 days, based on TCMEPx messages, on any tropical depressions, tropical storms, or hurricanes forecast to approach the western U.S.
- 6-hour wave height forecasts as issued

In the longer term, we expect that 6-hour probability plots depicting strike probabilities (indicate the likelihood that the center of a tropical system will be within a certain number of nautical miles of a given location) will be available in digital form. As this comes on line, they should concurrently be sent to WFOs in digital form.

E) Hydrometeorological Prediction Center (HPC)

- HPC should continue creating the best set of day 4 through 7 guidance grids (temperature, POP, dew point, cloud cover, and weather) at 5 km resolution at 6 hour frequency using all data at their disposal.

- WFOs can spend an appreciable amount of time creating day 4 through 7 grids. This is especially the case for days when the GFS/DGEX, the primary medium range model data available in AWIPS and IFPS, are considered poor solutions. In these instances, WFOs are left creating grids from scratch, drastically modifying model fields, or editing previous forecast grids. Since HPC is able to incorporate several medium range models, including ensemble data, in their forecast process, HPC grids may serve as a good starting point for WFOs. Each WFO can then add value to those grids based on their own local knowledge and research.

- HPC should put a greater emphasis on improving the quality of their grids through verification and research rather than creating additional grids or grids with greater temporal resolution.

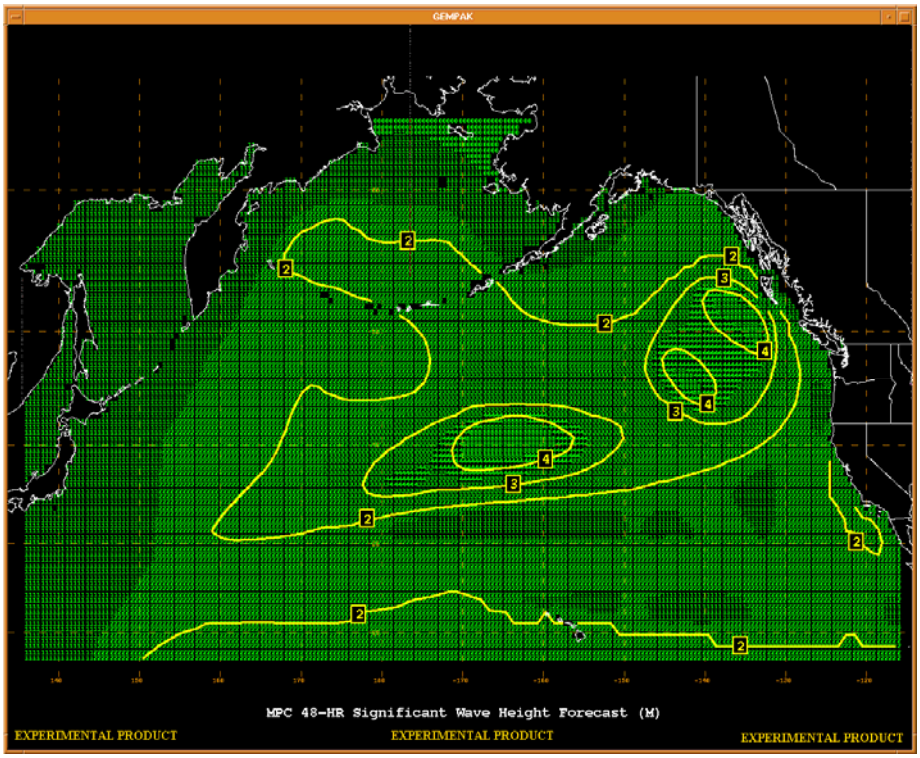
    - While HPC grids have the potential to be more accurate than the model data available to WFOs, there will still be deficiencies. For example, HPC may have the ability to create fairly accurate surface pressure fields, but the derived wind field which assumes geostrophic flow can be erroneous, especially in and around complex terrain. Gridded verification efforts along with other research efforts will help identify and improve upon these types of deficiencies.

- HPC should investigate ways to create grids at 2.5km resolution and make them operational in FY06.

    - While the NDFD only requires grids at 5km resolution, many offices are producing 2.5km grids to meet their local needs and customers. The 5km grids HPC is currently producing is not sufficient for these offices.

F) Ocean Prediction Center (OPC)

- OPC needs to get into grid production – especially for the offshore waters (~ 60 to 250 nm offshore). It appears some initial experimental work was done along these lines a couple of years ago, as OPC has posted to its web page some sample experimental gridded wave height and swell period forecast products from an initialization date of 25 June 2002 (and which presumably includes their subjective forecast input and isn't simply Wavewatch III model output) -- see http://www.opc.ncep.noaa.gov/grids/index.html



as well as some experimental gridded scatterometer winds for 17 February 2004 – see http://www.opc.ncep.noaa.gov/grids/data/index.html

The sample wave grids are at a resolution of 0.5 ^{o}lat by 0.5 ^{o}long, while the gridded scatterometer winds are at a resolution of 0.33 ^{o}lat by 0.33 ^{o}long. From the OPC web page, it appears that the gridded scatterometer wind product (but not the gridded wave products) is still being produced in real time.

Thus, a first recommendation is that these grids be generated in real-time and in AWIPS-compatible netCDF format, and added to the SBN data feed. OPC also needs to develop a procedure to downscale the above grids to the resolution of the IFPS forecast grids.

- At a minimum, following on the above, OPC needs to issue a gridded version of its offshore (PZZ) waters forecasts, to be included in the SBN data feed. This would enhance coordination between the gridded marine zone forecasts issued by the individual WFOs and the OPC offshore waters forecasts.

- Each of the leading component individual wave sets is needed from the Wavewatch III model output – not just the combined (total) sea height and swell direction which is all we're now receiving. Many coastal offices separate out primary swells, secondary swells, and wind waves in their gridded marine forecast products, and thus need the individual components.

- Assistance is needed from OPC in developing and implementing techniques for reasonably populating the swell height forecast grids in the nearshore waters. The only wave model presently available to forecasters is the Wavewatch III – currently run at a comparatively coarse 25-km resolution and known to be inadequate in the near-shore region. New models need to be developed and operationally-implemented that have much higher spatial resolution, that enable input of mesoscale coastal water wind features, and that incorporate wave-sea floor interactions. The **S**imulating **WA**ves **N**earshore (SWAN) model appears promising in this respect – as indicated by recent experimental implementation at 3 coastal WFOs (Eureka, CA, Jacksonville, FL and Portland, OR).

- The capability of forcing the wave model with forecaster derived wind grids is needed. At present, forecasters cannot choose which wind model(s) drive(s) the wave models, and they cannot modify the wind fields that are used in this regard. Thus, forecasters are currently left without gridded output from wave models to make direct use of unless they agree with the particular wind model solution driving the wave model – leaving them without recourse aside from antiquated manual methods in developing their gridded wave forecasts.

- OPC should provide probabilistic forecast guidance (in gridded form) of likelihood of exceeding critical thresholds with respect to wind, wave height and coastal surge height.

- OPC should pursue acquiring and then suitably processing (downscaling and converting to AWIPS netCDF format) U.S. Navy (FNMOC) Wavewatch model forecasts and Canadian wave model forecasts.

- OPC should pursue development of IFPS compatible gridded climatological analyses of wind and wave conditions in the coastal waters.

- OPC should develop gridded statistical wave guidance (similar to gridded MOS).

- OPC should continue work towards implementation of a high-resolution Great Lakes wave model.