

# Reference Frame Coordination Status Report

## EPN Multi-year Position/Velocity Product

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# EPN multi-year position and velocity solution

- Multi-year position & velocity solution
  - using **CATREF** [Altamimi et al. 2007]
  - expressed in **IGS14**
- EPN **daily** SINEXs: 1996-now
  - **EPN-repro2** solutions (1996-2013)
  - Operational solutions (2014-now)
- Solution is **updated each 15 weeks**:
  - Official Positions & Velocities in IGS14, ETRF2000 and ETRF2014
  - Station Classification (Class A&B)
  - List of position & velocity discontinuities
  - List of daily outliers
  - Cleaned position time series
- Rapid time series (updated on a daily basis)

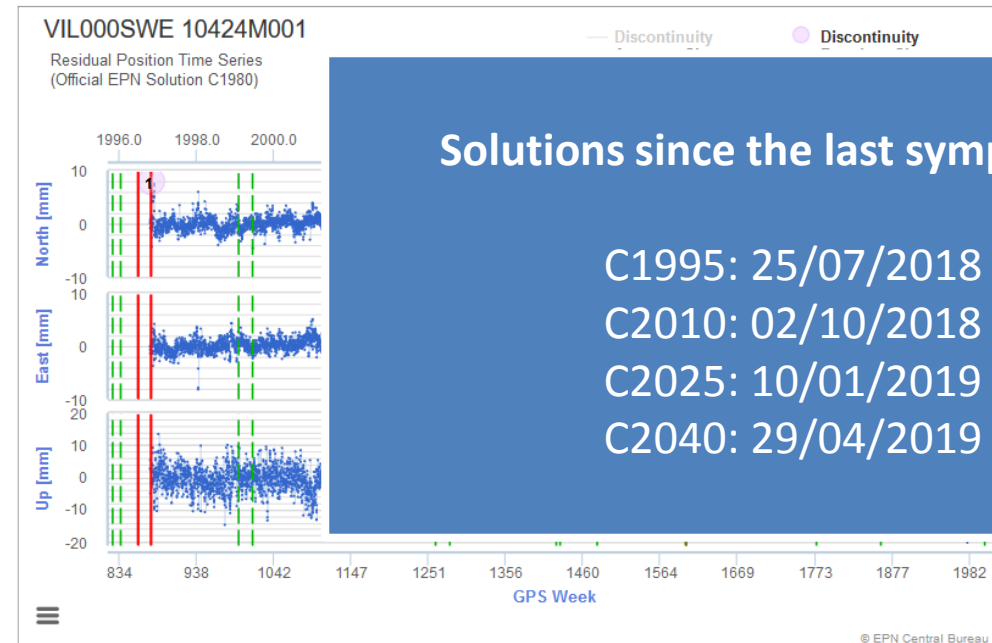
## MULTI-YEAR EPN SOLUTION

EPN station position time series:

VIL000SWE (Vilhelmina, Sweden) [Class A]

Other residual position time series: ITRF2014, IGS (no sitelog available at IGS), Nevada Geodetic Laboratory

OFFICIAL, SOLUTIONS INCLUDED UP TO 16-12-2017 (GPS WK 1799) ([READ MORE](#))



[Download Residual Position Time Series data](#)

[http://epncb.oma.be/\\_productsservices/timeseries](http://epncb.oma.be/_productsservices/timeseries)

[http://epncb.oma.be/\\_productsservices/coordinates](http://epncb.oma.be/_productsservices/coordinates)

# Additional SSC file format

## CLASS\_A EPN STATION POSITIONS AND VELOCITIES

REFERENCE FRAME: ETRF2014 AT EPOCH OF 2010.0

CUMULATIVE SOLUTION OF GPSWEEKS [ 0834 - 2040 ]

RELEASE NAME: EPN\_A\_ETRF2014\_C2040

RELEASED ON 29/04/2019 BY EPN REFERENCE FRAME COORDINATOR (Juliette LEGRAND, ROB, BELGIUM)

EPN\_A\_ETRF2014\_C2040.SSC

DOMES NB.	SITE NAME	TECH. ID.	X/Vx	Y/Vy	Z/Vz.	Sigmas	SOLN	DATA_START	DATA_END	REF. EPOCH
CLASS			-----m/m/Y-----							
10001M007	SMNE	GPS SMNE	4201792.244	177945.189	4779286.725	0.001 0.001 0.001	1	00:322:00000	08:118:86370	10:001:00000
10001M007			-.0001	-.0002	-.0000	0.0001 0.0001 0.0001				
10001M007	SMNE	GPS SMNE	4201792.254	177945.193	4779286.734	0.001 0.001 0.001	2	08:120:00000	09:069:86370	10:001:00000
10001M007			-.0001	-.0002	-.0000	0.0001 0.0001 0.0001				

## CLASS\_A EPN STATION POSITIONS AND VELOCITIES

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EPN\_A\_ETRF2014\_C2040\_ext.SSC

DOMES NB.	SITE NAME	TECH. ID.	X/Vx	Y/Vy	Z/Vz.	Sigmas	SOLN	DATA_START	DATA_END	REF. EPOCH
CLASS			-----m/m/Y-----							
10001M007	SMNE	GPS SMNE	4201792.243 <sup>99</sup>	177945.189 <sup>38</sup>	4779286.725 <sup>26</sup>	0.000 <sup>12</sup> 0.000 <sup>04</sup> 0.000 <sup>13</sup>	1	00:322:00000	08:118:86370	10:001:00000
10001M007			-0.0001 <sup>2</sup>	-0.0001 <sup>7</sup>	-0.0000 <sup>4</sup>	0.0000 <sup>2</sup> 0.0000 <sup>1</sup> 0.0000 <sup>1</sup>				
10001M007	SMNE	GPS SMNE	4201792.254 <sup>38</sup>	177945.192 <sup>77</sup>	4779286.734 <sup>32</sup>	0.000 <sup>13</sup> 0.000 <sup>05</sup> 0.000 <sup>14</sup>	2	08:120:00000	09:069:86370	10:001:00000
10001M007			-0.0001 <sup>2</sup>	-0.0001 <sup>7</sup>	-0.0000 <sup>4</sup>	0.0000 <sup>2</sup> 0.0000 <sup>1</sup> 0.0000 <sup>1</sup>				

[ftp://epncb.oma.be/epncb/station/coord/EPN/EPN\\_A\\_ETRF2014\\_C2040\\_ext.SSC](ftp://epncb.oma.be/epncb/station/coord/EPN/EPN_A_ETRF2014_C2040_ext.SSC)

# Station Classification

# Actual station classification

## Class A

**Suitable as reference station  
for ETRS89 densifications**

Positions at the 1 cm precision at all epochs  
and velocities at the 1 mm/yr precision

Positions & Velocities are published

## Class B

**Not suitable as reference station  
for ETRS89 densifications**

Positions have a 1 cm precision  
at the epoch of minimal variance

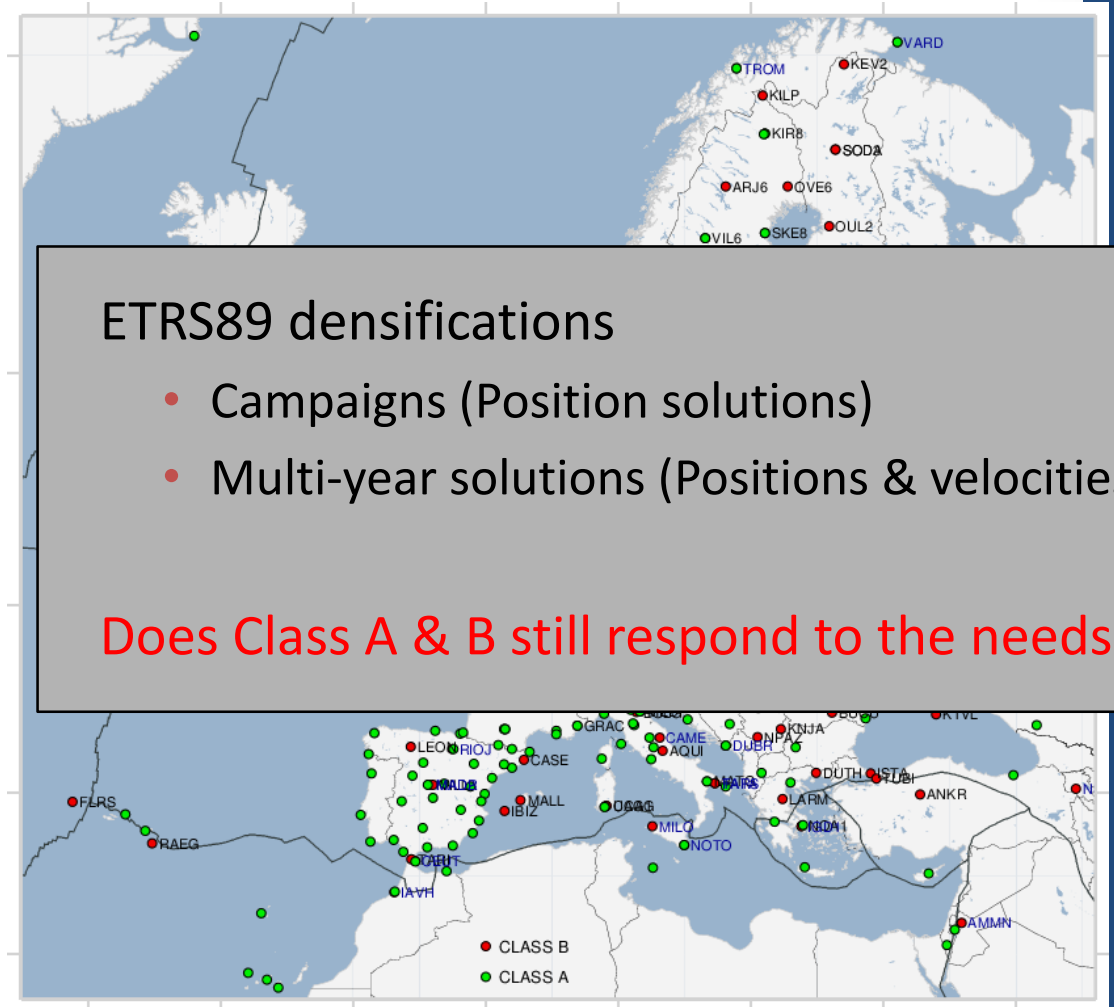
Positions at epoch of minimal variance are published

Velocities are not published

## ETRS89 densifications

- Campaigns (Position solutions)
- Multi-year solutions (Positions & velocities)

**Does Class A & B still respond to the needs ?**



# Goal

- Assess the ability of an EPN station to be used as reference station
  - Precision of positions and velocities
  - Stability of the time series
  - Level of noise or signals in the time series

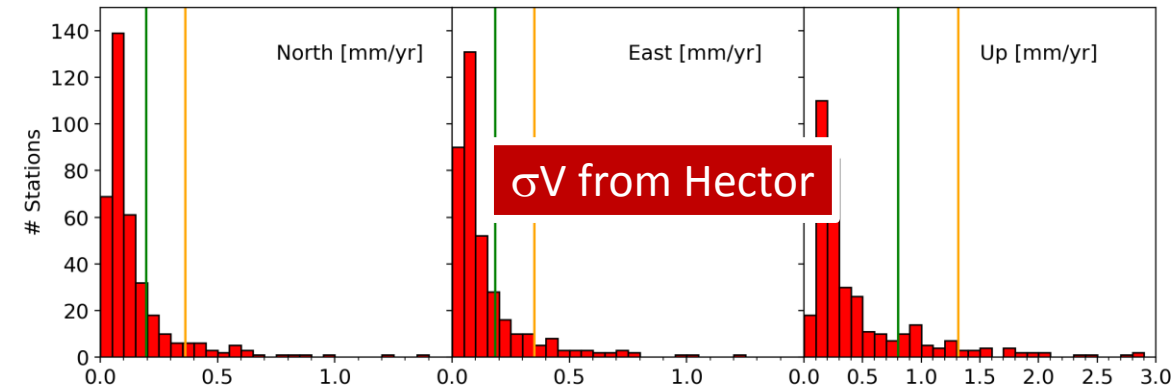
# Velocities: realistic error estimates

- Good position estimates require reliable velocities
- Velocity error estimates coming from CATREF are too optimistic
  - ⇒ derive more realistic error estimates on velocities by taking into account temporal correlated noise
- Positions + Velocities + Residuals from CATREF are used to take benefit from the well referenced Position Time Series
  - ⇒ Hector developed by [Bos et. al. 2013] used to estimate:
    - linear trend
    - annual, semi-annual signals
    - assuming temporal correlated noise (power-law + white noise)

# Comparison CATREF vs HECTOR

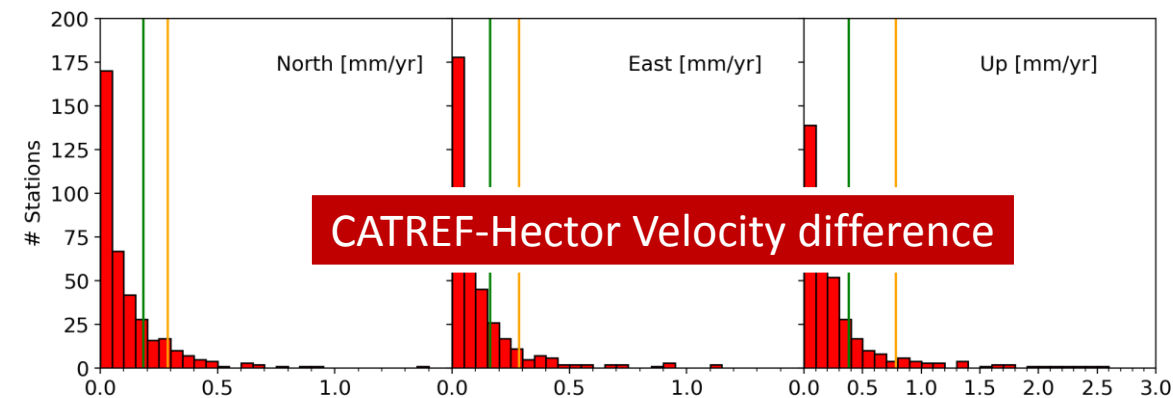
- Use more realistic error estimates from Hector to assess the quality of the station
- Use a 2<sup>nd</sup> estimate of the velocity from Hector to compare with CATREF estimate in order to assess the reliability of the velocity estimation
- Remaining Issues:
  - stations with long history and instabilities are not detected

Histograms of the velocity errors from Hector



75% of the velocity errors are  
< 0.2 mm/yr for the horizontal  
< 0.8 mm/yr for the vertical

Histograms of the velocity difference between CATREF and Hector

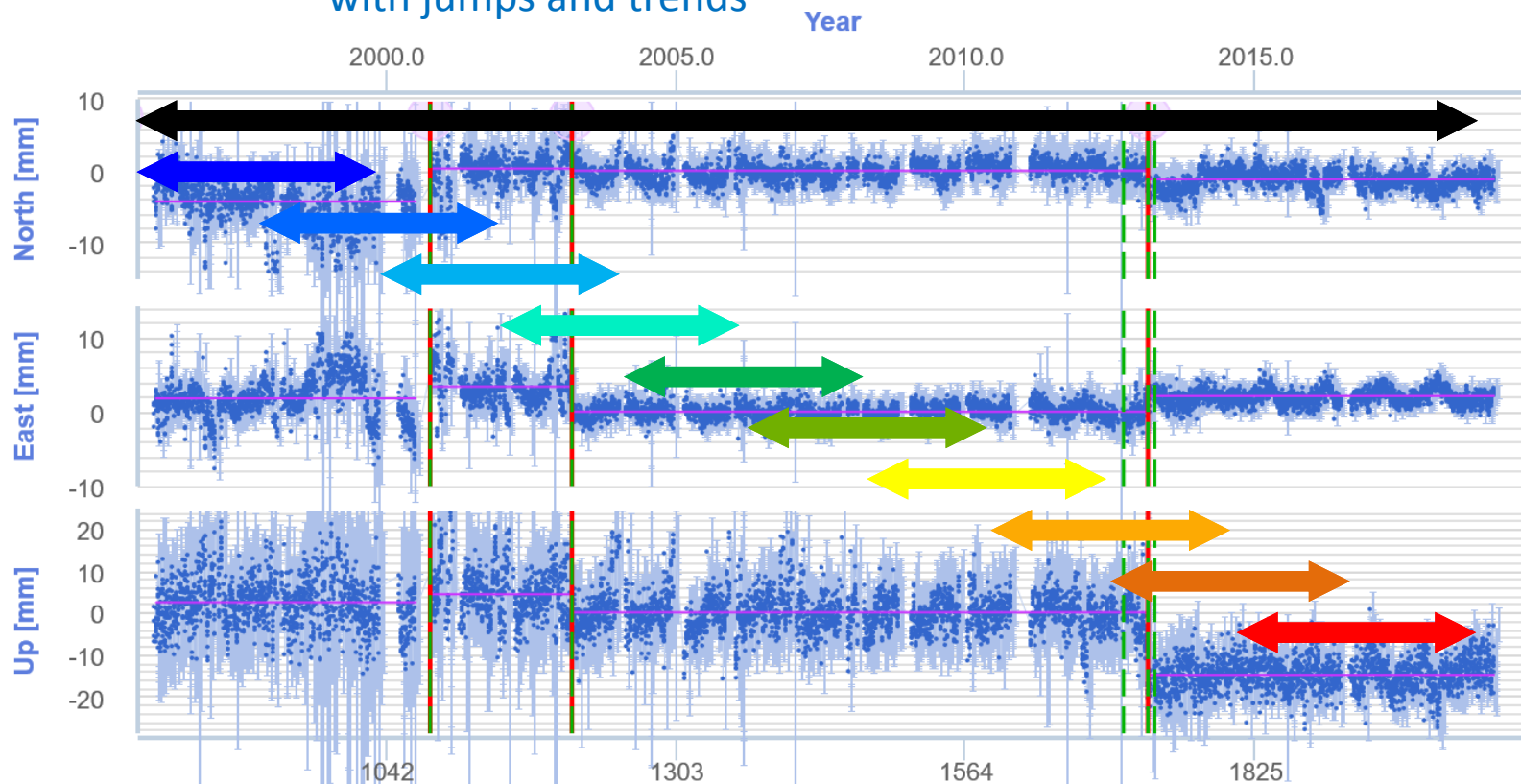




# Station stability & Velocity Variability

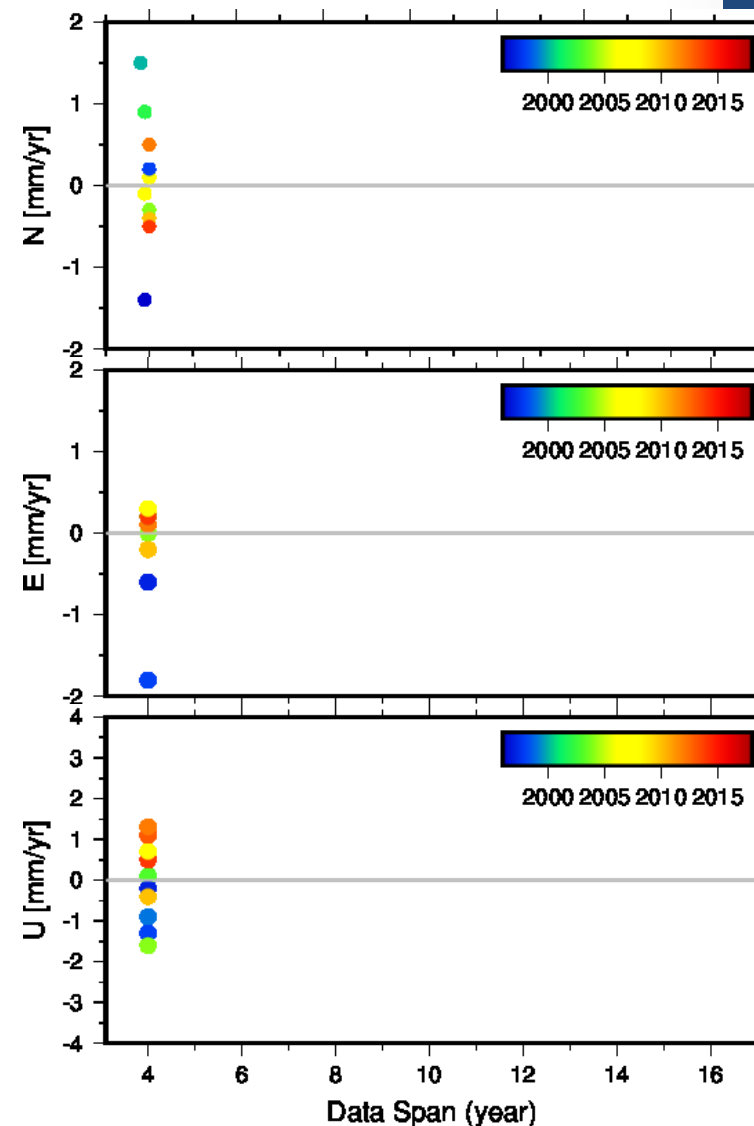
KIRU00SWE 10403M002

Input time series: position time series  
with jumps and trends



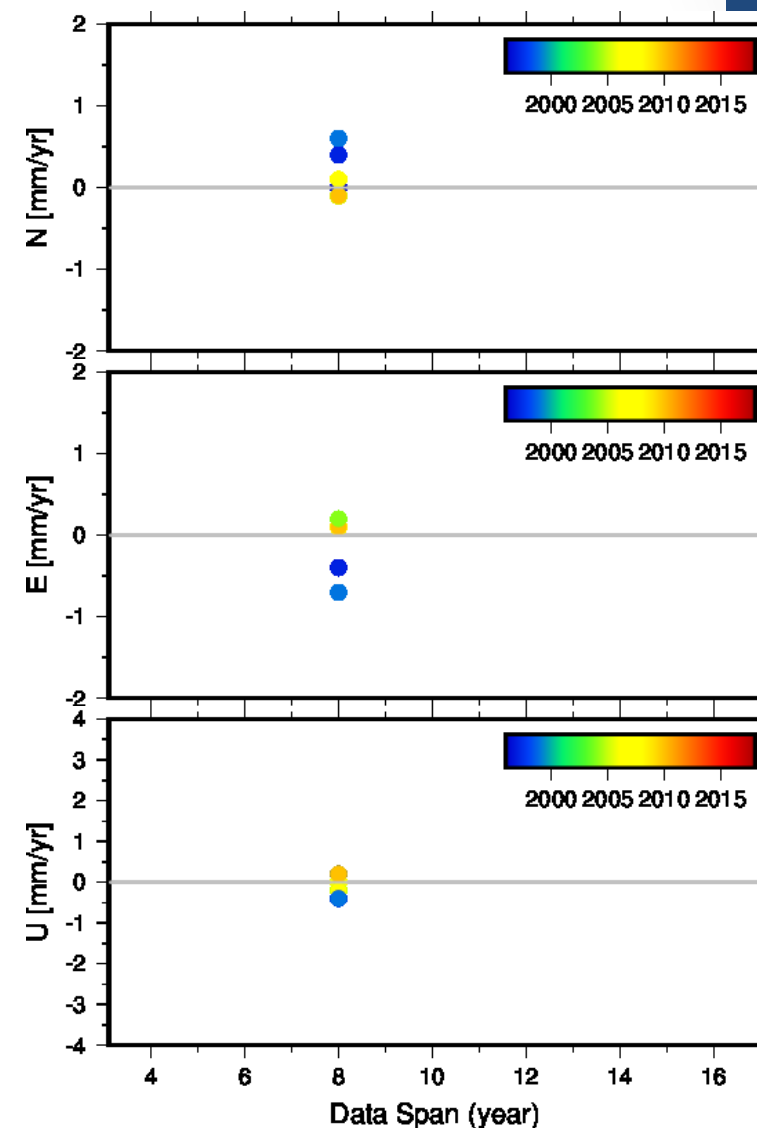
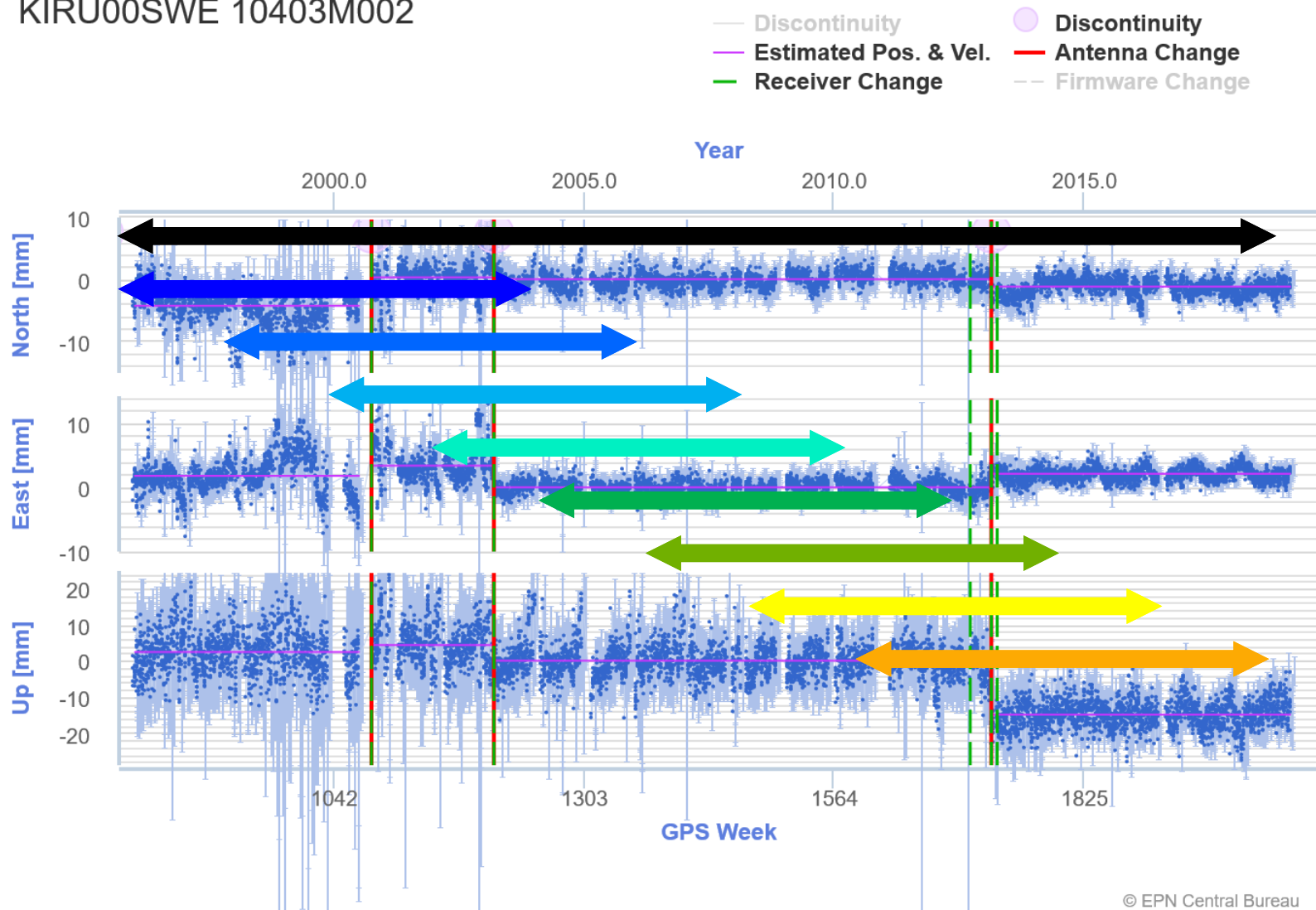
Estimation: velocity and position offsets

© EPN Central Bureau



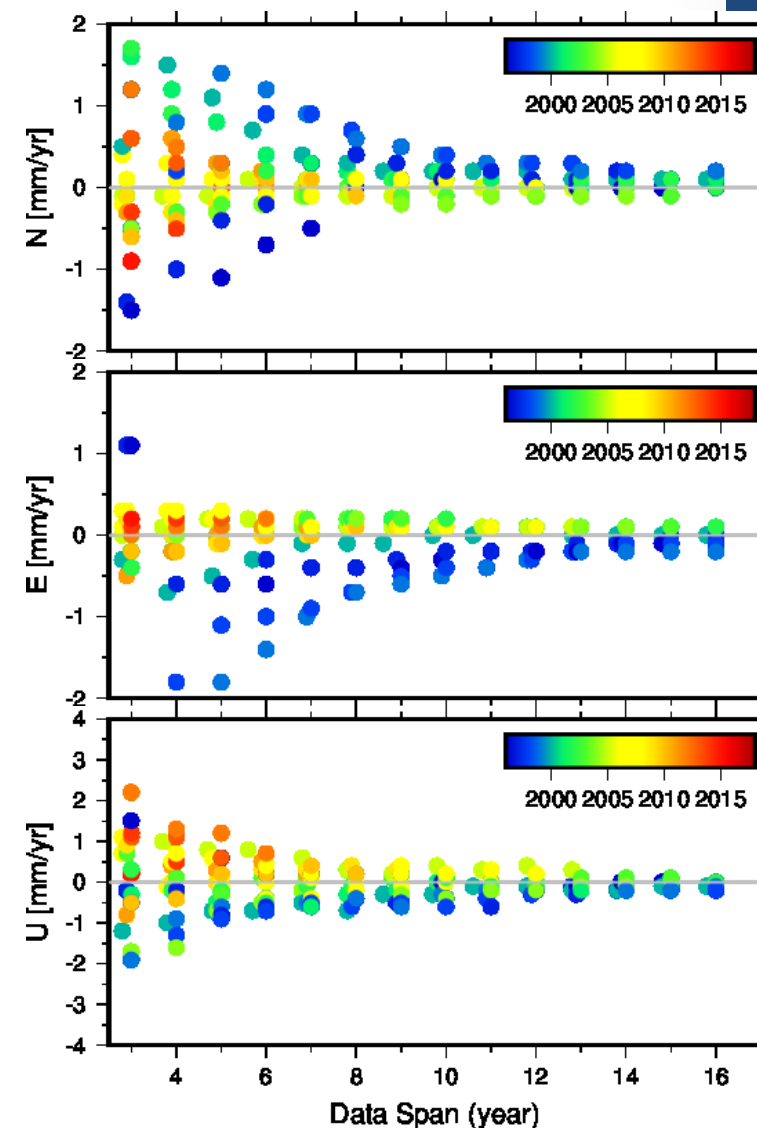
# Station stability & Velocity Variability

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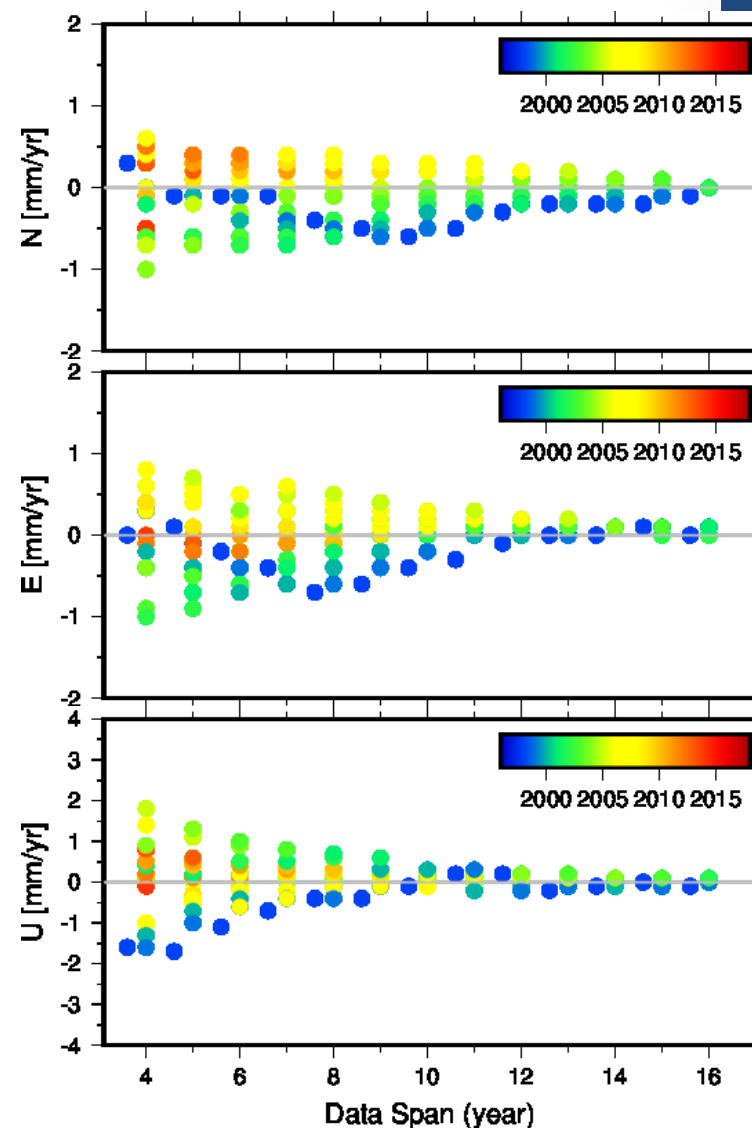
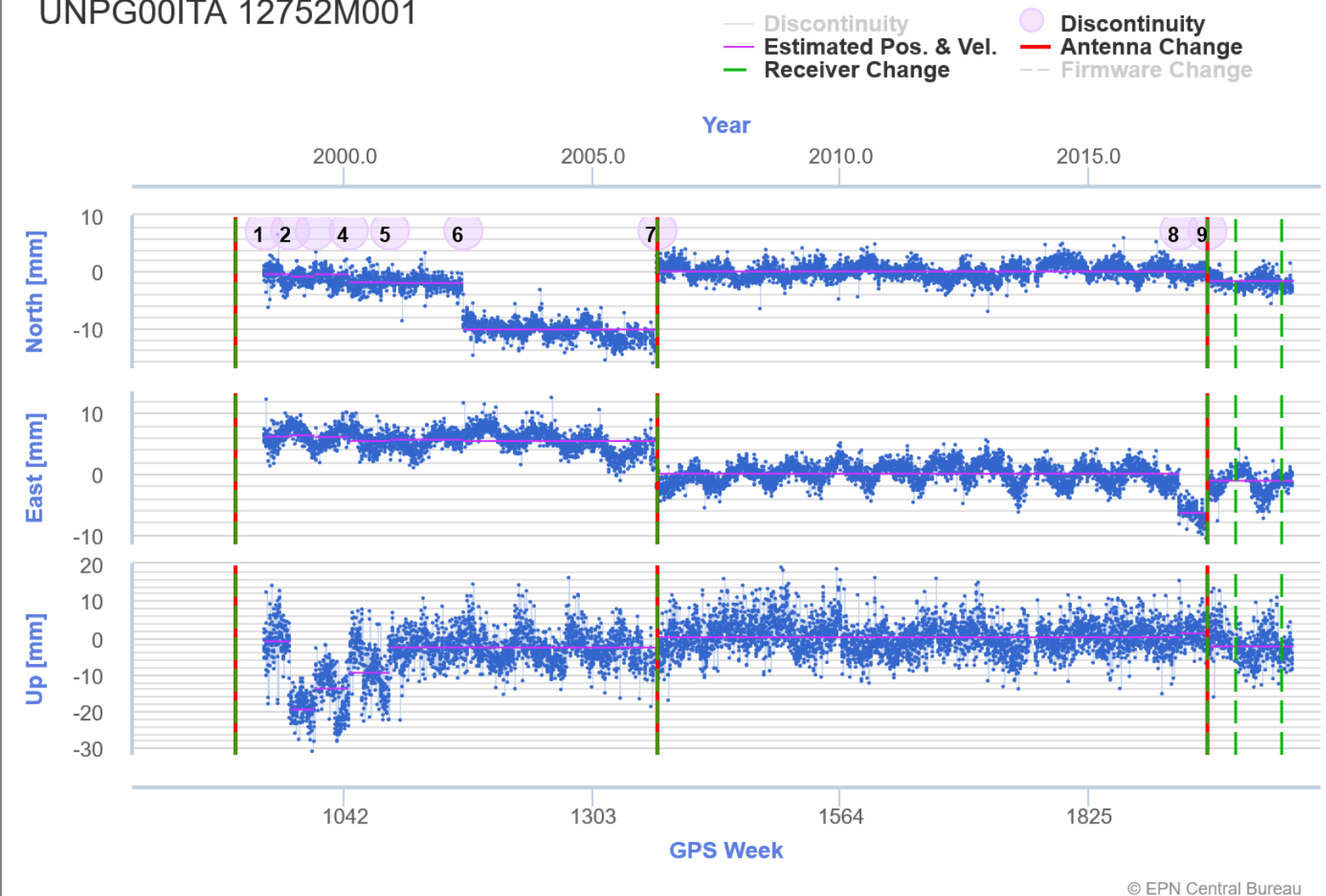
# Station stability & Velocity Variability

KIRU00SWE 10403M002



# Station stability & Velocity Variability

UNPG00ITA 12752M001



# Velocity Variability & Velocity Variability

ZYWI00POL 12220S001

— Discontinuity  
— Estimated Pos. & Vel.  
— Receiver Change  
— Discontinuity  
— Antenna Change  
— Firmware Change

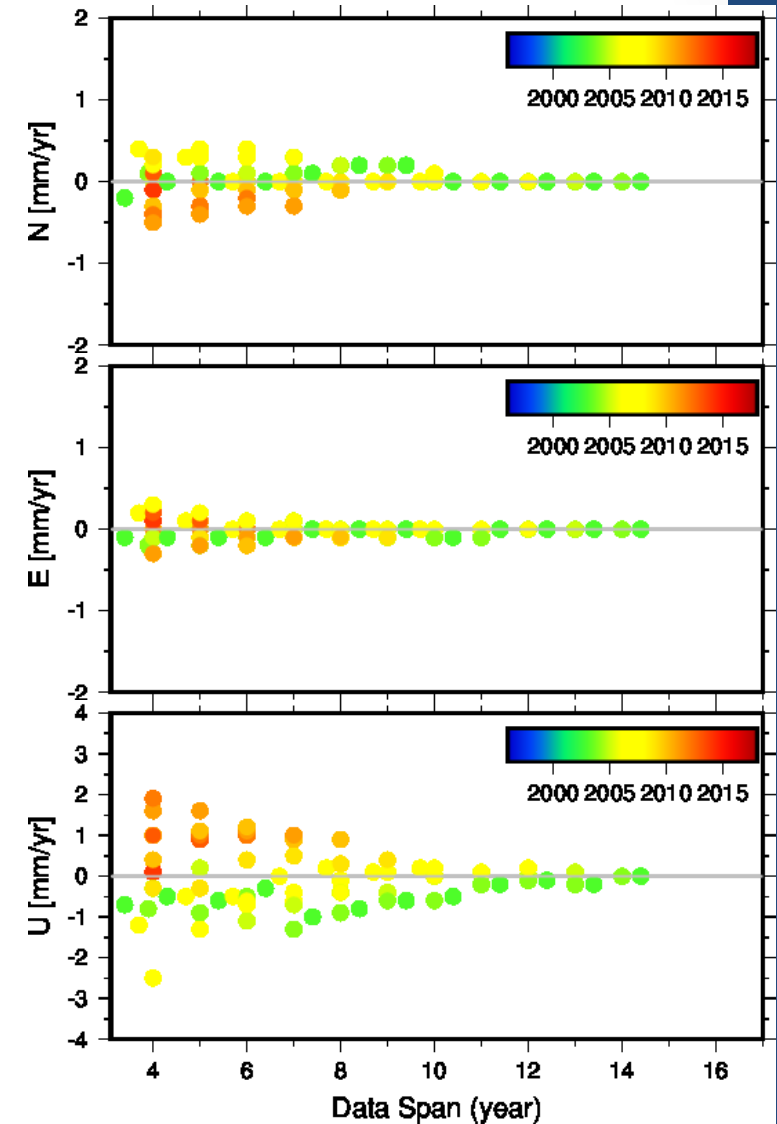
Year

2000.0 2005.0 2010.0 2015.0

GPS Week

1042 1303 1564 1825

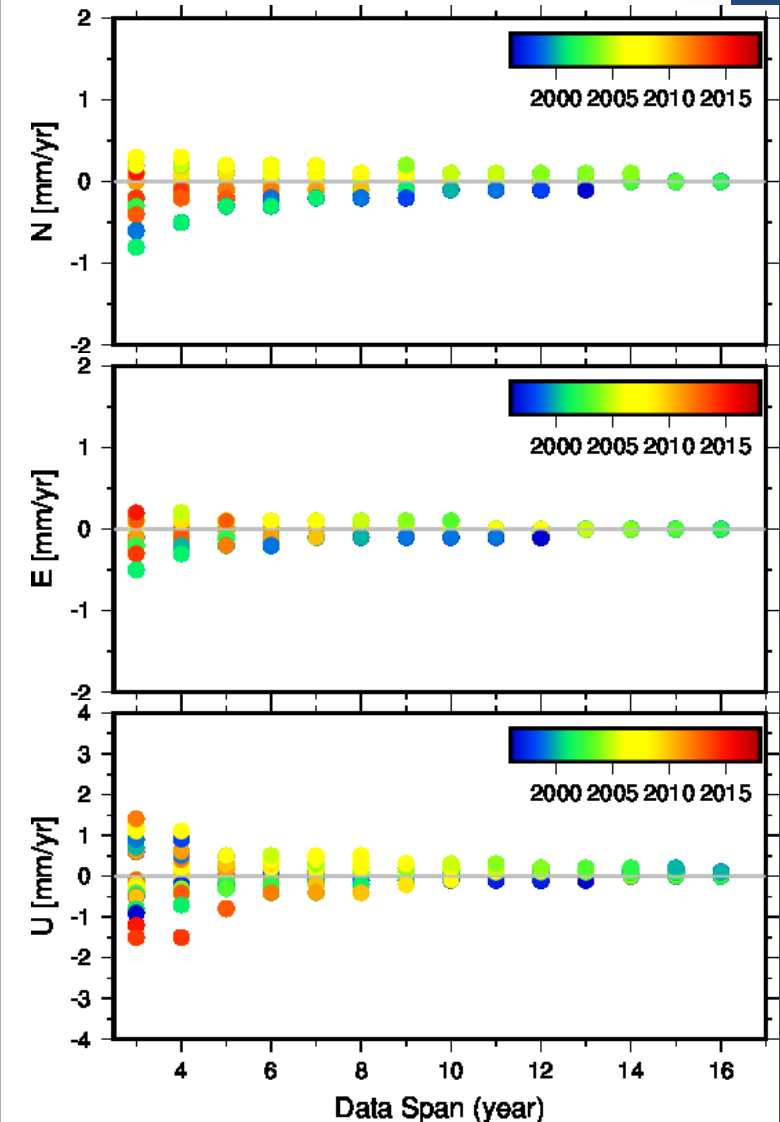
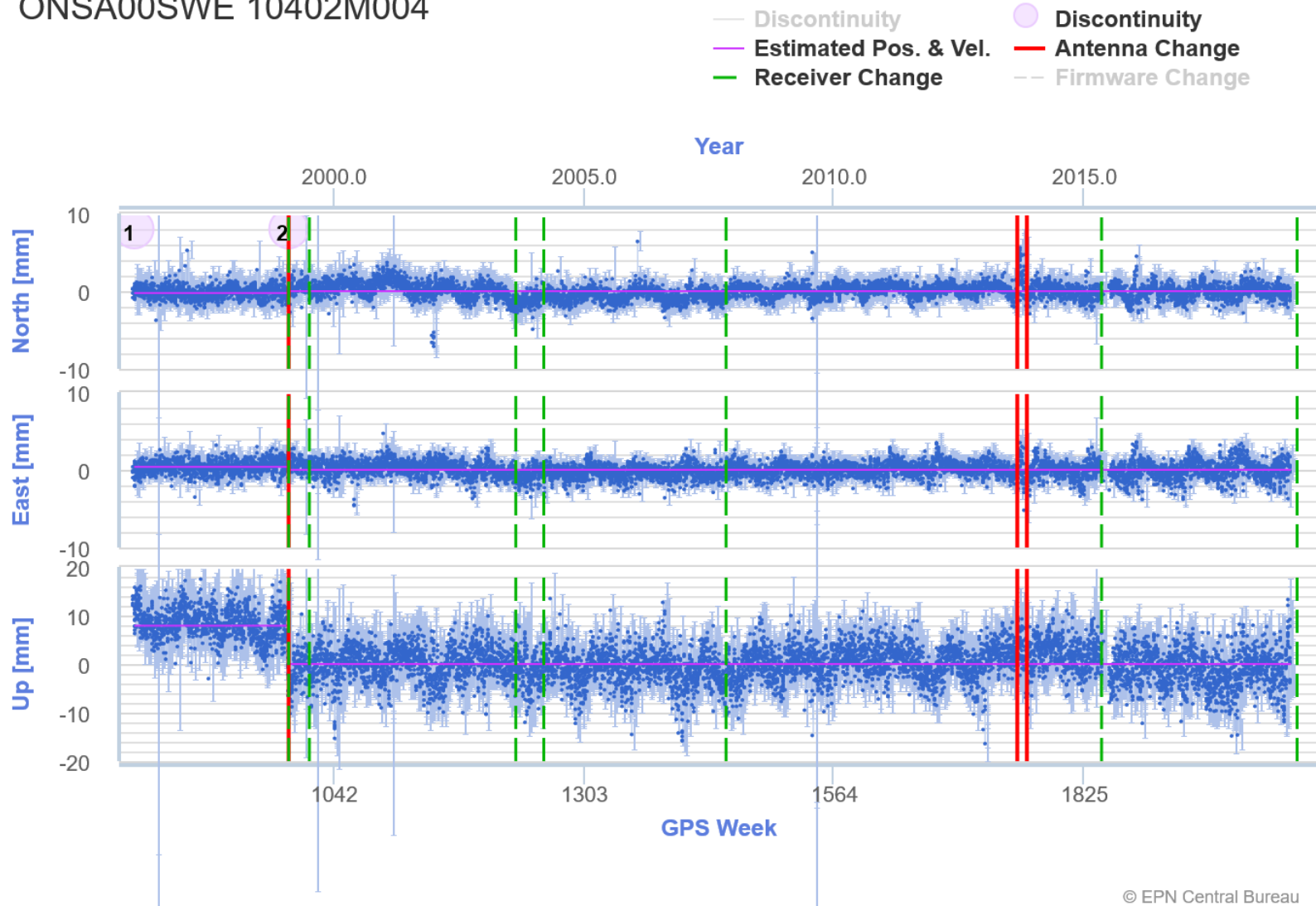
© EPN Central Bureau





# Velocity Variability & Velocity Variability

ONSA00SWE 10402M004



# Station stability & Velocity Variability

MARS00FRA 10073M008

— Discontinuity  
— Estimated Pos. & Vel.  
— Receiver Change  
— Antenna Change  
— Firmware Change

Year

2000.0

2005.0

2010.0

2015.0

North [mm]

East [mm]

Up [mm]

The more the time span of the  
ETRS89 multi-year densification  
differs from the time span  
in the EPN multi-year solution



The more the station needs to be stable  
The less the velocity can vary

1042

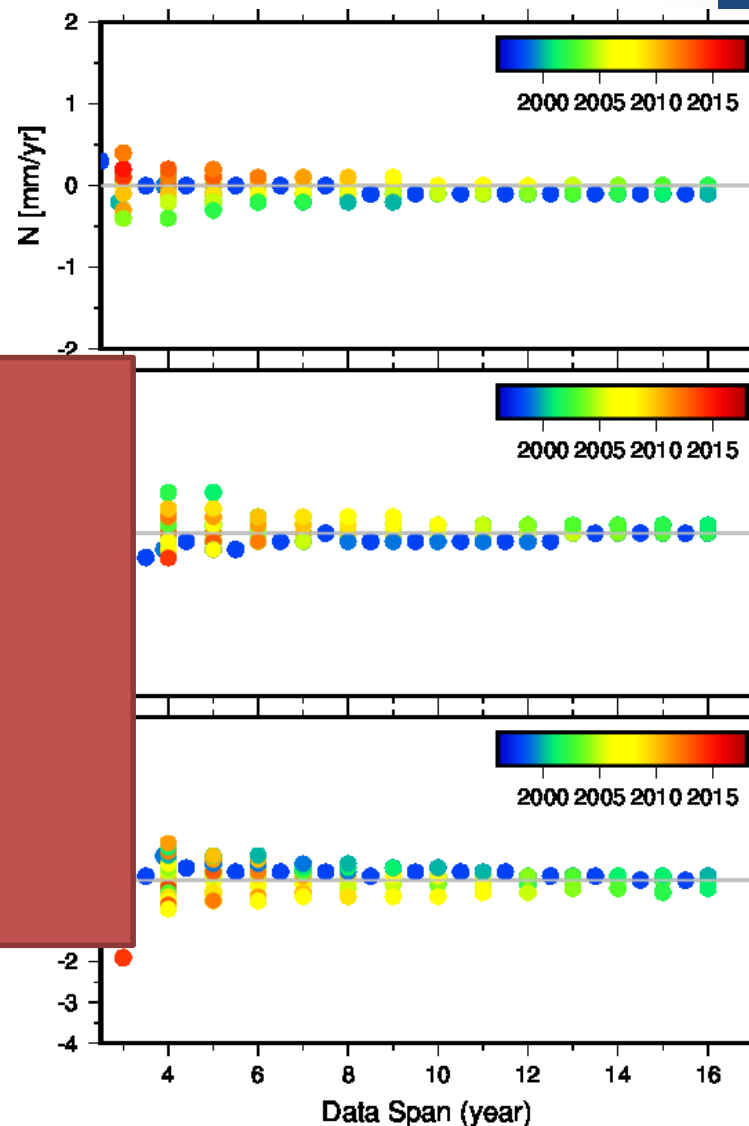
1303

1564

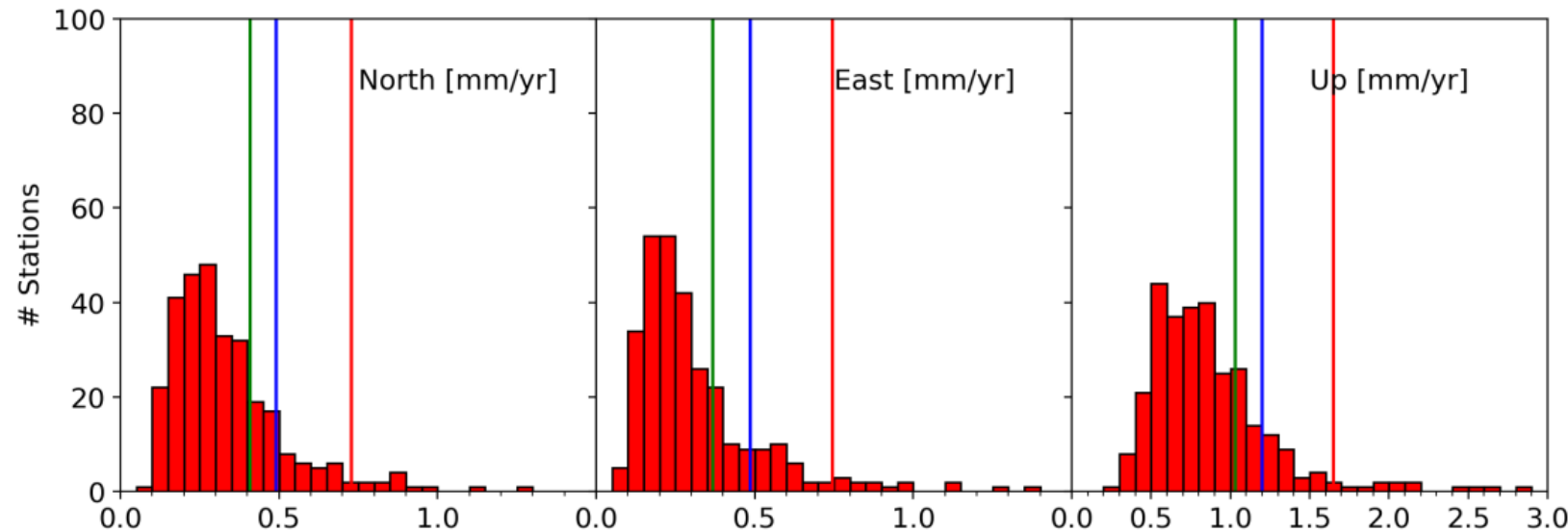
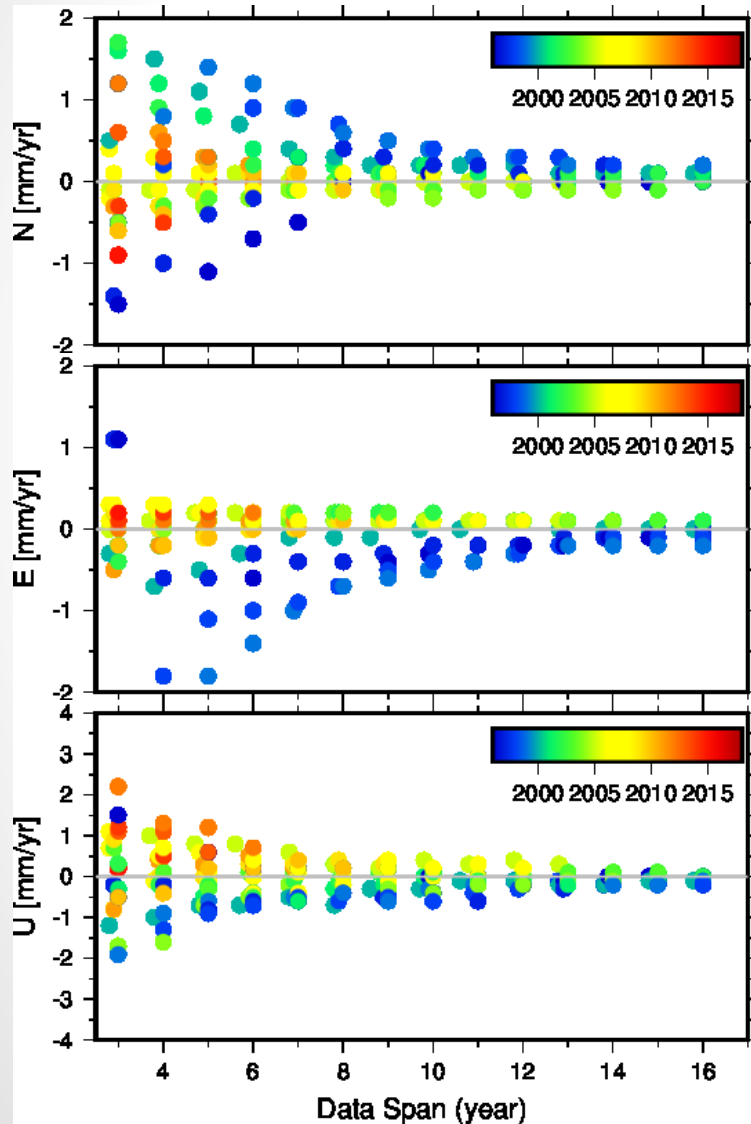
1825

GPS Week

© EPN Central Bureau



# Velocity Variability



STD of the velocity differences between the velocity estimated with the segment ( $> 4$  years) and the full period



# Actual station classification

## Class A

**Suitable as reference station  
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**Not suitable as reference station  
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at the epoch of minimal variance

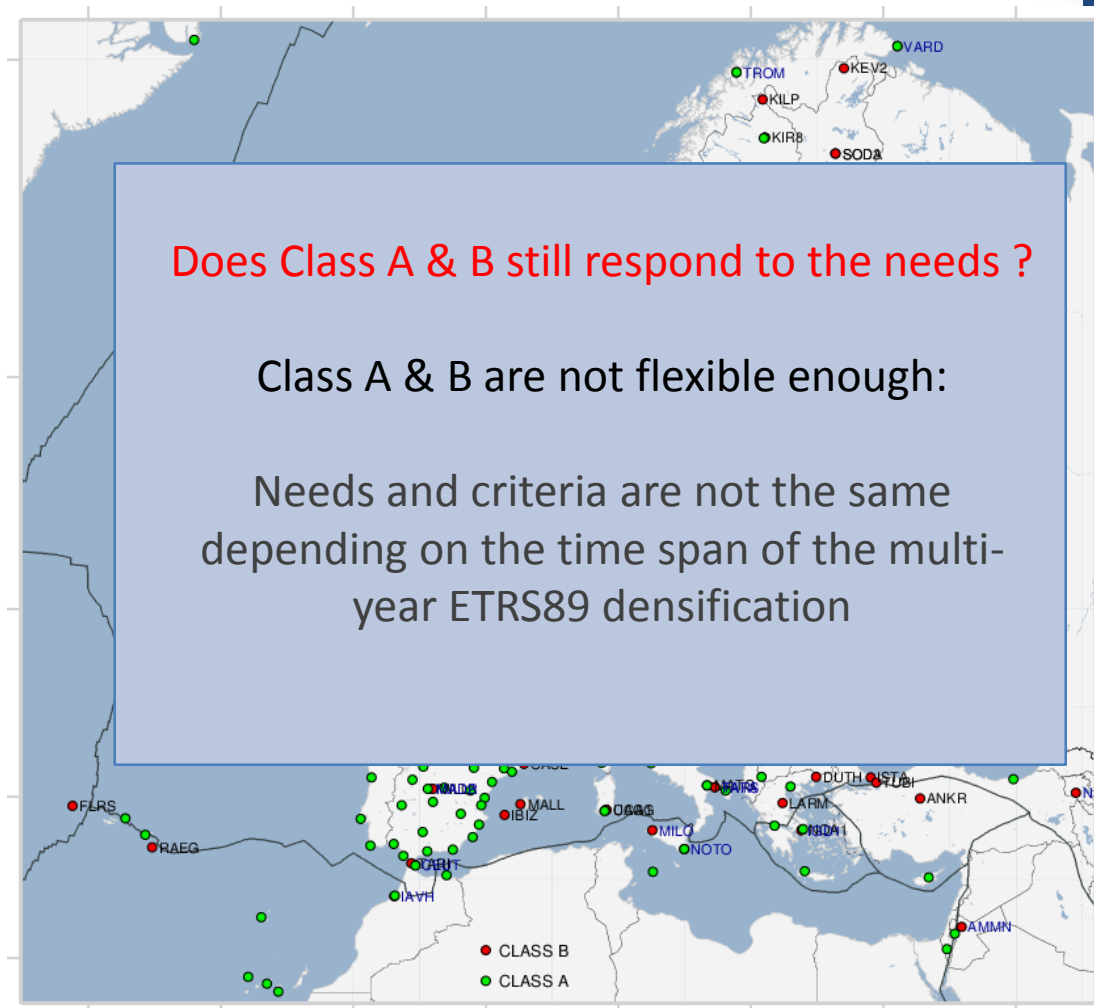
Positions at epoch of minimal variance are published

Velocities are not published

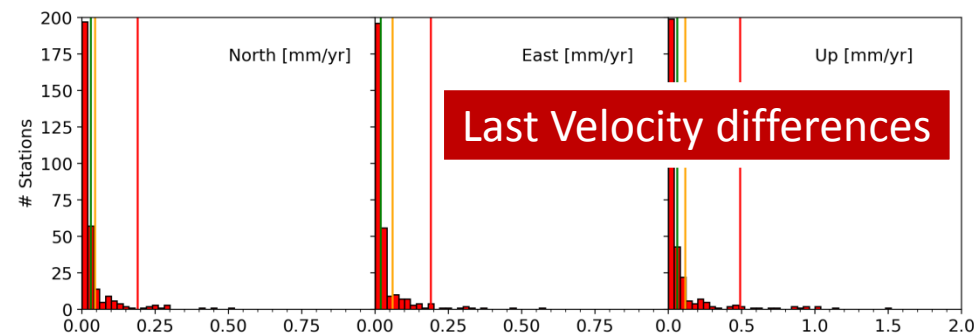
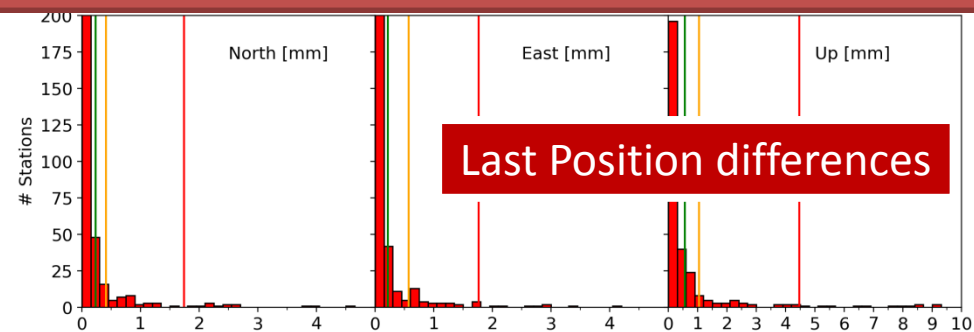
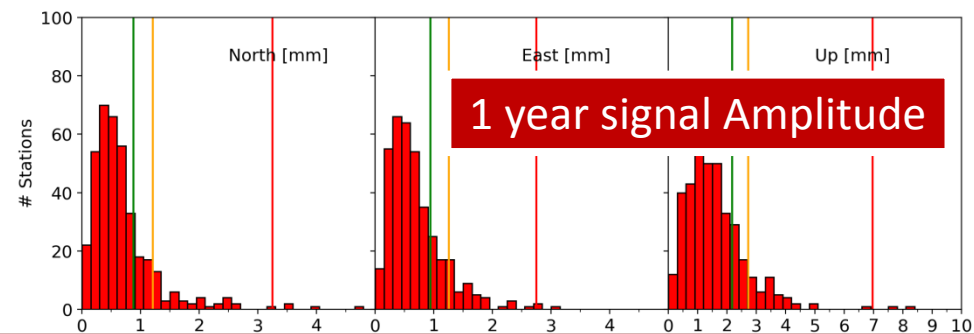
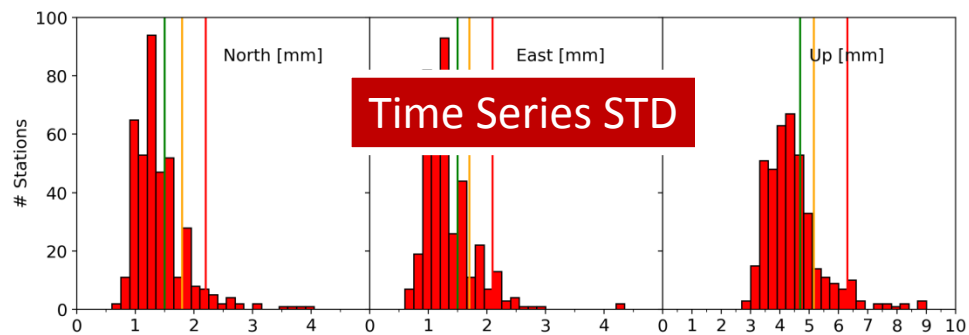
Does Class A & B still respond to the needs ?

Class A & B are not flexible enough:

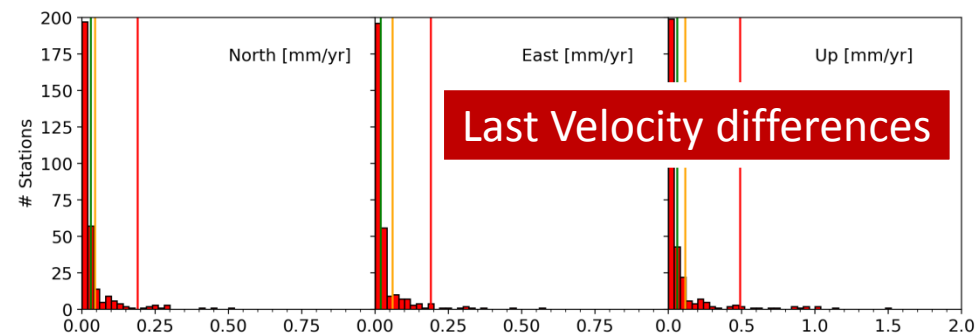
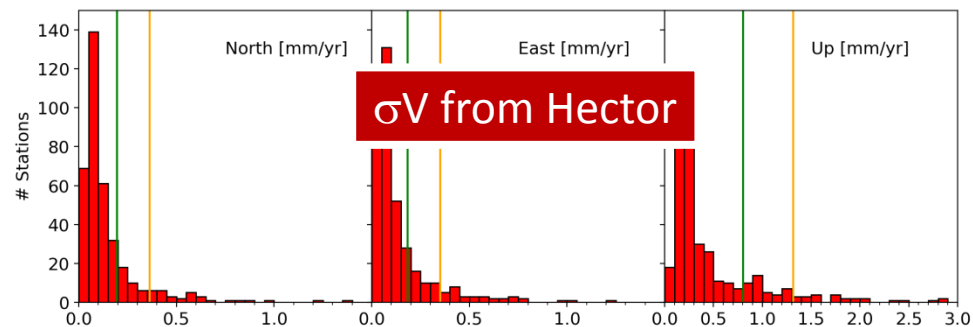
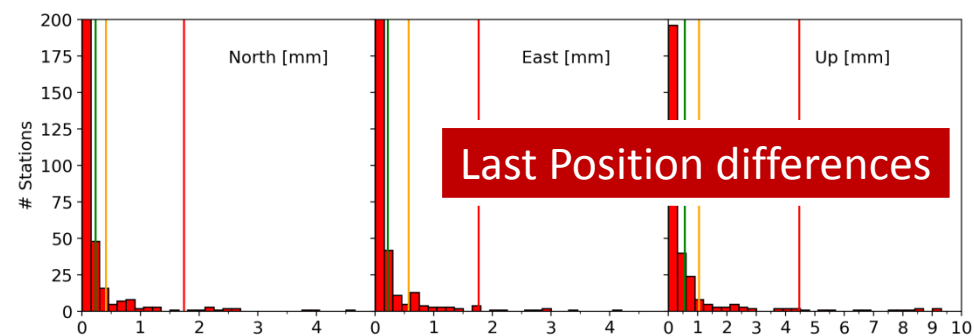
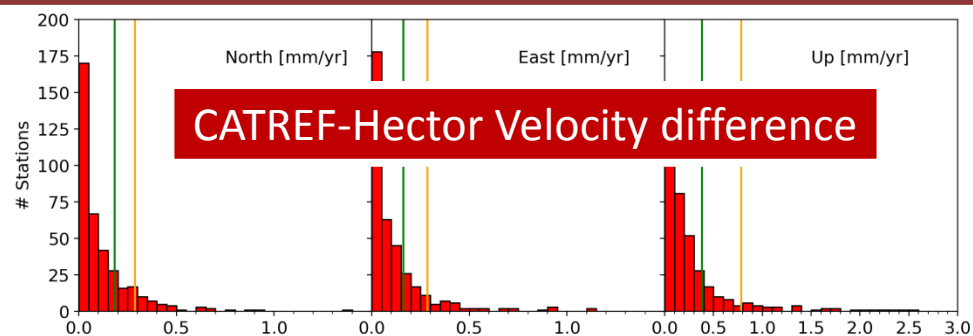
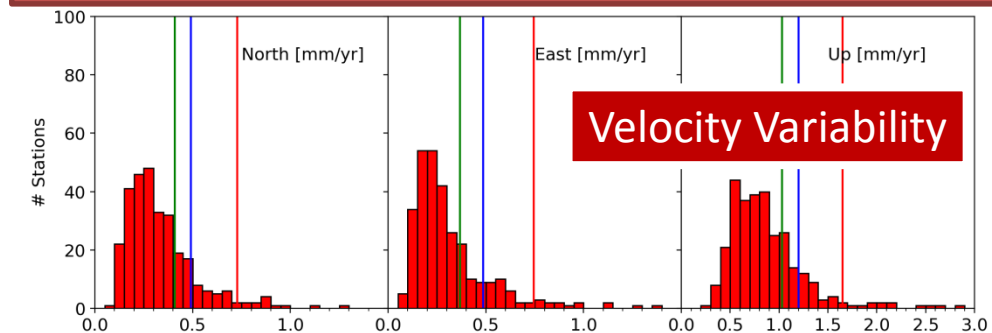
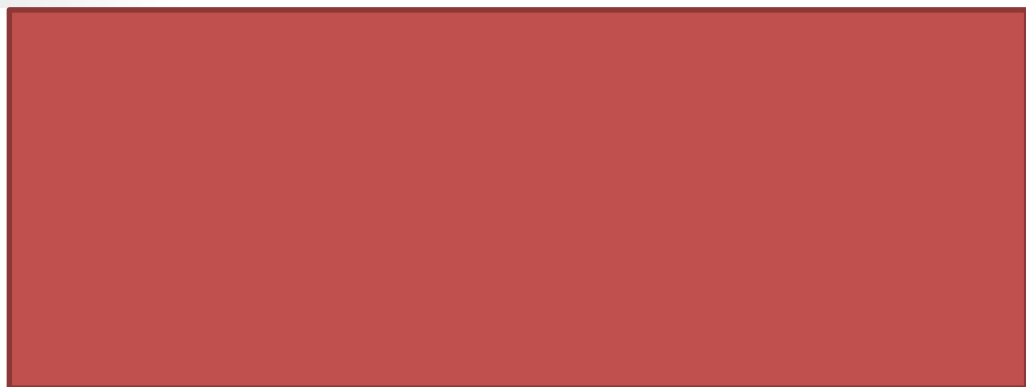
Needs and criteria are not the same  
depending on the time span of the multi-  
year ETRS89 densification



# Criteria for classification



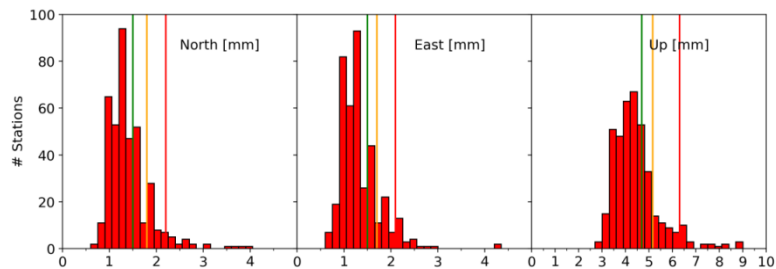
# Criteria for classification



# Time Series STD & 1 year signal Amplitude

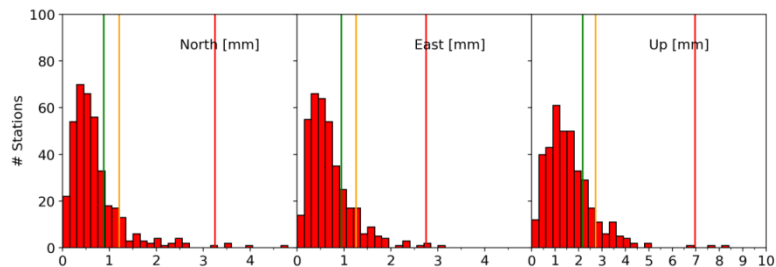
- Time Series STD:

STD over the full time span of the residual time series

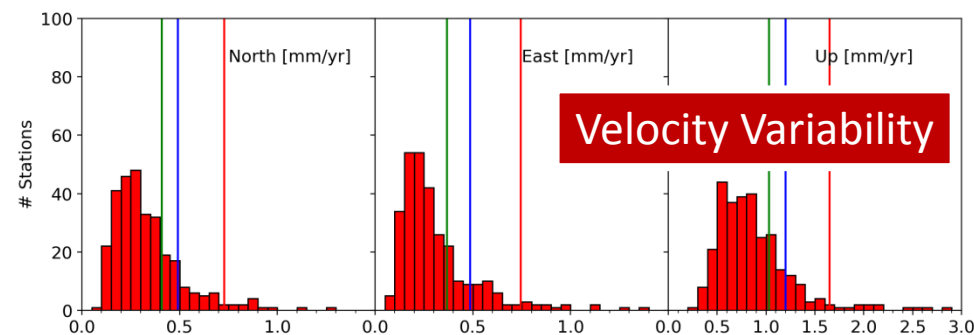
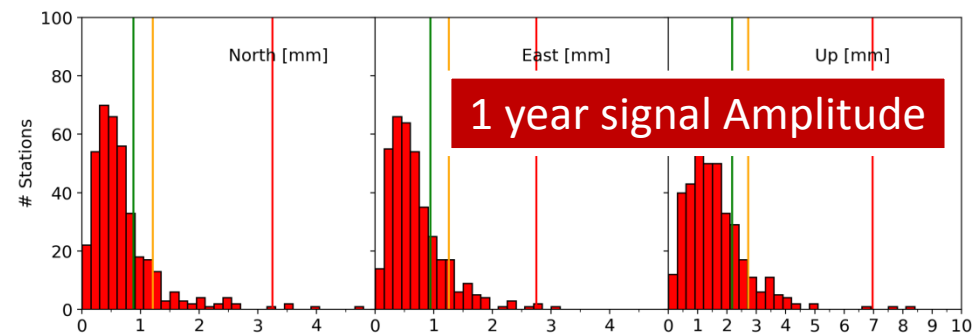
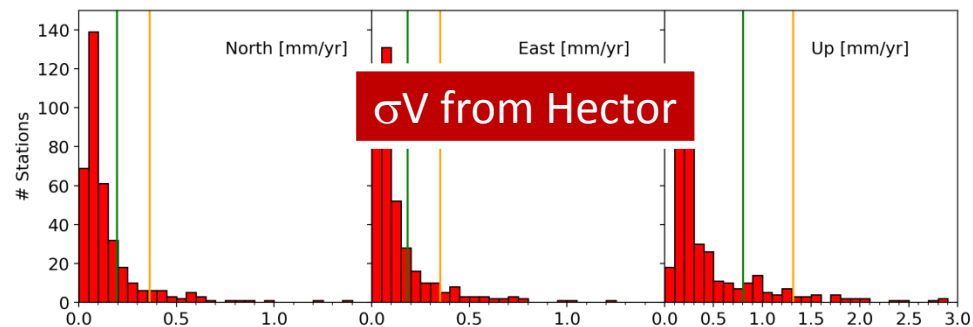
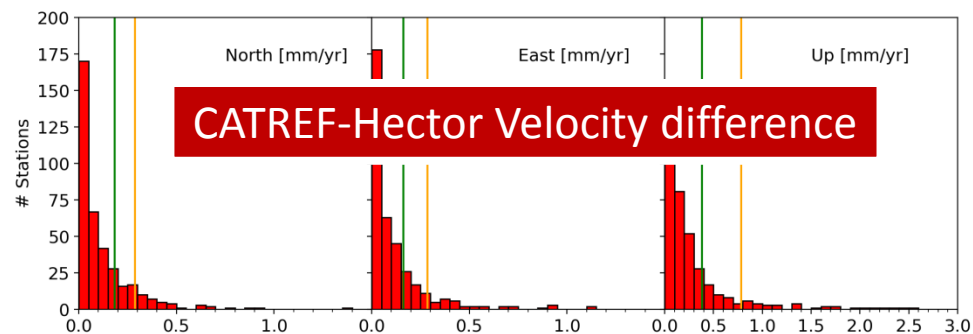
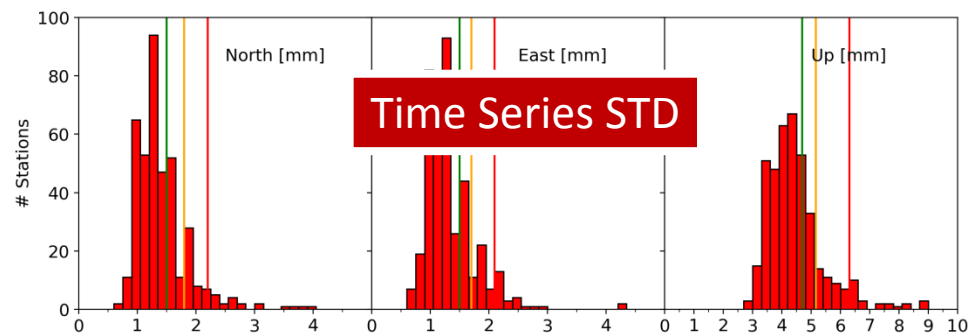


- 1 year signal Amplitude:

Amplitude of the annual signal

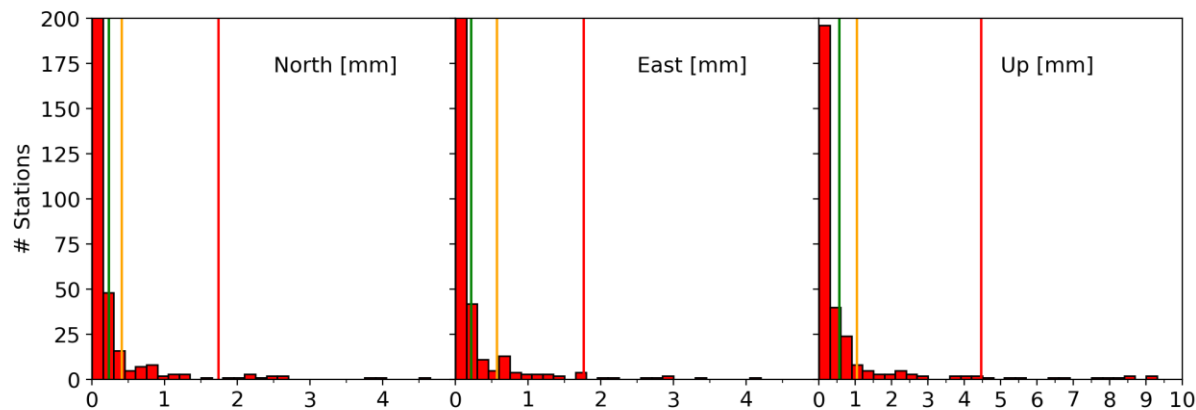


# Criteria for classification

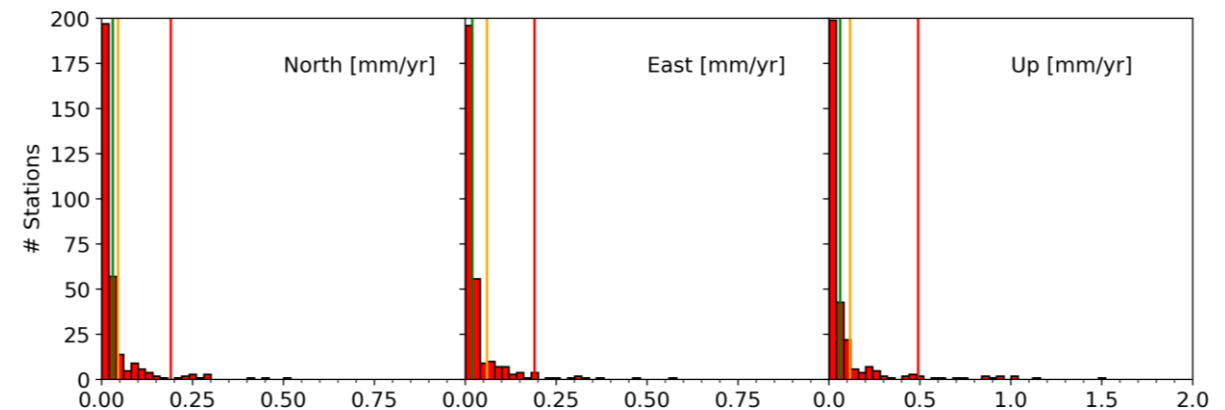


# Position & Velocity differences between the 2 last official EPN multi-year solutions

- Comparison of positions and velocities between the current C2040 and the previous solution C2025
- Last solution number observed in the current solution
- Only values for stations observed between GPS Week 2025 and 2040
- Positions are compared at GPS Week 2040

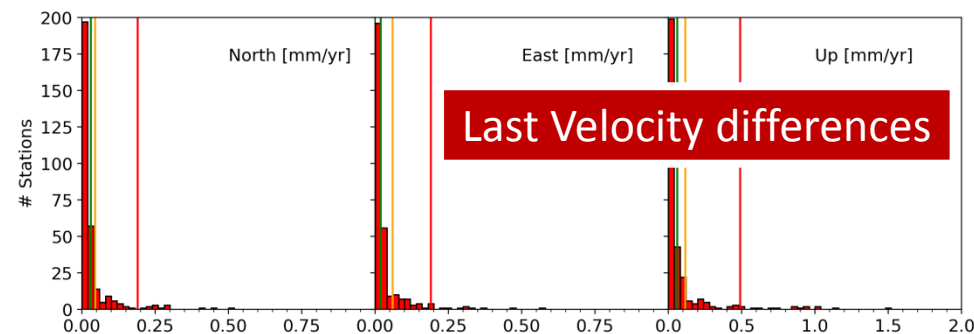
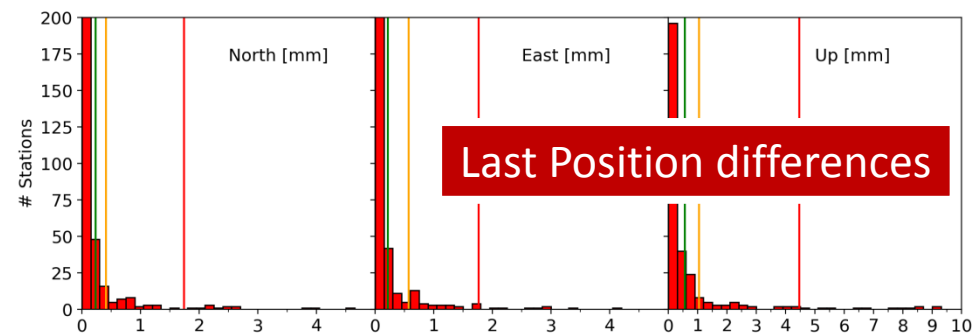
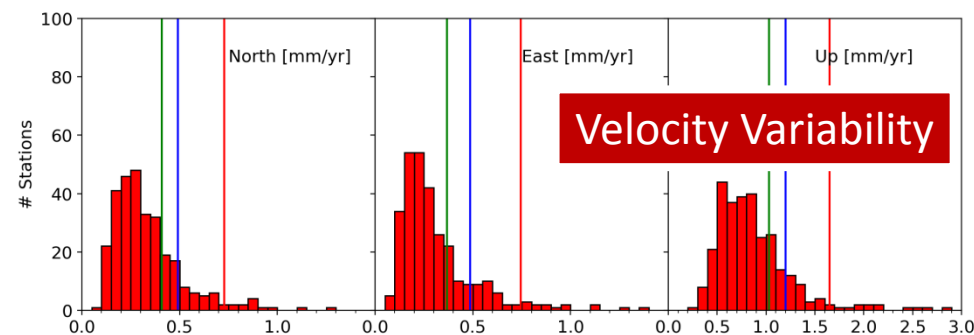
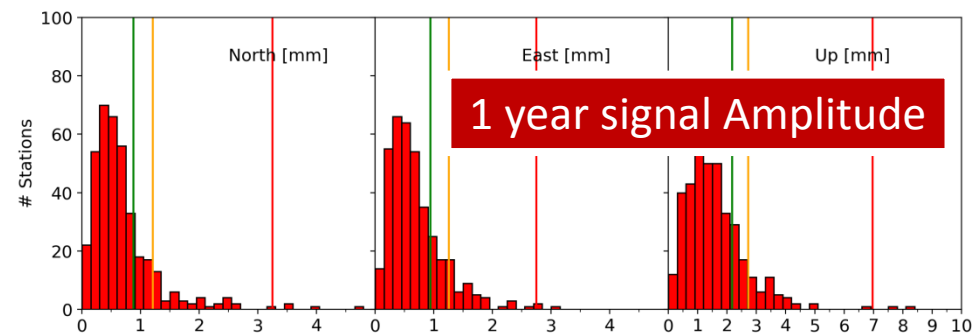
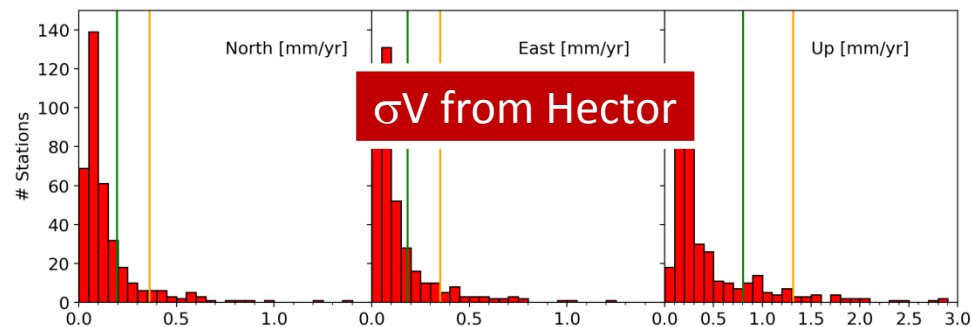
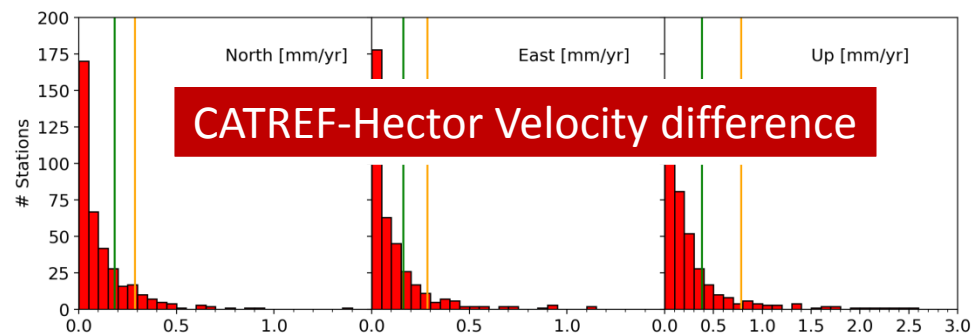
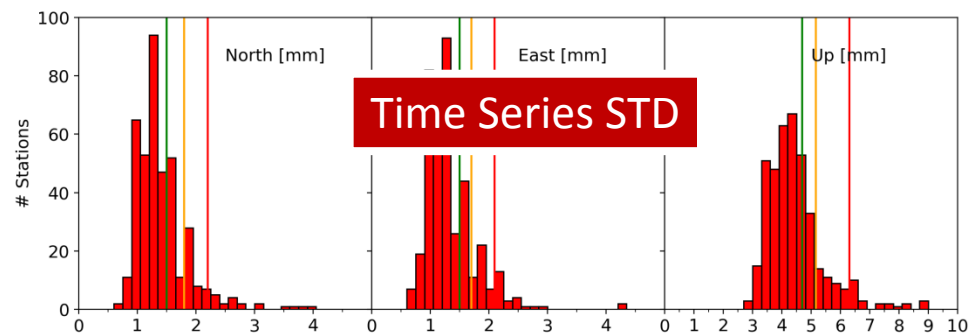


Last Position differences



Last Velocity differences

# Criteria for classification

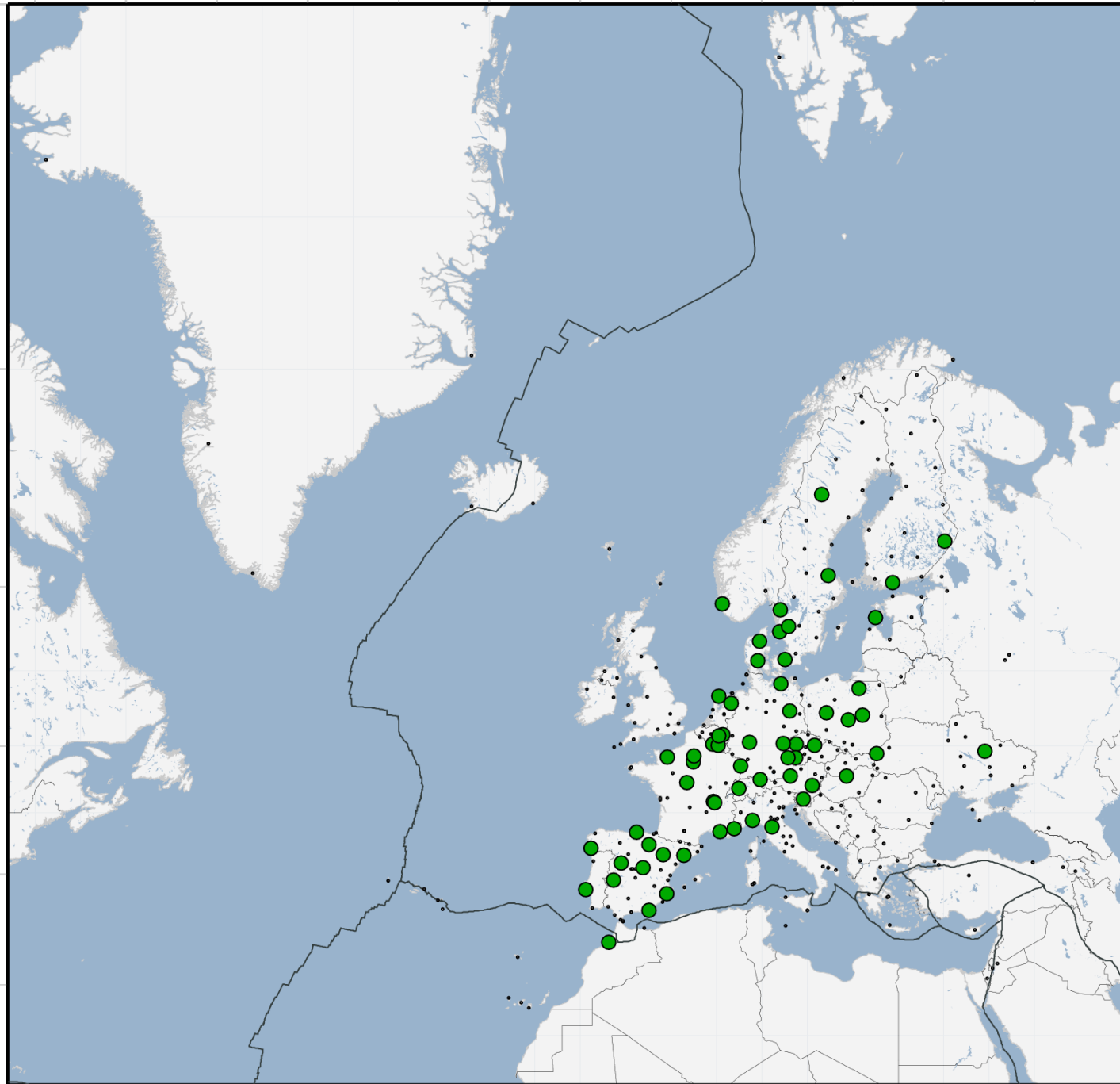


## A1: **all** criteria < Percentile 75

Stations which are in  
the 75% best stations  
for all criteria

Reference stations  
suitable for any type of  
ETRS89 densifications

No usable reference  
stations at the  
edges of the  
network





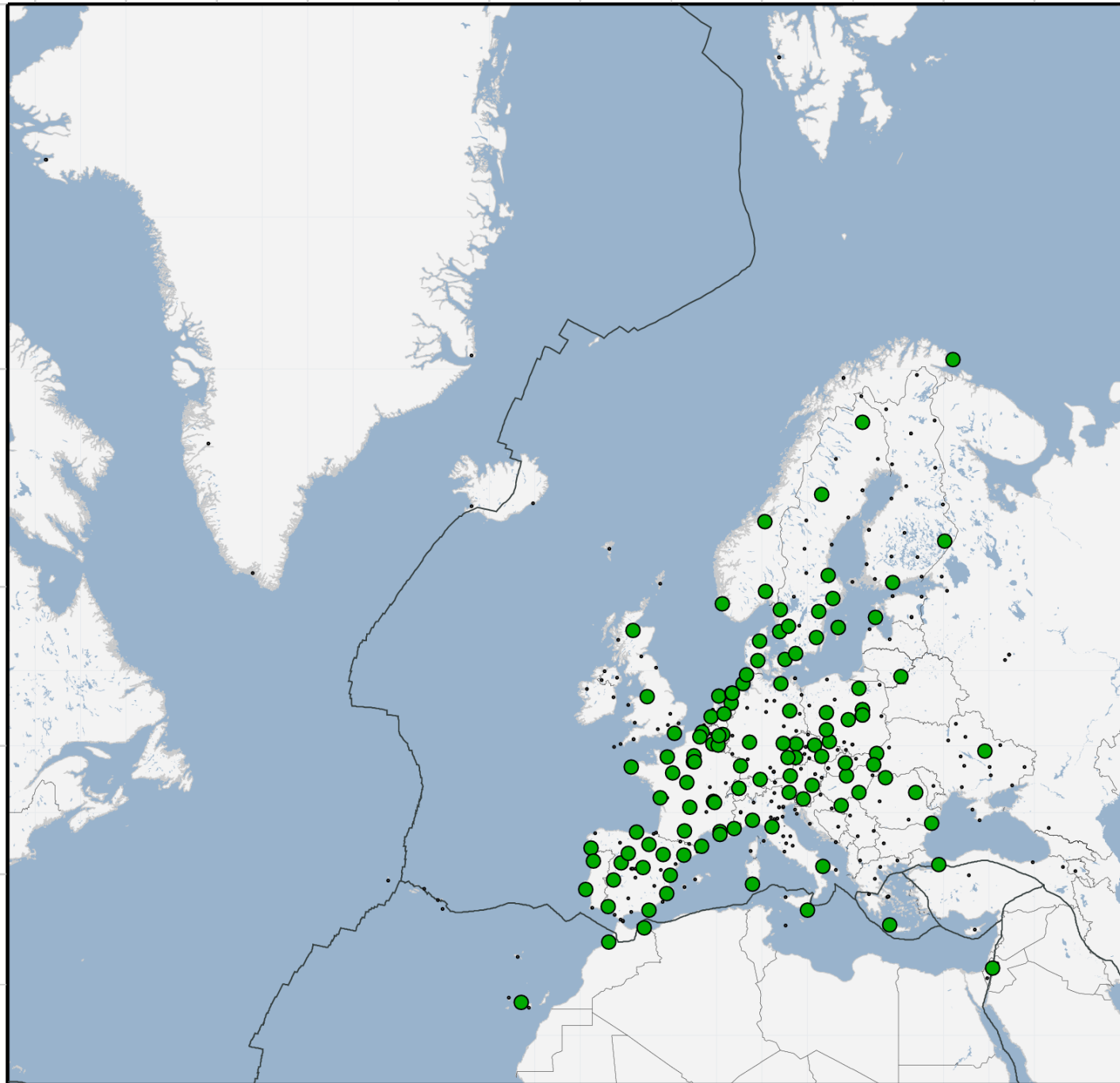
## A2:

- velocity variability < Percentile 75
- other criteria < Percentile 85

adding mostly stations with  
higher noise level (edge of  
the network) or higher  
annual signals

Reference stations suitable for  
any type of ETRS89  
densifications

Be more careful with  
campaigns

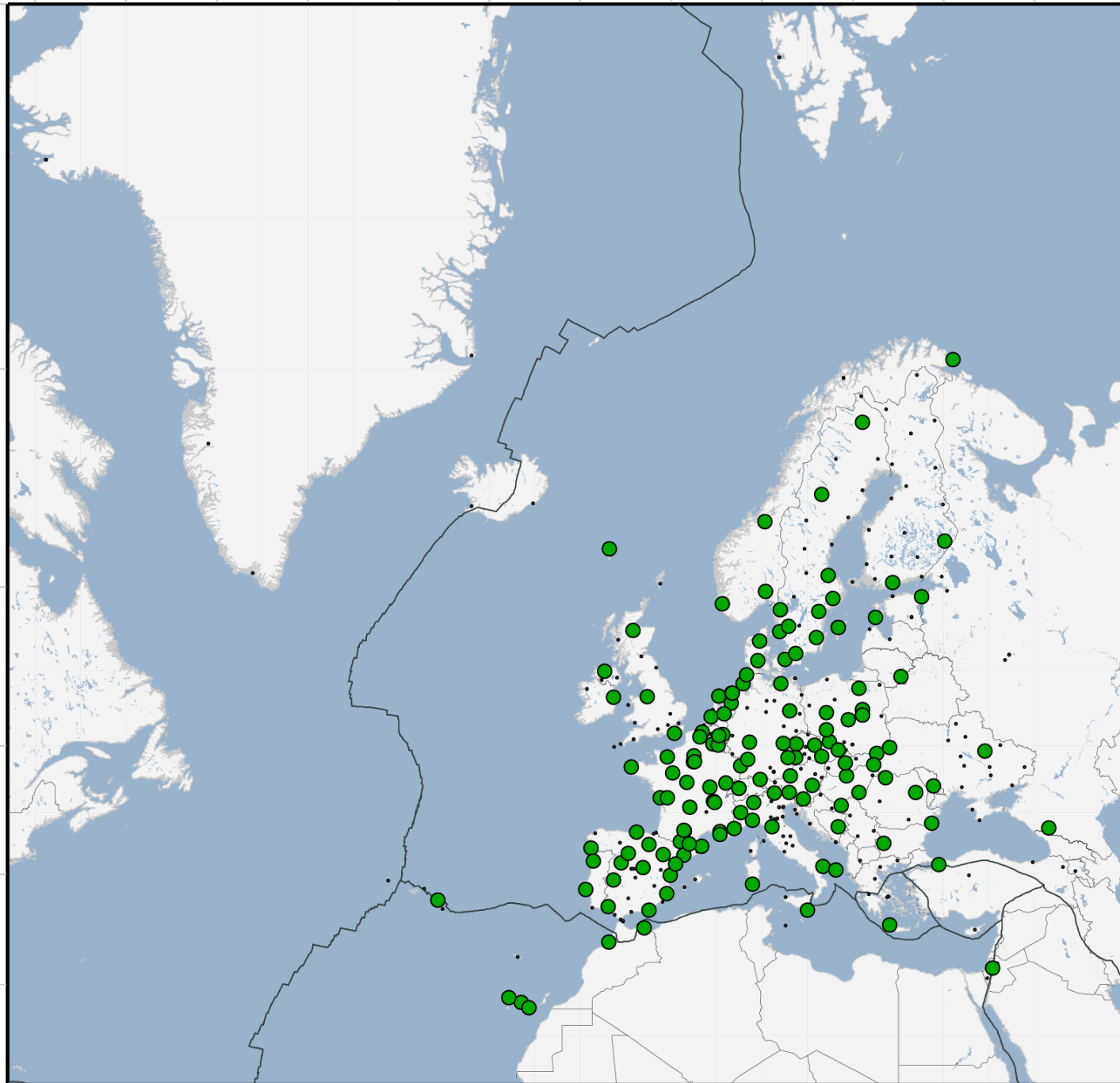


## A3:

- velocity variability < Percentile 75
- no threshold for annual signal amplitude and/or time series STD
- other criteria < Percentile 85

adding stations with even  
higher noise level or higher  
annual signals

Reference stations probably not  
suitable for campaigns or short  
term multi-year ETRS8  
densifications



# Conclusion on station classification

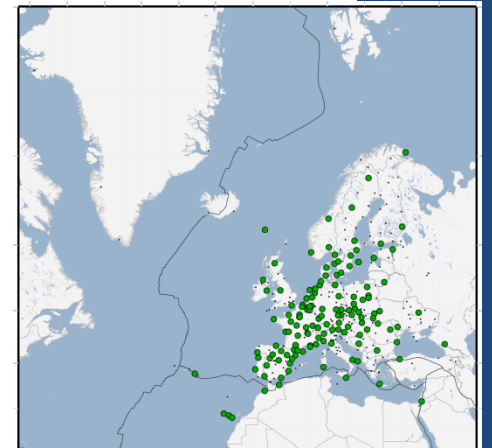
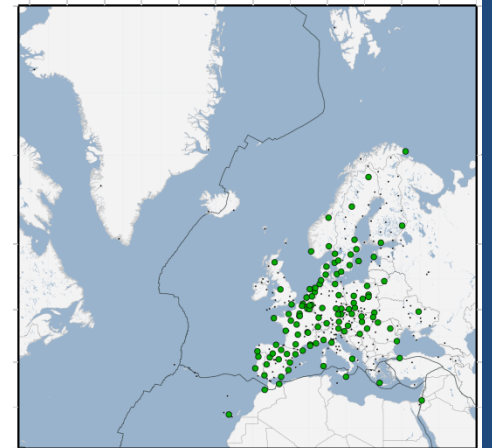
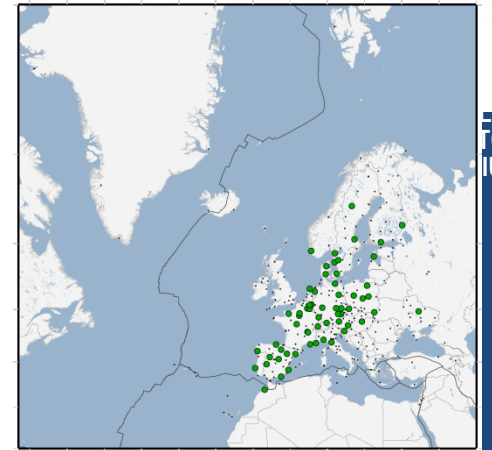
Based on the 3 examples:

- The more stations you add to the network and the more you loosen the criteria, the more you need to use the stations with care
  - Especially for campaigns (sensitive to noise or signals)
  - and for short term velocity solutions (sensitive to velocity variability)

Goal is to:

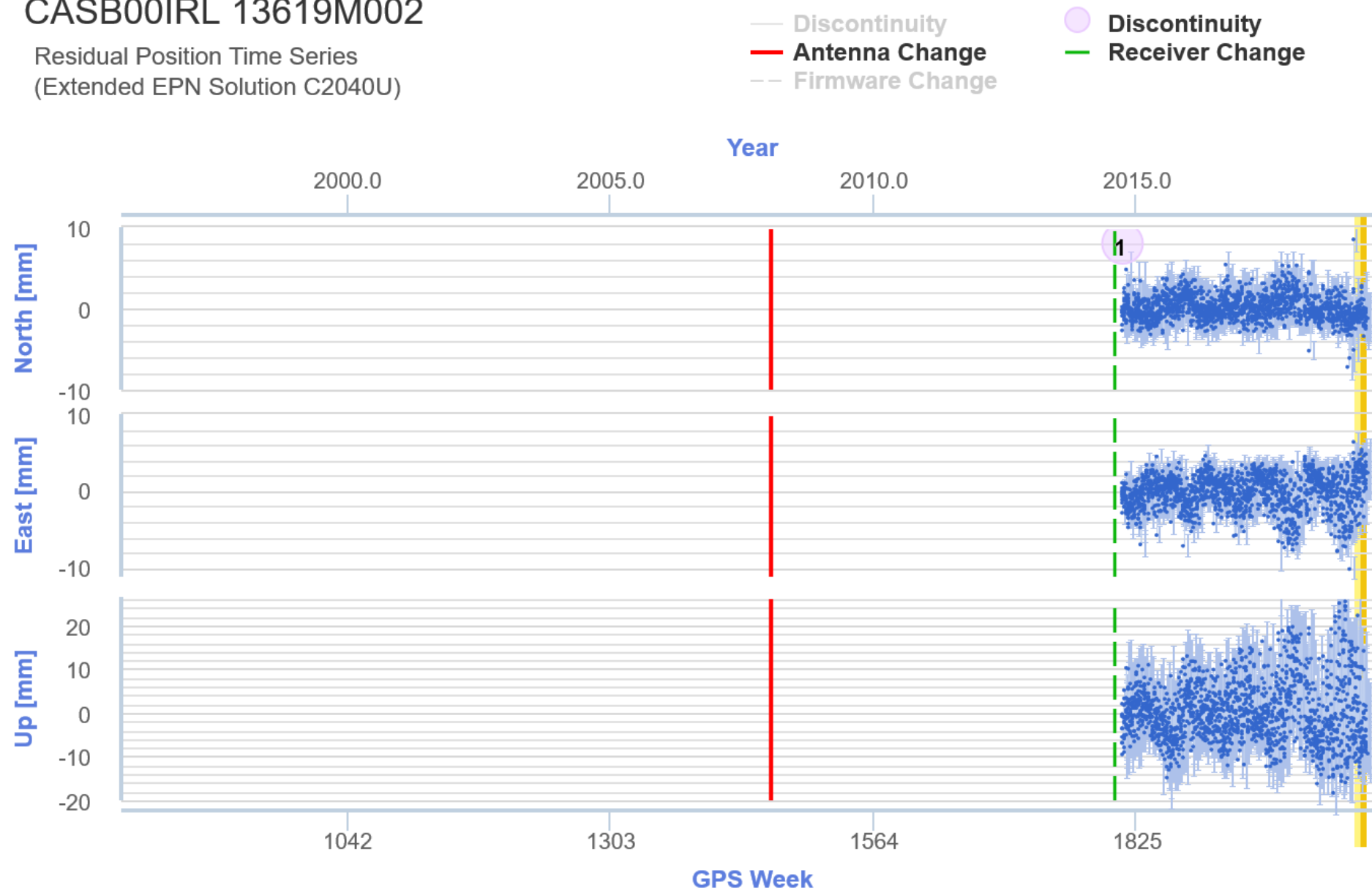
- Define different level of classes with different thresholds depending on the application
- Online tool to help the users to choose the best EPN reference stations suitable for their applications

Define new reference frame products  
Update of the “Guidelines for EUREF Densifications”



# CASB00IRL 13619M002

Residual Position Time Series  
(Extended EPN Solution C2040U)



Please have a look at the time series of your stations  
from time to time!

If you know the reason of the problem,  
let me know ([juliette.legrand@oma.be](mailto:juliette.legrand@oma.be)  
or [epncb@oma.be](mailto:epncb@oma.be)),  
it will help me to handle it correctly.

All information about the stations is welcome!

