Analysis and Research at the Haystack Observatory

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Abstract

New mapping functions that incorporate easily accessible *in situ* atmospheric information have been incorporated in the *solvk* analysis package at Haystack. For middle and high latitudes the mapping function contribution to the vertical error budget is significantly reduced.

A study has been initiated on how to utilize VLBI to better understand the antenna characteristics of the GPS satellites. A better model for the GPS satellite phase center will help resolve possible discrepancies between the VLBI and GPS terrestrial reference frame scales.

1. Geodetic Research at the Haystack Observatory

The primary objectives of analysis activities at Haystack Observatory are to improve the underlying models in order to obtain better accuracy and precision and to better understand the uncertainties that limit the space geodetic techniques. Since there are many similarities between VLBI and GPS, it is natural to investigate both common error sources and and those that are unique in order to obtain the best results from both techniques. This has led us to study the atmosphere model, which can be applied to either, and the characteristics of both satellite and receiver antennas of GPS.

Atmosphere models

Gridded global numerical weather models provide *in situ* meteorological information. The geopotential heights of an isobaric surface, for example the 200 hPa surface, serve as a useful parameter for the hydrostatic component of the mapping function [3]. The improvement relative to the widely used NMFh [2] is shown in Figure 1 for a mid-latitude site; the scatter of the mapping function at 5° is an indication of the error that will be introduced in the vertical. The improvement in modeling precision, interpreted as approximate vertical error as a function of latitude, is illustrated in Figure 2.

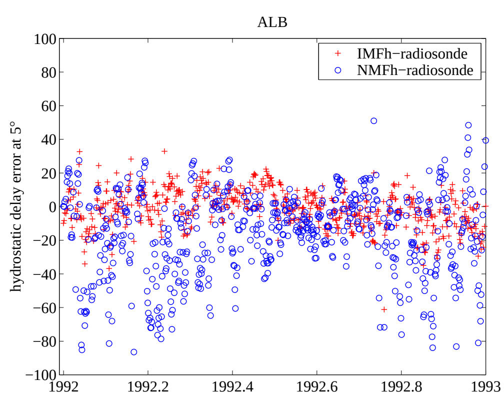

Figure 1. Temporal errors of hydrostatic mapping functions. The difference with respect to raytracing of radiosonde profiles for the IMF and NMF hydrostatic mapping functions at 5° elevation.

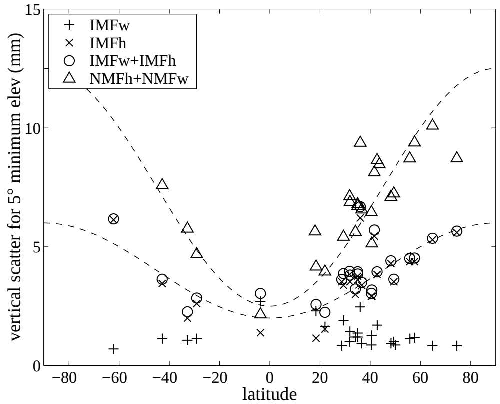

Figure 2. Vertical error induced by hydrostatic mapping functions. The approximate contribution of the hydrostatic and wet mapping functions to the vertical error for VLBI or GPS experiments with a minimum elevation of 5°. The dashed lines are of the form cos(2*latitude) and are intended only to guide the eye to the expected height uncertainties for the combined hydrostatic and wet mapping function errors for IMF and for NMF.

The relative value of the two hydrostatic mapping functions has been tested by comparison of the variation of the baseline lengths for the CONT94 VLBI data, assuming that they are constant over the short period of that campaign. The standard deviation of the lengths is slightly smaller using IMFh than using NMFh. No correction was made for atmospheric pressure loading, and, since this effect may have a comparable contribution to the scatter, this may account for the marginal improvement.

VLBI, GPS, and the Terrestrial Reference Frame

The direction-specific instrumental delay (phase center variation) of GPS ground antennas differs by antenna model. The Dorne-Margolin choke ring antenna has been assumed to be uniform, but measurement of the phase pattern in anechoic chambers and by a rapid cycling among satellites by a “robot” [4] suggest a large elevation-dependent error. For this error to be reasonable the GPS satellites must have a compensating phase error to avoid a large discrepancy between GPS and VLBI in the scale of the terrestrial reference frame. A joint working group composed of representatives from the IVS, IGS, and ILRS and chaired by Brian Corey has been studying the feasibility of using differential VLBI observations of GPS satellites and nearby extragalactic sources to measure the phase pattern of the transmitted L1/L2 GPS signals. The aim is both to measure the phase center locations of the GPS phased array transmitters and to “map” the relative magnitudes and phases of the drive voltages of the individual phased array elements. The required accuracy on the VLBI fringe phase is $< 10°$, or < 5 mm in differential range, after correction for propagation media effects, extragalactic source position uncertainty, etc.; this level of accuracy will likely be difficult to achieve.

2. Outlook

Both of these projects will continue. For the evaluation of the atmosphere models, *solvk* [1] will be updated with atmospheric pressure loading and with an improved ocean loading model. The amount of data will be extended to cover at least a full year in order to evaluate any annual components in the results.

Upon completion of the study to determine the feasibility of using VLBI to characterize the GPS satellite antennas, a decision willl be made on whether to proceed, and, if the project looks promising, funding will be sought.

References

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