Schweizerische Eidgenossenschaft
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EUREF-TWG Project: Monitoring of official national ETRF coordinates on EPN web

E. Brockmann

Starting point

- Need for homogeneous national reference frame (Eurogeographics, INSPIRE): ETRF
- ETRF is widely acknowledged and used as the reference frame for Europe
- National ETRF coordinates were in the past mainly computed from campaigns – today permanent networks define national reference frames
- Umbrella EUREF: EPN web portal gives detailed information on coordinates. Coordinates are mainly “scientific” oriented:
    - weekly
    - ITRF / ITRF-densification ETRF coordinates
    - EPN cummulative coordinate set

Project idea

- Collection of all EPN sites which are used in the countries for reference frame realization and which therefore have official national ETRF coordinates.
- Demonstration of the “homogeneity” of the ETRF realization
- Usefull additional info on the EPN web (no control of the countries; publication only if agreed by countries)
- In future extendable to a “monitor system” for the countries.

- Project started at LAC Meeting Frankfurt / TWG Meeting Munich (Oct./Nov. 2008): 15 countries asked to deliver coordinates – all other countries were asked to report on it in the national reports

Proposal: official national ETRF coordinates on EPN web site

EPN

http://www.epncb.oma.be/_trackingnetwork/coordinates/stationcoordinates4onestation.php?station=ZIMM

2. B) Positions computed by the EPN Combination Centre

	epoch t_0	X_{weekly}	Y_{weekly}	Z_{weekly}
IGS05	2009.24 (Wk No 1525)	4331297.0061 ± 0.0012	567555.9578 ± 0.0004	4633133.9850 ± 0.0012

2. A) Positions/velocities computed from the EPN time series analysis (release 14/04/2009)

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X_{EPN}	Y_{EPN}	Z_{EPN}	VX_{EPN}	VY_{EPN}	VZ_{EPN}
182/96 - 310/98	2000.0	4331297.344 ± 0.000	567555.634 ± 0.000	4633133.722 ± 0.000	-0.0005 ± 0.0001	-0.0005 ± 0.0000	0.0001 ± 0.0001
310/98 - 309/06	2000.0	4331297.333 ± 0.000	567555.637 ± 0.000	4633133.710 ± 0.000	-0.0005 ± 0.0001	-0.0005 ± 0.0000	0.0001 ± 0.0001
309/06 - 064/09	2000.0	4331297.332 ± 0.001	567555.639 ± 0.000	4633133.710 ± 0.001	-0.0005 ± 0.0001	-0.0005 ± 0.0000	0.0001 ± 0.0001

1. A) Positions/velocities published by EUREF (release Dec. 2008)

ETRF2000*	epoch t_0	Position (m)			Velocity (m/y)		
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182/96 - 310/98	2000.0	4331297.342 ± 0.000	567555.634 ± 0.000	4633133.720 ± 0.000	0.0012 ± 0.0001	0.0004 ± 0.0000	0.0020 ± 0.0001
310/98 - 365/05	2000.0	4331297.331 ± 0.000	567555.637 ± 0.000	4633133.708 ± 0.000	0.0012 ± 0.0001	0.0004 ± 0.0000	0.0020 ± 0.0001

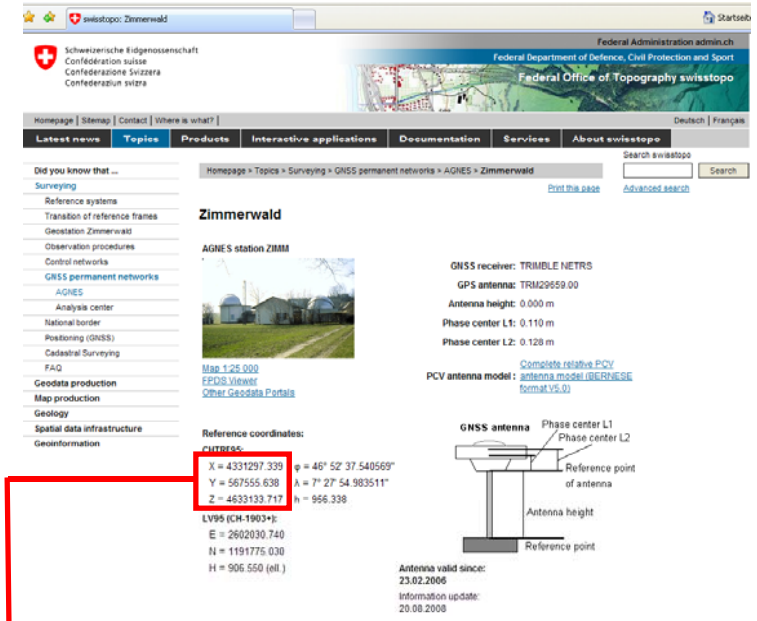
1. B) Positions/velocities published by the IERS

ETRF2000(R05)	epoch t_0	Position (m)			Velocity (m/y)		
		X_{IERS}	Y_{IERS}	Z_{IERS}	VX_{IERS}	VY_{IERS}	VZ_{IERS}
start - 310/98	2000.0	4331297.341 ± 0.001	567555.635 ± 0.000	4633133.719 ± 0.001	0.0000 ± 0.0001	-0.0003 ± 0.0001	0.0004 ± 0.0001
310/98 - 365/05	2000.0	4331297.332 ± 0.001	567555.636 ± 0.000	4633133.709 ± 0.001	0.0000 ± 0.0001	-0.0003 ± 0.0001	0.0004 ± 0.0001
ETRS89	epoch t_0	Position (m)			Velocity (m/y)		
		X_{IERS}	Y_{IERS}	Z_{IERS}	VX_{IERS}	VY_{IERS}	VZ_{IERS}
ETRF2000 start - 312/98	1989.0	4331297.347 ± 0.004	567555.633 ± 0.002	4633133.717 ± 0.004	-0.0007 ± 0.0004	0.0001 ± 0.0002	-0.0001 ± 0.0005
ETRF2000 312/98 - 365/00	1989.0	4331297.342 ± 0.004	567555.635 ± 0.002	4633133.712 ± 0.005	-0.0007 ± 0.0004	0.0001 ± 0.0002	-0.0001 ± 0.0005
ETRF97 start - 365/98	1989.0	4331297.331 ± 0.004	567555.636 ± 0.003	4633133.701 ± 0.004	0.0015 ± 0.0005	-0.0004 ± 0.0004	0.0008 ± 0.0005
ETRF96 start - 365/97	1989.0	4331297.331 ± 0.003	567555.643 ± 0.003	4633133.693 ± 0.003	0.0020 ± 0.0003	-0.0009 ± 0.0004	0.0026 ± 0.0003

international

national

National level (e.g. CH)



If station used in national networks basing on ETRS

ETRF93	Epoch 1993.0	4331297.339	567555.638	633133.717

Personal communication (e-mail) from NMA / using standardized file format

File format for information exchange

File name: CHE_200810021.ETRF

Station	DOMES	X	Y	Z	Frame	Epoch	valid from	to
						yyyy*mm*dd	yyyy*mm*dd	yyyy*mm*dd
ZIM2	14001M008	4331300.1443	567537.0824	4633133.4977	ETRF93	1993 01 01	2007 11 09	
ZIMM	14001M004	4331297.3388	567555.6380	4633133.7174	ETRF93	1993 01 01	1988 01 01	

File name: SWE_200903013.ETRF

Station	DOMES	X	Y	Z	Frame	Epoch	valid from	to
						yyyy*mm*dd	yyyy*mm*dd	yyyy*mm*dd
KIR0	10422M001	2248123.5038	865686.5326	5886425.5943	ETRF97	1999 07 01	1993 08 01	
MAR6	10405M002	2998189.7132	931451.5886	5533398.4735	ETRF97	1999 07 01	1993 08 01	
ONSA	10402M004	3370658.8318	711876.9387	5349786.7450	ETRF97	1999 07 01	1999 02 02	
SKE0	10426M001	2534031.1978	975174.4040	5752078.3436	ETRF97	1999 07 01	1993 08 01	
SPT0	10425M001	3328984.8136	761910.0660	5369033.4748	ETRF97	1999 07 01	1995 12 01	2007 06 08
SPT0	10425M001	3328984.8211	761910.0677	5369033.4857	ETRF97	1999 07 01	2007 06 08	
VIL0	10424M001	2620258.8912	779137.9797	5743799.2762	ETRF97	1999 07 01	1993 08 01	
VIS0	10423M001	3246470.5614	1077900.3132	5365277.9025	ETRF97	1999 07 01	1993 08 01	

Number of EPN sites with official national ETRF coordinates

Not yet asked (EPN sites)

Ok: (xx CRD delivered / EPN sites)

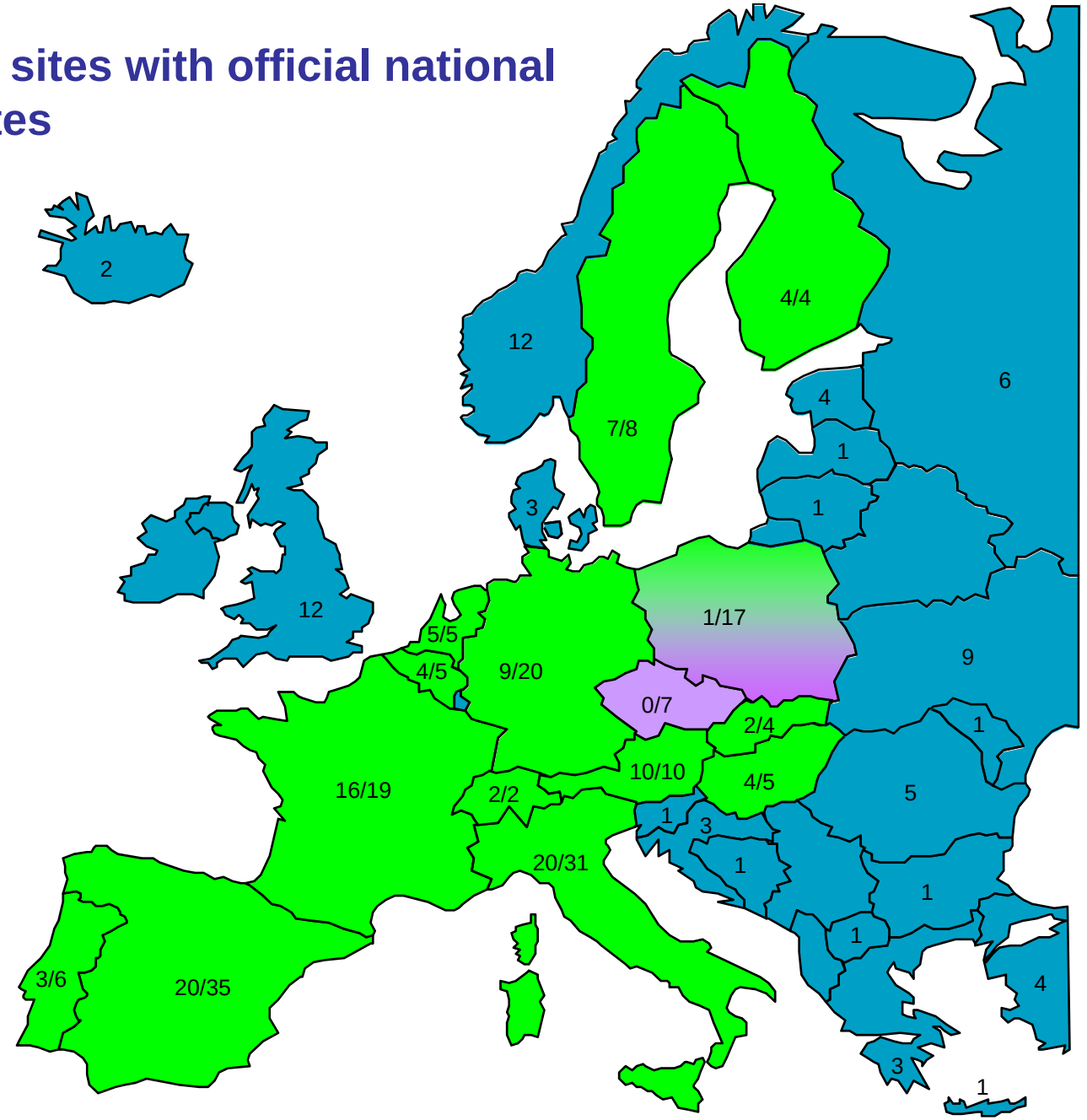
No EPN sites used: (xx CRD delivered / EPN sites)

Greenland:4
Israel: 2
Morocco: 2
Armenia: 1

EPN: 39 countries
223 sites

All 15 countries sent coordinates

Partly more site coordinates delivered (additional national + outside of the country)

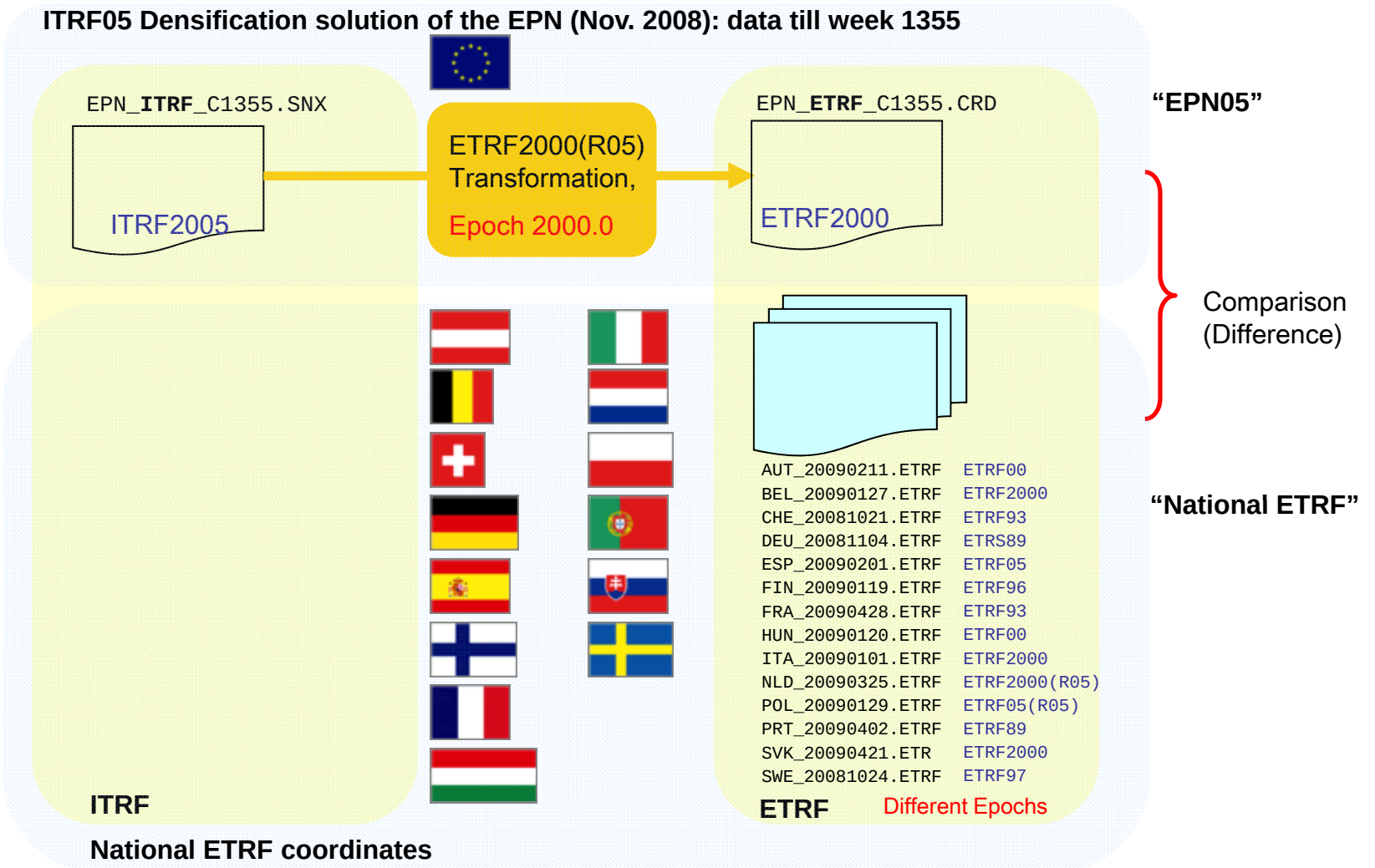


Status: 1.5.2009

Reference solution

- ITRF05 densification solution of the EPN
  - published in Dec. 2008
  - aligned to ITRF2005 with minimum constraints
  - data from 0860 – 1355 [same as ITRF2005, Dec. 2005; before Nov. 2006 (week 1400)] **EPN_ITRF_C1355.SNX**
  - based on relative antenna phase center variation model, which is also true for many national reference frame realizations
  - regarded as a “scientific” coordinate solution
  - presently reference solution with more frequent updates are provided (Kenyeres, 2009)

Comparison with EPN05 densification: Method used



Comparison with EPN05 densification: alternative Method using EPN web

EPN

National level (e.g. CH)

international

national

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ETRS89	epoch t_0	Position (m)			Velocity (m/y)		
		X_{IERS}	Y_{IERS}	Z_{IERS}	VX_{IERS}	VY_{IERS}	VZ_{IERS}
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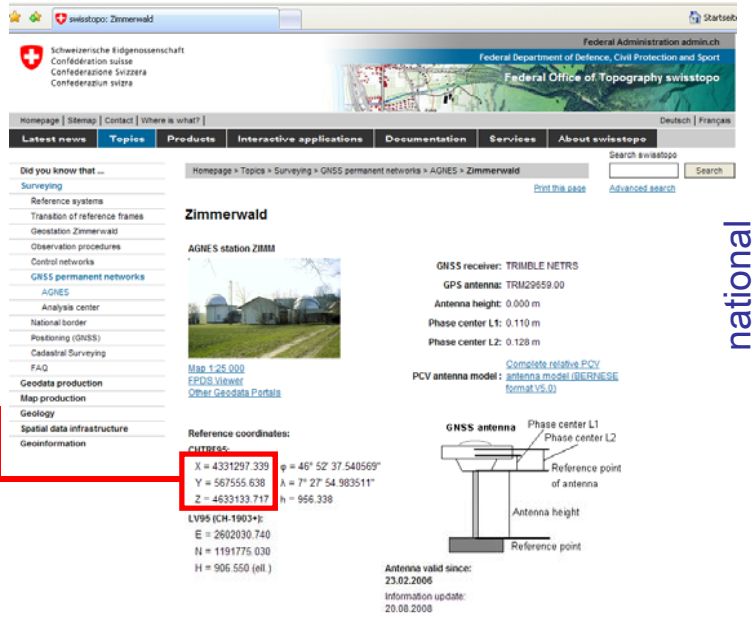
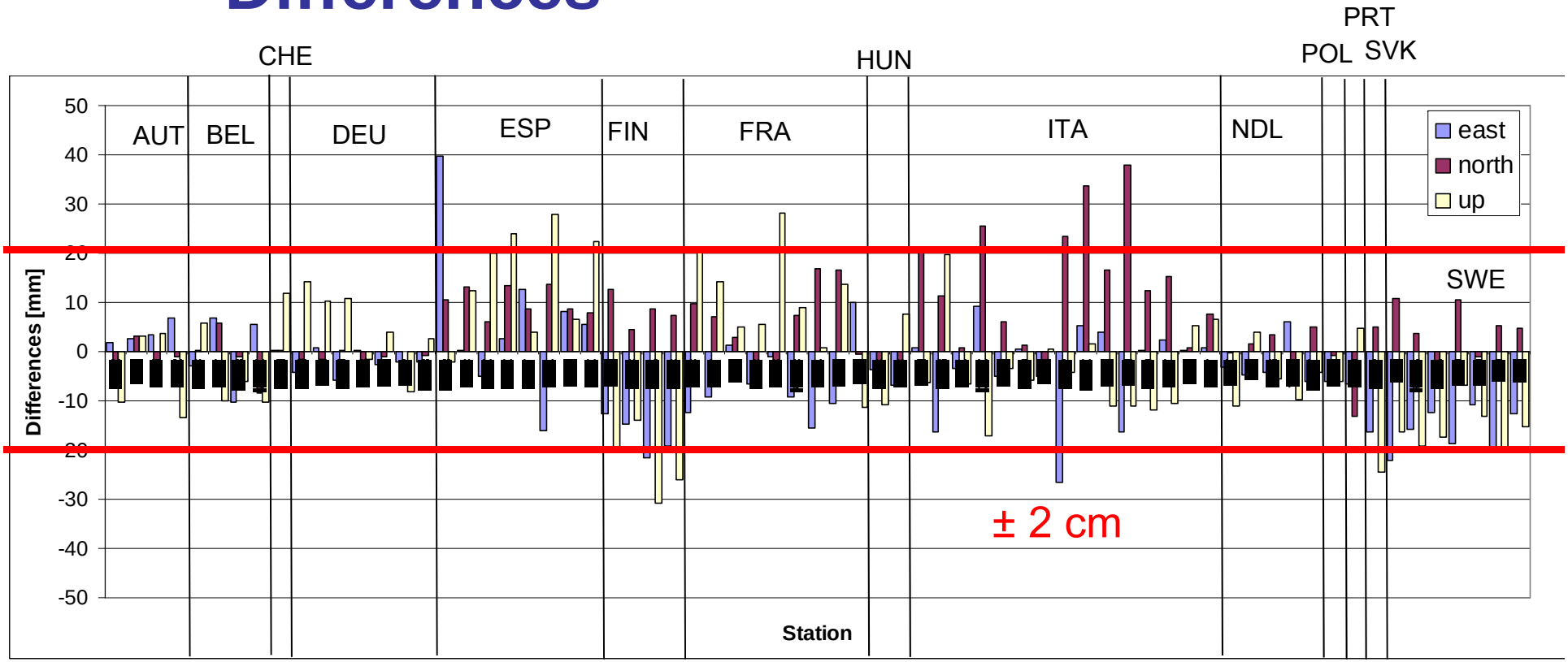


- requested to report in the national report
- on sub-mm identical to method using SNX SSC file rounded to 1 mm

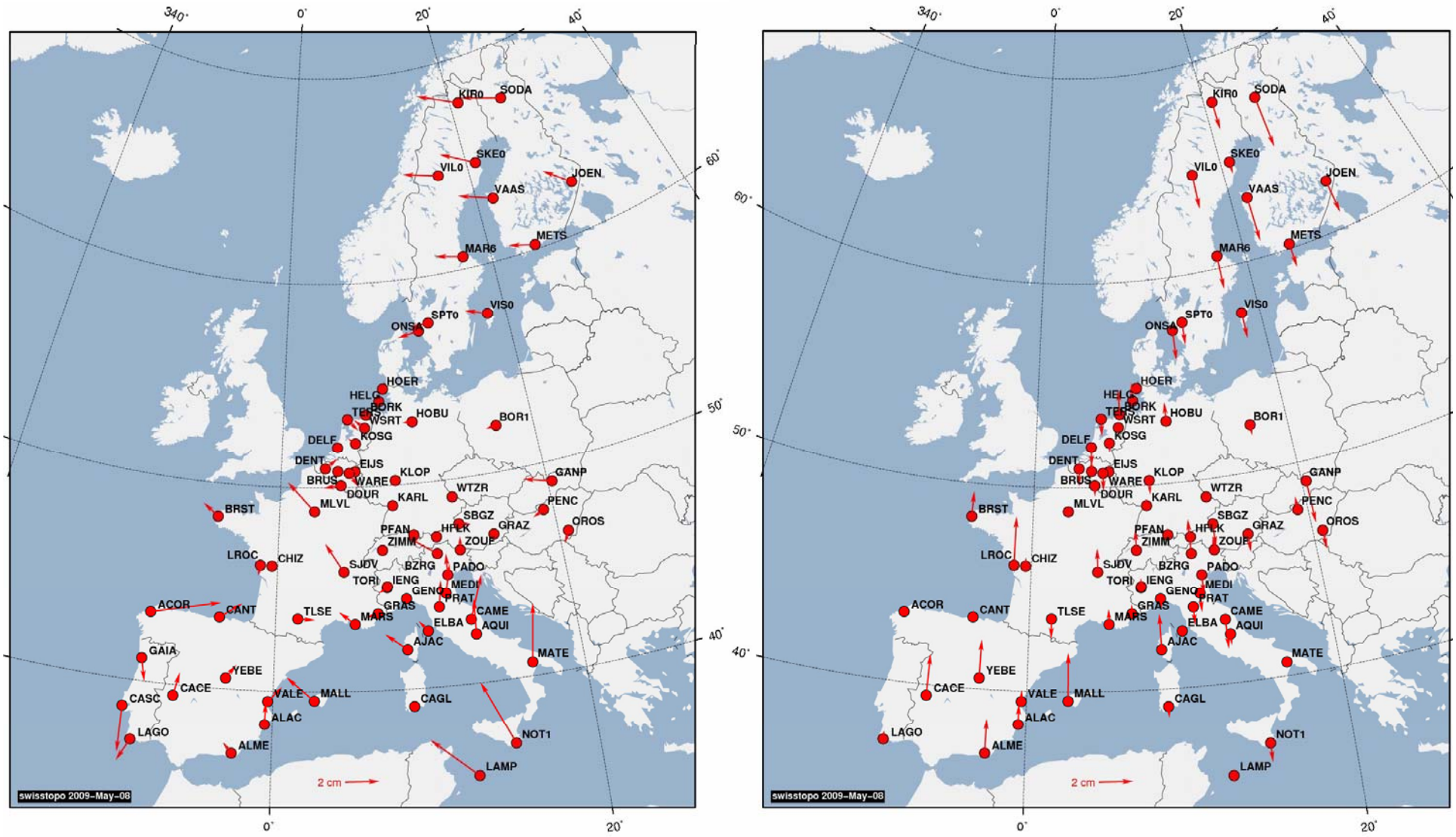
http://www.epncb.oma.be/_trackingnetwork/coordinates/stationcoordinates4onestation.php?station=ZIMM

Comparison with EPN05 densification Differences



- 70 sites, 1 sites under investigation due to vertical antenna reference point (GAIA)
- Mean bias in mm (E,N,U): -4, 6, -1 mm
- Mean std in mm (E,N,U): 10, 9, 13 mm

Comparison with EPN05 densification
Differences: horizontally + vertically



Comparison with EPN05 densification: remarks

- EPN densification solution only compared for sites with a long observation period (18 sites excluded because marked in EPN_ETRF_C1355.SSC)
- Differences of 1-3 cm are expected due to
  - different ETRFYY definitions and reference epochs
  - transition from campaign to permanent stations
  - different analysis models and software used
  - different station setups (antenna changes) – most recent EPN station setup was used for the comparisons
  - mapping agencies cannot change coordinates frequently
  - location on “non-stable plate” (South Italy)

- Feedback to 15 countries sent. No objections of the countries to publish the national official ETRF coordinates on the EPN web page.

Conclusion

- Countries did a great job computing ETRF coordinates for permanent EPN stations !!!
- Scientific coordinates released by EUREF are a usefull reference (collaboration of many countries)
- Proof of the „compatibility“ within Europe, which is essential for projects within INSPIRE and EuroGeographics
- Integration of national coordinates into EPN and/or EU-CRS webpage would prove the collaboration on an European level
- Advantage also for EUREF in case of datum definition discussions (future development of ETRS89; Lidberg et al., 2009), if the used coordinates in the countries are known.

“Instructions” for national representatives

National ETRF coordinates for EPN stations of ALL countries desirable (if no objection against publication):

- **Send country file CCC_YYYYMMDD.ETRF** (CCC: national 3-character ISO 3166 code, YYYYMMDD: year, month and day of the information update to: **elmar.brockmann@swisstopo.ch**
- **till September 15, 2009**
- Example file: http://www.swisstopo.admin.ch/swisstopo/geodesy/pnac/divers/etrf_monitor/CCC_YYYYMMDD.ETRF
- Thanks to your kind cooperation !

Paper copies of the present status and all necessary information are available

Future plans

- Start will be coordinated by E. Brockmann -> operational service will be realized by EPN central bureau (coordinate publication + display of the differences in a suited graphical or numerical way) . Feedback to the countries before publication on web is guaranteed.
- Installation of an update mechanism of coordinate changes (e.g. as established with station log)
- “Quick Monitoring” as an option:
  - Automated comparisons with scientific coordinates derived within EPN based on the 5-weekly / 15-weekly updated accumulated solution (Kenyeres et al., 2009) or last weekly EPN combination (Habrich, 2008)
  - Setup of an EUREF service for the contributing countries in case of larger differences.

Acknowledgements

- Thanks to all already contributing and all future contributing countries / persons !

- Thanks also to A. Kenyeres (“EPN05” solution) and C. Bruyninx and D. Mesmaker for the information on the EPN stations and published coordinates.

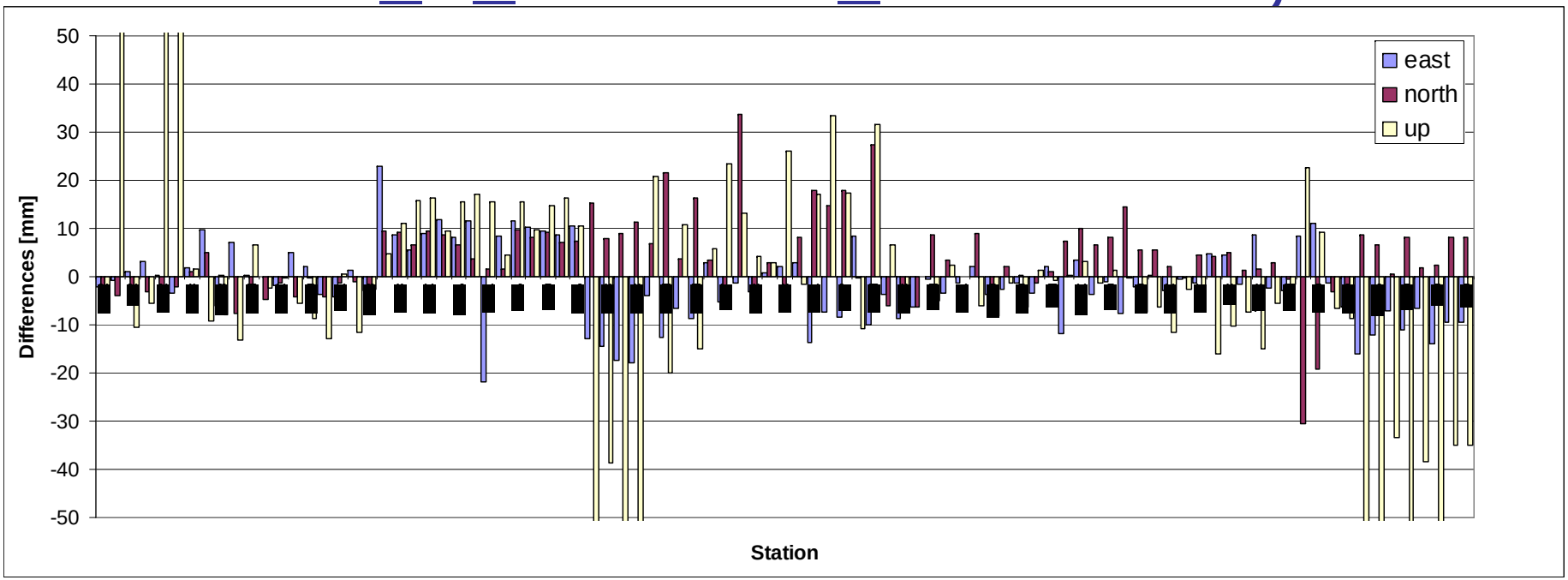
- Thanks in advance to the contributions of the national representatives till September 15.


euref

Options

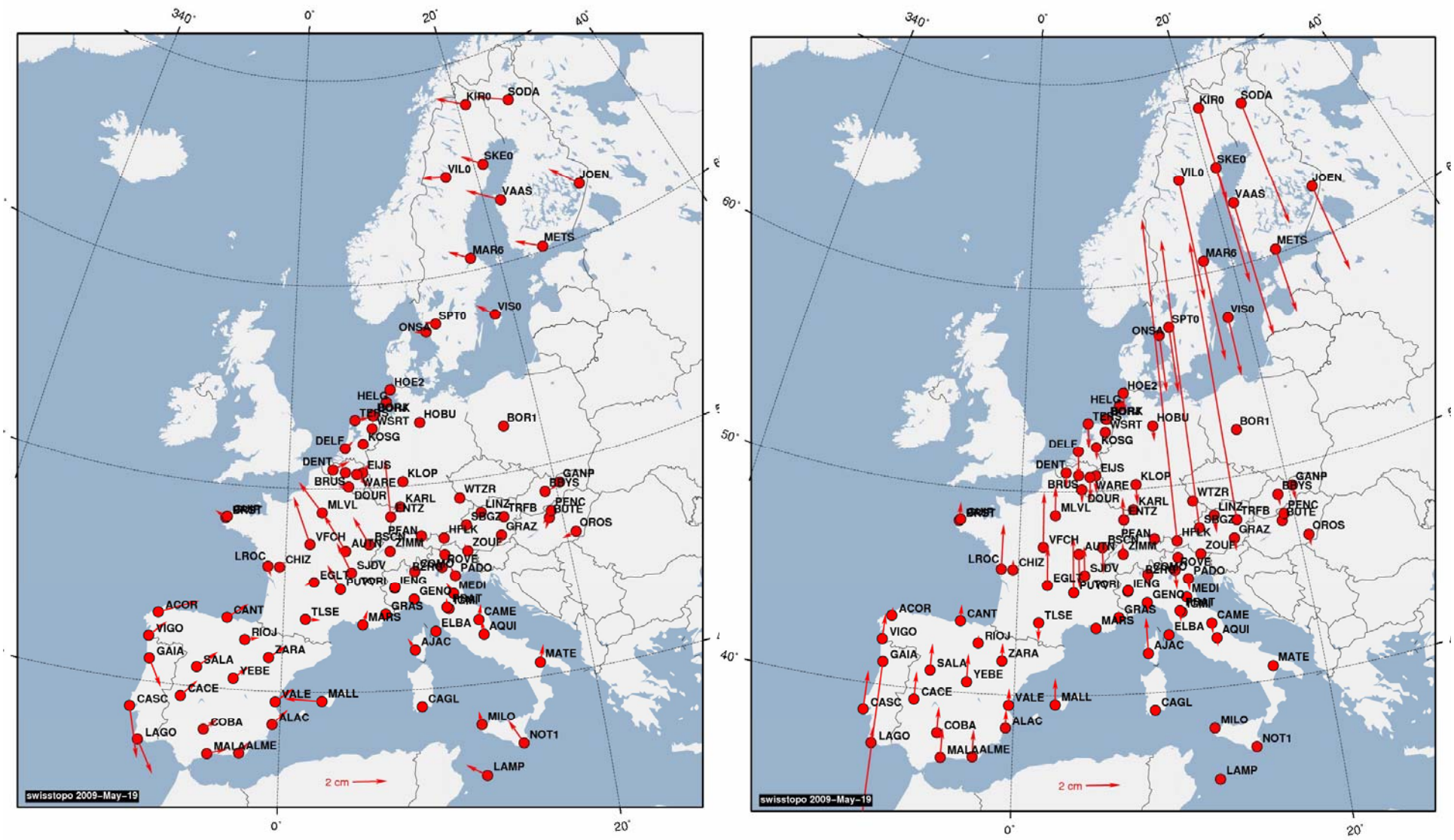
- Format matters
  - Coordinates, reference frame in IGS log file
  - or via an xml-File instead of an formatted ASCII file (xml as data exchange within GIS community)

Comparison with EPN_A_ITRF2000_C1525.SNX; 2005.0

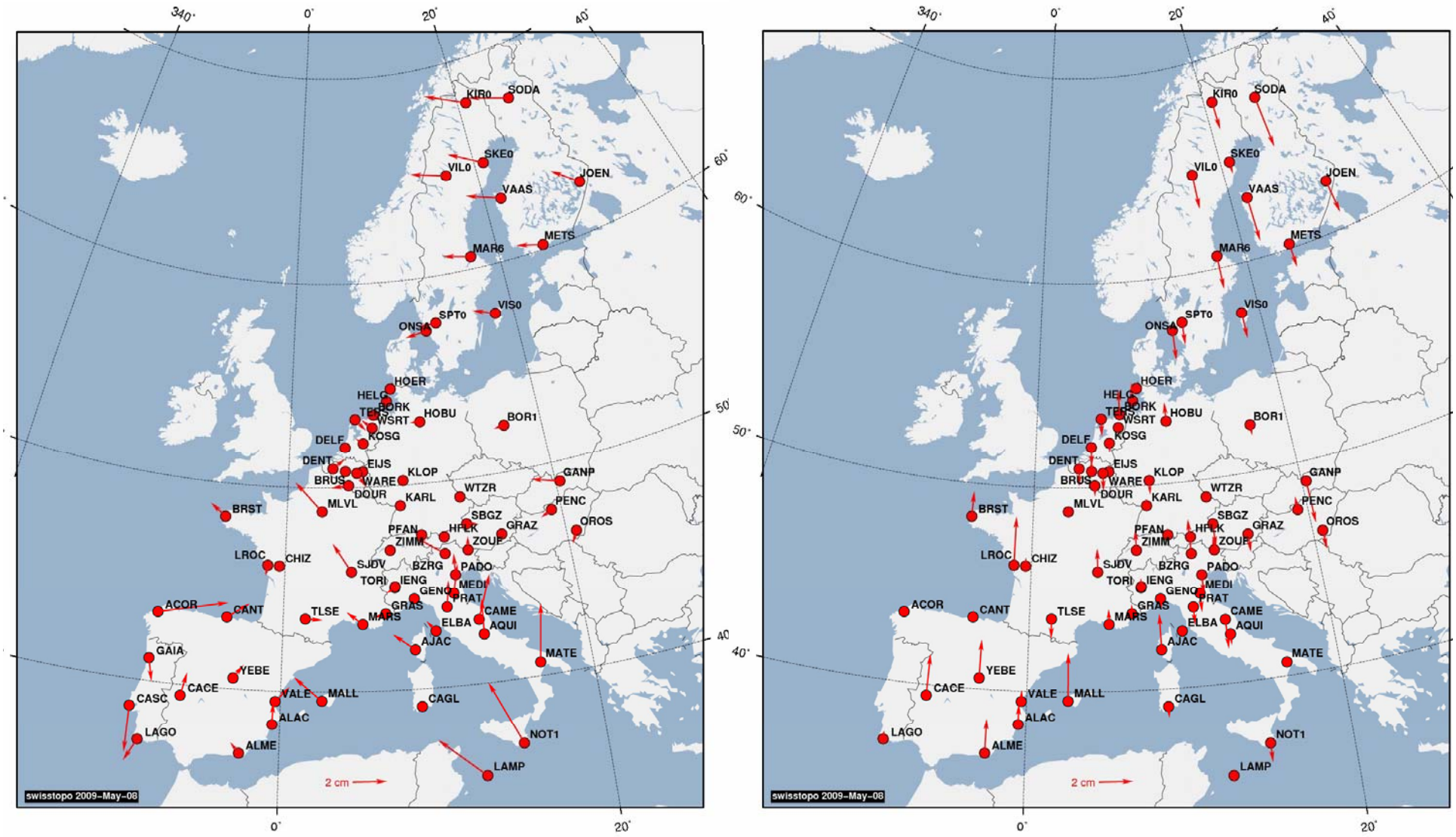


- 93 sites, 1 sites under investigation due to vertical antenna reference point (GAIA)
- Mean bias in mm (E,N,U): -1, 4, 0 mm
- Mean std in mm (E,N,U): 8, 8, 39 mm

Comparison with EPN_A_ITRF2000_C1525.SNX
Differences: horizontally + vertically (Ep. 2005.0)



Comparison with EPN05 densification
Differences: horizontally + vertically Ep. 2000.0



Status of the EPN

39 countries

223 sites

Status: 1.5.2009

Example EPN coordinates ITRF/ETRF

ETRF2000(R05) Trafo parameters

ETRF2000(R05) Trafo parameters

ZIMM

To obtain the site positions at an epoch t different from t_0, apply the site velocities: $X(t) = X(t_0) + (t-t_0)*V_X$; $Y(t) = Y(t_0) + (t-t_0)*V_Y$; $Z(t) = Z(t_0) + (t-t_0)*V_Z$
Periods indicated in red are of reduced quality (e.g. caused by short observation history) and should be used with care.

1. EPN POSITIONS/VELOCITIES

1. A) Positions/velocities published by EUREF (release Dec. 2008)

ETRF2000*	epoch t_0	Position (m)			Velocity (m/y)		
		X_{EPN}	Y_{EPN}	Z_{EPN}	VX_{EPN}	VY_{EPN}	VZ_{EPN}
182/96 - 310/98	2000.0	4331297.342 ± 0.000	567555.634 ± 0.000	4633133.720 ± 0.000	0.0012 ± 0.0001	0.0004 ± 0.0000	0.0020 ± 0.0001
310/98 - 365/05	2000.0	4331297.331 ± 0.000	567555.637 ± 0.000	4633133.708 ± 0.000	0.0012 ± 0.0001	0.0004 ± 0.0000	0.0020 ± 0.0001

*ETRF2000 is the conventional reference frame used to realise the ETRS89

ITRF2005	epoch t_0	Position (m)			Velocity (m/y)		
		X_{EPN}	Y_{EPN}	Z_{EPN}	VX_{EPN}	VY_{EPN}	VZ_{EPN}
182/96 - 310/98	2000.0	4331297.141 ± 0.000	567555.787 ± 0.000	4633133.883 ± 0.000	-0.0126 ± 0.0001	0.0180 ± 0.0000	0.0127 ± 0.0001
310/98 - 365/05	2000.0	4331297.130 ± 0.000	567555.789 ± 0.000	4633133.871 ± 0.000	-0.0126 ± 0.0001	0.0180 ± 0.0000	0.0127 ± 0.0001

1. B) Positions/velocities published by the IERS

Last ETRS89/ITRS realization (release July 2006):

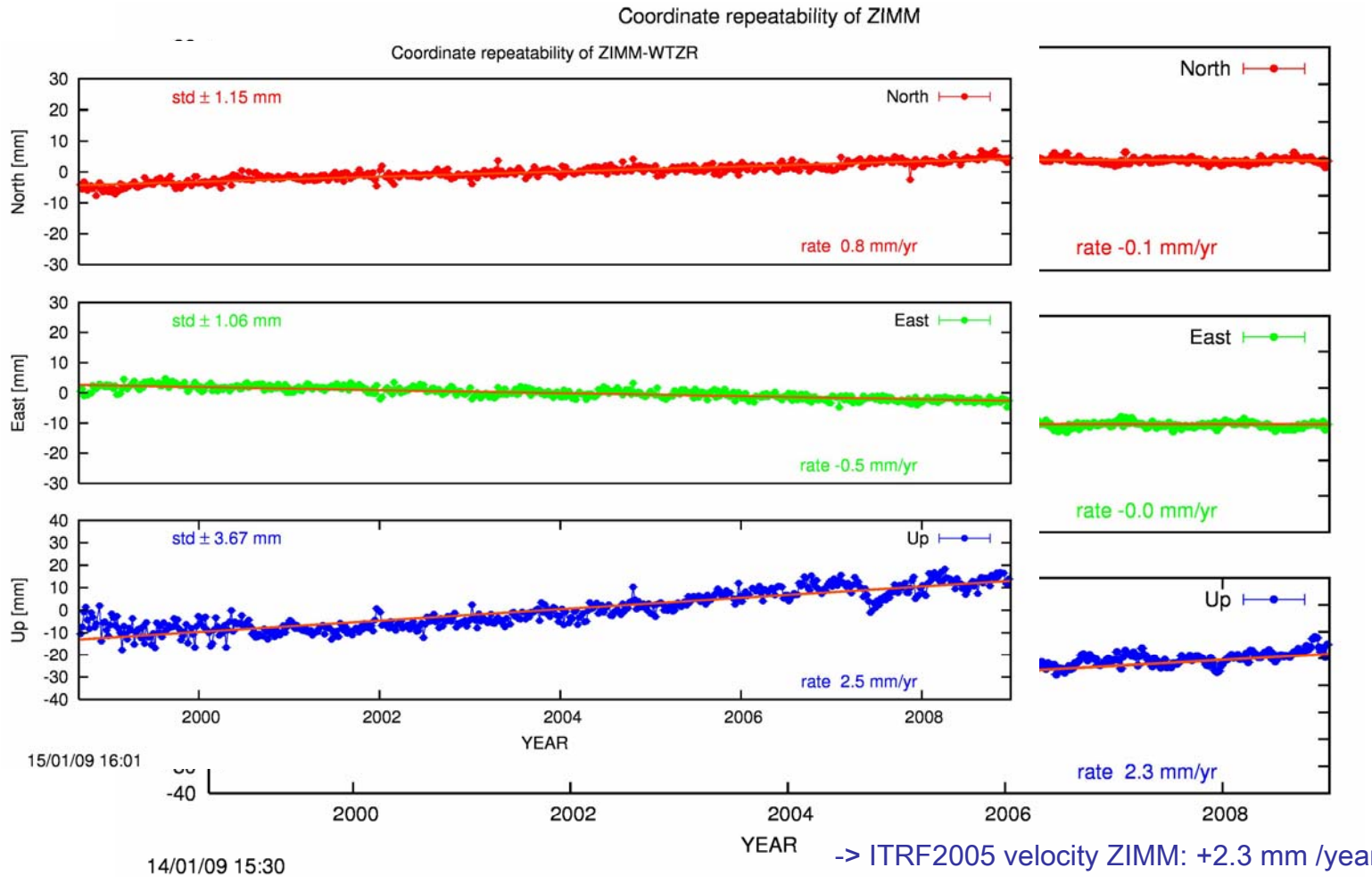
ETRF2000(R05)	epoch t_0	Position (m)			Velocity (m/y)		
		X_{IERS}	Y_{IERS}	Z_{IERS}	VX_{IERS}	VY_{IERS}	VZ_{IERS}
start - 310/98	2000.0	4331297.341 ± 0.001	567555.635 ± 0.000	4633133.719 ± 0.001	0.0000 ± 0.0001	-0.0003 ± 0.0001	0.0004 ± 0.0001
310/98 - 365/05	2000.0	4331297.332 ± 0.001	567555.636 ± 0.000	4633133.709 ± 0.001	0.0000 ± 0.0001	-0.0003 ± 0.0001	0.0004 ± 0.0001

ITRF2005	epoch t_0	Position (m)			Velocity (m/y)		
		X_{IERS}	Y_{IERS}	Z_{IERS}	VX_{IERS}	VY_{IERS}	VZ_{IERS}
start - 310/98	2000.0	4331297.140 ± 0.001	567555.787 ± 0.000	4633133.882 ± 0.001	-0.0126 ± 0.0001	0.0181 ± 0.0001	0.0127 ± 0.0001
310/98 - 365/05	2000.0	4331297.131 ± 0.001	567555.789 ± 0.000	4633133.872 ± 0.001	-0.0126 ± 0.0001	0.0181 ± 0.0001	0.0127 ± 0.0001

-> ITRF2005 EPN05 densification ZIMM: +2.3 mm /year
WTZR: +0.8 mm /year
ZIMM-WTZR: +1.5 mm /year ≠ 2.5 mm/year

Timeseries AGNES

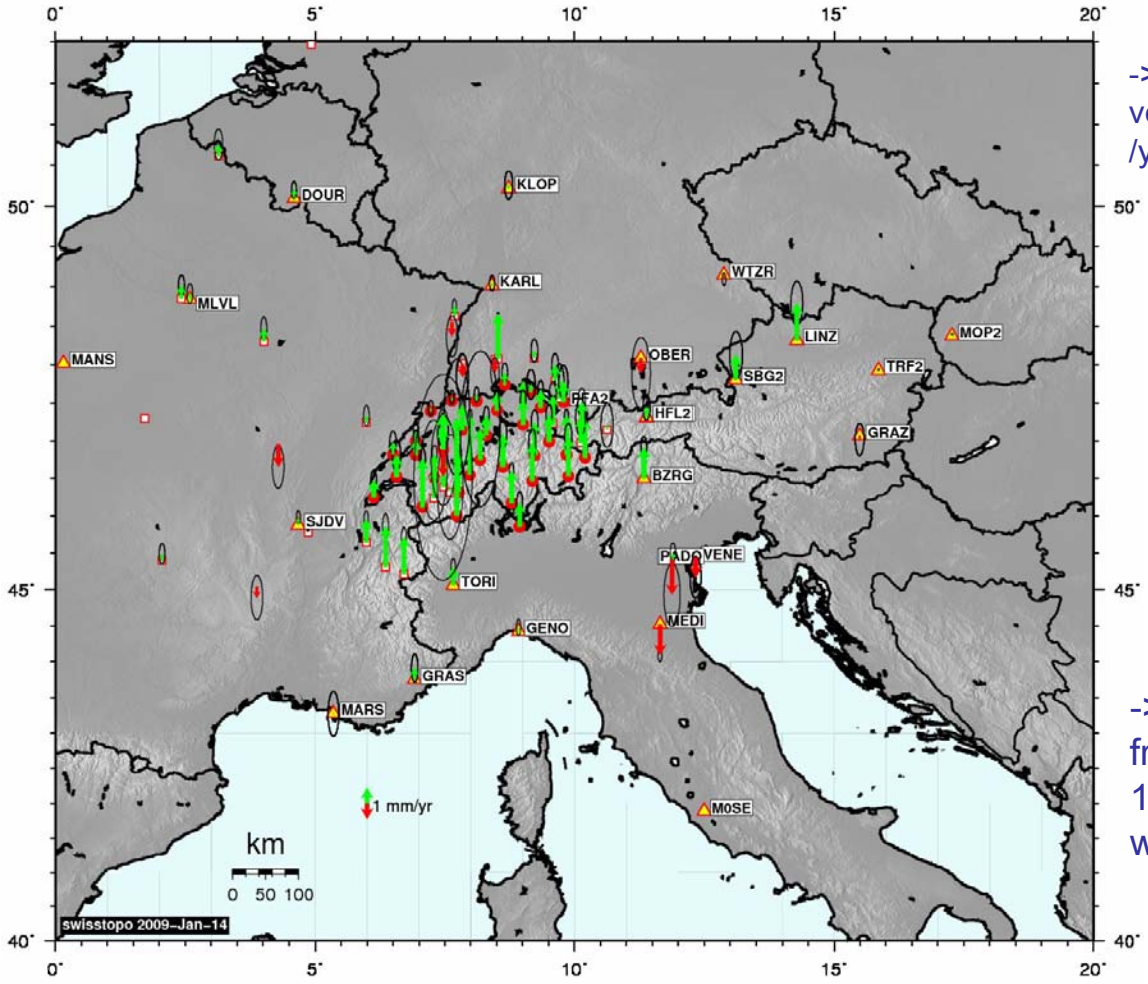
10 years weekly solutions, velocities estimated;
Datum definition: ZIMM (ITRF2005 vertical velocity)



-> ITRF2005 velocity ZIMM: +2.3 mm /year

-> ITRF2005 velocity WTZR: +1.5 mm /year
ZIMM-WTZR: 0.8 mm / year ≠ 2.5 mm/year

Velocities AGNES: vertical relative to ITRF2005 ZIMM



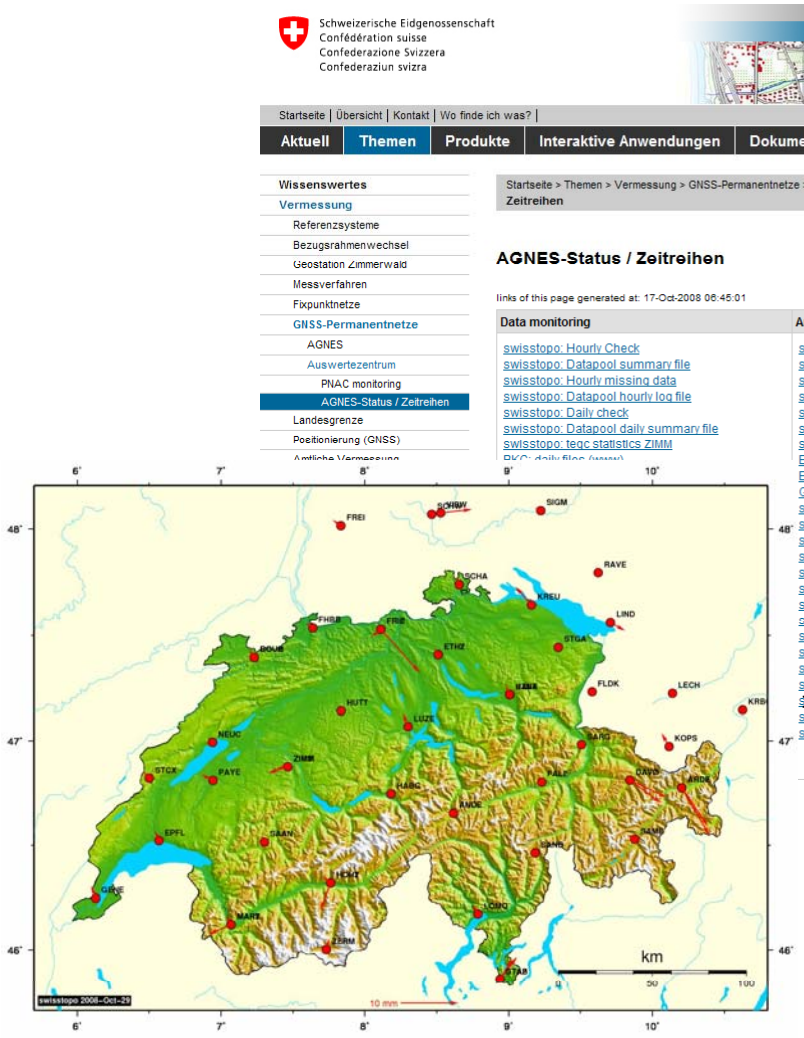
-> reasonable ITRF2005 velocities ZIMM: +2.3 mm /year

-> comparison with results from levelling basing on 100 years of observations will be done

Relative velocity-"constraints": 0.001 mm/year

Example swisstopo

Difference between
“official” and
scientific coordinates



NUM	NAME	FLG	RESIDUALS IN MILLIMETERS		
1	ANDE	E T	0.6	-1.3	1.6
1	ARD2	E T	-8.6	4.9	-10.0
1	ARDE	E T	-6.9	4.7	-6.4
1	BOU2	E T	1.2	-1.0	-0.4
1	BOUR	E T	-0.3	-1.1	-0.2
1	DAV2	E T	-4.2	5.6	-5.6
1	DAVO	E T	-3.2	6.5	-4.5
1	EPFL	E T	1.3	-0.2	0.5
1	ETH2	E T	1.2	-0.3	0.1
1	ETHZ	E T	-0.6	0.1	-0.5
1	FALE	E T	-0.2	-0.8	0.3
1	FHBB	E T	0.9	-1.3	-0.2
1	FLDK	E T	0.2	-0.3	-2.0
1	FREI	E T	0.8	-1.3	0.2
1	FRI2	E T	-4.7	6.7	19.4
1	FRIC	E T	-1.5	-1.4	-0.3
1	GENE	E T	1.7	-1.0	-2.2
1	HABG	E T	1.4	0.3	-2.3
1	HOH2	E T	1.0	-1.0	1.1
1	HOHT	E T	-4.6	-1.6	-6.4

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swisstopo: MULTI helmert to official crd