Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office of Topography swisstopo

wissen wohin
savoir où
sapere dove
knowing where

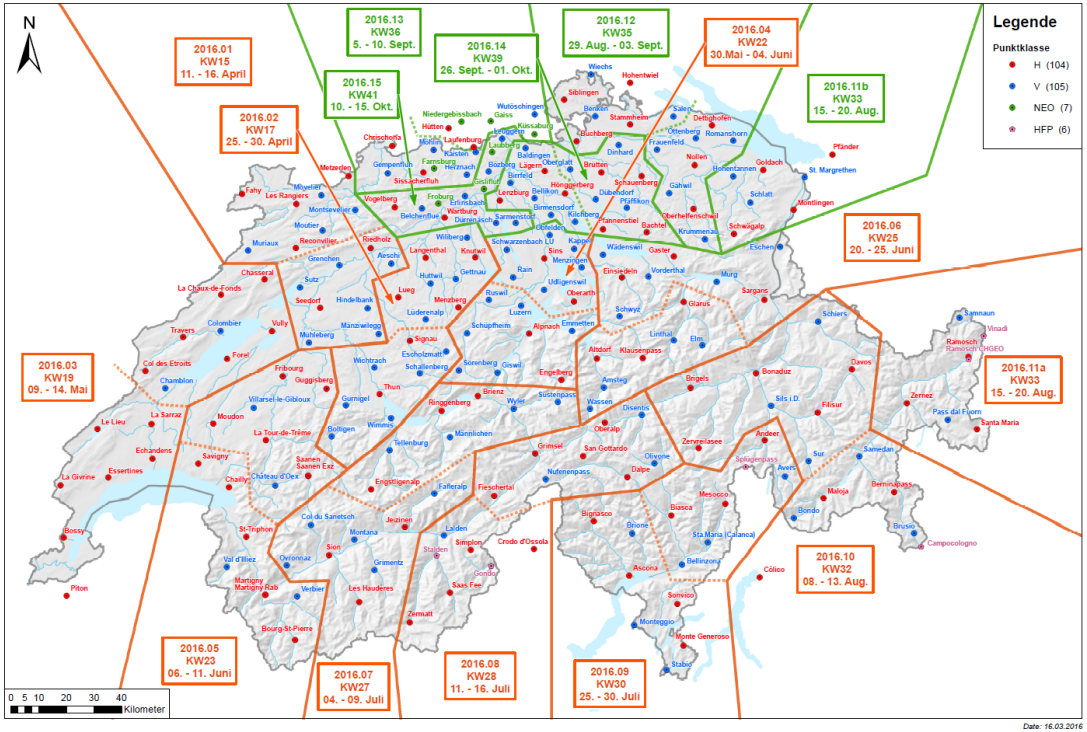
swisstopo

Maintaining the Swiss Terrestrial Reference Frame CHTRF using Multi-GNSS

E. Brockmann, D. Ineichen, S. Lutz, S. Schaer

CHTRF2016: Multi-GNSS field campaign

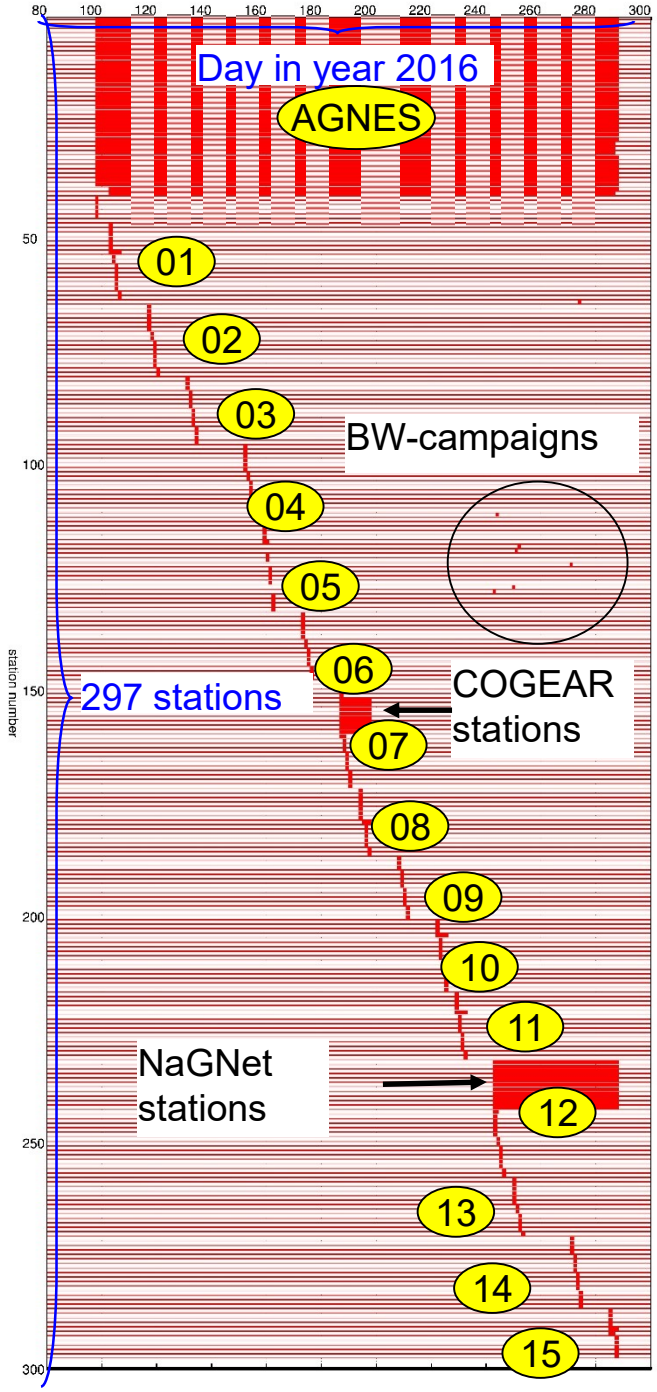
- All ~200 reference points measured in summer 2016 (1988-1995 establ., 1998, 2004, 2010 remeasured every 6 years)
- Multi-GNSS knowledge extension (permanent analysis later because campaigns are less time-critical)



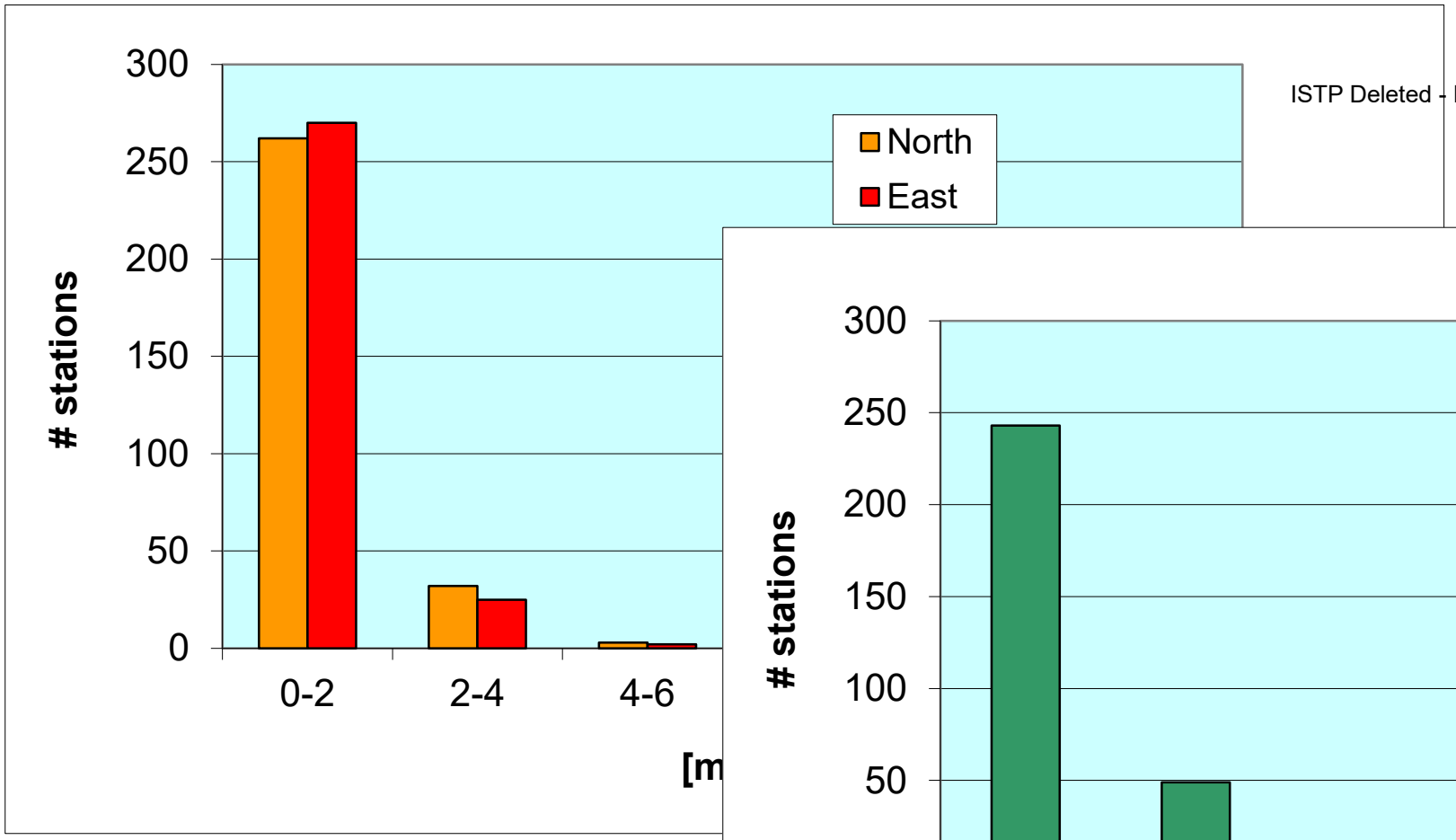
Campaign 2016

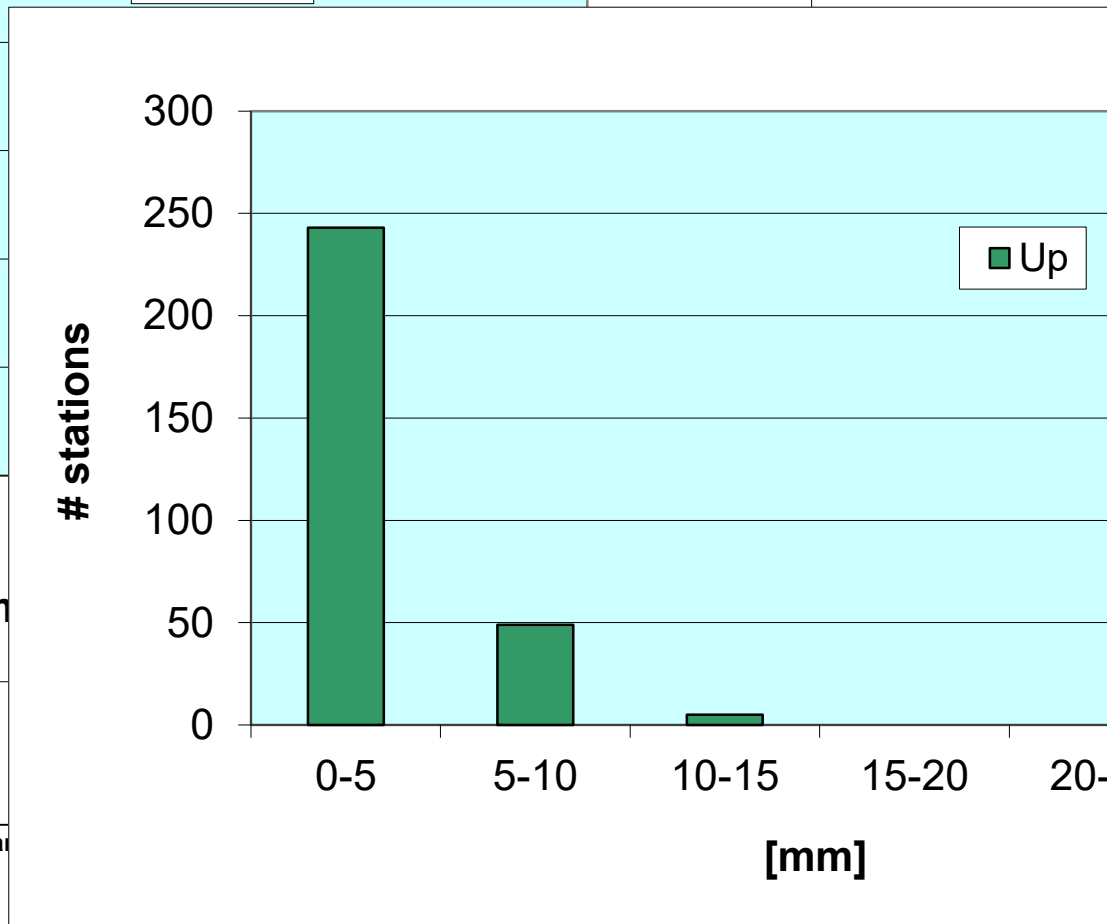
- 10 observers
- 15 weeks (Mo – Sa)
- 297 points (incl. AGNES)
- ~ 44.6 h observations / point
- 5 campaigns from Baden-Württemberg integrated (6 h measurements, separated in time)

- Analysis using BSW5.3 (development version)
- Analysis delay 1-2 months – CODE Multi-GNSS orbits not operational in 2016

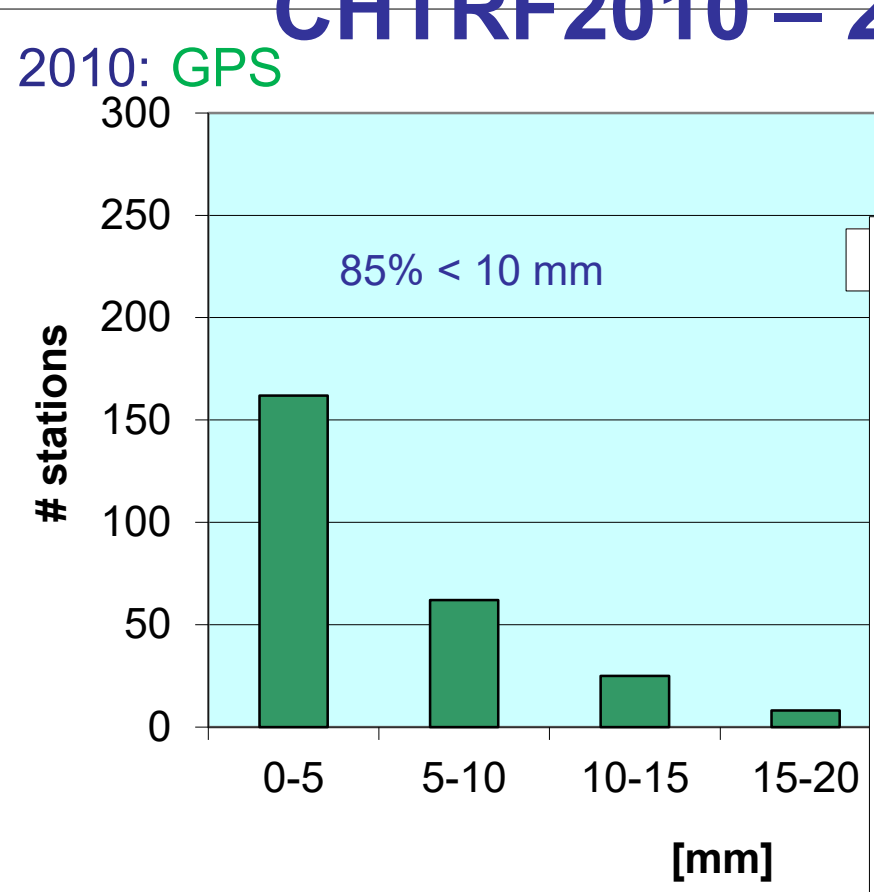


Repeatability horizontally / vertically

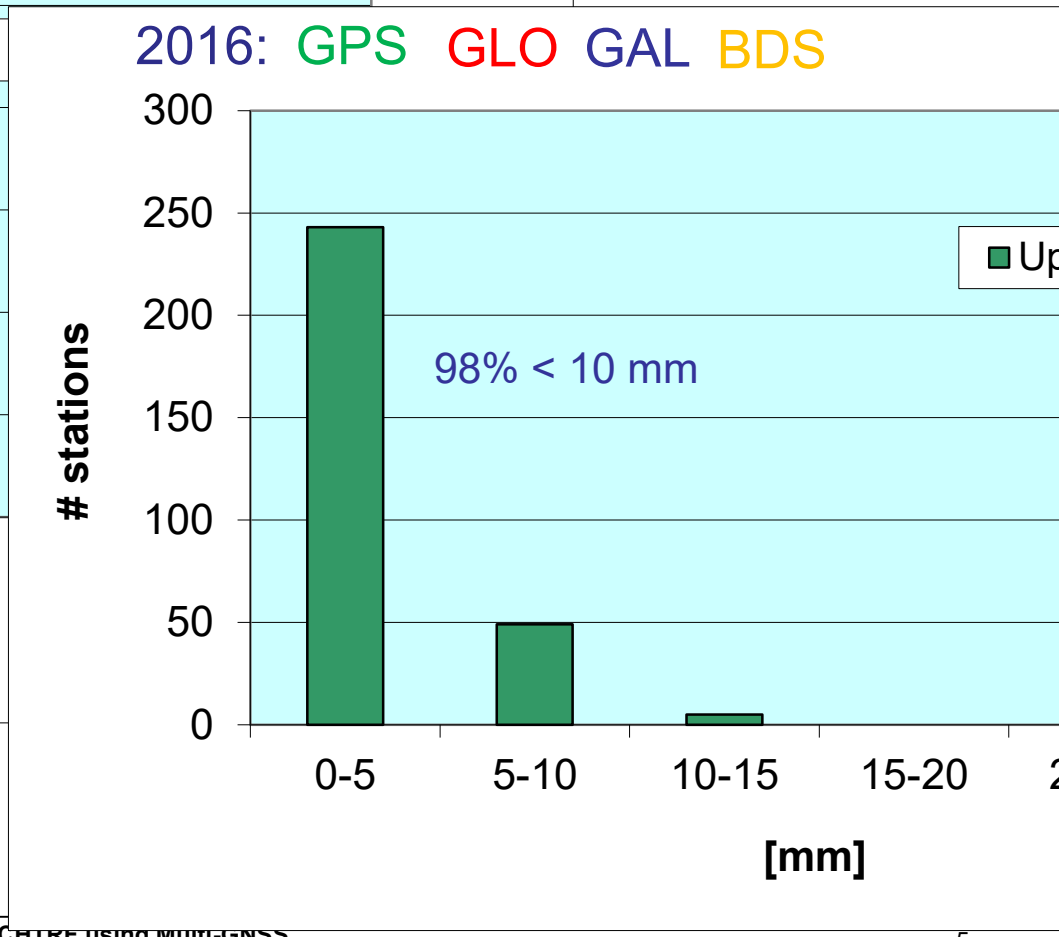




Height repeatability: comparison CHTRF2010 – 2016



ISTP Deleted - MIX



Improvement due to GPS -> Multi-GNSS?

ISTPs: „Inter system translation parameter“

- one MIX coordinate (+TRP): N,E,U,T

4

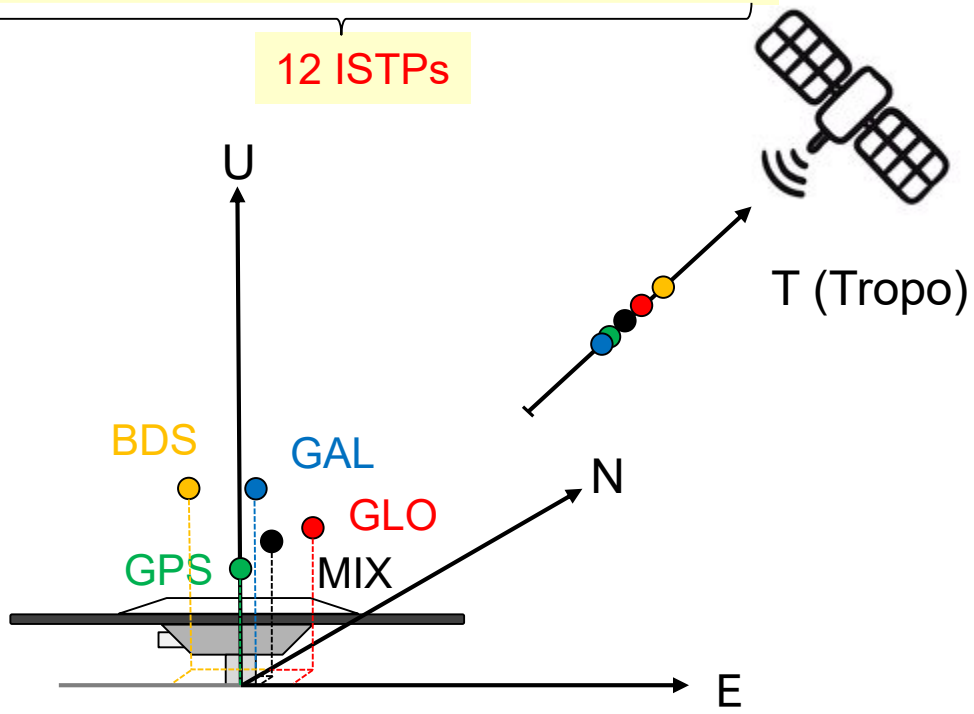
or

- per satellite system one coordinate (+TRP):
  N,E,U,T | N,E,U,T | N,E,U,T | N,E,U,T

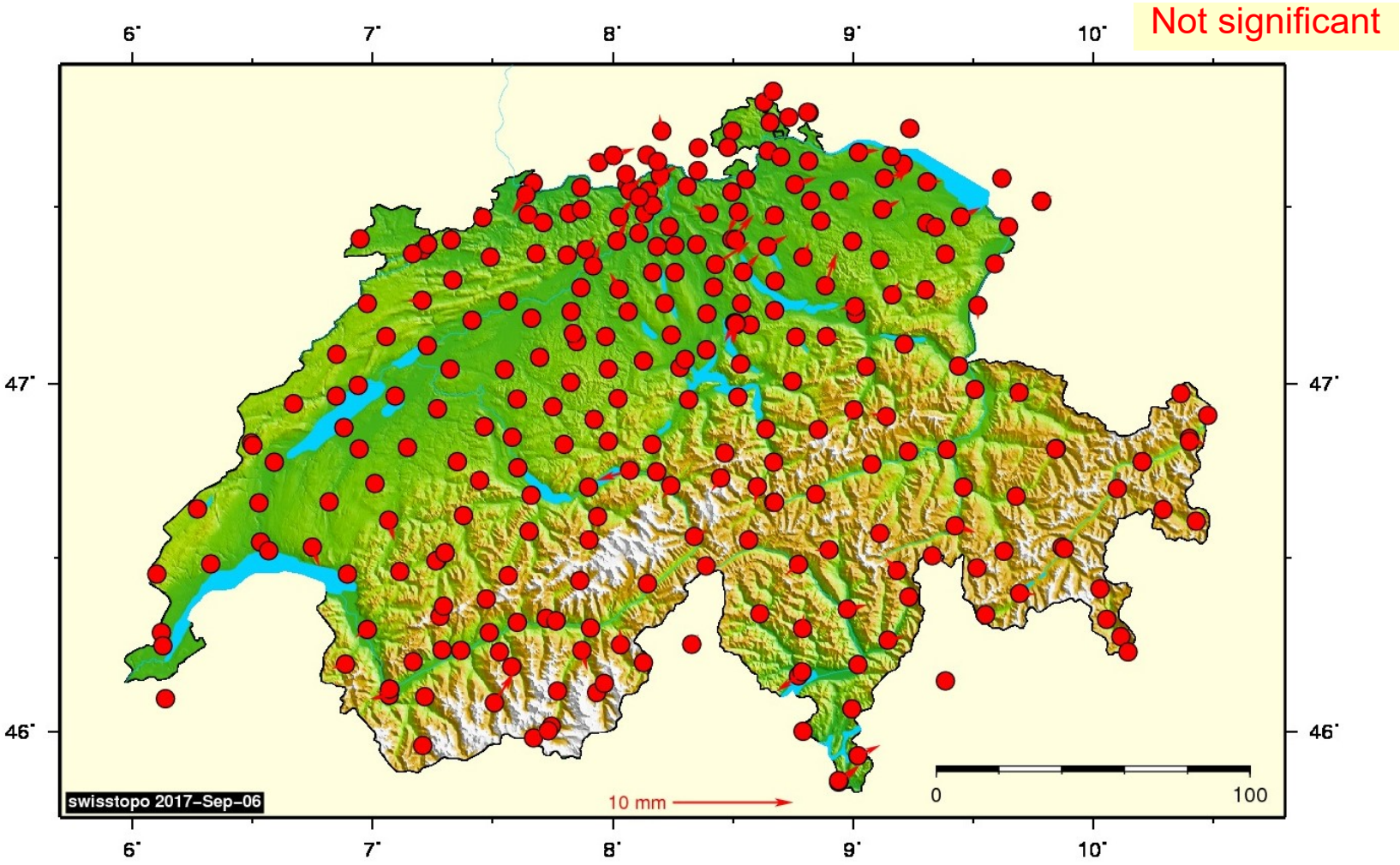
4x4

Reference | dN,dE,dU,dT | dN,dE,dU,dT | dN,dE,dU,dT

12 ISTPs

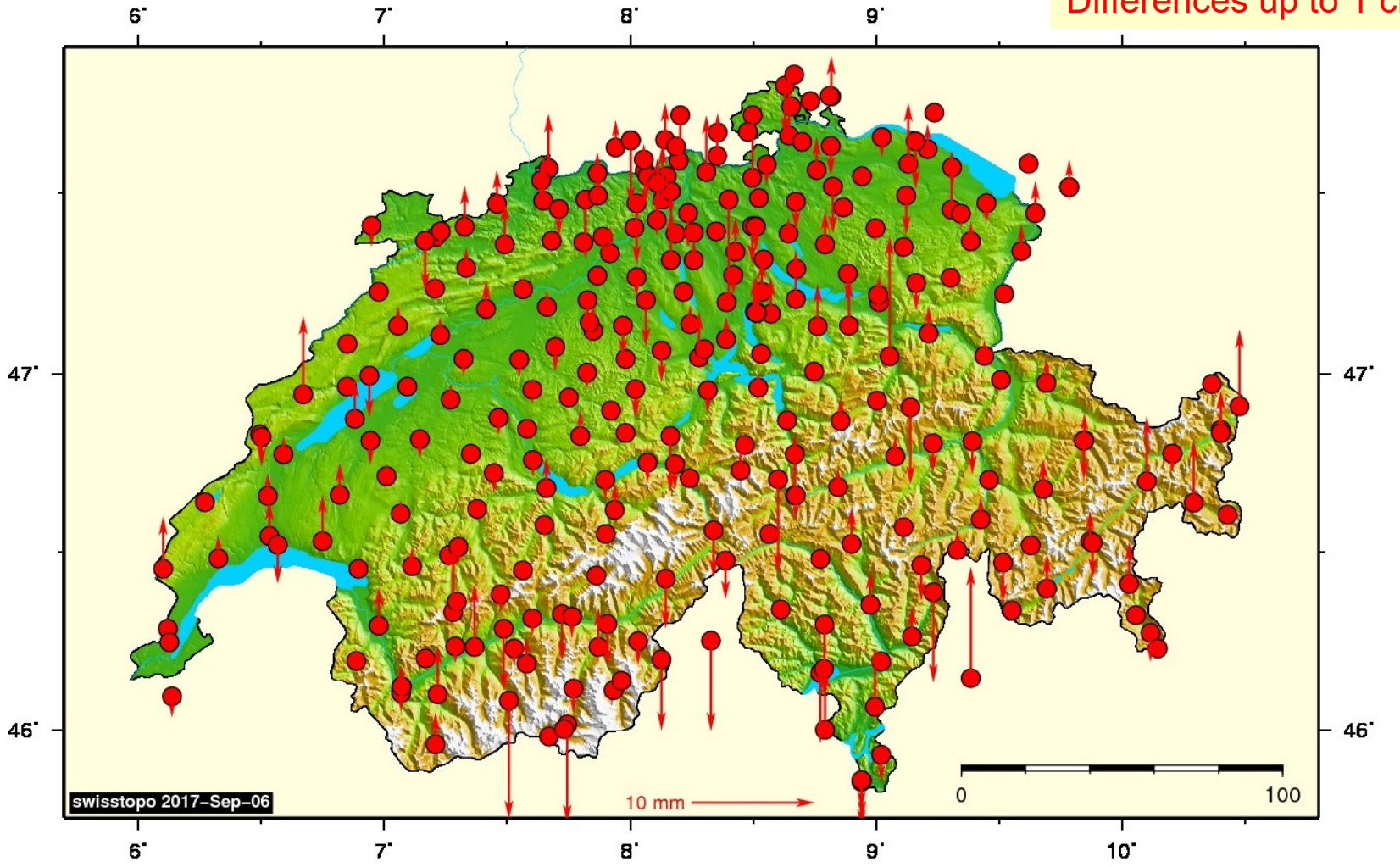


CHTRF16 hor. difference: MIX-GPS



CHTRF16 vertical difference: MIX-GPS

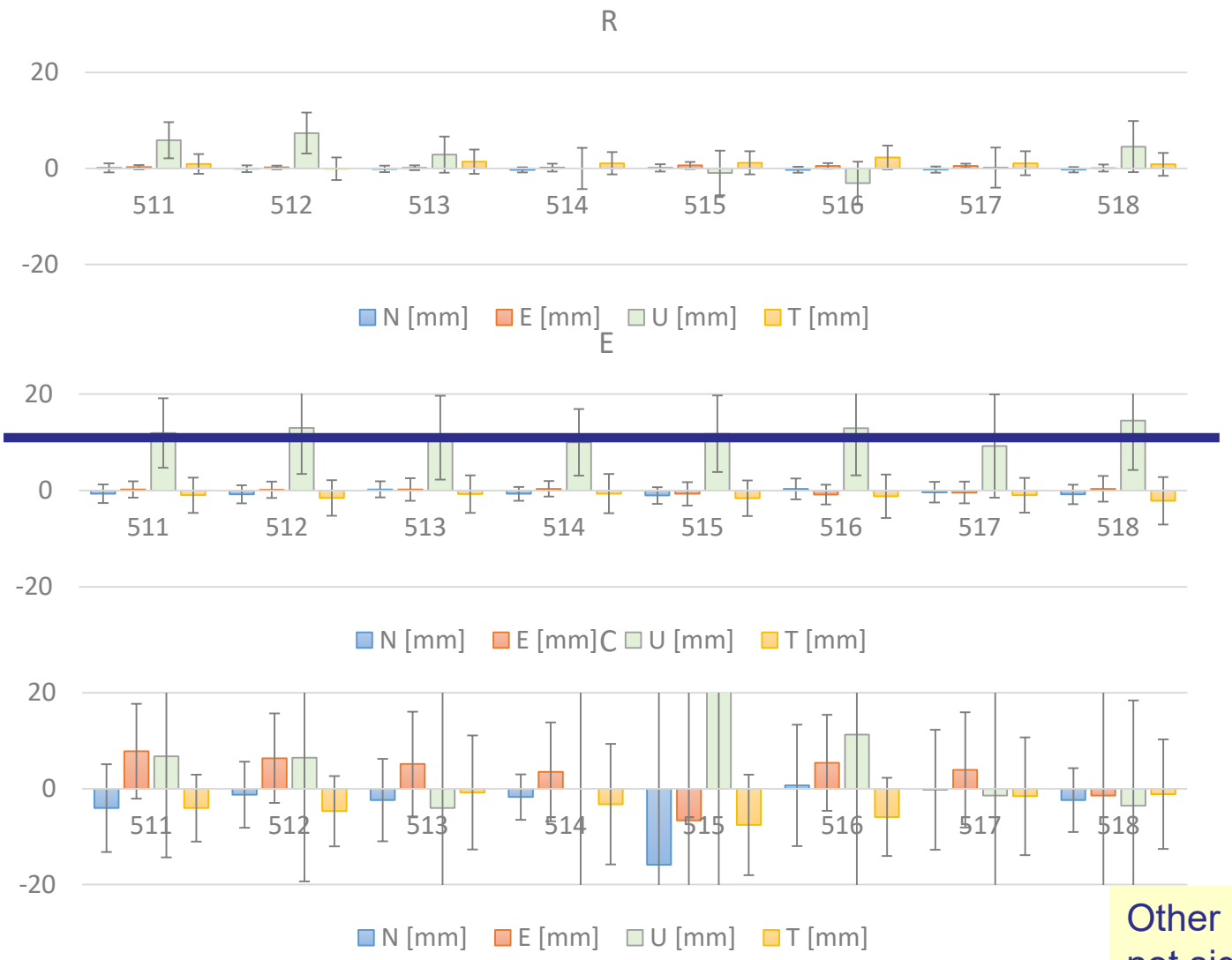
Differences up to 1 cm



ca. 30 observations / antenna

ISTPs field equipment

GPS (Ref)



GLO

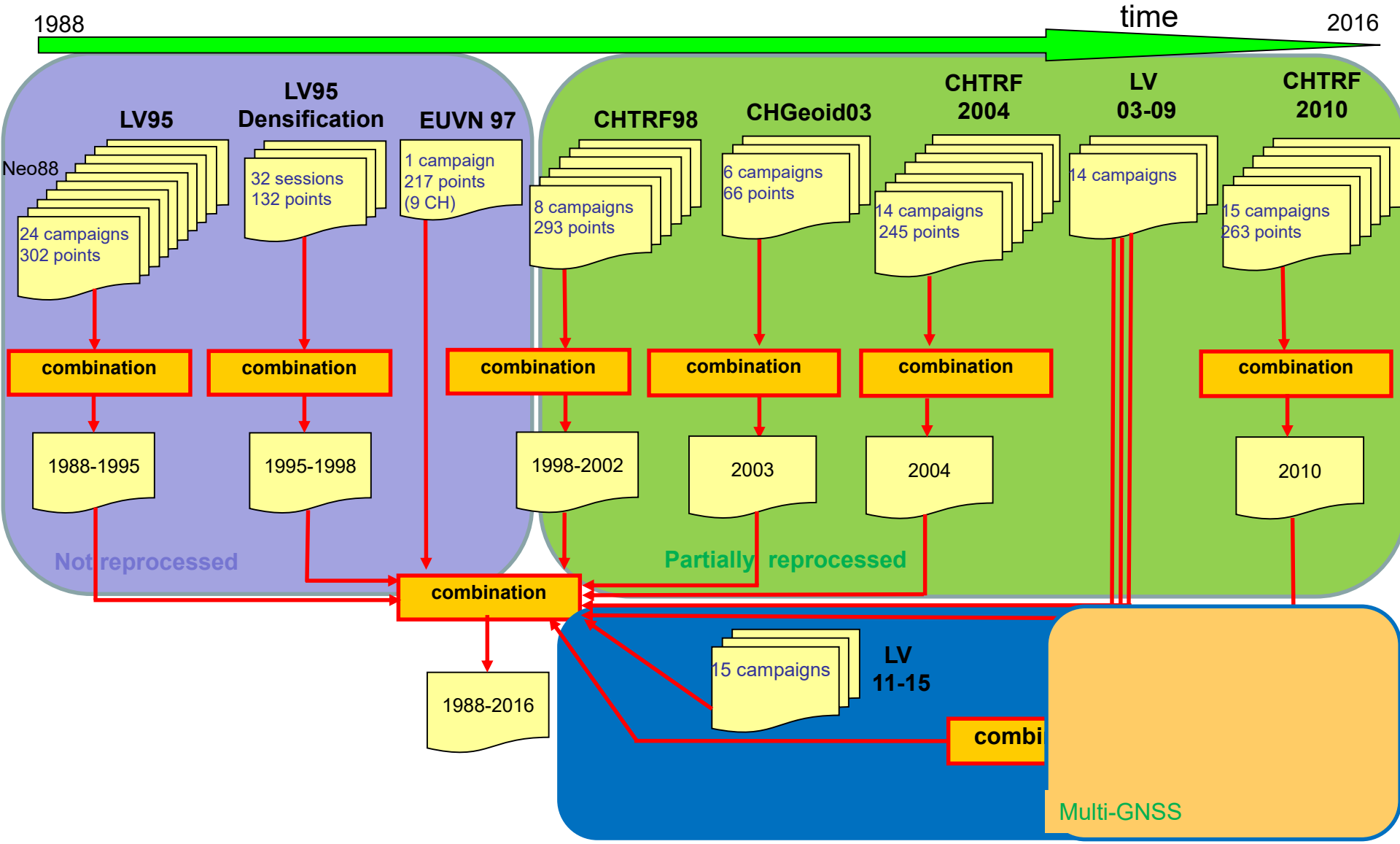
GAL

BDS

Up GAL:
12 ± 2 mm
significant

Other ISTPs
not significant

CHTRF: combination scheme



Combination types

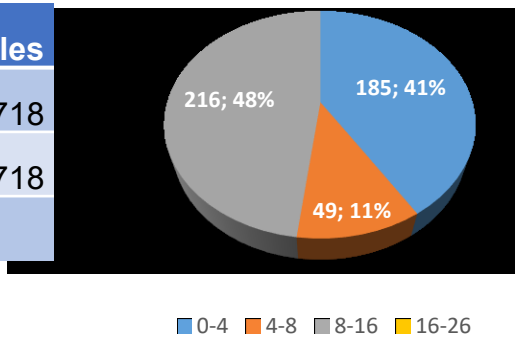
Solution type	remark
REP_CAMP REP_CAMP_C REP_CAMP_C Velocities	All campaigns starting **1998** (reprocessed; major campaigns sub-combined)
ALL_DAY ALL_DAY_C ALL_DAY_C Velocities	All campaigns starting **1988** (1988 – 1997 **sub-combination w/o reprocessing**) and all other based on session solutions

Repeatabilities

Length of time series

REP_CAMP

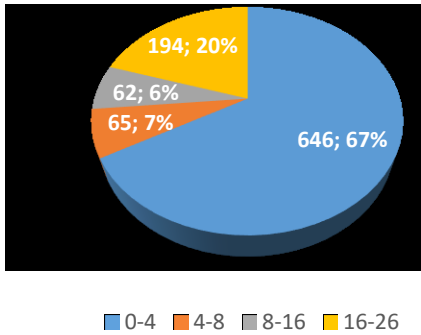
comment	#CRD / #VEL ([%])	sN [mm]	sE [mm]	sU [mm]	# Session Files
CRD	450 / 0 (0%)	2.1	1.8	6.7	1718
CRD+VEL	450 / 223 (50%)	1.4	1.1	6.7	1718
improvement [%]		31.7	36.7	0.4	



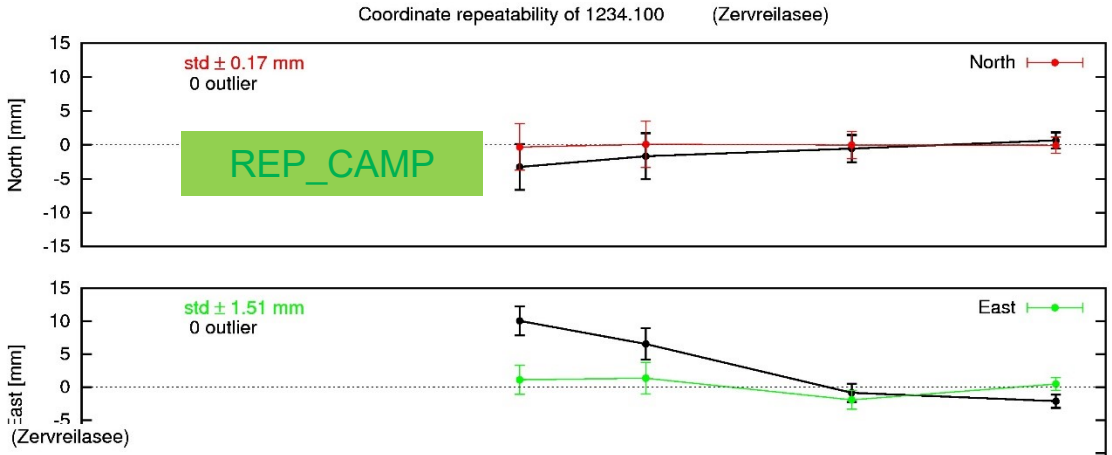
Only horizontal velocities
(too many antenna changes and too weak heights)

ALL_DAY

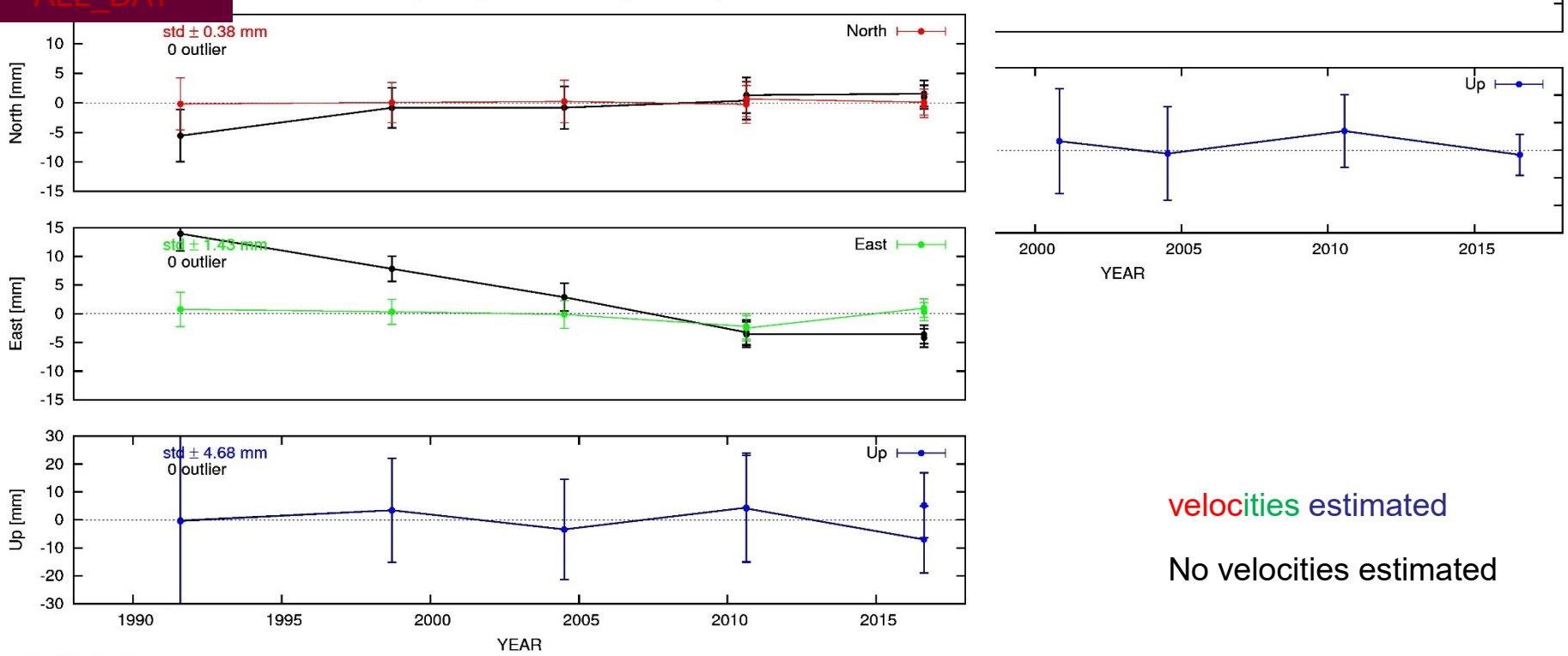
comment	#CRD / #VEL ([%])	sN [mm]	sE [mm]	sU [mm]	# Session Files
CRD	967 / 0 (0%)	2.2	1.6	5.4	16538
CRD+VEL	967 / 310 (33%)	1.7	1.4	5.3	16538
improvement [%]		23.1	14.1	0.7	



Example Zervreilasee



ALL_DAY

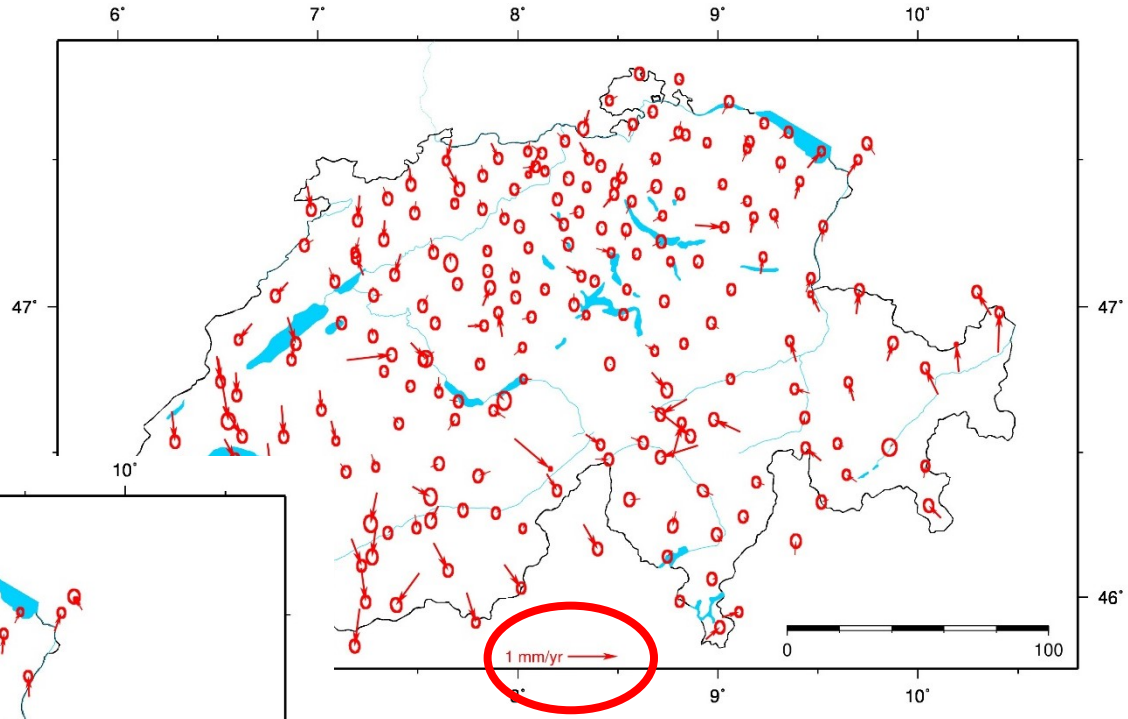


velocities estimated

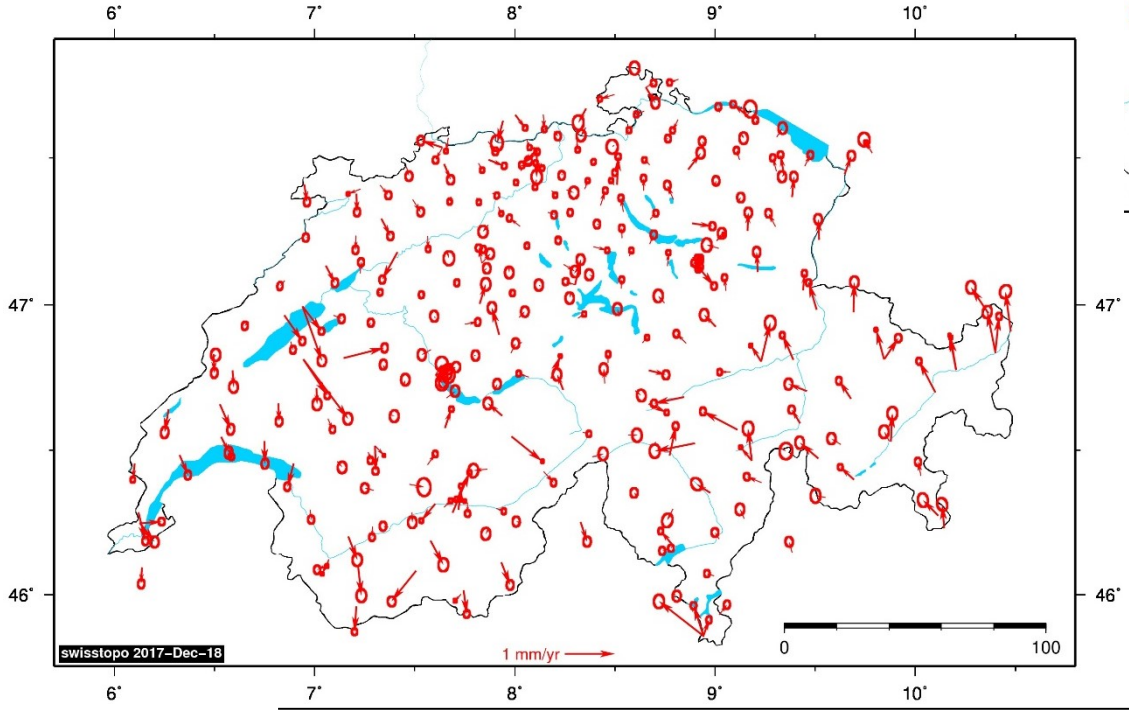
No velocities estimated

Velocity Fields

REP_CAMP 205 sites

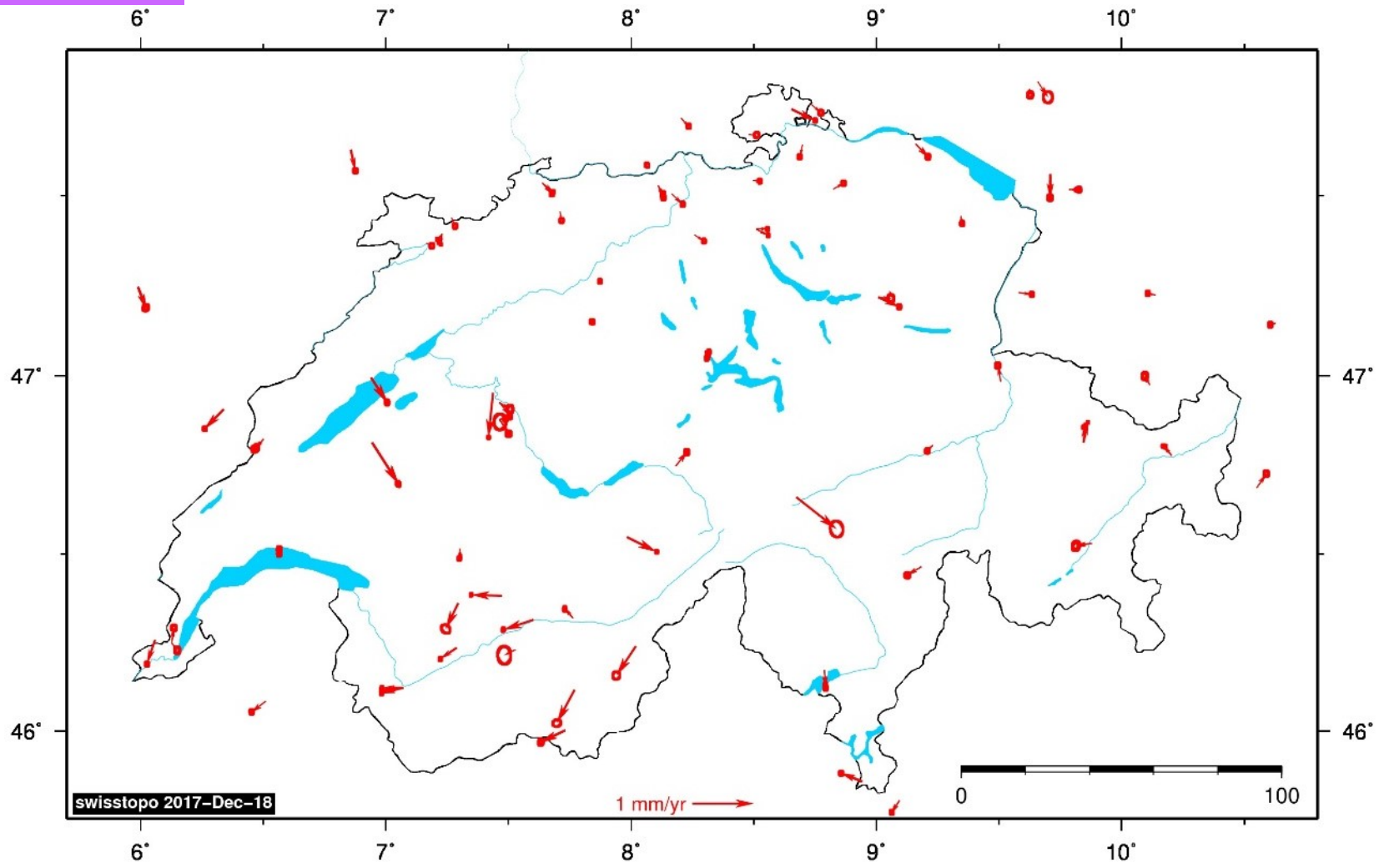


ALL_DAY
285 sites



Velocity field: Permanent Network

AGNES



Statistics of velocity fields

Solution type	# velocities (after QC)	Standard deviation [mm/year] from zero field		Mean formal rms [mm/year] *15	
		North	East	North	East
CHTRF2004	176	0.35	0.33	-	-
CHTRF2010	233	0.27	0.23	0.122	0.168
REP_CAMP	205	0.30	0.20	0.083	0.114
ALL_DAY	285	0.31	0.20	0.067	0.089
AGNES	57	0.20	0.22	0.040	0.051
2016: Diff. REP_CAMP-ALL_DAY	202	0.11	0.10	-	-

Summary

- Multi-GNSS (GPS+GLO+GAL+BDS) measurements used for reference frame maintenance (permanent network and campaign data)
- Quality control CHTRF2016 fine (repeat. better for height)
- Long-term combination successful, but a preliminary velocity field, yet
  - based on partial reprocessing campaigns back till 1998
  - Similar field as derived 2010 (small horizontal velocities: 0.2-0.3 mm/yr standard deviation w.r.t zero field)
  - Velocity field already used within EUREF WG “EU Dense Velocities” → presentation S. Lutz