Estimation of snow SWE using passive RFID tags as radar reflectors

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Passive radio-frequency identification (RFID) tags are used massively to remotely identify industrial goods, and their capabilities offer new ways to monitor the earth's surface, already applied to coarse sediments, landslides, rock fissures and soils (see review of Le Breton et al., 2021). We introduce a method to estimate the variations in snow water equivalent (SWE) of a snowpack using an 865–868 MHz RFID system based on commercial off-the-shelf devices. The system consists of a vertical profile of low-cost passive tags installed before the first snowfall, on a structure that is minimally disruptive to the snowpack. The tags are interrogated continuously and remotely by a fixed reader located above the snow. When adding new layers of fresh snow, the phase delay of the communication signal between the reader and the tag increases linearly with the variation of SWE. The method is tested both in a controlled laboratory environment, and outdoors on the Col de Porte observation site, in order to cross-check the results with a well-documented reference dataset (Lejeune et al., 2019). The experiments demonstrate that SWE can be estimated by this non-contact and non-destructive RFID technique. However, multipath interferences in the snowpack can generate errors up to 40 mm of SWE. This error is mitigated by using multiple tags and antennas placed at different locations, allowing the RFID measurements to remain within +/-10% of the cumulated precipitations (outdoor) and snow weighting (laboratory). In complement, the system can also estimate whether the snow is wet or dry, using temperature sensors embedded in the tags combined with the received signal strength. Using this approach with a mobile reader could allow the non-destructive monitoring of snow properties with a large number of low-cost, passive sensing tags.

Le Breton, M., Liébault, F., Baillet, L., Charléty, A., Larose, É., Tedjini, S., 2021. Dense and long-term monitoring of Earth surface processes with passive RFID -- a review.