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Background

At RESPONSE 26-2019in Warzaw in June 2019 Sweden and Denmark advocated for increasing the accuracy of Seatrack Web (STW) by adding live data as a source to the prognosis for trajectories of oil spills. The aim is to improve accuracy considerably. The project would need further elaboration before decision whether it should go into the update of the Baltic Sea Action Plan (BSAP). The idea of STW development was broadly supported at the meeting.

At RESPONSE 27-2020 in Vejle in February 2020 the STW proposal for BSAP was only discussed very briefly due to a dense agenda for the meeting.

Since RRESPONSE 27-2020 the proposals for BSAP have been discussed at HELCOM BSAP UP Workshop on maritime activities, including underwater noise, non-indigenous species and response actions (BSAP UP WS-SEA) held online on 2-4 September 2020. Adding live data to STW was not discussed, as the proposal has not been formally agreed and finalised by the Response Working Group.

To be included in the updated BSAP a recommendation on the proposal must be formally reviewed and agreed on by RESPONSE 28-2020 and endorsed by HOD 59-2020. Response agreement is the basis for completing a formal BSAP action proposal while the final decisions on which actions to be included in the updated BSAP will be taken by HODs, based on the agreement by the Response Working Group.

Development of STW will need financing. Sweden and Denmark envisage that support by the Response Working Group could potentially be utilised as the rationale and facilitator for applying for EU funding. However, Denmark and Sweden recommend the wording in the proposal for STW development – if agreed - to be with an open door in case the required financial foundation cannot be met.

To facilitate the discussion at RESPONSE 28-2020 Denmark and Sweden has asked their STW experts to explain STW and the development potential in a short technical document as found enclosed. The experts' assessment is that current monitoring buoys will present a very local and ineffective data source while HF radars and satellites are effective sources that can monitor and provide data for large areas. The project development description is far from exhaustive but should be sufficient to facilitate discussion. Costs mentioned in the paper are at this moment only estimates but will of course be validated before any decision to execute the proposed project.

Action requested

The Meeting is invited to take note of this document containing the background, discuss the technical development of Seatrack Web based on the technical information in the Annex and consider the possible inclusion of a new action for the updated BSAP on adding live data to STW.

Suggested development of the Seatrack Web system

1. Introduction

Today's operational ocean forecasts for the Baltic Sea–North Sea region include variables such as salinity, temperature, ice conditions, sea surface height, and ocean currents. In addition, wave characteristics are also forecasted using wave forecast models. These forecasts are closely connected to and forced by the general weather forecasts as presented to the public. For the coastal region, sea surface height is arguably the most important forecast variable, with its great effect on coastal communities and harbours. The coastal region is also very important from economical and ecological points of view. Larger oil spills in these regions have great impacts on local ecology, economy, as well as human recreational areas. One way of lowering the impact of oil spill accidents is to give authorities ample warning, to be able to take sufficient measures. Such an early warning system depends heavily on both accurate weather forecasts and accurate ocean current forecasts, including the effects of waves. Despite its importance, modelling and observations of the coastal ocean is still a very much neglected area.

2. Background

Representatives from the Helcom Response group have approached the STW representatives in Sweden and Denmark and requested elaboration on potential development of the Seatrack Web system. In the proposal for actions in the 2021 update of the Baltic Sea action plan the request is specified as: "Further develop regional preparedness and response related services including Seatrack Web to have integrated live feed from online devices such as sea current monitoring buoys, radars etc. no later than 2027. Work for full integration between satellite coverage and drift modelling by Seatrack Web. "

The development will be divided into two main parts, each with different sub developments.

The two main parts are:

1. Integrate and use current measurements within the Seatrack Web system.
2. Early warnings system for Seatrack Web based on satellite images.

3. Integrate and use current measurements within the Seatrack Web system.

3.1. Improving the drift forecast

Seatrack Web is an operational oil drift forecasting system covering the Baltic Sea and North Sea areas. The system is available over the Internet, which enables users to start an oil drift simulation on a server and have the results presented in their local computer.

Seatrack Web consists of three separate parts. The first part is the operational weather and ocean forecasting system, including an oceanographic circulation model, which provides the necessary wave and current fields. The second part is the drift, spreading and weathering model. The drift model, called PADM, takes the wave and current fields and calculates a drift trajectory and spreading pattern. The execution of PADM is controlled by the third part of the system, which is the web application. It handles the communication and comprises a graphical user interface (GUI) in a web browser, where the user can start and visualize a drift simulation.

The first request stated in the proposal for Baltic Sea action plan is an integration of live feed current measurements. It is not possible to integrate observations in the actual drift forecast done by PADM. Instead, the best way of using current measurements for improving the drift forecast is to assimilate these observations in one way or another in the oceanographic circulation models that forces PADM. However, there are some aspects that need to be considered.

Just like high and low pressure systems form in the atmosphere, similar eddies form also in the ocean, and just like in the atmosphere, the ocean eddies affect and control much of the ocean currents. The main difference is that whereas the horizontal scale of the atmospheric eddies are of the order of hundreds of km, the scale of the ocean counterpart is about 1-10 km in the Baltic Sea, increasing to about 30 km in the Atlantic Ocean. This implies that an observational network characterizing oceanic eddies in the Baltic Sea - North Sea region needs to have a resolution of the order of a few km, which cannot be solved by in situ buoy measurements. Rather, remote sensing techniques must be used for the ocean. This can be achieved in different ways. One common approach is to use a coastal network of short-wave radars (HF Radars). Such a system of two HF radar stations, located on the Swedish west coast looking out over the Skagerrak, was temporarily leased in a former project (SARACUS) during 2014-2015. During the project, the system was tested for reliability as well as for quality. The HF radar data was also tested in data assimilation experiments with good results (e.g. Axell and Liu, 2017).

It should be mentioned that an alternative, or complement, to HF radar stations is to use doppler data from satellites, but the geographical and temporal coverage are not anywhere near that of a coastal network of HF radars. Such a coastal network could be used at least for the Skagerrak, Kattegat, the Danish Straits, the south-western Baltic Sea, and probably parts of the Baltic proper. Further north, the salinity of the surface water becomes increasingly lower, which decreases the reach of HF radar. Here satellite data would be increasingly important.

The Seatrack Web system is presently installed and in operational use at three of the partners in the consortium, i.e., SMHI (Sweden), FCOO (Denmark), and BSH (Germany). Each of these has their own circulation model, and also their own data assimilation strategy. What is common, though, is the need for dense 2D fields of current measurements.

3.1.1. Development stages at SMHI:

- System for downloading and preparation of observations (200h)
- Implement radial velocities in the data assimilation system (500h)
- Implementing of “ensemble” by changing initial fields (320h)
- Validation and test of ensemble (160h)
- Performance test and tuning (100h)
- Monitoring and documentation (40h)
- Prepare for production environment (40h)
- Administration and project management (140)

Estimated total development time: 1500h. Current rate for 2020 is ~93 EUR/hour.

Estimated increase in yearly costs related to monitoring and management: 15 000 EUR. This yearly cost could be financed by increased license fee for Seatrack Web Helcom.

This development task can be finalized during a period of 2 years. If decided during 2022 it is possible to develop and implement this 2024-2025

3.1.2. Development at FCOO

Implementing data assimilation is already planned at FCOO, based on the various observation data (not only current measurements) already present in the HELCOM area. The data assimilation will however benefit greatly if dense 2D fields of current measurements would be available.

3.1.3. Requirement for implementation

For this development it is necessary to have a 2D field of current measurements. This new dataset has to be provided by the Helcom members. If the data is not available then this development stage will not be possible to perform. Unfortunately single buoys are not enough to assimilate. A rough estimate regarding the cost of HF radar is around 200 000 EUR for a system consisting of two radars. The number of radars needed is related to the local area and water salinity.

It is not necessary to have a 2D field of current measurements covering the whole domain. However, the system will most probably only improve where we have observation coverage, and in other areas the forecast can even be worse. For these areas it might still be necessary to run the model for the full domain without data assimilation, i.e., the present day situation.

3.2. Additional use of current measurements

In addition to use current measurements to improve drift forecasts, they can also be used to calculate drift forecast uncertainties. These can be presented in Seatrack Web together with the drift simulation, to either strengthen or weaken the trust in the simulation. It could further be possible to show the actual current measurements in the GUI, which when compared to calculated currents, give a sense for the accuracy of the drift simulation.

It should also be noted, that a readout of actual currents is vital for Search And Rescue operations.

4. Early warnings system for Seatrack Web based on satellite images.

The goal of this development is to use satellite images to start automatic simulations that will notify a specific user (by email) if the simulation results indicate that oil will drift to a predefined area. This development is highly dependent on the deliveries of satellite images and the quality of this data. The Seatrack Web system itself will not be able to determine if the detection is oil or not, it will simply start a simulation with the information provided. Simulations will be carried out within 20 minutes, if there are less than 15 satellite detections. Seatrack Web cannot influence the time that passes before we get the processed satellite image.

4.1. Development stages:

- Download and process satellite data (160h)
- Start a simulation based on satellite data (160h)
- Automatic start of simulation based on satellite data (200h)
- Implementation of users areas of interest (120h)
- Implementation of email notifications (100h)
- GUI-support to see active alarms and to complete them (160h)
- Performance test and tuning (120h)
- Monitoring and documentation (40h)
- Prepare for production environment (40h)
- Administration and project management (100)

Estimated total development time: 1200h. Current rate for 2020 is ~93EUR/hour.

Estimated increase in yearly costs related to monitoring and management: 10 000 EUR. This yearly cost could be financed by increased license fee for Seatrack Web Helcom.

This development task can be finalized during a period of 2 years. If decided during 2021 it is possible to develop and implement this 2022-2023

4.2. Requirement for implementation

This development will require that user specify areas that are of interest to them and deliver this in a specified format. These areas should be considered quite static since it will require manual work to update them.

Most importantly is a secure and operational flow of satellite images from for example EMSA. The system will be highly dependent on this and will not work without. This has to be provided by the Helcom group.

5. Reference

Axell, L., and Liu, Y., Ensemble-based data assimilation of observations into NEMO-Nordic, Proceedings from 8 th EuroGOOS Conference, Bergen, 3-5 October 2017, 2017.