ABSTRACT

SAR techniques are commonly thought for oil spill detection and monitoring. Operational services are soon to come at European scale thanks to the development of GMES services and the strong investment of the European maritime security Agency in the field. Complementary to SAR, the paper proposes to develop the benefits of combining and exploiting operational oceanography assets to support such oil spill monitoring service and to anticipate on potential emergency situations. Therefore the paper will develop and illustrate technically the following topics:

- benefits of space oceanography (Sea surface Temperature, colour, ocean fronts detection) to reduce false alarms in oil spill detection by SAR
- benefits of ocean variables hindcasts, nowcasts and prediction in oil spill drift forecasting.

The paper will then illustrate how such techniques can support operational oil spill management from the maritime user point of view participating to all operational phases of the oil spill management. The paper will thus develop some operational scenarios:

- Support to preparedness and rehearsals with seasonal met-ocean climatologies, seasonal risk indicators
- Support to oil spill emergency operations with met-ocean forecasts (marine meteorology, sea surface currents and sub surface ocean variables such as temperature and currents) combined with in situ buoys deployment
- Support to risk capitalisation with reanalyses and modelling of past situations, simulation of scenarios, support to rehearsals and scenarios replays.

As a conclusion, a tentative list of improvement paths to make such space-based capacities operational will be drawn.

1. REFERENCE SCENARIOS

Typical use cases for an oil spill monitoring and drift forecasting service are relative to Pollution Monitoring, Management and Combat as well as to Polluters Prosecution.

1.1 Intentional Pollution

The key user requirement is to get information on the oil slicks (location, area ...) and on the polluters (location, size, direction, speed ...) in near real time, i.e. typically within 30 minutes on specific regions of high risk. This information is derived from near-real time “coarse monitoring” data such as SAR images and auxiliary data (meteorological and oceanographic data). Analysed scenes would have to be available in near real time to allow the responsible agencies to deploy other resources to identify and deal with those responsible for the spill/leakage as well as the management of the combat operations.

1.2 Crisis Situation due to Accidental Pollution

The requirement is quite different to get regularly (typically daily) four types of data:

- Near-real time "regular monitoring" data i.e. SAR images and auxiliary data such as meteorological and oceanographic data
- "Alert monitoring" data on a geographical area of interest, including data from in situ devices

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and/or aerial means

- Data from advanced forecasting models
- Data from Expert/Decision support system

2. STATE OF THE ART

2.1 Major Progress with SAR

The use of Earth Observation (EO) data from satellites is an essential tool when used in conjunction with traditional observation techniques, such as aircraft and surface vessels, to achieve synoptic monitoring of oil spill events. It ranges from prevention to response at local, regional and national levels. Two of the major advantages of using EO data are the relatively low cost, when compared to aircraft monitoring, and the large area of coverage. Many years of practical research have shown that the best satellite sensors for monitoring oil pollution were Synthetic Aperture Radars (SAR). These sensors make use of energy transmitted at microwave frequencies (not detected by the human eye). They provide imagery coincident with the oil spill, due to the dampening effect of oil on water, and offer a large coverage area, together with day and night capabilities.

The European Maritime Safety Agency (EMSA) is then starting up in April 2007 an operational SAR based monitoring service for pollution monitoring.

The minimization of the false alarm rate and the maximization of the detection probability do stand as key EMSA requirements.

2.2 Potential of New Oceanographic Models

In the 90’s, several systems have been developed by the oceanography community. These monitoring and forecasting systems provide in real time a realistic description of the oceans, offering a set of validated analysis and forecasts products together with services and human expertise.

Based on ocean models with assimilation of both in-situ and space observations data, these tools constitute integrated systems able to provide the user community with a physical and -in a near future- a biological and geochemical three dimensional description of the ocean.

This capacity is available at Mercator-Ocean on a global scale with a ¼° resolution (a new system with a 1/12° resolution will be operated in 2008) and on the Atlantic ocean and the Mediterranean sea with a 1/15° system. The other European centres involved with Mercator-Ocean in the framework of the GMES programs, Mersea, Boss4GMES, Marcoast and the future Marine Core Service propose a set of high resolution systems offering a portfolio of services and products of high quality on the different European seas and basins.

In addition to that general description of the oceans in real time, the European partners have developed a capacity to tune this information in order to cover the needs on the downstream service providers. Intermediate users in charge of coastal modelling (within ECOOP GMES project for example) or Oil Spill Drift forecast (within Marcoast GMES-ESA project, for example) can therefore find useful and validated information to force or to assimilate in their systems.

In addition, the European operational oceanography capacity proposes a set of indicators that synthesises the information to address the specific needs of some end-users such as European environmental agencies.
3. BENEFITS OF OPERATIONAL OCEANOGRAPHY

Several benefits can indeed be awaited from operational oceanography outputs, and according to oil spill service chain state-of-the-art review (Ref.1).

3.1 False Alarm Reduction

Key to the problem of operational oil spill detection is to reduce the number of false alarms given by the system while not letting a single real oil spill pass through the filter undetected. A particular emphasis should thus be put on the reduction of the false alarm rates for oil spills detections. Fig.3 illustrates that SST and ocean colour maps (right) can delineate a frontal area who could be interpreted as oil slick on the SAR image (left).

![Figure 3: Use of metocean data for false alarm reduction (courtesy Boost Technologies)](image)

Figure 4: Oil spill detection with ocean colour product (courtesy Oceanography Centre of Cyprus).

![Figure 4: Oil spill detection with ocean colour product](image)

3.2 Use of Oceanographic Products for Detection

High resolution ocean colour information (such as coming from ENVISAT MERIS Full Resolution or AQUA MODIS 250 m resolution) is usable for oil spill detection. This has been put in evidence during last major oil pollution crisis in Lebanon as shown in Fig.4. This potential capability could be operated in a conjunction mode in a single platform, as for ENVISAT with ASAR and MERIS full resolution, or in real time with distinct but synchronised platforms.

![Figure 4: Oil spill detection with ocean colour product](image)

3.3 Combined Use of Models, SAR and In Situ Means

In accidental spill scenario, buoys are proven tools already used for example in the Erika and Prestige accidents.

![Figure 5: Oil spill tracking with Argos buoys during Erika accident](image)

Figure 6: Use of multiple operational oceanography sources for a SAR based monitoring service

When a major oil spill occurs, the tracking of oil slicks by surface drifting is recommended in order to cross information. In this case, direct observation by SAR is not always sufficient due to dependency on metocean
conditions and to the revisit constraint. The prediction of the drift of slicks by a model needs also to be validated by observation or by the mean of buoy-tracking satellite detection. Reliable remote sensing of buoy is then very helpful to track the slicks and guide aerial surveillance aircraft (see Ref.2). Combined use of metocean data, drift models, SAR images, Argos buoys has also been implemented in the frame of the ESA GMS ROSES project in Spain (see Ref.3).

In this case study, buoys have been dumped on an artificial spill and used for validation/comparison with oceanographic model outputs (Fig.6 top), while wind information extracted from SAR can be used for validation/comparison with meteorological model outputs or in support to ship detection with other sea state information (Fig.6 bottom).

3.4 Operational Oceanography Products and Services

The outputs of the forecasting systems (and also observation products) offer a realistic high resolution description of the ocean. Temperature, currents (and potentially salinity to better understand the meso-scale dynamic) are parameters of interest for oil spill management applications. In particular they have been proved to constitute a good contribution to the quality of drift forecasts. Research activities led by Météo-France in the Prestige case have clearly shown the improvement of the outputs of the Mothy model when ocean parameters are used in the simulation of the spill positions (see Fig. 8). It can be concluded that the “4D” description (3D in space and 1D in time) constitutes an important contribution of operational oceanography.

In addition, CLS in collaboration with Mercator-Ocean has developed two oil spill risk indicators. The first indicator (indicator A, Fig. 10) is a map showing the pollution risk level along the shore with a three colours scale-green, yellow, red- ranging from low to high potential risk. The second indicator (indicator B) shows sections of shipping routes which presents a potential coastal pollution risk with the same classification using previously mentioned colours. These indicators are computed from a drift model where several thousands of particles are sown daily along the main shipping routes. These routes are defined from the Traffic Separation Schemes positions established by the International Maritime Organization. Atlantic TSS as provided by IMO. These two monthly indicators are produced from time series data using currents and wind stress provided by the Mercator-Ocean forecasting systems and they
display:

- which part of shipping routes presents a potential risk of coastal pollution,
- which part of the shore is more expounded to coastal maritime pollution.

Figure 10: Indicators examples (indicator A on the left, indicator B on the right)

4. THE GMES PERSPECTIVE

The Oil Spill management has been identified by the GMES program early in its development. Some demonstrations have been made in the R&D activities within the EC projects (Mersea and Boss4Gmes) and a portfolio of services is available in the ESA Marcoast project. In this project, an end-to-end service ranging from SAR detection to oil spill drift forecast has started in April 2007.

In the same way, the future Marine Core Service will propose an extended set of products and services aiming to address operationally the needs of service providers in charge of oil spill management. In this framework, some dedicated products and services will be produced by the partners of the Marine Core Service: Both the Thematic Assembly Centres in charge of the observation data management and the Monitoring and Forecasting Centres will produce useful information in four main sectors:

- For Oil Spill detection, the Thematic Assembly Centres (together with the EMSA service) will provide both the end users (Local, national & maritime authorities) and the intermediate users (the spill drift forecast service provider for the initialisation and validation of its model) with a real time and local high resolution mapping of the spill.
- For a deep description of the oceanic region impacted by the spill, a set of statistics and time series data together with human expertise will be available for both the end users (Local, national & maritime authorities) and the intermediate users (the local meteo office…).
- For oil spill drift forecast service, the Marine Core Service will provide the drift forecast service provider with a mapping of the spill (based on observations) and forecast data describing the physical ocean as required by the drift model.
- For information to the citizens, some reports and maps will be proposed to decision makers, member states and European agencies.

All the actors of the oil spill chain should therefore find in this portfolio the useful information for the downstream services. In addition, the R&D activities led in the framework of the currents European projects will improve the benefits of the use of operational products. The Marine Core service will therefore be the first step for the consolidation of a real, reliable and sustainable service.

5. CONCLUSION

End to end demonstrations of the oil spill management have shown the high interest of the use of integrated systems.

In addition, the products and services proposed by operational oceanography have in a sensible way improved the quality of the spill forecasts and, in the same time, have brought to the community of users (decision makers, local and national agencies, spill drift forecast service providers…) a new type of information on the state of the ocean.

All the pieces of this puzzle will benefit of the research and organisational activities led currently in the framework of European projects.

On the other hand, the future Marine Core Service will consolidate its portfolio of products and services and it will durably install its connections with the oil spill management actors. The success of its operational qualification will be a great signal for its future collaborations with the downstream services.

6. REFERENCES

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