8.9 THE GENERATION OF PRODUCTS IN INTERACTIVE FORECAST PREPARATION

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1. INTRODUCTION

The National Weather Service (NWS) has been developing automated product preparation systems for more than 25 years (Glahn 1970). The Techniques Development Laboratory developed one of the first interactive systems of this type--the Interactive Computer Worded Forecast (ICWF) beginning in 1985. The concept of Interactive Forecast Preparation (IFP) is key to achieving modernized forecast operations at NWS field offices through the use of the Advanced Weather Interactive Processing System (AWIPS). With IFP, forecasters employ a family of techniques to prepare forecasts of weather elements in a common digital database from which many forecast products are automatically composed and formatted.

The current NWS product preparation technique is named the Interactive Forecast Preparation System (IFPS). IFPS is a consolidation of the ICWF (Ruth and Peroutka 1993) and the AWIPS Forecast Preparation System (AFPS) (Mathewson 1996) developed by the Forecast Systems Laboratory. IFPS is being deployed with AWIPS (Meiggs et al. 1998) and will evolve to become the NWS' product generation tool.

In IFPS, digital forecasts are stored as grids and digital forecast matrices (DFM). The gridded forecasts of weather elements are spaced regularly across a Lambert conformal projection and have nominal spacings which range from 4 km to 20 km. DFMs define weather at a point or over a geographic region, specifying values at 3-h intervals. A variety of techniques keep the two types of forecasts coordinated and consistent.

Automated product generation techniques like those described below generate a set of forecasts which are consistent with each other and can be easily updated. The benefits of a digital forecast database are not limited to product generation. In the near future, forecast verification values will be extracted directly from the database, and software will compare the digital forecast with observations and digital forecasts from surrounding sites.

This paper describes a number of forecast products which IFPS generates as well as a technique which allows users to view NWS forecast grids via the World Wide Web (WWW). A companion paper in this volume (Ruth et al. 1998) describes the various techniques IFPS provides that allow the forecaster to modify the digital forecasts.

2. WORDED FORECASTS

Worded forecast products have been a part of meteorology since the science's inception. Words can be very expressive, and they can communicate a sense of the forecaster's confidence level. Worded forecasts are often used by people who are "doing something else," that is, not giving the forecast their complete attention. This suggests the worded products will continue to have a place in the NWS product suite as other forms (tabular, graphical, gridded) become readily available. Worded forecasts are the only forecasts the user community can readily use while driving cars or packing school lunches.

Automated product generation techniques cannot capture the range of language used by human authors in worded products or communicate all their subtleties. However, these techniques do generate clear phrases in a style which is natural. The IFP system provides hundreds of configuration parameters which are set by the site and by the individual forecasters. These configuration parameters control the generation of phrases, and allow each office to adapt forecast wording to suit its particular preferences.

2.1 *Zone Forecast*

Fig. 1 contains a sample Zone Forecast (ZFP) which was generated by IFPS. Zone Forecasts receive wide dissemination throughout the United States, and forecasters demand great precision and flexibility in wording them. As a result, a great deal of IFPS development resources have been spent adding features to this capability.

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.TODAY...RAIN LIKELY.  SNOW LIKELY ABOVE 2500 FEET.
SNOW ACCUMULATION BY LATE AFTERNOON 1 TO 2 INCHES
ABOVE 2500 FEET.  COLDER WITH HIGHS 35 TO 40.
SOUTHEAST WIND 5 TO 10 MPH SHIFTING TO THE SOUTHWEST
EARLY THIS AFTERNOON.  CHANCE OF PRECIPITATION 70
PERCENT.
```

Figure 1: Sample Zone Forecast.

The product forecasts a number of common weather elements for two days. Specific algorithms generate forecast text for precipitation (Cammarata and Kosarik 1992b), sky cover (Cammarata and Kosarik 1992a), temperature (Kosarik et al. 1992), and wind (Kosarik and Cammarata 1992). The individual phrases are then merged into a smooth-flowing forecast with the important elements emphasized by appearing first.

Some of the most recent additions to this product include forecasts for days 3-5, special text processing for updated forecasts (Meiggs et al. 1997) and the addition of local effect phrases (Calkins and Peroutka 1997).

2.2 *Fire Weather Forecast*

During the summer of 1996, IFP developers worked with forecasters at the NWS Weather Forecast Office (WFO) in Boise, Idaho (BOI) to apply IFP techniques to Fire Weather forecasting (Peroutka et al. 1997). A number of worded and tabular forecast products emerged from this effort. This led to a hybrid text/tabular product; Fig. 2 shows a sample. (Portions have been removed for space considerations.) This format will be implemented within IFPS during 1998.

2.3 *Voice-ready Radio Forecasts*

NOAA Weather Radio (NWR) provides voice broadcasts of weather information throughout the United States via a nationwide network of VHF-FM radio transmitter sites. NWS WFOs provide the messages which this system transmits. The existing radio programming consoles, which use obsolete audiotape technology, are being replaced with digital-to-voice technology. Messages will then be able to flow directly from IFPS applications into the weather radio console, where they will be converted automatically to audio and sent to transmitter sites for broadcast to the public.

```
.TODAY...              Sunny
 slope/valley winds: upslope/upvalley 4-8 mph.
 ridgetop/winds:      Southwest 10-20 mph.
.TONIGHT...            Clear
 slope/valley winds: downslope/downvalley 2-5 mph.
 ridgetop winds:      northeast 5-10 mph.

Station   Elev   Temperature      Relative Humidity
          (ft)   YDY   TDA   TNT    YDY   TDA   TNT
Upper     7000   76    78    40     14    15    40
Mid       5000   82    69    45     13    14    43
Lower     3500   95    96    55     11    12    45
---------
LAL                     1     1
Haines Index      4     5     5
Transport               SW
 Winds (mph)            10-15
RH recovery                 Poor
Chance (pct) of
 Wetting Rain           0     0
```

Figure 2: Proposed Fire Weather Forecast.

The first IFP product which will be generated for NWR voice synthesis will be the Service Area Forecast (SAF). The SAF has much in common with the ZFP--weather elements, valid times, etc., but its treatment of geography differs. While a typical ZFP includes areas chosen for their homogeneous weather, the areal coverage of an SAF is determined by the broadcast characteristics of the local transmitter. Calkins et al. (1998) describes this technique and provides samples.

2.4 *Watch/Warning/Advisory Products*

IFPS includes techniques which help forecasters issue Watches/Warnings/Advisories (W/W/A)--elements that are central to NWS operations. Fig. 3 contains a sample Tornado Warning generated by IFP. Ruth et al. (1998) describes the user interface which the forecaster uses to generate this and other W/W/As.

```
OKCTOROKC ALL 111500
TTAA00 KOKC DDHHMM
OKC047-053-111500-

BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE OKLAHOMA CITY OK
845 AM CDT THU SEP 11 1997

THE NATIONAL WEATHER SERVICE IN OKLAHOMA CITY HAS
ISSUED A TORNADO WARNING EFFECTIVE UNTIL 1000 AM
CDT FOR PEOPLE IN THE FOLLOWING COUNTIES IN...

NORTH CENTRAL OKLAHOMA...
         GARFIELD            GRANT.

AT 845 AM CDT NATIONAL WEATHER SERVICE DOPPLER
RADAR INDICATED A TORNADO NEAR XXX.  THIS STORM
WAS MOVING TO THE XXX AT XX MPH AND WILL AFFECT
XXX...XXX...XXX AND XXX IN THE NEXT HOUR AND 18
MINUTES.

IF YOU ARE IN THE PATH OF A TORNADO...THE SAFEST
PLACE IS A BASEMENT.  GET UNDER A WORKBENCH OR
PIECE OF STURDY FURNITURE.  IF NO BASEMENT
IS AVAILABLE...SEEK SHELTER IN AN INTERIOR ROOM
SUCH AS A CLOSET ON THE LOWEST FLOOR.  USE
BLANKETS...PILLOWS...OR CUSHIONS TO COVER YOUR
BODY.  AVOID WINDOWS.
```

Figure 3: Sample Tornado Warning.

2.5 *Terminal Aerodrome Forecasts*

Fig. 4 contains a sample Terminal Aerodrome Forecast (TAF). These forecasts of aviation weather elements are prepared according to a rigorous set of rules which are set by international agreements. They are valid for a small area around an airport (Saint Joseph, Missouri, in the sample). Weather elements include wind

```
KSTJ 212011Z 212018 20022G32KT P6SM BKN040
     FM0100 21018G28KT P6SM SCT040 PROB40 0207 5SM
      -SHRA OVC025
     FM0700 30015KT P6SM SCT100
```

Figure 4: Sample Terminal Aerodrome Forecast.

direction and speed, weather, visibility, cloud amount and cloud height. The IFP techniques used by forecasters to prepare these forecasts include a set of cloud layers initialized from the Local AWIPS MOS Program (LAMP) (Oberfield 1996) and gridded data from the digital forecast database.

3. **Tabular Products**

Tabular weather forecasts present their information to a reader quickly and effectively. They lend themselves to graphic enhancements (cute icons for sky cover, bar graphs for maximum/minimum temperature). Tabular products also permit the exchange of digital forecast data between computers over the most rudimentary of communication paths. IFPS techniques have made it possible for WFOs to generate tabular products which would be too time-consuming to type.

3.1 *Coded Cities Forecast*

Fig. 5 shows a sample Coded Cities Forecast (CCF). This product provides a summarized 2-day forecast in a very compact form. The fields include station identifier, a one-letter weather code for each day, forecast maximum and minimum temperatures, and probabilities of precipitation. Some WFOs have extended this format to include as many as 7 days of forecast information. In the extended form, the forecast for each station occupies two lines.

```
ATL AA 059/084 061/087 062 20100
MCN AA 061/087 060/088 062 20100
SAV BB 067/090 067/089 066 20210=
```

Figure 5: Sample Coded Cities Forecast

3.2 *Revised Digital Forecast*

One of the needs frequently expressed by NWS customers is a need for more detailed forecasts. Adding too much detail to worded forecasts makes them unwieldy. The Revised Digital Forecast (RDF) provides significantly more detail, but uses a tabular format to present its information. Fig. 6 shows a sample RDF for Sedalia, Missouri. (Portions of the Thursday forecast were removed for space considerations.) Note that most forecast elements are specified in 3-h intervals for the first 2 days, including temperature, dew point, wind, and sky cover. Weather (rain showers and thunderstorms in this sample) is shown as a set of probabilities over each 3-h period. Thus the forecast calls for likely showers and thunderstorms for Tuesday, a chance of thunderstorms early Tuesday night, and a slight chance of thunderstorms late Tuesday night. The forecast for days 3 through 5 is shown with 12-h precision rather than 3-h.

```
DMO
              TUE  09/02/97     \     WED  09/03/97
CDT        02 05 08 11 14 17 20 23 02 05 08 11 14 17 20 23 02 05

POP 12HR                   60          50          10           0
QPF 12HR              .50-.99     .10-.24           0           0
MAX QPF               .50-.99     .10-.24           0           0
MX/MN                      87          59          72          52
TEMP              77 83 85 82 76 70 65 61 62 66 69 67 61 58 56 54
DEWPT             71 72 71 70 68 64 60 56 54 51 48 47 47 46 46 46
RH                82 70 63 67 76 81 84 84 75 58 47 49 60 64 69 74
WIND DIR          SW  E  N  N  E  E  N  N NE NE NE NE NE NE NE NE
WIND SPD           2  3  3  7  8 14 13 13 14 14 13 10  7  5  5  3
CLOUDS            OV OV OV BK OV OV OV BK SC CL CL CL CL CL CL CL
RAIN SHWRS         L  L  L  L
TSTMS              L  L  L  L  C  C  S  S

             \FRI 09/05/97\SAT 09/06/97\SUN 09/07/97\MON 09/08/97
CDT        20 02 08 14 20  02 08 14 20  02 08 14 20  02 08 14 20

POP 12HR         0     0     10    10     10    10     10    20
MX/MN           50    75     52    76     54    77     56   999
CLOUDS          CL    CL     SC    SC     SC    BK     SC   999
```

Figure 6: Sample Revised Digital Forecast.

The RDF product challenges the forecaster. There is little room for ambiguity here. It also provides a very effective means to communicate the forecaster's cognitive view of the forecast to the user community. Tabular products as complete as the RDF are too cumbersome for the public at large. This information can readily be converted to a more appealing graphic presentation.

3.3 *SHEF-encoded Zone and Station Forecasts*

The Standard Hydrometeorological Exchange Format (SHEF) (Office of Hydrology 1996) provides a flexible text-based code for the transfer of weather forecasts. It has been used mainly to encode data which are transmitted between NWS WFOs and River Forecast Offices (RFC). Fig. 7 shows a portion of a SHEF-encoded forecast for 3-h temperature, dew point, and wind, as well as maximum/minimum temperature. The forecasts are valid for 2 days for West Virginia Zone 5 (WVZ005, Wayne County). This product has been used to communicate temperature forecasts from the Charleston, West Virginia, WFO to the Wilmington, Ohio, RFC for use in snow melt algorithms.

```
.E WVZ005 0912 Z DH09/DC9709120728/ TAIFZZZ/DIH03/
.E1 58/57/59/68/73/73/65/60/57/55/59/70/76/76/67/60/57/56
.E WVZ005 0912 Z DH09/DC9709120728/ TDIFZZZ/DIH03/
.E1 57/56/56/57/56/56/57/57/55/54/55/56/56/56/57/58/57/56
.E WVZ005 0912 Z DH21/DC9709120728/ TAIFZXZ/DIH24/76/78
.E WVZ005 0912 Z DH21/DC9709120728/ TAIFZNZ/DIH24/53/54
.E WVZ005 0912 Z DH09/DC9709120728/ UDIFZZZ/DIH03/
.E1 36/36/36/27/27/27/36/36/36/36/36/36/32/32/36/36/36/36
.E WVZ005 0912 Z DH09/DC9709120728/ USIFZZZ/DIH03/
.E1 00/00/00/05/08/08/00/00/00/00/00/00/05/05/00/00/00/00
```

Figure 7: Sample SHEF-encoded Forecast.

3.4 *Basin-averaged Precipitation Forecast*

The forecast products described thus far have been based on DFMs for forecast zones or individual stations. NWS forecasters who use IFP techniques have been migrating toward manipulating their forecasts on grids.

IFPS includes techniques which generate products based on this gridded portion of the database.

Fig. 8 shows a SHEF-encoded quantitative precipitation forecast (QPF) for several sub-basins of the Ohio River. A forecaster created a set of gridded QPF forecasts at 6-h intervals, and the product generation software computed basin averaged QPF for each of the basins and formatted the product.

:	12Z	18Z	00Z	06Z	12Z	12Z	
:	09/17	09/17	09/18	09/18	09/18	09/18	
FRMW2	.00/	.00/	.10/	.05/	.00/	.14/	:Frametown WV
FTLK2	.00/	.00/	.11/	.09/	.00/	.20/	:Fishtrap Lake
GALW2LN	.00/	.00/	.20/	.00/	.00/	.20/	:Gallipolis OH lwr(N)
GALW2LS	.00/	.00/	.17/	.00/	.00/	.17/	:Gallipolis OH lwr(S)
GALW2UPR	.00/	.00/	.21/	.00/	.00/	.21/	:Gallipolis OH upr(N)
GALW2US	.00/	.00/	.13/	.02/	.00/	.16/	:Gallipolis OH upr(S)
GLEW2	.00/	.00/	.11/	.02/	.00/	.13/	:Glenville WV
GLNW2	.00/	.00/	.13/	.06/	.00/	.20/	:Glen Hayes WV
GLYK2	.00/	.00/	.17/	.01/	.00/	.18/	:Grayson Lake
GNUK2	.00/	.00/	.18/	.00/	.00/	.18/	:Greenup
GRAK2	.00/	.00/	.17/	.01/	.00/	.18/	:Grayson
HNTW2N	.00/	.00/	.19/	.00/	.00/	.19/	:Huntington OH (N)
HNTW2S	.00/	.00/	.14/	.02/	.00/	.17/	:Huntington WV (S)
HYSV2	.00/	.00/	.10/	.08/	.00/	.18/	:Haysi VA

Figure 8: Quantitative Precipitation Forecast

4. GRIB-encoded Forecasts

The tabular QPF product shown above captures much of the information that the forecaster entered into the gridded database, especially if the sub-basins are small. To completely represent the forecast, however, one must actually access the grids. Recent developments in IFP techniques have made it possible to give users this capability.

Before WFOs can share gridded forecasts, one must identify an effective medium for exchange. The World Meteorological Organization (WMO) has defined a standard format for the exchange of weather product messages in gridded binary form named GRIB (Dey 1996). GRIB provides a compact form of transmitting grids, using only the number of bits required to accurately represent the gridded data. WFOs using IFP techniques are in the process of establishing GRIB-based data exchanges with RFCs.

Viewing software has been developed which allows anyone to examine GRIB forecasts via the WWW (LeFebvre et al. 1996). In the initial implementation, forecasters generate GRIB-encoded messages from grids of selected weather elements. Maximum/minimum temperature and QPF are the first weather elements. These messages are transferred to a central host at NWS Headquarters. The GRIB messages are decoded and stored. Several of the grids are converted to images appropriate for display and downloading.

When a user contacts the server with a Java-enabled browser, several applets are downloaded to the local computer which enable it to query and render gridded forecasts. (See Fig. 9.) This applet is called the Graphical Forecast Viewer (GFV). Once a set of gridded forecasts is loaded into the GFV, the user can select among the available weather elements, query grid values beneath a roaming cursor, and animate a time series of images. Another option launches a temporal viewer. (See

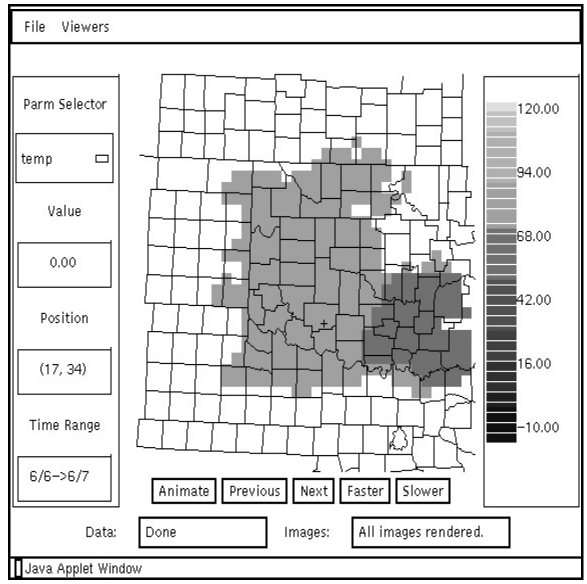

Figure 9: Graphical Forecast Viewer.

Fig. 10.) The temporal viewer displays a time series of values at the selected grid point.

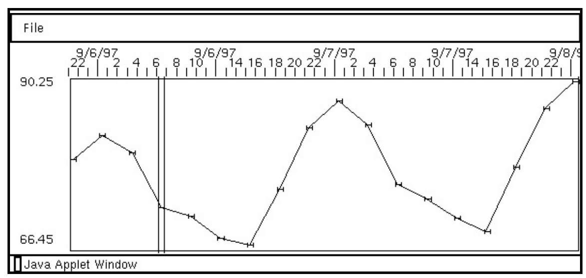

Figure 10: GFV Temporal Display

A WWW site is being prepared at this writing which will allow general access to gridded forecasts prepared at selected WFOs. Links to this site will be available from the home pages of these WFOs as well as the FSL and TDL home pages. In time, the central site and the GFV can be replaced by the Local Data Aquisition and Dissemination (LDAD) capabilities of AWIPS.

5. CONCLUSION

NWS forecasts have been issued primarily in worded form for years. IFP techniques, however, have provided NWS forecasters with the tools needed to generate new products in a variety of forms. Tabular products have brought the first changes to this area since they are easily transmitted across existing communications circuits. Graphical and gridded products are under development as well as the tools users will need to view them.

Product generation techniques will continue to expand to help forecasters prepare more products. These will include Fire Weather and Marine forecasts, a zone-like product with statewide coverage named the State Forecast (SFP), and an aviation product named the Transcribed Weather Broadcast (TWEB).

The products presented in this paper were all developed at national laboratories for implementation at WFOs throughout the NWS. This does not represent the limits of IFPS. Locally developed applications are in place generating specialized products at some IFPS sites already. The number of these applications will grow as local developers learn to use the digital forecast database.

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