

E2 SERVICE – UPDATE

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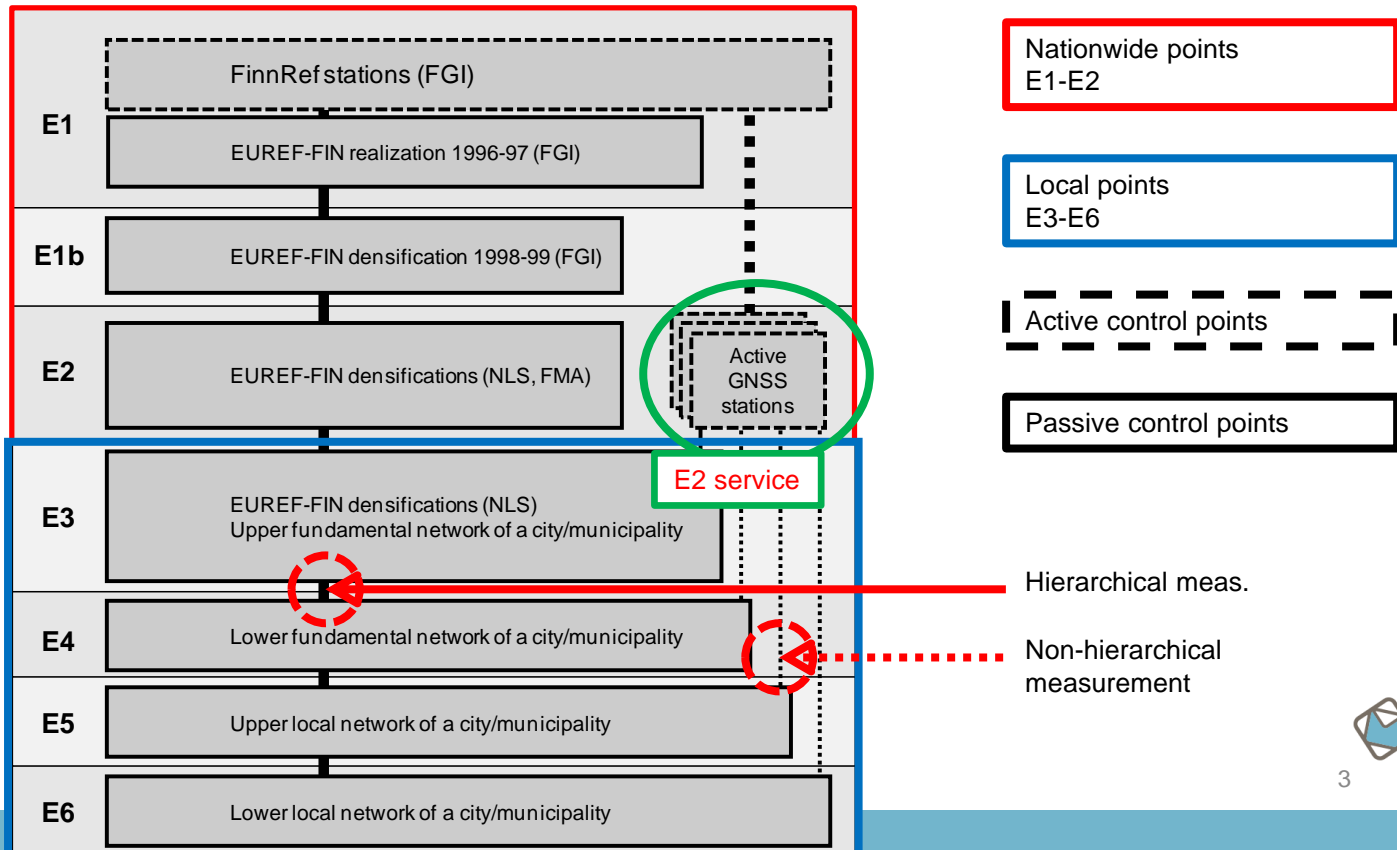
NLS
FINNISH GEOSPATIAL
RESEARCH INSTITUTE
FGI

NKG WGRF meeting
Reykjavik, Iceland, March 10-11, 2020

BACKGROUND

- Early 2000's Finnish government decided not to open accurate governmental positioning service (Network RTK, NRTK)
- Positioning services provided by private companies
- While measurement techniques revolutionized and amount of users grew, guidelines were needed to control the quality of measurements
- Recommendation for the public administration (JHS) no 184 (12/2012) guides the measurements of control points in EUREF-FIN (<http://www.jhs-suositukset.fi/suomi/jhs184>)
- Includes also guidelines for determining official EUREF-FIN coordinates for **active control points** (permanent GNSS stations)
 - Large active networks to be included in the **nationwide second order EUREF-FIN network E2**

CLASSIFICATION OF EUREF-FIN CONTROL POINTS



ACTIVE STATIONS IN (NATIONWIDE) E2 NETWORK

- Number and usage of CORS stations increased rapidly in 21st century
 - Need for guidelines and classification (status)
- **Station or network of stations can/should be classified in E2 if:**
 - it produces positioning services
 - it is spatially wide use or number of users is large
- Guidelines and requirements to include station or network of stations to nationwide E2 network can be found in separate guidelines, briefly:
 - Station equipment, location/surroundings, data transfer
 - Processing of coordinates and monitoring
 - **FGI determines the coordinates (E2 processing center)**
 - Station data has to be available to the FGI to be able to determine the coordinates and to ensure their quality in time (**monitoring**)
 - E2 web pages (in Finnish): <https://www.maanmittauslaitos.fi/tutkimus/asiantuntijapalvelut/e2-laskentapalvelu>
 - Up-to-date list of approved stations

E2 STATUS

- **Monitoring of reference station coordinates**, not the positioning service itself
- **FGI (NLS):**
 - Provides coordinates and expects their usage in the positioning service
 - Ensures that the network is well-aligned to the EUREF-FIN reference frame and that coordinates fulfill E2 criteria, also in time
- **Service provider:**
 - Responsible of using the E2 coordinates in the positioning service
 - Responsible of informing FGI about all changes at stations (decommissioning, re-locations, antenna changes,...)
 - Responsible of the quality of the positioning service
- **User/client:**
 - Assurance that all E2 qualified services are compatible regarding the reference station coordinates (real-time positioning still a responsibility of service provider and user/surveyor – JHS184 guides control point measurements)
- System has worked well even if on recommendation basis – users have requested E2 status while tendering services → both nationwide and one local service providers have applied E2 status
 - Currently ~200 stations with E2 status

BERNESE PROCESSING

Daily processing (E2_R2S)

Weekly solutions (E2_ADD)

The main parameters and models used in processing:

Input data	
GPS+GLO observations	Continuous data at 30 seconds interval in RINEX 2.11 format
Orbits	CODE final products (IGS14)
Datum	Weekly combined solution (V03) by FGI (NKG LAC)
Antenna calibrations	Absolute individual corrections (by GEO++, Germany) for reference stations
	Type calibration corrections tables for E2 GNSS stations
Parameters and models	
Observables	Carrier phase double differences
	Elevation cut-off angle 10 degree
	L3 linear combination
Receiver clock biases	Estimated using code observations of individual receivers, eliminated in double differences
Satellite clock biases	Eliminated in double differences
Data rejection criteria	Low RINEX data quality, e.g. too few observations
	Double difference phase residual screening, threshold 4 mm for a normalized zenith residual
	Baseline data exceeding over-all sigma of 6 mm excluded as whole
Ambiguities	SIGMA algorithm
Ionosphere	L3 linear combination eliminates ionospheric effects
Troposphere	Dry part is modelled using VMF grid files based on numerical weather modelling by ECMWF
	Wet part (zenith path delay) is estimated using Vienna mapping function (VMF) at 1-hour intervals for individual sites
	No troposphere gradient parameters estimated
Tidal displacement	Solid Earth tides implemented in Bernese 5.2. according to IERS conventions 2010
Ocean loading modelling	FES2004
Atmospheric loading	Ray Ponte, 2003
Datum definition	Minimum constrained solution to observation epoch IGS14 of the reference sites (27 stations FinnRef etc.)

E2 COORDINATES

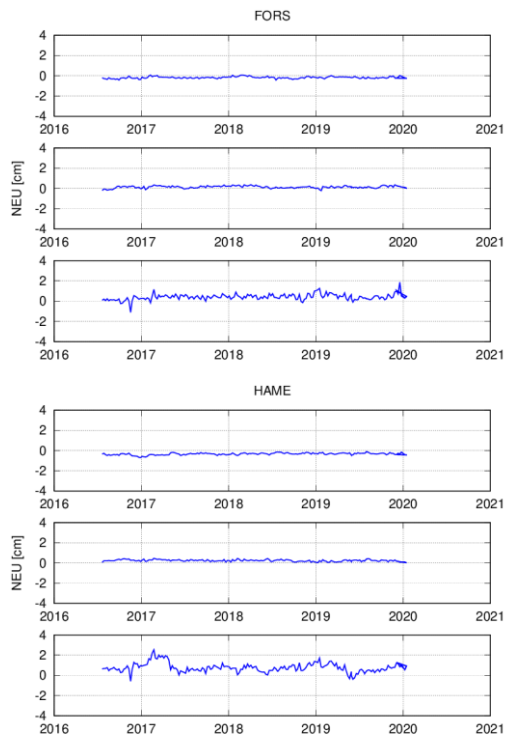
- Daily processing in ITRF
 - Same/similar routines as for NKG AC processing
 - Using NKG FGI solution as the backbone
- Determining reference station coordinates
 - 5 weeks of data
- ITRFyy(tc) coordinates **transformed to EUREF-FIN with the NKG transformation**
 - Using **PROJ** (NKG parameter file):
> echo X Y Z tc | cct +proj=pipeline
+step +init=NKG:ITRF2014 +inv
+step +init=NKG:FI
For monitoring part additionally:
+step +proj=tmerc +lon_0=27 +x_0=500000 +k_0=0.9996

E2 MONITORING

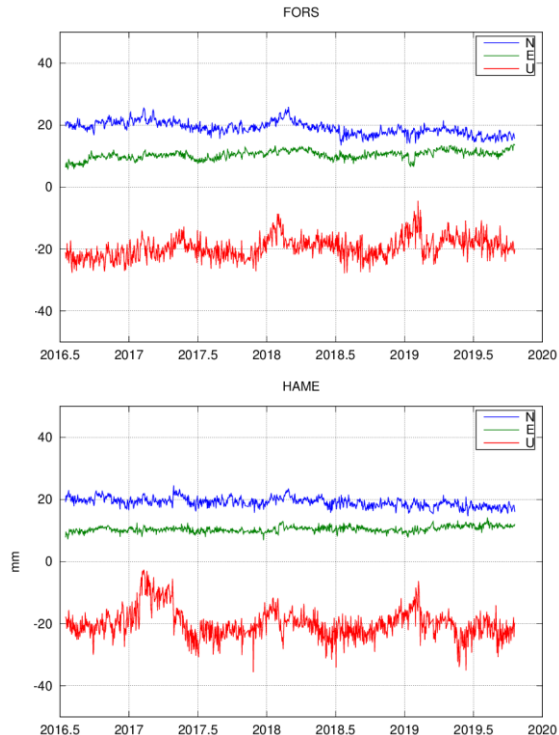
- Monitoring validity of E2 coordinates in EUREF-FIN → time series
- Time series
 - ITRF residual time series plots
 - EUREF-FIN plots
- Changing E2 coordinates
 - Antenna change and station re-location (service provider should inform but may be also visible in monitoring)
 - Other unknown causes exceeding thresholds (analyzed from a data window not single daily solution)
- In the future: more automatic

MONITORING EXAMPLES: GOOD

EUREF-FIN

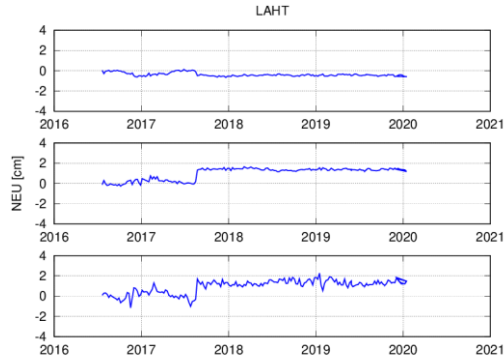


Residual ITRF

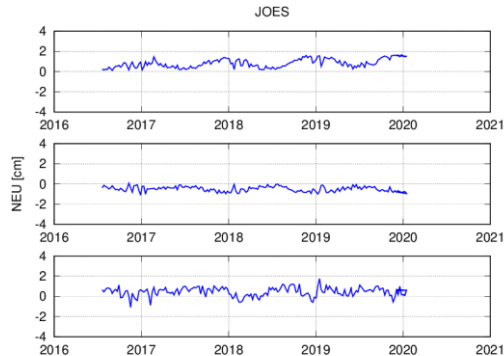


MONITORING EXAMPLES: ISSUES

EUREF-FIN

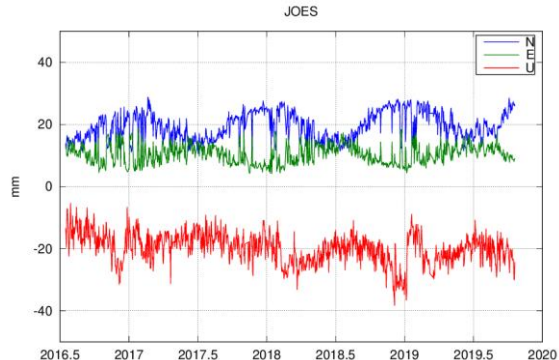
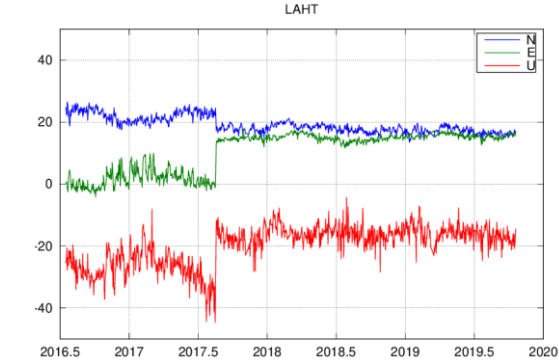


Antenna change:



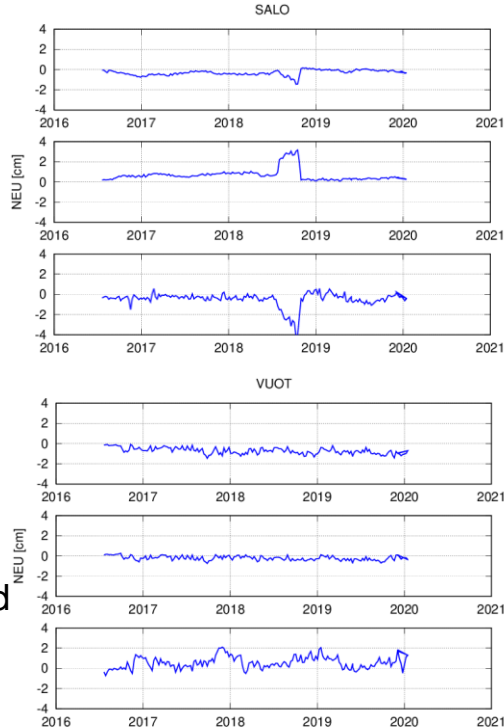
Unknown:
Larger amplitude

Residual ITRF



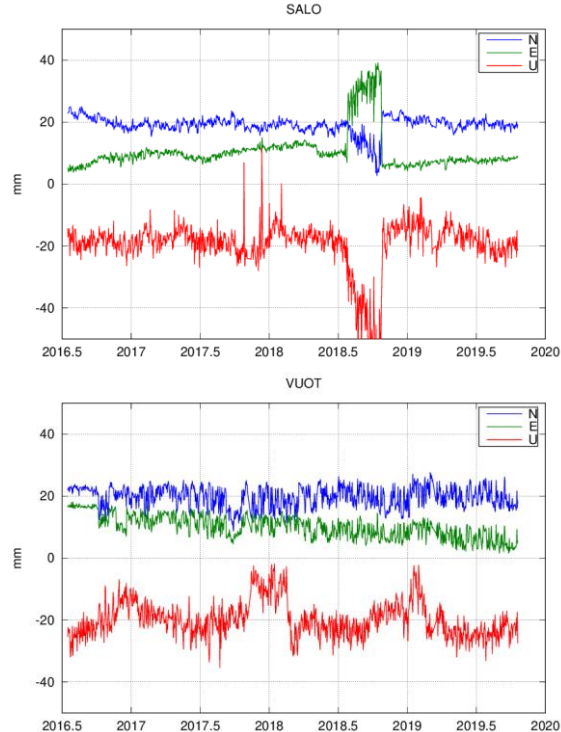
MONITORING EXAMPLES: ISSUES

EUREF-FIN



Strange jump,
Normalizes later

Residual ITRF



Snow?
East drift corrected
in EUREF-FIN

FUTURE DEVELOPMENT

- Monitoring currently manual/semi-automatic
 - Only plotting of time series and manual inspection
- Automize monitoring analysis
 - Bad data (data qc, results/time series)
 - Coordinate shifts/jumps → new E2 coordinates
- Webpage
 - Data quality
 - Time series

THANK YOU!



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