5.2 TOOLS FOR MODEL INTERPRETATION IN THE INTERACTIVE FORECAST PREPARATION SYSTEM

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1. INTRODUCTION

Concurrent with the development of the Advanced Weather Interactive Processing System (AWIPS), the National Weather Service (NWS) has been developing and testing technique software for the Interactive Forecast Preparation System (IFPS). The NWS is now in the process of training forecasters from Weather Forecast Offices (WFO) around the country to use the first fully-fielded version of IFPS. This process began in early 2001 and is projected to take more than two years to complete (Ruth 2000). Forecasters use a variety of techniques within IFPS to create a digital database of sensible weather elements used to compose official NWS products (Peroutka et al. 1998). These techniques free the forecaster from having to type products by hand and allows them to focus on the meteorology of a given weather situation.

Tools within IFPS allow forecasters to interact with a common digital database (Ruth et al. 1998). Grids of sensible weather are derived from numerical forecast model output. Although numerical models do not directly produce the sensible elements needed to prepare public forecasts, these elements may be derived by using either statistical techniques or meteorological algorithms. Initial guidance for IFPS sensible weather grids is created from Model Output Statistics (MOS) (Glahn and Lowry 1972). Currently, MOS guidance grids are available for the Nested Grid Model (NGM), the Medium Range Forecast model (MRF), and the Aviation model (AVN). Additionally, guidance grids for IFPS are derived by using objective interpretation algorithms and model-based soundings (Weir 1998). The latest version of IFPS gives WFOs the ability to tailor algorithms used to derive the sensible weather elements (LeFebvre et al. 2002). Sources for algorithmically-derived grids include Eta, AVN, NGM, MRF, Meso-Eta, Rapid Update Cycle (RUC), and the LAPS hourly analysis of observations. These model grids are available within AWIPS at a relatively coarse grid-spacing, typically 80km or 40km. However, IFPS grid initialization techniques use high-resolution terrain data to interpolate sensible weather elements to a finer mesh grid. Grid spacing is WFO-configurable and can range from 20km to 1.25km spacing.

The availability of high-resolution grids of sensible weather guidance presents new challenges in forecast preparation. Numerical model output continues to increase in both spatial and temporal resolution (Kalnay et al. 1998), as well as accuracy, providing forecasters with grids containing unprecedented meteorological detail. With this trend only continuing, forecasters are faced with the daunting task of preparing an increasing number of high-resolution grids in a limited amount of time. IFPS techniques used to prepare these grids must maximize efficiency as well as retain the ever-increasing spatial and temporal detail inherent in the underlying model grids.

IFPS provides two different techniques with which to prepare a digital database of sensible weather grids. The Graphical Forecast Editor (GFE) (Lefebvre 1995) is a grid editor that allows forecasters to prepare sensible weather grids by using a variety of tools, ranging from simple gridpoint value adjusting (e.g., increment/decrement gridpoints) to "Smart Tool" scripts. One of the advantages of the GFE is the high degree of control that is available for the preparation of forecast grids. As the number of sensible weather fields and the temporal/spatial resolution of those fields increases, so too will the number of grids a forecaster will be asked to prepare. As numerical models improve, it will be increasingly difficult for forecasters to add significant value to such an overwhelming number of grids through grid editing techniques.

IFPS model interpretation tools enable the forecaster to tailor high-resolution model guidance by interactively adjusting weather element thresholds that are used to produce sensible weather grids (Ruth and Du 1997). The paper presented here describes new developments and the future direction of model interpretation in IFPS. Grids produced from interpretation techniques retain both the temporal and spatial continuity of the original model guidance. Forecasters never edit model grids directly with model interpretation. Instead, they manipulate a

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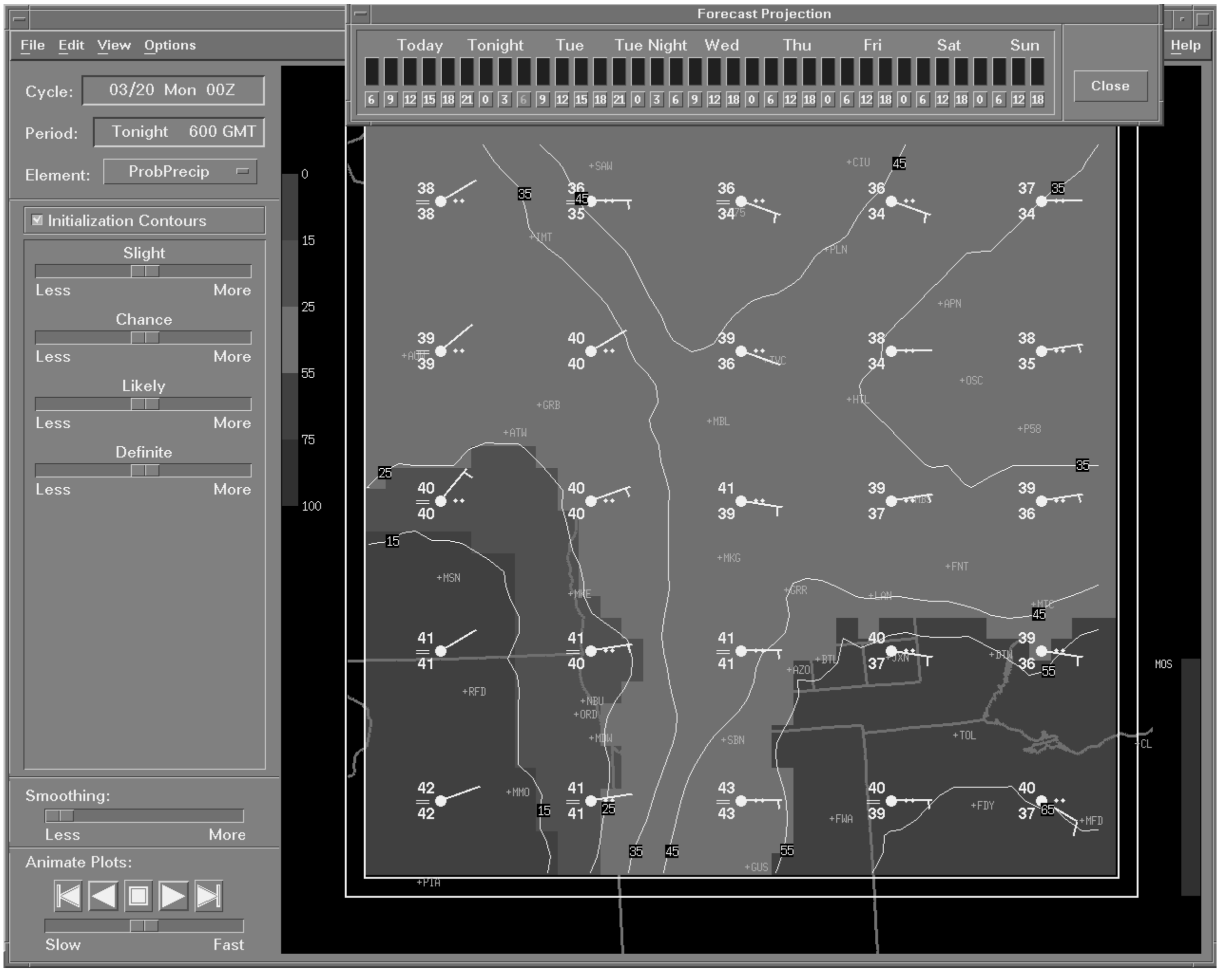


Cycle: 03/20 Mon 00Z

Period: Tonight 600 GMT

Element: ProbPrecip

☑ Initialization Contours

Figure 1: Slider bar interface for probability of precipitation

variety of slider bar interface tools that modify thresholds used to reinterpret model guidance grids. Model interpretation can be a very powerful and efficient way to prepare the large numbers of grids that are needed for NWS products.

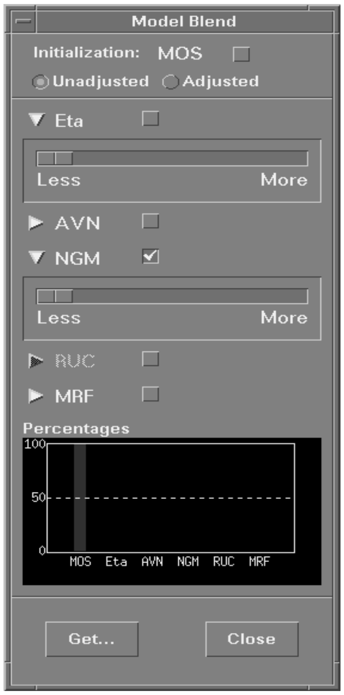
2. MODEL INTERPRETATION AND THRESHOLDS

In contrast to direct editing of grids, forecasters using the model interpretation technique make adjustments to a set of instructions which are used to evaluate the weather element grid. These instructions, or thresholds, are applied to the original model guidance grids. With every threshold adjustment, the technique software applies the new instruction along with the previous set of instructions to the original model grids. Unlike grid editing, the order in which the instructions are made is irrelevant. Threshold adjustments can be copied in time, interpolated through a range of time, or reset to some default value. As forecasters make adjustments they view the resultant changes on a high-resolution color image of the weather element (Fig. 1). Most thresholds are modified by using simple slider bar interface tools. Moving the slider bars left or right either raises or lowers the threshold values used to interpret the grid. In the context of model interpretation, thresholds are any numerical value used to differentiate categories for a particular sensible weather element. The categories themselves may be those used in NWS operations (e.g. “Scattered” or “Clear”). They may be values used to initialize categorical forecasts from model probabilities (e.g. frozen or freezing precipitation), or they may be defined as a discrete range of values (e.g. 0.5-1.0 inches QPF). Regardless of the type of threshold, when a forecaster lowers the threshold value for a particular category, the result is to progressively reveal those areas of the grid which might be included in that category.

The slider bars on the left hand side of Fig.1 show categories for probability of precipitation. By moving the slider bar for the “Chance” category to the right (the “More” direction) a forecaster lowers the numerical threshold that defines the boundary between “Slight” and “Chance”. This progressively reveals areas of the grid closest to the Chance category. As this threshold is adjusted, the precipitation probability image is updated to show the result. Depending on breakpoint settings in the Forecast Projection Window (top of Fig.1), the adjustments will be copied or interpolated forward and/or backward in time.

3. MODEL BLENDING

Grids from the previously-mentioned models are available to the model interpretation technique, including in the future, ensemble guidance. The starting point in model interpretation is choosing the best source of guidance. Typically this will be the model(s) or ensemble members that tend to have what the forecaster considers to be the best solution for the current weather situation. The model interpretation technique provides the capability to blend two or more sources of guidance together throughout the forecast period. To blend model guidance, a forecaster opens the Model Blend tool (Fig. 2). They may choose to use the default guidance source, replace it with another, or with a blend of models. To add another model to the blend, the slider bar for that model is moved to the right. This progressively adds more of that model to the blend. Temporal discontinuities when blending models are avoided by setting breakpoints in the Forecast Projection Window. The model interpretation technique will automatically interpolate the blend adjustments in time.



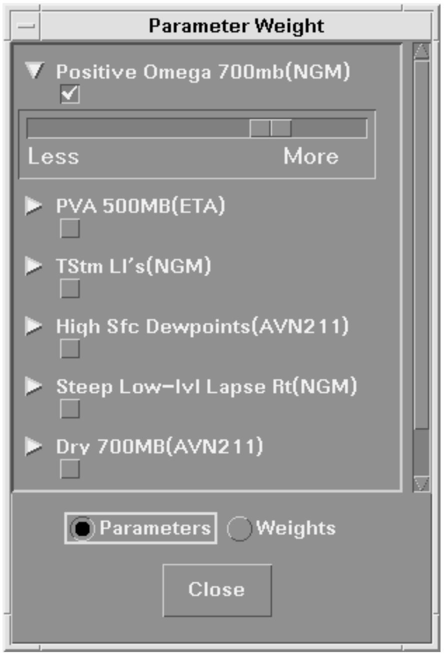
Initialization: MOS ☐
● Unadjusted ○ Adjusted
▼ Eta ☐
▶ AVN ☐
▼ NGM ☑
▶ RUC ☐
▶ MRF ☐

Figure 2: Model blend

When the model blend for a given weather element has been set, the blend may be copied to any or all of the other sensible weather elements. The forecaster selects “Copy To...” in the model blend window and chooses which element(s) to copy the adjustments to. For temperature elements (T, Td, MaxT/MinT), there is an additional option. One of the various sources of MOS guidance may be combined with one of the algorithmically-derived sources (e.g., NGM MOS + MesoEta). This is not a model blend, but rather a direct combination of the two sources. Algorithmically-derived temperature grids at a high spatial resolution show details such as the effect of topography that MOS temperature grids cannot. However, model temperature grids may exhibit a warm or cold bias. MOS temperature grids are reasonably accurate at gridpoints nearest to MOS stations. A MOS + model guidance grid combines MOS station temperature values with the high resolution model temperature grid. The model interpretation technique assigns the gridpoint nearest a MOS station the MOS temperature value. A delta field is computed from the model grid and an 9-point smoothing algorithm is applied to the deltas. The smoothed deltas are mapped back to the grid. The result is a grid that retains the spatial detail of the original model guidance with the influence of MOS station temperatures.

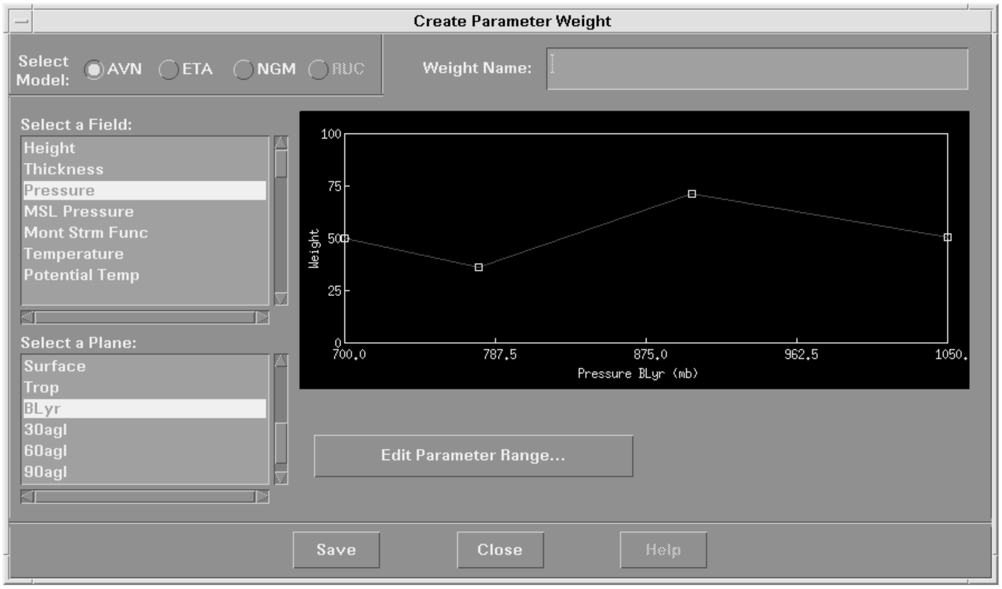
4. MODEL PARAMETER WEIGHTS

Adjustments made to categorical thresholds and the model blend are always applied uniformly to every gridpoint. To target threshold adjustments to specific areas of the grid, the model interpretation technique uses the concept of weights. Three general types of weights are defined, geographic weights, sensible element weights, and model parameter weights. These are described by Ruth (1998). With model parameter weights, forecasters adjust sensible weather grids based on surface and upper level parameters from numerical forecast models. For



▼ Positive Omega 700mb(NGM) ☑
▶ PVA 500MB(ETA) ☐
▶ TStm LI’s(NGM) ☐
▶ High Sfc Dewpoints(AVN211) ☐
▶ Steep Low-lvl Lapse Rt(NGM) ☐
▶ Dry 700MB(AVN211) ☐
● Parameters ○ Weights

Figure:3: Parameter weight tool



Select Model: ● AVN

Select a Field: Pressure

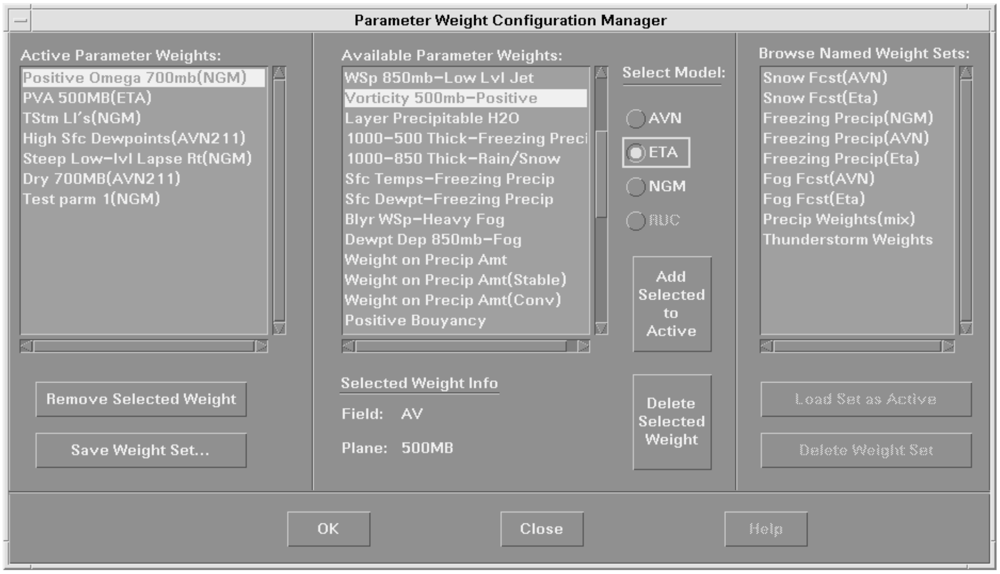
Select a Plane: BLyr

Figure 4: Create parameter weight interface

example, increase snowfall amounts where Eta 700MB upward vertical velocities are greater than 10 microbars per second (Fig. 3). Another example would be to increase the chance of severe thunderstorms on those areas of the grid where AVN lifted indices are -4 or below. Model interpretation directly integrates numerical model fields into the forecast preparation process with parameter weights. The parameter grids are contoured and overlaid directly on top of the sensible weather displays at coinciding projections. The forecaster does not have to look at two different display screens when making adjustments to the forecast.

Model parameter weights are created via an interface that allows the forecaster to choose from a source model, a parameter, and a level (see Fig. 4). A weight-to-parameter value function is created by using a graphical interface. Breakpoints that define a linear function are adjusted by dragging them with a mouse. The resulting function is given a descriptive name (e.g., ProbSevere LI's) and saved to a database. The functions can be redefined at a later time by using a weight editor interface.

To manage the potentially vast numbers of parameter weights that can be created, the model interpretation technique provides a configuration interface (Fig. 5).



Select Model: ● ETA

Selected Weight Info

Field: AV

Plane: 500MB

Figure 5: Parameter weight configuration tool

Parameter weights can be loaded, unloaded, deleted, and grouped into sets of common functionality all from within the configuration interface. Parameter weight sets are a quick way to load several parameter weights that can be used for a specific weather scenario, such as snowfall forecasts, severe weather, fog, etc.

5. GRID DEFORMATION

One limitation of threshold adjustment tools is they do not afford the level of control over changes to the forecast that a grid editor does. To address this lack of control, the concept of grid deformation was introduced. Grid deformation is a model interpretation tool that employs graphical manipulation of contours as a way of targeting adjustments to specific areas of the grid. Deformation extends the concept of threshold adjustment to include thresholds at every gridpoint. By using simple contour modification tools (e.g., draw, erase, label), the forecaster adjusts thresholds at gridpoints, called delta values. For every weather element grid, there is an associated delta grid. As contours of the sensible weather element are modified, or new ones are drawn, the underlying delta grid is recomputed. The delta grid is applied to the model guidance much the same way as a parameter weight. As with other types of thresholds, delta grid adjustments can be applied over a range of time or interpolated between forecast projections.

It should be pointed out that grid deformation is not editing of weather element grids. The contour manipulation tools are only used to edit the delta grids, and the deltas are applied to the sensible weather just as any other threshold. Similar to other model interpretation tools, the order in which the adjustments are made does not make a difference. Grid deformation is particularly useful for "fine-tuning" a forecast.

6. INTERSITE COORDINATION

The increasing shift in emphasis within the NWS from text-based to digital forecast products presents unique challenges. One of these is the coordination of gridded forecasts between WFOs. A tool recently added to the model interpretation software allows a WFO to query surrounding WFOs and obtain their model blend adjustments. The same tool will also return surrounding WFO's time-space adjustments. Time-space adjustments are described in Ruth (1998). The blend and time-space adjustments are considered the model interpretation initialization. The idea is that discontinuities in forecast grids between WFOs may be minimized if adjacent offices begin with similar blends of guidance.

When a forecaster initiates the intersite coordination process, the model interpretation technique acquires the latest saved version of model blend and time-space adjustments from a site-configurable list of surrounding WFOs (Fig. 6). As the adjustments are retrieved, the corresponding buttons for each WFO become active. Forecasters may then select to load settings from any of the adjacent WFOs as their initialization. Alternatively, they may opt to set their model blend and/or time-space adjustments to an average of any or all of the surrounding WFOs. It is anticipated that intersite coordination will be a particularly useful tool as the NWS embarks upon its National Digital Forecast Database (NDFD) program which is currently being tested at 17 WFOs. With the NDFD, mosaics of forecast grids will be created at the national level from WFO-generated grids.

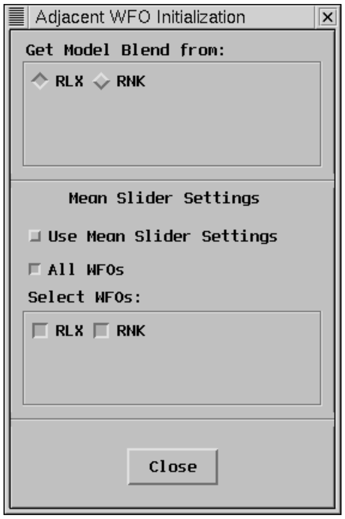


Figure 6: Intersite coordination interface

7. FUTURE ENHANCEMENTS

Several improvements to model interpretation are currently being developed or will be in the very near future. One is inter-element consistency checking. This feature will perform rule-based consistency checks between sensible weather elements. For example, forecast snow where model-interpreted temperatures are less than 32 degrees and ProbPrecip is greater than 35%. With rule-based consistency checking, the order of adjustments is irrelevant. Consistency rules are applied to the interpretation of the underlying model data with every threshold adjustment. This is in contrast to grid editing, where the order in which elements are edited and consistency checks are applied must be carefully considered.

Another planned enhancement is the incorporation of the previous set of forecast grids for use in adjusting the current forecast. Often, forecasters prefer to start with the previous cycle's data rather than all new model guidance. The availability of the previous cycle's sensible weather grids will potentially further reduce the amount of time spent in forecast preparation. New weather elements will also be added to model interpretation, including visibility and cloud decks.

8. CONCLUSION

The IFPS model interpretation technique is a continually improving software tool. Model interpretation software has been ported to low-cost Pentium-based PC hardware, running the Linux operating system. This new hardware enables model interpretation to take advantage of the increasing spatial resolution available in gridded model guidance. It is anticipated that model interpretation software will be a key component of the NWS forecast preparation process as the number and resolution of grids continues to increase over time, and especially as new ensemble guidance becomes available to WFOs.

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