A Wet-Season Rainfall Climatology to Support Airline Arrivals at Key West

Matthew Bloemer and Andy Devanas
NWS WFO Key West, FL

Introduction and Motivations

The Island of Key West is served by an airport with a single runway, which has a length that is very near to the operational minima for modern narrow-body aircraft such as the Boeing 737. As such, various airline carriers have developed approach and landing procedures that are highly specific to the Key West International Airport (EYW). Critical forecast elements to these airlines include low level wind shear, and rainfall probabilities. In particular, Southwest Airlines has operational concerns with landings if the runway is wet. Their concern was the predictability of summer convection, and this prompted a precipitation climatology study covering the "convective" or "wet season". This poster presents an overview of the climatology that was developed, and especially emphasizes the applicability of this work to directly support Southwest Airline's operations at Key West.

Methodology

For the purposes of this climatology, the local "Wet Season" is defined as the months of June through September. Over 68 percent of the annual rainfall occurs in the Florida Keys during this four-month period. The months of May and October are transitional periods, although significant rainfall can occur during these months. They are excluded from the study because May more commonly resembles a "Dry Season" rainfall regime, and October can be influenced by synoptic scale systems of mid-latitude origin, especially in the later half of the month. The heart of the wet season is the focus of this study as these are the months when psuedo-barotropic conditions prevail, and synoptic scale influences are minimal. With this knowledge, and with the assumption that deep layer moisture and thermodynamic instability are abundant during the wet season, the primary driver of convection is assumed to be mass convergence resulting from boundary interactions in the lower troposphere. These boundaries generally move with the prevailing low level flow, which to a good approximation, is represented by the 1000 mb to 850 mb mean layer wind. The traditional 1000 mb to 700 mb mean-layer "storm motion" is not used in this study, as convective triggers in the marine environment are generally found in the lower levels of the atmosphere.

The bulk of the data used in this study were obtained from the National Climatic Data Center. To most closely reflect the valid climate "normal" period, hourly rainfall data values at Key West and other select South Florida observing stations were examined for the 1981-2010 time period. Twice-daily low level winds were obtained from a corresponding 30-year dataset of Key West rawindsonde soundings. The diurnal rainfall climatology was stratified by boundary layer flow regime (separated into the eight cardinal directions), with the goal of developing a systematic prediction scheme of probable rain chances based on the direction of the boundary layer flow.

Results

As a baseline, the relative frequency of measurable rainfall at Key West and several other South Florida observing stations was calculated (Figure 1). From this figure it is clear that the Key West hourly trends showed near equal chances of rain across an average 24-hour diurnal cycle. This is in stark contrast to the Florida mainland, where wet season rainfall frequencies show a pronounced mid-afternoon maximum, due to the sea-breeze convection. In a barotropic marine environment however, rain chances are nearly "flat" across a diurnal cycle, as the land masses of the Florida Keys are generally not of sufficient size for meso-beta scale sea-breeze convection.

Further analysis reveals that the wet season diurnal climatology at Key West shows very little variability from June through September, except for a gradual increase in rain chances through the wet season. This analysis is summarized in figure 2, and the increase in rain frequency is presumably due to the slight increase in atmospheric precipitable water and conditional instability values through the late summer and early autumn months. The frequency of passing Atlantic tropical waves also increases during this period. The only month of the wet season that shows a significant diurnal signal however, is July . This is in accordance with other prior studies that show July winds to be nearly stagnant, as the Bermuda high entrenches itself across the southeast United States and northwest Caribbean. The resulting light flow allows for locally developed cloud lines to become the primary drivers of convection.

The diurnal rain probabilities for each flow regime are directly compared to climatology in Figure 3. The easterly and southeasterly flow regimes constituted the majority of the cases from the 30 year analysis. As such, the diurnal rain chances most nearly resembled the climatological values in these cases. Of a more unique nature, the northeasterly wind flow regime shows three diurnal maximum, each of which can be attributed to specific individual triggers. Beginning in the early afternoon, the northeasterly wind regime is the most prime direction for the creation of locally-induced island cumulus cloud line showers and thunderstorms. Secondly, the late evening rainfall maxima can be attributed to collapsing mainland convection that migrates to the southeast across the islands. Lastly, and most particularly under light wind regimes, the overnight maxima in rainfall is attributed to remnant cloud line boundaries that convectively initiate in due to a gradual increase in marine nocturnal boundary layer instability. The last wind regime that is of sufficient consequence to this study is the southerly wind flow regime, which is dominated by nocturnal Cuban land breeze boundaries that cross the Straits of Florida after the collapse of afternoon convection over the island.

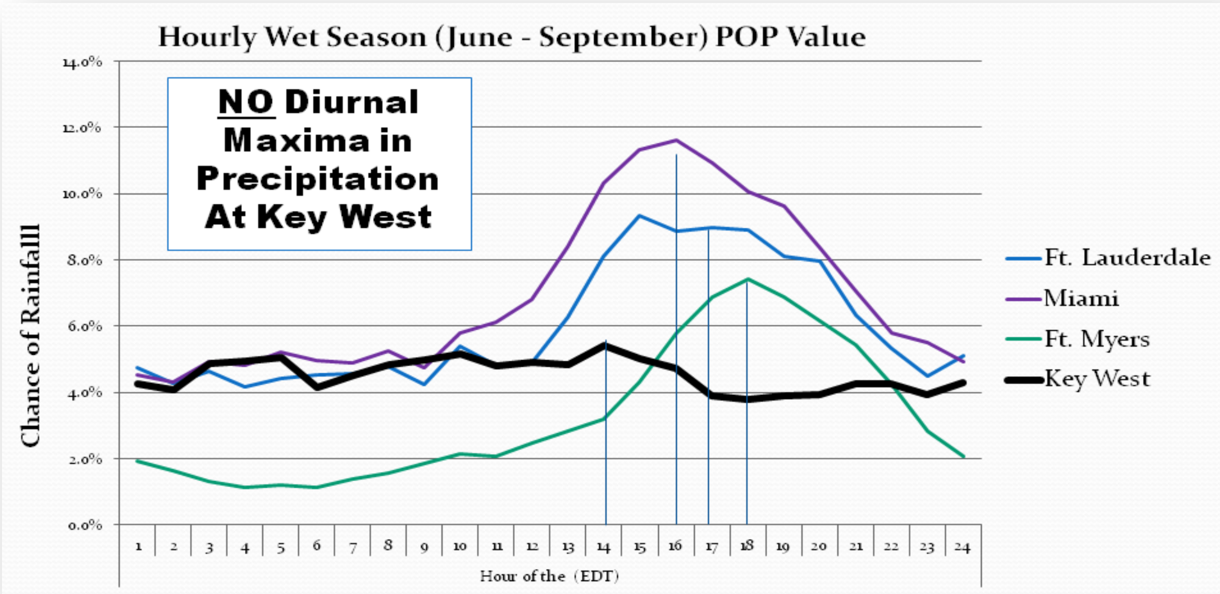

Figure 1: Comparison of the rain chances for the island of Key West with other prominent locations in the mainland of Florida.

Month of the year

Hour of the Day (EDT)	MAY	JUN	JUL	AUG	SEP	OCT
1	3.4%	3.7%	3.0%	4.6%	5.6%	5.2%
2	3.1%	3.7%	3.0%	3.8%	5.9%	5.0%
3	3.6%	3.3%	3.1%	6.0%	7.8%	5.5%
4	3.4%	4.4%	2.4%	5.1%	8.3%	6.1%
5	3.4%	4.7%	3.8%	5.9%	7.1%	5.5%
6	2.3%	3.8%	2.3%	4.0%	7.9%	4.7%
7	2.4%	4.2%	2.5%	4.8%	7.9%	5.3%
8	2.0%	4.6%	4.3%	4.8%	6.7%	6.6%
9	3.1%	4.1%	4.5%	6.3%	7.0%	4.7%
10	3.1%	5.2%	4.1%	5.5%	8.0%	5.1%
11	2.5%	5.1%	4.3%	6.2%	6.1%	4.6%
12	2.8%	4.6%	5.9%	6.0%	5.8%	4.4%
13	2.5%	4.8%	5.6%	5.5%	7.3%	3.4%
14	2.6%	3.9%	6.2%	6.8%	8.1%	5.0%
15	2.5%	4.4%	5.3%	6.3%	6.3%	5.3%
16	2.3%	3.8%	5.0%	5.4%	7.2%	4.8%
17	1.7%	3.1%	3.9%	4.3%	6.0%	4.4%
18	1.7%	3.4%	3.3%	4.6%	5.8%	3.8%
19	1.8%	3.9%	3.0%	4.4%	5.8%	4.4%
20	2.3%	3.9%	2.0%	5.1%	6.6%	3.9%
21	2.4%	5.2%	2.9%	4.8%	5.9%	4.4%
22	2.6%	5.3%	2.9%	4.2%	6.4%	4.2%
23	2.4%	5.3%	2.0%	4.2%	5.7%	4.1%
24	3.6%	3.6%	2.3%	5.4%	6.0%	5.1%

<u>Figure 2</u>: The hourly percentage of rain chances for each month of the wet season, also including the transitional months of May and October.

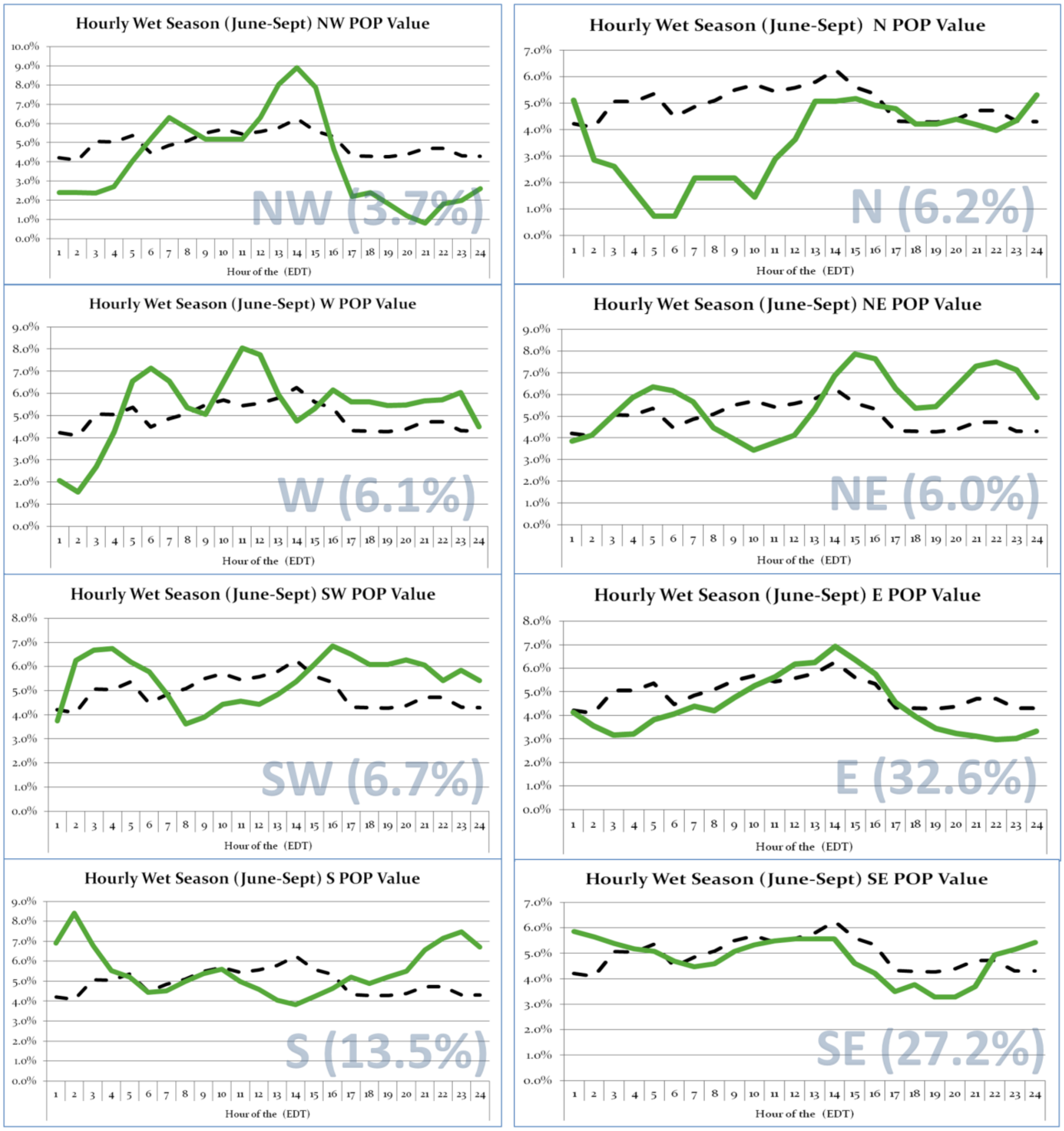

Figure 3: This series of charts compares the base climatology diurnal rainfall chances that occur regardless of flow regime (black dashed line) with the diurnal rainfall chances that occur under the eight cardinal low level wind flow directions. (solid green lines). The low level wind flow direction is labeled in the bottom right hand corner of each chart, and a percentage of the total cases that each wind regime represents follows in parentheses.