Analysis of Anti-Ice Coatings on Field Operational Anemometers

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THE PROBLEM

Freezing precipitation causes ice to accumulate on anemometers as the supercooled rain droplets freeze upon contact. The accumulated ice restricts the anemometer's ability to rotate and causes wind speed reports to be severely underestimated. This can be problematic in a number of industries...

Aviation

- Accurate wind measurements are critical for aircraft takeoff and landing safety.
- The Juneau Airport Wind System relies on the accuracy of seven anemometer sites and three wind profilers to warn pilots of turbulence (Cohn et al. 2004; Mueller et al. 2004).

Wind Energy

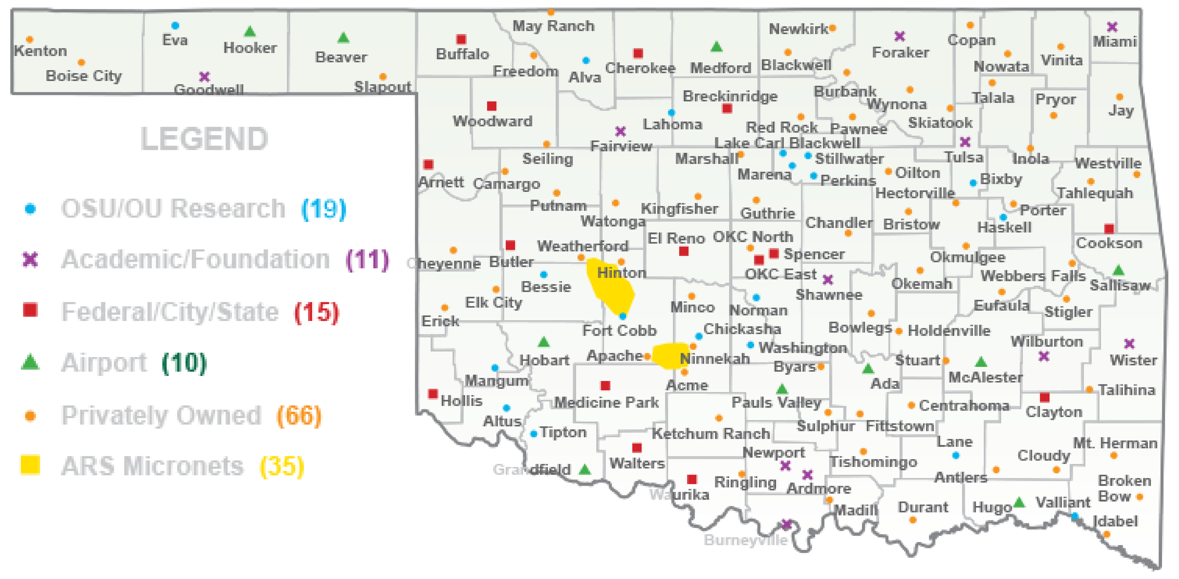
- Wind turbines depend on anemometer and wind vane readings.
- Energy production is reduced in icing conditions as wind turbines will not operate when the anemometer reports wind speeds of 0 m/s (Botta et al. 1998; Laakso et al. 2010).

Climatology

- Freezing rain can cause significant losses in wind data.
- The Oklahoma Mesonet lost 26 days, six hours, and 50 minutes of wind observations from 2006 to 2016 due to ice accumulation. Icing has been seen to affect ASOS stations as well (Ryerson and Ramsay 2007).

ABOUT THE OKLAHOMA MESONET

- A network of 121 observation stations across Oklahoma.
- 1.5-m air temperature
- 1.5-m relative humidity
- 10-m wind speed, gust, and direction
- 2-m wind speed
- Atmospheric pressure
- Rainfall
- Data are collected every five minutes, quality controlled, distributed, and archived.



THE ANTI-ICE TECHNOLOGIES

R.M. Young© Heavy Duty Wind Monitor — Alpine

- Covered with an 'ice-resistant' coat.
- Black for maximum absorption of heat.
- Specifications:
  - Accuracy: 1% or 0.3 m s^{-1}
  - Minimum Threshold: 1.0 m s^{-1}
  - Resolution: 0.1 m s^{-1}
  - Price: $1498.00

R.M. Young© Wind Monitor coated in NeverWet®

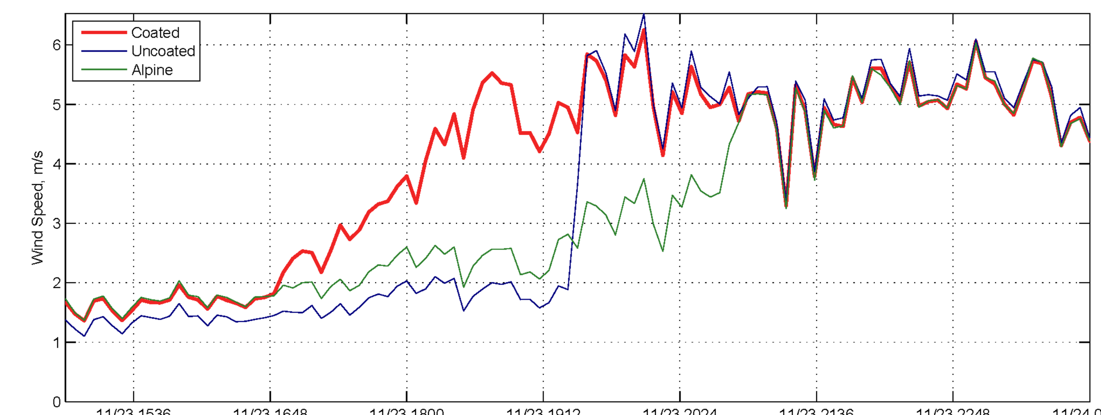
- Coated in NeverWet, a super-hydrophobic material, which is extremely water repellant.
- Specifications:
  - Accuracy: 1% or 0.3 m s^{-1}
  - Minimum Threshold: 1.0 m s^{-1}
  - Resolution: 0.1 m s^{-1}
  - Price: $998.00

Ideally, a superhydrophobic surface will repel a supercooled droplet before it is able to freeze to the surface (Cao et al. 2009).

FREEZING PRECIPITATION EVENTS

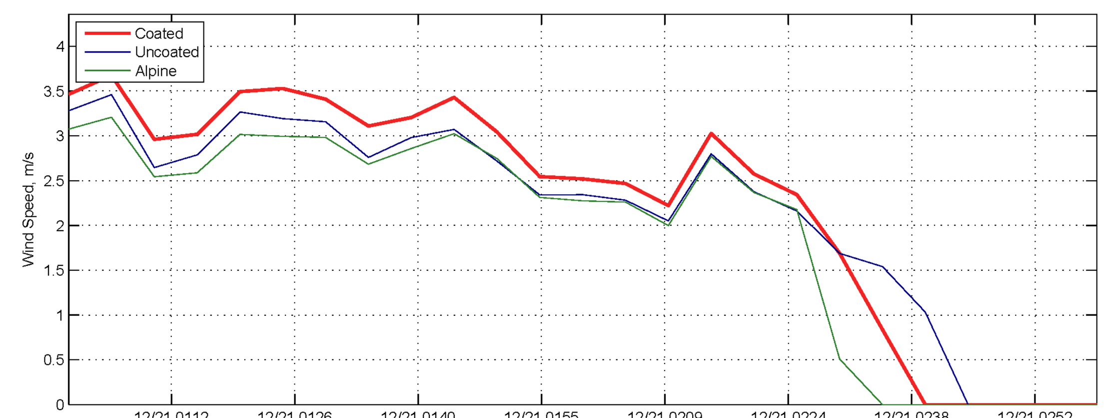
Between 19 Nov. 2013 and 30 Nov. 2015, six freezing precipitation events in Norman, OK were identified by the Oklahoma Mesonet. In these events, the "Alpine" and "coated" anemometers were compared with a standard "uncoated" R.M. Young© Wind Monitor. Differences greater than 0.6 m s^{-1} and unexplained drops to 0.0 m s^{-1} in the measured wind speeds were indicative of anemometer icing. Measured wind speeds under 1.3 m s^{-1} cannot be compared to suggest icing due to the anemometer's accuracy and minimum threshold.

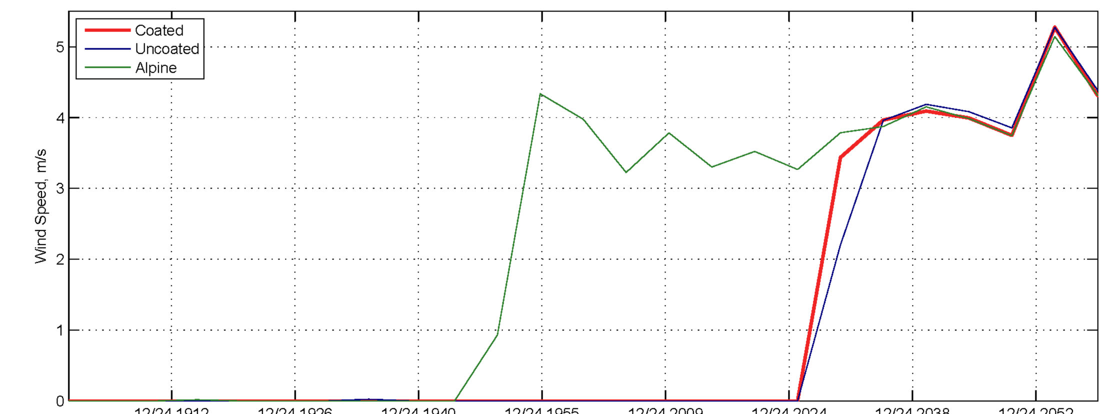
22 – 24 Nov. 2013



Top: Icing occurs. **Bottom:** Anemometers thaw.

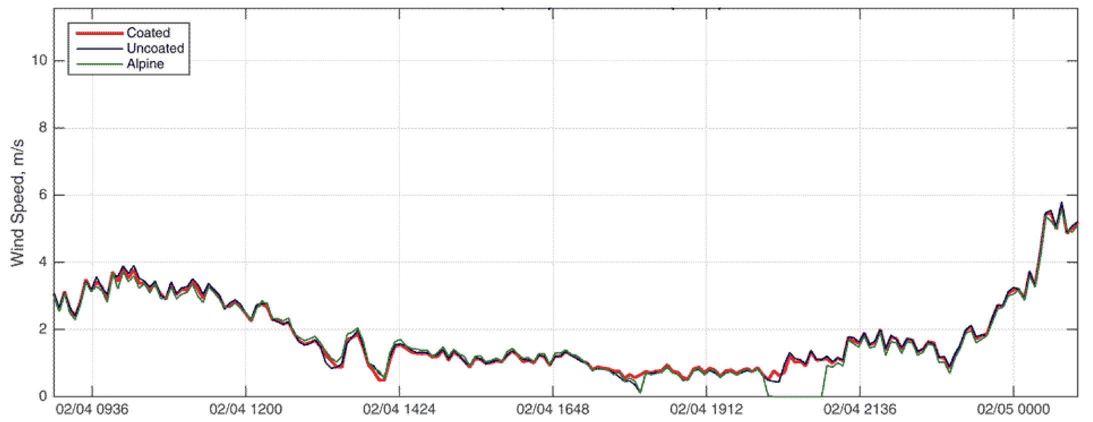
20 – 24 Dec. 2013



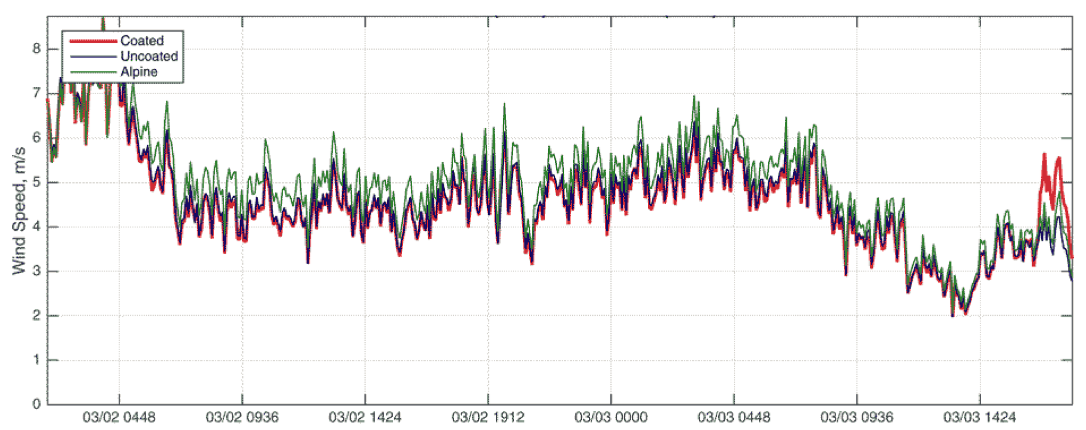


Top: Icing occurs. **Bottom:** Anemometers thaw.

4 – 5 Feb. 2014

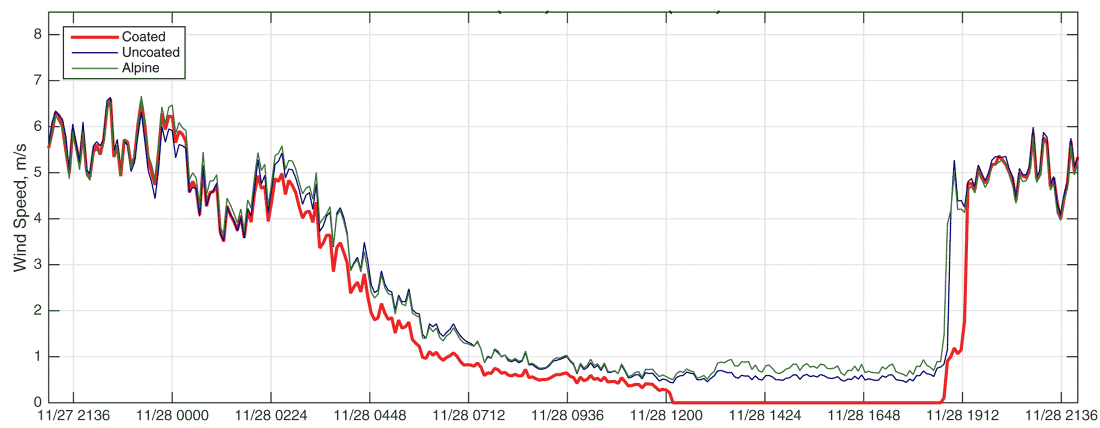


2 – 3 Mar. 2014



28 Feb. – 1 Mar. 2015

27 – 28 Nov. 2015



RESULTS

22 - 24 Nov. 2013

1900 - 2250 UTC on Nov. 22
- Measured wind speeds differ by more than 0.6 m s^{-1}.

1655 - 2050 UTC on Nov. 23
- Measured wind speeds differ by more than 0.6 m s^{-1}.
- Coated, uncoated, and Alpine anemometers appear to thaw at 1815, 1935, and 2055 UTC, respectively.

20 - 24 Dec. 2013

0230 UTC on Dec. 21 - 2035 UTC on Dec. 24
- Measured wind speeds differ by more than 0.6 m s^{-1}.
- The anemometers measure 0.0 m s^{-1} at 0245 UTC.
- Alpine, coated and uncoated anemometers appear to thaw at 1955, 2035, and 2035 UTC, respectively on Dec. 24.

4 - 5 Feb. 2014

2050 UTC on Feb. 4
- Measured wind speeds differ by more than 0.6 m s^{-1} when Alpine drops to zero.
- Measurements are below 1.3 m s^{-1} for the event.

2 - 3 Mar. 2014

0550 UTC on Mar. 2 - 0710 UTC on Mar. 3
- Measured wind speeds differ by more than 0.6 m s^{-1} intermittantly. Alpine anemometer reports higher values.

1645 - 1750 UTC on Mar. 3
- Measured wind speeds differ by more than 0.6 m s^{-1}. Coated anemometer reports higher values.

28 Feb. - 1 Mar. 2015

1800 UTC on Feb. 28 - 1940 UTC on Mar. 1
- Measured wind speeds do not differ during event.
- Wind speeds drop below 1.3 m s^{-1} for much of the event.

27 Nov. - 28 Nov. 2015

0400 - 0600 UTC on Nov. 28
- Measured wind speeds differ by more than 0.6 m s^{-1}. Coated anemometer reports lower wind speeds.

0730 - 1920 UTC on Nov. 28
- Wind speeds drop below 1.3 m s^{-1} for much of the event.
- Coated anemometer at 0.0 m s^{-1} from 1210 - 1845 UTC.
- Uncoated, Alpine, and coated anemometers appear to thaw at 1855, 1855, and 1920 UTC, respectively.

CONCLUSION

- **The Alpine anemometer appeared to perform better in two events, but worse in two events.**
- **The coated anemometer appeared to perform better in two events, but worse in one event.**
- **The coated and Alpine anemometers were not consistenly more accurate that the uncoated anemometer in these six case studies.**
- **The two anti-ice technologies were not found to be effective anti-ice technologies and their implementation would not help improve wintertime measurements in the Oklahoma Mesonet.**

References available upon request