Radiance-Based Evaluation of CWBGFS Cloud Simulation: from the View of Himawari-8 Observation

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video: https://youtu.be/YS4B3p3jnuE

Outline

- Introduction
  - The evaluation of NWP model clouds (Why and How)
- Methods and Data
  - Satellite observation/derived cloud properties
  - Radiative transfer model
- Results
  - Cloud occurrence frequency
  - CSI (Critical Success Index)
  - BTD analysis
- Summary

Himawari-8 observation

CWBGFS: spatial resolution~25km

The model grid is not accurate to simulate the real world!

In other word, the parameterization scheme is necessary!

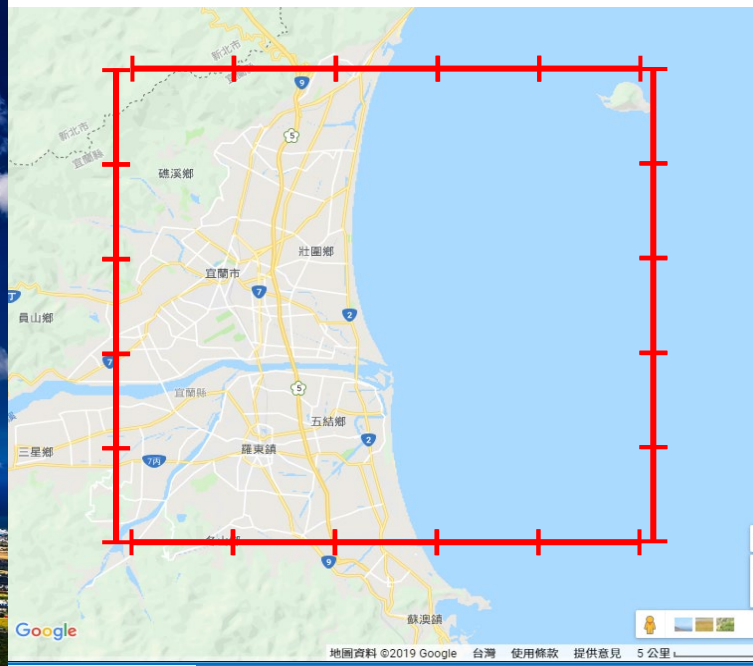
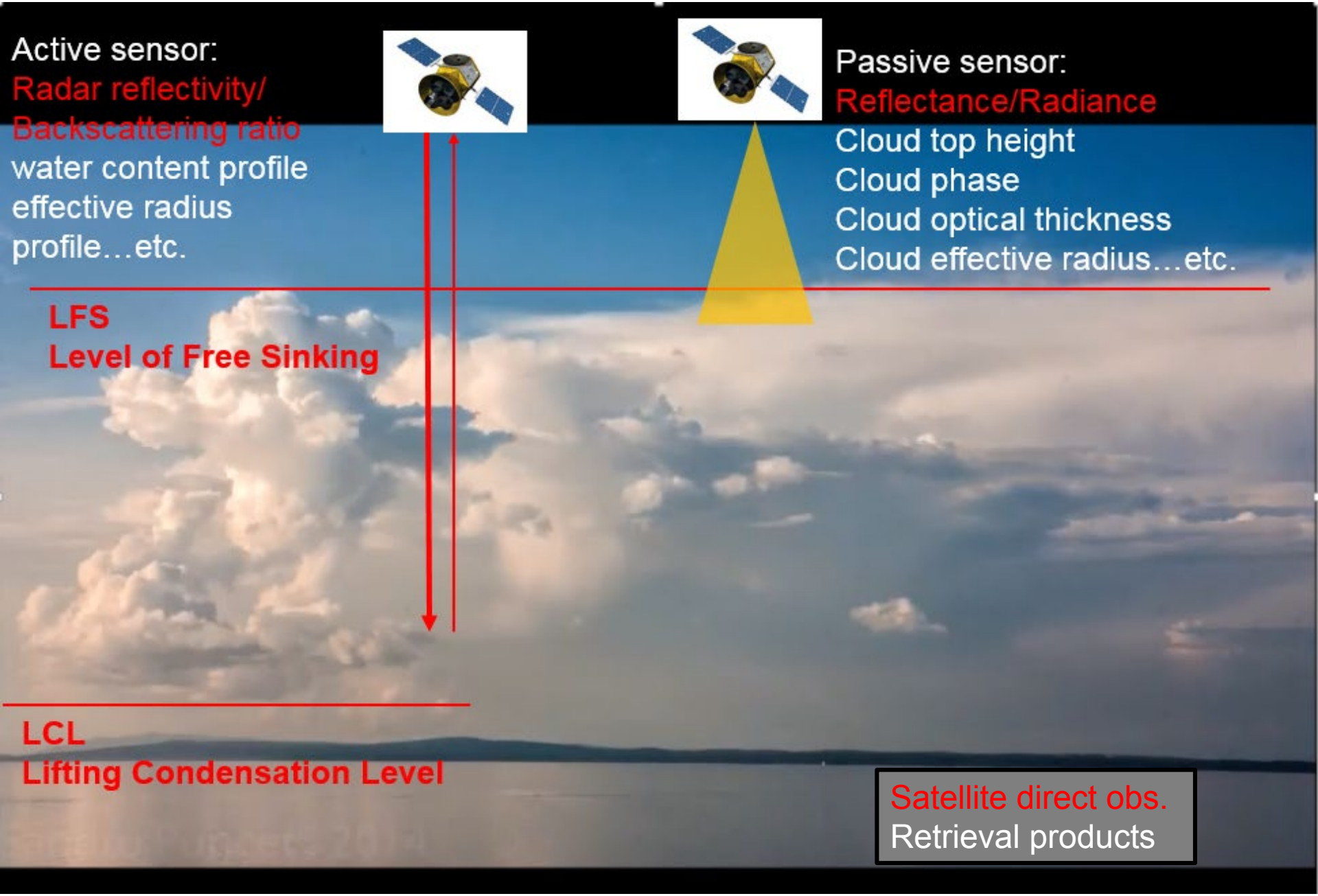


Photo: 陳志通

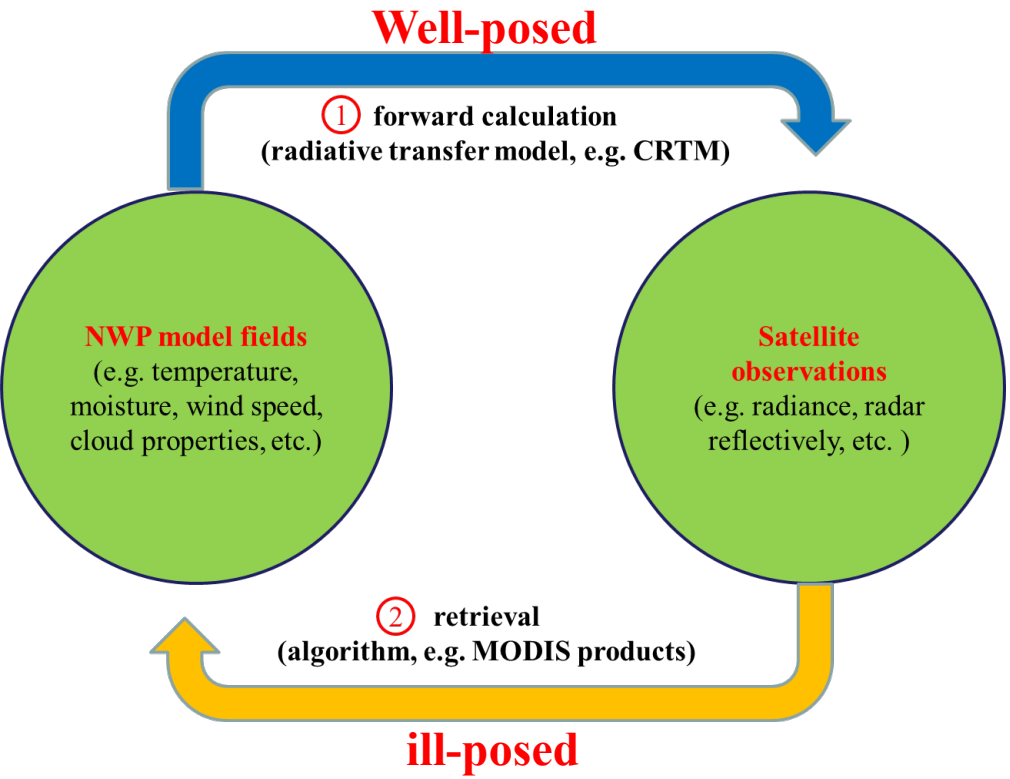
The Evaluation of NWP Model

model vs ground-based observations	model vs model	model vs satellite
grid vs point	grid vs grid	grid vs grid
1. Spatial resolution not comparable 2. Spatial density is not enough	Rely on the quality of the reference model	1. Wile coverage 2. Objective 3. Can not compare to the NWP model directly



https://youtu.be/j-psY7YUvgU

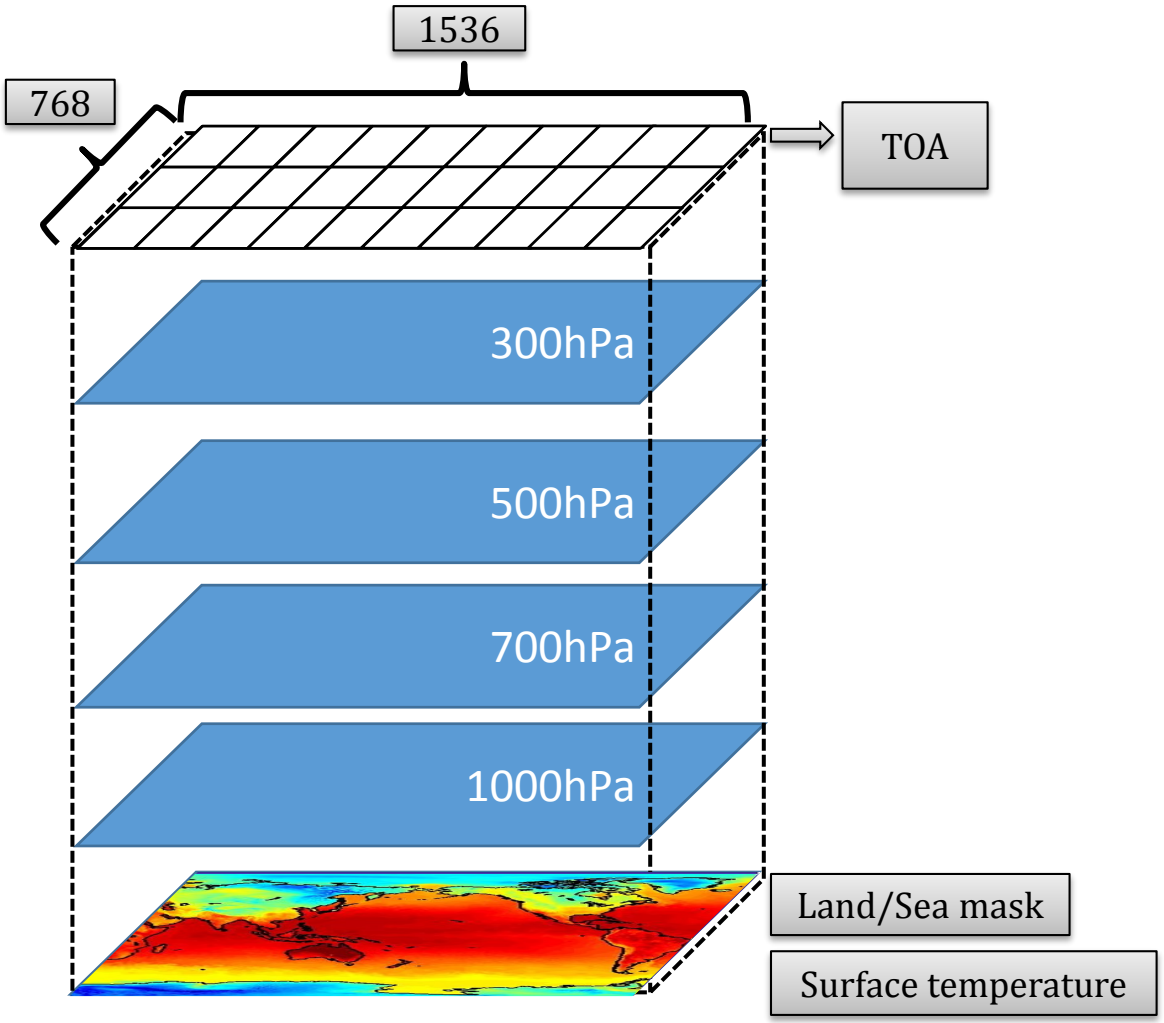
Retrieval vs. Radiance (BTs)



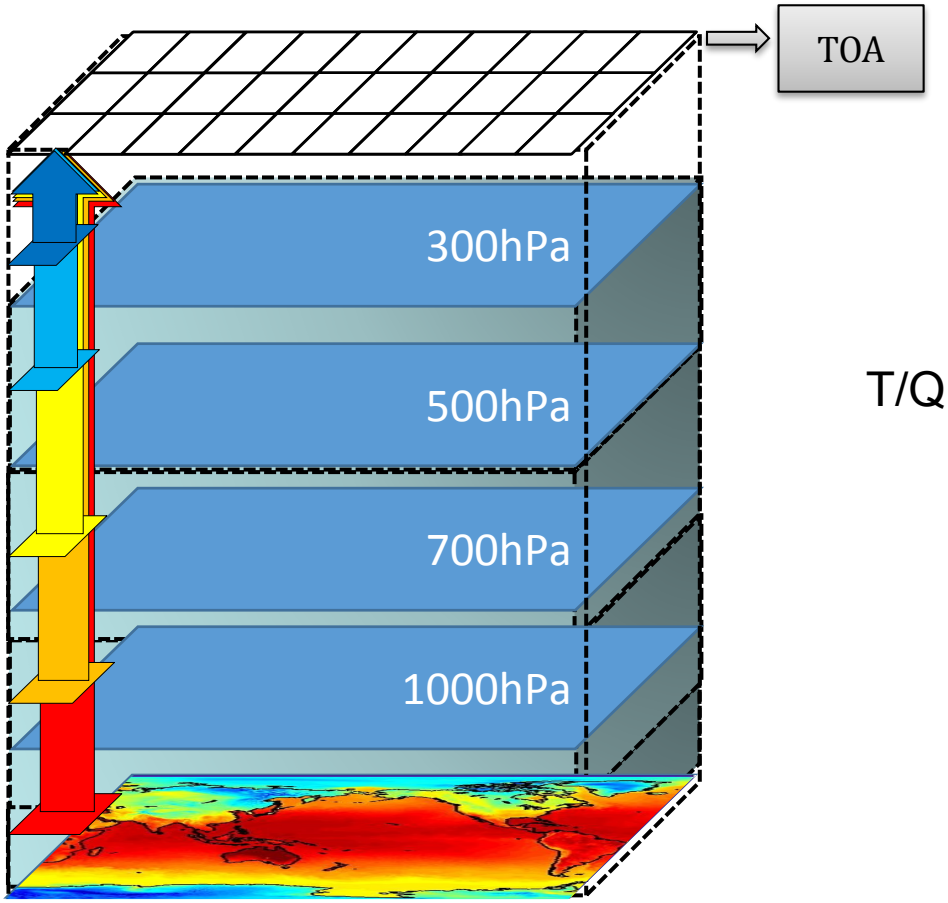
Validation of BTs
1. **less uncertainty** because it is direct satellite measurements
2. **Can not identify the problem** of cloud simulation clearly in NWP model

Validation by rtvl. Products
1. The retrieval algorithm involve some **uncertainties**
2. **Provide comparable cloud parameters** (e.g. CTP, COT, etc.) to NWP models
3. More expansive then forward calc.

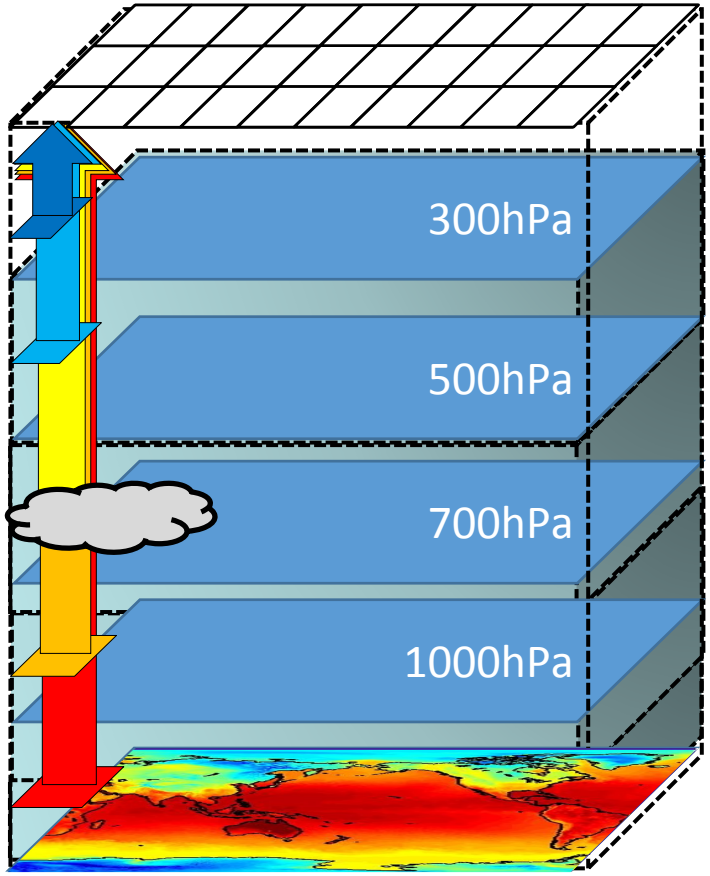
Radiative Transfer Model

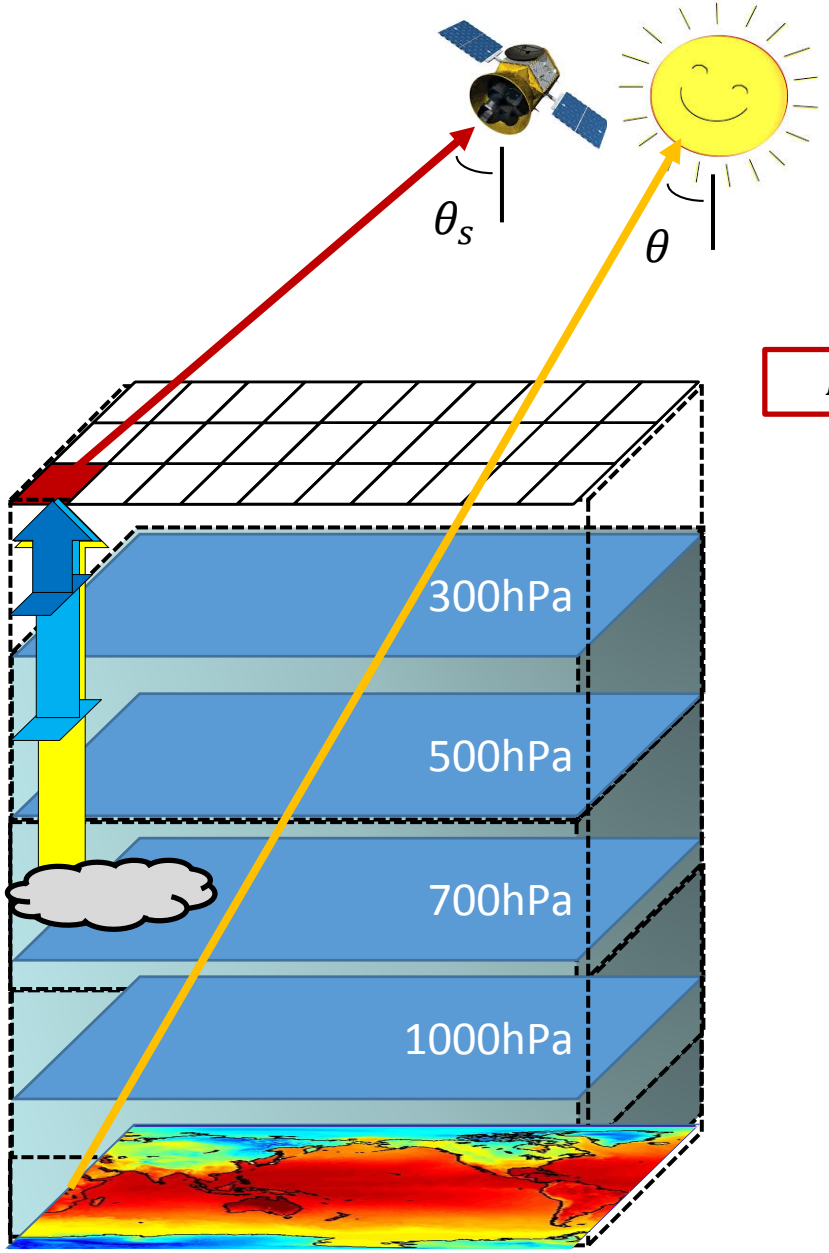


P_levels:
010,020,030,050,070,100,150,200,250,300,400,500,700,850,925,H00

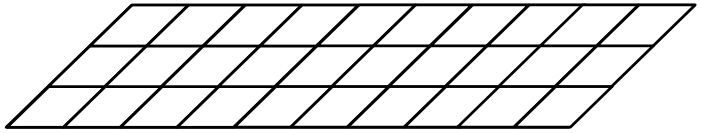


T/Q

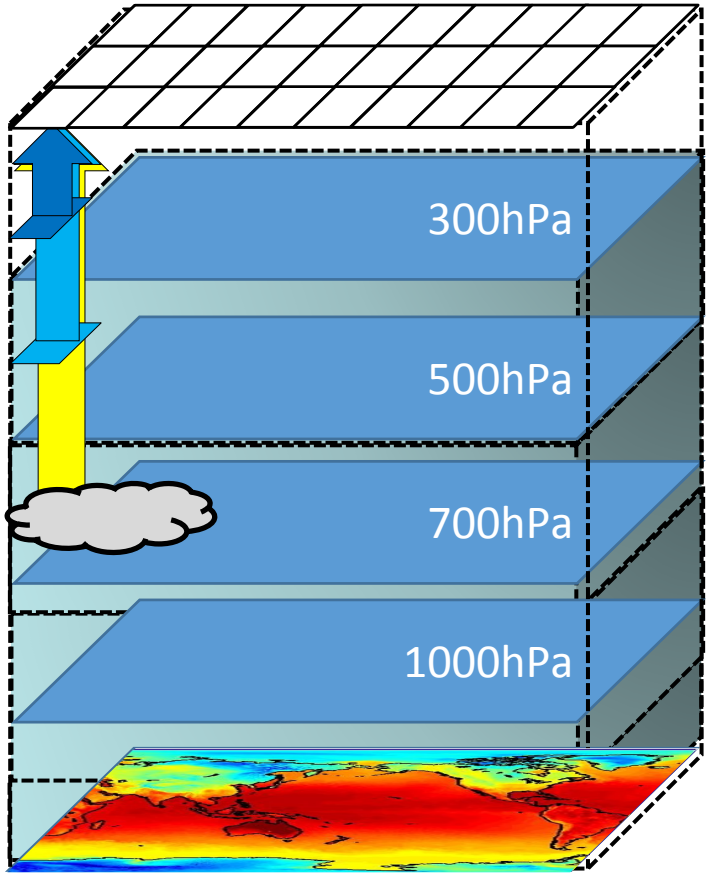

300hPa
500hPa
700hPa
1000hPa



R_λ Radiance at TOA



Simulated BT/r

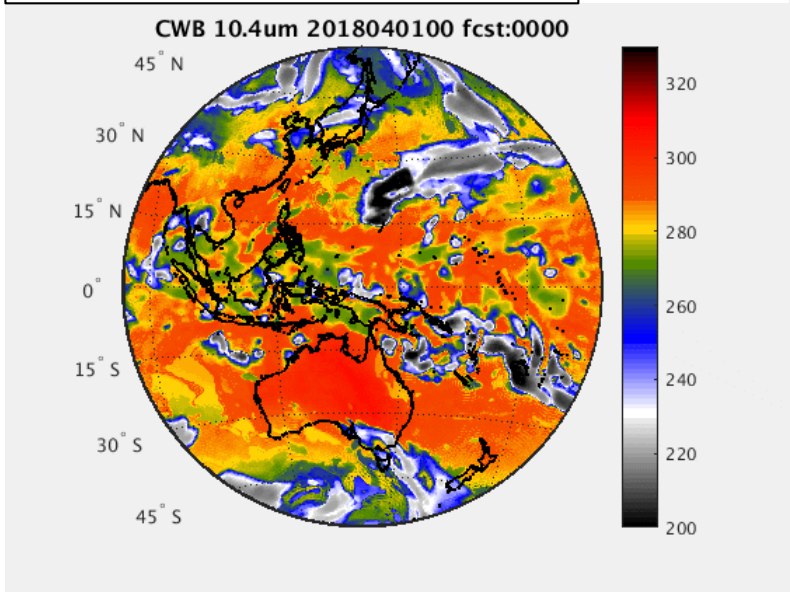


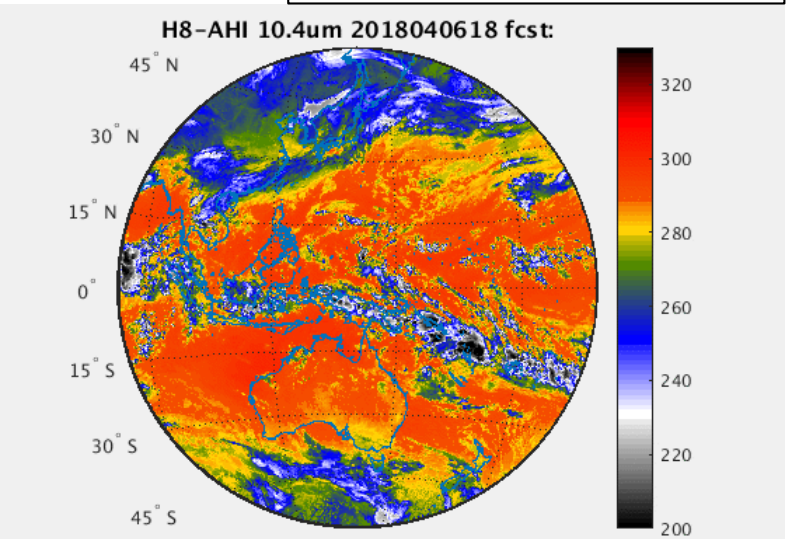
Simulated Cloud Images

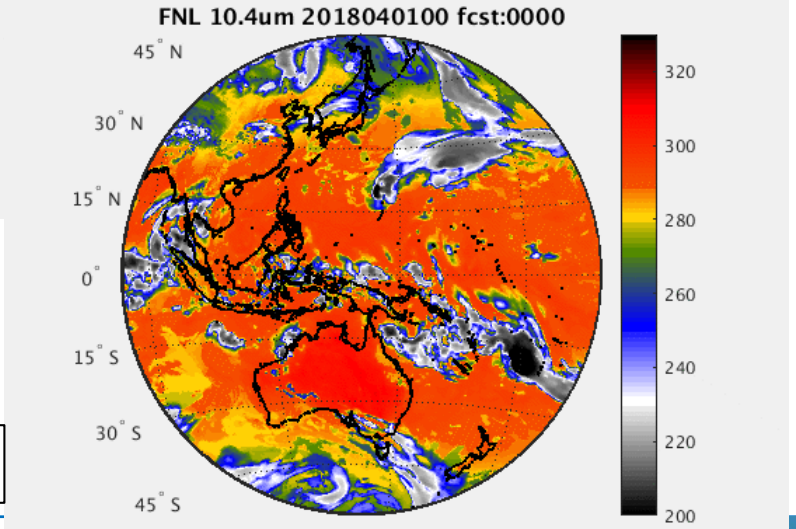
Himawari-8 obs. BT

Date: April to July 2018

CWBGFS simulated BT (fcst.-00 hr)

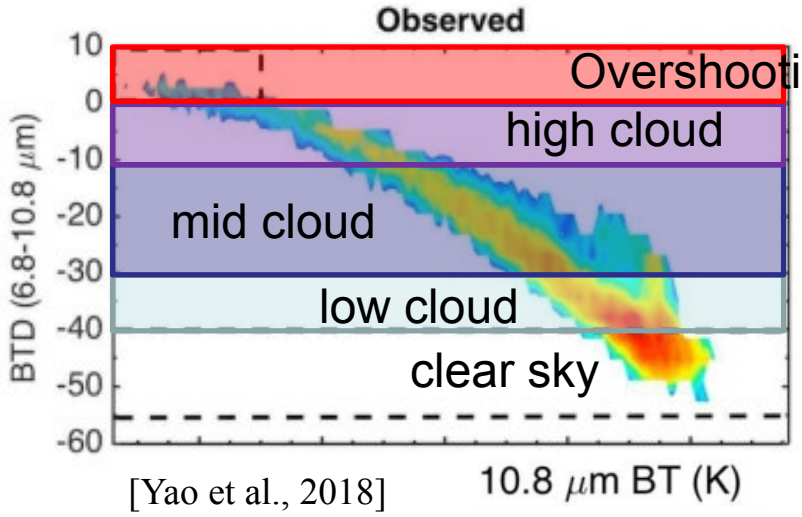




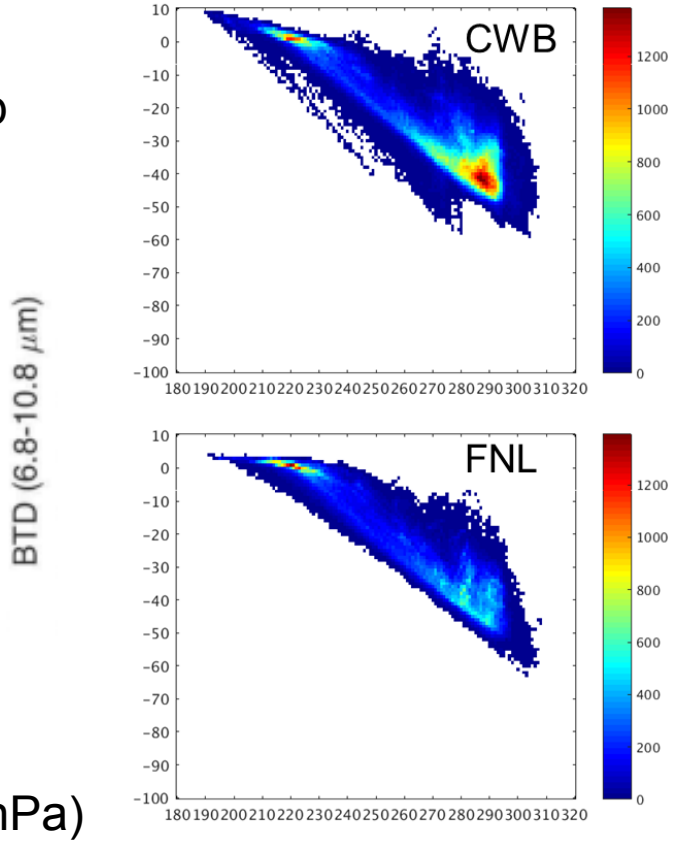


NCEP FNL simulated BT

Cloud Identification (6.8-10.8μm)



[Yao et al., 2018]

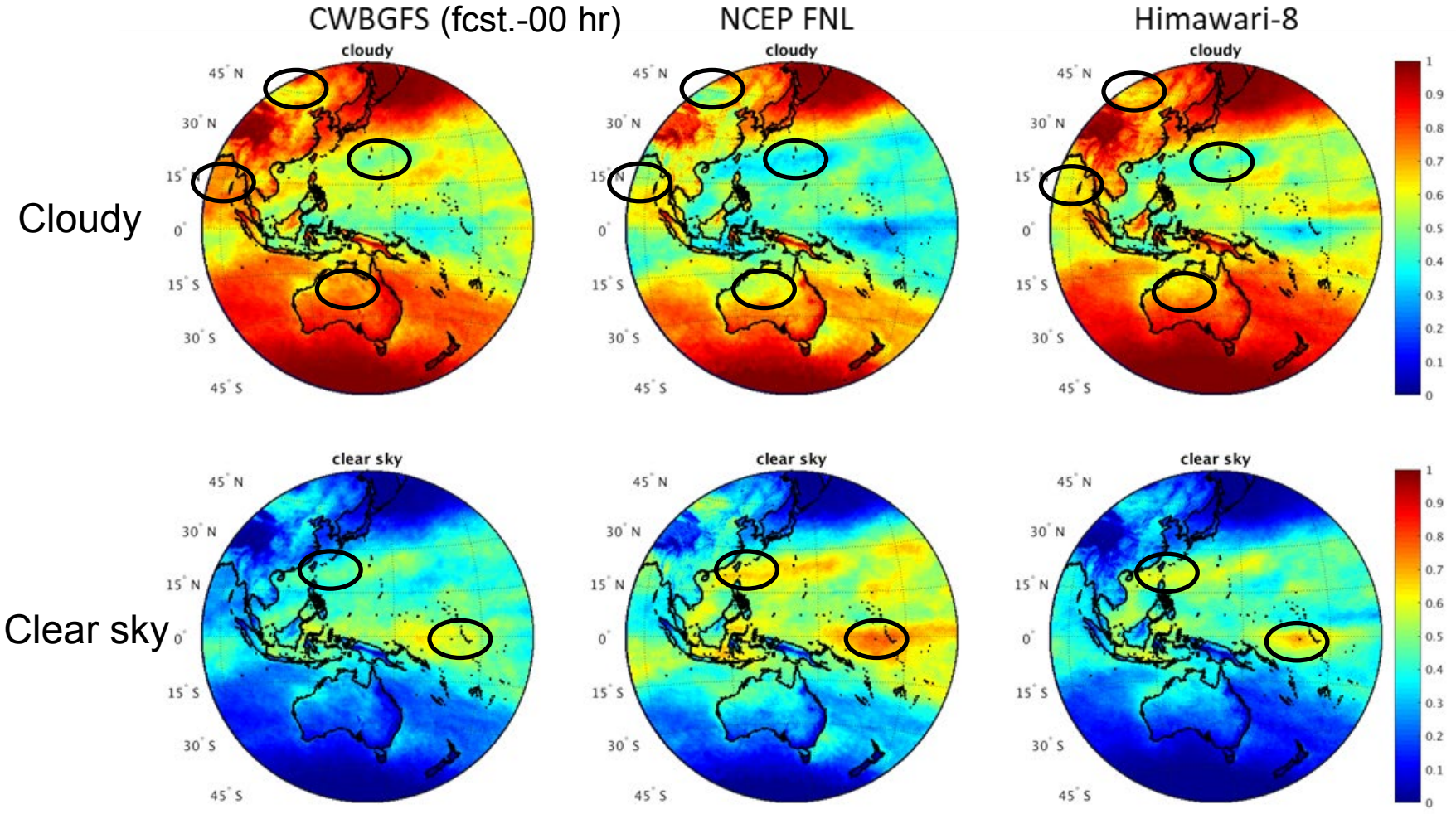


BTD characteristics:

Classify clouds at different altitudes (Mecikalski and Bedka, 2006)

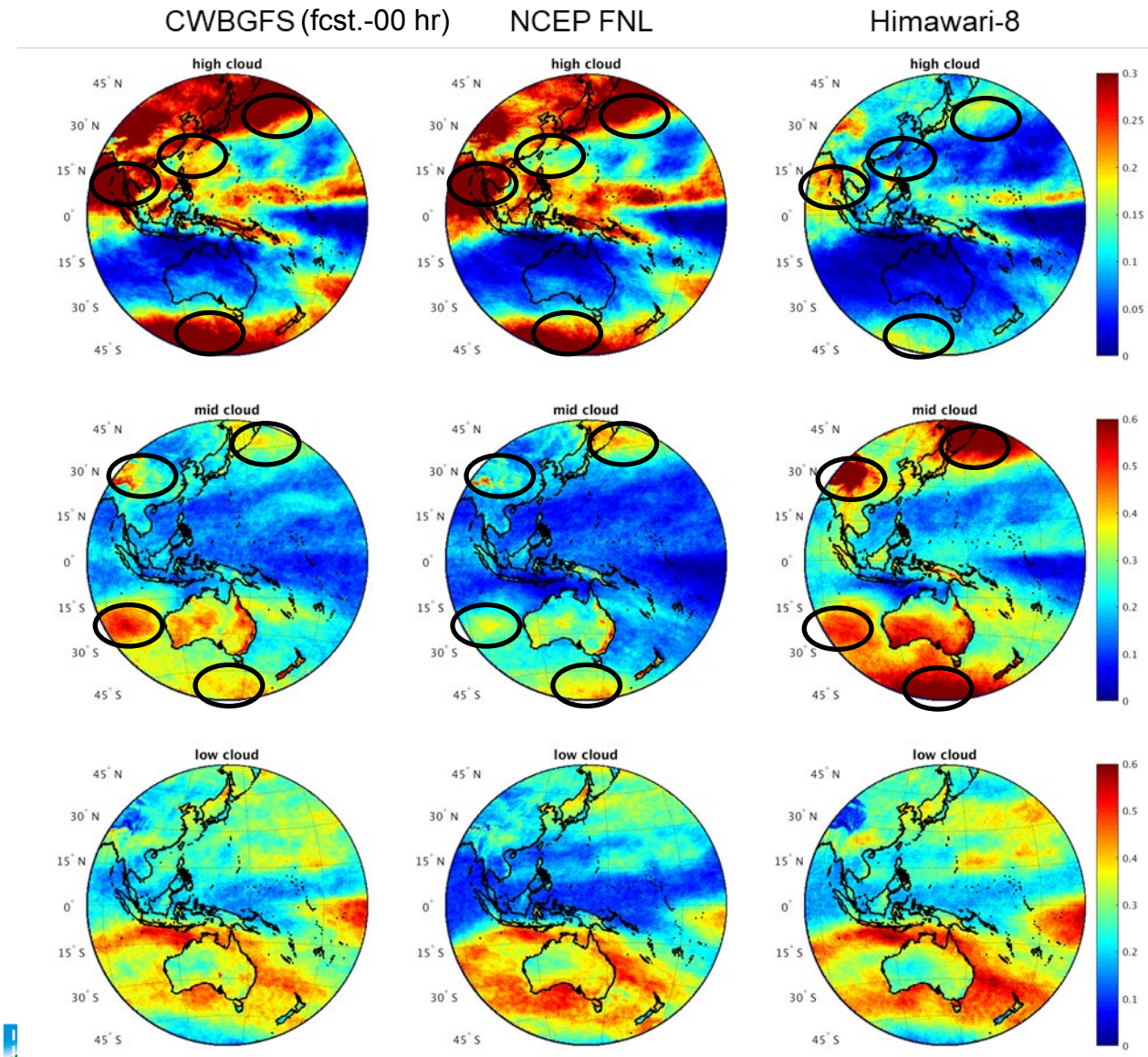
1. Negative (-55 ~ -40K): clear sky
2. Negative (-40 ~ -30K): low cloud tops (below 850hPa)
3. Negative (-30 ~ -10K): mid cloud top (850hPa to 500hPa)
4. Negative (≥-10K) : high cloud top (over 500hPa)
5. Positive and very cold at 10.8μm : overshooting cloud top

Total Cloud Occurrence Frequency



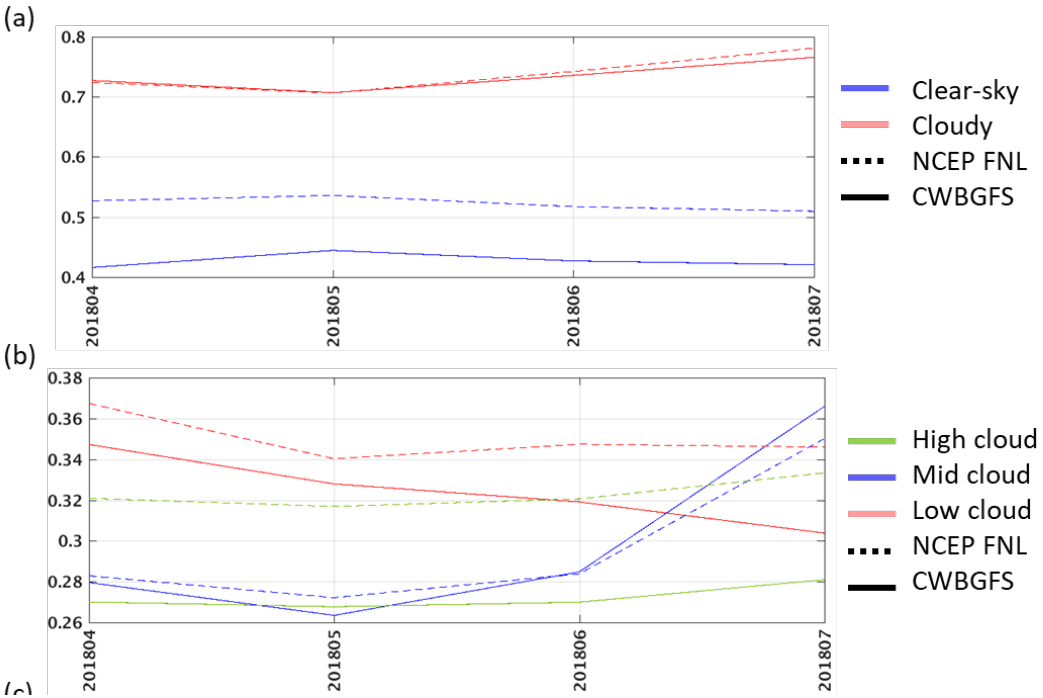
April to July 2018

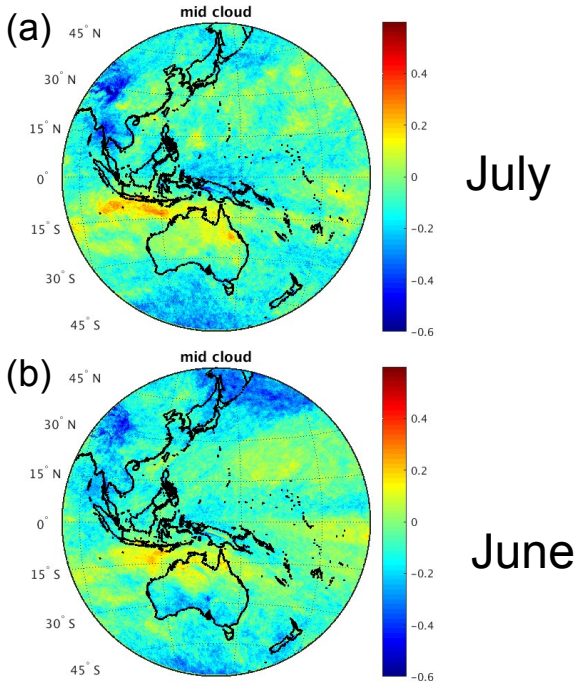
Cloud Occurrence Frequency



Critical Success Index (CSI)

$$\mathrm{CSI} = \frac{Hit}{(Hit + False + Miss)}$$

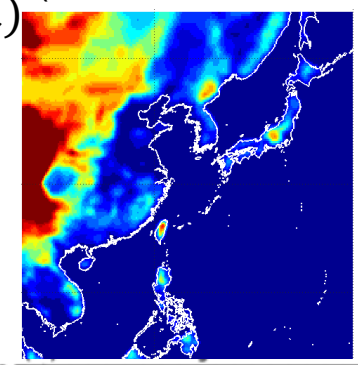




Brightness Temperature $(10.4\mu m)$

BT (K)		D1	D2	D3	D4	D5	Land	Ocean
		High level cloud						
CWB	Mean	219.93	219.45	219.28	219.41	223.73	221.73	219.55
	M_error	-9.22	-10.00	-2.99	-9.82	-9.71	-9.96	-8.94
FNL	Mean	219.86	220.15	217.63	221.02	224.25	222.01	219.35
	M_error	-8.24	-8.67	-4.40	-7.97	-8.37	-8.86	-8.04
		Mid level cloud						
CWB	Mean	266.91	260.03	255.40	260.63	271.66	268.01	265.90
	M_error	-2.51	-3.11	-1.81	-3.38	-2.39	-1.40	-3.19
FNL	Mean	265.25	259.01	251.30	258.63	270.06	266.91	264.03
	M_error	-2.00	-3.18	-4.81	-4.17	-1.42	-1.11	-2.50
		Low level cloud						
CWB	Mean	284.14	282.67	285.45	284.90	285.54	283.90	284.13
	M_error	-1.10	-1.23	-1.02	-1.50	-0.84	-1.10	-1.11
FNL	Mean	285.43	283.17	286.25	285.00	286.96	285.19	285.38
	M_error	0.08	-0.47	-0.92	-1.01	0.50	0.10	0.04

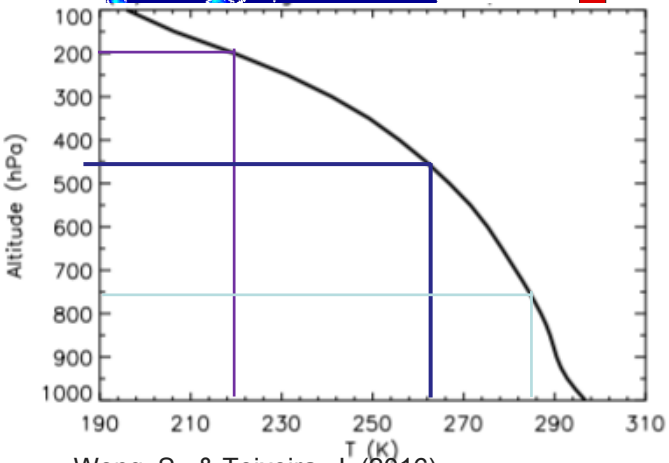
D2: 大陆沿岸及西太平洋
(100°E~150°E, 5°N~50°N)



地形高度(m)

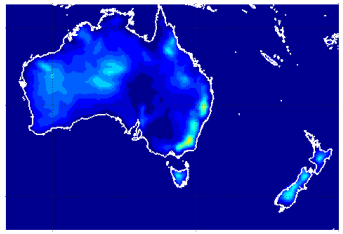
2000

1800



Wong, S., & Teixeira, J. (2016)

D5: 澳洲及南太平洋
(110°N~180°N, 10°S~50°S)



Take Home Message

- The satellite observation provide a proper reference to verify the global model clouds.
- We implement three inspection of cloud model:
  - Cloud occurrence frequency:
    - cloud radiative forcing, total energy budget
  - CSI
    - location of cloud
  - Brightness Temperature
    - intensity of cloud

Summary

- The total cloud occurrence frequency of CWBGFS is consistent to satellite observation, but a little overestimate near Taiwan.
- Both CWBGFS and NCEP FNL overestimate the high level cloud and underestimate the mid level cloud.
- The cold bias of CWBGFS brightness temperature in high level cloud indicate that the cloud develop too high/thick.