DSO contribution to EUREF Densification and a dense velocity field for Greece

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Presentation Structure

DSO Recent Activity

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 five 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.

Important results, include:

- the recent volcanic activity in *Santorini* (e.g. Papoutsis et al., 2013),
- the 2014 *Kefallonia* earthquakes (e.g. Anastasiou, Chouliaras, et al., 2014)

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.

The DataSet

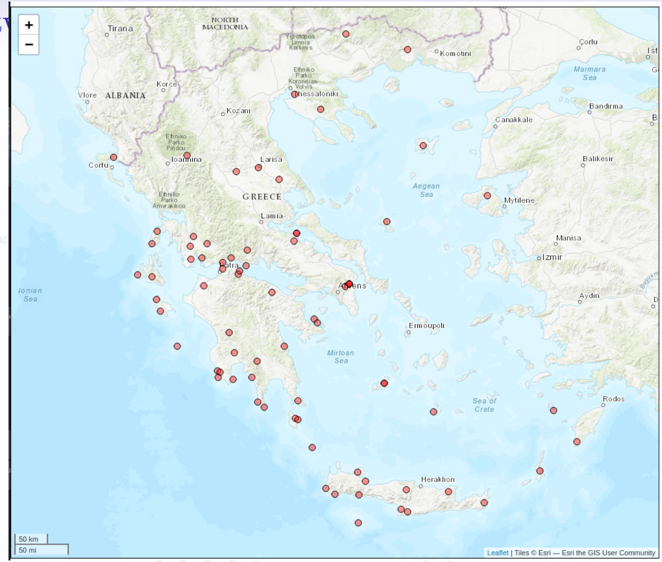
Routine processing for precise positioning, assumes a well established, credible dataset (metadata). This has proven to be rather challenging! Lately, the introduction of `M3G` has provided assistance.

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** 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



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.

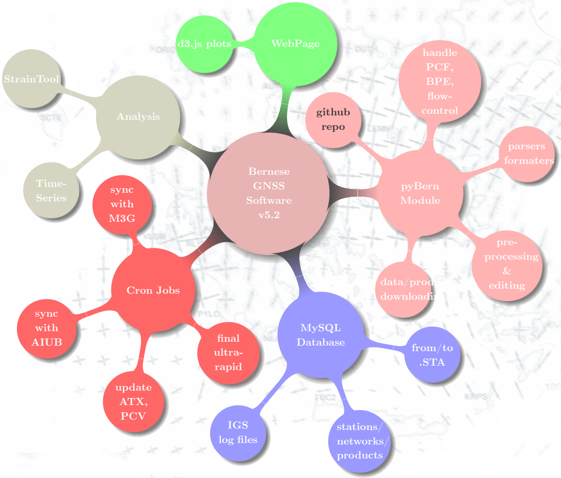
- credible time-span
- only covers the Corinth Rift
- different providers (including surveying & cadastral services)
- no log files & equipment changes

http://dionysos.survey.ntua.gr/dso/enceladus/

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)
- **Time-series** analysis (integrated in routine processing on regular intervals)
- **Strain Rates** via StrainTool (on user demand)



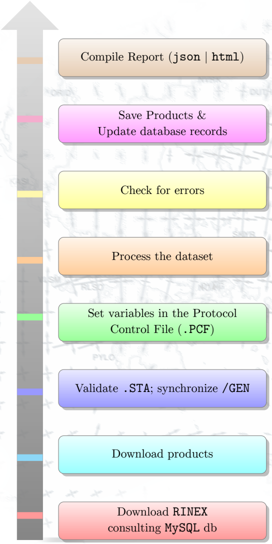
Compliance wrt EUREF standards

Processing is consistent with EUREF standards (Guidelines for Analysis Centres).

- SINEX with required info/blocks,
- Reference frame IGb14,
- IERS Conventions 2010,
- IGS/CODE products,
- ocean loading corrections (FES2004),
- 3° elevation cut-off angle; elevation dependent weighting,
- GMF and/or VMF1; Chen-Herring gradient parameter,
- amiguities fixed (length-dependent algorithm),
- use GLONASS obs (when available)
- use ATX files - individual calibrations

Workflow

```
$>ddrun.sh --year= --doy= --session=
--bern-loadgps= --campaign=
--satellite-system= --solution-id=
--save-dir= --analysis-center=
--use-ntua-products=
--append-suffix= --elevation-angle=
--update= --pcv=
--apply-exclude-list
```



Results & Output

4. Solution Indetifiers

Array of Objects

expand

5. PCF Variables

Array of Objects

expand

6. Saved products

Array of Objects

expand

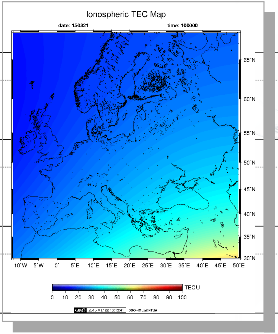
7. Warnings

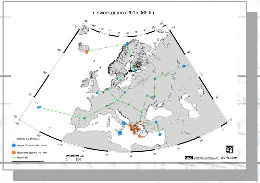
Array of Objects

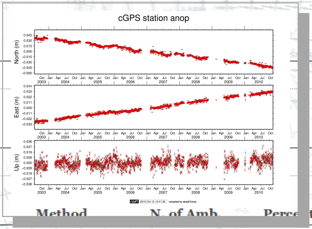
expand

8. Ambiguity Resolution SUmmary

Array of Objects





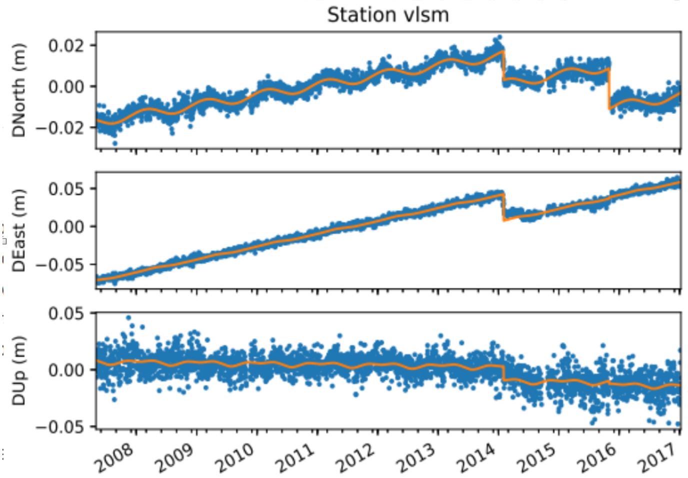


Baseline	sta1	sta2	length (km)	Method	N. of Amb.	Perce[illegible]tance	Satellite system
AUKL	AUT1	KLOK	139.7	pbnl	74	54.1	GPS
AULE	AUT1	LEMN	199.6	pbnl	60	55	GPS
KCTL	KATC	TILO	59	pbnl	50	90	GPS
KLRL	KLOK	RLSO	174.2	pbnl	74	41.9	GPS

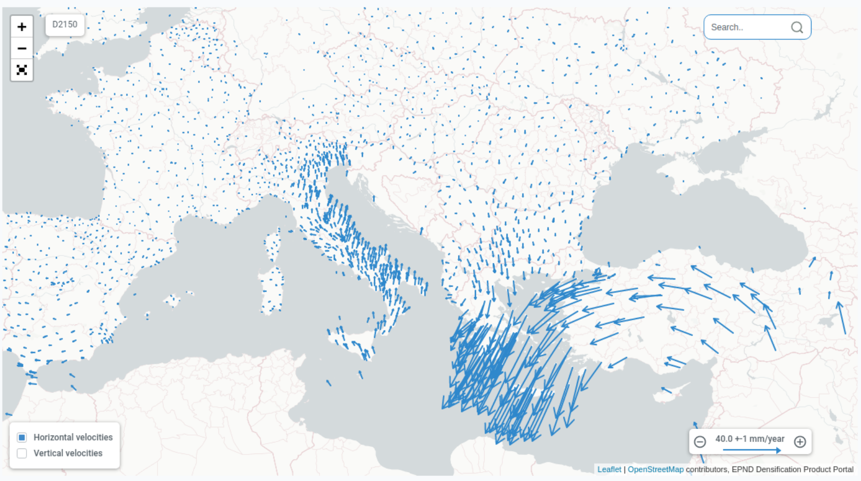
Coordinate estimates - Time series analysis

We analyze time-series using in-house software tools, 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 (using periodograms),
- velocity changes (e.g. inflation of Santorini isl.),
- post-seismic decay (still under development)



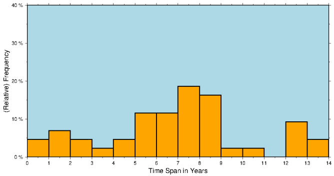
Velocity field in Europe - Densfication project

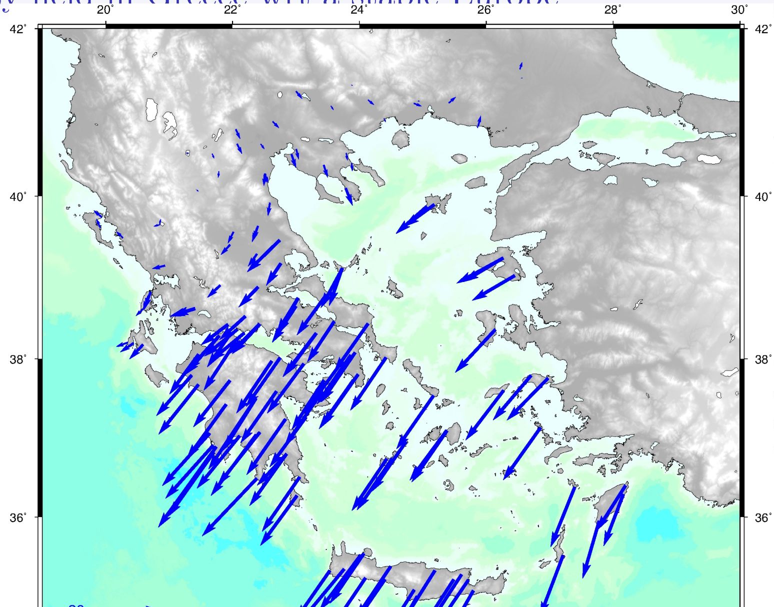


https://epnd.sgo-penc.hu/velocities/

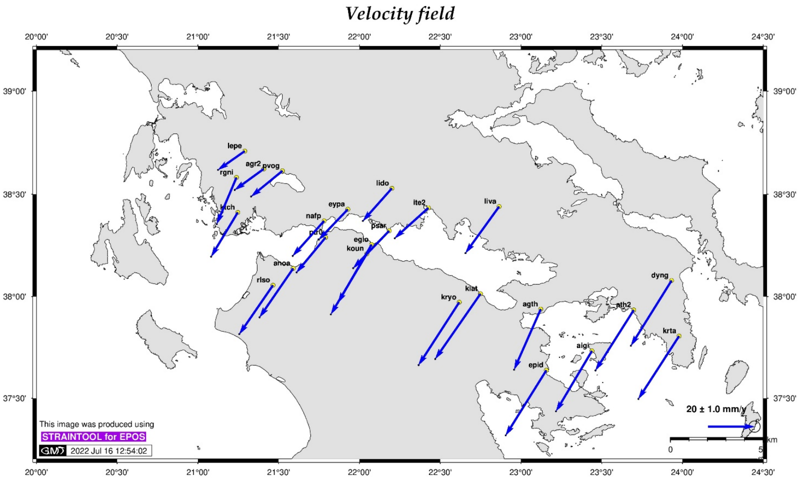
Velocity field in Greece wrt a stable Europe

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



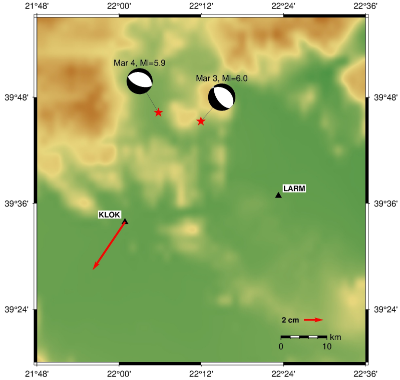


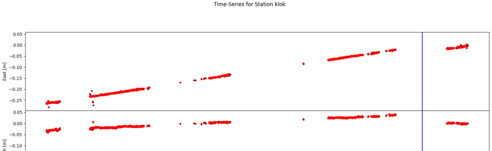
Focus on specific regions - Corinth Gulf



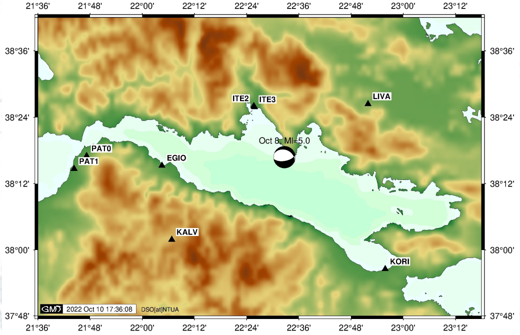
Recent Earthquakes

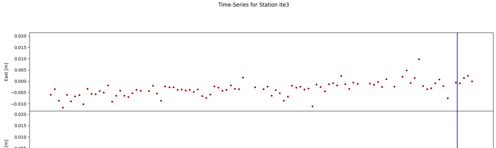
Thessaly 2021





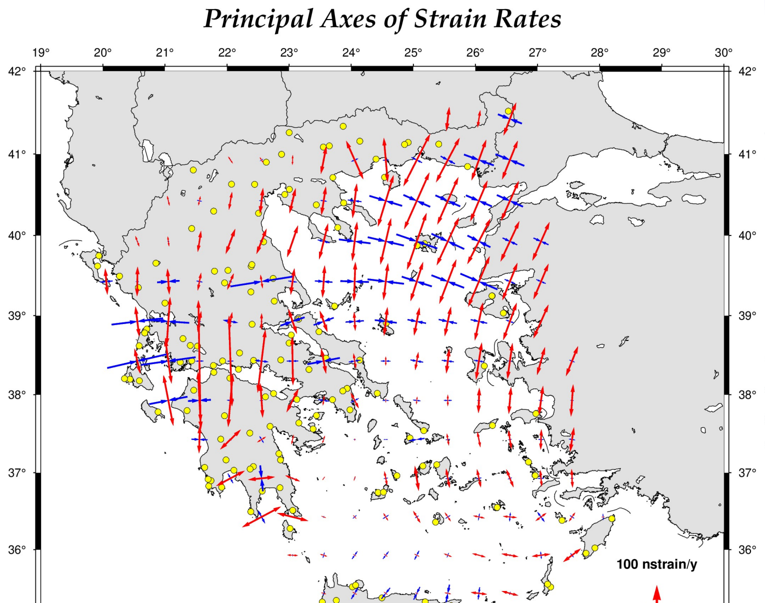
Itea 2022





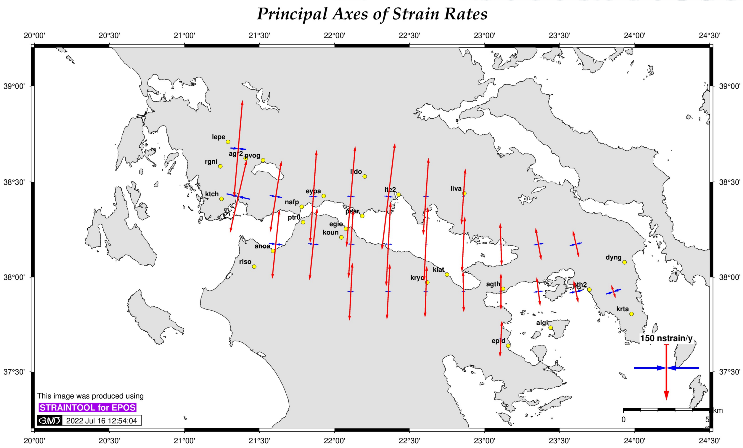
Strain rates

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



Strain rates - focus on specific region

- 25 Permanent GNSS Station
- grd step 0.25°



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).

Thank you for your attention!

References I

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