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Development of algorithms for tsunami detection by High Frequency Radar based on modeling tsunami case studies in the Mediterranean Sea

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Where coastal tsunami hazard is governed by near-field sources, Submarine Mass Failures (SMFs) or earthquakes, tsunami propagation times may be too small for a detection based on deep or shallow water buoys. To offer sufficient warning time, it has been proposed by others to implement early warning systems relying on High Frequency Surface Wave Radar (HFSWR) remote sensing, that has a dense spatial coverage far offshore.
A new HFSWR, referred to as STRADIVARIUS, has been recently deployed by Diginext Inc. to cover the “Golfe du Lion” (GDL) in the Western Mediterranean Sea. This radar, which operates at 4.5 MHz, uses a proprietary phase coding technology that allows detection up to 300 km in a bistatic configuration (with a baseline of about 100 km). Although the primary purpose of the radar is vessel detection in relation to homeland security, it can also be used for ocean current monitoring.
The current caused by an arriving tsunami will shift the Bragg frequency by a value proportional to a component of its velocity, which can be easily obtained from the Doppler spectrum of the HFSWR signal.
Using state of the art tsunami generation and propagation models, we modeled tsunami case studies in the western Mediterranean basin (both seismic and SMFs) and simulated the HFSWR backscattered signal that would be detected for the entire GDL and beyond. Based on simulated HFSWR signal, we developed two types of tsunami detection algorithms:
(i) one based on standard Doppler spectra, for which we found that to be detectable within the environmental and background current noises, the Doppler shift requires tsunami currents to be at least 10-15 cm/s, which typically only occurs on the continental shelf in fairly shallow water;
(ii) to allow earlier detection, a second algorithm computes correlations of the HFSWR signals at two distant locations, shifted in time by the tsunami propagation time between these locations (easily computed based on bathymetry). We found that this second method allowed detection for currents as low as 5 cm/s, i.e. in deeper water, beyond the shelf and further away from the coast, thus allowing an earlier detection.