METHODS OF CORRECTION FOR THE "WET" ATMOSPHERE IN ESTIMATING BASELINE LENGTHS FROM VLBI

G. Elgered, J. L. Davis, T. A. Herring, and I. I. Shapiro
Center for Astrophysics
60 Garden Street
Cambridge, MA 02138

ABSTRACT. The error in VLBI estimates of baseline length caused by unmodelled variations in the propagation path through the atmosphere is greater for longer baselines. We present and discuss series of estimates of baseline lengths obtained using different methods to correct for the propagation delay caused by atmospheric water vapor. The main methods are use of data from a water-vapor radiometer (WVR) and Kalman-filtering of the VLBI data themselves to estimate the propagation delay. Since the longest timespan of WVR data associated with geodetic VLBI experiments was obtained at the Onsala Space Observatory in Sweden, we present results for the following three baselines: (1) Onsala–Wettzell, FRG (920 km), (2) Onsala–Haystack/Westford, MA (5600 km), and (3) Onsala–Owens Valley (7914 km).

1. INTRODUCTION

This paper addresses the utility of water-vapor radiometers (WVR) in geodetic radio-interferometry experiments. The WVR data are providing *a priori* information about the wet delay. It is also possible to estimate a correction to any *a priori* delay during post-processing. The estimate can be of a mean zenith bias for the entire experiment or of values of samples of, say an assumed random (Markov) process. We have analyzed 77 experiments (made during 1980–1985) several times, each time with a different method to correct for the wet delay at Onsala, but with the atmospheric delays for all other sites (as well as the clocks) modeled as Markov processes.

2. RESULTS AND DISCUSSION

The results are presented in Table I as weighted root-mean-square (WRMS) scatters of baseline lengths about estimated slopes. The WRMS value is a measure of repeatability. We also present one solution where observations made at elevation angles lower then 25° ($\epsilon < 25°$) at Onsala were deleted since low elevation angle observations are not important when no delay corrections are estimated (*Herring* 1986). The WRMS for the Wettzell–Onsala baseline is given with respect to its mean value since no baseline change is expected. For this baseline, when the WVR data are used in place of the Markov process, the WRMS decreases from 5.2 to 4.0 mm. If we assume that atmospheric delay errors are not correlated with other errors, and that the wet atmospheres over Wettzell and Onsala are statistically similar, the WRMS would be 2.2 mm were a WVR installed at Wettzell. The results for the Haystack/Westford–Onsala baseline are presented for each of the former antennas separately since the WRMS is significantly different in the two cases. This

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 543–544.

TABLE I. BASELINE LENGTH REPEATABILITY

Baseline Onsala to	Method used to correct for the wet delay at Onsala: *A priori*	Adjustment	Mean baseline[5] +919660 m (mm)	WRMS about mean (mm)
Wettzell[1]	None	Offset	999 ± 1	5.8
Wettzell[1]	None	Markov	1000 ± 1	5.2
Wettzell[1]	WVR	Offset	999 ± 1	5.1
Wettzell[1]	WVR	None	996 ± 1	4.0
Wettzell[1]	WVR ($\epsilon > 25°$)	None	996 ± 1	4.4
			Slope[5] (mm/year)	WRMS about slope (mm)
Haystack[2]	None	Offset	17.8 ± 1.4	14.1
Haystack[2]	None	Markov	19.0 ± 1.2	12.8
Haystack[2]	WVR	Offset	16.1 ± 1.2	12.5
Haystack[2]	WVR	None	14.2 ± 1.5	15.0
Haystack[2]	WVR ($\epsilon > 25°$)	None	16.6 ± 1.1	11.5
Westford[3]	None	Offset	15.9 ± 2.5	21.6
Westford[3]	None	Markov	17.8 ± 2.1	18.3
Westford[3]	WVR	Offset	14.5 ± 2.5	21.8
Westford[3]	WVR	None	13.7 ± 2.8	23.1
Westford[3]	WVR ($\epsilon > 25°$)	None	15.8 ± 2.3	18.8
Owens Valley[4]	None	Offset	12.8 ± 4.0	39.1
Owens Valley[4]	None	Markov	12.7 ± 3.2	31.4
Owens Valley[4]	WVR	Offset	10.3 ± 3.2	31.3
Owens Valley[4]	WVR	None	9.0 ± 6.1	57.6
Owens Valley[4]	WVR ($\epsilon > 25°$)	None	11.4 ± 3.6	35.4

[1] 25 experiments [2] 36 experiments [3] 45 experiments [4] 29 experiments
[5] The sigmas are scaled so that reduced $\chi^2 = 1$ (*Herring et al.* 1986).

difference indicates that the accuracy of the Westford–Onsala baseline estimates is not limited by atmospheric errors. It is also clear that low elevation observations do not improve the accuracy of baseline length estimates when WVR data are used and no adjustment to the *a priori* delay is estimated. Finally, for the longest baseline (Owens Valley–Onsala) it appears better to estimate a correction to the zenith delay inferred from the WVR data rather than to discard low elevation observations, because a bias affects the accuracy of the vertical position which is more important for estimates of length of longer baselines.

3. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The differences in the rates obtained with the different methods are small compared to 1 cm/year. It is important to minimize possible biases in the atmospheric delays inferred from WVR data. A main source of such bias is the uncertainty of the attenuation coefficients due to water vapor. Another important task is to find the "best" elevation cut-off angle when WVR data are to be used.

ACKNOWLEDGMENTS

This work was supported by the Air Force Geophysics Laboratory, contract F–19628–86–K–0025; NASA grant NAG5–538; and NSF grants EAR–83–06380 and EAR–86–18989.

REFERENCES

Herring, T.A., *J. Geophys. Res.*, **91**, No. B9, pp. 9177–9182, 1986.
Herring, T.A. et al., *J. Geophys. Res.*, **91**, No. B8, pp. 8341–8347, 1986.