Emergency Spatial Pre-SCAT Arctic Coastal Project: eSPACE

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ABSTRACT:

Environment Canada has a significant deficiency in terms of preparedness for a potential environmental emergency along the coastlines in the Arctic Region. Increased exploration, increased ship traffic as well as climate change are three major reasons why Environment Canada intends to initiate a National project in Canada's north. The emergency Spatial Pre-SCAT for Arctic Coastal Ecosystems (eSPACE) project is focused on developing a capacity to use Earth Observation to enhance our state of preparedness for emergencies in the North. A baseline of coastal information is required for wildlife management and emergency response. The information will be used for many purposes, including prioritizing and coordinating on-site spill response activities. This project is part of the MORSE-Arctic Coastal Initiative, which focuses on the information needs of Arctic coastal users in governmental, non-governmental, municipal, industrial and scientific organizations. This initiative involves remote sensing satellites that can provide a cost effective means of obtaining Earth Observation (EO) information in the vast, barren and often inaccessible Arctic areas and their coastal zones. To this end, the Canadian Space Agency (CSA) and the European Space Agency (ESA) have initiated an inter-agency activity to develop and demonstrate the use of EO data for monitoring coastlines and coastal processes in the Arctic. Environment Canada will achieve this project in partnership with the CSA and the partners involved in the MORSE Initiative.

RÉSUMÉ:

Environnement Canada a un manque majeur en terme de préparation pour une potentielle urgence environnementale le long des rives dans la région de l'Arctique. Trois raisons majeures sont en cause pour initier un nouveau projet national pour le nord du Canada, il s'agit de : l'augmentation de l'exploration pétrolière, l'augmentation du trafic maritime et les changements climatiques. Le projet nommé « emergency Spatial Pre-SCAT for Arctic Coastal Ecosystems (eSPACE) » est mis en place afin de développer les capacités d'utiliser les observations de la terre pour améliorer notre état de préparation en cas d'urgences dans le nord. L'information sera utilisée pour différents buts, incluant la priorisation et la coordination des activités d'interventions lors de la réponse aux urgences. Ce projet fait partie d'une initiative appelée « MORSE-Arctic Coastal Initiative », lequel est dirigée sur les besoins des utilisateurs des côtes de l'Arctique tel que les gouvernements, les organismes non-gouvernementales, le municipal, l'industrie et les organisations scientifiques. Cette initiative impliquant l'imagerie satellitale peut fournir un coût raisonnable pour obtenir de l'information sur les observations de la terre dans les vastes, arides et souvent inaccessibles régions de l'Arctique et ses zones côtières. Enfin, l'Agence spatiale canadienne (ASC) et l'Agence spatiale européenne (ASE) ont initié une activité inter-agences pour développer et démontrer l'utilisation des données d'observations de la terre afin de faire le monitoring des côtes et des processus côtiers dans l'Arctique. Environnement Canada réalisera ce projet en partenariat avec l'ASC et les partenaires impliqués dans MORSE Initiative.

1. INTRODUCTION

Many government agencies, predominantly federal, have functional security and emergency preparedness responsibilities that pertain to, or are affected by, shipping activity in Arctic Canada. Environment Canada has an important role in terms of preparedness for a potential environmental emergency along the coastlines; however there is a significant information gap in the Arctic Region. The Arctic presents different challenges and its geography is impressive. There are many opportunities for economic development in the north, many of which involve activities that increase the risk of an incident that may impact local populations and the fragile ecology. Increased exploration activities, increased shipping traffic and climate change are three majors reasons why Environment Canada intends to initiate a national project in Canada's north to improve emergency preparedness and response. The eSPACE project is focused on developing a capacity to use Earth Observation to enhance our state of preparedness for emergencies in the North. Baseline coastal information is required for wildlife management and emergency response; information generated will be used for many purposes, including operational prioritization and coordination of on-site spill response activities by Environment Canada and other stakeholders.

The objectives of the project are: a) to identify and map shoreline characteristics, coastal habitats, and resources at risk in the three pilot sites in the Arctic region, b) to develop methods using satellite technology and compare it to current protocol (video by helicopter) and c) to establish partnerships in order to improve habitat conservation and preparedness for environmental emergencies and in the north.

The eSPACE project is part of a new joint initiative from the Canadian Space Agency (CSA) and European Space Agency (ESA) called MORSE-Arctic Coastal Initiative. The initiative focuses on information needs of Arctic coastal ecosystems that can be met by Earth Observation (EO) data from satellites. eSPACE is a multi-agency project to develop and demonstrate the use of EO data for emergency preparedness and response as well as habitat conservation on Canada's northern coasts. In addition to providing data to the Environmental Emergencies program, eSPACE will coordinate aerial and ground-based surveys with the Canadian Wildlife Service to identify coastal habitats for Bird Conservation Region (BCR) planning and Species at Risk programs (SARA) in arctic ecosystems.

This paper will outline the description of the project, the technical approach and methodology, the three pilot sites, the expected results and the discussion.

2. TECHNICAL APPROACH AND METHODOLOGY

2.1 Technical approach

Traditional data development for shoreline classification and sensitivity analysis includes manual interpretation of oblique videotape imagery collected in a helicopter at altitudes less than 300m. This method has been successfully applied to the majority of southern Canadian coastlines. The data is interpreted by separating shorelines into work units characterized by relatively homogeneous physical and sedimentary characteristics (Owens, H.E. and Sergy, G., p. 1.9), as described in the Shoreline Cleanup and Assessment Technique (SCAT) manual. The name of this database at Environment Canada is the Pre-Scat database. The SCAT method is used when the shorelines are impacted by an oil spill on the water. This database is useful in order to identify which kind of substrates are touched and improves response by assisting in the choice of the clean-up method. This state of preparedness is important for the stakeholders involved during an emergency. Environment Canada worked on a national classification of types of shoreline. The classification for the marine shoreline types is separated into 15 different types.

These types are:

- Bedrock - Cliff/vertical
- Bedrock - Sloping/Ramp
- Bedrock - Platform
- Glacier/Ice Shelf
- Man-Made Solid
- Man-Made Permeable
- Sand Beach
- Mixed Sediment Beach
- Pebble/Cobble Beach
- Boulder Beach
- Mud Flat
- Sand Flat
- Mixed Sediment Flat
- Pebble/Cobble/Boulder Flat
- Wetland

The eSPACE project will develop remote sensing classification procedures to support shoreline segmentation and sensitivity analysis in the arctic and verify that the products are as reliable as the traditional approach. The classification of substrate types for the southern shoreline has been established, but the substrate on the northern shoreline is different and therefore needs a different classification system. The types that need to be added for the north can be divided in two parts. The first part is different types of substrates that we can find on the shorelines and the second part is when the shore-zone is covered by snow or ice. We are working on the new classification that will be used in remote sensing classification procedures. The types are:

First types:

- Tundra Cliff: Ice Rich
- Tundra Cliff: Ice Poor
- Inundated Low-lying Tundra
- Peat Shoreline
- Perched Beach
- Driftwood line

Second types:

- Snow (only)
- Frozen swash (FSW)
- Frozen Spray (FSP)
- Ice Foot (IFT)
- Ice-push Ridge (IPF)
- Grounded Floes (GFL)
- Glacier Ice (GLC)
- Nearshore Ice
- Combination shore zone snow and ice

2.2 Methodology

In recent years, satellite remote sensing has been used in shoreline extraction and mapping, including geological, geomorphological and vegetation characteristics. A variety of optical (Landsat TM, SPOT, IKONOS, and IRS) and SAR (Radarsat-1, ERS-1) sensors have been used to map shorelines in various geographic regions. Practical experience mapping coastlines in the arctic suggests that integrated use of optical and SAR imagery improved shoreline discrimination. In areas where erosional coastal types are dominant, a combination of multi-scale, multi-temporal imagery and more sophisticated pattern recognition techniques are more appropriate for coastal type discrimination.

This project will focus on Canadian and European (and associated) sensors that are freely available to Canadian government departments. Optical analysis will be completed using SPOT 5 acquisitions from 2005-2010 currently available on GeoBASE and archived Landsat imagery, where appropriate. New acquisitions will be focused on Radarsat-2, MERIS, and ALOS sensors. Research will be conducted using airborne hyperspectral and LIDAR systems to support future potential space-borne systems (i.e. ENMAP). Advanced radar techniques including InSAR, Polarimetry and PolInSAR as well as innovative image analysis (i.e. object-based) will also be explored to produce the high-resolution shoreline classification required for operational spill preparedness and response.

Furthermore, we will need to compare and validate the results of remote sensing and EO data with the traditional methods used for the southern coastlines. In addition to this, we will also do oblique videotape imagery with Lidar technology.

3. STUDY REGIONS

Three pilot regions will be used in this project: 1- Mackenzie River Delta and Beaufort Sea 2- Hudson's (Churchill port) and James Bay 3- Part of the Labrador Coast.

These regions include three different geographic areas of the Arctic region in Canada, including a variety of coastal ecosystems and habitats. They have a high risk of spills from current or future development activity or associated shipping routes and have been identified as a priority for Environment Canada in terms of sensitive ecosystems and need for emergency preparedness.

3.1. Mackenzie River Delta and Beaufort Sea

This region is very active with drilling platforms, exploration activities and seismic surveying studies. These projects might face higher maritime risk (collision/stuck in the ice) because of

the old ice that is staying longer than usual and, in some cases, moving further south from its' normal limits. In addition, ship traffic in this area includes a few adventurer vessels, research vessels and ships traversing the Northwest Passage. Furthermore, maritime re-supply traffic, which will navigate through the Mackenzie River Delta and Beaufort Sea, is expected to increase over the next few years.

3.2 Hudson's and James Bay

Over the last number of years, the ice cover has significantly decreased in Hudson's Bay (Churchill's port) allowing shipping activities to start a month earlier (early July-November). An active port at Churchill provides a shorter route for prairie grain to European markets than the Great Lakes and St. Lawrence River route and is ideal for shipping products to and from Europe, Russia, Africa, Latin America and the Middle East. Ecotourism is also expected to increase in the area due to many wildlife resources that can be observed in many parts of the Bay. Both side of James Bay include sensitive ecosystems that are important for many species of birds. Many First Nation communities are located along the shoreline and they receive hydrocarbons and other cargo by ship. There are many risks during the transfer of cargo from ships at these primitive unloading areas. Land-use planning is underway in the far north of Ontario including exploration and potential expansion of mining which may increase marine traffic and pressure on these ecosystems.

3.3 Labrador Coast

As the Canadian Arctic waters gain in popularity, cruise ship activities have increased and represented 10% of the maritime circulation in 2008. In addition, mining prospection and exploration activities in the north have been positively affected by climate change; as a result many vessels are expected to navigate along the Labrador coast in the near future. Plans to lengthen the railway will increase industrial activities on the Labrador Coast and subsequent increases in the maritime re-supply traffic are expected**.**

4. EXPECTED RESULTS AND OUTPUTS

4.1 Coastal sensitivity and shoreline maps for the three study sites in northern Canada.

The result will be a database on the coastal sensitivity resources as well as a shoreline segmentation (Pre-SCAT) database for the three study sites. These two databases will be on the National Emergency Mapping system, which is a webGIS for Environment Canada. This webGIS is available for all stakeholders involved during an emergency in Canada and all partners included in this project.

Here you have an example (figure 1) of the map from NOAA in Alaska, which represents the final result that we would like to achieve with EO data:

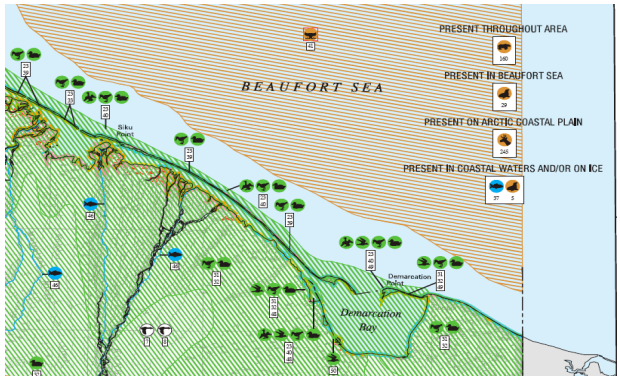

Figure 1. Example of Alaska coastal sensitivity and shoreline mapping from NOAA.

5. DISCUSSION

The eSPACE project will be a coordinated effort with the CSA/ESA sponsored MORSE initiative. This project will continue to build capacity in Environment Canada's Science and Technology Branch to support a wide variety of programs using space-based remote sensing.

eSPACE products will be relevant and timely inputs to the Integrated Ocean Management Plan currently in progress in DFO's Beaufort Sea Large Ocean Management Area and the Beaufort Regional Environmental Assessment (BREA) led by Indian and Northern Affairs Canada (INAC) and the Joint Secretariat (Inuvialuit Settlement Region). A large initiative led by the International Institute for Sustainable Development (IISD), the Hudson Bay Inland Sea Initiative, will also benefit from our work.

A variety of working groups and initiatives of the Arctic Council have also identified priorities and objectives that will be addressed by eSPACE, including many of the research questions on biodiversity and operational preparedness in Canada's north.

Specifically, eSPACE will interface with the Arctic Council's CAFF (Conservation of Arctic Flora and Fauna) and EPPR (Emergency Prevention, Preparedness and Response) working groups to provide relevant data, research results and build collaborations. Products from this work will contribute to the assessment of biodiversity of arctic shoreline habitats. Results will allow us to identify potential risks to sensitive habitats due to increased sea-level, changes in ice scouring and other associated effects of climate change. The development of E.O. methods for shoreline assessment will lead to the ability to easily update operational preparedness maps and effectively monitor the impacts and adaptation to climate change in the north; results that are difficult to obtain with conventional census and inventory techniques alone.

Other projects and groups may be identified and added during the realization of the project. For example, Parks Canada Agency (PCA) is another partner that may benefit from eSPACE. They have many new Parks in development in the north as well as existing sites close to our pilot sites; they may be involved as a stakeholder during an emergency operation. In addition, collaboration with Indian and Northern Affairs Canada may include protocols for spill prevention and

preparedness in communities and communication and mitigation measures during an emergency.

6. CONCLUSION

The eSPACE project will be the first project where the EO data will be used to enhance the state of preparedness for environmental emergencies in Canada. This cartography will involve governments, industries and communities in the North of Canada. We consider that the three objectives will be achievable within the timeline and we believe that eSPACE products and partnerships will be of tremendous interest to a variety of organizations and stakeholders interested in coastal ecosystems in the Arctic.

Sensitivity mapping and the segmentation of shoreline is recognized internationally as a good tool during an oil spill in the sea. Many countries in the world have undertaken this project for their coastlines but the north is a new and unknown region for many countries that have limits above the 60^{th} parallel. We hope that our methodology will be exportable to many partners around the world that have the same type of geography as Canada. We have an enormous country to manage and if we can use the EO data and remote sensing to accelerate our state of preparedness, it will be a very positive result for us.

In conclusion, many habitats in the north have not been mapped and it will be, at the same time, a good opportunity to better understand and increase our knowledge of the biodiversity in the north.

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