IBPlott – A System for Operational Use of Spaceborne SAR Information in the Baltic Sea

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ABSTRACT

The two most heavily navigated waterways in the word, where seasonal sea ice plays an important role in navigation, are the Gulf of St. Lawrence in Canada and the Baltic Sea in Europe. Spaceborne SAR has been used operationally by the icebreakers in the Baltic Sea since 1992, and now both RADARSAT and ENVISAT ASAR data are delivered to end-users. The captain and mates on board the icebreakers interpret the images using a workstation called IBPlott developed by VTT. The GIS type of workstation combines and displays all available relevant information required for making routing and assistance decisions. The information available are – satellite images, ice charts, positions and destinations of the ships moving in the area, visualization of current speed and tracks (from the AIS system), ice forecasts, water level and weather forecasts as well as the most recent observations. In this paper we present the operational system in use for making SAR images available to the end-users in near real time in the Baltic Sea combining the satellite images with other information products. The end user experiences of the system and future development ideas are shortly presented.

Keywords: Sea ice, Baltic Sea; SAR, Ice navigation, Navigation support system

1 INTRODUCTION

The two most heavily navigated waterways in the word, where seasonal sea ice plays an important role in navigation, are the Gulf of St. Lawrence in Canada and the Baltic Sea in Europe. The total cargo turnover in the Baltic Sea was in 2003 about 731 million tons, and it is expected to grow up to 1.2 billion tons by 2020 [1]. Some 40% of marine transportation takes place during winter months.

Winter navigation is made possible by the use of icebreakers, ice-strengthened vessels and by restricting navigation. In the winter 2006-2007 there will probably be 8-9 Finnish, 7 Swedish, 3 larger plus several smaller Russian icebreakers, one Estonian, one Latvian and 2 Danish icebreakers operating in the Baltic Sea. While the traffic has increased, the number of icebreakers has not increased. The smoothness of traffic has been possible due to by better ice monitoring, where the use of EO data has become more and more important. Icebreakers need detailed ice information for route planning. Considerable savings in ice navigation could be made by optimizing the use of satellite based operational ice monitoring [2], [3].

Spaceborne SAR has been used operationally by the icebreakers in the Baltic Sea since 1992 [4]. The first trials used ERS-1 data, and since 1998 Finland and Sweden have jointly acquired 100 - 150 RADARSAT scenes per ice season for ice monitoring and icebreaker operations.

In 2005 the end-user requirements of an important user group, i.e. the captains and mates on board the icebreakers, was investigated. The results of the questionnaire indicated that the regular users on the icebreakers considered it easy to interpret the SAR-satellite images. The desired interval between the images was once a day, although an interval that would depend on the weather conditions would be the optimum. A majority of the users wanted either to have a user selectable resolution or a better resolution than the 400 m used today.

In this paper [1] we describe the ice navigation support system developed for icebreakers operating in the Baltic Sea, and show how satellite data is utilized together with other observational and forecast data in ice navigation. The system is used operationally during the winter months, and it consists of an on board end-user system called IBPlott developed by VTT Technical Research Centre of Finland, and data processing and delivery systems on the server side ashore developed and run by Finnish Institute of Marine Research and VTT.

2 THE SYSTEM USED IN THE BALTIC

In the Baltic, the ships have to contact the icebreakers when approaching the ice edge to get advice on what waypoints to follow. For their operational and tactical navigation and assistance planning the icebreakers require information about prevailing and forecasted ice conditions in order to plan safe and cost-efficient routes through the ice field. The goal is to minimize the total time the ships have to wait for icebreaker assistance with the available icebreaker resources. The operative system we have developed for icebreakers consists of an on board end-user system called IBPlott, and data processing and delivery systems on the server side ashore.

2.1 End-user system

IBPlott is used by all the Finnish and Swedish icebreakers within the Baltic Sea and it is part of the IBnet system that is used to coordinate and communicate the daily assistance activities of the icebreakers. IBPlott is the geographical user interface of the IBnet system. It displays geo-located information on the screen as symbols and images, and provides mechanisms for users to interact with the objects in the IBnet database. In addition to presenting relevant traffic related information, IBPlott also displays observational and forecast data to the user. Observations and forecasts about the weather and ice conditions are essential information for ships navigating through the ice in a dynamic and ever-changing environment. Figure 1 shows examples of IBPlott presenting SAR images and an image combined with an ice model forecast.

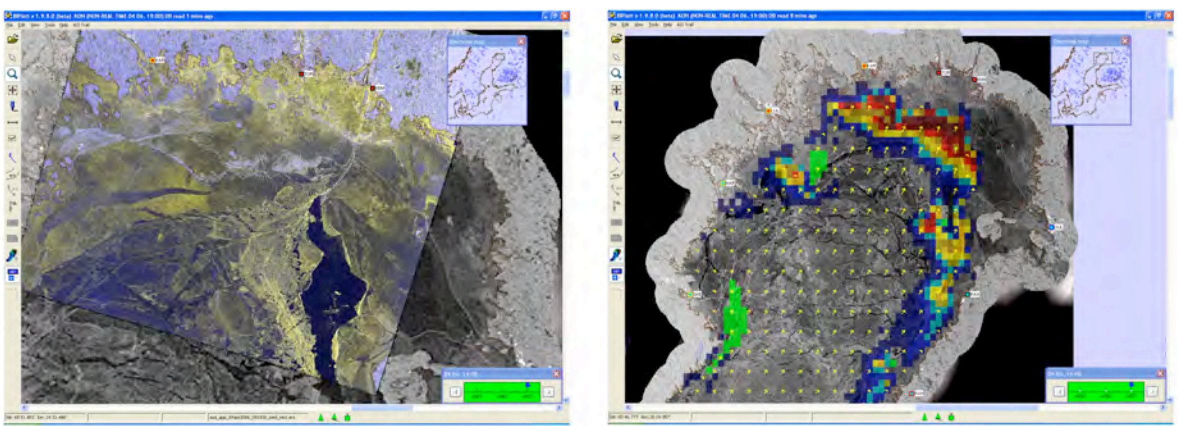

Figure 1. IBPlott presenting SAR image mosaic (on the left) and ice model forecast on top of a SAR image (on the right)

Satellite images are the most important source of observational information. Satellite images are presented on the screen in geographically correct locations, and multiple images can be opened as an image mosaic. Mosaic presentation makes it possible to have images from different sensors, in different resolutions, and from different times presented at the same time on the screen for comparison. Other observational data parameters that help the interpretation of satellite images are drawn on top of the images. Ice charts and ice thickness charts [5] help captains estimate the thickness of the ice field, wind observations tell about the current weather conditions elsewhere, and water level observations can be used to estimate sea currents that constitute one of the forces affecting the ice drift. IBnet is connected to the Automatic Identification System, AIS, and IBPlott has access to the latest position and speed observations as well as some history of the locations of all ships navigating in the Baltic Sea. This makes it possible to present trails of the ships colored

[1] A more extensive paper will be submitted to the Canadian Journal of Remote Sensing, special section "OceanSAR 2006"

as a function of the ship speed, which gives additional observational information about how the ships perform in the prevailing ice conditions.

For route planning support, forecasts are important in addition to observational data. Wind and air pressure forecasts are the primary forecast information source presented on the screen, but also water level predictions are used in determining ice field movements. In addition to weather models, IBPlott also presents ice model forecasts that give statistical estimates in a few mile grid about the ice field properties, like thickness, ridging density and ice field movement (see Figure 1 for an example).

2.2 Data processing and delivery

The image data processing and delivery chain is depicted in **Figure** 2. The raw Radarsat data is received and processed at satellite station in Tromsö, Norway (KSAT), and the image data are then transferred using FTP and Internet to the Finnish Ice Service in Helsinki. Processing of the images consists of cutting the areas of interest from the remapped image, scaling the image to 8 bits, and then compressing it before sending to the icebreakers (See Figure 2). During the last two years ENVISAT ASAR images have also been used, and in the winter season 2005-2006 the ASAR images have been transferred from the ESA rolling archive in ESRIN, Italy. These images have been acquired within the PolarView project. The use of MODIS images was prototyped in the winter 2005-2006 and will be delivered to icebreakers during the next winter season 2006-2007.

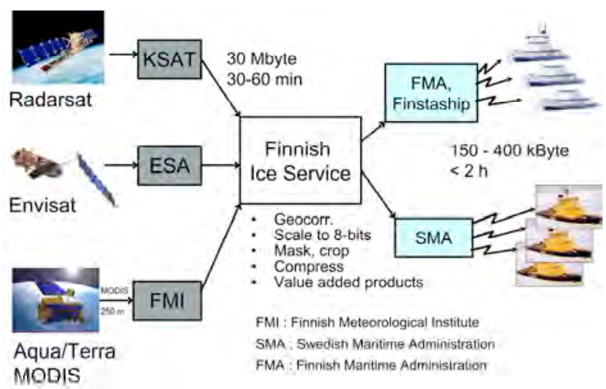

Figure 2. Delivery chain of satellite data to on board users.

During the season 2005-2006, 163 RADARSAT-1, and 82 ENVISAT ASAR images were processed and delivered to the Finnish icebreakers. 60% of these were also delivered to the Swedish icebreakers. On average, 0.7 images/day were delivered during the most intensive month, February 2006.

3 DISCUSSION

Comparing with the user requirements, the actual frequency of image delivery is not far away from meeting the demand. Interpretation of the SAR images by the experienced users is not considered difficult, as most of the end-users in the Baltic Sea have several years of experience from SAR imagery. The resolution could be increased from the presently used 400m resolution, although many users are satisfied with the present resolution. Discussions with the users indicate that real-time information from the AIS system gives important add-on information about both the traffic situation and how the ice situation affects the performance of the ships.

New functionality and products are introduced mainly by means of pilot projects. The most recent products are numerical ice models and products based on dual-polarised images. The challenges are: 1) developing proper algorithms and mechanisms for producing and transferring the products 2) validation of the products, 3) usability and 4) training.

New ways of presenting SAR based products to the end-users have been piloted in research-oriented projects with funding from ESA and national funding agencies. VTT and FIMR participate in two such projects: PolarView (a GMES project) and POL-ICE (a nationally funded project in cooperation with

Canada). End-user feedback through questionnaires and seminars show that a rather long introduction time is needed to make the users comfortable with new products.

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