THE LONG TERM STABILITY OF VLBI EARTH ORIENTATION MEASUREMENTS

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ABSTRACT. Tectonic motions will, in general, change the orientation as well as the length of baselines used in Very Long Baseline Interferometry (VLBI), and will thus cause slow divergences between Earth orientation results obtained with different VLBI networks, as well as between VLBI results and those obtained by Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR). Such drifts (on the order of a milliarcsecond / year) are inherently interesting as well as being significant in combinations of orientation results from different sources. The geodetic study of tectonic motions is also closely connected to research into the nature and causes of systematic errors in data from the modern techniques of space geodesy. We describe both a special coordinate system found to be of use in the analysis of VLBI data and tectonic motion estimates for a VLBI baseline stretching from California to Australia.

1. Geometrical Nature of Errors in Geodetic VLBI

Understanding the distribution of errors in single baseline geodetic VLBI is an important step in the validation of global geodesy. We have found a special coordinate system, the Transverse, Vertical, Length (TVL) coordinate system, to be very useful in analysis of VLBI data. This system is defined by the baseline vector (the length component) and the cross product between the vectors from the center of the Earth to the telescopes at the ends of the baseline (the transverse component), with the vertical component completing a right handed orthogonal system. The transverse is defined so that a positive transverse motion moves one end of the baseline in a counterclockwise fashion as seen from above the other.

Only a small region of the sky is visible from both ends of a intercontinental baseline, forming a narrow sector oriented along the transverse direction. Since the geometrical distribution of observations largely determines the inherent accuracy of baseline vector estimates, the transverse component is relatively well determined even for very long baselines, while the accuracy of the length and vertical components decreases with increasing length. In addition, errors in modeling the atmospheric propagation delay at an observatory, probably the largest source of systematic errors in geodetic VLBI (Herring et al. 1986), are highly correlated with the local vertical component of the position of the observatory. Such "local vertical" errors will cause errors in the baseline length and vertical components, but not in the baseline transverse, since this component is in the horizontal plane at both ends of the baseline. Similar errors are present in multi-baseline VLBI data and the effects of unmodeled local vertical errors should be accounted for in the design and analysis of observations from global VLBI networks.

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 369–370.

https://doi.org/10.1017/S0074180900135041 Published online by Cambridge University Press

2. The relative tectonic motion of Australia and California

The Australia - California baseline of the Deep Space Network (DSN) has a large transverse tectonic velocity and is thus quite sensitive to tectonic motions. Figure 1 shows the difference between VLBI baseline transverse measurements for this baseline and a Kalman smoothing of LLR, SLR and non-DSN single baseline VLBI; only measurements with formal errors < 5 milliarcseconds are shown for clarity. (The data used are described in the BIH Annual Report for 1986, and the Kalman filter in Morabito et al. 1987). The baseline vector is defined as pointing from California (longitude 243^{o}E and latitude 35^{o}N) to Australia (149^{o}E and -35^{o}N); the baseline length is ~10,589 km. The observed motion is in excellent agreement with the AM1-2 model of Minster and Jordan (1977), with a drift rate estimate of 9.6 times the formal error. The scatter of the residuals is clearly time correlated, but the observed drift would be significant at the 99.5% level even assuming the ~50 day correlation time of Herring et al. (1986).

ACKNOWLEDGEMENTS. The work described in this paper was supported by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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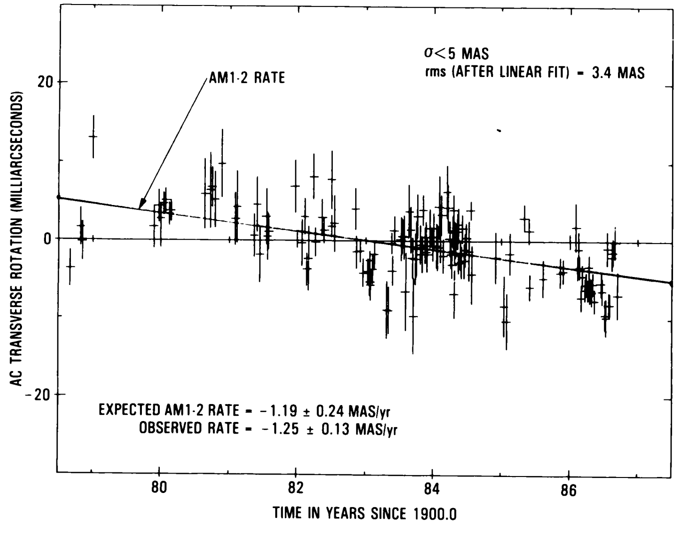

Figure 1. Estimates of the transverse orientation change of the DSN Australia - California baseline minus a smoothing of other data, together with the Minster and Jordan AM1-2 tectonic rate estimate.

https://doi.org/10.1017/S0074180900135041 Published online by Cambridge University Press