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Application of GNSS tomography in 3D representation of atmospheric moisture during large scale intense precipitation events with Poland as an example

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Severe weather is a growing threat to people and infrastructure all around the world. In Central Europe the most common event of this kind is extensive and prolonged precipitation that may cause a large scale flooding. Such weather results from the synoptic scale convergence of air masses in cyclonic systems formed in the southern part of Central Europe. Abundant rainfall results from strong cyclogenesis organized in the form of quasi-stationary atmospheric thermal asymmetry within a low barometric pressure system. Such cyclone gains its energy from condensation of the atmospheric moisture transported from S through SE and E to NE sectors, which ascends over the cold air coming from the sector NW and N. Frontal surface separating two air masses predominantly resembles anabatic cold front.

As it is very important to represent atmospheric processes behind severe weather as precisely as possible, we decided to apply GNSS tomography model TOMO$_2$ to resolve the water vapour content before, during and after some intense precipitation events. The GNSS tomography is a technique that allows to reconstruct, from the GNSS satellite-receiver signal slant troposphere delay, a 3D pattern of water vapour content estimated with the spatial resolution of half the distance between the GNSS receivers and time resolution similar to the estimated troposphere delay. The applied technique allows to get full picture of tropospheric water vapour content at all locations covered by GNSS network.

In this study we investigate: 1) the meteorological correctness of the tomography retrieval, 2) whether the achieved temporal and spatial resolution of the troposphere water vapour content will provide new information about spatial distribution of precipitation enhancement mechanisms. Two events were investigated: in May 2014 and in September 2014. The tomography retrievals have been compared with radiosonde profiles and numerical weather prediction (NWP) model. We show better agreement of tomography data with radiosonde data than NWP has with radiosonde. The main result of this study is a significant improvement of both spatial and temporal resolution of atmospheric moisture field representation over the area of Poland during the evolution of those precipitation events. The potential use of GNSS moisture data for better understanding of intense precipitation events has been also discussed.