IGS08:

Elaboration, consequences and maintenance of the IGS realization of ITRF2008

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All IGS ACs are gratefully acknowledged for their contribution to the elaboration of IGS08 and igs08.atx.

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History of IGS reference frames

• Since 2000, the IGS has used its own realizations of the successive ITRFs as reference for its products.
• A new reference frame (RF) based on ITRF2008, IGS08, will be adopted as of week 1632 (17 April 2011).
Elaboration of IGS08

• Initially intended to be a subset of « good » GNSS stations from ITRF2008
  (Their actual positions should remain close to the ITRF2008 linear model.)

• A selection was made based on the ITRF2008 results:
  - Data span
  - Maximum time span between two discontinuities
  - Number of discontinuities
  - Absence of velocity discontinuities
  - Standard deviation of velocity
  - Residual time series

• When possible, preference was given to stations with special equipment:
  - Robot-calibrated antennas
  - GPS+GLONASS capability
  - External atomic clock
  - Co-location with other techniques
Selection result

Full IGS08 network: 232 stations; global coverage, but heterogeneous density
Ground antenna calibration updates

• An updated set of antenna calibrations, igs08.atx, will be adopted together with IGS08.
  - 15 new robot calibrations (+9 copies for similar antenna types)
  - 46 updated robot calibrations
  - All converted calibrations updated
  - ... (more in IGSMAIL-6355)

• Implication for IGS08:
  - ITRF2008 made indirect use of the igs05.atx calibrations.
  - But IGS08 has to be consistent with the latest igs08.atx calibrations.
  - Stations affected by calibration updates should either be dropped from IGS08 or have their ITRF2008 coordinates corrected.

• Remark:
  - The same problem had to be solved with the transition from (ITRF2005; relative calibrations) to (IGS05; absolute calibrations).
  - Differences are much smaller from (ITRF2008; igs05.atx) to (IGS08; igs08.atx).
  - Future convergence of ground antenna calibrations is expected but uncertain.
Ground antenna calibration updates

• Impact on IGS08 station coordinates assessed by:
  - PPP tests (IGN, ESA, CNES)
  - Parallel solutions from 8 Analysis Centers

• Good overall agreement
  (Although fixing ambiguities has a noticeable impact for some antenna types.)

Shifts estimated from PPP tests and parallel AC solutions
Ground antenna calibration updates

- Corrections derived from the IGN PPP tests were finally applied to the ITRF2008 coordinates of 65 stations (87 different time spans).
- IGS08 was NOT re-aligned to ITRF2008.
IGS05 → IGS08 transformation

• Total transformation =

  Global Helmert transformation due to the ITRF2005 → ITRF2008 datum change (1) + Station-specific corrections due to ground antenna calibration updates (2)

• IGS05 → IGS08 transformation parameters estimated using 118 stations:
  - *** These parameters only describe part (1) of the total transformation. ***
    (A version of IGS08 in which coordinate corrections had NOT been applied was used.)
  - ITRF2005 → ITRF2008 transformation parameters are given in blue for comparison.

<table>
<thead>
<tr>
<th>Transformation parameters at epoch 2005.0</th>
<th>TX (mm)</th>
<th>TY (mm)</th>
<th>TZ (mm)</th>
<th>SC (ppb)</th>
<th>RX (mas)</th>
<th>RY (mas)</th>
<th>RZ (mas)</th>
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<tr>
<td>TX</td>
<td>1.5</td>
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<td>0.04</td>
<td>0.009</td>
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<th>Rates of transformation parameters</th>
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<th>dTY (mm/y)</th>
<th>dTZ (mm/y)</th>
<th>dSC (ppb/y)</th>
<th>dRX (mas/y)</th>
<th>dRY (mas/y)</th>
<th>dRZ (mas/y)</th>
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<td>0.009</td>
<td>0.009</td>
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IGS05 → IGS08: Advice to users

• How to transform results from the (IGS05; igs05.atx) framework to the (IGS08; igs08.atx) framework?

• Because of the ground antenna calibration updates, a direct Helmert alignment to IGS08 is not appropriate.

• Proposed method:

  1) Correct station positions to account for the calibration updates
     • Latitude-dependent models for the impact of calibration updates on station coordinates are available.
     • Perl scripts from J. Griffiths can be used to compute and apply corrections from these models.
     • More in IGSMAIL-6356

  2) Helmert alignment to IGS08
Satellite antenna calibration updates

- Computation of new satellite z-PCOs was necessary because of:
  - the -1 ppb scale difference between IGS08 and IGS05,
  - the correlation between satellite z-PCOs and the terrestrial scale.

- GLONASS PCVs were re-estimated. (But GPS PCVs are unchanged.)

- Procedure for GPS:
  - Reprocessed SINEX solutions from 5 ACs
  - Remove constraints
  - Apply constraints in scale, origin and orientation wrt ITRF2008
  - Weighted average over time and ACs

- Procedure for GLONASS:
  - Reprocessed GNSS solutions from CODE and ESA
  - Re-estimation of z-PCOs and PCVs
  - Solutions aligned to IGS08
  - GPS satellite antenna corrections kept fixed
IGS08 core network

• Motivation:
  - When stacking weekly solutions aligned to an inhomogeneous RF, parts of the geophysical or local signals are absorbed by the weekly transformation parameters.
    ⇒ Station-dependent annual signals can be reduced/amplified and/or shifted.

• This aliasing can be reduced by using a well-distributed RF. (Collilieux et al., 2010)

• IGS08 core network = well-distributed sub-network of IGS08
  - 91 primary stations
  - Up to 4 substitute stations for each primary station

• Recommended for any alignment of a global network to IGS08

• Will be used to align the IGS weekly combined solutions
IGS08 core network

The 91 primary stations of the IGS08 core network
IGS08 core network

Simulations using synthetic data:

Differences at the annual frequency between true values & residuals of a 7-parameter transformation:

\[ x(t) = \ln \cos(\omega t) + \text{Out} \sin(\omega t) \]

Weekly translations and scale factors:

<table>
<thead>
<tr>
<th></th>
<th>East</th>
<th>North</th>
<th>Up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In (mm)</td>
<td>Out (mm)</td>
<td>In (mm)</td>
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<tr>
<td>Full IGS08</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
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<tr>
<td>IGS08 core</td>
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<td>0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Annual signals are better retrieved if « IGS08 core » is used instead of the full IGS08 network.

Loading model includes:
- Atmospheric loading
- Non-tidal ocean loading
- Continental water loading

(T. van Dam, University of Luxembourg)
Many IGS08 stations were subjected to discontinuities since 2009.5.

Today:
- XXX / 232 usable IGS08 stations
- YY / 91 usable core stations

Rate of loss seems to accelerate.
Proposal for IGS08 updates

- To avoid a future crisis situation for the IGS products, it will probably be necessary to consider regular updates of IGS08 before the next ITRF release.

- Suggestion to overcome discontinuities:
  - Some months after a discontinuity occurred, compute an offset using the IGS cumulative solution:
    \[ dX = X_{after}(IGS \, cum.) - X_{before}(IGS \, cum.) \]
  - Introduce post-discontinuity coordinates in IGS08 using this offset:
    \[ X_{after}(IGS08) = X_{before}(IGS08) + dX \]
  - Only applicable if velocity is unchanged (no post-seismic deformation).

- Suggestion to overcome station substitutions:
  - When an old station is eventually decommissioned after having run several years in parallel with a new station at the same site, compute a « local tie » using the IGS cumulative solution:
    \[ dX = X_{new}(IGS \, cum.) - X_{old}(IGS \, cum.) \]
  - Introduce the new station in IGS08 using this « local tie »:
    \[ X_{new}(IGS08) = X_{old}(IGS08) + dX \]
  - Only applicable if velocities are identical.

- In the IGS08 covariance matrix, new off-diagonal terms would be zero. But are they used by anyone?
Thanks for your attention!