Περίληψη εργασίας για το συνέδριο 26th IUGG General Assembly 2015

Geodetic and seismological analysis of the January 26, 2014 Cephalonia Island earthquake sequence.

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On January 26, 2014 a strong earthquake of magnitude Mw=5.8 occurred on Cephalonia Island followed by a similar magnitude earthquake Mw=5.7 one week later on February 3, 2014. Extensive structural damages, landslides and many damages on the island's main roads, harbour and airport caused mainly on the western and central part of the island. The first event located 2km eastern of Lixouri town and was followed five hours later by a strong aftershock of magnitude Mw=5.3. The second strong earthquake located in the north part of Paliki eninsula (North-East Cephalonia).

Geodetic data of six permanent GNSS stations were available and analysed in this study both in pro and post seismic terms, using 30sec and 1Hz data where available. The time series analysis shows the effect of each event at nearby stations.

Seismological data are used to determine the focal mechanisms of the earthquake sequence and an attempt to investigate the homogeneity of the mechanisms and the stress field of the area is presented in the study.

Geodetic analysis and seismological results are used to understand the mechanism of the events.

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Abstract

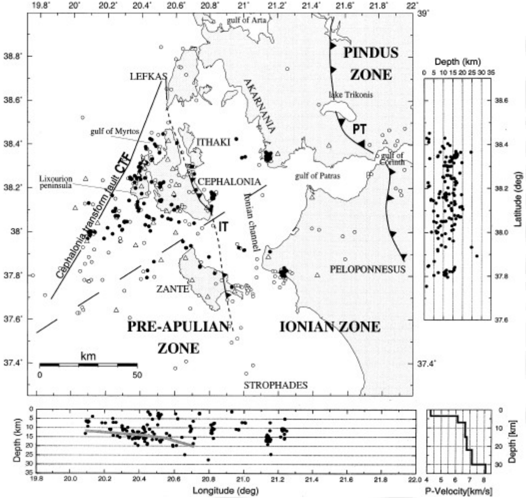
On January 26, 2014 a strong earthquake of magnitude Mw=5.8 occurred on Cephalonia Island followed by a similar magnitude earthquake Mw=5.7 one week later on February 3, 2014. Extensive structural damages, landslides and many damages on the islandâĂŹs main roads, harbour and airport caused mainly on the western and central part of the island. The first event located 2km eastern of Lixouri town and was followed five hours later by a strong aftershock of magnitude Mw=5.3. The second strong earthquake located in the north part of Paliki eninsula (North-East Cephalonia). Geodetic data of six permanent GNSS stations were available and analysed in this study both in pro and post seismic terms, using 30sec and 1Hz data where available. The time series analysis shows the effect of each event at nearby stations. Seismological data are used to determine the focal mechanisms of the earthquake sequence and an attempt to investigate the homogeneity of the mechanisms and the stress field of the area is presented in the study. Geodetic analysis and seismological results are used to understand the mechanism of the events.

Tectonic Setting

Cephalonia Island is located at the Ionian Sea (Western Greece) and constitutes one of the most active zones of shallow seismicity in the Eastern Mediterranean area

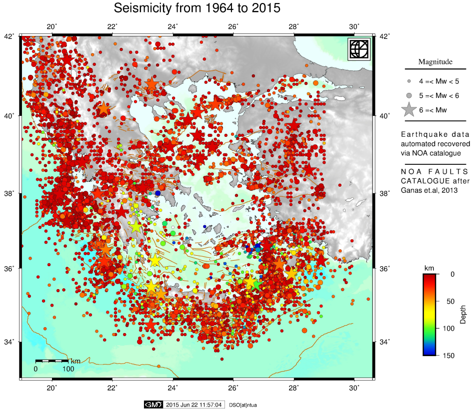
All four types of plate boundary occur:

- Collision
- Subduction
- Transform
- Spreading

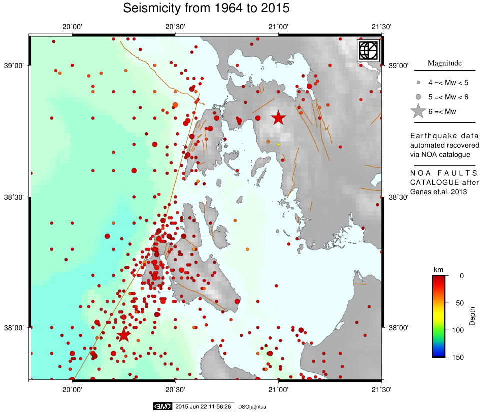


[Sachpazi et. al., 2000]

Seismicity in Greece



Seismicity in Greece from 1964 to 2015 with M>4



Region of Cephalonia Island

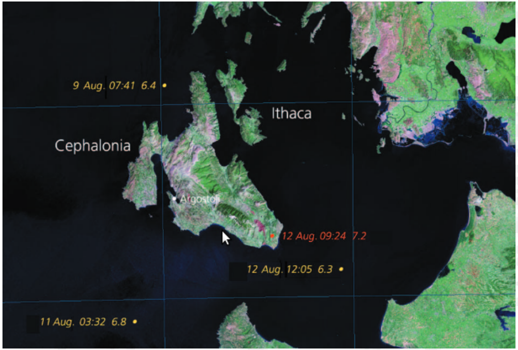
Cephalonia Earthquakes 1953

The consequence of the complicated tectonic setting is the production of extremely high seismicity and large, catastrophic earthquakes

The largest earthquake

August 12, 1953, M=7.3

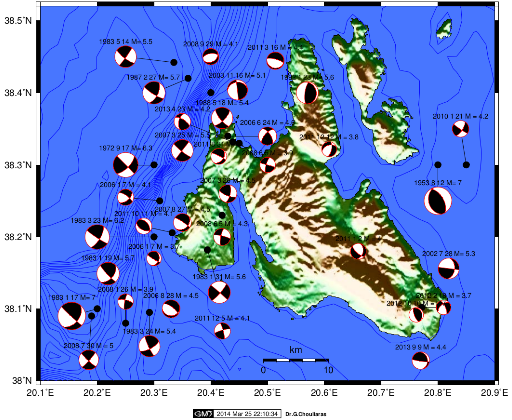
one of the most destructive earthquakes in the recent Greek history



Disaster images

Historical Focal Mechanisms

1953 - 2013

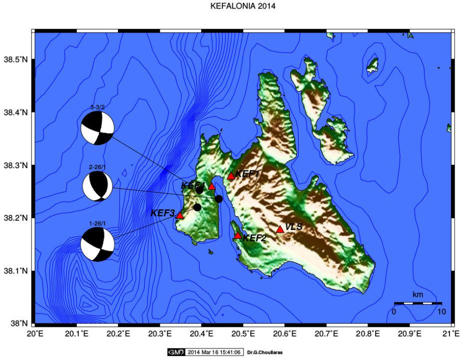


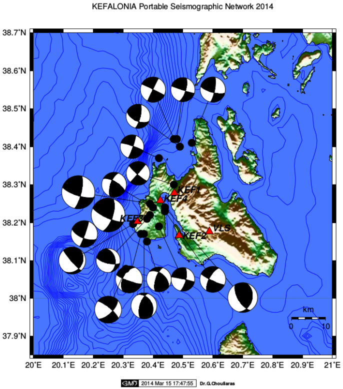
Cephalonia focal Mechanisms from 1953 to 2013

66 Events

M = 3.5 - 7

2014 Earthquake Sequence



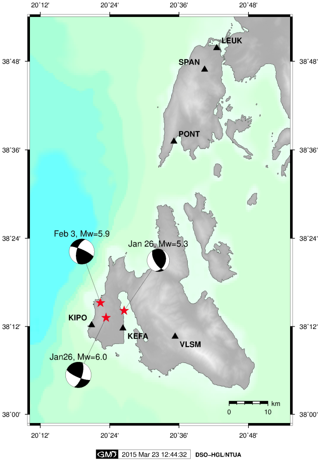


NOA-IG seismological stations[1] and focal mechanisms[2] of the 2014 seismic sequence

[1] http://www.gein.noa.gr/en/networks/other-networks/portable-seismic-network

[2] http://bbnet.gein.noa.gr/HL/seismicity/moment-tensors

Geodetic Network



Station Name	Location	Dist (km)	Inst	Data
VLSM	Valsamata, Cephalonia	18	NOA	30-s RINEX
KIPO	Kipouria, Caphalonia	7	NOA	30-s RINEX; *no data during the eq sequence*
PONT	Ponti, Lefkada	44	NOA	30-s RINEX
SPAN	Spanochori, Lefkada	63	NOA	30-s RINEX
KEFA	Lixouri, Cephalonia	7	Tree-Comp. CO	30-s and 1-s RINEX
LEUK	Leukada	70	Tree-Comp. CO	30-s and 1-s RINEX; *available only during the first eq*

Processing

30s data

All available data are routinely processed via Bernese GNSS Software v5.2 [1].
Each sub-network is processed twice:

- just a few hours after the end of day using ultra-rapid products and
- after a time lag of 20 days using final products

Processing Options

We strive to keep our processing options and models in close accordance to the IGS[1] analysis centers.

- Reference frame : follow IGS realization ⇒ currently IGb08 via three no-net-translation conditions imposed on a set of selected stations.
- Double-difference approach, ambiguities resolved to integers (when possible); algorithm depends on baseline length.
- Tropospheric mapping function : VMF1
- Ionospheric information is either extracted from CODE[2] models, or from NTUA's ultra-rapid solution.
- Absolute antenna calibration model (current IGS .atx).
- Sampling rate 30seconds, cut-off angle 7°, iterative residual check.

1Hz data

- BKG Ntrip Client (BNC)
- Undifferenced 1Hz carrier phase data
- Broadcast corrections for satellite orbits
- Broadcast corrections for satellite clocks

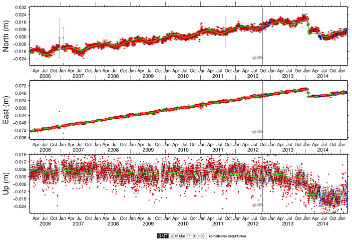
[1] International GNSS Service

[2] Center for Orbit Determination in Europe

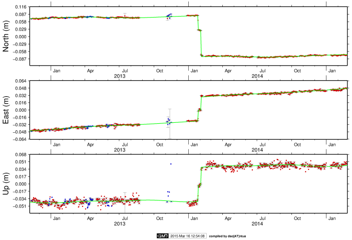
Time Series

Daily 30s data

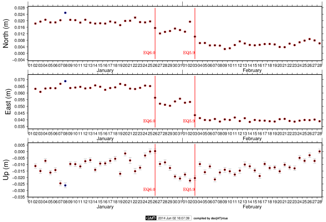
cGPS station vlsm



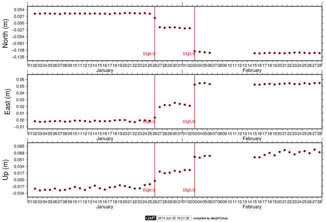
cGPS station kefa



cGPS station vlsm



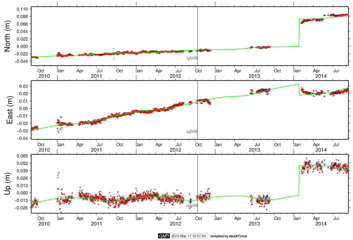
cGPS station kefa



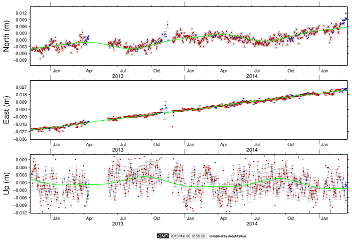
Time Series

Daily 30s data

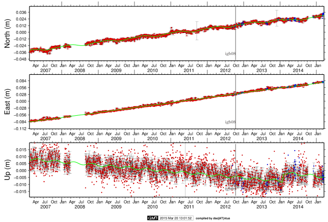
cGPS station kipo



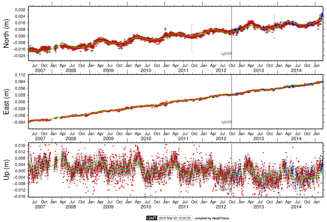
cGPS station leuk



cGPS station pont

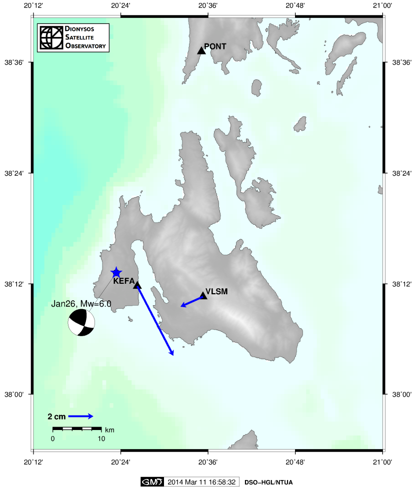


cGPS station span



January 26th, 2014

Displacement of GPS Stations



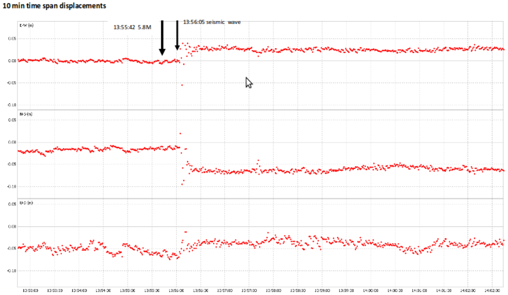
Station	Solution	Jun 26th dNorth	dEast (mm)	dUp
KEFA	daily[a]	-54.7	26.2	32.2
	2-per[b]	-47.8	21.7	24.5
	PPP[c]	-47.0	25.0	-
VLSM	daily[a]	-7.8	-18.6	-9.8
	2-per[b]	-7.6	-19.6	-8.4

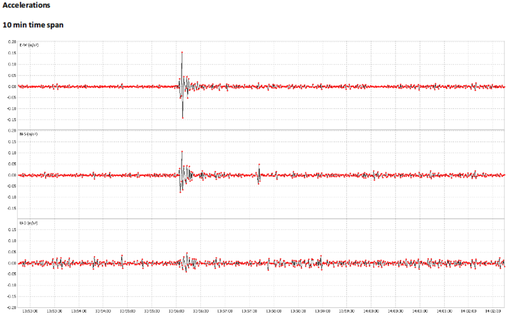
Table: co-seismic displacements for stations KEFA and VLSM

[a] DD, 30sec daily solution
[b] seperate the day of the event, prior to and after the earthquake
[c] PPP-BNG

January 26th, 2014

1Hz PPP Data Analysis - Station KEFA





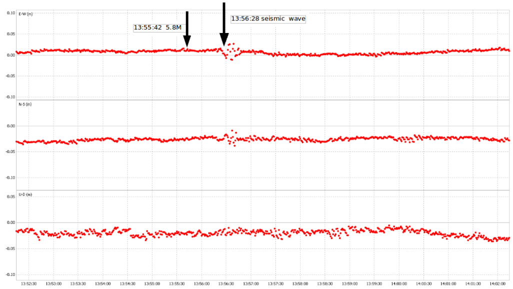
Earthquake event: 13:55:42 (GPS Time)

seismic wave recorded: 13:56:05 (GPS Time) **23s delay**

January 26th, 2014

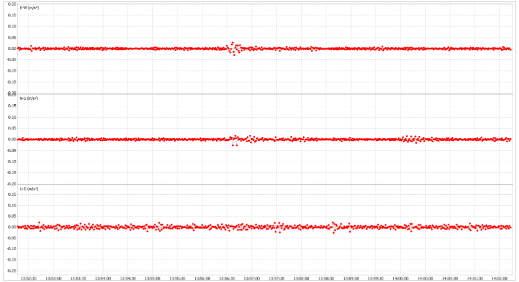
1Hz PPP Data Analysis - Station LEUK

10 min time span displacements



Accelerations

10 min time span

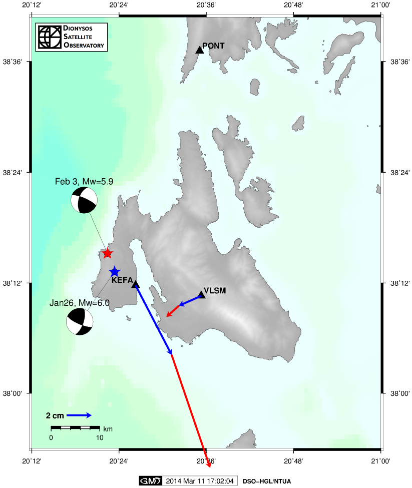


Earthquake event: 13:55:42 (GPS Time)

seismic wave recorded: 13:56:28 (GPS Time) **46s delay**

February 3rd, 2014

Displacement of GPS Stations



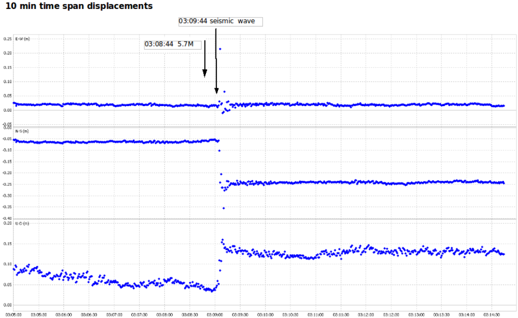
Station	Solution	dNorth	Feb 3rd dEast (mm)	dUp
KEFA	daily[a]	-91.0	31.0	33.0
	PPP[b]	200.0	0	80.0
VLSM	daily[a]	-9.0	-10.0	2.0

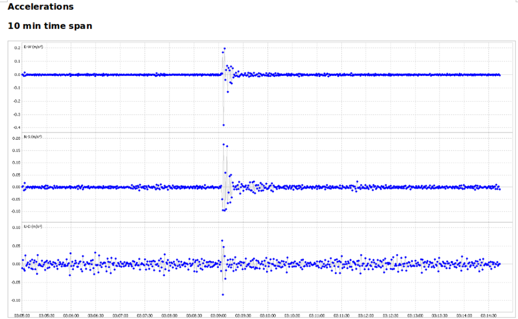
Table: co-seismic displacements for stations KEFA and VLSM

[a] DD, 30sec daily solution
[b] PPP-BNG

February 3rd, 2014

1Hz PPP Data Analysis - Station KEFA



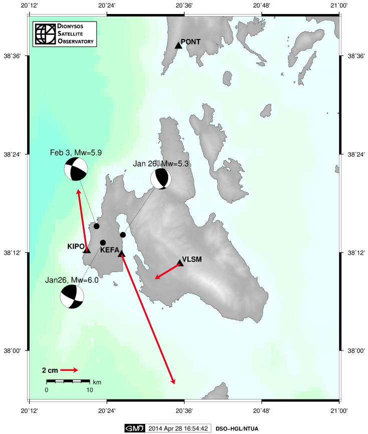


Earthquake event: 03:08:44 (GPS Time)

seismic wave recorded: 03:09:04 (GPS Time) **20s delay**

Earthquake sequence

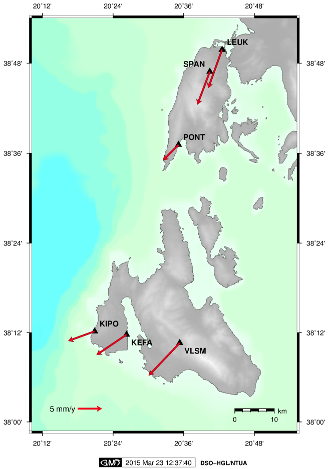
Total Displacements for Both Earthquakes



Station	Solution	Jan 26 - Feb 03 dNorth	dEast (mm)	dUp
KEFA	daily	-147.0	60.0	65.0
VLSM	daily	-17.0	-28.0	-8.0
KIPO	daily	70.0	-10.0	56.0

Table: co-seismic displacements for stations KEFA, VLSM and KIPO

Velocity Field



CODE	V_N	σ_{V_N}	V_E	σ_{V_E}	V_U	σ_{V_U}
			(mm/yr)			
KEFA	-4.2	3.0	-6.19	2.0	2.48	3.0
VLSM	-6.77	4.0	-6.42	4.0	-0.54	4.0
KIPO	-1.99	3.0	-5.46	-2.0	1.39	2.0
PONT	-3.24	3.0	-3.2	5.0	-2.27	4.0
SPAN	-6.8	0.0	-2.5	0.0	-1.05	0.0
LEUK	-7.97	0.0	-2.86	0.0	-0.68	1.0

Table: Tectonic Velocities w.r.t. fixed Europe

Conclusions I

- Permanent displacements are only observed at stations KEFA, VLSM and KIPO.
- Despite the significant seismic influence at stations KEFA, VLSM and KIPO, no change of the tectonic movement can be observed.
- The opposing movement in direction between KIPO and KEFA indicate that the activated fault zone possibly lays between these two sites (Ganas et al., 2015).
- Kinematic behavior of the stations is not affected.
- Vertical offsets vary between -2 and 3 cm. Station KEFA and KIPO are uplifted, while for VLSM a downshift of approximately 2 cm is evident.
- PPP and DD approach result in the same conclusions for the offsets induced by the first earthquake; this is not the case for the second earthquake.
- Co-seismic displacements of GPS stations are in agreement with the focal mechanisms of the earthquakes.
- Stress field of the region, as shown by the analysis of the focal mechanisms of historical earthquakes, is consistent with the velocity field derived from GPS data.

Thank you very much for your attention !

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