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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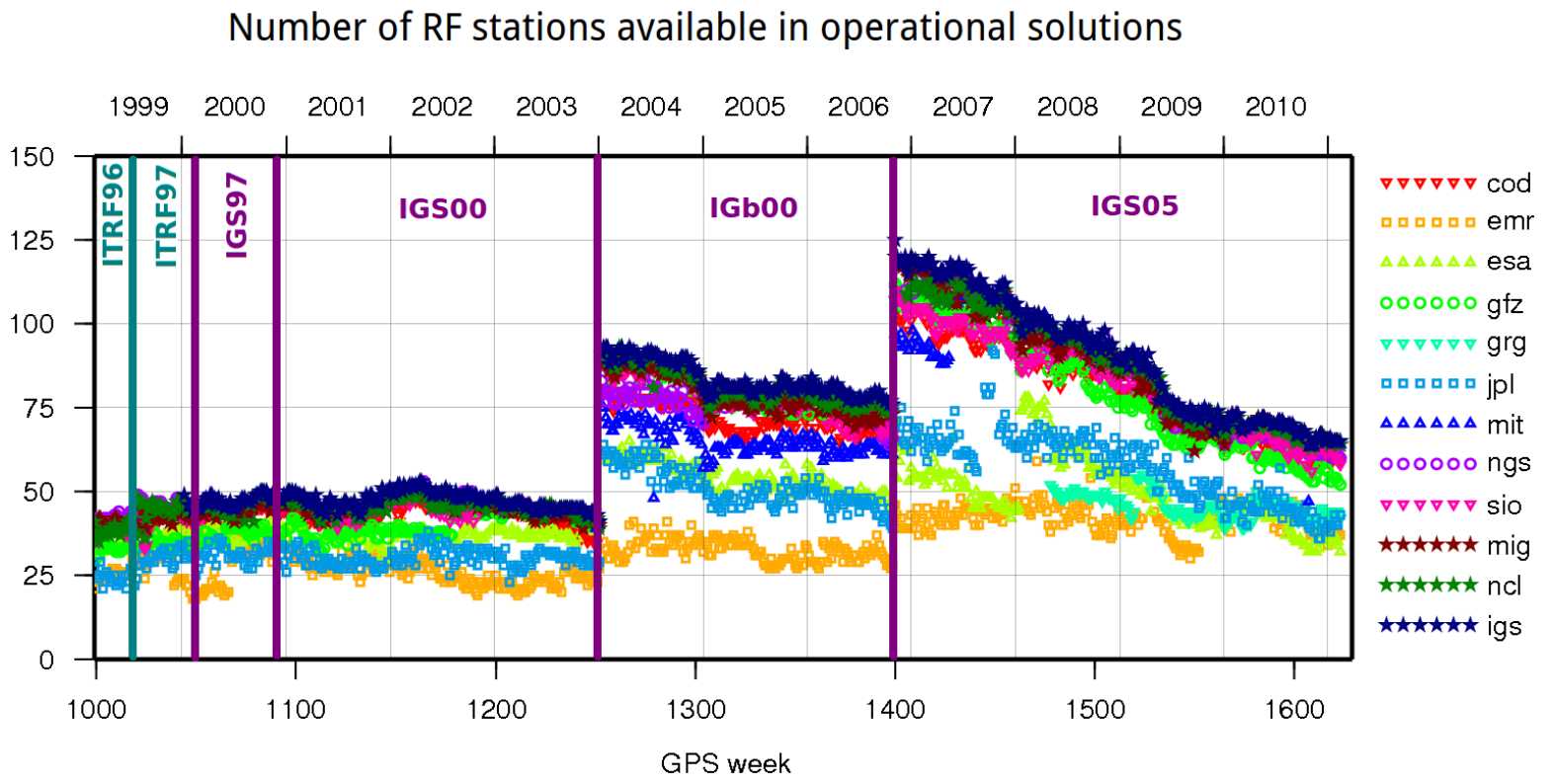
History of IGS reference frames

- 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

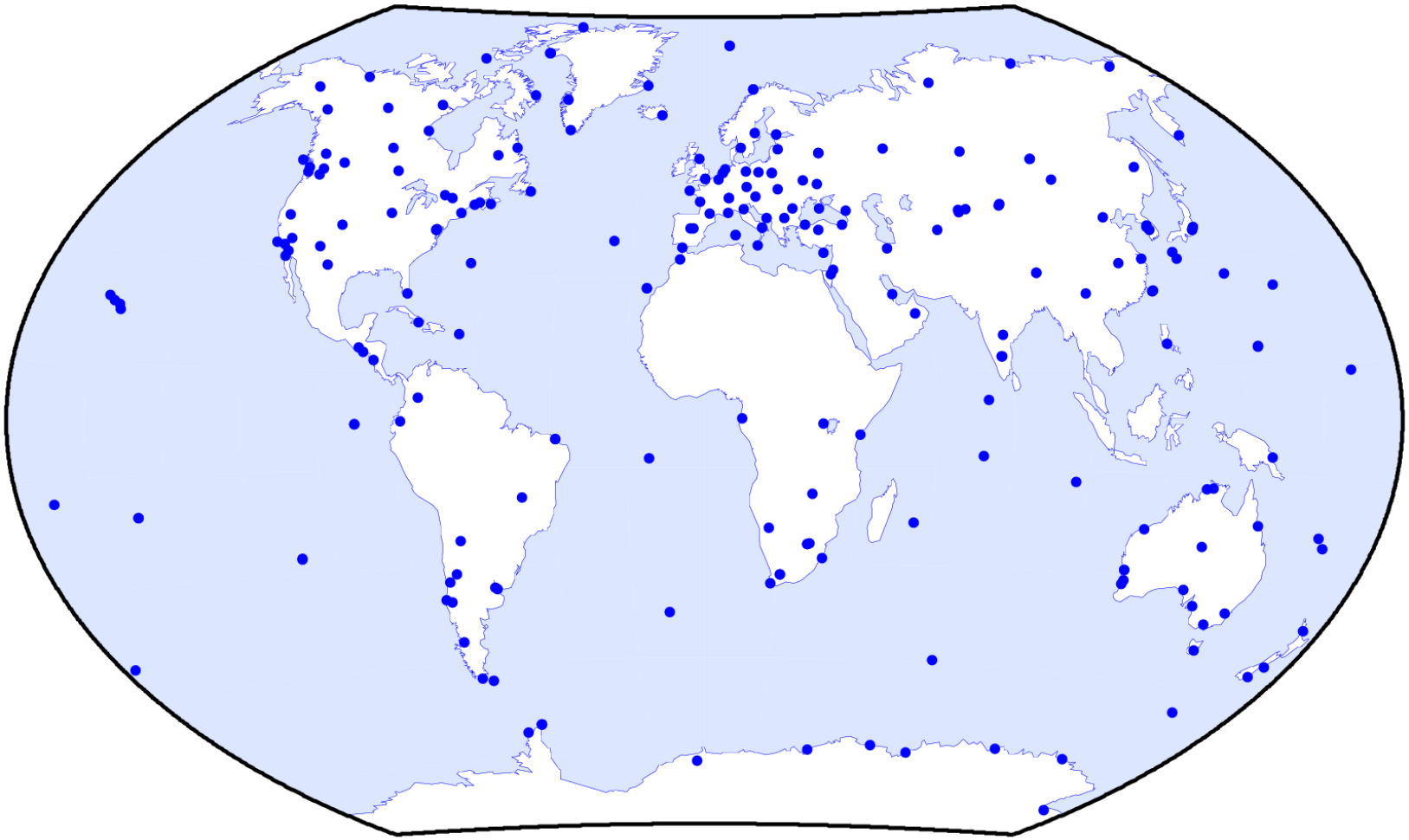
- Initially intended to be **a subset of « good » GNSS stations from ITRF2008**

  (Their actual positions should remain close to the ITRF2008 linear model.)

- A selection was made based on the ITRF2008 results:
  - Data span (> 5 yr)
  - Maximum time span between two discontinuities (> 3 yr)
  - Number of discontinuities (< 5)
  - Absence of **velocity** discontinuities
  - Standard deviation of velocity (< 0.3 mm/yr)
  - Residual time series (RMS + visual inspection)

- 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



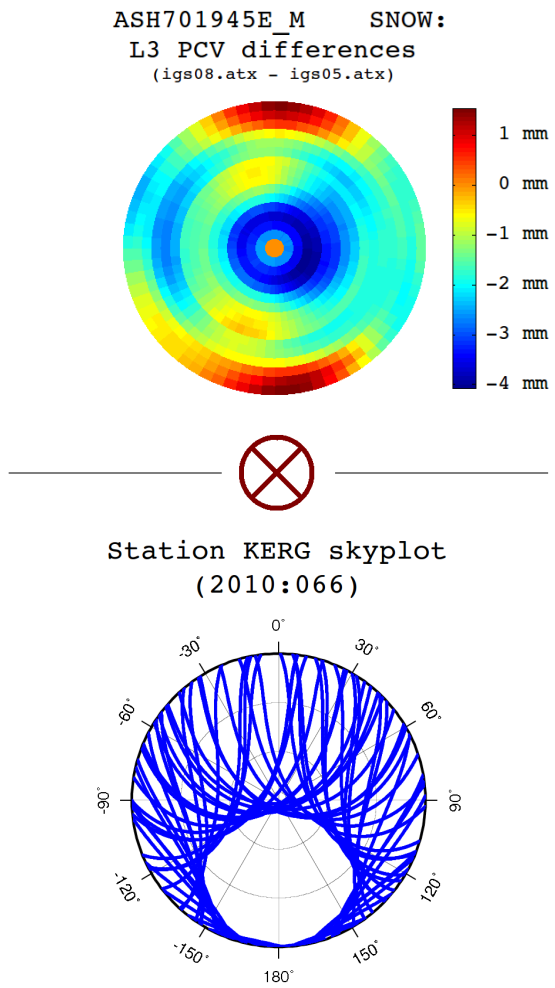
Full IGS08 network: 232 stations; global coverage, but heterogeneous density

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.

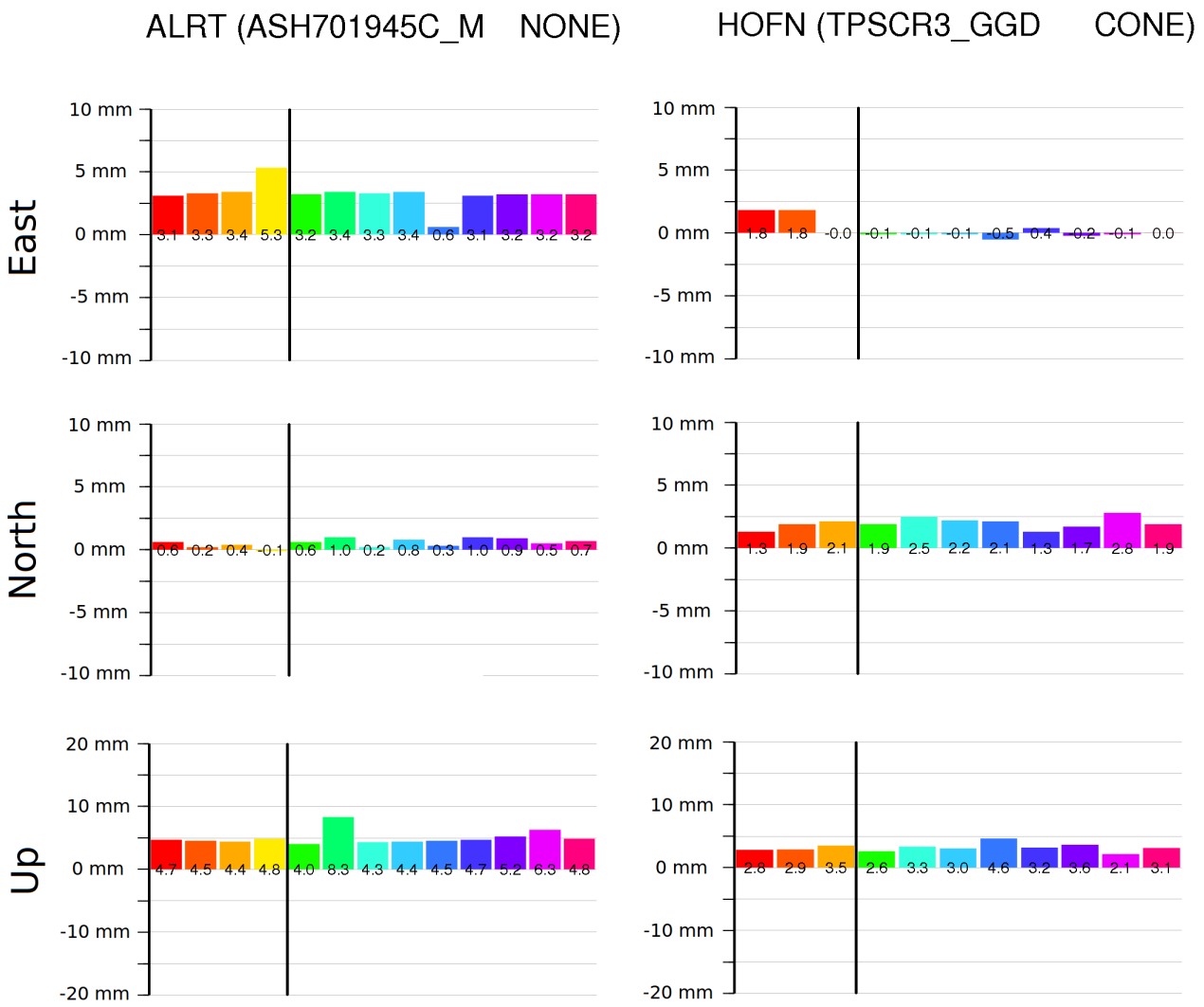
- Remark:
  - The same problem had to be solved with the transition from (ITRF2005; relative calibrations) to (IGS05; absolute calibrations).
  - Differences are much smaller from (ITRF2008; igs05.atx) to (IGS08; igs08.atx).
  - Future convergence of ground antenna calibrations is expected but uncertain.



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

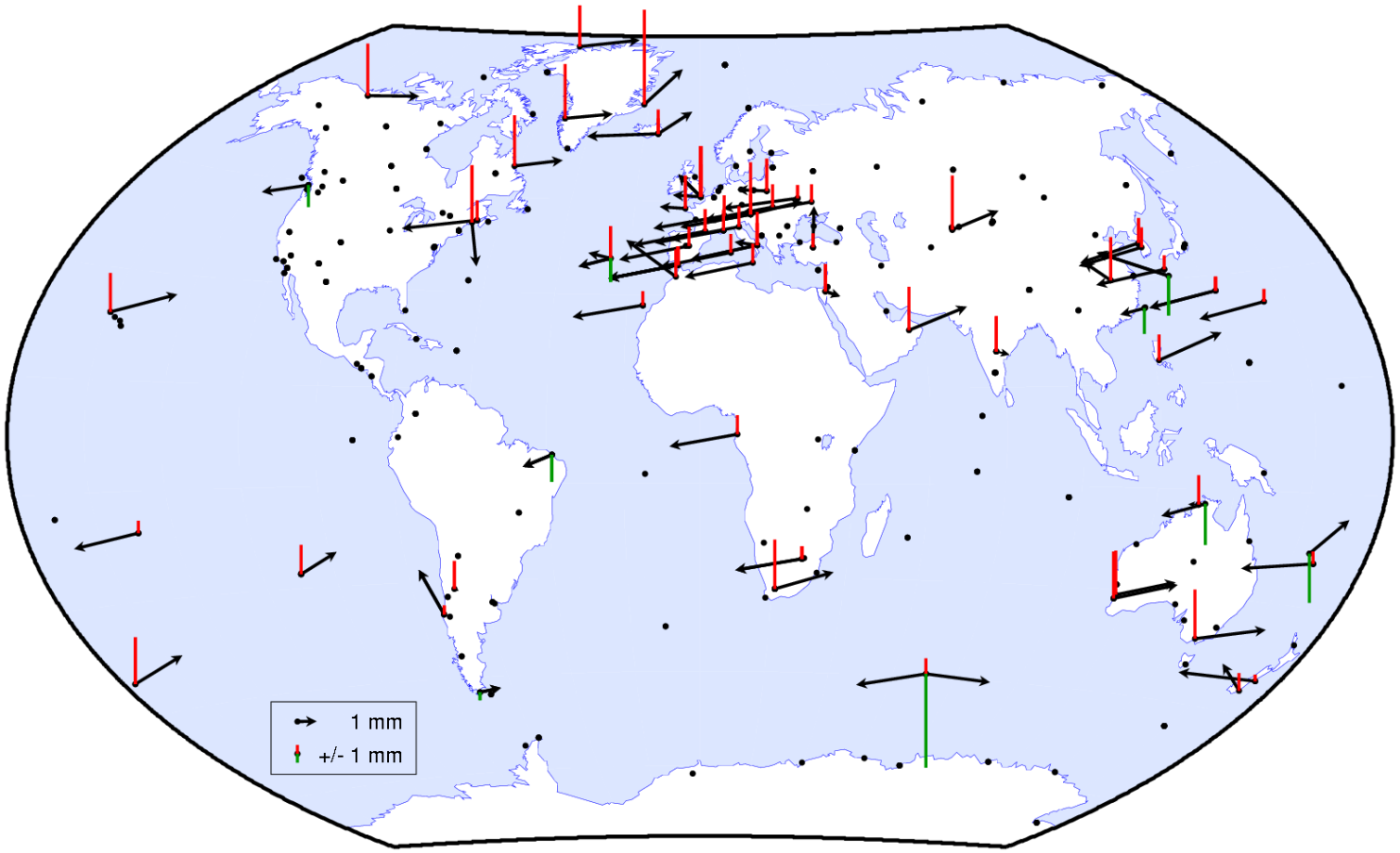
  (Although fixing ambiguities has a noticeable impact for some antenna types.)



Shifts estimated from PPP tests and parallel AC solutions

PPP tests	Parallel AC solutions		
IGN	COD	GRG	
ESA float	EMR	MIT	
ESA fixed	ESA	NGS	
CNES	GFZ	SIO	
	Combination		

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.

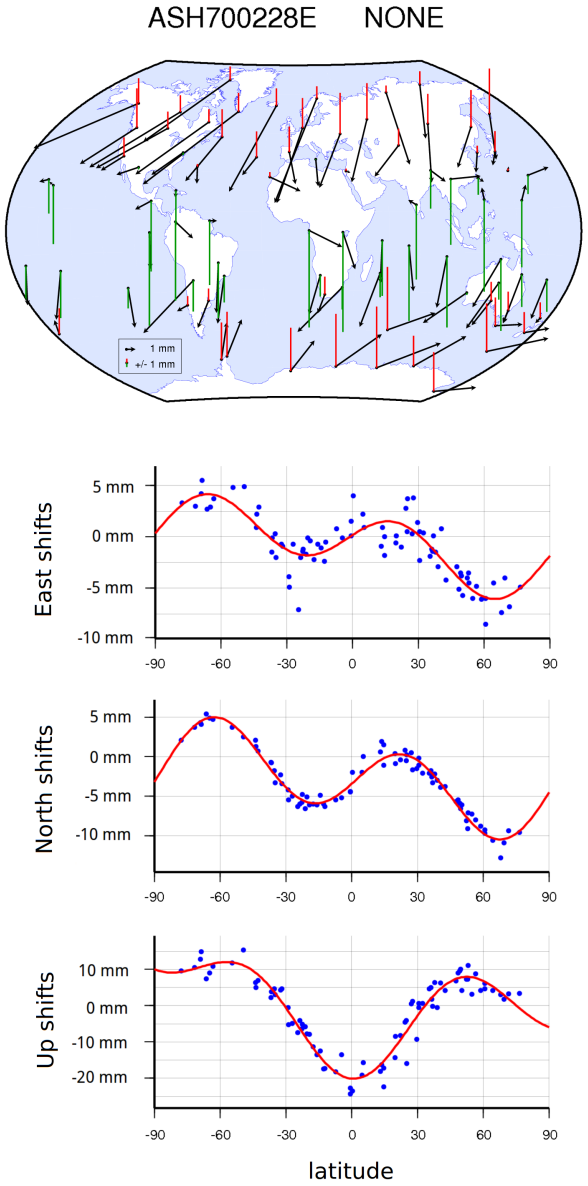
Transformation parameters at epoch 2005.0	TX (mm)	TY (mm)	TZ (mm)	SC (ppb)	RX (mas)	RY (mas)	RZ (mas)
	1.5 0.5	-0.0 0.9	5.8 4.7	-1.04 -0.94	-0.012 0.000	0.014 0.000	0.014 0.000
+/-	0.2	0.2	0.2	0.04	0.009	0.009	0.010
Rates of transformation parameters	**dTX (mm/y)**	**dTY (mm/y)**	**dTZ (mm/y)**	**dSC (ppb/y)**	**dRX (mas/y)**	**dRY (mas/y)**	**dRZ (mas/y)**
	-0.1 -0.3	-0.0 0.0	-0.1 0.0	0.01 0.00	-0.002 0.000	-0.003 0.000	0.001 0.000
+/-	0.2	0.2	0.2	0.04	0.009	0.009	0.010

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



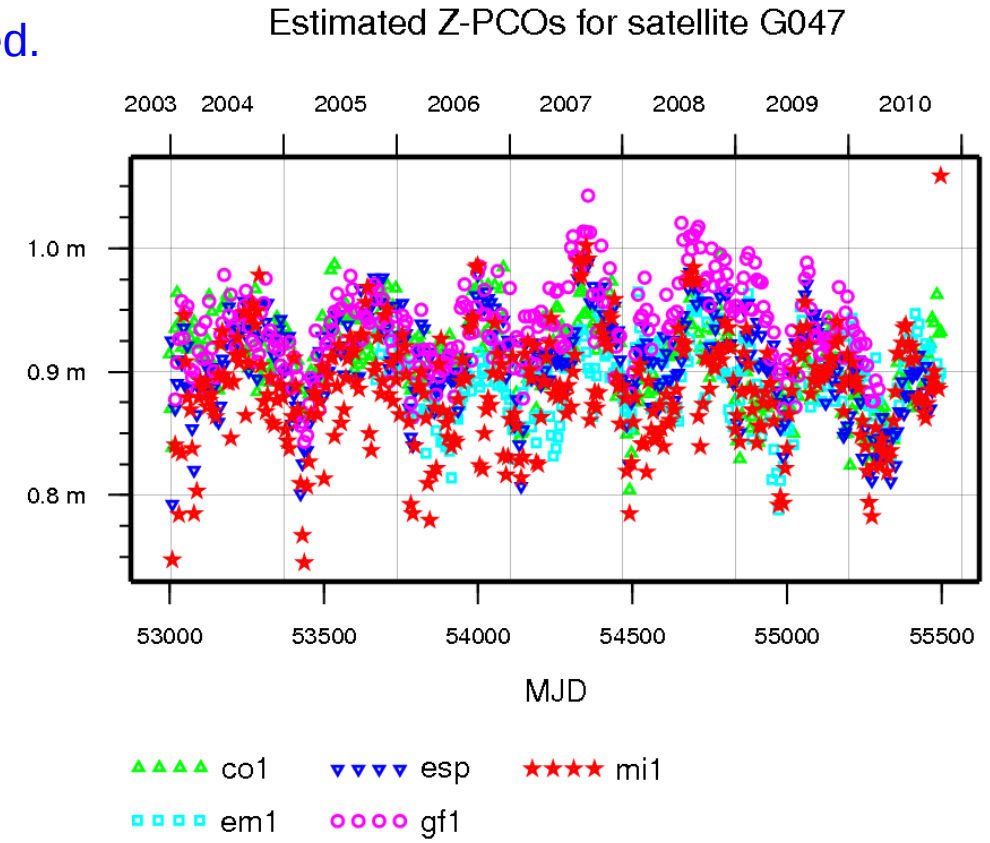
Satellite antenna calibration updates

- 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 global solutions aligned to an inhomogeneous RF, parts of the geophysical or local signals are absorbed by the Helmert 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)

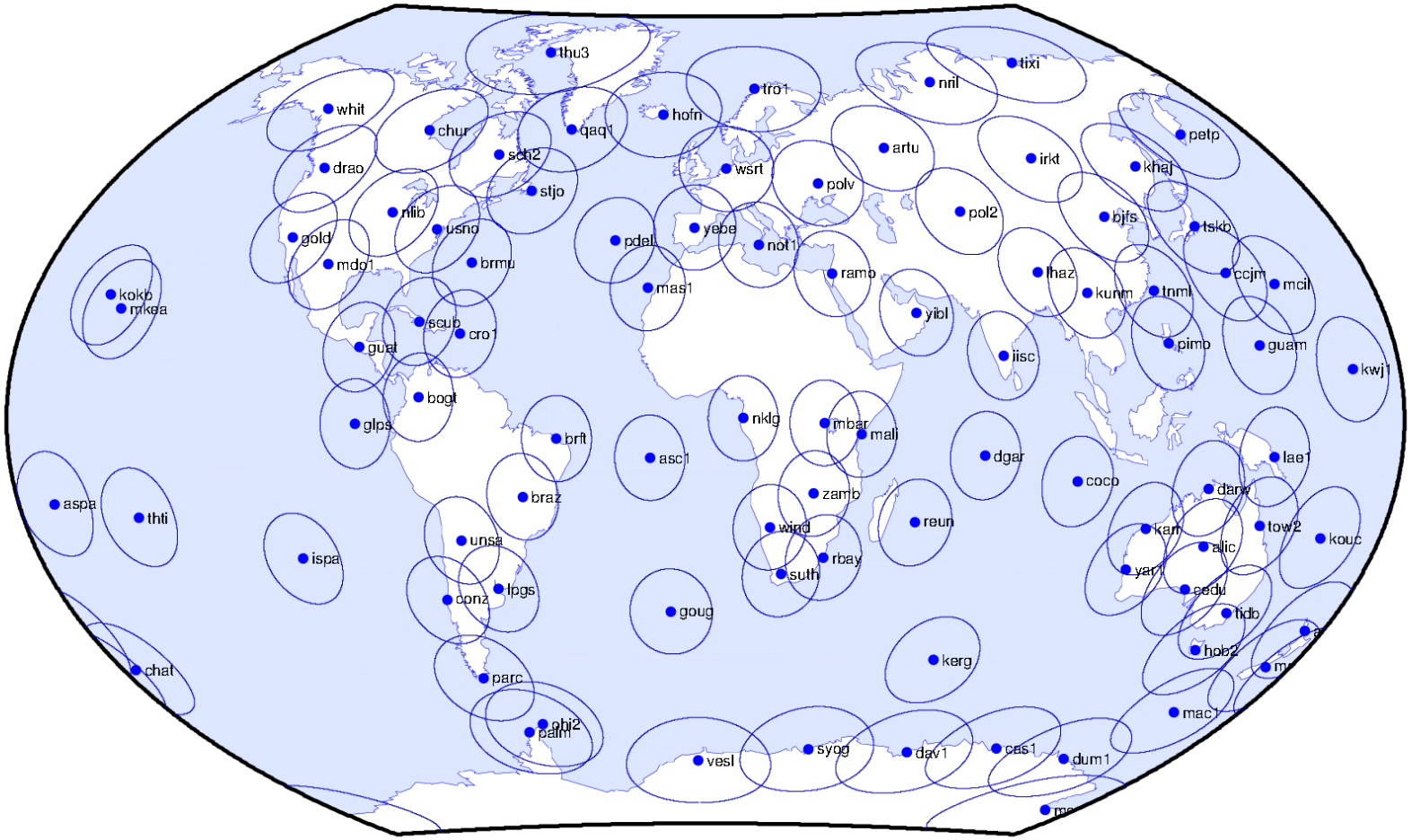
- IGS08 core network = well-distributed sub-network of IGS08
  - 91 primary stations
  - Up to 4 substitute stations for each primary station

- Recommended for any alignment of a global solution 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:

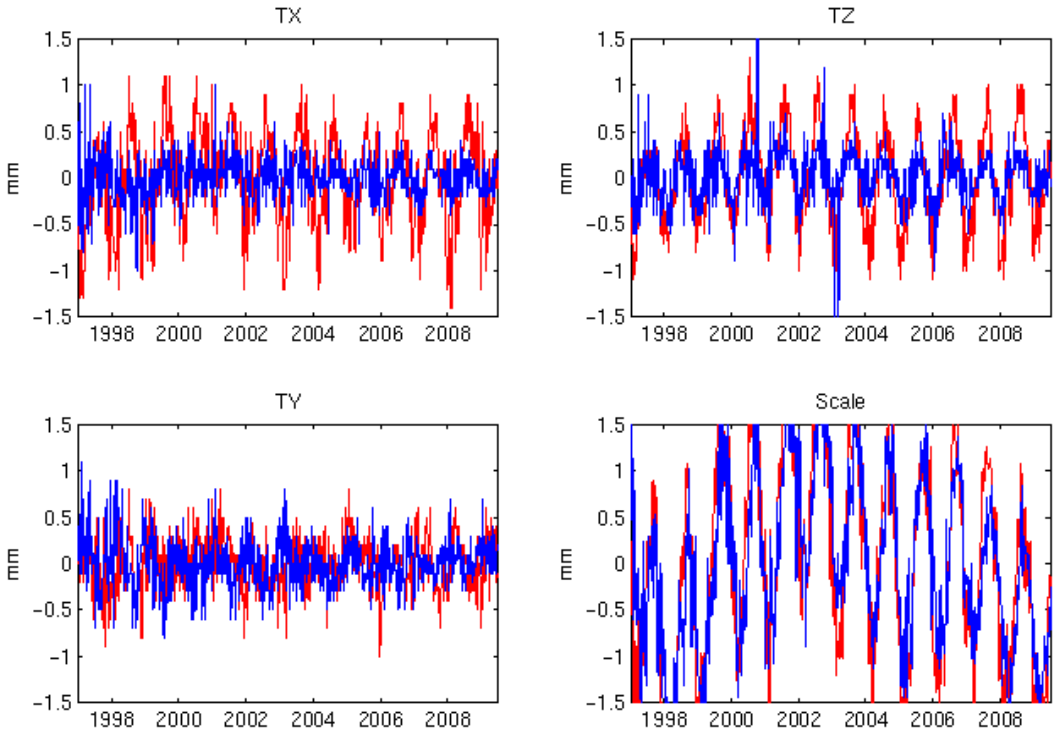
Differences at the annual frequency between true values & residuals of a 7-parameter transformation:

$x(t) = \mathbf{In}\cos(\omega t) + \mathbf{Out}\sin(\omega t)$

	East		North		Up	
	In (mm)	Out (mm)	In (mm)	Out (mm)	In (mm)	Out (mm)
Full IGS08	**0.3**	**0.3**	**0.4**	**0.2**	**1.0**	**1.3**
IGS08 core	**0.1**	**0.1**	**0.2**	**0.1**	**0.6**	**1.1**

Weekly translations and scale factors:

Full IGS08 **IGS08 core**



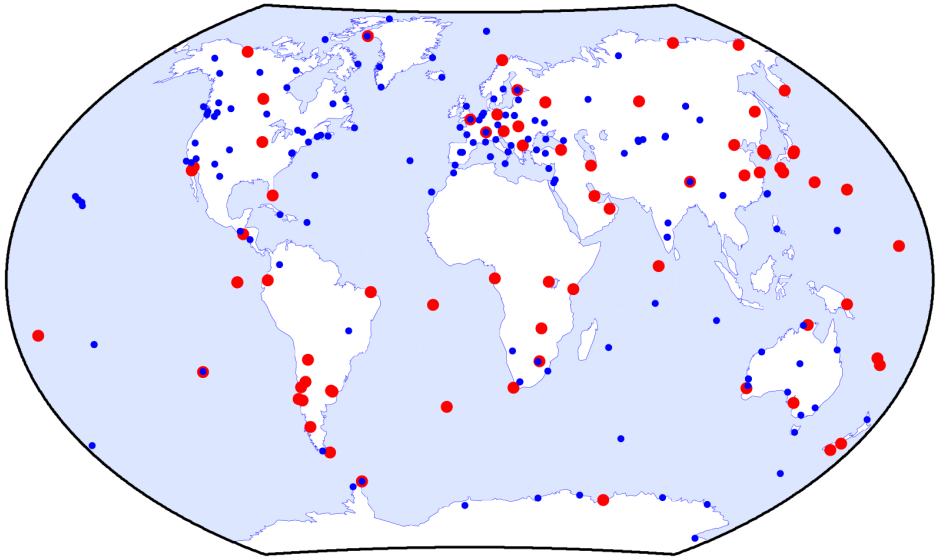
Annual signals are better retrieved if « IGS08 core » is used instead of the full IGS08 network.

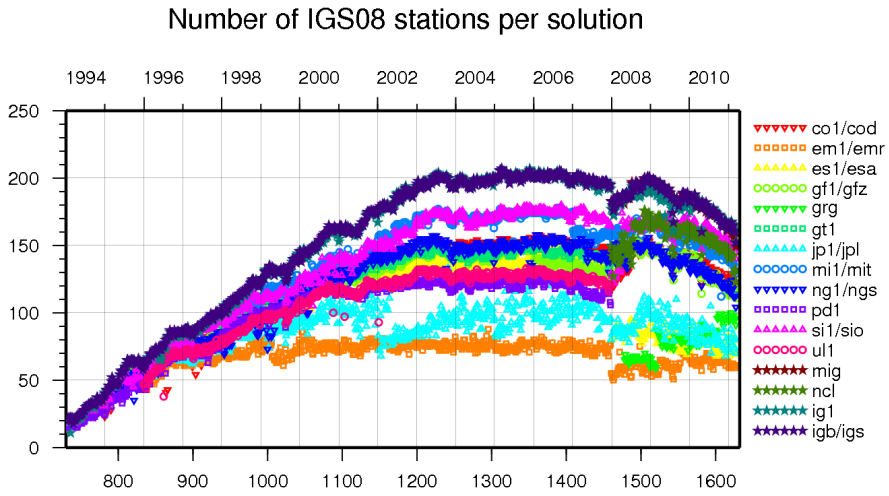
Loading model includes:
- Atmospheric loading
- Non-tidal ocean loading
- Continental water loading

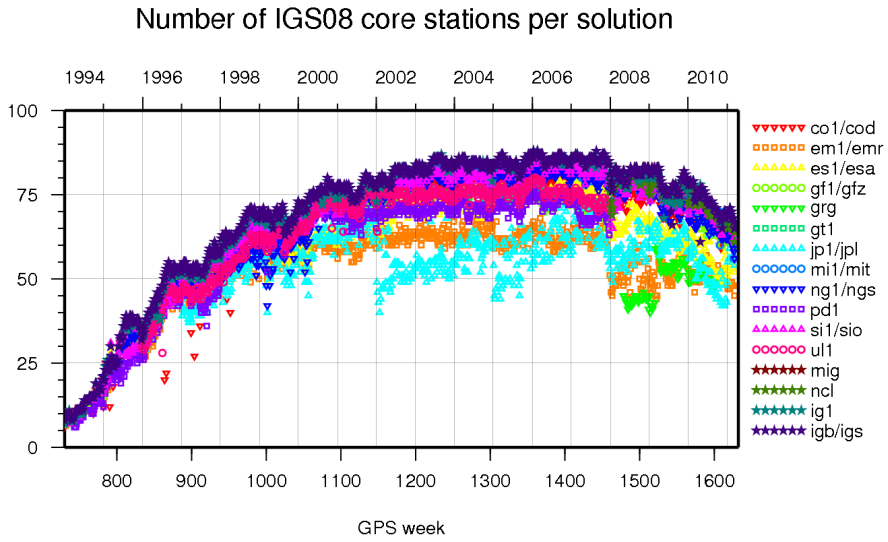
(T. van Dam, University of Luxembourg)

IGS08 decay

- Many IGS08 stations were subjected to discontinuities since 2009.5.
- Week 1627 (19 March 2011):
  - **153** / 232 usable IGS08 stations (see map)
  - **65** / 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:

    $$dX = X_{after}(\text{IGS cum.}) - X_{before}(\text{IGS cum.})$$

  - Introduce post-discontinuity coordinates in IGS08 using this offset:

    $$X_{after}(\text{IGS08}) = X_{before}(\text{IGS08}) + dX$$

  - 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:

    $$dX = X_{new}(\text{IGS cum.}) - X_{old}(\text{IGS cum.})$$

  - Introduce the new station in IGS08 using this « local tie »:

    $$X_{new}(\text{IGS08}) = X_{old}(\text{IGS08}) + dX$$

  - 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!