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Snowpack (snow water equivalent) monitoring

Snow is the major source of water for human society impacting: drinking water, agriculture, energy, and manufacturing. In the western United States 85% of our fresh water comes from snowpack. Winter snowpack has been deviating from historical norms, with regions experiencing both record high and record low snowpack. For example, during the 2017/2018 winter snowpack monitoring stations in Montana and Wyoming saw more than 130% of the 1981 to 2010 mean snowpack; while stations in Utah, and Colorado saw less than 60% of the mean snowpack. The need to understand these changes has created a call for expanded snowpack monitoring networks, both at the national, state, and local level. Understanding the water stored in snowpack requires understanding of a parameter called snow water equivalence (SWE). Most automated SWE monitoring relies on snow pillows, ten-foot rubber bladders filled with ~150 gallons of antifreeze used to weigh the snow. The cost of installing and maintaining these sensors and their associated environmental impact is a hinderance to the needed for network expansion. This creates a need for a dramatically new type of sensor with both a lower economics cost and lower environmental cost.

Development of a new sensor

In response to this need NWB Sensors is developing the Snomonstor™, a new fully electronic fluid-less snowpack measurement technology targeting the replacement of antifreeze filled snow-pillows in snowpack measurement networks. This system enables measurement of snow depth, density, liquid water content (LWC), and SWE. The ability to measure these four snow parameters with a single sensor is unprecedented in the current market. Currently to measure all four of these parameters requires a suite of sensors. Alternatively, parameters such a SWE and depth are measured, and other parameters such as LWC are modeled. This reliance on models can lead to uncertainty in water availability, stream flow runoff, and potentially associated flooding.

This work is supported by Small Business Innovation Research Program (SBIR) grant no. 2016-33610-25361 from the USDA National Institute of Food and Agriculture[1]. The Montana SBIR/STTR Matching Funds Program provided additional support. The support enabled NWB Sensors to build prototype snow sensors, deploy them at two USDA Natural Resource Conservation Service operated Snow Telemetry (SNOTEL) sites, collect experimental data, and used these data to develop algorithms that derived snow parameters. Figure 1 shows the Snomonstor installed at the West Yellowstone SNOTEL site during the 2016/2017 winter. Figure 2 shows the SWE derived by the SNOTEL snow pillow and the Snomonstor. Agreement with an adjacent snow pillow was within ±7mm of SWE during both acculturation and ablation. This is well below the error of the snow pillow itself. While LWC is not measured at this site,

[1] Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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derived LWC data compared well to published studies and showed daily melt-freeze cycles. Modeling suggest LWC can be derived accurately to 0.1%.

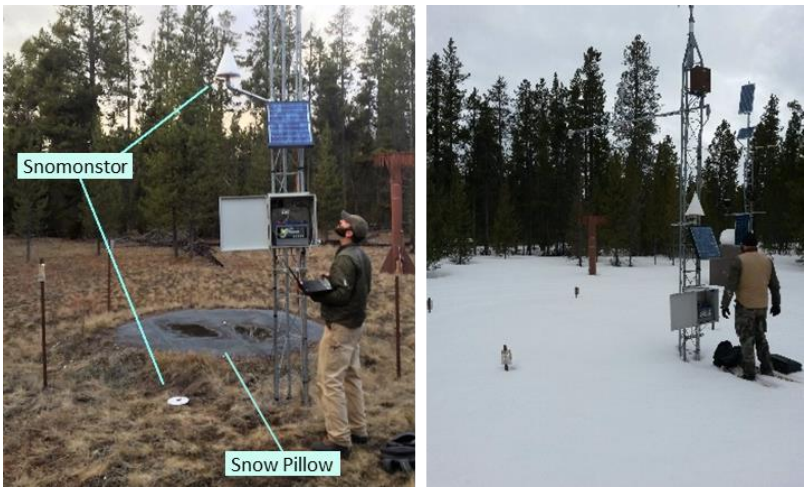

Figure 1. Prototype Snomonstor deployed at West Yellowstone SNOTEL site. The gray rubber bladder of the snow-pillow can be seen next to the Snomonstor antennas in the left image.

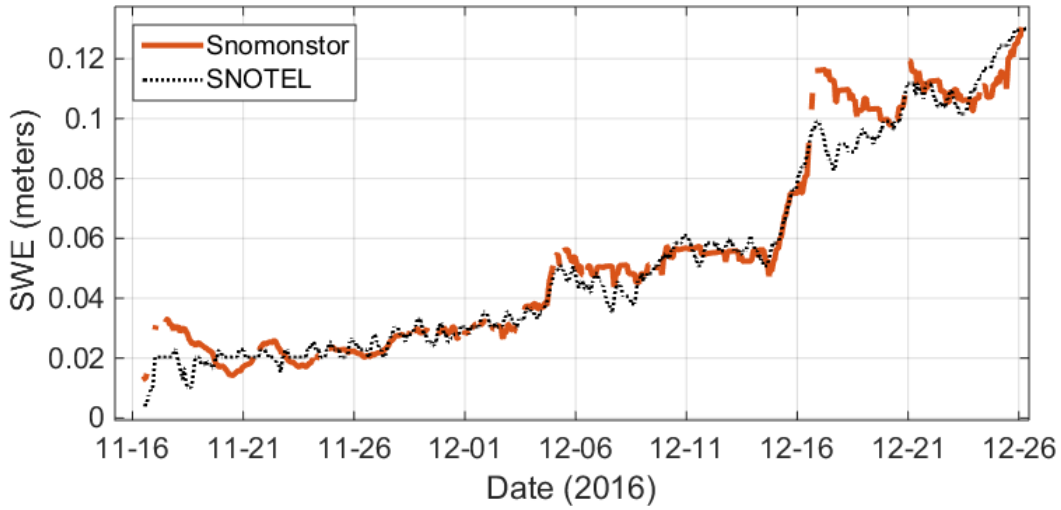

Figure 2. SWE data from the SNOTEL snow pillow and the Snomontor deployed at West Yellowstone SNOTEL site.

Compared to snow pillows the Snomonstor will have significantly lower cost of ownership, a much smaller footprint, and provide a full set of snow parameters. This will reduce costs in automated snow monitoring networks by replacing snow pillows, snow scales, and manual sample sites. Our sensors have the potential to broadly enable snowpack measurement at weather installations, including prairie locations where snowpack currently goes largely un-quantified. The Snomonstor will increase snowpack data quality and quantity.