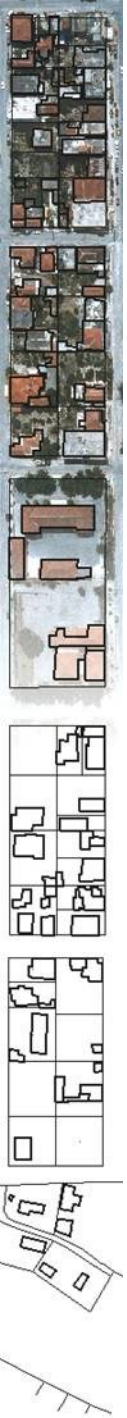
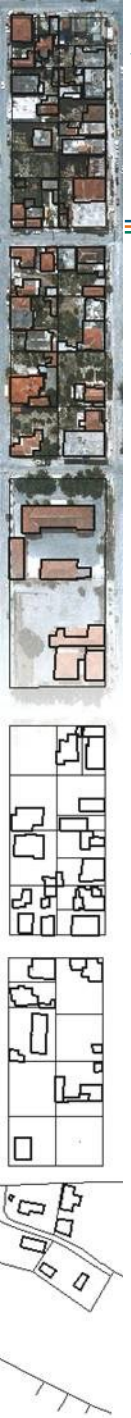


NATIONAL CADASTRE & MAPPING AGENCY S.A.

Estimation of tectonic velocities using GPS Precise Point Positioning: The case of Hellenic RTK-network HEPOS

M. Gianniou, I. Stavropoulou

National Cadastre and Mapping Agency S.A.



Outline

1. Motivation
2. Dataset
3. Processing strategy
4. Estimated velocities and velocity field
5. Evaluation of results
6. Conclusions

1. Motivation

The velocity field in Greece is intense and inhomogeneous.

Apart from the constant motion, discontinuities often occur due to geological phenomena (mainly earthquakes).

The problem of maintaining a reference frame in seismo-tectonically active areas is being studied at international level.

Two EUREF WG are currently working on this:
‘EPN Densification’, ‘Deformation models’.

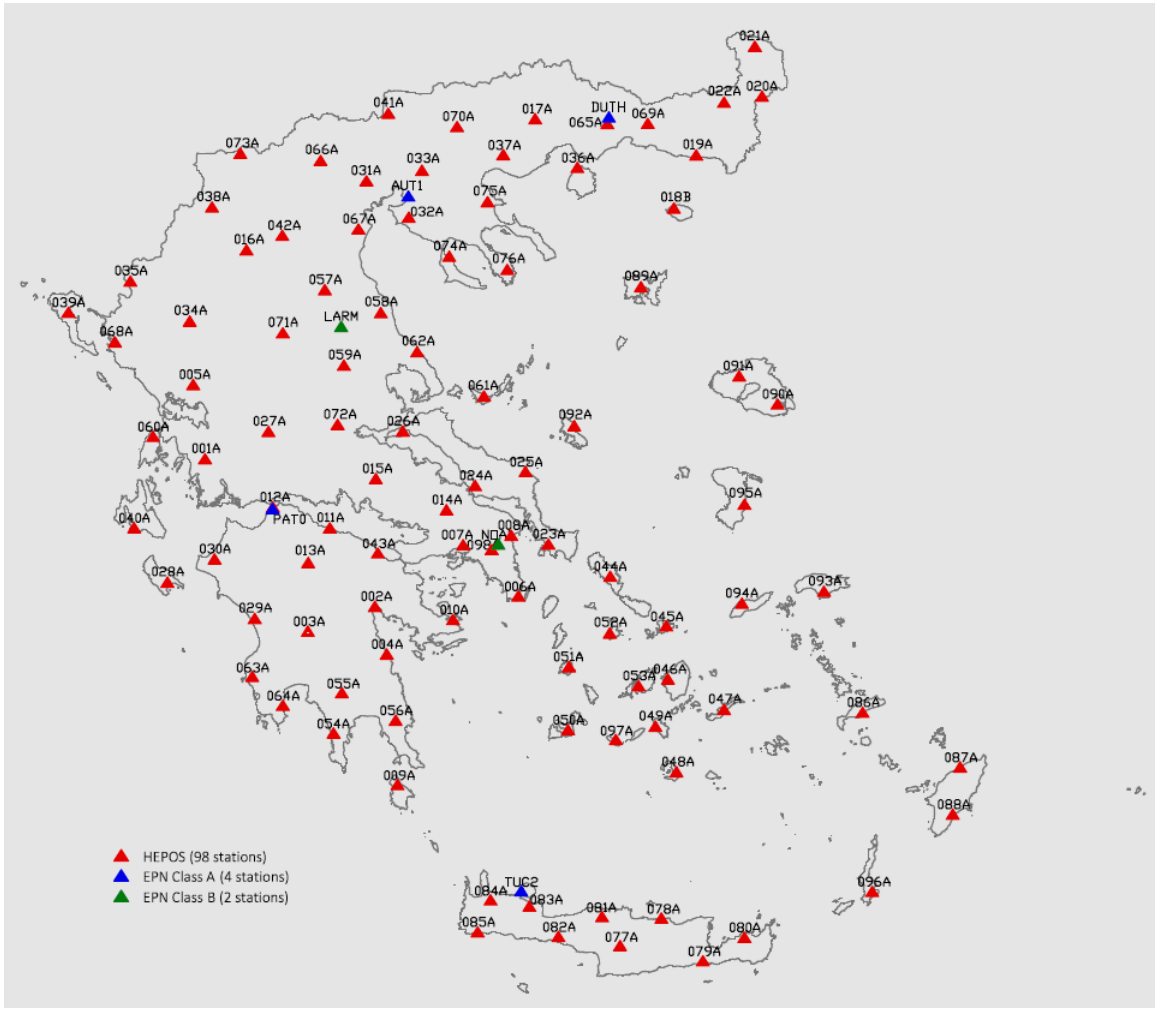
The tectonic activity in Greece is systematically monitored in the context of operating HEPOS.

2. Dataset

Stations used

104 Stations:

- 98 HEPOS stations
- 6 EPN stations

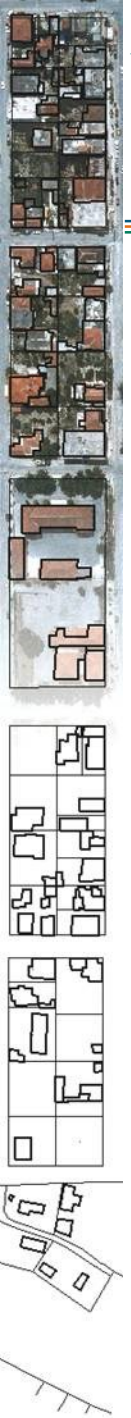


2. Dataset

Data span of data used for the estimation of velocities

- **HEPOS stations: 7.5 years**
- **EPN stations: 4.4-7.5 years**

Stations			Observations	
Network	#	Station code	Time period	Duration (years)
HEPOS	98	001A-098A	2008.0 - 2015.5	7.5
EPN Class A	4	AUT1 TUC2 DUTH PAT0	2008.0 - 2015.5 2008.0 - 2015.5 2008.7 - 2015.5 2009.1 - 2015.5	7.5 7.5 6.8 6.4
EPN Class B	2	NOA1 LARM	2008.0 - 2015.5 2011.1 - 2015.5	7.5 4.4
Total	*104*			



3. Processing strategy

Processing of GPS data

- **Method: PPP**
- **Software: CSRS-PPP**
- **Orbits (Final IGS precise orbits)**
- **Clocks (IGS clk files)**
- **Processing interval: 30 sec**
- **Elevation mask: 10^{o}**
- **Computation of one daily solution (24 hours) per month (i.e. 90 solutions in 7.5 years)**

3. Processing strategy

Computation of velocities

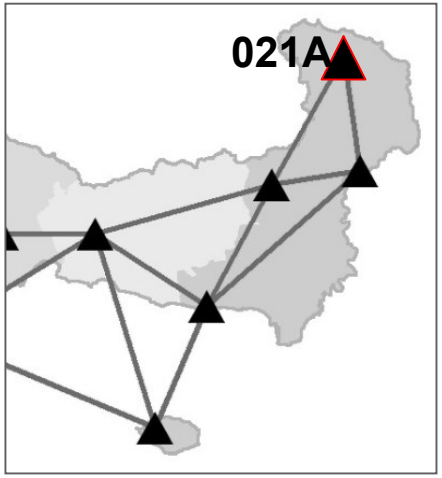
- Frame transformations for expressing all solutions in ITRF2008(IGb08)
- Removal of effects of local geophysical phenomena (earthquakes, volcanic activity) that have caused permanent station displacements
- Computed horizontal velocities are expressed in the TM87 projection of the national system (GGRS87/TM87)

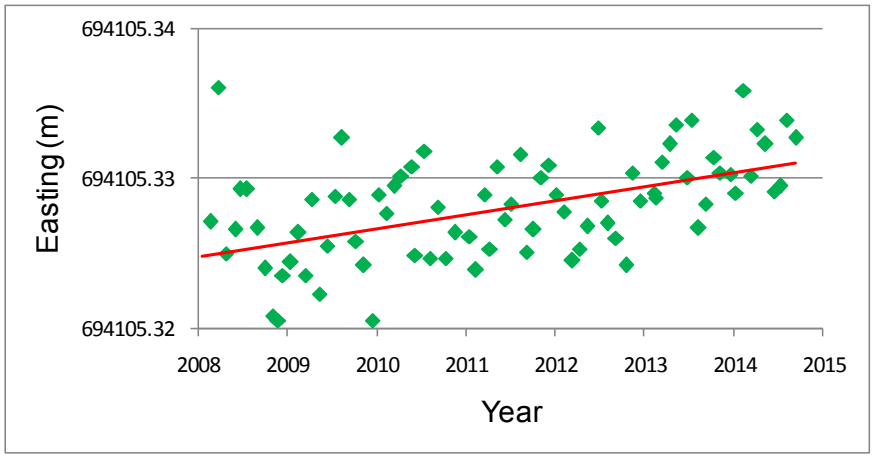
4. Estimated velocities and velocity field

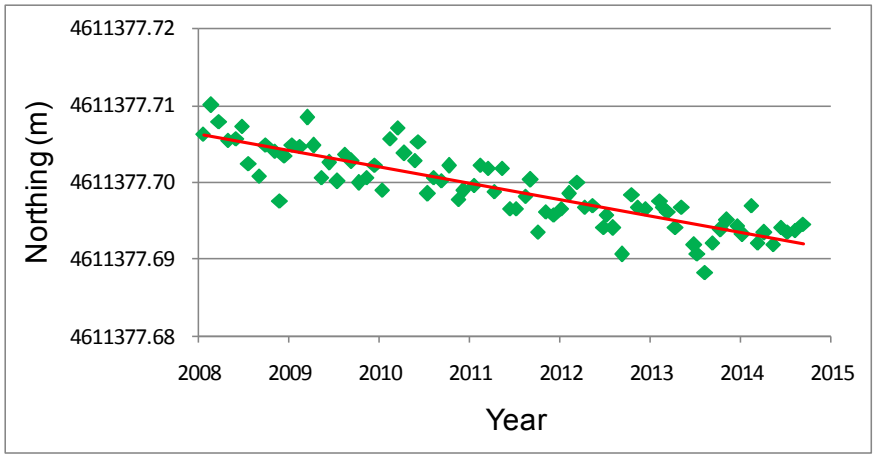
Examples of produced time-series

Horizontal velocity ~ 2 mm/yr

station 021A





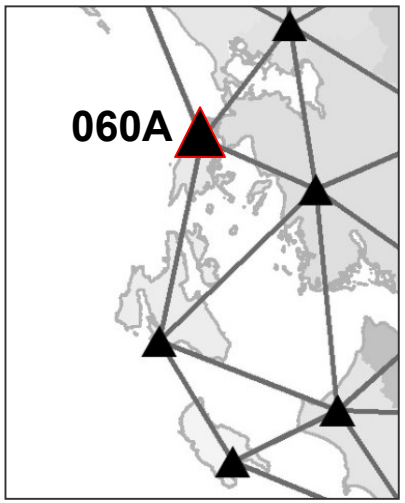


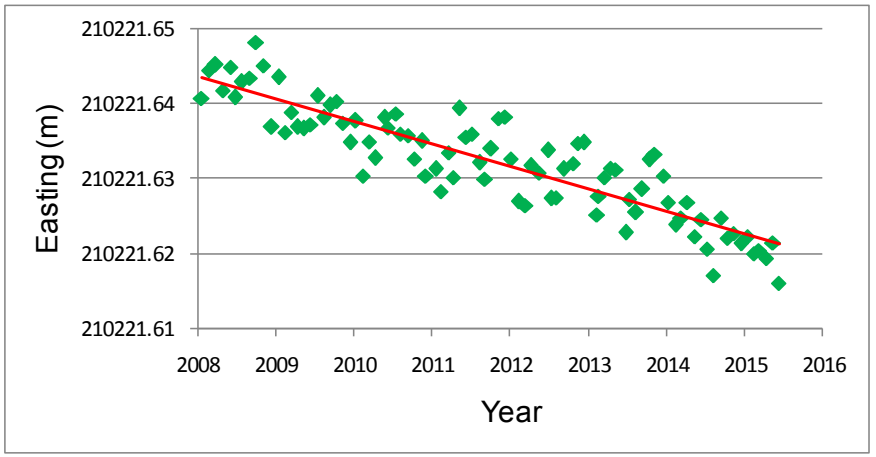
4. Estimated velocities and velocity field

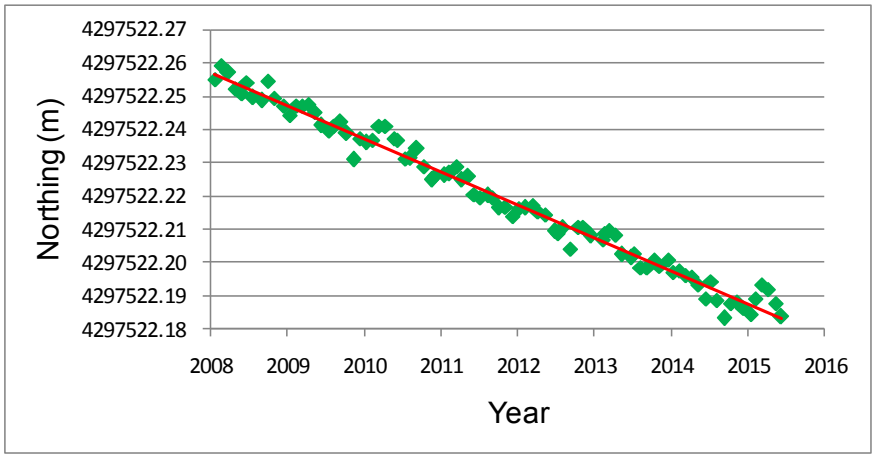
Examples of produced time-series

Horizontal velocity ~ 1 cm/yr

station 060A





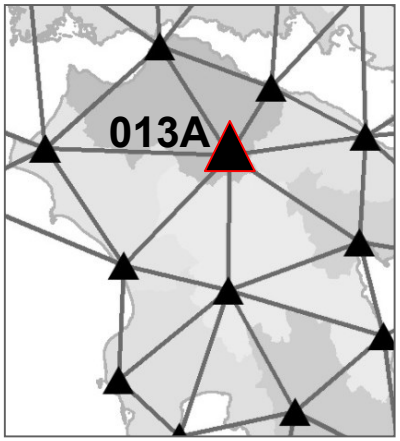


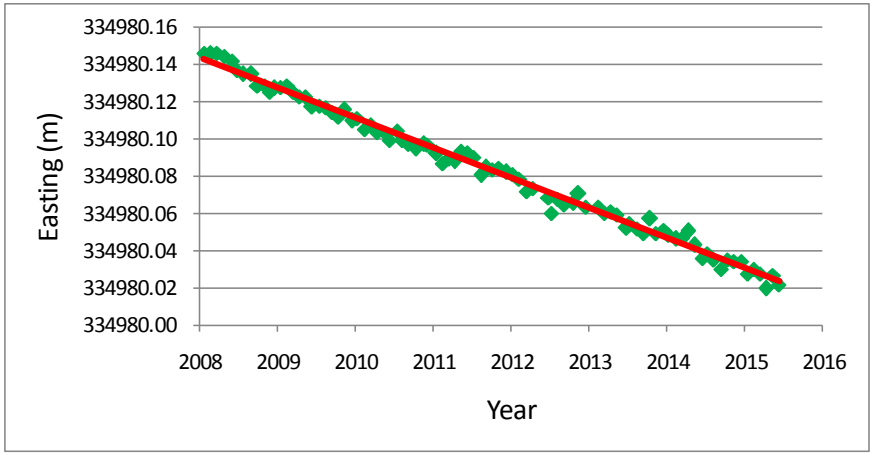
4. Estimated velocities and velocity field

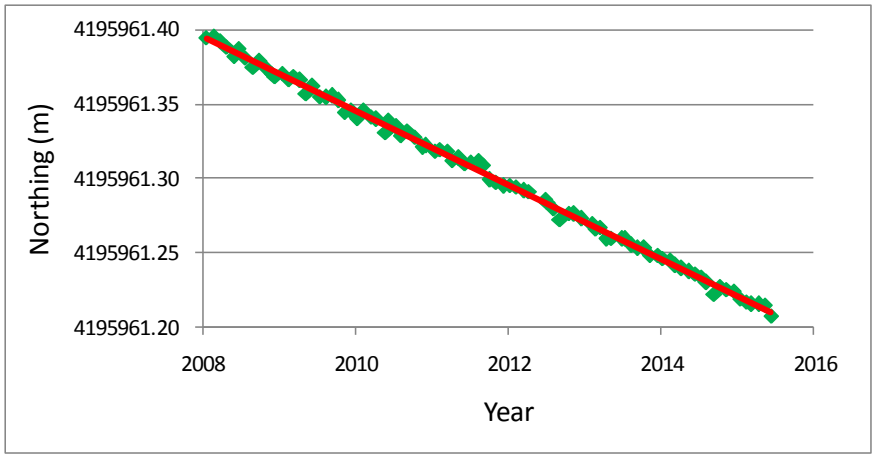
Examples of produced time-series

Horizontal velocity ~ 3 cm/yr

station 013A







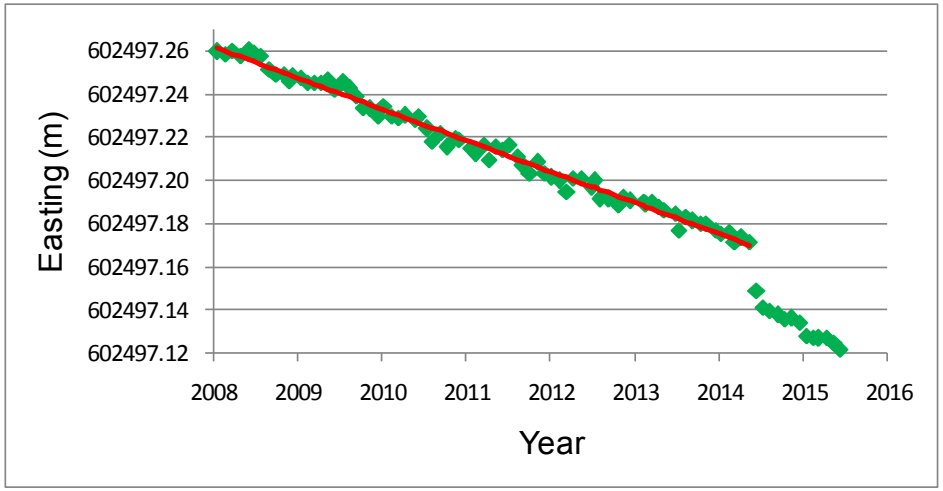
4. Estimated velocities and velocity field

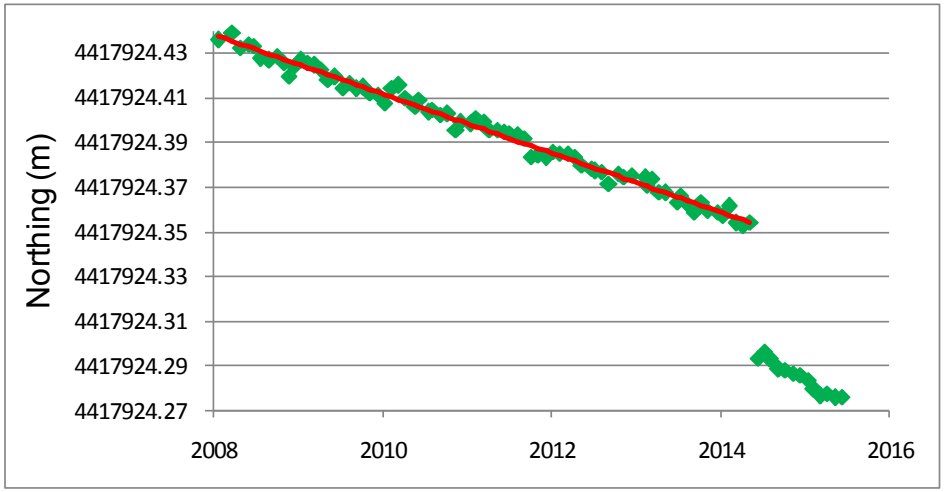
Examples of discontinuities due to local geological effects

The May 24, 2014 Samothrace (North Aegean Sea) earthquake

station 089A

Velocities computed ignoring epochs later than 2014.39.

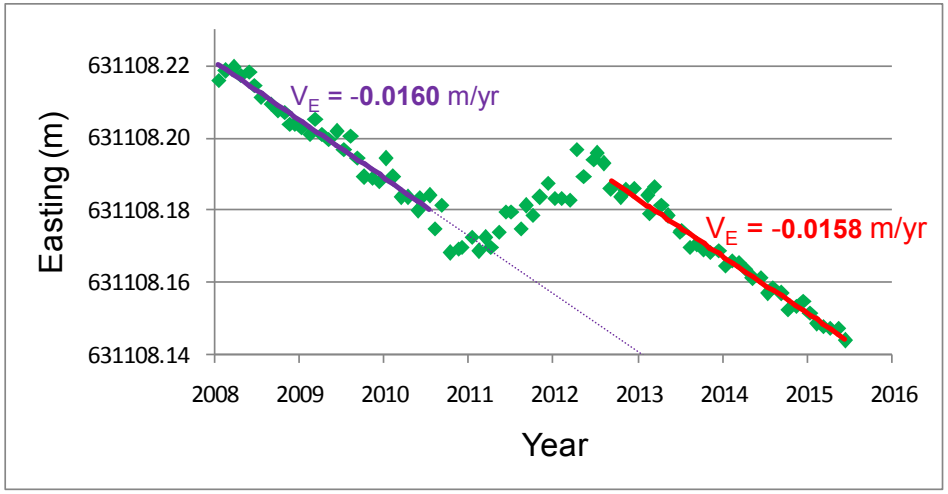


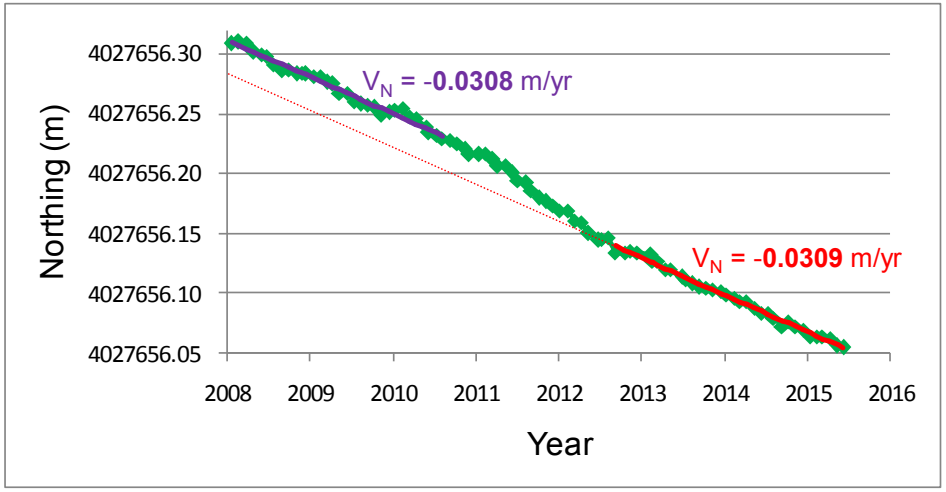


4. Estimated velocities and velocity field

Examples of discontinuities due to local geological effects

2011-12 inflation of Santorini volcano
station 048A





Velocities estimated for the period before & after the inflation match at the level of ±0.0002 m/yr.

4. Estimated velocities and velocity field

The effects of the following geological events have been removed for the estimation of velocity

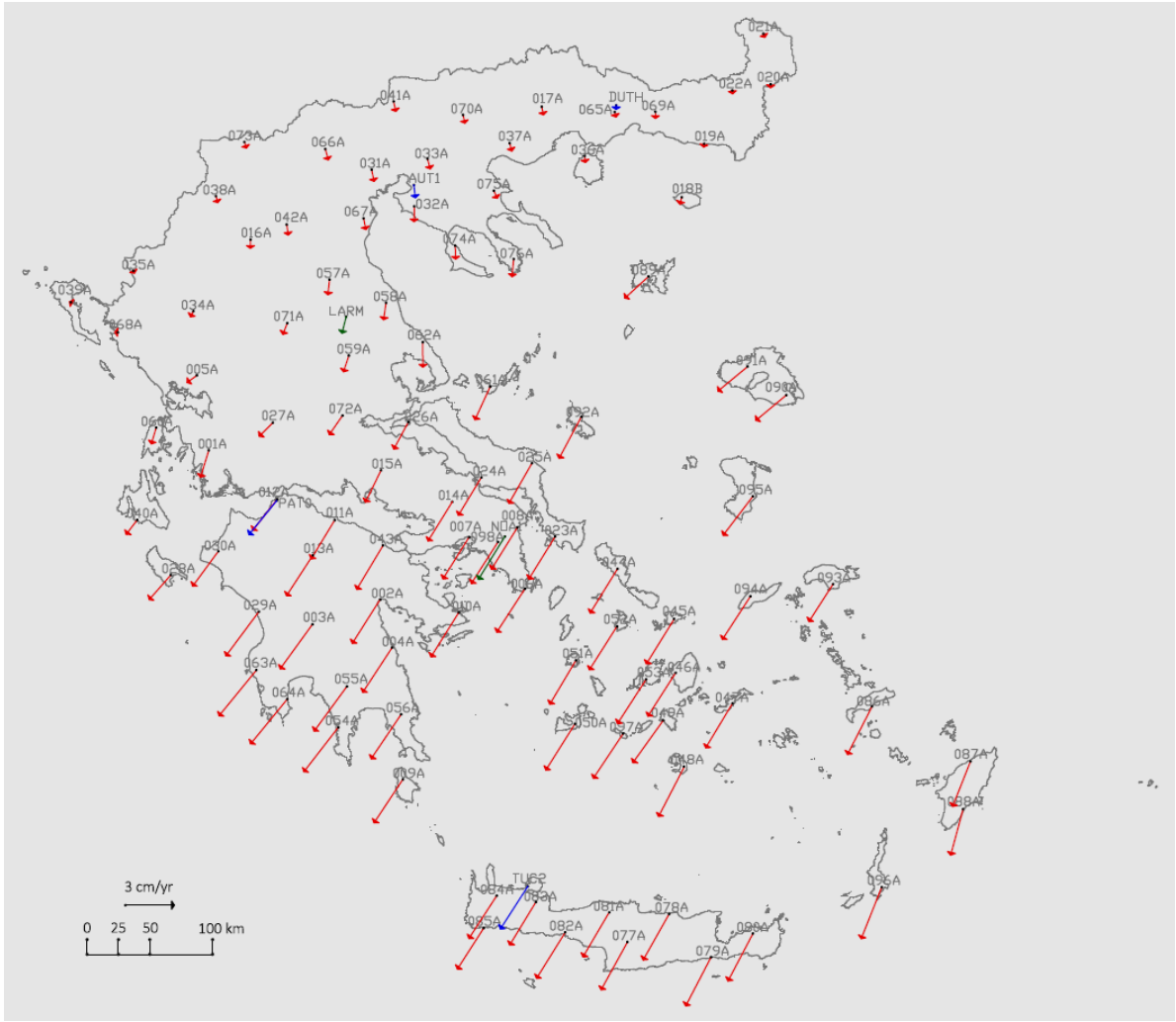
Event	Date	Area	Type
1	14/2/2008	Methoni	Earthquake (Mw 6.7, D: 35 km)
2	8/6/2008	Andravida	Earthquake (Mw 6.4, D: 31 km)
3	26/1/2014 3/2/2014	Cephalonia	Earthquake (Mw 6.1, D: 16 km) Earthquake (Mw 5.9, D: 5 km)
4	24/5/2014	Samothrace	Earthquake (Mw 6.9, D: 11 km)
5	2011-2012	Santorini	Volcano inflation

4. Estimated velocities and velocity field

Estimated horizontal velocity field in ETRF2000

104 stations:

- **98 HEPOS**
- **4 EPN Class A**
- **2 EPN Class B**



For comparison reasons, EUREF velocities are shown for the 4 EPN Class A stations *(EPN_A_ETRF2000_C1875.SSC).*

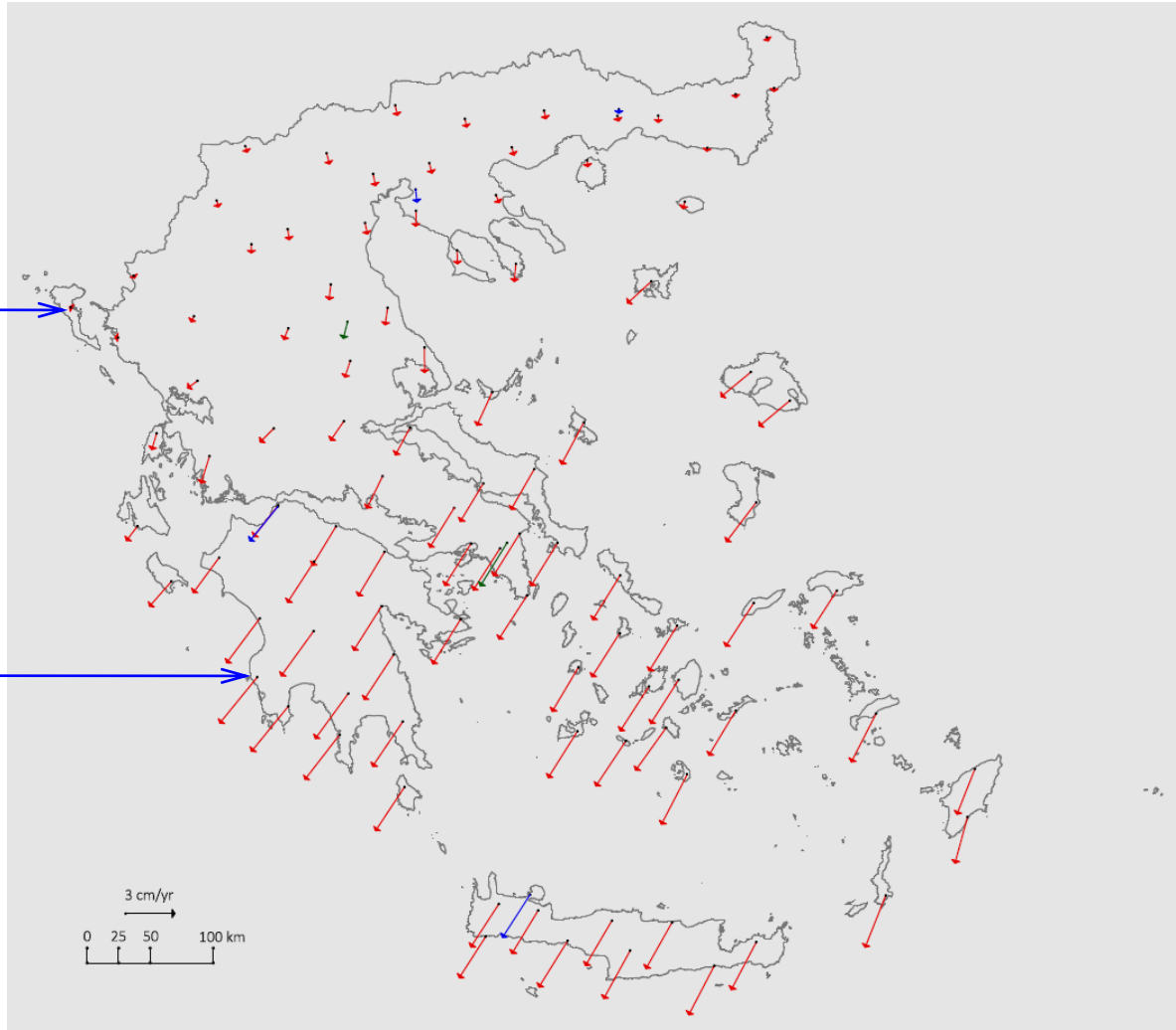
For the 2 EPN Class B stations PPP velocities are shown.

4. Estimated velocities and velocity field

Estimated horizontal velocity field in ETRF2000

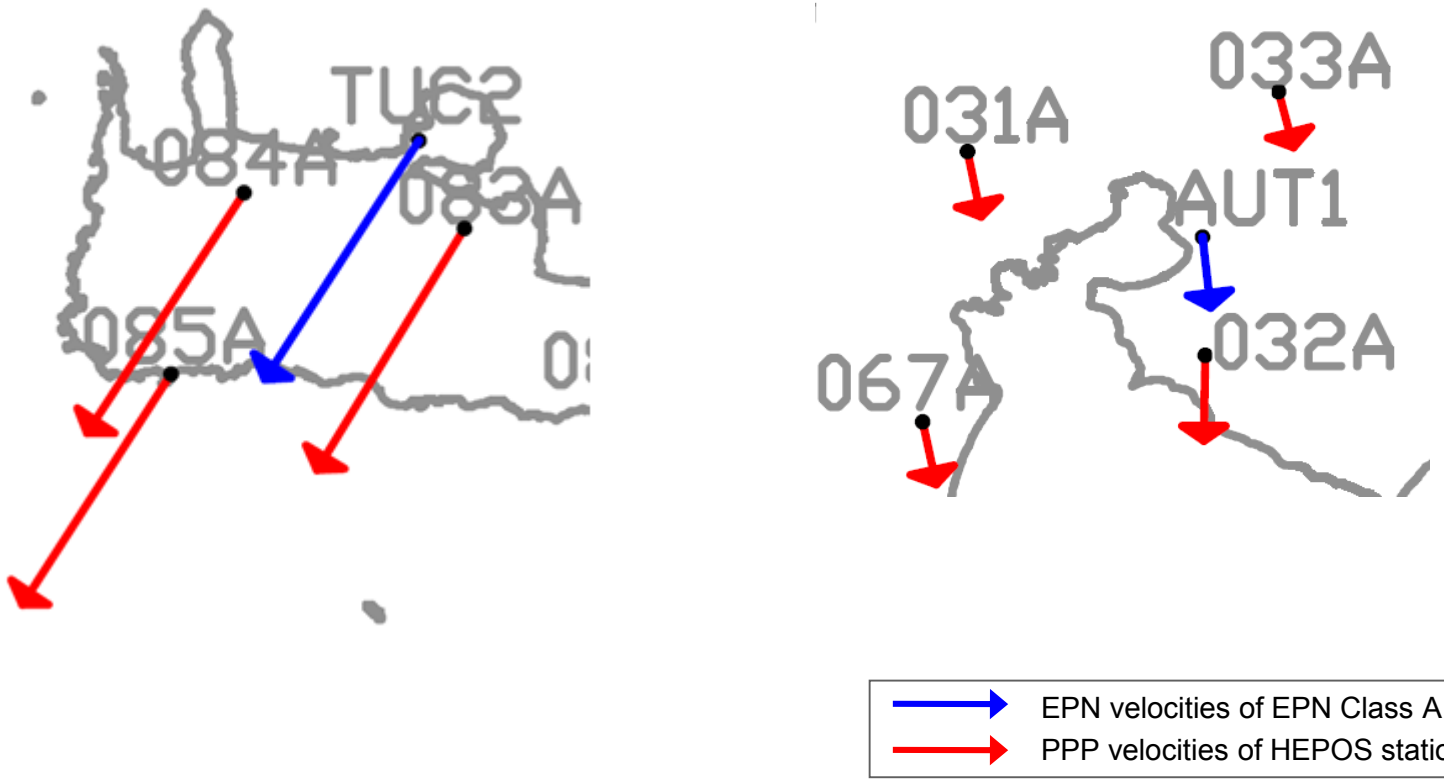
Smallest velocity:
0.0009 m/yr
station 039A

Largest velocity:
0.0363 m/yr
station 063A



5. Evaluation of results

Consistency between EPN & PPP velocities



5. Evaluation of results

Comparison of EPN & PPP velocities

Frame: ITRF08(IGb08)

EPN Station	EPN velocities (EPN_A_IGb08_C1875.SSC)			PPP velocities			Differences		
	V_X	V_Y	Y_Z	V_X	V_Y	Y_Z	DV_X	DV_Y	DY_Z
AUT1	-0.0149	0.0208	0.0041	-0.0152	0.0212	0.0035	**0.0003**	**-0.0004**	**0.0006**
PAT0	0.0016	0.0088	-0.0047	0.0019	0.0086	-0.0053	**-0.0003**	**0.0002**	**0.0006**
DUTH	-0.0168	0.0186	0.0088	-0.0168	0.0193	0.0083	**0.0000**	**-0.0007**	**0.0005**
TUC2	0.0029	0.0100	-0.0095	0.0030	0.0106	-0.0093	**-0.0001**	**-0.0006**	**-0.0002**

Differences between EPN and PPP velocities are in the order of 10^{-4} m/yr.

6. Conclusions

- PPP solutions can be used for the efficient estimation of tectonic velocities of permanent reference stations.
- Using data spanning over several years, even a daily solution per month proved to be sufficient for achieving accuracies in the order of 10^{-4} m/yr.
- Results from HEPOS network are of good quality and could contribute to the study of velocity field in Greece.

Acknowledgments

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