1.7 A CASE STUDY OF SEA-BREEZE CONVERGENCE AND LIGHTNING-INITIATED FIRE IN THE TAMPA BAY AREA

Arlene G. Laing*, University of South Florida, Tampa, FL
Charles H. Paxton, National Weather Service, Ruskin, FL

1. Introduction

A study of the structure of the lower troposphere associated with a lightning-initiated fire on 30 May 2002 was made possible by the deployment of three NOAA wind profilers (Fig. 1) around Tampa Bay during the Bay Regional Air Chemistry Experiment (BRACE). While the primary mission of the temporary NOAA wind profiler network was to investigate nitrogen deposition, the occurrence of a lightning-initiated fire on May 30 provided an opportunity to study fire weather. The fire occurred along Interstate-75 a few miles from the National Weather Service office in Ruskin. The location of the fire close to the interstate facilitated rapid response from the fire fighters and the fire did not become a major event. An analysis of the convective instability, boundary layer wind velocity, moisture characteristics, precipitation, and lightning distribution will be presented.

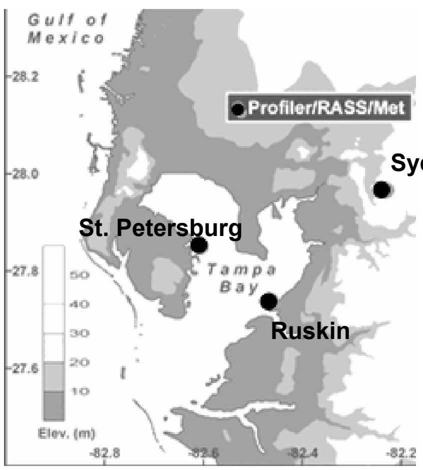

Figure 1.

Locations of wind profilers during BRACE May 2002 and topography of Tampa Bay

2. Data and Methodology

Synoptic and mesoscale analyses were determined from surface and upper air observations, visible and infrared imagery. Mesoscale analysis also incorporated profiler data from the surface to 4km (wind velocity, temperature, surface meteorological conditions) as well as base reflectivity from the WSR-88D in Ruskin, FL. Soundings were used to derive commonly used convective indices for assessing the stability and moisture in the lower troposphere.

* *Corresponding author address*: Arlene G. Laing, University of South Florida, Geography, SOC107, 4202 E. Fowler Ave, Tampa, FL 33620, e-mail: alaing@luna.cas.usf.edu

3. Large-Scale Environment and Climate

Through May 2002, the synoptic regime was dominated by high pressure across the southeastern US resulting in warmer and drier than normal conditions across much of Florida (Fig. 2). Late April through the first two weeks of May was very dry. Measurable precipitation occurred during the third week of May. From 17 to 21 May, west central Florida was affected by pre-frontal squall lines, a cold front, and a weak surface low pressure over the Gulf of Mexico. In the wake of the frontal passage, strong northeasterly winds prevailed through 28 May. For the remaining three days of May, strong sea-breezes and associated thunderstorms were the dominant features in a weak synoptic regime. The accumulated precipitation for May was ~1.1in at Tampa International and 1.3in. at St. Petersburg. The combination of prolonged dry conditions and increased thunderstorm activity favored wildfire initiation.

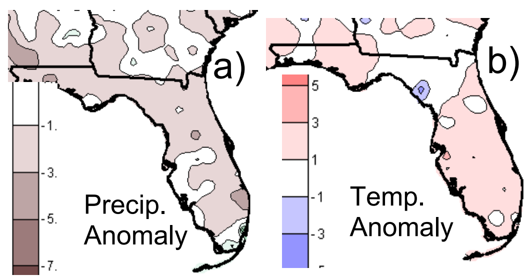

Figure 2. Departure from normal a) Precipitation (in) and b) Temperature (ºF), May 2002 (NOAA SERFC)

The synoptic environment on 30 May was benign with weak surface pressure gradients (Fig. 3), but also, from 1200UTC sounding (Fig 4), weak low-mid tropospheric shear and high CAPE (1279Jkg^{-1}), which favors development of strong thunderstorms.

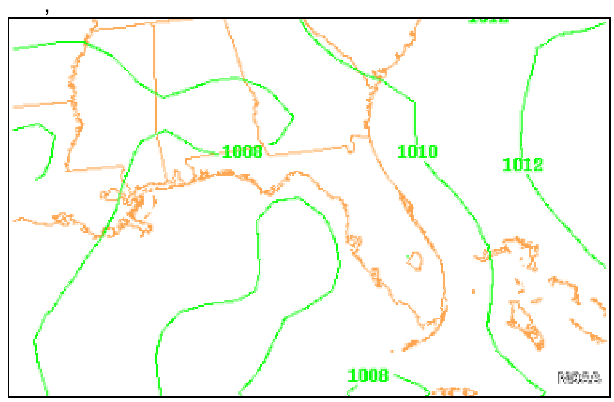

Figure 3. Analysis of mean sea-level pressure at 1200 UTC 30 May 2002

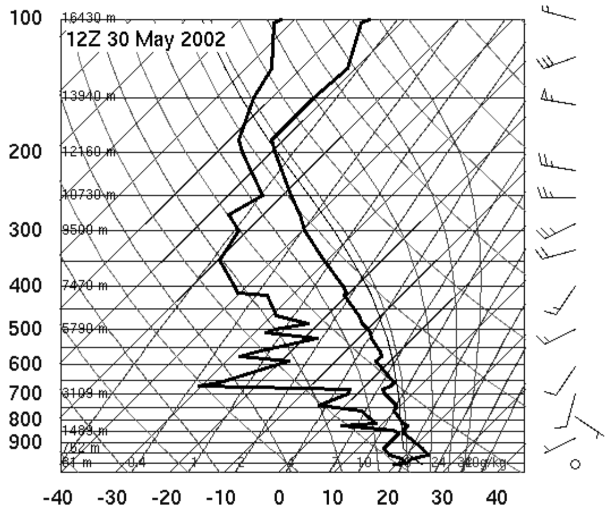

Figure 4. Sounding for Tampa, 1200 UTC, May 30 2002

4. Lightning, Precipitation, and Fire Initiation

Analyses of the precipitation and lightning during the 1998 wildfire outbreaks indicate prevalence for most fire initiation to occur along the periphery and outside of heavy rain areas (Laing and Paxton 2002). It is interesting to note that the fire was not started by any among the large cluster of negative cloud-to-ground flashes but was started at approximately 2145UTC by *an isolated, positively-charged flash outside the anvil and heavy rain areas* (Fig. 5). This result is not surprising because although most of the 1998 most fires were started by negatively flashes, positive flashes were more efficient at initiating wildfires, i.e., positive flashes had a higher ratio of fire starts to flash frequency (Laing and Paxton 2002).

5. Sea-Breeze Circulation

The conceptual development of sea breezes is well understood but the topography along the west Florida coast creates a unique interaction among sea breezes, bay breeze, river breeze, thunderstorm outflow boundaries, and the synoptic circulation in the atmosphere. The major urban centers also enhance the daytime land-water differences and further complicate the sea-breeze evolution.

Under the dominant climate regime during the warm season in Florida, easterlies would push the eastern sea breeze front towards the west-coast sea breeze front, where the two converge to create a thunderstorm maximum over west central Florida. On 30 May, the eastern sea breeze advanced toward the west coast (Fig 6a-b.) but stronger surface westerly flow developed during the late afternoon. At 1915UTC, the convergence line had become more organized with thunderstorm outflow north of Tampa Bay overwhelming the sea breeze. From Tampa southward, the onshore flow was 10-25knots with stronger gusts, which propelled the thunderstorms eastward towards the center of the peninsula (Fig. 6c-d). New thunderstorms developed along the outflow boundaries of the sea breeze convergence. The flash originated from one of those later thunderstorms, not directly from the sea breeze convergence.

The vertical structure of the boundary layer wind velocity around Tampa Bay was captured, for the first time, by high resolution wind profiler measurements. Even for this strong sea breeze event, the circulation rarely extends above 500m (Fig. 7a). The temporal evolution of the surface and near surface winds is primarily tied to the solar heating cycle (Fig. 7b), however, thunderstorm outflow boundaries can interrupt or enhance the sea-breeze circulation (Fig 6). In this case, the land breeze lasted from 0300 to 1000UTC, and then the winds became light and variable before the sea-breeze arrived at approximately 1900UTC and lasted through 2300UTC.

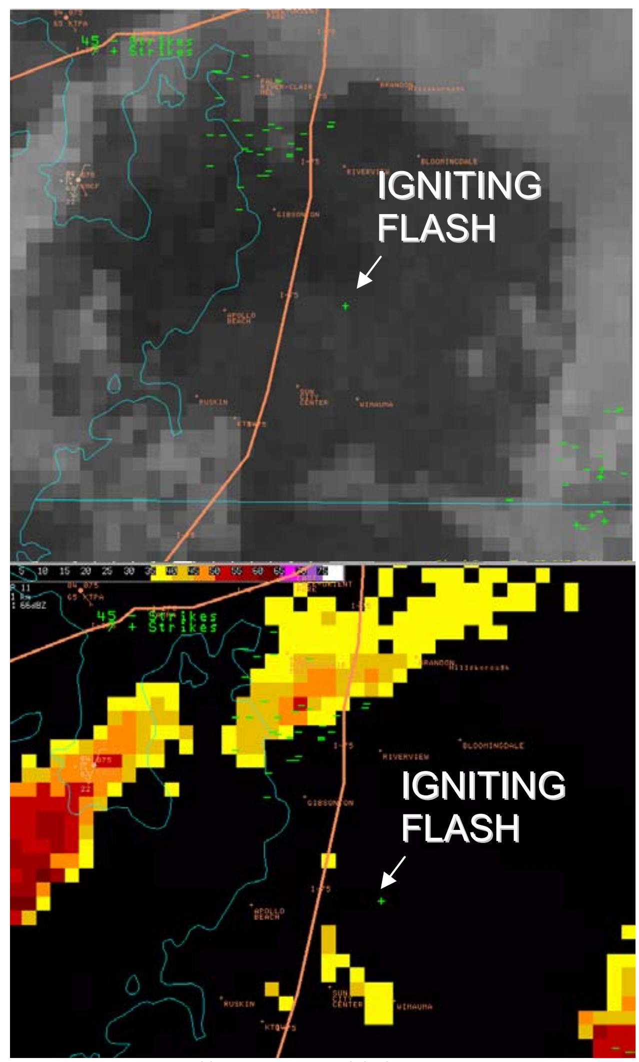

Figure 5. Negative (-) and Positive (+) Cloud to ground lightning flashes for the 15minute period ending at 2145UTC overlaid on (a) visible satellite image for 2145UTC 30 May 2002 and (b) base reflectivity above 35dBz on a map of Hillsborough County including inter state highways and towns.

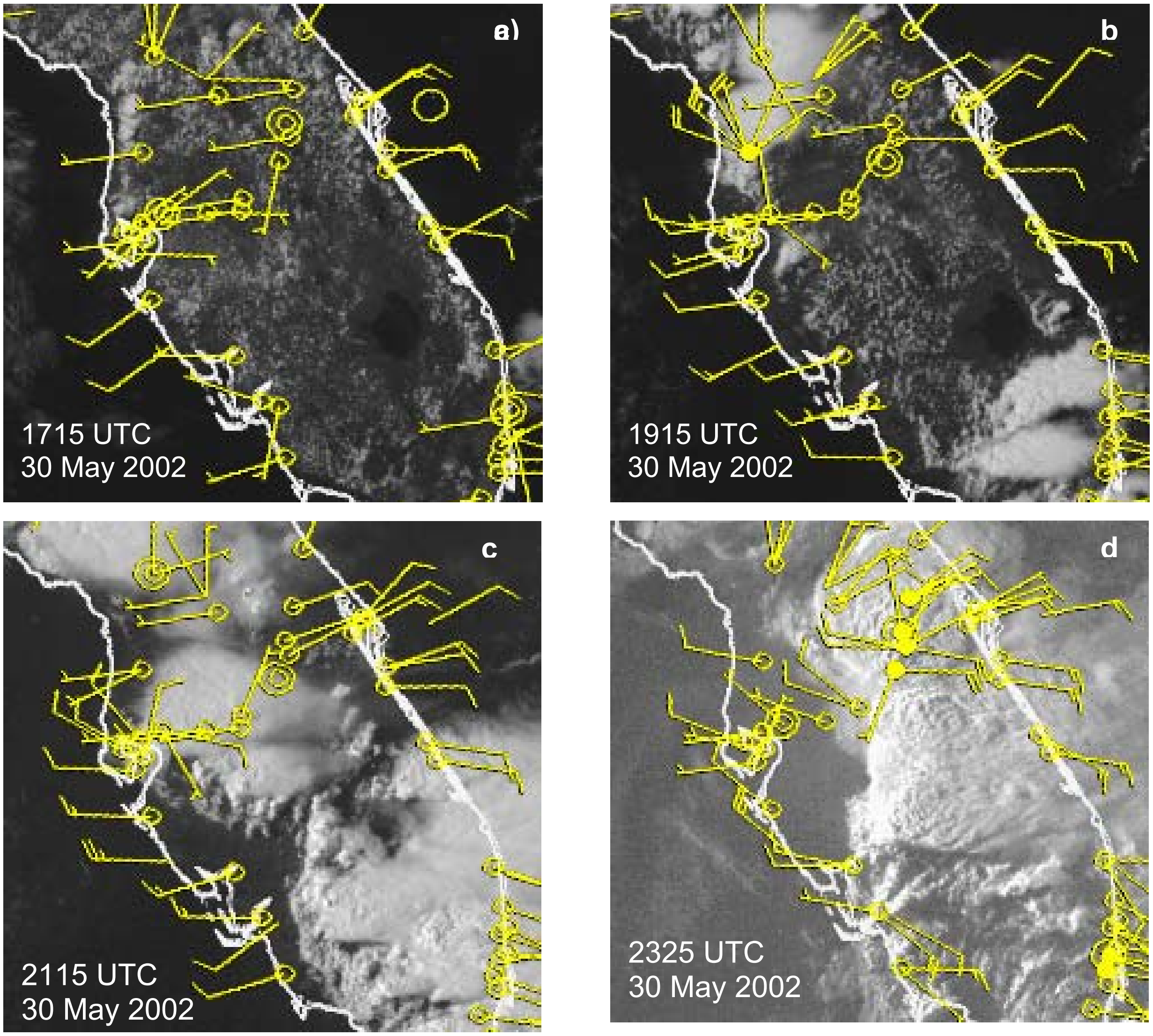

Figure 6. Visible satellite images overlaid with wind barbs for a) 1715UTC, b) 1915UTC, c) 2115UTC, and d) 2325UTC 30 May 2002, respectively. (courtesy, COMET program)\

6. Concluding Remarks

Various factors interacted to create favorable conditions for a lightning-initiated fire. High pressure over the southeast for most of May established large-scale subsidence and dry surface conditions. On the day of the fire, local topographical forcing dominated the weather, producing strong sea breeze and associated thunderstorms. Strong westerly flow propelled the western sea breeze front well east of its normal position. The thunderstorms were accompanied by frequent lightning but the wildfire was started, not in the high density locations but, by an isolated, positive flash. The igniting flash occurred on the periphery of high rain areas, a characteristic that is similar to the 1998 Florida wildfires. Further investigation will focus on the convective and wildfire indices prior to and during the event.

References

Laing, A.G. and C.H. Paxton, 2002: Assessment of wildfire environments in Florida during 1998. *Papers and Proceedings, Applied Geography Conferences*, 25, 285-293. Binghampton, NY.

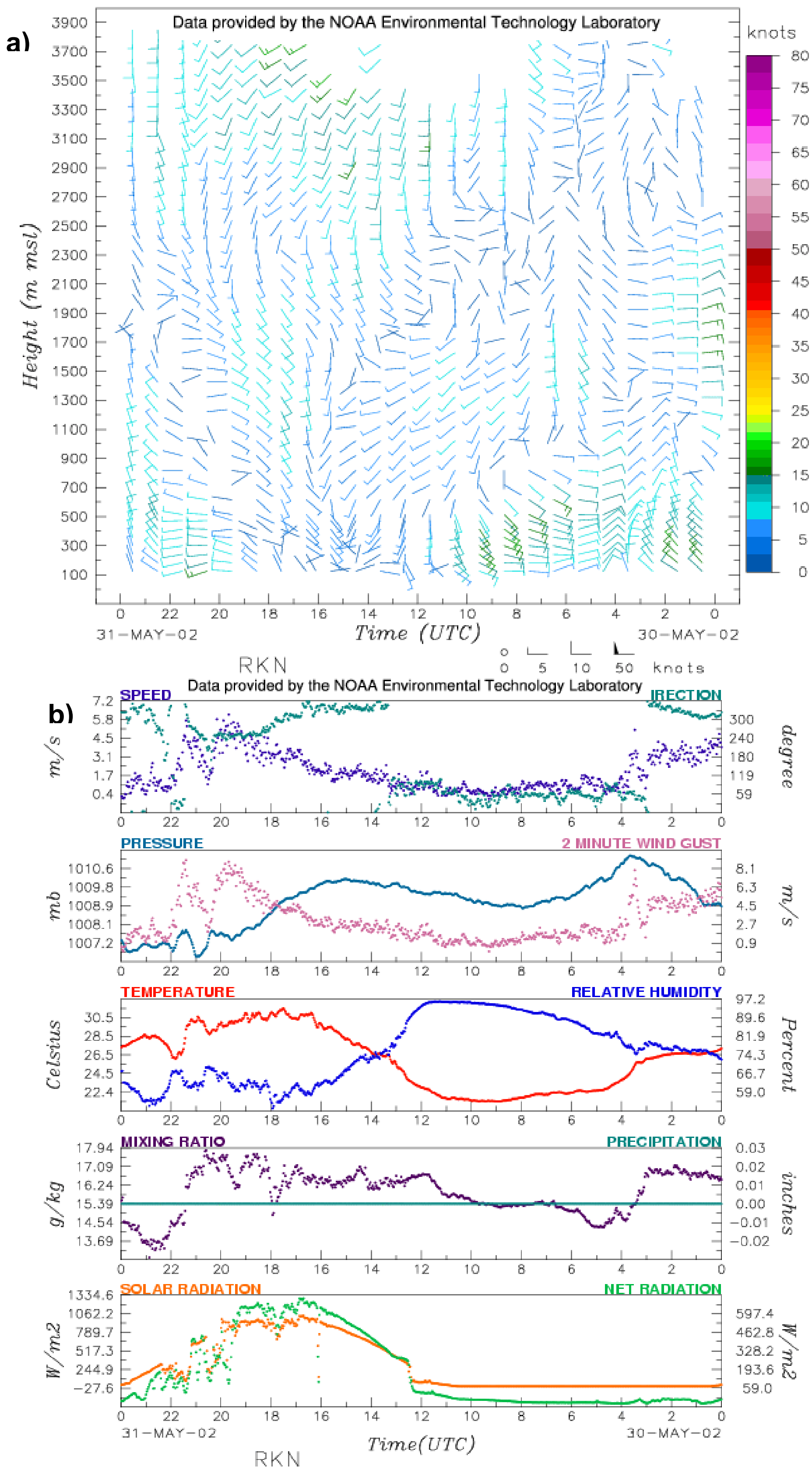

Figure 7. a) Wind velocity profile and b) surface meteorological conditions on 30 May 2002 at Ruskin, FL