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Analysis of SSMIS data

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Abstract

SSM/I and AMSR have for some time been used in the OSI-SAF project to deliver valuable information on ocean and sea ice in the polar regions. Since the DMSP satellite F16 was launched in 2003 a new instrument has been available, the SSMIS. This is however at the moment not implemented in the OSI-SAF data stream. This report is an investigation on the quality of the SSMIS data in order for them to be part of the OSI-SAF data stream. The data are converted to ASCII and a comparison has been made of SSMIS and SSM/I over a selected area in arctic.

Resumé

Rapporten er en undersøgelse af SSMIS data, så de kan komme til at indgå i OSI-SAF projektets database. SSMIS dataene konverteres til ASCII og sammenlignes med SSM/I data over et udvalgt område i arktis.



Introduction

The Special Sensor Microwave Imager Sounder (SSMIS) was launched in 2003 on board the Defence Meteorological Satellite Program (DMSP) satellite F16. It is the successor of the Special Sensor Microwave Imager (SSM/I) instrument which is flown on for instance the DMSP satellites F13, F14 and F15. The DMSP satellites are all in a 101 minute sun-synchronous near-polar orbit at an altitude of 830 km above the surface of the Earth. The combination of day/night and dawn/dusk satellites allows monitoring of global information. The instruments cover polar regions at least twice per day. (NGDC, 2007) The SSMIS scans at a constant 45-degree angle from nadir and intersects the Earth's surface at a constant incidence angle of 53.1 degrees. The swath width on the ground is 1707 kilometres. The channels and the footprint size of the SSMIS instrument is seen in Table 1.

Channel	Frequency (GHz)	Polarisation	Footprint (km)
1	50.3	V	38 x38
2	52.8	V	38 x38
3	53.6	V	38 x38
4	54.4	V	38 x38
5	55.5	V	38 x38
6	57.3	V+H	38 x38
7	59.4	V+H	38 x38
8	150.0	H	14 x13 (imager)
9	183±6.6	H	14 x13 (imager)
10	183±3.0	H	14 x13 (imager)
11	183±1.0	H	14 x13 (imager)
12	19.35	H	73 x 47
13	19.35	V	73 x 47
14	22.235	V	73 x 47
15	37.0	H	41 x 31
16	37.0	V	41 x 31
17	91.655	H	14 x13 (imager)
18	91.355	V	14 x13 (imager)
19	63.28+0.235	V+H	75 x 75
20	60.79+0.358±0	V+H	75 x 75
21	60.79+0.358±2	V+H	75 x 75
22	60.79+0.358±5.5	V+H	75 x 75
23	60.79+0.358±16	V+H	75 x 75
24	60.79+0.358±50	V+H	75 x 75

Table 1 Channels, frequencies, polarisation and footprint size for the SSMIS instrument (Laue et al., 2007, NOAA, 2007)

The Comparison

The SSMIS data are downloaded from UK Met office in Binary Universal Form for the Representation of Meteorological data (BUFR) format. The data are decoded to ASCII with BUFRDC decoding software from The European Centre for Medium-Range Weather Forecasts (ECMWF). (ECMWF, 2007) It is the plan that the SSMIS data should be converted directly to Network Common Data Form (NetCDF) when used in the Ocean and Sea Ice Satellite Application Facility (OSISAF) data chain. The seven channels with frequencies close to the frequencies of SSM/I are written to a file with latitude and longitude. One file for each BUFR file. The SSM/I channels and frequen-



cies are listed in Table 2.

At the moment the received SSMIS data are not modified in any way. The investigation will reveal whether it is necessary to calibrate the data.

Channel	Frequency (GHz)	Polarisation
1	19.35	H
2	19.35	V
3	22.235	V
4	37.0	H
5	37.0	V
6	85.5	H
7	85.5	V

Table 2 The channels, polarisation and frequency of the SSM/I instrument (Laue et al., 2007)

The SSM/I files for the comparison are collected from the OSI-SAF data chain in binary format. Different time periods are chosen for the comparison. The time period December 8 to December 12 2007 is chosen as a contiguous period and February 26 to 28 2008 as single days. February 28 is also used to compare with different satellites. Only measurements which is no more than one hour apart in the area 70.0 degrees to 89.9 degrees latitude and -189.9 degrees to 189.9 degrees longitude are compared. The maximum distance between two measurements for comparison are 0.01 degrees in both latitude and longitude. The brightness temperatures are compared directly and the differences are together with the brightness temperatures written in a file.

Five days comparison

The differences for the entire period (December 8 – 12) are collected and plotted in different ways. For the low frequencies, 19.35 GHz to 37.0 GHz, there are 186 points in the comparison. For the high frequency 91.655 GHz and 85.5 GHz there are 68 points in the comparison. The SSMIS frequency 91.655 GHz are compared to the SSM/I frequency 85.5 GHz. Here larger errors can be expected since the different frequencies are influenced in different ways by the atmosphere. The sea ice coverage retrieval with the 91.655 GHz signal are strongly influenced by the liquid water path (LWP) at high latitudes. (Laue et al., 2007)

The results of the comparison are presented in various ways. In Figure 1 the brightness temperatures are plotted against each other. The plots should then be a straight line if the SSMIS and the SSM/I were measuring exactly the same.

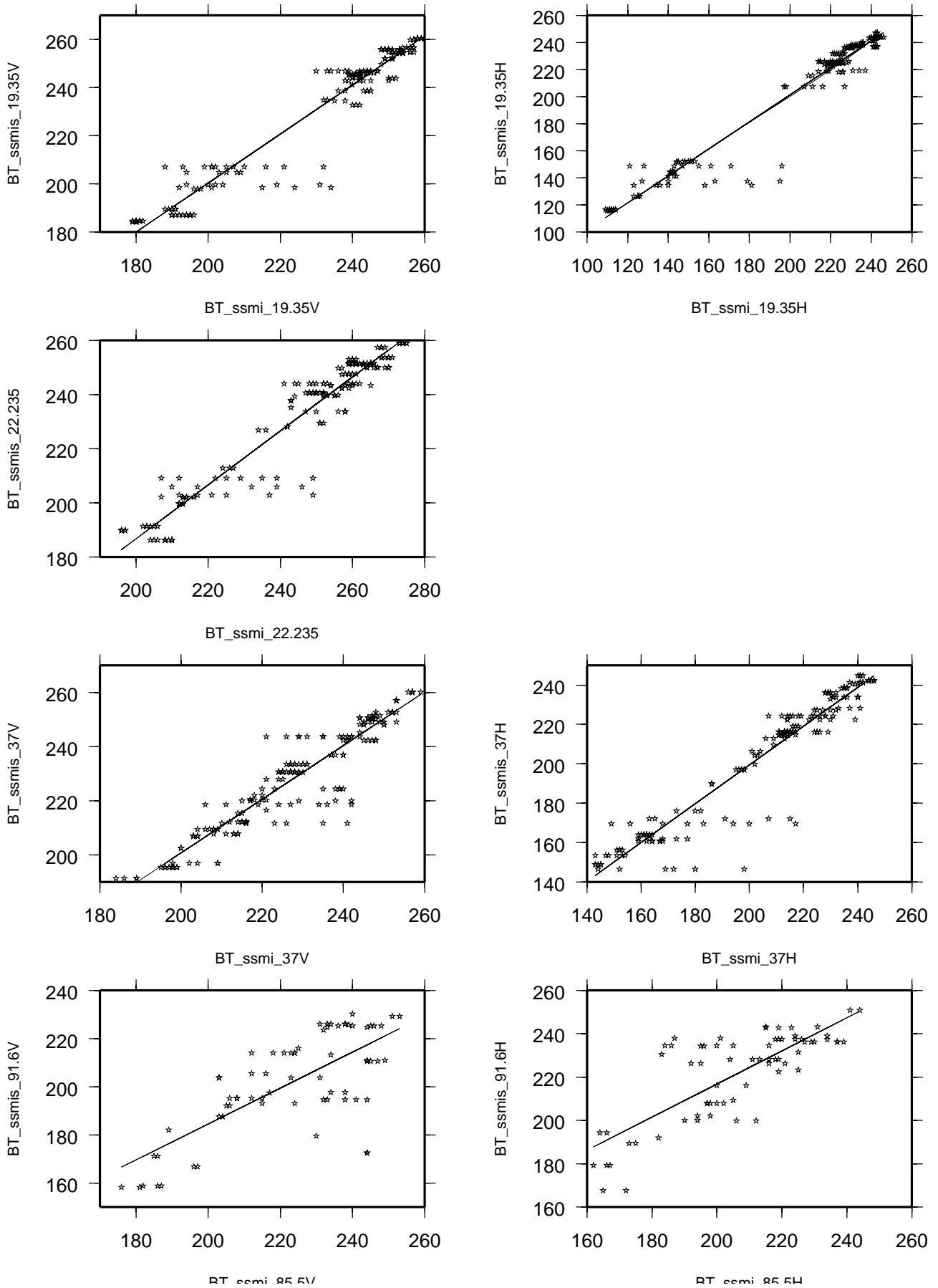


Figure 1 The brightness temperatures of the different frequencies, SSMIS vs. SSM/I. The straight line is the best fit.

The brightness temperatures are for the entire period and only points that are within the criteria specified in the previous section are plotted. From these figures it is obvious that the 91.655 GHz SSMIS channel can not be directly compared to the 85.5 GHz SSM/I channel. This is however not investigated further in this report. In Table 3 the slope of the straight lines of Figure 1 is listed. This indicates the correlation of the data.

19.35V	19.35H	22.235V	37.0V	37.0H	85.5V- 91.655V	85.5H- 91.655H
1,018	0.9978	0.9964	0.9917	0.9841	0.7467	0.7631

Table 3 The slope of the lines of figure 1.

The differences between the brightness temperatures are plotted in Figure 2 - 5. The plots shows differences in the entire period over the Arctic.

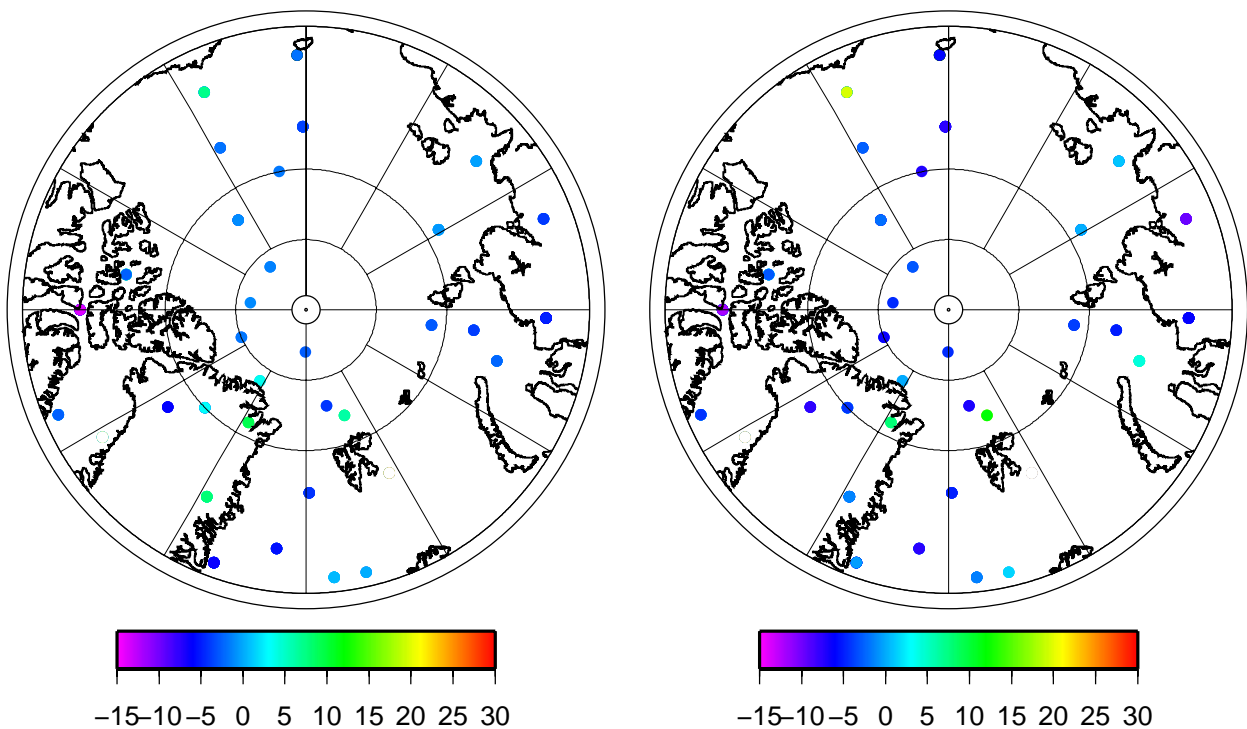


Figure 2 Differences between brightness temperatures of SSM/I and SSMIS for frequency 19.35 GHz. The vertical polarisation is to the left and the horizontal polarisation is to the right

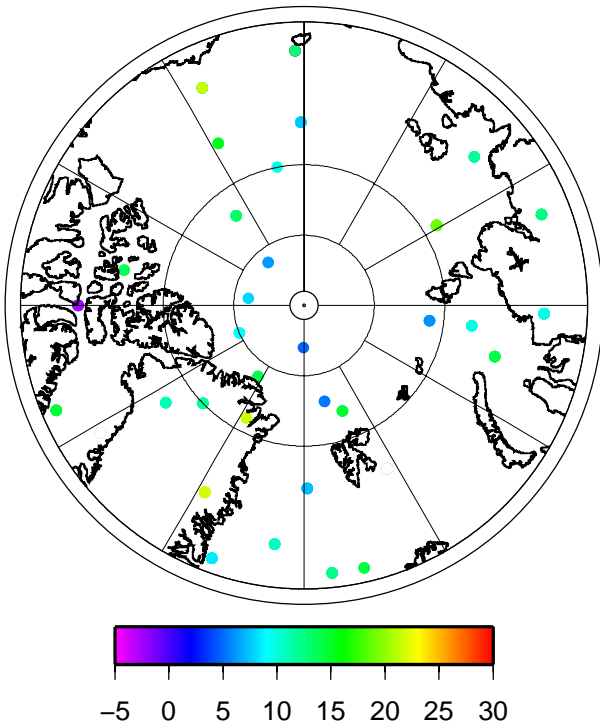


Figure 3 Differences between brightness temperatures of SSM/I and SSMIS for frequency 22.235 GHz vertical polarisation.

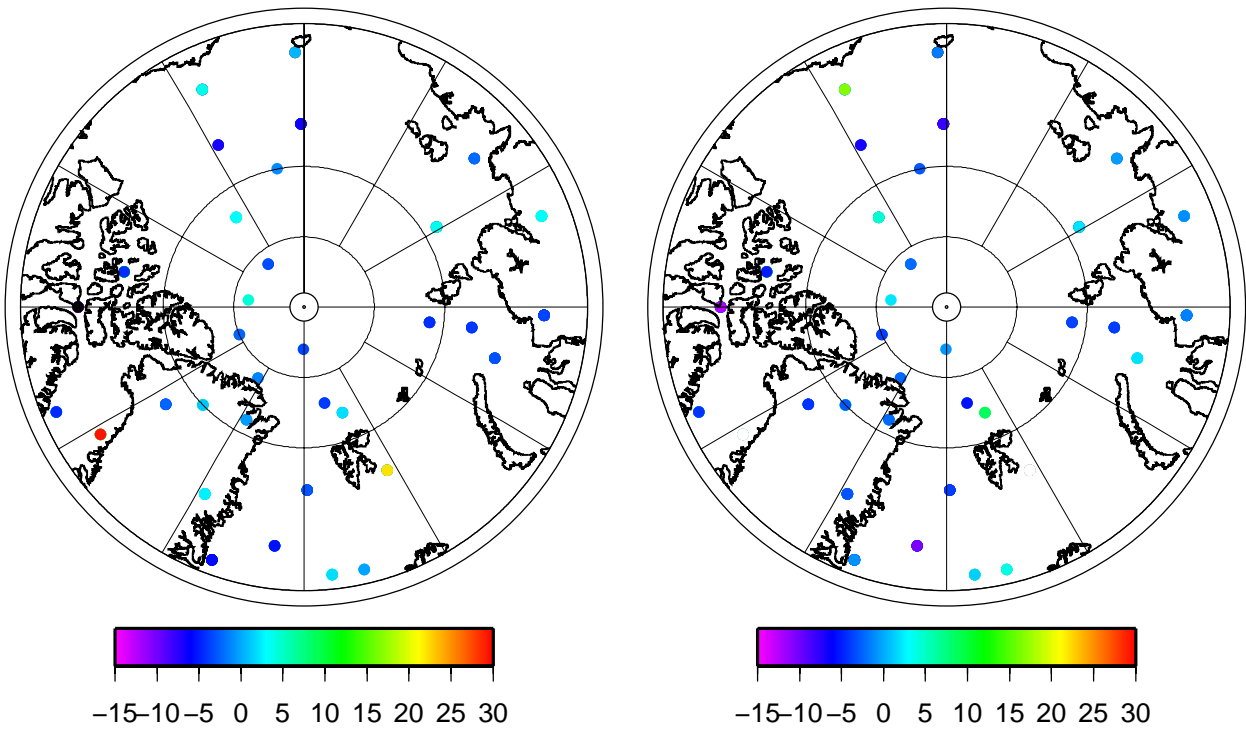


Figure 4 Differences between brightness temperatures of SSM/I and SSMIS for frequency 37.0 GHz. The vertical polarisation is to the left and the horizontal polarisation is to the right

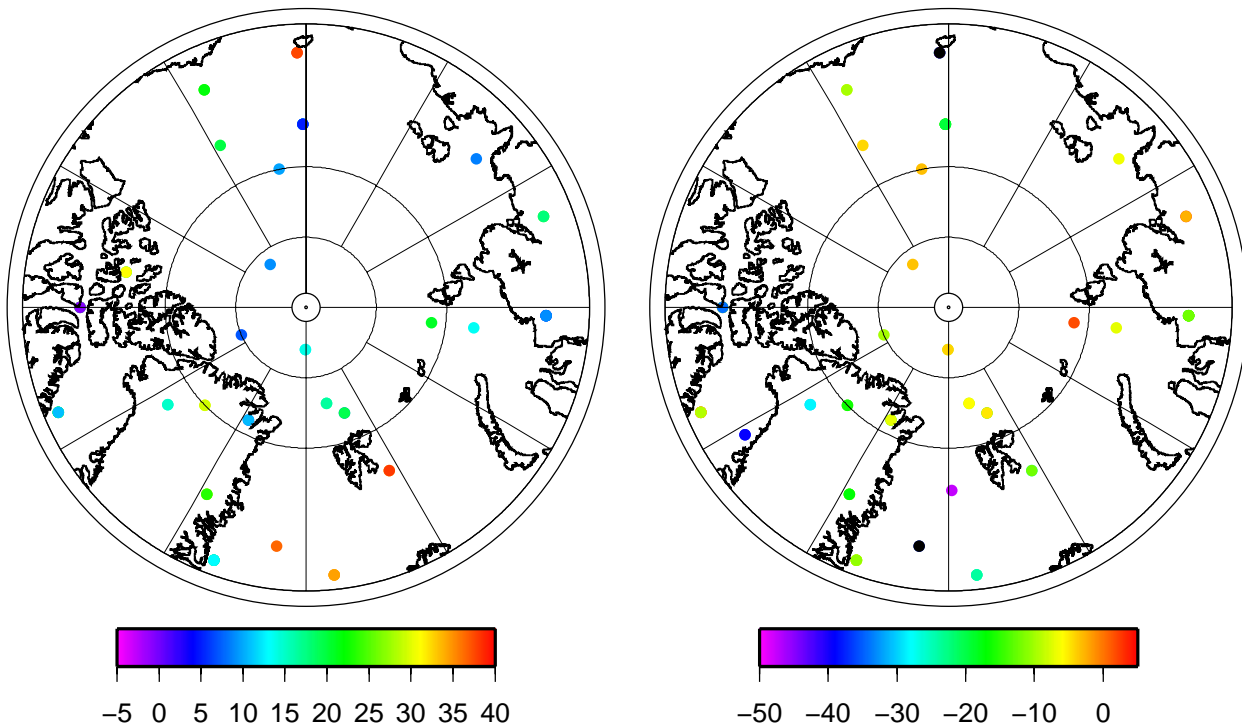


Figure 5 Differences between brightness temperatures of SSM/I and SSMIS for frequency 85.5 GHz and 91.655 GHz respectively. The vertical polarisation is to the left and the horizontal polarisation is to the right

The mean and standard deviation of the differences of the different channels and polarisations are listed in Table 4.

Channels to compare (SSM/I-SSMIS)	Mean	St. dev.	Max difference	Min difference
19.35H-19.35H	-1.00	9.58	-27.81	57.56
19.35V-19.35V	-0.63	6.63	-18.99	35.46
22.235V-22.235V	13.04	14.81	-2.95	46.19
37.0H-37.0H	0.76	9.45	-20.6	51.45
37.0V-37.0V	-0.33	6.65	-22.68	29.33
85.5H-91.655H	-15.03	20.45	-50.90	12.14
85.5V-91.655V	20.72	25.85	-2.01	71.54

Table 4 Comparison of brightness temperatures from SSM/I and SSMIS with mean and standard deviation of the differences together with the minimum and maximum value of the comparison.

Single day comparison

For the period February 26 – 28 2008 the days are compared separately and for February 28 the SSMIS data are compared to SSM/I data from all three satellites F13, F14 and F15. The mean value and the standard deviation are listed in Table 5 and the minimum and maximum differences are listed in Table 6. On February 26 there are 56 points for the low frequencies and 18 points for the high frequency in the comparison. February 27 there are 41 points for the low frequencies and 15 for the high frequency. The comparison with SSM/I on satellite F14 are not used since only one point was within the criteria's. In the comparison with SSM/I on satellite F13 there are 26 points for the low frequencies and 6 points for the high frequency and for satellite F15 there are 39 points for the low frequencies and 16 points for the high frequency.



SSMIS Frequency GHz	February 26		February 27		February 28 F13		February 28 F15	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
19.35 V	-3.21	4.92	-2.41	3.70	-1.19	2.22	-2.05	3.31
19.35 H	-4.86	6.75	-4.54	6.34	-3.58	4.34	-3.59	5.20
22.235V	1.14	4.00	2.24	4.48	1.12	2.25	2.68	4.27
37 V	-3.38	4.75	-2.32	9.29	-0.62	3.82	-0.38	8.59
37 H	-4.84	6.38	-2.88	10.46	-1.58	4.07	-1.35	10.10
91.655 V	21.83	32.03	15.40	17.39	18.83	20.90	17.75	21.75
91.655 H	-23.61	30.74	-2.13	5.90	-0.33	4.86	-9.13	17.70

Table 5 Mean and standard deviations for comparisons of single day SSMIS and SSM/I data.

SSMIS Frequency GHz	February 26		February 27		February 28 F13		February 28 F15	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
19.35 V	-17.24	8.79	-11.42	2.58	-5.23	2.68	-8.54	5.88
19.35 H	-24.88	7.48	-16.59	2.41	-8.77	1.23	-12.78	10.68
22.235V	-14.15	13.3	-9.08	10.56	-2.80	5.76	-2.94	15.72
37 V	-14.63	5.42	-29.0	12.49	-7.60	7.10	-13.35	35.63
37 H	-19.18	6.24	-33.05	10.74	-8.57	6.43	-14.86	42.64
91.655 V	-8.48	59.52	4.79	28.09	15.71	23.76	8.37	48.88
91.655 H	-57.63	0.5	-10.62	8.06	-7.02	8.42	-515.46	0.46

Table 6 Min and max differences for comparisons of single day SSMIS and SSM/I data.

Selected frequencies are plotted in Figure 6-8. The first 2 figures show the brightness temperatures and the last figure indicate the differences. The high frequencies are not plotted due to very few points in the analysis. It is clear from Table 5 and 6 that these frequencies can not be compared directly.

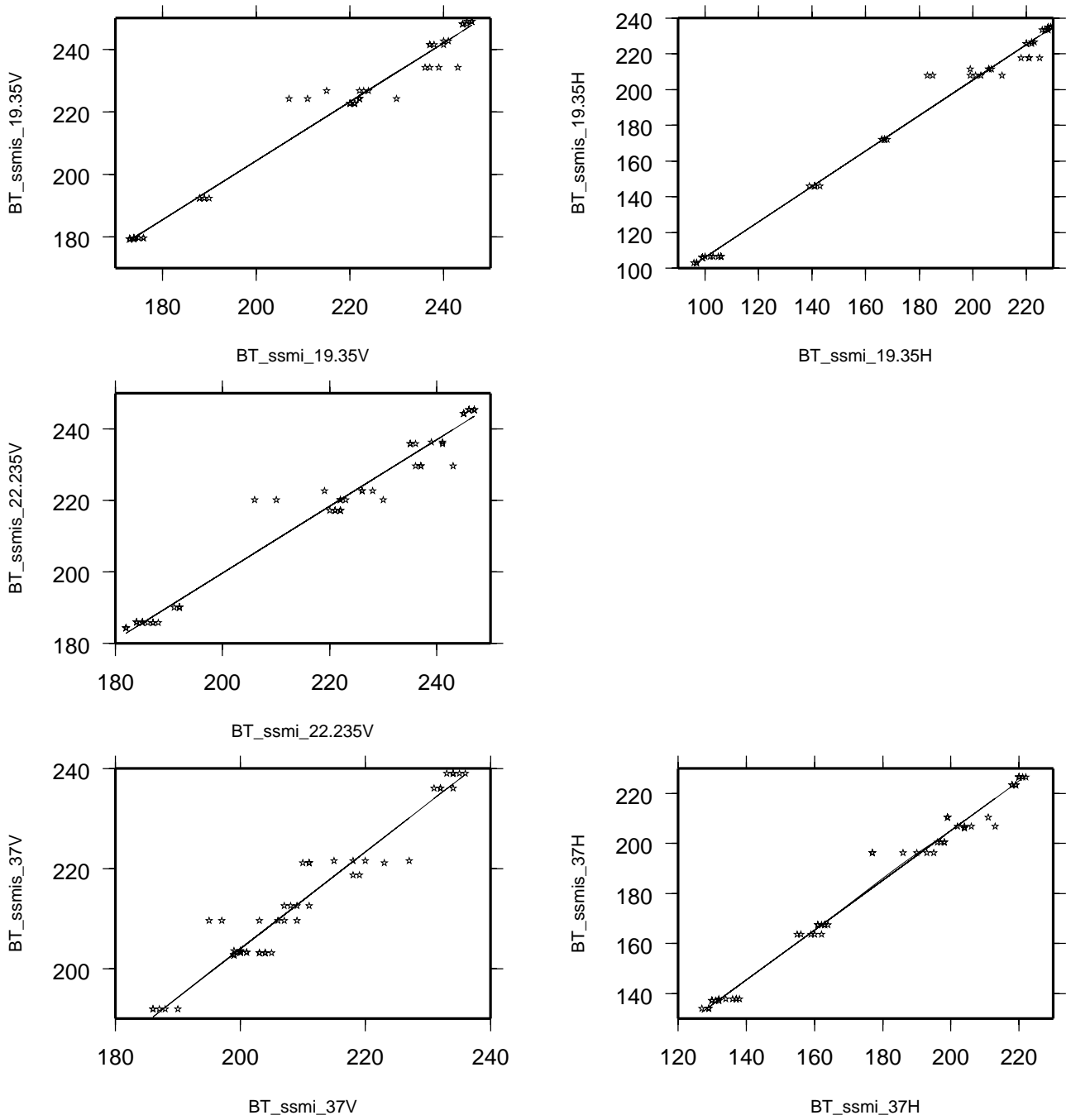


Figure 6 The brightness temperatures of the different frequencies, SSMIS vs. SSM/I. The straight line is the best fit. The data are from February 26 2008

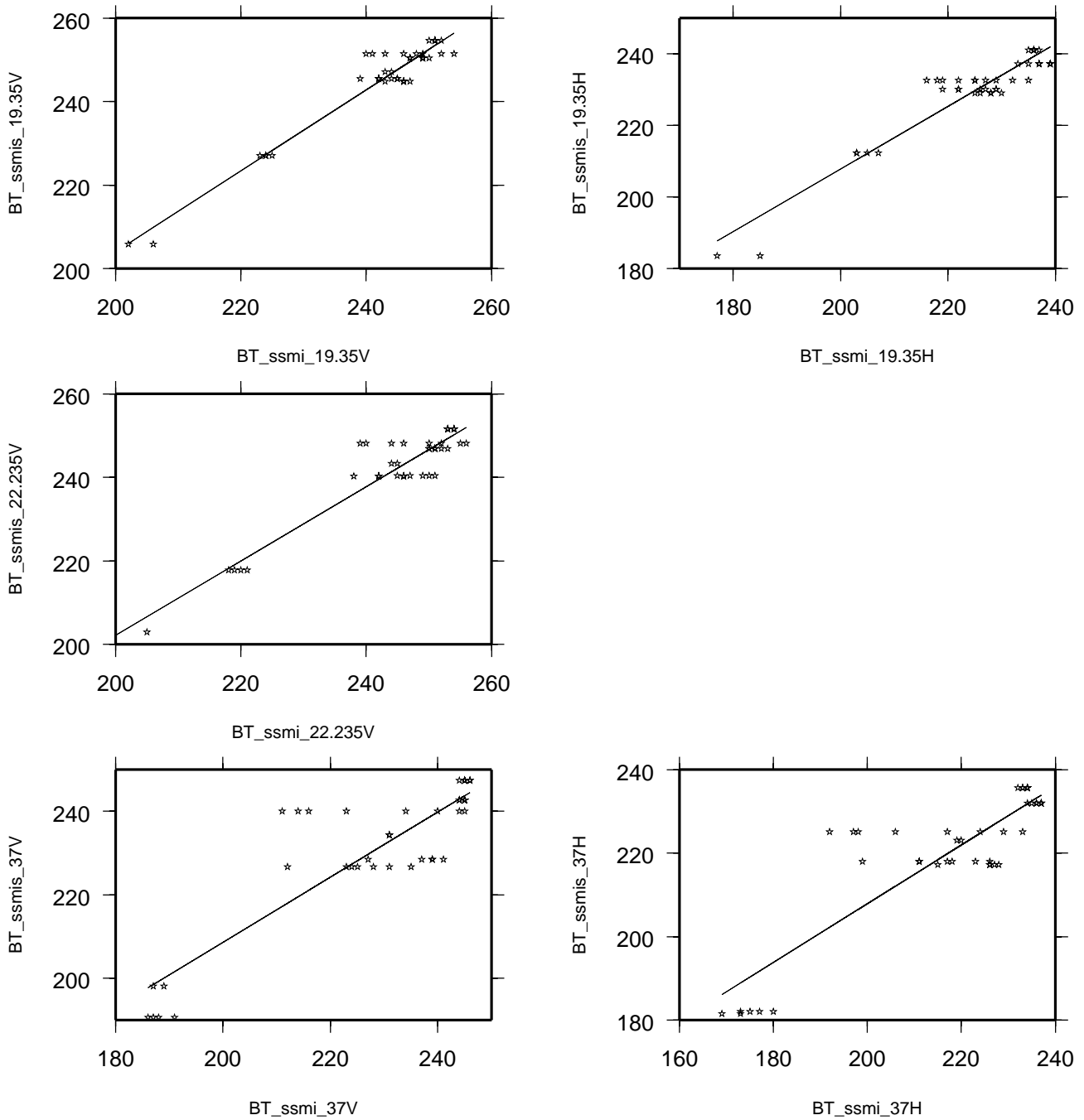


Figure 7 The brightness temperatures of the different frequencies, SSMIS vs. SSM/I. The straight line is the best fit. The data are from February 27 2008

Figure 6 and 7 shows that there are large differences both from day to day and channel to channel on how well the data fits. The slopes are listed in Table 7. Also the slopes of the comparisons on February 28 are listed.

Date	19.35V	19.35H	22.235V	37.0V	37.0H
Feb. 26	0.9428	0.9929	0.9337	0.9690	0.9943
Feb. 27	0.9679	0.8740	0.8898	0.7800	0.7032
Feb. 28 F13	0.8963	0.9297	0.9019	0.8864	0.8957
Feb. 28 F15	0.9388	0.9588	0.9085	0.7949	0.8323

Table 7 The slope of the lines of Figure 6 - 7 and for the same comparison for February 28 for satellite F13 and F15

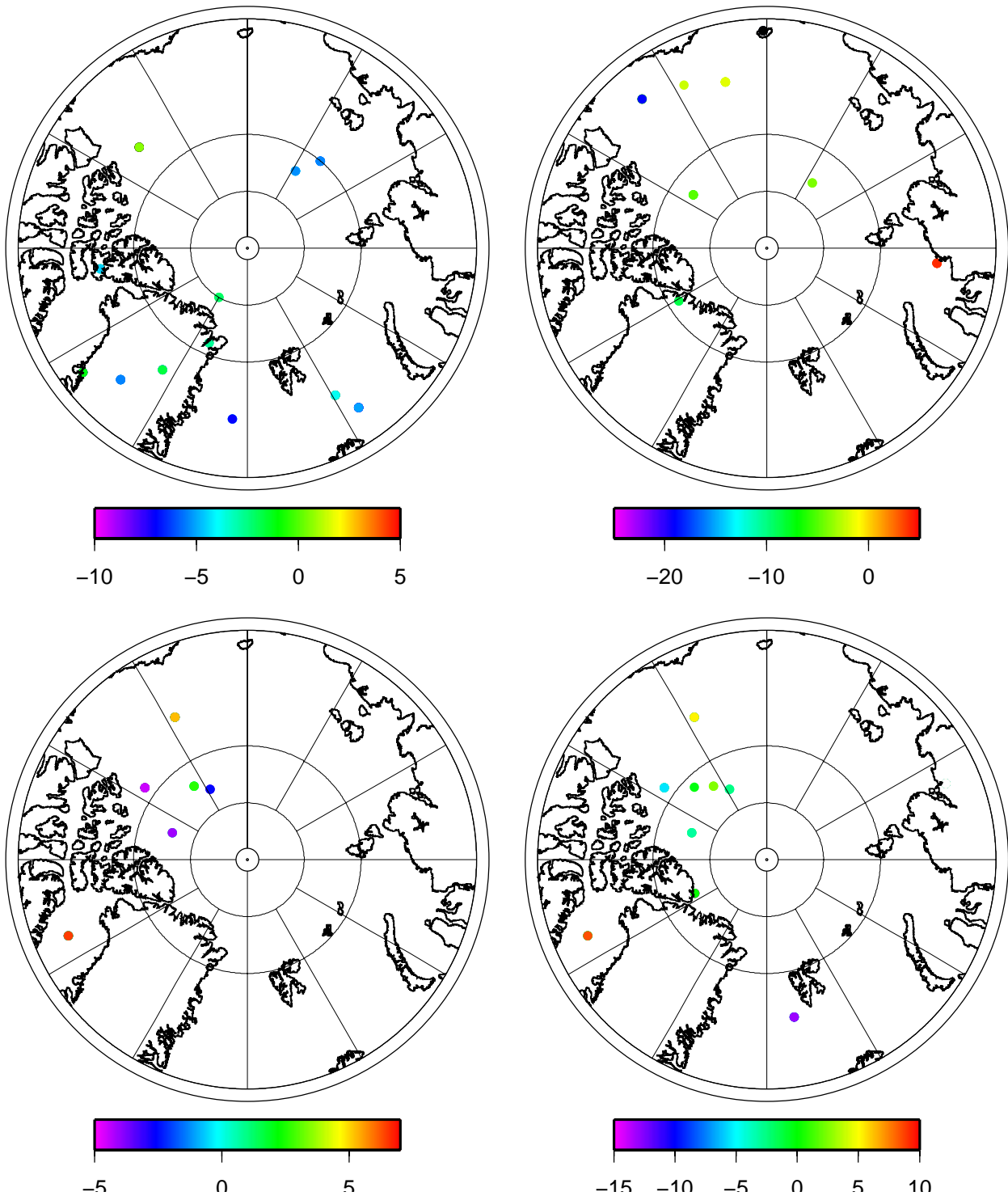


Figure 8 Differences between brightness temperatures of SSM/I and SSMIS for frequency 37.0 GHz horizontal polarisation. The top left are data from February 26 and the top right are data from February 27. The bottom left are data from satellite F13 on February 28 and the bottom right are data from satellite F15 on February 28.

The Result

From the comparison it is obvious that the high frequencies of SSMIS and SSM/I can not be compared directly. For such a comparison to be made some calibration is necessary. Otherwise one should instead compare the end products for instance ice concentration. This could also be the next



step in the analysis of the SSMIS data.

Just as the SSM/I data some quality control is necessary with the SSMIS data. As it can be seen even from the few days in this report the quality of the SSMIS data are not stable. There are days with fewer data and days with much data.

This investigations have only looked at the raw data and not the final products. It is found that the data should be used in a test case and the quality of the final products should be investigated further. The data should properly be calibrated before use. At the same time some quality control of the raw data should be implemented to prevent days with no or little data to be part of the analysis.



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