On synergy + complementarity between InSAR & GMSS
EGMS perspective

Land Monitoring

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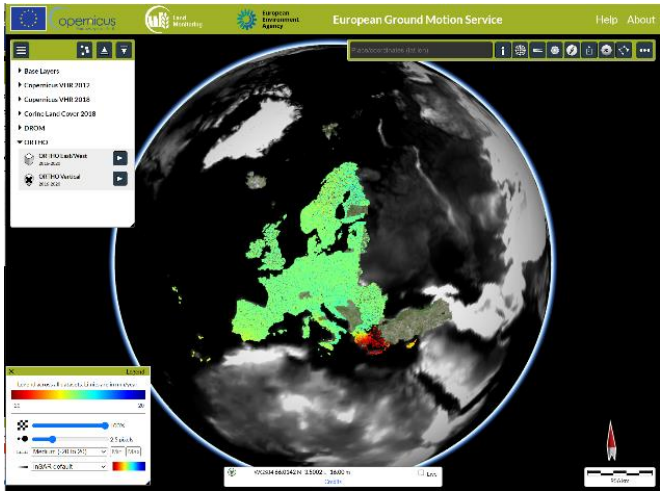
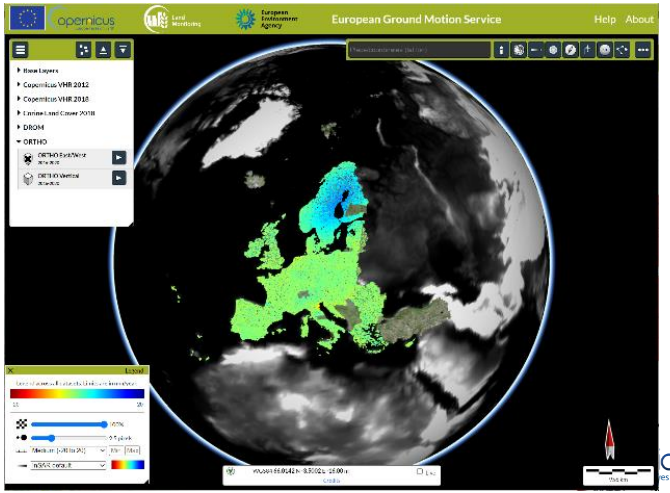
[Pre-Introduction]: What is EGMS?

- The first continental-scale InSAR ground deformation monitoring service
- Based on the full-resolution processing of Copernicus Sentinel-1 satellite data
- Service launch & initial products on May 19th 2022
- Complete product portfolio by the end of June 2022.

https://egms.land.copernicus.eu/





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Introduction

What this presentation is about:

Why & how GNSS data is used in EGMS?

What this presentation is **NOT** about:

How to manage & grid GNSS data…

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Why GNSS for EGMS?

EGMS requirement: *"EGMS Level-2B and Level-3 products shall be referenced to a well-defined geodetic frame [currently ETRF2000]"*

Synergy between GNSS and InSAR

InSAR features:

- Dense & relative measurements
- Very *precise* on short and medium spatial scales (<50km)
- Only 1D LoS measurement (2D exploiting ascending/descending)

GNSS features *(in EGMS context)*:

- Sparse & "absolute" measurements
- Accurate on spatial scales larger than spacing of GNSS stations (>50 km)
- 3D measurements

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Why gridded GNSS velocity model for EGMS?

"Why are we not doing non-linear, and why we are gridding…?"

Why GNSS?

- InSAR is "relative" technique (EGMS Level-2a product)
- GNSS for "anchoring"

Why gridded GNSS velocity model?

- GNSS stations prone to influence of local motion
- [Density is a separate issue]

Important-side-notes:

- Local phenomena observed with InSAR at much higher spatial resolution
- Large-scale motion (>50 km) not expected to have significant non-linear components
- Many GNSS stations don't cover the complete time span of the baseline EGMS product

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"Why are we not doing non-linear, and why we are gridding…?"

Why GNSS?

- InSAR is "relative" technique (EGMS Level-2a product)
- GNSS for "anchoring"

Why gridded GNSS velocity model?

Derive the "absolute" average velocity on long spatial scales (>50 km) from GNSS and retrieve relative local motion (<50 km) from InSAR

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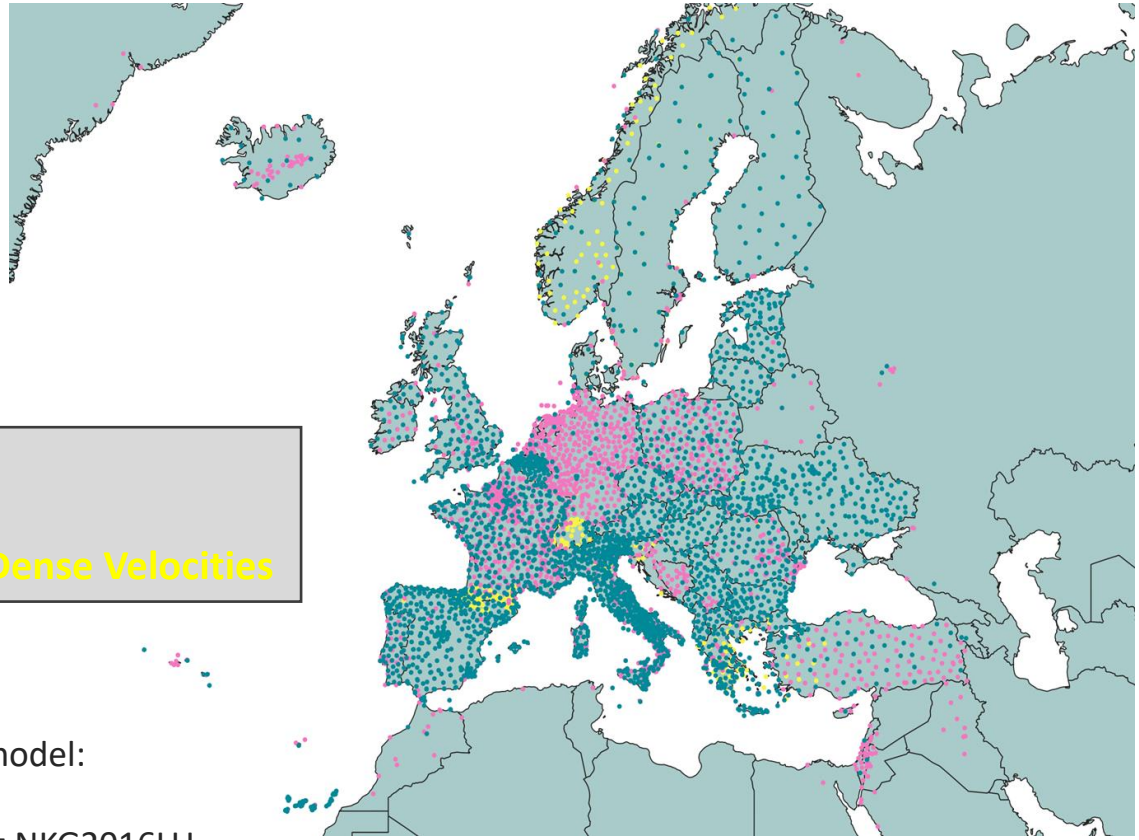
A-EPND: Input Data



Primary: EPND
Secondary: Nevada Geodetic Lab
Gap filler: EUREF WG on European Dense Velocities

Auxiliary data for constraining the model:

- Tectonic boundaries
- Other existing models, including NKG2016LU

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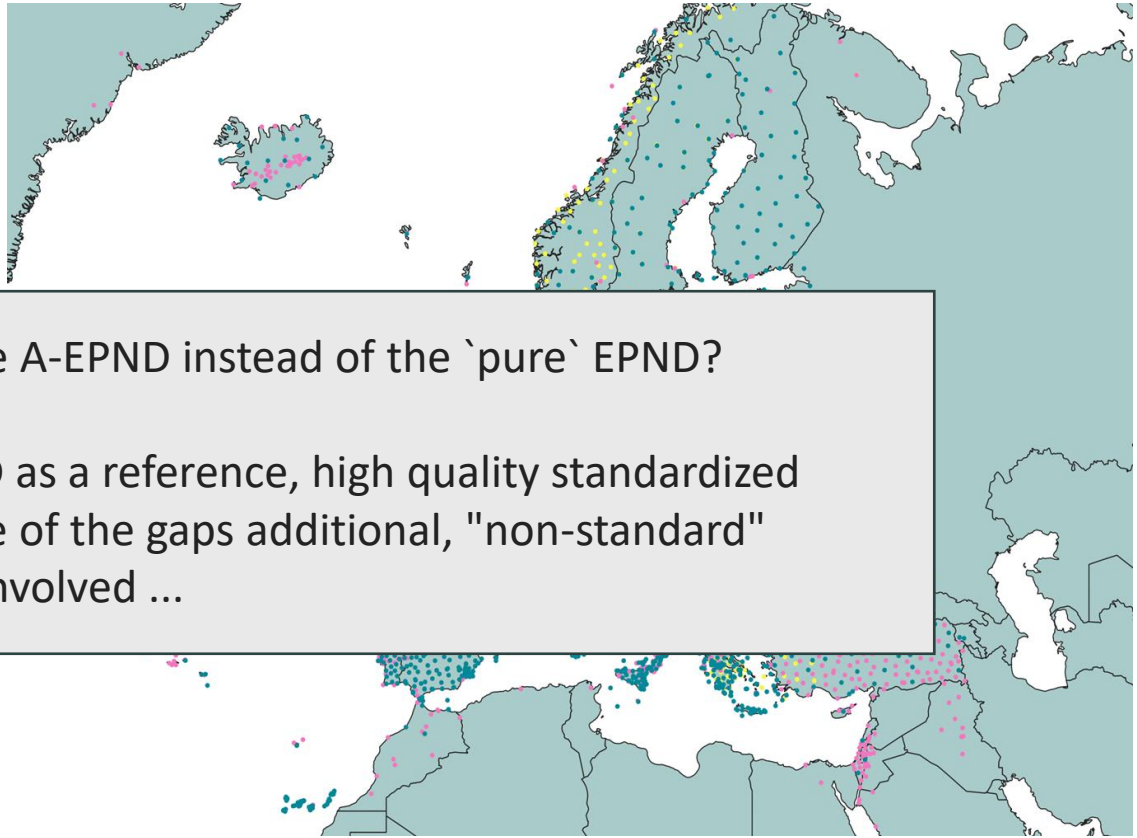
A-EPND: Input Data



Q: Why we used here A-EPND instead of the `pure` EPND?

A: We consider EPND as a reference, high quality standardized solution, but because of the gaps additional, "non-standard" solutions had to be involved ...

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A-EPND: Approach

- **Step 1:** Data-preprocessing - “Selection of applicable stations”
  - (outlier removal, etc)
- **Step 2:** Trend remove
  - partially based on existing models (Iceland, Scandiavia)
  - tectonic boundaries (Eastern Mediterranean)
- **Step 3:** Collocation [Moritz, 197x]
- **Step 4:** Trend restore
- **OUTPUT:**
  - 50 km posting
  - Lambert Azimuthal Equal Area Europe, EPSG:3035

EGMS A-EPND document publicly available at:
https://land.copernicus.eu/user-corner/technical-library/egms-gnss-calibration-report

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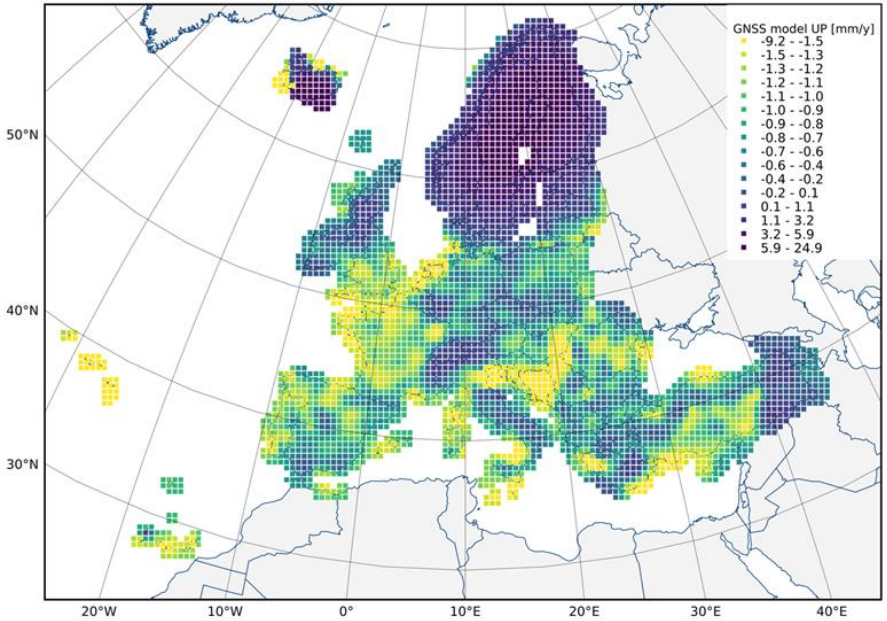
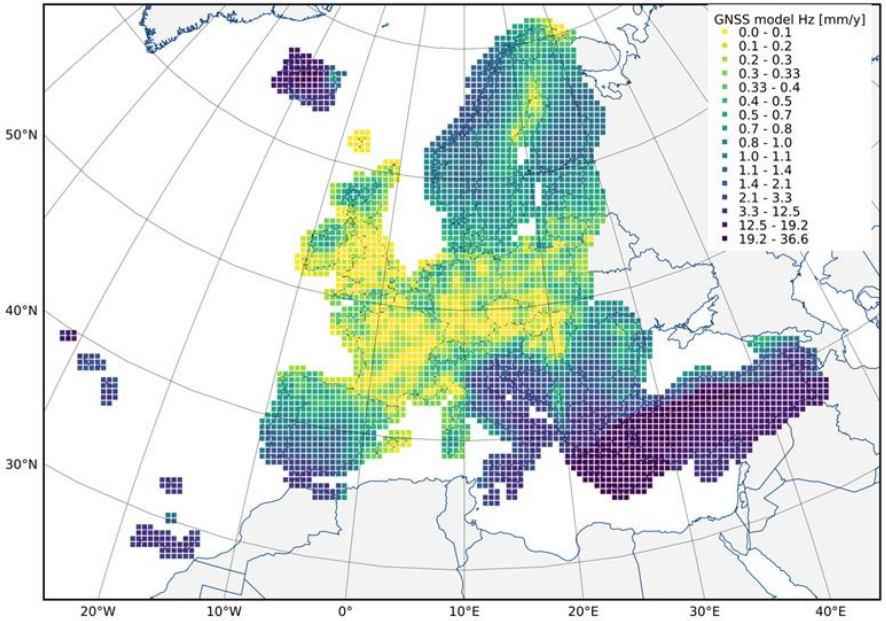
A-EPND: Model

VERTICAL velocity component of A-EPND



HORIZONTAL velocity component of A-EPND



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A-EPND: Vertical velocity component

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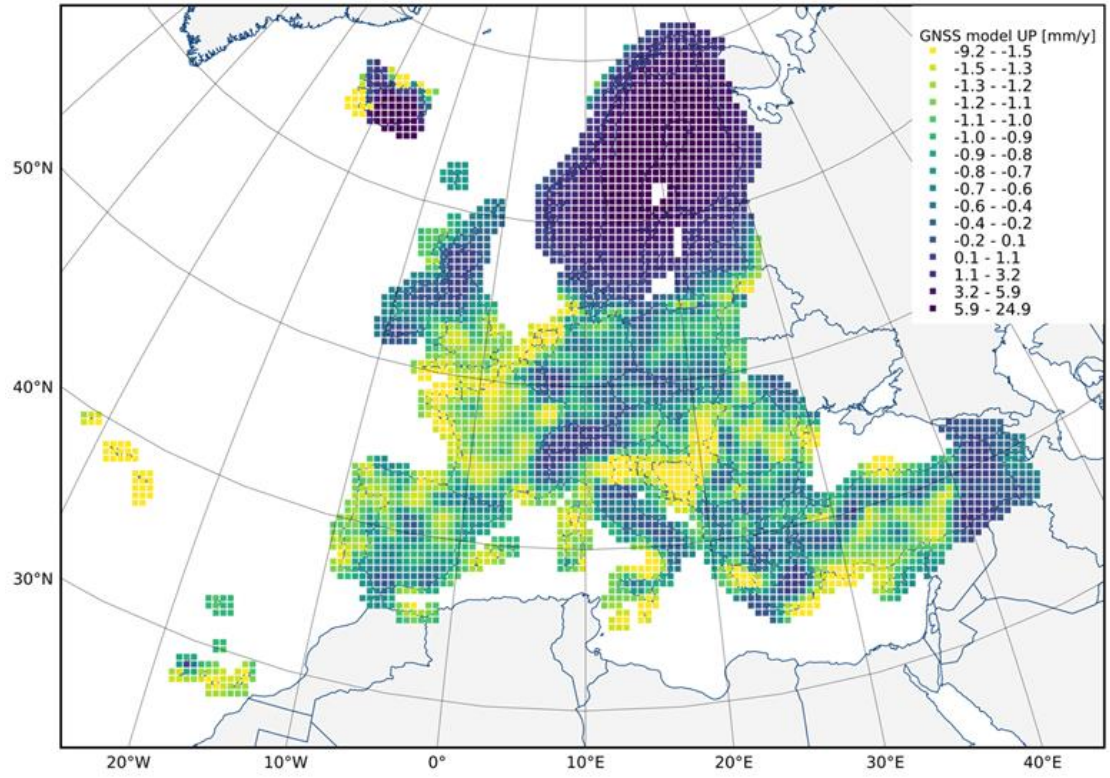

Side-notes:

- Scandinavia post glacial uplift
- Alps (uplift)

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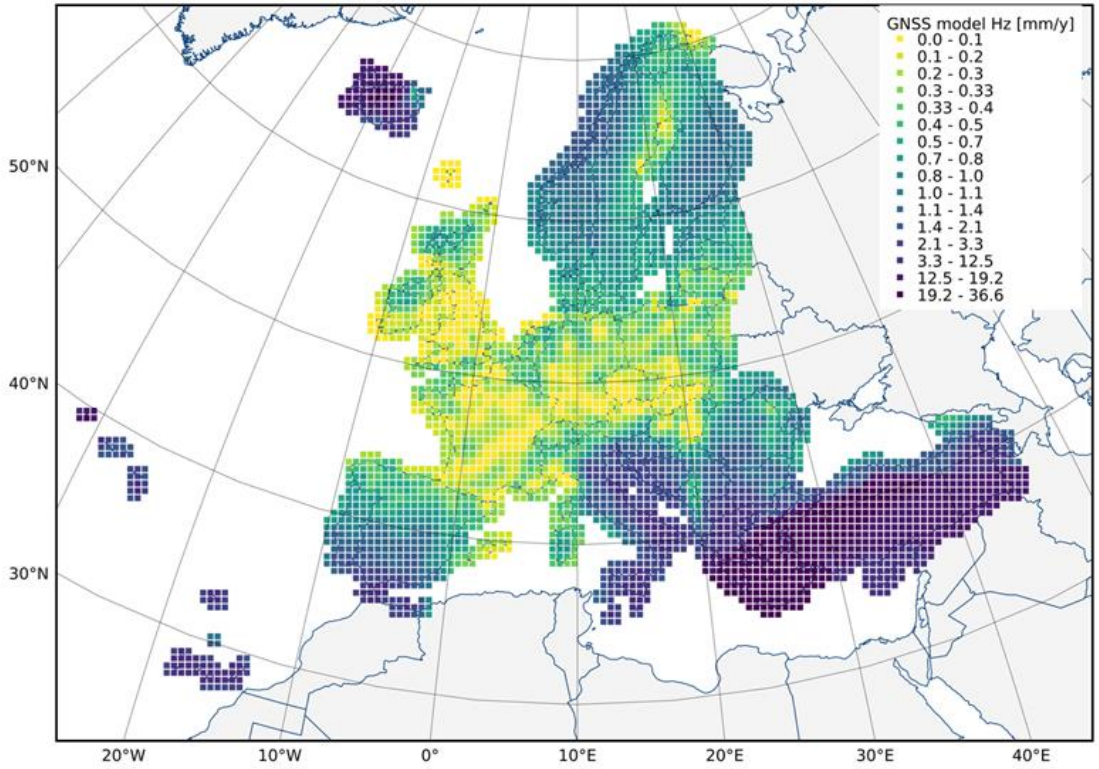
A-EPND: Horizontal component



Side-notes:

Turkey and Greece:

- multiple plate boundaries between tectonic units

Gibraltar:

- Eurasian - African plate boundary

Iceland (two different tectonic plates):

- Eastern parts:
  - on same plate as Europe (smaller values)
- Western parts:
  - on North American plate (large motion in West direction)

"How to make InSAR 'absolute' for EGMS"

Reminder of the InSAR GNSS argument, EGMS perspective:

InSAR strong/weak:

Good: Very dense, Accurate on short spatial scales

Bad: Relative, 1D only (line-of-sight)

Ugly: Very limited sensitivity to North-South component

GNSS strong / weak:

Good: Absolute, 3D, (conditionally) very accurate on long spatial scales

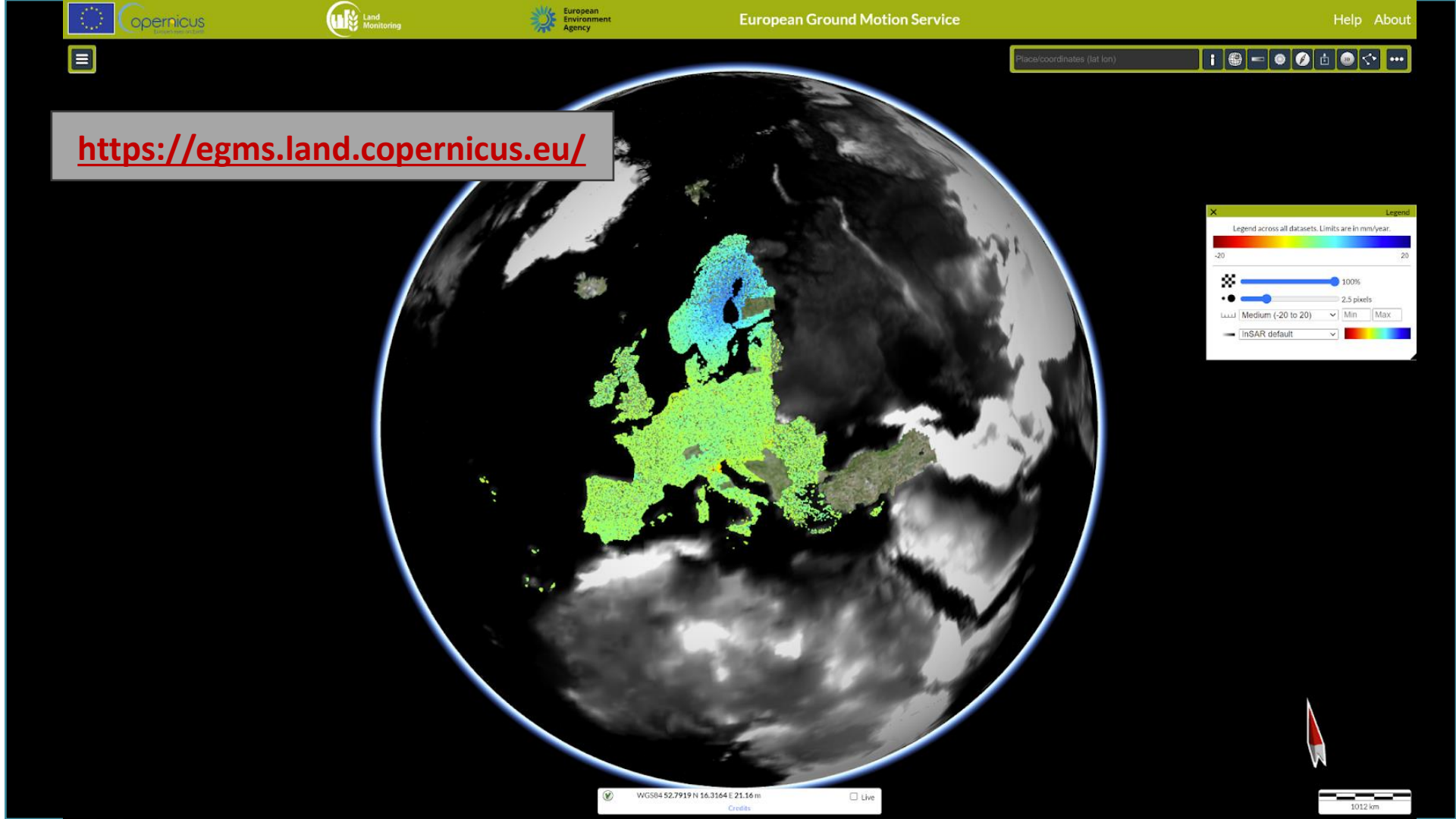
Bad: Prone to local motion influence, careful long-term maintenance of stations needed, limited number of *good* stations

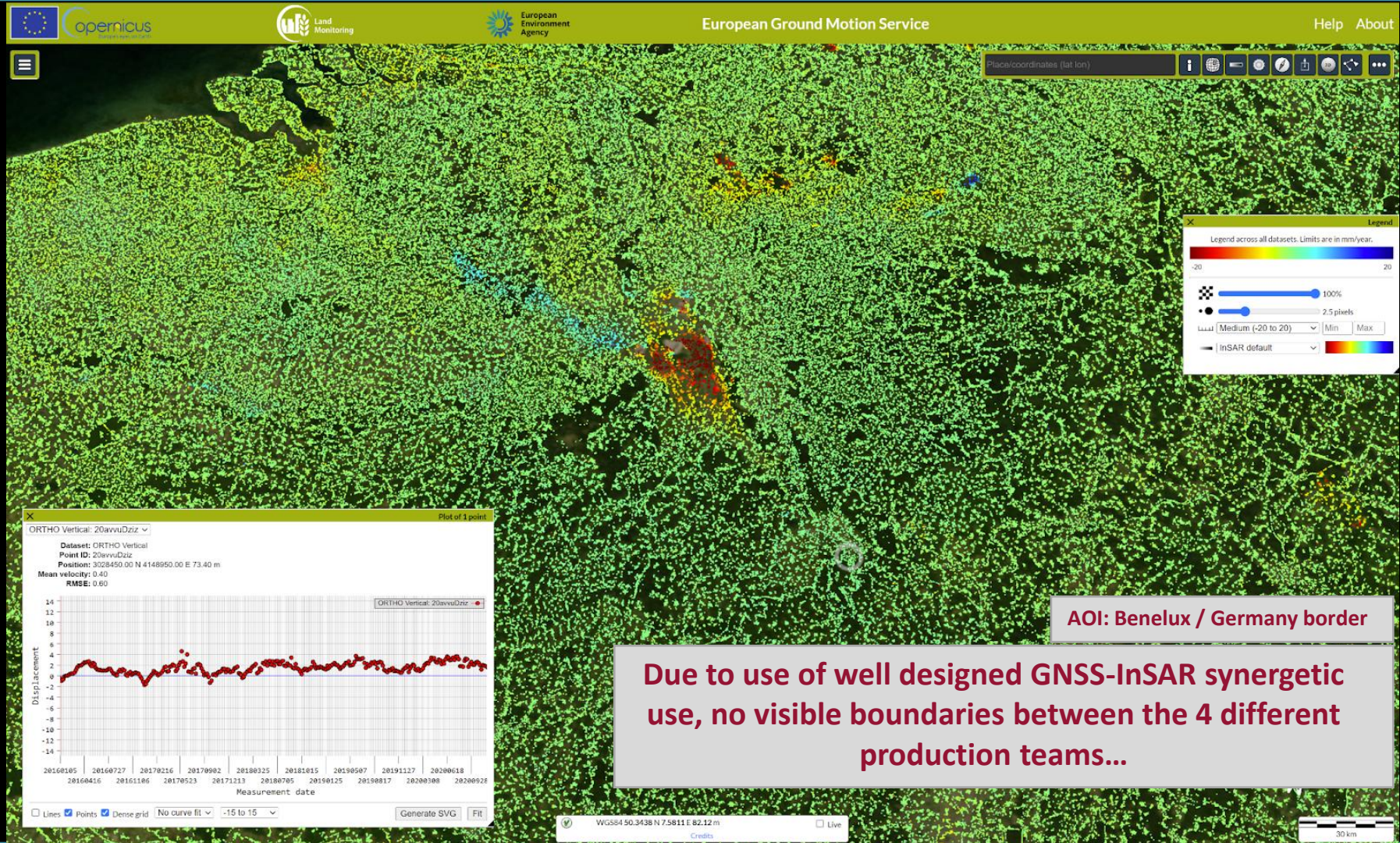
Ugly: Very sparse

Application of AEPND in EGMS

Approach:

- Anchor InSAR LoS products to GNSS model - *datum transformation*
  - GNSS 3D velocity model projected on SAR line-of-sight
  - Correction of long spatial scales only (>25-50 km)
  - Correction of linear component (trend) only
- The EGMS 100m product (currently available at egms.land…) is constructed from the GNSS-anchored Line-of-Sight products from different radar geometries (ascending / descending)
  - *Limitations:* InSAR almost blind to NS motion -> NS component from GNSS


European Ground Motion Service
Help
About
Place/coordinates (lat lon)
https://egms.land.copernicus.eu/
Legend
Legend across all datasets. Limits are in mm/year.
-20
20
100%
2.5 pixels
Medium (-20 to 20)
Min
Max
InSAR default
WGS84 52.7919 N 16.3164 E 21.16 m
Live
Credits
1012 km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Legend
Legend across all datasets. Limits are in mm/year.
-20
20
100%
2.5 pixels
Medium (-20 to 20)
Min
Max
InSAR default
Plot of 1 point
ORTHO Vertical: 20avvuDziz
Dataset: ORTHO Vertical
Point ID: 20avvuDziz
Position: 3028450.00 N 4148950.00 E 73.40 m
Mean velocity: 0.40
RMSE: 0.60
Displacement
Measurement date
Lines
Points
Dense grid
No curve fit
-15 to 15
Generate SVG
Fit
AOI: Benelux / Germany border
Due to use of well designed GNSS-InSAR synergetic use, no visible boundaries between the 4 different production teams…
WGS84 50.3438 N 7.5811 E 82.12 m
Live
Credits
30 km

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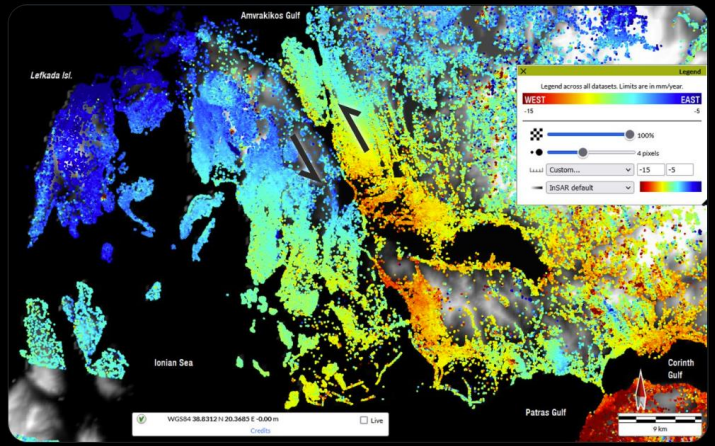
External Validation by public exposure

Sotiris Valkaniotis
@SotisValkan

Browsing through the new European Ground Motion Service by @CopernicusLand (e.copernicus.eu/EGMS); Horizontal motion shows the distinct interseismic displacement along the NNW-SSE sinistral Katouna Fault Zone, western central Greece. Offset of ~2mm/yr for the East-West comp.



8:50 PM · May 22, 2022 · Twitter Web App

12 Retweets **54** Likes

The tectonic fault preserved at high resolution due to density of InSAR and the GNSS anchoring approach

Dr Gareth Funning @gfun · May 22
Replying to @SotisValkan and @CopernicusLand
That really sharp velocity contrast could mean there is shallow locking/possible creep, or that there are unfixed unwrapping errors in some of the interferograms. I'd want to confirm it wasn't the latter - there's lots of disconnected areas of coherence.
1 · 3

Sotiris Valkaniotis @SotisValkan · May 22
I already knew about this from a colleague's detailed work, just happy to see it in the EGM viewer. And yes, there's a lot of unconnected unwrapping patches (esp small islands) elsewhere.
3

Dr. Paula M Figueiredo @pm_figueiredo · May 22
Replying to @SotisValkan and @CopernicusLand
how reliable do you think this is?
1

Sotiris Valkaniotis @SotisValkan · May 22
It's reliable. Happened to know beforehand about this from the ongoing work of a colleague. Note that this a product that has to compromise over multiple uses (tectonic, anthropogenic, landslide etc) and multiple regions.
2 · 5

Show replies

Credit: @SotisValkan + Geophysics Twitter Community

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Summary & outlook

Synergy between InSAR and GNSS “worlds” successfully demonstrated and operationalized on a continental scale

EGMS is open for any suggestions, criticism, and questions…

Future improvements of GNSS/InSAR synergy in Europe

- *Formal:* EUREF & Copernicus
- *Practical:* improvements in the spatial coverage of reliable GNSS stations, interaction with various EUREF WGs
- *Technical:* a dynamic vertical datum for Europe?

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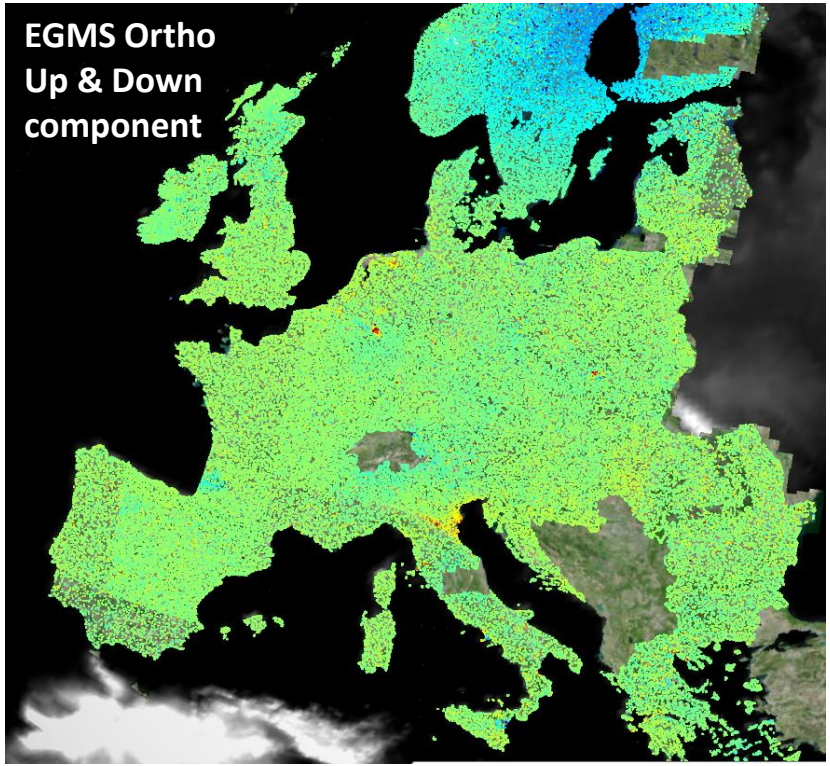

To view the products:

https://egms.land.copernicus.eu/

To download the products **[end of June 2022]:**

https://egms.land.copernicus.eu/archive

To learn about the products:

https://land.copernicus.eu/pan-european/european-ground-motion-service

A-EPND model available for download by end of June 2022

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Anticipated Q & A

Q: Why are you not using a single GNSS station?

A: Single stations are not used in “calibration” of InSAR data because:

- Avoid propagation of ‘unknown’ local motion / autonomous motion
- EGMS portfolio derives local / regional motion from InSAR
- More useful for external validation of the products

Anticipated Q&A

Q: Will you be resourcing to Corner Reflectors / Active Transponders?

A: Considerations:

- CRs are mainly useful for relative / local scale monitoring, and/or external validation.
- CRs mounted very close to the permanent GNSS station are interesting, but requires very long common time series to be useful.
- Active transponders have reliability issues, as reported by the community, over the temporal scales relevant for the EGMS portfolio (years/decades)
- Anticipated application of artificial targets in the EGMS validation activities

Anticipated Q & A

Q: Why after "calibration" with GNSS, tectonic motion was visible in Greece (and uplift in Norway) but not in Italy.

A: The most prominent component of the large-scale motion of Italy in ETRF reference frame is NS, which is not available in the EGMS portfolio due to “blindness” of InSAR to NS. Specifically:

- The EW component in Italy is present, but much smaller than in Greece, thus the default colorscale limits of the EGMS viewer need to be tuned to see it.