Inter-Comparison of Data Between Sonic and Propeller Anemometers

2013 Summer Internship
National Data Buoy Center
Hunter Greene

Mentors: *Regina Moore*, *Pete Lessing*, *and James Elliott*

My Background

- Senior at Mississippi State University
- Seeking B.S in Geosciences
  - Concentration: Professional Meteorology

Mentors:

- Regina Moore- NDBC Engineer
- Pete Lessing- NDBC Engineer
- James Elliott- NTSC Engineer

National Data Buoy Center (NDBC)

- Designs, develops, operates, and maintains a network of data collecting buoys and coastal stations.
- Serves as a data assembly center for receiving, quality controlling, and disseminating measurement data.

Anemometers

Propeller Anemometer

- Wind turns the propeller
- Connected to a weather vane
- Weather vane keeps anemometer properly aligned
- Propeller blades indicate wind speed while the weather vane shows direction

Sonic Anemometer

- Based on time of flight of sonic pulses (ultrasonic sound waves) between pairs of transducers
- Measurements between transducers are combined and calculated to produce a single wind vector

Anemometers

Propeller Anemometer

RM Young Model 05103

- Accurate data
- Main issues are maintenance and longevity

Sonic Anemometer

RM Young Model 85106

- How accurate is the data?
- Requires less maintenance
- Lower threshold speed

Anemometers Used for Study

Data taken around Hurricane Isaac (8/27/12 – 9/4/12) @ NDBC

- Test Stand Propeller and Sonic Anemometers
- OSTF1 Propeller and Sonic Anemometers

Data taken from 6/10/13 – 6/17/13

- Buoy #41047
- Buoy #40140

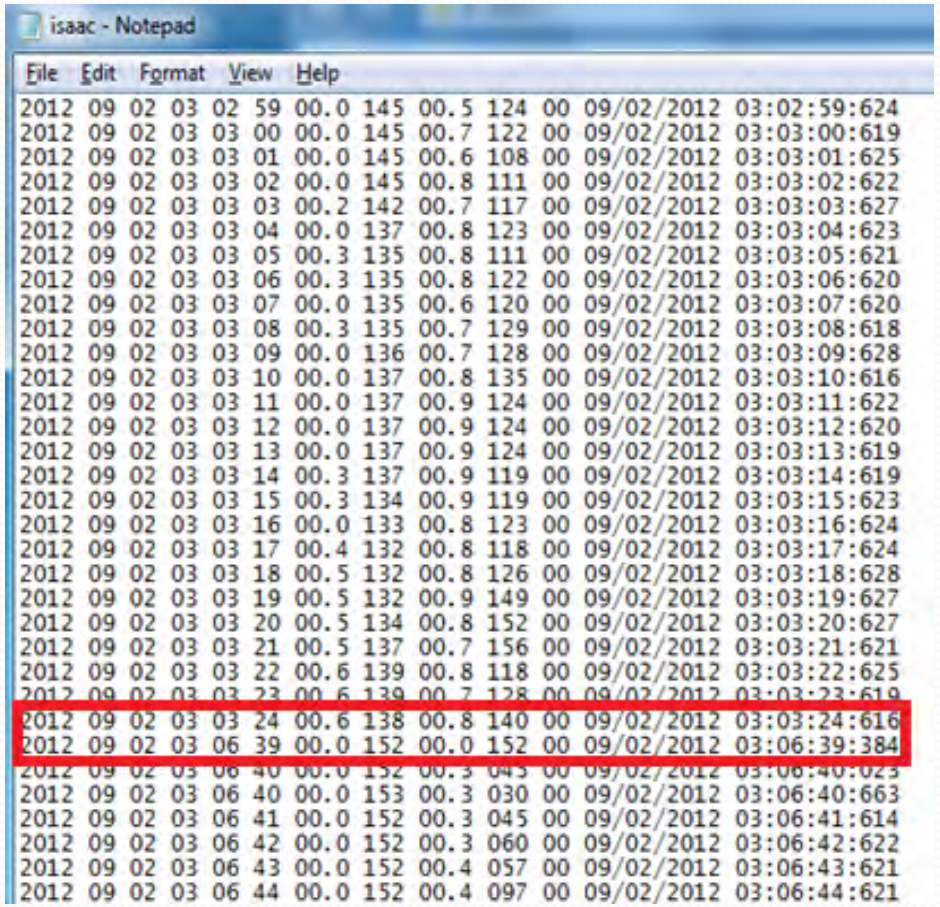
Methods

- Imported large .txt files(nearly 700,000 lines) into Excel, where raw data was organized using VBA scripting to make the data more readable.
- Computed differences between wind speed and direction measurements taken by propeller and sonic anemometers simultaneously.
- Transferred calculated data from Excel to Matlab where further statistical analysis was performed.
- Drafted scripts in Matlab to create informative charts and graphs of calculated data.

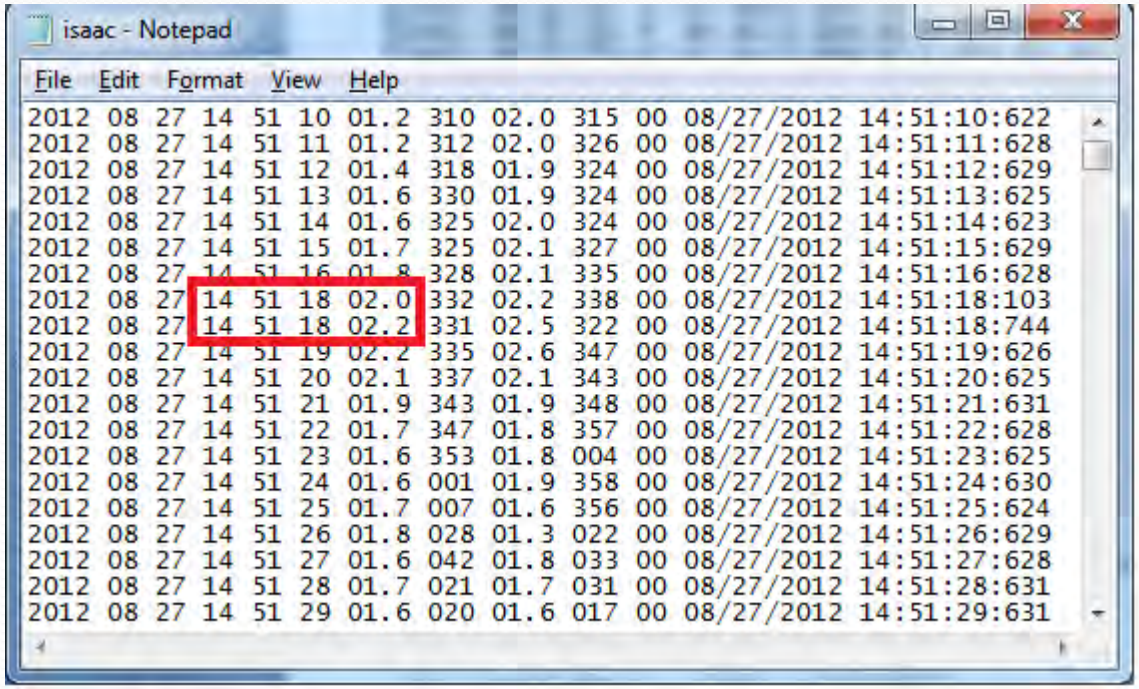
Glitches in the System

- Missing 3 minutes and 15 seconds (195 data points) starting at 9/2/2012 @ 03:03:24 and skipping to 03:06:39.

- Likely a power failure

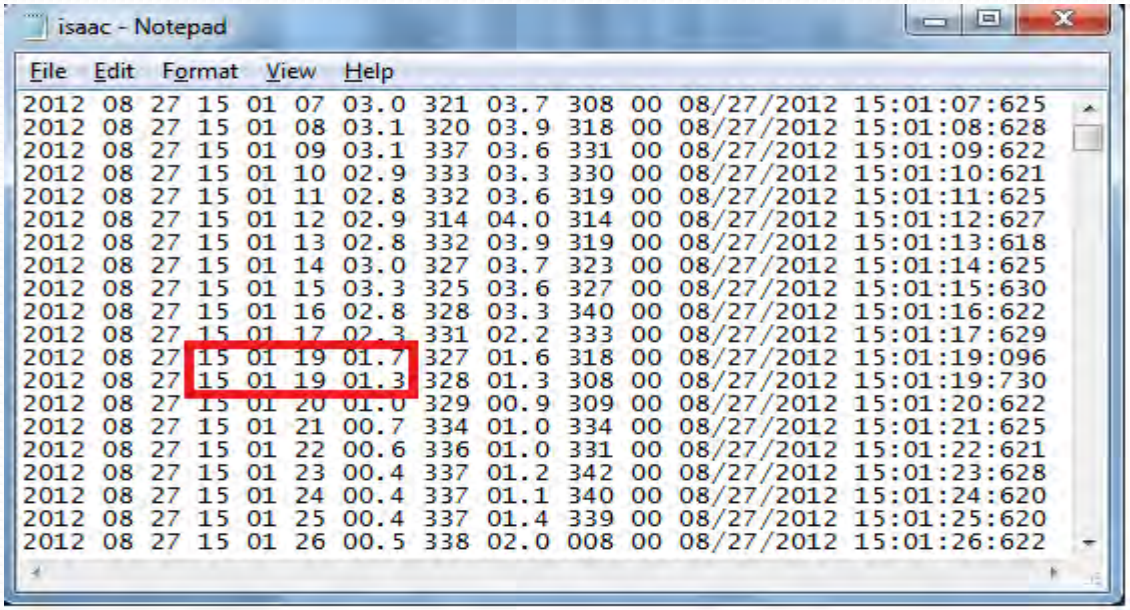


System Limitations



- In this image, **2 data points were recorded** at the <u>18 second mark</u> on 8/27/12 @ 14:51:18.

System Limitations



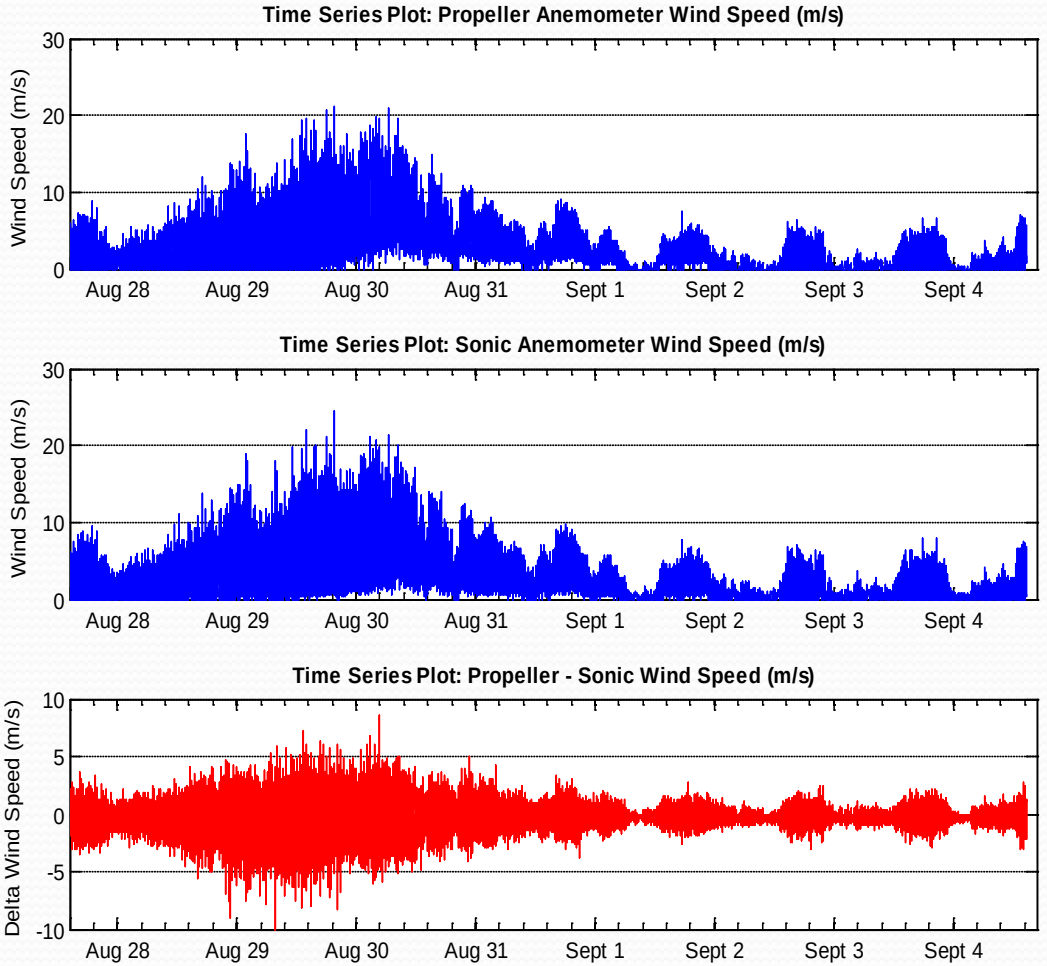
- In this image, the same problem occurs exactly 10 minutes and 1 second later. You can see there **are 2 data points recorded** at the 19 second mark on 8/27/12 but @15:01:19.
- Occurs every *10 minutes and 1 second* throughout the file regardless if the hour or day changes.

Time Series Results

- 3 Time Series Plots from Isaac

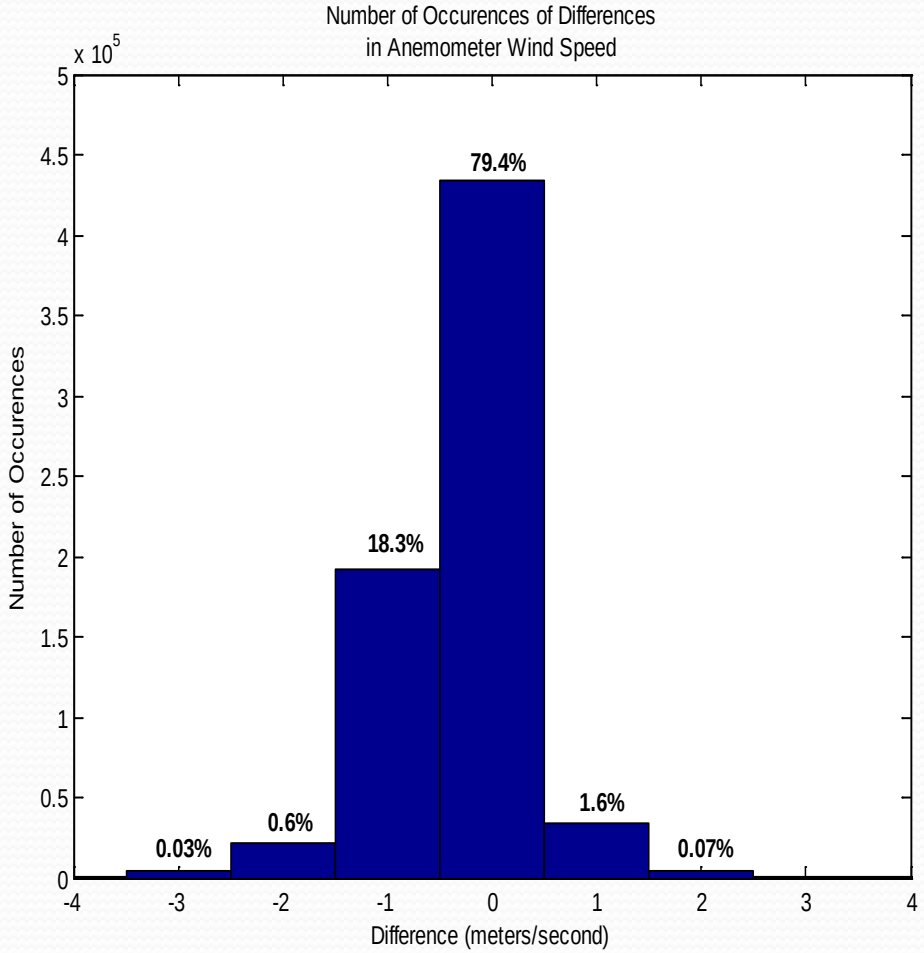
- 3rd plot shows absolute error between anemometers

- Data collected every second from 8/27/12 at 14:37:31 UTC to 9/4/12 at 15:06:35 UTC.



Time Series Results

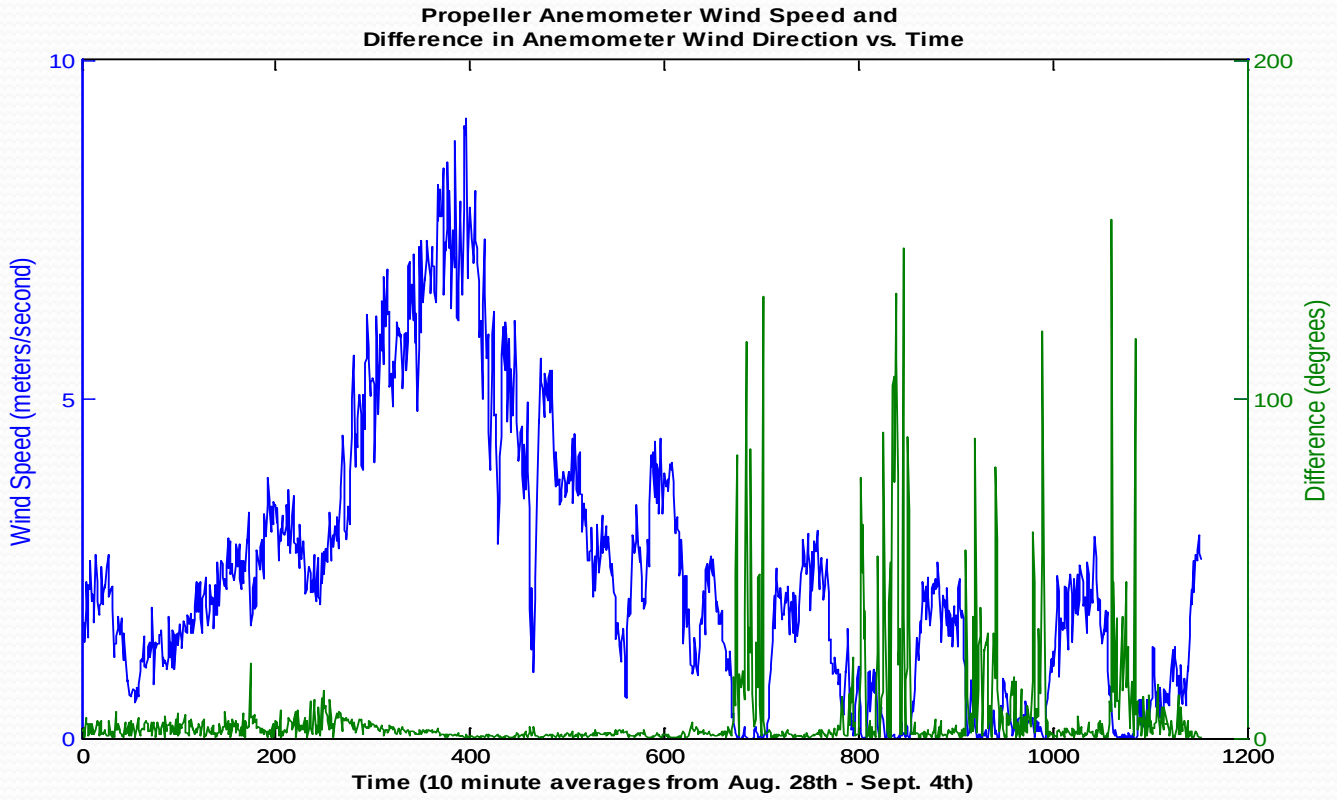
- 8 bin histogram showing distributions of the absolute error in wind speed from Isaac Time Series Data.



Average Time Series Results

• 2 y-axis plot with blue showing wind speed, and green showing difference in observed direction.

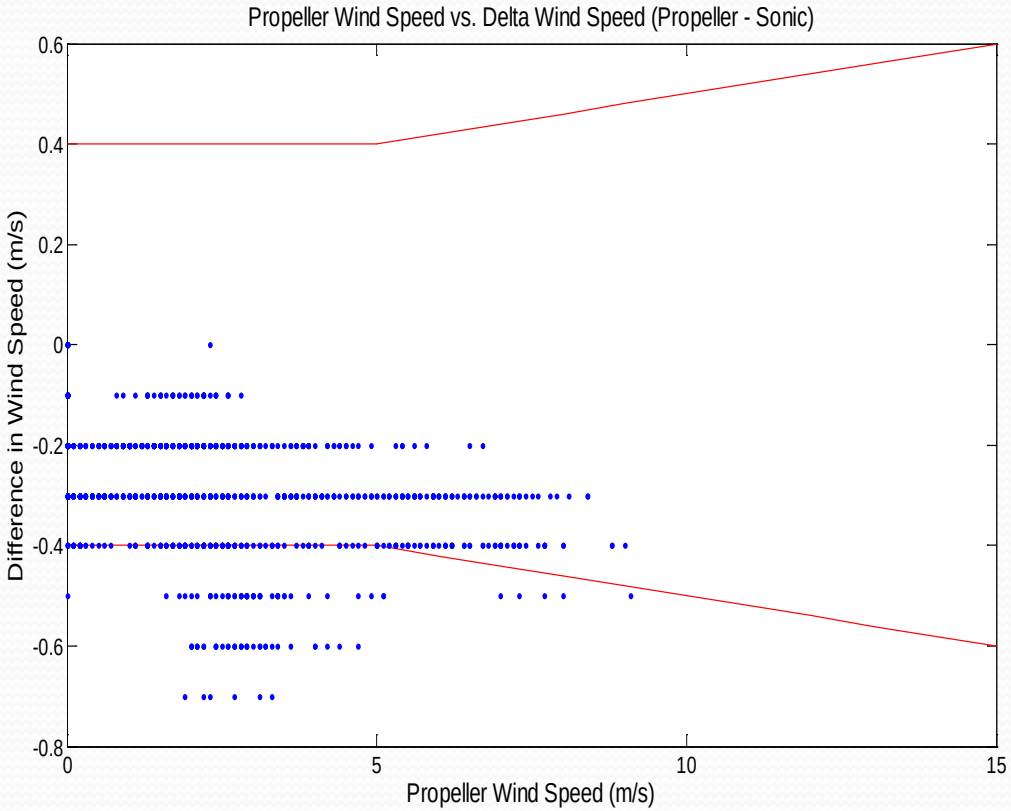
• Differences in measured direction have a tendency to increase when the measured wind speed is at or near 0.



Average Time Series Results

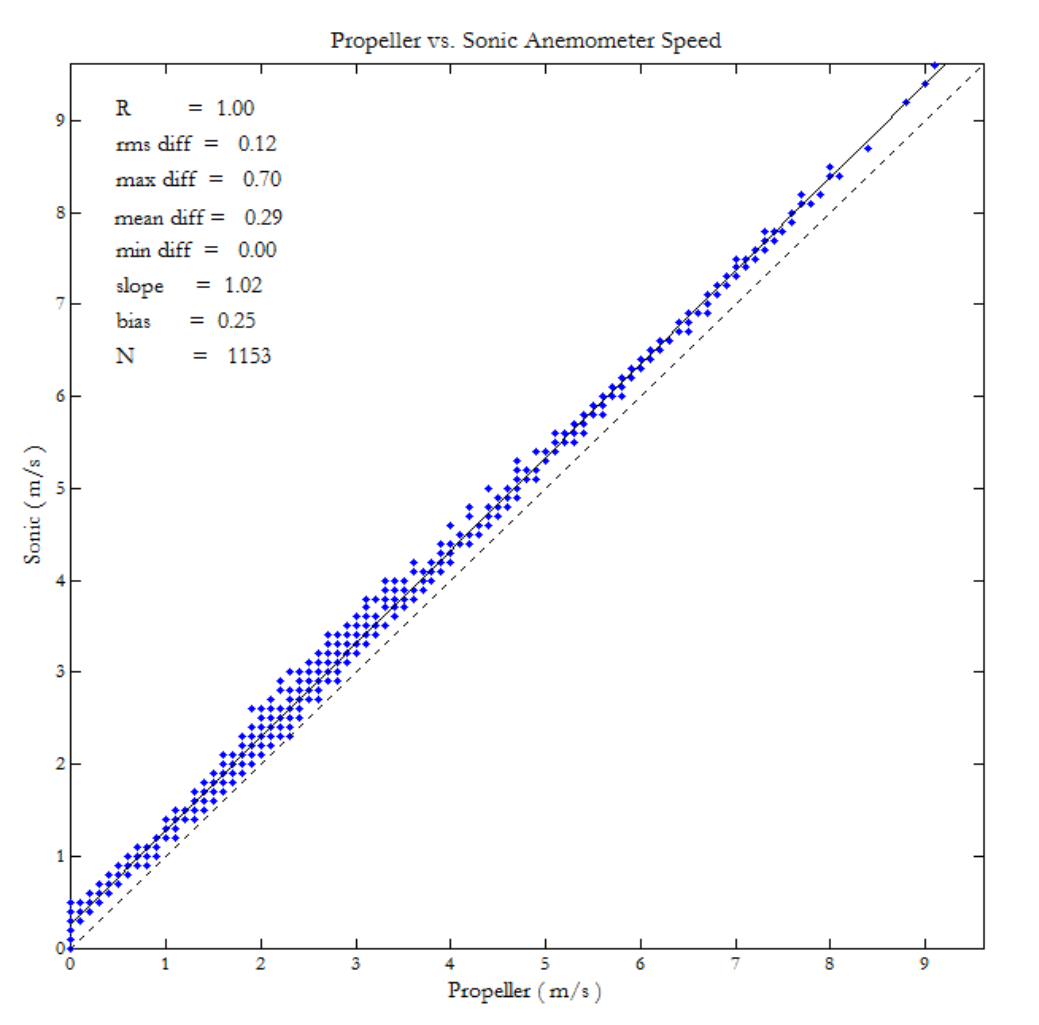
- Error bar plot showing absolute error in wind speed between anemometers from the averaged Time Series Data.

- 1014 data points



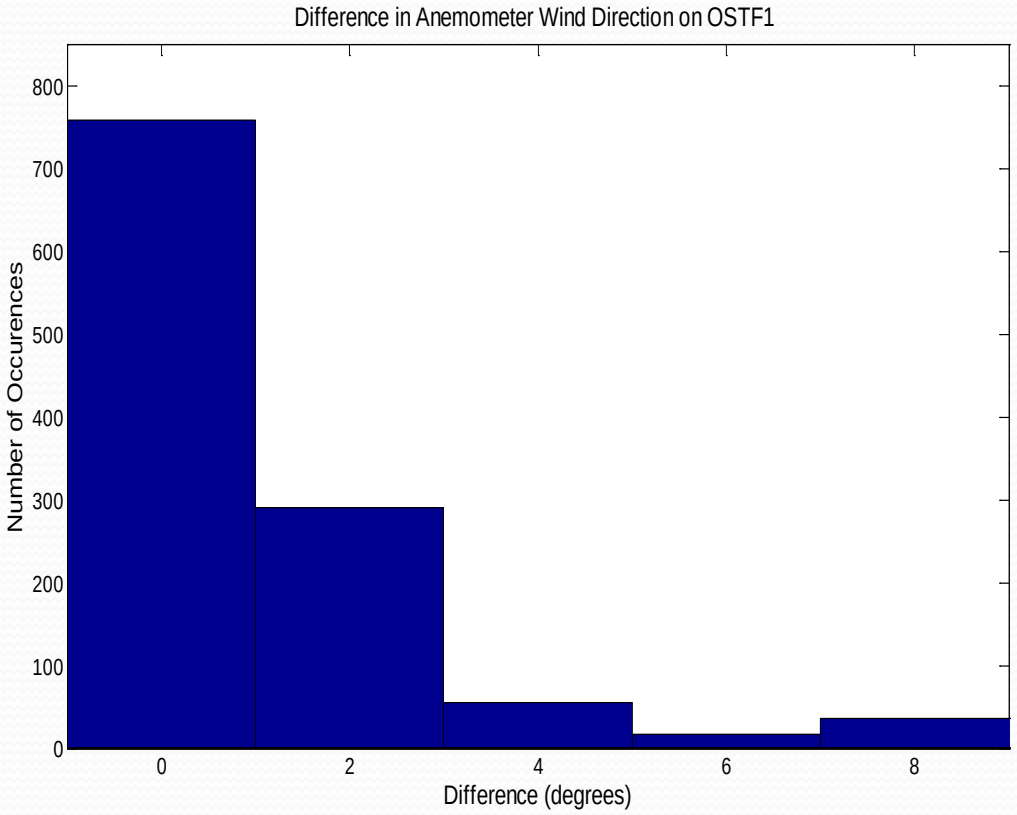
Average Time Series Results

- Comparing Anemometer Speeds from the averaged Time Series Data
- Near perfect correlation
  - R = +1.0
- Slight bias with Sonic always measuring about 0.25 m/s faster than Propeller
- Maximum difference is 0.70 m/s



OSTF1 Data Results

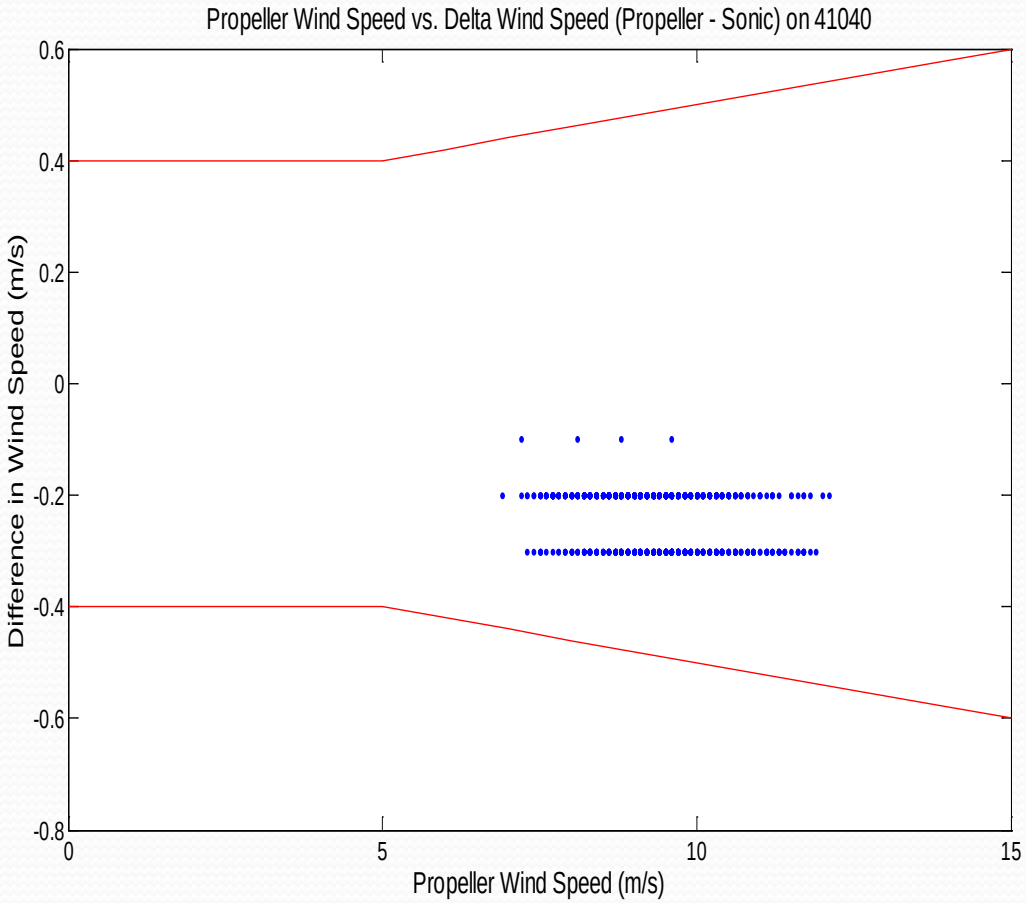
- Histogram showing distributions of the absolute error in wind direction between anemometers on sensor test facility (OSTF1)



Real Time Data Results

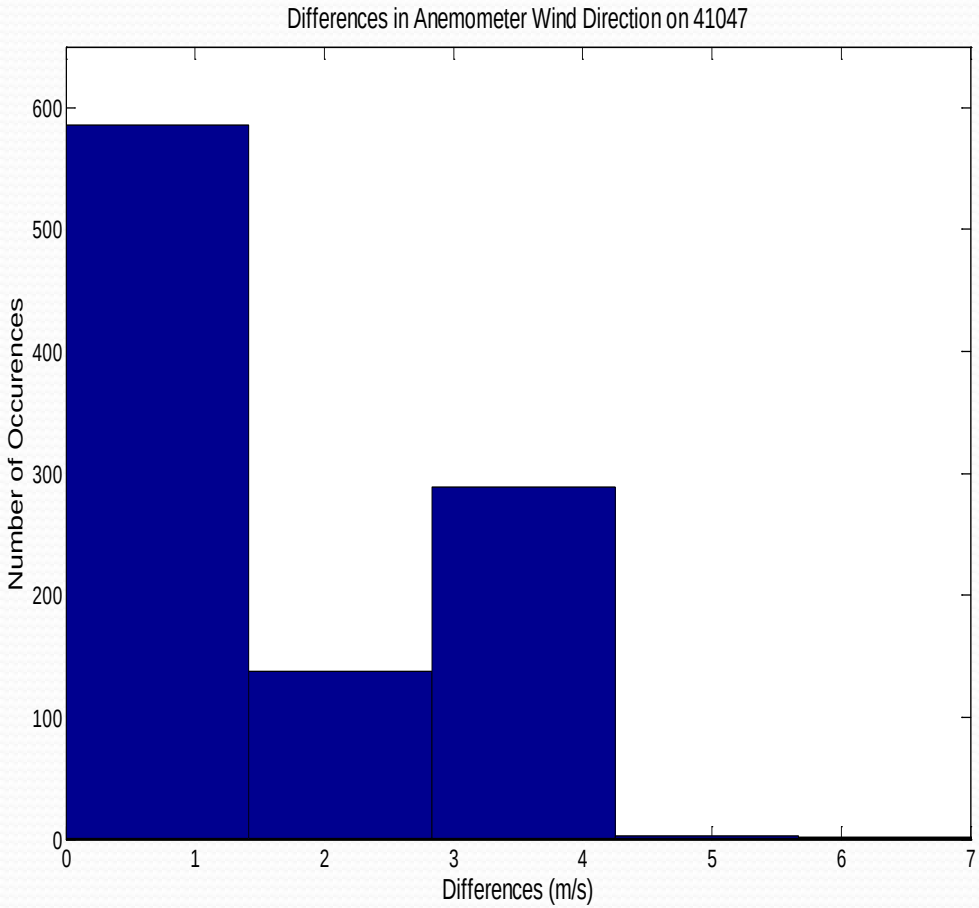
- Error bar plot showing absolute error in wind speed between the sonic and propeller anemometers on 41040

- 1014 data points



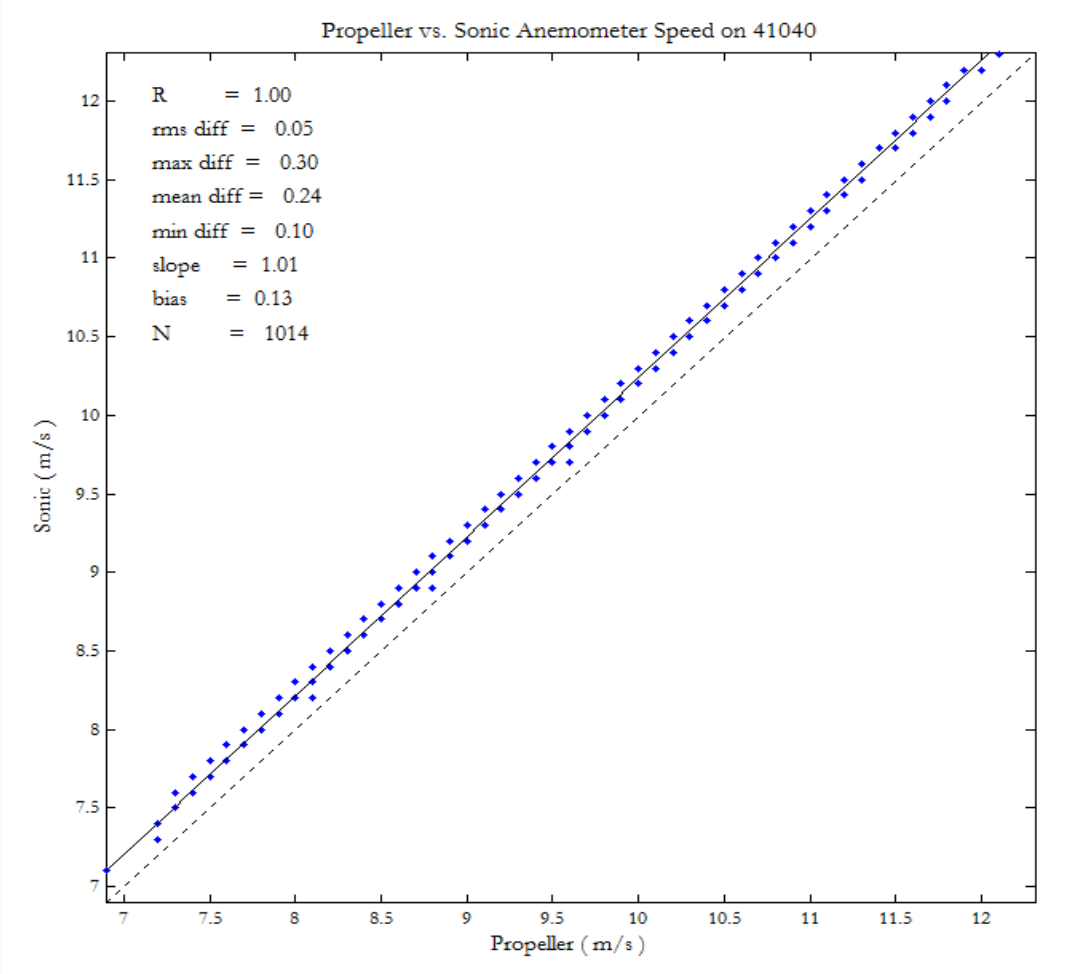
Real Time Data Results

- Histogram showing distributions of absolute error in wind direction between the propeller and sonic anemometers on 41047



Real Time Data Results

- Comparing Anemometer Speeds on 41040
- Biased towards Sonic Anemometer by 0.13 m/s
- Near perfect correlation
  - R = +1.0
- Maximum difference is 0.30 m/s



Conclusions

- With the exception of one glitch, no data was lost during the week of Hurricane Isaac from the Time Series Data.
- Raw Time Series Data has much larger differences than averaged data.
  - Consequence of “smoothing effects” caused by averaging.
- The sonic anemometer on average is slightly faster than the propeller anemometer (possibly due to threshold speeds).
- The difference in direction between anemometers increases dramatically when the measured propeller wind speed is less than 1 m/s.
  - 99% chance that if the difference in wind direction between anemometers is greater than the standard deviation of the delta, then the measured propeller speed is less than 1 m/s.

Content/Skills Learned

- Value of NDBC
- Matlab
- Excel
- Statistical/Comparative analysis techniques
- Graphing/plotting

Challenges

- New to Matlab
- Going from meteorology to engineering
- Work environment
- Thinking on my own

Final Thoughts

- Value of Internship
- Cool meetings
- Connections
- Career Outlook

Acknowledgements

- NDBC
- Mississippi State/NGI