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# Underwater acoustic evidences of the 2011 autumnal floods in the Ligurian region

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In the northernmost sector of the western Mediterranean Sea the Ligurian Sea is a deep basin showing peculiar hydrodynamic and meteo-oceanographic features. The region is characterized by steep Alpine and Apennine southward slopes with the watershed at few tens of kilometers at the most far from the coast. This geological complexity and a particular atmospheric circulation coupled to the fact that the Ligurian coasts are among the most urbanized and industrialized along the entire Mediterranean coastline, determine a high flood hazard, especially in late summer – early autumn when the Ligurian Sea is still warm and strong perturbations reach the basin from the south.
Over the past 40 years there have been about 40 major flash floods (about one flash flood per year) associated with severe damages and loss of human lives. The latest flash flood event occurred in Autumn 2011, which is the subject matter of this study. Late summer 2011 was dominated, as usual in the recent decades, by a prolongation of the hot season with clear skies and temperatures above climatology so that ocean had sufficient time to store a large amount of heat capable of emitting a strong evaporation in the air layers above and, through interactions with the cool and wet near surface atmospheric layers, to give rise to powerful convection.
Such type of events can be partially forecasted by atmospheric models, monitored at a large scale through remote sensing using radars and satellites, observed in their real time evolution by land hydro-meteorological stations. Among other observational systems, underwater acoustics can contribute to the monitoring of these phenomena through the use of off-shore deployed sensors that collect and process underwater noise in the ocean.
Indeed, ambient noise in the ocean is a combination of natural and anthropogenic sounds that include breaking waves, precipitation, vocalizations of marine mammals, ship noise and sonar. Since 2009, a Passive Aquatic Listener (PAL), i.e. an autonomous underwater acoustic recording and processing instruments, has been deployed on an off-shore observatory moored at the center of the Ligurian basin, 80 km far from the coast, almost at the boundary of the coverage of the national meteorological radar network. The instrument, whose “catchment basin” is proportional to the deployment depth, is able to collect, detect, and quantify precipitation over sea in real time, thus, it can be potentially used to integrate the other observing tools and to provide an early warning of the incoming perturbation from the sea to the coast.
PAL was able to detect precipitation over the ocean and to quantify the rainfall rate with only minor differences with respect to a co-located pluviometer hosted on a surface buoy for the flash flood-inducing storms on October 25 and November 4, 2011. The acoustic evidences of these types of heavy convective systems have clear distinctive features with respect to the background noise due to other natural or man-made sources so that these characteristics could be exploited to monitor and precisely estimate the rainfall at the surface.