A CHARACTERIZATION OF WIND FLOW IN AND AROUND AN ALTER SHIELDED SNOWGAUGE

Scott D. Landolt, Matthew L. Tryhane, Roy M. Rasmussen, Jeffrey Cole

National Center for Atmospheric Research, Boulder, CO

1. INTRODUCTION

Single Alter shields are currently used with many snow gauges to improve their catch efficiency. Snow gauges using Alter shields require a correction factor to be applied for various wind speeds in order to obtain the true snowfall amount (Rasmussen et al., 2001). The higher the wind speed, the larger the correction factor that needs to be applied due to the larger under-collection of the gauge in the shield. Previous airflow measurements around Alter shields have been mainly conducted in wind tunnels. In order to characterize outdoor performance, an outdoor study was undertaken using 3-D sonic anemometers to measure the horizontal and vertical wind flows around Alter shields.

Four sonic anemometers were used for the study collecting data at a rate of 30 Hz. All four were setup in the free stream wind flow at 2 meters above ground for a period of several weeks to allow a tilt correction to be calculated (see discussion in section 2). Once the tilt corrections were calculated, two of the sonic anemometers were left in the free-stream wind (named FS1 and FS2). The third sonic anemometer had a single Alter shield built around it with the sensing heads at approximately the height of the top of the shield (named SS). The fourth had a single Alter shield built around it as well as a GEONOR snow gauge casing (named GS) (Fig. 1). The anemometer sensing heads were positioned just above the gauge orifice. While the GEONOR snow gauge design is not the optimal design for maximum collection efficiency (Goodison et al., 1998), it is one of the standard snow gauges used with single Alter shields. The sonic anemometers were then left to run till the end of the winter season (~mid May) collecting data during both precipitation and non-precipitation events. The characteristics of the wind flow and its likely impact on precipitation efficiency are presented here.

2. SONIC CALIBRATION AND TILT CORRECTION

While every effort was taken to ensure the sonic anemometers are level and oriented to true north, a tilt correction is still required to account for slight offsets in the leveling of the sonic anemometers. The raw sonic anemometer data was corrected using the Planar Fit (PF) Method (Wilczak et al., 2004). The PF Method corrects the raw data and orients the data with respect to a streamline coordinate system. This allows for the corrected vertical wind speed

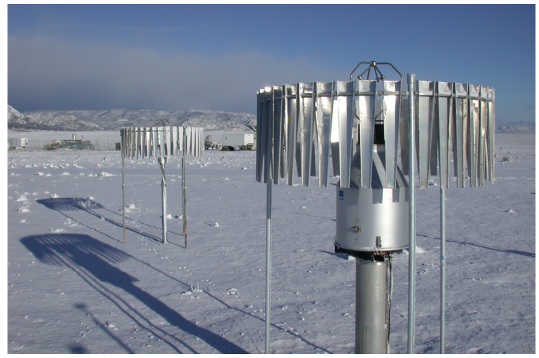

Figure 1 – View of the sonic anemometers inside the single Alter shields. The one in the foreground has the GEONOR casing inside.

component to be normal to the surface for which the horizontal wind speed is flowing over. It also allows for any vertical wind speed bias to be calculated and removed from the raw dataset. 15 minute averages were calculated for all three components of the wind during an initial three week training period. This averaged data was then used to calculate a set of adjustment coefficients needed for each wind component. It is important to note that the sensors cannot be moved or another tilt correction would need to be applied. These tilt corrections were then applied to data collected from the rest of the study period.

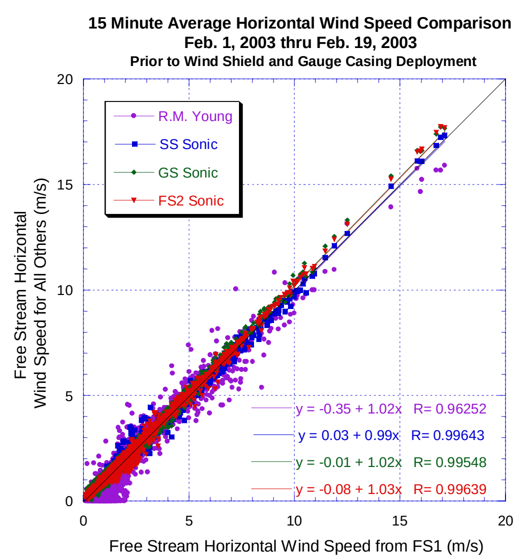

Figure 2 – Comparison of horizontal winds from all sonic anemometers before shields were installed.

3. INTERCOMPARISON

An intercomparison of all four sonic anemometers was done before any shields or gauge casings were installed to ensure all four sonic anemometers were properly calibrated. Fig. 2 shows 15 minute averaged horizontal wind speeds from FS1 compared against the other sonic anemometers as well as an R.M. Young anemometer that was deployed at the same height near the location of the sonic anemometers. Excellent agreement is shown between the sonic anemometers and the R.M. Young.

Once the wind shields and GEONOR casing were installed around the SS and GS sonic anemometers, two months of data was collected during both precipitation and non-precipitation events. Fig. 3 shows the comparison of FS1 versus the three other sonic anemometers for the months of March and April. FS1 and FS2 have a near perfect correlation. SS shows a dramatic reduction in horizontal wind speed (~75% for winds below 10 m/s and ~50% for winds at 15 m/s). GS shows a dramatic reduction in the lower wind speeds but at higher wind speeds (> 10m/s), the efficiency of the shield at reducing the wind drops off significantly.

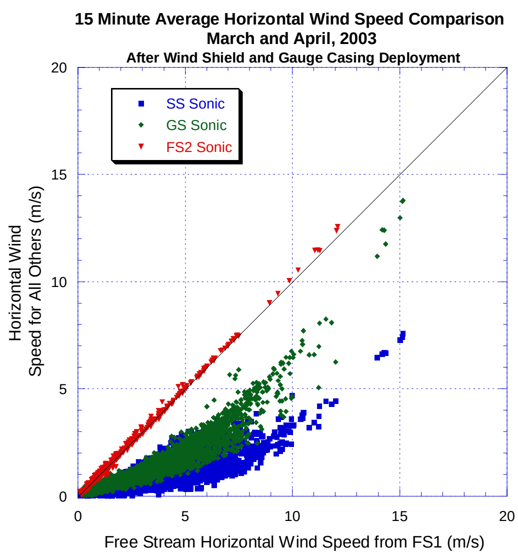

Figure 3 - Comparison of horizontal winds from all sonic anemometers after the wind shields and GEONOR casing were installed.

Vertical wind speed plays a crucial role in the collection efficiency of the gauge inside the shield. Fig. 4 shows the vertical wind speeds of both SS and GS as compared to the free-stream horizontal wind speed from FS1. For horizontal wind speeds less than 10 m/s, the vertical wind measurements ranged mostly from ± 0.5 m/s with increasingly negative (downward) vertical wind speeds. This occurred for horizontal wind speeds up to 10 m/s for both SS and GS. Once the horizontal winds reach greater than 10 m/s, SS and GS diverge with SS continuing to show stronger downward motion while GS exhibited a strong

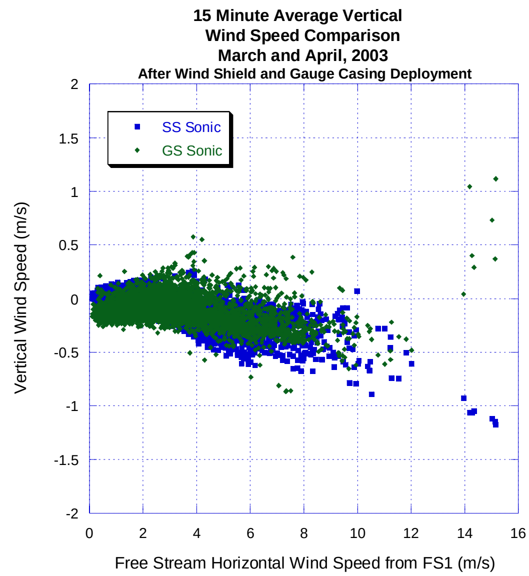

Figure 4 – Comparison of vertical wind speeds inside the shields versus the horizontal free stream wind.

positive (upward) motion. For horizontal wind speeds less than 10 m/s, the difference in the vertical wind speed for GS and SS remains ± 0.5 m/s (Fig. 5). For horizontal wind speeds greater than 10 m/s, the difference in the vertical wind speed for GS and SS increases dramatically to a point where a 15 m/s wind gives a greater than 1.5 m/s vertical wind speed difference.

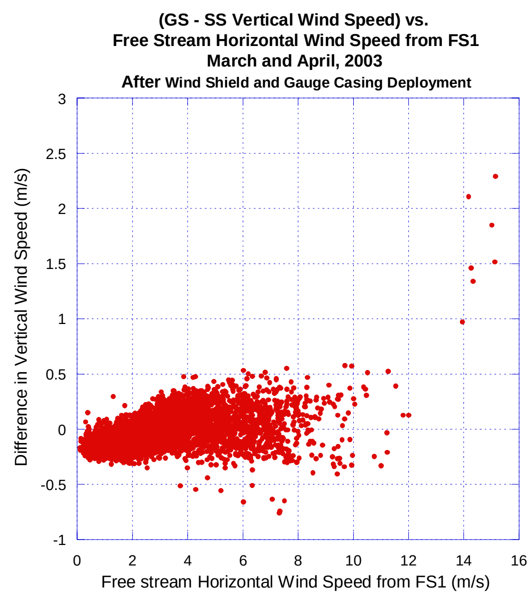

Figure 5 – Difference in vertical wind speed from shielded sonic anemometers versus the free stream horizontal wind.

Fig. 6 summarizes the range of vertical wind speeds measured by FS1, GS and SS. While FS1 shows little vertical bias, even at high wind speeds, GS shows a strong upward vertical tendency while SS shows a strong downward vertical tendency at wind speeds greater than 10 m/s.

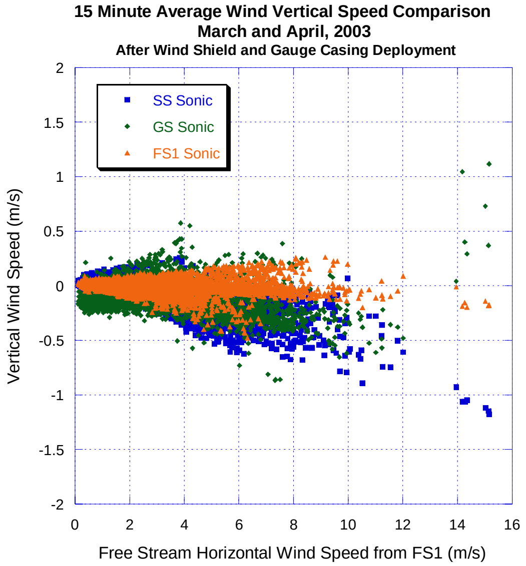

Figure 6 – Same as Figure 4 including the free stream sonic anemometer.

4. CONCLUSIONS

It is well documented that the collection efficiency of an Alter shielded GEONOR decreases with increasing horizontal wind speed (Rasmussen et al., 2001). The results above show that the single Alter shield by itself significantly decreases the horizontal wind speed and increases the downward vertical motion inside the shield. This result helps explain the process whereby a single Alter shield increases the collection efficiency for snow as compared to an unshielded snow gauge.

When a GEONOR snow gauge is placed inside the shield, the wind flow inside the shield is significantly modified for wind speeds over 10 m/s. Vertical wind speeds increase upward and horizontal wind speeds are decreased very little from the ambient flow. These upward motions are most likely the result of the airflow impacting the slanted sidewalls of the GEONOR due to the extreme upward deflection of the Alter shield slats during high winds (Fig. 7). At lower wind speeds, the configuration with the Alter shielded GEONOR changes the wind flow very little compared to flow in the single Alter shield. These results suggest that the Alter shielded GEONOR may significantly undercatch at high wind speeds due to the presence of an updraft preventing snow from falling into the collection bucket. These results help explain recent measurements at Denver International Airport (DIA) where zero snow amounts were collected for wind speeds greater than 10 m/s despite the observation of snow.

Figure 7 – The deflection of the single Alter slats during a high wind event.

Acknowledgements: This research is in responses to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy of the FAA.

5. REFERENCES

Goodison, B.E., Louie, P.Y.T., and Yang D. 1998: WMO Solid Precipitation Measurement Intercomparison, Final Report. *Instruments and Observing Methods, Report No. 67.*WMO/TD – No. 872.

Rasmussen, R., Dixon, M., Hage, F., Cole, J., Wade, C., Tuttle, J., McGettigan, S., Carty, T., Stevenson, L., Fellner, W., Knight, S., Karplus, E., Rehak, N., 2001: Weather Support to Deicing Decision Making (WSDDM): A Winter Weather Nowcasting System. *Bulletin of the AMS*, Vol 82., No.4. 579-595.

Wilczak, J.M., Oncley, S.P., Stage, S.A., 2001: Sonic Anemometer Tilt Correction Algorithms. *Boundary Layer Meteorology*, 99, 127-150.