Analysis and Research at the Haystack Observatory

Arthur Niell, Brian Corey

Abstract

Analysis efforts at the Haystack Observatory have been concentrated on improving the accuracy of geodetic VLBI measurements. The primary result has been the development of better models for the variation with elevation of the delay through the atmosphere.

1. Geodetic Research at the Haystack Observatory

Although Haystack Observatory is best known for the design and production of VLBI systems for data acquisition and correlation, considerable effort has been invested in improving the accuracy of geodetic VLBI measurements. This has included the planning and scheduling of special Research and Development projects such as the ATD, ERDE, and the early CONT experiments. All were designed primarily to provide data to investigate how to better measure the vertical component of station position. These and the later CONT series provide an excellent data set for testing model changes intended to improve accuracy.

Analysis

Our analysis of geodetic VLBI data uses the *solvk* package [1] with data bases obtained from Goddard Space Flight Center. The *solvk* set of programs was developed with modeling of the atmosphere a primary concern. One goal of our research is to compare the available geodetic VLBI analysis packages on a set of high quality data in order to evaluate the effect of different models. Of particular interest is any difference in results that may depend on how the atmosphere is parameterized. For example *solvk* models the atmosphere zenith delay and the gradient of the delay as stochastic processes while *solve* allows only a piecewise continuous variation in time but with constraints on the amount of change after fixed time intervals.

Atmosphere Research

The NMF mapping functions [2] that were developed at Haystack for the hydrostatic and wet components of the atmosphere are in wide use for both VLBI and GPS. These were based on a seasonal model and do not accurately reflect daily to weekly variation. A new model is being developed that will make use of daily measurements of the atmosphere to be obtained from assimilated weather data sets or, on shorter time scales, from the output of numerical weather predictions from one of the major forecast services [3].

Instrumentation

Instrumental polarization may be a significant error source as higher accuracy is sought through the use of phase delays. Experiments to determine the polarization characteristics of most antennas in the geodetic network have been carried out and correlated and need only be analyzed.

Terrestrial Reference Frame

The accuracy of the terrestrial reference frame depends on the quality of the ties among the various techniques at common sites. At Westford the GPS and VLBI antennas are only 60 m apart,

and the conventionally measured vector has a nominal accuracy of a few millimeters. However, the apparent difference in vertical position between the GPS and VLBI determinations for the ITRF at the common mark is a few centimeters. Leveling has been repeated, and GPS measurements have been made to confirm the accuracy of the local ties. The leveling repeats within a millimeter for the position of the GPS antenna, but differs from earlier measurements for the VLBI antenna by a centimeter. More seriously, the GPS height has a serious systematic uncertainty of several centimeters that depends on the analysis. This problem, due to multipath and near-field scattering in the vicinity of the GPS antenna [4], is known to affect all GPS sites at some level. Methods to reduce or calibrate the effect are being tested.

2. Outlook

During the first year of IVS we hope to complete the new mapping functions and evaluate the accuracy and feasibility on a large set of VLBI data using *solvk*. These data will provide the basis for comparison with other analysis packages (e.g. *solve*, OCCAM, GLORIA, MODEST) using either the new mapping function or reverting to one currently in use.

Analysis of the polarization data should help us to understand why we are not achieving the accuracy expected for the parameters of the individual VLBI systems. Increasing the number of baselines and stations for which phase delays can be utilized should also provide additional accuracy and better data for studying the atmosphere effects on VLBI.

As errors in the vertical are reduced for all techniques the determination of the Terrestrial Reference Frame can be improved.

References

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