WERA
Ocean Remote Sensing

Significant Surface Current Velocity Changes measured by the Ocean High-Frequency Radar after the great 2011 Japan Tsunami

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The ocean high-frequency (HF) radar, which is based on electromagnetic wave propagation along the salty and good conducting ocean surface, provides a unique capability for continuously monitoring large areas of ocean. This type of radar is usually operated at a radio frequency between 3 and 30 MHz to provide a grid coverage of ocean surface that could extend more than 250 km off the coast. These large ranges are of high interest for many interesting applications such as research in oceanography, vessel detection and tracking, search and rescue, transport and distribution of pollutants, etc. These radar systems recently became an operational tool for coastal monitoring worldwide.

The HF radar system WERA (**W**av**E** **RA**dar) was originally designed at the University of Hamburg; nowadays it is completely manufactured by the Helzel Messtechnik company in Germany. The WERA system is operated as a low-power ocean radar providing simultaneous measurements and mapping of surface current velocity and direction, wind parameters, ocean wave height and directional spectrum. The WERA system is based on a modular design that can be easily installed at the coast and adapted to the requirements of an actual application.

One of the WERA systems was in operation on March 11, 2011, when the Great 2011 Japan tsunami waves hit the Chilean coast after 22 hours of propagation time throughout the Pacific Ocean. The radar was located near Rumena, Chile, and supplied ocean surface monitoring in that region. The radar measurements were recording during several hours while tsunami wave train was arriving at the coast. Bragg-resonant backscattering by ocean waves with a half of the electromagnetic radar wavelength allows measuring the ocean surface current velocity using space-time processing. The ocean surface current field changes due to a tsunami event were evaluated using the measured HF radar backscatter spectra. The unique chance to observe a natural tsunami event by means of WERA radar showed that such radars are capable to measure tsunami surface current velocity with a resolution of a few cm/s. Significant deviations in ocean current measurements were observed by the radar system at distances up to 40 km off the coast. It was also observed that as soon as the tsunami waves were moving into shallower water, the surface velocity was increasing. To identify a tsunami induced signature in a measured current field, a moving-average filtering technique to remove regional surface currents was used. After applying this technique the unique tsunami wave train was clearly seen in radar measurements. Furthermore, it was compared with water level measurements by the tide gauge located 50 km to the south from the radar site. The tsunami wave periodicity was estimated for measurement data. It showed agreement estimating two tsunami wave periods of 14 min and 32 min for both tide gauge and radar measurements.

Installed along the coastal regions at tsunami risk the ocean HF radars can contribute to tsunami early warning systems. If these radar systems would have been already installed at the coast, it is just an additional software package to enable real-time support for tsunami detection and its monitoring.

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