Onsala Space Observatory – IVS Analysis Center

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Abstract

We briefly summarize the activities of the IVS Analysis Center at the Onsala Space Observatory during 2009 and give 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 complementary techniques.

2. Simulations for VLBI2010: Assessment of Atmospheric Turbulence for VLBI

During 2009 we continued to contribute to the simulations for the VLBI2010 project [1] and to the VLBI2010 design [2]. Using simulated and observed data from CONT05 and CONT08, we assessed the importance of atmospheric turbulence for geodetic VLBI [3], [4]. For this purpose, we used a method to simulate wet delays in a turbulent atmosphere [5], [6]. Seven different sets of turbulence parameters C_n^2 were used for these simulations, including standard C_n^2 values from literature (simulations S-1 and S-2), C_n^2 values derived from high-resolution radiosonde profiles (S-3 to S-5), and C_n^2 values derived from GPS observations at the CONT08 stations (S-6 and S-7). Clock errors were simulated as the sum of a random walk process, an integrated random walk process, and an integrated integrated random walk process. The observation noise was simulated as white noise with a standard deviation of 30 ps.

We analyzed the simulated and the observed data sets with the CALC/SOLVE software [7] using an identical analysis strategy. Radio source positions, polar motion, and the earth rotation angle were fixed to apriori values. The earth rotation rate and nutation offsets were estimated as daily parameters. Station positions were estimated for all participating stations, applying no-net-translation and no-net-rotation conditions. Clock and atmosphere parameters were estimated as piece-wise linear functions with an interval length of 20 minutes, and horizontal gradients were estimated every 6 hours. Figure 1 shows the repeatabilities of the three dimensional station position grouped according to the analysis. Results from the analysis of the seven simulated data sets (S-1 to S-7) and the observed data (Ref) are presented.

The study shows that atmospheric turbulence is the major error source for geodetic VLBI today. It also shows that the best agreement with the observations are obtained for the simulations using C_n^2 obtained from the variance of the zenith total delay estimated from GPS data (S-6 and S-7).

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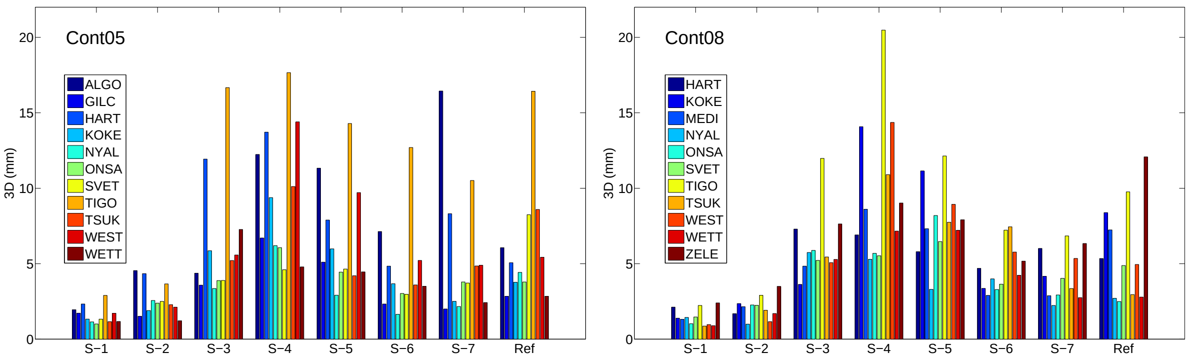

Figure 1. Repeatabilities of the three dimensional station positions grouped according to the analysis (simulations S-1 to S-7 and reference solution Ref) for CONT05 (left) and CONT08 (right). The participating stations are shown with colored bars in the order listed in the key. Be aware that the color codes are different for CONT05 and CONT08.

3. Simulations for VLBI2010: Impact of Telescope Slew Rates

We studied the impact of the telescope slew rates on the geodetic results if a new and fast radio telescope is added to the existing VLBI network of rather slow telescopes [8]. In principle, faster slew rates do improve the accuracy of, for example, the derived station coordinates. However, fast slew rates also mean increased mechanical stress for the telescope. Furthermore, we show that by adding a fast telescope to a network of slower telescopes, the amount of idle time increases. A good balance between increased accuracy for the geodetic results and increased mechanical stress has to be found. This means that it might be advantageous to control and successively adapt telescope slew rates of newly added fast telescopes in the transition from today's VLBI network to the future VLBI2010 network.

4. An Assessment of Long Time Series of Atmospheric Water Vapor Content

During 2009 we assessed the possibility of validating long time series of the atmospheric water vapor [9]. An overall motivation was to determine the relationship—and its uncertainties—between trends in the atmospheric water vapor and trends in the ground temperature. For this study we used one decade of data from GPS and VLBI observed at the Onsala Space Observatory, and additionally radiosonde (RS) data from the Gothenburg-Landvetter Airport, covering November 1996 to November 2006. Figure 2 shows the corresponding time series of the equivalent zenith wet delay.

The results show that the three data sets give comparable accuracy for time series of atmospheric water vapor. However, we also find that the frequency of VLBI experiments observed at the Onsala Space Observatory is too low to validate estimated linear trends using data acquired over a ten year period.

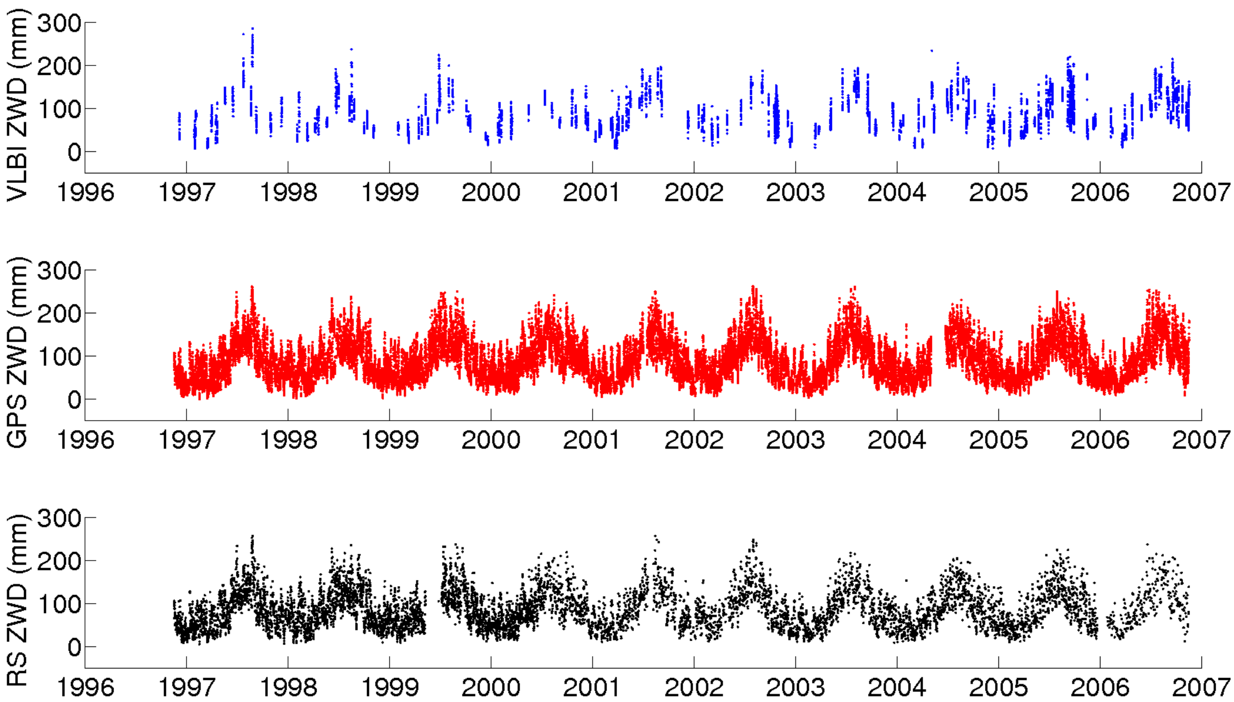

Figure 2. Time series of the equivalent zenith wet delay (ZWD) estimated from VLBI data (top), GPS data (middle), and radiosonde (RS) data (bottom).

5. Ultra-rapid dUT1 Observations

We compared the results of the Fennoscandian-Japanese ultra-rapid dUT1 experiments [10] with the corresponding values of the IERS Bulletin-A, the IERS rapid service) and the IERS Bulletin-B [11]. As a reference for the comparison, we used the IERS C04 series. The study shows that the agreement of the ultra-rapid dUT1 results with IERS C04 is on the same level as the IERS rapid values. However, the latency of the ultra-rapid dUT1 values is much shorter and can be on the order of a couple of minutes [12].

6. Contribution to the IVS Trop Project

During 2009 we started again slowly to contribute to the IVS Trop Project. So far we contributed time series of tropospheric parameters for CONT08. The plan is, however, to restart a regular contribution with the results of all R1 and R4 sessions.

7. Ocean Tide Loading

The automatic ocean tide loading provider [13] was maintained during 2009. A small bug in the refinement stage of the loading provider was corrected, and the new ocean model TPXO.7.2 was added [14].

8. Outlook

The IVS Analysis Center at the Onsala Space Observatory will continue its efforts to work on specific topics relevant for space geodesy and geosciences. During 2010 we plan to intensify the analysis of VLBI data and, for example, restart our contribution to the IVS TROP project.

References

[1] Behrend D, Böhm J, Charlot P, Clark T, Corey B, Gipson J, Haas R, Koyama Y, MacMillan D, Malkin Z, Niell A, Nilsson T, Petrachenko B, Rogers A E E, Tuccari G, & Wresnik J (2008) Recent progress in the VLBI2010 development. In: *Proc. IUGG XXIV General Assembly 2007*, Observing our Changing Earth, IAG Symposia, 133, 833–840, Springer, `doi:10.1007/978-3-540-85426-5`.

[2] Petrachenko B, Niell A, Behrend D, Corey B, Böhm J, Charlot P, Collioud A, Gipson J, Haas R, Hobiger T, Koyama Y, MacMillan D, Malkin Z, Nilsson T, Pany A, Tuccari G, Whitney A, & Wresnik J (2009) Design Aspects of the VLBI2010 System. **NASA/TM-2009-214180**, 58 pages.

[3] Nilsson T, & Haas R (2009) An Assessment of Atmospheric Turbulence for CONT05 and CONT08. In: *Proc. 19th EVGA Working Meeting*, G. Bourda, P. Charlot, and A. Collioud (eds.), 39–43.

[4] Nilsson T, & Haas R (2010) Impact of atmospheric turbulence on geodetic very long baseline interferometry. *Journal of Geophysical Research*, `doi:10.1029/2009JB006579`, in press.

[5] Nilsson T, Haas R, & Elgered G (2007) Simulations of atmospheric path delays using turbulence models. In: *Proc. 18th EVGA Working Meeting*, J. Böhm, A. Pany, and H. Schuh (eds.), 175–180.

[6] Nilsson T, & Haas R (2008) Modeling Tropospheric Delays with Atmospheric Turbulence Models. In: *Proc. 5th IVS General Meeting*, A. Finkelstein and D. Behrend (eds.), 361–370.

[7] Ma C, Sauber J M, Bell L J, Clark T A, Gordon D, Himwich W E & Ryan J W (1990) Measurement of horizontal motions in alaska using very long baseline interferometry. *Journal of Geophysical Research*, **95(B13)**, 21 991–22 011, `doi:10.1029/JB095iB13p21991`.

[8] Garcia-Espada S, Colomer Sanmartin F, & Haas R (2009) Simulations of Different Antenna Velocities in VLBI Networks. In: *Proc. 19th EVGA Working Meeting*, G. Bourda, P. Charlot, and A. Collioud (eds.), 169–172.

[9] Elgered G, Haas R, & Nilsson T (2009) Atmospheric VLBI: A method to validate long time series of water vapour content. In: *Proc. 19th EVGA Working Meeting*, G. Bourda, P. Charlot, and A. Collioud (eds.), 49–53.

[10] Sekido M, Takiguchi H, Koyama Y, Kondo T, Haas R, Wagner J, Ritakari J, Kurihara S, Kokado K (2008) Ultra-rapid UT1 measurements by e-VLBI. *Earth Planets and Space*, **60**, 865–870.

[11] Haas R, Sekido M, Kurihara S, Hobiger T, Wagner J, Kondo T, Koyama Y, Tanimoto D, Takiguchi H, Kokado K, Ritakari J, & Mujunen A (2009) Ultra-rapid dUT1-observations with e-VLBI. Presentation at *IERS Workshop on EOP Combination and Prediction, Warsaw, 19-21 October 2009*, `www.cbk.waw.pl/EROPPW2009/contributions/session1/session1.1/mon09_Haas_et_al_IERS_2009.pdf`.

[12] Matsuzaka S, Shigematsu H, Kurihara S, Machida M, Kokado K, & Tanimoto D (2008) Ultra Rapid UT1 Experiment with e-VLBI. In: *Proc. 5th IVS General Meeting*, A. Finkelstein and D. Behrend (eds.), 68–71.

[13] 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.

[14] Egbert G D, & Erofeeva L (2002) Efficient inverse modeling of barotropic ocean tides. *Journal of Atmospheric and Oceanic Technology*, **19**,183–204.