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An Evaluation of Geodetic Positioning Error Simulated using the New Ray Tracing Algorithms through the JMA Mesoscale Analysis Data

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We evaluate atmospheric parameters (equivalent zenith total delay and linear horizontal delay gradients) derived from slant path delays obtained by new ray tracing technique [Hobiger et al., 2007] through the Japan Meteorological Agency (JMA) mesoscale analysis (MANAL) data with 10 km horizontal resolution. We numerically also estimate position changes caused by the horizontal variability of the atmosphere by means of simulation analysis using the ray-traced slant delays. Our ultimate purpose is to establish a new method for reducing atmospheric effects on geodetic positioning. We first seek to establish the level of positioning error due to intense mesoscale and local scale phenomena.

The JMA/MANAL data which we used in our study provides temperature, humidity and pressure values at the surface and at 21 height levels (which vary between several tens of meters and about 31 km), for each node in a 10 km by 10 km grid that covers Japan islands, the surrounding ocean and eastern Eurasia. We first reconstruct modified grid scheme based on the original JMA/MANAL data for adapting the new ray tracing algorithms with analytic expressions. The topography used in the data is retrieved from ETOPO2 data set.

For each grid point we invert the simulated slant delays using an isotropic and an anisotropic delay model. The isotropic model has only one parameter - the zenith total delay (ZTD). The anisotropic delay model [e.g. Chen and Herring, 1997] has two additional lateral gradient parameters. We compare the ’true’ ZTD, computed by directly integrating the atmospheric refractivity field of the grid data, with the ZTD estimated by least squares inversion of the ’observed’ slant delays obtained by ray tracing. We did this using the isotropic and the anisotropic delay model.

In addition we also numerically estimate atmospheric parameters and site position changes simultaneously from the ray-traced slant delays, assuming single point positioning without coordinate constraints. We consider the vector between the true position and estimated position to be the positioning error. This estimation is performed to investigate the behavior of the positioning errors generated by local atmospheric disturbances, the relation between the slant delay errors and the vertical positioning errors and so on. At present the 3-hourly operational products of MANAL data are only available by JMA. Thus, we mine the data field at intermediate hours obtained by time interpolation in order to evaluate temporal change of estimates.

We find that the large horizontal positioning errors through the modified JMA/MANAL data set at a single epoch of 0000 UT 18 October 2004. The maximum of the errors up to 7 cm is represented in the south of Kyusyu island where a complex distribution of water vapor associated with an extremely large-scale and powerful Typhoon No. 23 and it is not reduced by isotropic mapping function.