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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 municipalities. In the western United States 85% of our fresh water comes from snowpack. Winter snowpack has been deviating from historical norms, with both record high and record low snowpack. During the 2017/2018 winter snowpack monitoring stations in Montana and Wyoming saw more than 200% of the 1981 to 2010 mean while stations only a few hundred miles away in Idaho, Utah, and Colorado saw less than 50% of the annual snowpack. The need to understand these changes there has created a call for expanded snowpack monitoring networks, both at the national, state, and local level. Understanding the water stored in snowpack required 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 mix used to weigh the snow. The cost of installing and maintaining these sensors at 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 stream flow runoff and potentially associated flooding.

With funding provided by a United States Department of Agriculture (USDA) small business innovative research grant and matching funds from the State of Montana, NWB Sensors built a prototype of our snow sensors, deployed it at two USDA operated Snow Telemetry (SNOTEL) sites, collected 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 ant 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, derived LWC data compared reasonably to published studies and showed daily melt-freeze cycles. Modeling suggest LWC can be derived accurately to 0.1%.

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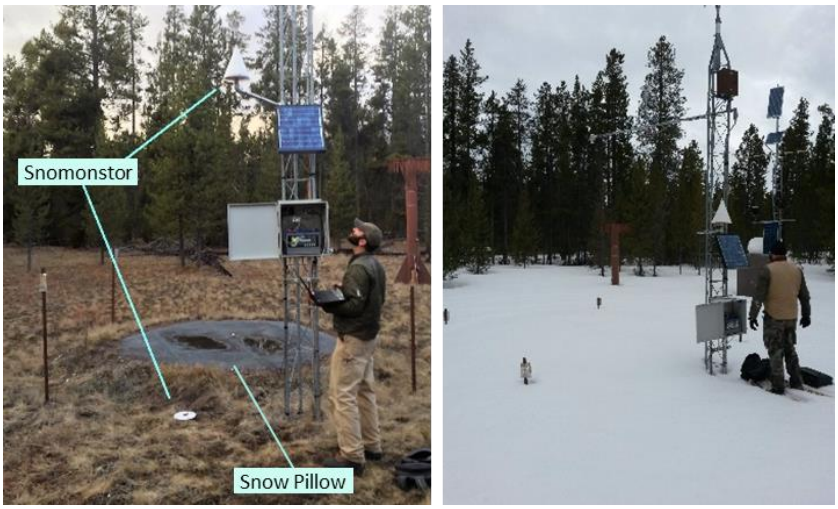

Figure 1. Prototype Snomonstor deployed at West Yellowstone SNOTEL site. The gray rubber bladder of the snow-pillow can be seen next to the Snomonstor in the left image.

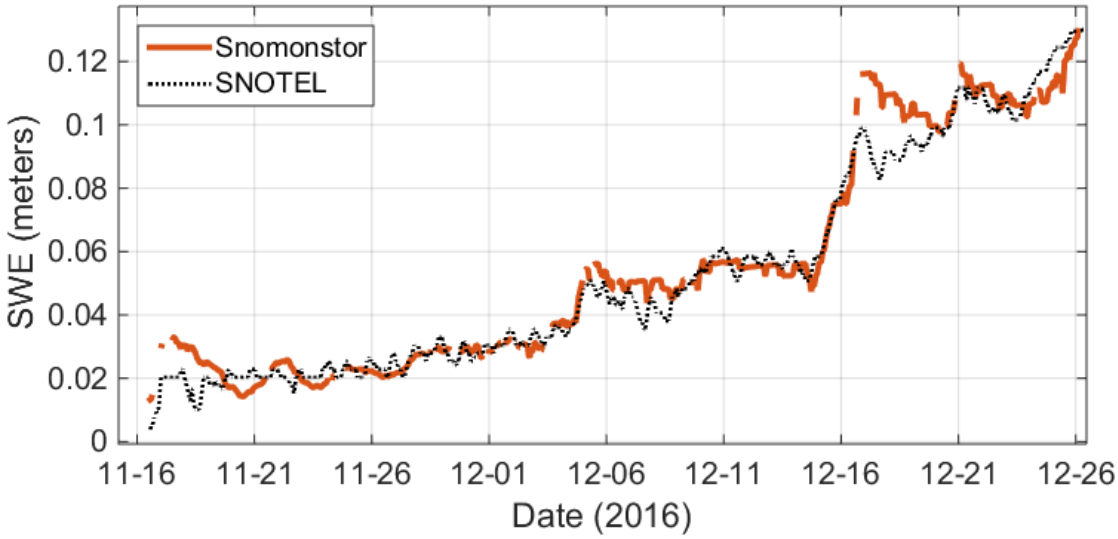

Figure 2. SWE data from the SNOTEL snow pillow and the Snomonstor deployed at West Yellowstone SNOTEL site.

Compared to snow pillows the Snomonstor will have significantly lower cost of ownership, a smaller footprint of approximately one foot, 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. SNOTEL and similar snow monitoring networks our sensors have the potential to broadly enable snowpack measurement at weather installations, in particular at prairie locations where snowpack currently goes largely un-quantified. The Snomonstor overcomes barriers to automating manual sites, enables replacement of manual sampling with automated sensors, and will increase snowpack data quality and quantity.