New tools for fire danger assessment in Florida

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1. Introduction

The National Weather Service Graphical Forecast Editor Suite (GFESuite) will be used in forecast offices to produce graphical weather forecasts. The GFESuite provides forecasters with: 1) a method to input a combination of forecast models, 2) tools to graphically adjust the fields, then 3) Formatters to output forecasts into graphics, text forecasts, and even html files for web based forecasts.

To produce graphical forecasts, the forecaster follows these steps: 1) Choose and load preferential forecast models. 2) Graphically adjust the fields using GFESuite editing tools. 3) Save and publish the forecast. 4) Make graphics, text, and html files. 5) Transmit the products to AWIPS, and to the web server. Graphical forecasts provide more detail than text based forecasts by revealing spatial weather trends for example, fire weather interests will be able to follow humidity trends and timing of wind shifts and precipitation

The software's scripting and grid manipulation capability extends farther though, and provides methods to derive new fire weather forecast parameters. For example, results from a wind regime based lightning climatology are imported as grids and merged with precipitation forecasts, new grid based dispersion and fire behavior indices are calculated based on model sounding data, and smoke plume forecasts are overlaid on detailed maps.

With a potentially overwhelming number of grids for forecasts that extend to five or seven days, the GFESuite software developers built scripting capability into the software. These scripts can streamline processes that may require many mouse clicks to accomplish otherwise. Portability is another asset of the GFESuite. A Linux based laptop can easily accommodate the software for field operations. When model availability is limited in the field, Incident Meteorologists can easily draw key fields and derive other grids using smart tools. Those grids provide a more complete picture of the fire weather.

This study looks at: 1) critical fire weather forecast elements, 2) methods to incorporate those elements into a graphical forecast using GFESuite "Smart Tools", 3) possibilities for the future .

2. Critical Fire Weather Elements

During the spring and early summer of 1998 over 2300 fires scorched nearly a half million acres of Florida at a cost of over 620 million dollars. The Florida Division of Forestry (FDOF) attributes lightning as the primary ignition source during this outbreak (31% during 1998). The 1998 fires occurred after a winter season of record rainfall. During the winter season prior to these events, Florida was influenced by rainy El Nino conditions generating precipitation 200% above normal for October, December and February. By April, May, and June, rainfall was less than 50 percent of normal and considerable solar radiation and evaporation dried Florida's vegetation.

Paxton et al. (2001) compared conditions present during a major outbreak period and a suppression period, during 1998 to identify features useful for fire weather forecasts. Both events were characterized by: high Keetch-Byram drought indices (KBDI), adequate instability and moisture for convection, light surface wind flows, opposing east and west coast sea breezes, and light winds aloft. The period of suppression was associated with passage of an upper trough and intrusion of subsident air over much of Florida. In comparison, the fire outbreak was associated with nearly stationary convection with heavy rain and abundant lightning leading to initiation of fires particularly outside rain areas. The next day though, limited convection developed with little or no rainfall. This allowed smoldering lightning fires to develop and spread.

In general, Brotak and Reifsnyder (1977), Brotak (1994), and Potter (1996), indicated typical fire weather elements important to fire weather interests include: KBDI and other short to long term moisture assessments, gradient and localized winds, relative humidity (RH), instability in lower atmospheric levels resulting in high mixing heights, lightning, rainfall, and smoke dispersion. Low stability and high mixing heights, promote organized smoke columns that lead to faster burn rates. Low relative humidity will also increase the rate of fire spread. Other factors influencing fire behavior are: fuel moisture, terrain slope, fuel continuity, and ignition processes.

Several methods are used to determine the severity of fire weather conditions on a day to day basis. Fire Weather Watches and Red Flag warnings, which vary by region, are usually based on low values of RH and high wind values. In Florida, the high values of the Lavdas dispersion index (LDI) (Lavdas, 1991) call attention to conditions conducive to wildfires. The Lower Atmospheric Severity Index (LASI), Haines (1988), also known as the "Haines Index", makes a simple assessment of stability and moisture in the lower part of the atmosphere and is used to quantify the atmosphere's contribution to the growth potential of wildfires. The LDI makes several indirect assumptions of stability and the LASI does not incorporate the contribution of wind to wildfire potential.

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3. New Tools

GFESuite scripting capability greatly extends the usefulness of the software. GFE procedures and Smart Tools provide the capability to: blend model fields, add current analyses for initial or short term forecasts, produce grid based indices such as the clearing index (Gibson, 2001), Lavdas dispersion index, and stability indices from vertical model fields.

Although coarse, vertical model data adds the third dimension to GFESuite Based forecasts. Mixing heights can be computed, and then moisture, stability, and wind calculations can be made for the mixed layer. Simple smoke plume forecasts take the dispersion indices a step farther. Using vertical wind and stability data a simple model provides smoke plume location grid. When topography plays a role in weather prediction, smart tools work with topographic queries for calculating ground levels and can be extended to model localized circulations.

To provide a more comprehensive index for wildfire spread, that includes vertical assessments of RH, wind speed, and stability, a new computation is introduced. Using a SmartTool within the GFESuite, a mixing height is computed from a derived model sounding. Then, a mixed layer lapse rate is computed. Next, the difference of the surface dewpoint depression and average dewpoint depression in the mixed layer are computed. Then, the sum of surface wind speed and average wind speed (transport wind) is made. Terrain heights are considered for these calculations. Finally a dimensionless value is calculated (Eq. 1.).

$$1.\ \textbf{PL Index} = \frac{(T_{sfc} - T_{mix}/H_{mix})\ (WIND_{sfc} + WIND_{avg})}{(DPDEP_{sfc} - DPDEP_{avg})}$$

Where:

- **T** is temperature (C)
- **H** is Height
- **DPDEP** is the dewpoint depression
- **WIND** is wind speed (ms^{-1})
- **sfc** refers to the terrain surface
- **mix** refers to the mixing height level
- **avg** refers to the average from the surface to the mixing height

In general, conditions are more prone to wildfires when values are negative. This may be enhanced in several ways to simplify the index for users, including normalizing this to a 0 to 100 scale. When available in gridded form, the KBDI may be incorporated into the script to provide a more thorough analysis of the wildfire threat.

4. Conclusions

The capabilities of the GFESuite are largely unexplored. This collective set of tools will allow the forecast process to advance considerably. Forecasters will concentrate on providing more detail to the forecasts, and scripts will help define problem areas.

Short term future capabilities include many possibilities. One is, automated web based spot wildfire forecasts that tap into the gridded database to produce a text table. At this point Lightning frequency prediction is still more art than science but once climatologies are computed that indicate dependant sounding parameters, grid-based excessive lightning forecasts will follow. Another near future use of the GFESuite is a wind regime based, hourly lightning climatology (Lericos et al., 2000). These grids of hourly lightning frequency and location can be used as a first guess field for convective precipitation and lightning frequency within the GFESuite. Table 1. shows the product grid names and fields derived from the new GFESuite based fire weather Smart Tools.

Table 1. Fire Weather Smart Tools

Name	Field 1	Field 2	Field 3
Clearing Index	Transport Wind	Mixing Height	
Haines	Surface RH	Stability	
Lavdas Dispersion	Transport Wind	Mixing Height	Stability factor
Plume Forecast	Transport Wind	Mixing Height	Fire Area
Fire Weather Watch	Surface Wind	Relative Humidity	
Red Flag Advisory	Surface Wind	Relative Humidity	Lavdas Dispersion
Paxton-Laing	Surface and Transport Wind	Dewpoint Depression	Lapse Rate

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