Estonia Latvia Programme
European Union
Linking Estonia and Latvia
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Wind and Ice

Overview of RP1 and plans for RP2

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MSI

Climatological parameters relevant for wind farming		SAR	HIRLAM
Mean annual wind speed	10m a.g.l.; 100m a.g.l	ok	ok
Weibull A		ok	ok
Weibull k		ok	ok
Mean monthly wind speed			
January	10m a.g.l.; 100m a.g.l	ok	ok
February	10m a.g.l.; 100m a.g.l	ok	ok
March	10m a.g.l.; 100m a.g.l	ok	ok
April	10m a.g.l.; 100m a.g.l	ok	ok
May	10m a.g.l.; 100m a.g.l	ok	ok
June	10m a.g.l.; 100m a.g.l	ok	ok
July	10m a.g.l.; 100m a.g.l	ok	ok
August	10m a.g.l.; 100m a.g.l	ok	ok
September	10m a.g.l.; 100m a.g.l	ok	ok
October	10m a.g.l.; 100m a.g.l	ok	ok
November	10m a.g.l.; 100m a.g.l	ok	ok
December	10m a.g.l.; 100m a.g.l	ok	ok
Wind direction			
Mean annual wind direction (12 sectors 30 deg /16 sectors 22.5 deg)			ok
Mean annual air density			ok
Max air density			ok
Min air density			ok
Energy			
Mean annual energy density (W/m2)		ok	ok
Other relevant meteorological parameters			
Mean annual temperature			ok
Minimum temperature			ok
Maximum temperature			ok
Days of temperature below -20C per year			ok
Mean relatve humidity %			ok

5) Identification of wind field parameters relevant for wind farming (integral, statistical parameters of data series, derived parameters as gusts, turbulence gradients) (Est 2, Lat 2).

- Activity 5: List of parameters that will be retrieved from satellite SAR imagery and HIRLAM (EE) atmospheric model

SAR imagery

- 1) Downloading, preprocessing and archiving of satellite (optical and SAR- Synthetic Aperture Radar) data from years 2000-2010 for wind map retrieval (Est 2)
- Activity 1: Satellite images acquired with SAR (Syntetic Aperture Radar) sensor were downloaded and preprocessed for further analysis and marine wind field retrieval during RP2 and RP3. In total **1931 SAR images** were downloaded and preprocessed that covered entirely or partially the study area (Gulf of Riga). An overview of the number of SAR images per year is given in Table 1.

Year	Nr. of images
2002	28
2003	157
2004	209
2005	238
2006	231
2007	255
2008	235
2009	271
2010	307

•Table 1. Overview of preprocessed satellite (SAR) imagery for wind field retrieval. (Output 1)

- Satellite part of Output 3. All routinely available satellite data that is needed for wind and ice map calculations has been downloaded and preprocessed.

- However, during the RP2 and RP3 additional specific high resolution satellite imagery will be ordered (funds on BL7 "satellite images") which is necessary for development of methods/algorithms for wind and ice map retrieval.

SAR wind retrieval principles

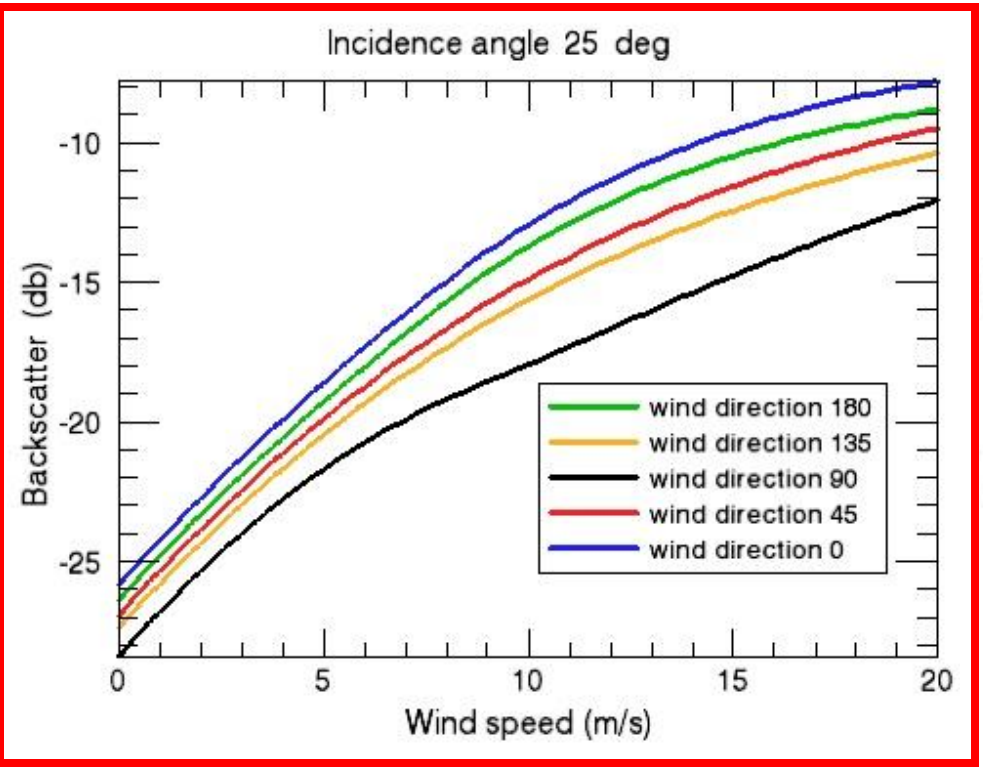
- CMOD5 - wind retrieval algorithm (Hersbach, 2002; Hersbach et al, 2007)
- CMOD5.N - wind retrieval algorithm for neutral winds (Hersbach, 2008; Hersbach, 2010)
  - Re-tuning of coeficients (28)
- σ°_{m} - measured radar backscatter
- σ°_{s} - simulated backscatter
- $\sigma^{\circ}_{s}(v,\Phi,\theta)=B0(v,\theta)*(1+B1(v,\theta)\cos(\Phi)+B2(v,\theta)*\cos(2\Phi))^{1.6}$
  - B0 describes dependancy on wind speed and incidence angle
  - B1 upwind-downwind effects
  - B2 upwind-croswind effects

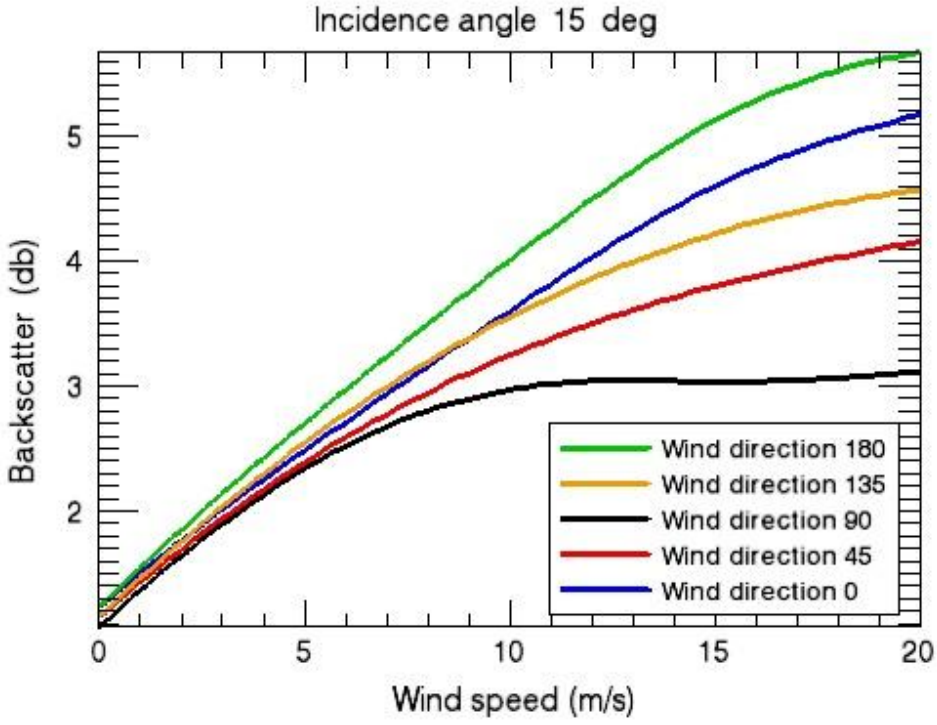
θ - incidence angle of radar beam

Φ- angle between wind direction (HIRLAM or in situ) and satellite flight direction

v- wind speed (0…….25 m/s) with 0.2 m/s bins

Backscatter dependace on wind speed and incidence angle





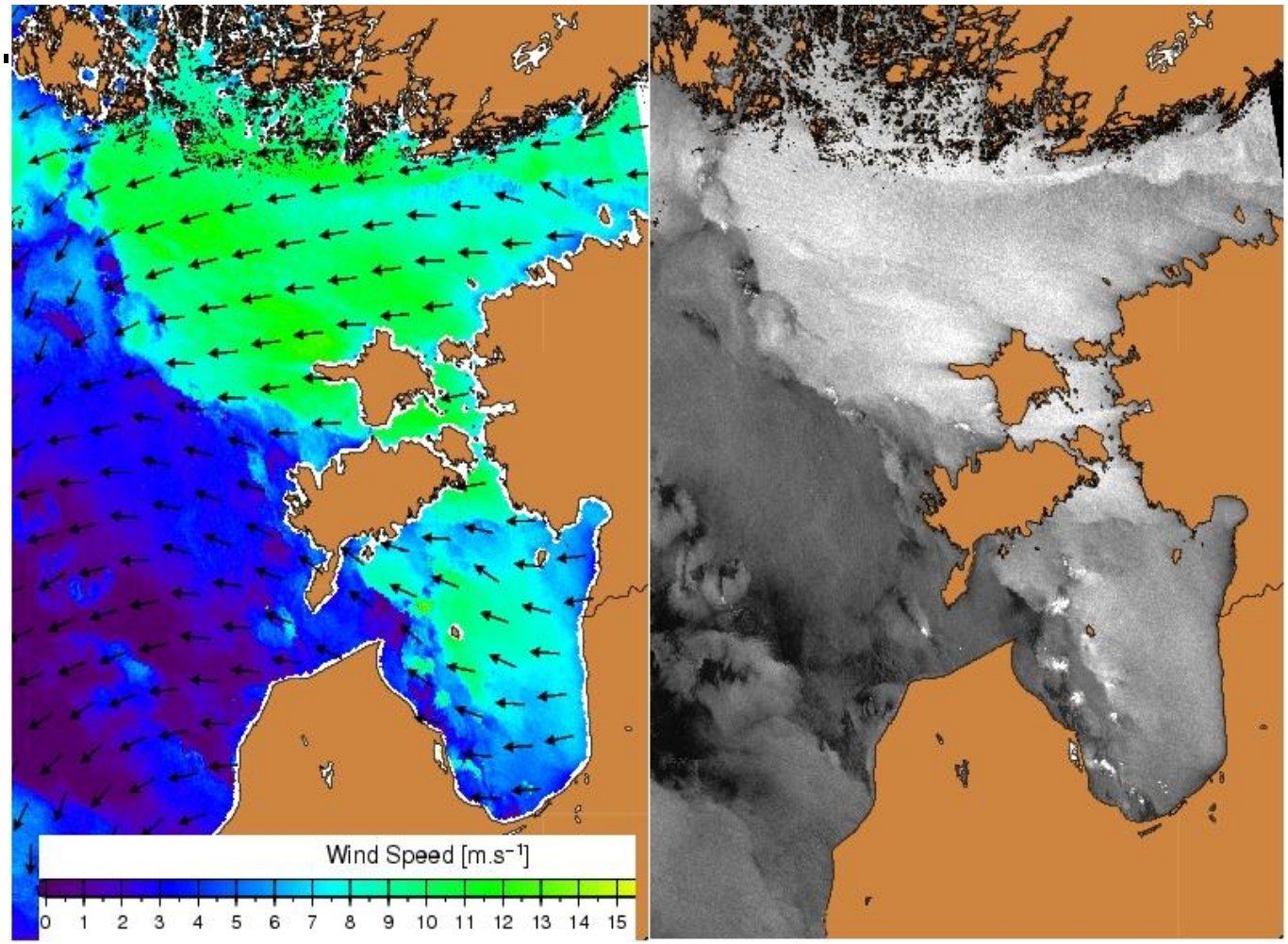
Cost function

- Maximum likelihood estimation (MLE)
- Finding minima between measured radar backscatter (σ°_{m}) and simulated backscatter (σ°_{s})

- MLE= $[(\sigma^{\circ}_{m} - \sigma^{\circ}_{s})/\Delta\sigma]^2$

  $\Delta\sigma = 0.078\sigma^{\circ}_{m}$
- The values of wind speed and direction corresponding to minimal vaule of MLE will be considered as wind speed on SAR image.

- We can retrieve wind speed for each pixel after comparing the measured σ°_{m} value with the simulated σ°_{s} values (that correspond to a specific speed/direction pair).



Future plans: wind

- A1) Development of algorithm for wind retrieval from radar imagery and implementation of the algorithm on the test dataset (Est 2). In progress
  - CMOD5
- 3)Development of method for extrapolating marine wind to coastal area. (0)

- ***Conclusion***
  - Data downloaded
  - Theoretical CMOD5 model “works”

Questions about wind?

ICE

Optical satellite imagery

- 2) Preprocessing of historical satellite (radar and optical imagery) data from years 2000-2010 for ice map retrieval (Est 2)
- Activity 2: Downloading and preprocessing of optical satellite images was carried out. The optical satellite images for retrieval of sea ice information during years 2002-2010 were downloaded/pre-processed. In total **437 optical images** are now **ready for further analysis** during RP2 and RP3. 109 images are totally cloud free and cover the entire study area while 328 images are partially (at least 50% cloud free) contaminated by cloud cover. An overview of the number of optical images per year can be seen in Table 2.

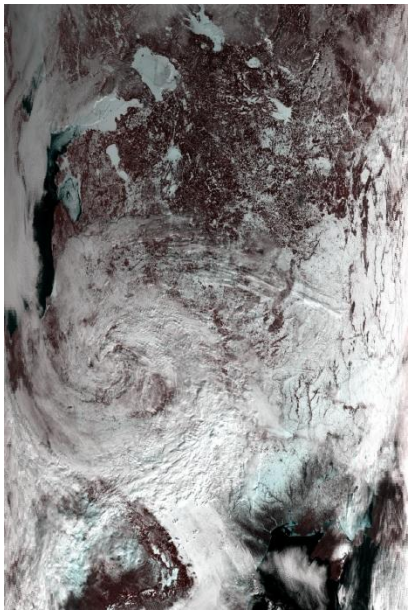
Winter	Total nr. of images	100% cloud free	Slightly clouded
2002/2003	63	18	45
2003/2004	46	16	30
2004/2005	55	10	45
2005/2006	56	15	41
2006/2007	46	8	38
2007/2008	32	7	25
2008/2009	41	7	34
2009/2010	44	9	35
2010/2011	54	19	35

Table 2. Overview of preprocessed optical satellite imagery for ice information retrieval. (Output 1)

Interpretation of ice optical imagery

- Downloading from NASA site

Example of raw image



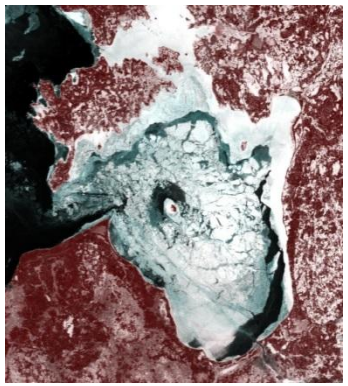
Spatial resolution: 250 m 2 channels in visible

- Exclude cloud covered images
- perform geocorrection (UTM 34?)
- Resize data

LR: 56.821224 24.849529

AL: 58.920598 21.549761

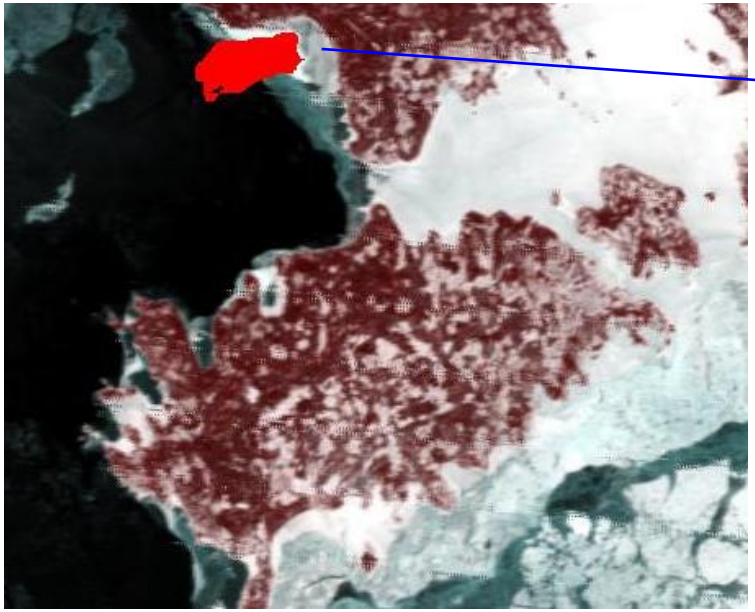
Resized and geocorrected image

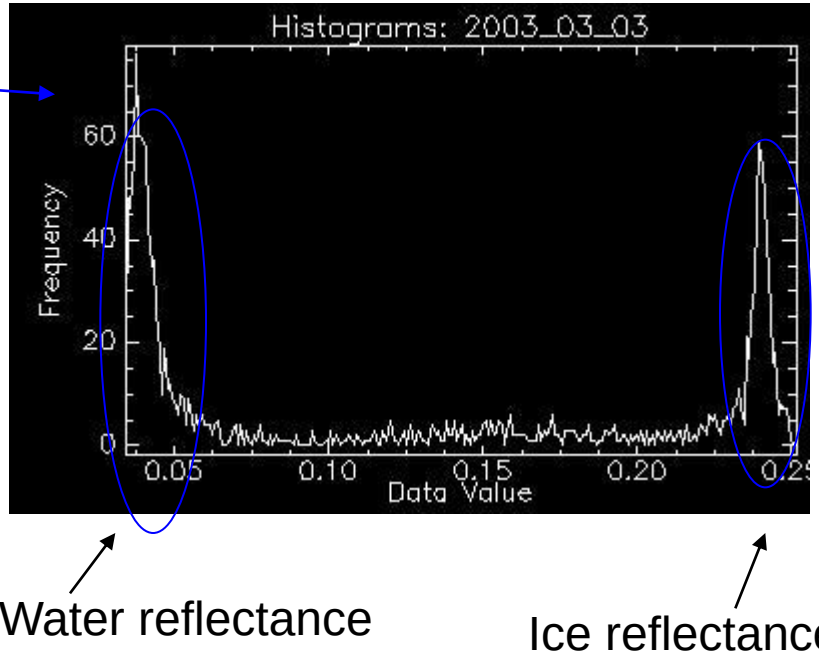


• Masking of land (land mask has 250m resulution and is obtained from summer images based on reflectance difference between land and water)

•Defining the threshold for distinguishing between ice and water

based on reflectance histogram analysis





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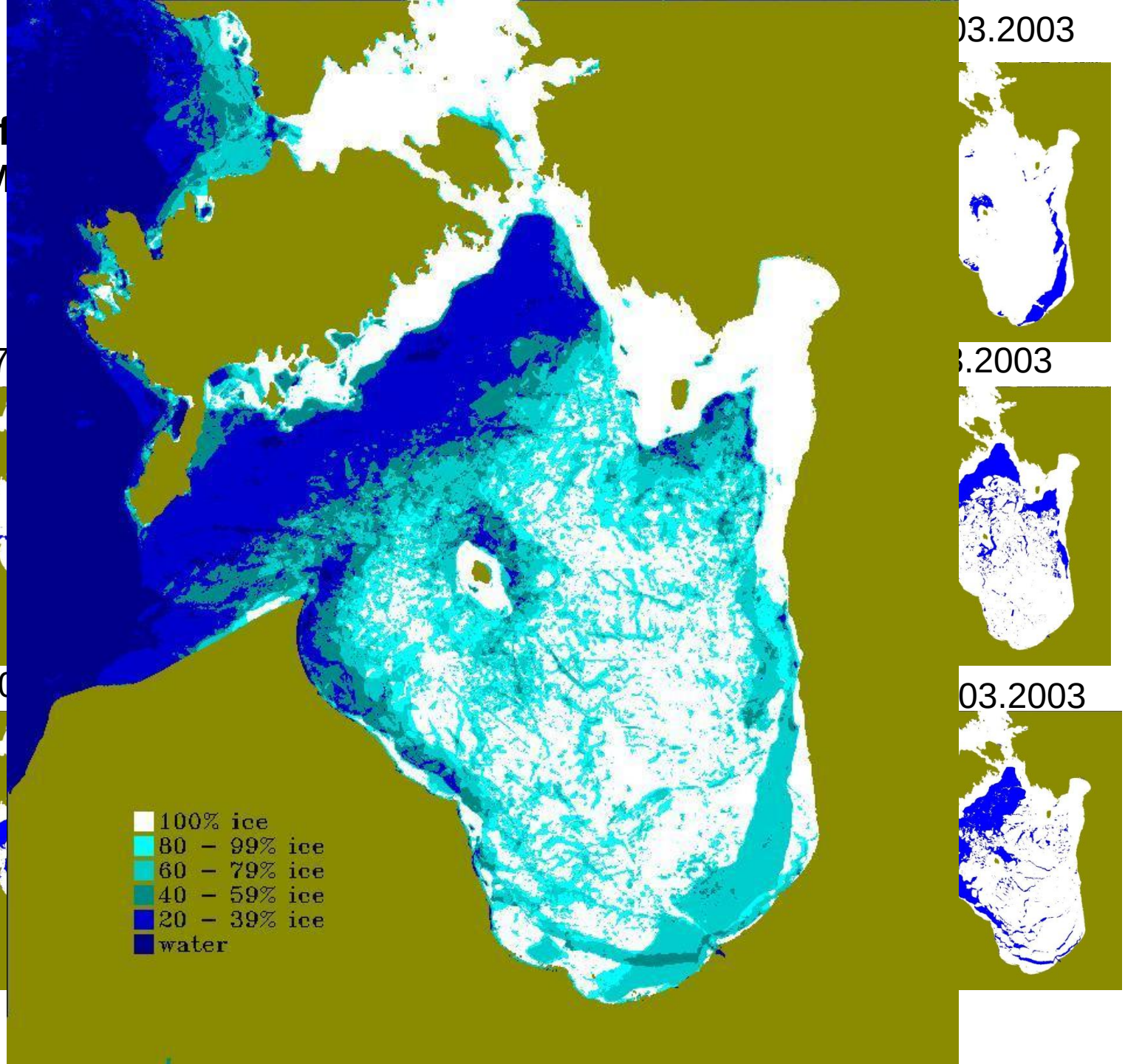

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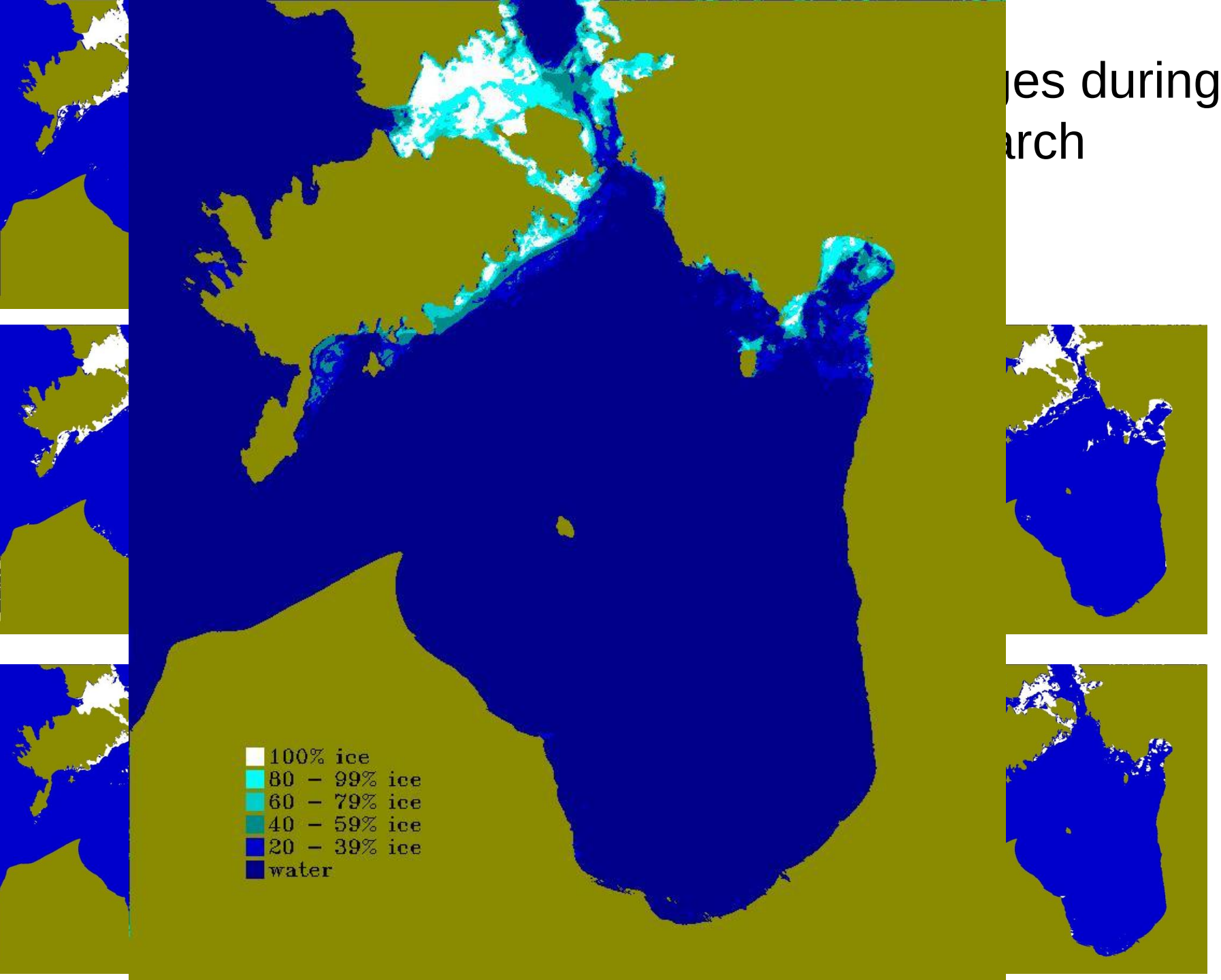
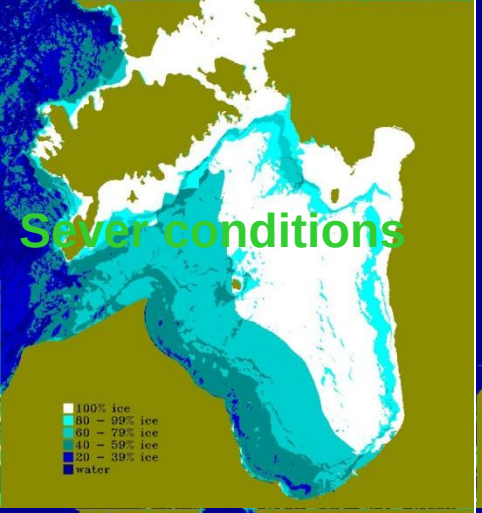
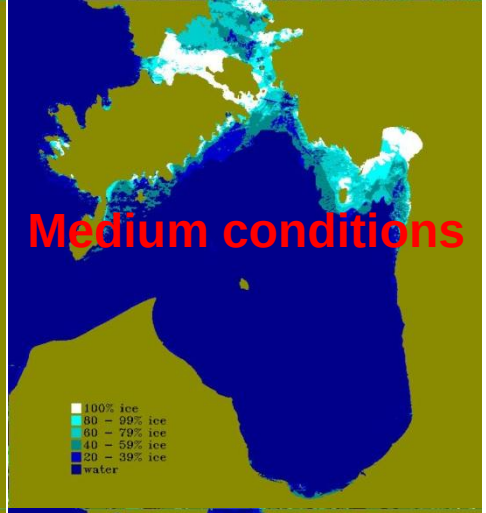
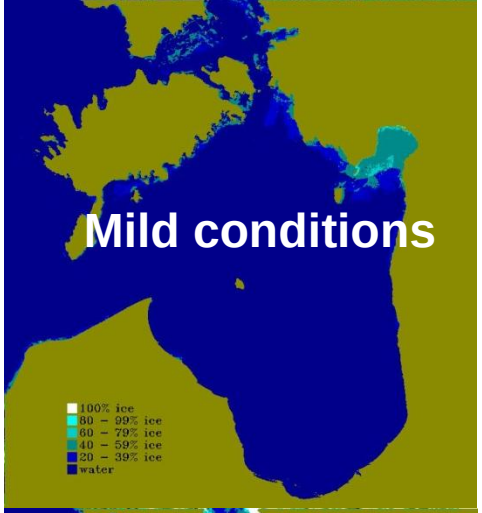
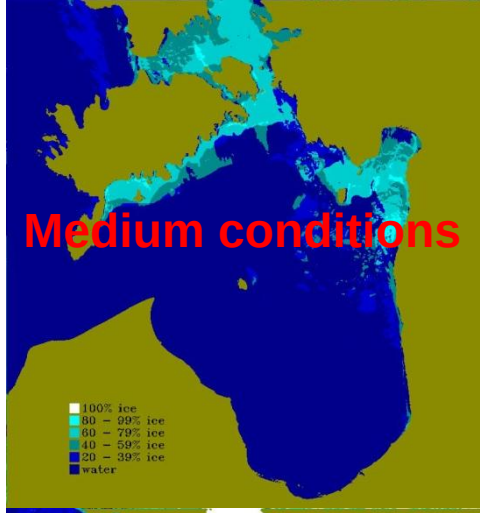
arch

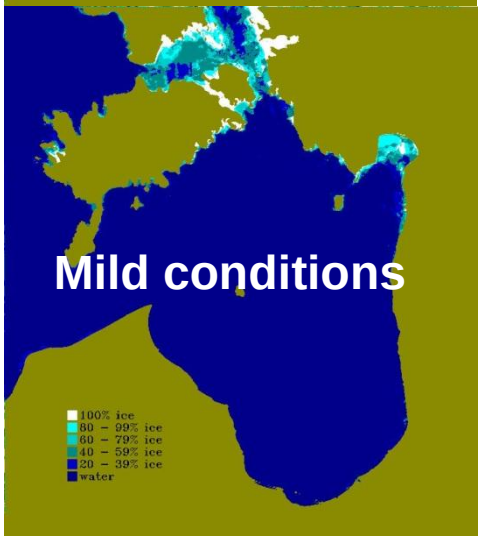


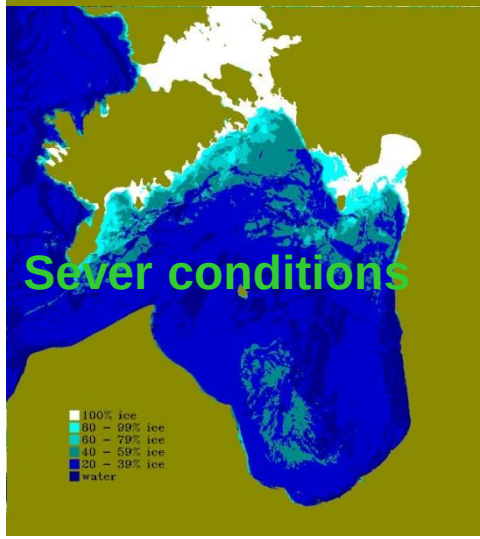


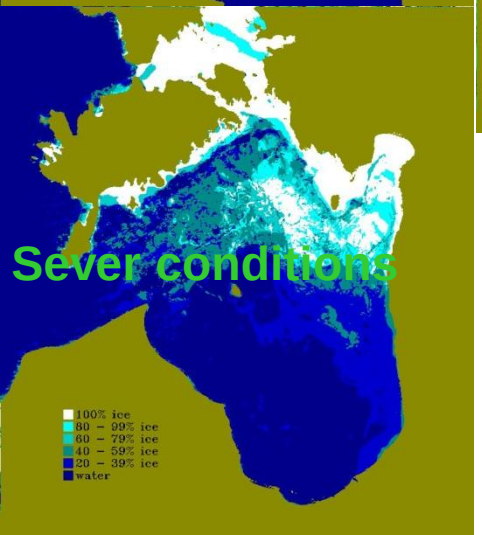




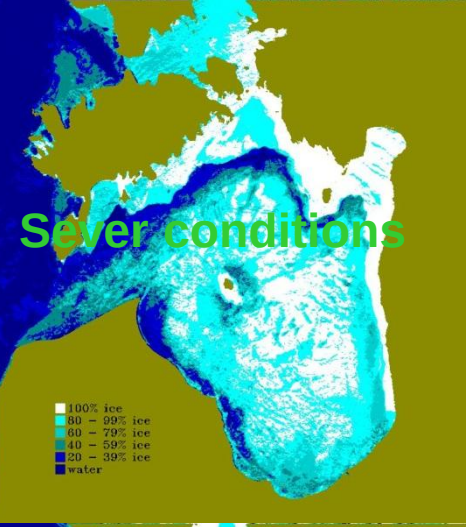


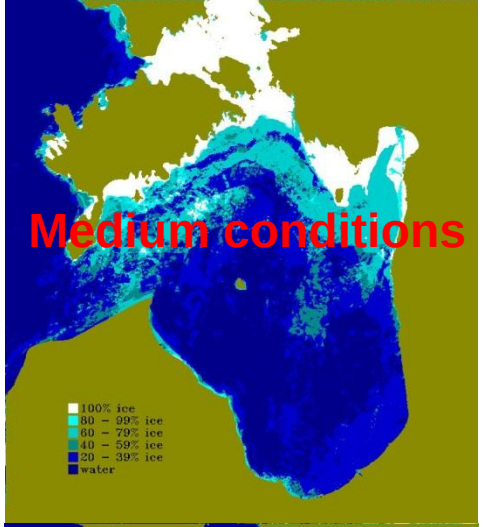


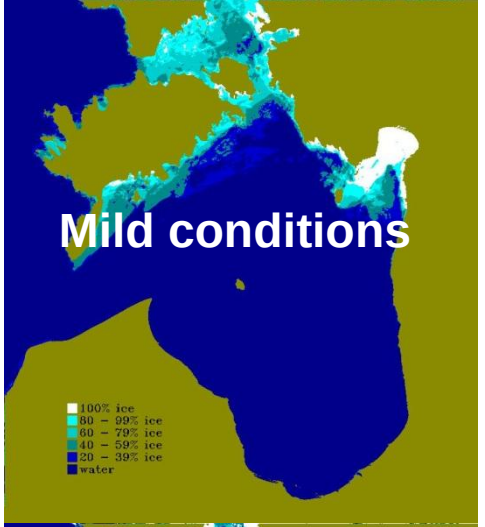


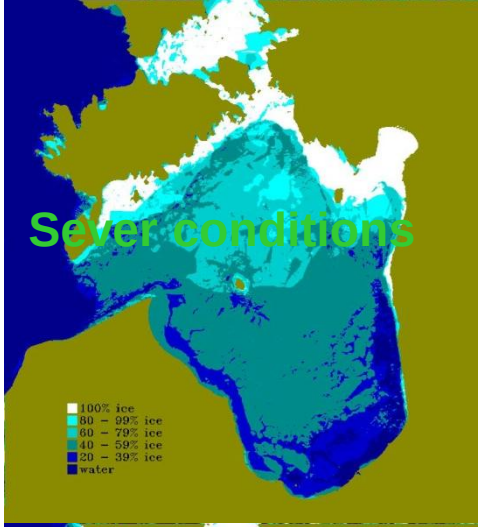


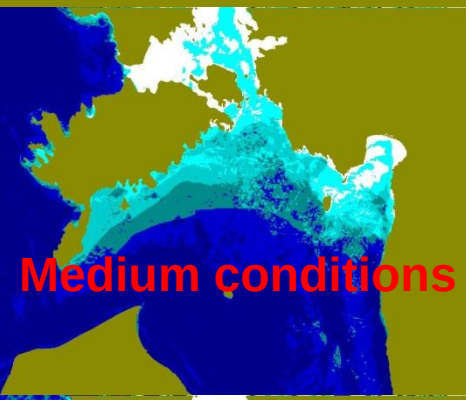
Average ice cover during January: 2003 - 2011

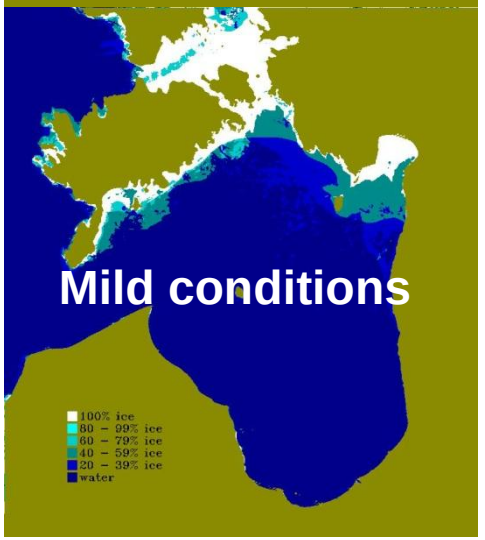


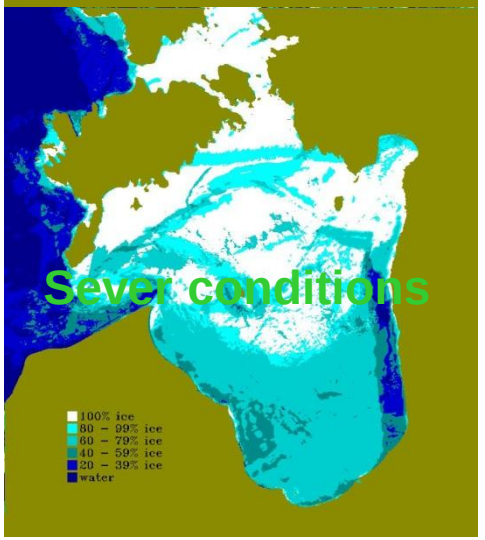


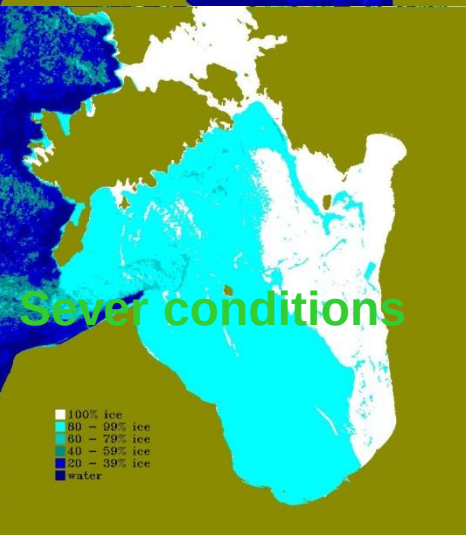




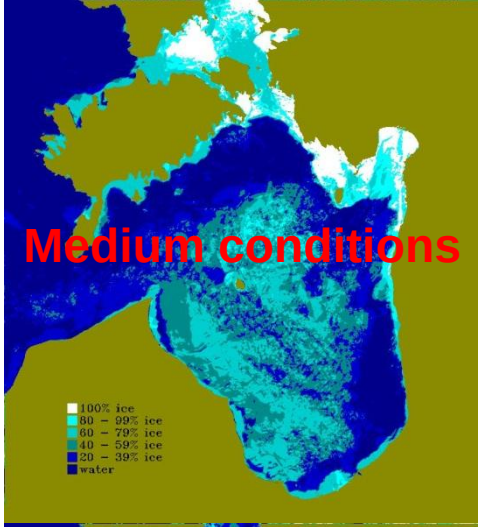


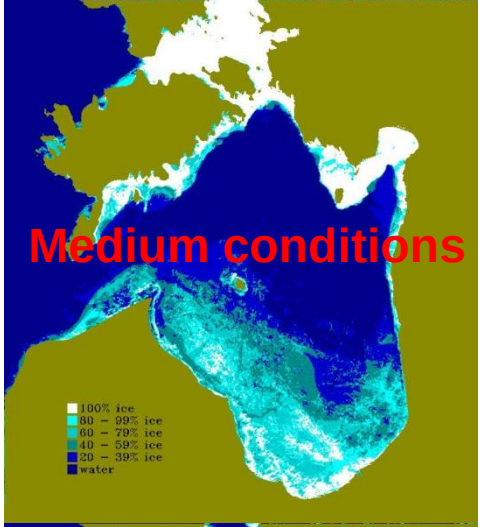


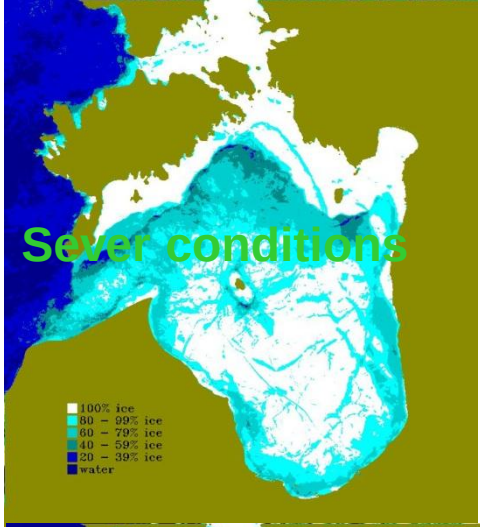


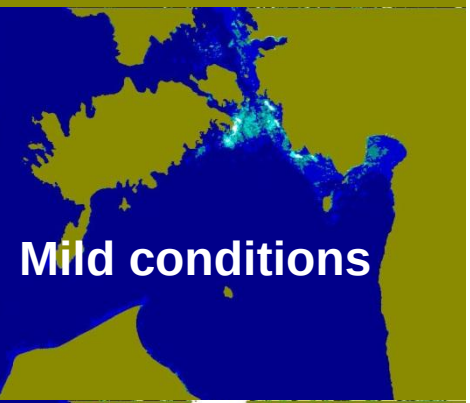


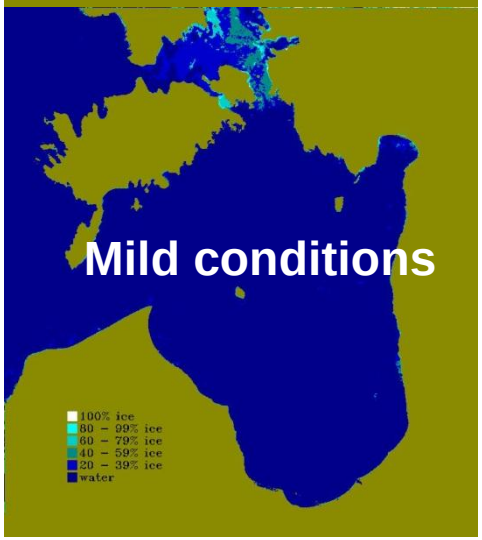
Average ice cover during February: 2003 - 2011

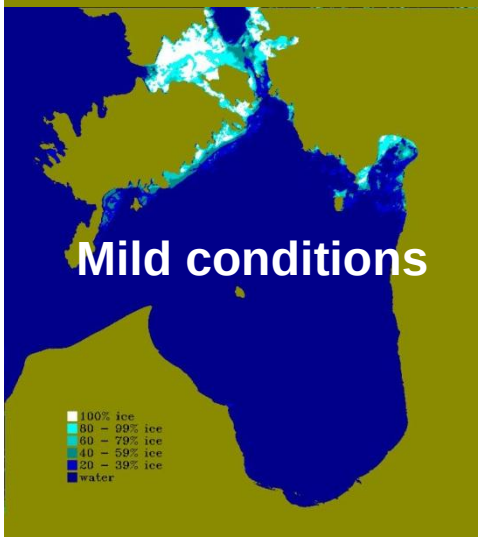


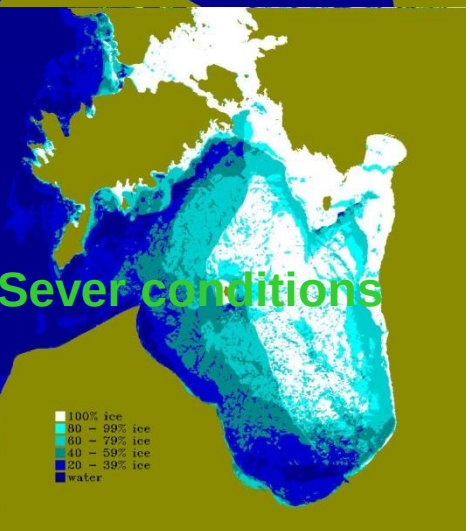










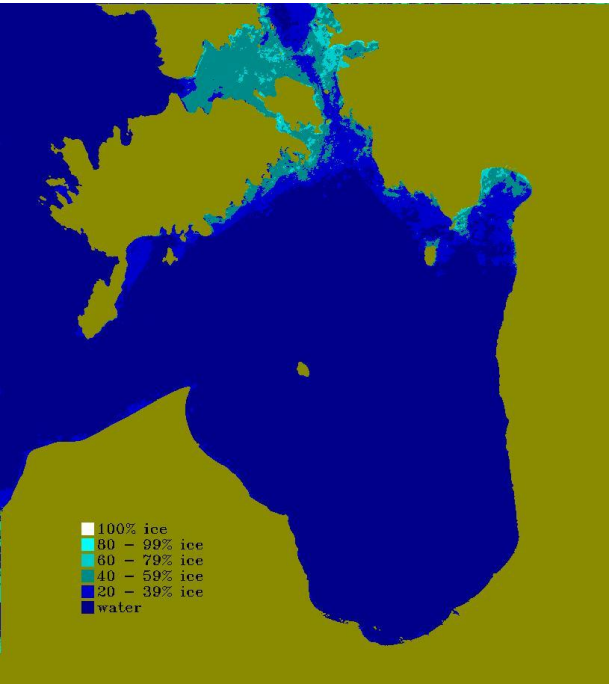


Average ice cover during March: 2003 - 2011

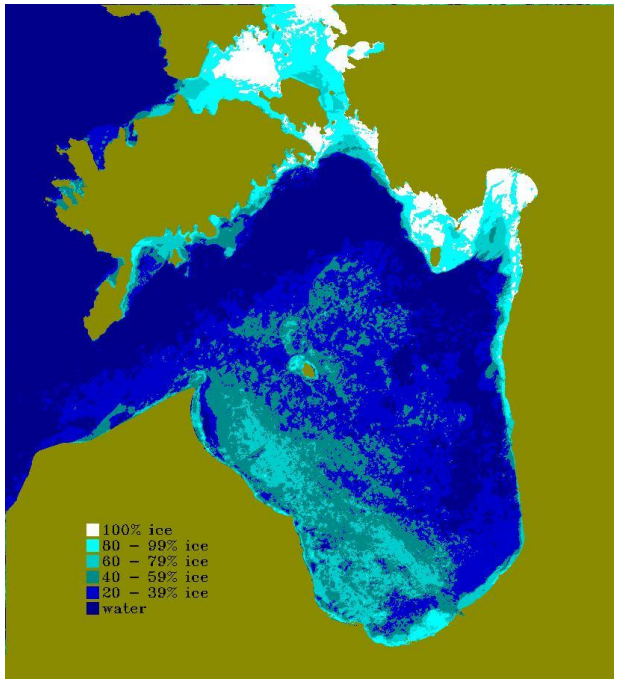
Average ice cover situation in March for different winter scenarios

- Mild
- Medium
- Severe

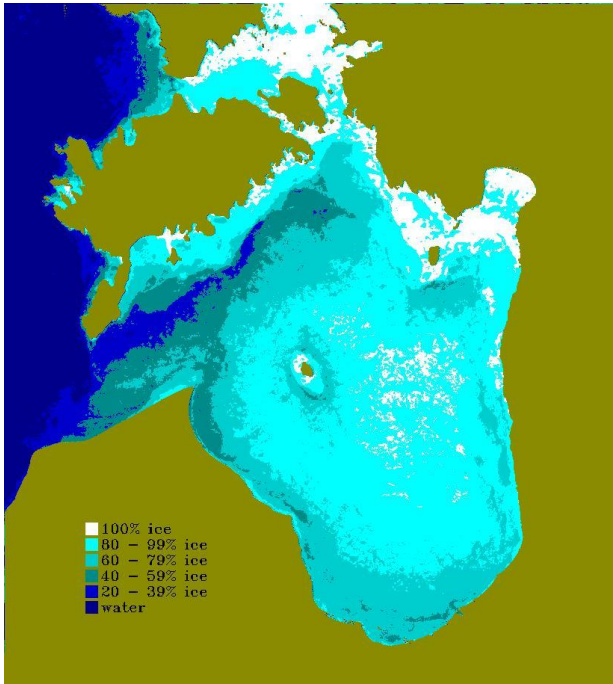
2007, 2008, 2009
March



2004, 2005
March



2003, 2006, 2010, 2011
March



Future plans: ice

- A2) Development of algorithm for ice map retrieval from optical satellite imagery complemented with radar data. Implementation of the developed algorithm using test dataset (Est 2). in progress
- Method has been developed and implemented for optical satellite imagery.
- Ice maps from optical satellite imagery are practically completed
- We need to decide which is/are the final ice map(s)/product(s) that is/are included in the “Final Tool”
  - Monthly
  - Annual
  - Winter scenarios
  - etc

Thank you!

Questions about ice?

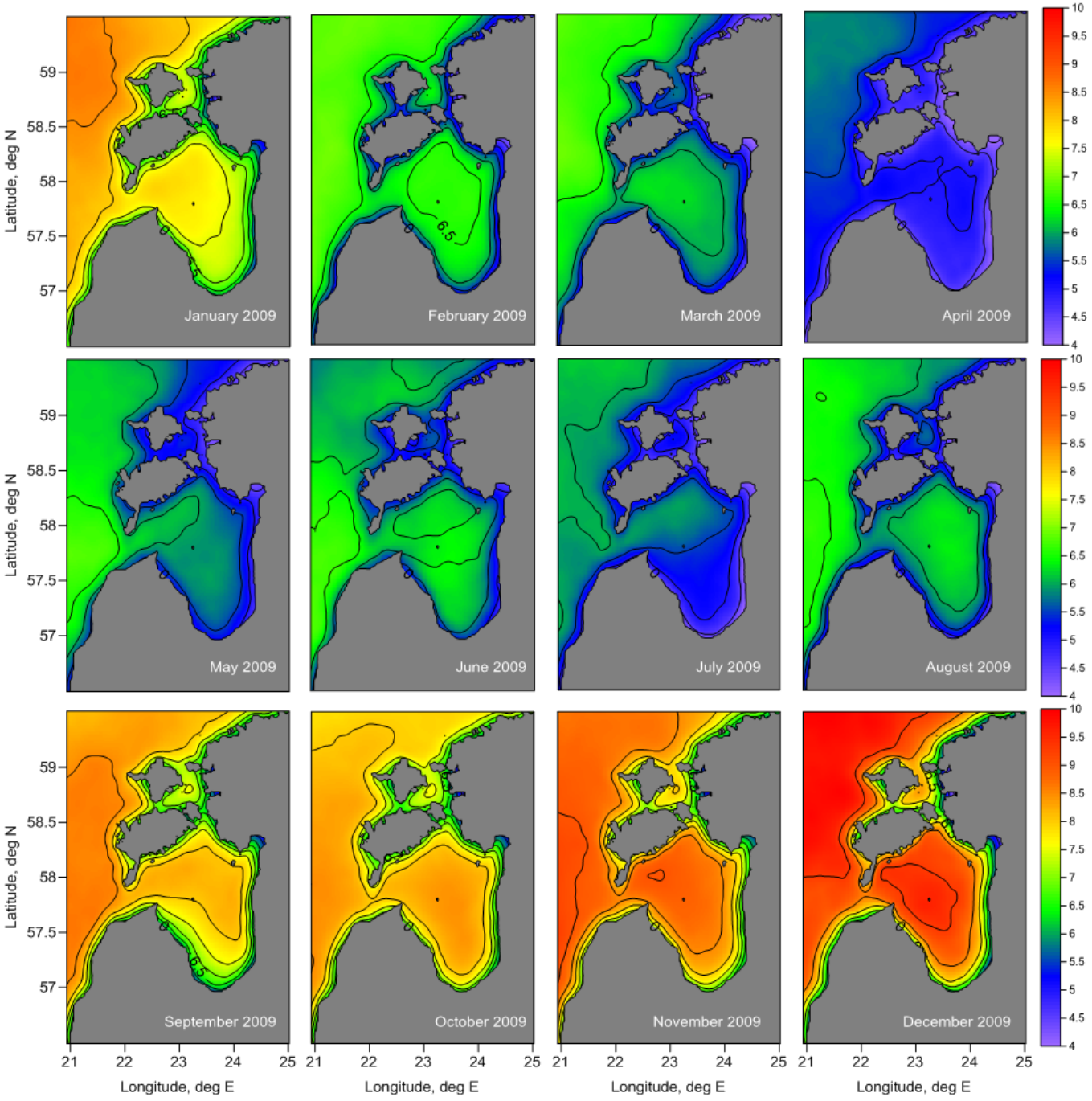
HIRLAM

HIRLAM (EE) data

- Additional activity relaated to activity 4: Data fields from operational atmospheric model HIRLAM (EE) were mobilized for retrieval of wind field information relevant for wind farming. An overview of collected HIRLAM (EE) model fields is given in Table 3.

Year	Nr. of 6h fields	Percentage (%)	Nr. of 3h fields	Percentage (%)
2002	1460	100.0%	none	-
2003	1460	100.0%	none	-
2004	1464	100.0%	none	-
2005	1460	100.0%	none	-
2006	1395	95.5%	2790	95.5%
2007	1035	70.9%	2070	70.9%
2008	1351	92.3%	2702	92.3%
2009	1441	98.7%	2882	98.7%
2010	1432	98.1%	2864	98.1%

Table 3. Overview of downloaded HIRLAM (EE) model fields with 3 and 6 hour temporal resolution and percentage of all possible fields for the period 2000-2010



Monthly mean wind speed (m/s) at 10m height in the Gulf of Riga during 2009.

EE HIRLAM

Status and plans for RP2

- A1) Development of algorithm for wind retrieval from radar imagery and implementation of the algorithm on the test dataset (Est 2). In progress
- A2) Development of algorithm for ice map retrieval from optical satellite imagery complemented with radar data. Implementation of the developed algorithm using test dataset (Est 2). In progress
- A3) Development of method for extrapolating marine wind to coastal area (land) using satellite imagery. Validation of the results using in situ measurements and/or marine/coastal wind parameters derived from the in situ data (Est 3, Lat 1). 0
- A7) Development of methods for calculation (deriving) of relevant parameters from climatic (and HIRLAM-EE) wind calculations (Lat 3, Est 1). In progress

leftovers

– neutral wind is stronger than non-neutral - bias 0.2m/s