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Ground-based GNSS for climate research: review and perspectives

Rosa Pacione[1], Marcelo Santos[2], Galina Dick[3], Jonathan Jones[4], Eric Pottiaux[5], Annette Rinke[6], Roeland Van Malderen[7], and Gunnar Elgered[8]

[1]e-Geos/ASI-CGS, Matera, Matera, Italy (rosa.pacione@e-geos.it)
[2]University of New Brunswick Fredericton, Canada (msantos@unb.ca)
[3]GFZ German Research Centre for Geosciences, Potsdam, Germany (galina.dick@gfz-potsdam.de)
[4]Met Office, Exeter, United Kingdom (jonathan.jones@metoffice.gov.uk)
[5]Royal Observatory of Belgium, Brussels, Belgium (Eric.Pottiaux@oma.be)
[6]Alfred Wegener Institute, Potsdam, Germany (Annette.Rinke@awi.de)
[7]Royal Meteorological Institute of Belgium, Brussels, Belgium (roeland@meteo.be)
[8]Chalmers University of Technology, Onsala, Sweden (Gunnar.Elgered@chalmers.se)

In climate research, the role of water vapour can hardly be overestimated. Water vapour is the most important natural greenhouse gas and is responsible for the largest known feedback mechanism for amplifying climate change. It also strongly influences atmospheric dynamics and the hydrologic cycle through surface evaporation, latent heat transport and diabatic heating, and is, in particular, a source of clouds and precipitation.

Atmospheric water vapour is highly variable, both in space and in time. Therefore, measuring it remains a demanding and challenging task. The Zenith Total Delay (ZTD) estimated from GNSS observations, provided at a temporal resolution of minutes and under all weather conditions, can be converted to Integrated Water Vapour (IWV), if additional meteorological variables are available. Inconsistencies introduced into long-term time series from improved GNSS processing algorithms, instrumental, and environmental changes at GNSS stations make climate trend analyses challenging. Ongoing re-processing efforts using state-of-the-art models aim at providing consistent time series of tropospheric data, using 24+ years of GNSS observations from global and regional networks. GNSS is reaching the “maturity age” of 30 years when climate normal of ZTD/IWV (and horizontal gradients) can be derived. Being not assimilated in numerical weather prediction model reanalyses, GNSS products can also be used as independent datasets to validate climate model outputs (ZTD/IWV). However, what is the actual use of GNSS ZTDs in climate monitoring? What are the advantages of using GNSS ZTDs for climate monitoring? In addition, what would be the best ZTD time series to serve the climate community?

The presentation will provide a review of the progress made in and the status of using GNSS tropospheric datasets for climate research, highlighting the challenges and pitfalls, and outlining the major remaining steps ahead. We will show examples demonstrating the benefits for climate monitoring brought by using GNSS ZTD and/or IWV datasets in complement to other observations.

This contribution is related to the activities of JWG C.2: Quality control methods for climate applications of geodetic tropospheric parameters, https://iccc.iag-aig.org/joint-work-groups/216, of the IAG Inter-Commission Committee on "Geodesy for Climate Research" (ICCC).