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Distinguishing between Medicanes and common seasonal storms using microseism

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Microseism, the most continuous seismic signal on the Earth generated by the interaction between the hydrosphere, the atmosphere, and the solid Earth, is a useful tool for acquiring information about climate change. Indeed, several authors dealt with the relationship microseism-sea state and microseism-cyclonic activity, considering in particular tropical cyclones, hurricanes, typhoons, and recently Medicanes (small-scale tropical cyclones that occur in the Mediterranean Sea). In this study, we analyze, from a seismic point of view, several meteorological events that occurred in the Mediterranean Sea during the period November 2011 - February 2023. In particular, we consider 9 Medicanes and 4 more common storms. Despite the marked differences between them, each of these events caused heavy rainfall, strong wind gusts, violent storm surges with significant wave heights usually greater than 3 meters, and damage along the exposed coast. Occasionally, these events caused deaths and injuries. In this work, we analyzed the seismic signal recorded by 104 seismic stations, installed along the Italian, Maltese, Greek, and France coastal areas, and 15 seismic stations, installed in the Etnean area used only to perform array analysis. We deal with the relationships between the considered meteorological events and the features of microseism in terms of spectral content, space-time variation of the amplitude, and source locations tracked using two different methods (a grid search approach based on seismic amplitude decay and array techniques). By comparing the positions of the microseism sources, obtained from our analysis, with the areas of significant storm surges, retrieved from hindcast data, we observe that the microseism locations are in agreement with the actual locations of the storm surges for 10 out of 12 events analyzed (two Medicanes present very low intensity in terms of meteorological parameters and the microseism amplitude does not show significant variations during these two events). In addition, we also carried out two analyses that allowed us to obtain

both the seismic signature of these events, by using a method that exploits the coherence of continuous seismic noise, and their strength from a seismic point of view, called Microseism Reduced Amplitude. By integrating the results obtained from these two methods, we can “seismically” distinguish Medicanes and common storms. Consequently, we demonstrate the possibility of creating a novel monitoring system for Mediterranean meteorological events by incorporating microseism information alongside with other techniques (e.g. wave buoy, wave gauge, and High-Frequency coastal radar) commonly used for studying and monitoring meteorological phenomena. In addition, since the seismometers were among the first geophysical instruments installed, it is possible to digitize old seismograms and examine historical data shedding new light on extreme weather events in a climate change scenario.