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Spatial analysis of GNSS tropospheric slant delays using a dense network of receivers
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Urban areas are facing increasing threats due to the sudden development of localized thunderstorms and torrential rain, which can cause floods, trigger landslides and damage crucial infrastructures. While such local heavy rain events are difficult to be forecasted by current numerical weather prediction models, short-term predictions at local scales could potentially benefit from reliable measurements of the temporal and spatial variability of water vapor in the atmosphere. In order to support the nowcasting and forecasting of these phenomena and to improve the resilience of local communities against rain-related threats, it is needed to improve the horizontal resolution of water vapor observation sites by deploying sufficiently dense networks of monitoring stations.

Fixed receivers of known coordinates tracking GPS satellites can be used for water vapor monitoring, since 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 (GPS meteorology). Indeed each receiver-satellite pair can be seen as a device that scans the troposphere along a continuously varying direction as the satellite moves with respect to the position of the receiver. The traditional approach to GPS meteorology sees the averaging of all slant delays above low elevation thresholds, after having mapped them to the zenith direction. When using very dense networks of receivers, however, the averaging cones defined by low elevation thresholds overlap significantly and produce a horizontal smoothing effect. It is thus necessary to select high elevation slant delays for each station in order to preserve the high resolution observation capability of a dense network of receivers.

GPS satellites alone do not provide continuous coverage at sufficiently high elevation angles (e.g. higher than 70 degrees), therefore the integration of GPS with other Global Navigation Satellite Systems (GNSS) is required. The fast development of new GNSS constellations will soon provide the means to increase the number of receiver-satellite pairs, and consequently to increase the capability of each receiver to continuously observe the troposphere along directions close to the zenith. In addition, the particular geometry of the Quasi-Zenith Satellite System (QZSS), once the constellation is completed, will provide a means to monitor the amount of water vapor along slant paths continuously close to the zenith direction in Japan, without the need to switch between different systems.

In this work we analyze the spatial distribution of GNSS tropospheric slant delays observed by a dense network of receivers deployed near Kyoto, Japan. Slant delays estimated from QZSS observations by the first launched satellite are included in the analysis, comparing them with those estimated using high-elevation GPS satellites and analyzing their azimuthal dependency. The current status of new GNSS constellations and their potential benefits for meteorology are also briefly discussed.

キーワード: GNSS, troposphere, slant delays, water vapor
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