MIT Haystack Observatory Analysis Center

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Abstract

The primary contribution of Haystack Observatory to analysis of geodetic VLBI data is improvement of accuracy in the estimation of atmospheric delay. In the past year investigation was begun of the possible contribution of high horizontal resolution Numerical Weather Models to better understand the delay due to small-scale structure of water vapor.

1. Geodetic Research at the Haystack Observatory

The MIT Haystack Observatory is located approximately 50 km northwest of Boston, Massachusetts. Geodetic analysis activities have been primarily directed to improving the accuracy of the estimation of atmosphere delay and thus reducing errors in the geodetic analysis. This work, along with operating the geodetic VLBI correlator and with supporting operations at the Westford, GGAO, Gilmore Creek, and Kokee Park geodetic sites, is supported by NASA through a contract with the Goddard Space Flight Center.

2. High Resolution Numerical Weather Model for Atmosphere Anisotropy

New atmosphere mapping functions have previously been developed that are based on Numerical Weather Models (NWM) which provide *in situ* values for the atmosphere state variables of temperature, humidity, and pressure. These more accurate mapping functions will improve the estimation of atmosphere delay and geodetic parameters as well as allow evaluation of the errors in previous generations of mapping functions.

The two mapping functions developed for operational use, IMF [1] and VMF [2], use data from a global NWM, either the National Center for Environmental Prediction (NCEP) or the European Centre for Medium-range Weather Forecasts (ECMWF), having horizontal resolutions of 2.5° an 0.3°, respectively. Even the resolution of ECMWF, corresponding to about 30 km, is ten times larger than the scale height of the water vapor, thus significantly limiting knowledge of the horizontal variation of the delay due to water vapor. To evaluate the potential improvement in geodetic analysis through better knowledge of the anisotropy of the water vapor, I am working with Mark Leidner of Atmosphere and Environmental Research, Inc, to use weather forecasts with resolution as small as three kilometers to determine the small-scale structure of the water vapor.

To obtain this resolution the Penn State/NCAR MM5 numerical weather model software has been installed on a Linux cluster at Haystack to produce twelve hour forecasts in nested grids of 81, 27, 9, and 3 km for the stations and time period of CONT02. Eventually, three dimensional raytraces through the forecast fields will be used to provide mapping functions for the VLBI analysis of the CONT02 data.

The initial effort has been to evaluate the information obtained from the NWM by comparison with mapping functions calculated from the radiosondes profiles of temperature and humidity at sites within the three kilometer grids. We have found that, at least for the region around Westford, the calculation of the azimuthally symmetric mapping functions does not depend on the horizontal

resolution or forecast time (out to twelve hours). While this is the expected result, it is necessary to validate that the MM5 is being operated at the level of accuracy needed for the VLBI analysis.

The hydrostatic mapping function comparison for the radiosonde site at Albany, NY, USA, is shown in Figure 1. The largest deviations are for radiosonde profiles that are missing significant amounts of data, suggesting that the NWM may provide a more uniform source of data, provided the accuracy is sufficient.

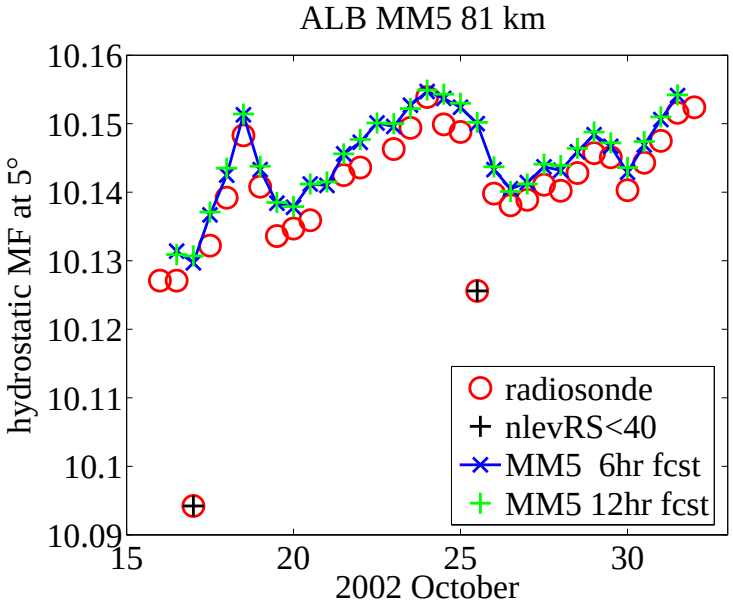

Figure 1. Hydrostatic mapping function at 5° for site ALB (Albany, NY, USA) for the CONT02 period using radiosonde data and meteorological parameters from the MM5 six and twelve hour forecasts.

3. Outlook

Following completion of validation of the vertical profiles for the other seven sites, the effects of horizontal anisotropy will be investigated. A site of particular interest is Kokee, which is in the midst of a very asymmetric water vapor field and which often must be used with a pattern of observing that is very asymmetric in azimuth.

The goal is to ascertain whether inclusion of high resolution information on the water vapor field obtained from a NWM improves the estimation of geodetic parameters for VLBI, and thus potentially for GPS.

References

[1] Niell, A.E.: Improved atmospheric mapping functions for VLBI and GPS, Earth, Planets, and Space, 52, 699-702, 2000.

[2] Boehm, J. and H.Schuh: Vienna Mapping Functions in VLBI Analyses, Geophys. Res. Letters, 2004.