Modelling the 3D complexities of a subduction interface: the Calabrian Arc (Italy)

Francesco E. Maesano, Mara M. Tiberti and Roberto Basili

Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy

TSUMAPS NEAM Probabilistic TSUnami Hazard MAPS for the NEAM Region — Funded by European Union Humanitarian Aid & Civil Protection

Ritmare

OBJECTIVES

Reconstruct in detail the shallow subduction interface (<20 km)

Constrain the deep part of the slab top surface (40 - 350 km)

Obtain a seamless 3D surface of the Calabrian subduction

Update the Italian database of seismogenic sources

1 Tectonic setting and dataset

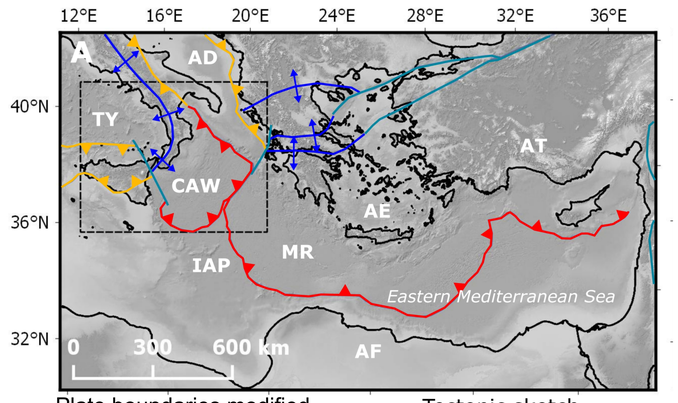
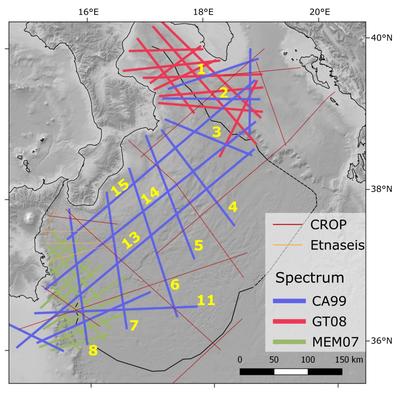


Plate boundaries modified from Carafa et al., 2015

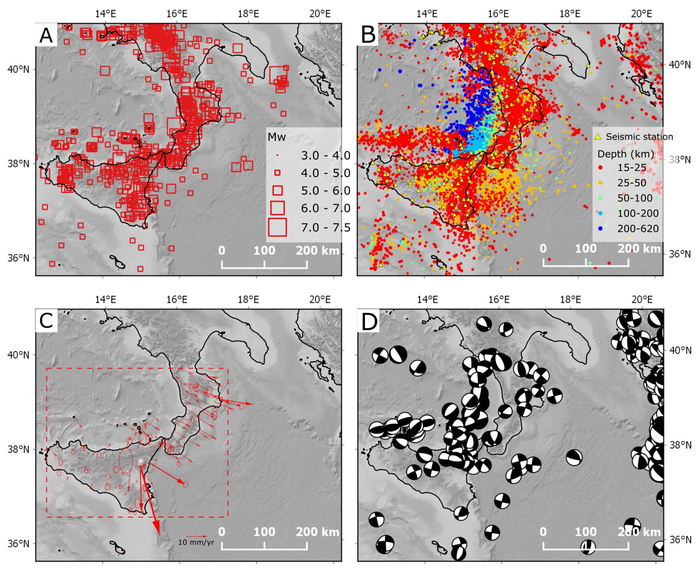
Tectonic sketch
- Subduction front
- Collisional front
- Extensional deformation
- Transform margin



The Calabrian Arc is a one-of-a-kind subduction zone. It features one of the shortest subduction segments (<150 km), one of the thickest accretionary wedges, and the oldest subducted (280 Myr) oceanic crust of the World.

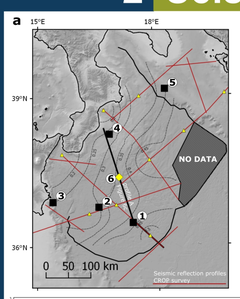
The evolution of the Calabrian Arc is controlled by slab roll-back that started in the Late Miocene (8-10 Myr; Goes et al., 2004; Faccenna et al., 2005), due to the sinking of the Ionian oceanic crust. The effect of plate convergence on the subduction process gradually decreased since the start of continental collision in Sicily (late Miocene -Pliocene).

At present, the subduction process controls the south-eastward migration of the upper plate and active faulting within it (Tiberti et al., 2016). Despite a convergence rate of 1-5 mm/yr (e.g. Devoti et al., 2011) and significant in-slab seismicity below 40 km depth (Chiarabba et al., 2008), its shallow interface shows little signs of seismic activity.

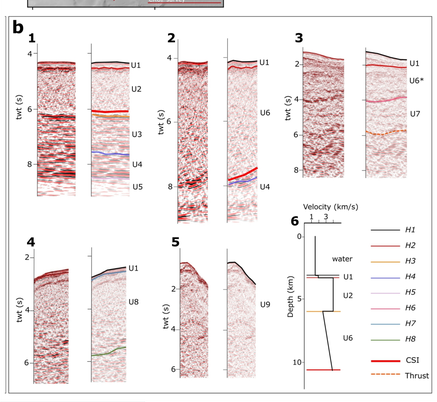


A - Historical seismicity from CPTI15 (Rovida et al., 2016).
B - Instrumental seismicity 2005-2016 (ISIDe WG, 2016).
C - GPS velocities. Fixed Africa reference (Devoti et al., 2011).
D - Regional Centroid Moment Tensor solution (http://www.bo.ingv.it/RCMT/).

2 Seismic facies and velocity model

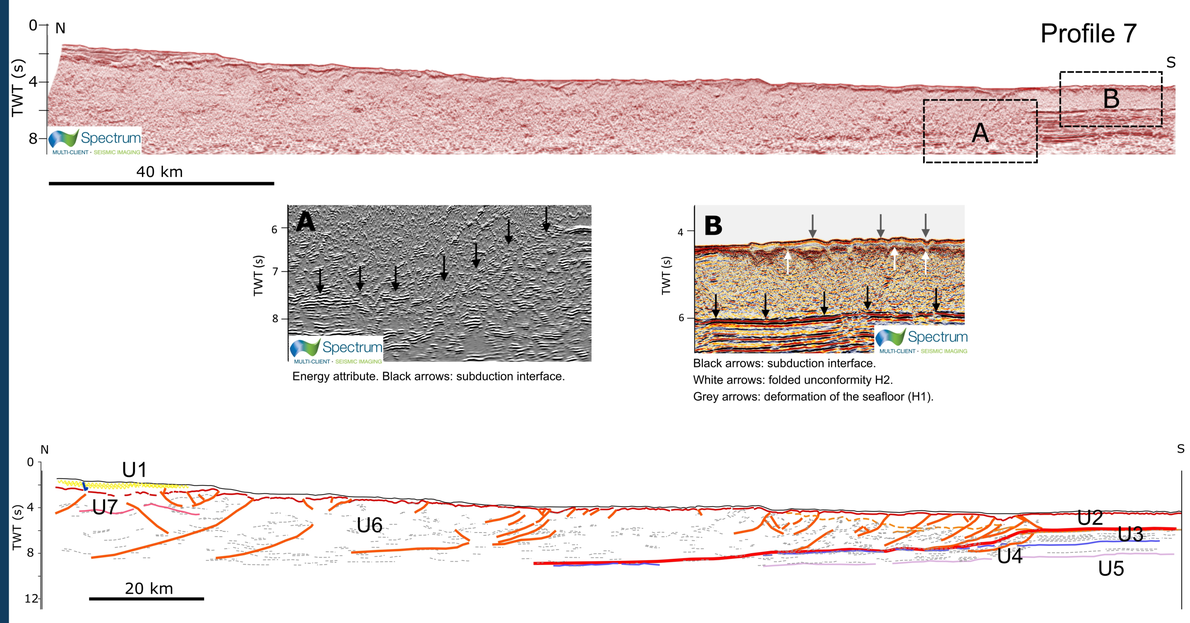


ID	Description
H1	Seafloor reflector.
H2	Regional angular unconformity at the top of U2. Where U2 is absent, it represents the top of U6.
H3	HA reflector representing the unconformity and correlative conformity at the top of U3.
H4	Planar and continuous reflector representing the top of U4.
H5	HA-LF reflectors identified in most of the seismic lines and representing the top of U5.
H6	HA-LF reflector, generally dipping seaward, interpreted as the top of U7.
H7	Intra-Messinian unconformity recognized in all the seismic profiles crossing U8.
H8	HA-LF reflectors at the base of U8.



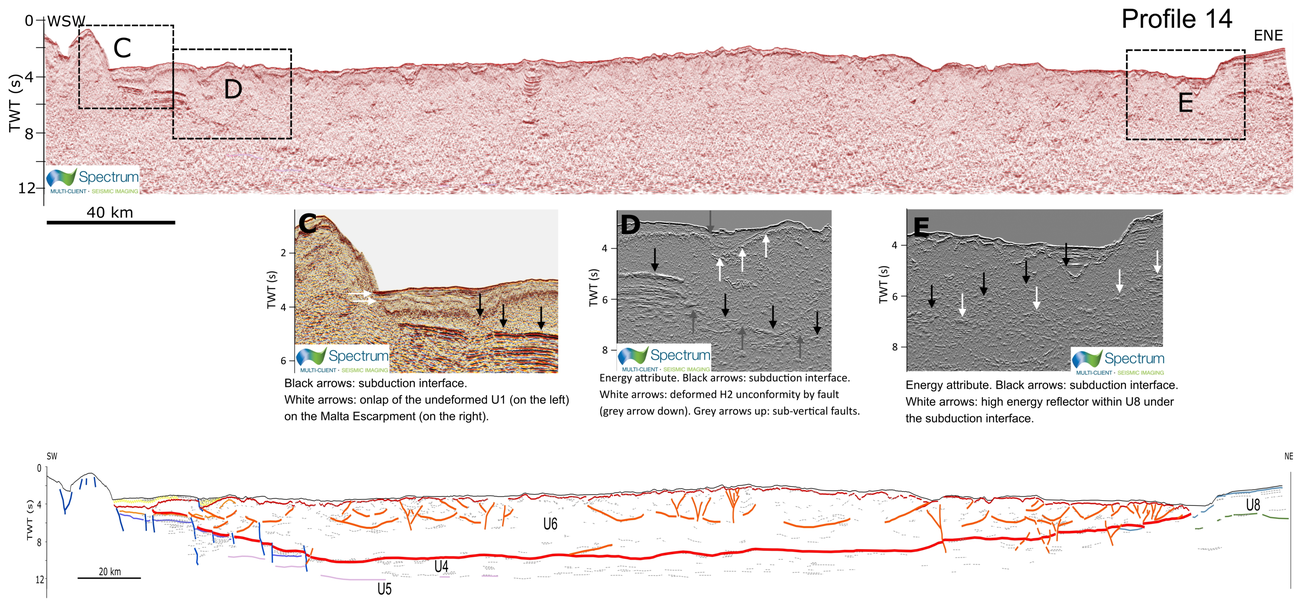
ID	Seismo stratigraphic facies	Age	Description
U1	Well layered HF-LA reflectors with presence of numerous unconformities.	Pliocene - Holocene	Unconsolidated siliciclastic turbiditic and distal deposits often associated with chaotic bodies at the base of the succession.
U2	HA and quite continuous reflectors at the top, overlying a highly homogeneous reflection-free zone bounded at the base by a planar HA reflector.	Messinian	Salt-bearing complex related to the tectonic stacking of Messinian evaporites.
U3	Alternating HA-LF, subparallel reflectors, bounded at the top by a continuous HA reflector; this unit can be differentiated from the accretionary wedge only in the external regions.	Paleocene (?) - Tortonian	Siliciclastic deposits (analogue of outcropping units in Sicily and Southern Apennines) marked by on-lap on U4.
U4	LA-LF subparallel reflectors characterized at the base by high-amplitude reflectors 0.3 s TWT thick.	Triassic - Cretaceous	Pelagic carbonate sediments (analogue of outcropping units in Sicily and Southern Apennines), covering the Ionian oceanic crust.
U5	Noisy seismic facies located under a HA-LF seismic reflections at 8.5 s TWT in the external area of the accretionary wedge.	Permian (?) - Triassic	Ionian oceanic crust.
U6	Chaotic and highly deformed LA seismic facies with some LF-HA discontinuous reflectors.	Mesozoic - Pliocene	Calabrian Accretionary Wedge made up by the tectonic stacking of U3, U4, and U7.
U7	Transparent seismic facies bounded at the top and the base by HA reflectors.	n.a.	Calabrian metamorphic (?) unit.
U8	Mainly transparent seismic facies bounded by HA reflectors related to erosional unconformity at the top and by LF-HA reflectors at the base.	Mesozoic - Messinian	Apulia platform carbonates.
U9	Layered HF seismic facies in the upper part; transparent seismic facies in the lower part.	Mesozoic - Miocene	Hyblean platform carbonates.

3 Seismic reflection profiles interpretation



Energy attribute. Black arrows: subduction interface.

Black arrows: subduction interface.
White arrows: folded unconformity H2.
Grey arrows: deformation of the seafloor (H1).

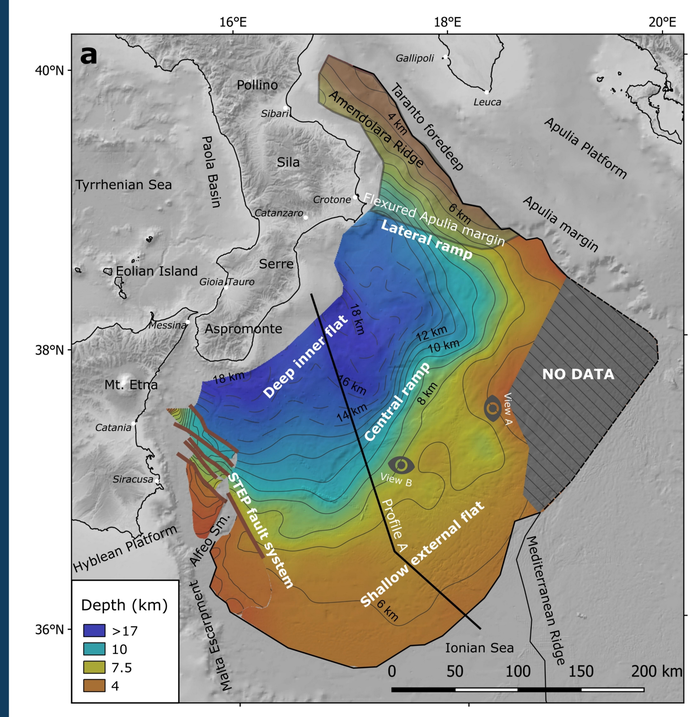


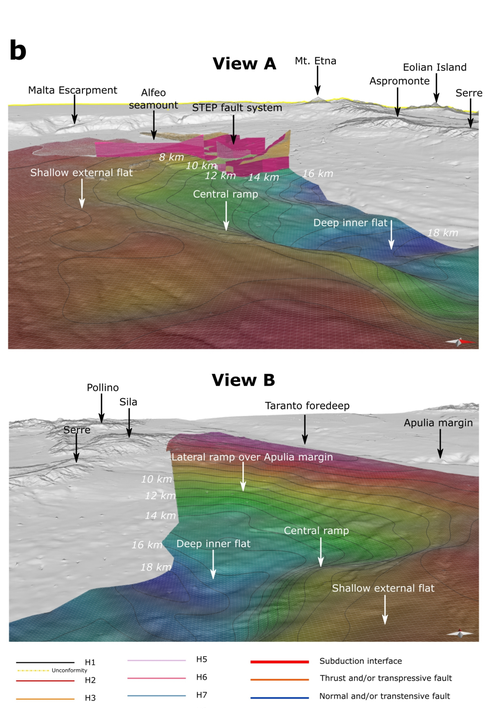
Black arrows: subduction interface.
White arrows: onlap of the undeformed U1 (on the left) on the Malta Escarpment (on the right).

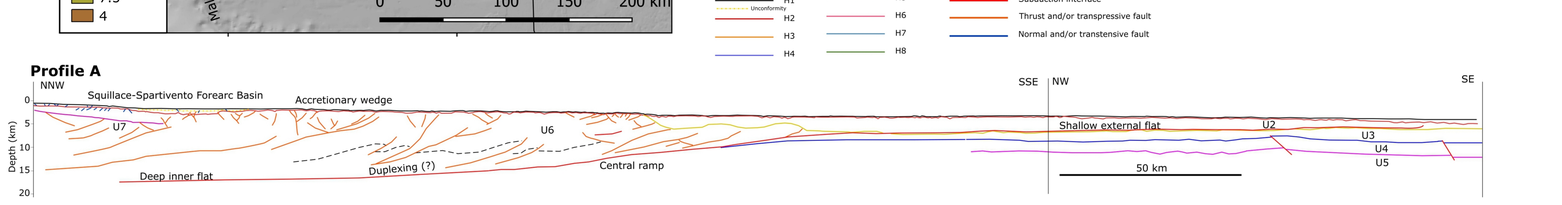
Energy attribute. Black arrows: subduction interface.
White arrows: deformed H2 unconformity by fault (grey arrow down). Grey arrows up: sub-vertical faults.

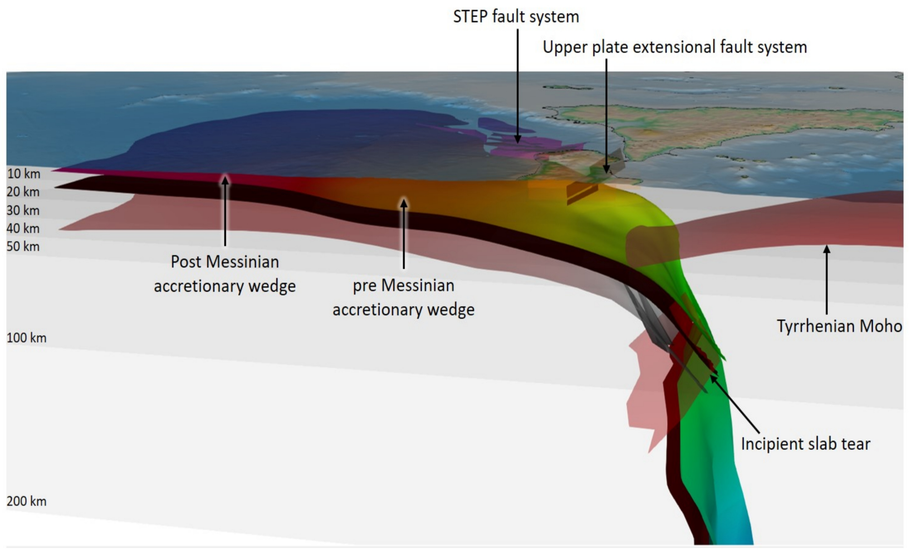
Energy attribute. Black arrows: subduction interface.
White arrows: high energy reflector within U8 under the subduction interface.

4 Subudction interface - shallow part (<20 km)

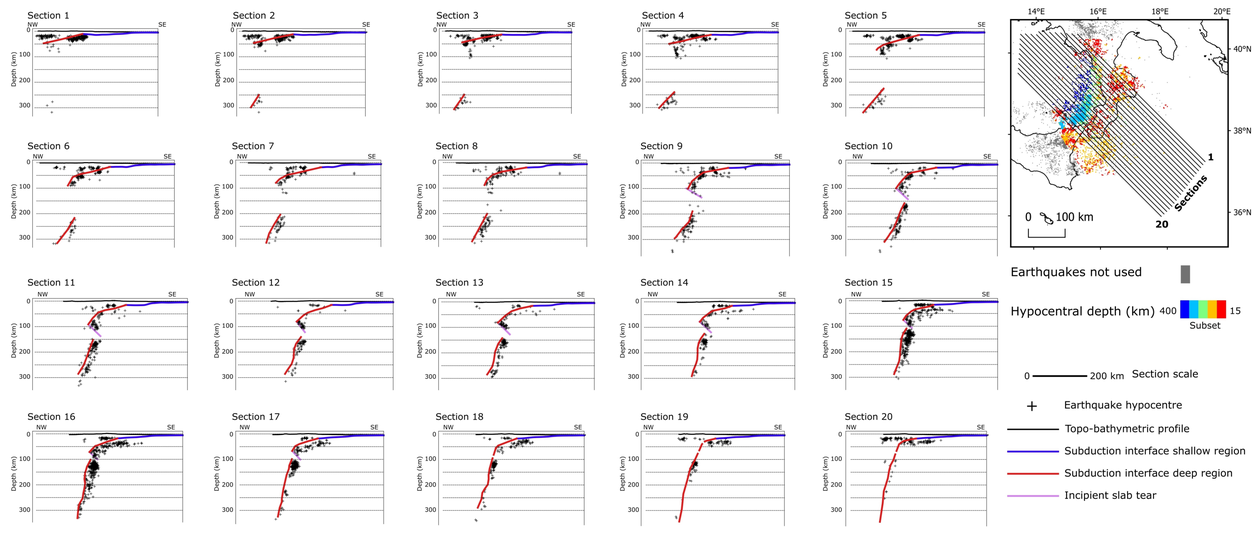




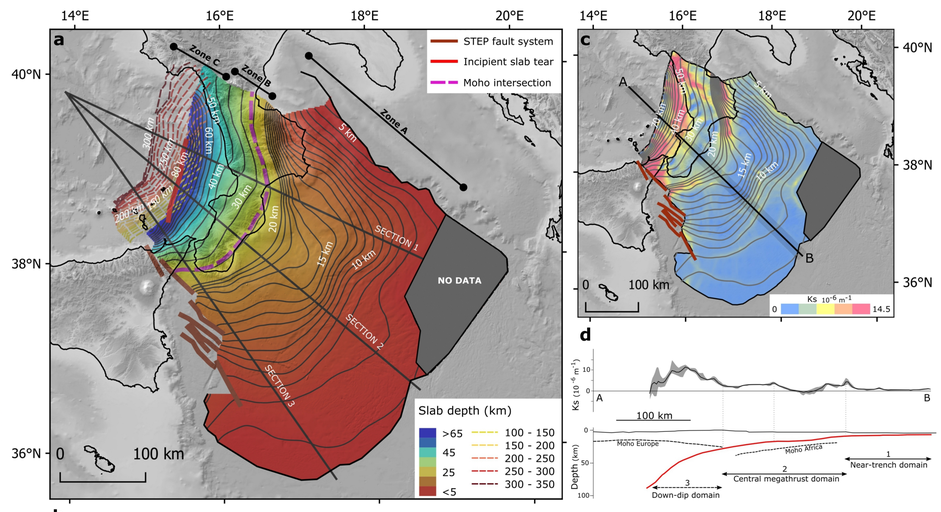




5 Seismicity distribution



6 Integrated slab model



www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

The Calabrian Arc: three-dimensional modelling of the subduction interface

doi: 10.1038/s41598-017-09074-8

Acknowledgments and References

Multichannel seismic reflection surveys in the Ionian sea are kindly provided by Spectrum under a Confidentiality Agreement (CA-60) with INGV.
Porf. R. Nicolich kindly provided the Etnaseis seismic profiles
CROP seismic profiles are provided by CNR-ISMAR.
The bathymetric Digital Terrain Model is derived from SRTM30 Plus V6.0 data files. Beckeret al. (2009), Global Bathymetry and Elevation Data at 30 Arc Seconds Resolution: SRTM30_PLUS, Marine Geodesy, 32:4, 355-371, 2009.
Midland Valley Ltd is acknowledged for making available the Move software to INGV under Academic Software Initiative (ASI).
This poster benefits from the financial support of TSUMPAS-NEAM, RITMARE, Porto Empedocle, and PON Massimo Projects.

(1) Carafa, M. M. C.et al. (2015), Neotectonics and long-term seismicity in Europe and the Mediterranean region, J. Geophys. Res. Solid Earth, 120,doi:10.1002/2014JB011751.
(2) Chiarabba, C. et al. (2008), The southern Tyrrhenian subduction zone: Deep geometry, magmatism and Plio-Pleistocene evolution, Earth and Planetary Science Letters, doi:10.1016/j.epsl.2008.01.036.
(3) Devoti, R. et al. (2011), Earth and Planetary Science Letters, doi: 10.1016/j.epsl.2011.09.034.
(4) Faccenna, C. et al. (2005), Constraints on mantle circulation around the deforming Calabrian slab, Geophys. Res. Lett., doi:10.1029/2004GL021874.
(5) Goes, S. (2004), A recent tectonic reorganization in the south-central Mediterranean, Earth and Planetary Science Letters, doi:10.1016/j.epsl.2004.07.038.
(6) ISIDe working group (2016) version 1.0, doi: 10.13127/ISIDe.
(7) Maesano, F.E., et al. (2016) Deep view of the Subduction-Transform Edge Propagator (STEP) fault in the Calabrian Subduction Zone. EGU General Assembly 2016.
(8) Neri, G., et al. (2009), Subduction beneath Southern Italy close the ending: results from seismic tomography. SRL doi: 10.1785/gssrl.80.1.63
(9) Rovida A., et al. (2016), CPTI15, the 2015 version of the Parametric Catalogue of Italian Earthquakes. Istituto Nazionale di Geofisica e Vulcanologia. doi: 10.6092/INGV.IT-CPTI15.
(10) Tiberti, M.M., et al. (2016), Understanding seismogenic processes in the southern Calabrian Arc: a geodynamic perspective, Italian Journal of Geosciences. doi:10.3301/IJG.2016.12