Physics sensitivity of regional mesh refinement in CAM

Zhuxiao Li and Rich Neale

w/ Colin Zarzyki, Mark Taylor, Mike Levy and Peter Lauritzen

Motivation

- Regional mesh refinement is an economic way to do the global run with regional high resolution to resolve the smaller scale processes for climate study.
- It will be a helpful tool if:

1. The refinement mesh behaves consistently with its corresponding uniform mesh.

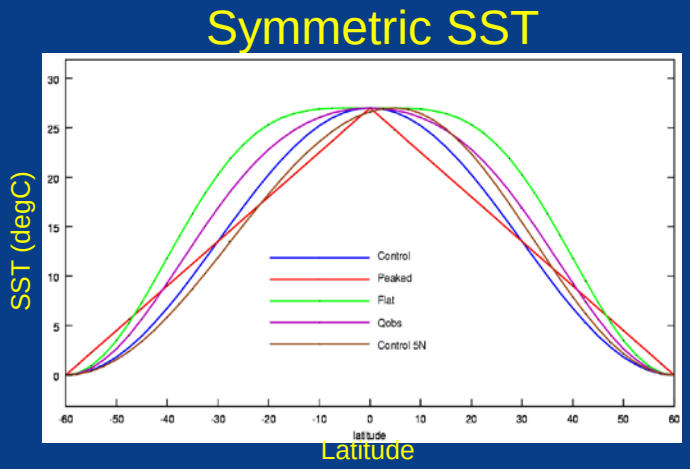
2. Apply scale-aware parameterization or just get rid of the physics sensitivity to grid-size.

Introduction

- We examined the grid-size sensitivity in both uniform and regionally refined mesh by CAM runs.
- Also investigated the behavior consistency between the two kinds of meshes.
- Performed some parameter adjustment in CAM to mitigate the grid-size dependency.

CAM Simulations

- Configuration: Aqua Planet Experiment with described SST.
- Models: CAM4 and CAM5
- Mesh: 2, 1, 0.5 and 0.25 degree uniform grid, Tropical Regionally Refined mesh (2->0.25deg) by CUBIT.



The CAM family

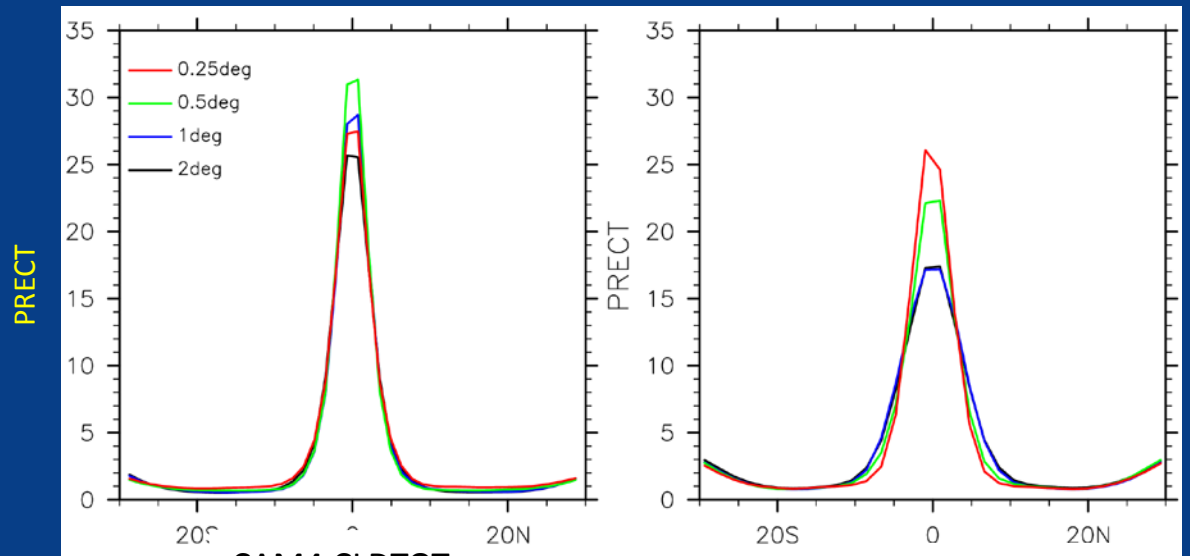
Model	CAM3	CAM4	CAM5
Release	**Jun 2004**	**Apr 2010**	**Jun 2010**
PBL	Holtslag-Boville (1993)	Bretherton et al (2009)	Bretherton et al (2009)
Shallow Convection	Hack (1994)	Hack (1994)	Park et al. (2009)
Deep Convection	Zhang-McFarlane (1995)	Neale et al. (2008)	Neale et al. (2008)
Microphysics	Rasch-Kristjansson (1998)	Rasch-Kristjansson (1998)	Morrison-Gettelman (2008)
Macrophysics	Rasch-Kristjansson (1998)	Rasch-Kristjansson (1998)	Park et al. (2011)
Radiation	Collins et al. (2001)	Collins et al. (2001)	Iacono et al. (2008)
Aerosols	Bulk Aerosol Model	Bulk Aerosol Model BAM	Modal Aerosol Model Ghan et al. (2011)
Dynamics	Spectral	Finite Volume	Finite Volume

= New parameterization/dynamics

Zonal-mean PRECT and CLDTOT by the uniform mesh runs

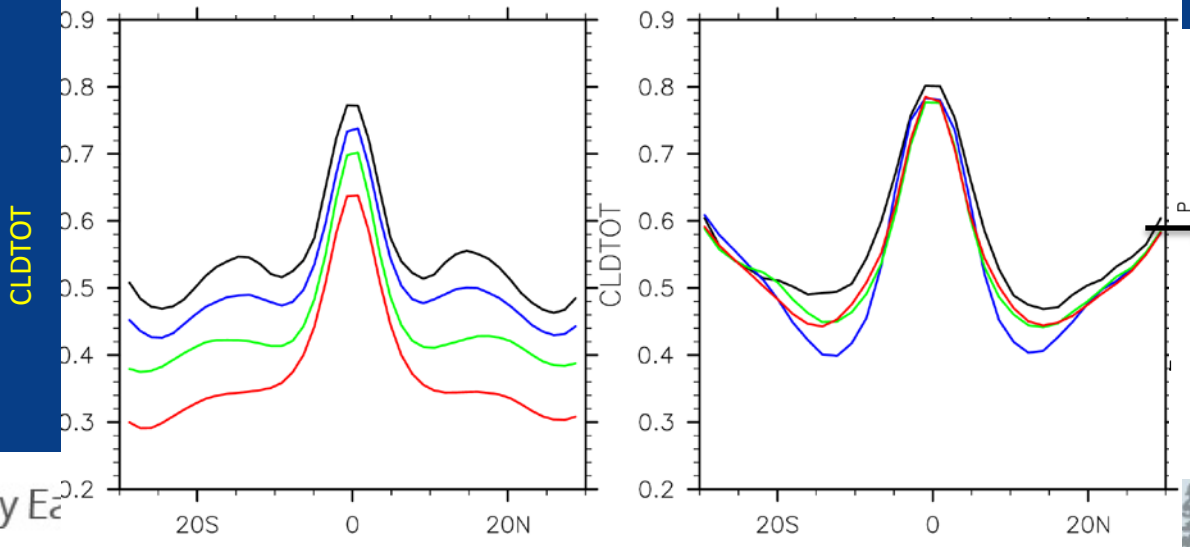
CAM4 PRECT

CAM5 PRECT

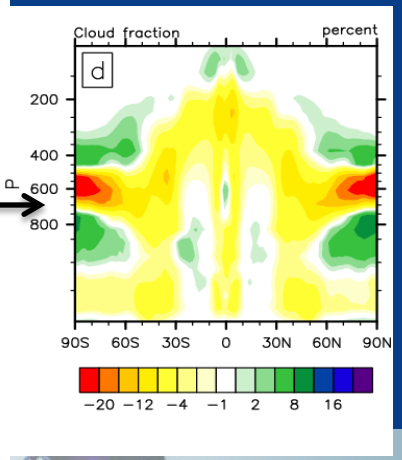


CAM4 CLDTOT

CAM5 CLDTOT

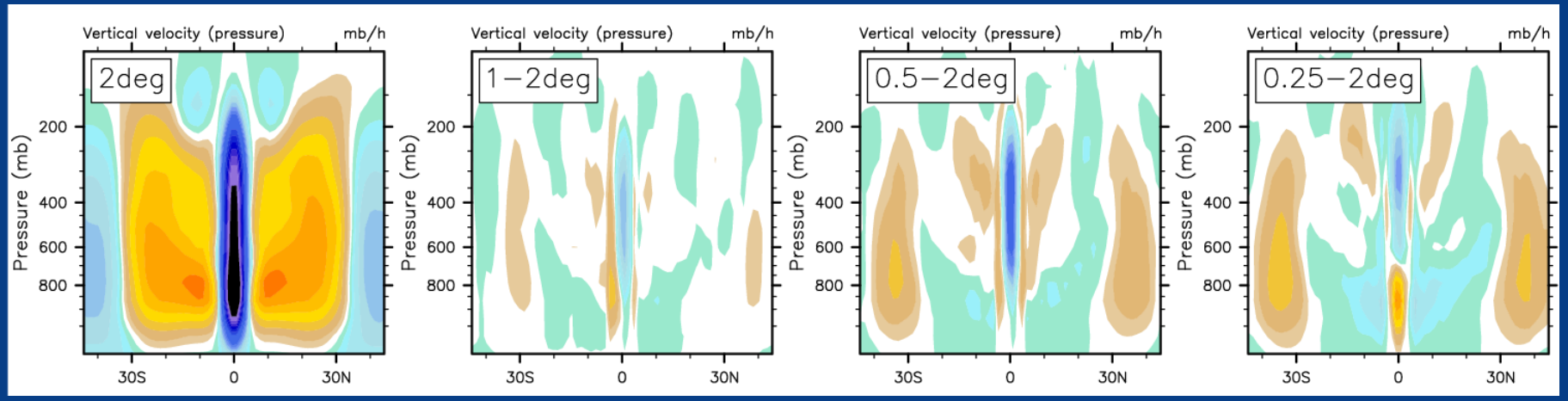


CAM5 PRECT and CAM4 CLDTOT change more monotonically

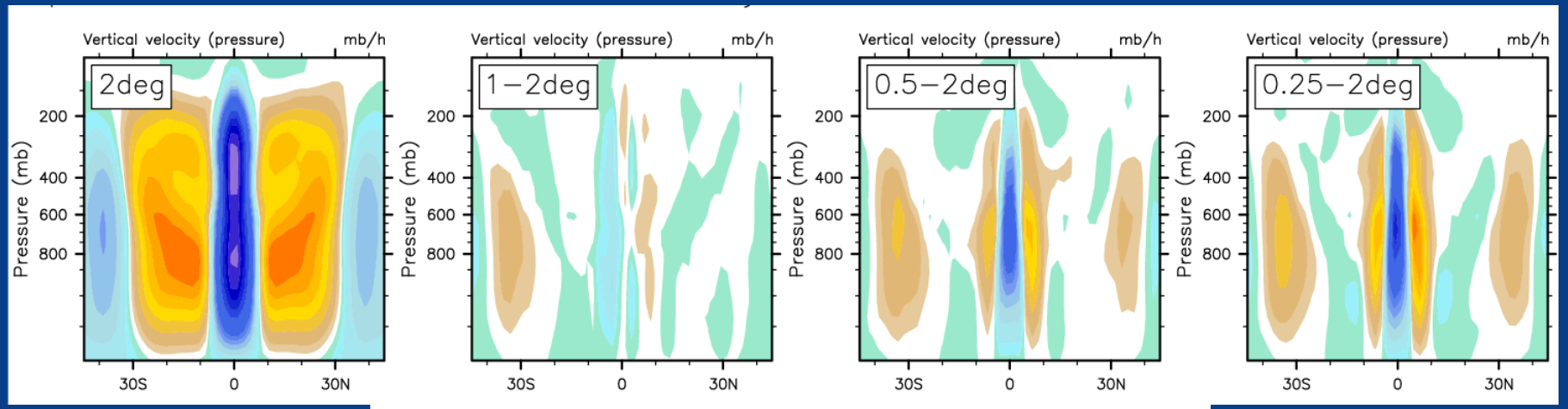


Zonal Mean Vertical Velocity in uniform runs

CAM4

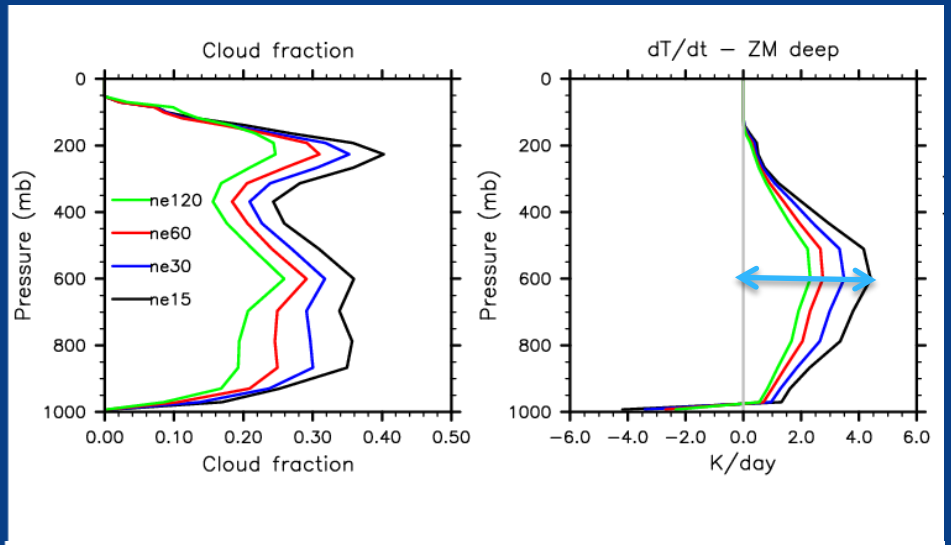


CAM5

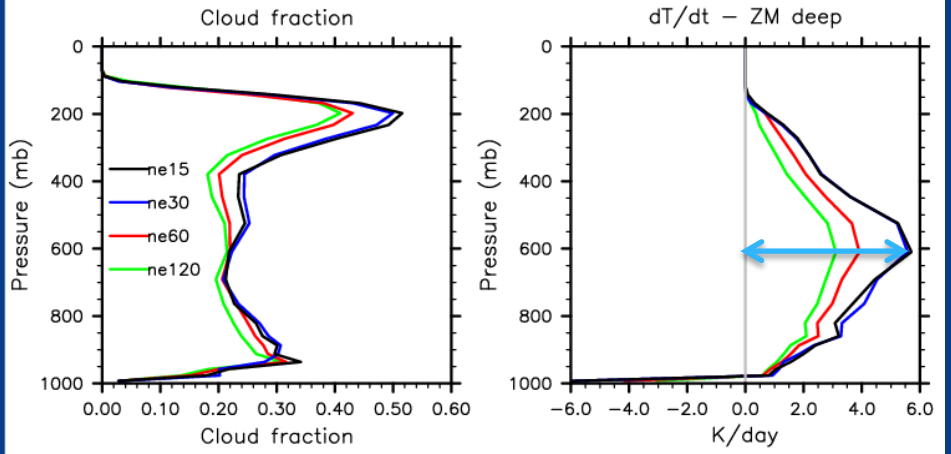


Cloud and T tendencies (>10mm/day) in uniform meshes

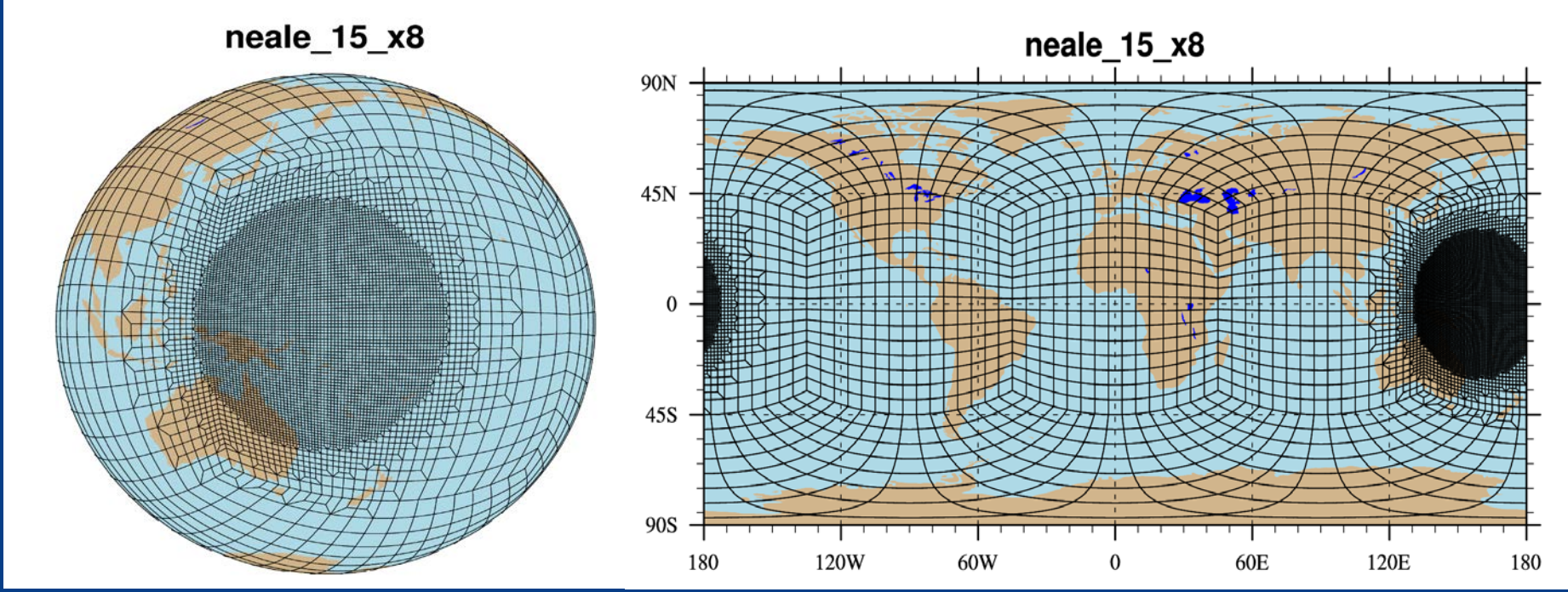
CAM4



CAM5



Regionally refined mesh (2->0.25deg)



Regionally refined domain: 130E-190E, 30S-30N, over west pacific tropical area

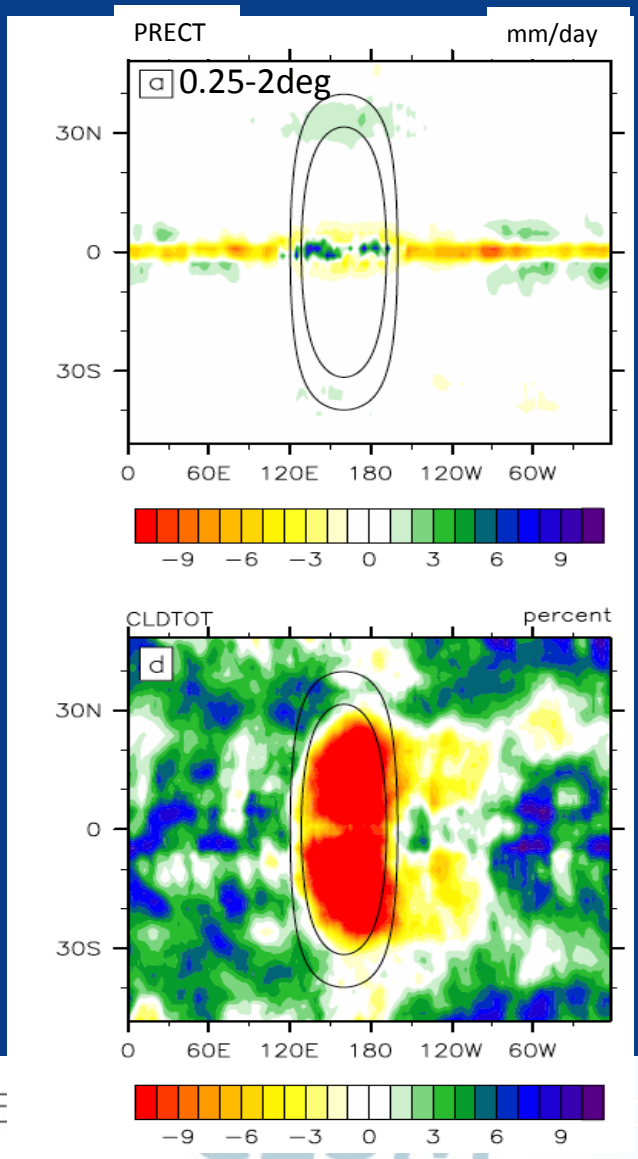
Anomaly PRECT and CLDTOT by Regionally Refinement runs from their corresponding 2deg runs

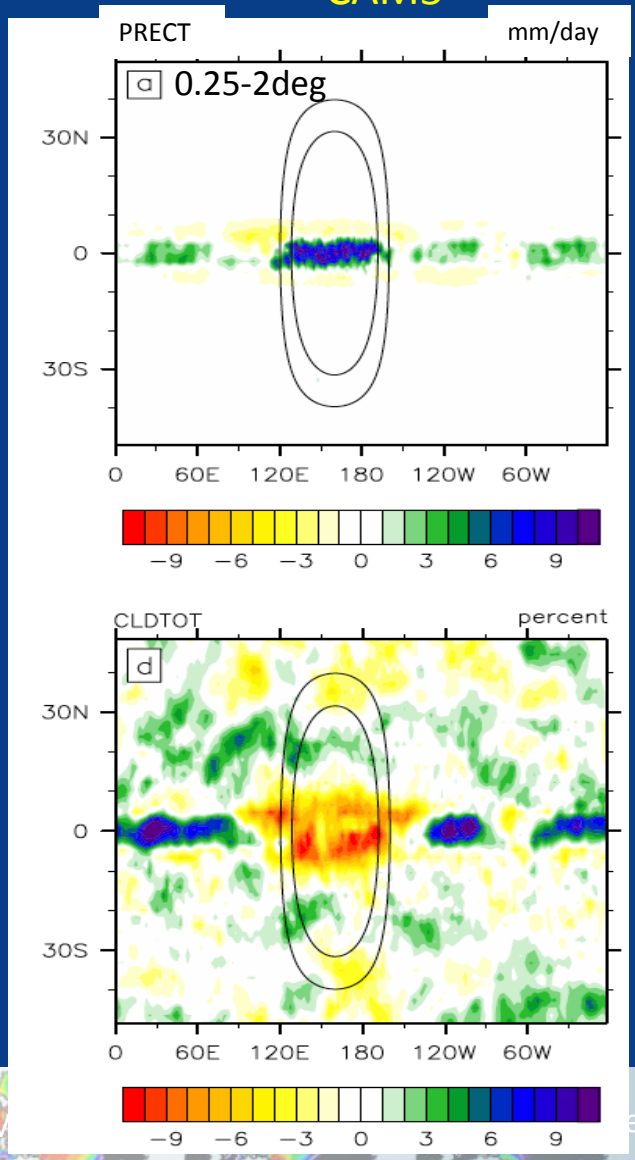
CAM4

CAM5

PRECT

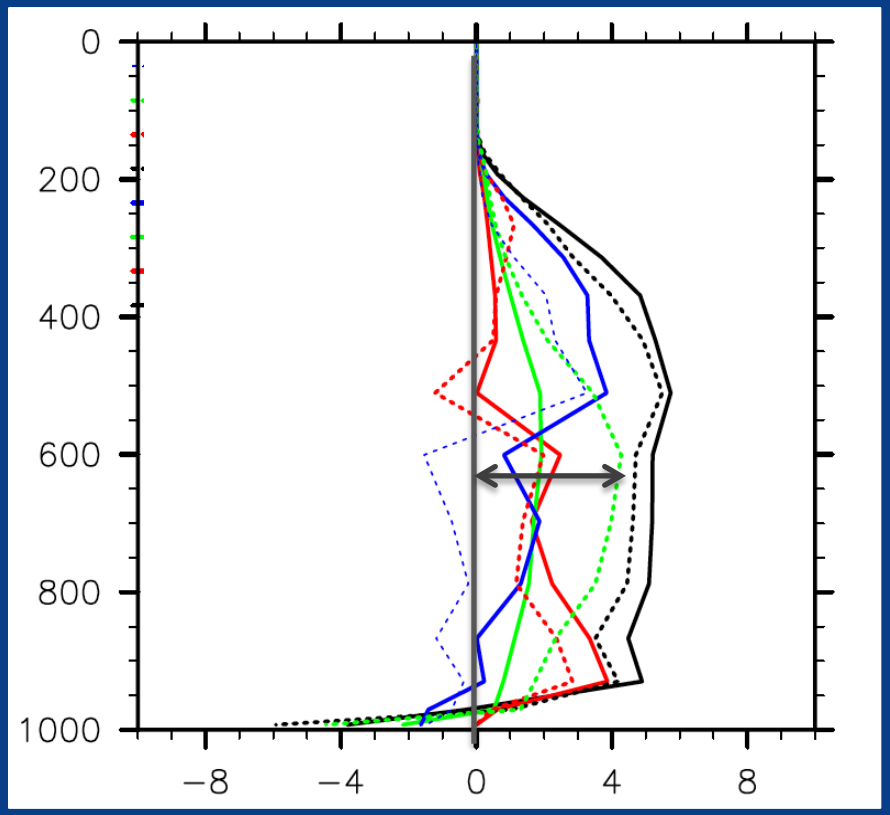
CLDTOT



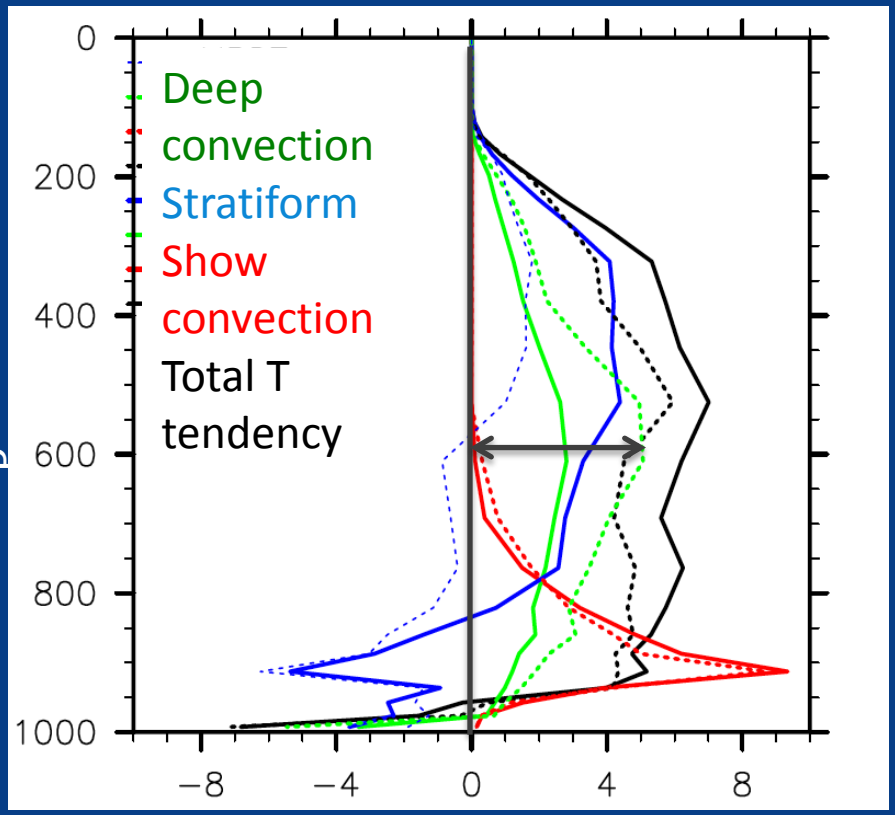


Temperature tendencies from several schemes inside and outside of the refined area

CAM4



CAM5



Deep convection Scheme

Convection Sensitivity Experiments

Deep Convection scheme shows the most consistent sensitivity to resolutions in both CAM4 and CAM5 runs.

ZM scheme --> convective timescale(TAU) -->
Vertical velocity <--> grid-size

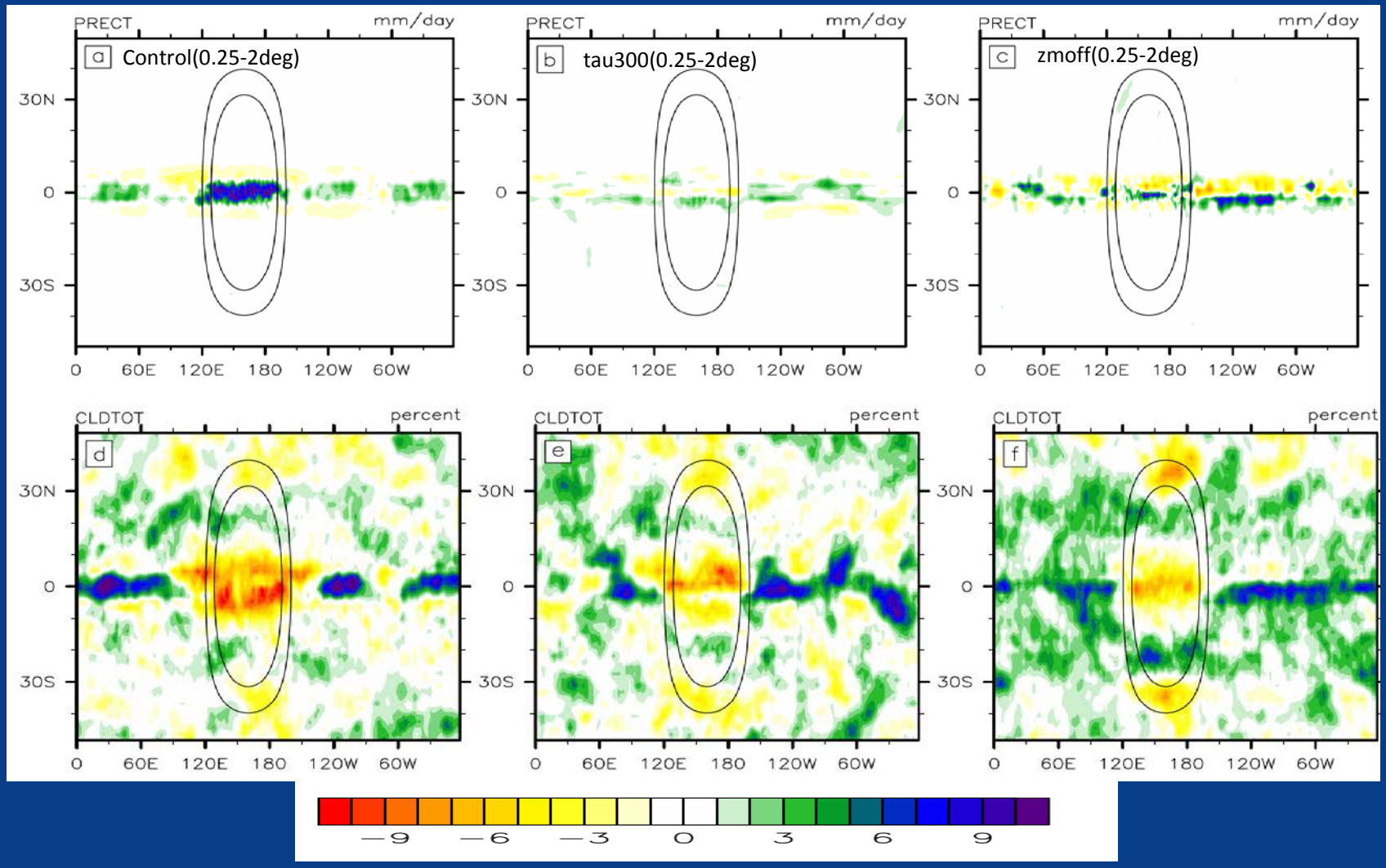
Convective timescale (TAU) experiments:

1. Control runs: tau=1800s, by CAM4 and CAM5 default
2. TAU_300 runs: tau= 300s
3. ZMOFF runs: tau is infinity, by turn off the ZM scheme

Anomaly PRECT and CLDTOT by the 3 TAU experiments in Regionally Refinement runs by CAM5.3

PRECT

CLDTOT



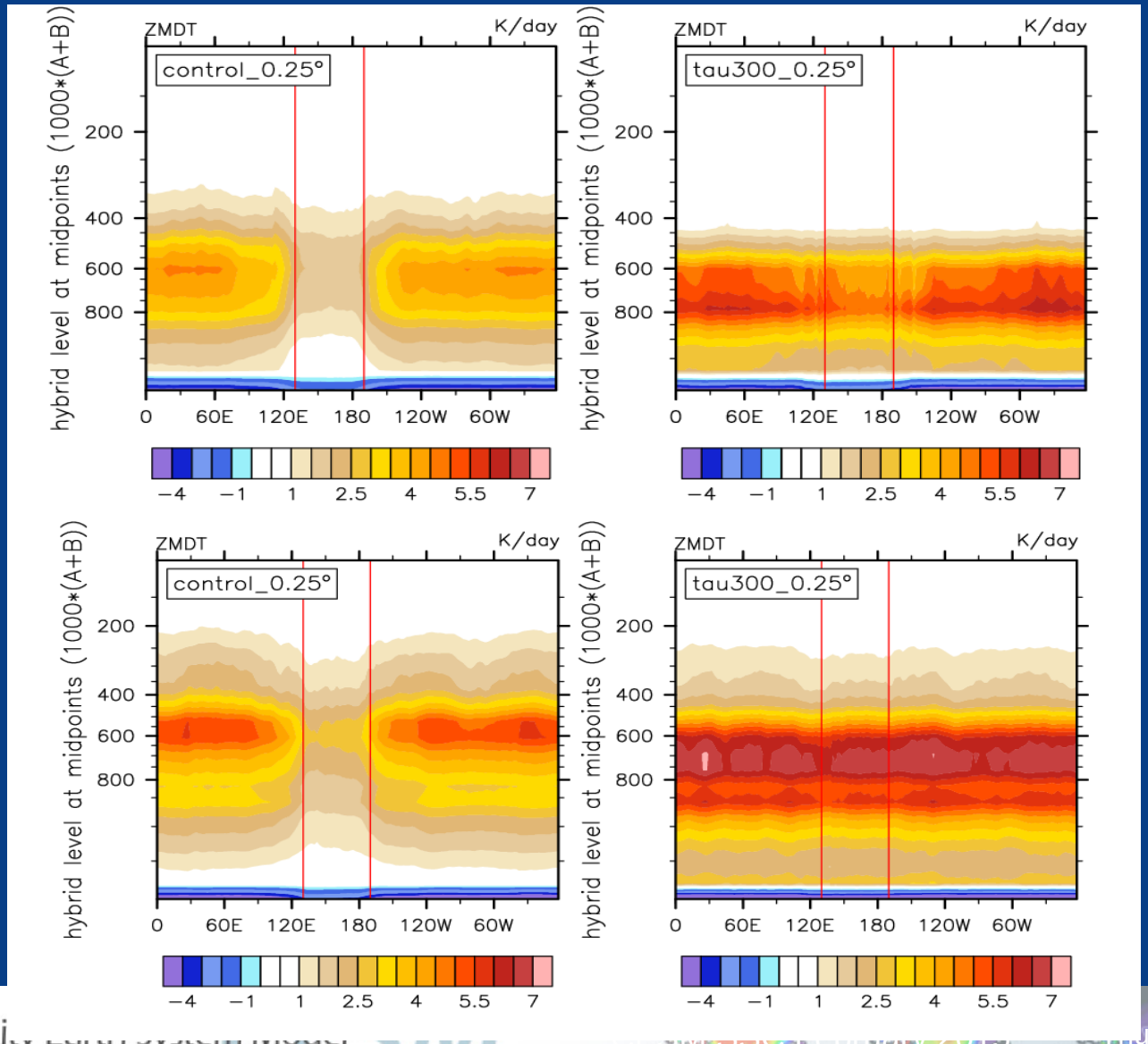
T tendency by ZM scheme in control and TAU runs

Control

TAU300

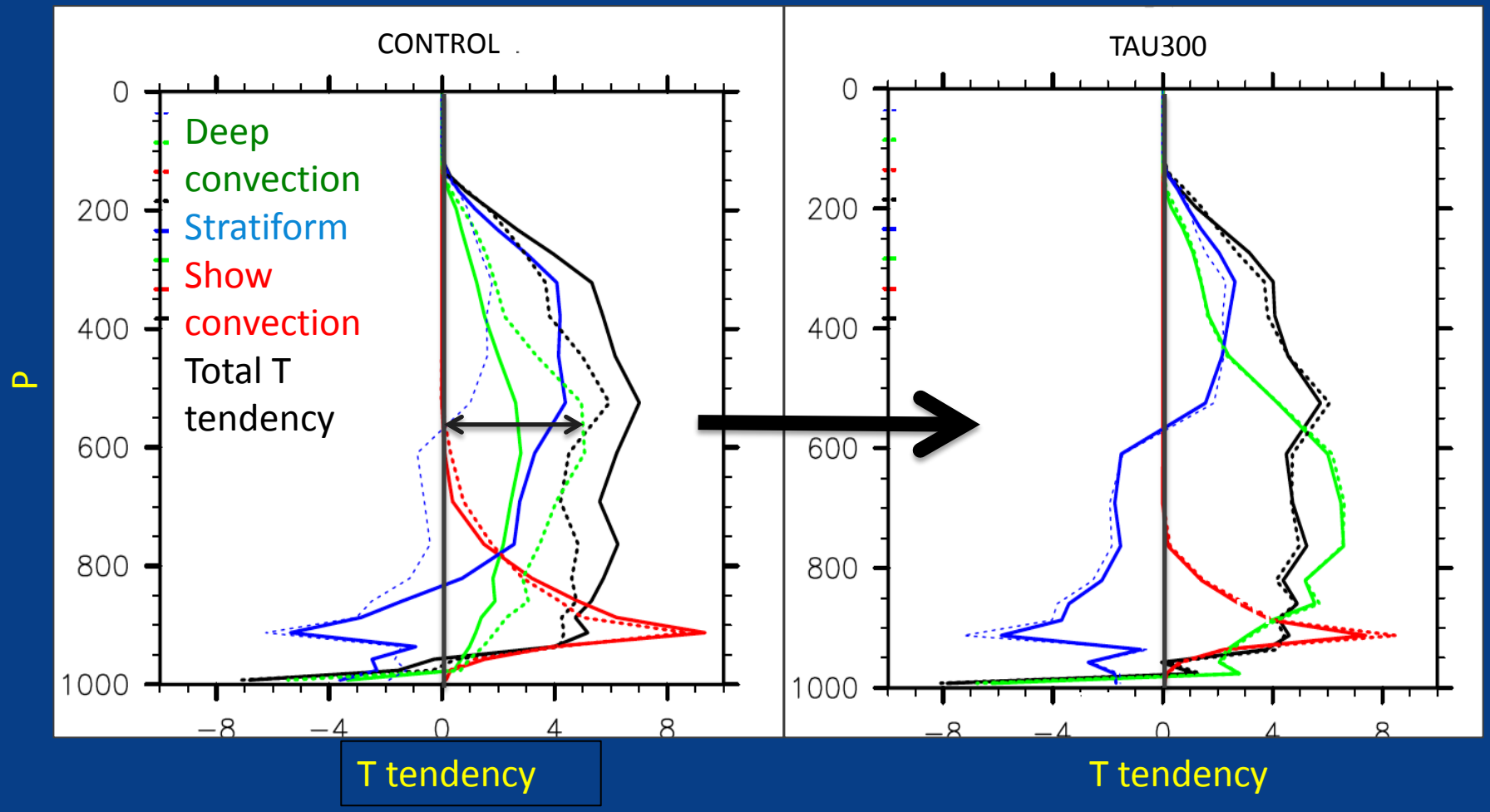
CAM4

CAM5



ZMDT become more uniform along tropical area (5S-5N)
In TAU runs.

T tendencies inside and outside of the refinement region for control and TAU experiments by CAM5.3



Conclusions

1. There are significant physics sensitivity to grid size (CAM4-cloud; CAM5 rainfall)

1. The physics sensitivity are well translated into the regionally refinement runs.

3. Shorter convective timescales (300s.vs.1800s) can mitigate the physics dependency on grid-size.

4. Regionally mesh Refinement is a good and economic tool to do the climate study, especially the regional climate research.

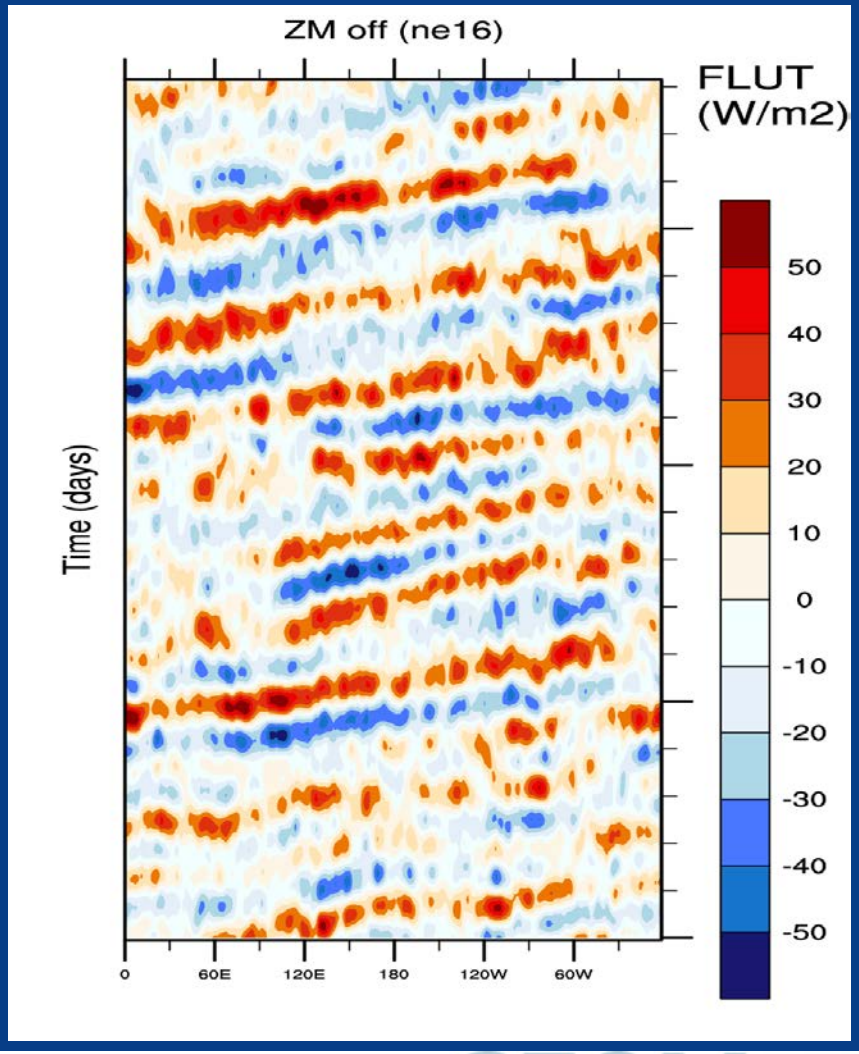
Future plan:

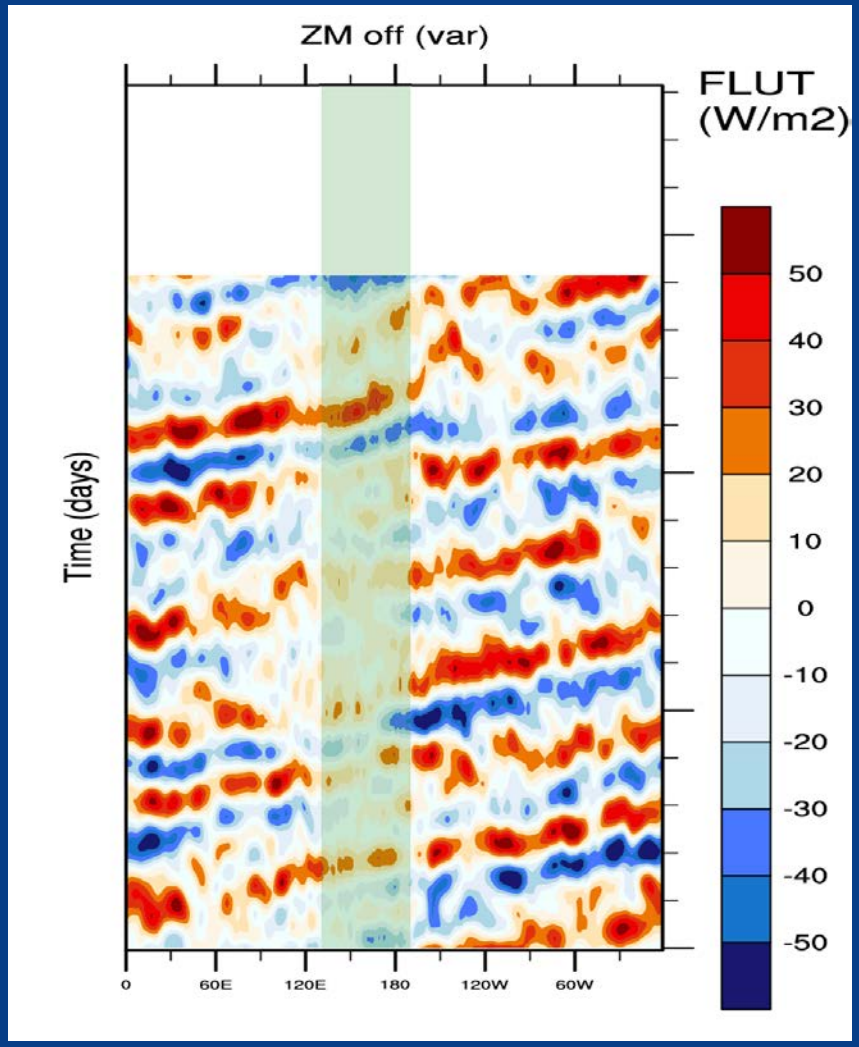
1. Try to adjust more parameters that impact the grid-size sensitivity through the diagnostic on the physics behaviors of the regional refinement runs.

2. Do AMIP run to investigate the characters of the regionally refined mesh with surface forcing.

Knowledgement

Thanks Colin Zarzyki, Mark Taylor, Mike Levy and Peter Lauritzen for their helps on the refinement mesh and configuration.


ZM off (ne16)
FLUT
(W/m2)
Time (days)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
60E
120E
180
120W
60W


ZM off (var)
FLUT
(W/m2)
Time (days)
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40
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120W
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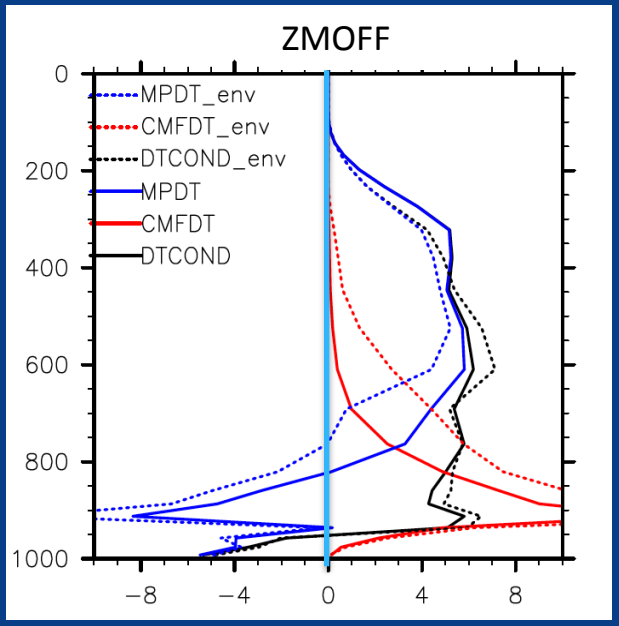
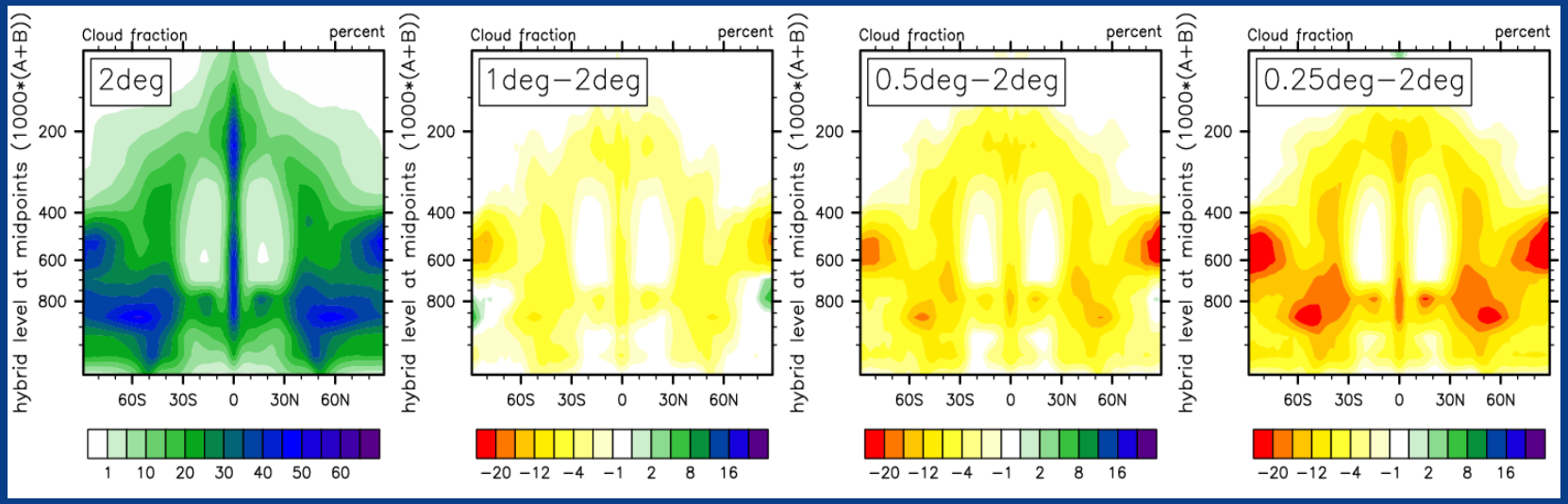

ZMOFF
MPDT_env
CMFDT_env
DTCOND_env
MPDT
CMFDT
DTCOND
0
200
400
600
800
1000
−8
−4
0
4
8

Zonal mean monthly CLOUD Fraction in uniform runs

CAM4



CAM5