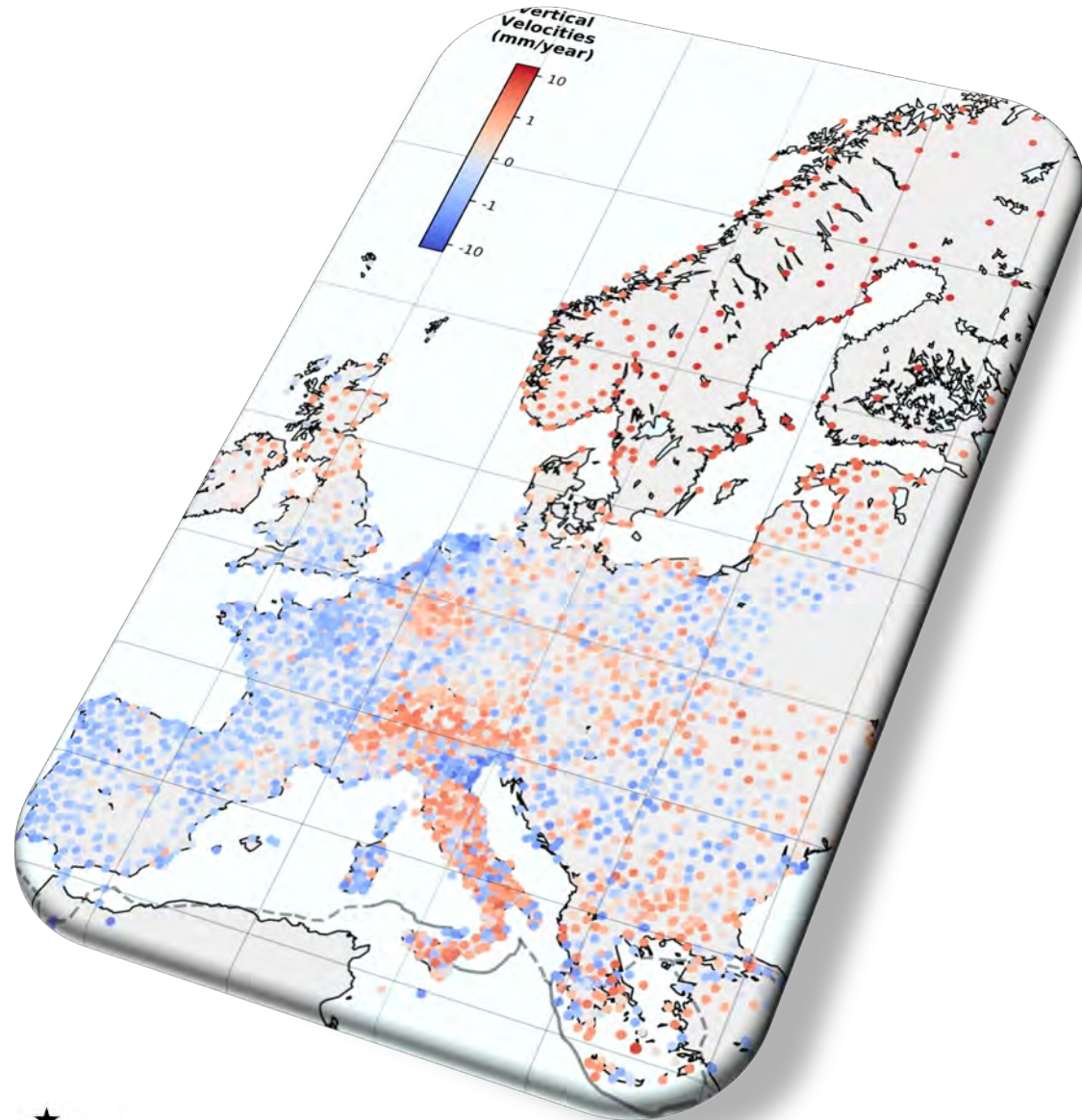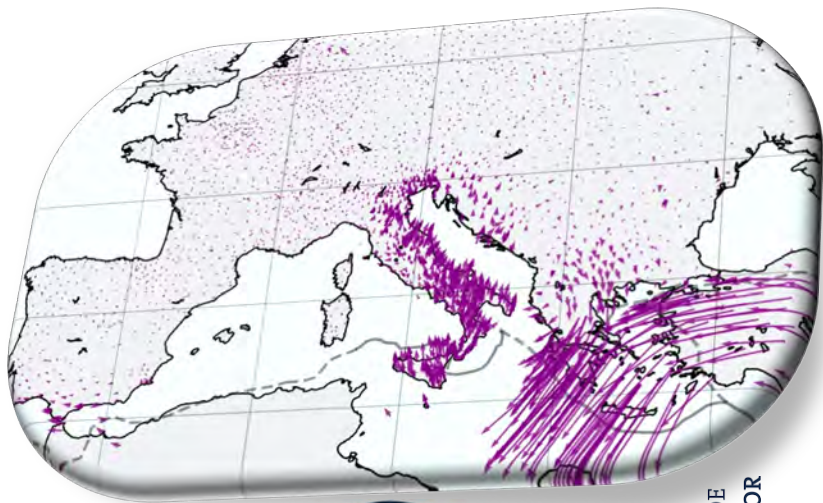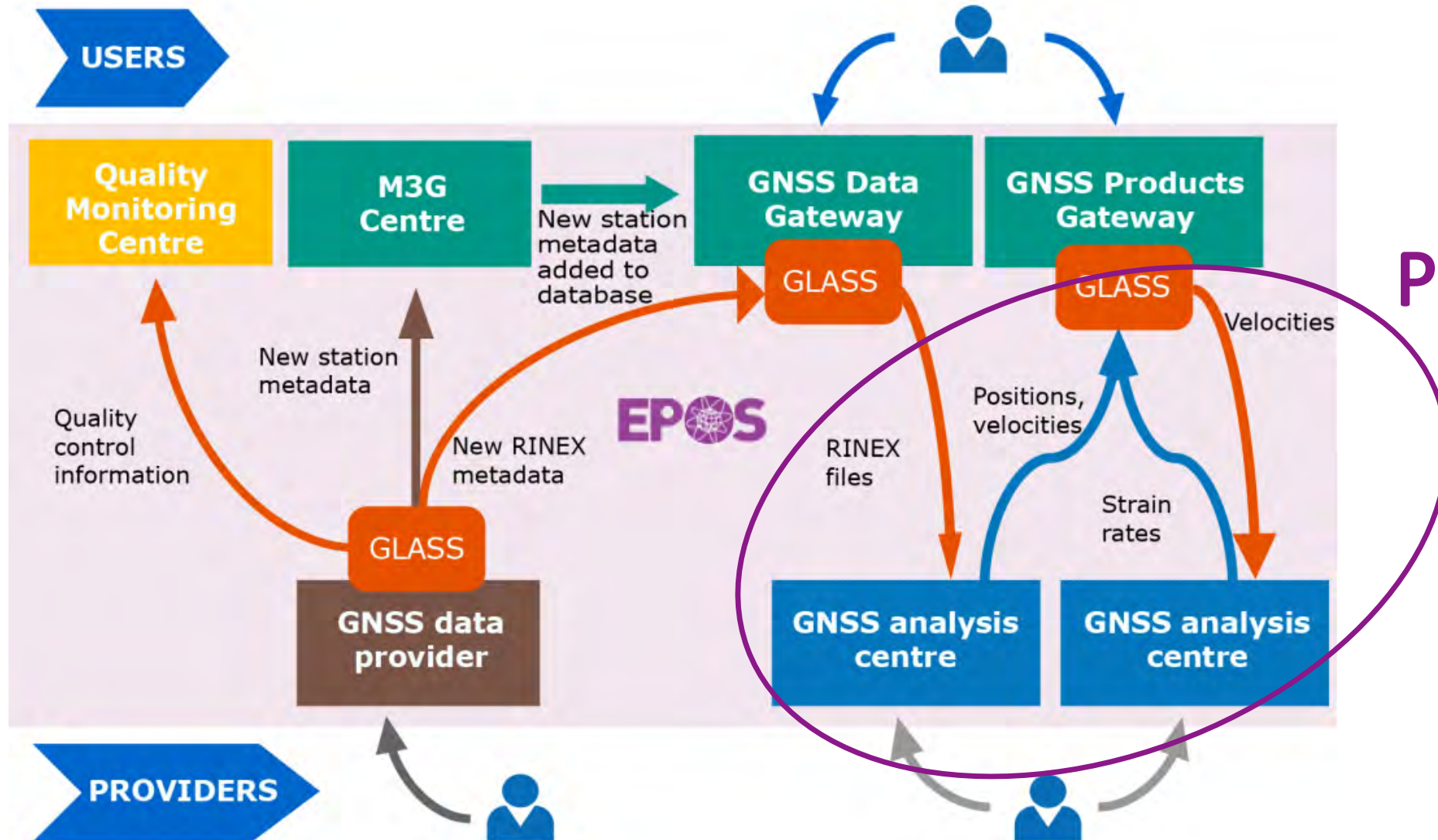# EPOS GNSS Products

What Product For What Usage?

Presenter : Anne Socquet
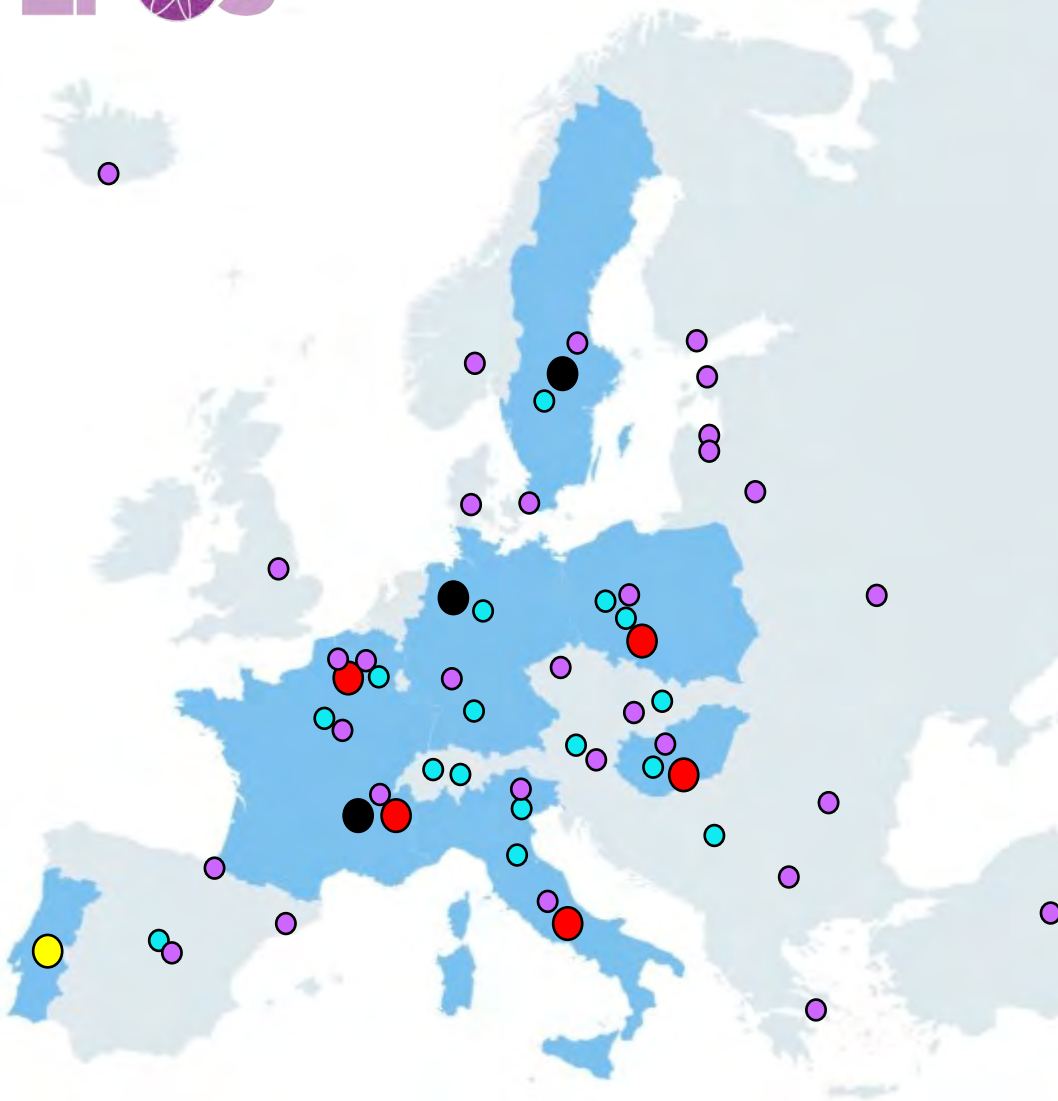Contributors : EPOS-GNSS Product Working Group

EPOS GNSS work flow

Who contributes to EPOS GNSS Products ?

Pan-European Service providers for EPOS-GNSS Products

- 🔴 5 Analysis Centers
- 🟡 1 Product Gateway
- ⚫ 3 Other Product-Related Services

National contributions to EPOS-GNSS Products

- 🔵 16 EUREF Analysis Centers

- 🟣 30 Analysis Centers for EPOS-EUREF-Densified

GNSS DATA AND PRODUCTS

What are the GNSS products?

Daily / Weekly Positions

Daily / Weekly Position Time Series

Secular velocities

Strain rate maps

What are the different products labels? What are their specificities?
EPOS, EUREF, EPOS-EUREF

Two product solutions developed specifically for EPOS

Principles:

- **Open science, reproducible**
  - **All data available:** RInEx from EPOS-GNSS Data Gateway, metadata available & verified
  - **Fully documented** processing strategies using **open-source softwares**

- **Specifically designed for geophysical studies** (including for slow movements)
  - Each solution is internally-consistent, generated @ a single Pan-European processing center with one strategy
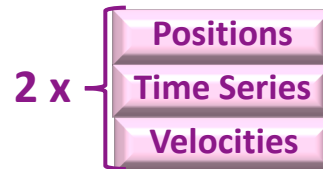
616 EPOS stations
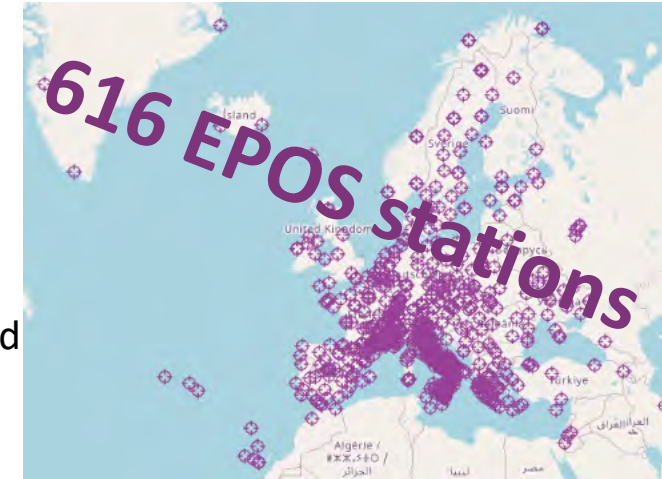
Daily positions & Multi-year solutions @ 2 Pan-European EPOS Analysis Centers

2 x — Positions / Time Series / Velocities

Quality Check

Independent cross-comparison and validation @ Pan-European Analysis Combination Center

- ➢ Two independent daily solutions :
  - generated @ 2 independent processing centers
  - with 2 independent processing Strategies & Softwares :

Double difference GAMIT/GLOBK/PYACS Automatic updates @ D-2 & D-25	PPP GIPSY-OASIS-II Regular Updates

- ➢ Automated outlier rejection, introduction of discontinuities in time series
- ➢ Velocities Computed with MIDAS, station classification based on uncertainty

- ➢ Comparison of Positions Time Series using CATREF
- ➢ Identification of outlier and inconsistencies
- ➢ Validation or feedback to the EPOS Analysis Centers

What are the different products labels? What are their specificities?
EPOS, **EUREF**, EPOS-EUREF

Original EUREF product made available through the EPOS GNSS Product Gateway

353 EPN stations

Principles:

- **Open data :** RInEx available from EPN data centers, metadata available & verified

- **Specifically designed for geodesy and reference frame studies :**
  - Geodetic-class stations from the EUREF Permanent Network (EPN)
  - Densifies ITRF over Europe and provides access to European Terrestrial Reference Frame (ETRF/ETRS89)

Regional daily position solution
@ 16 EPN Analysis Centers →

Daily and Weekly Combined Positions
@ EPN Analysis Combination Center →

Positions

Multi-year Solution
@ EPN Reference Frame Analysis Center

Positions
Time Series
Velocities

- ➢ each station processed by at least 3 ACs to insure redundancy and increase reliability
- ➢ 3 softwares: Bernese, Gamit, Gipsy

- ➢ Pan-European combinations with Bernese
- ➢ Each AC solution is compared to the combined solution to identify and reject outliers
- ➢ Aligned to IGS14 using no-net-translation

- ➢ Updated each 15 weeks
- ➢ Using CATREF
- ➢ Outlier rejection by visual inspection of time series, introduction of position and velocity discontinuities, station classification based on velocity uncertainties from Hector and velocity variability

What are the different products labels? What are their specificities?

EPOS, EUREF, **EPOS-EUREF**

Densification Product from EUREF and EPOS

Principles:

- **Provide a densified velocity field,** including non-EPOS stations that do not release raw data (yet?)

2410 sites

Regional daily position solution @ 30 EPND & EPOS Analysis Centers

➤ 3 softwares: Bernese, Gamit, Gipsy

icgc.cat

➡ **Multi-year Combined Solution @ EPOS-EUREF Combination Center**

- Positions
- Time Series
- Velocities

➤ Weekly Combined Positions Time Series using CATREF
➤ Velocities using CATREF, MIDAS, HECTOR
➤ Station metadata harmonization
➤ Outlier rejection by automated and visual inspection of time series, introduction of position and velocity discontinuities, velocity filtering, removal of non-representative stations (data quality or monumentation)

What products for what usage? Use Cases

UC1 : Structural geologist wants to get the secular displacement rates and the strain rate maps in Spain

Recommended products :
- EPOS–EUREF densified Velocity field from LTK rotated wrt Stable Europe
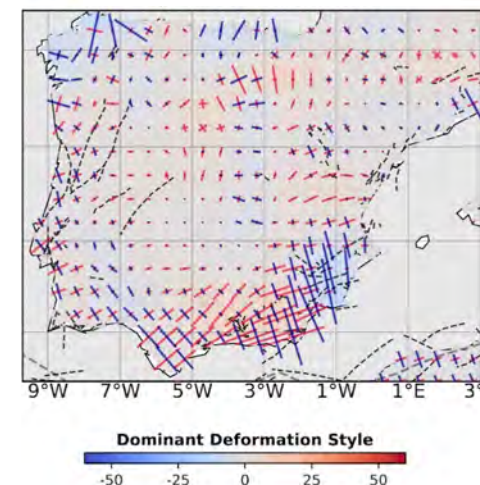- Strain Rate products from LM

Additional products :
- EPOS velocity fields from INGV and UGA-CNRS rotated wrt stable Europe
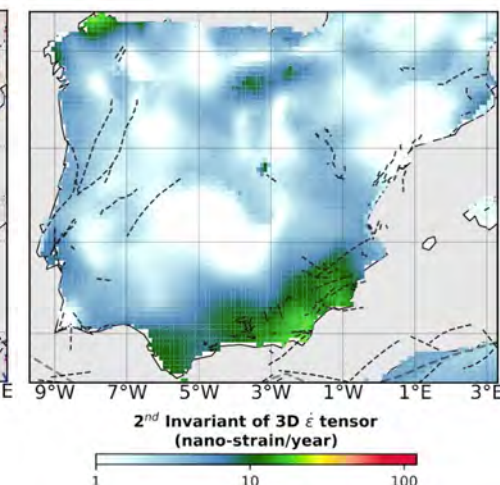- EUREF velocity field from ROB-EUREF rotated wrt stable Europe

Secular GNSS Velocities (EPOS-EUREF solution)

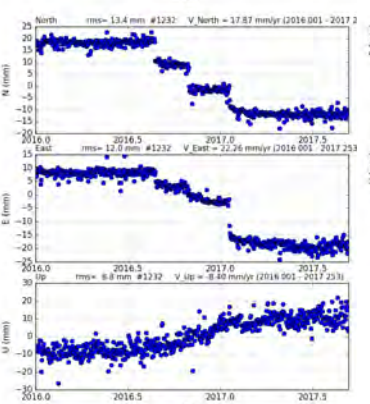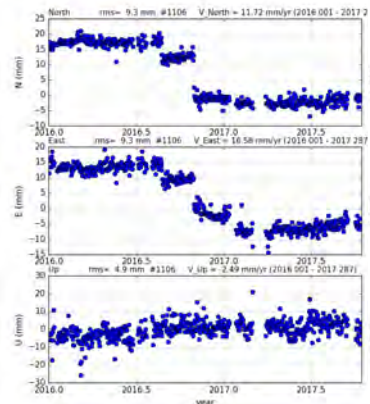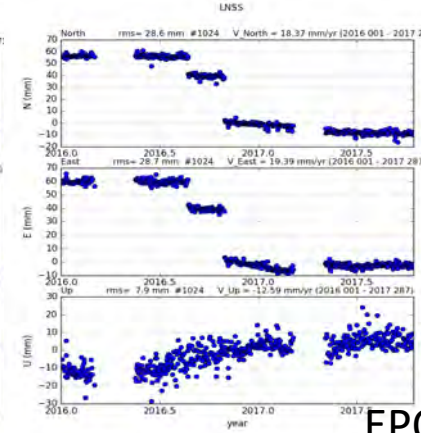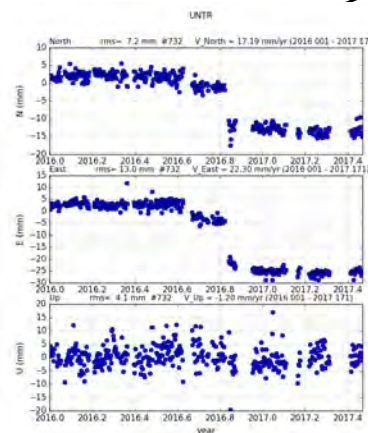Style of Deformation

Strain Rate

Dominant Deformation Style

2nd Invariant of 3D $\dot{\varepsilon}$ tensor (nano-strain/year)

Piña Valdes et al., in prep

What products for what usage? Use Cases

UC2 : Seismologist wants to get the time series associated with the 2016 earthquake sequence in Italy

Recommended products :
- EPOS daily time series from INGV and UGA-CNRS

Additional products :
- EUREF daily time series from ROB-EUREF
- EPOS-EUREF densified weekly time-series from LTK

EPOS position times series showing displacements associated with Amatrice (Mw 6.0) & Norcia (Mw 6.5) earthquakes
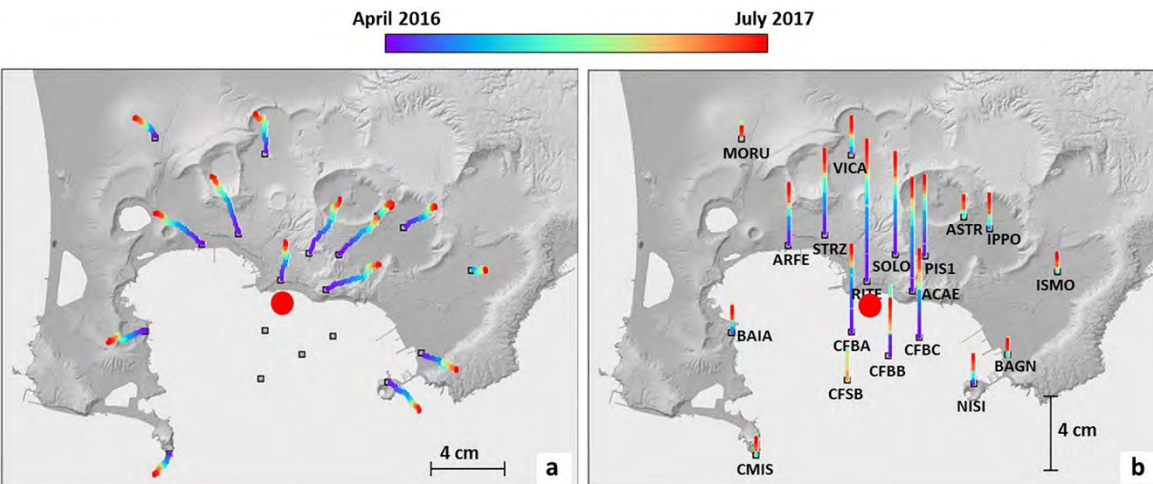
What products for what usage? Use Cases

UC3 : Volcanologist wants to get updates on time series in the area affected by recent volcanic unrest
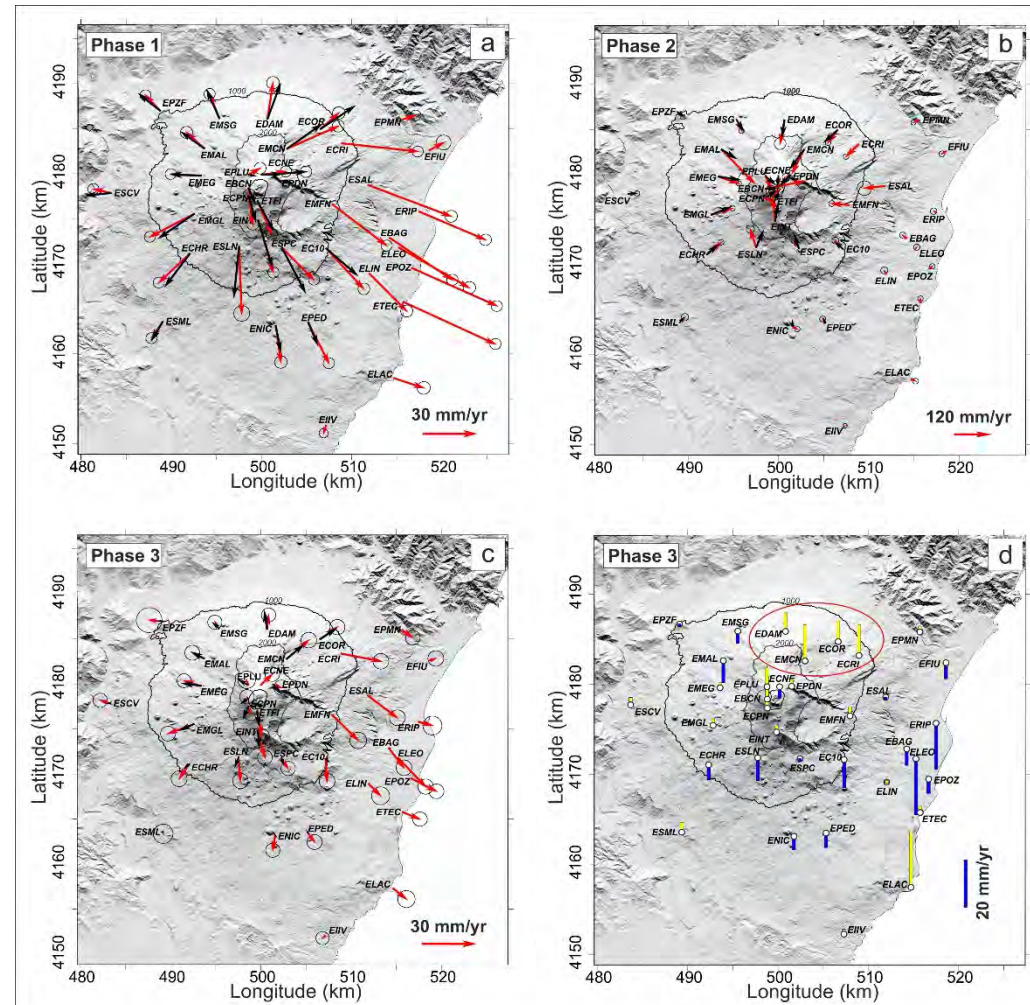
Recommended products :
- EPOS daily time series from UGA-CNRS (rapid solution)

Additional products:
- EPOS daily time series from INGV
- EUREF daily time series from ROB-EUREF

Campi Flegrei caldera GPS deformation between April 2016 and July 2017 (Iannaccone et al., 2017)

Inflation/deflation processes before/after an eruption onset at Mt Etna (modified from Bruno et al., 2012)
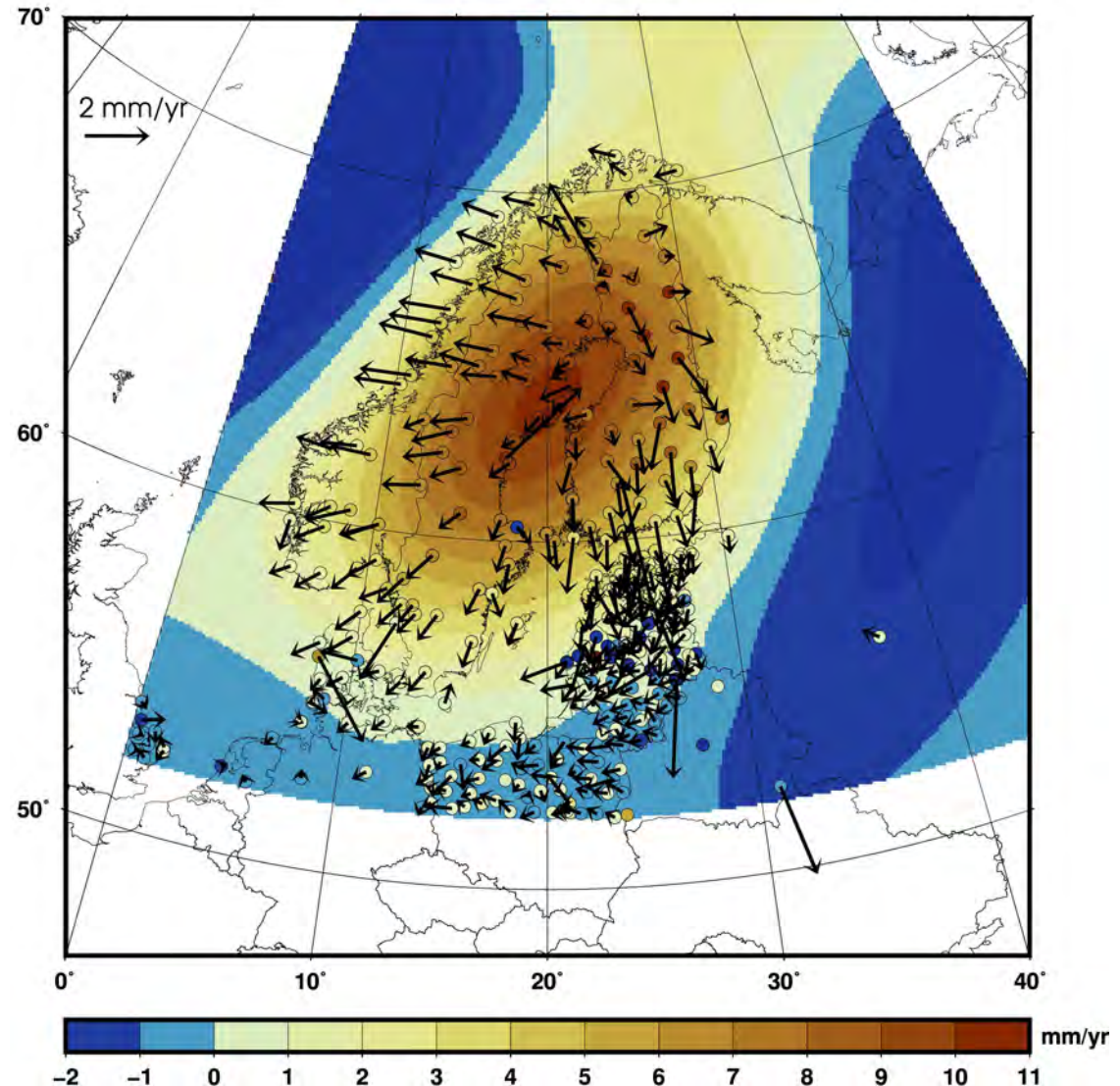
What products for what usage? Use Cases

UC4 : Geodynamicist wants 3D velocities
to constrain models of isostatic rebound

Recommended products :
- EPOS–EUREF densified Velocity field from LTK
  rotated wrt Stable Europe

Additional products :
- EPOS velocity fields from INGV and UGA-CNRS
  rotated wrt stable Europe
- EUREF velocity field from ROB-EUREF rotated
  wrt stable Europe

Horizontal & Vertical velocities of EPOS-EUREF solution compared to
model of Glacial Isostatic Adjustment NGK2016LU (Vestol et al. 2019)
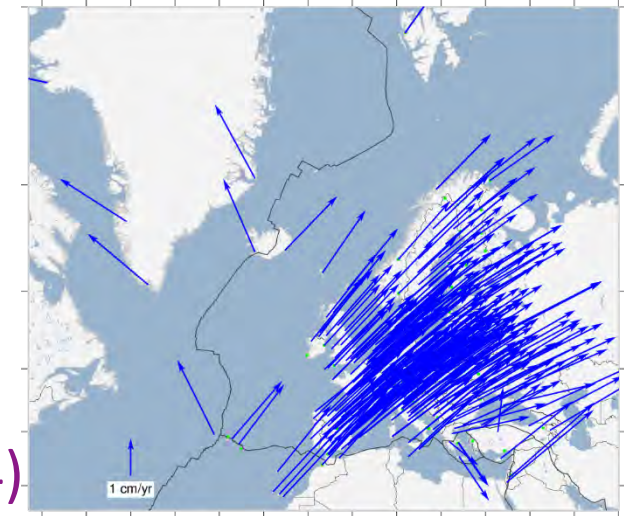
What products for what usage? Use Cases

UC5 : Geodesist wants to get reference positions and velocities for his processing
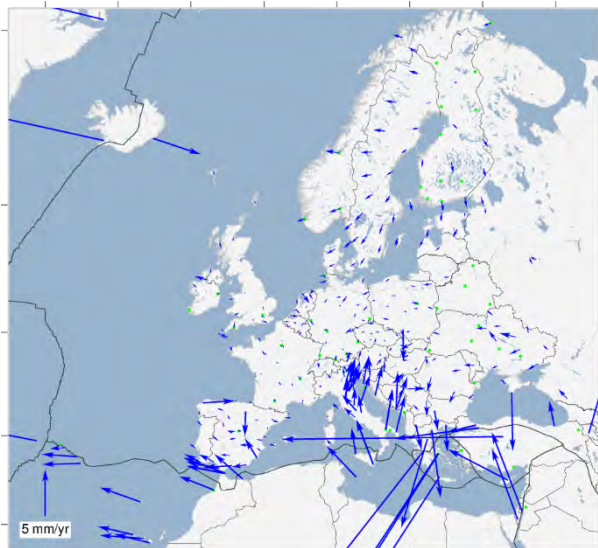
Recommended products :

- EUREF Positions and Velocities (SINEX format) from ROB-EUREF wrt ITRF2014 or ETRF2000/2014

Additional products :

- EPOSPositions and Velocities (SINEX format) from UGA-CNRS or INGV wrt ITRF2014
- EPOS–EUREF Positions and Velocities (SINEX format) from LTK wrt ITRF2014

1 cm/yr

ITRF2014 (IGb14)

```
+SOLUTION/ESTIMATE
*INDEX TYPE___ CODE PT SOLN _REF_EPOCH__ UNIT S __ESTIMATED VALUE____  _STD_DEV___
    1 STAX    BOR1  A    1 10:001:00000 m    2 0.373835836922076E+07 0.12576E-03
    2 STAY    BOR1  A    1 10:001:00000 m    2 0.114817378419497E+07 0.57041E-04
    3 STAZ    BOR1  A    1 10:001:00000 m    2 0.502181581428678E+07 0.15176E-03
    4 VELX    BOR1  A    1 10:001:00000 m/y  2 -.173659211197266E-01 0.74991E-05
    5 VELY    BOR1  A    1 10:001:00000 m/y  2 0.156528761430914E-01 0.35223E-05
    6 VELZ    BOR1  A    1 10:001:00000 m/y  2 0.865199891742149E-02 0.91018E-05
```


5 mm/yr

ETRF2014

```
+SOLUTION/ESTIMATE
*INDEX TYPE___ CODE PT SOLN _REF_EPOCH__ UNIT S __ESTIMATED VALUE____  _STD_DEV___
    1 STAX    BOR1  A    1 10:001:00000 m    2 0.373835873071839E+07 0.12576E-03
    2 STAY    BOR1  A    1 10:001:00000 m    2 0.114817344767030E+07 0.57041E-04
    3 STAZ    BOR1  A    1 10:001:00000 m    2 0.502181562212145E+07 0.15176E-03
    4 VELX    BOR1  A    1 10:001:00000 m/y  2 -.151748349201475E-03 0.74991E-05
    5 VELY    BOR1  A    1 10:001:00000 m/y  2 -.372108189692187E-03 0.35223E-05
    6 VELZ    BOR1  A    1 10:001:00000 m/y  2 -.498730946492080E-03 0.91018E-05
```

GNSS DATA AND PRODUCTS

Thanks for you attention - Any Questions?

Where can you get EPOS GNSS Products ?
https://gnssproducts.epos.ubi.pt/

→ see presentation about the product portal