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Densified GNSS-based water-vapor monitoring network in Rotterdam using low-cost single-frequency receivers

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Accurate sensing of water vapor is crucial for the now- and forecasting of rainfall in numerical weather prediction (NWP) models. Especially severe weather events are characterized by their small spatial scale. Improved forecasting of such events is essential for flood-prone areas and urban stormwater systems which rely on precise rainfall forecasts. Current operational meteorological systems undersample the amount of precipitable water vapor (PWV) which has proven to be an important indicator for rainfall forecasts. There are several possibilities to detect water vapor in the atmosphere. Traditional radiosonde launches offer precise data but are limited in their spatial extent and their trajectory is limited by the wind. Satellite-image-based measurements offer a good spatial resolution but are limited in temporal extent. One possibility to overcome these limitations is to expand existing ground-based GNSS networks. European nationwide GNSS monitoring systems are characterized by inter-station distances typically in the order of tens of kilometers. Due to economic reasons, the densification cannot be achieved with expensive geodetic-grade dual-frequency receivers. Instead, low-cost single-frequency sensors can be used to achieve higher receiver network density. In this work we present first results and an analysis of the error budget from the newly installed regional continuous monitoring network in the urban testbed of Rotterdam. In order to process the data in Precise Point Positioning (PPP) mode, the existing dual-frequency receiver network was used to account for the ionospheric error. The newly installed network consisted of four additional low-cost single-frequency GNSS receivers and was characterized by inter-station distances between 4-5 kilometers. We present comparisons with radiosonde, co-aligned dual-frequency PPP results and existing PWV monitoring campaign reference datasets. This experiment aims to address the feasibility of small-scale water vapor monitoring using low-cost devices. It focuses on the improvement possibilities of such a densification for numerical weather modeling and may help to improve extreme rainfall forecasting.