5.9 IMPLEMENTATION CHALLENGES OF IFPS AT A FORECAST OFFICE WITH COMPLEX TERRAIN

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1. INTRODUCTION

The National Weather Service (NWS) is in the process of implementing the Interactive Forecast Preparation System (IFPS) nationwide as part of the Advanced Weather Interactive Processing System (AWIPS). This deployment of IFPS will provide a new method of producing a suite of text and gridded forecast products. The development and testing of tools that make up the components of IFPS have been in the works for over a decade (Meiggs et al 1998). Until recently, little progress had been made in implementing IFPS at NWS offices with responsibility for producing weather forecasts in regions of complex terrain. Various issues dealing with poor grid resolution and text phrase wording have delayed the implementation in the western United States. However, rapid advancements in computer technology and the affordability of high performance personal computers have greatly improved the grid resolution in IFPS. Offices with complex terrain can now produce gridded forecast products at a finer resolution than what is offered by the present operational Numerical Weather Prediction (NWP) models. Grid resolutions on the order of 1 to 5 kilometers (km) can adequately depict the terrain features that influence spatial changes in weather. Although the grid resolution issue has been addressed, additional enhancements in grid initialization, grid editing, and grid sampling techniques are still required. Other issues related to human factors such as forecaster acceptance of the software and changes in the methodology of composing weather forecasts need to be addressed.

The integration of IFPS at a forecast office with complex terrain is a major undertaking and challenge that cannot be overlooked. The NWS Weather Forecast Office (WFO) in Tucson, Arizona has participated in the Rapid Prototype Project (RPP) and the IFPS alpha testing of the LINUX PC and AWIPS mixed hardware solution. This paper discusses the challenges of implementing IFPS in regions of complex terrain from a WFO perspective. It also discusses some preliminary approaches and ideas to enhance IFPS capabilities for use in the western United States.

2. GRID RESOLUTION ISSUE

The current implementation of IFPS on AWIPS has a grid resolution of 20 km that does not adequately depict the variation in terrain that can significantly influence changes in weather. In many regions of the western United States, populous areas in the mountains and valleys can fall within one 20 km square grid. This clearly poses a problem when trying to forecast for the two different areas. The mountain location might be experiencing snow and temperatures more than 20 degrees Fahrenheit lower than the valley site. In this case, the forecaster would not be able to properly describe the variability in weather contained by the 20 km grid box. For this reason, IFPS developers modified the software components to handle finer grid resolutions as part of the RPP and alpha testing. Affordable high performance personal computers running the LINUX operating system enabled RPP and IFPS alpha sites to configure for 2.5 to 5 km resolutions.

The Tucson WFO subjectively determined that the 2.5 km resolution depicted the terrain in southeast Arizona well enough without significantly sacrificing system performance and software response times. Starting in January 2000 as part of the RPP, gridded forecasts of temperature, relative humidity, and probabilities of precipitation were routinely prepared using the Graphical Forecast Editor (GFE) component of IFPS. Experimental text and graphical products were introduced at the same time and disseminated to customers via a local web site.

3. NEED FOR IMPROVED GRID INITIALIZATION

The model initialization process in IFPS is based on derived surface weather elements from several sources, including Model Output Statistics (MOS), NWP models, and previous forecasts. Gridded MOS forecasts are preprocessed from randomly spaced point data and applied to a grid using a configurable station-to-gridpoint map. Although grid points can be weighted to certain MOS sites, the present technique tends to produce rather flat fields that generally do not capture terrain features. This lack of spatial detail is of particular concern to WFOs dealing with complex terrain.

Model-based initialization grids are derived from NWP models using various physical formulae, rule-based logic, and empirical algorithms (Wier 1999). The interpolation method used in downscaling the NWP to the local IFPS grid does not try to add value objectively to the model output. However, adjustments to true surface elevation are made to provide more realistic estimates in mountainous regions. Routine experience at the Tucson WFO suggests that the Eta model post processed 2 meter temperatures and dew points adjusted to true surface provide useful first guess fields. Other model derived surface temperatures and dew points, especially from the Medium Range Forecast (MRF), are somewhat less than useful. Furthermore, predictions of surface winds in complex terrain remain a problem for larger scale NWP models which have a difficult time simulating the diurnal mountain and valley flows. Overall, the daily use of these model-based initialization grids indicates that significant enhancements are still required before the

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first guess fields can save forecasters time editing grids.

The GFE smart initialization will open the door for local and regionally developed algorithms to be used in deriving the first guess fields from NWP models. This will allow field forecasters to incorporate local climatology and rule of thumb experience in the initialization process. Certain algorithms, such as for snow level and precipitation type, will likely need to be regionally based so that consistency can be maintained across WFO areas of responsibility. Eventually, the addition of meso-scale NWP models should lead to improved first guess fields; thus, reducing the time spent editing grids.

4. GRID EDITING IN COMPLEX TERRAIN

One advantage of editing weather grids over complex terrain is that several parameters bear strong relationships to topographic elevation and orientation. These parameters, elevation, and slope orientation relationships can be used to enhance the basic grid editing tools and techniques. The GFE and model interpretation slider applications are the two components of IFPS that forecasters use to manipulate high-resolution grids. The two applications differ in how they represent terrain features. The GFE utilizes a static topography grid that matches the configured IFPS resolution. This underlying grid can be accessed through locally developed editing tools known as smart tools. The terrain grid can also be queried on-the-fly to define edit areas. In contrast, the model interpretation slider application relies on predefined geographic weights that forecasters raise or lower to adjust model thresholds (Ruth 1998). Although both applications account for terrain in different ways, they can be used to complement each other. The slider tools can provide broad brush adjustments in a time effective fashion, with more detailed modifications made using the GFE.

The GFE framework provides tools that can extend its basic editing capabilities through the use of the Python scripting language. As part of the RPP, the smart tool concept was extended to procedures that can be designed to automate some of the grid editing functions. However, the NWS has not yet put a lot of resources into developing smart tools and procedures to the level of maturity needed for a smooth transition to grid editing. Eventually, new grid editing tools and techniques will be developed through the expandable framework of the GFE.

Several approaches to grid editing that capitalize on the parameter-elevation relationship have been used successfully in an operational mode. Simple methods like editing temperature and dew point weather grids by elevation ranges have been utilized. More elaborate techniques that focus on point editing capabilities using a background field from a NWP model or climate grid to spatially distribute an element are being investigated. One such technique that shows some promise uses gridded mean monthly maximum and minimum temperatures along with a simple inverse distance squared interpolation scheme to spatially distribute point temperature forecasts. Point editing tools are currently not available in IFPS, but are of interest to forecasters that tend to key off of point data when preparing their forecasts. These potential point tools may help reduce the time spent editing grids, and ease the mind set transition from the point based approach to a more spatial oriented methodology.

5. LOCAL EFFECT TEXT PHRASES

Text products have been the NWS's primary means of disseminating weather forecasts to the public for several decades. The IFPS will continue to support the generation of text products, but eventually the NWS Digital Forecast Database (NDFD) is anticipated to become the flagship product. Until then, WFOs forecasting for areas with complex terrain will continue to have unique requirements for concise text phrases that describe the spatial variability in weather caused by geographical features. Text products that summarize the weather over mountains and valleys or beaches and inland locations use phrases called local effects. These local effect phrases help convey to the user the range or exceptions in the weather across the forecast area. For example, "LOWS FROM THE 40S MOUNTAINS TO THE 70S LOWER DESERTS" and "MOUNTAIN SNOW AND VALLEY RAIN" are considered local effect phrases.

The IFPS supports two different methods of generating text products. The primary way is through editing the Digital Forecast Matrix (DFM) which is a summary of all the gridded weather elements for a specific NWS zone or state county. The other method supported by the GFE skips the DFM editing process and generates the text phrases directly from the gridded database. Both methods require grid sampling algorithms to summarize the weather elements for a given forecast area. The GFE supports locally developed sampling and text phrase algorithms through the use of the Python scripting language. The DFM method is limited to a few sampling algorithms, but the text phrases are highly configurable through the use of Informix database tables.

The support for local effect phrases also differs between the DFM and GFE frameworks. The DFM strategy uses two matrices, one that summarizes the entire NWS zone and the second DFM for the local effect area. The current implementation does not support separate sampling of the grid points that define the local effect area from the whole zone. Rather, the forecaster is presented with a DFM that represents the entire zone, and manual manipulation of the local effect DFM is required for the desired text phrases. In other words, the local effect DFM is not initially populated with the sampling of the weather grids that define the local effect area. Future IFPS builds are expected to fix this short coming and add some flexibility to handle different types of local effect phrases for each forecast time period (Peroutka et al. 2002).

The GFE utilizes predefined edit areas for the local effects which can be sampled separately from the larger zone forecast area. Built in Python methods designed to reference edit areas by name and take the intersection or union of multiple areas can be called through text generation scripts. These Python methods along with additional text phrase methods can be combined in a fashion to create local effect phrases. For a Python programmer, the GFE text generation tools are easy to customize and extend for local use. Several text product formats including tables, phrases, free form, and combinations are supported. Simple language translators are also available for WFOs interested in bilingual products.

The Tucson WFO has implemented several standard NWS products successfully in an operational mode using the GFE text generation tools. These text products included combined phrase and tabular formatted Fire Weather Forecast (FWF), Coded Cities Forecast (CCF), and the public Zone Forecast Product (ZFP) temperature and precipitation table. During the Summer thunderstorm season, a free form and tabular Hazardous Weather Outlook (HWO) was generated with the GFE. Tabular text products are the easiest to implement in terms of configuration time and forecaster acceptance. Text products that incorporate local effect phrases such as the ZFP have been more difficult to implement. This is mainly due to the multitude of phrases used by different forecasters.

6. HUMAN FACTORS

One of the most challenging aspects of integrating any new technology is how to address human related issues. In the case of IFPS, many issues ranging from forecaster resistance to product ownership will surface during the implementation process. A few of these growing pains can be mitigated by taking the time to prepare forecasters for upcoming changes through brown bag seminars and one-on-one training sessions. A gradual approach to introducing components of IFPS may also help, but not so slow that the process drags on without any clear results.

The Tucson WFO implementation of the IFPS was unique in some respects compared to other NWS offices. Tucson approached this process by first introducing the grid editing capabilities of the GFE as opposed to just editing DFMs to obtain text products. A limited number of weather elements were gradually integrated into the forecast routine as part of the RPP. This allowed forecasters to become more comfortable with the basic grid editing functions after they completed two one-on-one training sessions over an eight month period. At first, forecasters were reluctant to incorporate the grid editing into their forecast process. The grid editing was just viewed by many forecasters as an extra duty. Furthermore, the complexity of editing weather grids was rather overwhelming for a few forecasters. Most of these forecasters did not have a clear vision of how gridded products could help improve and expand NWS services. This lack of vision contributed to their fear of change that resulted in little action on their part as far as practicing and seeking additional training.

The salesmanship of the NDFD is so critical in the early stages of the implementation process. Management and forecasters must have a clear understanding of how the gridded weather forecasts will be disseminated and used by customers. The Tucson WFO tried to provide forecasters with a clearer vision by designing simple graphical and interactive web applications for viewing the gridded forecasts (Flatt and Sampson 2002). This helped some of the reluctant forecasters by visually showing them how future gridded weather information could be presented and utilized.

By far the most difficult adjustments for forecasters were centered around the text products. The concept of having a single database in which text products can be derived threatened their individuality and ownership of the forecast. This individuality also made it difficult for the IFPS focal points responsible for configuring the software. Each forecaster had a unique way of wording the forecast for the same weather. For example, one forecaster may have a strong preference for using “VARIABLE HIGH CLOUDINESS” versus “PERIODS OF HIGH CLOUDS”, or “HIGHS FROM THE UPPER 50S WEST TO MIDDLE 60S EAST” rather than “HIGHS IN THE UPPER 50S TO MID 60S”. Although this sounds rather trivial, it is a high profile issue for forecasters. Eventually, the lack of consensus on wording lead to the formation of a team of forecasters tasked with standardizing the text phrases for the Tucson WFO products. These standardized phrases were considered acceptable for the computer generated products. Any changes to the wording in these products were welcomed, especially if it made adjustments to the meaning of the forecast. The standard phrases should facilitate the final switch to IFPS generated ZFPs in early 2002.

7. SUMMARY

The deployment of the IFPS represents a major change in the way forecasters prepare and disseminate predictions of sensible weather. Forecast offices dealing with complex terrain will be faced with many challenges in implementing the IFPS. Although significant progress has been made at a WFO with varying topography, more needs to be done in areas of grid initialization, grid editing, and text generation.

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