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First Results from CONT05

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Abstract

CONT05 was a 15-day campaign of continuous VLBI sessions with a network of eleven globally distributed stations in September 2005. One of the main design goals for CONT05 was to obtain the highest accuracy that VLBI is capable, with some practical limitations, over the continuous two-week period. We discuss the scheduling and geometrical design for CONT05 and present preliminary analysis results on EOP precision, baseline length precision, and the observed subdaily EOP estimates compared with a tidal model. Daily EOP values determined by CONT05 have a precision matched only by the larger RDV sessions. Formal errors are in the range of ∼35–40 μasec for X and Y pole, ∼1.4–1.5 μs for UT1, and ∼75 and ∼30 μasec for nutation in longitude and obliquity.

1. Introduction

During the period September 12–27, 2005 the IVS conducted a campaign of continuous observing using a network of 11 antennas. The plan for CONT05 was to obtain the highest accuracy that VLBI is capable, with practical limitations, over the continuous two-week period. Goals of CONT05 were to address several scientific questions including the origin of discrepancies between high frequency (subdaily) Earth Orientation Parameters (EOP) tidal models and observed subdaily EOP, to study technique improvement, to study reference frame accuracy day to day, and to compare measurements made by co-located geodetic systems.

Figure 1. CONT05 Observing Network.

The CONT05 campaign was the latest in a series of continuous campaigns beginning with CONT94. Figure 1 shows the station locations of the CONT05 network, which has more stations and generally better global distribution than the previous campaigns. Nevertheless, it would have been desirable to have more southern latitude stations or at least more stations at latitudes less than 20°N. We discuss the scheduling and geometrical design for CONT05 and present preliminary analysis results from the campaign.

2. Network Selection and Session Scheduling

In order to determine which stations were to participate in the CONT05 campaign, a pool of 14 candidate stations was selected. The selection was based on the high quality performance of the stations, on the experience from previous CONTs, and on the results of simulation studies. A call for participation was sent to the candidate stations. All stations agreed on becoming a CONT05 station except for Seshan (due to a scheduled hardware upgrade) and Hobart (lack of observing time). Fortaleza's participation was dependent on a timely upgrade to the Mark 5 system which unfortunately was not possible. The final network consisted of 11 stations as depicted in Figure 1.

The schedules were created using NASA's sked software. The observing mode corresponded to the IVS-R1 sessions with an observation rate of 256 Mbit/s. With the network fixed, several different schedules with varying scheduling parameters were made and the best schedule was chosen based on the expected EOP formal uncertainties.

Special care was taken for the selection of the radio sources. The sources for the schedules were based on the best 80 sources of the good geodetic source catalog. One source was taken out due to known source structure. Five other sources were taken out using a scoring scheme derived from the number of non-detections of the most recent (six months) R1 and R4 sessions. Only sources that had non-detection rates of less than 15% were retained. The number of sources being used for the scheduling was 74.

3. Quality Assessment

An obvious measure for the quality of the CONT05 data set are the formal uncertainties of the parameters solved for in the adjustment process. Table 1 compares the EOP formal uncertainties from CONT05 and from the R1, R4, and RDV series in 2005. Intra-scan observations on baselines from the same station are correlated due to unmodeled noise (such as station-inherent instrumental errors and atmospheric delays). Not accounting for this correlation has the formal uncertainties decrease too rapidly with the number of stations. Scaling up the formal uncertainties of an N-station network by a factor of $\sqrt{\frac{(N-1)}{2}}$ yields a more realistic measure of the observed uncertainty. Table 1 shows that the uncertainties (not scaled up) were significantly better for CONT05 than for the operational R1 and R4 series. Also the larger 2005 RDV sessions did not attain the high precision of the CONT sessions. Only a comparison to earlier RDV sessions (e.g., 2003-2004) shows a similar precision. Another way of assessing the precision of a series of experiments is to compute the baseline length repeatability. This measure has the advantage that it is independent of translation or rotation that can be absorbed into station topocentric coordinate time series. Figure 2 shows that the baseline length repeatabilities over all CONT05 baselines are at the 1 ppb level. All of the TIGOCONC baselines are longer than 8000 km and have the largest repeatabilities. With non-TIGOCONC baselines, the precision is 0.7–0.9 ppb.

To assess the EOP accuracy of the CONT05 data set, we compared the EOP results with values derived from GPS. For that we computed the differences VLBI–GPS for CONT05 as well as

Table 1. Average EOP formal uncertainties for selected sessions of the observing year 2005.

Series	Number	X-pole	Y-pole	UT1	Psi	Eps
		μas	μas	μs	μas	μas
CONT05	15	37	37	1.5	76	28
R1	50	73	72	3.0	157	62
R4	49	68	65	2.5	149	60
RDV	5	44	51	2.6	89	35

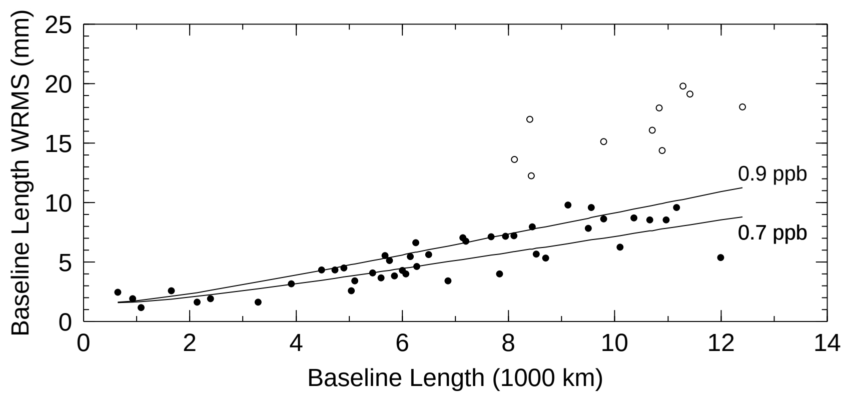

Figure 2. CONT05 baseline length repeatability where TIGOCONC baselines are denoted by open circles

for the R1 and R4 series during 2005. To do this we interpolated (cubic spline) the International GNSS Service (IGS) EOP series [2] to the VLBI epochs. Figure 3 shows the corresponding polar motion differences. The CONT05 EOP series are significantly closer to the IGS series (by about 50–60%) than either the R1 or R4 series. The statistics of the differences are given in Table 2.

Table 2. WRMS and χ^2/dof after removing offsets and biases for the polar motion and length of day differences between VLBI and GPS for CONT02 and CONT05 and the 2005 R1 and R4 series

Parameter	CONT02		CONT05		R1		R4	
	WRMS	χ2/dof	WRMS	χ2/dof	WRMS	χ2/dof	WRMS	χ2/dof
X-pole (μas)	99	3.1	55	2.1	92	2.4	96	2.2
Y-pole (μas)	65	1.9	36	0.9	91	2.5	106	2.9
X-pole rate (μas/d)	202	1.1	198	3.3	275	2.2	328	2.1
Y-pole rate (μas/d)	264	3.9	158	2.1	286	2.2	284	1.7
LOD (μs/d)	12.1	2.2	16.7	6.0	17	3.9	18.5	3.7

Possible reasons for the improved EOP agreement for CONT05 include (1) that the R1 and R4 networks only had 7–8 stations whereas CONT05 had 11 stations—in fact, a few R1 networks were subsets of the CONT05 network—and (2) that the global distribution of sites was generally

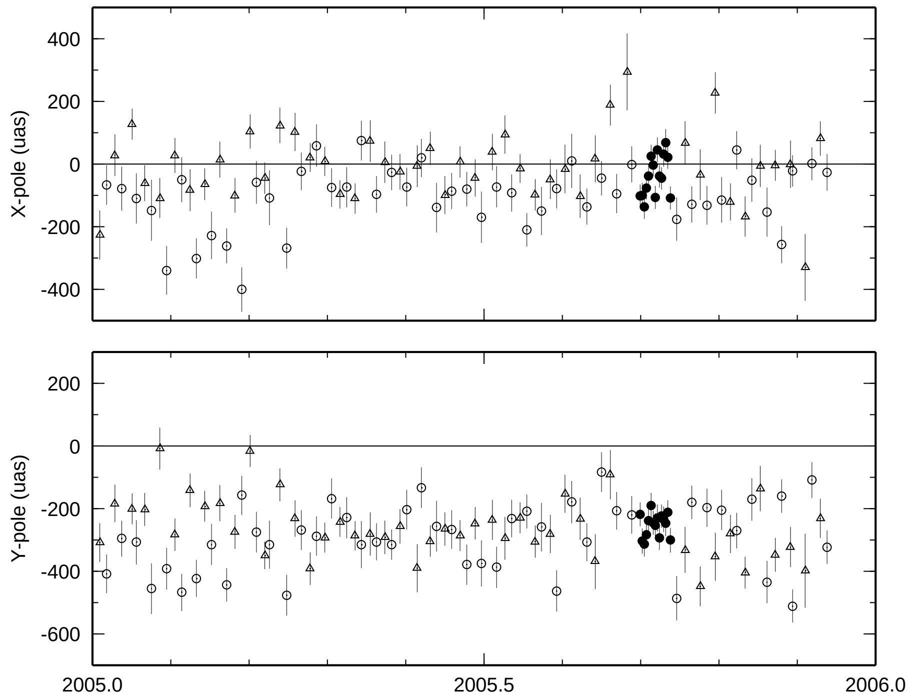

Figure 3. Polar motion differences between VLBI and GPS for the CONT05 series (solid circles), the R1 series (open triangles), and R4 series (open circles).

better for CONT05 than for the R1 and R4 experiments. In order to test this hypothesis, several test runs were made using subsets of the full CONT05 network. The agreement between EOP values from IGS and from VLBI subnets degraded significantly. Using these subsets, the EOP RMS differences were about twice as large as for the full CONT05 network.

4. Subdaily Earth Orientation Parameters

One of the principal motivations for doing the CONT series is to study the subdaily Earth orientation. We performed a solution to estimate EOP at 1-hour intervals using constraints of 10 mas/day for polar motion and 1 ms/day for UT1. The estimated subdaily UT1 series relative to the slowly-varying daily a priori series is shown in Figure 4. Superimposed is the high frequency tidal model of Gipson [1996] in which polar motion and UT1 tidal terms were estimated from all the VLBI data from 1980-1997.

Table 3 provides a summary of several statistics regarding daily and subdaily estimates of EOP from the CONT campaigns. It can be seen that the formal EOP precision for CONT05 is significantly better than the previous campaigns. Subdaily residuals have been computed after removing a high frequency tidal model from Gipson [1996; updated model in 1999 with more data]. These residuals have an RMS of about 180 μas, which is somewhat greater than the formal uncertainties. It is likely that these residuals are due mainly to atmospheric and oceanic angular momentum variation.

Table 3. Formal EOP uncertainties (precision) and subdaily residuals from continuous campaigns.

Network	Daily Precision X (μas)	Daily Precision Y (μas)	Daily Precision UT1 (μs)	Hourly Precision X (μas)	Hourly Precision Y (μas)	Hourly Precision UT1 (μs)	Subdaily Residual RMS X (μas)	Subdaily Residual RMS Y (μas)	Subdaily Residual RMS UT1 (μs)
CONT94	46	43	1.9	185	228	7.8	185	176	10.4
CONT96	69	65	2.5	208	196	8.6	238	207	10.2
CONT02	50	40	1.7	196	157	8.0	201	183	11.4
CONT05	32	33	1.2	120	117	5.2	170	167	10.2

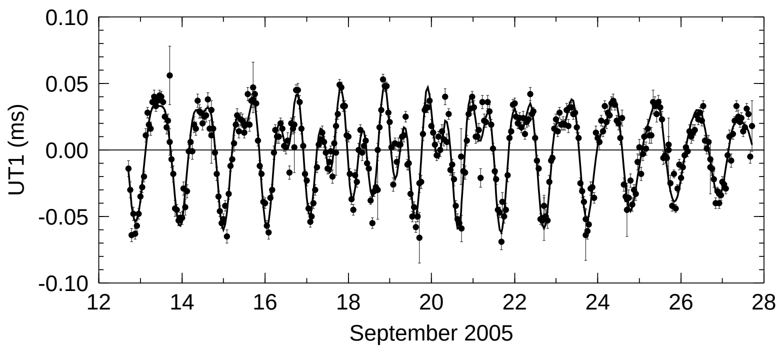

Figure 4. Subdaily estimates of UT1 at hourly intervals (dots) compared to Gipson's updated tidal model (solid line).

5. Conclusions

Daily EOP values determined by CONT05 have a precision matched only by the larger RDV sessions. Formal errors are in the range of ~35–40 μasec for X and Y pole, ~1.4–1.5 μs for UT1, and ~75 and ~30 μasec for nutation in longitude and obliquity. The CONT05 data set appears to be highly suitable for inter-technique comparisons, investigation of geophysical signals, and technique improvement studies.

6. Acknowledgements

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