Oceanic rainfall estimation from TMI observations by using mesoscale cloud model and microwave radiative transfer model

[1]Wann-Jin Chen [2]Yung-Ching Lin [3]Christine Chiu [4]Gin-Rong Liu
[1]Dept. of Environmental. Information. and Engineering., Chung Cheng Institute. of Technology, National Defense University
[2] Weather Wing, Air Force
[3]Goddard Space Flight Center, NASA,
[4]Center for Space and Remote Sensing Research, NCU

content

1. Motivation and purpose

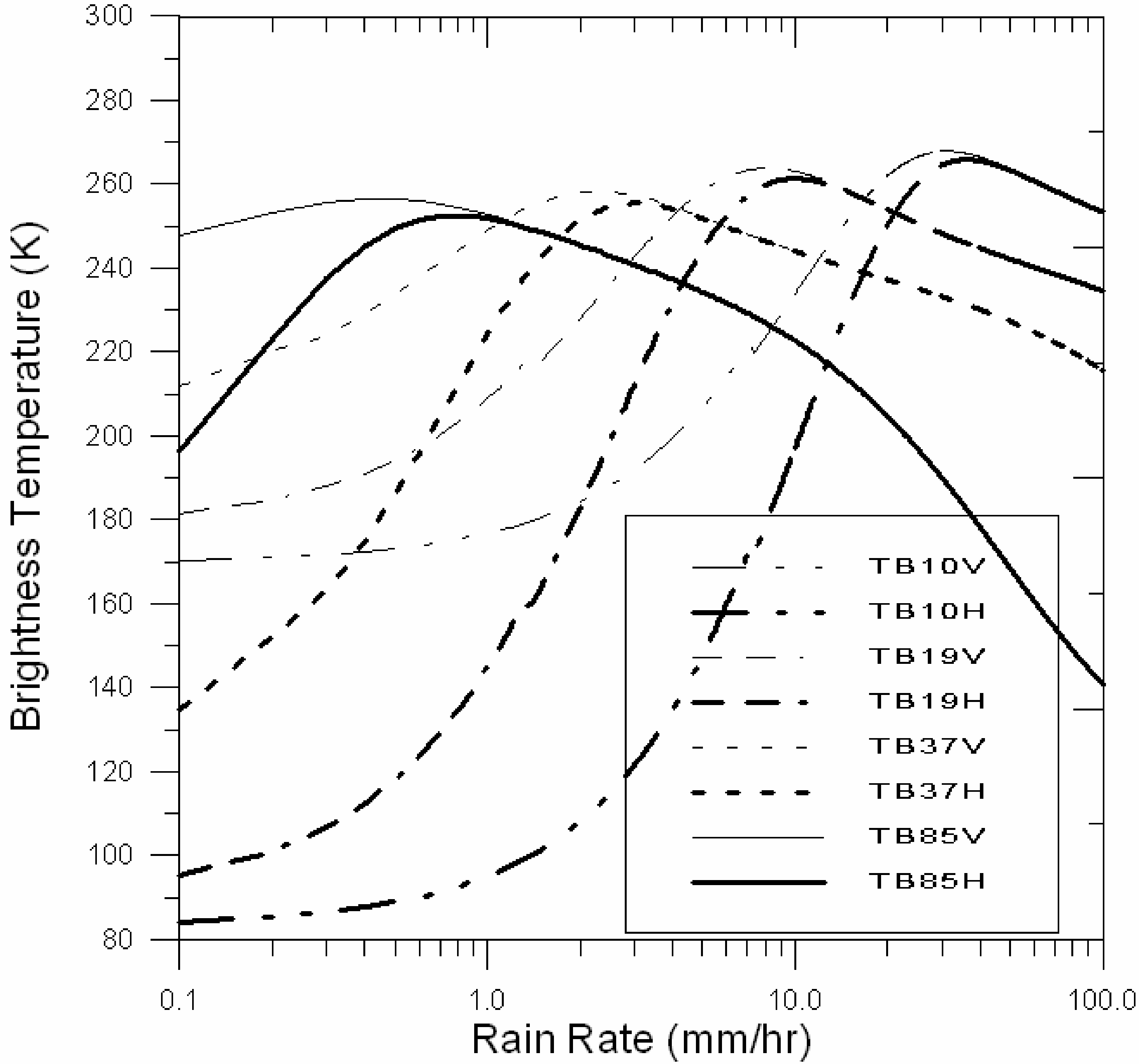
- Reducing natural disasters caused by Typhoon.
- Establishing a physical satellite rainfall retrieval for typhoon rainfall estimation.

2. Model and data

- Weather Research Forecasting model
- Radiative Transfer Model (provided by Guosheng Liu at Florida State University)
- Bayesian retrieval method

Typhoon cases

No.	Typhoon name	Intensity	Sinmulation time (UTC)	
			starting	ending
01	SEPAT	intense	2007081400Z	2007081800Z
02	KROSA	intense	2007100300Z	2007100700Z
03	WIPHA	intense	2007091600Z	2007091812Z
04	MITAG	strong	2007112112Z	2007112512Z
05	KAEMI	strong	2006071900Z	2006072518Z
06	SAOMAI	intense	2006080600Z	2006081006Z
07	SHANSHAN	strong	2006091112Z	2006091712Z


Brightness Temperature (K)
300
280
260
240
220
200
180
160
140
120
100
80
0.1
1.0
10.0
100.0
Rain Rate (mm/hr)
TB10V
TB10H
TB19V
TB19H
TB37V
TB37H
TB85V
TB85H

Definition of *P* value

***P*：normalized polarization difference (attenuation index)**

$$P = \frac{T_v - T_h}{T_{v,o} - T_{h,o}}$$

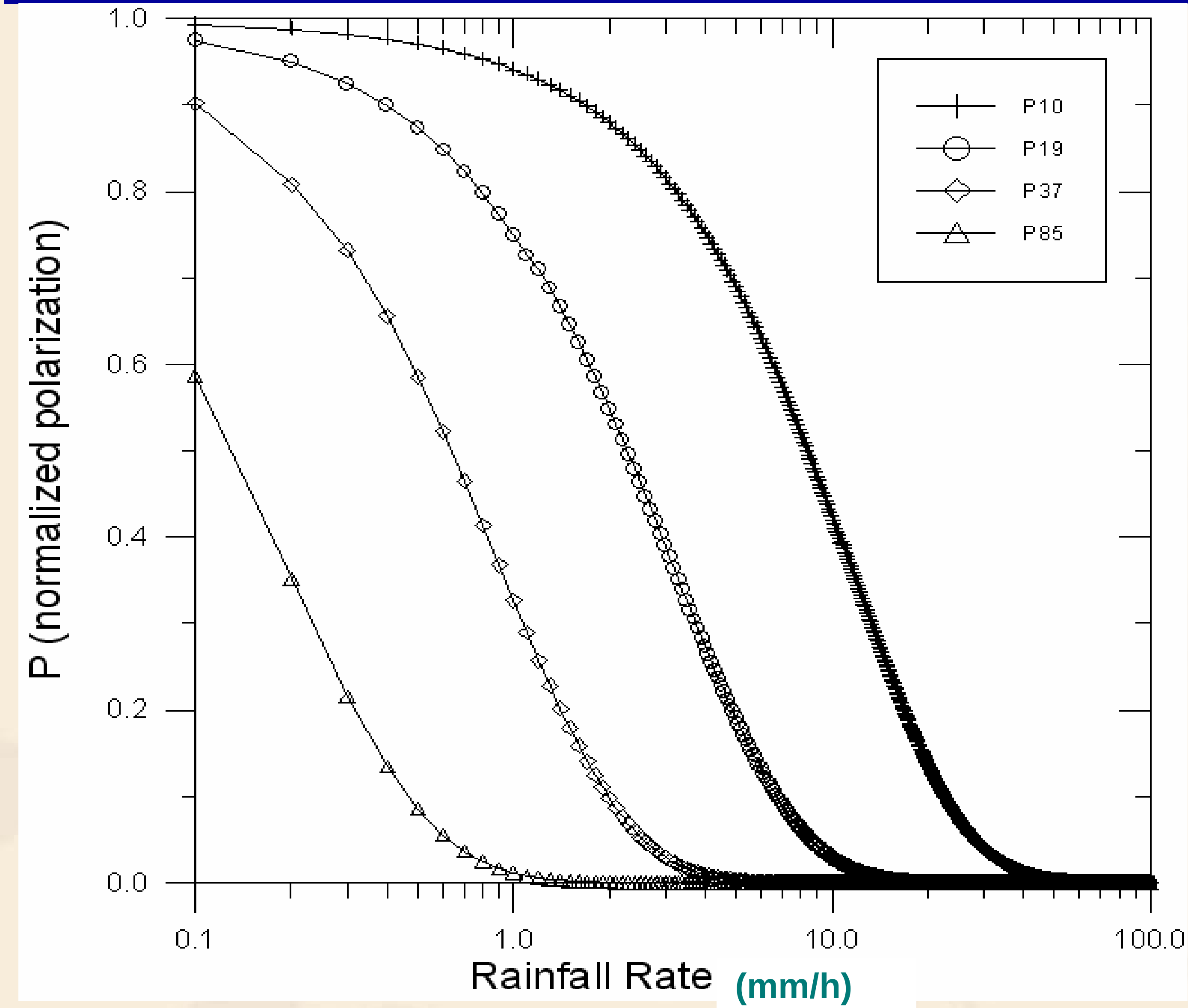
$T_v - T_h$ ← Observation of TMI

$T_{v,o} - T_{h,o}$ ← Under cloud free of TMI

(Petty, 1994)

- Reducing the signal from the ocean surface and isolating the effects of rain clouds (Chiu, 2003)

Normalized Polarization Difference, *P*



***P* decreases with increasing rain rate**

Bayesian method

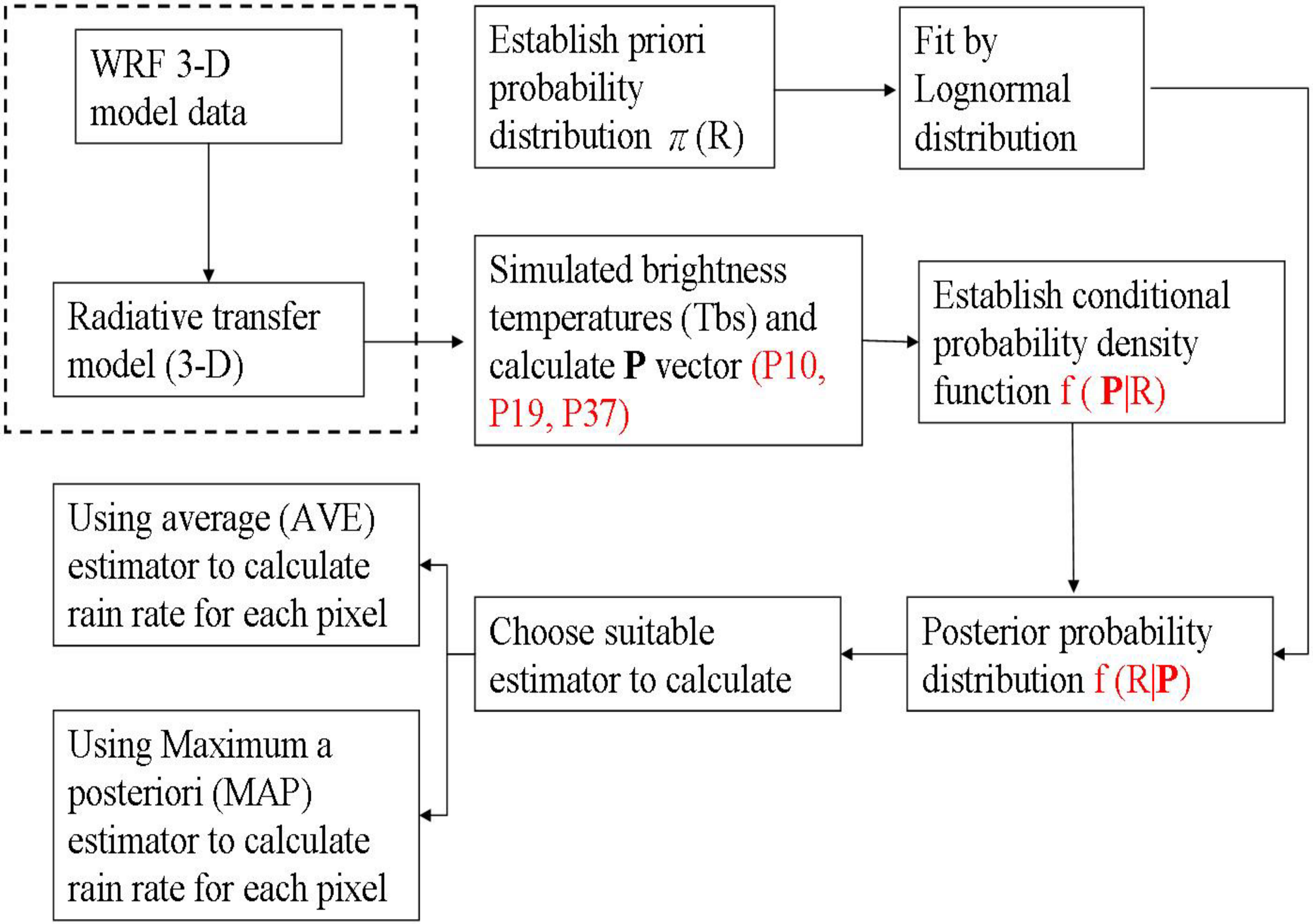
$$\pi(R/P) \propto f(P/R)\pi(R)$$

$f(P/R)$: conditional probability, given rain rate

$\pi(R)$: prior distribution

$\pi(R/P)$: posterior probability

Flowchart of Bayesian method



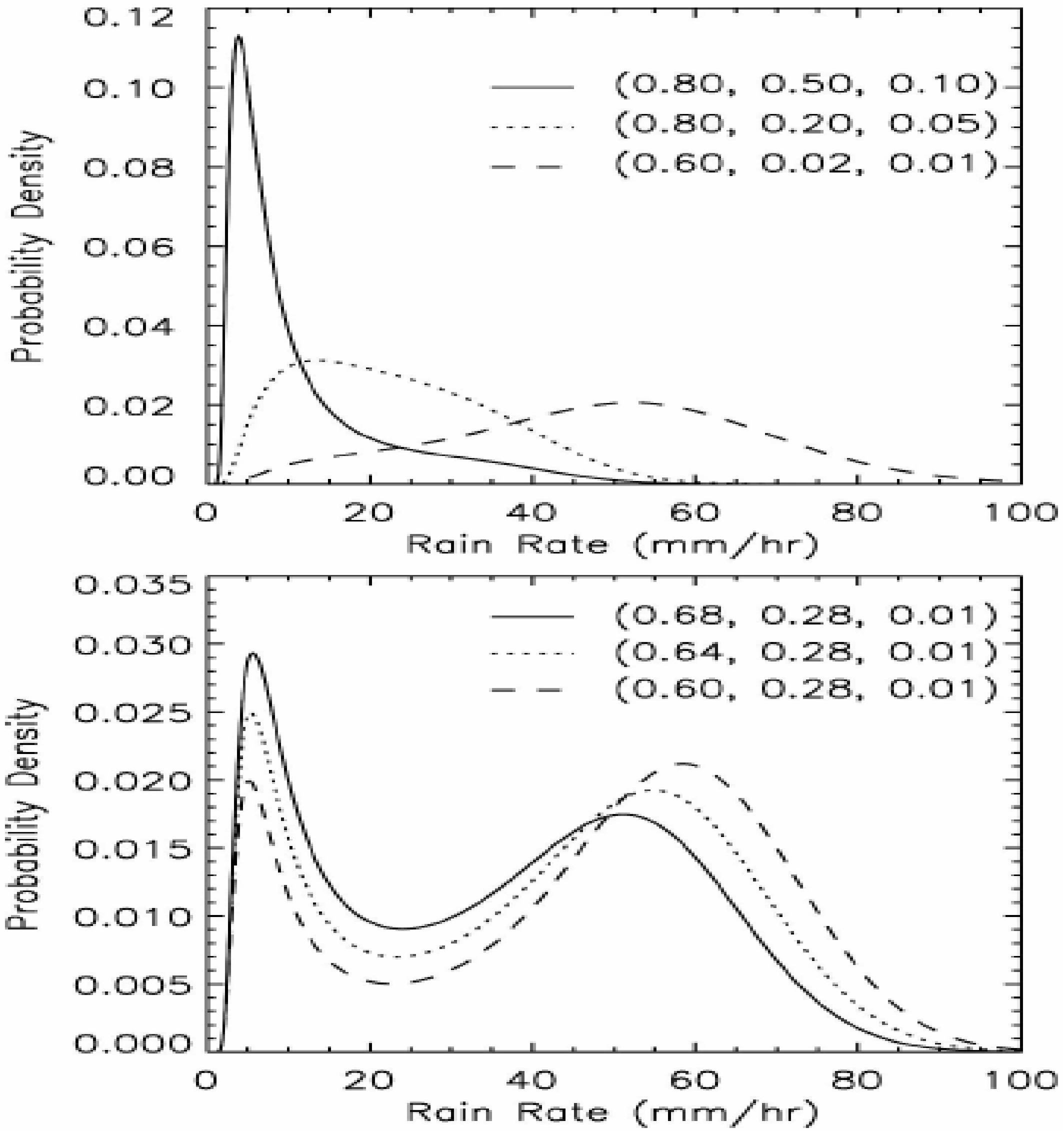


FIG. 2. Examples of derived posterior rain-rate distributions at some given P vectors in experiment R0. The observation vector (P_{10}, P_{19}, P_{37}) is presented by the three numbers in parentheses.

(Chiu and Petty, 2006)

4. Result and discussion

quantitative rainfall

validation

Case 1 Typhoon Aere (2004)

Case 2 Typhoon Krosa (2007)

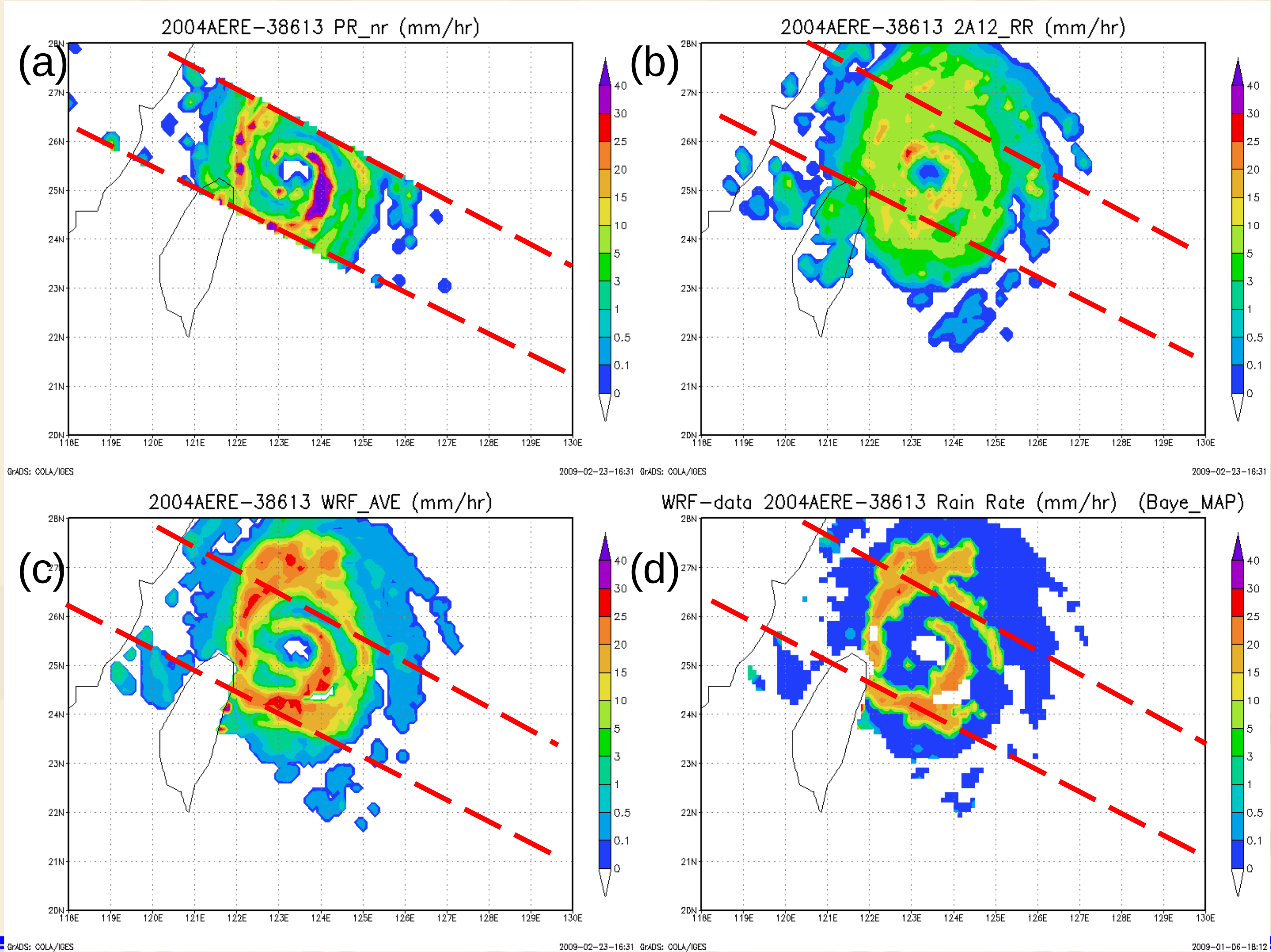
validation

- The retrieval rain rate products : rain map probability

  Baye-AVE : average estimator

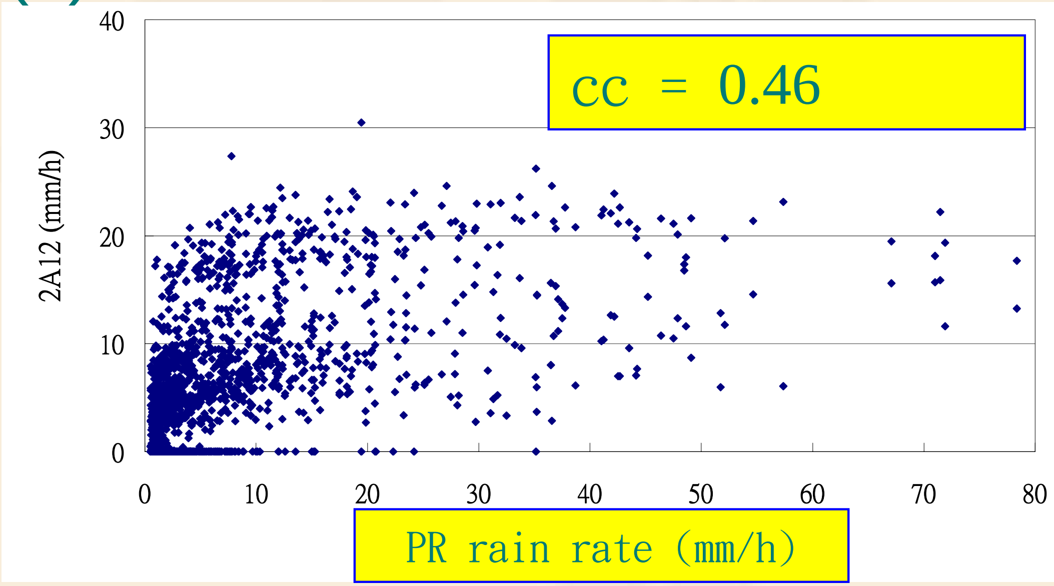
  Baye-MAP : maximum a posteriori
- PR near surface rain rate : ground truth
- Comparison with 2A12 product, which was retrieved by simple Bayesian method

case1：Typhoon Aere 2004/8/24 0902 UTC

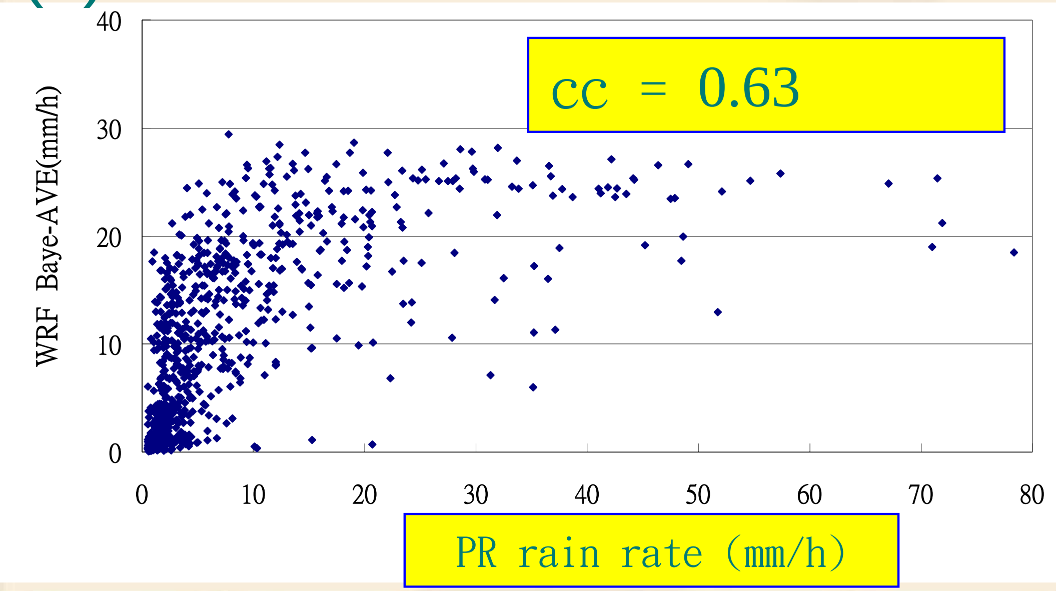


Comparison of AERE PR rain map with (a)2A12 (b)Baye_AVE (c)Baye_MLE

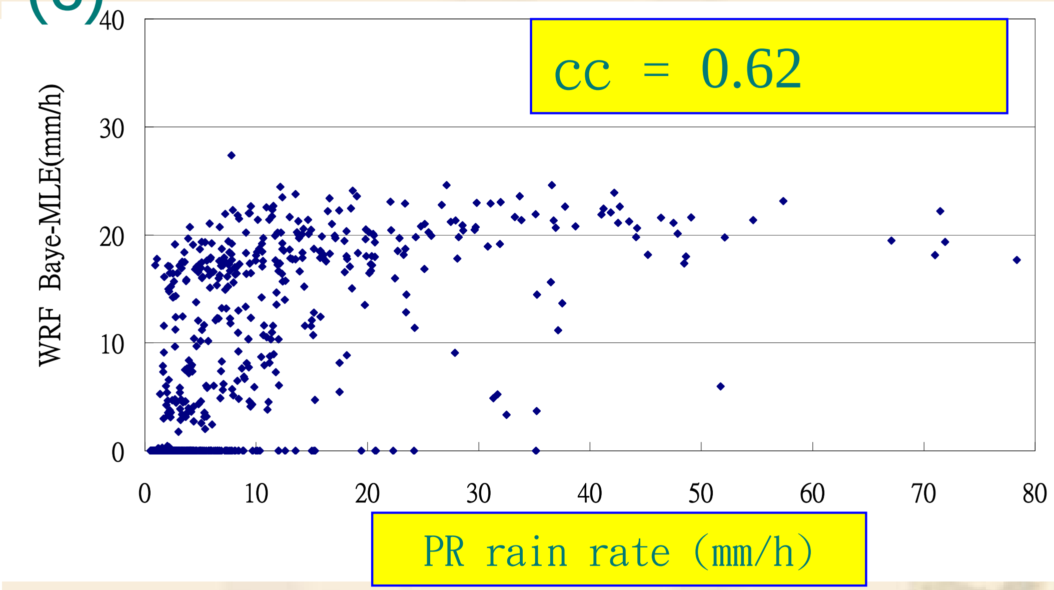
(a)



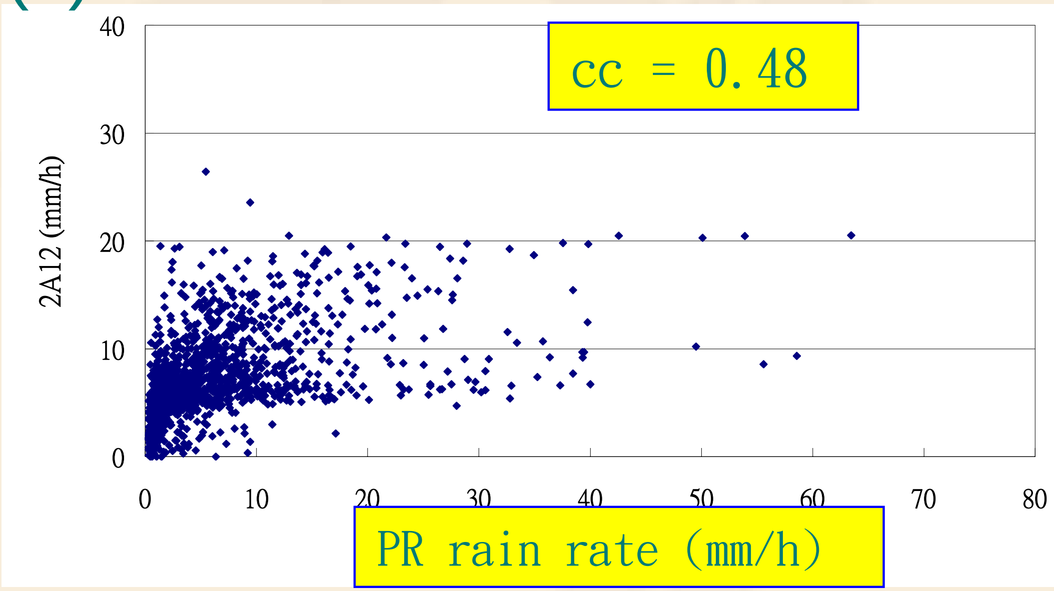
(b)



(c)

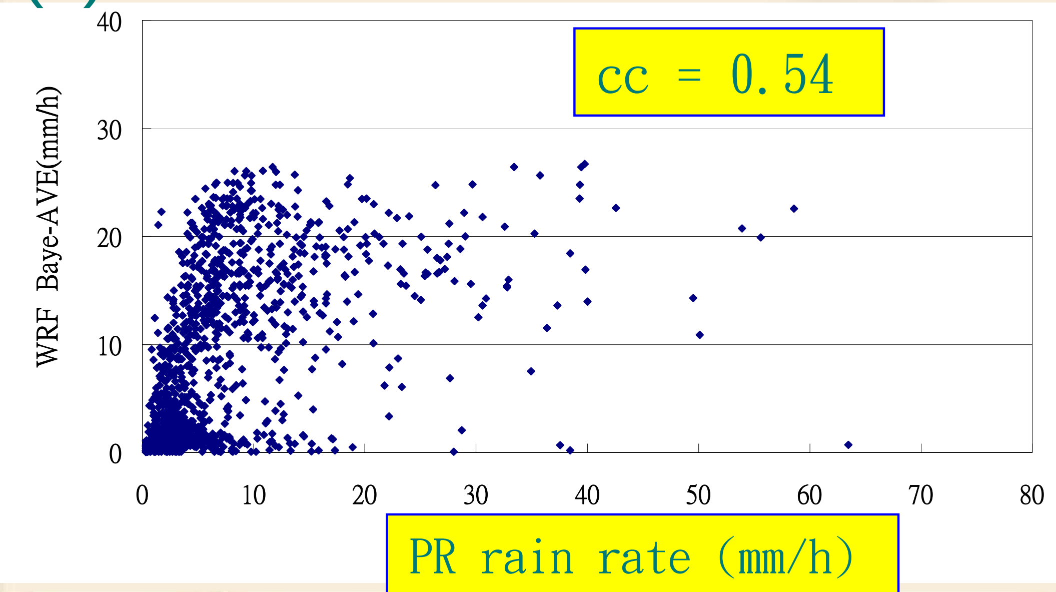


(a)

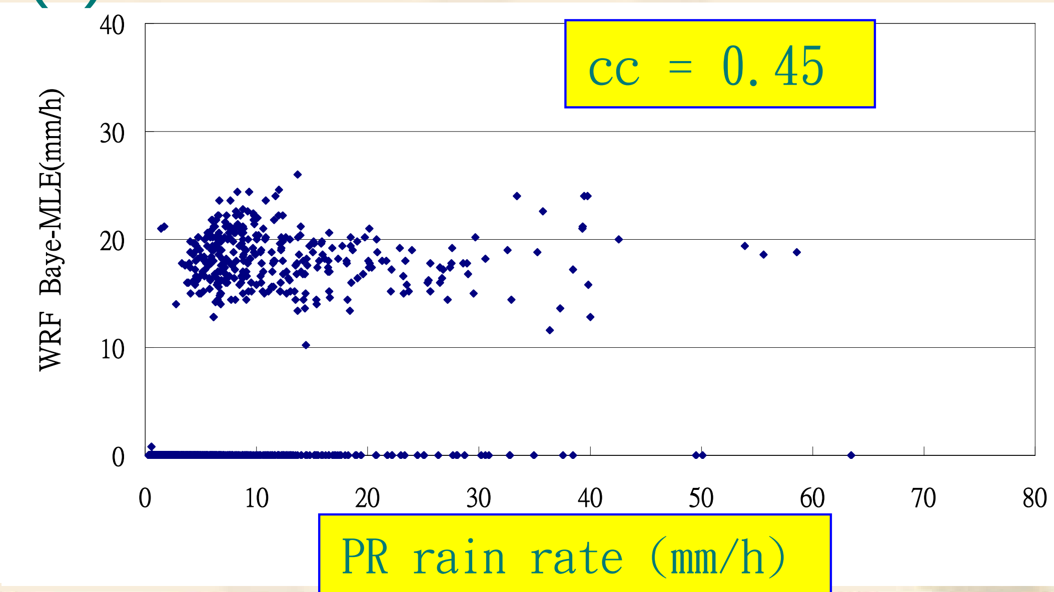


Comparison of 2007 KROSA PR rain map with (a)2A12 (b)Baye_AVE (c)Baye_MLE

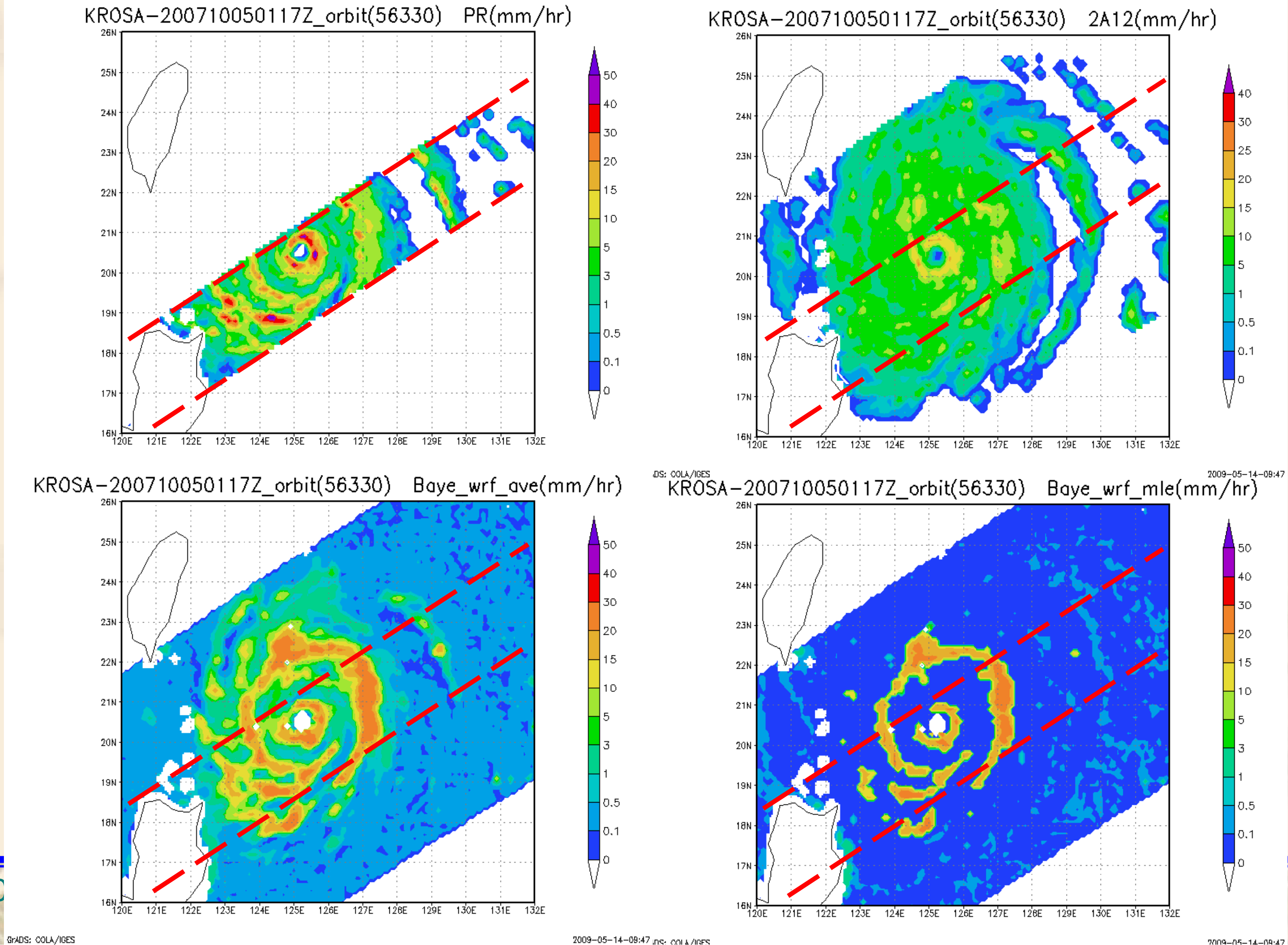
(b)



(c)



case 2 : Typhoon Krosa 2007
2007/10/05 0117 UTC



5. Summary and future works

- Combining WRF and LRTM to establish a physical rainfall retrieval algorithm is available.

- The results show that overall our Baye_AVE products can catch the strong rain band of Typhoon better than that of 2A12, especially in eyewall and outside rainbands.

- The Baye_AVE products can receive the best correlation coefficient between PR rain truth and shows that it can provide more accurate rain map over ocean.
- Joining more microwave sensors in our algorithm to provide more high temporal resolution rain map.

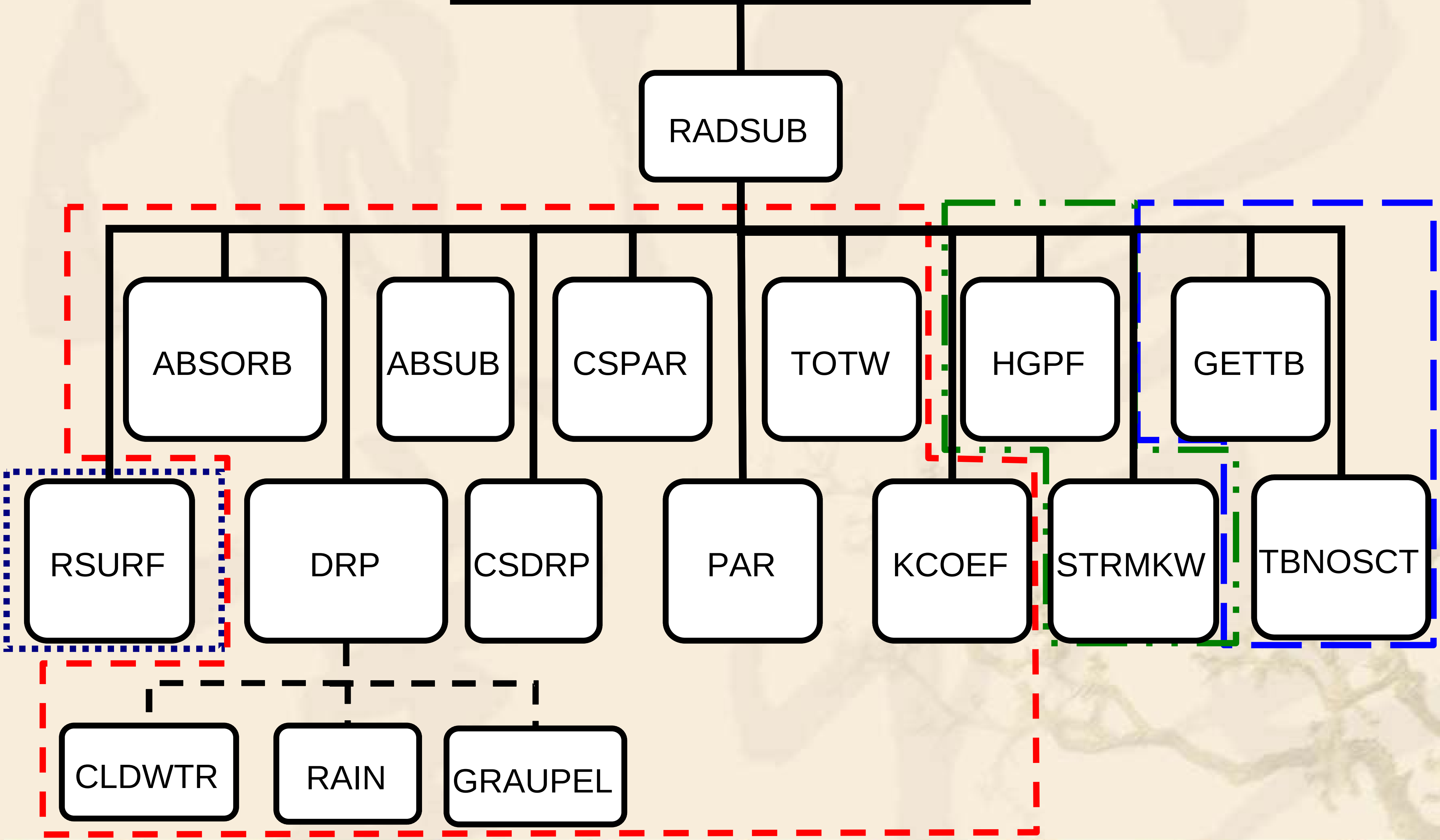
Thank you for your attention !

Backup

WRF model setup

- version: WRF v2.2.1
- initial field : from NECP
- grid size :1 degree by 1 degree
- update interval : 6 hours
- Model parameter setting
- microphysics : WSM6 (WRF Single-Moment 6 - class)
- boundary: YSU (Yonsei University method)
- Cumulus parameter : KF (Kain-Fritsch)

LRTM Calculation Outline



WRF input

hydrometeor distribution (g/kg)

1. cloud liquid water
2. cloud ice water
3. rain
4. snow
5. graupel

temperature (K)

relative humidity $(\%)$

pressure (hPa)

altitude (m)

sea surface temp (k)

sur. wind speed (m/s)

LRTM calculation

1. surf. emissivity
2. absorption coef.
3. size distribution of water ,snow, ice
4. emissivity
5. scattering
6. absorption
7. TB value

LRTM output

Vertical bright temperature (K)

Horizontal bright temperature (K)

Total integrated liquid water (g/m^2)

Total integrated ice water (g/m^2)