An Evaluation of the practicability of current mapping functions using ray-traced delays from JMA Mesoscale Numerical Weather Data

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INTRODUCTION

We have developed a new tool to obtain atmospheric slant path delays by ray-tracing through the meso-scale analysis data for numerical weather prediction developed by Japan Meteorological Agency (JMA) with 10 km horizontal resolution[1] (hereafter, we call this "JMA 10km MANAL data"). These data is operationally used for the purpose of weather forecast and considered for our study. We have created ray-tracing routines and named the tools "KAshima RAytracing Tools (KARAT)" [1]. We evaluated atmospheric parameters (equivalent zenith wet delay and linear horizontal delay gradients) derived from slant path delays using KARAT. We also estimate position changes caused by the horizontal variability of the atmosphere by running simulations using the ray-traced slant delays in order to examine the position error magnitude and its behavior under meso-scale atmospheric disturbances. Finally, we assessed empirical mapping functions, developed for use in space geodesy, by comparison with KARAT slant delays.

KARAT

KARAT have been developed at the National Institute of Information and Communications Technology (NICT), Japan and is capable of calculating total slant delays and ray-bending angles. We perform a successive 19 months run of KARAT calculations from March 2006 to September 2007. The JMA data which we used in our study provides temperature, humidity, and pressure values at the surface and at 21 pressure levels (which are equal to steps of several meters to kilometers up to about 31 km), for each node in a 10 km by 10 km grid that covers all Japanese islands, the surrounding ocean and Eastern Asia.

We first resample the original JMA grid to a modified grid which allows to run the new ray tracing algorithms using analytic expressions. The topography used in the data is retrieved from the SRTM30 digital elevation data set. At present the 3-hourly operational products are only available by JMA. Thus, a linear time interpolation is used to obtain results at arbitrary epochs what allows also to evaluate temporal change of estimates.

POSITION ERROR SIMULATION

We numerically estimate position changes caused by the horizontal variability of the atmosphere using KARAT, assuming single point positioning. 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.

ASSESSMENT OF MAPPING FUNCTIONS

We can evaluate empirical mapping functions developed for GPS and VLBI by comparing equivalent slant delays. Modern mapping functions such as the Isobaric Mapping Function (IMF)[2], Global Mapping Function (GMF)[3], and Vienna Mapping Function (VMF)[4] have been successfully used to estimate site dependent zenith delays in the past few years. The lateral spatial variation of wet delay is reduced by linear gradient estimation. However, the mapping function errors associated with the lateral heterogeneity of the atmosphere have not been assessed sufficiently so far.

Our first goal is to see how well the modern anisotropic mapping functions can mimic the directional variability associated with the intense mesoscale disturbances typical of the Japanese monsoon. We will present comparisons between 'observed' slant delays using KARAT and those calculated using the best-fit isotropic and anisotropic mapping functions.

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