Sea ice concentration data record over Arctic based on Chinese satellite-borne microwave radiometer

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Introduction

➢ Sea ice concentration (SIC) is one of the important parameters that can reflect the characteristics of sea ice. The National Snow and Ice Data Center (NSIDC) provides the SIC data of the north and south poles for nearly 40 years since 1978 by using the satellite radiometers.

➢ According to the report of NATURE, F18 and AMSR2 in orbit have been out of service, and there is no subsequent launch plan. Precious sea ice record data lasting nearly 40 years is in danger of being broken.

➢ The observation frequency band of China's Haiyang-2 (HY-2) and Fengyun-3 (FY-3) Series satellites microwave radiometer is similar to that of the United States DMSP / SSMIS, which has the potential to become the main data source of polar sea ice observation.

In this study, we developed an inter-sensor calibration the Tb between FY3C/MWIR, and F17/SSMIS, and we systematically evaluated temporal continuity of the daily sea ice concentration products over polar region from FY3C/MWIR data.

Data and Preprocessing

Data

➢ FY-3C/MWIR brightness temperature data
➢ F17/SSMIS brightness temperature data

The radiometric parameters of these two sensors are listed in the below Table1.

Table 1. Parameters comparison of F17/SSMIS and FY-3C/MWRI

Satellite	DMSP-F17	FY-3C
Sensor	SSMIS	MWRI
Orbit height(km)	850	836
Viewing angle(°)	53.1	45
AECT	5.31pm	1.40~2.00pm
Channels used in this study:footprint (GHz:km×km)	19.3: 70×45 22.2: 60×40 37.0: 38×30	18.7: 30×50 23.8: 27×45 36.5: 18×30
Swath width(km)	1700	1400

The SIC operational products provided by the NSIDC were used to compare with the retrieved result with FY-3C data.
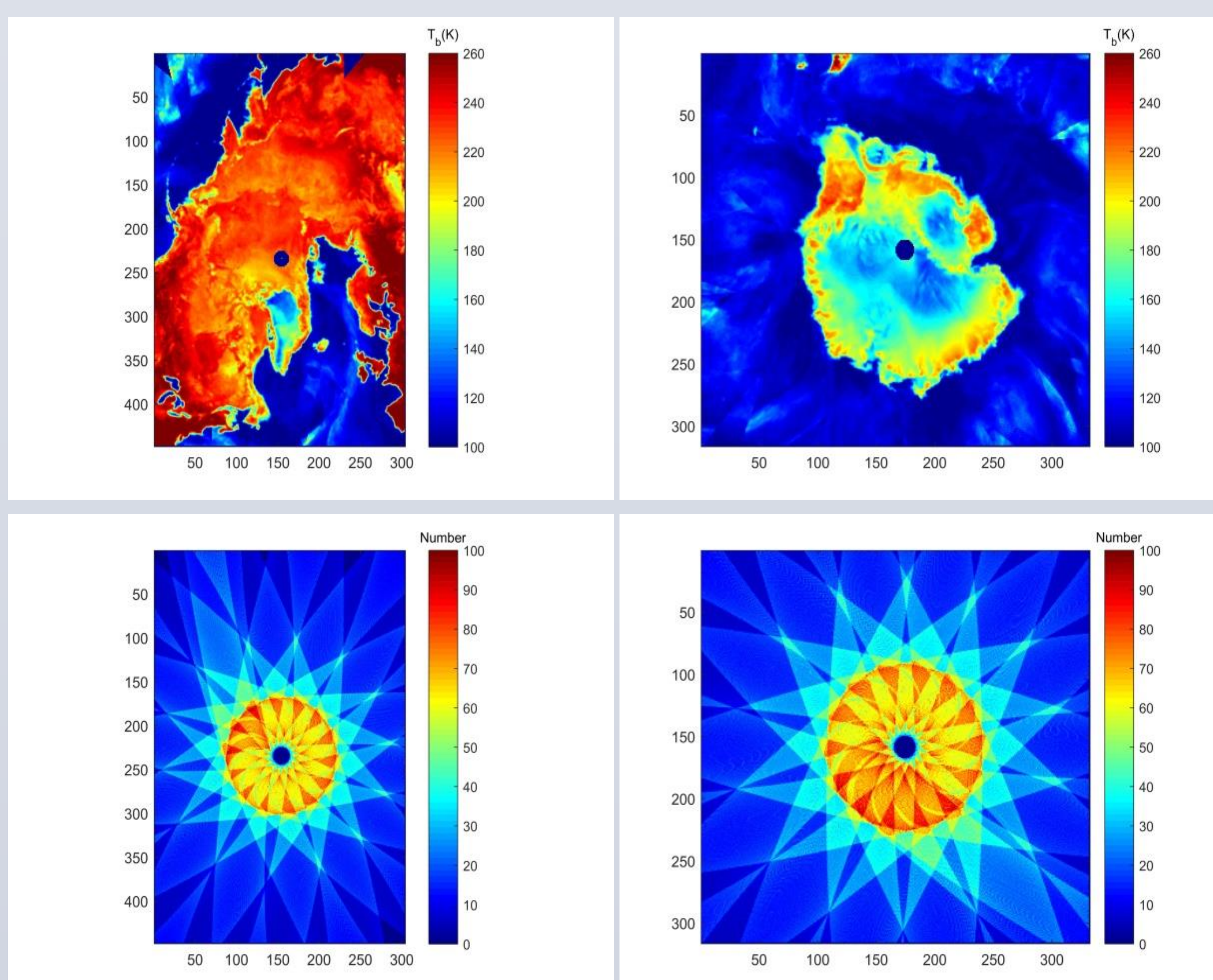

Figure 1. Brightness temperature (19H) and observation times of Arctic and Antarctic

Projection

The daily 14 tracks brightness temperature data of SSMIS and MWRI are reconstructed to a polar plane grid using polar stereographic projection formulae, respectively. Figure 1 reflects the number of observations of each pixel of polar plane grid obtained by resampling and most of the areas are mainly concentrated in 20-70.

Inter-sensor calibrations

1. According to the method of projection in the last subsection, each swath data is projected at the north and south poles with the spatial resolution of 12.5km, and then the observation of land area are eliminated.

2. The data matchup was carried out with the spatial window of 12.5km and the temporal window of 1 hour.

3. Based on the matched Tb data of each band, the corresponding linear regression coefficients were calculated.

In order to calculate the calibration coefficient more accurately, we selected the matched data of the 1st, 11th and 21th days of each month to obtain the calibration coefficients of 12 months. With the coefficients, the calibrated Tb data of MWRI was used to retrieve the SIC in the subsequent work.
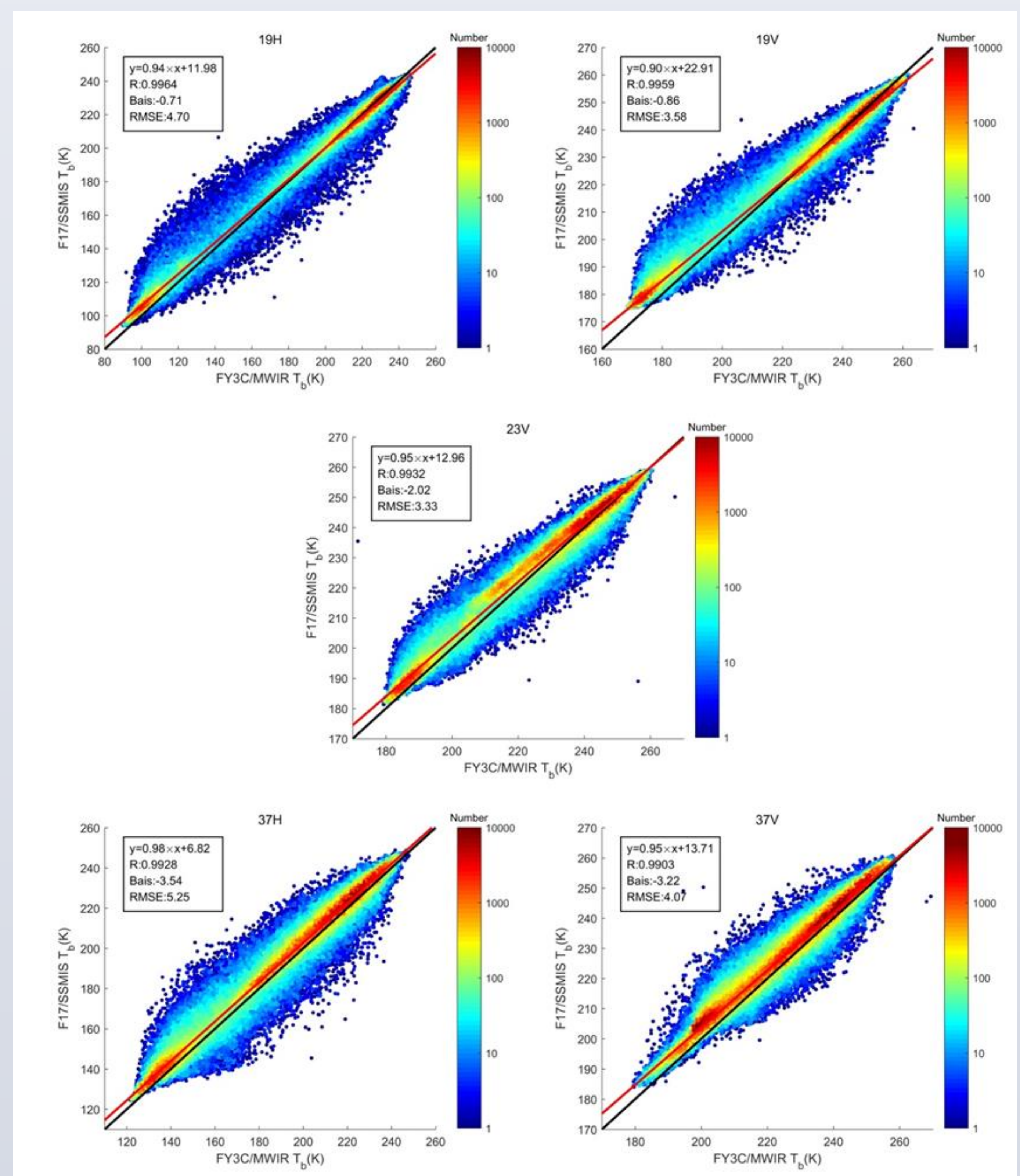

Figure 2. Scatter diagrams of matched data of 3 days of March 2016

➢ Totally 565114 pairs of brightness temperature for each channel were compared.

➢ The point numbers are calculated with the base 10 logarithm and displayed according to the colorbar.

➢ The 1:1 line is shown with black line and the established inter-sensor calibration model is shown with red line.

➢ The textbox lists the detailed information including the inter-sensor calibration formula, matched data's correlation coefficient (R), bais and root mean square error (RMSE).

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Based on the inter-sensor calibration coefficients, the Tb at all channels of MWRI were calibrated. After the calibration, the correlation coefficients between amounts of F17/SSMIS and FY3C/MWRI at the 19H, 19V, 23V, 37H and 37V channels improved from 0.9399 to 0.9855, from 0.7788 to 0.9688, from 0.9091 to 0.9812, from 0.9097 to 0.9918, from 0.5930 to 0.8552, respectively. The calibration effects of vertical polarization are better than those of the horizontal polarization.
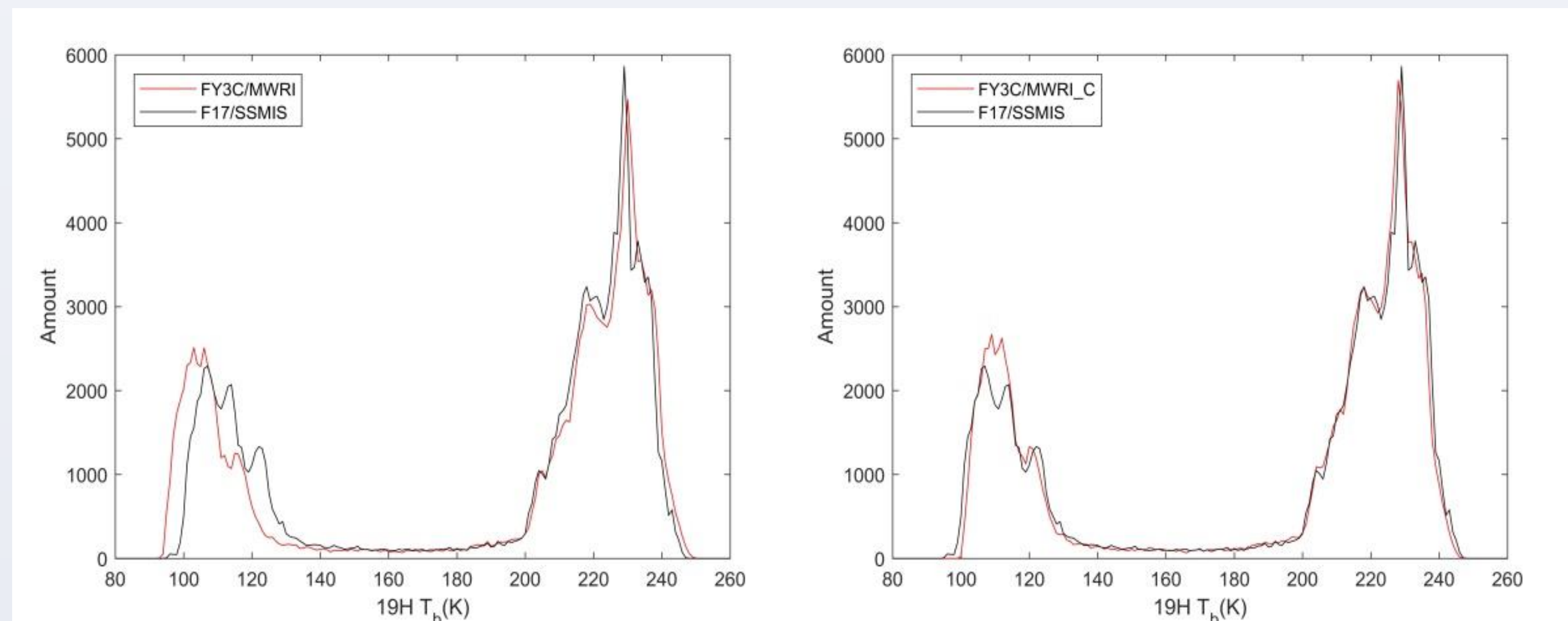

Figure 3 F17/SSMIS, original FY3C/MWRI and calibrated FY3C/MWRI brightness temperature of 1 March 2017 for each channel (left: F17/SSMIS and original FY3C/MWRI; right: F17/SSMIS and calibrated FY3C/MWRI).

Sea ice concentration retrieval

1. The sea ice concentration of polar zone with 25km spatial resolution was calculated with NASA Team algorithm.
2. The spectral gradient ratios GR(37/19) and GR(22/19) were used as the weather filters.
3. The land-to-ocean spillover effect, also called land contamination, can be removed with Parkinson et al. (1987) method
4. For the residual weather pollution and land contamination that can not be removed by weather filter, sea ice masks were used to remove.
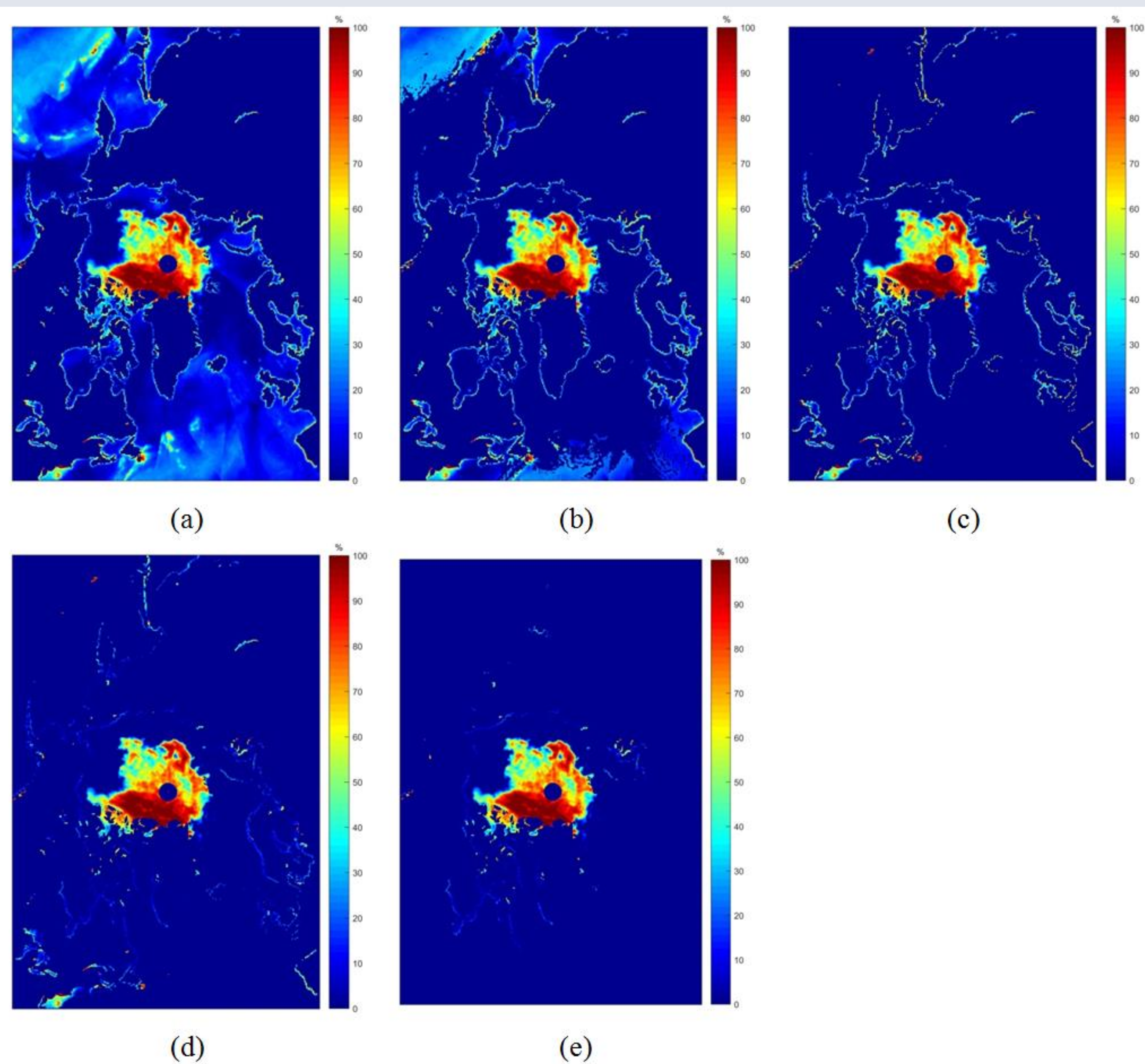

Figure 4. step-by-step correction results from the preliminary results of retrieved SIC to the final results using the brightness temperature data of August 26
a: the preliminary result of SIC inversion.
b: the result with GR(37/19) weather filter to remove the false sea ice caused by liquid water (0.1-0.3mm) over the high latitude area.
c: the most false sea ice caused by weather effects can be removed with the further processing with GR(22/19).
d: the result with land contamination correction method
e: the valid ice mask was used to remove the residual weather pollution and land jurisdiction.

Inter-sensor comparison in SIC

In order to verify the accuracy of the obtained SIC data, the sea ice extent (SIE) was calculated based on the daily SIC and then compared with the result of NSIDC. From figure 5, it can be found that the SIE change trend of the north and south poles in the four years are basically the same as that of NSIDC products.
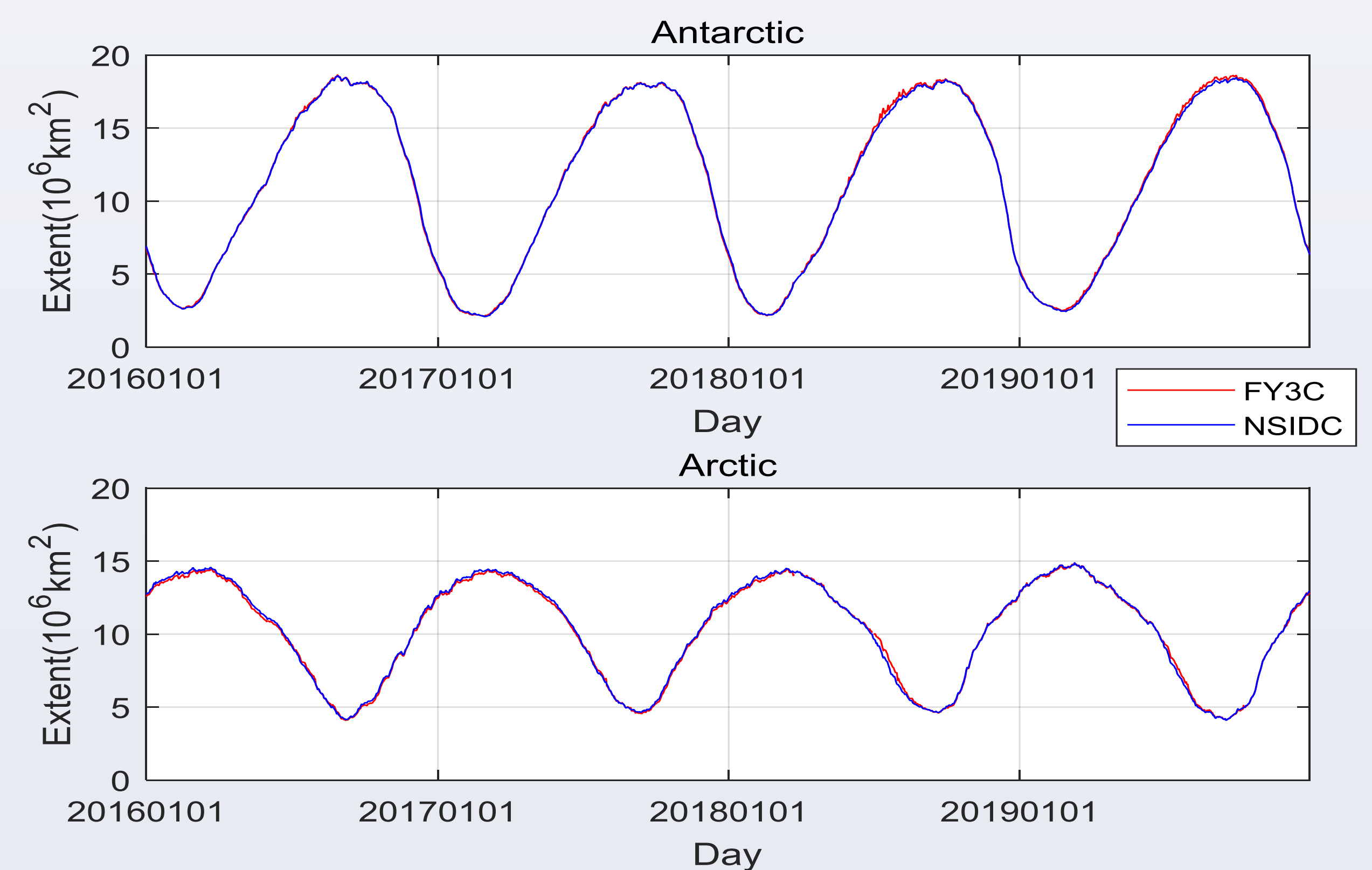

Figure 5. Daily SIE compared with NSIDC over Arctic and Antarctic

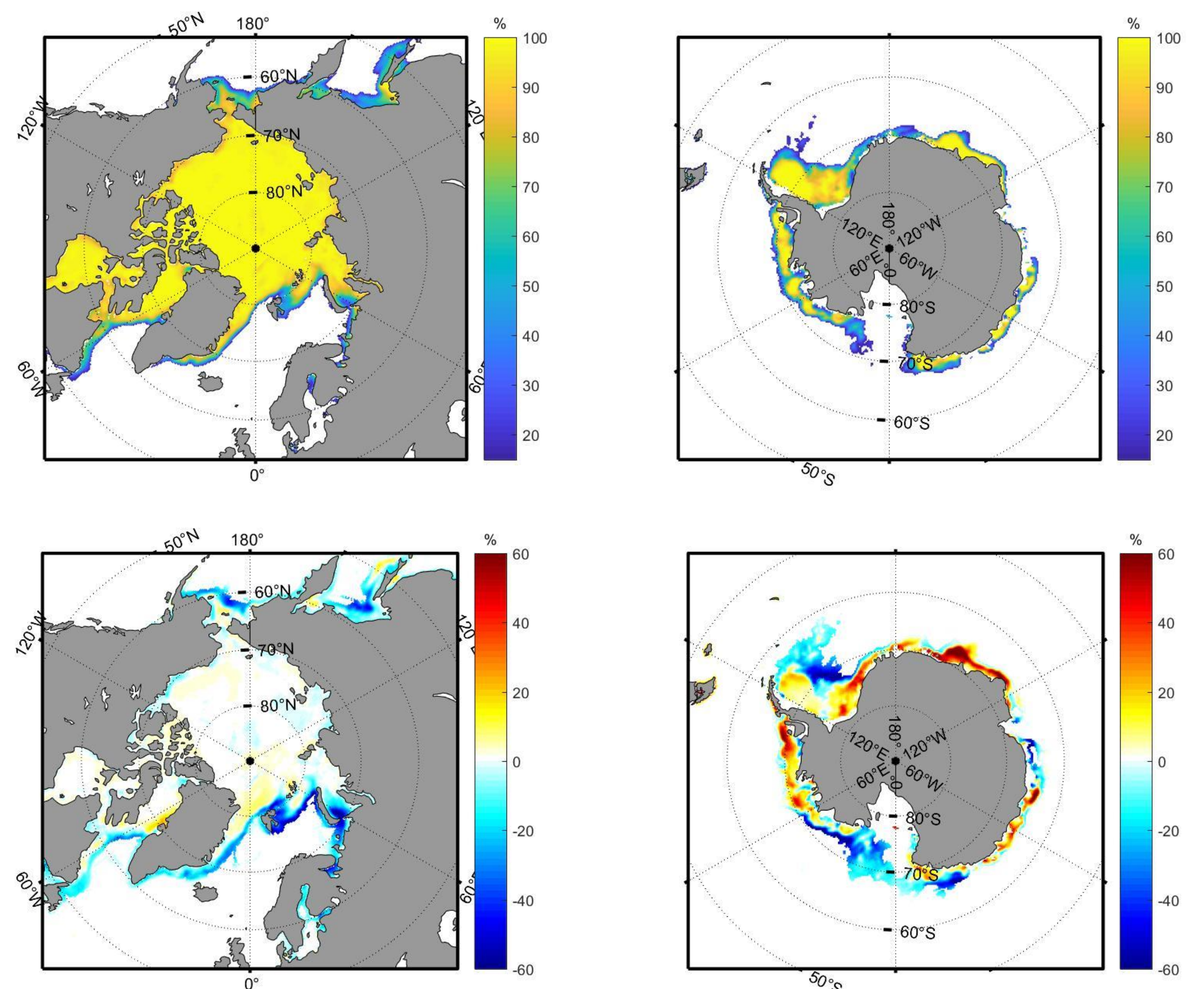Based on the daily SIC, the monthly SIC and monthly SIC anomaly can be calculated.

Figure 6. Monthly SIC (left) and monthly SIC anomaly (right) of Jan. 2019.

Conclusion

➢ In this paper, the method of inversion of polar sea ice density using FY3C satellite microwave radiometer is studied, and the SIC data set with strong consistency with NSIDC products is obtained, and the results are preliminarily verified.

➢ The results of this study lay a foundation for the release of operational polar SIC products of China's independent satellites, and the products can guarantee the continuity of polar sea ice records in the past 40 years facing interruption.