Information for the

Comparison Campaign of VLBI Data Analysis Software

DeDeCC1, April 2010

by Lucia Plank and Johannes Böhm

---

1 Introduction

Strictly speaking, the IERS Conventions give an instruction manual how to calculate for geodetic VLBI observations the theoretical delay including all corrections. In practice, different software packages follow different calculation strategies, vary in the usage of correction models and are sometimes limited in their ability to adopt recently updated Conventions. This might lead to systematic errors and different results in VLBI data analysis. Goal of the *De*lay and partial *De*rivatives *C*omparison *C*ampaign (*DeDeCC*) is to compare different VLBI analysis software packages on the basis of the computed delay and its partial derivatives, in order to detect present inadequatenesses in the modeling part. Therefore various sessions shall be simulated, using a single baseline over different time periods, considering short-term as well as long-term effects.

2 Practical Approach

While the actual VLBI delay models (e.g. the Consensus Model, Eubanks 1991) ensure to be accurate at the 1-picosecond level (0.3 mm), other parts of geodetic VLBI modeling are much more uncertain. For this study, we expect agreement/discrepancies at the millimeter level (10^{-12} s).

As applied/non applied models and corrections during the delay modeling predominanlty cause effects at exactly this order of magnitude (or even bigger), best possible harmonization of the various software concerning the modeling procedure is essential, in order to enable reliable comparison results.

3 Object of comparison

Object of comparison is the computed value of τ, the time delay of signal reception between station 1 and station 2.

$$\tau_{comp} = \tau_{geometric} + \tau_{gravitationional} + \tau_{tropo} + \tau_{axis\,offset} + \tau_{thermdef}$$

A detailed description of the used models for station displacements, high frequency variations of the EOP and other necessary corrections is given in section 4.2.

4 DeDeCC1

DeDeCC1 is the first attempt to compare results from the participating analysis groups. The experiment covers two time periods, one 14-days multi-session in 2001 and a single 24 hour session one year later. Investigations of the partial derivatives of τ are intended for a subsequent stage of the campaign.

4.1 Experiment

For DeDeCC1, observations of two stations (Westford, Wettzell) to one source (0642+449) are examined. The observations are arranged into fifteen 24 hour sessions, fourteen consecutive days from January 1^{st} 2001 to January 14^{th} 2001 and a single session one year later, on January 1^{st} 2002, with an observation interval of 30 minutes (*full mode*). In the *reduced mode* observations with low elevation or beneath the horizon are skipped (every day from 14:00 - 19:30). With 48 observations per day this gives a total number of 720 observations in the full mode, and corresponding 36 per day and total 540 for the reduced mode. Take a look at table 1 for a detailed observation schedule.

				full mode		reduced mode	
Station1	Station2	Source	Date	Time UTC	Obs.No.	Time UTC	Obs.No.
Westford	Wettzell	0642+449	2001-01-01	00:00:00	1	00:00:00	1
				00:30:00	2	00:30:00	2
				...	...	...	...
				...	...	13:30:00	28
				...	...	20:00:00	29
				...	...	...	
				23:30:00	48	23:30:00	36
Westford	Wettzell	0642+449	2001-01-02	00:00:00	49	00:00:00	37
				...	...	13:30:00	65
				...	...	20:00:00	66
				23:30:00	96	23:30:00	72
Westford	Wettzell	0642+449	2001-01-03	00-23:30	97-144	00-13:30, 20-23:30	73-108
Westford	Wettzell	0642+449	2001-01-04	00-23:30	145-192	00-13:30, 20-23:30	109-144
Westford	Wettzell	0642+449	2001-01-05	00-23:30	193-240	00-13:30, 20-23:30	145-180
Westford	Wettzell	0642+449	2001-01-06	00-23:30	241-288	00-13:30, 20-23:30	181-216
Westford	Wettzell	0642+449	2001-01-07	00-23:30	289-336	00-13:30, 20-23:30	217-252
Westford	Wettzell	0642+449	2001-01-08	00-23:30	337-384	00-13:30, 20-23:30	253-288
Westford	Wettzell	0642+449	2001-01-09	00-23:30	385-432	00-13:30, 20-23:30	289-324
Westford	Wettzell	0642+449	2001-01-10	00-23:30	433-480	00-13:30, 20-23:30	325-360
Westford	Wettzell	0642+449	2001-01-11	00-23:30	481-528	00-13:30, 20-23:30	361-396
Westford	Wettzell	0642+449	2001-01-12	00-23:30	529-576	00-13:30, 20-23:30	397-432
Westford	Wettzell	0642+449	2001-01-13	00-23:30	577-624	00-13:30, 20-23:30	433-468
Westford	Wettzell	0642+449	2001-01-14	00-23:30	625-672	00-13:30, 20-23:30	469-504
Westford	Wettzell	0642+449	2002-01-01	00-23:30	673-720	00-13:30, 20-23:30	505-540

Table 1: observation schedule

4.2 Delay modeling

4.2.1 Source Coordinates

- ICRF 1: the source coordinates are extracted from ICRF 1

name	right ascension [h min sec]	declination [d ' "]
0642+449	06 46 32.025985	44 51 16.59013

4.2.2 Station Locations

- ITRF 2005: m, m/y;

Station	x	y	z	v_x	v_y	v_z	axis offset
Westford	1492206.544	-4458130.519	4296015.554	-0.0152	-0.0014	0.0043	AZEL 0.3163
Wettzell	4075539.836	931735.313	4801629.400	-0.0156	0.0168	0.0104	AZEL -1e-4

- Solid Earth Tides: applied (IERS Conventions 2003 + electronic updates)
- Pole tide: applied (linear trend for mean pole offsets)
- Tidal Ocean Loading: applied; preferably FES2004 model, if other, please state.
- Atmosphere Loading: not applied

4.2.3 Earth Orientation

- UT1 and polar motion: in order to suspend the influence of different ways of interpolating ERPs, constant values for dUT1, x-pole and y-pole are assumed. Find the according EOP-file (IERS C04 format) attached.

x_p["]	y_p["]	UT1-UTC [s]	dX ["]	dY ["]
-0.073500	0.398000	0.0932000	0.0	0.0

Several models for (high frequency) ERP variations are available:

- Correction for the effect of zonal tides in UT1 (tver2000.f, Defraigne & Smits) for interpolation of EOP: not applied
- PM caused by oceanic tides (71 waves, Eanes): applied
- Lunisolar torque (10 waves, pm_gravi): not applied
- Precession/nutation: IAU 2000A, no a priori nutation corrections (dX, dY respectively dEps, dPsi) are applied.

4.2.4 A priori troposphere delay:

During the whole experiment, at both stations a constant air pressure of 1000 hPa is assumed.

- A priori hydrostatic ZD: applied (1000 hPa)
- A priori wet ZD: none
- Mapping function: Vienna Mapping Function 1 (VMF1)

4.2.5 Technique-specific effects:

- Thermal antenna deformation is applied; a constant temperature of 15° Celsius is used at the sites.
- Anenna axis offsets: applied (see above for values)
- station eccentricities: not considered

4.2.6 Geometric/relativistic delay model:

Following the IERS Conventions Chapter 11, the Consensus model should be used. Nevertheless, there exist other ways of calculating the theoretical delay including all necessary relativistic and gravimetric effects, which are implemented in the common VLBI software packages. In particular, differences exist on the chosen coordinate and time frame (BCRS, GCRS,...).

5 Who should take part?

This Call is sent to all IVS Analysis Centers. Although some of them might use the same software, we would like to ask for a solution of each analysis group. During the calculation the analysts still play an active role by making decisions on the settings, a fact we also want to investigate with the prospect of a consistent solution.

6 Why take part?

With this Comparison Campaign we hope to get a full picture of the consistency of VLBI delay modeling within the IVS, what will certainly improve the overall reliability of the IVS products. The results of this Campaign will be made available for everyone. Additionally, individual feedback will be given to every contributor, so that each Analysis Center can get the maximum benefit of it.

7 How to proceed

1. This information note together with all neessary files you can download from http://mars.hg.tuwien.ac.at/~lplank/DeDeCC.
2. Create an observation file compatible with your software. It should include 720 (540) observations for the full (reduced) mode, according to table 1.

Calc users: reduced databases were created by David Gordon and are provided at the DeDeCC website.

Occam users: all necessary files (NGS, CAT, EOP) can also be downloaded from the web.

3. When processing, try to keep as close as possible to the settings above. Fill out the analysis report as good as you can. Whenever you think that your software differs from others in a certain point, please note it there. The more information you give, the better your solution can be compared to others.

4. Store your calculated τ-values in a simple textfile. This should include 720 (540) values, preferably in seconds, at every observation epoch UTC. You can also hand in more than one file (e.g. one for each session). Please take care that your values are accurate to at least 10^{-13} s and that you give enough digits after decimal point.

5. Send the textfile together with the analysis report to lucia.plank@tuwien.ac.at. If you're unsure with some of your settings, you can send more than one version. All kind of additional information on your solution and/or other suggestions are very welcome as well!

8 Deadline

As mentioned in section 4 this Call is the first step of a thorough comparison of *all* parts of VLBI data analysis. Therefore the organizers would like to ask you for your submission till ***May, 31st, 2010***.

9 Organizers of the campaign

DeDeCC is organized by Lucia Plank (lucia.plank@tuwien.ac.at) and Johannes Böhm (johannes.boehm@tuwien.ac.at). For any questions, please don't hesitate to contact us.

Thank you for your participation in this study!