# FORECASTING CLOUD TO GROUND LIGHTNING DENSITIES ON THE FLORIDA PENINSULA

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## 1. INTRODUCTION

Among the highest cloud to ground lightning densities in the United States annually occurs in Florida and for energy companies these provide a major disruption to their operations. These lightning strikes are attributed to thunderstorms whose catalysts are from sea and lake breeze boundaries, fronts, mid and upper level disturbances and feeder bands from tropical cyclones. The low level steering flow located just above the boundary layer is a driver for these synoptic, mesoscale and microscale features and is the basis for this study. Working in concert with the steering flow are the comparisons to it with precipitable water values, lifted indices and the K index. In analyzing the impactful thunderstorms this study examines the thunderstorm intensities based on a lightning scale using a 4 year compilation of data (January 1, 2007 – December 31, 2011) as recorded by Schneider Electric meteorologists. The focus is on moderate or higher cloud to ground lightning strike densities that are most impactful for Schneider Electric energy clients in Florida. Using this data, the relationship with the steering flow is compared with the instability, temperature lapse rates, moisture depth and content indices for cloud to ground lightning densities in a 5 X 5 km grid over 1 hour of time using a minimum of 76 lightning strikes. This information is used to more accurately forecast the position and strength of thunderstorms to scale in Florida that give our energy clients the most issues for power interruptions and that assists in planning for mobilizing crews to where the highest lightning densities will occur.
Knowing 850 hPa flow is important. 850 hPA flow that converges with the coast typically produces higher lightning densities than opposing flow.

## 2. CONTROL

During the period of record and for use of this abstract/poster, 1257 instances of Level 3 or higher lightning storms were noted and analyzed. Figure 1 describes each level and how many lightning strikes corresponds to each level. Figure 2 displays the areas outlined where these lightning storms occurred.

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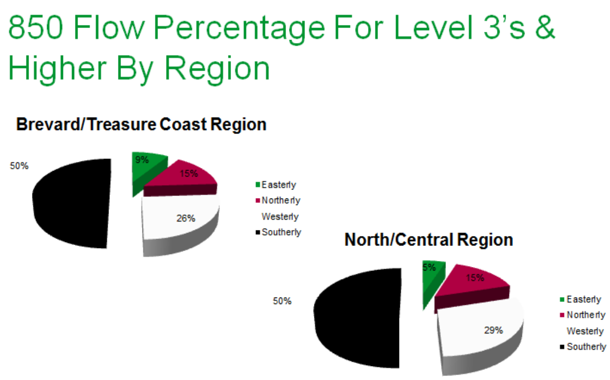
| Lightning Level | Lightning Strikes Per 5 X 5 km Grid Per Hour |
|---|---|
| 1 | 0 |
| 2 | 1-75 |
| 3 | 76-150 |
| 4 | 151-300 |
| 5 | 301-450 |
| 6 | 451+ |

**Figure 1:** *Lightning scale broken down into 6 levels. This corresponds to the amount of lightning strikes in a one hour period within a 5 X 5 km grid.*


**Figure 2:** *Florida Peninsula shown and the outlined areas are the territory where thunderstorms were analyzed broken down by region.*

## 3. 850 hPA WIND DIRECTION FORECASTING

In forecasting these Level 3 or higher lightning storms, our meteorologists found a correlation of southerly 850 hPA steering flows involving thunderstorms that produced more lightning. Southerly flows pump in the most moisture and lead the more cases of higher instability and in cases where they counter the opposing sea/lake breeze boundaries can produce more lightning strikes. In analyzing the data, southwesterly 850 hPA flows showed the highest percentage of Level 3 or higher lightning storms across North/Central, Brevard/Treasure Coast, East and South regions while southeasterly flows showed the highest percentage across the West region. Statistically this has been found to be true as noted in the Figures 3 and 4.



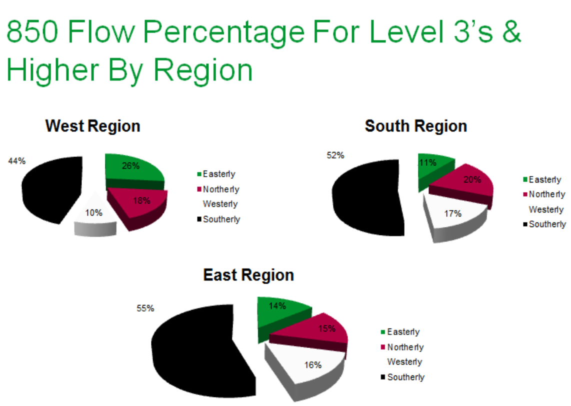




**Figure 3 (top), and 4 (bottom):** *Figure 3 depicts the 850 hPA flow divided into the Brevard/Treasure Coast region and North/Central region. Figure 4 depicts the 850 hPA flow divided into the West, South and East regions.*

As seen in the figures, the dominant flows for Level 3 or higher lightning storms by over 50% are southerly flows except in the West region where 44% of southerly flows contribute to the impactful lightning storms. Southerly flows in the West region can present an onshore flow which reduces convergence and does not usually produce the higher lightning storms however they do have a plurality of the cases compared to other wind flows. On the contrary, onshore steering flows contribute to the lowest percentage of Level 3 or higher lightning storms as noted with easterly flows for regions on the eastern half of the Peninsula and westerly flows in the West region.

## 4. 850 hPA WIND SPEED FORECASTING

While the 850 hPA direction is vital, the 850 hPA speed is very important in determining the speed of any convergent boundaries, i.e. sea/ and lake breezes which will aid in thunderstorm development and its propagation.

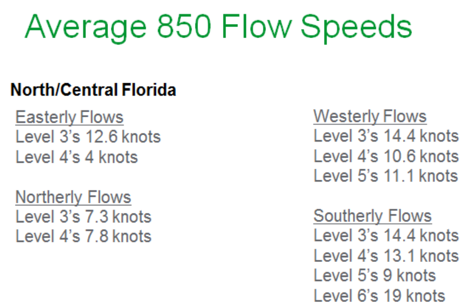



**Figure 5:** *Average 850 hPA speeds for each level lightning storm in the North/Central Region.*

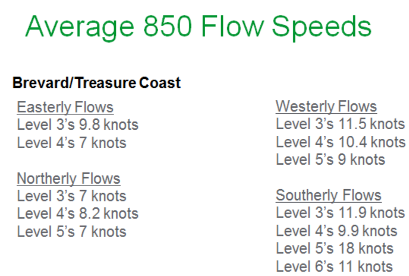



**Figure 6**: *Average 850 hPA speeds for each level lightning storm in the Brevard/Treasure Coast Region.*

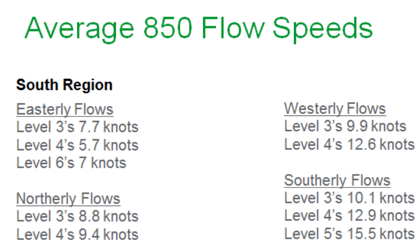



**Figure 7:** *Average 850 hPA speeds for each level lightning storm in the South Region.*

## Average 850 Flow Speeds

**West Region**

Easterly Flows
Level 3's 10.9 knots
Level 4's 9.2 knots

Westerly Flows
Level 3's 9.3 knots
Level 4's 9.6 knots

Northerly Flows
Level 3's 7.3 knots
Level 4's 7 knots
Level 5's 6.3 knots

Southerly Flows
Level 3's 11 knots
Level 4's 11.7 knots
Level 5's 4 knots

**Figure 8:** *Average 850 hPA speeds for each level lightning storm in the West Region.*

## Average 850 Flow Speeds

**East Region**

Easterly Flows
Level 3's 9.6 knots
Level 4's 6.7 knots

Westerly Flows
Level 3's 8.7 knots
Level 4's 10.6 knots
Level 5's 12.3 knots

Northerly Flows
Level 3's 6.3 knots
Level 4's 8.7 knots
Level 5's 8 knots

Southerly Flows
Level 3's 9.8 knots
Level 4's 11.3 knots
Level 5's 15.8 knots
Level 6's 4 knots

**Figure 9:** *Average 850 hPA speeds for each level lightning storm in the East Region.*

In the figures above describing average 850 mb speeds, they can vary by flow and by region. Just because a thunderstorm produces more lightning does not mean that 850 mb speeds slow necessarily. These depend on what catalyst is present to present the more impactful lightning events and can depend on sea/lake breeze boundaries and their interactions with fronts/troughs/tropical systems/mid/upper-level vortices though the latter impulses could occur independent of surface convergence factors.

## 5. INSTABILITY/MOISTURE FORECASTING

Working in concert with the 850 hPA flow one must consider the amount of instability and moisture that would be sufficient to produce Level 3 or higher lightning storms. These often depend on the region as well as the steering flow direction.

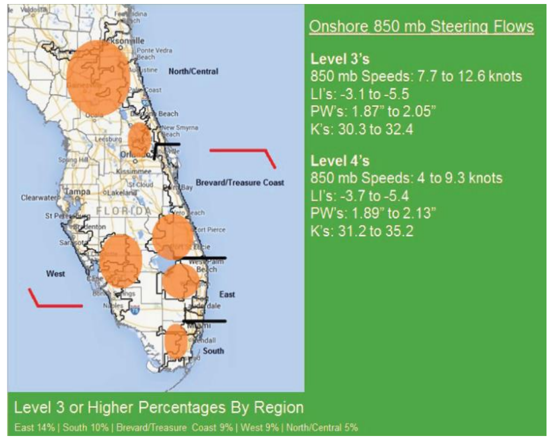



**Figure 10:** *Onshore 850 hPA steering flows with ranges of 850 hPA speeds, Lifted Indices, Precipitable Water vales and K Indices as well as the percentage by region of Level 3 or higher lightning storms. Areas highlighted in orange on the map correspond with where storms were commonly found in each region.*

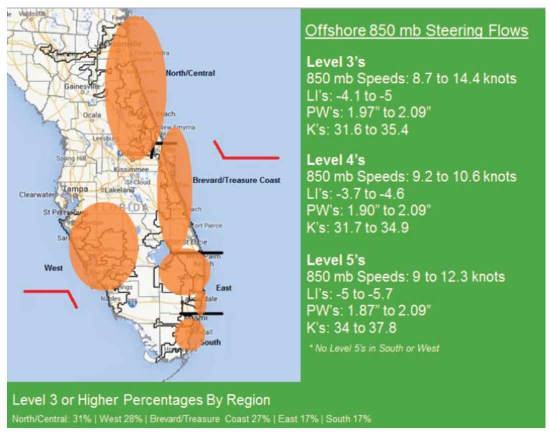



**Figure 11:** *Offshore 850 hPA steering flows with ranges of 850 hPA speeds, Lifted Indices, Precipitable Water vales and K Indices as well as the percentage by region of Level 3 or higher lightning storms. Areas highlighted in orange on the map correspond with where storms were commonly found in each region.*

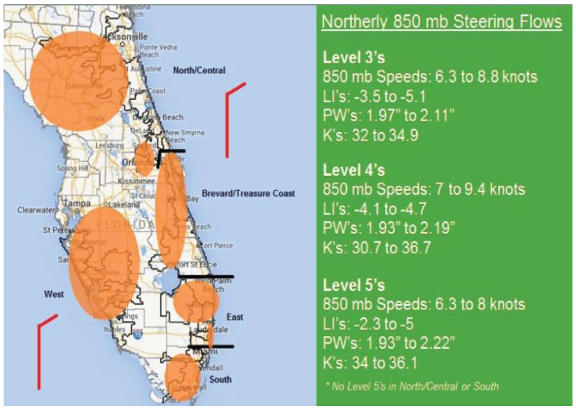



**Figure 12:** *Northerly 850 hPA steering flows with ranges of 850 hPA speeds, Lifted Indices, Precipitable Water vales and K Indices as well as the percentage by region of Level 3 or higher lightning storms. Areas highlighted in orange on the map correspond with where storms were commonly found in each region.*

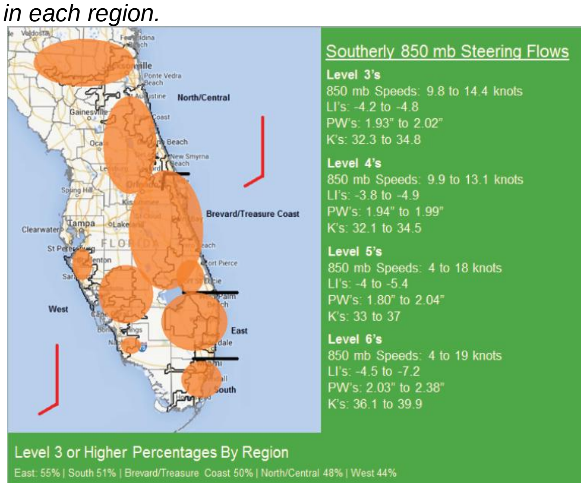



**Figure 13:** *Southerly 850 hPA steering flows with ranges of 850 hPA speeds, Lifted Indices, Precipitable Water vales and K Indices as well as the percentage by region of Level 3 or higher lightning storms. Areas highlighted in orange on the map correspond with where storms were commonly found in each region.*

In diagnosing these thunderstorms for forecast purposes, it was found that Lifted Indices (LI's), K Indices and Precipitable Water (PW's) values were helpful. For instability, there was more reliability using LI's than CAPE values as CAPE's often varied greatly on the situation. To handle the moisture content and depth of moisture, the K Index was a useful index as well with precipitable water values adding an extra layer to the moisture argument. While there is not a linear distribution with respect to higher moisture/instability levels to increasing level lightning storms, other synoptic/mesoscale factors need to be considered. Generally speaking with the higher level storms, Level 5 and 6 lightning storms, the ranges trended towards higher moisture and instability which can be ascertained in looking at the upper bounds in the above figures.

## 6. CONCLUSION

Considering the low level steering flow depending on region and how it interacts with various atmospheric features, a reasonable forecast for cloud to ground lightning density can be achieved in the Florida Peninsula. Knowledge of these conducive factors can provide energy companies with the heads up to make preparations for lightning interruptions especially for moderate and higher lightning storms.

## 7. REFERENCE

1. FPL Log files January 1, 2007-December 31, 2011. *Schneider Electric Files*