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Rapid Detection of Small Movements with GNSS Doppler Observables

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High-alpine terrain reacts very sensitively to varying environmental conditions. As an example, increasing temperatures cause thawing of permafrost areas. This, in turn causes an increasing threat by natural hazards like debris flow (e.g. rock glaciers) or rockfalls. The Institute of Geodesy and Photogrammetry is contributing to alpine mass-movement monitoring systems in different project areas in the Swiss Alps. A main focus lies on providing geodetic mass-movement information derived from GNSS static solutions on a daily and a sub-daily basis, obtained with low-cost and autonomous GNSS stations. Another focus is set on rapidly providing reliable geodetic information in real-time i.e. for an integration in early warning systems. One way to achieve this is the estimation of accurate station velocities from observations of range rates, which can be obtained as Doppler observables from time derivatives of carrier phase measurements.
The key for this method lies in a precise modeling of prominent effects contributing to the observed range rates, which are satellite velocity, atmospheric delay rates and relativistic effects. A suitable observation model is then devised, which accounts for these predictions. The observation model, combined with a simple kinematic movement model forms the basis for the parameter estimation. Based on the estimated station velocities, movements are then detected using a statistical test. To improve the reliablity of the estimated parameters, another spotlight is set on an on-line quality control procedure.
We will present the basic algorithms as well as results from first tests which were carried out with a low-cost GPS L1 phase receiver. With a u-blox module and a sampling rate of 5 Hz, accuracies on the mm/s level can be obtained and velocities down to 1 cm/s can be detected. Reliable and accurate station velocities and movement information can be provided within seconds.