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Characteristics and Limitations of Submerged GPS L1 Observations

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Extensive amount of water stored in snow covers has a high impact on flood development during snow melting periods. Early assessment of these parameters in mountain environments enhance early-warning and thus prevention of major impacts. Sub-snow GNSS techniques are lately suggested to determine liquid water content, snow water equivalent or considered for avalanche rescue. This technique is affordable, flexible, and provides accurate and continuous observations independent on weather conditions. However, the characteristics of GNSS observations for applications within a snow-pack still need to be further investigated.

The magnitude of the main interaction processes involved for the GPS wavelength propagating through different layers of snow, ice or water is theoretically examined. Liquid water exerts the largest influence on GPS signal propagation through a snow-pack. Therefore, we focus on determining the characteristics of GNSS observables under water.
An experiment was set-up to investigate the characteristics and limitations of submerged GPS observations using a pool, a level control by communicating pipes, a geodetic and a low-cost GPS antenna, and a water level sensor. The GPS antennas were placed into the water. The water level was increased daily by a step of two millimeters up to thirty millimeters above the antenna. Based on this experiment, the signal penetration depth, satellite availability, the attenuation of signal strength and the quality of solutions are analyzed. Our experimental results show an agreement with the theoretically derived attenuation parameter and signal penetration depth.

The assumption of water as the limiting parameter for GPS observations within a snow-pack can be confirmed. Higher wetness in a snow-pack leads to less transmission, higher refraction, higher attenuation and thus a decreased penetration depth as well as a reduced quality of the solutions.
In consequence, GPS applications within a snow-pack are heavily impacted by wetness which is even more pronounced during melting period.

In this poster, we present a short introduction to the principle, explain the developed algorithms and show results of experiments dedicated to the signal propagation in water.