

IAU/IAG Joint Working Group on the Theory of Earth Rotation

Sub Working Group 3: Numerical solutions and validation

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Mid-term report, purpose:

1. Status of the numerical solutions and validation
2. Selected list of authors contributing to the aims of SW3 (on the fly together with 1.)
3. Unsolved problems that should be discussed (last slide)

Status of the numerical solutions - 1

- Synthesis: there are various groups running numerical solutions for Earth rotation
- The individual approaches concentrate on certain specific phenomena/aspects:
 - More detailed Earth models: effects of 3-layered Earth model (Ferrandiz, Escapa, Getino)
 - More sophisticated computational methods: determination of FCN period based on a different computation method (Huang et al.)
 - Coupling of “solid” Earth components, e.g. core – mantle (Dehant et al.)
 - Interaction of Earth system components, e.g. coupled atmosphere – ocean angular momentum (F. Seitz, M. Thomas et al.)
 - Consistent relativistic formulation of Earth rotation (Gerlach, Klioner, Soffel)

Status of the numerical solutions - 2

- The results from numerical solutions suffer from
 - Simplified “solid” Earth models
 - Incomplete Earth system models or neglecting of certain parts or neglecting of certain coupling mechanisms
 - Methodological limitations of computations (e.g. of normal modes)
 - Unconsidered relativistic background
- The theoretical results are believed to be less precise than the current observational results from space geodetic techniques
 - Model parameters are compared with or even fitted to observations
 - As a consequence: improvements of space geodetic techniques do not necessarily help to improve the theory
 - For some observed effects there are no appropriate theoretical models available, e.g. IAU 2006/2000A does not include a FCN model. There is only an empirical model available on the IERS level that is valid until 2010 (Lambert et al.). This model cannot be applied for analysis of data after 2010 and thus not for consistent reanalysis!

EOP observation, basic remarks - 1

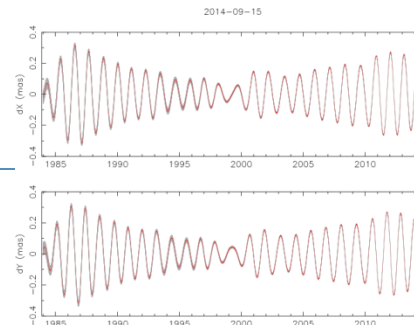
- Analysis: the space geodetic techniques have different capabilities to determine EOP
 - VLBI is the only technique to determine celestial pole offsets (CPO), dUT1 and terrestrial pole coordinates **consistently** at the same time
 - VLBI EOP refer to the currently best available realization of a **non-rotating reference frame** (ICRF2)
 - **GNSS terrestrial pole coordinates and LOD are more precise**, have a quasi-continuous sampling, and are available in almost real-time
 - In the GNSS and SLR analyses CPO and dUT1 have to be supported by values from VLBI and thus these pole coordinates and LOD are **not consistent** with CPO and dUT1 estimates
 - GNSS EOP refer to „frozen orbits“, i.e. the GNSS satellite orbits are integrated over one or a few days and it is assumed that they are non-rotating during these days
 - SLR EOP are handled in the same way. here orbits are usually integrated over a week or more

EOP observation, basic remarks - 2

- The space geodetic techniques have individual weaknesses (and strengths)
 - VLBI is **not** available **continuously** and the **terrestrial network** is rather **limited** and variable
 - GPS suffers from artifacts due to the so called **draconitic periods** (J. Ray et al.)
 - SLR is a little bit less precise than GNSS and VLBI in terms of EOP, **LLR is not included** anymore in the ITRF/EOP combination (but it would provide a more stable celestial system than the satellite techniques)
- It is usually optimistically assumed that those weaknesses are cured by a combination of the space geodetic techniques
 - Using different approaches for the combination results in significantly different results
 - The local ground measurements connecting the techniques (“local ties”) are not optimal
 - The conventional EOP are determined together with ITRF. But there are remaining geophysical signals in regularized ITRF station positions that are absorbed by EOP and there is no procedure to make sure that EOPs are consistent with ICRF

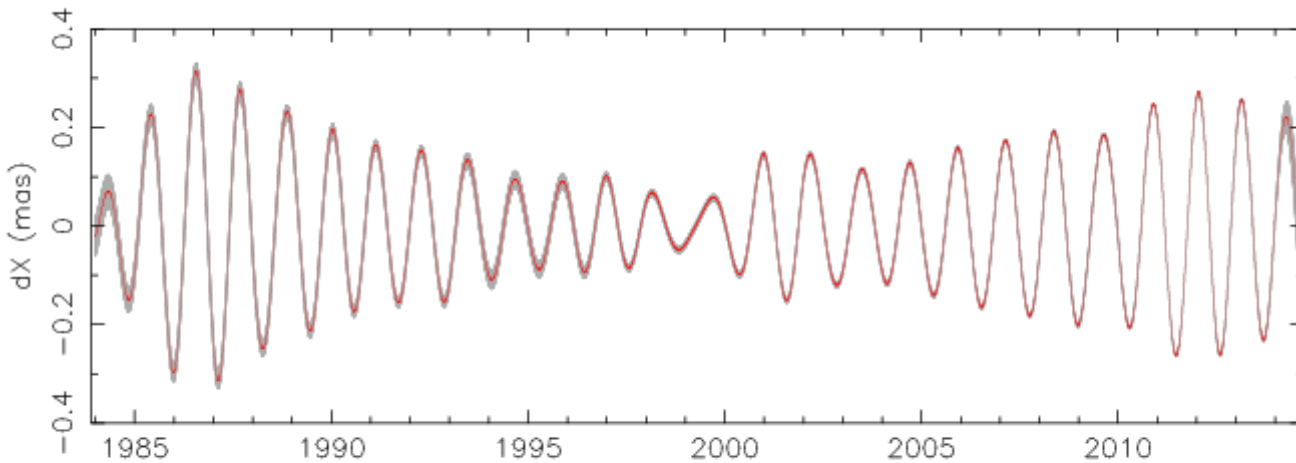
Status of the validations - 1

- Validation of IAU 2006/2000A precession/nutation by VLBI (Capitaine et al., Malkin et al.)
 - Values of CPO and main nutation terms require correction
 - Model parameters depend on the choice of the data and on the considered time span
 - VLBI observations can only reliably improve the shift of the celestial pole and the precession rate. A quadratic model significantly lowers the accuracy of the parameters
- Update of IERS FCN empirical model (Lambert et al., Malkin)
 - FCN model is updated 1/yr
 - FCN empirical model is „refitted to the IERS 08 C04 data“

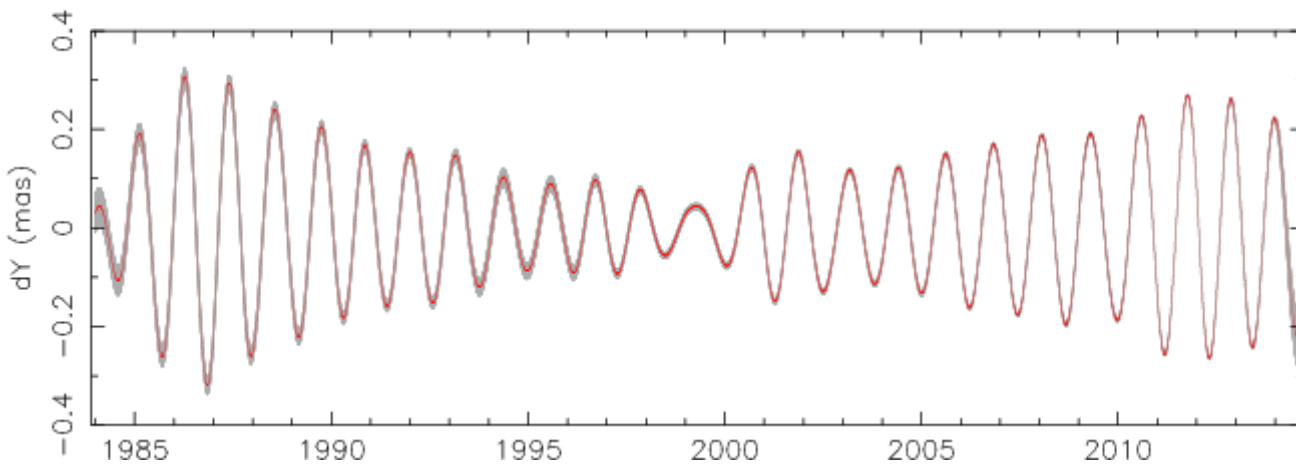


Status of the validations - 1

2014-09-15



Lambert et al.
(<http://syrtel.obspm.fr/~lambert/fcn/>):
evolution of the FCN
since 1984 up to ~ July
2014

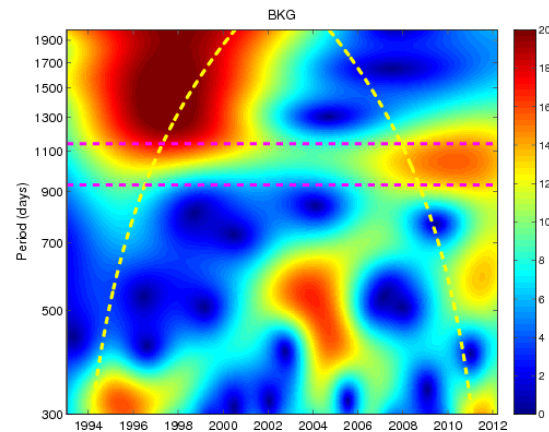


Status of the validations - 2

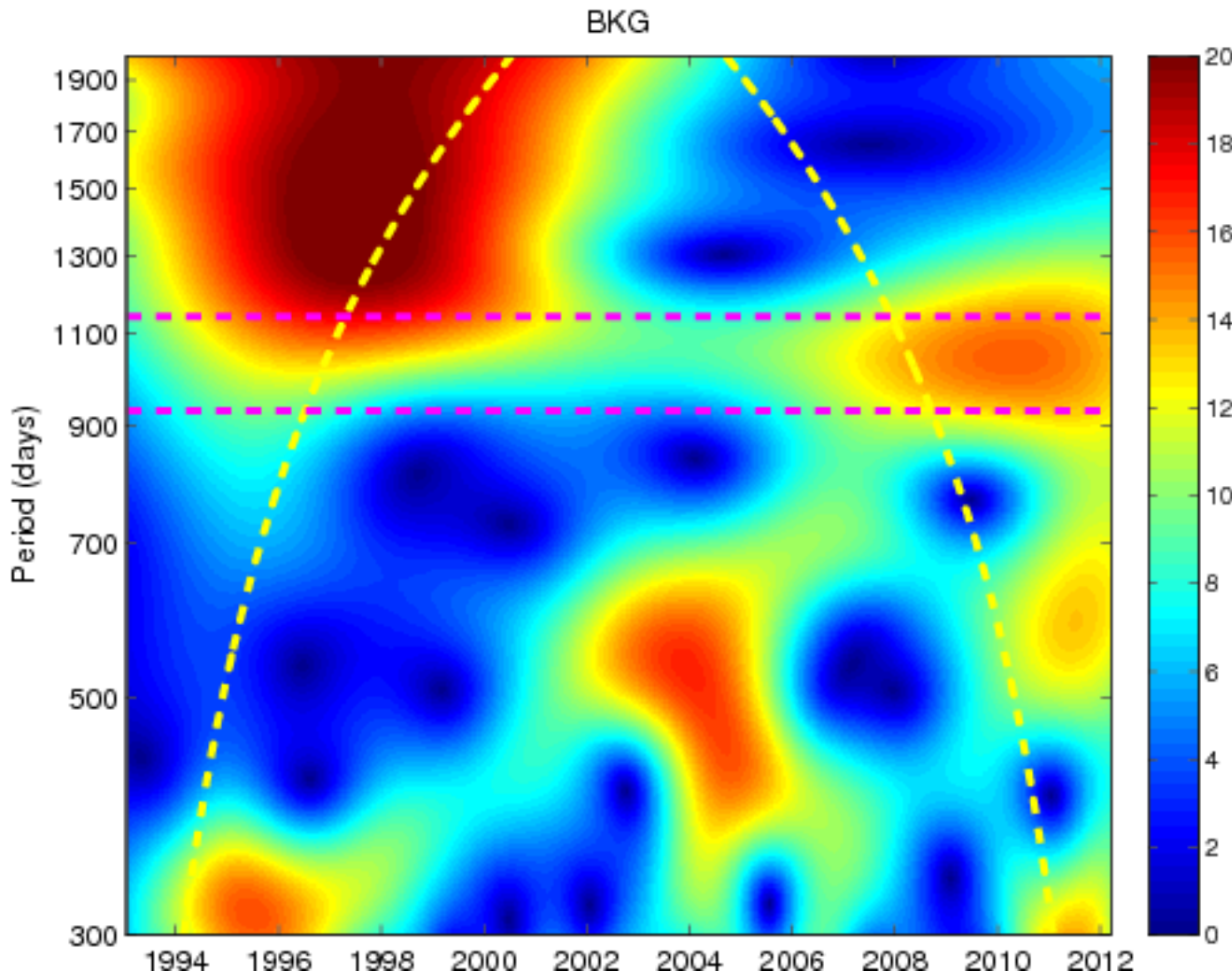
- The validations using space geodetic techniques suffer from
 - Inconsistencies (between the EOP, between the techniques, between the applied models) (Gross et al.; Heinkelmann et al. please find our poster)
 - The EOP repeatabilities reported by IAG technique services are „optimistic“
 - The true accuracy and the level of inconsistency of the EOP is not exactly known
- TRF positions contain geophysical signals (Thaller, Bloßfeld, Altamimi et al.)
 - Using a linear coordinate model causes systematic effects in the EOP
- EOP have to be updated regularly and need to be predicted
 - Post-processed and predicted values can be inconsistent
- The IUGG (Resolution 3, 2011) strongly recommends the determination of ICRF, ITRF, and EOP from a single monolithic fit (first steps: M. Seitz et al.)

Status of the validations - 3

- The theoretical results are believed to be less precise than the current observational results from space geodetic techniques
 - For celestial pole offsets empirical values are preferred for a priori data by analysts
- There is no observational evidence for certain phenomena, e.g. FICN (e.g. Lambert et al.)



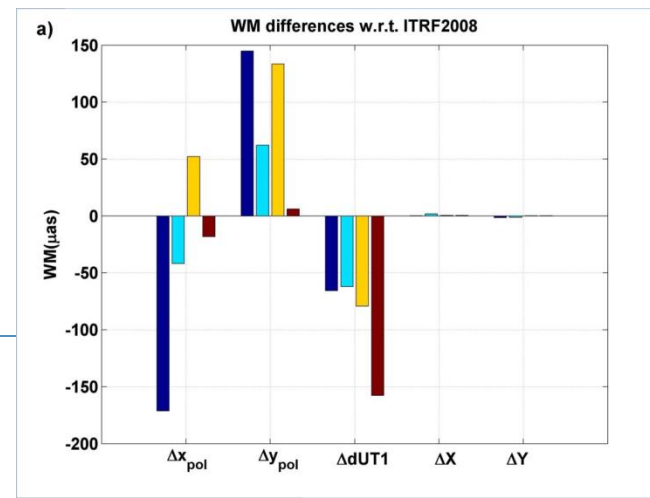
Status of the validations - 3



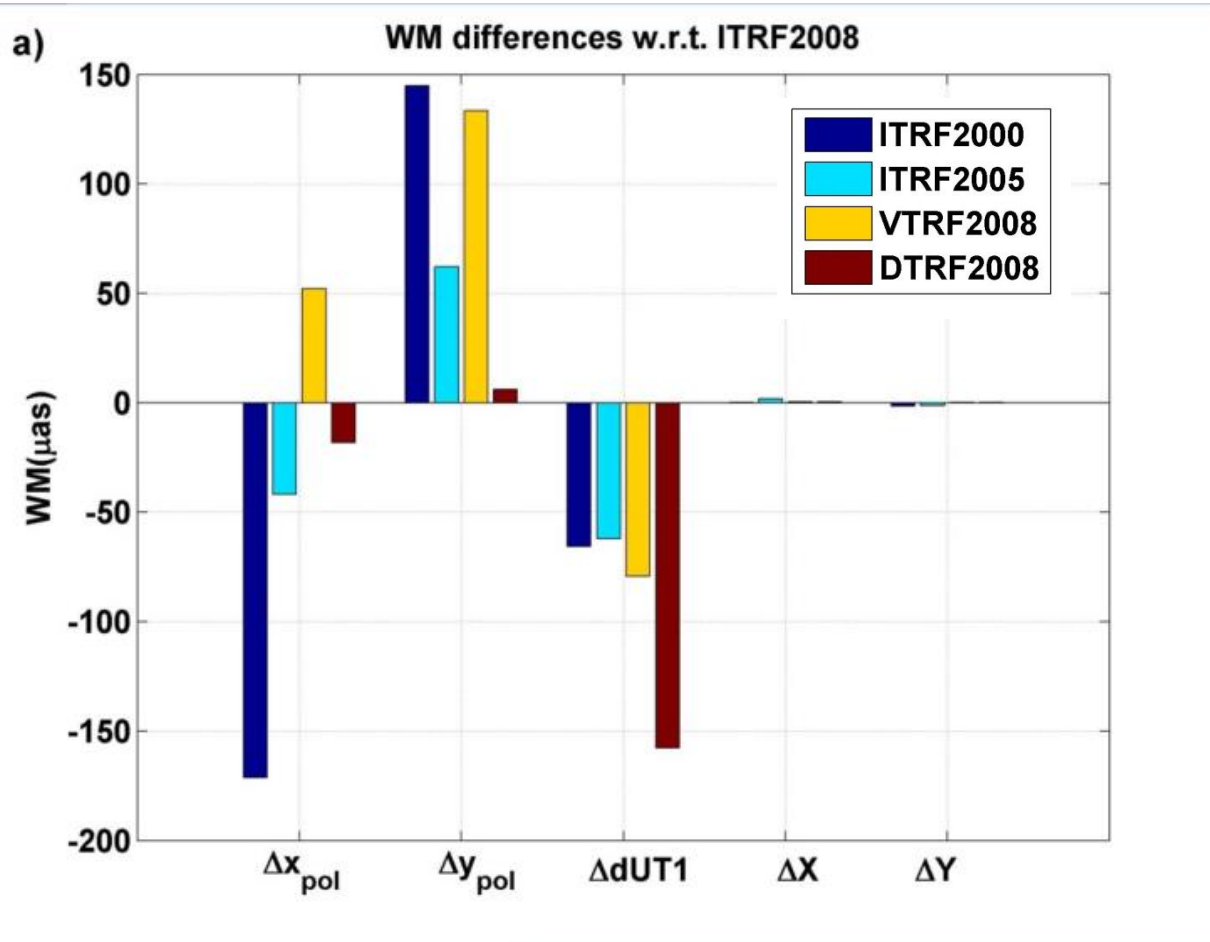
*Lambert et al. (2012):
Wavelet spectra of BKG operational nutation series. The horizontal dotted lines show the FICN frequency band around 1034 days following Mathews et al. (2002). Amplitude unit: as.*

Unsolved problems / discussion points

- Why are the models behind the data in terms of accuracy? What are the remaining key limiting factors of Earth rotation synthesis?
- Model validations should be done using official series or is it sufficient to use some individual solution?
- Can we recommend to go for a monolithic fit for the determination of ITRF, ICRF, and EOP (as IUGG did)? It would certainly minimize inconsistencies but are we ready for it?



Unsolved problems / discussion points



Heinkelmann et al. (poster Journées 2014):

Why is the combined frame (ITRF2008) rotated w.r.t. the VLBI single technique frame (in particular dUT1)?

Why is dUT1 so different between ITRF2008 (Altamimi et al.) and DTRF2008 (M. Seitz et al.)?