Comparing Composite Severe Weather Indices of Thunderstorm Activity on Sea-Breeze and Non-Sea-Breeze Days in the Mobile, Alabama Area

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Introduction

What are Severe Weather Indices (SWI)?
- Parameters which aid forecasters in determining weather type as well as severity (Rauber et al, 2017; Vasquez, 2015).
- Calculated from Atmospheric Soundings (Sounding).
- See Tables 1, 2, & 3 for descriptions of common SWIs.

What is a Sounding?
- Upper-air meteorological data (temperature, humidity, pressure, and wind speed and direction) obtained from weather balloons.
- Can be plotted on a special temperature-pressure chart known as a Skew-T Log-P Diagram (Skew-T) – See Figure 4.

What is a Sea Breeze (SB)?
- A common meteorological phenomenon that occurs along a body of water – See Figures 1 & 2.
- Frequent in summer (SB Season along the U.S. Gulf of Mexico [Gulf] coast is typically May through October).
- Forms when air temperature over land is greater than air temperature over water.
- Brings in relatively cool, moist air in the afternoon.

Two Types in Southwest Alabama (SW AL): SBs along Gulf and Bay Breezes (BB) on either side of Mobile Bay.

Why do We Care?
- Convergence at the leading edges of SBs and BBs can lead to thunderstorm formation (convection [conv]).
- Convection produces rainfall over an area and contributes to overall rainfall rate – See Figures 2 & 3.
- High rainfall rates can lead to flash flooding.
- Thunderstorms can also bring dangerous lightning and strong winds.

The Challenge: Forecasting the exact timing and location of SB-driven convection.

The Question: Which SWI is the best predictor for SB-driven convection?

Data & Method

Data
- Weather Surveillance Radar – 1988 Doppler (WSR-88D) radar data from Mobile, Alabama (KMOB). Data was limited to years 2011-2020, months of May through October, and times between 1400 Zulu and 2359 Zulu (08:00 am CST and 05:59 pm CST).
- Archived soundings from Slidell, Louisiana (KLIX), which were obtained from the University of Wyoming's Department of Atmospheric Science website (Atmospheric Soundings page).

Method
1. Used GR2-Analyst to analyze KMOB radar data for SBs and BBs in Mobile and Baldwin Counties in SW AL; constructed SB/BB case files for each year.
2. Categorized individual days as either a Dry SB Day (Fig. 1), a Convective SB Day (Fig. 2), a Dry Non-Sea Breeze (NSB) Day, or a Convective NSB Day (Fig. 3) – See Table 4.
3. Used Spyder environment to write Python code that reads in archived KLIX soundings and SB/BB case files from SB Period and calculates average (composite) SWIs for each of the four SB categories.
4. Used Microsoft Excel to create a table that lists the composite SWIs and a chart that depicts them.
5. Interpreted table, chart, and SWIs to determine which SWI(s) best predict(s) SB-driven convection.

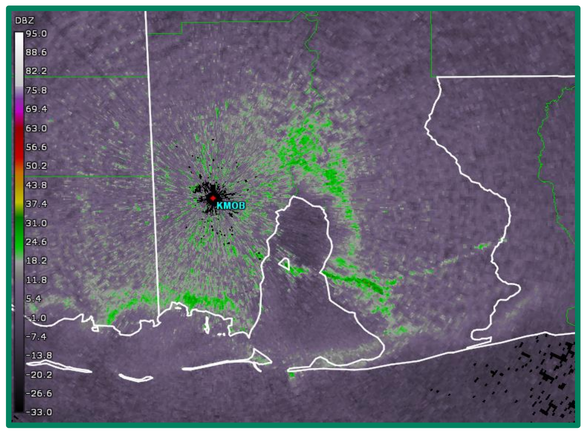

Figure 01: KMOB WSR-88D Radar Image of a Dry SB and BB Day in SW AL from 1747 Z on July 5, 2014. SBs and BBs are indicated by thin, green/gray lines.

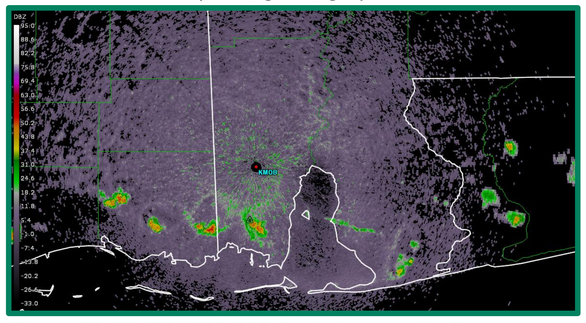

Figure 02: KMOB WSR-88D Radar Image of a Convective SB Day in Mobile County from 1914 Z on July 10, 2017. Convection is indicated by green/yellow/red blobs.

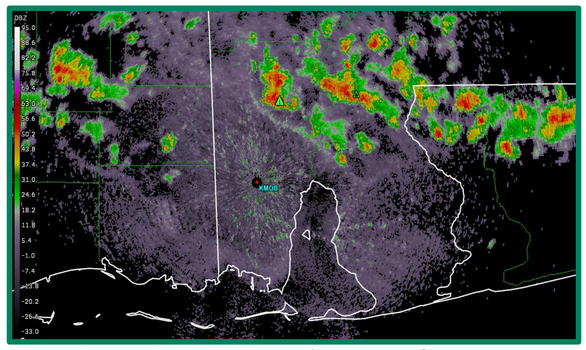

Figure 03: KMOB WSR-88D Radar Image of a Convective NSB Day in SW AL from 2009 Z on May 24, 2020.

Range	*K Index (KI)*
KI < 30	Heavy Rain Unlikely.
30 ≤ KI < 40	Heavy Rain Possible.
KI ≥ 40	Heavy Rain with Flooding Possible.

Table 01: The kind of weather typically associated with a few values of the K Index SWI. KI is used to aid forecasters in determining flash flooding potential (Rauber et al, 2017; Vasquez, 2015).

Range	*Total Totals (TT)*
TT ≤ 40	Thunderstorms Unlikely.
40 < TT < 55	Thunderstorms Possible.
TT ≥ 55	Severe Thunderstorms Possible.

Table 02: The kind of weather typically associated with a few values of the Total Totals SWI. TT is used to aid forecasters in determining how much moisture is in the atmosphere. It is similar to KI but is not used to determine flash flooding potential like KI is (Rauber et al, 2017; Vasquez, 2015).

Range	*Lifted Index*
LI ≥ 3	Rain Unlikely.
0 ≤ LI < 3	Rain Possible.
-5 < LI < 0	Thunderstorms Possible.

Table 03: The kind of weather typically associated with a few values of the Lifted Index SWI. LI is used to aid forecasters in determining how stable the atmosphere is. If the atmosphere is unstable, weather occurs (Rauber et al, 2017; Vasquez, 2015).

Category	*Description*	*Fig. #*
ConvSB	A day with both a sea breeze and conv.	Fig. 2
ConvNSB	A day with conv but no sea breeze.	Fig. 3
DrySB	A day with a sea breeze but no conv.	Fig. 1
DryNSB	A day with no sea breeze and no conv.	N/A

Table 04: Description and figure references for the four SB Categories explored in this study. It is important to note that the DryNSB category is not pictured because there is usually nothing to see on radar on DryNSB Days.

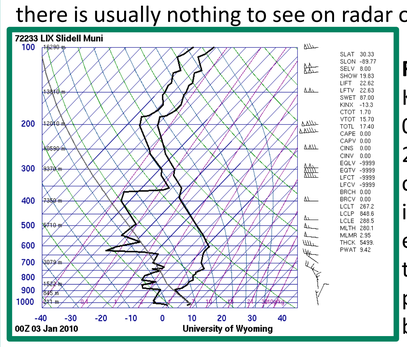

Figure 04: Example KLIX Skew-T from 00 Z on January 3, 2010. The black curve on the right is the environmental temperature profile, and the black curve on the left is the dew point temperature profile. Wind speed and direction are plotted in the wind barbs on the right-hand side of the graph, and the SWIs are listed on the right-hand side of the graph.

Results

Table 05 lists the Composite K Index, Total Totals, and Lifted Index Values that were obtained in this study.
- KI values range from 5.52 – 28.27. Each value falls within the "Heavy Rain Unlikely" range; however, two values – the ones for the ConvNSB and ConvSB categories – are close to the "Heavy Rain Possible" range (See Tables 1 & 5). This is a reasonable result.
- TT values range from 34.67 – 43.93. Two values – the ones for the DryNSB and DrySB categories – fall within the "Thunderstorms Unlikely" range while the other two values – the ones for the ConvNSB and ConvSB categories – fall within the "Thunderstorms Possible" range (See Tables 2 & 5). This is the expected result.
- LI values range from -3.16 – 2.65. Two values – the ones for the DryNSB and DrySB categories – fall within the "Rain Possible" range while the other two values – the ones for the ConvNSB and ConvSB categories – fall within the "Thunderstorms Possible" range. However, the DryNSB value is close to the "Rain Unlikely" rage (See Tables 3 & 5). This is an interesting result.

Figure 05 depicts the Composite K Index, Total Totals, and Lifted Index Values that were obtained in this study.
- KI is represented by the blue line, TT is represented by the purple line, and LI is represented by the pink line.
- KI has the greatest difference between the Conv Categories and the Dry Categories (indicated by the slope of the line between the ConvNSB and DrySB categories in the middle of the chart).

Category	*KI*	*TT*	*LI*
ConvSB	27.15	43.93	-3.11
ConvNSB	28.27	43.92	-3.16
DrySB	11.42	37.36	1.8
DryNSB	5.52	34.67	2.65

Table 05: Composite KI, TT, & LI values that were obtained in this study.

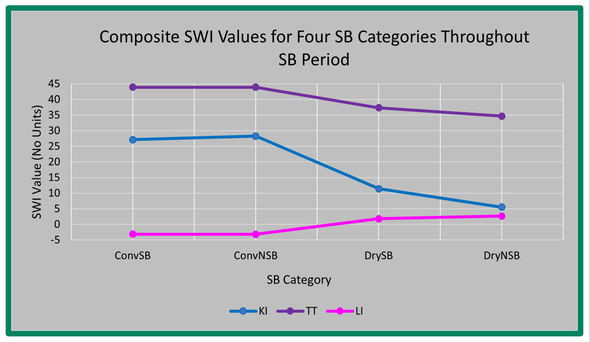

Figure 05: Chart depicting the Composite KI, TT, & LI values that were obtained in this study.

Note: Forecasters use SWIs as *guidelines* when determining weather type and severity. Because SWIs can either enhance each other or cancel each other out, forecasters will use words such as "typically" when describing weather associated with individual SWI ranges.

Conclusions

Of the three SWIs tested, the Total Totals produced the most conclusive result (See Tables 2 & 5).
Both Conv Categories – ConvSB and ConvNSB – fall within the "Thunderstorms Possible" range while both Dry Categories – DrySB and DryNSB – fall within the "Thunderstorms Unlikely" range.

There are no discernible differences between SB and NSB Categories in the K Index (See Tables 4 & 5).
Each value falls within the "Heavy Rain Unlikely" range.

Even though the K Index has the greatest difference between Dry and Conv Categories, it is the only SWI that does not span more than one of its "typical weather type and severity" ranges (See Table 5 and Figure 5).
TT and LI have both Dry Categories in one range and both Conv Categories in a second range.

Of the three SWIs tested, the Lifted Index produced the most interesting result (See Tables 3, 4, & 5).
Even though there are discernible differences between Dry and Conv Categories (DrySB and DryNSB fall within the "Rain Possible" range, and ConvSB and ConvNSB fall within the "Thunderstorms Possible" range), the more expected range for the Dry Categories would be "Rain Unlikely." However, it illustrates why different types of weather are only "typically" associated with individual SWI ranges.

References

- *Severe and Hazardous Weather: An Introduction to High Impact Meteorology*, Fifth Edition, 2017, by Robert M. Rauber, John E. Walsh, and Donna J. Charlevoix.
- *Severe Storm Forecasting*, 2015, by Tim Vasquez.

Acknowledgment

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