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GPS observations of a deep-seated gravitational slope deformation in northern Taiwan

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We established a continuous GPS network on a deep-seated gravitational slope in northern Taiwan to study the spatial-temporal evolution of the slope deformation. The targeted slope with the Huafan University campus built on top of it, is a translational deep-seated gravitational slope with a dip-slope of about 20° toward southwest and a potential sliding surface located at 10-40 m depth, composed of early Miocene alternations of sandstone and shale in northern Taiwan. We setup 12 single-frequency and 3 dual-frequency GPS stations on and outside the campus sliding area since May 2016 and the GPS data are processed with software RTKLIB and Bernese 5.0, respectively. During the thirty-month observation period, we found that three noticeable displacement events, with 10-60 mm, 10-20 mm and 4-12 mm horizontal displacements and 4-30 mm, 5-15 mm and 1-2 mm subsidence displacement accumulated within a month, occurred in September 2016, June 2017 and October 2017, respectively. These displacements concur with three apparent rainfall events which accumulated 1190 mm, 640 mm and 635 mm, respectively within 5-11 days. During each rainfall event, displacements gradually increase from top to the bottom, and displacement on the left flank is smaller than that on the right flank. For the dry season, the displacement creeps slowly with velocities of 7-13 mm/year toward southwest to south and moves downward at a rate of about 10 mm/year, which is subparallel to the dip-slip direction. The dry-season landslide motion is evidently affected by the dip-slope motion, other than the tectonic cause. We also conjecture that there is another sliding area located outside and below the campus, where two stations recorded substantial displacements. We combine the subsurface slip measured by the inclinometers with the surface displacement to understand the characteristics of the sliding body. We consider that the main cause of the weakening of the sliding shear zone is due to the rise of groundwater during the rainfall periods. During dry seasons the groundwater on the sliding surface may be retained to some extent to keep the slope persistently moving down-dip.