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Searching for natural oil seepage in the Dreki area using ENVISAT radar images.

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Key page

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Abstract:
The purpose of the study was to examine signs of natural oil seepage in the Dreki area, possibly indicating oil fields beneath the ocean floor. Such oil slicks can be observed in synthetic aperture radar images (SAR). SAR images from the ENVISAT satellite with 300 m pixel size, covering the Dreki area from the years 2006, 2007 and 2008, were acquired from the web browser of the Technical University of Denmark and analyzed for patterns of interest. Interesting patterns were found in June 2007, that could be associated with the presence of herring ships fishing in the area, and attributed to fish oil. A few other instances of interesting patterns are likely to be connected to fishing activities. The study does not confirm the existence of natural oil seepage from the Dreki area.

Keywords:
Oil slicks, remote sensing, SAR image analysis, natural oil seeps, oil spill, Dreki area, Icelandic continental shelf, petroleum prospecting

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Introduction

The purpose of the study was to examine signs of natural oil seepage in the Dreki area (figure 1), possibly indicating oil fields beneath the ocean floor. Such oil slicks can be observed in synthetic aperture radar images (SAR).

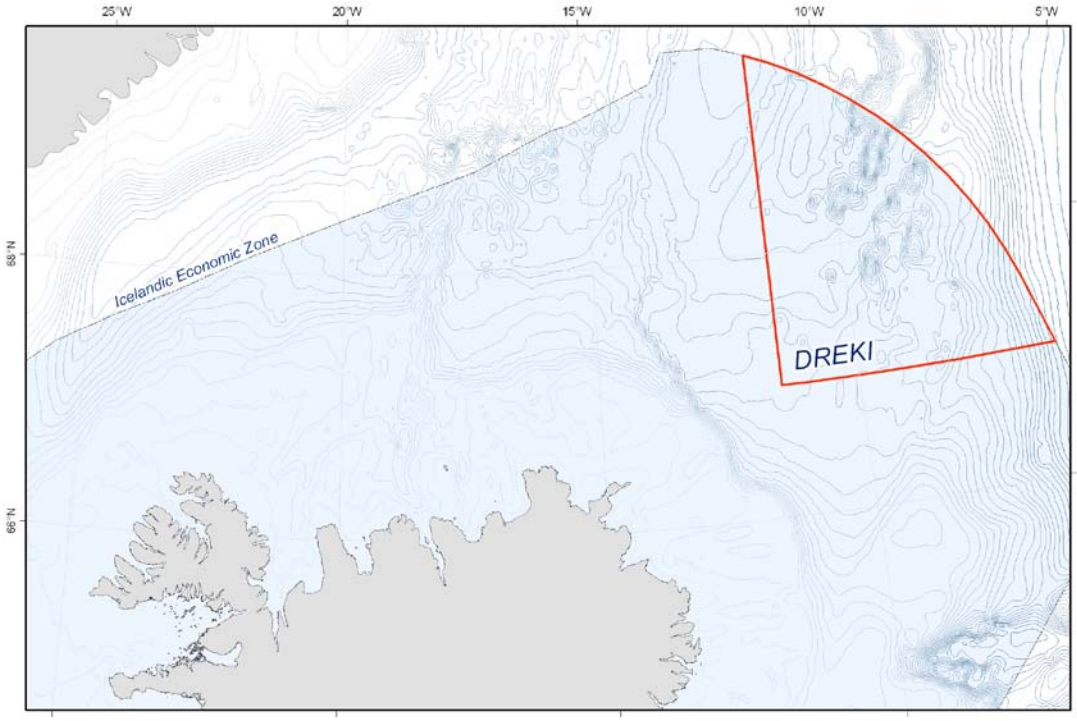


Figure 1. The Dreki area. The map is based on IS50V data from the National Land Survey of Iceland as well as data from the Icelandic Coast Guard.

The Technical University of Denmark (DTU) has maintained a web browser with SAR images from the ENVISAT satellite for a number of years. The images come in somewhat reduced spatial resolution, with 300 m pixel size at best. The images are sufficiently detailed to show patterns of interest, and once images with patterns that are possibly associated with oil slicks have been identified, images in much higher resolution can be ordered.

The project was initiated by the National Energy Authority, Kristinn Einarsson and Þórarinn Sveinn Arnarson, and carried out at the University of Iceland, Faculty of Earth Sciences. This report presents the first results of the study and a folder with data files and images accompanies the report.

Remote sensing of oil spills and seeps

Radar pulses are sent from satellites at a certain angle and are then backscattered from the surface of the earth. Surface roughness affects the backscatter greatly, and thus the signal received back at the satellite. Different surfaces respond differently to the radar pulses (figure 2). Flat areas, or calm seas, tend to reflect most of the radar pulse away and very little or no radar signal is received at the satellite.

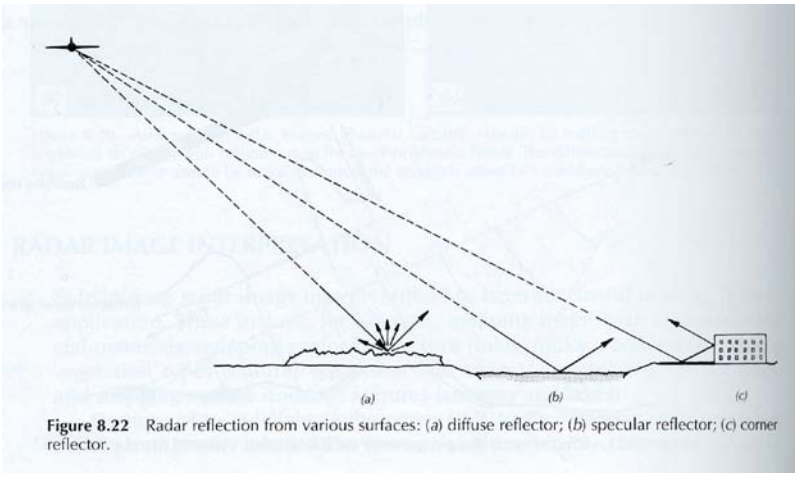


Figure 8.22 Radar reflection from various surfaces: (*a*) diffuse reflector; (*b*) specular reflector; (*c*) corner reflector.

Figure 2. Reflection of radar signal at the surface of the earth. Lillesand et al. 2004)

Such areas do therefore appear black or very dark in radar images (figure 2b). Rougher surfaces reflect radar signals more evenly, and such regions appear with lighter tone of gray in the images (figure 2a). If the surface that the radar signal lands on is perpendicular to the direction of the radar signal, or if the signal gets reflected from two flat surfaces at a certain angle, the satellite might receive most of the radar pulse back and such features will appear close to white in the images (figure 2c). Oil or grease at the surface of the ocean minimizes waves and oil infested patches on the ocean appear much darker than the ocean around it. If waves are high in the region and the ocean is quite rough, it can be very hard or impossible to interpret the associated images. Ships do often appear very bright in radar images, partly because of the double reflection, partly because parts of the ships can be perpendicular to the radar signal, and finally since metal is very reflective for the radar pulses.

Radar images have been used for a number of years to monitor and detect oil spills from ships. Kongsberg Satellite Services in Tromsø, Norway, provides real time services for certain shipping routes (KSAT 2009). Natural oil seepage appears in a similar manner in radar images, as dark patches or areas. The typical patterns from ships are more linear (figure 3), often showing the route of the ship and sometimes the ship is detected as a bright spot at the end of the dark line. Oil seeps can appear in more than one place simultaneously, and the pattern it creates on the surface is predominantly marked by wind and ocean currents at the time (figure 4). If oil stays on the surface for a while, the effects of wind direction and strength will start to show and the pattern will become more linear. After few hours, the oil at the surface will start to dissipate and spread and might become harder to detect.

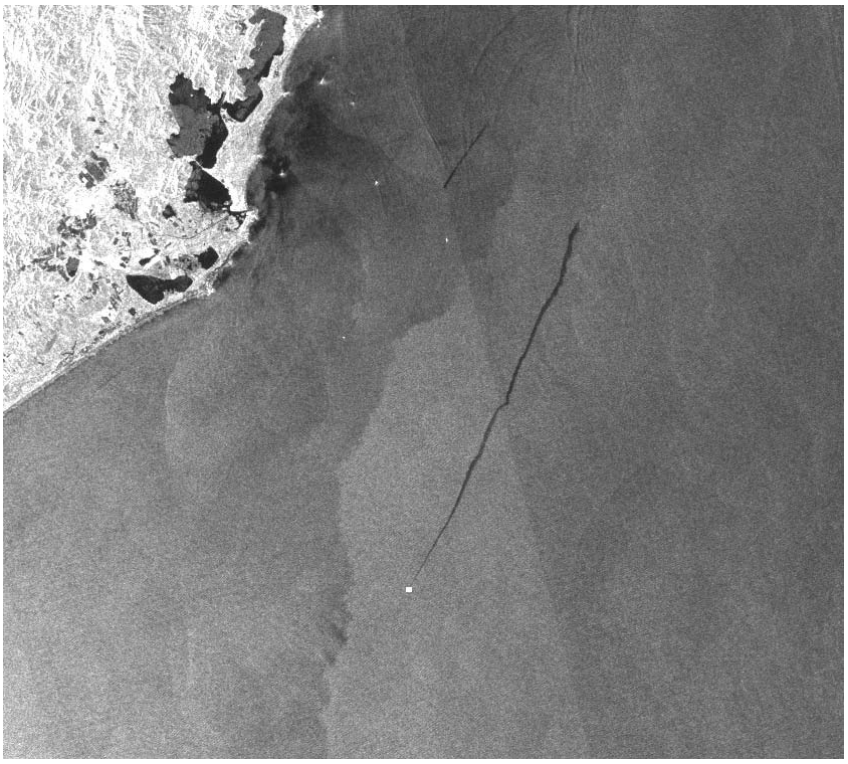


Figure 3. Oil spill from a ship off the coasts of Brazil. (KSAT 2009)

Figure 4. Marine oil seeps. (MDA 2009).

Methods

All available ENVISAT SAR images covering the Dreki area from the years 2006, 2007 and 2008 were examined on the Polar View browser (www.seaice.dk) of the Technical University of Denmark. The browser has a user manual (DCRS 2009). Roberto Saldo added a vector file with the outline of the Dreki area to the java program, which made all analysis much quicker. Every image was registered and classified according to orbit time, image resolution and quality, and further interpreted with possible oil slicks of natural origin in mind. Brief comments on noticeable weather related phenomena in the images were also noted. Possible and likely oil slick patterns were digitised into a geographical information system (GIS) ArcInfo. All the images for the years 2006, 2007 and 2008 are available on the Polar View browser.

An excel spreadsheet with comments on all the images will also become available as well as shapefiles for GIS.

Results

The results will be presented on a monthly basis for the year 2008 in this report, a detailed excel sheet for the year 2007 with one case study presented in the report. Relatively few images were of use from the year 2006.

Case study for June 2007

Interesting linear patterns were observed on a number of ENVISAT SAR images in June 2007. High resolution images were ordered for three dates: 15.6., 16.6 and 18.6. The Icelandic Coast Guard confirmed the presence of ships in the region at the time, and the Marine Research Institute gave detailed positions of herring ships in the Dreki region (figure 5). Quite a lot of fish oil is associated with herring fisheries (figures 6-8).

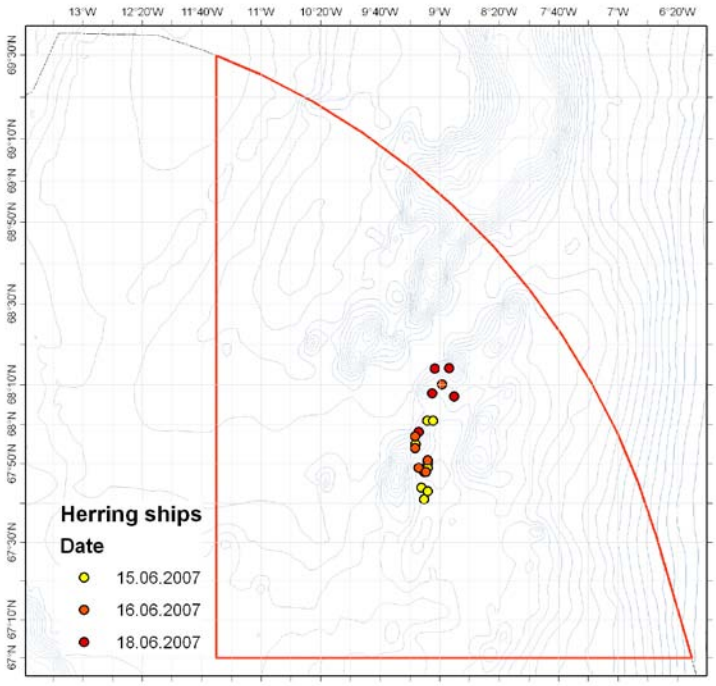


Figure 5. Position of herring ships on 15.-18.6.2007. Information from Þorsteinn Sigurðsson at the Marine Research Institute.

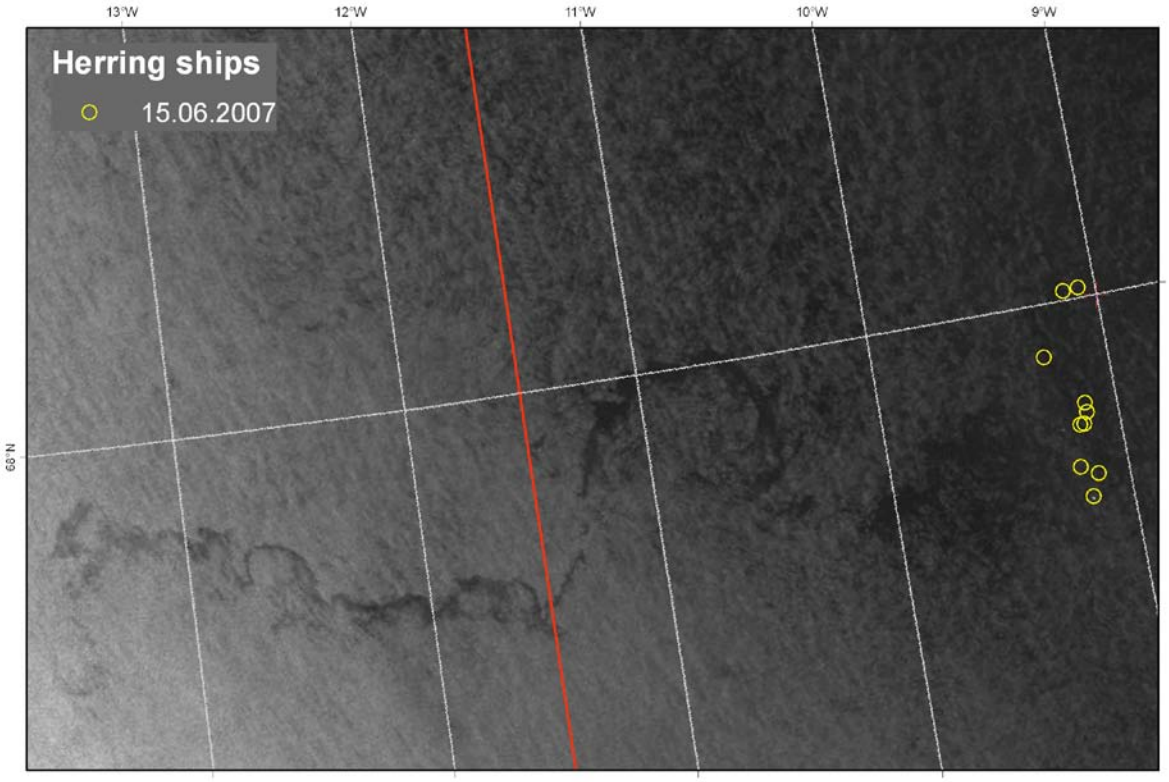


Figure 6. Herring ships and associated slick on June 15th 2007.

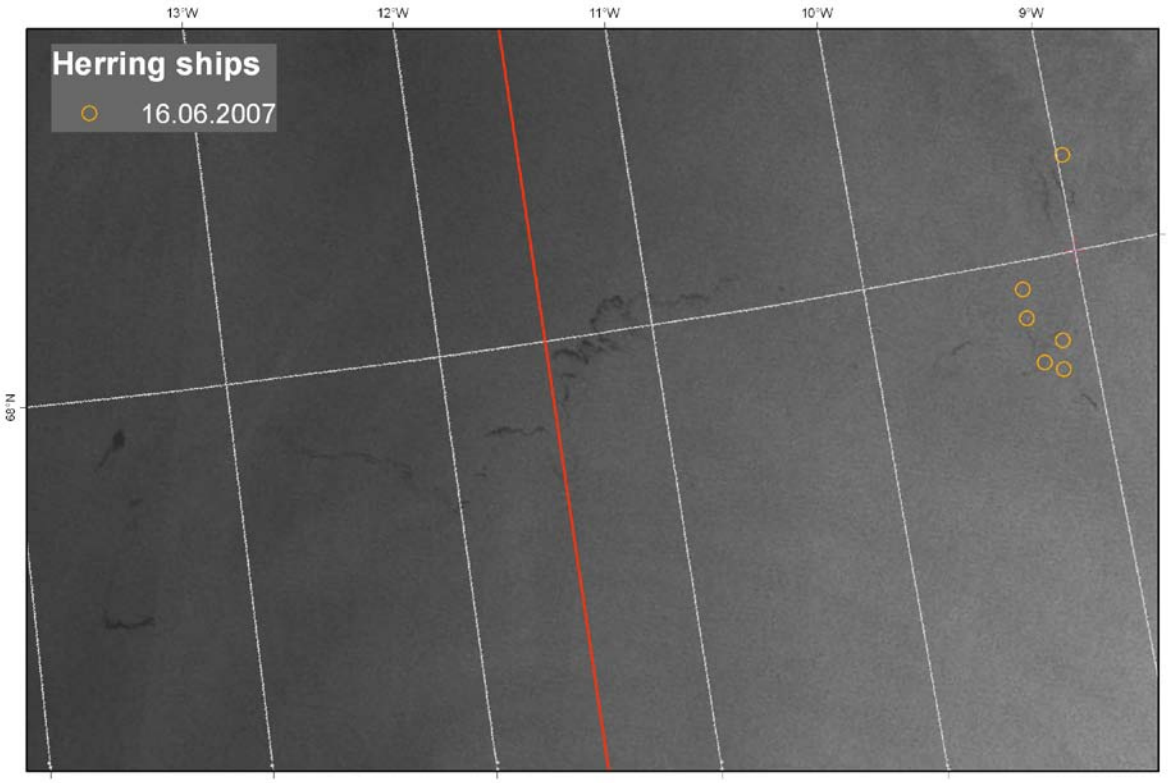


Figure 7. Herring ships and associated slick on June 16th 2007.

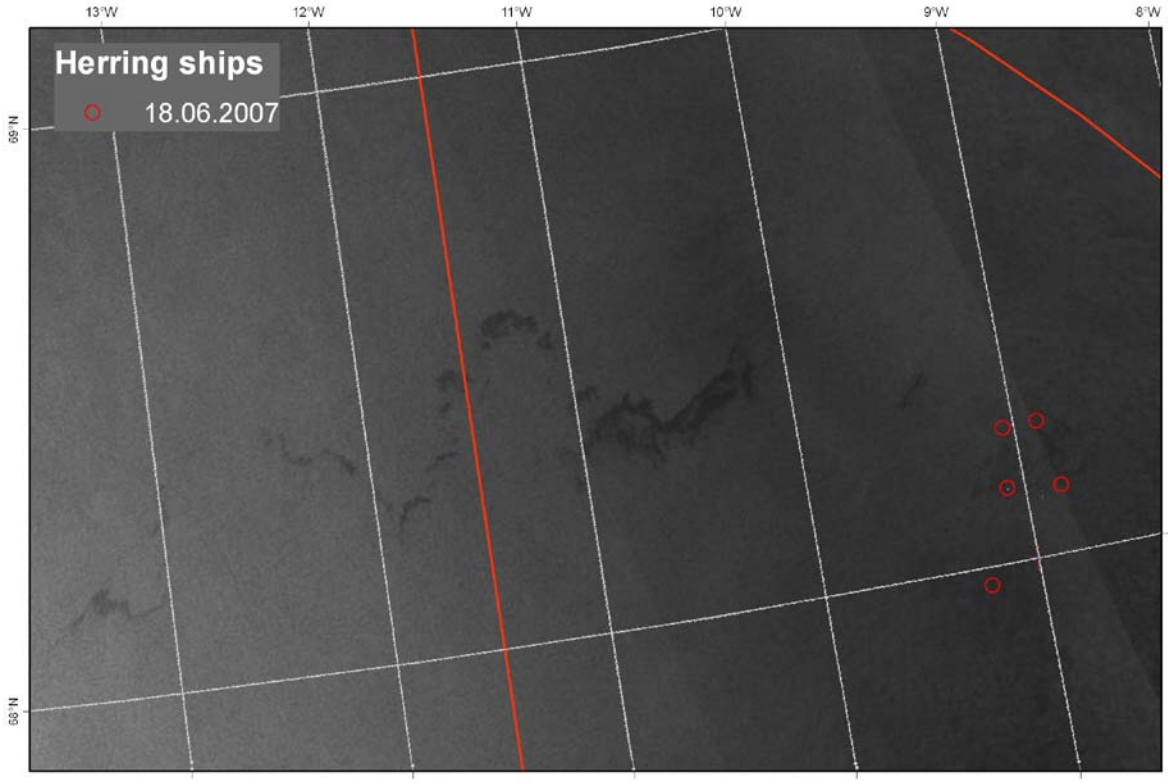


Figure 8. Herring ships and associated slick on June 18th 2007.

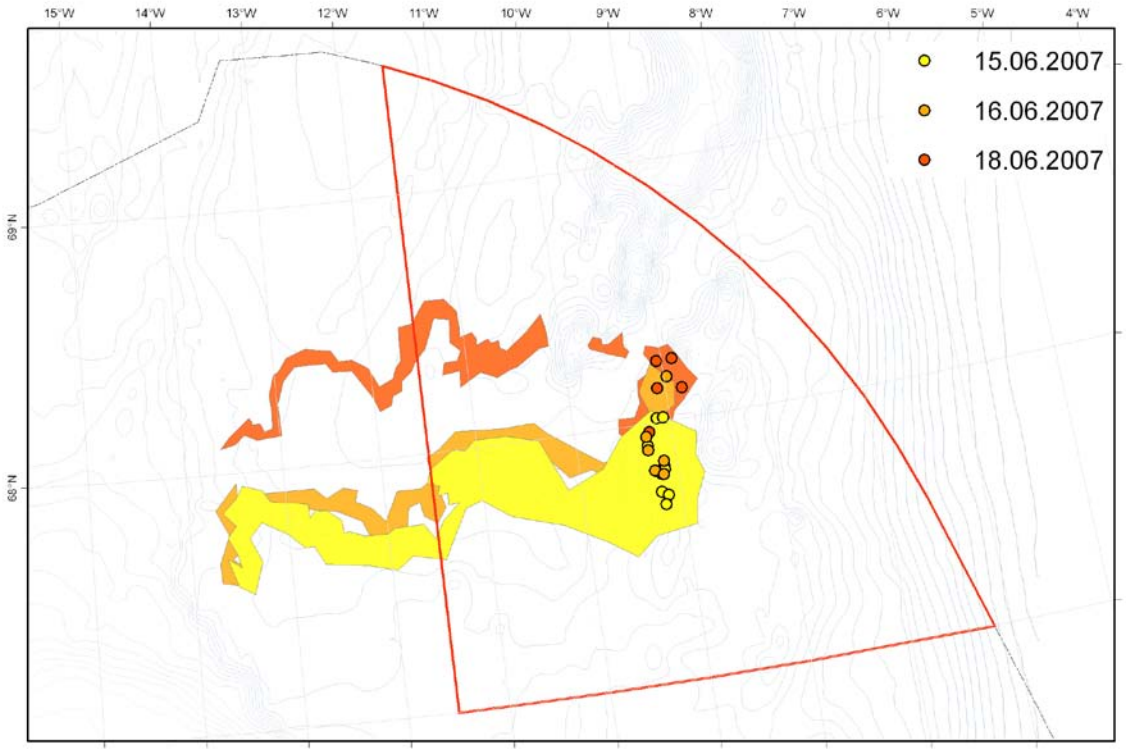


Figure 9. Herring ships and associated slicks from June 15th to 18th 2007. Winds were from S to SE at the time.

Summary for 2008

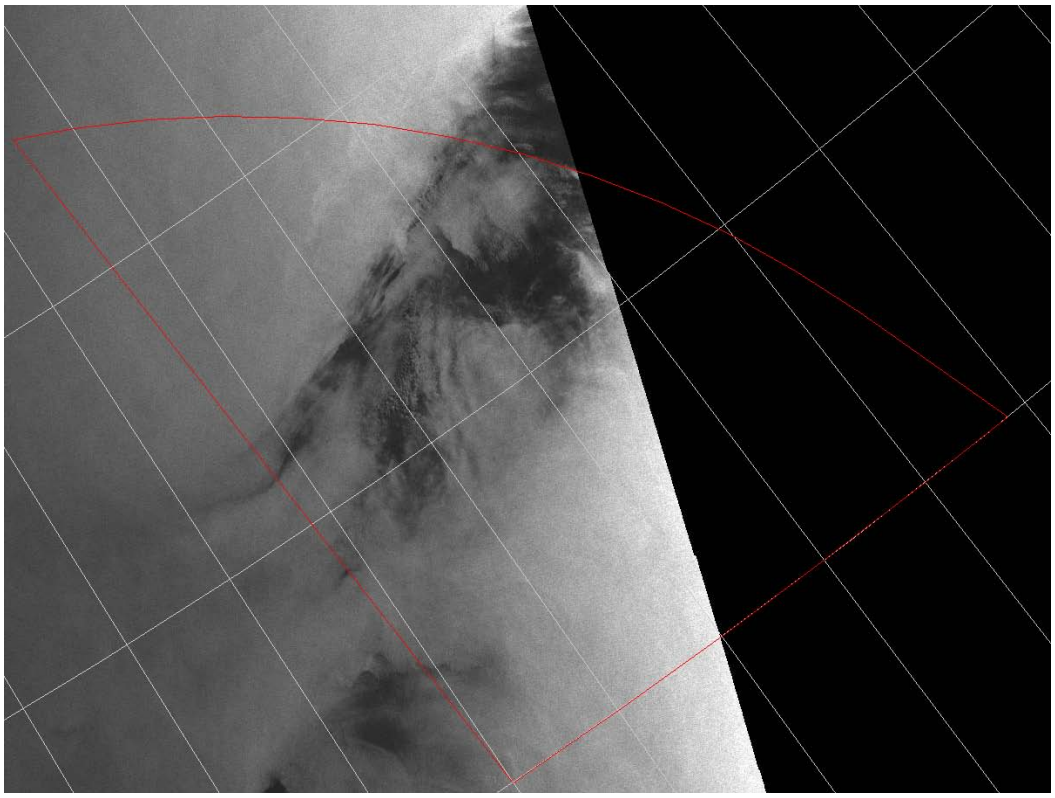
January 2008
Good images were obtained on January 2., 8., 11., 12., 18., 21. 22, 24, 25 and 27. None of them showed patterns that could be linked with oil seeps though many of them showed weather related patterns (fronts etc.).
Images of low quality were available on January 3., 5., 6., 14., 20, and 31.
Dates of no images, or images only showing a fraction of the Dreki area, are January 1., 4., 7., 9., 10., 13., 15., 16., 17., 19., 23., 26., 28., 30.

February 2008
Good images were obtained on February 2., 3., 12., 13., 15., 16., 18., 20., 21. 22. and 23. None of them showed patterns that could be linked with oil seeps though many of them showed weather related patterns (fronts etc.).
Images of low quality were available on February 19., 25., 26 and 28.
Dates of no images, or images only showing a fraction of the Dreki area, are February 1., 4., 5., 6., 7., 8., 9., 10., 11., 14., 17., 24., 27., 29.

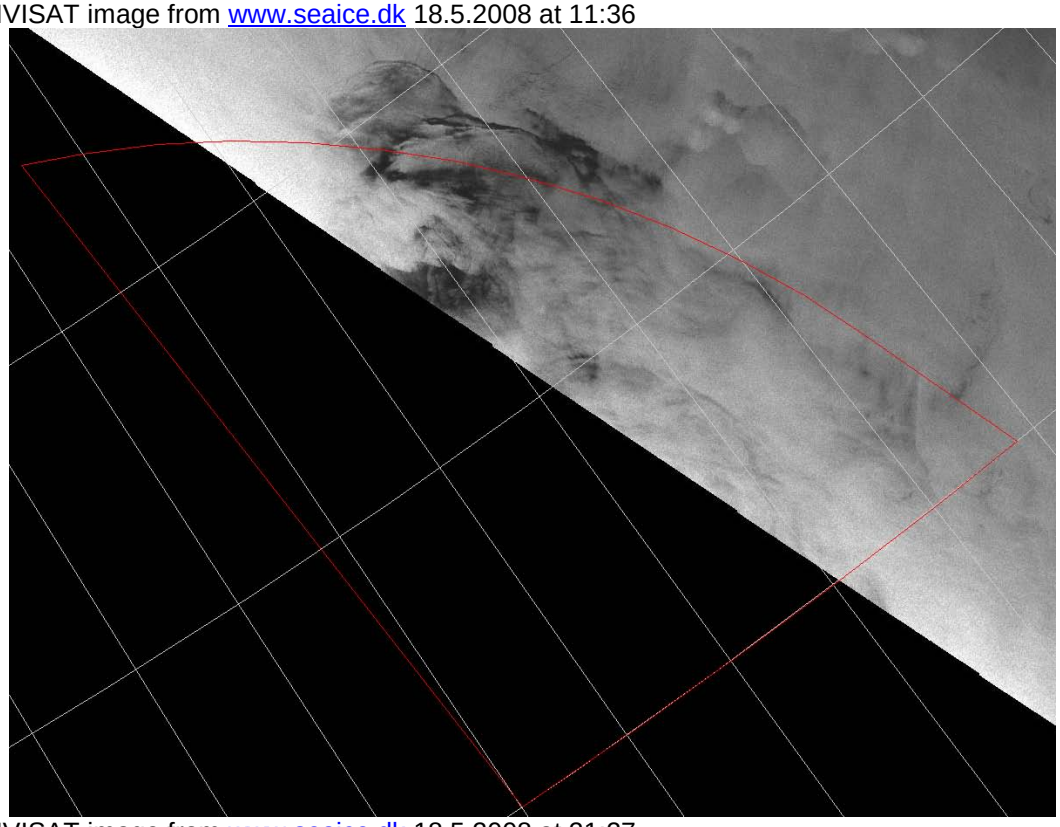
March 2008
Good images were obtained on March 2., 3., 4., 6., 8., 25., 27. and 30. None of them showed patterns that could be linked with oil seeps though many of them showed weather related patterns (fronts etc.).
Images of low quality were available on March 7., 9., 10., 12., 13., 14., 15., 16., 17., 18., 19., 20., 22., 26., 28., 29. and 31.
Dates of no images, or images showing only a fraction of the Dreki area, are March 1., 5., 11., 21., 23. and 24.

April 2008
Good images were obtained on April 7., 8., 9., 10., 11., 12., 13., 14., 15., 16., 17., 18., 20., 22. and 26. None of them showed patterns that could be linked with oil seeps though many of them showed weather related patterns (fronts etc.).
Images of poor quality were available on April 1., 2., 3., 4., 6., 19., 23., 24., 27., 28., 29. and 30.
Dates of no images or images showing only a fraction of the Dreki area, are April 5., 21 and 25.

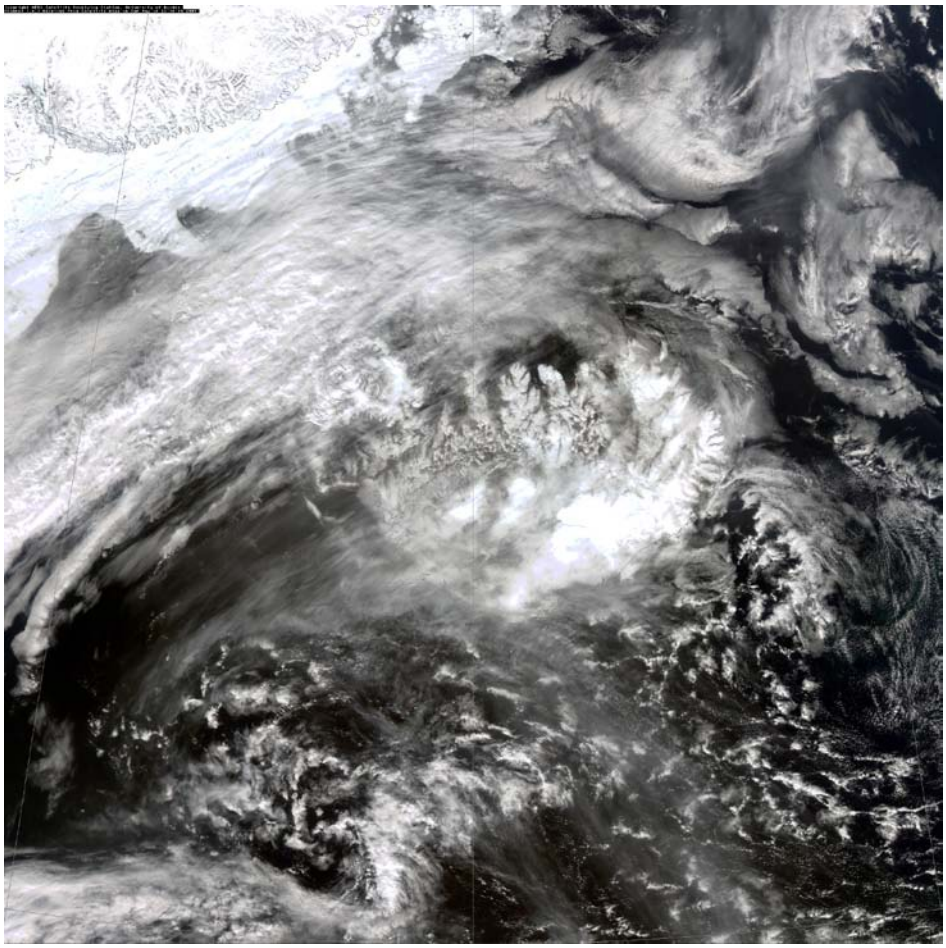
May 2008
The images from 18.5. showed interesting patterns though comparison with MODIS images suggest they are weather related. The ENVISAT image from the evening shows dark lines and patterns to the east of Dreki, and might be worth further study.



ENVISAT image from www.seaice.dk 18.5.2008 at 11:36

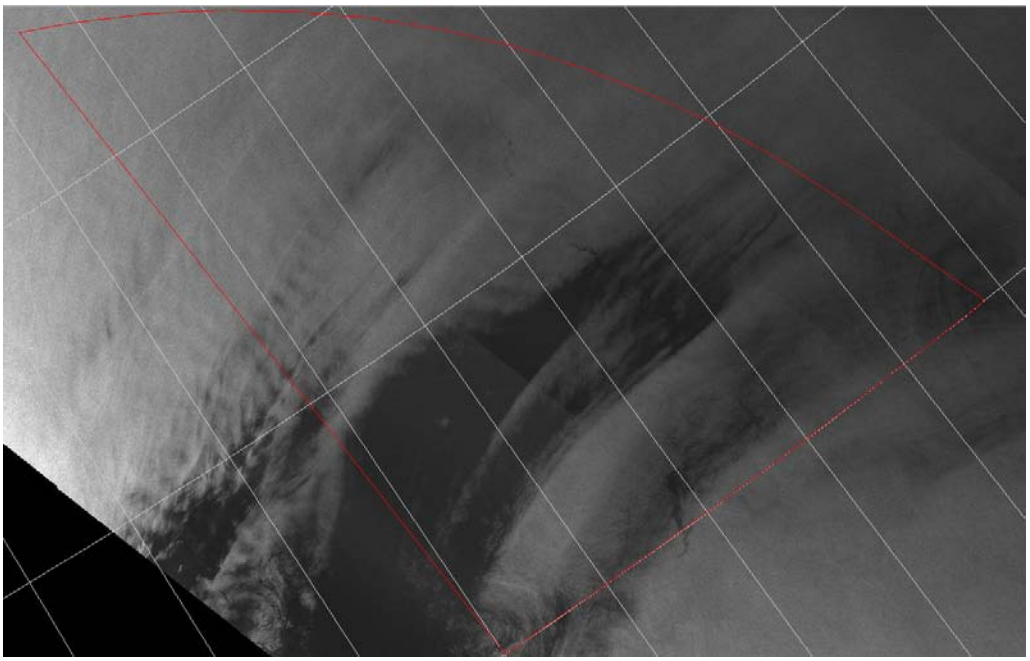


ENVISAT image from www.seaice.dk 18.5.2008 at 21:27

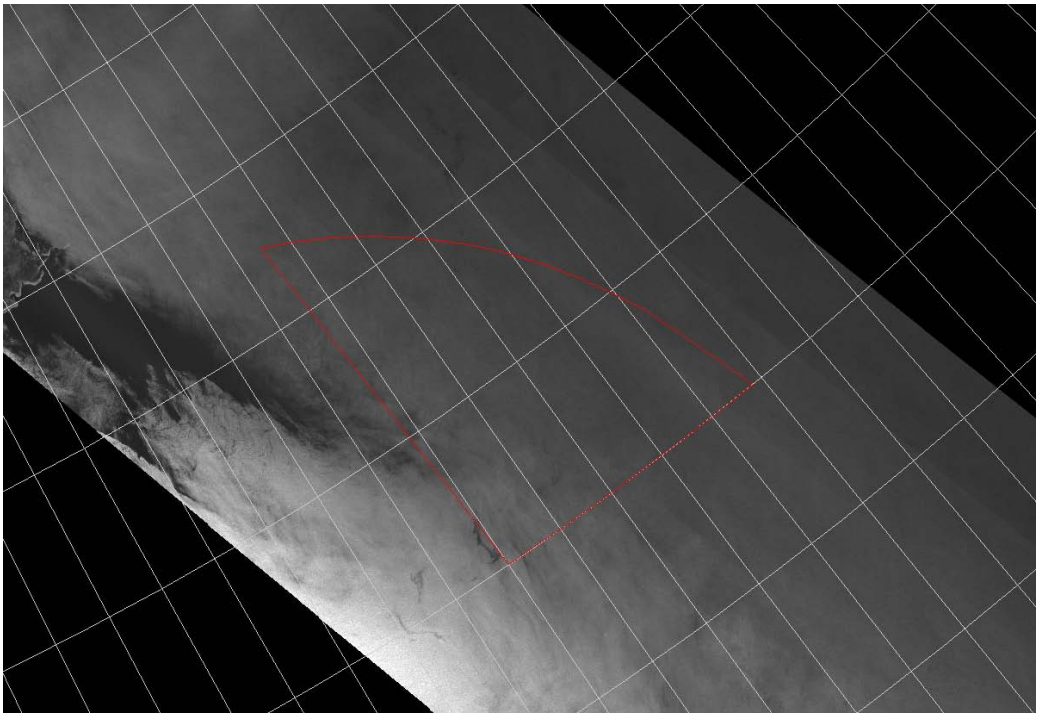


MODIS colour image from Dundee Satellite Receiving Station 18.5.2008 at 13:34

Images from 27.5.2008 were interesting since they contain dark lines and patterns, though they are affected by weather systems and therefore hard to interpret.



ENVISAT image from www.seaice.dk 27.5.2008 at 21:45.

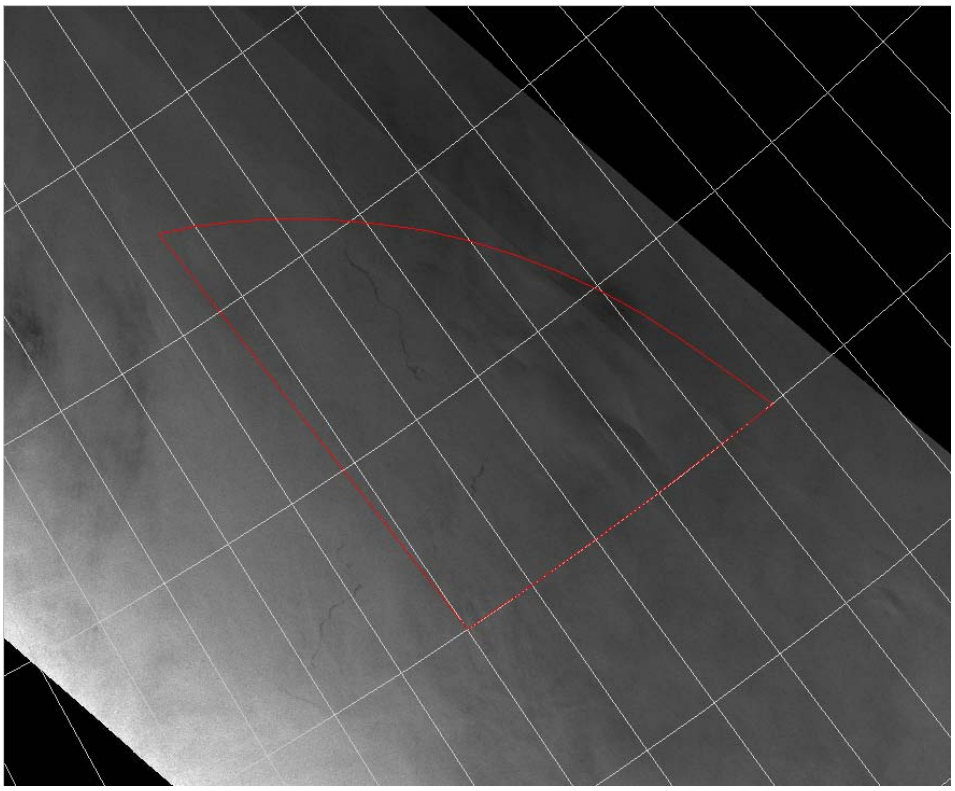


ENVISAT image from www.seaice.dk 30.5. 2008 at 21:51

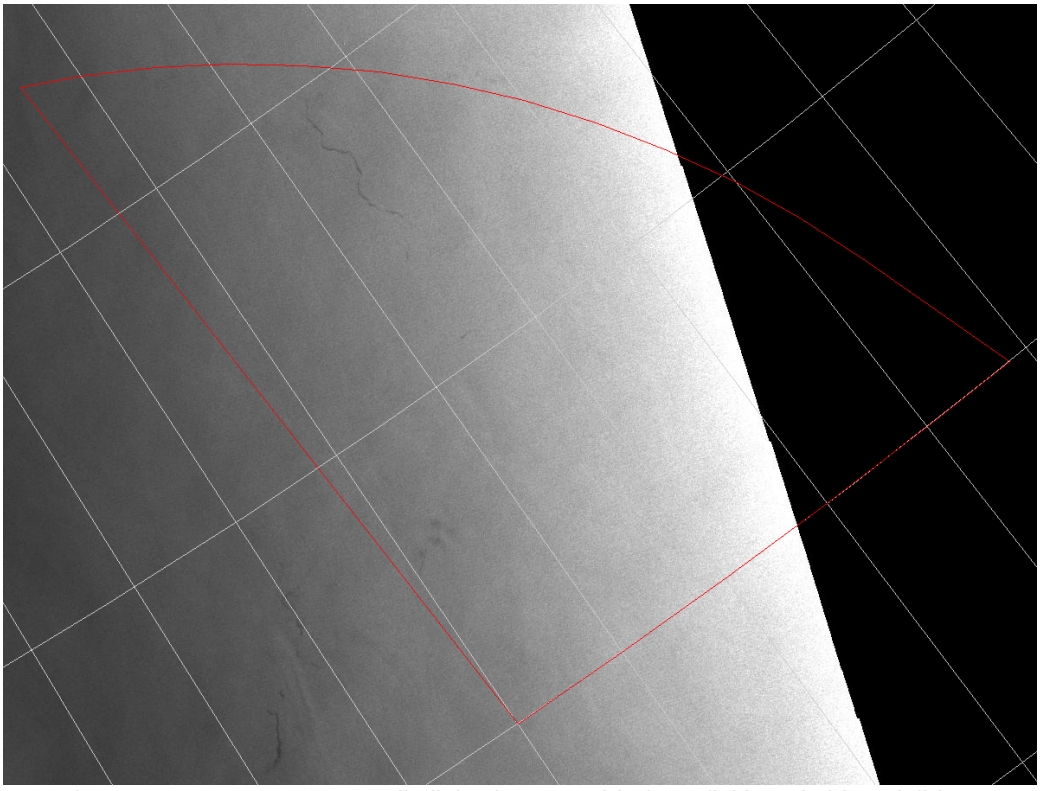
The image from 30.5. shows familiar pattern, which is likely to be connected to fishing ships in the area and one ship can be seen to the NW of the Dreki area.

Good images were obtained on May 1., 2., 3., 5., 6., 8., 10., 11., 13., 14., 15., 17., 18., 19., 21., 22., 24., 25., 27., 28. and 30. Some of them contained interesting patterns but it is very difficult to distinguish them from weather related patterns. Some of the lines might be due to fish oil from the herring ships.
Images of poor quality were available on May 9., 12., 16., 29. and 31.
No images were available on May 4., 7., 20., 23., and 26.

June 2008
The browser was down from 10.6.-17.6. so no images were available during that time. At the beginning of the month, a few images showed interesting patterns.



ENVISAT image 2.6.2008 21:57. Oil slicks (presumably from fish) and ships visible.



ENVISAT image 3.6.2008 at 11:29. Oil slicks (presumably from fish) and ships visible.

More interesting images were available in this month, all showing similar patterns.

Conclusions

This study does not confirm the existence of natural oil seepage from the Dreki area. No patterns similar to figure 4, with multiple epicentres showing the same drift pattern, were observed. However, single spots of calmer waters that could not be connected to ships or weather patterns were observed. It would be very interesting to examine these better and look at other image types from the same dates as well.

Oil slicks can only be observed when winds are relatively low. In the Dreki area, such conditions occur mainly in the spring and summer months whereas winds, and concurrent high waves, tend to prevail in the autumn and winter months. When conditions for studying natural oil seepage in the Dreki area are optimal, a number of herring ships are in the area, leaving trails of grease from the fish. The trails can become a few hundred km long. Shorter trails, that could also be oil seepage from the ocean floor, have also been observed but have to be studied in more detail. The Marine Institute in Iceland and the Icelandic Coast Guard were consulted to confirm the presence of ships in the region at the time of the satellite overpasses. Most of the trails could be connected to known ships in the area. However, a few patches that could not be connected to ships were observed, though mainly outside the Dreki area.

A few more images will be ordered in higher spatial resolution in order to attempt distinguishing between natural oil seepage and grease from fishing ships. A follow on study could include studying the weather and wave condition in the area at the same time as images were obtained. It would also be worth collecting more data on navigation in the area, though it is unlikely that all ships could be caught.

It should be possible to detect natural oil seeps in ENVISAT WSMF images (300m resolution), possibly in ENVISAT WSM images, but the ENVISAT GMM low resolution images that were also utilized in the project were of no or little use.

Further work

There are few occasions where it would be interesting to order high resolution images to study the patterns in more detail, especially single spots of calmer waters that appear in some of the images.
It is worth looking at MODIS and MERIS images for comparison, since studies elsewhere have shown that oil seeps can appear very clearly in the sun glint parts of the images.
Since a lot of the patterns were associated with herring ships, it would be good to get more information on ships in the area in order to distinguish better between fishing related patterns and possible oil slicks.
Finally, it is worth looking at weather information in more detail, and study in more detail how oil seepage patterns have been observed in other regions at similar water depths, in order to have a better understanding on what patterns to expect in the Dreki region.
Finally, it would be worth studying the whole Jan Mayen ridge region for natural oil seepage patterns.

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The authors would like to thank Þórarinn Sveinn Arnarson and Kristinn Einarsson at the National Energy Authority for introducing us to the project. Roberto Saldo at the Technical University of Denmark for maintaining the www.seaice.dk browser and for helping us with the project.
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The Icelandic Coast Guard for information related to navigation in the area and oceanic conditions in the Dreki area.

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