SATELLITE OIL SPILL DETECTION AND MONITORING IN THE OPTICAL RANGE

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ABSTRACT

Getting oil from the well to the refinery and from there to the consumers requires complex transportation and storage systems. Millions of barrels of oil are transported every day in tankers, pipelines and trucks. Unfortunately, not all the oil loaded into tankers every day in production areas is delivered to the end users: some is lost in accidental spills which have dramatic effect on marine ecosystems. But these man-made disasters represent a little percentage of the total input of oil from ships into the oceans. The biggest contribution to oceans oil pollution in fact is related to operational discharge from tankers (i.e. oil dumped during cleaning operations) that spread in the sea the equivalent of one full-tanker disaster every weak [1]. In order to reduce the environmental impact of such a kind of hazards, timely detection and continuously updated information are fundamental [2].

Satellite remote sensing can give a significant contribution in such a direction. Nowadays, SAR (Synthetic Aperture Radar) technology has been recognized as the most efficient for oil spill detection and description, thanks to the high spatial resolution and all-time/weather capability of the present operational sensors [3]. Anyway, the actual SARs revisiting time does not allow a profitable use of these instruments for a rapid detection and near real-time monitoring of these phenomena at global scale. The present SAR revisiting time will be improved when COSMO-Skymed Italian dual-mission, will be fully deployed (expected for the 2010), and a SAR constellation of four satellites will guarantee a refresh time until 12 hours [2]. But several open questions regarding costs and global delivery policy of such data, might limit their use in an operational context. Moreover, they present some limitations in detecting oil spill with high level of reliability related to the influence of wind speed in acquiring signal and the presence of natural films or rain cells that give an oil spill similar signal (*look-*

alikes) [3]. For the above mentioned reasons, passive optical sensors, on board meteorological satellites, thanks to their high temporal resolution (from a few hours to 15 minutes, depending on the characteristics of the platform/sensor), may represent, at this moment, a suitable SAR alternative and, in the next future, an useful complement for oil spill detection and monitoring.

Up to now, some techniques have been proposed for oil spill monitoring using satellite data acquired in the optical band [4]-[9] but, on the other hand, reliable satellite methods for automatic detection of oil spill in near real time are still currently missing. They, in fact, can localize the presence of an oil spill only after an alert and require the presence of a qualified operator. In particular, the oil spill detection techniques in the Middle (MIR) and Thermal (TIR) Infrared spectral regions exploit the different behaviour of oil and water in terms of thermal inertia [4][5][9]. Oil thermal inertia, in fact, is lower than sea water one, and so oil polluted areas usually show higher brightness temperature than sea water in TIR images collected in daytime, the opposite during the night [10][11]. Spurious effects, mainly due to local and environmental conditions, might anyway reduce the sensitivity of the identification. Visible (VIS) and near infrared (NIR) regions of the electromagnetic spectrum can also be used to detect the presence of an oil layer on sea surface, appearing less or more reflecting than the sea water [7][10][11].

Starting from these considerations, an innovative automatic technique for near real time oil spill detection and monitoring has been recently proposed [12]-[14]. It is based on the general RST - Robust Satellite Techniques, [15][16] - approach, originally named RAT - Robust AVHRR Technique [17] - which exploits long-term multi-temporal satellite records to obtain a former characterization of the measured signal, in term of expected value and natural variability, providing a further identification of signal anomalies by an automatic, unsupervised change detection step. Results obtained by using TIR data acquired by NOAA-AVHRR (National Oceanographic and Atmospheric Administration - Advanced Very High Resolution Radiometer) in channels 4 and 5 (respectively 10.3-11.3 μm and 11.4-12.4 μm), in different geographic areas and observational conditions demonstrate, also for comparison with traditionally techniques, excellent detection capabilities both in terms of sensitivity (to the presence even of very thin/old oil films) and reliability (up to zero occurrence of false alarms). An example is shown in Figure 1 where the results of application of a traditional fix threshold technique ([5], Fig.1a) are compared with the ones achieved by the proposed, RST-based methodology (Fig.1b), while analyzing one image of "Persian Gulf War" oil spill occurred in 1991. It could be noted that the application of traditional techniques (Fig.1a) on the event image results ineffective in discriminating oil spills areas because large unaffected sea zones, mainly caused by local warming phenomena, are also detected as polluted. Such a problem does not affect the RST approach (Fig.1b): only oil spill affected pixels are intercepted over the whole scene [14]. Results of a further improvement of the proposed approach, aimed to increase its sensitivity towards low intensity oil spill events (small size and/or the thickness of the slick), will be shown and discussed in this paper.

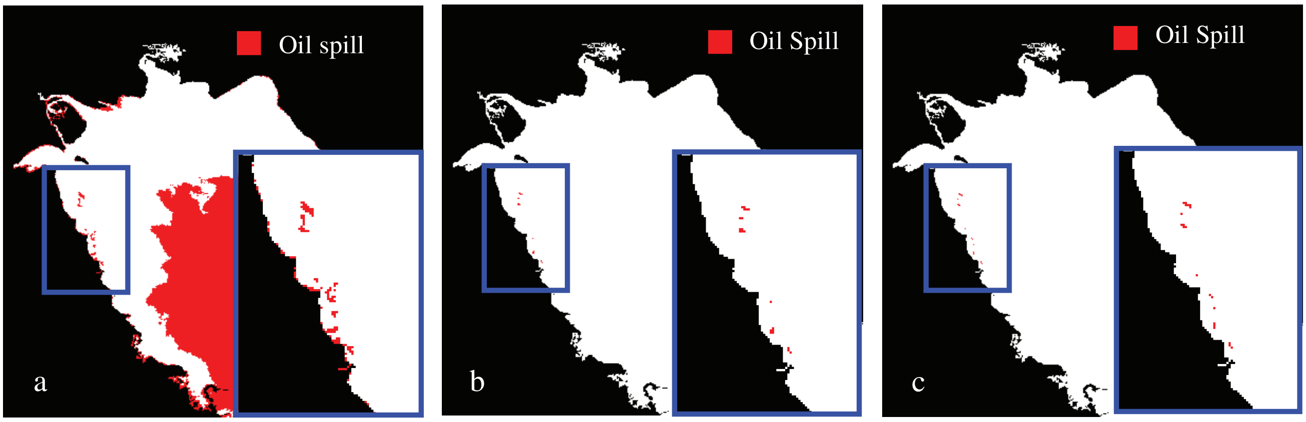

Figure 1: Comparison between fix threshold technique (a), RST technique (b) and RST recent development technique (c) in AVHRR channel 4 computed on the Persian Gulf image of 24 January 1991 at 10.31 GMT (13.31 LT). Anomalous pixels are depicted in red, land is masked in black.

In Fig.1c first preliminary achievements are shown. Note as, respect to Fig.1b, a better oil spill mapping (i.e. more pixels detected) has been achieved, without introducing any false alarm.

Moreover, results obtained by analyzing additional test cases, occurred in different geographic areas and with different oil spill signal intensity or extension will be also shown and discussed in this paper.

This furtehr improvement, as already done with the previous one [18], will be exported on TIR MODIS (Moderate Resolution Imaging Spectroradiometer) data. This will allow for an increase of the observational frequency for a timely detection and continuous monitoring of space-time evolution of spills.

In the future, the combined use of IR observations (each 3-6 hours from MODIS and AVHRR sensors) for timely oil spill detection and the VIS-NIR ones (provided only during daylight by MODIS) for accurate mapping, as well as the increased sensitivity of the proposed approach could all represent factors contributing to build an useful tool for the management of both big accidental oil spill events and small illegal discharges.

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