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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 (Le Breton et al., 2910, 2020, 2021b). 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. The key measured value is the increase of phase delay, induced by the new layers of fresh snow which slow down the propagation of the waves. 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.

Publications related to the project:

Le Breton, M., Baillet, L., Larose, E., Rey, E., Benech, P., Jongmans, D., Guyoton, F., Jaboyedoff, M., 2019. Passive radio-frequency identification ranging, a dense and weather-robust technique for landslide displacement monitoring. Eng. Geol. 250, 1–10. http://doi.org/10.1016/j.enggeo.2018.12.027

Le Breton, M., Grunbaum, N., Baillet, L., Larose, É., 2021a. Monitoring rock displacement threshold with 1-bit sensing passive RFID tag (No. EGU21-15305). Presented at the EGU21, Copernicus Meetings. http://doi.org/10.5194/egusphere-egu21-15305

Le Breton, M., Liébault, F., Baillet, L., Charléty, A., Larose, É., Tedjini, S., 2021b. Dense and long-term monitoring of Earth surface processes with passive RFID -- a review. Submitted. Preprint at: https://arxiv.org/abs/2112.11965v1

Lejeune, Y., Dumont, M., Panel, J.-M., Lafaysse, M., Lapalus, P., Le Gac, E., Lesaffre, B., Morin, S., 2019. 57 years (1960–2017) of snow and meteorological observations from a mid-altitude mountain site (Col de Porte, France, 1325 m of altitude). Earth Syst. Sci. Data 11, 71–88. http://doi.org/10.5194/essd-11-71-2019