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6.5

Real Time Mesoscale Modeling in Support of Fire Weather Forecasting

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1.0 Project Description

The state of Florida has led the nation with respect to wildland fire management for many years. New technologies are being investigated that will help maintain ,and perhaps even increase, that lead. In order to more accurately deal with the threat from wildfire, as well as manage the largest open burning program in the country, Florida has designed a wildland fire management system that is GIS based. This new system has integrated some of today's most sophisticated technology. Elements include an Oracle Database, an ARC/INFO database, and a mesoscale weather model, namely the National Center for Atmospheric Research (NCAR) / Pennsylvania State University (PSU) Fifth Generation Mesoscale Model (MM5) (Grell et al. 1994).

The fire weather and behavior module of the Florida Fire Management Information System (FFMIS) provides core GIS functionality to support the State of Florida's wildland and prescribed fire management programs. This module is based upon the same GIS approaches used by the Canadian Wildland Fire Information System (Lee, 1995). FFMIS spatially models the current and forecast state of surface weather, atmospheric stability, fire danger, fire weather index and fire behavior potential.

The following provides a brief description of the FFMIS fire science models, data management issues and GIS processing and map production.

The surface weather sub-system provides spatial displays of 1300 LST standard surface temperature, relative humidity, wind speed and wind direction observations. Displays of maximum and minimum temperature and relative humidity are also presented, as are 24 hour precipitation amounts and the number of days since rain. The source of weather observation data is from 110 weather stations located in and around the state of Florida. Forecast data is provided to FFMIS from the MM5 model at a regular grid spacing of 16 kilometers. These GIS layers provided by this sub-system are the principle inputs to the following models: Atmospheric Dispersion Index, Fire Danger Rating, Fire Weather Modeling, and Fire Behavior Potential. Each of these models is briefly described below.

1.1 Atmospheric Dispersion Index

The Atmospheric Dispersion Index (ADI) is an integer greater than or equal to one reflecting the efficiency of the atmosphere at carrying gaseous or small particulate matter away from its source. The ADI is based on the Gaussian Plume statistical model (Lavdas, 1986), where a Gaussian distribution of the pollutant concentration is expected in a finite box downwind of the source. The ADI uses surface and upper air (radiosonde) weather observations to estimate a mean wind vector and an upper bound (mixing height) for the turbulent surface layer, in which turbulent mixing aids in pollutant dispersion.

Calculations are presently performed at 0100, 0700, 1300, and 1900 LST, and include mixing height, transport wind speed and direction, and the Dispersion Index.

1.2 Fire Danger Rating

This module partially implements the 1988 version of the National Fire-Danger Rating System (NFDRS) (Deeming, et al 1978, Cohen and Deeming, 1985, Burgan 1988). Outputs implemented for the State of Florida include the 10 hour, 100 hour and 1000 dead fuel moistures; Keetch-Byram Drought Index, Woody Greeness Factor, Ignition Component, Spread Component, Energy Release Component and Burning Index.

1.3 Fire Weather Modeling

The Canadian Forest Fire Weather Index (FWI) System (Canadian Forest Service, 1984; Turner and Lawson, 1978; Van Wagner, 1987) is the basis for modeling and interpreting fire weather. The FWI system estimates forest floor moisture conditions using empirical models driven by the 1300 LST weather observations and forecasts.

1.4 Fire Behavior Potential

In contrast to the NFDRS and FWI systems, the modeling of fire behavior potential provides absolute rather than relative measures of fire business. Using weather (FWI), fuels, and terrain information as inputs, quantitative predictions of fire growth, intensity, fuel consumption and crowning potential are derived. This sub-module is based on empirically developed equations from the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group, 1992).

2.0 MM5 Configuration

The MM5 has been shown to do quite well at representing the observed diurnal evolution of the coastal environment in a non-forecast, "research" mode with a doubly nested set of domains at 36 km, 12 km and 4 km (Herbster 1996) and, more recently, in an operational environment with a single domain of 15 km (Herbster and Watson 1998).

Table 1 MM5 configuration for DOF modeling program.

Configuration on a SGI Origin200 (2 CPUs), for a 24 hour simulation
Single Domain (67 N-S x 63 E-W)
16 km resolution
Nonhydrostatic - sigma coordinates (23 levels)
Simple ice physics
Multi-level PBL (Blackadar, similarity theory)
Sophisticated radiation scheme (w/ active clouds) - updated every 30 minutes
Grell Cumulus scheme
ETA model Initialization + 6 hourly BC's
1:20 clock time

The model resolution for this project was chosen to be 16 km, as this coincides with other spatial aspects of the database. Table 1 provides a general description of the current MM5 configuration for this project. The domain covers the entire state of Florida, extending into southern Georgia and Alabama. The MM5 can be initialized with a variety of models, though in practice the Eta model is being used.

A real time archive of model data generated by the National Center for Environmental Prediction (NCEP) has been established, and the modeling system has been configured to run with either the Rapid Update Cycle (RUC), Eta or meso-Eta models. In general, the Eta model is used to provide the initial and time dependent boundary conditions to the MM5. Anticipated changes in the Eta later this year should make support of the meso-Eta obsolete.

The MM5 is initialized with the initial period from the large scale model with the highest temporal resolution boundary conditions that are available being utilized (generally six hour). At this time no data assimilation is being conducted, though this is a possible enhancement that is being considered for future development.

Winds from the MM5 forecast are used to provide a source of time dependant guidance for the diurnally varying winds that are common to the bulk of this state over much of the year.

Figure 1 is an example of the 16 km resolution model output, valid at 1800 UTC, 29 June 1997, for this project. Note that the winds around the state show an interaction between the local sea breeze circulation and the large scale flow. The winds are plotted at alternating grid points to reduce the clutter in the figure. This type of local/regional variability in the low level wind field is consistent with observations and is critical for estimating where a smoke plume may be advected. This type of detail is not possible with any of the nationally run forecast models and is the primary motivation for running a mesoscale model as part of this project.

A second example of the MM5 output is provided in figure 2. In this case, 3 hourly precipitation associated with a slowly moving frontal system is presented. Notice the large precipitation totals over the western part of the

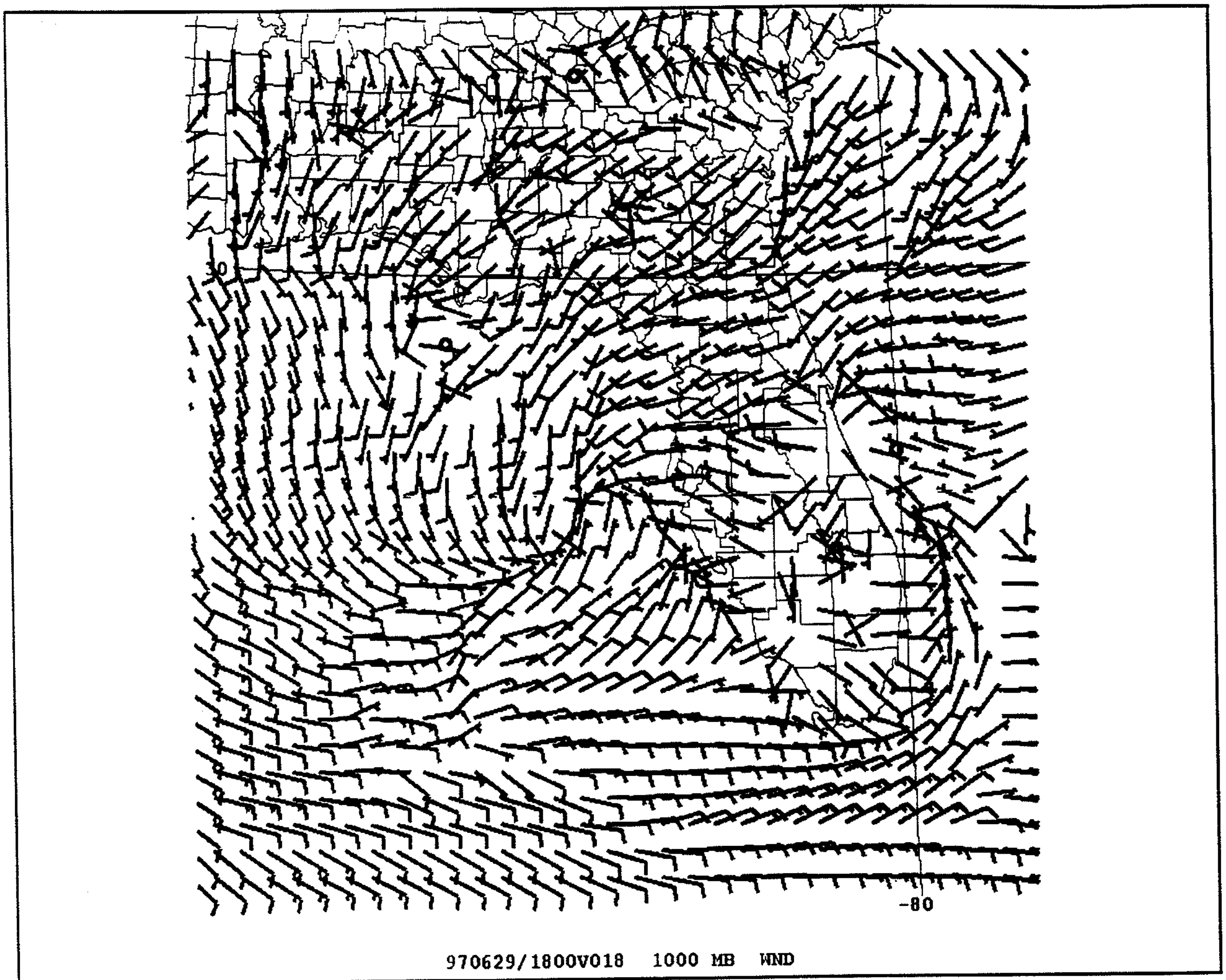

Figure 1 1000 mb winds from the DOF MM5 domain (16 km), valid 1800 UTC, 29 June 1997. Wind barbs are plotted at every other grid point.

peninsula, the same areas which experienced heavy localized flooding.

Additional information regarding the details of this project, including the details and examples of the user interface, is available at the following URL: **`flame.doacs.state.fl.us`**.

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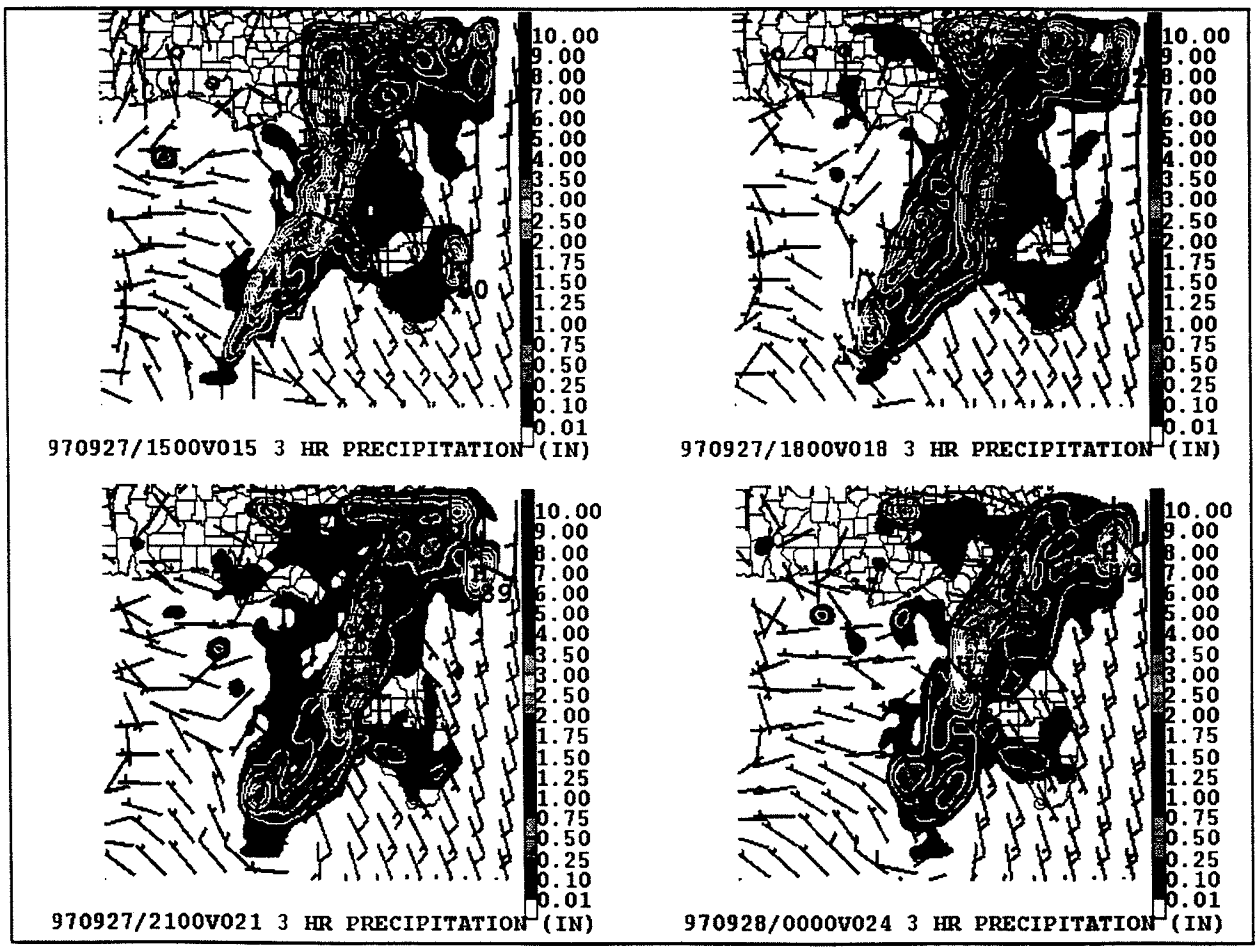

Figure 2 Three hourly precipitation and 10 m wind forecasts from the DOF MM5. Valid at 3 hour intervals beginning 1500 UTC 27 September 1, ending 0000 UTC 28 September 1997. Winds are plotted at every fifth gridpoint.