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Estimating Precipitable Water Vapour Using the Global Positioning System and Radio Occultation over Ethiopian Regions

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Abstract : The Global Positioning System (GPS) is a space-based radio positioning system, which is capable of providing continuous position, velocity, and time information to users anywhere on or near the surface of the Earth. The main objective of this work was to estimate the integrated precipitable water vapour (IPWV) using ground GPS and Low Earth Orbit (LEO) Radio Occultation (RO) to study spatial-temporal variability. For LEO-GPS RO, we used Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) datasets. We estimated the daily and monthly mean of IPWV using six selected ground-based GPS stations over a period of range from 2012 to 2016 (i.e. five-years period). The main perspective for selecting the range period from 2012 to 2016 is that, continuous data were available during these periods at all Ethiopian GPS stations. We studied temporal, seasonal, diurnal, and vertical variations of precipitable water vapour using GPS observables extracted from the precise geodetic GAMIT-GLOBK software package. Finally, we determined the cross-correlation of our GPS-derived IPWV values with those of the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-40 Interim reanalysis and of the second generation National Oceanic and Atmospheric Administration (NOAA) model ensemble Forecast System Reforecast (GEFS/R) for validation and static comparison. There are higher values of the IPWV range from 30 to 37.5 millimetres (mm) in Gambela and Southern Regions of Ethiopia. Some parts of Tigray, Amhara, and Oromia regions had low IPWV ranges from 8.62 to 15.27 mm. The correlation coefficient between GPS-derived IPWV with ECMWF and GEFS/R exceeds 90%. We conclude that there are highly temporal, seasonal, diurnal, and vertical variations of precipitable water vapour in the study area.

Keywords : GNSS, radio occultation, atmosphere, precipitable water vapour
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