Evaluation and Selection of Sites for Microwave Radiometer Calibration

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Outline

I. **Some Considerations about the CAL/VAL Sites Selection and Construction for Spaceborne Microwave Remote Sensors**

II. **Evaluation and Selection of Sites for Spaceborne Microwave Remote Radiometers**

I. Some Considerations about the CAL/VAL Sites Selection and Construction for Spaceborne Microwave Remote Sensors

1. Introduction
2. CAL/VAL site on land
3. CAL/VAL site on ocean

- **Some information provided by Dr. Hu YANG and Dr. Naimeng LU from NMSC/CMA, Dr. Weiguo ZHANG and Dr. Zhenzhan WAN from CSSAR.**

I.1 Introduction

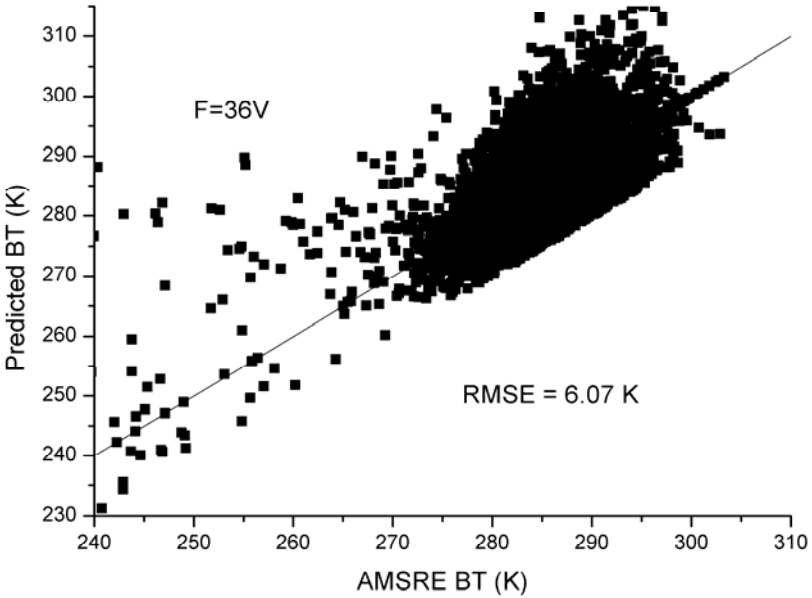
- As the implementation of earth observation program with microwave sensors, preparation for CAL/VAL sites selection and consideration had been started;
  - FY-3, HY-2, HJ-1C…
  - Some researches had been conducted since 2004:
    - Incorporation of CMA, NSOAS, CAS, and CAST.
  - Selection of land sites
  - Selection of ocean sites

I.2 CAL/VAL sites on land

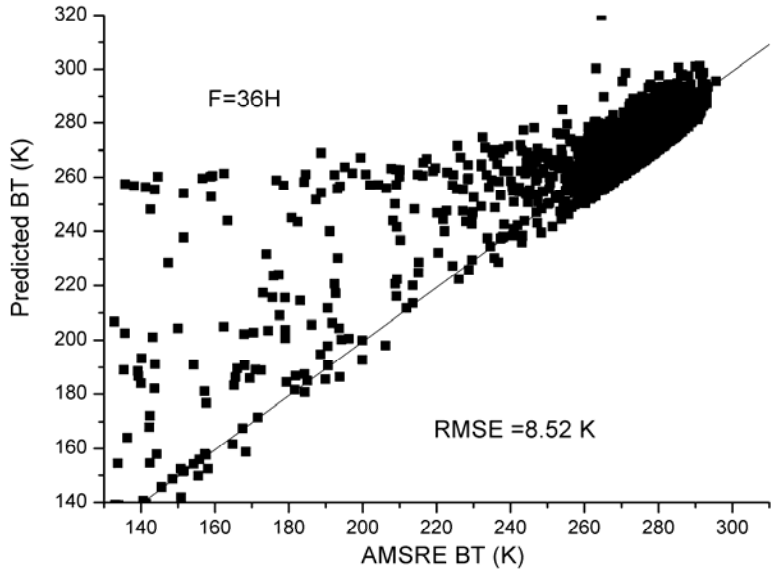
- **Takelimgan Desert**
- **DUNHUANG Gobi**
- **Amazon Forest**

Takelimgan Desert

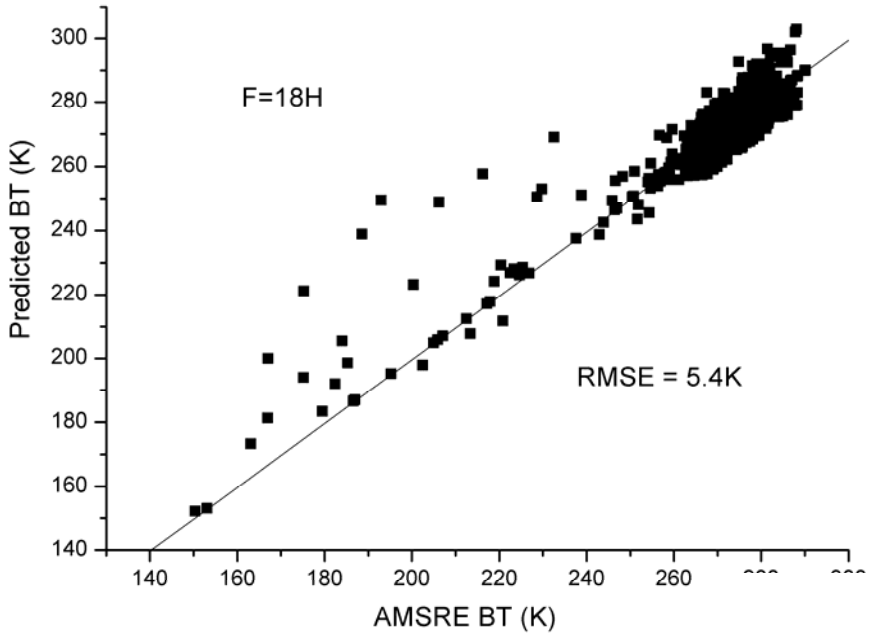
Location: lat = [40.5 39.0]; lon = [81.5 87.5];

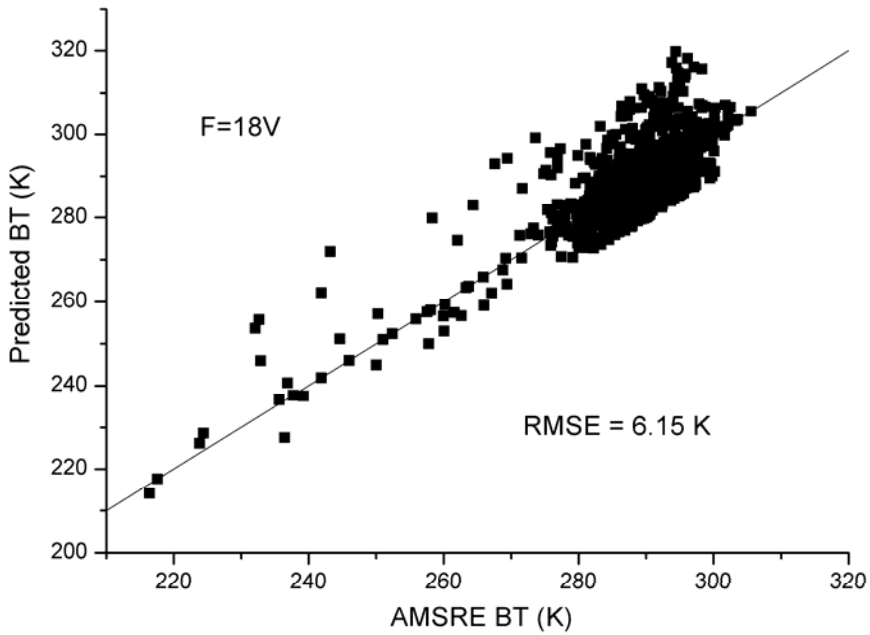

F=36V
RMSE = 6.07 K
Predicted BT (K)
AMSRE BT (K)
310
300
290
280
270
260
250
240
230
240
250
260
270
280
290
300
310

36GHz

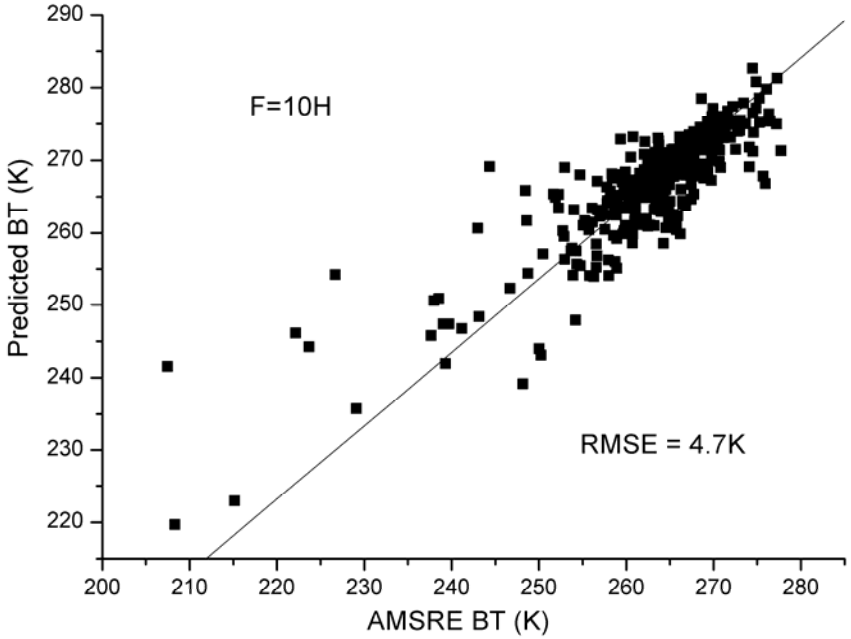

F=36H
RMSE =8.52 K
Predicted BT (K)
AMSRE BT (K)
320
300
280
260
240
220
200
180
160
140
140
160
180
200
220
240
260
280
300

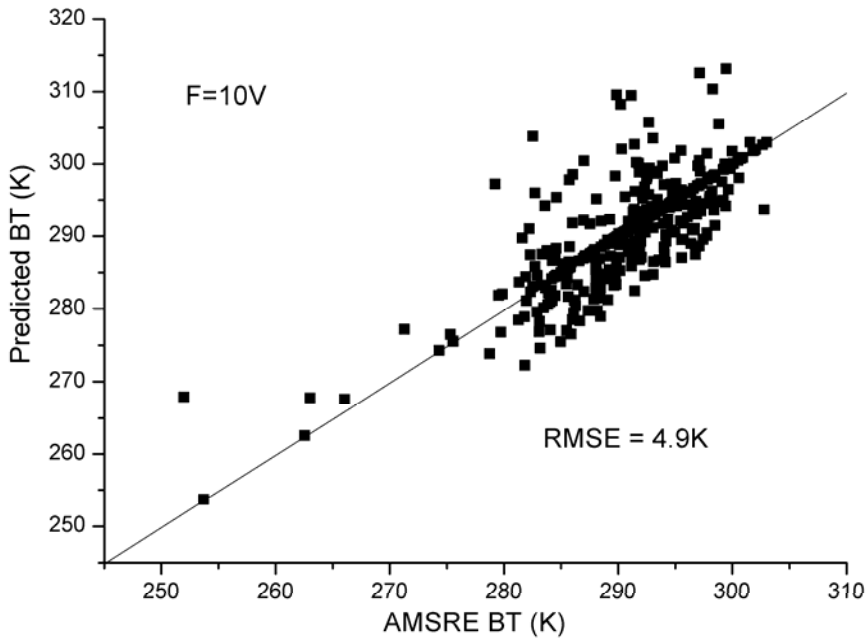
18GHz


F=18H
RMSE = 5.4K
Predicted BT (K)
AMSRE BT (K)
300
280
260
240
220
200
180
160
140
140
160
180
200
220
240
260

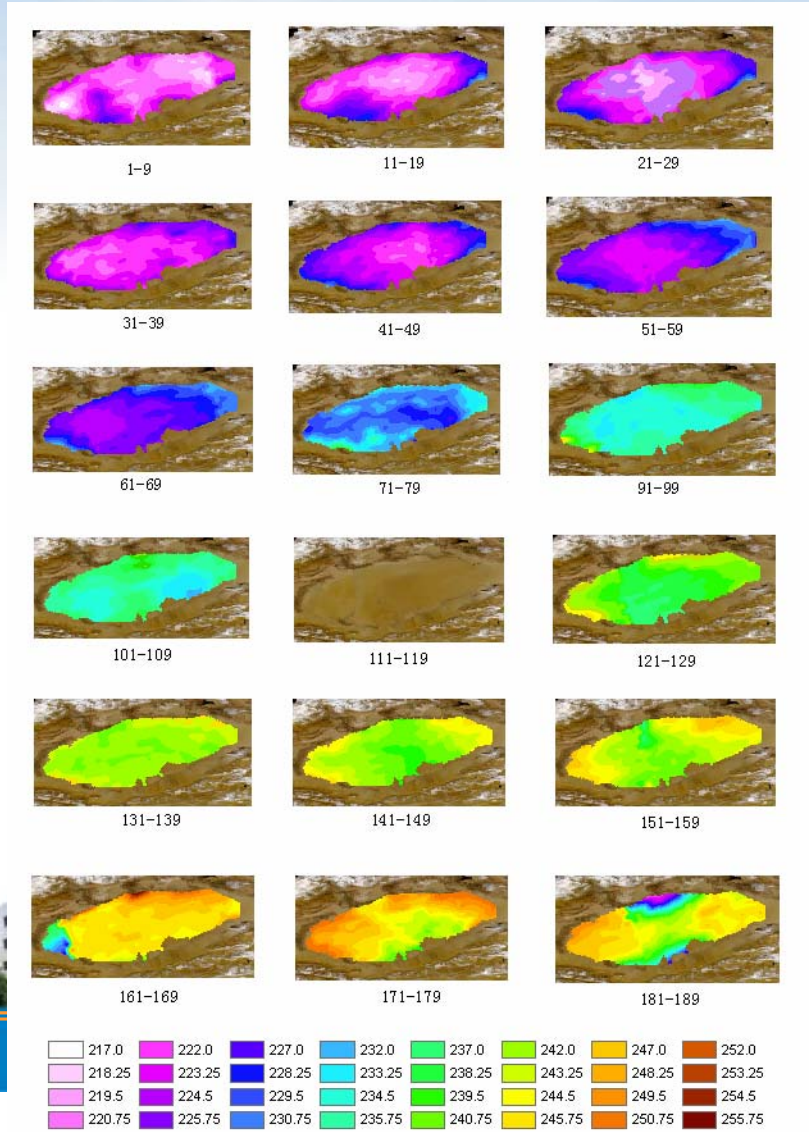

F=18V
RMSE = 6.15 K
Predicted BT (K)
AMSRE BT (K)
320
300
280
260
240
220
200
220
240
260
280
300
320

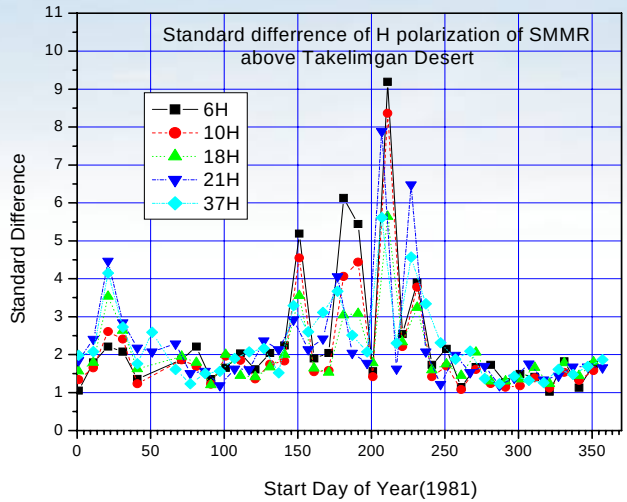
10GHz

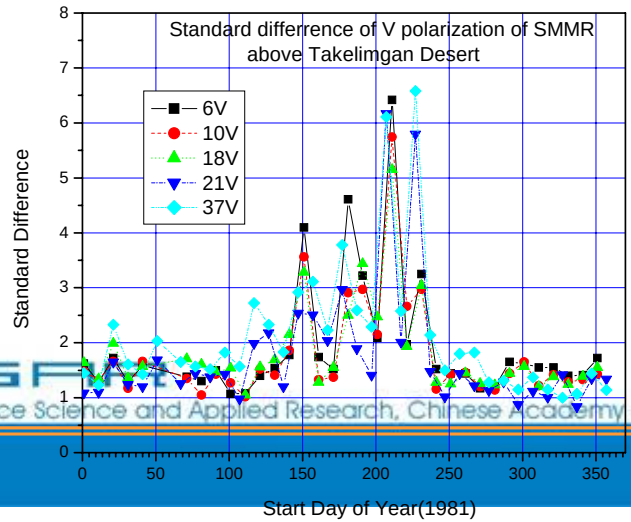

F=10H
RMSE = 4.7K
Predicted BT (K)
AMSRE BT (K)
290
280
270
260
250
240
230
220
200
210
220
230
240
250
260
270
280


F=10V
RMSE = 4.9K
Predicted BT (K)
AMSRE BT (K)
320
310
300
290
280
270
260
250
250
260
270
280
290
300
310

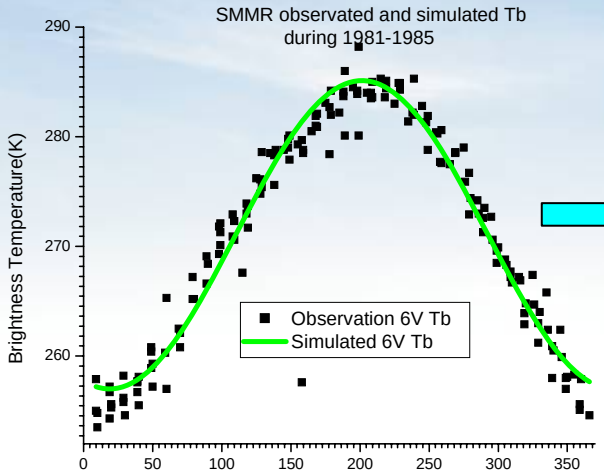
Radiometric data for homogenous

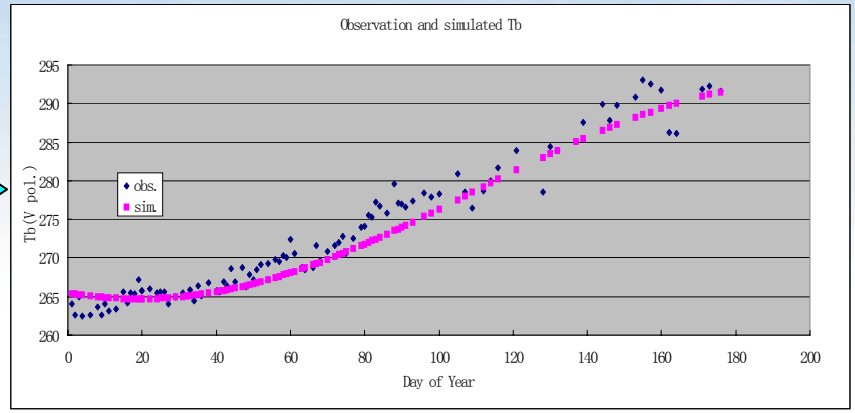






Radiometric data for stability

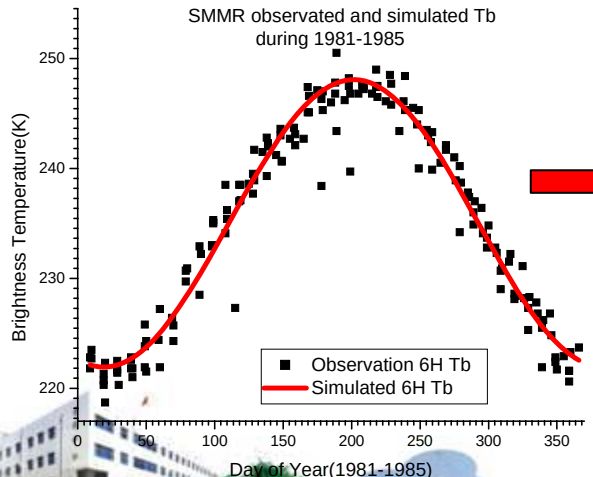


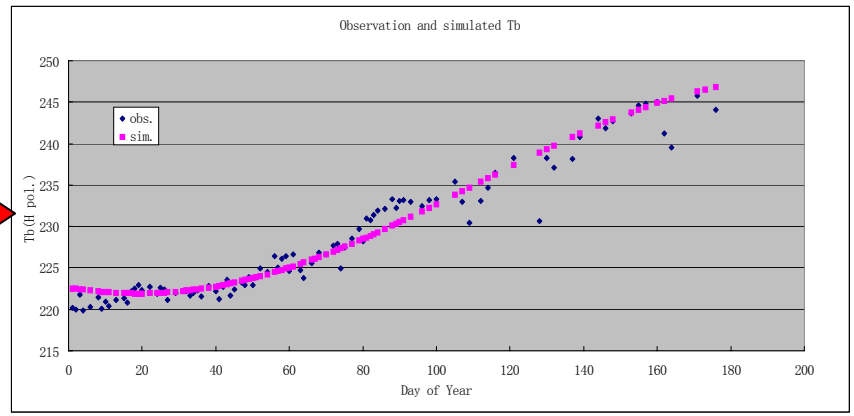


V pol.

SEE: 1.89K.

A constant bias





The simulation parameters got from SMMR is used for AMSR-E.

No ancillary data used in this simulation. It illustrate radiometric stability in climate scale, even freq, spatial resolution, incidence angle are different between the two sensors.

H pol.

SEE: 1.74K.

No bias

AMSR-E:2003 Jan.-Jun.
(Descending Orbit)

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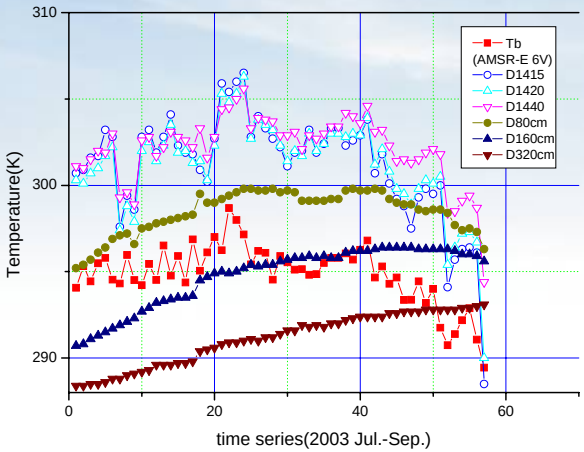
SMMR:1981-1985

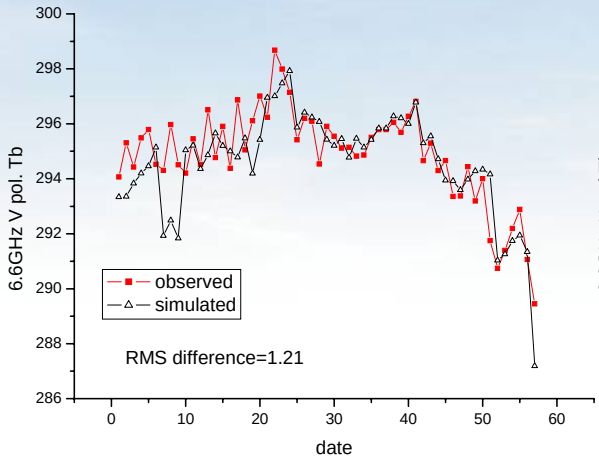
Radiometric data for predictability



AMSR-E Tb 6V channel and soil temperature in different depth (14:00, Jun.-Sep.,2003.)

Similar trend (Tb<>15,20,40cm).

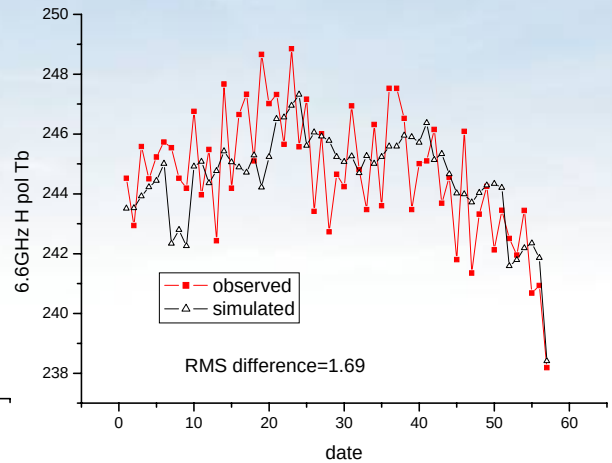
Deeper soil temperature is stable



Model simulation of AMSR-E 6V channel. SEE=1.21. (Ascending Orbit, Jun.-Sep.,2003, rainy day excluded)

Constant soil moisture profile used.

Using the same roughness parameters for all data.



Model simulation of AMSR-E 6H channel. SEE=1.69. (Ascending Orbit, Jun.-Sep.,2003 , rainy day excluded)

Constant soil moisture profile used.

Using the same roughness parameters for all data.

Tb in Summer fluctuate much bigger than Winter. But can be simulated with rather good accuracy (below 2K) by using only one point measurements of soil temperature.

Modle simulation illustrates the key points. Multiple layered RT used. Q-H method for roughness.

Soil temperature profile is the determine factor, especially for V channel.

Wind-induced roughness play an important role in H channel simulation.

Dunhuang

Location: lat = [40.5 39.0];lon = [94.10 94.50];

DUNHUANG Gobi, Gansu Province

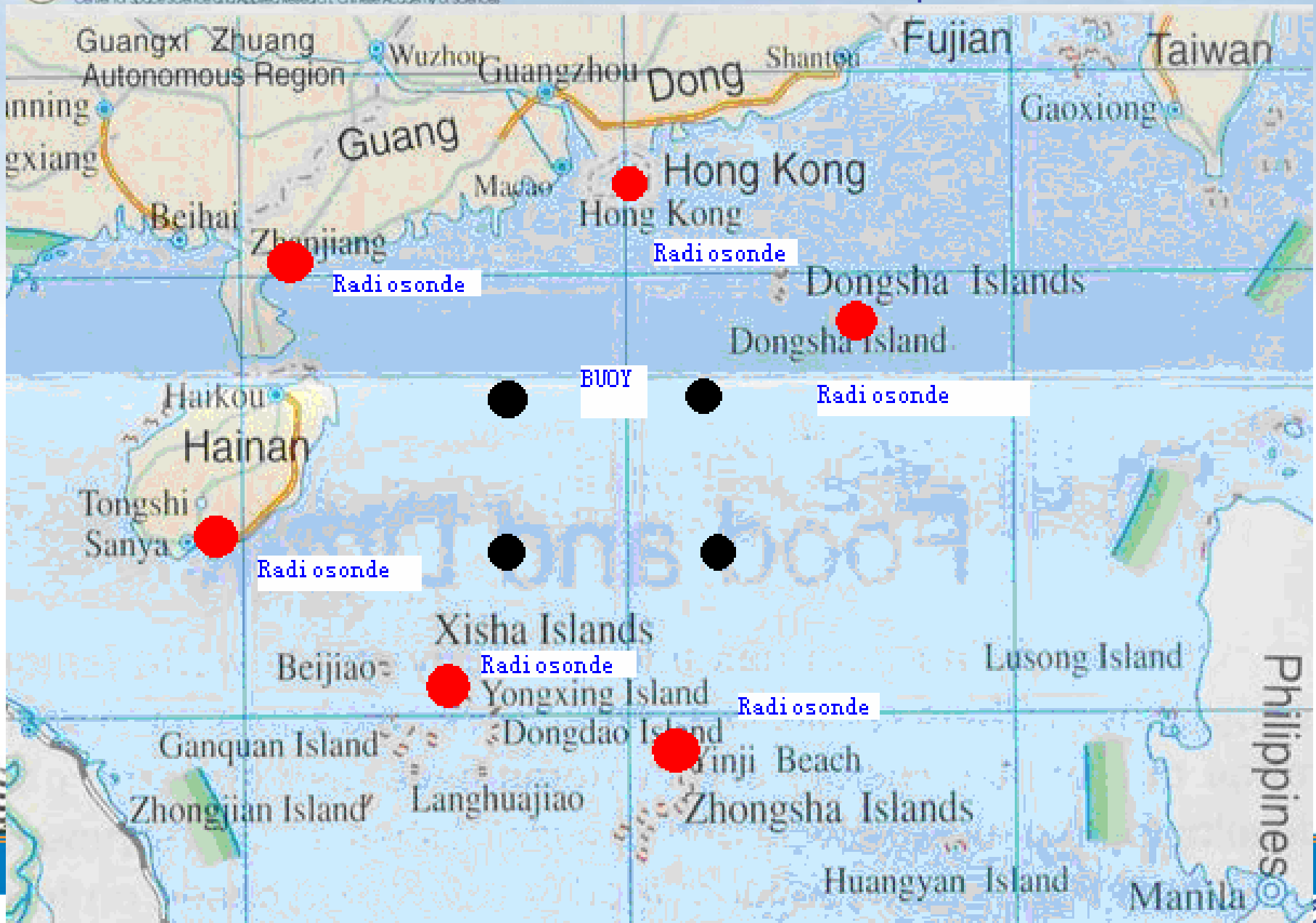
Amazon Forest

- Surface temperature： AQUA-MODIS 5km Average
- Atmospheric humidity/temperature contour： Ground based sounding
- Surface Emissivity:

	V	H
6.9	0.945	0.94
10.65	0.945	0.94
18.7	0.972	0.968
23.8	0.973	0.968
36.5	0.975	0.972
89	0.995	0.992

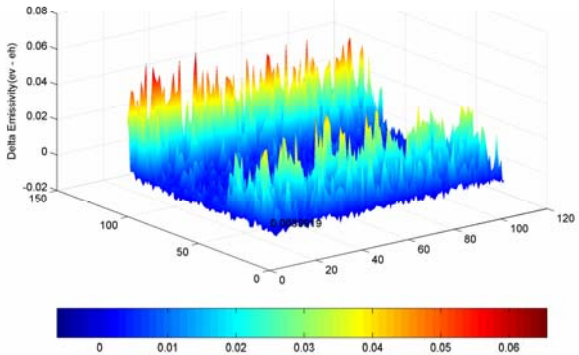
亚马逊雨林			
	AMSR-E	Model	Difference
6.9V	285.411115±1.608604	285.123403	0.3 K
6.9H	283.357386±1.625158	283.665398	0.3 K
10.65V	285.343014±1.947834	284.843070	0.5 K
10.65H	284.071985±1.915811	283.407728	0.6 K
18.7V	287.536144±2.434447	285.072228	2.5 K
18.7H	286.675587±2.383163	285.072228	1.6 K
23.8V	286.850273±2.242346	277.265319	9.6 K
23.8H	285.906056±2.260358	276.512027	9.4 K
36.5V	285.557617±2.053853	285.936082	0.4 K
36.5H	284.855963±2.028471	285.283601	0.4 K
89V	288.112784±2.762917	273.991405	14.2 K
89H	287.854924±2.717796	273.717398	14.1 K

I.3 CAL/VAL sites on ocean

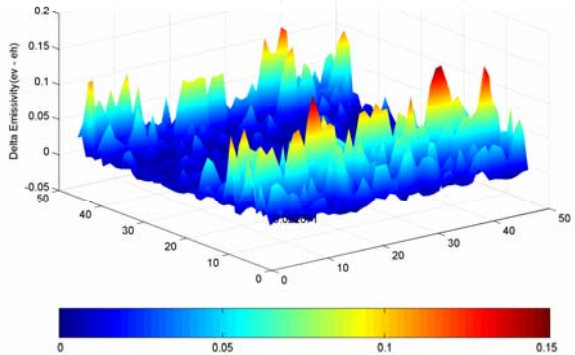

Guangxi Zhuang
Autonomous Region
Wuzhou
Guangzhou
Dong
Shantou
Fujian
Taiwan
Guang
Gaoxiong
Hong Kong
Macao
Hong Kong
Beihai
Zhanjiang
Radiosonde
Radiosonde
Dongsha Islands
Dongsha Island
BUOY
Radiosonde
Haikou
Hainan
Tongshi
Sanya
Radiosonde
Xisha Islands
Beijiao
Radiosonde
Yongxing Island
Radiosonde
Lusong Island
Ganquan Island
Dongdao Island
Yinji Beach
Zhongjian Island
Langhuajiao
Zhongsha Islands
Huangyan Island
Manila
Philippines

Polarization difference for the emissivity with different frequencies—south China Sea Area

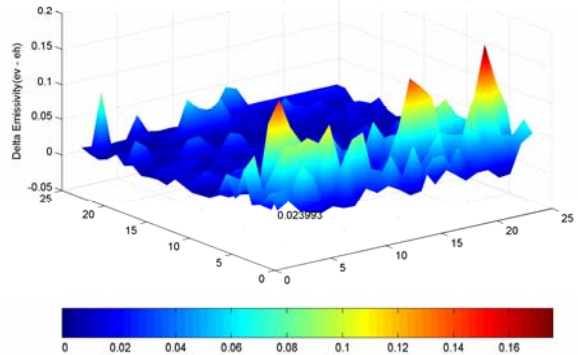
89GHz



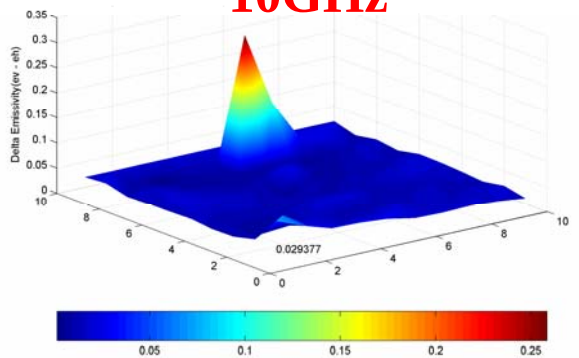
36GHz



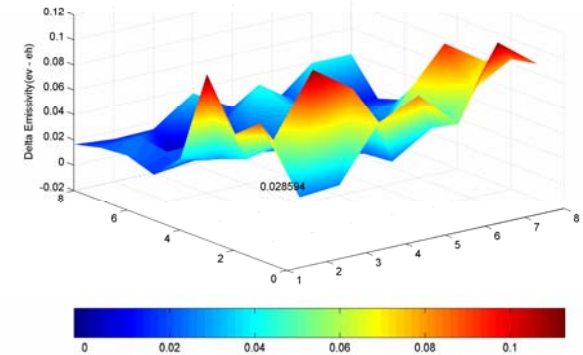
18GHz



10GHz



6GHz



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Comparison between calculated value and AMSR-E data

- Time: March, 2003
- Location: South China Sea: N[15,20]E[112,120]
- Data source: AMSR-E & NCEP data
- Time mismatch: 0.1hr
- Spatial mismatch: <0.5° for both latitude and longitude
- Data amount: 210745 after rain region removal
- Simulation model：Combination of FASTEM3 and MPM93 atmospheric absorbing model

Result

6.9V	−4.75581	1.229678	4.912212
6.9H	−2.90498	1.779265	3.406564
10.7V	−4.13117	1.077674	4.269415
10.7H	−2.73635	1.627501	3.183763
18.7V	−3.0754	1.454928	3.402193
18.7H	−3.15327	2.722991	4.166262
23.8V	−2.83885	2.167852	3.571923
23.8H	−3.82304	3.999207	5.532557
36.5V	−3.03224	1.664554	3.459077
36.5H	−2.72184	3.367499	4.329944
89.0V	−0.01913	1.800704	1.800801
89.0H	0.008952	4.471452	4.471451

II. Evaluation and Selection of Sites for Spaceborne Microwave Remote Radiometers

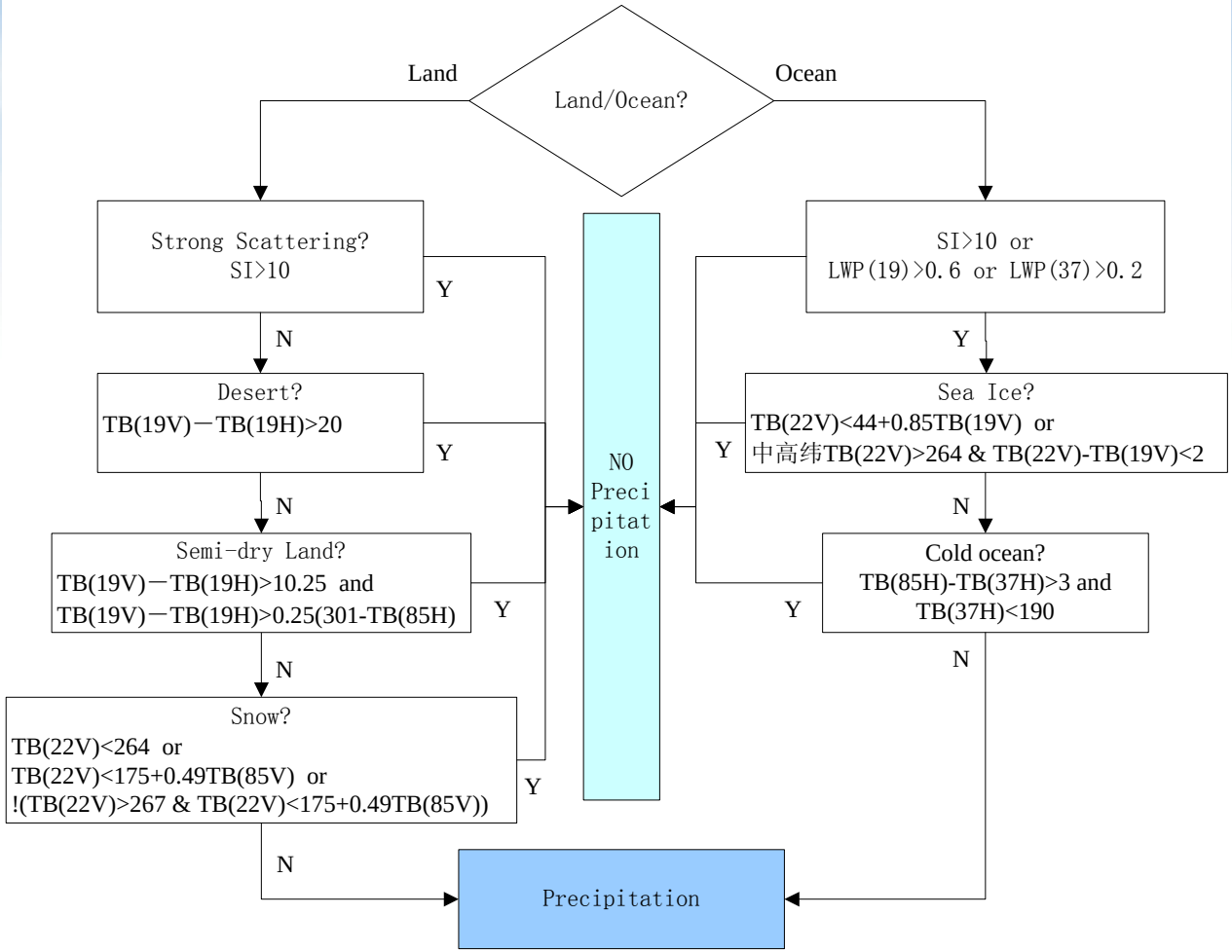
(Data and analysis provided by Dr. Nameng Lu from NMSC)

CSSAR
Center for Space Science and Applied Research, Chinese Academy of Sciences

Stability of long-time series of SSMI data

- Data: May-Oct, 1996
- Removal of abnormal with strong scattering
  - Precipitation
  - Snow
  - Sea Ice
  - Wind speed above 10m/s

Precipitation identification



SI:

Land: SI= (-0.44 TB(19V) - 1.775 TB(22V) + 0.00574 TB(22V)2 + 451.88) - 85V**

Ocean: SI= (0.7152 TB(19V) + 2.4387 TB(22V) - 0.00504 TB(22V)2 - 174.38) - 85V**

LWP(19) = -2.70 [ln(290-19V) - 2.84 - 0.4 ln(290-22V)]

LWP(37) = -1.15 [ln(290-37V) - 2.99 - 0.32 ln(290-22V)]

Wind speed retrieval for CAL Site:

1. Removal of area with sea ice and precipitation;
2. Sea surface wind speed retrieval;
3. Precipitation flags forSSM/I-GSW.

$$SSW\_SSM/I = [D_0 D_1 D_2 D_3 D_4] \begin{bmatrix} 1 \\ T_B(19V) \\ T_B(22V) \\ T_B(37V) \\ T_B(37H) \end{bmatrix}$$

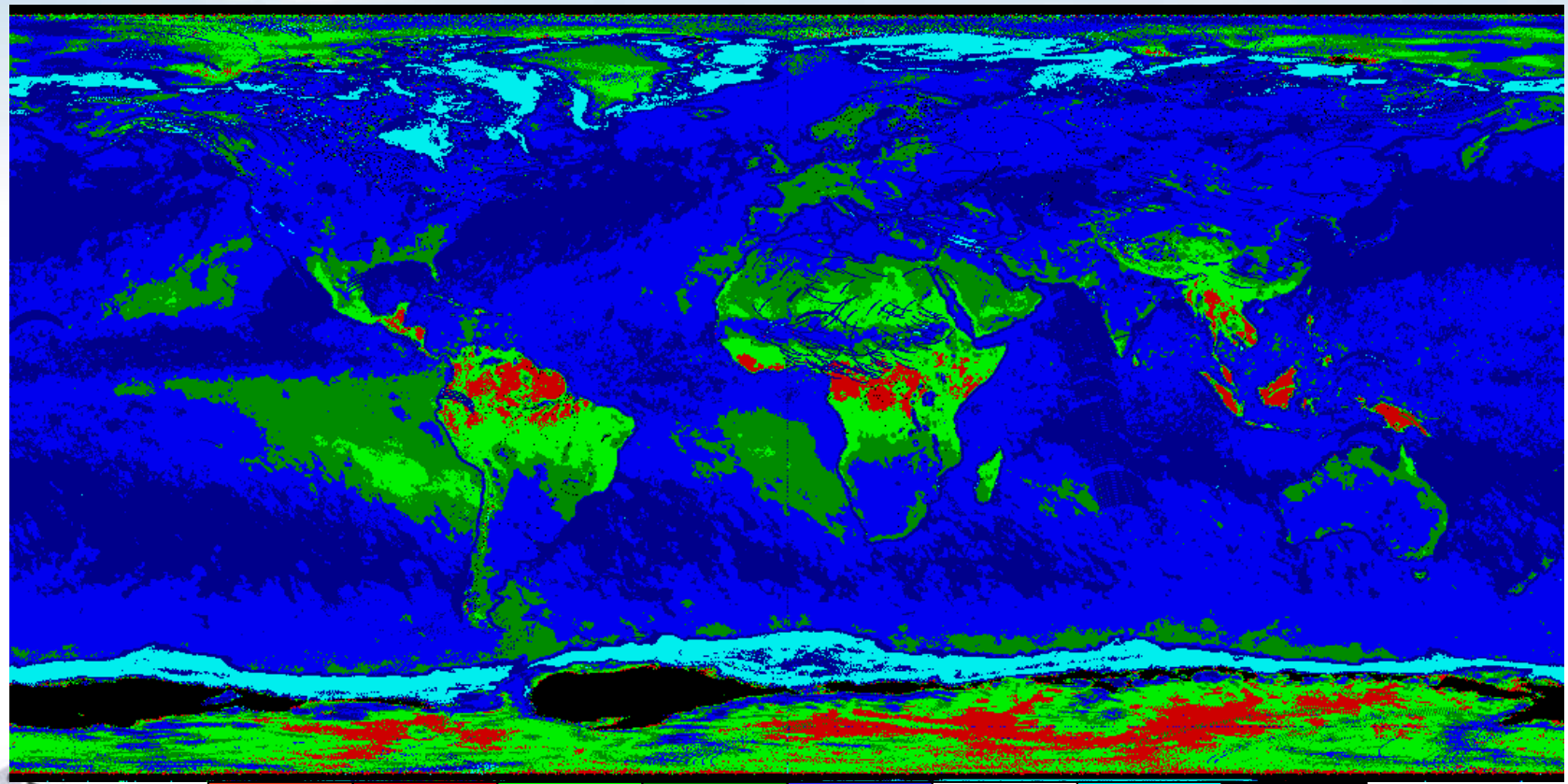
D_0 =147.90，D_1（19V）=1.0969，
D_2（22V）= -0.4555，D_3（37V）=-1.7600
D_4(37H)=0.7860

Precipitation flags for SSM/I-GSW

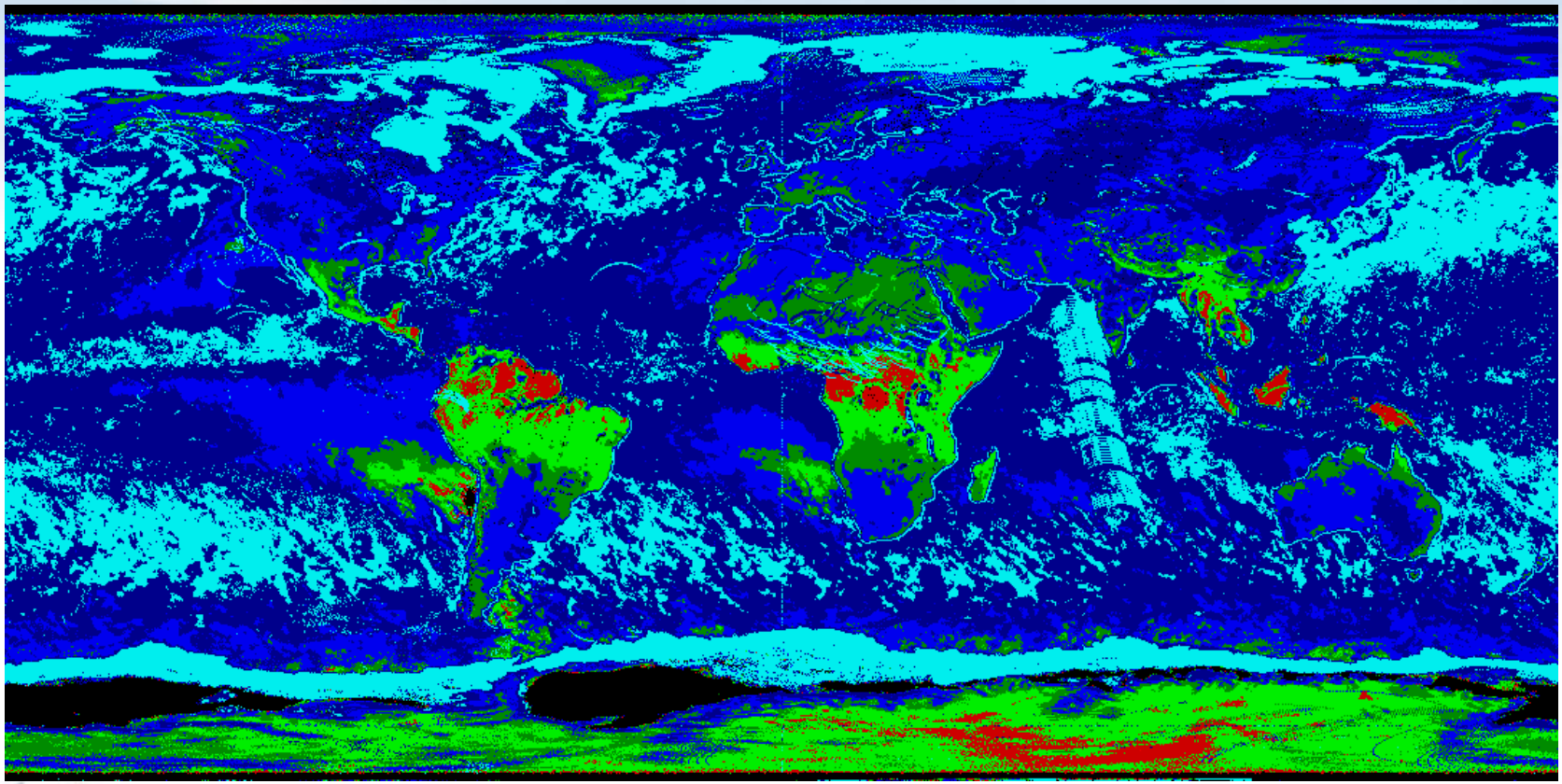
Rain Flag	Criteria	Accuracy
0	$T_B(37V)-T_B(37H) > 50$ T_B（19H）< 165	<2 m/s
1	$T_B(37V)-T_B(37H) < 50$ T_B（19H）> 165	2-5 m/s
2	$T_B(37V)-T_B(37H) < 37$	5-10 m/s
3	$T_B(37V)-T_B(37H) < 30$	>10 m/s

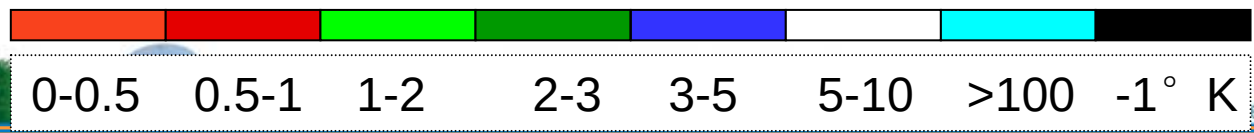
Standard Deviation of BT image from SSMI for five months (May-Oct, 1999)

standard deviation (STD) of BT from19V Channel: May-Oct (175days), 1999: -1K=invalid data

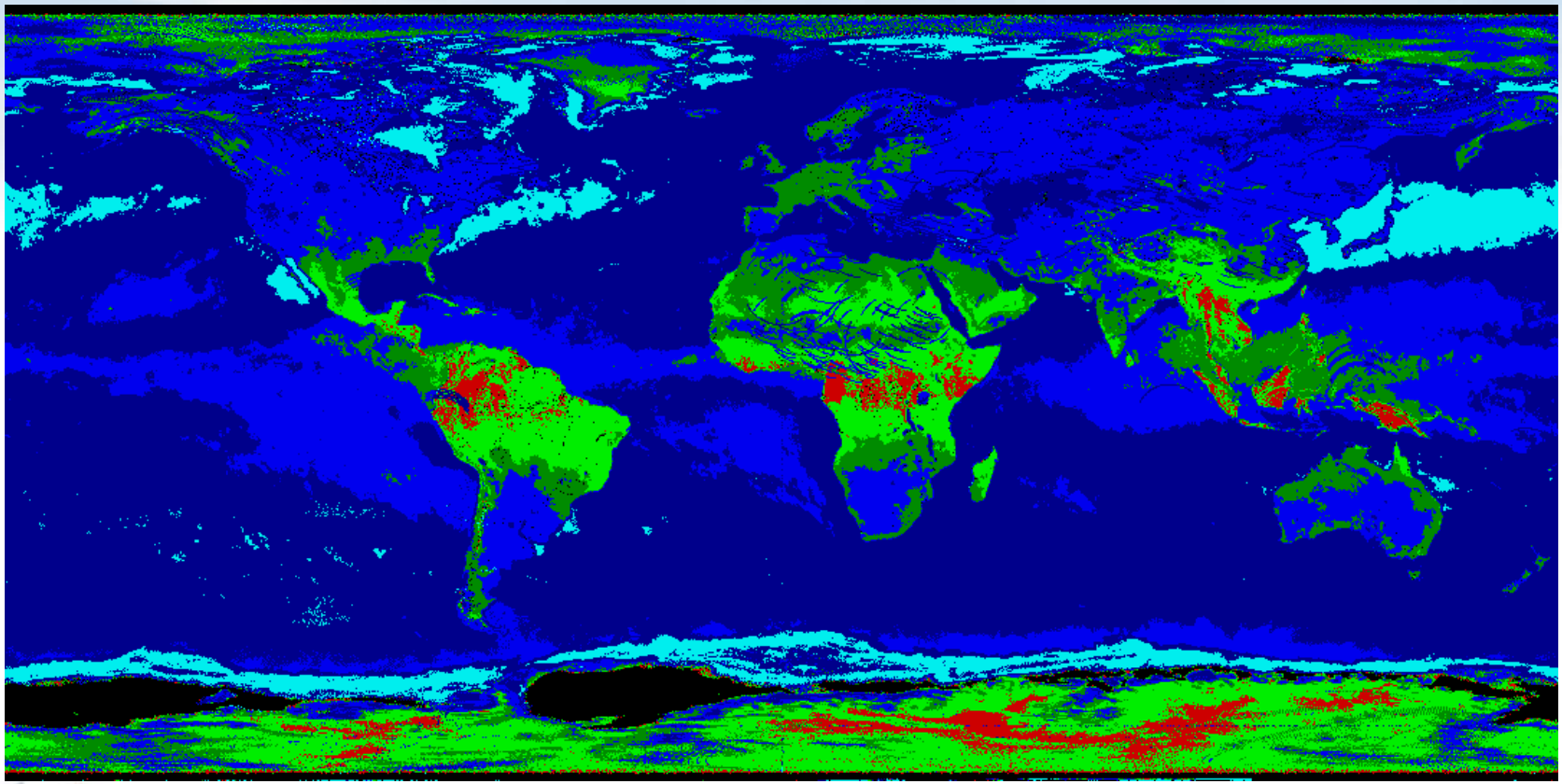


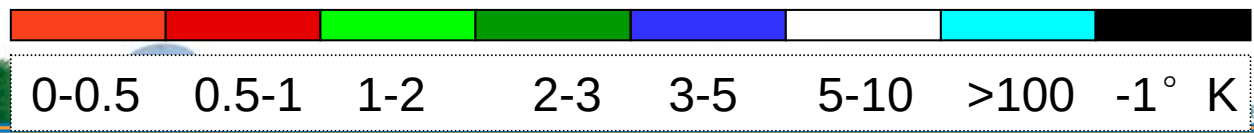
standard deviation (STD) of BT from19H Channel: May-Oct (175days), 1999: -1K=invalid data



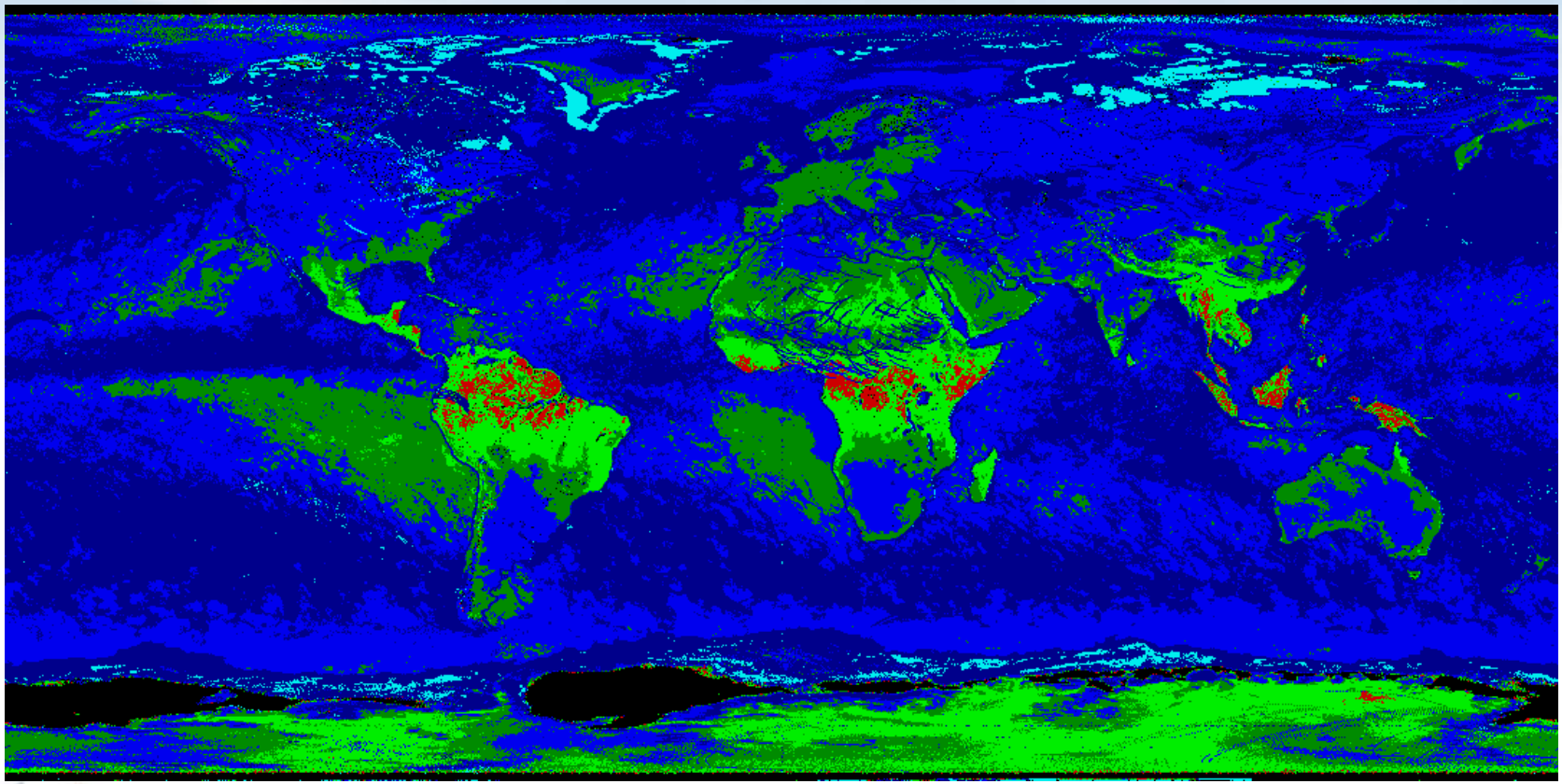


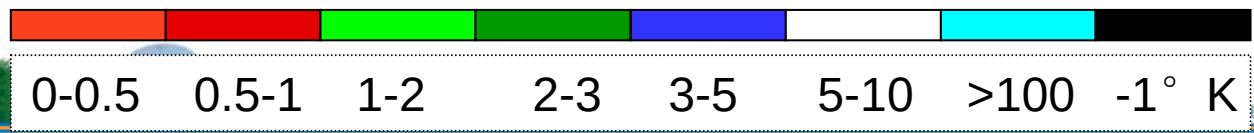
standard deviation (STD) of BT from 22GHz Channel: May-Oct (175days), 1999: -1K=invalid data



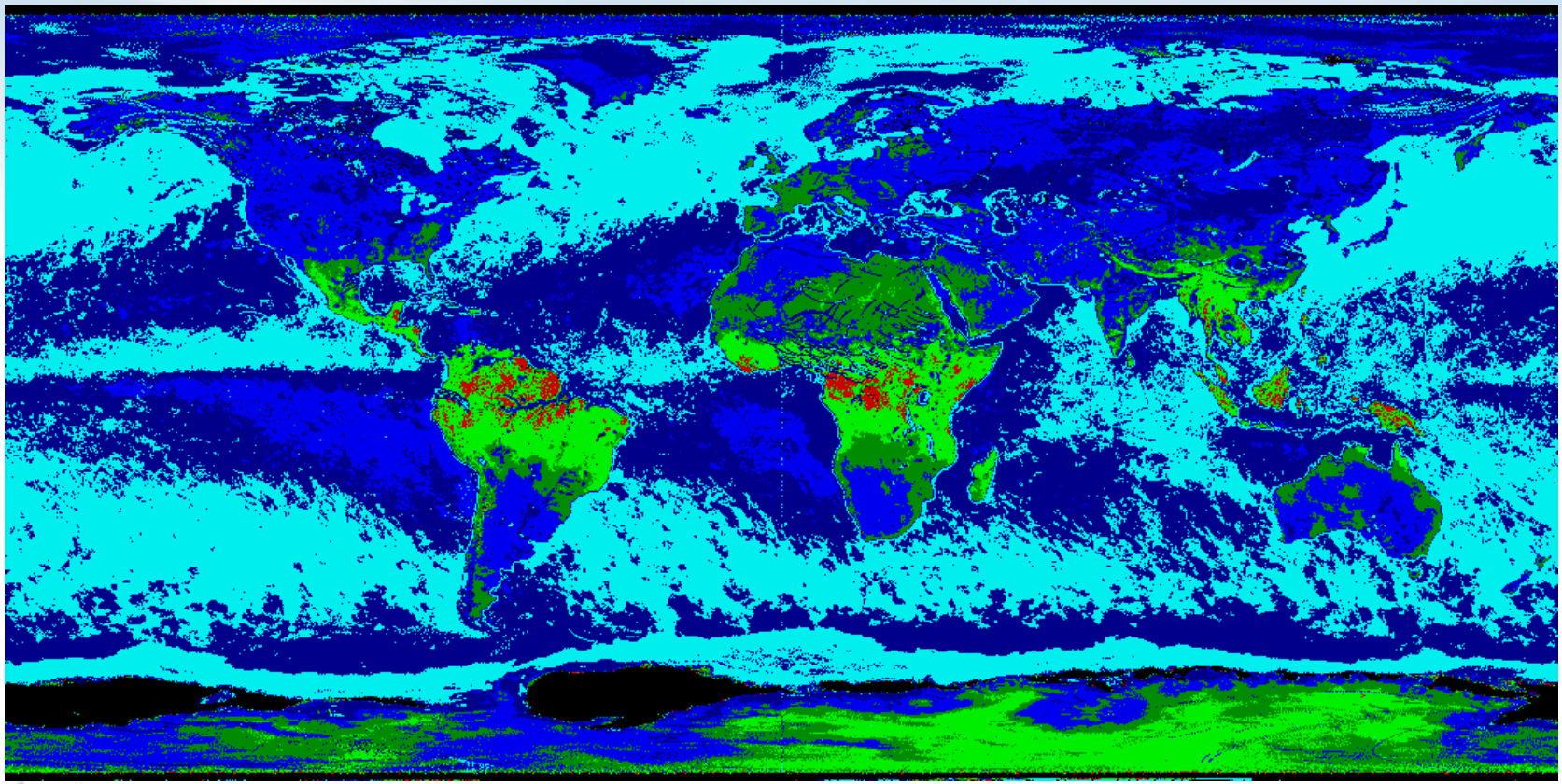


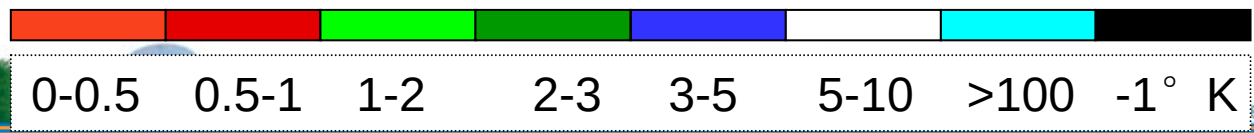
standard deviation (STD) of BT from 37V Channel: May-Oct (175days), 1999: -1K=invalid data



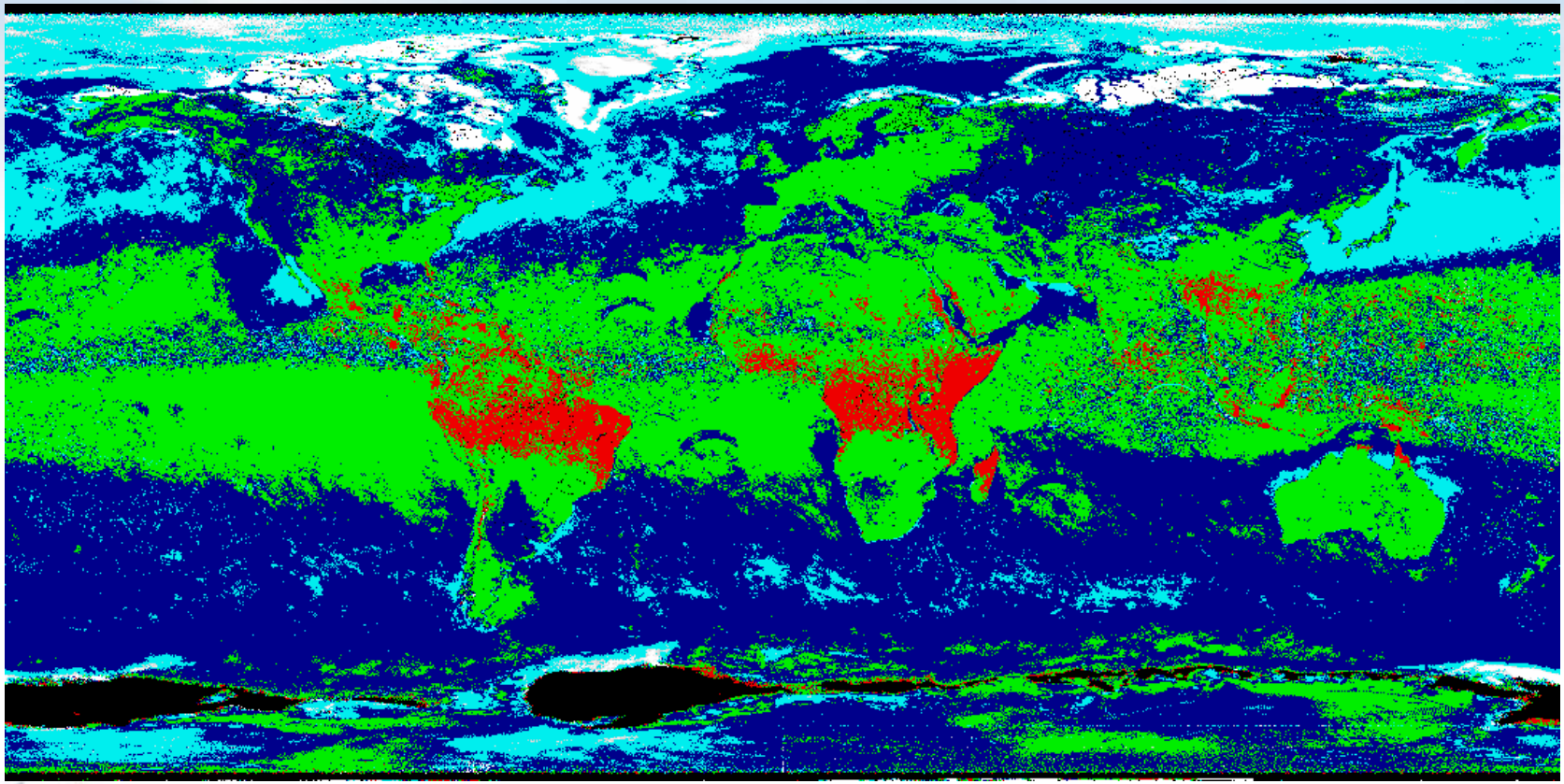


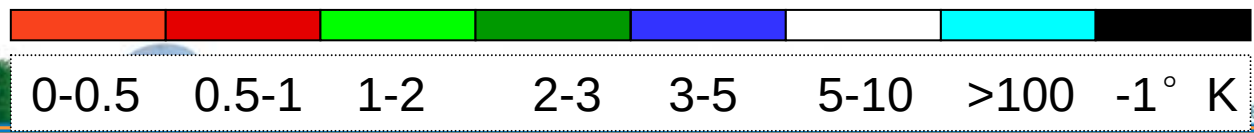
standard deviation (STD) of BT from 37H Channel: May-Oct (175days), 1999: -1K=invalid data



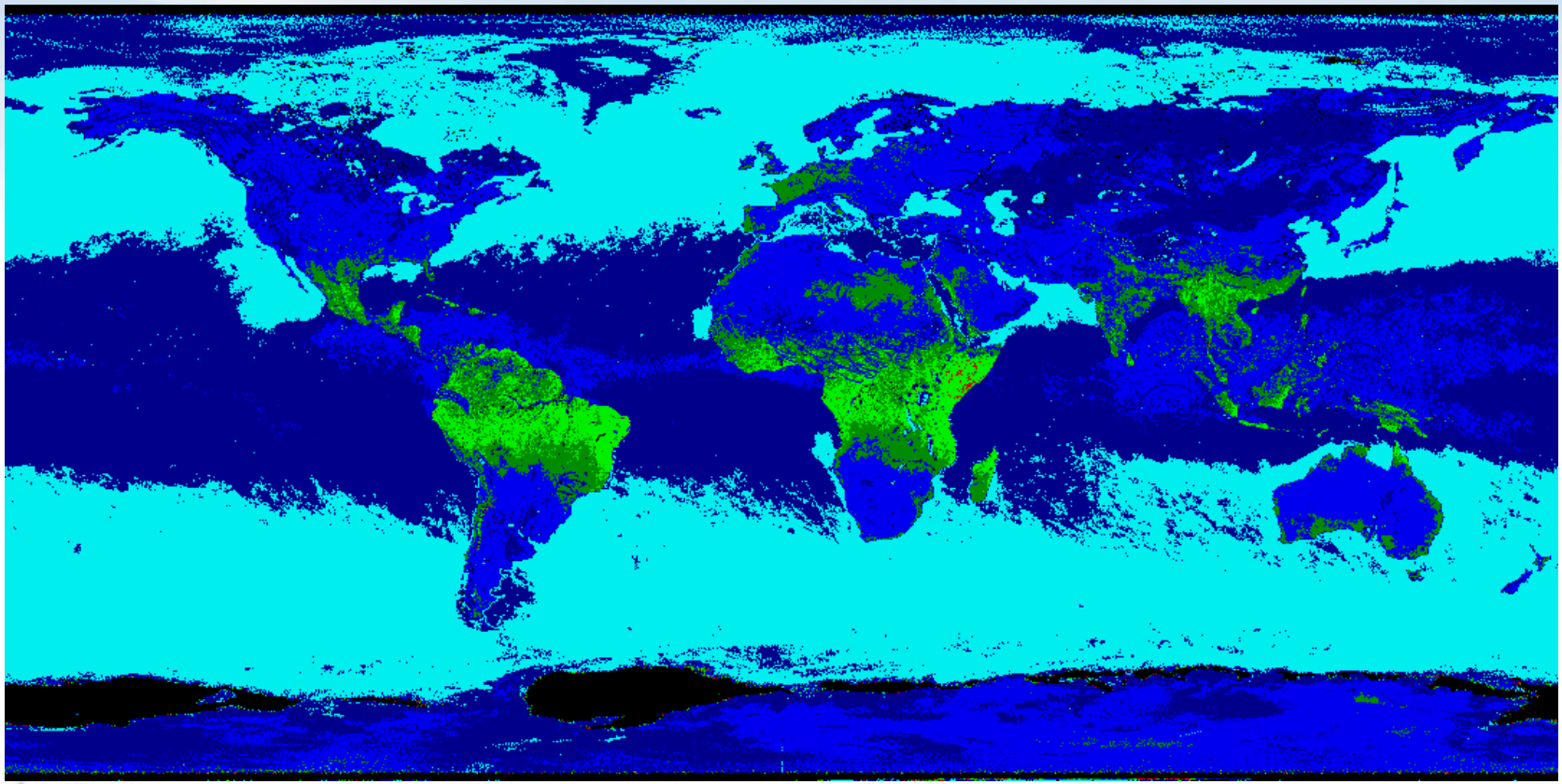


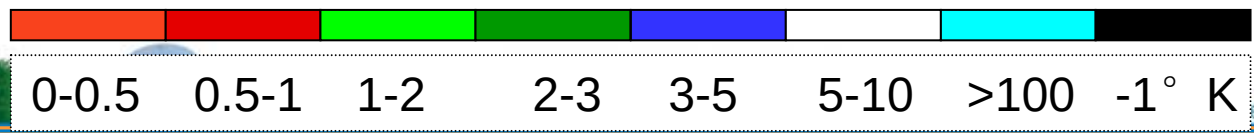
standard deviation (STD) of BT from 85V Channel: May-Oct (175days), 1999: -1K=invalid data





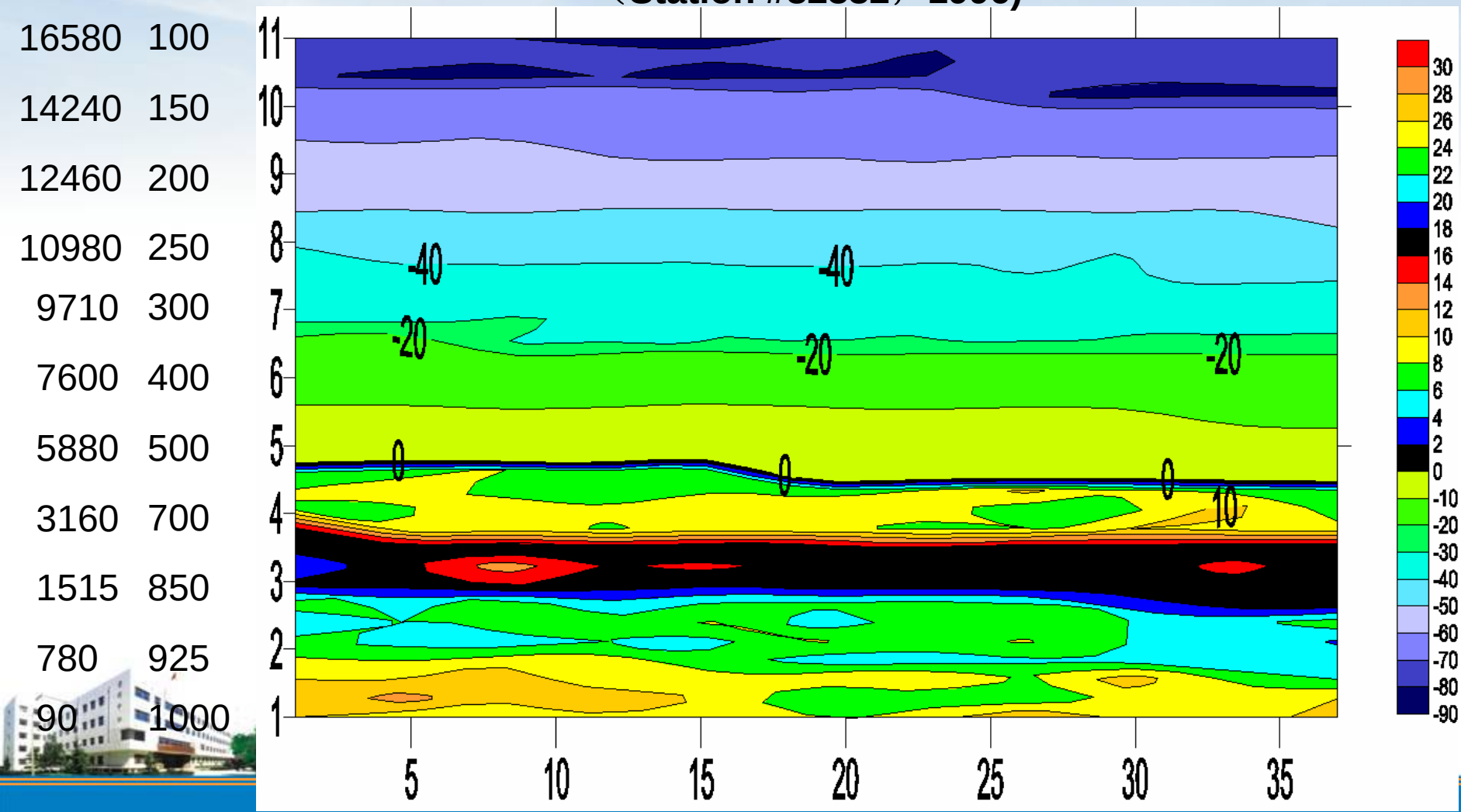
standard deviation (STD) of BT from 85H Channel: May-Oct (175days), 1999: -1K=invalid data





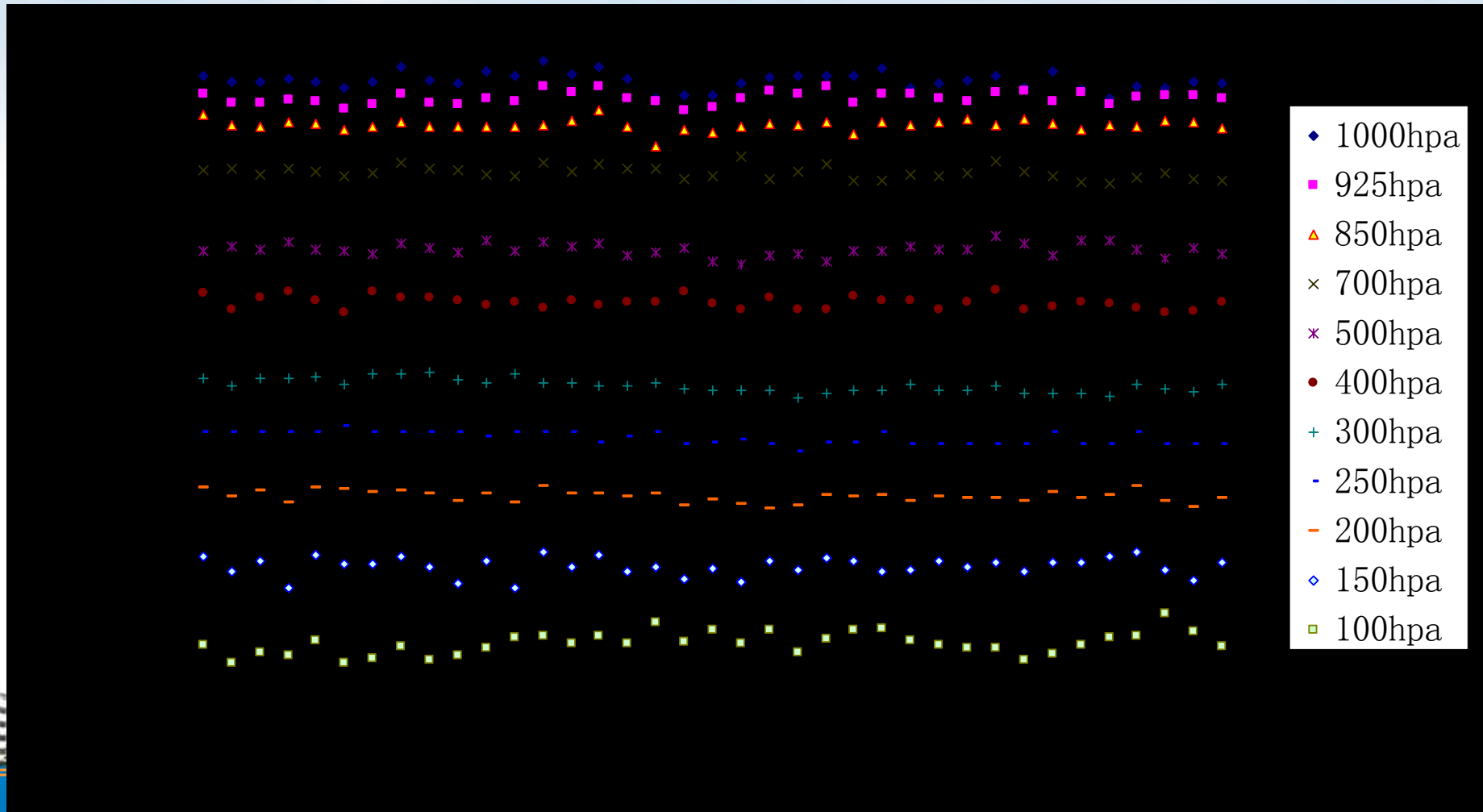
Amazon Sounding Isoline Plot

（Station #82332，1996)



Amazon Sounding Scattered point plot

（Station #82332，May-Oct,1996)

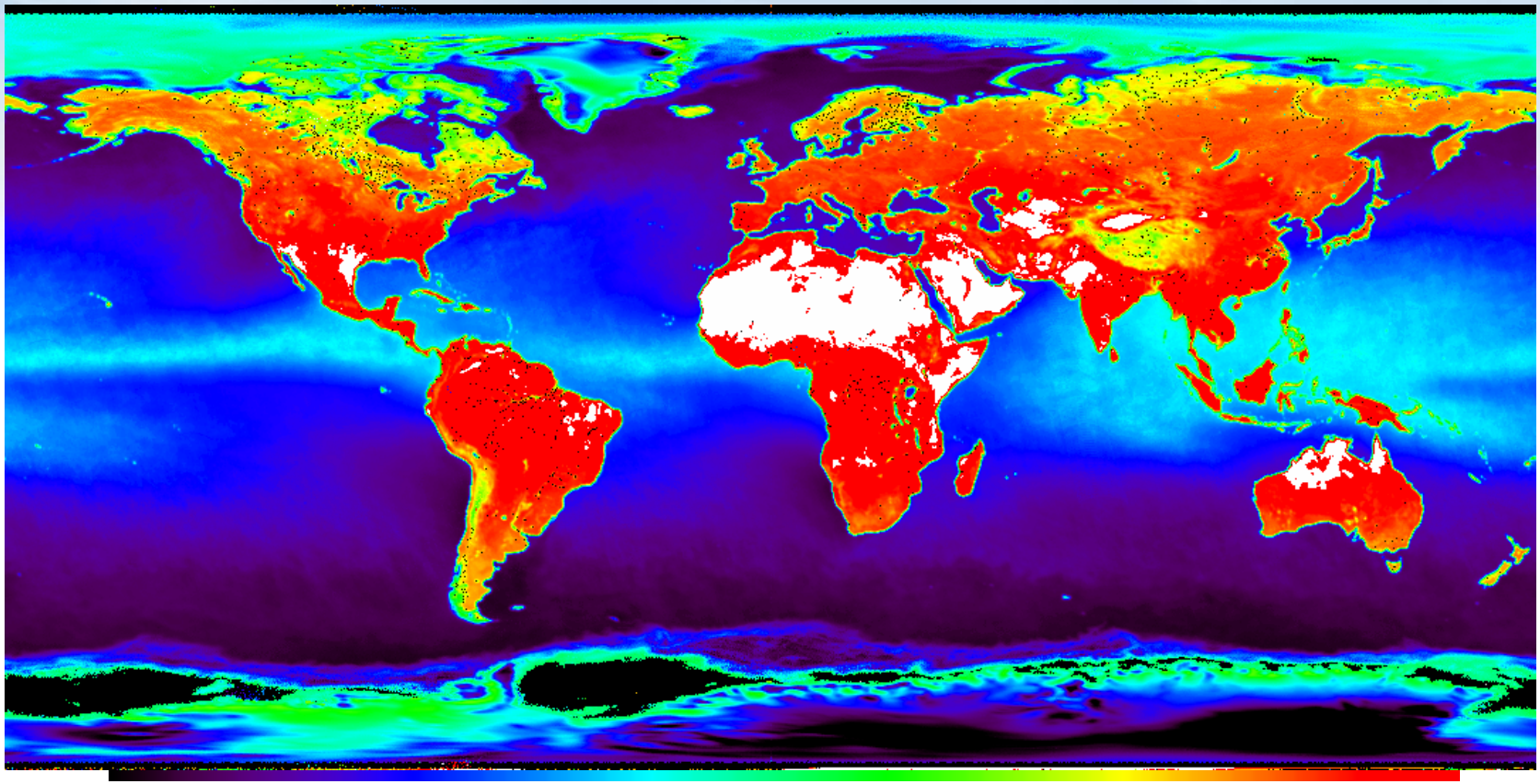


Initial Conclusions:

- Stabilities of channels of V-pols are better than H-pols;
- With frequency channels like SSMI, there are stable high BT areas in Amazon region;
- In China, south area of Yunnan Province and costal area of Fujian Province are the most stable with high BT.

Average BT image from SSMI for five months (May-Oct, 1999)

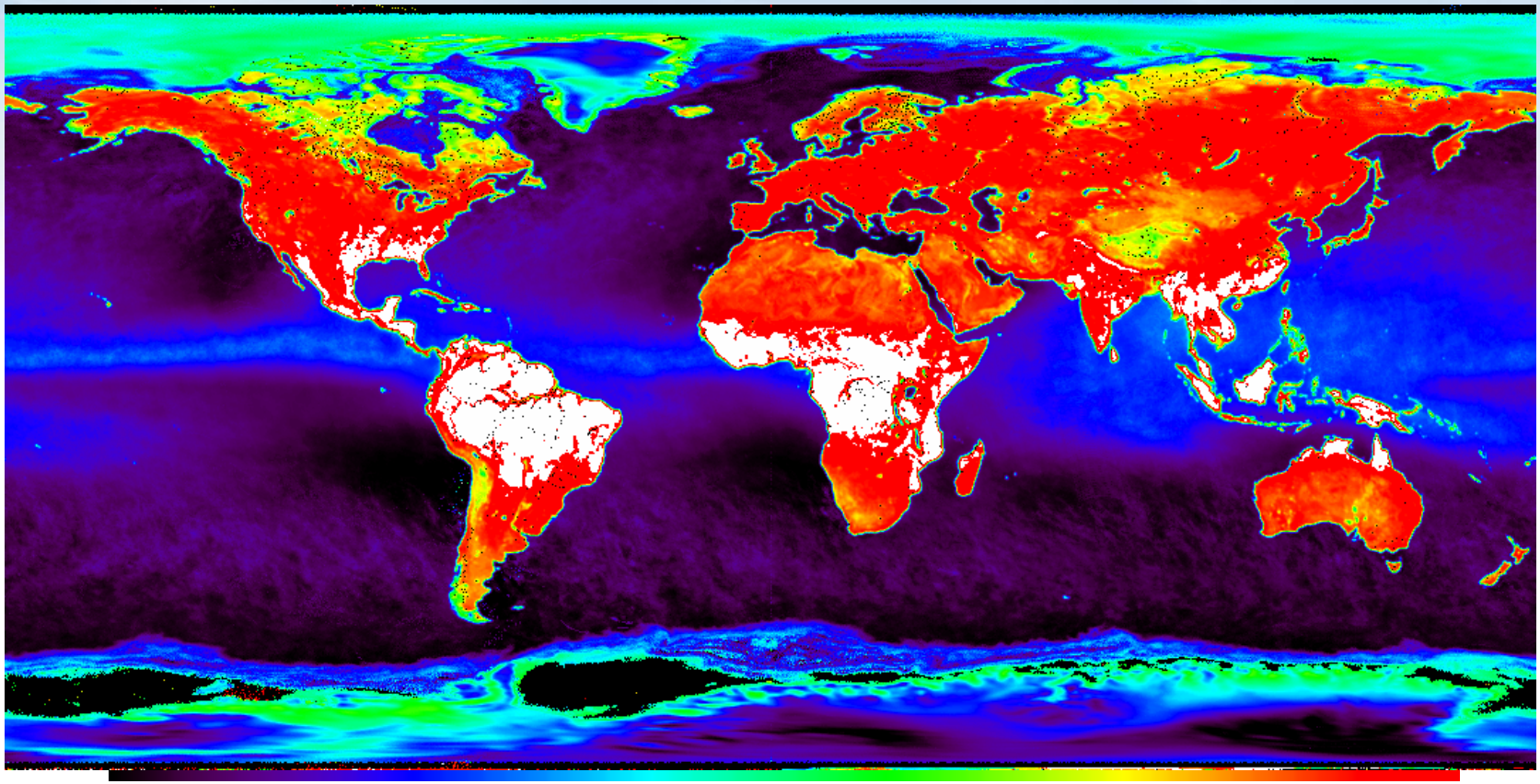
Monthly Average of 19V channel: May-Oct (175Days), 1999



cold

warm

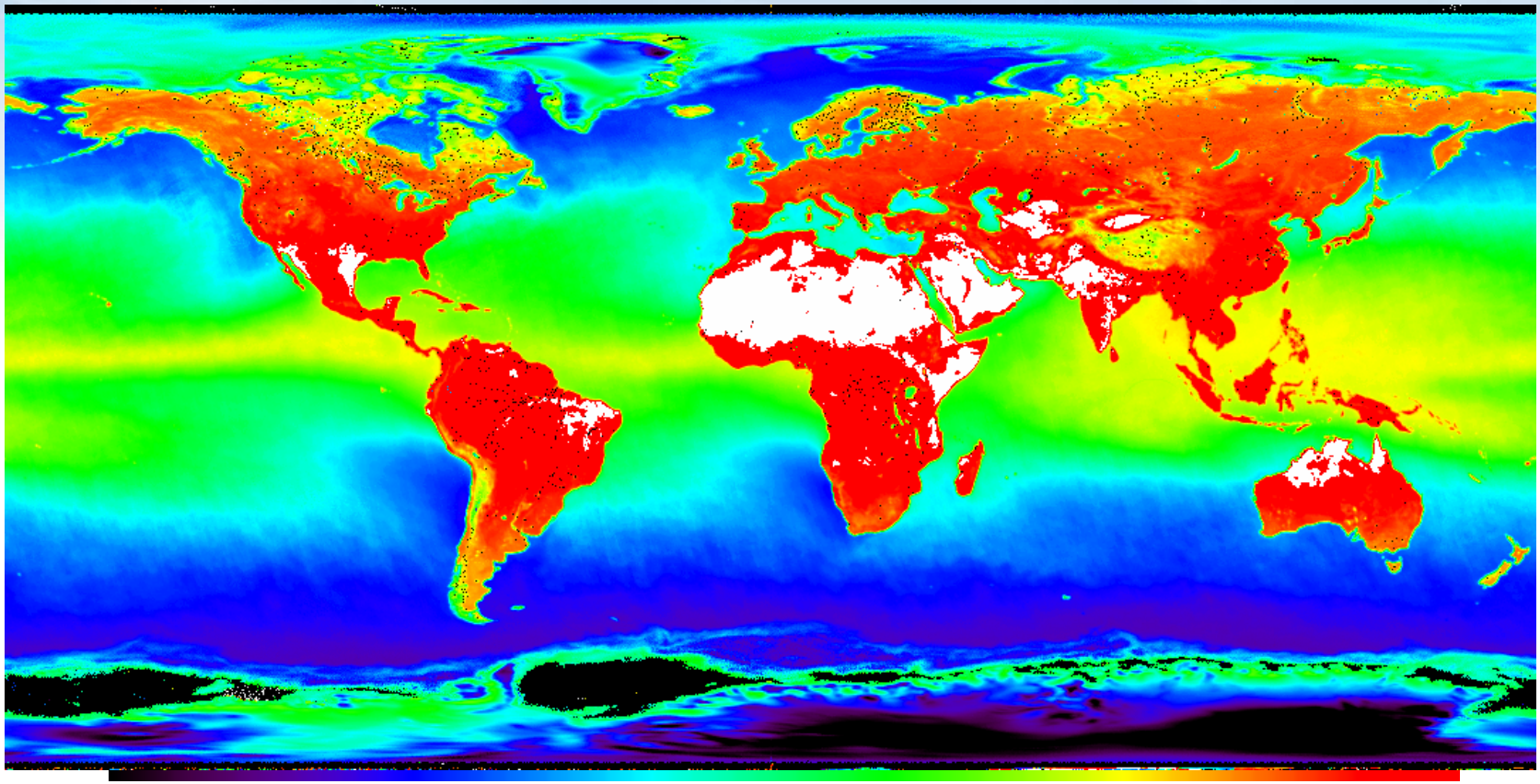
Monthly Average of 19H channel: May-Oct (175Days), 1999



cold

warm

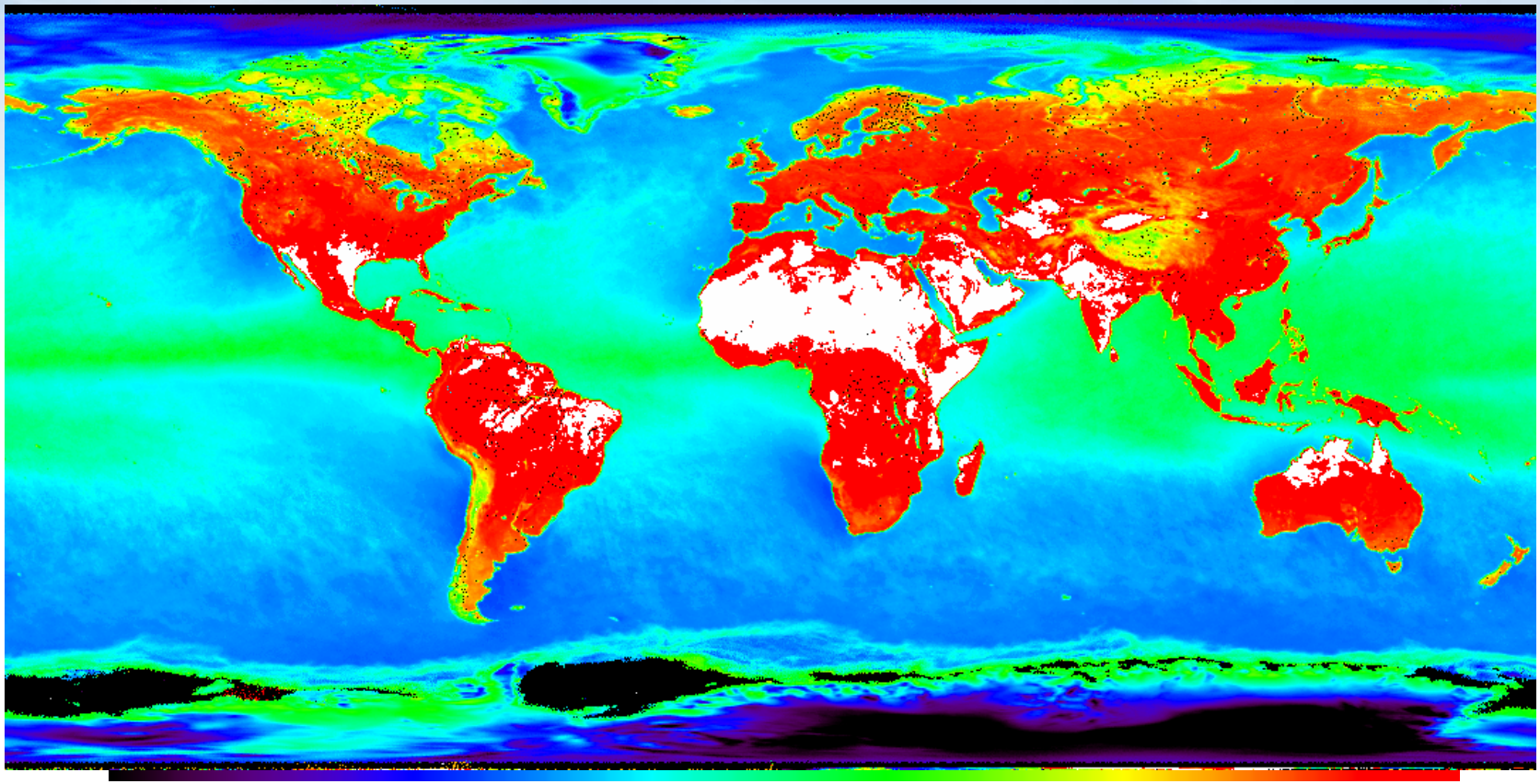
Monthly Average of 22GHz channel: May-Oct (175Days), 1999



cold

warm

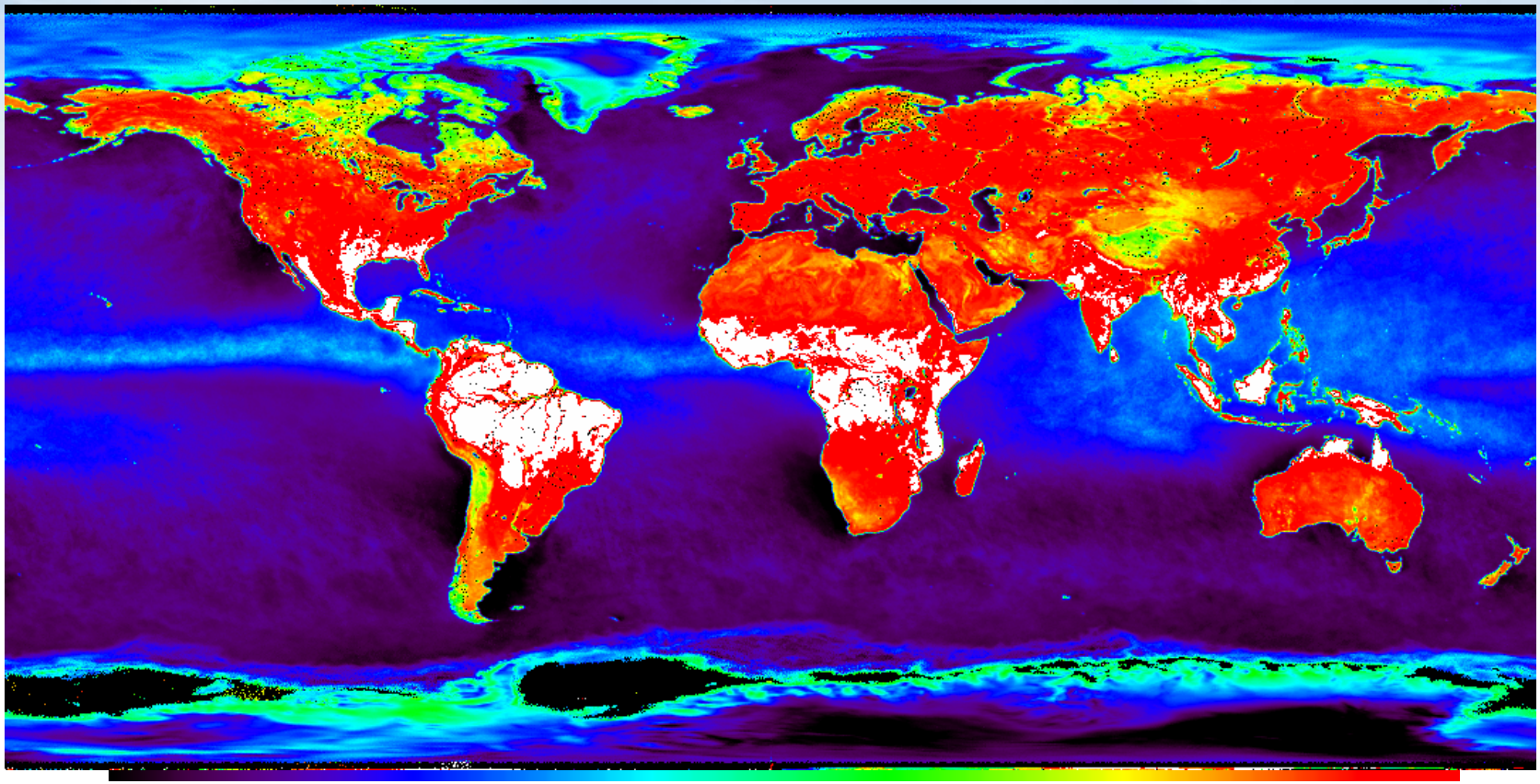
Monthly Average of 37V channel: May-Oct (175Days), 1999



cold

warm

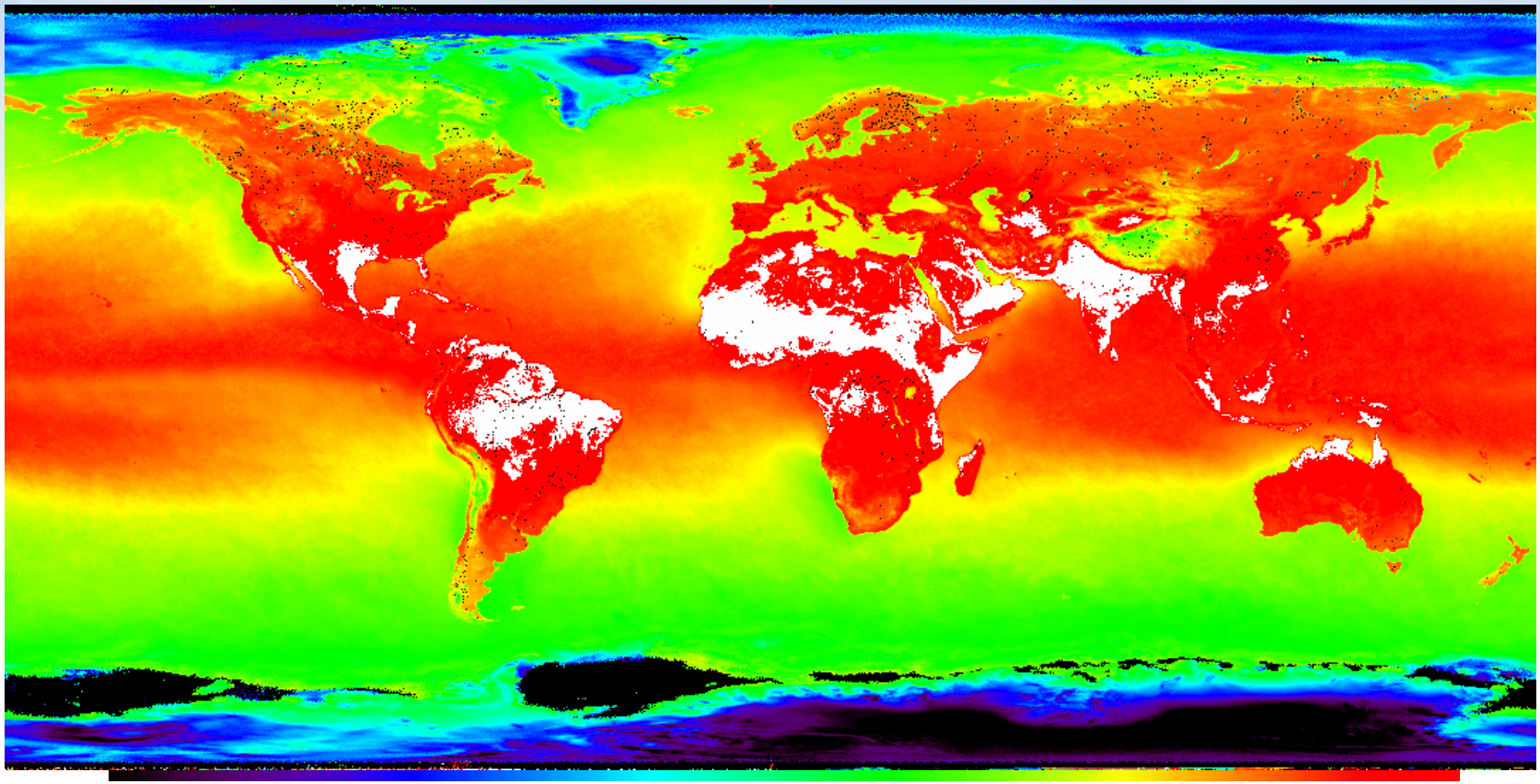
Monthly Average of 37H channel: May-Oct (175Days), 1999



cold

warm

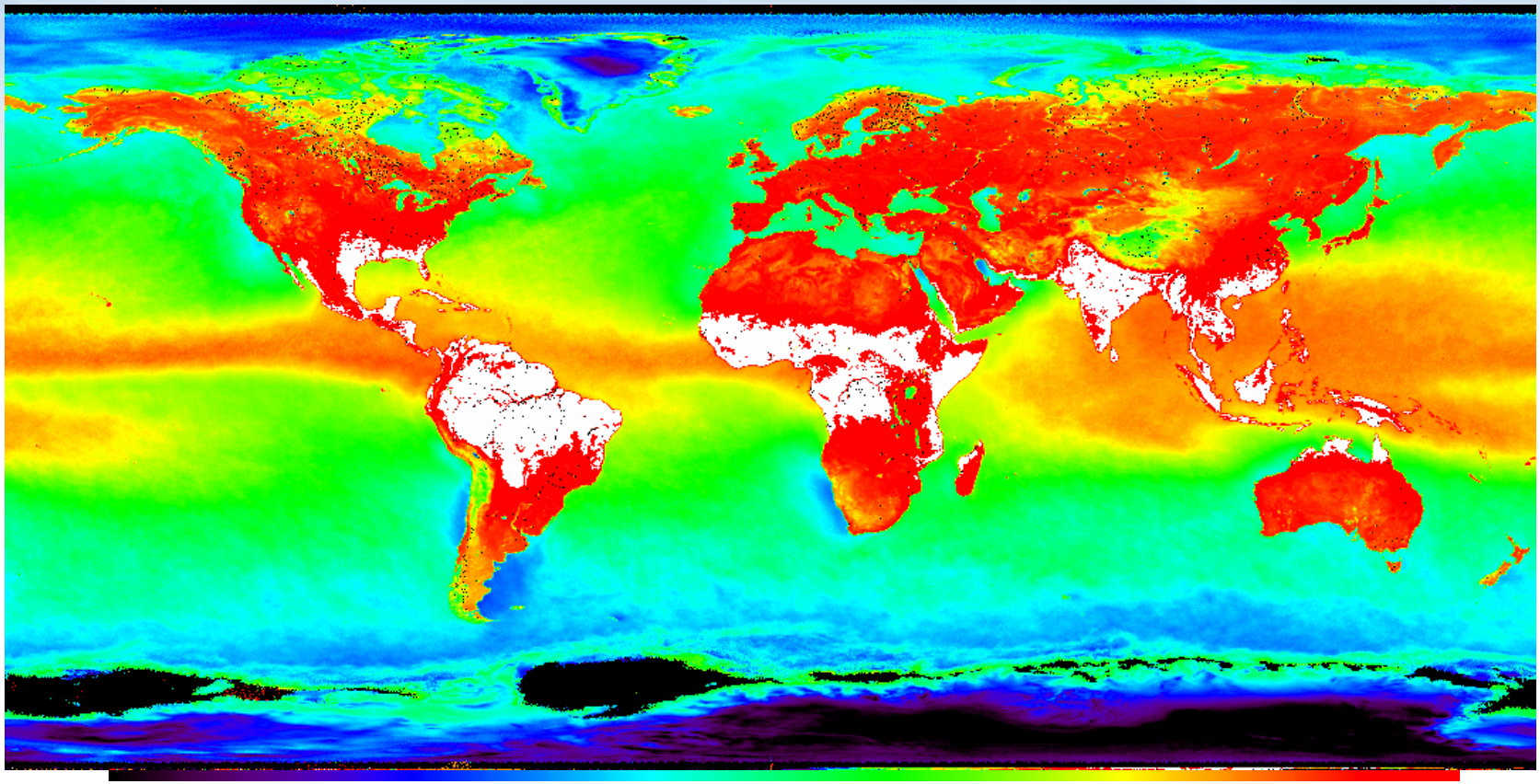
Monthly Average of 85V channel: May-Oct (175Days), 1999



cold

warm

Monthly Average of 85H channel: May-Oct (175Days), 1999



cold

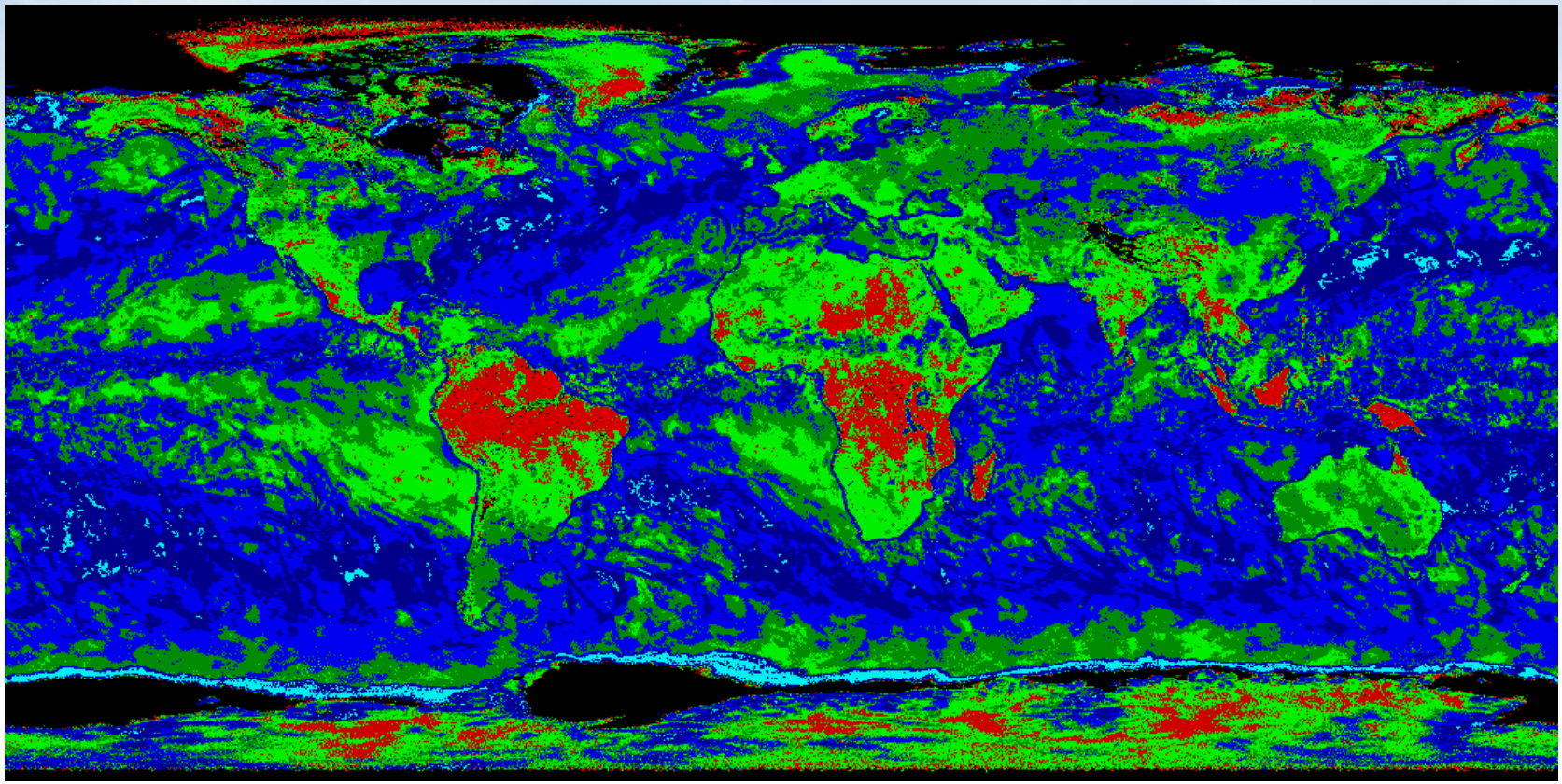
warm

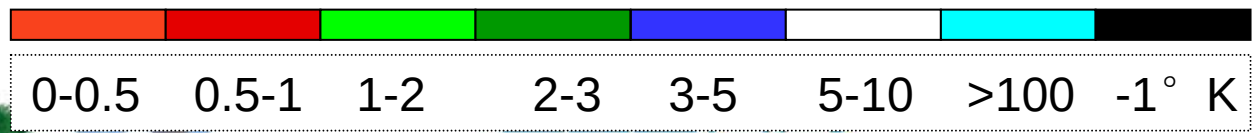
Initial conclusions:

- **Besides the desert area, Amazon region, southern Yunnan province and coastal area of Fujian Province have good BT image with high BT.**

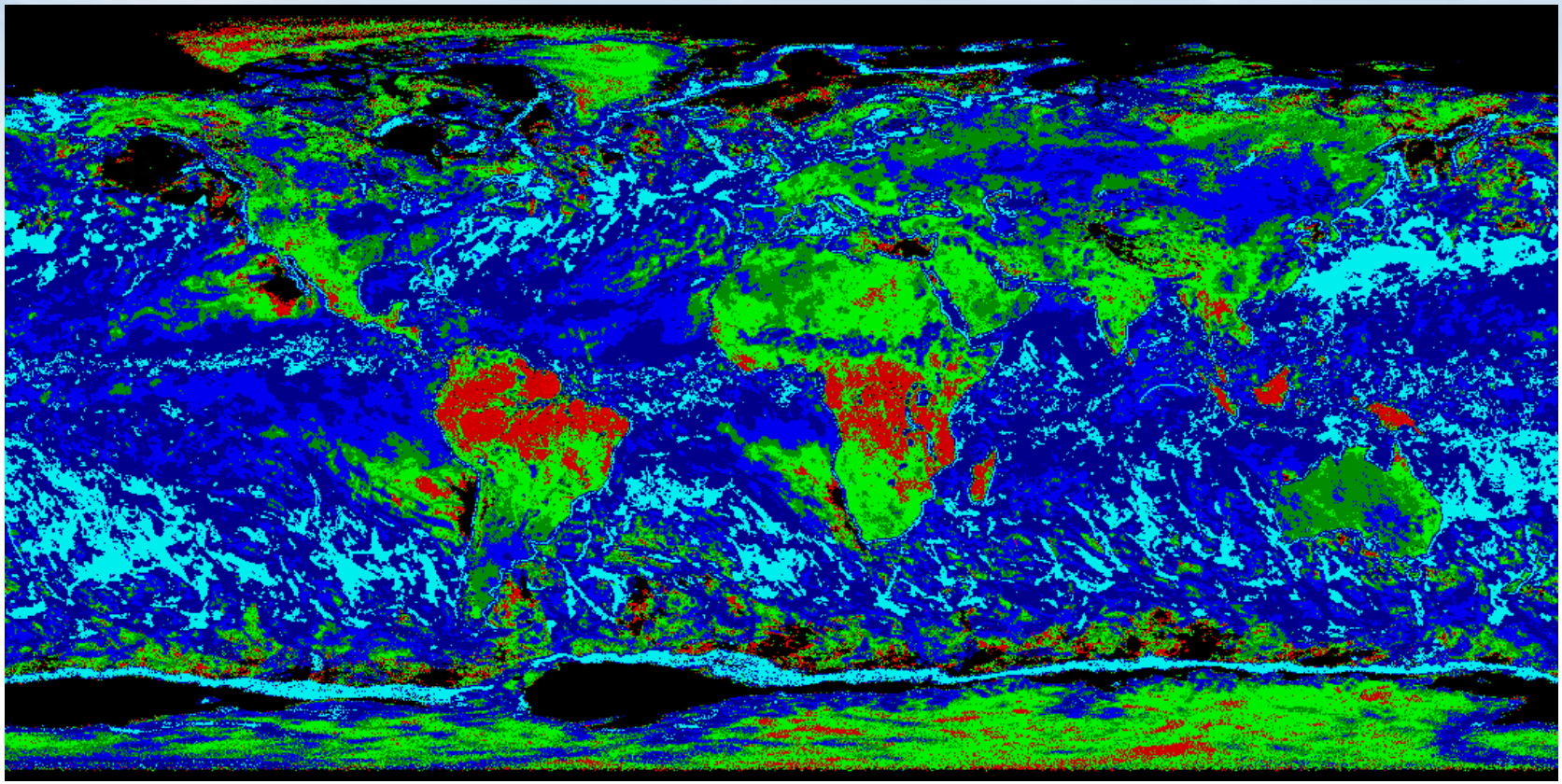
Standard Deviation of BT images from SSM/I for data of May, 1999

Standard Deviation of 19V channel: May, 1999



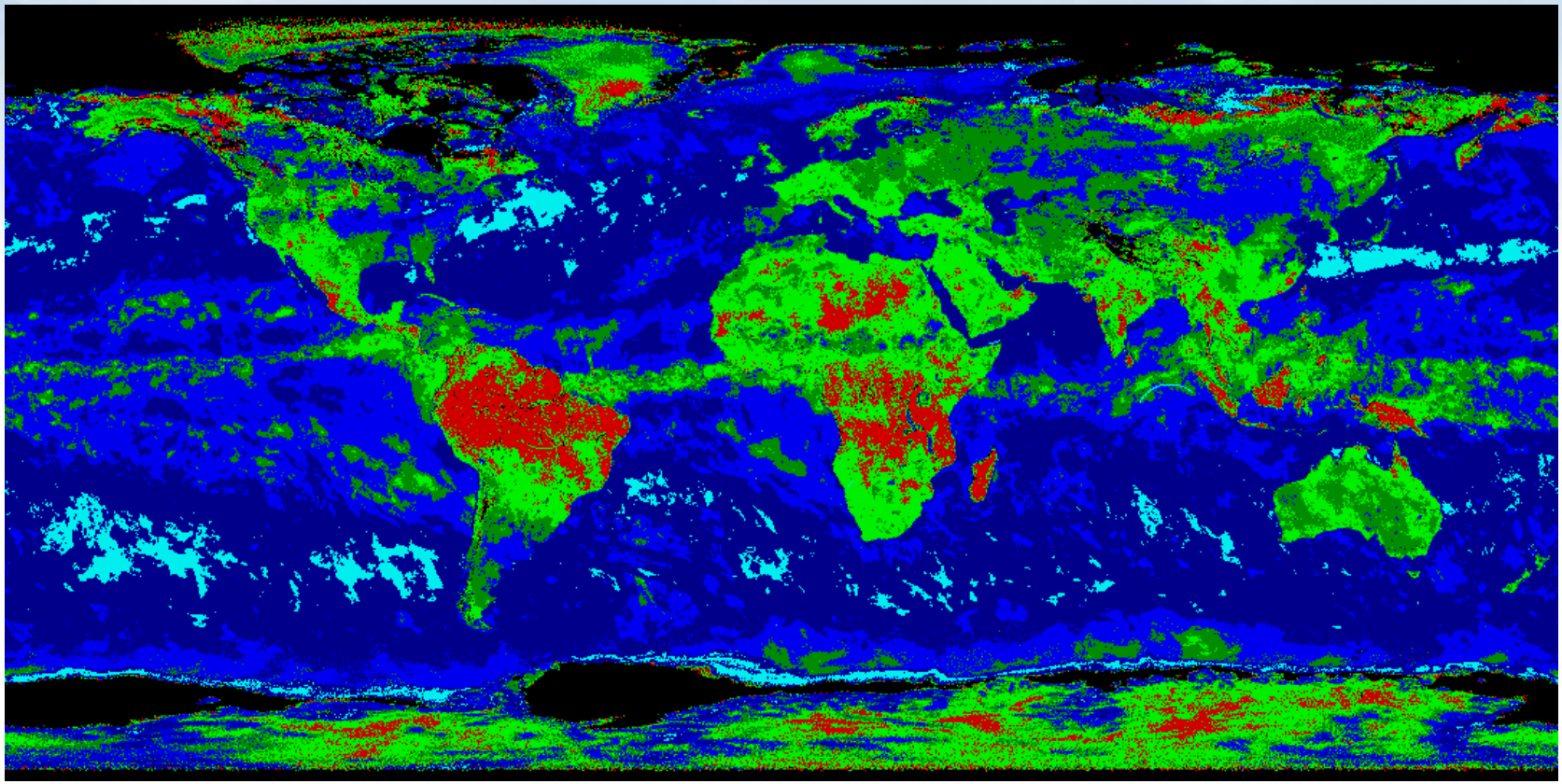


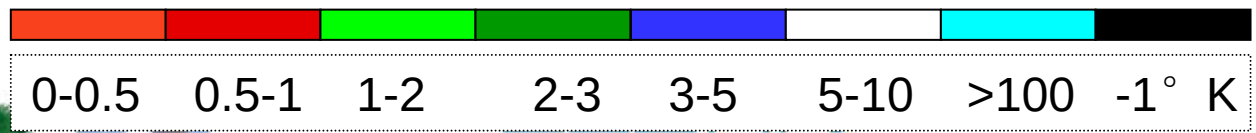
Standard Deviation of 19H channel: May, 1999



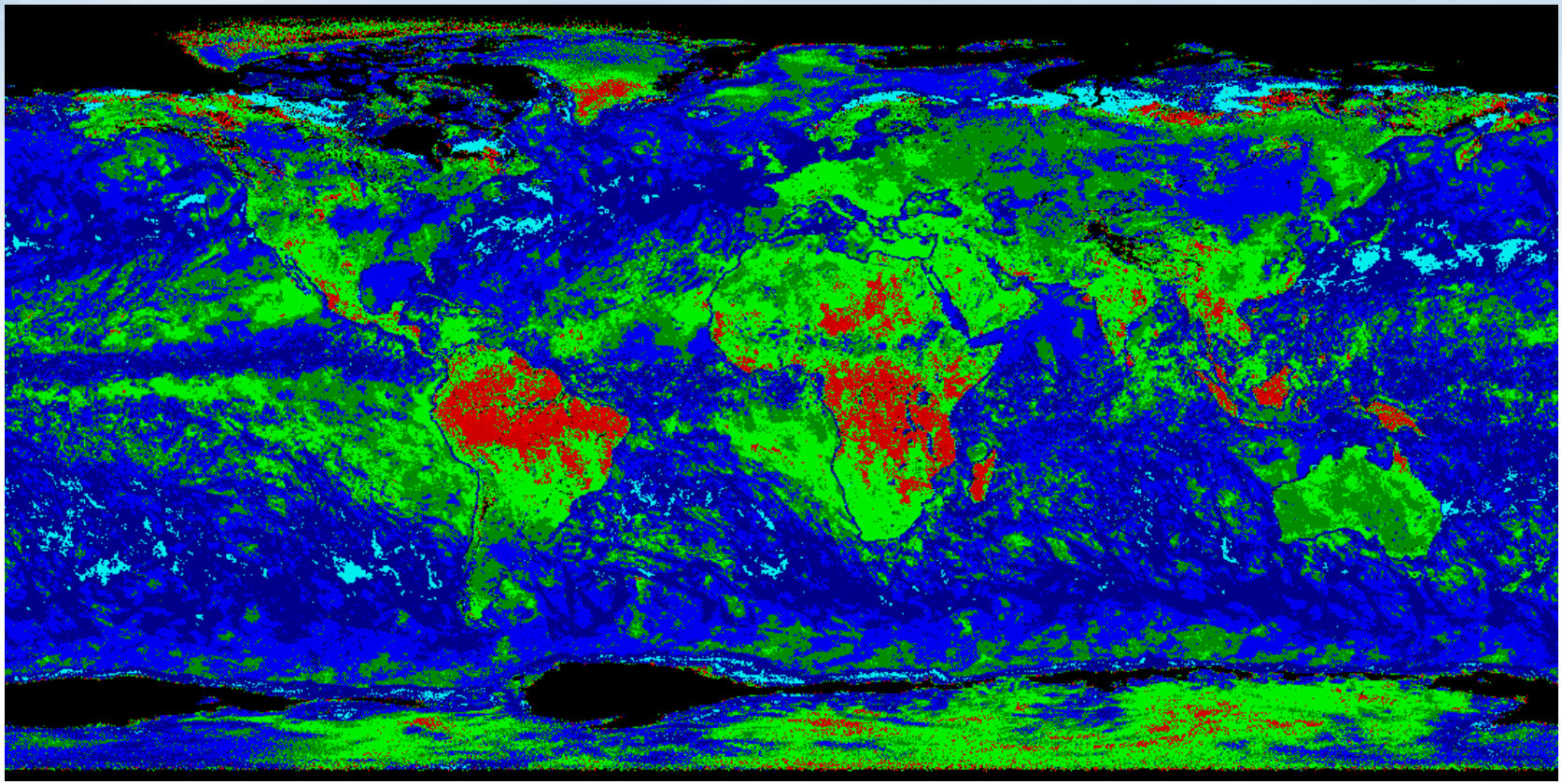
0-0.5 0.5-1 1-2 2-3 3-5 5-10 >100 -1° K

Standard Deviation of 22GHz channel: May, 1999



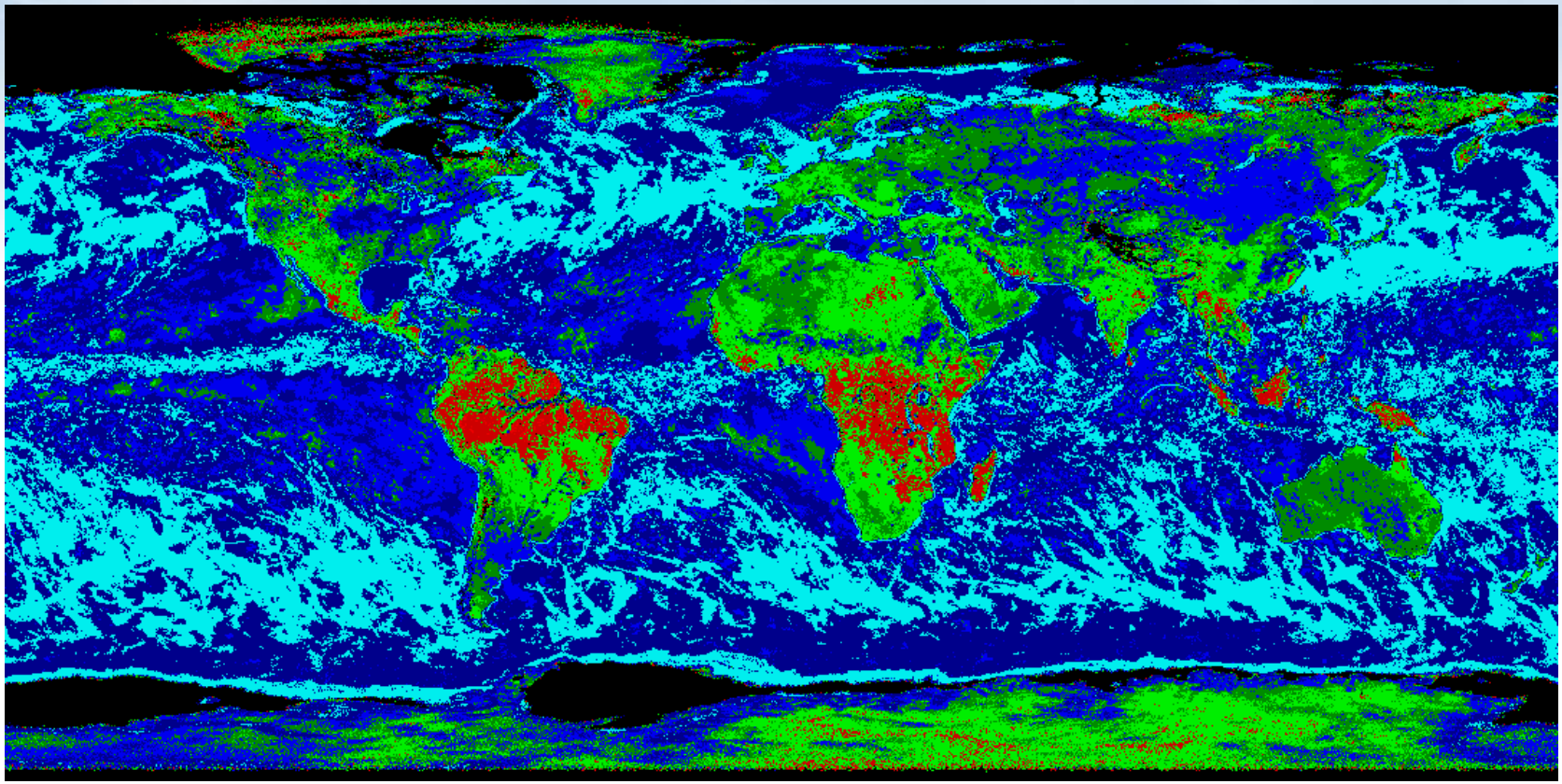


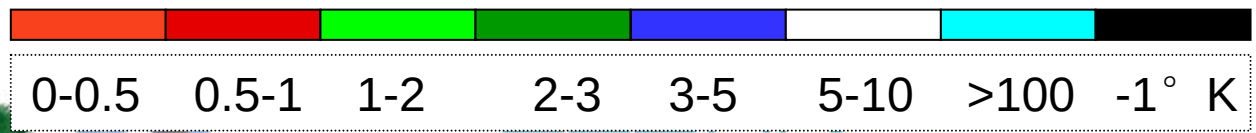
Standard Deviation of 37V channel: May, 1999



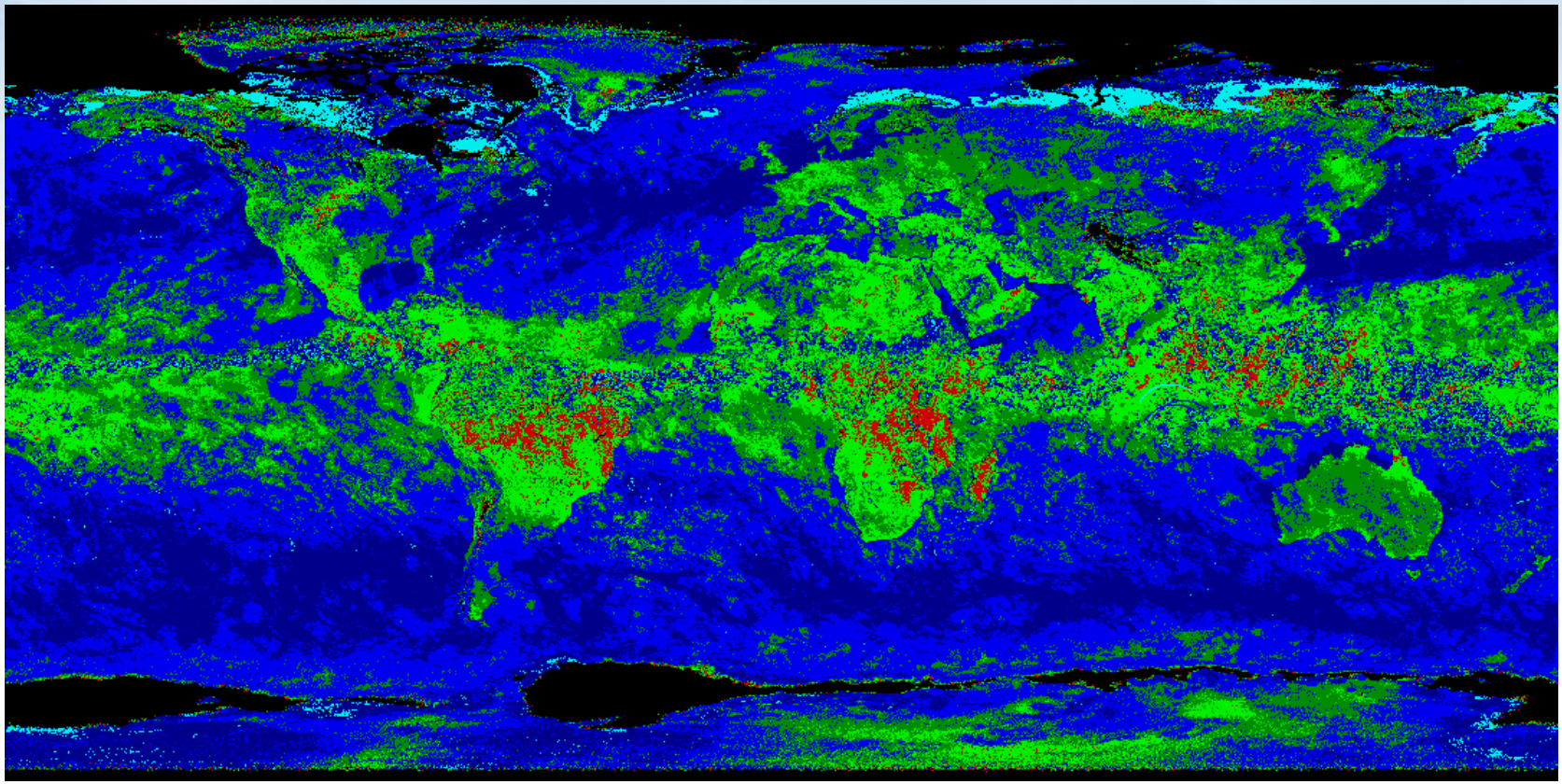
0-0.5 0.5-1 1-2 2-3 3-5 5-10 >100 -1° K

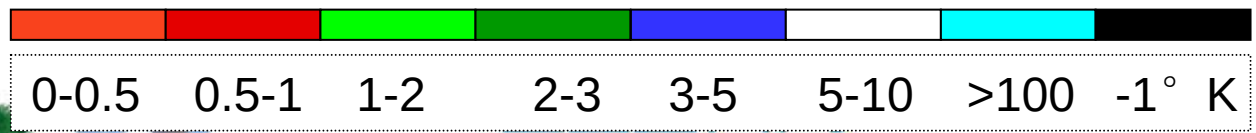
Standard Deviation of 37H channel: May, 1999



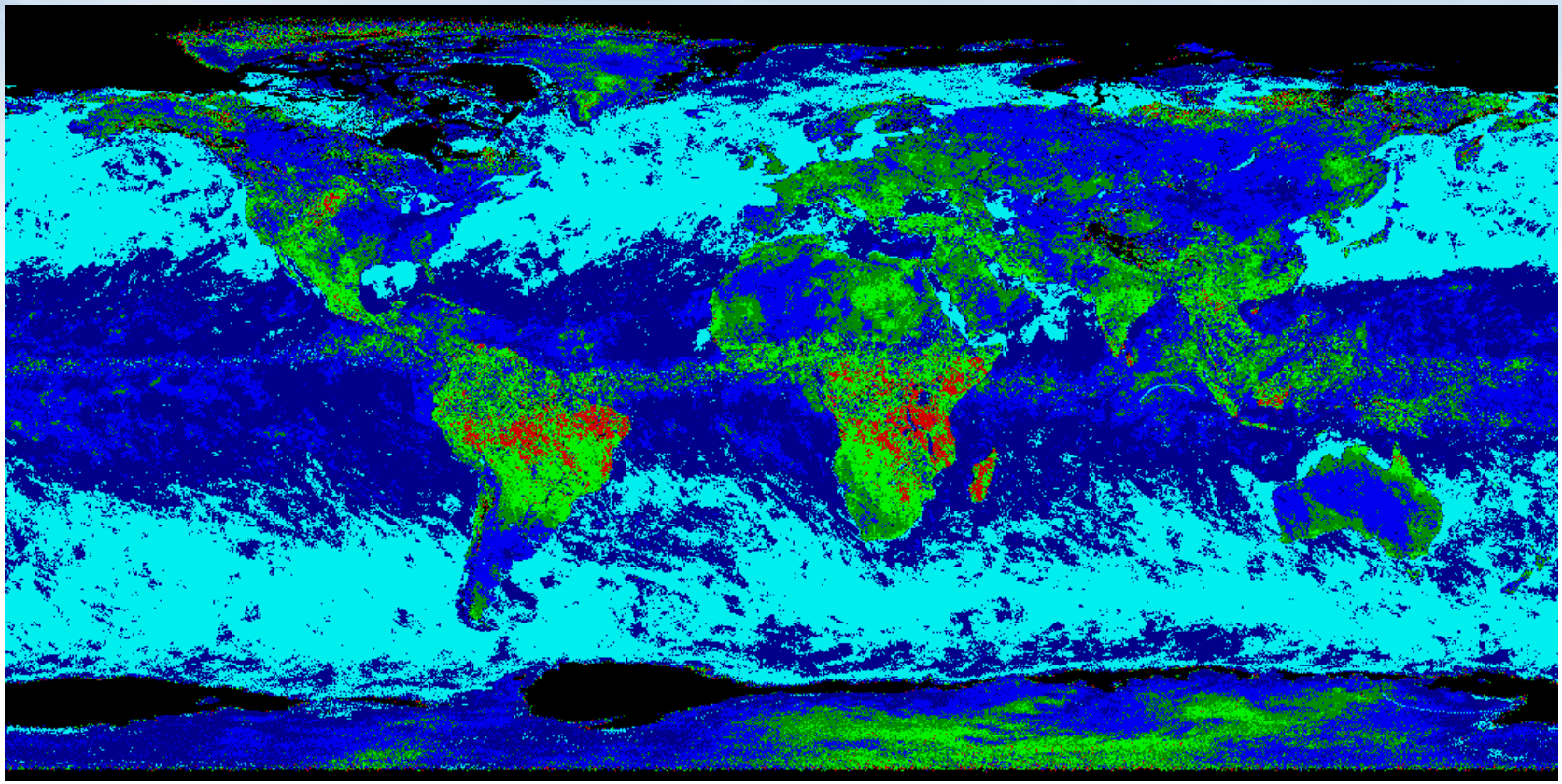


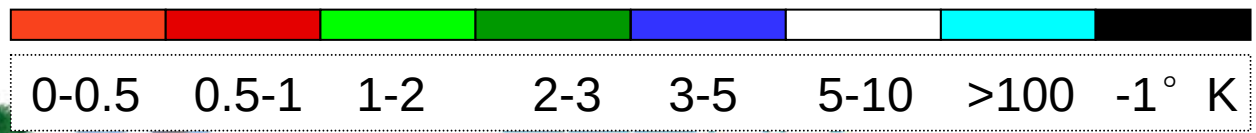
Standard Deviation of 85V channel: May, 1999





Standard Deviation of 85H channel: May, 1999



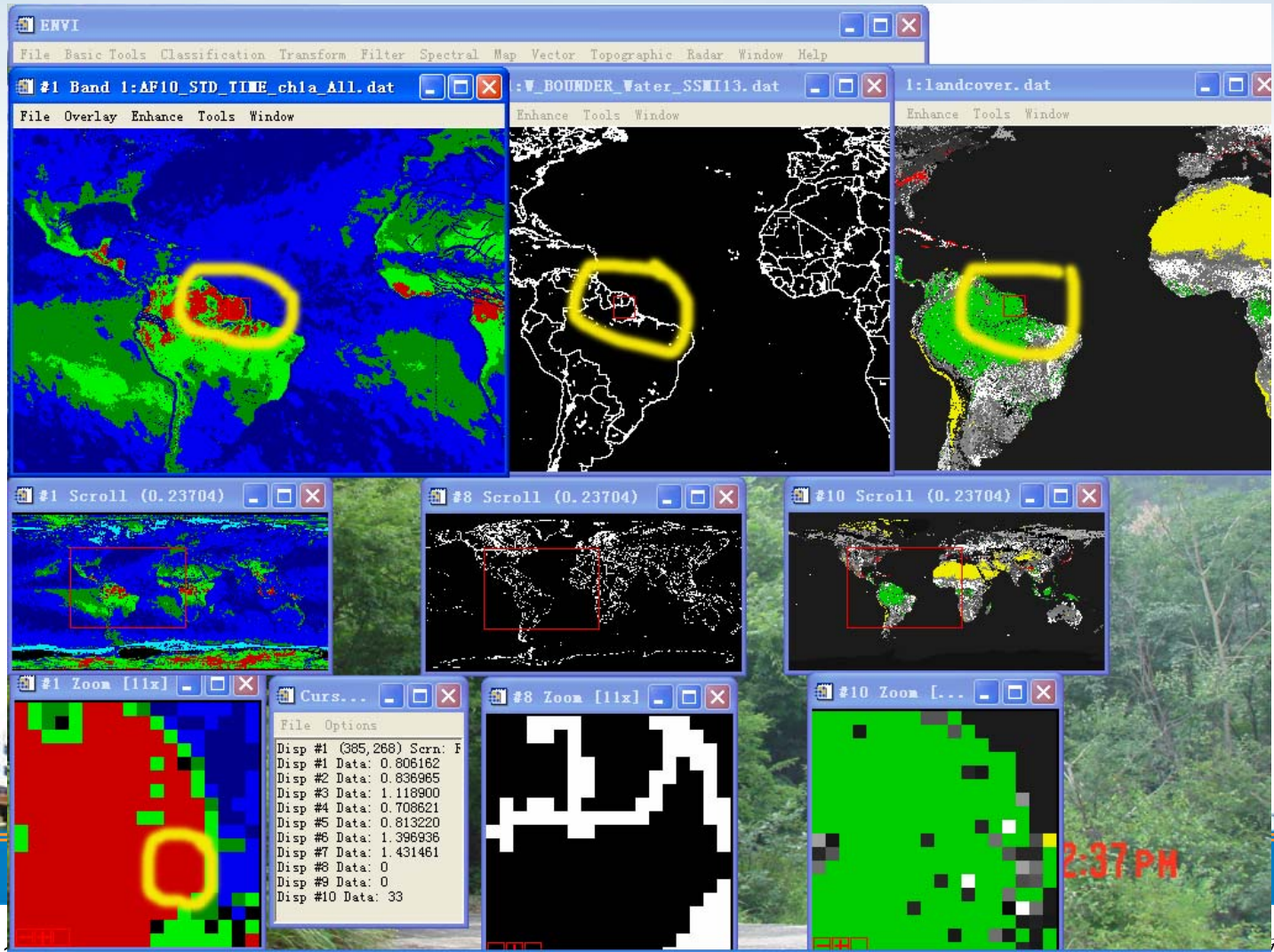


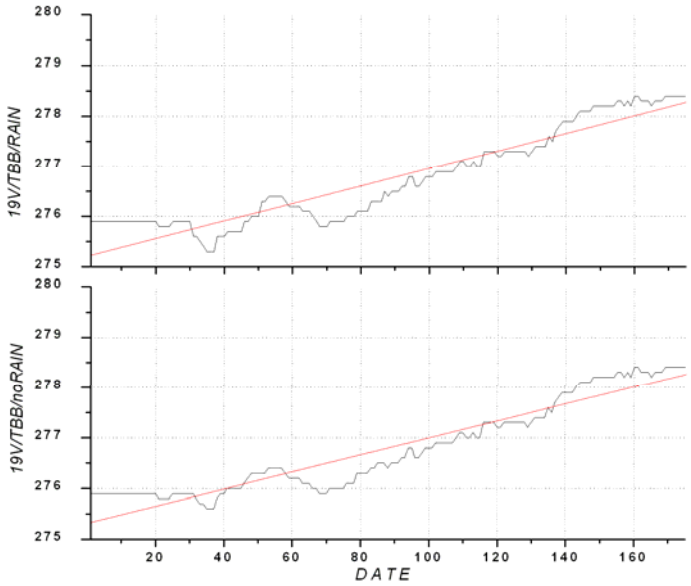
Intial Conclusions

- **Due to removal of seasonal variations to some extent, more stabilities obtained for Amazon region and Southern Yunnan Province and Coastal area of Fujian Province.**

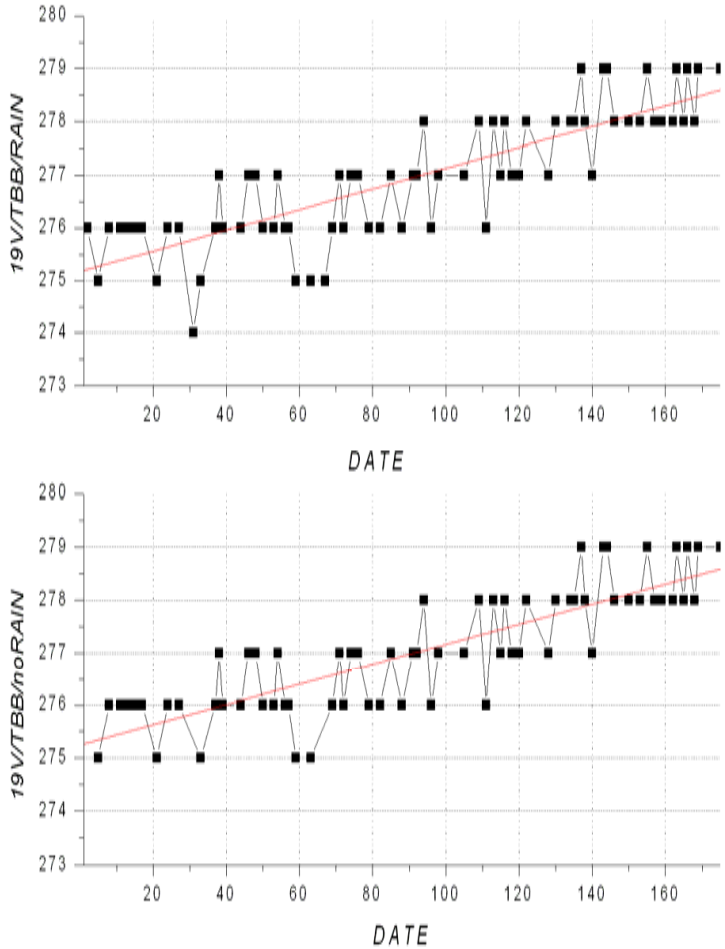
BT stablities of some specific area

- **Location 1-----Amazon area**

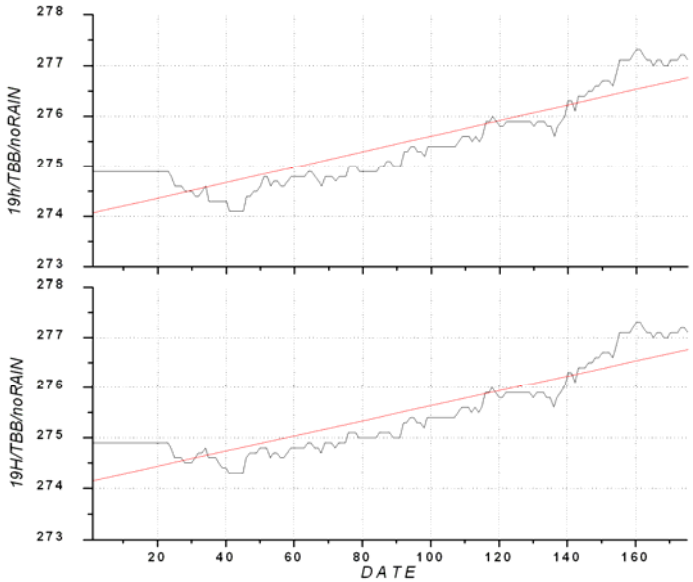




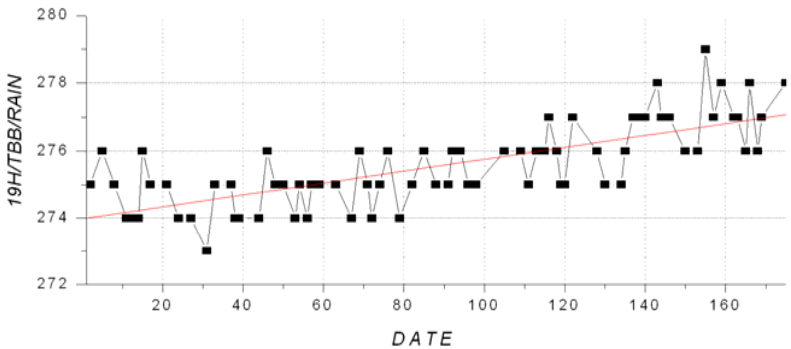
19V channel: sliding average for 20days from data of 175days.



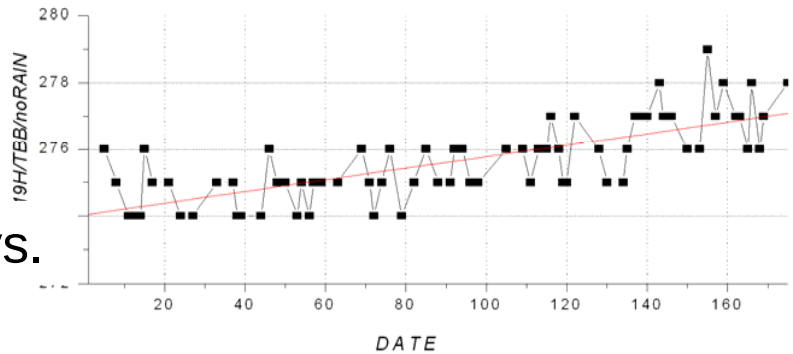
19V channel: daily series of 175 days



19H channel: sliding average for 20days from data of 175days.



19H channel: daily series of 175 days.



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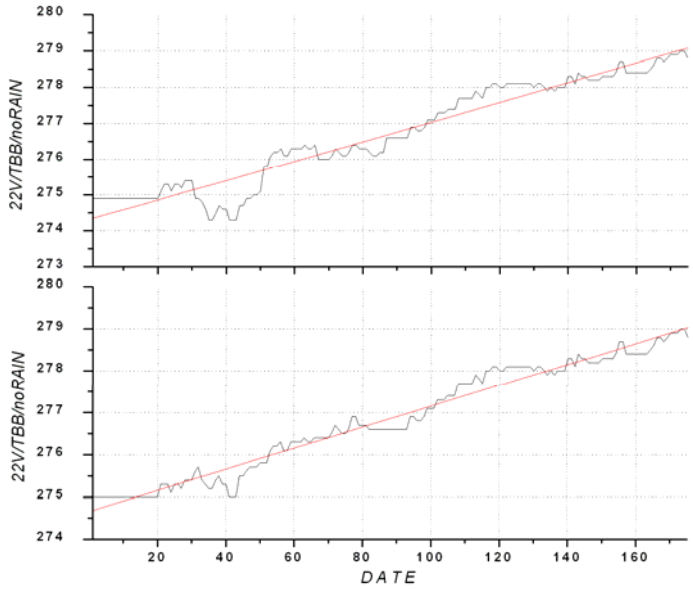
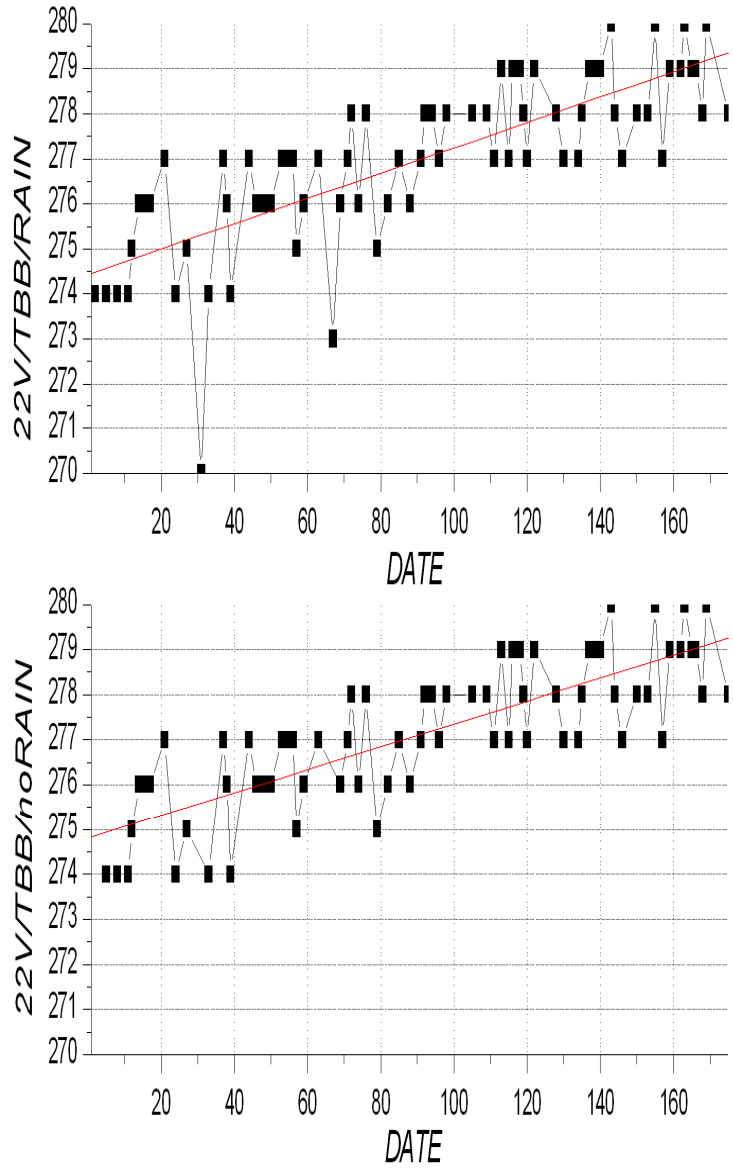
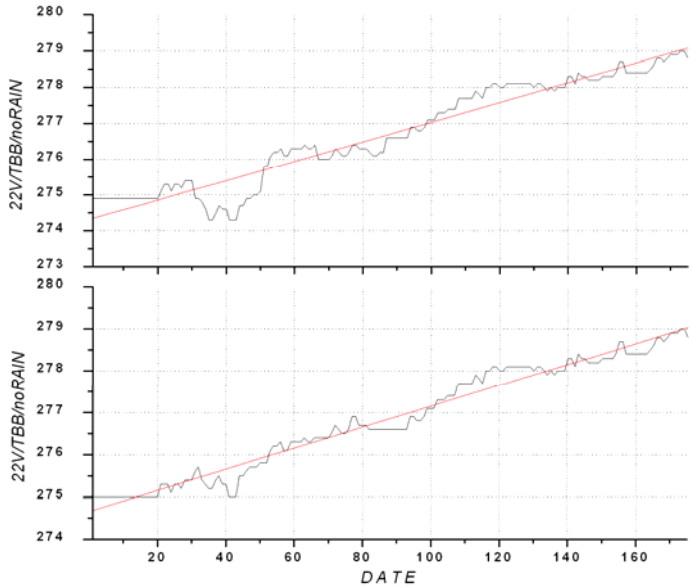


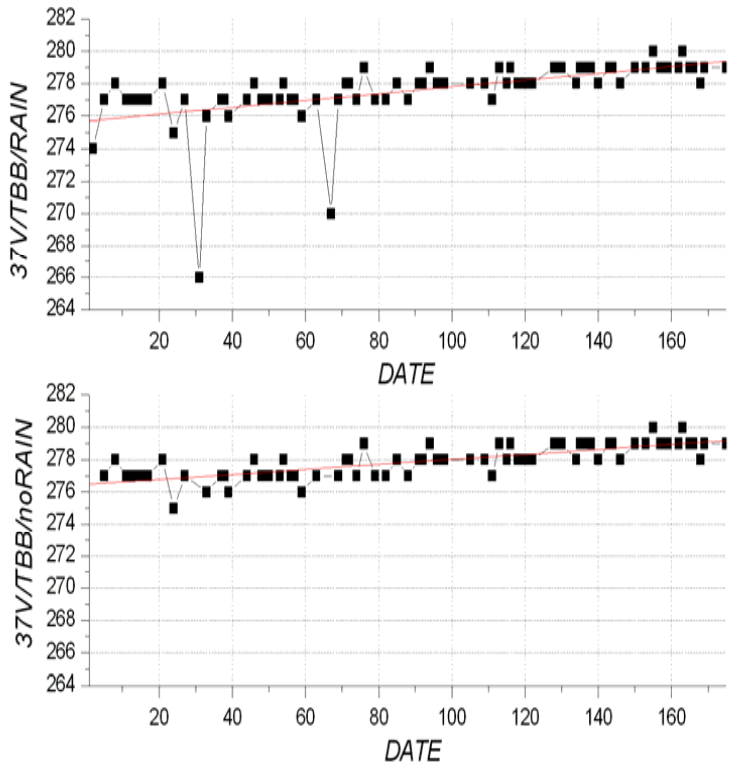
22G channel: sliding average for 20days from data of 175days.



22G channel: daily series of 175 days.



37V channel: sliding average for 20days from data of 175days.



37V channel: daily series of 175 days.

CSS
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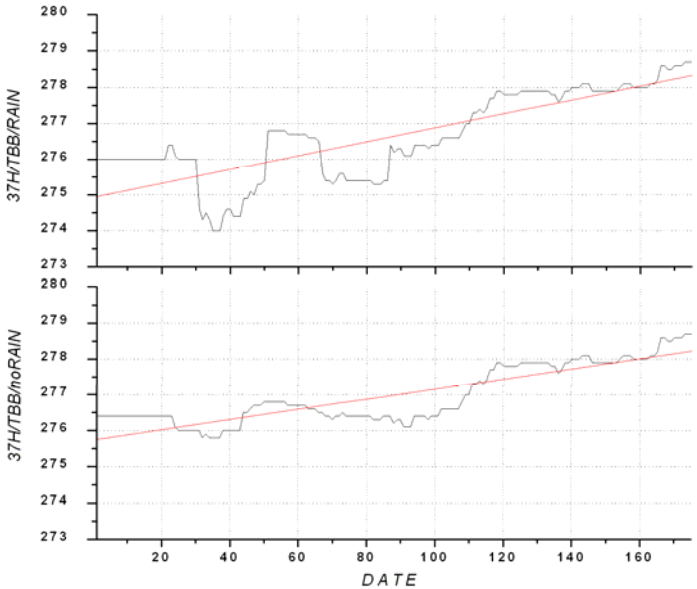
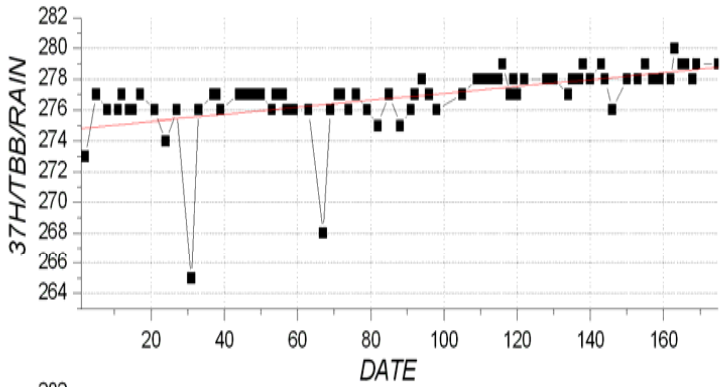
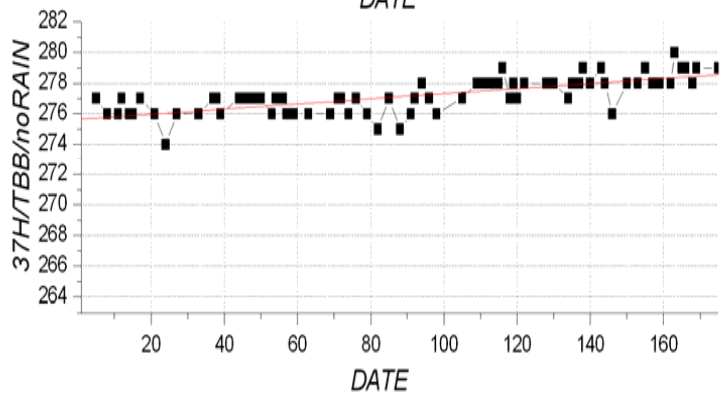


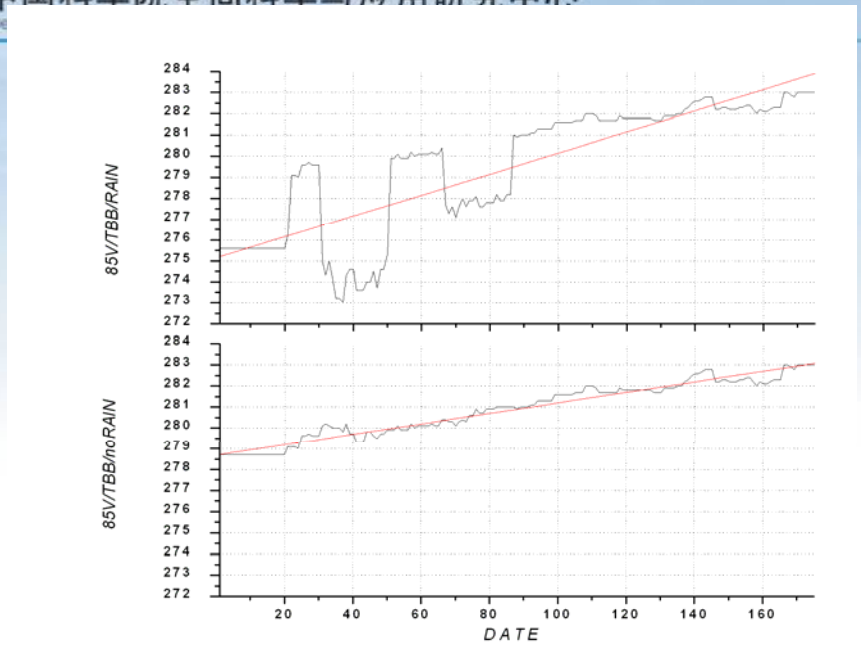
37H channel: sliding average for 20days from data of 175days.



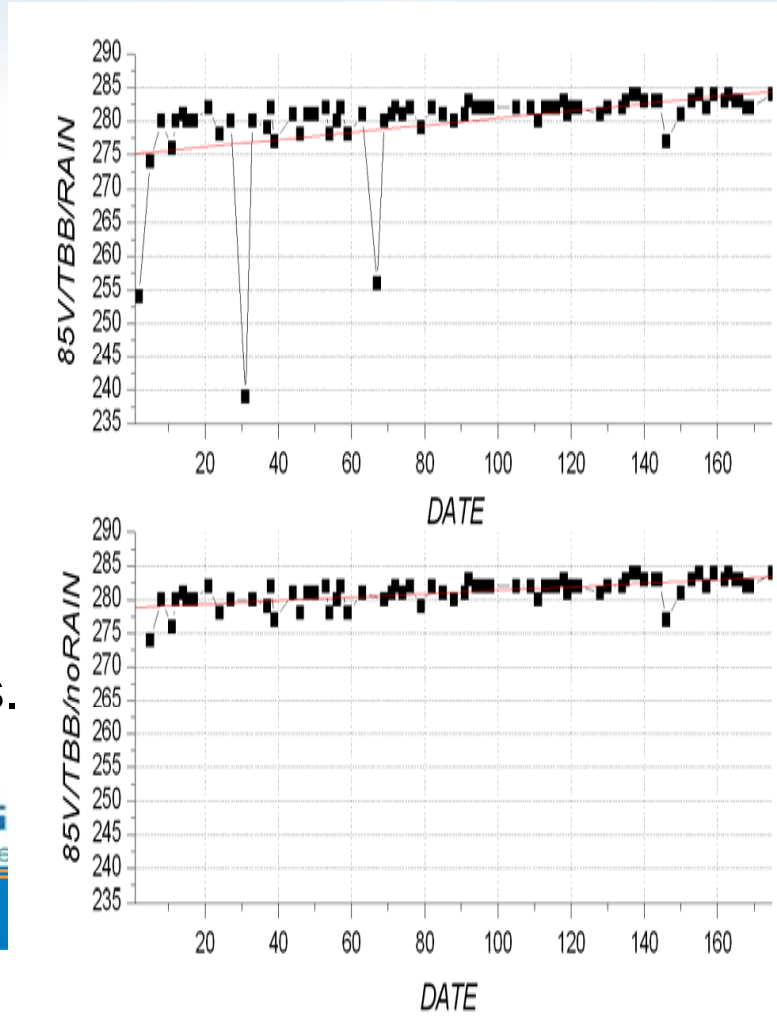
37H channel: daily series of 175 days.



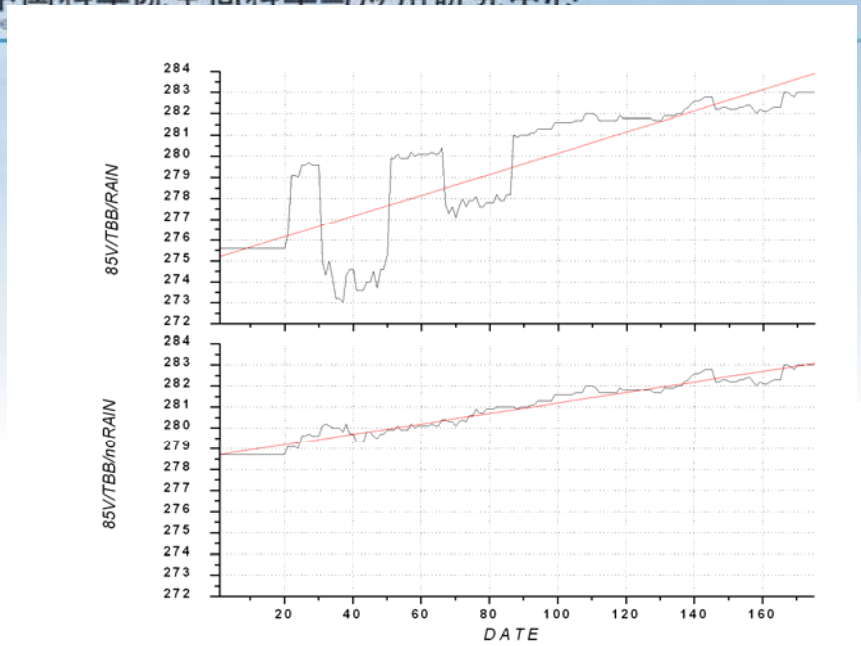
CSS
Center for Space Science and Applied Research, Chinese Academy of Sciences



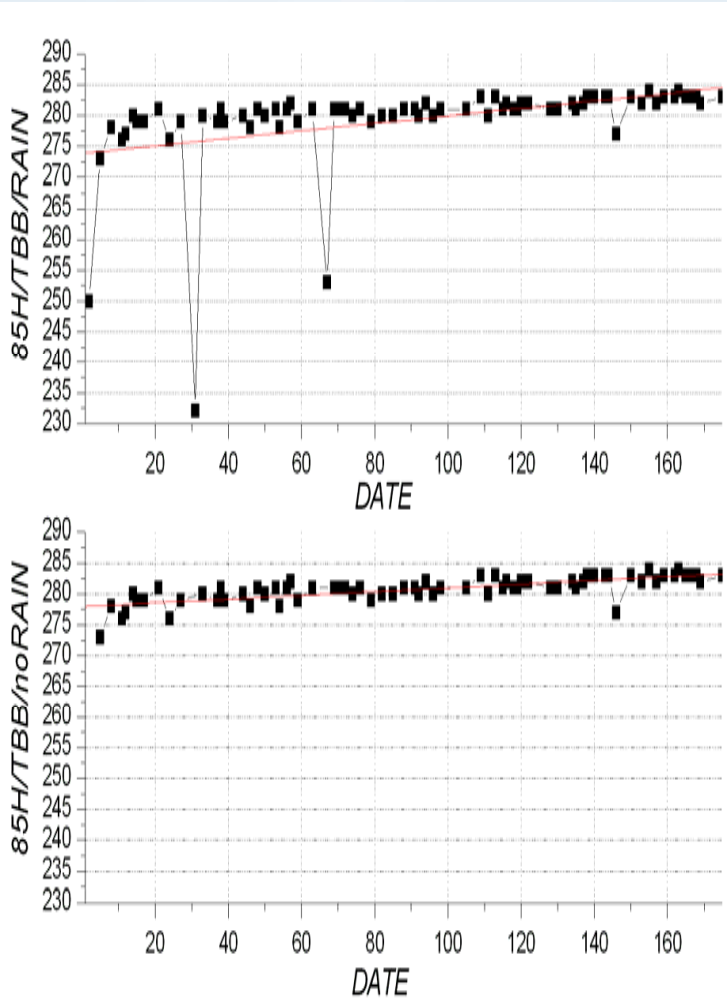
85V channel: sliding average for 20days from data of 175days.



85V channel: daily series of 175 days.

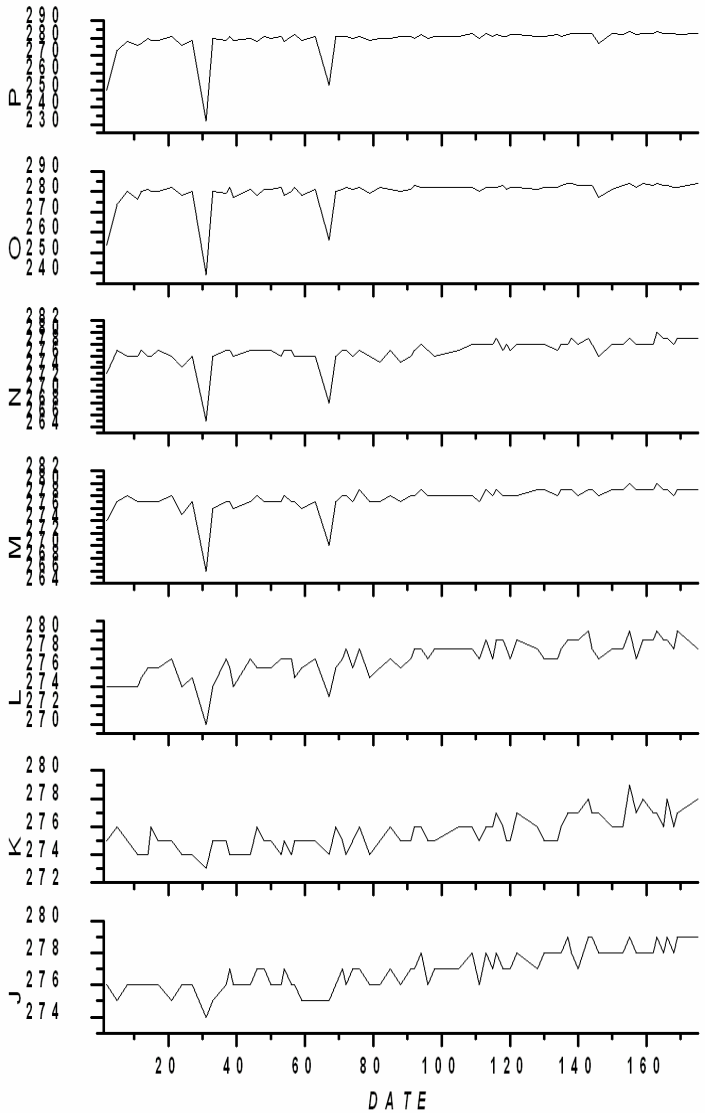


85H channel: sliding average for 20days from data of 175days.

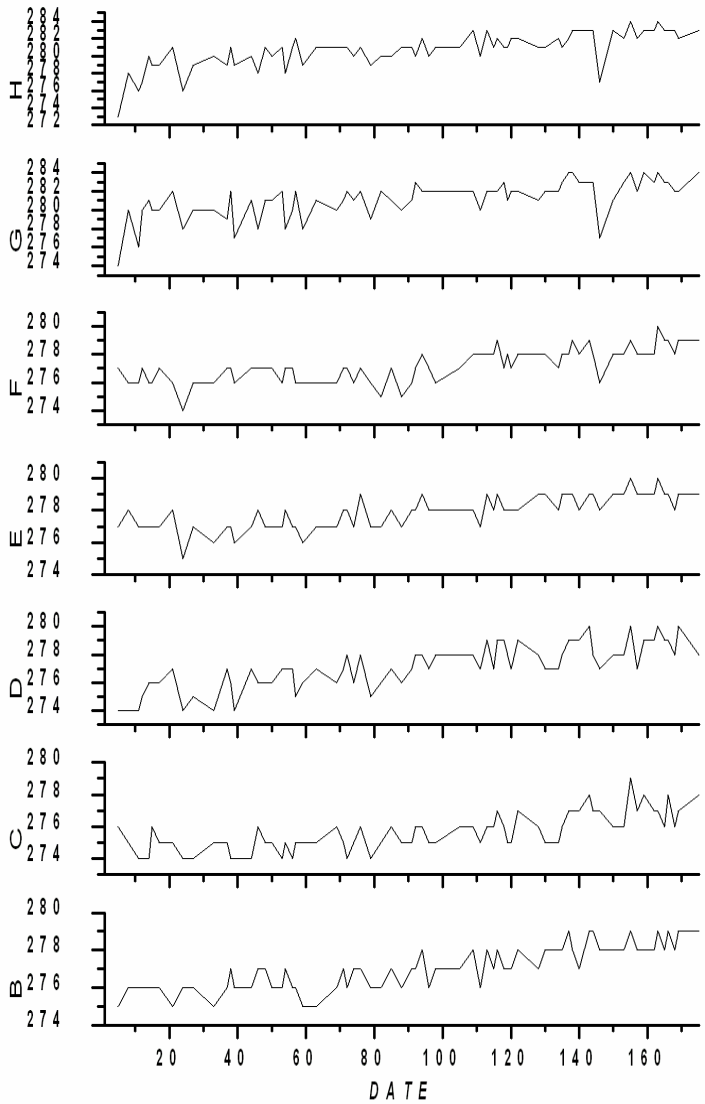


85H channel: daily series of 175 days.

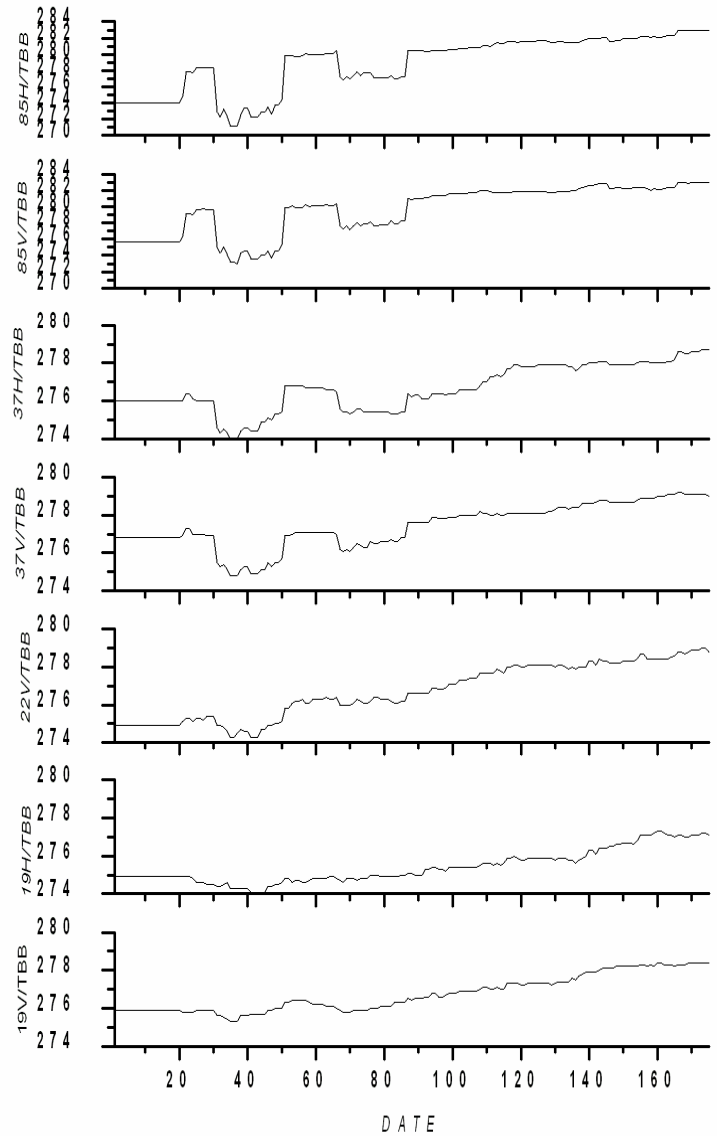
BT variation before precipitation removal



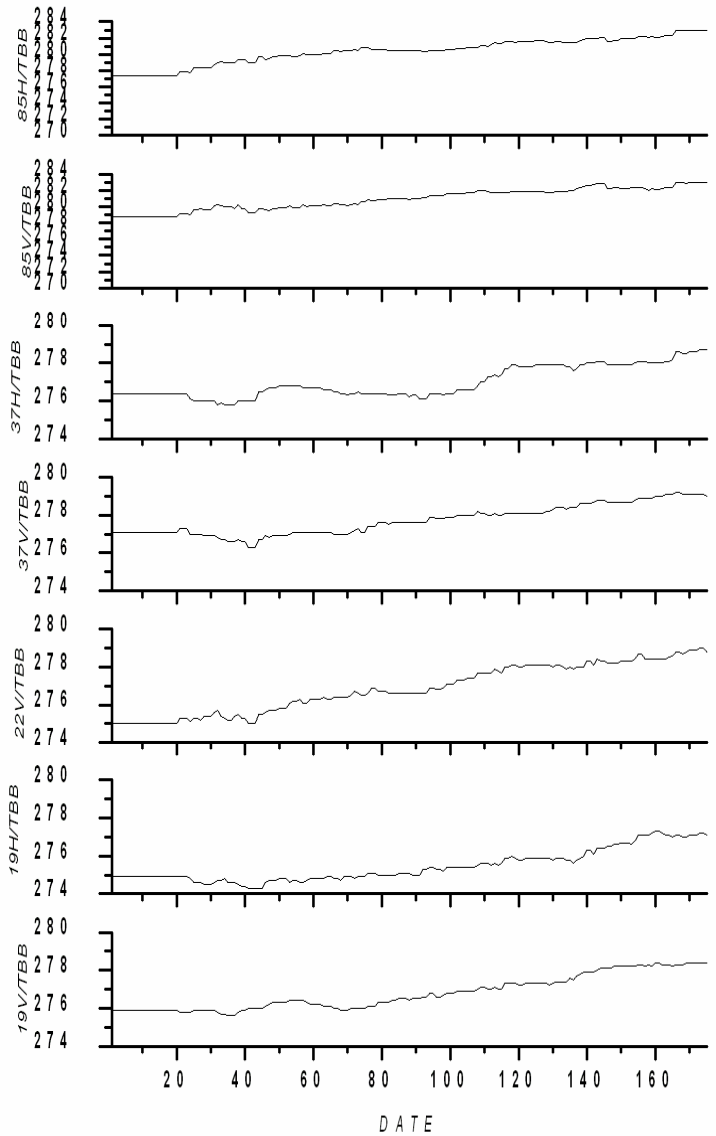
BT variation after precipitation removal



Sliding averaged (20days) BT variation before precipitation removal



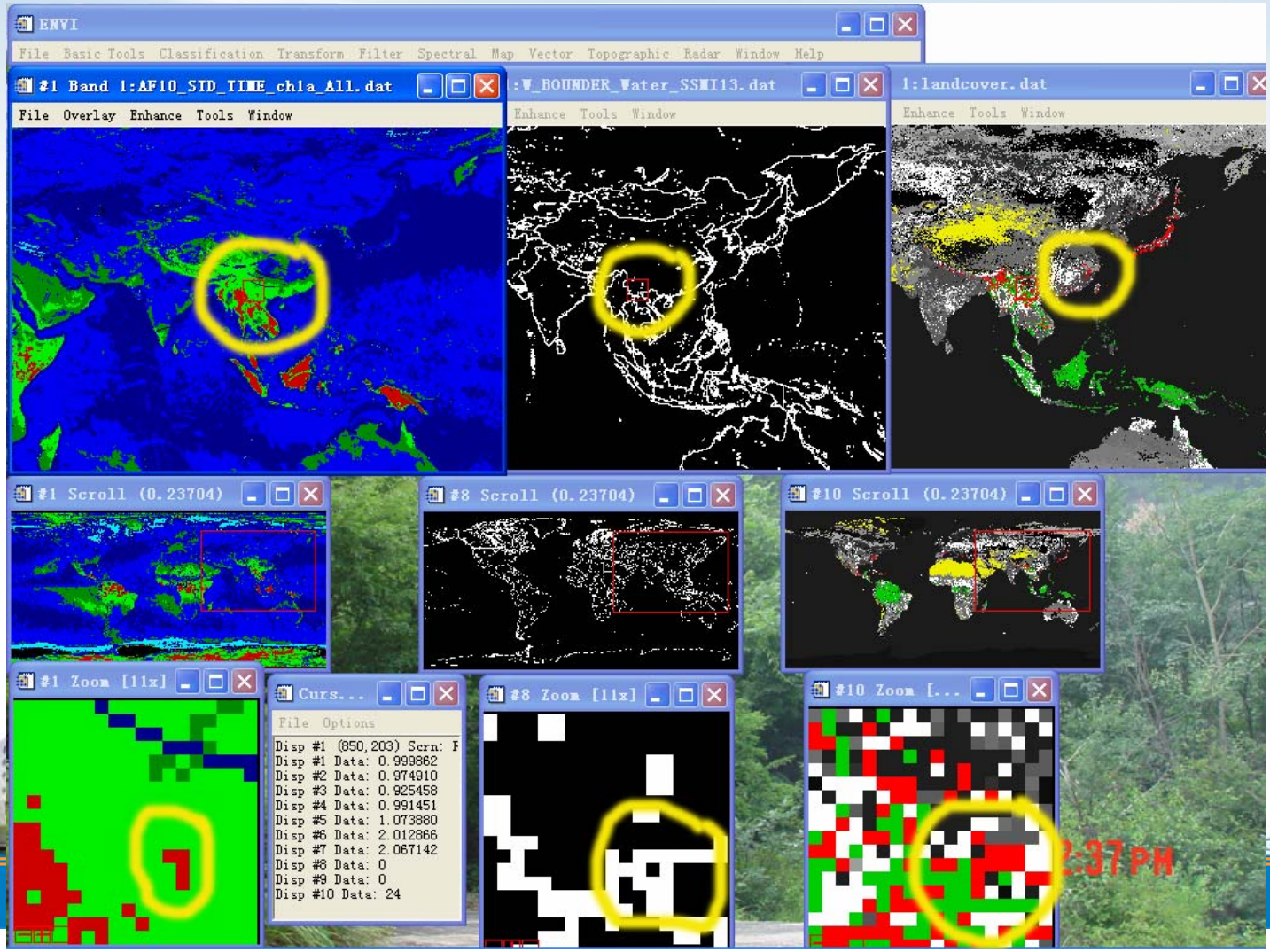
Sliding averaged (20days) BT variation after precipitation removal

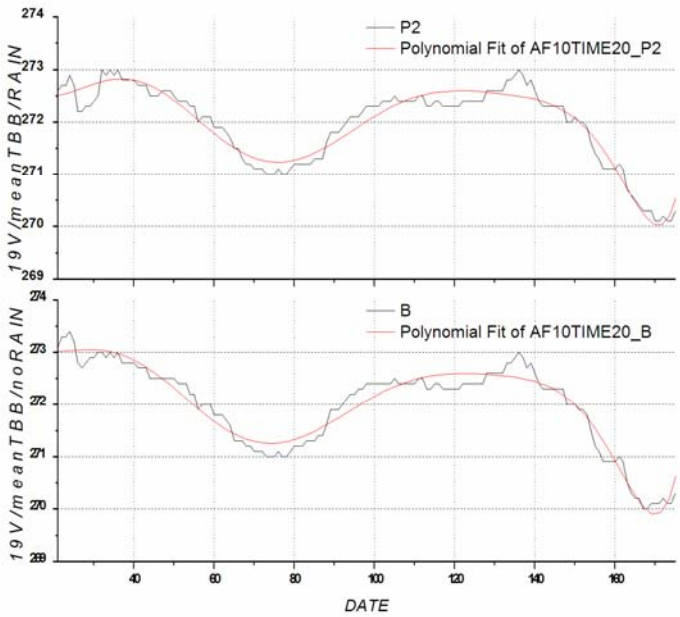


Initial Conclusions

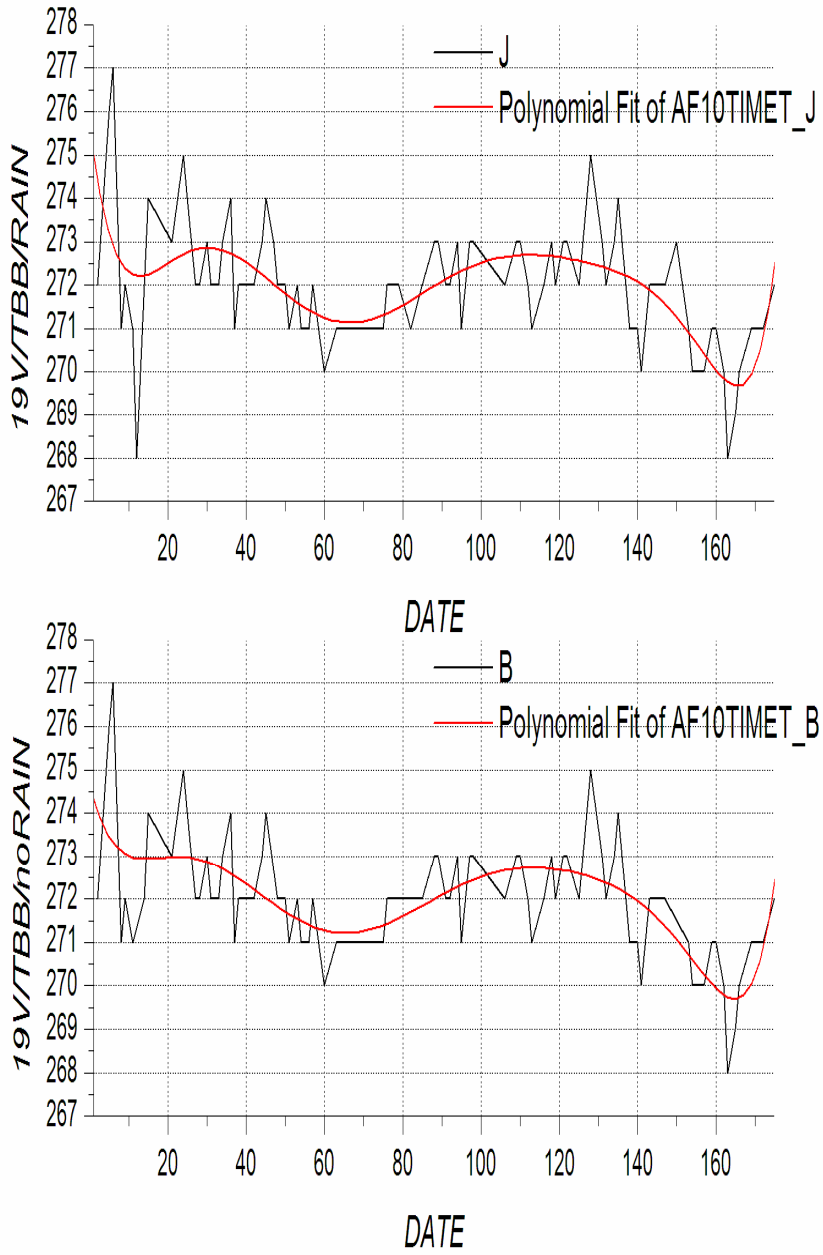
- From time series of BT image, the seasonal variations of Amazon area are very small , even for the 85GHz channels, which have the biggest variations, the lowest and highest BT difference is less than 10K;
- After sliding average of 20days, very stable (STD <0.8K) high BT target can be obtain in Amazon region.

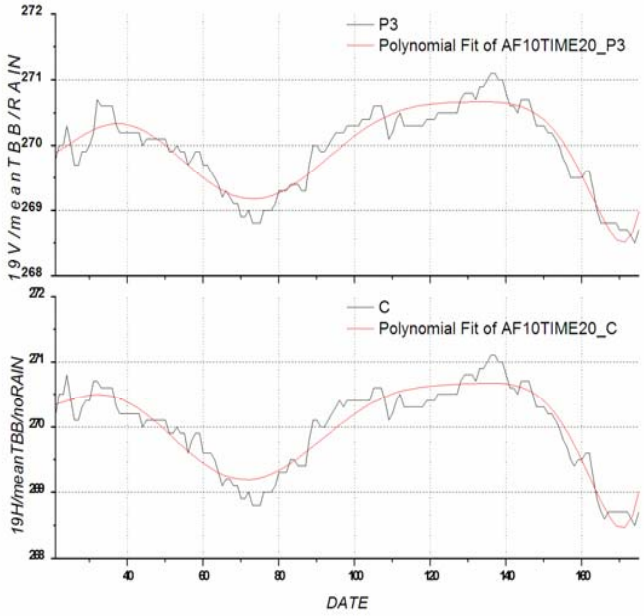
- **Location 2---Southern Yunnan Province:**



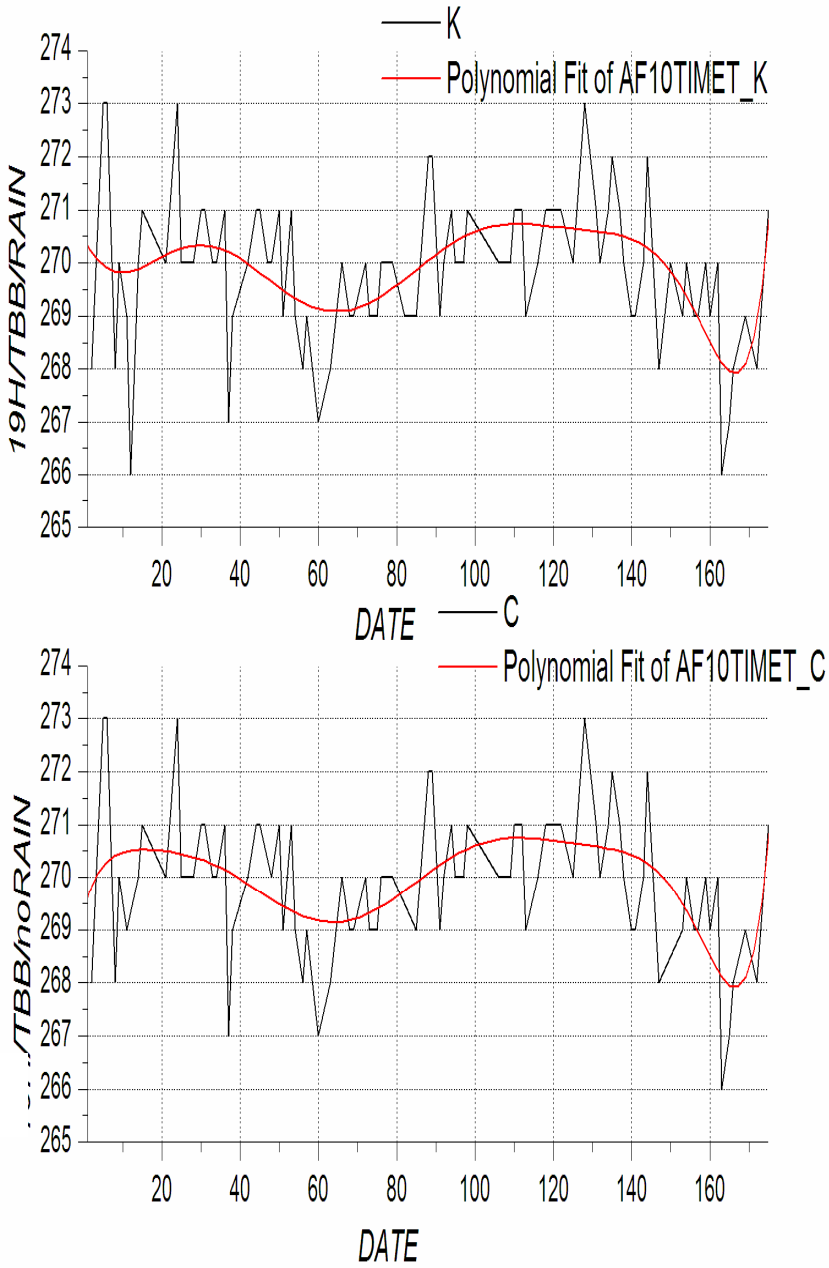


19V channel: sliding average for 20days from data of 175days.

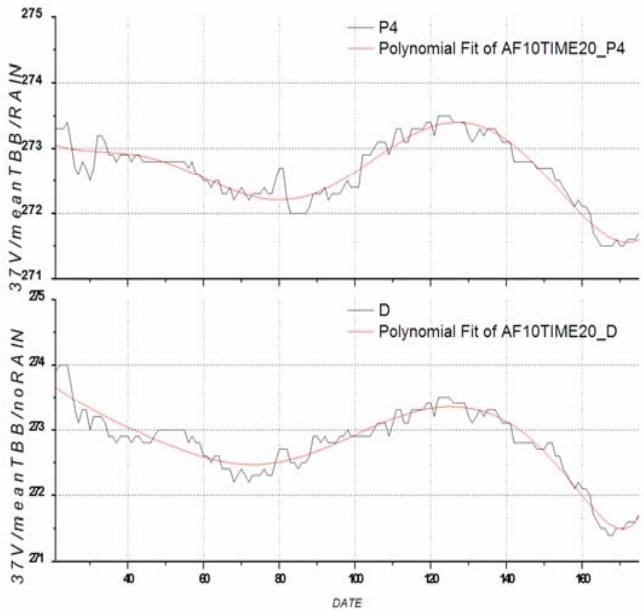




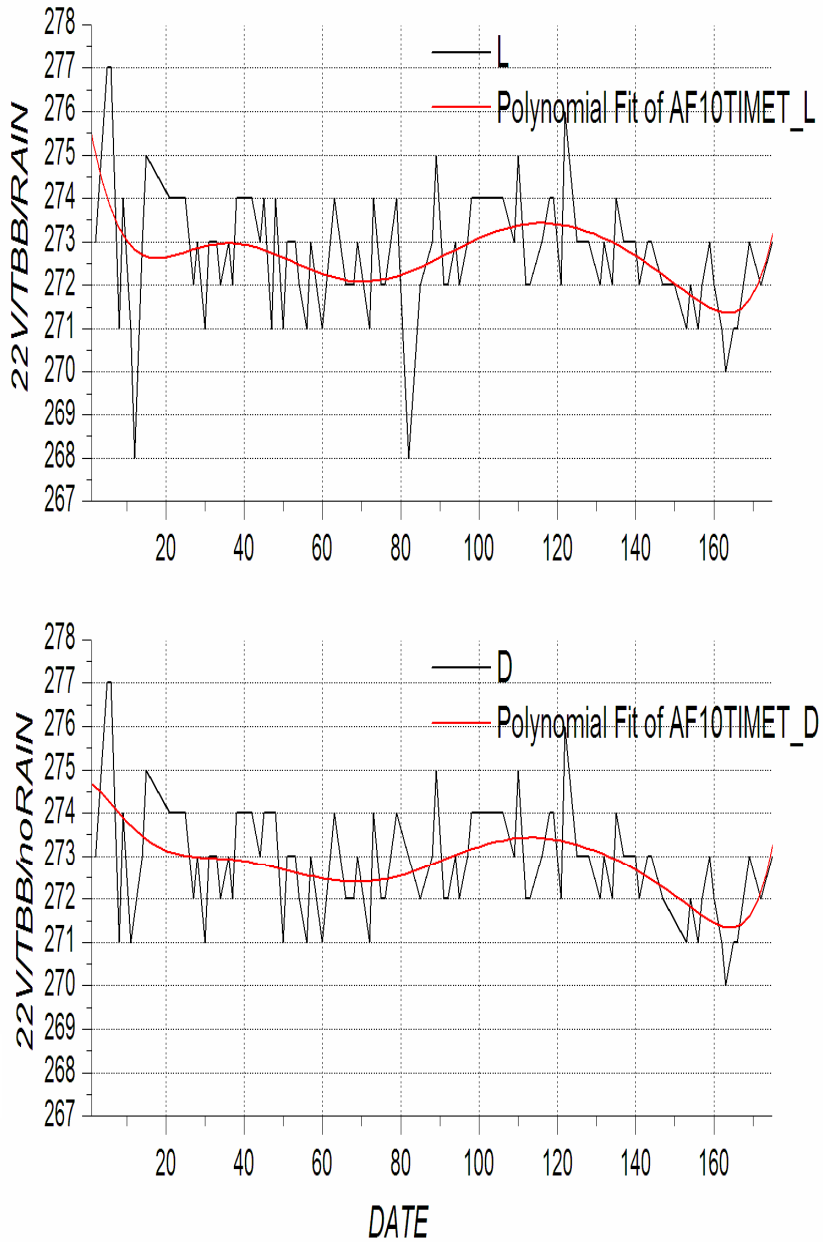
19H channel: sliding average for 20days from data of 175days.



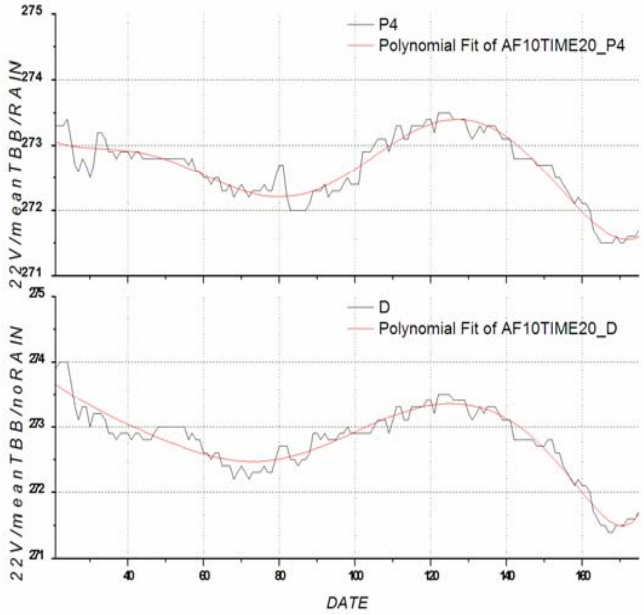
19H channel: daily series of 175 days.



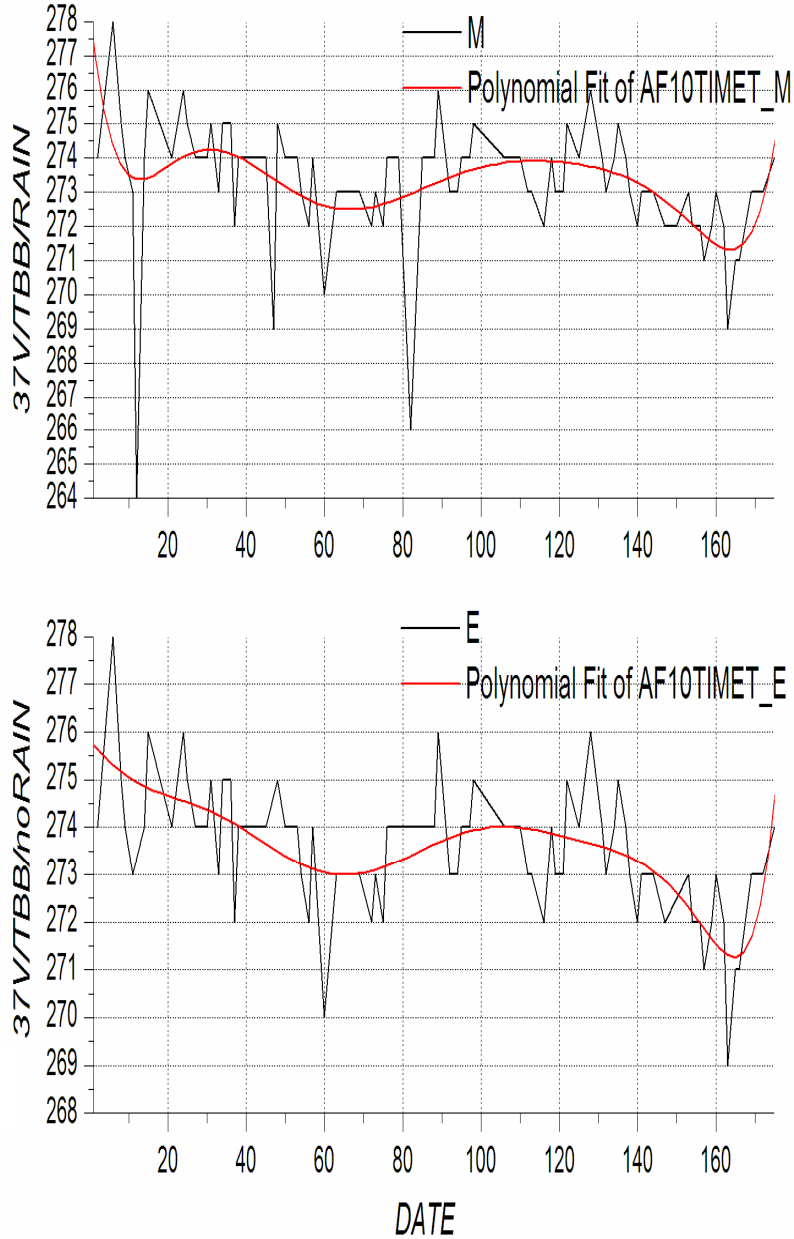
22GHz channel: sliding average for 20days from data of 175days.



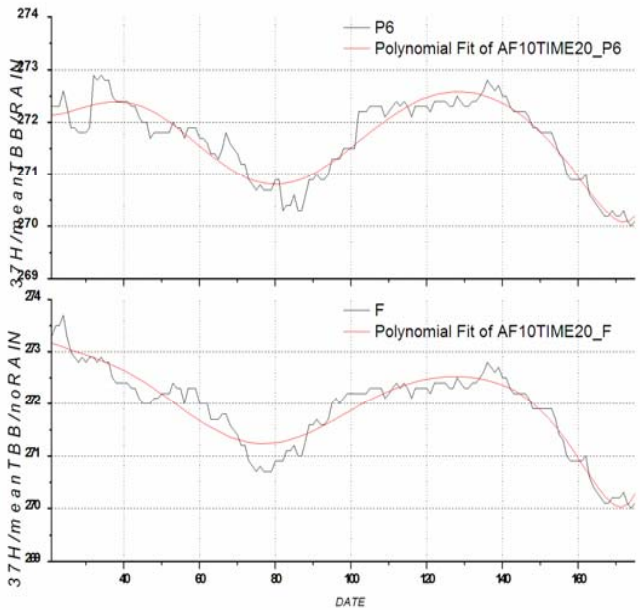
22G channel: daily series of 175 days.



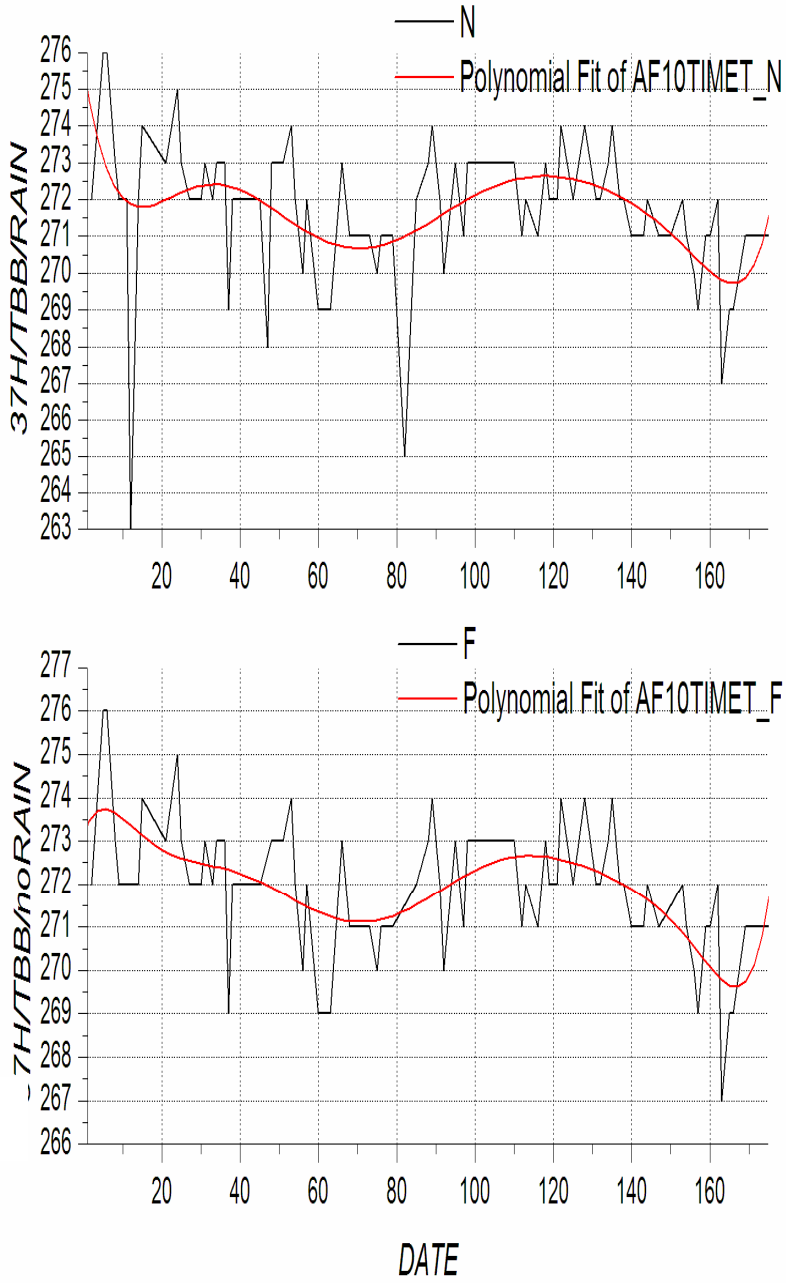
37V channel: sliding average for 20days from data of 175days.



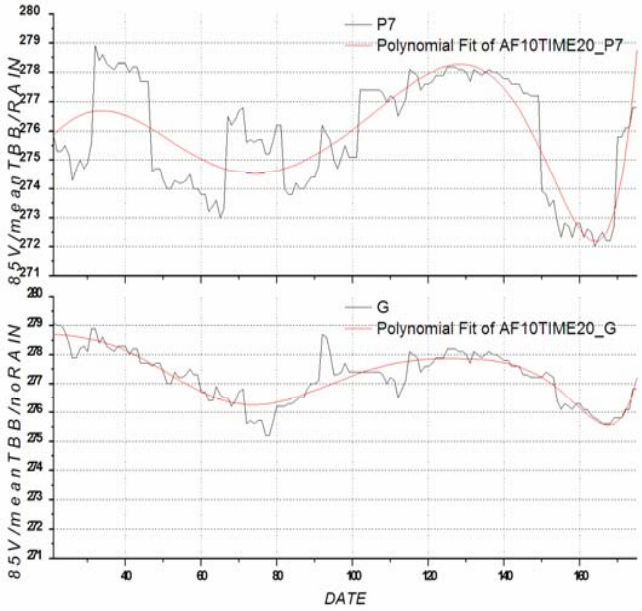
37V channel: daily series of 175 days.



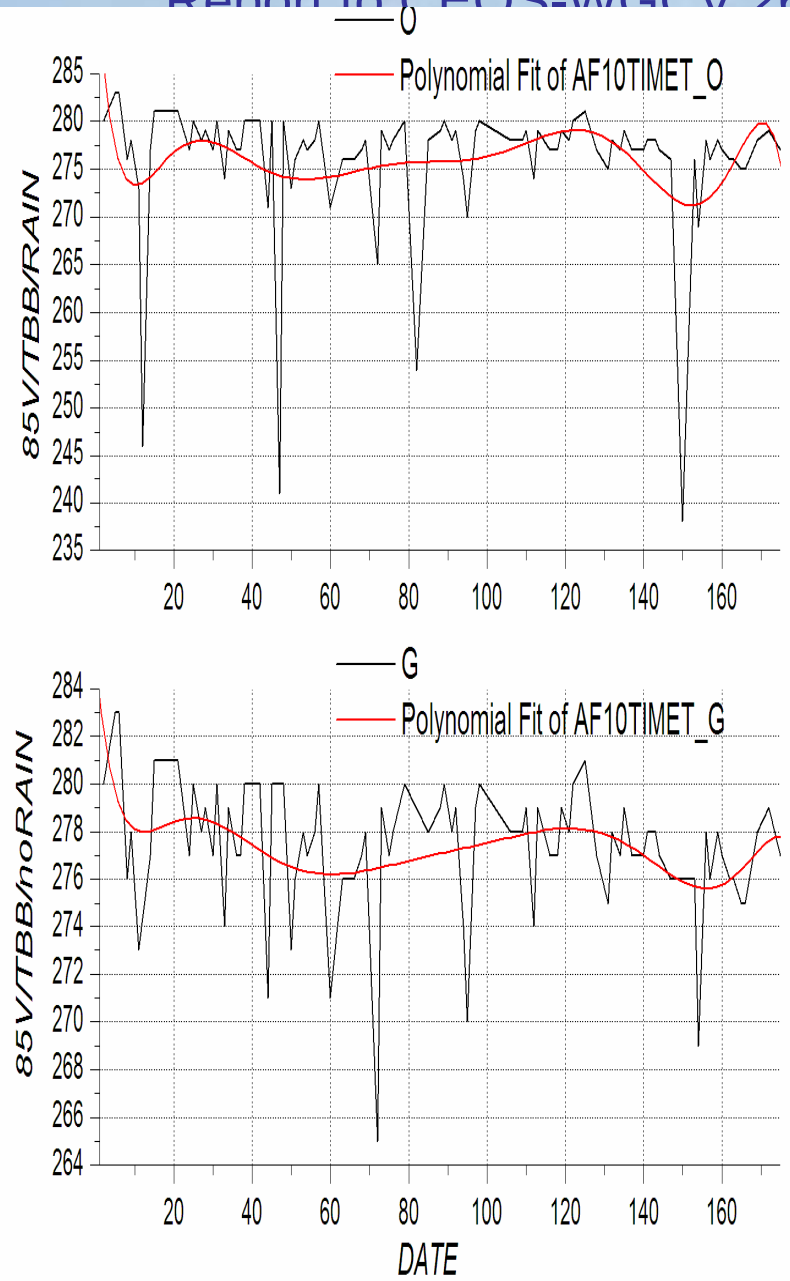
37H channel: sliding average for 20days from data of 175days.



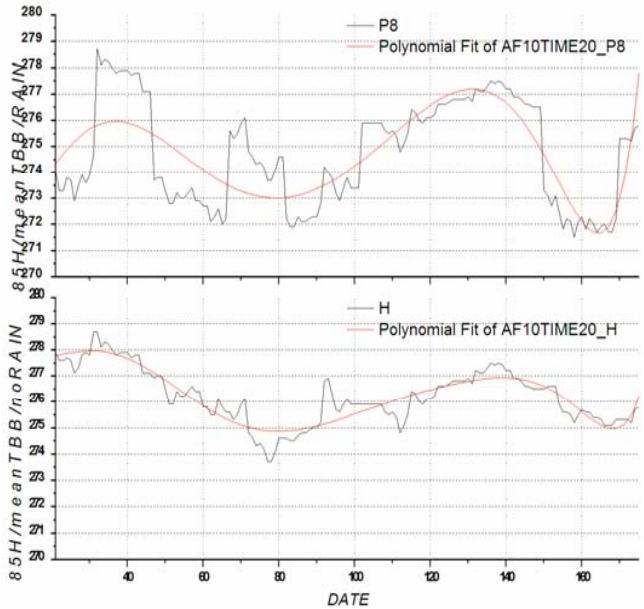
37H channel: daily series of 175 days.



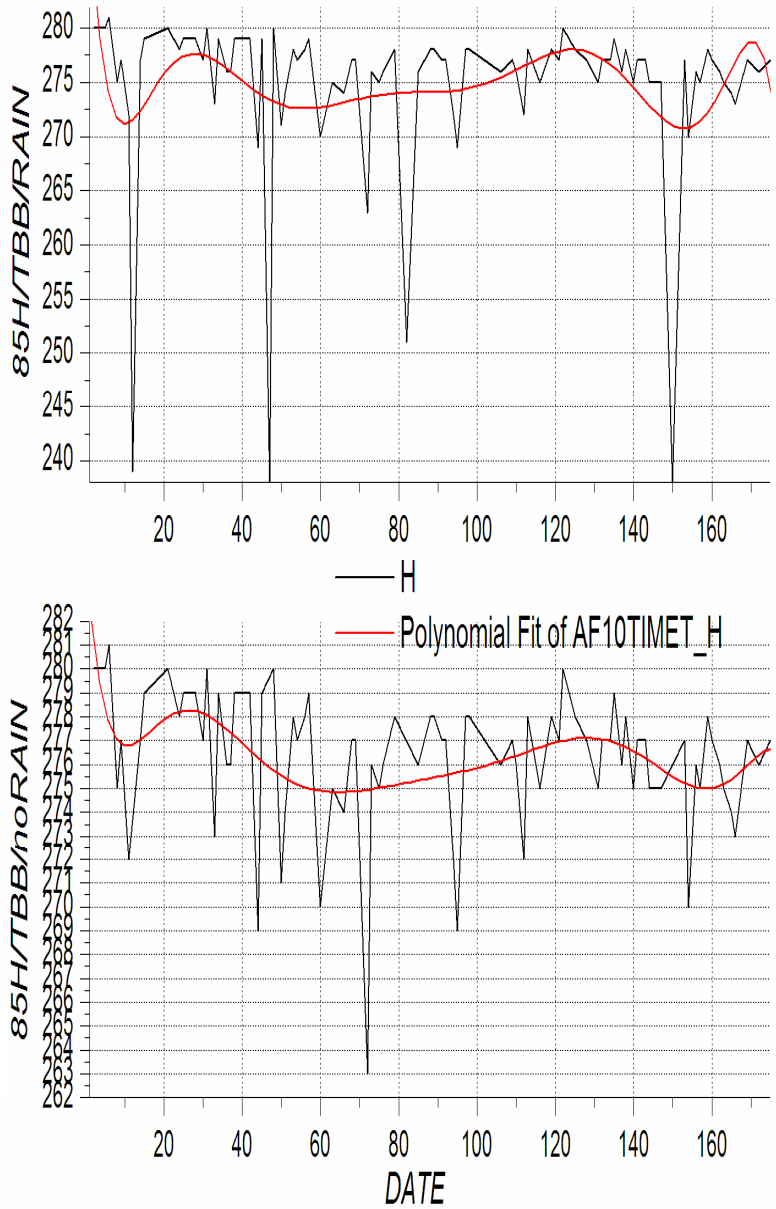
85V channel: sliding average for 20days from data of 175days.



85V channel: daily series of 175 days.

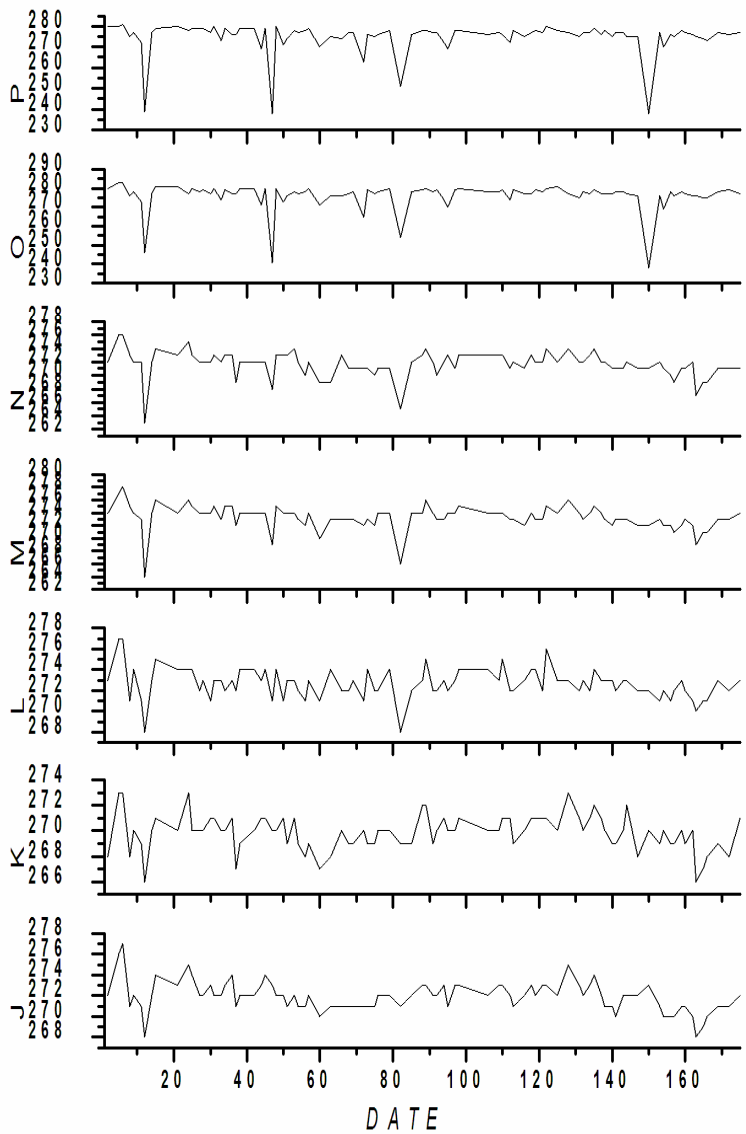


85H channel: sliding average for 20days from data of 175days.

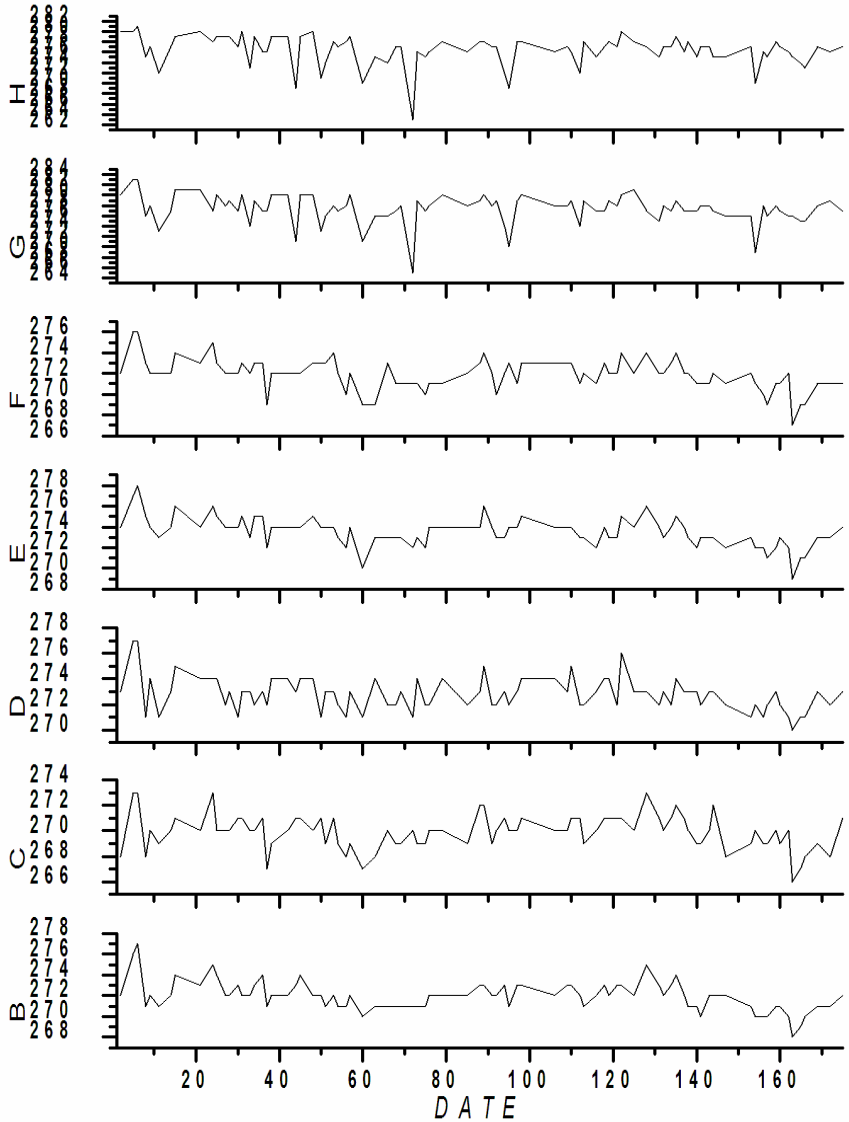


85H channel: daily series of 175 days.

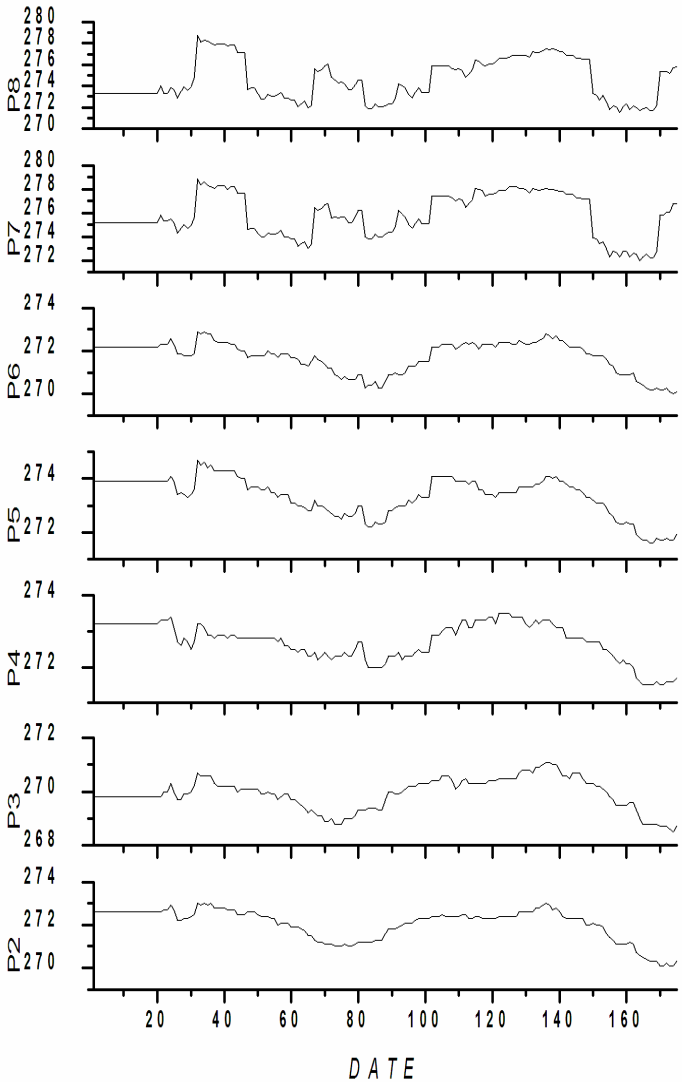
BT variation before precipitation removal



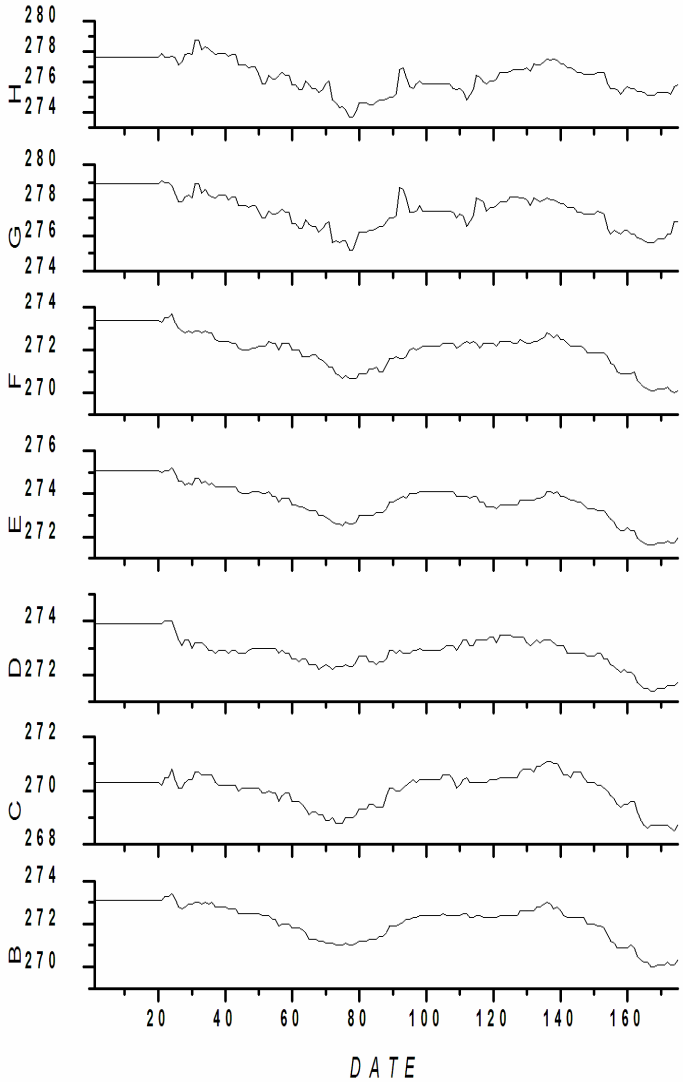
BT variation after precipitation removal



Sliding averaged (20days) BT variation before precipitation removal



Sliding averaged (20days) BT variation after precipitation removal

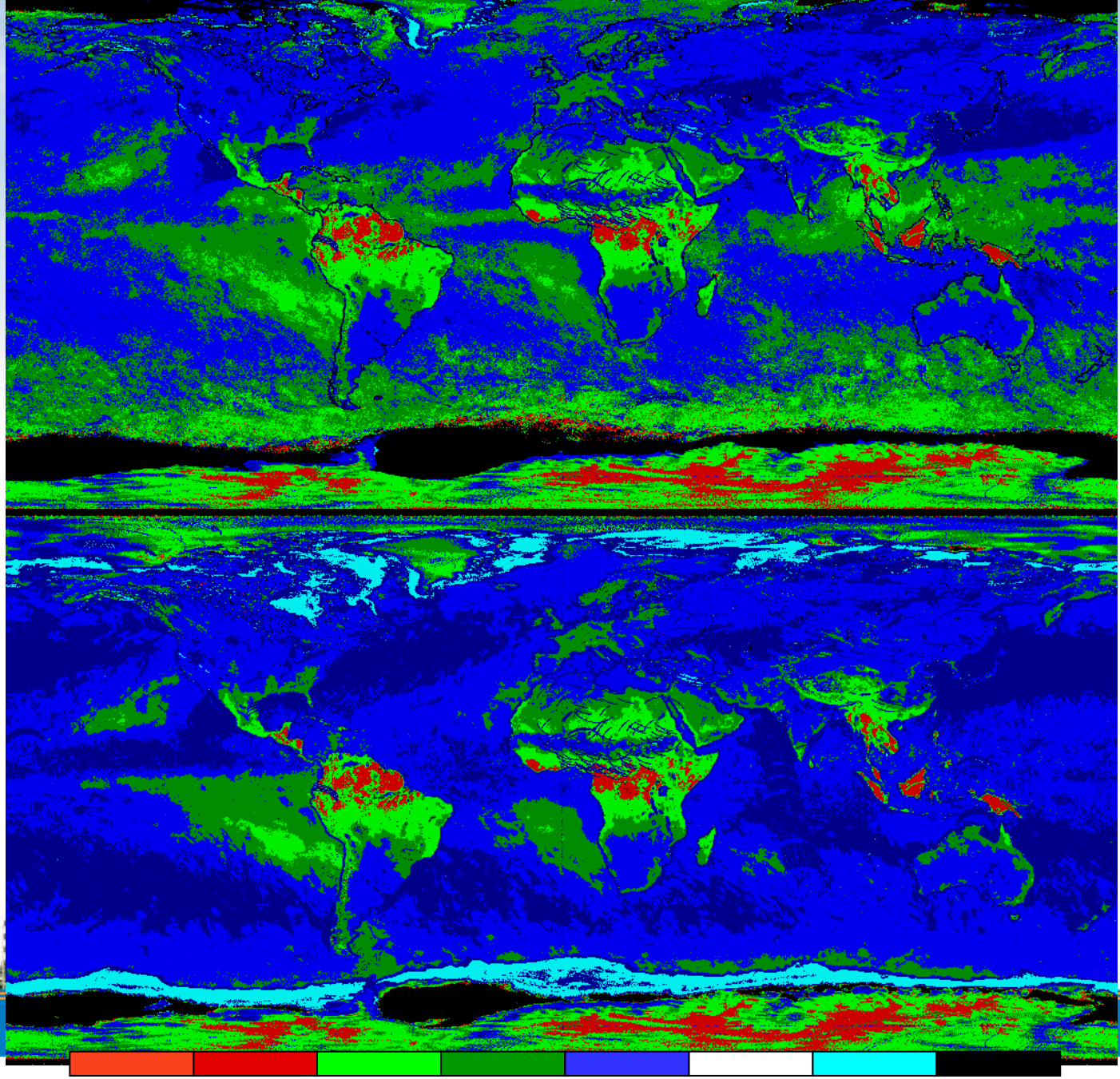


Initial Conclusions:

- From BT image time series analysis, some area of southern Yunnan Province has small seasonal variations, but the stability is less than the Amazon region;
- After sliding average, high BT target with stability about 1K can be obtained;
- With in situ sounding data corrections, high BT target with stability bettern than 1K is possible.

Standard Variation of 19V data of Ocean Surface Emission after Scattering Processing

(May-Oct, 1999: 0<SEA_wind<10m/s)



After Processing

Before Processing

Initial Conclusions

- **Even after sea surface wind speed threshold control, the stability (STD) of cold target with low BT on the ocean is twice or more than STD of Amazon region for more than one time.**

CONCLUSIONS AND SUGGESTIONS

1、**For the atmospheric transparent channels, Amazon rain forest can be very good warm target with high BT for microwave radiometry performance evaluations and validations;**

2、**Southern Yunnan Province and Coastal region of Fujian Province can be good transient calibrations sites after in situ atmospheric sounding corrections;**

3、**In Situ observation facilities are necessary to provide cold target with low BT for microwave calibration sites on the ocean.**

The end!