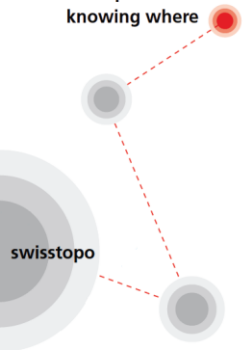




wissen wohin
savoir où
sapere dove
knowing where



Activities Permanent Networks and Reference Frames in Switzerland and Europe

E. Brockmann, D. Ineichen, S. Lutz



Programm

«Herbstanlass 2019»

23.10.2019 | 12 – 18
Geostation Zimmerwald [[web](#) | [loc](#)]

11.30 – 12.45	Mittagessen (fakultativ) im Restaurant National Bern [web loc]
13.30	Treffpunkt in Zimmerwald
13.45 – 14.45	Vorträge und Einblicke in die Forschungsgebiete • Geodäsie in der Schweiz • AGNES • Zukünftiges dynamisches CH-Referenzsystem • Swisstopo & Virtual Reality (VR) • Innovationsthemen swisstopo
14.45 – 15.30	Kaffeepause , Austausch und Networking
15.30 – 17.00	Geführter Rundgang in der Forschungsstation Zimmerwald • CH-geodätischer Fundamentalpunkt • Raumschrottbeobachtung • Satellite Ranging Teleskop
17.00 – 17.30	Ende der Veranstaltung



Breaking ground in
winter 1955, middle:
Prof. Dr. Max Schürer



Observatory with scaffolding, Spring 1956 - pure Astronomy («Sternwarte»)





Statistics

Number of pictures collected in Zimmerwald
with the Schmidt camera: **10 376**

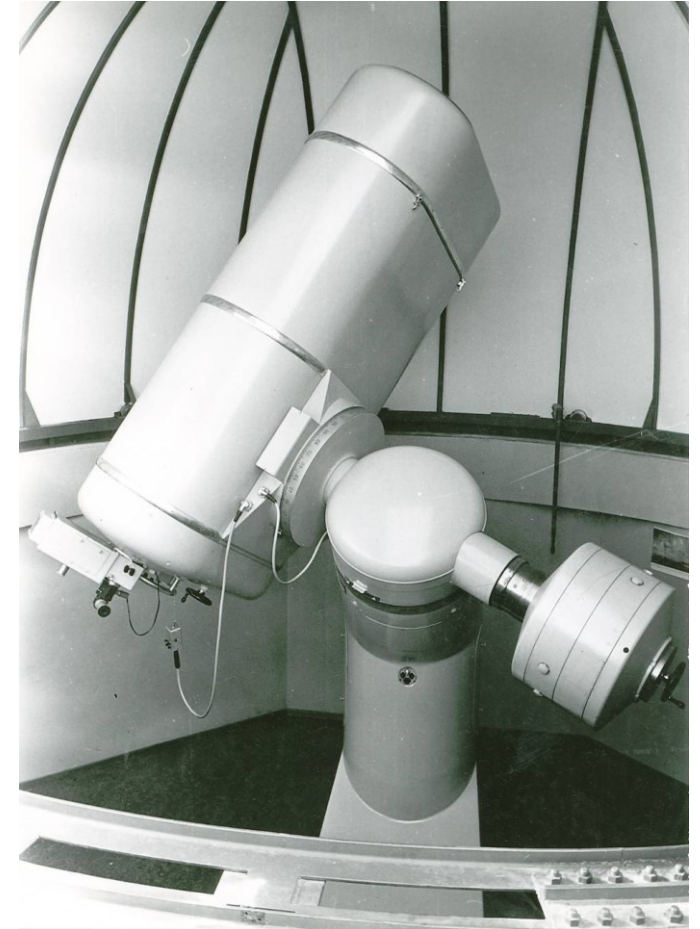
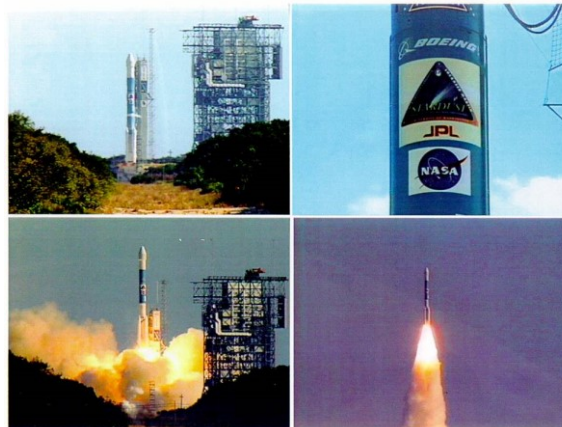
Number of newly-discovered objects:

ca. 50 supernovae und novae (exploding stars)

ca. 100 minor planets (asteroids, planetoids)

7 comets

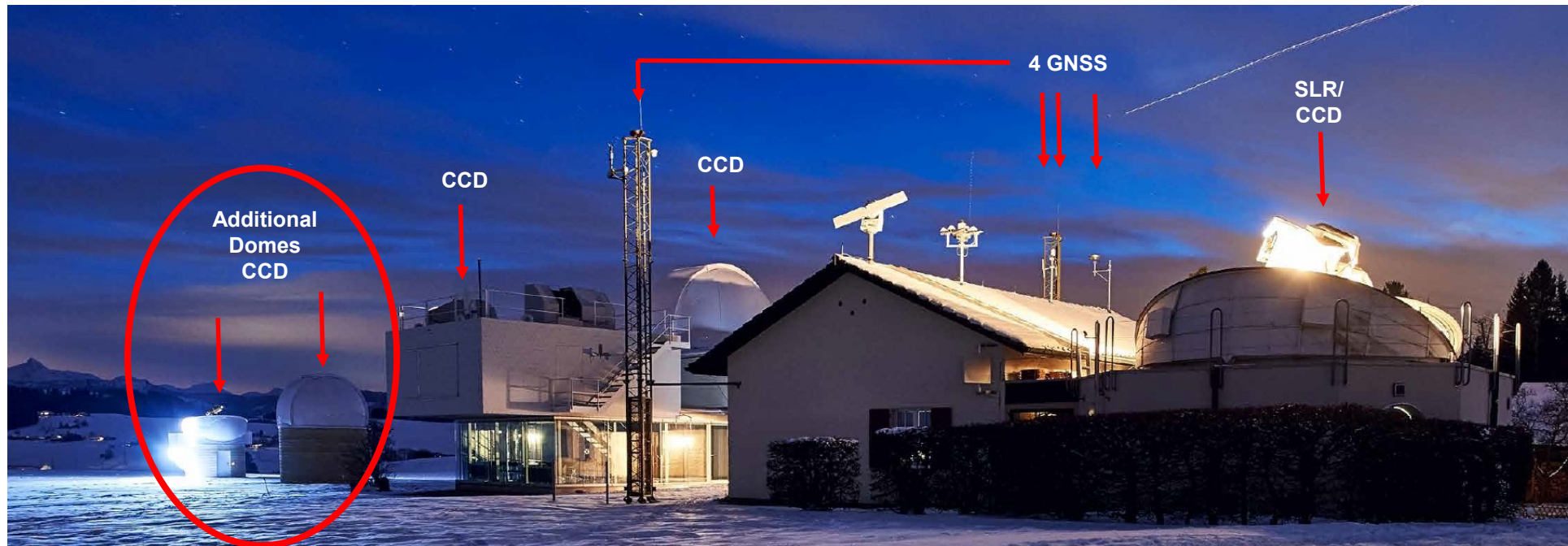
The comet „Wild/2“, discovered from Prof.
Dr. Paul Wild was „visited“ in NASAs
successfull Stardust-Mission (January 2,
2004 in 240 km distance)





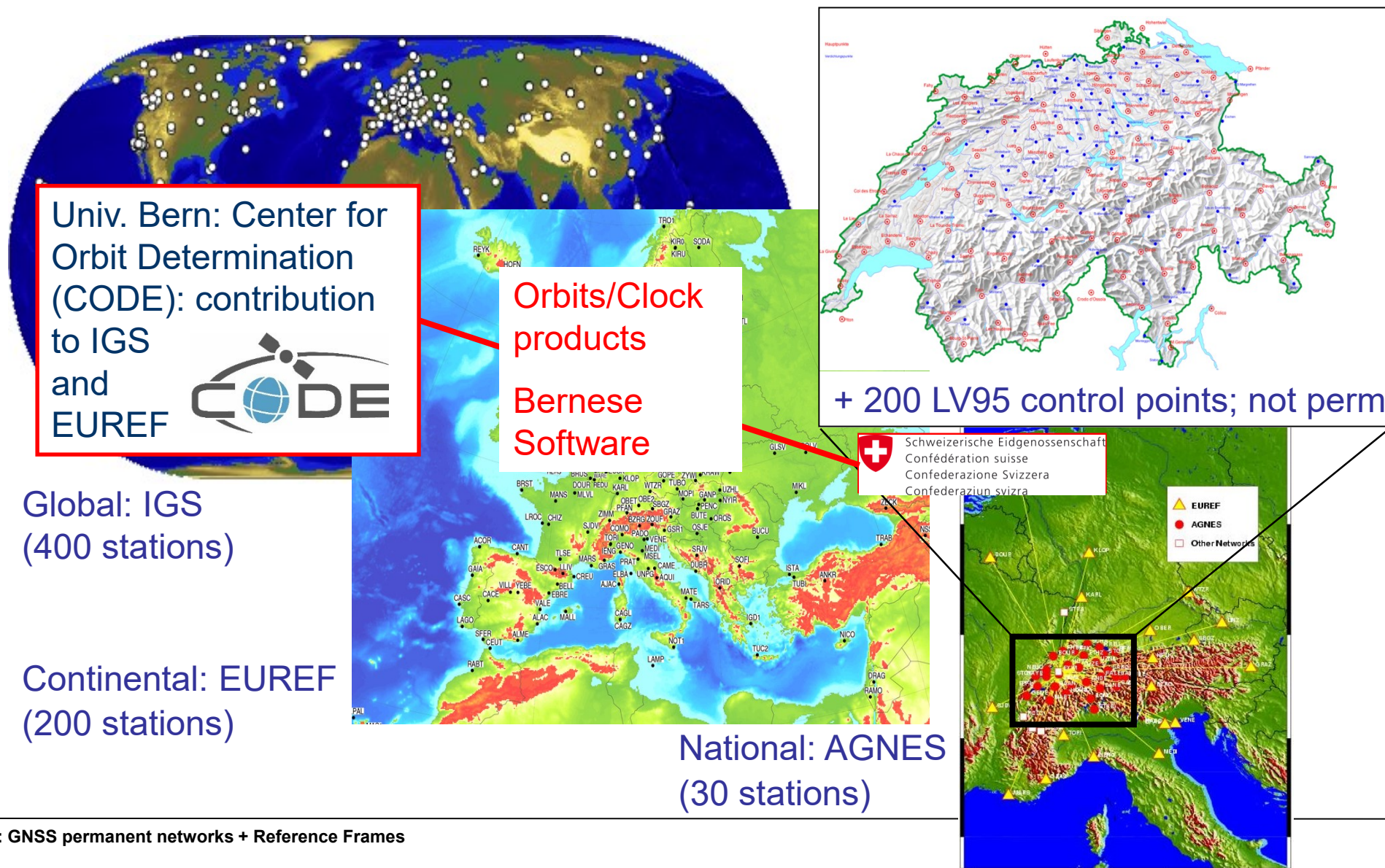
Geostation Zimmerwald

- 4 GNSS stations (ZIMM, ZIM2, ZIM3, ZIM4) actively delivering data to IGS/EPN
- SLR: Satellite Laser Ranging
- 2 additional CCD telescopes for space debris (since 2018)
- **Reference for all geodata in Switzerland and linking station to international networks**





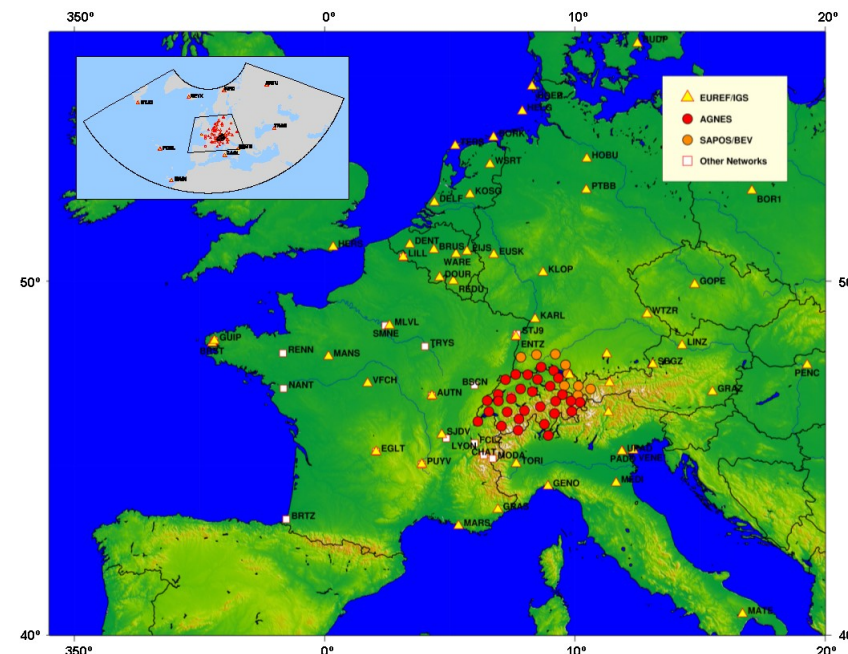
Hierarchical Permanent Networks





Analyses using Bernese GNSS Software at swisstopo

network (#stations)	availability	comments
EUREF sub-network (>60)	100 % daily	reference frame Europe 
AGNES + sub-network EUREF (>200)	100 % daily	reference frame Switzerland  Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
AGNES + sub-network EUREF (>200)	98 % hourly	monitoring + numerical weather prediction  Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra 



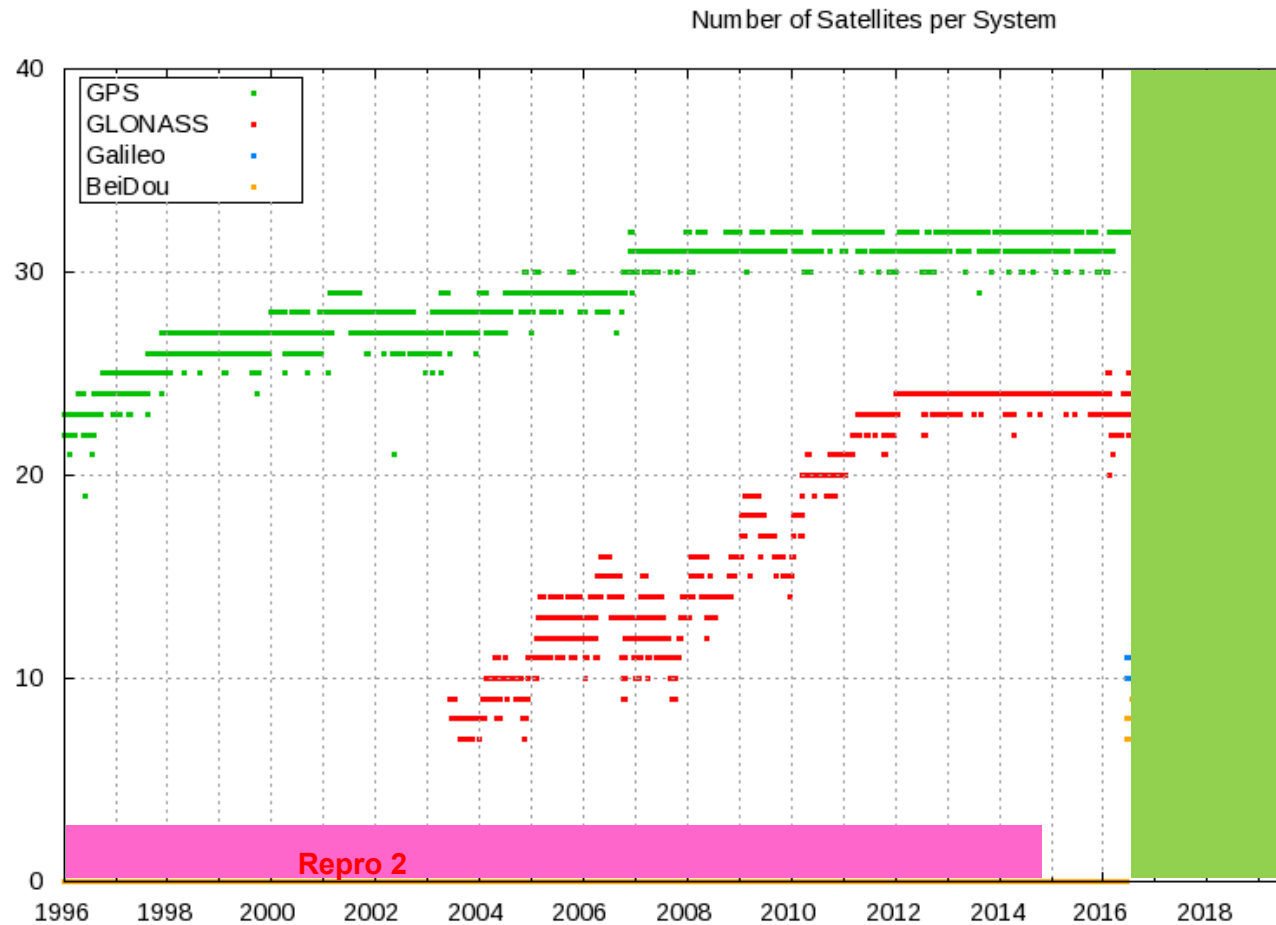
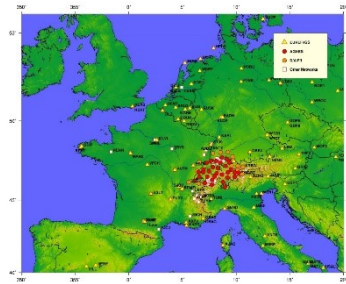
BSW53
July 2016
GREC
MGEX FINAL

11/17 EPNACs
May 2019
GREC
MGEX FINAL

BSW53
GR July 2016
GRE Sep 2019
ULTRA



Evolution Multi-GNSS at swisstopo Permanent Analysis Center (PNAC)



Monitoring System:

<http://pnac.swisstopo.admin.ch>

GPS: 32



Glomass: 24



Galileo: 24



Beidou (BDS3 not yet): 10



http://pnac.swisstopo.admin.ch/pages/en/agnes_statistics.html#NUM_SAT_SYS



Monitoring web-pages

<http://pnac.swisstopo.admin.ch>

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Administration admin.ch
Federal Department of Defence, Civil Protection and Sport
Federal Office of Topography swisstopo

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Did you know that ...
[Surveying](#)
Reference systems
Transition of reference frames
Geostation Zimmerwald
Observation procedures
Control networks
[GNSS permanent networks](#)
AGNES
Analysis center
PNAC monitoring
AGNES status / time series
National border
Positioning (GNSS)
Cadastral Surveying
FAQ
Geodata production
Map production
Geology
Spatial data infrastructure
Geoinformation

Homepage > Topics > Surveying > GNSS permanent networks > Analysis center > **AGNES status / time series**

Search swisstopo

Advanced search

[Print this page](#)

AGNES status / time series

RINEX AGNES status / time series

AGNES status / time series

Coordinate Monitoring status in Europe 05-May-2009 13:55:32 (DOY 125)

Select region
[Europe](#)
[Switzerland](#)

PNAC status by subject
[RINEX](#)
[NRT-Meteo](#)
[Coordinate Monitoring](#)

Processing details
[Processing details](#)

Legend
-
o.k.
Alarm found
No monitoring

swisstopo PNAC status: MONITORING Tue May 5 11:55:24 UTC 2009

Coordinate Monitoring status by site

ARTU	ANDE	ARDE	ARD2	AUTN	BOR1	BOUR	BOU2	BRST	BRUS
BSCN	BZRG	CABW	CAGL	DAYO	DAY2	EGLT	EPFL	ENIZ	ERDE
ETHZ	ETH2	FALE	FHRB	FLOK	FREI	ERIC	ERI2	GENE	GENO
GOPE	GRAZ	GUJP	HABG	HERS	HFL2	HOHT	HOH2	HUIT	JUDO
KALT	KIRO	KLOP	KOPS	KRBG	KREU	LDB2	LECH	LIND	LINZ
LOMO	LUZE	MOSE	MART	MAR2	MAS1	MATE	MEDI	MILO	MLVL
MOP2	NANT	NEUC	ONSA	PADO	PAYE	EDEL	PENC	PEA2	FLUY
RAVE	RENN	REYK	SAAN	SAME	SANB	SANT	SARG	SBG2	SCHA
SIGM	SMNE	STA2	STCX	STGA	STJO	TORJ	TRF2	VARE	VECH
VISW	WEHO	WITZ	YEBE	ZERM	ZIMM	ZIM2			

RINEX
Data

Meteo
results

Coordinate
results



Example: NEUC (20.10.2019)

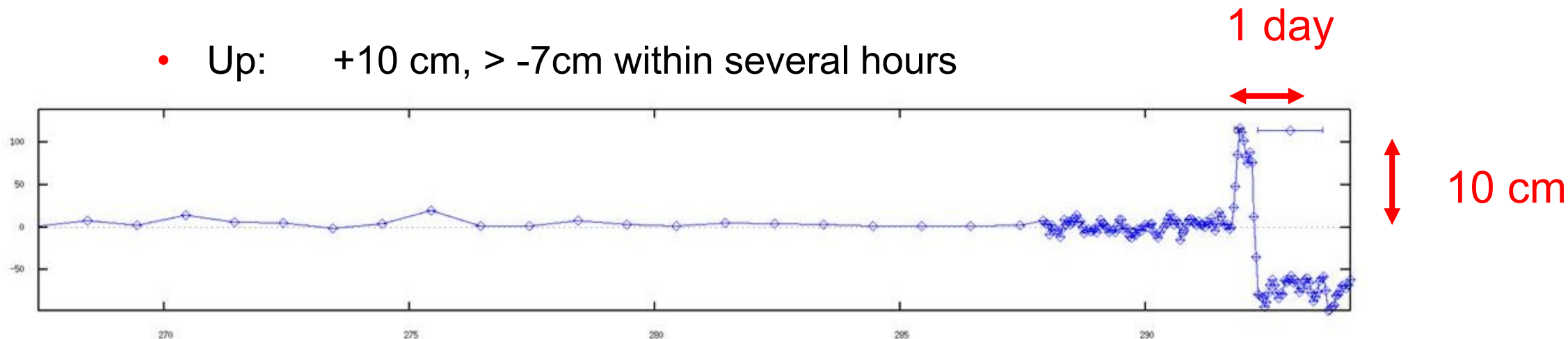


Sa. 19.10.2019 01:55

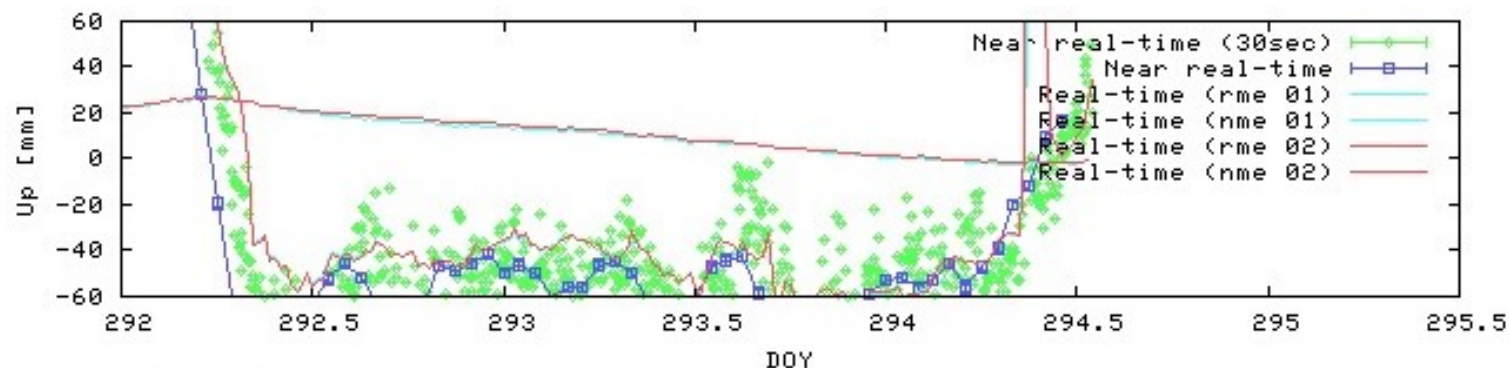
pnac@swisstopo.ch

STA/19/01:55(It02105a): ALARM_OUTLIER_NEUC: <http://pnac.swisstopo.admin.ch/pages>

- Up: +10 cm, > -7cm within several hours



water in inner choke ring



21/10/19 15:43



Reference for Multi-GNSS observations

- 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

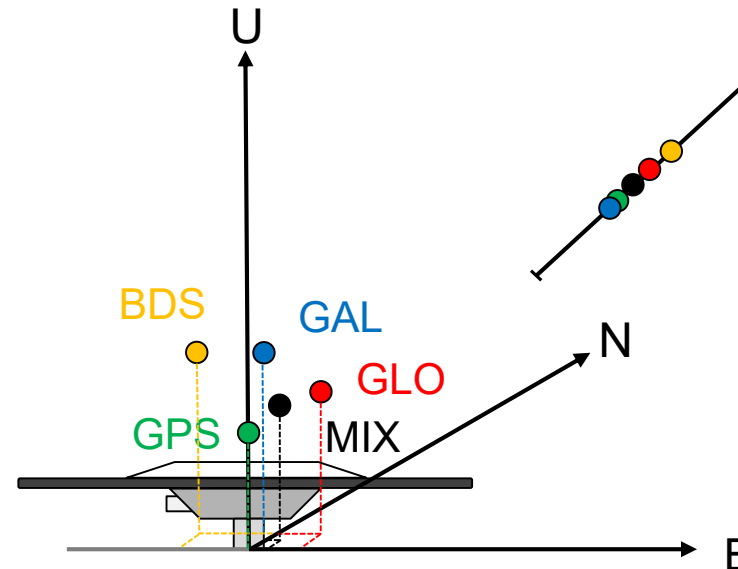
dN,dE,dU,dT

12 ISTPs



T (Tropo)

ISTPs:
„Inter **S**ystem
Translation **P**arameter“



No antenna
calibrations
available for
GAL, BDS



Multi-GNSS analysis: Intersystem parameters

- AGNES processing using Multi-GNSS
- Since Nov. 2016 on pnac web
- Differences worst case 1-2 cm e.g. GPS - GLO

GPS (Ref)

GLO

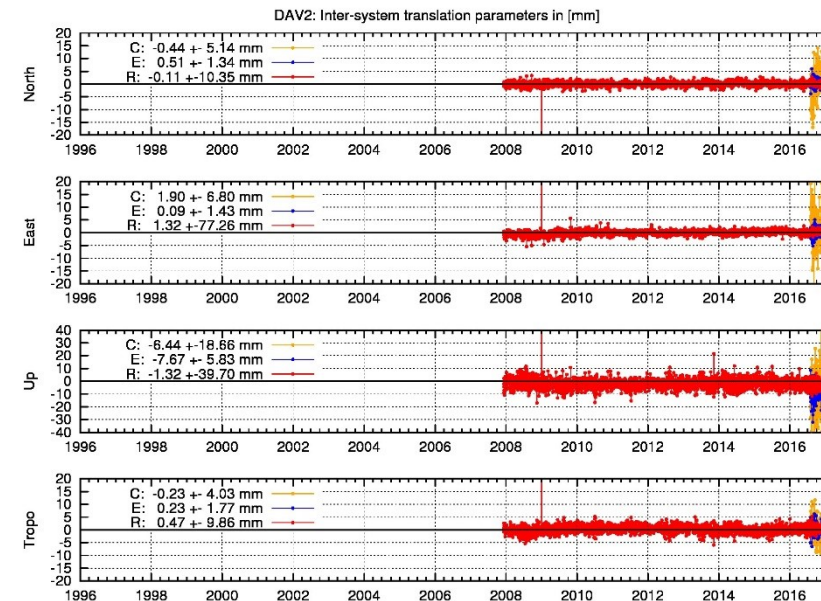
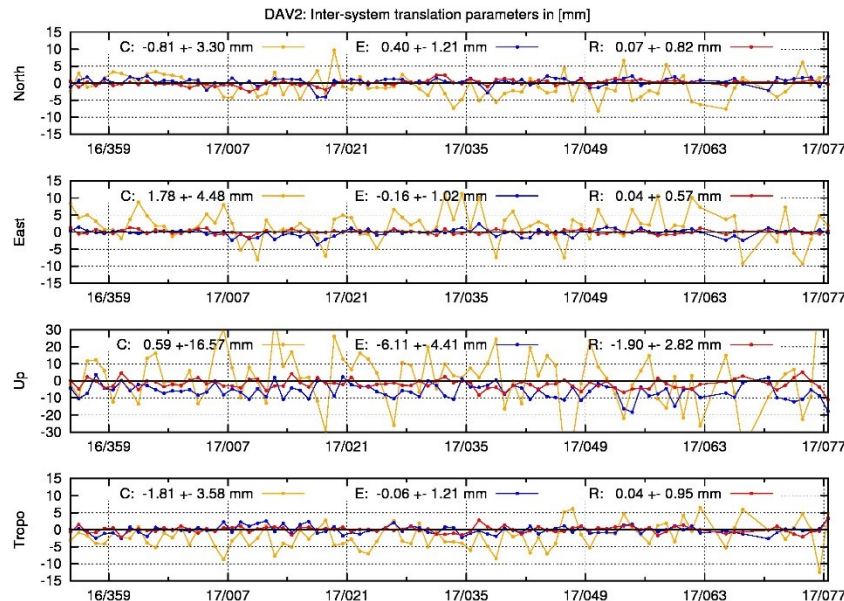
GAL

BDS

Daily: last month

DAV2

Daily: Long-term



GPS/GLO
from repro2

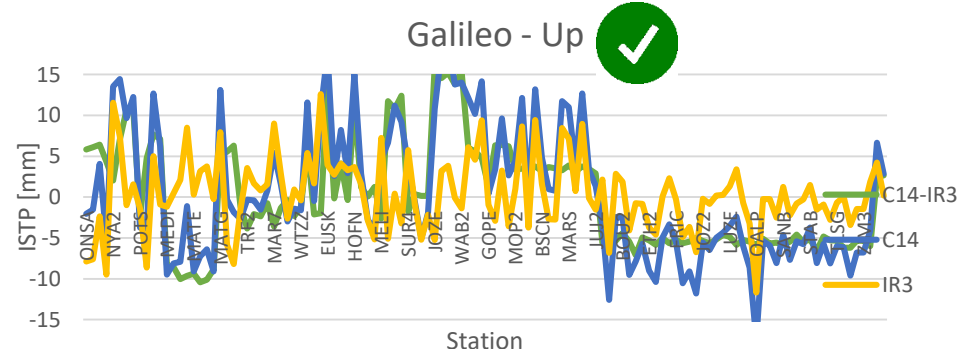
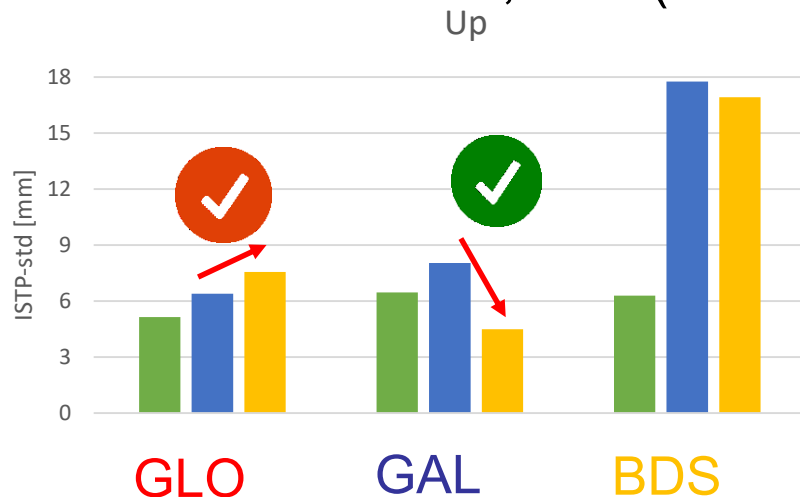
Multi-GNSS
BSW53



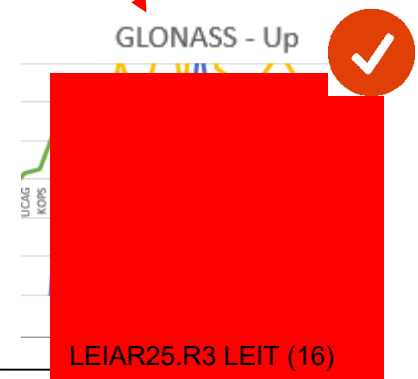
Galileo robot calibrations from Geo++

EUREF
Multi-GNSS
WG chair

- New Galileo+BeiDou antenna calibration values of Geo++ for IGS repro3 (IR3, June 2019)
- Impact study using 1 day of data (200 stations in Europe)
 - Difference GPS-Galileo smaller with IR3 compared to C14 (I14)
 - BeiDou values better than chamber values (vertically)
 - LEIAR25.R3 LEIT – GLONASS values worse (IR3 10-15 mm, C14 not significant)



Not a GLO problem, but GPS+GAL



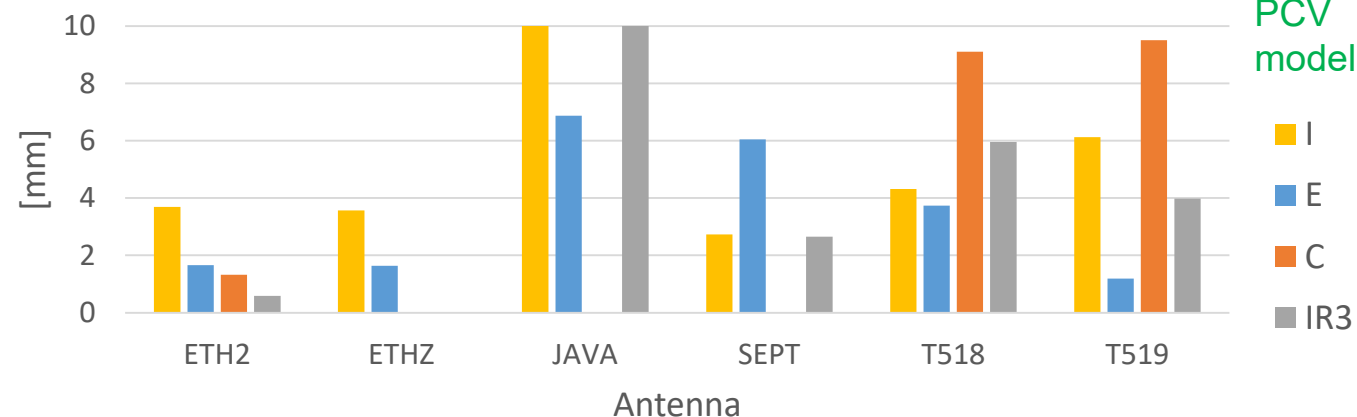


Multi-GNSS antenna calibrations

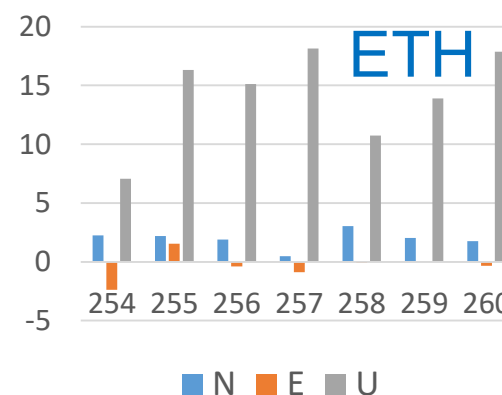
- Collaboration with ETHZ (phd D. Willi)
- Validation campaign with 2 swisstopo field antennas 518, 519 using 4 PCV mod.
 - ground truth comparison
 - Intersystem parameter checks
- New geo++ values Galileo IR3 show good agreement with GPS – will be used from now on...



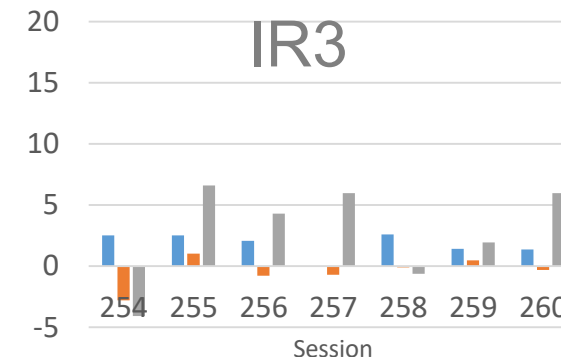
L3Y: 3D Differenz Ground Truth (GE, by antenna, 10 degree): E,I,C,IR3
PCVs



519 ETH PCV: GPS-Gal coordinates [mm]



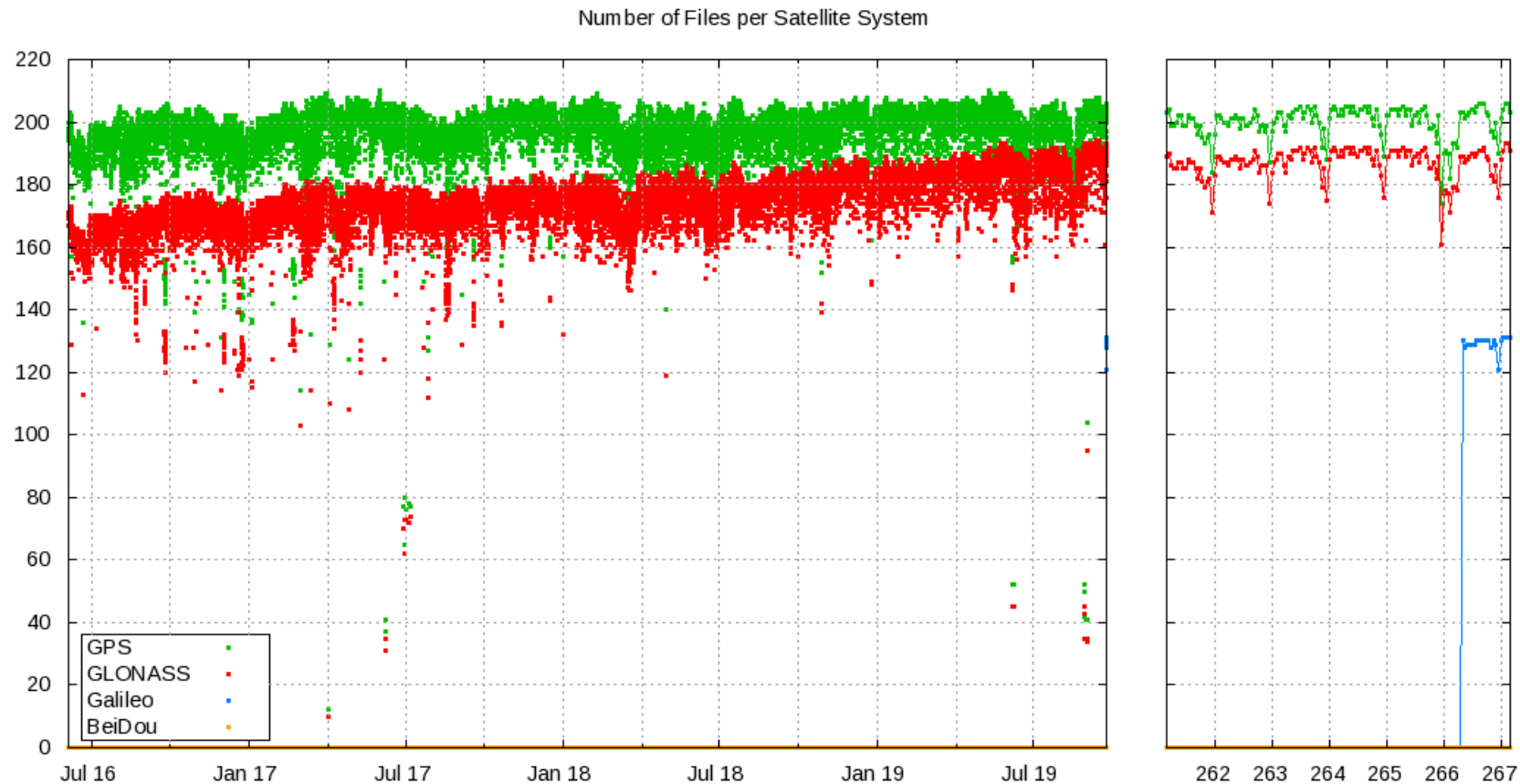
ISTPs G-E T519 IR3 PCV [mm]





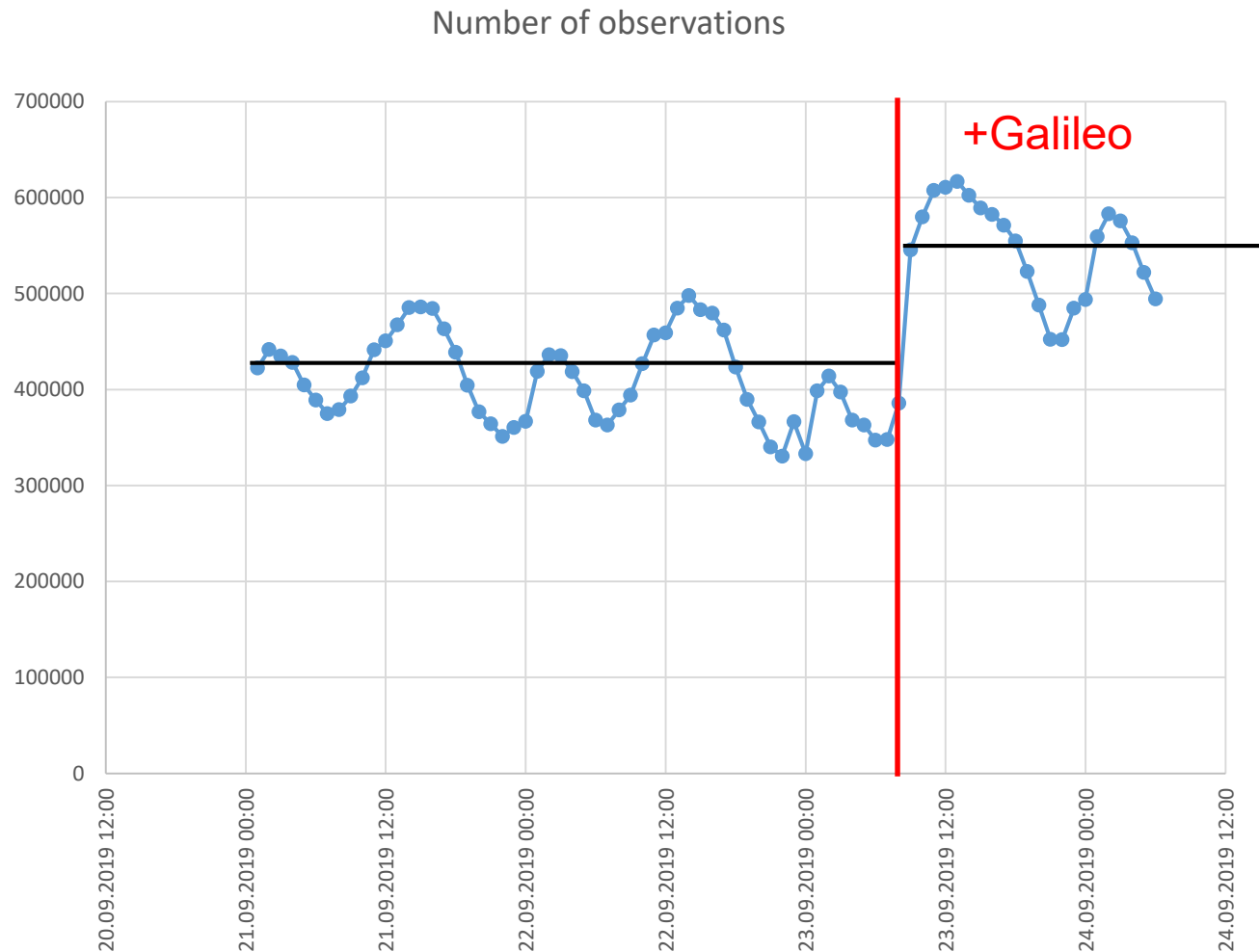
Galileo in Rapid and Ultra-Rapid products

CODE products including Galileo since 23.9.2019 (Tag 266)

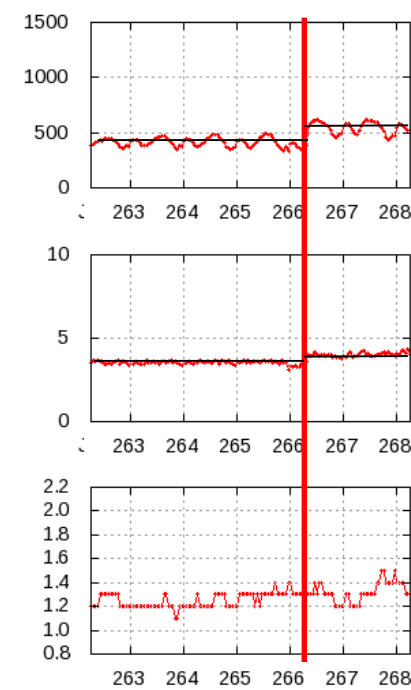




Impact: # of observations



~ 25-33 % more
observations in adjustment
(4 hour data)



#OBS/1e3

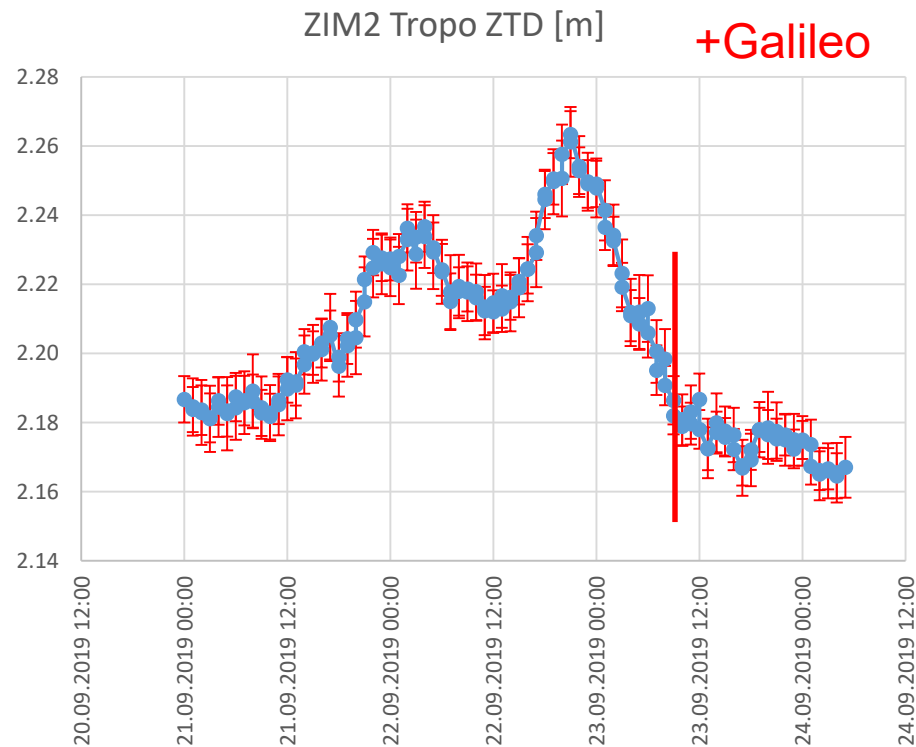
#PAR/1e3

RMS [mm]

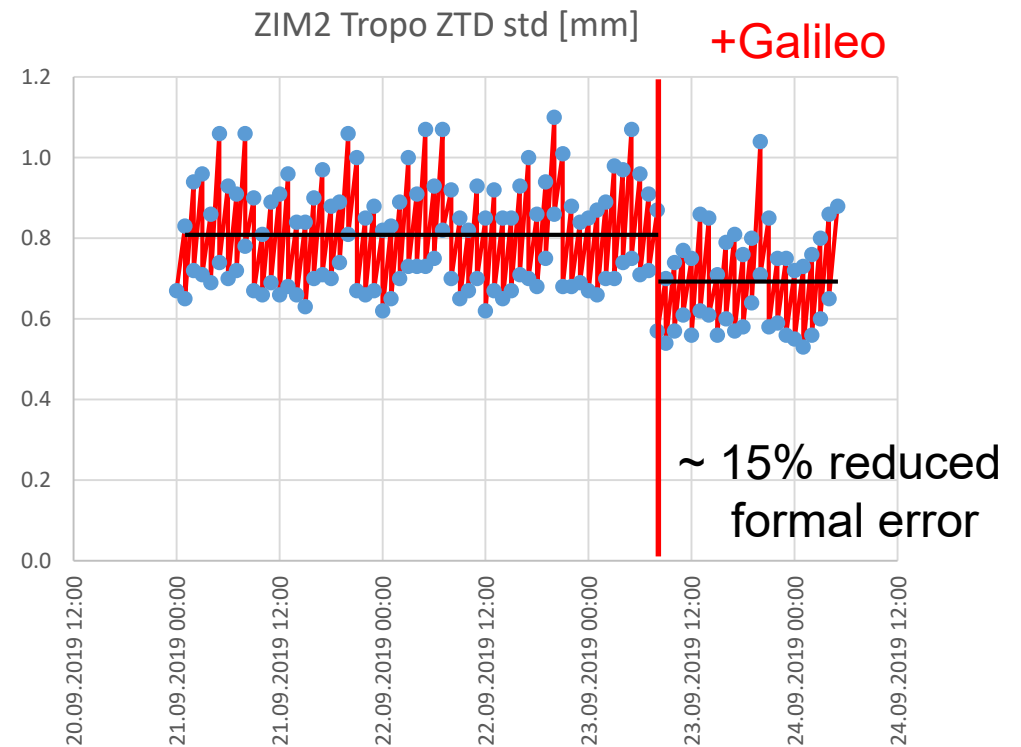


Troposphereparameter: ZIM2

Impact ZTD (+ std as error bar)



Impact standard deviation (formal error)





kPPP (kinematic Precise Point Positioning)

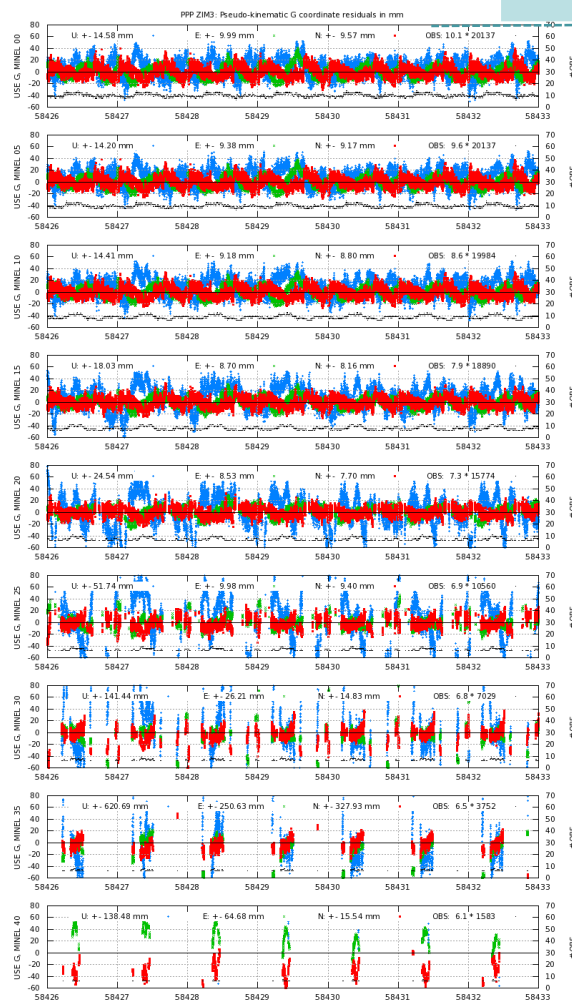
Nov.
2018

GPS CODE MGEX

GPS + GLO + GAL + BDS CODE MGEX

0-40 Elev.

BSW53:
ZIM3
1 week
PPP-
kinematic



0 Elev.

5 Elev.

10 Elev.

15 Elev.

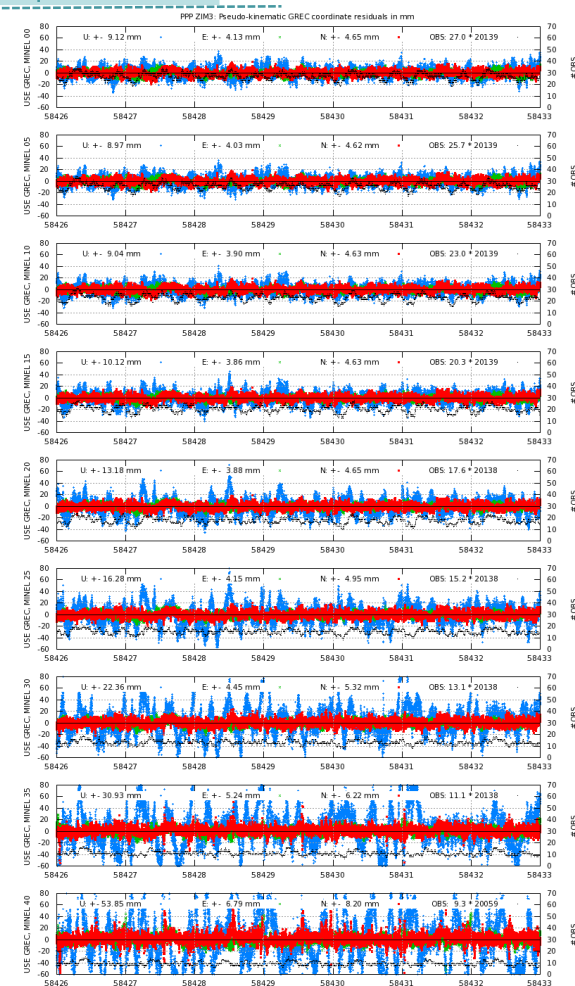
20 Elev.

25 Elev.

30 Elev.

35 Elev.

40 Elev.

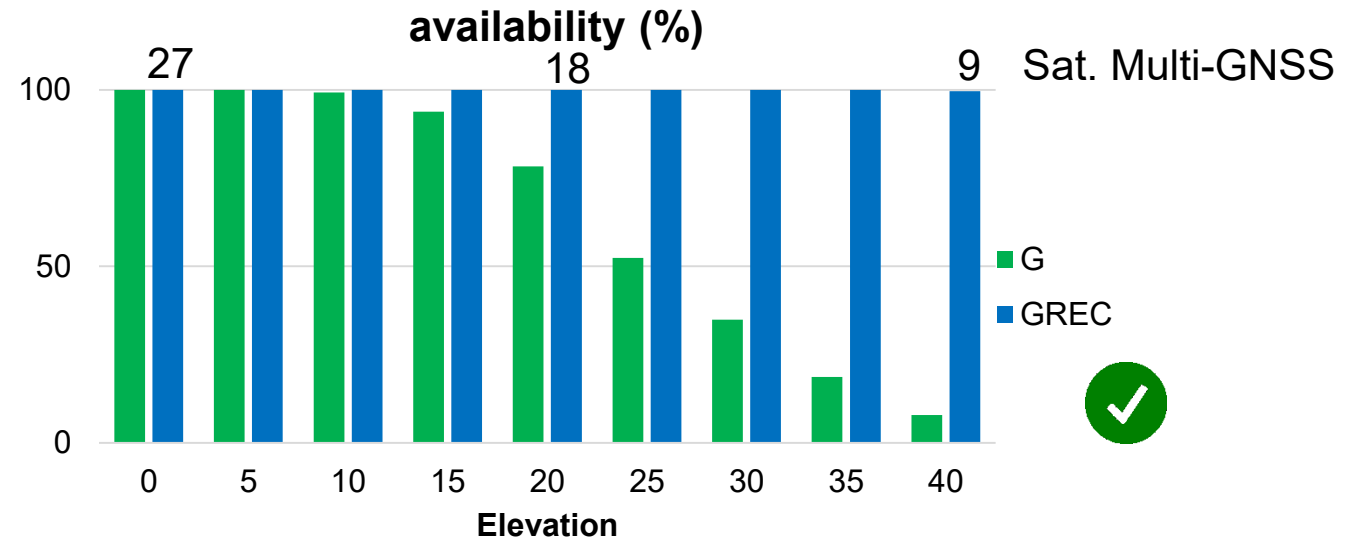
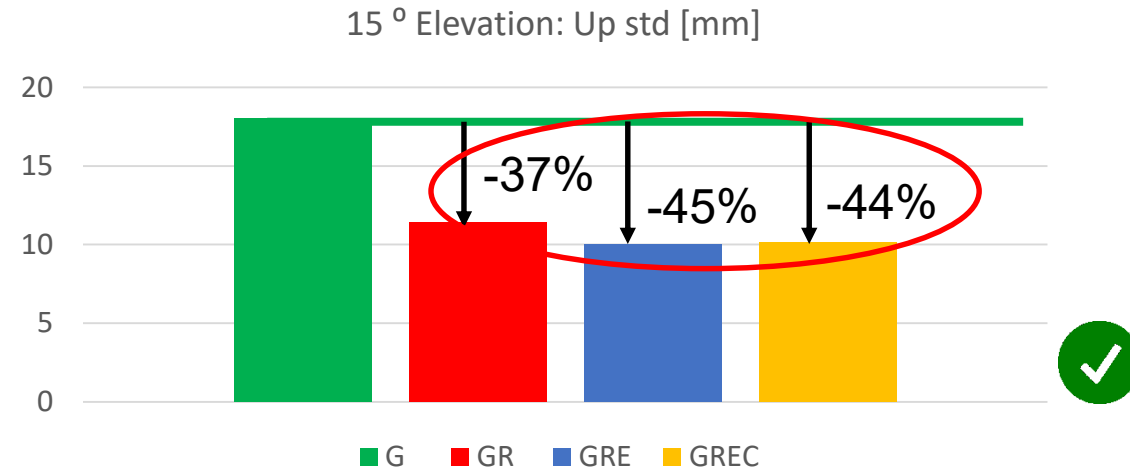


Availability under bad
conditions only for
kinematic GREC



kPPP: Improvement with Multi-GNSS

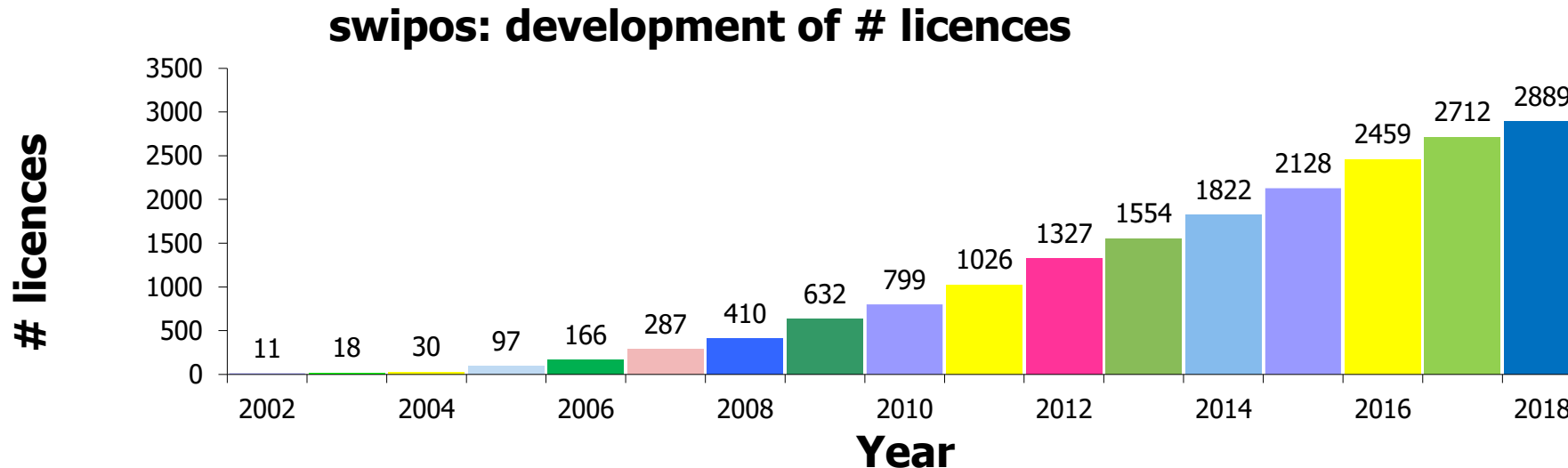
- Precision (0-15°)
improvement w.r.t GPS
 - ~35 % with **GLO** or **GAL**
 - ~45 % with **GLO** + **GAL**
 - No further improvement with **BDS**
- Availability (20-40°) w.r.t. GPS
 - Multi-GNSS allows coordinate results even under very bad conditions





Swiss Positioning Service swipos

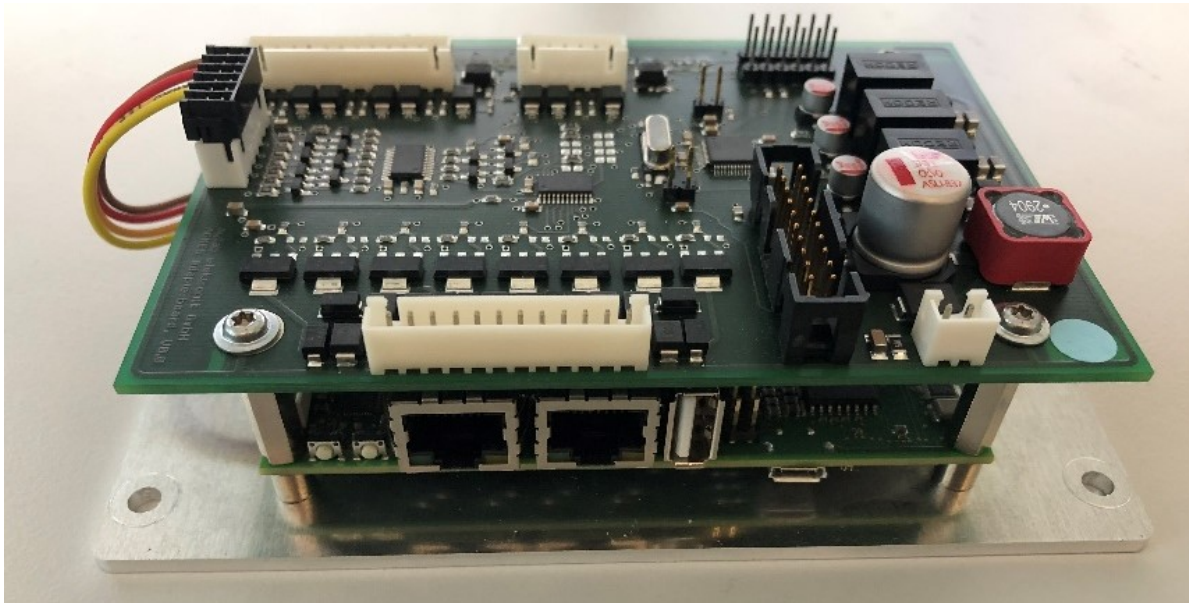
- Integration of BeiDou and Galileo in the Trimble Pivot Platform – Software (TPP 3.10) in June 2017; Trimble RTXNet – Processor Trimble RTX Real-time Orbits; currently TPP 4.1.3
- New RTCM 3.2 MSM mountpoints (GPS/GLO/BDS/GAL) are used by 20-25% users (status 27. Aug. 2019, 550 simultaneous user)





Infrastructure AGNES stations

- New IO-Controller -> Single Board Computer
- 5 units installed successfully, currently installed site-by-site («Zimmerwald first»...)



AGNES UPS CONTROLLER - web interface -

ioControl server version: 1.0

[AGNES station DACH](#)
[swisstopo AGNES](#)

Input

#	Current	Pin alias	Pin function
1	OFF	IN 1	general purpose input
2	OFF	IN 2	general purpose input
3	OFF	IN 3	general purpose input
4	OFF	IN 4	general purpose input
5	OFF	IN 5	general purpose input
6	OFF	IN 6	general purpose input
7	OFF	IN 7	general purpose input
8	OFF	IN 8	general purpose input
9	OFF	-	unused
10	OFF	CHARGER_FAIL	charger:processor_fail
11	OFF	POWER_FAIL	charger:power_fail
12	OFF	BAT_FAIL	charger:battery_fail

read now

☐ read continuously

Output

#	Current	Desired	Pin alias	Pin function
1	ON	☒	1-S	24V,relay
2	ON	☒	2-S	24V,relay
3	ON	☒	3-S	24V,relay
4	ON	☒	4-S	12V,relay
5	ON	☒	5-S	24V,relay
6	ON	☒	6-S	24V,relay
7	ON	☒	7-S	24V,relay
8	ON	☒	8-S	12V,relay

write now

☐ write immediately

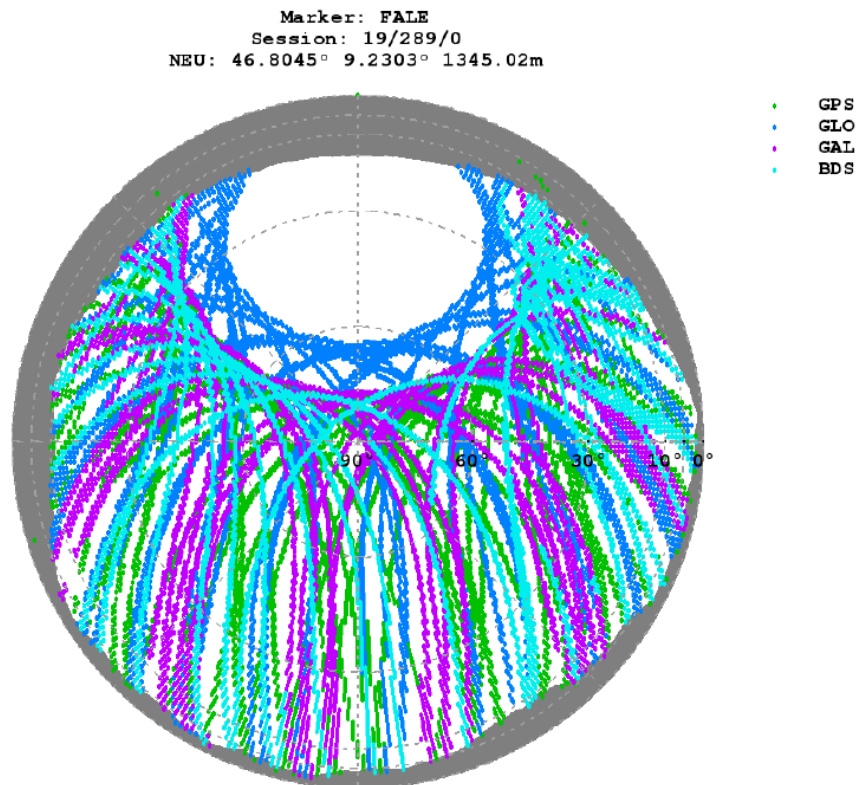
5 sec

Server connection okay



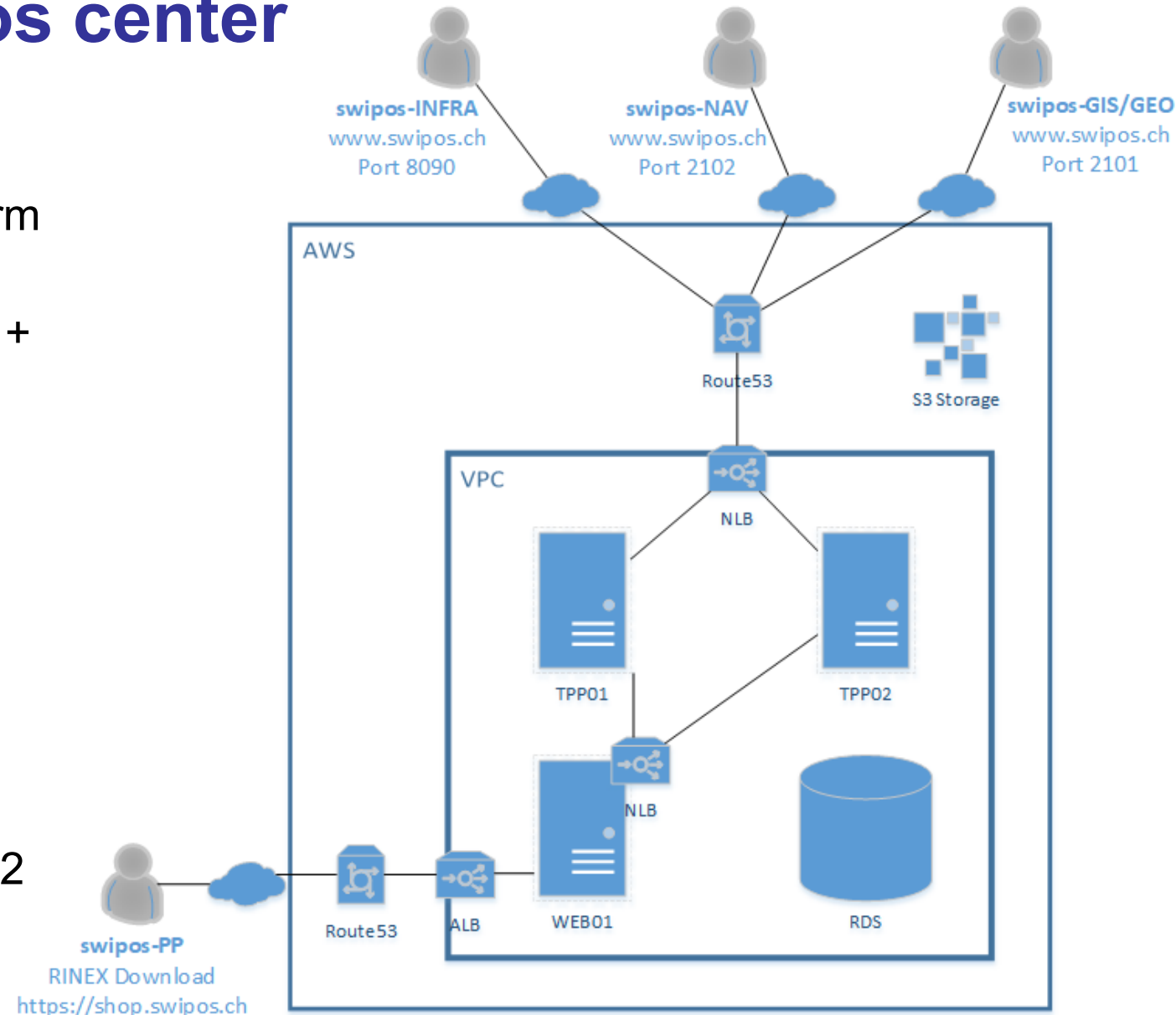
Falera: «On Air»: 16.10.2019

- No observation degradation visible (yet) ...



New operational swipos center

- Design principles
 - Infrastructure as code in git -> terraform & packer; generates OS image
 - Redundance: identical setup TPP01 + TPP02 (only Mac address and hostname)
- Amazon web service aws (Frankfurt)
- TPP 4.1.3. (production+ test)
- Mountpoints for data exchange D-A-F-I ready
- Rinex-3 data flow supported
- Communication station – operational center as well as swipos-INFRA: NTRIP2
- **Go-Live: 20.11.2019**

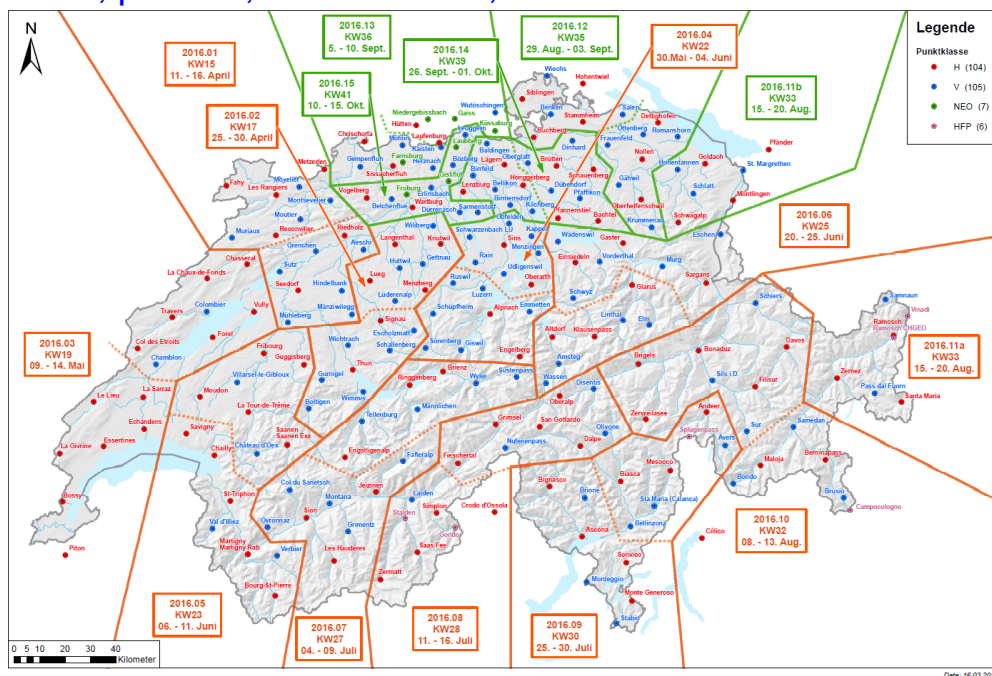




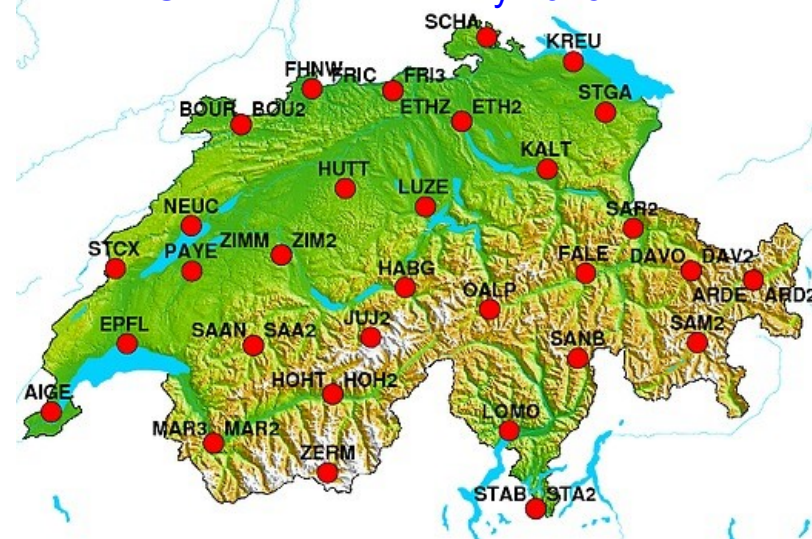
CHTRF2016: Multi-GNSS field campaign and AGNES permanent network

- 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**)

LV95; passive; ~200 stations, Multi-GNSS since 2016



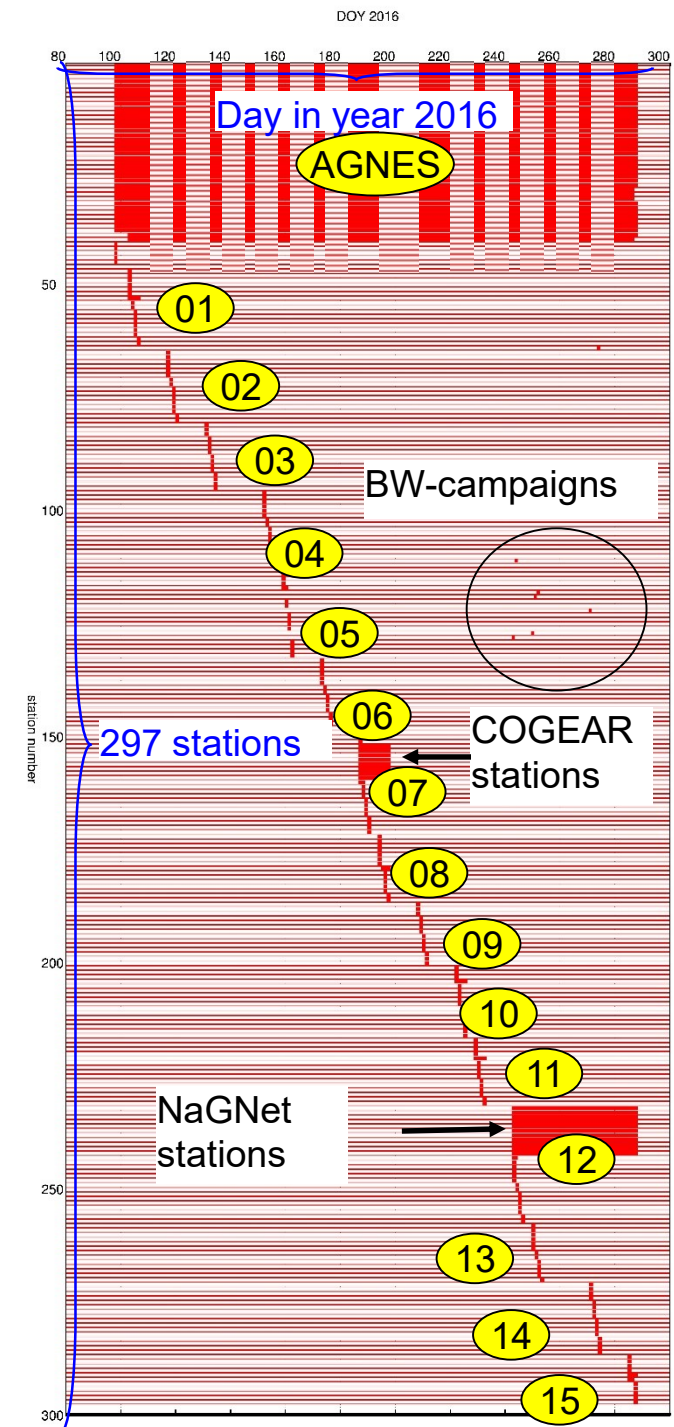
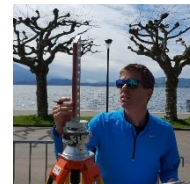
AGNES; active; 42 stations, Multi-GNSS since Feb-May 2015





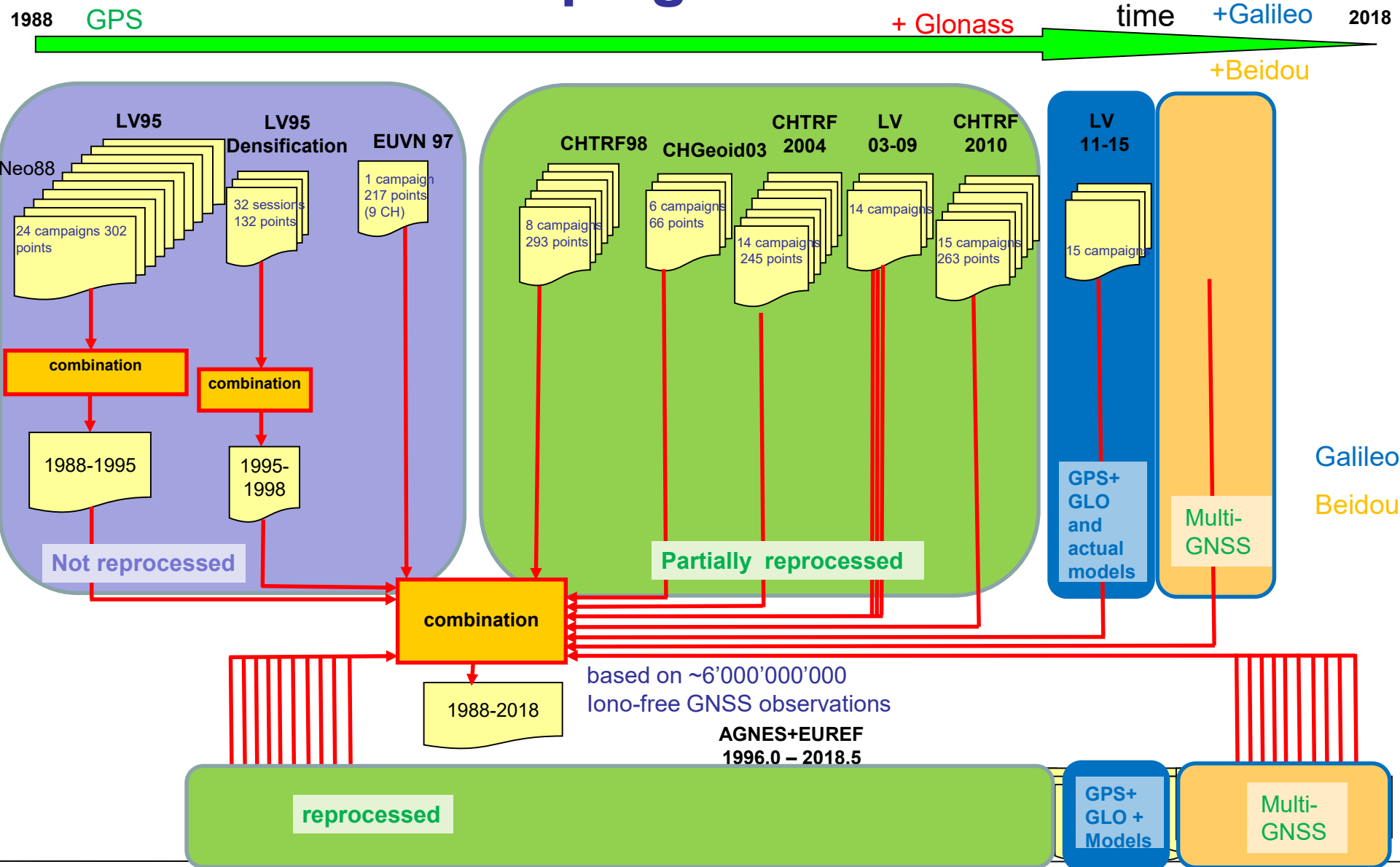
Campaign 2016

- 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



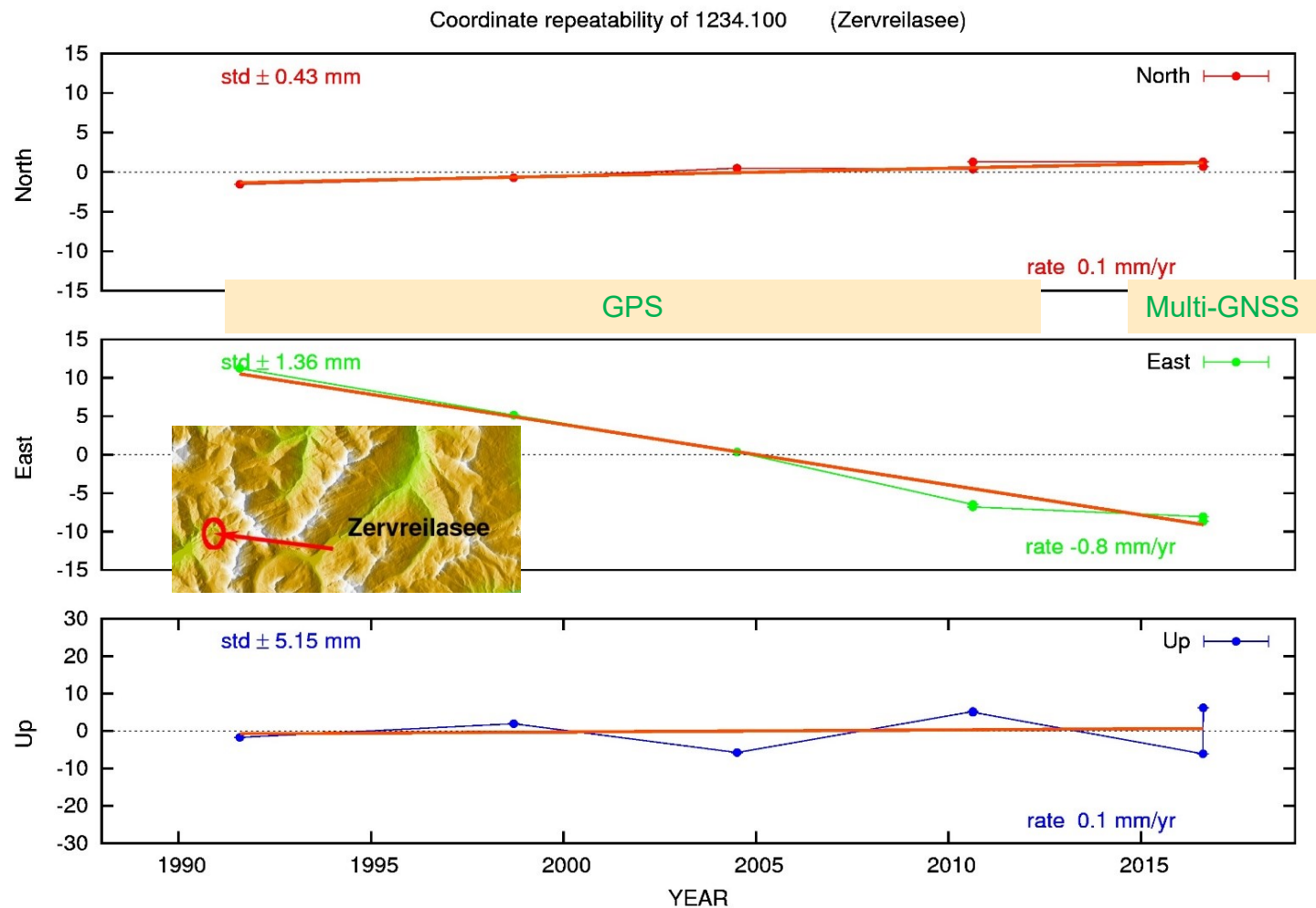
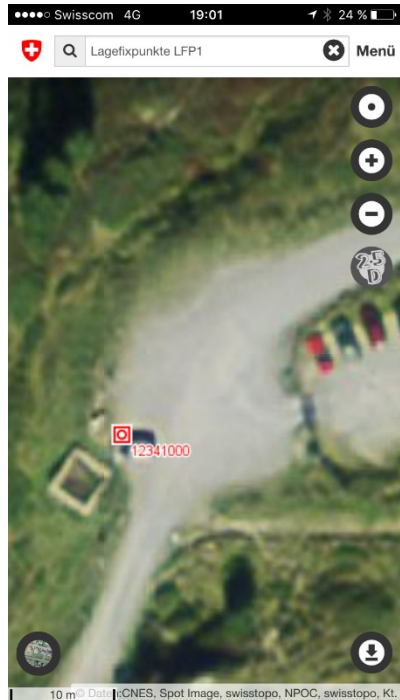


Combination Campaigns + Perm. Net



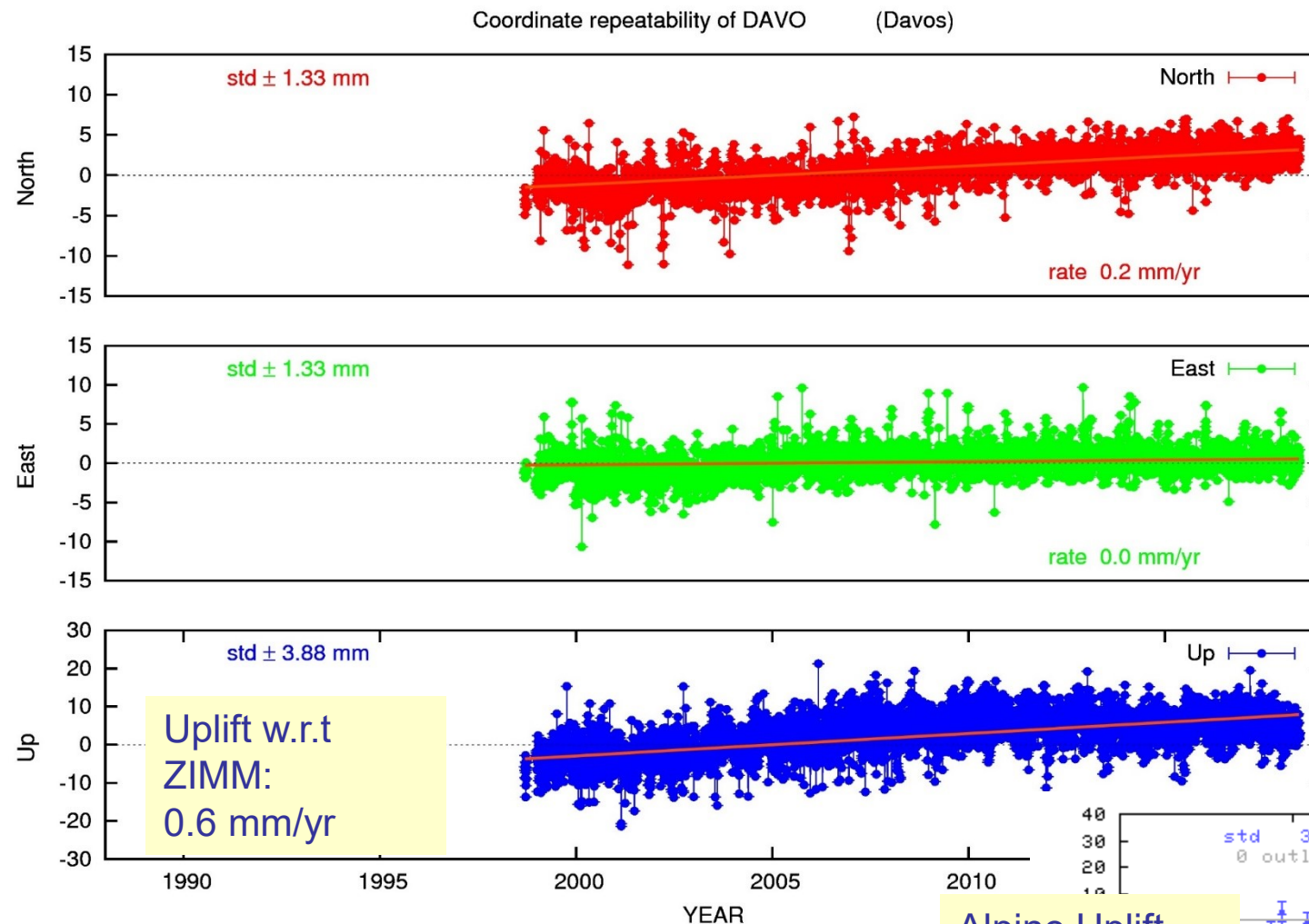
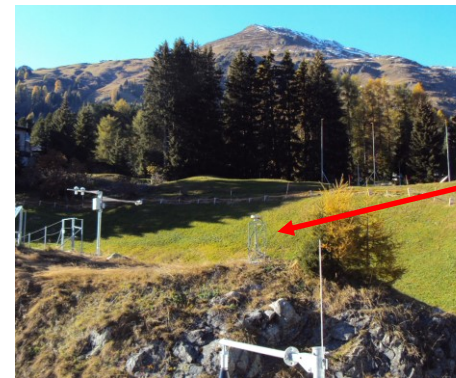


Example Zervreilasee



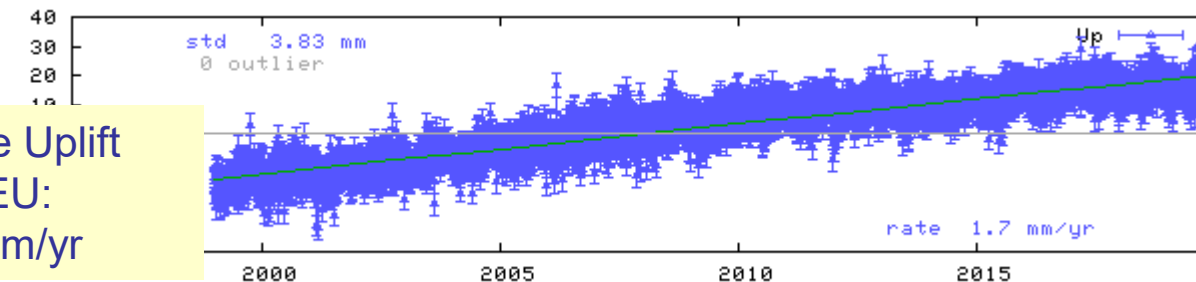


Repeatabilities: Example Davos



13/06/18 11:49

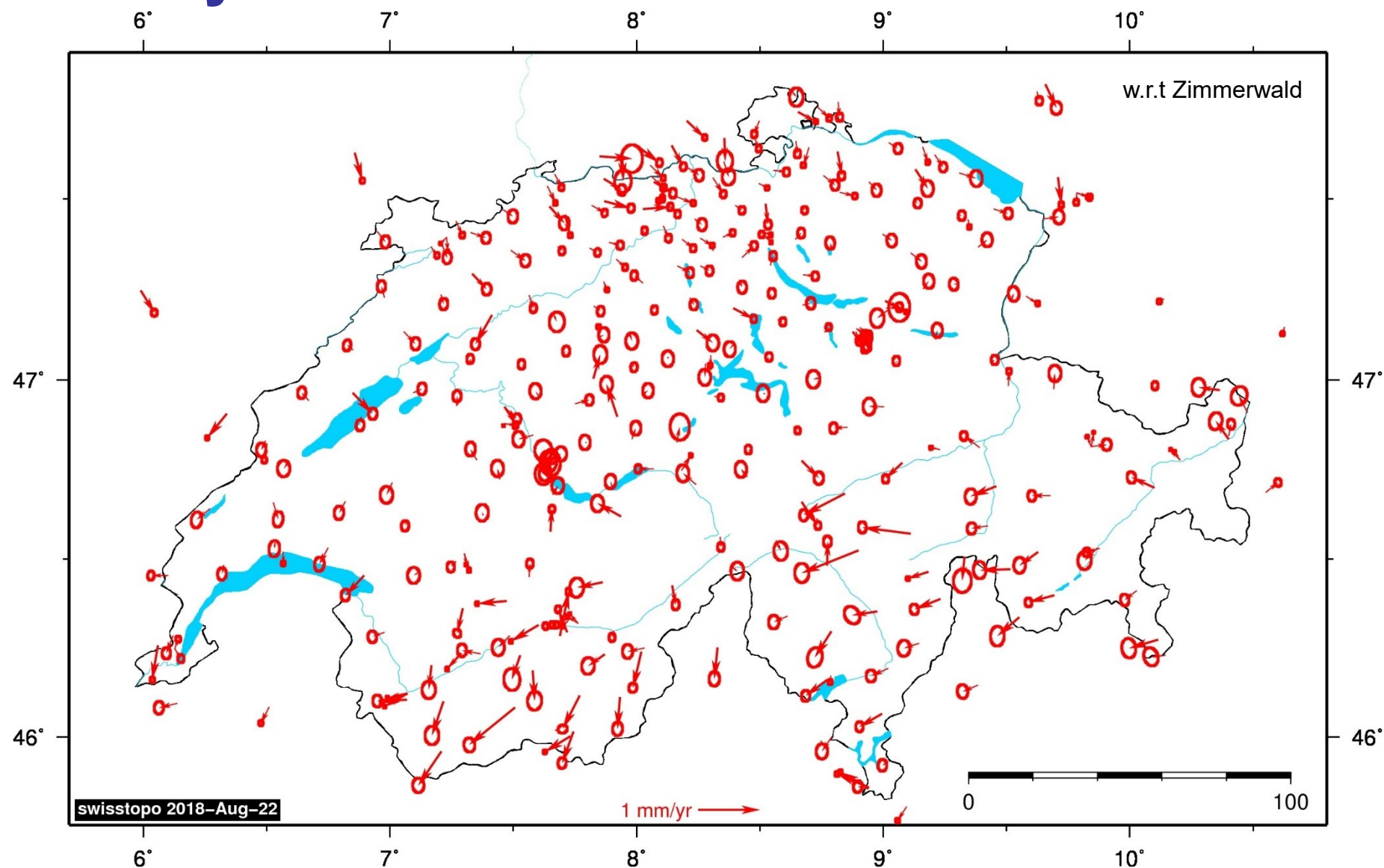
Alpine Uplift
w.r.t EU:
1.7 mm/yr





Velocity Fields

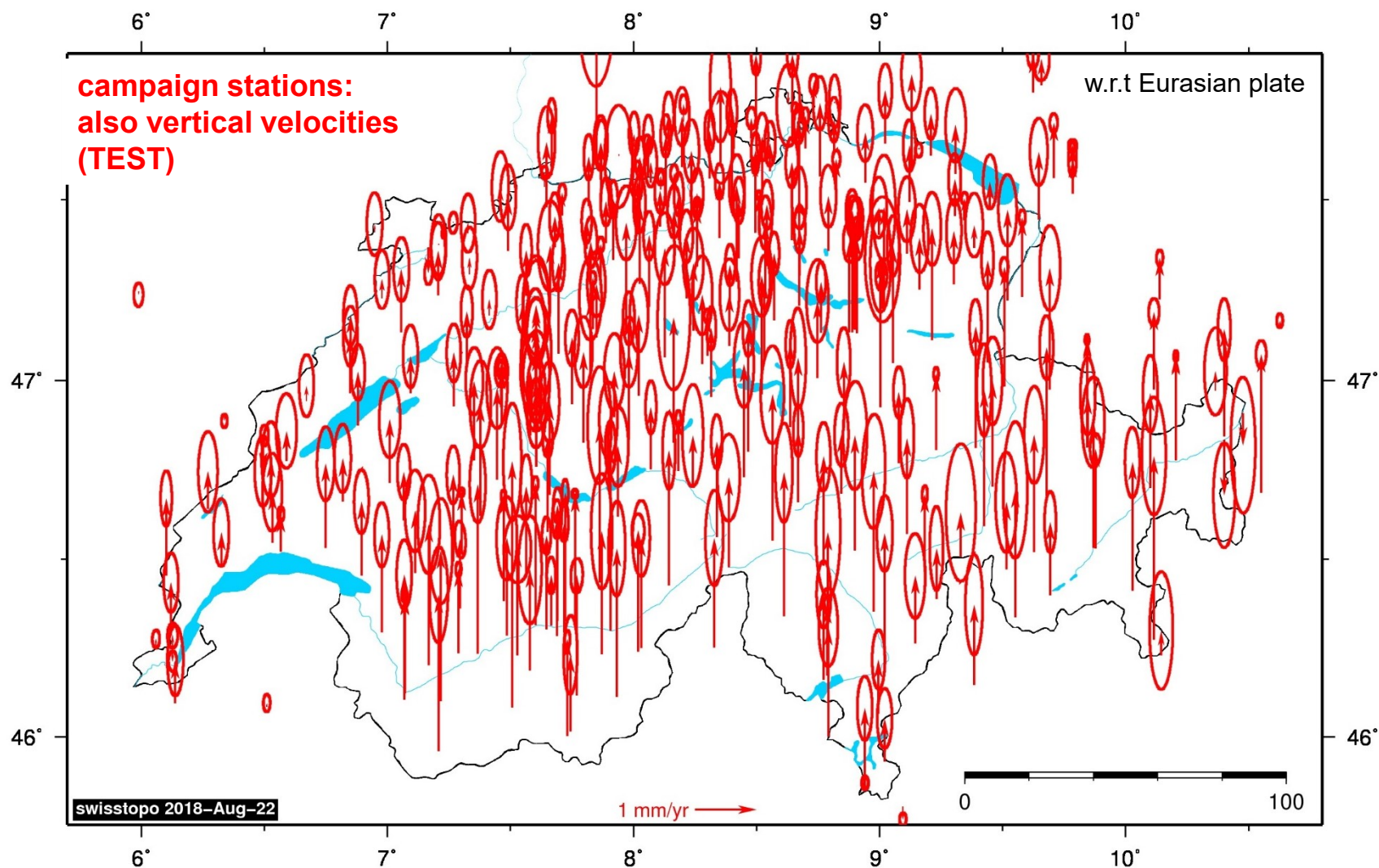
ALL_DAY_EU





Velocity Fields Vertically

ALL_DAY_EU





Publication on pnac web

CHTRF2016 coordinates in reference system CH1903+ at epoch 2018.0

<http://pnac.swisstopo.admin.ch/pages/en/chtrf.html>

Federal Administration > Departement: VBS
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Federal Office of Topography swisstopo
Geodäsie
Permanent Networks Analysis Center

CHTRF95

The reference frame CHTRF95 is realized by about 200 points which were selected in order to guarantee a stable location. All points are suited for GNSS measurements. This passive network densifies the Automated GNSS Network for Switzerland (AGNES).

Goals

The main goals are:

- The LV95 network realizes the Swiss reference frame CHTRF95. It serves as the basis for cantonal authorities and for municipalities for further densifications.
- Every 6 years, the network is re-measured in order to validate the stability of the reference points.
- CHTRF95 is currently defined as a static reference frame. Beside official LV95 coordinates also scientific CHTRF coordinates are computed which take into account possible movements of points. Also velocities for each point are computed and published.

Map with details:

Object-Information

CHTRF2016 stations and velocities (1234.100)

Point number: 1234.100
Point name: Zervreilasee
Point cat.: LV95 Hauptpunkt
Point info: [fpds-protocol](#)
Geographic coordinates: (WGS84) Latitude: 46.571266 ° Longitude: 9.112159 °
Height: 2035.141 m

Geocentric coordinates: (CHTRF95/ETRF93)
X: 4338372.775 m
Y: 695839.015 m
Z: 4610607.984 m

Swiss coordinates: (CH1903+)
E: 2728289.747 m
N: 1159144.214 m
H: 1984.279 m

Geoid (CHGeo04):
G: 1.932 m

Swiss velocities: (CH1903+)
vE: -0.8 mm/yr
vN: 0.1 mm/yr
vH: 1.6 mm/yr
dT: 25.0 years

Skyplot: [skyplot](#)
Repeatability: [replot](#)

2728'289.810, 1'159'144.263, 2'035.1

Map view in new window
Map view 3D in new window
Map view 3D+ell in new window
Mercator Map view 3D in new window (Mercator TEST-only, operational 2019)
Download kmz: kmz vel. 2D | kmz vel. 3D

Numerical values (coordinates at epoch 2018.0, horizontal velocities w.r.t. ZIMM, vertical velocities w.r.t. Europe, coordinates of AGNES sites available on individual station web page, are permanently updated and may change with changing instrumentation on the site)
published on July 9, 2018:

Number	Name	Swiss coordinates E, N, H, Geoid in m	Swiss Vel vE, vN, vH in mm/yr	FPDS	Skyplot Rep.	Map
1011.616	Wilechs	E: 2689269.596 N: 1294377.713 H: 704.856 G: 2.142	vE: 0.1 vN: -0.1 vH: -0.2	fpds-protocol	skyplot replot Map	
1012.680	Hohentwiel	E: 2705439.390 N: 1291348.751 H: 684.987 G: 1.575	vE: 0.0 vN: -0.2 vH: 0.0	fpds-protocol	skyplot replot Map	

Ort suchen oder Karte hinzufügen:
z.B. Bundesplatz 1 Bern, 46.7 7.5, Lärmkarte ...

Objekt-Information

CHTRF2016 stations and velocities (1234.100)

Point number: 1234.100
Point name: Zervreilasee
Point cat.: LV95 Hauptpunkt
Point info: [fpds-protocol](#)
Geographic coordinates: (WGS84) Latitude: 46.571266 ° Longitude: 9.112159 °
Height: 2035.141 m

Geocentric coordinates: (CHTRF95/ETRF93)
X: 4338372.775 m
Y: 695839.015 m
Z: 4610607.984 m

Swiss coordinates: (CH1903+)
E: 2728289.747 m
N: 1159144.214 m
H: 1984.279 m

Geoid (CHGeo04):
G: 1.932 m

Swiss velocities: (CH1903+)
vE: -0.8 mm/yr
vN: 0.1 mm/yr
vH: 1.6 mm/yr
dT: 25.0 years

Skyplot: [skyplot](#)
Repeatability: [replot](#)

2728'289.810, 1'159'144.263, 2'035.1

10 km

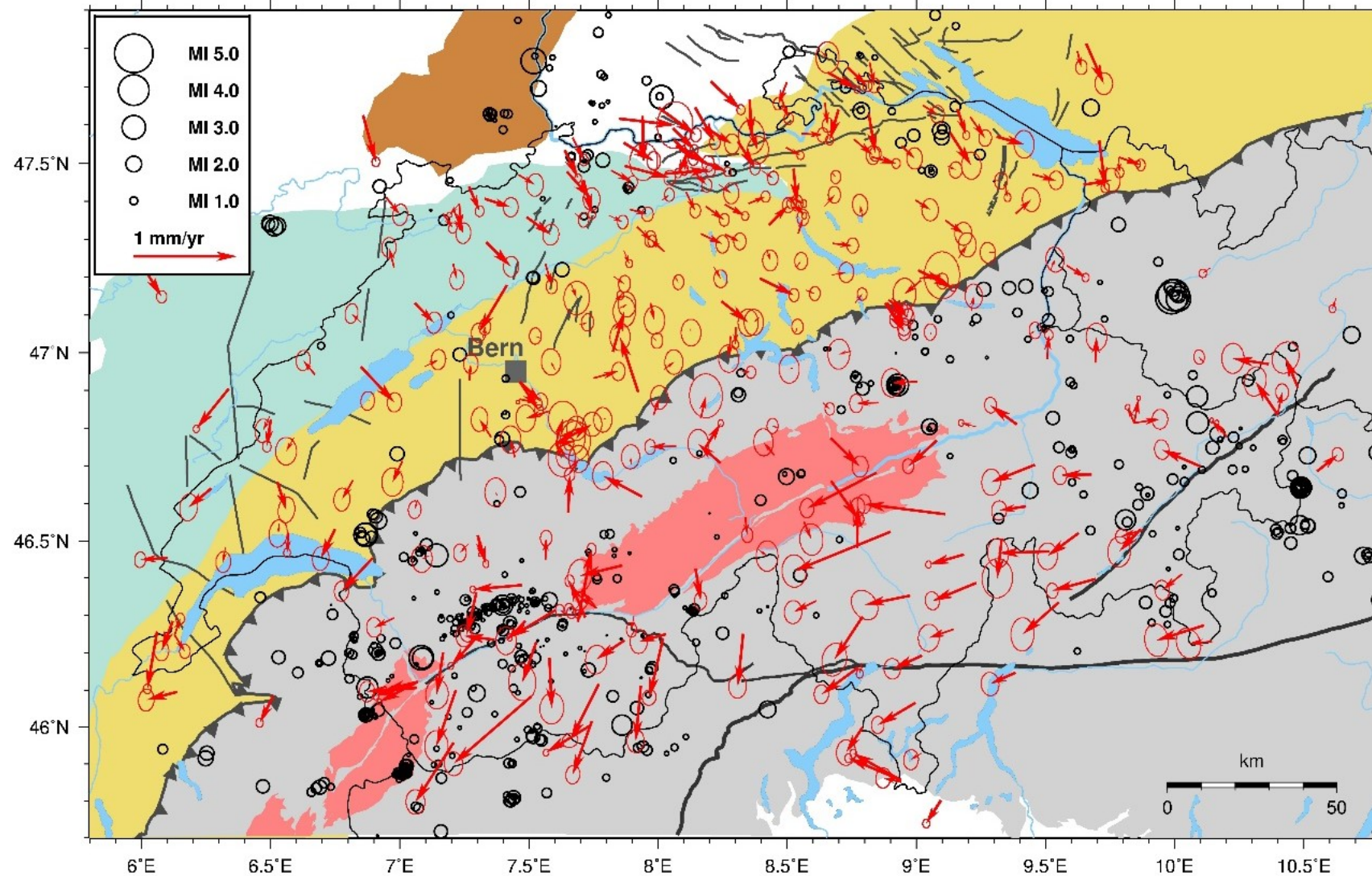
CH1903+ / LV95

Koordinaten (m): 2738'700.0, 1'163'800.0

geo.admin.ch Copyright & Datenschutzerklärung



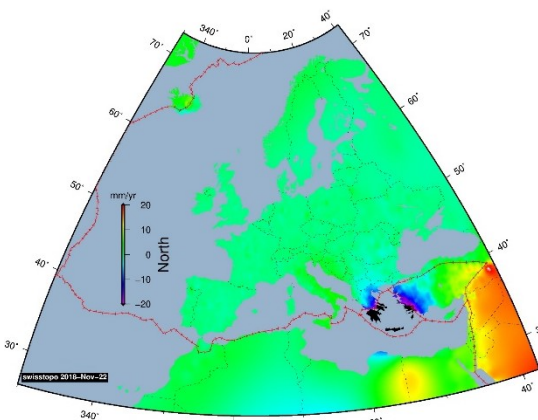
Correlation with Geology / Seismic





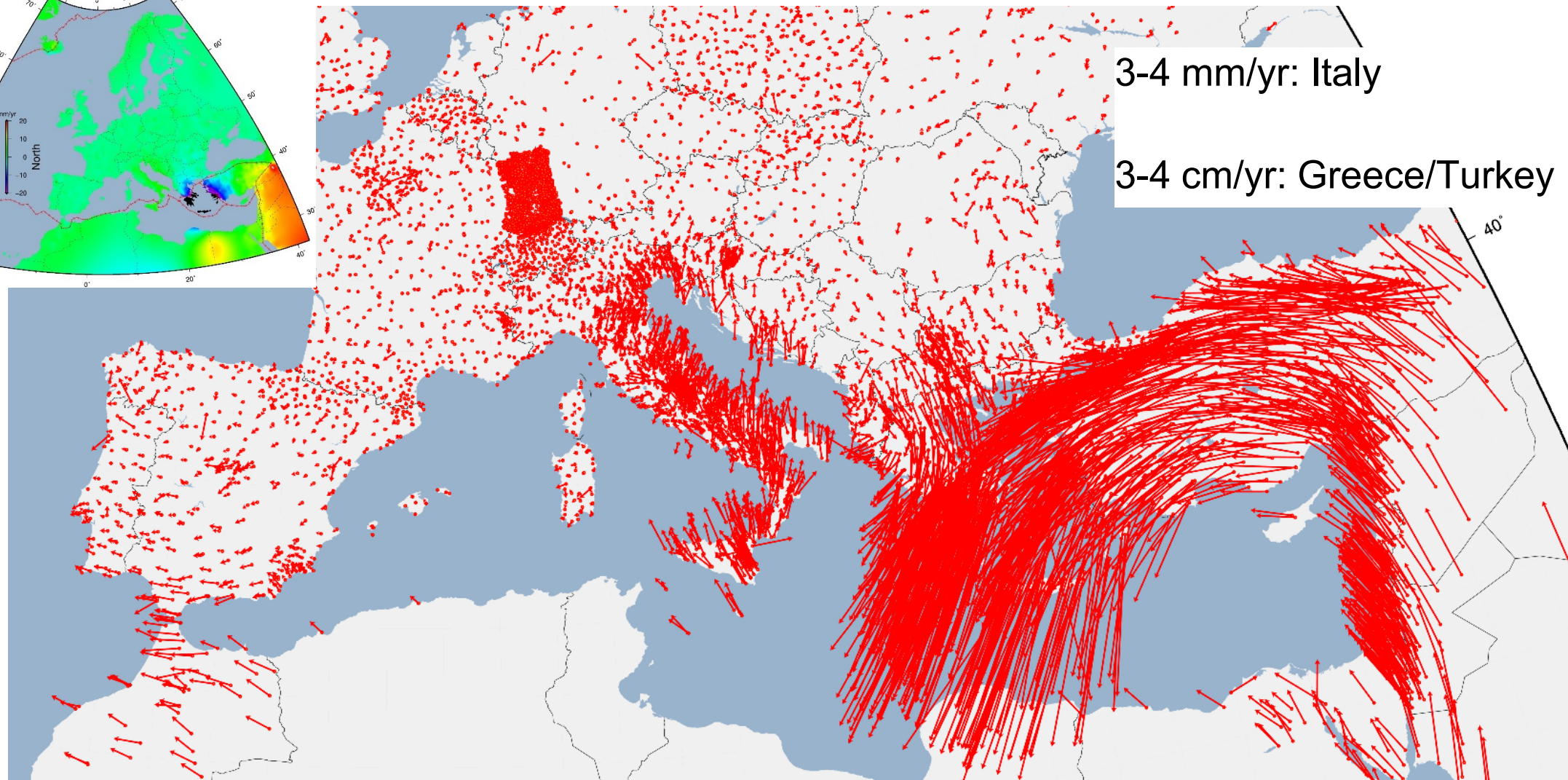
EU Dense Velocity Project

28 contributors, since 2017
~6000 station velocities
~0.2-0.3 mm/yr hor. standard deviation
~0.4-0.7 mm/yr up std



3-4 mm/yr: Italy

3-4 cm/yr: Greece/Turkey

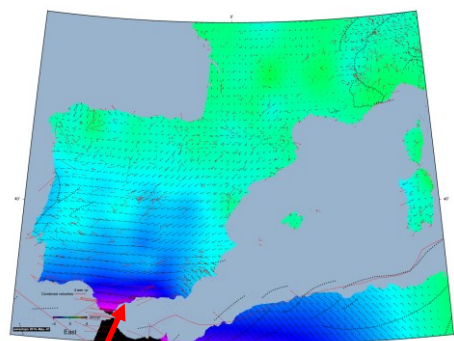




EU Dense Velocity Project

horizontally

—→ observed
—→ model
colored grid
mm/yr



South-Spain

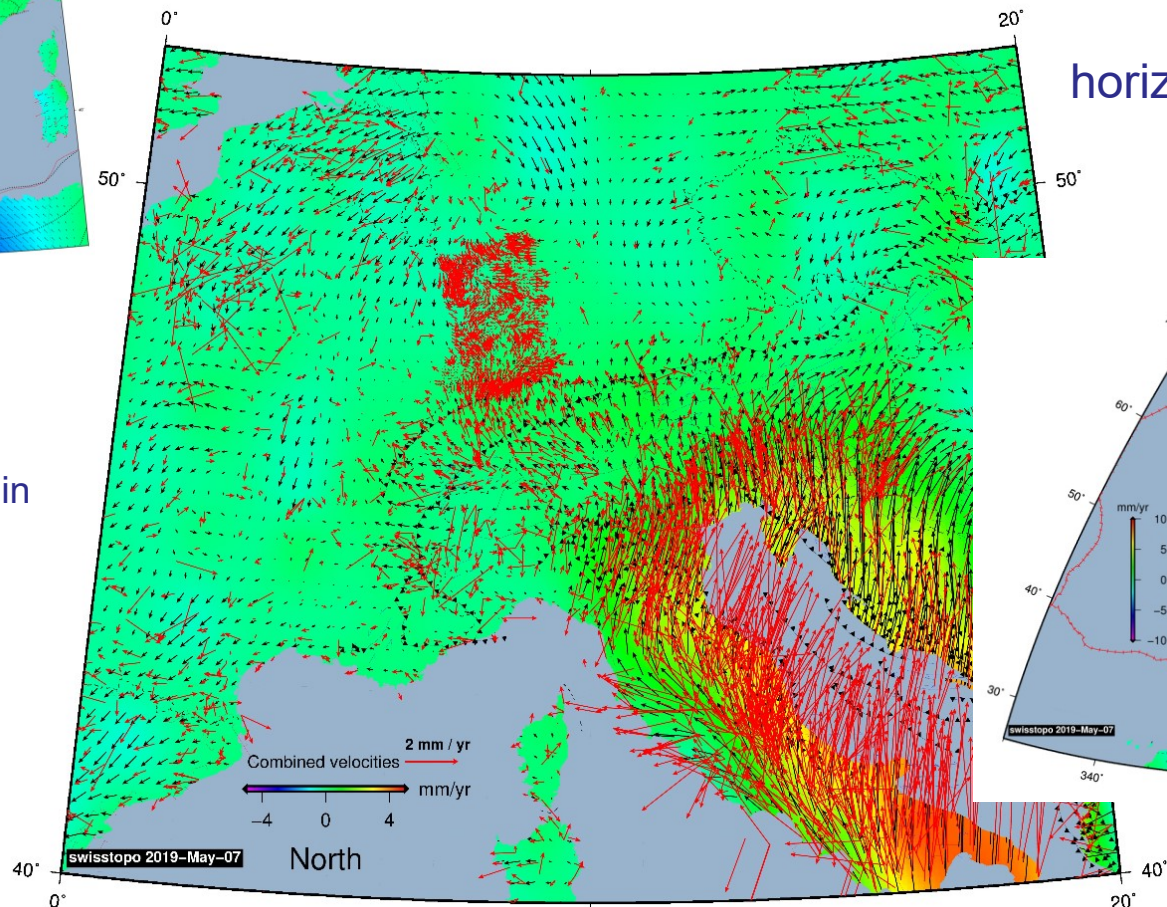
East velocities
~4 mm/yr
w.r.t. ETRF + North Spain

Static reference frame
newly defined

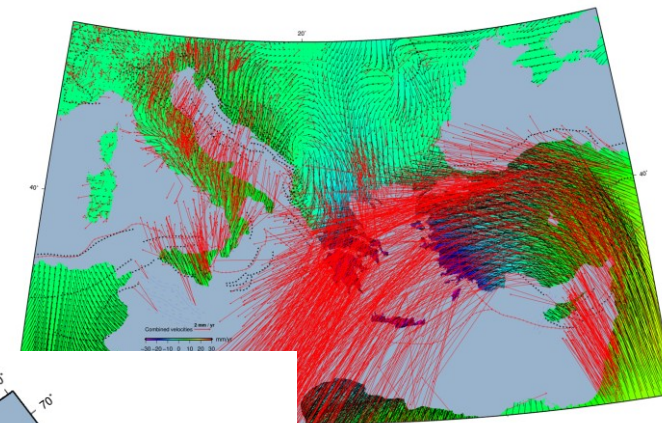
1.1.2017 : < 1 mm

July 2019 : < 10 mm

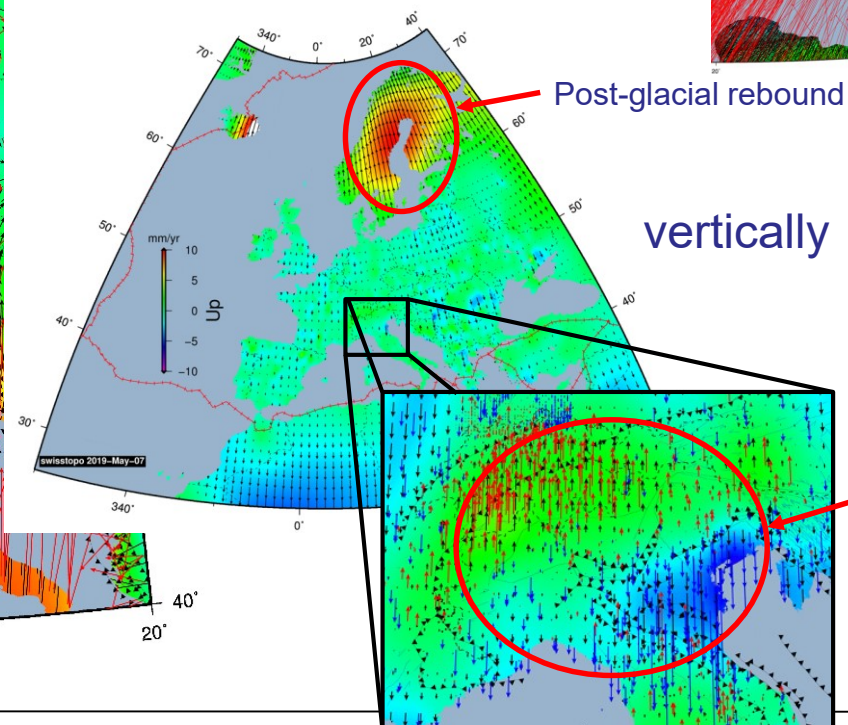
1.1.2022 : < 20 mm



horizontally



vertically



Post-glacial rebound

Alpine rise +
Po-basin
subsidence

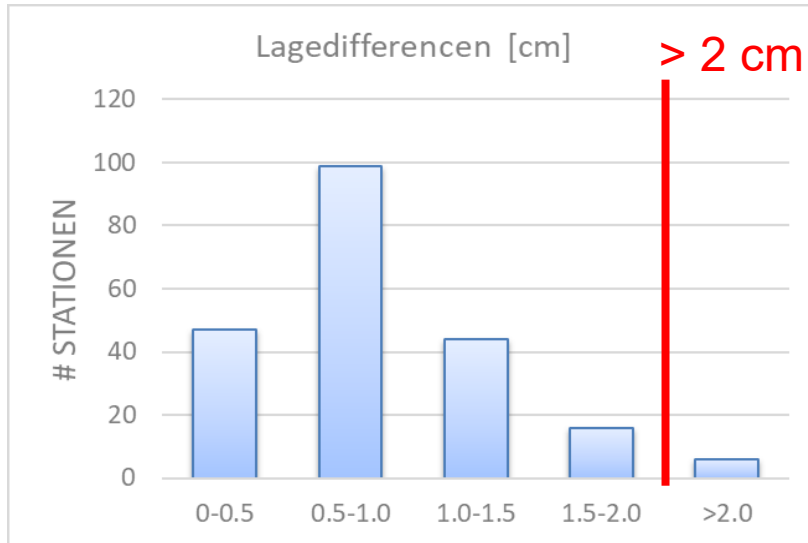
http://pnac.swisstopo.admin.ch/divers/dens_vel/000.html#VELOCITIES



Static reference frame – how long?

- Limits of 2 cm horizontal accuracy of LV95 reference points will soon be exceeded.

Status 2016
(200 points)
horizontally



«Nachführungskonzept Landesvermessung»

6 (2.8 %) of main- and densifikation points > 2 cm
(Hohentwil, Les Haudères, Santa Maria, Siblingen,
Zernez, Zervreilasee).

In 3 years (every 6 years) much more...

- A kinematik model (currently zero) need to be developed (in collaboration with EU) to maintain static reference frame on a longer view without changing coordinates. Solution (grid and software) must be easy to be implemented for all users.