Sea ice total concentration blended data set

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1. Overview

This document presents a description of the technique developed for processing ice charting data from different national sources (ice services) to construct a blended (joint) sea ice total concentration (CT) dataset spanning multi-decadal interval.

Resulting dataset contains gridded CT values in % (‘0’…’100’ and ‘101’ used to code presence of fast ice) and supplementary information on a hemispheric (90°N…45°N 0°….360°) geographical 0.25°by 0.25° with monthly interval. Presently the dataset spans interval from Jan 1901 to Jan 2013. For each grid-point following 5 parameters are coded:

(1) mean,
(2) minimum,
(3) maximum,
(4) number of cases and
(5) originating source (national ice service).

Each of 5 parameters is stored in a separate file in a binary 1 byte integer and tsv formats. Section 2 presents a brief description of initial ice charting data used and section 3 gives an overview of technique of data processing. Section 4 provides information on the file content and format. All initial, resulting datasets and developed codes are available by URL http://wdc.aari.ru/vms/blended

2. Initial ice charting data

Background

Ice charts are a value-add product of ice state initial information of various source, constructed on a basis of manual analysis by a qualified ice analyst from a national service. Ice charting has more than centennial history with regional aspects described by the World Meteorological Organization (WMO) technical publication No.574 [9]. A typical ice chart represents sea, lake or river ice conditions in a form of uniform ice zones spanning hundreds of meters – hundreds of km. Basic parameters describing ice conditions inside an ice zone include total concentration (coded in 1/10s, % or enumerated concentration intervals), stages of ice development (enumerated values, also a proxy for ice thickness) and their partial concentrations (coded in 1/10s), forms of ice (enumerated values). Fast ice belongs both to a ‘form of ice’ and concentration intervals. Other but not least important for the investigations ice parameters include surface topography (ridges), surface state (melt, snow), dynamic processes, etc. Observation and coding of ice parameters is done in accordance with the “WMO Sea Ice Nomenclature”, Volume I and III. Prior to 2000s ice charts were coded in a raster SIGRID format [11], since 2000s with advance of GIS ice charts are coded in a vector SIGRID-3 format [10]. A special “Global Digital Sea Ice Data Bank” (GDSIDB) project was initiated by the WMO in 1989 to facilitate exchange, archival and standardization of the ice charts collections, with 2 archival centers – the Arctic and Antarctic Research Institute (AARI) and the US National Snow and Ice Data Center (NSIDC). The GDSIDB project is presently supervised by the WMO-IOC JCOMM Expert Team on Sea Ice (ETSI) as well as the International Ice Charting Working Group (IICWG).

Data sources by ice services

Following sources of initial data on ice conditions were identified, processed and used for construction of blended dataset:

1. Russian Federation Arctic and Antarctic Research Institute (AARI) (a) Eurasian Arctic (Greenland – Chukchi Seas, Arctic Basin and Bering Sea) ice charts with 10-days periodicity (with gaps) for 1933-

1992 (2367 charts) in SIGRID format [1] and (b) 7-days period Eurasian Arctic (Greenland – Beaufort Seas, Arctic Basin, and Bering, Okhotsk, Baltic Seas) ice charts for 1999-Jan 2013 (5744 charts) in SIGRID-3 format [2]. Coverage in seasonal cycle is illustrated by Annexes 1a and 1b.

2. Canadian Ice Service (CIS) (a) 7-days period ice charts for Canadian Arctic (East Arctic, West Arctic, Hudson Bay and Eastern Coast) for 1968-1998 (3433 charts) in SIGRID format [3] and the same (b) for 2006-Jan 2013 (1190 charts) in SIGRID-3 format [4]. Coverage in seasonal cycle is illustrated by Annexes 2a and 2b.

3. USA National Ice Center (NIC) (a) 7 days period (weekly) and 14 days period (bi-weekly) Northern hemisphere charts for 1972-2002 (1576 charts) in Ease-Grid format [5] and the same (b) bi-weekly charts for 2003 - Jan 2013 (257 charts) in SIGRID-3 format [6]. Coverage in seasonal cycle is illustrated by Annexes 3a and 3b.

4. Baltic Sea Ice Meeting (BSIM), jointly compiled by Swedish Hydrological and Meteorological Institute (SHMI) and Finnish Institute for Marine Research (FIMR), 3-4 days period ice charts for the Baltic Sea for 1960-1979 (1042 charts) in Baltic code [7] translated to SIGRID format [8].

5. In addition to 1-4 the “Monthly Arctic Sea Ice Concentration Grids (January 1901 – July 1997)” [13], also known as John Walsh dataset (John E. Walsh U of Illinois, Dept of Atmospheric Sciences) was used to gain additional information prior to 1972 from the ice analysis sources not available presently in the WMO exchange formats, namely the Danish Meteorological Institute (DMI), Japan Meteorological Agency (JMA) and Naval Oceanographic Office (NAVOCEANO). Though very dubious, the “Kelly ice extent grids” source was kept as optional.

Summary number of charts and summary number of points by originating centers for the period January, 1901 – January, 2013 are given as Figure 1, and the summary absolute and % number of points by decades by originating centers for the period January, 1901 – January, 2013 are given as figure 2. Interdecadal differences of coverage in space are also illustrated by the Annex 5 where decadal statistics based on blended ice charting are shown. It is clearly visible that significant coverage in space for the Arctic starts by 1933 with advance of AARI ice charting while more or less quasi circumpolar ice charting starts by 1950s with advance of charting in Canada and USA. Complete coverage of the Arctic in seasonal cycle continues from Jan 1972 till present moment.

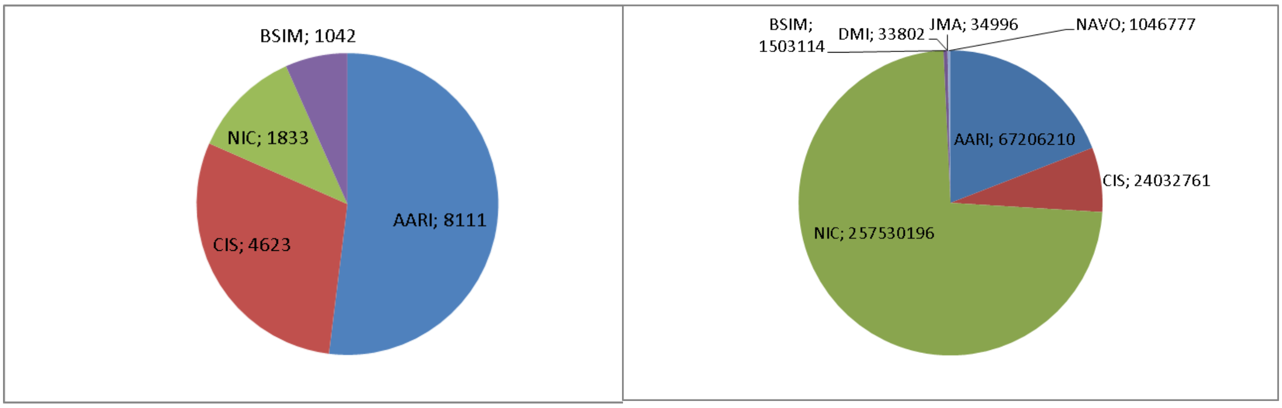

Figure 1 – Summary number of charts (left) and summary number of points by originating centers for the period January, 1901 – January, 2013

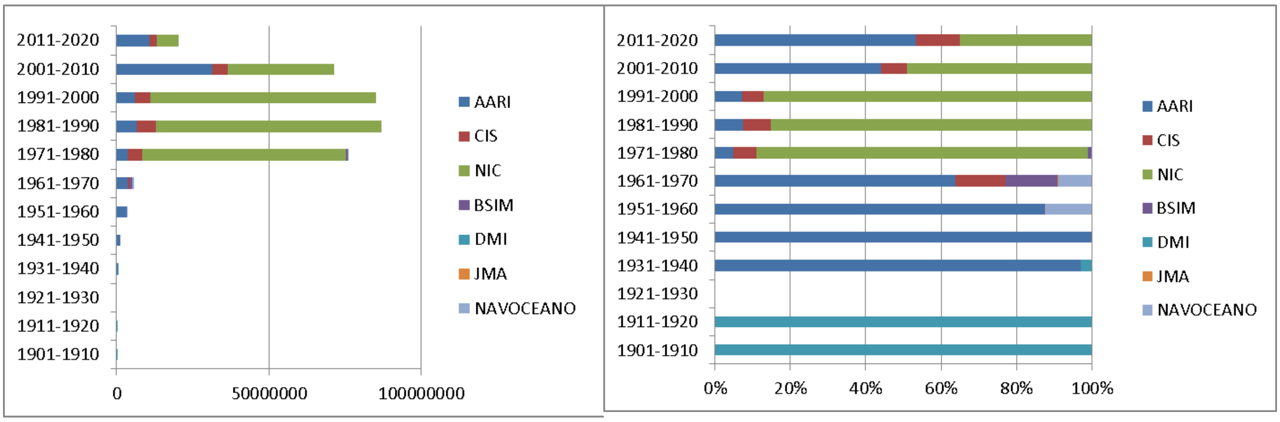

Figure 2 – Summary absolute and % number of points by decades by originating centers for the period January, 1901 – January, 2013

3. Data processing algorithm

Data processing includes 2 main steps:

1. construction of the CT layer [data]sets of geographical 0.25°x0.25° grids separately by originating service and format with preservation of initial periodicity
2. blending of individual CT layer datasets on a monthly scale on a geographical 0.25°by 0.25° grid with preservation for each cell the originating CT source, number of cases and range of variance.

3.1 Construction of the CT layer

Construction of CT-layer varied by data source and format and included the following sub-steps:

(1) extraction of CT-layer stored in geographical 0.25°x0.25° SIGRID-format charts (applied to 1a, 2a and 4 datasets)
(2) geotransformation of CT-layer in 25x25 km NP azimuthal equal area projection charts to geographical 0.25°x0.25° grid (applied to 3a datasets)
(3) rasterization of CT-layer from a vector SIGRID-3 format chart to geographical 0.25°x0.25° grid (applied to 1b, 2b and 3b datasets)
(4) merging of 0.25°x0.25° grids (corresponding to a certain single ice chart) to a single dataset (applied to 1(a,b), 2(a,b), 3(a,b) and 4 datasets)
(5) geotransformation of [5] from a rectangular ~1° grid to a geographical 0.25°x0.25° grid using the nearest existing within the 3x3 elements cell value, chosen in clockwise direction starting with 0°.

Rather trivial codes for implementation of the above sub-steps were written in GNU Fortran-95 with exception of rasterization sub-step which was implemented using GDAL software. Hence, resulting datasets are on the same 0.25°x0.25° spanning

- 90°-45° N and 0°-360° grid or 1440 columns x 180 rows (1a, 1b, 3a, 3b, 5)
- 90°-45° N and 180°-0° grid or 720 columns x 180 rows (2a, 2b)
- 70°-50° N and 0°-30° grid or 121 columns x 81 rows (4)

Each of the merged binary-format dataset has a rather simple structure:

- header as character(8) with a template DD.MM.YYYY
- CT-grid as integer(1) with northernmost westernmost value in left upper corner spanning 0…100 for total concentration, 101 – for fast ice and 122 – nodata value.
- both the header and each grid-line (row) is finalized by a 2-byte <LF><CR> code.

With exception of 4 and 5 construction of datasets 1(a,b), 2(a,b), 3(a,b) was checked manually by means of non-robust (maximum, minimum) and robust (median) values calculated in seasonal cycle. Stated statistics are represented as annexes 1 – 3 and show absence of mistakes in developed technique and absence of obvious mistakes in data.

3.2 Blending

Blending step was implemented as a single routine providing following steps:

(1) reading merged datasets 1(a,b), 2(a,b), 3(a,b), 4 and 5 one by one;

(2) accumulating sum, extreme maximum and minimum values occurred for each cell, number of cases and original source for each cell on monthly scale starting from Jan 1901 till designated moment (presently Jan 2013)

(3) finalization of resulting dataset by calculating mean values and populating grid cells with a zero number of cases by a nodata value ('122')

(4) writing resulting datasets (mean, minimum, maximum, number of cases and originating source) in a merged binary-format (specified above) and TSV format.

Following temporal and originating source restrictions were applied:

- dataset 3a (NIC Ease-Grid) was used only for the period up to Dec 2002 as a newer 3b starts from Jan 2003
- 5 (J.Walsh) was used only up to Dec 1971 and only for the cells originating from DMI, JMA or NAVOCEANO.

Code'grd2bld.f90' for implementation of the above blending sub-steps was written in GNU Fortran-95 as routine excepting parameters from a command-line and initialization file and is available in the following catalogue: http://wdc.aari.ru/vms/blended/f90/.

The same as step 3.1, quality check of results was done manually by means of checking non-robust (maximum, minimum) and robust (median) values calculated in seasonal cycle and by decades. Stated statistics are represented as annexes 4 – 5 and show absence of mistakes in developed technique and absence of obvious mistakes in data.

4. Content and structure of the blended datasets

Resulting blended dataset contains gridded CT values and supplementary information on a hemispheric (90°N…45°N 0°….360°) geographical 0.25°by 0.25° grid or 1440 columns x 180 rows with the northernmost westernmost 90N,0 value in left upper corner, with monthly interval. Presently the dataset spans interval from Jan 1901 to Jan 2013. Spatial extent of the resulting dataset and orientation of the grid is shown on figure 3.

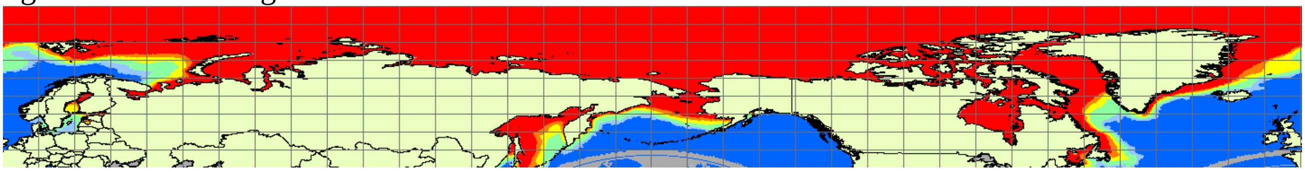

Figure 3 – Extent of resulting blended dataset

Blended dataset contains the following 5 parameters stored as separate files:

(1) mean,
(2) minimum,
(3) maximum,
(4) number of cases and
(5) originating source (national ice service).

Mean, maximum and minimum CT values are in % within interval '0'…'100', with '101' used to code presence of fast ice and '122' as nodata. Number of cases is an integer value starting with 0. Originating source is either '5' for a mixed origin, '10' for DMI, '20' for JMA, '30' for BSIM, '40' for AARI, '50' for CIS, '60' for NIC, '80' for NAVOCEANO and optional '90' for Kelly grids in case they are included (use very cautiously!).

Each dataset is stored in a TSV format and in a more compact merged binary-format (specified above) and is available in the catalogue http://wdc.aari.ru/vms/blended/

Citation:

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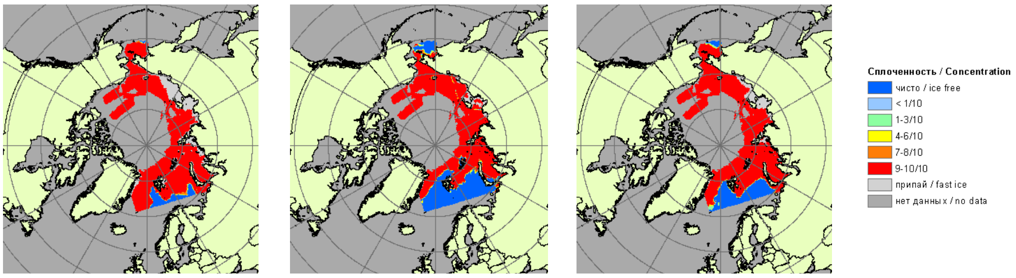
References:

1. *Historical Arctic and Antarctic Research Institute10-days period Arctic Ocean ice charts for1933-1992 period in WMO SIGRID format*. Digital media. – http://wdc.aari.ru/datasets/d0001/north/aari/
2. *Arctic and Antarctic Research Institute weekly regional ice charts for Eurasian seas in vector WMO SIGRID-3 format*. Digital media. – http://wdc.aari.ru/datasets/d0004/
3. *Historical Canadian Ice Service weekly regional ice charts for 1968-1998 period in WMO SIGRID format*. Digital media. - http://wdc.aari.ru/datasets/d0001/north/cis/
4. *Canadian Ice Service weekly regional ice charts in vector WMO SIGRID-3 format*. Digital media. - ftp://sidads.colorado.edu/DATASETS/NOAA/G02171/, http://wdc.aari.ru/datasets/d0031/
5. *US National Ice Center Arctic sea ice charts and climatologies for 1972-2007 period in gridded format* - http://nsidc.org/data/g02172.html, http://wdc.aari.ru/datasets/d0001/north/nic/ease-grid/
6. *US National/Naval Ice Center Weekly/Bi-Weekly Ice Analysis Producst.* Digital media. - http://www.natice.noaa.gov/products/weekly_products.html
7. *BASIS – A data bank for Baltic sea ice and sea surface temperatures* - http://www.trafi.fi/filebank/a/1352716465/eb4c1ad7b437abb6da7338cbac5e5544/10716-No_34_BASIS_-A_data_bank_for_Baltic_sea_ice_and_sea_surf.pdf,
8. *Historical Baltic Sea ice services 3-4 days periodicity ice charts for 1960-1979 period in WMO SIGRID format, based on BASIS data.* Digital media.- http://wdc.aari.ru/datasets/d0001/north/bsim/
9. Sea Ice information services in the world. WMO/TD, 2010 - No.574. (http://jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=96073).
10. SIGRID-3: A Vector Archive Format for Sea Ice Charts. - JCOMM Technical Report Series No. 24, 2004, WMO/TD-No. 1214 (http://jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=4439).
11. SIGRID format for Gridded Sea Ice Data. –WMO Commission for Marine Meteorology Abridged final report of the tenth session. Paris, 8-17 February, 1989. WMO No.716 - http://wdc.aari.ru/wmo/docs/sigrid/WMO_716_rec_11%28SIGRID%29.pdf
12. Ice Chart Colour Code Standard. - JCOMM Technical Report Series No. 24, 2004, WMO/TD-No. 1215. http://jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=4914
13. Walsh and Chapman Northern Hemisphere Sea Ice Data Set - http://www.cgd.ucar.edu/cas/guide/Data/walsh.html

Annex 1a – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on historical AARI ice charting for 1933-1992 in raster SIGRID format



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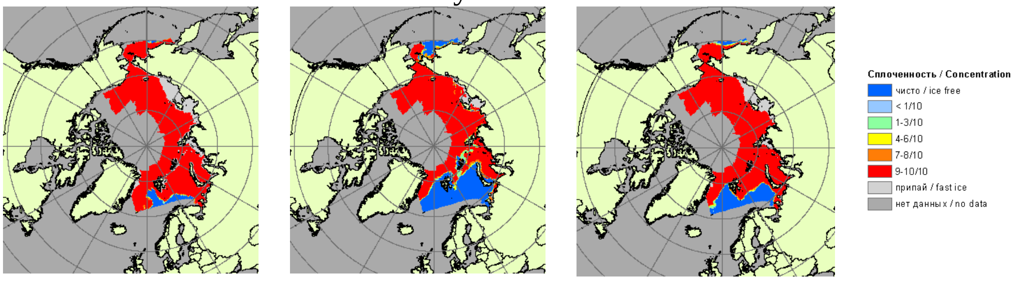

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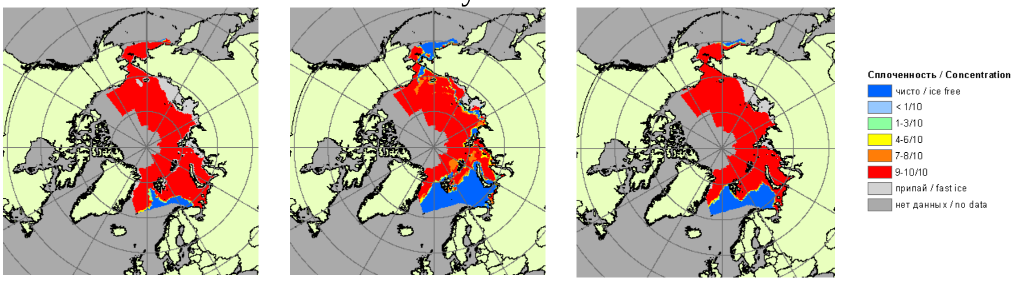

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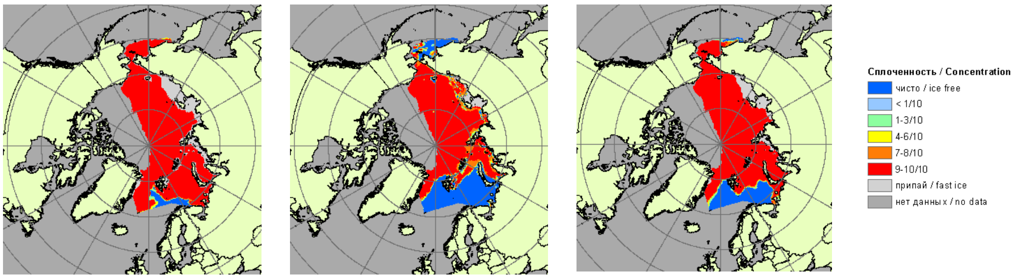

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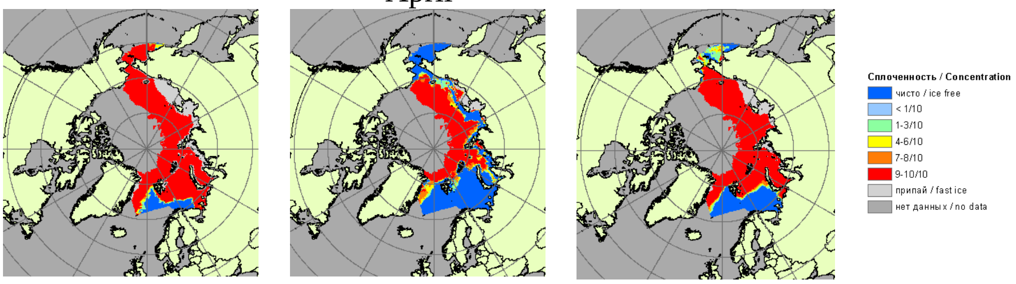

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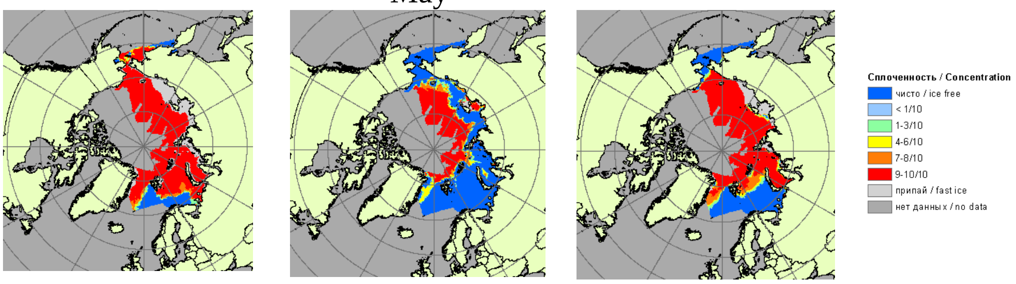

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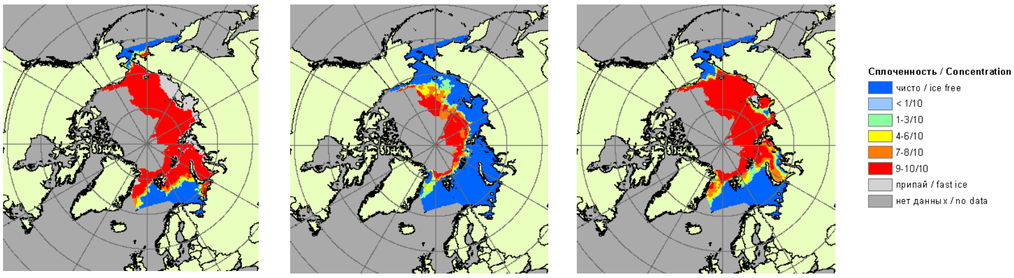

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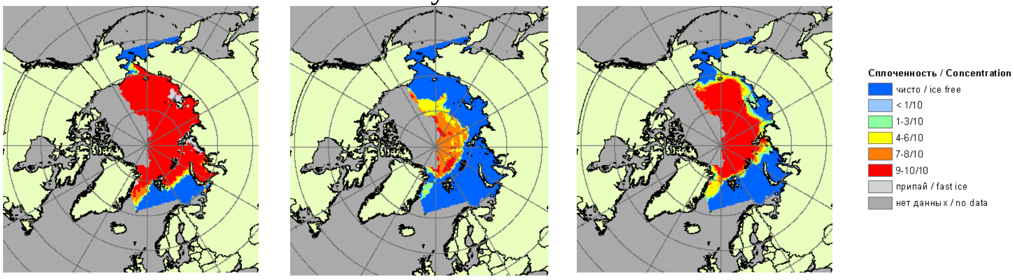

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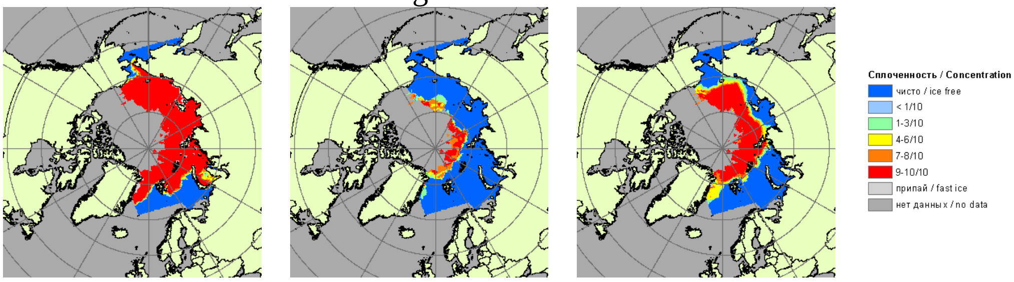

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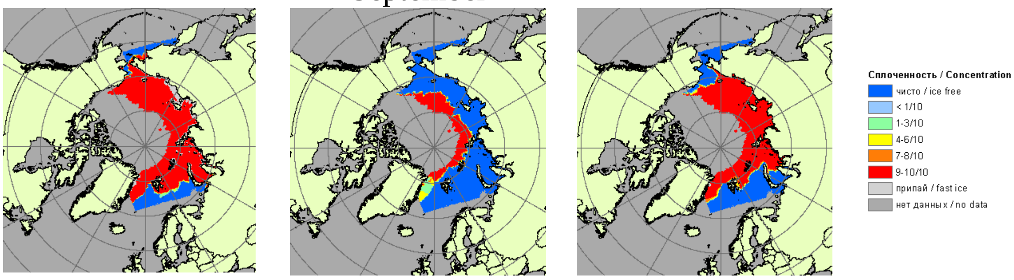

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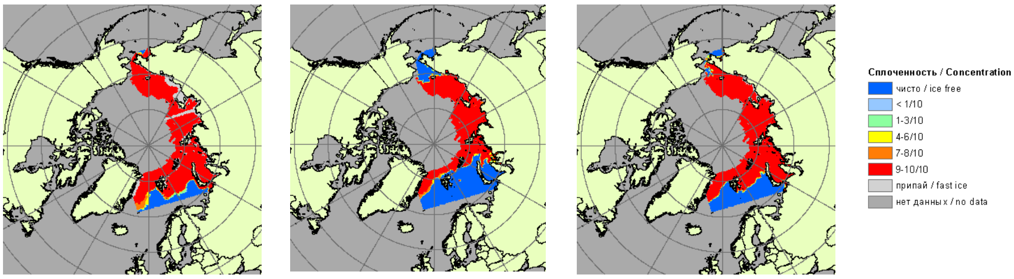

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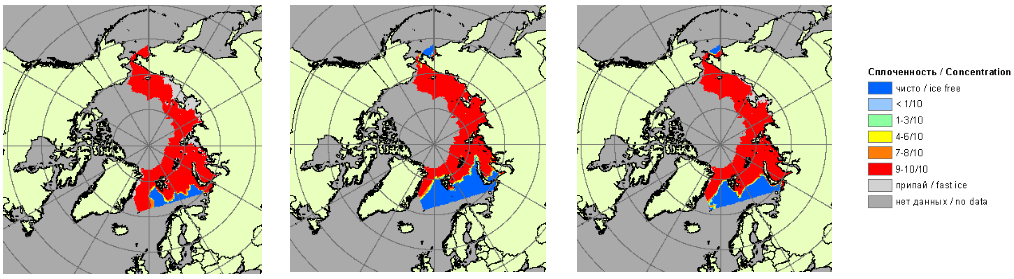
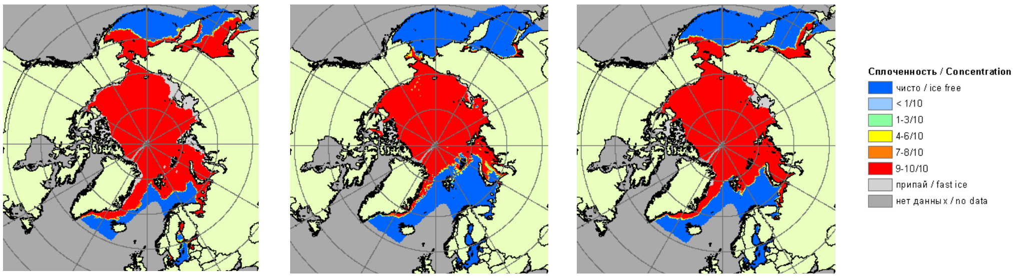


December

Annex 1b – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on current AARI ice charting for 1999-2012 in vector SIGRID-3 format



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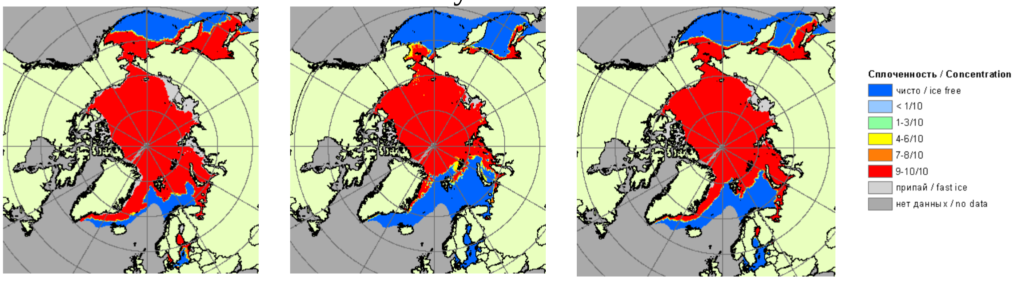

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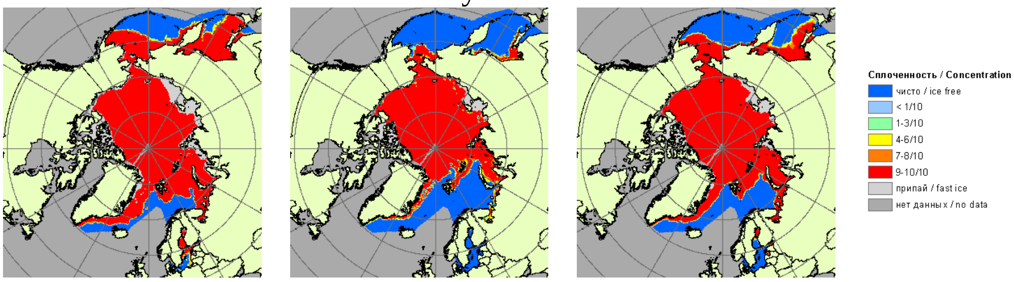

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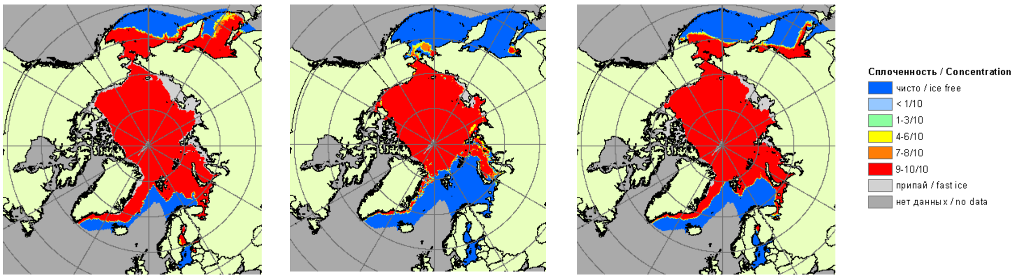

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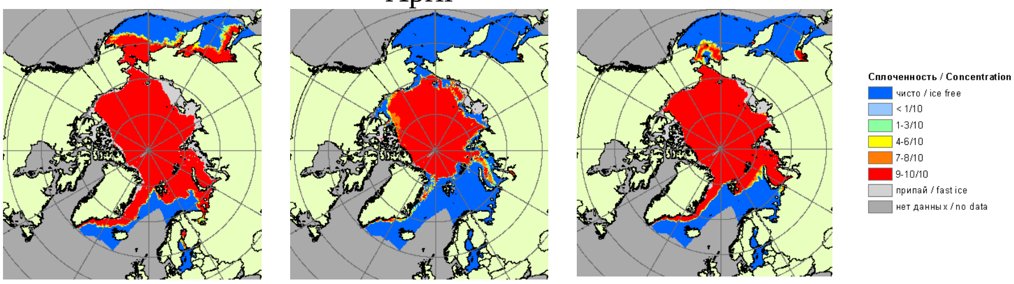

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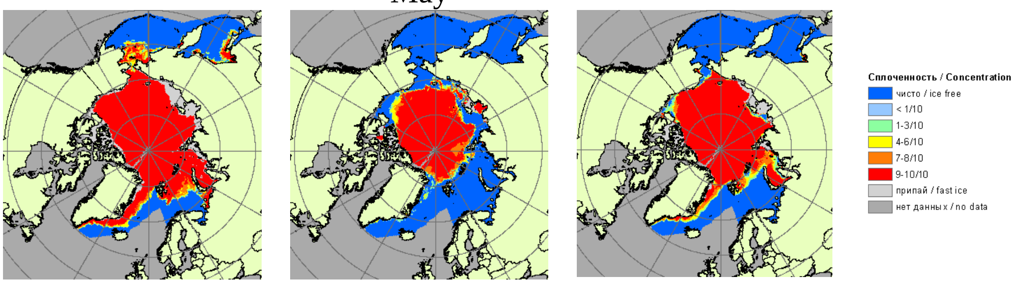

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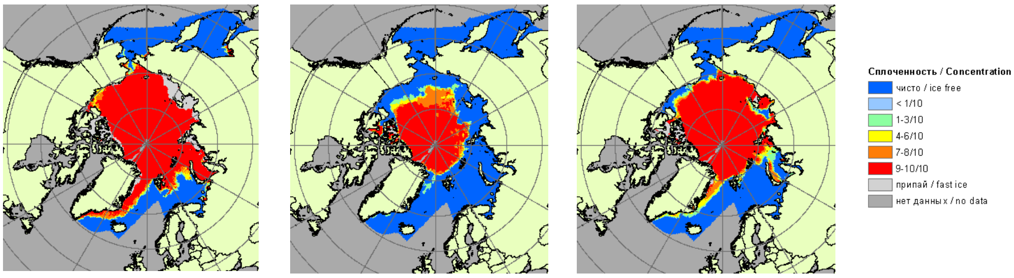

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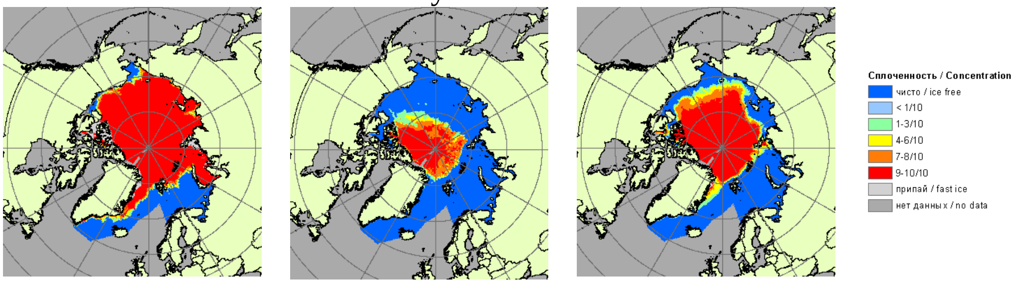

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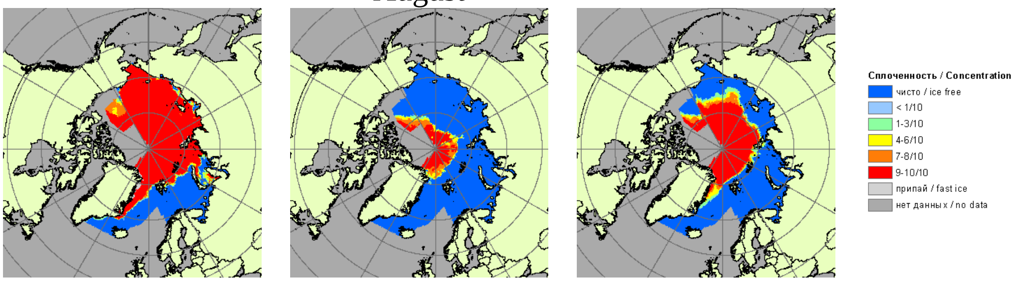

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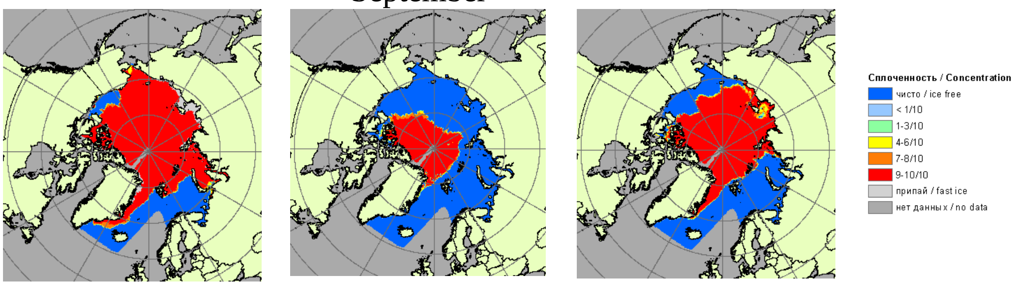

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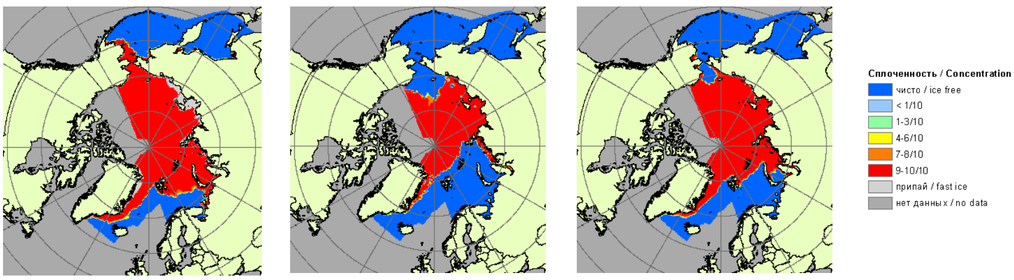

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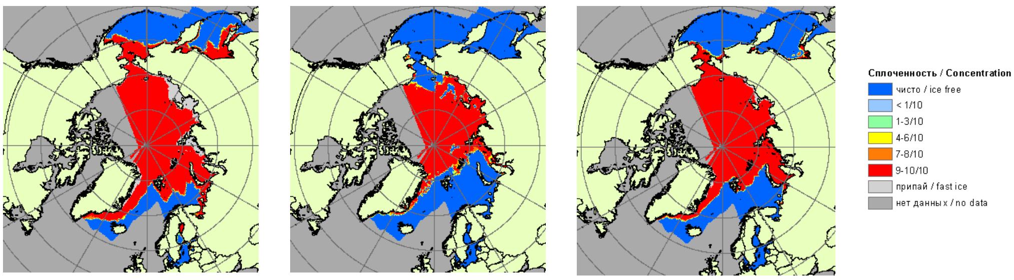
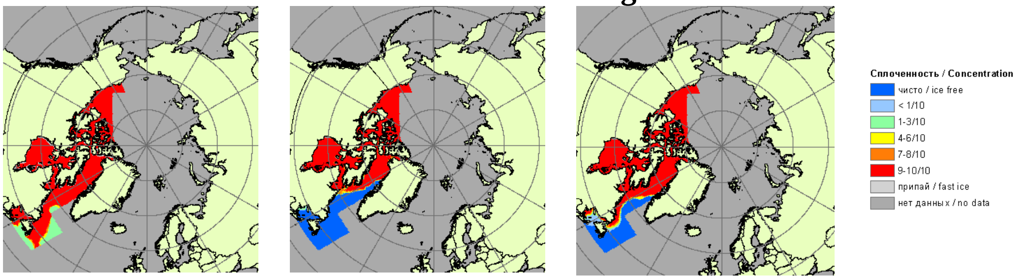


December

Annex 2a – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on historical CIS ice charting for 1968-1998 in raster SIGRID format



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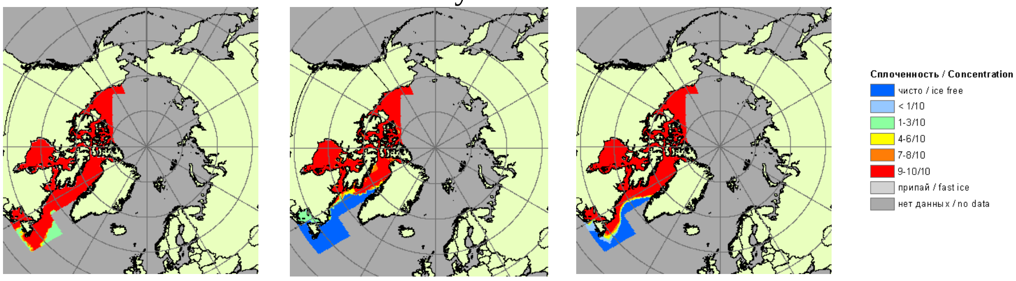

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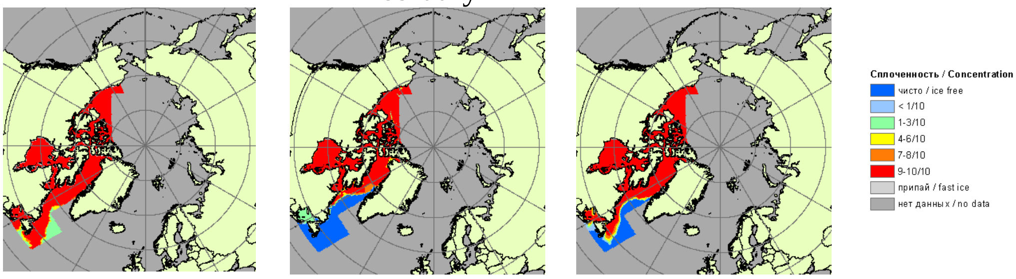

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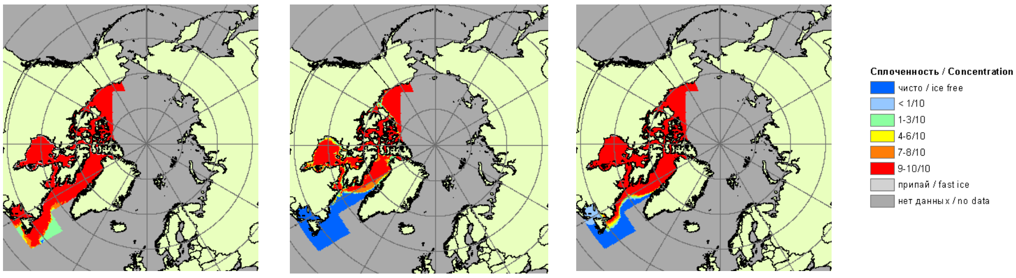

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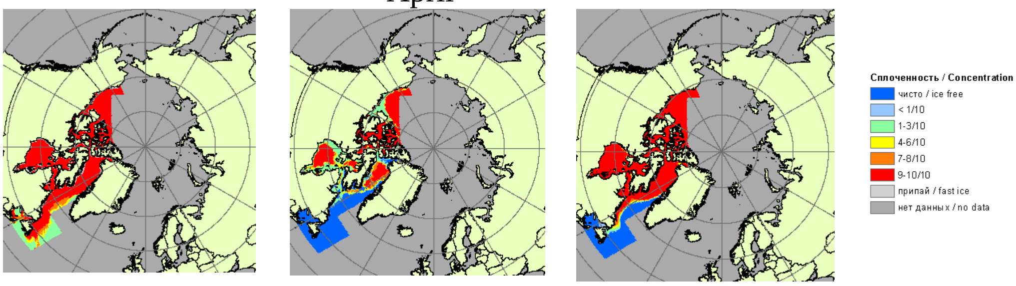

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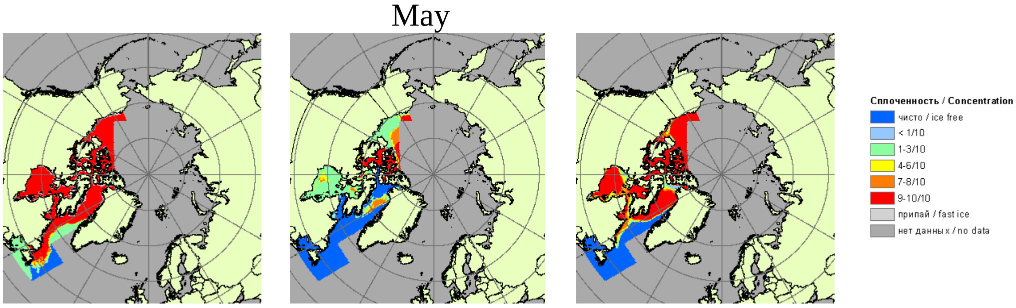

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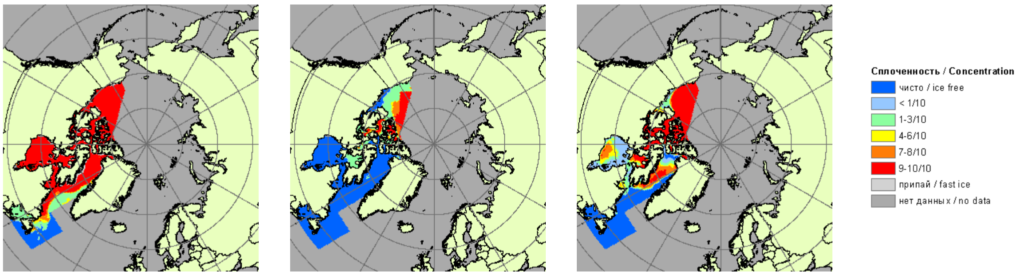

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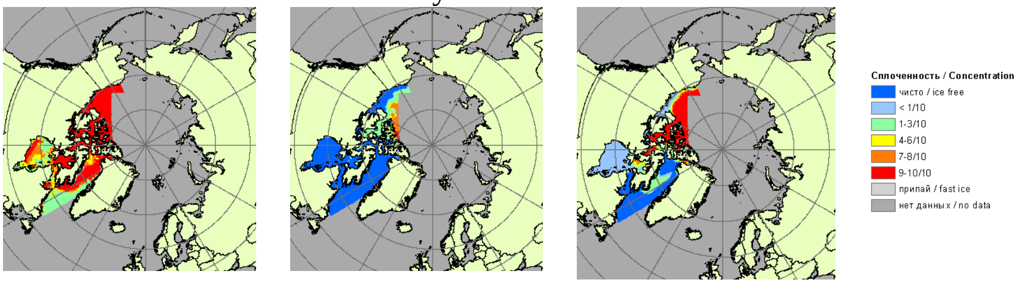

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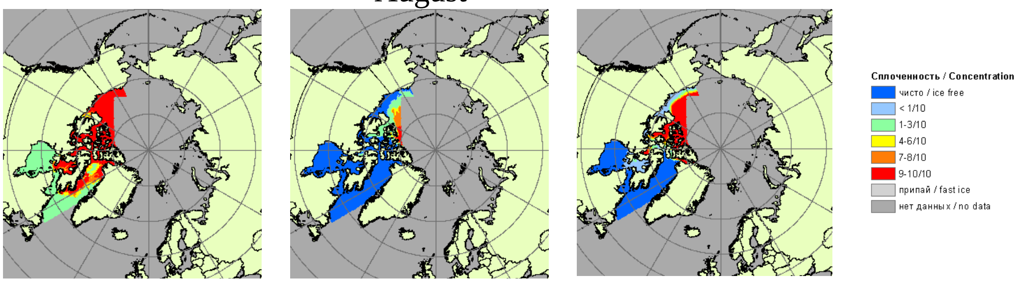

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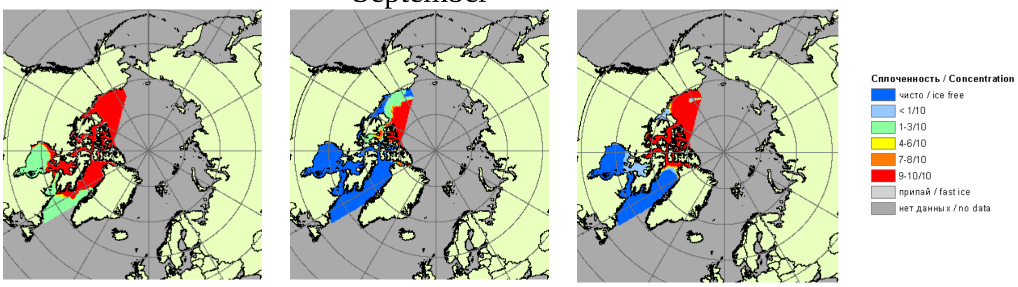

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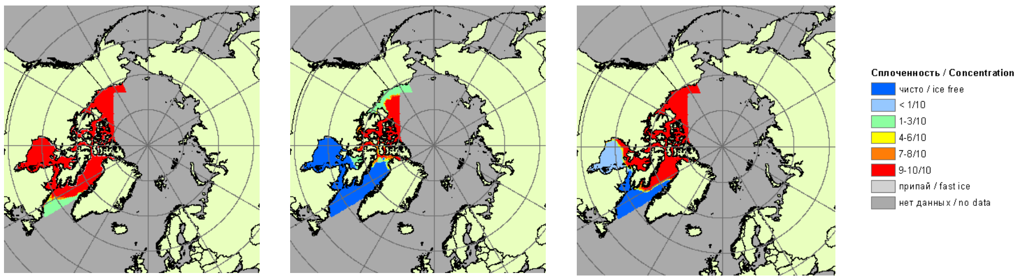

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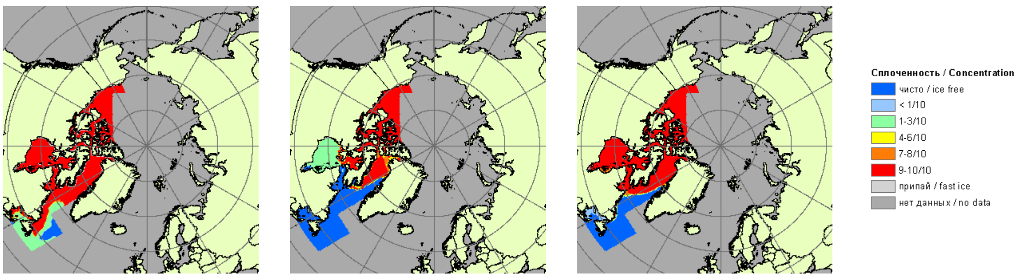
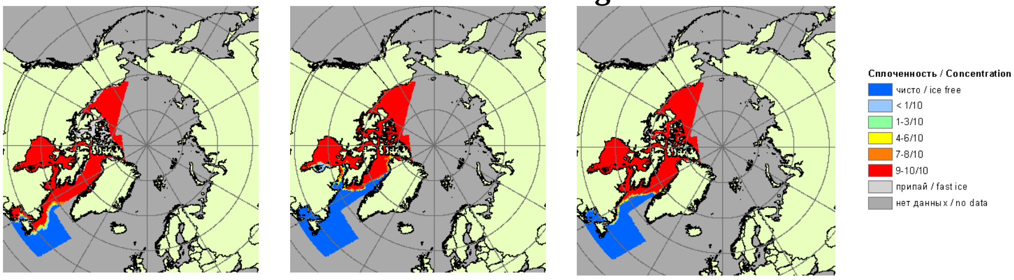
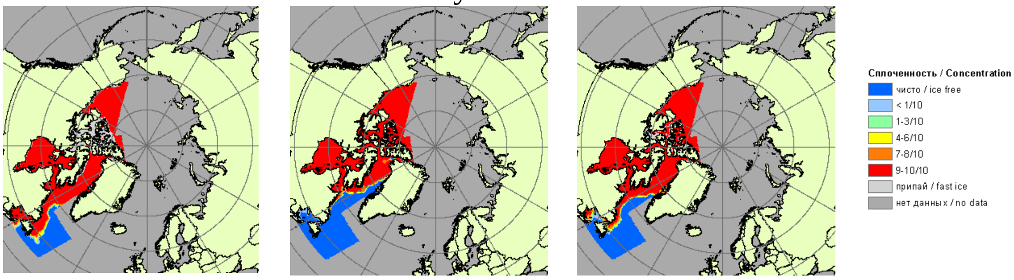


December

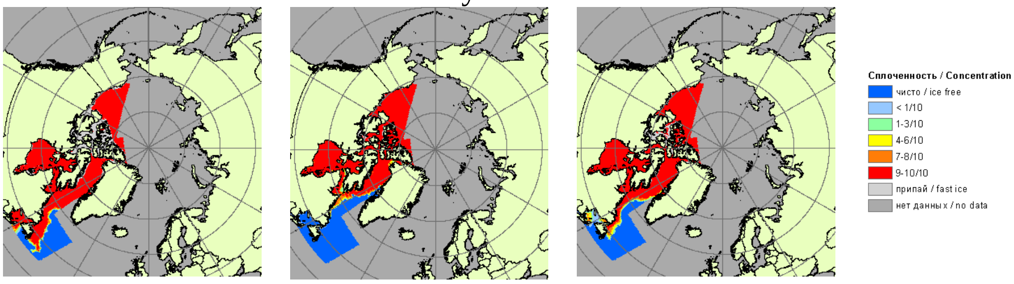
Annex 2b – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on current CIS ice charting for 2006-2012 in vector SIGRID-3 format



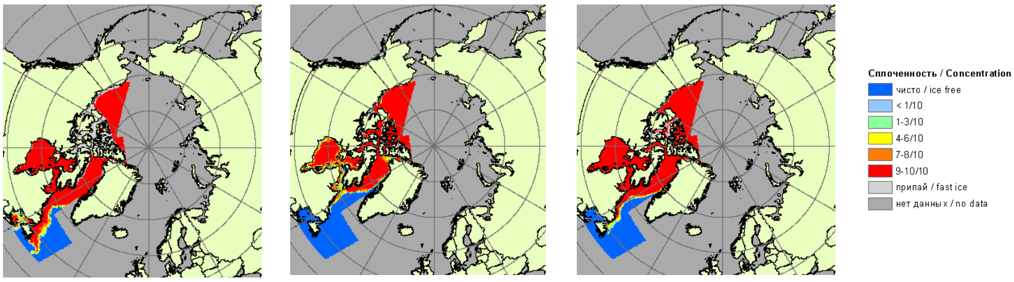
January



February



March



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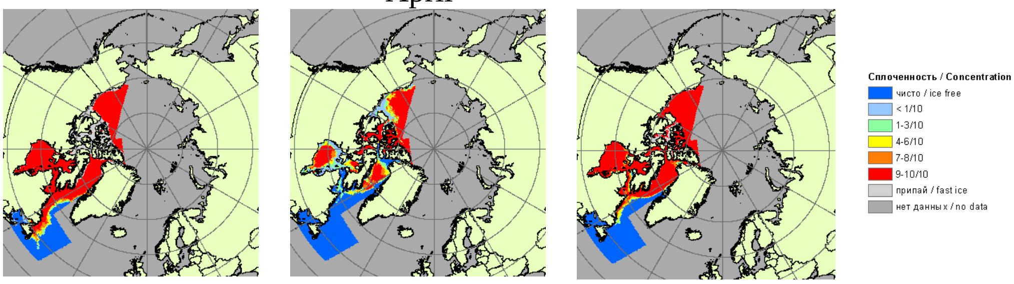

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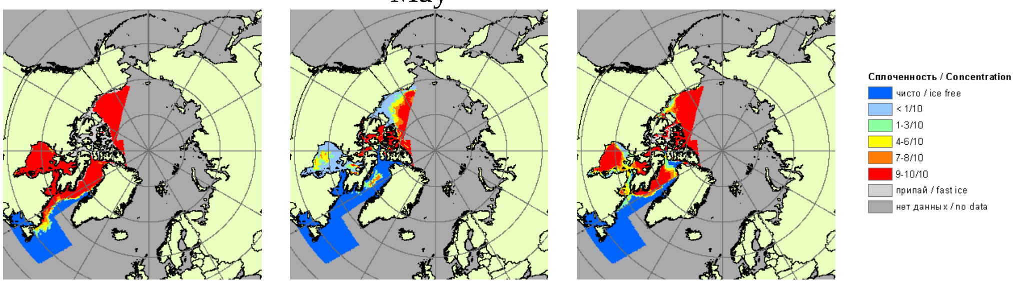

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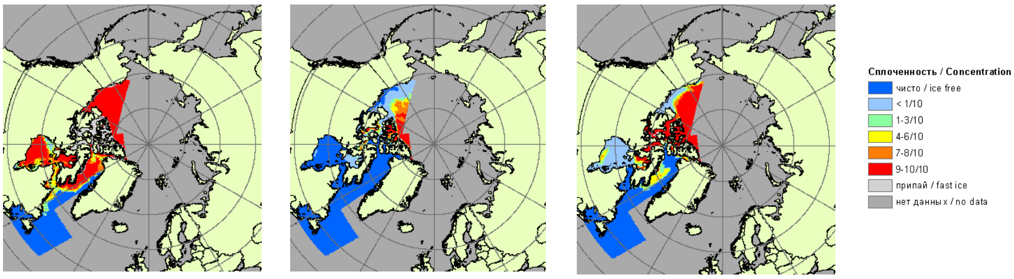

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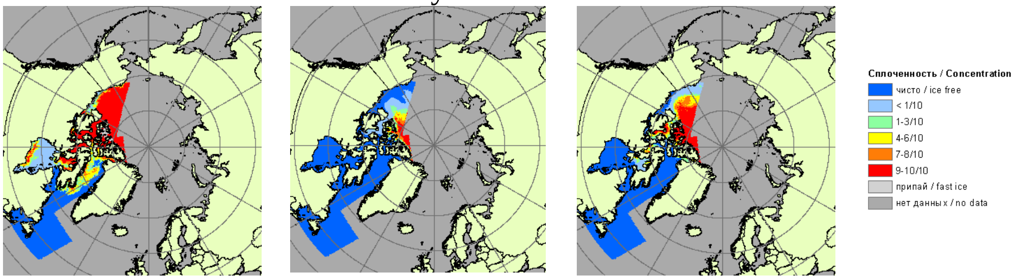
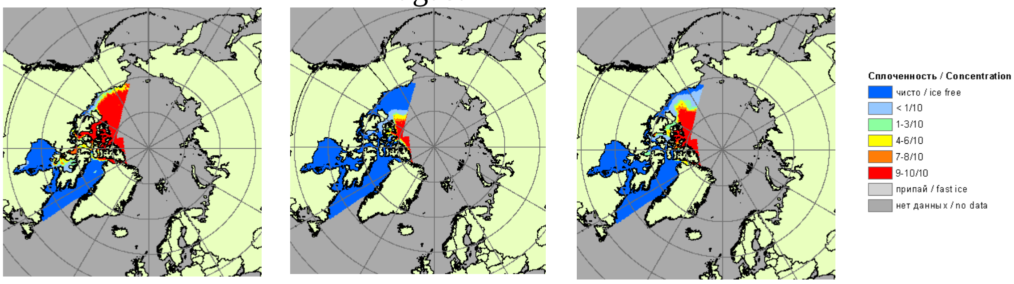


August



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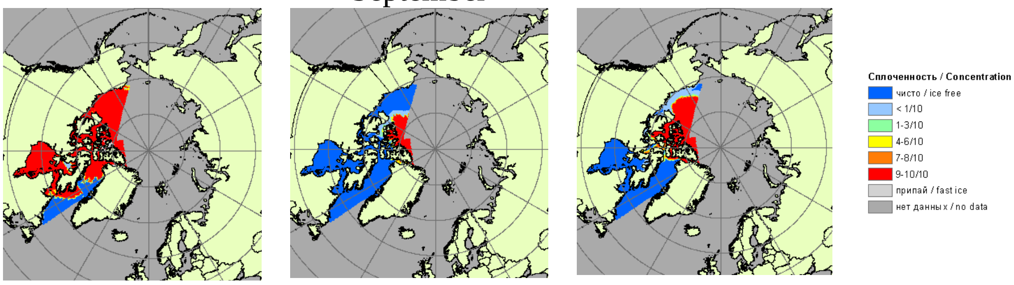

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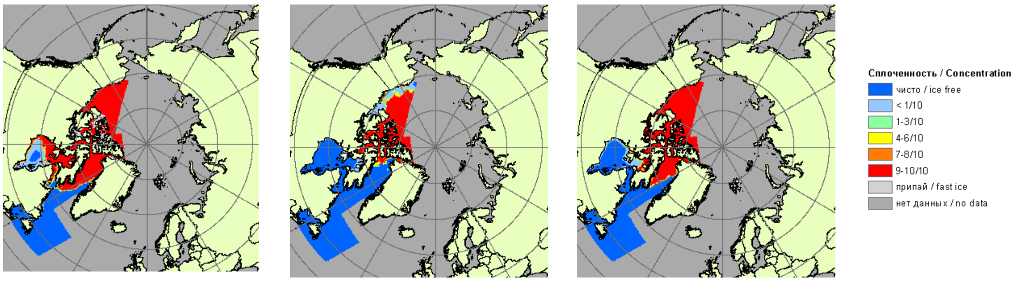
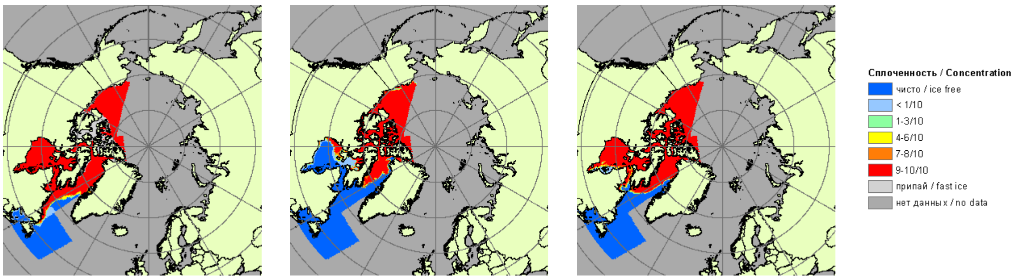
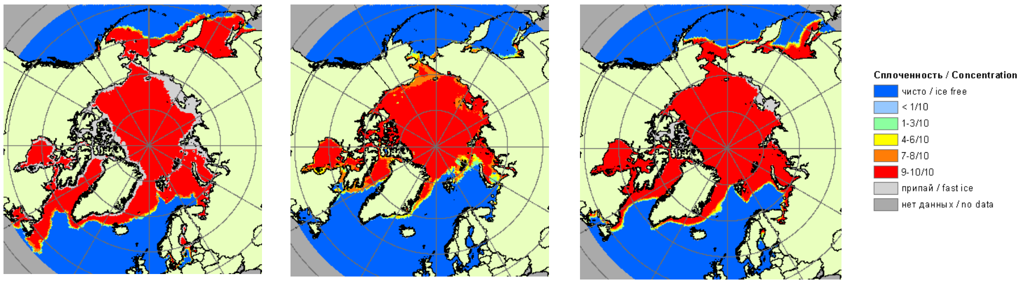


November

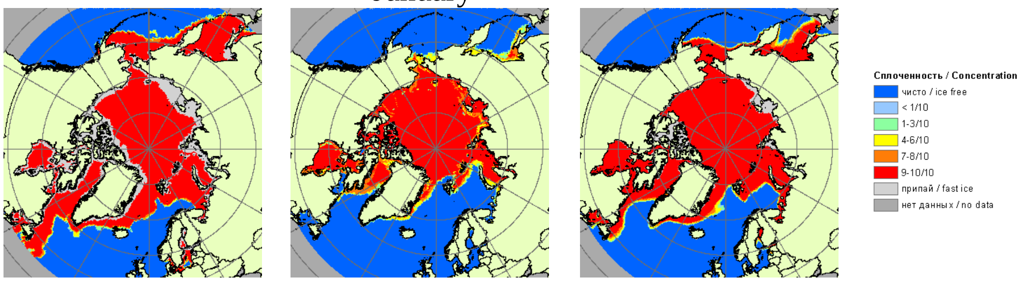


December

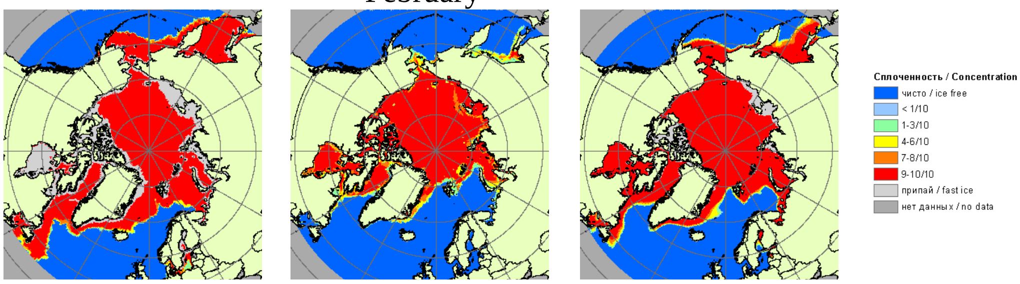
Annex 3a – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on historical NIC ice charting for 1972-2007 in raster Ease-Grid format



January



February



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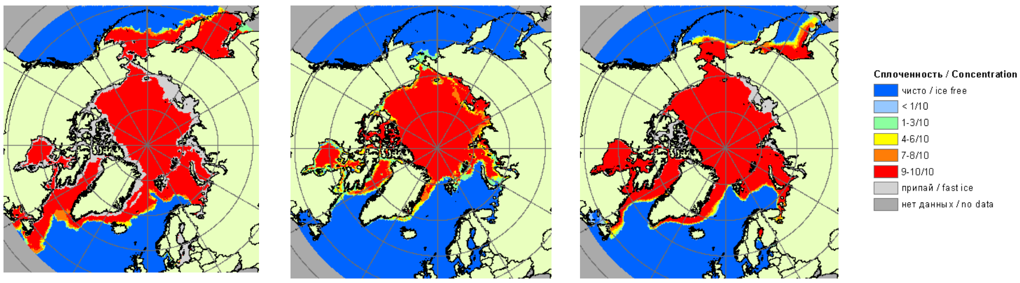

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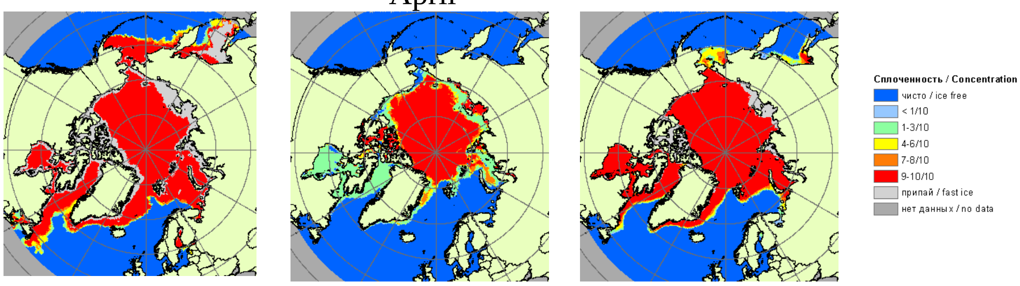
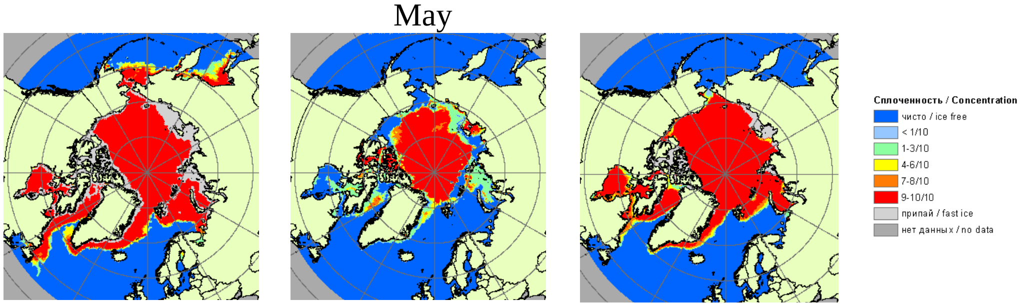


May



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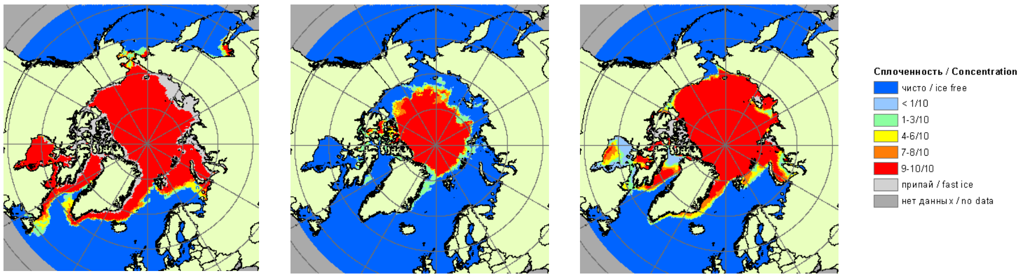

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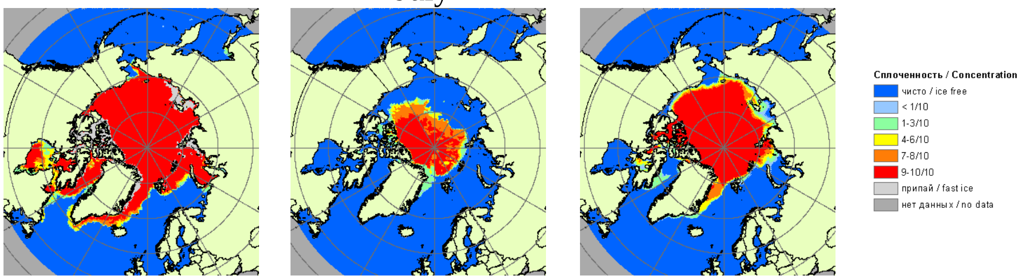
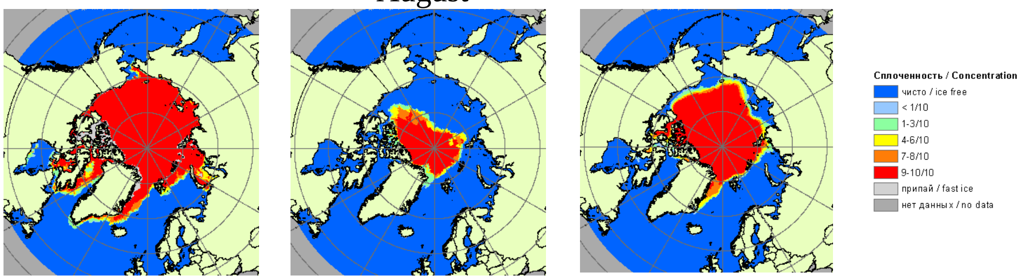


August



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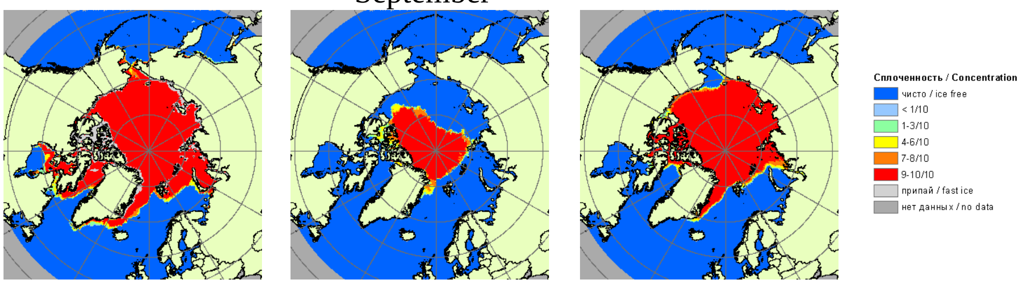
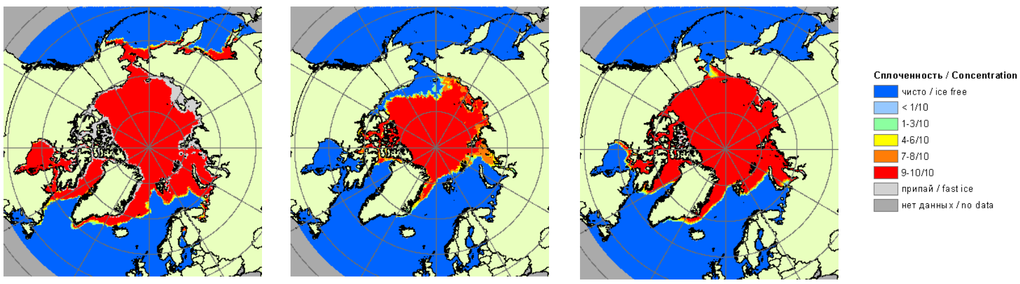


October



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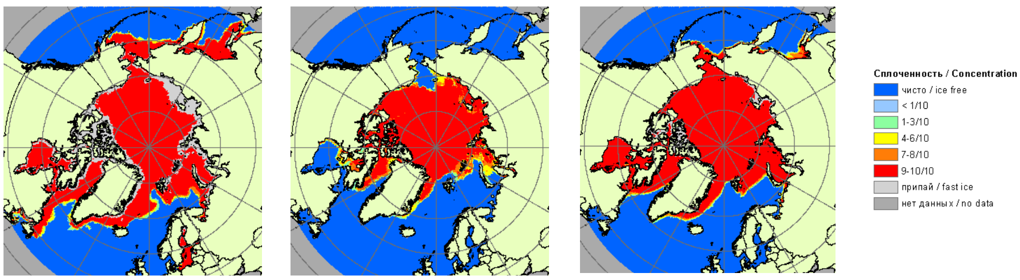
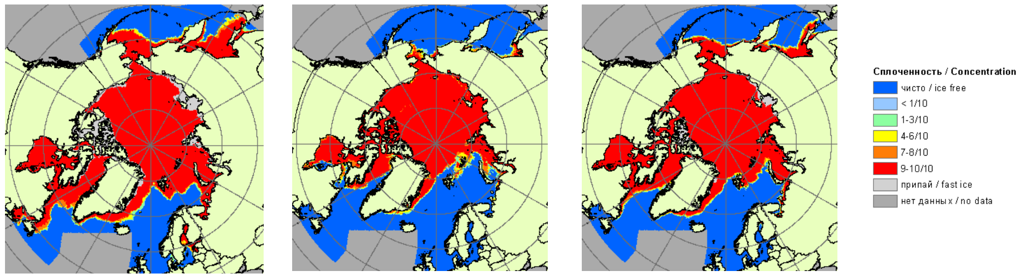
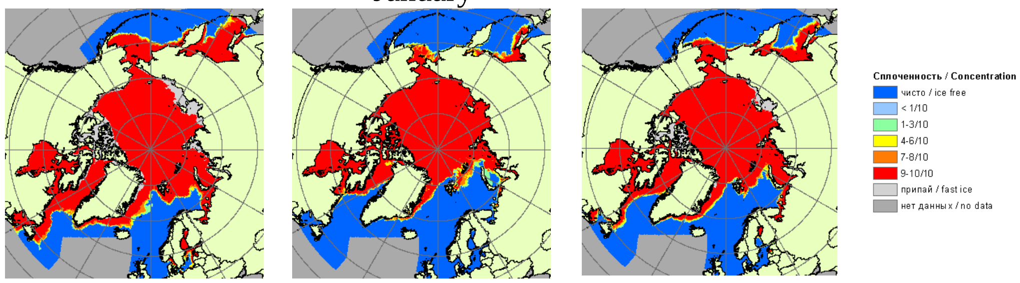


December

Annex 3b – Maximum (left), minimum (center) and median (right) monthly sea ice total concentration statistics based on current NIC ice charting for 2003-2012 in vector SIGRID-3 format



January



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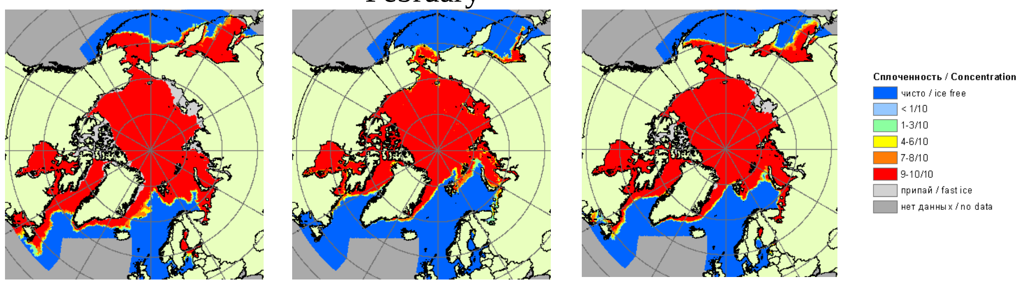
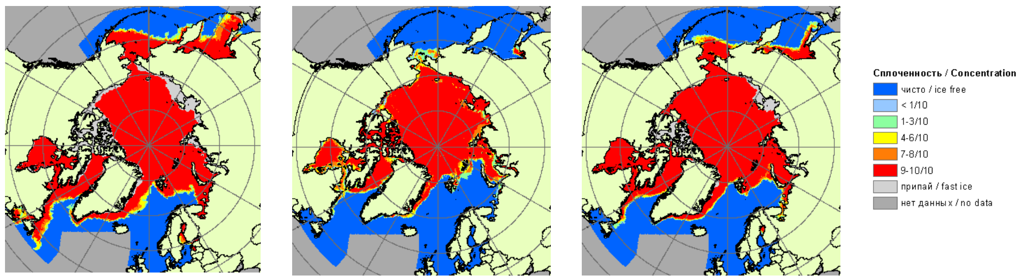


March



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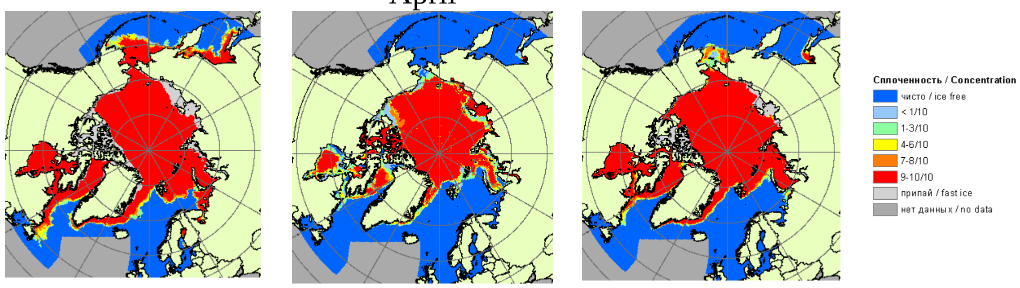
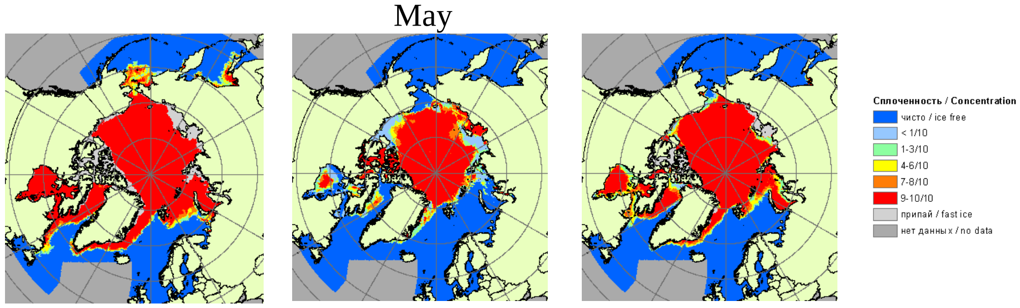


May



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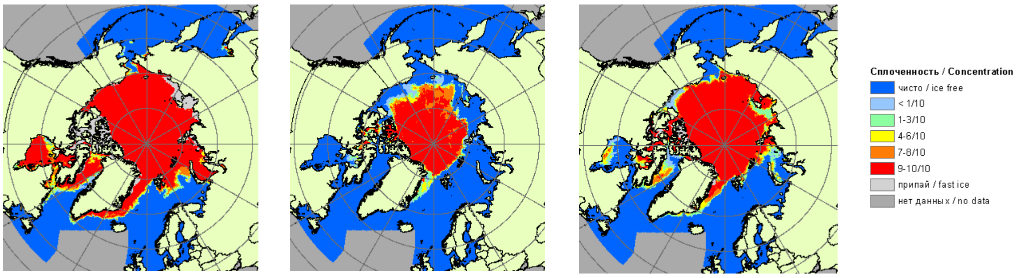

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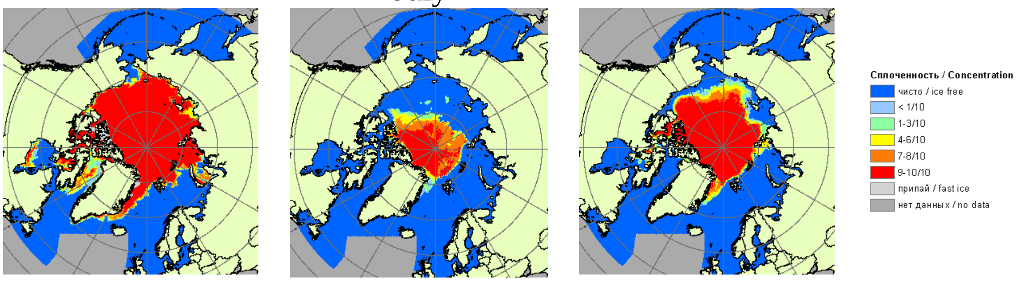

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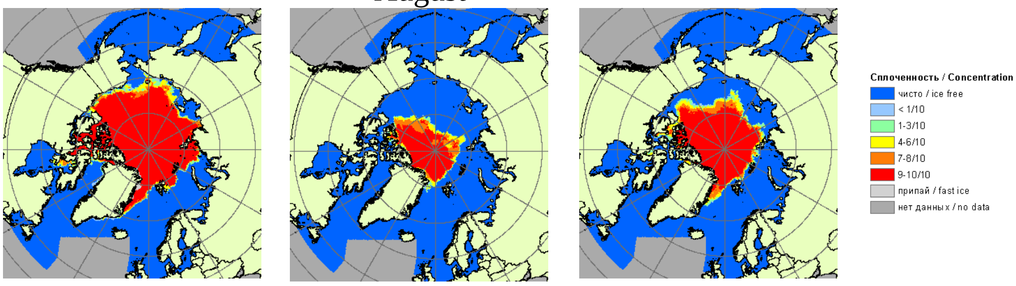

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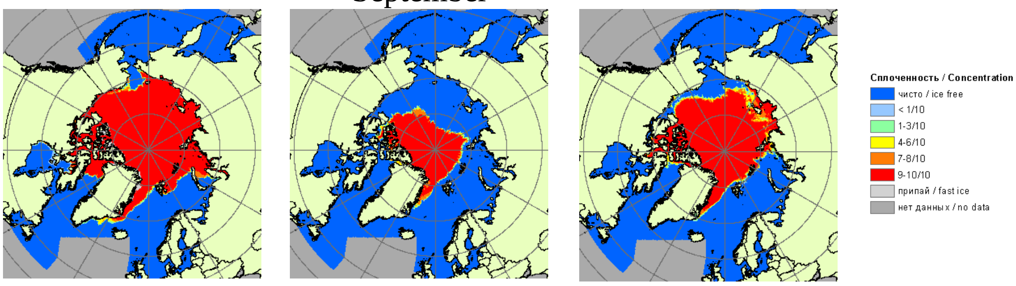

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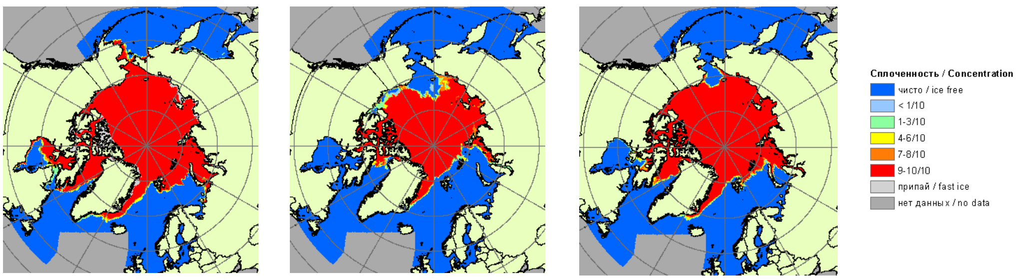

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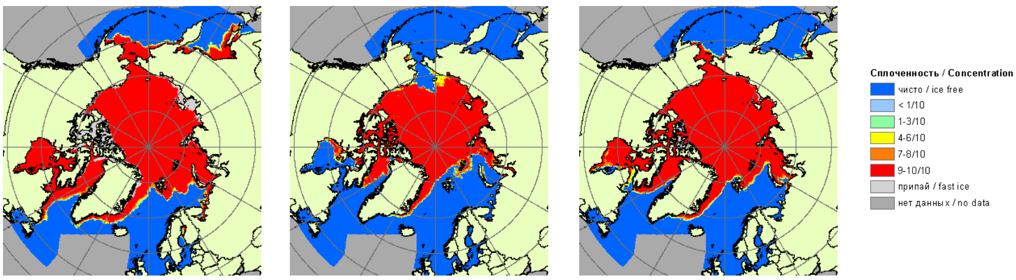
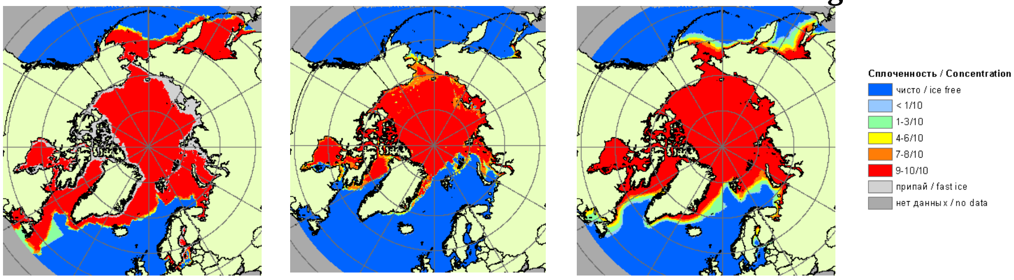
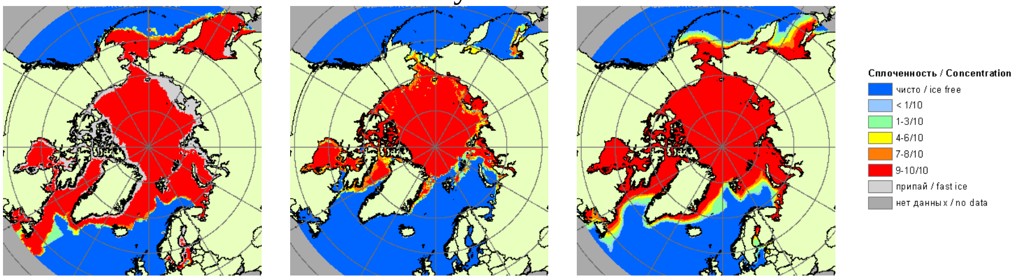


December

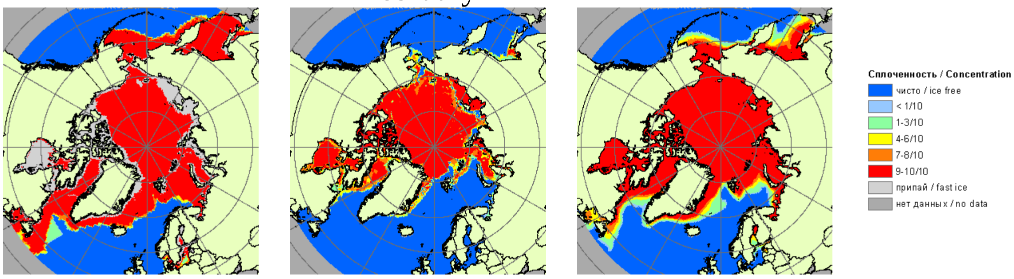
Annex 4 – Maximum of maximums (left), minimum of minimums (center) and trimean (right) monthly sea ice total concentration statistics based on blended ice charting for 1901-2012



January



February



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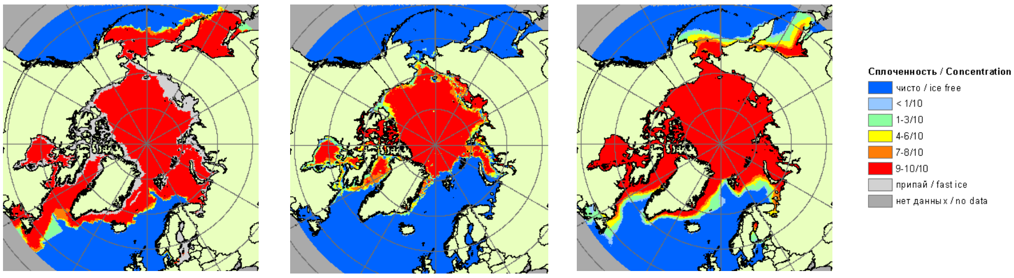

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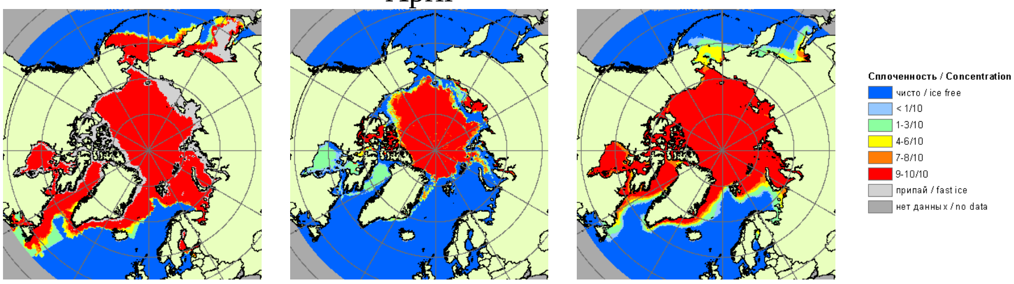
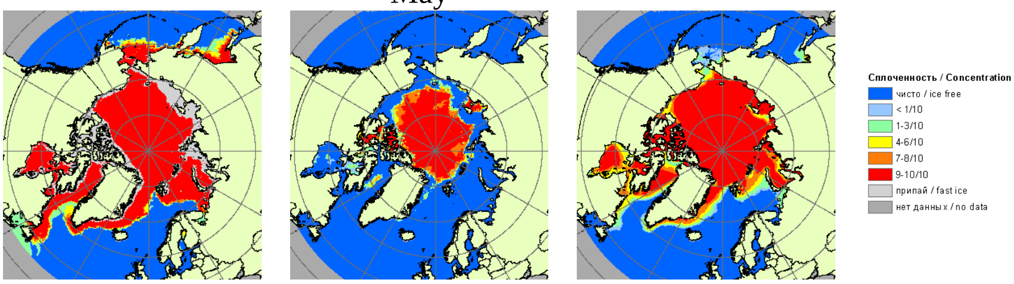
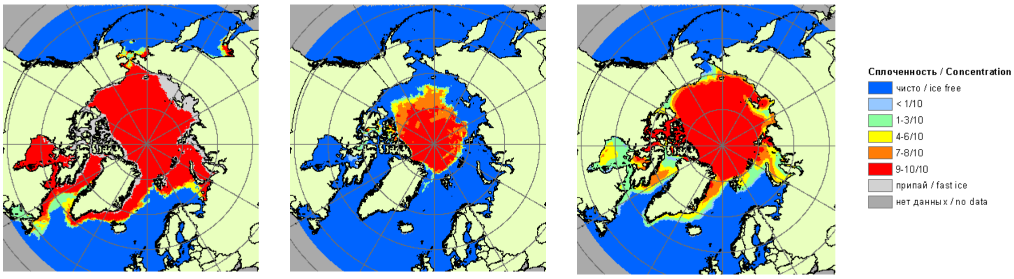


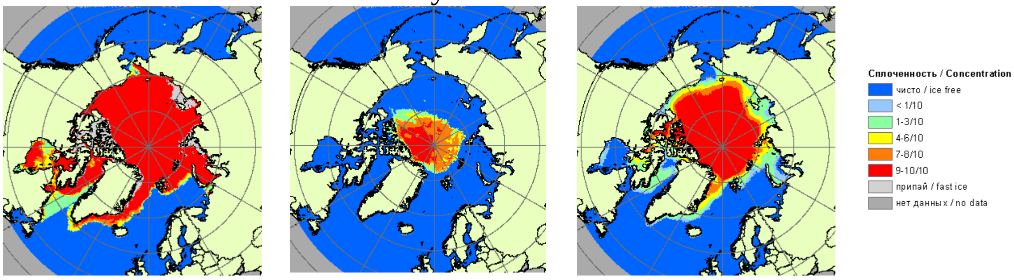
May



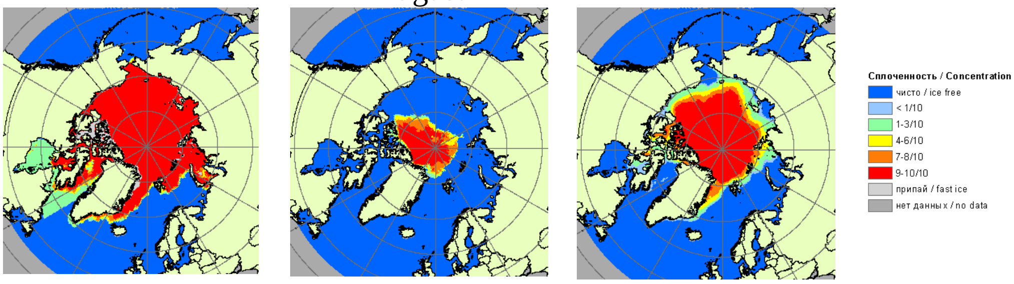
June



July



August



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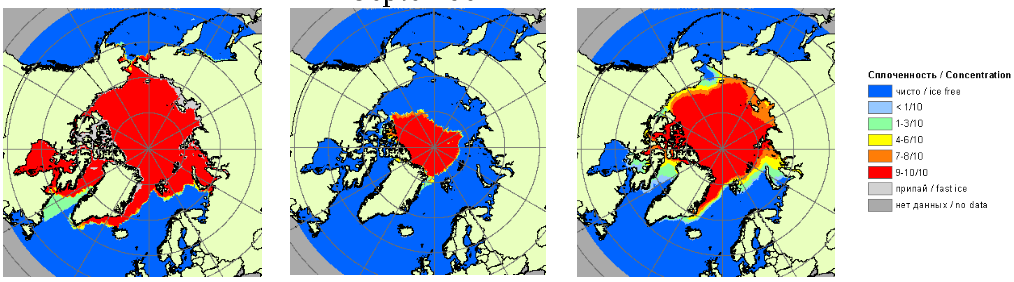
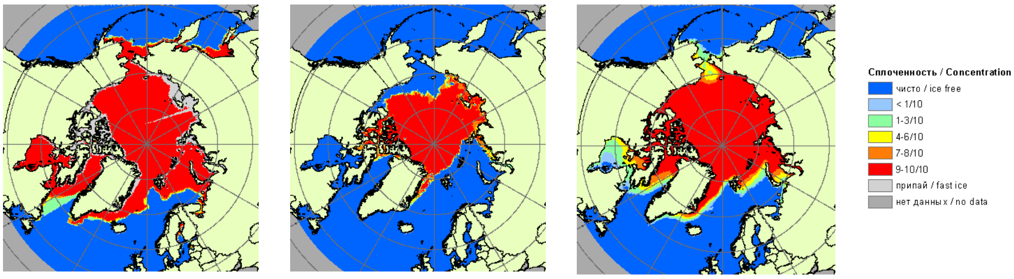
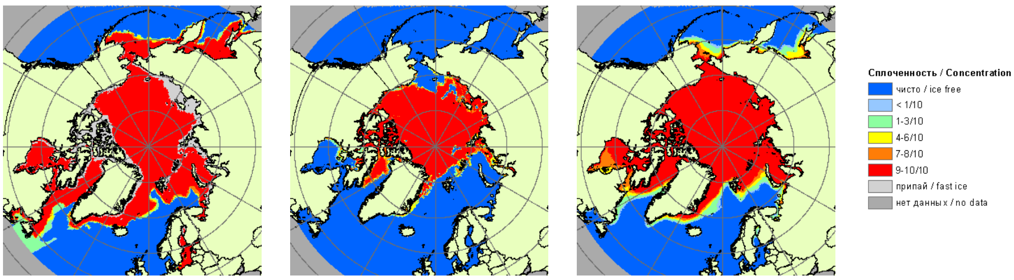


October

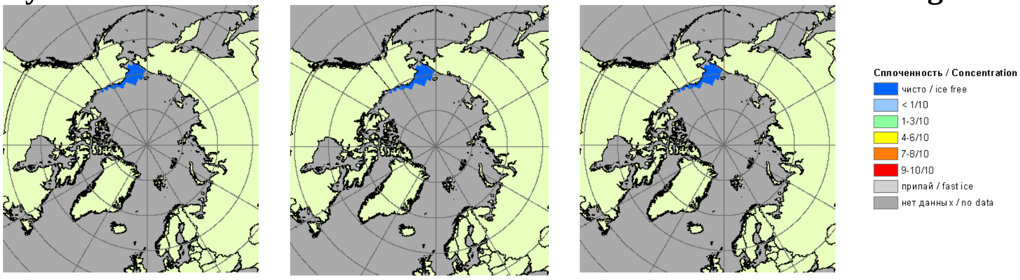


November

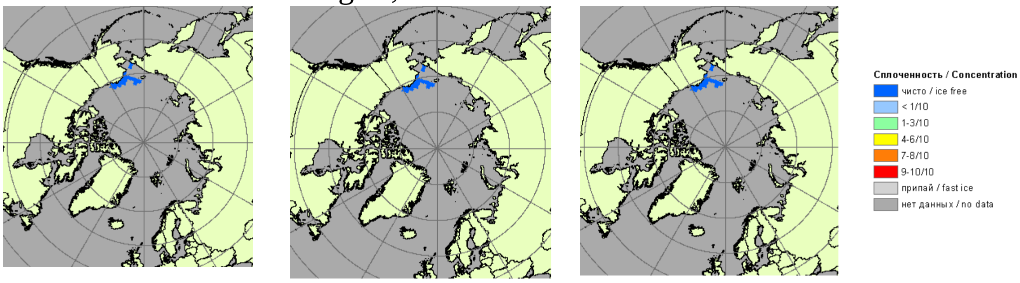


December

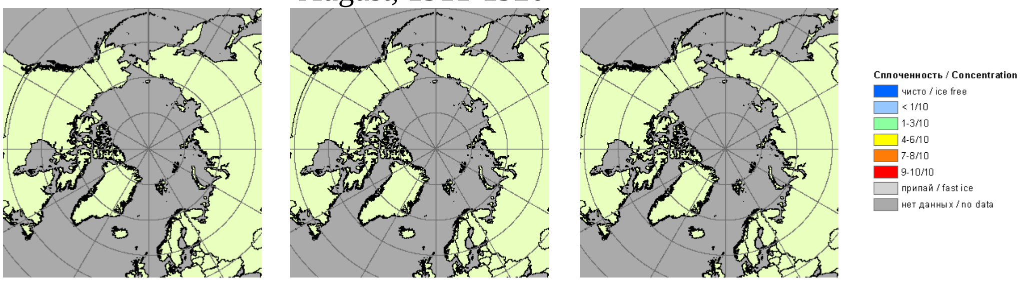
Annex 5 – Decadal maximum of maximums (left), minimum of minimums (center) and trimean (right) monthly sea ice total concentration statistics based on blended ice charting for 1901-2012



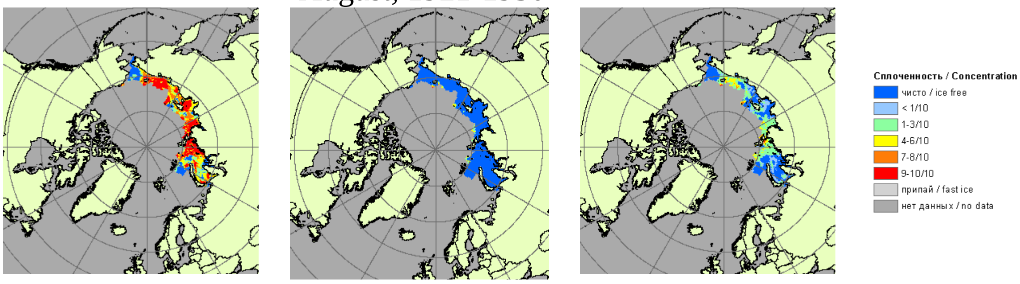
August, 1901-1910



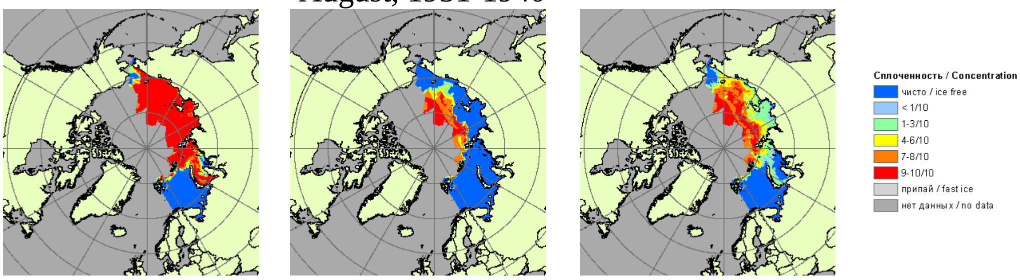
August, 1911-1920



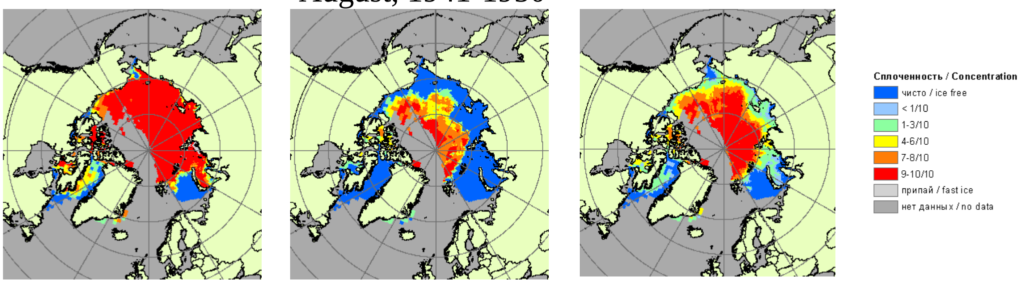
August, 1921-1930



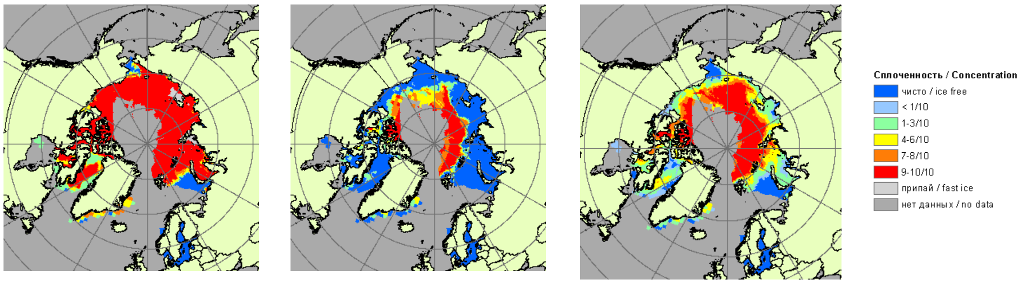
August, 1931-1940



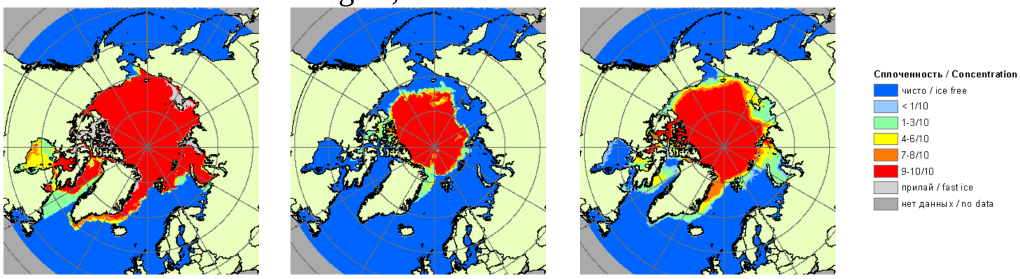
August, 1941-1950



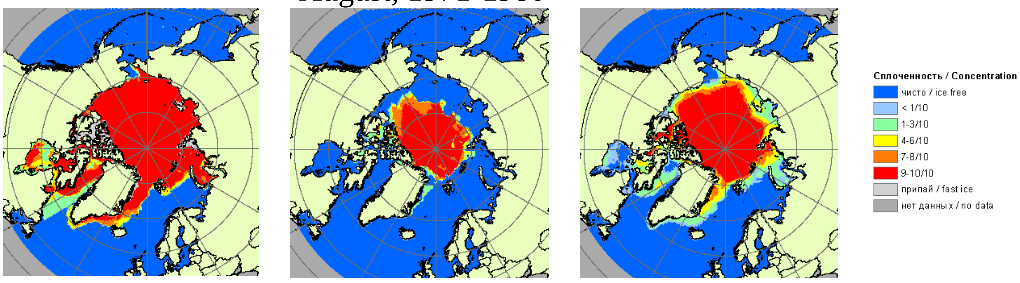
August, 1951-1960



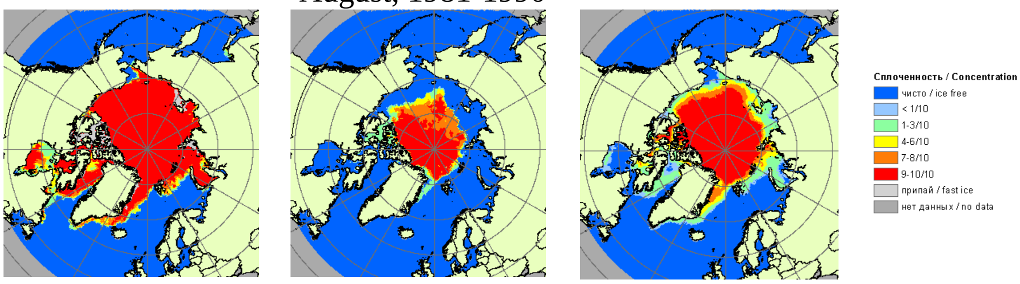
August, 1961-1970



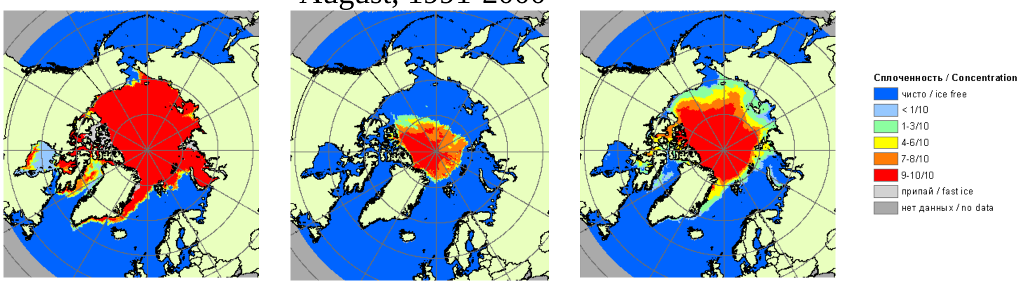
August, 1971-1980



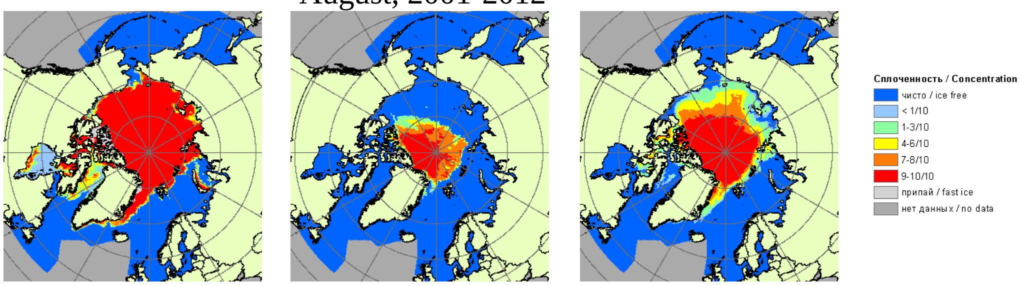
August, 1981-1990



August, 1991-2000



August, 2001-2012



August, 2006-2012