Geophysical Research Abstracts
Vol. 18, EGU2016-12916-1, 2016
EGU General Assembly 2016

Quantification of erosion and sedimentation using time-lapse gravimetry and Lidar in southern Taiwan

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After the 2009 Morakot typhoon, which triggered numerous large landslides in Taiwan, Mouyen et al. (2013) showed for the first time the potential of time-lapse gravity survey to infer the mass of sediments transferring by landsliding or through rivers. By providing an integrated measurement of masses, gravimetry might thus be complementary to common methods used to assess the sediments discharge of rivers. But the masses of rocks displaced by Morakot were exceptionally large as a result of the record-breaking rainfalls brought by this typhoon and one might wonder to what extent time-lapse gravimetry could record such sediment transfers. In order to better assess the capabilities of this method, we set a time-lapse gravity network dedicated to the monitoring of such sediments transfers in Paolai village (south-central Taiwan). Paolai is located near the large Laonong river where temporary alluvial deposits of sediments exist and face steep mountain slopes likely to experience landslides. Both features are considered as potential source of mass transfers, and in turn of temporal gravity changes. The first base gravity measurements were done in November 2015, using absolute and relative gravimeters, and will be repeated every year, before and after the typhoon season. In the same time, we also use a terrestrial lidar to scan the geometry of both the river and the mountain slopes, hence providing a detailed topographical survey of the studied area. Adding Lidar measurements is an efficient strategy to solve for the non-uniqueness of gravity solutions. Meanwhile, we use the Eros morphodynamic model, that combine landsliding and flooding models, to investigate various scenarios of landsliding and subsequent sediment transport and compute the gravity changes on a virtual network of gravimeters. This gives us insights on the expected order of magnitudes for these surface sediment transfers, which are useful to unravel the induced gravity signal from others sources such as local hydrology or vertical ground displacements. The modeling results also enable us to set network location that are best defined to detect mass changes associated with sediment transfer. The main objective of this study is to test whether time-lapse gravity brings a new and reliable information compared to present methods monitoring sediments transfers and landscape evolution.