

Polar View – A Breakthrough for Serving Northern Communities

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ABSTRACT

In 2001 the European Space Agency (ESA) Ministerial Council approved a 5-year program dedicated to Global Monitoring for Environment and Security (GMES), called the Earthwatch GMES Service Element (GSE). GSE is intended to develop information services to the public sector based on exploitation of earth observation (EO) satellites. Canada is also a participant in the GSE. In 2003, ESA awarded GSE contracts, each one having a value of more than \$2M. C-CORE of St. John's, Newfoundland was awarded one of these contracts for their Northern View proposal. With over 30 participants from five countries, Northern View ran for approximately 2 years and successfully demonstrated the utility and market for geospatial information for northern regions. In Stage 2 of the GSE which runs from 2005 to 2008, Northern View has merged with ICEMON, another GSE activity with focus on northern environments, to form Polar View. Polar View represents an international network composed of more than 70 participants from 12 countries with the long-term objective to become a “one-stop-shop” for information required by organizations and individuals concerned with policy, development, and environmental preservation in the Earth's polar regions. In addition to its primary focus on the Arctic and Antarctic, Polar View is also targeting areas in the mid-latitudes that are significantly affected by snow and ice. Polar View's comprehensive portfolio of EO-based services supports the monitoring and analysis of issues related to safe shipping, water management, marine environmental security and adapting to climate change.

Keywords: GMES, ESA, operational monitoring, sea ice, river ice, glacier, iceberg

1 INTRODUCTION

Global Monitoring of Environment and Security (GMES) is a joint initiative of the European Space Agency (ESA) and the European Commission. In November 2001 the ESA Ministerial Council approved a new program dedicated to GMES, called the Earthwatch GMES Service Element (GSE). It is the overall objective of GMES to attain an independent and comprehensive European capacity for the global monitoring of environment and security by 2008. Within this context GSE aims at raising the profile of earth observation (EO) among policy-makers and build awareness and acceptance among non-traditional users by delivering targeted EO based services to policy-relevant key user groups. In a competitive process, ESA initially funded ten activities for a “Consolidation Phase” that ran for approximately 20 months. During the Consolidation Phase two consortia, The Northern View and ICEMON were dedicated to providing EO-derived information about the Earth's northern regions – an area extending from the North Pole to the southern limit of arctic sea ice and icebergs.

Northern View and ICEMON built on existing service capabilities to demonstrate the utility and effectiveness of using EO data for northern monitoring, particularly in support of policy development. The success achieved by these programs confirmed that there is a significant requirement for such information. As a result, Northern View and ICEMON have now merged into Polar View, an international network composed of more than 25 participants from 12 countries. The Polar View Team consists of companies, government agencies and research institutes across Europe and Canada and is likely the most experienced and comprehensive group in the world of polar EO experts (Figure 1).

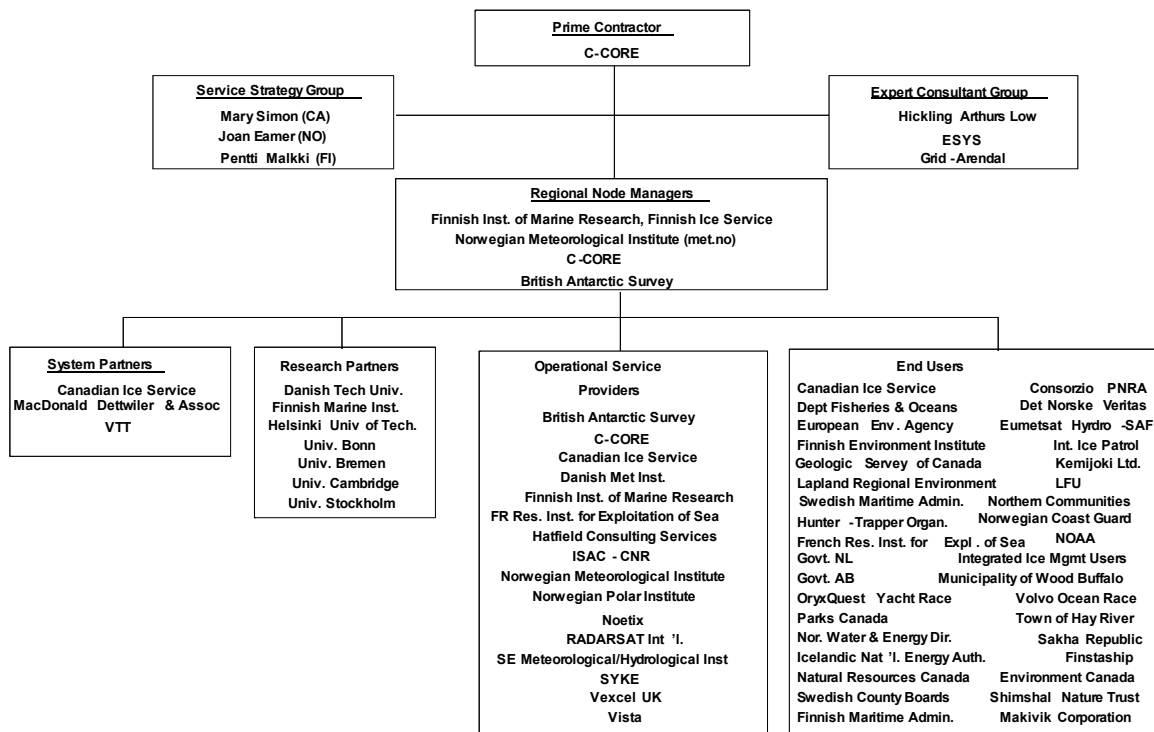


Figure 1. Polar View Team

Each organization brings diverse, complementary skills and experience to the Polar View program and is committed to establishing a dedicated service for addressing polar issues using EO technologies. Polar View delivers services to stakeholder groups who are interested in issues related to the environment, sustainable economic development, and safety in the polar regions. These groups include policy makers, government departments, northern residents, and public agencies. In addition, Polar View provides information for certain private clients and commercial interests, such as iceberg information to yacht races around the Antarctic and to hunters and trappers who travel and work in the North. It is the long-term objective to become the world's leading supplier of EO-derived information required by organizations and individuals concerned with policy, development, and environmental preservation in the Earth's polar regions. In addition to its primary focus on the Arctic and Antarctic, Polar View is also targeting areas in the mid-latitudes that are significantly affected by snow and ice. The Polar View's comprehensive portfolio of EO-based services consists of the following components:

- Iceberg and ship monitoring: near real-time location of icebergs and ships in iceberg infested waters
- Sea ice monitoring: near real-time provision of low, medium and high-resolution ice charts, ice thickness information and ice forecasts to ships navigating in waters affected by sea ice; near real-time provision of floe edge advisory to local residents to support hunting, fishing and tourism activities
- River ice monitoring: near real-time information on state and progress of river ice covers for flood forecasters and water managers
- Glacier and snow monitoring: operational analysis and assessment of glaciers and snow covered areas within the context of water resources management and hydropower generation

2 POLAR VIEW STRUCTURE

The Polar View network brings together more than 70 organizations from various backgrounds, including operational service providers, research partners and end-users. In order to address the variability and heterogeneity of information requirements for stakeholders concerned with polar environments, Polar View is organized as a distributed, highly integrated network of regional nodes. Managed by a designated node manager, each node has the flexibility to tailor service provision, marketing and promotion activities to meet regional requirements while coordinating with the other nodes on international and pan-regional activities. Table 1 shows the Polar View regional nodes, the geographic area of interest, or region, associated with each node as well as the designated node manager.

Table 1. Regional nodes and areas of interest

Polar View Regional Node	Area of Interest	Node Manager
Euro-Russian Arctic Node	Northern Europe and Arctic Russia	Norwegian Meteorological Institute (Met.No)
Baltic Node	Baltic Sea and Baltic Sea catchment basin	Finnish Institute of Marine Research (FIMR)
North American Node Antarctic Node	Canada and northern United States Antarctic and surrounding waters	C-CORE British Antarctic Survey (BAS)

3 POLAR VIEW OBJECTIVES AND APPROACH

It is the goal of Polar View to be the World's leader providing EO services and products for environmental monitoring and safety for polar regions. To this end, Polar View's cohesive international network is seeking to meet the following objectives:

- Build sustainable services and generate revenues from service provision to sustain Polar View
- Engage a wide spectrum of end-users who can be convinced of the value of the services and products
- Provide a suite of desirable EO-related services and products to public users
- Provide additional EO-related services and products to private users
- Interface in a mutually beneficial way with the cryospheric science and climate change community
- Generate revenues, either directly or indirectly, from the provision of the suite of services to sustain Polar View

The structure of Polar View is a significant move toward a truly distributed network, both in terms of service provision and management. Service providers are distributed across nine countries with a management team in each significant region. This provides local knowledge and contacts in the key regions. These local nodes are aligned in a network that supports them through international marketing and promotion and for coordination of pan-European or circumpolar activities. To be durable, there must be a long-term incentive for participants to remain members of Polar View. This incentive has many forms, including:

- Opportunities for meaningful interaction and transfer between the commercial and scientific communities

- Members of Polar View are exposed to the latest operational methods and techniques related to high latitude monitoring
- The substantial promotional work Polar View will be undertaking will provide opportunities to exploit that “brand recognition” and provide participants with instant credibility for new market entry
- Even with distribution restriction, considerable efficiencies will be gained through multiple use of imagery. More over, Polar View participants will benefit from preferred pricing for bulk purchases of imagery
- Polar View membership provides instant access to an international network of players in Earth observation
- Polar View participants gain access to political levels that they would not be able to access individually, for example the Arctic Council. This is particularly true for Value Adding Companies (VACs) and other commercial interests.

In order to promote common working practices and standards, Polar View’s matrix structure ensures vertical and horizontal integration. It is vertically integrated by geographic region and overlaid at the top by a management structure that ensures partnership protocols, service quality, and marketing and sustainability efforts are being adhered to within each region. It is integrated horizontally by technology leads that ensure adherence to sound scientific and technical principles across all regional nodes for each service line. The rules for joining, leaving and performing with Polar View will be well defined and available in a service partnership protocol.

4 POLAR VIEW SERVICES

Polar View offers a comprehensive portfolio of services to address the information needs of governments, policy makers, private organizations and other stakeholders concerned with issues pertaining to sustainable development, environment and security in the Earth’s polar regions, as well as any areas outside the Arctic or Antarctic that are affected by snow and ice. In particular, Polar View is providing its wide range of EO-based services to address the following priority themes:

- *Safe shipping*: a variety of ice charting services is offered as decision support to vessels operating in ice infested waters
- *Water management*: monitoring of inland snow and ice covers provides key information to users concerned with water resources management and flood hazard mitigation
- *Marine environmental security*: EO-based services address issues of contaminant transport and environmental monitoring
- *Adapting to climate change*: Polar View services helps northern residents to adapt to effects of climate change on fragile boreal environments

Responding to the above themes, the Polar View service portfolio comprises the following elements:

Iceberg and ship detection: Satellite iceberg detection is cost effective for near shore surveillance and can be conducted more cheaply than aerial patrol for mid and far offshore regions. This is especially relevant as additional oil fields come into production and exploration activities move further offshore into deeper waters where the iceberg frequency is much higher. A custom-developed algorithm extracts both icebergs and other targets, such as ships and offshore structures, from the SAR imagery. The algorithm generates a tabular detection report comprising target identification, location and detection confidence. The minimum size of detectable icebergs depends on image spatial resolution, shape of the iceberg look angle, and sea

state. Under optimal conditions, icebergs as small as the sensor resolution can be detected, with a probability of detection exceeding 90%.

High and medium resolution sea ice charting: The high-resolution ice charts are provided on a weekly basis with a focus on the Svalbard area and are used primarily for marine safety and environmental research. Primary end-users include ships operating in the waters around Svalbard and Norwegian Polar Institute doing habitat monitoring of polar bears. Other areas in the European and Russian Arctic can be covered on request. The ice charts are based on SAR images from ENVISAT or RADARSAT and analyzed into a colour coded ice concentration chart according to the WMO code. The normalized and gray tone enhanced images are especially well suited for detecting medium-scale features and large-scale textures. The ice chart production is done during working hours, but has 24-hour internal maintenance support and customer support service. With a geographic focus on Greenland, medium-resolution ice charts are constructed by manual visual interpretation of a variety of different satellite data, including global mode and wide swath ENVISAT and RADARSAT, optical and temperature AVHRR data from NOAA and later METOP, scatterometer data from Quikscat and METOP, and passive microwave data from DMSP SSM/I and AMSR. In addition to data from satellites, information about the atmospheric and oceanographic state is used by the ice analysts to aid interpretation.

Sea ice thickness charting: Ice thickness charts are operationally produced for the Baltic Sea after a SAR image has been received, using the latest available ice chart as an input. Then the ice field boundaries are refined, the thinnest and the thickest ice areas inside each ice chart segment are identified on the basis of the SAR signal statistics. The resulting thickness chart is then color coded according to the ice thickness based navigation restrictions. The spatial accuracy of the resulting ice thickness charts as well as routine ice charts has been analyzed using the electromagnetic induction based ice thickness measurements. The performed analysis has shown more accurate results for ice thickness charts. Currently, the ice thickness chart can use RADARSAT-1 ScanSAR Wide Mode images and ENVISAT ASAR Wide Swath images as its input image.

Met-ice-ocean forecasting: Polar View's met-ice-ocean forecasting service provides forecasts of ice motion, concentration, thickness, ridges and deformations for the Baltic Sea. The operational model is a multi-category sea ice model developed originally for climate research. The model physics and numerics are the same in both operational and climate simulations, with the only differences being the horizontal resolution and atmospheric forcing. The model resolves ice thickness distribution, i.e., ice concentrations of variable thickness categories, redistribution of ice categories due to deformations, thermodynamics of sea ice, horizontal components of ice velocity and internal stress of the ice pack. Presently, no assimilation is used for the model predictions. Horizontal resolution of the model is 1 nm.

Global sea ice monitoring: Polar View's global sea ice monitoring service provides a number of hemispheric sea ice products over large areas that are not customarily covered by national ice services. The resulting daily global sea ice products constitute an important source of information for operational, scientific and regulatory users. The service builds on existing capabilities by providing global sea ice products at improved spatial resolutions for the entire Arctic ocean. Products currently available include low and medium resolution global ice classification and concentration, as well as ice drift vectors derived from scatterometer, passive microwave and SAR data.

Floe edge monitoring: Northern communities depend on the floe edge for hunting and fishing, and it is a location of particular interest to the developing tourism industry. Traditional knowledge is becoming less effective in predicting ice conditions, possibly because of the effects of climate change. As a result, significant numbers of people need additional information to navigate safely in the ice-edge area. The information required by the local community is up-to-date image maps showing the location of the floe edge, where the ice is mobile, and where it is immobile or "fast". The product integrates satellite SAR imagery with an analyst's interpretation of the location of the ice floe edge, and the location of historical ice edges for the same time period. The ice-edge products will be stored on an online system and delivered electronically over the Internet. Users can download and print the products for their use. The service is currently being used in Amundsen Gulf (Banks Island, Franklin Bay, Holman, and Dolphin and Union Strait) and Lancaster Sound (Admiralty Inlet, Navy Board Inlet, Pond Inlet, and Prince Regent Inlet).

Near shore ice complex mapping: The interaction between sea ice and coastlines is complex and often dramatic. The presence of sea ice prevents waves from eroding coastlines, whereas increased open water may exacerbate the impacts of severe storms and storm surges. Bottom ice in shallow water interacts with sub-sea permafrost, which in turn may control erosion and sediment transport. Polar View's near shore ice complex mapping service involves performing a detailed interpretation of the sea ice conditions in the near shore area. WMO nomenclature and reporting of sea ice conditions are applied at a fine spatial scale. The best imagery for mapping fine detail is obtained from the SAR imagery. The combination of co-polarized and cross-polarized imagery is useful for ice type discrimination, particularly during the winter period.

River ice monitoring: The development of ice covers on large rivers is a dynamic process that can result in ice jamming and flooding of large areas. The severity and economic impact of floods related to ice dams is exacerbated by the danger of post-flooding freeze-up. The Polar View's river ice monitoring service delivers EO-derived information about the location and extent of river ice covers to decision makers in near real-time. This information is typically used in conjunction with other data sources to assess the level of threat posed by the formation of ice dams and to facilitate early warning and risk mitigation.

Lake ice monitoring: Polar View's lake ice monitoring service delivers EO-derived information about the location and extent of ice covers to decision makers in near real-time. This information is typically used in conjunction with other data sources to assess the level of threat posed by the freezing and melting. The freeze-up and the break-up dates are an indicator of the impact climate change is having on the environment.

Glacier monitoring: The glacier and snow monitoring service provides decision support tools for end-users using earth observation (EO) and numerical modelling. End-users are typically water resource regulators with links to the hydropower industry, environmental managers and related policy administrators. To this end, the service provides monitoring products and integrated glaciological analyses focusing on the impact of climate change on glacial discharge, current mass balance distribution and glacier dynamics and stability. Depending on the specific needs of each end-user, a variety of information products can be provided, such as glacier topography, glacier velocity fields, glacier facies distribution, snow retreat and glacier surface energy balance.

Snow monitoring: This service provides frequent updates on snow cover relating to relevant information for flood forecasting and early warning in central and northern Europe. The snow-monitoring service consists of two different processing chains for optical (AVHRR, MODIS) and SAR (ENVISAT, RADARSAT) imagery. The first product provides daily information on snow covered areas, the snow line, and snow free areas using medium resolution optical imagery. Snow is detected using ratio and threshold techniques for several spectral bands of the sensor. Products are provided within one hour after data reception. The second product identifies the extent of snow with a high content of liquid water from SAR data using ENVISAT ASAR in wide swath mode. A semi empirical backscatter model and change detection techniques are applied. The snow service outputs consist of EO based snow cover maps, snow line delineation and snow melt maps through classification of wet/melting snow. The products can be provided within several hours after data availability.

Backward trajectories of sea ice drift: This product is produced yearly for monitoring purposes based on the ice drift vectors provided by the French Research Institute for Exploitation of the Sea's (IFREMER). These backward trajectories will allow scientists to determine the source of sea ice in the marginal ice zone of the Barents Sea. IFREMER produces ice motion vectors during the winter months (October to April) as a product for the Polar View baseline portfolio. The motion vectors are derived on a 3 and 6-day frequency from QuikSCAT data. For each chosen point along the ice edge in the Barents Sea, backward trajectories are calculated to their position at the beginning of the previous October. In addition, several points within the Barents Sea ice pack are chosen, and backward trajectories are calculated. Thus, for simulation of ice transport and subsequent statistical analysis, 3-day average maps of sea ice drift fields and sea ice concentration are produced on the same grid. As the time series grows, a variety of users will benefit from backward trajectory data to use as a tool for statistical analyses with respect to design and location of offshore installations and activities.

Climate change adaptation indicators: Polar View products and services are typically designed to provide support to user operations. The dynamic nature of the environment requires regular monitoring and timely response to aid in user planning and decision-making. A by-product of the services is a time history of the environmental parameters monitored throughout the season and from year to year. Although the utility of the product for the operational user diminishes with time after an image is acquired, the products are meaningful to other users, particularly in the form an archive containing a continuous historical record. Polar View services are a very important information source for those who must assess and make decisions on climate change. Therefore a high quality, annual report of Polar View Climate Change Indicators will be produced. The indicators will be used by international and national assessment and outreach programs and will be available for future Arctic Climate Impact Assessments undertaken by the Arctic Council. An annual report on Polar View climate change indicators will be produced.

A summary of Polar View service lines, priority themes, service lines and geographic area of application is provided in Table 2.

Table 2. Priority themes, service portfolio elements and geographic coverage

Priority Theme	Service Portfolio Elements	Geographic Coverage
Safe shipping	Iceberg and ship detection	Northwest Atlantic, Antarctic
	High and medium resolution sea ice charting	Svalbard, Barents Sea, Greenland, Antarctic
	Sea ice thickness charting	Baltic Sea
	Met-ice-ocean forecasting	Baltic Sea
	Global sea ice monitoring	Arctic and Antarctic
Water management	River ice monitoring	Canada, Finland, Russia, US
	Lake ice monitoring	Canada, Finland
	Snow monitoring	Northern and central Europe
	Glacier monitoring	Canada, Northern Europe
Marine environmental security	Backward trajectories of sea ice drift	Barents Sea
	Iceberg and ship detection	Northwest Atlantic, Antarctic
	High and medium resolution sea ice charting	Svalbard, Barents Sea, Greenland, Antarctic
	Sea ice thickness charting	Baltic Sea
	Met-ice-ocean forecasting	Baltic Sea
Adapting to climate change	Global sea ice monitoring	Arctic and Antarctic
	Near shore ice complex mapping	Canada
	Floe edge monitoring	Canada
	River ice monitoring	Canada, Finland, Russia, US
	Lake ice monitoring	Canada, Finland
	Snow monitoring	Northern and central Europe
Glacier monitoring	Canada, Northern Europe	
Climate change adaptation indicators		

5 SUMMARY AND CONCLUSION

Polar View is an earth observation (EO) or satellite remote-sensing program, focused on both the Arctic and the Antarctic. Polar View is supported by the European Space Agency (ESA) and the European Commission with participation by the Canadian Space Agency. It promotes the utilization of satellites for public good and in support of public policy in the areas of environment, sustainable economic development, and safety. The Polar View Team consists of companies, government agencies and research institutes across Europe and Canada and is likely the most experienced and comprehensive group in the world of polar EO experts. Each organization brings diverse, complementary skills and experience to the Polar View program and is committed to establishing a dedicated service for addressing polar issues using earth observation technologies. Polar View has participants from Canada, Finland, France, Germany, Norway, Sweden, United Kingdom, and Denmark.

The Polar View delivers services to stakeholder groups who are interested in issues related to the environment, sustainable economic development, and safety in the polar regions. These groups include policy makers, government departments, northern residents, and public agencies. Polar view also collaborates with the national ice centres in generating and providing expanded and more detailed information sets. In addition, Polar View provides information for certain private clients and commercial interests such as iceberg information to yacht races around the Antarctic and to hunters and trappers who travel and work in the North. The goal for Polar View is to be the World's leader providing EO services and products for environmental monitoring and safety for the Polar Regions. The Polar View service portfolio has evolved to meet the key information needs of polar stakeholders that can be addressed with EO data. Current Polar View service lines include:

- Iceberg and ship detection
- High and medium resolution sea ice charting
- Sea ice thickness charting
- Met-ice-ocean forecasting
- Global sea ice monitoring
- River ice monitoring
- Lake ice monitoring
- Snow monitoring
- Glacier monitoring
- Backward trajectories of sea ice drift
- Near shore ice complex mapping
- Floe edge monitoring
- Development of climate change adaptation indicators

These services are designed to address polar policies, in the area of environmental protection, sustainable economic development, and safety. Functionally, Polar View is a highly integrated network of regional nodes structured somewhat like a multi-national corporation. This Polar View structure has nodes for the Baltic (land and sea ice), Europe and Russia (the Euro-Arctic Node), and North America. Each node is a consortium in itself and managed by a Node Manager.