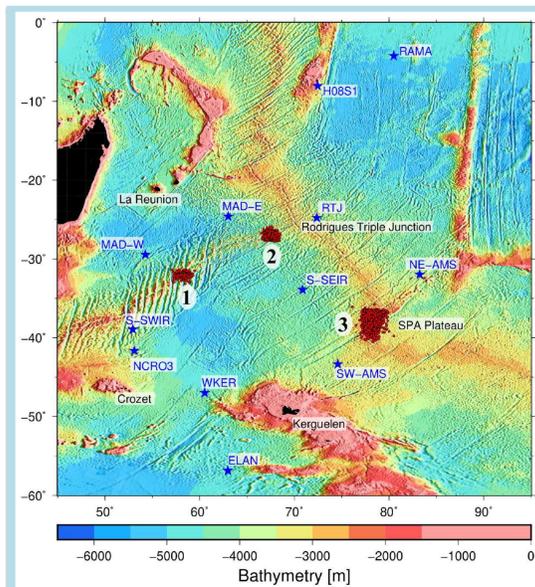


Hydroacoustic detections of seismic swarms along mid-ocean ridges in the Indian Ocean

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Seismic clusters of volcanic and tectonic events along mid-oceanic ridges are inherent to seafloor spreading. Land-based seismic networks lack the low-level seismicity related to such clusters due to the rapid attenuation of seismic waves in the solid Earth. However, regional studies using autonomous underwater hydrophones overcome this difficulty due to their sensitivity to low-frequency hydroacoustic waves, known as T-waves, that travel in the SOFAR (SOund Fixing And Ranging) channel over very long distances with little attenuation. Using hydroacoustic records from the OHASISBIO network and permanent stations of the CTBT Organization, we have examined few clusters (found in land-based catalogues) between the Atlantis II Fracture Zone and Rodrigues Triple Junction (RTJ) of the ultraslow spreading Southwest Indian Ridge (SWIR; ~14 mm/a), occurred in 2018 as well as near Saint-Paul and Amsterdam Islands (SPA plateau) of the intermediate spreading Southeast Indian Ridge (SEIR; ~60 mm/a), occurred in 2012. The hydroacoustic analysis of such clusters improves the number of detections by 10 to 50 fold and helps to understand the nature of spreading processes along these mid-oceanic ridges. Swarms along SWIR comprise short-duration and highly energetic impulsive events probably originating from the interaction of activated fresh lava flows with sea water. Such impulsive events are not observed in the swarm along SEIR.



Hydroacoustic Network

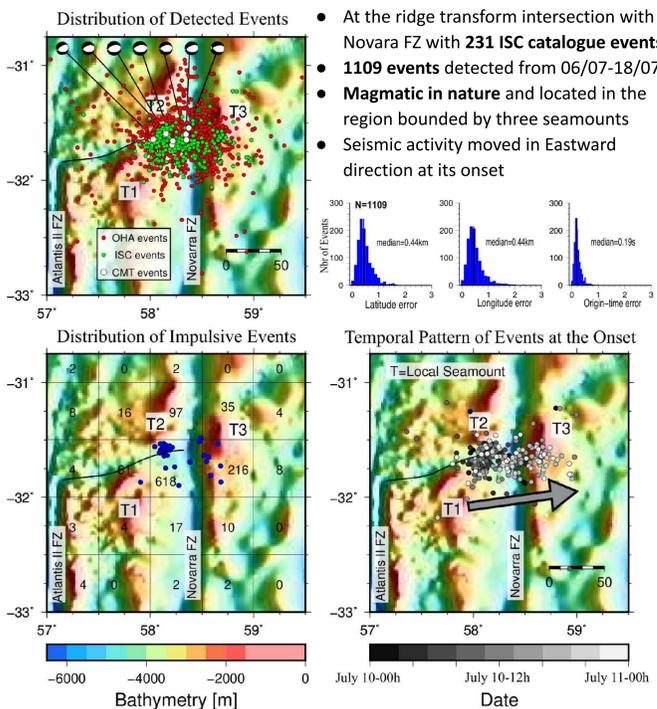
- To detect low-magnitude earthquake events, lacking from land-based catalogues, we examined hydroacoustic data (T-waves) recorded by autonomous hydrophones (AuHs) from the OHASISBIO network moored in the Southern Indian Ocean and permanent stations of CTBT Organization (H08S1 and H01W1).
- The OHASISBIO is a long-term hydroacoustic program for monitoring the seismic activity of the three Indian spreading ridges, and vocal activity of large marine mammals in the Southern Indian Ocean, and the oceanic low-frequency noise.
- Detected and analyzed the hydroacoustic events corresponding to two swarms in 2018 on SWIR: swarm-1 (near Novara FZ), swarm-2 (near RTJ), and a swarm in 2012 on SEIR: swarm-3 (near SPA plateau).

Method

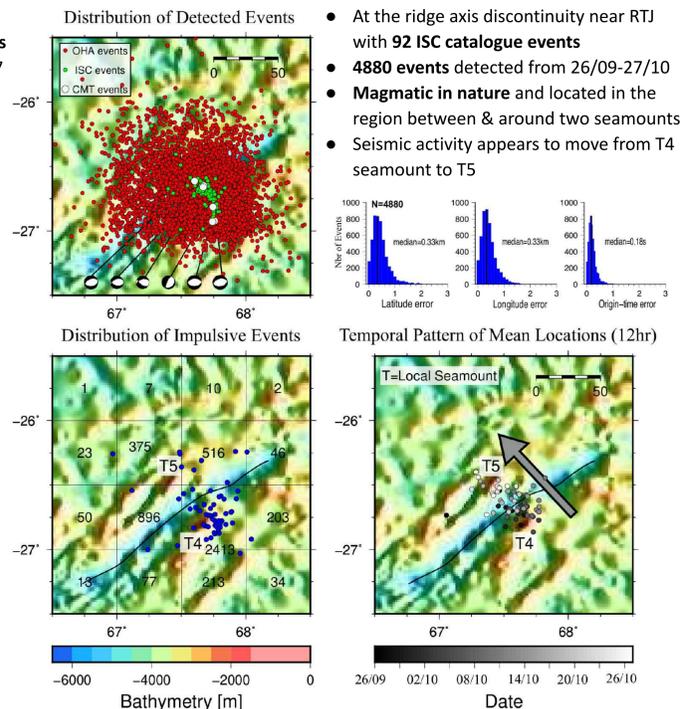
- Search events in land-based catalogues (ISC, GCMT)
- Pick T-wave arrival times at maximum energy in spectrograms
- Build up catalogues of hydroacoustic detections with the events' origin time, location and Source Level (acoustic magnitude)
- Repick and re-analyze the events to improve the errors in location and origin time by ~10 fold
- Understand the nature of dense seismic clusters by observing their spatial and temporal distributions

Seismic Clusters on SWIR

Swarm-1 near Novara FZ

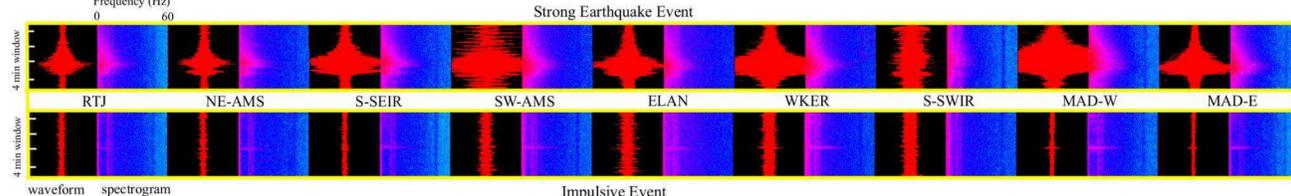
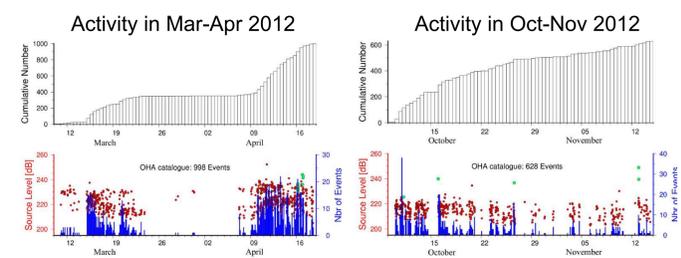
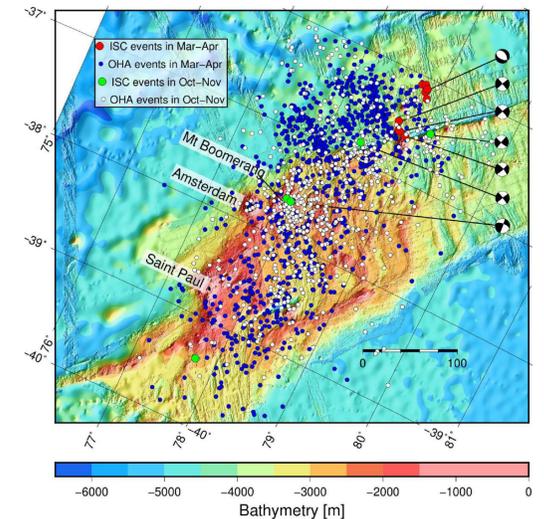


Swarm-2 near RTJ



Seismic Cluster on SEIR

Swarm-3 near SPA plateau



- Impulsive events are energetic and of short duration (<10 sec) compared with earthquakes, and located on slopes of seamounts near the ridge axis
- May represent thermal explosions resulting from direct magma supplies on the seafloor of active volcanoes

- Occurred in two intervals; March-April (998 events) and October-November (628 events) in 2012 near SPA plateau
- Shows wider spatial-distribution compared with Swarm-1 and Swarm-2
- No observations of impulsive events
- In November, activity is more clustered near Boomerang Seamount
- Quiet period between two temporal clusters in March-April
- Few temporal episodes of seismic activity in October-November

Conclusions

- Swarm-1 and Swarm-2 in 2018 on SWIR are magmatic in nature:
 - Presence of highly energetic impulsive events
 - Initial propagation and clustering of events near local seamounts
 - Absence of clear tectonic mainshock-aftershock sequence
- Swarm-3 in 2012 on SEIR
 - Wider and episodic distribution of events over SPA plateau
 - Prospective: Link complex nature of the seismic activity with the geodynamic context of SPA plateau