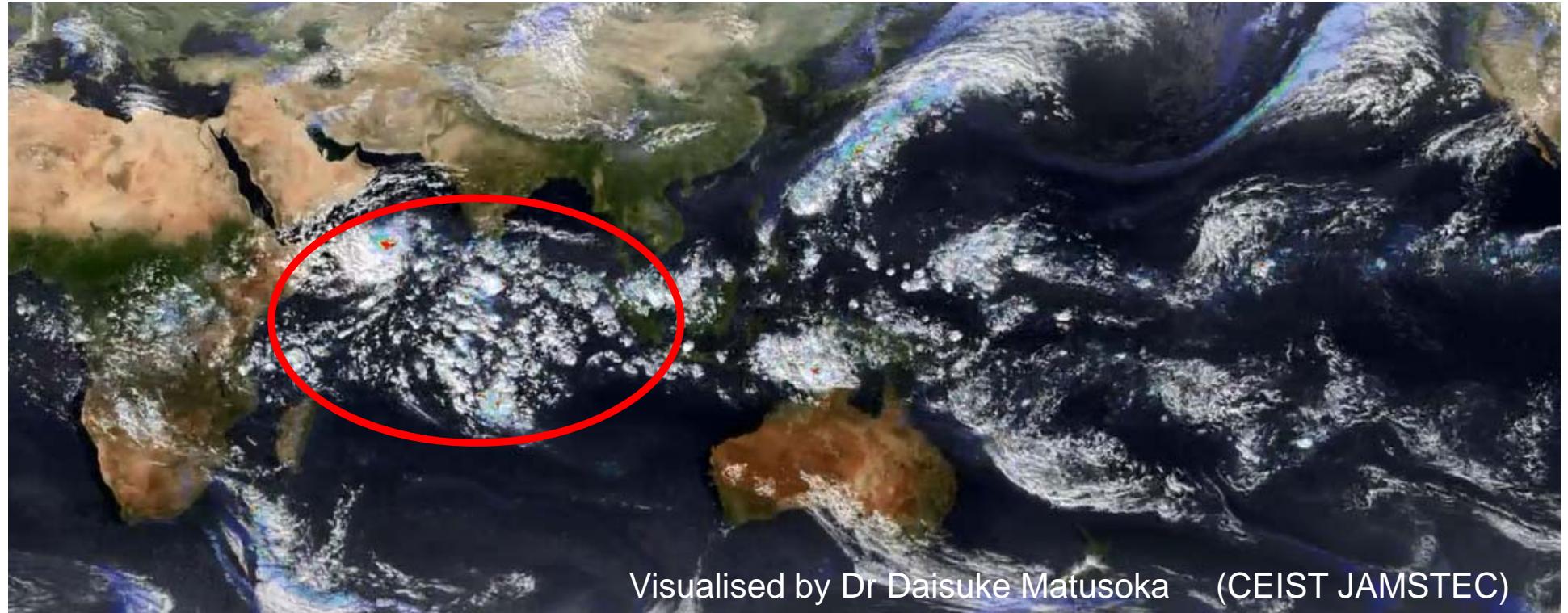


全球雲解像モデルNICAMによる延長予測可能性の研究



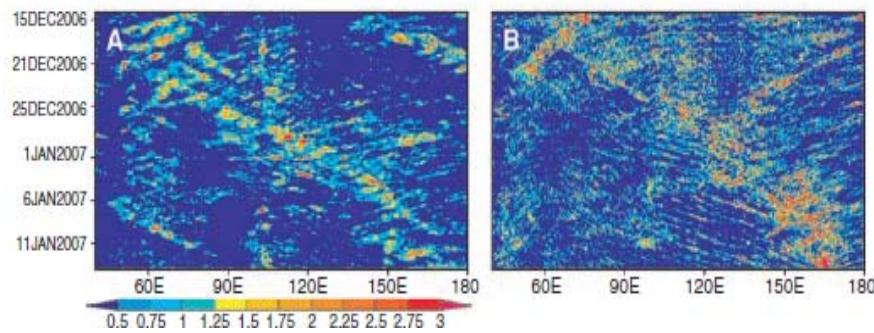
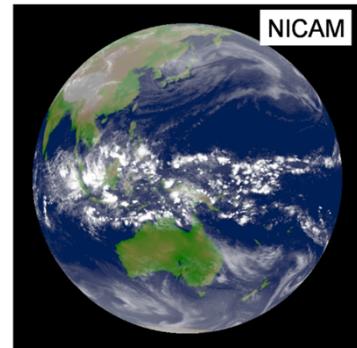
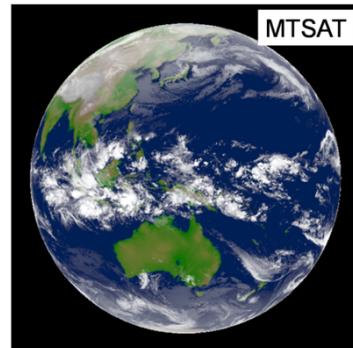
Visualised by Dr Daisuke Matusaka (CEIST JAMSTEC)

Masaki Satoh (AORI, Utokyo/JAMSTEC)

Thanks to Tomoki Miyakawa, Hiroaki Miura, Hirofumi
Tomita, Hisashi Yashiro, Akira T. Noda, Yohei Yamada,
Chihiro Kodama, Masahide Kimoto, and Kunio Yoneyama

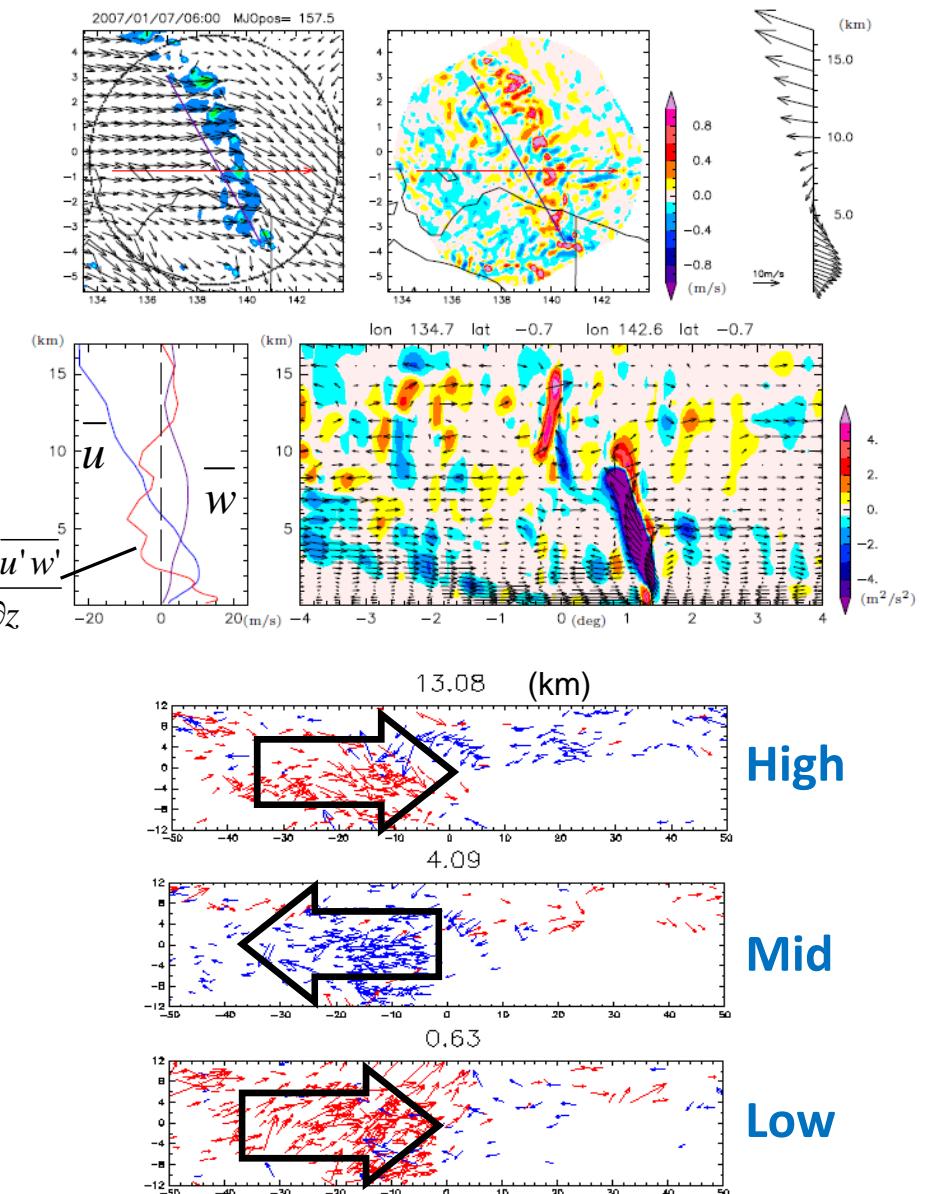
Global “cloud resolving” model NICAM and the MJO

(14 km \sim 870 m)



Successful MJO simulation
by NICAM Miura et al. 2007, *Science*

$$-\frac{1}{\rho} \frac{\partial \bar{\rho} u' w'}{\partial z}$$



Convective momentum transport (CMT)
Miyakawa et al. 2012, *JAS*

K computer



(from Fujitsu web page)

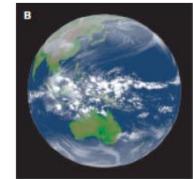
14 km resolution 30 days --> 15 hours using 0.8 %

7 km resolution 30 days --> 20 hours using 3 %

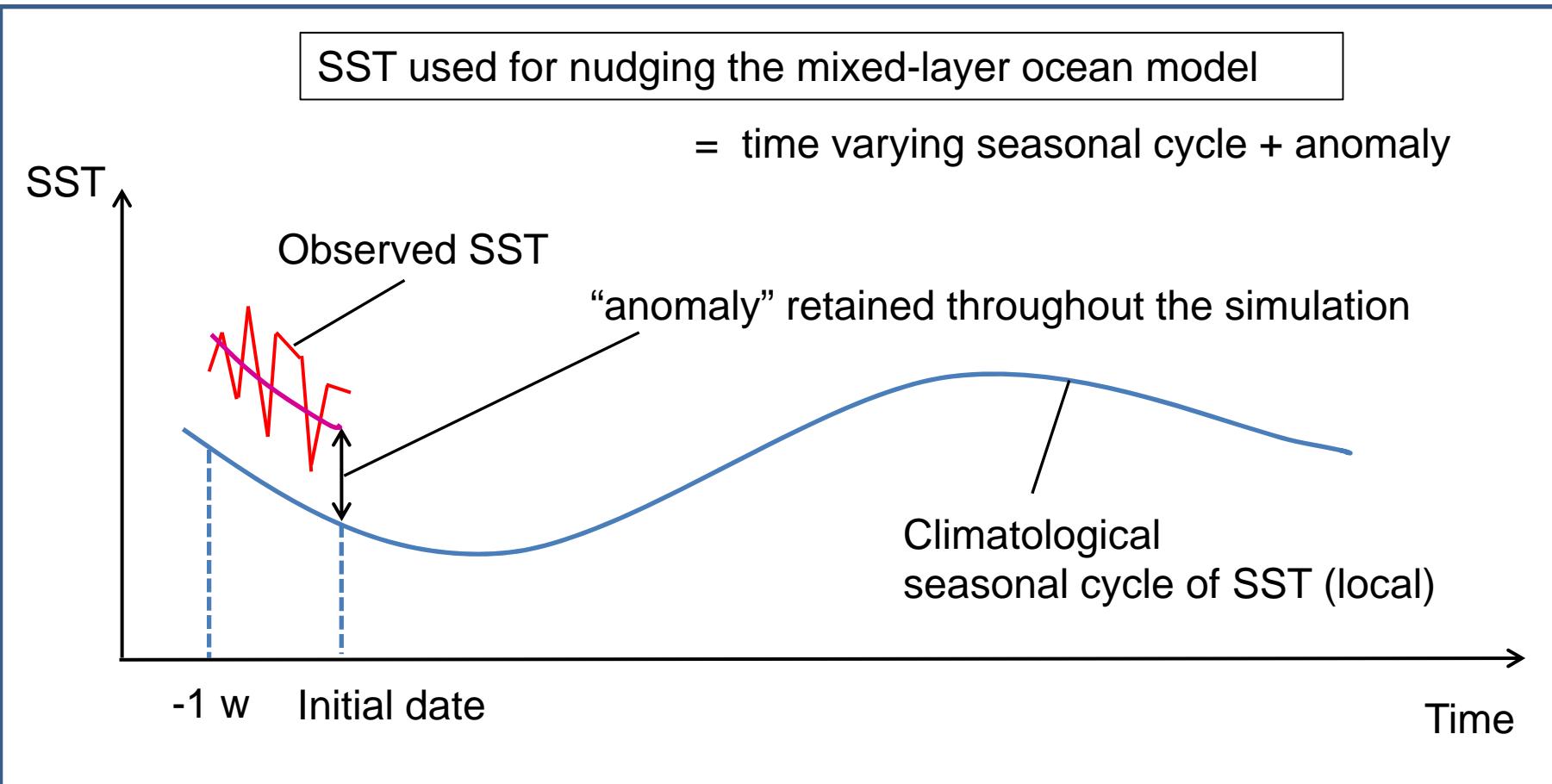
3.5 km resolution 30 days --> 36 hours using 13 %

if K computer is not crowded.

Model Configuration (NICAMK-2012)



Horizontal grid	Icosahedral grid (14 km, 7 km, 3.5 km)
Vertical grid	Lorenz grid 38-layer, 0 ~ 38,000m
Integration	40 days
Dynamic equation	Full compressive, nonhydrostatic
Cumulus parameterization	none
Turbulence / surface flux	Mellor Yamada – Nakanishi-Niino level 2
Radiation / aerosol	MSTRNX (Sekiguchi 2004)
Cloud microphysics	NSW6 Single moment scheme (multiple ice phases)
Surface process	<u>1-D Mixed layer ocean model / MATSIRO land model</u>
Initial condition	Era-interim
Boundary conditions	<u>Nudging towards persistent anomaly SST</u> E-topo5 topography, Matthews vegetation UGAMP ozone climatology (for AMPI2)



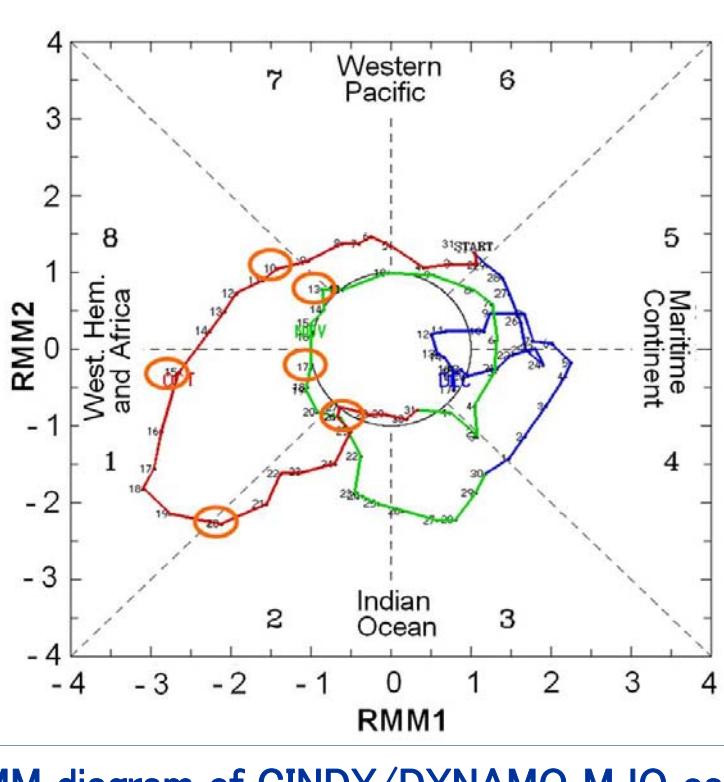
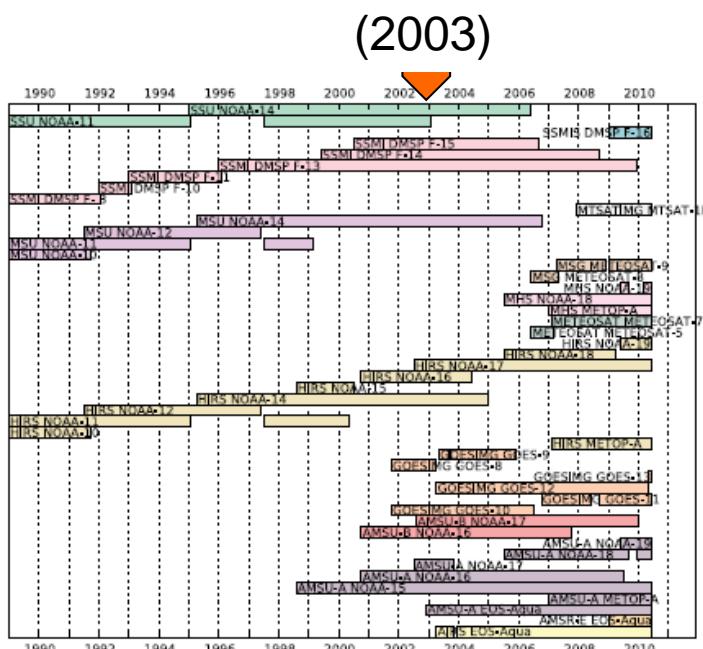
Case and initial date selection

Criteria:

- 2003 - 2012, Winter cases (October – March)
- Average amplitude of phases 2 – 5 ≥ 1 in RMM diagram
 \Rightarrow 19 MJO cases

Initial dates:

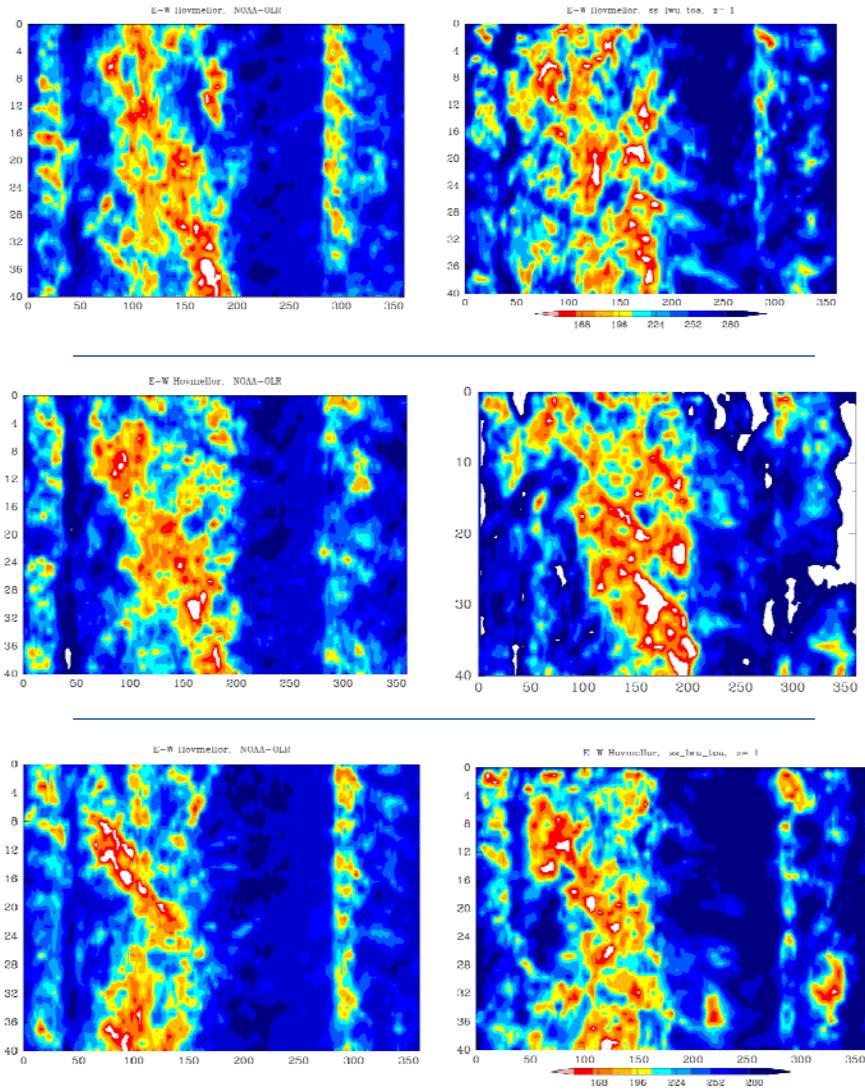
- The first day the MJO enters Phase 2
- The first day the MJO enters phases 1 and 8, if traceable.
 \Rightarrow 54 initial dates



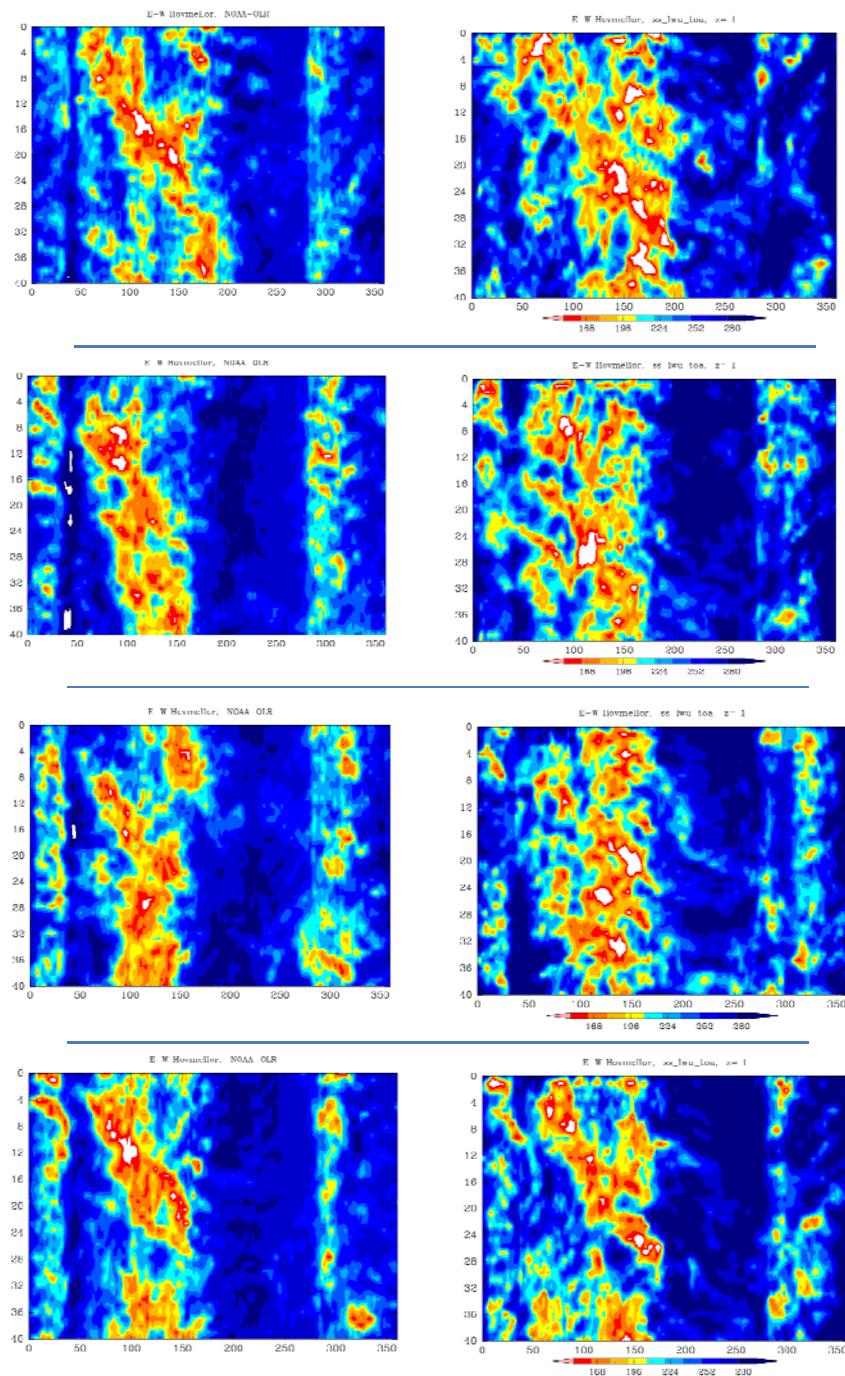
RMM diagram of CINDY/DYNAMO MJO cases.
(RMM by Bureau of Meteorology)

14 km, 40 day simulations

NOAA



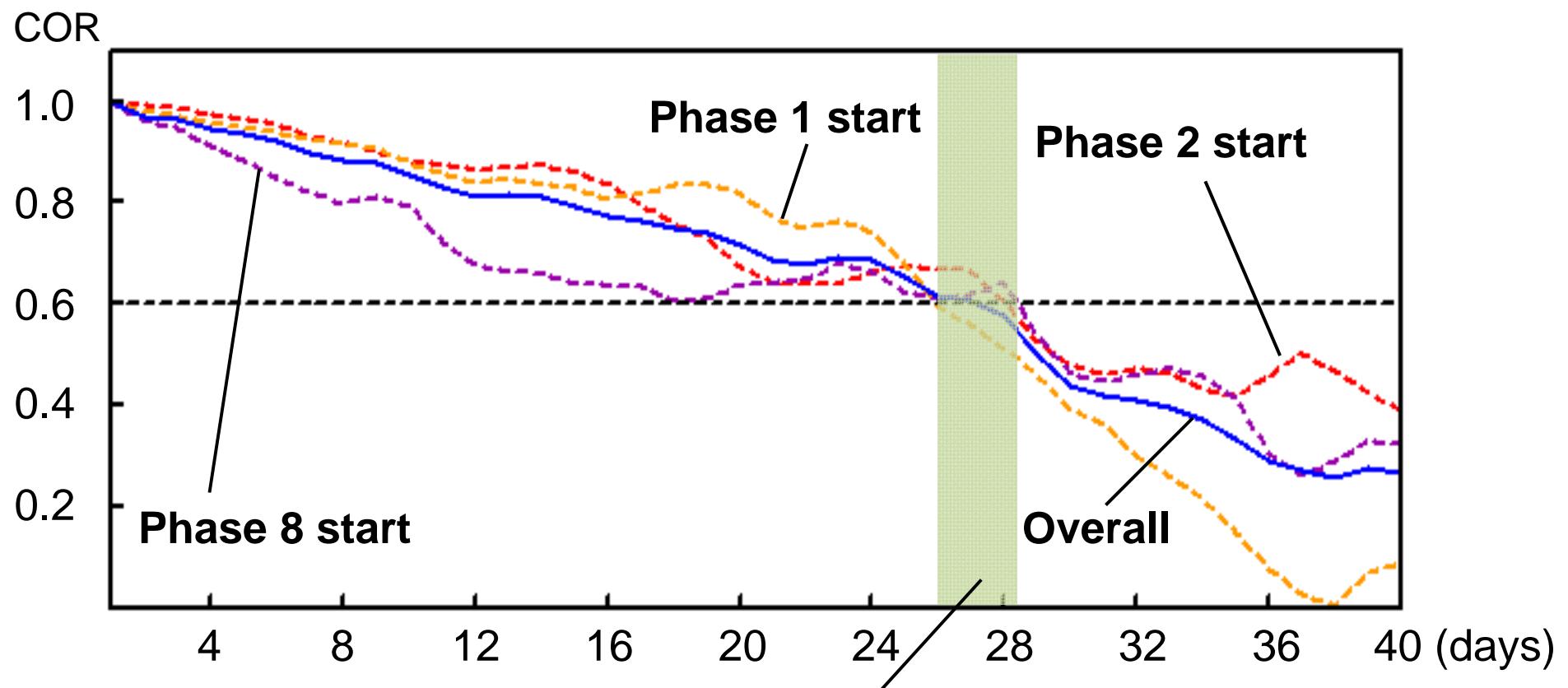
NICAM



Bivariate correlation score of NICAM

$$COR(t) = \frac{\sum_{i=1}^N [(a_1(i,t)b_1(i,t) + a_2(i,t)b_2(i,t))]}{\sqrt{\sum(a_1(i,t)^2 + a_2(i,t)^2)} \sqrt{\sum(b_1(i,t)^2 + b_2(i,t)^2)}}$$

a : RMMs of reference data
b : RMMs of Model
t : Lead time
i : case ID

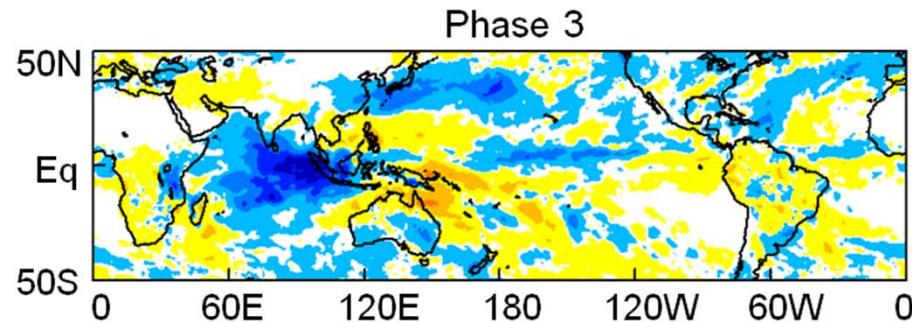


COR >0.6 maintained for 26 – 28 days

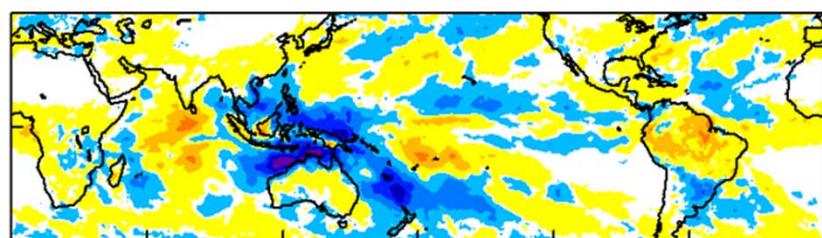
(Miyakawa et al. 2014, *Nature Comm.*)

MJO phase composited rainfall anomalies

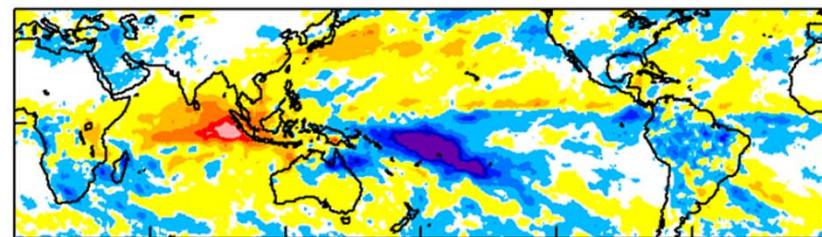
a) Observation (GPCP 1DD)



Phase 5

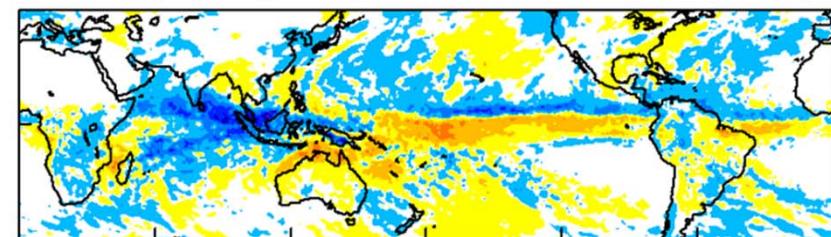


Phase 7

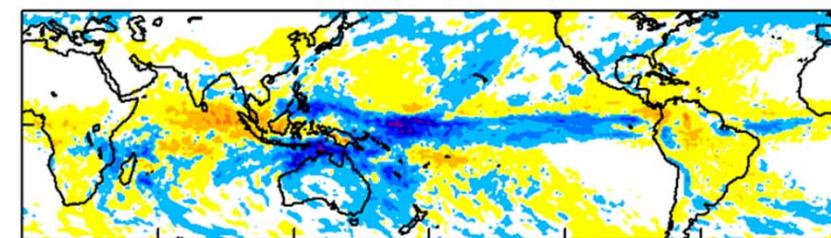


b) Simulation

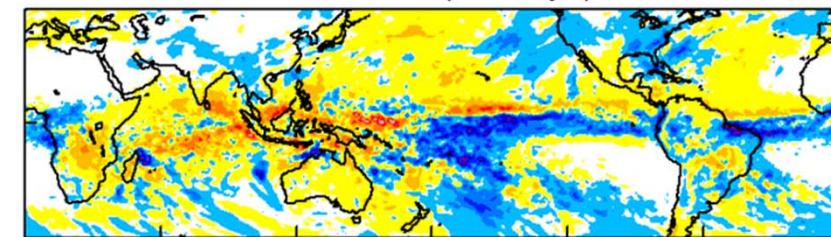
Phase 3 (average days from initial date = 16 days)



Phase 5 (25 days)



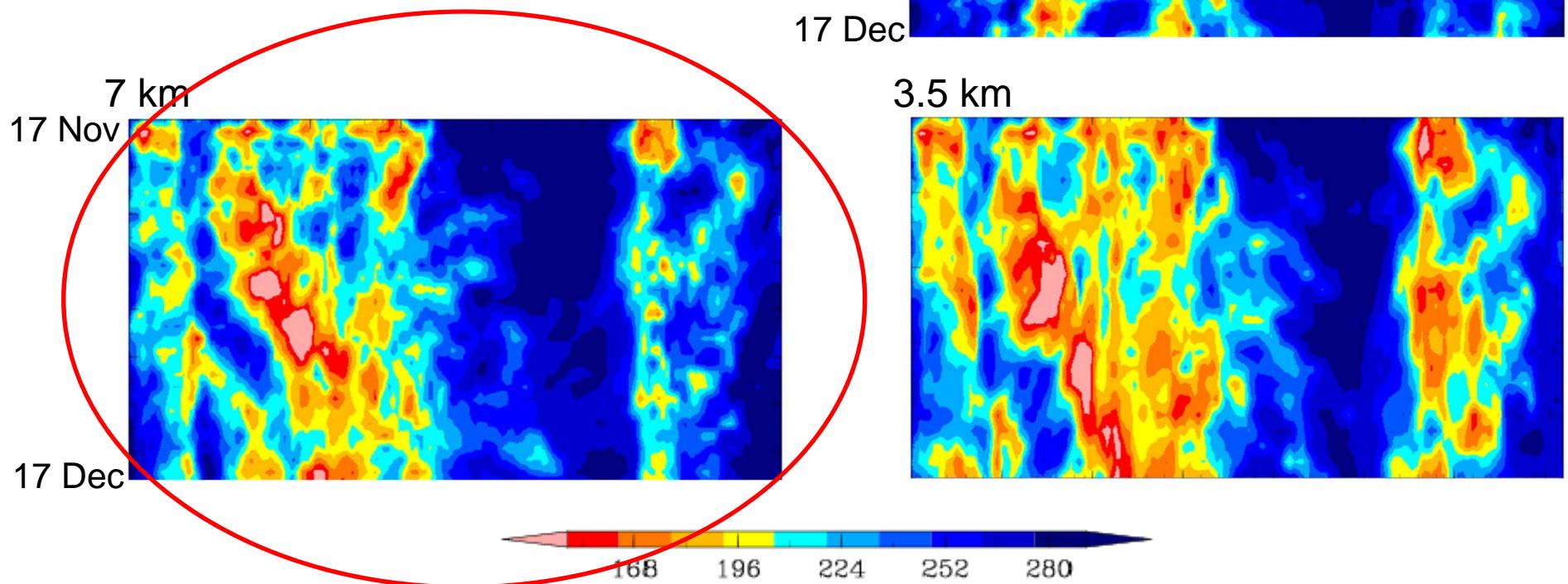
Phase 7 (28 days)



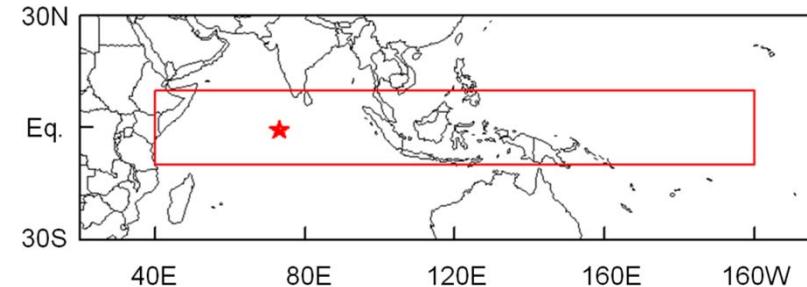
(Miyakawa et al. 2014, *Nature Comm.*)

Resolution dependencies

Simulations of CINDY/DYNAMO
MJO case 2 with 14 km, 7 km,
and 3.5 km.

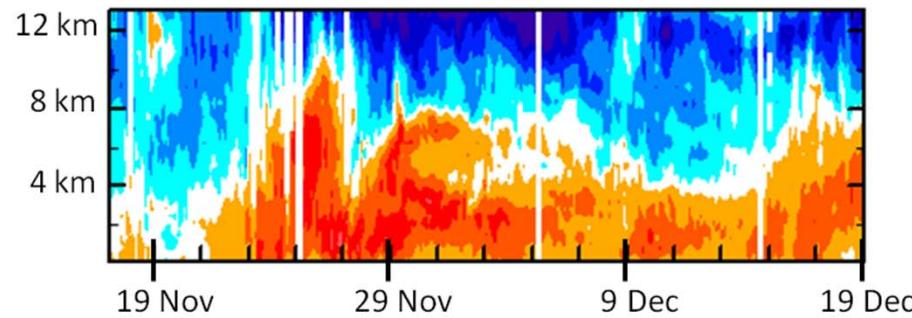


CINDY2011/DYNAMO case
(2nd MJO)

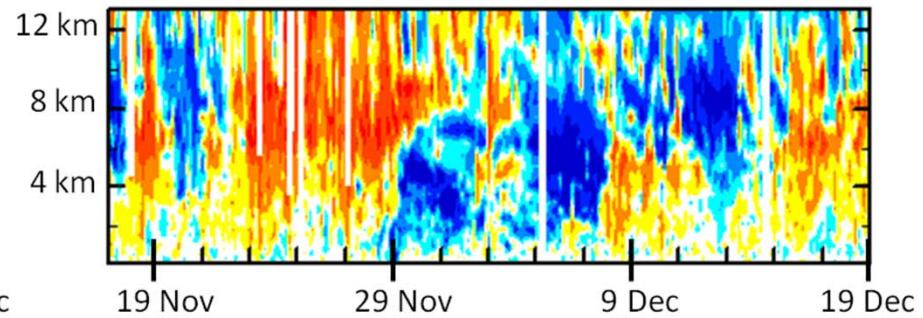


Time—height sections over Gan Island (73.2E, 0.7S)

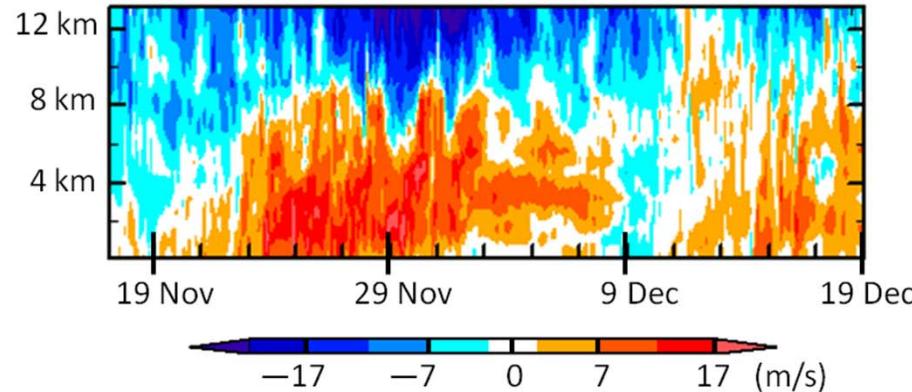
a) Observed zonal wind



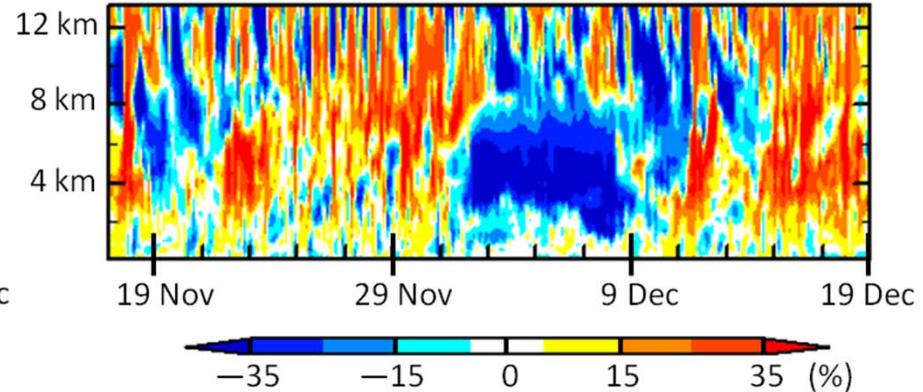
b) Observed RH anomaly



c) Simulated zonal wind



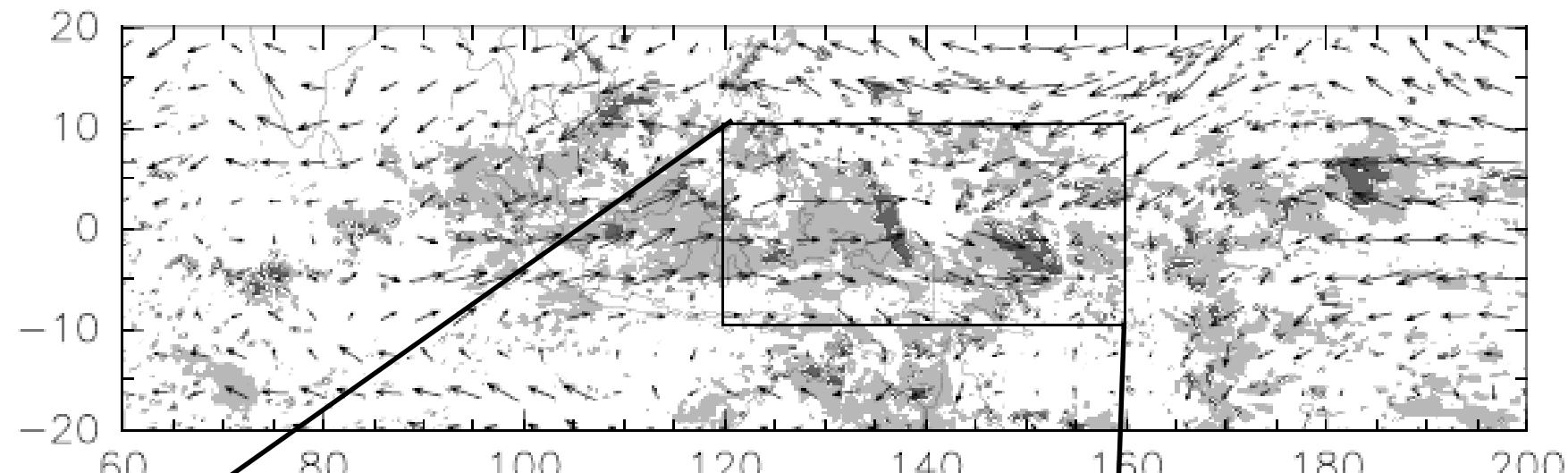
d) Simulated RH anomaly



(Miyakawa et al. 2014, *Nature Comm.*)

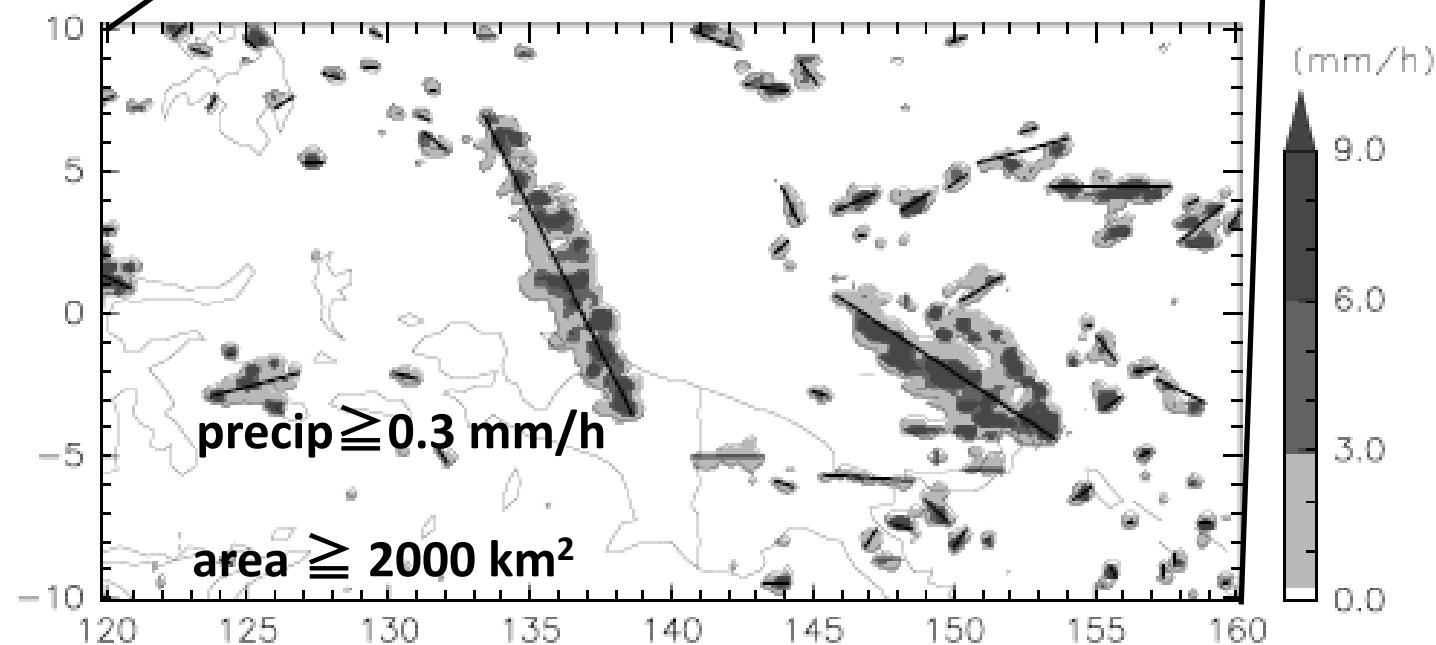
運動量輸送 CMT analysis using the MJO data of Miura et al. 2007

NICAM 2006 / 01 / 07 00:00 Surface rain, OLR, horizontal wind (1.5 km)



Identified rainband axes

(Miyakawa et al. 2012)

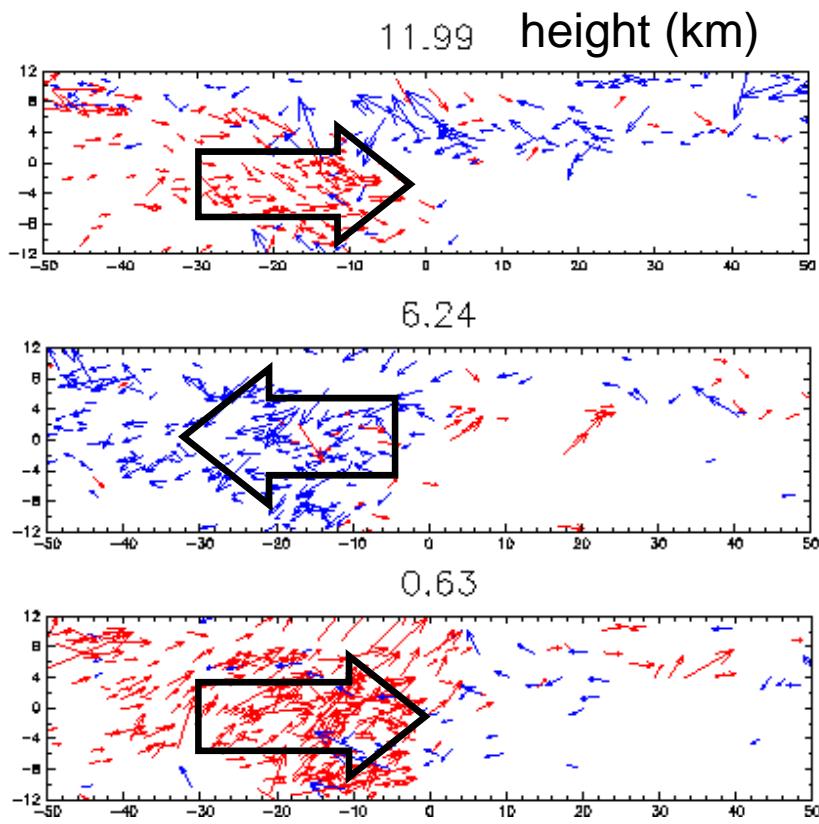


Miura 2007 vs CINDY/DYNAMO #2

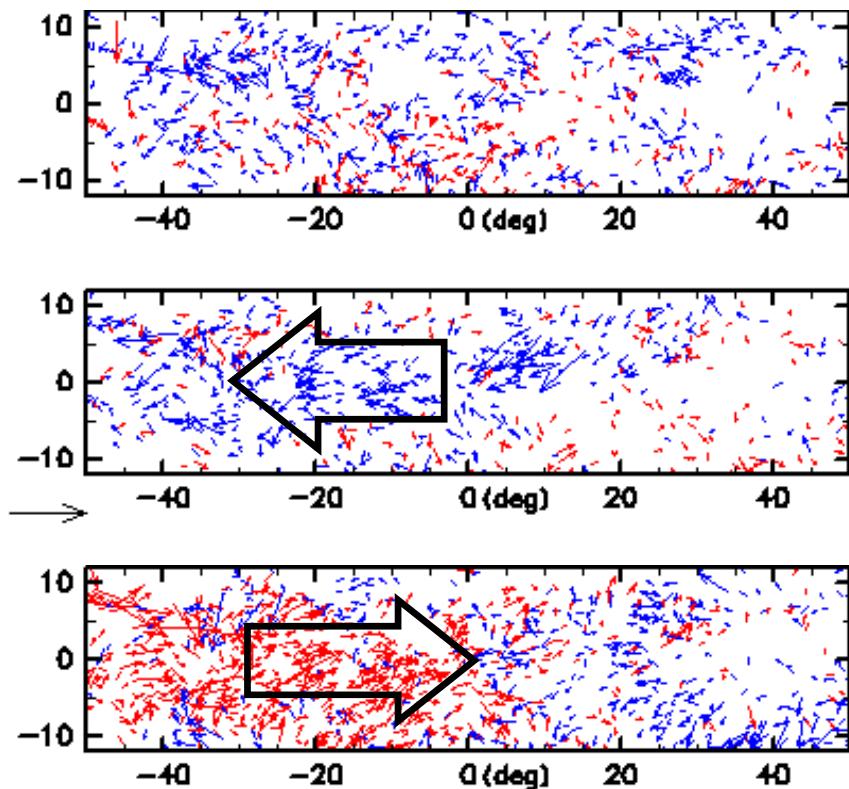
Vectors : acceleration due to CMT on \bar{u}, \bar{v}

red / blue : positive / negative zonal component

CMT from Miura 2007 experiment
(Miyakawa et al. 2012)



CMT from CINDY/DYNAMO 2nd event simulation

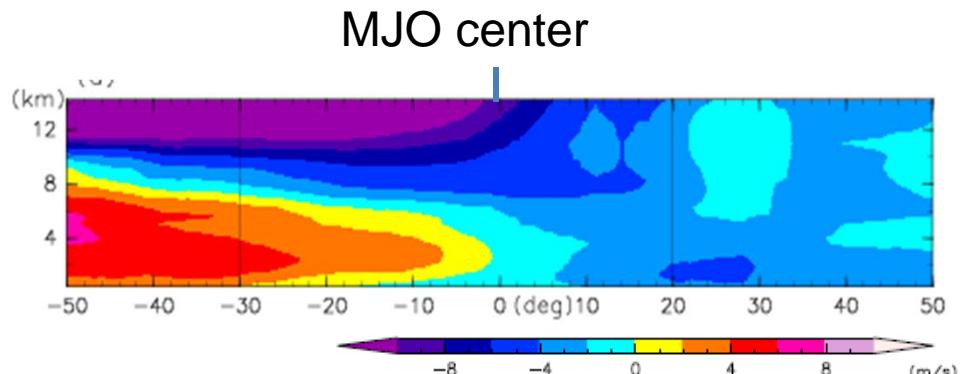
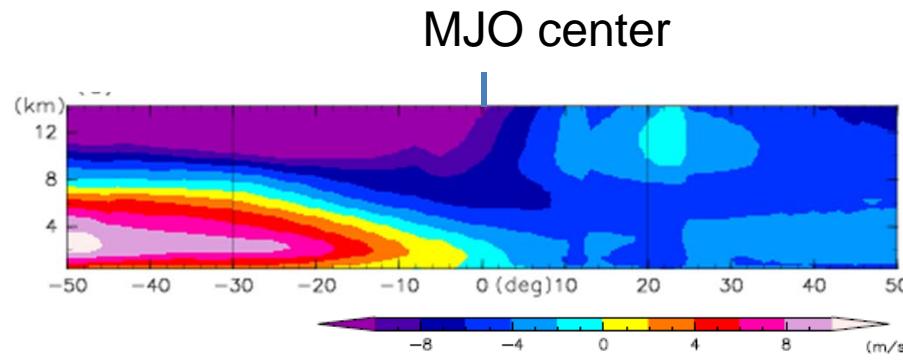


Vertical section of CMT around MJO

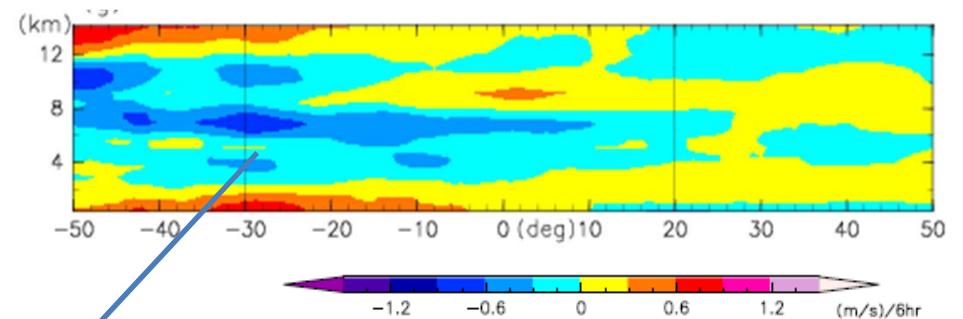
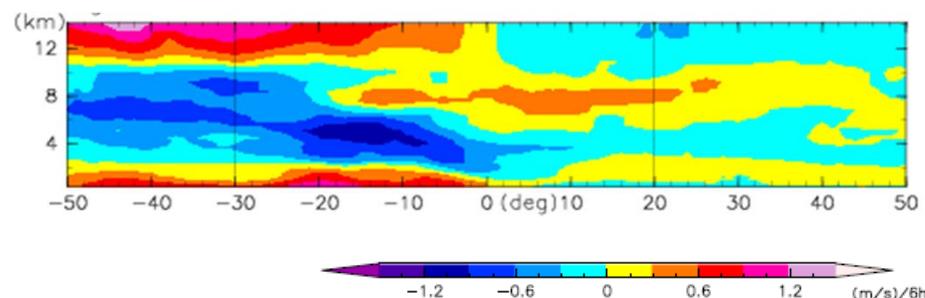
Miura 2007 MJO event

CINDY/DYNAMO 2nd MJO event

Composed zonal wind



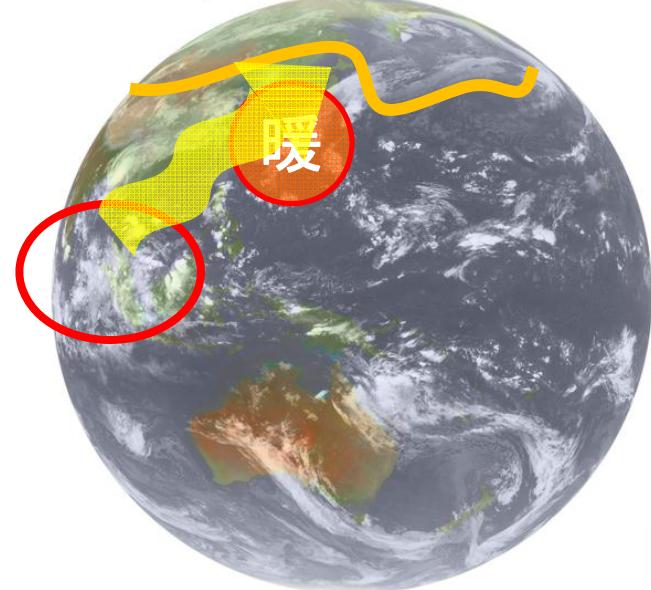
Composed zonal CMT



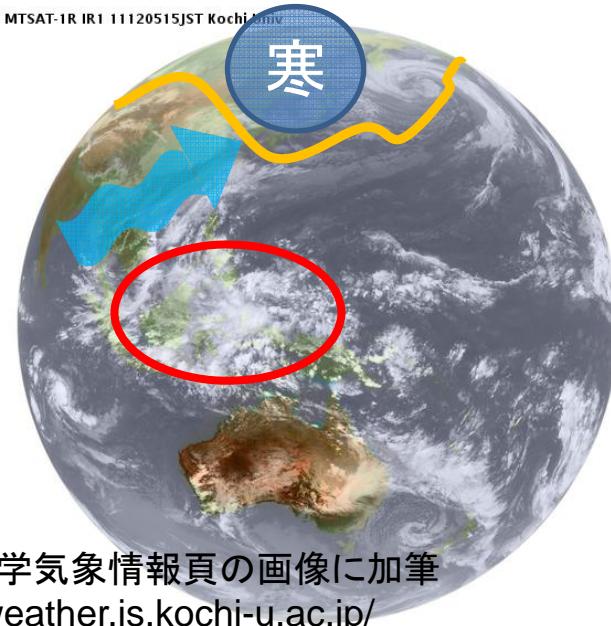
CMT effect smaller?
Less coherent?

MJOの日本への影響例

MTSAT-2 IR1 11102000JST Kochi Univ

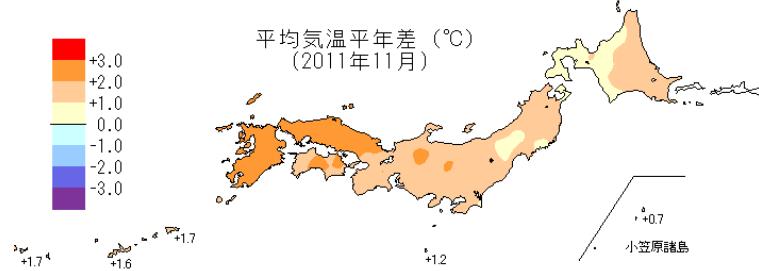


MTSAT-1R IR1 11120515JST Kochi



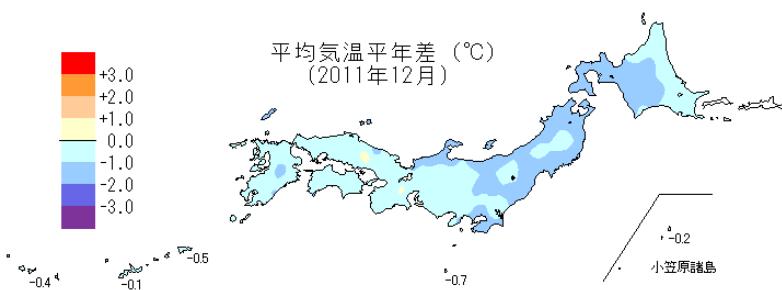
高知大学気象情報頁の画像に加筆
<http://weather.is.kochi-u.ac.jp/>

2011年秋の異常高温と厳冬



2011年10月下旬～11月 MJOがインド洋で
大きく発達
持続的な加熱の影響がジェット気流を蛇行さ
せて記録的な暑さに。

気象庁報道発表資料



MJOの活動がインドネシア付近で活発だった
12月はインド洋の対流は抑制され、一転して
寒冷化。

まとめ

超精密な最先端気象モデル**NICAM** × スーパーコンピュータ「**京**」によって、

- ・熱帯の雨に支配的な影響を及ぼす**マッデン・ジュリアン振動(MJO)**の
1ヶ月予測が可能であることが実証された。
- ・MJOに伴う運動量輸送解析：観測でも従来モデルでも得られなかったCMTの統計的描像が得られつつある
- ・日本を含む中緯度の**予測精度向上**にもつながると期待できる。

※責任を持って情報を提供するために予報現業機関の力が不可欠
※情報を最大限活かすためには分野を越えた取り組みが必要

今後もさらに計算機の進歩が進めば

- ・さらなる予測精度向上
- ・**気候変動予測**の不確実性軽減（台風100年雲解像シミュレーションなど）につながることも期待される。

※同時にモデル開発/改良、観測による検証を**継続**してソフトパワーを維持することが重要