5.4 GENERATING DIGITAL FORECAST MATRICES FROM GRIDDED FORECASTS IN THE INTERACTIVE FORECAST PREPARATION SYSTEM

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1. INTRODUCTION

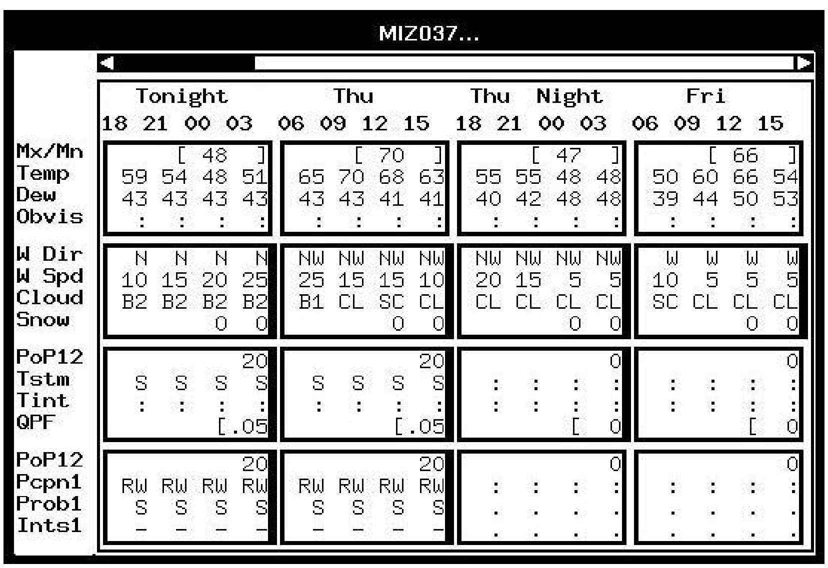
The National Weather Service is currently implementing an Interactive Forecast Preparation System (IFPS) that assists forecasters in creating a digital database consisting of gridded weather elements. With IFPS, forecasters interact with a gridded database by using a variety of techniques as described by Ruth, et al. (1998). The forecaster then generates a suite of forecast products as described by Peroutka, et al. (1998). This paper describes one of the important steps in IFPS in which values in the gridded database are transformed so that text and tabular products can be generated.

1.1 *Digital Forecast Matrix*

One of the first steps in creating text and tabular products in IFPS is to condense large amounts of gridded data into values that are representative for an area. These values, when organized by weather elements and time, are called a Digital Forecast Matrix (DFM). A DFM can represent a forecast at a single point, e.g., an airport; or an ensemble of gridpoints representing counties, public, marine, and fire weather zones; or geophysical features, e.g., terrain above 5,000 ft. Fig. 1 shows a DFM for a public zone. The application that summarizes gridded data and generates DFMs is called the grid unloader.

2. ALGORITHMS

In creating a DFM, one or more gridpoints must be selected for the grid unloader to sample. Besides selecting which gridpoints are to be used for a DFM, each gridpoint is given a weight as well. This weighting factor is an important parameter to be used in the grid unloader's algorithms. Gridpoint weighting allows each site to "bias" the grid unloader's results toward geographical features such as valleys or populations such as cities. IFPS provides a graphical user interface, called mod_wgts, that allows the site to select which gridpoints are to be used for zones and stations and assign weight values as well. Fig. 2 presents a portion of the mod_wgts display showing a public zone with its gridpoints selected and the weights to be used to generate a forecast for this zone. This figure shows that the weights in this zone are



MIZ037...

	Tonight				Thu				Thu Night				Fri			
	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15
Mx/Mn		[	48	]		[	70	]		[	47	]		[	66	]
Temp	59	54	48	51	65	70	68	63	55	55	48	48	50	60	66	54
Dew	43	43	43	43	43	43	41	41	40	42	48	48	39	44	50	53
Obvis	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
W Dir	N	N	N	N	NW	NW	NW	NW	NW	NW	NW	NW	W	W	W	W
W Spd	10	15	20	25	25	15	15	10	20	15	5	5	10	5	5	5
Cloud	B2	B2	B2	B2	B1	CL	SC	CL	CL	CL	CL	CL	SC	CL	CL	CL
Snow			0	0			0	0			0	0			0	0
PoP12				20				20				0				0
Tstm	S	S	S	S	S	S	S	S	:	:	:	:	:	:	:	:
Tint	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
QPF				[.05				[.05			[	0			[	0
PoP12				20				20				0				0
Pcpn1	RW	RW	RW	RW	RW	RW	RW	RW	:	:	:	:	:	:	:	:
Prob1	S	S	S	S	S	S	S	S	.	.	.	.	.	.	.	.
Ints1	–	–	–	–	–	–	–	–	.	.	.	.	.	.	.	.

Figure 1. A Digital Forecast Matrix

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biased to emphasize gridpoint values in the southern half of the area.

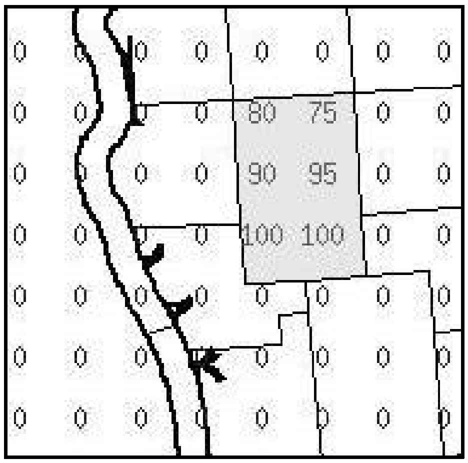

Figure 2. The mod_wgts GUI

A single algorithm cannot summarize all of the weather elements in the IFPS gridded database. It is necessary to categorize the weather elements into two types: continuous and discrete. The criterion for determining which weather element belongs to which category is simple: "Given a set of values, is it possible to generate an arithmetic average for this weather element?" If the answer is "Yes," then the element is considered to be a continuous type, otherwise it is a discrete element. Applying this criterion results in most elements being considered continuous; precipitation and obstruction-to-vision are considered discrete types.

2.1 *Algorithms for Continuous Weather Elements*

The easiest weather elements to summarize are those that take on a continuum of values. For such elements, a simple weighted average is used

$$\bar{a} = \sum_{t=t_0}^{T} \sum_{n=1}^{N} \frac{w_n a_{n,t}}{w_n} \qquad (1)$$

where N is the total number of points encompassed by an area; $a_{n,t}$ is the value at the n^{th} gridpoint at time t and w_n is the weight of the n^{th} gridpoint. For most elements, values in the DFMs are computed from grids found in a 3-hour "window." For weather elements like snow and quantitative precipitation forecast amounts, it was deemed more sensible to pick the highest and lowest values found within the area rather than using an average. For vector fields, such as wind and swell, if the field is fairly uniform in direction, an average works well. However, if wind and swell direction vary widely over an area, a prevailing direction and speed (or height) is chosen instead. For wave heights, the maximum value found in a marine zone is chosen as it is likely to be at the end of the fetch.

2.2 *Algorithms for Discrete Weather Elements*

Unlike the continuous weather elements, it is not possible to "average" discrete precipitation elements. It is necessary to use different algorithms that make meteorological sense in order to derive a representative forecast for these elements. These algorithms involve the addition of another weight based on the probability of precipitation events and filtering to remove "insignificant" events.

2.2.1 *Probability Weights*

Precipitation events such as "scattered rain showers," "widespread rain," or "chance of snow" cannot be summarized using grid weights alone: the probability of the precipitation must also be considered to determine its significance. Each probability qualifier for precipitation is assigned a weight as shown in the table below.

Table 1. Probability Qualifier Weights

Probability Qualifier		Value
Isolated	Slight Chance	1
Widely Scattered	Chance	2
Scattered	Likely	3
Occasional	Numerous	4
Widespread	Definite	5

2.2.2 *Elimination of Precipitation Events*

From the earliest days of IFPS, precipitation grids initialized by MOS guidance would often produce a variety of precipitation events in a short period of time, particularly during the winter season with its wide variety of freezing, frozen and liquid precipitation. The forecaster would have to manually remove these "insignificant" events from the DFMs to keep the text generators from creating precipitation phrases that would switch from one type to another several times during the period. This often resulted in a confusingly worded forecast. Therefore, algorithms using site-configurable thresholds were devised to remove "insignificant" events. These thresholds reside in a file which each office can customize. Table 2 shows some typical threshold values and will be used in the example that follows.

In the first step, precipitation events are filtered by precipitation states using scores and site-configurable thresholds. All precipitation events for an area for a 12-hour period are categorized based on precipitation state (liquid, frozen, or freezing). Using the gridpoint weight, w_n, and the probability weight of the event, p_n at that gridpoint, the grid unloader uses the following algorithms (Eq. 2,3,4) to calculate sums for liquid, freezing and frozen states, respectively. In turn, scores for each of the three precipitation states are then summed to produce a total "state" score (Eq. 5). A typical

Table 2. Typical thresholds for precipitation

Characteristic	Threshold
Liquid	5%
Frozen	10%
Freezing	30%
Rain	5%
Rain Showers, Sleet, Snow	10%
Snow Showers, Freezing Drizzle, Freezing Rain	25%
Drizzle	30%
Freezing Rain Showers, Sleet Showers	90%

$$s_l = \sum_{n=1} p_n^l w_n \quad (2)$$

$$s_f = \sum_{n=1} p_n^f w_n \quad (3)$$

$$s_z = \sum_{n=1} p_n^z w_n \quad (4)$$

$$S = s_l + s_f + s_z \quad (5)$$

distribution of precipitation states for a 12-hour period in a winter mixed precipitation forecast is shown in Fig 3. The fractional contribution of each precipitation state to the total score is compared to site-defined thresholds. If the threshold is met or exceeded for a particular state, then these precipitation events are kept for the final filtering step. After examining Table 2 and the results in Fig. 3, freezing precipitation will not be considered in the final step.

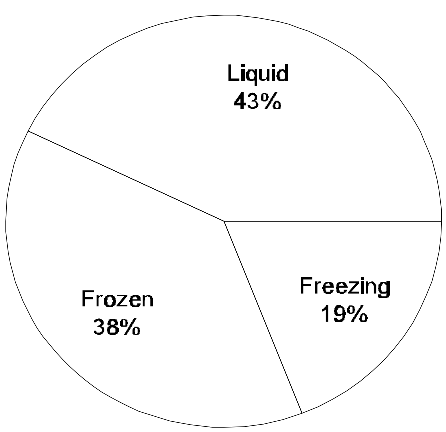

Figure 3. Typical distribution of precipitation states.

The final step involves categorizing the remaining precipitation events according to its characteristic (sleet, snow showers, rain, rain showers, etc.). Again, "scores" for each characteristic are created based on the gridpoint weight and the probability of each event. In turn, these values are summed to create another total. Fig. 4 shows the contribution of each characteristic to the final sum. If the contribution of a given characteristic to the total meets or exceeds its site-configurable threshold, then these precipitation events are considered "significant." Once the "significant" precipitation events have been determined for the period, the application then proceeds to "unload" only these precipitation types for the period. For this period, drizzle will not be unloaded based on the threshold for drizzle in Table 2 and the results shown in Fig. 4. These filtering steps are repeated for each 12-h period in the DFM. The algorithms for precipitation are designed to allow individual WFOs to completely control the amount of filtering or smoothing of precipitation events, or even turn it off.

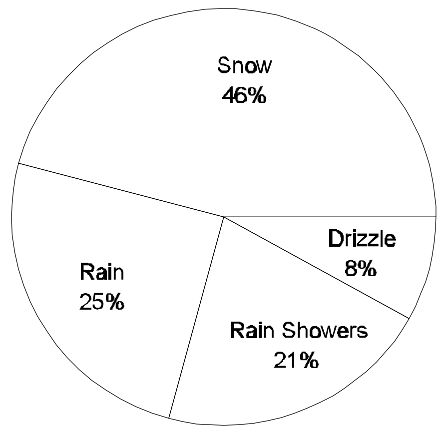

Figure 4. Contribution of each precipitation type.

The remaining discrete weather elements such as probability of thunderstorms and obstruction-to-vision are handled in a similar, although less complex, manner as precipitation.

3. WILDCARDS AND LOCAL EFFECTS

With the implementation of improved grid editing techniques in IFPS, it is now possible for each office to create customized "weather" types such as "Heavy Frost," "Dangerous Heat" and "Lake Caution" and place them on the grids. These customized weather types are called "wildcards." While processing precipitation events, if the grid unloader comes across gridpoints with "wildcard" values, they are excluded from the filtering algorithms described in section 2.2. Instead, after the grid unloader is finished with processing the "true" precipitation events, the wildcards are unloaded in remaining unused "spaces" of the DFM normally reserved for precipitation.

With AWIPS migration to PCs, and subsequent increase in computing power and memory, forecasters can now edit grids with spacing of 5 km or less in IFPS, making "local effects" on grids possible. Using the techniques described in a companion paper (Peroutka, et al. 2002), the forecaster can select the types and times of a local effect. The grid unloader uses this information to partition the gridpoints for a public zone into two or more sets: one set of gridpoints belonging to one (or more) local effect(s); the remaining points belonging to a base DFM. The grid unloader runs twice: first time to exclude local effect gridpoints to generate "base" DFMs; the second run of the unloader uses only the local effect gridpoints to generate local effect DFMs. The same algorithms for continuous and discrete elements described previously are used to create local effect DFMs.

4. SUMMARY

A set of algorithms is described for summarizing data extracted from grids into a form suitable for the IFPS text and tabular product generators. The algorithm used for continuous weather elements using gridpoint weights is quite simple and straightforward. Creating a representative precipitation forecast is more complex and uses the precipitation probability in conjunction with gridpoint weights to implement a simple filtering scheme to remove short-lived and insignificant events. Each office has the ability to control the amount of filtering or even turn it off.

5. REFERENCES

Peroutka, M. R., M. G. Oberfield, J. T. Davis, and R. Yu, 2002: Identifying local effects in gridded forecasts for the Interactive Forecast Preparation System. *Preprints Interactive Symposium on the Advanced Weather Interactive Processing System (AWIPS),* Orlando, Amer. Meteor. Soc., elsewhere in this volume.

_____, R. K. Meiggs, and M. B. Romberg, 1998: The generation of products in Interactive Forecast Preparation. *Preprints 14th International Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology,* Phoenix, Amer. Meteor. Soc., 350-354.

Ruth, D. P., M. A. Mathewson, T. J. LeFebvre, and P. K. Wu, 1998: Interpretation and editing techniques for Interactive Forecast Preparation. *Preprints 14th International Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology,* Phoenix, Amer. Meteor. Soc., 345-349.