Unified Analysis Workshop 2007

Session 3 Standardization/Extension of Common Parameterization
Chair: **BÖHM J.**
Co-Chair: **LUCERI C., SPRINGER T., WILLIS P., LUZUM B., WILMES H.,**

This session of the UAW is about defining common standards for the models and parameterization of quantities estimated by space geodetic techniques (station coordinates, Earth orientation parameters, troposphere parameters, gravity field coefficients …). This includes the consistent use of a priori values as well as partial derivatives to estimate the residual parameters.

The consistent treatment is even more important if these parameters are not reduced but combined at the normal equation level, as it will certainly be the case with the troposphere parameters (from the space geodetic techniques observing at radio wavelengths).

One general problem that arises is the treatment of model improvements. On the one hand there should be series from all techniques where consistent models are used for the whole history of observations and for all techniques.
On the other hand, there are always improvements of the models; thus, another series will be created that has discontinuities but uses the best models presently available. Consequently, standardization of common parameterization has the clear implication that in principle there should be two series that will be maintained by the techniques:

A) One series for the IERS / GGOS with a fixed specification which does not change with time but which is not the most accurate possible; with some techniques this can only be realized within reprocessing campaigns (e.g. for the IGS).

B) Another series for the AC's own purposes which is the 'best solution' but potentially not continuous.

There will be models in the future that will surpass existing ones, but which cannot be applied backwards. (Example: high resolution numerical weather models will become available for the whole Earth that will allow the application of 3-D ray-tracing routines to remove the troposphere delays; but there will be no way to create these high resolution numerical weather models for the whole history of VLBI observations backwards.)

Define common standards for a priori values/models to be used for these parameters

There are models given by the IERS Conventions that do not need to be discussed at the UAW (Earth tides, Nutation, relativistic effects, pole tide (?), atmosphere loading ...) because there is a clear recommendation to use or not to use them.

On the other hand, several models and strategies are necessary for the analysis where there is no clear recommendation in the IERS Conventions but where we need to be consistent across the techniques.

Examples are ocean loading, hydrostatic (a priori) troposphere delays, partial derivatives for the estimation of residual troposphere delays, or a priori models for (sub-daily) Earth rotation parameters.

Examples:

- presentation by V. Tesmer on experiences with CONT02 and GGOS-D

(See also: Snajdrova, K; Boehm, J; Willis, P; Haas, R; Schuh H. 2006. Multi-technique comparison of tropospheric zenith delays derived during the CONT02 campaign, *Journal of Geodesy* 79(10-11):613-623, doi: 10.1007/s00190-005-0010-z)

Troposphere parameters (radio techniques: GNSS, VLBI, DORIS)

(possible suggestion, although not the most precise available:)

a priori hydrostatic:	Davis et al. (1985) applied on the pressure from GPT (Boehm et al. 2007)
hydrostatic mapping:	hydrostatic GMF (Boehm et al. 2006)
wet mapping (partial):	wet GMF
gradient partial north:	cot (e)·GMFh·cos (a)
gradient partial east:	cot (e)·GMFh·sin (a)

(There are techniques which do not estimate horizontal gradients. See position paper for Session 2.)

There will be a short presentation by J. Boehm in Session 2 about the biases when using different models in GPS, VLBI and DORIS analysis.

Mind that the total zenith delay difference between the antenna reference points needs to be known a priori. Common meteorological sensors at the sites would be very useful (presentation by A Niell in Session 2).

Earth orientation parameters

(See also the position paper for Session 2 with more details what the techniques do.)

For the nutation, IAU2000A can be used as a priori model. The a priori model for polar motion and UT1-UTC/LOD is not uniquely defined because IERS C04 (v05) is given once daily at 0:00 UT. The linear interpolation for GPS is clear if the session lasts from 0:00 to 24:00, but it is not so clear if the VLBI sessions lasts from 17:00 to 17:00.

Lagrange interpolation is widely used in VLBI analysis, but this makes it impossible to determine offset and rate of the ERP as sum of a priori and estimated offsets and

rates. There has to be agreement across the techniques which a priori values for the ERP are used.

Should we apply a priori models for sub-daily ERP and - if yes - which?

Caveat:
There are high correlations between sub-daily ERP (retrograde diurnal polar motion) and nutation parameters (and orbital parameters). Thus, constraints on daily nutation values need to be applied, but not on GPS orbits (Thaller et al. 2007).

Station coordinates

The same models (and epochs) for station displacements after an earthquake need to be taken into account by all techniques. (This might only be possible at a second stage at the combination level as often relaxation phenomena can be observed.)

Should we adopt time periodic terms for station coordinates (1 year, 6 months ...)?

Geocenter Motion

- presentation by E. Pavlis
- presentation by P. Willis about systematic errors in DORIS Z-Geocenter time series

Compilation of parameters and models where standardization is required when including terrestrial AG and SG observations

Standardization of models for gravity corrections: precondition for consistent intercomparison of gravity-gravity and gravity-geometrical methods.

- Atmospheric effects:
  - absolute gravity: conventions for reduction to normal pressure
  - offset corrections for barometric measurements (instrumental comparison)
  - modelling of bottom-pressure independent effects (attraction and deformation) with 3-D meteorological models.
  - validation of atmospheric models in comparison with high resolution gravity time series
- Solid Earth Tides:
  - treatment of anelasticity for long period tides (> diurnal up to 18.6 year) extension of IERS-conventions?
  - agreement btw. models for geometric and gravimetric techniques (results of local analysis?)
- Ocean Loading Effect:
  - separation from solid Earth tides in tidal analysis (gravimetry)
  - choice of model consistent with anti-aliasing products used for satellite derived potential models (GRACE, GOCE) – definition of a quasi-standard?
- Instrument related reductions: unification of “datum height” for all terrestrial gravity measurements (e.g. 1 m); reduction to zero height above ground leads to problems with non linear gravity gradients!

Global gravity reference frame: replacement for IGSN 71

- improved (relative) accuracy due to instrumental development
- realisation by a worldwide set instruments; regular intercomparison ensures unique absolute level
- worldwide distribution permanent regional comparison stations:
  - worldwide gravity reference (AG), monitoring of instrumental stability
  - monitoring gravity changes in combination with SG; basis for further studies (centre of mass changes, combination with satellite derived geopotential models)
- Database for absolute measurements (IAG-service?)

Combination with time dependent satellite derived geopotential models (GRACE): due to the need in regularization and filtering for truncation of the spherical harmonics: damping of signal! Calibration behalf of high precision, continuous terrestrial gravity measurements.

- combination of SG and AG, GGP network
- need in consistent reductions (see above)
- bridge of different spatial resolution: point measurements versus mean values over several 100 km^2, separation of local mass changes (local hydrology) from regional trends main task, comparison based on principal components of the signal (EOF/SSA).
- different resolution in time: agreement about filtering techniques

Combination with geometrical measurements

- geometrical measurements: deformation only
- gravimetric measurements:
  - gravity changes due to change of position
  - deformation induced potential changes as well as changed Newtonian attraction
- separation of both effects with combination enables estimation of mass changes
- local ties: regular monitoring of geometrical relations btw. monuments essential!

Testing and Checking

In order to get the best agreement between the Analysis Centers, is essential that there is not only an agreement on certain models but that their implementation is thoroughly checked, too (C Luceri, T Springer).

➢ presentation by T. Springer

➢ presentation by E. Pavlis about ILRS benchmarks

Also, acceptance tests for stations are a valuable tool to improve the homogeneity of the network performance.

➢ presentation by H. Mueller about acceptance tests by the ILRS

Define common standards for the time resolution (intervals) and reference epochs of parameters (weekly, daily, sub-daily ...)

Time intervals have to be selected in a way that the parameters can be combined at a later stage. There are several possibilities, one of which is:

7 days, 1 day, 12 h, 6 h, 2 h, 1 h, 20 min, 10 min, ...

Prerequisite is that the time intervals can be exactly divisible by all shorter time intervals.

The intervals have to fit into integer hours. This means that software packages need to be changed if the time intervals start with the first observation. For each time interval, a linear function should be set up; however, there are several ways to realize linear functions, e.g. with offset and rate or with two offsets:

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I    a0 + (t-t0)·r1           offset a0 and the rate r1
II   a0 + (t-t0)/dt·(a1-a0)   offsets a0 and a1
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Both approaches need two parameters per linear segment, although in case II these parameters are partly identical, and thus the number of parameters decreases. Also, continuity is automatically guaranteed.

For each parameter, a minimum requirement will be necessary. E.g. if the minimum requirement for the wet zenith delay is 1 hour, the linear functions can be estimated every 1 hour, 20 min, ... At a later stage in the combination process, these non-continuous linear segments can be combined to continuous linear segments with a time interval of one hour.

Which time scale should be used for the linear functions, UTC?

Extend the SINEX format to allow for additional parameter types and parameterizations

- ✓ presentation by M. Rothacher

Define the set of parameters to be used for the next ITRF200x realization

Station coordinates and velocities, Earth orientation parameters, Troposphere parameters (wet zenith delays and gradients).

But also: breaks (epochs) in time series of station coordinates, periods for which data from a specific technique should not be used (see example for DORIS at http://ids.cls.fr/documents/report/IDS_for_ITRF2004_v1_0.pdf = P. Willis, L. Soudarin, H. Fagard, J. Ries, R. Noomen, IDS recommendations for ITRF2004)

Draft program:

Presentations in Session 3 at the UAW (We have 60 minutes for presentations and 30 minutes for discussion and action items) : Thus, I would like to kindly ask each speaker to save some minutes for the discussion.

Johannes Boehm (5 minutes)

Present an introduction and overview.

Volker Tesmer et al. (15 minutes)

Experiences with CONT02 and GGOS-D:

- (dis-)advantage of different functional models
- representation of a prioris
- reference epochs
- combined estimation of polar motion (rates) and nutation (rates)
- pole tide ...

Pascal Willis (10 minutes)

Systematic errors in DORIS Z-Geocenter time series

Tim Springer (10 minutes)

Discuss the usefulness of having "reference" values for ALL the IERS 2003 models. Discuss a way of improving "standard" software and a central place to maintain the version.

Erricos Pavlis (10 minutes)

ILRS benchmark
Example: geocenter

Horst Mueller (10 minutes)

Acceptance tests by ILRS

Markus Rothacher (10 minutes)

Proposal for extended parameterization in SINEX
(see his email from 9 Nov 2007)

General discussion and action items (20 minutes)

Discussion and action items

- Each AC will need to maintain two solutions ..
- Which functional model should we apply for the continuous piecewise linear functions?
- Should we set up a pilot project? Could be based on CONT05, and it might be similar to what was done in Germany for CONT02.
- Do the techniques really follow the IERS Conventions? Do we need an action item to develop an inventory as to who used what in their s/w?
- Do we need an “authority” over the techniques (ITRS, GGOS?) that maintains a single list of “breaks” at each site by technique. (Not only for earthquakes)
- …