A Unified Convection Scheme : 'UNICON' PARK

CESM Meeting. Breckenridge. CO.

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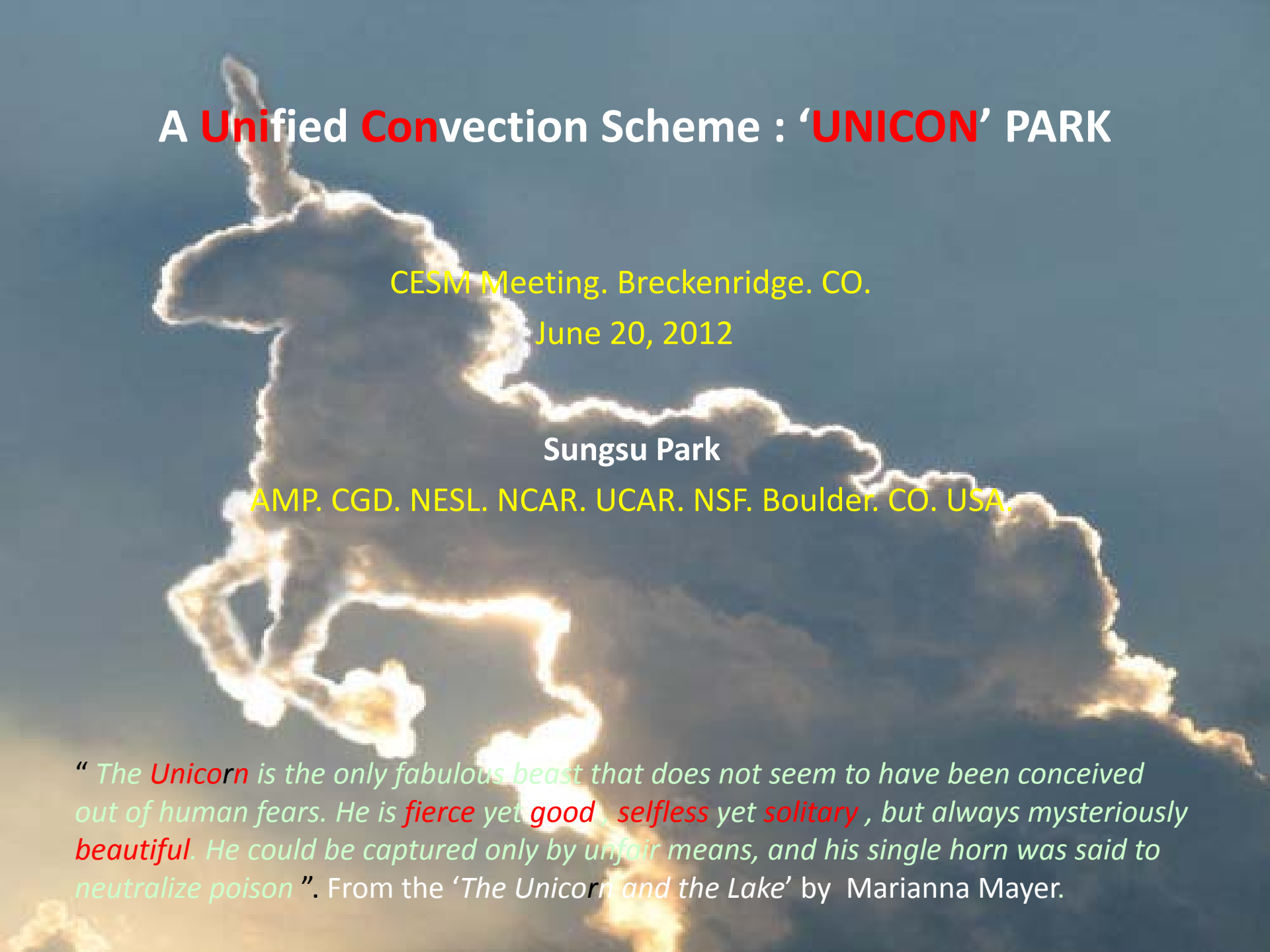
AMP. CGD. NESL. NCAR. UCAR. NSF. Boulder. CO. USA.

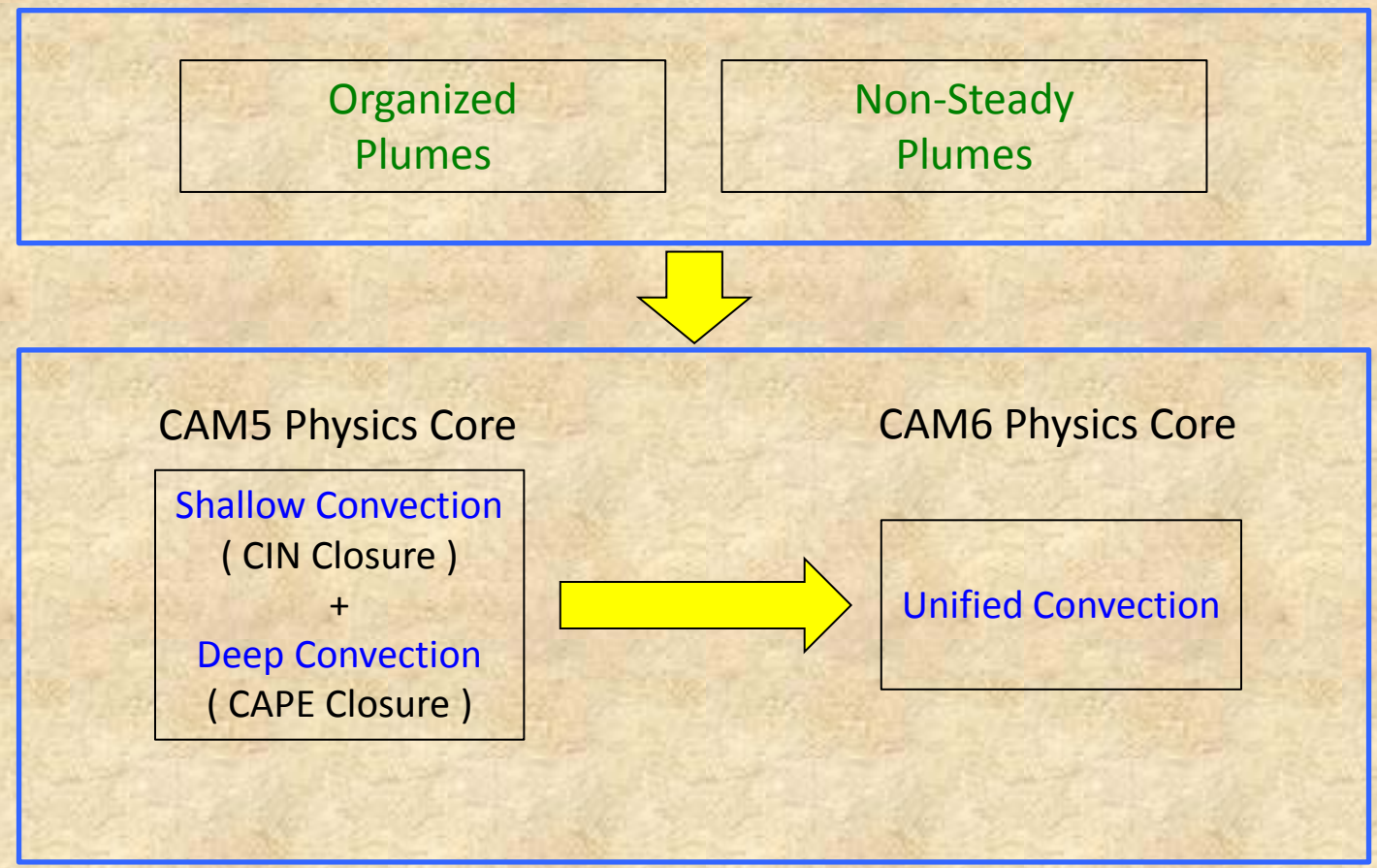


" The Unicorn is the only fabulous beast that does not seem to have been conceived out of human fears. He is fierce yet good , selfless yet solitary , but always mysteriously beautiful. He could be captured only by unfair means, and his single horn was said to neutralize poison ". From the '*The Unicorn and the Lake*' by Marianna Mayer.

Evolutions of CAM-CESM1

Model	CCSM3 (2004)	CCSM3.5 (2007)	CCSM4 (Apr 2010)	CESM1 (Jun 2010)
Atmosphere	CAM3 (L26)	CAM3.5 (L26)	CAM4 (L26)	CAM5 (L30)
Boundary Layer Turbulence	Holtslag-Boville (93) Dry Turbulence	Holtslag-Boville	Holtslag-Boville	Bretherton-Park (09) UW Moist Turbulence
Shallow Convection	Hack (94)	Hack	Hack	Park-Bretherton (09) UW Shallow Convection
Deep Convection	Zhang-McFarlane (95)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)
Cloud Macrophysics	Zhang et al. (03)	Zhang et al. with Park & Vavrus' mods.	Zhang et al. with Park & Vavrus' mods.	Park-Bretherton-Rasch (10) Revised Cloud Macrophysics
Stratiform Microphysics	Rasch-Kristjansson (98) *Single Moment*	Rasch-Kristian. *Single Moment*	Rasch-Kristian. *Single Moment*	Morrison and Gettelman (08) *Double Moment*
Radiation / Optics	CAMRT (01)	CAMRT	CAMRT	RRTMG Iacono et al.(08) / Mitchell (08)
Aerosols	Bulk Aerosol Model (BAM)	BAM	BAM	Modal Aerosol Model (MAM) Liu & Ghan (2009)
Dynamics	Spectral	Finite Volume (96,04)	Finite Volume	Finite Volume
Ocean	POP2 (L40)	POP2.1 (L60)	POP2.2 - *BGC*	POP2.2
Land	CLM3	CLM3.5	CLM4 - *CN*	CLM4
Sea Ice	CSIM4	CSIM4	CICE	CICE

A Strategic Plan for Next Generation CAM6



OUTLINE

I. Brief Description on the UNICON

II. CAM5 Simulation

- Climatology
- Diurnal Cycle of Precipitation
- Madden-Julian Oscillation

III. SUMMARY

Overview of UNICON

I. A completely new sub-grid vertical transport scheme by non-local asymmetric turbulent eddies :

- Developing a conceptual framework : July. 2006 ~ Jan. 2009.
- Mathematical formulation and coding : Jan.2009 ~ Nov. 2009.
- Intensive debugging, refinement and test : Nov. 2009 ~ Present.
- Code : ~ 20,000 Lines, Computation time : ~ CAM5 shallow convection scheme when n=1.

II. Some of unique aspects of UNICON are

- Consistent closure for all scalars (q_t, θ_c, u, v, w, A_m, $A_\#$, R)
- Updraft plume mixing rate as a function of plume radius R
- Launch correlated multiple plumes with different thermodynamic properties and R
- Generic treatments of 'convective downdraft' and 'detrainment'
- Treatment of 'vertical tilting of updraft plume'
- Parameterization of sub-grid 'meso-scale organized flows'
- Unified treatment of 'shallow/deep', 'dry/moist', and 'forced/free' convections
- No CIN/CAPE closures : 'fully dynamic plume model' without any equilibrium assumptions
- Well-harmonized with CAM5 local symmetric turbulence scheme (i.e., moist PBL scheme)
- Scale-awaring parameterization – minimal sensitivity to $\Delta x \bullet \Delta y$, Δz, Δt

Global CAM5 Simulation

- Replace CAM5 deep and shallow convection schemes by UNICON.
- 1.9°lat x 2.5°lon horizontal resolution forced by observed SST.
- No detailed tuning yet : a preliminary single simulation.

Climatology

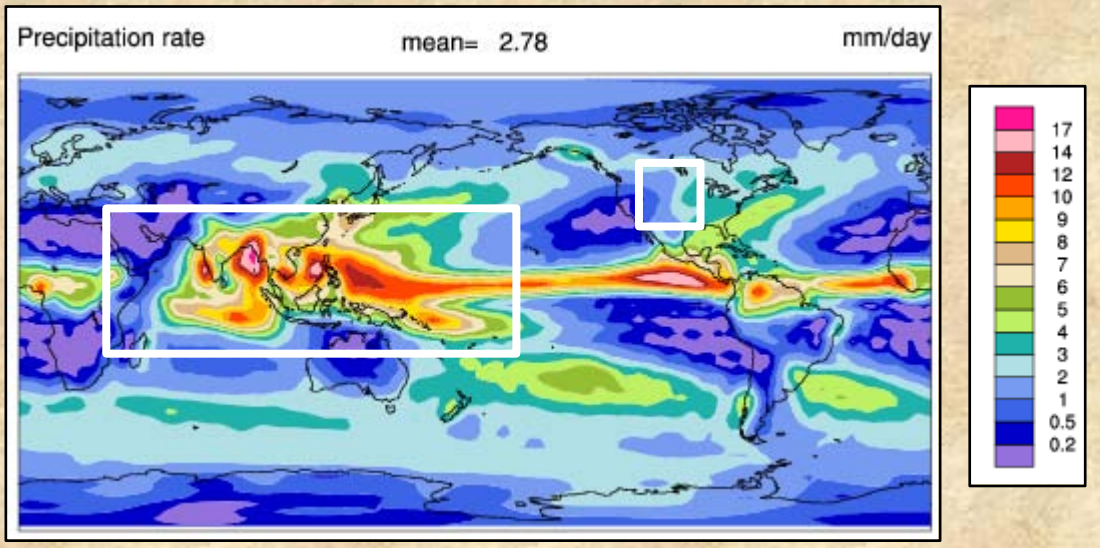
Diurnal Cycle of Precipitation

Madden-Julian Oscillation

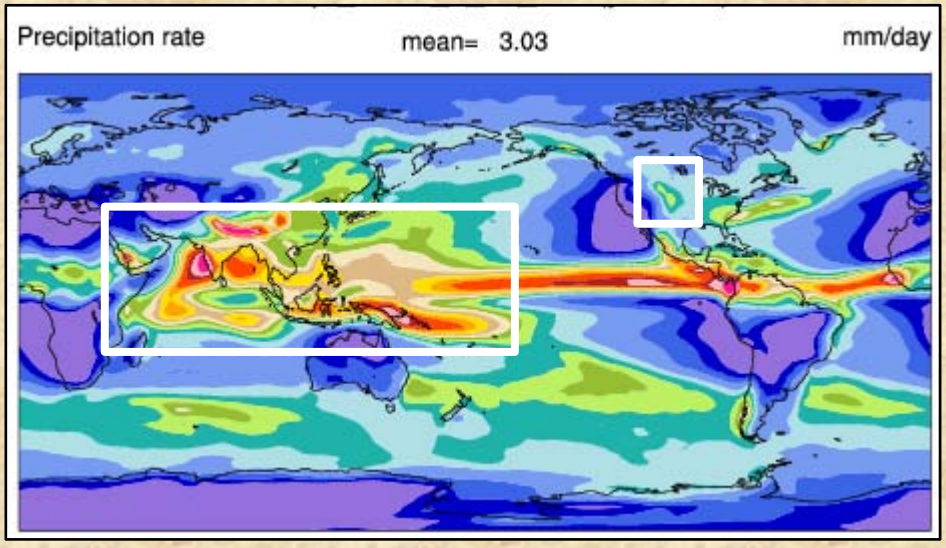
} Long-standing unsolved issues

Precipitation Climatology. JJA.

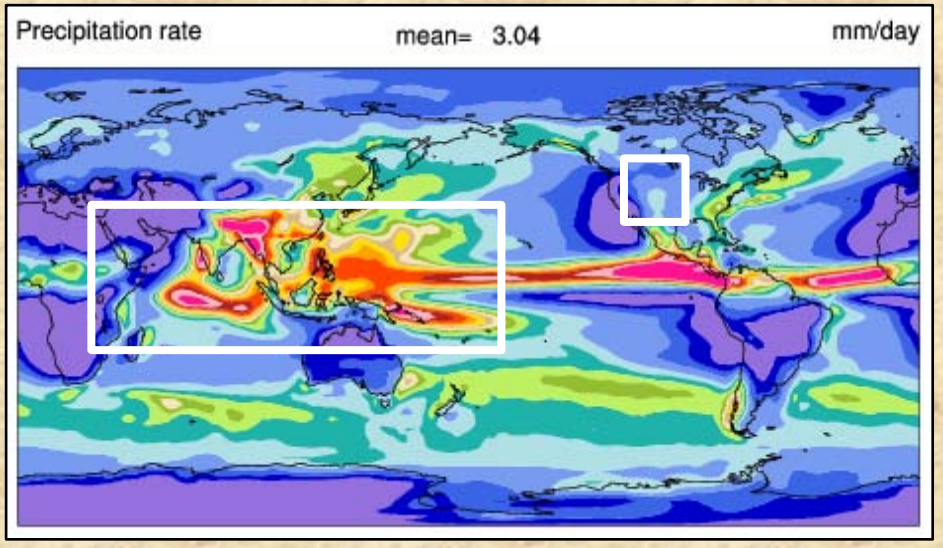
OBSERVATION



CAM5

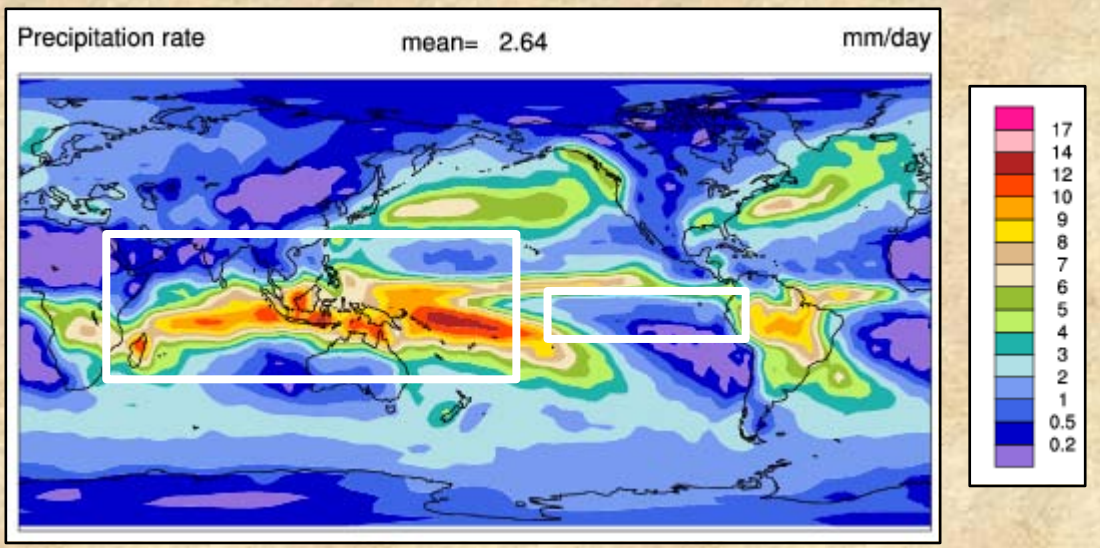


UNICON

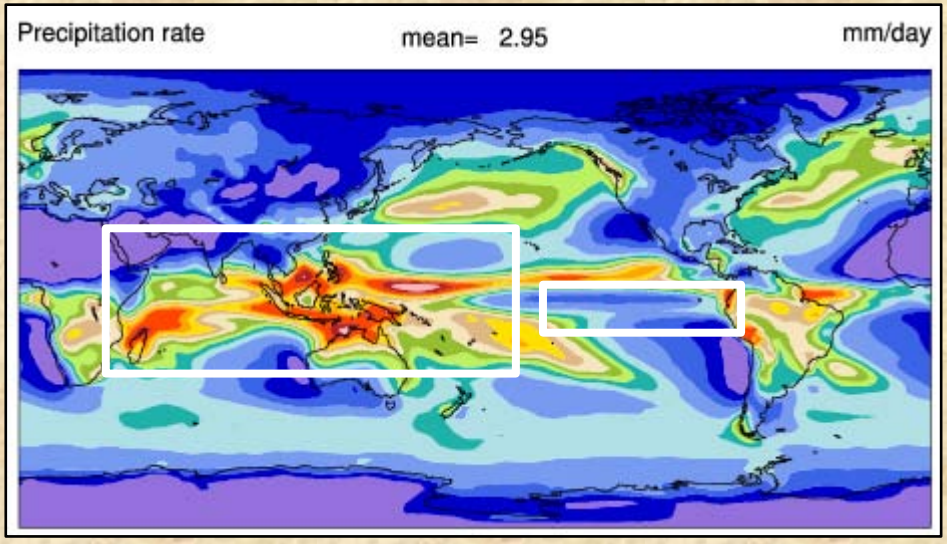


Precipitation Climatology. DJF.

OBSERVATION



CAM5



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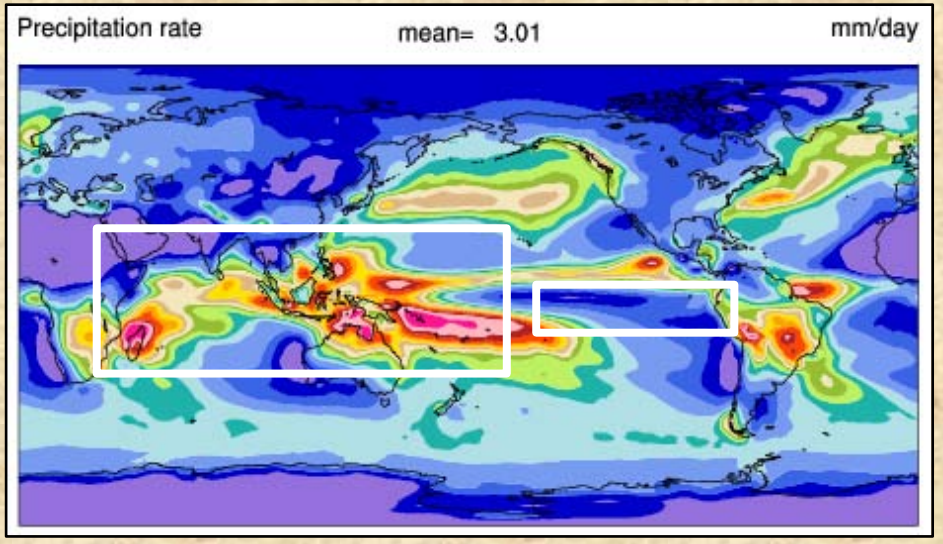
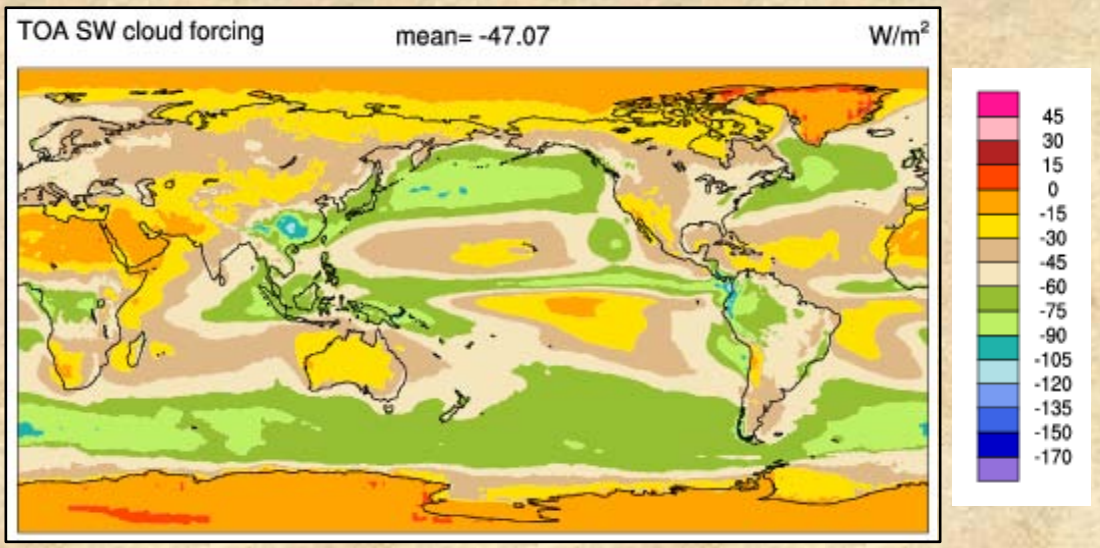


Δ SW Cloud Radiative Forcing. ANN.

OBSERVATION



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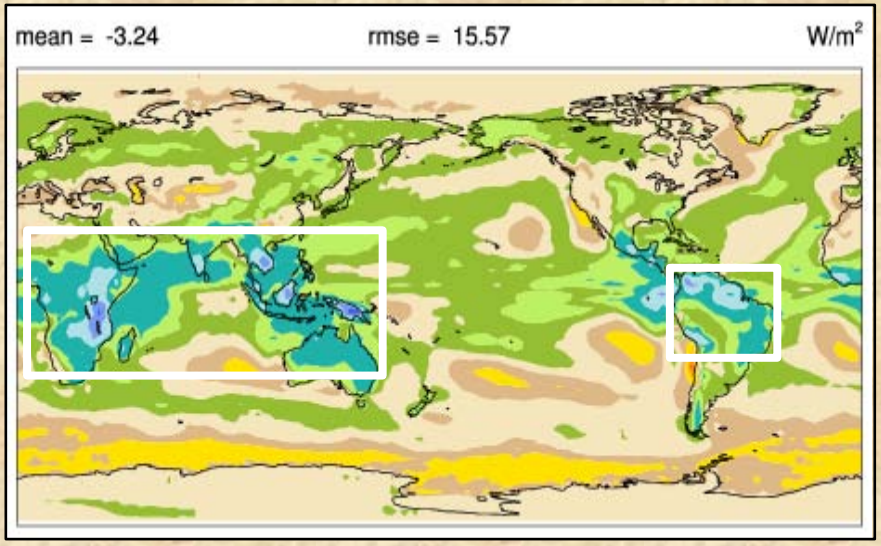

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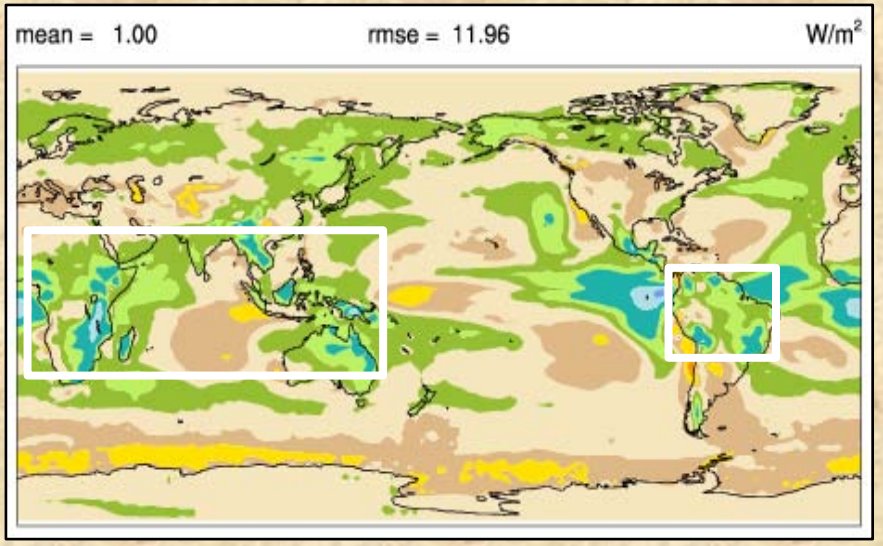
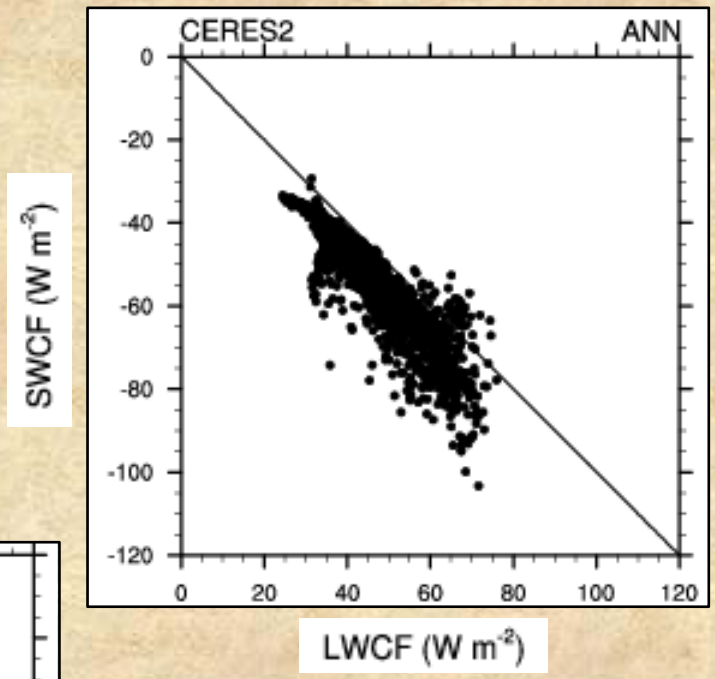


SWCF vs LWCF. Warm Pool. ANN.

OBSERVATION



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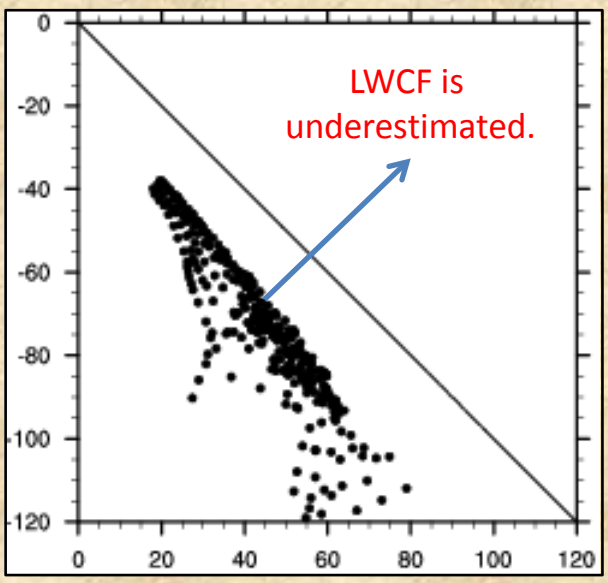

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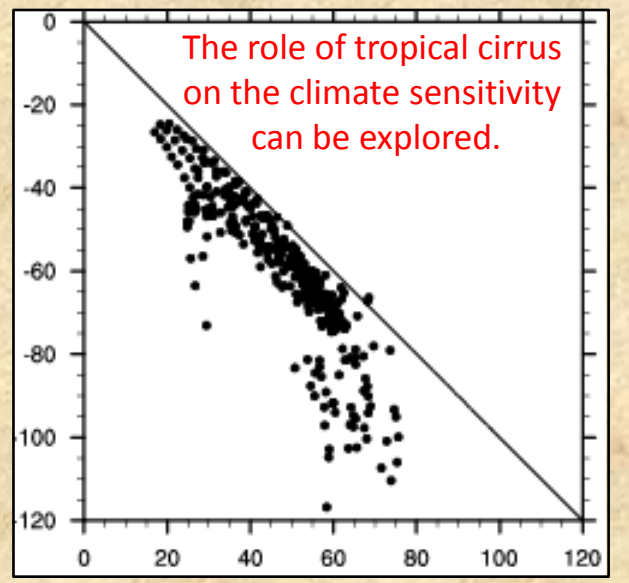
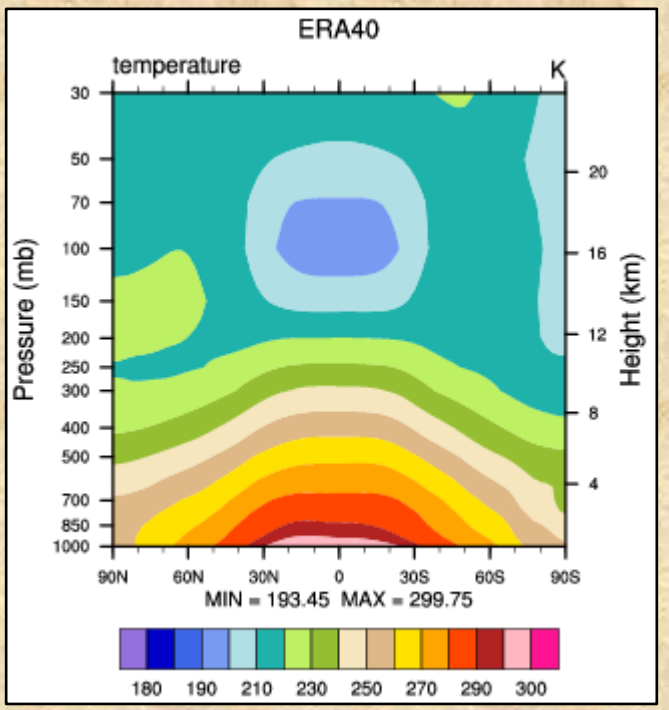
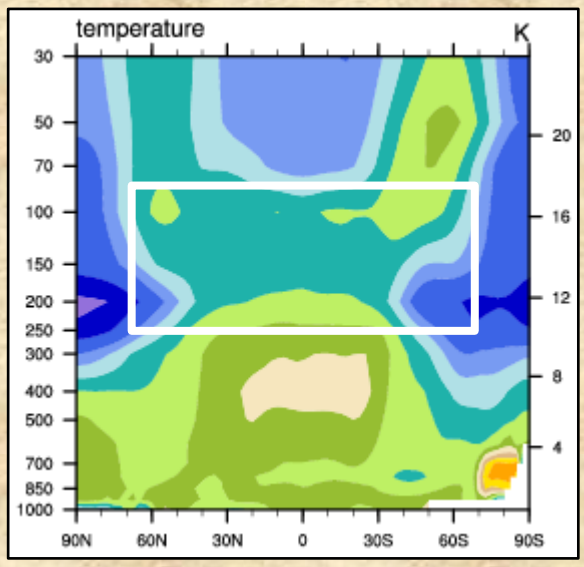


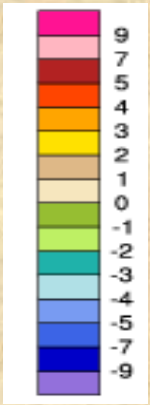
ΔT. ANN.

OBSERVATION



CAM5





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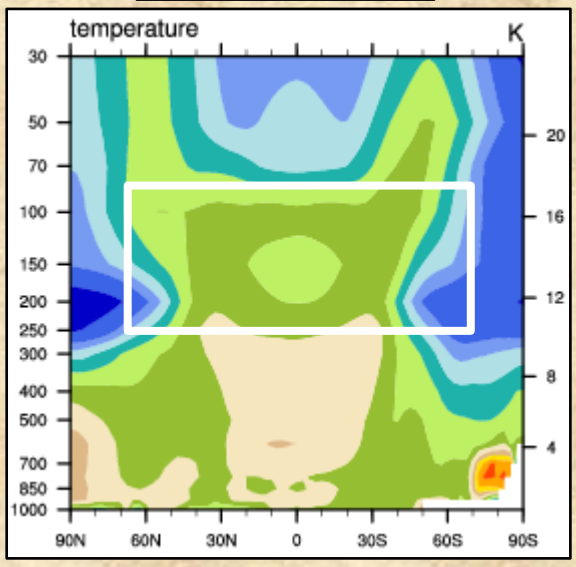
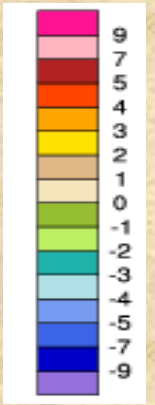




Cumulus Fraction & Condensate. ANN.

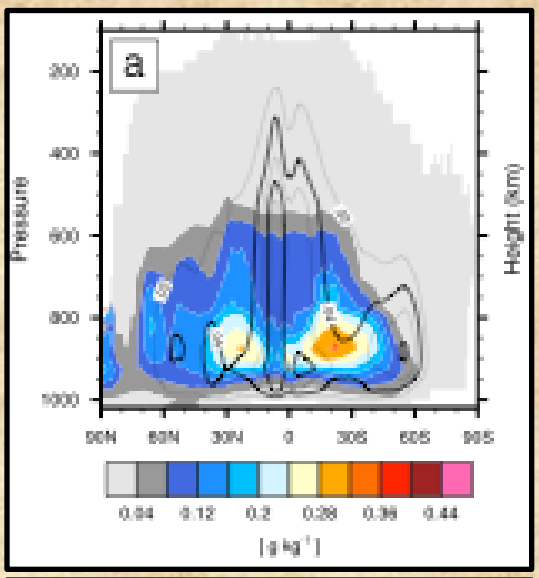
Large Cu fraction
Small In-Cu Condensate

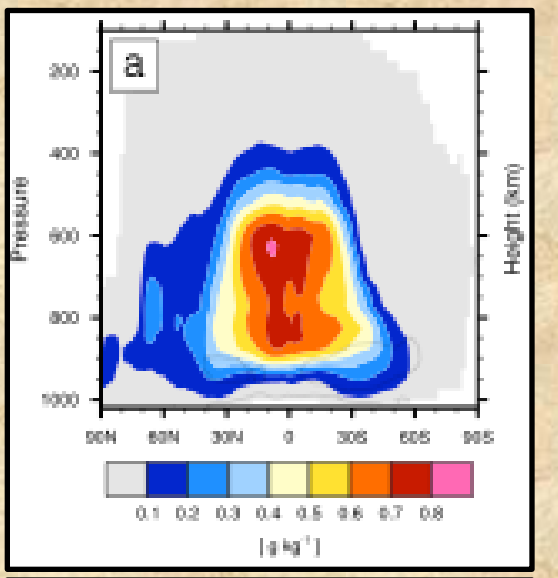
CAM5

UNICON

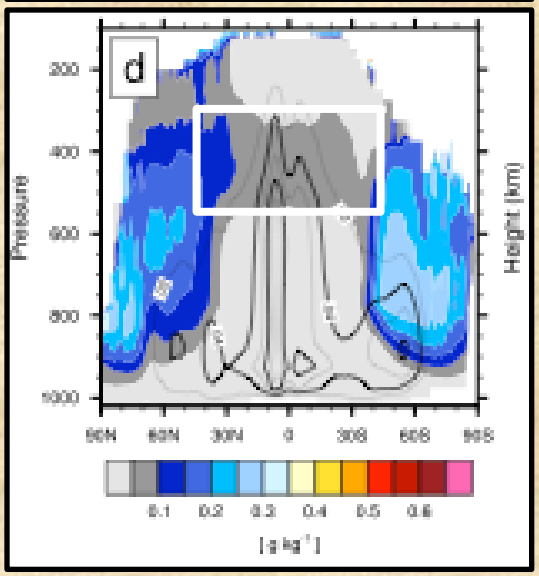
Small Cu fraction
Large In-Cu Condensate

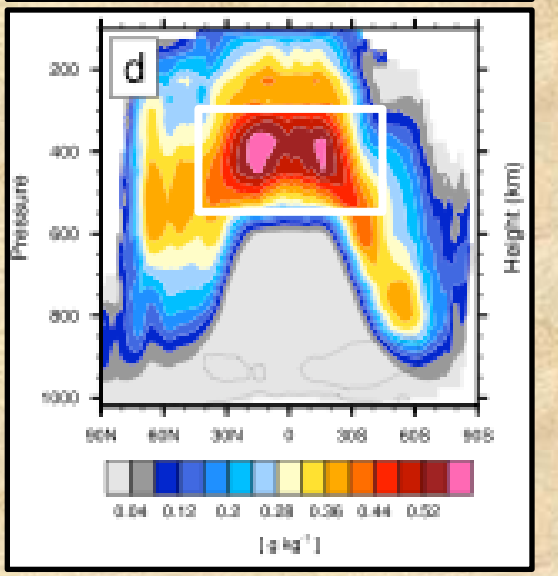
In-Cumulus LWC





In-Cumulus IWC



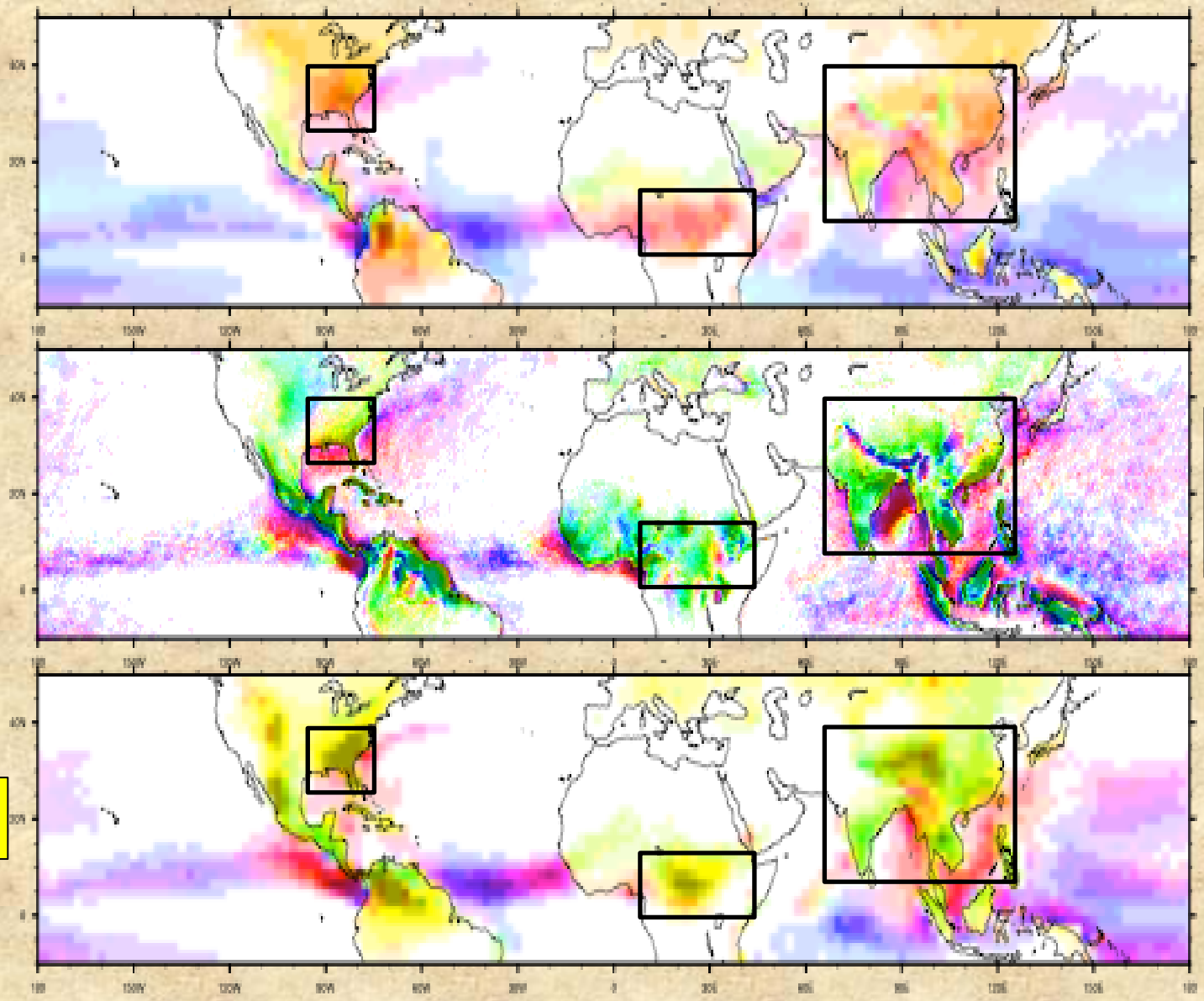


Diurnal Cycle of Precipitation. JJA.

CAM5

OBS

UNICON



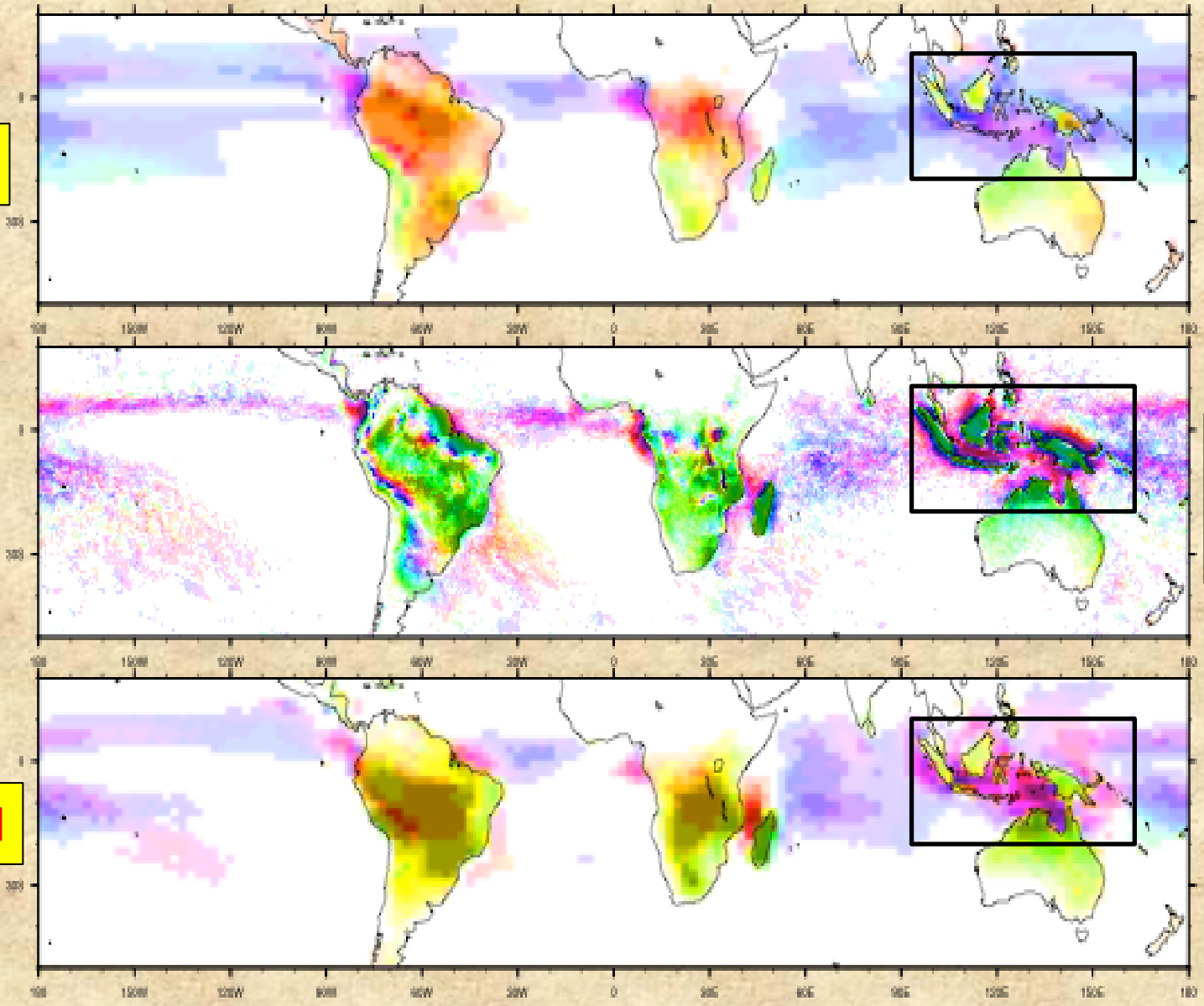
Local Hour of Max Precip

Diurnal Cycle of Precipitation. DJF.

CAM5

OBS

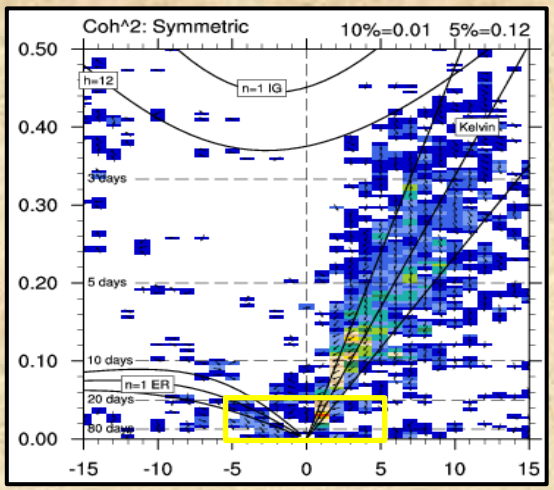
UNICON



Local Hour of Max Precip

Madden-Julian Oscillation

CAM5



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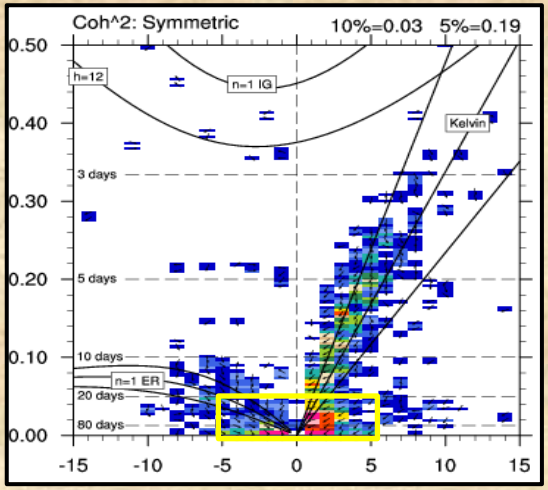

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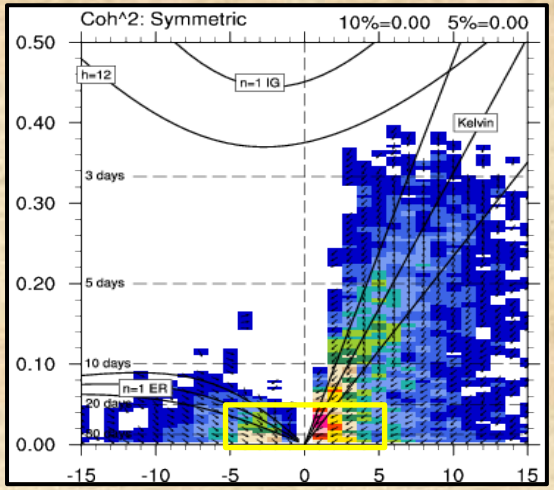

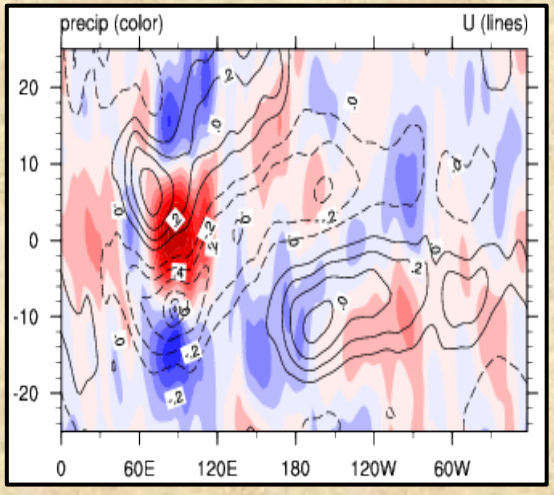

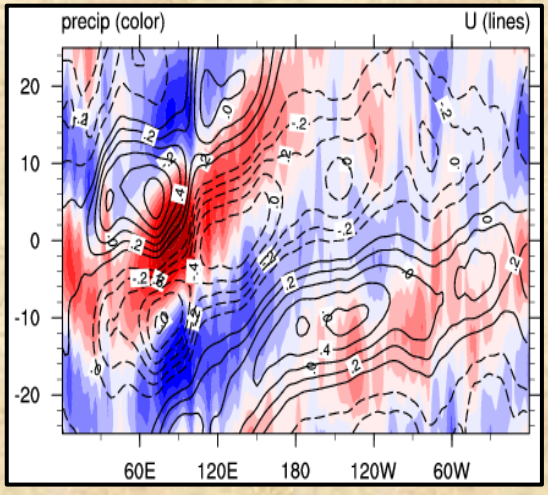

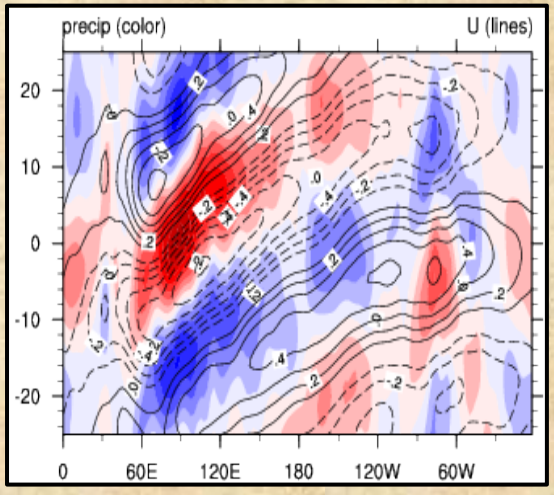

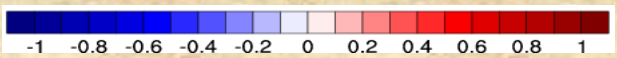

SUMMARY

- UNICON is a sub-grid vertical transport scheme by non-local asymmetric turbulent eddies and a scale-awaring parameterization well harmonized with CAM5 moist turbulence scheme without double-counted transport.
- UNICON simulates all shallow-deep, dry-moist, and forced-free convections within a single framework.

- The 1st round of model development with thorough debugging is completed.
- UNICON well simulates MJO and diurnal cycle of precipitation with improved climatology with some aspects of future improvement (e.g., too strong regional precipitation over ocean). Most importantly, UNICON ***knows how to turn on-and-off*** MJO ***and*** diurnal cycle of precipitation.

- On-going works and future plans
  - Constrain several key parameters (a_u, R_u, c_0, c_ε, c_δ) from OBS/LES.
  - Objective tuning (i.e., UQ approach)
  - Test in "coupled / high-resolution (both in $\Delta x \bullet \Delta y$ and Δz)" configuration.