

PWV retrieval by radiosondes and GPS receivers in Indonesia: spatial and time variations associated to rain events

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Flooding due to local convective rain is a serious problem in the urban area of Jakarta, Indonesia. However, accurate prediction of local heavy rainfall events by means of current mesoscale numerical prediction models is difficult, partly because of lacking meteorological observations in Indonesia. Spatial and time variations of water vapor over a given area are expected to increase before precipitation occurs, due to the accumulation of water vapor in the lower troposphere, followed by convective instability. A means to reliably and continuously monitor Precipitable Water Vapor (PWV) is needed in order to detect such variations before the formation of rain clouds. GPS meteorology, i.e. the retrieval of PWV above a GPS station of known coordinates, is a useful technique to achieve this objective. The GPS signal delay induced by tropospheric refractivity is related to the amount of water vapor along the slant path between each satellite and the receiver antenna, therefore each fixed GPS station can be effectively employed as a sensor that continuously monitors the PWV with high temporal resolution (down to few seconds). By deploying multiple GPS stations that concurrently estimate the amount of PWV at different locations within an area of interest, one can evaluate the spatial and time fluctuations of the water vapor field, and investigate their relation to rain events.

We conducted a PWV observation campaign from 23 July to 5 August 2010 by using five GPS receivers installed at four different locations in Jakarta and Bogor, on Java island, Indonesia. Radiosondes were launched three to four times a day, from a site co-located with two of the receivers, in order to validate the GPS-derived PWV data. The validation resulted in a root mean square error of 2-3 mm. The influence of atmospheric pressure and temperature on GPS-derived PWV can be significant, therefore it was evaluated by referring to ground pressure and temperature measured by weather stations, and radiosonde temperature profiles. A regular semi-diurnal pressure oscillation was observed, showing an amplitude ranging from 3 to 5 hPa, which corresponds to 1.1-1.8 mm in PWV. A temperature inversion layer was observed in the radiosonde profiles during the night, which resulted in an error of about 0.5 mm in the retrieved PWV.

During the campaign, there was a passage of precipitation clouds over western Java, moving southwestward from the Equator towards the Indian Ocean, from 26 to 29 July. A second precipitation event, with localized rain clouds near Bogor, occurred on 2 August. Both events were observed also by a C-band Doppler Radar, operated in Serpong by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as part of the HARIMAU project. The highest value of GPS-derived PWV (about 68 mm) was observed on 27 July, coinciding with the first rainfall event. Spatial and time variations in the estimated PWV between the four sites were enhanced before both the analyzed rainfall events, on 27 July and 2 August. We thus suggest the possibility that the spatial and time inhomogeneity of PWV detected by a network of GPS receivers could be used to support the prediction of rainfall events.

Keywords: PWV, GPS, precipitation, Indonesia