Evaluation of Two Ultrasonic Snow Depth Sensor for National Weather Service Automated Surface Observing System Sites

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Introduction

In the late 1980's the National Weather Service (NWS) deployed the Automated Surface Observing System (ASOS) at airport locations. The introduction of automated sensors for measuring surface conditions eventually led to the abandonment of snow measurements because there was no automated alternative for measuring snow. The NWS is now exploring the possibility of installing ultrasonic snow depth sensors at ASOS sites. This study will compare 2 different sensors as well as manual and automated data. The final product will be an algorithm that will derive traditionally measured 6 hour snowfall from the constant snow depth measured by the sensors. The algorithm will need to take into account melting, compaction and spatial variability. These sensors will be installed at locations where humans will not be taking side by side measurements and the need for a reliable algorithm to extract traditional measurements is very important to the integrity of the historic data record.

Sensors

The two sensors that are being tested are the Judd Communications sensor which costs around $500 and the Campbell Scientific sensor which costs around $1000. The Campbell sensor also has extra costs associated with needing a temperature sensor to correct for the speed of sound in air which is included with the Judd Communications sensor. The photo on the left is the Judd Communications sensor, the photo on the right is the Campbell Scientific sensor.

Figure 1: The Judd Communications Sensor (left) and the Campbell Scientific Sensor (top right)

Data and Methods

Manual and automated data from the Judd sensor was collected during the 2003-2004 snow season from 3 sites: Fort Collins, CO, Stove Prairie, CO and New Brunswick, OH. For the 2004-2005 season there will be a total of 15 sites testing both sensors and making 6 and 24 hour manual measurements of snowfall, snow depth, snow water equivalent and gage precipitation. Additional manual measurements include snow crystal type, wind speed, presence of blowing snow etc. The locations of all the stations are shown below.

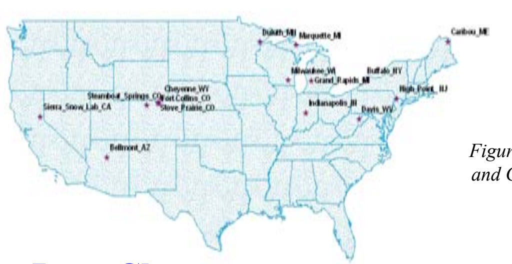

Figure 2: Site Locations Testing the Judd and Campbell Snow Depth Sensors along with Manual Observations.

Data Clean-up

The following steps were taken to smooth the raw data:

1) Change negative readings to zero.
2) If the time step observation was greater than the maximum manual observed snow depth +10, the data was flagged and reported as missing. The addition of 10 was picked after testing different values, +10 gave the most reasonable number of missing values.
3) If the change from t to t+1 was greater than + 0.5" or less than –0.5" (over 5 minutes), the time step was flagged and reported as missing.
4) A 15 period moving average trend line was computed to make a smooth line of snow depth.

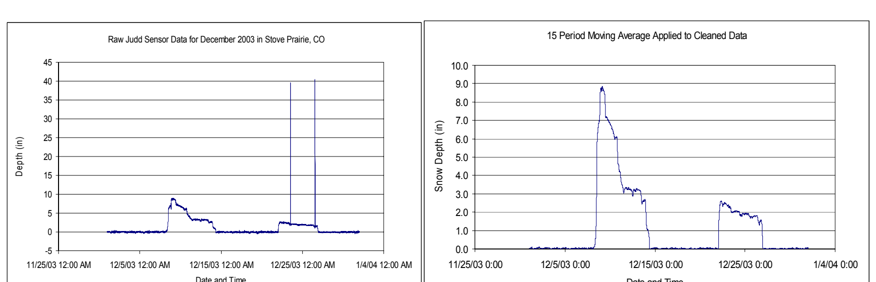

Figure 3: Raw Data Comparison to Cleaned Data with a 15 Period Moving Average.

Manual and Automated Data Comparison

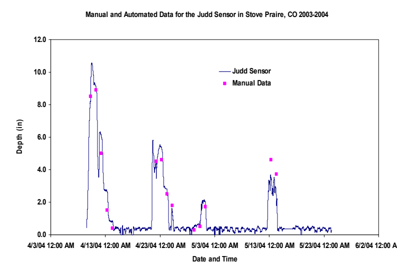

Figure 4: Manual Data and Automated Judd Sensor Data from 3 Storm Events in Stove Prairie, CO.

Figure 4 shows that the manual measurements of snow depth near the sensor and the actual measurement by the sensor seem to be reasonably accurate.

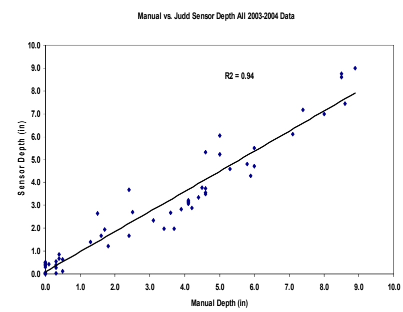

Figure 5: Manual Total Depth vs. Judd Sensor Total Depth with an R^2 value of 0.94 which suggests the sensor is doing a fairly good job of representing what is occurring at this particular site.

Figure 5 shows that when manual snow depth and automated snow depth are plotted against each other, the linear regression yields an R^2 value of 0.94. This suggests that the sensor is accurately representing the total depth of snow on the ground.

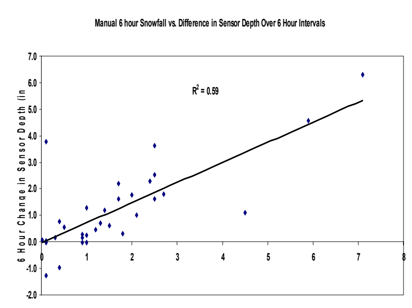

Figure 6: Manual 6 Hour Snowfall Measurements vs. 6 Hour Change in Sensor Depth (in).

Figure 6 is the linear regression of 6 hour manual snowfall measurements plotted against the difference in the sensor reading over the same 6 hour period. This regression yields an R^2 value of 0.59. This suggests that there are other factors that should be taken into consideration when trying to accurately represent the 6 hour snowfall from the sensor snow depth.

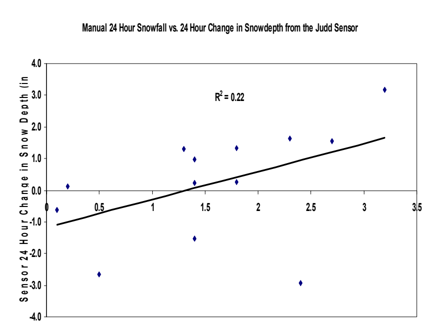

Figure 7: Manual 24 Hour Snowfall Measurements vs. 24 Hour Change in Sensor Depth (in).

Figure 7 shows the linear regression for the 24 hour snowfall manual measurement on the 24 hour difference in the sensor snow depth reading. The regression yields an R^2 value of 0.22, this suggests that there is too much variability over the 24 hour period to accurately represent the 24 hour snowfall.

Sensor Comparison

References

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