Large-footprint evaluation of Soil Moisture and Snow-Water Equivalent by a single Finapp Cosmic-Ray Neutron sensor

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As droughts periods and extreme weather events become more frequent, it is of paramount importance to expand the ability to monitor water-related environmental parameters like Soil Moisture (SM) and Snow-Water Equivalent (SWE). Cosmic Ray Neutron Sensing (CRNS) is bridging the scale gaps that result from existing technologies: namely point-scale measurements, that are hardly representative of large areas, and space-borne remote sensing, that is hardly representative of the in-depth variability of snow layers or the water content in soil.

CRNS is based on the fact that neutrons coming from space can penetrate tens of cm of soil or hundreds of snow, where they strongly interact with hydrogen, of which water and snow are rich, such as valuable information can be obtained by counting them. Finapp developed and tested a custom scintillator for neutron detection, obtaining a new kind of CRNS probe, light, compact, and easy to install. After proper calibration, our CRNS probe allows to obtain either SM or SWE from the neutron counts, providing a real-time, direct evaluation in a large footprint (up to dozens of hectares), in continuous and autonomous operation regime.

We present the outcome of tests performed across different seasons in 2022 and 2023 at two experimental sites on the Italian Alps: Colle del Nivolet in Piemonte region and Cima Pradazzo in Veneto region, where saturation and footprint effects were observed, respectively, for the measurment of SWE. The possibility of a dual use of a single probe mounted above ground, switching between the evaluation of SWE and SM across the year, is showcased [Fig. 1]. This configuration is suitable for mid-mountain locations and offers to maximize the monitored area (snow at distances up to 200 m was detected around Cima Pradazzo) while maintaining a reasonable SWE saturation level (reached at about 250 mm SWE at the Nivolet site).

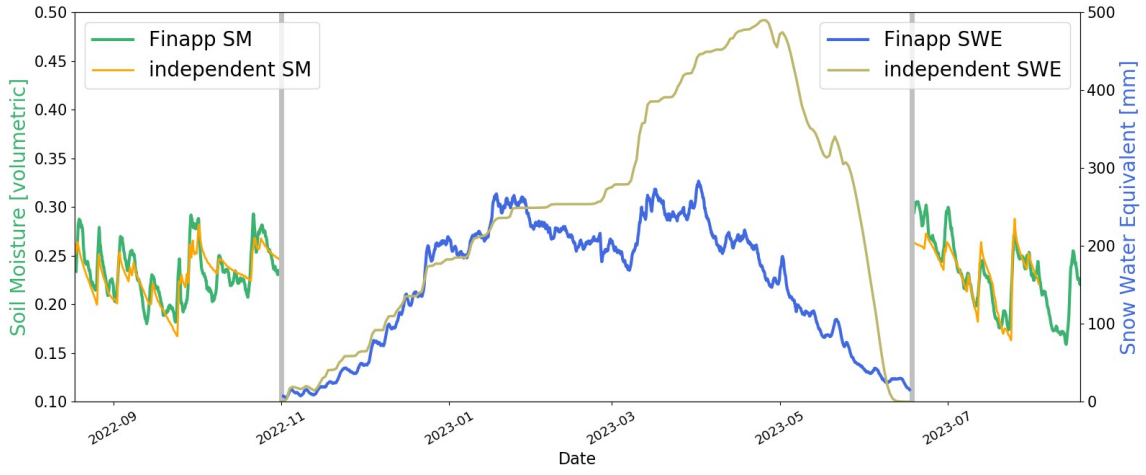


Fig. 1: demonstration of the dual-use of a Finapp probe at the Colle del Nivolet site and the reach of saturation for SWE. Independent trends of SM and SWE provided by TDR measurements and nivometer data + snowpack modelling, respectively.

The above capabilities open to a range of on-field applications related to monitoring climate evolution also in remote areas, possibly evaluating risks correlated to either the SM or SWE amounts (fire, landslides, avalanches, floodings), and strategically assessing water resources for agriculture, industry and hydroelectric power generation.