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Simulation of GNSS LEO satellites constellation for 3D water vapor monitoring

The GNSS signal is an important data source for weather applications: ground-based stations produce point-like observations of water vapor with unprecedented stability and a fast update rate. Space-based receivers mounted on the LEO satellites deliver reliable profiles of the troposphere, regardless of weather conditions. Both data types, so far with two different operators, are used by global atmospheric weather model producers. The global ground-based infrastructure of GNSS receivers reached maturity and a stable number of receivers (e.g. stations of International GNSS Service), with signs of densification of the networks in industrialized regions like Japan, China, Europe, and the USA. The space sector, in particular Spire Global, GeoOptics, Tianmu, PlanetIQ, and Yunyao, are currently outnumbering the public sector organizations, such as EUMETSAT and NOAA, in the quantity of satellites with GNSS sensors.
Inspired by the increasing number of GNSS networks, we have conducted simulations to explore the potential of new observation concepts, based on dense satellite constellation for monitoring the atmospheric state. Therefore, we considered the following configurations: a set of satellites arranged in a strings-of-pearls formation, an extension of the number of satellites in the current orbital planes, and an increase in the number of orbital planes. Simulations were based on Two-Line Element (TLEs) data obtained from Spire Global's Radio Occultation (RO) satellites, and orbit simulations using the FreeFlyer software. We used the in-house developed 3D ray-tracing software in conjunction with the Integrated Tomography (INTOMO) package to reconstruct tropospheric path delays for each RO event and to process them together in an integrated solution using tomographic principles. In this presentation, we analyze the impact of the various satellite configurations on the retrieval of 3D tropospheric refractivity and make use of the simulation results to identify potential new monitoring concepts for future satellite missions.

References

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Primary author: Mr MAKUCH, Sebastian (Wrocław University of Environmental and Life Sciences)

Co-authors: Mr CEGŁA, Adam (Wrocław University of Environmental and Life Sciences); Dr MÖLLER, Gregor (Technische Universität Wien); Prof. SOŚNICA, Krzysztof (Wrocław University of Environmental and Life Sciences); Ms HANNA, Natalia (Technische Universität Wien); Dr HORDYNIEC, Paweł (Wrocław University of Environmental and Life Sciences); Prof. ROHM, Witold (Wrocław University of Environmental and Life Sciences); Dr ADAVI, Zohreh (Technische Universität Wien)

Presenter: Mr MAKUCH, Sebastian (Wrocław University of Environmental and Life Sciences)

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