Review on the Reprocessing Activities of the EPN

Christof Völksen

Bavarian Academy of Sciences and Humanities, Germany

Bayerische
Akademie der Wissenschaften

Arguments for Reprocessing

During the period 1996 to 2015 different reference frames were realised, different standards and models applied, software changes and many other things led to inconsistencies in the coordinates.

- One reference frame for the whole time
- Consistent standards and conventions are required, e.g.
  - Antenna-PCV, Trop.-Models, IERS conventions, etc.
- Reducing inconsistencies in the time series
- Improved resolution of the velocity/deformation field
- Supports the realisation / densification of the reference frame
- Results are the optimal tool for studying geodynamics
  - Reprocessing is today a common approach for crustal deformation studies

Bayerische
Akademie der Wissenschaften

Historical Development

Year	Group
2002	University of California, R. Nikolaidis; (1991-2002)
2006	**Potsdam Dresden Group (PDR05), 1992-2005**
2007	BEK: subnetwork of the EPN (PDR05),1996 – 2005
2008	MUT/ROB: entire EPN-Network (PDR05),1996 - 2006
2008	IGS Repro1 (IGS05), 1994 – 2007 ⬜ ITRF2008 ACs: CODE, EMR, ESA, GFZ, JPL, MIT, NGS, PDR, SIO
2009	EPN-Repro1 (IGS05), 1996 – 2007 (Jan.) (834-1408)
2013	IGS Repro2 (IGb08), 1994 – 2013 ⬜ ITRF2014 ACs: CODE, EMR, ESA, GFZ, GRGS, JPL, MIT, NGS, SIO
2013	EPN-Repro2 (IGb08), 1996 – 2013 (834 – 1771)

Bayerische
Akademie der Wissenschaften

EPN-Repro1

- Started in 2009 finished by 2012

- Participation by all LACs

- Regional network strategy applied by using reprocessed Orbits
    - Orbits and EOP: PDR05, JPL (repro), IGS Repro1

- Performance of a benchmark test for optimal estimation of processing strategies (Pilot Phase)

- Covering data between 1996 and 2007 (Jan.)

EPN-Repro1 Contributions

Organisation	LAC	Software	Data Centre	Combination Centre		Multi Year Combination
				NEQ	Trop.	
ASI	X	GIPSY	X	-	-	
BEK	X	Bernese	X	-		
BKG	X	Bernese	X	**X**	**X**	
DEO	X	GIPSY	-	-	-	
GOP	X	Bernese	-	-	-	
IGE	X	Bernese	X	-	-	
IGN	X	Bernese	X	-	-	
MUT	X	Bernese/GAMIT		-	-	
NKG	X	Bernese	-	-	-	
OLG	X	Bernese	X	-	-	
ROB	X	Bernese	**X!**	-	-	
SGO	X	Bernese	-	-	-	**X**
LPT	X	Bernese	-	-	-	
SUT	X	Bernese	-	-	-	
UPA	X	Bernese	-	-	-	
WUT	X	Bernese	-	-	-	

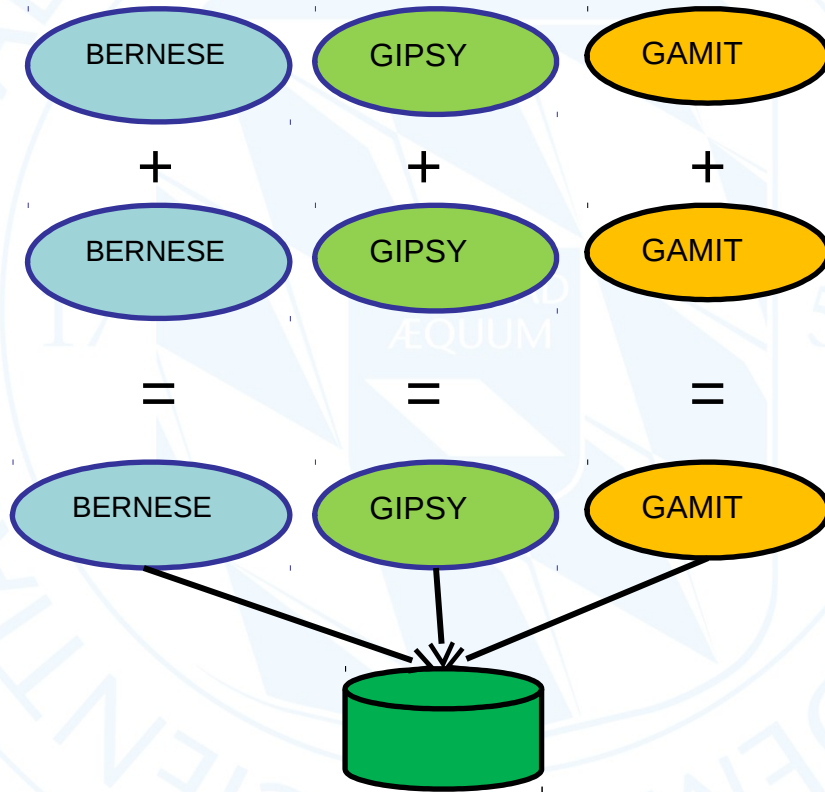Bayerische
Akademie der Wissenschaften
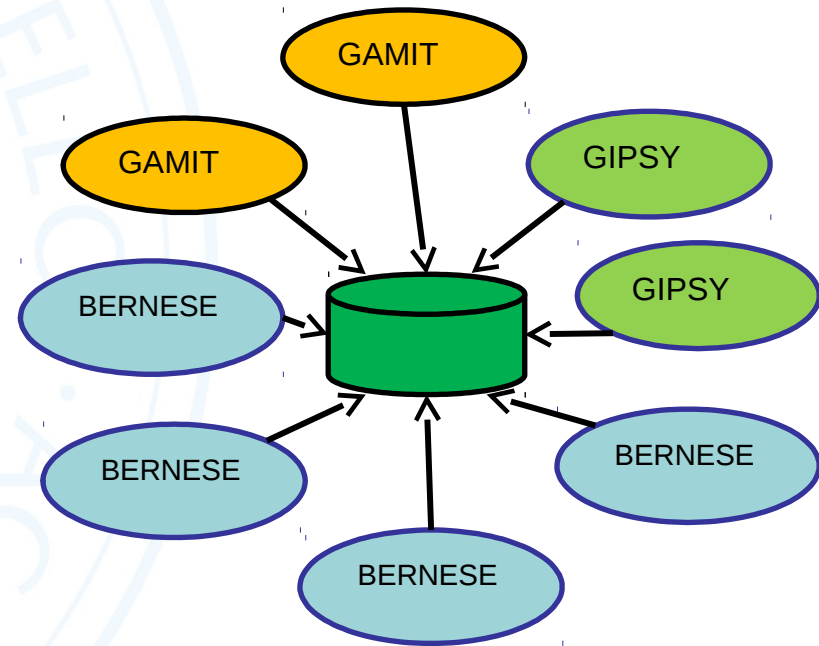
EPN-Repro1: Benchmark Test (RMS Helmert Transformation)
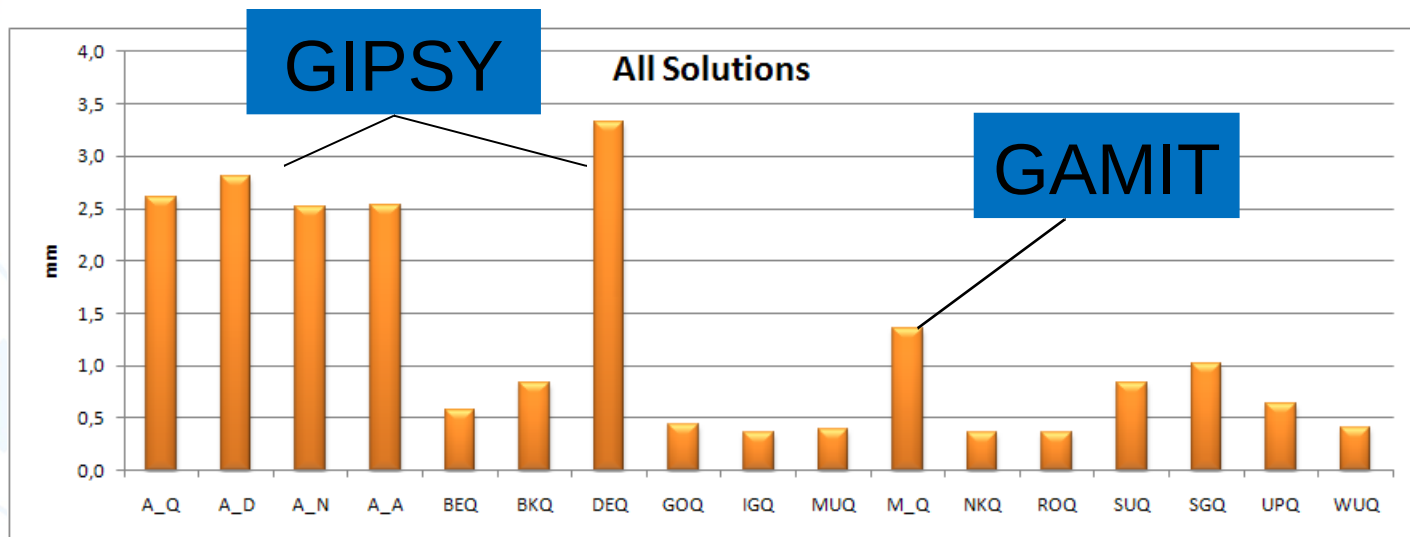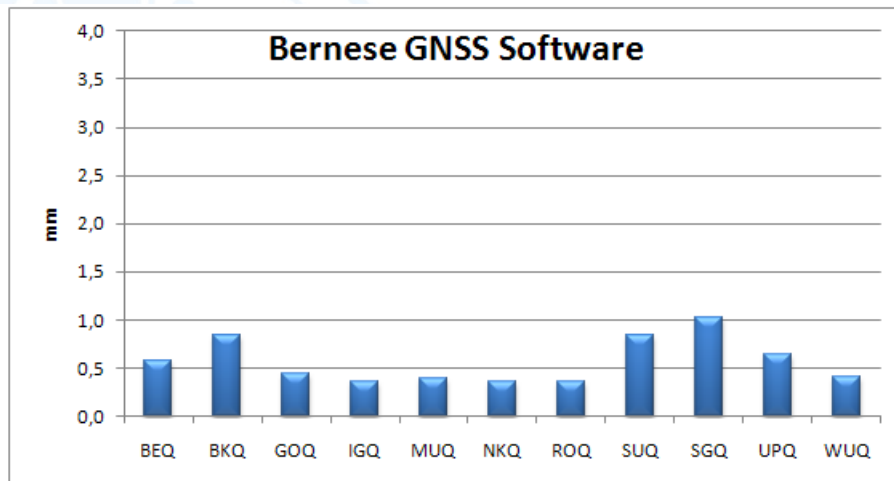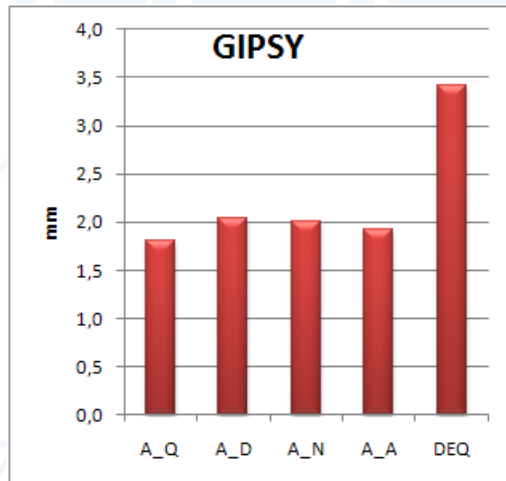
Combination of Daily Solutions

By software packages

Stronger impact by GIPSY&GAMIT

Any daily solution

Dominated by BERNESE

Bayerische
Akademie der Wissenschaften

EPN-Repro2

- Introduction of the ITRF2008 required a new reprocessing campaign (EPN-Repro2)

- Activities in parallel to IGS Repro2, similar approach e.g.:
    - Implementation of the new IERS conventions
    - Higher order correction terms for the ionosphere

- EPN uses individual calibrations while IGS uses type mean PCV

- A smaller group of ACs participates in EPN-Repro2

- GNSS observations provided by the historical archive centre at EPNCB (mandatory)

Bayerische
Akademie der Wissenschaften

Contributors EPN-Repro2

- **GNSS Analysis Centres (ACs):**
  - Centro di Geodesia Spaziale, Italy (ASI)
  - Geodetic Observatory Pecny, Czech Republic (GOP)
  - Instituto Geografico National, Spain (IGE)
  - Swisstopo, Switzerland (LPT)
  - Military University of Technology, Poland (MUT)
- **Combination of daily Normal Equations (NEQ)**:
  - Military University of Technology, Poland (MUT)
- **Combination of Troposphere Parameters (ZTD)**:
  - Centro di Geodesia Spaziale, Italy (ASI)
- **Multi-Year-Combination**:
  - Satellite Geodetic Observatory,Budapest SGO
- **Coordination:** Bavarian Academy, Munich (BEK)

Bayerische
Akademie der Wissenschaften

Benchmark: Test of the strategies (4 weeks of Data)
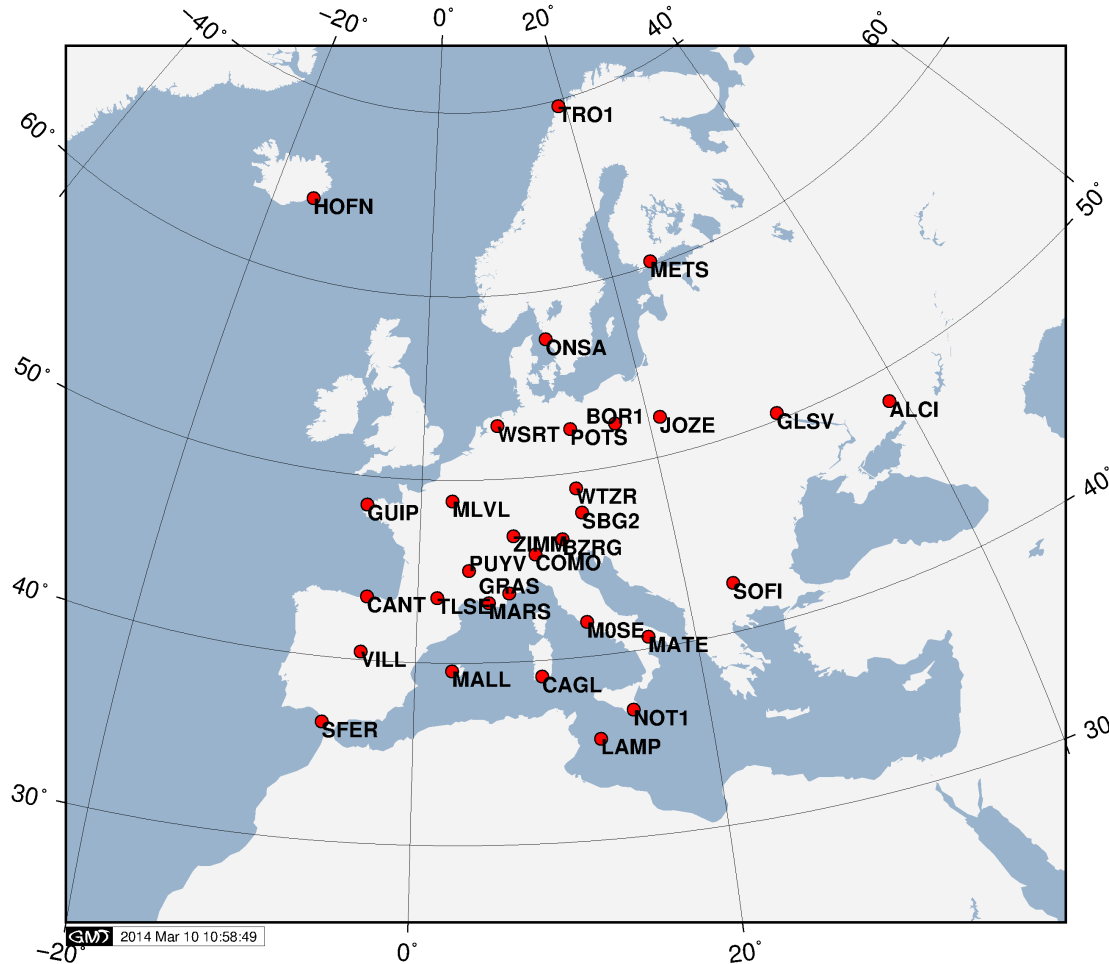
GNSS	#
GPS	32
GLONASS	21
Galileo	19

- Performed Spring 2014
- IGE Autumn 2014
- Products are available at BKG Data Centre

Bayerische
Akademie der Wissenschaften

Internal consistency of solutions (benchmark test):

- ## GOP (old):

SOL	PCV	Tropo	Elev.	S_N [mm]	S_E [mm]	S_h [mm]
GO0	IGS+EPN	GMF	3	1.47	1.61	4.87
GO1	IGS+EPN	VMF1	3	1.46	1.61	4.75
GO2	**IGS+EPN**	**VMF1**	**7**	**1.45**	**1.60**	**4.73**
GO3	IGS+EPN	VMF1	10	1.47	1.61	4.78

- ## LPT:

SOL	PCV	Tropo	NT-ATML	$S_{N \text{ [mm]}}$	S_E [mm]	S_h [mm]
LP0	**IGS**	**GMF**	**No**	**1.49**	**1.46**	**4.70**
LP1	**IGS+EPN**	**VMF1**	**Yes**	**1.44**	**1.42**	**4.13**

Bayerische
Akademie der Wissenschaften

Contributions

	AS0	GO0	GO2	GO4	IG0	LP0	LP1	MU0	MU1	MU4
SW	GIPSY 6.2	BSW 5.2			BSW 5.2	BSW 5.2		GAMIT 10.5		
GNSS	**G**	**G**			**G + R**	**G + R**		**G**		
SOLUTION TYPE	PPP	NET			NET	NET		NET		
STATIONS	**ALL EPN+ IGS CORE**	**ALL EPN**			**PART EPN**	**PART EPN + IGS(8)**		**ALL EPN**		
ORBITS	**JPL R2 (prelim.)**	**CODE R2**			**CODE R2**	**CODE R2**		**CODE R2**		
ANTENNAS	**IGS08**	**IGS08 + IND.**			**IGS08 + IND.**	**IGS08**	**IGS08+ IND**	**IGS08**	**IGS08+ IND**	**IGS08**
IERS	2010	2010			2010	2010		2010		
GRAVITY	EGM08	EGM08			EGM08	EGM08		EGM08		
TROPOSPHERE Estimated Param	ZTD (5min) GRAD (5min)	ZTD (1h) GRAD (6h)			ZTD (1h) GRAD (6h)	ZTD (1h) GRAD (24h)		ZTD GRAD 10	ZTD (1h) GRAD in Zenith (24h)	
MAPPING FUNCTION	VMF1	GMF	VMF1	VMF1	GMF	GMF	VMF1	VMF1		
ZTD/GRAD time stamp	hh:30 24 estimates/day	hh:30 24 estimates/day			hh:30 24 estimates/day	hh:00 (and hh:30) **24**(+24) estimates/day		hh:30 24 estimates/day		
IONOSPHERE	(HOI included)	CODE (HOI included)			CODE (HOI included)	CODE (HOI included)		CODE IONEX + IGRF11 (HOI included)		
REF. FRAME	IGb08	IGb08			IGb08	IGb08		IGb08		
OCEAN TIDES	FES2004	FES2004			FES2004	FES2004		FES2004		
T-ATML	NO	NO			YES	YES	YES	YES		
NT-ATML	NO	NO	NO	YES	NO	NO	YES	YES	NO	NO
ELEV. CUTOFF	**3**	**3**			**3**	**3**		**5**		
Delivered SNX/TRO Files [from week to week]	**0835-1772**	**836-1771**			**835-1816**	**835-1772**		**835-1771**		

Bay Akademie der Wissenschaften

Sites represented in 3 solutions

Bayerische
Akademie der Wissenschaften
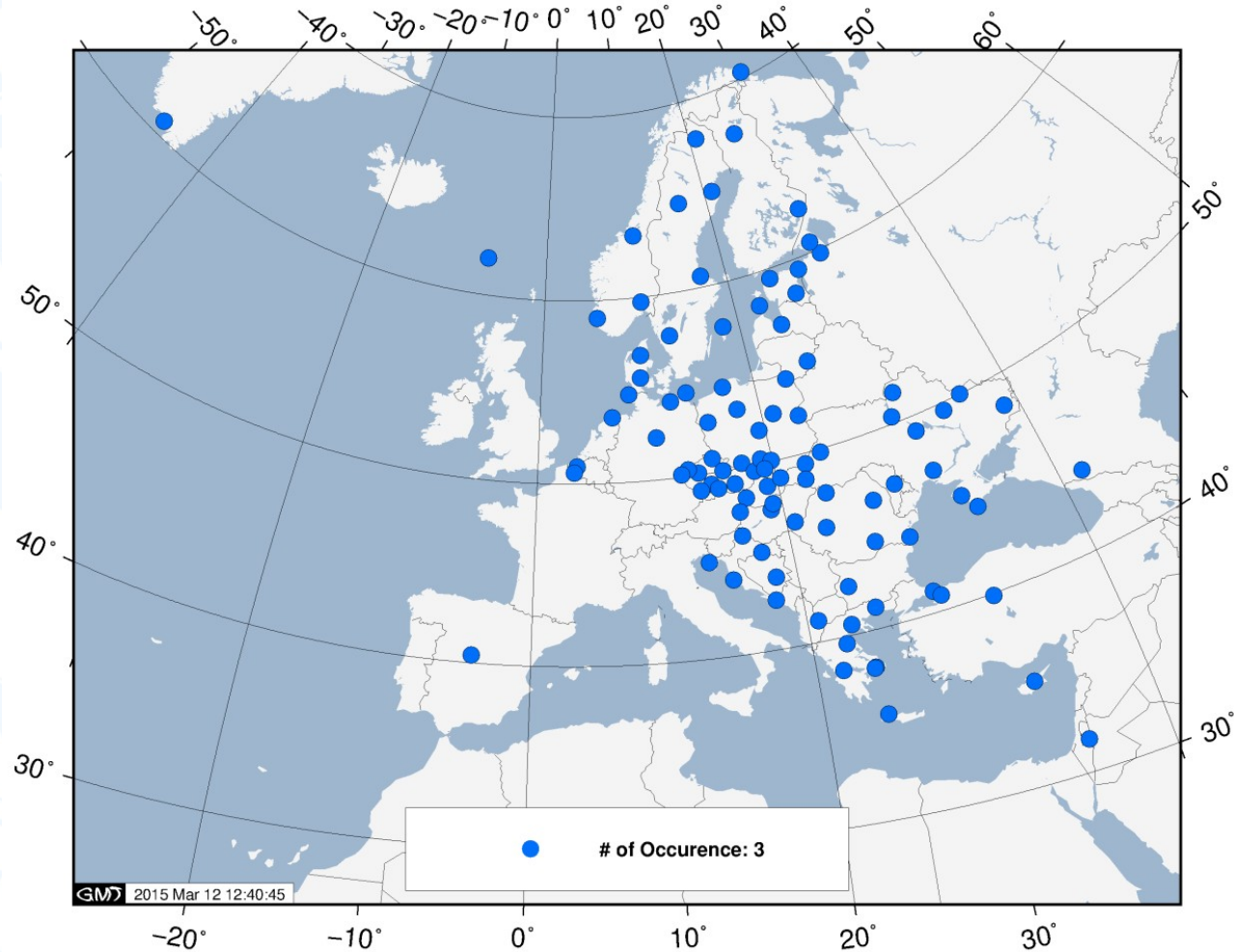
Sites represented in 4 and 5 solutions
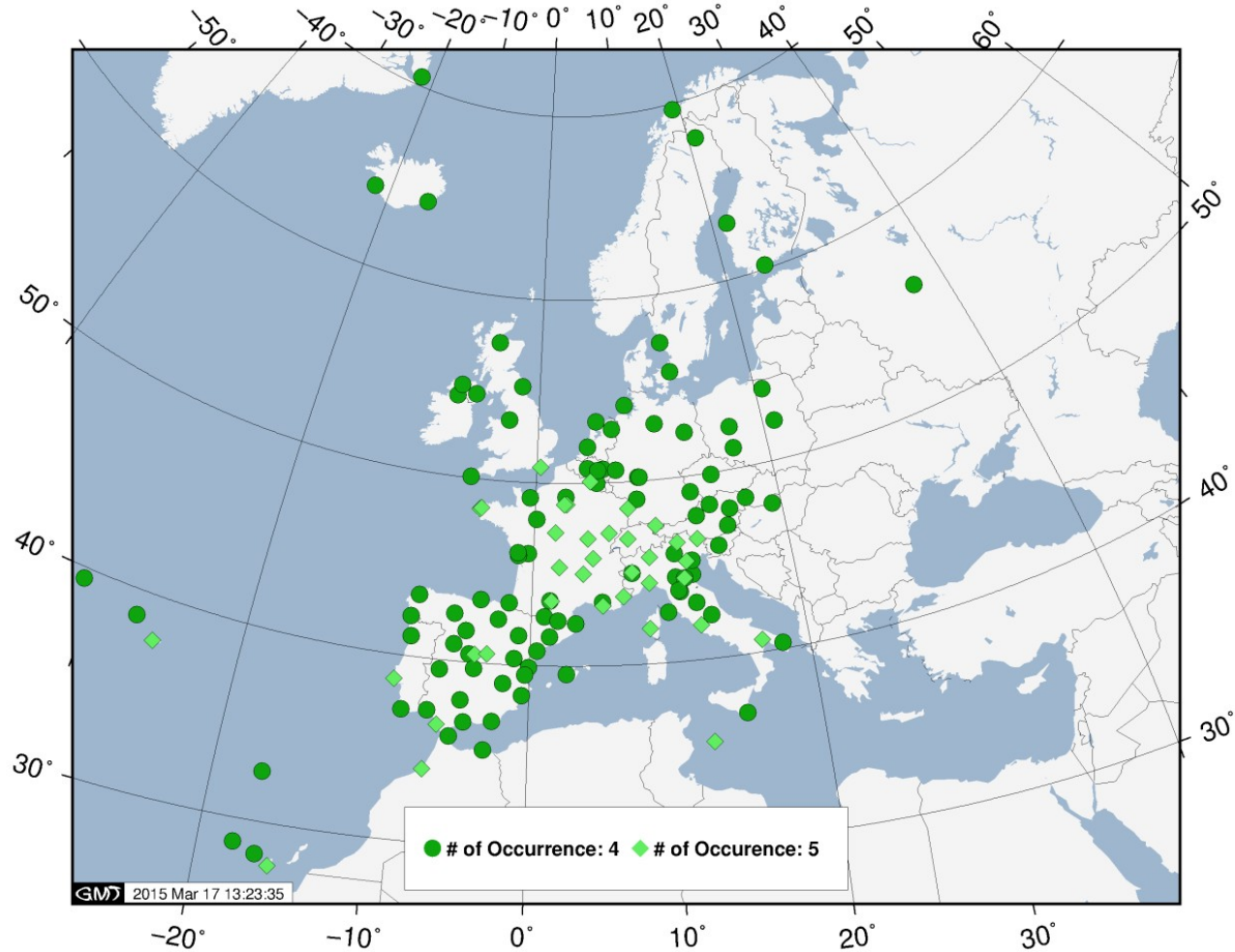
Not on map: NYA1 (4), SCOR (5)

Features of the solutions

- GLONASS
  - available since 2003, only used in solutions by LPT and IGE
- Different antenna PCV corrections used in the uploaded solutions („type mean" and „type mean + individual)
  - Available solutions offer the possibility to elaborate the difference and generate corrections
- Orbits are mostly homogeneous (CODE Repro 2) with exception of ASI
- Mixture of solutions with or without correction for Non-Tidal-Atmospheric Loading (NT-ATML)
  - removed on NEQ-Level for MUT

Example: Differences between Antenna *Type Mean* and *Individual PCV*
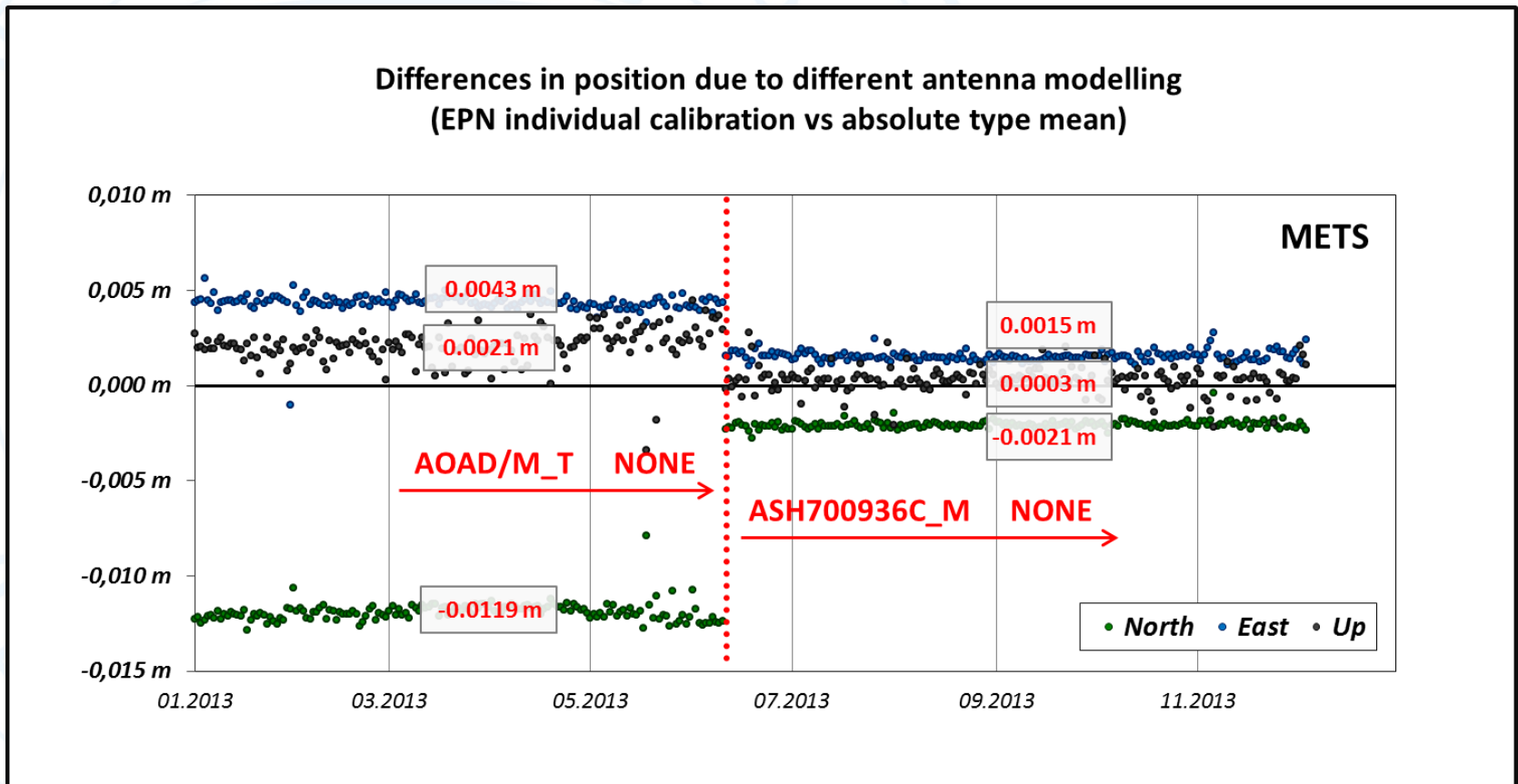
Provide by MUT, Andrzej Araszkiewicz

"Indiv. PCV" versus "Type Mean" PCV

SITE	Antenna	Radome	Serial #	North [mm]	East [mm]	Up [mm]
BZRG	LEIAR25.R4	LEIT	25220	-1.0	-1.9	-1.7
CANT	LEIAR25.R4	LEIT	25066	2.2	-1.2	1.7
HOFN	TPSCR3	CONE	70218	-0.1	1.1	1.2
METS	**AOAD/M_T**	**NONE**	**519**	**11.5** 11.9	**-4.9** -4.3	**-1.5** -2.1
SOFI	LEIAR25.R3	LEIT	60008	2.1	-2.3	7.1
WTZR	LEIAR25.R3	LEIT	20031	0.1	-0.6	-2.5
ZIM2	TRM29800.00	NONE	60369	0.2	1.1	0.7

Differences of site coordinates after neglecting individual PCV in PPP mode (GIPSY). Seven sites of the benchmark network are affected.

Bayerische
Akademie der Wissenschaften

Products and Combination

- Products
  - BKG Data Centre: login required
- Combination of daily SINEX
  - MUT: K. Szafranek & A. Araszkiewicz
  - ADDNEQ & CATREF & (GLOBK)

REPORT MUT

- Combination of Troposphere Parameters
  - ASI: R. Pacione & B. Pace
  - ASI Software

REPORT ASI

- Multi Year Combination
  - SGO: A. Kenyeres
  - CATREF

Bayerische
Akademie der Wissenschaften

Summary

- Daily SINEX are completely uploaded since August `15

- Some of the contributions are yet not consistent (e.g. PCV, NT-ATL)
  - Correction via offsets might be used (coordinates only)

- The introduction of the ITRF2014 might require another reprocessing effort

- Reprocessing is likely to become a continuous task of the EPN activities
  - Has been acknowledge by the Dedicated Analysis Centre (DAC) for Reprocessing at GOP (Geodetic Observatory Pecny)