Analysis Coordinator Report

John Gipson

Abstract I present the IVS analysis coordination issues of 2014. The IVS Analysis Coordinator is responsible for generating and disseminating the official IVS products. This requires consistency of the input data by strict adherence to models and conventions.

1 IVS Analysis Workshop and Software Demonstration

The IVS Analysis Workshop was held on March 7, 2014 in Shanghai, China in conjunction with the IVS General Meeting. As usual, the Workshop provided a useful forum for analysts to discuss various issues. Space limitations preclude a full discussion, but it is worthwhile mentioning a few 'action items' and what subsequently happened.

1.1 Analyst Comments

The Goddard VLBI group has been producing session reports for all IVS sessions since 2000. These reports summarize what was discovered in the process of analyzing the sessions, and they contain information about clock breaks, station performance, etc. I have heard that other IVS analysts use these reports, particularly if they notice something 'funny' with the data. David Gordon of GSFC suggested that the other ACs which are responsible for particular sessions take over the task of writing the Analyst Comments for their sessions. USNO agreed to serve as a test case and expects to start submitting the comments for the R4s in early 2015. I look forward to other Analysis Centers which are responsible for specific sessions taking part in this effort.

1.2 Multi-tone Phase Cal

Arthur Niell suggested that the correlators should begin using Multi-tone Phase Cal. Alessandra Bertarini from the Bonn Correlator agreed to process a set of sessions using Multi-tone. These sessions would be compared to sessions processed 'normally'. In the summer and fall of 2014 Alessandra processed the CONT14 sessions using both single-tone and multi-tone phase-cal. David Gordon edited and analyzed these sessions. I compared the results of the two data sets. The multi-tone results tended to be better from several criteria. The number of observations was larger in the multi-tone databases, indicating that the correlator was able to recover more observations. The average session fit was lower, indicating that the data was more consistent within a session. The baseline scatter over CONT14 was lower with multi-tone, indicating that the data was more consistent across the sessions. But it turned out that the vertical position for Zelenchukskaya changed by about 1 cm in the multi-tone sessions compared to the single-tone. This shift was consistent across all of the sessions.

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1.3 UT1 at Finer Intervals

At short time scales UT1 exhibits stochastic variation. The error in extrapolated UT1 given an initial offset and rate grows as 35 $\mu s\ T^{(3/2)}$, where T is measured in days. For 24-hour sessions, current VLBI software produces either A) an overall offset and rate for UT1 for each session or B) UT1 at 24-hour tabular points surrounding and including the session. The UT1 formal errors for the best sessions is on the order of 2 μs. This suggests that we could accurately measure UT1 at intervals of six hours. It was decided to pursue this on a trial basis although no results are in yet.

2 IAG/GGOS/IERS Unified Analysis Workshop

The Unified Analysis Workshop was held at Caltech in June 2014 and chaired by Tom Herring. There were representatives from all of the Geometric Techniques and talks about many subjects. I will restrict myself here to two issues of the most relevance to VLBI. First there was an extended discussion of the scale of the TRF. The scale is important because GPS, which provides densification of the ITRF, is relatively insensitive to scale. Hence the scale must be set by other techniques, and in practice it is set by VLBI and SLR. John Ries who works in SLR gave an overview of this issue. The scale determined by VLBI and SLR differs by about 1 ppb, which translates to a difference in local up of 6 mm. This result has been more or less consistent over the last 15 years. As we strive for millimeter level accuracy it is important that we resolve this issue. One possible explanation advanced by Ries is that this may be due to differences in how the techniques model the effects of General Relativity. This should certainly be re-examined. Dan MacMillan of GSFC gave a talk about various things that can affect the scale of the TRF as measured by VLBI, for example the effect of not modeling gravitational deformation in VLBI antennas. Neglecting this effect will change the estimate of local up which will go directly into the scale. But the sign and magnitude of this effect depend on the characteristics of the antenna, and there is no compelling reason why the effect would be positive for all or most of the antennas. One can determine the effect of gravitational deformation either through direct measurement or structural modeling of the antenna. (See the references which list papers by Artz, Nothnagel, Sarti, and Abbondanza discussing this issue.) Neither approach is inexpensive. But I encourage groups that have resources to make these measurements on the antennas for which they are responsible. Johannes Böhm gave a talk about the effect of Glacial Isostatic Adjustment (GIA) models on the difference in scale between VLBI and SLR. If all of the VLBI and SLR sites were co-located with each other, these models would affect both techniques identically. But because this is not the case, changing the models will affect the techniques differently and could in principle result in scale differences. But the magnitude of the effect seems too small. Another issue that affects all of the techniques is modeling of High Frequency Earth Orientation Parameters (HF-EOP). The importance of this effect was predicted in the early 1990s, [Herring and Dong], and the first models were adapted in the mid 1990s (see for example [Gipson 1996]). I gave a talk comparing empirical HF-EOP models derived from Space Geodesy [Artz 2011, Bockmann 2010, Gipson 2009, Steigenberger 2006] to Tidal models derived from satellite altimetry data [Ray 1994, Ray 1996, Egbert 1994]. Once the effects of Libration are included, both the Space Geodesy models and the Tidal models generally agree with each other. But if you look at the models in more detail, it is clear that the Space Geodesy models cluster together, with the RMS difference being $\sim$2 μs, as do the Tidal models, also with an RMS difference of 2 μs. The RMS difference between the Space Geodesy and the Tidal Models is $\sim$4 μs, suggesting there is room for improvement. Harald Schuh gave a talk "Combined short period EOP model" that reported on a collaboration that plans to derive a new and improved High Frequency Earth Orientation (HF-EOP) model based on better tidal modeling. It is possible that this model will agree better with the empirical data.

3 ITRF2013 Becomes ITRF2014

In March 2013, Zuheir Altamimi issued a call for participation in ITRF2013. This was to include data from the geometric techniques through December 2013. Because of some quality control issues, the IGS had not submitted a solution as of early December 2014. Zuheir

asked the Analysis Coordinators of the different techniques if they would be willing to extend their data by submitting a contribution through December 2014. The end product would be not ITRF2013 but ITRF2014. The hard deadline for the submission would be February 28, 2015. I contacted Sabine Bachmann of the IVS Combination Center to see if this was feasible on her end. When she replied in the affirmative I polled the various IVS Analysis Centers that had submitted VLBI solutions to ITRF2013 to see if they were willing and able to process another year of data with a deadline of January 31, 2015. All of the ACs agreed to do this. Ten IVS Analysis Centers submitted solutions for ITRF2013 and ITRF2014 using five software packages. The software and the number of ACs were, in order of popularity: A) Calc/Solve, five ; B) VieVS, two; C) Geosat, one; D) Occam, one; E) Quasar, one. Calc/Solve continues to be the most widely used software package, but it is good to have other packages to which to compare results. As a side-effect of doing the combination, in the course of comparing the results from different ACs with each other, many discrepancies were found. Sabine Bachmann notified the respective ACs about this, and many bugs and setup errors were found and corrected. This sort of feedback is crucial to making the VLBI products better.

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