P6.7 **THE MESOSCALE ENVIRONMENT AND LIGHTNING DISTRIBUTION DURING THE 1998 FLORIDA WILDFIRES**

Arlene G. Laing*, University of South Florida, Tampa, FL
Charles H. Paxton, National Weather Service, Ruskin, FL
Scott L. Goodrick, Florida Division of Forestry
Dave Sharp and Peter F. Blottman, National Weather Service, Melbourne, FL

1. Introduction

During late spring and early summer 1998 over 2300 fires scorched nearly a half million acres of Florida at a cost of over 500 million dollars. The intensity and frequency of the wildfires was unprecedented, oftentimes sending smoke columns more than 30000 ft, leading to the evacuation of entire counties, closing of major highways, destruction of homes and businesses. Among the lessons learnt during that season was the need to improve certain aspects of wildfire forecasting including timing and magnitude of: low-level moisture variability, diurnal circulation characteristics (sea and land breezes), convection, precipitation, and lightning initiation. Lightning played a major role in igniting 31% of the total number of fires that eventually covered 79% of the total acres burnt.

Although most of Florida had record rainfall associated with the El Nino (Ropeleski and Halpert 1996) during the previous winter, dry conditions during the spring left those same areas vulnerably dry (Fig. 1.). Extreme fire conditions were created by record heat during May and June. Numerous wildfires erupted in early May, the largest in the Appalachicola National Forest. By late June, Florida was experiencing more than 80 new fires per day with the largest and most frequent occurrences in northeastern counties (FL climate divisions 2 and 3). On 22 July, the season finally subsided with increased summer precipitation.

Interestingly, while extreme fire conditions existed throughout much of the state, wildfires were highly variable in space and time. Fire managers have raised concerns that widely applied indices like the Keetch-Byram Drought Index may be poorly correlated with fire business (acres burned, large fires, ignition) and inadequate on a day-to-day basis (USDA-Forest Service, 2001). A better understanding of the mesoscale processes is needed to help forecasters and fire managers meet the challenges presented by prolonged drought conditions in Florida.

It is hypothesized that conditions in proximity of the sea breeze provided a localized environment for fire initiation from lightning and fire growth from increased instability and stronger winds; but little rainfall. Conversely, it is suggested that fires and smoke altered the diurnal sea and land breeze circulations.

* *Corresponding author address*: Arlene G. Laing, University of South Florida, Geography, SOC 107, 4202 E. Fowler Ave, Tampa, FL 33620, e-mail: alaing@luna.cas.usf.edu

This study investigates relationships among lightning distribution, mesoscale environmental parameters, and rainfall during the 1998 Florida wildfires.

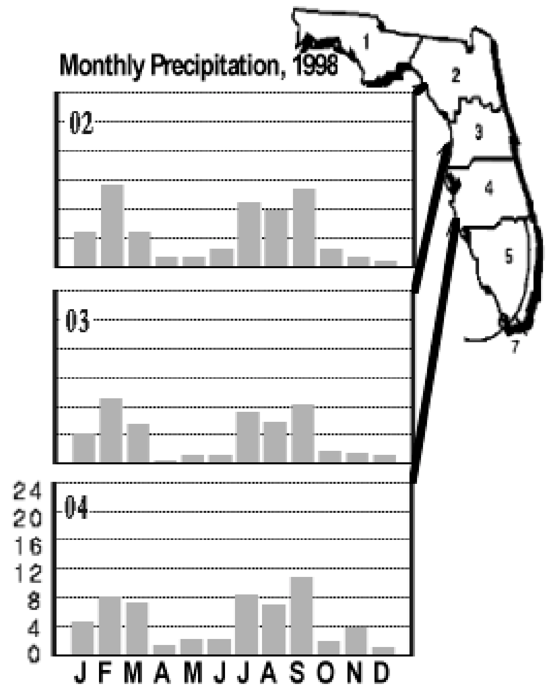


Figure 1. Monthly 1998 precipitation (inches) for Florida Climate Divisions with the maximum number of fires.

2. Data and Methods

Fire data was obtained from the Florida Division of Forestry (FDOF). From that extensive database, eight episodes were chosen as case studies based on total acres and number of new fires. Particular attention has been paid to periods of major wildfire outbreaks and suppression.

Synoptic and mesoscale environments were determined by analysing surface and upper air observations. Visible and infrared GOES imagery was been combined with surface data to determine the evolution of convective weather systems and diurnal mesoscale circulations. Mesoscale analysis incorporated base reflectivity and daily precipitation data from the WSR-88D in Melbourne, FL.

Lightning data (location, peak current, and multiplicity) and FDOF derived lightning-initiated fire data were imported into a Geographic Information Systems (GIS,). *ArcView* GIS was used for spatial analysis and for generating plots of flashes and fire initiation points on a Florida country map. A fire danger flowchart and graphical interface is being develop and compared with fire danger indices being used in Europe and Canada (Viegas et al. 2000)

3. Weather Favoring Ignition and Spread

Fire managers require guidance from forecasters on fire initiation and spread. Since lightning plays a significant role, it is important to investigate the environment that produces high rates of flashes. Fire spread is strongly influenced by a number of factors like, large-scale subsidence, dry cold frontal passage, and thunderstorm downdrafts. The impact of various types of weather will be discussed in subsequent sections.

4. Large-Scale Subsidence

The large-scale surface patterns indicated an atypical predominant surface high-pressure area over the Gulf of Mexico providing a rather dry northerly flow into the fire areas (e.g., Fig 2). The synoptic environment led to a sharp decrease in moisture in the lower atmosphere and, with each dry surge, progressively less moisture to modify the subsiding air. The result was a period of high temperatures, record drought, and wildfires.

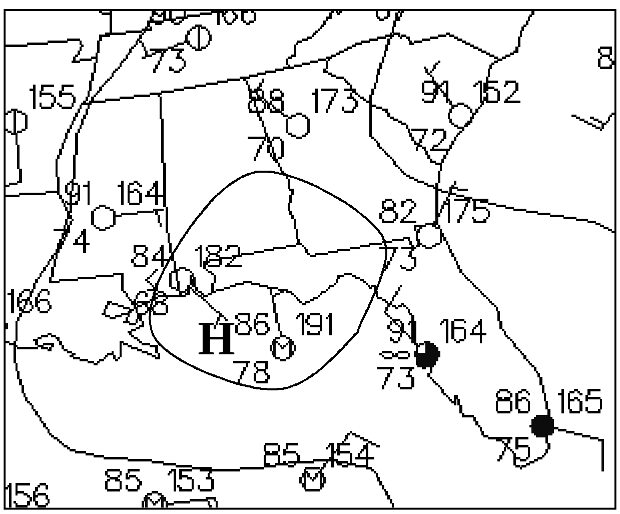


Figure 2. Surface observations and analysis, 00 UTC 24 July 1998

5. Lightning Distribution

Between 26 May and 3 July 1998, the daily frequency of flashes over Florida was positively correlated with new fire starts. For example, the total number of flashes that occurred on 19 June was ten times greater than occurred on 10 June. It is not surprising to discover that only one new fire occurred on 10 June while 81 new fires began on 19 June.

The hourly frequencies reveal a more complicated picture (Fig. 3). Over periods of less than six hours, a dramatic increase in flash frequency does not immediately translate into large numbers of new fires. High flash density is a necessary condition for fire initiation, but it is not sufficient to cause rapid combustion and is also not well correlated to total acres burnt (not shown). The lag time between flashes and fire initiation is dependent on such factors as antecedent precipitation, fuel type, lower tropospheric temperature, humidity, and wind.

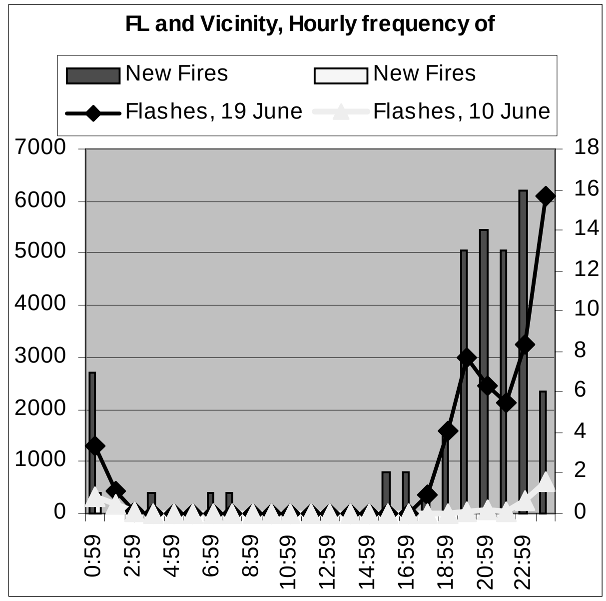


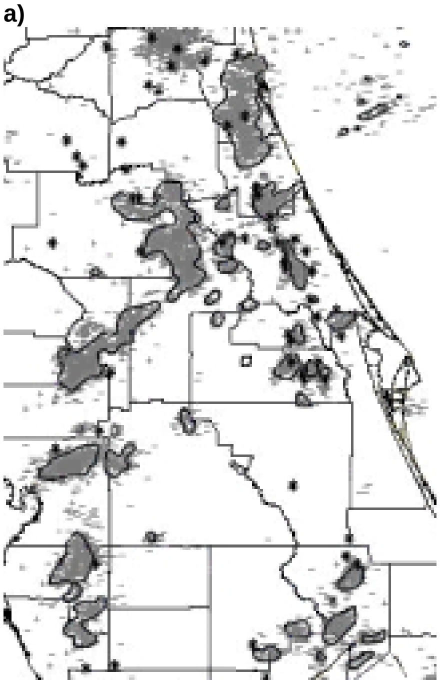
Figure 3. Frequency distribution of flashes and new fires across Florida and vicinity on 19 June 1998 (dark lines) and 10 June (pale lines)

6. Precipitation, Lightning, And Fires

Preliminary analyses indicate the prevalence for location of most fire initiation points along the periphery and outside of heavy rain areas. An example of the spatial distribution of precipitation, flashes, and FDOF lightning-initiated fire locations is illustrated in Figure 4. The precipitation, while welcome, was accompanied by tremendous amounts of cloud to ground flashes and was sufficient to dampen the existing fires only briefly. It is also interesting to note that new fire starts on the 20th were located in those areas where lightning struck the day before. As noted earlier, other factors were at play in the timing of ignition, namely, the high concentration of palmetto-galberry and pine --vegetation that is highly conducive to ignition and spread of fires.

Peak current charges do not appear to have much impact on fire start or size. Preliminary attempts to identify flashes responsible for each fire showed that, surprisingly, most fires were associated with negative flashes. This result may be due to the fuel characteristics and the method of identifying fire ignition points. Since certain fuels smolder for long periods before full-blown combustion, flashes could occur 48-60 hours prior to the fire start time. In addition, the fire points are at the center of sectors of varying sizes.

a)



b)

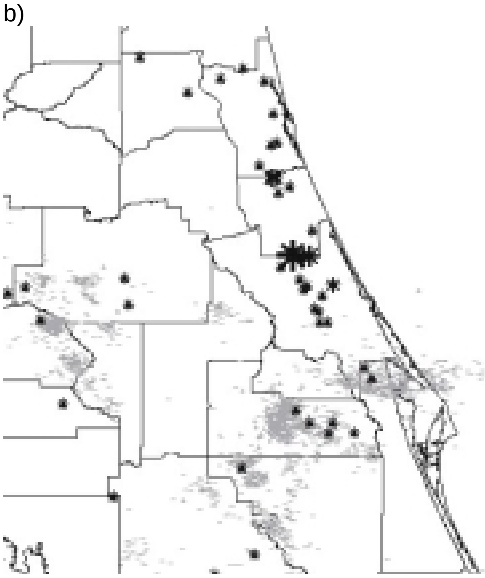
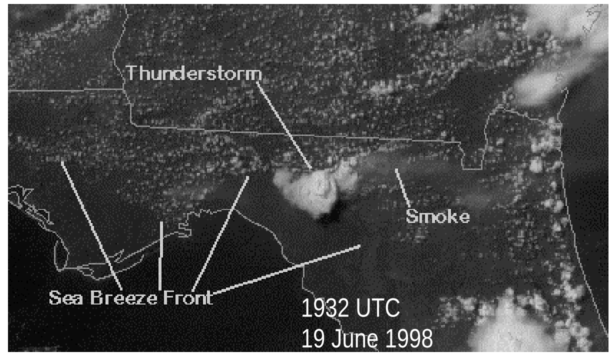


Figure 4. a) Lightning flashes (+,-), precipitation > 0.75 inches from 12UTC 19 Jun –12UTC 20 June 1998 (solid lines), and center of new fire sector (*); b) flashes and new fires graduated according to total acres for the period 12UTC 19 Jun –12UTC 20 June 1998.

7. Mesoscale Interaction: Sea-Breeze and Fire

As noted in Section 6, the convection produced lightning that ignited a large percentage of the fires. In turn, those fires also modified the convection. Figure 5 shows one instant during which fire and smoke interacted with the sea-breeze convergence zone and produced a strong a very strong thunderstorm complex. The surface analysis features a weak trough stretching from the panhandle to the Georgia coast and an area of relative humidity less than 46% in the vicinity of the fires over northern Florida. Given the weak synoptic environment, it is clear that the mesoscale processes were paramount in the development of this convective system. Note also the prevailing westerlies that have driven the western sea breeze front far inland while in the northeast, the convergence zone hugs the coast line. This tendency for the east-coast convection to remain nearly stationary led to lightning strikes and fires just inland of the coast in areas that received limited rainfall (Fig. 6).



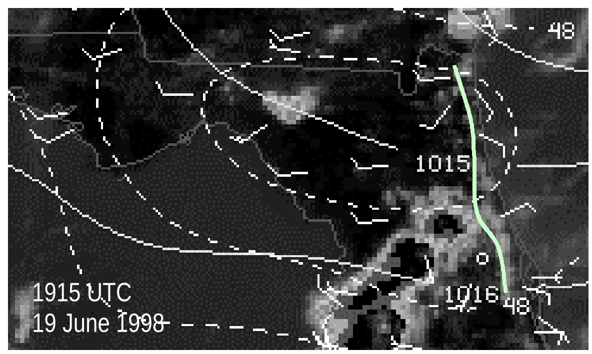


Figure 5. 19 June 1998, a) Visible image of sea-breeze front convergence with smoke from forest fire, 1932 UTC (courtesy, FDOF) and b) Enhanced IR image overlaid with isobars (solid), relative humidity (dashed), and wind barbs, 1915 UTC. Thick white line denotes the eastern sea breeze convergence zone.

8. Comparison of Suppression and Major Outbreak

The 1998 fire season was challenging for fire managers because of the scale of the events but also because the frequency of fires and acreage varied daily and hourly exacerbating the situation. Identification of weather conditions associated with two extreme episodes is expected to contribute to improvements in fire weather forecasting and deployment of fire-fighting resources. The 10 June (period of suppression) and 19-22 June (maximum number of daily fire starts and largest fires) were two such cases.

Satellite images from 10 June shows very little convection, apart from two small system over southern Florida and west of Cape Canaveral (Fig. 7). By 2300UTC, a trough of low relative humidity extended south through the state after the passage of a strong upper level trough. In comparison, deep convection

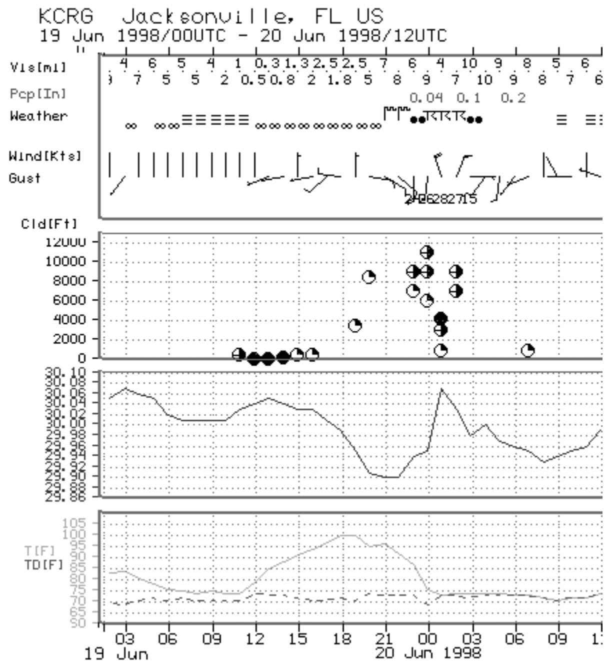


Figure 6. Meteorogram for Jacksonville, FL, 03 UTC 19 June to 12 UTC 20 June 1998.

dominates the weather on the 19th (Fig 8). A strong mesohigh develops beneath the deep convection that remains quasi-stationary over north Florida. Strong outflow from the convection (> 15kts) converged with the eastern sea breeze front. Total fire acreage increased from 23,000 to 173,000 acres between 19 and 20 June in response to the lower tropospheric wind, humidity, and temperature changes. Fire spread is tied to movement of thunderstorm downdrafts because this very stable air can drive fires without regard to topography. In the mid-upper levels strong westerly wind shear prevailed on 10 June in contrast to the weak middle level shear present on 19 June (not shown) that enhanced the development of steady, deep convection over the northeastern counties.

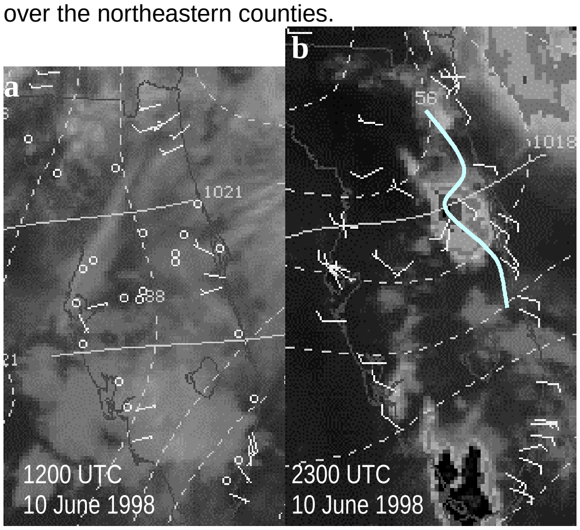


Figure 7. Same as 5 except a) 1200UTC, b)2300 UTC 10 June 1998

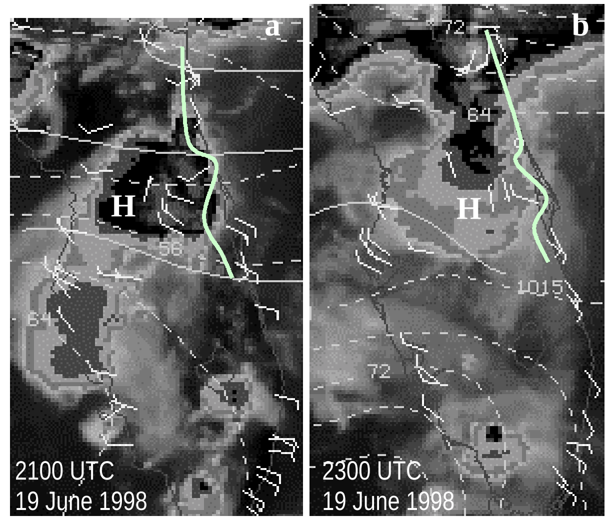


Figure 8. Same as 5 except for a) 2100UTC and b)2300 UTC 19 June 1998

5. Concluding Remarks

Convection that developed during the late spring and early summer produced nearly stationary convection with considerable lightning leading to initiation of fires particularly outside rain areas. Conversely, the interaction of the sea-breeze convergence zone and smoke from existing fires lead to the development of deep convection.

Subsequent research will focus on developing statistical relationships among flash-ignition lag time, fuel type, total acres, and lower atmospheric wind and moisture characteristics. Comparisons will be made with Fire Danger indices in use in Europe, Canada, Australia, and other parts of the US.

Acknowledgements

This paper is funded under a cooperative agreement between the National Weather Service and the University Corporation for Atmospheric Research, the COMET Outreach Program, Award No S99-18115. The Florida Division of Forestry provided the lightning-initiated fire database and Global Atmospheric Inc provided lightning data.

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