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Real-time GNSS meteorology – state of the art and challenges

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Global Navigation Satellite System (GNSS) signal delays depend on pressure, temperature and water vapour content along the propagation path and thus links between GNSS and meteorology. GNSS remote sensing of the troposphere, called GNSS meteorology, provides observations with spatial and temporal resolutions that are higher than any other troposphere sensing technique, and operates under all weather conditions. The main product of GNSS meteorology, namely the zenith total delay (ZTD), can be assimilated into Numerical Weather Prediction (NWP) models, in order to improve forecasting. In Europe, the E-GVAP project for monitoring water vapour with GNSS supports NWP with ZTDs obtained from a near real time processing, with a latency below 1 hour.

Recent developments of GNSS have led to a significant increase of the number of operational satellites, so that currently more than one hundred satellites are available to the user. These improvements are supported by the provision of satellite orbits and clock products within the International GNSS Service (IGS) Multi-GNSS Experiment (MGEX). Real-time products are already available for GPS since 2013, which implies that real-time ZTD can be estimated. Currently, real-time products for GLONASS, Galileo and BeiDou are also made available, which means that a four-system constellation can be used to permanently sense the troposphere with minimum latency. Although this creates the possibility to use GNSS meteorology products for nowcasting, major developments in GNSS data processing and satellite products are still required in order to reach the expected accuracy and reliability of real-time ZTD.

This contribution summarizes the state of the art and future challenges of real-time GNSS meteorology. It will be demonstrated, that the accuracy of real-time ZTD from GPS can reach 10 to 20 mm. During severe weather conditions, GNSS data processing can benefit from global weather forecast by adjusting the stochastic model of ZTD. On the other hand, the inhomogeneity of real-time GNSS products requires optimization of inter-system weighting of observations, which can lead to an improvement of the accuracy of ZTD can reach up to 14%, if done properly. In order to overcome other shortcomings of real-time GNSS troposphere products and be able to study the assimilation of real-time products into NWP models, the “Real-Time GNSS for European Troposphere Delay Model” (ReS4ToM) project has been launched. This initiative is funded under the Marie Sklodowska-Curie Action Individual Fellowship for 2019-2021. The presentation will include a brief overview and discuss the visions and goals of this project.