Onsala Space Observatory – IVS Analysis Center

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Abstract

This report briefly summarizes the activities of the IVS Analysis Center at the Onsala Space Observatory during 2011 and gives examples of results of ongoing work.

1. Introduction

We concentrate on a number of research topics that are relevant for space geodesy and geosciences. These research topics are addressed in connection to data observed with geodetic VLBI and complementing techniques.

2. Assessment of Ultra-rapid dUT1-sessions

Since 2007, Onsala and Tsukuba have cooperated in a project to perform so-called ultra-rapid dUT1-sessions. For these sessions, real-time data transfer, near real-time correlation, and an automated near real-time data analysis allows the determination of dUT1 results with very low latency. In the beginning of the project, these sessions were dedicated Intensive-style sessions on one baseline for about 1 hour. Since 2009, normal 24-hour-long IVS sessions have also been observed in ultra-rapid mode. We performed a preliminary assessment of the dUT1 results derived in ultra-rapid mode [1]. The agreement between the ultra-rapid dUT1 results and the IERS final results is about 30 msec, i.e. approximately on the same level as the agreement between the IERS rapid results and the IERS final results. However, the ultra-rapid dUT1 results have a much lower latency and are, for example, available already during ongoing 24-hour IVS sessions.

3. Multi-technique Comparisons of Zenith Wet Delay Estimates

We compared 10-year-long time series of atmospheric zenith wet delay data [2]. These data were derived from VLBI, GPS, and ground-based radiometry at the Onsala Space Observatory, radiosondes from Landvetter airport, at a distance of about 37 km from Onsala, and the reanalysis product from the European Center for Medium-Range Weather Forecast. This comparison significantly extends previous work focussing on VLBI CONT-sessions only, see e.g. [3]. The best agreement over the 10 year period is seen between GPS and VLBI with a mean bias of −3.4 mm and a standard deviation of 5.1 mm. The ECMWF product shows a positive bias of about 7 mm with respect to the other techniques.

4. Trends in the Amount of Integrated Atmospheric Water Vapor

We also compared long term trends in the amount of integrated atmospheric water vapor derived from four different techniques [4]. The four techniques are VLBI, GPS, ground-based radiometry at the Onsala Space Observatory, and radiosondes from Landvetter airport, at a distance of about 37 km from Onsala. The time series cover up to 30 years of data, and the four techniques detect individual positive trends in the integrated water vapor (IWV) on the order of 0.3 to 0.6

kg/m^2 per decade. The IWV data derived from the techniques agree with correlation coefficients on the order of 0.95 and better and root mean-square differences of less than 2 kg/m^2.

5. Raytracing through the High Resolution Numerical Weather Model HIRLAM

We used the conformal theory of refraction to perform raytracing through data of the High Resolution Numerical Weather Model HIRLAM, and we computed slant delays for 15 European geodetic VLBI sessions between 2005 and 2007 [5]. Compared to our previous raytracing approaches, the new approach enables us to include atmospheric inhomogenities.

6. Ocean Tides at Onsala

We used data recorded with the GNSS-based tide-gauge at Onsala [6] to determine ocean tidal constituents and compared these to theoretical models. The results indicate that the accuracy of global ocean models is restricted in the Skagerrak and Kattegat, and refined regional ocean tide models are necessary [7, 8].

7. Ocean Tide Loading

The automatic ocean tide loading provider [9] was maintained during 2011. Three new ocean tide models, DTU10 [10, 11] from the Danish University of Technology, EOT11a (which is an updated version of ET08a [12]) from DGFI Munich, and HAMTIDE [13] from the Institute of Oceanography at Hamburg University, were included.

8. VLBI Observations of GLONASS Satellite Signals

We continued to work on the analysis of VLBI observations of GLONASS satellite signals observed on the baseline Onsala – Medicina [14]. Fringes were successfully found with two different and independent software correlators.

9. Outlook

The IVS Analysis Center at the Onsala Space Observatory will continue its efforts to work on specific topics relevant to space geodesy and geosciences. During 2012 we plan to intensify our activities, in particular concerning VLBI data analysis.

References

[1] Haas R, Hobiger T, Sekido M, Koyama Y, Kondo T, Takiguchi H, Kurihara S, Kokado K, Tanimoto D, Nozawa K, Wagner J, Ritakari J, Mujunen A, Uunila M (2011) Near real-time monitoring of UT1 with geodetic VLBI. In: W. Alef, S. Bernhart, A. Nothnagel (eds.): *Proc. 20th Meeting of the European VLBI Group for Geodesy and Astrometry*, 64–66.

[2] Ning T, Haas R, Elgered G, Willén U (2011) Multi-technique comparisons of 10 years of wet delay estimates on the west coast of Sweden. *Journal of Geodesy*, online published November 22, 2011, doi:10.1007/s00190-011-0527-2

[3] Teke K, Böhm J., Nilsson T, Schuh H, Steigenberger P, Dach R, Heinkelmann R, Willis P, Haas R, Garcia-Espada S, Hobiger T, Ichikawa R, Shimizu S (2011) Multi-technique comparison of troposphere zenith delays and gradients during CONT08. *Journal of Geodesy*, **85(7)**, 395–413, doi:10.1007/s00190-010-0434-y

[4] Haas R, Ning T, Elgered G (2011) Long-Term Trends in the Amount of Atmospheric Water Vapour Derived From Space Geodetic and Remote Sensing Techniques. *ESA Proceedings WPP 326 : Proc. 3rd Int. Colloquium – Scientific and Fundamental Aspects of the Galileo Programme*

[5] García-Espada S, Haas R, Colomer-Sanmartin F (2011) Application of ray-tracing through the high resolution numerical weather model HIRLAM applying the Conformal Theory of Refraction. In: W. Alef, S. Bernhart, A. Nothnagel (eds.): *Proc. 20th Meeting of the European VLBI Group for Geodesy and Astrometry*, 133–137.

[6] Löfgren J, Haas R, Johansson J M (2011) Monitoring coastal sea level using reflected GNSS signals. *J. Advances in Space Research*, **47(2)**, 213–229, doi:10.1016/j.asr.2010.08.015

[7] Löfgren J, Haas R, Scherneck H-G (2011) Three months of local sea-level derived from reflected GNSS signals. *Radio Science*, **46**, (RS0C05), doi:10.1029/2011RS004693

[8] Löfgren J, Haas R, Scherneck H-G (2011) Sea-Level Analysis Using 100 Days of Reflected GNSS Signals. *ESA Proceedings WPP 326 : Proc. 3rd Int. Colloquium – Scientific and Fundamental Aspects of the Galileo Programme*

[9] Scherneck H.-G., Bos M. (2002) Ocean Tide and Atmospheric Loading. In: *IVS 2002 General Meeting Proceedings*, N.R. Vandenberg and K.D. Baver (eds.), **NASA/CP-2002-210002**, 205–214.

[10] Andersen OB, Knudsen P (2009) The DNSC08 mean sea surface and mean dynamic topography. *J. Geophys. Res.*, **114, C11**, doi:10.1029/2008JC005179

[11] Andersen OB (2010) The DTU10 Gravity field and Mean sea surface. *Second international symposium of the gravity field of the Earth (IGFS2)*, Fairbanks, Alaska.

[12] Savcenko R, Bosch W (2008) EOT08a - empirical ocean tide model from multi-mission satellite altimetry. *DGFI Report 81*, Deutsches Geodätisches Forschungsinstitut (DGFI), München.

[13] Taguchi E, Stammer D, Zahel W (2010) Estimation of deep ocean tidal energy dissipation based on the high-resolution data-assimilative HAMTIDE model. (to be submitted to J. Geophys. Res.).

[14] Tornatore V, Haas R, Duev D, Pogrebenko S, Casey S, Molera-Calves G, Keimpema A (2011) Single baseline GLONASS observations with VLBI: data processing and first results. In: W. Alef, S. Bernhart, A. Nothnagel (eds.): *Proc. 20th Meeting of the European VLBI Group for Geodesy and Astrometry*, 162–165.