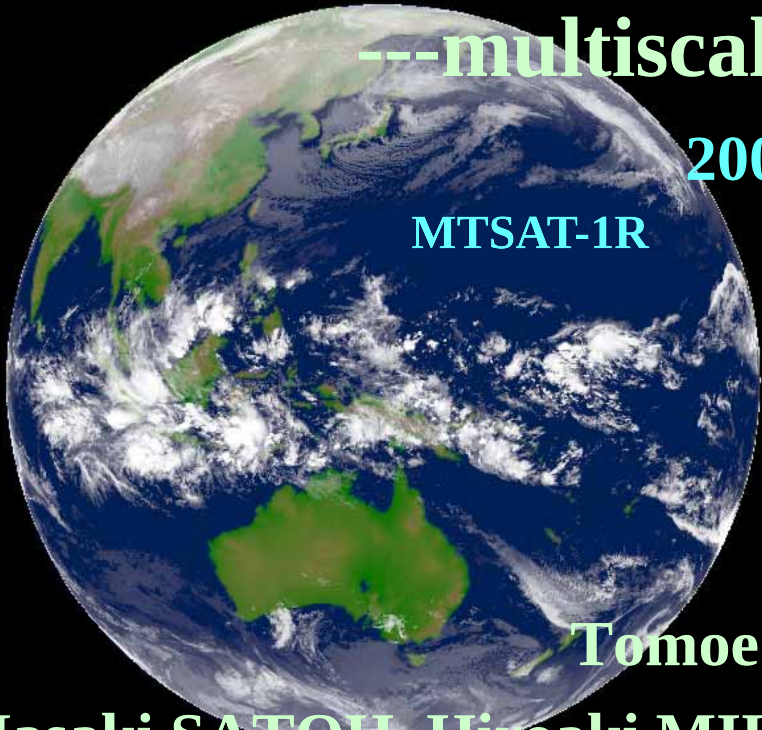
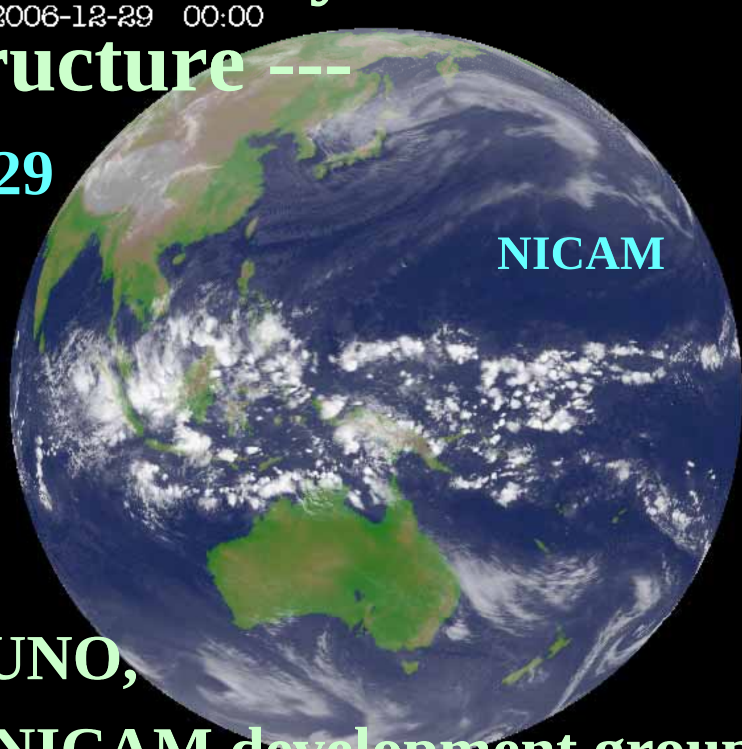
Global cloud-resolving simulations of MJO events in November 2006 - January 2007

---multiscale structure ---

2006/12/29





Tomoe NASUNO,

Masaki SATOH, Hiroaki MIURA, NICAM development group

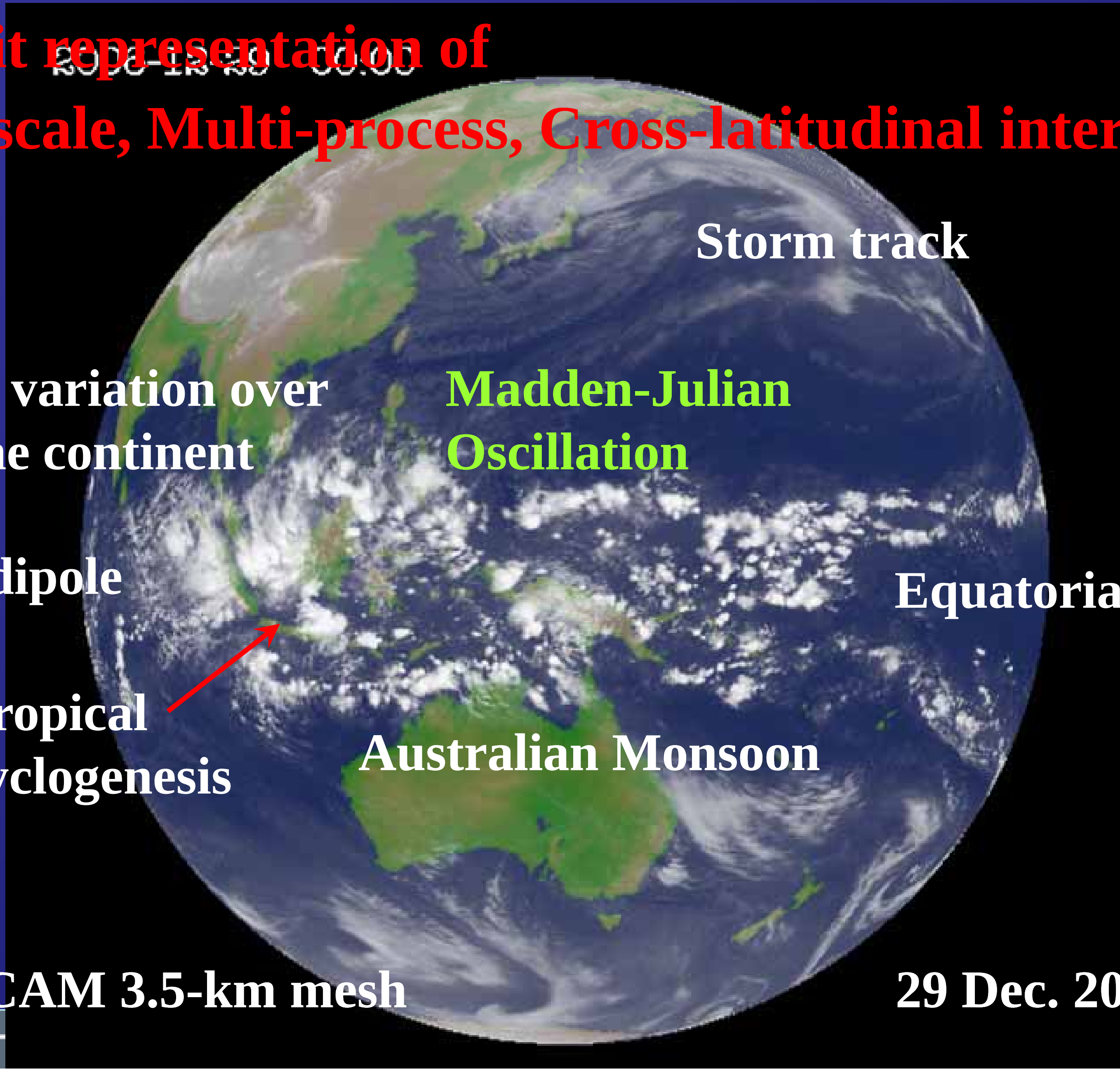
FRCGC, JAMSTEC

MISMO workshop

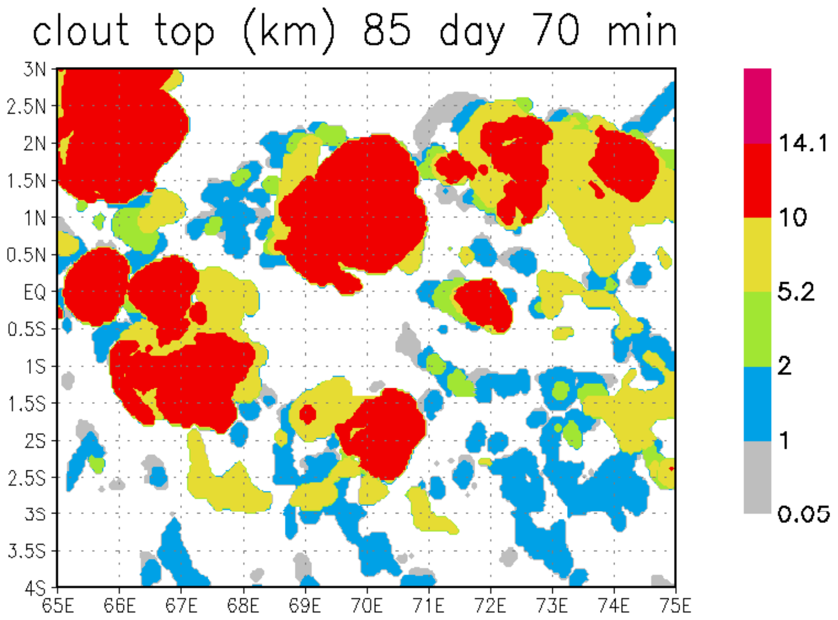
Yokohama, 25 November, 2008

Capability of global cloud-resolving simulations

Explicit representation of
Multi-scale, Multi-process, Cross-latitudinal interactions



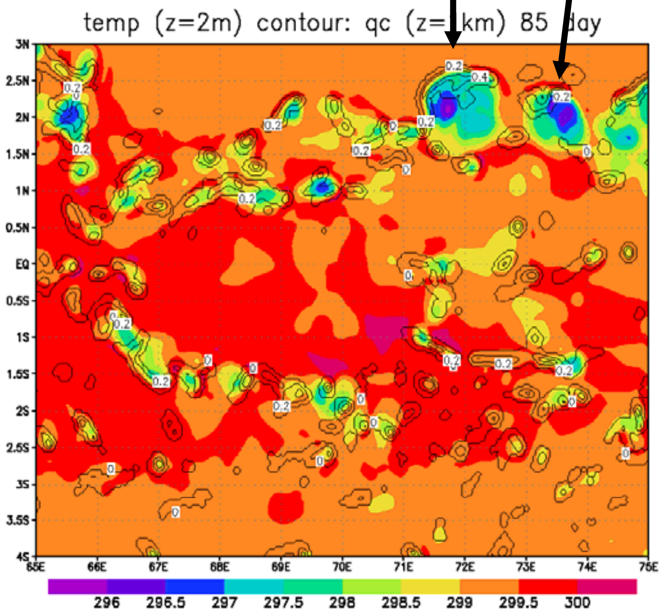
NICAM
3.5-km mesh
Aquaplanet case

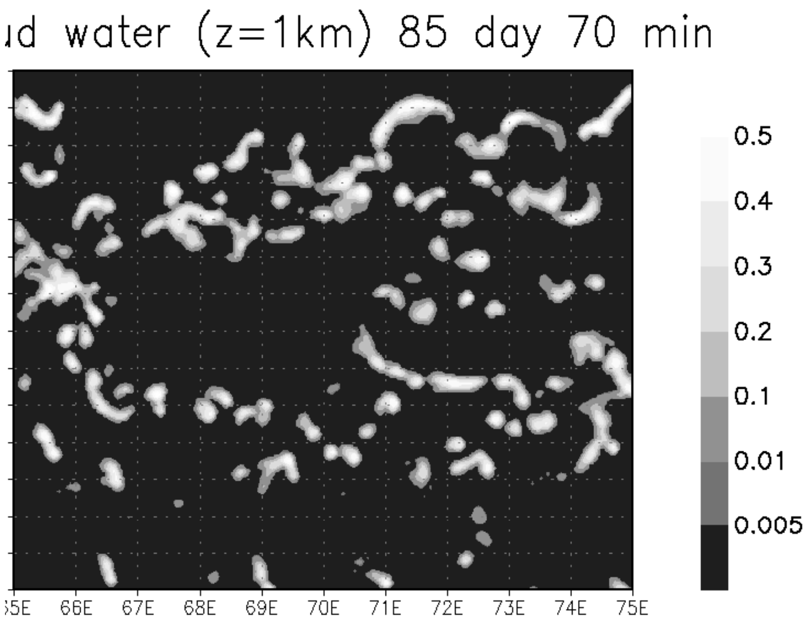


Cloud top height (km)

Temperature
z = 2 m

Cold pools, downdrafts



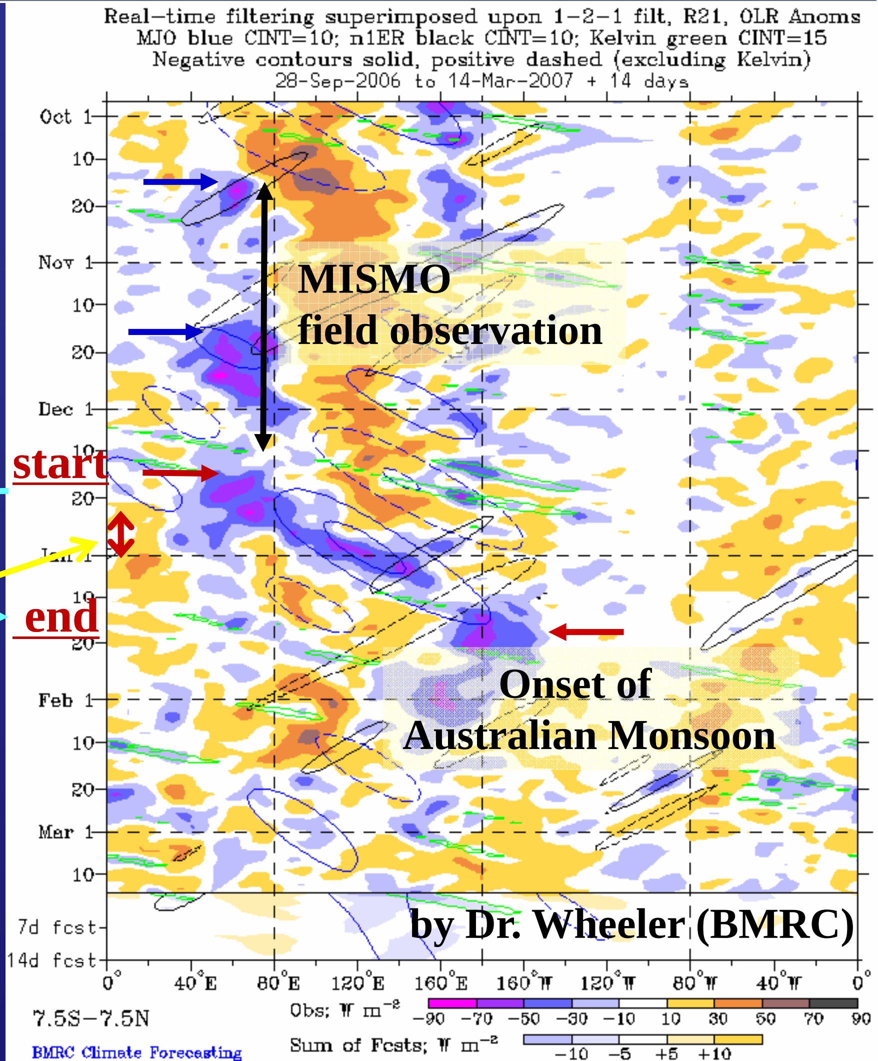


Cloud water Content (g/kg)
z = 1 km

te Model

Experimental setup (an MJO event Dec.2006-Jan.2007)

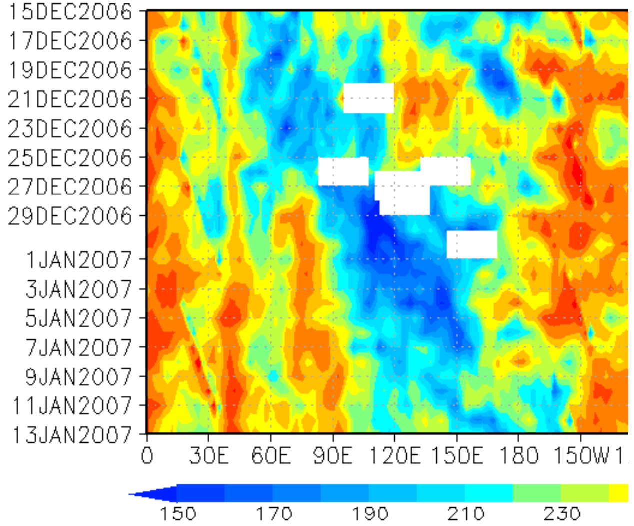
Horizontal mesh size:
14 km, 7 km, 3.5 km
Vertical domain:
0 m ~ 38,000 m, 40-levels (stretch grid)
Initial conditions:
NCEP tropospheric analyses data
(6 hourly, 1.0x1.0 degree grids)
2006-12-15 00:00:00 (14- and 7-km run)
→ 1-month integration
2006-12-25 00:00:00 (3.5-km run)
→ 7-day integration
Boundary conditions:
Reynolds SST, Sea ICE (weekly data)
ETOPO-5 topography,
Matthews vegetation
UGAMP ozone climatology (for AMPI2)



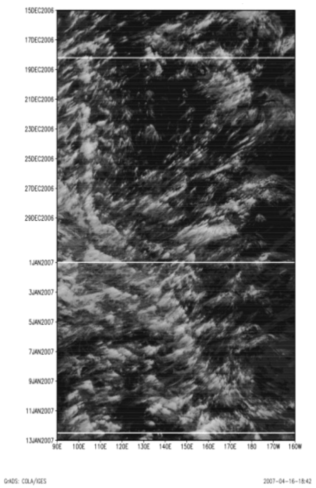
Miura et al. 2007; An Madden-Julian Oscillation event simulated using a global cloud-resolving model. Science, 318, 1763(2007); doi: 10.1126/science.1148443.

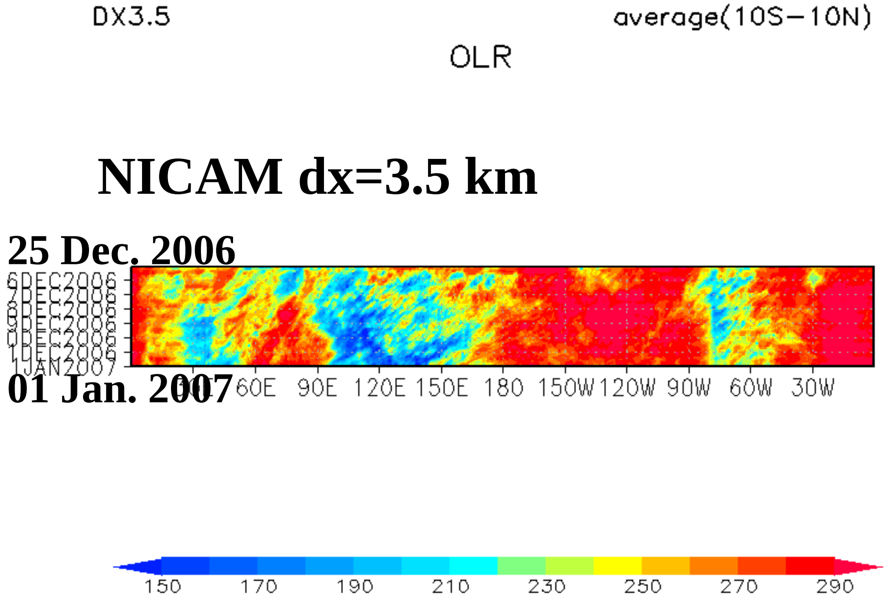
http://www.bom.gov.au/bmrc/clfor/cfstaff/matw/maproom/OLR_modes/h.6.ALL.EQ.html

NOAA OLR



MTSAT TBB





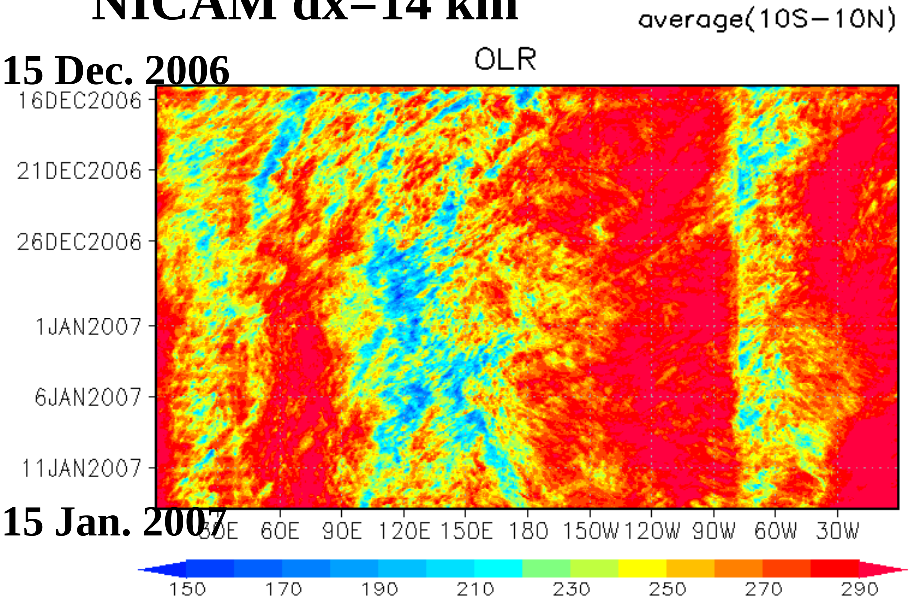
NICAM dx=3.5 km

25 Dec. 2006

01 Jan. 2007

NICAM dx=14 km

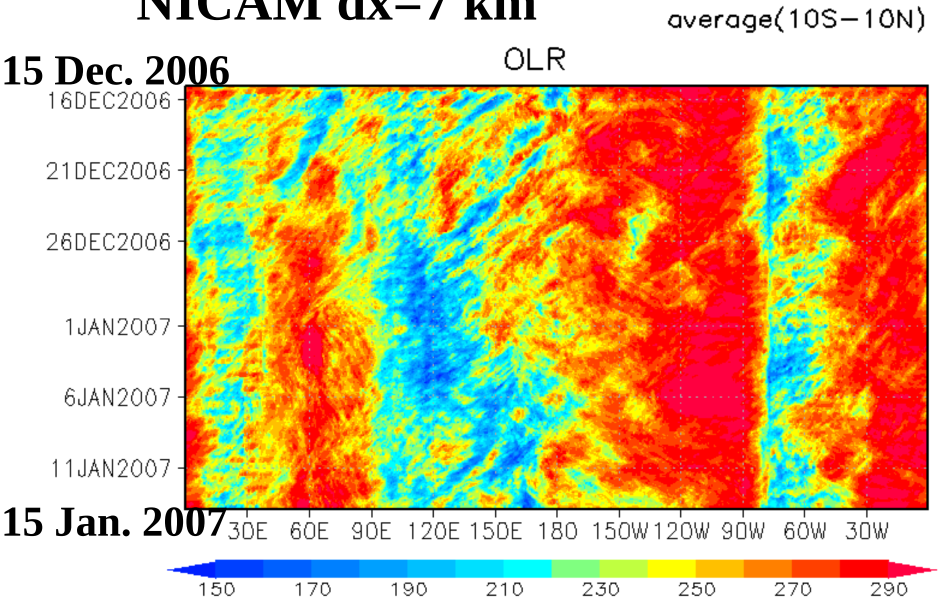
15 Dec. 2006



15 Jan. 2007

NICAM dx=7 km

15 Dec. 2006



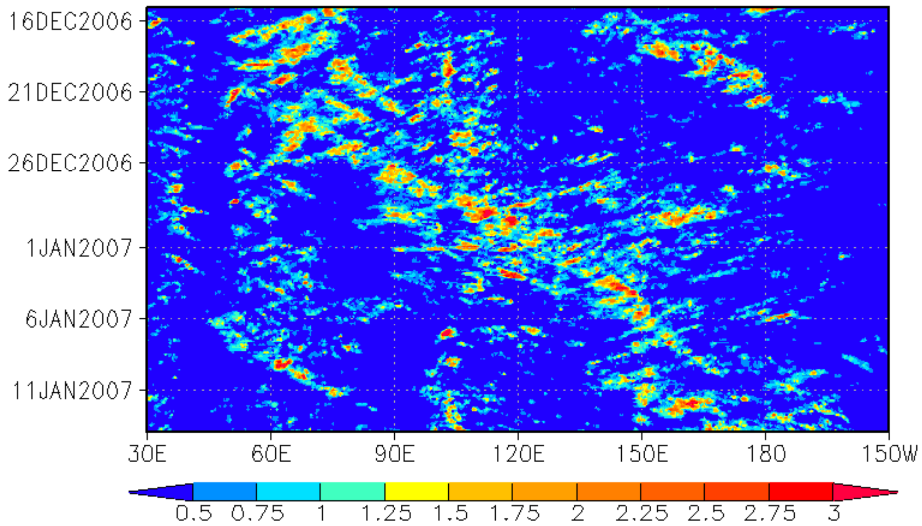
15 Jan. 2007

References (Nov 2006-Jan 2007 simulations)

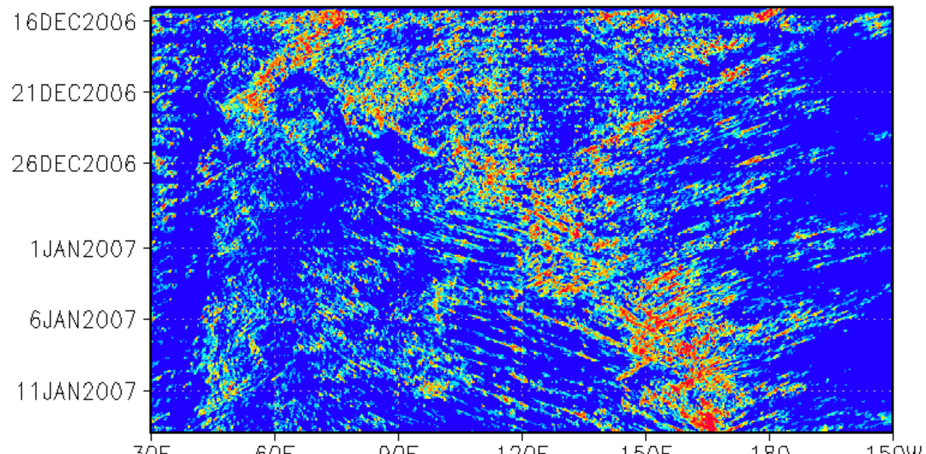
- Miura, H., M. Satoh, T. Nasuno, A. T. Noda, and K. Oouchi, 2007: An Madden-Julian Oscillation event simulated using a global cloud-resolving model. *Science*, 318, 1763-1765. : overview
- Satoh, M., 2008: Numerical simulations of heavy rainfalls by a global cloud-resolving model. *J. Disaster Research*, 3, 33-38. : overview, diurnal cycle
- Inoue, T., M. Satoh, H. Miura, and B. Mapes, 2008: Characteristics of cloud size of deep convection simulated by a global cloud resolving model over the western tropical Pacific. *J. Meteor. Soc. Japan*, in press. : cluster size distribution (vs. MTSAT)
- Masunaga, H., M. Satoh, and H. Miura, 2008: A joint satellite and global CRM analysis of an MJO event: Model diagnosis. *J. Geophys. Res*., 113, D17210, doi:10.1029/2008JD009986. : condensates (vs. TRMM, CloudSat/CALIPSO)
- Fudeyasu, H., Y. Wang, M. Satoh, T. Nasuno, H. Miura, and W. Yanase, 2008: The global cloud-system-resolving model NICAM successfully simulated the lifecycles of two real tropical cyclones. *Geophys. Res. Lett.*, in press : TC formation and lifecycles
- Nasuno, T., H. Miura, M. Satoh, A. T. Noda, and K. Ouchi, 2008: Multi-scale organization of convection in a global numerical simulation of the December 2006 MJO event using explicit moist processes. *J. Meteor. Soc. Japan*, in revision : multiscale
- Sato, T. et al. (submitted): diurnal cycle of precipitation
- Taniguchi et al (in preparation) : EOF analysis (vs. NCEP)
- Miura (submitted) : sensitivity experiments

Hovmöller diagrams: precipitation, temperature

Precipitation (10S-5N) **TRMM PR**

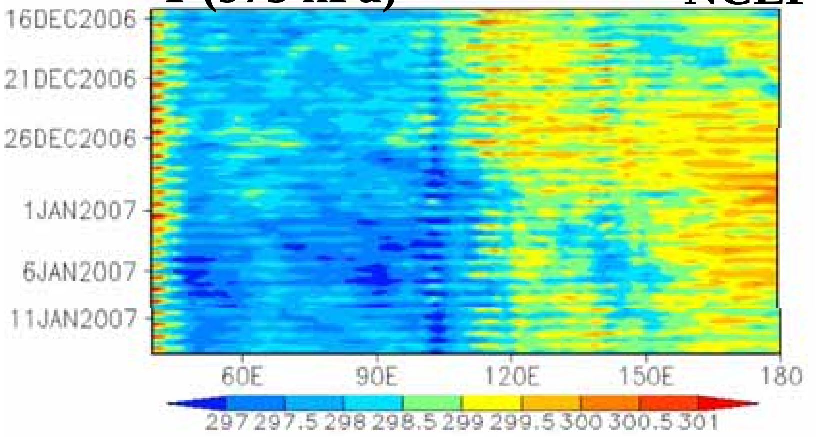


NICAM dx=7 km

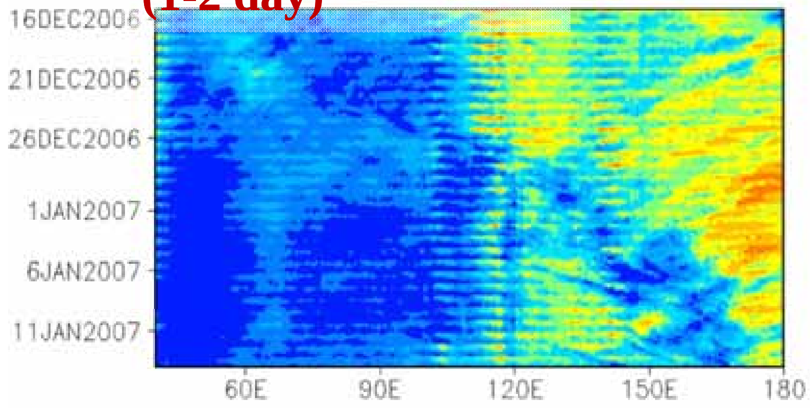


Eastward 10-15 m/s
1000-2000 km
(1-2 day)

T (975 hPa) **NCEP**



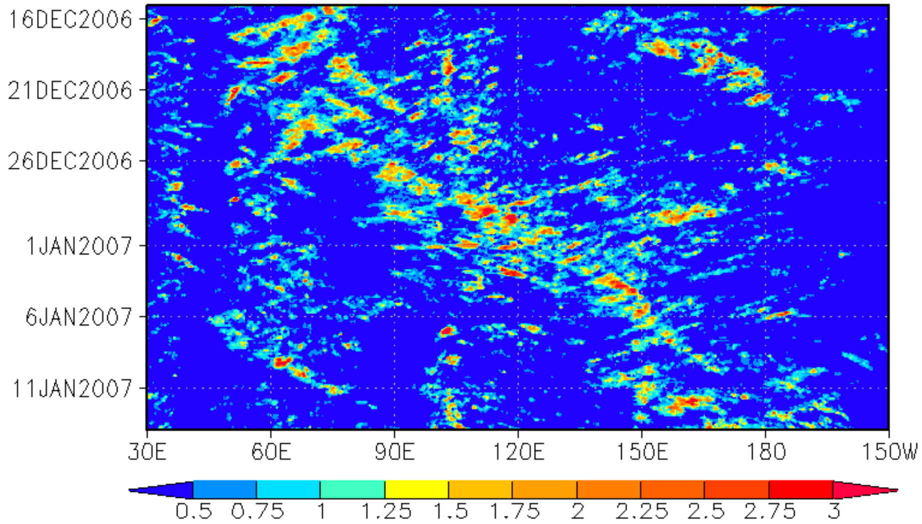
NICAM dx=7 km



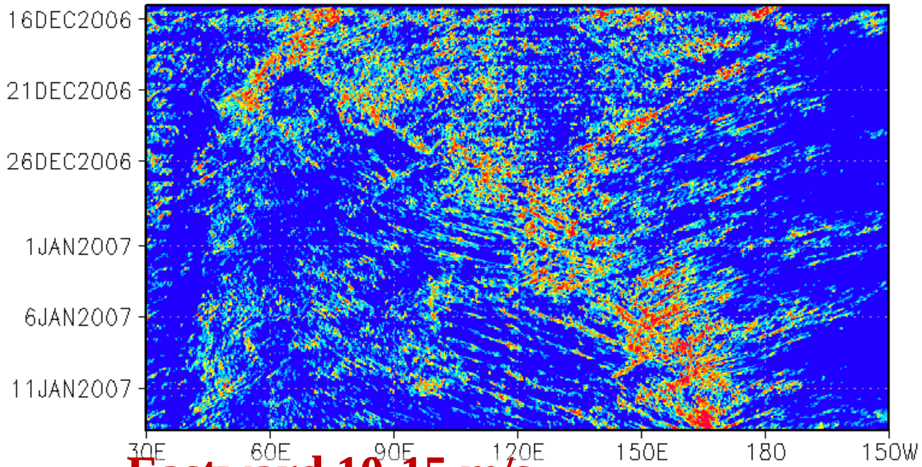
Miura et al. 2007; An Madden-Julian Oscillation event simulated using a global cloud-resolving model. Science, 318, 1763(2007); doi: 10.1126/science.1148443.

Hovmöller diagrams: precipitation, zonal wind

Precipitation (10S-5N) **TRMM PR**



NICAM dx=7 km



Eastward 10-15 m/s
1000-2000 km
(1-2 day)

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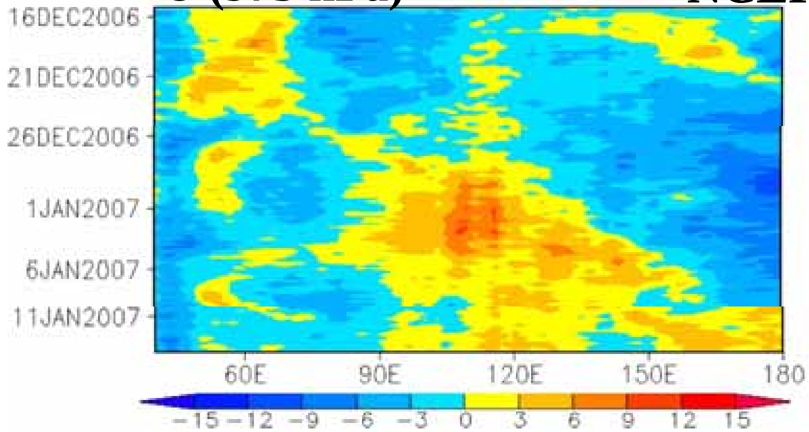
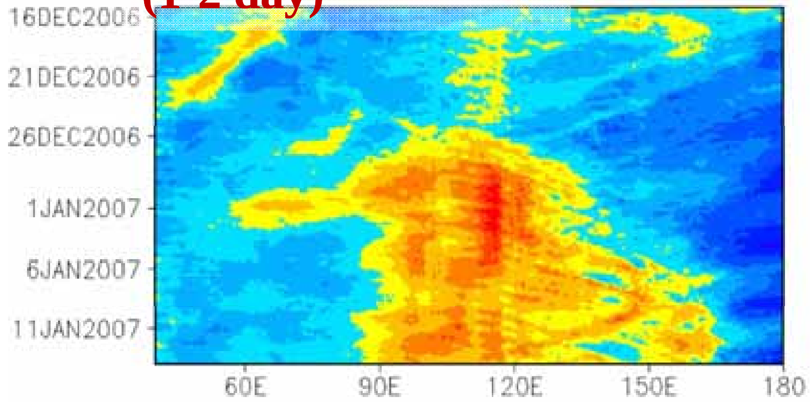


NICAM dx=7 km



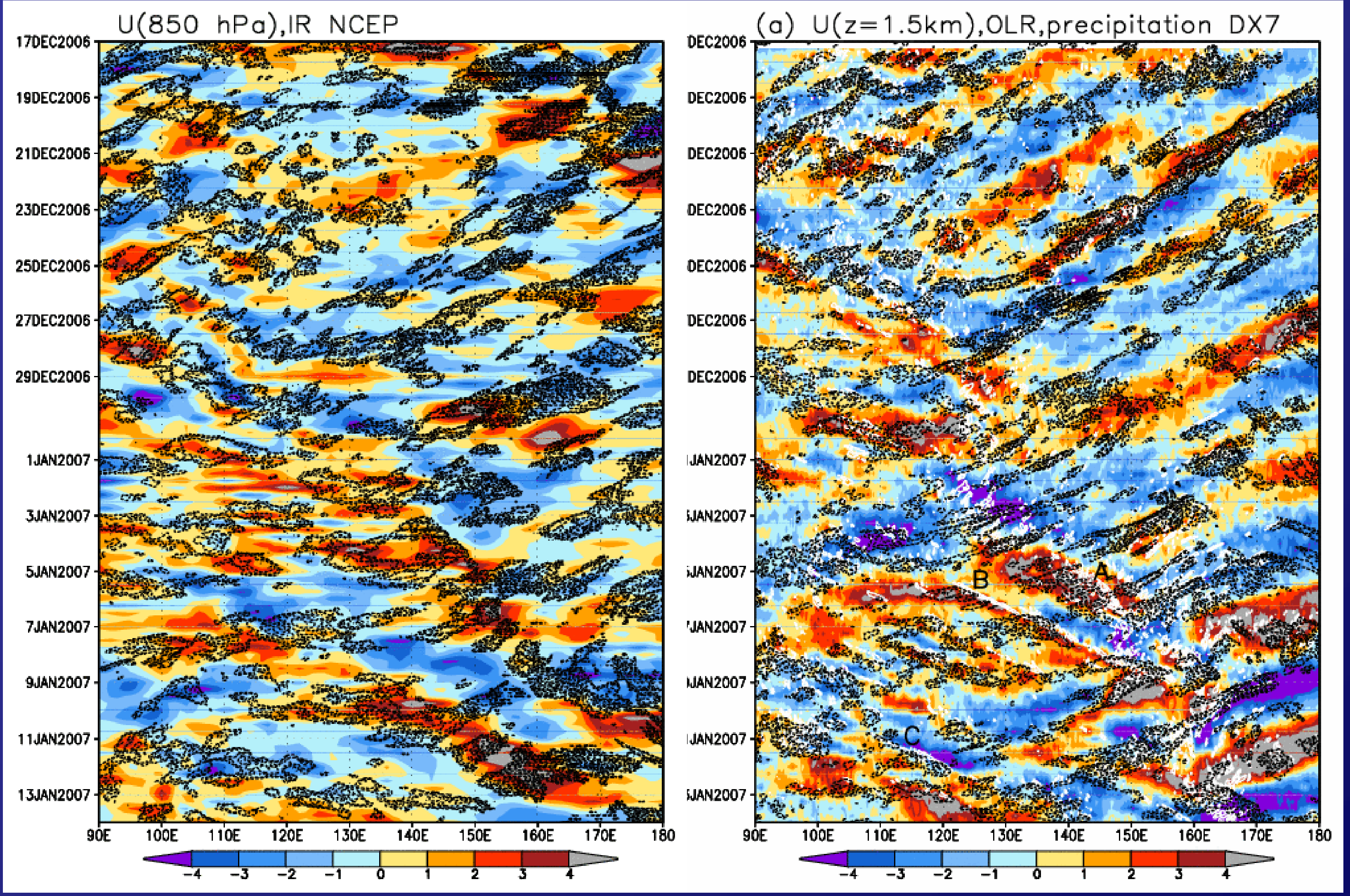
Miura et al. 2007; An Madden-Julian Oscillation event simulated using a global cloud-resolving model. Science, 318, 1763(2007); doi: 10.1126/science.1148443.

Zonal wind (4-day running mean subtracted)

NCEP

NICAM dx=7 km

3N-3S average



Black lines: IR TBB

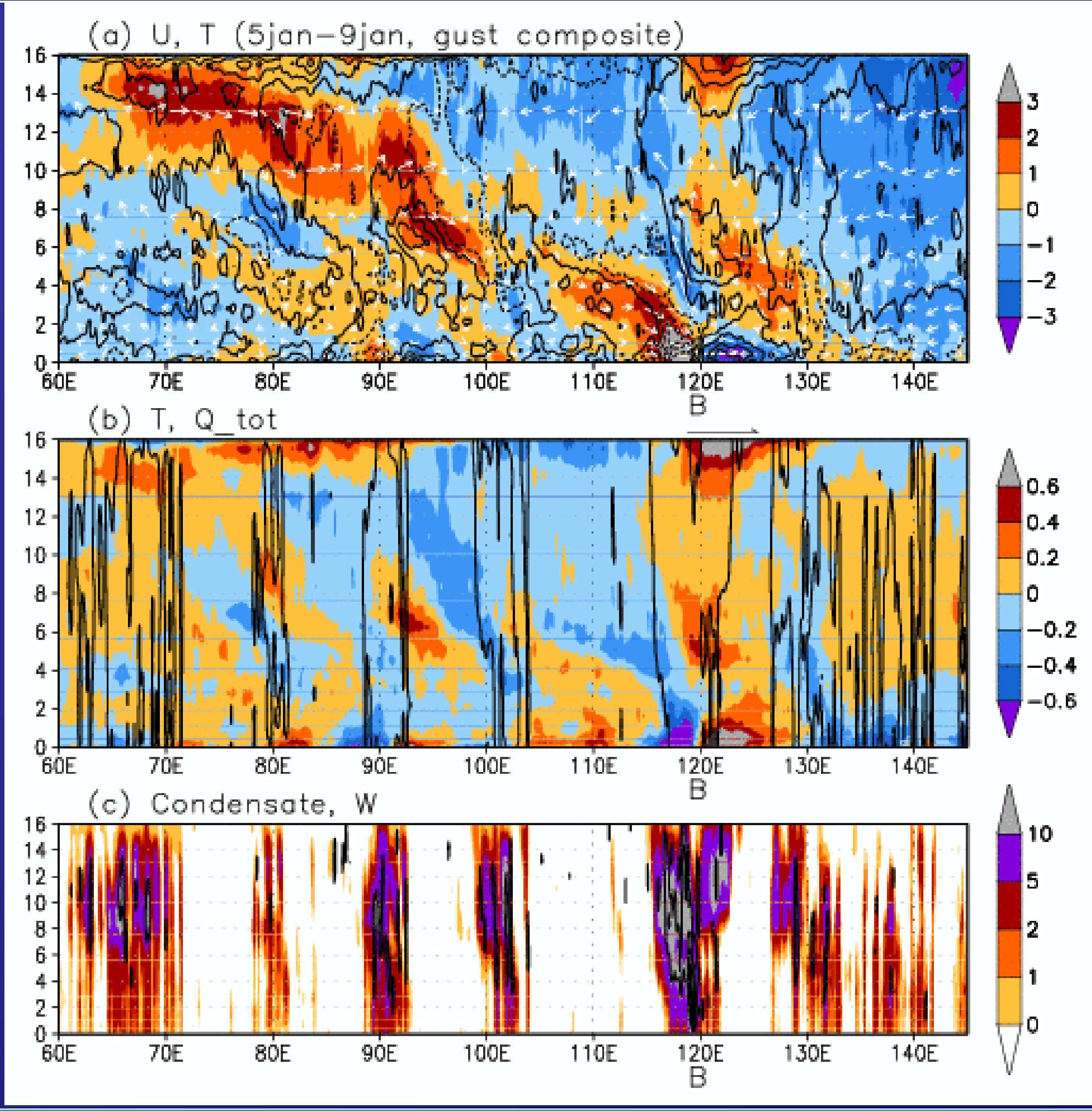
Black lines: OLR, white: precipitation

Vertical structure; composite along gust front

Zonal velocity
contour: temperature

Temperature
contour: condensate

Condensate
contour: vertical velocity



3N-3S average

(a) (b) Deviations from time average

zonal wavenumber-frequency spectra

symmetric

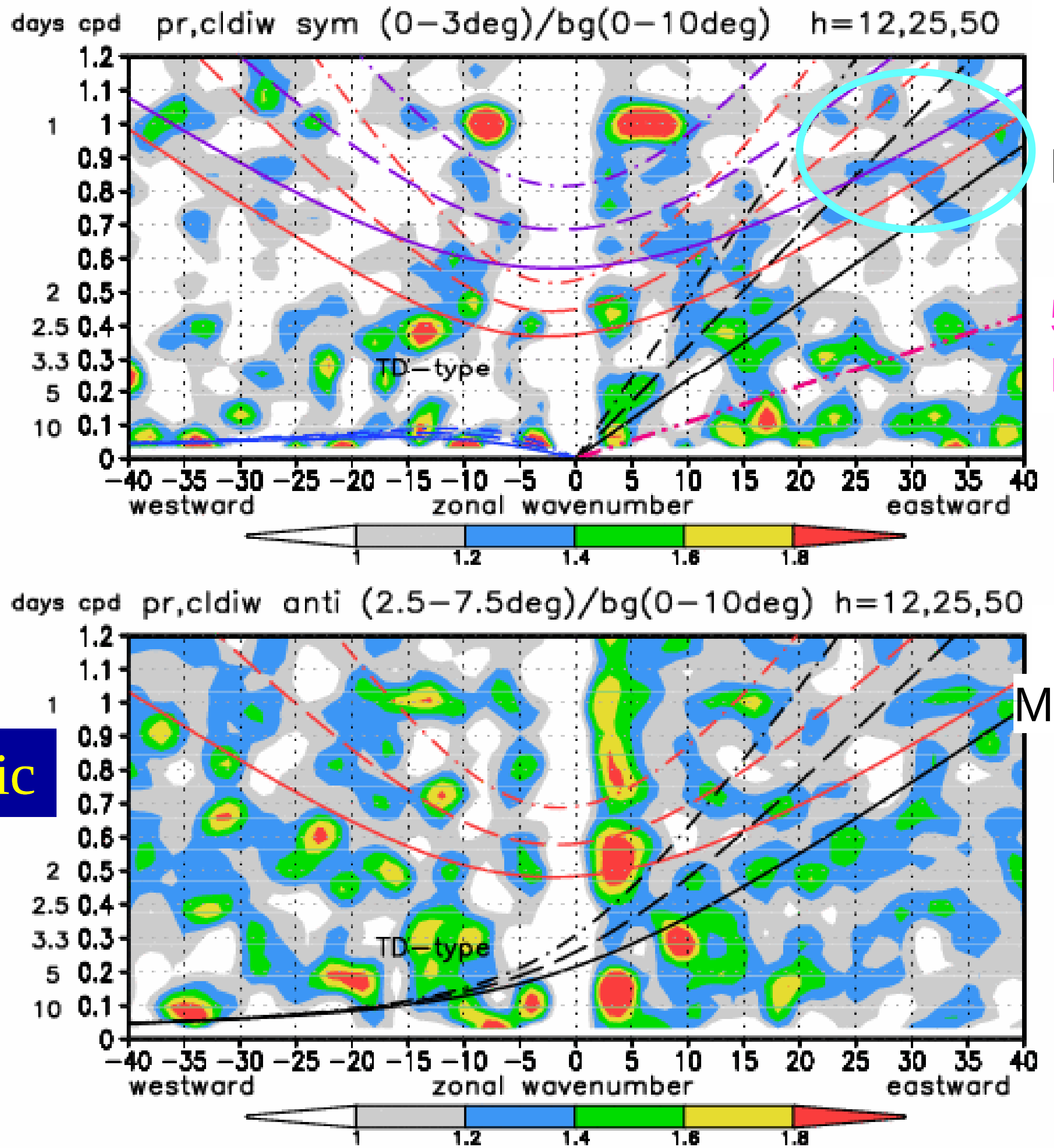
Single 30-day series of Precipitation , cloud water + cloud ice

Divided by Background Spectra:

anti-symmetric

40 (10) times 1-2-1filter

No tapering
Not detrended



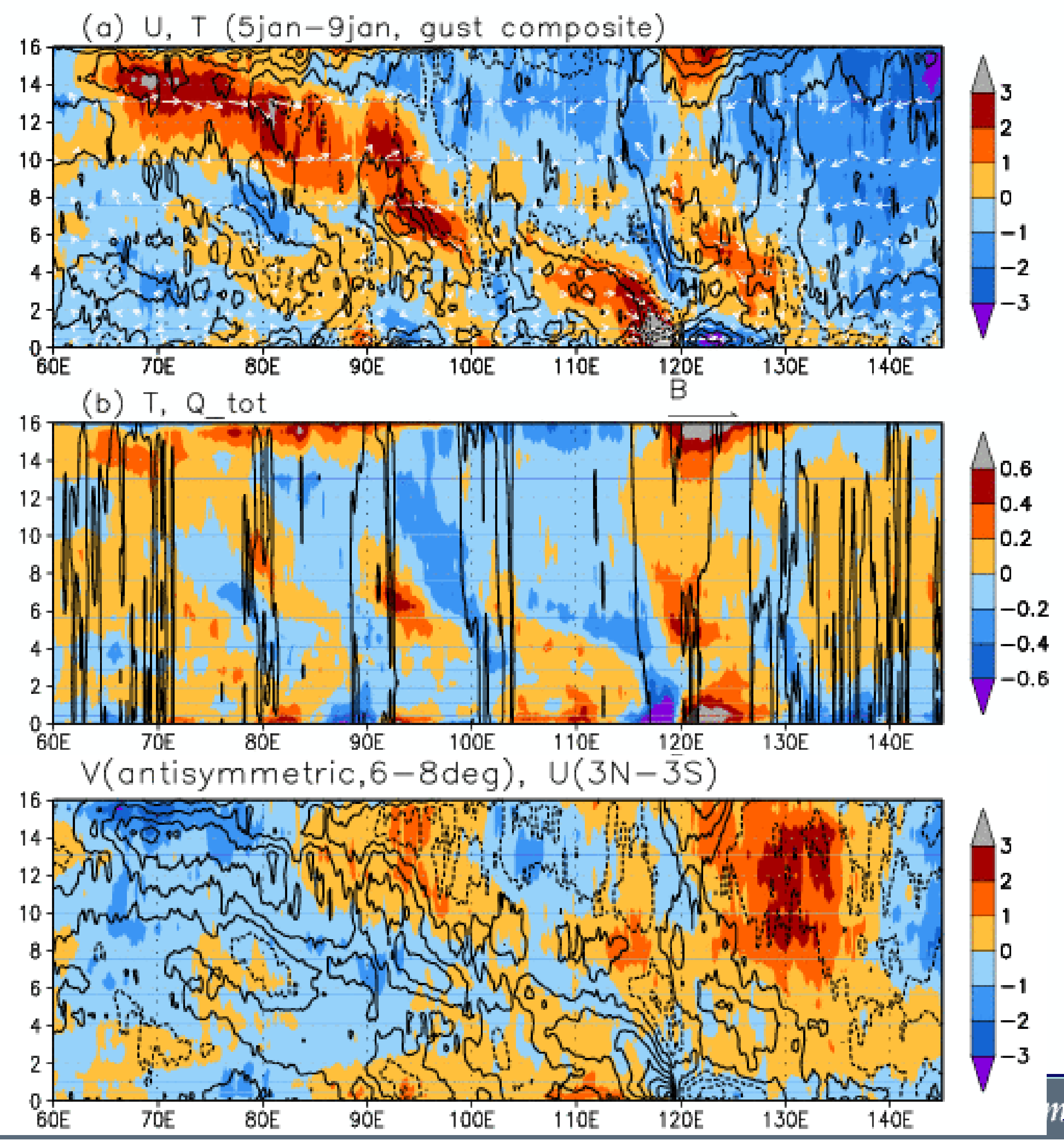
IGW (n=3)
IGW (n=1)
Kelvin
5 m/s
MJO
IGW (n=2)
MRG, EIGW(n=0)

Vertical structure; composite along gust front

Zonal velocity
contour: temperature

Temperature
contour: condensate

Meridional Velocity
contour: zonal velocity



3N-3S average

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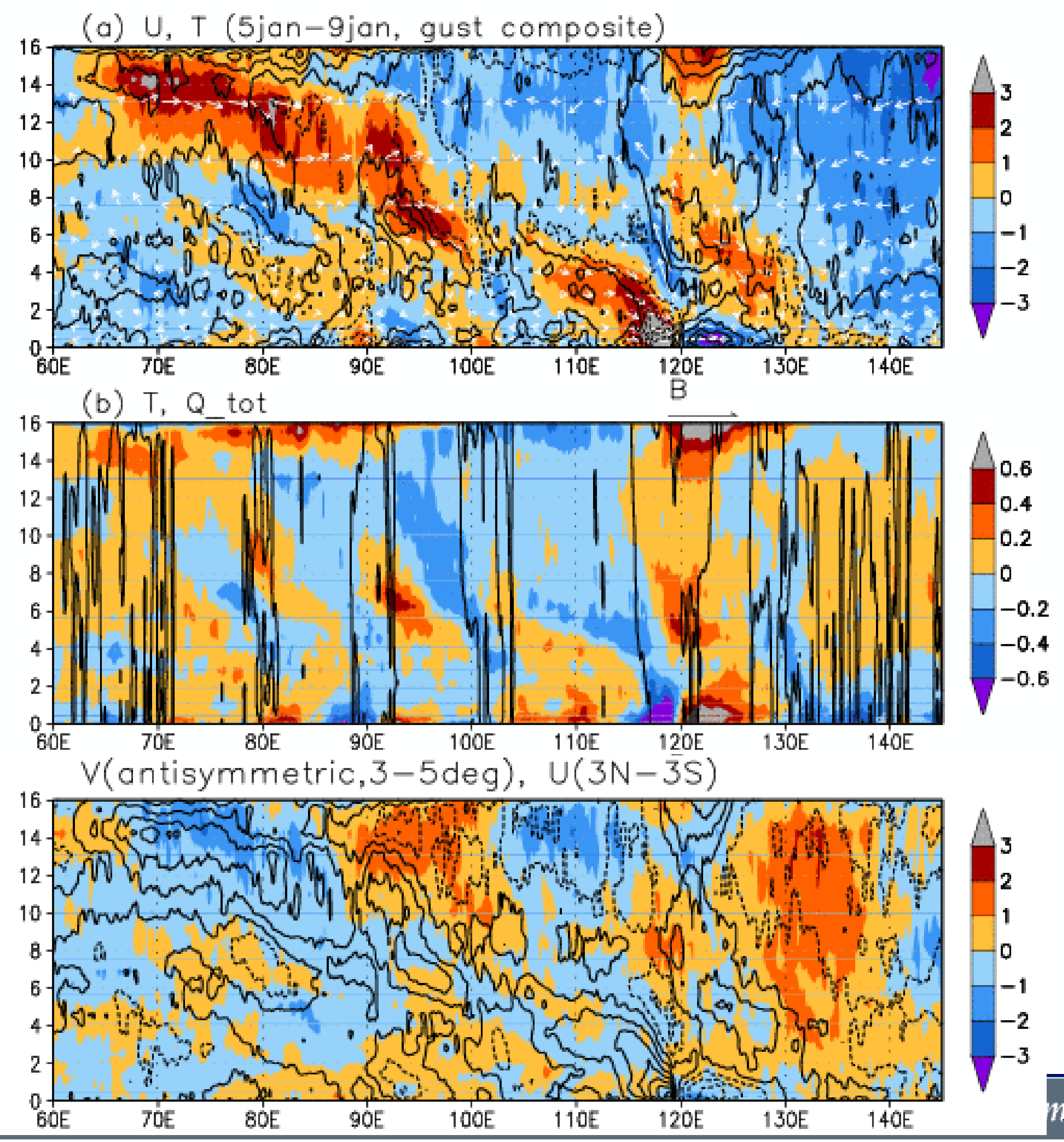
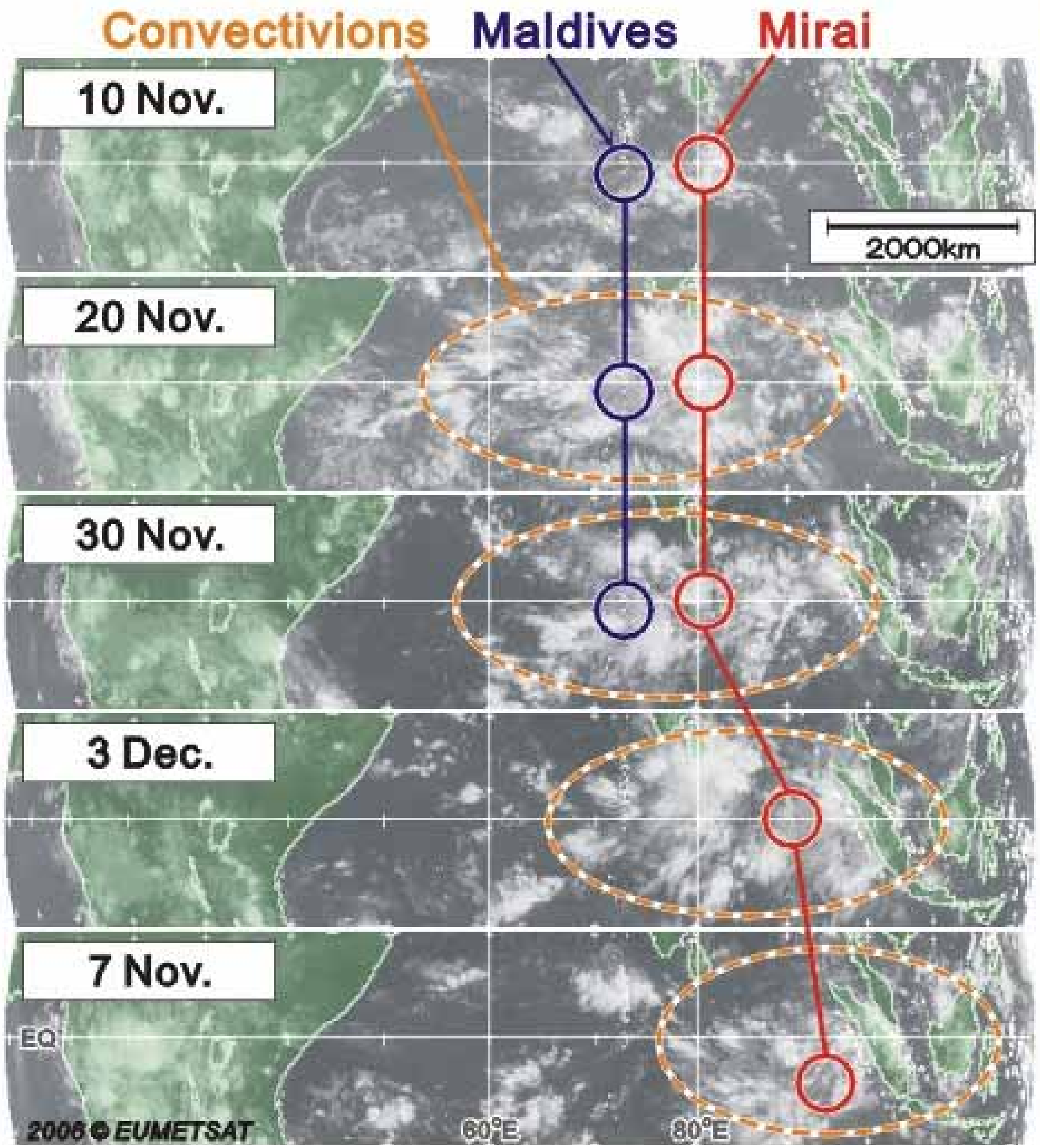
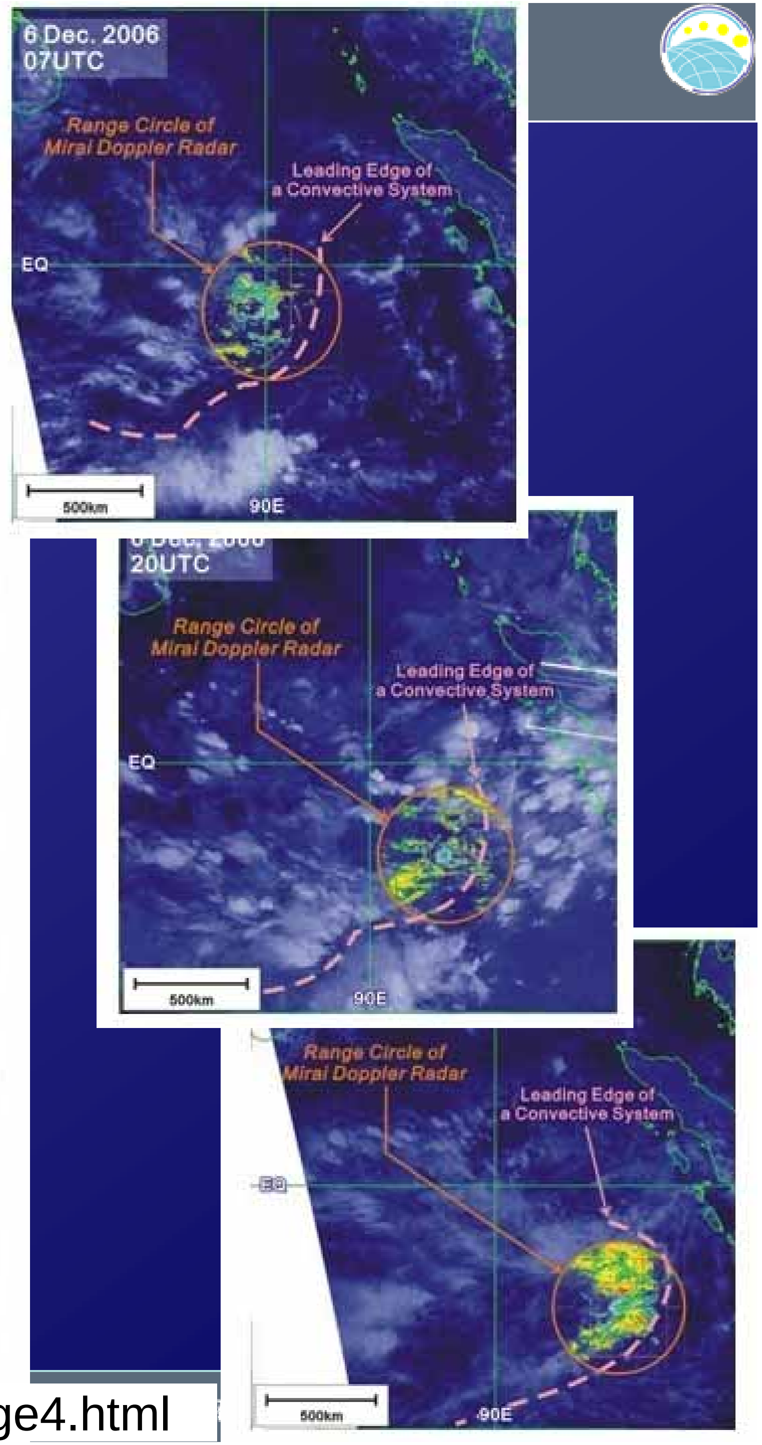


3N-3S average

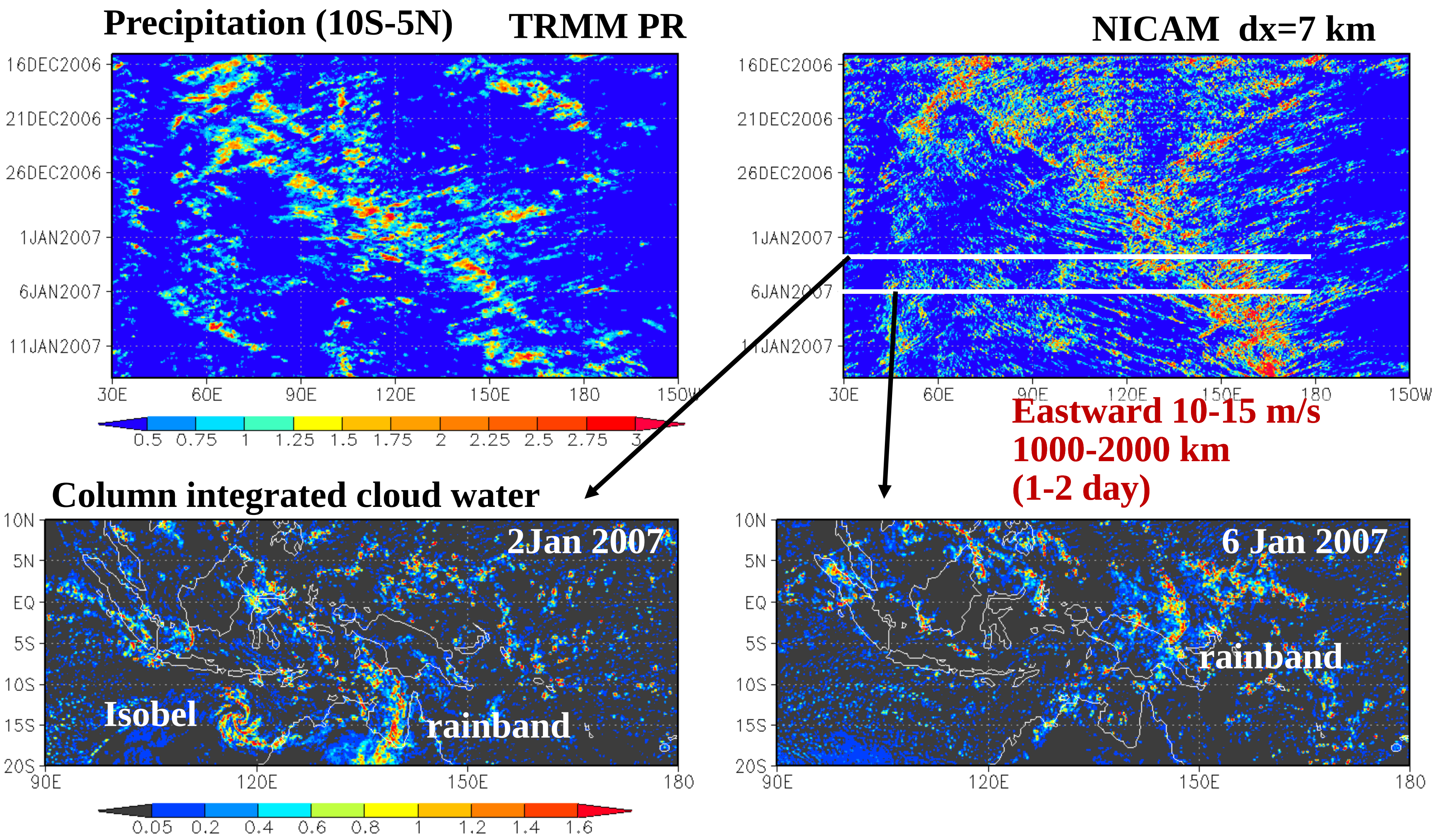
(a) (b) Deviations from time average

MISMO





http://www.jamstec.go.jp/jamstec-e/PR/0701/0122/image4.html



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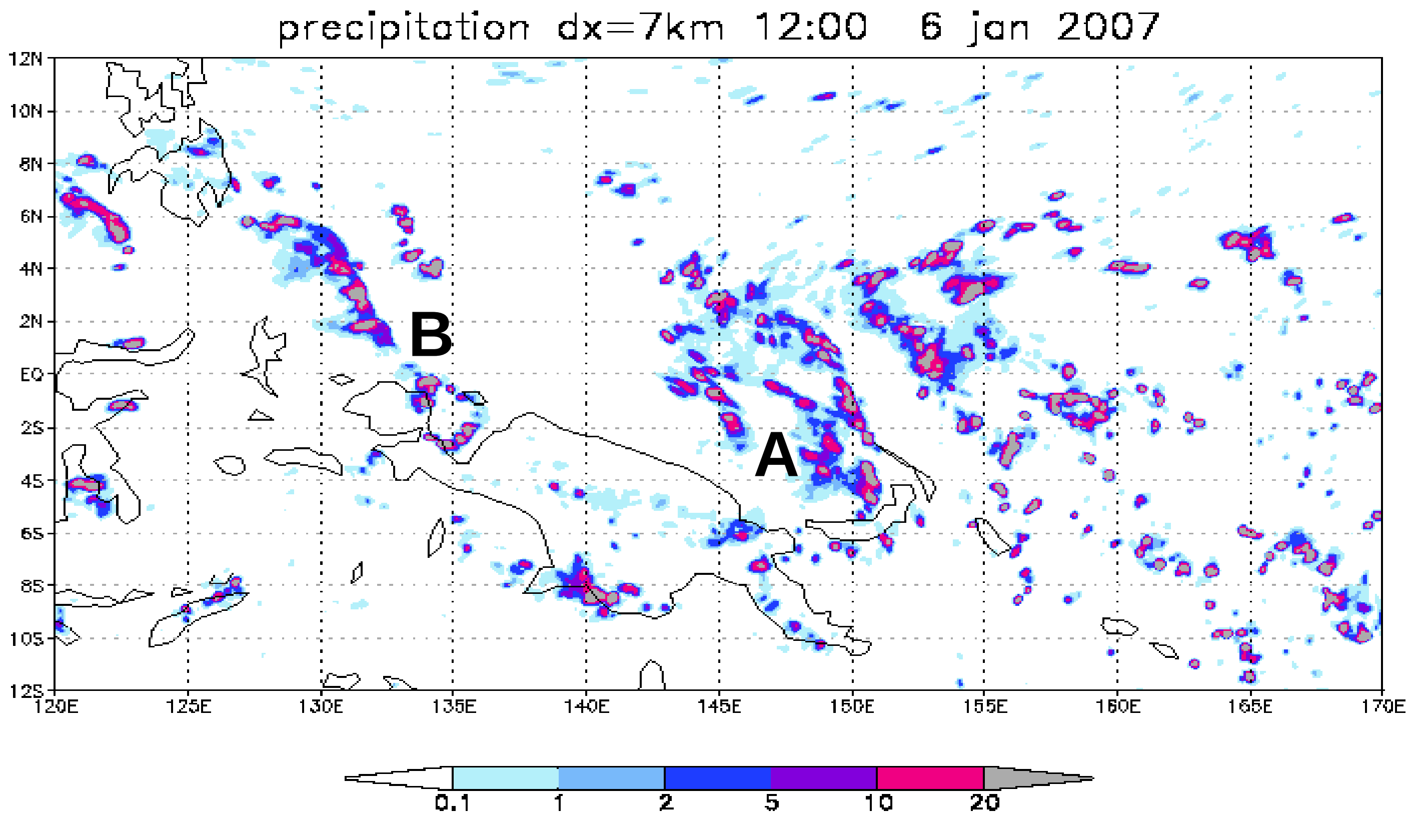
NICAM (dx=7km)

Similar feature in observations ??
(Dr. H. Yamada)



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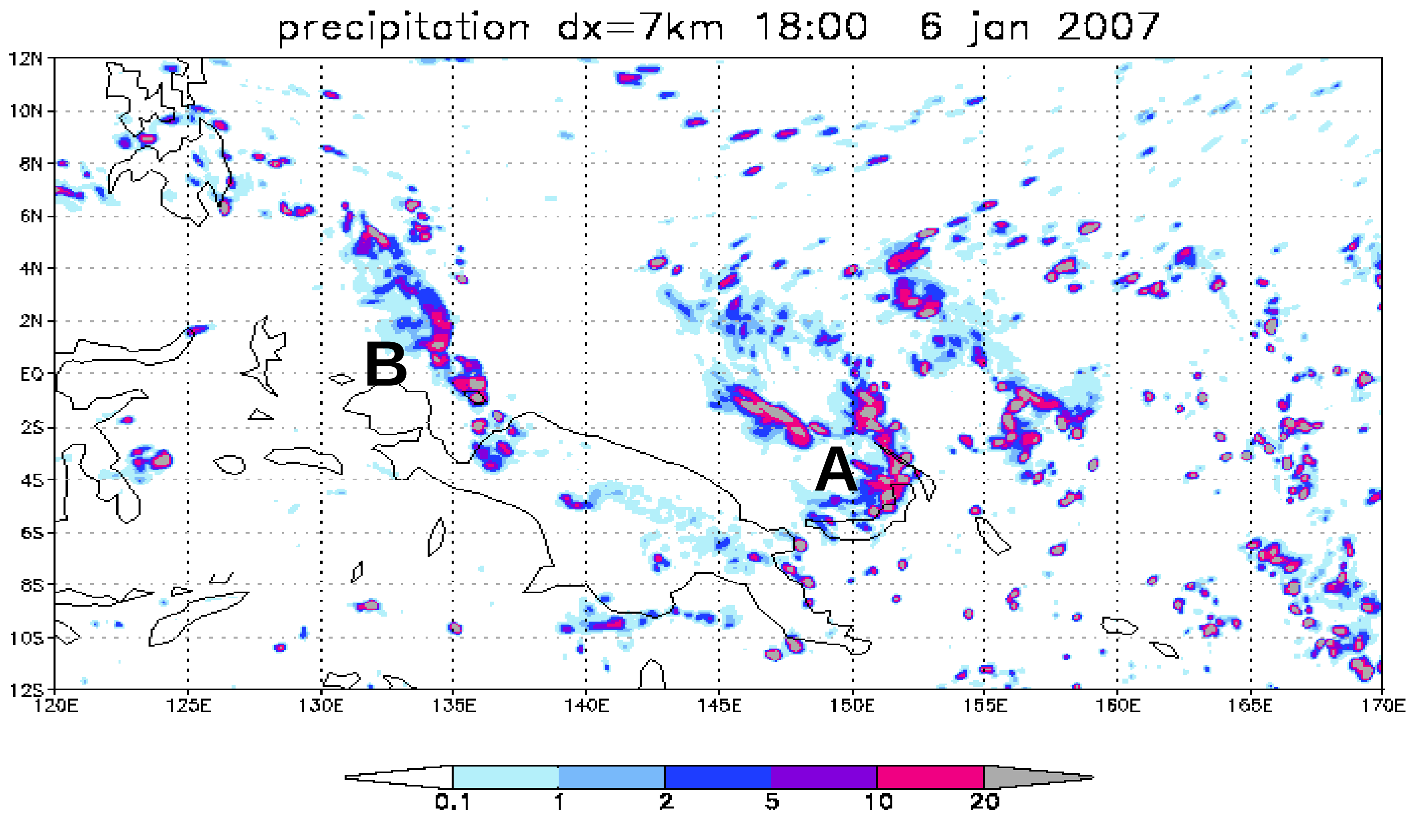

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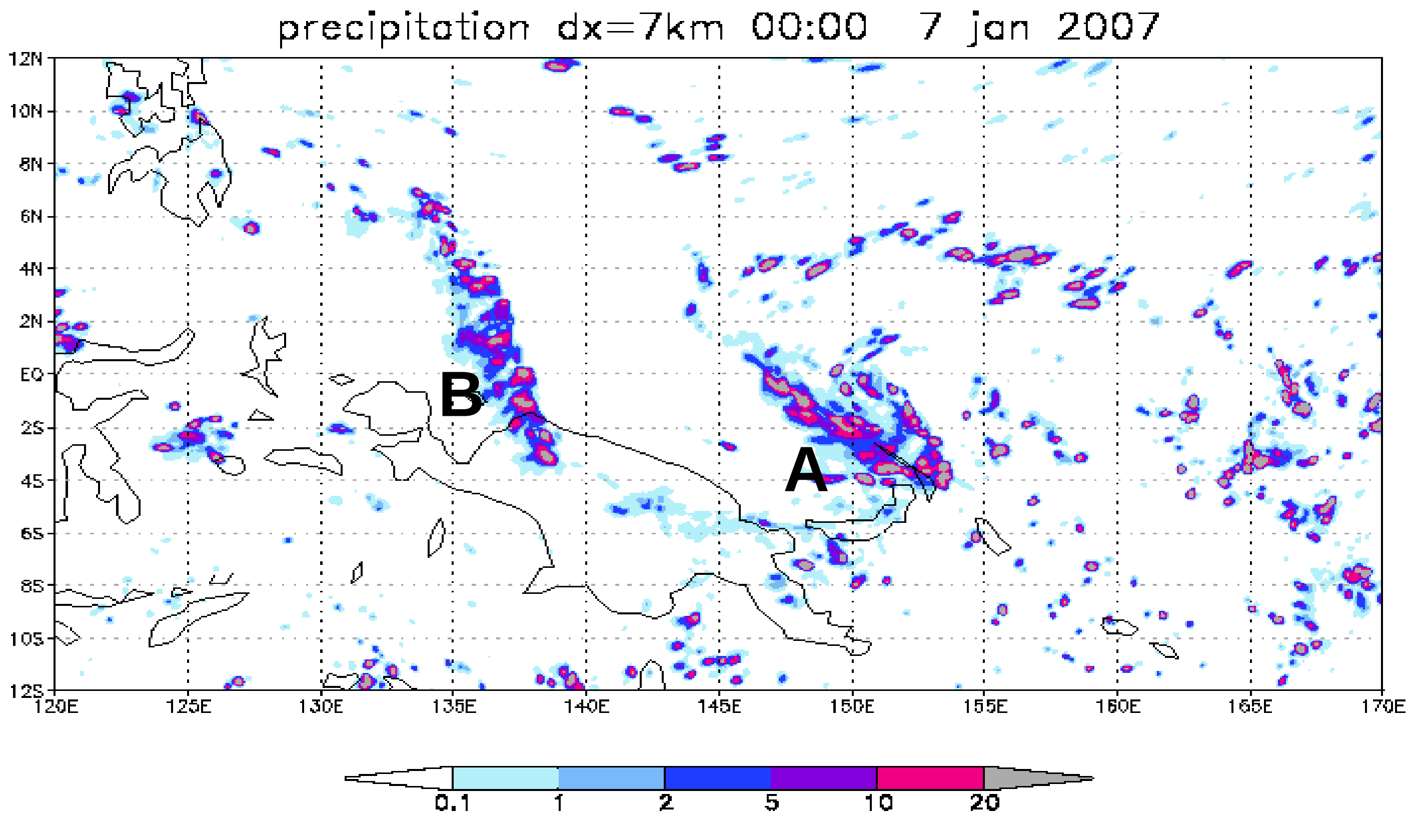

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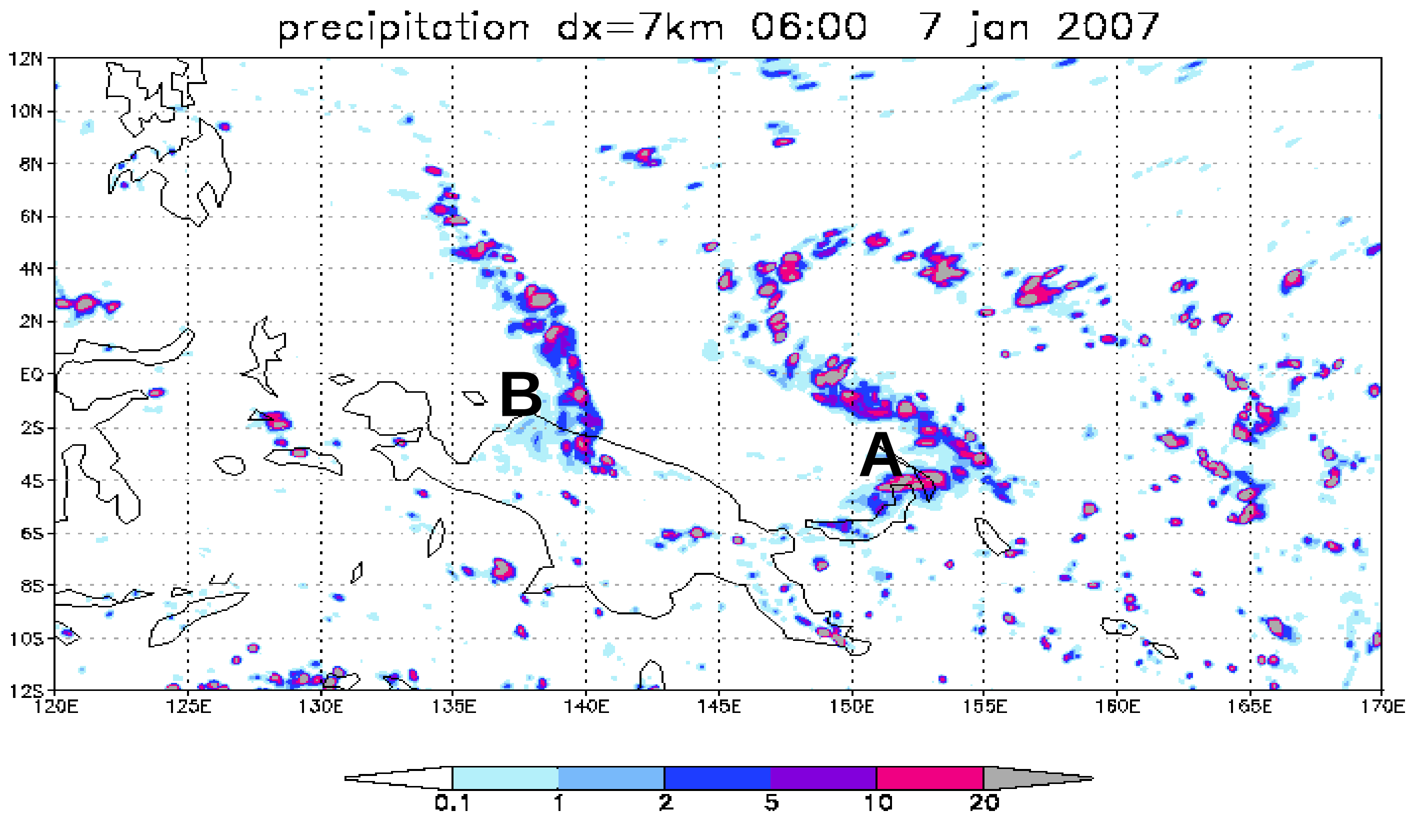

NICAM (dx=7km)

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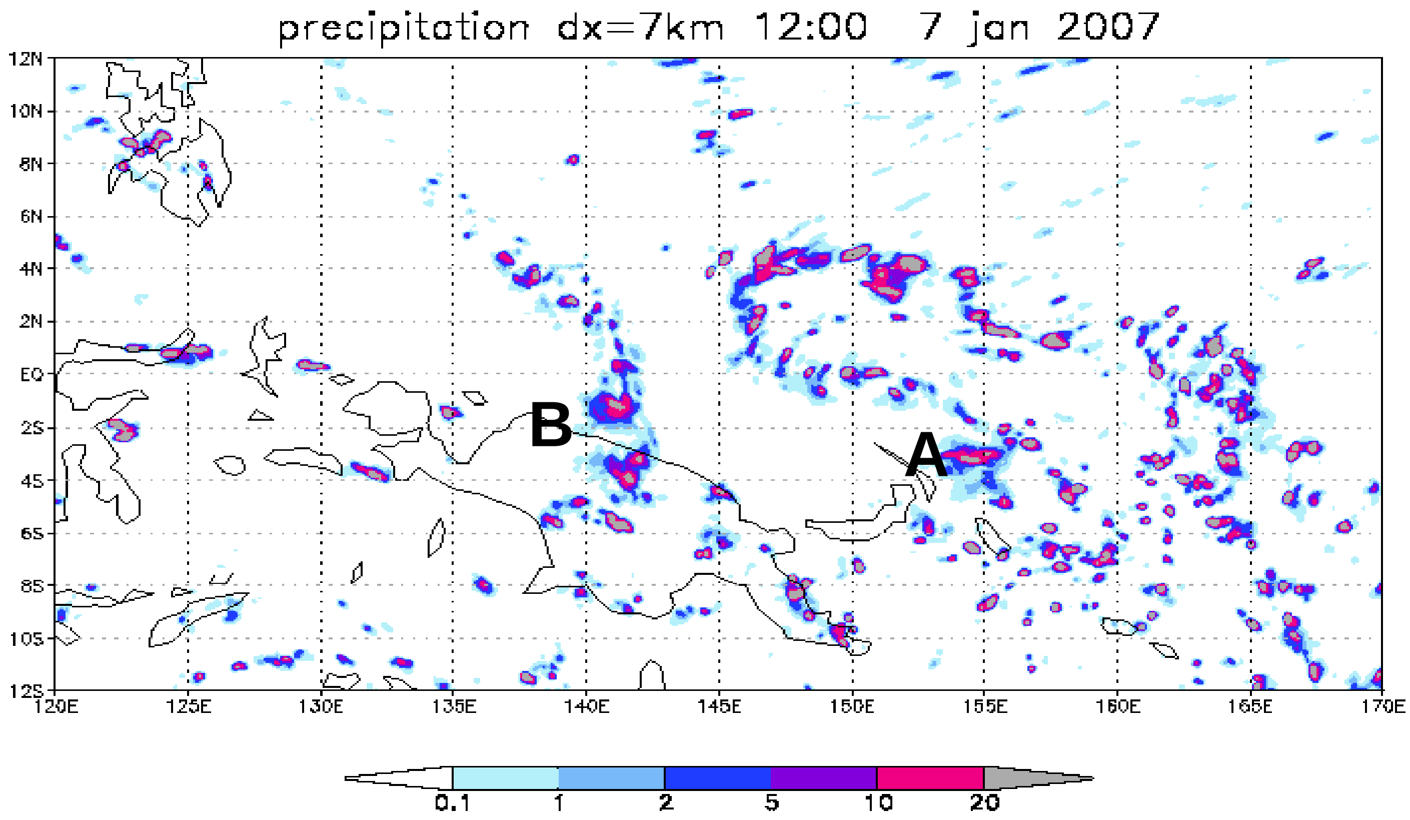
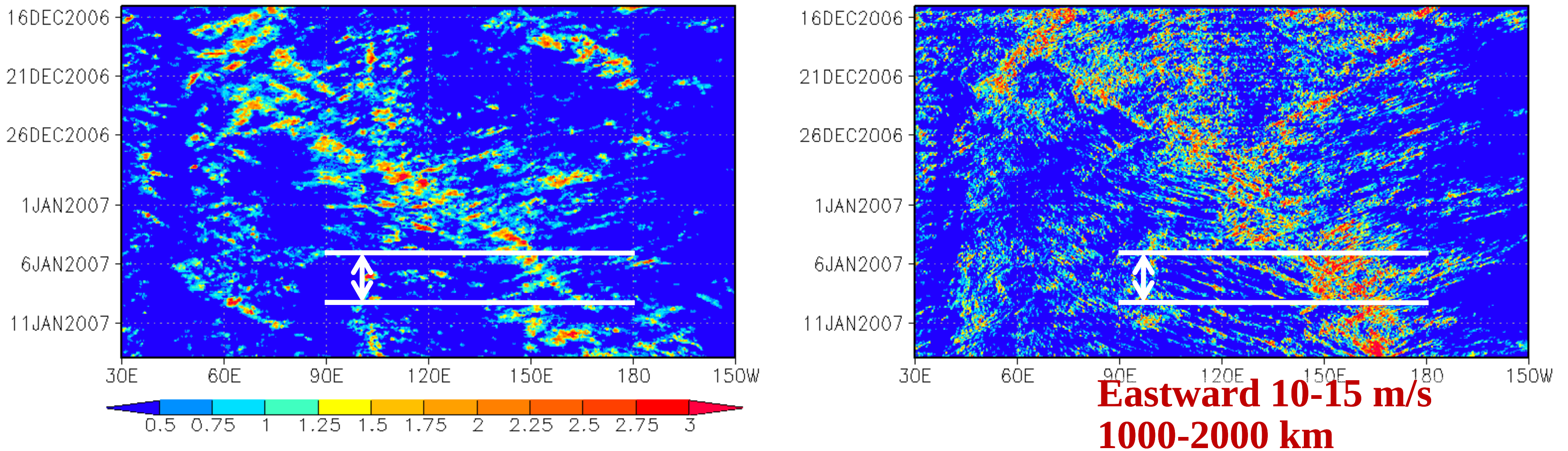
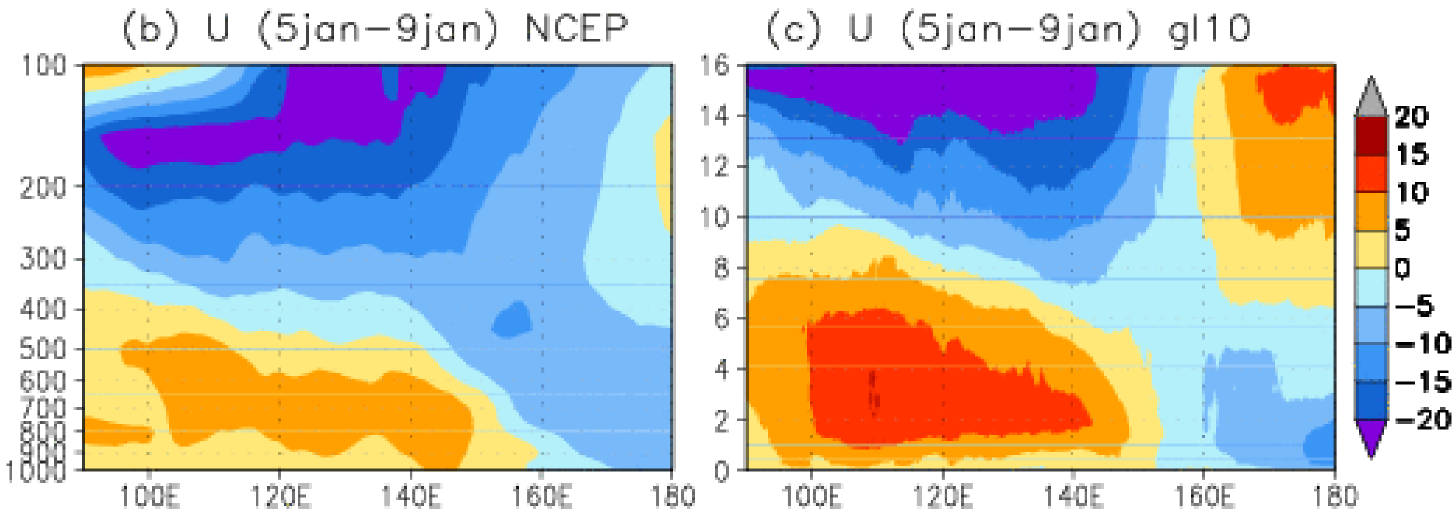


Precipitation (10S-5N) TRMM PR NICAM dx=7 km



Eastward 10-15 m/s
1000-2000 km
(1-2 day)



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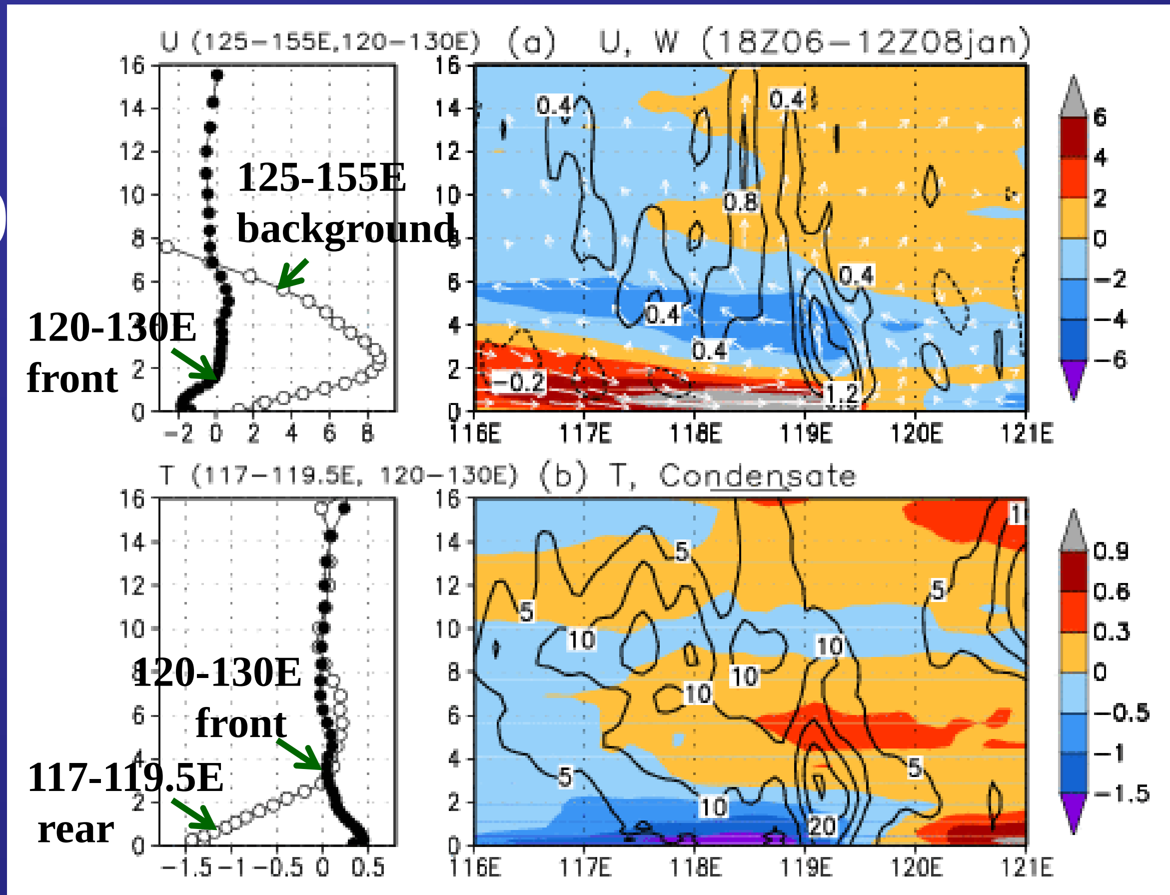
Vertical structure; composite along gust front

3N-3S average

Rainband B

area-average

NICAM (dx=7km)



Zonal velocity
contour:
Vertical velocity

Temperature
contour:
Condensate

Squall-type cluster

Summary

Global cloud-reolving simulation of a boreal winter MJO event (December 2006-January 2007)

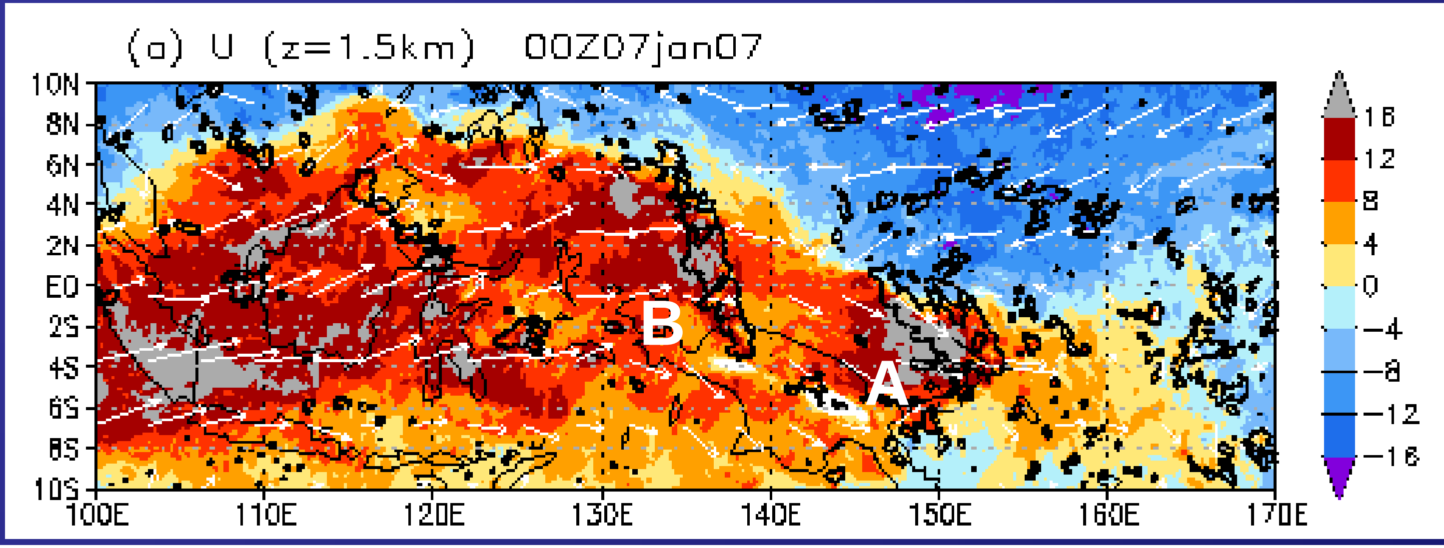
- **eastward propagating convective signal 10-15 m s^{-1}, 1000-2000 km scale, ～2 day period (< superclusters) , consisted of cloud clusters**
- **similar to those observed by Dunkerton and Crum (1995), Ichikawa and Yasunari (2007) ･･･ exist regardless of the MJO.**
- **accompanied with squall-type clusters when the vertical easterly shear associated with the MJO was enhanced (major system ?).**
- **at least two types of wave disturbances were relevant to the organization of the squall-type clusters**

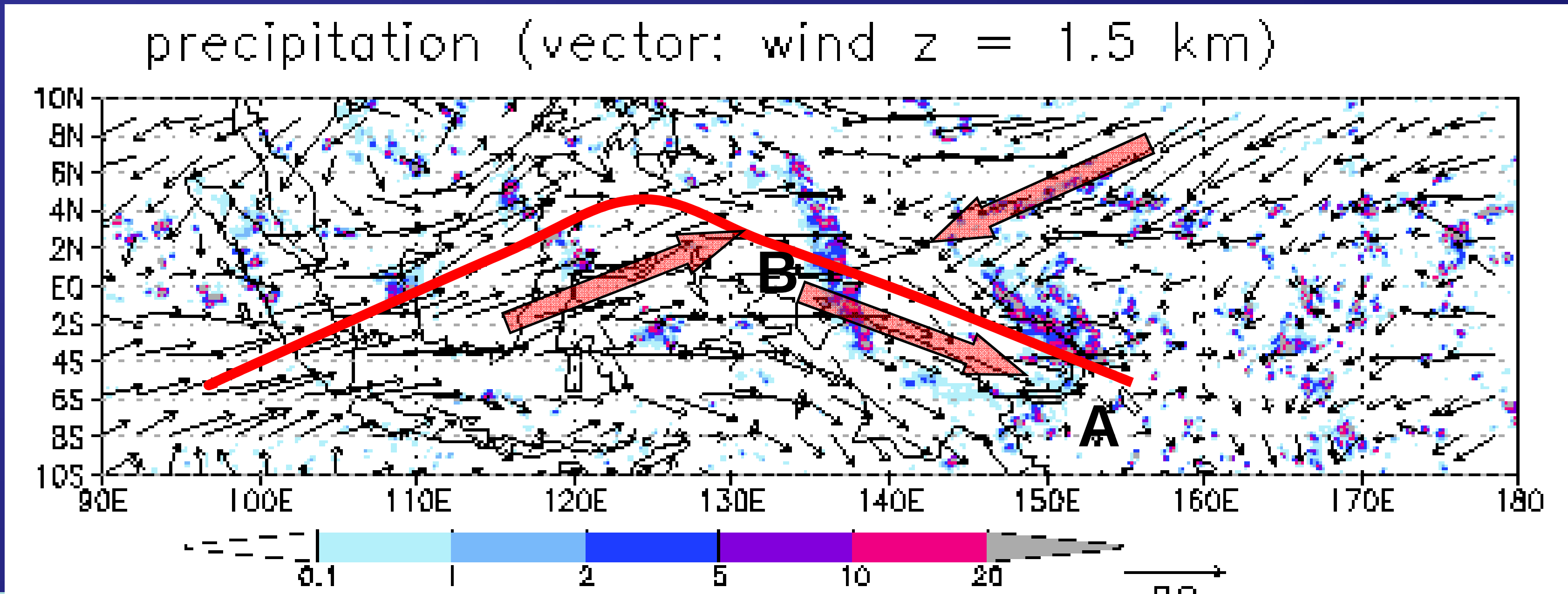
  1. equatorially trapped gravity waves (10-15 m s^{-1}, 1000-2000 km scale）

  2. modified mixed Rossby-gravity waves

→ Nonlinear interactions of wave disturbances & moist convection

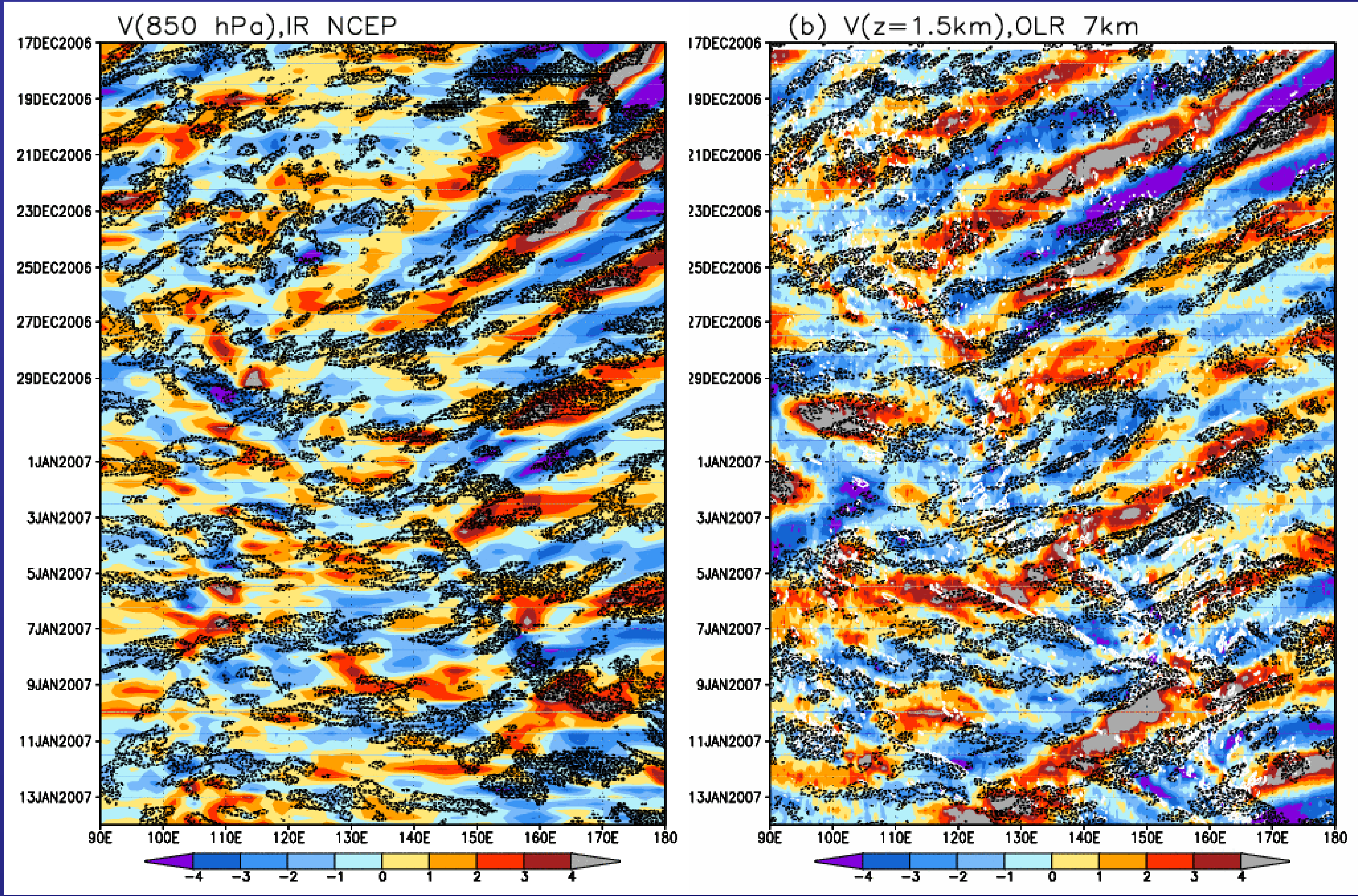
→ Upscale effects of convection on the MJO-scale dynamics


(a) U (z=1.5km) 00Z07jan07
10N
8N
6N
4N
2N
EQ
2S
4S
6S
8S
10S
100E
110E
120E
130E
140E
150E
160E
170E
B
A
16
12
8
4
0
−4
−8
−12
−16


precipitation (vector: wind z = 1.5 km)
10N
8N
6N
4N
2N
EQ
2S
4S
6S
8S
10S
90E
100E
110E
120E
130E
140E
150E
160E
170E
180
B
A
0.1
1
2
5
10
20

meridional wind (4-day running mean subtracted)

NCEP **NICAM dx=7 km** **3N-3S average**



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