ICE CONDITIONS IN THE GULF OF RIGA

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About Sea-Ice

Gulf of Riga is well known for its seasonal ice cover. The ice conditions in Gulf of Riga can vary significantly from year to year due to weather conditions. As soon as the first minus temperatures occurs, the ice emerge on the low separated bays starts. It is not only the average temperature that affects the ice, changes in wind can make ice conditions more severe even if temperatures are normal. The ice in the Gulf of Riga exists as fast ice and drift ice. Fast ice is situated in coastal and archipelago areas, where the depth is less than 15 meters. It develops during early ice season, and remains until the melting period. The drift ice has a dynamic nature being forced by winds and currents. Depending on the year, the ice cover season on the Gulf of Riga starts between late November and middle January. The length of the ice season, which can last until late April, is in the range of 3-5 months. In addition to interannual ice cover variations there are significant spatial variations between different Gulf areas. The use of satellite imagery enables to monitor ice extent during different winter scenarios. Data from Moderate Resolution Imaging Spectroradiometer (MODIS) is used for ice extent monitoring and for characterization of average winter conditions.

Studied parameters and results

The ice climate in the Gulf of Riga can be characterized by the extent of the ice cover, the duration of the ice season and probability of ice. Based on ice cover extent information obtained from satellite images the winters from 2002 to 2011 were divided into three classes: severe, medium and mild.

- In severe winters the first sea ice typically begins to form at the beginning of December. The maximum ice coverage is usually reached in February or March and sea ice remains until May.
- In medium winters the first ice usually forms at end of December or at the beginning of January. Last ice in medium winters can be seen middle April.
- In mild winters the ice begins to form in January and melts by the beginning of April. (Tabel 1)

Ice probability

There is a great variation in the ice probability from year to year (Fig.2). Ice probability during different winter scenarios can be seen on Figure 4.

In mild winters (2006/2007, 2007/2008, 2008/2009) almost the entire study area was most of the time ice free. Only shallow coastal regions have ice probability less than 50%.

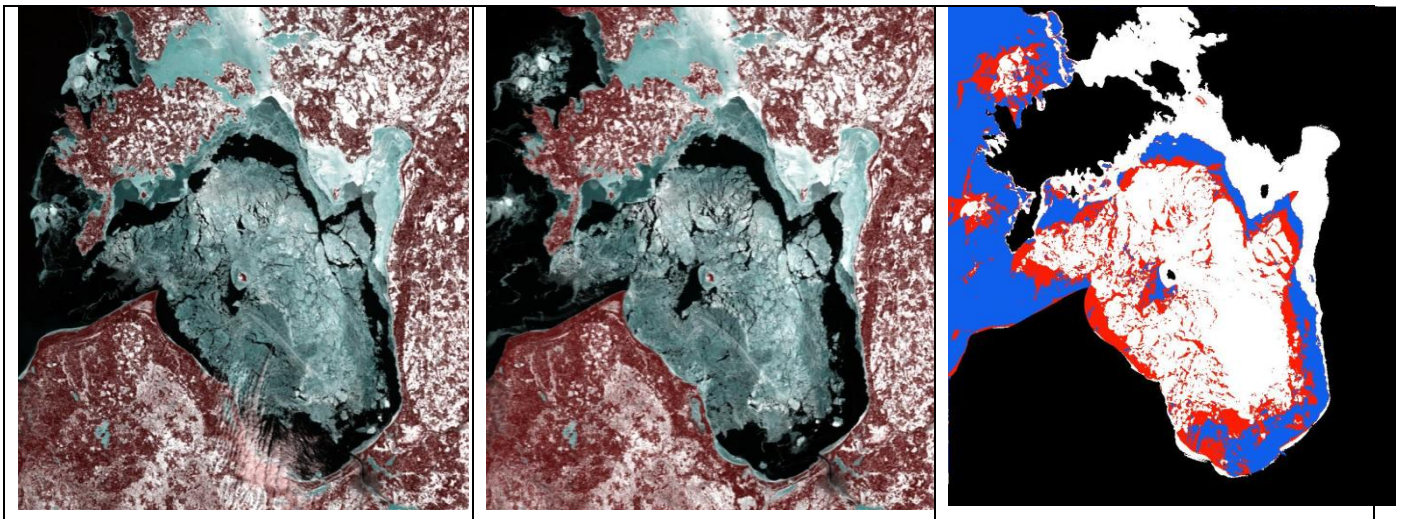
In case of winters with medium ice conditions (2003/2004 and 2004/2005) the ice cover probability of the coastal areas and archipelago during the ice season is less than 70%. In the open area of Gulf of Riga the ice probability is less than 20%.

During severe winters (2002/2003, 2005/2006, 2009/2010 and 2010/2011) almost all of the Gulf of Riga freezes over. Pärnu Bay and other low coastal areas has ice probability over 80% and open part of Gulf of Riga more than 50%.

The average ice cover map which includes data from 366 images from years 2002-2011 shows, that the northern part of the study area (Moonsund and Gulf of Pärnu) has ice cover probability over 60% (winters during 2002-2011) while the corresponding value for the rest of the area up to 30%. Western parts of Saaremaa and Hiiumaa are covered by ice only in severe winters. On southern part of Saaremaa can be seen the unfrozen patch of water. (Fig. 6 (a))

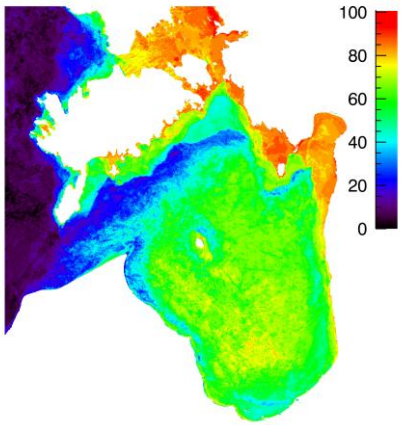
Ice days

The number of ice days in different winters can be seen on figure 3. There is great variation between different winter scenarios. Therefore it is also important to calculate average maps for different winter classes, which give a good overview of the temporal stability of the ice (Fig.5). In the severe winters the number of ice days was in the range 135-149, in medium winters the number was in the range 100-126 and in the mild winter in the range 83-97.
The average ice cover map which includes data from 366 images shows, that on average the maximum number of ice days during 2002-2011 was 114 days (Fig. 6b) Moonsund and Gulf of Pärnu was covered by ice more than 76 days. The ice covered the open part of Gulf of Riga around 30-40 days. The western part of Saare- and Hiiumaa is covered by ice less than 10 day.

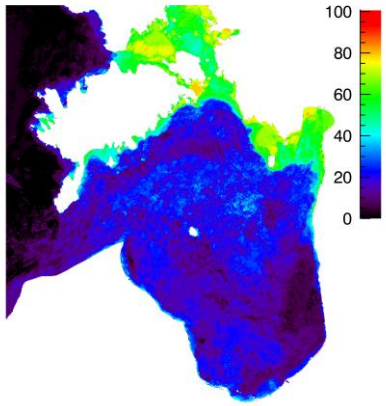


a) b) c)

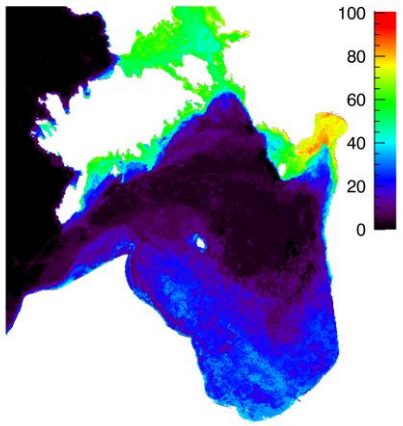
Figure 1. a) 15 March 2011 b) 16 March 2011.c) Image showing ice movements between15 March 2011 and 16 March 2011: red area shows regions of where cover hanged du to ice drift between those two days, blue area represents open water and white represents the area where ice was resented on both days.



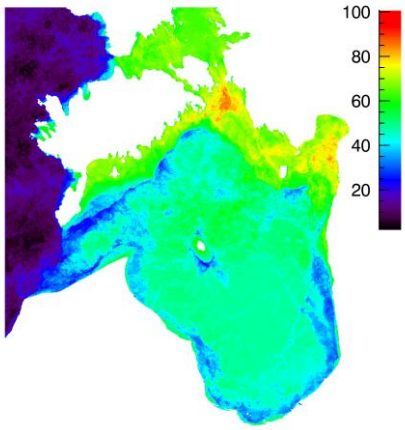
2002/2003 severe winter.
Maximum ice probability 94%



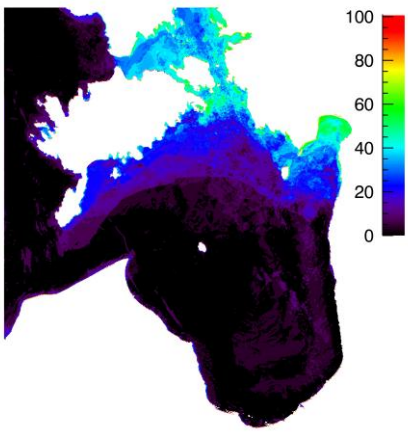
2003/2004 medium winter.
Maximum ice probability 74%



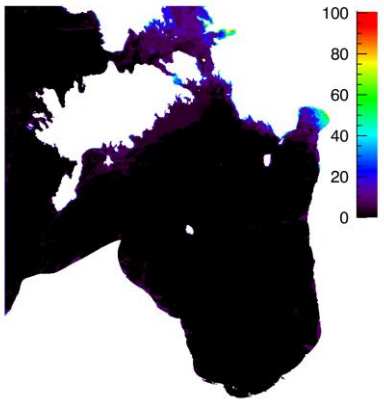
2004/2005 medium winter.
Maximum ice probability 85%



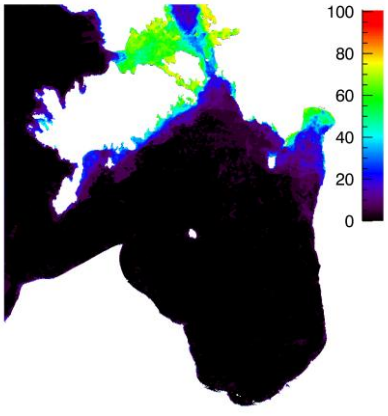
2005/2006 severe winter.
Maximum ice probability 88%



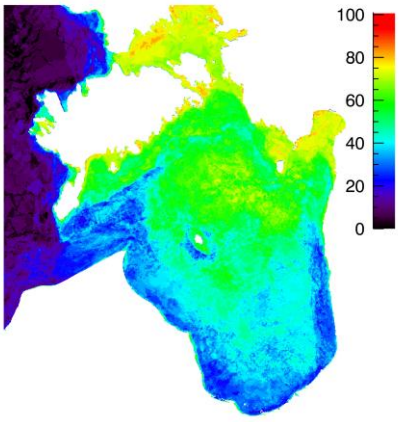
2006/2007 mild winter.
Maximum ice probability 60%



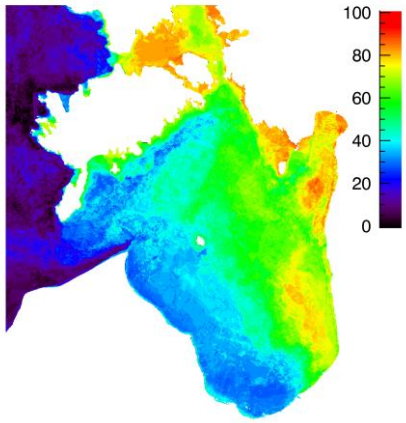
2007/2008 mild winter.
Maximum ice probability 59%



2008/2009 mild winter.
Maximum ice probability 70%



2009/2010 severe winter.
Maximum ice probability 88%



2010/2011 severe winter.
Maximum ice probability 90%

Figure 2. Ice cover probability maps for winters 2002/2003-2010/2011.

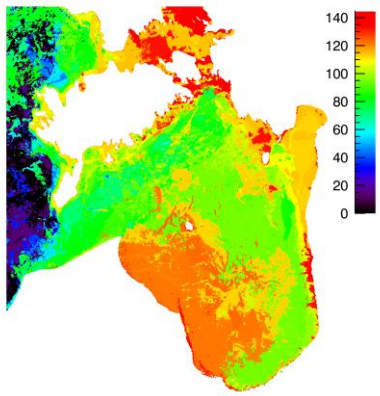
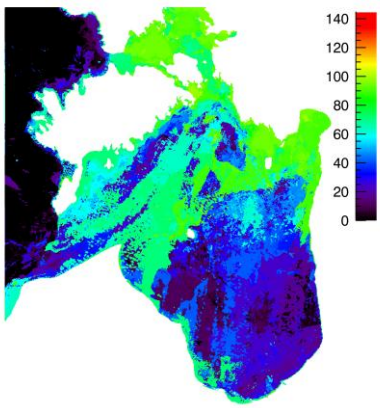
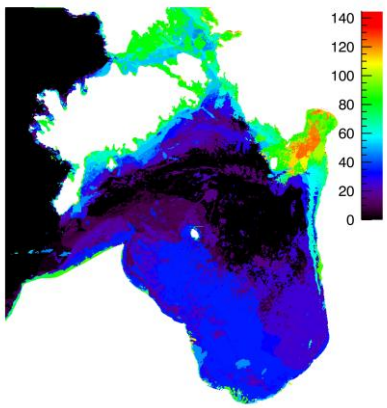
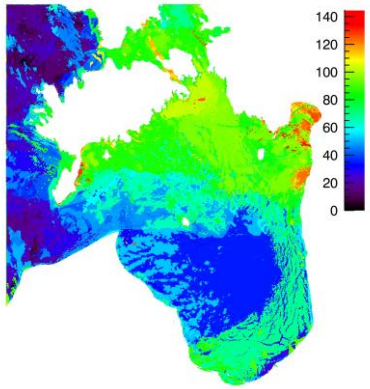
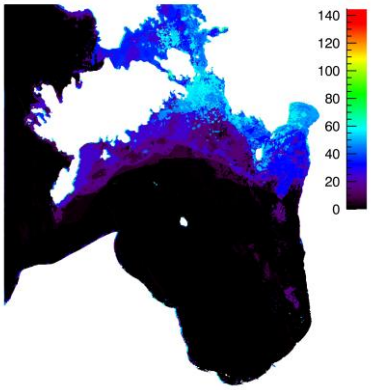
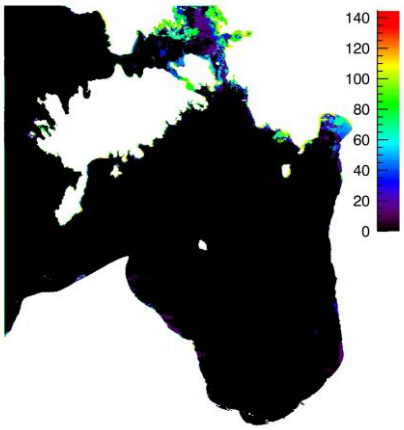
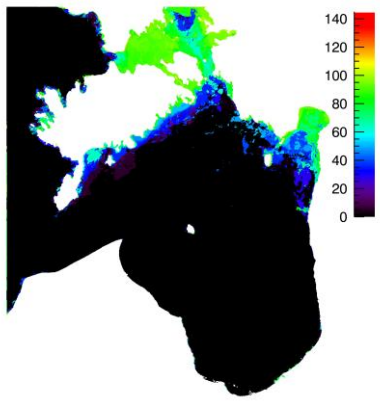
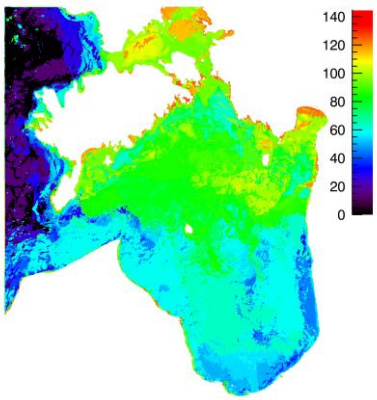
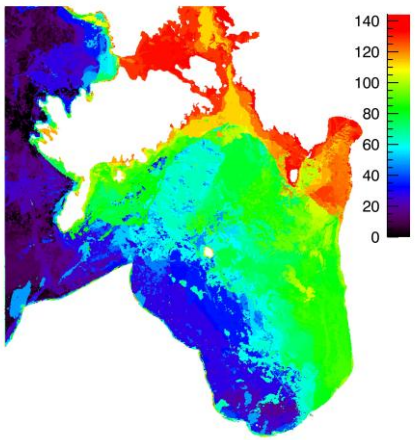
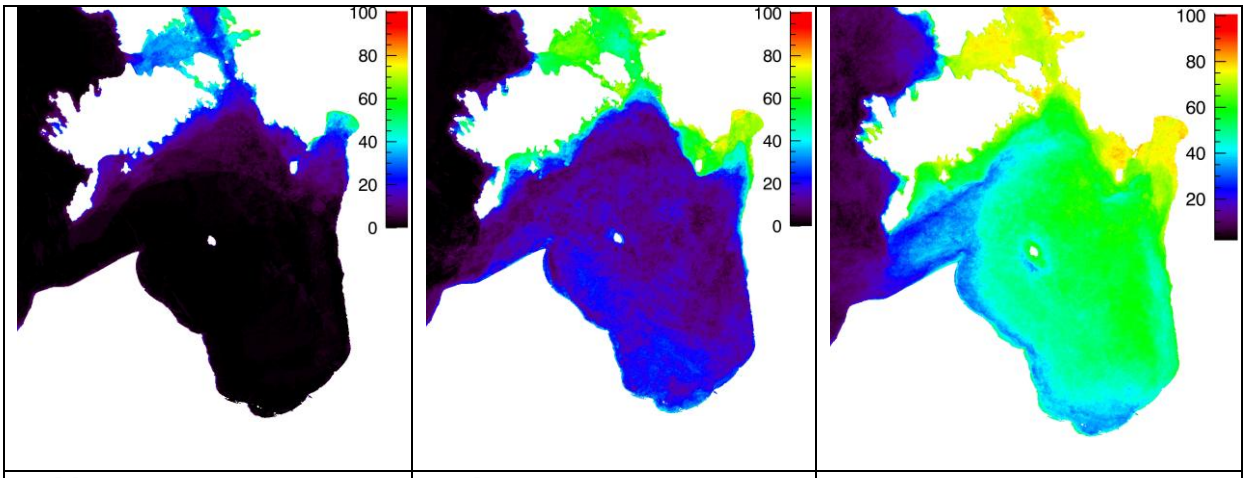
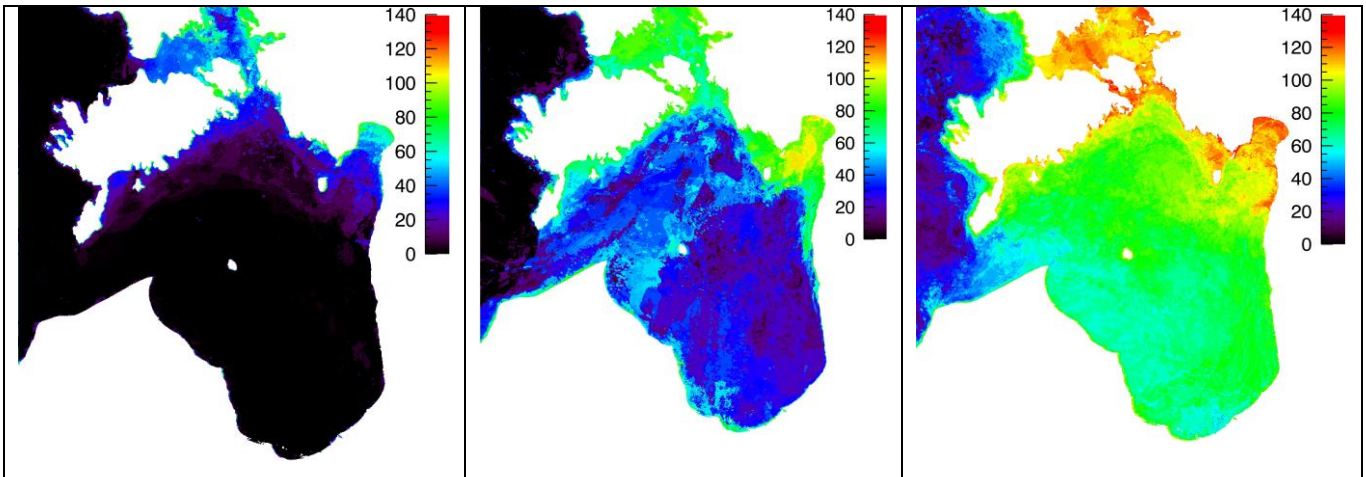
		
2002/2003 severe winter. Maximum ice days 142	2003/2004 medium inter. Maximum ice days 100	2004/2005 medium winter. Maximum ice days 126
		
2005/2006 severe winter. Maximum ice days 149	2006/2007 mild winter. Maximum ice days 92	2007/2008 mild winter. Maximum ice days 83
		
2008/2009 mild winter. Maximum ice days 97	2009/2010 severe winter. Maximum ice days 135	2010/2011 severe winter. Maximum ice days 146

Figure 3. Maps of number of ice cover days for winters 2002/2003- 2010/2011.



Mild winters 2006/2007, 2007/2008 and 2008/2009	medium winters 2003/2004 and 2004/2005	severe winters 2002/2003, 2005/2006, 2009/2010 and 2010/2011

Figure 4. Maps showing the ice probability with 1km spatial resolution during different winter scenarios.



Mild winters 2006/2007, 2007/2008 and 2008/2009	medium winters 2003/2004 and 2004/2005	severe winters 2002/2003, 2005/2006, 2009/2010 and 2010/2011

Figure 5. Image showing the number of ice days during different winter scenarios.

Tabel 1: Ice freezing and melting dates, ice seasons length and average air temperatures. (temperature data was provided by EMHI, Kihnu station).

Winter	First ice	Last ice	Length of the ice season (days)	Winter average(C°)	Winter scenarios
2002/03	6.12.2002	30.04.2003	145	-2,4	Severe
2003/04	01.01.2004	8.04.2004	102	0,6	Medium
2004/05	21.12.2004	17.04.2005	117	0,2	Medium
2005/06	19.12.2005	30.04.2006	132	-1,3	Severe
2006/07	3.01.2007	1.04.2007	88	2,2	Mild
2007/08	14.01.2008	6.04.2008	83	2,7	Mild
2008/09	1.01.2009	8.04.2009	97	1,5	Mild
2009/10	14.12.2009	28.04.2010	135	-2,1	Severe
2010/11	1.12.2010	28.04.2011	148	-1,3	Severe