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Analysis of the sea ice concentration(SIC) in Subarea 48.6, research blocks 2,3,4, and 5 with sea surface temperature(SST) and statistical models

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Abstract

An Analysis of the sea ice concentration (SIC) in research blocks 2,3,4, and 5 of subarea 48.6, with sea surface temperature(SST) and statistical models is presented. For research block 4, the SIC in 2019 was the highest for the last 4 years (2016-2019). For research block 5, the SIC in 2019 was also as high as in 2016 but around the west of block 5 the SIC in 2019 was much lower than in 2016. The lower SST anomalies corresponds to the higher SICs in 2019 both in research blocks 4 and 5 and vice versa. The chart of the SIC as per HYCOM corresponds well to the SIC derived from data by the University of Bremen(AMSR2). Repeated Accessibility(RA) in research blocks 4 and 5 with statistical models, where the limit of navigability for fishing vessels is set at 20 % SIC, was calculated. It should become possible to predict the accessibility to research blocks 4 and 5 with the model in cooperation with HYCOM.

Analysis

1. *Research blocks of Subarea of 48.6 exploratory fisheries (Figure 1)*

There are four research blocks 2,3,4 and 5 in Subarea 48.6. Research block 2 is located north of 60°S and the other blocks are located south of 60°S (Figure 1). More than 80% of the sea ice concentration remains during 7 months from April to November in research blocks 4 and 5. In block 3, ice is present for 5 months from July to December. In block 2, some ice is present only from August to October with only a maximum of 50% SIC in research block 2 (Figure 2).

2. *Data sources of sea ice concentration (SIC) and sea surface temperature (SST) anomaly*

The SIC provided by the University of Bremen (https://seaice.uni-bremen.de/sea-ice-concentration/) based on the Advanced Microwave Scanning Radiome- ter 2 (AMSR2) and the photo of Global Imagery Browse Services (GIBS) by NOAA (https://developer.earthdata.nasa.gov/gibs/gibs-api-for-developers, https://worldview.earthdata.nasa.gov) are analyzed for the ice concentrations. The resolutions of the ice concentration of the AMSR2 are 3125m and 6250m/grid and that of GIBS is 250m/grid (https://seaice.uni-bremen.de/data/amsr2/asi_daygrid_swath/s6250/2019/apr/Antarctic/,https://seaice.uni-bremen.de/data/amsr2/asi_daygrid_swath/s3125/2019/apr/Antarctic3125/). (http://map1.vis.earthdata.nasa.gov/wmts-geo/MODIS_Terra_CorrectedReflectance_TrueColor/default/2019-02-15/EPSG4326_250m).

The sea surface temperature (SST) is from the ERDDAP of NOAA (https://coastwatch.pfeg. noaa.gov/erddap/index.html).

3. *Seasonal SIC based on the concentration in 2018 (Figure 2)*

Research block 4 and 5 are covered by ice spatially at almost 100% concentration, except for 4 months from December to March. The SIC of research blocks 4 and 5 starts to decrease at the beginning of November and then decreases faster after the beginning of January. In the middle of February the SIC starts to increase and reaches almost 100% spatial coverage in April and remains from March through to October. Ice in research block 3 starts to decrease at the beginning of November, one month earlier than the decrease in research blocks 4 and 5, and it decreases faster by the end of November. From the middle of December until the the beginning of June, there is no ice in research block 3 at all. After June, ice starts to return to the block 3 and increase rapidly, reaching 100%

spatial coverage in June and remains as such from the beginning of July until to the end of October.

In research block 2, there is no ice except for the period from the middle of August to October. The SIC in research block 2 reaches a maximum of approximately 25% coverage and this block is never covered 100 % by ice at any part of the year.

4. *Evaluation of the data for the analysis of the SIC in the subarea 48.6 (Figure 3)*

Figure 3 suggests that the chart of the SIC as per AMSR2 and the satellite photo of GIBS of February 16th 2019 correspond well to each other , so that the data used in the analysis is deemed as realistic for the analysis of the SICs in the Subarea 48.6 with four research blocks 2 - 5. However, satellite photo imagery has its limitation, as this is only available when cloud coverage is minimal.

5. *Charts of the SICs of 15th Mar, in 2016 - 2019 (Figure 4)*

Although the ice charts shows different spatial SIC patterns each year, for research block 4, the SIC in 2019 was the highest for the period 2016-2019. In 2016, there was almost no ice in research block 4 while there was very thick ice around research block 5. Around research block 5, the SIC in 2019 was also as high as in 2016 but to the west of research block 5 the SIC was much lower in 2019 than in 2016. In both 2017 and 2018, the SICs in research blocks 4 and block 5 were much lower than in 2016 and 2019.

6. *Four-year comparison of the SIC of 15th Mar. from 2016 - 2019 in research block 4 and 5 (Figure 5)*

It is found that for research block4 (lower), the SIC in 2019 was the highest for the 4-year period while the SIC of research block 4 in 2016 was the lowest . On the other hand, for research block 5 (upper), the SIC in 2019 was the second

highest for 2016-2019 while in 2017 it was the lowest.

7. *Five-year summer dynamics of monthly SIC for Subarea 48.6 from December to March, seasons 2014/15-2019 to 2018/2019 with Sea Surface Temperature(SST) (Figure 6)*

For December, the SIC in the 18/19 summer was higher than in the 16/17 and the 17/18 as the SIC was decreasing in December from 2015 to December 2017 dynamically and increasing from December 2018 to March 2019. It is clearly shown that the SIC in 2019 was much lower than in the other years. For January, February, and March, the trend is almost the same as the trend for December, but it is also clear that especially for January and February both in 2017 and 2018 the SICs were much lower than in the other years.

It is found that the SST had the opposite trend against the SIC (WG-SAM-17/10, WG-FSA-17/08, WG-SAM-16/42 Rev. 1) which means that a positive spike(sharp increase of SST) in the SST anomaly corresponds to a lesser SIC and vice versa. In 2019, the SST anomalies had positive spikes but not as pronounced as in 2017 and 2018, which means that the SST in 2019 was at the intermediately high level of SST same as was the SIC. As the positive spike became smaller and the SST decreased, the dynamics of the SIC may tend to increase for the following season. But currently there is not enough evidence(data) to show whether this is temporally phenomena or not.

8. *Four-year plots of daily SST of research block 4 (upper) and block 5 (lower) (Figure 7)*

The SST in research block 5 in 2019 was the second lowest for 2016-2019 and the SST in research block 4 was the lowest. The lower SST corresponds to the higher SIC in 2019 in both research blocks 4 and 5.

9. *Plots of monthly SST anomaly in research block 4(upper) and block 5(lower) from 2002 - 2019 (Figure 8)*

According to the monthly plot of the SST anomalies of both research blocks 4 and 5 from 2002 to 2019, there seems to have been 5-6 year phases of positive and negative anomalies during January- March of each year. The positive and negative spikes correspond well to the lower and higher SIC respectively. As the positive spikes occurred both in block 4 and 5 during January - March in 2017 and 2018, the SICs were the lowest both in research block 4 and 5. The lower SSTs anomalies correspond to the higher SICs in 2019 both in block 4 and 5 and vice versa.

10. *Modeling of SIC and SST through HYCOM model(Figure 9)*

The data server of HYCOM model provides 3-hourly SICs in the Antarctic (https://www.hycom.org/dataserver). The chart of the SIC using HYCOM corresponds well to the SIC of Univ. of Bremen. Accordingly, it is possible to forecast a realistic SIC prognosis using the HYCOM model if the evaluation with the AMSR2 and HYCOM is developed further. The oceanographic analysis by CTD data from Tronio as well as ERDDAP of NOAA will contribute to the sea ice analysis and should with the study on the hypothesis on *D. mawsoni* population dynamics (WS-DmPH-18/06).

11. *Repeated Accessibility(RA) in research block 4 and 5 with the statistical models by Pehlke et al. (2018)*

The Mean repeated accessibility (RA) in research block 4 and 5 with the limit of fishing navigability at 20 % SIC (Figure 10).

5-day moving average of mean repeated accessibility (RA) of all cells in research block 4 and 5 throughout the year for a threshold of 20 % SIC (Figure 11).

The background information on the sea ice analyses and the respective calculation steps are described in detail in WG-SAM-18/01. Further discussion on the RA with the other information, such as HYCOM, will be conducted in the WG-FSA-2019.

References

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- H. Pehlke, K. Teschke and T. Brey, 2018, Predicting fishing ground accessibility in the Antarctic Weddell Sea, WG-SAM-18/01

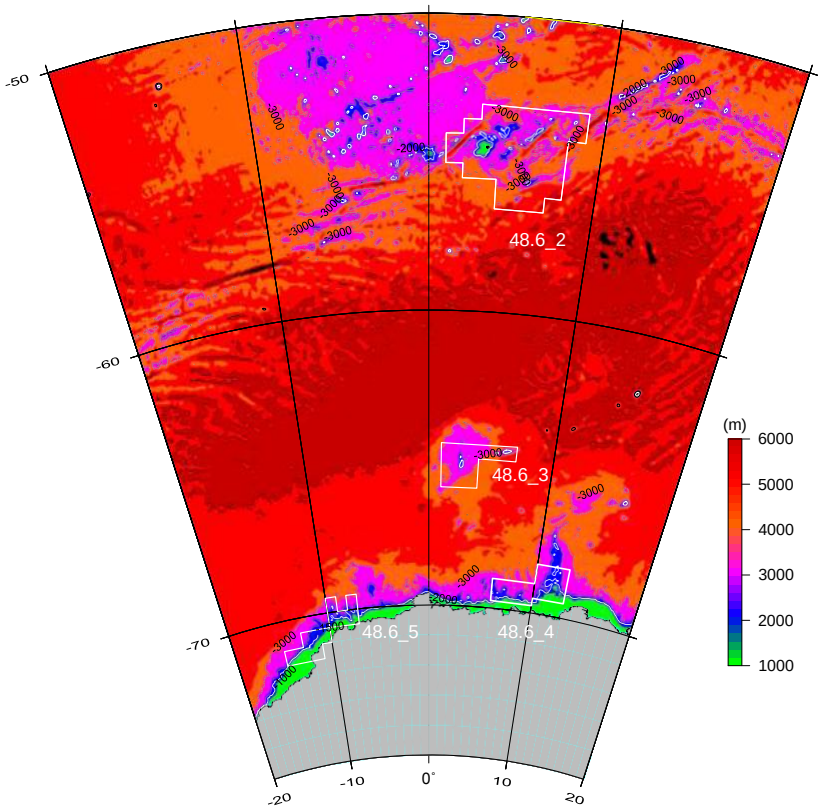


Figure 1. Location and topography of Subarea 48.6. There are four research blocks 2,3,4 and 5 in 48.6 where the research block 2 is located north of 60°S with other blocks south of 60°S.

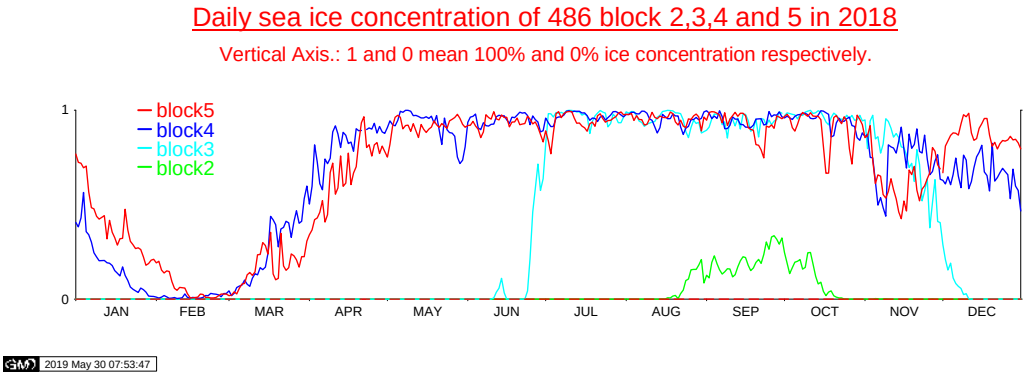


Figure 2. Daily sea ice concentrations (SICs) in 2018. The SICs are from the University of Bremen.(https://seaice.uni-bremen.de/sea-ice-concentration/)

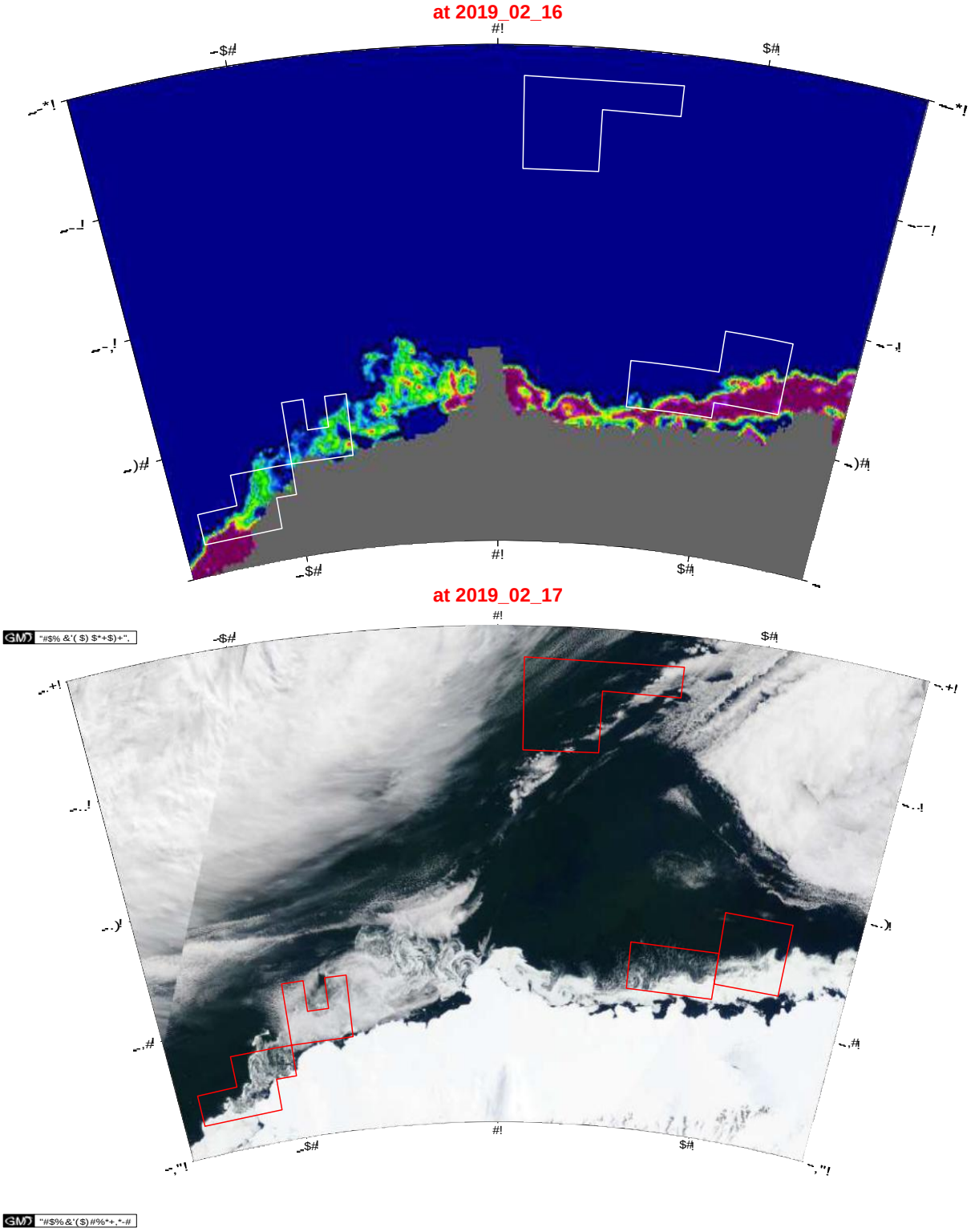


Figure 3. Sea ice concentrations (SICs) according to the University of Bremen and satellite photo image from NASA, middle of Feb. 2019. (https://seaice.uni-bremen.de/data/amsr2/asi_daygrid_swath/s3125/2019/apr/Antarctic3125/,http://map1.vis.earthdata.nasa.gov/wmts-geo/MODIS_Terra_CorrectedReflectance_TrueColor/default/2019-02-15/EPSG4326_250m).

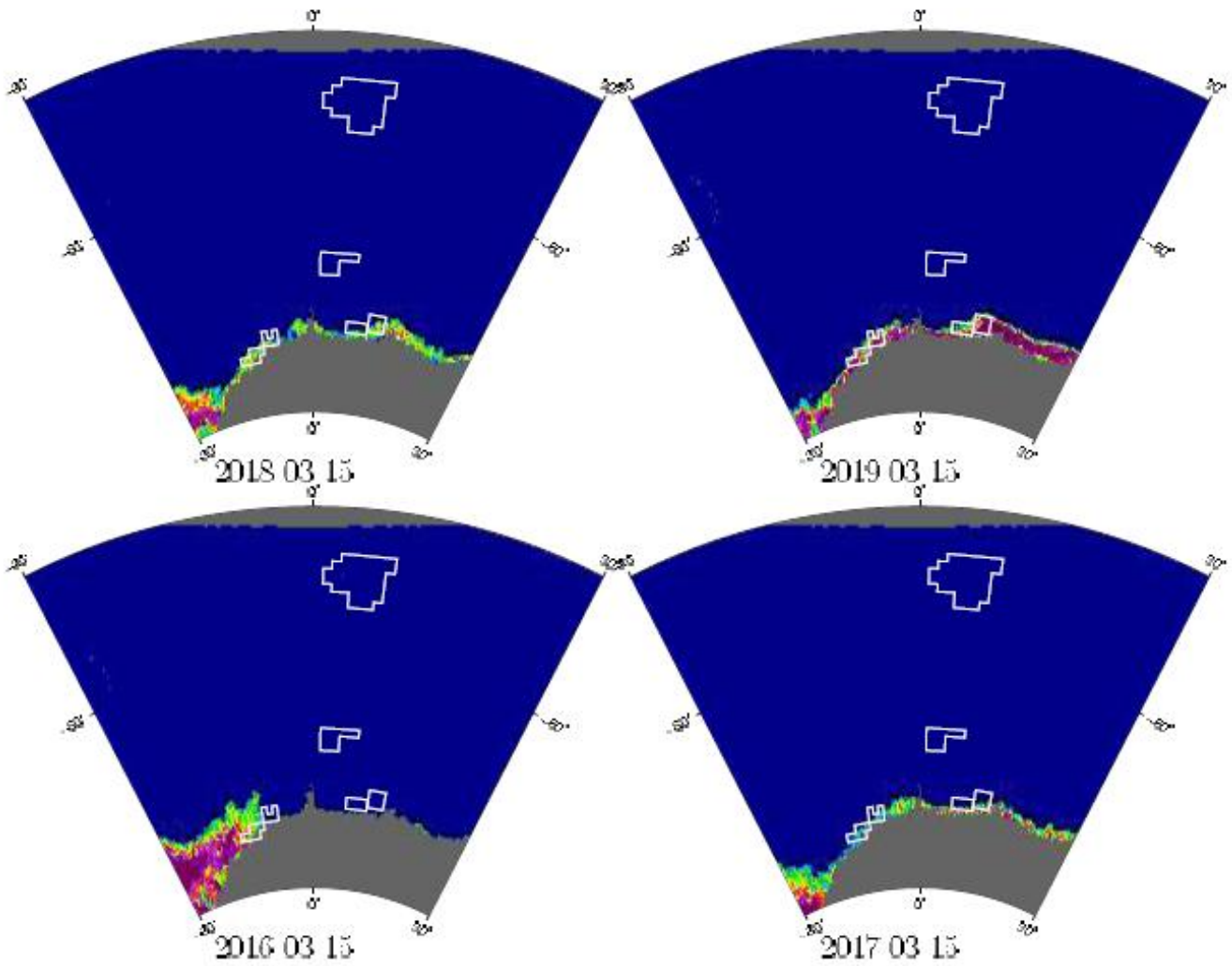
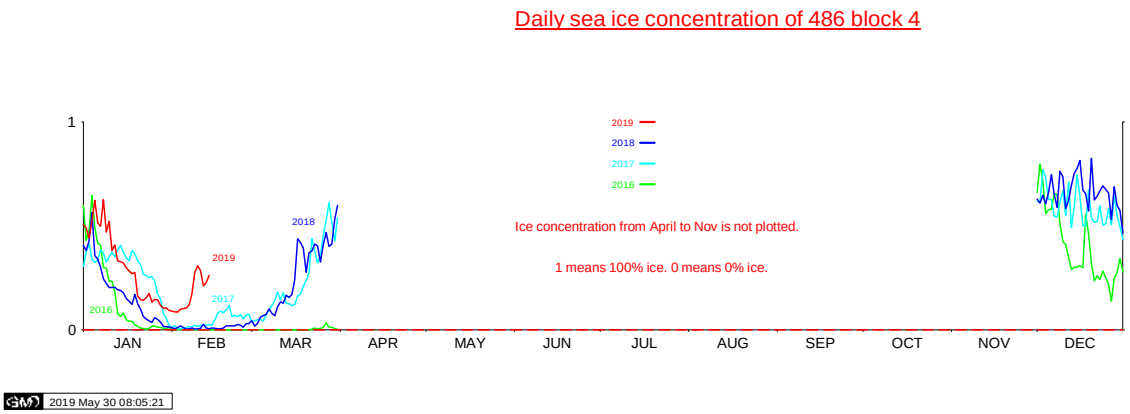


Figure 4. SICs of March 15, 2016- 2019.



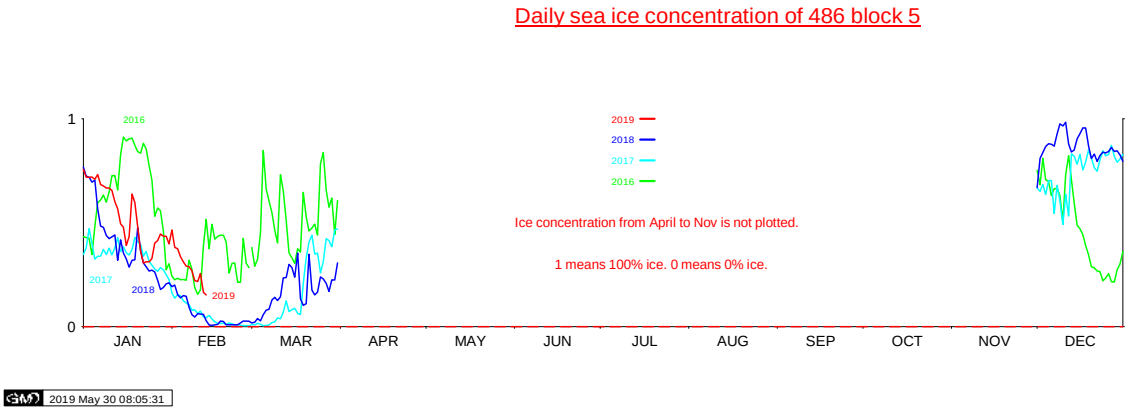


Figure 5. Daily plot of of the SICs in 48.6 research block 4(upper) and 5(lower).

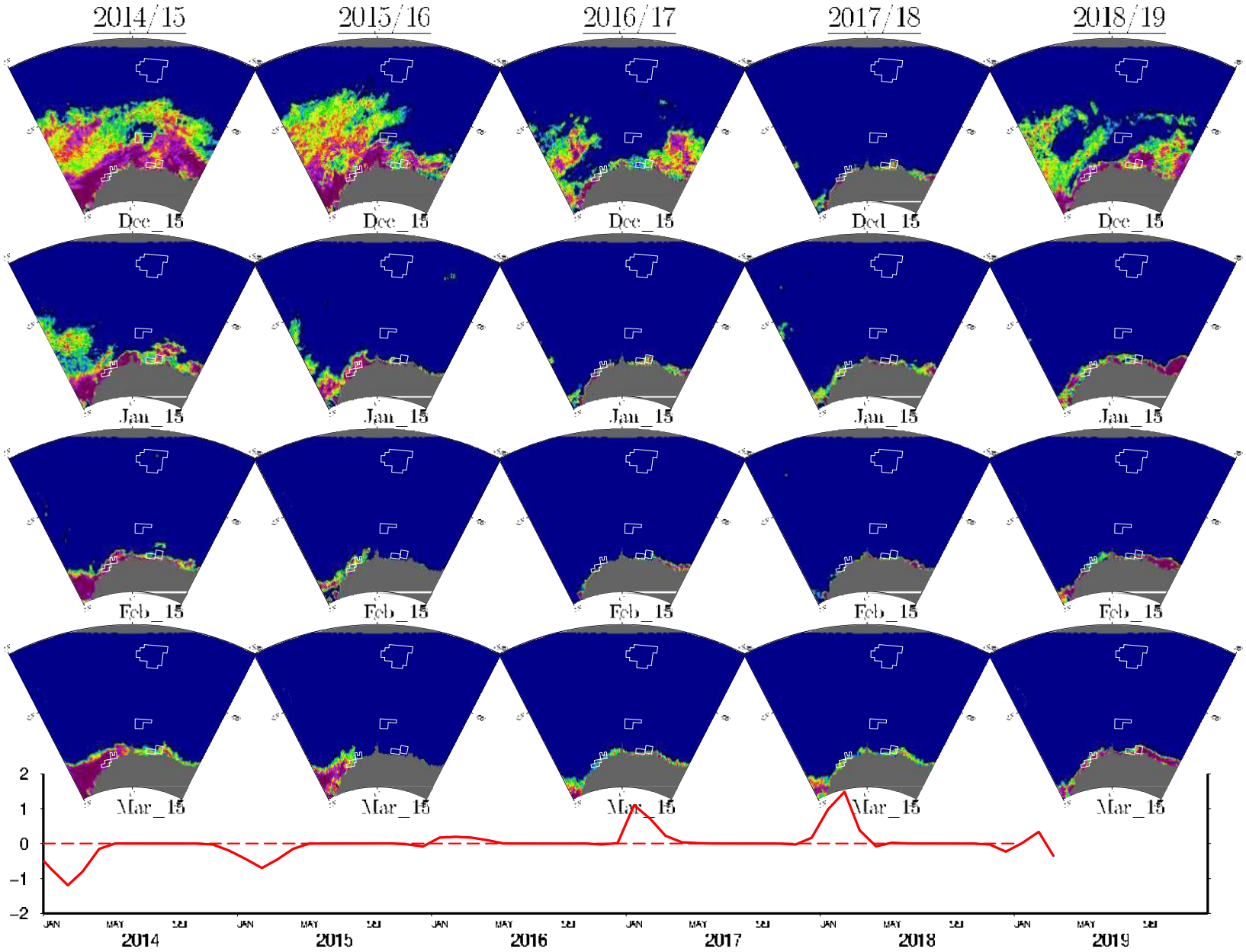
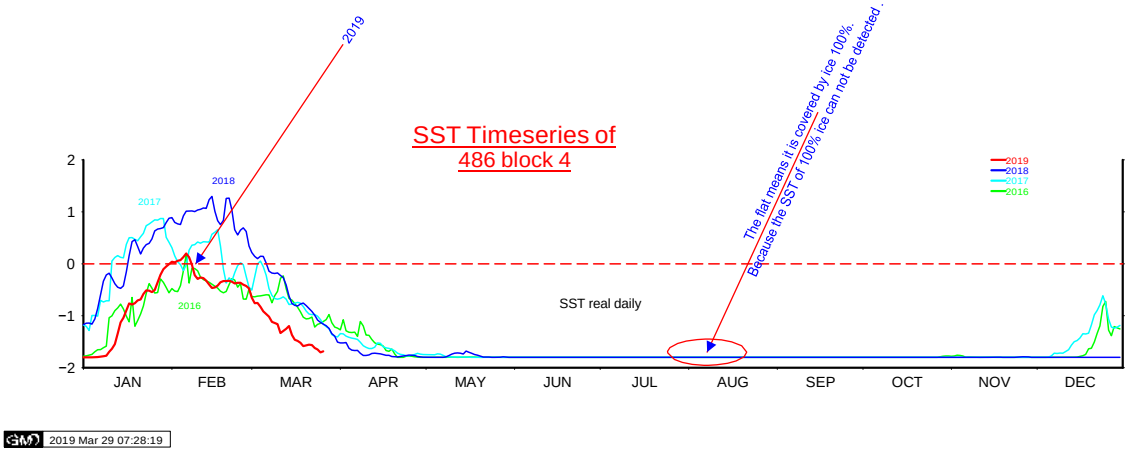


Figure 6. Five-year dynamics of the monthly SICs in the southern part of Subarea 48.6 from December to March 2014-2019 with SST anomaly. In the dynamics of the SST anomaly of block 4 for 2015-2019(lower). The flat(zero) part of the plot from April to December means that it is 100% covered by ice.



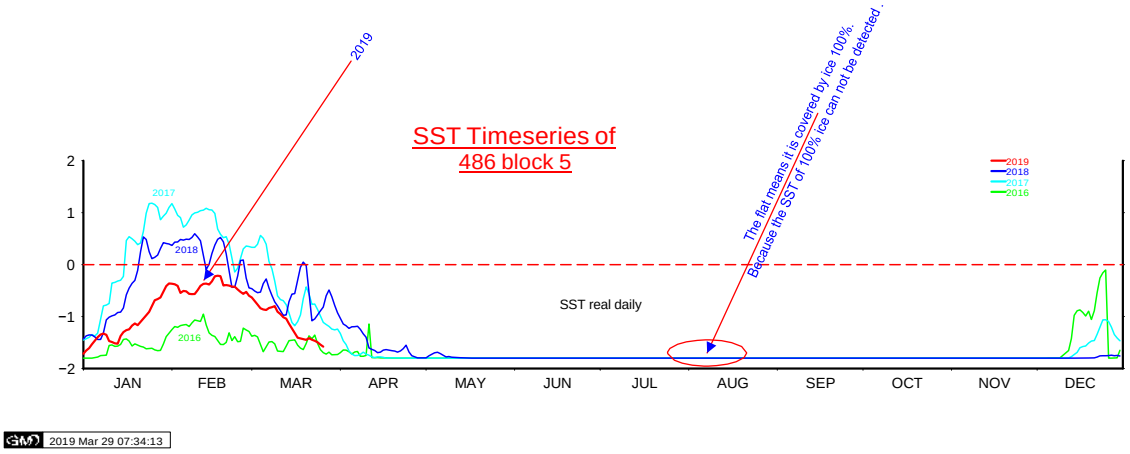
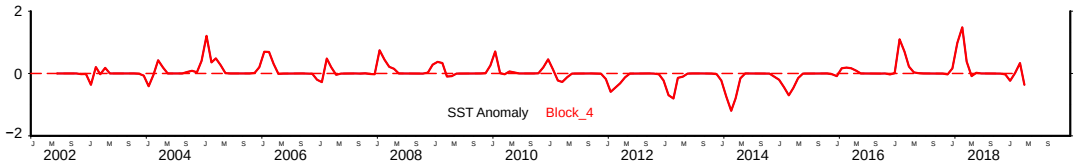


Figure 7. 4 years plot of the daily SST of research block 4 (upper) and block 5 (lower).



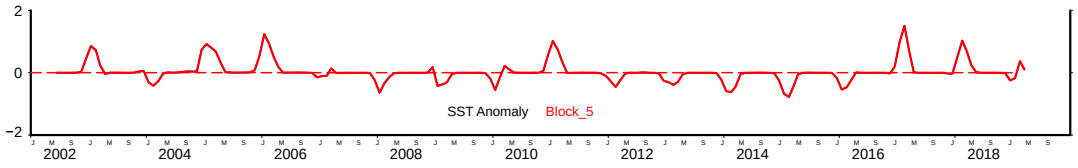


Figure 8. Plots of the monthly SST anomaly of research block 4(upper) and block 5(lower) from 2002 - 2019.

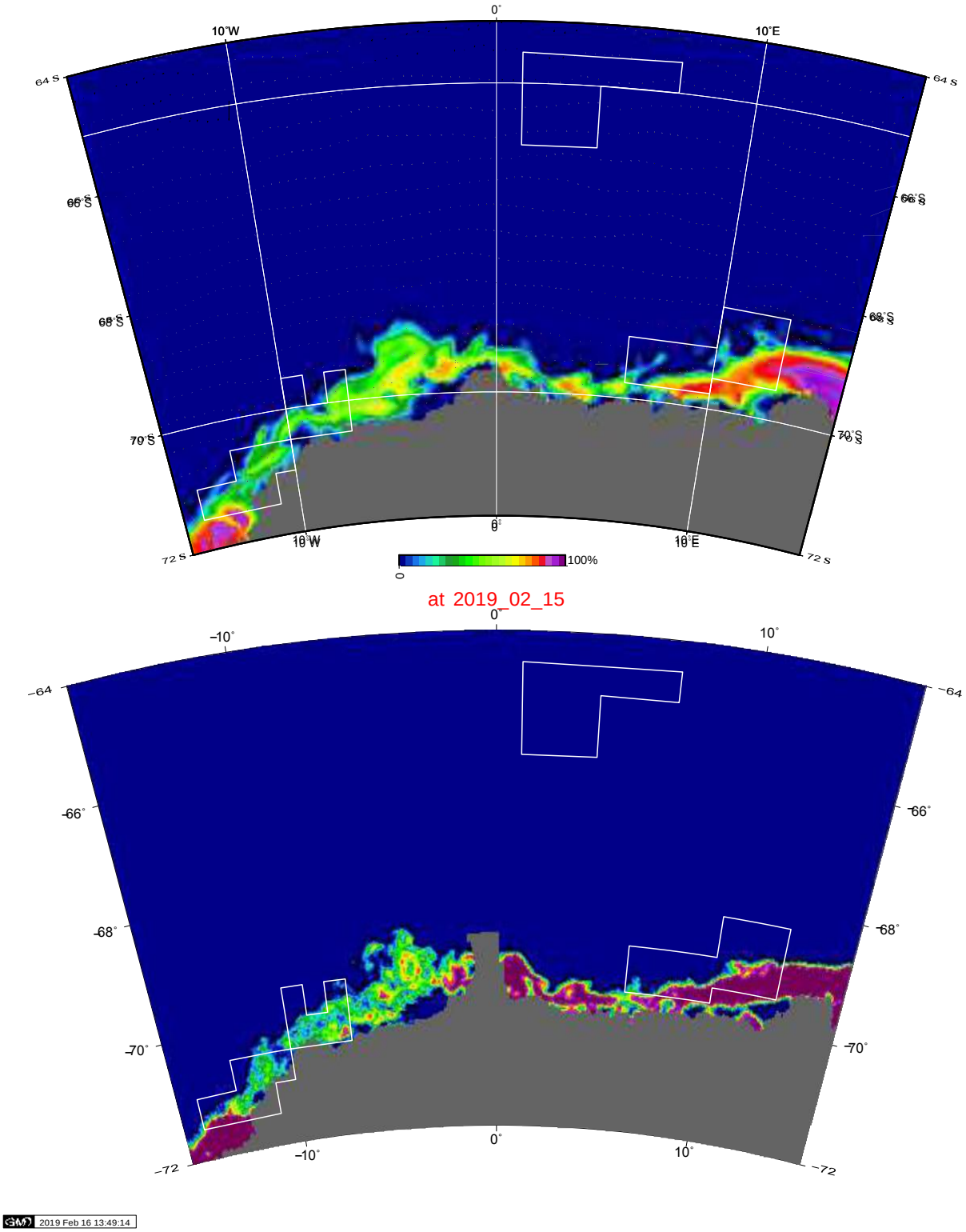


Figure 9. The SIC (upper) of Mar. 15th 2019 by HYCOM model (http://tds.hy com.org/thredds/dodsC/GLBy0.08/expt_93.0) with that by the SIC (lower) by Univ. of Bremen based on AMSR2 (https://seaice.uni-bremen.de/data/amsr 2/asi_daygrid_swath/s3125/2019/apr/Antarctic3125).

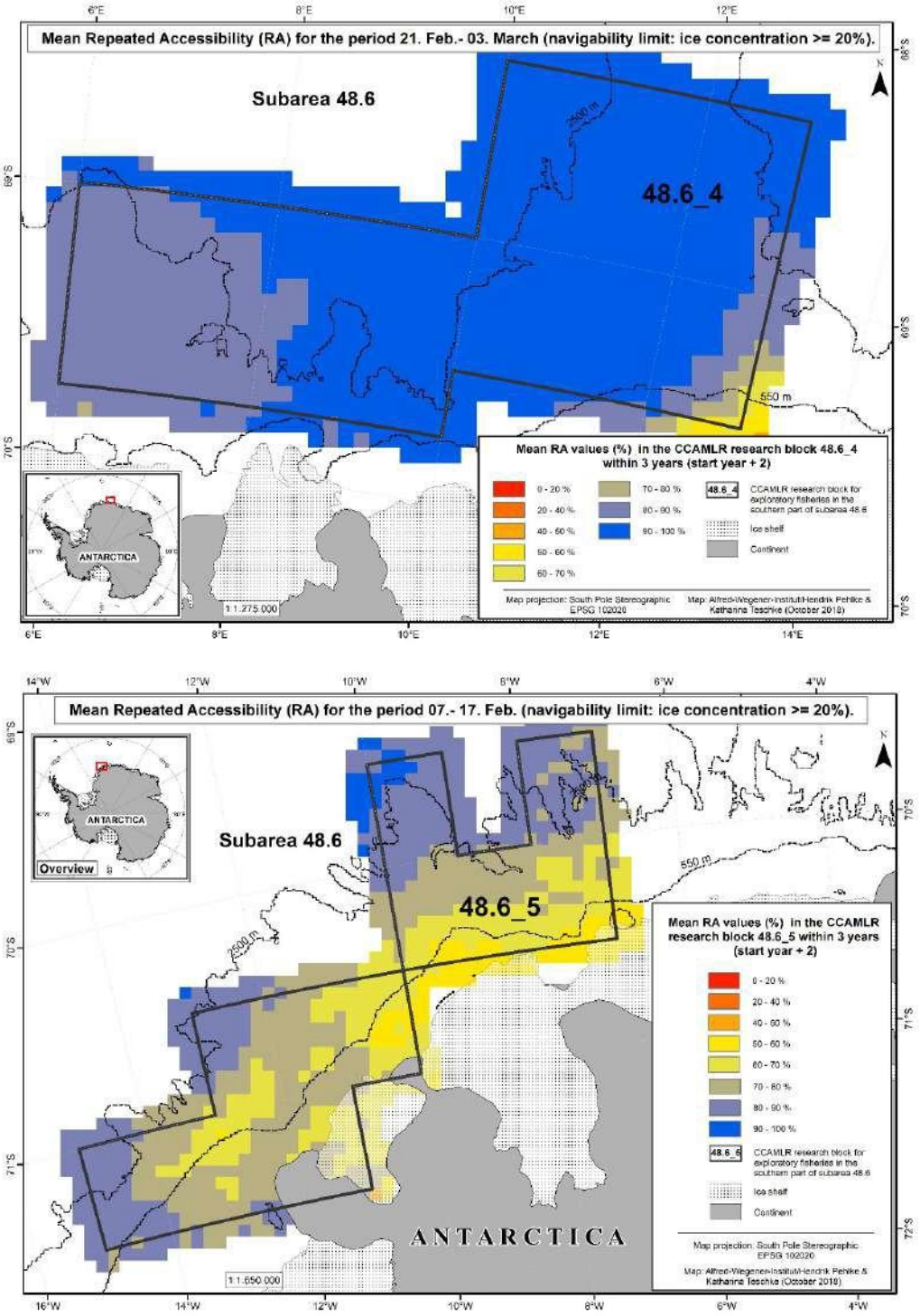


Figure10. Mean repeated accessibility (RA) in CCAMLR Research Block 4(upper) and 5 (lower) for the period for 21 February to 3 March and 7 to 17 February (period = day with max. RA ± 5 days). The limit of navigability for fishing vessels is set at 20 % sea ice concentration.

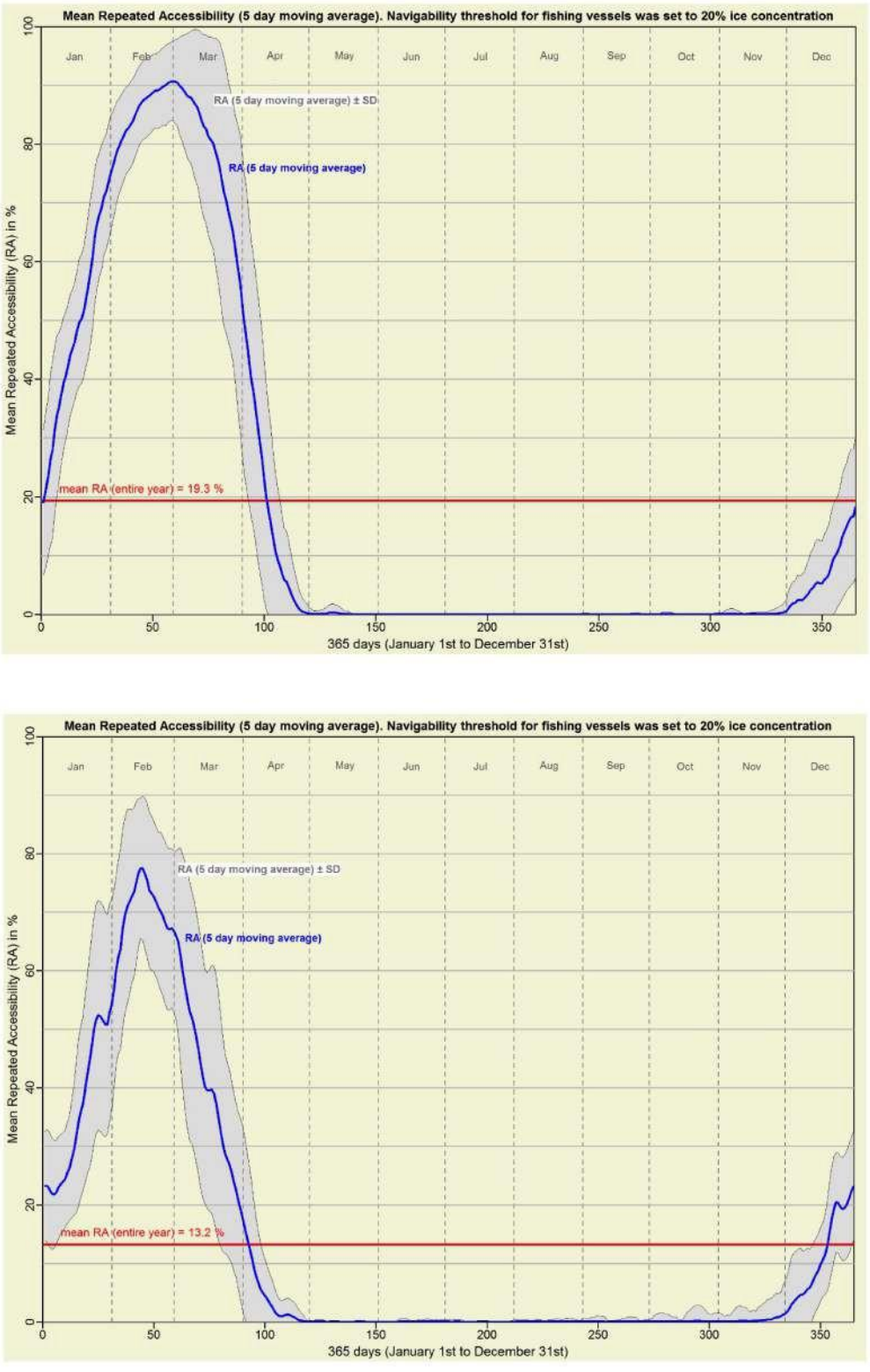


Figure 11. 5-day moving average of mean repeated accessibility (RA) of all cells in research block 4(upper) and 5(lower) throughout the year for a threshold of 20 % sea ice concentration. The moving average of a day is the mean of the value of that day and the four days before it.