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Investigating the potential of GNSS-modules for inflow avalanche measurements

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A detailed knowledge of avalanche dynamics is crucial to optimize flow models that allow avalanche simulation tools to be effectively used for dimensioning mitigation measures or identifying endangered terrain. There are different ways to observe the dynamics in an avalanche during the flow. It can be achieved with remote sensing approaches or fixed sensor systems that interact with the flow. In this Abstract we introduce an inflow sensor system, the so called AvaNodes that are equipped with a variety of sensors, investigating the potential of Global Navigation Satellite System (GNSS) modules.

The AvaNode is a cube with 16 cm side length. It is designed to flow in the avalanche and obtain GNSS position and velocity, inertial measurement unit (IMU) based accelerations, angular velocities and the magnetic flux densities, and temperature by means of an infrared thermometer.

The utilized GNSS modules are from the ublox CAM-M8 series, that have a position accuracy of 2 m and velocity accuracy of 0.05 m/s, according to the datasheet.

To estimate the position accuracy of the AvaNode while covered with snow, experiments were performed with the AvaNode buried in snow at different depths at a known location. Results show that the position accuracy is highly dependent on the number of satellites that the module currently tracks, ranging between 2 and 10 meters. To estimate the GNSS velocity accuracy while the AvaNode is covered with snow, a dynamic experiment with moving sensors was performed. The AvaNode was transported on a sledge while it was buried in 10 and 20 cm of snow. An accuracy in the range of 0.5 m/s was observed, allowing to potentially investigate the dynamics in real avalanches. The influence of burial or snow cover depth did not show conclusive influence on the results and requires further investigation. In 2021 this inflow sensor system was used in two avalanche experiments, on March 15 and 16, obtaining start and end positions, as well as promising GNSS velocities. On March 15 one AvaNode was transported by an avalanche, where the GNSS velocity shows a maximum of 15 m/s and a duration of 50 seconds of the avalanche. On March 16 two AvaNodes were picked up by an avalanche, both showing similar velocity distributions, with a maximum velocity of 17 and 13 m/s.