



IVS contribution to the ITRF2014

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Outline

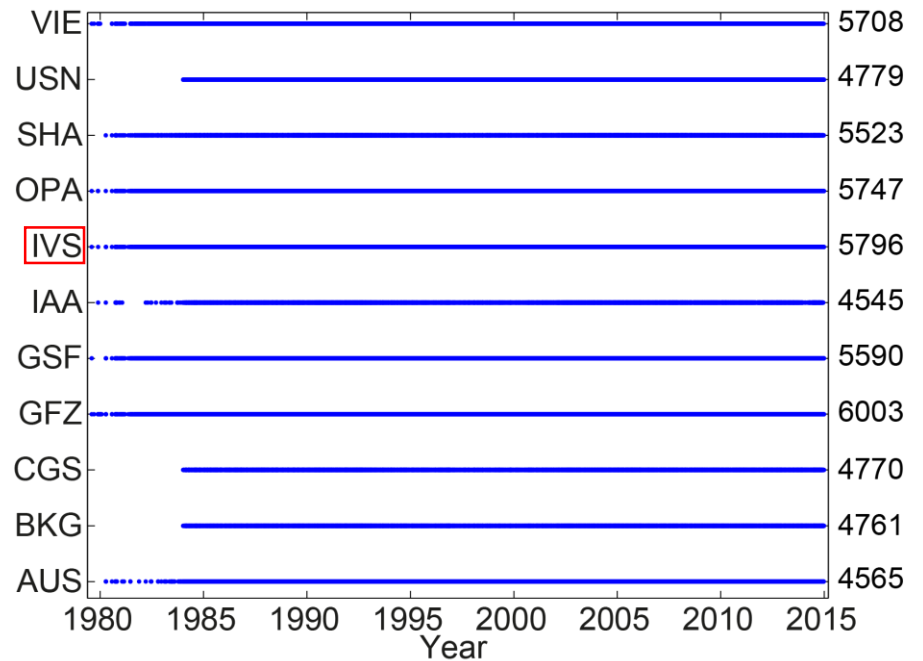
- Input contribution / submission
- Analysis method
- Results
 - Station Coordinates
 - Earth Orientation Parameters (EOP)
- How to access to data and results
- Conclusions – What did we learn?
- Summary

Data I

- 24h VLBI sessions
- Datum free normal equations in SINEX format
- Station coordinates and EOP

10 ACs (5 s/w packages) submitted SINEX files including sessions from 1979 until Dec. 31, 2014:

Contributing Analysis Centers (AC):



Data II

AC	Name	Software	Operational AC	ITRF2014 submitted	included
AUS	Geoscience Australia, Australia	OCCAM	under review	yes	no
BKG	Federal Agency for Cartography and Geodesy, Germany	Calc/(nu)Solve	yes	yes	yes
CGS	Centro di Geodesia Spaziale, Italy	Calc/(nu)Solve	under review	yes	yes
DGFI	German Geodetic Research Institution	OCCAM	yes	no	no
GFZ	German Research Center for Geosciences	VieVS	under review	yes	yes
GSFC	Goddard Space Flight Center, USA	Calc/(nu)Solve	yes	yes	yes
IAA	Institute of Applied Astrometry, Russia	Quasar	yes	yes	yes
NMA	Norwegian Mapping Authority, Norway	Geosat	no	yes	no
OPAR	Observatory of Paris, France	Calc/(nu)Solve	yes	yes	yes
SHAO	Shanghai Observatory, China	Calc/(nu)Solve	no	yes	yes
USNO	US Naval Observatory, USA	Calc/(nu)Solve	yes	yes	yes
VIE	Vienna University of Technology, Austria	VieVS	under review	yes	yes

Data III

Various problems appeared within the data analysis at the ACs, e.g.

- different axes offset or eccentricity files used,
- problem with writing routines,
- parameter naming,

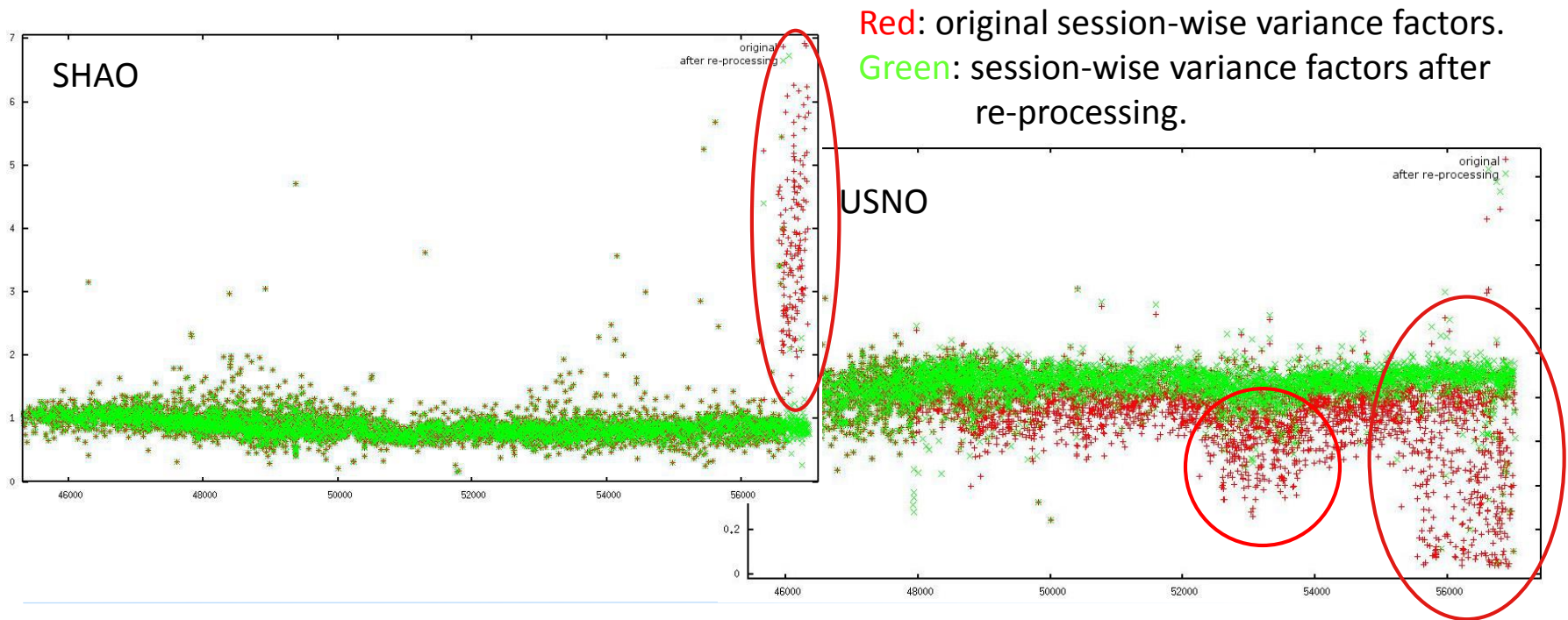
which have all been solved.

Original IERS CfP contained data until 2014.0. Analysis of additional year 2014:

- Analysis consistent to previous years not possible for all ACs
→ complete reprocessing necessary for 3 ACs.
- Inconsistencies in the variance factors (next slide).
- AC AUS data excluded from combined solution (station accuracy, bug fixed).

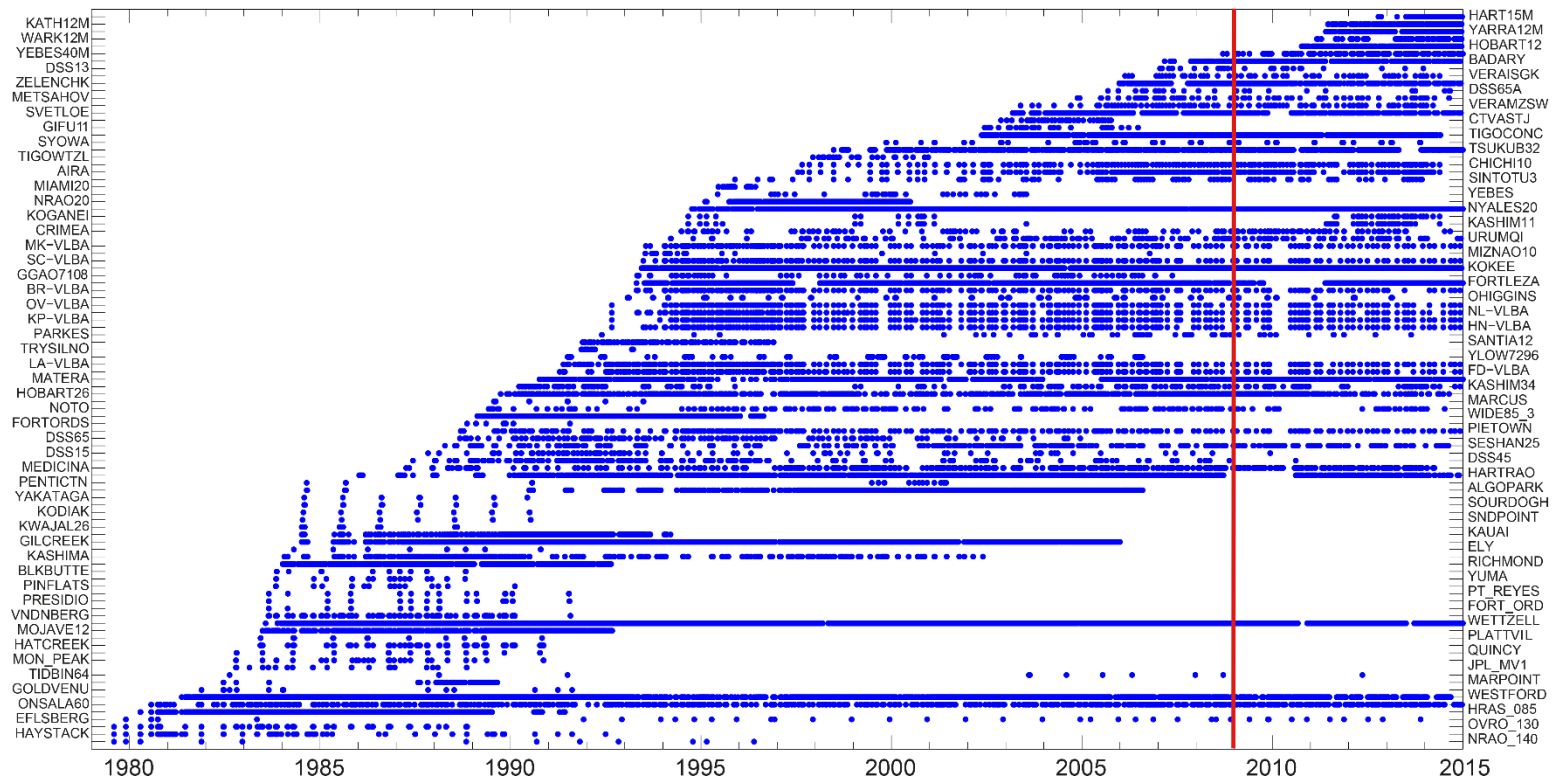
Data IV

- Data quality inconsistencies found and corrected (variance factor)



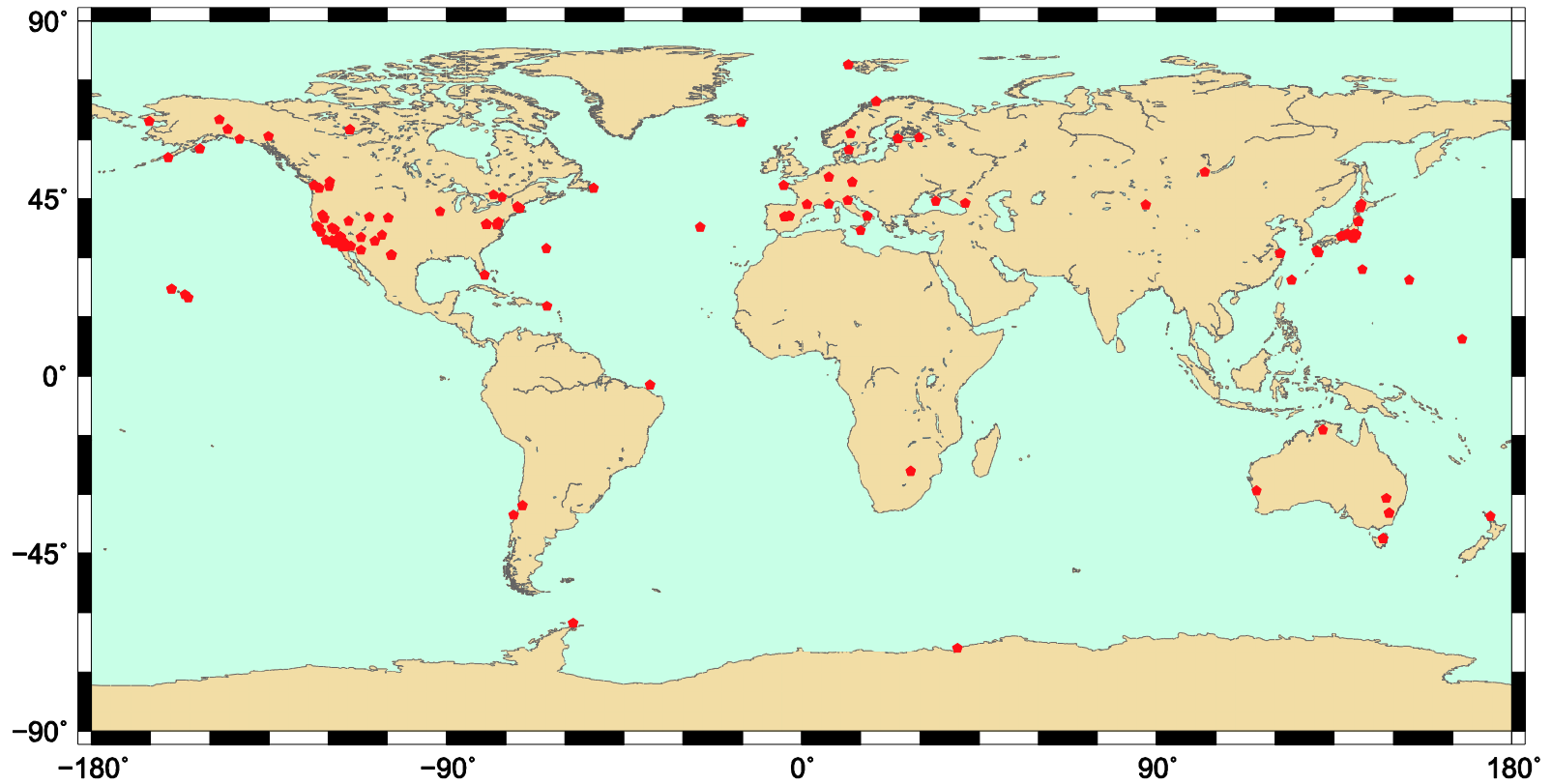
Data V

Station participation (> 10 observed sessions)
Overall 158 different stations.

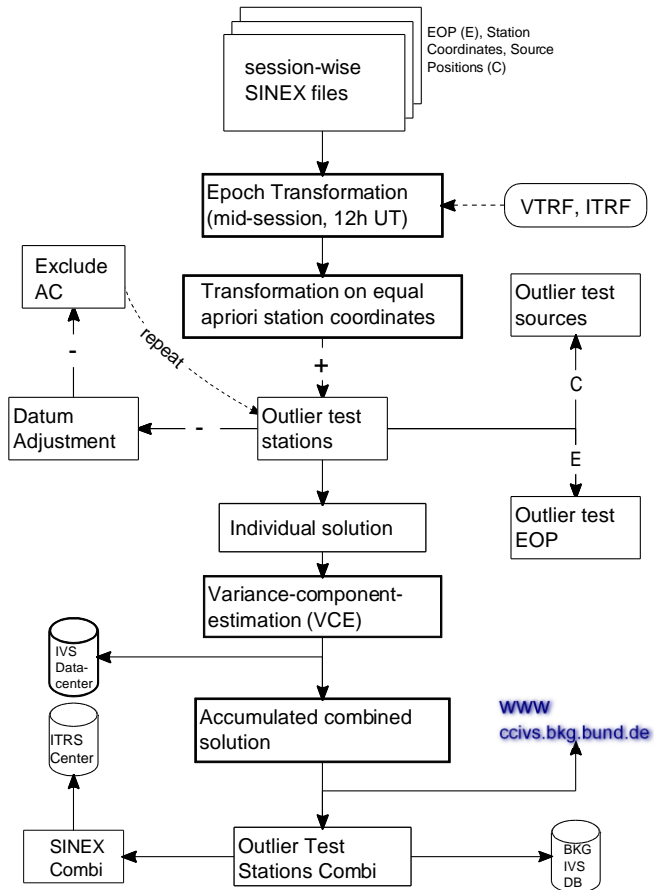


Data VI

IVS Station distribution.



Analysis I



Parameter:

- Station Coordinates
- Earth Orientation Parameters (X-, Y-Pole + rates, dUT + LOD, dX, dY)

Analysis II

Hypothesis:

Improved statistics for a combined solution compared to the individual solutions.

Combination on the level of normal equations with predefined analysis conventions (models, absolute terms, etc.).

Major differences to IVS ITRF2008 contribution:

- Transformation on 12h UT for all parameters
(ITRF2008: mid-session)
- Improved outlier test
(static / fixed threshold → dynamic / LMS)

Analysis III

Major differences to IVS ITRF2008 contribution (cont.)

- Solid Earth Tide, Pole Tides:
IERS Conventions 2003 → IERS Conventions 2010
- Nutation:
IAU2000A (without Free core nutation) → IAU2006 (without Free Core Nutation)
- Gradients:
MacMillan(1995) with wet VMF1 → Chen-Herring Gradients

Analysis IV

Major differences to IVS ITRF2008 contribution (cont.)

- Source positions:
Constrained on ICRF1+Ext.1 or individual CRF → constrained on ICRF2 *a priori* position (defining sources)

Major differences to IVS routine (rapid / quarterly) combination:

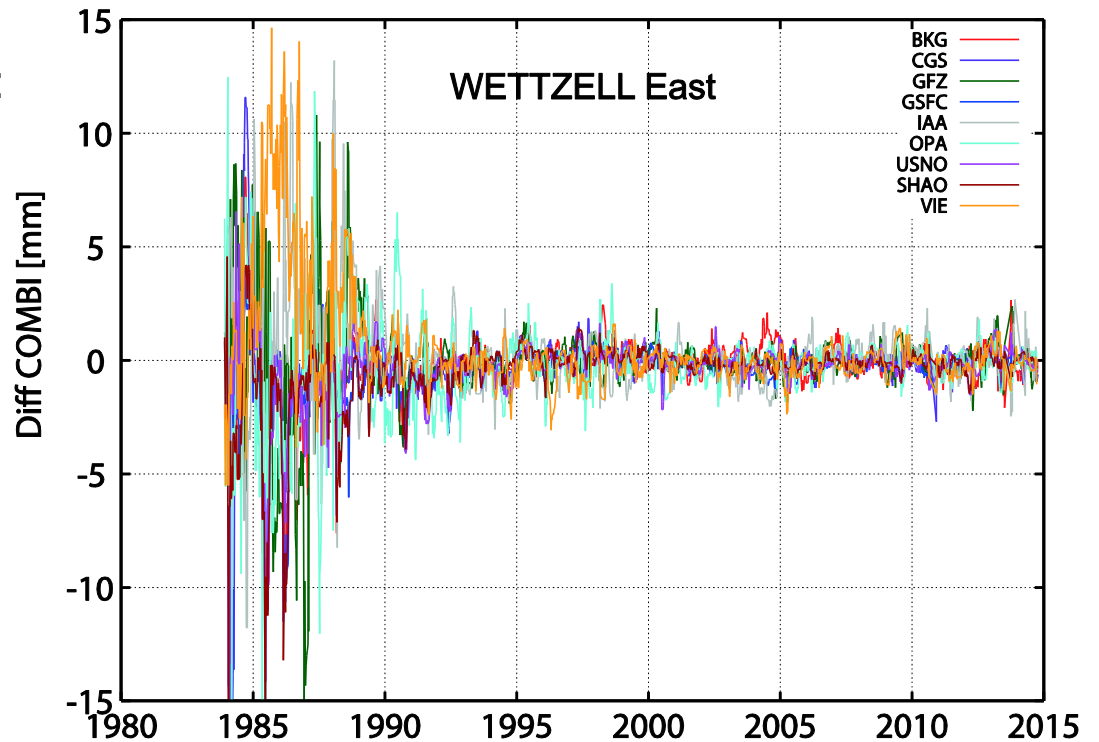
- Non-tidal atmospheric loading not applied (annual / semi-annual model applied *a posteriori*)
- Dedicated IVS ITRF2014 axis offset information file

Results I

Station Coordinates

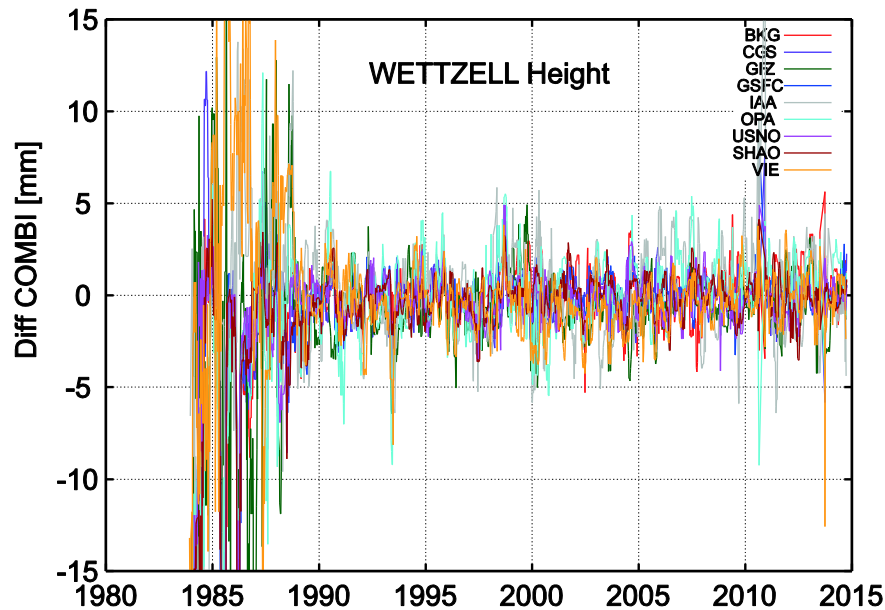
Improvements around 1990s:

- More VLBI stations.
- Larger network size.
- Better global distribution.
- More sources observed.

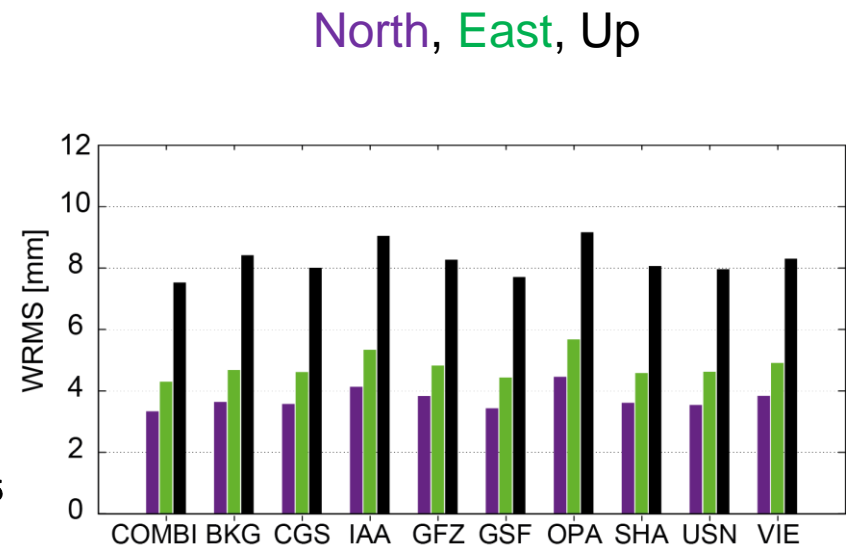


Results II

Station Coordinates



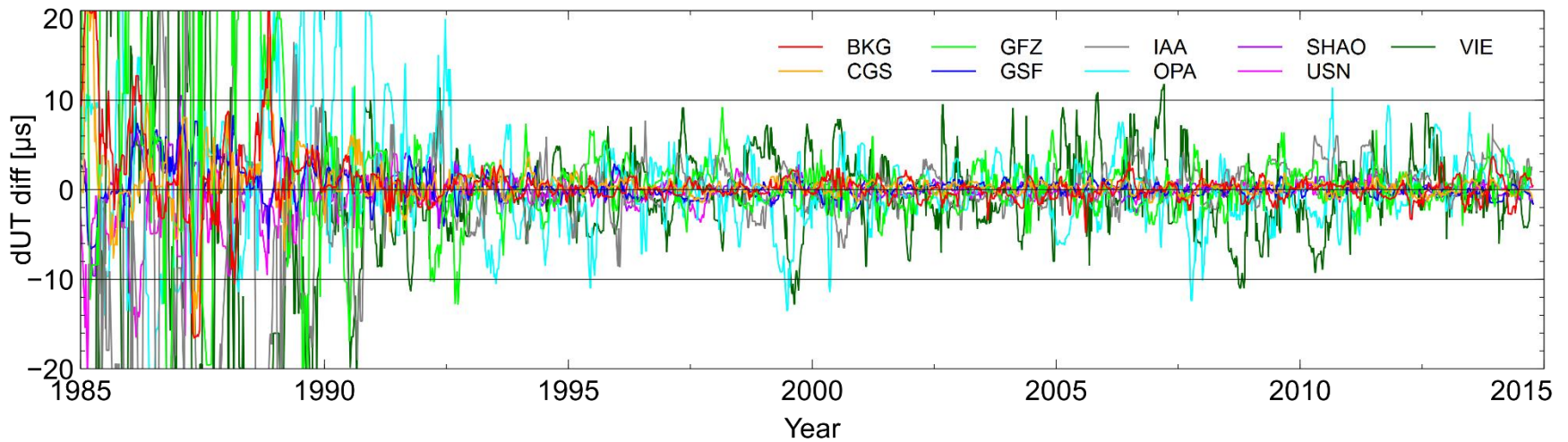
Station coordinates WRMS of all stations



Results III

EOP

Internal comparison w.r.t. combined solution



Results IV

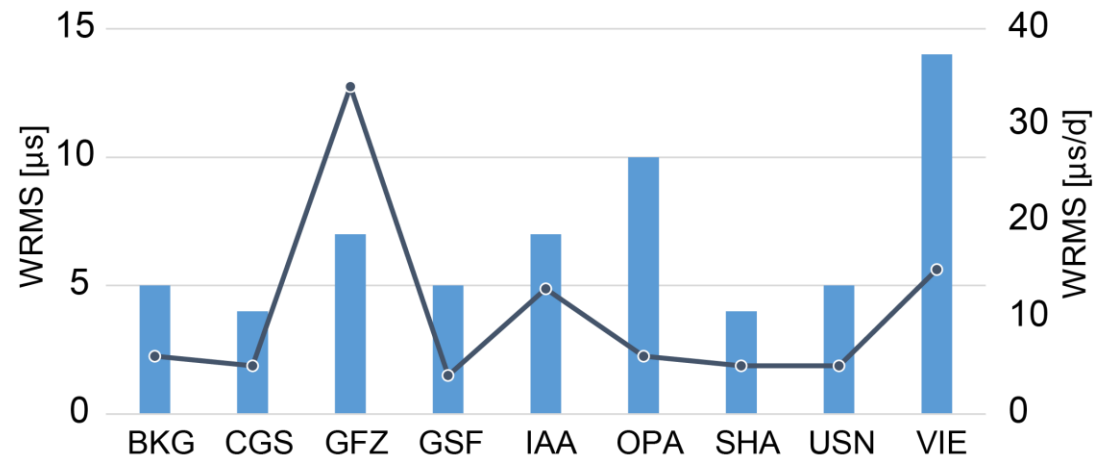
EOP

WRMS of the differences w.r.t. combined solution

VIE dUT:
Offset (PWL) → offset +
drift

dUT, LOD

Possible cause of elevated WRMS:
Change of parameterization within the combination process (not on the analysis basis – under investigation for operational combination).

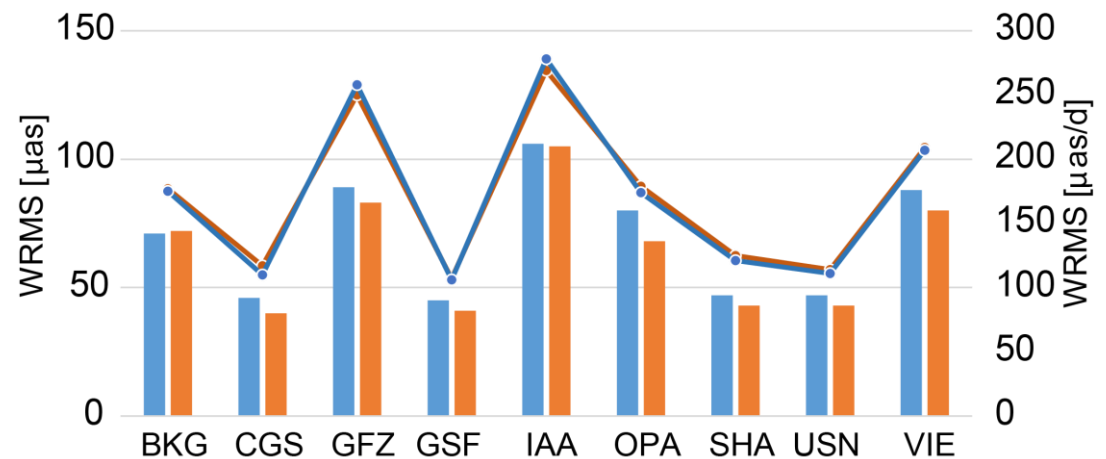


Results V

EOP

WRMS of the differences w.r.t. combined solution

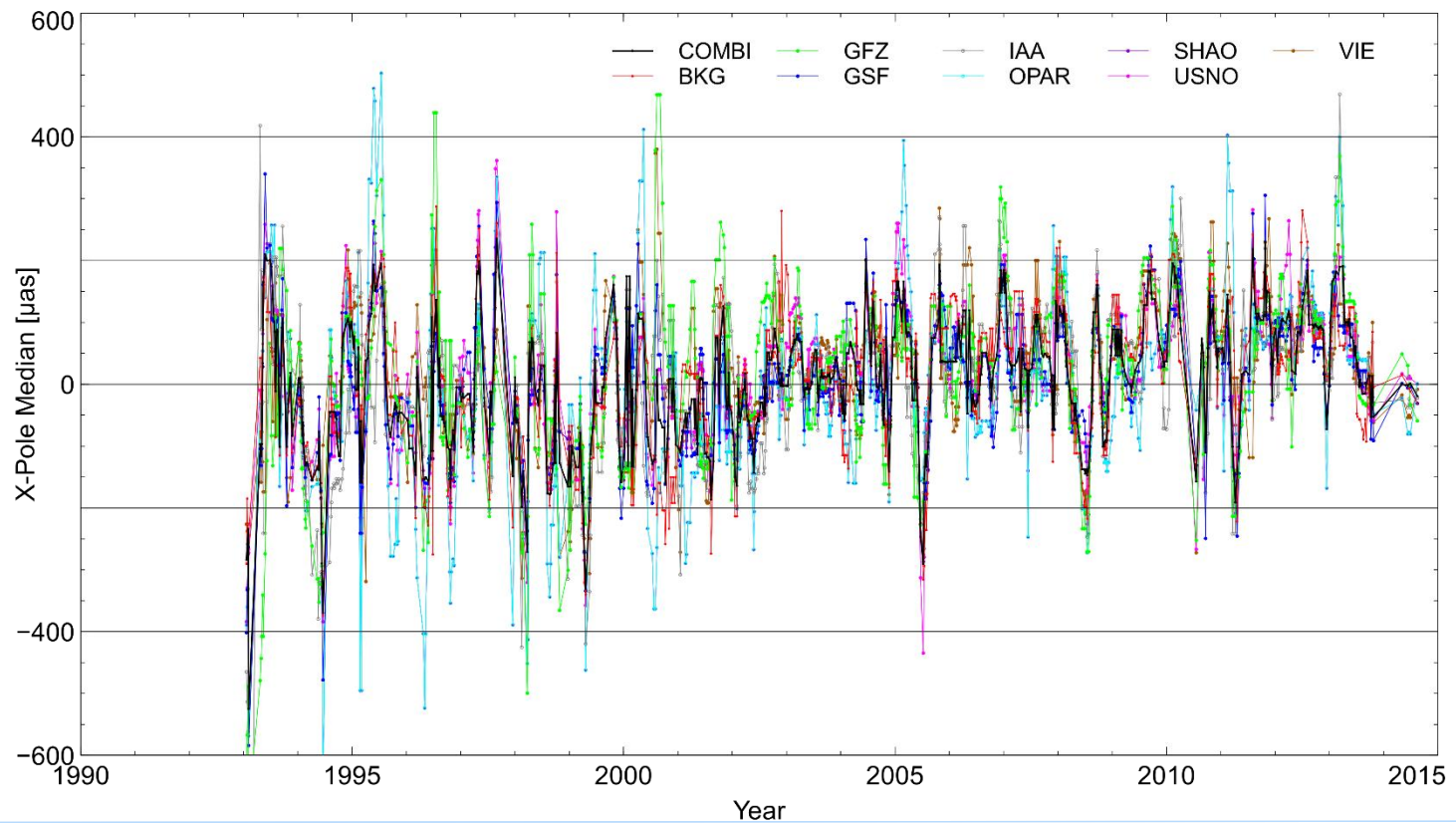
X-Pole (+rate), Y-Pole (+rate)



Results VI

EOP

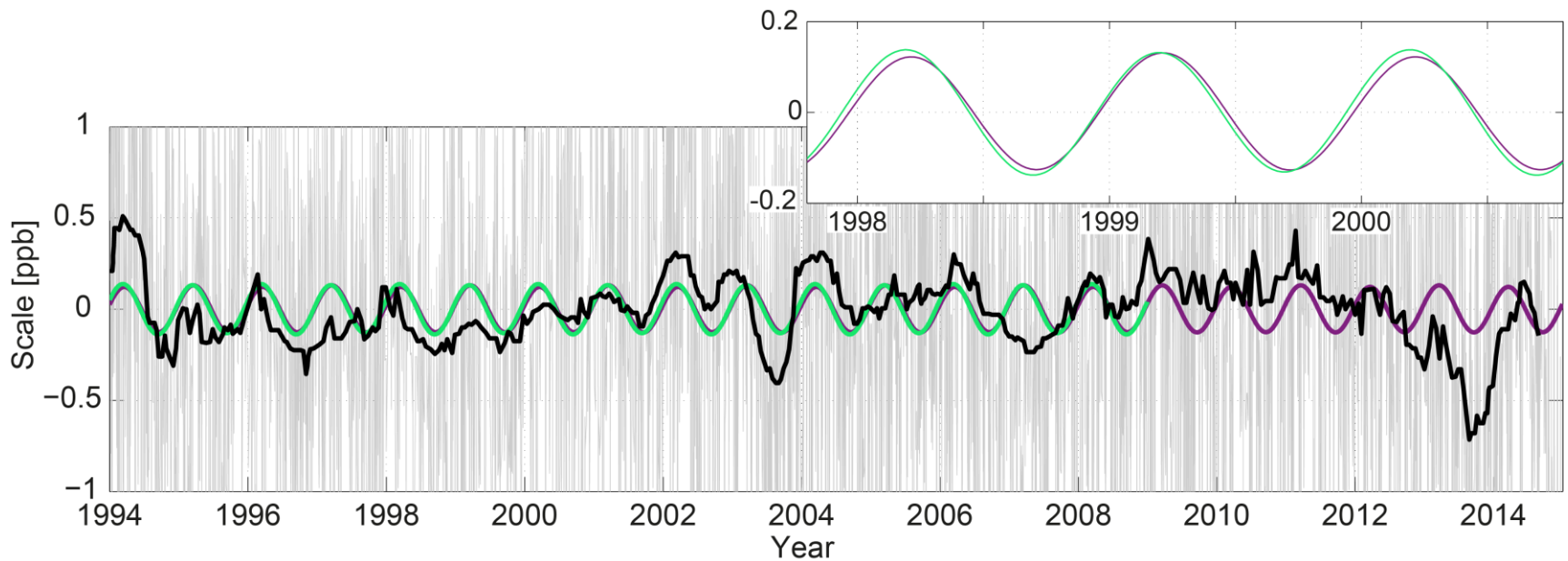
External comparison w.r.t. IERS-08-C04



Results VII

Scale - Internal comparisons

- Single combined session w.r.t. VTRF2014 (black)
- Annual signal 1979-2015.0 (purple)
- Annual signal 1979-2009.0 (green)

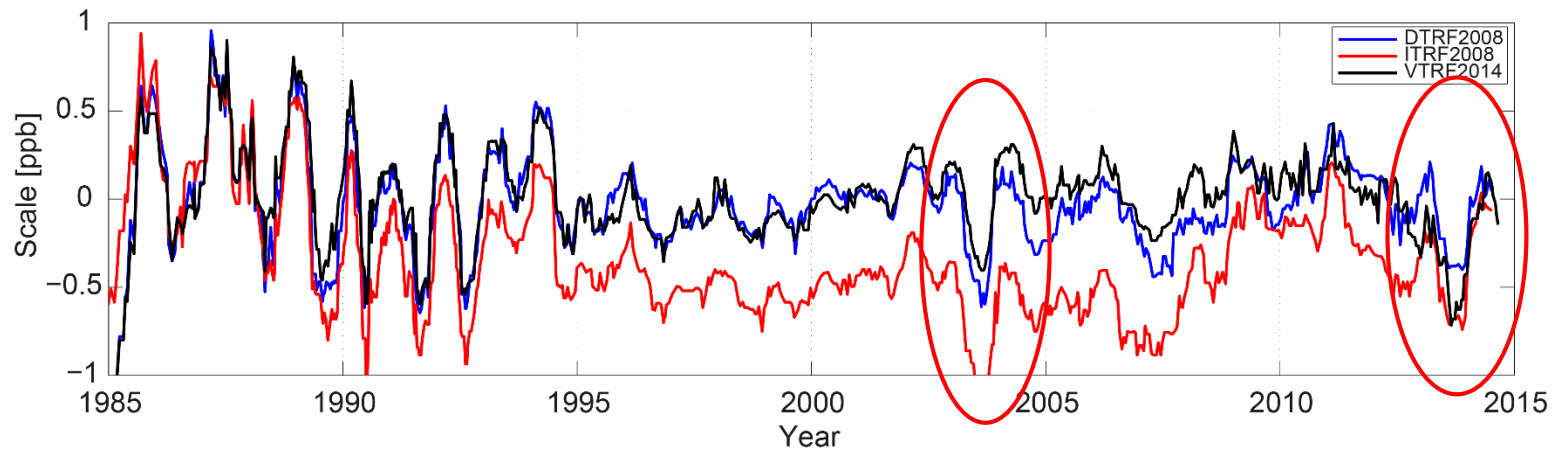


Results VIII

Scale - External comparison

Single combined session w.r.t.:

- DTRF2008 (blue)
- ITRF2008 (red)
- VTRF2014 (black)

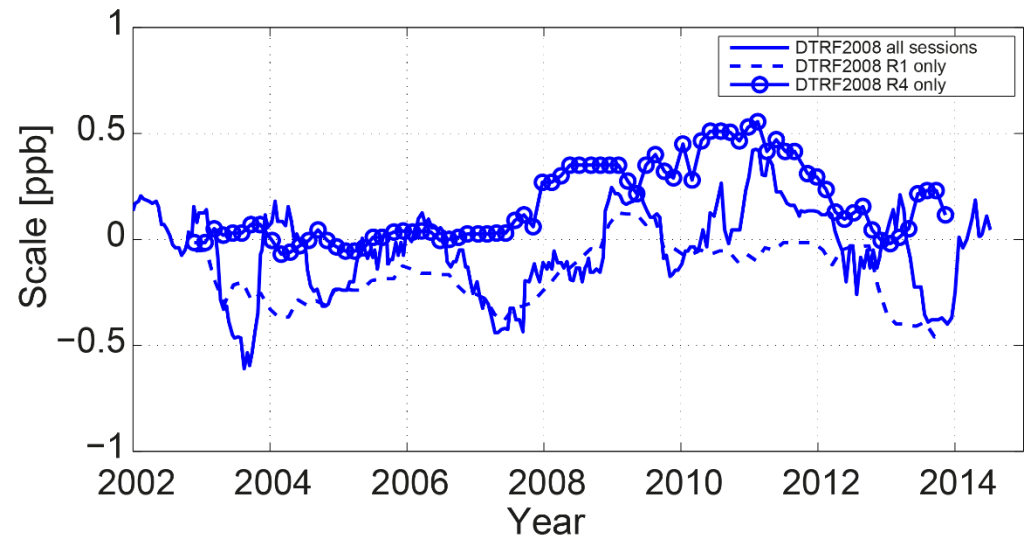


Results IX

Scale - External comparison cont.

Network size / geometry
dependency

Session weighting in global
solution?



Results X

Scale

14 parameter Helmert Transformation between VTRF2014 and DTRF2008 / ITRF2008:

HT Parameter	DTRF2008				ITRF2008			
	Positions		Velocities (per yr)		Positions		Velocities (per yr)	
T_x [mm]	-2.1	(± 0.8)	-0.5	(±0.8)	-0.8	(± 0.6)	-0.4	(± 0.6)
T_y [mm]	-0.1	(± 0.8)	-0.6	(± 0.8)	0.6	(± 0.6)	-0.4	(± 0.6)
T_z [mm]	1.1	(± 0.7)	0.2	(± 0.7)	-1.1	(± 0.6)	0.1	(± 0.6)
R_x [mas]	-0.03	(± 0.03)	-0.006	(± 0.03)	-0.02	(± 0.02)	-0.008	(± 0.02)
R_y [mas]	0.06	(± 0.03)	0.002	(± 0.03)	-0.01	(± 0.02)	0.006	(± 0.02)
R_z [mas]	-0.12	(± 0.03)	0.006	(± 0.03)	0.01	(± 0.02)	0.012	(± 0.02)
Scale [ppb]	0.11	(± 0.11)	0.02	(± 0.11)	0.44	(± 0.09)	-0.02	(± 0.09)

How to access to data and results? I

Retreat: “Low visibility of IVS results”

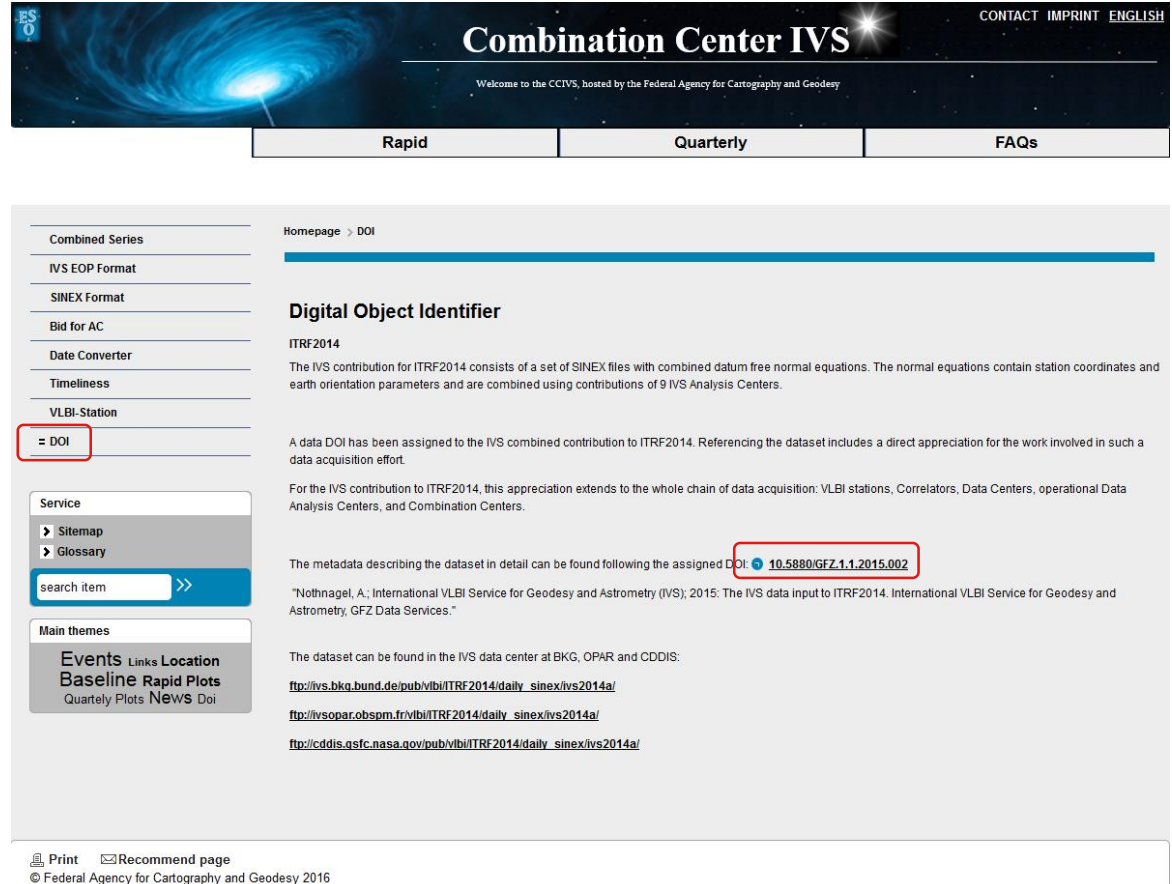
- All AC + combined contributions are available in the IVS data centers (BKG, CDDIS, OPAR)
- A paper on this subject will be published in the Journal of Geodesy:
Bachmann, S et al. „IVS contribution to ITRF2014“
(accepted)
- Preliminary results: IAG Symposia REFAG2014 (DOI [10.1007/1345_2015_136](https://doi.org/10.1007/1345_2015_136))
- IVS GM 2016 Proceedings

How to access to data and results? II

Presentation of results on the (newly designed) IVS Combination Centers website:

- Time series of station coordinates, baselines, EOP, scale
- Individual and combined results
- Link to data DOI

ccivs.bkg.bund.de



The screenshot shows the website header with the logo 'ES O' and the title 'Combination Center IVS'. Below the header are navigation tabs for 'Rapid', 'Quarterly', and 'FAQs'. The main content area is divided into two columns. The left column contains a list of services: 'Combined Series', 'IVS EOP Format', 'SINEX Format', 'Bid for AC', 'Date Converter', 'Timeliness', 'VLBI-Station', and 'DOI' (highlighted with a red box). Below this is a 'Service' section with a search bar and a 'Main themes' section with links for 'Events', 'Location', 'Baseline', 'Rapid Plots', 'Quarterly Plots', and 'News Doi'. The right column shows the 'Digital Object Identifier' for ITRF2014, with a DOI number '10.5880/GFZ.1.1.2015.002' highlighted in a red box. The footer includes 'Print', 'Recommend page', and '© Federal Agency for Cartography and Geodesy 2016'.

→ IVS GM 2016 Poster

How to access to data and results? III

Data DOI - Citable data

The screenshot shows a dataset page for 'The IVS data input to ITRF2014'. The page includes a 'Cite as' section with the citation: 'Nothnagel, Axel; International VLBI Service for Geodesy and Astrometry (IVS); et al. (2015): The IVS data input to ITRF2014. International VLBI Service for Geodesy and Astrometry, GFZ Data Services. <http://doi.org/10.5880/GFZ.1.1.2015.002>'. The 'Data Files' section lists 'sinex_v2.0_documentation_pdf.zip' (86997 bytes) with download links for OPAR (FTP), BKG (FTP), and CDDIS (FTP). The 'Abstract' section describes the Very Long Baseline Interferometry (VLBI) technique and the datasets published here. The 'Data Description' section provides a detailed overview of the data and its use in the ITRF2014 release. The 'Related Work' section lists related publications, including 'Böckmann, S., Artz, T., & Nothnagel, A. (2009). VLBI terrestrial reference frame contributions to ITRF2008. Journal of Geodesy, 84(3), 201-219.' and 'Schuh, H., & Behrend, D. (2012). VLBI: A fascinating technique for geodesy and astrometry. Journal of Geodynamics, 61, 68-80.'

- [10.5880/GFZ.1.1.2015.002](http://doi.org/10.5880/GFZ.1.1.2015.002)
- Established at GFZ, Germany
- Abstract, Keywords, contact
- Links to data files in IVS data center (freely available)
- Meta data / data description
- Etc.

Reference:

"Nothnagel, A.; International VLBI Service for Geodesy and Astrometry (IVS); 2015: The IVS data input to ITRF2014. International VLBI Service for Geodesy and Astrometry, GFZ Data Services."

Conclusion

What we have learned

A lot...

- Collecting data always takes longer than expected [..]
- Improvement of weighting strategies of the ACs.
- Scale irregularities: further investigations of the sessions and the network configuration, and other influences (e.g. drought).
- EOP parameterization: offsets vs. offset + drift → ongoing subject of investigation and discussion.
- [...]

Summary

- 5796 combined sessions submitted to IERS ITRS Center (ITRF2008: 4539)
- 9 ACs (ITRF2008: 7)
- Time span: 1979.0 - 2015.0 (ITRF2008: 1979.0 – 2009.0)
- Improved models and analysis methods
- More VLBI stations, especially in the southern hemisphere
- ITRF2014 released

Thank you for your kind attention!

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