JF2: Refractive Effects on Transatmospheric Paths

Techniques for Minimizing Tropospheric Path Delay Effects in Astrometric and Geodetic VLBI

Robert N. Treuhaft, Roger P. Linfield, Lawrence P. Teitelbaum, and Jaroslava Z. Wilcox
Jet Propulsion Laboratory, MS 238-700
California Institute of Technology
Pasadena, California 91109 USA
(Phone: 828-354-6236, Fax: 818-393-4965)

Introduction

Tropospheric refractivity inhomogeneities cause ≈50-picosecond (15-mm) radio propagation delay excursions over 1000-second time scales at 20-degree elevations [1]. These delay fluctuations are a dominant error source for astrometry and geodesy done with Very Long Baseline Interferometry (VLBI) [2], as well as Global Positioning System (GPS) geodesy. The delay fluctuations arise primarily from refractivity fluctuations in tropospheric water vapor, but fluctuations in dry-component refractivity are also important at the mm level. After a review of how uncorrected tropospheric refractivity fluctuations affect radio source position and baseline vector determination at the few-nanoradian (nrad) and few-cm level respectively, techniques for minimization of tropospheric errors to the 100-picoradian (1-mm) level will be discussed.

Tropospheric Refractivity Effects in Astrometry and Geodesy

The component of VLBI delay from which astrometric and geodetic information is extracted is the geometric delay. It involves the dot product of the baseline with the radio source position unit vector. Tropospheric fluctuation errors cause delay effects which have the same signature as source position and baseline vector shifts. This paper will describe how tropospheric delay fluctuations affect astrometric and geodetic parameters, using a model for the spatial and temporal structure of refractivity fluctuations [1].

Minimizing Tropospheric Delay Fluctuation Effects

Stochastic models of refractivity fluctuations can be used to optimally estimate astrometric or geodetic parameters [2,3]. The limits to optimal estimation are at the nrad or cm level. It is theoretically possible for stochastic modelling to perform at the 0.5-nrad or 5-mm level, but this accuracy would require detailed knowledge of tropospheric dynamics above the observing site, which is costly and impractical. For astrometric purposes, it is highly desirable to calibrate the tropospheric delay at the mm level. A calibration scheme involving water vapor radiometry, atmospheric temperature and water vapor profiling, VLBI and GPS measurements, and infrared spectroscopy will be described. The performance of this technique, which should be near the mm level, is currently being assessed.

References

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[3] T. Herring, J. Davis, and I. Shapiro, *J. Geophys. Res.*, 95, 12,561, 1990.