Report to CEOS-WGCV 25

Considerations about CAL/VAL Sites Construction for Spaceborne Microwave Remote Sensors

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Outline

I. Recent Progresses of the Earth Observation Programs with Spaceborne Microwave Remote Sensors

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

I. Recent Progresses of the Earth Observation Programs with Spaceborne Microwave Remote Sensors

1. Introduction to China's earth observation satellites with microwave sensors
2. Meteorological Satellite Series
3. Environment and Disaster Monitoring Satellite Series
4. Oceanic Environment Monitoring Satellite Series

I.1 Introduction to China's Earth Observation Programs with Spaceborne Microwave Sensors

- **China's Earth Observation Satellites Series**
  - **FY-Series**
  - **HY-Series**
  - **HJ-Series**
  - **ZY-Series**

FY-Series

- FY, abbreviation of "FengYun" (wind and cloud in Chinese)
- meteorological satellite series, include the polar-orbit and geostationary-orbit satellite.
  - FY-odd number (1,3,…): Polar orbit
    - Optical, infrared sensors
    - Microwave/mmw sensors from FY-3
  - FY-even number(2,4,…): Geostationary Orbit
    - Optical, infrared sensors
    - Microwave/mmw sensors are considered for FY-4

HY-Series

- HY, abbreviation of “HaiYang” (ocean in Chinese)
- sea satellite series
  - HY-1, ocean color sensors
    - Optical and infrared imager
    - Archived data open to public
  - HY-2, ocean dynamic environment measurement
    - Radar altimeter, radar scatterometer, microwave imager
  - HY-3, ocean environment monitoring
    - SAR

HJ-Series

- HJ, abbreviation of "HuanJing" (environment in Chinese)
- earth observation small satellite constellation for environment and disaster monitoring
  - HJ-1A,1B
    - optical and infrared imager
  - HJ-1C
    - S-band SAR

ZY-Series

- ZY, abbreviation of “ZiYuan” (resources in Chinese)
- optical and infrared imaging satellite series for earth observation, emphasis on land monitoring.
  - ZY
  - CBERS

I.2 Meteorological Satellite

- **FY-3**
  - **Flight model completed recently**
  - **Ready for launch in 2006**
  - **Scheduled to be launch in 1st half of 2007**
- **FY-4**
  - **Sensor development started in 2006**
  - **Satellite development begin by the end of the 11th five-year-plan (2010)**

microwave temperature sounder onboard FY-3

Channel	1	2	3	4
Central Frequency (GHz)	50.3	50.595±0.115	54.940	57.290
Absorption Atmospheric Components	Transparent Window	O2	O2	O2
Bandwidth (MHz)	180	2×170	400	330
Radiometric Sensitivity (K)	0.5	0.4	0.4	0.4
Dynamic Range (K)	3-340	3-340	3-340	3-340
Absolute Calibration Accuracy (K)	1.2	1.2	1.2	1.2

microwave humidity sounder onboard FY-3

Channel	1	2	3	4	5
Central Frequency (GHz)	150 (v-pol)	150 (H-pol)	183±1	183±3	183±7
Absorption Atmospheric Components	Transparent Window	Transparent Window	H_2O	H_2O	H_2O
Bandwidth (MHz)	1000	1000	500	1000	2000
Radiometric Sensitivity (K)	0.9	0.9	1.1	0.9	0.9
Dynamic Range (K)	3-340	3-340	3-340	3-340	3-340
Absolute Calibration Accuracy (K)	2.0	2.0	2.0	2.0	2.0

microwave imager onboard FY-3

Channel	1	2	3	4	5
Central Frequency (GHz)	10.65	18.7	23.8	36.5	89
Bandwidth (MHz)	180	200	400	900	4600
Radiometric Sensitivity (K)	0.5	0.5	0.8	0.5	1.0
Dynamic Range (K)	3-340	3-340	3-340	3-340	3-340
Absolute Calibration Accuracy (K)	1.0	2.0	2.0	2.0	2.0

Preliminary considerations about the MMW/subMMW sensors for FY-4

- **Atmospheric humidity sounding:**
  - **183.310GHz（±0.3GHz，0.9GHz，1.65GHz，3.0GHz，5.0GHz，7.0GHz）;**
  - **380.97GHz（±0.4GHz，1.5GHz，4.0GHz，9.0GHz）;**
- **Transparent windows: 150GHz，220GHz，340GHz;**
- **Atmospheric temperature sounding:**
  - **118.750GHz（±0.4GHz，0.7GHz，1.1GHz，1.5GHz，2.1GHz，3.0GHz，5.0GHz）;**
  - **424.763GHz（±0.3GHz，0.6GHz，1.0GHz，1.5GHz，4.0 GHz）;**
- **Antenna type: real aperture (diameter 2-3 meters), mechanical scan**

I.3 HJ-1C Satellite

- S-band SAR
  - Flight model completed and ready for launch in 2006
  - Scheduled to launch before 2007
- 2 observation modes
  - The normal observation mode: SCANSAR-right side continuous strip imaging mode;
  - The default observation mode: fix narrow strip imaging mode (single look imaging).

S-band SAR onboard HJ-1C

Central Frequency	3200MHz
Bandwidth	60MHz
Pulse width	>30μs
PRF	2600Hz～3050Hz
Average RF power	>250W
Minimum σ°	<-20dB
Dynamic range	>60dB
Radiometric Sensitivity	<3dB
Spatial Resolution	<20m（4Looks/distance direction） <5m（Single Look）（default mode）
Swath	100km 40km（default mode）

I.4 HY-2 Satellite

- China's first comprehensive microwave remote sensing satellite for oceanographic applications
  - Payload and satellite development: 2006-2008.
  - Preliminarily scheduled to launched in 2009.
- Sensors
  - Radar altimeter: C-band, Ku-band
  - Radar scatterometer: Ku-band
  - Microwave Imager

Dual Frequency RA onboard HY-2

Frequency (GHz)	13.58, 5.25	Pulse Width (μs)	102.4
Pulse Compression Ratio	33000	Sea Surface Height Precision (cm)	4 (after correction)
Significant Wave Height Precision (m)	<10% or 0.5m	Significant Wave Height Range (m)	0.5~20(after post-processing)
Backscattering Range (dB)	-25~+35	Backscattering Precision (dB)	0.5
LF Bandwidth (MHz)	Ku: 320/80/20 (Adaptive selection) C: 160		
Peak Power (W)	20W	PRF (kHz)	1~4
Ground footprint (km)	16	Antenna Dimension (m)	1.4
Polarization	VV	Antenna Gain (dB)	Ku: >43; C:>35

Radar Scatterometer onboard HY-2

Frequency (GHz)	13.255	Pulse Width(ms)	0.65~1.2
LF Bandwidth(MHz)	3~6	Polarization	HH, VV
Backscattering Range (dB)	-40~+20	Backscattering Precision (dB)	0.5
Wind Speed Range (m/s)	2~24 (after processing)	Wind Speed Precision (m/s)	2 (after processing)
Wind Direction Range (º)	0~360	Wind Direction Precision (º)	20
Swath Width (km)	>1400		
Peak Power (W)	120W	PRF (Hz)	100~200
Ground Resolution (km)	25~35	Antenna Dimension (m)	1.3

Microwave Imager onboard HY-2

Frequency (GHz)	6.6	10.7	18.7	23.8	37
RF Bandwidth (MHz)	350	250	250	400	1000
Polarization	V,H	V,H	V,H	V	V,H
BT Sensitivity(K)	0.5	0.5	0.5	0.5	0.8
Calibration Precision	1K@180~320K				
Swath Width (km)	1600				
Ground Resolution(km)	100	62	36	30	18
Dynamic Range (K)	3~350				
Receiver Linearity	>0.999				
Main Beam Coefficient	>95%				
Scanning Mode	Conically				

II. 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
4. CAL/VAL over the Takelimgan Desert

II.1 Introduction

- **As the implementation of earth observation program with microwave sensors, preparation for CAL/VAL sites selection and consideration had been started;**
  - **Some researches had been conducted since 2004:**
  - **Selection of land sites**
  - **Selection of ocean sites**

II.2 CAL/VAL sites on land

(Information provided by

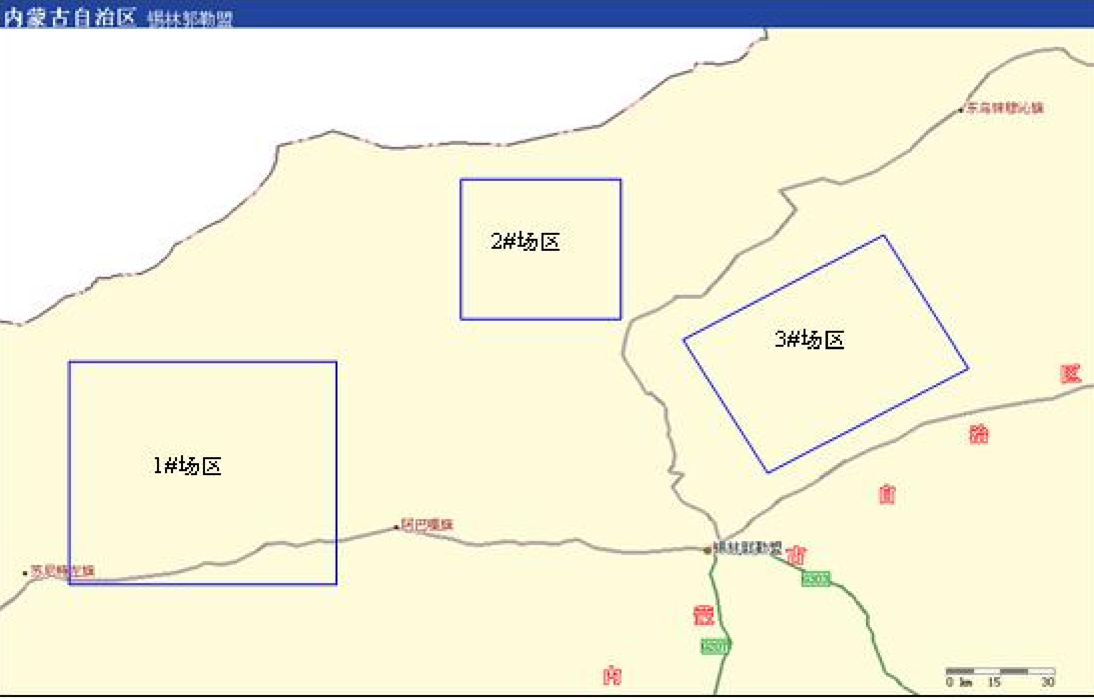
Dr. Hu YANG & Dr. Naimeng LU from CMA)

Site Research

DUNHUANG Gobi, Gansu Province

Etuoke,

Inner Mongolia



Su’nite

Inner Mongolia

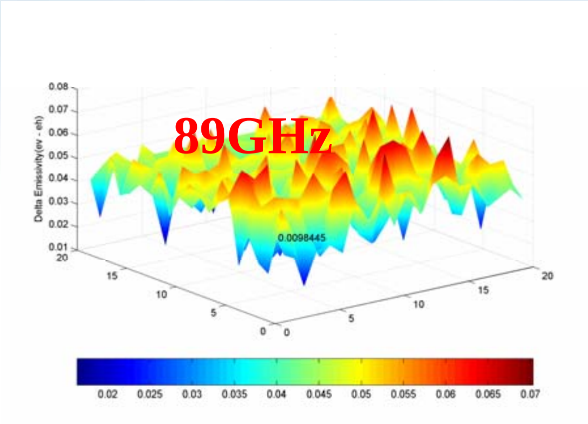
Alukerqin

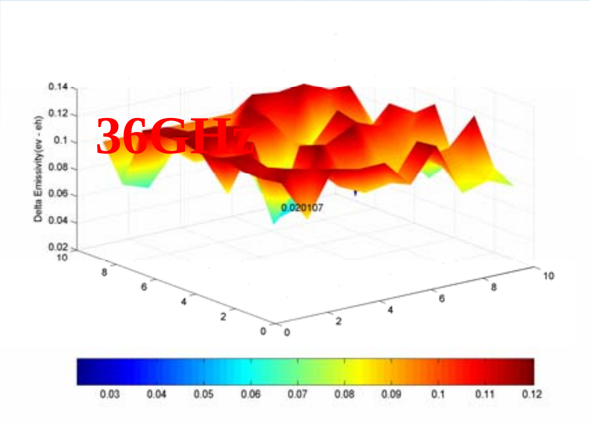
Inner Mongolia

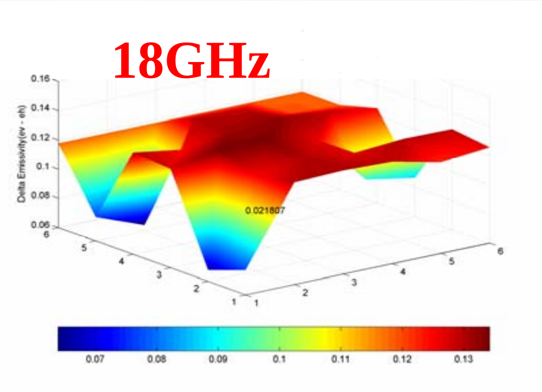
Polarization difference for the emissivity with different frequencies

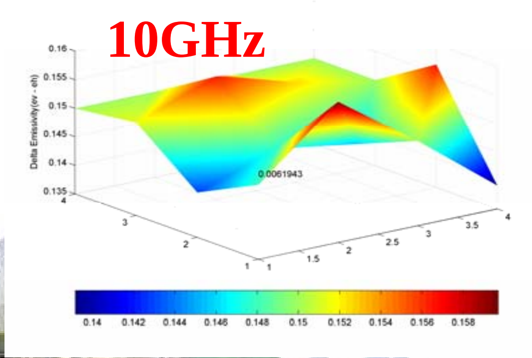
Takelimgan Desert

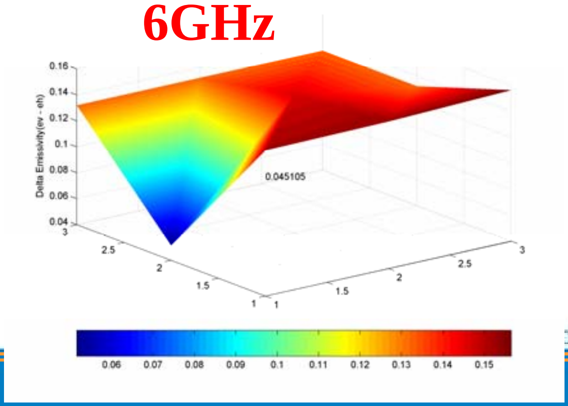
Location: N[40 39]; E[82 83] **Area: 100x100km**





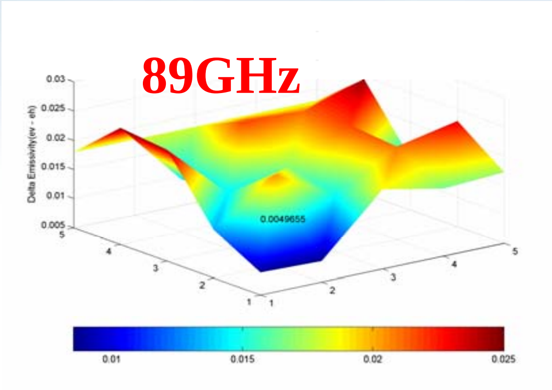


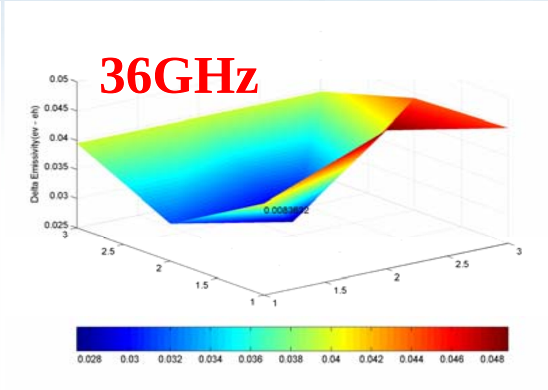


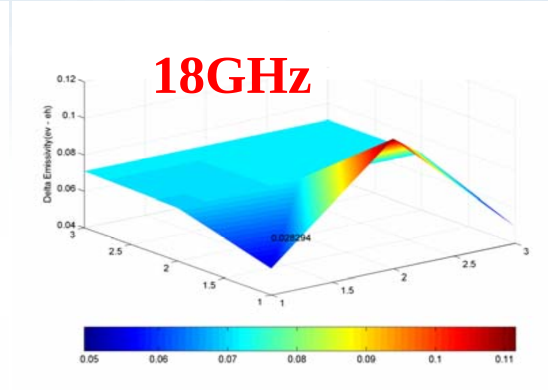


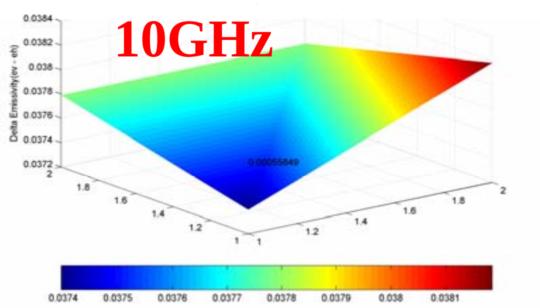
Dunhuang

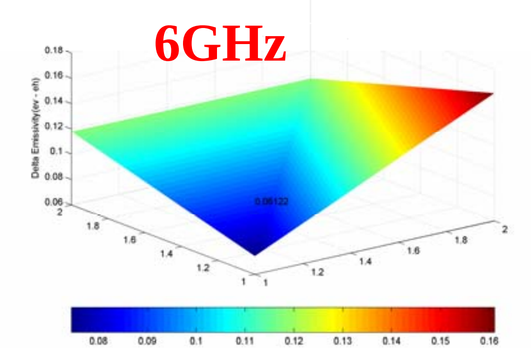
Location: N [40.25 40.08], E [94.20 94.40]   Area: 30x30km







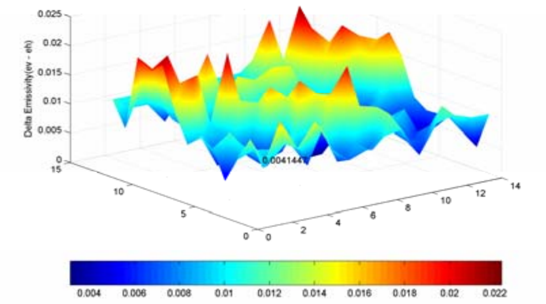




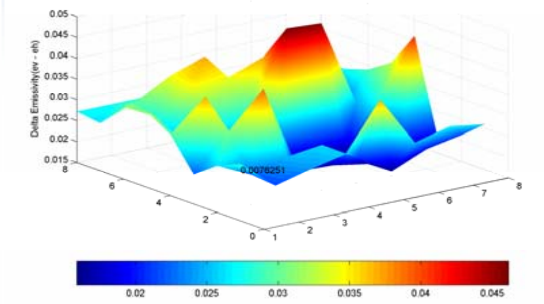
Etuoke

Location: N [39.65 39.13]E [107.18 107.85]   Area: 70x70km

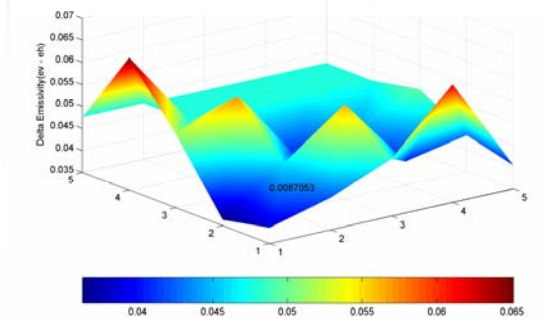
89GHz



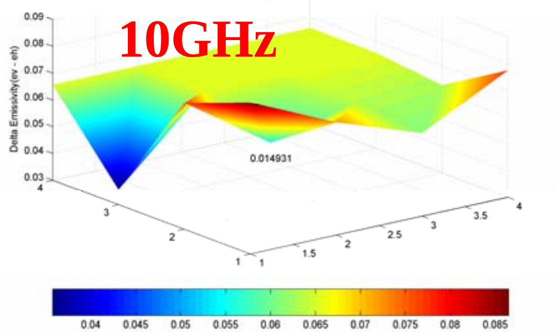
36GHz



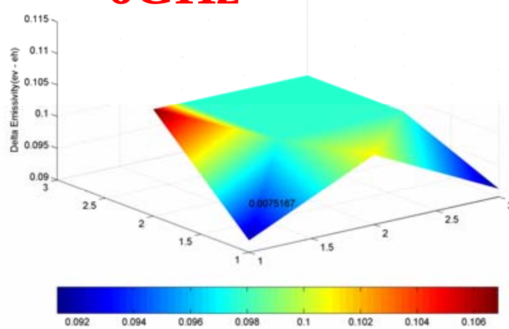
18GHz



10GHz



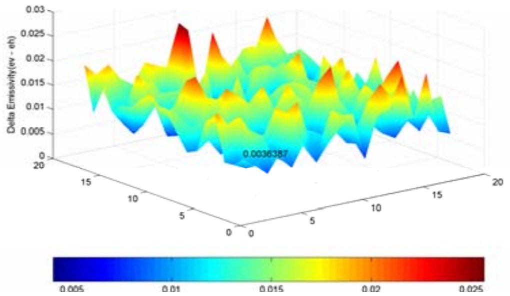
6GHz



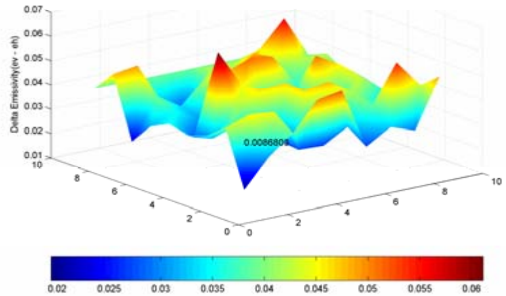
Su'nite

Location: N [44.50 43.75]E[113.63 114.62] **Area: 70x70km**

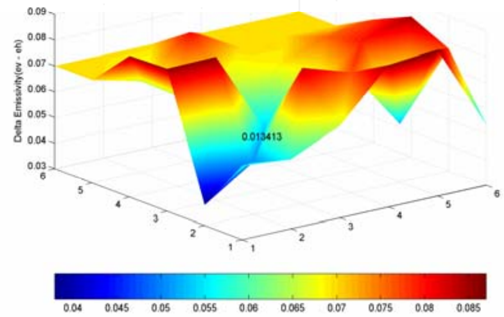
89GHz



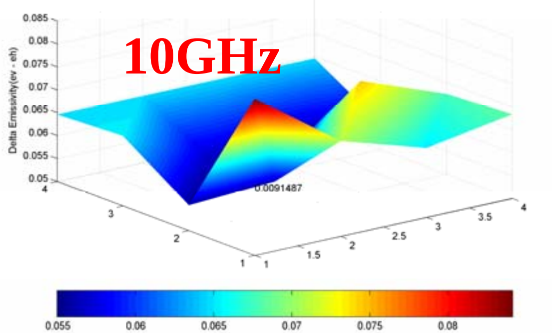
36GHz



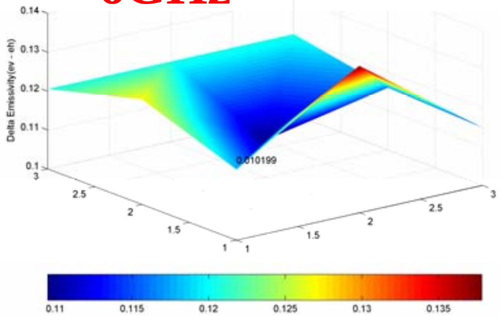
18GHz



10GHz



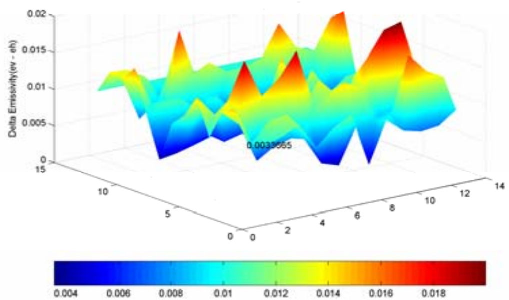
6GHz



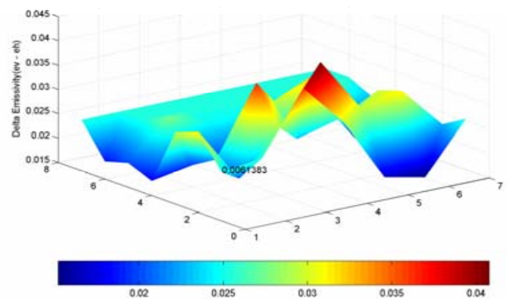
Alukerqin

Location: N [44.13 43.63]E[120.23 120.93]   Area:70x70km

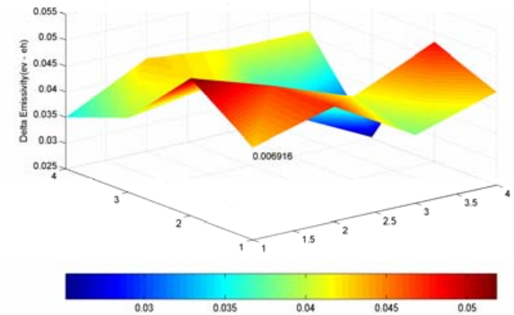
89GHz



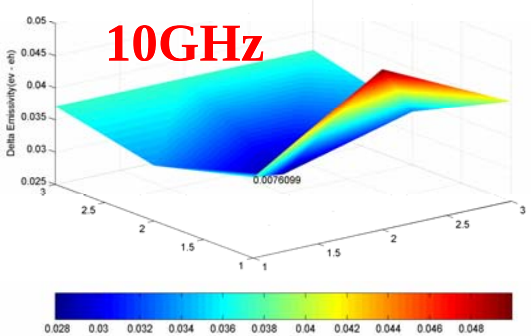
36GHz



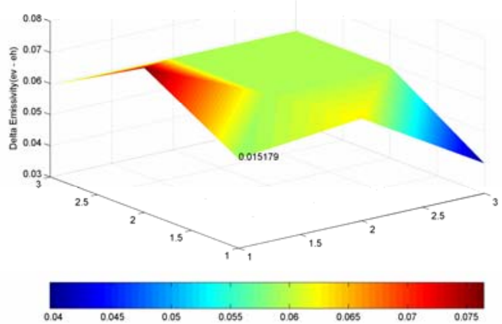
18GHz



10GHz

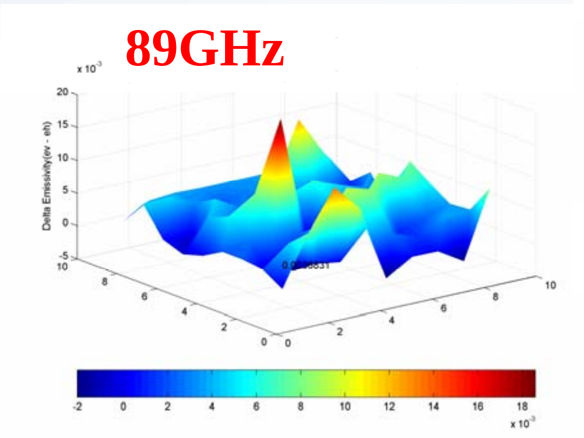


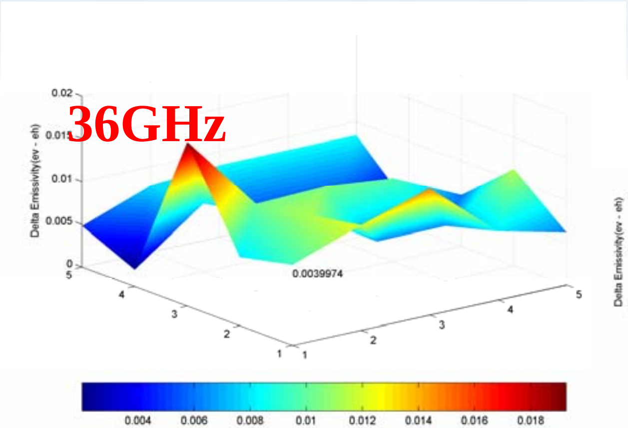
6GHz

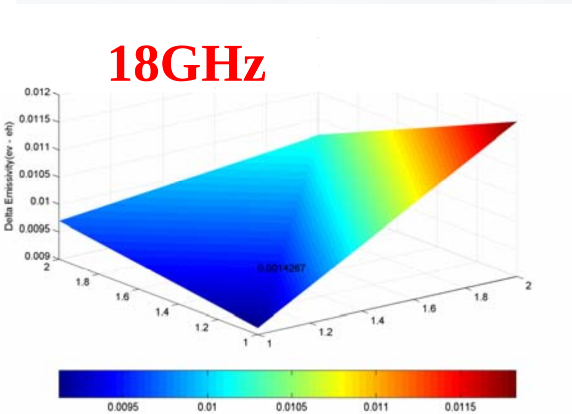


Jiangxi Province

Location: N [25.45 25.15]E[115 115.6]   Area: 30x60km





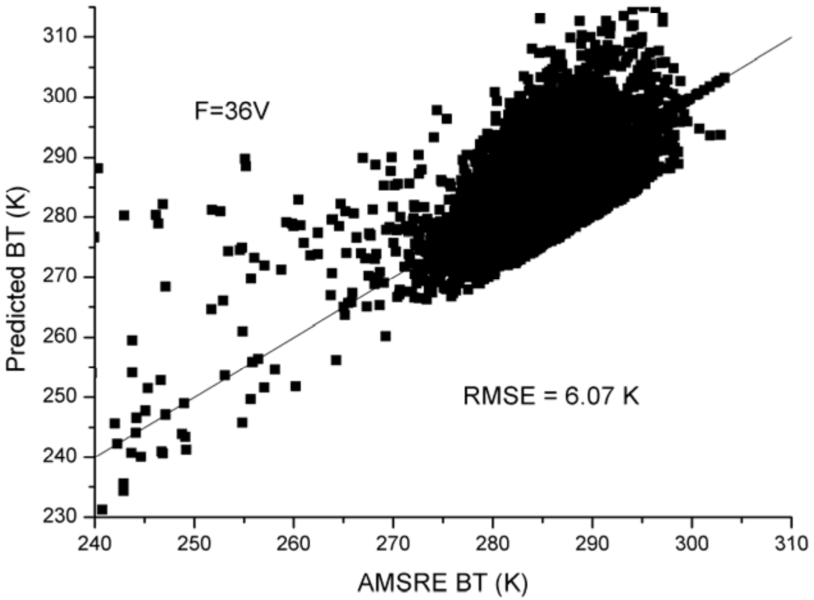


Brightness Temperature Precision

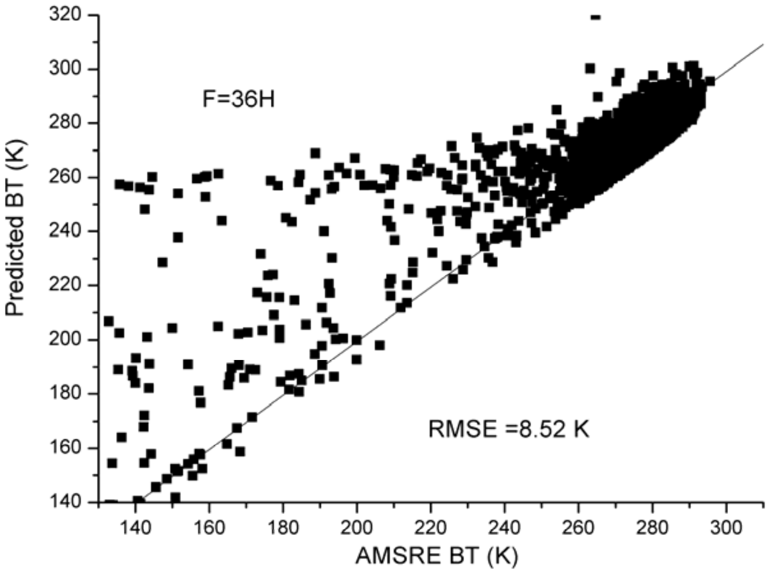
calculated value vs. AMSR-E data

Takelimgan Desert

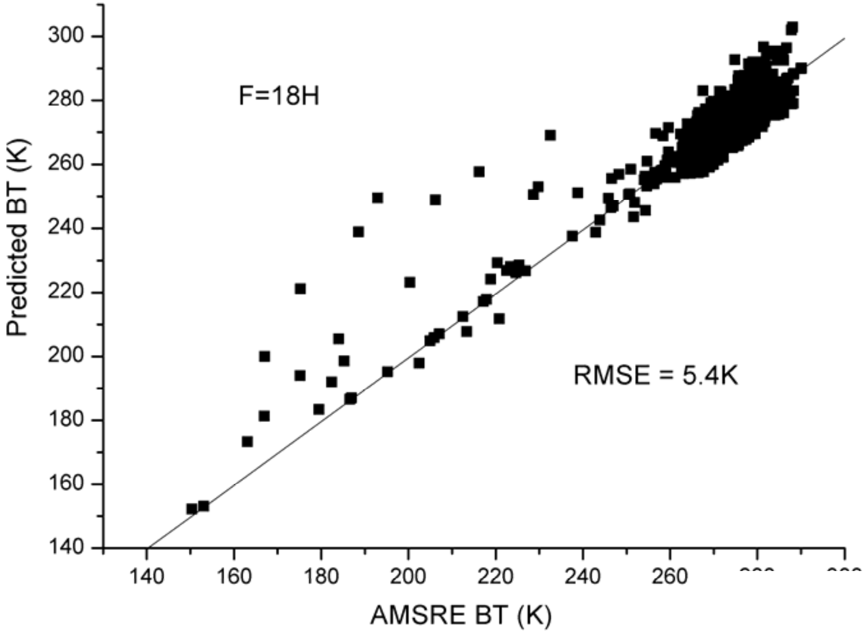
Location: lat = [40.5 39.0]; lon = [81.5 87.5];

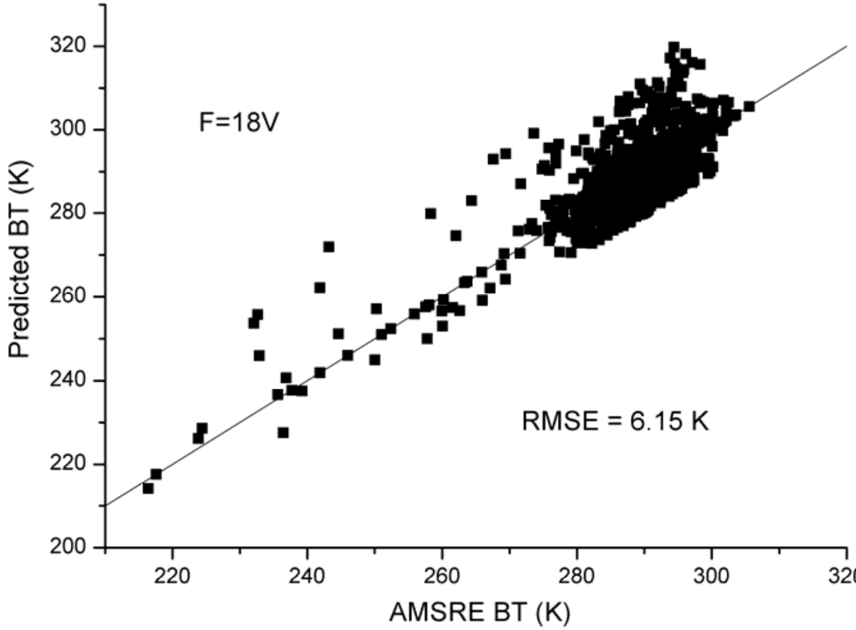

F=36V
RMSE = 6.07 K
Predicted BT (K)
AMSRE BT (K)
310
300
290
280
270
260
250
240
230
240
250
260
270
280
290
300
310

36GHz

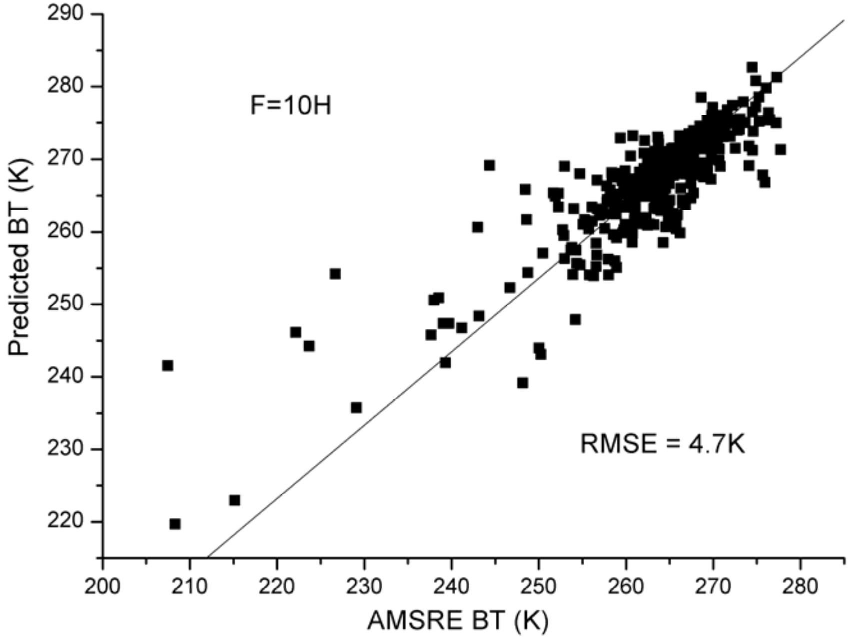

F=36H
RMSE =8.52 K
Predicted BT (K)
AMSRE BT (K)
320
300
280
260
240
220
200
180
160
140
140
160
180
200
220
240
260
280
300

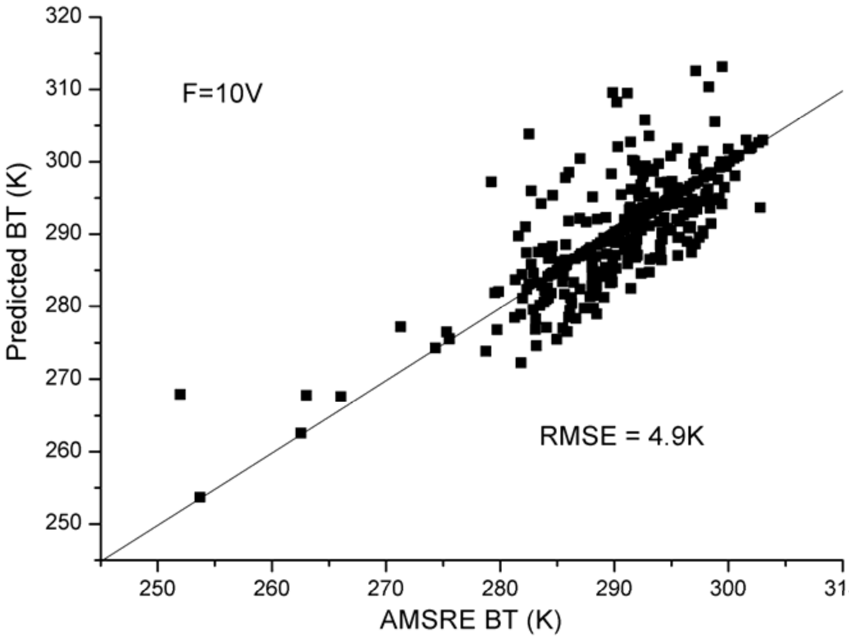
18GHz


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


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

10GHz

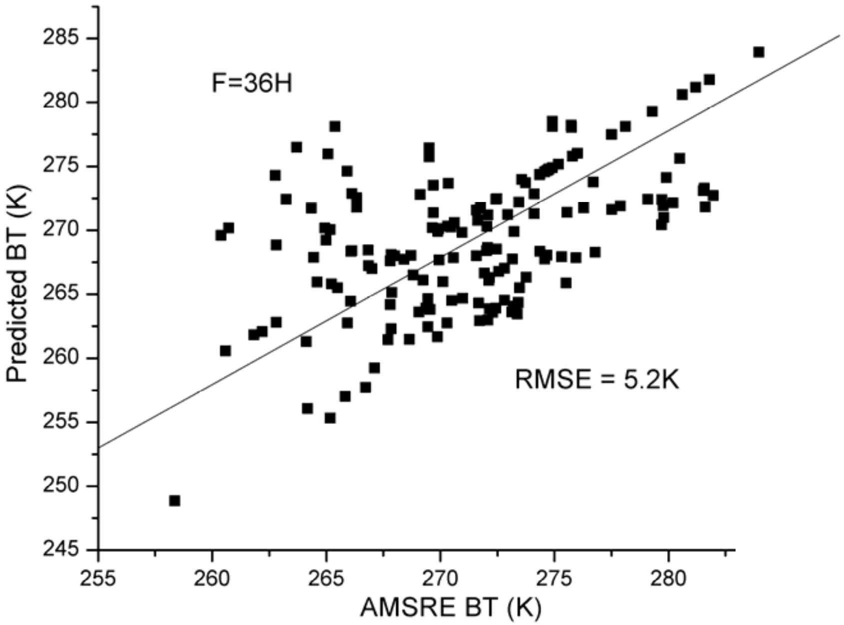

F=10H
RMSE = 4.7K
Predicted BT (K)
AMSRE BT (K)
290
280
270
260
250
240
230
220
200
210
220
230
240
250
260
270
280

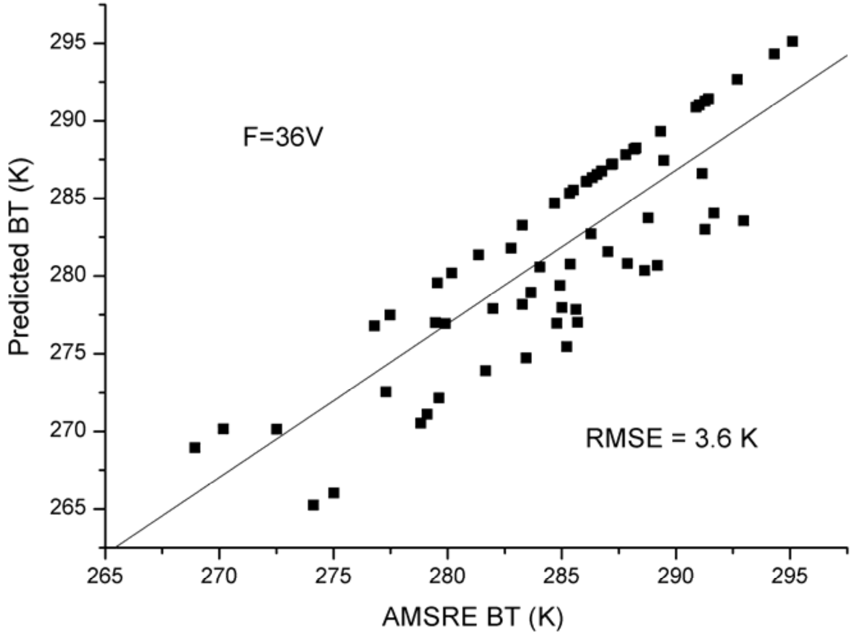

F=10V
RMSE = 4.9K
Predicted BT (K)
AMSRE BT (K)
320
310
300
290
280
270
260
250
250
260
270
280
290
300
310

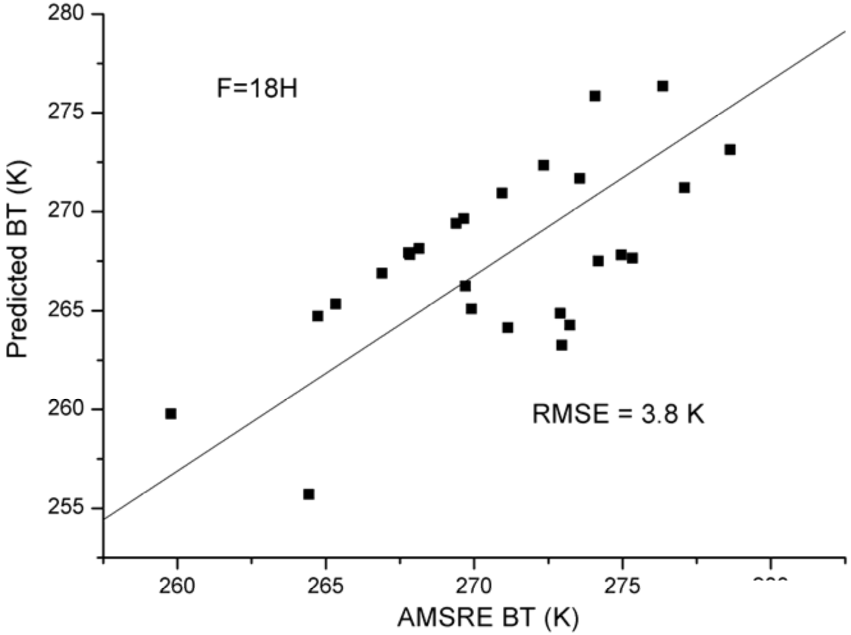
Dunhuang

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

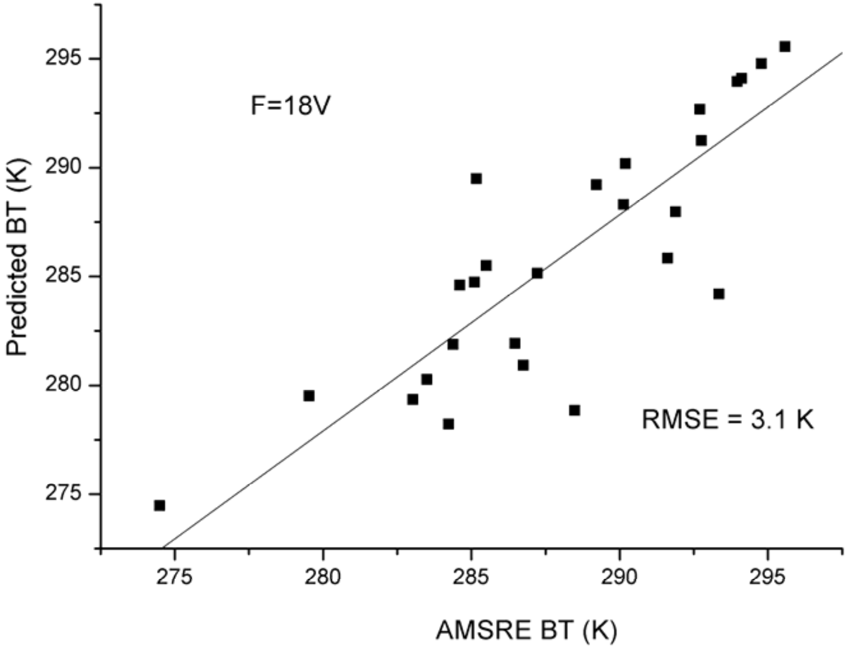
36GHz

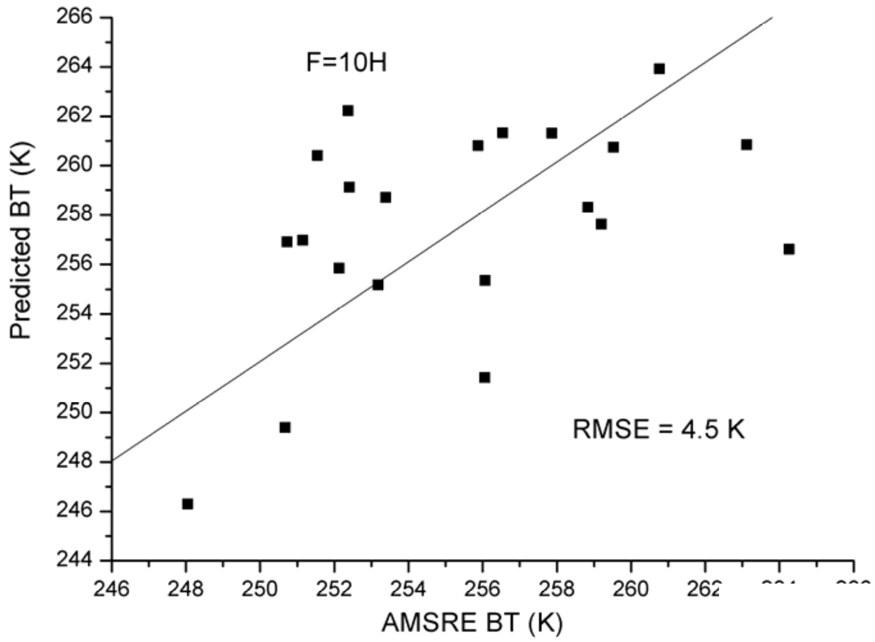

F=36H
RMSE = 5.2K
Predicted BT (K)
AMSRE BT (K)
245
250
255
260
265
270
275
280
285
255
260
265
270
275
280


F=36V
RMSE = 3.6 K
Predicted BT (K)
AMSRE BT (K)
265
270
275
280
285
290
295
265
270
275
280
285
290
295

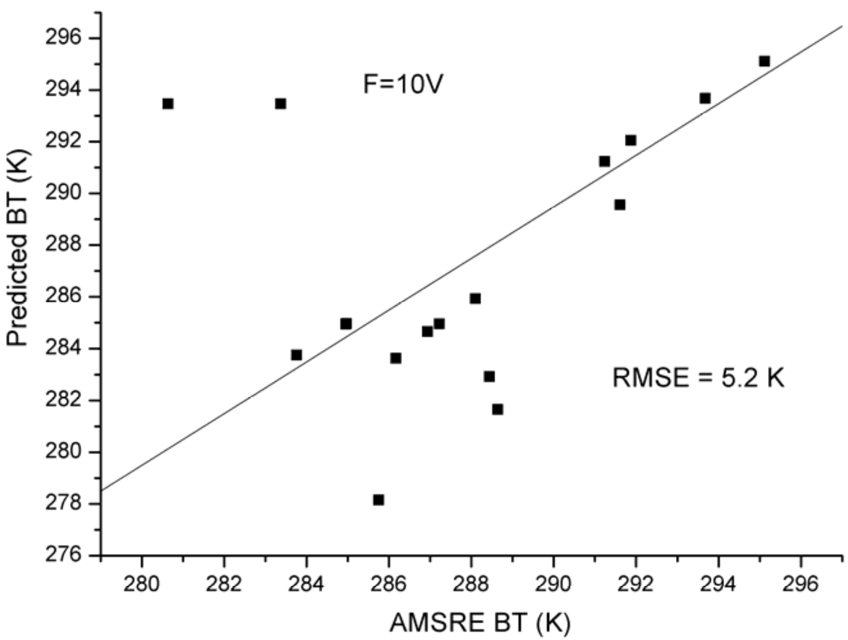

F=18H
RMSE = 3.8 K
Predicted BT (K)
AMSRE BT (K)
280
275
270
265
260
255
260
265
270
275

18GHz


F=18V
RMSE = 3.1 K
Predicted BT (K)
AMSRE BT (K)
295
290
285
280
275
275
280
285
290
295


F=10H
RMSE = 4.5 K
Predicted BT (K)
AMSRE BT (K)

10GHz


F=10V
RMSE = 5.2 K
Predicted BT (K)
AMSRE BT (K)

Amazon Forest

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

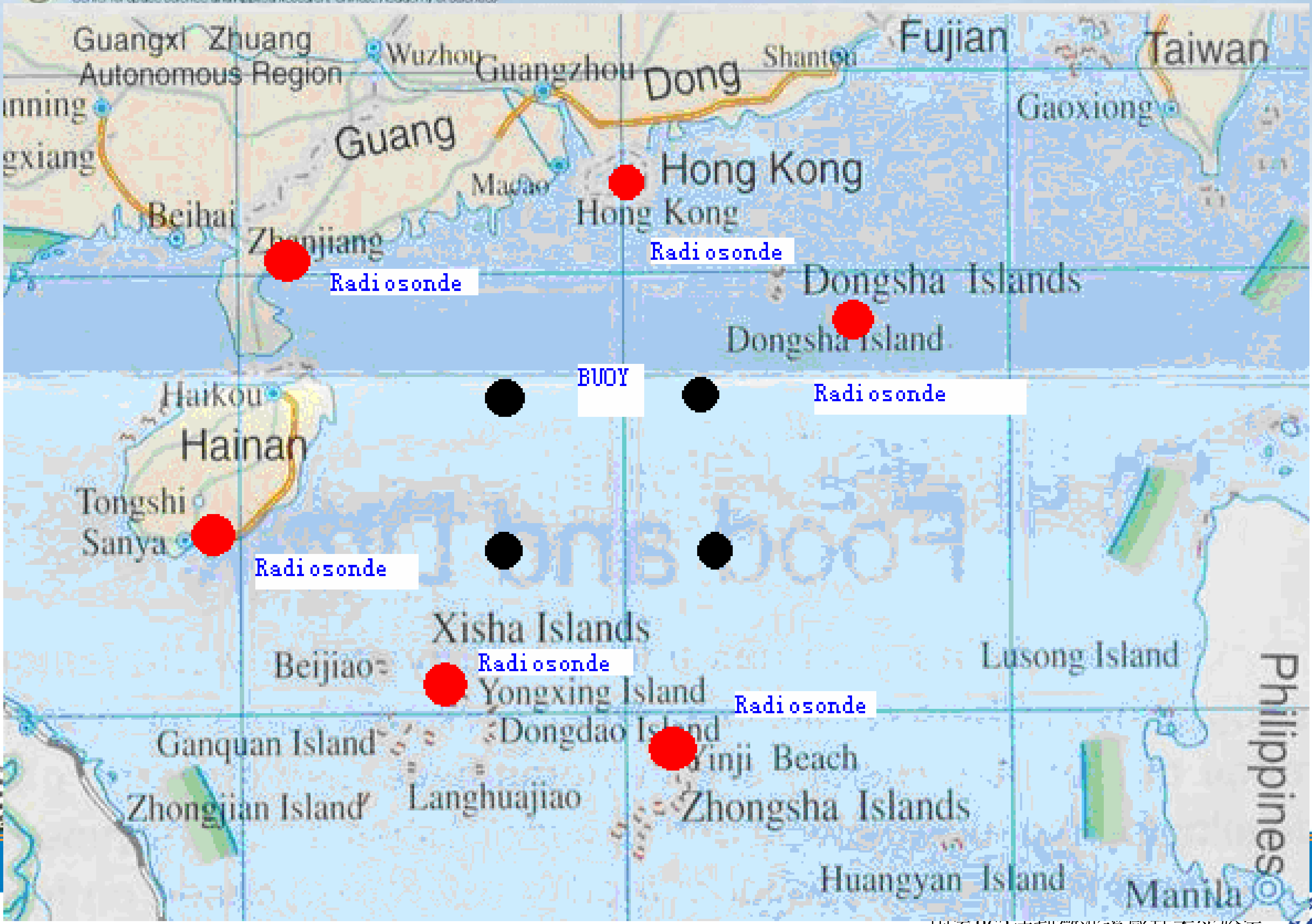
	V	H
6.9	0.945	0.94
10.65	0.945	0.94
18.7	0.972	0.968
23.8	0.973	0.968
36.5	0.975	0.972
89	0.995	0.992

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

II.3 CAL/VAL sites on ocean

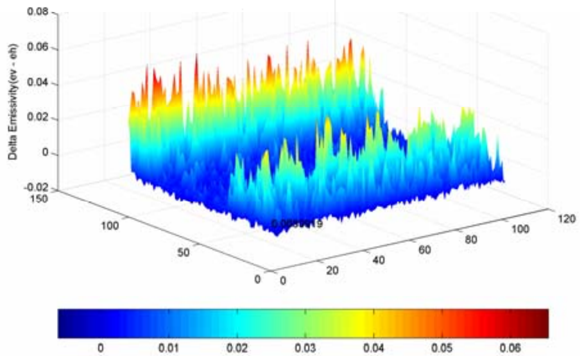
Information provided by

Dr. Zhenzhan WANG from CSSAR/CAS

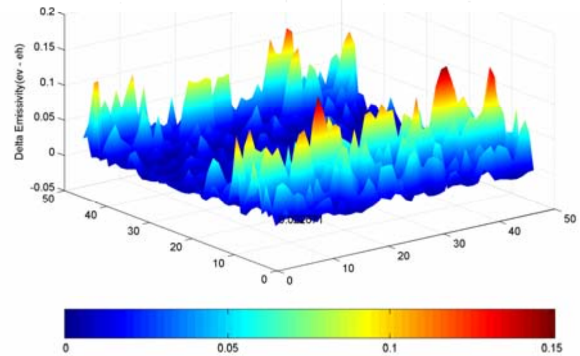

Guangxi Zhuang Autonomous Region
Wuzhou
Guangzhou
Dong
Shantou
Fujian
Taiwan
Gaoxiong
Guang
Beihai
Zhanjiang
Macao
Hong Kong
Hong Kong
Radiosonde
Radiosonde
Dongsha Islands
Dongsha Island
BUOY
Radiosonde
Haikou
Hainan
Tongshi
Sanya
Radiosonde
Xisha Islands
Beijiao
Radiosonde
Yongxing Island
Radiosonde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

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

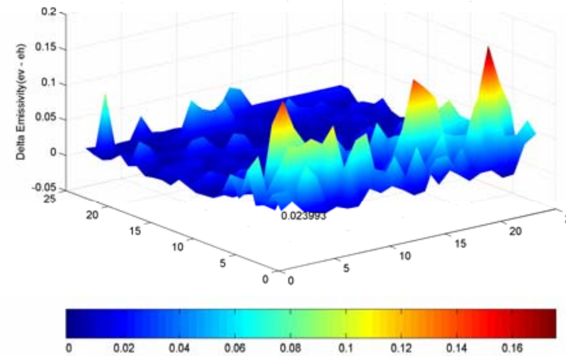
89GHz



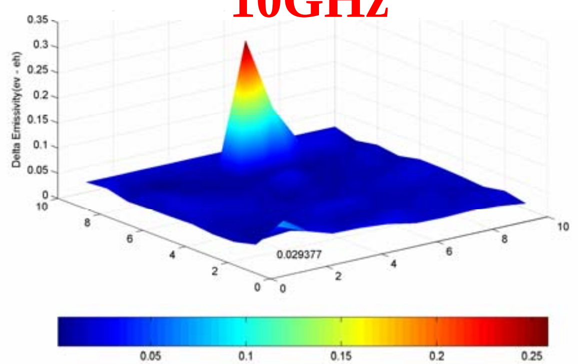
36GHz



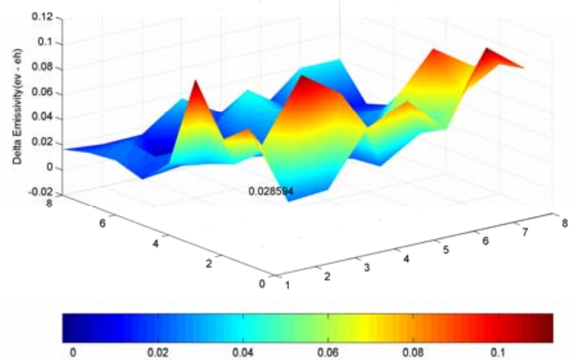
18GHz



10GHz



6GHz



lied Research, Chinese Academy of Sciences

Equipment Considerations

- Ground Based/Airborne Microwave radiometers
- Calibration standards and specifications
- Buoy network (5)
- Measurement platform
- Information system
- Atmosphere sounding station and precipitation monitoring radar

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.4 Calibration and Validation over the Takelimgan Desert

Information provided

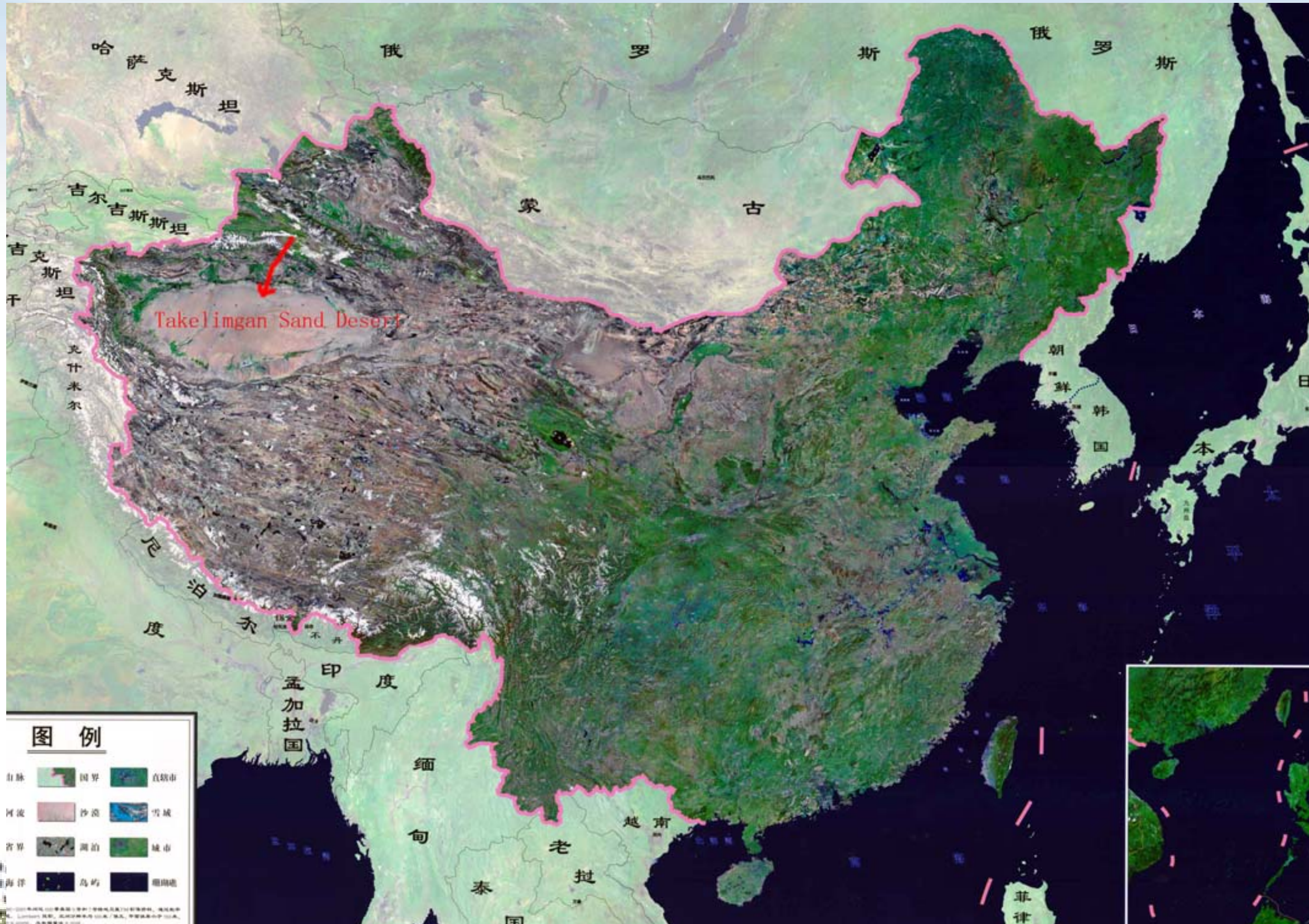
by Dr. Weiguo ZHANG from CSSAR/CAS

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

Calibration and Validation over the Takelimgan Desert

- It is necessary to do vicarious calibration of low frequency spaceborne microwave radiometer by monitoring large areas of uniform, stable and known characteristics . This is especially true for the ongoing L band mission such as ESA SMOS.
- In tradition, tropical rain forest, calm ocean are used as two-point external calibration sites. But at lower frequency, especially L band, the stability and predictability of rain forest at spaceborne scale are in challenge.
- In this context, we therefore put forward an proposal to ESA SMOS mission to use the Takelimgan Sand Desert as another choice of vicarious calibration of MIRAS onboard SMOS. The proposal is approved and the desert has been selected as one of the two vicarious calibration sites of the mission (another is Dome C, which is taken care by Italian scientists, rain forest is still under investigation).

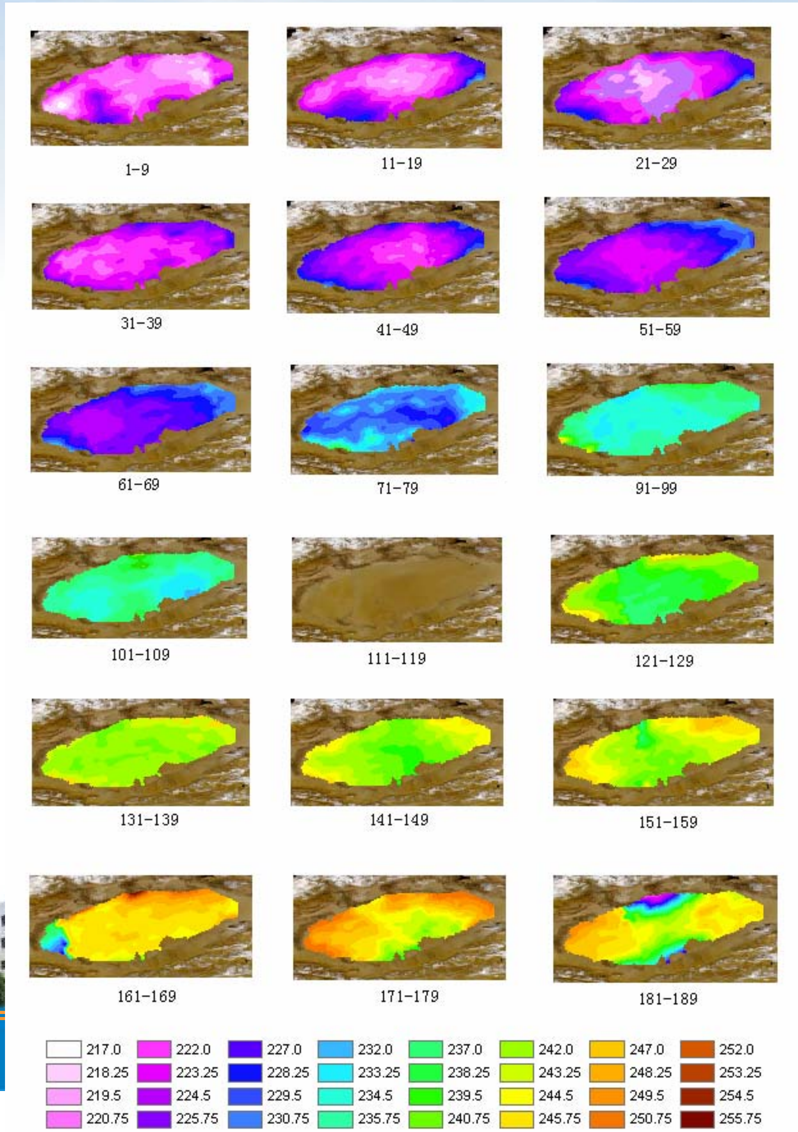
Position of the desert

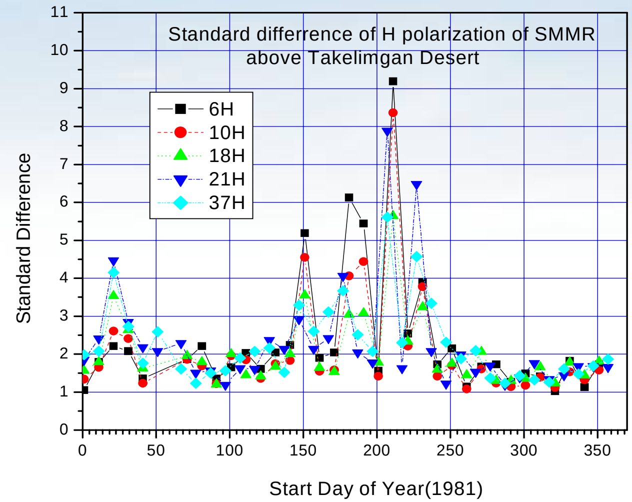


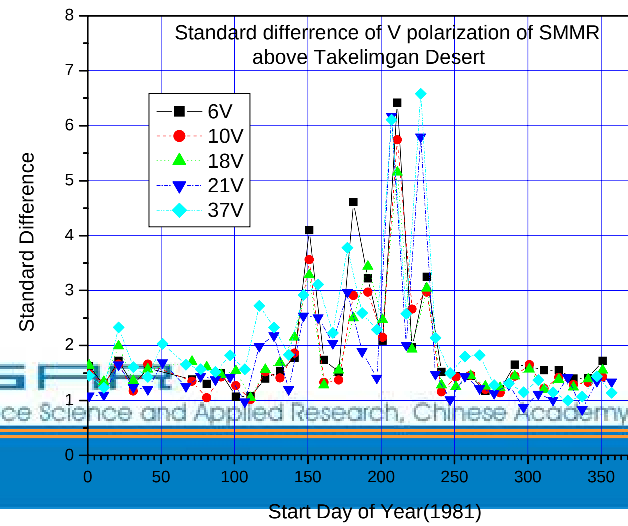
Rationale behind the idea

- The desert is of large area, which fits well with the large FOV of spaceborne low frequency microwave radiometer.
- Its stability and homogeneous characteristic from a viewpoint of microwave radiometric.
- The radiometric behavior can be predicted may be predicted with a significant level of accuracy .
- It is relatively easy to access .Sand Desert road. Airborne and field experiments can be carried out without too much difficulties.

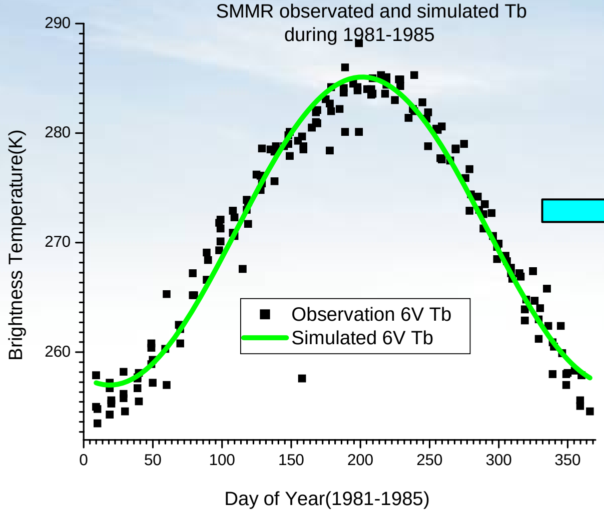
Radiometric data for homogenous

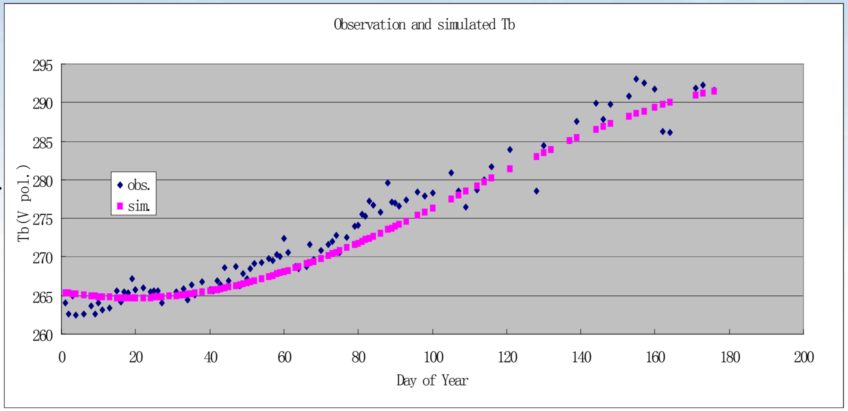






Radiometric data for stability

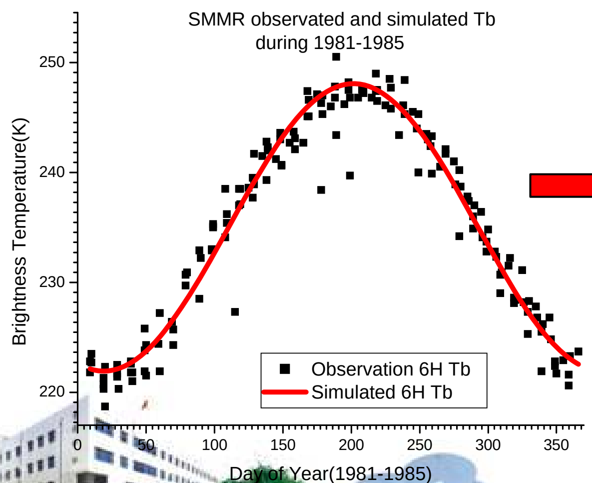


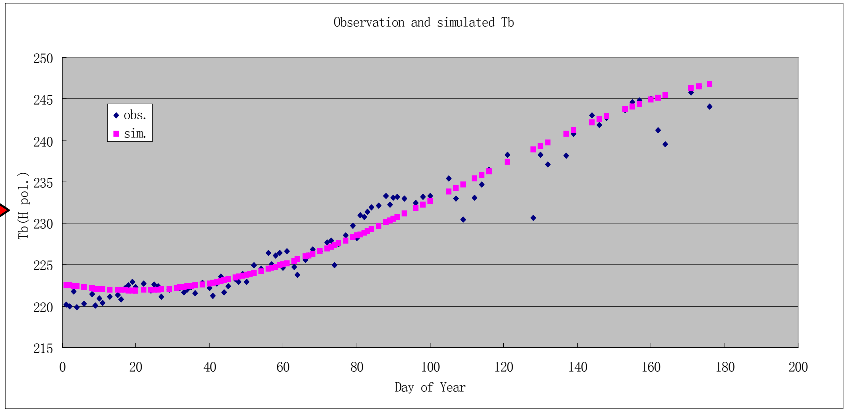


V pol.

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.

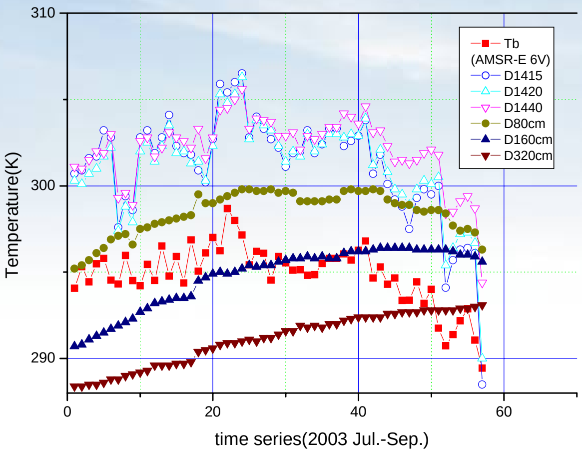
SEE: 1.74K.

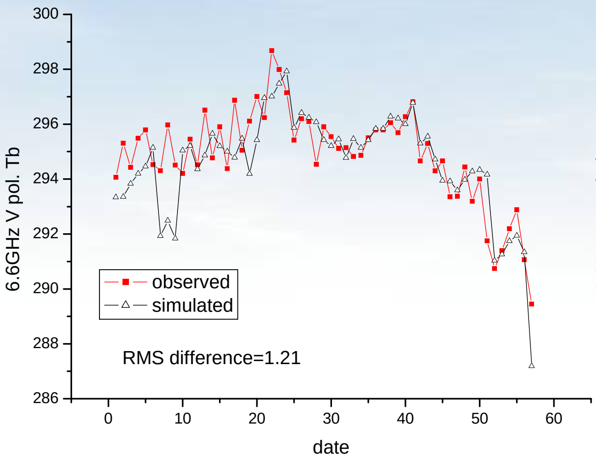
No bias

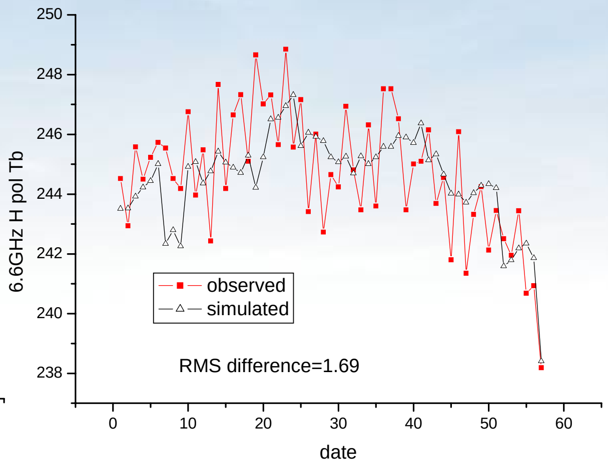
AMSR-E:2003 Jan.-Jun.
(Descending Orbit)

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.

Cooperation With ESA

esa **Earth Explorers** The Living Planet Programme
European Space Agency

g the Earth | Living Planet | **Earth Explorers**

News

Preparing for data from SMOS

The SMOS Validation and Retrieval Team

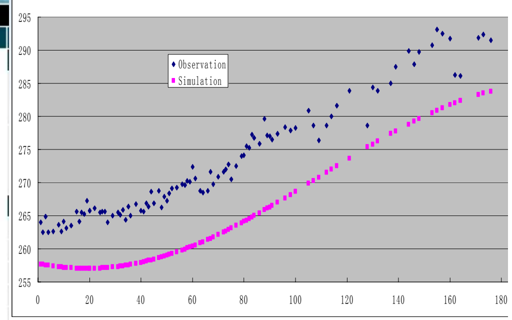
5 December 2005
Around 60 scientists from all over the world recently gathered for the first time to prepare for when ESA's Soil Moisture and Ocean Salinity mission releases its first data. The SMOS Validation and Retrieval Team met in Avila in Spain for the 4-day meeting to discuss how best to ensure that the eventual data from the mission is as accurate as possible.

The scientists attending the meeting were selected following an Announcement of Opportunity released by ESA earlier this year and the team's first meeting marks an important step in the progress of the SMOS mission due for launch in 2007.

The SMOS instrument

Whilst the instrument is thoroughly calibrated on the ground prior to launch, the actual in-orbit configuration still holds a number of possible uncertainties; for example, will the antenna patterns have changed due to the rigors of launch? Is the temperature distribution between the 69-licef receivers really as it was when modelled on the ground? Do radiation, solar heating and the Earth's albedo have an effect on the measurements? These are all important questions that cannot be fully answered before launch. Also, while ground-based or airborne instruments can be regularly recalibrated this can't be done for an instrument in space. In fact, the calibration equipment on board the spacecraft is subject to the same environmental stress as the instrument itself leading to another area of uncertainty.

Therefore, it is important to validate the SMOS data by comparing it with data taken on the ground or from the air over spatially and temporally stable sites – referred to as 'vicarious calibration'. These areas include the Taklimakan desert in northern China, and the vast homogeneous ice field at Dome



SMOS

Posters session 1 (Chair: P. Van Oevelen)

This poster session is devoted to the topics 1,2 and 3

Holmes	An alternative approach to derive Surface Temperature profiles for SMOS.
Font	The algorithmic approach to compute SMOS sea surface salinity L2 products
Naeimi	Progress in remote sensing of soil moisture: An evaluation of current operational soil moisture products
De Rosnay	Multiscale validation of SMOS brightness temperature and products over West Africa.
Kim	Evaluation of Antarctic and Tropical Forest sites for Calibration and Cross-Calibration of Spaceborne L-band Radiometers
Lopez-Baeza	Soil Moisture Characterisation at the Valencia Anchor Station
Dransfeld	Temporal and spatial Salinity Variations in the GIN Sea

18:15 Ice Breaker

19:00 Adjourn

Tuesday May 16th

Session 2: Cal/Val Activities (Chair: E. Kim)
Aim summary of the planned cal val activities so as to identify gaps and how to fill them as well as introducing to all what is intended

8:30	AO Summary and main points (Avila summary)	S. Delwart
9:00	The Aquarius approach	G. Lagerloef D. leVine
9:30	ARGO upper salinity measurements: perspectives for L-band radiometers calibration and retrieved sea surface salinity validation	J. Boutin
9:50	Estimating an empirical SMOS forward model and its co-variance by the use of Neural Networks	M. Crépon
10:10	Validation and application of SMOS data in Canadian waters	J. Gowers
10:30	Assessment of instrument stability and calibration by using extended targets: Antarctic plateau (Dome-C) and forests	G. Macelloni

10:50 Coffee break

11:10	Ground based validation of SMOS soil moisture in the U.S	T. Jackson
11:30	Microwave radiometric characteristics of the Takelimgan Sand Desert and its implication to SMOS vicarious calibration	WG. Zhang

11:50 Discussion

12:15 Lunch

Sessions 3: Physics of measurements (Chair: J. Font):
Aim: state of the art in forward modelling and agreeing on consolidated forward models

13:15	Summary of activities at ESA (studies)	M. Berger

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

The end!