Scientific Results from the EPOCH'92 Observations Organized by the USNO

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ABSTRACT. In order to assess the reality of any high frequency rotational variations observed during the EPOCH'92 campaign, a series of special Navy-Experimental Global (or NAVEX-G) sessions were coordinated by the USNO to provide periods of observations by two independent Very Long Baseline Interferometry (VLBI) networks during part of EPOCH'92. The NAVEX-G network used the NAVNET Green Bank antenna together with radio telescopes in Chile, Italy, South Africa, Canada and Japan. This truly global network provided orientation accuracy comparable to the lower noise (but smaller) NASA network run simultaneously, and thus a means of assessing the validity of any small high frequency variations in Earth orientation observed during this period. This paper presents a brief description of these NAVEX-G observations and the results obtained from them.

1. INTRODUCTION

The SEARCH-92 campaign organized by the International Earth Rotation Service included a special observing period called EPOCH'92 (July 25-August 8, 1992), intended to study high-frequency variations in Earth rotation. To complement the period of almost continuous VLBI observations organized by the U.S. National Aeronautics and Space Administration (NASA), the U.S. Naval Observatory (USNO), in addition to the on-going weekly NAVNET VLBI sessions, organized a series of four Navy Experimental-Global (NAVEX-G) observing sessions using VLBI antennas in Green Bank, (U.S.A.), Algonquin (Canada), Kashima (Japan), Matera (Italy), Santiago (Chile) and Hartebeesthoek (South Africa). The primary purpose of these NAVEX-G observations was to determine the reality of high frequency variations in the orientation of the Earth, and the level of systematic and random errors in VLBI determinations of these variations, through comparisons between independent simultaneous VLBI sessions of the highest possible quality. The NAVEX-G observations were fully successful in meeting these goals, and high quality data were obtained from each session, with a total of 2247 successful observations being obtained (in addition to the 1293 observations obtained from regular NAVNET sessions during EPOCH'92).

2. RESULTS OF THE NAVEX-G EPOCH'92 OBSERVATIONS

The NAVEX-G measurements sessions were intended to, and did, provide Earth orientation estimation accuracy comparable to the simultaneous NASA Research and Development (R&D) sessions. The NAVEX-G achieved this accuracy through the use of a truly global network with up to 6 stations in 5 continents, the size of the network being specifically intended to compensate for the sensitivity of the R&D observations. Data were obtained on baselines up to 12,419 km long, and the bulk of the data were obtained from baselines of about 1 1/2 Earth radii in length. Good results were obtained from these long baselines, and the actual UT1 and polar motion formal errors from the two networks were roughly equal. Both networks provided roughly a factor of two increase in sensitivity over that obtained by the IRIS-A and NAVNET sessions during the same period.

The existing IERS standards [1] were found to be inadequate to reduce the global scale NAVEX-G sessions due to their neglect of the tidally driven diurnal and semidiurnal variations in UT1 and polar motion. This effect is striking in the NAVEX-G sessions during EPOCH'92. When these data are reduced in the standard fashion, estimating one set of 24 hour averaged values for UT1, polar motion and nutation offsets, the weighted root mean square (rms) post-fit residual scatter of the interferometric delays was

±52.0 picoseconds. When the data are used to estimate hourly piecewise linear variations in UT1 and polar motion, the weighted rms drops to ±43.6 picoseconds (a strongly significant 30% reduction in variance). The data processing for future global NAVEX sessions was modified to do a final editing and weighting of the data using the hourly piecewise linear parametrization of high-frequency Earth orientation changes.

The NAVEX-G data have been used in a number of initial comparisons between simultaneous VLBI sessions ([2], [3]), as well as in comparisons between VLBI and data from the Global Positioning system (see, e.g., [4]), and with other data types such as atmospheric angular momentum data. When the EPOCH'92 R&D and NAVEX-G VLBI data are used to estimate the UT1 and polar motion on an hourly basis, there are 104 hourly values with simultaneous data. The R&D and NAVEX-G data have an rms difference (in all three components of Earth orientation) of about ±0.5 milli arc seconds (mas). Although in polar motion the observed residual scatter is consistent with the root sum square (rss) of the R&D and NAVEX-G formal errors, the UT1 differences are significantly larger than would be expected from the formal errors, evidence of roughly ±0.4 mas of unmodeled errors. In general, the observed hourly fluctuations in UT1 and polar motion agree well, but not perfectly, with independent models of the tidally forced diurnal and semi-diurnal orientation changes, and it is clear that these tidal variations are the dominant source of orientation changes at periods between about two days and one hour. These comparisons bound any non-tidal variations in orientation in this period range during EPOCH'92 to be ≤ about 0.4 mas rms in all three components of orientation

The EPOCH'92 results show that accurate, high quality VLBI Earth orientation results can be obtained from global networks. Global scale VLBI offers a number of advantages, including the maximum sensitivity to Earth orientation changes and the best means of decoupling orientation changes from local and regional motions of the antennas, such as those caused by ocean tidal loading. Global scale VLBI also avoids the "edge effect" found in smaller networks, where certain stations on the edge of the network cannot obtain complete sky coverage due to their distance from the rest of the network. In order to investigate the long term stability and accuracy of orientation results from global networks the USNO organized a series of six global sessions during 1993, with the number of stations used being increased from six to a maximum of ten. These large networks thus have sufficient redundancy to be divided into sub-networks, each providing independent orientation data of good quality. This on-going work thus extends and complements the EPOCH'92 NAVEX-G simultaneous sessions, in order to determine better the sources of systematic error limiting the accuracy of geodetic VLBI. Similar global experiments were organized during the January, 1994, CONT-94 period, to provide another period of simultaneous observations between independent VLBI networks.

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