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Session: SM 1.1

General Contributions on Earthquakes, Earth Structure, Seimology

Live chat: Tuesday, 05 May 2020, 10:45 – 12:30

# Recent instrumental seismicity of the southwest Matese Massif (Sannio-Matese area - Italy): a contribution on the seismotectonics setting.

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## INTRODUCTION

The Matese Massif (Figure 1) is the major mountain range of the Sannio-Matese, which is the transition area between central and southern Apennines. The Massif is located among the seismogenic sources of large destructive historical Earthquakes (e.g. 1349, MW =7.0; 1688, MW = 6.6; 1805, MW = 6.8). Previous studies on the instrumental seismicity of the Sannio-Matese have shown that the seismic activity along and close to the Matese Massif is prevalently characterized by the occurrence of sparse low magnitude events (ML<2.5) and by seismic sequences with low to moderate magnitude ($M_{Wmax}$=5.0) with hypocenters within the uppermost crust. Last relevant seismic sequence occurred between the late 2013-early 2014 following an $M_W$=5.0 earthquake. This sequence struck the internal southern side of the Massif in an area where no evidence of active faulting has been recorded so far (Ferranti et al., 2015). The 1805 Earthquake affected the northern slope of the Massif whereas the 1349 and 1688 Earthquakes affected the southern side. The 1349 Earthquake, that includes at least three main shocks, given its age, stands out due to the lack of reliable and sufficiently vast historical documentation. Gallo & Naso (2009), on the basis of geological, geomorphological and historical analysis, proposed a SW dipping 125 striking 22 km length normal fault, named Aquae Iuliae Fault (AIF), as responsible for one of the main shocks of this Earthquake. Considering that the degree of knowledge about the location, geometry and kinematics of the active faults is not detailed for the southern side of the Matese and that this information can be obtained from the study of the background seismicity, here is analyzed the seismicity occurred in 2009-2019 time interval along and close the Massif, in particular, in the area of the 1349 Earthquake.

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# 1997-2019 SEISMICITY

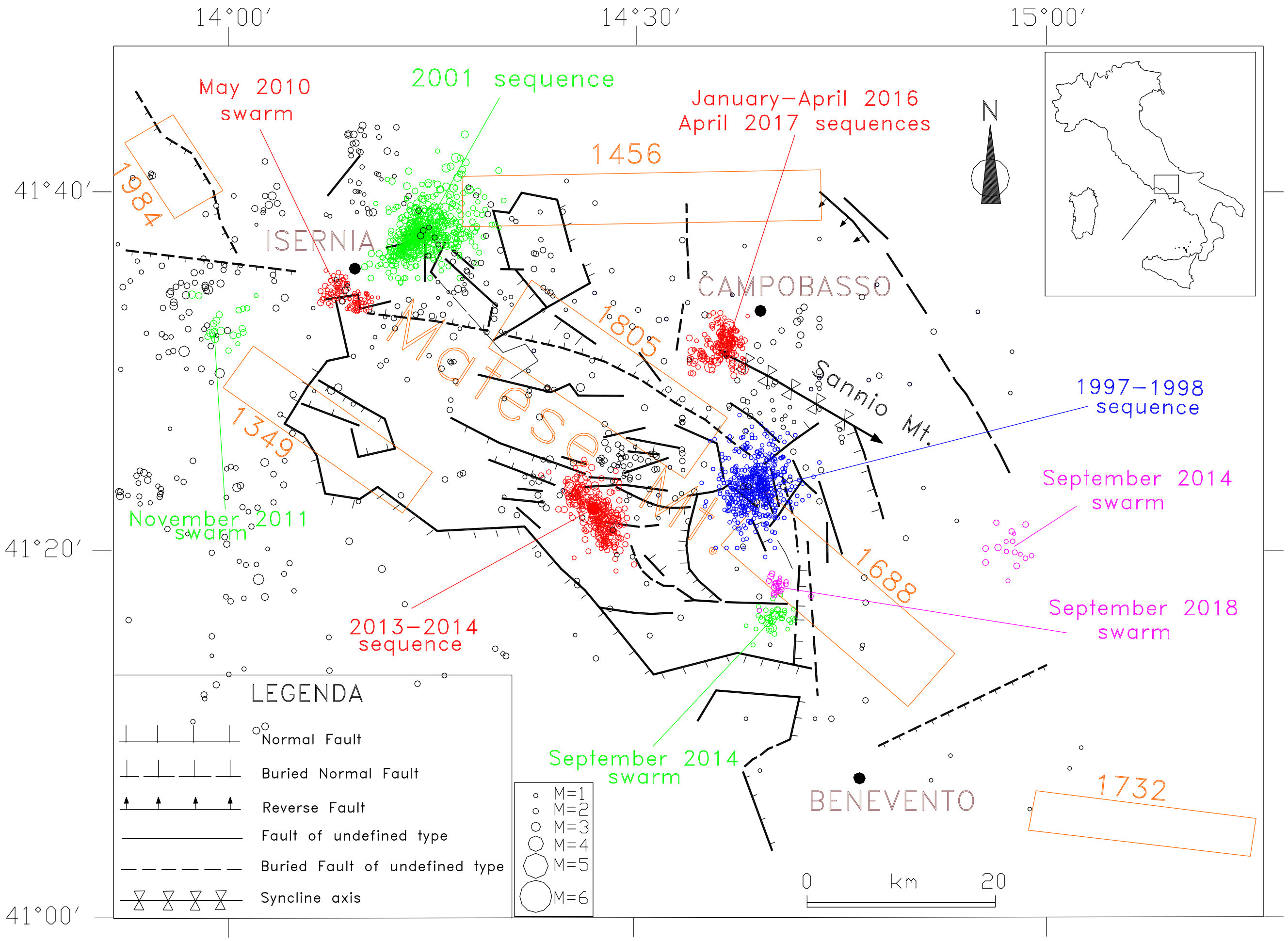


**Figure 1**: Main structural lineaments of the study area (redraw after CNR-PFG, 1983) on which are reported the seismogenic sources of the strong historical earthquakes (rectangles with the years) resulting in DISS 3.2.1 (2018) and the epicentral distribution of the seismicity that occurred between 1997 - 2019 in and around the Matese Massif (data from Milano et al., 2008; Fracassi & Milano, 2014; Milano, 2014, this paper).

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# DATA

The digital waveforms of the seismic events occurred in the study area, related to the 2009–2019 time interval and recorded by INGV seismic network, have been collected and analyzed. A manual re-picking of the P- and S-wave arrivals has been performed in order to correct any miss interpretation present in the catalogue, focusing our attention on S-phase for the reliability of the focal depth, and to obtain a P-wave polarity data-set to compute constrained Fault Plane Solutions. For location purposes we selected the events recorded by a minimum of five stations and with at least five P- and four S-phase readings. The earthquake locations have been performed using the HYPOINVERSE-2000 code (Klein, 2002) utilizing a velocity model already used for previous studies on the area (e.g. Milano et al., 2008).

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# THE 2009-2019 RELOCATED SEISMICITY

The epicentral distribution (Figure 2), with the exception of the 2013-2014 seismic sequence and the cluster relative to the 2016 and 2017 sequences close to Campobasso (not reported in Figure 2; see Figure 1 for location), shows that the relocated seismicity consists of both single events, with magnitude generally less than 2.5, and low magnitude seismic swarms ($M_{Lmax}$<3.3). Most of the hypocenters of single events are in the first 15 km of the crust and only 4 of them had $3.0 \leq M_L \leq 3.7$. These last are located in the westernmost sector of the study area (see also Figure 3 for their location). The focal mechanisms of these events show solutions compatible with normal dip-slip faults with limited strike-slip component (Figure 3). The common element of these focal mechanisms is the presence of a SW dipping, ~ NW-SE striking plane. The surface projection of the P- and T-axes of the focal mechanisms agree with the large scale stress field acting in the Apennines, showing, in particular, sub-horizontal T-axes along the NE-SW direction.
With regards the low magnitude seismic swarms, they occurred in 2010, 2011, 2014 and 2018. The first two are located in proximity of the NW edge whereas the other two are located close the SE edge of the Matese Massif.

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# RELOCATED SEISMICITY 2009-2019

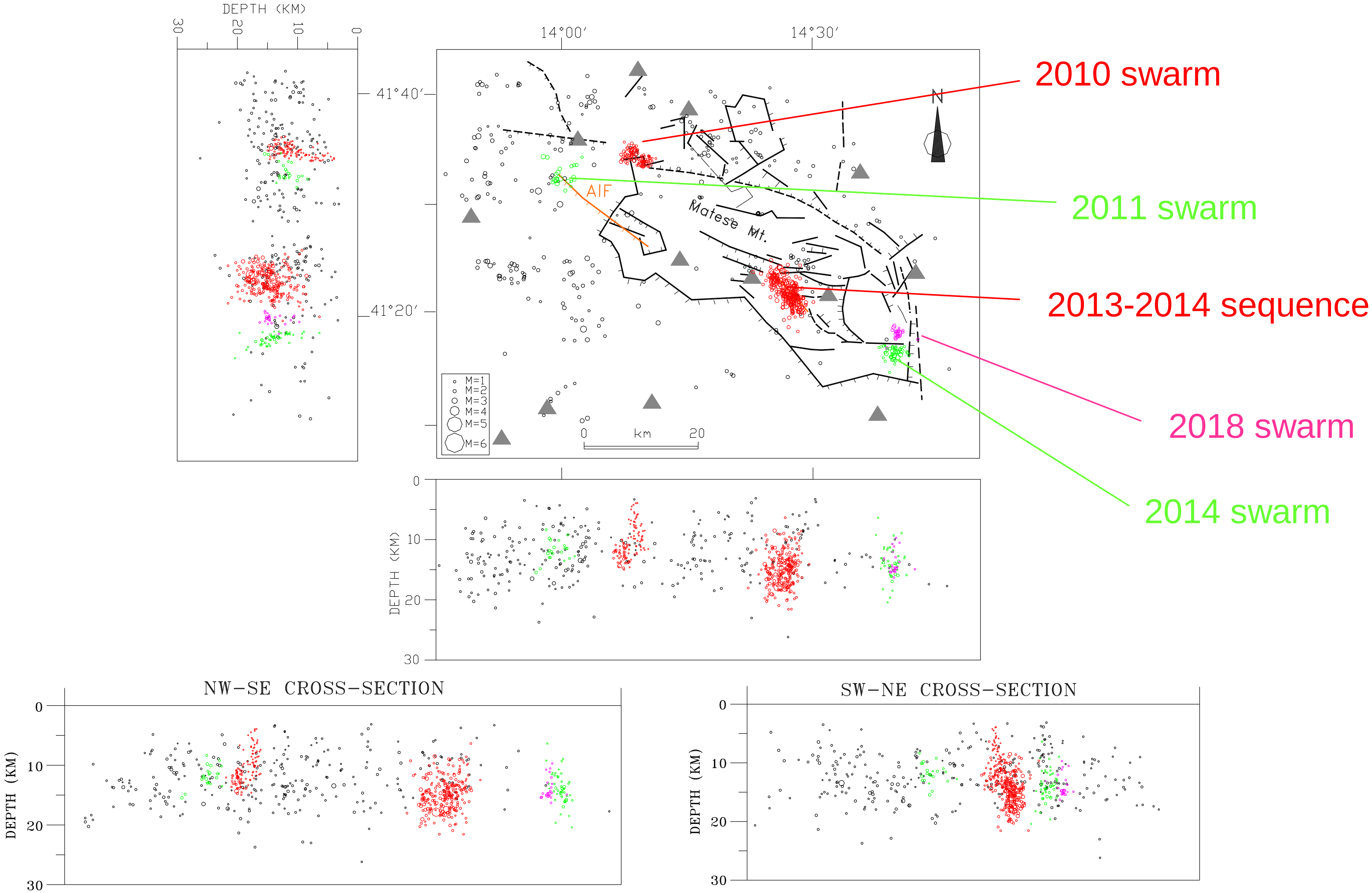


**Figure 2**: Hypocentral distribution of the relocated seismicity. The gray triangles represent the permanent seismic stations.

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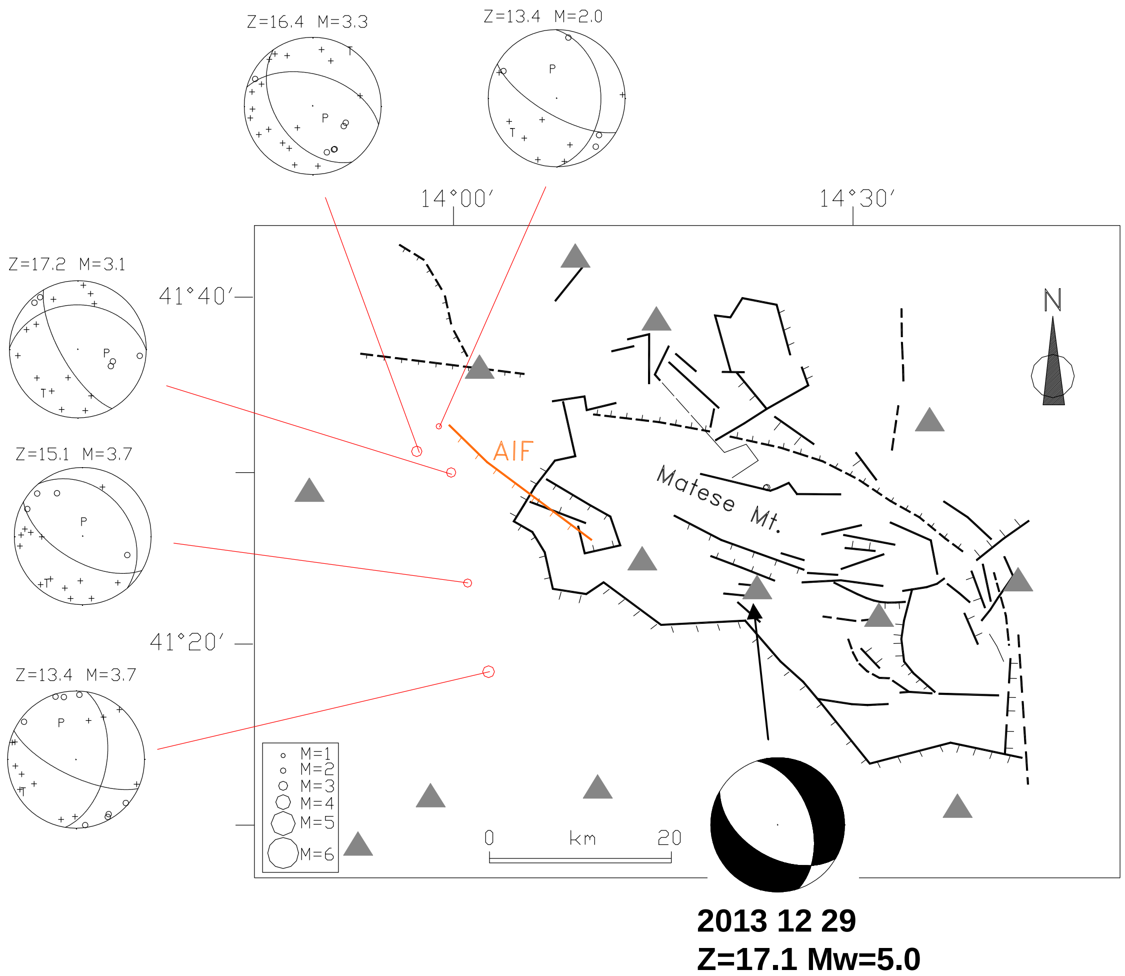
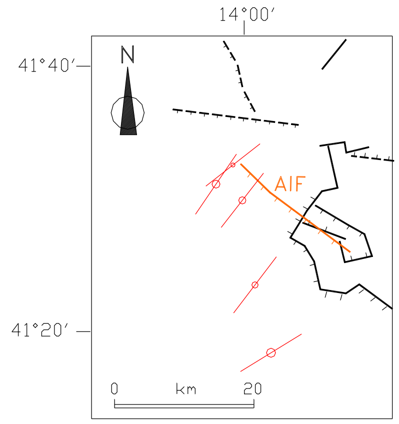
# FOCAL MECHANISMS SINGLE EVENTS




## T-AXES DISTRIBUTION




## P-AXES DISTRIBUTION

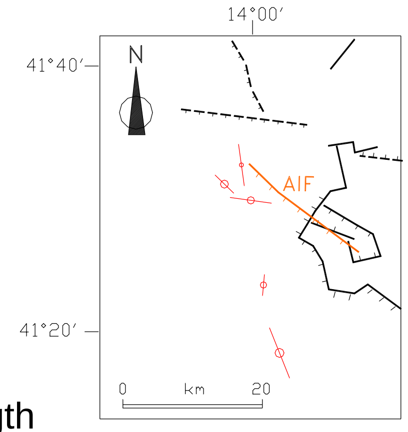



**Figure 3**: Fault plane solutions and surface projection of the T- and P-axes (length of axes proportional to the cosine of the plunge). The focal mechanism of the main event of the 2013-2014 sequence is also reported. The gray triangles represent the permanent seismic stations.

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# 2010 AND 2011 SEISMIC SWARMS

Relatively to the seismic swarms localized in the west sector (Figure 4), the first one's took place at the end of May 2010 and it was triggered by an earthquake of $M_L$=3.3 (May 29th, 15:04). About 150 events, with magnitude ranging between 1.0 and 2.5, occurred within the next 48 hours from the main event. The epicentral distribution does not show a clear alignment. Hypocenters are confined between 5 and 15 km in depth.
The focal mechanisms show different solutions (Figure 5). However, they can be grouped in: normal dip-slip with a limited strike-slip component, e.g. that relative to the event triggering the swarm ($M_L$=3.3), and strike-slip solutions, with a minor dip-slip component. T-axes of the first group are aligned roughly along the NNE-SSW direction whereas those of the second group along NNW-SSE direction. The two groups of focal mechanisms reflect the differences observed in the visual inspection of the seismograms. Anyway, a common element of the focal mechanisms is the presence of SW dipping, ≈ NW-SE striking plane.
The second swarm occurred at the beginning of November 2011 and it is constituted by about 20 events with magnitude ranging between 1.5 and 2.5. The events are located close to the NW edge of AIF (Figure 4). Hypocenters are almost all between 9 and 12 km in depth. The focal mechanisms of three events with $M_L$ ~ 2.5 and depth ~ 12 km show strike-slip solutions with about NNE-SSW and WNW-ESE striking nodal plane (Figure 5). The surface projection of the sub-horizontal T- and P-axes aligned along NE-SW and NW-SE directions, respectively.

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# 2010 AND 2011 SEISMIC SWARMS

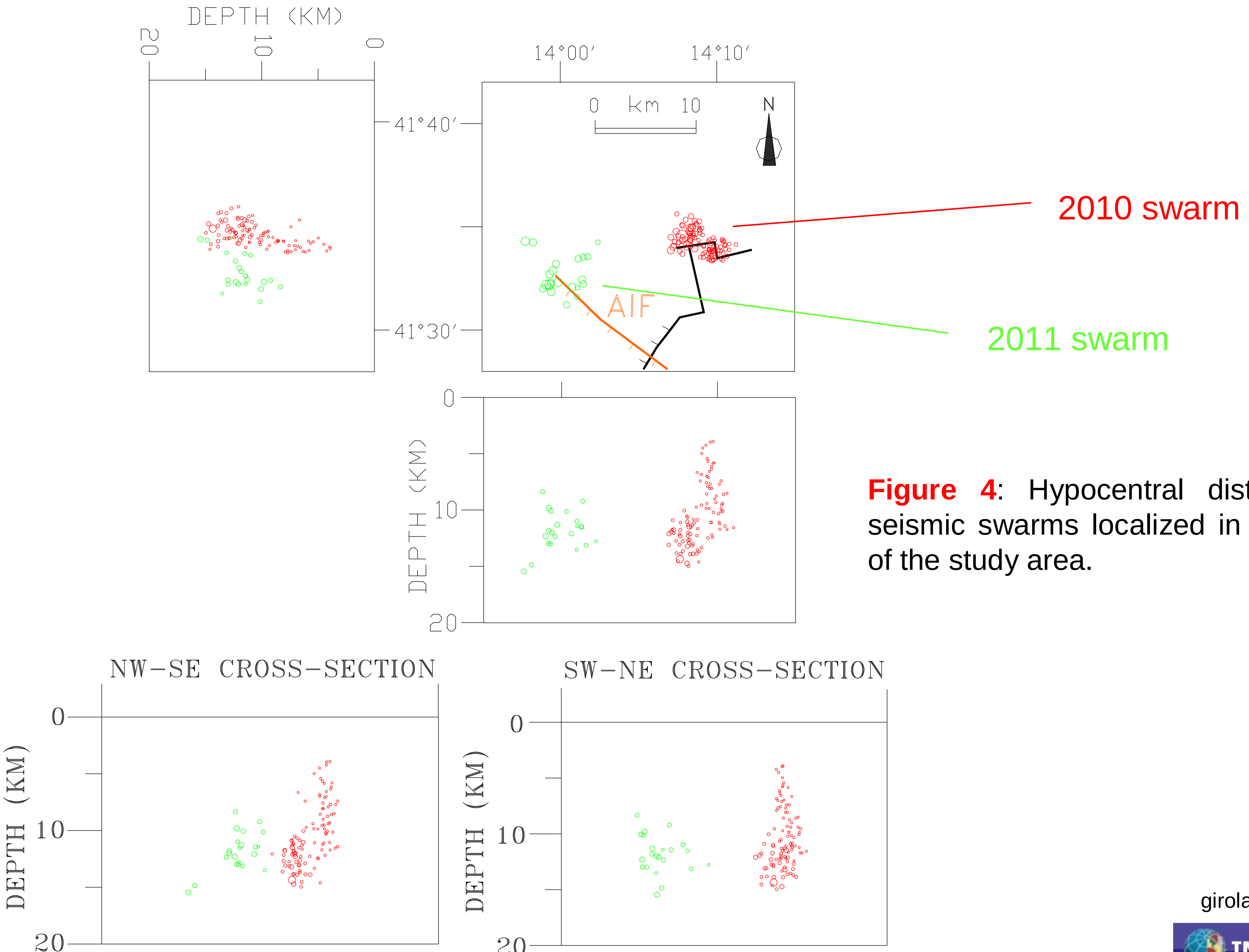


**Figure 4**: Hypocentral distribution of the seismic swarms localized in the west sector of the study area.

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# FOCAL MECHANISMS OF 2010 AND 2011 SEISMIC SWARMS

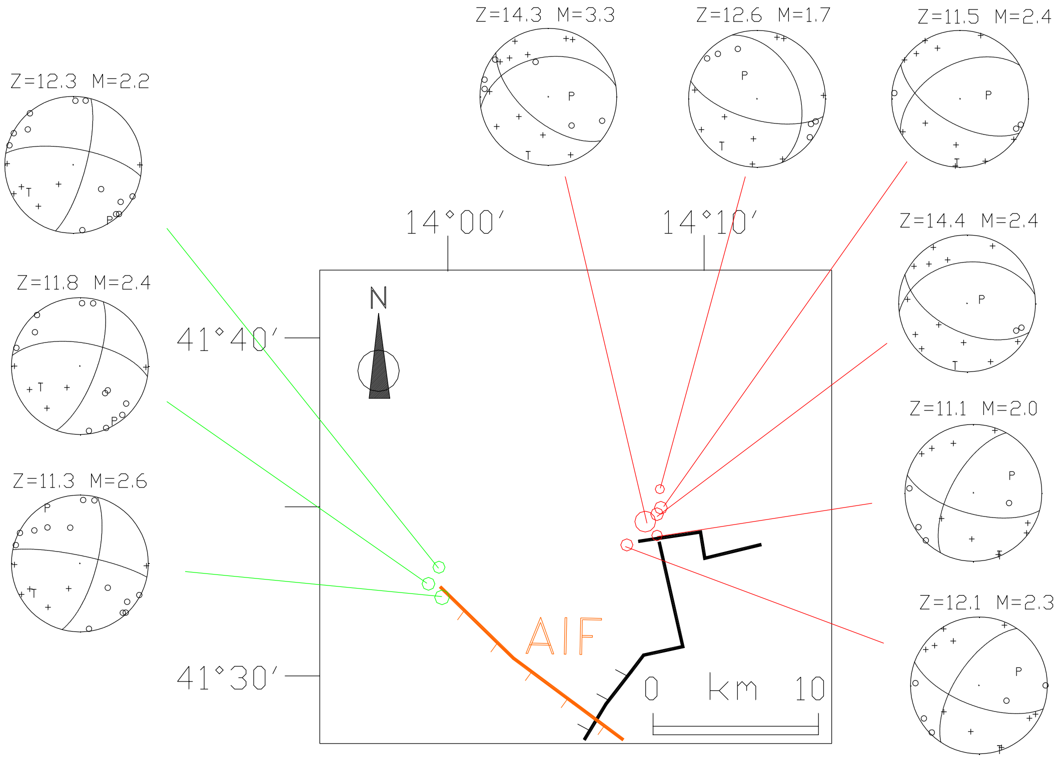
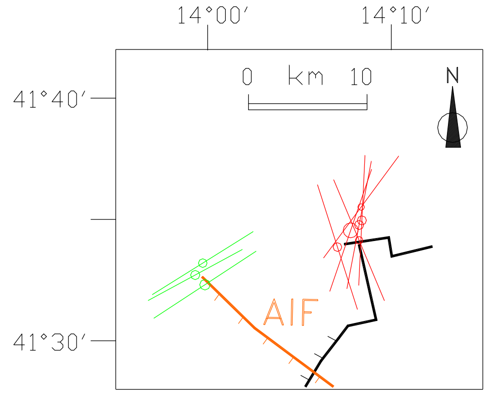
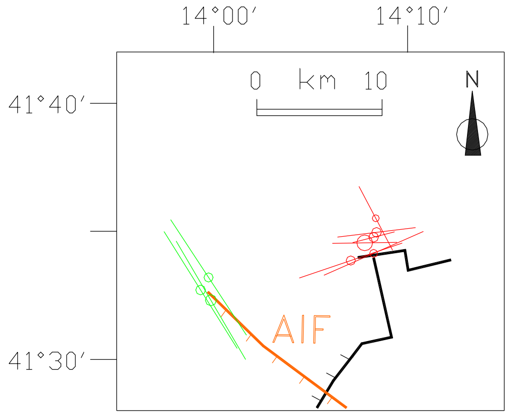



**Figure 5**: Fault plane solutions of the 2010 and 2011 seismic swarms and surface projection of the T- and P-axes (length of axes proportional to the cosine of the plunge).

## T-AXES DISTRIBUTION




## P-AXES DISTRIBUTION





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# 2014 AND 2018 SEISMIC SWARMS

With regard to the seismic swarms occurred in the east sector of the study area, the first one's took place on September 25, 2014 (Figure 6). This swarm was not triggered by a main event but started with a $M_L$=1.6 event. It lasted about 36 hours in which about 50 events, with magnitude between 1.5 and 2.8, occurred. The epicenters are concentrated in a circular area with a radius of about 2 km; hypocenters are almost all between 9 and 16 km in depth. The N-S hypocentral distribution shows a deepening towards South. The focal mechanisms of the few events with $M_L$>2.0 show solutions compatible with normal dip-slip solutions with T-axes in NNE-SSW direction (Figure 7).

Like the 2014 swarm, the September 2018 one's was not triggered by a main event. It is constituted by about 25 events with magnitude between 1.5 and 3.1. The most energetic event occurred on September 9 ($M_L$=3.1). Almost all events have depth between 14 and 16 km. The focal mechanisms show strike-slip solutions with about N-S and E-W striking planes. The T-axes are aligned along NE-SW direction.

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# 2014 AND 2018 SEISMIC SWARMS

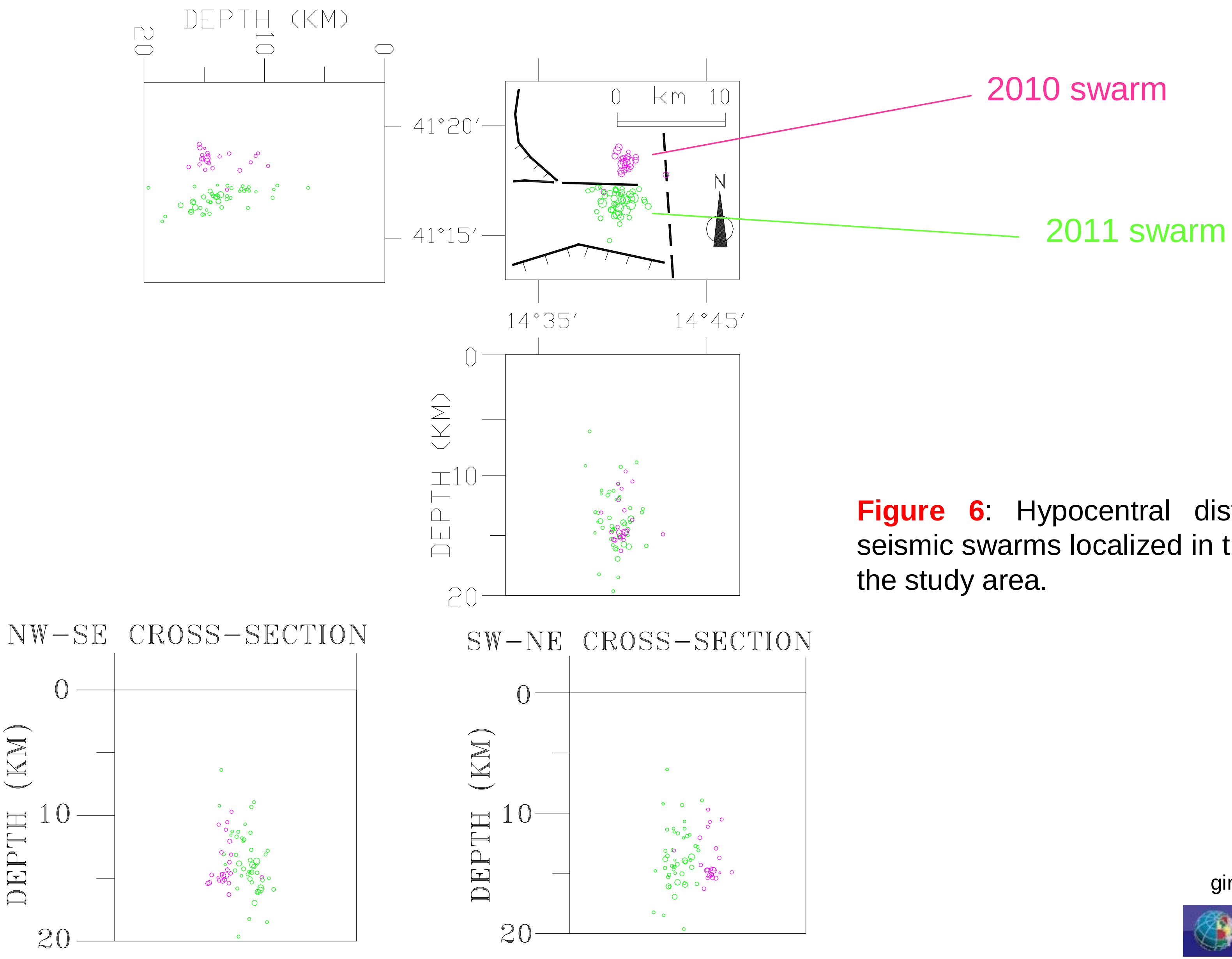


**Figure 6**: Hypocentral distribution of the seismic swarms localized in the east sector of the study area.

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# FOCAL MECHANISMS OF 2014 AND 2018 SEISMIC SWARMS

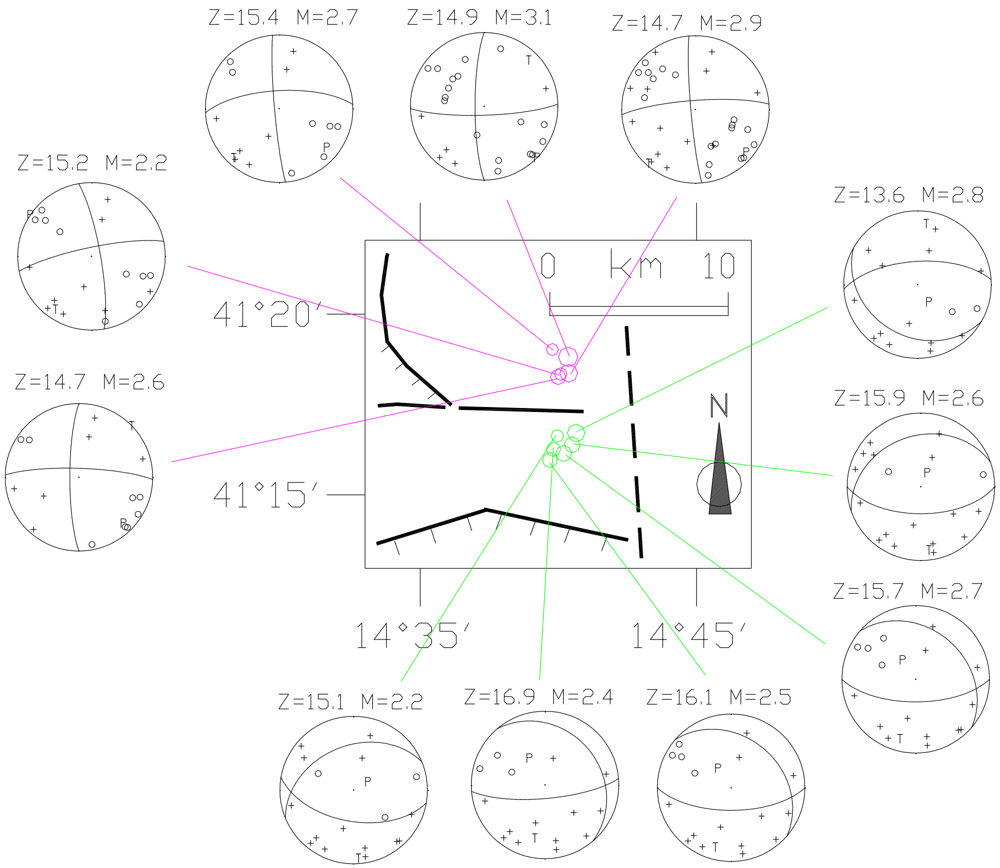
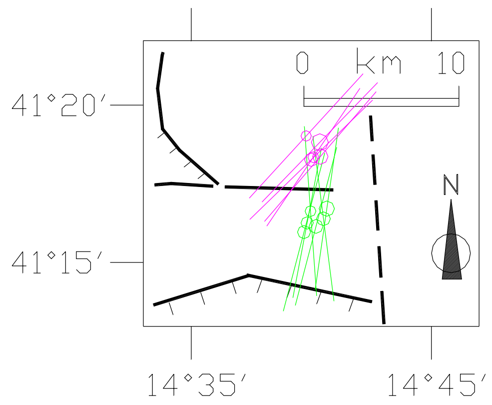
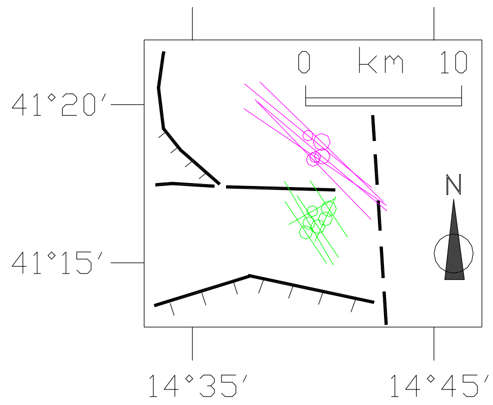



**Figure 7**: Fault plane solutions of the 2014 and 2018 seismic swarms and surface projection of the T- and P-axes (length of axes proportional to the cosine of the plunge).

## T-AXES DISTRIBUTION




## P-AXES DISTRIBUTION





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# Few Concluding Remarks

## Although this is work in progress:

The focal mechanisms of the single events located in the west sector of the study area have similar depth and fault plane solution to that the main shock of the 2013-2014 sequence. Previous study evidences that this sequence developed on a SW dipping, NW-SE striking plane. Considering the strike direction and dip of the plane of this sequence, those of AIF and the results of the focal mechanisms of the single events in this study, the southwest side of Matese Massif would seem to be characterized by SW dipping, NW-SE striking faults system.

The 2010 and 2011 seismic swarms, even if they are about 10 km away, have different characteristics. Their occurrence can be compatible with a high fractured medium in which the release of seismic energy occurs in a diffused way on fault segments with very small dimension.

The 2014 and 2018 swarms are very close to each other. Although the depth of the events is similar, the focal mechanisms show different kinematics that, however, is consistent with the large scale stress field acting in the Apennine Chain.

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