REPORT ON ACTIVITIES OF THE SUB-WORKING GROUP 3 “NUMERICAL SOLUTIONS AND VALIDATION” OF THE IAU/IAG JOINT WORKING GROUP ON THEORY OF EARTH ROTATION

R. HEINKELMANN
Helmholtz Centre Potsdam, GFZ German Research Center for Geosciences
Telegrafenberg, 14473 Potsdam, Germany
e-mail: heinkelmann@gfz-potsdam.de

ABSTRACT. In this report I briefly summarize the latest activities of the Sub Working Group 3: Numerical Solutions & Validation members under the IAU/IAG Joint Working Group on Theory of Earth Rotation. I present a list of selected publications and point out unsolved problems that could be addressed by the Sub Working Group.

1. THE SUB WORKING GROUP

Sub Working Group 3 on Numerical Solutions & Validation consists of 18 members chaired by R. Heinkelmann. The communication among the Sub Working Groups is ensured by cross - Sub Working Group members. Those members are printed in bold fonts in Table 1.

Chao, B.F.	Taipei	**Gross, R.**	USA	**Rogister, Y.**	France
Chen, W.	China	**Huang, C.-L.**	China	Sansaturio, M.E.	Spain
Dehant, V.	Belgium	Luzum, B.	USA	**Schuh, H.**	Germany
Ferrándiz, J.	Spain	Malkin, Z.	Russia	**Seitz, F.**	Germany
Gambis, D.	France	Navarro, J.F.	Spain	Thomas, M.	Germany
Gerlach, E.	Germany	**Ray, J.**	USA	**Wang, Q.J.**	China

Table 1: Members of the Sub Working Group 3: Numerical Solution & Validation. The members in bold characters are members in other Sub Working Groups as well.

2. STATUS OF THE NUMERICAL SOLUTIONS AND VALIDATIONS

The results from numerical solutions suffer from simplifications of solid Earth models, from incomplete consideration of the interactions of the spheres of the Earth system or from neglecting of certain coupling mechanisms between some of the solid Earth components. In addition, there are computational limitations and limitations through the neglected relativistic background. There are various groups working on improving numerical solutions of Earth rotation. Recent progress has been obtained in particular through the following activities:

- inclusion of more realistic non-rigid Earth models such as elastic Earth models (Getino & Ferrándiz, 1995), two layer Earth models (Getino, 1995; Getino, et al., 2000, Getino & Ferrándiz, 2001, Ferrándiz, et al., 2004) or three layer Earth models (Escapa, et al., 2001), and the symbolic processor for the Earth rotation theory (Navarro & Ferrándiz, 2002),
- development of refined numerical methods such as the application of the Galerkin method for the determination of a new multiple layer spectral method (Huang & Zhang, 2015),
- coupling of certain solid Earth components, e.g. core-mantle boundary (Huang, et al., 2011; Malkin, 2013) or inner core boundary (Dehant, et al., 2013),
- interaction of spheres of the Earth system, e.g. coupled atmosphere-ocean angular momentum (Seitz & Thomas, 2012), and the
- formulation of Earth rotation in a consistent relativistic setting (Klioner, et al., 2010; Gerlach, et al., 2012).

Validation of Earth rotation theory can be achieved by comparison with results obtained from space geodetic techniques. The determination of Earth Orientation Parameters (EOP) is based on the analysis of observations of the space geodetic techniques that are combined applying various procedures. Since the two last International Terrestrial Reference Frames (ITRF) the conventional EOP are determined together with the ITRF, currently IERS 08 C04 together with ITRF2008 (Altamimi, et al., 2011), what ensures the consistency among those products. The TRF coordinate model allows for a simple determination of a position at an epoch inside the data time span. Without a significant loss of quality it can also be used for the extrapolation to the outside of the data time span. Different from that, the EOP are treated as time series with a sampling of usually one day. Consequently, the EOP have to be predicted or updated and between the part that is determined together with ITRF and the updates the consistency has to be ensured. The consistency with the International Celestial Reference Frame (ICRF) is only indirectly achieved via the VLBI observations that enter the ITRF and EOP computations. Within the multi-technique combination, so far no special attention has been paid on the consistency with ICRF. The VLBI observations are adjusted together with other observations that refer to other space segments, for example to satellite orbits. The ICRF and those space segments do not necessarily have the same orientation giving rise to inconsistencies.

For the quality of the validation using space geodetic techniques the consistency among the techniques and among the reference frames is of highest importance. Various studies have been carried out to assess the level of consistency among the conventional reference frames and the EOP, e.g. Malkin (2012); Heinkelmann et al., (2015a, 2015b). Progress in the validation of the IAU 2006/2000 precession-nutation has been achieved in particular through comparison with VLBI data (Capitaine, et al., 2009; Capitaine, et al., 2012; Malkin, 2014b). The validation shows that the values of the celestial pole offset and the main nutation terms require correction.

In the current situation the theoretical results are believed to be less precise than the observational results from space geodetic techniques. Besides the abovementioned limitations this is partly due to the fact that some of the observed effects are free modes that can not be rigorously predicted, e.g. the free core nutation (FCN). The current IAU2006/2000 precession-nutation model includes only an empirical model for FCN[1]. This model needs to be updated and the updates have to be made consistent with the original model that was derived from the data used for the creation of ITRF2008 and IERS 08 C04. As an alternative to the deterministic model, FCN can be described by stochastic models, e.g. by time series models (Brzeziński & Kosek, 2004). The other way around there are predicted motions that have not yet been observed, e.g. the free inner core nutation (FICN; Lambert, et al., 2013; Malkin, 2014a). The confirmation of the FICN through observations would probably help the theoretical developments significantly. As a consequence, model parameters are compared to or fitted to observations. Hence, improvements of the observations of the space geodetic techniques do not necessarily help to improve the theory of Earth rotation. The quality of reduction of space geodetic observations by applying the models of Earth rotation lags behind the quality of the observations and prohibits further progress in the analysis.

3. REFERENCES

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