Update on DSO's contribution to EUREF Densification and new activities

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EUREF 2024 SYMPOSIUM
05-07.06.2024
BARCELONA
CATALONIA, SPAIN

euref IUGG IAG AIG International Association of Geodesy ICGC Institut Cartogràfic i Geològic de Catalunya

Presentation Structure

DSO last year

Dionysos Satellite Observatory (DSO) of the National Technical University of Athens (NTUA), has developed and maintains an automated processing scheme to accommodate the routine analysis of all available continuous GNSS stations in Greece.
This daily analysis process is implemented for over ten years now (not always continuous though dues to various problems), yielding results which help us further understand the complicated tectonic setting of Greece and nearby regions.
Updates:

- archive old data (from 1995) for reprocessing,
- add PPP PRIDE near real time processing for high rate
- start updateting for strain Tool

Motivation

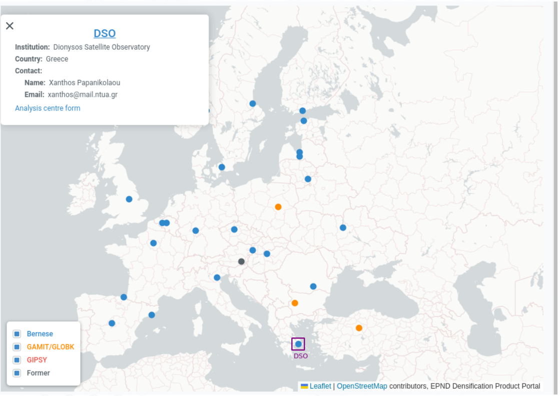
Routine GNSS processing and site/network monitoring is crucial, because:

- Greece lies in a region of utmost tectonic and volcanic unrest (e.g. active volcano in Santorini isl.),
- results & products are important to a series of fields spanning the whole range of Geosciences,
- helps us follow and apply state-of-the-art technologies in GNSS analysis & Satellite Geodesy and expand & modernize our research activity,
- contribute to the GNSS/EUREF community and be involved in ongoing/future projects,
- improve our academic services (NTUA is a University)

Throughout the last years, routine processing & monitoring has hepled us gain a more thorough view of the complex tectonic and volcanic setting of Greece.

Contribution to EPN Densification up to now

- Start our contribution from 2016
- Proccessing and upload daily SINEX files including 78 station
- Data processing from GPS week 1400 up to 2238 on IGb14
- Change to IGS20 (old Bernese)



The Data Set

Routine processing for precise positioning, assumes a well established, credible dataset (metadata). This has proven to be rather challenging! Lately, the introduction of `M3G` has provided assistance.

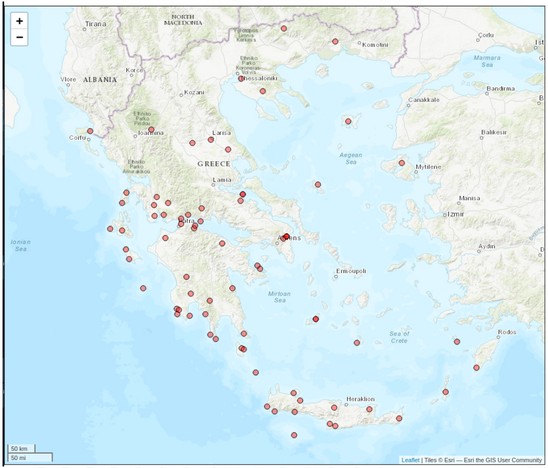
Currently we process whatever we can get our hands on ...
Problems:

- Inhomogenous dataset (`RINEX` of various versions, raw files, etc).
- Various maintainers, different mentalities.
- Different aquisition methods/rates.
- No log files for mainteners with no geodetic interest (e.g. surveying companies).
- Wide variety of equipment (not always included in `atx` files).

Network GREECE

Network `Greece` includes the majority of the available sites (≈100) but not all of them are (always/currently) active. Various providers but all with geodetic interest & equipment.

- covers all of Greece
- different (geodetic type) equipment
- credible time-span (early 2004 - now)
- all free available GNSS data
- large data gaps & inactive stations

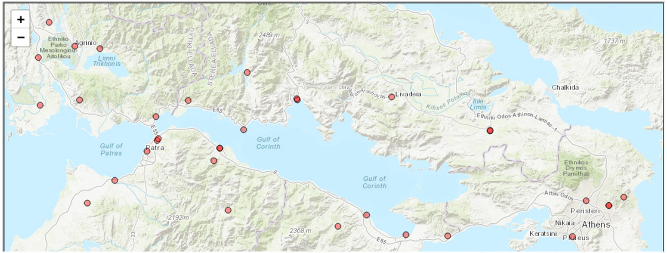


-» Network GREECE

Local Networks

The **Corinth Rift** network is centered around the Cortinth Gulf, a region of special tectonic interest. Larger site density compared to the rest of Greece.

- credible time-span
- only covers the Corinth Rift
- different providers (including surveying & cadastral services)
- no log files & equipment changes

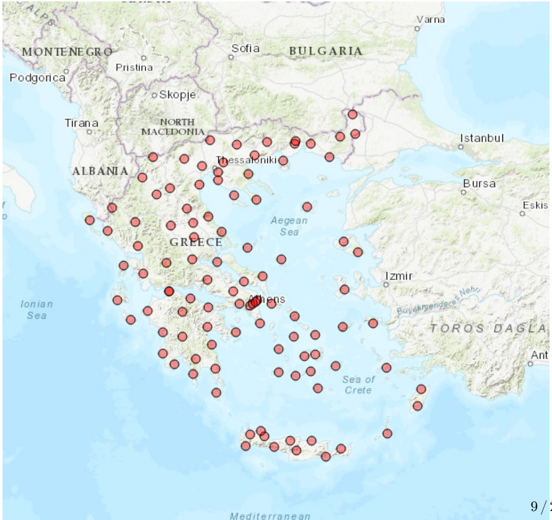


-» Network EnCeladus

Network HEPOS (new processing)

Network **HEPOS**

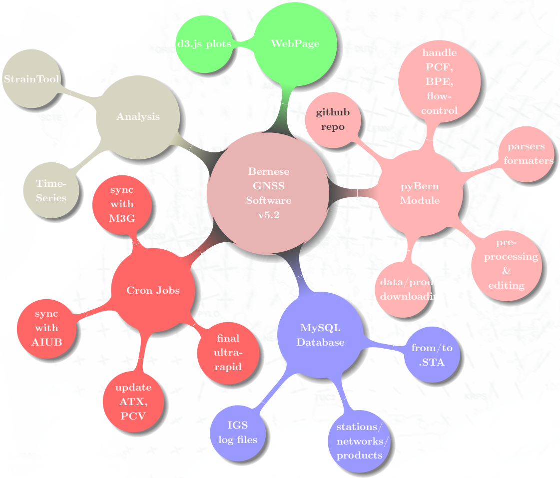
- covers all of Greece
- equipment
- credible time-span (early 2004 - now)
-
- large data gaps & inactive stations



The Scheme

The core tool/software is `Bernese GNSS Software v5.2`(Dach et al., 2007).
Integration with

- **MySQL** database,
- **Python** module (product/data downloading, pre-processing, driving cron jobs, etc) `https://github.com/DSOlab/autobern`
- **Time-series** analysis (integrated in routine processing on regular intervals)
- **Strain Rates** via StrainTool (on user demand)



Upgrade planning - switch to IGS20

⇒ New release Bernese GNSS Software v5.4

New values on processing options:

- Reference frame `IGS20`
- Oceans loading corrections (`FES2014`)
- `VMF3` for tropospheric modeling
- `ATX` file: `igs20.atx`
- Long filename of products according to new IGS convention

⇒ ⇒ Reprocess all available data from late '90s up to now

Results & Output

4. Solution Indetifiers

Array of Objects

expand

5. PCF Variables

Array of Objects

expand

6. Saved products

Array of Objects

expand

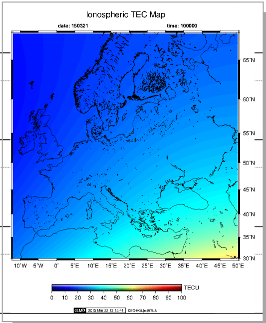
7. Warnings

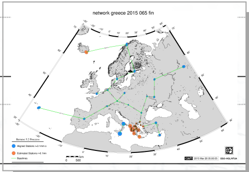
Array of Objects

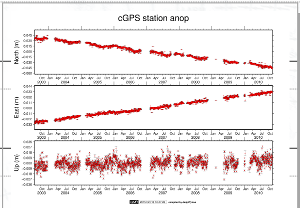
expand

8. Ambiguity Resolution SUmmary

Array of Objects





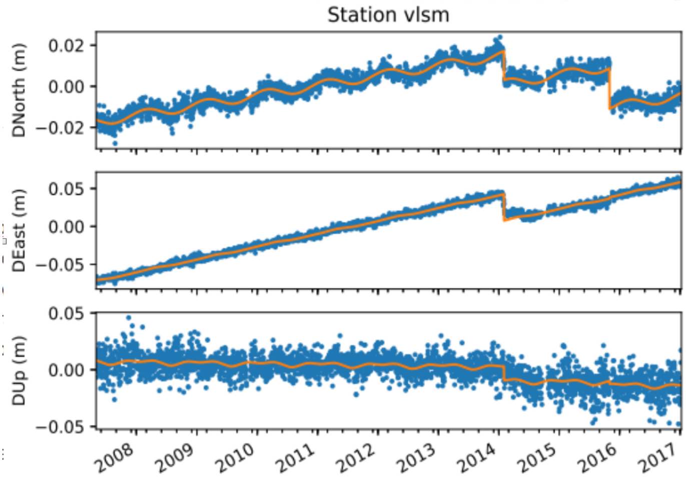


Baseline	sta1	sta2	length (km)	Method	N. of Amb.	Percentance	Satellite system
AUKL	AUT1	KLOK	139.7	pbnl	74	54.1	GPS
AULE	AUT1	LEMN	199.6	pbnl	60	55	GPS
KCTL	KATC	TILO	59	pbnl	50	90	GPS
KLRL	KLOK	RLSO	174.2	pbnl	74	41.9	GPS

Coordinate estimates - Time series analysis

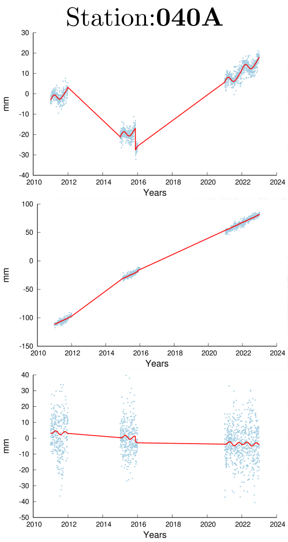
We analyze time-series using Hector Package (Bos et al., 2012), to estimate:

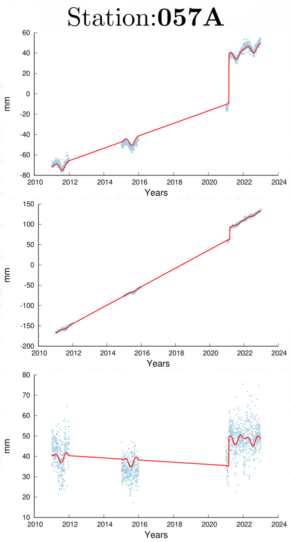
- tectonic velocities (linear trends),
- offsets/jumps due to miscellaneous reasons (e.g. instrumentation changes, earthquakes, etc); note that this step requires a-priori knowledge of such events (log-files, NOA earthquake catalogue)
- harmonics signals,
- velocity changes (e.g. inflation of Santorini isl.),
- post-seismic decay (still under development)



Συσχετισμός ασυνεχειών με σεισμούς

date	Δn	Δe (mm)	Δu
Station: 040A			
26.01.2014	-43.1	25.2	2.2
17.11.2015	-10.8	1.7	3.1
Station: 057A			
03.03.2021	47.9	27.6	14.0



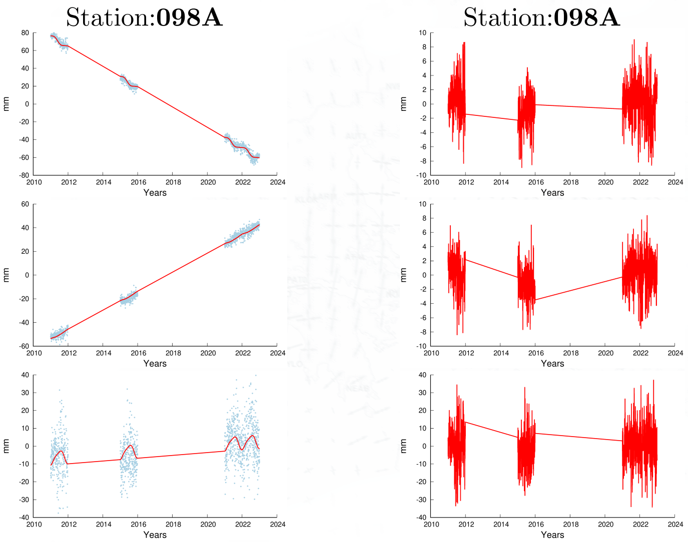


Αρμονική ανάλυση

$$\sum_{i=0}^{n_F} s_i sin(\omega_i t) + c_i cos(\omega_i t)$$

Παράδειγμα αποτελεσμάτων:

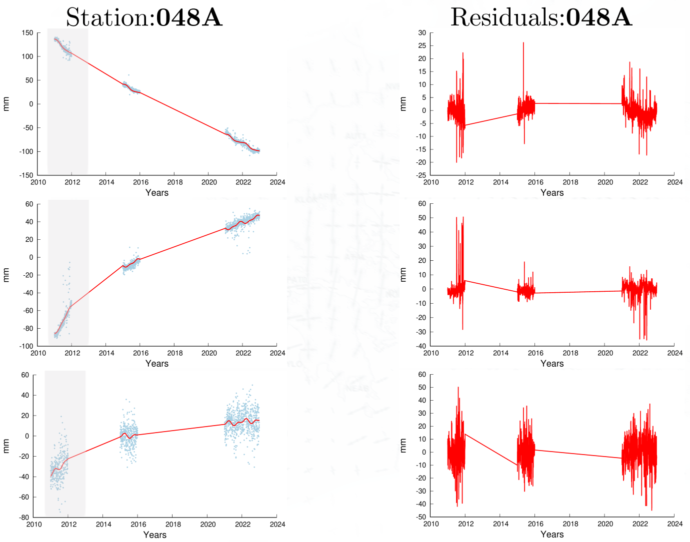
```
--------------------------------
trend: -11.398 +/- 0.086 mm/year
--------------------------------
cos yearly : 1.428 +/- 0.255 mm
sin yearly : 1.804 +/- 0.280 mm
Amp yearly : 2.316 +/- 0.266 mm
Pha yearly : 51.629 degrees
--------------------------------
cos hyearly : -0.418 +/- 0.206 mm
sin hyearly : -0.128 +/- 0.217 mm
Amp hyearly : 0.493 +/- 0.195 mm
Pha hyearly : -162.958 degrees
--------------------------------
```



Ειδικές περιπτώσεις - Σαντορίνη

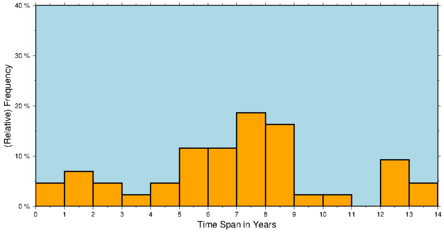
Εκτίμηση αλλαγή ταχυτήτων στον σταθμό της Σαντορίνης:

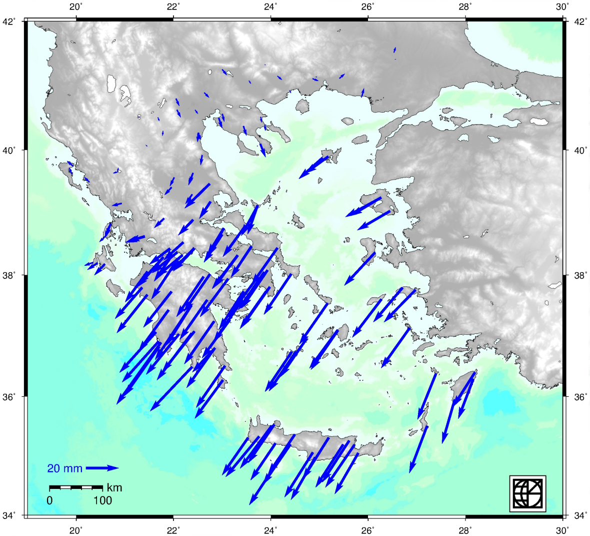
comp	$<\sim$2013 (mm/yr)	$>\sim$ 2013
north	-30.1	-17.5
east	31.3	7.0
up	17.2	2.1



Velocity field in Greece wrt a stable Europe

- 100 station
- data availability > 3 years
- Velocity field w.r.t. a stable Europe (Kreemer et al., 2014)



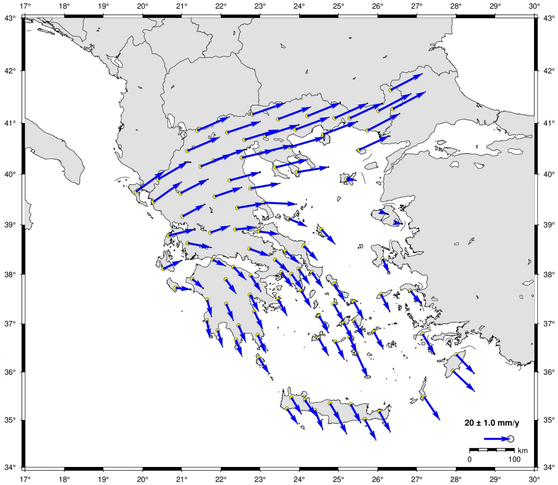


Velocity field of HEPOS Network

Velocity Field

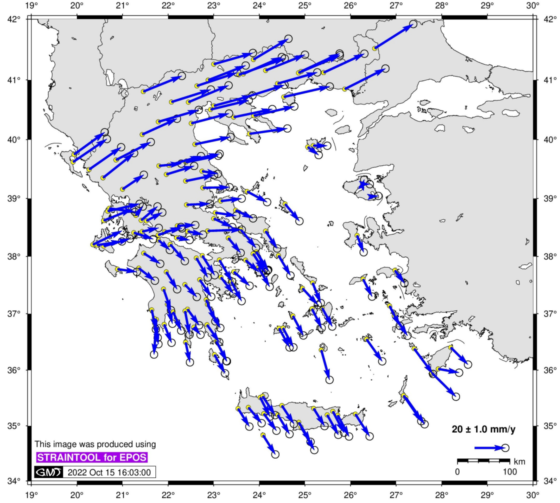
Η ταχύτητες κυμαίνονται ανά συνιστώσα:

comp	min (mm/yr)	max
north	-17.9	15.5
east	2.4	26.0
up	-5.5	4.7

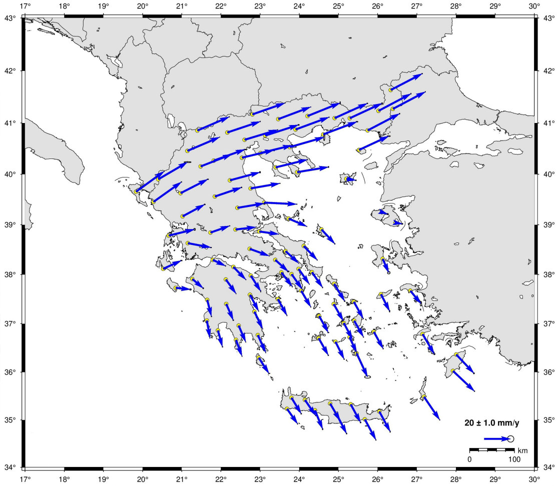


Compare velocity field of different networks

DSO_GRC_2021

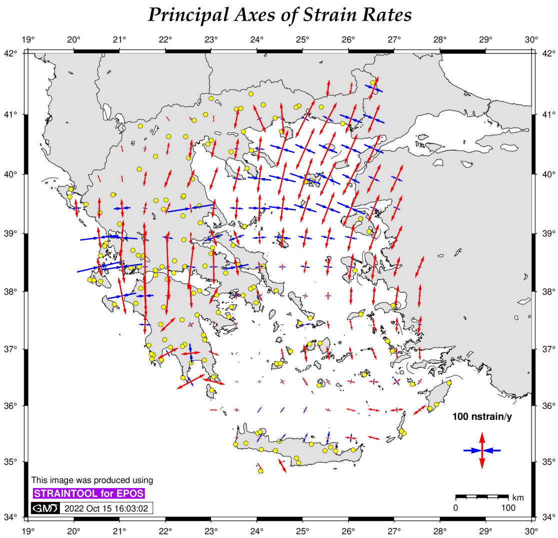


DSO_HPS_2022



Strain rates

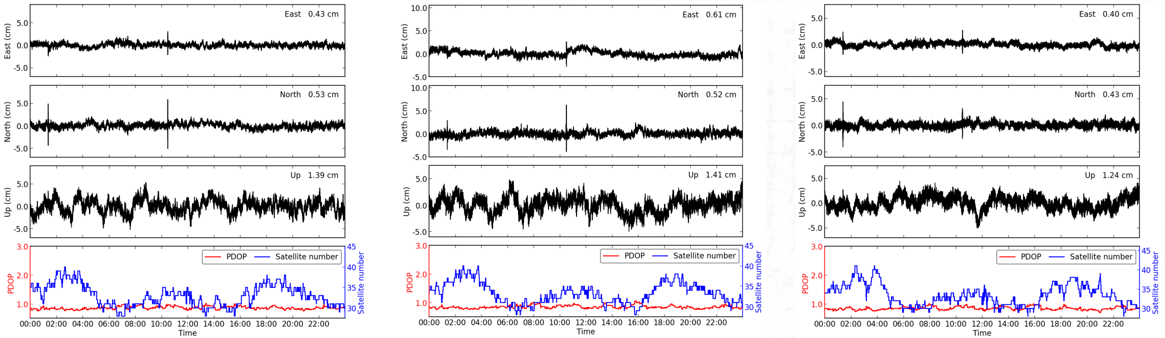
- **StrainTool** software used to estimate strain tensor parameters (Anastasiou, Papanikolaou, et al., 2021)
- grid step 0.5°



High rate (1Hz) PPP processing

PRIDE PROCESSING

Effect from Turkey eq 230206



Focus on stations

Discussion / Conclusions

- Greece is located in a complex tectonic background with many changes in the kinematics of the area.
- Routine processing and monitoring are very important and revealing for Greece; products are requested by and disseminated to a wide range of Geoscientists.
- Greece's crustal dynamics are evidently complex and inhomogenous; a difficult task to model by Reference Systems (especially non-dynamic, such as the ones currently in use).
- A dense velocity field for accurate estimation of ground/tectonic motions in the region will help to develop a stable local reference frame and the connection of the region with the global and European reference systems.
- The continuous monitoring of the networks gives useful results for the effect of strong earthquakes or other "abrupt" phenomena; small, dense networks are of great help (even with instrumentation of non-geodetic accuracy).
- Our plan: grow up our team and be more involved to the GNSS/EUREF community.

Thank you for your attention!

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