P1.1 FLORIDA WILDFIRE INITIATION AND ENVIRONMENTAL CONDITIONS DURING 1998

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1. Introduction

In response to the unprecedented Florida wildfire outbreaks of 1998 and the prolonged activity of the last two years, new emphasis has been placed on fire weather forecasting. Starting in late spring and continuing through early summer 1998 over 2300 fires scorched nearly a half million acres of Florida at a cost of over 600 million dollars. The intensity and frequency of the wildfires oftentimes sent smoke columns more than 30000 ft, led to the evacuation of entire counties, closure of Interstate 95 and major Florida highways, and destruction of homes and businesses. This study examines the role of lightning, sea-breeze convergence, precipitation, fuel-type, and large-scale circulations on fire initiation and daily fire spread during that period.

2. Data and Methods

Fire data was obtained from the Florida Division of Forestry (FDOF). From a database of lightning-initiated fires, including start dates and time, geographic coordinates, total acres, fuel type, 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 analyses were determined from surface and upper air observations. Visible and infrared GOES imagery was 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.

Soundings were used to derive convective indices including the Lower Atmosphere Severity Index or Haines Index that is used widely in fire weather forecasts. The Haines Index ranges from “2” (moist and stable airmass with very low fire growth potential) to “6” (dry and unstable airmass with high fire growth potential).

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 developed (Paxton and Laing, 2001).

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3. Florida Climate and Fire Situation

While excessive precipitation in Florida is expected with El Niño episodes (Ropelewski and Halpert, 1996), precipitation was 200% above normal for Oct-Dec 1997. However, subsequent dry conditions left those same areas vulnerable. That spring Florida climate was ranked among the driest in 104 years (Fig. 1).

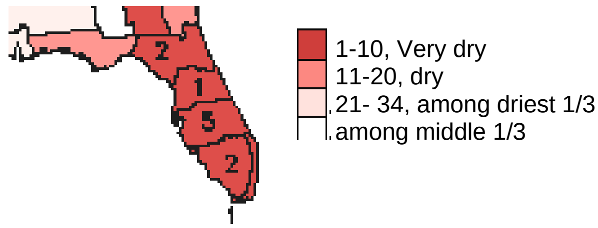

Figure 1. Precipitation Ranking by Climate Division for April - June 1998 with respect to April-July, 1896-1998. (NOAA, Climate Prediction Center)

The season began in early May with numerous wildfires mainly in northwestern counties. By late June, Florida was experiencing more than 80 new fires per day with the largest and most frequent occurrences in northeastern counties. On 22 July, the season finally subsided with increased summer precipitation.

Interestingly, while extreme fire conditions existed throughout much of the state, fires were highly variable in space and time (Fig 2). Fire managers raised concerns that widely applied indices like the Keetch-Byram Drought Index may be poorly correlated with fire business (acres, large fires, ignition) and inadequate on a daily basis (USDA-Forest Service, 2001). A better understanding of synoptic and mesoscale environments is needed for forecasters and fire managers to meet the challenges presented by prolonged drought in Florida.

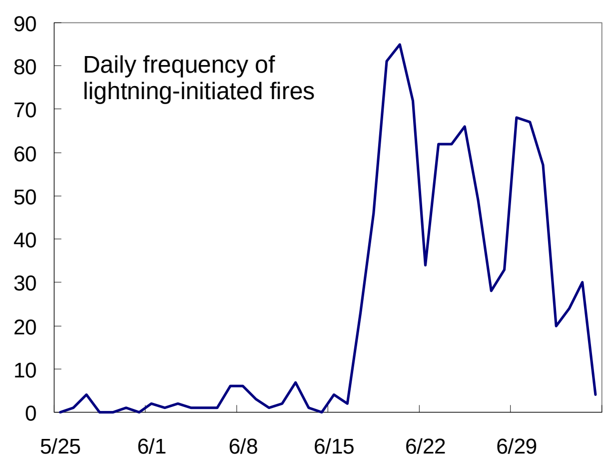

Figure 2. Daily frequency of lightning-initiated fires, 25 May-5 July 1998

4. Fire Initiation and Spread: Influencing Factors

During the 1998 fire season, lightning ignited 31% of the total number of fires that eventually covered 79% of the total acres burnt. Since lightning is so significant, it is important to distinguish environments that favor high rates of flashes.

Fire spread, meanwhile, is strongly influenced by a number of factors like, large-scale subsidence, dry cold frontal passage, and thunderstorm downdrafts. Various factors that influence fire weather will be discussed in subsequent sections.

4.1 Large-Scale Subsidence

The large-scale surface patterns indicated an atypical predominant surface high-pressure area over the Gulf of Mexico causing rather dry air flow into the fire areas from the north and northwest (e.g., Fig 3). The synoptic environment led to a sharp decrease in moisture in the mid-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.

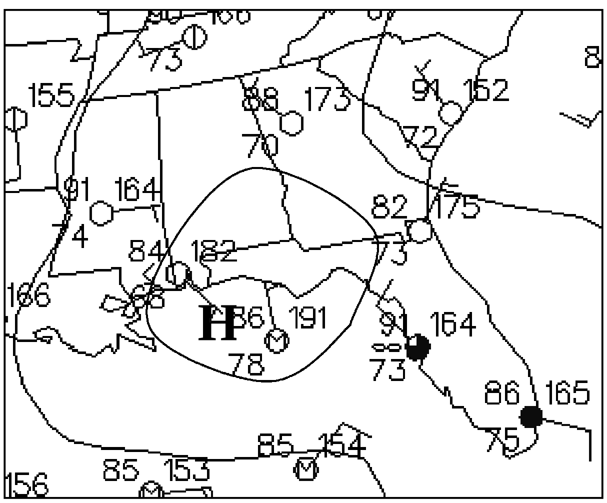

Figure 3. Surface observations and analysis, 00 UTC 24 July 1998

4.2 Lightning Distribution

The daily frequency of cloud to ground flashes over Florida was positively correlated with new fire starts. For example, more than ten times more flashes occurred on 19 June than occurred on 10 June. Not surprisingly, lightning ignited only one new fire on 10 June compared with 81 new fires on 19 June.

The hourly frequencies reveal a more complicated picture. 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.

4.3 Precipitation, Lightning, and Fires

Preliminary analyses indicate the prevalence for most fire initiation to occur along the periphery and outside of heavy rain areas. An example of the spatial distribution of precipitation, flashes, and lightning-initiated fire is illustrated in Figure 4.

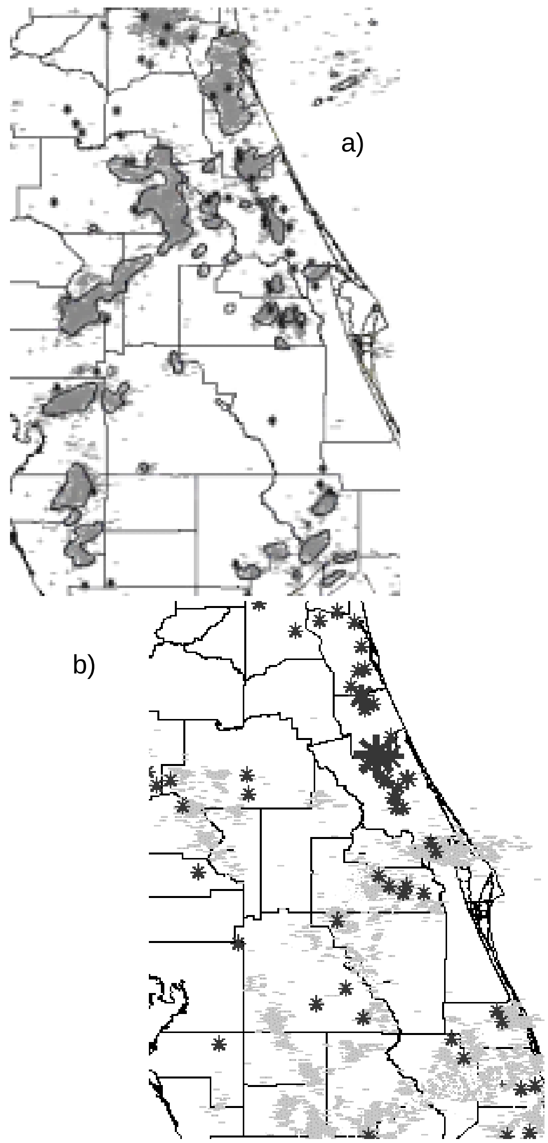

Figure 4. a) Lightning flashes (+,-), precipitation > 0.75 ins from 12UTC 19 June–12UTC 20 June (solid lines), center of new fire sector (*); b) flashes and new fires graduated according to total acres for the period 12UTC 20 June –12UTC 21 June 1998.

The precipitation, while welcome, was accompanied by tremendous amounts of flashes and was sufficient to dampen the existing fires only briefly. Another contributing factor was the high concentration of palmetto-galberry and pine, vegetation that is highly conducive to ignition and spread of fires (Fig. 5).

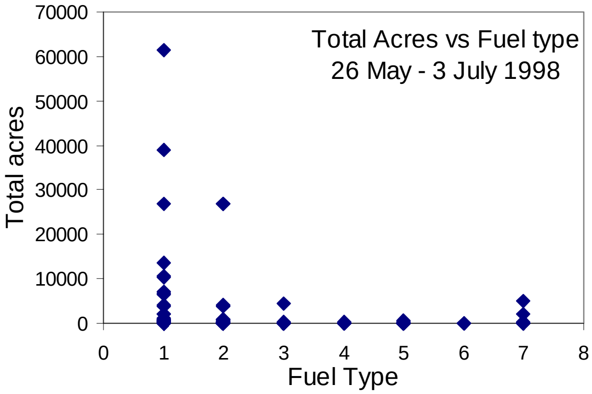

Figure 5. Scatter plot of fuel types and total acres for lightning initiated fires. Fuel type 1 is palmetto-galberry.

Peak current charges do not appear to have much impact on fire start or area. Preliminary identification of flashes responsible for each fire showed that 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. Moreover, the locations represent the center of sectors with varying sizes not the exact point of ignition.

4.4 Mesoscale Interaction: Sea-Breeze and Fire

Deep convection produced lightning that ignited a large percentage of the fires. In turn, those fires also modified the convection. Figure 6 shows one instant during which fire and smoke interacted with the sea-breeze convergence zone and formed a 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 fire vicinity. Given the weak synoptic environment, it is clear that the mesoscale processes were critical to the formation of this complex.

Under the most commonly observed climate regime, easterlies would propel the eastern sea breeze front toward the west coast front, where the two would merge to create a flash density maximum over west central Florida. However in 1998, prevailing westerlies, drove the western sea breeze front far inland while in the east, the convergence zone hugged the coastline. 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.

5. Comparison of Suppression and Major Outbreak

The 1998 fire season was challenging for fire managers because the scale of the events, e.g. fire frequency, varied dramatically on a daily basis (Fig 2).

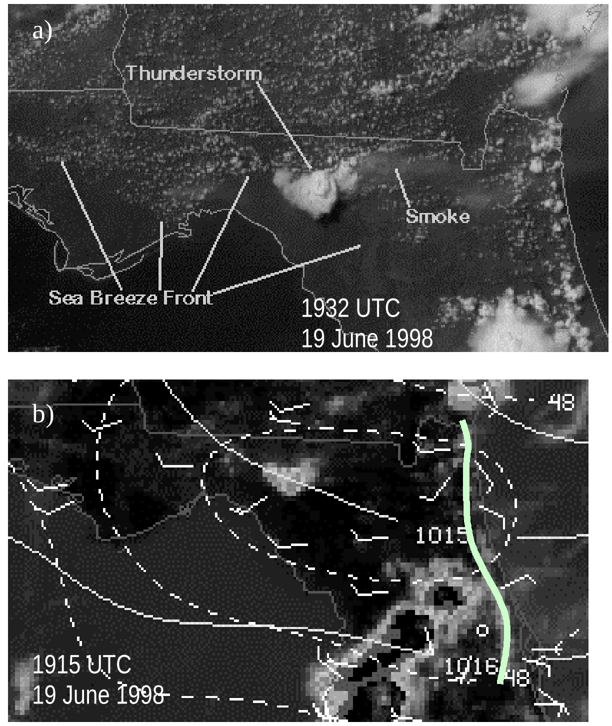

Figure 6. 19 June 1998, a) Visible image of sea-breeze front convergence with smoke from forest fire, 1932 UTC (courtesy, FDOF) and b) Enhanced IR image overlaid with isobars (solid), relative humidity (dashed), and wind barbs, 1915 UTC. Thick white line denotes the eastern sea breeze front.

Identification of weather conditions associated with two extreme fire episodes will aid in better forecasts and allocation 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 systems over southern Florida and west of Cape Canaveral (Fig. 7a). By 2300UTC, low relative humidity extended south through the state after the passage of a strong upper level trough (Fig 7b). In contrast, deep convection dominates the weather across the peninsula on the 19th (Figs. 7c,d). A strong mesohigh developed beneath the deep convection that remains quasi-stationary over north Florida. Strong outflow (> 15kts) from the convection converged with the eastern sea breeze front. Between 19 and 20 June, total fire acreage increased from 26,000 to 178,000. The Haines Index was useful for differentiating between suppression and outbreak but not in distinguishing rapid fire spread between 19 and 20 June (Fig. 8). Lower atmospheric winds, especially those associated with surface mesohighs (Fig. 7c,d) appear to be instrumental in the rapid fire expansion. Fire spread is closely tied to movement of thunderstorm downdrafts because this very stable air can drive fires without regard to topography. In addition, 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 northern counties.

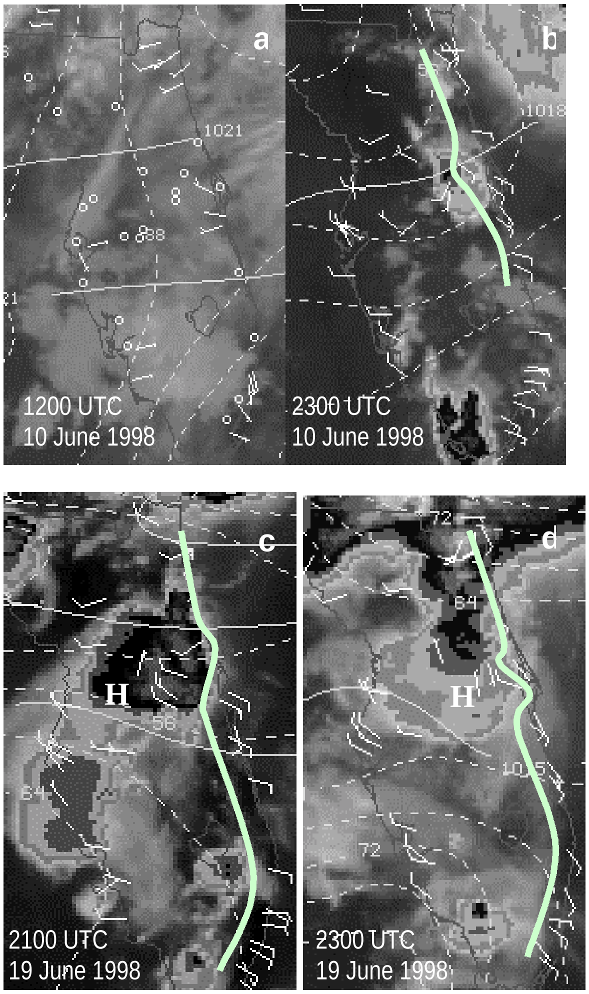

Figure 7. Same as 5 except for Suppression, a) 1200UTC, b) 2300 UTC 10 June 1998 and Outbreak, c) 2100UTC and d) 2300 UTC 19 June 1998

6. Concluding Remarks

Various factors interacted to create favorable conditions for the extraordinary wildfire outbreaks in Florida during 1998. Notably, high pressure over the southeast established large-scale subsidence and drying of the mid-lower atmosphere. This atypical pattern was characterized by westerly and northwesterly flow that propelled the western sea breeze front well east of its normal position. Sea breeze convergence that developed during the late spring and early summer produced nearly stationary convection along the east coast with considerable lightning leading to initiation of fires particularly outside rain areas. Conversely, interaction of the sea breeze convergence zone with smoke from existing fires led to the development of more deep convection.

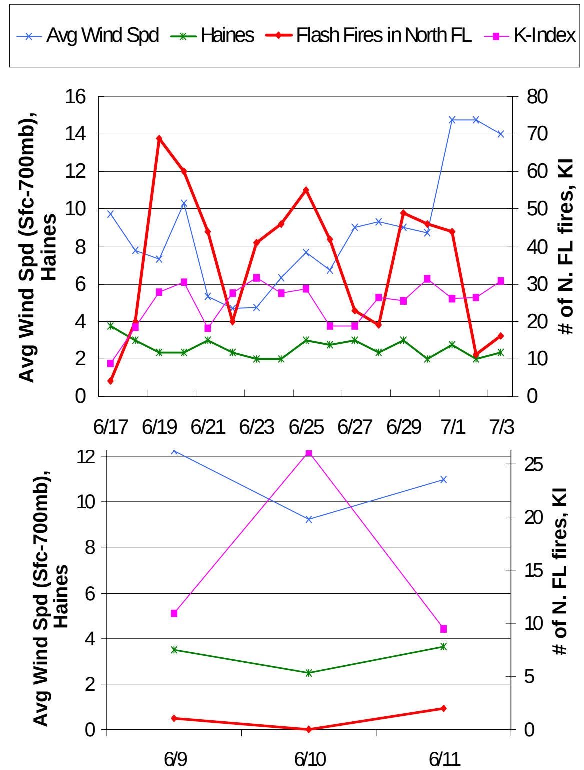

Figure 8. Time series of lower atmospheric environmental indices and daily flash fire frequency north of 27.5 degs. 1200 UTC averaged soundings for TBW, TLH, JAX, and sometimes, XMR, VPS. a) 17 June - 3 July, the period with most frequent and largest fires and b) 9-11 June when only three new lightning initiated fires occurred in north FL.

Subsequent research will focus on developing statistical relationships among flash-ignition lag time, fuel type, total acres, lower atmospheric wind and moisture characteristics. Comparisons will be made with Fire Danger indices used in Europe (Viegas, et al, 2000), Australia, and other parts of North America.

Acknowledgements

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