THE IERS RETREAT: HOW TO IMPROVE EARTH ROTATION PRODUCTS?

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ABSTRACT. The IERS held a two-day retreat in Paris on May 23-24, 2013. The outcome of the discussions at the retreat are presented with respect to Earth Rotation studies. Special focus is given on the plans to improve the Earth rotation products of the IERS.

1. INTRODUCTION

The International Earth Rotation and Reference Systems Service (IERS) held its second retreat in Paris at the University Paris-Diderot from May 23-24, 2013. As the first IERS retreat took place in 2003, the second retreat aimed to revise the IERS activities during the past ten years. The main goal was to revise the products and developments of the IERS and to establish directions for the IERS over the next years to ensure that high accuracy products are generated regularly.

The IERS retreat was organized in seven sessions with the following conveners:

1. Move towards "real-time" products (H. Schuh, J. Wickert)

2. Rigorous combined products (Z. Altamimi, M. Seitz, R. Biancale)

3. Long-term stability and parameterization of the reference frame (X. Collilieux, D. Thaller)

4. Next generation of models and center-of-mass products (T. van Dam, R. Gross)

5. EOP prediction improvements (B. Luzum, C. Bizouard)

6. Unification of product formats (T. Herring, L. Soudarin)

7. Mechanism for IERS evolution (B. Richter, C. Ma)

The presentations given by the conveners and invited key persons are available at the IERS website: `http://www.iers.org/nn_10902/IERS/EN/Organization/Workshops/Retreat2013.html`. A summary of the discussions prepared by the IERS Analysis Coordinator can be found at this website, too.

The following chapters will summarize the major points of the IERS retreat related to the Earth rotation products.

2. TOWARDS REAL-TIME: UT FROM INTENSIVES

In Session 1 the current real time products of the IERS have been presented. One of the main "real-time" products are the VLBI Intensive sessions which are performed in order to determine UT with a low latency and at (nearly) daily intervals. Currently, three VLBI Intensive sessions are scheduled: INT1 (baseline Wettzell-Kokee), INT2 (baseline Wettzell-Tsukuba) and INT3 (baselines Wettzell-Tsukuba-NyÅlesund). Figure 1 shows the configuration and scheduling of the VLBI Intensive sessions. Daily dUT1 estimates based on these 1h observing sessions are derived.

The VLBI Intensive sessions aim to provide UT1 in "real-time" with the lowest latency possible. Table 2 shows the latency of VLBI Intensive sessions as it is achieved at the moment. In general the latency is a few hours only, but it may happen that the dUT1 estimates are provided with a latency > 1 day. The usage of eVLBI is a major step forward to reduce the latency.

As a consequence of the short observation interval (i.e., one hour only), there are only very few observations for the VLBI Intensive sessions. This situation causes problems for the parameter estimation:
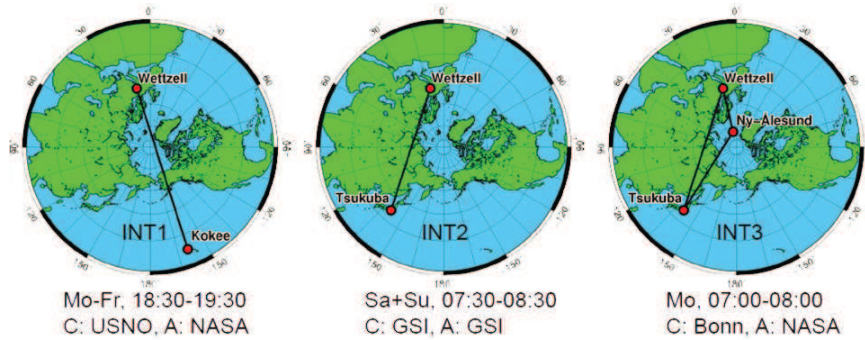
Figure 1: Configuration of the Intensive Sessions (from: Haas (2013))

Session name	Observing date/time	Correlation	Analysis	Latency correl. since end of observ.	Latency dUT1-res. since end of observ.
INT3 – 089	Apr 08, 07:00-08:00	Apr 08, 14:51	Apr 08, 18:26	06:51	10:26
INT1 – 089	Apr 08, 18:30-19:30	Apr 09, 04:54	Apr 09, 05:10	09:24	09:40
INT1 – 099	Apr 09, 18:30-19:30	Apr 10, 04:32	Apr 10, 17:45	09:02	22:15
INT1 – 100	Apr 10, 18:30-19:30	Apr 11, 02:15	Apr 11, 17:48	06:45	22:18
INT1 – 101	Apr 11, 18:30-19:30	Apr 12, 02:26	Apr 12, 03:19	06:56	07:49
INT1 – 102	Apr 12, 18:45-19:45	Apr 15, 15:10	Apr 15, 17:48	19:25	24:03
INT2 – 103	Apr 13, 07:30-08:30	Apr 15, 09:57	???	49:27	???
INT2 – 104	Apr 14, 07:30-08:30	Apr 15, 09:59	???	25:29	???

Figure 2: Latency of Intensive Sessions (from: Haas (2013)

1. Polar motion has to be kept fix; usually predicted values are available only;

2. Station coordinates have to be fixed on a priori;

3. Difficulties to estimate troposphere delay reliably;

Possible improvements are expected by combining with GNSS (Global Navigation Satellite Systems) solutions:

1. Polar motion determined by GNSS: use, e.g., IGS Ultra-Rapid or Rapid products

2. Troposphere determined by GNSS: combined VLBI-GNSS analysis including troposphere combination

Thaller et al. (2008) demonstrated that such type of VLBI-GNSS combination has the potential to improve the UT estimates derived from the Intensive sessions.

3. TOWARDS REAL-TIME: IGS EOP

The International GNSS Service (IGS) has launched its "Real-Time Service (RTS)" on April 1, 2013. Products of this service are at the moment only orbits and clocks, but it should be feasible to get also accurate EOPs in real time. The IGS will look into this aspect, but this requires a format allowing real-time dissemination of EOPs. A common product format has been discussed during the IERS retreat in Session 6 "Unification of product formats" (see below). Figure 3 shows the maximum and the mean latency as well as the outage periods of the IGS RTS. It can be seen, that an data outage is very seldom and that the latency is $< 1 - 4$ seconds in general.
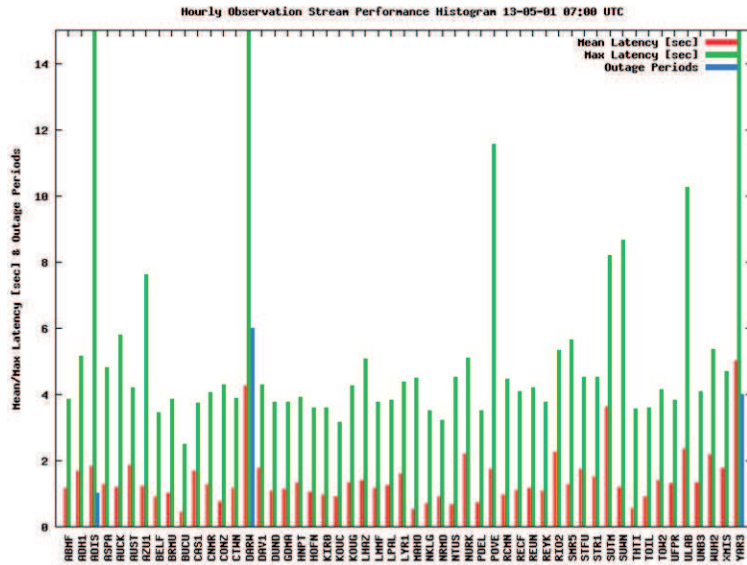
Figure 3: Latency of IGS RTS (from: Wickert (2013).

4. IERS RAPID SERVICE / PREDICTION CENTER

In Session 5 of the IERS retreat, possibilities for EOP prediction improvements have been presented and discussed. The IERS Rapid Service / Prediction Center provides multiple solutions of IERS EOP predictions per day: at 0310 UTC, 0910 UTC, 1710 UTC and 2110 UTC. The solutions are timed to take advantage of the latest IGS products. The solutions take approx. 10 minutes to complete, with a time split between data downloads and software run time.

Potential improvements of the products can be seen in the following fields:

- The data input is not optimized for 4 EOP solutions per day. A better temporal distribution is needed.

- The data combination algorithm is not optimal. Alternative methods have to be investigated.

EOP prediction can be improved by improving the input EOP data, the processing algorithm, the EOP modeling, and the geophysical analysis and forecast.

Figures 4 show how the EOP input data can be improved:

1. Reduce latency (left figure): reduce the time between the last observation and the epoch where the prediction is provided.

2. Improve accuracy (right figure): improve the accuracy of the input data.

Besides the improvements of the EOP, the analysis and forecast of the geophysical fluids also have to be improved. Four recommendations evolved from the discussions during the IERS retreat:

- Formal errors needed for data from AAM analysis (= internal validation).

- Inter-comparison between different sources of AAM data (= external validation).

- Request more frequent updates of AAM data (actually 6 hours).

- OAM should be provided operationally in real-time.

Figure 5 gives an overview on the current latency and accuracy of the IERS Rapid products.

Figure 6 shows the current latencies for rapid products and the expected latencies for the future: < 15 hours for the AAM, GPS (Ultras) from IGS RTS, < 24 hours for SLR, < 2 hours for VLBI Intensive sessions and < 2 days for VLBI 24-hour sessions.
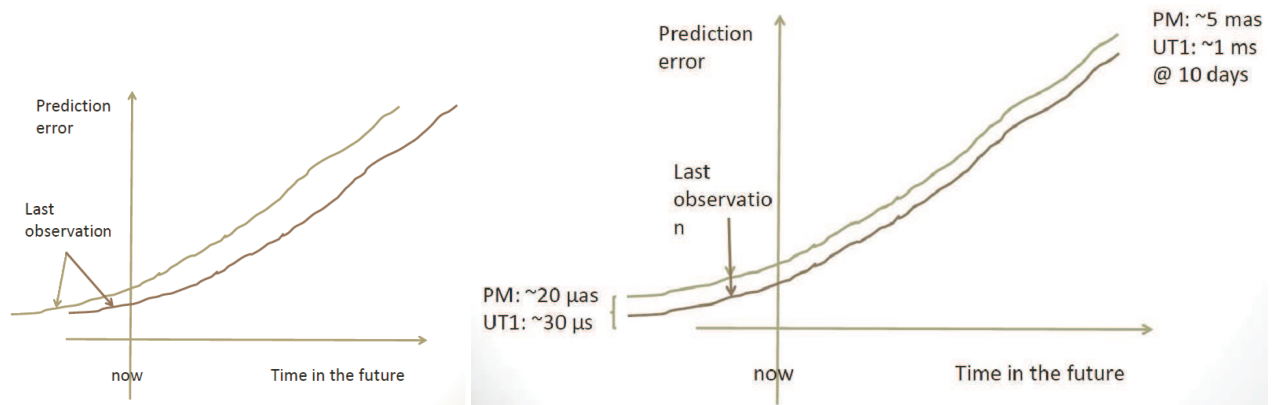
Figure 4: Impact on the quality of the prediction if: (1) the latency is reduced (left picture), or (2) the accuracy is improved (right picture). (from: Luzum (2013)).

Input	Latency	Refresh rate	PM Accuracy	UT1/LOD Accuracy
AAM	~18-42 hours	1/day		~60 µs/day
GPS (Ultras)	~15 hours	4/day	~20 µas	~15 µs/day
SLR	48-72 hours	1/day	~200 µas	
VLBI Intensives	~8-32 hours	1-2/day		~20 µs
VLBI 24-hour	10-17 days	2/week	~200 µas	~5 µs

Figure 5: Current latency and accuracy of IERS Rapid products (from: Luzum (2013))

5. REVISION OF THE IERS TERMS OF REFERENCE

The latest version of the IERS Terms of Reference (ToR) is dated October 10, 2010[1]. As the IERS is a service, it should follow the needs of the users and review from time to time whether the ToR are still adequate to satisfy the needs of the users. The IERS retreat is a good opportunity to review the IERS ToR. In view of improving the Earth orientation products of the IERS, there are three Product Centers of interest:

- The Rapid Service / Prediction Center and the Earth orientation Center are responsible for Earth orientation parameters.

- The ITRS Center is responsible for the maintenance of the ITRS/ITRF.

The crucial point is that the ITRF computation does not concentrate solely on station positions anymore, but provides a consistent longterm solution for station positions **together with** Earth rotation parameters since the realization of ITRF2005 (Altamimi et al., 2007). Therefore, the question arises whether separated product centers for ITRF and Earth orientation are outdated, and whether a product center for rigorous combination on a "daily" (or weekly) basis would be much more adequate to provide the users with the best possible Earth orientation products? This question is, however, not that easy to answer as it would look at a first glance. Therefore, the decision on this subject will be adjourned until results from the IERS Working Group on "Combination at the observation level' (COL)" are available.

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[1]http://www.iers.org/ToR

Figure 6: Expected latencies in future (from: Luzum (2013))

6. IMPROVEMENT OF PRODUCT FORMATS

In Session 6, die unification of IERS product formats have been investigated. The IERS provides diverse EOP products on its website[2]. Figure 7 shows the IERS website with different EOP products. The critical point is that different formats are used for different product levels (Bulletin A, B and C04). In an ideal case, all important characteristics should be merged into one common format, and all IERS Earth orientation products should be provided in the common format.

In summary, the following issues have been identified to be improved:

- One common format for all Earth orientation products.

- EOP rates should be included in the files. Currently, only Length of Day (LOD) is given, but no polar motion rates.

- The leap second file (Bulletin C) is not machine readable.

- No format for Real-Time distribution of EOP currently available.

The IERS Analysis Coordinator works towards improvements of the format issues.

Figure 7: IERS EOP Data Website

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[2]http://www.iers.org/EOP

7. SUMMARY

In summery, all IERS retreat participants have passed a very good 2-day IERS retreat in Paris with many ideas and fruitful discussions. Several topics have been identified with potential for improving the IERS products and better satisfy the needs of the users. The main issues regarding EOPs have been formulated:

1. Move towards Real-Time,

2. Move towards combined EOP products (e.g. for Intensives),

3. Improvements for EOP prediction,

4. User-friendly common product formats.

Some of the innumerable activities are already ongoing - others will follow in the near future.

8. REFERENCES

Altamimi, Z., Collilieux, X., Legrand, J., Garayt, B., Boucher, C., 2007, "ITRF2005: A new release of the International Terrestrial Reference Frame based on time series of station positions and Earth Orientation Parameters", J. Geophys. Res.(Solid Earth), 112, B09401, doi:10.1029/2007JB004949.

Haas, R., 2013, "The IVS Intensive sessions on their way to near real-time", presented at the IERS Retreat 2013, held at Paris on May 23-24, 2013.

Luzum, B., 2013, "EOP Prediction Improvements", presented at the IERS Retreat 2013, held at Paris on May 23-24, 2013.

Wickert, J., 2013, "International GNSS Service New Products for Real-Time Applications", presented at the IERS Retreat 2013, held at Paris on May 23-24, 2013.

Thaller, D., Tesmer, V., Dach, R., Krügel, M., Rothacher, M., Steigenberger, P., 2008, "Combining VLBI intensive with GPS rapid solutions for deriving a stable UT time series", In: Finkelstein, Behrend (eds.) Proceedings of the 5th IVS General Meeting, held at St. Petersburg, March 3-6, 2008, pp. 8-13.