European Maritime Safety Agency

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Non-paper

EMSA's view on further development of oil spill modelling

The aim of this paper is to present EMSA's view on the use of oil spill models within the CleanSeaNet service for oil spill monitoring and surveillance. The Agency intends to further develop the service to facilitate polluter identification and pollution response. In view of the open FP7 call for GMES downstream services the Agency would like to illustrate how these services could be linked to CSN.

EMSA CleanSeaNet Service

The discharge of oil from ships, oil platforms and other sources causes significant damage to European coasts and to the marine environment in general. The impact of oil pollution on the ecology of coastal and marine ecosystems and the species that inhabit them is particularly destructive following massive oil spills caused by maritime accidents. Operational discharges of oil from ships, whether accidental or deliberate, is a growing concern as levels of maritime traffic increase, and will cause a significant detrimental impact on the marine environment over time. Monitoring for illicit spills and using appropriate backtracking models will enable fast and efficient response by authorities to identify the polluter and to support prosecution. In the case of a major spill response teams have to be supported with the best available oil location, drift and weathering information. Forecasts of beaching would enable prioritisation of efforts to collect oil at sea Therefore effective monitoring and response mechanisms for both operational discharges of oil and accidental oil spills are necessary.

Directive 2005/35/EC on ship sourced pollution, and on the introduction of penalties for infringements, tasks EMSA to work with Member States to develop technical solutions and to provide technical assistance in relation to the implementation of the Directive. In line with this, the Agency provides the European operational CleanSeaNet service[1] (CSN) for oil slick detection based on satellite sourced synthetic aperture radar (SAR) images, which assimilates, harmonizes and distributes the required products to all EU and EFTA states.

[1] http://CleanSeaNet.emsa.europa.eu

CSN will be a long term service and will adapt to changing needs. It became operational in April 2007 and is under continuous development.

CleanSeaNet supplies analysed images from data provided by the European Space Agency's ENVISAT and Canada's RADARSAT satellites. There is partial satellite coverage of EU waters per day and selected images can be ordered depending on the needs of each individual Member State. These may range from comprehensive coverage of a nation's offshore waters to the provision of selected images in perceived high risk areas. The processed and analysed information is sent simultaneously to the national authorities in the affected Member States and to EMSA. The time from data acquisition by the satellite to the receipt of processed information by pollution control authorities should not exceed 30 minutes. Should the presence of pollution be suspected, coastal authorities can decide whether they wish to deploy aircraft or surface vessels to assess the situation in greater detail before deciding if there is a need for further action. If significant pollution is confirmed, the national operational response mechanism may be activated.

CleanSeaNet also has an important role to play in the case of a major accidental oil spill in EU or adjacent waters, at which time it will respond rapidly by providing analysed satellite radar images over the affected area. The International Charter for Space and Major Disasters provides a unified system of space data acquisition and delivery to those affected by disasters and CleanSeaNet operates within the framework of the Charter as Project Manager.

It is the intention of CSN to provide all the information, which takes the individual coastal effects into account, as a combined information package ("one-stop-shop") to support time critical response activities. CSN intends to provide meteorological and sea state information, vessel traffic information and links to forecast and hindcast (backtracking) models which are tailored for specific sea areas. A more effective collection of evidence against potential polluters could be achieved by matching vessel tracking data with hindcasting and satellite SAR imagery provided by CleanSeaNet to link detected spills with a possible ship source. In addition drift forecasting services are necessary to predict the drift of an illegal discharge to support Member States' decision making for emergency response to a major oil slick. The existence and widespread advertising of such services will increase the likelihood of detection and prosecution and therefore act as a strong deterrent to would-be offenders. The service should rely on one or more established models which have been developed for specific sea areas. However some Member States do not have yet the full operational access to these models.

Requirements for oil spill modelling

In 2009 EMSA intends to begin to integrate oil spill modelling functionality within CleanSeaNet. For this purpose EMSA requires access to state of the art combined drift and weathering predictions using regional sea models with appropriate atmospheric and oceanographic forcing terms for the CSN service area. CleanSeaNet would therefore require:

- Forecasting of oil drift for pollution response operation support; high resolution models (approximately 1km) are required capable of forecasting the evolution of an oil slick (dispersed oil plume and residual surface slick) out to a forecast time of no less than 96 hours in advance

- Oil spill hindcasting (back-tracking) for collection of evidence for no less than 24 hours in the past
- A 3D model would be appreciated taking Ekman transport into account and allowing the prediction of mixing in the water column and on the surface (e.g. subsurface vertical and horizontal advection, dispersion of entrained and dissolved oil components)
- Weathering prediction (e.g. physical and chemical fate of oil over time, spreading, evaporation, dispersion, emulsification, biodegradation, sedimentation, dissolution)
- Multi-model approach with the capability to intercompare the model results by the Member State user
- User select mode and automatic mode (triggered by spill alerts) and ability to run model on previous CSN oil spill detections
- Validation data on all models available
- Training on the use of the models services/products

All these high resolution oil spill models require accurate boundary, initial and forcing conditions. Assimilated and SAR derived wind and swell information could be used to improve the quality of the models. The first model outputs must be on timescales consistent with those of the SAR data processing.

For reasons of sustainability and further improvements, models should be maintained by developers who have the technical capability as well as knowledge of local conditions to correctly operate and update them.

Implementation

Oil spill data is sensitive information and should only be accessible to users nominated by the European Member States. EMSA has to ensure the protection of this information and cannot allow CSN data to be distributed by third parties to users not authorised to receive CSN data. Therefore EMSA intends to implement an integrated information system ('One-stop-shop') for CSN with services harmonised across Europe comprising satellite imagery, oil spill data, oceanographic information, spill modelling and ship tracking data. The source of modelling results from third parties will be acknowledged by CSN. If distribution of CSN data by third parties to users nominated by Member States would be requested, this would require dedicated Service Level Agreements and data exchange procedures between EMSA and these third party distributing entities.

EMSA will seek to apply the following principles for implementation:

- A distributed architecture would allow the use of established models to be plugged into CSN. CSN would therefore act as a central 'hub' for data dissemination. Triggered due to detected possible spills by CSN, data exchange procedures will send CSN oil spill detection data to initiate the appropriate local models. Model prediction results will then be returned to the Agency for display and distribution via the CSN interface.

- A nested approach, where local / regional high resolution models are nested inside basin scale models to take advantage of best available forcing data e.g. ocean circulation, particularly improved ocean current data, tidal, atmosphere and waves
- Oil spill models should be tailored and appropriate for individual sea basins
- Users should be able to have preferably a choice of several oil spill models for European waters and therefore be able to access and visualise on the CSN interface more than one model for a particular basin – ensemble approach could be considered
- EMSA would anticipate having Service Level agreements (possibly including reciprocal data sharing arrangements) in place with model operators.
- EMSA should be provided with results of model validation e.g. validation by drifter tracking

Regarding technical implementation EMSA expects to define with the relevant model providers the best standards for:

- Specification of products and services: Time-step interval, backward-forward drift Oil spill location, time, oil properties/type, quantity
- Algorithms applied : Langrangian/ Eulerian mode
- Data exchange formats and protocols: data exchange interfaces between EMSA CleanSeaNet 'hub' and the external models (in XML, shapefiles or derivatives, KML, OpenDAP, netCDF, ...) input files, output file
- Visualisation and mapping: map of surface slick, slick extent evolution, multi model visualisation ("spaghetti plot"), depth and mixing information, distinction between dispersed oil and residual surface slick
- Presentation/visualisation of data via Web Services e.g. WMS, WFS, …

The models obviously need certain input parameters to operate. When activating the models, the EMSA CSN service could supply the following parameters to model operators[2]:

- Oil spill detection information (time, location, area, characteristics) and spill polygon information
- Feedback information from Member States if available
- SAR wind and SAR swell information

SAR data, which characterise the extent of the spill on the sea surface, could be used for re-initialisation of the models and act as validation of drift and evolution predictions.

Services should comply with the directive on "Infrastructure for Spatial Information in the European Community" (INSPIRE)[3] to be able to provide the users with integrated spatial information services according to these standards. Standardisation should cover elements

[2] These data have copyright restrictions and cannot be used for purposes other than oil spill modelling in the framework of CSN and can not be distributed to other entities unless there is prior agreement with EMSA.

[3] Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), http://www.ec-gis.org/inspire/

like data format, resolution of the products (in time and space), quality but also the data exchange conditions between the services themselves.

Oil spill modelling in the context of GMES Marine Core Service and EU-FP7 actions

GMES is regarded to be the major European programme for Earth Observation for the next decade. EMSA's opinion is that this programme should provide relevant and needed earth observation information to support its services.

GMES will provide services in several domains including, inter alia, the Marine field. EMSA regards its CleanSeaNet oil spill monitoring service as one of the first examples of a fully operational GMES service consisting of both Marine-Core-Service (MCS) elements and downstream service components.

The FP7 project "MyOcean", another MCS element (upstream service), will be available from 2009[4]. This GMES Fast Track service for marine applications may provide important products for CSN as they offer the basic oceanographic data which are necessary for forecasting, hind-casting and modelling of the spill behaviour (weathering). The Agency expects that there will be proposals in response to the present FP7 Call[5] on Pre-operational validation of GMES Fast Track services and products including downstream services building upon the existing upstream services. Only the combination of both (upstream and downstream services) will finally provide to the Member States the full information they are requesting for their operations.

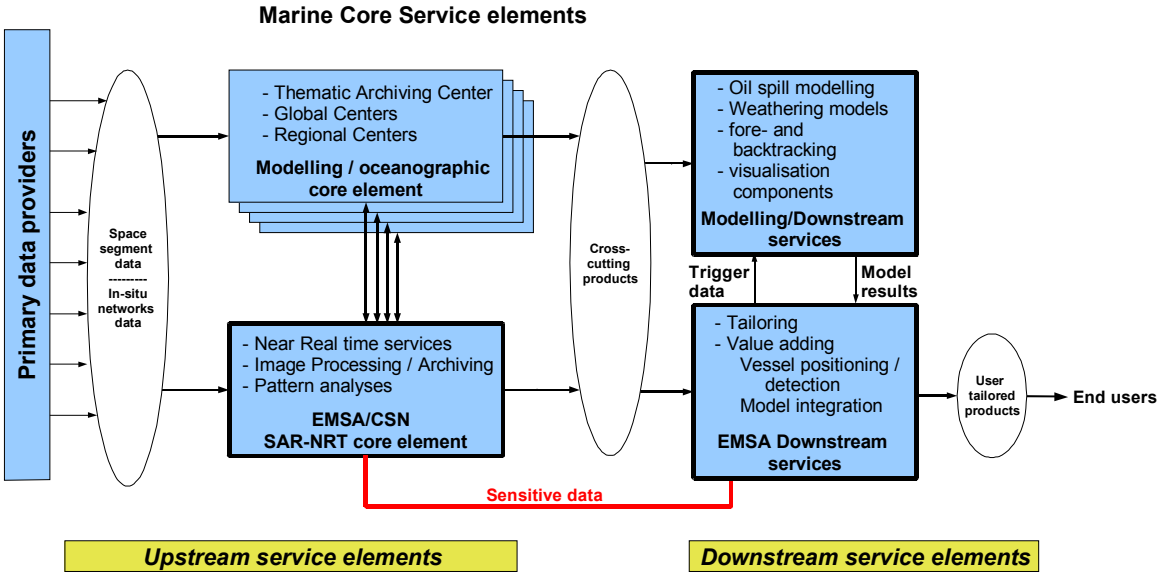

Fig.1: Schema indicating the individual actors and data exchange streams of modelling capacity within CSN.

[4] Extract of the call: "The MCS will deliver regularly monitored and validated information on three-dimensional ocean state, dynamics and ecosystems, sea-ice with the spatial resolutions and timeliness of delivery chosen to meet downstream service requirements. Nowcasts, forecasts and analyses are covering a period of 20-50 years which will be produced and used to monitor and understand the changes in the state of the ocean. Indicators which summarise this knowledge will be developed."

[5] Second call for proposals under the 7th Framework Programme's Space Theme, published 3 September 2008 addressing GMES downstream services: http://ec.europa.eu/enterprise/space_research/proposals.htm

EMSA regards itself to be an important intermediate user of GMES services as it will use the GMES data products but also provide enhanced and assimilated products to the MS[6]. Therefore it is requested that future GMES services will adapt their portfolio so that EMSA and Member States needs can be fulfilled. This needs the integration and interaction of global, regional and local models, which are also operated nationally at different locations in Europe. EMSA would appreciate if future GMES marine services would contribute to EMSA services in such a way that the Agency is able to link the models to the EMSA CSN service as described in this paper.

The downstream service providers should integrate the local, high resolution models operated by local and regional agencies, to allow a uniform service throughout European waters. These local models (a compilation can be found from EuroGOOS SEPRISE project[7]) must have therefore access to boundary conditions provided by regional sea models, to ensure accurate representation of oceanic conditions and effective characterisation of the oil slick (e.g. weathering, evaporation, advection, beaching etc). Access to geographic information of sensitive ecosystems, shoreline types and local infrastructure is also essential.

The existing EU-FP6 projects like MerSea, but also the ESA-GSE service elements like MarCoast can be seen as pre-cursor services as they are providing already pre-operational service elements and elements in development. EMSA would welcome the outcome of the call on downstream services and would seek to work closely with the potential partners in elaborating the appropriate technical solution for implementation of modelling capacity within CSN. In particular the implementation of downstream services from this call should take account of and be coherent with future planned CSN development. The services should focus on additional components complementing the existing CSN services.

[6] CleanSeaNet upstream services:

- The SAR imagery (provided by the ground segment under the responsibility of ESA)
- The pattern recognition (provided by the MCS as it is of interest for other users as well)

[7] EuroGOOS SEPRISE project documentation: http://www.eurogoos.org/content_seprise/index_seprise.php