Equipment Accuracy Standards and Calibrations for AGCI's interactive Roaring Fork Observation Network

Jan. 14, 2019

The following table (Table 1) includes manufacturer standards for accuracy for equipment used at iRON stations, excepting soil moisture sensors which are listed in Table 2 (next page). Standards in Table 1 were retrieved from manufacturer websites and equipment manuals and have not been tested in-lab by AGCI.

Table 1

Equipment Type	Manufacturer	Accuracy
6 in diameter tipping-bucket rain gauge RG3	Onset Computer Corporation	(+/-) 1.0% (up to 1 in/hour)
12-bit temperature/relative humidity smart sensor S-THB-M002	Onset Computer Corporation	*Temp:* (+/-) 0.21°C from 0° to 50°C (0.38°F from 32° to 122°F) *RH:* (+/-) 2.5% from 10% to 90% RH (typical), to a maximum of (+/-) 3.5% including hysteresis at 25°C (77°F); below 10% and above 90% (+/-)5% typical
12-bit temperature smart sensor (used for soil temperature) S-TMB-M006	Onset Computer Corporation	<(+/-) 0.2°C from 0° to 50°C (<(+/-)0.36°F from 32° to 122°F)
ultrasonic depth sensor (used for snow depth) For Use with Hobo RX3000 Logger	Judd Communications	(+/-) 1 cm or 0.4 % distance to target (0.4% distances by station: Northstar Transition Zone Northstar (+/-) 0.74cm; Independence Pass (+/-) 1.19cm)

Access to equipment manuals used to determine product accuracy are listed below in the order in which equipment appears in the table.
1. 6 in diameter tipping-bucket rain gauge (RG3). (Onset) https://www.onsetcomp.com/files/manual_pdfs/10241-M%20MAN-RG3%20and%20RG3-M.pdf
2. 12-bit temperature/relative humidity smart sensor (S-THB-M002): (Onset) https://www.onsetcomp.com/files/15932-B-Testing-Sensirion-RH-Sensors-White-Paper.pdf
3. 12-bit temperature smart sensor (used for soil temperature) (S-TMB-M006): (Onset) https://www.onsetcomp.com/files/manual_pdfs/7105-O%20S-TMB%20Manual.pdf
4. Ultrasonic depth sensor (for use with RX3000 logger) (Judd Communications): https://www.onsetcomp.com/files/19212-C%20Using%20Judd%20Sensor%20with%20RX3000%20Station.pdf

The EC-5 and 10HS sensors were gravimetrically calibrated in-lab by taking sensor readings of soil moisture after recorded volumes water were mixed into a known volume of soil collected from each site. A regression equation was developed for each depth and station to relate sensor readings to actual soil moisture volumes. Root mean squared error (RMSE) was calculated based on the observed soil moisture volume and soil moisture predicted by the regression equations. RMSE ranged from 0.01 m^3/m^3 (at Northstar Transition Zone, 20 cm depth) to 0.09 m^3/m^3 (Northstar Transition Zone, 50 cm depth) with an overall average RMSE of 0.03. Generally, measurements in loam soils had lower RSME values, while those in sandier soils had higher values. In the available literature, calibration results for the Decagon sensors were within +/– 0.02 m^3/m^3 to 0.05 m^3/m^3 accuracy of soil moisture for most soil mineral compositions in laboratory settings (Kizito et al., 2008). In-lab calibrations for iRON yielded similar results (Osenga, 2018).

The following table displays calibration equations applied to decagon 10-HS and EC-5 sensors by station location and soil depth. Rather than using manufacturer standards for the Decagon 10-HS and EC-5 sensors, soil moisture sensor calibrations were carried out in-lab by AGCI using soil samples from each station. For 20cm and 50cm depths where soil type remained constant, 10-HS sensors were not calibrated separately for each depth, and RMSE values are therefore the same.

Table 2

Station Name, ID	RMSE (m^3/m^3): EC-5 Decagon (5cm depth)	RMSE (m^3/m^3): 10-HS Decagon (20cm depth)	RMSE (m^3/m^3): 10-HS Decagon (50cm depth)	RMSE (m^3/m^3): 10-HS Decagon (100cm depth)
Sky Mtn, 1	0.024	0.027	0.027	N/A
Smuggler Mtn, 2	0.022	0.012	0.012	N/A
Glassier Ranch, 3	0.021	0.072	0.072	0.072
Brush Creek, 4 (a & b sensors)	0.031	0.036	0.036	N/A
Glenwood Springs, 5	0.032	0.018	0.018	N/A
Northstar Aspen Grove, 6	0.019	0.028	0.028	N/A
Northstar Transition Zone, 7	0.028	0.010	0.087	N/A
Spring Valley, 8 (a & b sensors)	0.051	0.044	0.044	N/A
Independence Pass, 9	0.013	0.019	0.019	N/A

The above table summarizes in lab RMSE results for in-lab calibration carried out with site and depth specific soil samples for Decagon EC5 and 10HS soil moisture sensors in use with Onset Hoboware RX3000 or RXU30 logger boxes. (In-lab tests showed no difference in results as a consequence of logger box model.)

References

Kizito, F., Campbell, C. S., Campbell, G. S., Cobos, D. R., Teare, B. L., Carter, B., & Hopmans, J. W. (2008). Frequency, electrical conductivity and temperature analysis of a low-cost capacitance soil moisture sensor. *Journal of Hydrology*, *352*(3–4), 367–378. doi:10.1016/j.jhydrol.2008.01.021

Osenga, E. C. (2018). iRON Methods Used for Calibration of Decagon 10HS, EC5 Soil Moisture Probes (Version 1). Zenodo. Retreived from https://doi.org/10.5281/zenodo.1294073