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Detection of hazardous ground movements with instantaneous velocity estimates by GNSS

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Based on high-rate estimates of GNSS receiver velocity, it is possible to detect ground movements at the level of millimeters-per-second instantaneously; By including multi-GNSS measurements, signals at the sub-mm/s level can be detected. This can be achieved in standalone mode, meaning no GNSS real-time correction data from reference stations is needed. Based on experiments with robotic equipment, we will highlight the capability of the algorithm to augment real-time landslide early warning systems in the Swiss alps. Another application is the detection of strong earthquakes: Based on GNSS measurements for more than 40 stations of a 6.5 magnitude event in central Italy, it is demonstrated that seismic primary (P) waves can be detected, which was also proven by comparing with strong-motion seismometer data. A GNSS-only earthquake hypocenter localization comes very close to official seismic solutions. Additionally, we will demonstrate some interesting aspects of the algorithms' capability to monitor GNSS phase noise, and emphasize the high quality of the Galileo carrier phase signals. Finally, aspects on the sensitivity of various GNSS positioning products for the detection of ground movements will be briefly discussed. We conclude that GNSS-based displacement detection can give an important contribution to natural hazard early warning systems across multiple time scales.