

# Evaluating Data Quality and Performance Characteristics of An Ultrasonic Anemometer Versus Propeller Anemometers in Subarctic Western Alaska

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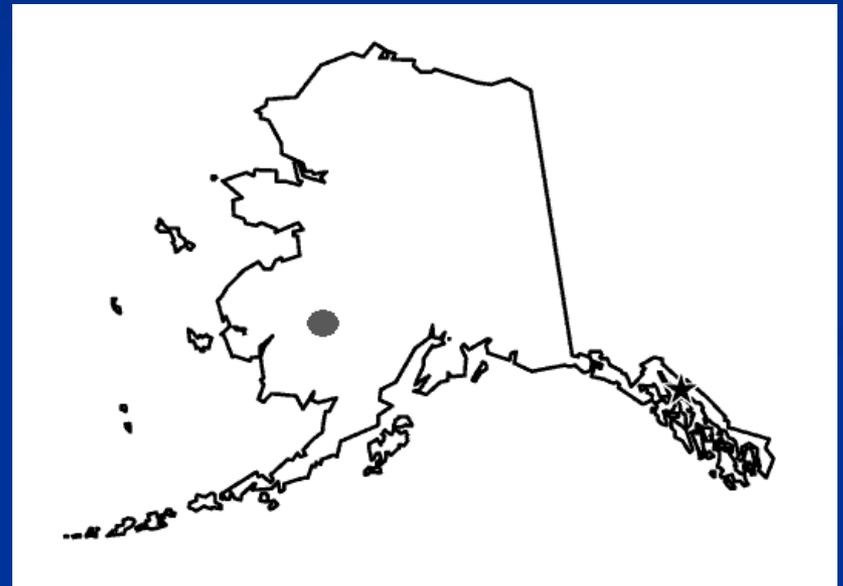
# ABSTRACT

In November 2008, a heated ultrasonic anemometer was collocated with an existing propeller and vane wind monitor and a vertical wind speed propeller anemometer in southwestern Alaska. The goal of the collocated install was to obtain higher data recoveries though the winters of this remote location where rime ice often causes the propeller type anemometers to fail, significantly reducing data recoveries. Data comparisons were conducted to ensure ultrasonic data quality and accuracy would match those of the propeller instrumentation. The effects of extremes in meteorological conditions on the operation of the ultrasonic and propeller anemometers were evaluated, as well as the resultant meteorological data quality and data recovery rates. Finally, data comparisons between the ultrasonic and propeller anemometers were also evaluated for biases and errors.

- Site background
- Identify problems collecting data
- Differences in sensors, calibrations
- Data comparisons to determine accuracy
- Data recovery rates
- Data biases and errors

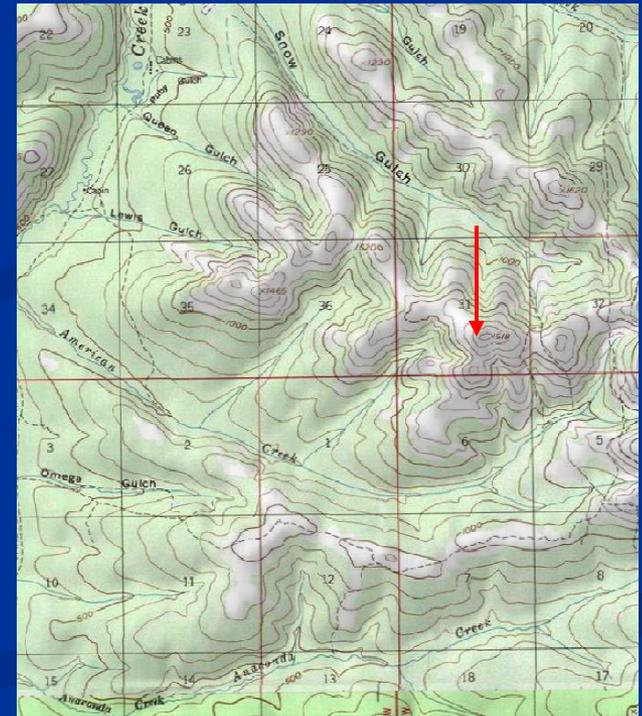
# BACKGROUND

- November 2008
  - Existing propeller and vane anemometer
  - Existing propeller vertical wind speed anemometer
  - Ultrasonic anemometer added
- Remote location of southwestern Alaska 300 miles west-northwest of Anchorage
- The purpose of the monitoring program is to document the regional atmospheric baseline and to collect adequate data in preparation of an air quality permit application



# BACKGROUND

- Site collects wind speed and direction, vertical wind speed, temperature at 10 and 2 meters, barometric pressure, and solar radiation data



# PROBLEMS



# PROBLEMS

- Project site is prone to severe rime ice accretion, September - April
  - Strong northerly winds
  - High relative humidity
  - Subzero temperatures
- Loss of wind speed and direction data at these sites
- Wind turbines cease to operate, loss of power to site
- Remote site location, maintenance via snowmobile or helicopter only (weather permitting)
- Solution: try an ultrasonic



# PROBLEMS

Year	Sonic	WS/WD	V <sub>ws</sub>
2007 <sup>1</sup>	--	88.3	75.8
2008	--	84.8	79.0
2009			
2010			
2011			

1- Program started April 1, 2007

**Required 90% data recovery over  
four consecutive monitoring quarters**

# PROBLEMS



Important to note that data recoveries would be improved if:

- Site was “local” and easy to access
- Site had more favorable winter weather
- Sensor replacements and calibrations could be completed

# PROBLEMS

Make and Model	Range	Power Requirement
RM Young 05305AQ	0-50 m/s	15 VDC (5 mA)
RM Young 27106	0-35 m/s	5-15 VDC (11 mA)
Biral Research	0-45 m/s	24 VDC (430 mA)



# PROBLEMS

Make and Model	Measurement Method	Operation
RM Young 05305AQ	Magnet induced pulses 1800 RPM = 9.2 m/s WD Potentiometer	2-axis movement
RM Young 27106	Tach-generator transducer 0.0049 m/s per RPM	1-axis movement
Biral Research	Sonic pulses	No moving parts No maintenance



# PROBLEMS

- Little to no EPA/ADEC/air quality guidance regarding sonic anemometers in 2008
- Sonic anemometer would have to meet standard anemometer accuracy and range requirements
- Heated sensor would require a significant upgrade to the remote power generation
- Sonic anemometer would be compared to the prop and vane anemometer to show data validity since that is the accepted method



# PROBLEMS

## Propeller and Vane

- Visible system inspections
- Wind speed and direction torques
- Wind direction orientation
- Wind direction linearity
- Wind speed linearity
- Routine maintenance
- Calibrations completed on and off tower
- Install and go system

## Heated Ultrasonic

- Visible system inspection
- Orientation
- Path length measurements
- “Zero” check
- Compare data to standard
- No maintenance
- Calibrations on tower only
- Many user defined options

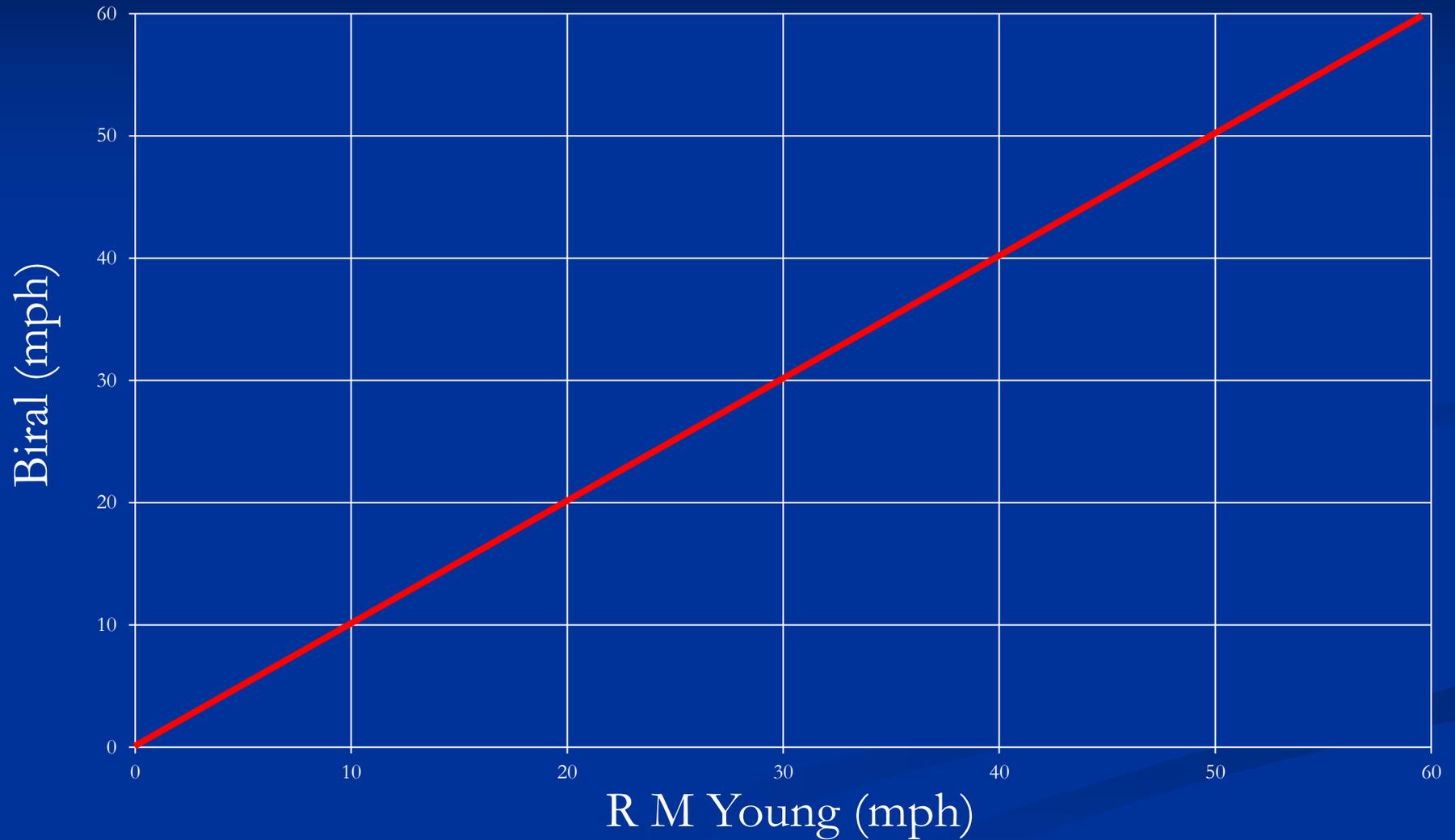
# PROBLEMS



# DATA

- Data are 15-minute averages
- Periods of known sensor icing resulting in error or zero values have been removed from the dataset
- Data invalidated during calibrations and audits, some data invalidated due to said calibrations and audits

# DATA



# DATA

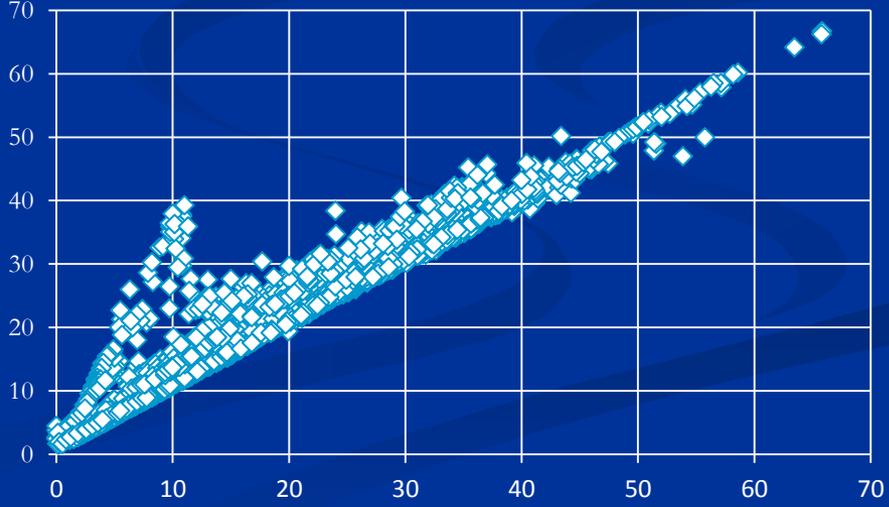
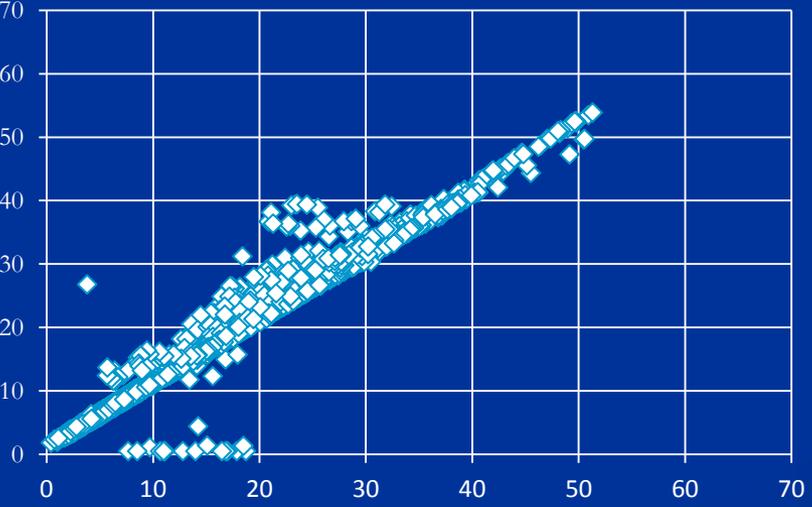
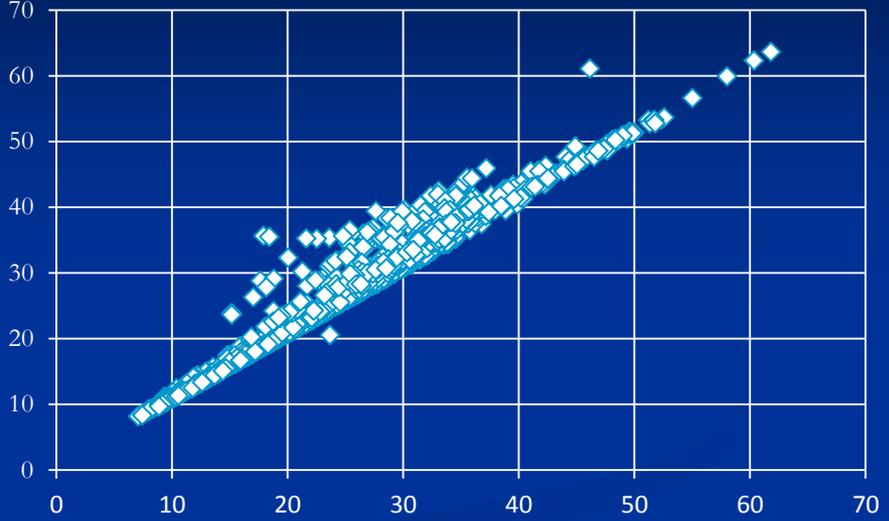
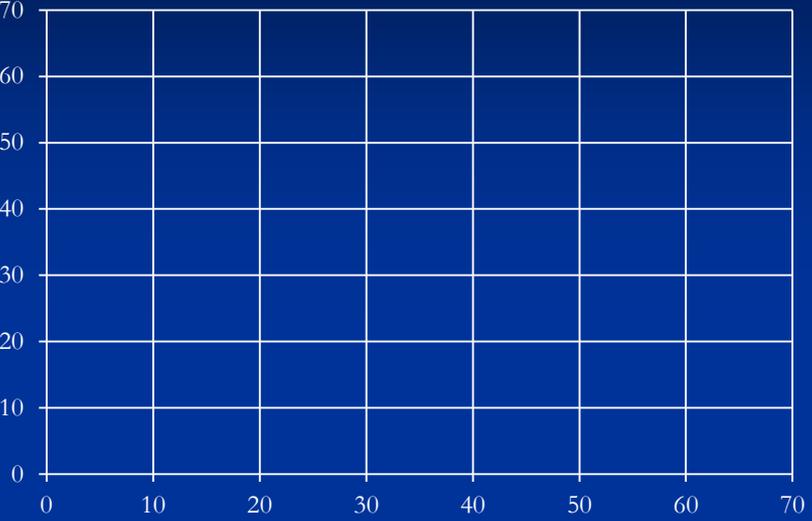
First Quarter  
Jan 1 – Mar 31  
Winter

Second Quarter  
Apr 1 – Jun 30  
Spring

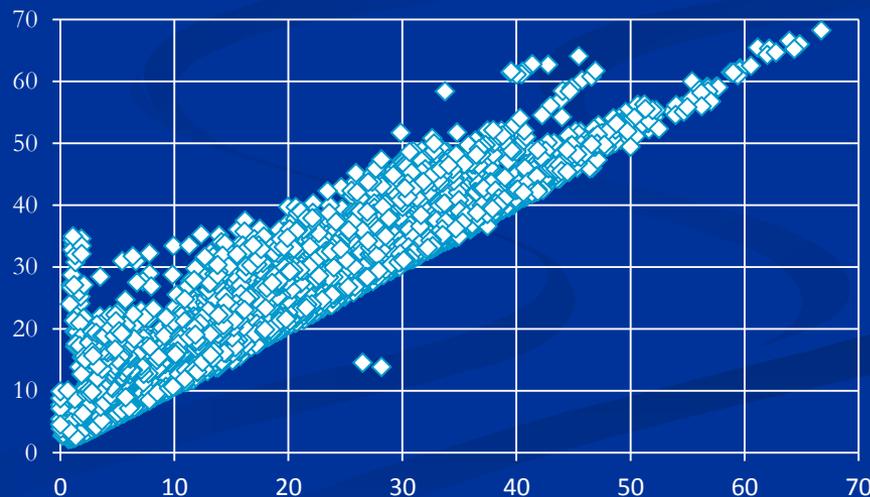
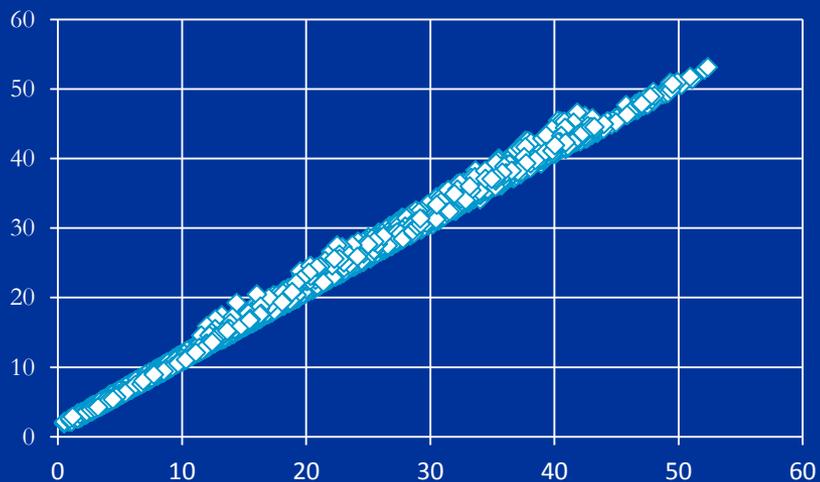
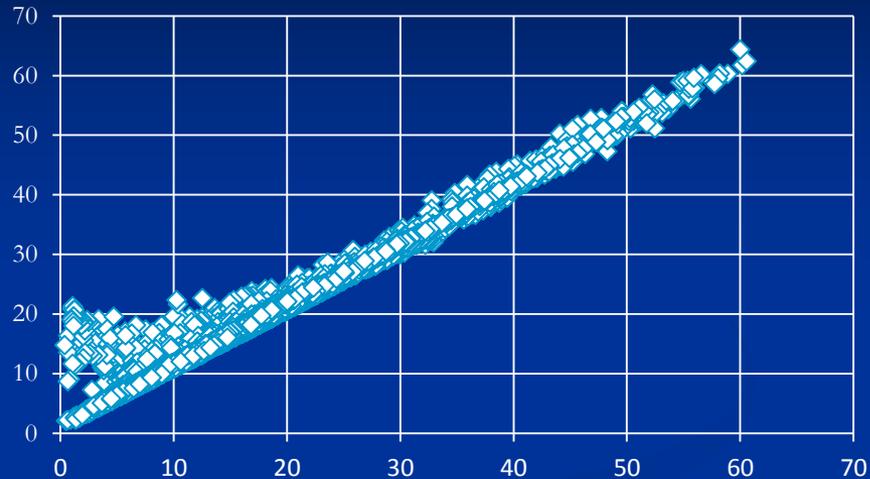
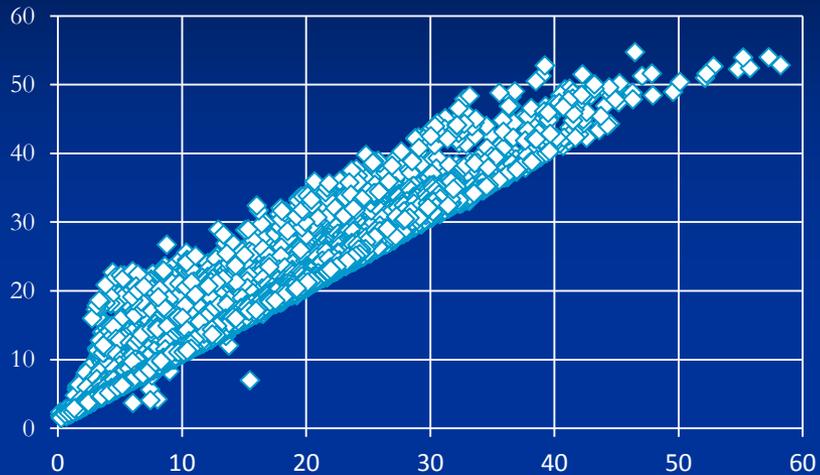
Third Quarter  
Jul 1 – Sep 30  
Summer

Fourth Quarter  
Oct 1 – Dec 31  
Fall

# WIND SPEED DATA - 2009



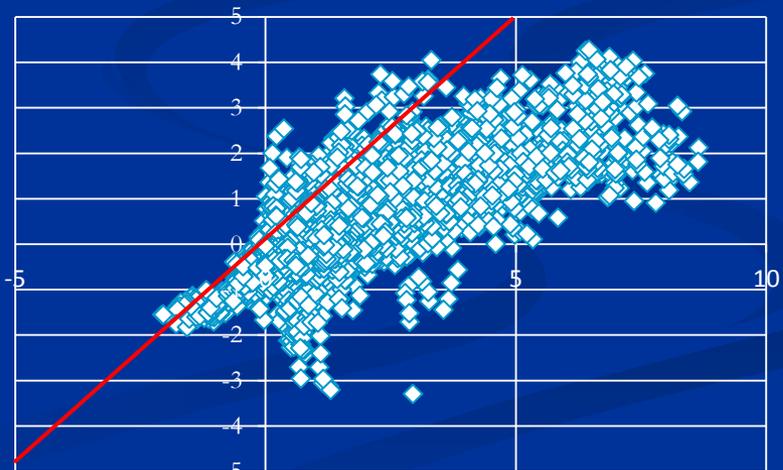
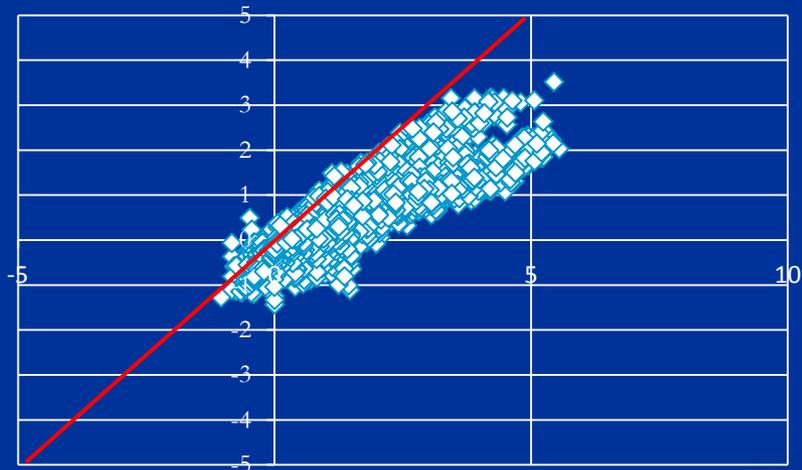
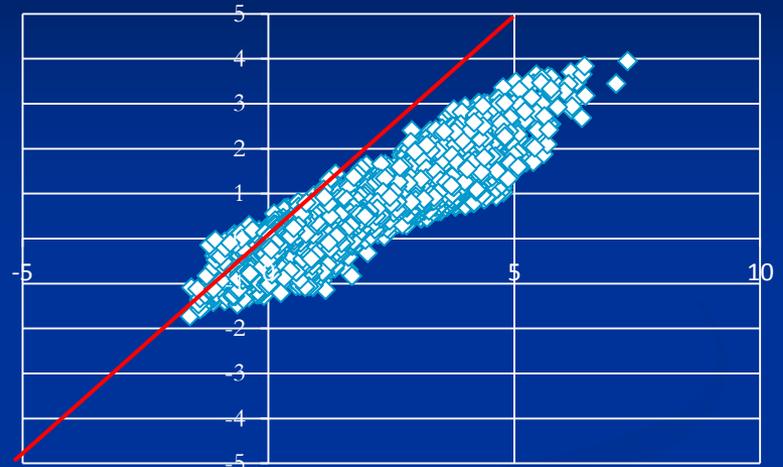
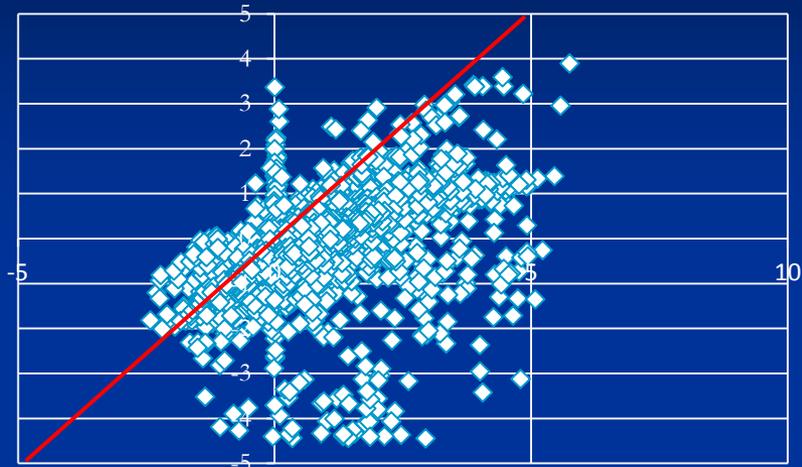
# WIND SPEED DATA - 2010



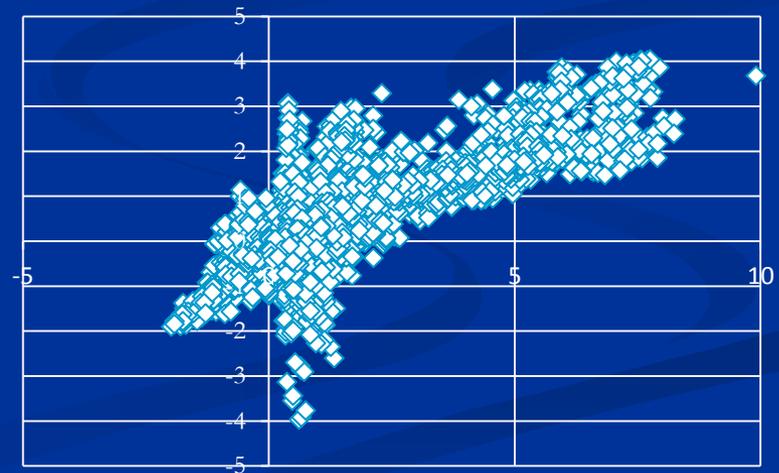
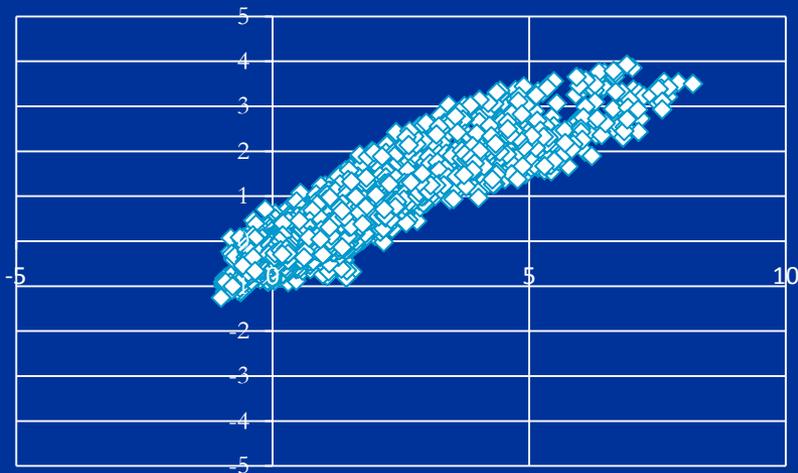
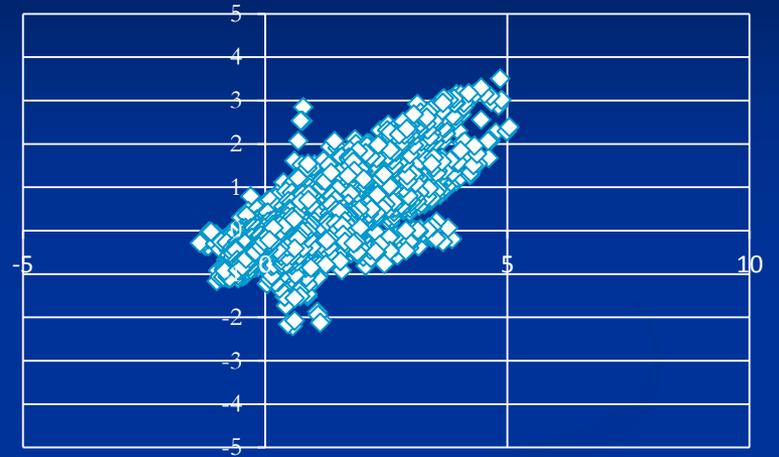
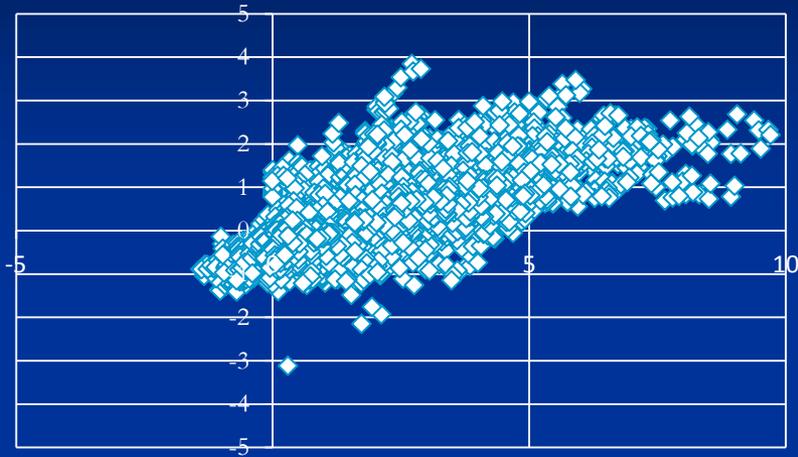
# WIND SPEED DATA

- In the warmer months, data agreement is great
- In the colder months, icing influences the propeller anemometer more frequently than the ultrasonic
- Periods of known sensor icing are removed from the data yet direct sensor comparisons reveal icing biased data
- Propeller “over speeding” not common
- Data disagreement slowly increasing with time, possible shifting in the ultrasonic anemometer
- Room for improvement in data processing

# VWS DATA - 2009



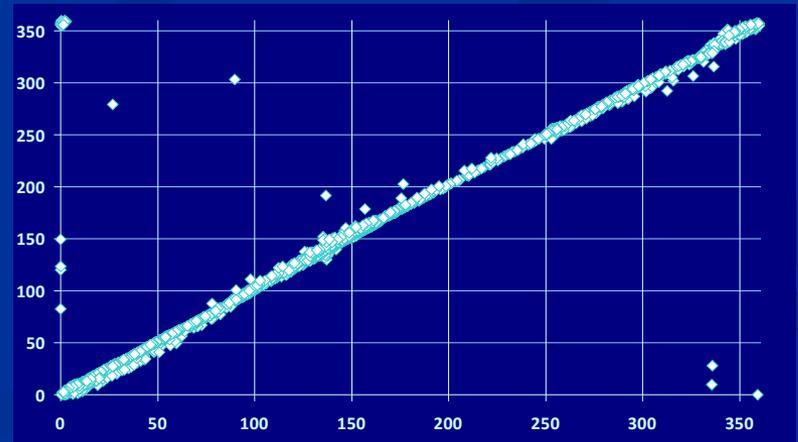
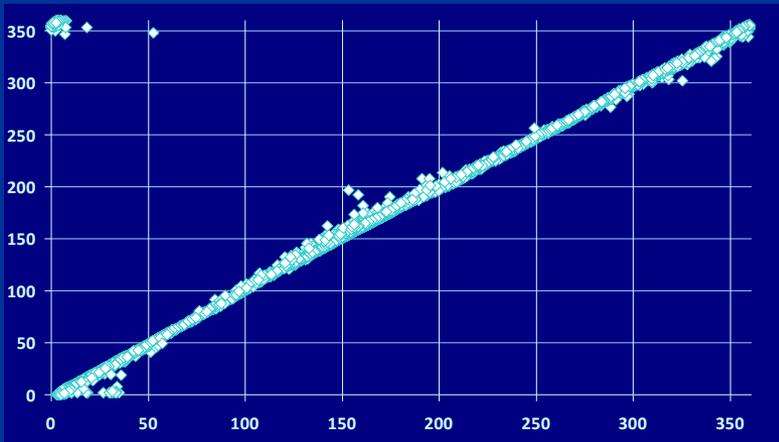
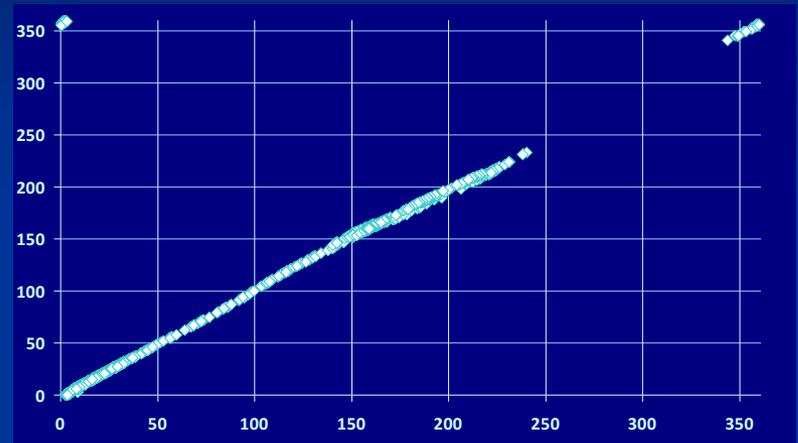
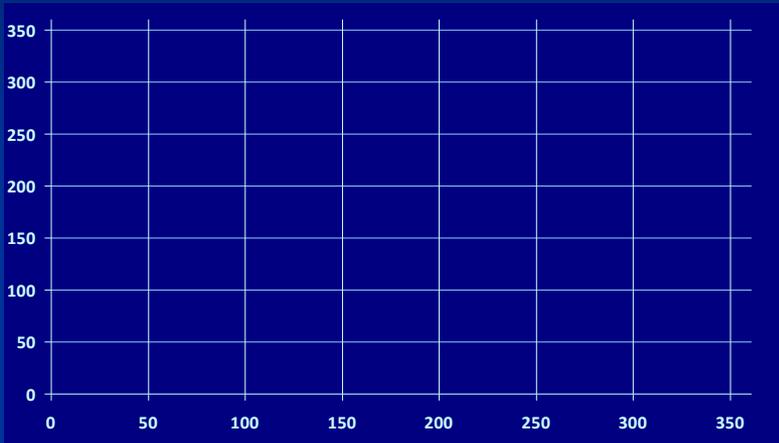
# VWS DATA - 2010



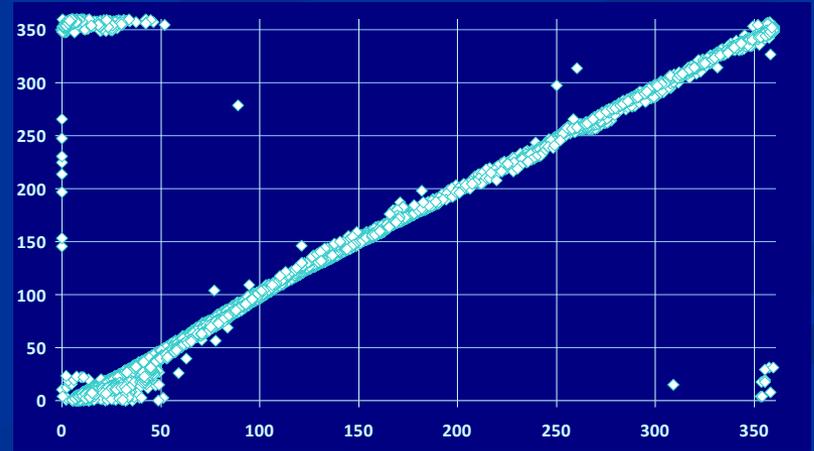
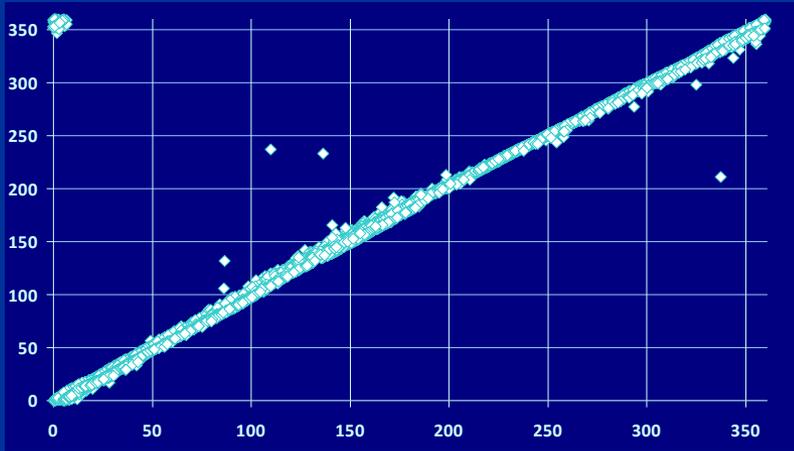
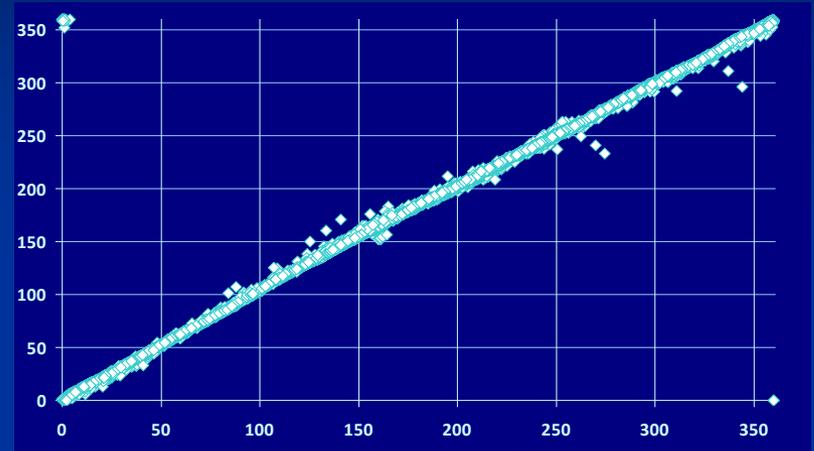
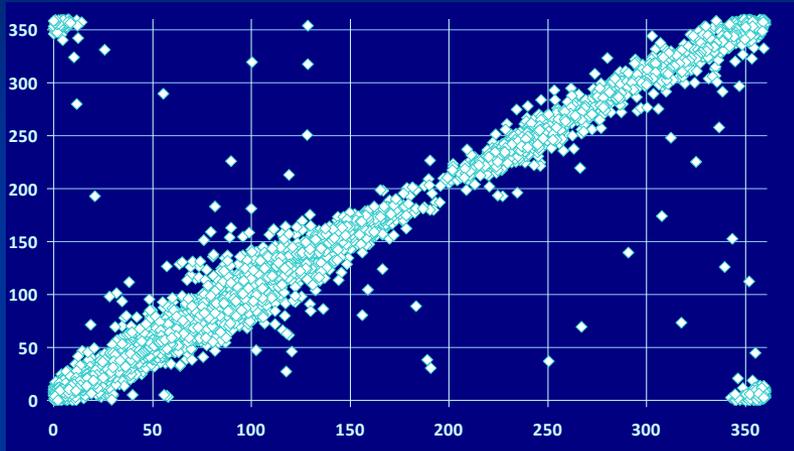
# VWS DATA

- Data agreement is better in the warmer months than the colder months
- Periods of known sensor icing are removed from the data yet direct sensor comparisons reveal icing biased data
- Propeller “over speeding” very common, due to ice and/or terrain
- Propeller anemometer measuring almost twice the wind speeds of the ultrasonic. Which is correct?

# WIND DIRECTION DATA - 2009



# WIND DIRECTION DATA - 2010



# WIND DIRECTION DATA

- Data agreement is better in the warmer months than the colder months
- Periods of known sensor icing are removed from the data; biases are not as common in wind direction as they are in wind speeds
- More “noise” in the data during colder months:
  - Ice build up reduces starting torques of the vane?
  - Ice on the vane causes overshooting of actual wind direction?

# CONCLUSIONS

- Problem: Sonic anemometer would have to meet standard anemometer requirements:
  - Sonic anemometer appeared to perform better at this site
- Problem: Significant upgrade to the remote power generation:
  - Completed with the addition of two 100W wind turbines
- Problem: Sonic anemometer would be compared to the prop and vane anemometer to show data validity:
  - In this extreme and abnormal environment, it appeared to perform better.
- Problem: EPA requires 90% data recovery over four quarters:
  - The ultrasonic anemometer allowed us to achieve that

# CONCLUSIONS

Year	Sonic	WS/WD	V <sub>ws</sub>
2007 <sup>1</sup>	--	88.3	75.8
2008	--	84.8	79.0
2009	90.7	29.3 <sup>2</sup>	79.8
2010	99.1	92.4	83.8
2011	93.0	66.2 <sup>2</sup>	72.1

1- Program started April 1, 2007

2- Semiannual Calibrations and Audits invalidated data

# CONCLUSIONS

- Reminder: this meteorological station is located in an extremely harsh environment
- Propeller and ultrasonic anemometer data recoveries could have been higher with better site access
  - Icing on wind turbines results in their self-destruction
  - Lack of power generation resulting in low battery voltage, no heat for ultrasonic
  - Not able to access site to perform maintenance for various reasons (weather, transport availability, daylight hours, etc)



# Any Questions?

