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Impact of inconsistent use of IERS Conventions on PPP results

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Introduction

The IERS Conventions define the standard reference systems realized by the International Earth Rotation and Reference Systems Service (IERS) and the models and procedures used for this purpose. State-of-the-art processing of space geodetic data requires, in principle, to adopt the latest version of the IERS Conventions, e.g., IERS 2010. This means, however, to frequently update analysis software packages accordingly, which cannot always be realized immediately due to several reasons, e.g., operational constraints. Small inconsistencies are an unavoidable consequence.
The impact of the use of inconsistent IERS Conventions is assessed by processing GNSS data from a global station network. Orbits and clocks from GPS and GLONASS satellites resulting from a reprocessing based on the IERS 2010 Conventions are used for a Precise Point Positioning (PPP) of the stations. On the one hand, the PPP is done with consistent IERS 2010 Convention models and on the other hand, the older IERS 2003 Conventions are used for the PPP. Results of static and kinematic analyses are compared and investigated to quantify and qualify the impact of an inconsistent use of the IERS Conventions.
The Bernese GNSS Software (Dach et al., 2007) is used for this assessment.

Differences in the IERS Conventions

The detailed description of the modifications and updates from the IERS 2003 to 2010 Conventions would fill a seperate poster. On the one hand, algorithms/definitions have changed implying software modifications. On the other hand, models are replaced implying in most cases only the replacement of an input file for the processing. The most relevant differences for this study are given here (for more details and additional references we refer to Petit and Luzum, 2010):
Transformation between the International Terrestrial Reference System (ITRS) and the Geocentric Celestial Reference System (GCRS):
- Precession and nutation: switch from IAU2000 to IAU2006 resolution
- Libration in polar motion is added

Geopotential:
- Global geopotential model: switch from EGM96 to EGM2008
- Ocean tides: switch from CSR 3.0 to FES2004
- Ocean pole tide added

Displacement of reference points:
- Ocean loading: additional constituent tides
- Conventional mean pole: definition changed

Description of Experiment

- Time period: Oct 31 - Dec 25, 2010 (eight weeks)
- CODE (Dach et al., 2009) reprocessed GPS+GLONASS orbits and clocks fully consistent with the IERS Conventions 2010
- Data: GPS + GLONASS data from 71 stations (Figure 1)
- Precise Point Positioning (PPP) with 5 min sampled data; static for all stations, additionally kinematic solutions are generated for selected stations
- Four different solutions A B C D

Solution	A	B	C	D
ITRS <=> GCRS*	IERS2010	IERS2003	IERS2003	IERS2003
Ocean tide model**	FES2004	FES2004	CSR3.0	CSR3.0
Gravity field model**	EGM2008	EGM2008	EGM2008	JGM3***
Reference frame	IGS08	IGS08	IGS08	IGS08

* This includes other changes in the Conventions, e.g., the conventional mean pole definition.
** These models are needed for the numerical integration of the GNSS orbits.
*** At CODE the JGM3 gravity field model is used together with the IERS Conventions 2003 (instead of EGM96). Solution D corresponds to the models currently used in the operational CODE processing, which will be switched to the IERS Conventions 2010 soon.

Solution A is based on the IERS Conventions 2010 and serves as reference solution. The PPP solution is consistent to the input GNSS orbits and clocks. Solutions B C D are mainly based on the IERS Conventions 2003, whereas some models are consistently used with the IERS Conventions 2010.

Poster compiled by H. Bock, April 2012
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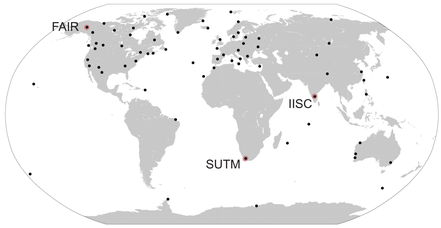

Figure 1 Stations used for PPP; three selected stations FAIR, SUTM, and IISC are marked.

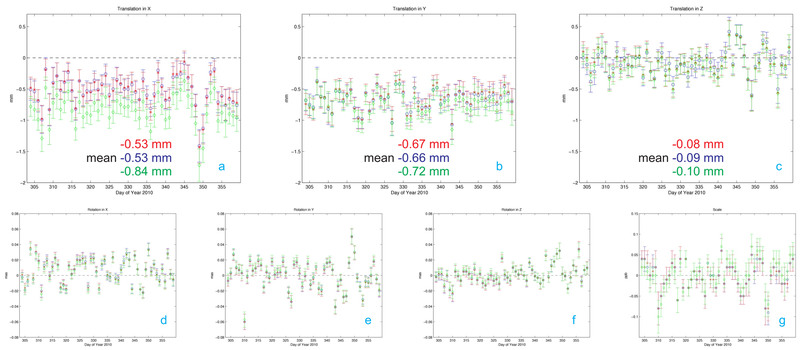

Figure 2 Helmert transformation parameters for solutions B, C, and D with respect to solution A. Rotations in x,y, and z (d,e,f) and scale (g) are very small and not significant. Translations in x,y, and z (a,b,c) are small as well, but the mean translations in x and y are significantly different from zero. The different definition of the conventional mean pole is probably the reason for this. It has not been further investigated why solution D using the JGM3 gravity field model shows larger mean translations in x and y.

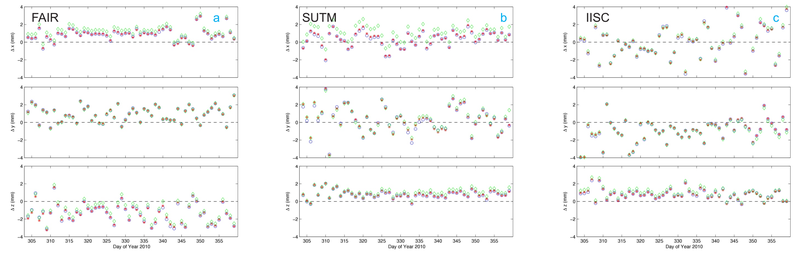

Figure 3 Coordinate differences in x, y, and z for static solutions B, C, and D with respect to static solution A; FAIR (a), SUTM (b), IISC (c). These three stations are a small sample and the results do not support the results for the Helmert parameters in all cases. Nevertheless, it can be noticed that station coordinate differences show systematic effects as well. The results of high precision applications have to be interpreted with care, if IERS Conventions are not used completely consistent.

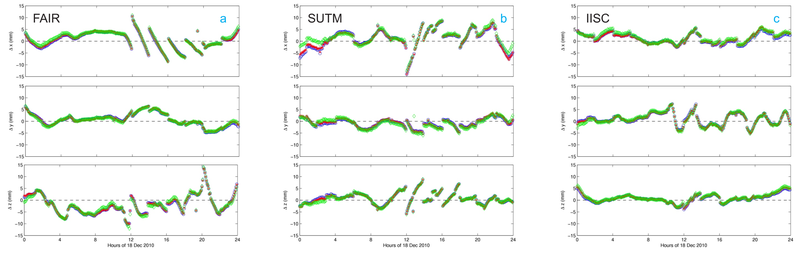

Figure 4 Coordinate differences for kinematic solutions B, C, and D with respect to kinematic solution A on 18 December, 2010; FAIR (a), SUTM (b), IISC (c). It is again a small sample. In principle, the differences are within +- 5 mm, but some jumps up to 15 mm occur in the kinematic positions. They are connected to the boundaries of the two-hourly troposphere parameters. The reference solution A shows obviously a different behaviour than all the other three solutions (see also Figure 5). The different models used for the numerical integration of the GNSS orbits have a minor impact on the differences in the kinematic positions.

Description of Experiment - continued

In order to check the impact on the network each day a seven-parameter Helmert transformation is performed based on the coordinates of the 71 stations (Figure 1). Solutions B, C, and D are compared with reference solution A (Figure 2). Global systematic effects may be noticed in the Helmert parameters.

The static PPP results from three stations (FAIR, SUTM, IISC) from solutions B, C, and D are compared with reference solution A (Figure 3). Differences in x, y, and z may reveal systematic effects of the different used IERS Conventions on single coordinate solutions in different areas on the Earth.

Kinematic PPP solutions (18 December 2010) from three stations (FAIR, SUTM, IISC) from solutions B, C, and D are compared with the kinematic PPP reference solution A (Figure 4).

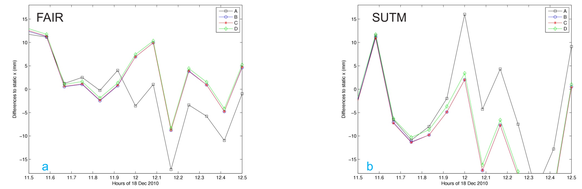

Figure 5 Behaviour of kinematic coordinate in x (relative to static solution) for a time span of one hour (11:30 - 12:30) on 18 Dec 2010 for FAIR (a) and SUTM (b). If comparing with the other epochs of this interval one cannot characterize the changes in the kinematic positions at 12:00 for solution A as jumps. The change in the position is in opposite to the three other solutions and therefore it occurs in Figure 4 as jump for both FAIR and SUTM. The reason for the opposite change in the kinematic position is, however, not yet completely understood.

Summary

The impact of inconsistent use of the IERS Conventions is assessed for PPP solutions. Different solutions with different level of inconsistency are generated and compared to a reference solution, which is consistent with the current IERS Conventions 2010.
Helmert transformation parameters derived from 71 globally distributed PPP stations show the largest systematic impact probably due to the modified definition of the conventional mean pole from IERS Conventions 2003 to 2010.
Static coordinate results for single stations indicate systematic effects of up to 1-2 mm as well, but they do not directly support the findings from the Helmert transformation parameters.
Kinematic results are mainly affected by the different modeling/definition of the transformation between ITRS and GCRS. The sampling of the troposphere parameters can be noticed in the results as well, at least the kinematic results for the reference solution show sometimes an opposite change in the position as the other three solutions.

Kinematic PPP solutions are more affected (up to cm) by inconsistently used IERS Conventions than static PPP solutions (few mm).
For high precision applications one has to be aware of the systematic effects due to the inconsistent use of the IERS Conventions.

References

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Dach et al.(2009) GNSS processing at CODE: Status report. Journal of Geodesy 83(3-4), pp 353-365. doi: 10.1007/s00190-008-0281-2
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