On-line Reference Station Selection Tool

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ROYAL OBSERVATORY OF BELGIUM

EUREF Symposium, Online from Ljubljana, 26 May 2021

Context

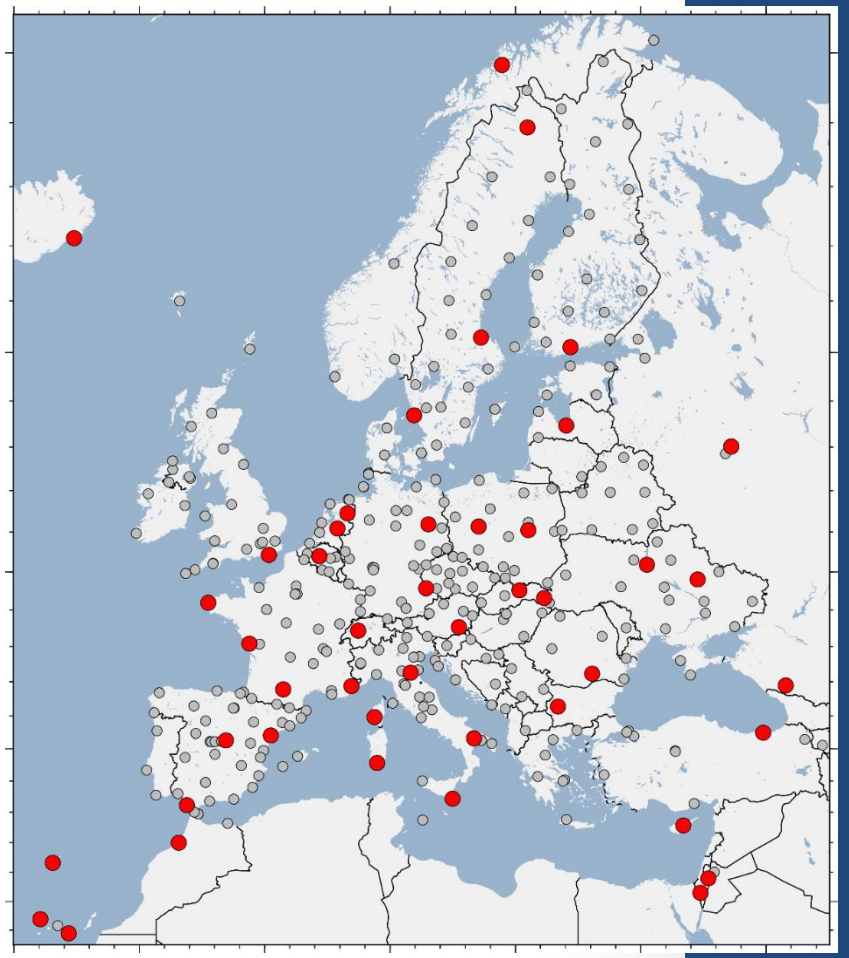
- To tie the densification campaign to the EUREF reference frame product, it is necessary to include in the GNSS data analysis “reliable” and “stable” reference stations

- How to choose “reliable” and “stable” reference stations?
  - a station classification

https://epncb.oma.be/_productsservices/ReferenceFrame/Station_Classification.php

  - a web tool

https://epncb.oma.be/_productsservices/ReferenceFrame



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How to select reference stations ?

- **Basic principle:**
  - **Spatial distribution** of the reference stations around and in the area of interest
  - A **good consistency** between the densification positions/velocities and the reference positions/velocities

- But we don't know if the station shows a good agreement before the processing !

- How to increase the chance of having a good agreement between position and velocity estimates?
  - Use same processing options as the reference solution
  - Use the same position/velocity discontinuities
  - Use the same outlier rejection policy
  - Select **stable and suitable reference stations**:
    - Use the **Web Tool for Reference Station Selection**:

"Guidelines for EUREF Densifications"

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EUREF Permanent GNSS Network

https://epncb.oma.be/_productsservices/ReferenceFrame

ORGANISATION | NETWORK & DATA | PRODUCTS & SERVICES | DOCUMENTATION | NEWS, EVENTS & LINKS

ANALYSIS CENTRES
- Introduction
- Contributing Agencies

POST-PROCESSED PRODUCTS
- Daily/Weekly Combined EPN Positions
- Tropospheric Delays
- EPN-repro1
- EPN-repro2

MULTI-YEAR PRODUCTS
- Positions & Velocities
- Position Time Series
- Reference Frame
- EPN Densification NEW

REAL-TIME PRODUCTS
- Satellite Orbit & Clock Correction Streams

SERVICES
- ETRF/ITRF Coordinate Transformation

Reference Frame:
- EPN Station Classification
- Tool for Reference Station Selection
- Tool Description
- Station List

This tool aims at choosing suitable reference stations in order to tie a densification solution to the **EPN multi-year position and velocity soluti… 1996-01-01 (GPS Week 0834) to 2021-02-20 (GPS Week 2145)**, following the Guidelines for EUREF densifications.
The user must use the same outliers and discontinuities of the EPN multi-year solution. The tool is based on the station classification of the EPN stations (more about the background of the station classification and the values of the station classification for the EPN solution C2145) and on a set of criteria used by the tool to define the status Recommended, Usable or Not Recommended as reference station (more about the tool criteria).
The primary goal of this tool is to help the user select suitable EPN reference stations to to be added to his network during the preparation of the processing of his densification solution.

Input

BEGIN AND END DATES OF THE DENSIFICATION SOLUTION

Begin Date: YYYY-MM-DD

End Date: YYYY-MM-DD

Default values are begin and end dates of the (last) EPN multi-year solution C2145 from 1996-01-01 (GPS Week 0834) to 2021-02-20 (GPS Week 2145).

D REFERENCE STATIONS

…ion List:

Insert 9-char ID of station(s) separated by comma's, e.g.
CAEN00FRA,DARE00GBR,ENTZ00FRA,HELG00DEU,VFCH00FRA,WARN00DEU

…s "not recommended" a…

Submit

Begin Date

End Date

< 3 years → **Position Solution**

> 3 years → **Position & Velocity Solution**

Get in Touch with the EPN Central Bureau

Results

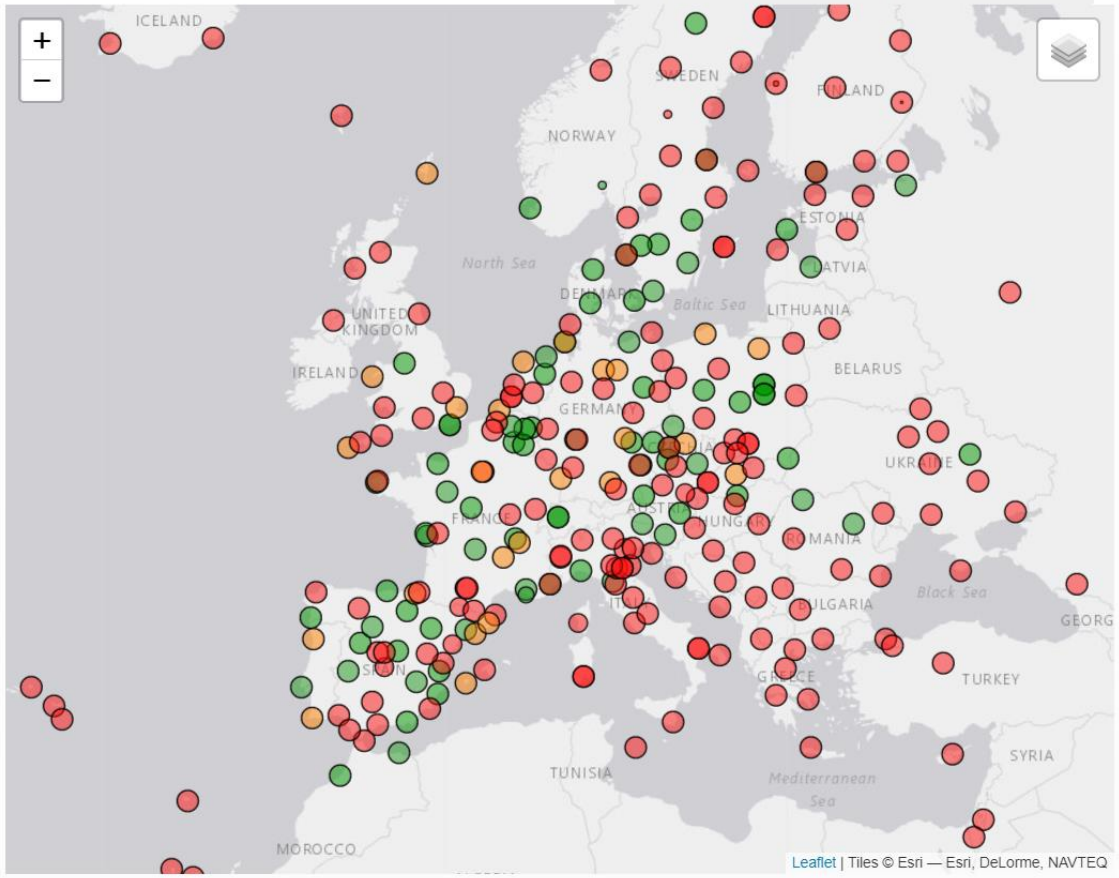
SOLUTION TYPE

The Densification Solution has **31 days** of data.

Criteria for a Position Solution are applied (More).

Map Legend | How to show information about a station ? | How to select/unselect a station?

Minimize the Non-Selected Stations | Show All the Stations



LIST OF SELECTED REFERENCE STATIONS

STATION INFORMATION

Find a Station

Example: Position solution
(01/01/2021 – 31/01/2021)

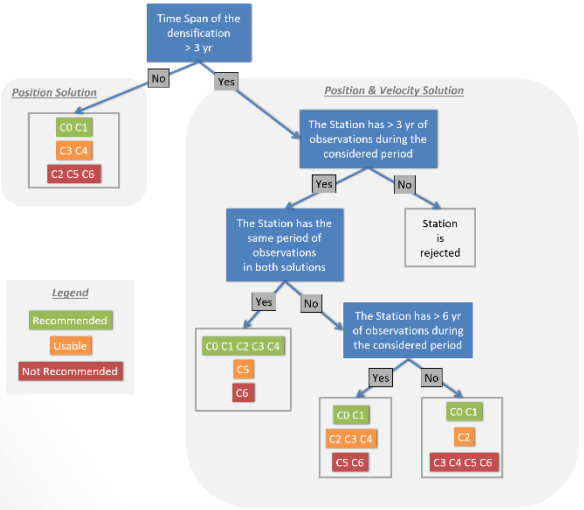
Stations having data
during the considered period:

Color coded **recommendation**:
Recommended, Usable, Not recommended

Recommendations and Decision Model

- Station recommendation (Recommended, Usable, Not recommended) depends on:
  - Solution type
    - Positions
    - Positions + Velocities
  - Category of the station
  - Observation availability of the station in the EUREF Reference Frame Product
- Decision model

More about the station categories
http://epncb.oma.be/_productsservices/ReferenceFrame/Station_Classification.php



More about the decision model
http://epncb.oma.be/_productsservices/ReferenceFrame/Tool.php

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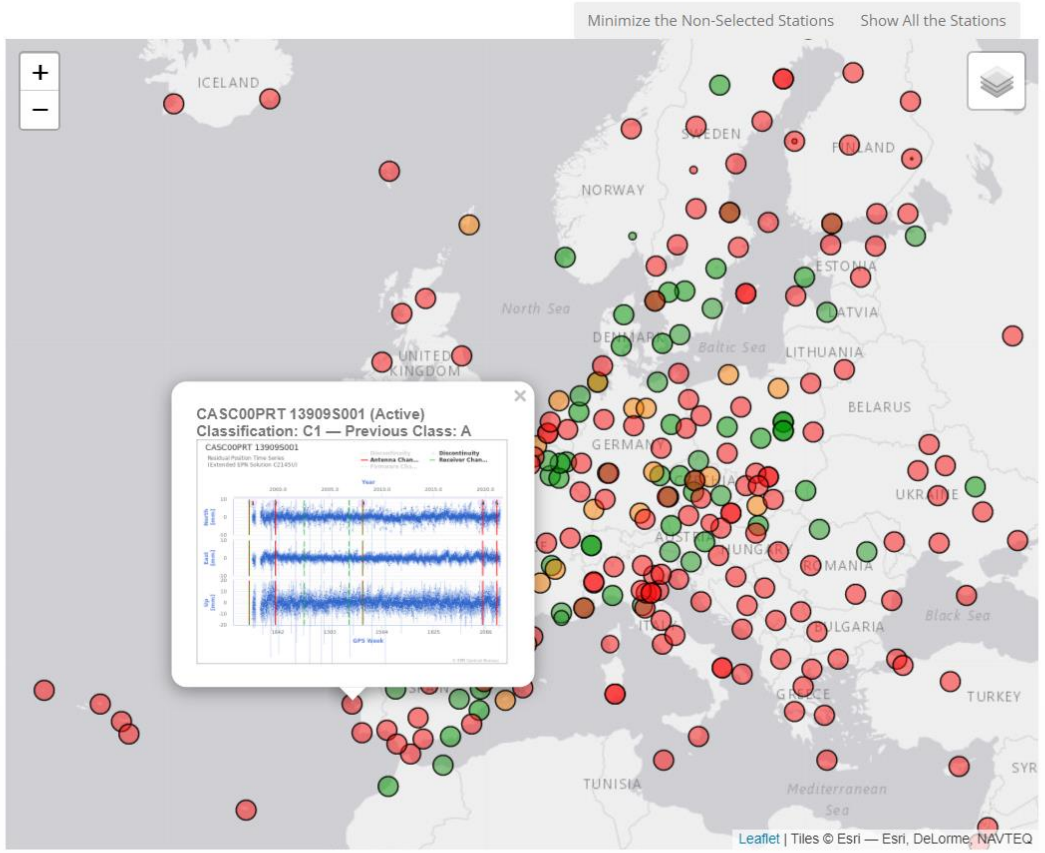

Recommendation

Category of the station

Number of days of observation

Number of position/velocity discontinuities during the considered period

Detrended position time series to see the position changes

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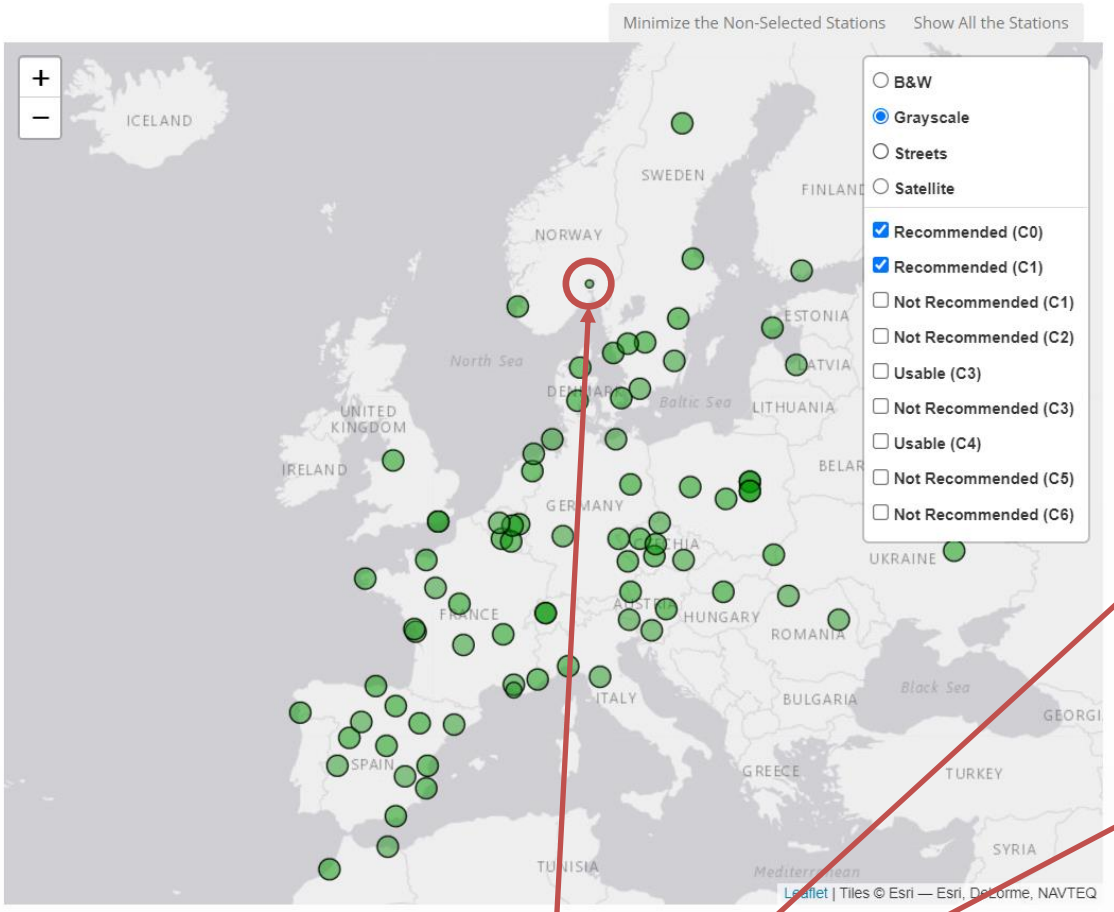
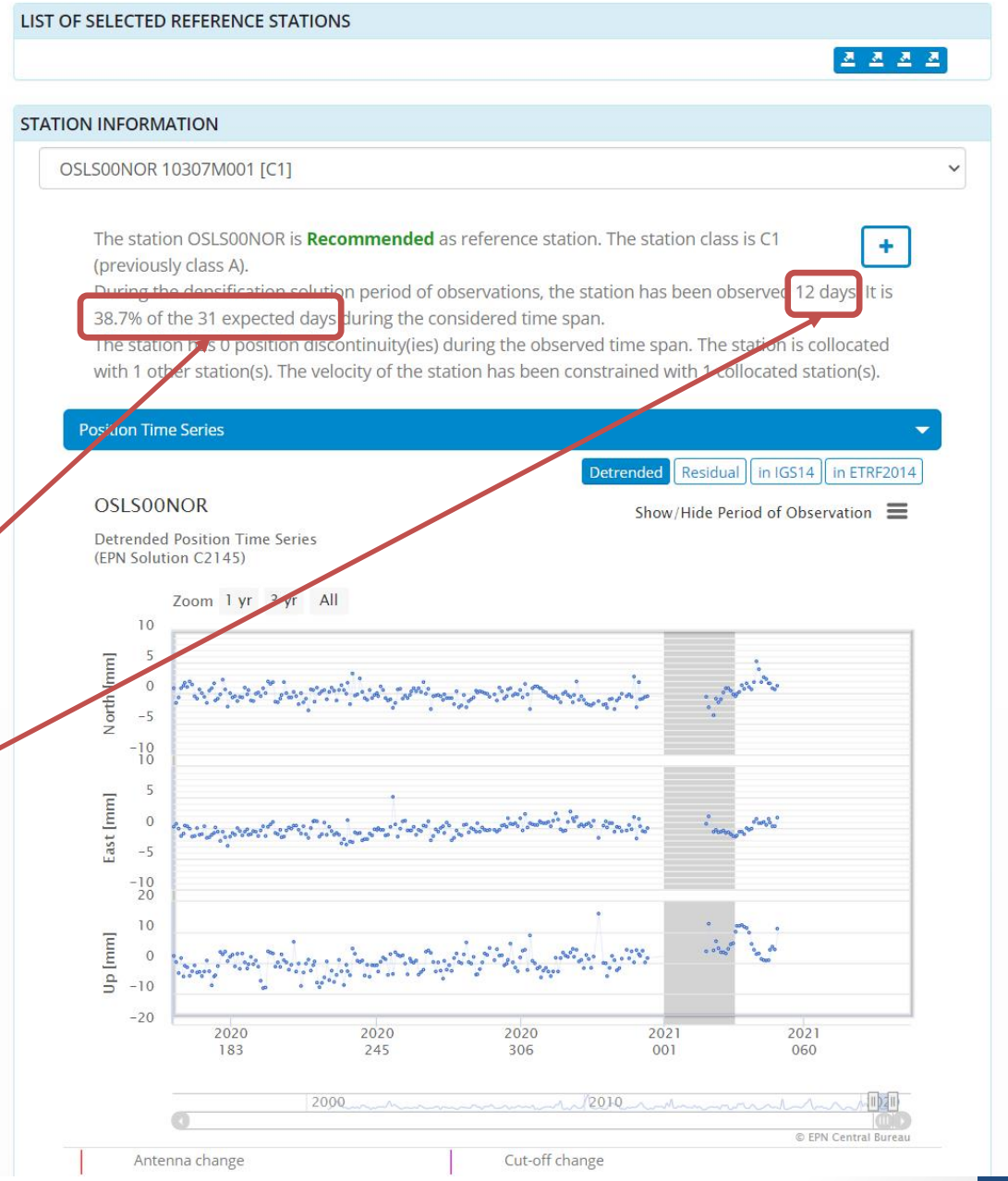
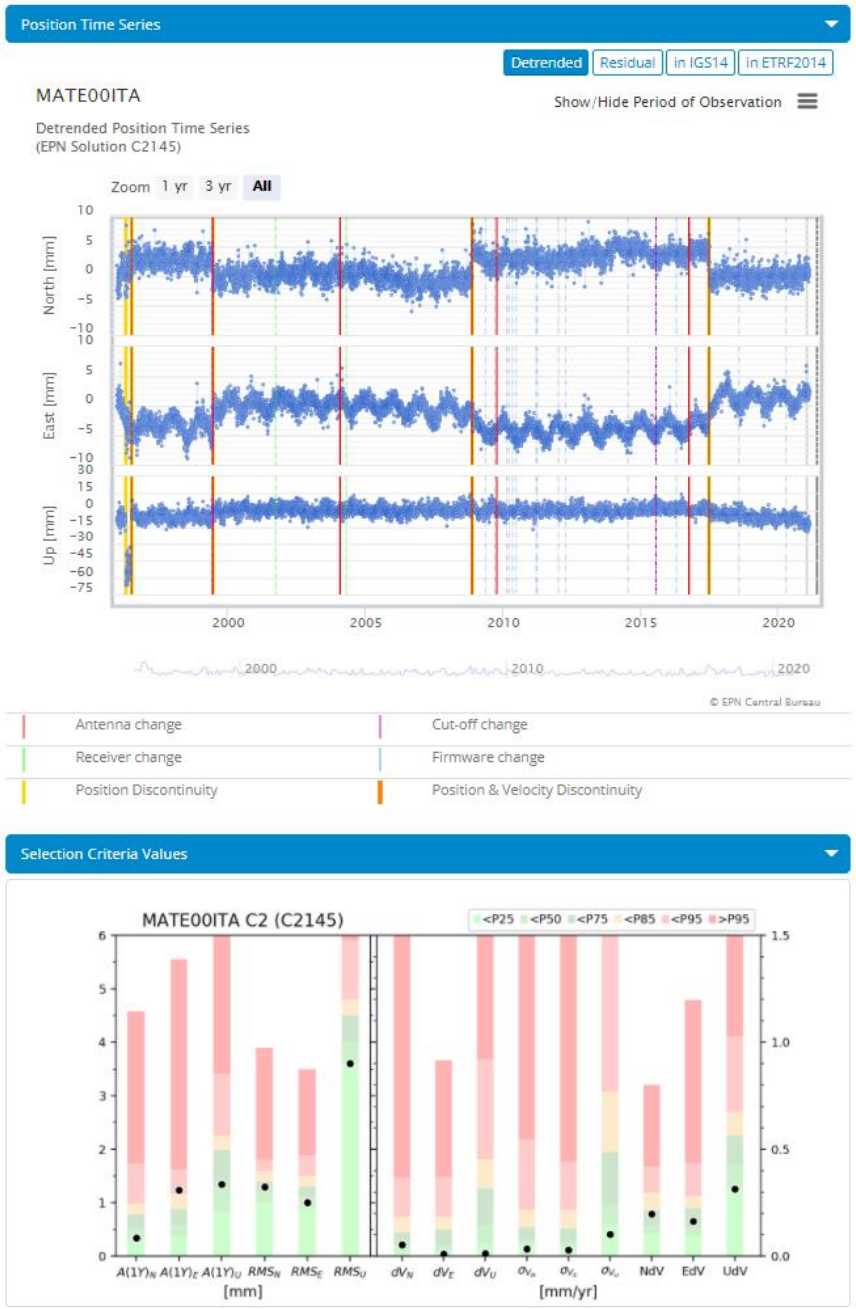




Number of days of observation in the EUREF Refence Frame product during the considered period

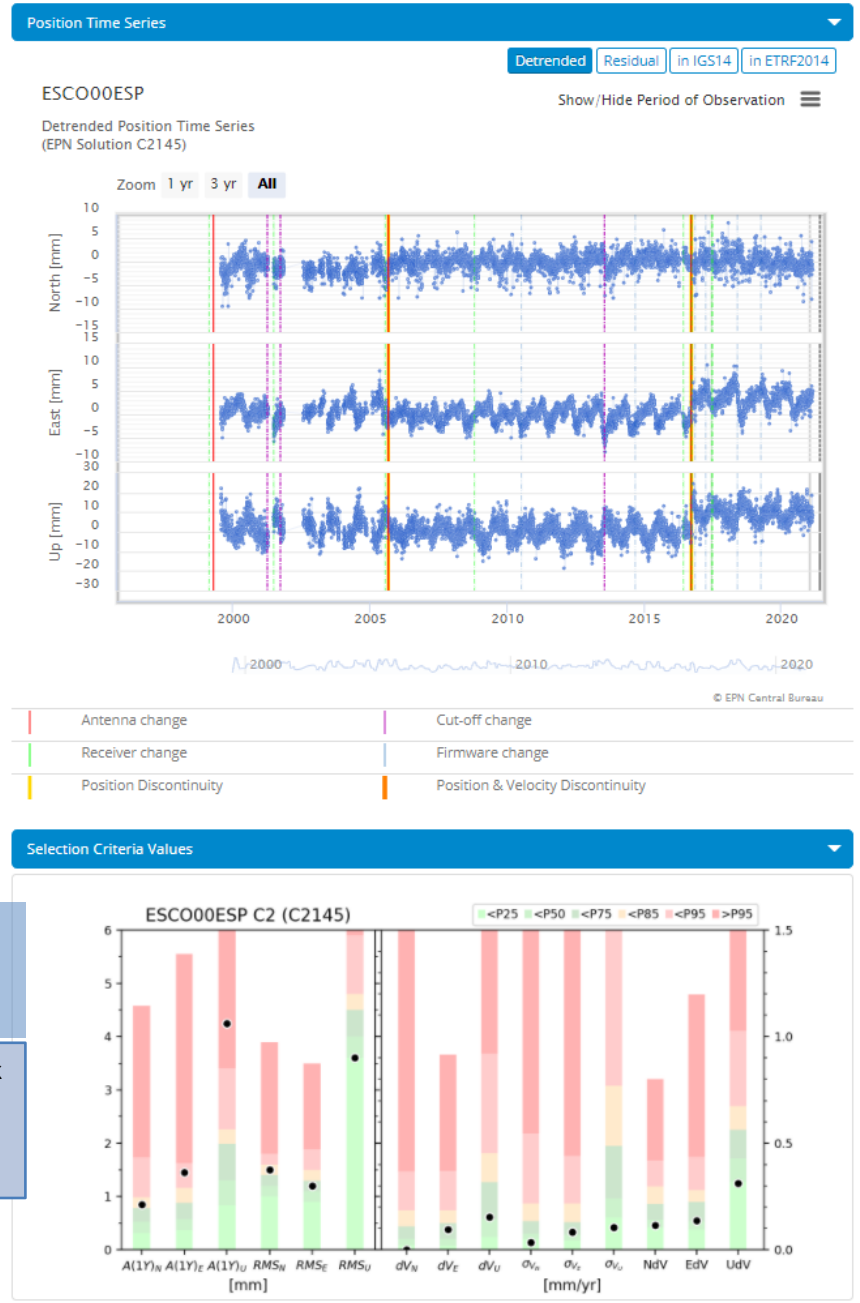
Performance of the stations: Positions



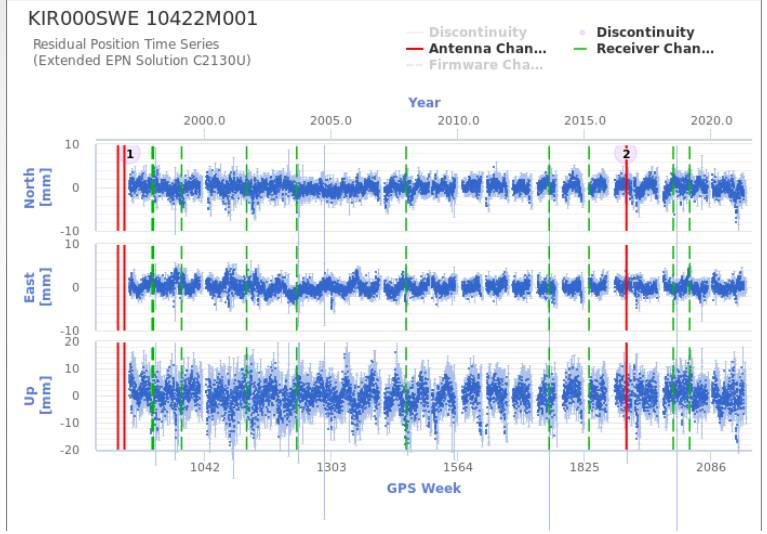
Position time series

Performance of the station on the 5 criteria

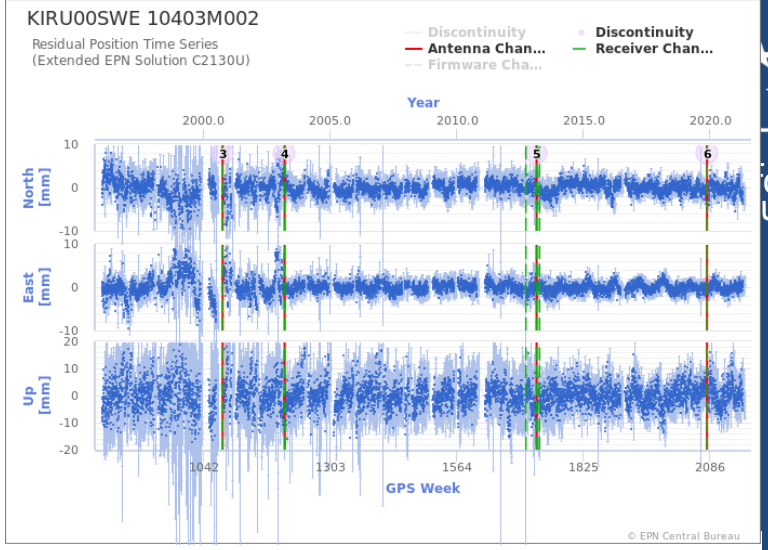
Compare the performance of a station (black dots) with the performance of the EPN stations (percentiles shown with colored bars)



Performance of the stations: Positions/Velocities



Position time series



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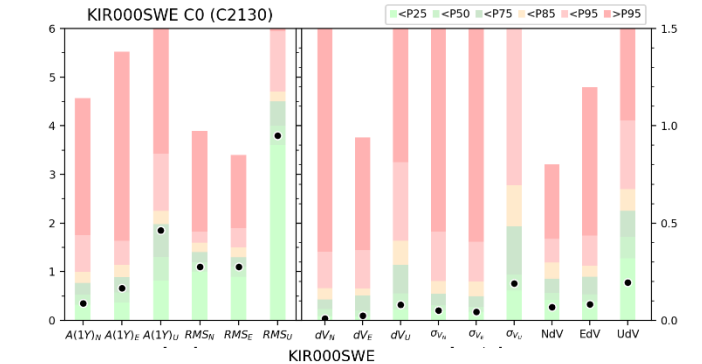
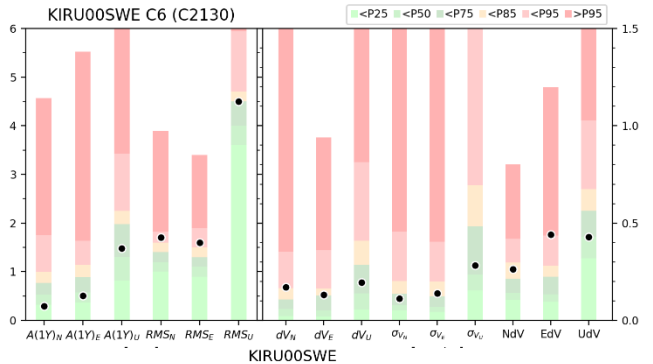
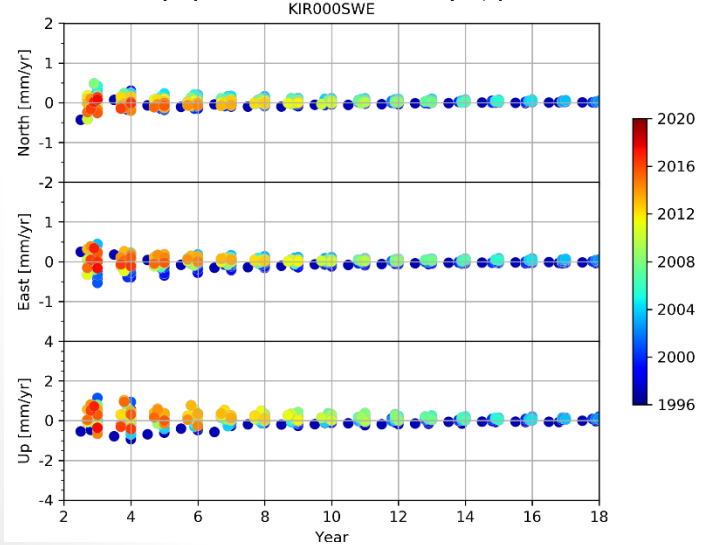
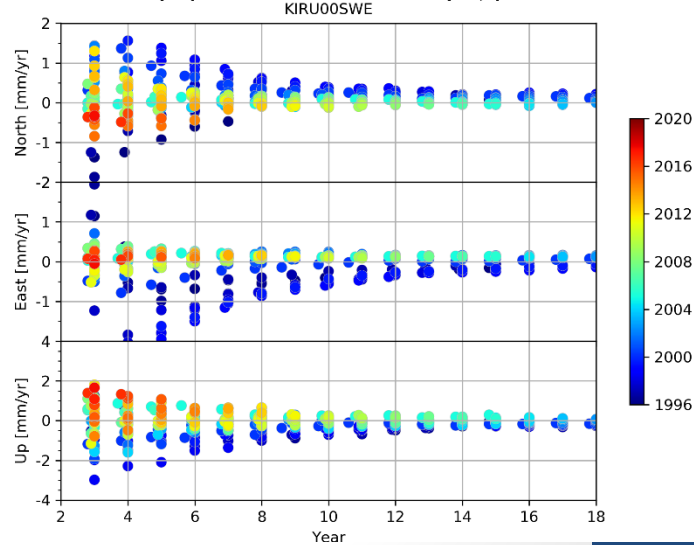




Velocity Variation

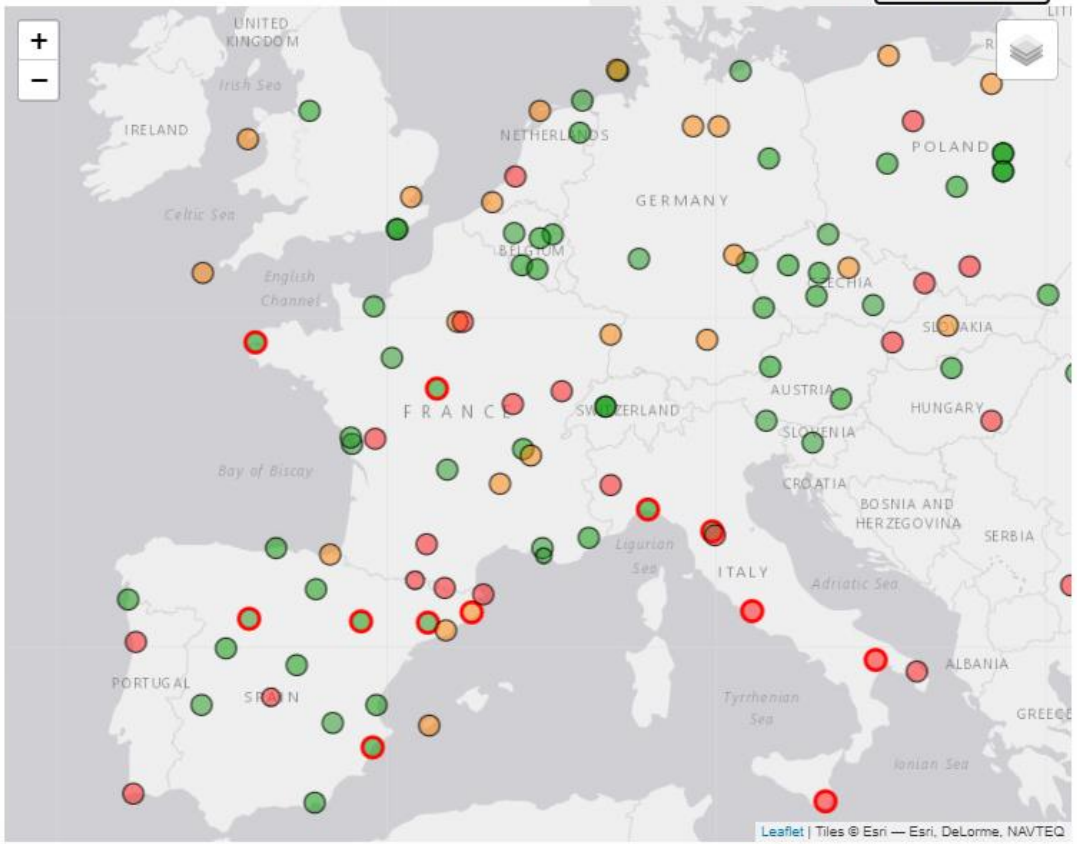
Difference between velocity estimated using data from different moving time windows with the velocity obtained using the full data set of the station as it is included in the multi-year EPN solution





Hide non selected

Minimize the Non-Selected Stations | Show All the Stations



LIST OF SELECTED REFERENCE STATIONS

ALAC00ESP ✖ BELL00ESP ✖ BRST00FRA ✖ CASE00ESP ✖ GENO00ITA ✖ MOSE00ITA ✖ MATE00ITA ✖ NOT100ITA ✖ PRAT00ITA ✖ VALA00ESP ✖ VFCH00FRA ✖ ZARA00ESP ✖

STATION INFORMATION

BADH00DEU 14288M001 [C1]

Add/Remove the station to/from the list of selected reference stations

The station BADH00DEU is **Recommended** as reference station. The station class is C1 (previously class A).
During the densification solution period of observations, the station has been observed 31 days. It is 100.0% of the 31 expected days during the considered time span.
The station has 0 position discontinuity(ies) during the observed time span.

Position Time Series

Detrended | Residual | in IGS14 | in ETRF2014

BADH00DEU

Show/Hide Period of Observation

Detrended Position Time Series
(EPN Solution C2145)

Antenna change | Cut-off change
Receiver change | Firmware change
Position Discontinuity | Position & Velocity Discontinuity

add the station to the selected list of reference stations

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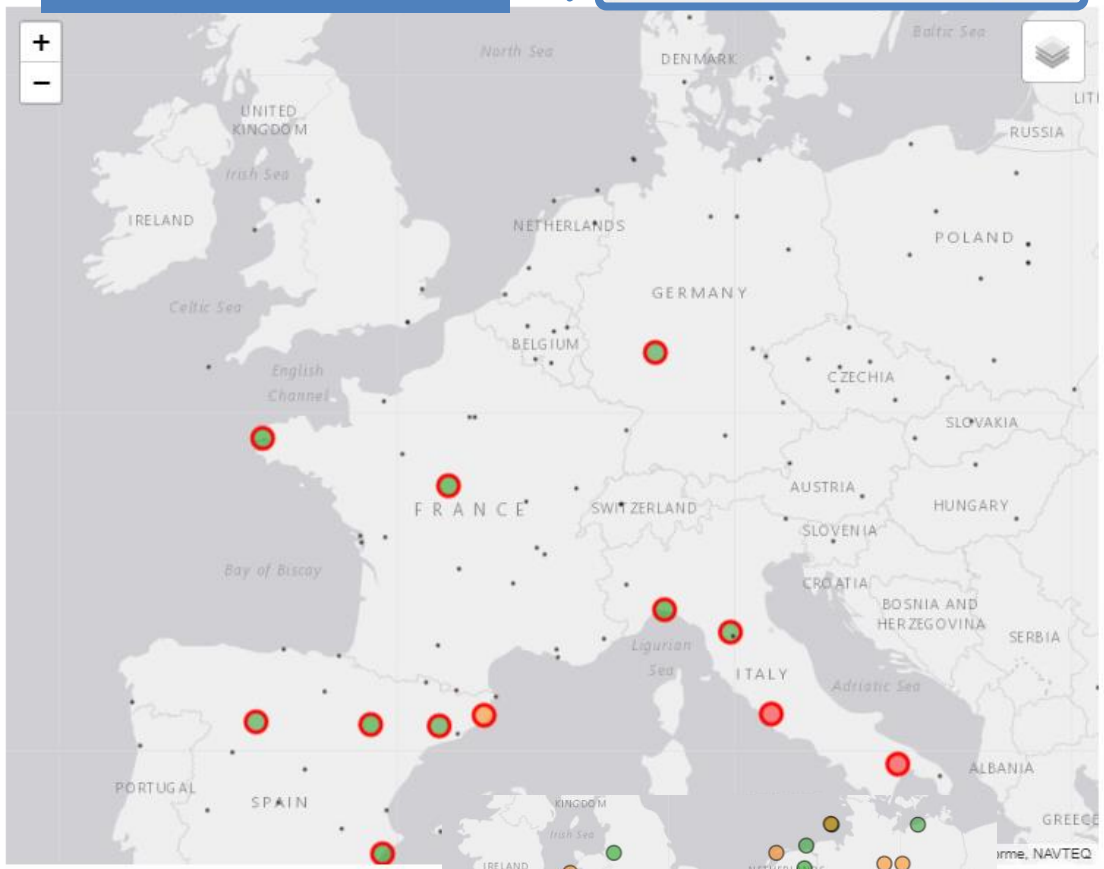
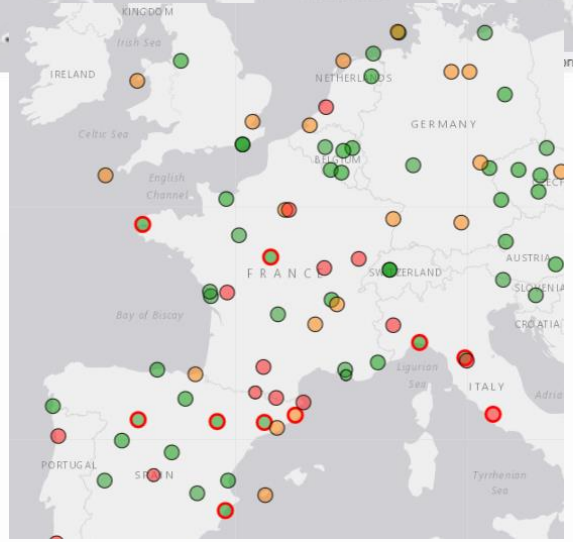
Show/hide non selected stations

Minimize the Non-Selected Stations | Show All the Stations





LIST OF SELECTED REFERENCE STATIONS

ALAC00ESP ✖ BADH00DEU ✖ BELL00ESP ✖ BRST00FRA ✖ CASE00ESP ✖ GENO00ITA ✖ MOSE00ITA ✖
MATE00ITA ✖ NOT100ITA ✖ PRAT00ITA ✖ VALA00ESP ✖ VFCH00FRA ✖ ZARA00ESP ✖

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Selected

Position Time Series

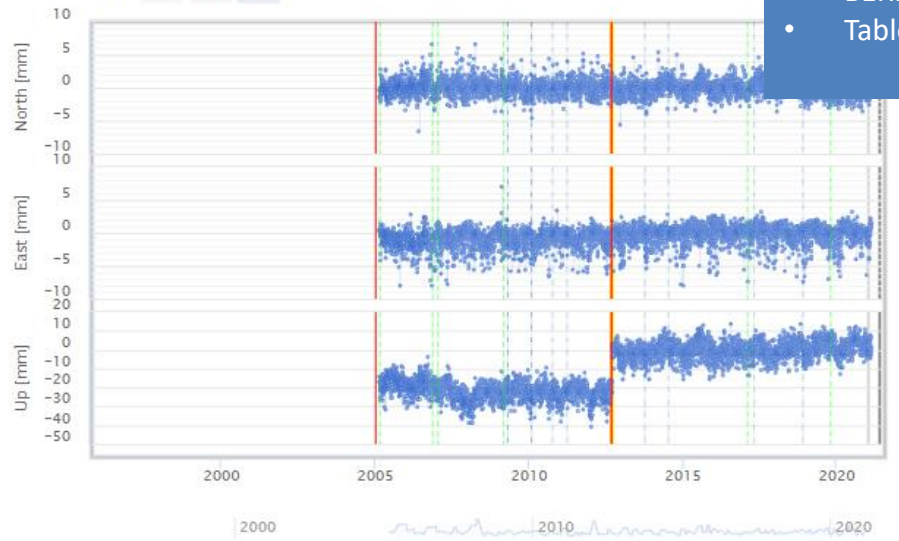
Detrended | Residual | in IGS

BADH00DEU

Show/Hide Period of O

Detrended Position Time Series
(EPN Solution C2145)

Zoom 1 yr 3 yr All



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Antenna change	Cut-off change
Receiver change	Firmware change
Position Discontinuity	Position & Velocity Discontinuity

Export list of the selected reference stations in various formats:

- List of Stations
- CATREF
- BERNESE (FIX)
- Table with criteria values

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Conclusion

- **Web Tool** to help the selection of optimal reference station
  - Based on the **EUREF Reference Frame Product**
    Multi-year position & velocity solution in IGb14 updated each 15 weeks
  - Show stations on an **interactive map**
  - With recommendation: **Recommended**, **Usable**, **Not recommended**
    based on station categories, solution type (Positions, Positions & Velocities), period of observation
  - provides necessary **information** for the **user** to **decide** to select or not a reference station
    - Select only “recommended” reference stations
    - Select “not recommended” reference stations making the choice based on the performance of the station
  - **Export** the list of selected stations in various format

- In the future:
  - Revisit the station categorization to refine the recommended reference station list
  - Extend the tool to work on the extrapolated part of the station time series
  - Develop API

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Links

EUREF Permanent Network Central Bureau

https://epncb.oma.be/

EUREF Reference Frame Product

https://epncb.oma.be/_productsservices/coordinates/

https://epncb.oma.be/_productsservices/timeseries/

Guidelines for EUREF densifications

https://doi.org/10.24414/ROB-EUREF-Guidelines-DENS

Tool

https://epncb.oma.be/_productsservices/ReferenceFrame/

Background on the Station Categories

https://epncb.oma.be/_productsservices/ReferenceFrame/Station_Classification.php

Background on the tool

https://epncb.oma.be/_productsservices/ReferenceFrame/Tool.php

Contact

juliette.legrand@oma.be or epncb@oma.be

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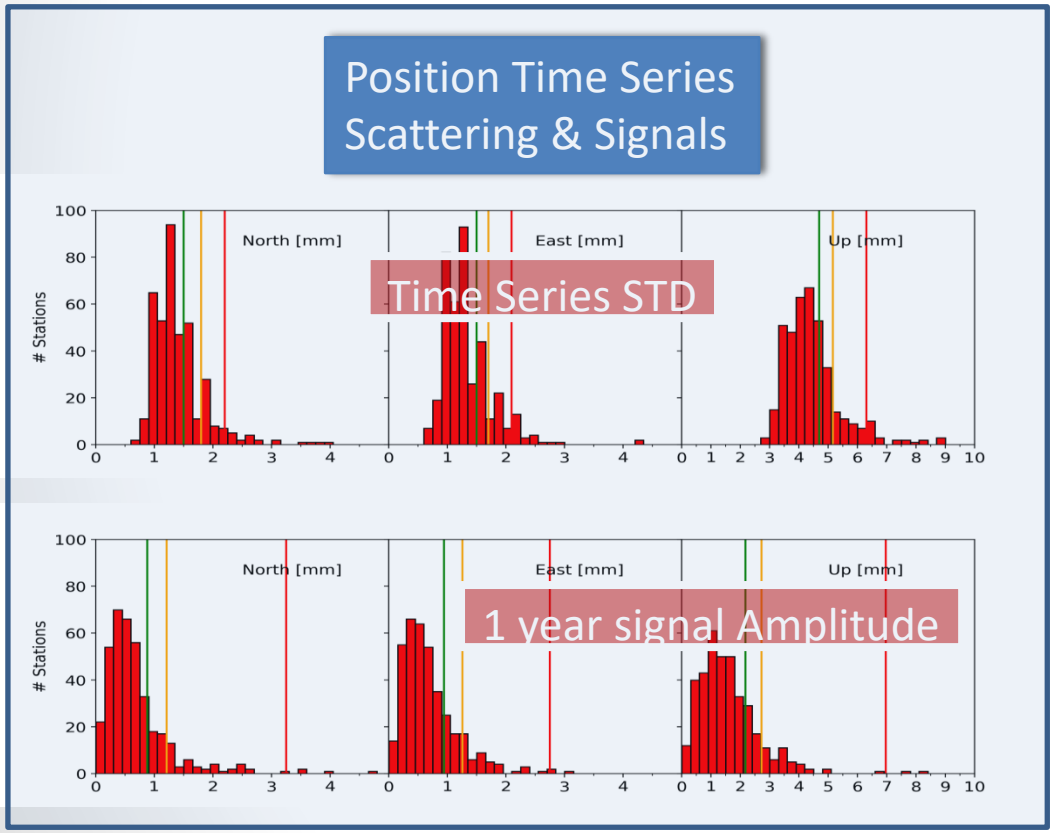
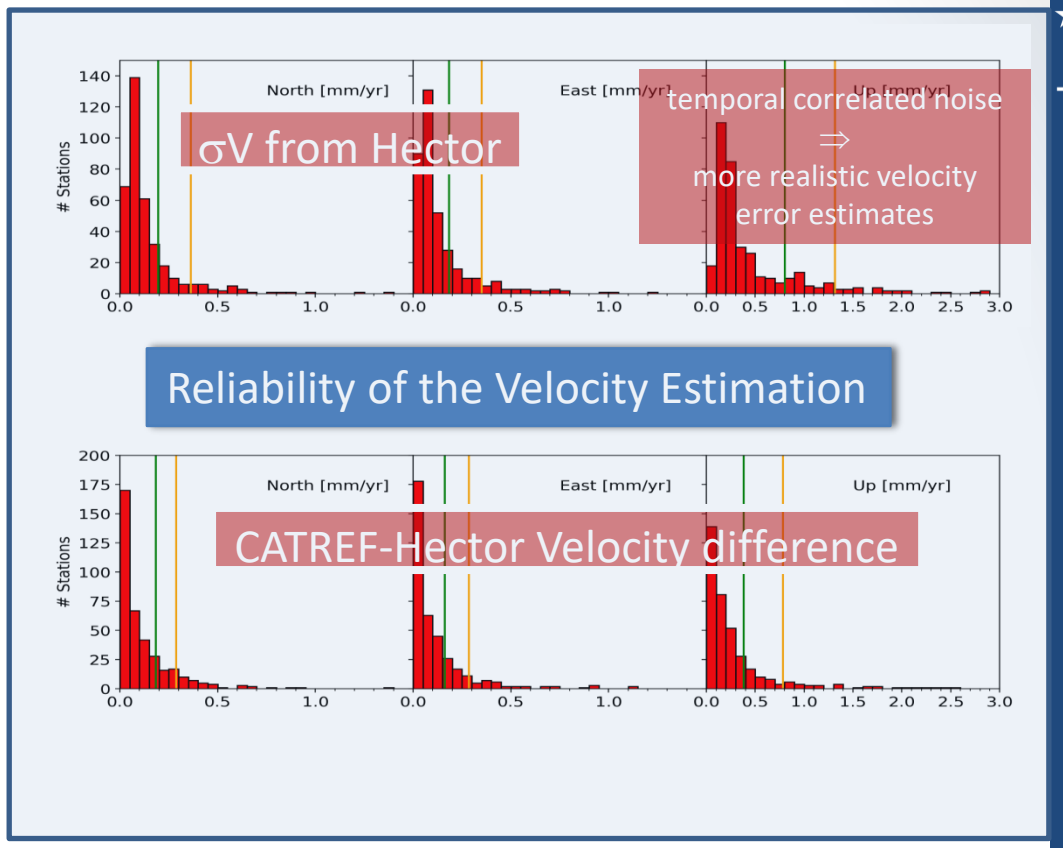
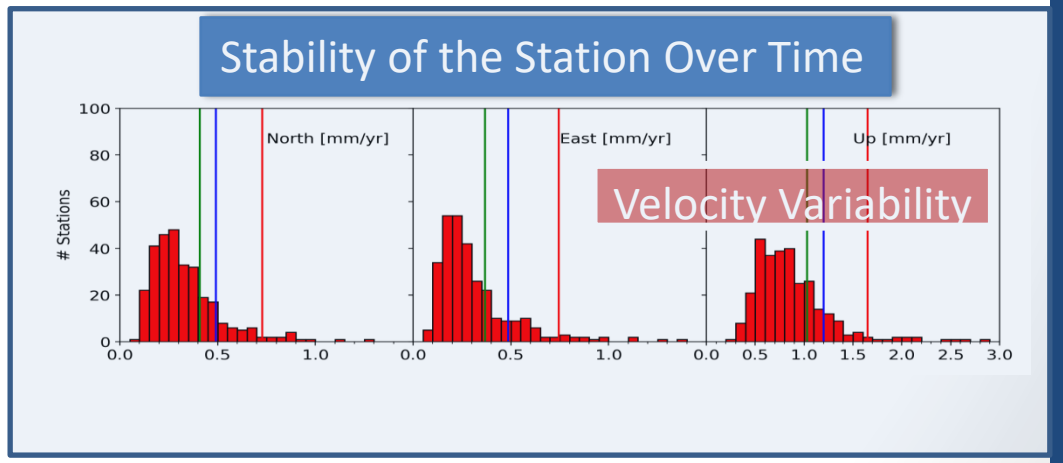
Backup Slides

Station Categories (1/3)

6 categories based on the performance of the station on 5 criteria







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Station Categories Velocity Variability (2/3)

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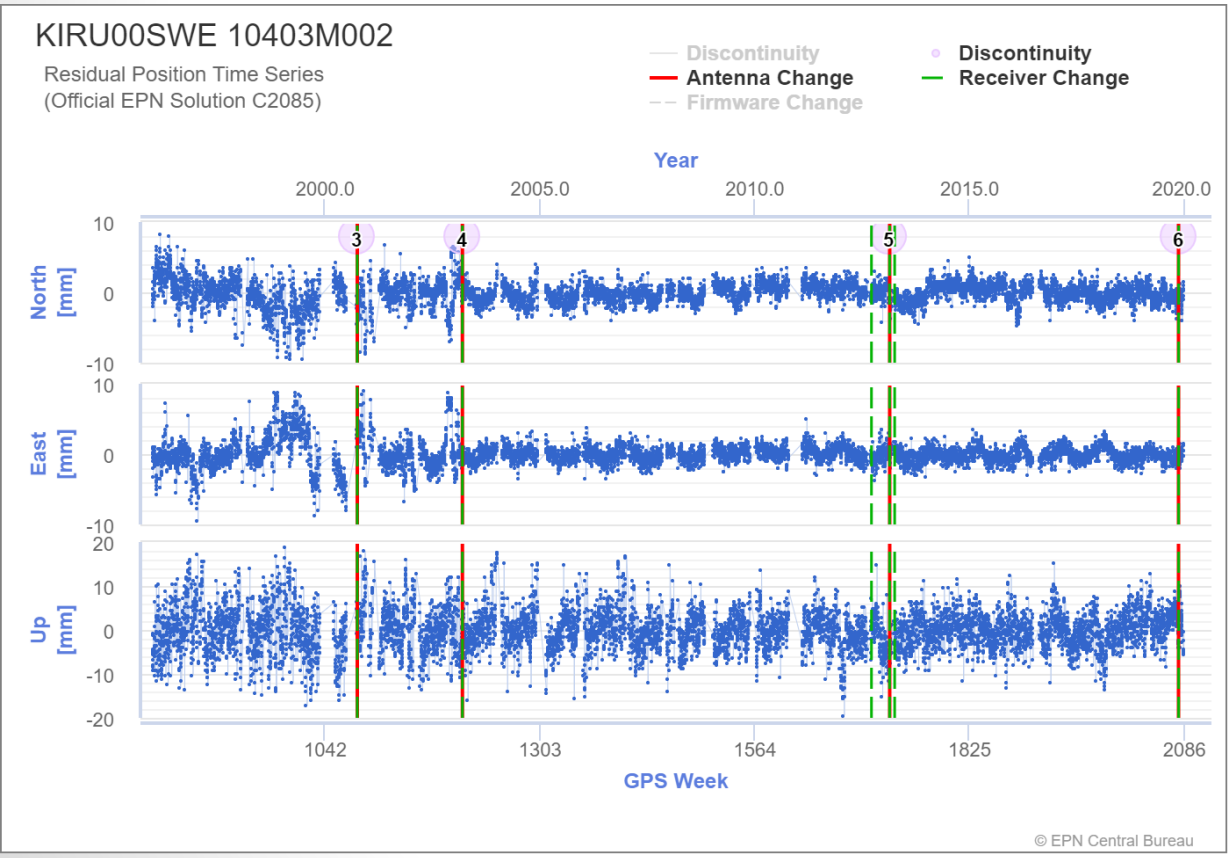
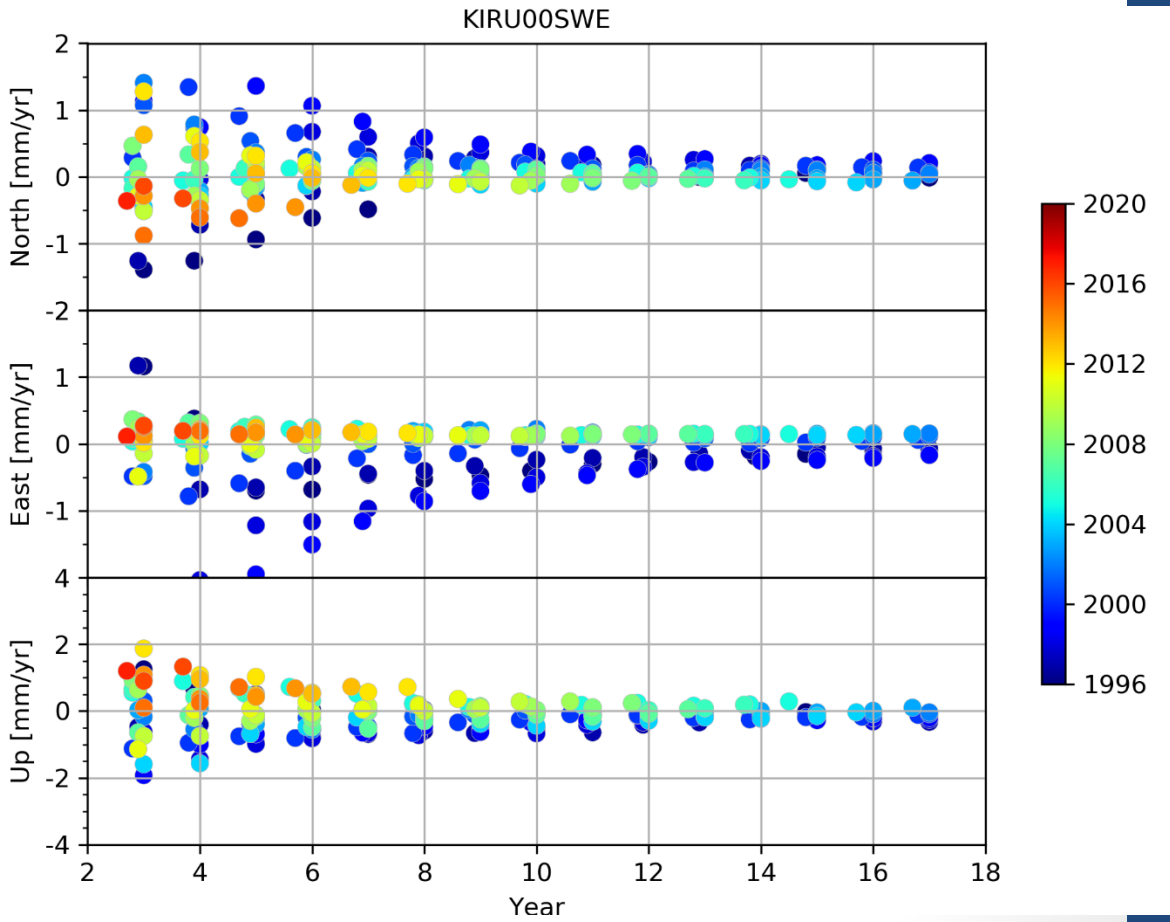
Input time series: position time series with jumps and trends

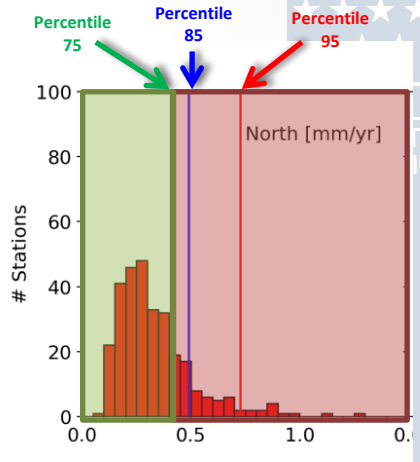


Differences between the velocities based on various time windows (3 to 18 years) and the velocity based on full data set of the station



Station Categories (3/3)

Name	Number	Criteria					Comment
		Velocity variability	Timeseries RMS	Amplitude 1Y signal	$DV_{Catref-Hector}$	σ_{Hector}	
C0	58	< Percentile 75	< Percentile 75				Most Stable Stations
C1	37	< Percentile 75	< Percentile 85				
C2	48	< Percentile 75	No threshold		< Percentile 85		Stable but Noisy or with Seasonal Signals
C3	12	< Percentile 85	< Percentile 85				Less Stable
C4	15	Not Available - Short time series	< Percentile 85				
C5	73	< Percentile 85	No criteria > Percentile 95				Even Less Stable
C6	124	velocity variability > Percentile 85 and/or 1 or more other criteria > Percentile 95 or Short time series with 1 or more criteria > Percentile 85					Less Reliable
Short	60	< 3yr - not applicable					No velocity published



Value < Percentile 75

- Keep the 75% best stations for the considered criteria
- Reject the 25 % worst stations for the considered criteria

Solution type 1: Positions

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Period of observation: 2019-01-01 – 2019-02-01

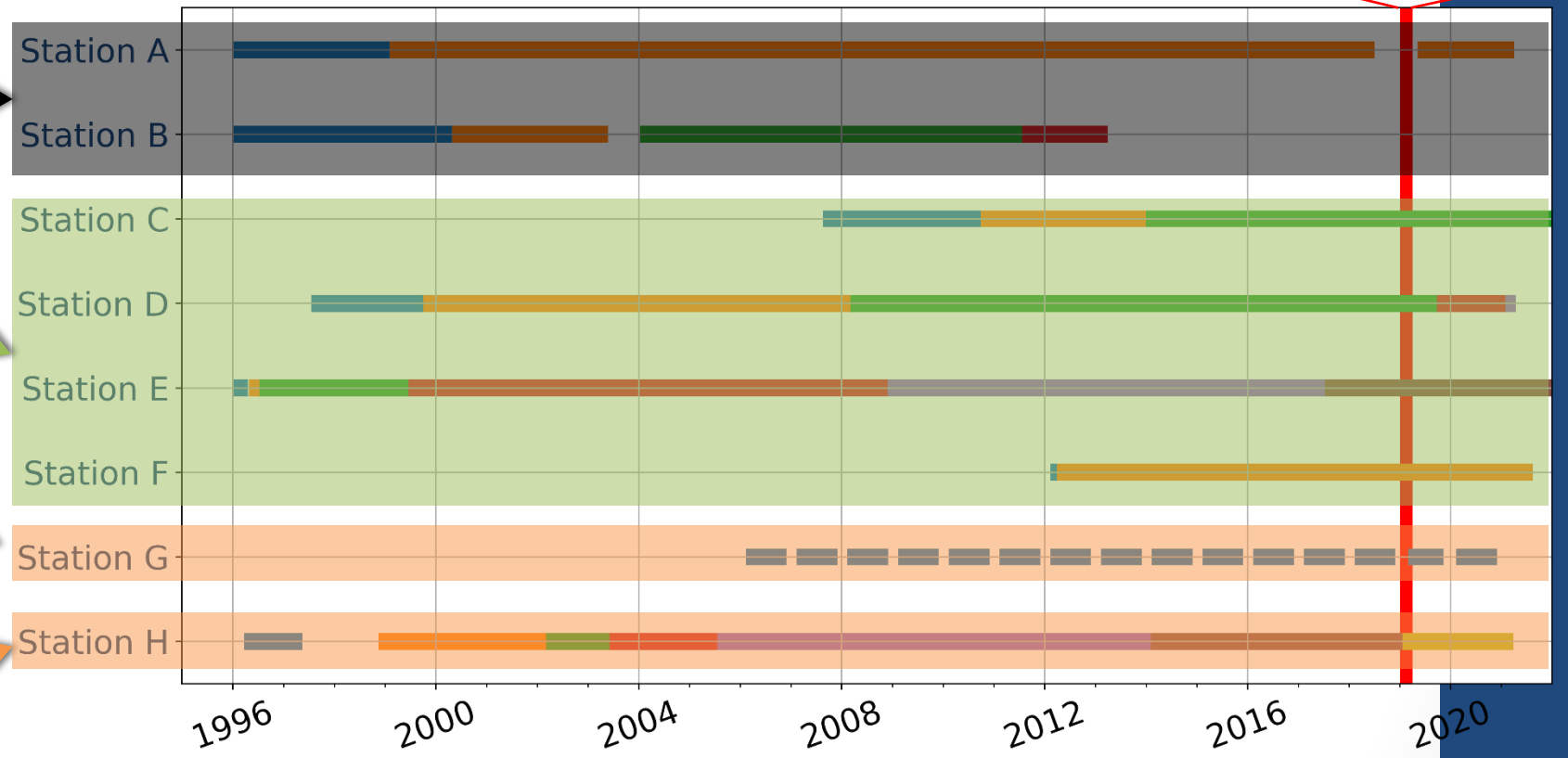
Potential reference frame stations

No data during the period of observation

Has data during the period of observation

Few data during the period of observation

Position discontinuity during the period of observation



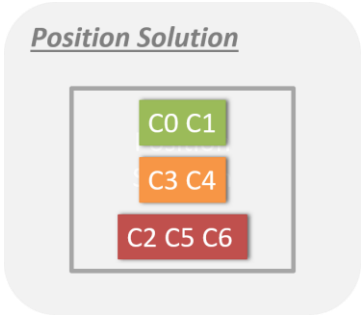
Observation availability in the EUREF Reference Frame Product

Solution type 1: Positions – Decision Model

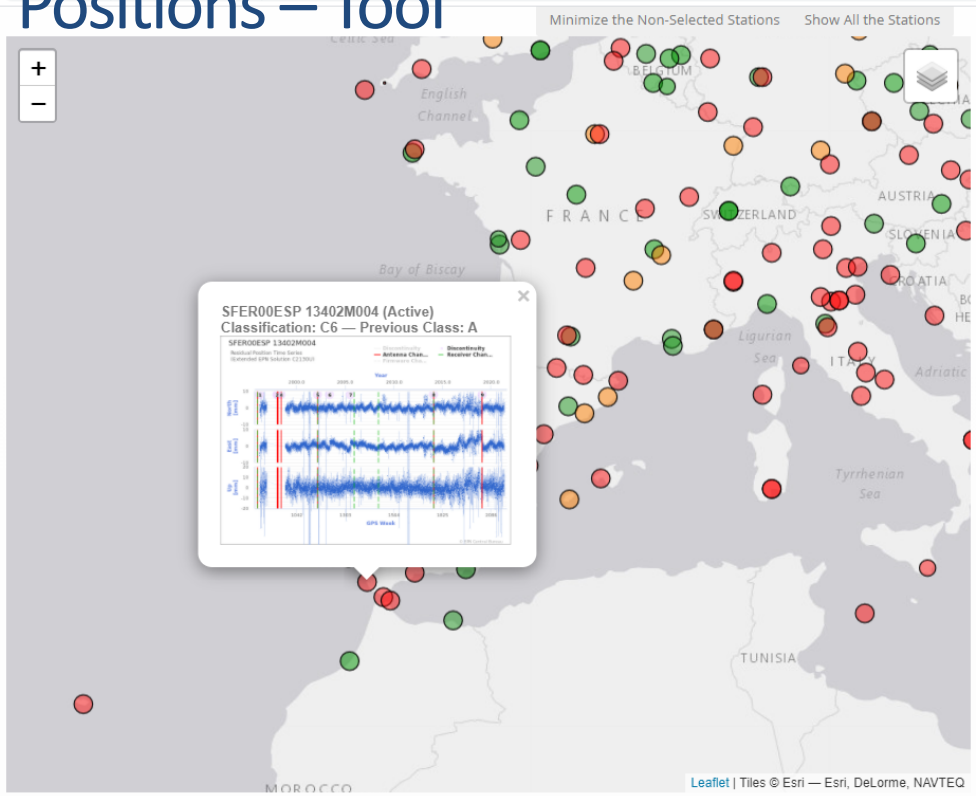
- Criteria 1: Observation availability in the EUREF Reference Frame Product during the period of observation
  - no days available ⇒ station not proposed in the list
  - Number of days in time series shown on the map with marker size

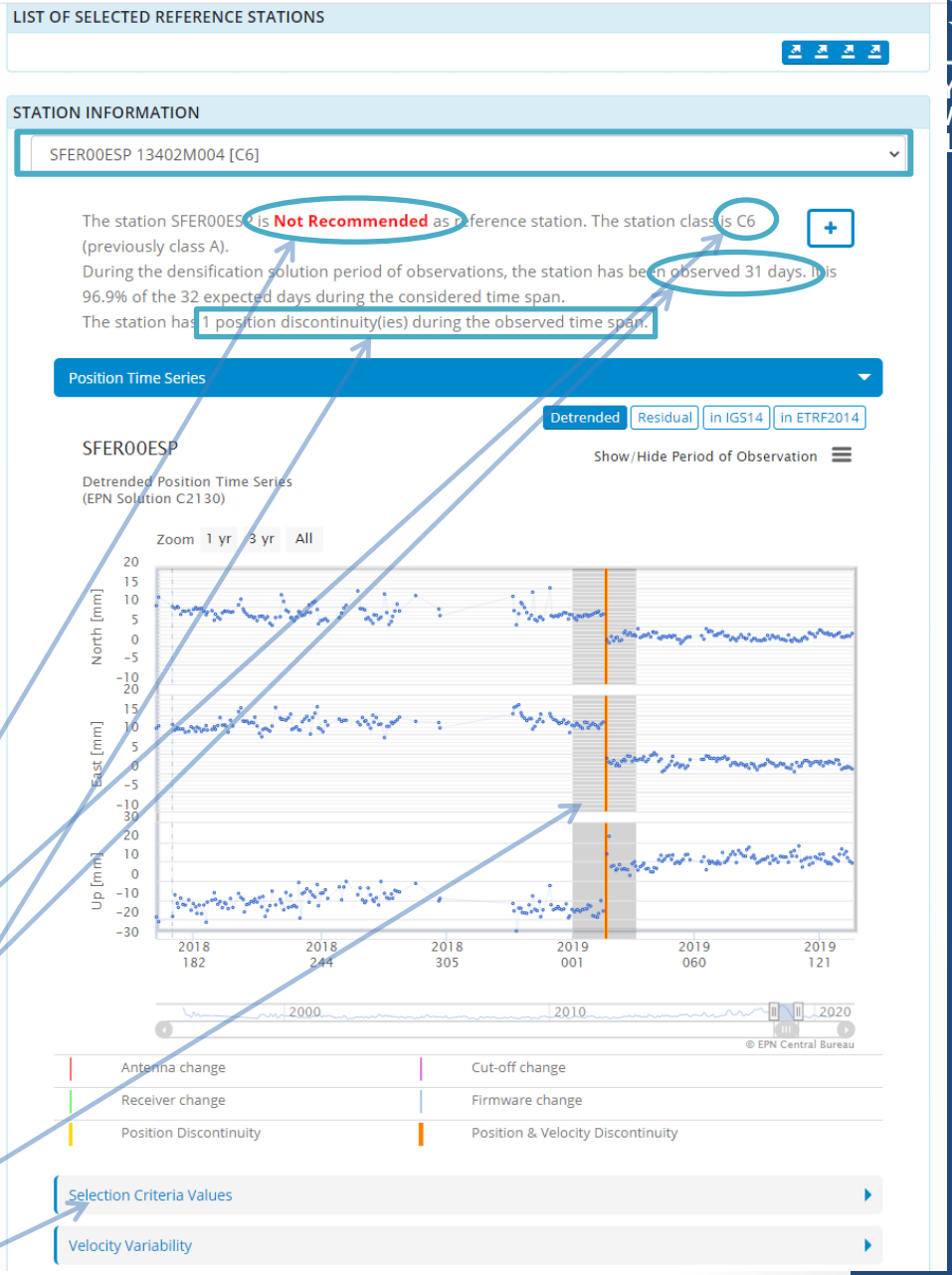
- Criteria 2: based on station categories
  - Recommended: C0, C1
  - Usable: C3, C4
  - Not Recommended: C2, C5, C6
    - C2: noisy time series and/or seasonal signals
    - C5/C6: instabilities and/or noisy time series and/or seasonal signals

- Relevant information:
  - Number of discontinuities during the period of observation
  - Detrended position time series
  - Plots showing the performance of the station



Solution type 1: Positions – Tool





Click or select a station ⇒ relevant information:

- Recommendation
- Category of the station
- Number of days of observation
- Number of position/velocity discontinuities during the considered period
- Detrended position time series to see the position changes
- Station Performances

Solution type 2: Positions - Velocities

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Period of observation: 2007-12-01 – 2018-12-31

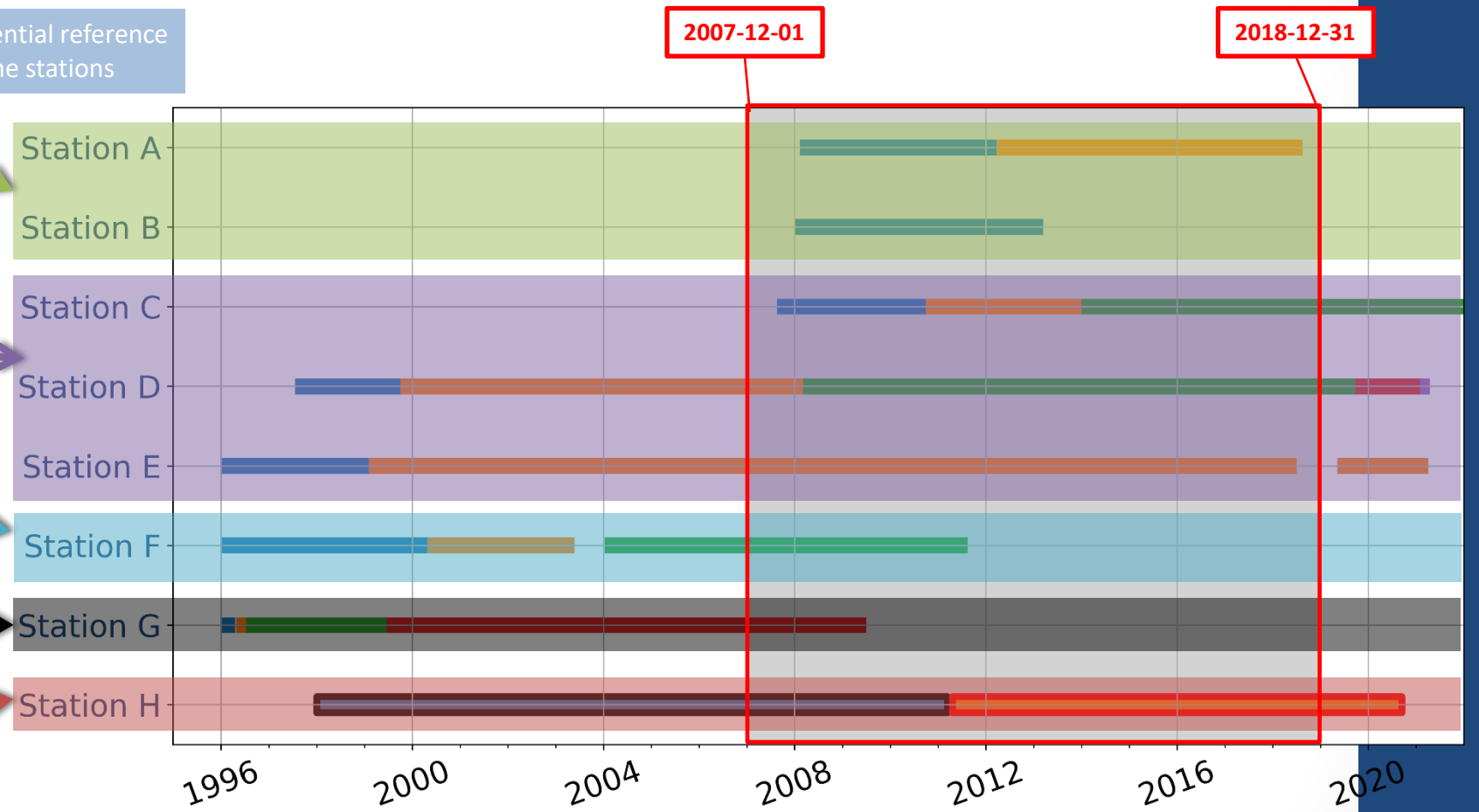
same period of observation in both solutions

≠ periods of observation > 6 years

≠ periods of observation < 6 years

< 3years

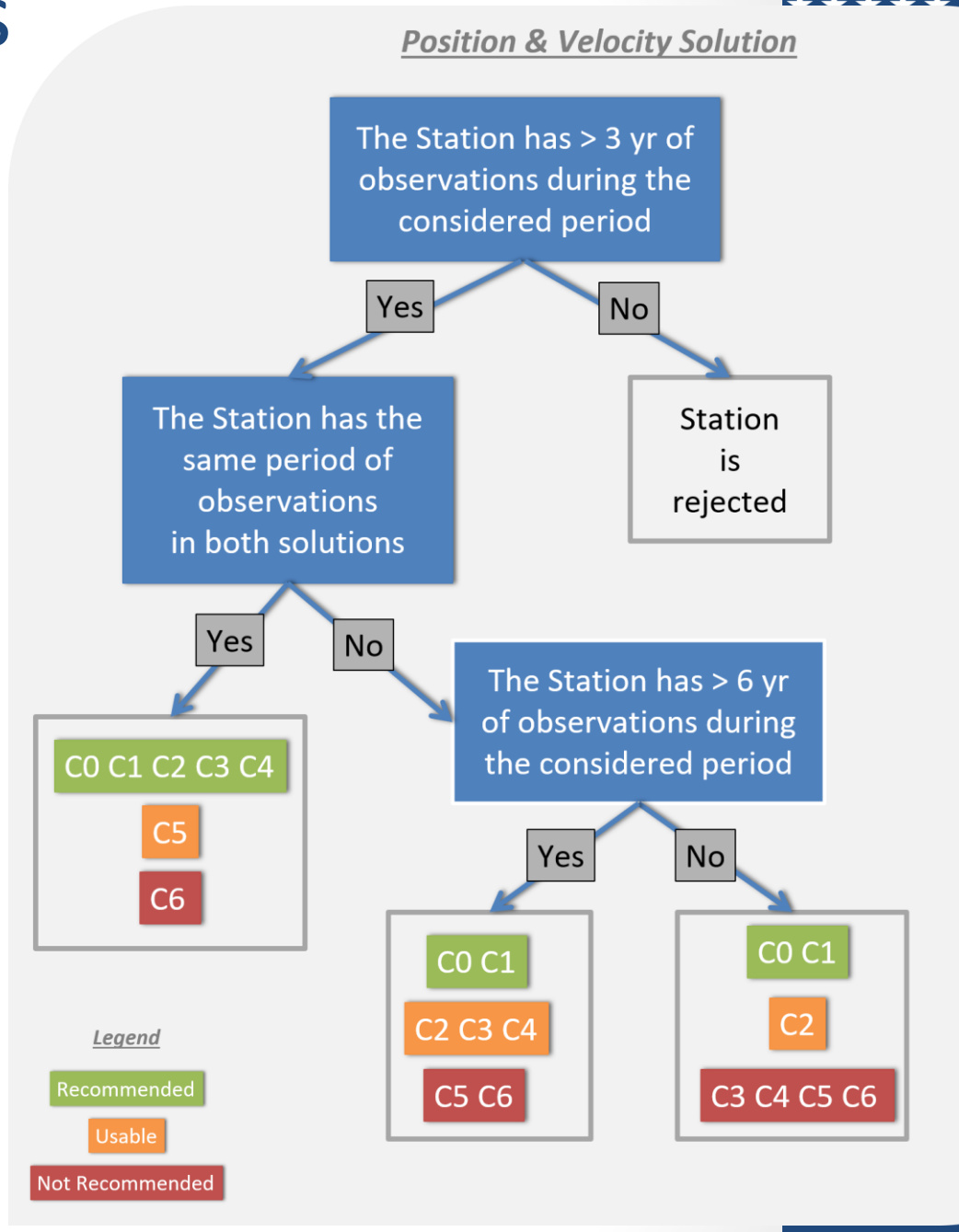
Velocity change during the period of observation



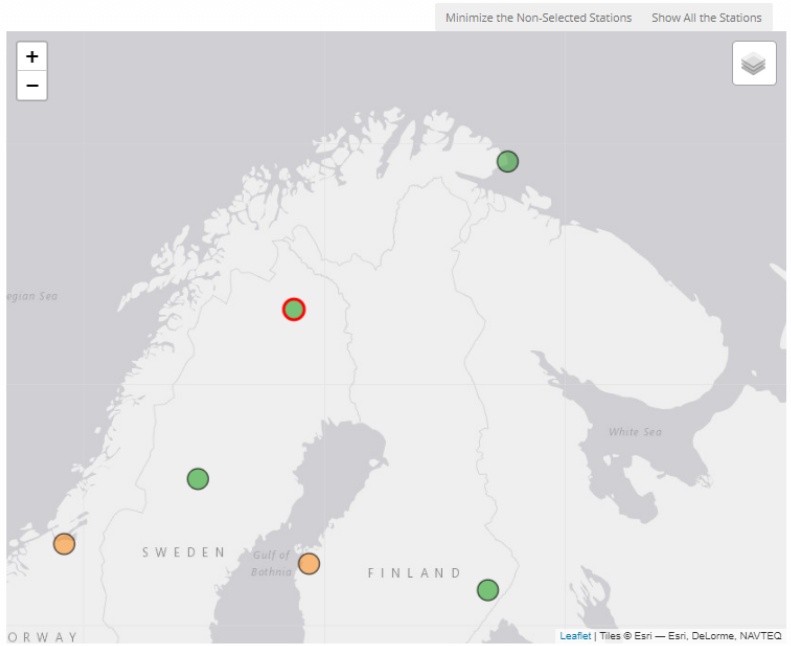
Observation availability in the EUREF Reference Frame Product

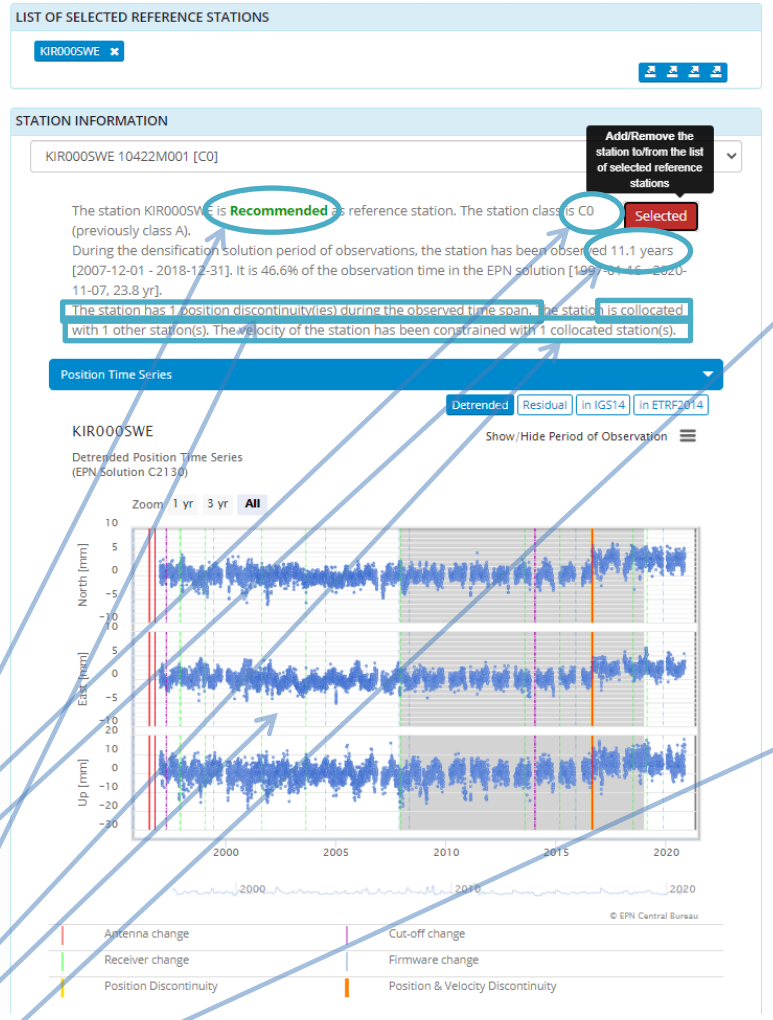
Solution type 2: Positions – Velocities Decision Model

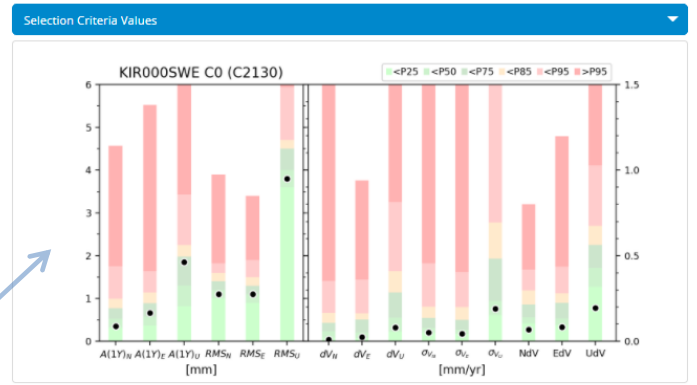
- Criteria 1: Observation availability in the EUREF Reference Frame Product during the period of observation
  - < 3 years ⇒ station not proposed in the list
  - Number of years in time series shown on the map with marker size
- Criteria 2: based on station categories
  - Depends on the number of years of observation
- Relevant information:
  - Number of position/velocity discontinuities during the period of observation
  - Collocated stations with velocity constrained
  - De-detrended position time series
  - Plots showing the performance of the station
  - Velocity variability plots

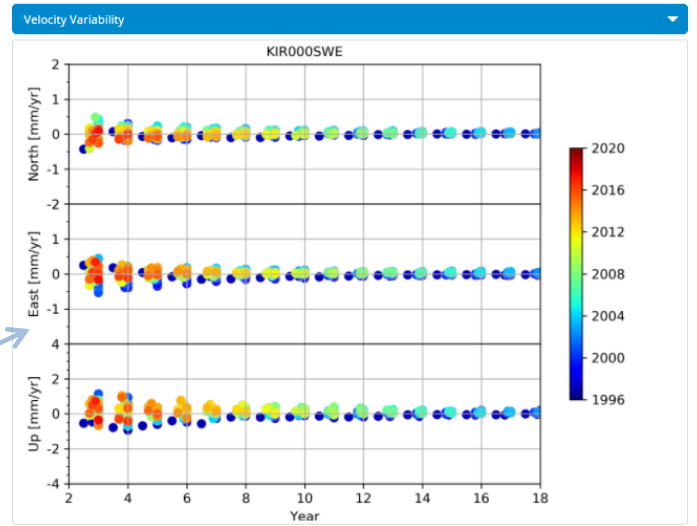


Solution type 2: Positions – Velocities Tool









Relevant information:

- Recommendation
- Station category
- Number of years of observation
- Number of position/velocity discontinuities during the period of observation
- Collocated stations with velocity constrained
- De-detrended position time series
- Plots showing the performance of the station
- Velocity variability plots

ROYAL OBSERVATORY OF BELGIUM