Near real-time forecasts using a global nonhydrostatic model NICAM for field campaigns

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Japan Agency for Marine-Earth Science and Technology

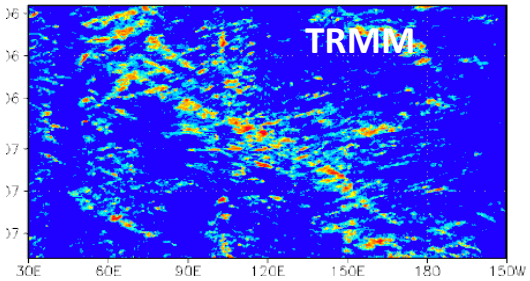
The 4th International Workshop on Nonhydrostatic Models

Nov. 30- Dec. 2, 2016 , Hakone, Japan

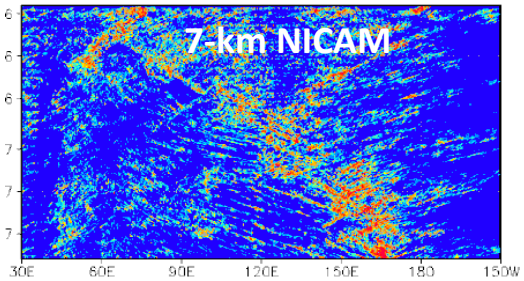
JAMSTEC field campaign and NICAM simulations

JAMSTEC RV MIRAI

2006/12/15-2007/1/16



Miura et al.(2007, Science)



- **MISMO (2006) MJO onset … First series of hindcast experiments of MJO**（Miura et al. 2007, 2009）
- **PALAU2008, PALAU2010, PALAU2013 BSISO, TC genesis global 3.5-km mesh simulations** (Hashino et al. 2013, 2016; Rho et al. 2016; Nasuno et al. 2016; Yamada et al. 2016)**; First near real-time forecasts using stretch NICAM** (Oouchi et al. 2012)
- **CINDY2011/DYNAMO MJO onset … Near real-time forecasts with stretch NICAM** (Nasuno 2013)**; global 14-km mesh hindcasts** (Miyakawa et al. 2014; Miura et al 2015)
- **Pre-YMC (2015) the Maritime Continent and MJO … near real-time forecasts with 7- and 14-km mesh NICAM**

Goal:

Observing the weather and climate system in the Maritime Continent to improve understanding and prediction of its local variability and global impact

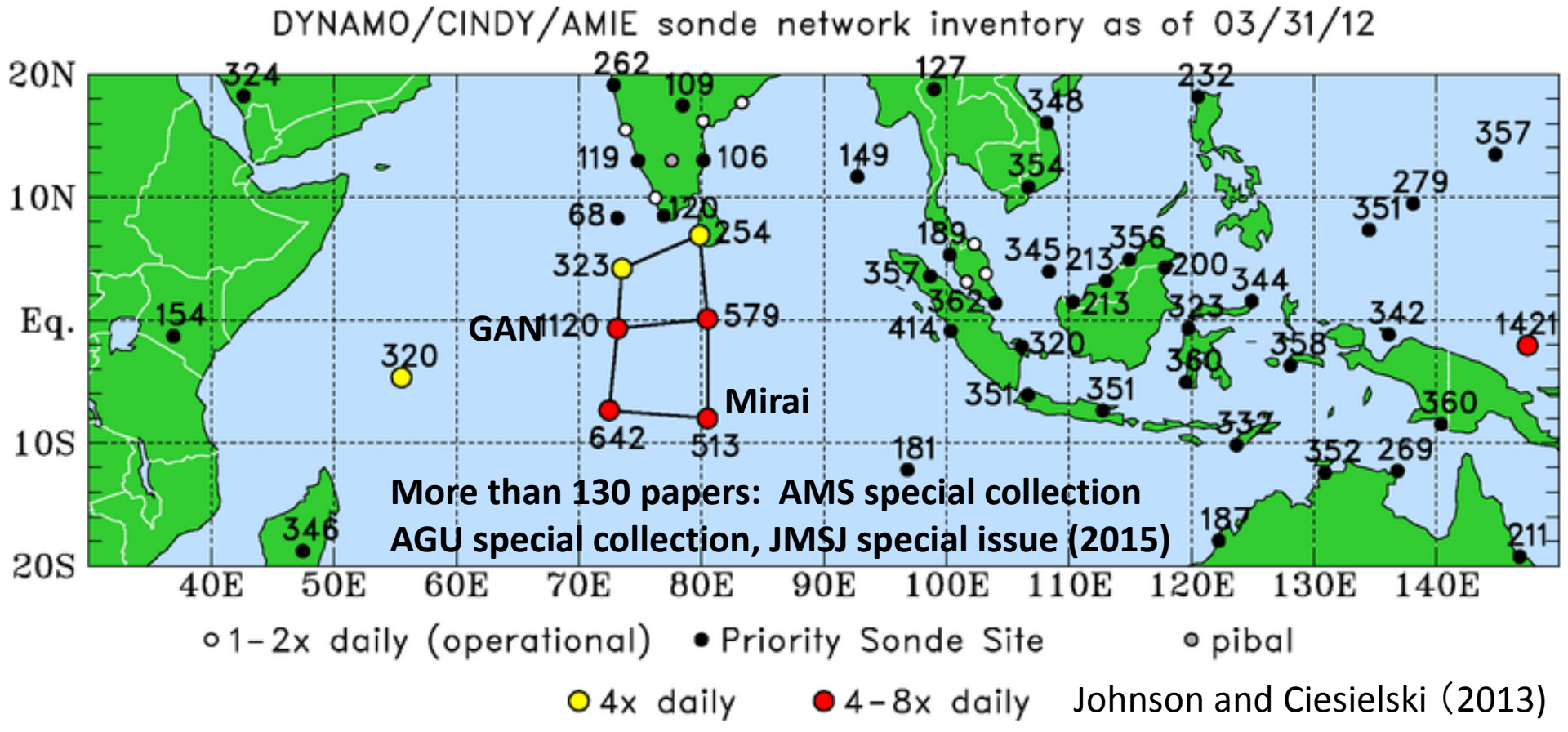
CINDY2011 / DYNAMO

Cooperative Indian Ocean experiment on intraseasonal variability in the Year 2011 / Dynamics of the Madden-Julian Oscillation

1 October 2011- 31 March 2012

Goal :

collect **in-situ observations** to advance our understanding of **MJO initiation** process and to improve **MJO prediction and simulation**.



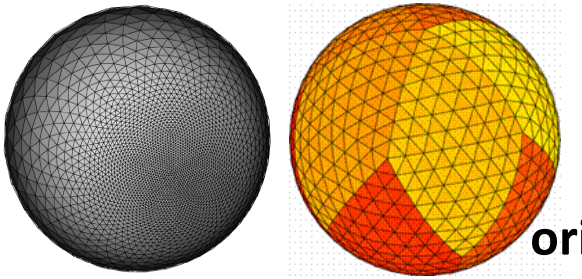
Johnson and Ciesielski（2013）

NICAM simulation (real-time forecasts)

Nasuno (2013, SOLA, 9, 69-73)

Nonhydrostatic ICosahedral Atmospheric Model
Satoh et al. (2008, 2014)

stretched grid
Tomita (2008)



original grid

Model: regionally stretched NICAM

Resolution: 14~56 km mesh (center: 80E, 8S), 40 levels

Domain of output data: 20-140E, 53S-37N

Length of forecasts: 7-days (6.5-days useful)

Period: 1 Oct. 2011-31 Jan. 2012

Frequency: daily

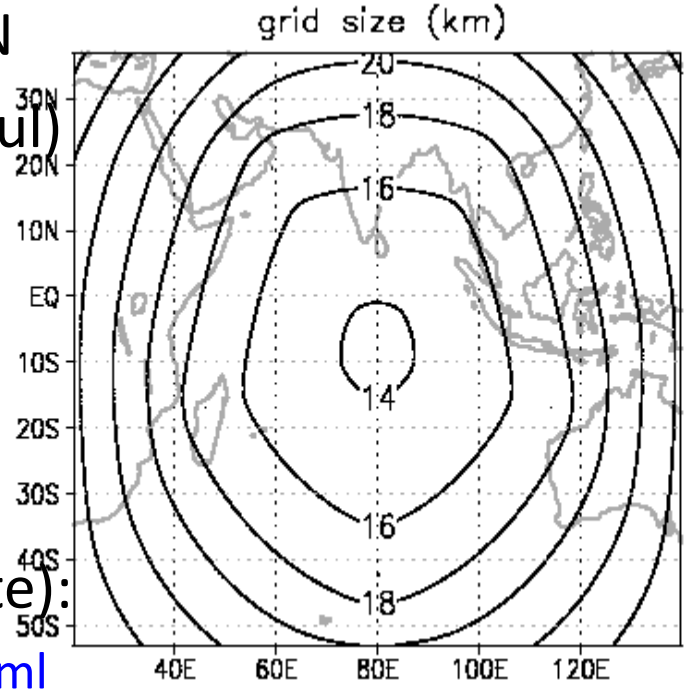
initialization: NCEP_FNL, interpolation

SST: slab ocean model (1-layer)

Data access (CINDY2011 JAMSTEC web site):

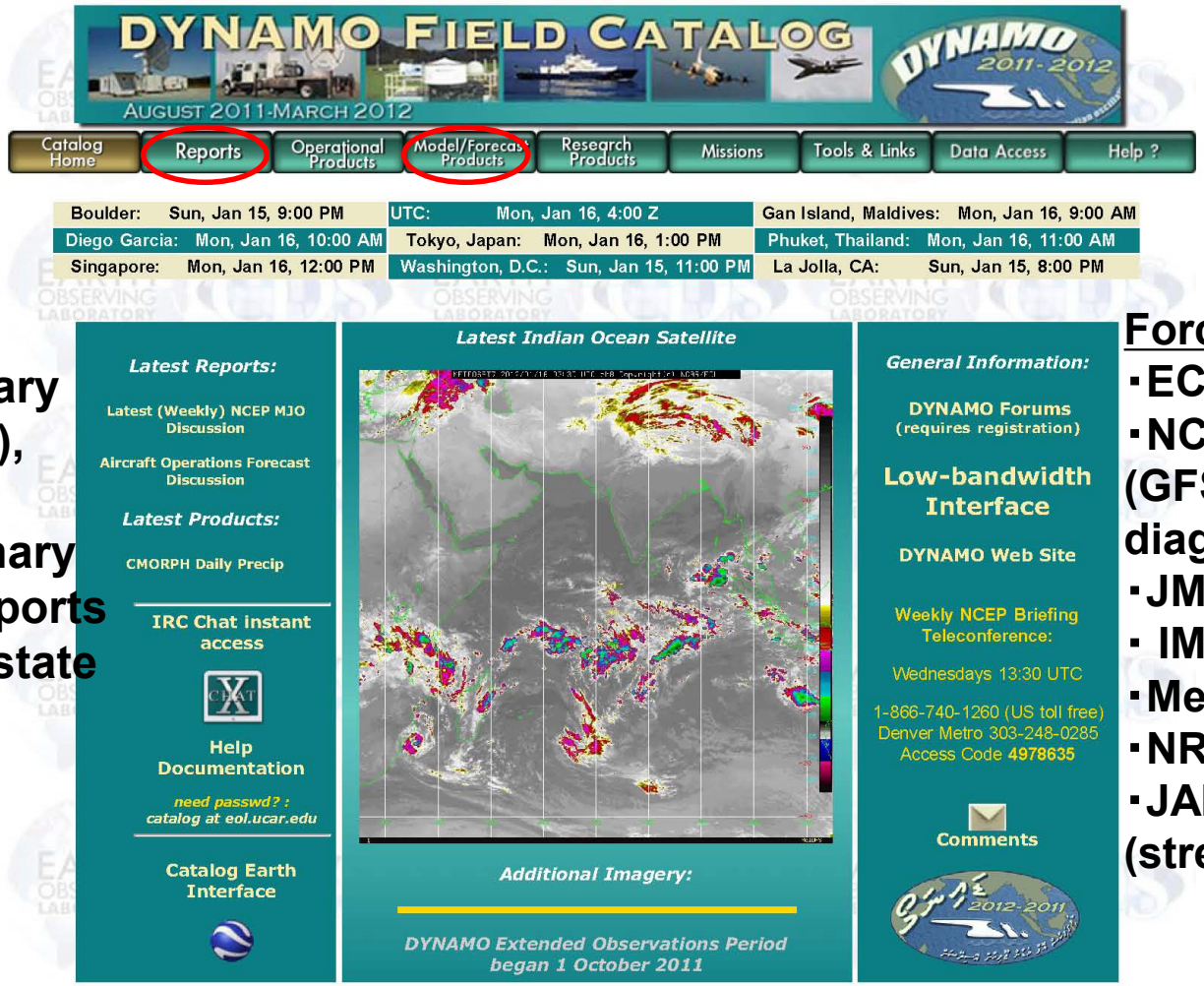
http://www.jamstec.go.jp/iorgc/cindy/obs/obs.html

link from DYNAMO page
(http://data.eol.ucar.edu/master_list/?project=DYNAMO)



EOL/DYNAMO FIELD CATALOG - Home

http://catalog1.eol.ucar.edu/dynamo/index.html

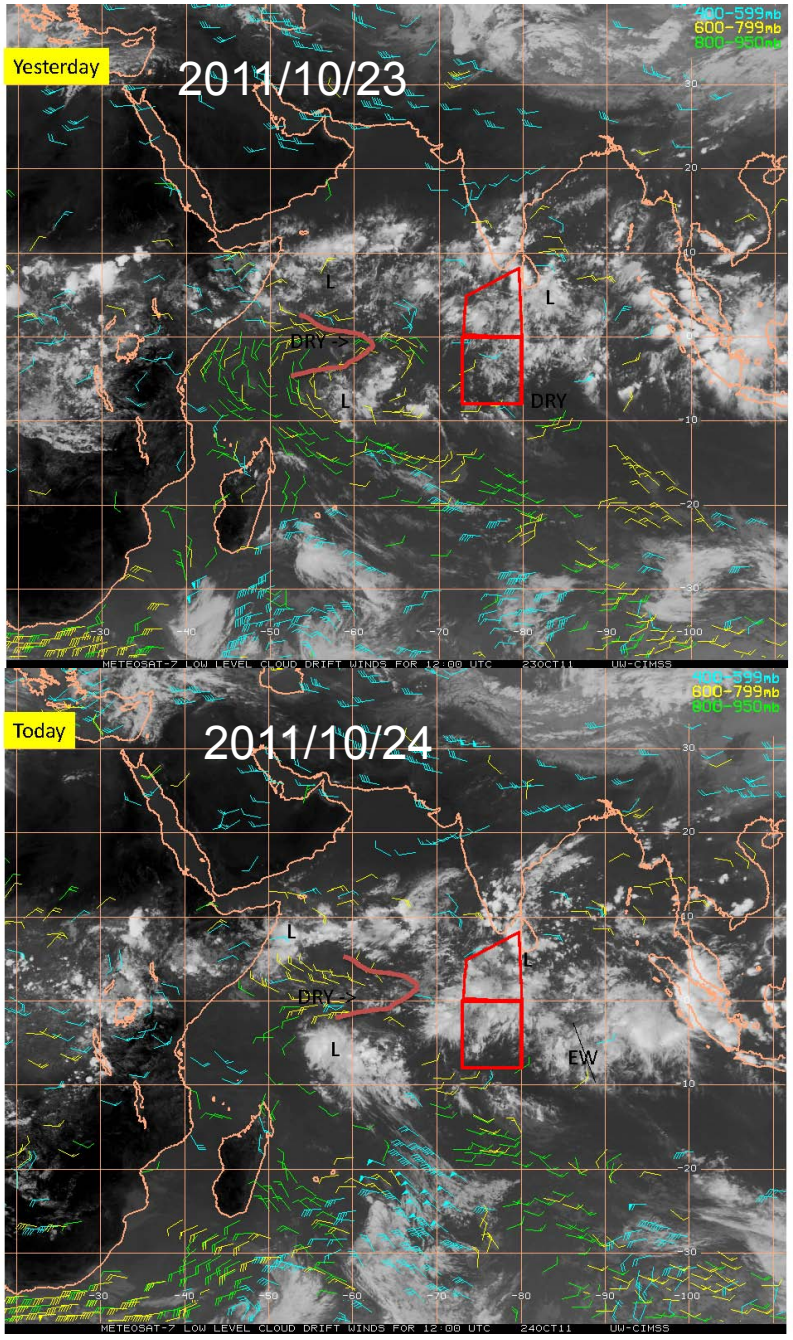


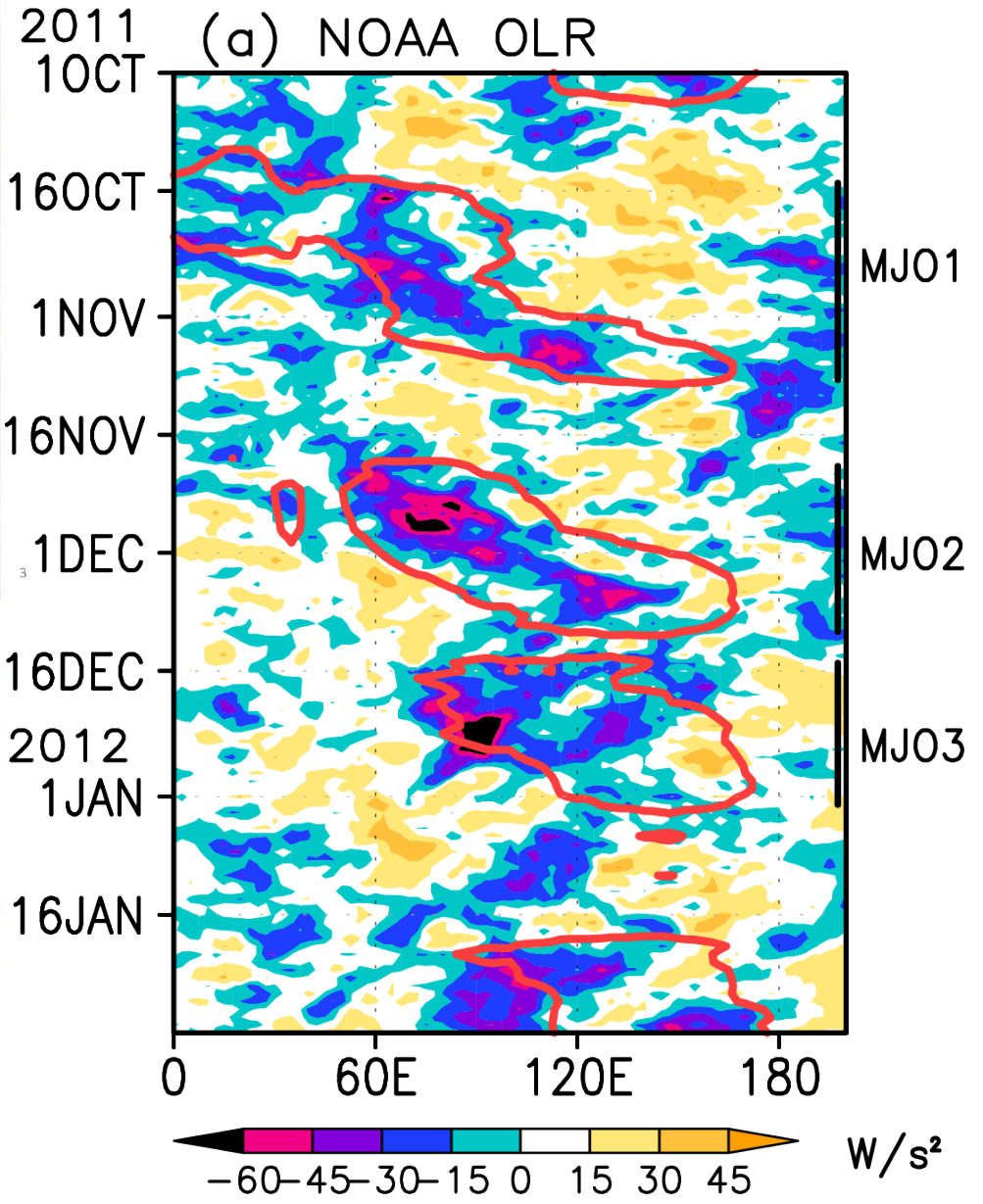
Reports

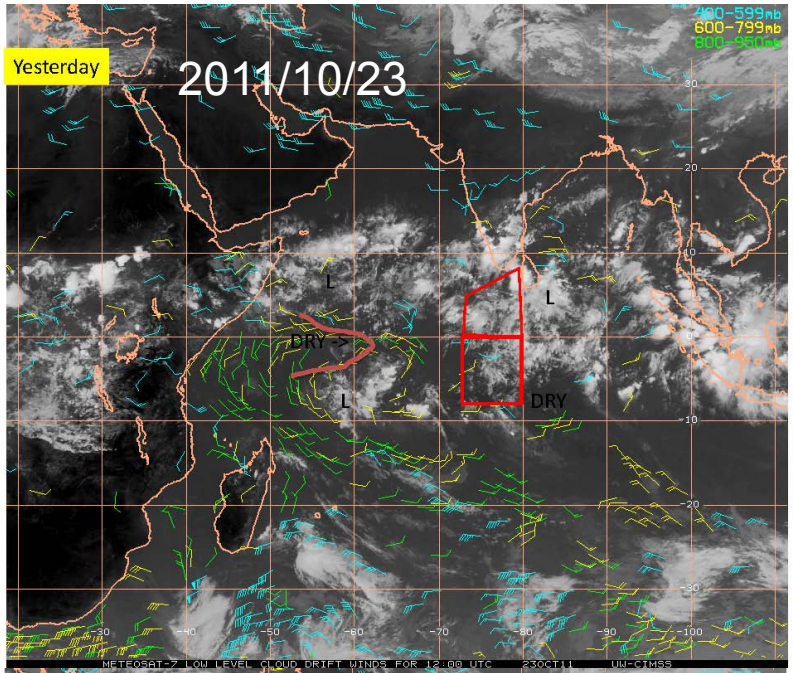
- Weekly Summary (teleconference),
- Daily Report
- Science Summary
- Operational reports
- Intraseasonal state summary

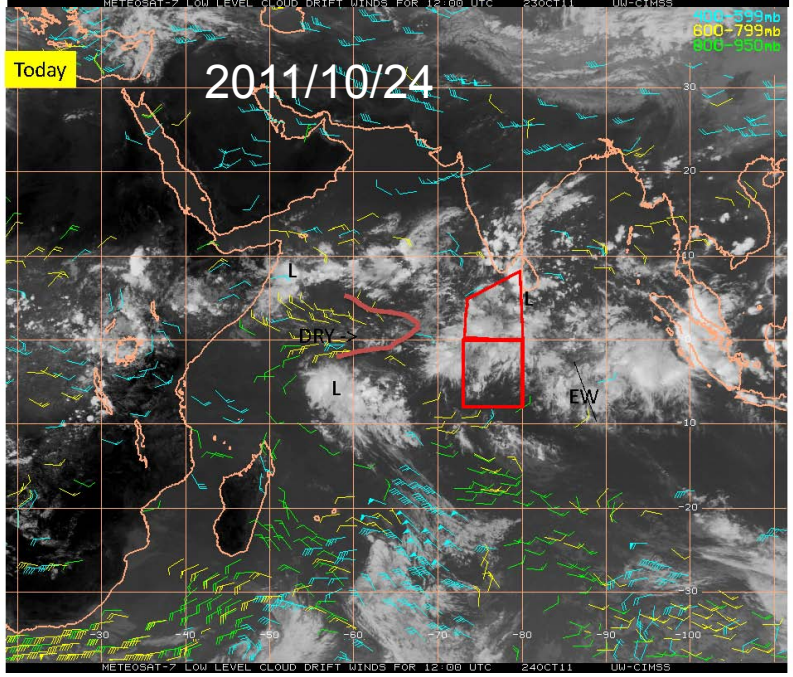
Forcasts/Models

- ECMWF
- NCEP CPC (GFS, GEFS, CFS, diagnostics)
- JMA
- IMD
- Meteo-France
- NRL (COAMPS)
- JAMSTEC (stretched NICAM)

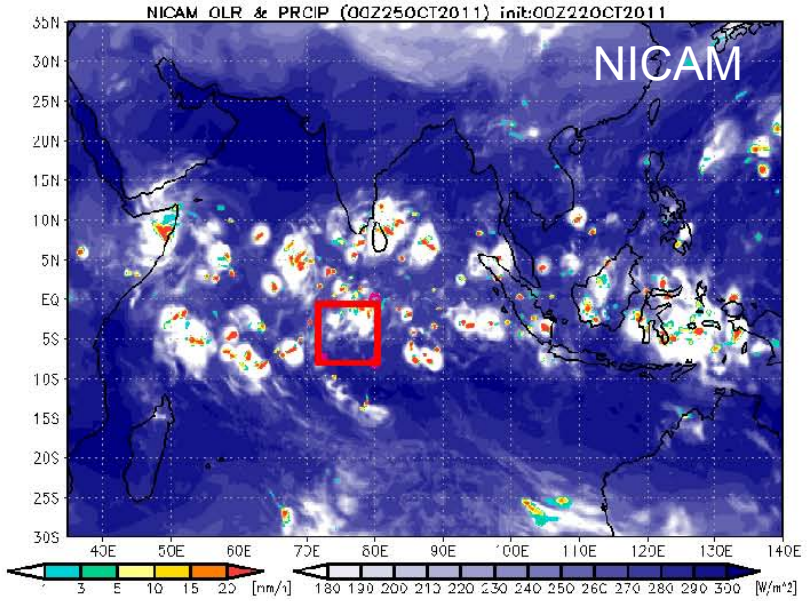

Yesterday
2011/10/23
L
L
DRY
L
DRY
METEOSAT-7 LOW LEVEL CLOUD DRIFT WINDS FOR 12:00 UTC 23OCT11 UW-CIMSS
Today
2011/10/24
L
L
DRY
L
EW
METEOSAT-7 LOW LEVEL CLOUD DRIFT WINDS FOR 12:00 UTC 24OCT11 UW-CIMSS

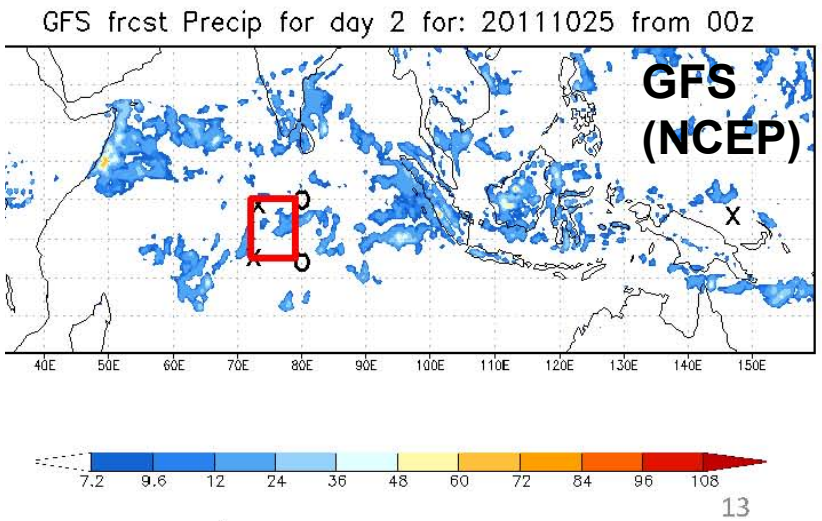

2011
10CT
16OCT
1NOV
16NOV
1DEC
16DEC
2012
1JAN
16JAN
(a) NOAA OLR
MJO1
MJO2
MJO3
0
60E
120E
180
−60 −45 −30 −15 0 15 30 45
W/s²


Yesterday
2011/10/23
400-599mb
600-799mb
800-950mb
L
DRY
L
L
DRY
METEOSAT-7 LOW LEVEL CLOUD DRIFT WINDS FOR 12:00 UTC 23OCT11 UW-CIMSS


Today
2011/10/24
400-599mb
600-799mb
800-950mb
L
DRY
L
L
EW
METEOSAT-7 LOW LEVEL CLOUD DRIFT WINDS FOR 12:00 UTC 24OCT11 UW-CIMSS

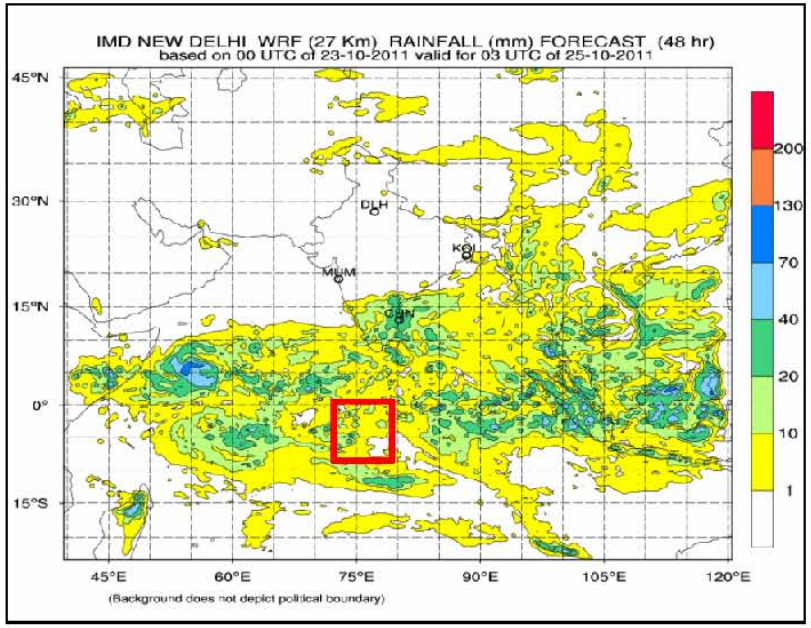
t. – 0Z 25 Oct.

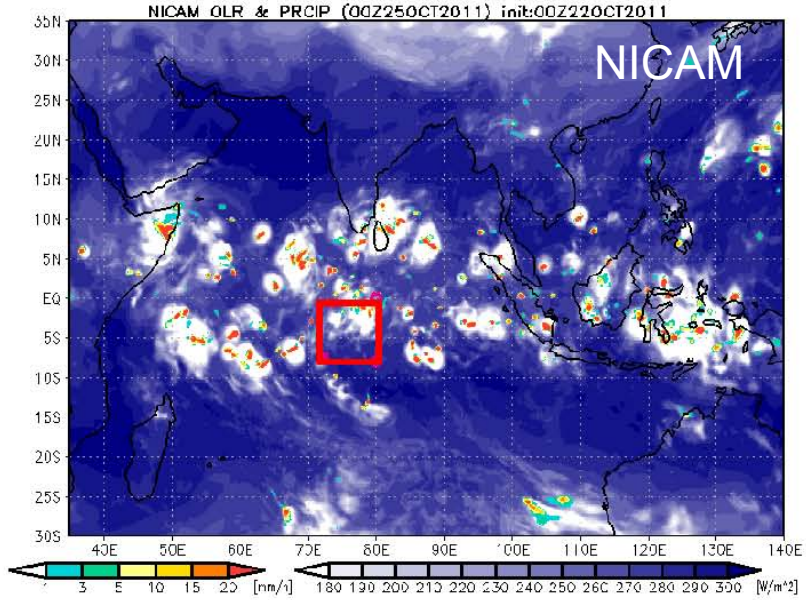

NICAM OLR & PRCIP (00Z25OCT2011) init:00Z22OCT2011
NICAM
35N
30N
25N
20N
15N
10N
5N
EQ
5S
10S
15S
20S
25S
30S
40E
50E
60E
70E
80E
90E
100E
110E
120E
130E
140E
3 5 10 15 20 [mm/h]
180 190 200 210 220 230 240 250 260 270 280 290 300 [W/m^2]


GFS frcst Precip for day 2 for: 20111025 from 00z
GFS
(NCEP)
40E
50E
60E
70E
80E
90E
100E
110E
120E
130E
140E
150E
7.2 9.6 12 24 36 48 60 72 84 96 108

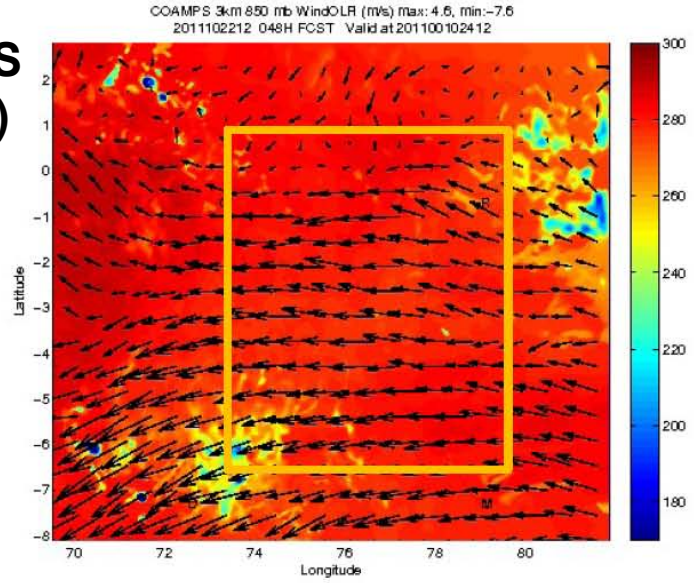
Day 1: 0Z 24 Oct. – 0Z 25 Oct.

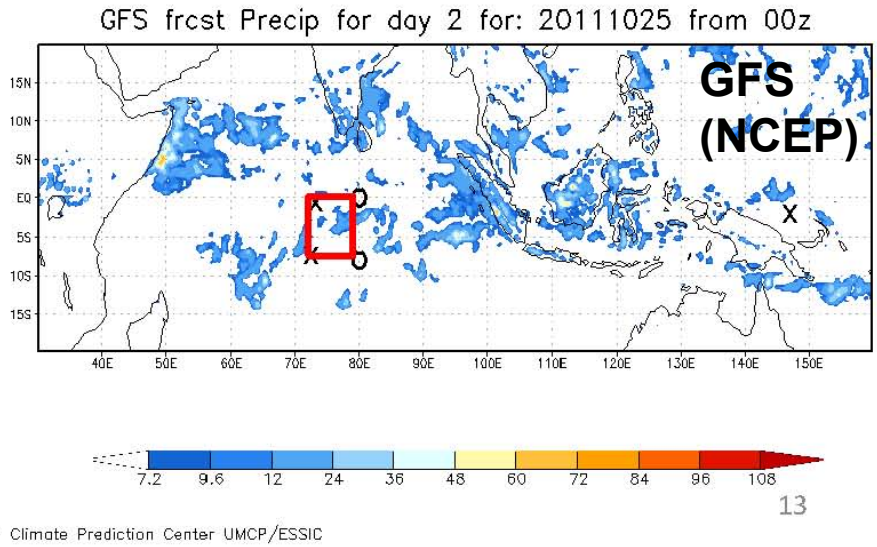
WRF (IMD)





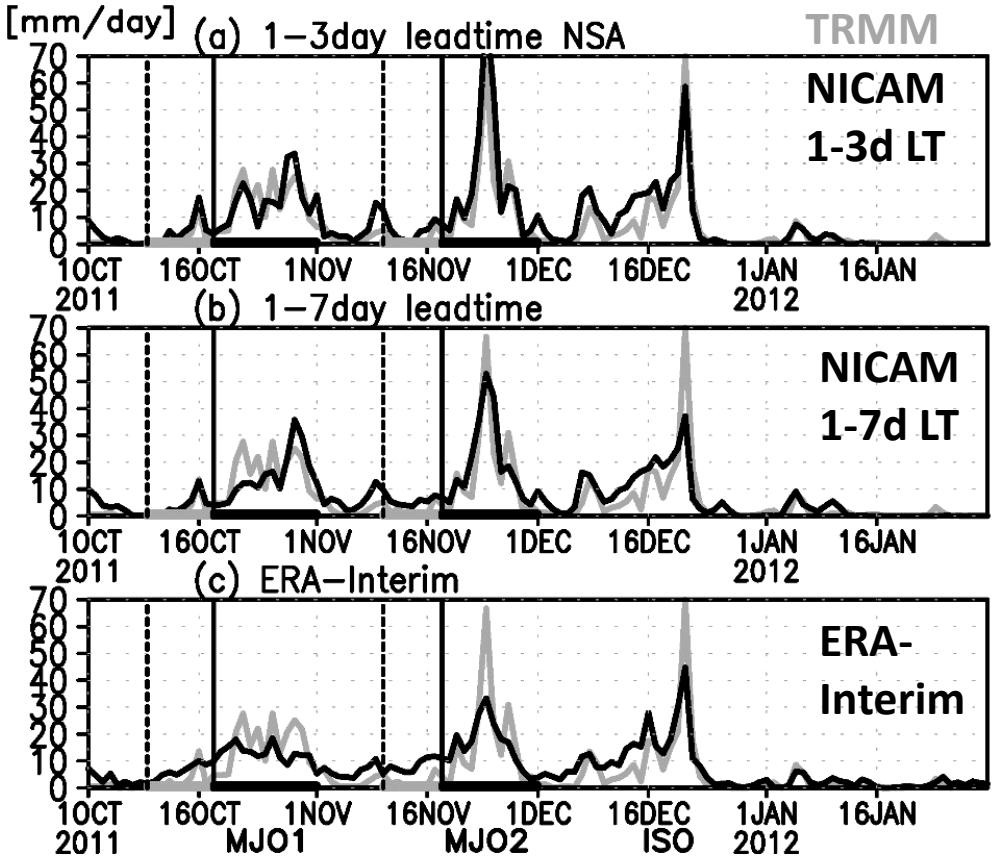
COAMPS (NRL)





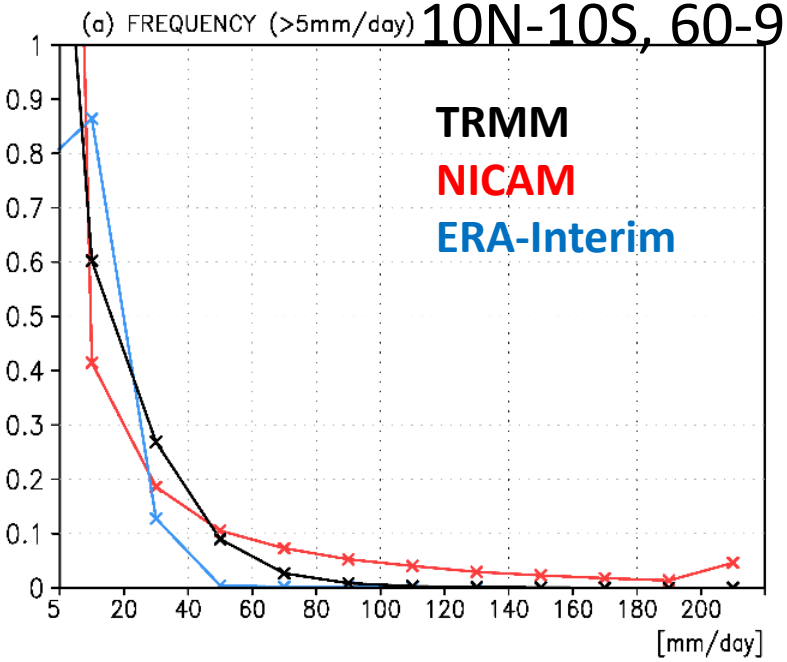
· Climate Prediction Center UMCP/ESSIC

Precipitation (comparison with TRMM 3B42v7)



Contrast between active and suppressed period is well represented

PDF of surface precipitation 10N-10S, 60-90E

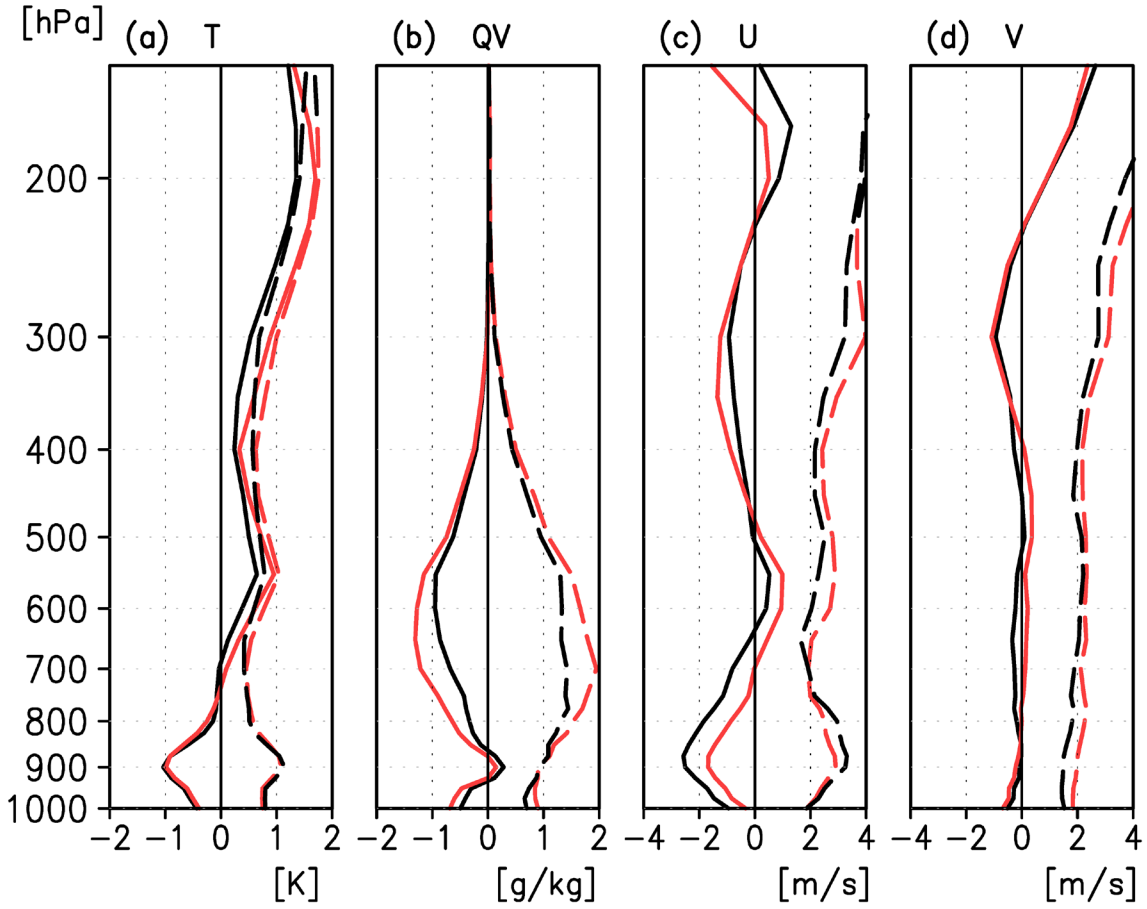


Strong precip: excessive
Moderate precip: insufficient

Nasuno et al., in revision

Model evaluation: deviation from radiosonde sounding

CINDY2011/
DYNAMO
Period mean



GAN (73E, 0.75S)

Forecast
--- 1-3 day
--- 1-7 day

Solid: anomaly
Dashed: RMSE

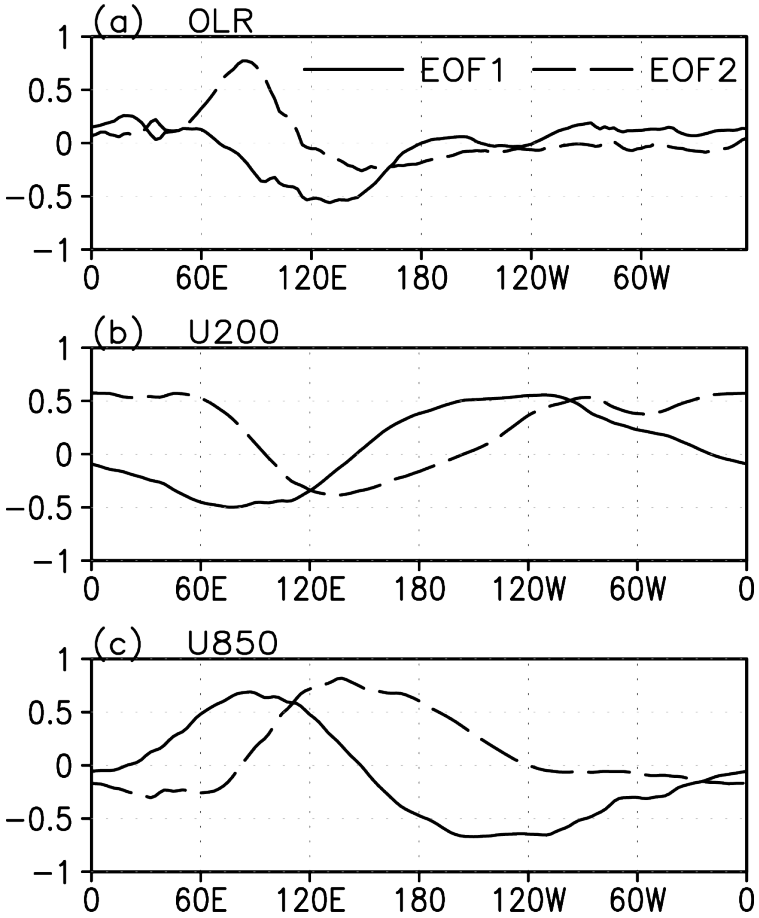
Dry & Warm bias in 900-400 hPa more subsidence (associated with too vigorous convection)

Fig. 9 The IOP mean sounding biases at Gan Island (73E, 0.7S) in (a) temperature, (b) specific humidity, (c) zonal and (d) meridional wind. NICAM simulations minus observations at the 1-3-day (black), and 1-7-day (red) day lead time average (solid lines) and root mean square differences (dashed lines) are plotted.

Nasuno et al., in revision

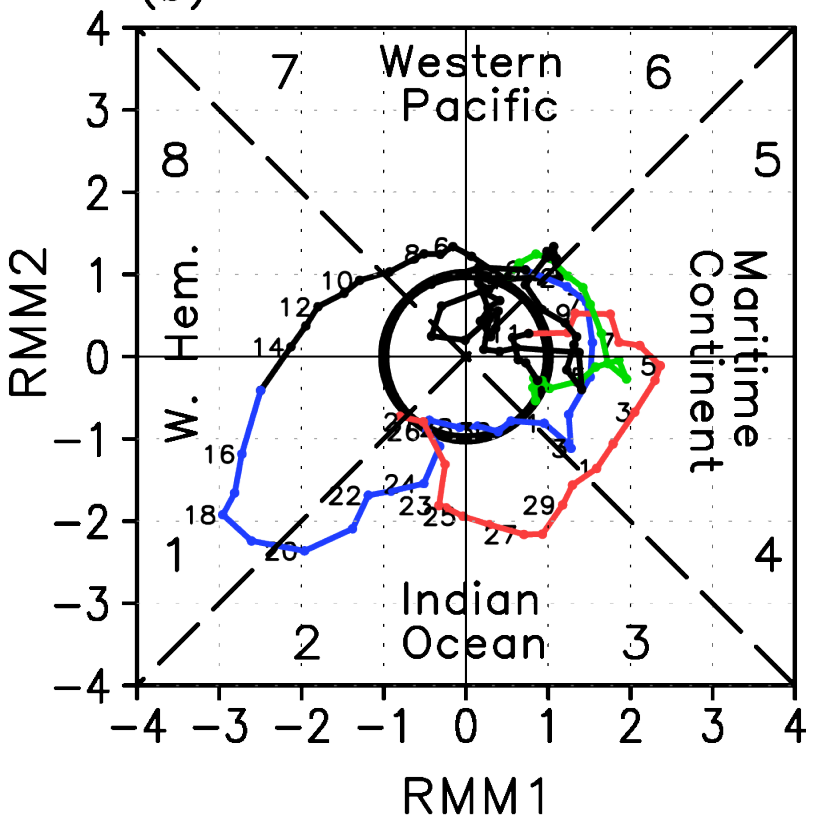
Evaluation of MJO forecast skill in stretch NICAM

Represent MJO amplitude and propagation by linear combination of zonal structure of two leading EOF mode of OLR, U850, and U200.



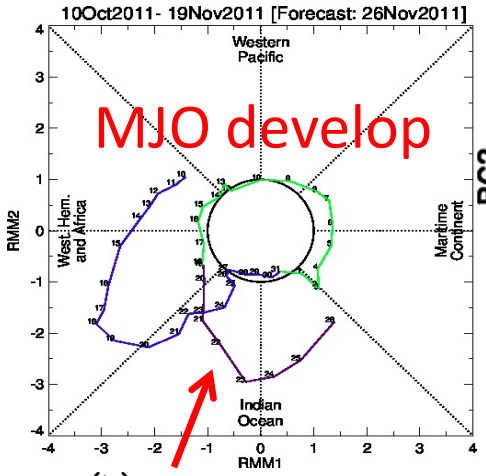
Realtime multivariate MJO index (RMM) diagram

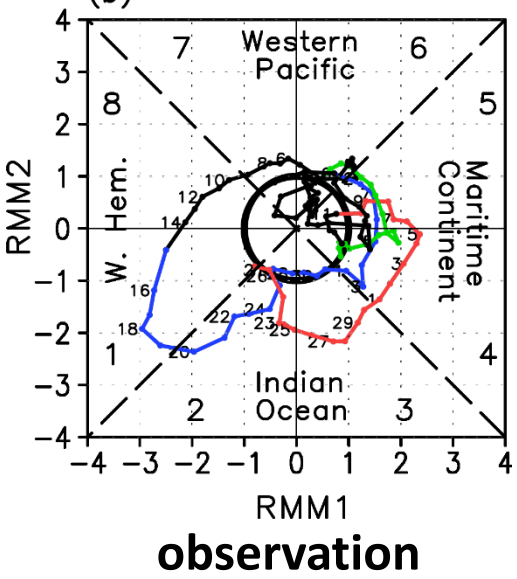
Wheeler & Hendon (2004)



MJO forecast skill

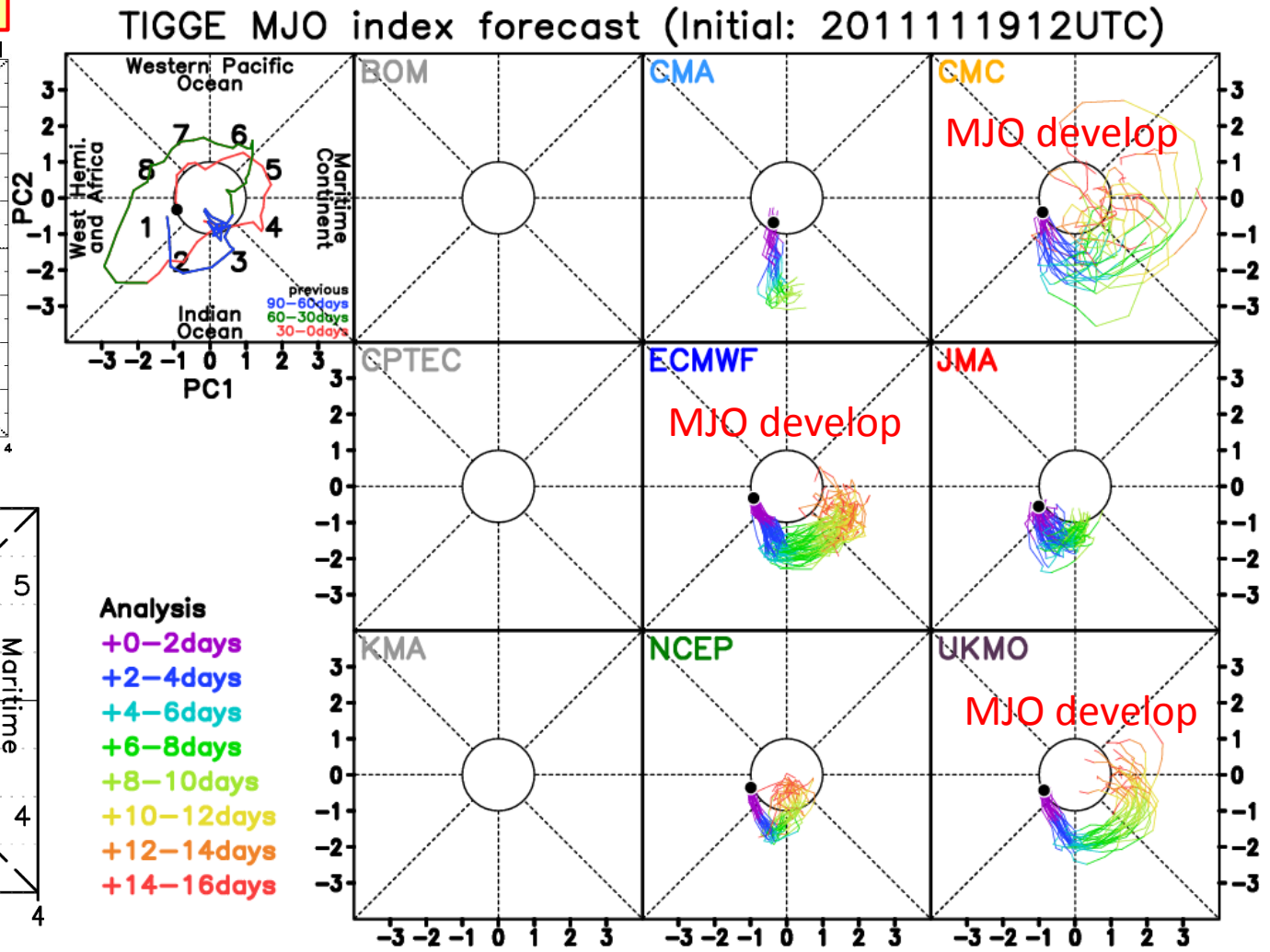
Stretch NICAM





observation

Operational forecasts by Dr. Matsueda



http://tparc.mri-jma.go.jp/TIGGE/tigge_MJO.html

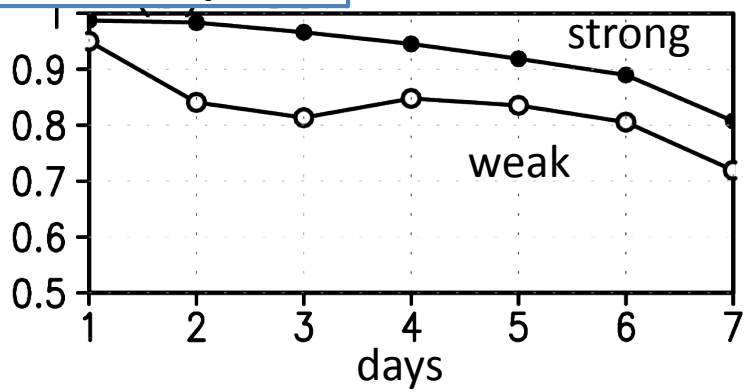
MJO forecast skill score

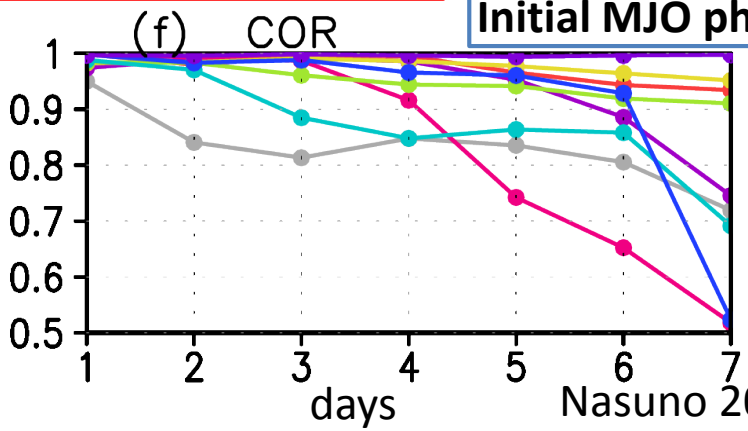
$$COR^i(t,\tau) = \frac{a_1(t)f_1^i(t,\tau) + a_2(t)f_2^i(t,\tau)}{\sqrt{a_1(t)^2+a_2(t)^2}\sqrt{f_1^i(t,\tau)^2+f_2^i(t,\tau)^2}}$$

Dependence on Initial MJO amplitude

Stretch NICAM (>14-km mesh)

Dependence on Initial MJO phase

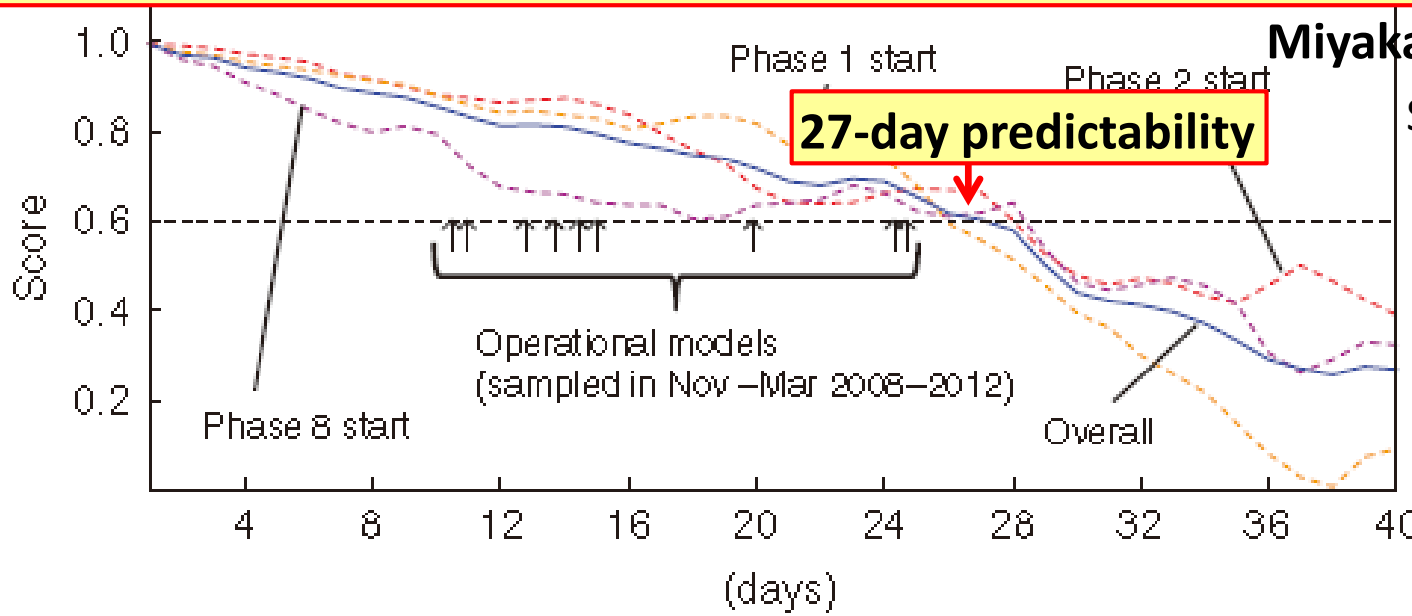




related to Systematic Biases in flow fields

Nasuno 2013

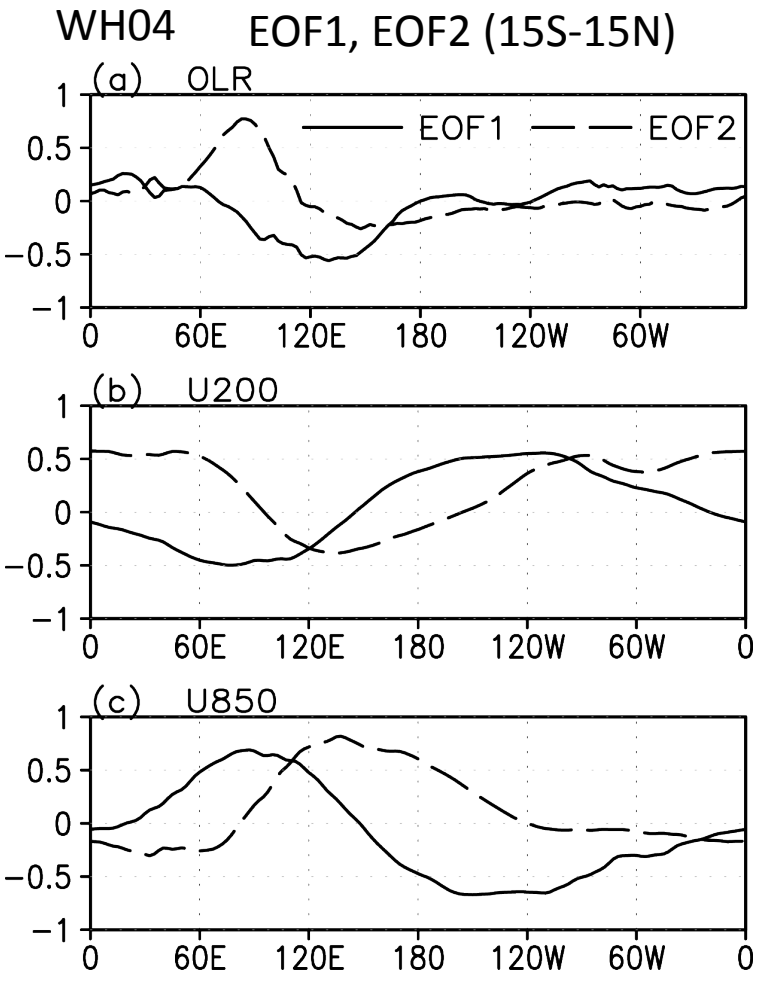
Global 14-km mesh NICAM ensemble hindcasts (54 members)

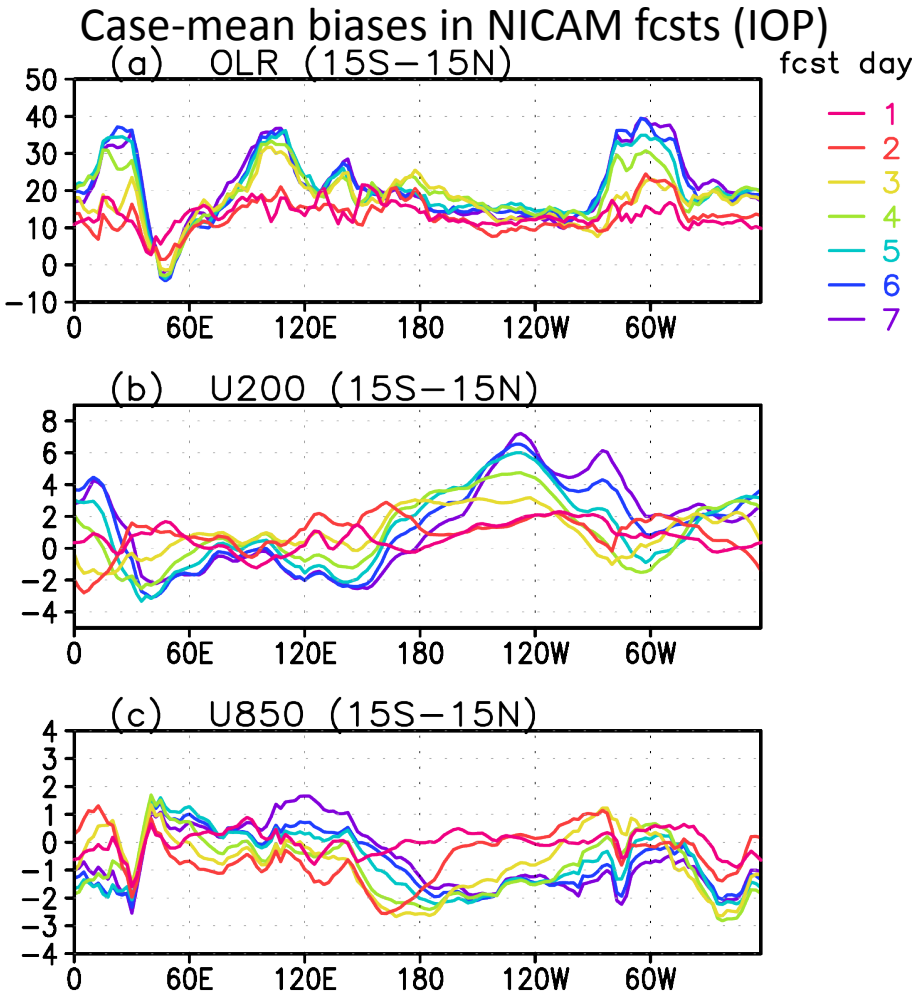


Miyakawa et al. 2014

Start from (MJO phase 8, 1, 2)

Evaluation of MJO forecast skill in stretch NICAM





Growth of biases in circulations centered on the Maritime Continent (similar to EOF1)
Leads to systematic positive biases in RMM1.
The RMM2 error is more related to OLR error (suppressed convection over the IO)

Nasuno (2013)

Summary

- **Stretch NICAM (>14-km mesh, week-long)** was used for **near real-time forecasts** in CINDY/DYNAMO campaign.
- **Precipitation: active and suppressed phase of MJO** are well captured by explicit treatment of convection, but with excessive (insufficient) occurrence of strong (moderate) precipitation.
- **Sounding: dry & warm biases** (related to convection bias)
- **MJO skill score:** Evolution of the MJO events were predicted at COR ~0.8, better performance for larger initial MJO amplitude, dependence on initial MJO phase, due to the systematic biases in flow fields and convection.

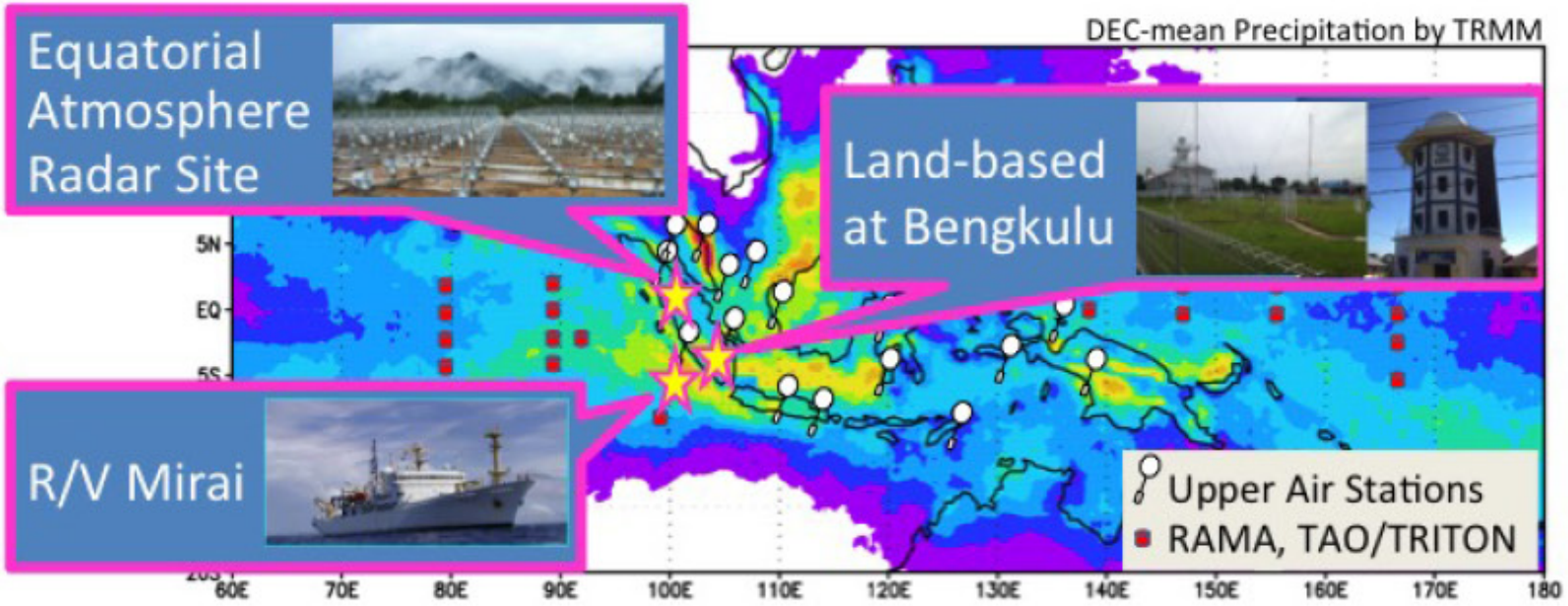
→ Bias correction will improve forecast skill for operation

Goal:

Observing the weather and climate system in the Maritime Continent to improve understanding and prediction of its local variability and global impact

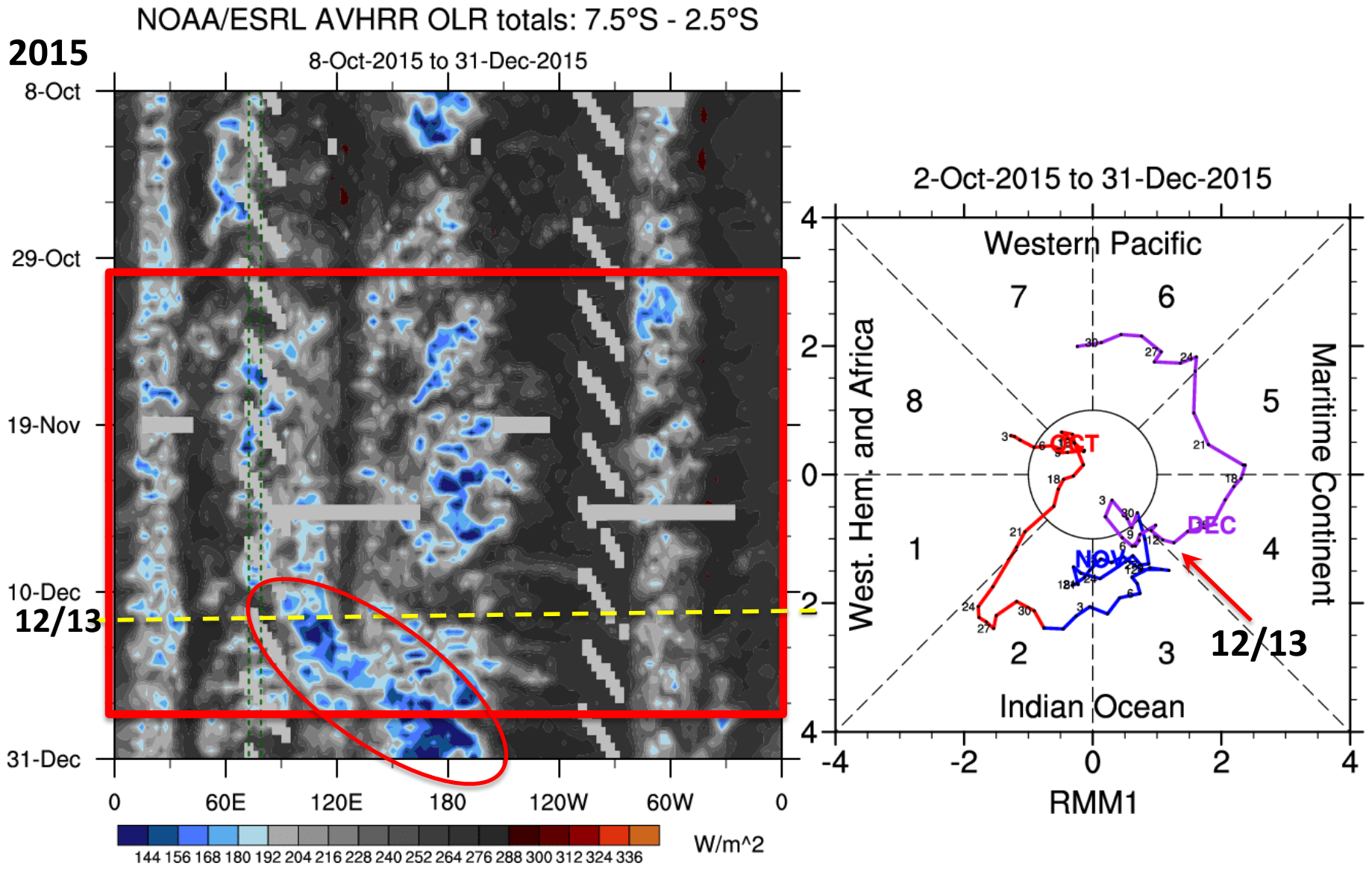
Global non-hydrostatic simulation of the Pre-YMC field campaign in 2015

Objective: deepen our understanding of
the relationship between local convection and MJO



NICAM Simulations for pre-YMC campaign

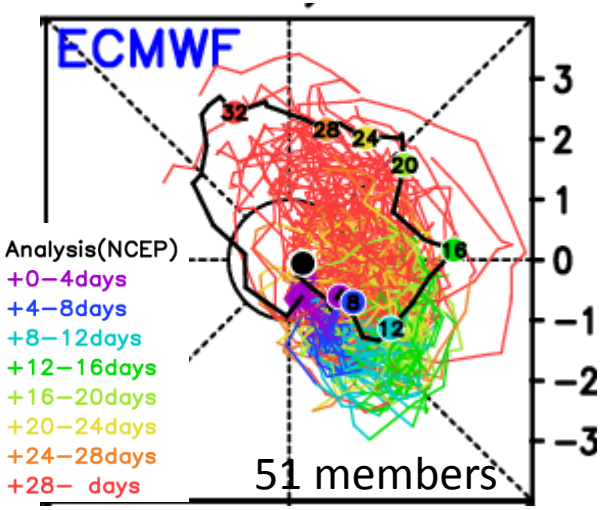
- horizontal mesh size: **7 km (7-days), 14 km (30-days)**
- vertical levels: 40L (0 m ~ 38,000 m)
- cloud microphysics : NSW6 (Tomita 2008)
- **convective parameterization: off**
- turbulence : MYNN level 2 (Nakanishi and Niino 2004; Noda et al. 2010)
- radiation : MSTRN X (Sekiguchi and Nakajima 2008)
- land surface : MATSIRO
- **initial data** (atmosphere, land-ocean surface): interpolated from **NCEP final analysis (1.0x1.0)**
- **SST: 1. prescribed (climatology + initial anomaly)**
  2. predict using slab ocean model



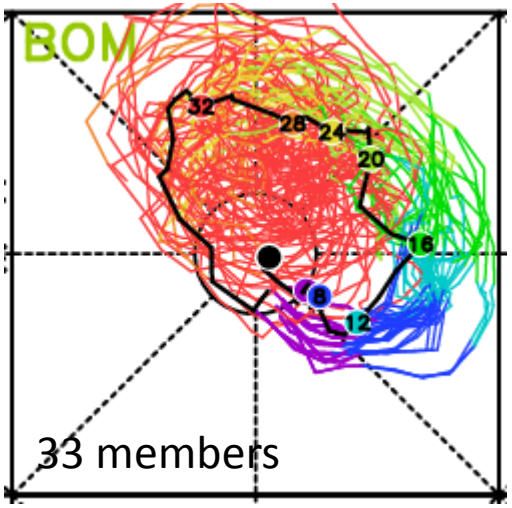
CICS-NC http://monitor.cicsnc.org/mjo/rmm/

Wheeler and Hendon (2004) diagram for the Pre-YMC period

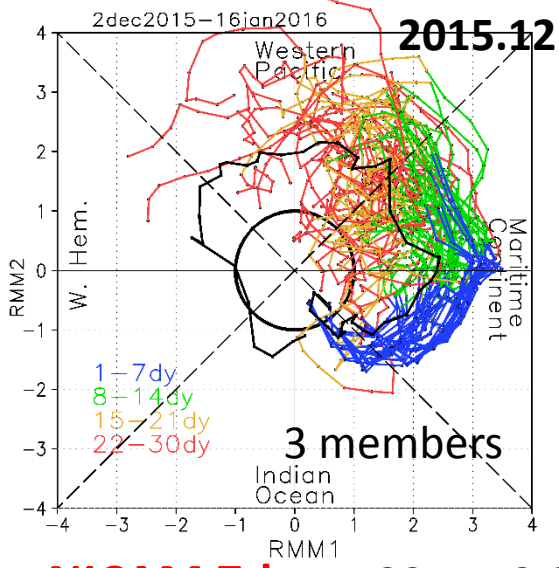
2015.12.03 init



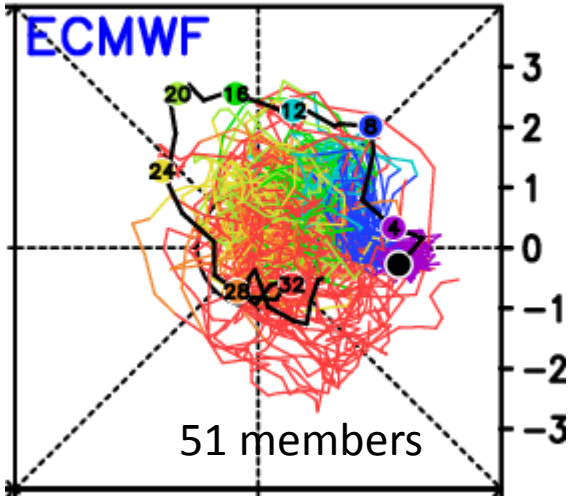
2015.12.03 init



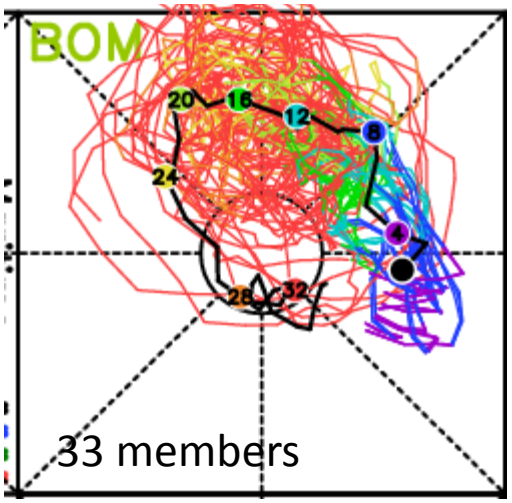
NICAM 14-km **2015.12.02-2015.12.17 init**



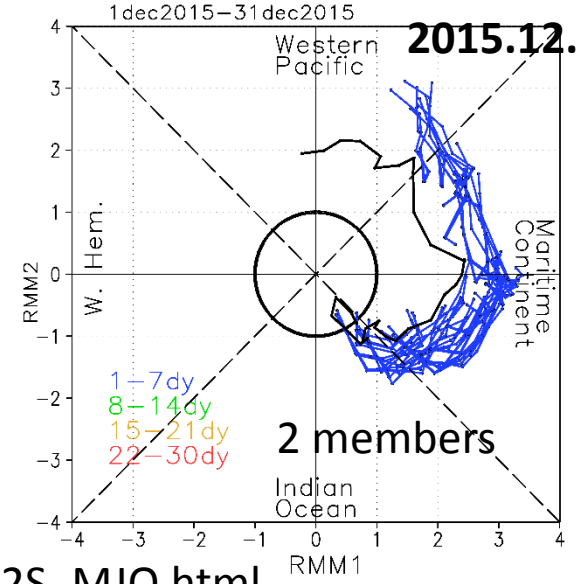
2015.12.17 init



2015.12.17 init



NICAM 7-km **2015.12.01-2015.12.25 init**



S2S MJO forecasts http://gpvjma.ccs.hpcc.jp/S2S/S2S_MJO.html

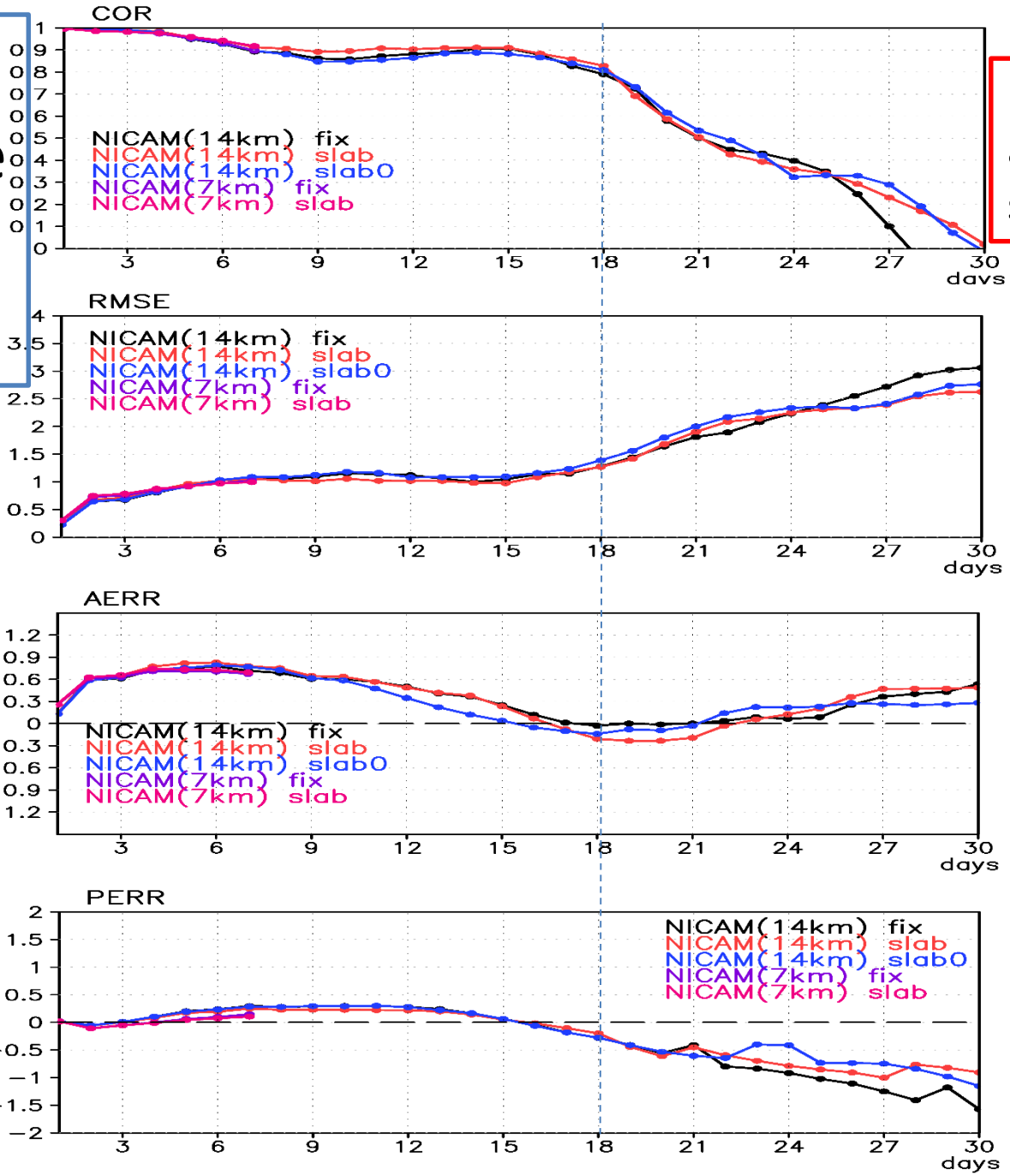
S2S data portal http://apps.ecmwf.int/datasets/data/s2s/levtype=sfc/type=cf/

Realtime Multivariate MJO index skill score

Wheeler and Hendon (2004)
Cottschalck et al (2010)

Systematic Amplitude and Phase errors

Ensemble mean
28 runs: 14-km
55 runs: 7-km



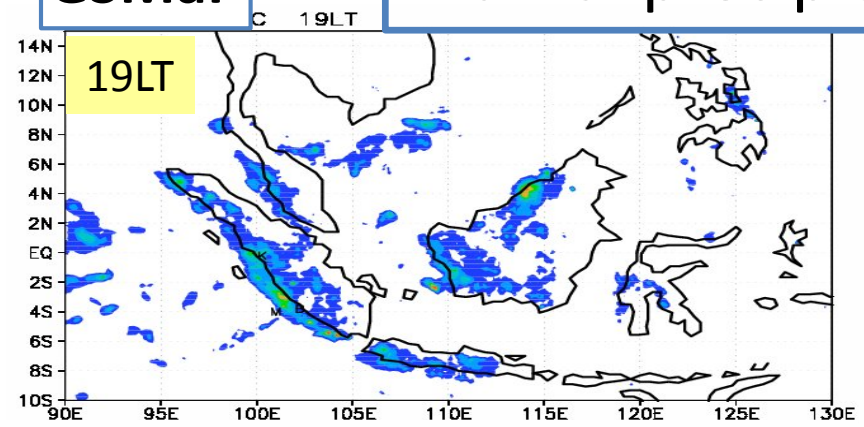
15-18 day acceptable skill

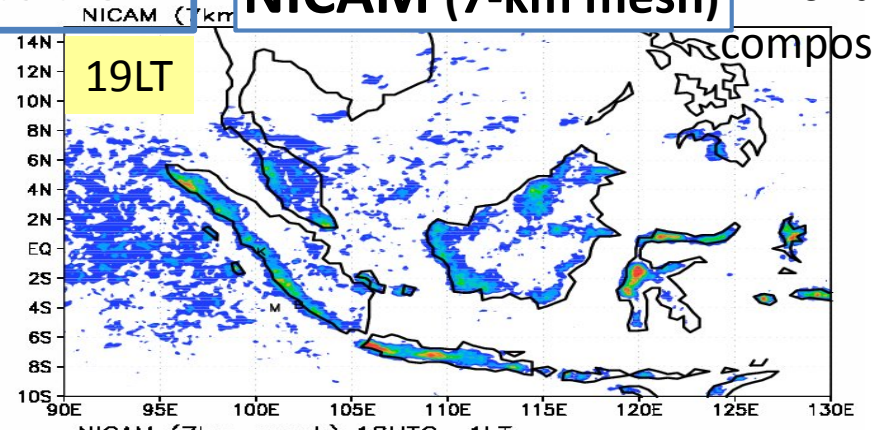
Diurnal precipitation

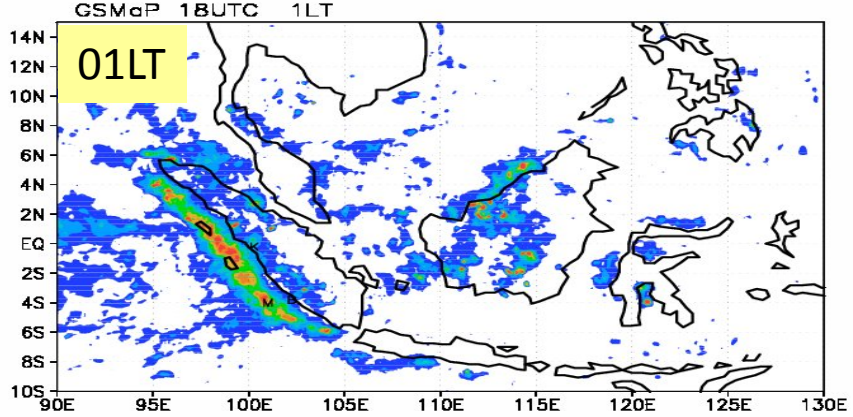
GSMaP

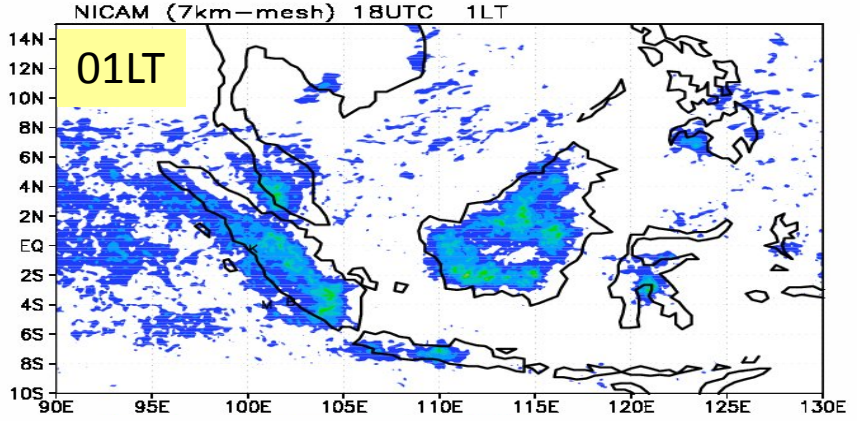
NICAM (7-km mesh)

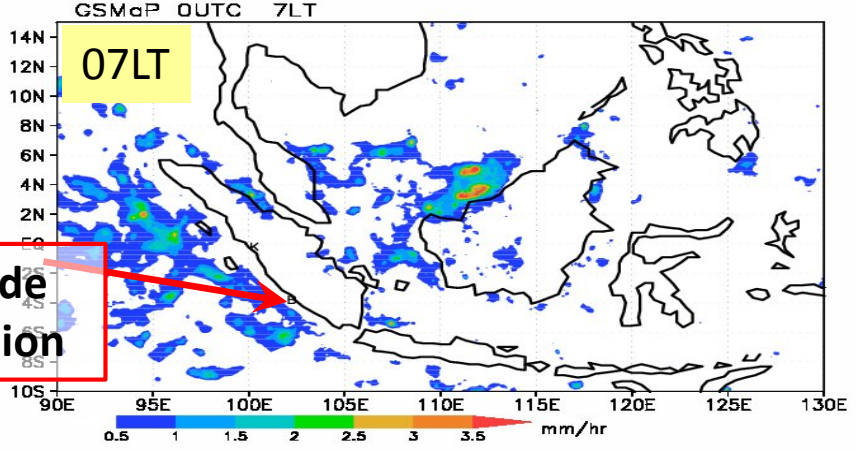
40 run composite

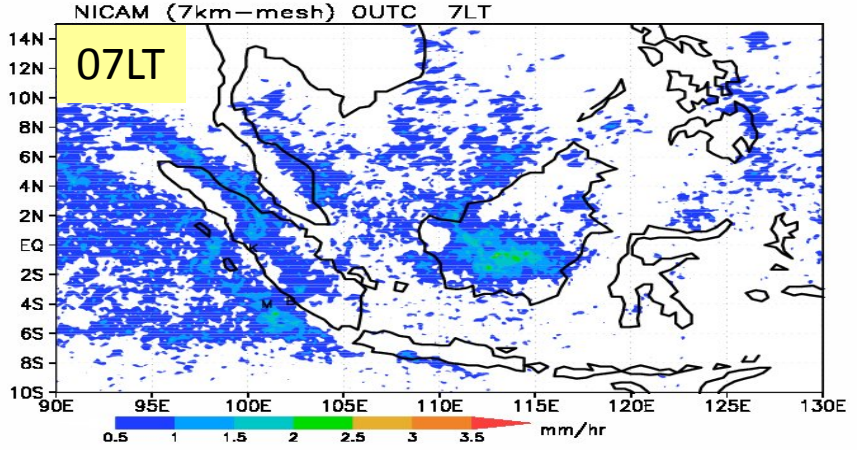












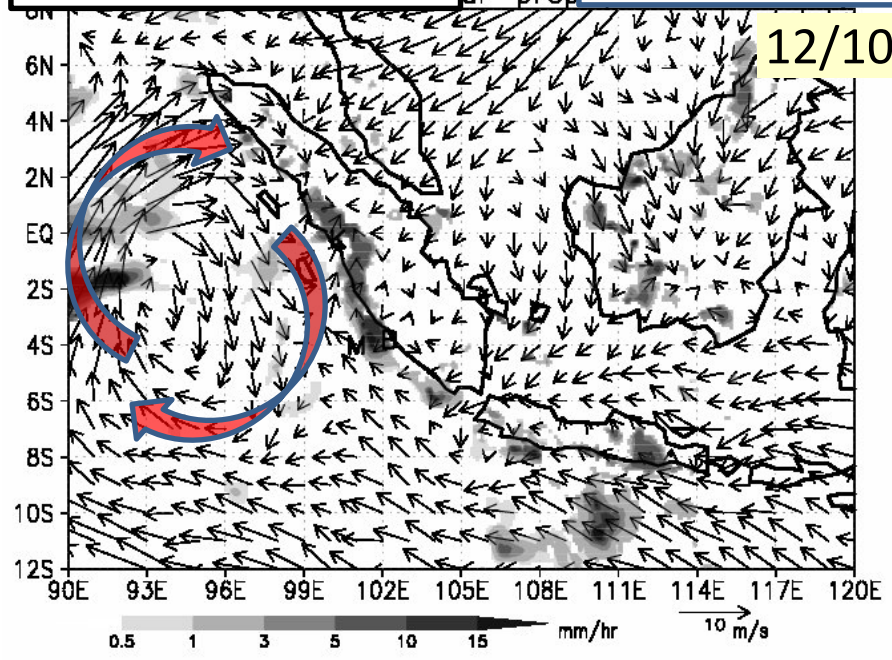
sonde station

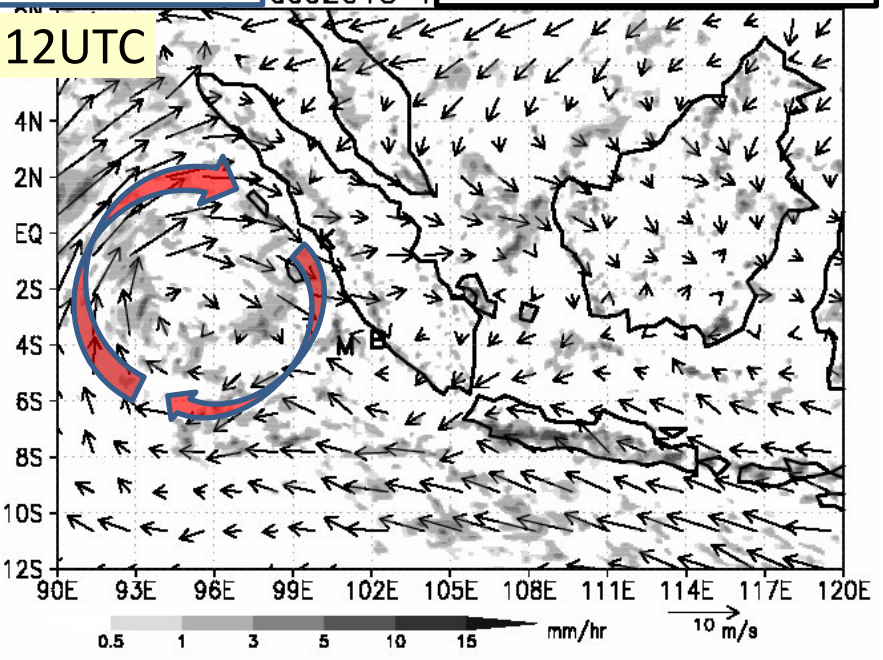
Precip, 850 hPa wind

GSMaP, NCEP_FNL

NICAM 7km mesh

12/10 12UTC





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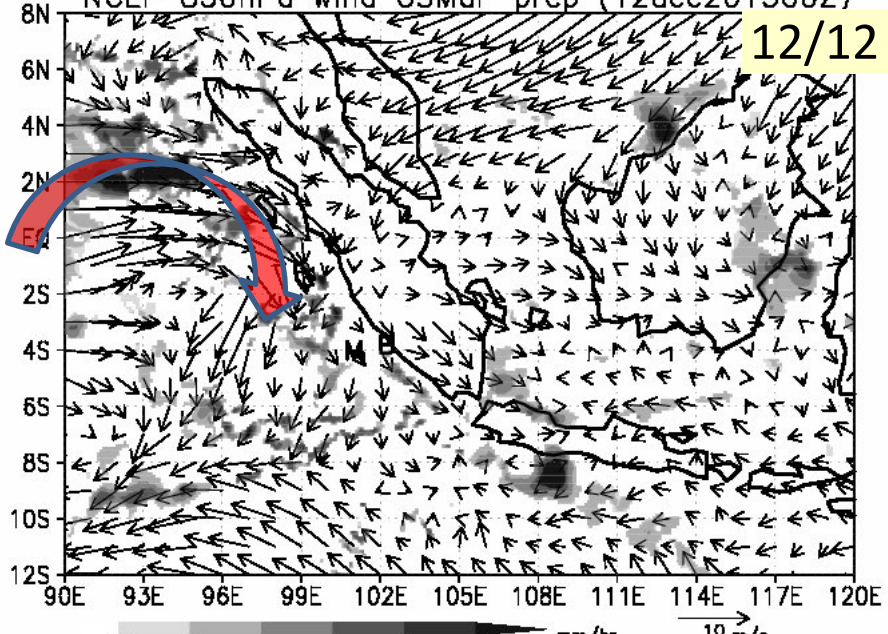
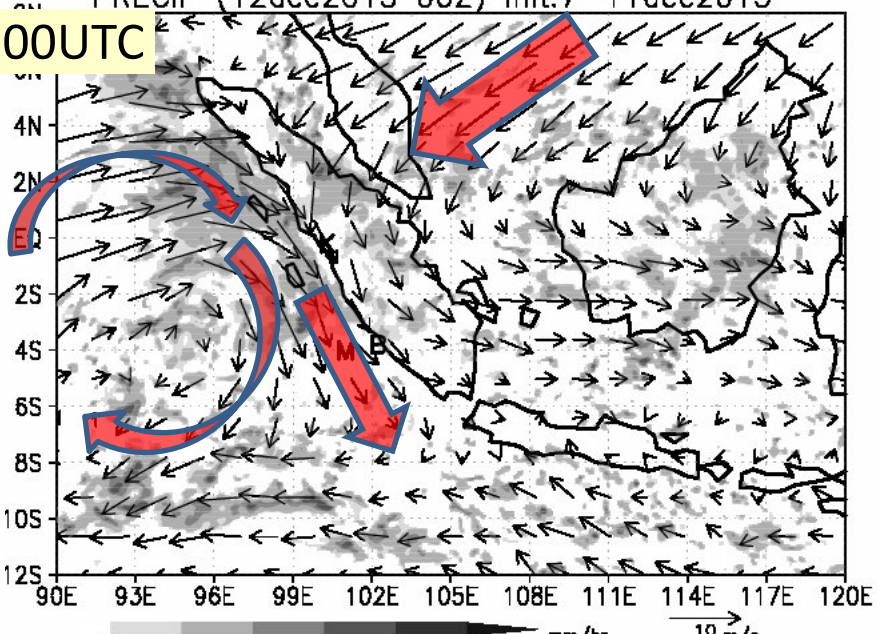


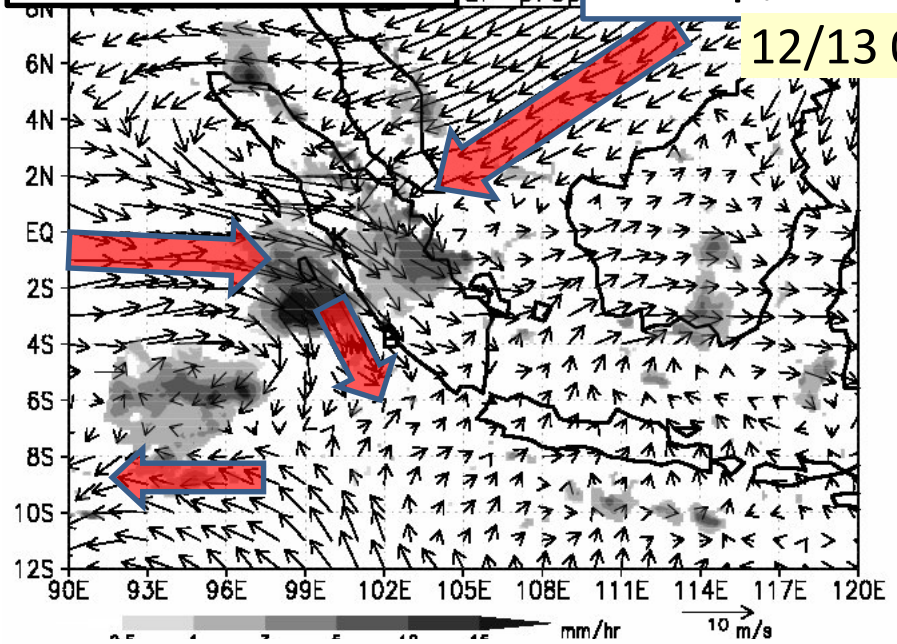


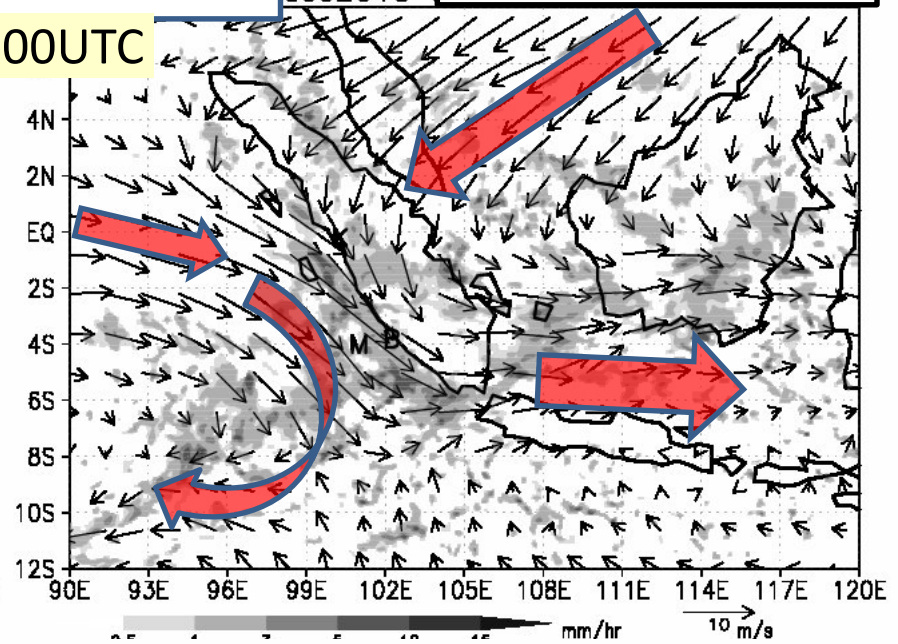
Precip, 850 hPa wind

GSMaP, NCEP_FNL

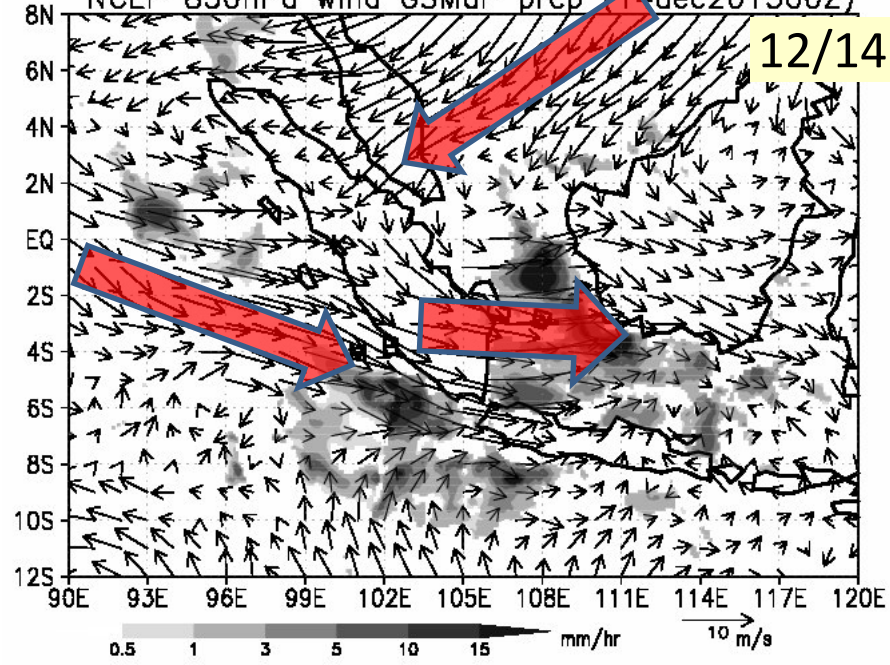
NICAM 7km mesh

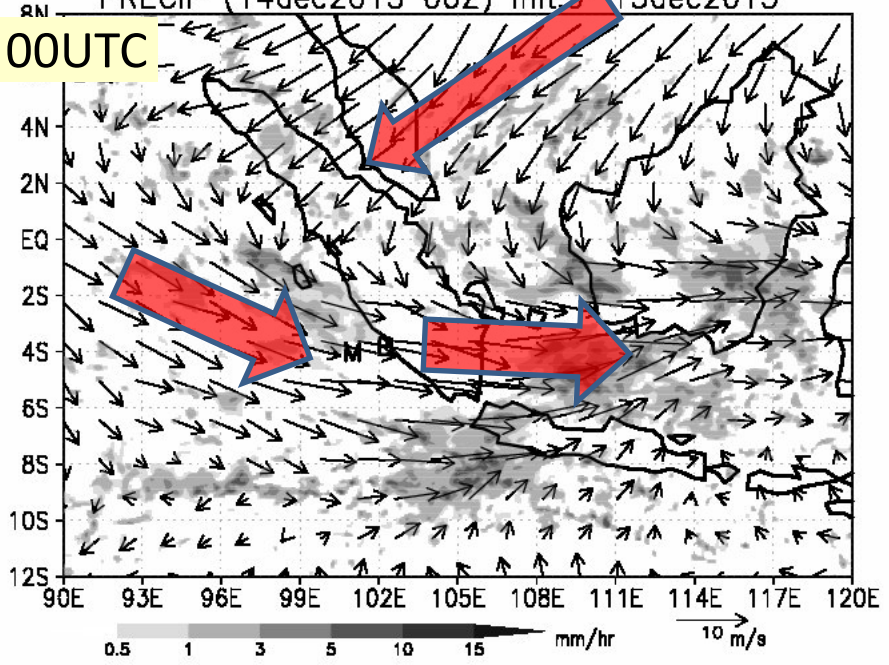
12/13 00UTC





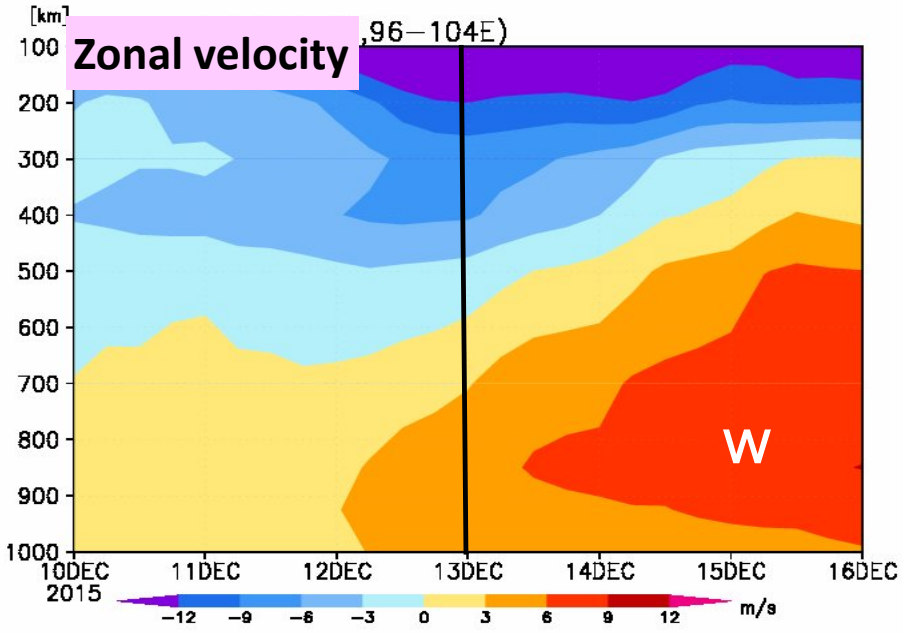
12/14 00UTC

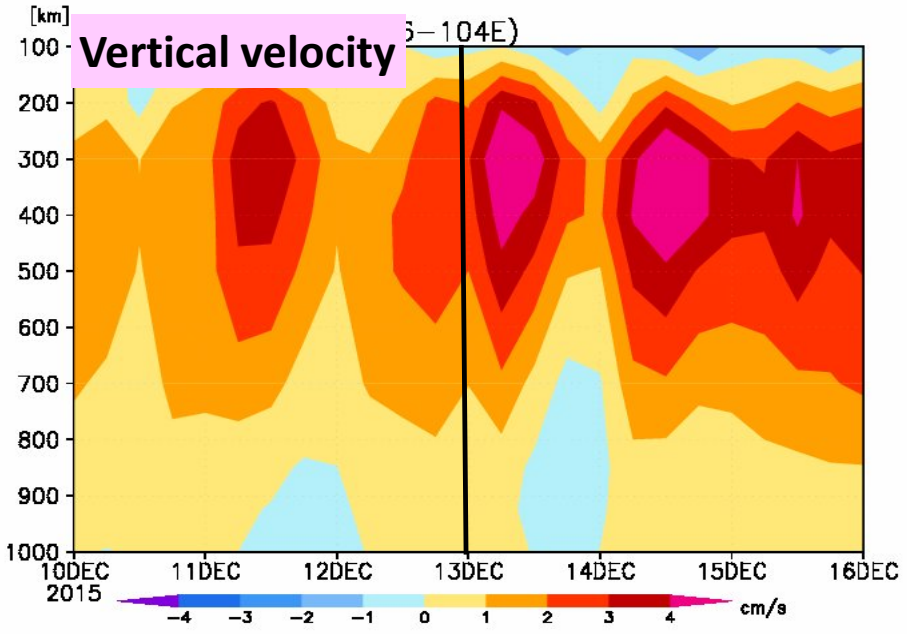


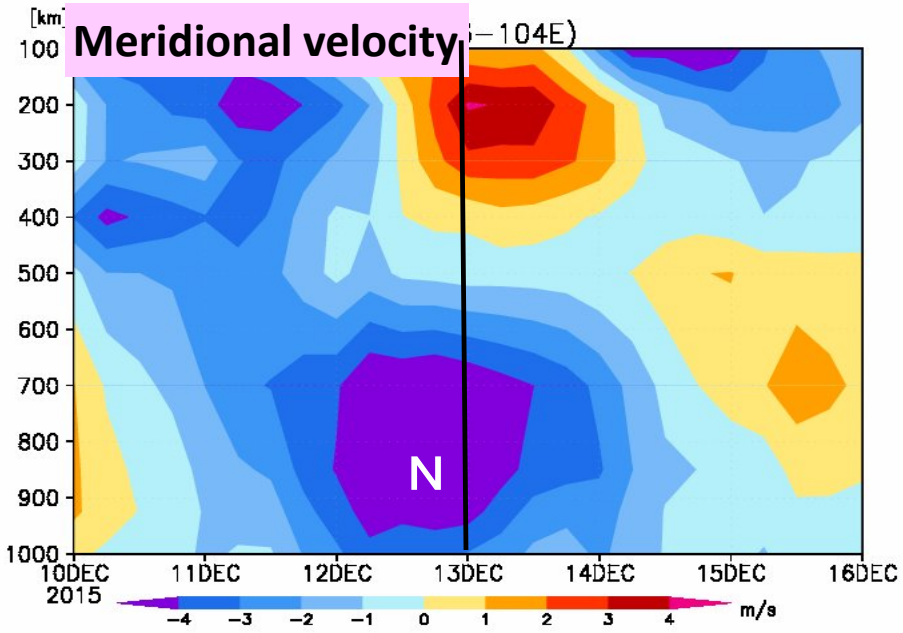


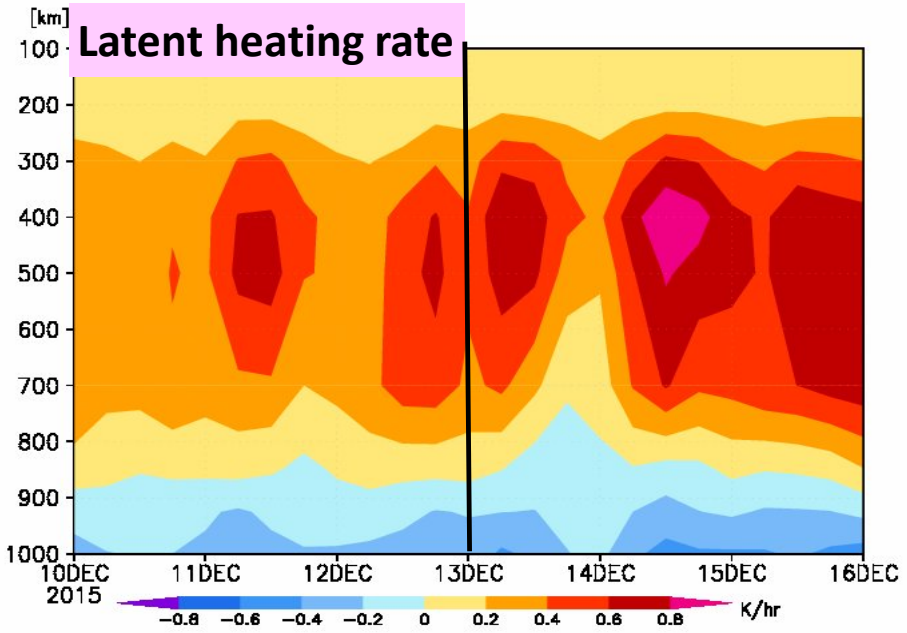
Time-height section (EQ-6S, 96-104E)

NICAM 7km mesh



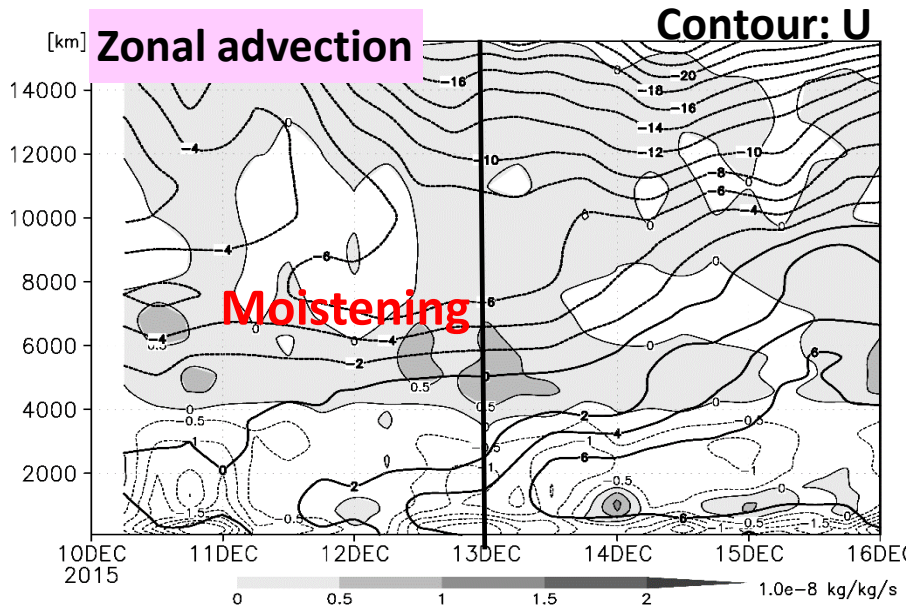


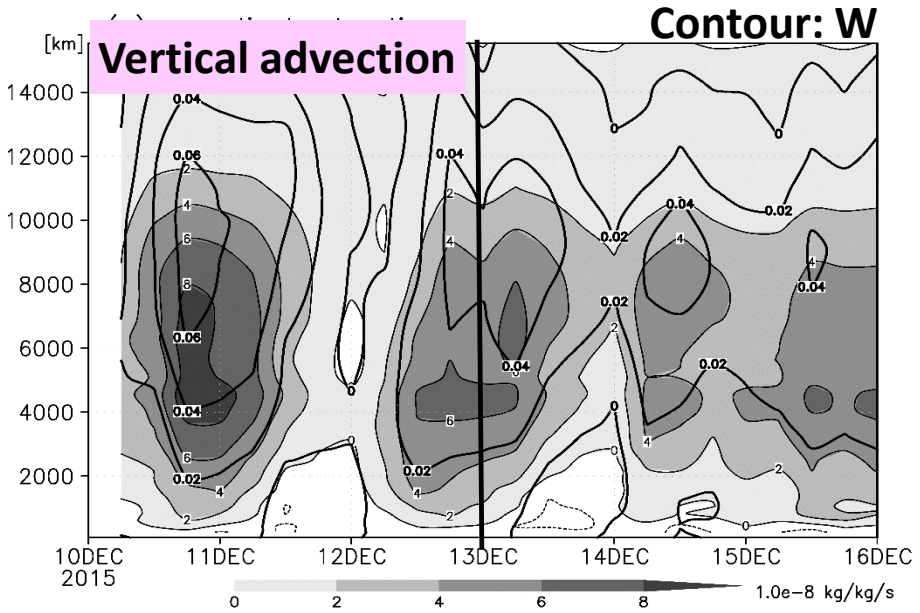


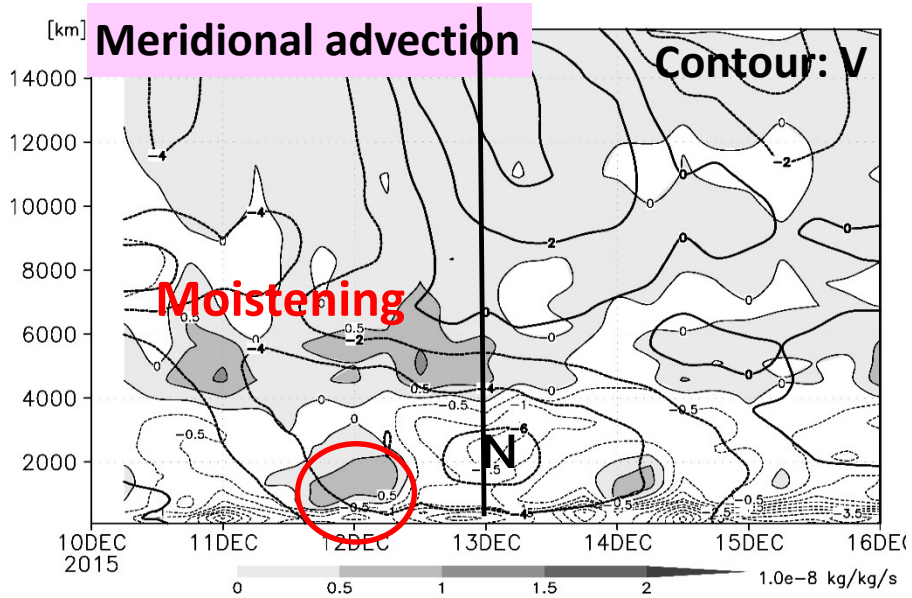


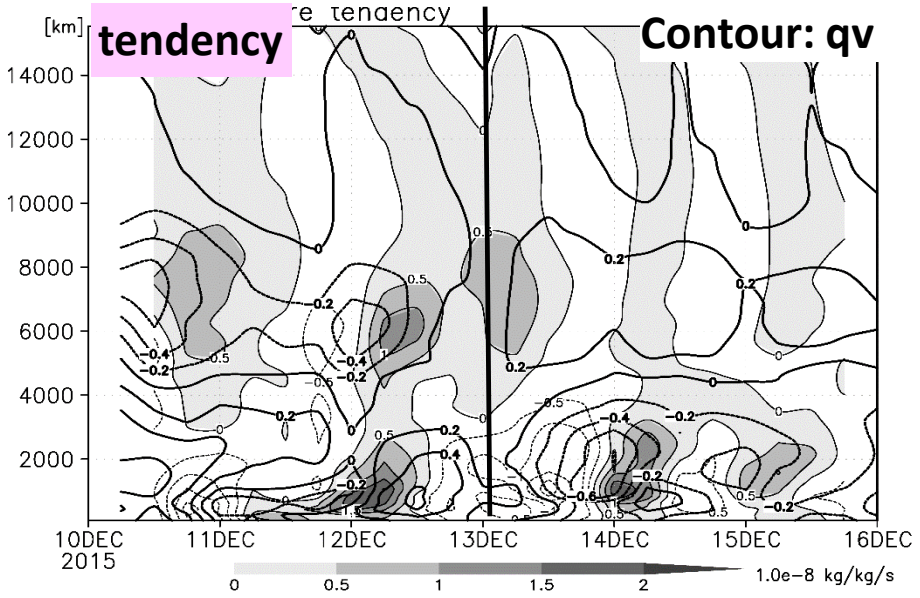
Moisture budget in southeast Sumatra (EQ-6S, 96-104E)

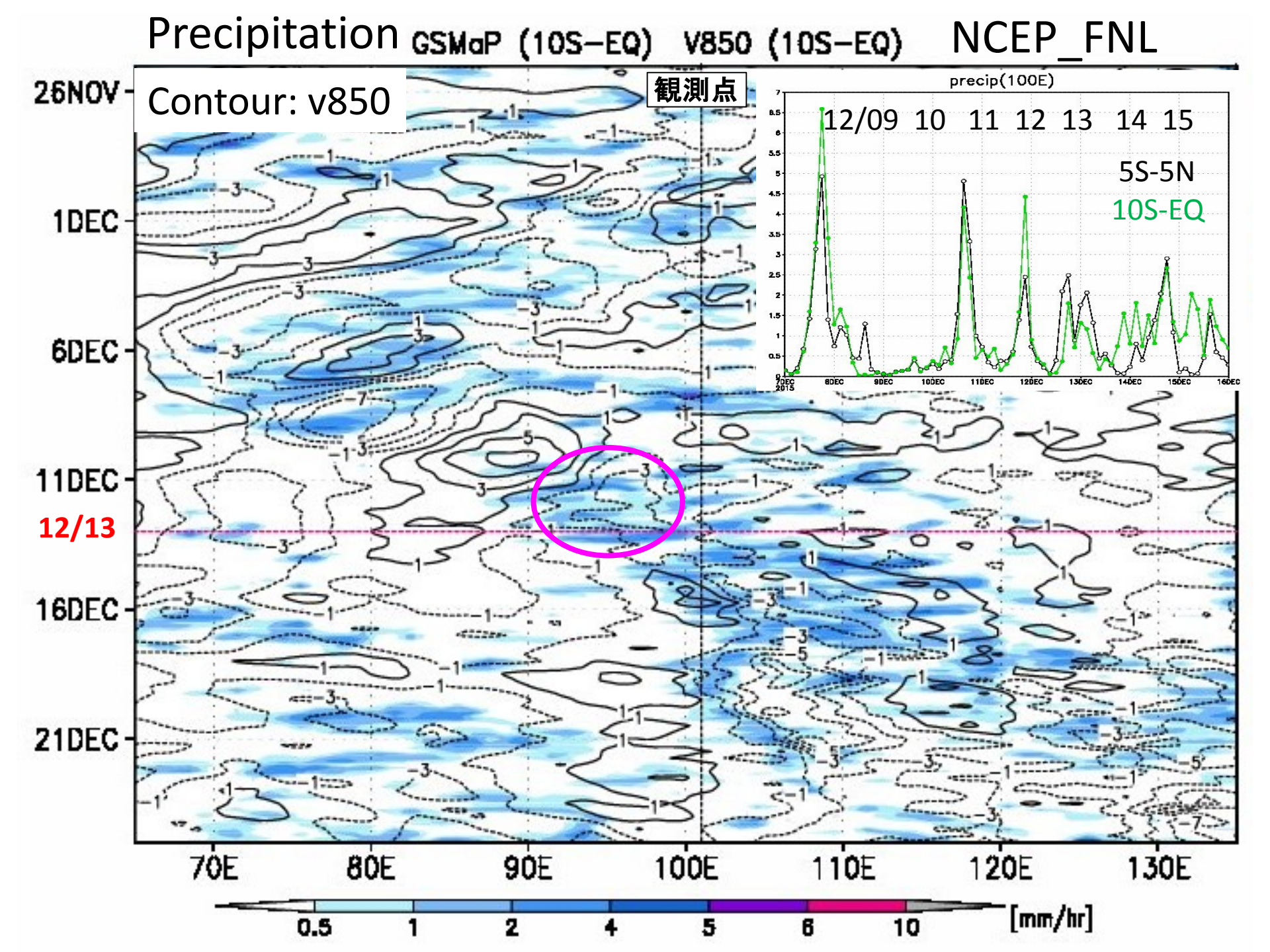
NICAM 7km

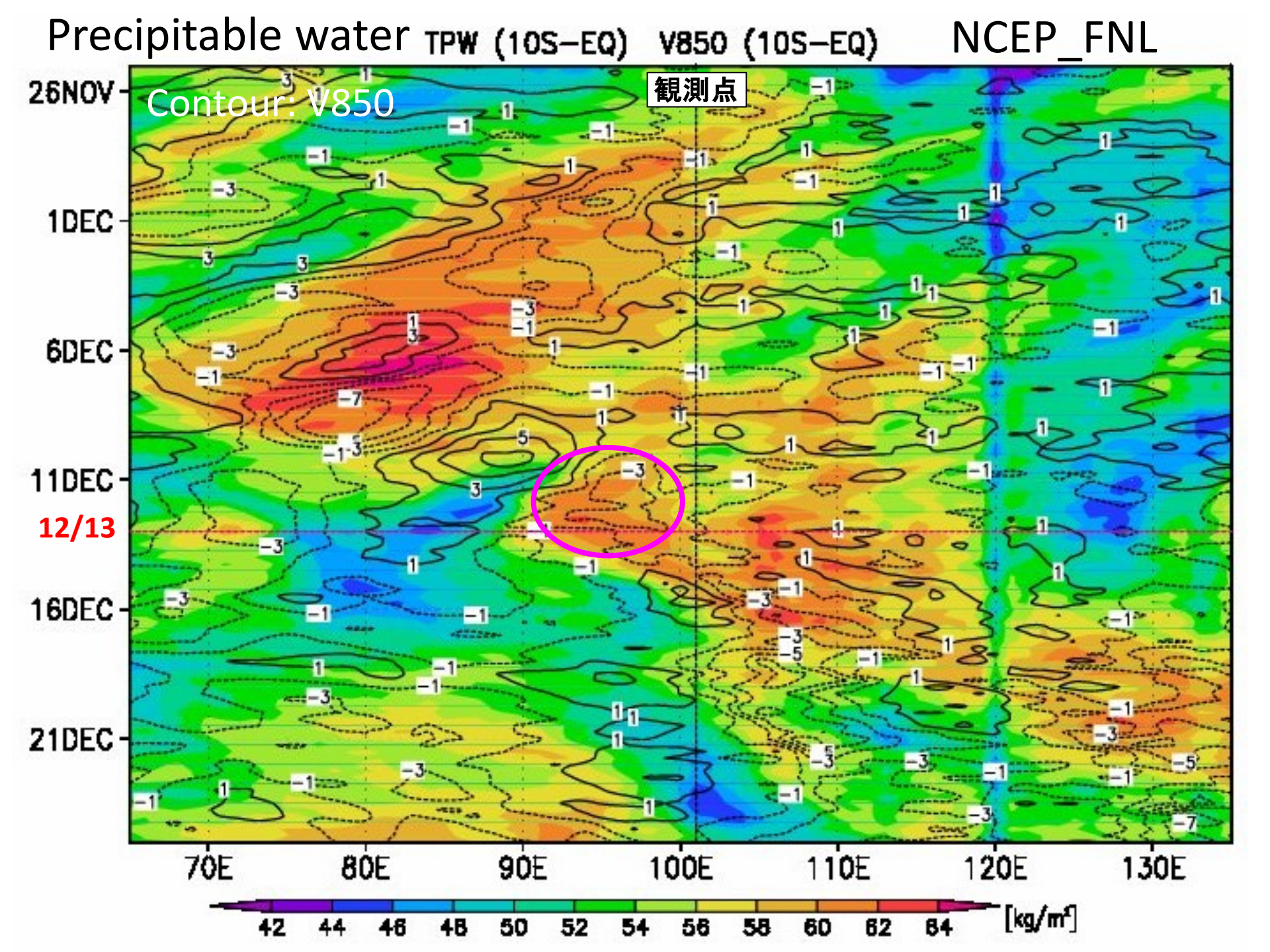








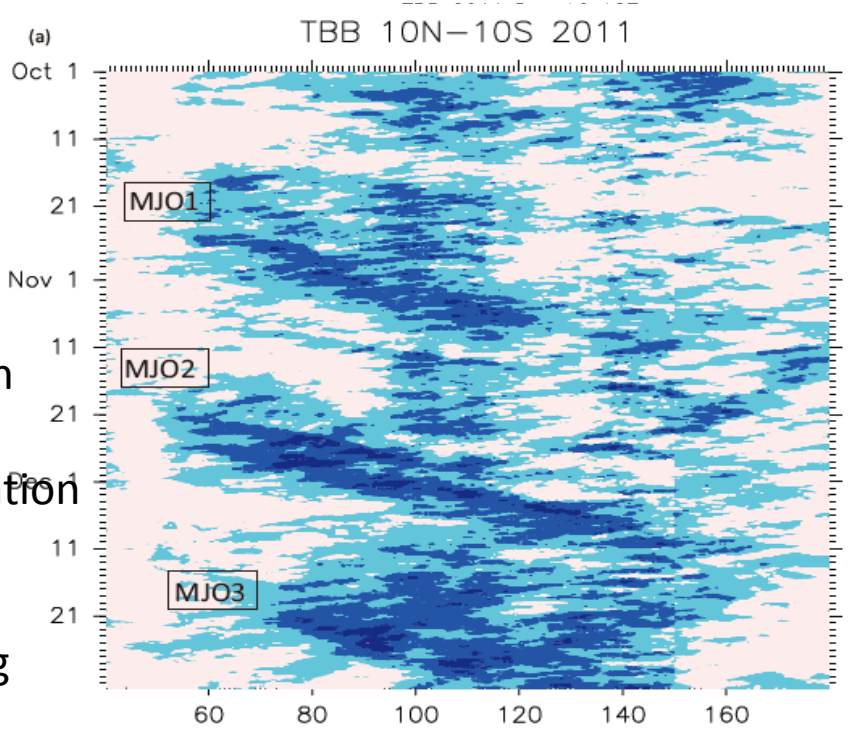

Precipitation GSMaP (10S-EQ) V850 (10S-EQ) NCEP_FNL
Contour: v850
観測点
precip(100E)
12/09 10 11 12 13 14 15
5S-5N
10S-EQ
26NOV
1DEC
6DEC
11DEC
12/13
16DEC
21DEC
70E
80E
90E
100E
110E
120E
130E
0.5
1
2
4
5
6
10
[mm/hr]

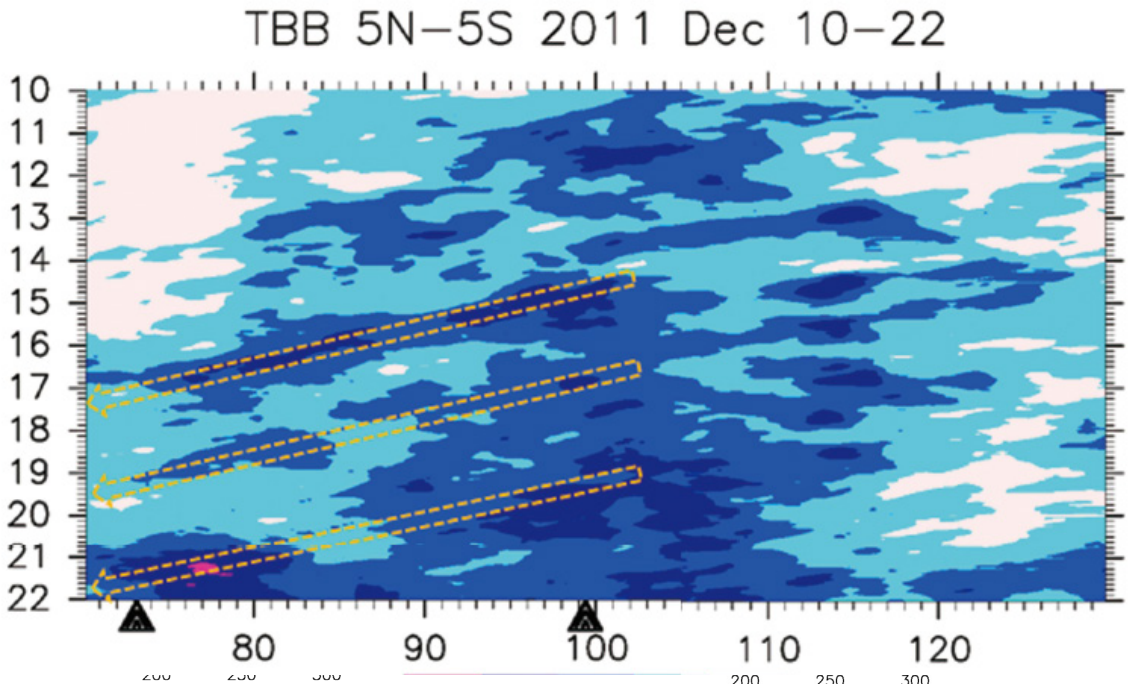

Precipitable water
TPW (10S-EQ) V850 (10S-EQ)
NCEP_FNL
Contour: V850
観測点
26NOV
1DEC
6DEC
11DEC
12/13
16DEC
21DEC
70E
80E
90E
100E
110E
120E
130E
42 44 46 48 50 52 54 56 58 60 62 64
[kg/m²]

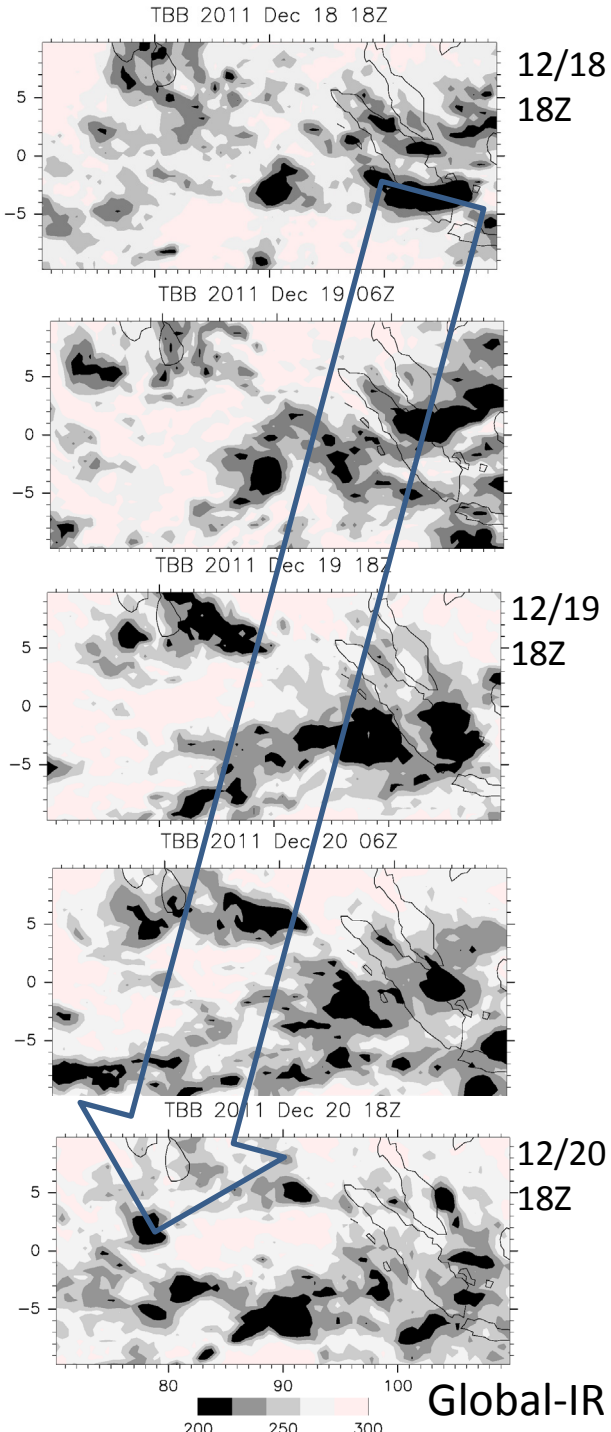
Kubota et al. 2015

Onset of MJO3
CINDY/DYNAMO

The MC
Diurnal Convection
→ 2-day waves
westward propagation
→ moistening
over the IO
→ Preconditioning
of MJO3







- Summary
- Global 7-km (14-km) week- (month-) long NICAM forecasts for Pre-YMC campaign
- **MJO skill score**: COR~0.8 for 18 days
- **Diurnal cycle**: late afternoon peak over land early morning peak over ocean is simulated, but with phase delay and weaker coastal peak.
- **MJO development over the MC**: interaction among diurnal convection, equatorial waves, and MJO are suggested. → pursued in YMC campaign

* NICAM forecasts (Nov-Dec, 2017, + extra period)