Indonesian seas Numerical Assessment of the Coastal Environment (IndoNACE)

Executive Summary

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Institute Technology of Bandung
Agency for Marine & Fisheries Research and Development

ESA study manager: Gordon Campbell, Margaret O'Sullivan

Alcantara Study Reference No.: 14.197.37
Study Type: Pilot
Contract Number: 4000114612/15/F/MOS

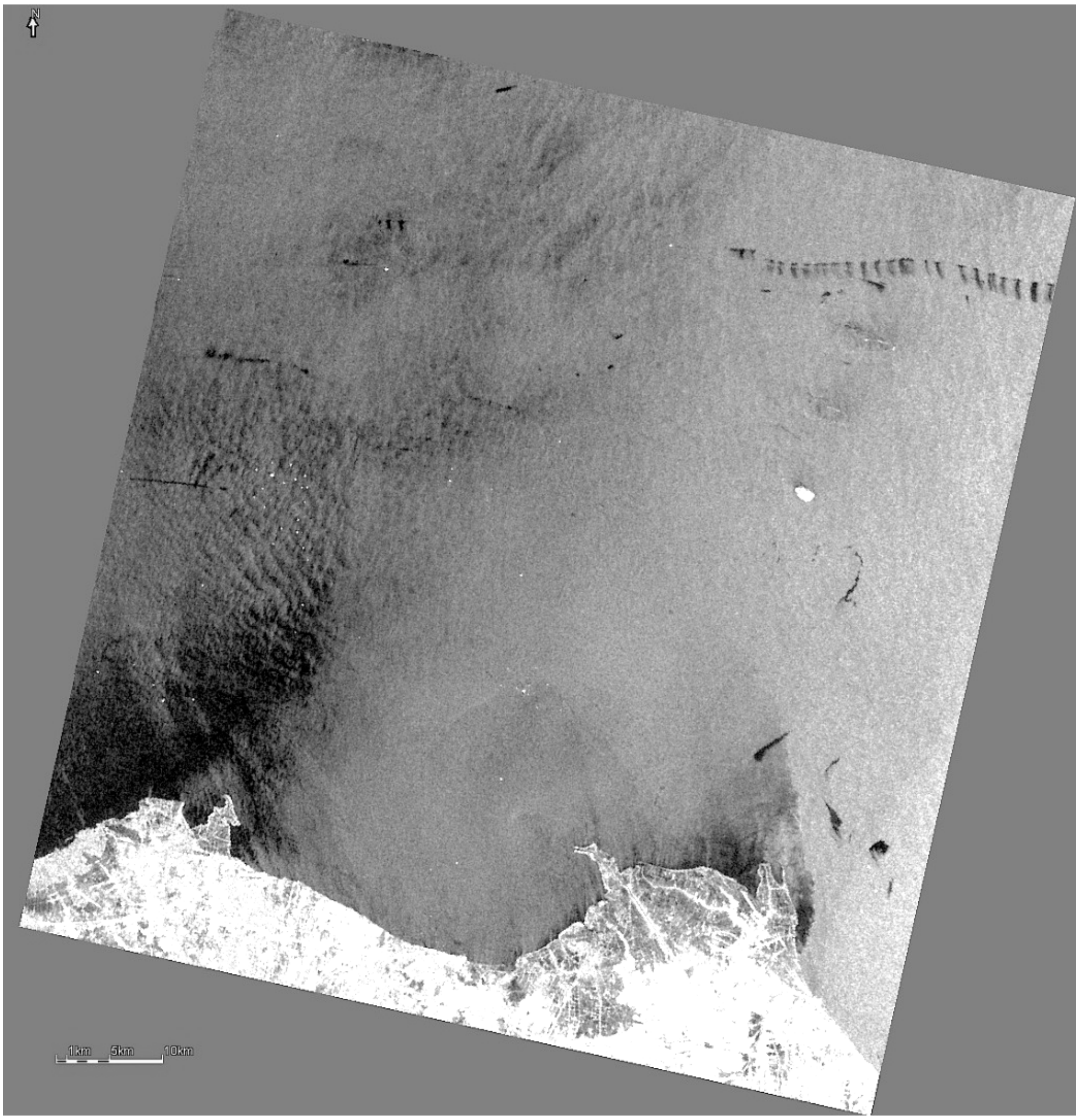

Fig. 1. Envisat ASAR image (82 km × 88 km) of the Java Sea, north off Java (Eretan Bay is in the lower image centre), acquired on 8 December 2005 at 02:25 UTC. Throughout the image small dark patches can be delineated, which are due to mineral oil spills. However, dark areas on the lower left and off the coast are due to low wind. The upper right part of the image is a Marine Protected Area (MPA).

Motivation:

This Pilot Study aimed at improving the information on the state of the Indonesian marine environment that is gained by combining satellite data, maps of particularly vulnerable coastal areas and model simulations.

Methodology:

Synthetic aperture radar (SAR) data were used to produce oil pollution density maps of two dedicated areas (regions of interest, ROI) in Indonesian waters. In parallel, maps of particularly vulnerable coastal areas within both ROI were produced, which are based upon United Nations Environmental Program (UNEP) -data complemented by environmental data hosted by the Indonesian partner institute. An existing numerical model was adapted and, in combination with a tracer dispersion model, high-resolution numerical forward and backward tracer experiments were performed. Using the previously gained information sets on existing pollution and on sensitive coastal areas as input for the tracer experiments we demonstrate that our approach can be used to identify strongly affected coastal areas (with most oil pollution being driven onshore), but also sensitive parts of major ship traffic lanes (where any oil pollution is likely to be driven into marine protected areas.

Results:

1. During both field surveys several oil spill around Pari Island were found.
2. The hydrodynamical model results show a good agreement of tidal amplitudes and phases compared to observational data collected during the field surveys.
3. The model results during the 5-days backward simulations show that the origin of oil is situated to the east and north of Pari Island.

Publications:

Gade, M., B. Mayer, T. Pohlmann, M. Putri, and A. Setiawan (2016a): Using SAR Data for a Numerical Assessment of the Indonesian Coastal Environment. Proceed. ESA Living Planet Symp. 2016, Prague, Czech Republic, 9-13 May, 2016.

Gade, M., B. Mayer, T. Pohlmann, M.R. Putri, A. Setiawan (2016b): An Assessment of the Indonesian Coastal Environment based on SAR Imagery. Proceedings on IEEE International Geoscience and Remote Sensing Symposium, Beijing, 10-15 July 2016.

Putri, M.R., A. Setiawan, T. Pohlmann, B. Mayer, and M. Gade (2016): The Assessment of Oil Pollution in Seribu Islands Based on Remote Sensing and Numerical Models. Proceed. ESA Living Planet Symp. 2016, Prague, Czech Republic, 9-13 May, 2016.

Extended description of one particularly relevant result

Taking into account the inhomogeneous spatial coverage by all available ASAR images we calculated the normalised mean polluted area in km² as the ratio of the total spill-covered area and the SAR coverage, for simplicity given for an amount of 100 SAR images. The normalised mean polluted area is rather independent of the heterogeneous data coverage and, given a 'critical SAR coverage' at any place in both ROIs, allows comparisons of both ROIs and objective conclusions. Binned into a 0.05° × 0.05° grid they are shown in Fig. 2.

It is interesting to note that, after the analysis of all available ASAR images, in most cases hot spots of marine oil pollution are found in the open sea. Moreover, hot spots in terms of the total

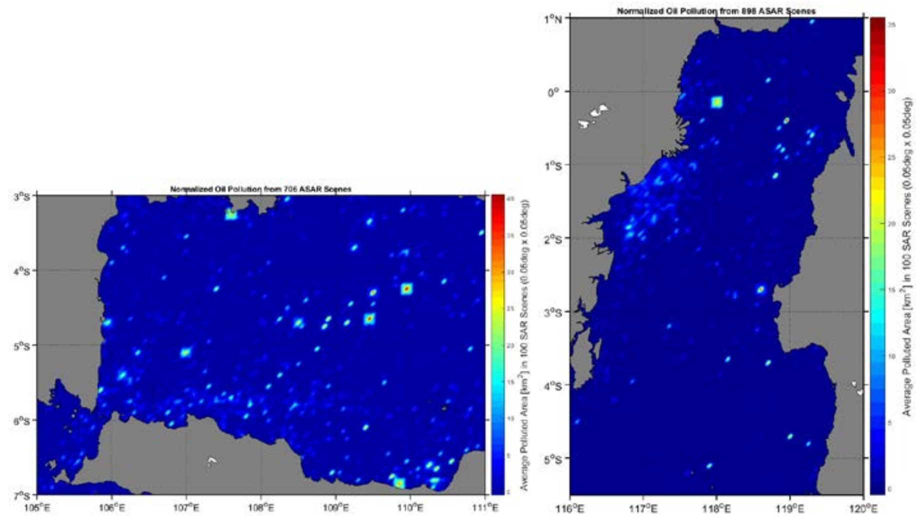

Fig. 2. Normalised mean polluted area per 0.05° × 0.05° grid cell and per 100 SAR images, as detected in approx. 1600 ENVISAT ASAR images of the two IndoNACE ROI, 'Java Sea' (left) and 'Strait of Makassar' (right).

amount of detected oil spills are no longer areas of highest normalised pollution. However, all industrial coastal areas in both ROIs coincide with regions where the mean oil pollution in a 0.05° × 0.05° grid cell exceeds 5 km² per 100 SAR images, i.e., 50,000 m² per single SAR image. Statistically, the areal fraction of pollution in those areas, therefore, is at least 0.2%, but can easily reach 1.5% in certain locations in the central Java Sea and open Strait of Makassar. This is the fractional areal that is polluted at any time, according to our analyses of approx. 1600 ASAR scenes.

The environmental conditions in both ROIs are subject to strong seasonal changes, mainly driven by the changing general wind patterns (Monsoon). Therefore, we had a closer look at seasonal changes in our findings, and in particular the monthly distribution of the pollution detected in ASAR imagery. Those monthly distributions of the normalised mean polluted area for the ROI 'W Java Sea' are shown in Fig. 3. It is obvious that least pollution was found from June to August, i.e., during the south-west monsoon, when only few bright spots can be found in the respective panels of Fig. 3. In contrast, the maps for September, October, and November indicate an overall higher pollution during that time of the year. In January and February, i.e. during the north-east monsoon, fewer but larger oil spills were detected in the images, thus causing extreme local maxima of the normalised mean polluted area.

The seasonality of the total amount of observed oil pollution in the Western Java Sea is demonstrated in Fig. 4. The upper panel shows in blue the total number of oil spills detected in each month of the year and in black the monthly distribution of the approx. 700 ASAR images. The lower panel shows the respective number of oil spills per SAR image of that ROI, i.e., the ratio of the upper two. It is obvious that the largest number of oil spills was found from March to May and from September to December. We note that these periods mark the transition from the north-west monsoon to the south-east monsoon, and vice versa. During those periods, the overall current pattern in the Java Sea changes (see above) and a greater amount of water from the inner Java Sea is driven towards south-west, thereby reaching those areas where the highest pollution was encountered.

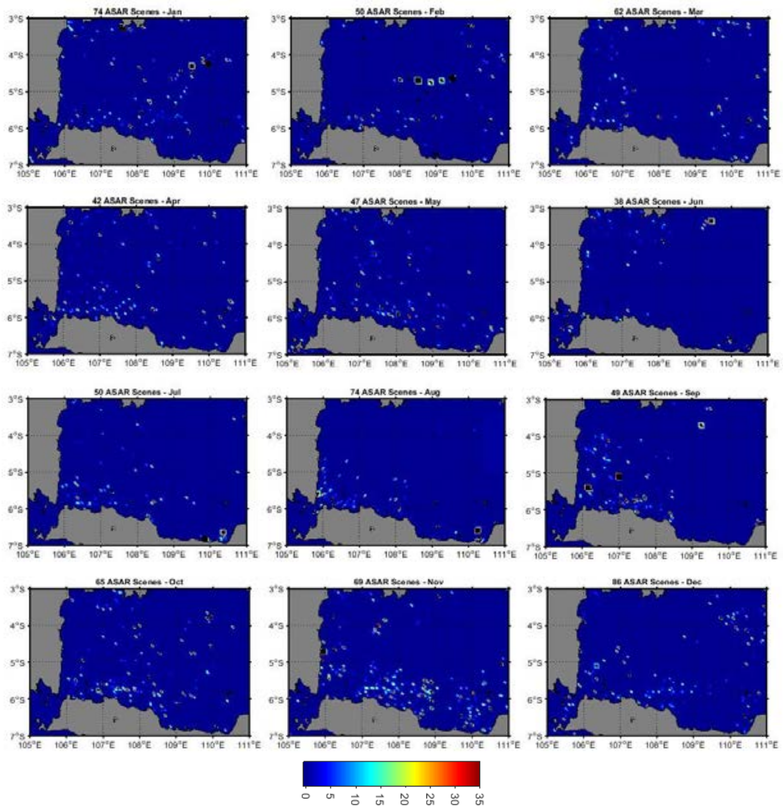

Fig. 3. Monthly distribution of the normalised mean polluted area per 0.05° × 0.05° grid cell and per 100 ASAR images, for the ROI 'W Java Sea'.

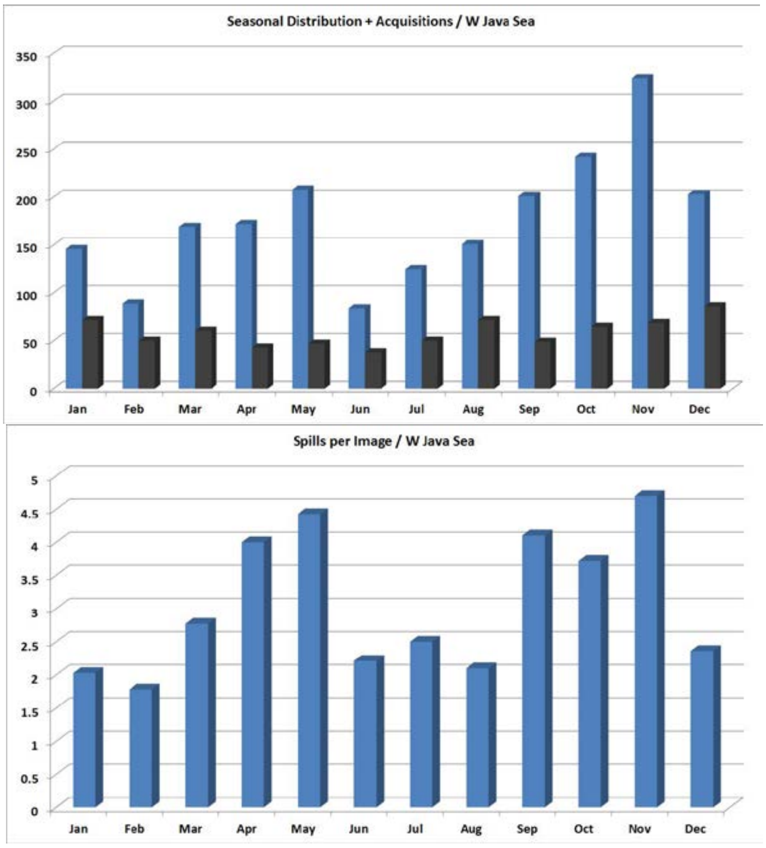

Fig. 4. Seasonal oil pollution in the ROI 'W Java Sea'. Upper: distribution of the numbers of oil spills (blue) and distribution of the ASAR images (black). Lower: respective distribution of the average numbers of oil spills per SAR image.

The monthly distribution of the normalised mean polluted area for the ROI 'Makassar Strait' is shown in Fig. 5. Obviously, the southern part of this ROI is generally less polluted, and in the north-eastern part, along the coast of Sulawesi, less pollution was found in March, May, July, and August. During the remaining months, many locations in the entire ROI show an enhanced normalised mean pollution, although we also note that, because of the partly low SAR coverage in certain months and regions, care has to be taken when those local maxima are interpreted. The petroleum industrial region off the Kalimantan coast is always subject to oil pollution, but no correlation with major ship traffic lanes can be seen. Again, we may conclude that ship traffic is not the primary source of oil pollution in the ROI 'Makassar Strait'.

The corresponding seasonality of the total amount of observed oil pollution in the Makassar Strait is shown in Fig. 6. Here, high pollution rates (average number of spills per SAR image, lower panel) were found in December and January, when the north-west monsoon drives additional water from the Banda Sea in the north into the Makassar Strait, thereby slowing down the overall current speed. Moreover, and similar to the Java Sea, another maximum in the monthly distribution was found in March, April, and May, during the transition from the north-west monsoon to the south-east monsoon. The change in the overall wind field, along with the corresponding change in the overall current pattern, appears to trigger the appearance of marine oil pollution in ASAR imagery.

These results demonstrate the feasibility of our approach, to combine numerical tracer modelling with (visual) SAR image analyses, and they help in better understanding the observed seasonality.

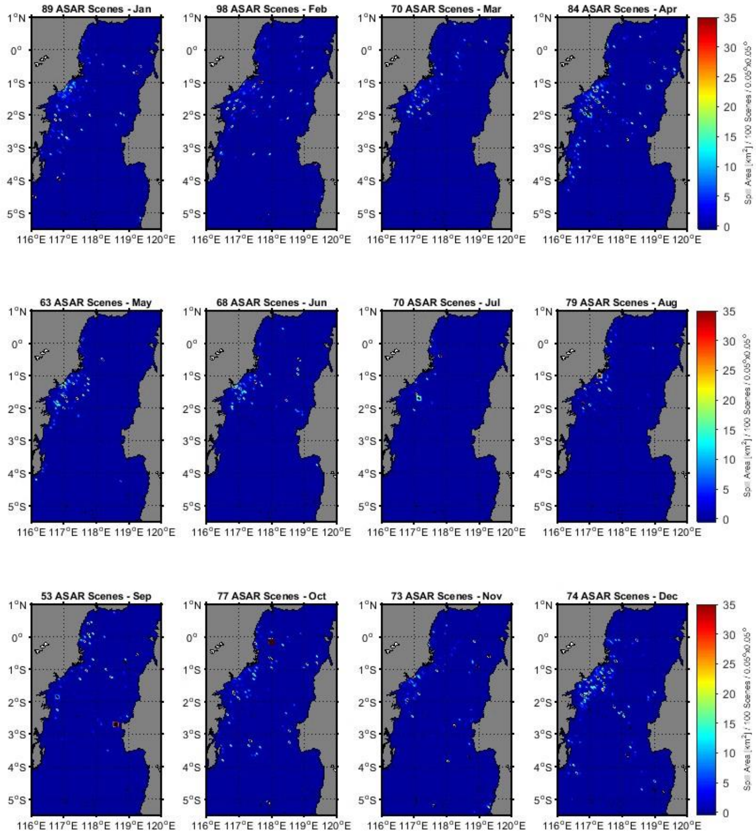

Fig. 5. Monthly distribution of the normalised mean polluted area per 0.05° × 0.05° grid cell and per 100 ASAR images, for the ROI 'Makassar Strait'.

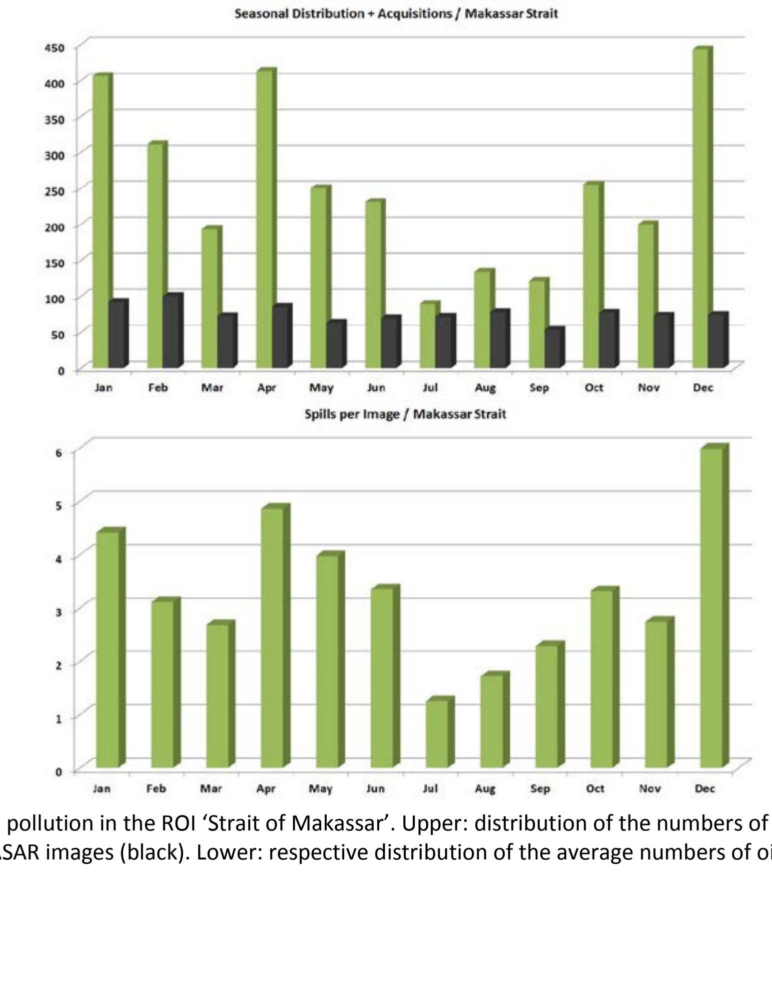

Fig. 6. Seasonal oil pollution in the ROI 'Strait of Makassar'. Upper: distribution of the numbers of oil spills (green) and distribution of the ASAR images (black). Lower: respective distribution of the average numbers of oil spills per SAR image.

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Questionaire

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	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	It does not apply/ Do not know
The topic behind this Alcantara project was interesting and relevant	X					
The study description clearly explained what was required		X				
The administrative effort required for this project was high (strongly agree), low (strongly disagree)					X	
The interaction with the ESA Technical Officer was important for the success of the project	X					
The interaction among all partners in this study was satisfactory	X					
After the Alcantara study we will continue this research		X				
After the Alcantara study we will continue our cooperation with the home institution of the external researcher		X				
During this Alcantara project we increased our knowledge about ESA and its programmes	X					
The research team would be willing to propose themes for new studies open to other groups (please specify below)	X					
The project produced results that could be extrapolated to other regions (please specify below)	X					
The project produced satisfactory results (SA) unexpected events affected results (SD - please specify below)	X					
The study budget was appropriate to carry out the work	X					
Other comments						X