6.9 A NEW APPROACH TO FIRE WEATHER FORECASTING AT THE TULSA WFO

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1. INTRODUCTION

The modernization of the National Weather Service (NWS) has given the local Weather Forecast Office (WFO) access to many new technologies. One of these provides the ability to create graphical areal forecasts. Through the Graphical Forecast Editor (GFE) (FSL GFE 2001), a forecaster can edit high resolution model output grids to produce graphical fire weather forecasts with resolutions of 5 km or less. Algorithms have also been locally developed to create tabular fire weather forecasts from the edited fields. The forecast process then provides the meteorologist an opportunity to adjust model forecasts for local biases and terrain effects. The Tulsa, Oklahoma WFO has been a test office for this new technology and has been using it to create high-resolution text and graphical fire weather forecasts since March 2001.

Forecasters at the Tulsa WFO are among the first in the country to use the GFE to produce graphical forecasts. Forecasters can select model output grids from the various National Centers for Environmental Prediction (NCEP) short range models. From these fields, forecasts of temperature, relative humidity, mixing height, transport wind speed and direction, ventilation rate, and other parameters are modified to make hourly graphical forecasts and three-hourly tabular forecasts. Finally, dissemination of these products is achieved by the many different communications systems including the Emergency Management Decision Support (EMDS) (FSL EMDS 2001) system which can display both the graphical and text products in one auto-updating display.

2. PRODUCT PREPARATION

The Interactive Forecast Preparation System (IFPS) (MDL 2001) is the cornerstone of the modernized NWS forecast process. The GFE (Fig. 1) developed at the National Oceanic and Atmospheric Administration's (NOAA) Forecast Systems Laboratory (FSL) is the first step in creating a digital forecast database from which the graphical and text products will be generated. Forecasters initialize the GFE by choosing model grids from the Nested Grid Model (NGM), Eta, or Aviation (AVN) forecast model produced at NCEP. The forecaster chooses the model initialization which is best modeling the atmosphere at the current time or typically handles certain forecast parameters best such as diurnal temperature changes, dewpoint trends, and winds. The forecaster may also choose to initialize the GFE using a blend of these models for different forecast parameters or by using the previous forecaster's edited grids as a starting point for the current forecast cycle.

Once the forecaster has determined which is the best model, the GFE is initialized with three or six hourly model grid data across a 48 hour time span. The GFE then interpolates hourly grids between the three or six hourly model data. It is at this stage that the forecaster begins editing each field individually. For example, forecasters edit mixing height and transport winds based on their interpretation of the weather pattern. Other fields that are edited to help derive fire weather products include: hourly temperature, hourly dewpoint, daily maximum and minimum temperatures, and hourly relative humidity.

Scripts that perform calculations on the forecast fields, called Smart Tools, are often used to help create additional fields such as Heat Index and Relative Humidity. This enables the forecasters to edit the grids using meteorological concepts and provide consistency checks as necessary. Several Smart Tools are regularly used at Tulsa. The first Smart Tool that is employed ensures that the dewpoint temperature never exceeds the ambient air temperature. Another Smart Tool calculates the maximum and minimum temperature from the hourly temperature grids. Relative humidity grids are created from the temperature and dewpoint grids.

More tools are being developed specifically for fire weather purposes. One Smart Tool, which is being developed locally at WFO Tulsa, calculates mixing heights. A Smart Tool is also being developed for Transport Winds. Surface winds are forecast at 33 feet

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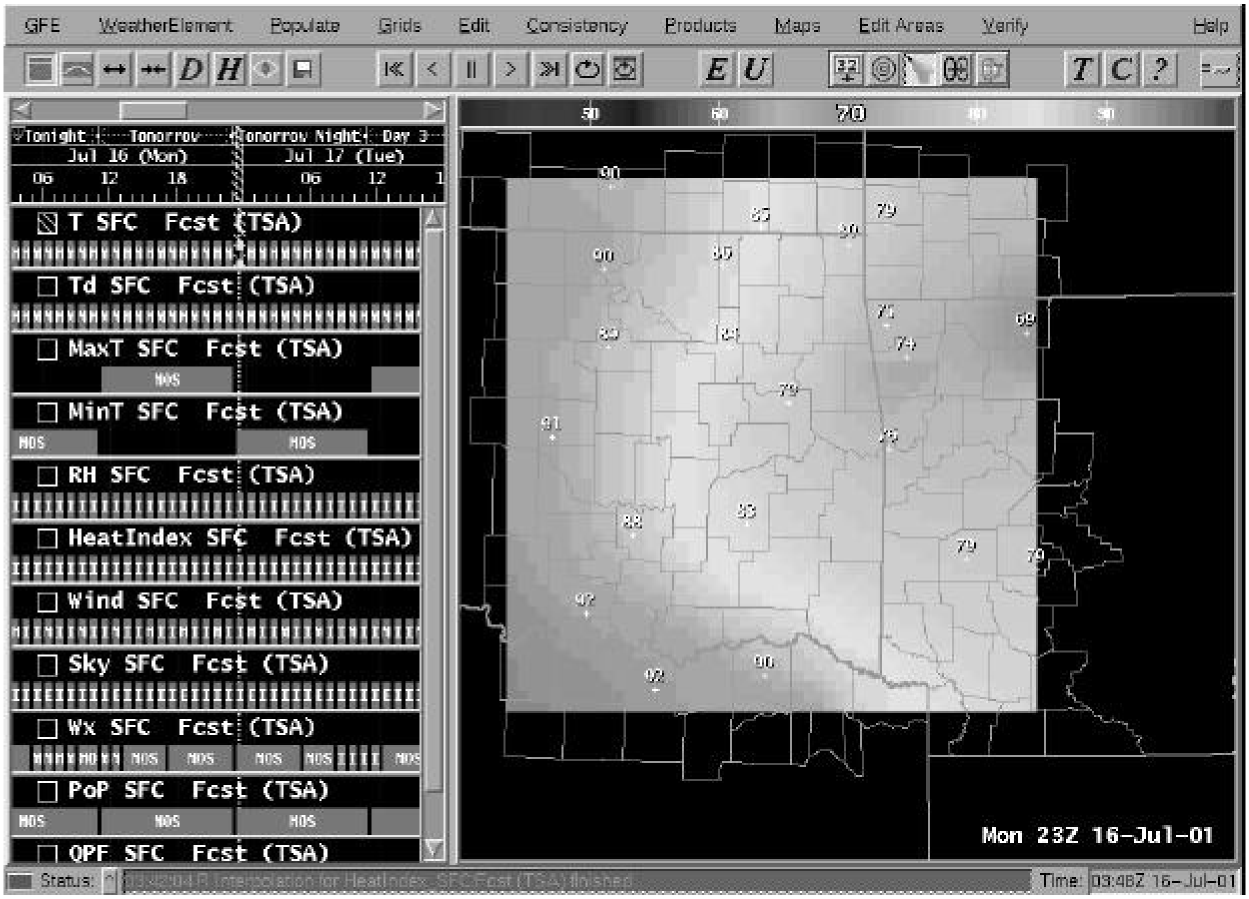

Figure 1. GFE software showing forecast fields and image currently being edited.

above ground level (AGL) in the NWS public forecasts. However, fire weather surface winds need to be forecast for 20 feet (AGL). A Smart Tool will reduce the 33 foot winds down to the 20 foot level, and these winds will be used in the fire weather forecast.

Some meteorological parameters show little change during certain weather patterns. The forecaster can use another feature of the GFE which allows them to copy grids and paste them into later time periods. Another helpful feature of the GFE allows previous forecast data to be used if new model grids are unavailable or stray from the thinking of the forecasters. In static weather patterns, it is often advantageous to initialize the data with the previous forecast, which offers accuracy and consistency beyond the new model data.

There are several tools available within the GFE to help the forecaster better represent weather trends specific to the Tulsa County Warning/Forecast Area (CWFA). The terrain varies in Eastern Oklahoma and Northwest Arkansas ranging from the Ouachita and Ozark Mountains in the east to the plains in the west.

Some of these areas within the Tulsa CWFA have been delineated and can be selected in the GFE. The forecaster can then assign values to the specific region. For example, the Arkansas River bisects the Tulsa CWFA and is one region where mixing heights typically fall to zero at night and winds become light and variable or calm. The forecaster can assign a specific mixing height and calm winds to the river valley locations, and show higher values in other sections of the CWFA. Another tool available to the forecaster involves the interpolation function of the GFE. Temperatures often rise rapidly in the morning and fall quickly at night, and the forecaster is able to indicate this trend in the hourly grids by interpolating over small time ranges of a few hours or less.

Once the grids are completed, the forecast grids are transferred to the Zones component of the IFPS for final adjustments. It is during this transfer that the graphical images are created. The final step is to send the data to the Product Generation portion of the IFPS where the text products will be generated.

3. GRAPHICAL PRODUCTS

Once the grids have been edited and have undergone a quality control check by the forecasters, they are converted to portable network graphic (PNG) files (Figs. 2 and 3). A PNG image is generated for every grid in the database. All of the graphical products currently being created are available hourly out to 48 hours. The graphic images have high resolutions of 5 km or less over a 500 X 500 km domain and are composed of information from thousands of data points in the GFE. Graphical forecast images can be tailored using scripts to contain weather elements in the form of images, graphical overlays, vectors or a combination of these.

Several grids are currently being disseminated by the forecast staff at WFO Tulsa. Surface temperature images are displayed with surface wind vectors overlaid. Relative humidity images are also available with surface wind vectors overlaid. Figure 3 shows the precision provided by the GFE showing how a cold front creates a strong mixing height gradient across the Tulsa CWFA.

In addition, the grids are converted into Java Serialized Objects and sent to the EMDS website. The display of graphical products is determined by the

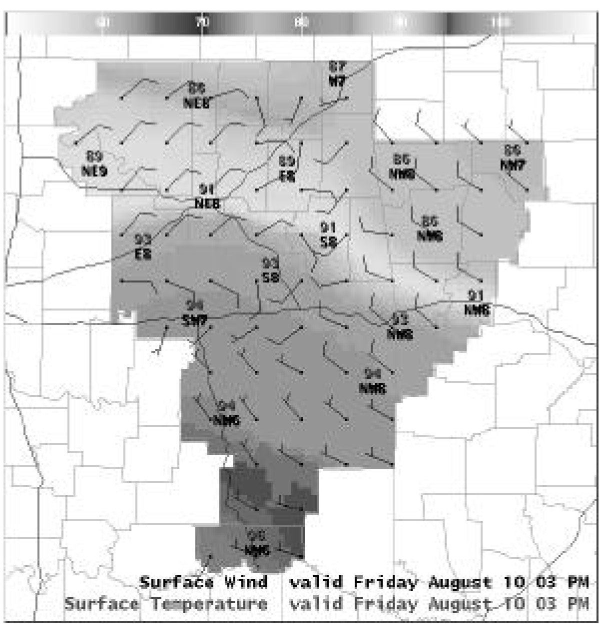

Figure 3. PNG image with surface temperature (F) and surface wind vectors (kts).

EMDS user and will be discussed in more detail later in this paper. Finally, the grids are ingested into the IFPS

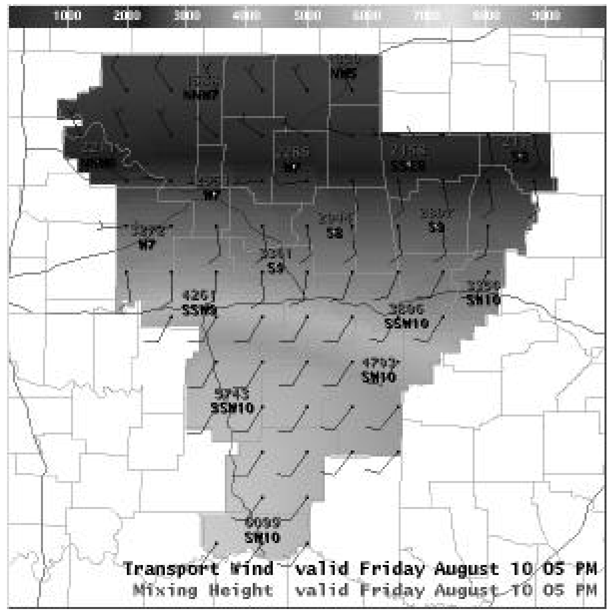

Figure 2. PNG image with mixing height (ft.) and transport wind vectors (kts).

matrices for text product generation.

4. TEXT PRODUCTS

Text products are created in the IFPS using the data from the edited grids and the information contained in other sections of the IFPS. The advantage of the IFPS is that all of the forecasts come from the same source. This ensures that the data used to generate the public forecasts, such as the Zone Forecast Product (ZFP) and Revised Digital Forecast (RDF), will also be used to generate the fire weather forecasts. This guarantees that all forecast products issued will be consistent.

Two fire weather text products are created. The first is the routine issuance of the Fire Weather Forecast (FWF) (Fig. 4). This is one of two standard formats used by the NWS for fire weather forecasts. Fire weather users in the Tulsa CWFA have shown a preference for a tabular format, which differs from the narrative format commonly used in other regions.

The FWF is comprised of a discussion section, body and extended forecast. The discussion allows the forecaster to address their confidence in the forecast and highlight particular areas of concern. This is included in an effort to blend the narrative and tabular fire weather forecasts into one complete FWF product.

The body of the FWF consists of three time periods

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EASTERN OKLAHOMA FIRE WEATHER FORECASTS
NATIONAL WEATHER SERVICE TULSA OK
700 AM CDT THU AUG 9 2001

.DISCUSSION...
HIGH PRESSURE OVER THE GULF COAST AND AN APPROACHING COLD
FRONT WILL RESULT IN SOUTH TO SOUTHWEST WINDS OVER THE AREA
TODAY.  WINDS ALOFT ARE FROM THE SOUTHWEST AND WILL HELP
TEMPERATURES BECOME QUITE WARM TODAY...WITH LOW RELATIVE
HUMIDITIES.  THE FRONT IS EXPECTED TO MOVE INTO EASTERN
OKLAHOMA AND NORTHWEST ARKANSAS ON FRIDAY AND FRIDAY NIGHT.
THIS WILL INCREASE RAIN CHANCES ON FRIDAY AND SATURDAY.


OKZ060-061-064>067-070-100021-
CREEK-MUSKOGEE-OKFUSKEE-OKMULGEE-ROGERS-TULSA-WAGONER-
INCLUDING THE CITIES OF...BRISTOW...CLAREMORE...MUSKOGEE
...OKEMAH...OKMULGEE...TULSA...WAGONER
700 AM CDT THU AUG 9 2001

                      TODAY           TONIGHT         TOMORROW

CLOUD COVER           MOSTLY SUNNY    PARTLY CLOUDY   CLOUDY
MAX/MIN TEMPERATURE   102             77              92
MAX/MIN HUMIDITY (%)  34              74              40
AM WIND (MPH)         S 12                            S 7
PM WIND (MPH)         S 15            S 10            N 10
PRECIP TYPE           NONE            TSTMS           TSTMS
PRECIP CHANCE(%)      10              20              30
PRECIP AMOUNT (IN)    0               .01-.10         .10-.24
MIXING HEIGHT (M)     1900            200             1000
TRANSPORT WIND (M/S)  SW 6            S 2             SW 5
VENTILATION RATE      11400           400             5000

.DAY 3 THROUGH 7 FORECAST..................................
.FRIDAY NIGHT...MOSTLY CLOUDY WITH A CHANCE OF THUNDERSTORMS.
LOW IN THE UPPER 60S. CHANCE OF RAIN 30 PERCENT.
.SATURDAY...PARTLY CLOUDY WITH A CHANCE OF SHOWERS AND
THUNDERSTORMS. HIGH NEAR 90.
.SUNDAY...PARTLY CLOUDY. A SLIGHT CHANCE OF SHOWERS AND
THUNDERSTORMS. LOW NEAR 70 AND HIGH IN THE LOWER 90S.
.MONDAY...MOSTLY CLEAR. LOW IN THE UPPER 60S AND HIGH NEAR 90.
.TUESDAY...MOSTLY CLEAR. LOW IN THE UPPER 60S AND HIGH IN THE
LOWER 90S.
.WEDNESDAY...MOSTLY CLEAR. LOW IN THE UPPER 60S AND HIGH IN
THE MID 90S.
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Figure 4. Example of the tabular FWF issued by the Tulsa WFO.

of various weather parameters. Maximum and minimum temperature, as well as relative humidity are included. Winds at 20 feet (AGL) and transport winds are also forecast. A 12 hour probability of precipitation (POP) forecast is included with the amount and type of precipitation expected. Maximum and minimum mixing height and ventilation rate are more fire weather parameters that are included. There are several advantages of this format. One benefit is that users can immediately see if mixing heights will meet minimum requirements for prescribed burns, or if dangerous fire suppression conditions will develop.

An extended forecast is appended after the body of the FWF and includes weather information through day seven. This forecast is also used in the public forecast.

The second form of the fire weather forecast is the experimental Fire Weather Forecast (FWFx) and comes directly from the RDF (Fig. 5). This product is considered experimental due to its innovative way of presenting three hourly data currently in the RDF with fire weather forecast parameters. In addition, the Tulsa WFO is the only NWS office in the country issuing an experimental FWFx product.

The FWFx contains similar information as the FWF. The differences lie in the way the data are presented. The FWFx is an extension of the RDF with fire weather parameters added. This product presents forecast weather data in three hour time blocks. Similar to the FWF, 12 hour POP and precipitation amount are presented as well as maximum and minimum temperature. However, the FWFx provides the weather forecast as it is changing in time. The FWFx not only shows wind direction, but how it changes in speed and direction throughout the day. In addition, the FWFx also shows changing temperature, dewpoint and relative humidity throughout the day.

The FWFx will be the next cornerstone of fire weather forecasting. It will not only provide fire weather users with maximum and minimum mixing height data, but also help refine the times when mixing heights will change rapidly. Initial feedback from fire weather users has been very positive. The FWFx should greatly help in fire suppression and in planning prescribed burns due to its increased time resolution.

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EASTERN OKLAHOMA FIRE WEATHER FORECASTS
NATIONAL WEATHER SERVICE TULSA OK
700 AM CDT THU AUG 9 2001

OKZ060-061-064>067-070-100021-
CREEK-MUSKOGEE-OKFUSKEE-OKMULGEE-ROGERS-TULSA-WAGONER-
INCLUDING THE CITIES OF...BRISTOW...CLAREMORE...MUSKOGEE...OK
OKMULGEE...TULSA...WAGONER
700 AM CDT THU AUG 9 2001

              THU  08/09/01     \     FRI  08/10/01     \
CDT        03 06 09 12 15 18 21 24 03 06 09 12 15 18 21 24 03

POP 12HR                   10          20          30
QPF 12HR                    0     .01-.10     .10-.24     .10
MX/MN                     102          77          92
TEMP           79 89 96100 95 86 80 77 76 82 88 92 86 78 73 6
DEWPT          71 71 70 69 69 69 68 68 67 67 66 65 66 66 65 6
RH             77 56 43 37 43 57 67 74 74 61 48 41 51 67 76 8
WIND DIR        S  S  S  S  S  S  S SW  S  S SW NE NE NE  N
WIND SPD       10 15 15 15 10 10  5  5  5 10 10 10 10  5  5
CLOUDS         SC SC SC SC SC SC B1 B1 B1 B1 B1 B1 B1 B2 B2 B
RAIN SHWRS
TSTMS                             S  S  C  C  C  C  C  C  C
HEAT INDEX          102106100                   94


MIX HEIGHT      4 11 17 19 10  2  2  2  3  6  9 10  7  1  1
TR WIND DIR     S SW SW SW SW  S  S  S  S SW SW SW NE NE NE
TR WIND SPD     3  5  6  6  4  2  2  2  3  5  5  1  1  1  1
VENT RATE       1  5 10 11  4  4  4  4  9  3  4  1  7  1  1
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Figure 5. Example of the FWFx issued by the Tulsa WFO.

5. PRODUCT DISSEMINATION

5.1 *NWWS*

The NOAA Weather Wire Service (NWWS) is a

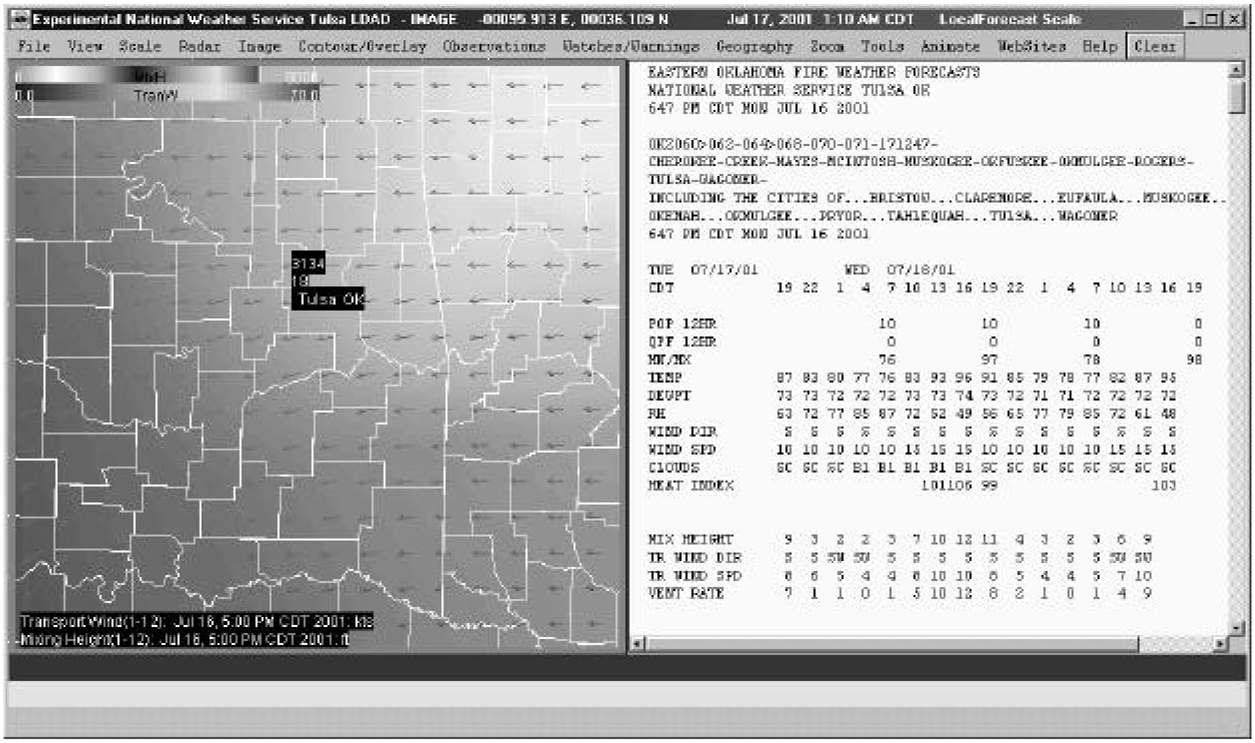

Figure 6. EMDS application displaying mixing height graphic and transport winds (left), with the FWFx text product (right).

subscription service that provides text products to its subscribers. The FWF is disseminated via this system and either stored on the recipient's computer system or printed.

5.2 *EMWIN*

The Emergency Managers Weather Information Network (EMWIN) (NWS 2001) is a service that allows users to obtain weather forecasts, warnings, and other information directly from the NWS in almost real time. EMWIN is intended to be used primarily by emergency managers and public safety officials who need timely weather information to make critical decisions. EMWIN can provide both text and image data by radio, internet, or satellite transmission.

5.3 *Internet*

When the fire weather forecast is issued by the Tulsa WFO, two products are actually generated and sent. The first is the FWF which is the standard fire weather forecast. This is used operationally in the field. The other is the FWFx. Both of these products are sent to the WFO Tulsa website. These products can be viewed either by the whole product or from a clickable county map. By selecting a specific county, a webpage will be dynamically generated with the FWFx product for that county. In addition, other pertinent fire weather information such as current surface observations and radar imagery are presented. In addition, the PNG images generated from the GFE grids can be viewed on the WFO Tulsa website. The user can select which type of image they want to view. Forecasts are available from the most current model run, as well as previous versions. In addition, the images can be presented in various time intervals. For example, the user can choose forecast images displayed every hour, or every three hours, or every six hours, etc.

5.4 *EMDS*

In July 2001 the Tulsa WFO became the first NWS office to disseminate graphical products generated in the GFE via the EMDS. The EMDS is a java applet/ application that displays weather information in a highly graphical, multi-windowed, multi-modal display that includes images, graphics, text and sound (Fig. 6). One of the significant differences between the EMDS and displaying static images on the internet is that the EMDS actually displays the grid data and not just a static image. This allows the EMDS user to sample the image or contour overlay to get more precise readouts. In addition, EMDS allows users to load multiple products onto one display pane such as an image of mixing height with transport wind vectors overlaid on top. Other features of the EMDS include looping of products, zooming, auto updating when new products arrive, and the ability to view the text version of the fire weather product side by side with the graphical version.

6. CONCLUSIONS

The advent of advanced forecast preparation technologies has revolutionized how forecasts are prepared in the modernized NWS. Software such as the GFE and IFPS have allowed forecasters to prepare high resolution graphical and text products for all users of NWS products and services. These new technologies are now being applied to fire weather forecasting and will allow users of fire weather products and services to receive much more information than they have received in the past.

Additional work remains to be done on incorporating more terrain-based information in graphical products as well as refining the information provided in text products issued by the NWS. As more NWS offices begin using some of these new technologies, it is hoped that products such as those discussed in this paper will evolve from experimental to the national standard. Further information and color images relating to this paper can be found at the following URL:

http://www.srh.noaa.gov/tulsa/science.

7. ACKNOWLEDGMENTS

The authors would like to thank Steve Nelson for all his work in implementing the GFE and for developing the scripts to create the fire weather text products. We would also like to thank Steve Amburn for his thorough review of this manuscript.

8. REFERENCES

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NWS, 2001: Emergency Managers Weather Information Network website. [Available on-line at http://iwin.nws.noaa.gov/emwin/index.htm.]