Contributions of Global cloud-resolving model simulations to YOTC

M. Satoh
Center for Climate System Research, Univ. of Tokyo
Research Institute for Global Change(formery FRCGC), JAMSTEC

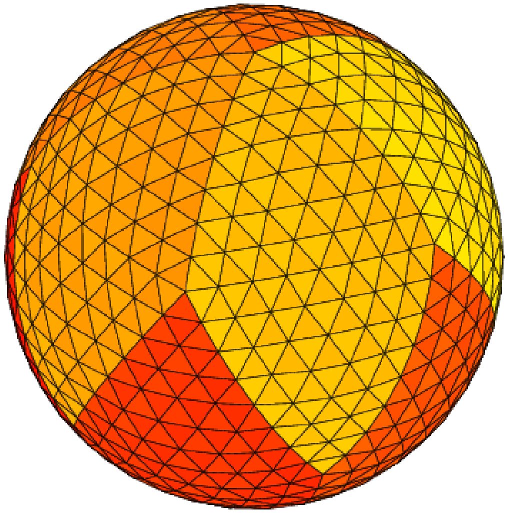
Courtesy of
H. Yamada (JAMSTEC) and W. Yanase (UT)
T. Nakazawa (MRI), H. Fudeyasu and P. Liu (IPRC)
K. Oouchi and H. Taniguchi, H. Tomita and T. Nasuno (JAMSTEC)
T. Inoue & T. Seiki (CCSR), H. Miura (CSU)

YOTC Implementation Workshop 13-15th July 2009
East –West Centre, University of Hawaii

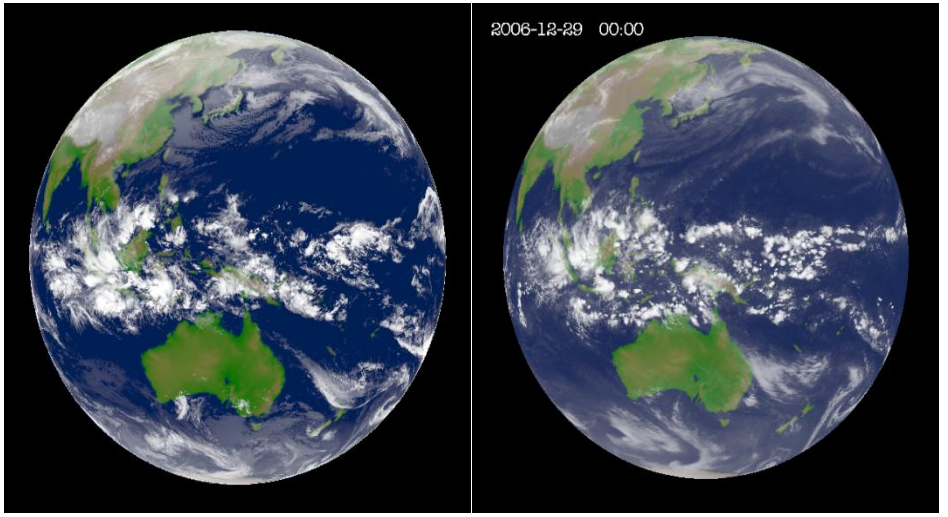
Contents

- NICAM overview and some recent results
- TC Fengshen simulations: June 2008
- 3.5km mesh simulations and satellite comparisons
- Contributions of NICAM to YOTC
  - Experiments, plan and suggestions

NICAM outlines



MTSAT-1R, IR NICAM 3.5km, OLR



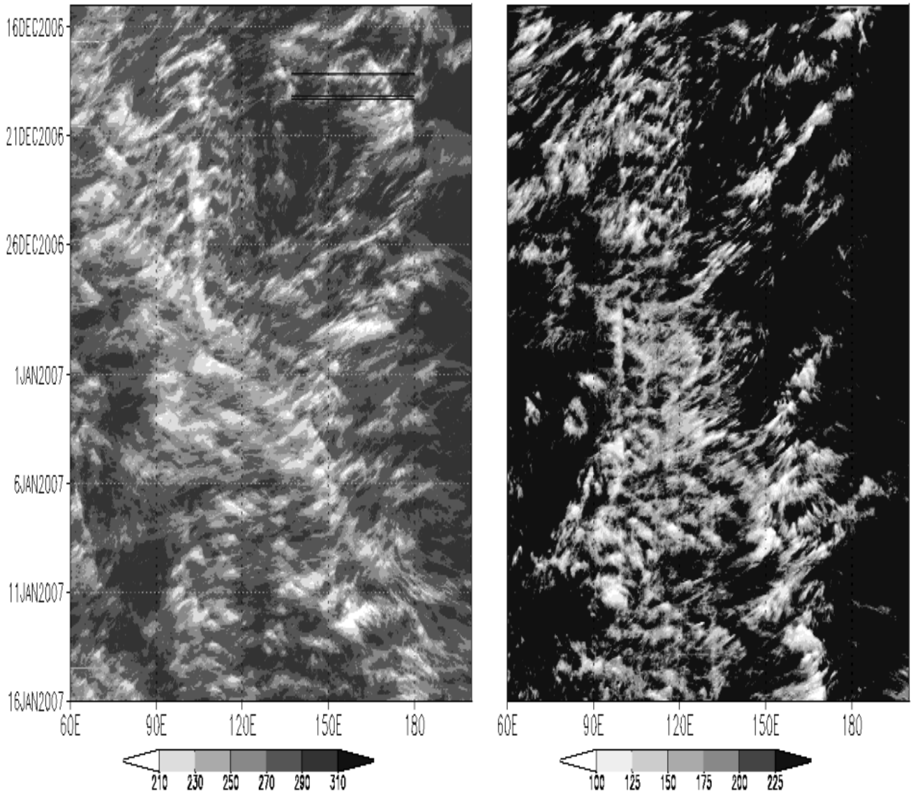
Miura et a.(2007,Science)

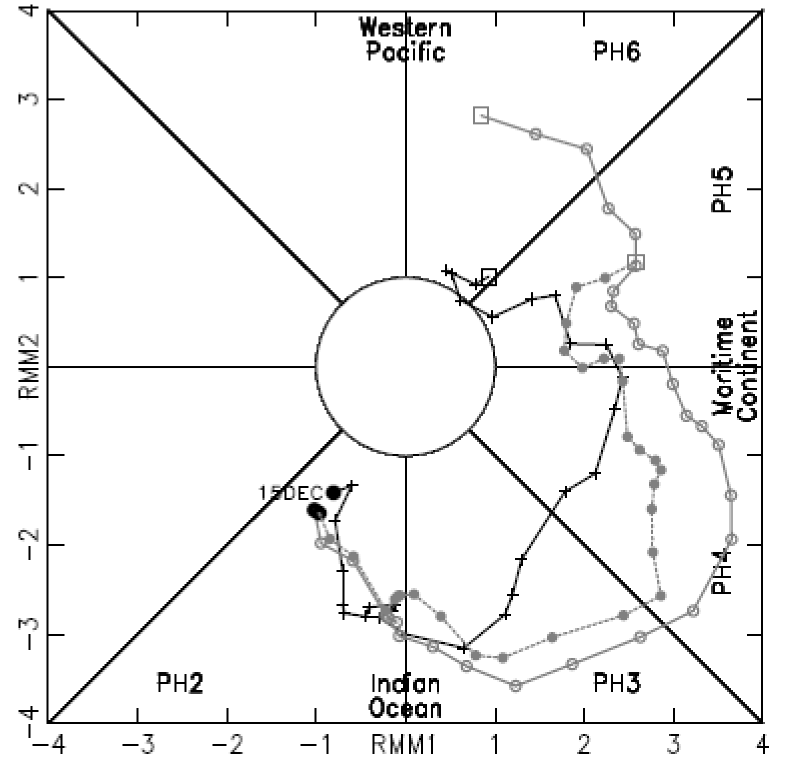
- Outline of NICAM
  - Nonhydrostatic ICosahedral Atmospheric Model
  - for Global Cloud-Resolving Simulations (Satoh et al., 2008, JCP)
  - Development since 2000 (Tomita and Satoh 2004, Fluid Dyn. Res.)
  - First global dx=3.5km run in 2004 (Tomita et al. 2005, GRL)
- MJO and Tropical Cyclones
- High resolution simulations comparable to satellite observations

Realistic MJO simulation

Miura et a.(2007,Science), Nasuno et al.(2009,JMSJ),

NCEP/CPC IR NICAM 7km, OLR

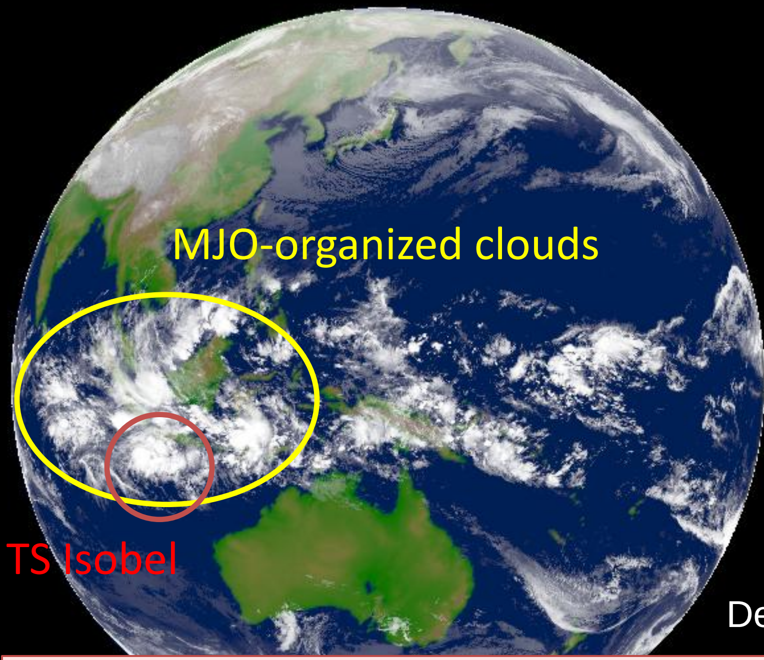




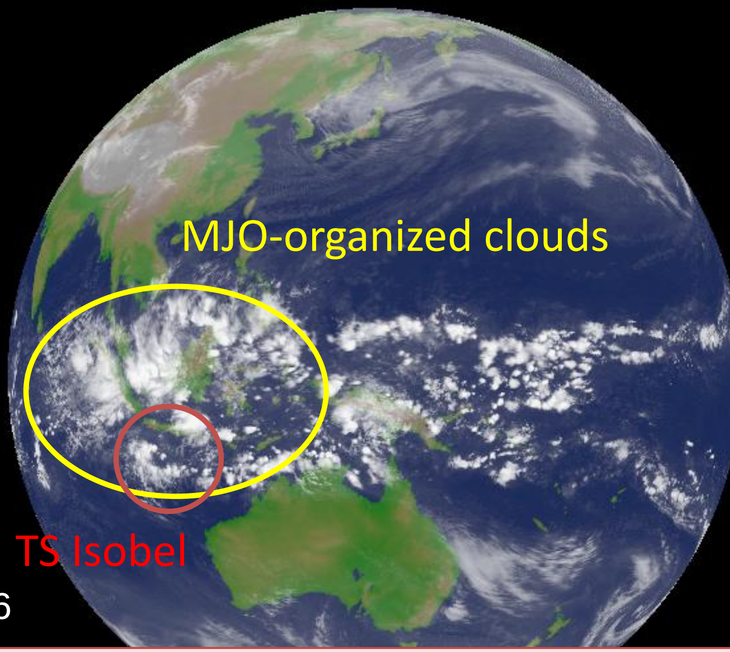
Liu et al. (2009, MWR)

MJO and Tropical cyclone

MTSAT-1R



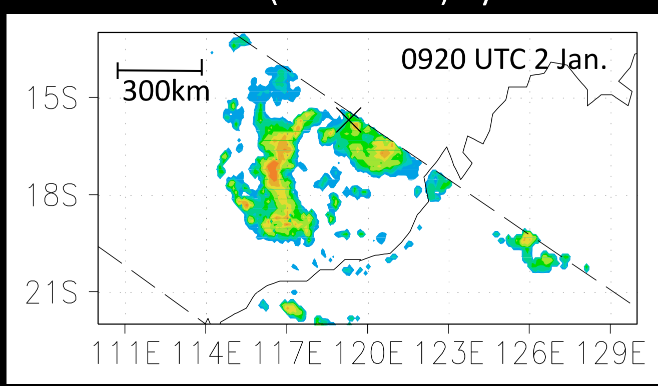
NICAM



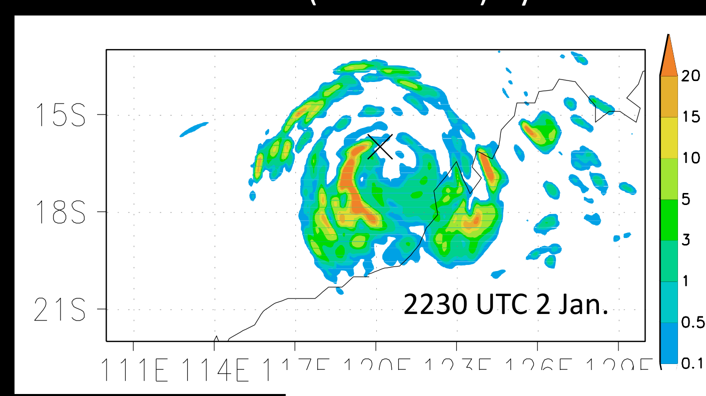
Dec. 29 2006

NICAM reasonably produced not only the large-scale circulation, such as the MJO, but also the embedded mesoscale features, such as TC rainbands.

Surface rain rate (mm hour^{-1}) by TRMM-TMI

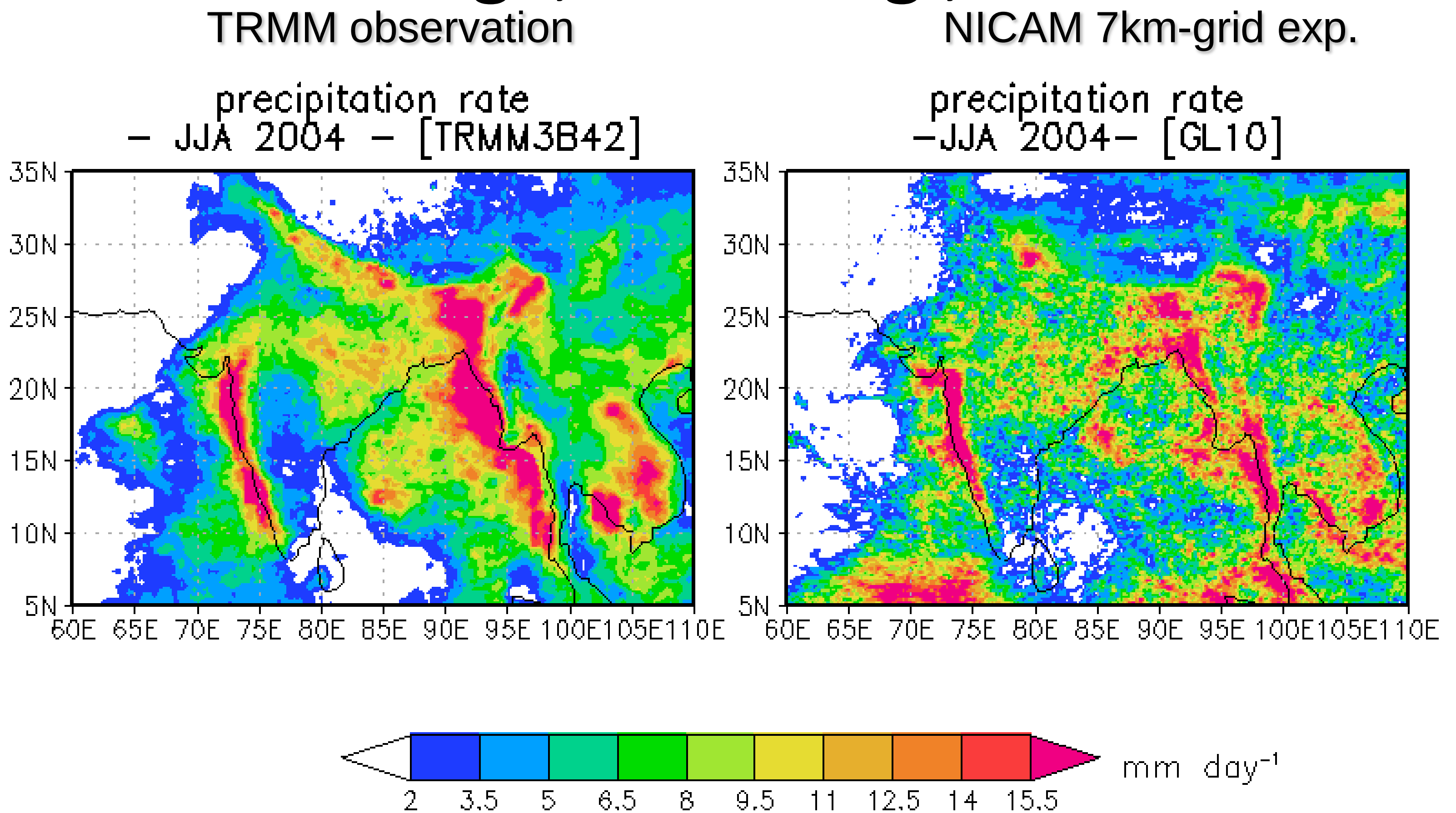


Surface rain rate (mm hour^{-1}) by NICAM



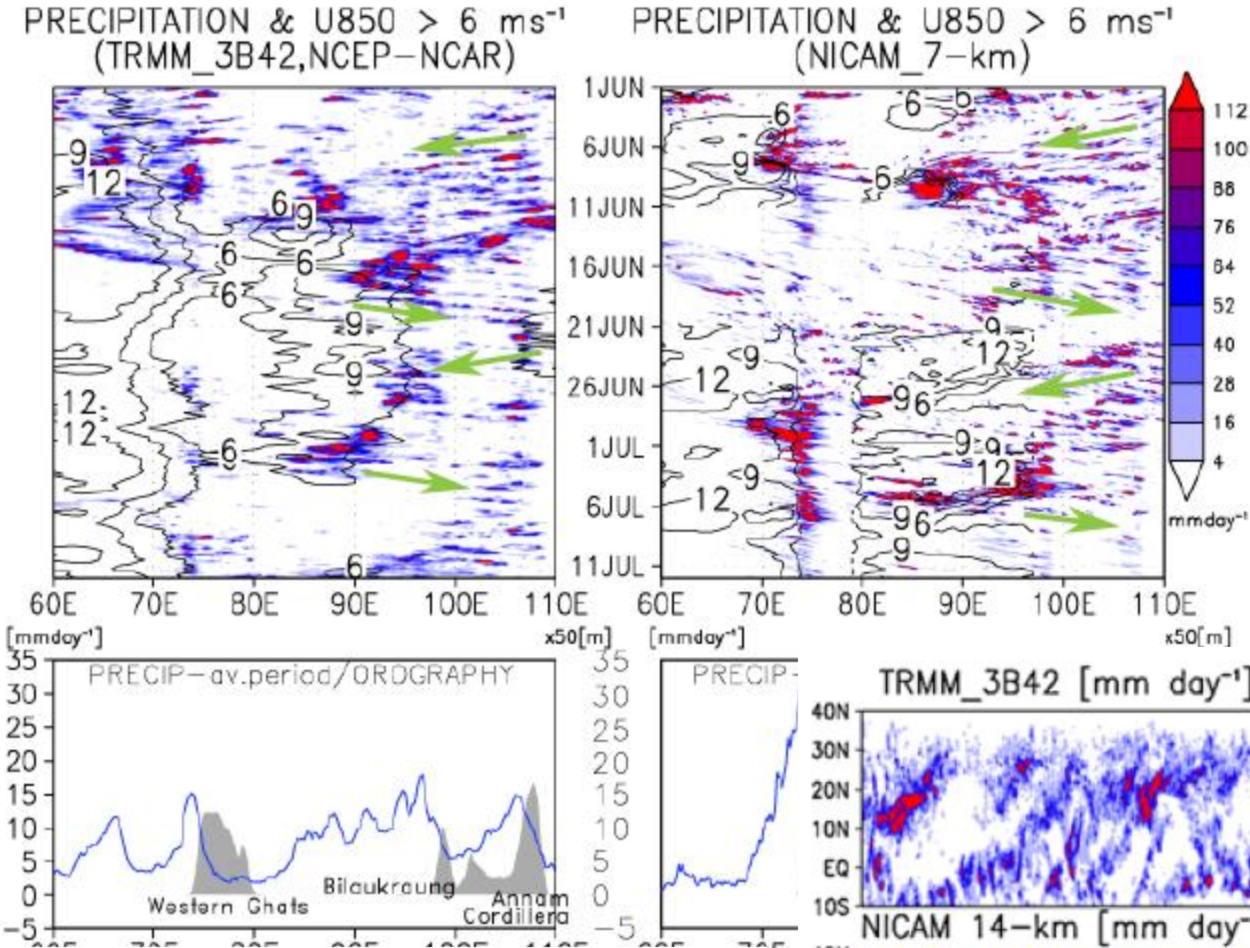
Fudeyasu et al. 2008 GRL

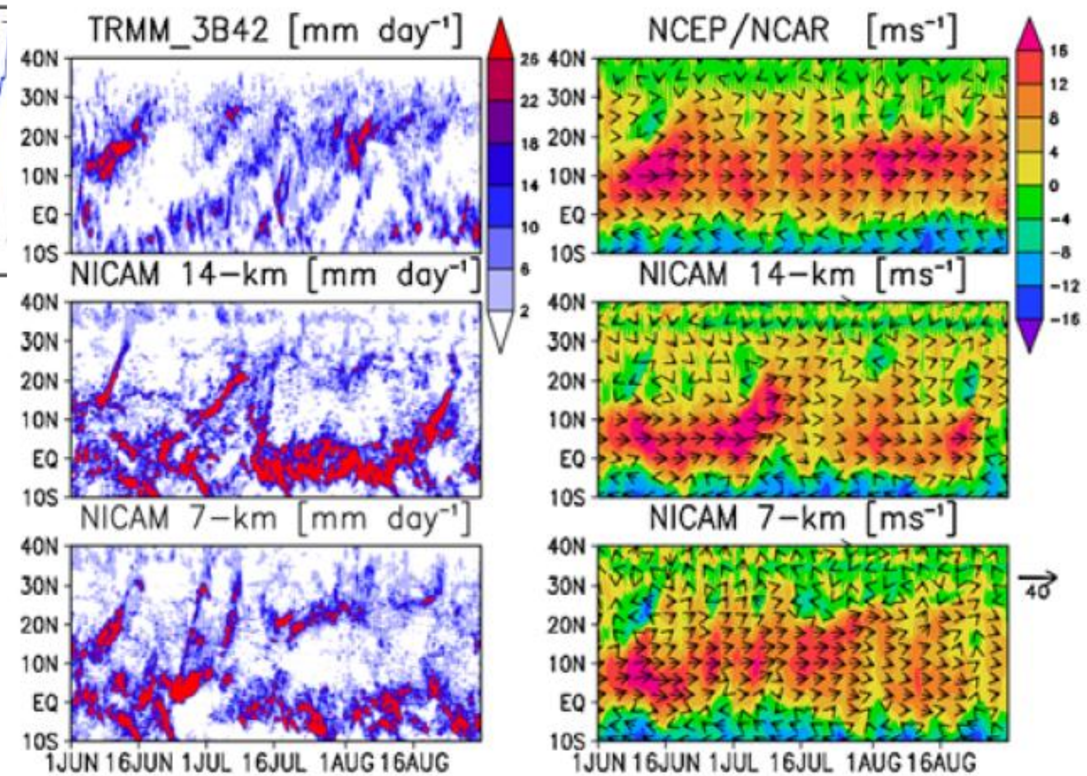
Precipitation distribution over south Asia average, June-Aug., 2004



Oouchi et al. (2009, *Geophys. Res. Lett.*)

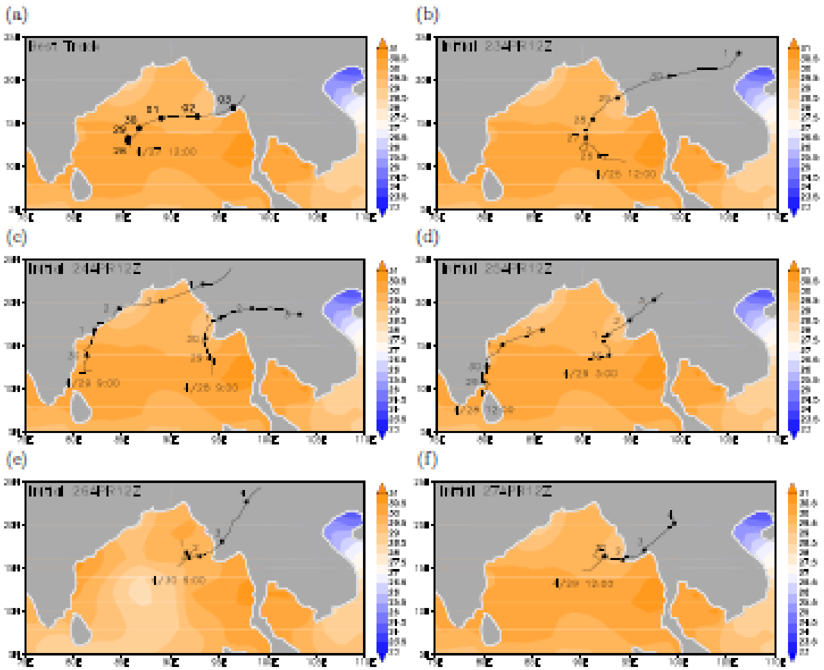
Oouchi et al. (2009, *Geophys. Res. Lett.*)

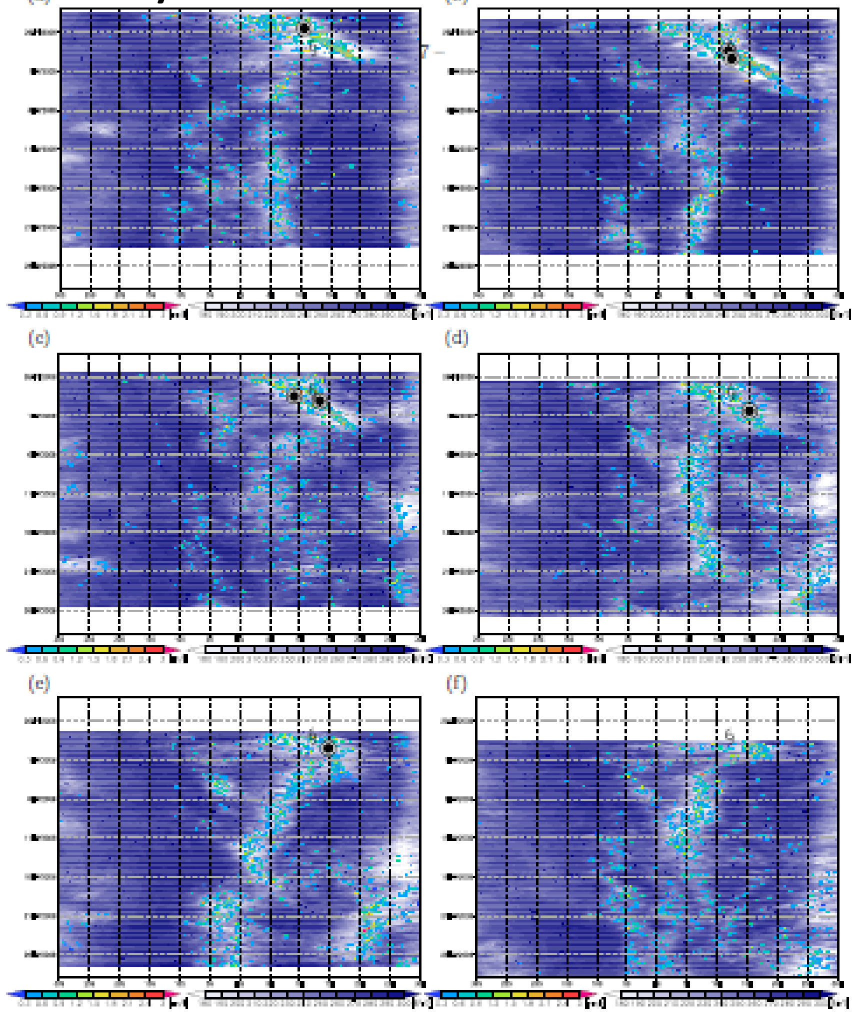




Diurnal cycle and ISV (northward propagation of convective system) in the Indian Ocean are realistically captured.
JJA 2004

Myanmar cyclone Nargis (2008) ensemble simulations
TC genesis captured with ISV and MJO
26 Apr. – 26 May 2008

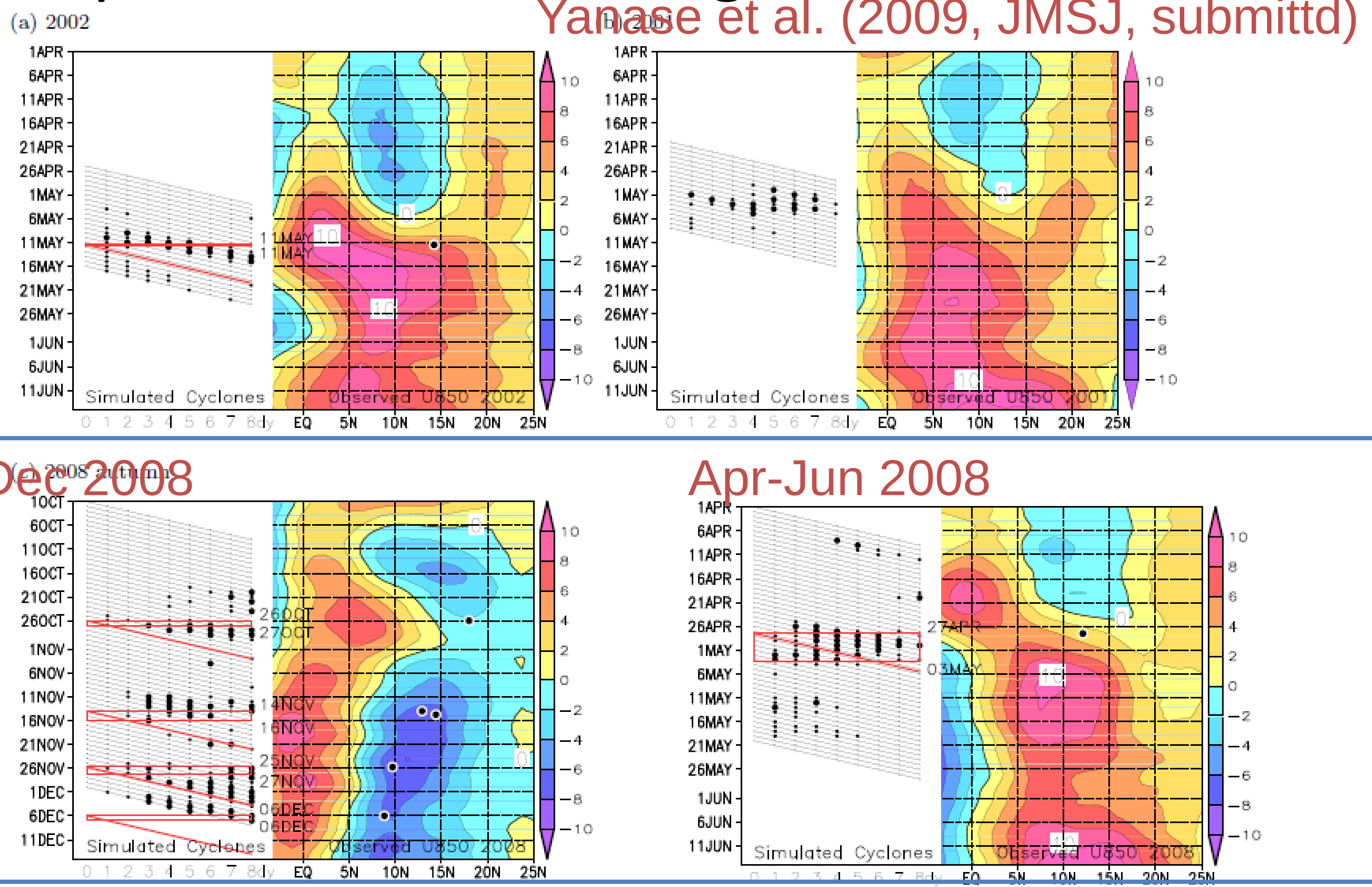




Taniguchi et al. (2009, JMSJ, submitted)

TC cyclogenesis in Indian Ocean is generally captured with ISV using stretch-NICAM

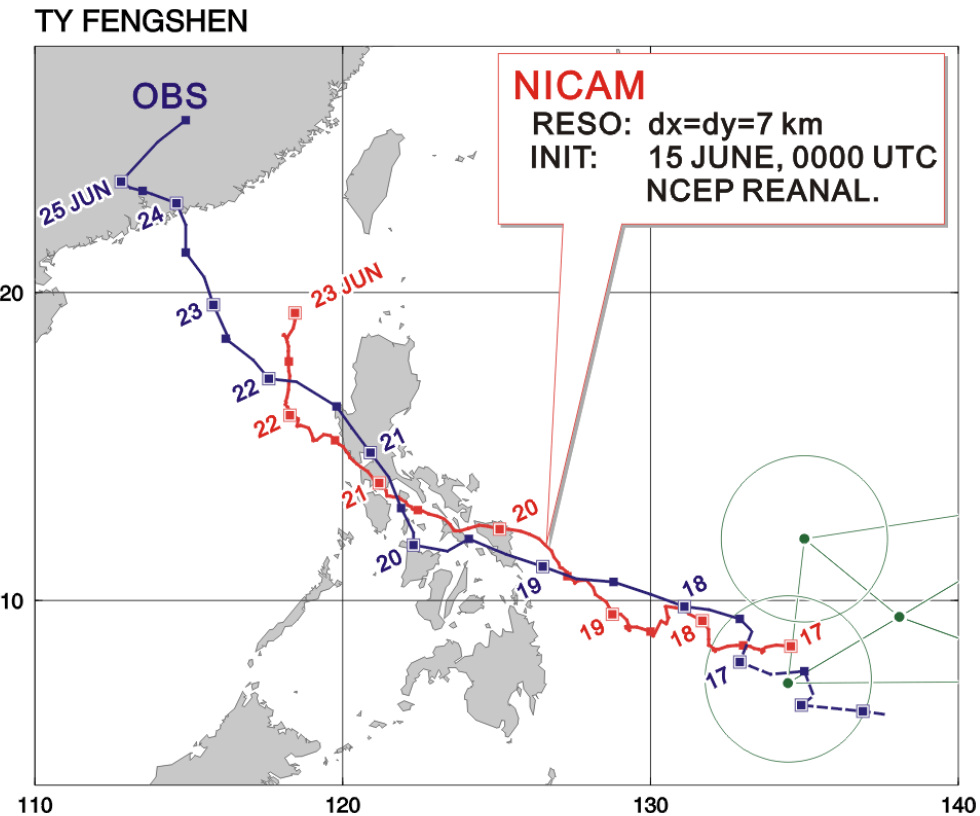
Yanase et al. (2009, JMSJ, submittd)

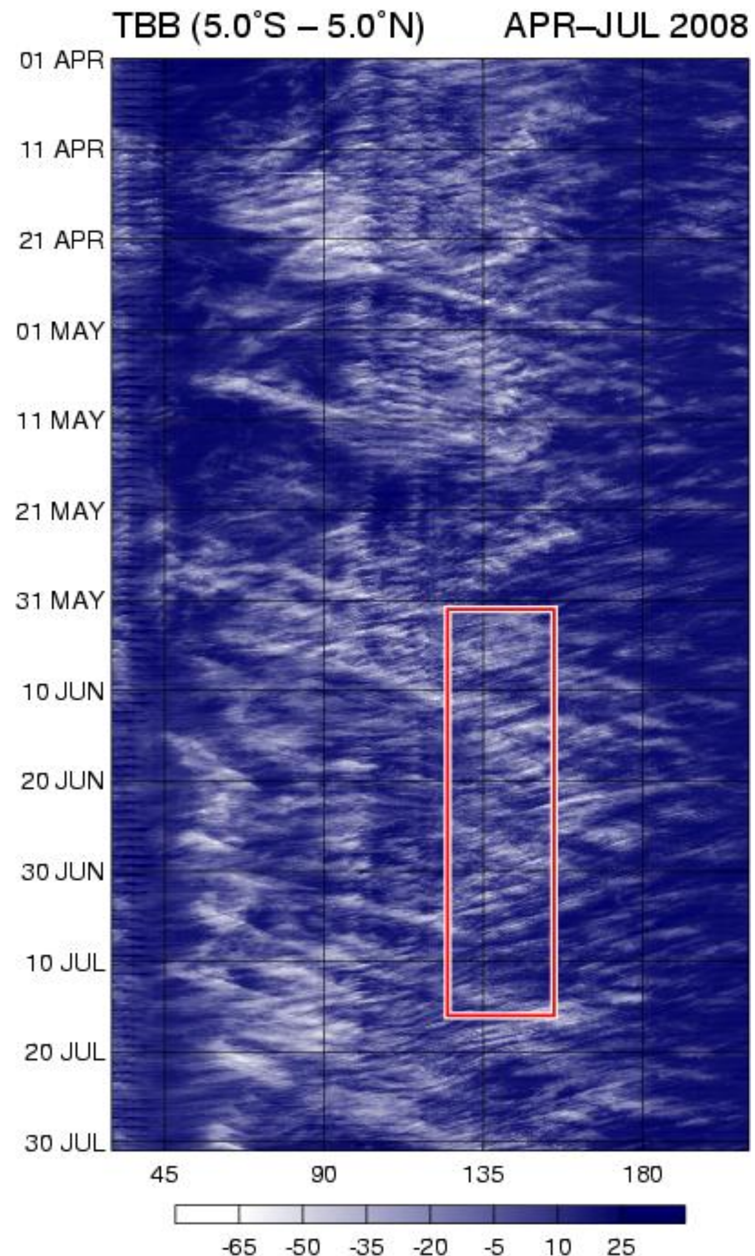


TC FENGSHEN: JUNE 2008

FIELD OBSERVATION AND NICAM PRELIMINARY SIMULATIONS

TC Fengshen: June 2008

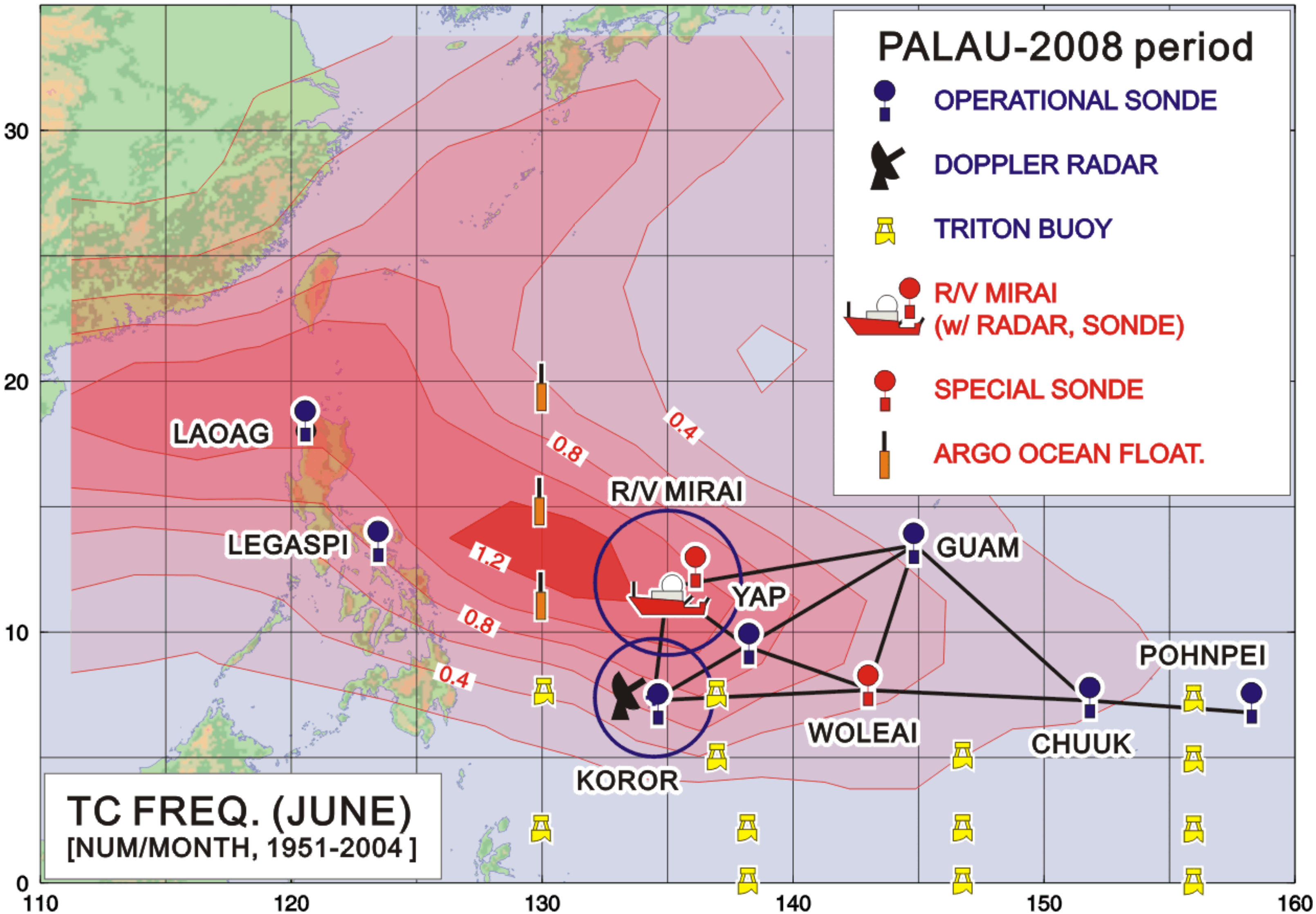




Simulation of Fengshen (2008):

- **Initialization 3 days before genesis**
- **Typhoon development and track similar to the observation**
- **Plan of more simulations with a higher resolution (dx=dy=3.5 km)**

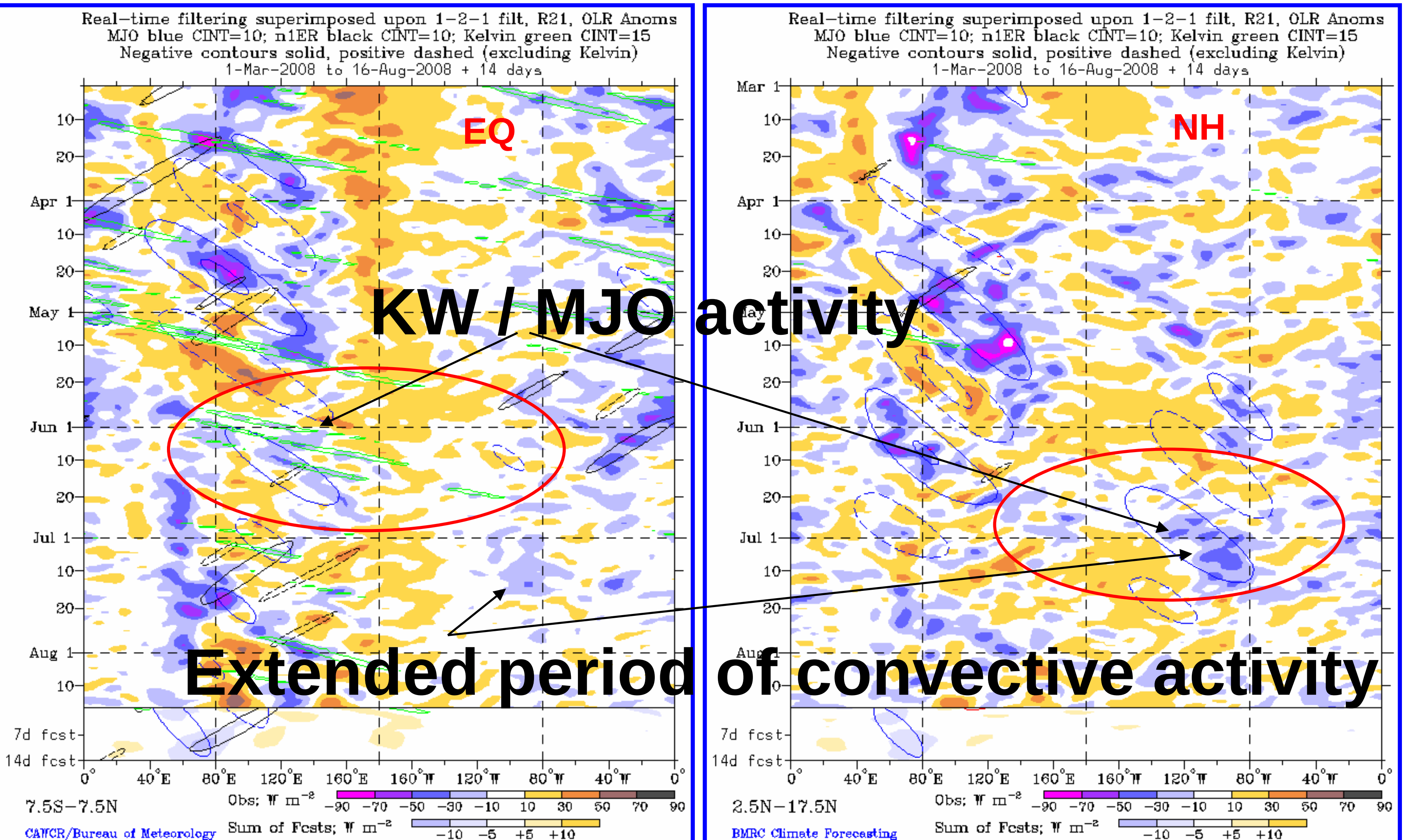
PALAU-2008 Field Experiment



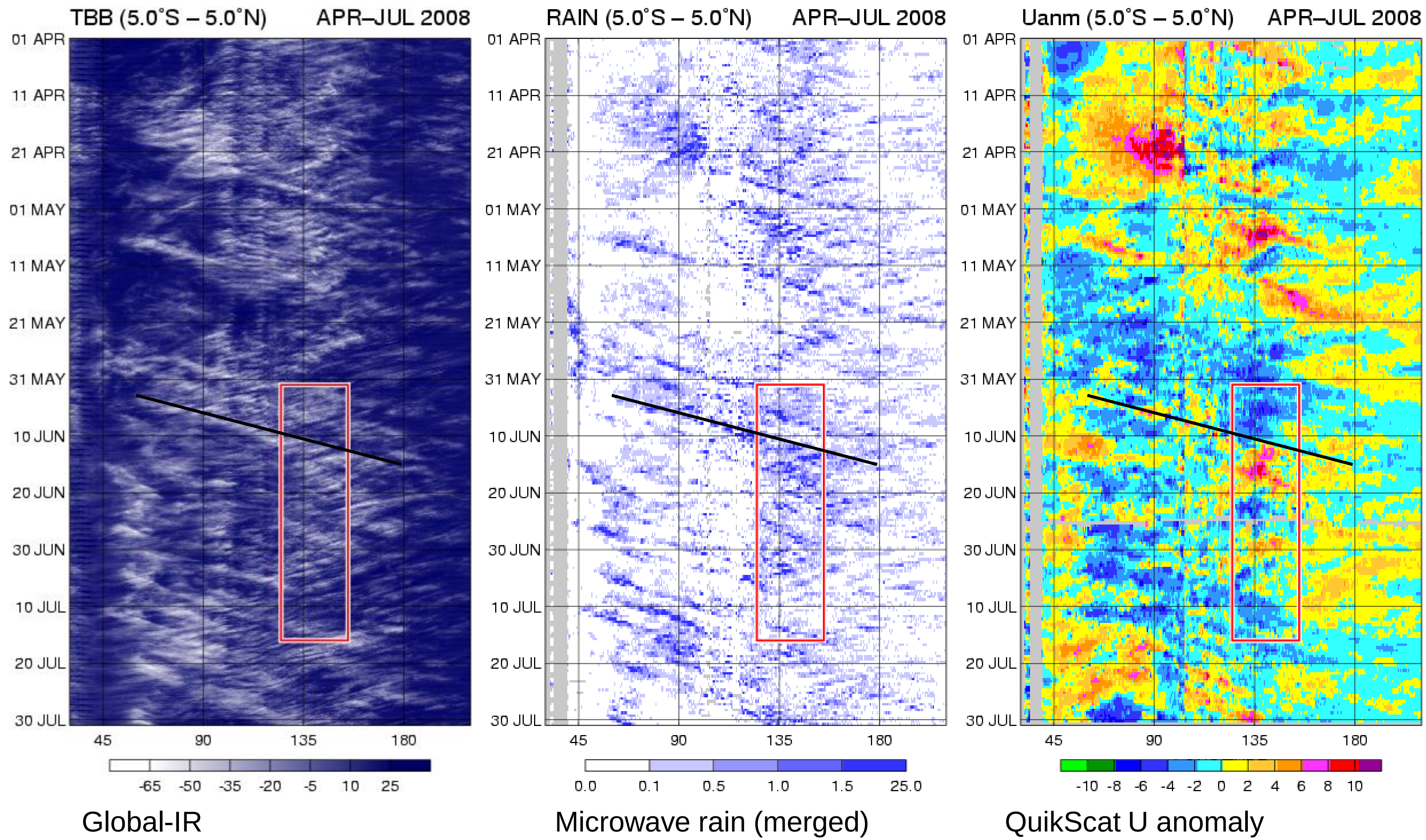
EXAMPLE: Synoptic Event of Interest June/July 2008

MJO/Kelvin Waves -> E.Pac ITCZ -> TCs -> Gulf Surge -> NA Monsoon -> Flash Floods AZ, NM

Contributed by J. Gottschalck/NCEP & M. Wheeler/ABOM

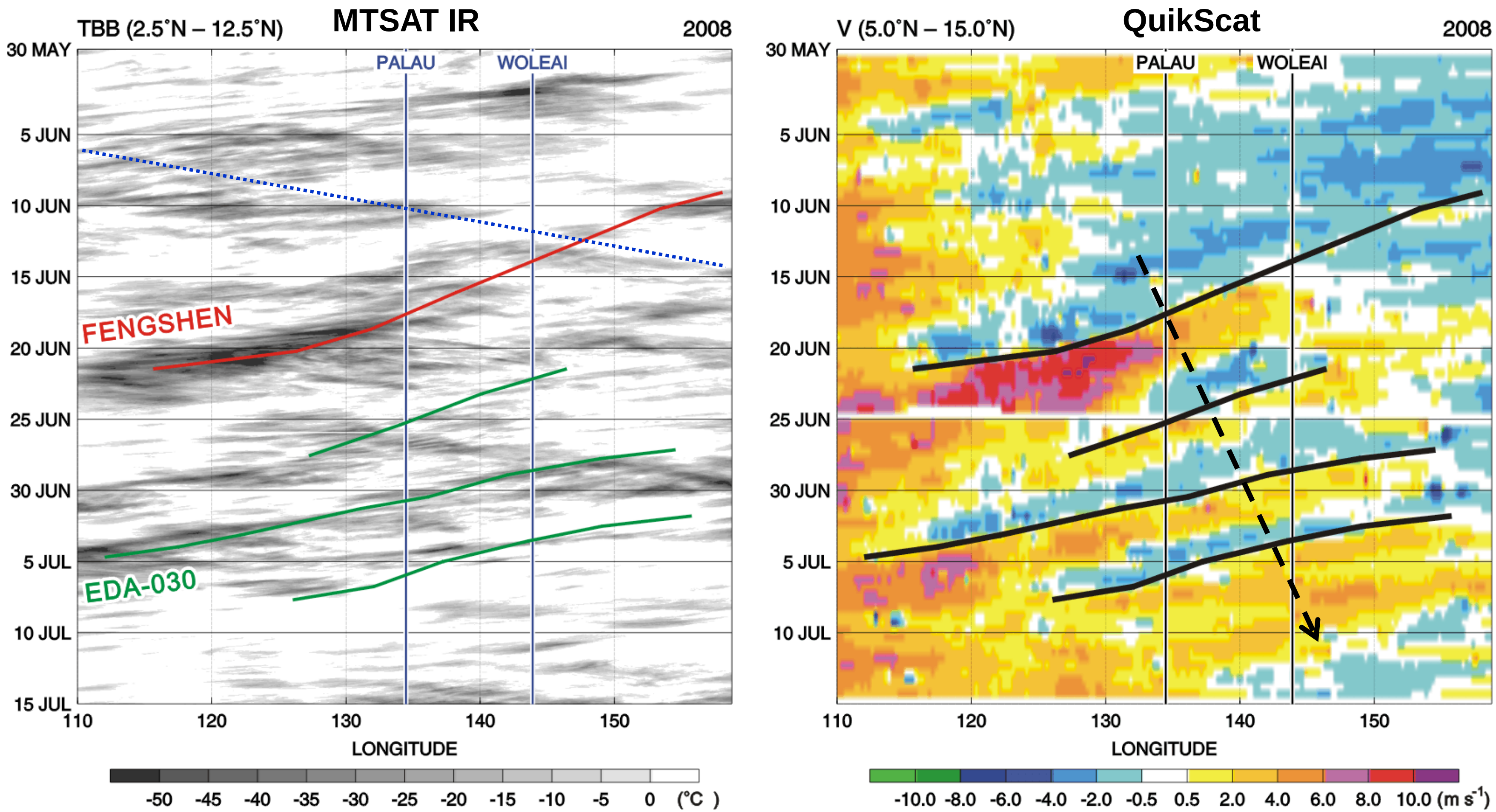


Hovmöller diagrams (5S-5N)



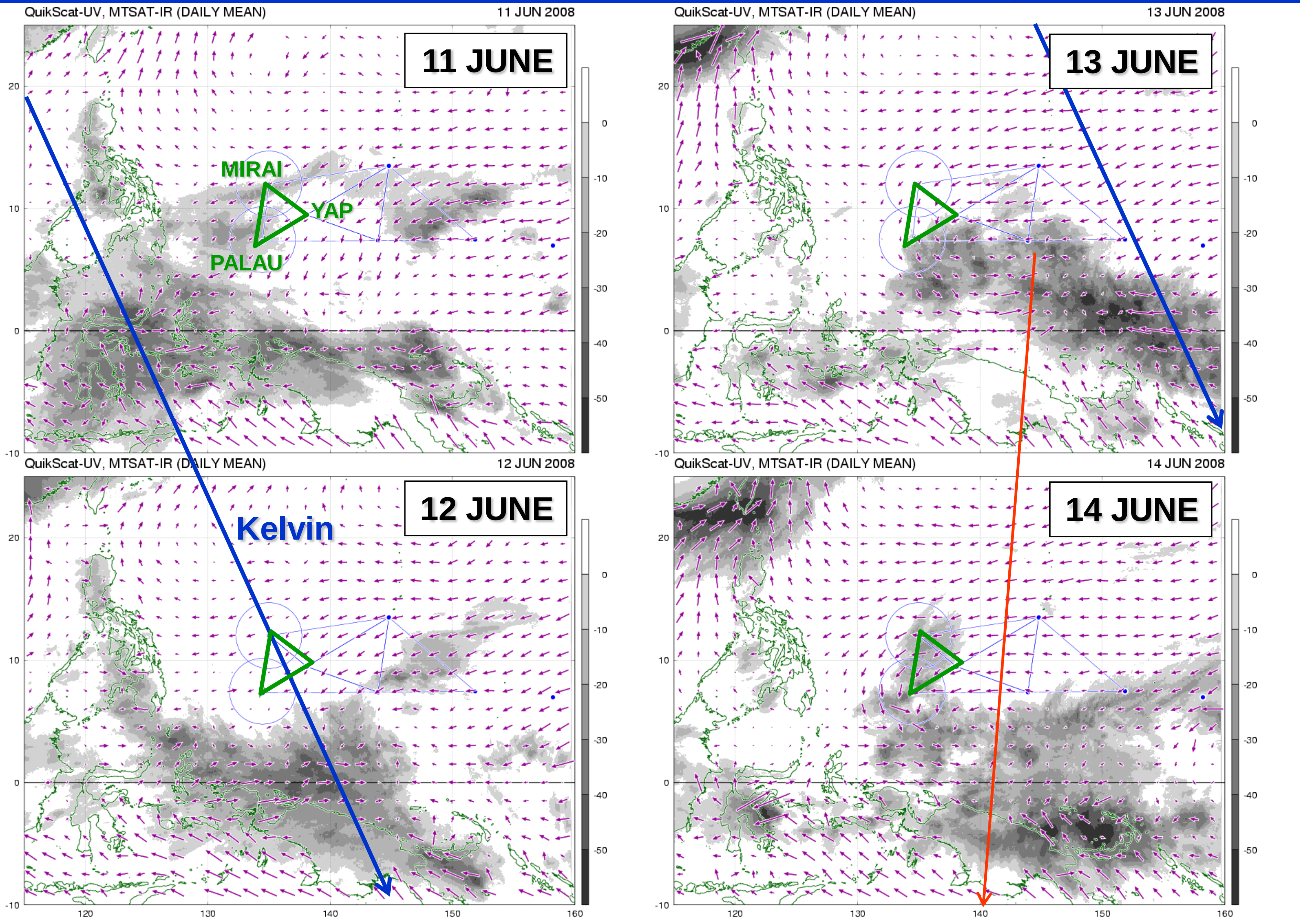
Eastward propagating (Kelvin) signals with westerly anomalies in mid June

Hovmöller diagrams (West Pac)

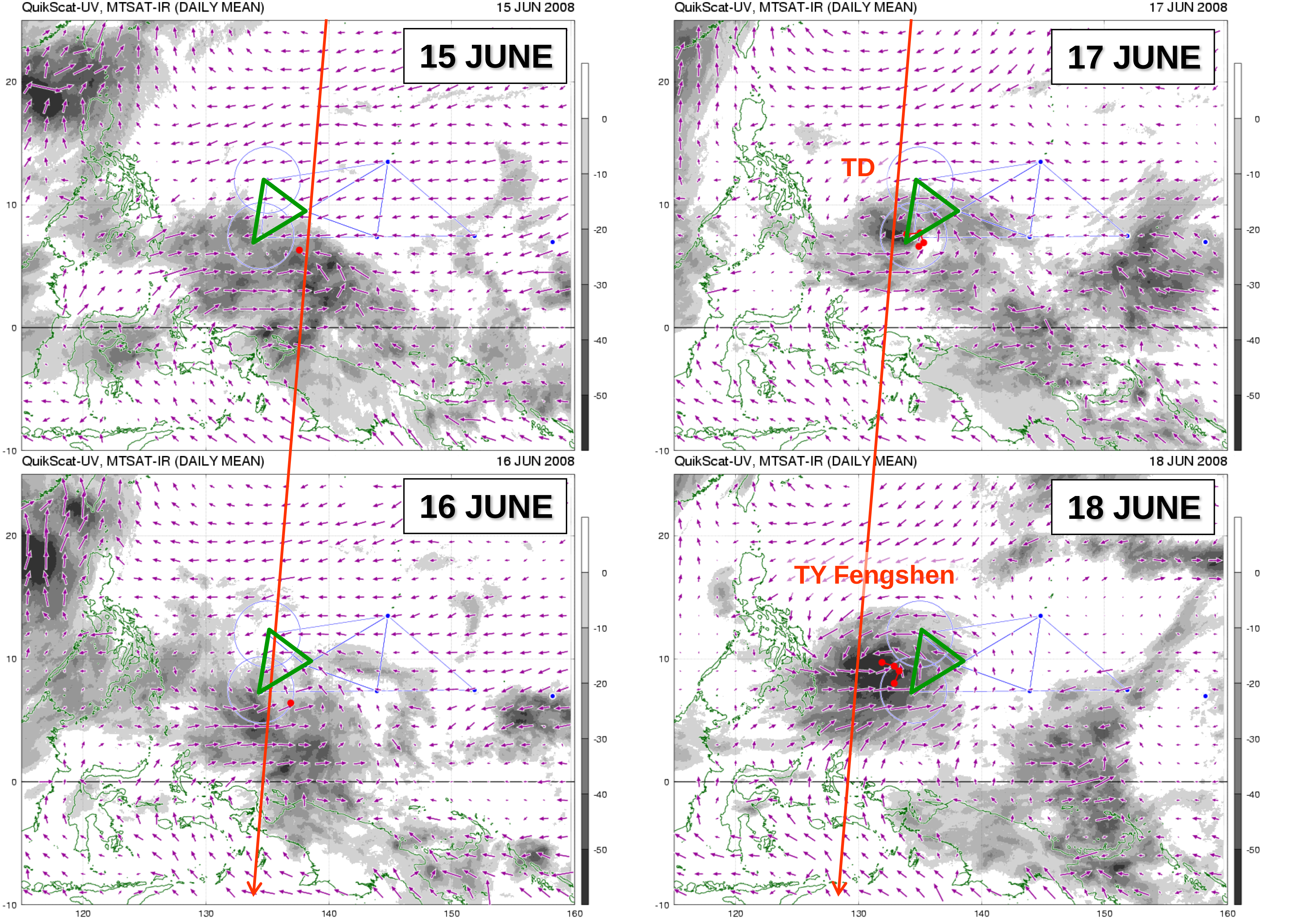


- Four westward-propagating off-equatorial disturbances.
- One grew into TY Fengshen while others didn't grow.
- Slowly eastward propagation of the whole packet, like the behavior of MRG/TD-type waves (Dickinson and Molinari 2002; Straub and Kiladis 2003)

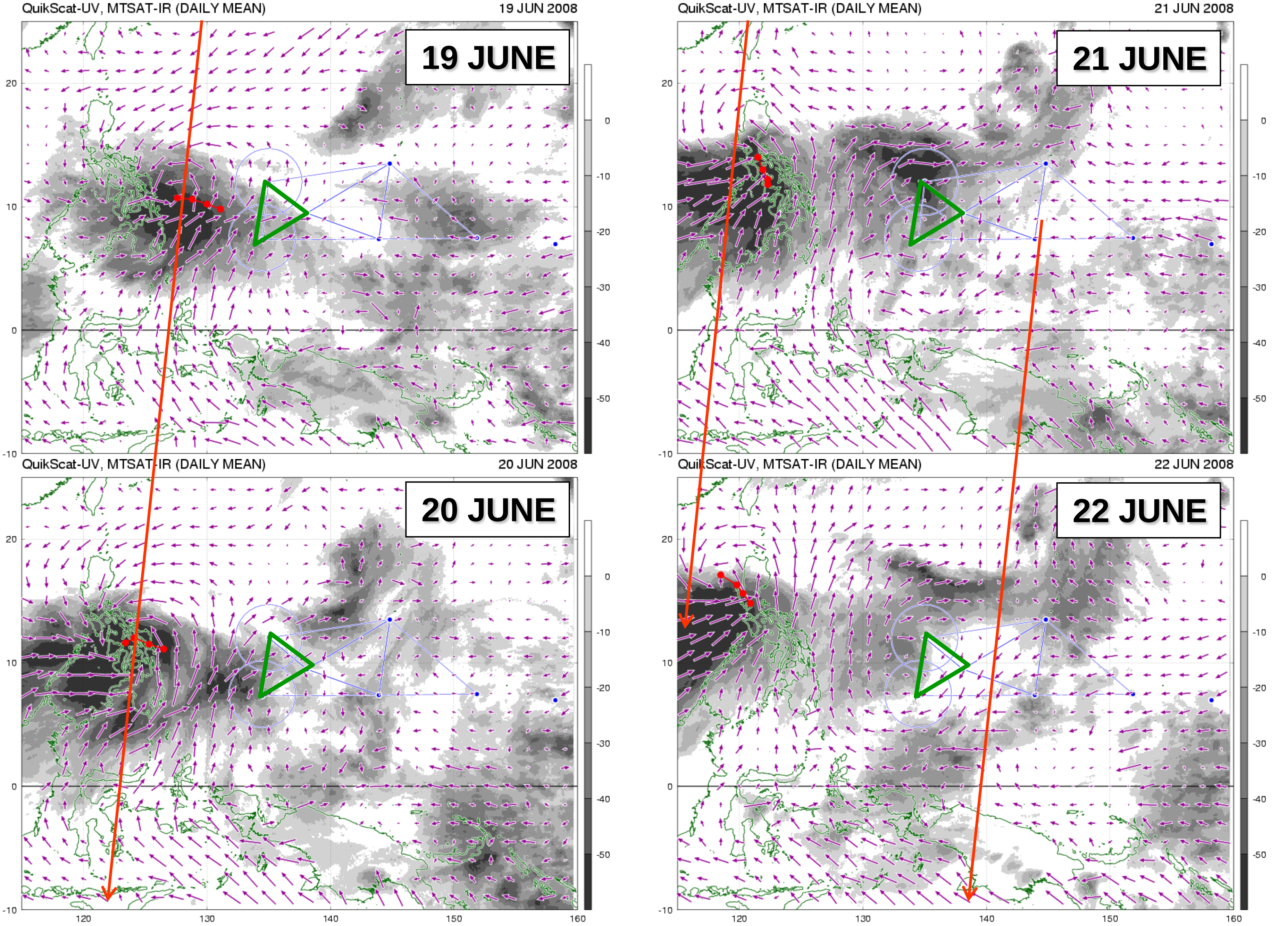
Horizontal distribution (11-14 June)



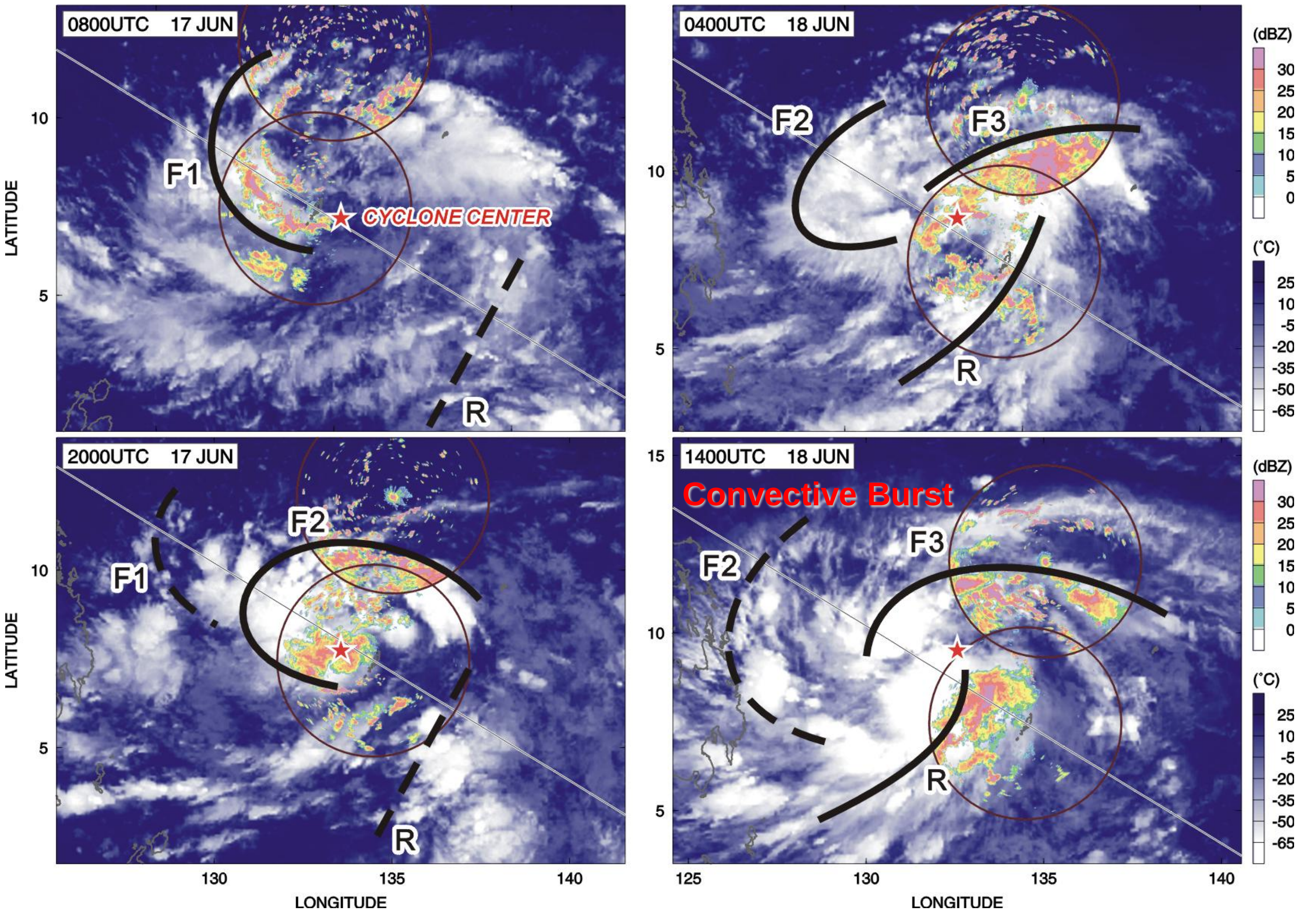
Horizontal distribution (15-18 June)



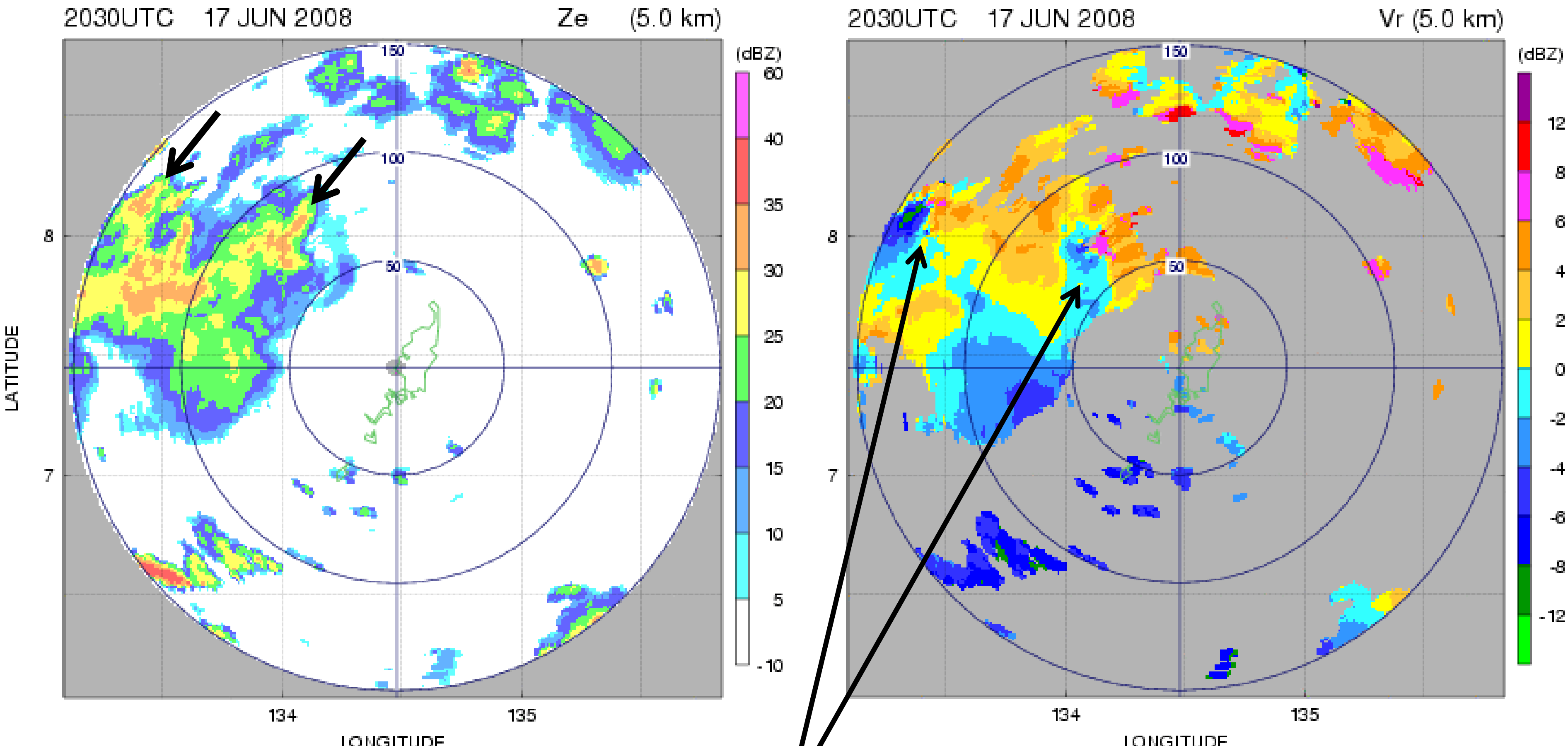
Horizontal distribution (19-22 June)



Evolution of Cloud Bands (relative to pre-TC center)



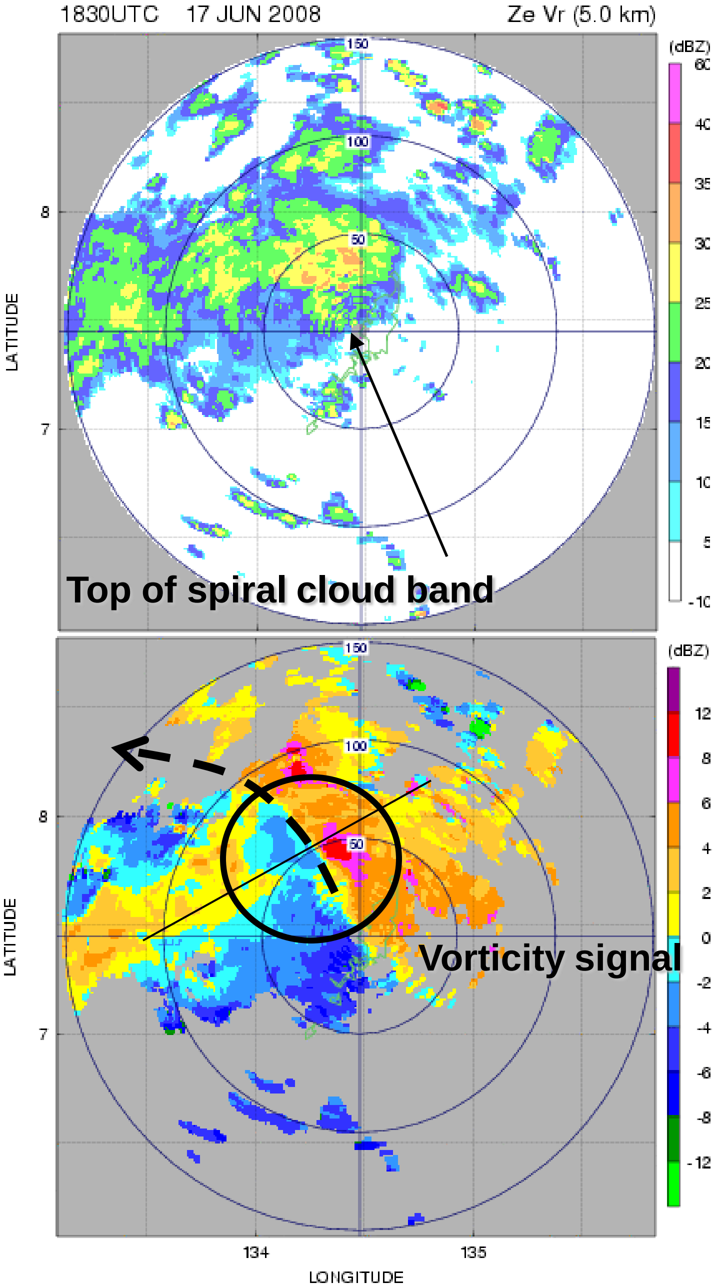
Meso-scale convection and vorticity at the cyclogenesis stage

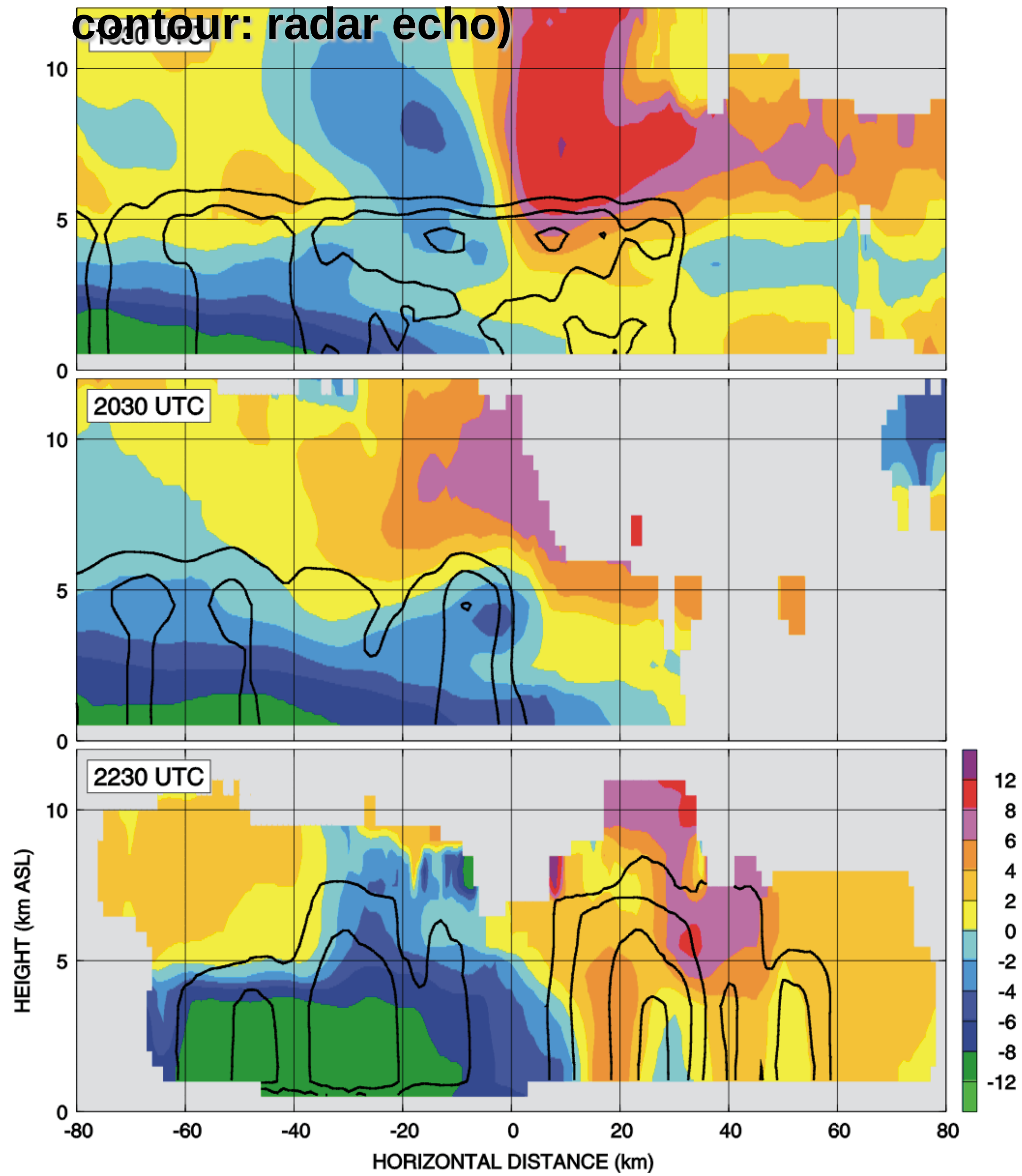


Mesoscale convective vortices in the mid troposphere

(mainly within the fore-side cloud system)

Meso-scale convection and vorticity at the cyclogenesis stage

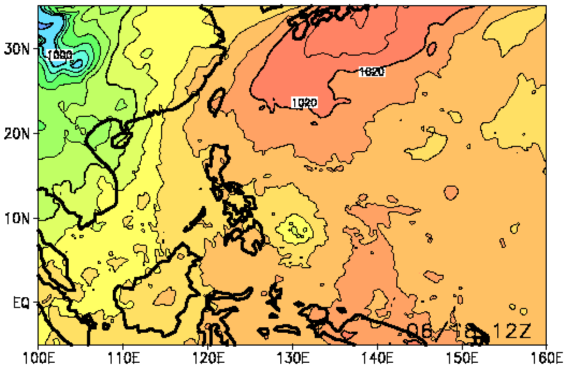




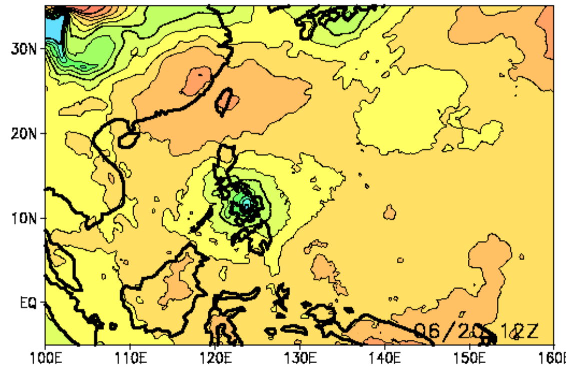
NICAM TC Fengshen simulation

Stretched-7km-grid; Init 12UTC 16th Jun (Genesis: 12UTC 18th)

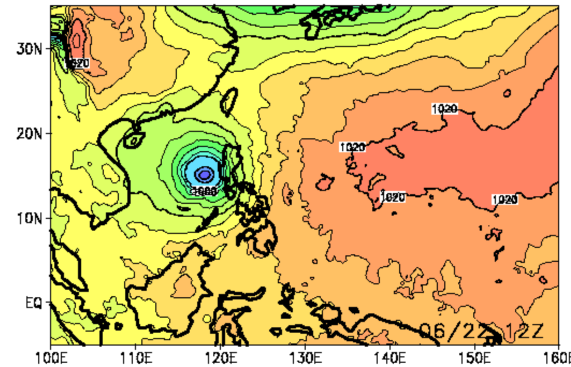
NICAM: 12UTC 18th



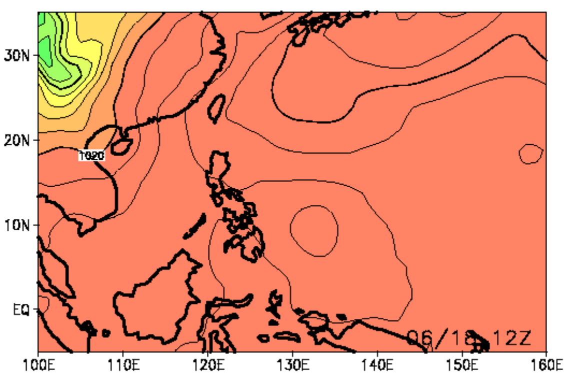
NICAM: 12UTC 20th



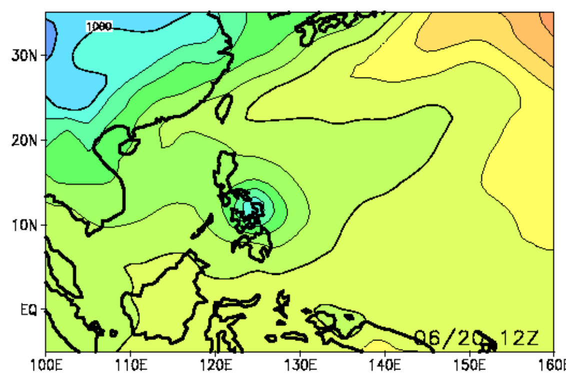
NICAM: 12UTC 22nd



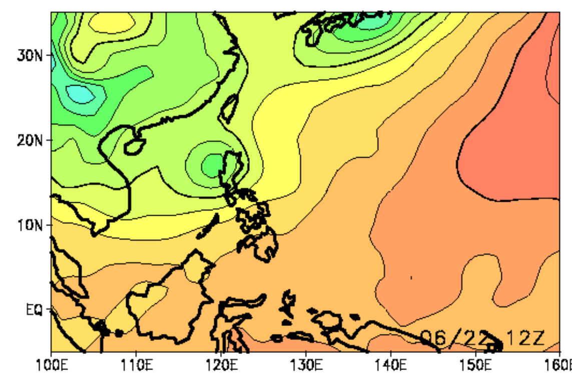
JCDAS: 12UTC 18th



JCDAS: 12UTC 20th



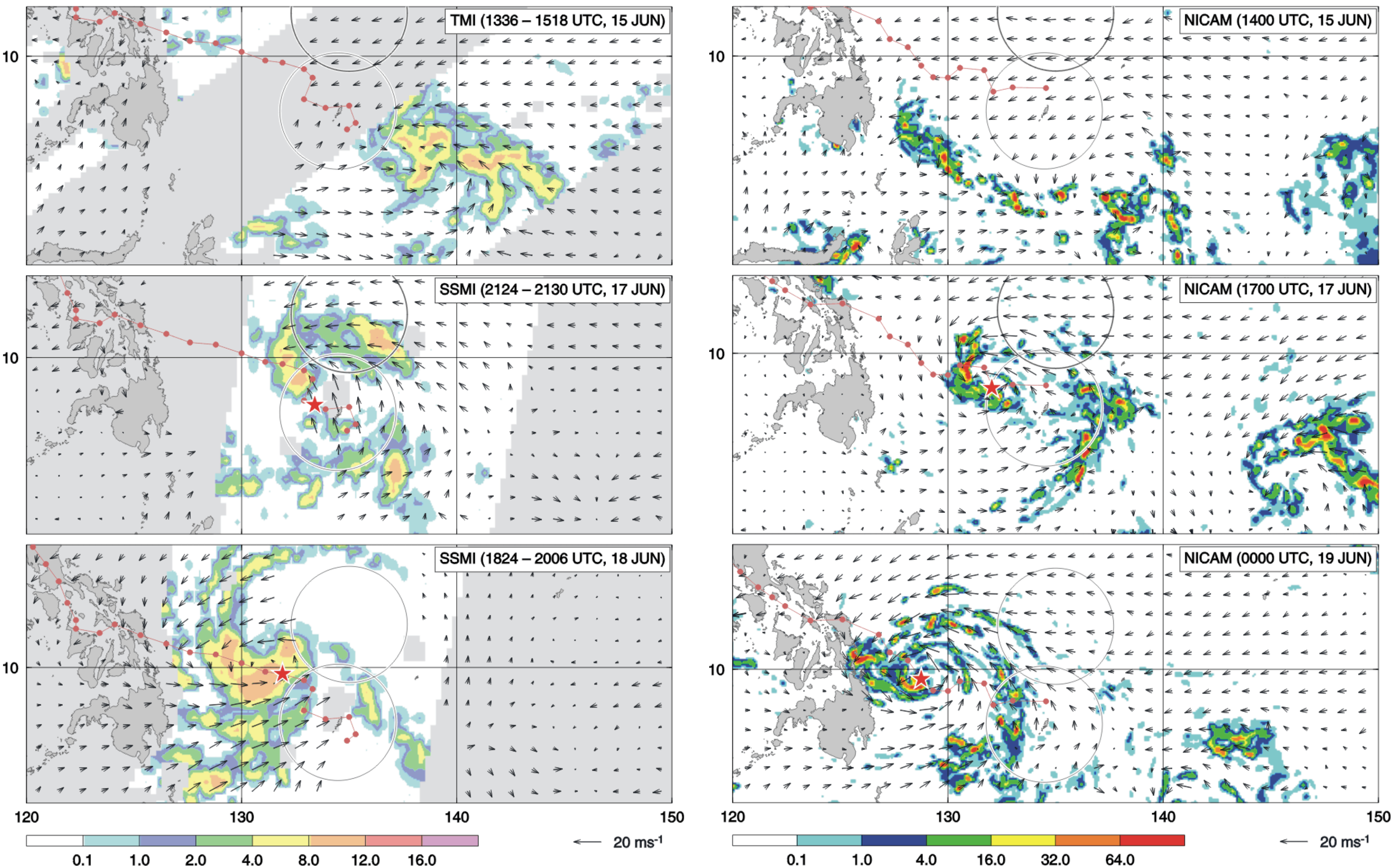
JCDAS: 12UTC 22nd



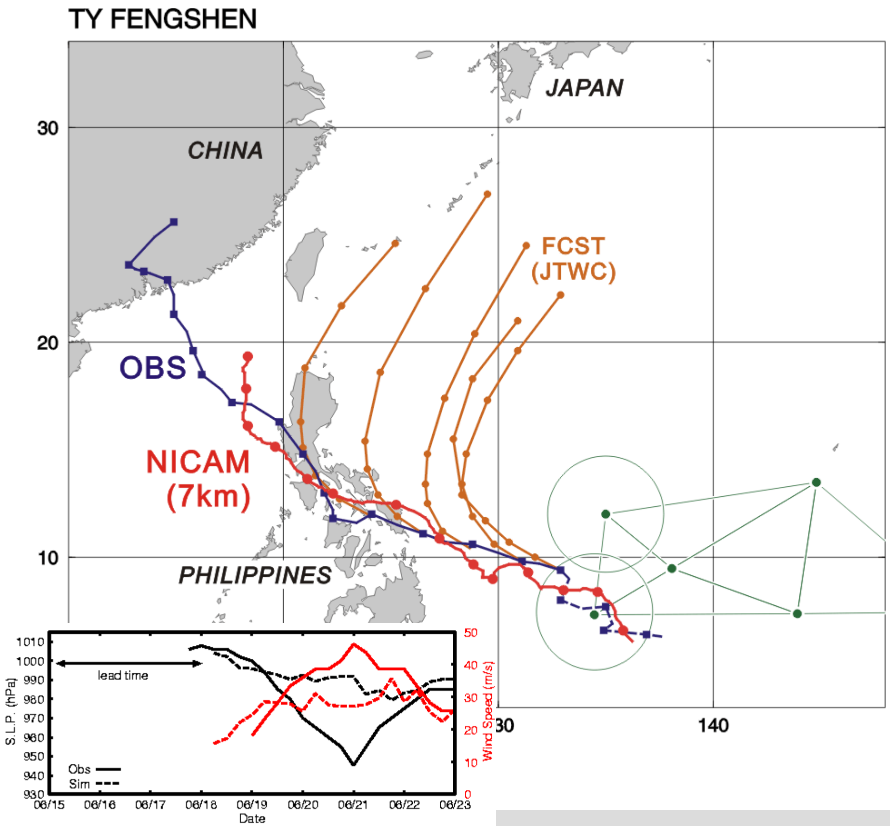
Simulation using NICAM (dx=7km)

OBS. (MW rain, sea-level wind)

NICAM (rain, UV at z=10m)



Erroneous poleward bias in ALL forecast models



Forecast Track Errors

	24	36	48	72	96	120
JTWC	108	169	206	308	658	874
CONW	115	192	262	430	703	838
AVNI	124	205	276	512	780	1005
EGRI	105	141	158	228	471	589
GFNI	165	259	354	534	791	848
NGPI	125	214	319	541	770	934
#CASES	14	14	12	11	6	6

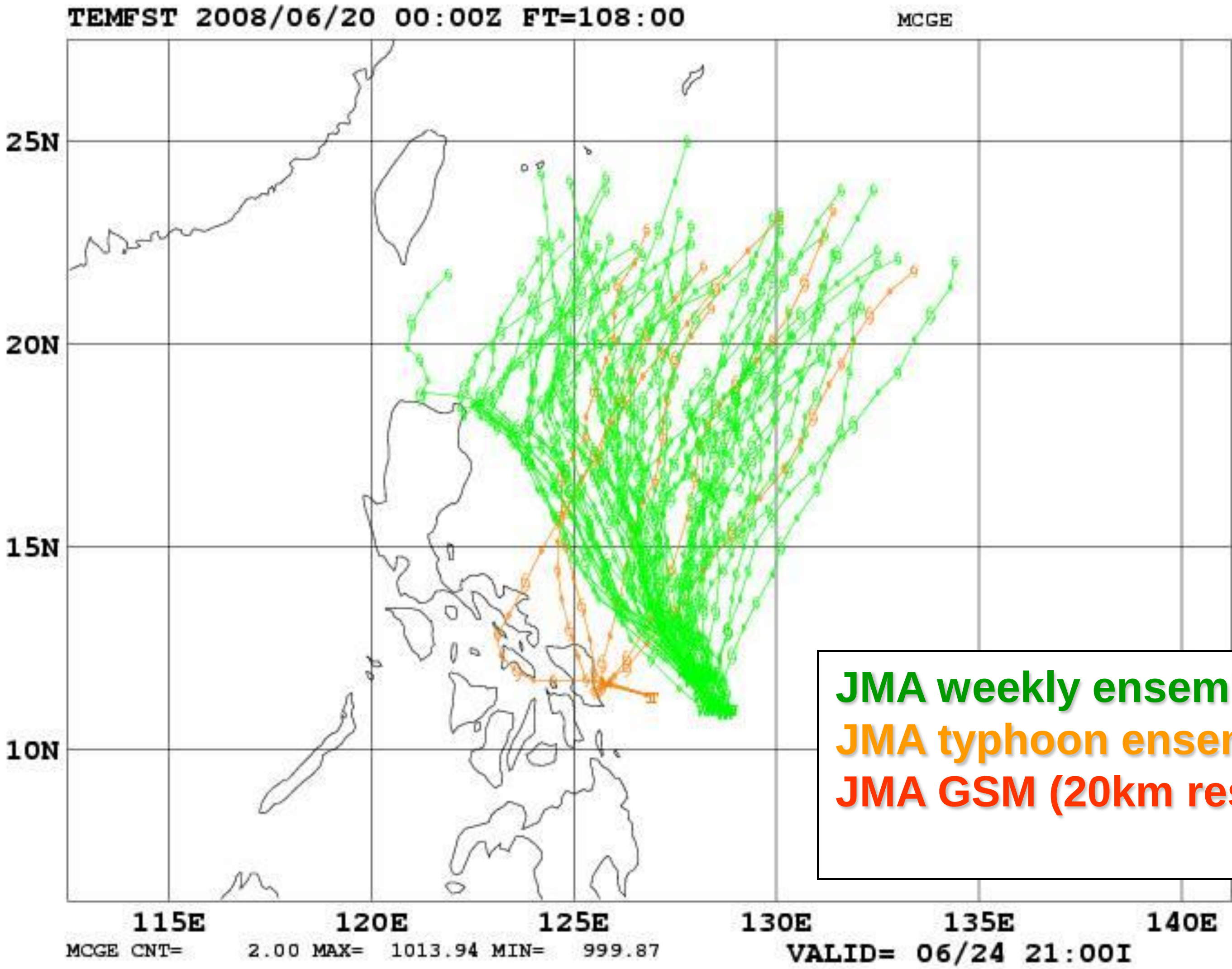
Table 1-5: Average FTE (Homogeneous Comparison) Through Tau 120

- JTWC: JTWC official forecasts
- CONW: JTWC model consensus
- AVNI: GFS model
- EGRI: UK Met Office model
- GFNI: GFDN model
- NGPI: NRL NOGAPS model

JTWC's 2008 Annual Tropical Cyclone Report (ATCR), Page 38:
(http://metocph.nmci.navy.mil/jtwc/atcr/2008atcr/2008atcr.pdf)

"It is highly unusual to have all forecast guidance be incorrect, so JTWC forecasters were reluctant to go against all the models, resulting in highly inaccurate official forecasts. Immediate evaluation by the modeling community is necessary to determine the root causes of the unreliability of the dynamic models in this case."

Track forecast (init. 00UTC, 20 June)

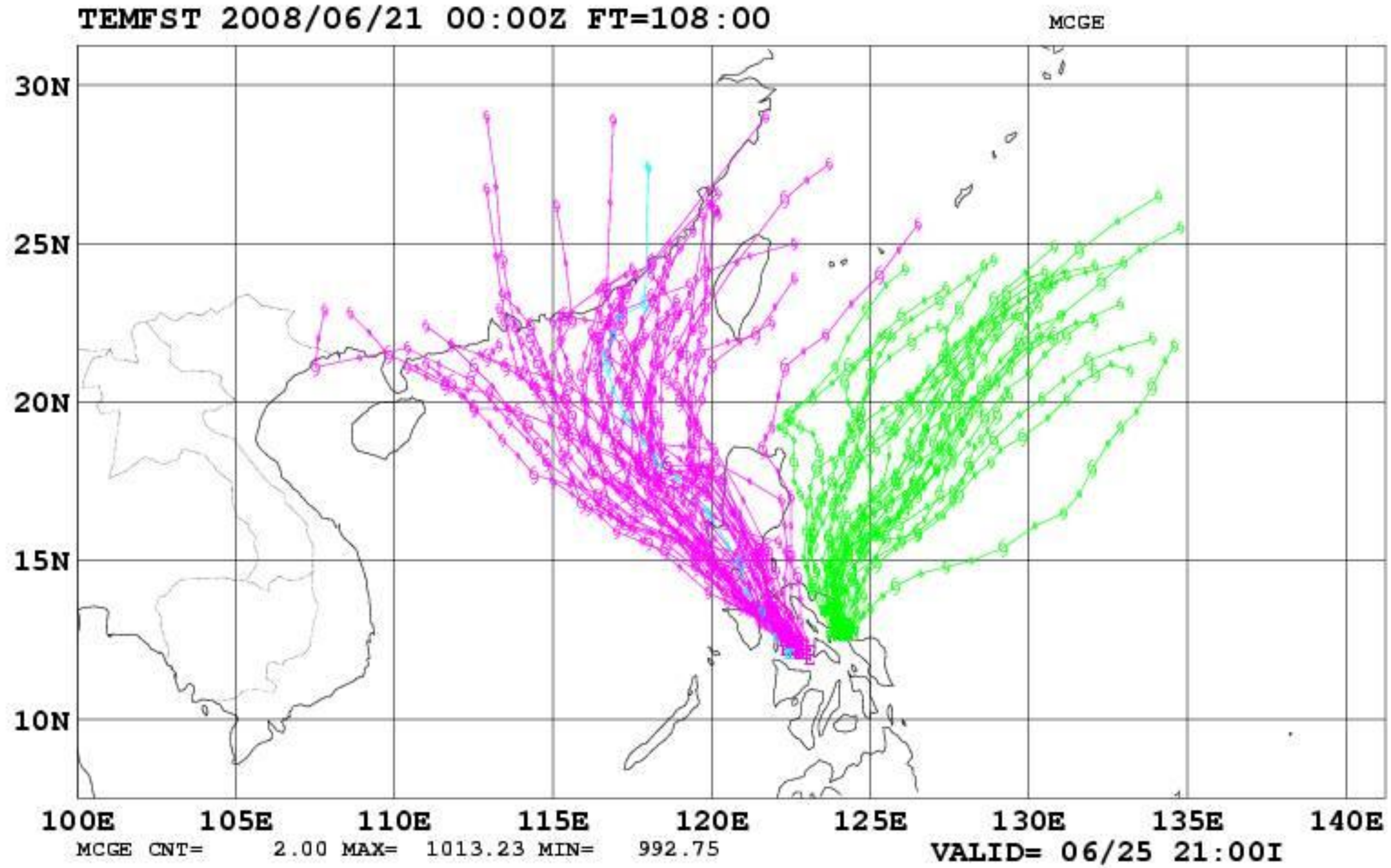


JMA weekly ensemble (51 members)

JMA typhoon ensemble (11 members)

JMA GSM (20km resolution)

Track forecast (init. 00UTC, 20 June)

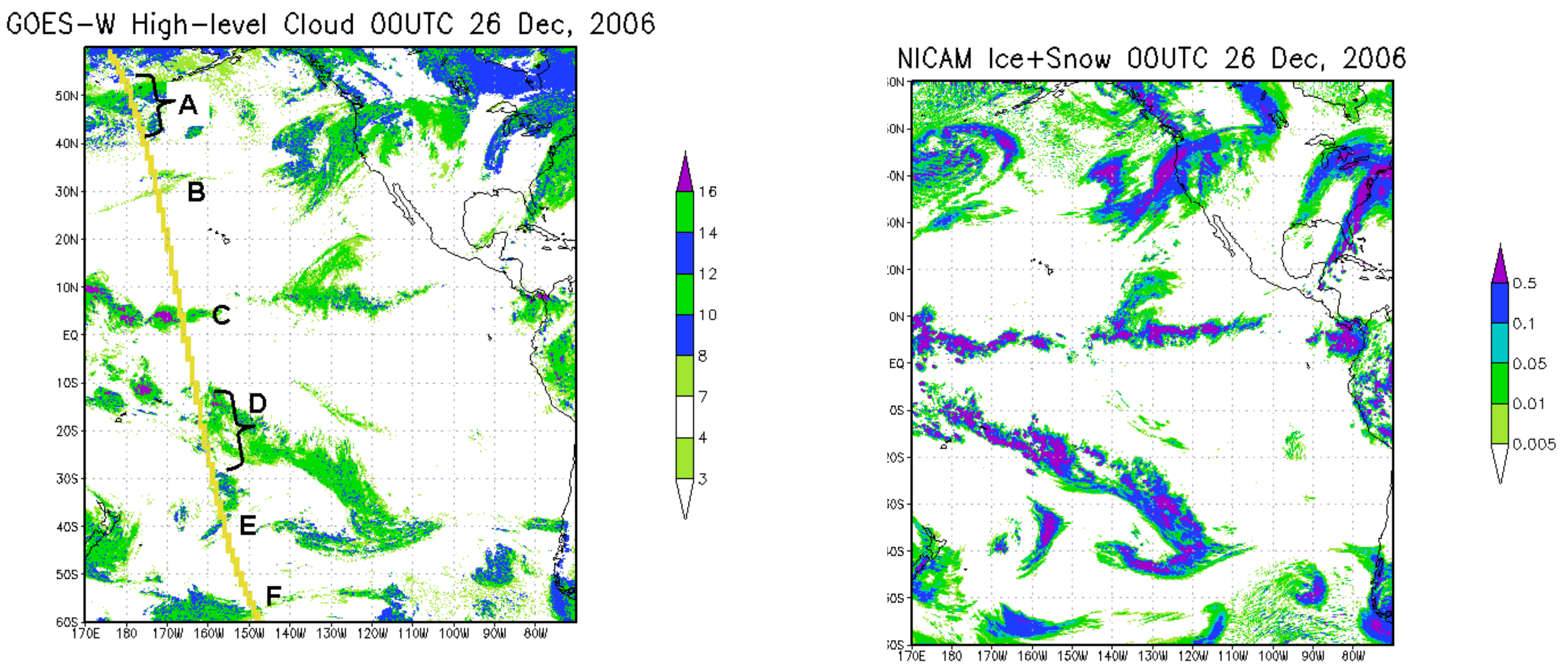


JMA weekly ensemble (51 members)
JMA typhoon ensemble (11 members)
JMA GSM (20km resolution)
ECMWF ensemble (51 members)

SATELLITE COMPARISONS

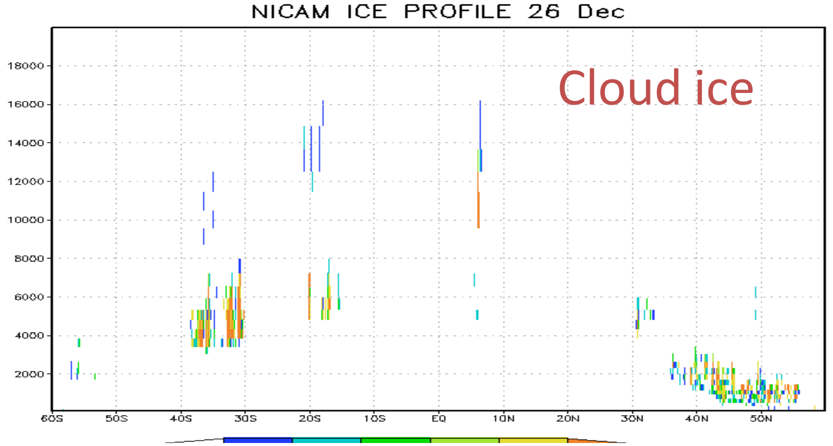
3.5KM MESH SIMULATIONS AND CLOUD PROPERTIES

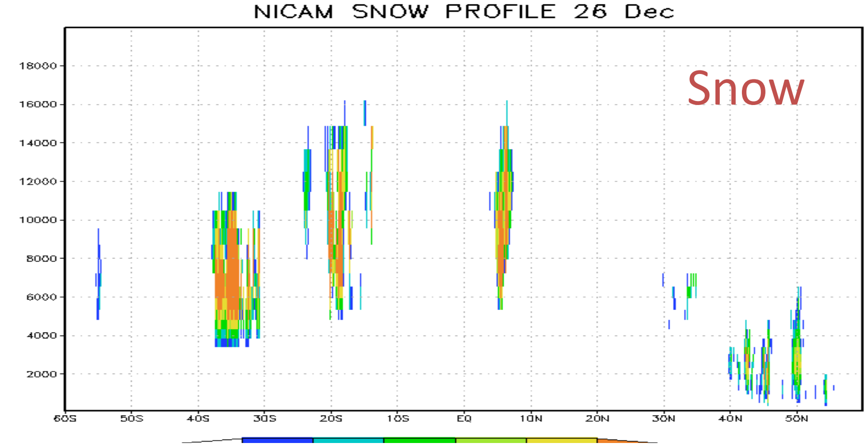
NICAM 3.5 km mesh global simulation comparable to satellite observation



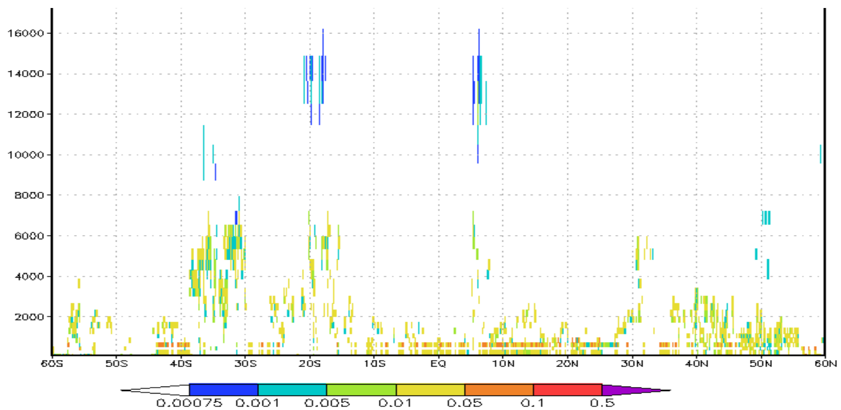
Ice cloud evaluation by split windows

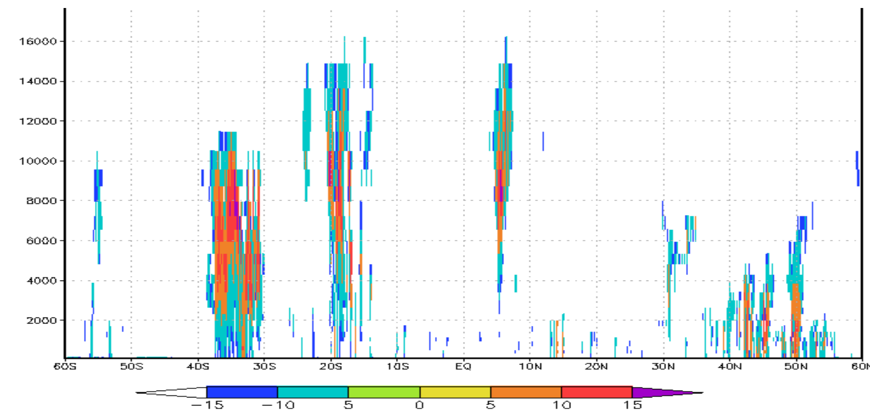
Inoue et al.(2009, JGR, submitted)

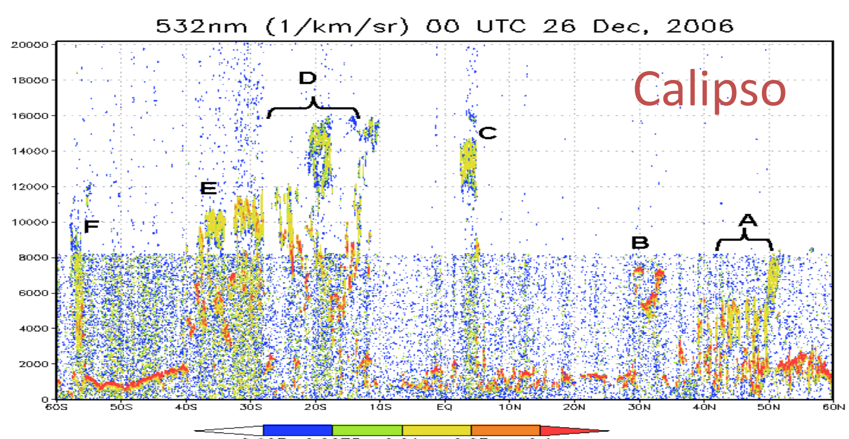


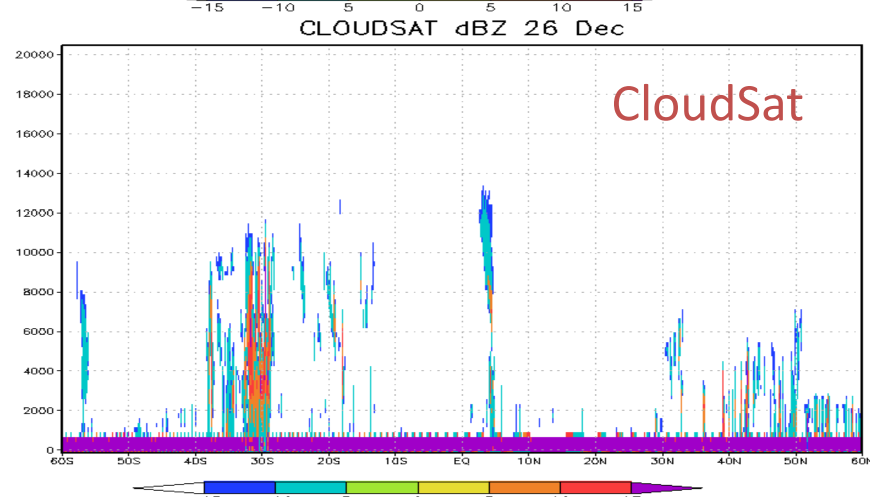


Calipso/CloudSat simulated reflectivities by COSP



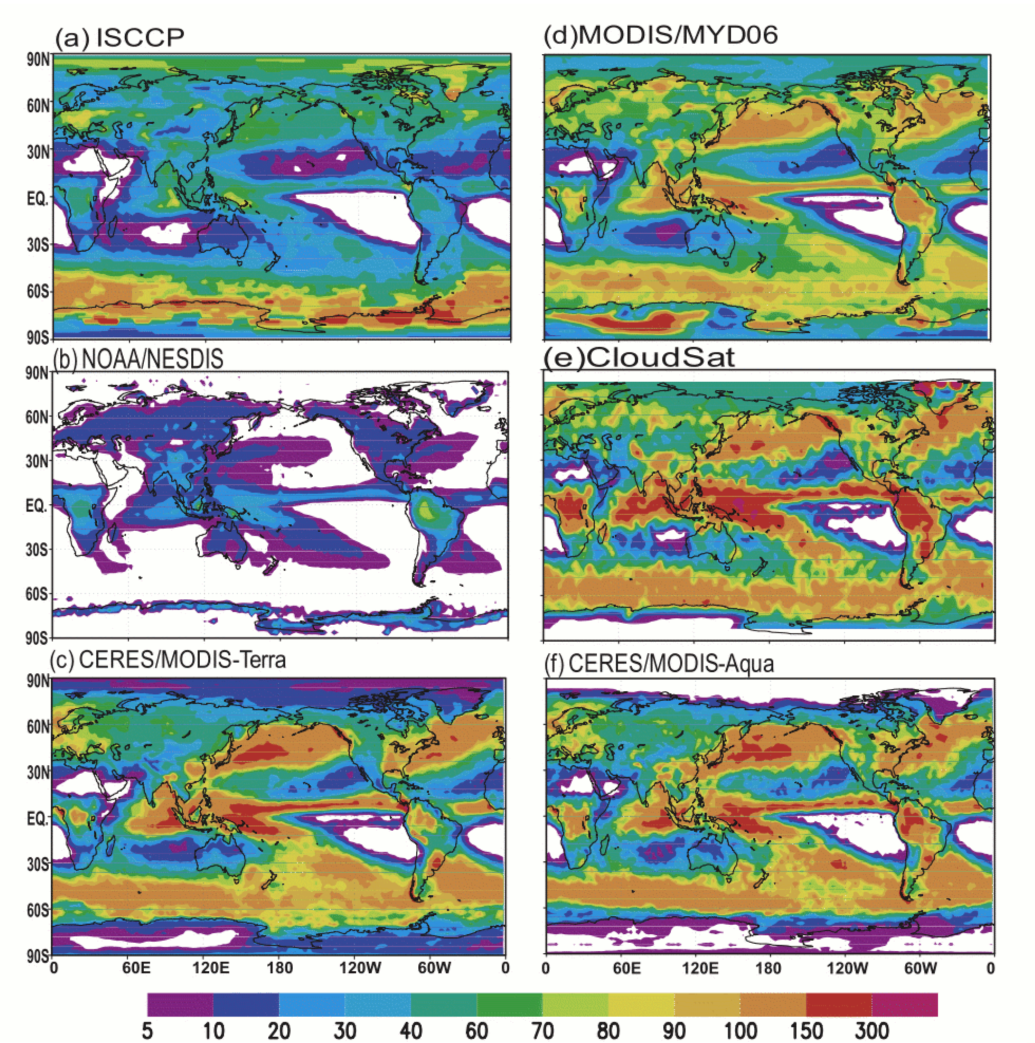




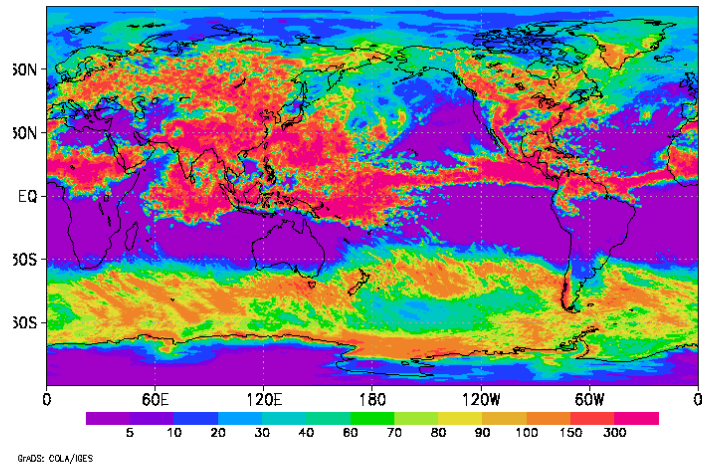


observation

IWP

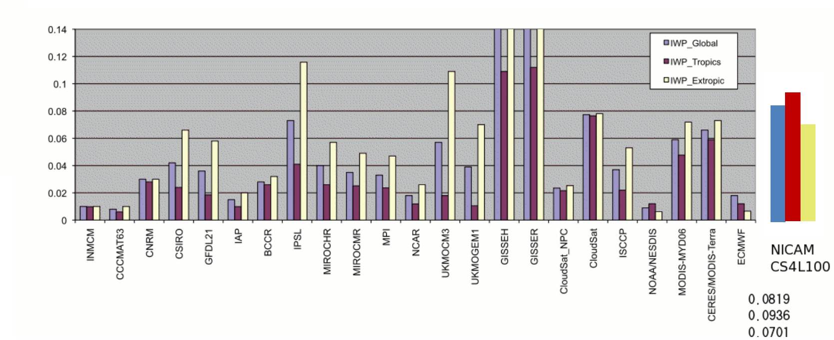


Waliser et al. (2009)



NICAM

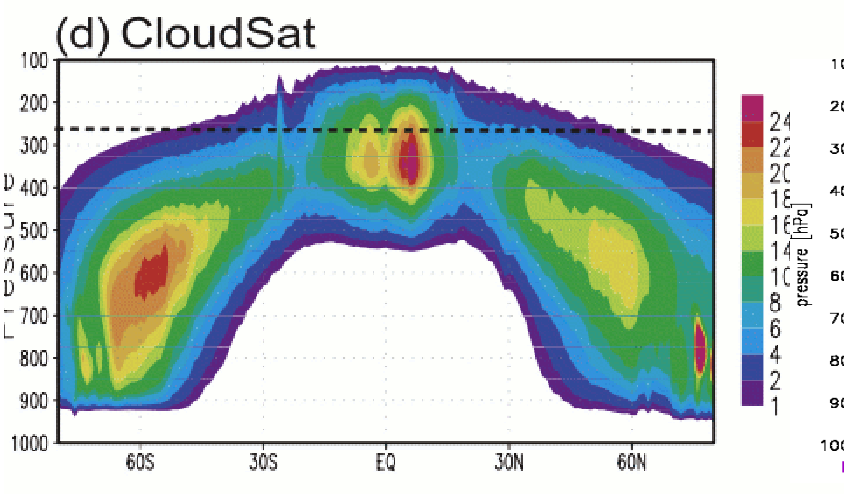
Iga et al.
(2009,in preparation)

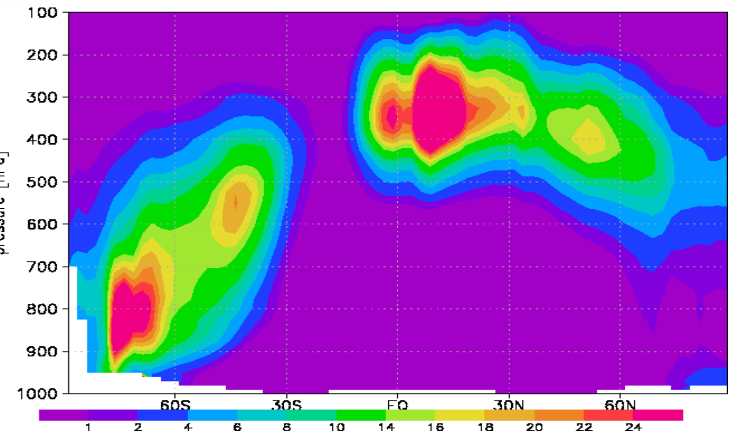


NICAM IWP is larger than the observed range of IWP.

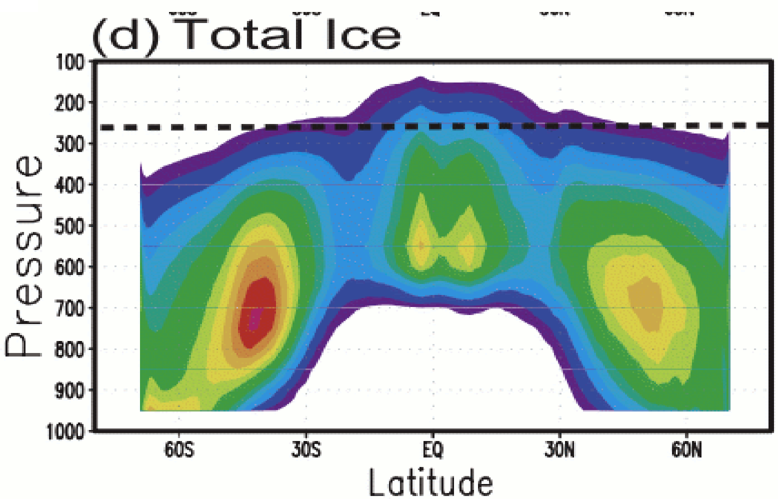
I W C

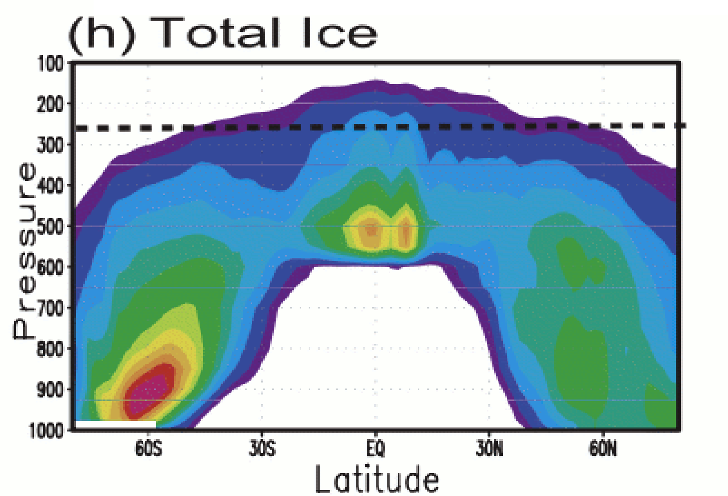
NICAM CS4L100





NICAM IWC is larger in the tropics



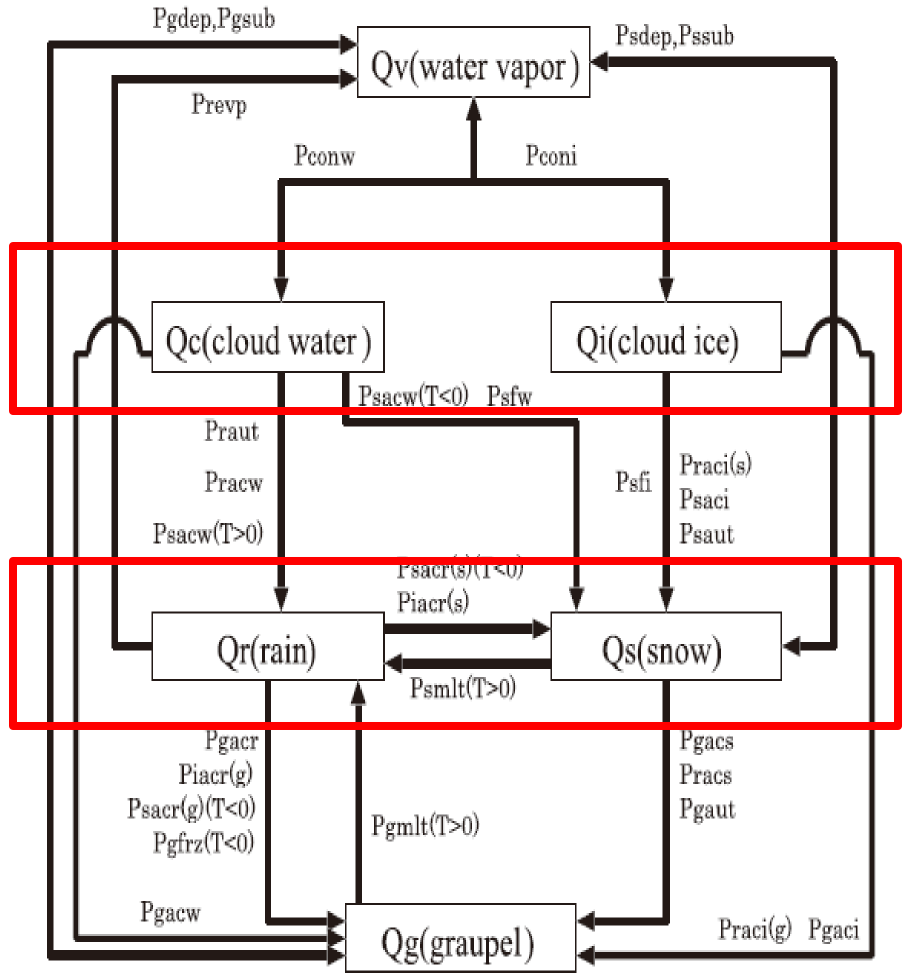


RAVE

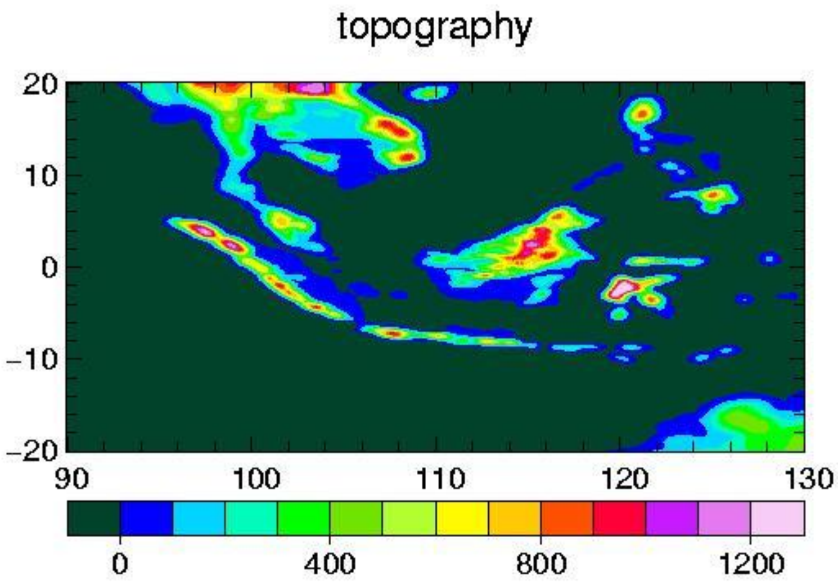
fvMMF

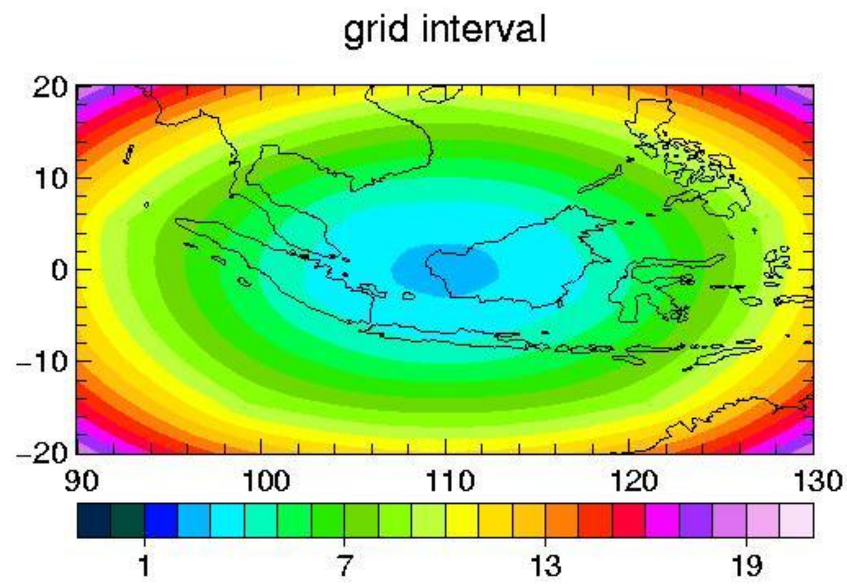
Cloud Microphysics Schemes of NICAM

- Grabowski (1998)
- NSW6 (Tomita 2008,JMSJ)
  - Single-moment 6-categories of water
- NDW6 (Seiki-Mitsui)
  - Double-moment 6-categories of water



Stretch-NICAM exp.

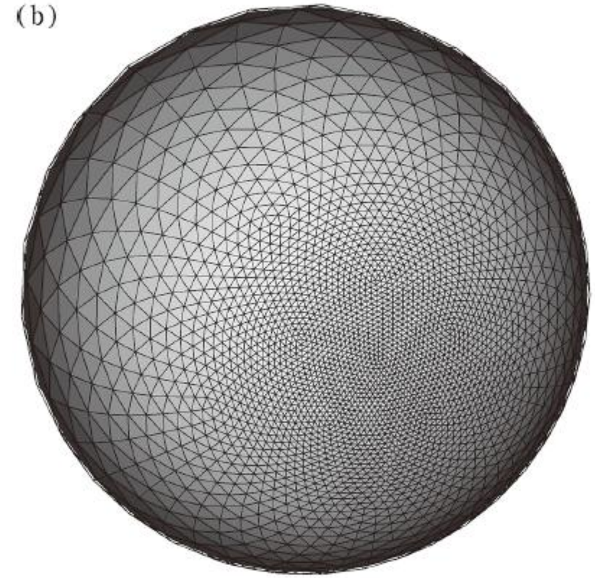




- Use of NICAM as a regional model: local-CRM: (Tomita, 2008,JMSJ)
- dx=2.5km-250km

  Stretch factor=100, Glevel8
- Integration: 2007.1.1.12-1.5.12
- Sensitivity to cloud microphysics scheme

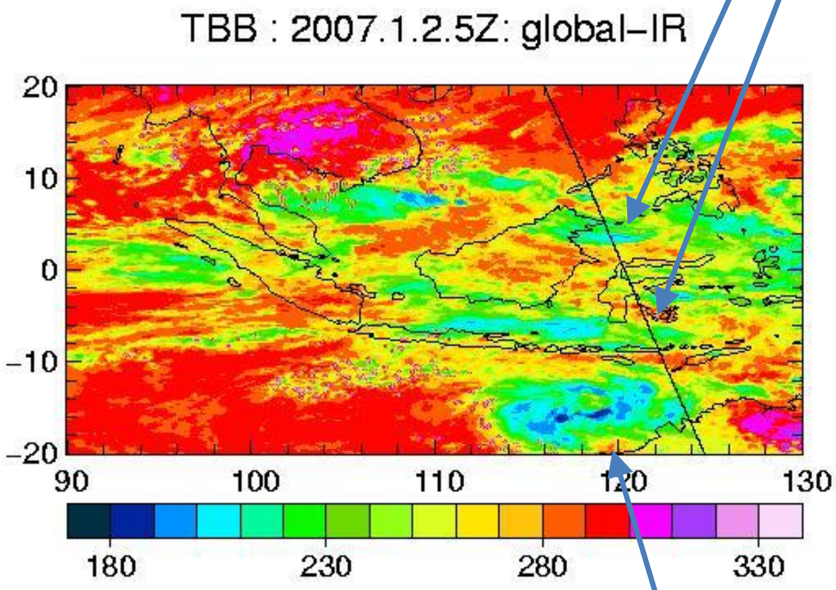
  NSW6

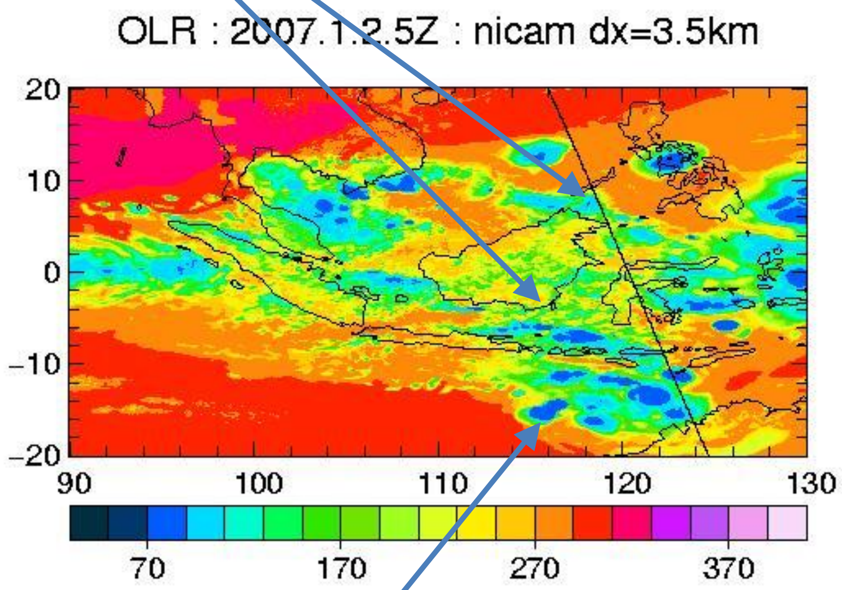


Stretch-NICAM exp.

5UTC 2 Jan. 2007

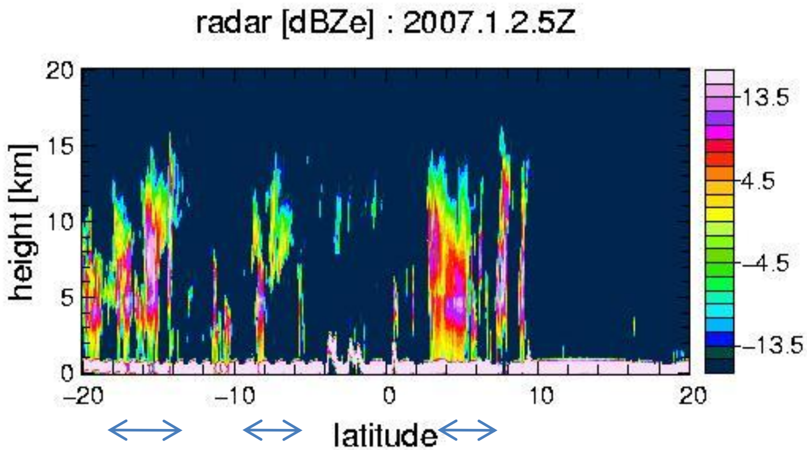
Cloud band

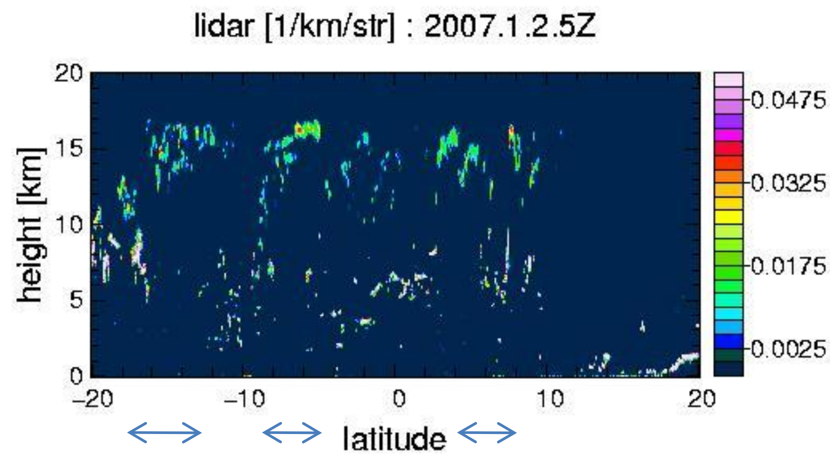




Tropical Cyclone
ISOBEL

CloudSat/CALIPSO

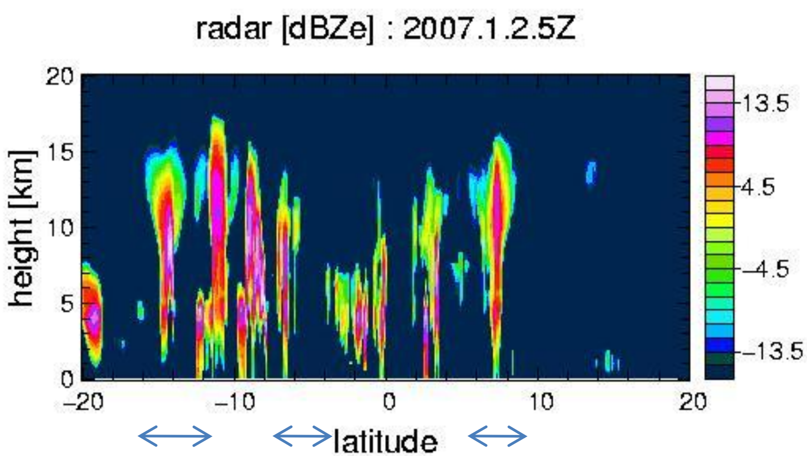


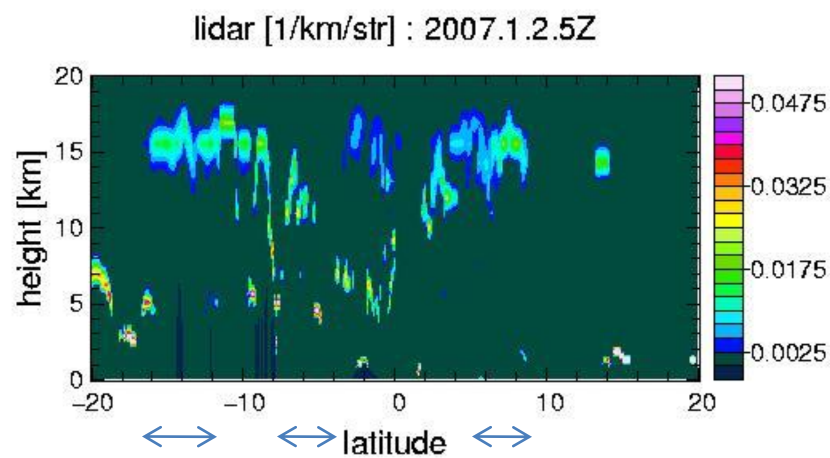


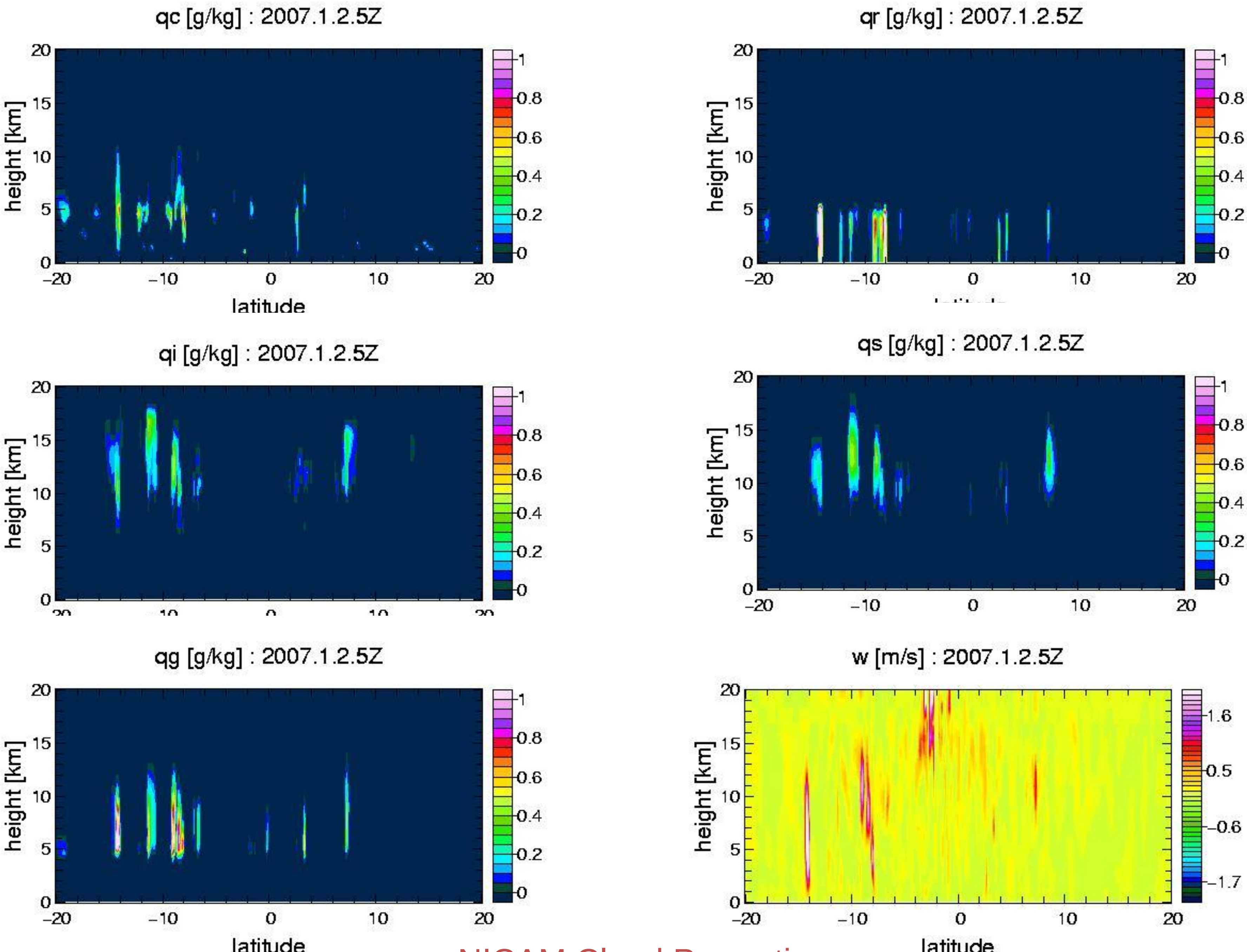
TC

Cloud Bands

NICAM with COSP



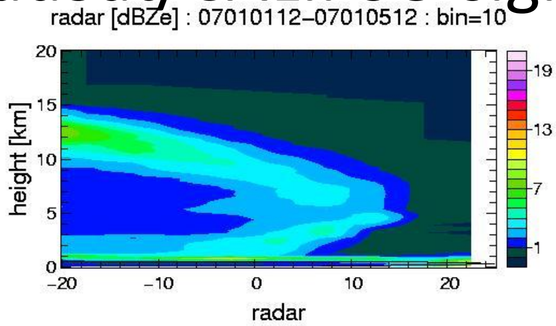


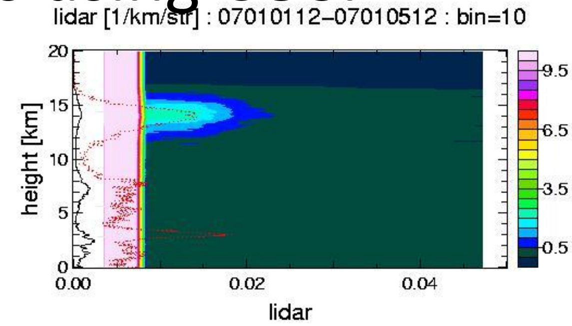


NICAM Cloud Properties

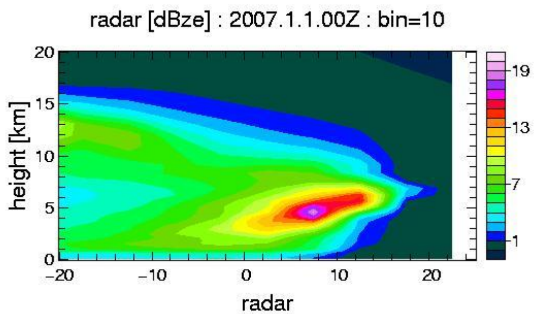
Sensitivity to cloud microphysics schemes: CFADS of CloudSat/CALIPSO signals using COSP

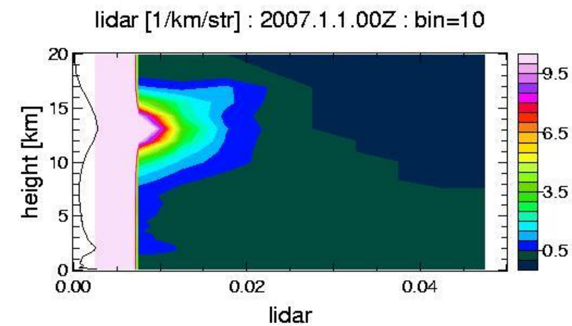
CloudSat/CALIPSO



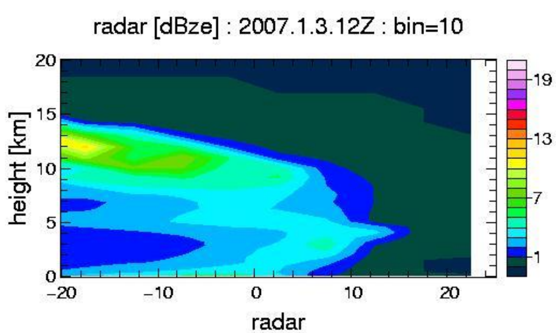


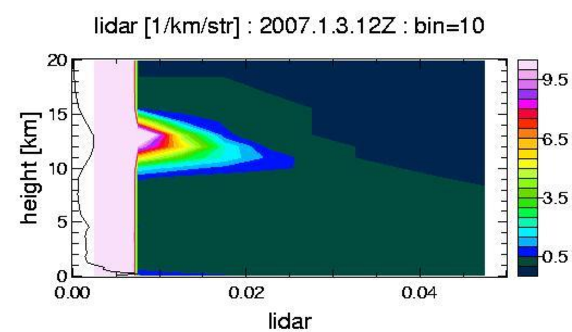
Grabowski(1998), NICAM-GCRM 3.5km (90-130E, 20S-20N)





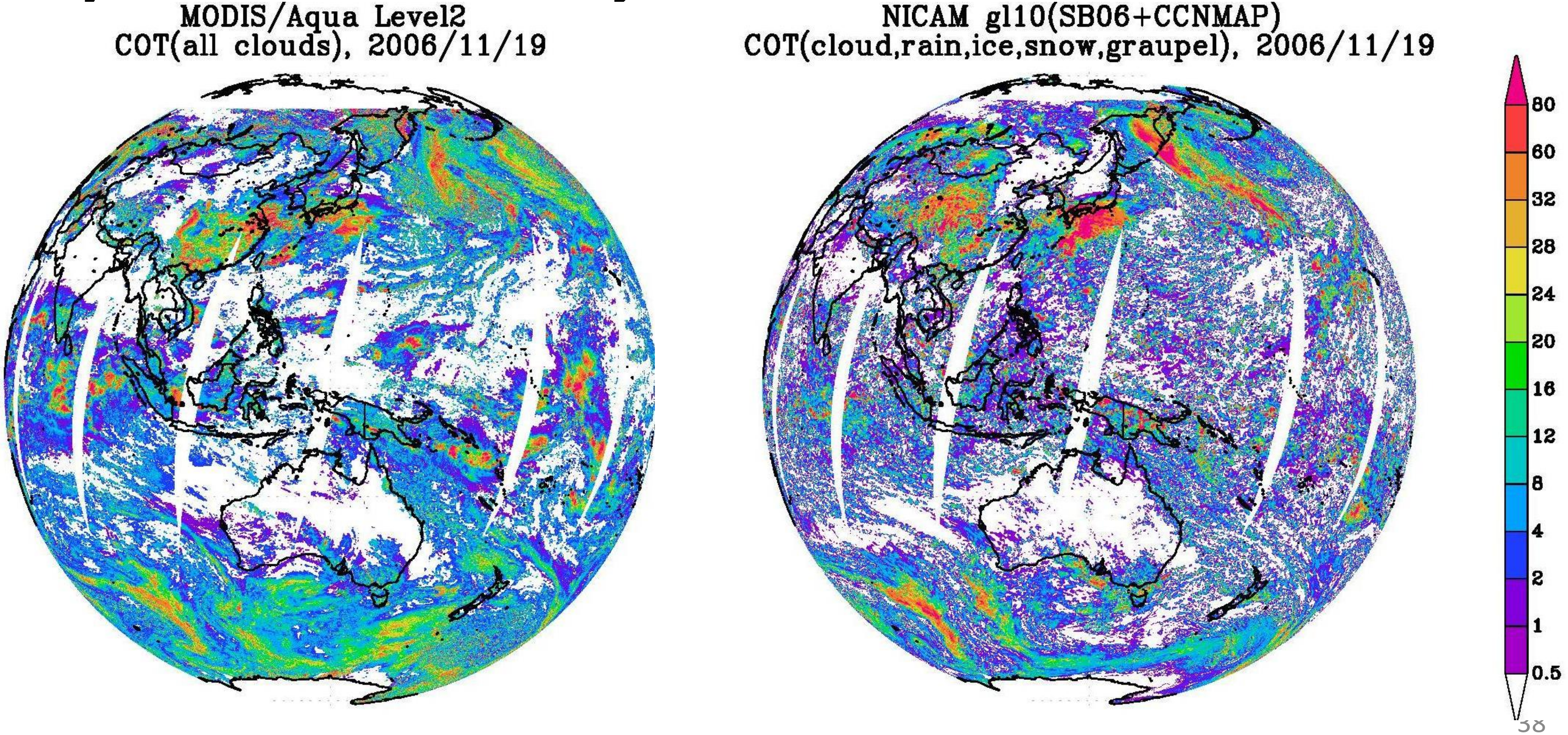
NSW6 (Tomita 2008), stretched-NICAM dx=2.5~5km





Pilot simulations of 2-moment cloud model with Global 7km resolution.
Comparisons with satellites and further challenges.
(Validation of 2-moment cloud model)

Nakajima lab. Seiki Tatsuya.



Summary

- NICAM simulations
  - MJO and ISV (Miura et al., 2007; Nasuno et al., 2009 JMSJ; Liu et al, 2009 MWR; Oouchi et al. 2009 GRL)
  - TC (Fudeyasu et al. 2009, GRL)
  - Diurnal cycle (Sato et al. 2009, J. Clim.)
  - Ensembles for ISV & TC genesis
    (Taniguchi & Yanase 2009 JMSJ)
- Evaluation using satellite data
  - GMS
  - CloudSat/CALIPSO & TRMM PR

Contribution to YOTC

- May 2008: TC Nargis & after
  - ISV/Northward Propagation and TC genesis
- June 2008: TC Fengshen
  - Obs. Palau2008/2010

- Experiments, plan and suggestions
  - Global 3.5 km run for a week
    - 15-25 June 2008
  - MJO Ensemble simulations 7km
    - 1 or 2 months x several runs
  - Multiscale structure and meso-scale convective systems
  - Comparison with satellite observations
  - Output data, time interval?