ENVISAT preparations at the Norwegian Defence Research Establishment

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Space-based maritime monitoring and surveillance has been a focus area for The Norwegian Defence Research Establishment (FFI) for over a decade. Throughout the ERS and RADARSAT-1 era, FFI has performed applied research that helped establish today's operational services for radar satellite-based oil spill and fisheries monitoring in Norway. Through analysis of some 2-3000 synthetic aperture radar (SAR) images, ground rules were established for capabilities and limitations of the ERS and RADARSAT-1 instruments in monitoring fishing vessels, oil spills and many oceanographic and meteorological processes. The experience also helped us to anticipate capabilities of new satellite systems such as the Advanced Synthetic Aperture Radar (ASAR), part of the ENVISAT payload. As the European Space Agency launched its ENVISAT Announcement of Opportunity (AO) programme for research and demonstration projects in 1998, Some of the answers lie in three proposals that were submitted to ESA in 1998, and later approved as part of ESA's ENVISAT AO programme.

Flexible imaging geometry and wide swath coverage, while unavailable on ERS-1 & 2, are familiar features of RADARSAT-1. Thus, the most obvious new ENVISAT SAR capability is the Alternating Polarization mode (ALTPOL), providing a dual-polarized imaging mode that is hitherto untried in routine space based Earth observation. Furthermore, huge technical advances have been made in on-board data storage, as well as data downlinks and satellite communications. This means that SAR imaging access to more remote regions is greatly enhanced, and opens up new possibilities in use of such data for routine observation. With ENVISAT it will be possible to image remote regions and downlink data either via the geostationary relay satellite Artemis, or store it on board for downlink to a location ground station in Scandinavia.

Ocean areas under Norwegian jurisdiction

The AO proposals therefore focus on three topics: 1) Use of ALTPOL mode data for ship detection and fisheries monitoring, 2) Detection and monitoring of fishing vessels and ice bergs in the South Atlantic and Antarctica, and 3) Observation and monitoring of urban scatterers with multiple incidence angles and polarization. The following paragraphs give a brief presentation of the projects

ALTPOL mode for ship detection

The Norwegian focus for operational satellite radar-based ship detection has, so far, been concentrated on monitoring the remote areas of Jan Mayen and the northern Barents Sea. With such a vast area to monitor (see Fig 1), wide area coverage is of prime importance for locating fishing fleets and doing directed patrol flights with aircraft when necessary. With RADARSAT-1, our experience has shown that the ScanSAR Narrow Far mode provides

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Dan J Weydahl graduated from University of Salford, UK, in 1988, and joined FFI to work on terrestrial applications of SAR. He completed a doctoral thesis in 1998 on change detection using satellite SAR.

the best combination of resolution (50m) with coverage (300 km × 300 km per scene). Also this mode looks fairly far off to the side (30º-45º incidence angles), which reduces clutter from the ocean surface and enhances ship-to-sea contrast. This is helped further by RADARSAT-1's horizontally polarized radar signals, which provide lower return from the ocean than the vertically polarized data of ERS-2. For ENVISAT Wide Mode, however, resolution has been sacrificed for, among other things, image quality, and the smallest detectable vessel is predicted to be about twice that of RADARSAT-1 for optimum conditions. The ALTPOL mode, while not providing such wide coverage, will, however, provide the opportunity to receive data not only with the transmitted polarisation (e.g. VV for vertically polarised transmit and receive), but also the opposite polarisation (e.g. VH). Scatterers with complex geometry can reflect strongly in both of these cases, while the ocean backscatter will be greatly subdued for VH or HV images, even for steep incidence angles. This means that we have much greater choice of beams and coverage for acquiring low-backscatter images over the ocean. The question then becomes – do ships have "complex geometry" for radar reflection? If so, we should have good contrast between them and the ocean even for steep incidence angles, but not everyone is convinced that this is the case. Proof of the pudding will be when we acquire the first ENVISAT ALTPOL data over the ocean, which is proposed to be done in the North Sea, Straits of Dover and the Oslofjord. This should provide a large variety of ships where we can also obtain some complementary data for evaluating the results.

Feasibility of ENVISAT ship detection for fisheries enforcement in the South Atlantic/ Antarctica

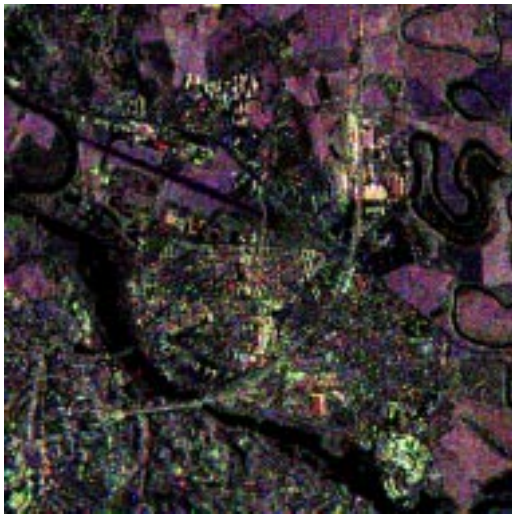
Norway is one of the signatories to the CCAMLR convention (Convention on the Conservation of Antarctic Living Marine Resources), which came into force in 1982 and regulates the ecosystem management around Antarctica. However, because of the enormous areas covered by the Convention and the large distances to populated areas, actual enforcement of the regulations is a very complex task. So new technology is needed, and ENVISAT offers a possibility for quick access to SAR imagery, and thus detection of fishing vessels in these Southern waters. However, a key question will be whether it is possible to distinguish between the SAR signature of ships and icebergs of similar size. The project will study the Antarctic iceberg SAR signatures, and demonstrate fast monitoring of selected South Atlantic and Antarctic waters. The project will mainly involve scientists from FFI and Norwegian Polar Institute. Assuming a successful launch of ENVISAT in early 2002, we expect the main project period to be the first half of 2003. The SAR imagery will mainly be acquired over waters around Bouvet Island and coastal waters outside Dronning Maud Land (see Fig 2).

Map of the South Atlantic showing Bouvet Island.

Observation of urban scatterers

Incidence angle, aspect angle, resolution and polarisation are important factors contributing to the radar backscatter properties of objects. FFI has already conducted studies of the incidence angle (Fig 3) and aspect angle effects on radar satellite images by using a combination of ERS and RADARSAT-1 data. The results show that merging SAR backscatter from two or more incidence angles leads to a more complete picture of the amount of man-made objects present within a given geographical area.

With ENVISAT, polarisation will be included in these studies. The project "Analysis of ASAR polarization signatures from urban areas using multiple incidence angles" will be conducted in the period 2002-03. The main test area for image acquisition will be Lillestrøm 20 km east of Oslo. It is believed that the polarimetric dimension will add further knowledge about man-made objects. This will in turn lead to recommendations with respect to the optimal combination of ASAR imaging modes for monitoring of scatterers in urban areas.



This picture is a combination of 3 RADARSAT-1 images acquired over the Lillestrøm area in Fin Mode. The images are combined into one picture using the red, green and blue channels. The image in each channel was acquired at a different incidence angle: 38.5 ^{0} (red), 43 ^{0} (green), and 46.7 ^{0} (blue).