P2.29 SOME CHALLENGES OF USING GRAPHICAL FORECAST EDITOR(GFE) OPERATIONALLY IN DIVERSE TERRAIN.

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Introduction

The Graphical Forecast Editor (GFE) is part of the Interactive Forecast Preparation System (IFPS), which the National Weather Service will be using in the near future to generate most of the forecast products. GFE/IFPS is a major change in concept for the preparation for forecast products. Currently, the job of the forecaster is to develop a conceptual model of the evolution of the atmosphere **and** to compose a series of text products based on the conceptual model. A significant amount of time can be devoted to creating the text products, and there is always the possibility for discontinuity among the various products.

One major goal of GFE/IFPS is to allow the forecaster to concentrate more on developing a conceptual model for the evolution of the atmosphere. The forecaster will graphically edit various forecast fields using GFE to match his/her conceptual model of the evolution of the atmosphere. Once the editing of gridded fields is complete, scripts will run to translate the gridded fields into a digital forecast database, various images and text based products. The forecaster may have to adjust the text products slightly, but he/she will not have to spend a significant amount of time composing text products.

There are several other advantages to composing the gridded fields. Generating products from one set of gridded fields will result in consistency among the various products. Graphical representations of the various fields will make temporal and spatial consistency much easier. Graphic images of the forecast will be viewable by the public and values for any point in the country can be extracted from a national database.

Forecast grids

Currently, the plan is to produce forecast values for 3 hour intervals of surface temperature, surface humidity, surface winds, cloud cover and sensible weather for the first three days of the forecast cycle. Probability of precipitation and snowfall will be produced for twelve hour periods. From the temperature data, daily maximum and minimum temperatures will be produced.

For days 4-7 of the forecast cycle, 12 hourly values for maximum or minimum temperature, sky cover and sensible weather will be produced. (These temporal intervals are not constrained by GFE. Theoretically, GFE can produce hourly grids for the seven day forecast cycle.)

When graphically creating the forecast fields, they are in essence being made for many individual grid boxes in the forecast area. The appropriate size for these grid boxes is determined by several factors. One factor is the topography. How fine a resolution is needed to adequately represent the topography? Another question is how fine of a grid spacing is needed to adequately represent the various meteorological fields in complex terrain? A third factor is computer power. How fine of a grid spacing can the computer resources handle?

The western half of the forecast area for Weather Forecast Office (WFO) Pueblo has complex mountainous terrain including seven mountain ranges with peaks rising over 3.6 km, and many of the mountain rising over 4.0 km. Elevation changes of 1 km or more over the distance of several kilometers is common. The forecast area also contains high mountain valleys such as the San Luis Valley and the Upper Arkansas River Valley. The eastern half of Pueblo's forecast area consists of the high plains of southeast Colorado.

Figure 1 shows the topography for a portion of the Pueblo forecast area for grid sizes of 2 km (2 km x 2 km grid box), 5 km and 20 km. The 2 km grid box lists some of the main terrain features. The mountain in the upper right quadrant is Pikes Peak and the Northern Sangre De Cristos is the northwest-southeast mountain range near the center of the image. With the 5 km resolution, the major topographic features are still clearly evident, but they are more blocky. The maximum height of the mountain peaks, such as Pikes Peak is also lower. In the 20 km grid, the major

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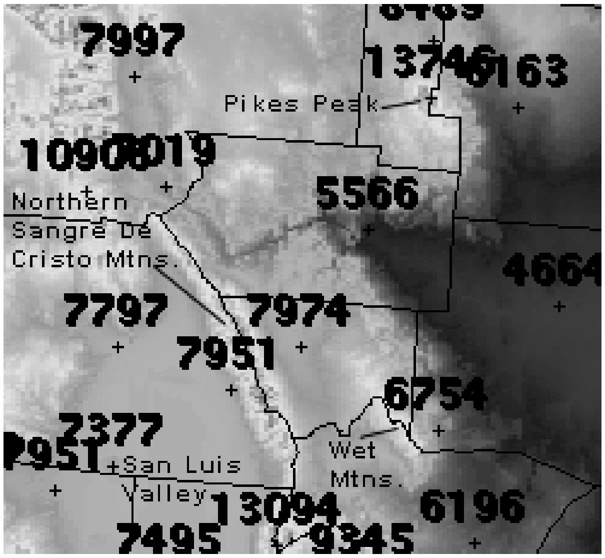

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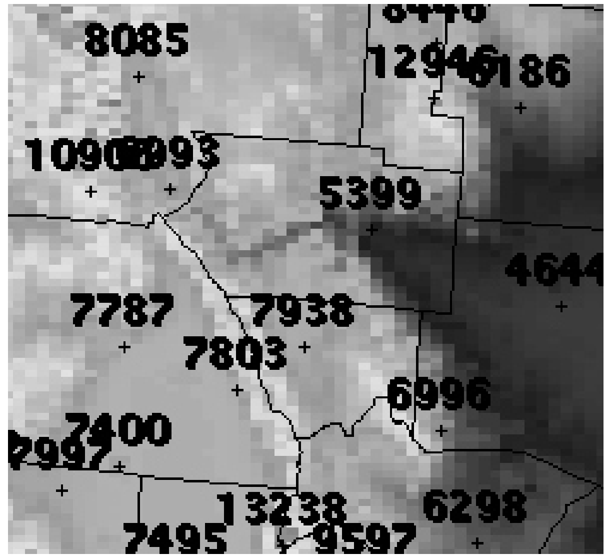

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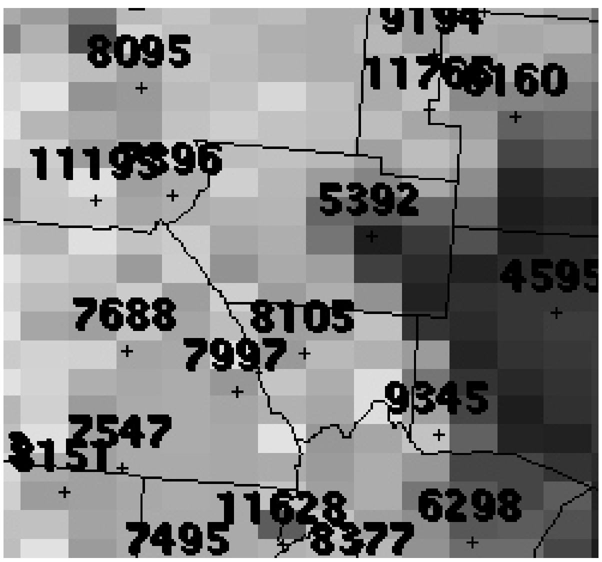

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Figure 1. Topography in the GFE for a portion of the mountainous terrain in WFO Pueblo's forecast area. Numbers are heights of various locations in feet MSL. A) is for a grid size of 2 km and it shows some of the topographic features , B) is for a grid size of 5 km, C) is for a grid size of 20 km.

mountain ranges are unrecognizable. WFO Pueblo has found that the 2 km grid resolution is adequate for properly representing the major terrain features and the various forecast fields which are influenced by topography.

The current workstations on AWIPS have sufficient processing power for grid sizes around 19 km. However, the National Weather Service has purchased for each WFO Linux PC's which have enough processing power to handle 2 km grids satisfactorily.

Importing numerical data into GFE

Each forecast cycle will consist of a multitude of forecast grids. It would be an immense workload to "hand-draw" each grid from scratch for each forecast cycle. Instead, the forecaster will very often use a "first-guess" for each grid (unless this first guess is completely wrong). One source for the first-guess field would be the previous forecast. If the previous forecast was satisfactory, then the forecaster will make some adjustments to the previous forecast. If there are significant changes to the forecast or new grids need to be created, then the first guess for the fields will very likely be based on numerical model input.

For each forecast cycle, new three hourly grids will need to be created. During the afternoon, new day 7 grids will be created. Given how each grid in the GFE would have to be created from scratch at some point and numerical model output will very likely be used to provide a first guess for the grid, almost every grid in GFE will have some basis on numerical model output.

Importing model data into the GFE is not as simple as directly taking data from the model and mapping it to the GFE grid. One problem is that the numerical model does not explicitly represent all the necessary forecast fields. For example, cloud cover is not an explicit field in the

National center for Environmental Prediction (NCEP) models available on AWIPS. (AWIPS is the National Weather Service computer system for display of data and composition of products at a WFO.) Another field not explicitly represented is precipitation type. GFE obtains values for these fields by using scripts, called Smart Tools, to derive the fields in the GFE. For example, the Smart Tool for cloud cover examines the vertical profile of moisture to estimate the amount and height of cloud cover. A WFO can create and customize smart tools to derive these fields.

A second difficulty with initializing the GFE grids is the available grid scale of the numerical models. Experience at WFO Pueblo suggests that a grid scale of 2 km or less is needed to adequately represent the topography and forecast fields. The ETA model run at NCEP currently has a grid spacing of 12 km. However, because of current machine and satellite bandwidth considerations, the finest grid spacing available on AWIPS is 40 km, which is smoothed from the 12 km grid spacing of the current ETA. (As of the time of this abstract, late March 2002, we are working on a project to get some surface fields at 12 km grid spacing into AWIPS.)

There are many difficulties in trying to map data from a 40 km grid (or even 12 km grid) into a 2 km grid in complex terrain. One difficulty is that the model data will not have any effects from finer scale terrain features. The finer scale topography can influence surface wind speeds and direction through various influences including forced channeling, pressure channeling and local diurnal effects. Mountain wave effects will not be adequately identified by the 12 km grid. The finer scale topography can influence temperature and humidity. The coarser grids will not be able to identify features such as trapping or draining valleys which can significantly affect nighttime temperature and humidity.

A second problem is that there can be a significant difference between the surface elevation on a coarser grid versus the actual topography. Adjusting surface temperature and humidity, especially during the nighttime, can be difficult. Thirdly, the coarser grids cannot properly represent topographical influences on other fields including cloud cover and precipitation type.

Local experiences

Since the Summer 2001, WFO Pueblo has been configuring and testing GFE/IFPS, and training on GFE/IFPS has been occurring since December 2001. The office has not routinely used GFE/IFPS to compose forecast, and the office will start composing forecasts using GFE/IFPS on 15 April 2002. The office has completed training on GFE and developed some Smart Tools. From this limited experience, the following has been noted on use of GFE in our forecast area:

1) Overall, GFE works better on the relatively flat eastern plains of Colorado. In regions where there are not sharp topographic differences, the 40 km input grids can represent the atmosphere adequately. Adjustment of the grids is easier because the changes can be applied more uniformly.

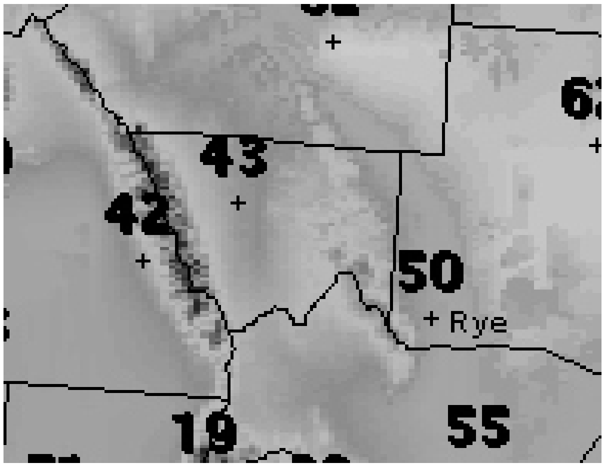
2) During the daytime, GFE can do an adequate job of representing the thermal and moisture fields. Smart Tools have been developed to provide temperature and humidity based on an assumed mixing depth. Figure 2 shows an example of forecast maximum temperatures, based on dry adiabatic decent from a mixing height, on the 2 km, 5 km and 20 km grids. The values of the maximum temperature and spatial resolution depend on the grid size. For example, Rye, which is along the east slopes of the Wet Mountains at about 2050 m MSL, has a temperature of 37°F (2.7°C) on the 20 km grid and 50°F (10.0°C) on the 2 km grid.

3) The GFE performs poorly for minimum temperatures under moderate to strong radiational cooling conditions. In complex terrain, nocturnal temperatures can vary greatly laterally and vertically depending on the drainage characteristics and location along a slope.

4) The coarse numerical model grids available to the forecaster do not adequately represent tight orographic precipitation gradients. The forecaster has to adjust the grids for snowfall based on local experience.

5) The fine scale wind features in complex terrain cannot be adequately represented. The coarse resolution model data can identify the diurnal mountain-plains circulation on the eastern plains. However, locally determined circulations of terrain induced flows cannot be identified

6) The grids imply a forecasting ability for a fine spatial and temporal scale. While the overall forecast may be very accurate, some of the finer scale details may not be adequately represented. For example, winds and temperatures may vary significantly over a short distance especially during the nighttime and during the diurnal transitional



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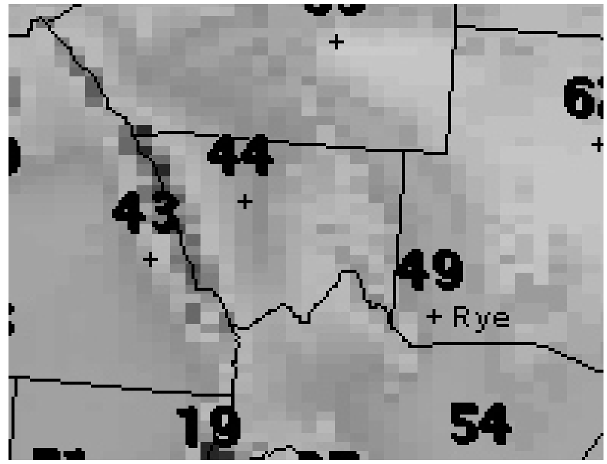

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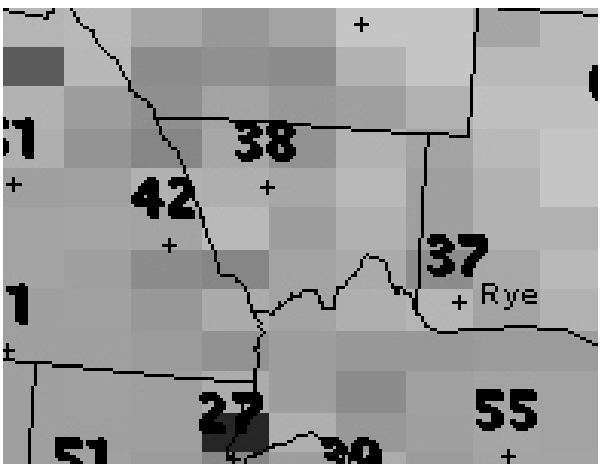

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Figure 2: Examine of maximum temperature forecast in GFE using Smart Tool which calculates temperatures by dry adiabatic decent from a mixing height. The town of Rye is labeled. The northwest to southeast mountain range in the western part of the figures is the northern Sangre De Cristo Mountains. Temperatures are in (°F). A) 2 km grid, B) 5 km grid size, C) 20 km grid size.

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periods. Forecast grids for every 3 hours also indicate a finer temporal detail for all the grid points than what can be provided. Caution is needed for blindly using these grids for detailed forecast such as spot fire weather forecasts.

7) The grids are providing forecasts for remote high elevation locations, such as mountains above tree line. These locations would not be adequately covered in the text zone products written for mountain ranges.

8) Using numerical weather prediction guidance (MOS) to adjust the digital forecast database is difficult in complex terrain. Often, forecast values from MOS are significantly better than the initial first guess fields from the numerical models. The MOS values represent a forecast for a single point, but the forecaster would want to apply the "adjustment" from MOS to a significant portion of the forecast grid. In uncomplicated terrain, the adjustments from MOS can applied fairly easily to significant portions of the grid. However, the adjustments from MOS are not easy to apply in complex terrain. For example, how can the temperature and dew point adjustments from MOS, for a station in a valley, be applied to the slopes of the mountain, the mountain top, or even a valley on the other side of a mountain? MOS adjustments for fields such as wind and cloud cover may be even more difficult to apply.

Conclusions

GFE/IFPS is a vast improvement in the preparation and dissemination of routine forecast products. Complex terrain adds many complications to the preparation of the forecasts. The complex terrain causes significant changes in the forecast fields over relatively short distances and GFE/IFPS grid sizes of 2 km or less are needed to adequately represent these changes. To meet these challenges, improvements of the spatial and temporal resolution of numerical output available to the forecasters are needed. In addition, improvements to Smart Tools and use of MOS guidance will be needed to provide more accurate forecasts in complex terrain especially at locations which are not close to MOS sites.