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SUMMARY

In this report we describe the changes in the icebergs distribution in the Barents and Kara seas. The analysis is carried out only for 2012 using ASTER images for the winter season (March April). This analysis was carried out near the boundaries of the outlet glaciers in Franz Josef Land and Severnaya Zemlya. Maps of icebergs distribution were created based on the ASTER images for each area, from these maps a density maps were created. The results were compared with maps from the Atlas of Arctic Icebergs (1996) by Valentin Abramov. There is some similarity when it comes to the patter of the icebergs distribution but there are differences with numbers of icebergs. And the reason maybe to difference in sources data and also in the atlas they use the average for several years.

1 Introduction

1.1 Background

Icebergs are scattered pieces ice floating in the ocean originating from glaciers. Icebergs are found in large quantities both in the Arctic Ocean and in the Antarctica. Icebergs are often found in the same areas as sea ice, which is generated by freezing of the surface layer of the ocean. Icebergs and sea ice have highly different physical properties (size, shape, density, thickness) as well as distribution.). Icebergs have small horizontal scale but are much thicker. In the Antarctica, the size of icebergs can become very large, several km, but in the Arctic the normal size of icebergs is of order 100 m. The small horizontal scale makes detection more difficult and the large thickness represent huge masses of ice which is a threat to ships and operating platforms in polar regions.

Icebergs drifting in the ocean are one of the most dangerous threats to offshore operations. Icebergs are commonly found off eastern Canada, around Greenland, in the Barents Sea and several places in the Russian Arctic (Figure1). On Grand Banks, there is a specific iceberg monitoring and management system to avoid collision between icebergs and platforms. In the Barents Sea area, systematic monitoring of icebergs was conducted by Russian aircraft surveys for many decades, but in the last 15 years there have been no regular iceberg surveys in this area [Sandven, 2007].

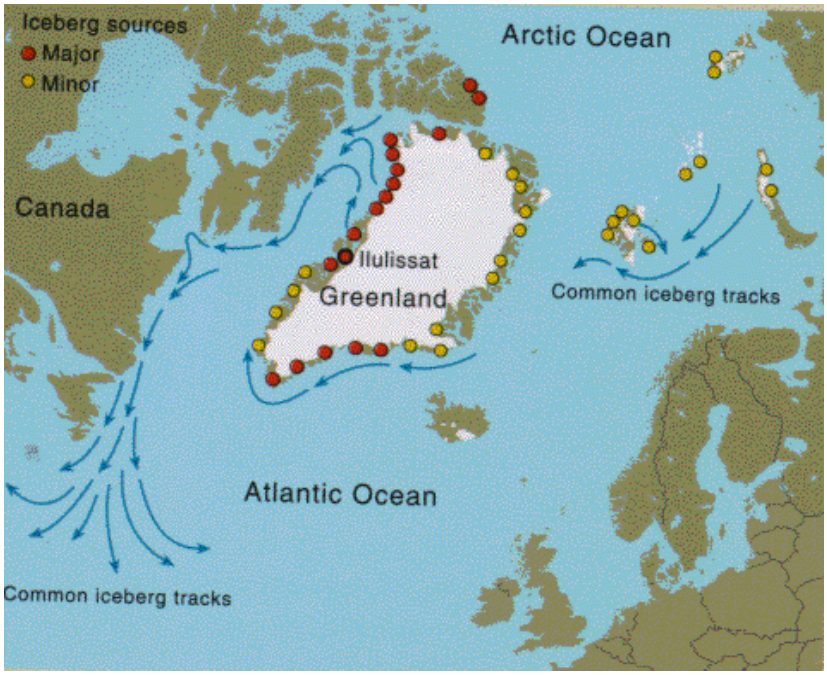


Figure 1 Icebergs in the European sector of the Arctic are produced by calving from glaciers in Greenland, Svalbard, Franz Josef Land, Novaya Zemlya and Severnaya Zemlya

Nearly one quarter of the flux of Russian Arctic glacier flow is discharged as calving into sea water. Very approximate estimations show that iceberg flux is 2.5 km3 on Franz Josef Land - 60% of glacier run-off; 2.0 km^3 on Novaya Zemlya - 80%; 0.5 km^3 on Severnaya Zemlya - 25%. Additionally, 2.0 km^3 is lost because of the thermal decay and wave abrasion of the ice cliffs [Glazovsky, 2003]. These so-called tidewater glaciers dominate in the archipelagos, while floating ice tongues or ice shelves are much rarer. Meanwhile the iceberg discharge into the sea is poorly studied factor of glacier dynamics. The iceberg calving records from conventional observations are often short or completely lacking; hence conventional in situ measurements should be enforced by invaluable and often unique observational data provided by most recent satellite remote-sensing methods and techniques.

Icebergs are well detected from high-resolution visible images from Landsat, Aster, “Monitor-E” and other satellites, received in light conditions in absence of clouds. The iceberg identification is difficult when their size is about the sensor resolution, and when their size corresponds to 2-3 pixels (60-90 м), they are identified using one of the following features:

- presence of shadow,
- light patch – light reflection from sunny part of iceberg,
- texture of large tabular icebergs,
- presence of fracture near the iceberg due to its motion relatively ice.

Weather conditions, first, cloudiness and sun height, which determine a length of iceberg shadow and contrast between sunny side of iceberg and its surroundings, influence manifestation of these features. Icebergs are better detected in early spring, when they are surrounded with level ice and have long shadow due to small sun angles. The valuable complementary information for their detection provide tracks in sea ice in the form of ellipse, caused by tidal currents or inertial movements.

Use of SAR data can improve iceberg detection compared to optical data since SAR data are independent of cloud and light conditions. SAR images with resolution better than 100 m can improve the detection of larger icebergs of size of 100 m or more. However, in the Barents Sea and Kara Sea area, many icebergs are smaller, typically 10 – 50 m, and this will require SAR images with resolution of about 10m, provided by for example TerraSAR-X, RADARSAR-2 and CosmoSkymed.

1.2 Objective

The main objective is to analyze changes in iceberg distribution in the Barents and Kara seas. The analysis is carried out only for 2012 using ASTER images for the winter season (March April). This analysis was carried out near the boundaries of the outlet glaciers in Franz Josef Land and Severnaya Zemlya. The result were compared with Atlas of Arctic Icebergs (1996) by Valentin Abramov.

1.3 Report Organization

The remainder of this report is organized as follows. Section 2 is the study area and the data used, while Section 3 provides an overview of the methods. The last section, section 4, presents the results.

2 Data

2.1 Overview

During the project period satellite images available for the project was complied in a database. These, covers Russian data set from Roscosmos archives, ENVISAT, Radarsat2, landsat and ASTER, (for more detail see D2.21 and http://web.nersc.no/project/maires/sadweb.py?project=maires).

2.2 Data and study Areas

Two areas were selected to study icebergs distributions; these are Franz Joseph Land and Severnaya Zemlya (Figure 2)

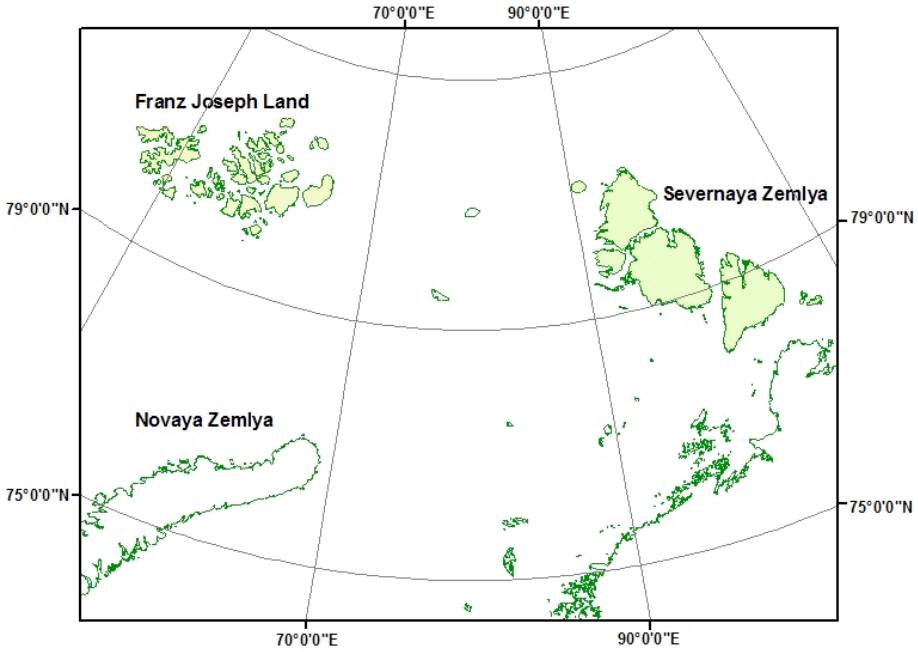


Figure 2 a map of the Russian arctic showing Novaya Zemlya, Franz Joseph Land and Severnaya Zemlya

Searching the project database, there are data from both optical and SAR images to carry this study. AS it was mentioned in previous deliverable (5.2) optical images is more reliable in detection of icebergs when there are available and cloud free. Reference to the main objective of this study is to study icebergs distribution; the first step is to have a good coverage of images for specific period (dates) for the investigated area. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) have a good coverage for both Franz Joseph Land (Figure 3) and Severnaya Zemlya (Figure 4) for the year 2012 for March and April. For the Landsat images the numbers are less and the coverage is never complete. Table 1 shows the numbers of optical images (ASTER and Landsat) available for the different project area till 2012.

Table 1: optical images covering the different project area

Area	ASTER	Landsat
Franz Joseph land	550	67
Novaya Zemlya	300	285
Severnaya Zemlya	890	47
Svalbard	620	192

ASTER is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI) and Japan's Earth Remote Sensing Data Analysis Centre (ERSDAC) the table below shows some ASTER technical specifications.

Table 2 ASTER technical specifications

Instrument	**VNIR**	**SWIR**	**TIR**
Bands	1-3	4-9	10-14
Spatial Resolution	15m	30m	90m
Swath Width	60km	60km	60km
Cross Track Pointing	± 318km (± 24 deg)	± 116km (± 8.55 deg)	± 116km (± 8.55 deg)
Quantisation (bits)	8	8	12

For Franz Joseph land the total numbers of images used are 34 images (Figure 3), all images are from March.

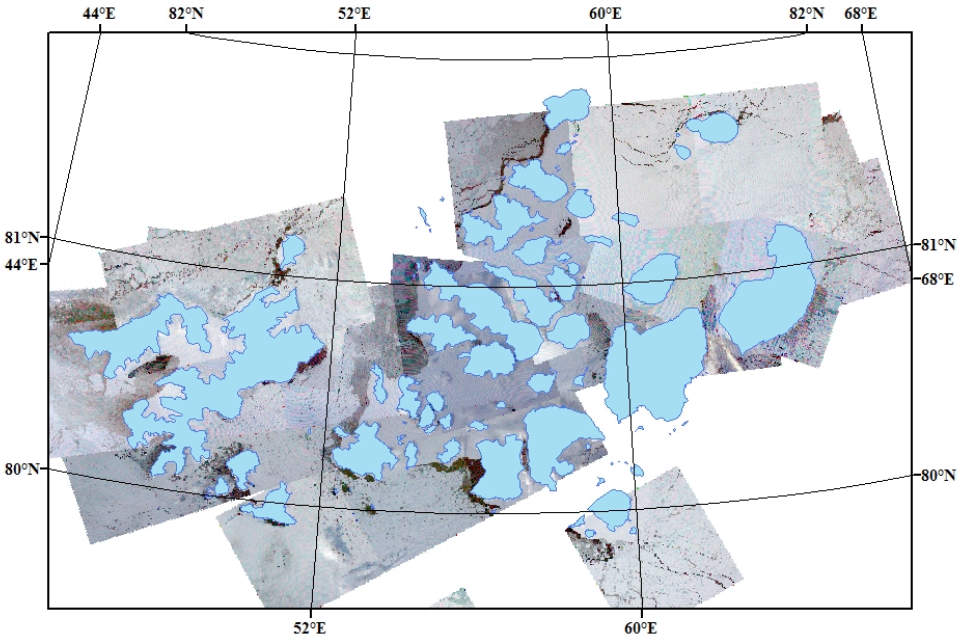


Figure 3 34 ASTER images March Franz Joseph Land

Severnaya Zemlya (Figure 4): 80 images were used (26 images from March and 54 images from April).

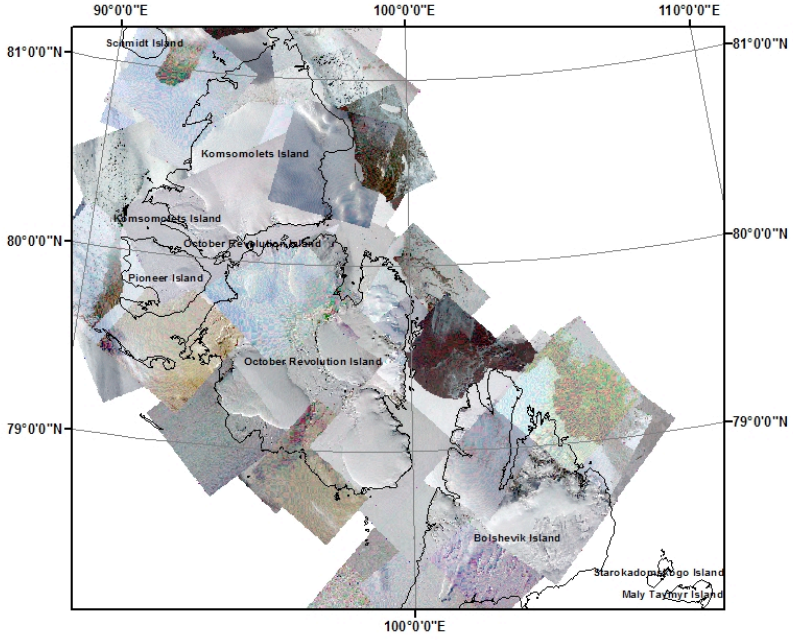


Figure 4 80 ASTER images from March and April Severnaya Zemlya

2.3 Methods

ASTER images are usually comes as HDF files. A python script was modified in ARC GIS to read the file and extract the 3 visible and near infra-red bands to a tiff format which is easy to handle in ARC GIS. A raster database containing the images in tiff format was created in the Arc GIS. The three bands of the images were projected in Red Green and Blue (RGB). Simple enhancement (contrast enhancement) was applied for the images to improve the visual interpretations.

The icebergs were deleted manually by zooming in and out of the images (the spatial resolution of the images are 15 m). When images are overlapped the iceberg is demarcated only one time from the first image since most of the icebergs are embedded in fast ice (no drifting). The following figures showing a zoom in part of the images covering some locations in the both study areas where the icebergs are easy to visualized.

Franz Joseph land

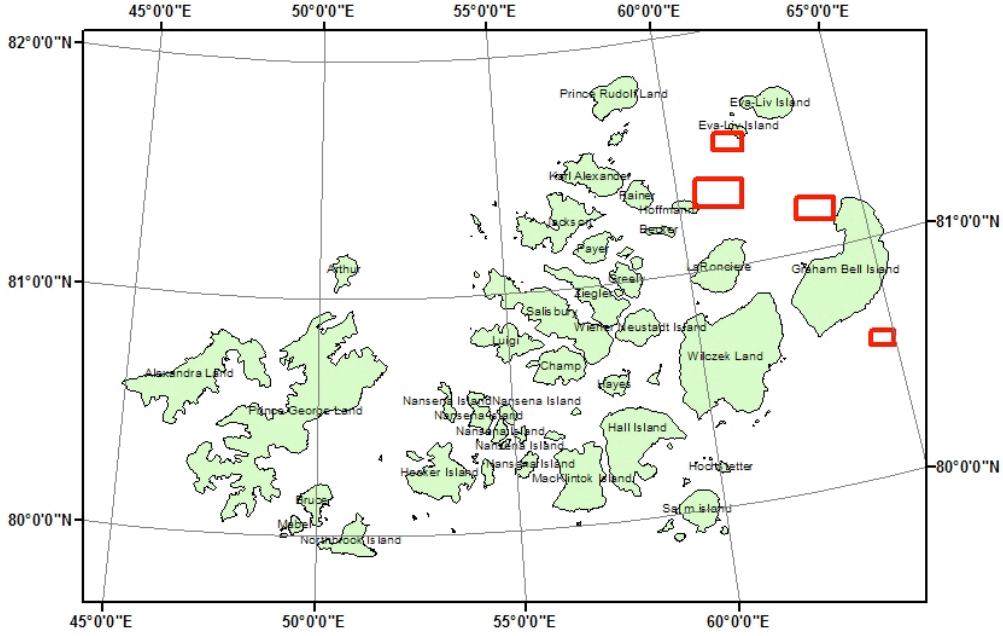
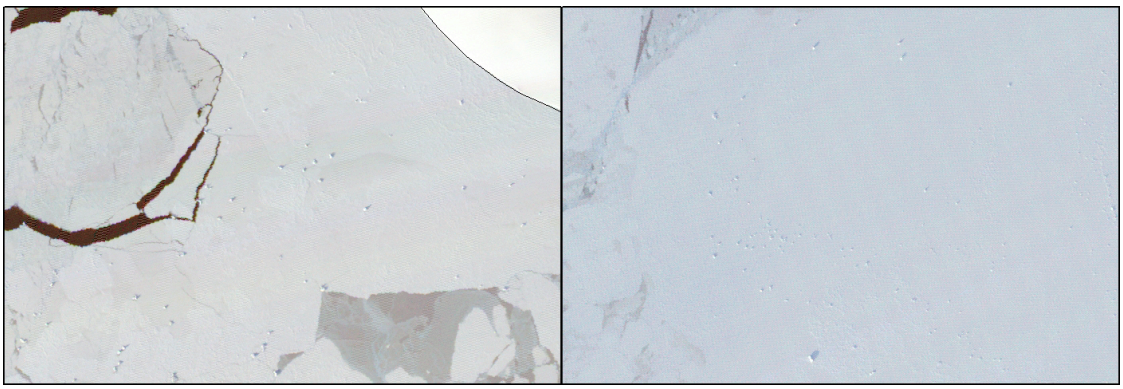


Figure 5 Franz Joseph land map showing the selected area are demarcated with red rectangulars.



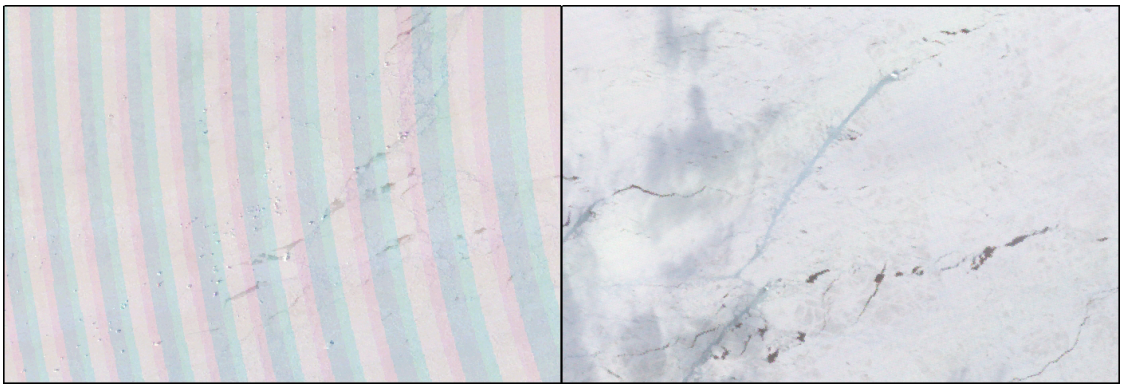


Figure 6 zoomed in part of the ASTER images used in the analysis the numbers in the image showing the location according in the above map.

Severnaya Zemlya

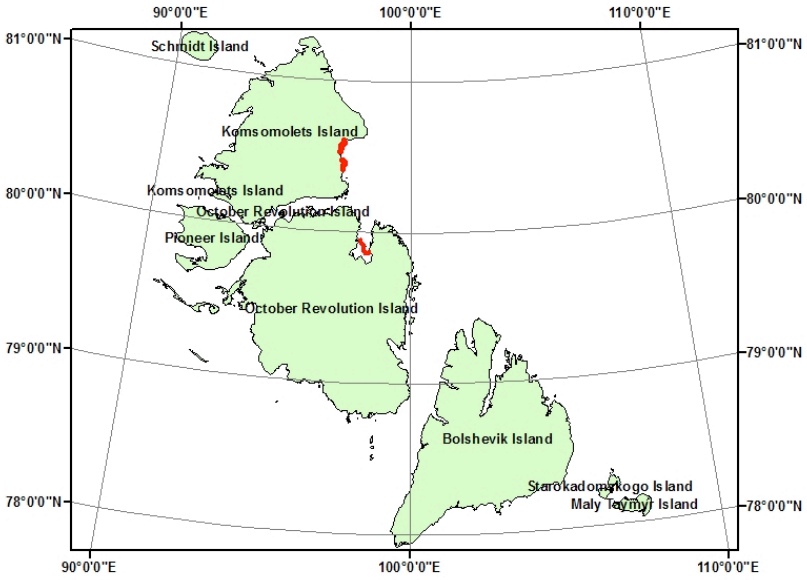
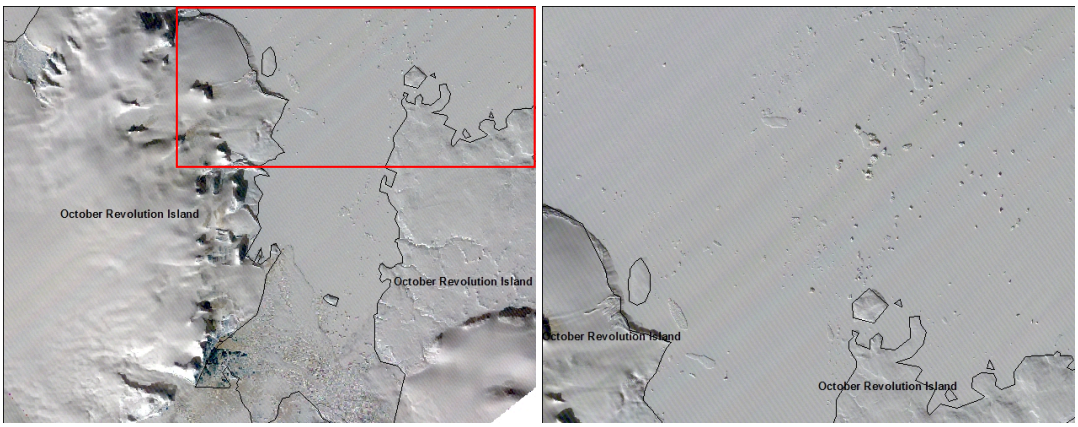


Figure 7 Severnaya Zemlya map where the selected areas are demarcated with red lines



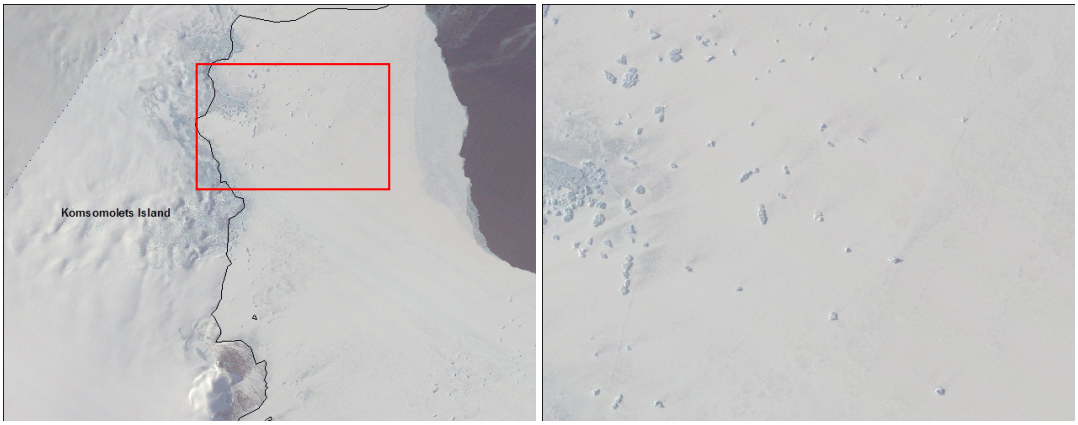


Figure 8 zoomed in part of the ASTER images used in the analysis the numbers in the image showing the location according in the above map.

To understand the distribution of icebergs in both areas, icebergs distribution maps were created from the icebergs maps. The method is based on point density function calculation available in the Arc GIS spatial analysis tool. The Point Density tool calculates the density of point features around each output raster cell. Conceptually, a neighbourhood is defined around each raster cell center, and the number of points that fall within the neighbourhood is totalled and divided by the area of the raster cell. There are main two parameters to be defined, the cell size (more for smoothing the maps) and the search radius within which to calculate density. Units are based on the linear unit of the projection of the output spatial reference (UTM is used here so the units are meters). Here we used 100 m for the cell size and for the radiuses which usually depending on the purpose of the density map creation we defined 500 km which in both areas are more than the length of the maps.

3 Results

3.1 Franz Joseph land

2600 icebergs detected and demarcated from the aster images (figure 9). The icebergs are distributed over the whole area and they are in difference sizes but the smallest will be around the pixel size of the image which is 15 meters.

For better understanding the distribution of the iceberg in the area and where are more icebergs calving, a density map was created based on point density method (figure 10). The highest density is around Hoffmann Island (there are no main calving areas here but maybe they were drifting from nearby calving glaciers. To compare the result with previous similar study (Atlas of the Arctic Iceberg), a contour map is created (Figure 11) where the isoline is representing the number of icebergs. This map is compared with the same month map from the Atlas (March) (Figure 12), the number of icebergs are different and the reasons for that may be due the in the Atlas they use the average from several years here it is only 2012, and also the source of data is different that may influence the number of icebergs mapped. They coincide on the density (both the result and the Atlas have they high density around Hoffmann Island.

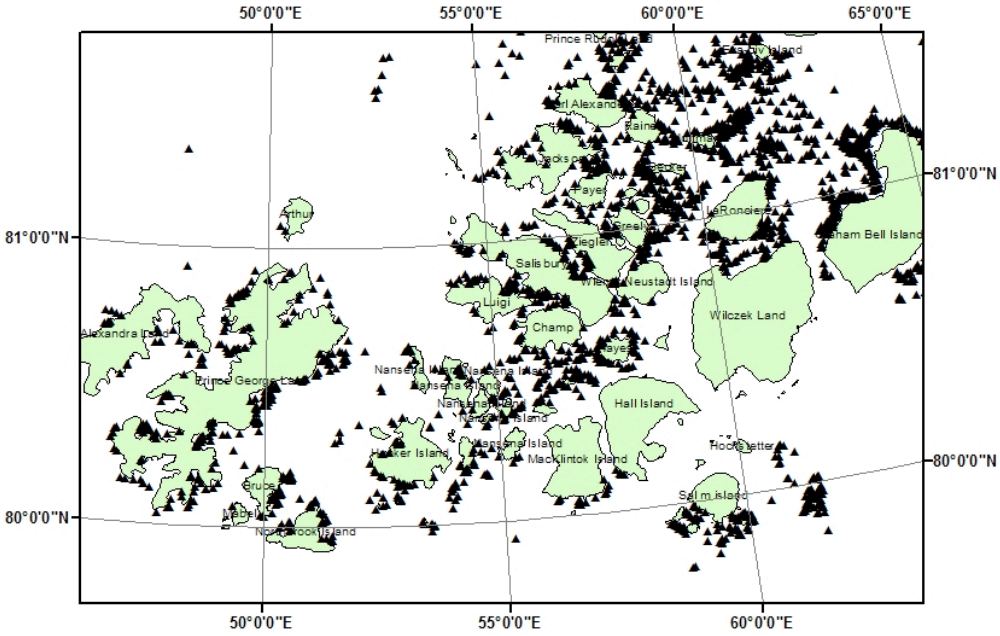


Figure 9 Franz Joseph land icebergs distribution map based on the ASTER images

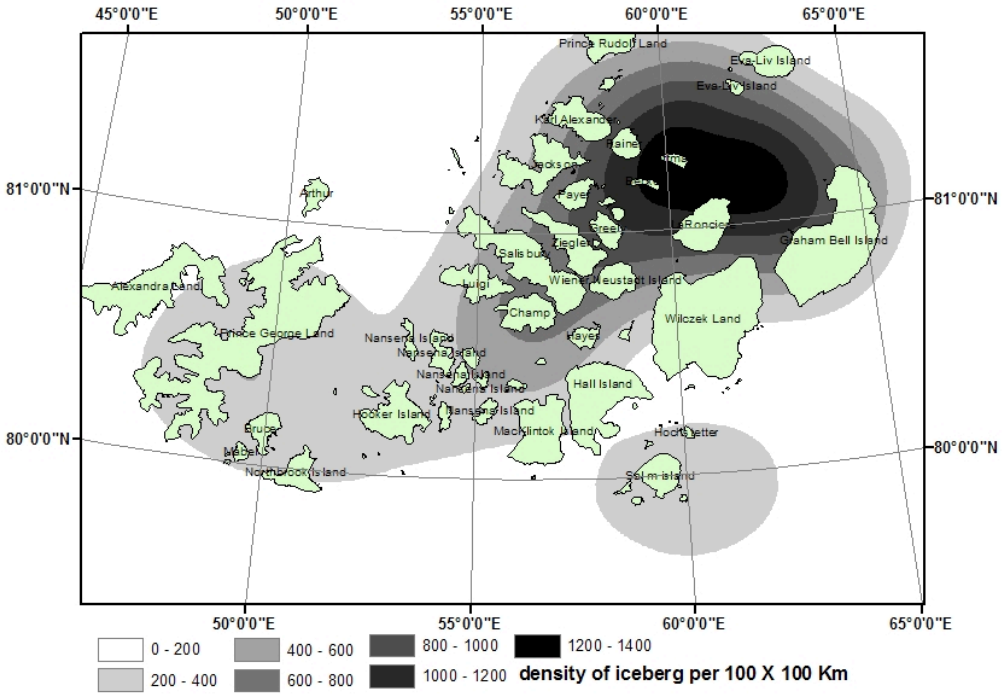


Figure 10 icebergs density map for Franz Joseph land produce from the icebergs distribution map

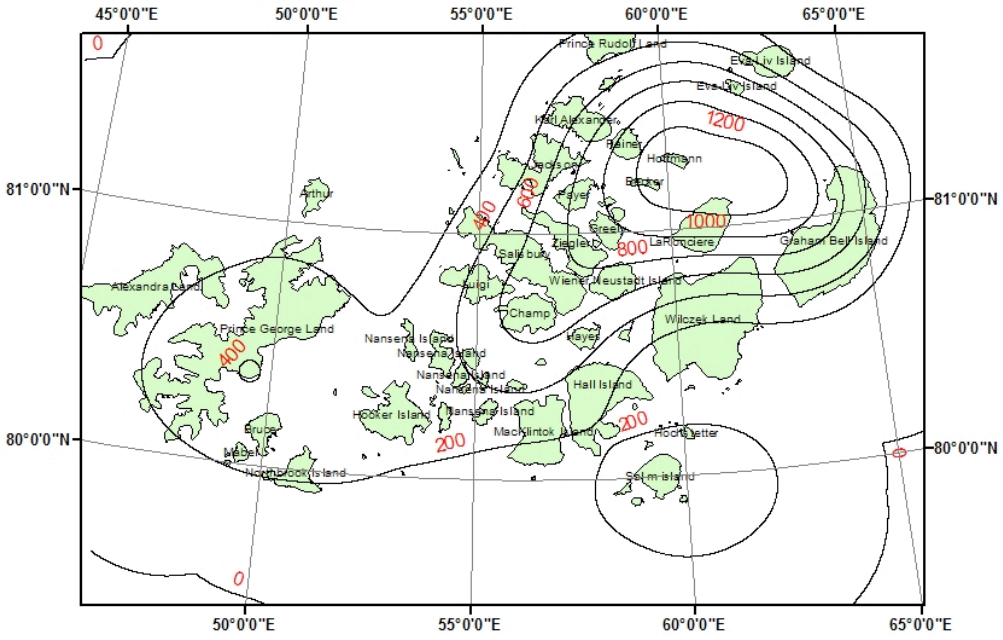


Figure 11 number of icebergs

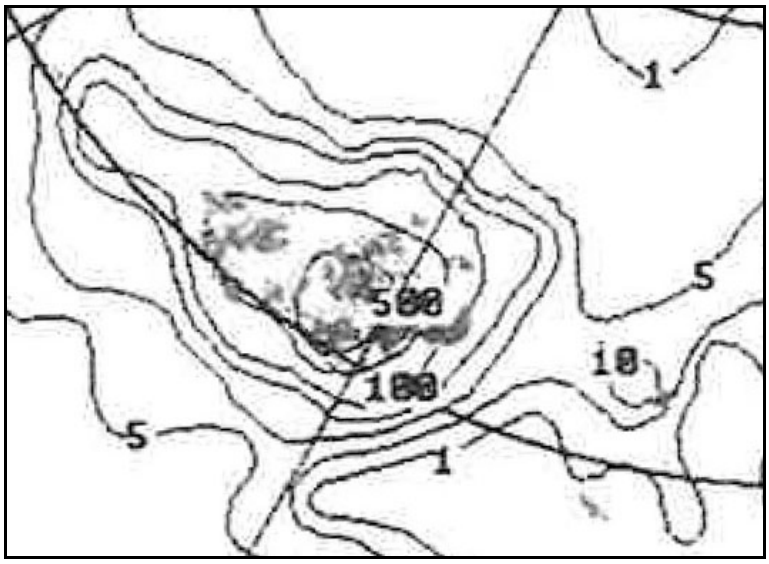


Figure 12 Icebergs average number for Franz Joseph land for the month of March (Atlas of the Arctic Iceberg)

3.2 Severnaya Zemlya

For Severnaya Zemlya more images are available to use and they are covering the entire islands, the total number of images are 80 images. 4470 icebergs were detected and demarcated. Most of the icebergs are detected in the east part of islands (Laptev Sea) and Krasnoi Armii Strait, where the out let glaciers calving, that maybe due to the fact there few (5 to 6) slow-moving outlet glaciers flow towards the Kara Sea and 26 fast-moving outlets reach the Laptev Sea. The main source is Matusevich Ice Shelf which is the largest remaining ice shelf in the Russian high arctic.

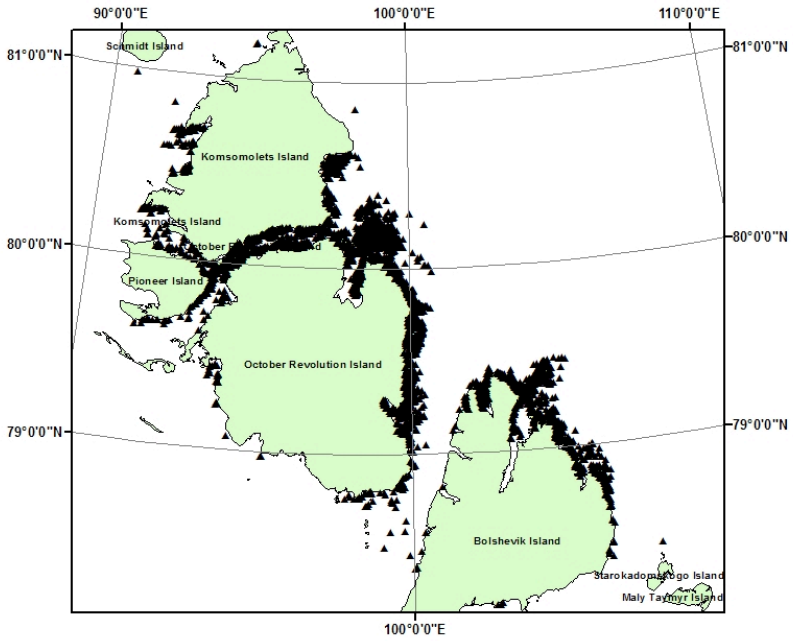


Figure 13 Severnaya Zemlya icebergs distribution map based on the ASTER images

The same procedures is followed here after creating icebergs distribution map (figure 13), a density map was created (figure 14). The highest density of icebergs is at fjord let to Matusevich Ice Shelf, and that is expected. Isoline iceberg number map was created (figure 15) and compared with map from the iceberg Atlas for the same period (figure 16). The number of icebergs from this study is much higher compared to the Atlas generally the number from this study is for one year while from the Atlas is an average from several years. Also the source of data is different but the main reason may be to the recent breakup of the Matusevich Ice Shelf which produces high number of icebergs.

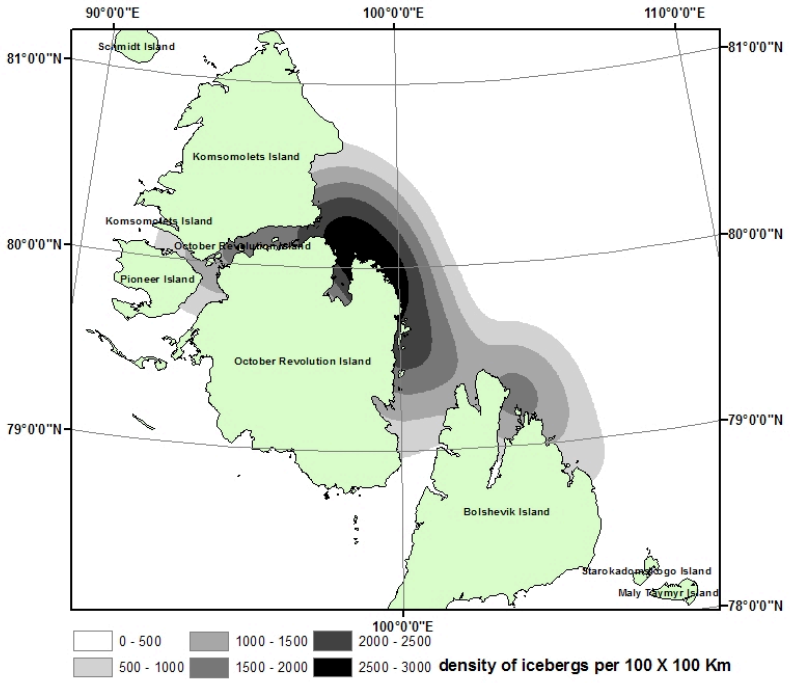


Figure 14 icebergs density map for Severnaya Zemlya produce from the icebergs distribution map

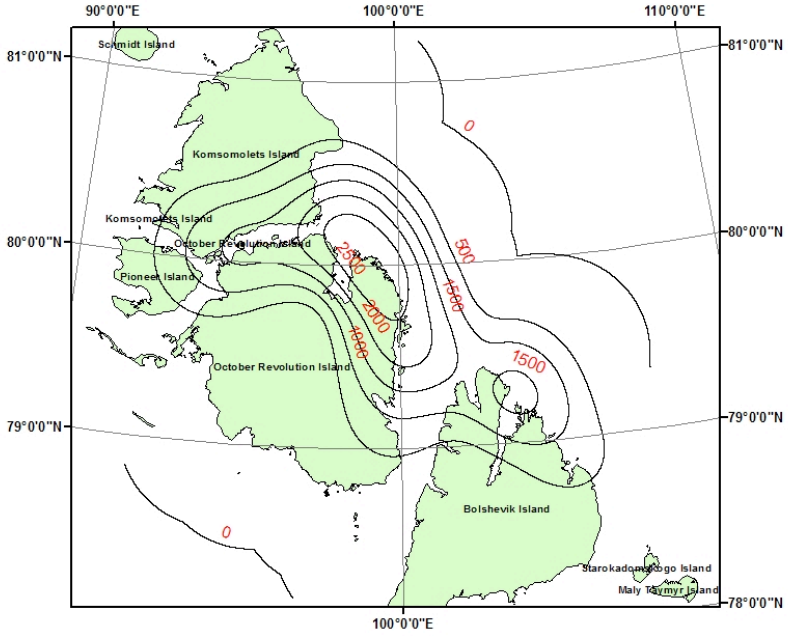


Figure 15 Isoline map showing the number of iceberg

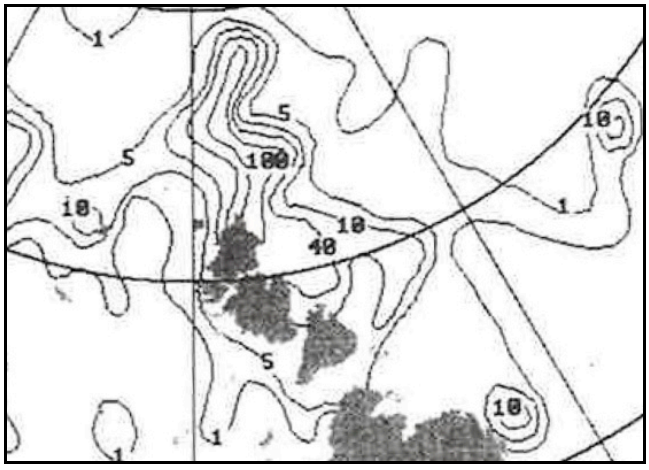


Figure 16 Icebergs average number for Severnaya Zemlya for the month of March (Atlas of the Arctic Iceberg)

4 Section 4

These maps will be more meaningful if they are produce more often using the same sensors (optical or SAR) for the same geographical area under the same conditions, and these case it will make it easy to study distribution change of icebergs in these area. Now with availabity of landsat8 and the new coming satellite Sentinels 1 and 2 this may improve much.

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