Coastal Radar "WERA", a tool for hazards management

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Abstract
At the French coast near Brest a pair of WERA ocean radar stations are operational since 2006. The range of these systems is about 120 km with a spatial resolution of 1.5 km and a temporal resolution of 3 measurements per hour. These two shore based stations cover an ocean area of about 10,000 km^2. The normal purpose of these systems is to provide actual maps of ocean surface currents and significant wave height for the Vessel Traffic Services and for Oceanographic research.

This paper shows how the provided ocean current and wave data are used to improve predictions of drifting objects in case of an accident. Presently, search and rescue tools are based on hydro-dynamical and atmospheric models to provide hindcast and forecast situations. Even if these oceanic numerical models are efficient to produce instantaneous maps of currents, the accuracy of derived Lagrangian trajectories is not sufficient for search and rescue purposes. Results of the SAR-DRIFT project show the significant improvement of the drift simulation, when using real-time current data provided by radar systems instead of using results from numerical models. This improved quality of the drift prediction can be very useful for Search and Rescue applications. In addition, this drift prediction can be used for the forecast of drifting oil spill or containers in case of an accident to make the management of the pollution more effective. Furthermore this tool can be used in case of oil pollution for backtracking any detected pollution to identify the origin and time of this pollution. This can help to identify the polluter.

1 Introduction of the WERA System

The WERA system (WavE RAdar) is a shore based remote sensing system using the over the horizon radar technology to monitor ocean surface currents, waves and wind direction [Gurgel, 2000]. This long range, high resolution monitoring system operates with radio frequencies between 5 and 50 MHz. A vertical polarized electromagnetic wave is coupled to the conductive ocean surface and follows the curvature of the earth. The rough ocean surface interacts with the radio wave and due to the Bragg effect back-scattered signals can be detected from ranges of more than 200 km. This effect was first described in 1955 by Crombie [Crombie, 1955] and the first radar system using that effect was developed by Barrick et al [Barrick, 1977] at NOAA in 1977.

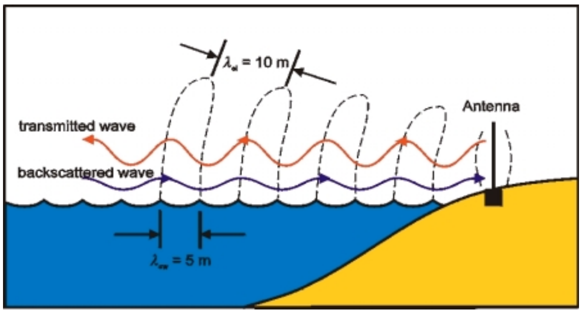

Figure 1: Principle of ocean backscatter due to the Bragg-effect

The Bragg effect describes the coupling of the electromagnetic wave with the ocean wave field. To fulfil the Bragg conditions the electromagnetic wave length needs to have twice the wavelength as the ocean wave, e.g. for a 30 MHz radar signal with Lambda 10 m, the corresponding ocean wave is 5 m. Reflections from waves that fulfil this condition will generate a dominant signature in the received signal spectrum due to in-phase summation of amplitudes.

2 Quality of Ocean Current Maps

World wide more that 40 systems are installed and numerous validation studies were carried out. In this paper we present data from an extreme dynamic ocean area off the French coast near Brest. The data are provided for the "Vigicote" project with a pair of 16 channel medium range WERA systems owned by SHOM (Oceanographical and Hydrographical Service of the French Navy). The radar operates at a centre frequency of 12.38 MHz with a bandwidth of 100 kHz (range cell size of 1.5 km) at 30 Watts rf-power.

Over a period of more than 12 months a study was carried out to validate the quality of the provided data by means of a comparison with buoy data [Cochin, 2006]. Furthermore the reliability was qualified by comparing the users demands for data availability with the resulting data.

The accuracy and reliability was studied by SHOM using an ADCP and a Wave Rider buoy for ground truthing [Helzel, 2009]. Both instruments were located about 30 km off the coast. Fig. 2 shows a typical current map. The comparison between the measurement data of the ADCP and the WERA system is displayed in Fig. 3.

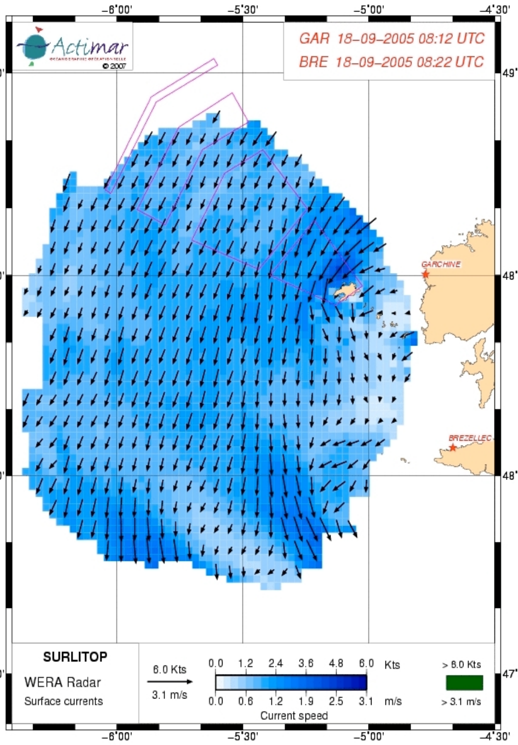

Figure 2. Surface current map with averaging time of 12 min and 1.5 km range cell size

The corresponding correlation between the ADCP and WERA data, displayed in figure, shows a correlation factor of 0.947. This excellent agreement proves the accuracy of the WERA system to measure ocean surface currents.

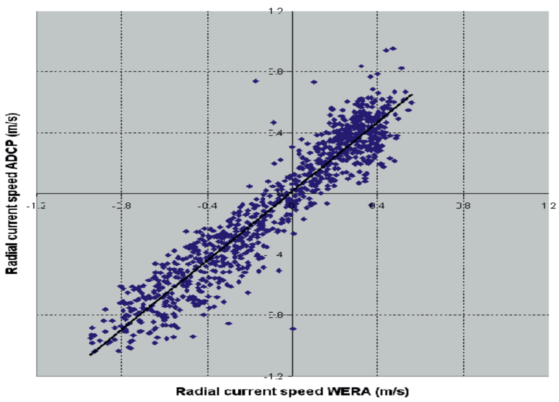

Figure 3. Comparison of radial current velocity measured with WERA and ADCP: r = 0.947

3 Applications of Drift Predictions

To test this technique for SAR applications, surface drifters were launched and tracked. The drift prediction for this simulated "man-over-board" situation were carried out by means of a 2D tidal model typically used for the SAR operations and by a drift prediction based on the ocean currents measured by the WERA systems.

The results clearly show that the drift prediction driven with the measured current data can keep close to the real drift trajectory much longer than the model driven prediction, see Fig. 4. This method would significantly increase the chance to find a lost person or drifting objects.

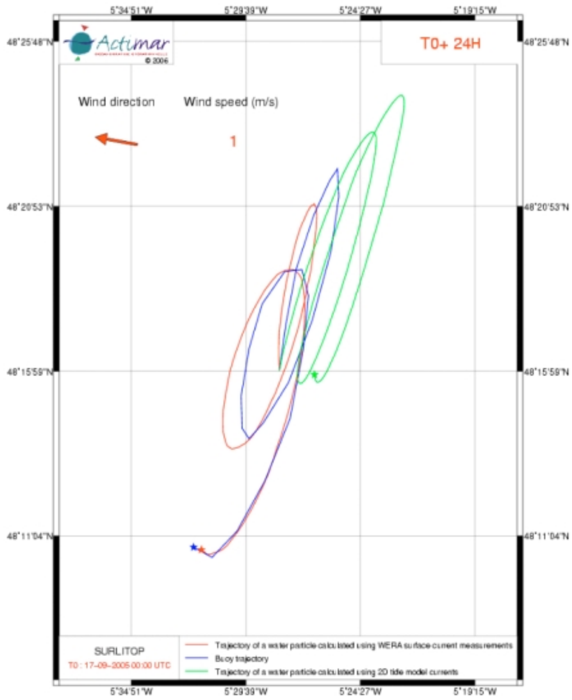

Figure 4. Drifting "person", real 24 hour trajectory plotted in blue, prediction based on 2D tidal model in green and prediction based on measured data in red

In combination with a stochastical estimation the drift of an oil accident can be predicted as well. A simulation of an accident near the French coast is displayed in Fig. 5.

In case of a smaller oil pollution, e.g. caused by illegal tank flushing, an observed oil slick can be "backtracked". This may enable the coast guard to identify the polluter.

4 In-situ experiments for SAR operations

In connection with the SAR-Drift project [Røang, 2009], two in-situ experiments were carried out in Norway and France with drifting objects. With the help of the Navy in both cases, models of containers and a real container were left to drift in the area of coverage of HF-radars. The current-induced drifts of the objects were first predicted using forecast models, and then re-computed using currents from the radar measurements. All the results show a very good agreement between the observed trajectories and the radar-computed ones, while the predicted drifts rapidly diverge from the real trajectories. Figure 6 shows the results for the real container in the Iroise sea. This emphasizes the importance of HF radars for search and rescue operations, especially in complex areas. After an accident, a much accurate estimation of the location of an object or body can be obtained using HF radar, compared to what can be done with forecast models.

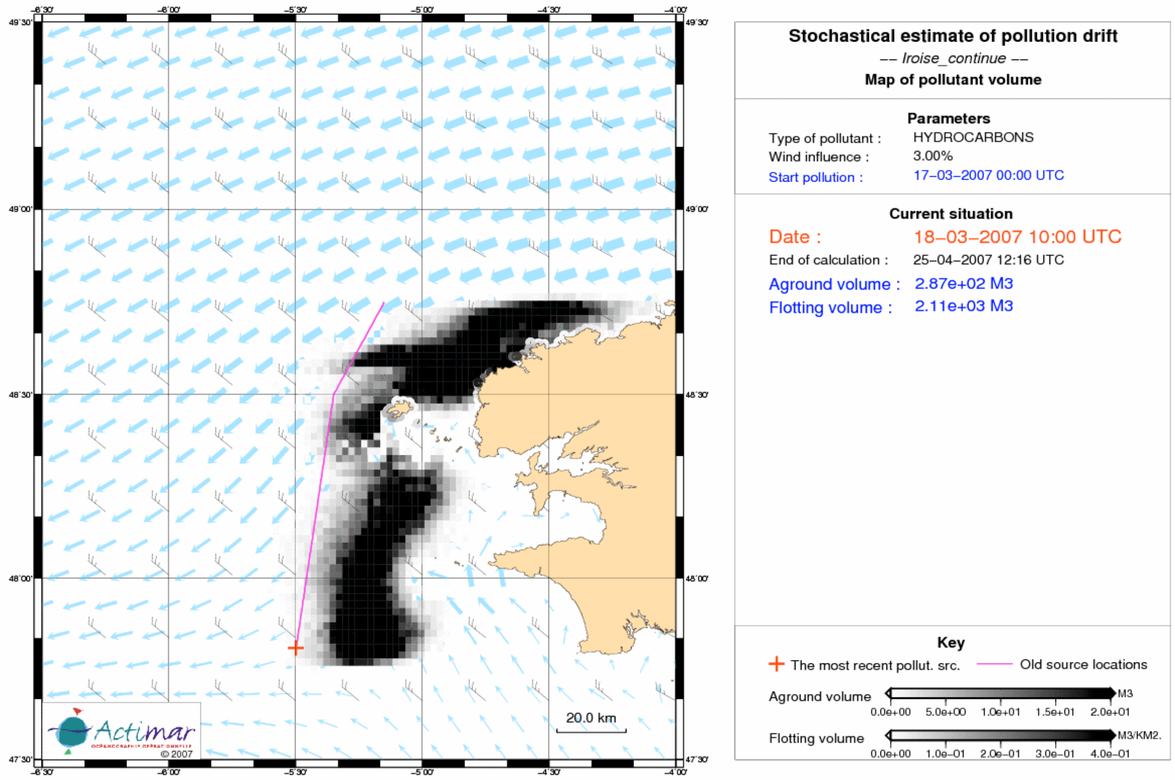

Figure 5. Drifting oil pollution with estimated volumes that are already aground, on-shore or still drifting.

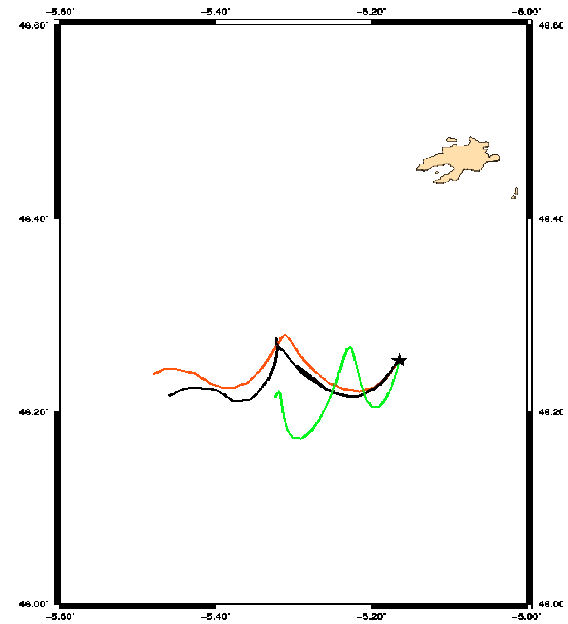

Figure 6 - Drift of a container in the Iroise Sea. The drift is computed using radar measurements and modelled currents. The black line indicates the real trajectory, green based on a model and red based on radar data.

5 Conclusions

The quality of the ocean radar data a valuable contribution to improve the quality of numerical models that are used for current drift predictions. Results from the experiments show the significant improvement of the drift simulation, if real-time current data are used that are provided by the radar systems. This can be a very valuable tool for Search and Rescue applications. In addition this drift prediction can be used for the forecast of drifting oil spill or containers in case of an accident to make the management of the pollution more effective. Furthermore this tool can be used in case of the detection of smaller oil slick for backtracking this slick to identify the origin and time of this pollution. This can help to identify the polluter.

6 References

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