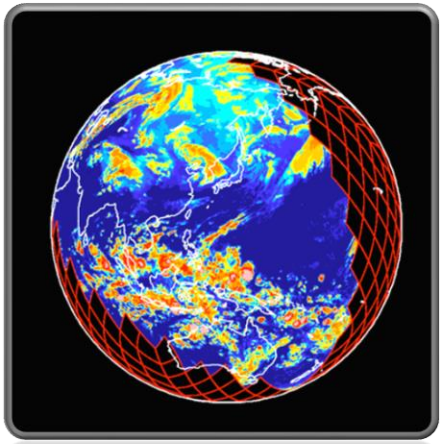
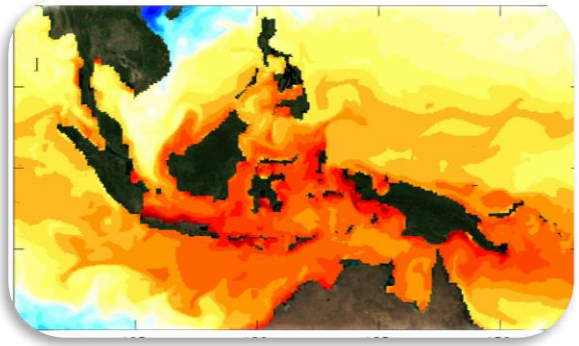
Current status of the ocean-coupled NICAM (NICOCO)





Tomoki Miyakawa (AORI, Univ. Tokyo)
and
NICOCO-team

A decade ago..

They say they want a revolution

Climate scientists call for major new modelling facility.

Olive Heffernan

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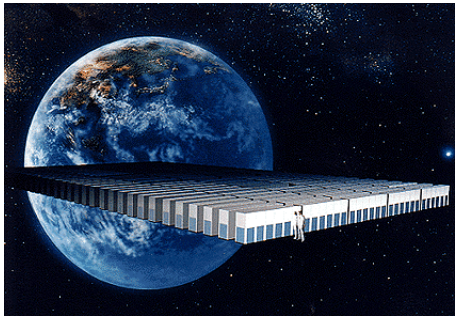
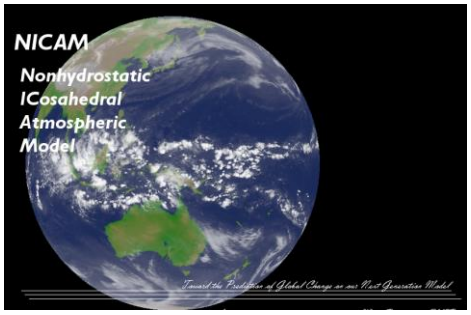
Beatles Fans

A summit by ~~top scientists~~ called for the need of "resolutions in the tens of kilometres, at least. And even higher resolutions — a kilometre or less" to revolutionize climate science

(*Nature*, 2008)





NICAM was opening that door, powered by the Earth Simulator@JAMSTEC.

Today

Summit, USA

Sunway TaihuLight, China

100-200 PFlop/s

Mistral, DKRZ

K computer, RIKEN

Oakforest PACS, Univ. Tokyo

4 - 25 PFlop/s

Post-K computer “富岳 Fugaku” 2021 ～
100 times faster than “京 K” ?

Today

Ryosuke
Shibuya

The DYAMOND Inititative

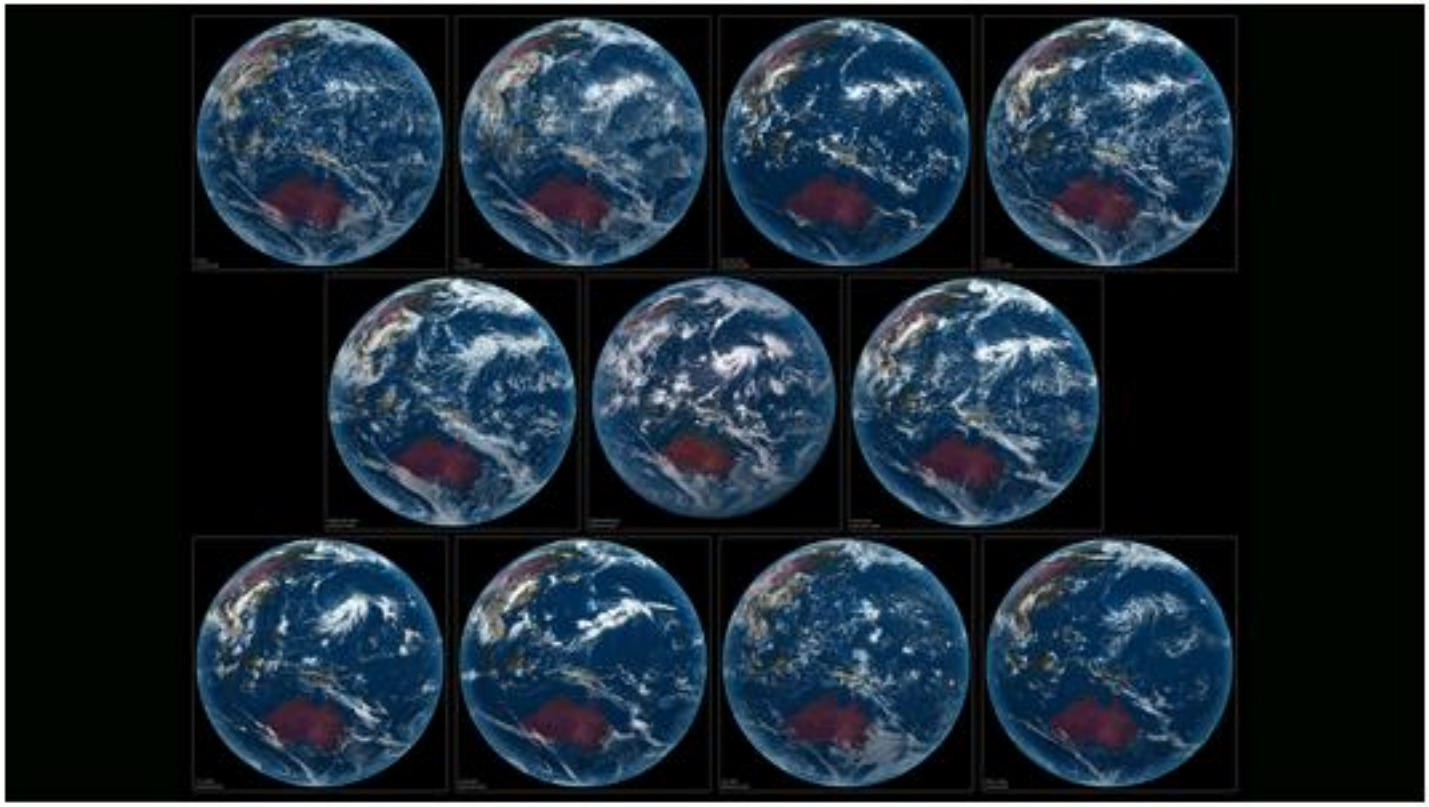
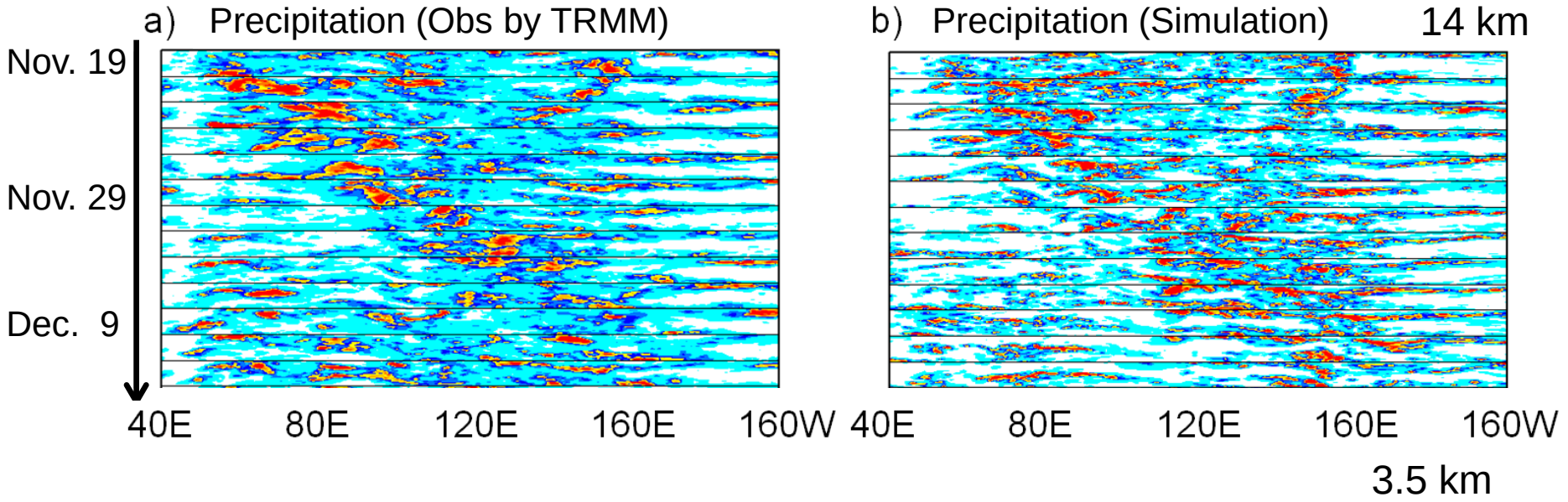


Figure: Simulation examples of the DYAMOND initiative (simulated day Aug 4th 2016). Can you tell which one is observation? By clicking on the image you can get a larger version (attention 20 MB)

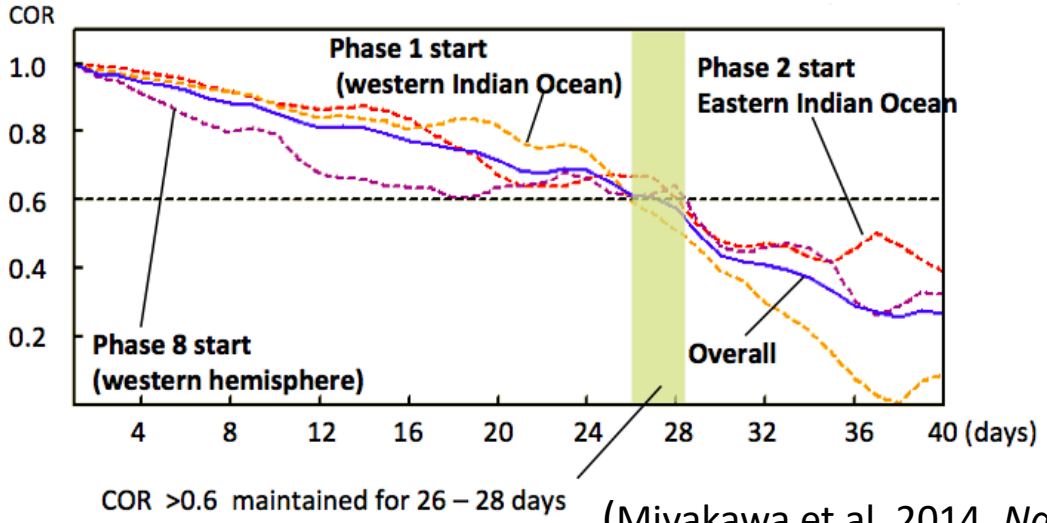
https://www.esiwace.eu/services/dyamond

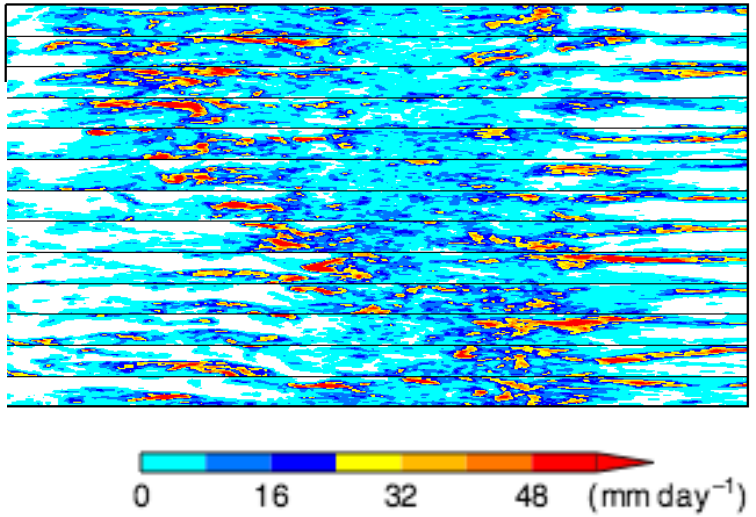
MJO simulations by atmospheric NICAM

CINDY2011/DYNAMO MJO event



Winter MJO prediction skills, 2003-2012





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

Today

Ryosuke
Shibuya

The DYAMOND Inititative

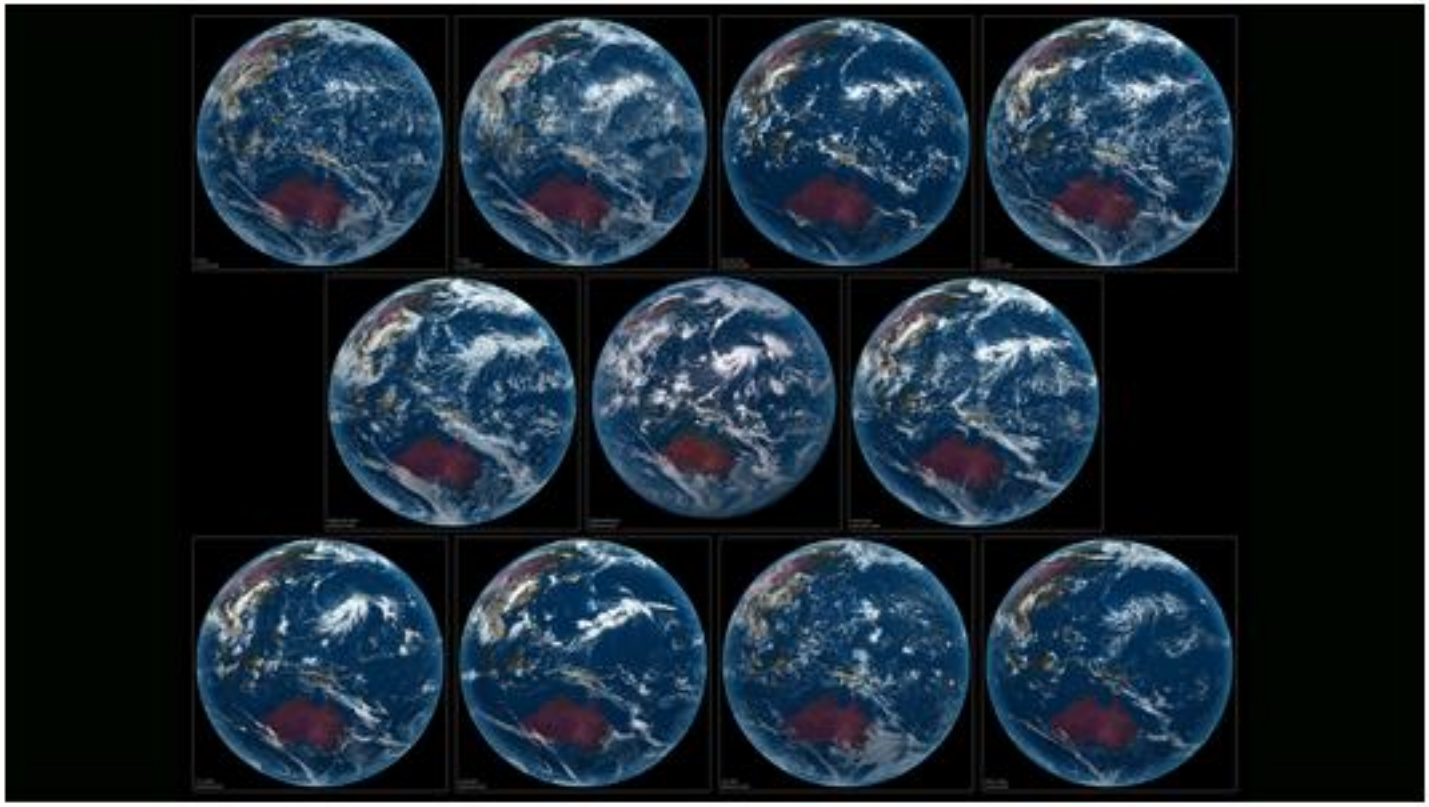


Figure: Simulation examples of the DYAMOND initiative (simulated day Aug 4th 2016). Can you tell which one is observation? By clicking on the image you can get a larger version (attention 20 MB)

https://www.esiwace.eu/services/dyamond

So, isn't it time for a

"revolution" of climate science?

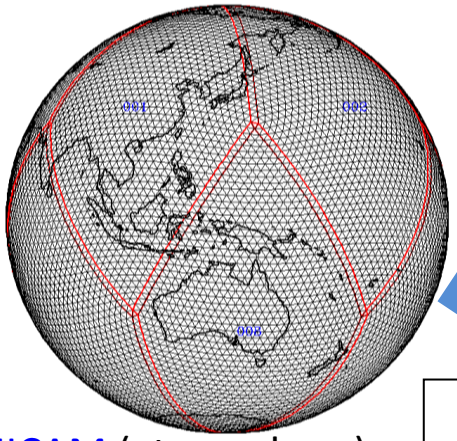
(at least at S2S / S2D scales?)

The ocean component is a
key ingredient, especially for climate simulations

Unfortunately, NICAM stands for…

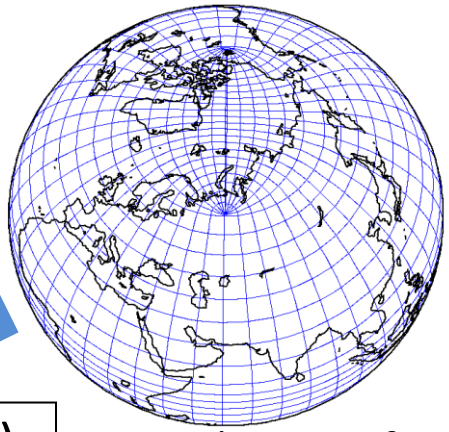
Nonhydrostatic ICosahedral Atmospheric Model

uh oh.

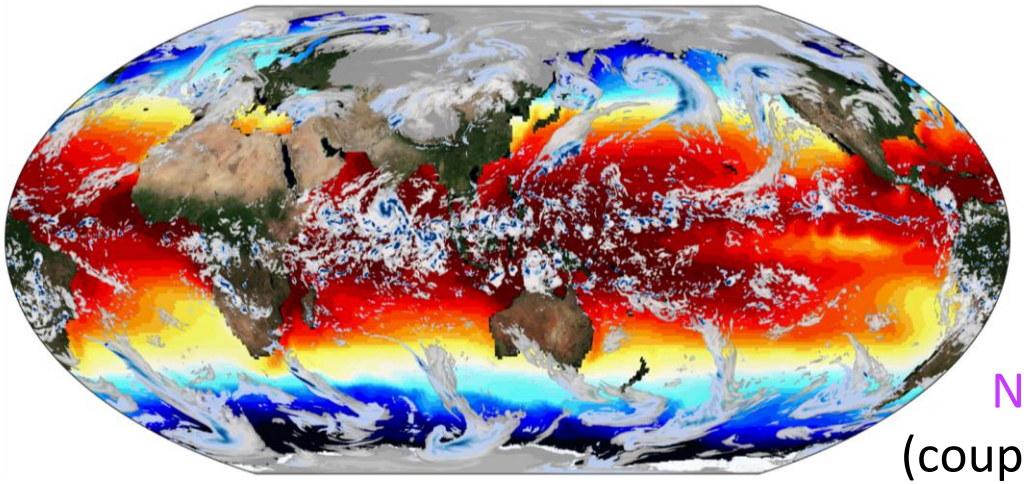


NICAM (atmosphere)
Icosahedral grid system

Coupler (J-cup)

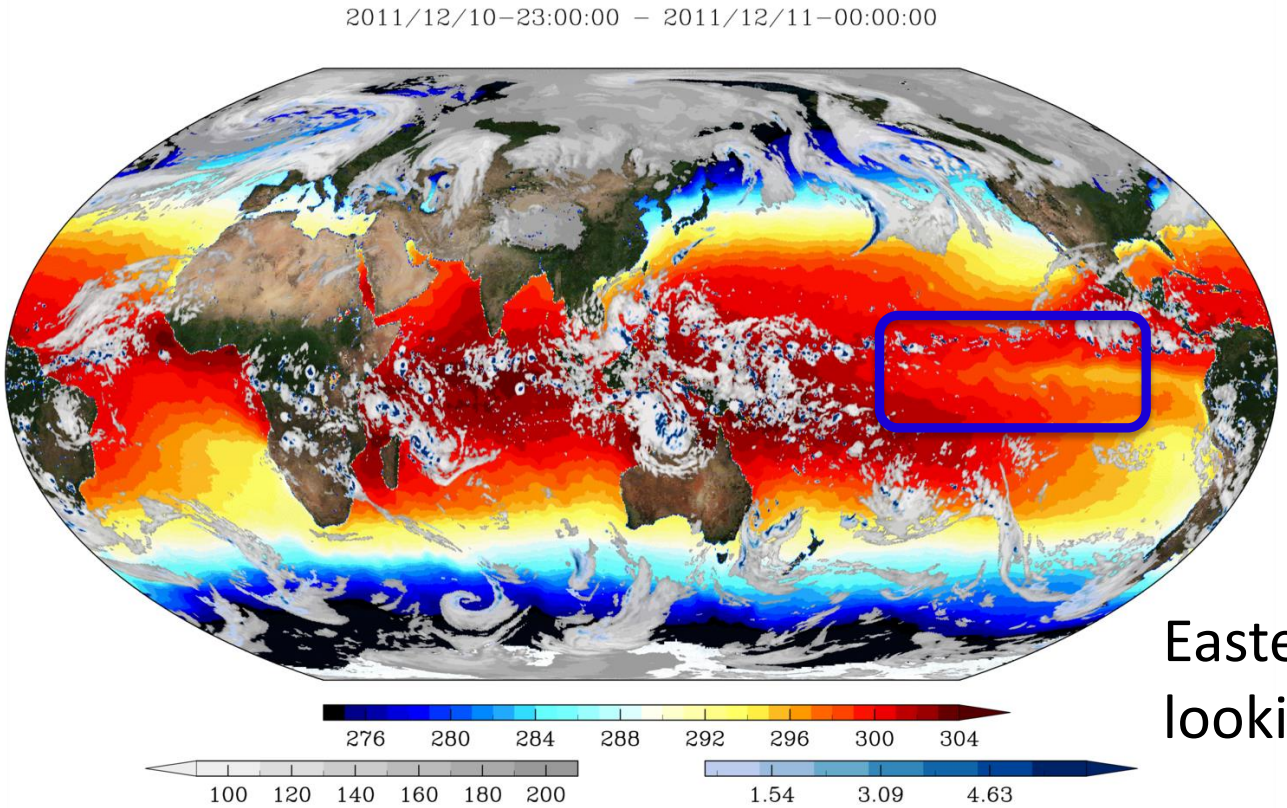


COCO (ocean of MIROC)
Tripolar grid system

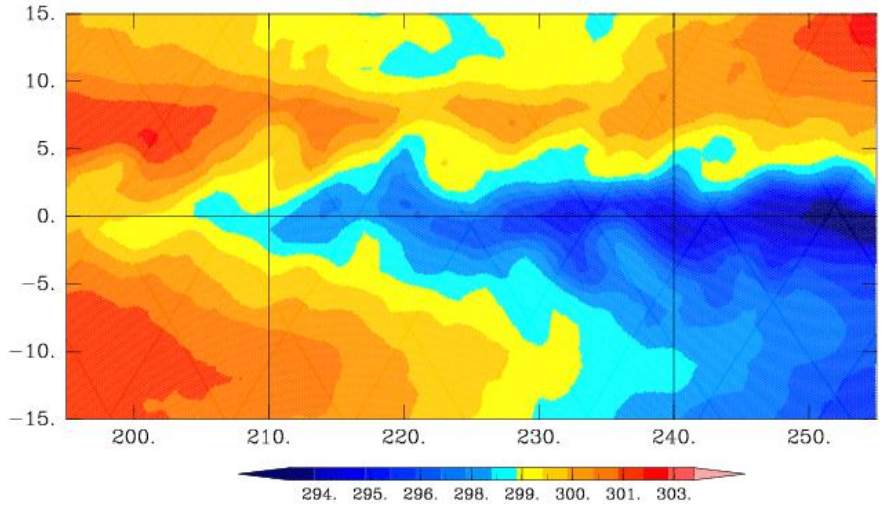


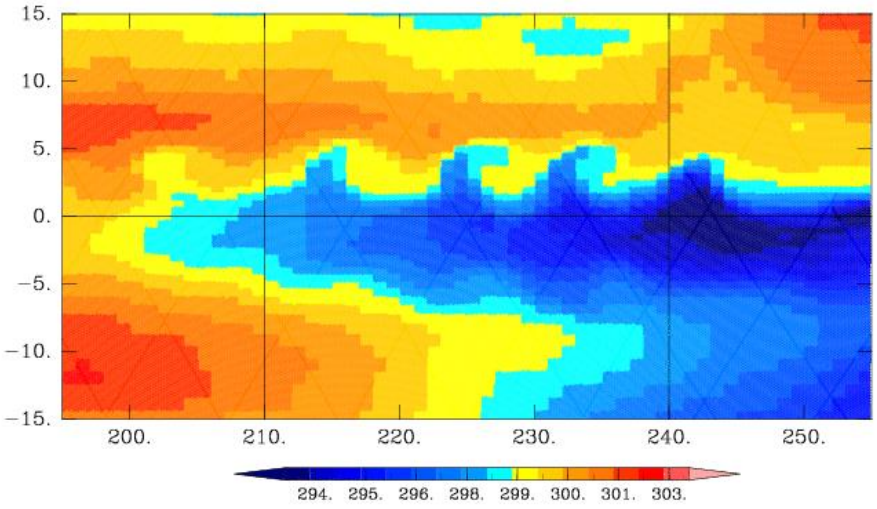
NICOCO
(coupled model)

Miyakawa et al. 2017, *GRL*

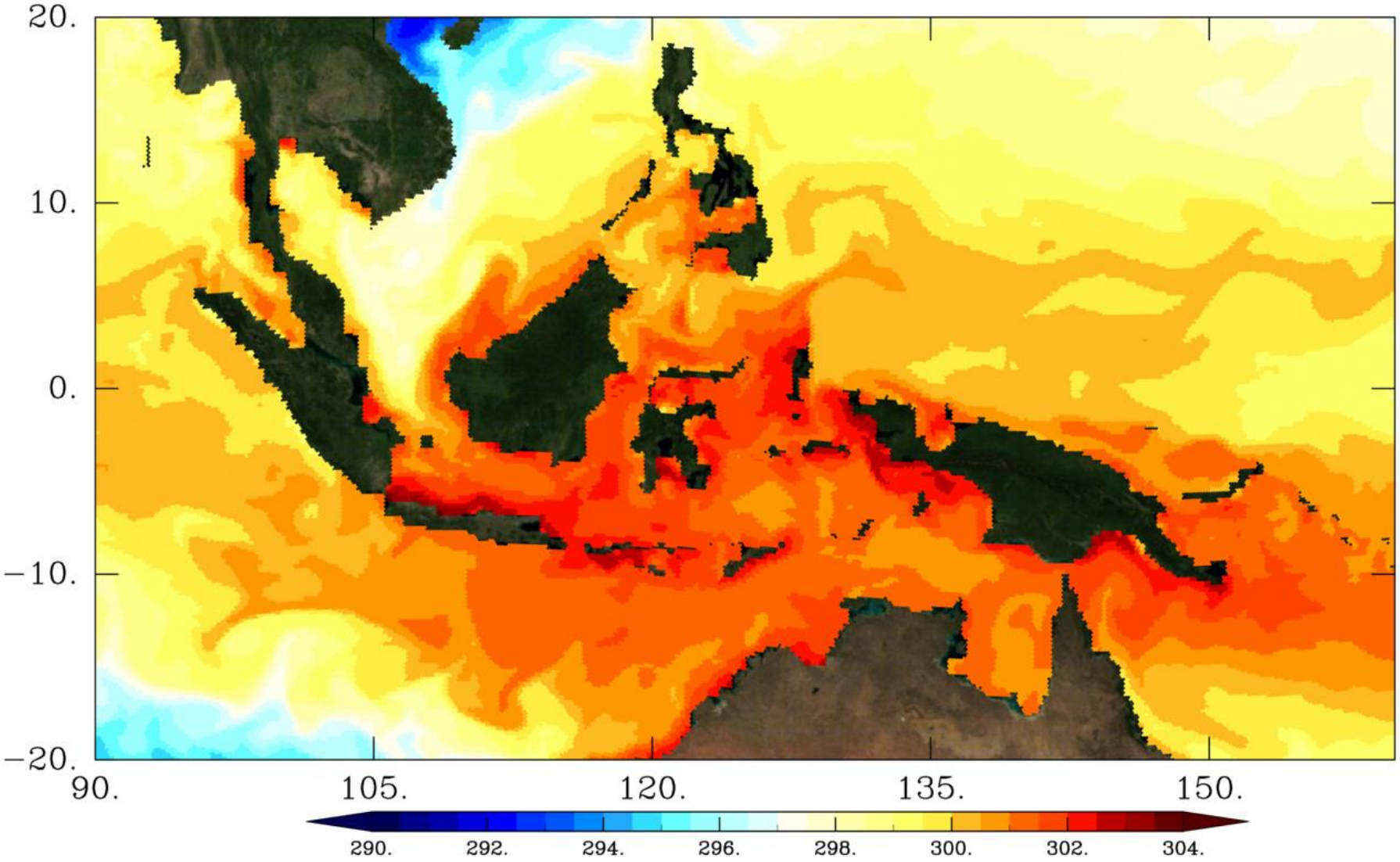


Eastern Pacific TIW looking better. (1 deg ver.)

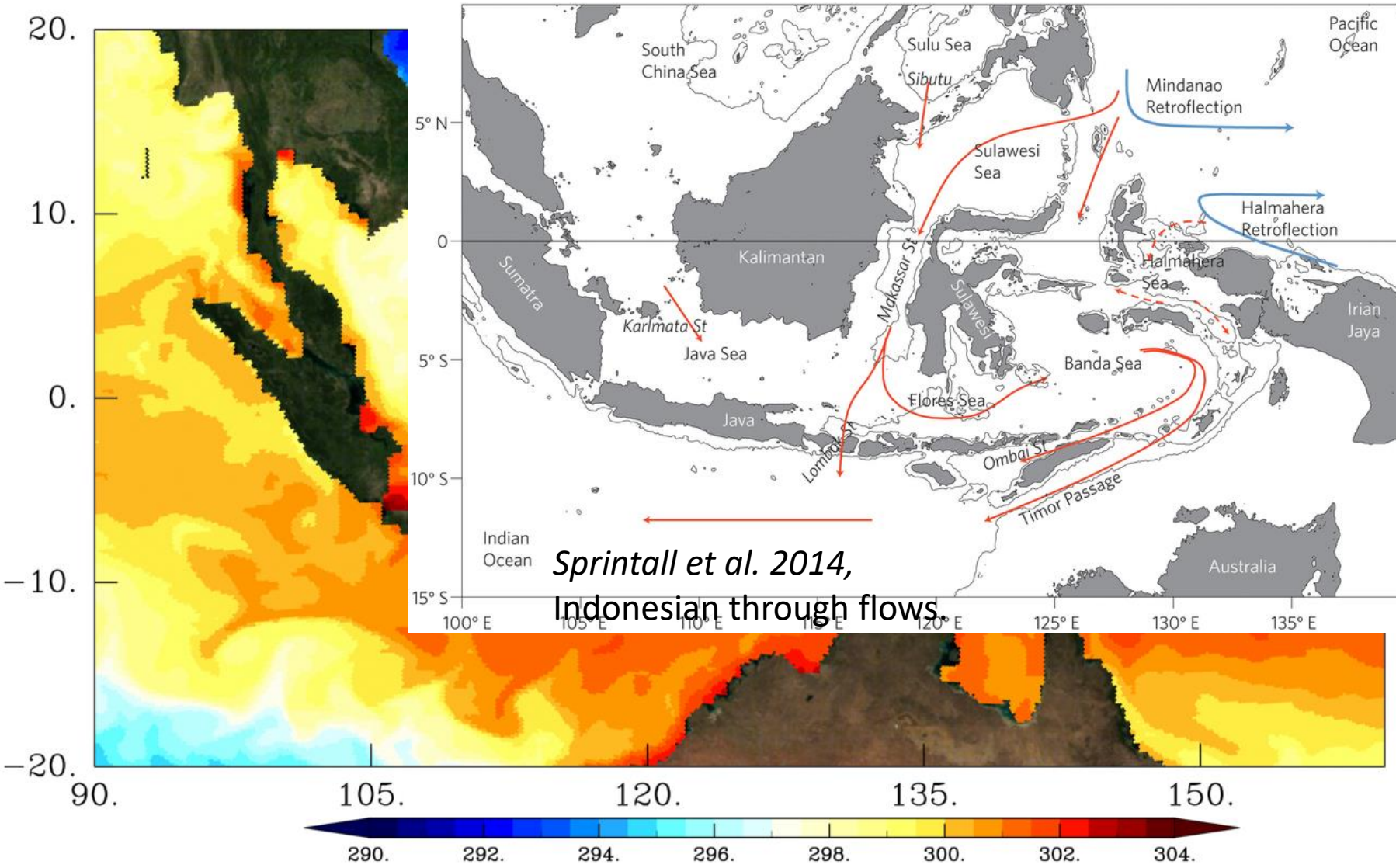




NICOCO 0.25deg



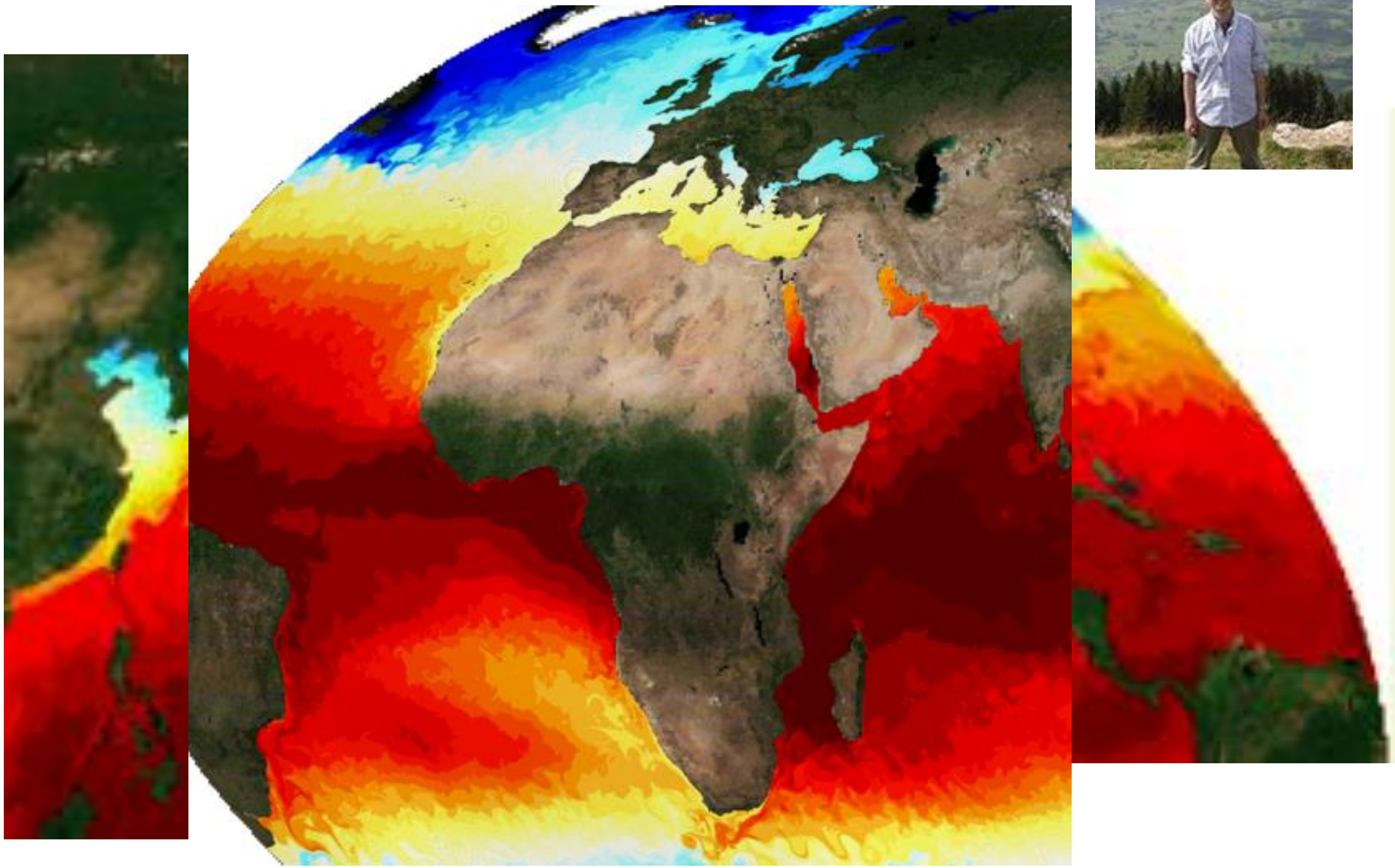
NICOCO 0.25deg



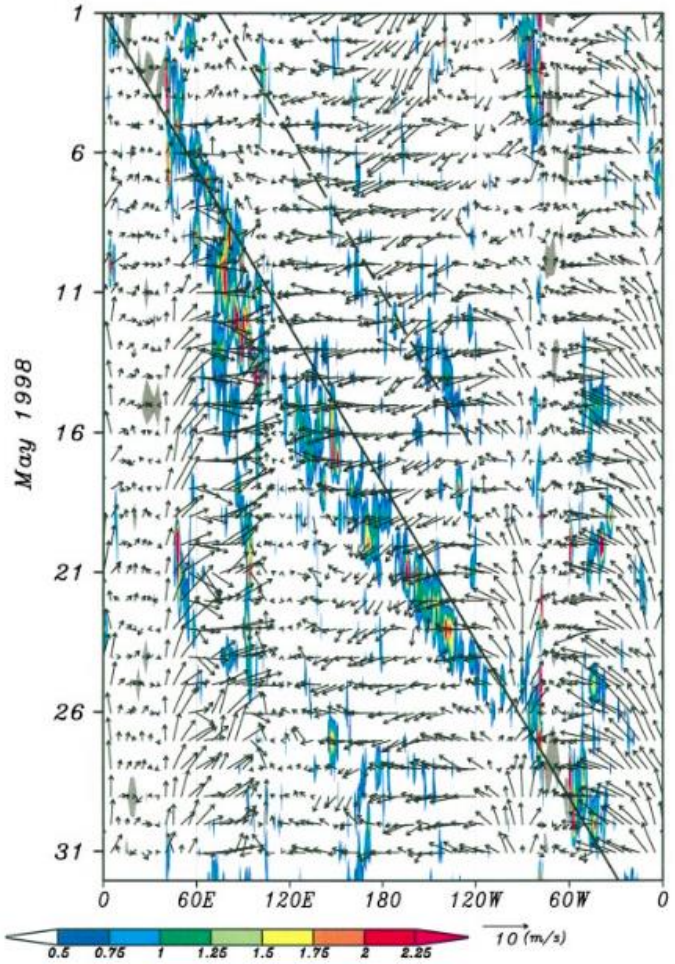
Sprintall et al. 2014,
Indonesian through flows.

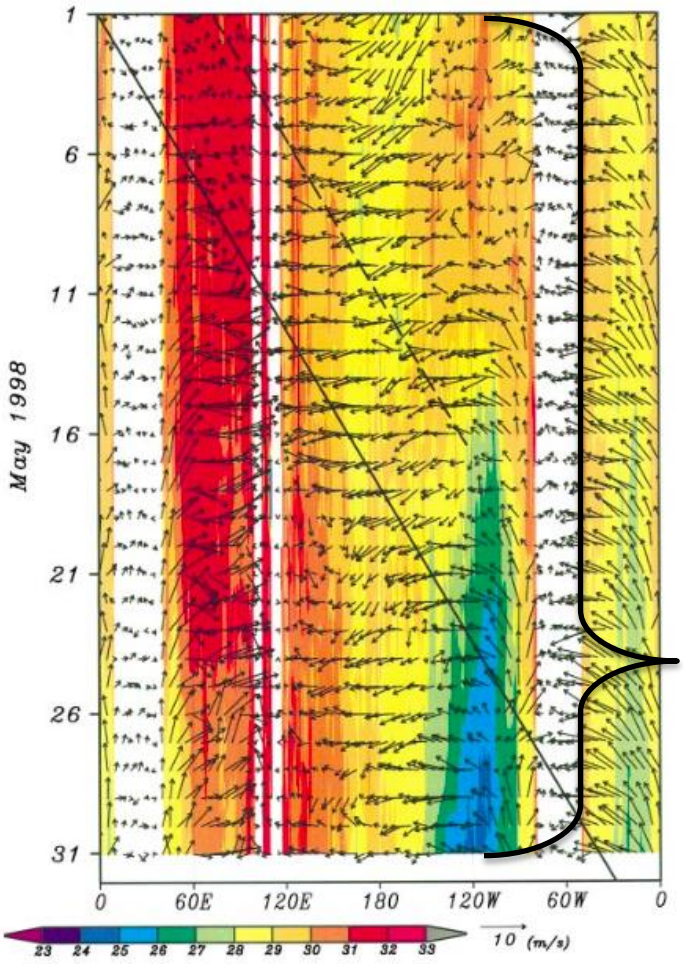
NICOCO 3.5km atm + 0.1deg ocean
“Cloud & eddy resolving” simulation

@ Oakforest PACS
Thx to Hisashi Yashiro



(Example of NICOCO usage)
Target MJO event (May, 1998)





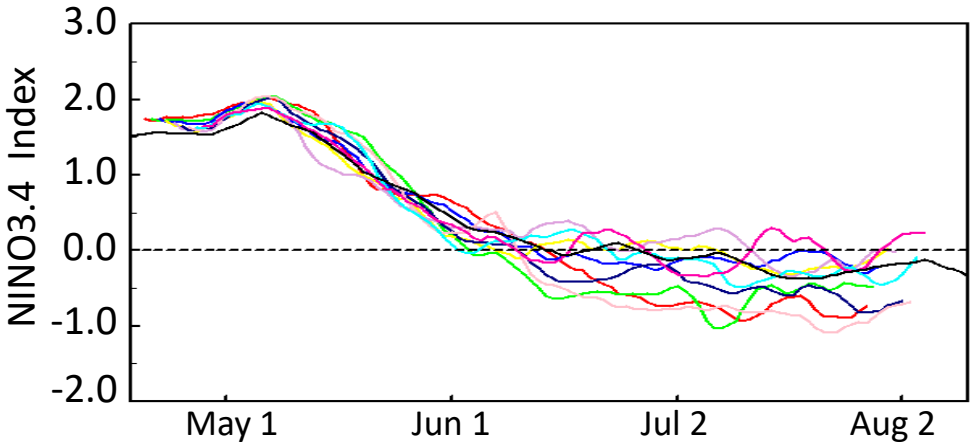
8 K temperature drop in 30 days. *McPhaden* 1999.

Takayabu et al. 1999,
MJO abruptly finishing off giant El Nino?

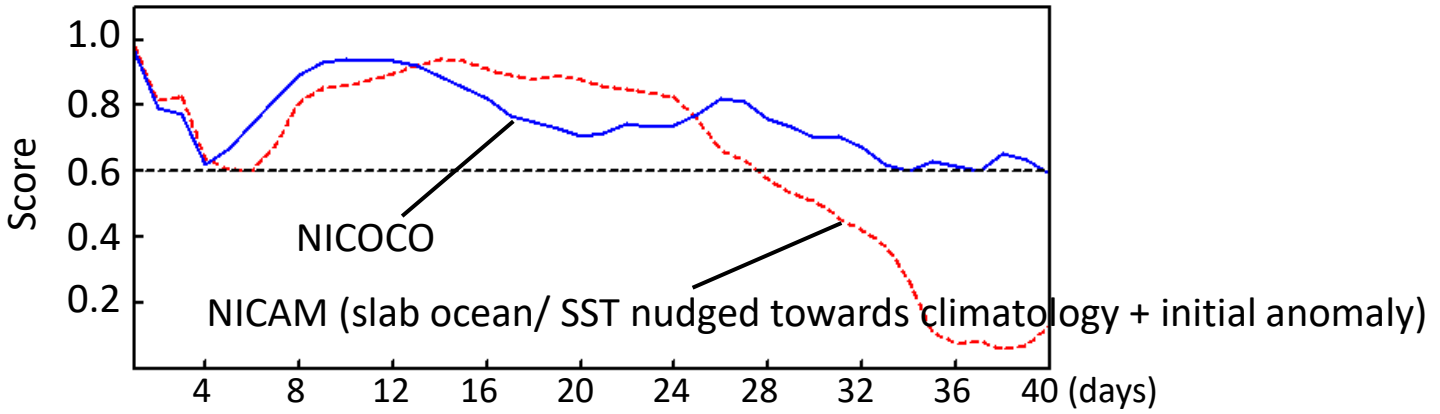
NICOCO, 9 members (Initial dates: Apr. 20 - Apr. 28, 1998)

(* Drift is estimated from 54 MJO exp and subtracted offline)

ENSO

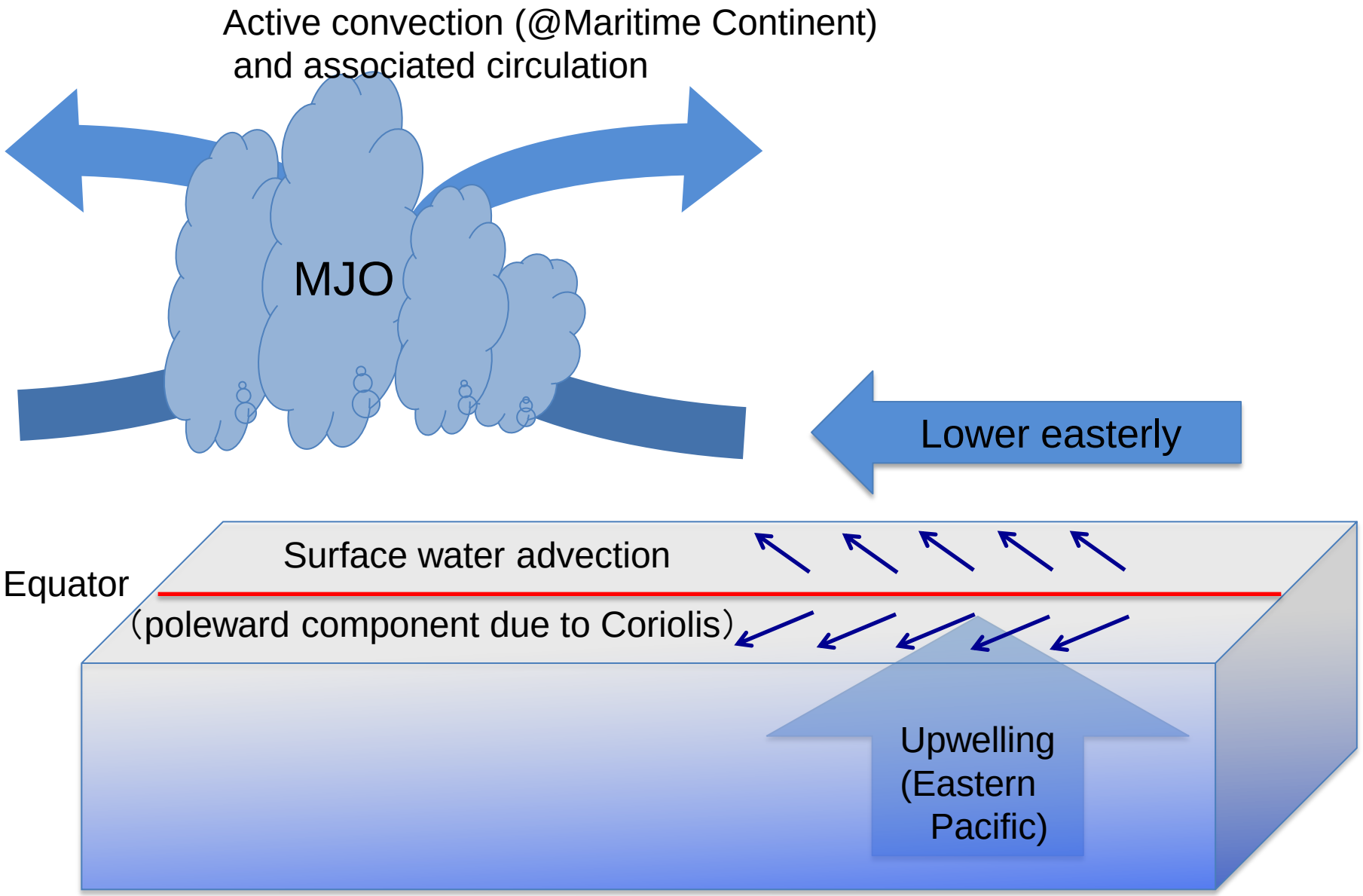


MJO prediction



Miyakawa et al. 2017, *GRL*

MJO remotely enhancing upwelling of cold subsurface water



Ocean-coupled global cloud resolving simulations may open the way for:

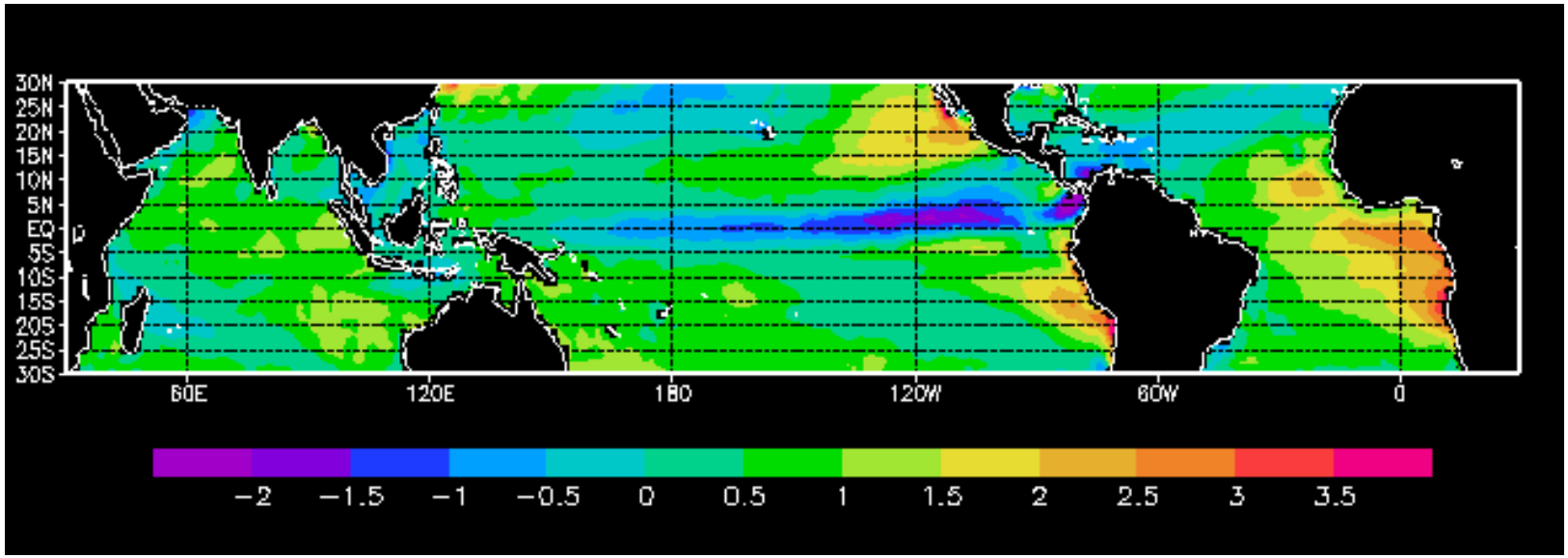
- Better understanding of Atmos.-Ocean interaction over oceanic fronts (Kuroshio, TIW, gulf stream, etc.)
- Improved prediction of ENSO, MJO
- Seasonal prediction for typhoon genesis
- Improved seasonal forecast of mid-latitude blocking events

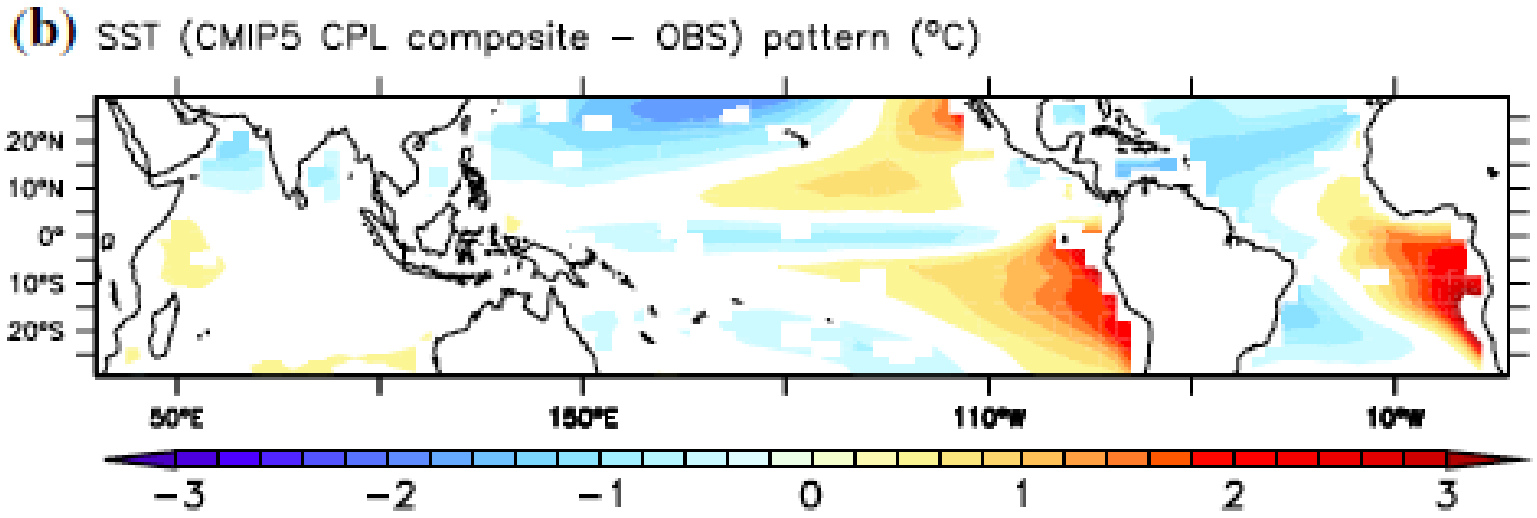
and more.

The big issue going forward:

SST Bias

(a) NICOCO (14-km atm & 1 deg ocn) SST Bias, day 100

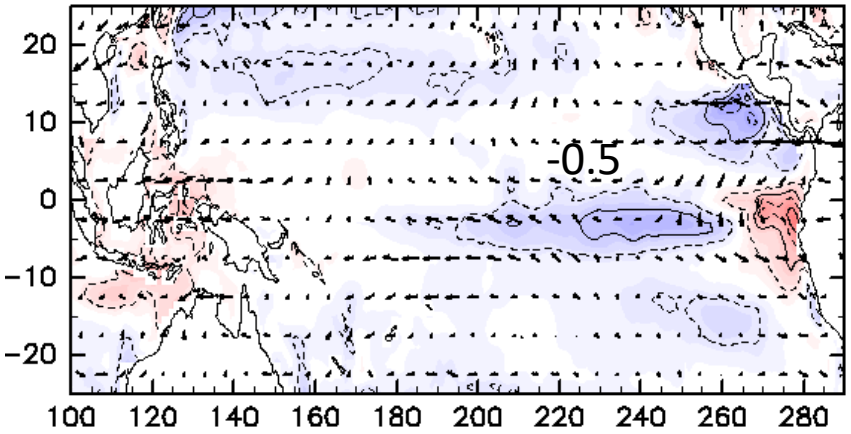




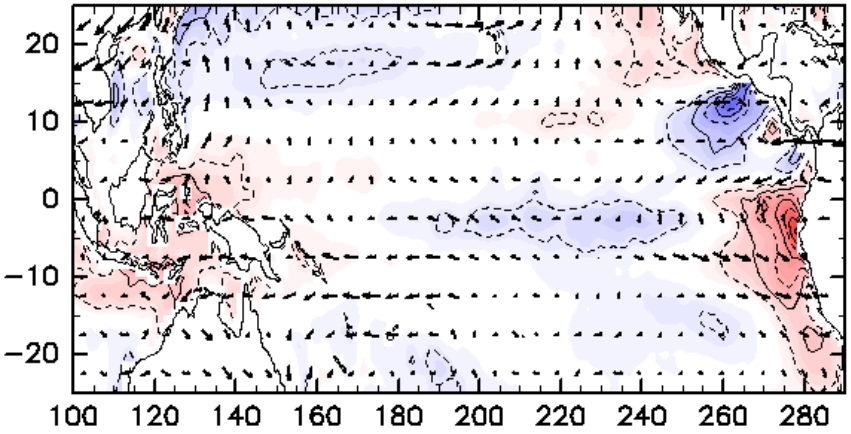
Mean SST bias of CMIP5 coupled historical simulation (Găinuşă-Bogdan et al., 2018)

Mean drift (SST, 850 wind: NICOCO 14 km atm, 1 deg ocean)

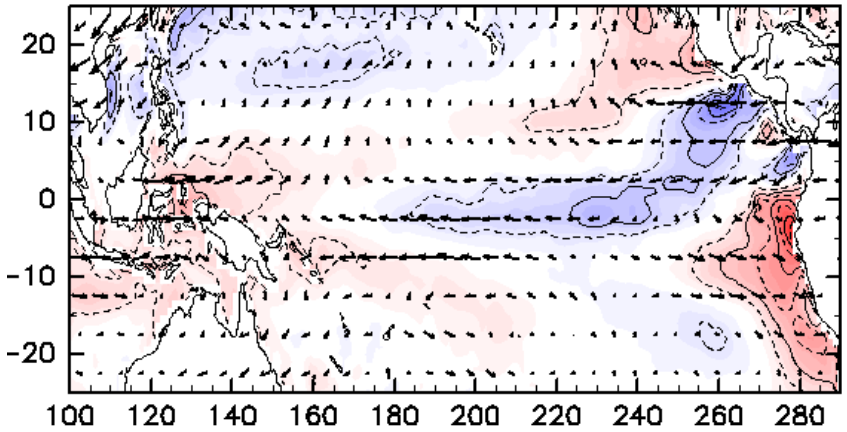
Day 10



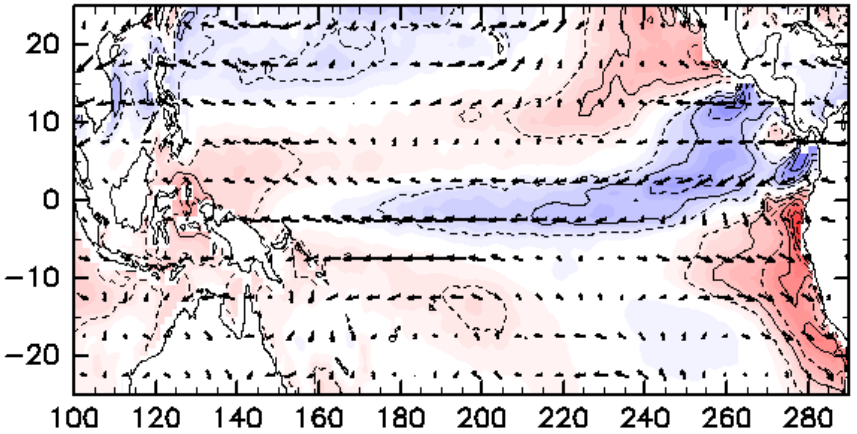
Day 30



Day 50



Day 70



-5 deg 5 deg

Current status of NICOCO SST bias

- SST bias for NICOCO (14km-1deg) is very similar to CMIP5 GCMs.
- Overestimation of trade wind is likely the cause.
- Sensitivity tests of SST bias to resolutions of atmosphere (7 km, 3.5 km) and ocean (0.25 deg, 0.1 deg) ocean are under way.

Summary

- Global cloud-resolving models are quickly becoming an accessible tool world-wide.

- Ocean-coupled versions of GCRMs have been expected to "revolutionize climate science" (at S2S/S2D scales for a start)

- NICOCO (ocean-coupled NICAM) show promising results, and can now execute "global cloud and eddy resolving" simulations

- We really need to work on SST bias

Summary

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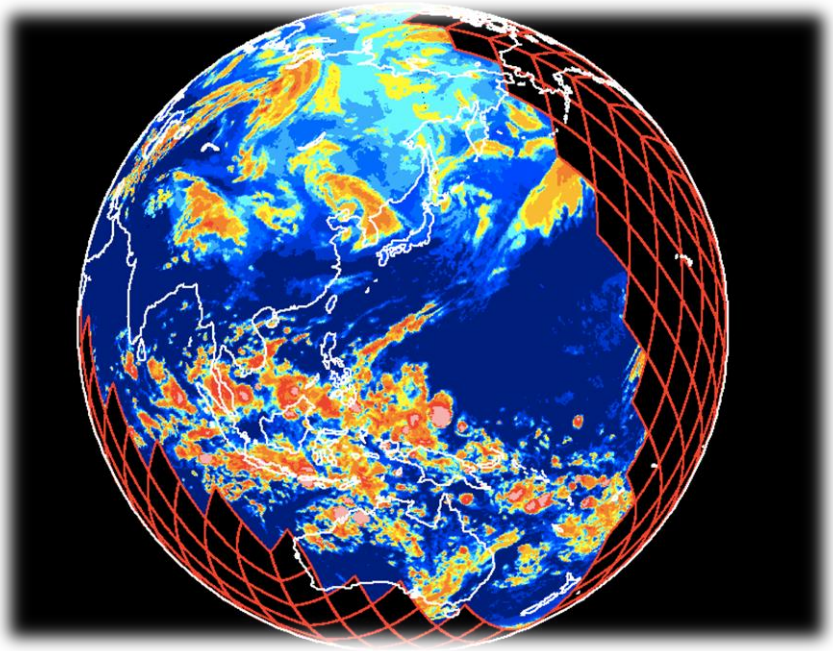
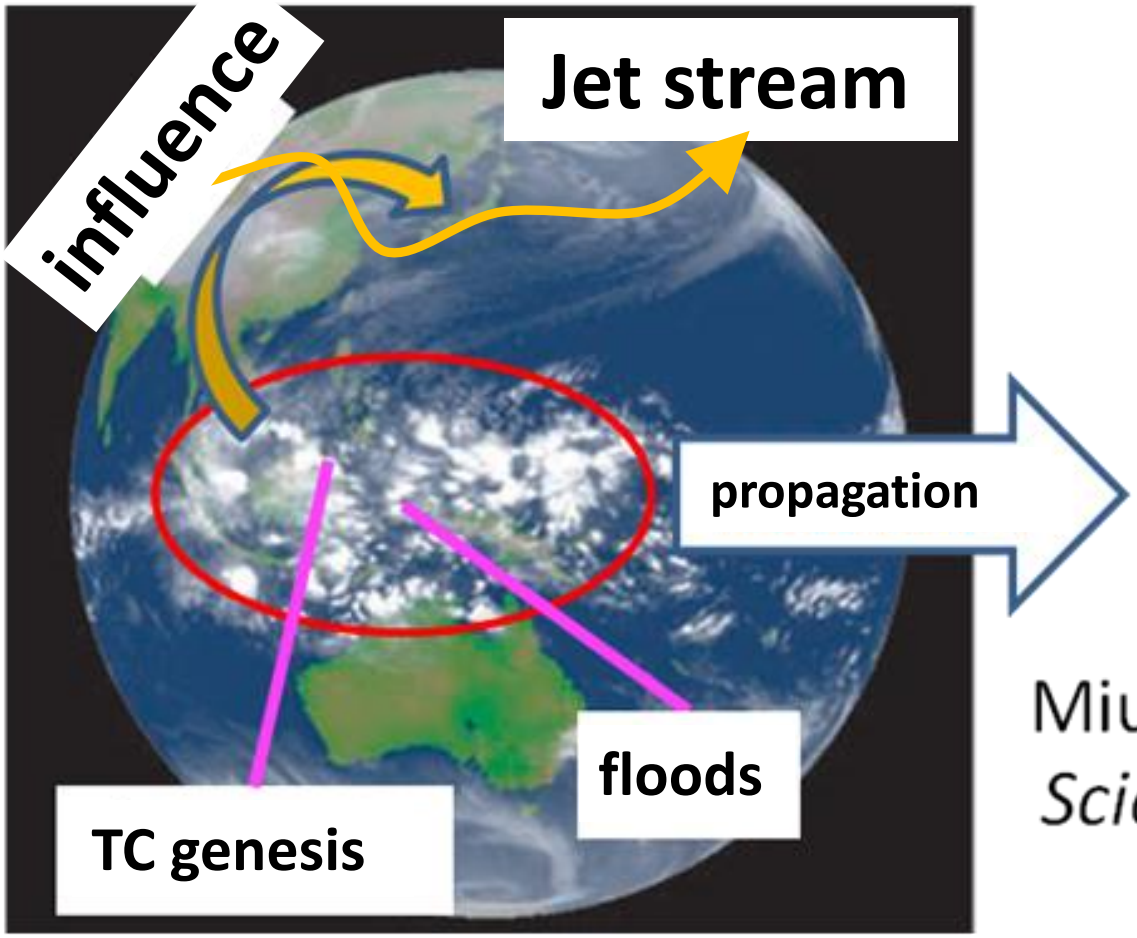
---> I came here to find collaborators



Happy Hacking!

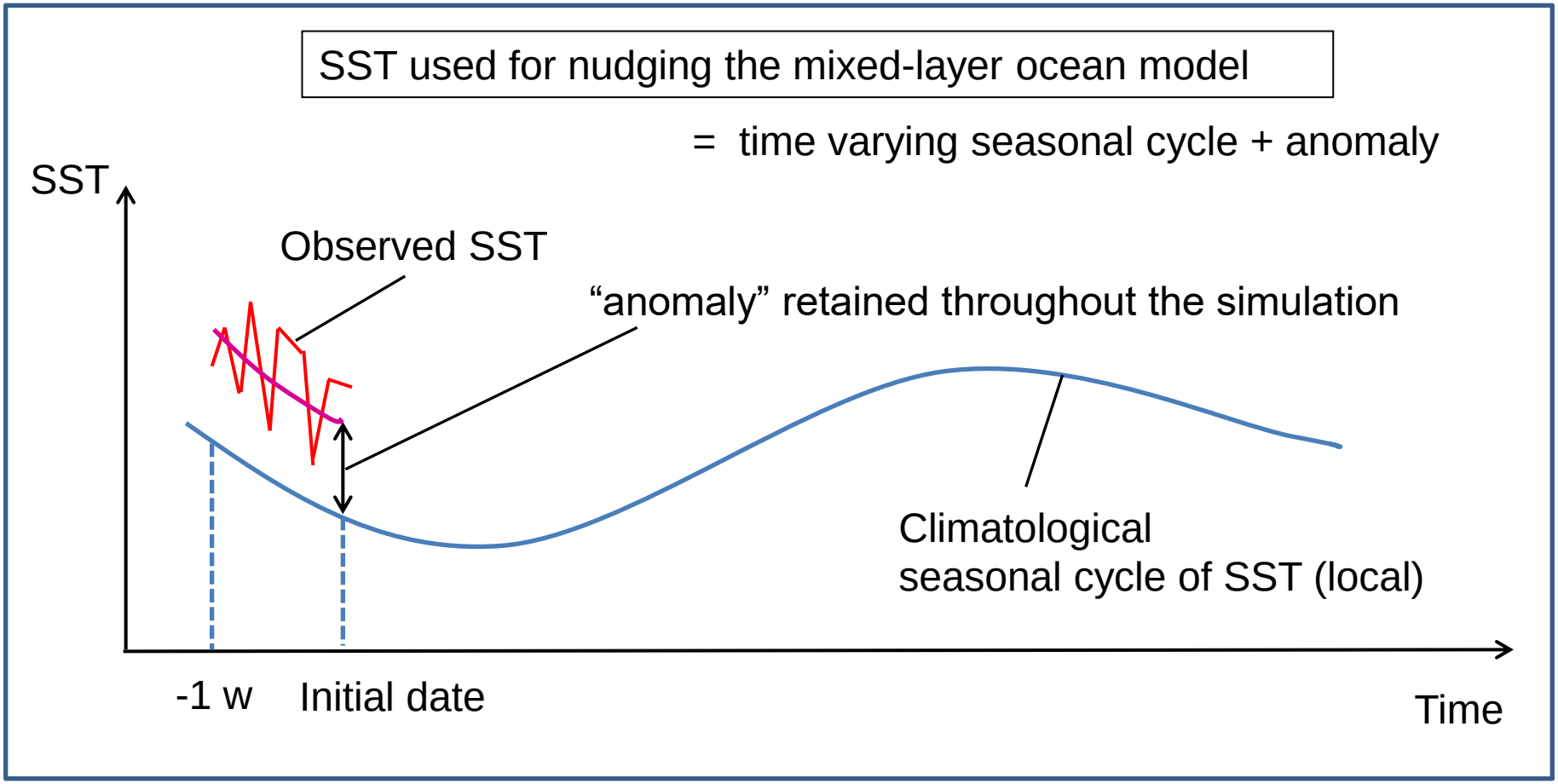
A Key to sub-seasonal/seasonal prediction：

Madden-Julian oscillation (MJO)



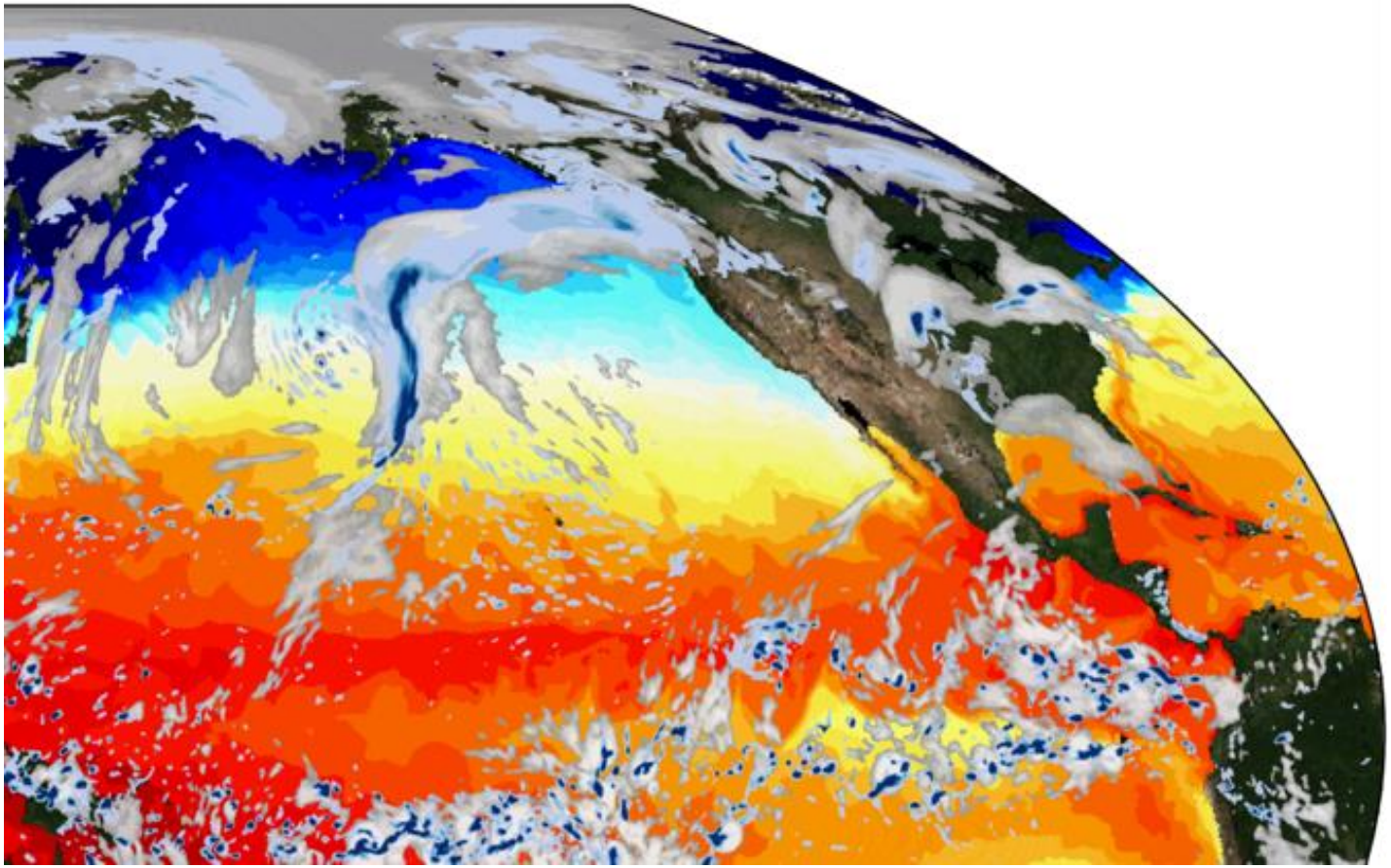
Miura et al. 2007
Science (edited)

SST used for atmospheric NICAM MJO skill evaluation

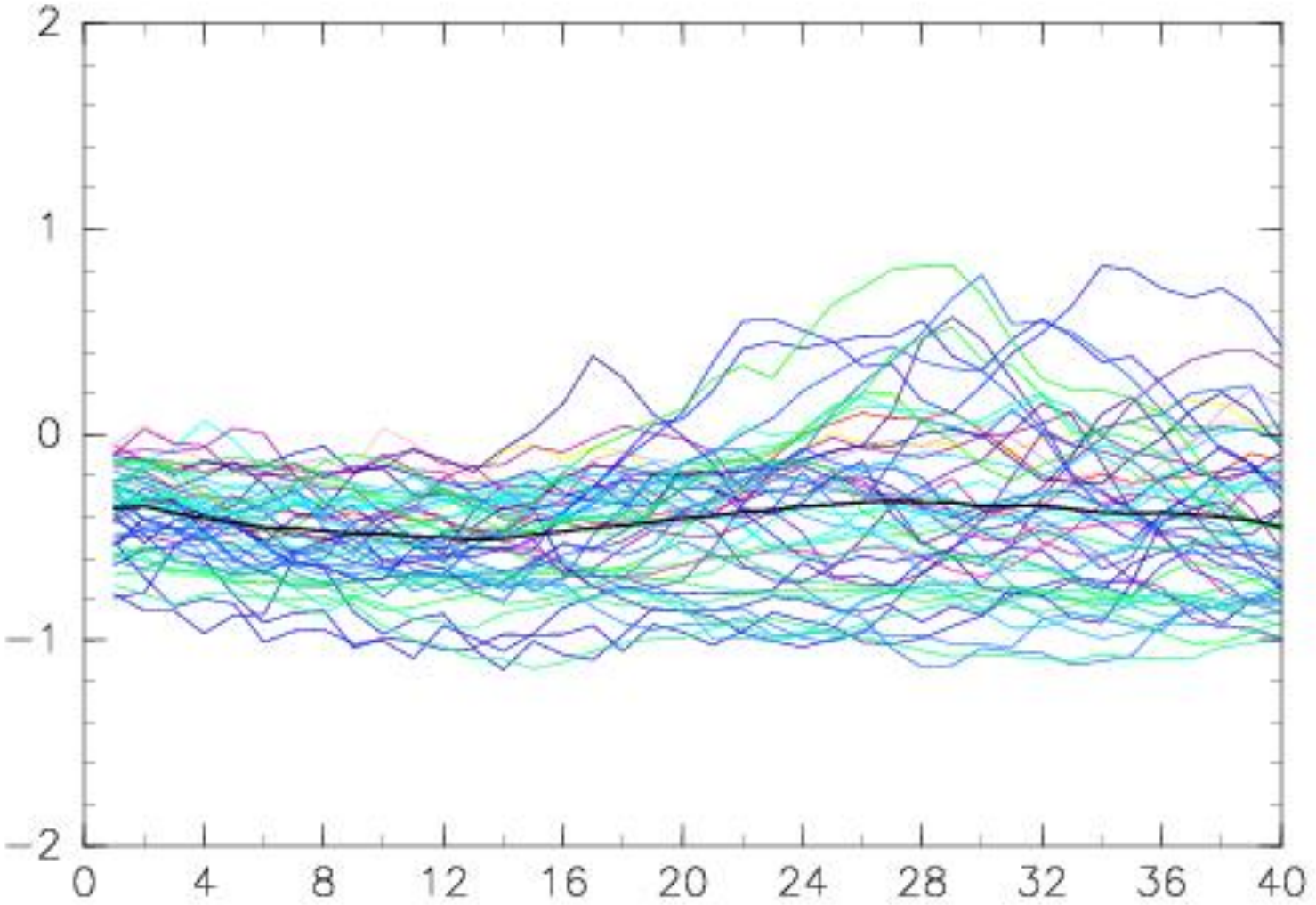


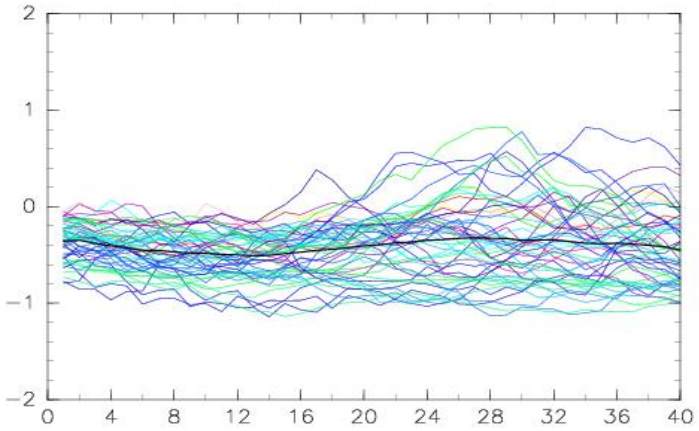
Allows “forecast mode” simulations, but performance get worse when ocean anomalies change rapidly.

NICOCO 0.25deg



NINO3.4, model bias

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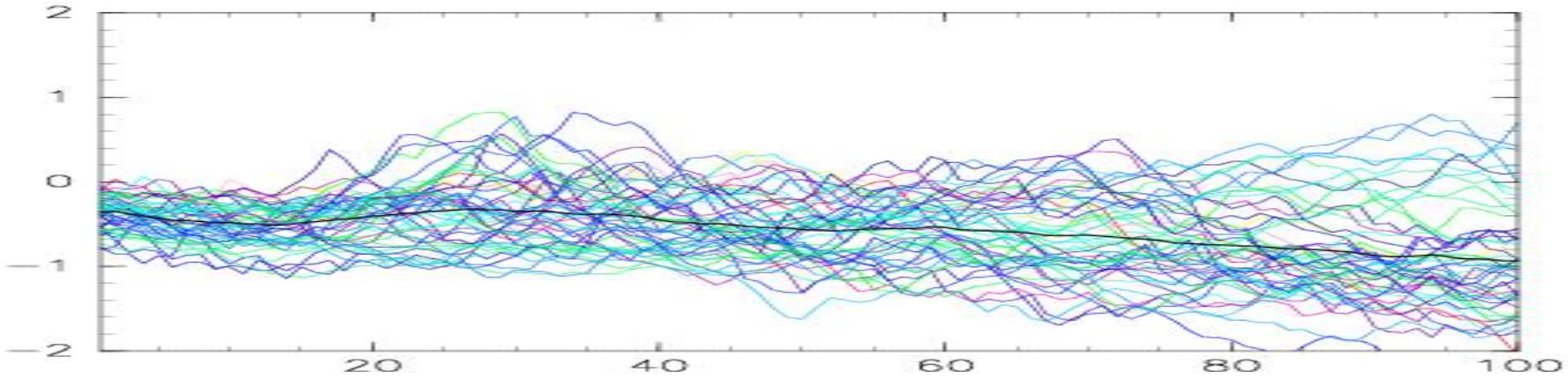
2
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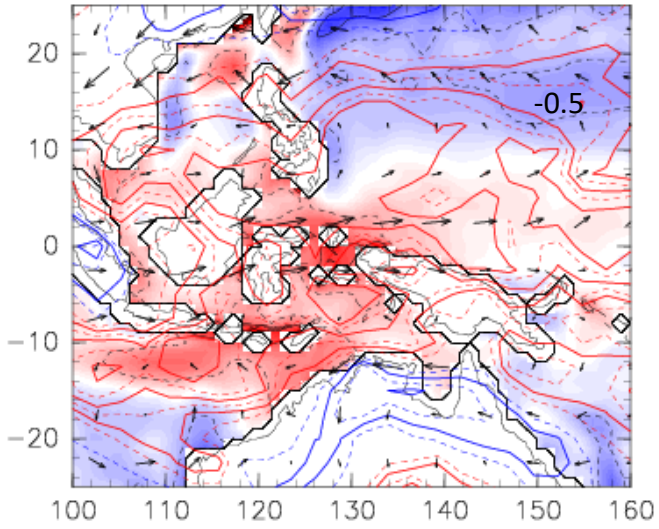
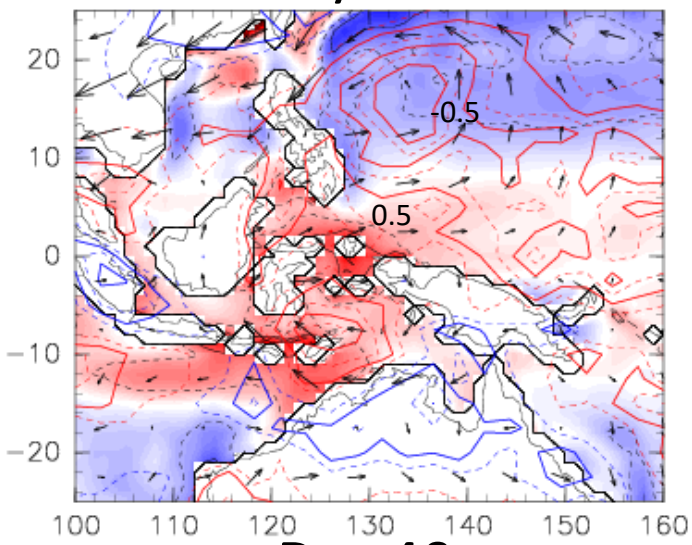
−1
−2
20
40
60
80
100

Mean bias (SST, OLR, 850 wind: NICOCO 53 cases)

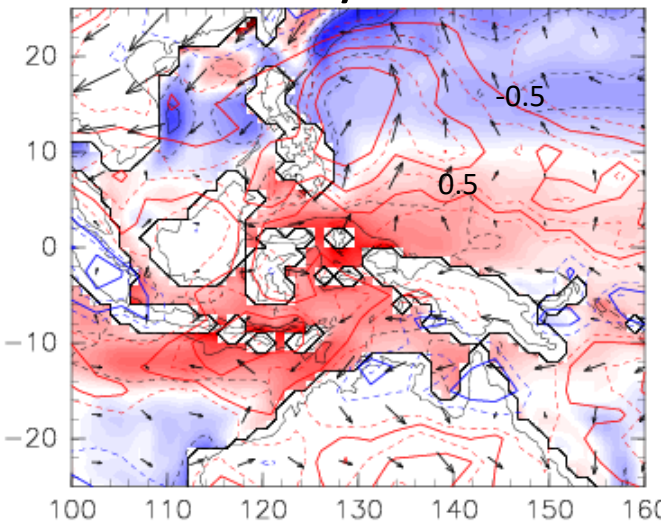
Day 10



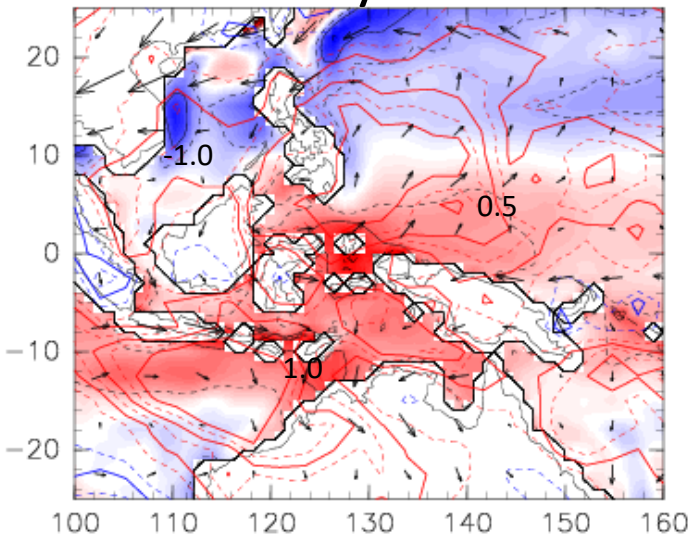
Day 20



Day 30

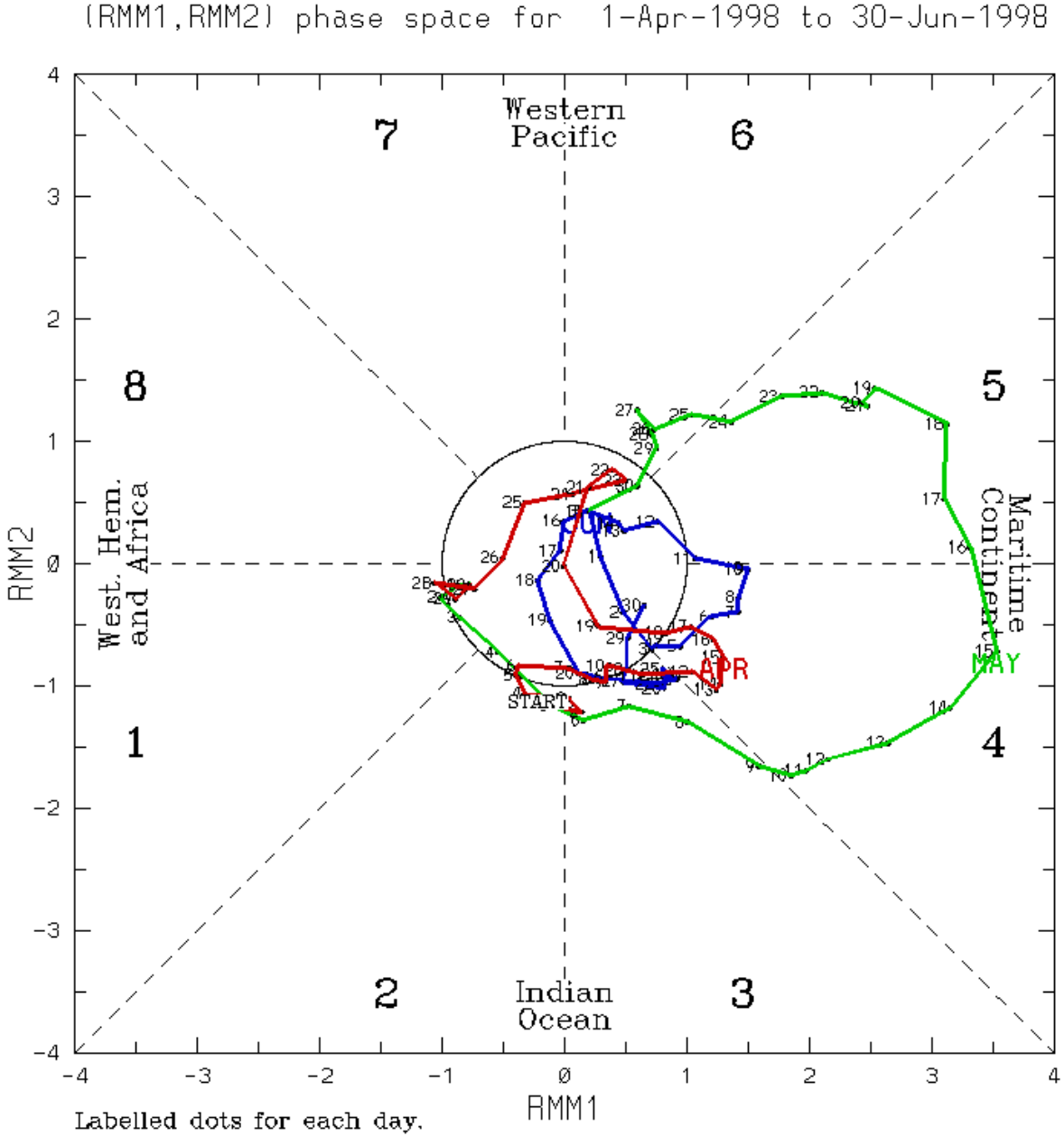


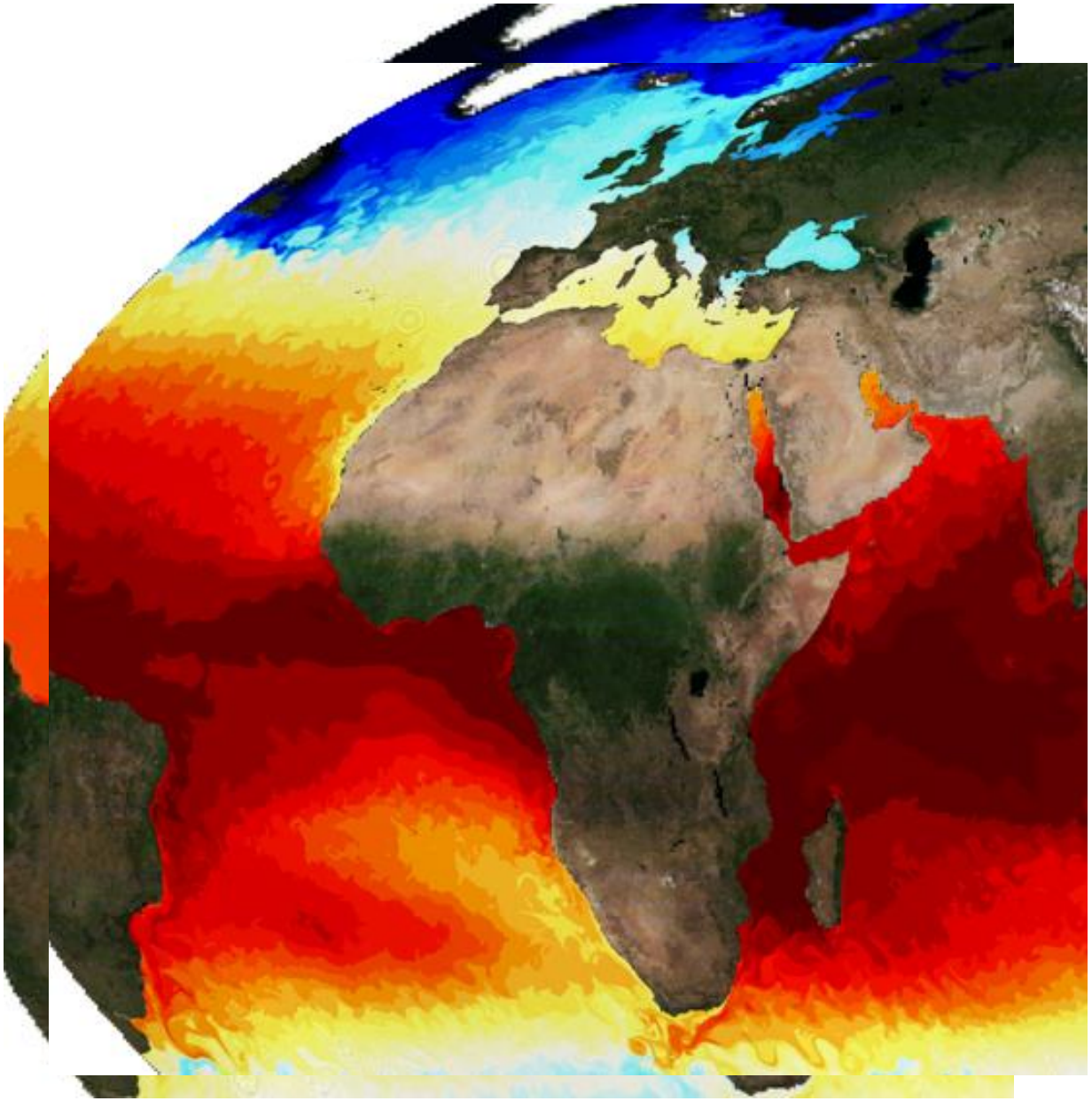
Day 40



-3 deg

3 deg



Labelled dots for each day.
Blue line is for Jun, green line is for May, red line is for Apr.

(C) Copyright Commonwealth of Australia 2013 . Bureau of Meteorology