



INTRODUCTION

In the state of Alabama, non-convective high winds have resulted in 2 deaths, 6 injuries, an estimated \$14,122,000 in property damage, and an estimated \$150,000 in crop damages, per National Weather Service (NWS) Storm Data since January 1st, 1973.

The NWS office in Huntsville, AL (HUN), issues an advisory for our County Warning Area (CWA) for non-convective winds if one of two criteria is met:

- Sustained wind speeds of at least 25 mph for 3 hours or more
- Wind gusts of at least 35 mph at any time

Additionally, a high wind warning is issued for:

- Sustained wind speeds of at least 40 mph for 1 hour or more
- Wind gusts of at least 58 mph at any time
- Widespread non-thunderstorm wind damage

In what ultimately started as a way to learn Python, the goal of this project was to isolate favorable wind directions, 3-hour pressure changes, and overall synoptic patterns for observed Wind Advisory criteria. Because at least a 30-year period of study was desired, the only two observation stations in the Huntsville County Warning Area (CWA) that met these requirements were Muscle Shoals (MSL) and Huntsville (HSV).

METHODOLOGY

Automated surface observing system (ASOS) hourly data for Muscle Shoals (KMSL) and Huntsville (KHSV) from 0000 UTC January 1st, 1973 through 2353 UTC July 1st, 2019 were obtained from the National Centers for Environmental Information (NCEI). Data were included in this study if they met the following conditions:

- 1. Sustained wind speed was greater than 25 mph or wind gust was equal to or greater than 35 mph
- 2. The time, date, wind speed, wind direction, and pressure reading were all present
- 3. No precipitation was occurring within one hour at the time of the wind/gust speed

This resulted in 882 data points at KHSV and 182 data points at KMSL. To limit the amount of convective events, the data was further restricted to occurrences between November and April. Histograms of each distribution (wind speeds > 25 mph and wind gusts > 35 mph for both KHSV and KMSL) were plotted alongside a wind rose for each permutation. Finally, composites of MSLP and 500 mb geopotential height anomalies in instances with wind gusts over 40 mph were computed via the ESRL page to determine favorable synoptic patterns. At HSV, there were 135 instances of wind gusts over 40 mph that fit within the parameters of this study, and only 30 instances at MSL. Repeated dates were removed from the list for these composite images to eliminate redundancy and skewing toward more prolonged winds.

HISTORY OF KHSV AND KMSL

The Huntsville weather observation (KHSV) has been located at Huntsville International Airport since October 29th, 1967, and was maintained as a part of the Cooperative Observer Program (COOP) through August 1st, 1994. During this time, the wind information recorded includes the direction and speed of the fastest 1-minute wind, as well as the direction and speed of the peak wind gust (analog). Beginning on August 1st, 1994, the ASOS was installed at the west side of the airport, 0.8 miles west of the previous location. The wind data recorded here is the direction and speed of the fastest 2-minute wind, as well as the direction and speed of the fastest 5-second wind (digital).

The Muscle Shoals weather observation (KMSL), like the HSV observation, began as a part of the COOP program located at the Muscle Shoals Municipal Airport from February 1st, 1939 until April 8th, 1997, at which point the ASOS was installed at the Muscle Shoals Municipal Airport, approximately 1.1 miles west of the previous location. Just as the ASOS at HSV, wind information recorded included the direction and speed of the fastest 2-minute wind, as well as the direction and speed of the fastest 5-second wind (digital).

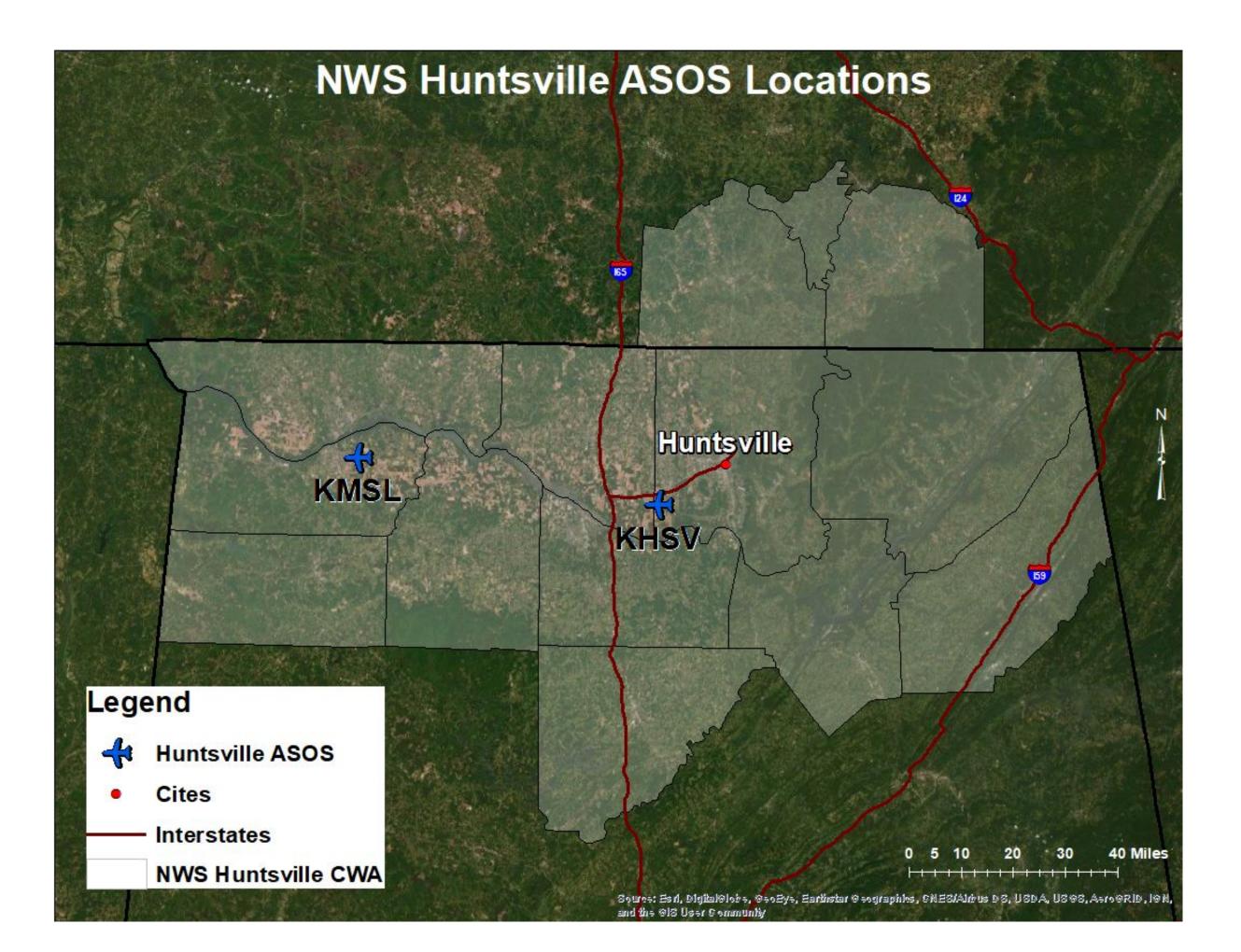


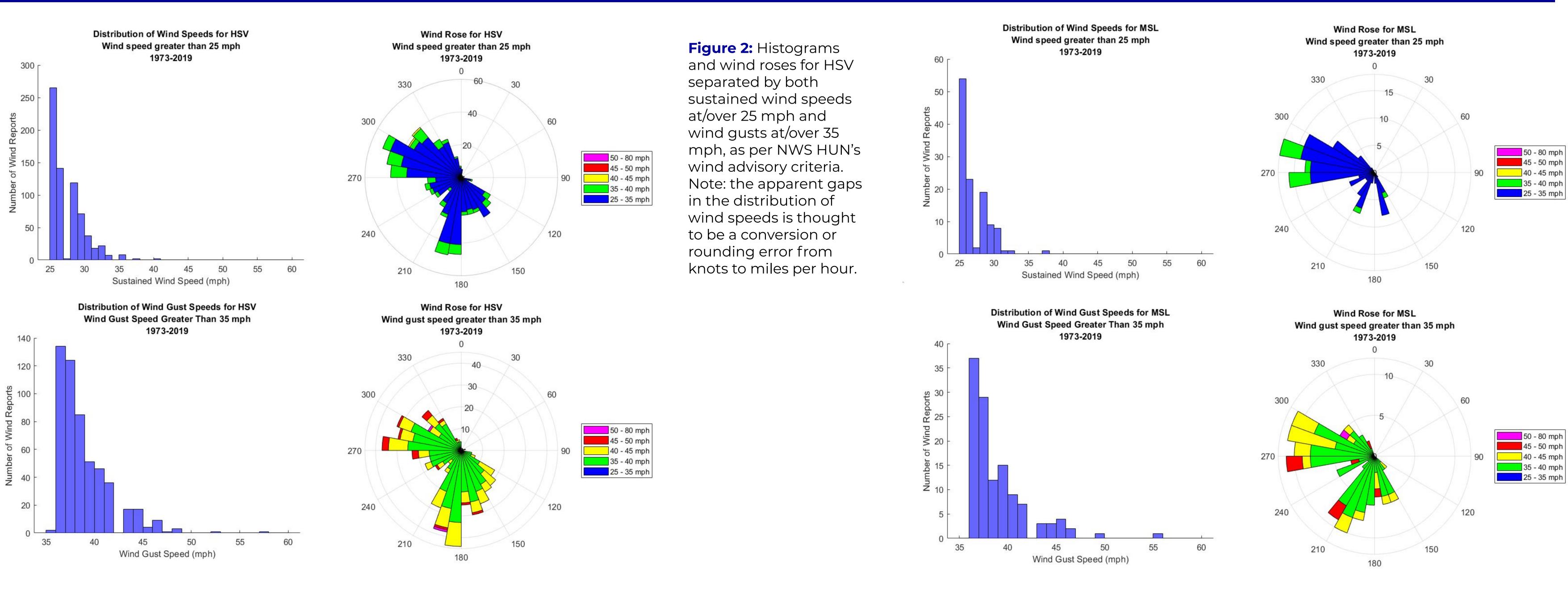
Figure 1: Location of both airports encompassed in this study, HSV (Huntsville) and MSL (Muscle Shoals) in the Huntsville County Warning Area (CWA).

 It is exciting to consider the potential of a dataset of this kind; additional stations should be incorporated to the synoptic patterns identified in this study. Additional regions could also be included in future studies. The greater the dataset, the better the representative composite maps. Composite soundings are another unexplored avenue which this study could incorporate. Of particular interest is the occurrence of wake-low meso-high events, and how low-level lapse rates relate to higher surface wind speeds and gusts.

We would like to thank ESRL for their webpage, Andrew Smith for his advisement with the programming and plotting, and the Huntsville WFO staff for their support as we developed this research and will continue to push it forward to assist in operations.

A Climatology of High Non-Thunderstorm Winds in the Tennessee Valley

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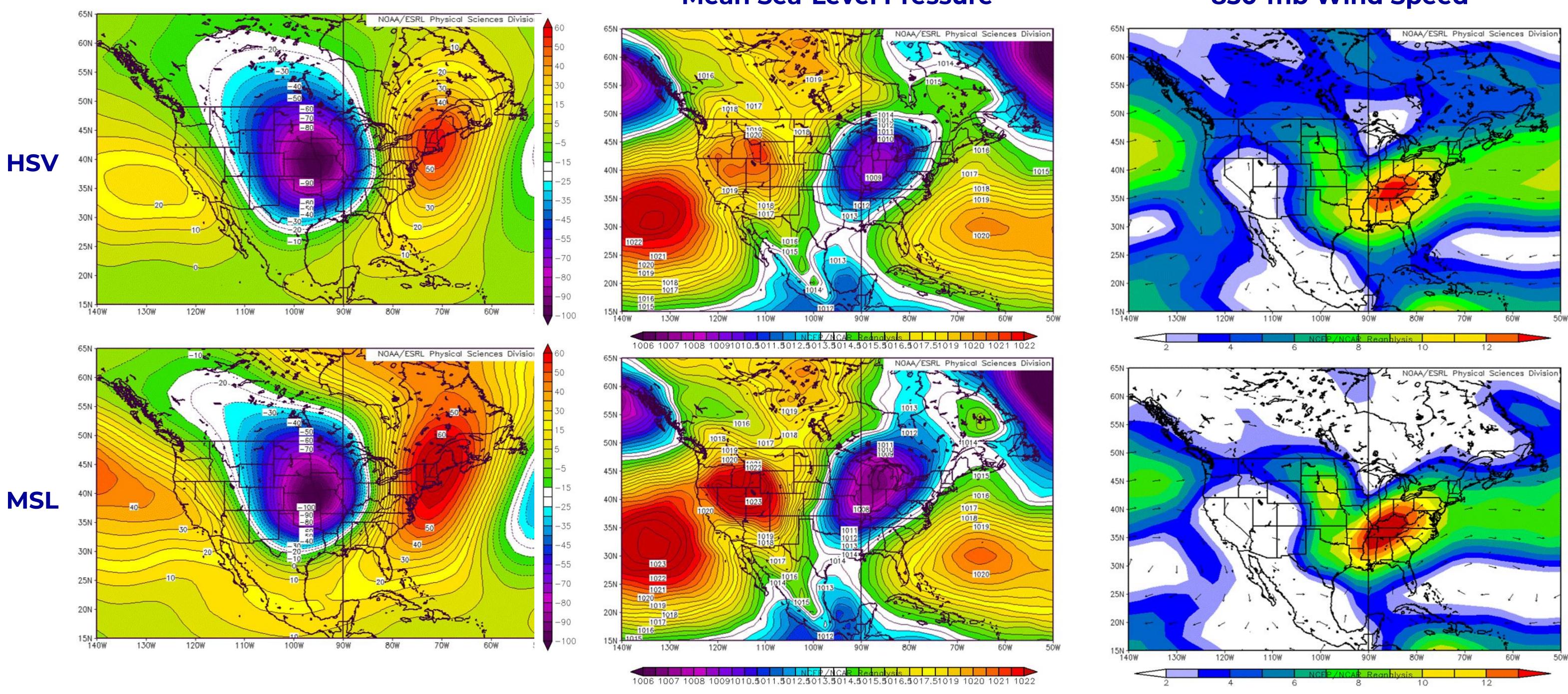


As anticipated, the frequency of higher wind speed increases for both sustained winds and gusts for both HSV and MSL. One may note that there are some gaps in the distributions in both Figs. 2 and 3, and this is hypothesized to be the result of a rounding error in the conversion from knots to miles per hour. A few occurrences may be present in each "gap", but this is the result of the associated METAR observation being manually edited.

In order to better visualize favorable wind directions and distributions of the occurrence of high winds in the Tennessee Valley, wind roses inspired by the displays from the Aviation Forecast Preparation System (AvnFPS) were created (Figs. 2 and 3). Polar coordinates are able to better signify favorable wind directions, which is then paired with a distribution of each wind speed/gust threshold cumulatively measured radially from the center. It should be noted that each color segment is representative of all total reports from that wind direction within the wind speed thresholds noted in the color key to the right of each wind rose.

Both stations indicate the most favorable wind directions are from the south. Despite the condition that no precipitation could be present in the METAR within one hour of the observation, a large portion of the wind events were west to northwesterly reports are the result of outflow from convective events, but further investigation is needed. From historical allegory, a more southerly component to the wind direction is more favorable for non-convective high wind events. In order to better investigate favorable synoptic setups to relate to the wind roses, composite images of 500-mb winds were retrieved via ESRL page for NCEP/NCAR reanalysis data (below).

For both HSV (Fig. 4, top row) and MSL (Fig. 4, bottom row), the 500-mb anomaly pattern depicts a longwave trough over the Plains with ridging along the Mid Atlantic and off the California coast. At the surface, MSLP composite imagery portrays low pressure generally from the Great Lakes region with strong ridging over the southern Atlantic. Lastly, the 850-mb winds and wind direction highlights a LLJ present over the Southeast/Appalachians. The placement of these synoptic features also highlights a more southerly component to winds, as was hypothesized.



FUTURE WORK AND ACKNOWLEDGEMENTS

500-mb Height Anomaly

Mean Sea-Level Pressure





Figure 3: As in Fig. 1 for

station KMSL in Muscle

Shoals, AL.

HISTOGRAMS, AND COMPOSITE SYNOPTIC PATTERN

850-mb Wind Speed

Figure 4: Composite plots for HSV (top row) and MSL (bottom row) containing 500 mb geopotential height anomaly (left), mean sea-level pressure (middle) and 850 mb mean vector winds (right). Images are daily composites of all days containing wind gusts at or above 35 mph for each station. The 35 mph threshold was selected since this is the defining threshold for Wind Advisory criteria at the Huntsville WFO, and due to the fact that impacts to outdoor objects and the environment (tree limbs) typically begin at this wind speed. Generally, the synoptic pattern revealed in these images indicates that wind gusts of this magnitude are favored from anomalous upstream troughs centered over the Upper Midwest into the Central Plains, and anomalous ridges centered over New England, with an attendant surface front to the west of the region, stretching from the Great Lakes region into the central Mississippi Valley. An 850 mb jet streak with winds around 12-14 m/s was also noted directly across the Tennessee Valley.

Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/"

Kalnay, E. and Coauthors, 1996: The NCEP/NCAR Reanalysis 40-year Project. Bull. Amer. Meteor. Soc., 77, 437-471.