# Norwegian Computing Center's
# ENVISAT AO projects

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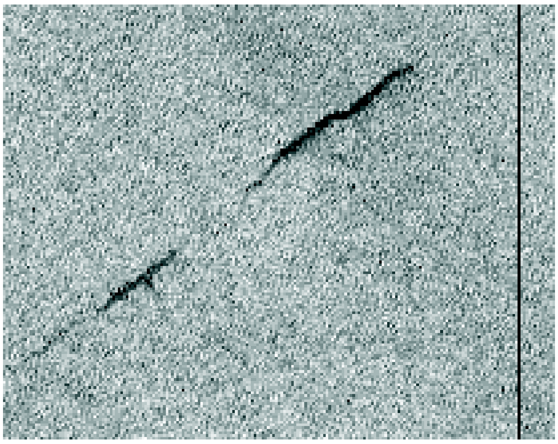
The Norwegian Computing Center's Remote Sensing Group (NCC) is involved in three ENVISAT AO projects. The themes of the projects correspond to key research areas in NCC: automatic detection of marine oil spill, snow monitoring for natural resource and climate applications, and land vegetation monitoring by spectrometry. The projects are presented in the following.

## Marine oil spill detection

Intentional oil spills from ships cleaning their oil tanks pose a significant treat to the environment. The Mediterranean Sea is a fragile ecological and economic area with frequent oil pollution, both intentional and accidental. It is estimated that around 330,000 tonnes of oil are deliberately dumped there each year. Other figures indicate that there may be as much as 1,000,000 tonnes dumped each year (five times the Amoco-Cadiz pollution).

A promising technique for monitoring a large sea area for oil-spill early warning is by means of satellite SAR. ERS-1 and 2 have been used for manual oil spill detection in North Europe for several years. With Radarsat and ENVISAT, frequent satellite coverage will be possible. The combined coverage of Radarsat and ENVISAT has the potential of near daily coverage. Despite the fact that large ships clearly can be located in a SAR image, they cannot be positively identified. However, expected new regulations requiring a GPS position recorder to be on ships carrying hazardous cargo will make it possible to identify the ship which dumped the oil with less requirement for extremely frequent coverage. One image a day could be sufficient. Frequent coverage also opens the possibilities of using SAR images not only as an early warning of an oil spill, but also as an aid during a possible clean-up operation or when monitoring a spill to see if it is a treat to fragile coastal zones or fisheries.

The role of an automatic oil spill classification algorithm in a system for environmental monitoring is to screen a large number of images to identify objects with a high probability of being oil slicks. These possible oil slicks are then presented to an operator for manual inspection. Presently, we do not believe that a fully automatic oil spill detection algorithm will be able to correctly discriminate between the most difficult oil slicks and their look-alikes. However, a semi-automatic procedure will greatly reduce the number of SAR images which need to be manually inspected compared to a fully manual detection procedure. Automatic methods are becoming more and more important as the amount of data to analyse increases with better coverage.



**Intentional oil spill released from a ship washing its oil tanks as observed by the SAR on ERS-2. The better temporal coverage of Envisat's ASAR makes effective oil-spill monitoring promising.**

Automatic identification of oil spills in SAR images is a very complex task because objects which resemble oil spills (called look-alikes) frequently occur, particularly in low wind conditions. Examples of oil spill look-alikes are organic film, grease ice, wind front areas, areas sheltered by land, rain cells, current shear zones, internal waves and up-welling zones. The SAR signature of an oil spill will depend on the external conditions. The contrast between the

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spill and its surroundings depends on a number of parameters like wind speed, wave height, and the amount and type of oil released. The shape of the spill will depend on whether the oil was released from a stationary object or from a moving ship, the amount of oil involved, and the wind and current history between the release and the image acquisition.

A framework for automatic detection with the following main elements has been developed at NR: (i) detection of dark spots; (ii) spot feature extraction; and (iii) dark spot classification. Advanced statistical modelling has been used to incorporate external information about location, weather conditions, and the expected contrast between the slick and its surroundings. All these parameters have been studied for the ERS SAR sensor using low-resolution images with a pixel size of 100 x 100 m. With the use of ENVISAT ASAR Wide Swath data, which has a different spatial resolution and different signal-to-noise characteristics and efficient number of looks, the algorithms need to be modified. The study will also include a few ASAR image mode medium resolution images to test if a higher radiometric resolution allows significantly better detection capabilities.

**Snow cover map of South-West Norway derived from ERS-2's ATSR-2 (green corresponds to snow-free, white to snow, brown to glacier, grey to clouds). Envisat's ASAR, MERIS and AATSR are promising for a multi-sensor approach to monitoring of snow variables.**

We have selected four test sites: one in the North Sea, one in the English Channel and two in the Mediterranean. The site in the North Sea is centred at the Troll B oil platform. The site covers an area with many oil platforms. Small oil outlets from platforms are quite common, making the probability of observing an oil spill in the test images high. The second test site is from the English Channel, where heavy ship traffic is forced through a narrow ship route. The third and forth test site are from the Mediterranean and represent areas very vulnerable with respect to pollution. The Delta Ebro region in Spain includes the major ship routes to Barcelona, Marseilles and Terragona. The Cyclades region in Greece covers the ship routes to Athens, to/from the Black Sea and to/from the Suez Channel. They have a high probability of observing oil spills.

# Snow parameter mapping

Monitoring of the seasonal snow is important for several purposes. In northern regions, the snow may generate more than half the annual runoff, putting specific demands on the models and other tools employed in managing this water resource. Risk of flooding enhances this demand, both in areas with stable winter coverage, and in areas only occasionally covered with snow. Snow is also an important natural resource for the hydropower industry. In the mountainous areas and in the whole Northern Europe, snowfall is a substantial part of the overall precipitation. In Finland 27% and in Norway about 50% of the annual average total precipitation is snow. Also, snow covered ground affects the energy exchange processes developing weather and climate, both locally and in large regions, and is an important element in meteorological and climate modelling. The snow pack, itself causes avalanches every year in alpine regions, enforces a high priority road clearing service both in cities and in rural areas, and affects many other aspects of human life.

Remote sensing instruments are the means of continuous monitoring of the snow cover, as successfully demonstrated in, e.g., Norway, Finland and USA. In the future, remote sensing, mainly by polar orbiting satellites, will play a key role in deriving information about the snow.

Some of the snow parameters can to some degree be measured by means of more than one remote sensing technique. The techniques may be complementary in the way that one technique works best under one condition while another technique works best under a different condition. Or several techniques could be combined if they work under similar conditions. This may be fruitful for improving spatial and temporal coverage, e.g. due to the cloud cover problem with optical data, or improve the accuracy by measuring the same parameter by different methods. Each of the parameters relevant for a multi-sensor approach is commented below:

## Snow cover area

The currently most accurate method of snow cover mapping is by means of optical techniques. However, this approach depends on cloud-free conditions. Wet snow cover can be mapped by SAR in areas with low vegetation. For mountainous areas, the zone of partial snow cover is usually the zone of snowmelt. Hence, this is the area needed to monitor most frequently. The high-elevation zone will probably remain snow covered for a longer period, and the low-elevation areas will probably remain snow free. This situation allows one to use a time series of less frequent optical images to map the low-frequent changes of snow cover and to use SAR to map the frequent changes in the melting zone. When both optical and SAR data are available, the combination can be used to improve the accuracy. The combinations of ENVISAT ASAR and AATSR will be tested for snow cover mapping. The higher spatial resolution of MERIS will also be studied and compared to ASAR.

### Snow wetness

Snow surface wetness may be used to more accurately predicting the time of snowmelt onset and the potential for a rapid release of liquid water. Snow wetness may be measured by both optical and radar methods. A special technique based on molecular absorption by water will be investigated using MERIS data. It has the potential of very accurate measurement of the water concentration. ASAR is very sensitive to the presence of liquid water in the snow and may be used as a qualitative water indicator. The combination of the two instruments will also be studied.

The work will be carried out as a collaboration between NORUT (principal investigator) and NR and Helsinki Technical University (co-investigators). The experiments are planned to take place at five test sites: Tuusula, Naamanka, Sodankyla in Finland and Heimdalen (Jotunheimen) and Kongsfjellet (Nordland) in Norway.

## Environmental land monitoring by imaging spectrometry

Long-term monitoring of vegetation on global and regional scales is an important environmental task. The goal of the proposed study of ENVISAT data is to automatically classify satellite data into coarse land cover types and predict biophysical parameters describing the type and conditions. The land cover classes will include different vegetation classes like spruce, pine, deciduous forest, low vegetation (found in mountain areas) and vegetation-free non-habitant regions (e.g., bare rock). In addition to the land cover class, parameters related to important environmental indicators like the amount of green vegetation, stress agents, and moisture stress index will be derived. The developed methodology may be considered to be part of Norway's establishment of a long-term environmental database for land areas. Mapping the status and conditions of vegetated regions may be performed every 5 or 10 years.

The amount of green vegetation may be derived from the leaf area index. Indicators of stress will be found by studying various chlorophyll parameters and the slope and position of the so-called red edge spectral feature from time series of images. Derivation of the moisture stress using MERIS will be attempted even if this sensor is not optimal for that purpose. Added information from the AATSR might be very useful to improve the capability of moisture stress mapping.

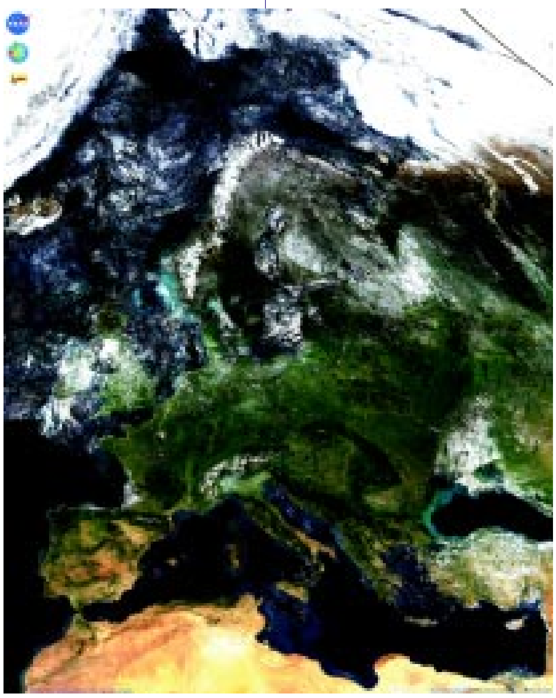
To derive robust estimates of biophysical parameters a time series of images acquired every second week during the growing season will be used. Only scenes, which have less than 10% cloud coverage for the test sites and their surroundings, will be used. AATSR images acquired simultaneously with MERIS data will be used for automatic identification of local regions with cloud coverage.

Three test sites in Norway have been selected: the Bardu site, the Ringebu site, and the Sandefjord site. These are test sites for the CORINE land cover mapping, and a large amount of field data, aerial images and vegetation maps are available for the sites. Each site covers an area of size18 x 23 km. The Bardu site has large local contrasts in forest of different type and marsh vegetation in elevations between 50 and 1500 m. The Sandefjord area consists of a complicated coastal terrain with mixed forest vegetation. It covers an elevation range from zero to300 m, and it is heavily cultivated. It contains large moraine regions, large agricultural areas and luxiriant vegetation. The Ringebu area represents a typical mountain range in southern Norway. Different vegetation types are found at different elevation ranges (from 200 to 1400 m).

For each test site, current map data and high-resolution satellite data from Landsat TM or SPOT will provide test and training data in establishing algorithms for classification based on MERIS data. Sub-pixel algorithms will be used to derive parameters on a finer scale than the 300 m resolution of the MERIS data. Based on training data from one or more of these sites, the robustness in predicting the vegetation parameters for a different site will be evaluated.

After completing the proposed study, we will have determined the suitability of medium resolution satellite data for mapping environmental parameters for the given land cover types. If the conclusion is that medium resolution data are suitable, then we will identify and describe the necessary improvements or developments of the methodology before it can be used operationally.

The work is collaboration between Norwegian Mapping Authority - Environmental Unit, Norwegian Institute of Land Inventory (co-investigators) and Norwegian Computing Center (principal investigator).



**A mosaic of several Terra MODIS images. Envisat's MERIS and AATSR sensors will in a similar way be suitable for monitoring the environmental status of vegetation at national, regional and global scales.**