DTRF2014: the new DGFI realization of the ITRS

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Plenary 6: Reference Frame
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DTRF2014

- **DTRF2014**: ITRS realization computed by DGFI-TUM
- Based on **combination of datum-free normal equations** of individual techniques reconstructed from SINEX files
- For the first time, **non-tidal loading signals are considered**
- **A conventional solution** (without non-tidal loading correction) was computed for validation purposes and **is presented in the following**.

Outline

- Input data and its analysis
- Solution statistics and datum realization of DTRF2014
- Internal and external validation of DTRF2014 (focus on DTRF scale)
- Summary and outlook

DTRF2014 – Input data

Space geodetic techniques:

	Service	Solution type	Resolution	Time span	
VLBI	IVS	free NEQ	session-wise	04/80 - 12/14	**35 years**
SLR	ILRS	loosely constrained solution	before 1993.0: 15 days after 1993.0: weekly	12/82 - 01/15	**32 years**
GNSS	IGS	minimum constraint solution	daily	01/94 - 02/15	**21 years**
DORIS	IDS	minimum constraint solution	weekly	01/93 - 01/15	**22 years**

Local ties and loading data:

	Provided by …	Format
Local ties	– co-location sites, surveying teams – collected and prepared by Z. Altamimi	SINEX
Non-tidal atmospheric, hydrological and oceanic loading data	– GGFC of the IERS • atmospheric: based on NCEP model • hydrological: based on GLDAS model • **oceanic: not used (data do not cover complete time span)**	free format

DTRF2014 – Parameters

Parameters contained in SINEX and used for DTRF2014:

				Daily EOP at noon epochs		
	Station positions	**Station velocities**	**Geocenter coordinates**	**Terrestrial pole**	**UT1**	**Celestial pole**
VLBI	X			offsets & rates	UT1 & LOD	offsets
SLR	X			offsets before 1993.0: 1/3d after 1993.0: daily	LOD before 1993.0: 1/3d after 1993.0: daily	
GNSS	X		X	offsets & rates	LOD	
DORIS	X			offsets		
DTRF2014	X	X	reduced	offsets & rates	UT1 & LOD	offsets

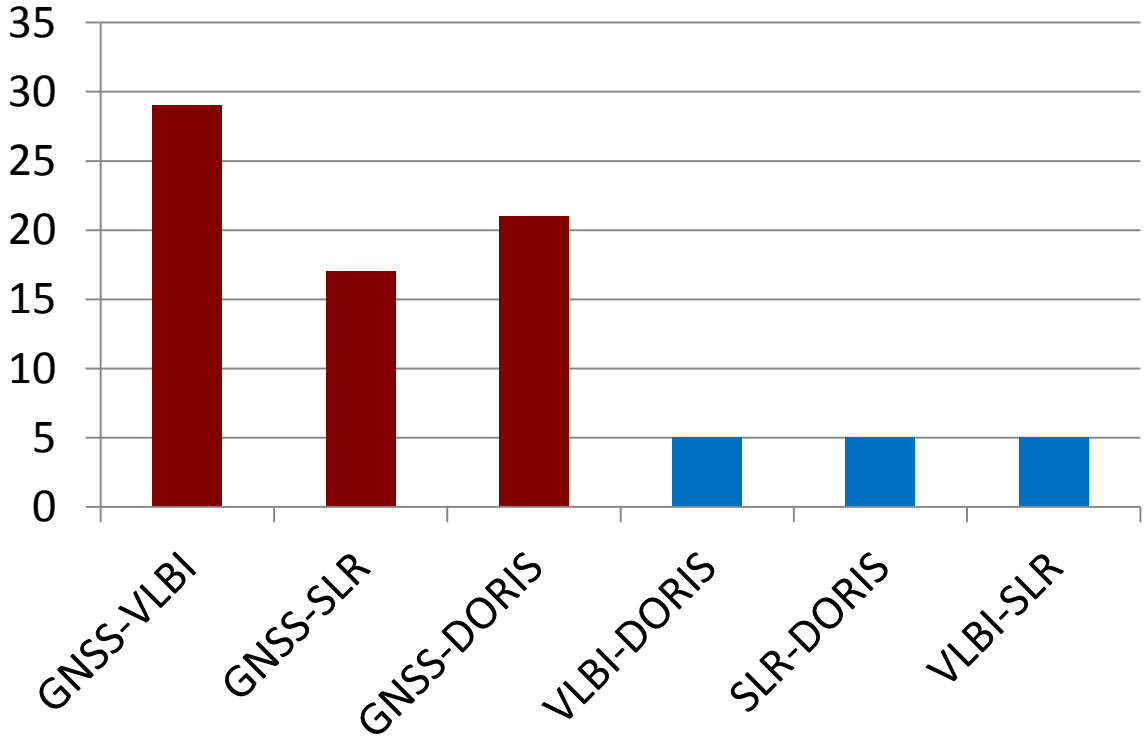
Geodetic datum

- origin: realized by **SLR** (complete time series used)
- scale: realized by **SLR and VLBI** (complete time series used)
- orientation: no-net-rotation conditions (**GNSS subnetwork**) w.r.t. DTRF2008

DTRF2014 – Multi-technique combination (constraints)

Number of DTRF2014 local ties at co-location sites: 82 (373 altogether)

	VLBI	SLR	DORIS
GNSS	29	17	21
VLBI		5	5
SLR			5



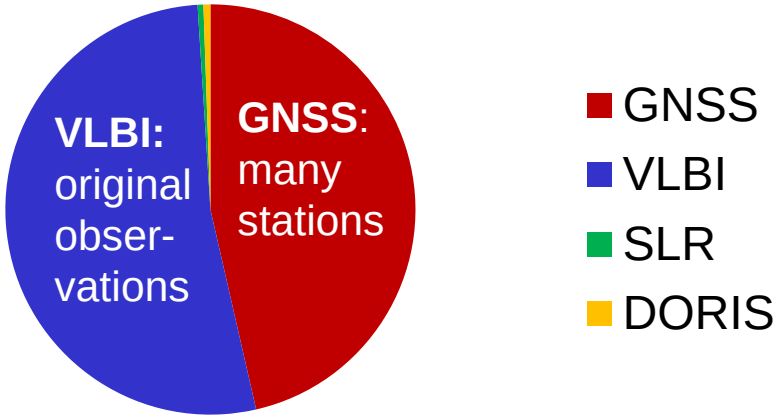
- GNSS are essential for the combination of all techniques!
- Local ties are selected using a threshold of 15 mm for 3D discrepancy

Number of equalized velocities (considering solution intervals): 381

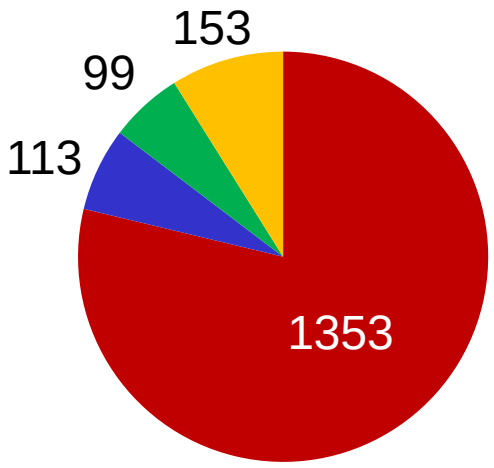
- Velocities are equalized using a threshold of 2 mm/yr

DTRF2014 – Solution statistics

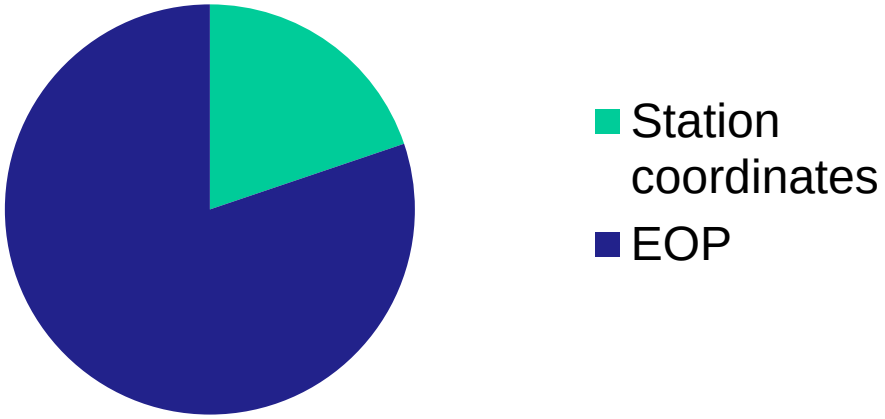
Number of observations: > 167 million



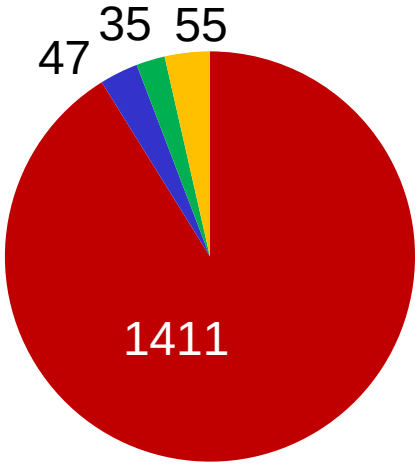
Number of sites: 1718



Number of unknowns: 80,335



Number of discontinuities: 1548



Size of NEQ: 49.2 GB

DTRF2014 – Internal validation (1/2)

DTRF2014 vs. single-technique

Helmert transformation w.r.t. single technique solutions
(aligned to DTRF2008, reference epoch 2000.0)

- DORIS not used for the datum definition

Offsets [mm] Rates [mm/yr]

	Origin			Scale	Orientation		
	Tx	Ty	Tz	Sc	Rx	Ry	Rz
SLR	0.1 ± 0.21 0.0 ± 0.04	0.6 ± 0.21 0.0 ± 0.04	0.9 ± 0.21 -0.1 ± 0.04	0.2 ± 0.21 0.0 ± 0.04			
VLBI				0.4 ± 0.09 0.1 ± 0.01			
GNSS					0.5 ± 0.02 0.0 ± 0.02	0.0 ± 0.02 0.0 ± 0.02	-0.2 ± 0.02 0.0 ± 0.02

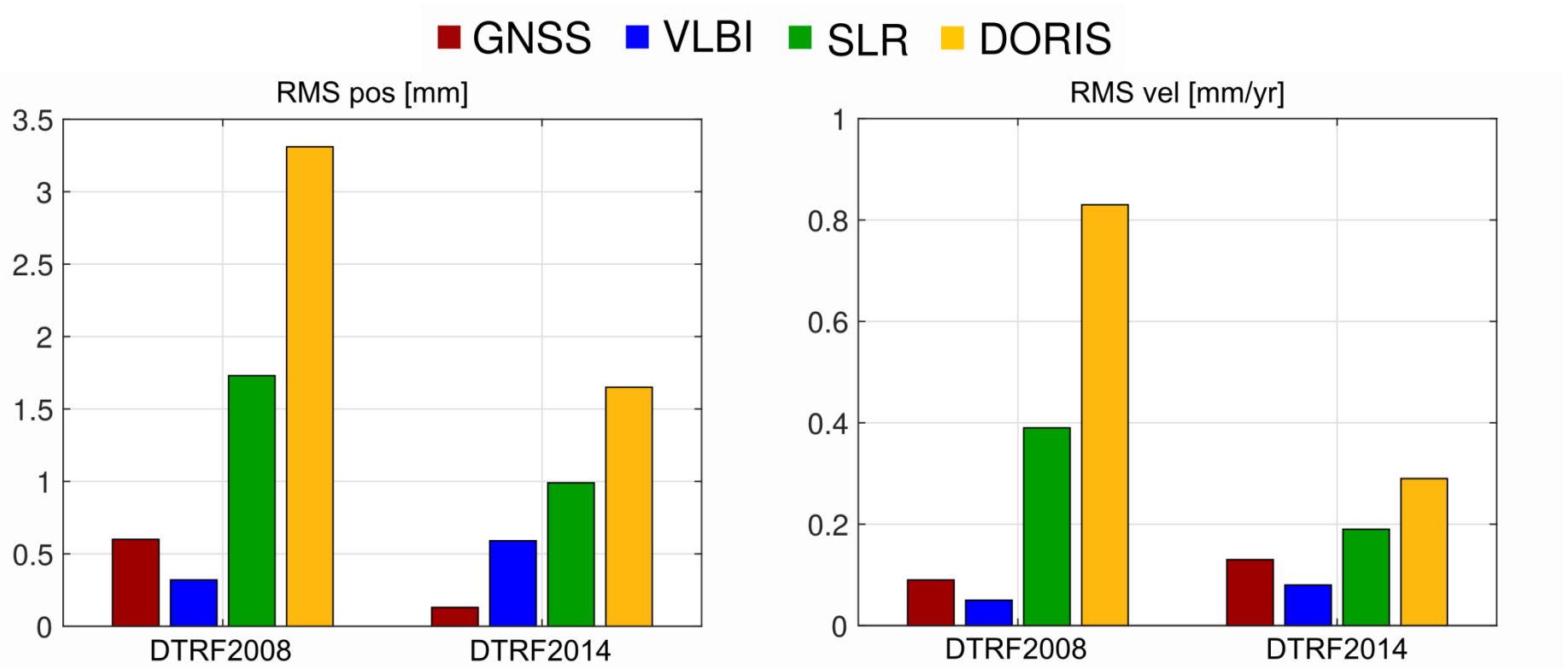
No significant scale change for SLR or VLBI due to combination (< 0.1 ppb)

- indication for a good agreement between SLR and VLBI scale

DTRF2014 – Internal validation (2/2)

DTRF2008/DTRF2014 vs. single-technique

Helmert transformation w.r.t. single technique solutions
(aligned to DTRF2008, reference epoch 2000.0)



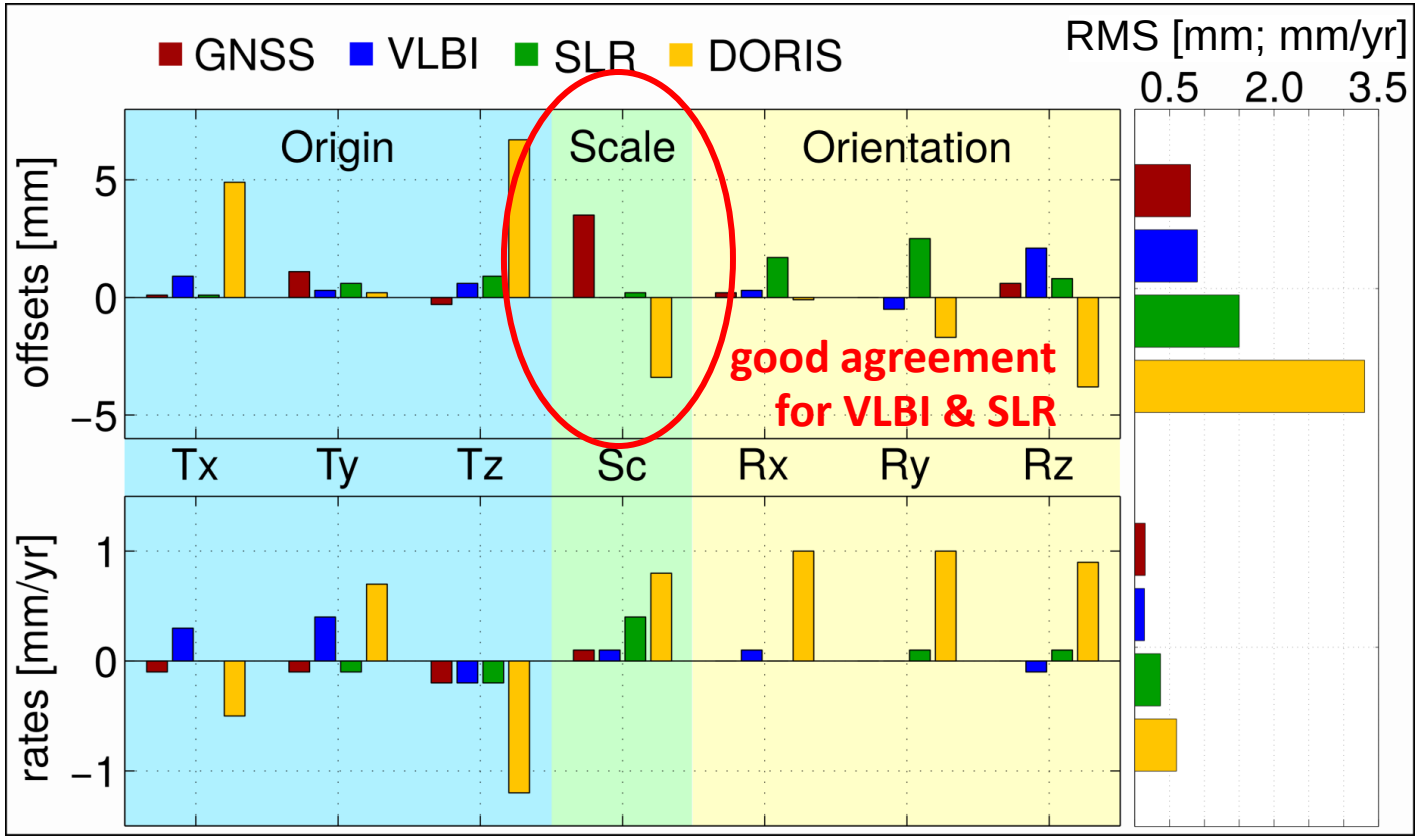
Deformation of network (RMS of Helmert transformation)

- The deformation caused by the combination is small for all techniques
- DTRF2014 shows smaller deformation than DTRF2008

DTRF2014 – External validation (1/2)

DTRF2014 vs. DTRF2008

Helmert transformation w.r.t. DTRF2008
(DTRF2014 orientation aligned to DTRF2008, reference epoch 2000.0)



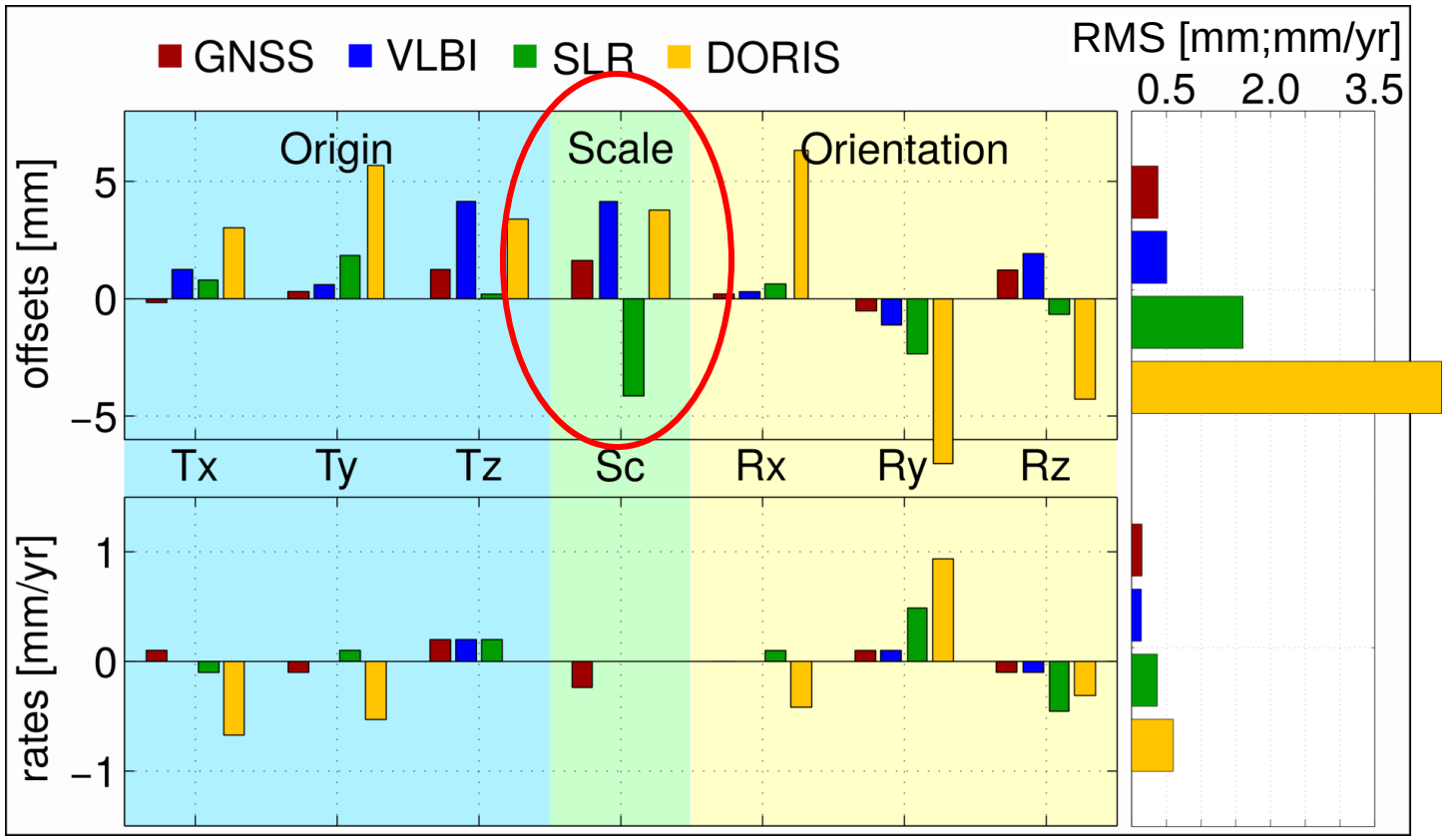
Agreement with DTRF2008: GNSS < 1 mm (ignoring scale bias of 3.5 mm), VLBI/SLR < 2.5 mm, DORIS < 7 mm

- Scale differences for GNSS (due to **albedo**, **antenna thrust**?) and DORIS: ±3.4mm

DTRF2014 – External validation (2/2)

DTRF2014 vs. ITRF2014

Helmert transformation w.r.t. ITRF2014
(DTRF2014 orientation aligned to DTRF2008, reference epoch 2000.0)



Agreement with ITRF2014: GNSS < 1.5 mm, VLBI/SLR < 3.5 mm, DORIS < 7.5 mm

➢ ITRF2014 scale difference between SLR and VLBI: 7 mm (about 1 ppb)

DTRF2014 – Open questions/suggestions to IGS

- Several ITRF2014 candidate stations do not meet TRF requirements
  - Stability of time series (high scatter, unstable monument, …)
  - Availability of data (only few observations)
  - ITRS Combination Centers (CCs) need a lot of time to detect unsuitable stations
  - Could the IGS provide a **list of stable and well-observed stations** which should contribute to the ITRF? Stations not meeting IGS standards could be reduced in the ITRF computation.
- Plenty of discontinuities (> 1400) split station position time series
  - Criteria for discontinuity significance?
  - High effort for ITRS CCs to set up discontinuity list
  - Could the IGS maintain a **discontinuity list that is kept up-to-date** and that could serve as a basis for the ITRF computation?

DTRF2014 – Summary

- GNSS contribution essential for ITRS realization
  - Most inter-technique co-locations w.r.t. GNSS (about 80 %)
  - GNSS subnetwork used to realize the orientation (NNR condition)
- GNSS stations agree within 1.5 mm between different realizations and different Combination Centers
- GNSS TRF scale shows a bias of 3.5 mm between DTRF2014 and DTRF2008, probably due to albedo and antenna thrust (comparable to IGN results)
- **No significant scale bias between SLR and VLBI in DTRF2008/DTRF2014**

DTRF2014 – Outlook

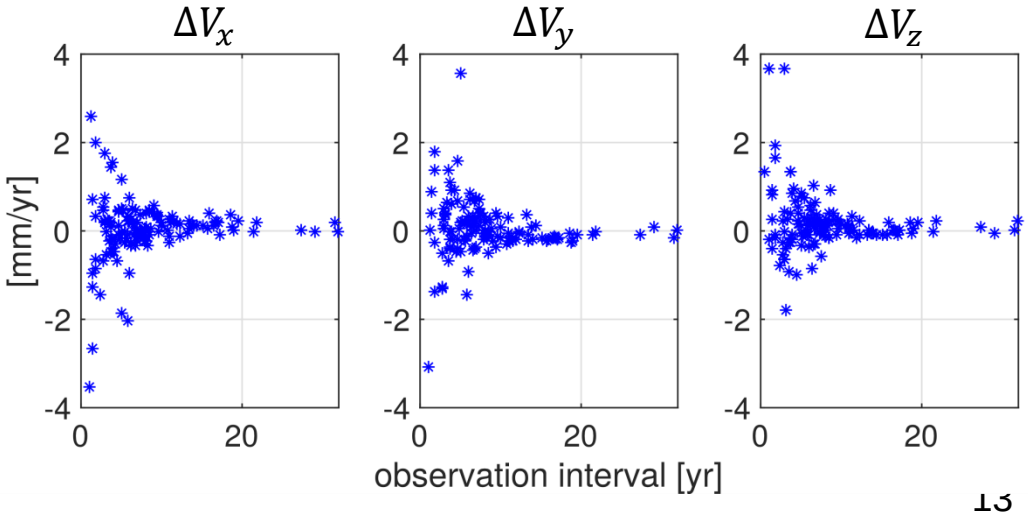
Which DTRF2014 improvements can be expected from the consideration of non-tidal loading (NT-L)?

- General improvement of standard deviations (precision) for all parameters
- Benefit for the accuracy of station coordinates with short observation time spans (< 2.5 years)
- Decrease of the scatter (WRMS) of coordinate residual time series and EOP differences w.r.t. IERS 08 C04

- Example: **SLR-only solution** with and without NT-L applied

WRMS	x-pole [mas]	y-pole [mas]	LOD [ms]
without NT-L	0.1989	0.1919	0.0320
with NT-L	0.1970	0.1904	0.0319

w.r.t. IERS 08 C04



DTRF2014 – Outlook

Final DTRF2014 solution comprises:

- **Station coordinate** (SSC) and **EOP files**
- **SINEX files** for all techniques including EOP and the full variance/co-variance matrix
- **Residual station position time series** that allow to derive the true position at epoch for all DTRF2014 stations
- **Loading time series** applied for the DTRF2014 computation

Validation of DTRF2014

- Further comparisons w.r.t. IGN and JPL solutions (stations and EOP)
- Manuela Seitz already provided SSC/EOP and SINEX files of conventional solution for validation (IAG Services)
  - Use of station coordinates and velocities (SSC, SINEX files)
  - In addition, use of consistently estimated EOP

The DTRF2014 and further information will soon be provided at
www.dgfi.tum.de

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