Neutral atmosphere delays and UT1 determination from VLBI Intensive sessions

Hobiger T.[1], J. Boehm[2], R. Ichikawa[1], T. Kondo[1,3], Y. Koyama[1], A. Pany[2], H. Schuh[2] and K. Teke[2]

(1) National Institute of Information and Communications Technology, Japan;
(2) Vienna University of Technology, Austria; (3) Ajou University, Suwon, Korea
(*) Contact: hobiger@nict.go.jp

Abstract

One-baseline one-hour VLBI (Very Long Baseline Interferometry) Intensive sessions are carried out each day to determine Universal Time (UT1). Azimuthal asymmetry of troposphere delays around the stations is usually ignored and not estimated because of the small amount of observations. In this study we use external information about the asymmetry for the Intensive sessions between Tsukuba (Japan) and Wettzell (Germany), which are carried out on Saturdays and Sundays, (1) from direct ray-tracing for each observation at Tsukuba and (2) in the form of linear horizontal north and east gradients every six hours at both stations.

INT2 sessions

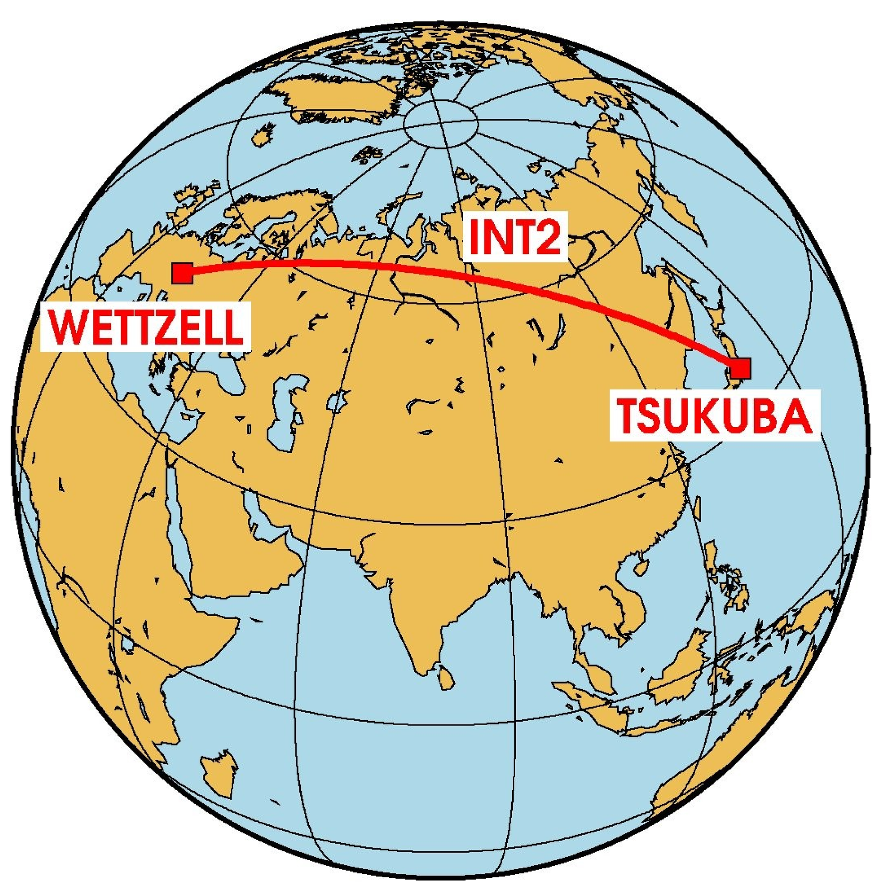

***Figure 1**: Baseline geometry of the INT2 experiments.*

VLBI analysis

Due to the few number of observations, troposphere gradients can not be parameterized when UT1 values are estimated. Since gradients have a significant impact on the UT1 results two different approaches are tested here. First, linear horizontal gradients (LHG) from global weather models are applied to both stations. Secondly, ray-traced troposphere delays (Kashima Ray-tracing tools-KARAT [1]), available only for the Japanese station (Tsukuba), are used to compensate the troposphere delay. The latter approach does not account for mm-accurate total slant corrections, but is expected to depict the local troposphere asymmetry well.

LHG gradients vs. KARAT

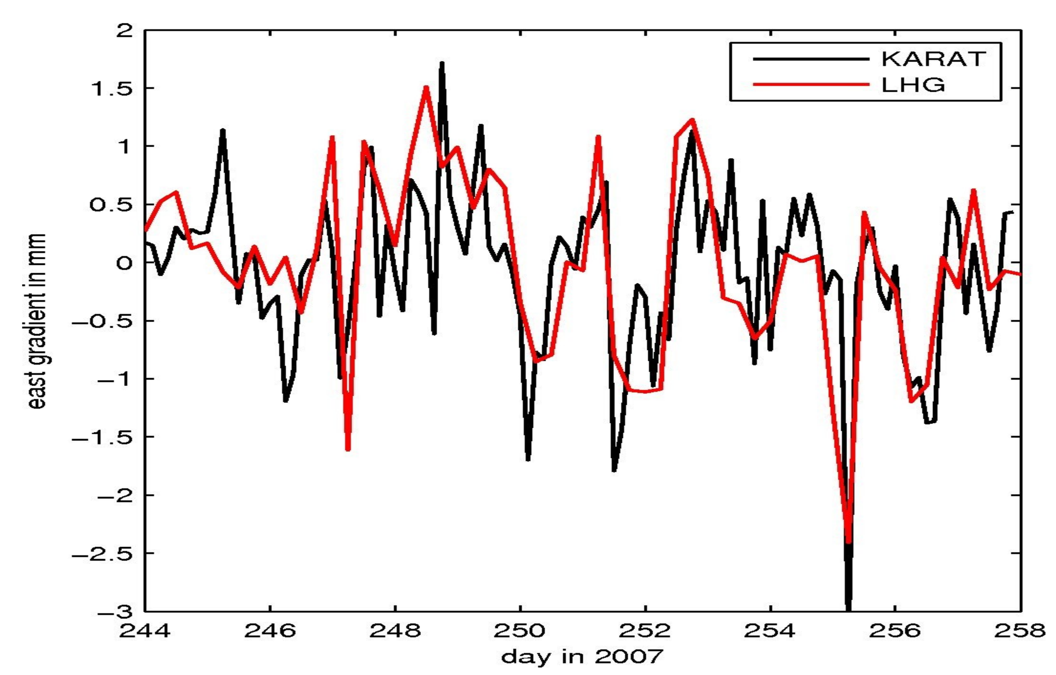

***Figure 2**: Total east gradients at station Tsukuba as derived with KARAT and with LHG during a period of rapid weather changes (a typhoon occurred on ~ day 250) in 2007. The east gradients vary generally between ± 2 mm with one extreme value at ± 3 mm. Empirical studies reveal that an un-modeled troposphere east gradient of 1mm leads to an UT1 error of 15µs*

Troposphere estimates at Tsukuba

Since ray-traced delays are not 100% accurate it is necessary to estimate residual troposphere errors by a basic mapping function. Figure 3 depicts the estimated wet delays at station Tsukuba as well as these residual troposphere delays.

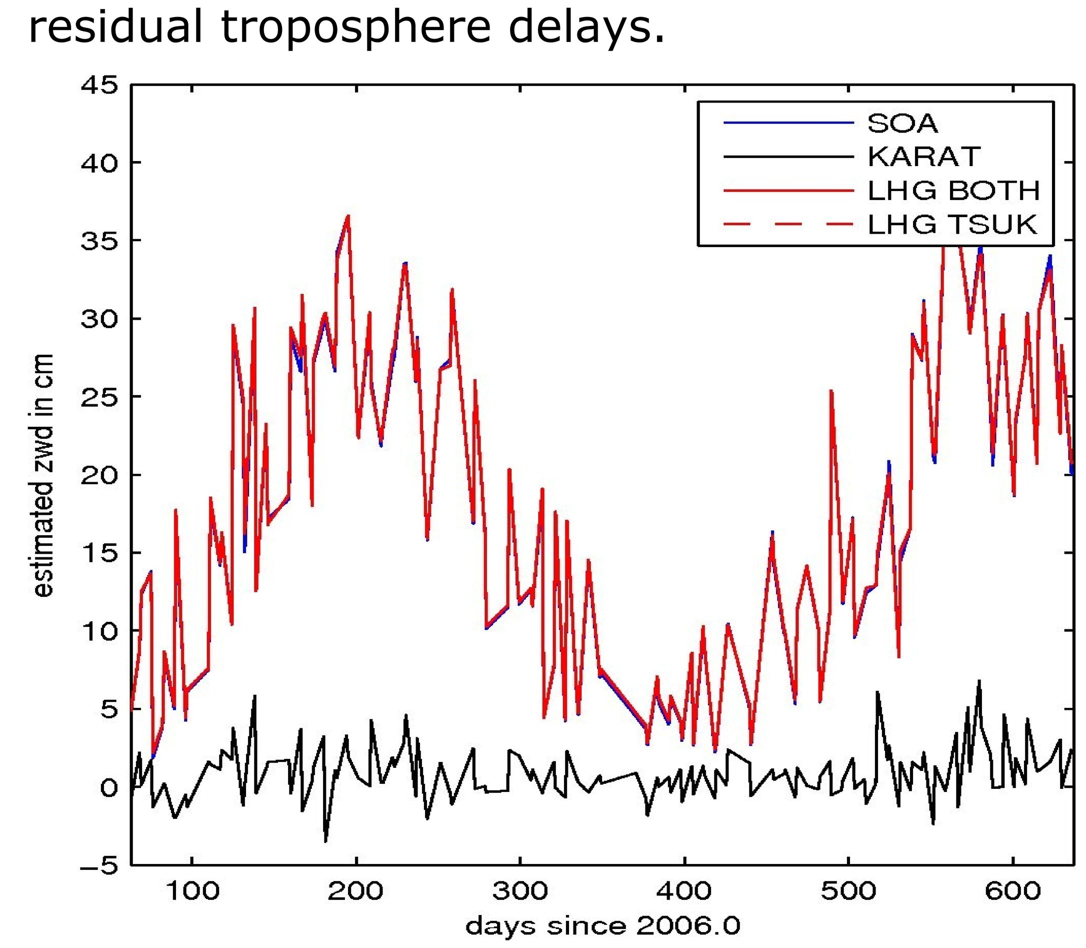

***Figure 3:** Zenith wet delays for station Tsukuba estimated in the VLBI analysis of the Intensive sessions. With all four strategies (state-of-the-art (SOA), LHG at Tsubuka only, LHG at both stations and KARAT slant delays) a single offset per Intensive session was estimated.*

Spectrum of the UT1 estimates

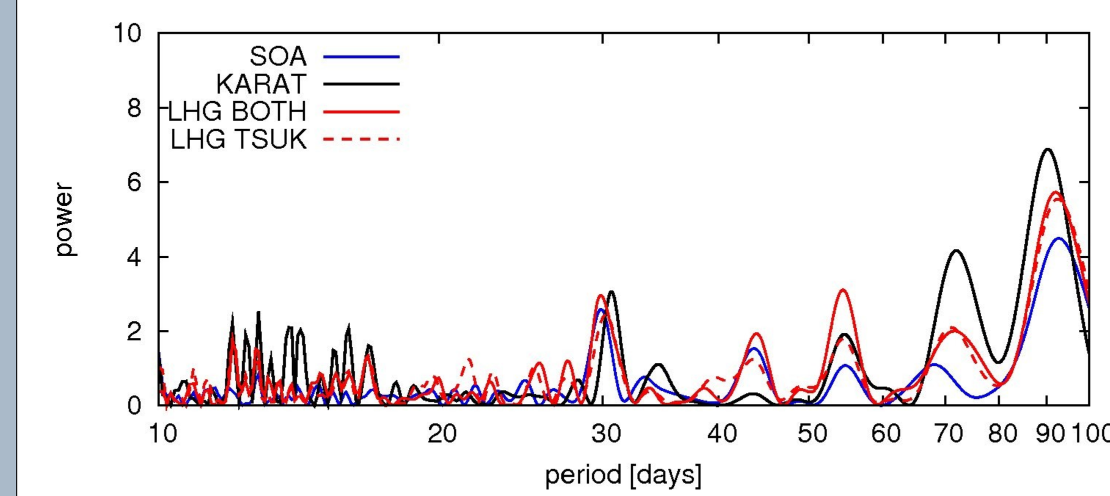

***Figure 4:** Lomb-Scargle periodogram of the UT1 estimates w.r.t. IERS 05 C04. The power at fortnightly periods is clearly increased using the delays from direct ray-tracing with KARAT.*

Differences w.r.t. IERS C04

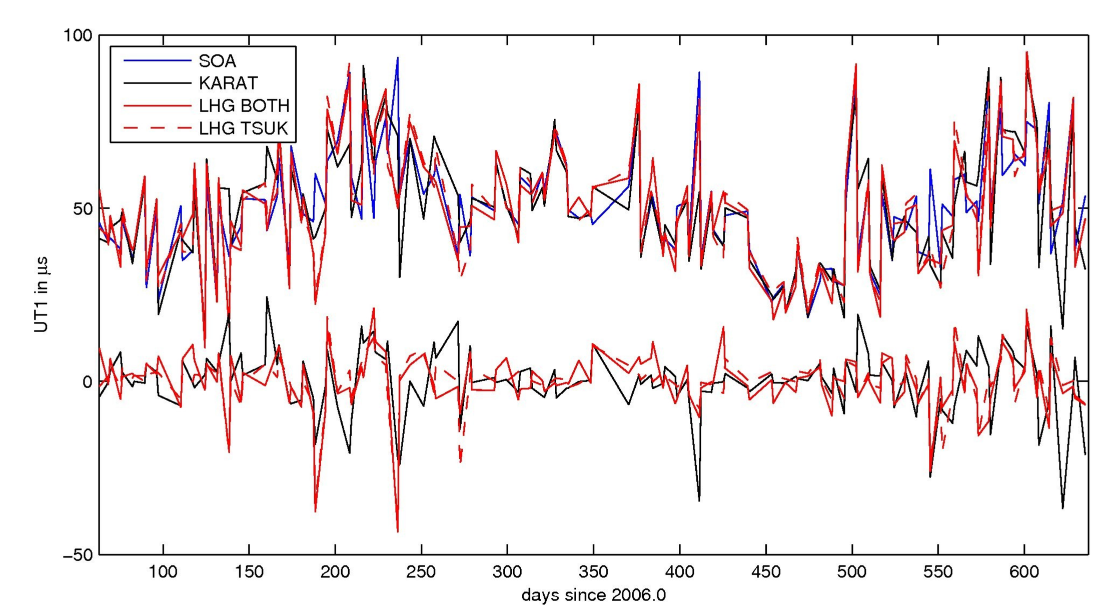

***Figure 5:** Hourly offsets of UT1 values for the INT2 sessions w.r.t. IERS 05 C04 (shifted by 50 µs for clarity). The differences are shown in the three lower lines (around zero) and they are in the sense KARAT/LHG minus state-of-the-art.*

Statistics

	A	B	C	D
SOA	13.3 µs	8.0 µs	23.7 µs	62.0 µs
LHG TSUKUBA	15.1 µs	7.9 µs	23.8 µs	65.4 µs
LHG BOTH	15.3 µs	7.9 µs	23.4 µs	64.5 µs
KARAT	14.8 µs	7.9 µs	22.8 µs	65.5 µs

Table 1: Column A: standard deviation of UT1 estimates w.r.t. IERS 05 C04 (plus ocean tidal terms) and after removing an annual fit; column B: mean formal errors of UT1 estimates; column C: standard deviation w.r.t. length-of-day estimates from GPS; column D: standard deviation w.r.t. modeled length-of-day variations caused by atmospheric angular momentum (AAM) excitation

Comparison with LOD from GPS

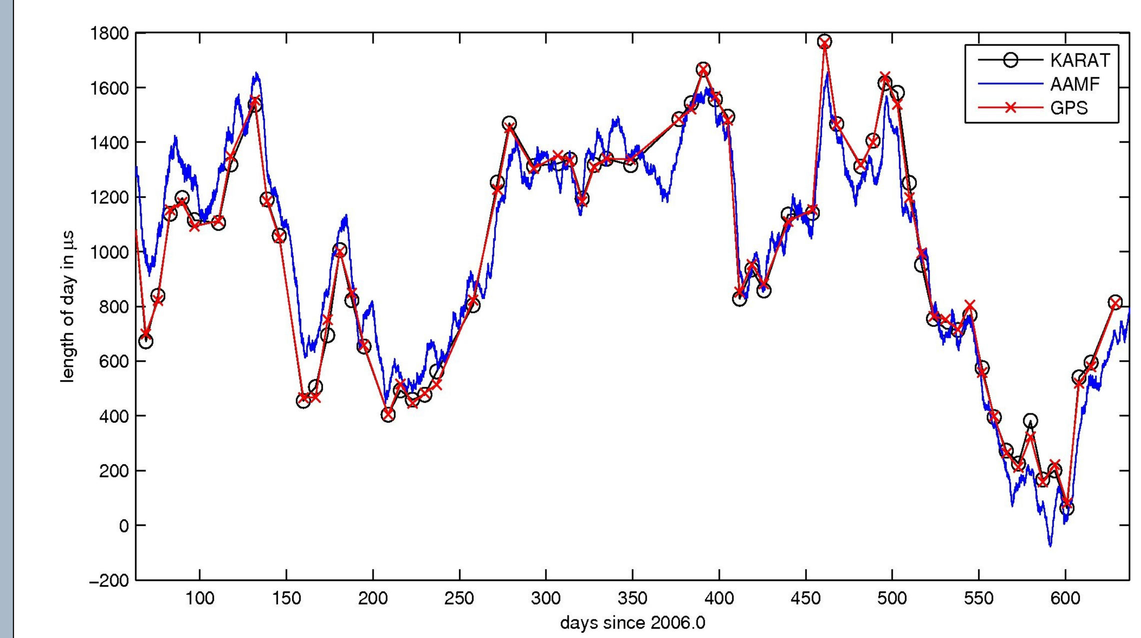

***Figure 6**: Length-of-day as determined with the KARAT approach from the Saturday and Sunday Intensives and as derived from motion and matter terms of the ECMWF. For clarity, only the KARAT approach is shown as representative for the Intensives.*

Conclusions

We use delays from direct ray-tracing with KARAT, and alternatively we apply linear horizontal gradients (LHG) to assess the impact on the determination of UT1. Compared to the combined IERS 05 C04 series (which already contains state-of-the-art UT1 estimates from Intensives), KARAT introduces significantly more power at periods of about two weeks compared to the linear horizontal gradients and the state-of-the-art approach in particular. If the UT1 estimates are converted to length-of-day, there is a slightly better agreement with daily GPS estimates for the KARAT series than for the other approaches (LHG and state-of-the-art). This is an indication that direct ray-tracing (like KARAT) has the potential to improve UT1 estimates from Intensives. A future task will be the provision of delays from direct ray-tracing at the other stations participating in Intensives and the application in VLBI analysis. Conceptually, this will be the best way to go if we consider future improvements of numerical weather models. More details about this study can be found in [2].

References

[1] Hobiger T., R. Ichikawa, Y. Koyama, T. Kondo., Fast and accurate ray-tracing algorithms for real-time space geodetic applications using numerical weather models, J. Geophys. Res., 113, D20302, 2008.

[2] Boehm J., T. Hobiger, R. Ichikawa, T. Kondo, Y. Koyama, A. Pany, H. Schuh, K. Teke, Neutral atmosphere delays and UT1 determination from VLBI Intensive sessions, submitted to Journal of Geodesy, 2009.

This work was supported by a Grant-in-Aid for scientific research (KAKENHI, No. 21241043).