Snow Water Equivalent monitoring at the regional level through a Finapp Cosmic Rays Neutron Sensors network

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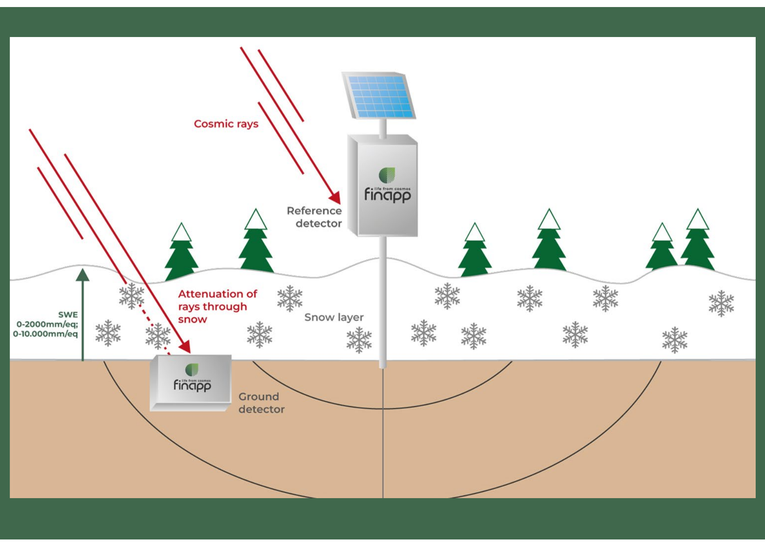
INTRODUCTION

The amount of snow accumulated during winter in mountain regions has a critical impact on the water resources available during cropping seasons, with Northern Italy and the Alps being a clear example of this relation. Optimizing both energy and water resources is crucial in light of the drought crisis of recent years, which necessitates improving the accuracy in monitoring the snowpack water content as Snow Water Equivalent (SWE). As this task is particularly critical and dangerous if snow coring needs to be performed by human operators in high altitude and remote zones, computational models have been developed to derive SWE estimations from snow height measured by nivometers, satellite observations and meteorological data. Recently, the development of new types of proximal sensors based on Cosmic Rays Neutron Sensing (CRNS) technology has opened the possibility of continuously providing SWE measurements in remote sites.



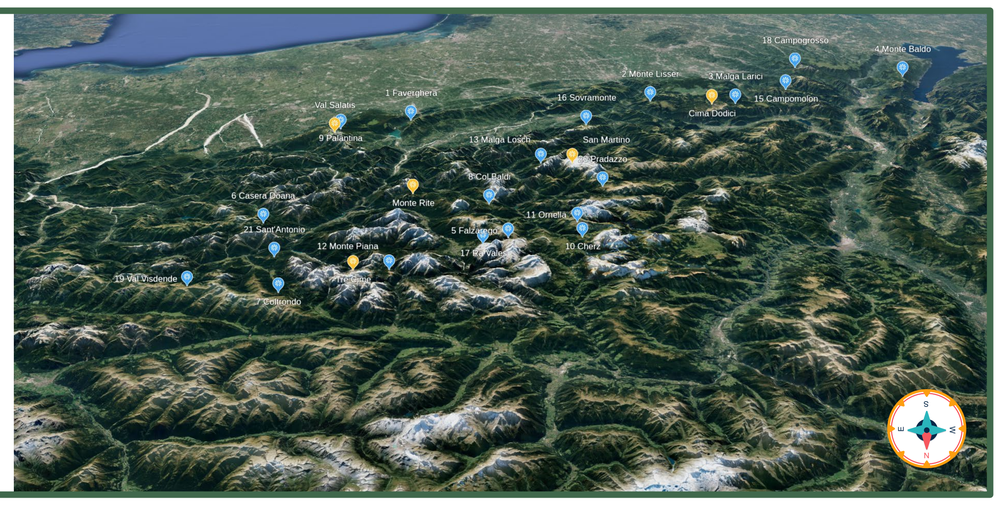
CRNS technology for SWE measurements

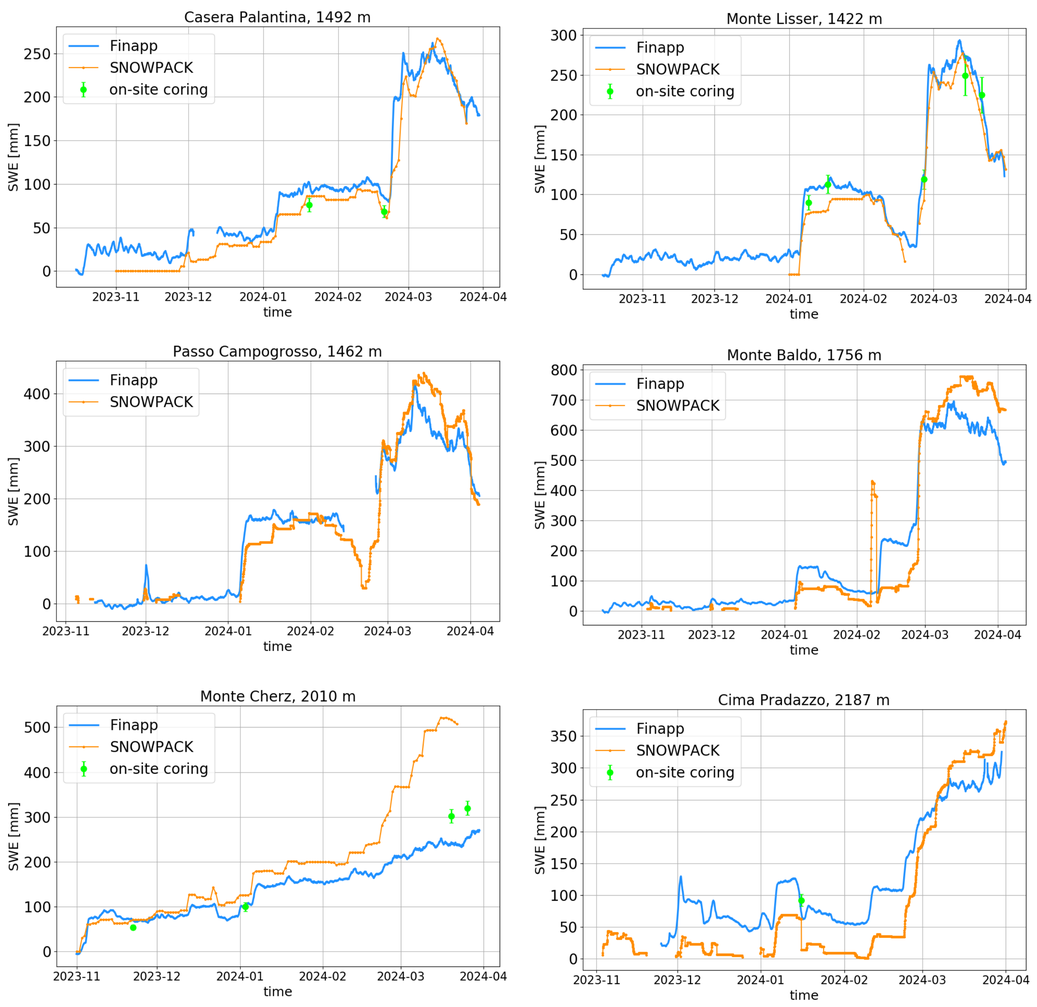
CRNS is based on the detection of neutrons, particles continuously flowing from space and strongly interacting with hydrogen atoms present in the water molecules. Therefore the absorption of neutrons in the environment is correlated to the presence of water and snow. A properly calibrated probe can directly convert neutron counts into a mass measurement of snow (mm SWE), overcoming the limits and the complexity of modelling stratification and spatial distribution of the snow(1). Compared to point-scale measurements, the collected signal is representative of a large area (averaging over its spatial inhomogeneity) whose radius can reach tens of meters.

The new ARPAV network of Finapp sensors

Finapp developed a light, compact and safe to carry sensor, easy to install even in remote areas(2). At the end of 2023, ARPAV acquire d and deployed the first full nivological network of Finapp sensors across the Veneto Alpin-region:

- 20 active probes (blue marks) + 5 to be installed (yellow marks)
- Altitude range: between 1400 and 2600 m a.m.s.l.
- Mountain area (defined as > 600 m a.m.s.l.): approx. 5000 km^2





Results

- Comparisons between SWE trends measured by Finapp (blue) and values obtained by independent, more traditional methods: on-site coring by expert technicians (lime dots) and the SNOWPACK model (orange). SNOWPACK calculation of SWE relies on the snow height measured by nivometers, making it an essentially punctual information(3). It also needs a set of auxiliary meteorological data including temperature, solar radiation and wind.
- Good agreement was observed in homogeneous sites. Differences were found to be related to inhomogeneous snow accumulation or issues with the SNOWPACK inputs. Situations have been found where SNOWPACK suffered of either bad representativity of the punctual position (Cima Pradazzo) or bad quality/unavailability of input meteorological information (Monte Cherz).
- Contrary to punctual sensors, CRNS probes take into account the snow inhomogeneities (due for example to terrain morphology or eolic transportation) by returning an average SWE value over the footprint. Strong footprint effects were observed especially in the Cima Pradazzo site, where the nivometer location is frequently swept by strong winds.
- Finapp measurement of SWE could be used to validate the SNOWPACK evaluations or to improve it by feeding it with areal information about the snow amount.

CONCLUSIONS AND PERSPECTIVES

CRNS probes continuously provide a measurement of SWE capable of being representative of a complex terrain morphology in a reasonably wide area. It can provide a solid comparison or input information for models whose evolution can be hindered by the inhomogeneous accumulation of the snow. Moreover, it can be used as a ground reference of a suitable pixel size for satellite passes. Therefore in sinergy with traditional approaches, it can significantly improve the hydrological balance at the basin and regional scale.

Bibliography

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