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Variable spatio-temporal clustering of microseismicity in the Eastern Hellenic Subduction Zone as possible indicator for fluid migration

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Spatio-temporal clustering of seismicity suggests that hypocenters of earthquakes do not occur randomly in space, time, and magnitude. Pore fluid pressure changes, as in case of earthquake swarms, and stress changes following a mainshock, as in case of aftershock sequences, are assumed as the main mechanisms causing spatio-temporal clustering of earthquakes. Seismic activity in subduction zones and spatio-temporal clustering of earthquakes is influenced by the release and migration of fluids in the incoming plate. This clustering is an indication for mutual triggering of seismic events. Thus, analysis of seismicity patterns in space and time can help to retrieve information on the underlying triggering mechanism including pore pressure changes due to migrating fluids.

At shallow depths (<50 km) fluids released by the subducting slab may explain the occurrence of earthquake doublets and multiplets showing swarm-like activity along and above the interplate seismogenic zone. At intermediate depths (from 70 to 300 km) the mechanisms generating earthquakes are still debated. The hypotheses of dehydration embrittlement, fluid related embrittlement, trasformational faulting, and plastic shear instabilities assume to a different extent the presence of fluids in the hypocenter regions.

We compare the spatio-temporal distribution of seismic clustering at shallow and intermediate depths to evaluate the presence of migrating fluids in the source region. The eastern segment of the Hellenic Subduction Zone is well suited for such a study because shallow and intermediate depth microseismicty with completeness magnitude around Ml2.0 has been observed by a dense temporary network during the EGELADOS seismic experiment (Oct. 2005 – Mar. 2007). At shallow depths we analyse 3 different regions of the forearc located in the outer (region 1), central (region 2), and inner part (region 3) of the Hellenic Forearc. We perform spatial clustering analysis through the detection of highly similar events which identify spatially clustered events of similar souce mechanism, and temporal clustering analysis by applying the Epidemic-Type-Aftershock-Sequences (ETAS) model to separate between internally triggered and externally forced events. Finally we perform autocorrelation analysis to investigate the spatio-temporal seismicity clustering and find evidence for mutual triggering of events. From similarity matrices we observe a decrease in the number of clusters of similar events from the outer toward the inner part of the sedimentary arc, and at intermediate depths (region 4), as well as a decreasing clustering in time. This is supported by the ETAS model which estimates 49%, 55%, 90% and 100% of independent events for the 4 regions, respectively. So we observe considerable temporal clustering in regions 1 and 2, minor clustering in region 3, and a strongly decreased level of mutual triggering in region 4 at intermediate depth. A similar trend is also visible in the autocorrelations which show spatio-temporal clustering in regions 1 and 2, and randomly distributed events in space and time in regions 3 and 4. We suggest that the different spatio-temporal patterns are influenced by the presence and migration of fluids on active faults. Thus, no migration of fluids on active faults is observed at intermediate depth.