DGFI part of project PN 5
Status report

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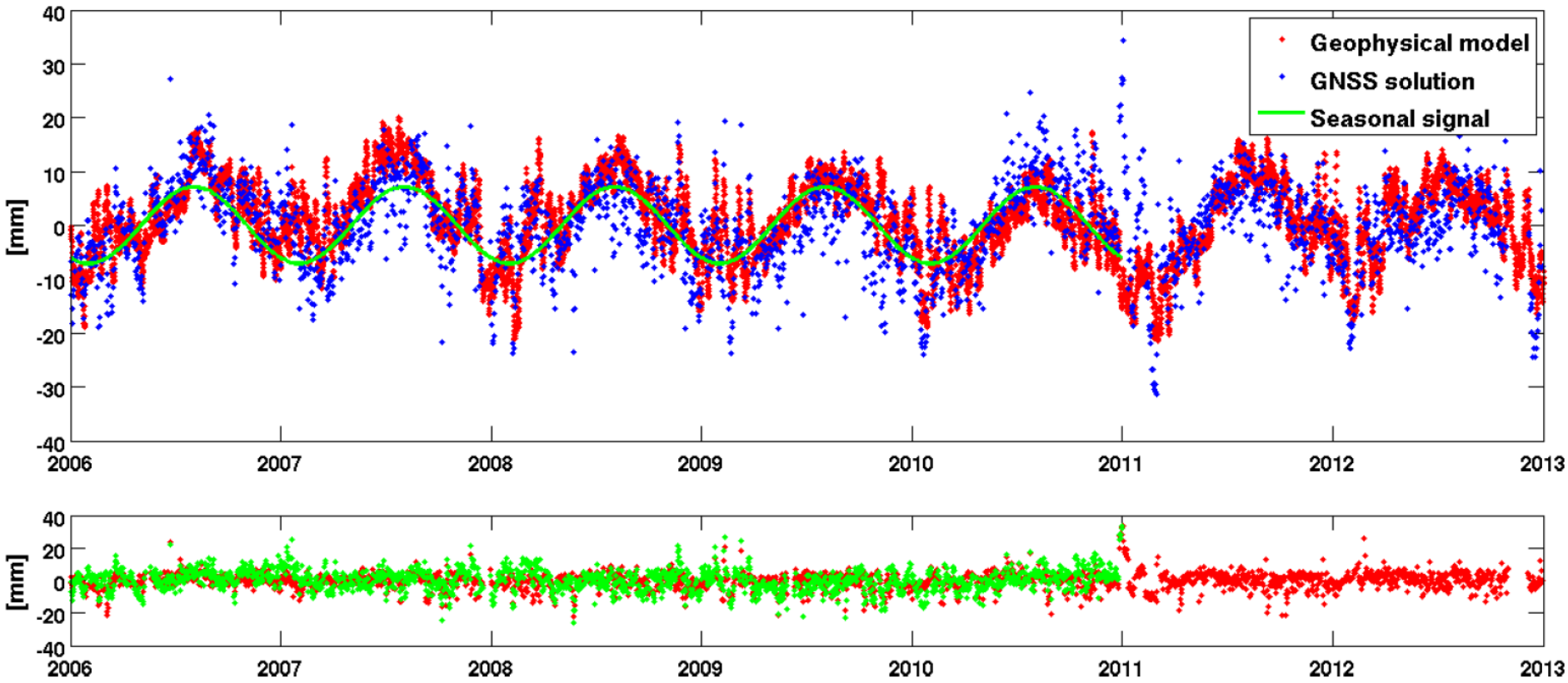
1st phase: work packages and schedule

Work Packages	1st Project Year				2nd Project Year				3rd Project Year			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP5300	***Development of refined combination strategies (NEQ level)***											
WP5310									Long-term comb.			
WP5320									**Non-linear motions**			
WP5330									Epoch combination			
WP5400	***Homogeneously processed observation time series***											
WP5410											Definition	
WP5420											**VLBI**	
WP5430											SLR	
WP5600	***Computation of long-term (LRF) and epoch reference frames (ERF)***											
WP5610											**LRF**	
WP5620											ERF	
WP5700	***Analysis and interpretation of results***											
WP5700												

GPS height time series for Zwenigorod (RUS)



- very good agreement between **estimated annual signal** (green) and **deformation from global geophysical fluid models** (GGF, red)
- still reasonable to investigate seasonal signals?

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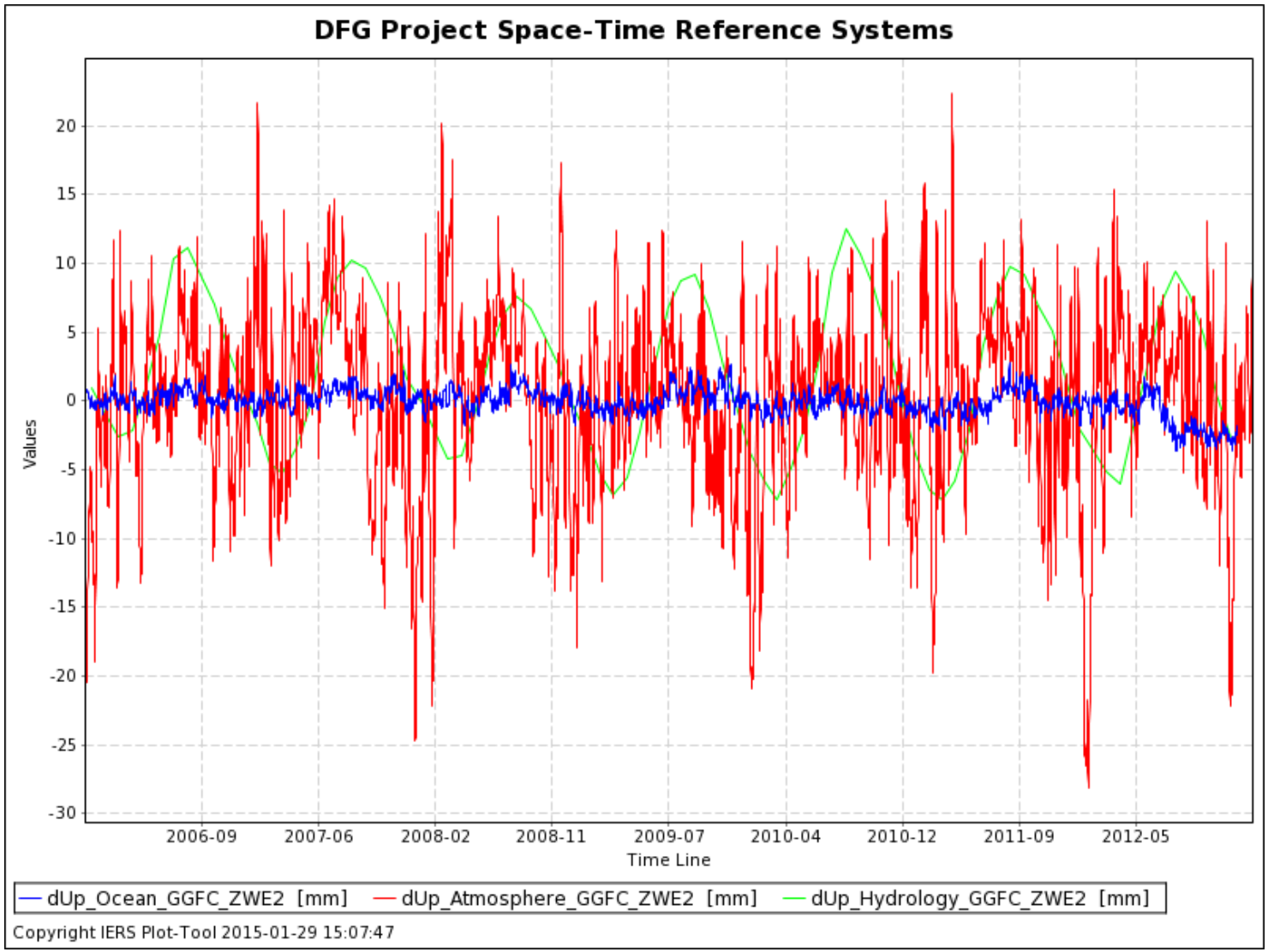
DFG Forschergruppe Referenzsysteme

BKG tool to plot impact of GGF: Zwenigorod (RUS)



amplitude of about 1 cm caused by hydrology

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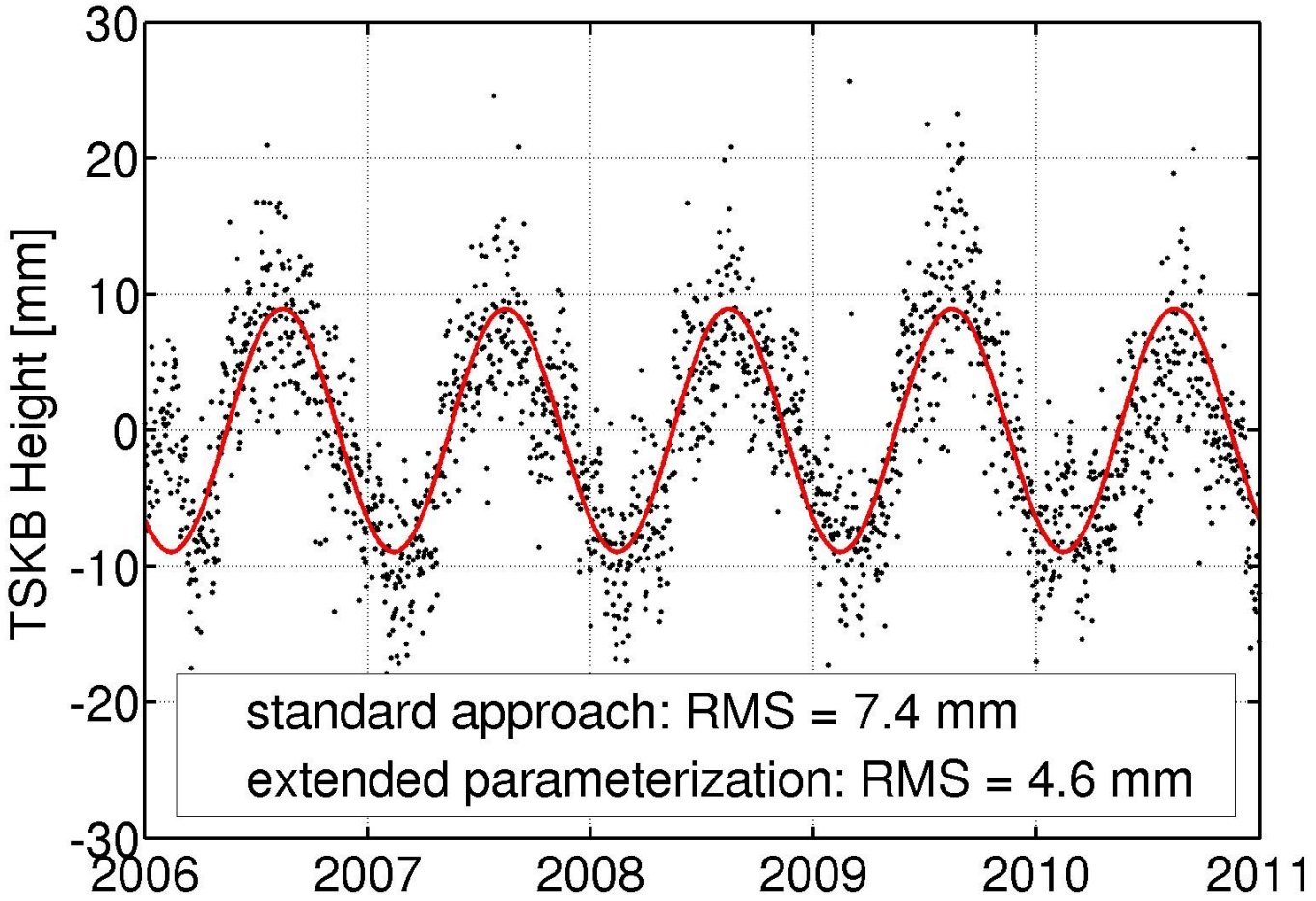
Annual height signal for Tsukuba (JPN)



- amplitude of Tsukuba comparable to amplitude of Zwenigorod
- significant reduction of RMS value

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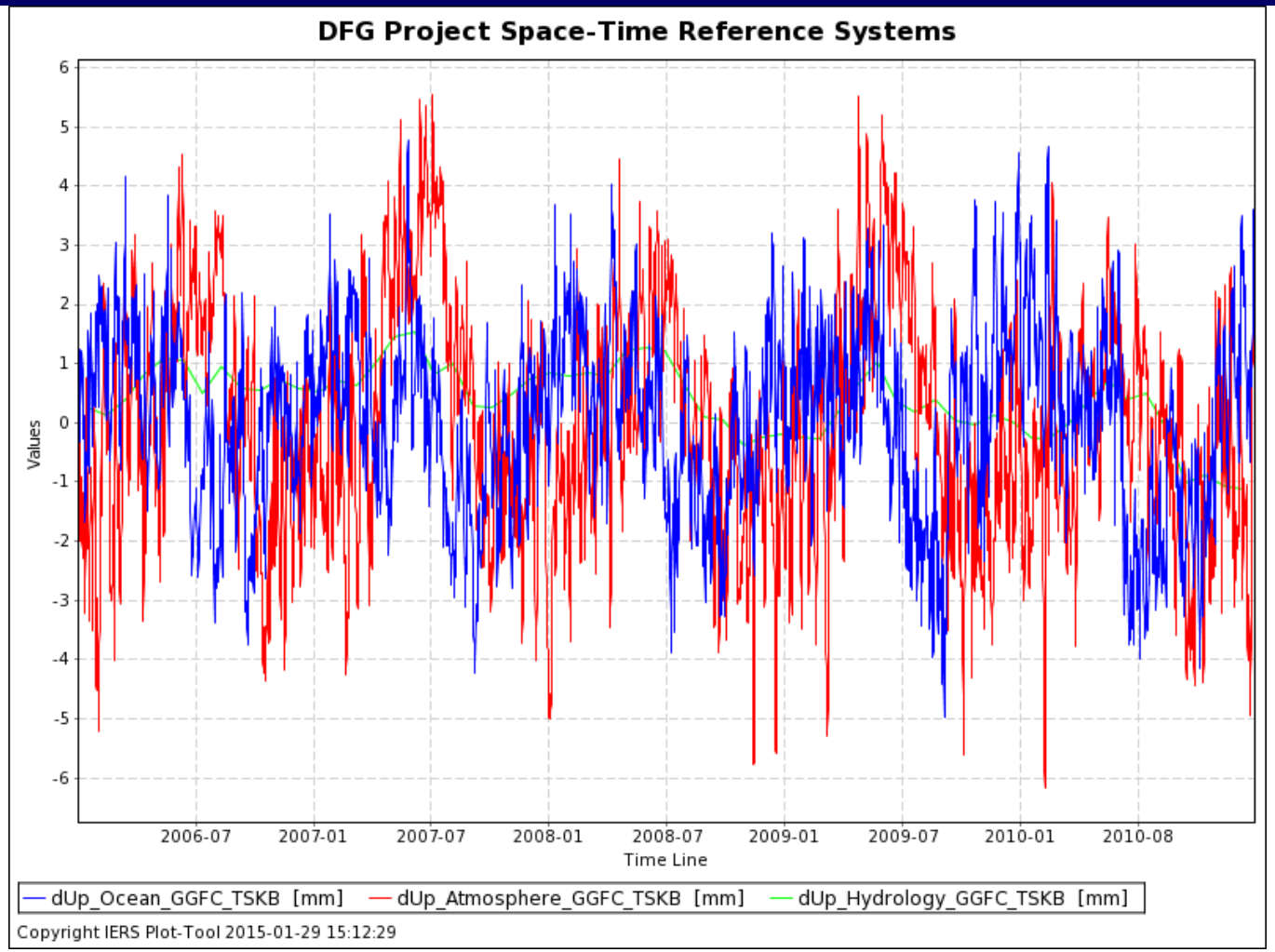
BKG tool to plot impact of GGF: Tsukuba (JPN)



- GGF only have an impact of 2-3 mm
- **regional or local effect** at Tsukuba cannot be compensated by global models

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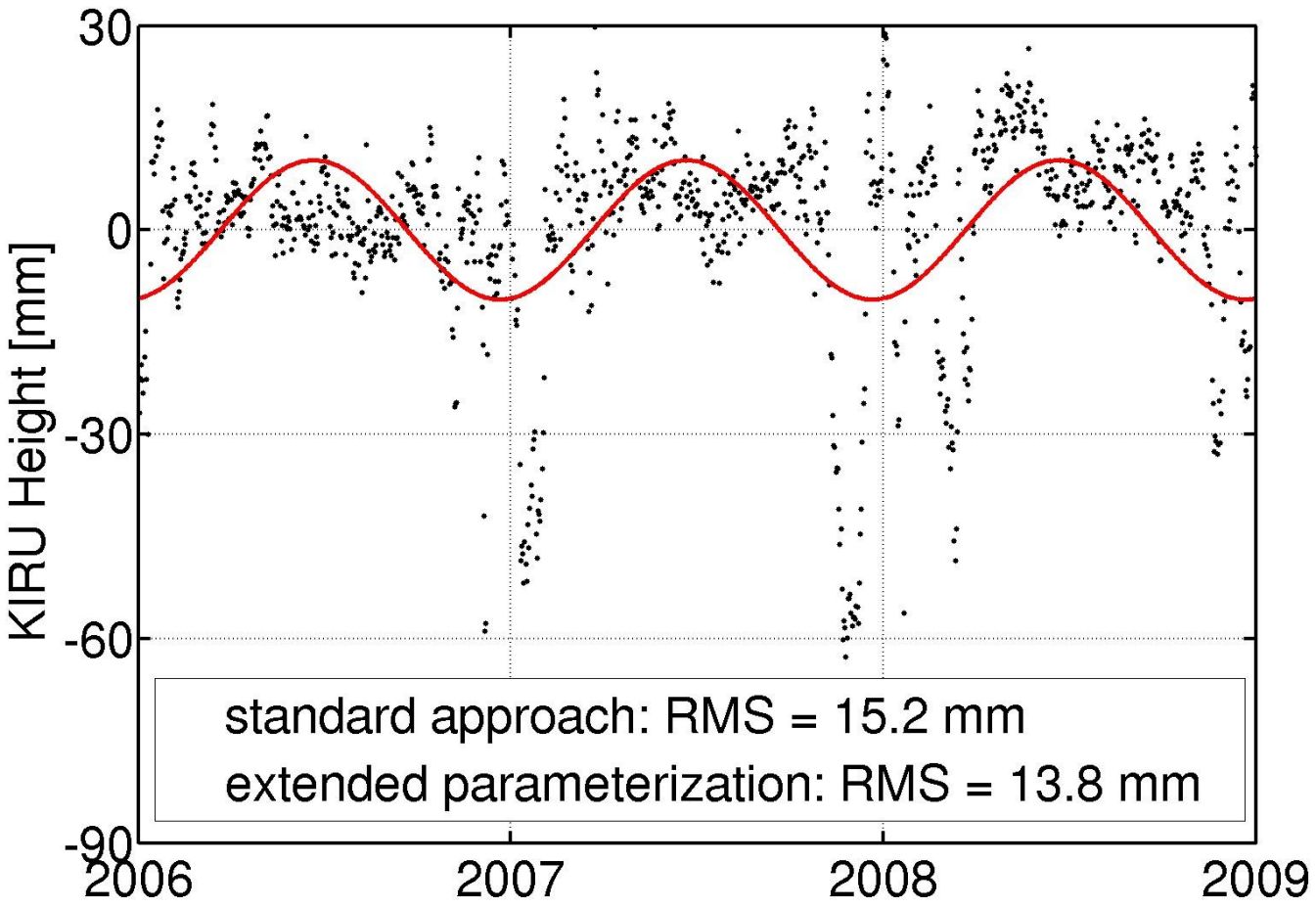
Annual height signal for Kiruna (SWE)



- coordinate time series have to be carefully checked
- **outliers** can distort the estimation of seasonal amplitudes

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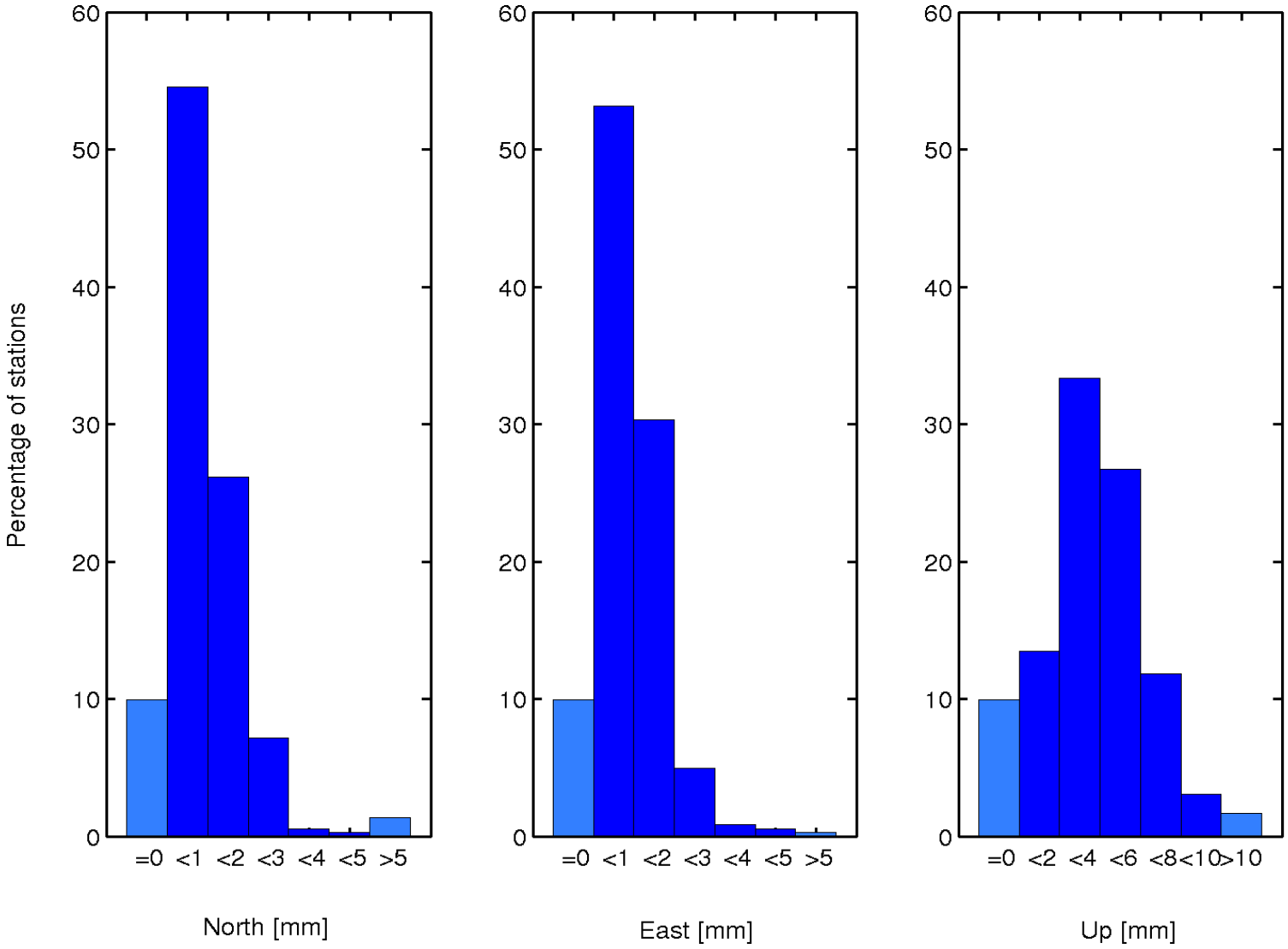
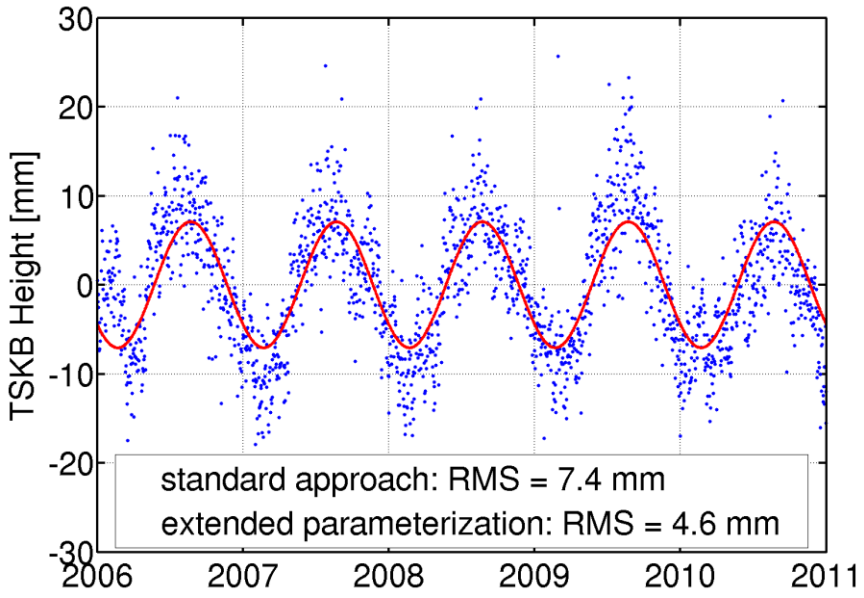
Magnitude of annual station signals

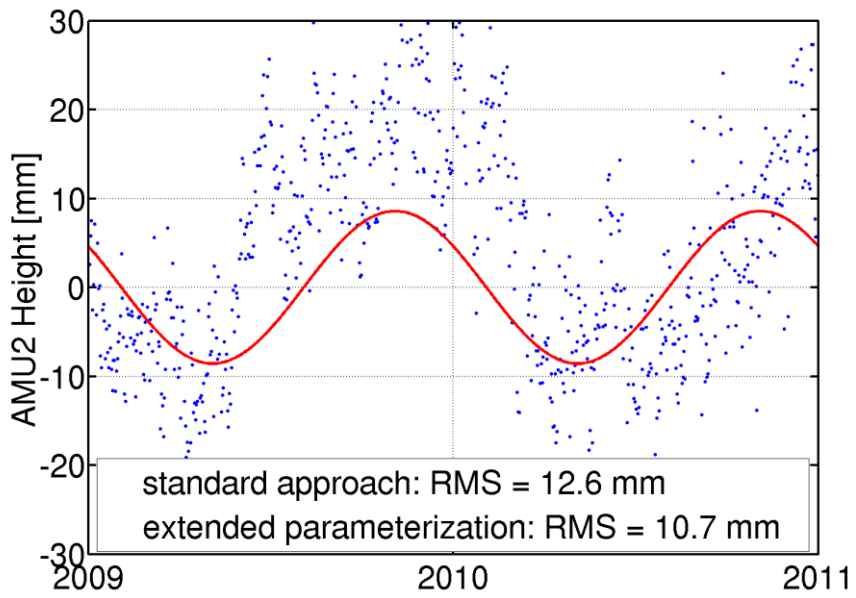


Impact of seasonal signals on station velocities

Solution with estimated seasonal signals vs. standard solution

Station	Amplitude [mm]	Velocity difference [mm/yr]		
		North	East	Up
TSKB, Japan	7.1	0.1	0.1	0.2
AMU2, Antarctica	8.6	1.2	0.1	0.3





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New VLBI processing software DOGS-RI

- currently detailed comparisons between OCCAM and DOGS-RI (a priori values, partial derivatives, intermediate results, etc.)
- operational OCCAM processing could benefit from comparisons:
  - a priori troposphere gradients not up-to-date
  - a priori coordinates interchanged in case of jumps
  - interpolation of a priori EOP wrong in certain cases
- **advantages of DOGS-RI**:
  - consistent with IERS 2010 Conventions
  - (dX, dY) instead of ($d\psi$, $d\varepsilon$)
  - correct relativistic calculation of partial derivatives w.r.t. parameters
  - difference quotients replaced by time derivatives
  - common adjustment of multiple sessions possible
  - improved handling of station coordinates and jumps

VLBI reprocessing (1)

- reprocessing to include **radio source coordinates**
- “outdated” OCCAM version is still used to do the preprocessing: identification of clock jumps, check of the quality of the cable calibration, detection of outliers
- final processing applying DOGS-RI will be necessary using the **OCCAM preprocessing options**
- current status: consistent set of solutions from **April 2008** until December 2014 available
- validation of the session solutions via the official **IVS combination** (rapid and quarterly solutions)

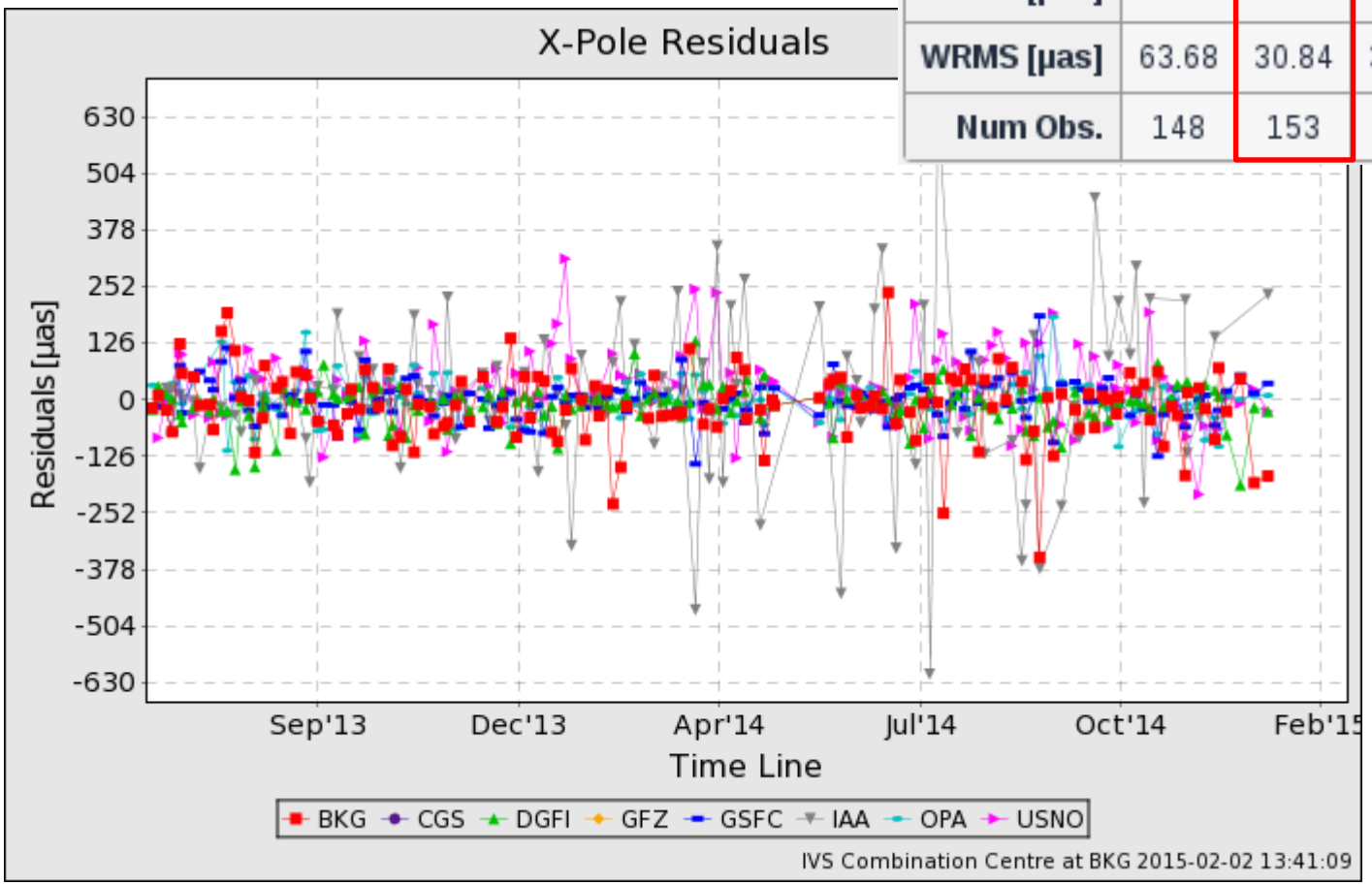
VLBI reprocessing (2)

Sessions successfully analyzed for the time span from April 2008 to December 2014:

Session type	#
APSG	11
CONT08	15
CONT11	15
CONT14	15
CRF	3
EUROPE	37
IVS-OHIG	19
IVS-R1	339
IVS-R4	340
IVS-R&D	44
IVS-T2	34
VLBA	40
Total	**912**

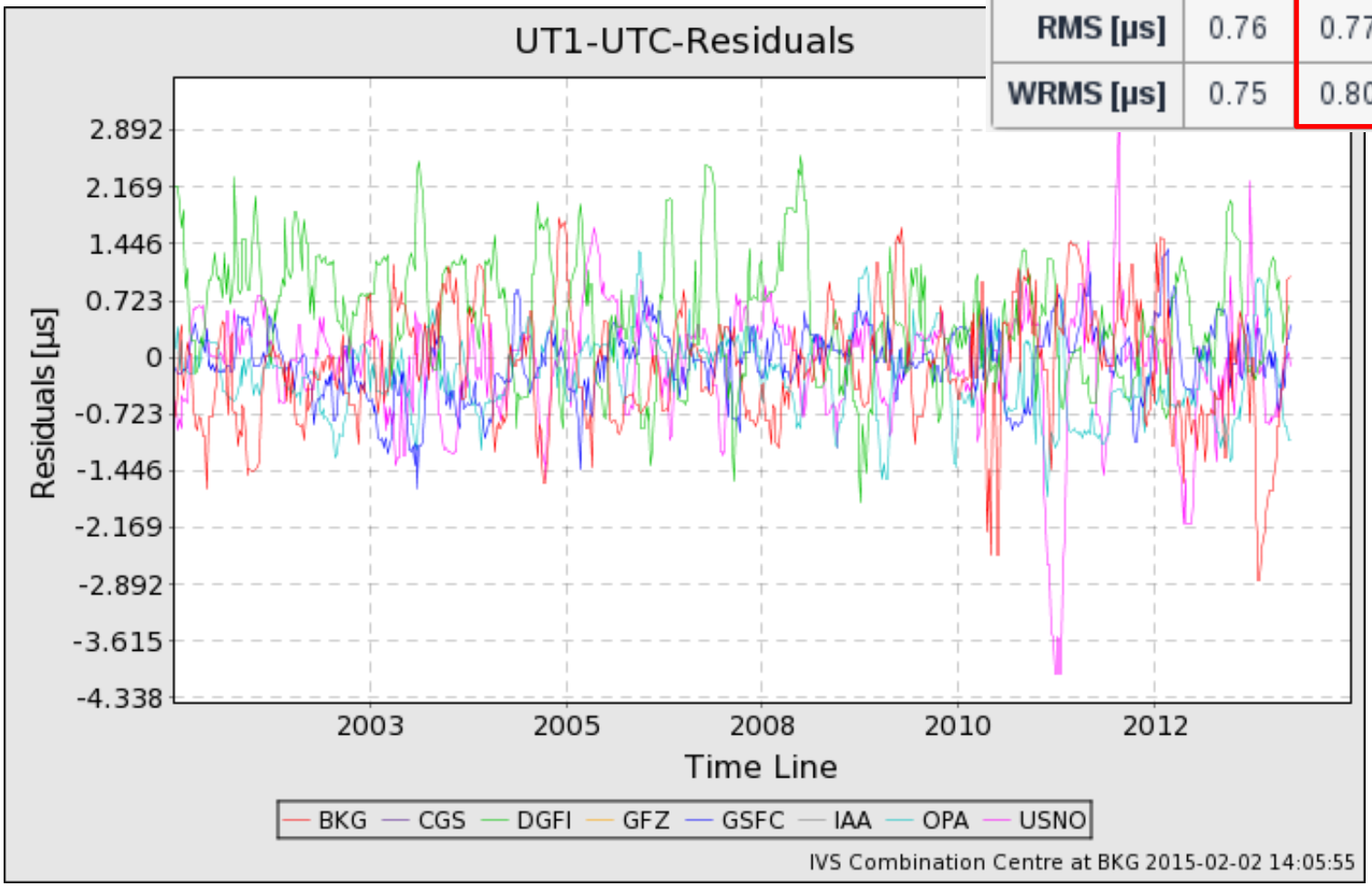
IVS rapid product (using R1/R4 sessions only)

	BKG	DGFI	GSFC	IAA	OPA	USNO
Offset [µas]	-7.14	-3.26	-2.14	+6.50	+3.39	+17.45
σ [µas]	5.25	2.50	2.59	20.15	2.72	5.31
RMS [µas]	77.98	44.37	44.00	182.26	45.27	79.98
WRMS [µas]	63.68	30.84	31.66	208.46	32.34	62.85
Num Obs.	148	153	151	108	142	141



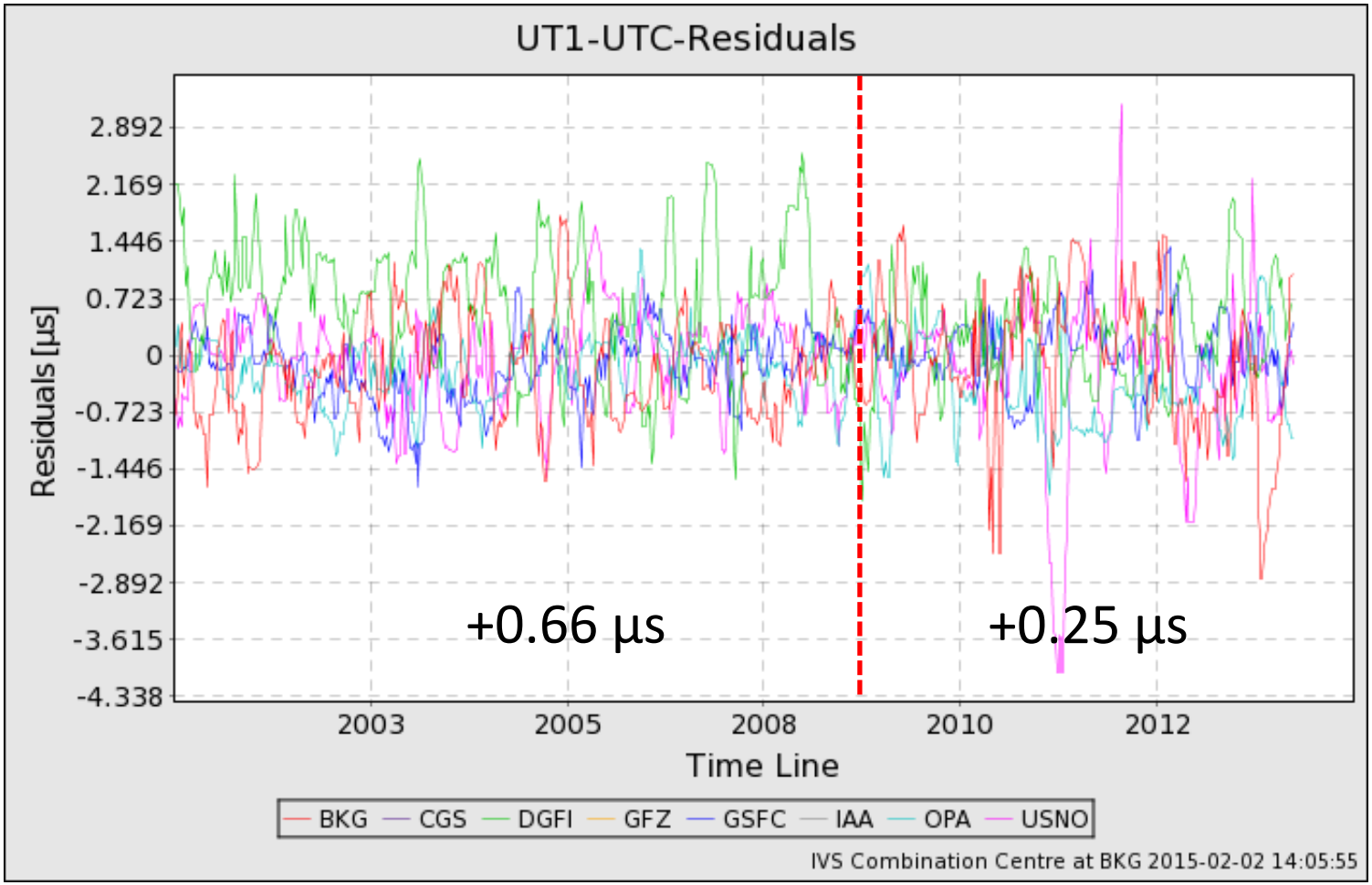
IVS quarterly solutions (using all 24 h sessions)

	BKG	DGFI	GSFC	OPA	USNO
Offset [µs]	+0.01	+0.53	-0.07	-0.21	+0.01
σ [µs]	0.03	0.03	0.02	0.02	0.03
RMS [µs]	0.76	0.77	0.45	0.50	0.76
WRMS [µs]	0.75	0.80	0.44	0.52	0.75



IVS quarterly solutions (using all 24 h sessions)

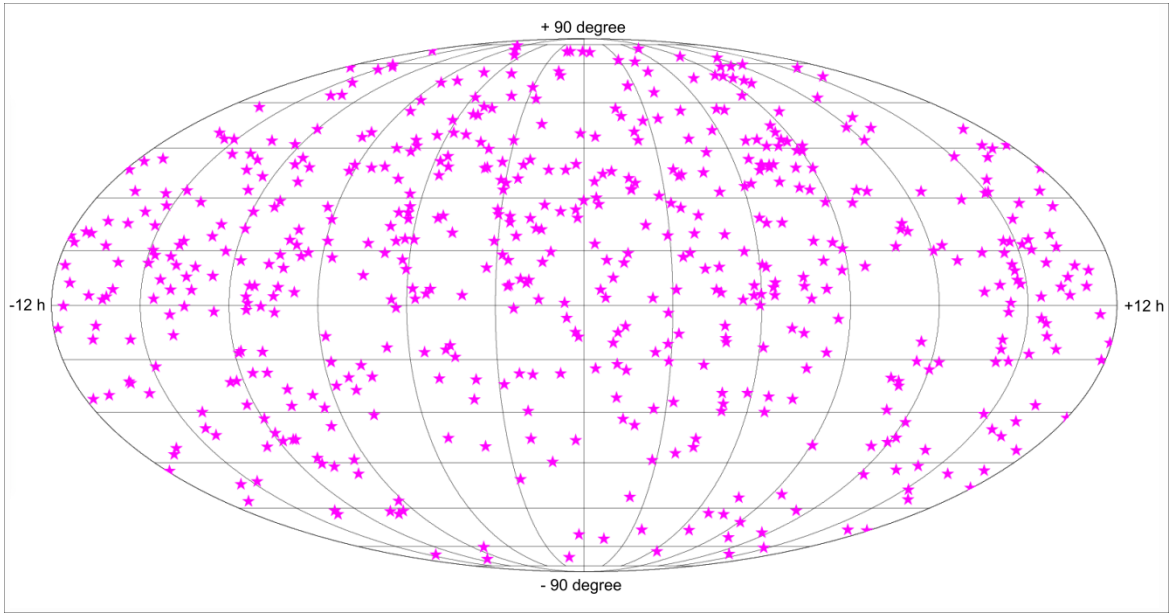
unclear whether improved behavior as of 2009 is connected to reprocessing



Multi-year VLBI-only reference frame (1)

- accumulation of all **R1 and R4 sessions** between April 2008 and December 2014 (tbd.: other session types)
- normal equations (NEQs) contain: station coordinates, **source coordinates**, EOP (pole coordinates/rates, ΔUT/LOD, $d\psi/d\varepsilon$)
- introduction of station velocities and discontinuities
- stacking of station and source coordinates
- constraints: NNR/NNT w.r.t. selected set of stations, NNR w.r.t. all sources

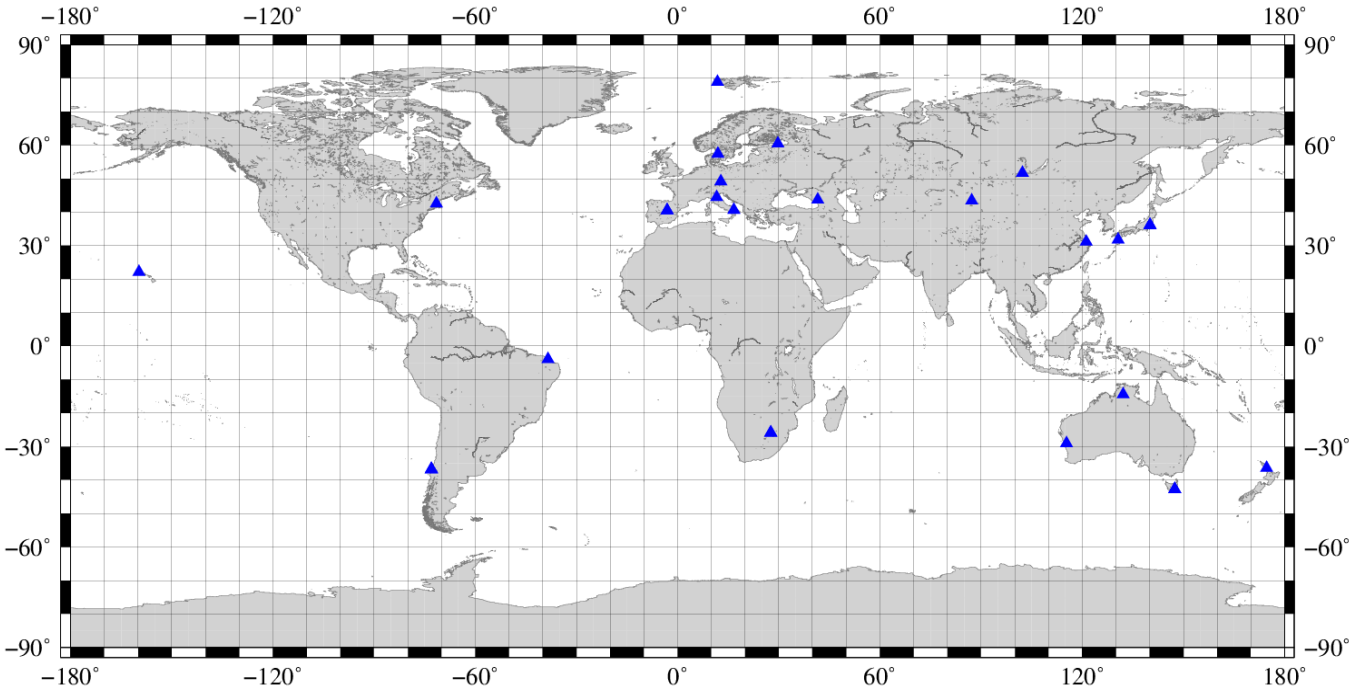
565 sources



Multi-year VLBI-only reference frame (2)

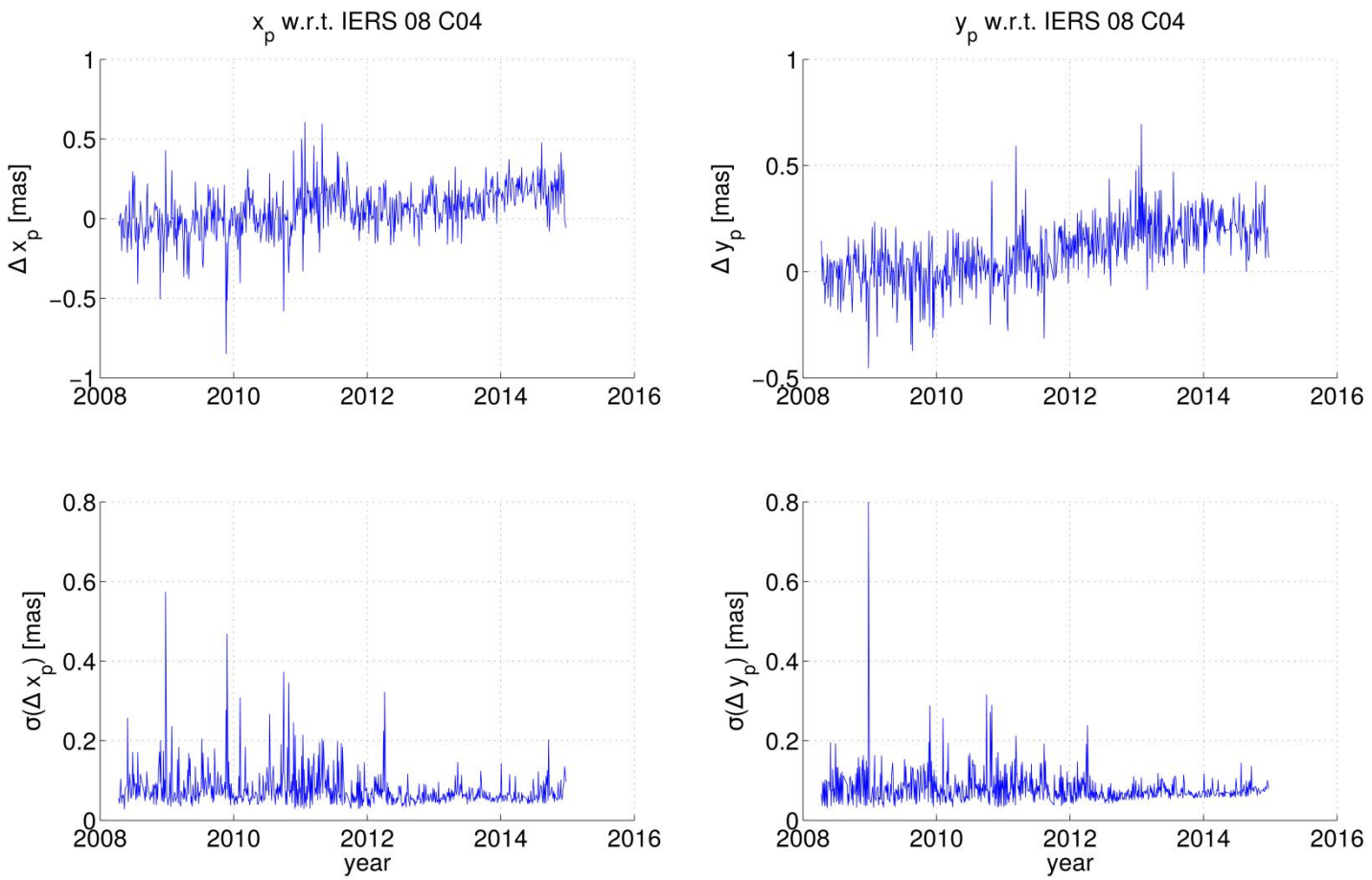
Validation via 14-parameter similarity transformation w.r.t. DTRF2008 (IVS-only):

- RMS of the transformation: 4.9 mm for coordinates, 0.6 mm/a for velocities
- significant scale bias (about 7 mm) and scale drift bias (about 0.7 mm/a) w.r.t. DTRF2008



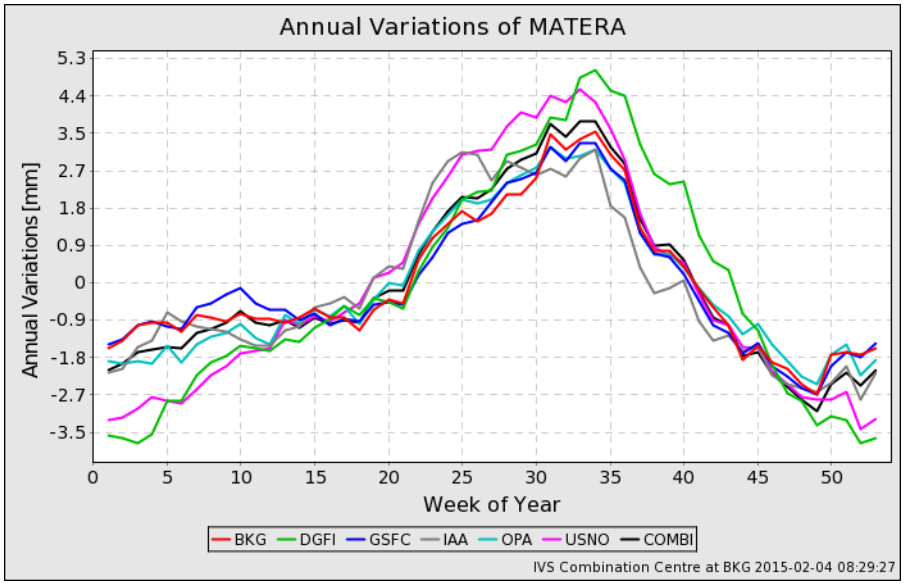
22 stations

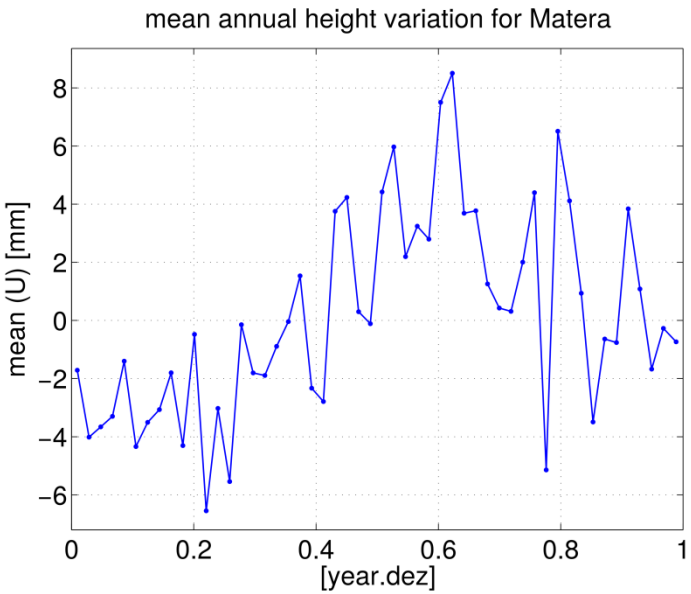
VLBI-only frame: pole coordinates

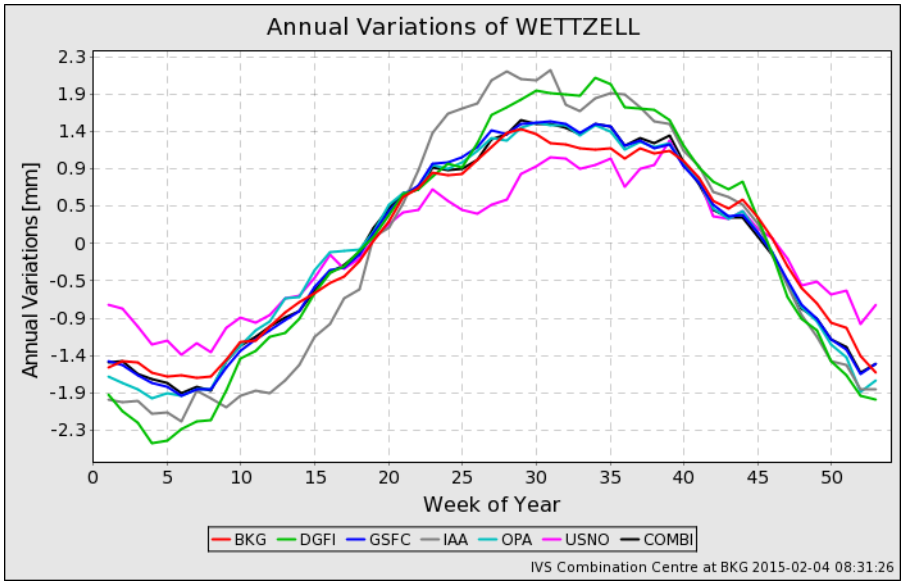


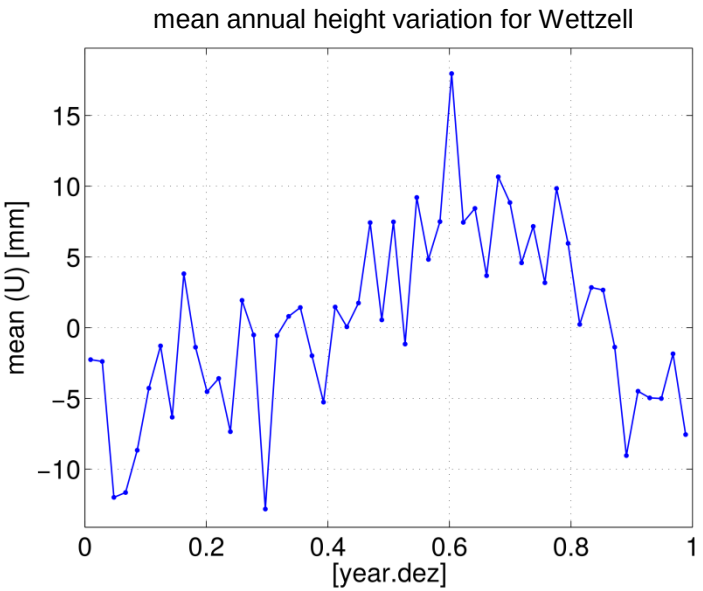
- systematic effects (e.g., drifts) have to be analyzed
- order of magnitude of the WRMS values is comparable to the IVS input for DTRF2008

VLBI-only frame: annual station signals









2nd phase: work packages and schedule

Work Packages	1st Project Year				2nd Project Year				3rd Project Year			
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WP5100	***Homogeneous reprocessing of GNSS, SLR and VLBI***											
WP5130									SLR			
WP5140									VLBI			
WP5200	***Multi-technique combined solutions for TRF+EOP***											
WP5220									Epoch reference frames			
WP5230									Multi-year solutions			
WP5300	***Study non-linear station motions based on four different methods***											
WP5310									ERF			
WP5320									Seasonal signals			
WP5340	Comparison											
WP5400	***Consistent estimation of TRF, EOP and CRF***											
WP5410	VLBI-only solution											
WP5420	Combined solution											
WP5440	Study impact and gain											

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WP5410	VLBI-only solution											
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WP5440	Study impact and gain											

2nd project phase

- Project proposal:
  "WP5100: […] Compared to the first funding period, the time span is extended to cover **20 years (1994-2013)** in order to get reliable statements on the improvement of the reference frame when using geophysical fluid models or parameterized seasonal signals."
- **only two** instead of three **project years** were granted
- DGFI-TUM intends to reduce the time span for the analysis of space geodetic data to **10 years (2004-2013)**

Summary

- good agreement between estimated annual station signals and deformation derived from global geophysical fluid models, if global loading phenomena dominate
- estimation of seasonal signals necessary to compensate local or regional effects
- short time series: problem to decorrelate station velocity and seasonal signals
- consistent VLBI time series available from April 2008 to December 2014
- accumulation of R1 and R4 sessions to multi-year reference frame successful; other session types tbd.
- annual signals for VLBI stations visible, but longer time series could be helpful