Wet Refractivity tomographic reconstruction over small areas using an ad-hoc GPS receivers network

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One of the most attractive scientific issues in the use of GNSS (Global Navigation Satellite System) signal from a meteorological point of view, is the retrieval of high resolution tropospheric water vapour maps. The real-time (or quasi real-time) knowledge of such distributions could be very useful for several applications, from operative meteorology to atmospheric modeling. Moreover, the exploitation of wet refractivity field reconstruction techniques can be used for atmospheric delay compensation purposes and, as a very promising activity, it could be applied for example to calibrate SAR or Interferometric-SAR (In-SAR) observations for land remote sensing. This is in fact one of the objectives of the European Space Agency project METAWAVE (Mitigation of Electromagnetic Transmission errors induced by Atmospheric Water vapour Effects), in which several techniques were investigated and results were compared to identify a strategy to remove the contribution of water vapour induced propagation delays in In-SAR products. Within this project, the tomographic reconstruction of three dimensional wet refractivity fields on a small atmospheric volume (16km x 20 km x 10 km height, from 2 km to 4 km horizontal resolution and 1 km vertical resolution), was performed considering real tropospheric delays observations acquired by a GNSS network (9 dual frequency GPS receivers) deployed over Como area (Italy), during 12–18 October, 2008.

Acquired L1 and L2 carrier phase observations have been processed in terms of hourly averaged Zenith Wet Delays. These vertical informations have been mapped along the correspondent line of sights (by up-sampling at 30 second sample times the 15 minutes GPS satellites positions obtained from IGS files) and inverted using a tomographic procedure. The used algorithm performs a first reconstruction (namely, the tomographic pre-processing) based on generalized inversion mechanisms, in order to define a low resolution first guess for the following step. This second step inverts GPS observables using a more refined algebraic tomographic reconstruction algorithm, in order to improve both vertical and horizontal resolution.

Despite limitations due to the network design, internal consistency tests prove the efficiency of the adopted tomographic approach: the rms of the difference between reconstructed and GNSS observed Zenith Wet Delays (ZWD) are in the order of 4 mm. A good agreement is also observed between our ZWDs and corresponding delays obtained by vertically integrating independent wet refractivity fields, taken by co-located meteorological analysis. Finally, during the observing period, reconstructed vertical wet refractivity profiles evolution reveals water vapour variations induced by simple cloud covering. Even if our main goal was to demonstrate the effectiveness in adopting tomographic reconstruction procedures for the evaluation of propagation delays inside water vapour fields, the actual water vapour vertical variability and its evolution with time is well reproduced, demonstrating also the effectiveness of the inferred 3D wet refractivity fields.

Even if results obtained were satisfactory, limitations due to the observation geometry, to the GNSS propagation delay information extraction form observables and to the applied tomographic technique will be highlighted, in order to trace the road-map toward future improvements in this challenging field.