

IMPROVING FLOOD AND FLASH FLOOD FORECASTS ACROSS SOUTH FLORIDA

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1. INTRODUCTION

The objective of this project is to better understand the parameters and meteorological conditions that are necessary for flood and flash flood events in South Florida to better predict when they may occur. Using flood and flash flood reports from February 1997-February 2015 in the South Florida region to compare meteorological characteristics, the mean meteorological conditions are determined. Upper air soundings from site KMFL for all flood and flash flood events are used to create a mean composite sounding. The RAwindsonde OBservation (RAOB) program is used to analyze the different soundings and determine what meteorological characteristics and parameters can explain these events. Events are also broken down into warm season and cool season as parameters and atmospheric conditions change depending on the time of year in South Florida. Events are then classified into synoptic conditions leading to flash flooding. Anomaly charts are created for various meteorological characteristics to show the anomalies that are present on Flood and Flash Flood event days compared to the 30 year climatological normal from 1981-2010. The results are expected to improve the accuracy of flood and flash flood forecasts for the Miami National Weather Service Forecast Office.

Floods are the most common hazard in the United States, occurring very often in South Florida. In South Florida, weather, including flood inducing rainfall, can be difficult to predict due to unique subtle synoptic and mesoscale features that are not characteristic of the traditional mid-latitude forecasting model. The South Florida forecast area has major cities, suburban and rural areas. The Flash Flood Potential Index (Fig 1.) in some locations is very high in densely urbanized areas along the Atlantic coast where flash floods occur the most. Flash Flood Potential Index uses land use, slope index, forest density, and soil texture to create a

geographic index grid. South Florida counties are continuing urbanizes creating more potential risk for flood and flash flood events for South Florida. It is important to understand the synoptic features and atmospheric conditions that are present in flood events to be prepared to inform the public and implement watches or warnings to mitigate the threat to life and property.

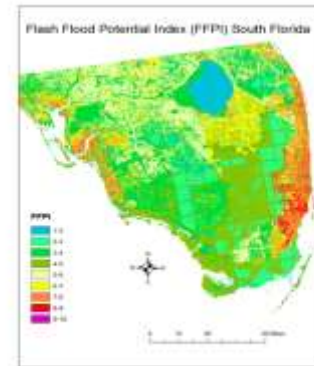


Figure 1- Flash Flood Potential Index (FFPI) for South Florida.

Using atmospheric anomalies of such features as wind, moisture, geopotential height and relative humidity you can better forecast for flood potential. Synoptic features such as nearby surface boundaries and fronts also play a role in flash flood potential. Using upper-air soundings CAPE, lapse rates and precipitable water anomalies can be used to help forecast if a flood event is more or less likely to occur. It is also important to know what time of year and what time of day flooding is most likely to occur. In figure 2 you can see that most flooding occurs in warm season from May 15 – October 15. Flooding occurs most often (60%) in the afternoon and evening hours as this is when convection and accumulation can occur to cause flooding.

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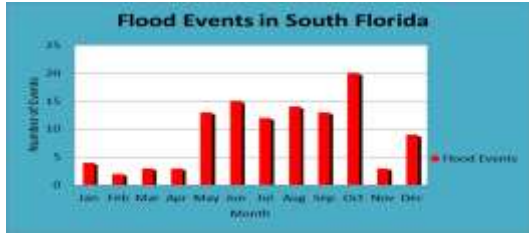


Figure 2- Flood Events in South Florida

2. SYNOPTIC FEATURES

In the South Florida forecast area, synoptic conditions can play a vital role in determination of flash flood potential. Frontal boundaries and tropical systems are major components that contribute to flash flooding in South Florida. For cool season, October 15-May 15, the greatest negative surface pressure anomalies were located along the Texas coastline and adjacent Gulf of Mexico on days where South Florida experienced flooding. The frontal boundary and tropical conditions tend to be more widespread flooding that could be one or multiple counties wide. In figure 2 you can see that over 65 percent of all flood and flash flood events are caused by Tropical waves/cyclones or frontal boundaries. In frontal synoptic meteorology South Florida is a prime location for stalled or stationary front. Stationary fronts are usually associated with flooding as storm motion is often very slow. Stationary fronts account for more than 50 percent of frontal caused flash flooding (Fig.4).

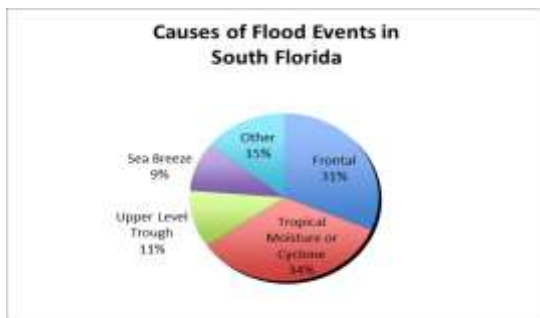


Figure 3- Causes of Flood Event in South Florida

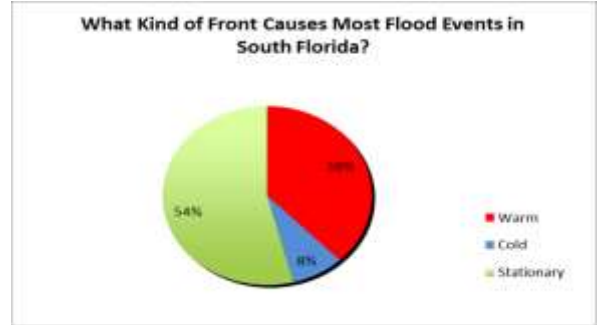


Figure 4-Frontal caused events in South Florida

Synoptic conditions such as geopotential height anomalies were also found on flash flood days. The negative 500mb height anomalies are of much greater magnitude on flooding days. The location of the low pressure can also vary on a season by season basis depending what time of year it is. For cool season, October 15-May 15, low pressure on the Texas coastline and western Gulf of Mexico flooding in South Florida. In warm season the mean low pressure center is located on the west Florida Coast during flash flood days.

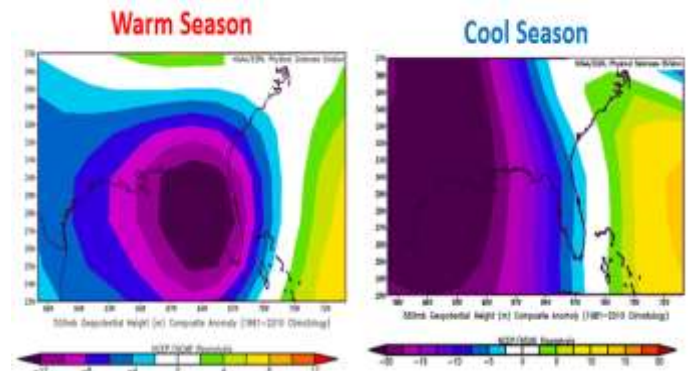


Figure 5- 500mb Geopotential Height Anomalies for different seasons.

3. ATMOSPHERIC CONDITIONS

Relative humidity throughout the atmosphere, precipitable water, CAPE, cloud depth, upper level wind anomalies all have effects on whether or not flash flooding or flooding occurs in South Florida. Using upper-air atmospheric soundings we can analyze these different conditions and categorize them in different seasons, synoptic features and causes. Anomalies and composite soundings were created to reference these different conditions.

Relative humidity was expected to be greater throughout the atmosphere in cool and warm season. In cool season you need about 20-25 percent higher relative humidity from the surface-500mb. However in warm season there is less of a need and only a 12-15 percent higher anomaly on these days.

| Season/ Synoptic Feature | CAPE (J/kg) |
|--------------------------|-------------|
| Warm Season | 1268 |
| Cool Season | 401 |
| Cold Front | 1918 |
| Warm Front | 309 |
| Stationary Front | 968 |
| Tropical Wave or Cyclone | 993 |

Figure 6- CAPE values different seasons and synoptic features

CAPE value plays a significant role as an indicator for flash flooding. In all flash flood and flood days a “tall and skinny” low CAPE value is often seen. However, there is some difference dependent on the season and the type of synoptic feature that is present at the time. You can see in figure 6 the difference in season and synoptic feature can affect the CAPE value.

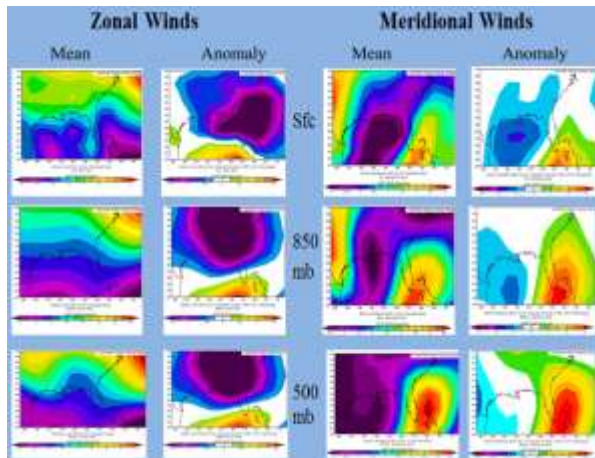


Figure 7- Mean and anomaly Zonal and Meridional winds during flood and flash flood events in South Florida.

Upper-level wind anomalies in the zonal and meridional direction also can be a precursor for flash flooding events. Flooding typically occurs when there is easterly low-level flow present. Positive

meridional wind anomalies (southerly flow) are favored on South Florida flood days. Moist lower levels are more important, upper levels are not as influential in flood events.

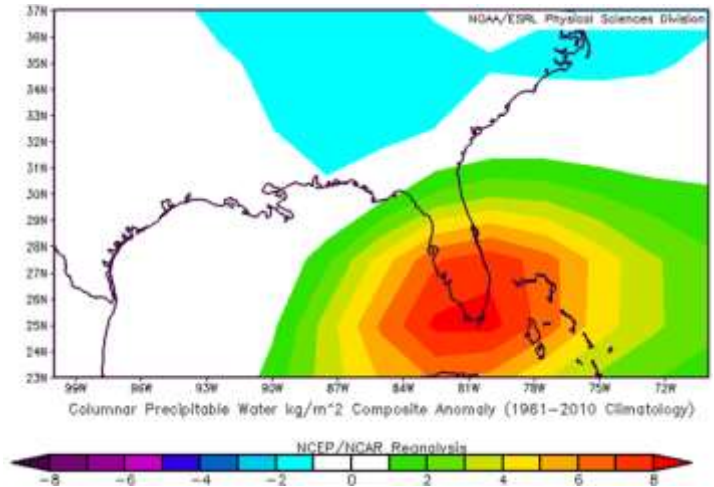


Figure 8- Anomaly Precipitable water levels for flooding events shows a clear bullseye over South Florida.

Warm moist air creates high precipitable water in the atmosphere which is needed for heavy rain events and flooding. On average precipitable water are 8 kg/m² more than the climatological average, with deviation from average necessary dependent on the season. Depending on the time of the year precipitable water levels percentages above normal can be around 125% in summer months to above 200% in cool season.

All of these features can easily be seen and analyzed using the upper-air sounding data that is acquired through radiosonde balloon release at 00z and 12z. The soundings provide data to determine the stability of the atmosphere and an aid in overall weather prediction. Using soundings from flood events in the past in South Florida composite analyzed soundings were created for reference. Mean soundings were created based on time of year and specific synoptic characteristic present, in addition to the mean sounding inclusive of all flood events. These soundings now can be used for comparison for forecasters to overlay real-time soundings to events in the past. All composite mean soundings are located in the figures below.

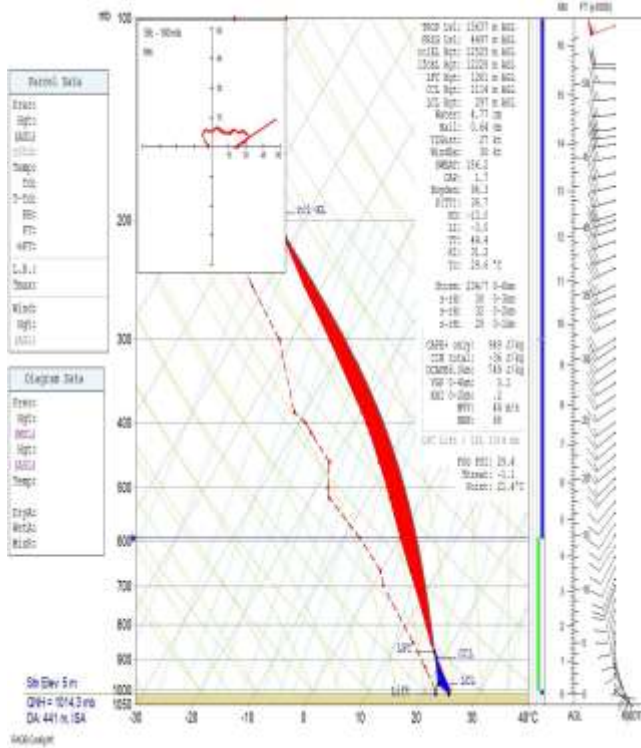


Figure 9- All flood events composite sounding.

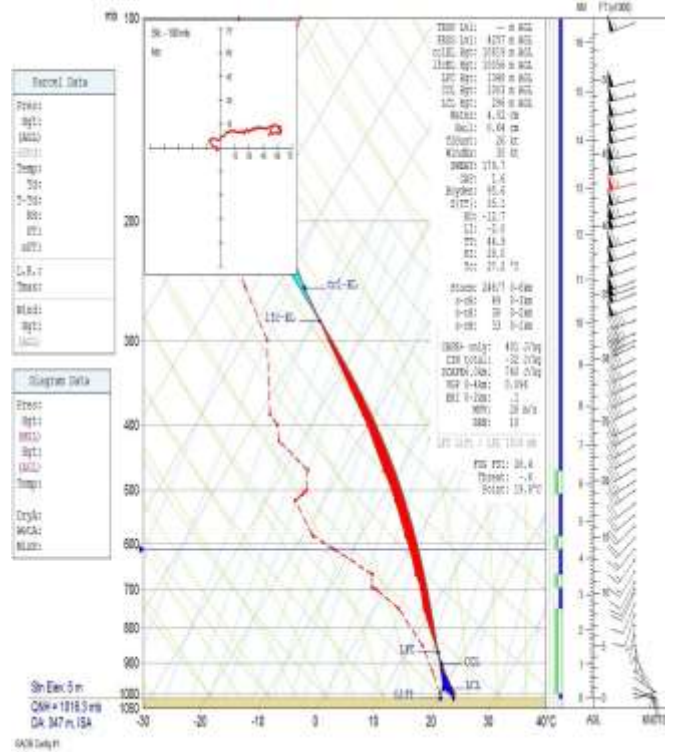


Figure 11- Cool Season (October 15- May 15) composite sounding

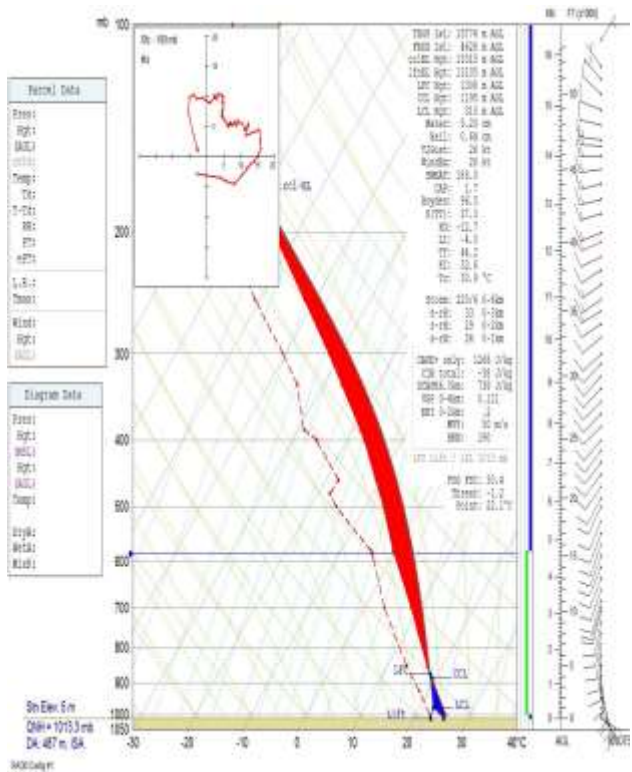


Figure 10- Warm Season (May 15-October 15) composite sounding

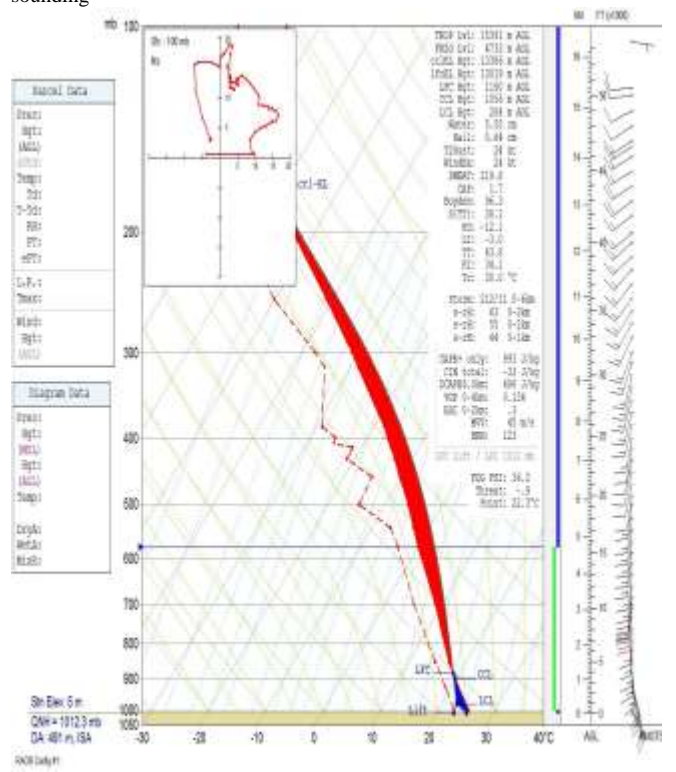


Figure 12- Tropical Cyclone or Wave composite sounding

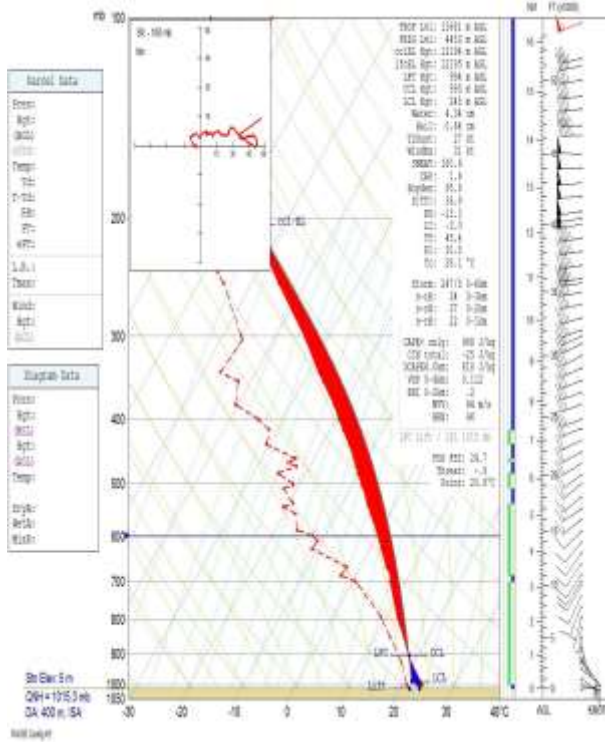


Figure 13- Stationary Front composite sounding

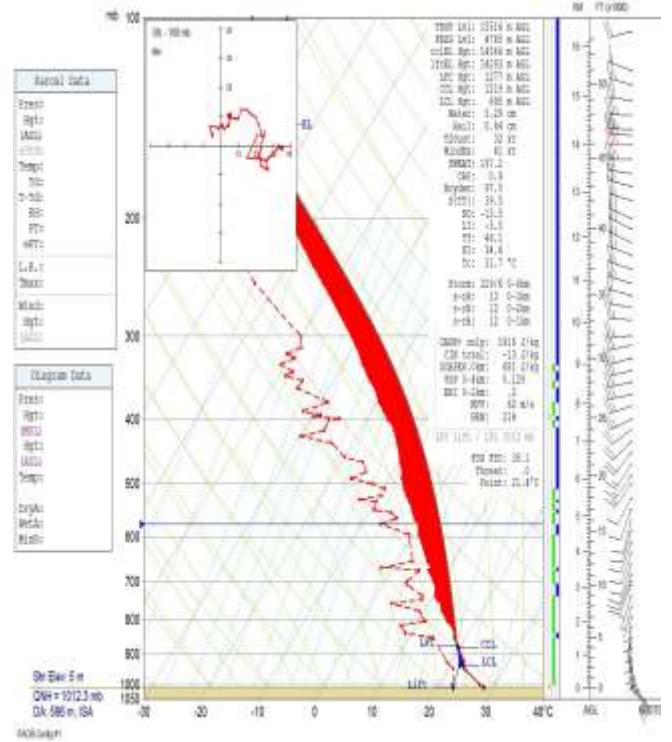


Figure 14- Cold Front composite sounding

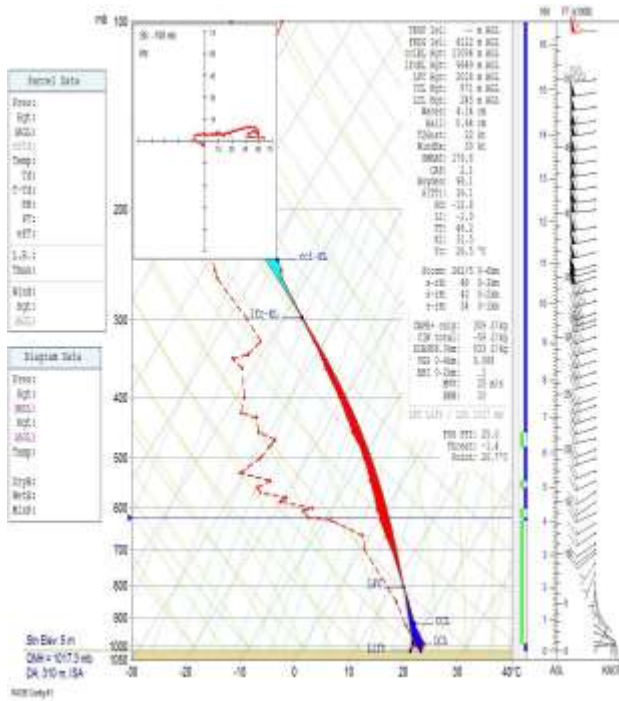


Figure 14- Warm Front composite sounding

In all of the composite mean soundings the wind profile is supported by the anomaly graphics. The tall and skinny CAPE is also graphically depicted. The low lifted condensation level (LCL) and high precipitable water values are also given. The findings of this research, including notably favorable synoptic features and atmospheric conditions have been utilized in a checklist that forecasters at WFO Miami use as guideline for forecasting flood and flash flood potential.

4. FLASH FLOOD CHECKLIST

Winds/storm motion

- Slow storm movement (MBE/Corfidi vector)
- 700 – 500 mb winds < 20 kts
- Upper level divergence
- Easterly near-surface flow
- Wind anomalies

Atmospheric Moisture

- Precipitable water \geq 175% normal Winter, 150% Spring/Fall, 125% Summer
- Pronounced moisture gradient
- Moisture anomalies

Synoptic-scale features

- Nearby surface boundary
- Low-level theta-e axis
- 1000-500 mb thickness diffluence
- Low LCLs
- Poor lapse rates – moist adiabatic

Other parameters

- “Tall and skinny” CAPE
- Warm cloud depth exceeding 3-4 km

5. CONCLUSION

Flash Flooding occurs mostly in urban areas in the major cities of the forecast area. Synoptic features and atmospheric conditions can help alert forecasters to better understand the potential and risk for flood and flash flood events in the South Florida. These findings can help with the alert time and forecast probability statistics to help inform the public in a timely matter about potential dangerous flooding situations.