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Realistic simulations of tsunami detection by High-Frequency Radar in British Columbia, Canada

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A promising technique for long-range detection of tsunamis is the use of shore-based High Frequency (HF) surface wave radars, also simply referred to as oceanographic radars. These over-the-horizon radars are routinely used for real-time monitoring of ocean surface currents up to a 70-80 km range, based on the Doppler shift the latter cause in ocean waves at the radar Bragg frequency. Quite recently there has been convincing numerical and experimental evidence that oceanographic radars can also be used to detect tsunami-induced surface currents. However, these need to be at least 0.15-0.20 m/s to be detectable, when considering environmental noise and background currents (from tide and mesoscale circulation). This limits the actual detection of tsunami currents to the near range, that is essentially to the continental shelf over which tsunami currents become strong enough; in many cases this does not leave enough time to issue an efficient warning, unless there is a wide shelf.

In recent work, some of the authors have proposed a detection algorithm that does not have this limitation and can detect an approaching tsunami in deeper water, beyond the continental shelf. This algorithm does not require "inverting" currents, but instead is based on spatial correlations of the raw signals recorded at two distant radar cells along the same wave ray, shifted in time by the tsunami propagation time along the ray. An elevated correlation would indicate the presence of a tsunami. We apply this algorithm to a realistic tsunami case study conducted, using a state-of-the-art long wave model, for sources (both seismic and landslide) and bathymetry off of Vancouver Island, BC. The propagation time between different radar cells is calculated with a Geometrical Optics approach using the Eikonal equation. This requires first determining wave rays' intersections with radar cells and computing a connectivity matrix between the latter. A model simulating the radar backscattered signal in space and time as a function of the simulated tsunami currents is then applied for the characteristics of the WERA HF radar deployed by ONC near Toffino, BC, on the Pacific Ocean side of the Island. Numerical experiments confirm that the main tsunami wave front can be traced in real-time by following the maxima of the time shifted cell-cell correlations.