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Integration of WERA Ocean Radar into Tsunami Early Warning Systems

Anna Dzvonkovskaya (1), Thomas Helzel (1), Matthias Kniephoff (1), Leif Petersen (1), and Bernd Weber (2)
(1) Helzel Messtechnik GmbH, Carl-Benz-Str.9, 24568 Kaltenkirchen, Germany (dzvonkovskaya@helzel.com), (2) gempa GmbH, Telegrafenberg, 14473 Potsdam, Germany (weber@gempa.de)

High-frequency (HF) ocean radars give a unique capability to deliver simultaneous wide area measurements of ocean surface current fields and sea state parameters far beyond the horizon. The WERA® ocean radar system is a shore-based remote sensing system to monitor ocean surface in near real-time and at all-weather conditions up to 300 km offshore. Tsunami induced surface currents cause increasing orbital velocities comparing to normal oceanographic situation and affect the measured radar spectra. The theoretical approach about tsunami influence on radar spectra showed that a tsunami wave train generates a specific unusual pattern in the HF radar spectra. While the tsunami wave is approaching the beach, the surface current pattern changes slightly in deep water and significantly in the shelf area as it was shown in theoretical considerations and later proved during the 2011 Japan tsunami. These observed tsunami signatures showed that the velocity of tsunami currents depended on a tsunami wave height and bathymetry. The HF ocean radar doesn't measure the approaching wave height of a tsunami; however, it can resolve the surface current velocity signature, which is generated when tsunami reaches the shelf edge. This strong change of the surface current can be detected by a phased-array WERA system in real-time; thus the WERA ocean radar is a valuable tool to support Tsunami Early Warning Systems (TEWS). Based on real tsunami measurements, requirements for the integration of ocean radar systems into TEWS are already defined. The requirements include a high range resolution, a narrow beam directivity of phased-array antennas and an accelerated data update mode to provide a possibility of offshore tsunami detection in real-time.
The developed software package allows reconstructing an ocean surface current map of the area observed by HF radar based on the radar power spectrum processing. This fact gives an opportunity to issue an automated tsunami identification message by the WERA radars to TEWS. The radar measurements can be used to confirm a pre-warning and raise a tsunami alert. The output data of WERA processing software can be easily integrated into existing TEWS due to flexible data format, fast update rate and quality control of measurements. The archived radar data can be used for further hazard analysis and research purposes.
The newly launched Tsunami Warning Center in Oman is one of the most sophisticated tsunami warning system world-wide applying a mix of well proven state-of-the-art subsystems. It allows the acquisition of data from many different sensor systems including seismic stations, GNSS, tide gauges, and WERA ocean radars in one acquisition system providing access to all sensor data via a common interface. The TEWS in Oman also integrates measurements of a modern network of HF ocean radars to verify tsunami simulations, which give additional scenario quality information and confirmation to the decision support.