26 July 2004

A Brief Report to the IFPS Science Steering Team (ISST) on Comments Regarding the Optimal Resolutions for Scientifically Valid Products and Digital Services

Task: A short-term focus group of National Weather Service (NWS) Southern Region (SR) Science and Operations Officers (SOOs) was to respond to the following question:

"Within the limits of predictability, what are the optimal spatial and temporal resolutions needed to provide a useful and versatile digital service while maintaining scientific validity?"

These solicited responses, recommendations and conclusions will be sent to the SR and eventually National ISST Representatives for review.

Description of Responses: This focus group is comprised of five SR SOOs who solicited, gathered and synthesized the responses. Each team member provided independent responses that were found to be in-depth, unique and well-thought out. Some of the team members solicited input from other NWS Meteorologists (referred to as 'respondents') who also have experience generating digital forecasts. ***Attachment A*** provides additional valuable concerns and responses for which this report would not be complete without mentioning (***Note*** - *In the interest of time, peripheral sidebar discussions on non-related topics were not included in this report*).

Main Response:

Optimal Spatial Resolution – ***It is unanimously felt that there is no simple answer to the posed question given the number of scientific complexities*** (to be revealed)***. It should be stated 'up front,' that each team member felt that the spatial resolution of 2.5 km has already increased beyond what is scientifically valid.*** Fundamentally, most argued this point based on the minimum resolvable wavelength issue (recall you need at least 3 points to define a wave in space and one should never attempt to subjectively analyze an inflection point any less than two times the average distance between stations). If we cannot measure\observe it, then how can we forecast it? This problem is further compounded by the fact that the humans live within the boundary layer where our current observing network struggles to accurately capture the thermodynamic and kinematic processes that occur. Moreover and on the topic of the 'optimal spatial resolution', one team member stated, *"Changing the spatial scale (temporal scale) in meteorology below 10 kilometers (several hours) is not the same as reducing it below 100 kilometers. (I recommend rereading chapters 2 ,4, section 6.2, and especially 9.6-9.7 of Holton 1992)"* And on the very same subject of scientific validity but from a different point of view, another team member stated, *"To estimate from values within a known*

range by assuming that the estimated value follows logically from the known values is not the case in GFE . It does not know land from sea or wheat field from forest, but it will still "extrapolate" 1024 grids at 2.5 km resolution from 4 points fed into it from an 80km AWIPS grid and no matter what, there is no way to replace mesoscale features resolved by the original model or really accurately adjust data for 2.5 km topography from such a gross, extrapolated point of departure." The latter responses certainly capture the overall tone and essence of the entire group response. Most importantly, ***none of the team members felt that we should be using 2.5 km as the optimal spatial resolution through Day 7 and for all parts of the United States.***

The general response to this question also revealed that a dilemma exists. It is felt strongly by some that this issue will one day have to be addressed before 'Digital Services' fully matures. ***The dilemma is that if we wish to depict terrain effects and evolving mesoscale features such as the sea-breeze to the public, then we must have the ability to resolve and have these show up in those graphics designated for public consumption.*** Taking the liberty of thinking outside of the box for a moment, this thought brings up the notion of having: **1)** graphics for public consumption and **2)** graphics that we verify internally with much lower resolution but with higher scientific validity *(I can say that the responses vividly pointed out the fact that gridded verification is seriously flawed without adequate 'ground truth' observations. As team leader, I opted to deliberately keep the discussion focused on the question at hand and not verification for which there are other focus groups)*. On this point, two respondents felt that we should use 1.25 km horizontal resolution for the public graphical forecasts, and another respondent stated that we should use 2.5 km to accomplish this task..

Other related responses include: **1)** the fact that we do not have adequate tools to continue producing graphics at 2.5 km spatial resolution, **2)** that each Weather Forecast Office (WFO) should be allowed to decide the best spatial resolution for it's customers given both varying terrains within individual county warning and forecast areas (CWFAs) and frequently evolving mesoscale forecast phenomena, **3) that we should begin with the lowest horizontal resolution in Day 1 and decrease that resolution proportional to the increase in forecast error until we are ultimately forced to use a probabalistic approach beyond Day 4.** Two team members and one respondent argued this point directly and one team member indirectly.

Finally, every team member conveyed that we also need to more closely consider an optimal resolution for each of the forecast elements (ie.. a surface dew-point field may at times may be more spatially homogeneous than the surface temperature field).

Optimal Temporal Resolution - ***Overwhelmingly, the vast majority of the discussion was centered around the limitations associated with the current spatial resolution. From this, the temporal limitations are implied.*** One team member felt that we are currently probably doing the best that we can given what we have to work with, (which means, they do not wish to see increased temporal resolution requirements beyond the current). This team member went on to say that even trying to resolve large scale

systems with a minimum resolution of 6 h can often be 'pie-in-the-sky' in the later periods. A respondent recommended that we should use 3 h resolution through 72 h and increase it to 6 h resolution beyond. Yet another respondent felt that we should use 1h resolution through 24 h, 3 h resolution from 25-72 h and either 6 or 12 h resolution beyond.

Conclusions and Recommendations:

- ❑ Unfortunately, there exists no simple answer to the posed question given the scientific complexities that exist in both resolving mesoscale phenomena and representing complex boundary layer kinematic and thermodynamical processes (**5/5 team members independently stated**).

- ❑ Discontinue using 2.5 km horizontal resolution as 'one size fits' all across the entire county. It is beyond the limits of scientific validity. But rather, allow each WFO to decide for themselves a scientifically valid spatial horizontal resolution given the terrain that exists and mesoscale phenomena that occur within each county warning area that is served (**3/5 team members independently and directly stated**).

- ❑ Allow spatial horizontal resolution to decrease proportional to increasing forecast error (**5/5 team members provided independent points that support this argument**).

- ❑ Once beyond Day 4, use a probabalistic platform to convey the forecast to our users (**3/5 team members independently stated**).

- ❑ Regarding the 'dilemma,' **one team member and two respondents felt** that there should perhaps be a set of internal grids (lower resolution) that we use to produce gridded verification and a set of external grids that would be sent to our users (higher resolution). For verification purposes, the former should take into account the number of observations located within any WFO's CWFA. The latter should be of the highest resolution possible so that our users can more easily visualize the effects of terrain and evolving mesoscale phenomena such as the sea-breeze (of course, realizing that some science fiction may be involved) on the forecast.

- ❑ Regarding an 'optimal temporal resolution', similar arguments apply as to why we have come too far too fast. **Most team members conveyed** that we should obviously decrease temporal resolution with increasing time, as we currently practice. **Two team members and four respondents suggested** that we should adopt the following: 1 h resolution through 24 hours, 3 h resolution between 25-72 h and 6 h resolution beyond 72 h..

Other Related Issues of Importance:

- *Two team members are wondering why we have been asked to provide this feedback since the announcement has already been made that the National Digital Forecast Database (NDFD) will become official as of 04 December 2004 at 5km resolution, and the recently published "NWS Digital Services Operations Concept" (June 2004) makes it clear that higher resolution is anticipated in the future. This is a legitimate question that we wish to put to the highest levels of ISST on behalf of our group. Does ISST seek to reverse these actions?*

- It was found that all team members felt that providing the nation with digital services was necessary in this day and age. However, most team members felt that the 'full speed ahead' approach without proper testing and refining was causing a serious loss in scientific validity of the products (this was especially being perceived by the employees who produce them, ie.. the forecasters).

- Simply, do not create more grids than we can reasonably quality control. How can we be responsible for what we cannot see?

- Attachment A -

- **On Spatial Resolution and Considering various Forecast elements:** *"We need a national high resolution SST dataset to properly do the coastal waters forecasts of wind and seas, air temperatures over the water, and as input to our future "Smart Tools" for the land temperature forecast for easterly (Atlantic) and westerly (Gulf) flow. Located within 100 kilometers of our coast (in our marine zones), the Gulf Stream/Florida Current is known to greatly impact wave height...but we don't know exactly where it is along the Florida and Georgia coasts on a daily basis, even during the winter months, when its impact is a maximum.* ***So how do we produce responsible wave grids a 5 kilometers (or 2.5)? That wave height differential of three feet could kill someone in a fishing boat****. Thanks to the NOAA Coastal Storms Initiative, at least we now have one offshore buoy to aide our forecasters and their 150 miles of coastal waters...but what about Miami and Key West, who have none?"*

- **On Spatial Resolution:** "*We know we have favored topographic locations for heavy rain events and tornadoes...though we can't prove it...that would require a GIS database within AWIPS. Having a 2.5 km grid resolution at hourly intervals only frustrates us because we do not have the tools we know that we need to forecast (or even build a climatology) at this spatial and temporal scale.*"

- **On Spatial Resolution:** "*This question has no single, simple answer, and is flawed by the apparent assumption that the GFE grids we are currently producing for digital service have some scientific validity as they are. As I have mentioned several times, to my knowledge, this has never been demonstrated. (later) ...Even the information the NWS is providing on "What is a Point Forecast?" never states that the NDFD point forecasts are either accurate or scientifically valid, only that they are "extrapolations*".

- **On Adequate Tools to Do Our Job and Going Too Far, Too Fast:** *"For hardware, we need graphics tablets to speed editing, especially for those disabled by being left-handed. No graphic artist would work on 168 grids in 8 hours without one. For software we need to be able to cut and paste a portion of the GFE grid and paste it across a time block. Think about slowing down a model front by twelve hours...so it is on the wrong side of the diurnal cycle thermodynamically, and correcting 24 hours worth of grids of temperature, humidity, wind speed and direction, seas, and sky/weather conditions. That would be a Smart Tool. So would a tool to drag a front forward 50 miles or back 50 miles...correcting all the associated grids and maintaining thermodynamic consistency. We do not have such tools. (later) ...Even if we did, the WFO and Regional bandwidth could not deliver it to the forecaster."*

- **On Adequate Tools to Do Our Job:** "*Along the same lines (the forecaster not knowing what he or she has forecast) another component is that the forecaster cannot even see a single 2.5 km grid in GFE without zooming in to the max, hence when zoomed out to the extent that the entire forecast area can be viewed (and GFE edit tools used without catastrophic results), the line drawn by the contour tool is probably wider than a grid box! How good can a forecast be when the forecaster can't even see the base spatial unit to which some "extrapolated" value is going to be applied?*"

- **On Smart Tools and Quality Control of Products we Produce:** *"And since we don't really have a means currently of populating GFE with real time observational data, attempting to repair the grids when you have 6 or 8 outflow boundaries is beyond human capability. So is really ever knowing what you forecast (at any time), since for a FA the size of ours (not really all that big, but we do have marine as well as land areas) a single quantity that is forecast for all grids, like wind, creates a little over 12.5 thousand forecasts for a single hour. Multiply that by 168 hours and you get 2.1 million. Take the whole range of parameters we are required to forecast by the IOC at their minimum temporal depth,* ***and we are producing over 10.1 million grid forecasts for a single forecast cycle. I presume it is obvious that it is not humanly possible to QC 10.1 million forecast elements, so our smart tools really better be smart."***

- **On the Use of a Probabalistic Platform:** " *I think that what the local EM's still want is a forecast more probabilistic in nature than articulate in detail. That is, they are more interested in how confident we are that something is going to happen than being able to access a digital database that has no information regarding our confidence in the data it contains. There are many ways to approach this graphically and still leave the current eye candy alone . . .*"

- **On Adjustable Spatial Resolutions:** "*We would like to see some improvements to the infrastructure that makes resolution a more flexible variable; as we noted the other day, a switch to 2.5km is not a minor endeavor in IFPS. Something that would allow higher resolution within the first few days...or easier switches depending on season (later) ...would allow us to balance forecaster workload with meteorological realities. (We realize that this isn't likely, nor would it be terribly easy to develop, but still, a man can dream :)*"

- **On the Role of those who Use IFPS in the Field and Field Support:** "*...- one solution does not fit all, and there are none more qualified than the scientists in the field to identify and resolve these issues. HQ should make all effort to help the field resolve any issue (identified by the field) before implementing a national solution that may break down at a regional level, including deployment of additional sensors or specialized modeling efforts if necessary.*"

- **On the Gridded Verification versus Public Grid Consumption Dilemma:** "*I see that we have two sets of spatial and temporal resolutions to define: one for the graphical forecasts that we share with the world, and another set by which we verify our forecast graphics. For the graphical forecasts that we share with the world . (later) ...go with the best resolution that we can given the limits of our current computing power. (later) ...This will allow us to provide the best looking graphics to the public. When we get down to actually verifying these forecasts, then we have to reduce the spatial and temporal resolution down to whatever we have to verify the data.*"