EGU21-5929
https://doi.org/10.5194/egusphere-egu21-5929
EGU General Assembly 2021

Tropospheric products as a signal of interest – overview of troposphere sensing techniques

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The microwave signals passing through the troposphere are delayed by refraction. Its high variations, both in time and space, are caused mainly by water vapor. The tropospheric delay used to be considered only as a source of error that needed to be removed. Nowadays, these delays are also a source of interest. The tropospheric delays or integrated water vapor are being assimilated into nowcasting or numerical weather prediction (NWP) models. Moreover, long time series of tropospheric observations have become an important source of information for climate studies. On the other hand, the meteorological data support the space-geodetic community by providing models that can be used to reduce the troposphere impact on the signal propagation. Furthermore, the delays calculated by one microwave technique can be used to mitigate the errors in others.

There are several ways of observing the troposphere, especially considering water vapor. The classical meteorological are: in-situ measurements, radiosondes or radiometers, which allow to sense the amount of water vapor directly. Another, indirect way of observing the water vapor distribution is by using the Global Navigation Satellite Systems (GNSS). This method is called GNSS meteorology. Other microwave techniques such as Very Long Baseline Interferometry (VLBI) or Interferometric Synthetic Aperture Radar (InSAR) are also capable to retrieve the atmospheric information from their signals.

This contribution shows an overview of the troposphere sensing techniques and their applications. We present multi-comparisons of the tropospheric parameters, i.e. refractivity, tropospheric delays in zenith and slant directions and integrated water vapor. The integration of the different data sources often leads to an improved accuracy of the tropospheric products but requires a careful preparation of data. The combination of the data sources allows for using the techniques of complementary properties, for example InSAR with very high spatial resolution with GNSS observations of high temporal resolution. With the emergence of new technologies, some traditional ways of tropospheric measurements can be augmented with the new methods. For

example, we have tested meteo-drones as an alternative to radiosondes. The comparisons with GNSS data shows a good agreement of the drone and microwave data, even better than with radiosonde. Moreover, we present the results of the GNSS data assimilation into NWP models and the developments towards multi-GNSS, real-time assimilation of advanced products such as slant delays and horizontal tropospheric gradients.