1. Introduction

The ice free wind sensor (IFWS) Vaisala Model NWS425 was first installed on ASOS in late 2005 to replace the legacy Belfort Model 2000 cup & vane anemometer. The legacy sensor had a tendency to freeze during icing weather events, resulting in missing or incorrect reports and excessive, and potentially dangerous, maintenance actions. In 2007, numerous problems were being reported with the IFWS which resulted in missing and erroneous wind reports. Subsequent analysis revealed these errors were associated with erroneous 3-second wind gusts or completely missing wind data. Further analysis indicated that birds are the primary cause of these errors. Additional errors were observed during the 2007-08 winter season due to ice build-up on the IFWS. The build-up was the result of heater failure which was caused by either power failure at the site during ice storms or failure of the heater control circuitry in some units. When bird activity or ice build-up occurs, the symptom is similar: a blocked path resulting in missing or erroneous data. Erroneous data from path blockages are reported as bogus wind reports by ASOS sites equipped with the Vaisala NWS 425 sonic anemometer. Gust and peak wind reports are particularly at risk due to the length of time a gust candidate persists within the algorithm. Bogus wind gust observations in excess of 100 knots are not uncommon. While every effort should be made to prevent the physical causes of bad data, an algorithmic solution is necessary for those times when blockages are unavoidable (i.e., ice-up due to a power outage during an ice storm). A robust, yet simple algorithm has been developed and tested by OPS 22 that will evaluate the validity of individual 5 second samples and determine if they will be used in ASOS wind algorithms.

2. Methodology

The QC Algorithm evaluates each 5 second sample against 9 criteria. This attempts to remove bad data caused by a variety of factors: birds, ice-up, blowing debris in the sample volume such as leaves or needle grass, etc. Any sample that does not meet one or more of the criteria is recorded in the 14 hour achieve but is NOT used in any of the ASOS wind algorithms. The 9 criteria are as follows:

- Signal Quality must be greater than or equal to 79
- Pass/Fail flag from the sensor must be set to Pass
- WS5* cannot exceed WS3* by more than 1 knot
- If WS5 is greater than or equal to 12knots, then the difference between WD5* and WD3* cannot exceed 30 degrees
- If WS5 is greater than or equal to 12knots, then WS3 must not exceed 2.5X the instantaneous 2 minute average wind speed
- If WS5 is less than 12 knots, then WS3 must not exceed 30 knots
- Both WS3 and WS5 must not exceed 165
- If the 2minute average wind speed is less than or equal to 6 knots and WS3 exceeds 6 knots, then WS3 must not exceed 2.5X the instantaneous 2 minute average wind speed
- 3 second sample averaging time must equal 3 and the 5 second averaging time must equal 5

* WS5 = 5 second average wind speed, WD5 = 5 second average wind direction
WS3 = 3 second average wind speed, WD3 = 3 second average wind direction

<u>75% Rule:</u> In addition to the above criteria, once 7 out of 24 samples have failed to meet all of the above criteria every sample thereafter is treated as suspect. As such, they are also achieved but not used in any of the ASOS wind algorithms until there are 18 <u>consecutive</u> samples which meet all 8 criteria.

<u>Algorithm turned off in high winds:</u> Because of the limited amount of data collected and analyzed for high wind cases, the QC algorithm shall be suspended and the sample automatically passed whenever the instantaneous 2 minute average wind speed exceeds 35 knots.

3. Results

The OPS 22 Quality Control Algorithm has been tested against 4002.1 hours worth of raw IFWS data collected from a cadre of ASOS sites under a wide variety of meteorological conditions. Roughly half of the data was contaminated by either bird activity or ice build-up on the sensor head. The results of the testing are summarized in the table below. The algorithm caught nearly 97% of all of the bogus gusts while throwing out less than two tenths of a percent of the good data.

QC Algorithm Test Results	
Good Data Rejected	0.17%
Bogus 14 – 24 knot gusts caught	96.2%
Bogus 24 – 49 knot gusts caught	99.1%
Bogus 50+ knot gusts caught	100%
All bogus peaks caught (25+ kts)	99.2%
All bogus gusts caught (14+ kts)	96.9%

It is worth noting that not all rejected good data are equal. The vast majority of the good data rejected takes the form of a few ordinary samples that are wrongfully rejected or the 90 seconds worth of samples that are rejected while the system recovers from a bird episode or ice blockage. Data rejection of this type will have minimal operational impact. However, the algorithm may on occasion reject operationally significant data from high frequency fluctuations in the wind. A case in point was data collected from a severe thunderstorm which occurred at Topeka, Kansas on April 11, 2008. The QC Algorithm tagged a 53 knot wind gust produced by the thunderstorm as suspect, while allowing a subsequent 45 knot wind gust to pass. As a result, the peak wind report would have reported a peak wind of 45 knots instead of 53.

4. Summary and conclusions

The ice free wind sensor (IFWS) Vaisala Model NWS425 was installed to replace the legacy Belfort Model 2000 cup & vane anemometer. In 2007, numerous problems were being reported with the IFWS which resulted in missing and erroneous wind reports. Subsequent analysis revealed these errors were associated with birds landing on the sensor head and causing path blockages. Additional errors were observed during the 2007-08 winter season due to ice build-up on the IFWS. Erroneous data from path blockages are reported as bogus wind reports by ASOS sites equipped with the Vaisala NWS 425 sonic anemometer. Gust and peak wind reports are particularly at risk due to the length of time a gust candidate persists within the algorithm. OPS 22 developed a QC Algorithm which evaluates each 5 second sample against 8 criteria. Additional quality control is done based on the fraction of the most recent 18 samples that pass these 8 criteria. Any sample that does not meet one or more of the criteria is achieved but is NOT used in any of the ASOS wind algorithms. The algorithm has been tested against over 4000 hours of real world IFWS data collected from a cadre of sites under a wide variety of meteorological conditions. The algorithm caught nearly 97% of all of the bogus gusts while throwing out less than two tenths of one percent of the good data. Although the algorithm filters out the vast majority of the bogus reports, it will <u>not</u> improve the problem of missing data. Therefore, for best results it is recommended that the algorithm be used in conjunction with a hardware solution (such as a bird deterrent device) to reduce the initial causes of bad data. A combination hardware-software solution stands the best chance for significantly reducing missing and bogus wind data.