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Severe weather investigation using GNSS signals - a new dimension of GNSS meteorology

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The Global Navigation Satellite Systems (GNSS) signals transmitted from satellites are subjected to atmospheric delays since the signals have to propagate through different layers of the atmosphere before GNSS receiver receives them. Two major distinctive effects according to the nature of the impact on the signal propagation are the ionosphere which is a dispersive media and the troposphere which is a non-dispersive layer.

In this study, our focus of research is concentrated on the troposphere and the severe weather phenomena caused by midlatitude cyclonic storms. GNSS tomography technique is used to investigate both the spatial and temporal structures of a cyclonic storm. New algorithms will be developed based on optimal integrations of various observation techniques, such as ground-based meteorological measurements, radiosonde data, numerical weather prediction (NWP) models, GNSS radio occultation (RO) profiles. Our initial results suggest that the ground-based GNSS CORS stations will play a major role in the integration process. The structure and distribution of the GNSS CORS network and satellite constellations in context of size and resolution of tomography model are investigated along with the a priori information required, observation and estimation time interval and precision and accuracy needs. A number of numerical analyses are carried out using actual measurements in different parts of the world to evaluate the new algorithms developed through international collaboration.

It is expected that GNSS tomography with a number of integrated measurements will provide an important insight into the vertical as well as the horizontal structure of different kinds of severe weather phenomena. It is also expected that GNSS tomography will become an important tool for the study of the severe weather processes, such as the development, maturation, and dissipation stages, which is complementary to other meteorological techniques such as weather radars and microwave radiometers. Potential usages of the new technique in real and/or near-real time would provide an exciting opportunity to launch monitoring and warning services that are able to offer vital information for community and decision makers.