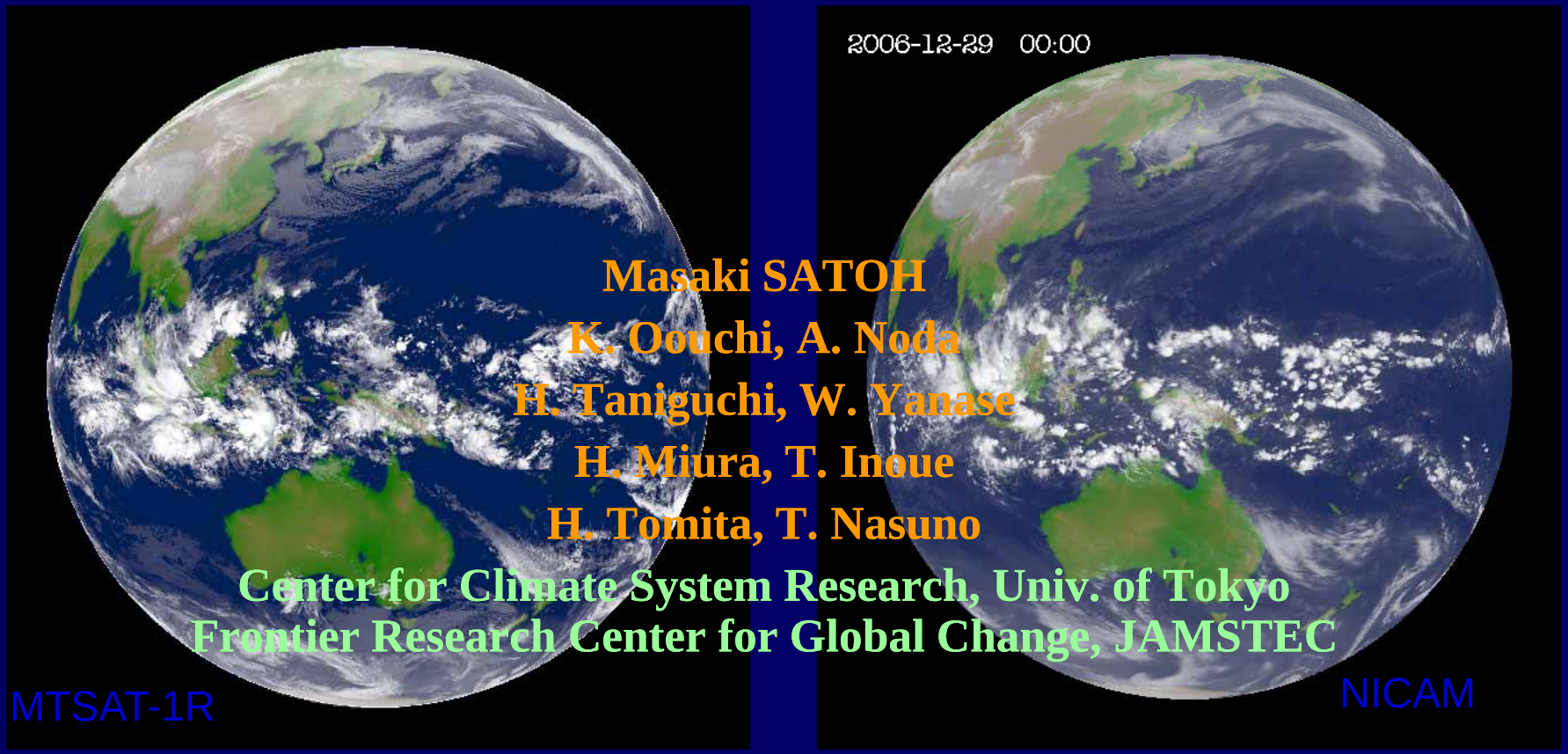
Use of a global cloud-resolving model NICAM for MJO studies



Masaki SATOH

K. Oouchi, A. Noda

H. Taniguchi, W. Yanase

H. Miura, T. Inoue

H. Tomita, T. Nasuno

Center for Climate System Research, Univ. of Tokyo

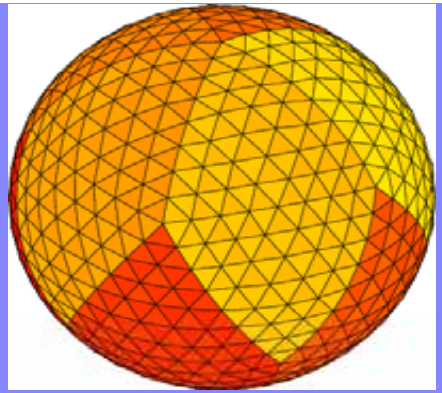
Frontier Research Center for Global Change, JAMSTEC

MISMO Workshop

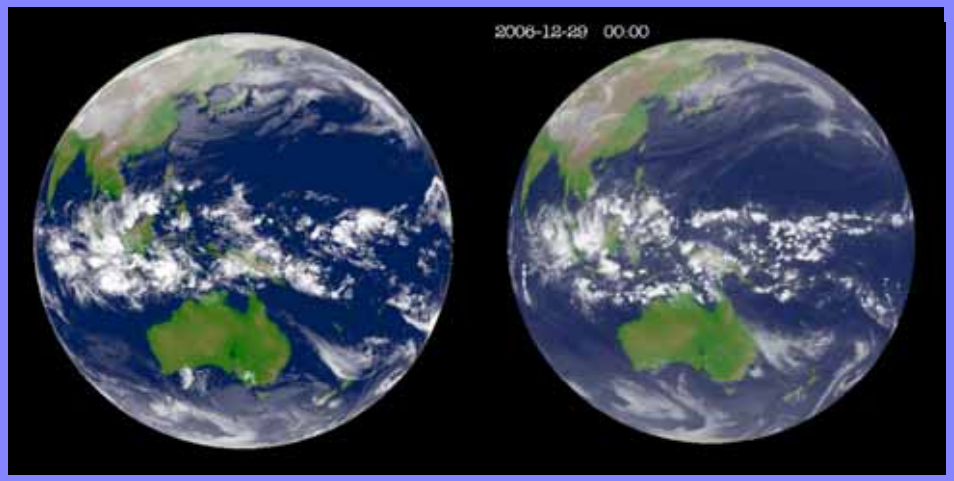
Yokohama, Japan, Nov. 26, 2008

Overview

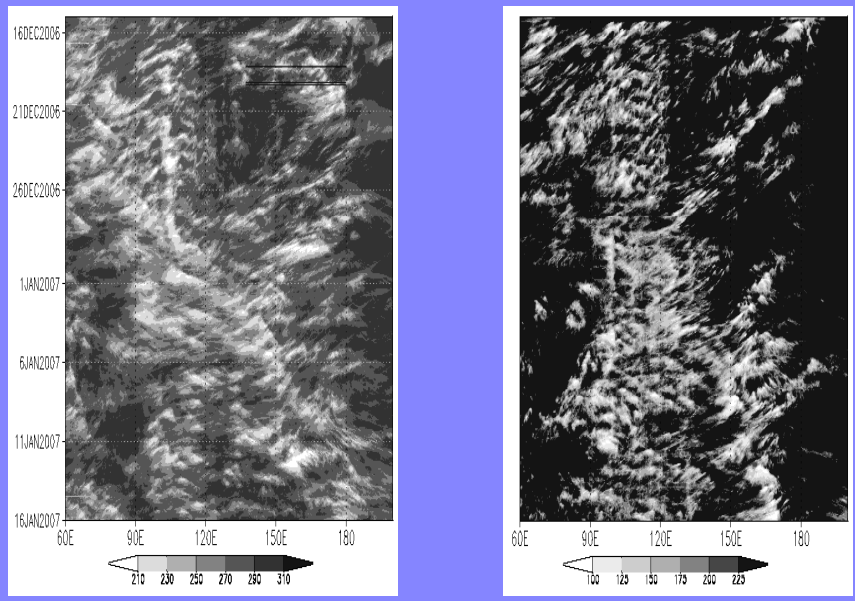
- Outline of NICAM
  - Global Cloud Resolving Model
  - NICAM (Nonhydrostatic ICosahedral Atmospheric Model)
- High-resolution simulation
  - A week run
- Seasonal march simulation
  - Boreal summer, 2004
- Myanmar cyclone exp., 2008
- Possible use of NICAM for MJO studies



MTSAT-1R, IR　　NICAM 3.5km, OLR

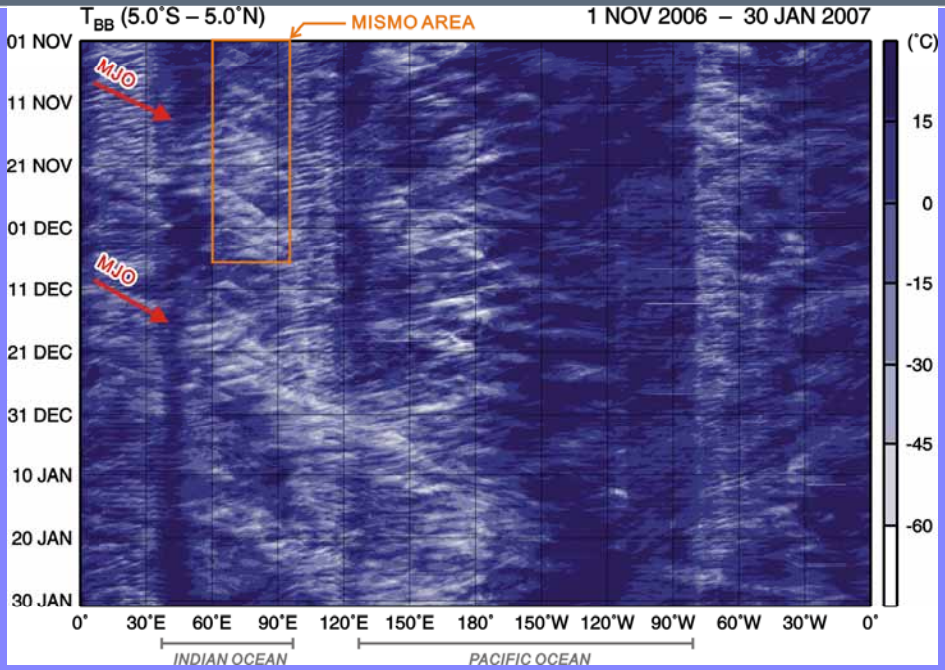


NCEP/CPC IR　　NICAM 7km, OLR



Miura et a.(2007), Nasuno et al.(2008)

NICAM simulation: MJO Experiment



Horizontal grid spacing:

14 km, 7 km, 3.5 km

Vertical domain

0 m ~ 38km, 40-levels (stretching grid)

Integration:

7km, 14km runs: 30 days from 15 Dec 2006

3.5km run: 7 days from 25 Dec 2006

Initial conditions:

Interpolated from NCEP tropospheric analyses (6 hourly, 1.0x1.0 degree grids)

2006-12-15 00:00:00 (14km and 7km runs)

2006-12-25 00:00:00 (3.5km run)

Boundary conditions:

Reynolds SST, Sea ICE (weekly data)

ETOPO-5 topography, Matthews vegetation

UGAMP ozone climatology (for AMPI2)

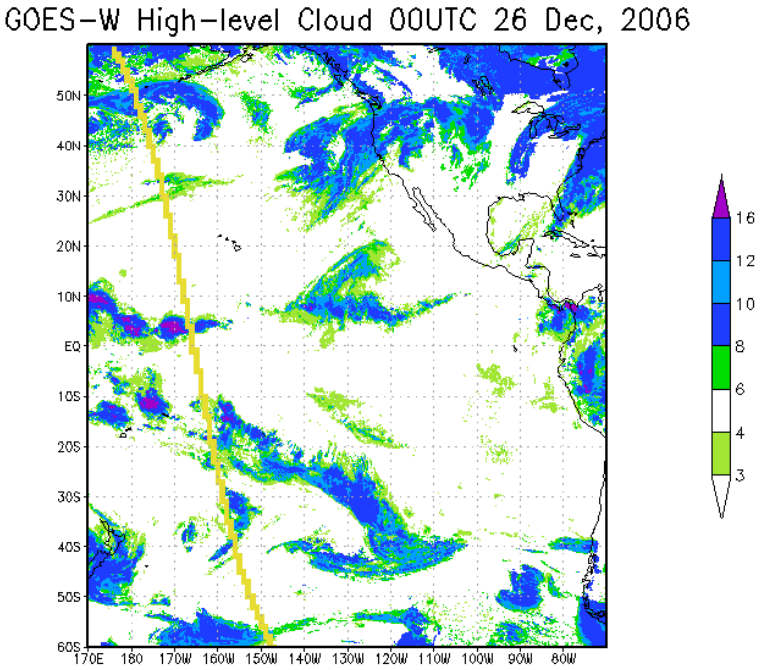
Miura et al. (2007, *Science*)

Comparison with split window analysis

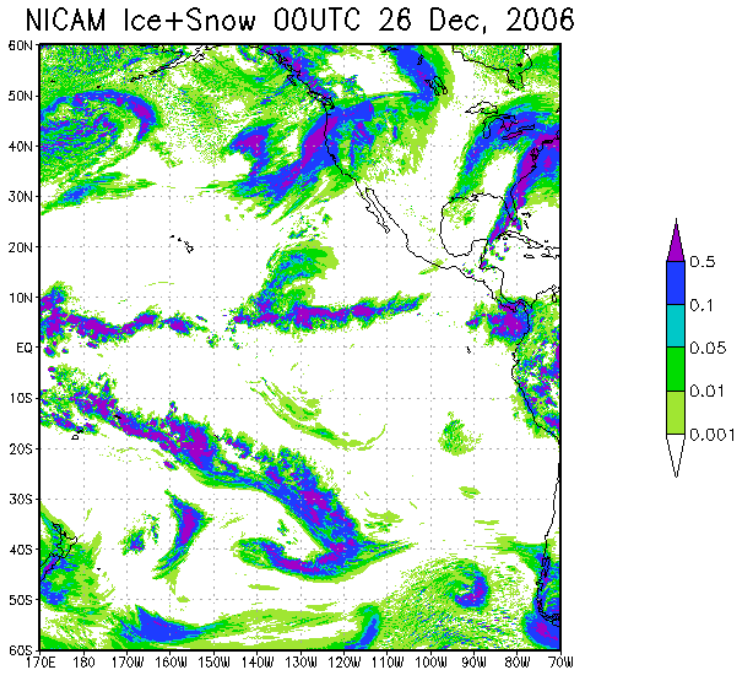
Inoue et al.(2008,to be submitted)

GOES-W high-level clouds

(split window)

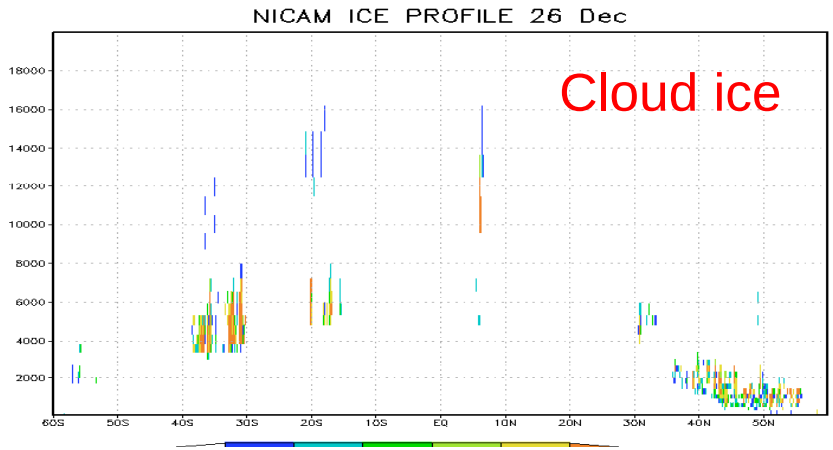


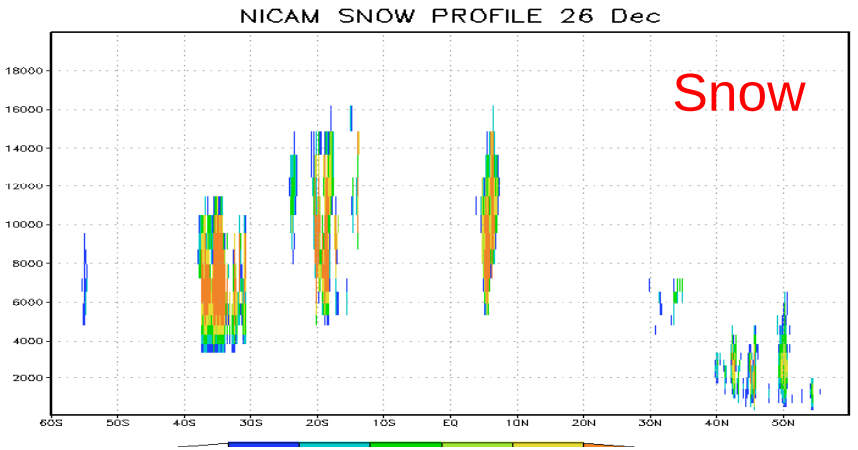
NICAM 3.5km Cloud Ice+snow



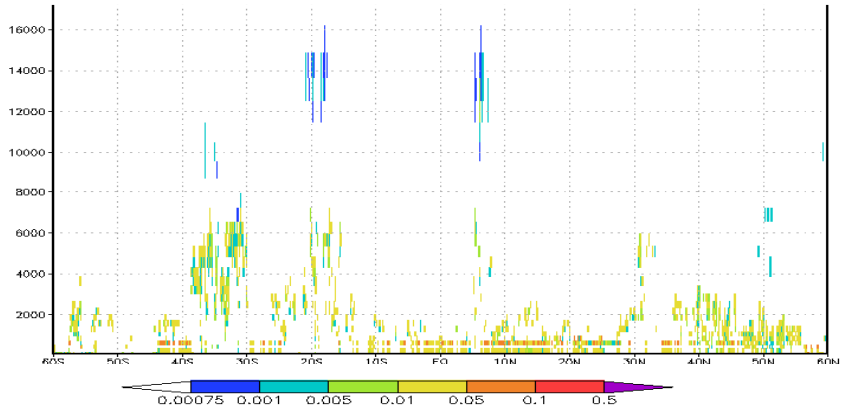
Split window analysis: Inoue (1987 JGR,1989 JMSJ)

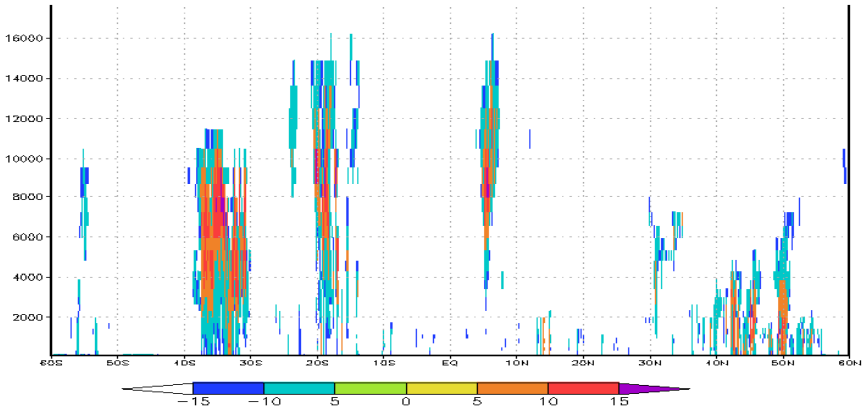
Classification by Tbb difference between 11μm and 12μm

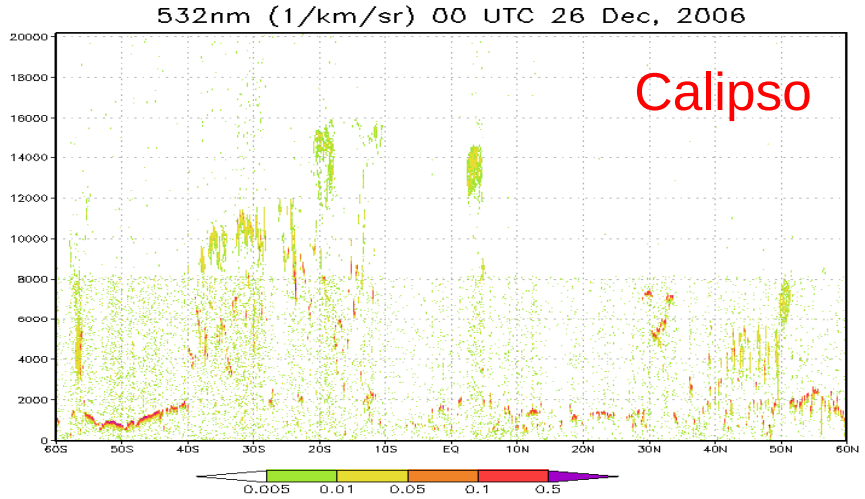


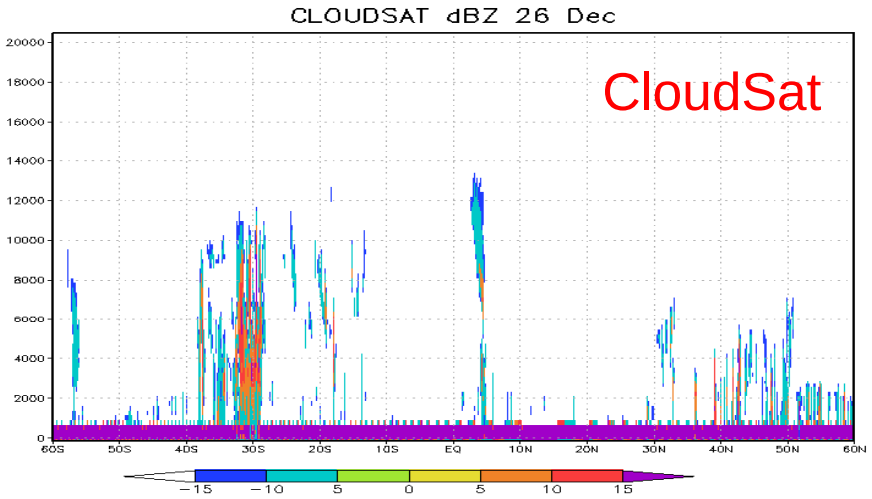


Calipso/CloudSat simulated reflectivities by COSP(Courtesy of M.Webb)

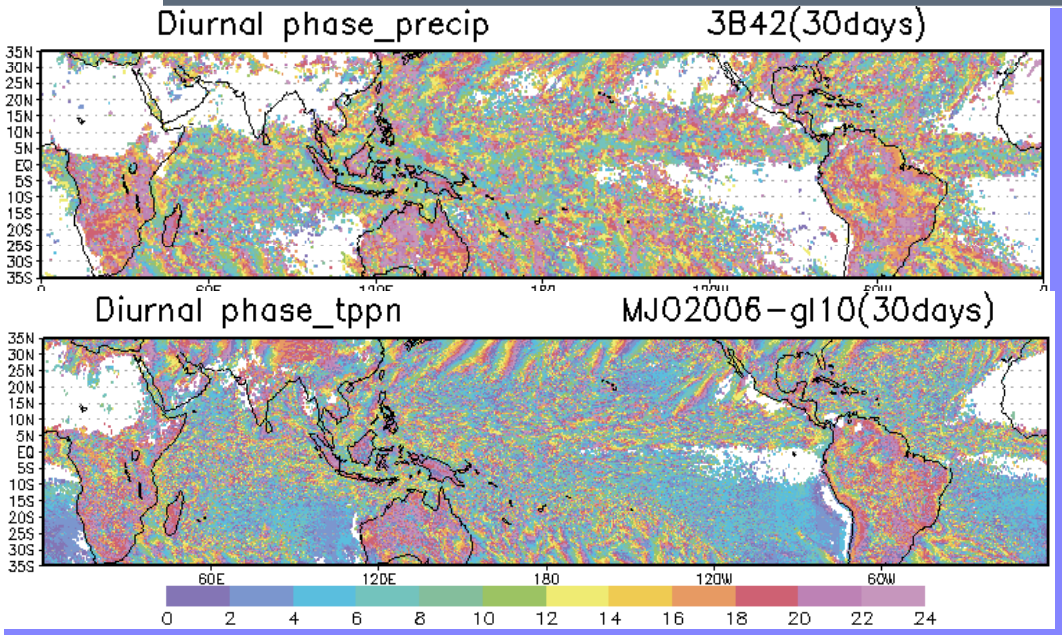




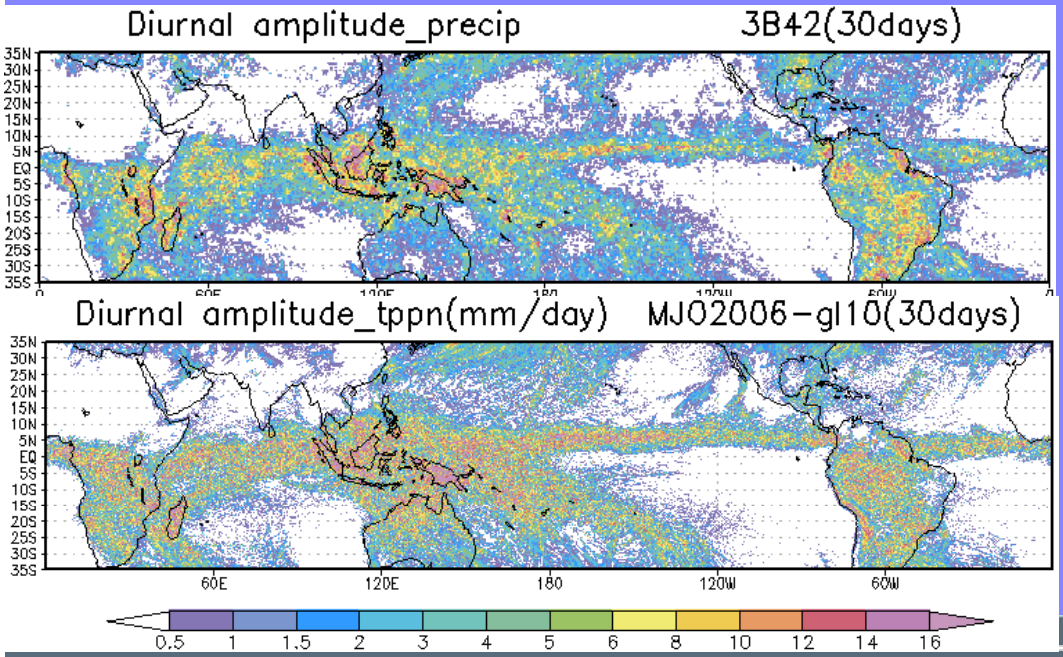




Diurnal variation of precipitation



Phase

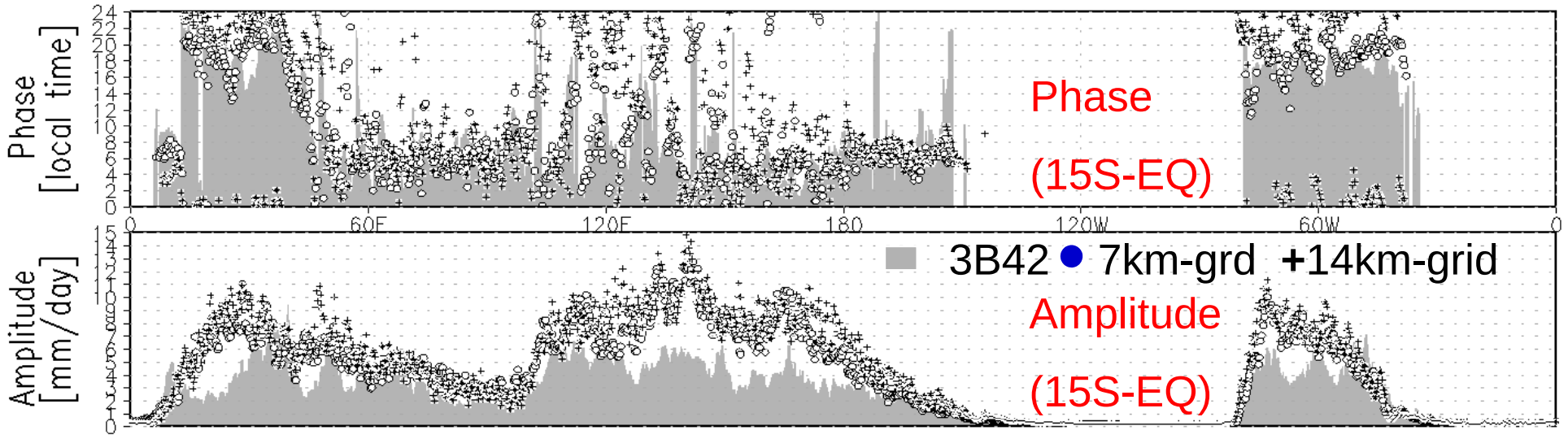


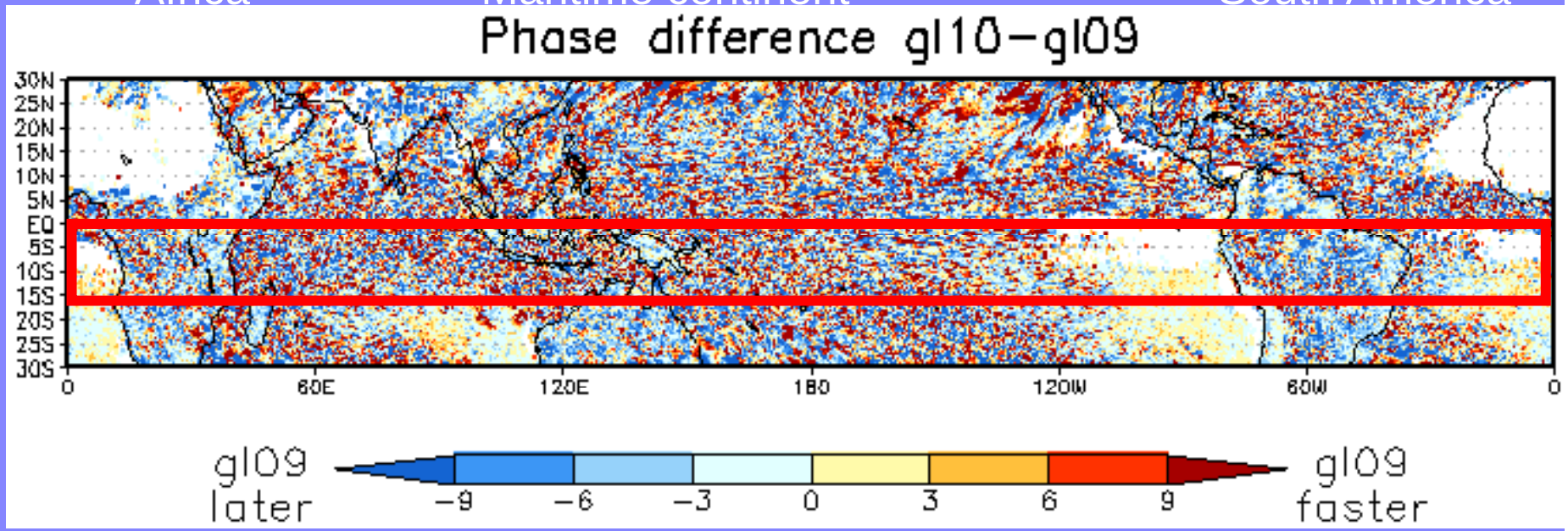
Amplitude

NICAM 7km vs TRMM 3B42

15 Dec 2006-15 Jan 2007

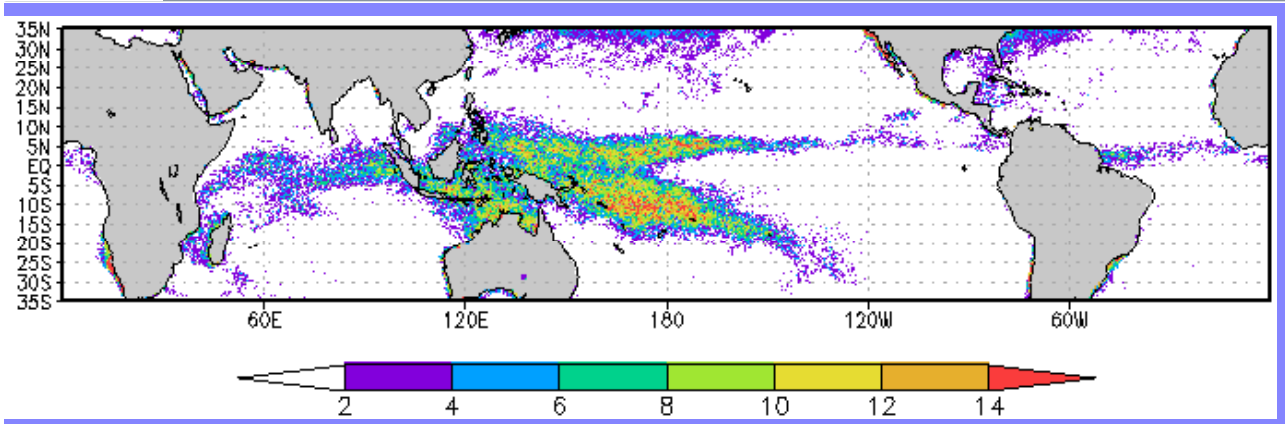
Sato et al.(2008)

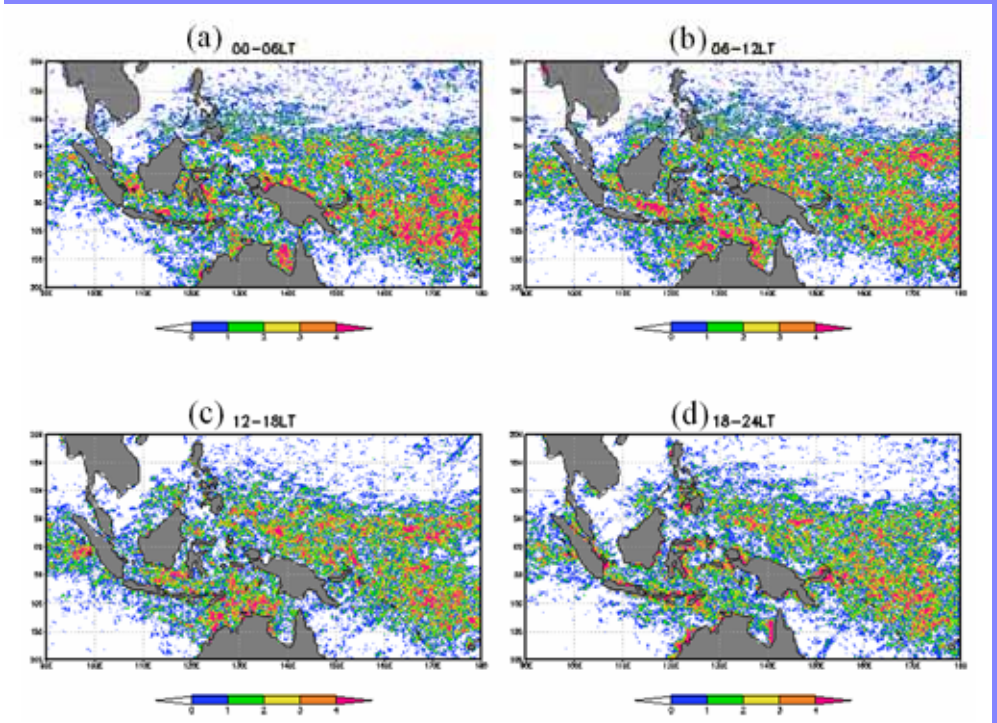




- Improvement of phase and amplitudes from 14km-mesh to 7km-mesh

Cold pool analysis





Frequency of cold pools:

Number of events of

temperature drop > 1.5K/90min

Diurnal variation

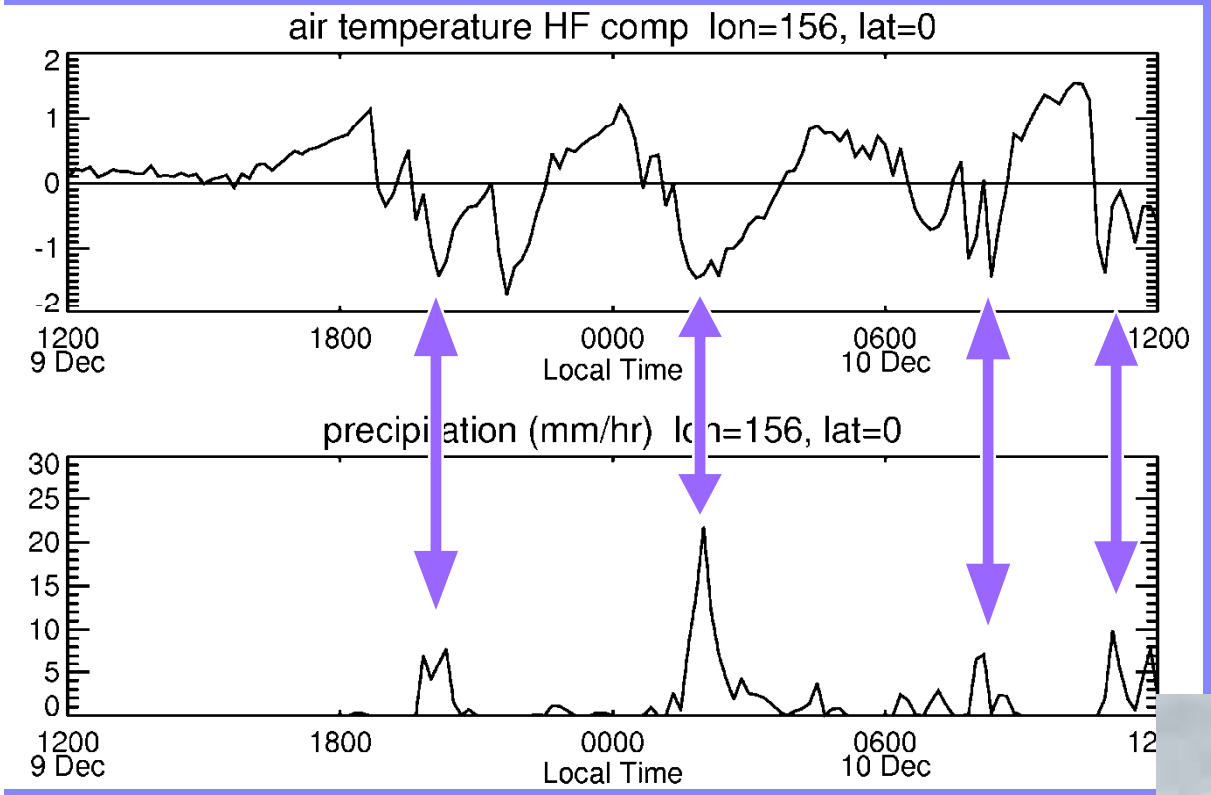
Off shore in the afternoon

Westward migration north of Australia

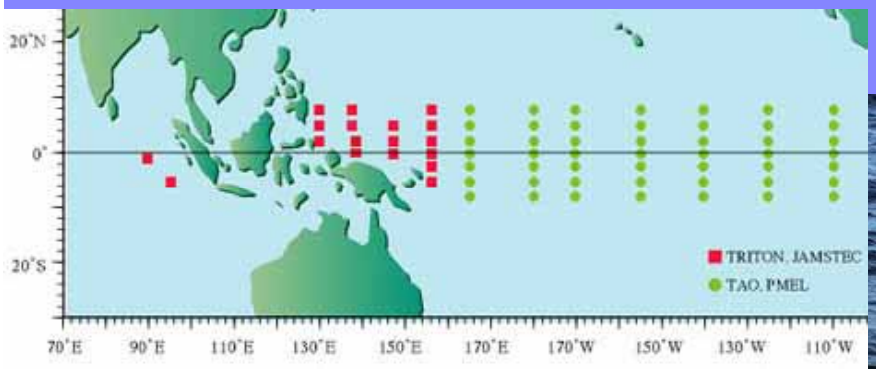
Sato et al.(2008, submitted)

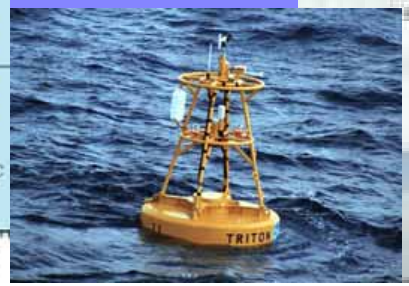
Observational temperature drop

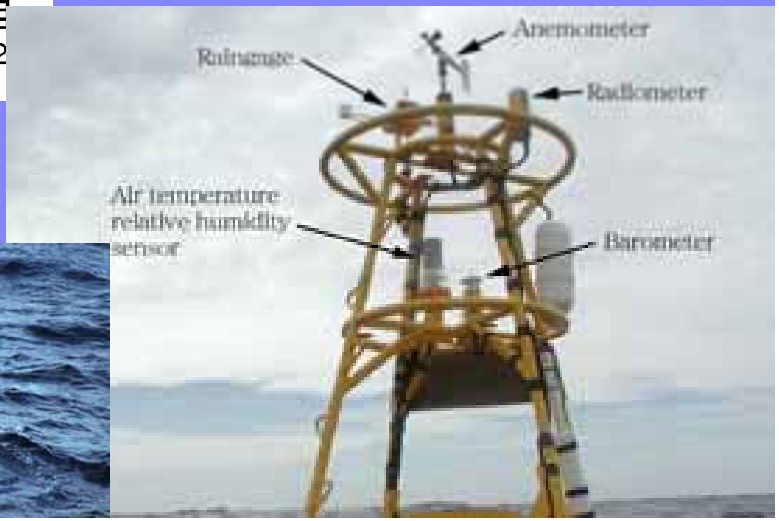
0° 156°E



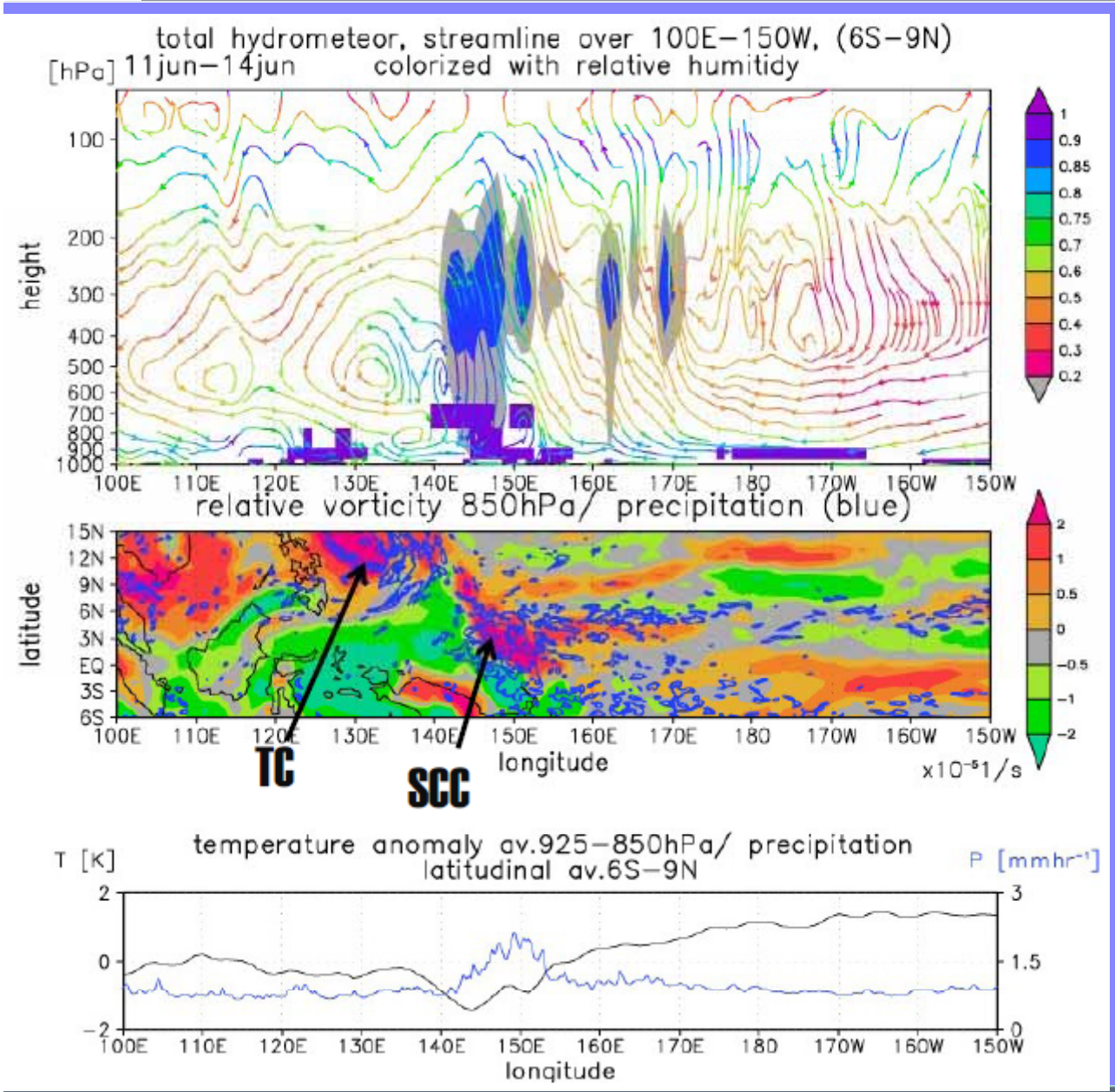
Triton Buoy observation: Courtesy of M. Nakura (JAMSTEC)





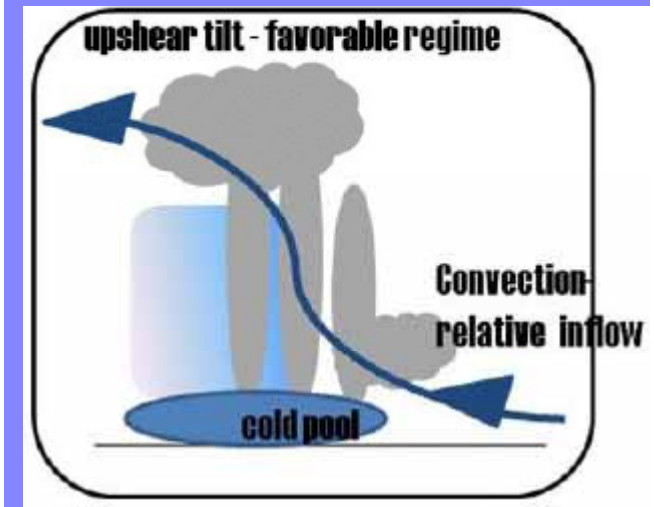


Super cloud cluster as a gigantic squall line



Oouchi et al.

(2008,submitted)



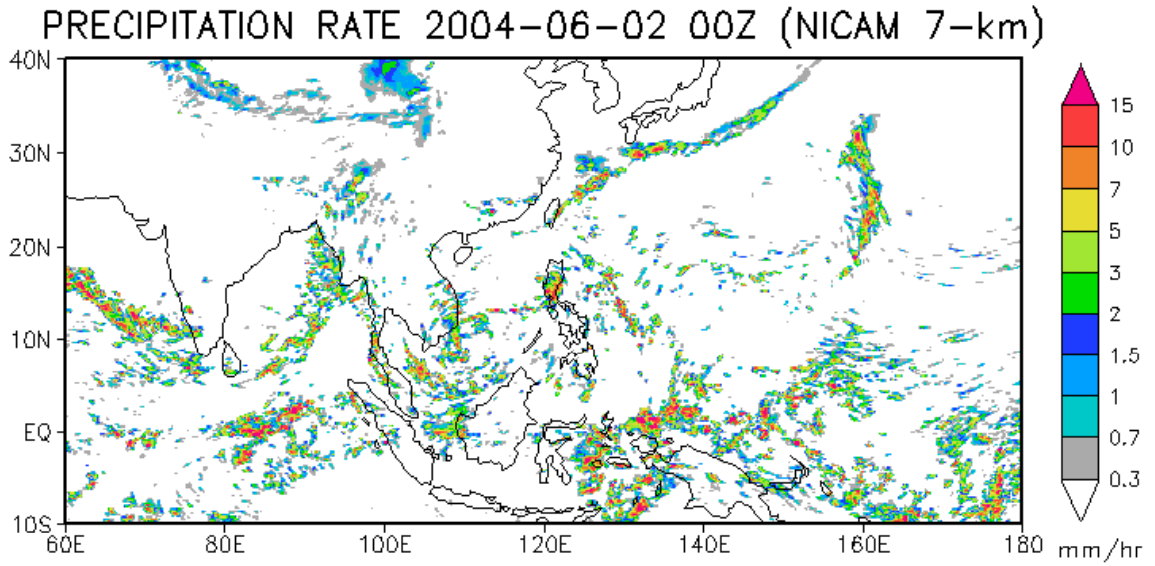
"Cold pool dynamics"

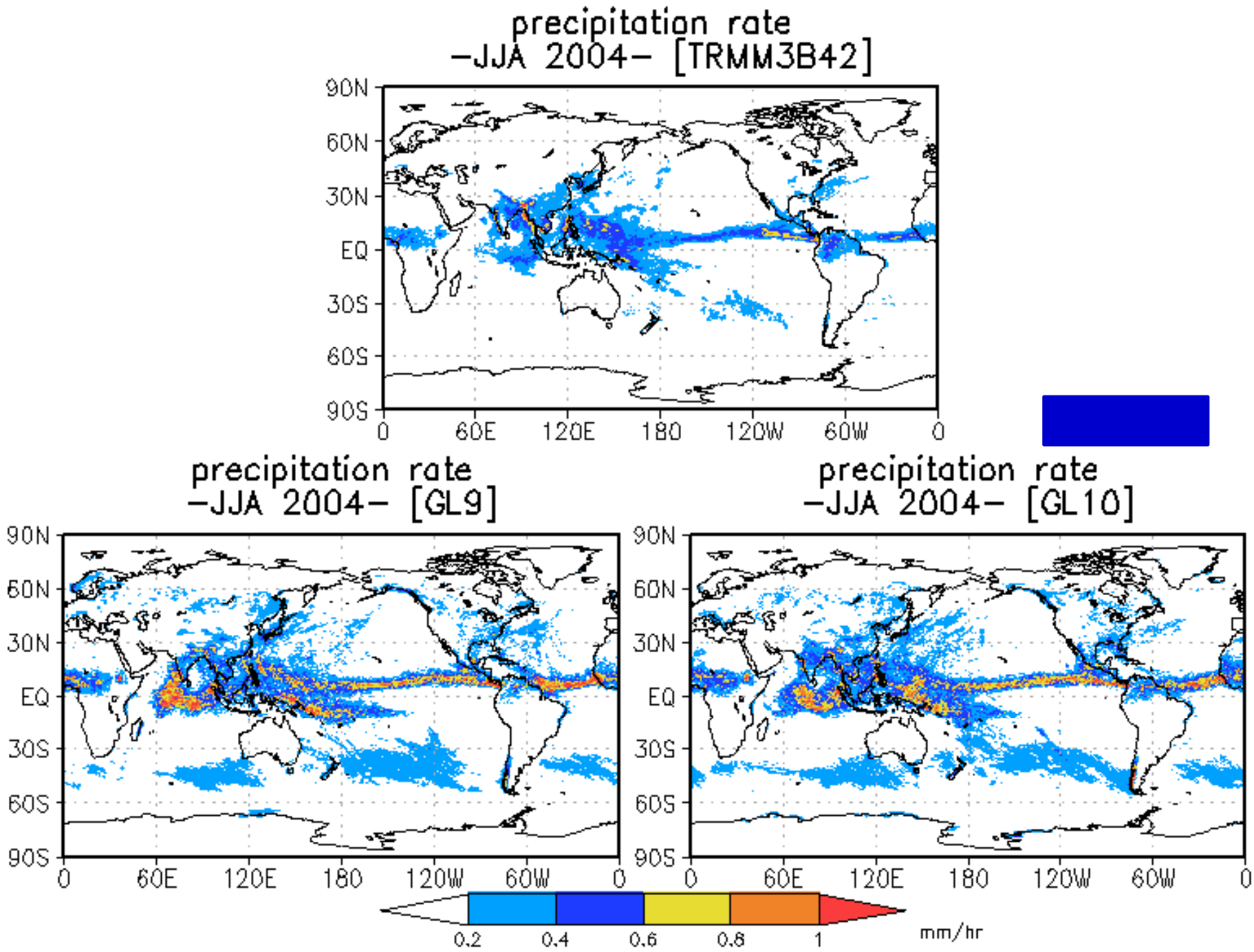
multi-scale interaction

both in time and scale

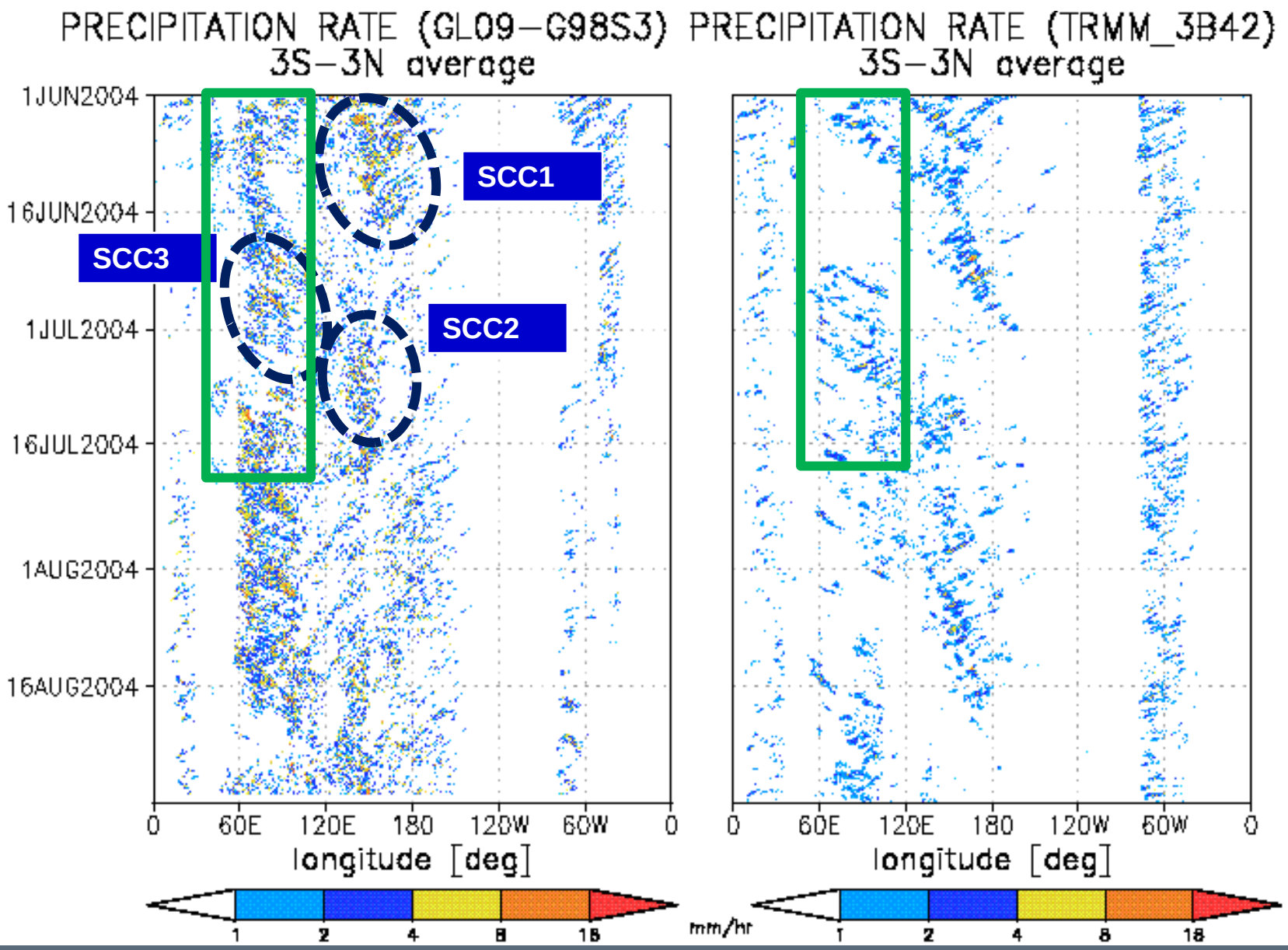
Seasonal march experiments by NICAM

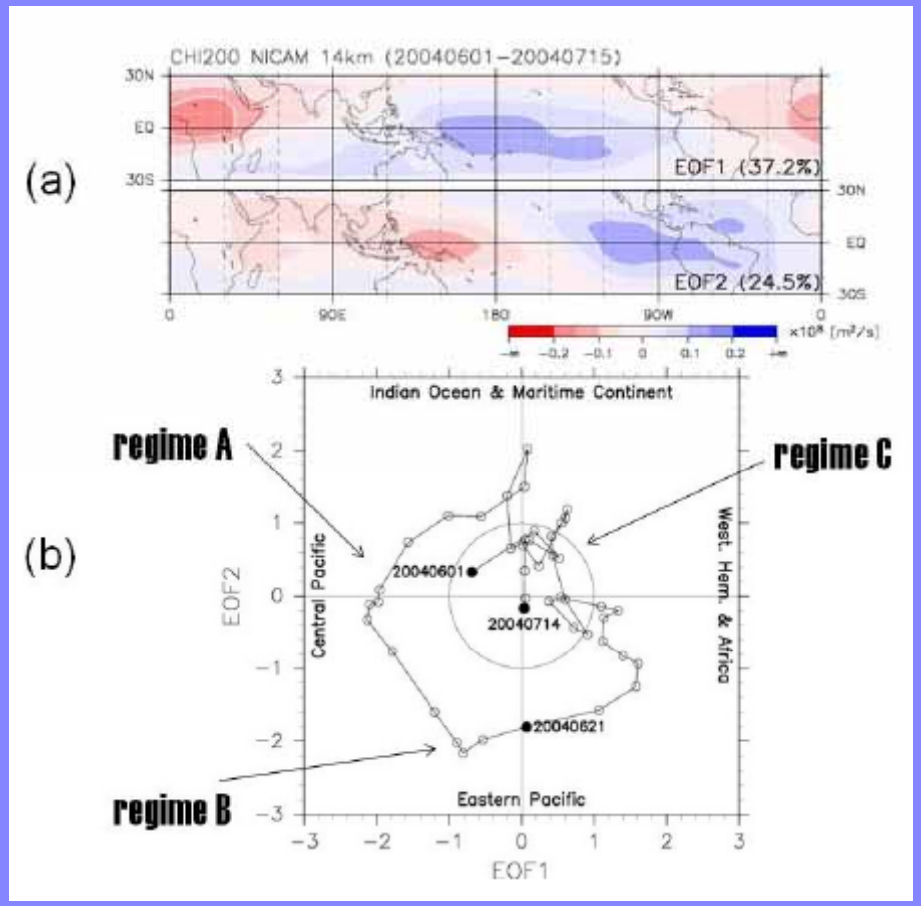
June-Oct, 2004 (160days) dx=14km
June-Aug, 2004 (90days) dx=7km




precipitation rate
−JJA 2004− [TRMM3B42]
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
precipitation rate
−JJA 2004− [GL9]
precipitation rate
−JJA 2004− [GL10]
0.2
0.4
0.6
0.8
1
mm/hr

Hovmoller of Precipitation: NICAM vs TRMM (Jun - Aug, 2004)

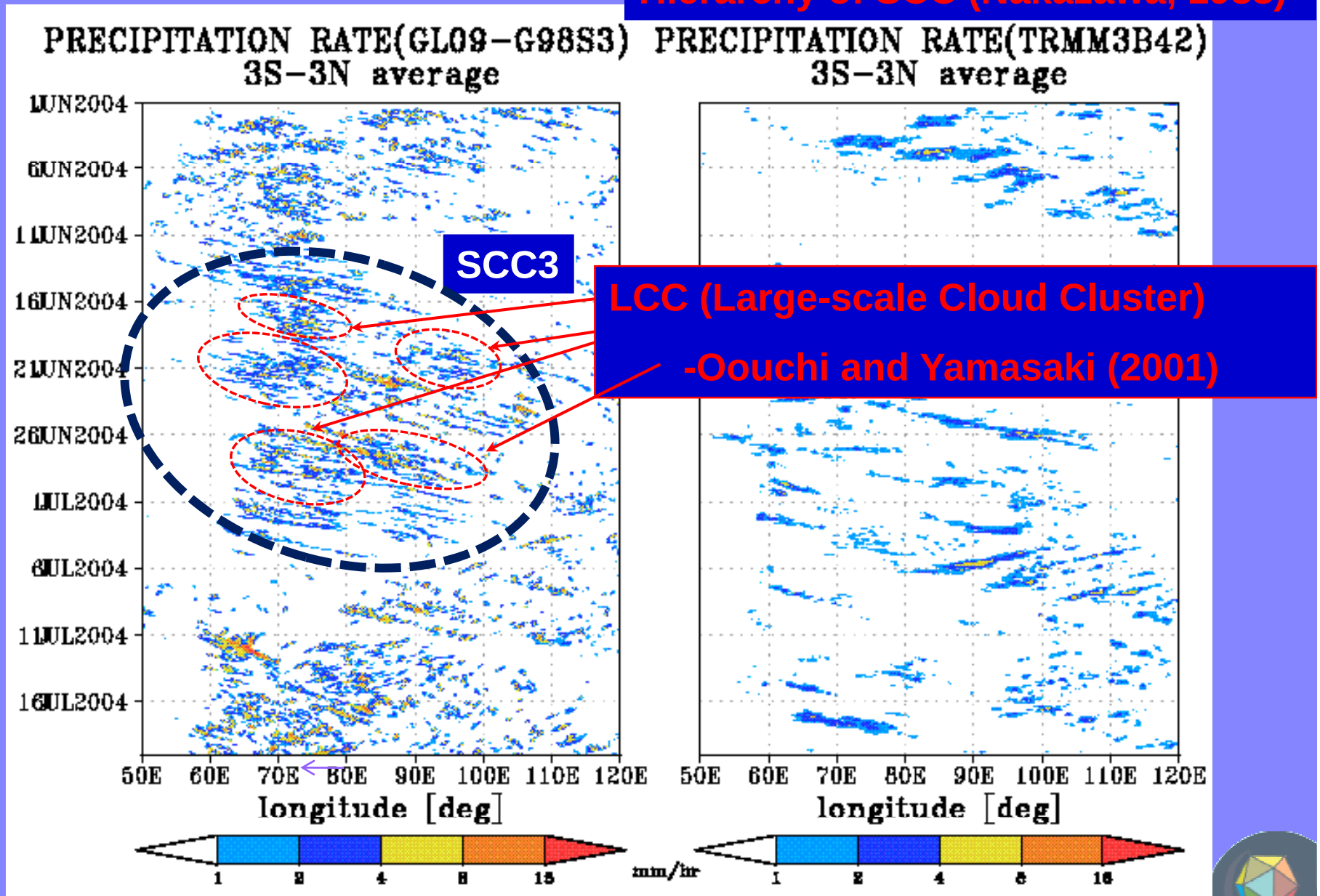




Oouchi et al.(2008,submitted)

Hierarchical convections embedded in SCC

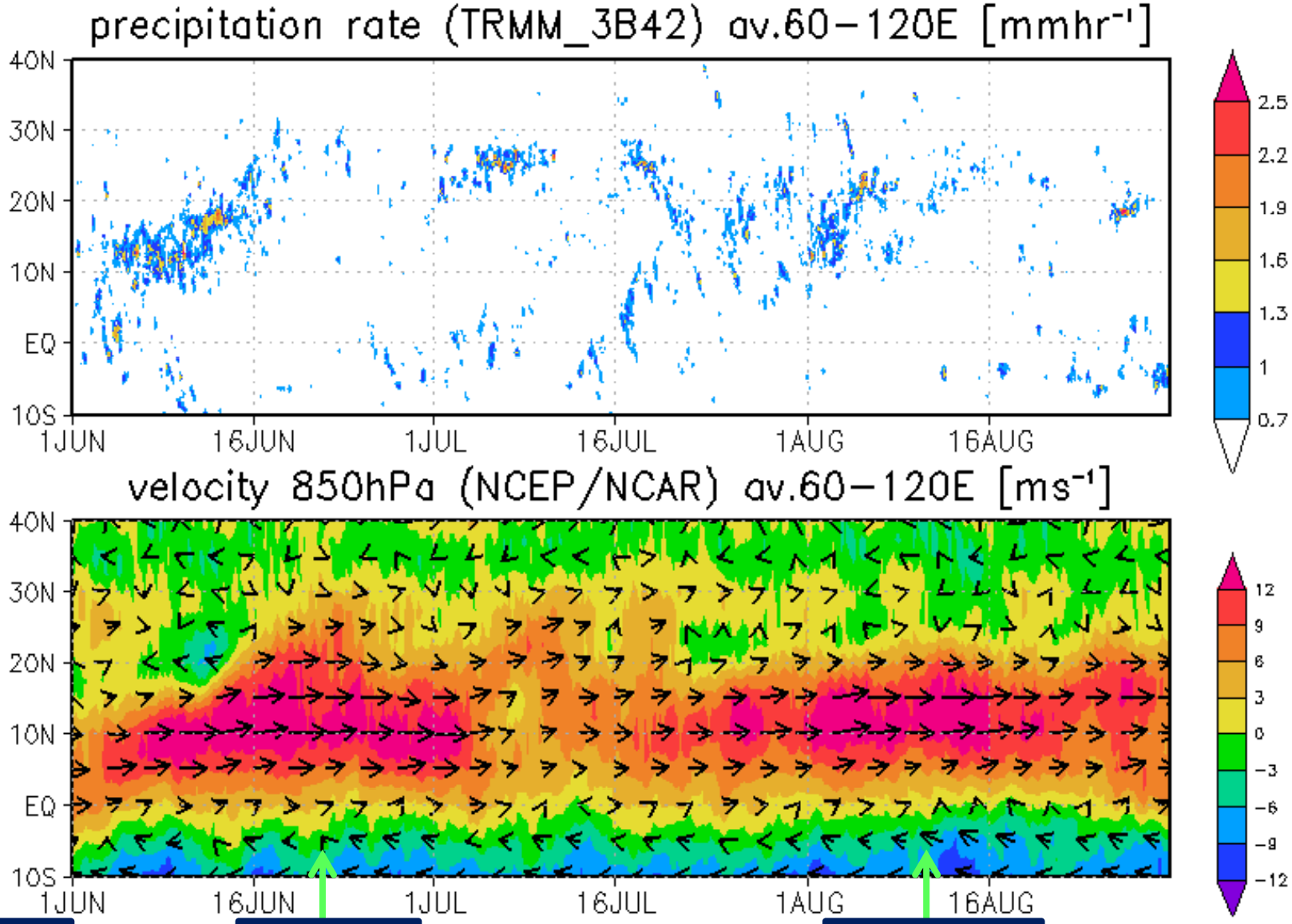
Hierarchy of SCC (Nakazawa, 1988)



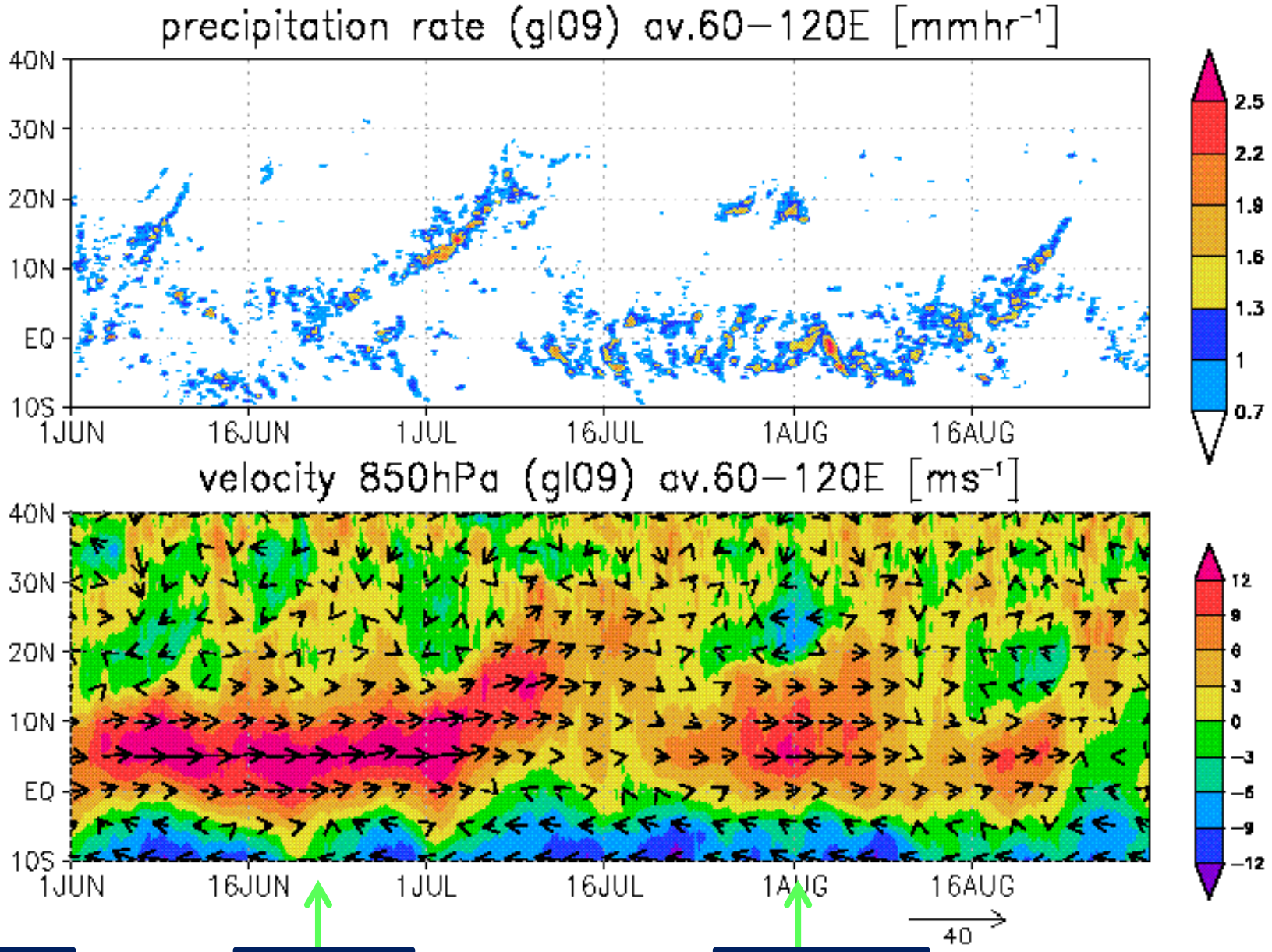
LCC (Large-scale Cloud Cluster)

-Oouchi and Yamasaki (2001)

Observation



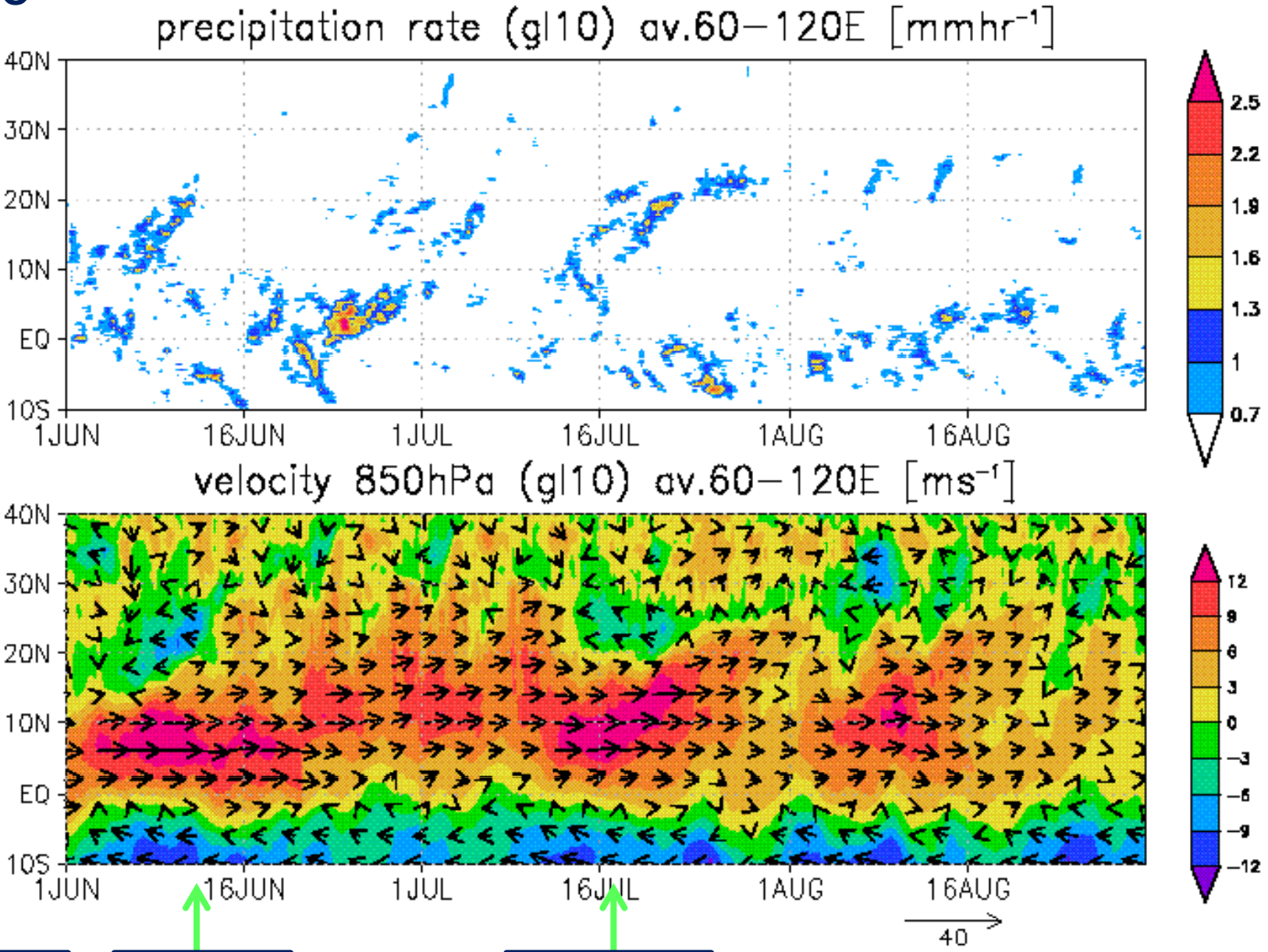
GL9



onset

1st-LLJ weakened 2nd-LLJ

GL10

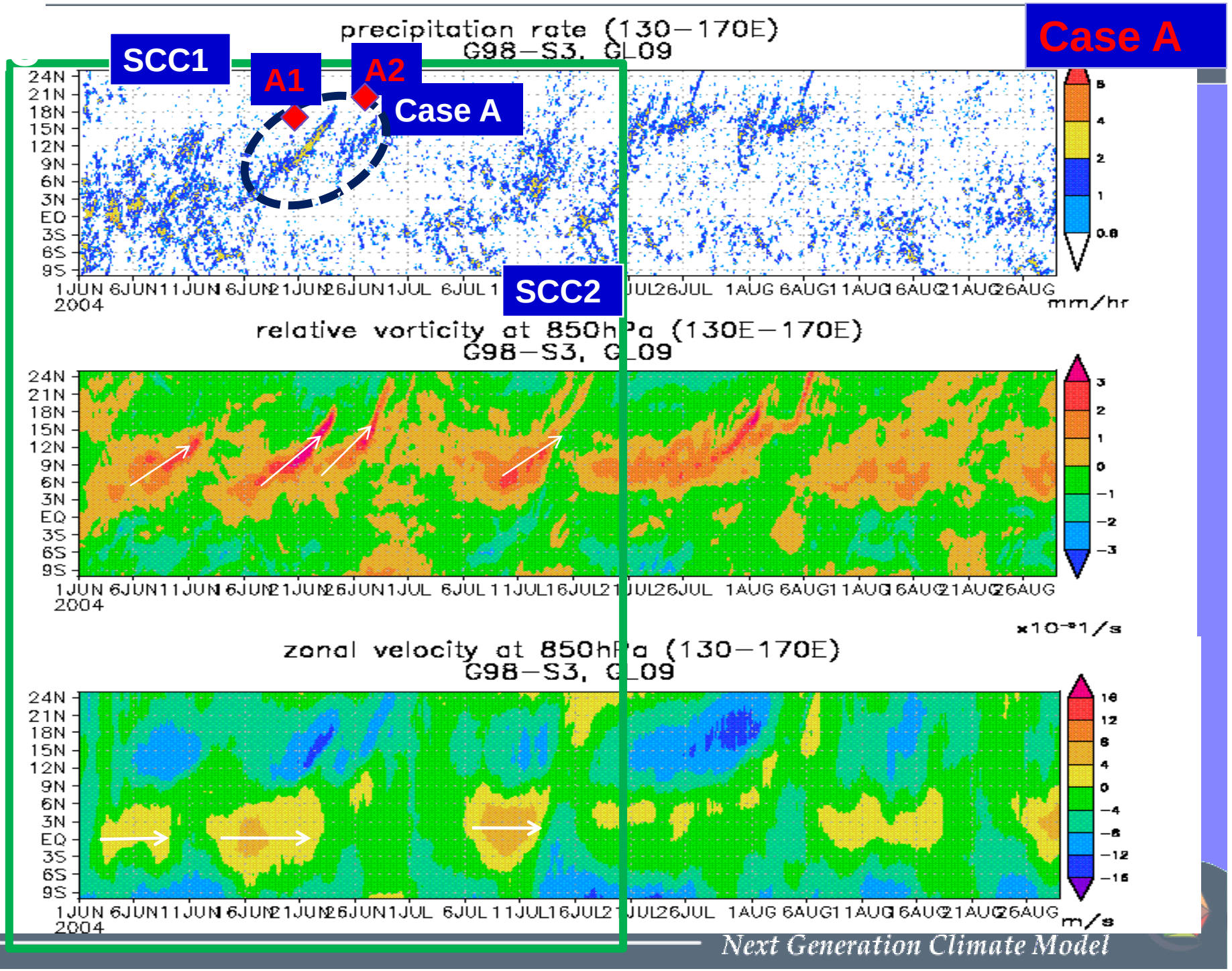


onset

1st-LLJ

weakened

2nd-LLJ


Case A
SCC1
A1
A2
Case A
SCC2
precipitation rate (130–170E)
G98–S3, GL09
mm/hr
relative vorticity at 850hPa (130E–170E)
G98–S3, GL09
×10⁻⁵1/s
zonal velocity at 850hPa (130–170E)
G98–S3, GL09
m/s
24N
21N
18N
15N
12N
9N
6N
3N
EQ
3S
6S
9S
1JUN 6JUN 11JUN 16JUN 21JUN 26JUN 1JUL 6JUL 11JUL 16JUL 21JUL 26JUL 1AUG 6AUG 11AUG 16AUG 21AUG 26AUG
2004

SIMULATIONS OF THE MONSOON ONSET AND CYCLONES

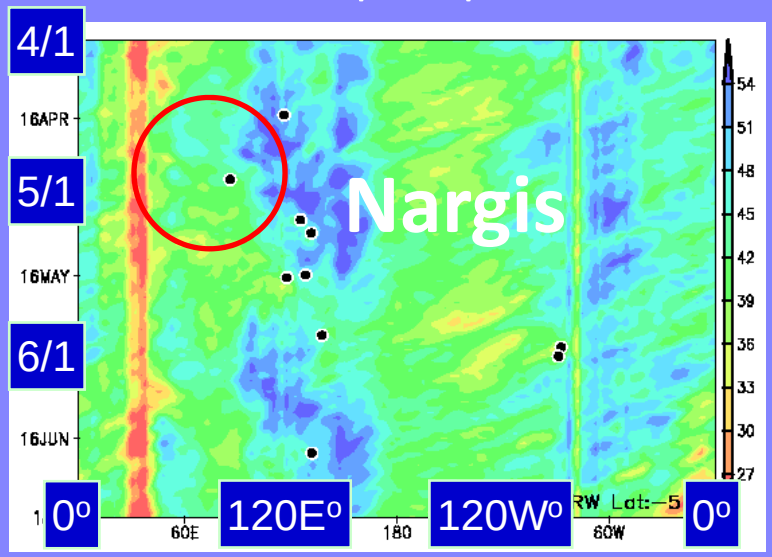
Nargis, Myanmar cyclone, Apr. 2008

by W. Yanase (CCSR, Univ. of Tokyo)

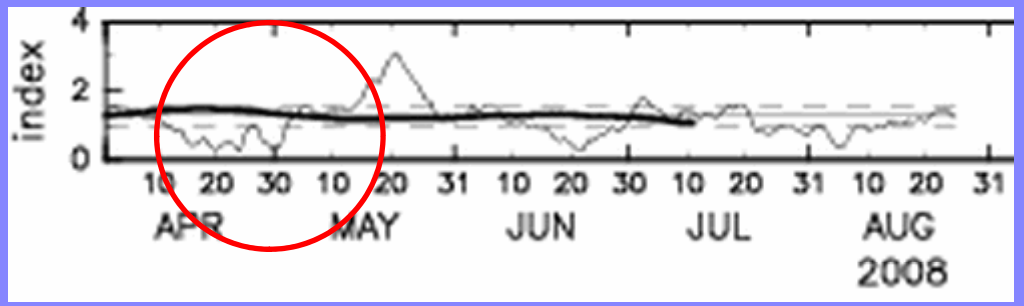
H. Taniguchi(FRCGC)

MJO signal

5°S-5°N, precipitable water



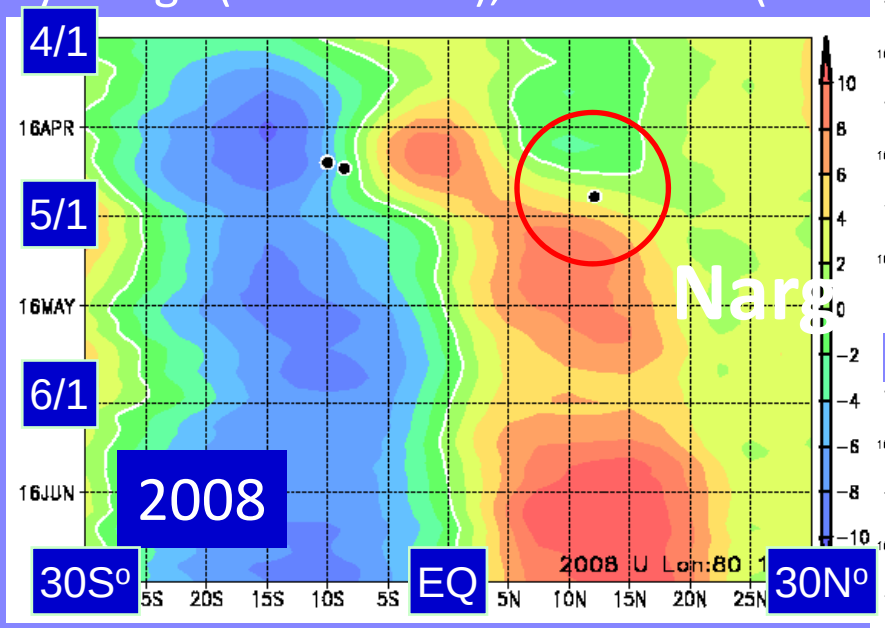
NCEP reanalysis; black circle: TC genesis



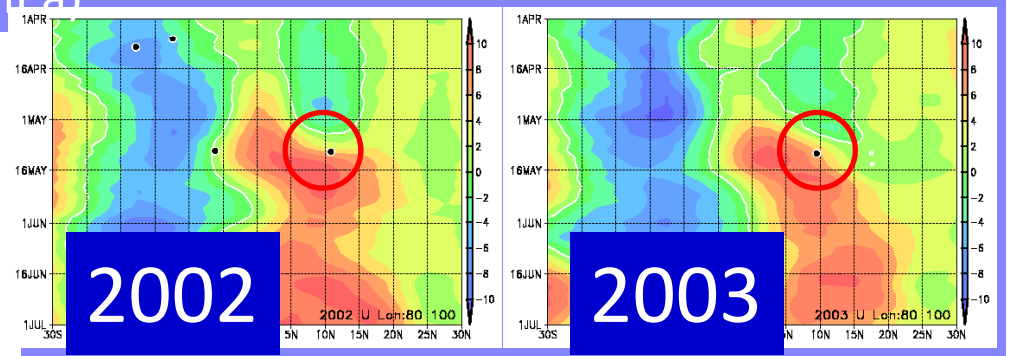
MJO Index (BMRC)

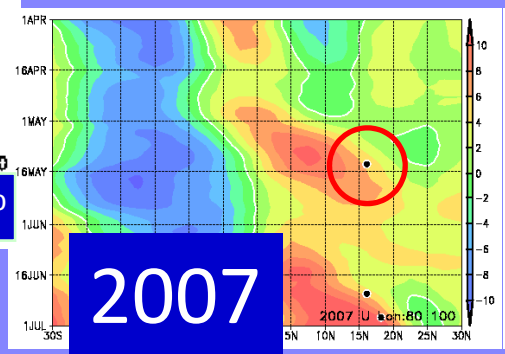
Latitude-time diagram

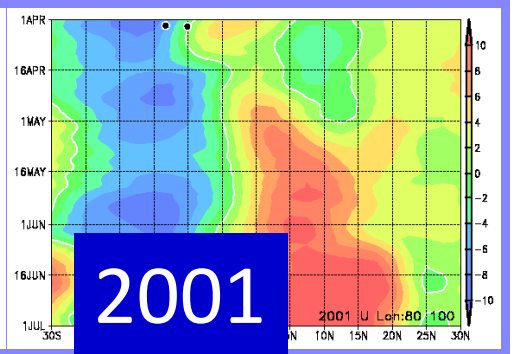
Bay Bengal(80ºE-100ºE), Zonal wind(850hPa)



TC発生位置を黒丸で示す



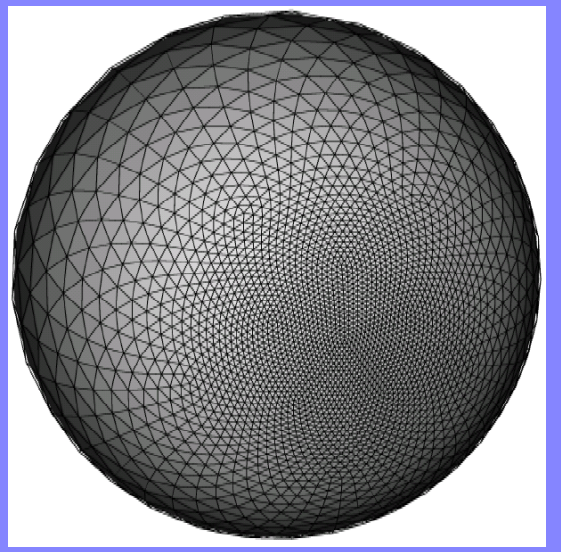




ベンガル湾で定常的な西風が形成される直前に
サイクロンが発生　(他の年でも見られる)

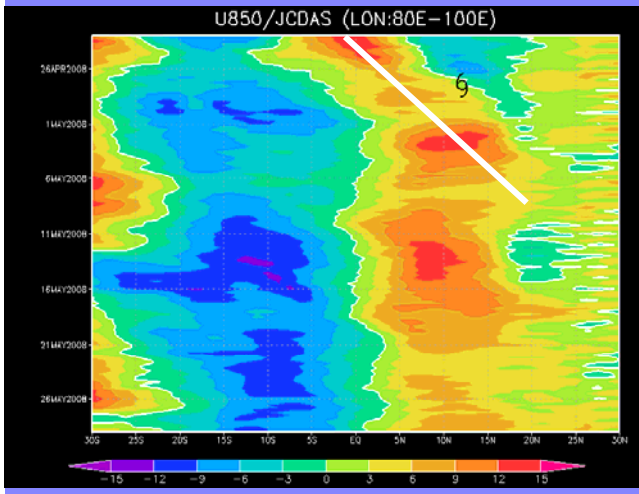
NICAM experiments

- **Global Cloud Resolving Simulations**
  - Dx=14km
- **Setched-model**
  - Dx=14km, 7km
  - Initial condition
    - 12h interval between 24-26 Apr
    - cf. Nargis genesis (12UTC, 27 Apr.)
    - Weekly SST
    - Cloud microphysics, NSW6

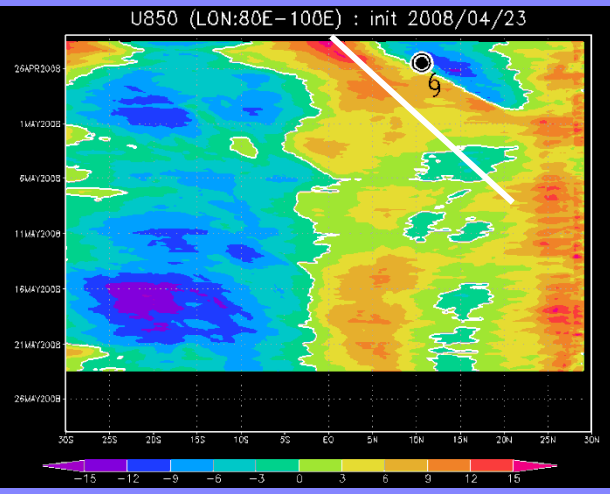


U850 (80E-100E)　Initial DAY 23-27

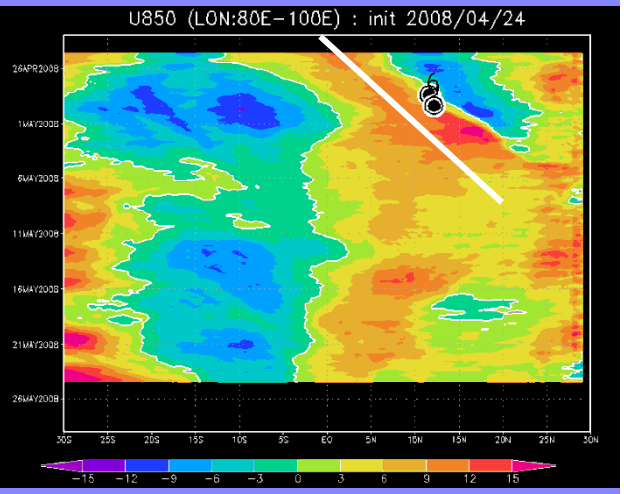
JCDAS



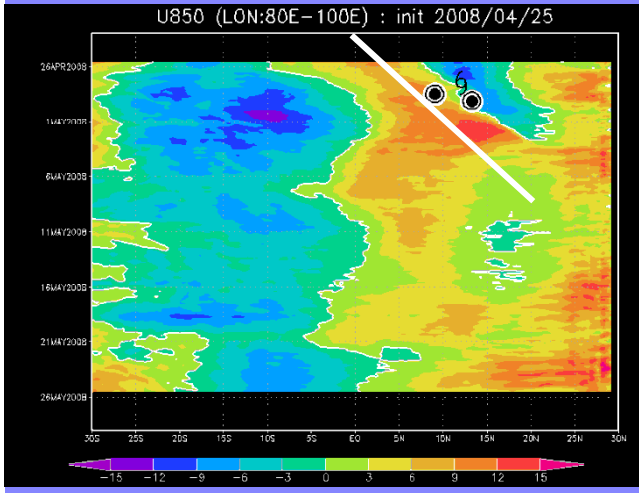
2008/04/23



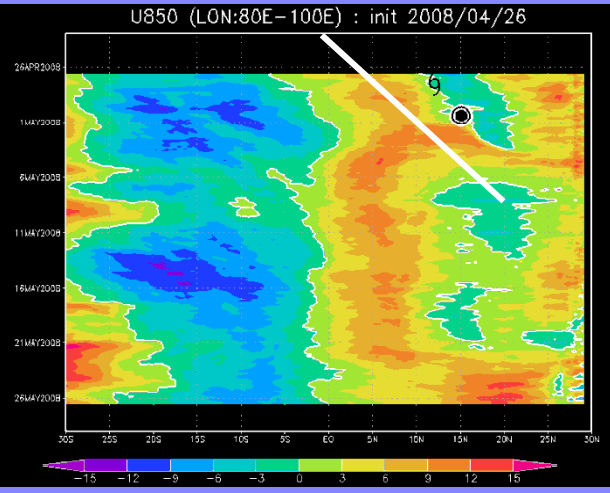
2008/04/24



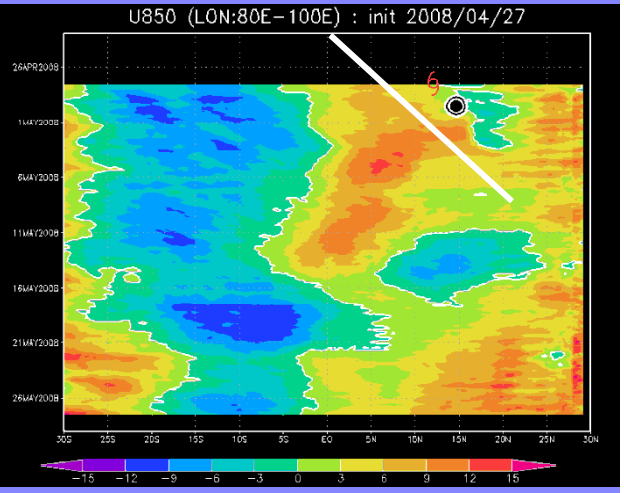
2008/04/25



2008/04/26

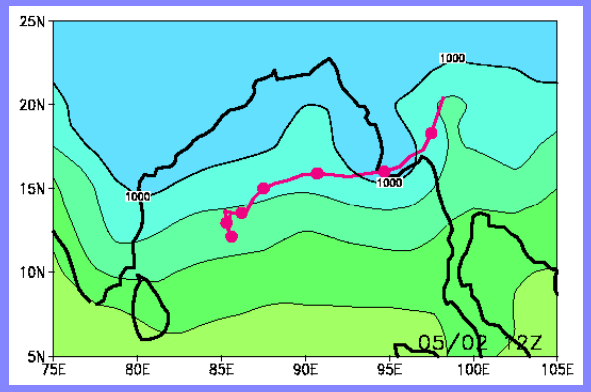


2008/04/27

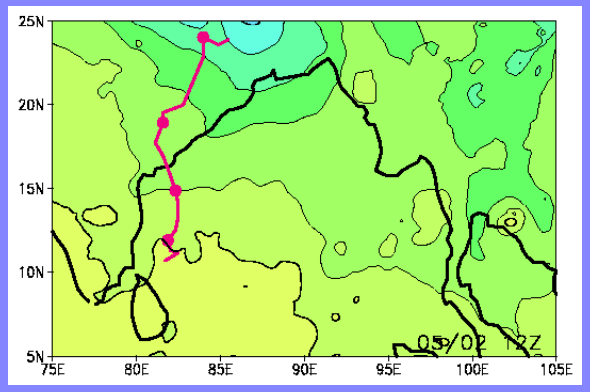


Dependency on Initial condition, resolution, domain
Init. 12UTC, 25 Apr., Analysis 12UTC 2 May, SLP

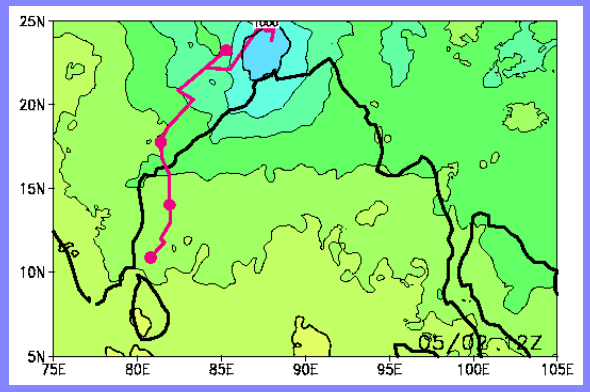
JCDAS再解析



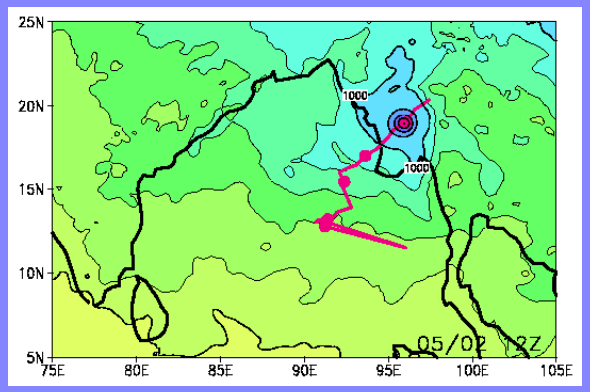
Stretch14km, NCEP init.



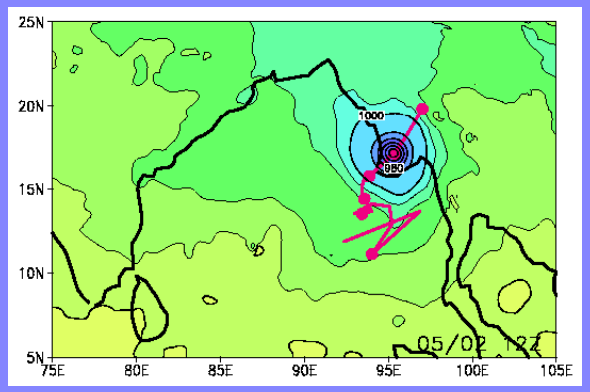
Stretch7km, NCEP init.



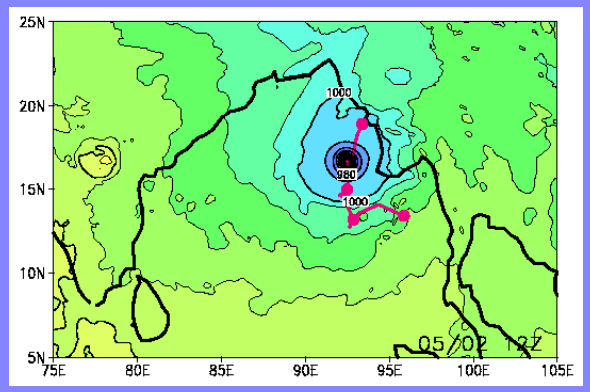
Global 14km, JMA init.



Stretch14km, JMA init



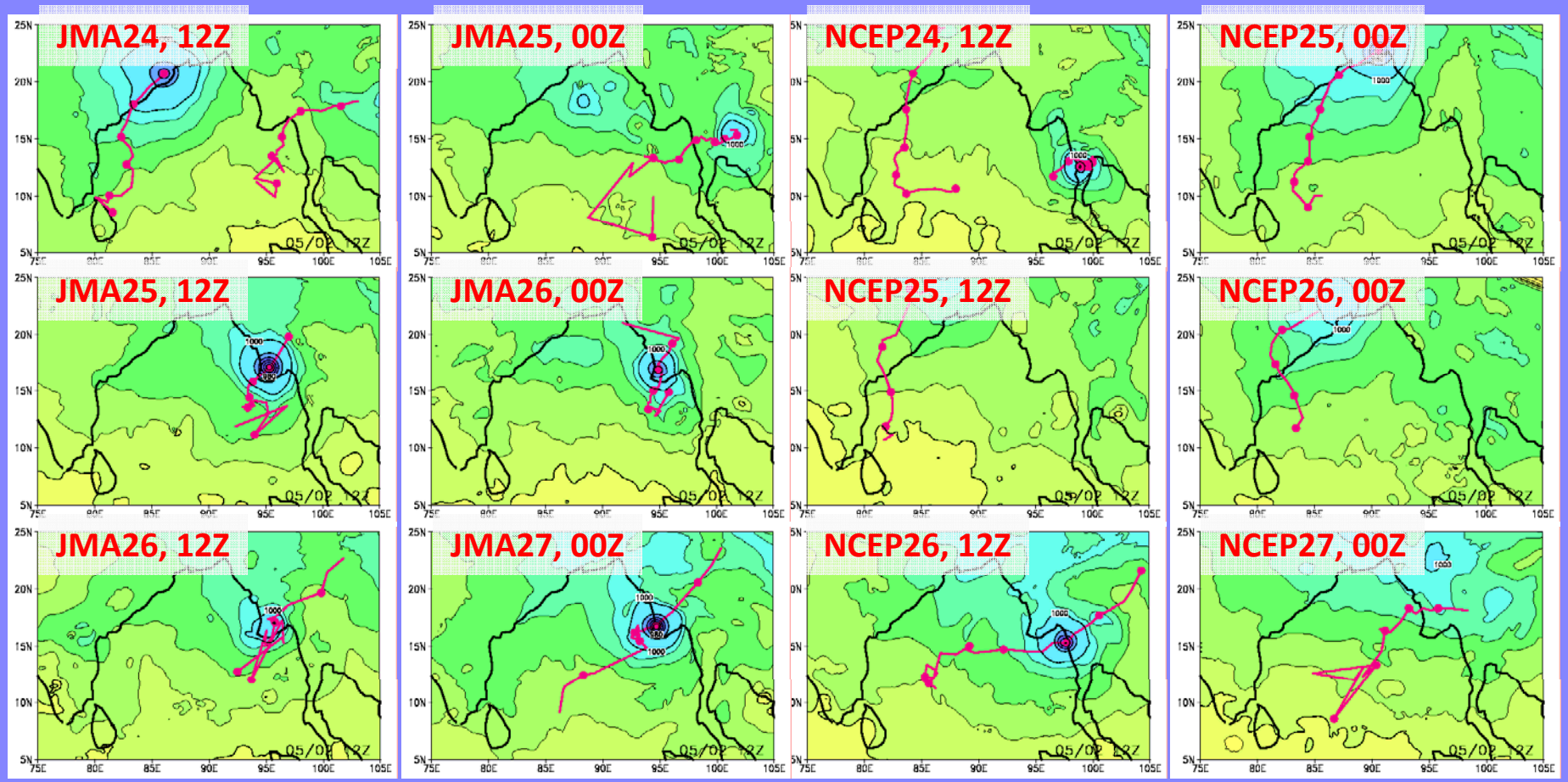
Stretch7km, JMA init



- サイクロンは発生するが、経路は再現されず
- 初期データ依存 > 解像度・領域依存

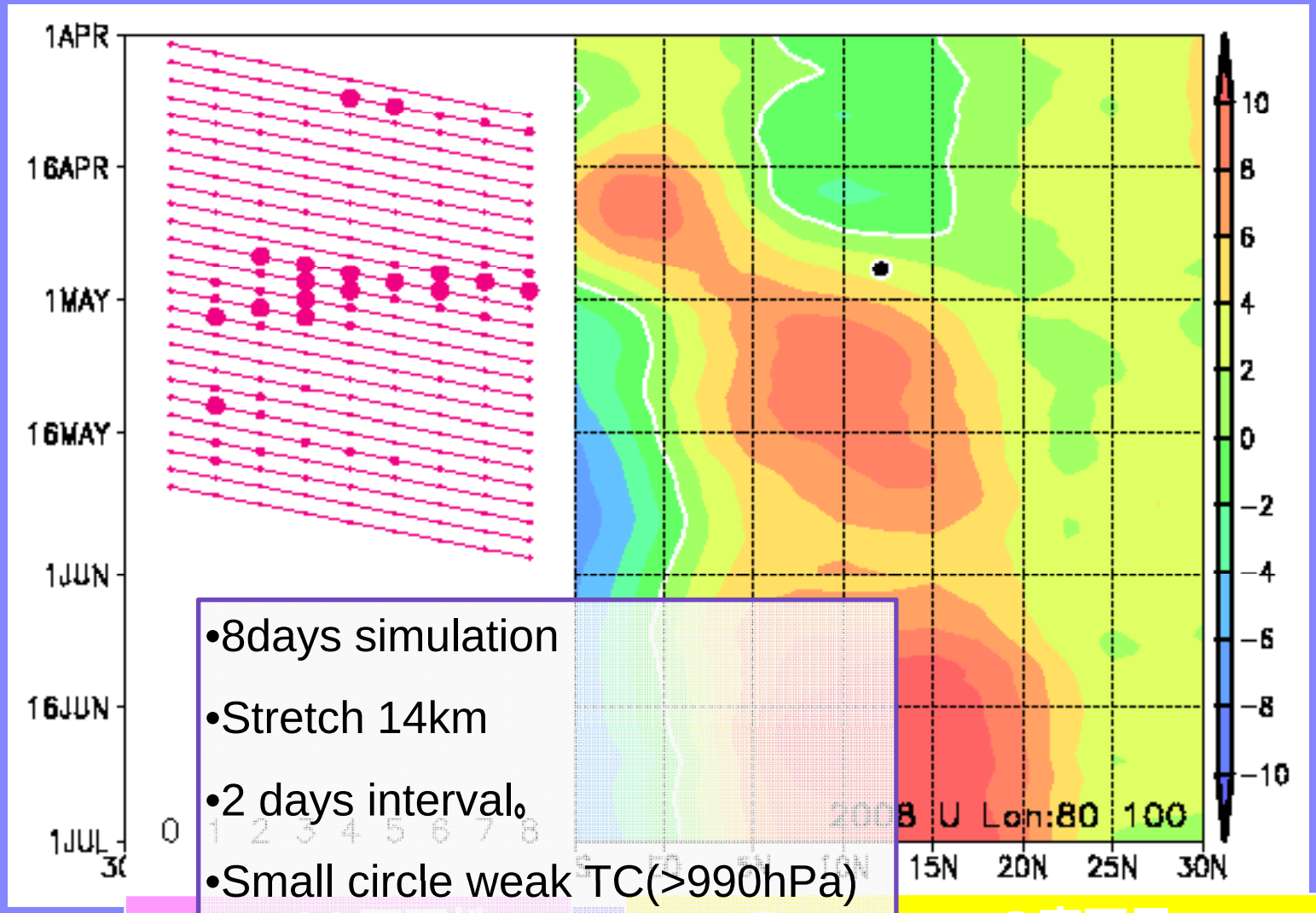
Initial conditon dependency

Stretch14km；12UTC 2 May, SLP



- 発生のタイミングや場所はばらつく
- ベンガル湾サイクロンの発生自体は再現される

Potential of Cyclogenesis, 2008



- 8days simulation
- Stretch 14km
- 2 days interval。
- Small circle weak TC(>990hPa)
- Large circyle: strong T(<990hPa)

NICAMでの再現性

数字は予報時間（日）

NCEPの80°E-100°Eの東西風(850hPa)

サイクロンの発生時刻（黒丸）

Possible use of NICAM exp

- Global 14km exp.: ~1month: several cases
- Global 7km exp., ~1month: a few cases
- Global 3.5km exp., ~1week: one case

- Stretch 7km(14km) exp.: ~1 week
  - many sensitivity studies

- Global or Stretch?
  - Remote effects: wave propagations
- Ocean, Land interactions

Possible use of NICAM for MJO studies

- **A few months simulations**
  - CTL: 7km, 1-3 months
  - Ensemble with 14km
  - Different initial conditions: 1 May, 1 Jun, 1 July, …
  - Summer and winter
  - MJO
- **Shorter snap shot runs**
  - 3.5km, a week
  - “Nature run”
  - Anvil clouds, cold pool dynamics: meso-circulations
  - Comparison with satellite obs
  - Diurnal cycle and multi-scale interaction