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# Vertical motions in New Zealand from dense GNSS network

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We present the estimated (present-day) rates of vertical deformations at the control network of 123 permanent GPS sites in New Zealand realized by the GeoNet. An analysis of GPS phase data is performed in a consistent way all over the considered data span with respect to the Precise Point Positioning (PPP) mode of GIPSY-OASIS II using JPL reprocessed products. The station positions and clocks, phase biases, and tropospheric delays and horizontal tropospheric gradients are estimated. The a priori zenith hydrostatic delay (ZHD) is calculated based on the station height and thus regarded as constant, while the zenith wet delay (ZWD) and the horizontal tropospheric gradients (north and east) are modeled as Random Walk (RW) variables, and are estimated every 5 min as time-dependent parameters. The solid Earth and pole tide corrections are treated according to the IERS Conventions 2010. The ocean loading corrections are applied based on the FES2004 ocean tide model. The antenna phase center models and the Global Mapping Function (GMF) are taken into account. The resulting daily solutions are aligned to the ITRF2008 reference frame using Helmert's parameter transformations (JPL x-files).
The results reveal that the northern regions of the North Island are relatively stable; the vertical rates are typically below 1 mm/year. The systematic tectonic subsidence of about 4-9 mm/year is detected at GPS sites in the central volcanic zone and southern regions of the North Island. Additional small local uplift is detected at several GPS sites in the central volcanic zone of the North Island which is more likely attributed to the volcanic and geothermal processes. In agreement with the results of latest studies, the positive velocity rates at GPS sites along the profile across the Southern Alps (western part of the South Island) indicates the uplift to about 6 mm/year. Elsewhere in the South Island (along the south and east coast) our estimated vertical rates at GPS sites are similar to the results from the geochronological data showing mainly small subsidence of about 2 mm/yr.