CINDY/DYNAMO Workshop
November 8, 2010 @ Yokohama

Plan on daily simulation using a cloud resolving model over the tropical Indian Ocean during the CINDY/DYNAMO2011

Taro Shinoda
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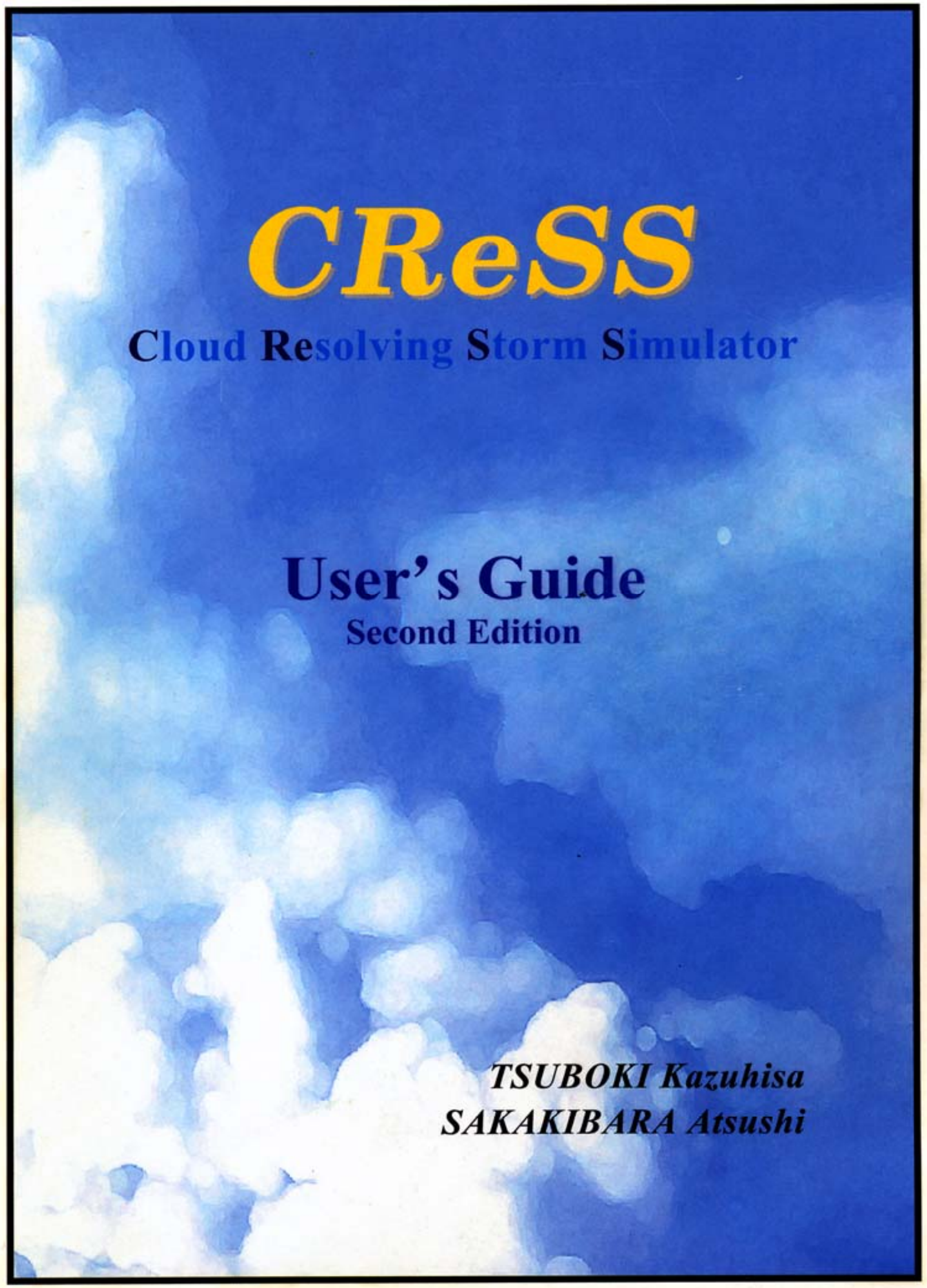
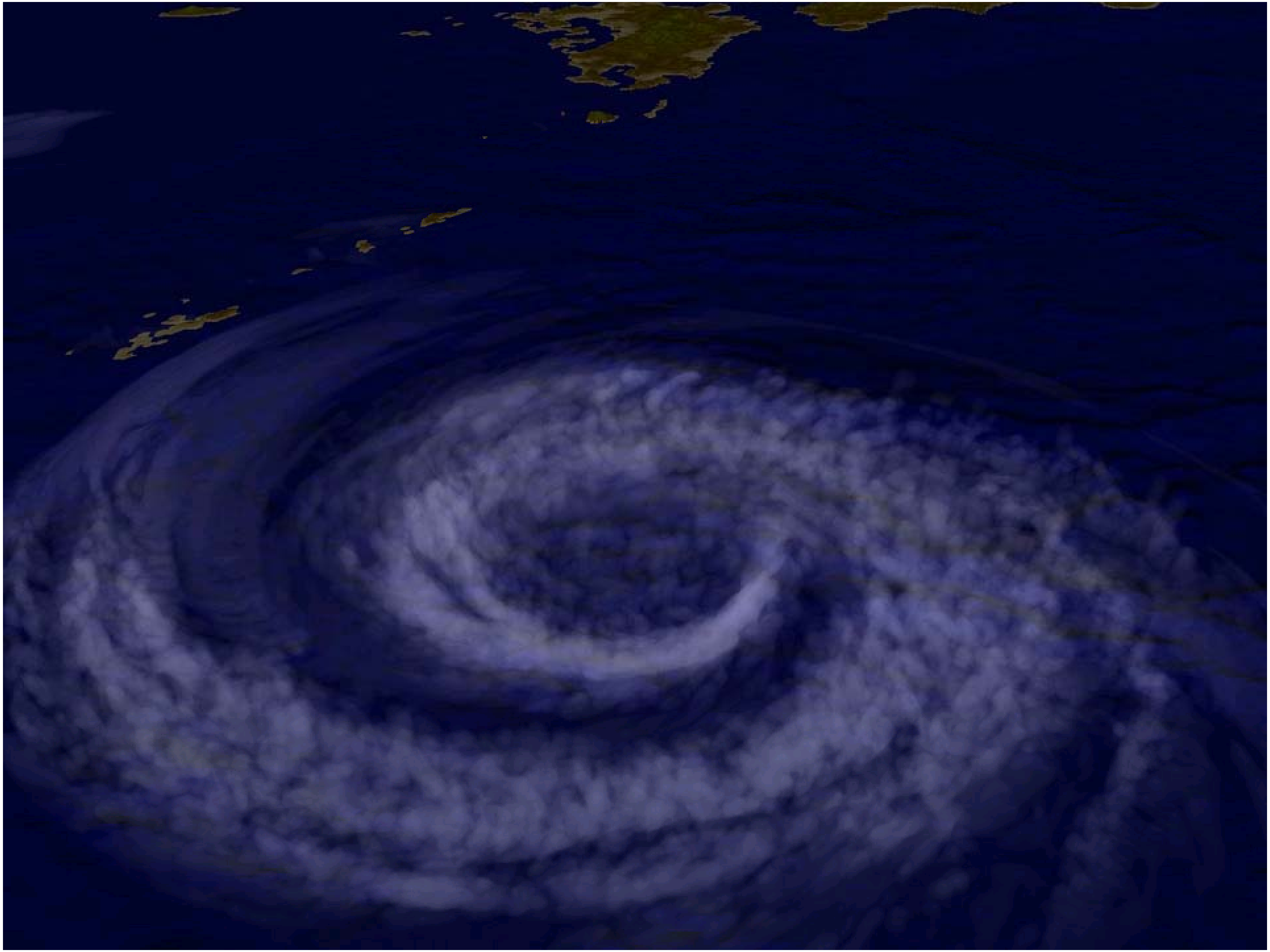
The Cloud Resolving Storm Simulator (CReSS)



Prof. Tsuboki have developed the CReSS for about 10 years.

- **The non-hydrostatic and compressible equation system.**
- **Terrain-following coordinate system.**
- **Finite difference method.**
- **Surface processes.**
- **Conformal map projections.**
- **6 categories water substances include cold rain processes.**
- **Parallel processing (Message Passing Interface: MPI and OpenMP).**



Plan on daily simulation during the CINDY/DYNAMO 2011

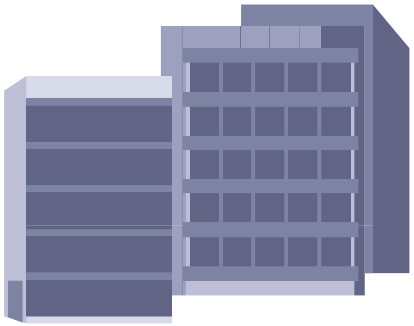
- We will conduct daily simulation using the CReSS with horizontal grid resolution less than 2.5 km during the CINDY/DYNAMO 2011.
- Semi-realtime Satellite Simulator (SDSU) calculation and validation on cloud fraction, frequency of TBB for infrared and microwave bands (and radar reflectivity as obtained from the TRMM) are applied for the daily simulation.
- If the initial reanalysis data of 3-D ocean (JCOPE2) are prepared, we will conduct daily simulation using the CReSS-NHOES (atmosphere-ocean coupled regional model).

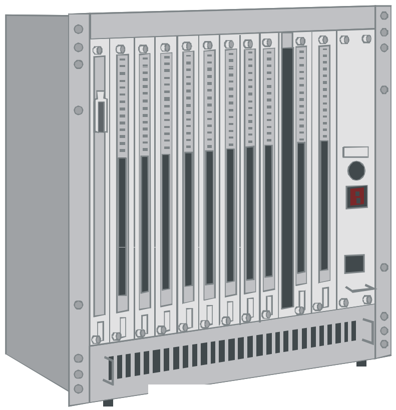
Daily simulation around Japan area using the CReSS

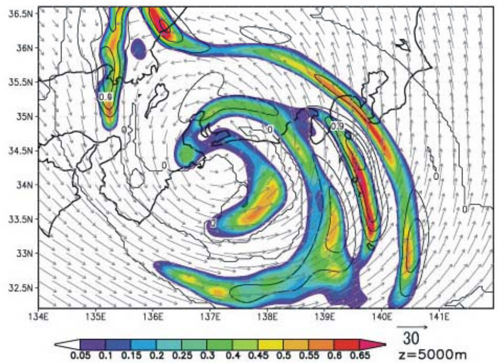
We have examined daily simulation around Japan area using the CReSS since May 2004.

JMA forcast GPV-data (GSM) from Japan Meteorological Business Support Center.
Initial and boundary condition

Results present in the web-site of our Lab.





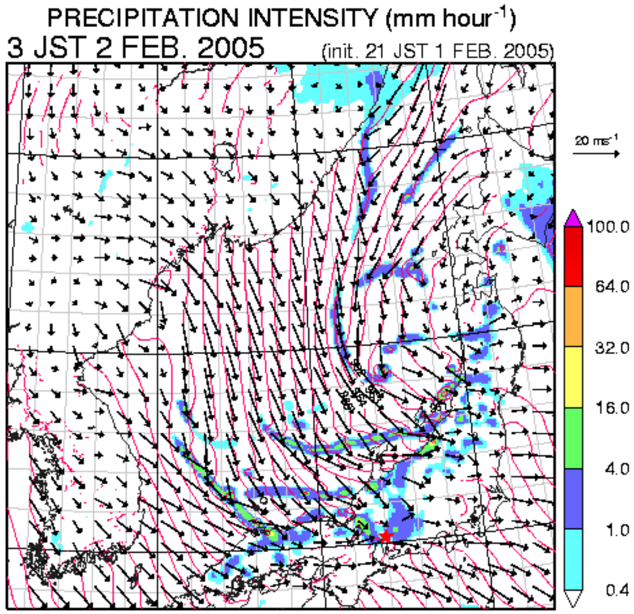


Simulation in our Lab. every day.

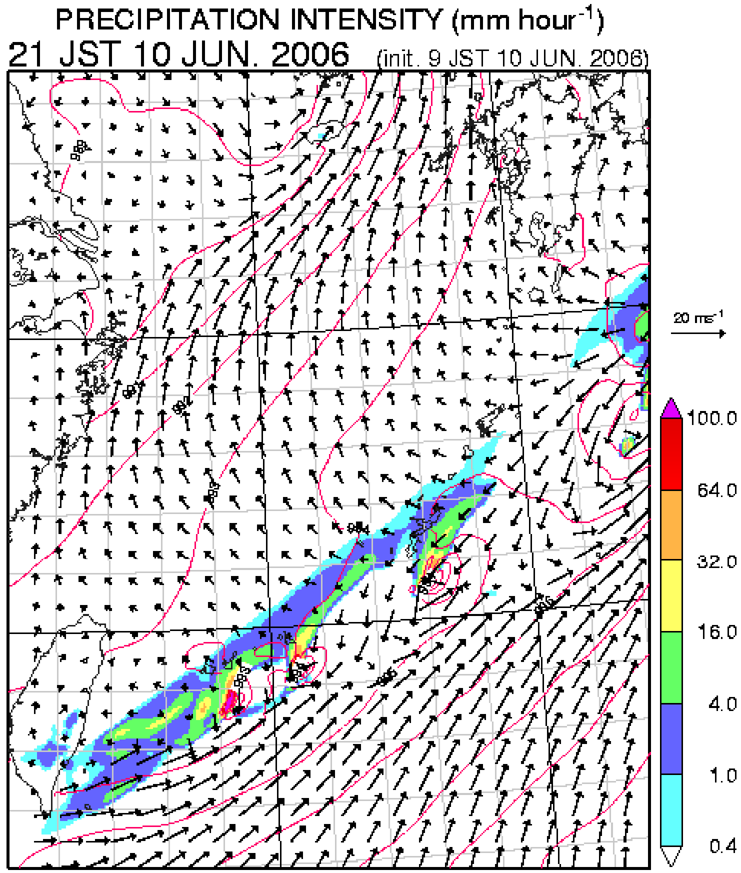
http://www.rain.hyarc.nagoya-u.ac.jp/CReSS/fcst_exp.html

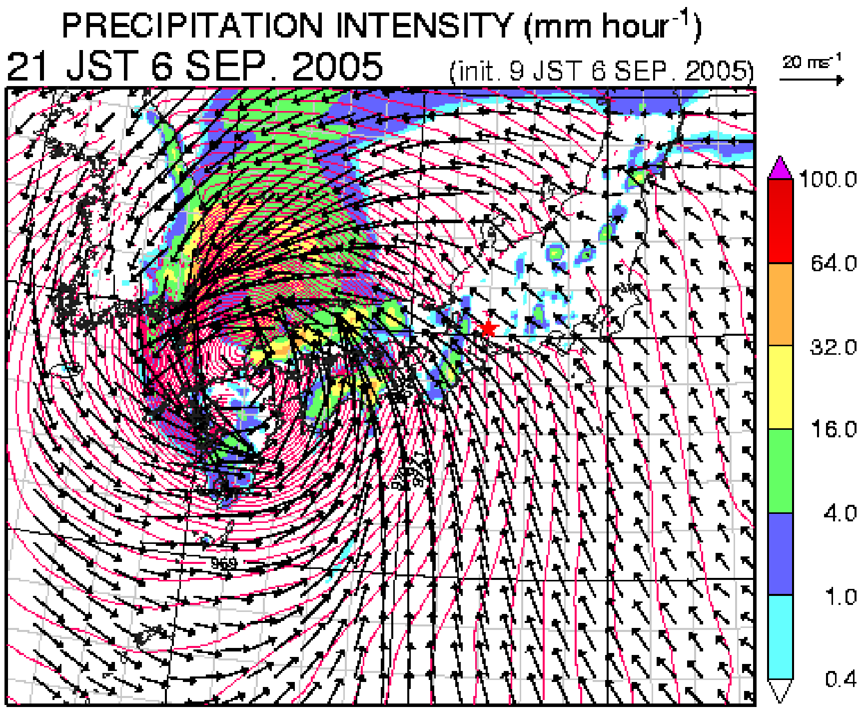
Sample of the daily simulations around Japan area

Heavy snowfall around Nagoya Feb. 01, 2005



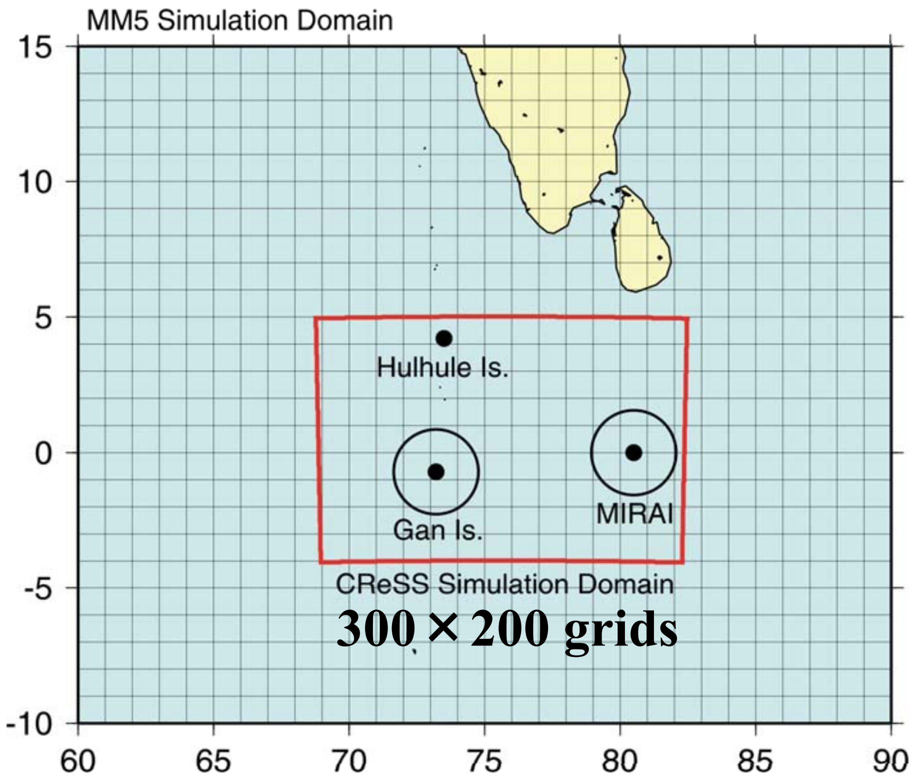
Heavy rainfall at Okinawa by the Baiu front Jun. 10, 2006

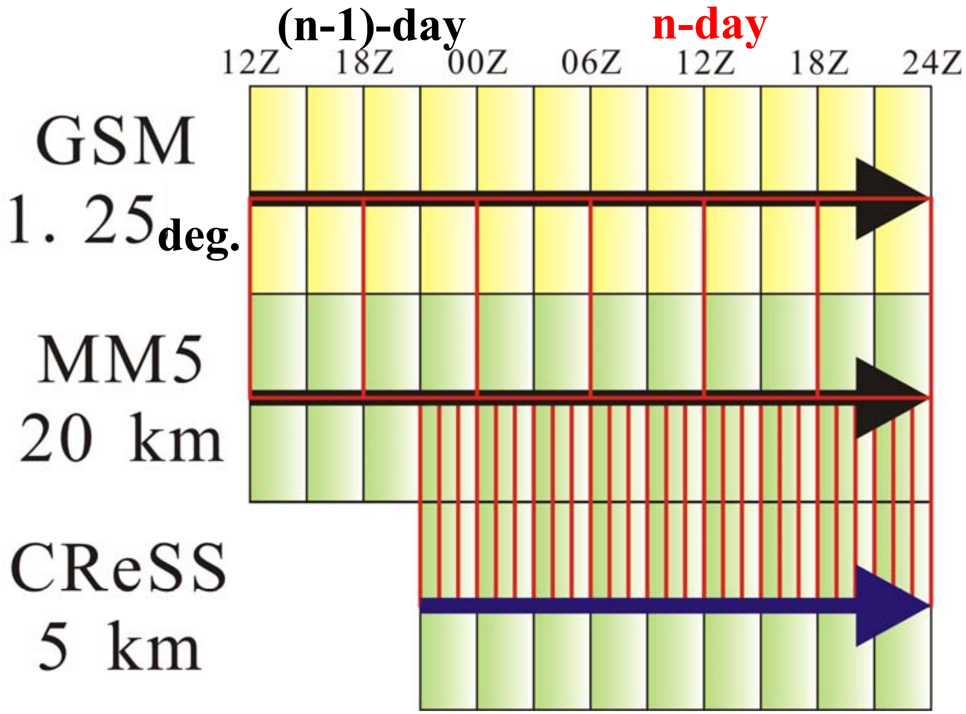




Heavy rainfall around Kyushu by Typhoon T0514 Sep. 06, 2005

Sample of the daily simulation (MISMO2006)



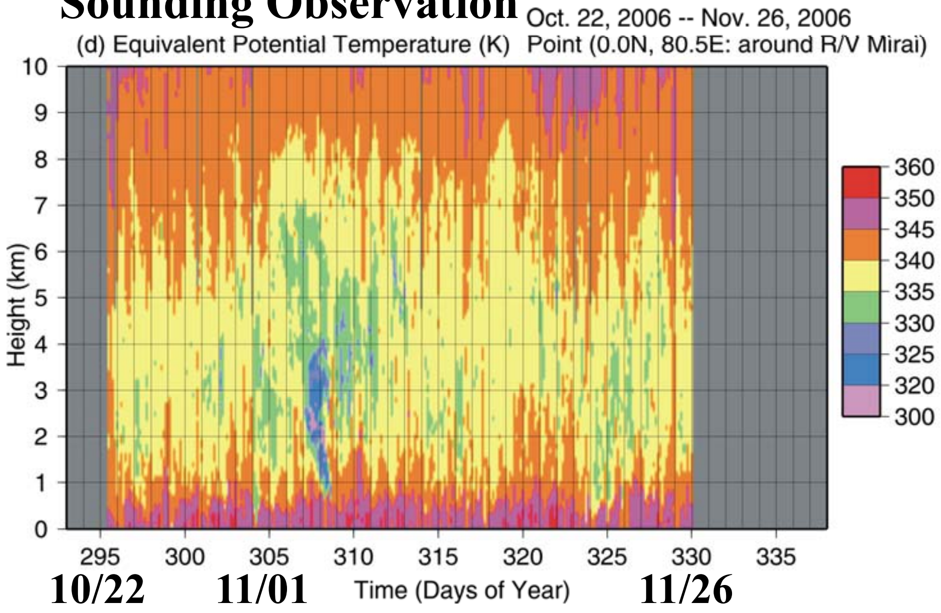


Simulation Period
Oct. 20 – Dec. 03, 2006

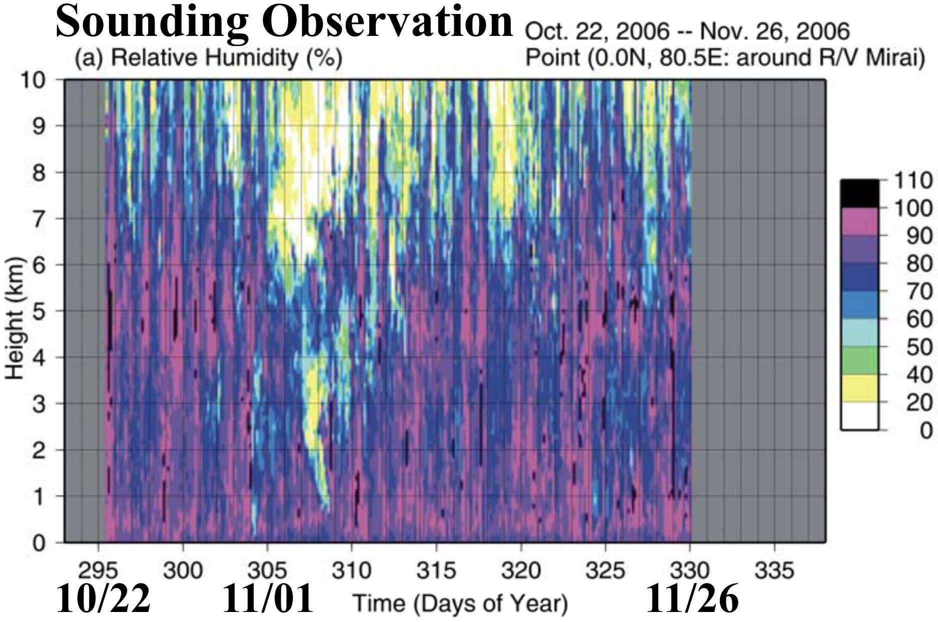
- **The GSM-GPV data were used as the initial and boundary conditions of the MM5 simulations.**
- **The results of the MM5 simulations were used as the initial and boundary conditions of the CReSS simulations.**

Time series of vertical profiles of EPT and RH (Sounding vs Model)

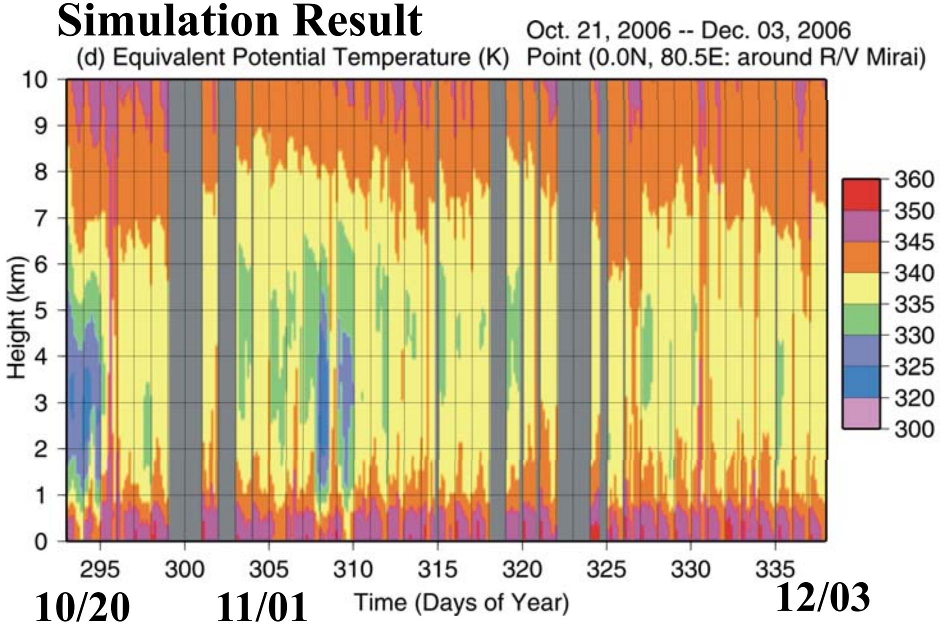
Sounding Observation



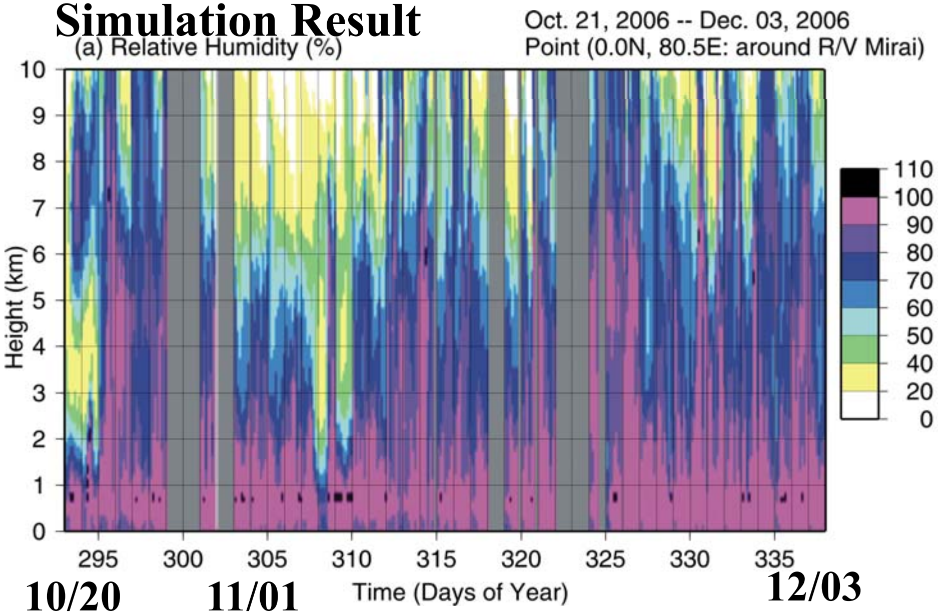
Sounding Observation



Simulation Result

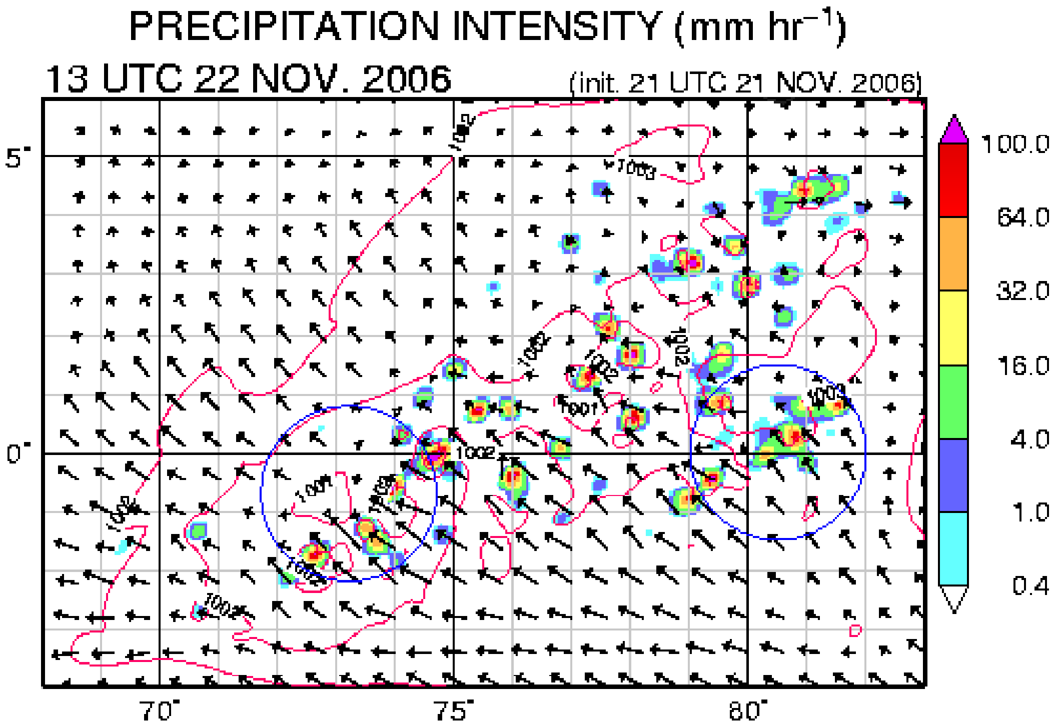


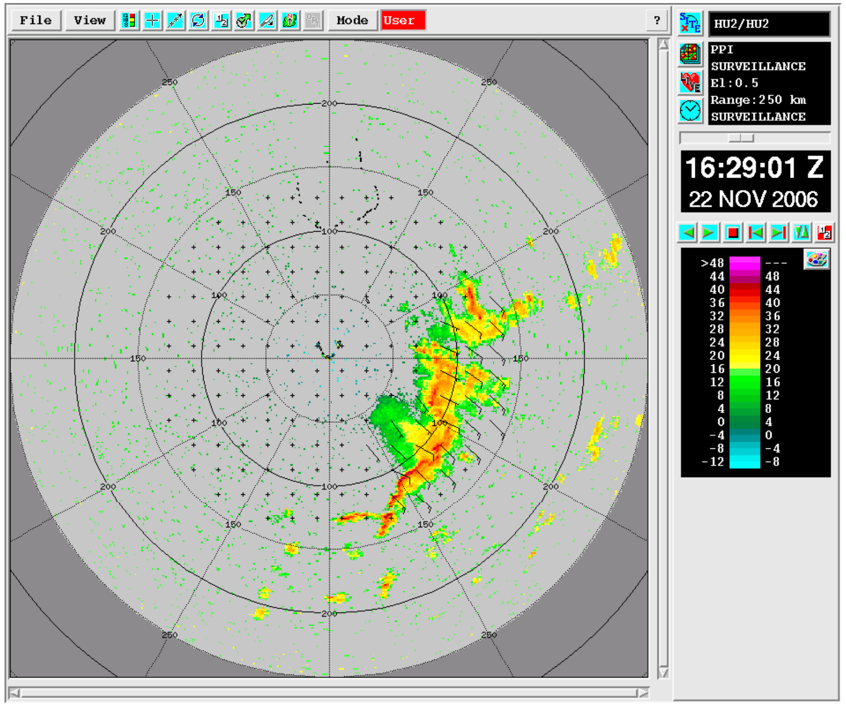
Simulation Result



Sample of the simulated precipitation system (MISMO2006)

Observed around Gan Island on Nov. 22, 2006





Provided by Dr. H. Yamada

*Precipitation cells aligns from SW to NE.

* These locate ahead of the strong southeasterly.

* Simulated time is different from observed one.

*Doppler radar observation at Gan Is.

*Line-shaped precipitation system aligns from SSW to NNE.

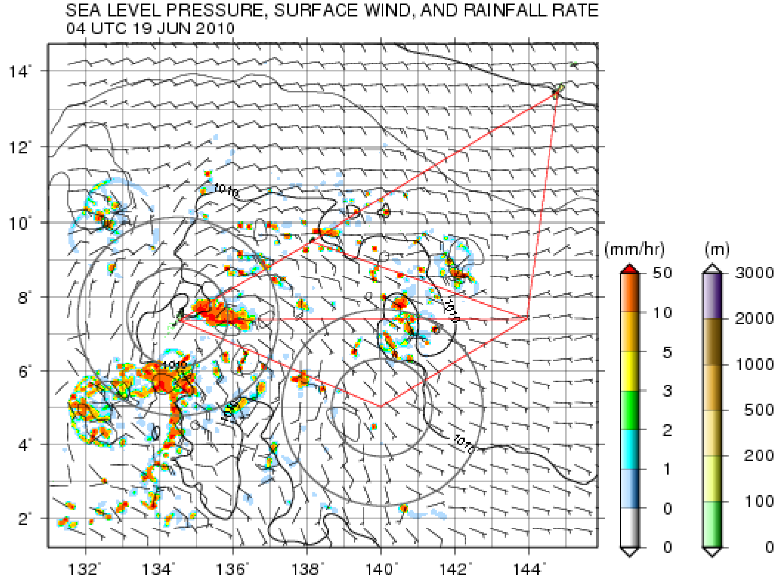
*It moves northwestward.

*Southeasterly wind behind the precipitation region.

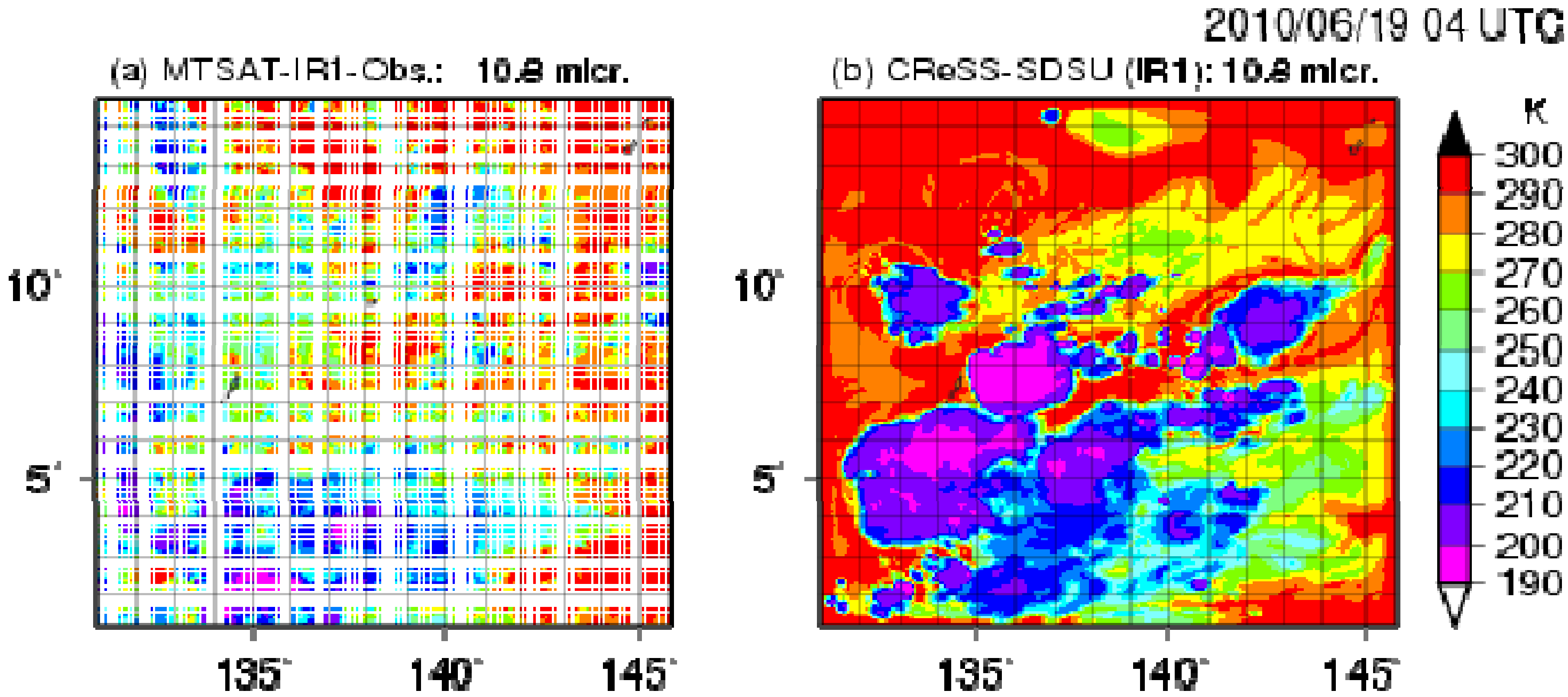
Framework of the daily simulation (PALAU2010)

The Cloud Resolving Model	CReSS ver2.3
Turbulent Parameterization	1.5-TKE (Klemp and Wilhelmson 1978)
	Mellor-Yamada Level 2 (Mellor and Yamada 1974)
Surface Parameterization	Bulk method (Louis et al. 1981)
Microphysical Parameterization	Cold rain（6 categories of water substances）
Radiative Parameterization	Included only the solar radiation absorption by cloud
Simulating Area	Horizontal ：652×600
	Vertical ：64 Layers (up to 25.6 km), Sponge layer (18 km)
Grid Spacing	Horizontal ：2.5 km
	Vertical ：Lowest 100 m, stretching
Time Step	6.0 sec. (non-sonic term)，3.0 sec.（sonic term）
Initial and Lateral Boundary Conditions	GSM (Horizontal resolution ～ 50 km)
Initial Time and Integrated Time	36 hours from 12 Z
Lower Boundary Conditions	SST data provided from JMA (MGDSST)
	GTOPO30 (Horizontal resolution ～ 1 km)
	USGS land-use categories

- **Simulation period:**
  April 26 ～ August 11, 2010

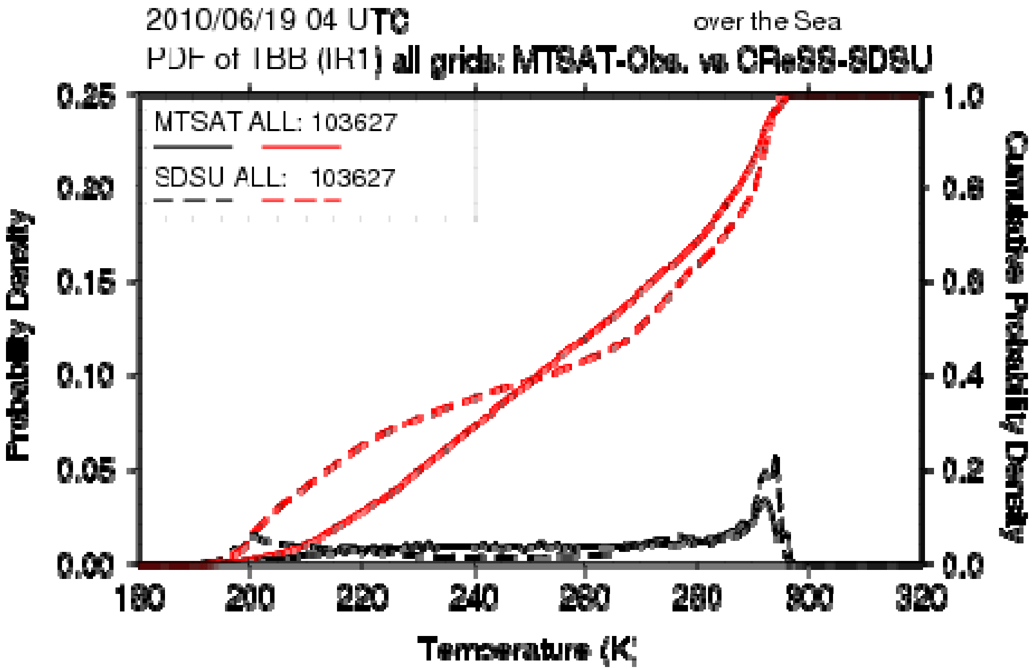


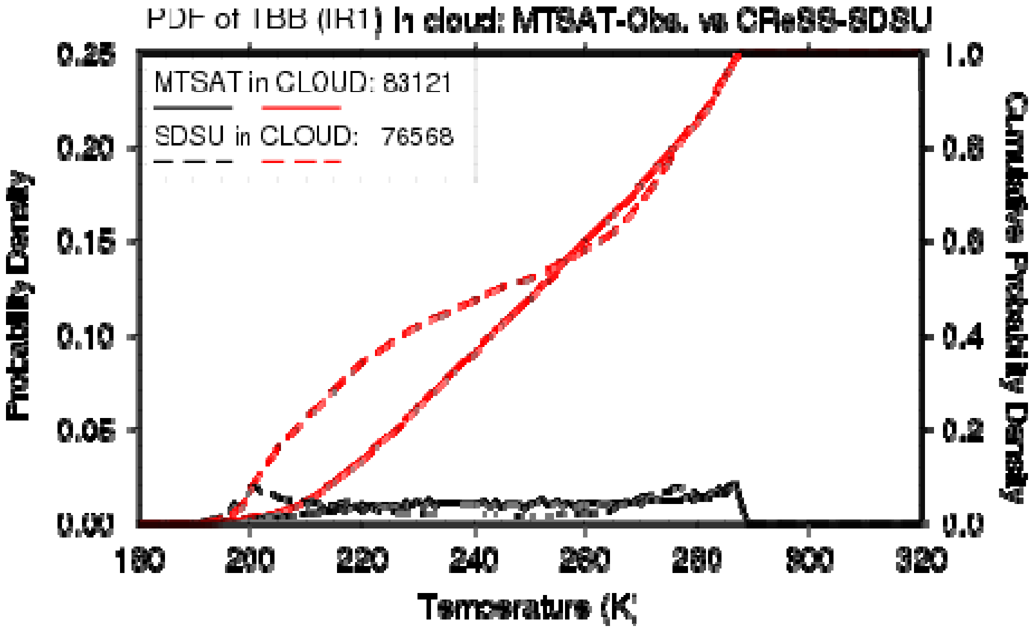
T_{BB}-IR distributions (MTSAT vs CReSS-SDSU: PALAU2010)



- MTSAT obs.: **Well-developed MCSs** develop over the southeast and southwest of Taiwan.
- CReSS-SDSU: **Only the southeastern MCS** is well reproduced.
- The **cloud cover** is seen over the almost all of the simulation region in the MTSAT obs. and CReSS-SDSU.

PDF of T_{BB}-IR (MTSAT vs CReSS-SDSU: PALAU2010)

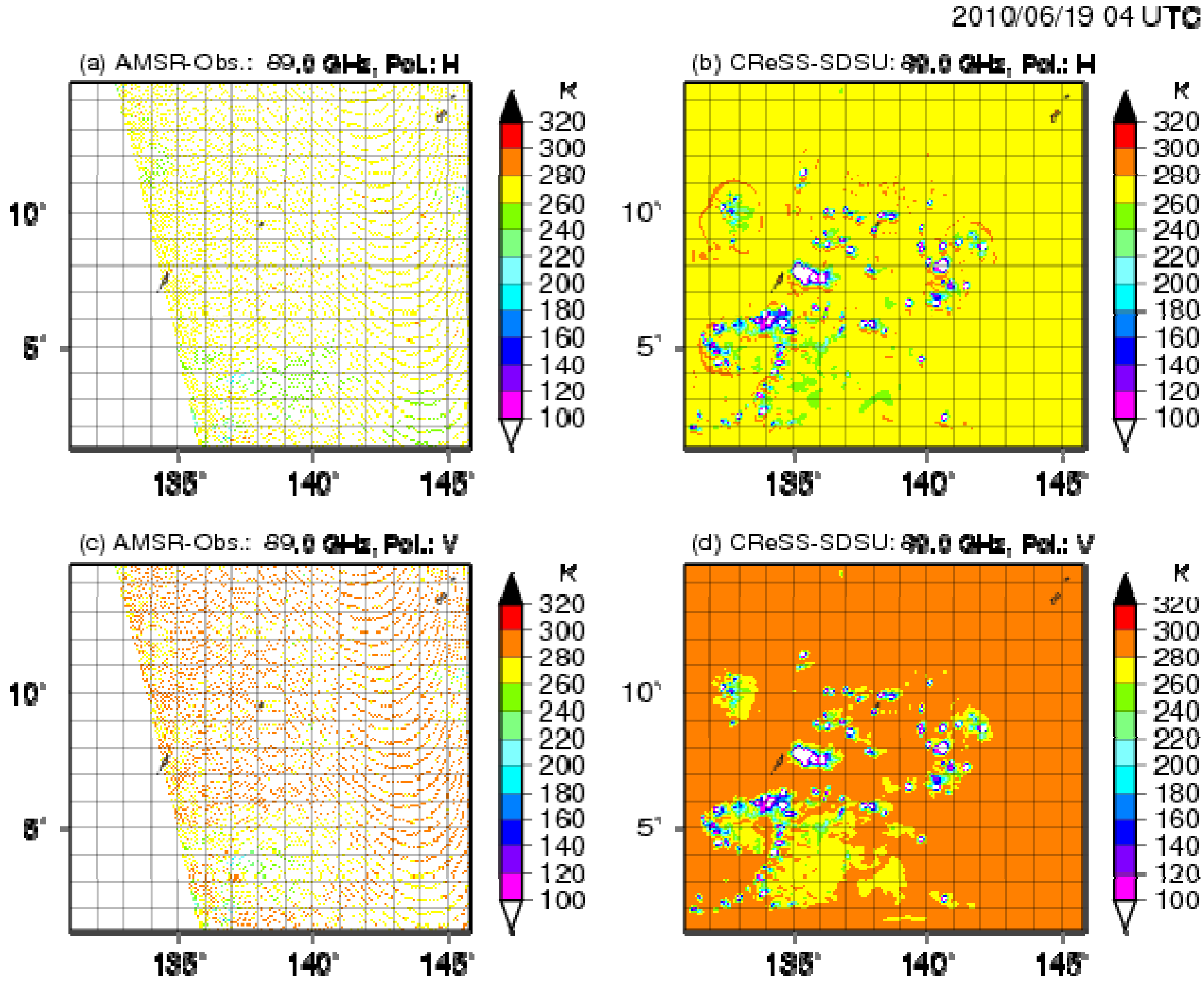




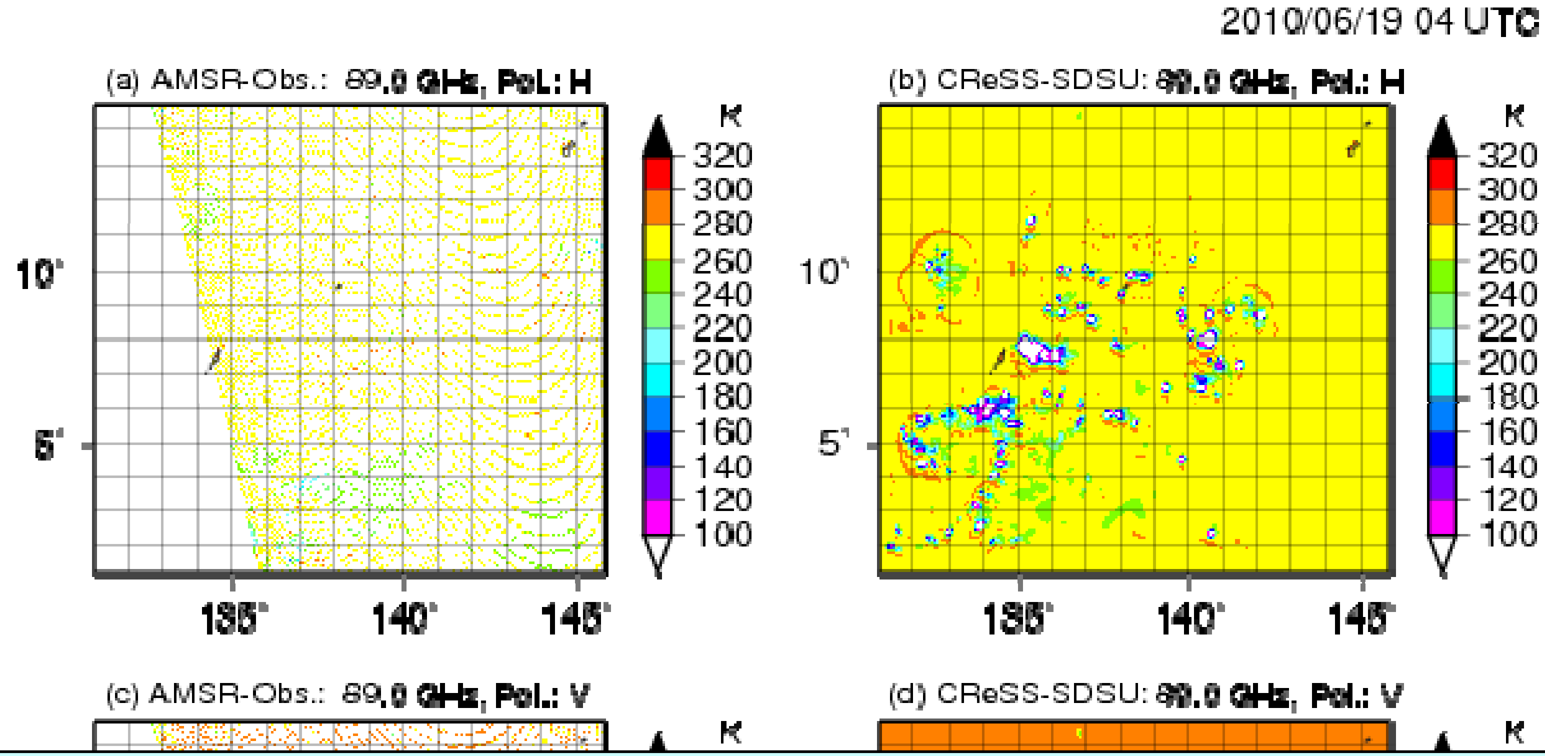
Solid lines: MTSAT obs.
Broken lines: CReSS-SDSU
Black: PDF
Red: Cumulative PDF

Frequency of upper (middle) clouds is greater (lesser) than that in the observation.
→ The simulation has a problem to reproduced the distribution of cloud-top height.

T_{BB}-MW 89GHz distributions (AMSR-E vs CReSS-SDSU)



T_{BB}-MW 89GHz distributions (AMSR-E vs CReSS-SDSU)



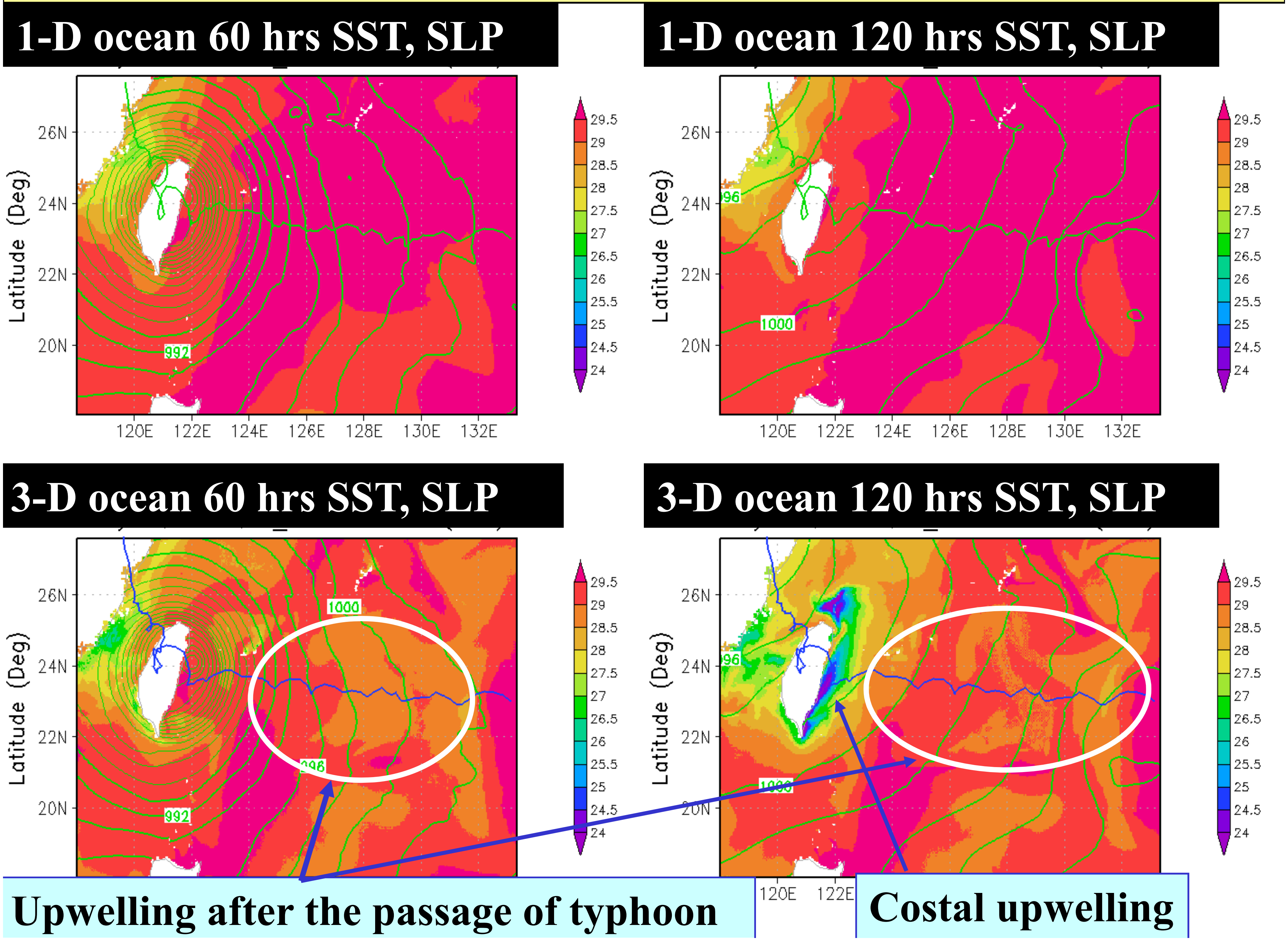
- **This frequency is sensitive to small-size ice particles in the upper.**
- **If large amount of ice particle exists, T_{BB} shows small values.**
- **Low T_{BB} areas are seen in the MCSs.**
- **Minimum T_{BB} values in the simulation are quite lesser than those in the satellite observation.**

→ This suggests excessive existence of solid hydrometeors in the upper troposphere over the MCSs

Development of the CReSS-NHOES

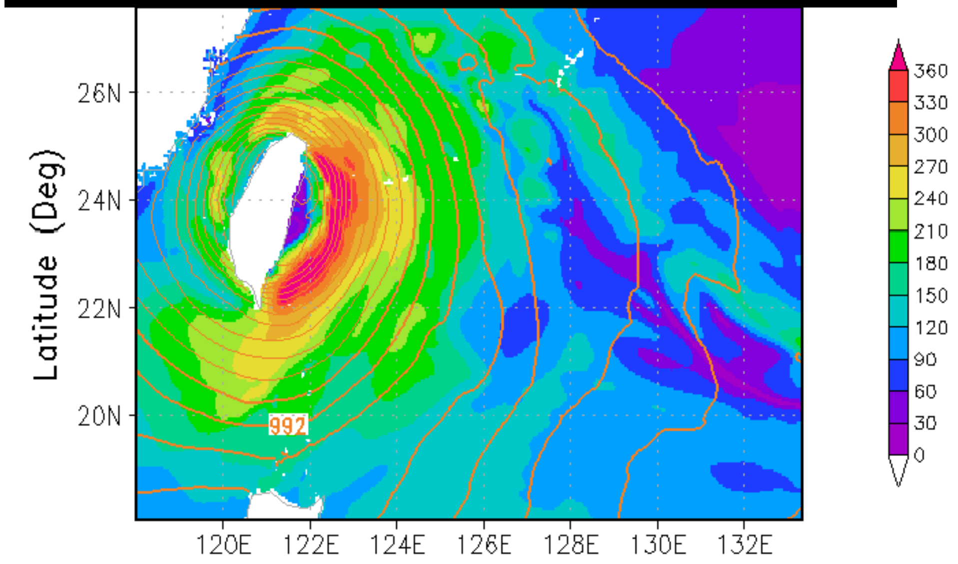
- The CReSS uses the slab-ocean scheme that solve the equation of heat conduction under the sea surface, but the initial vertical profile of temperature gives constant same as the prescribed SST.
- Dr. Aiki of JAMSTEC develop a three dimensional regional atmosphere-ocean coupled model in non-hydrostatic system, CReSS-NHOES.
- NHOES (NonHydrostatic Ocean model for ES)
  * Three dimensional nonhydrostatic ocean model
  * Hybrid terrain-following anz z-level system
  * Vertical mixed layer scheme near the surface is a simple diagnostic form base on bulk Richardson number (*Ri*).
- The CReSS-NHOES model is developed to use investigations for an effect of air-sea interaction.

Sample of the CReSS-NHOES simulation (T0908, Morakot)

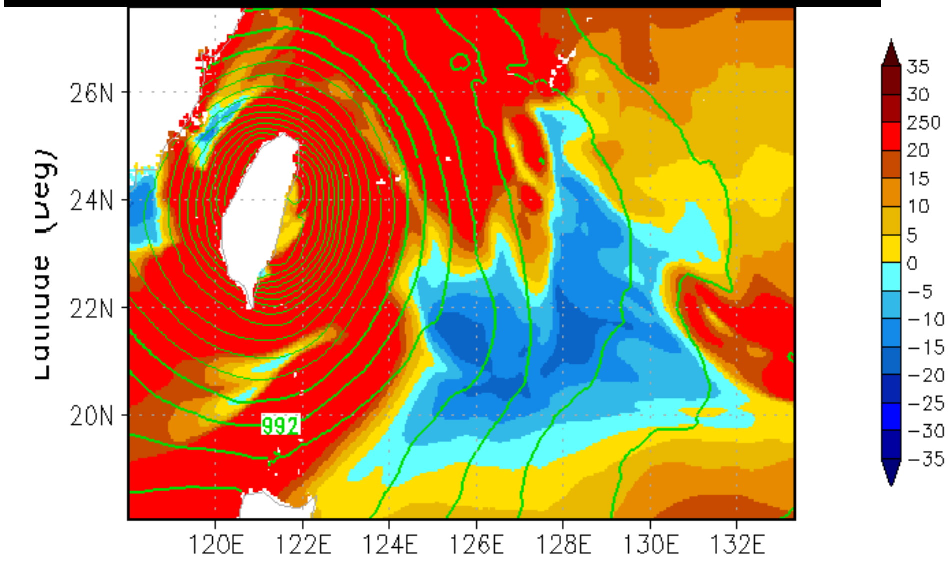


Sample of the CReSS-NHOES simulation (T0908, Morakot)

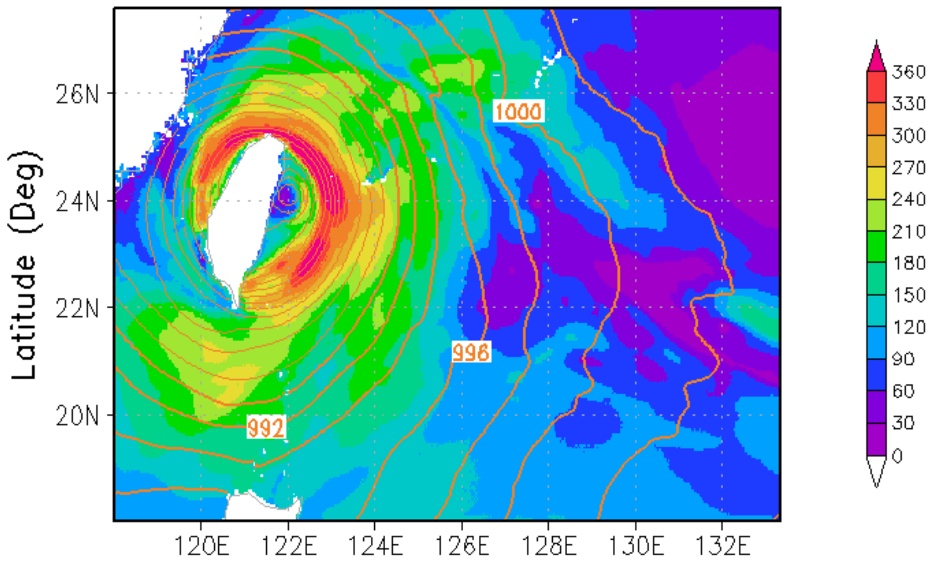
1-D ocean 60 hrs Latent Heat



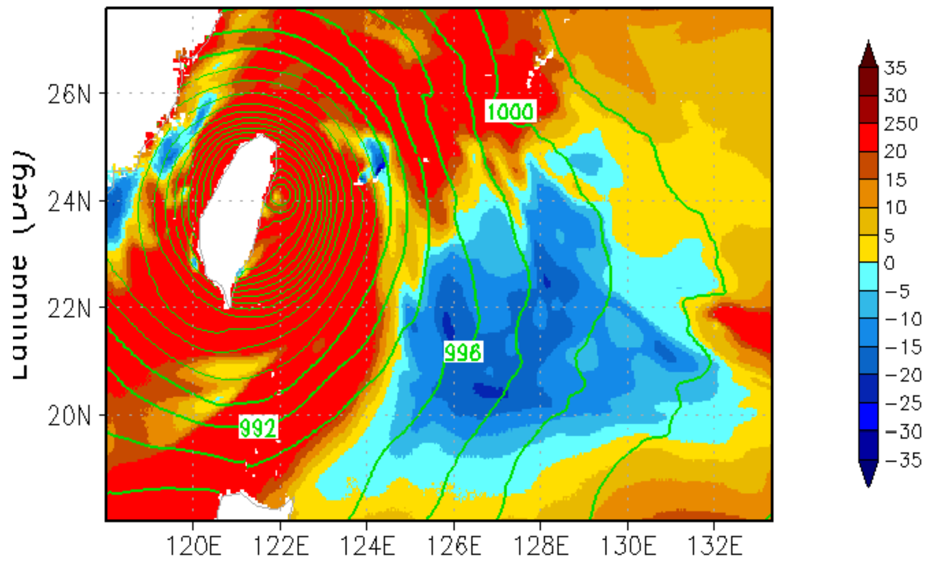
1-D ocean 60 hrs Sens. Heat



3-D ocean 60 hrs Latent Heat



3-D ocean 60 hrs Sens. Heat



Plan on daily simulation during the CINDY/DYNAMO 2011

Model	CReSS (CReSS-NHOES)
Domain	1500 km × 1500 km or wider
Resolution	2.5 km or less
	→ depend on domain and resolution
	→ also depend on Lab. plan
Period	Oct. - Dec. (Nov.) 2011
Forecase/Hindcast/Reanalysis	Forecast
	Basically using same configuration on PALAU2010
Release plan	YES
	for snapshot: realtime at web with password
	for data: please contact me
Timeline	?
Contact person	Taro Shinoda
	<shinoda@rain.hyarc.nagoya-u.ac.jp>

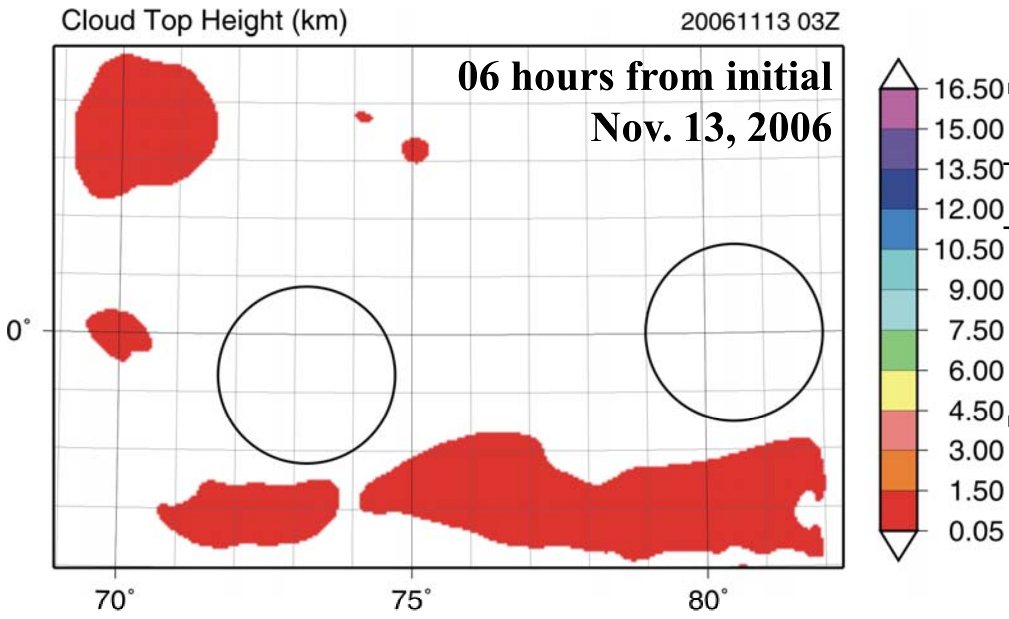
Plan on daily simulation during the CINDY/DYNAMO 2011

- We will conduct daily simulation using the CReSS with horizontal grid resolution less than 2.5 km during the CINDY/DYNAMO 2011.
- Semi-realtime Satellite Simulator (SDSU) calculation and validation on cloud fraction, frequency of TBB for infrared and microwave bands (and radar reflectivity as obtained from the TRMM) are applied for the daily simulation.
- If the initial reanalysis data of 3-D ocean (JCOPE2) are prepared, we will conduct daily simulation using the CReSS-NHOES (atmosphere-ocean coupled regional model).


Thank you

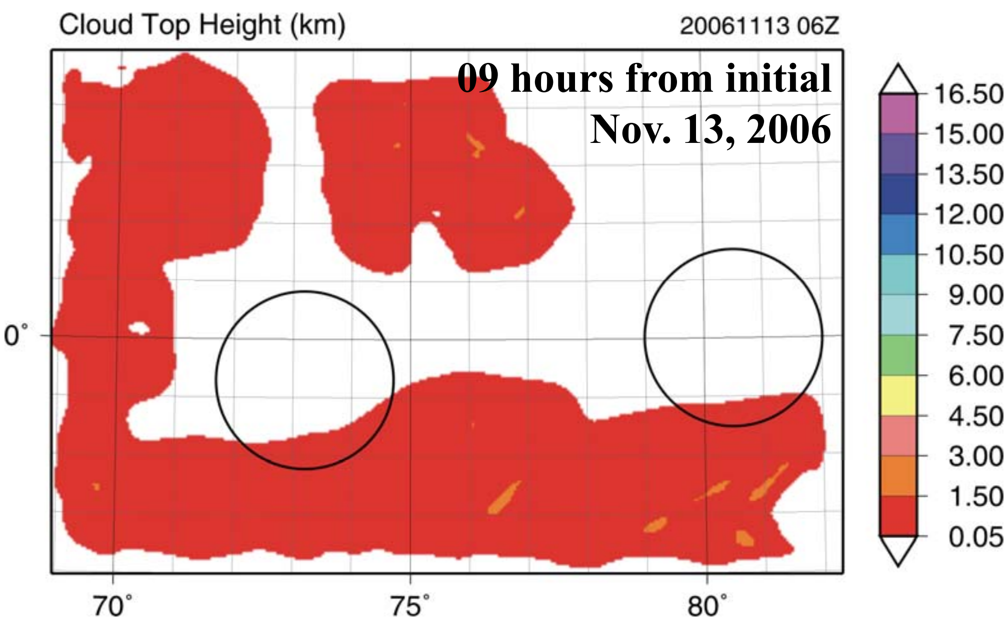
Backup Slides

Problem 1: Unrealistic Boundary Layer Clouds



- **Widespread lower clouds**
  → **Unrealistic!!**
  → **Water vapor is imprisoned and condensate in the BL**

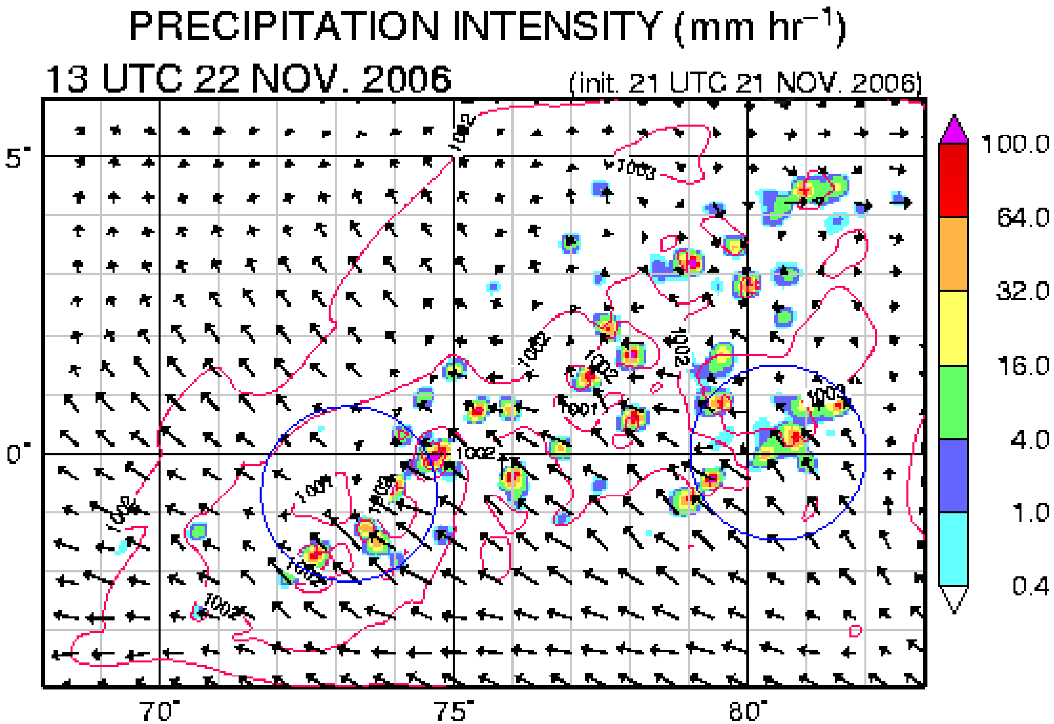
- **Shallow cumulus clouds transport water vapor from the BL to the FA.**
  → **We cannot reproduce this process.**

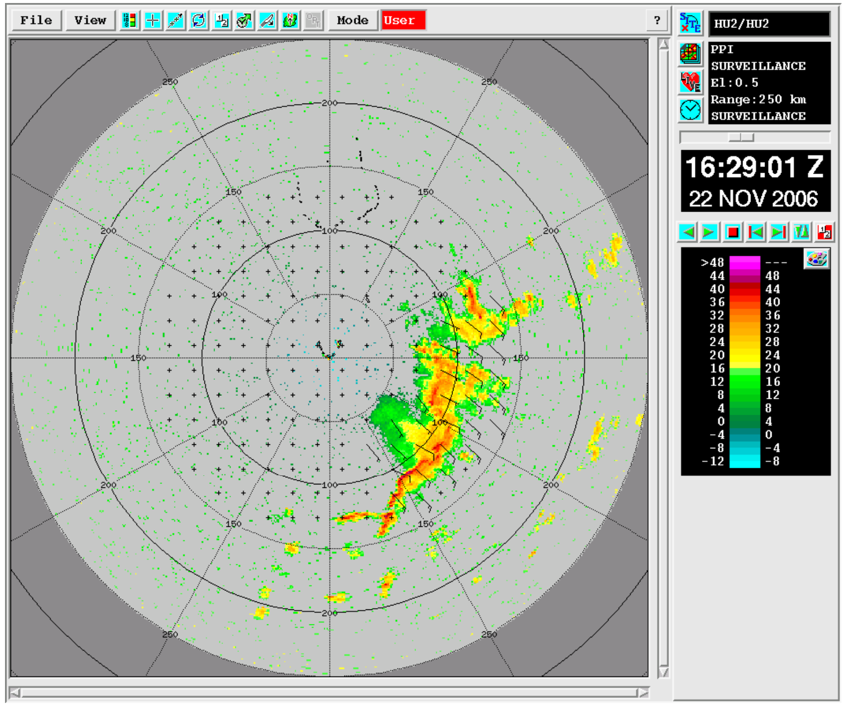


- **We have to introduce the shallow cumulus parameterization or use finer horizontal grid resolution.**

Problem 2: Cellar Precipitation Regions (not Precipitation System)

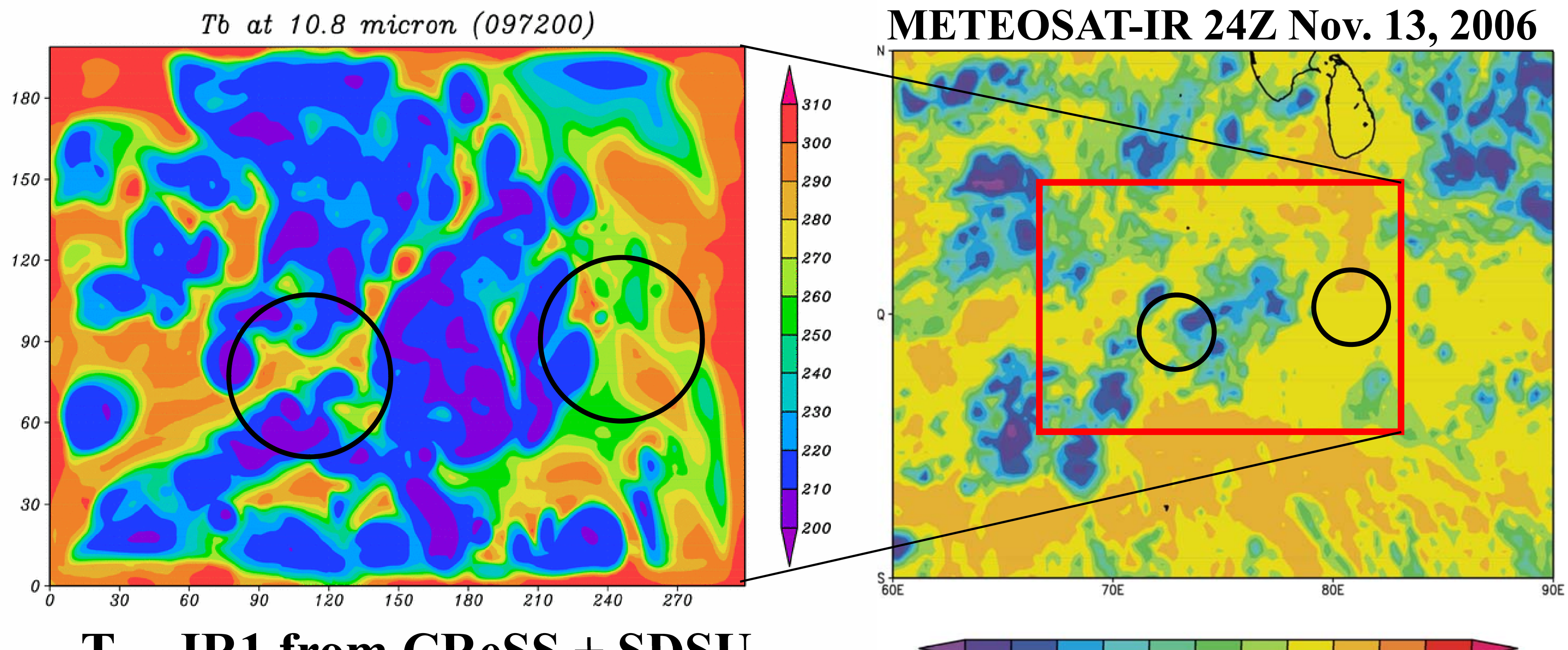
Observed around Gan Island on Nov. 22, 2006





- **Precipitation regions are cellar structure** **(～ 50 km),**
  the structure of the precipitation system is not reproduced.
- **Perhaps this structure depends on the horizontal grid resolution.**

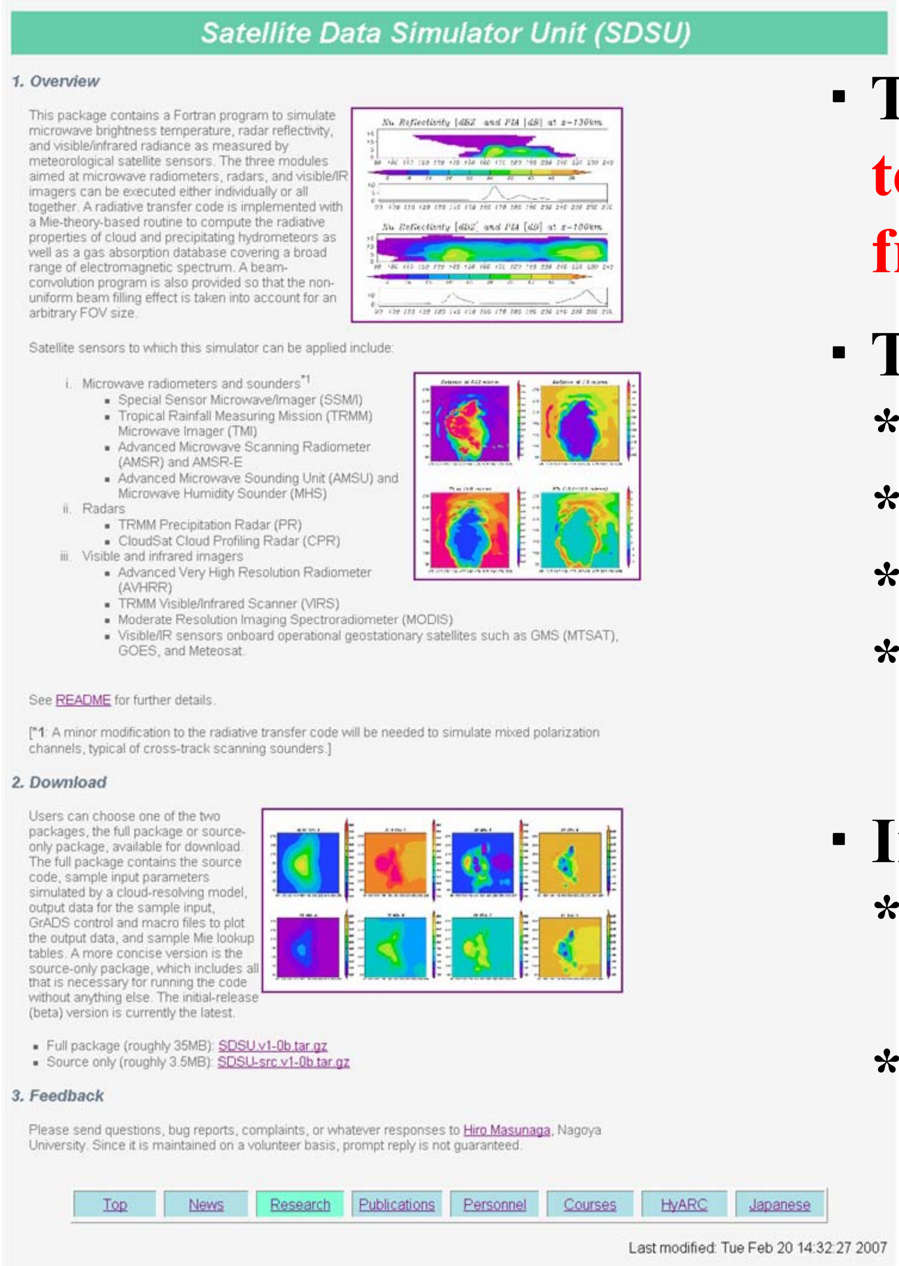
Problem 3: Large Amount of High Cloud Fraction



T_{BB}-IR1 from CReSS + SDSU
by Prof. H. Masunaga

- Large amount of high cloud fraction in the simulation result.
- We cannot find out the course of this result.
  * The horizontal grid resolution?
  * Bulk microphysical processes in the CReSS?

The Satellite Data Simulator Unit (SDSU)



Satellite Data Simulator Unit (SDSU)

1. Overview

This package contains a Fortran program to simulate microwave brightness temperature, radar reflectivity, and visible/infrared radiance as measured by meteorological satellite sensors. The three modules aimed at microwave radiometers, radars, and visible/IR imagers can be executed either individually or all together. A radiative transfer code is implemented with a Mie-theory-based routine to compute the radiative properties of cloud and precipitating hydrometeors as well as a gas absorption database covering a broad range of electromagnetic spectrum. A beam-convolution program is also provided so that the non-uniform beam filling effect is taken into account for an arbitrary FOV size.

Satellite sensors to which this simulator can be applied include:

i. Microwave radiometers and sounders*1
   - Special Sensor Microwave/Imager (SSM/I)
   - Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI)
   - Advanced Microwave Scanning Radiometer (AMSR) and AMSR-E
   - Advanced Microwave Sounding Unit (AMSU) and Microwave Humidity Sounder (MHS)

ii. Radars
   - TRMM Precipitation Radar (PR)
   - CloudSat Cloud Profiling Radar (CPR)

iii. Visible and infrared imagers
   - Advanced Very High Resolution Radiometer (AVHRR)
   - TRMM Visible/Infrared Scanner (VIRS)
   - Moderate Resolution Imaging Spectroradiometer (MODIS)
   - Visible/IR sensors onboard operational geostationary satellites such as GMS (MTSAT), GOES, and Meteosat.

See README for further details.

[*1: A minor modification to the radiative transfer code will be needed to simulate mixed polarization channels, typical of cross-track scanning sounders.]

2. Download

Users can choose one of the two packages, the full package or source-only package, available for download. The full package contains the source code, sample input parameters simulated by a cloud-resolving model, output data for the sample input, GrADS control and macro files to plot the output data, and sample Mie lookup tables. A more concise version is the source-only package, which includes all that is necessary for running the code without anything else. The initial-release (beta) version is currently the latest.

- Full package (roughly 35MB): SDSU.v1-0b.tar.gz
- Source only (roughly 3.5MB): SDSU-src.v1-0b.tar.gz

3. Feedback

Please send questions, bug reports, complaints, or whatever responses to Hiro Masunaga, Nagoya University. Since it is maintained on a volunteer basis, prompt reply is not guaranteed.

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Last modified: Tue Feb 20 14:32:27 2007

- The SDSU is developed to compute synthetic satellite data from CRM output by Dr. Masunaga.
- The SDSU is designed to simulate
  * microwave brightness temperature,
  * radar reflectivity,
  * visible and near-infrared radiances,
  * thermal infrared brightness temperature.
- Input parameters
  * P, PT, Qv, Qc, Qr, Qi, Qs, Qg, Ni, Ns, Ng, z
  * SST, Surface_winds, temp., humid.

http://precip.hyarc.nagoya-u.ac.jp/sdsu/sdsu-main.html

Brief summary of the comparison method in this study

CReSS simulation

SDSU calculation

MTSAT observation

Infrared band

Compare!!

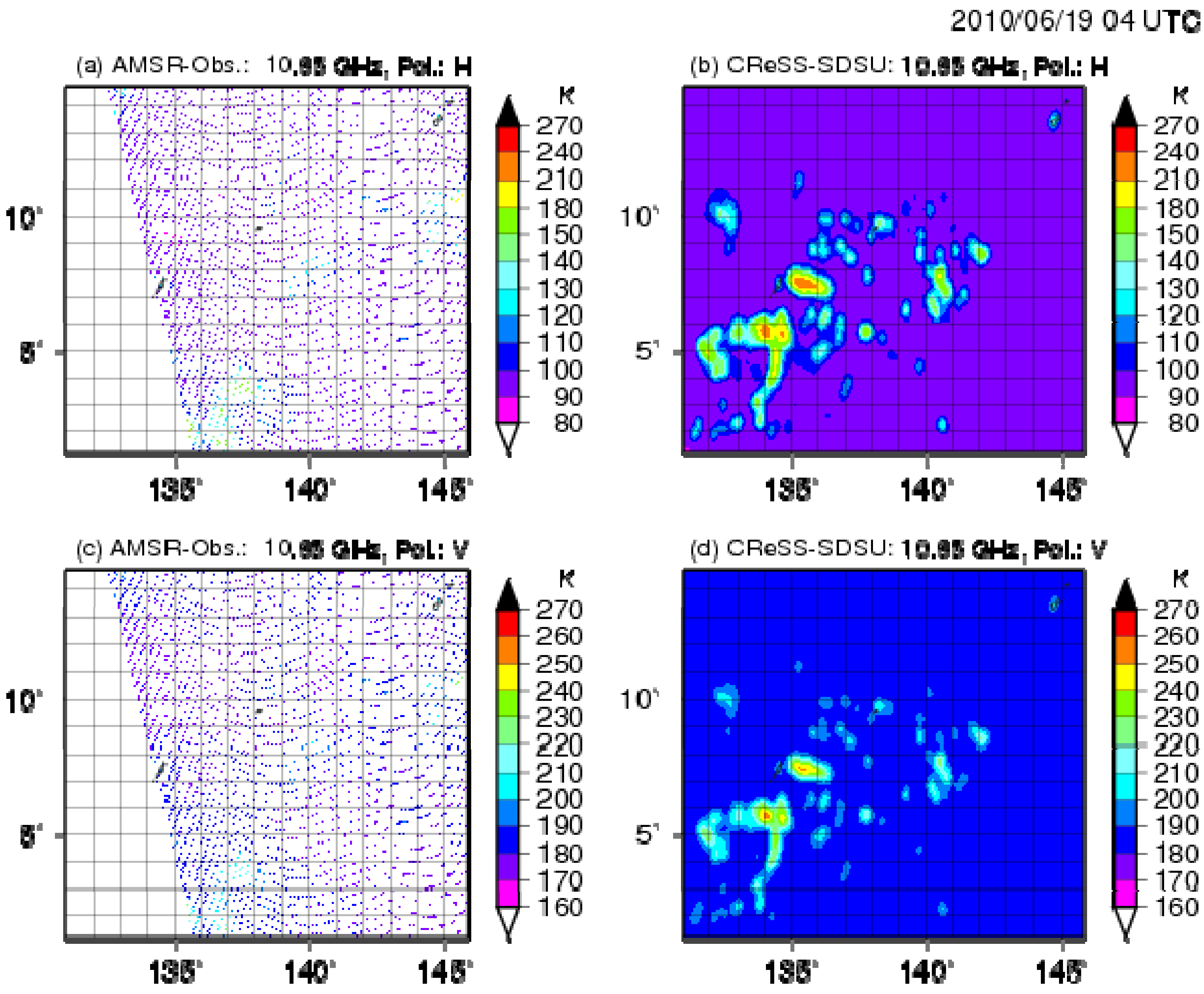
Microwave Band

AMSR-E observation

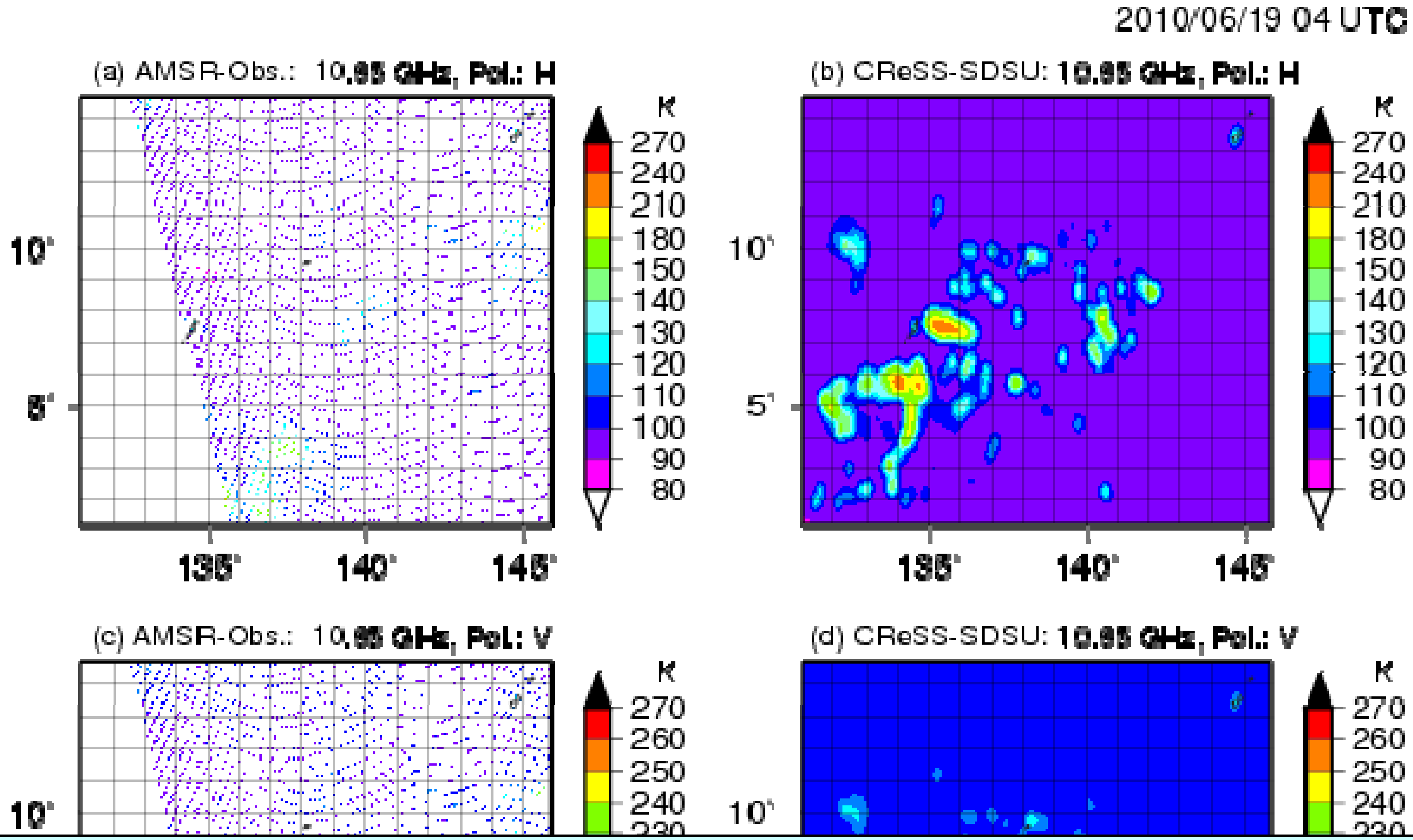
We can evaluate statistical results on

- the cloud-top height,
- the cloud fraction
- mixing ratio of water vapor,
- mixing ratio and DSD of hydrometeors.

T_{BB}-MW 10.65 GHz distributions (AMSR-E vs CReSS-SDSU)

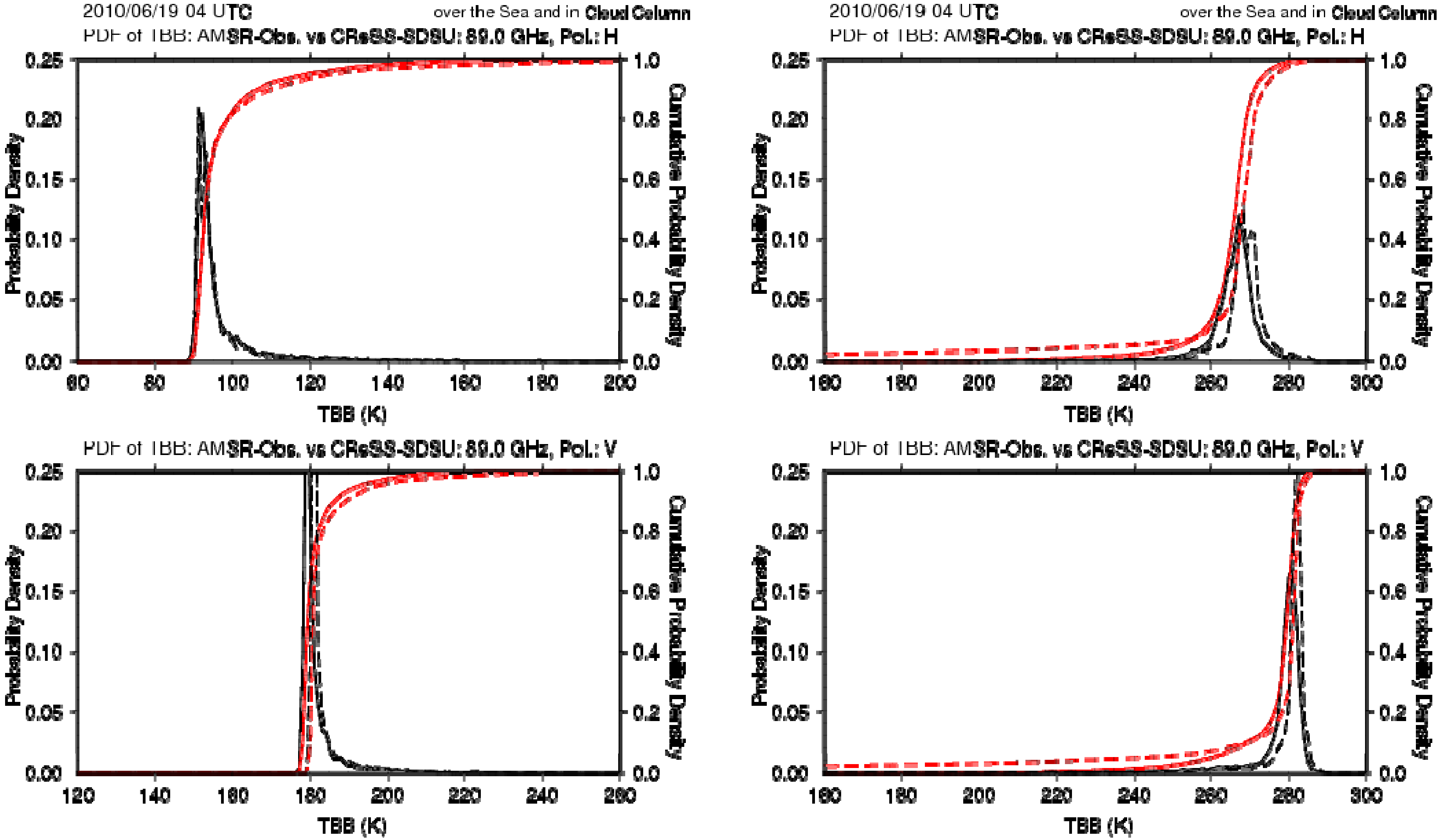


T_{BB}-MW 10.65 GHz distributions (AMSR-E vs CReSS-SDSU)



- **This frequency (10.65 GHz) is sensitive to heavy rainfall area shown by higher T_{BB} exceeding 120 K for horizontal polarization.**
- **High T_{BB} areas are seen in the MCSs.**
- **High T_{BB} areas are reproduced in the simulation in southeast of Taiwan (T_{BB} exceed 180 K).**

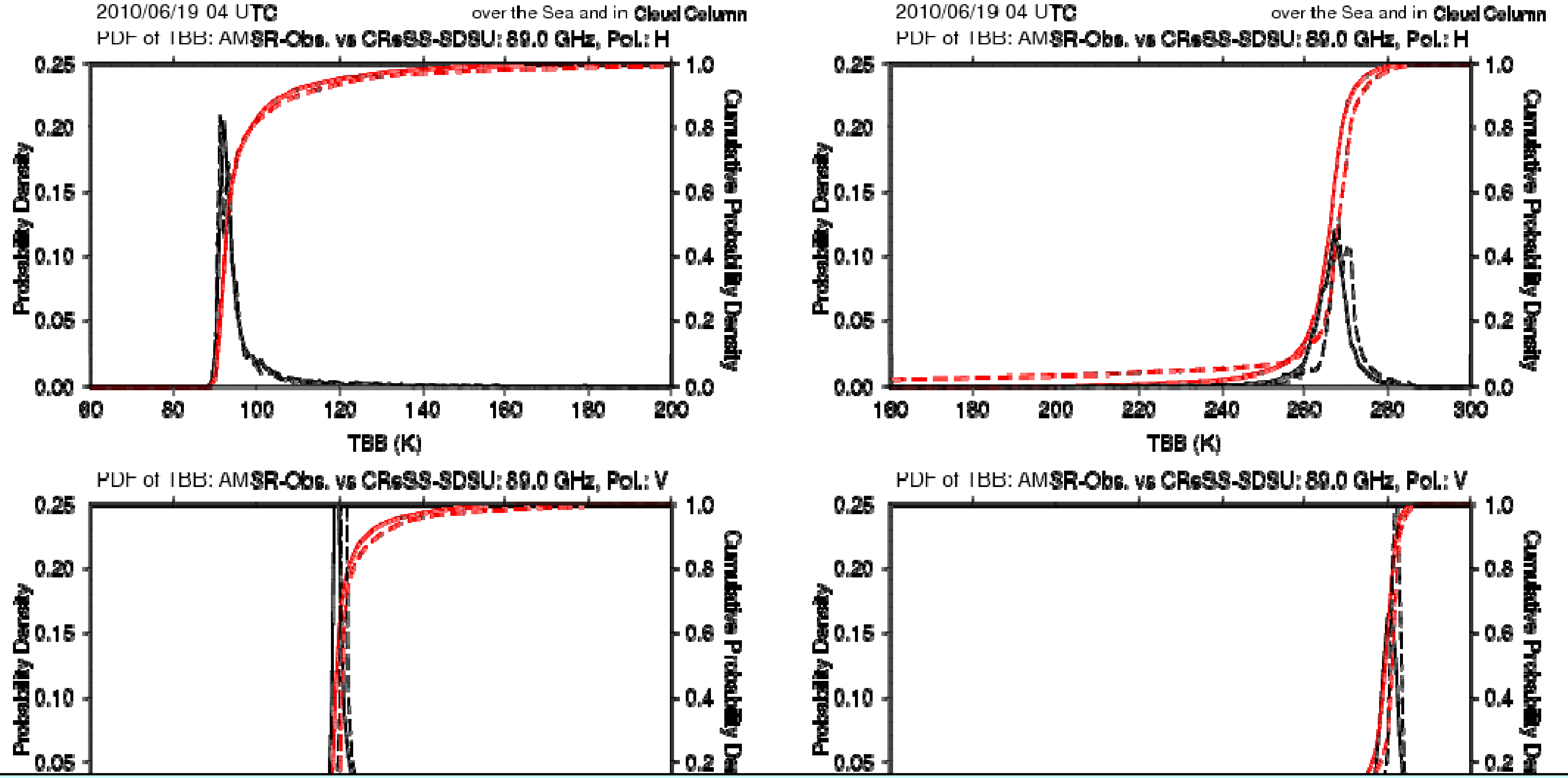
PDF of T_{BB}-MW 10.65 and 89.0 GHz (AMSR-E vs CReSS-SDSU)



Solid lines: AMSR-E obs.
Broken lines: CReSS-SDSU

Black: PDF
Red: Cumulative PDF

PDF of T_{BB}-MW 10.65 and 89.0 GHz (AMSR-E vs CReSS-SDSU)



- For 10.65 GHz H-pol.: The PDF shape is quite resembled.
- For 89 GHz H-pol.: Frequency of lower TBB (less than 250K) in the simulation is quite larger than that in the observation.

→ This also suggests excessive existence of solid hydrometeors in the upper troposphere over the MCSs