Scale-Adaptive Physics Parameterization with Inter-Process Consistency :

A Unified Convection Scheme, 'UNICON'

AMWG. Feb. 11. 2013.

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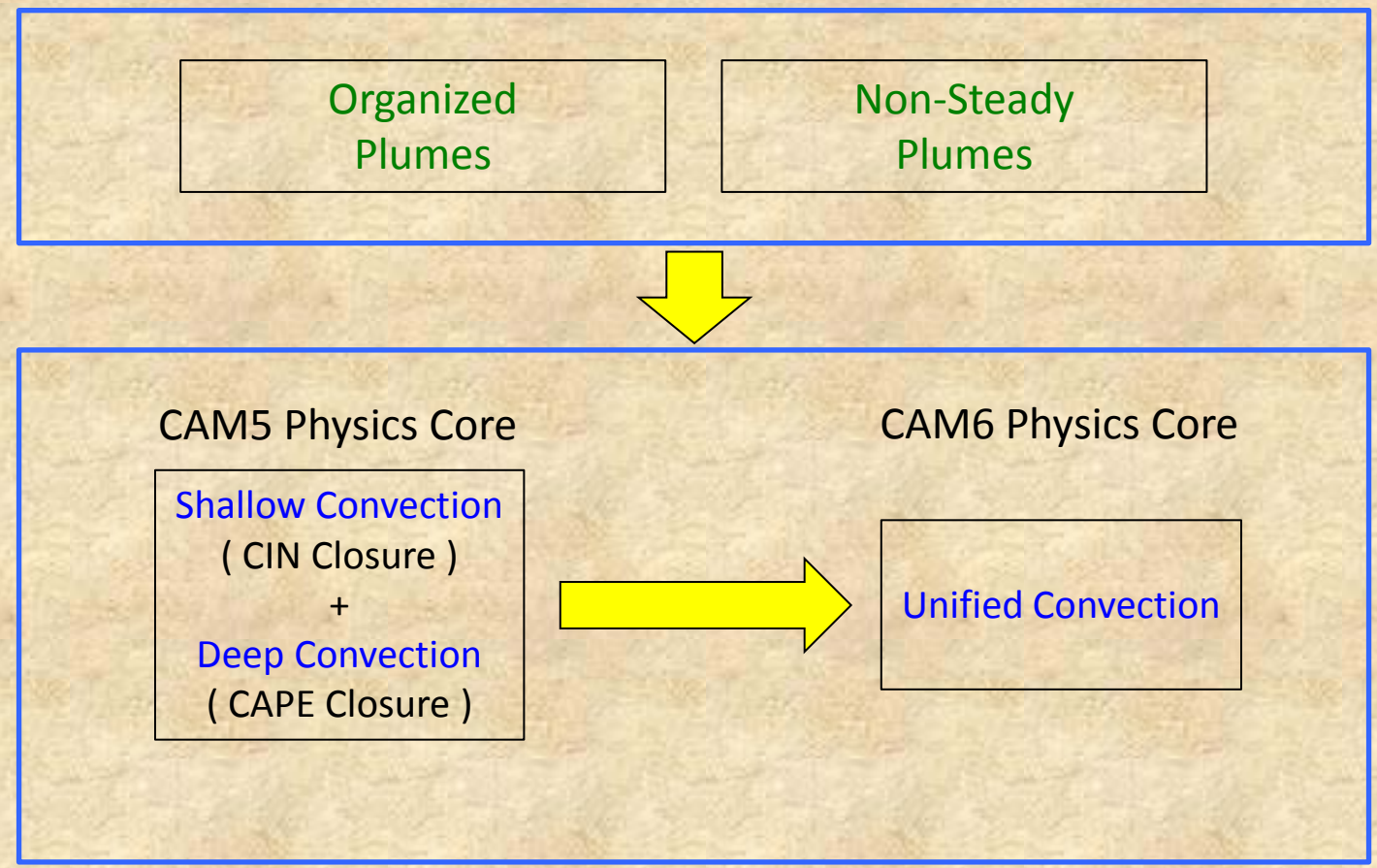
A Strategic Plan for the Next Generation CAM6



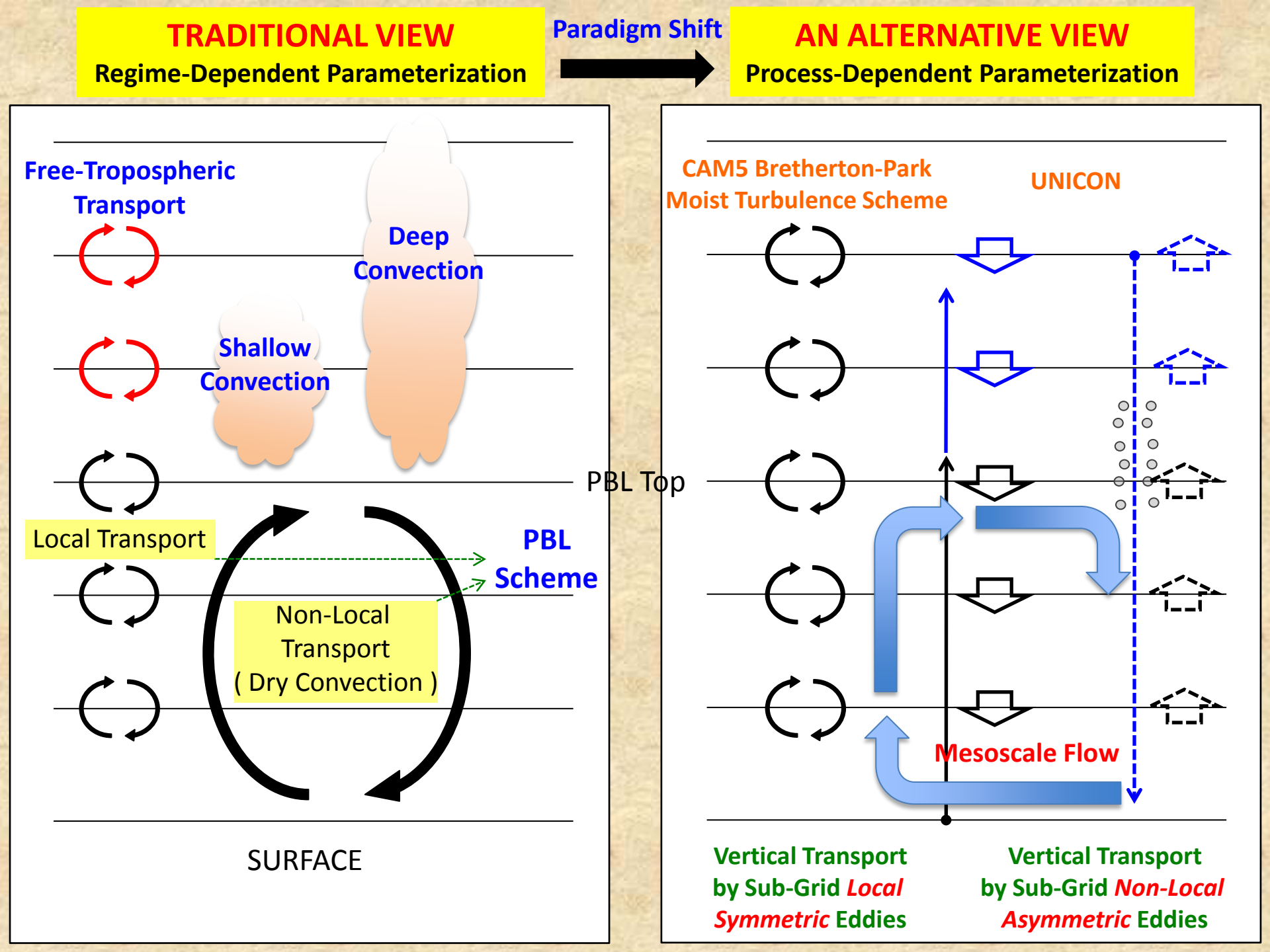
Overview of UNICON

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

- Development History : July. 2006 ~ 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 an inverse 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-adaptive parameterization – minimal sensitivity to $\Delta x \bullet \Delta y$, Δz, Δt
- Process-based vertical transport and wet deposition of aerosols and chemical species

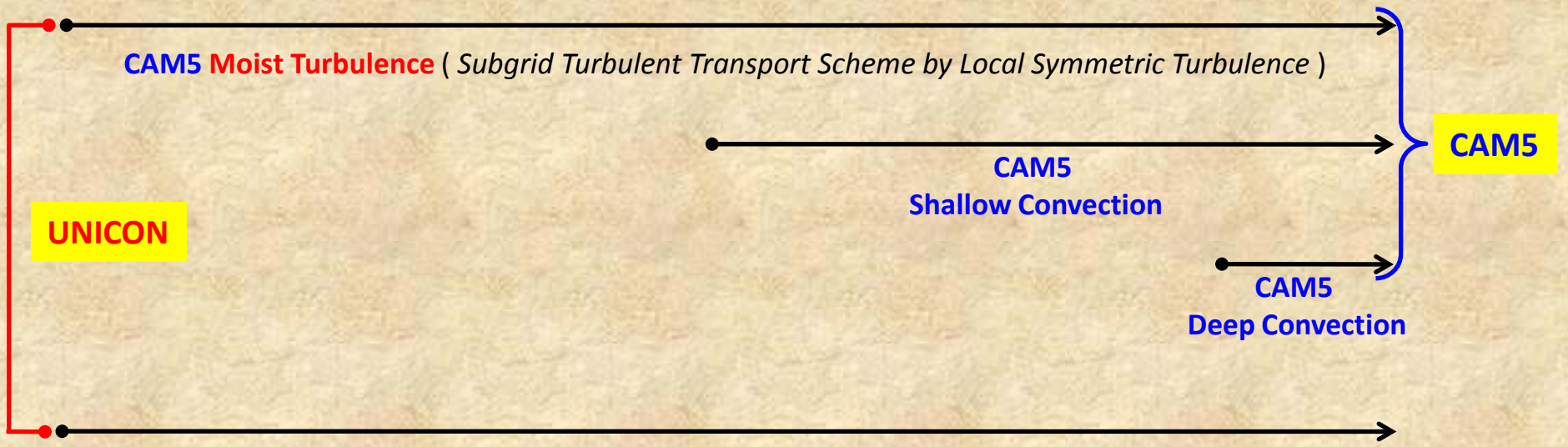

TRADITIONAL VIEW
Regime-Dependent Parameterization
Paradigm Shift
AN ALTERNATIVE VIEW
Process-Dependent Parameterization
Free-Tropospheric Transport
Deep Convection
Shallow Convection
Local Transport
PBL Scheme
Non-Local Transport (Dry Convection)
SURFACE
PBL Top
CAM5 Bretherton-Park Moist Turbulence Scheme
UNICON
Mesoscale Flow
Vertical Transport by Sub-Grid Local Symmetric Eddies
Vertical Transport by Sub-Grid Non-Local Asymmetric Eddies

OPERATING REGIMES
UNICON vs CAM5

DCBL DYCOMS STCU BOMEX ARM95, ARM97, GATEIII, TOGAII

Stable PBL ➔ Dry Conv. ➔ Sc. Conv. ➔ Sc to Shallow Cu ➔ Shallow Cu ➔ Deep Cu

(**Conv**ection) (**S**trato**c**umulus) (**Cu**mulus)



Comparison of UNICON and CAM5 with SCAM

SKILL SCORE = rmse (UNICON,OBS) / rmse (CAM5,OBS)

(T, Q_v, PRECT)

CASES	**SKILL SCORE** OF **UNICON** RELATIVE TO **CAM5**	
	L30. Δt = 1200 [sec]	**L80**. Δt = 300 [sec]
DCBL	0.97	0.98
DYCOMS	0.92	0.90
BOMEX	**0.48**	**0.46**
ARM97	0.82	0.97
GATEIII	0.83	0.87
Average	0.80	0.84

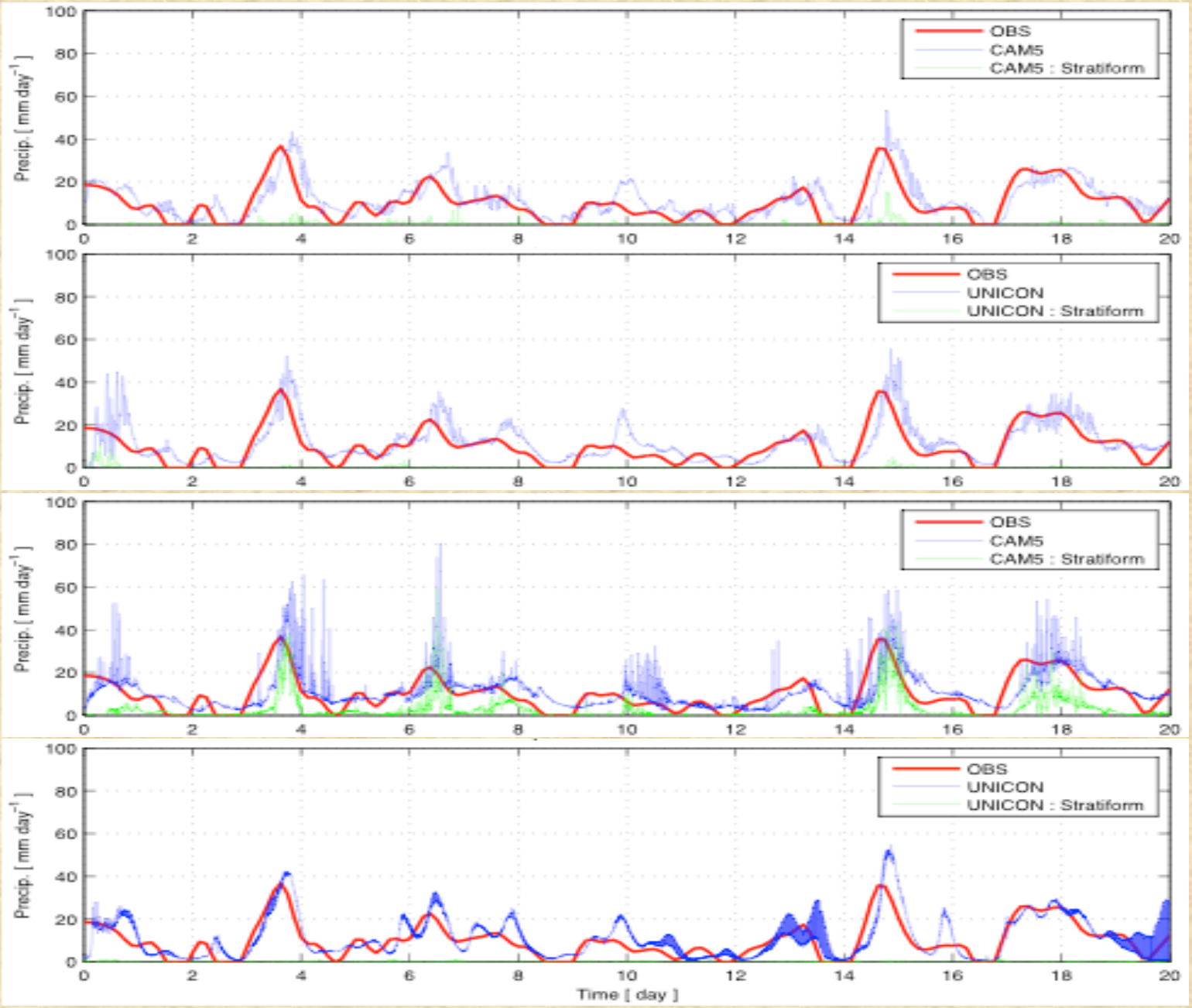
Surface Precipitation Rate. GATEIII.

CAM5
L30

UNICON
L30

CAM5
L80

UNICON
L80



Global Simulation

- Replace CAM5 deep and shallow convection schemes by UNICON.
- ‘L30 vertical’ & ‘1.9°lat x 2.5°lon horizontal’ forced by observed SST.
- No detailed tuning yet : a preliminary single simulation.
- Use a single plume (n = 1) in UNICON.
- Include activation bug fix both in CAM5 and UNICON.

Climatology

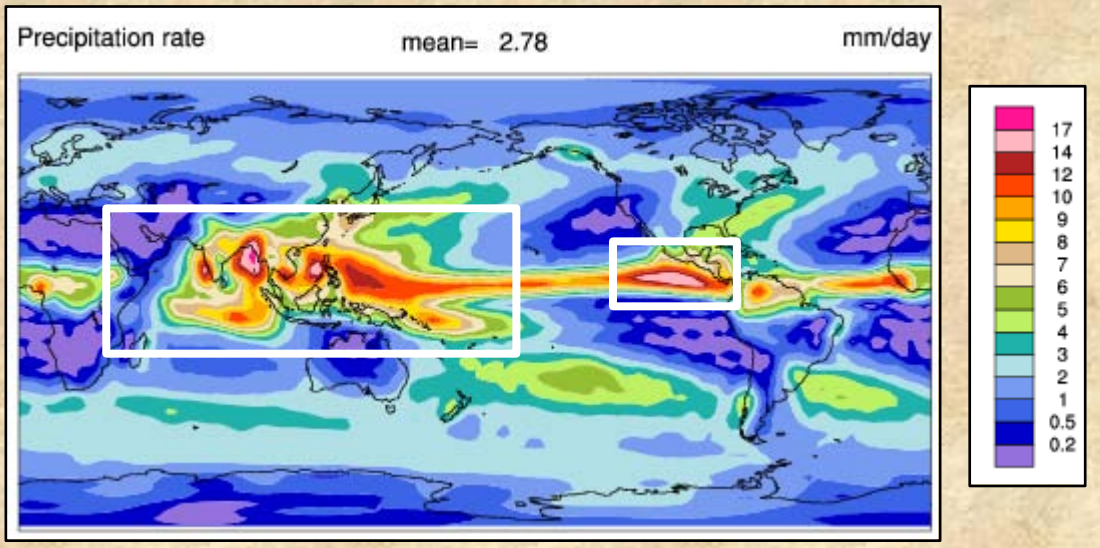
Madden-Julian Oscillation

Diurnal Cycle of Precipitation

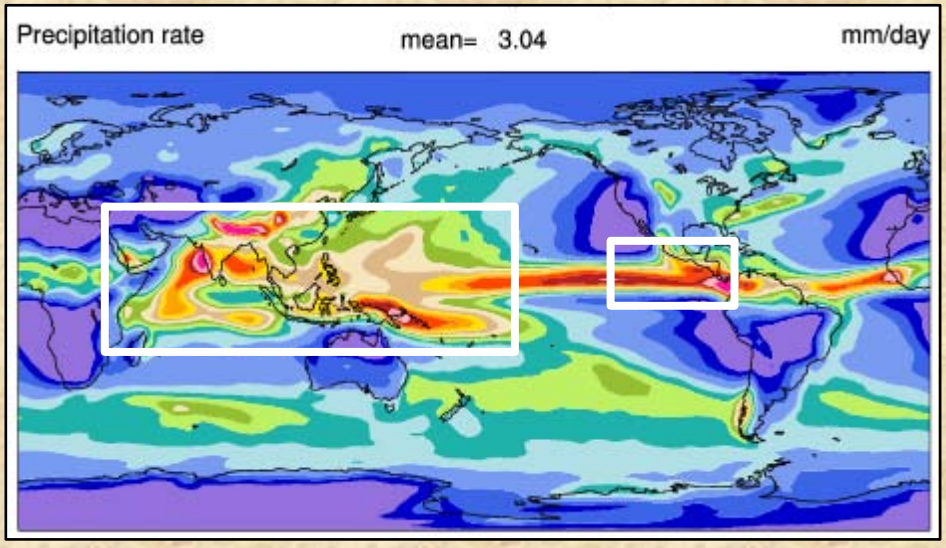
Long-standing unsolved issues

Precipitation Climatology. JJA.

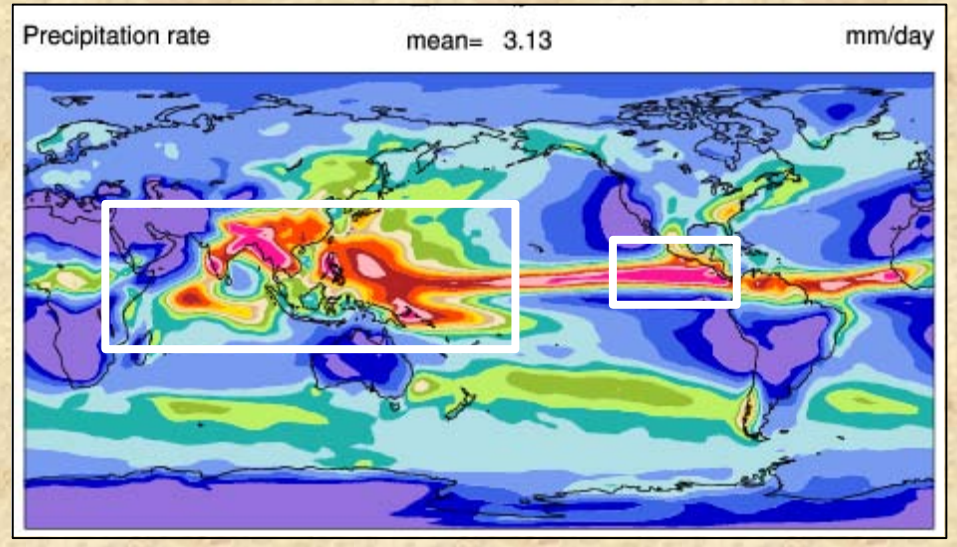
OBSERVATION



CAM5

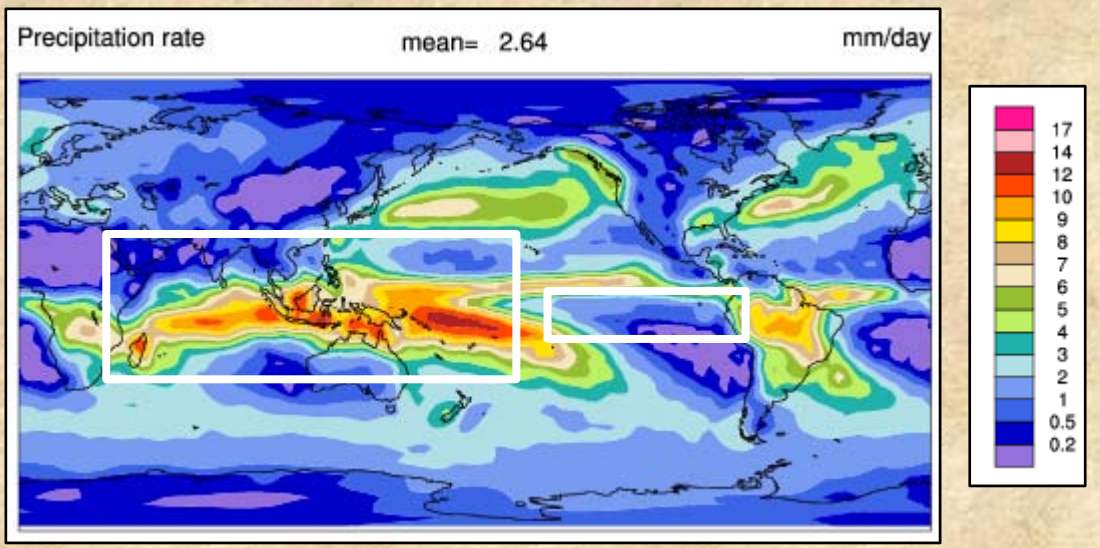


UNICON

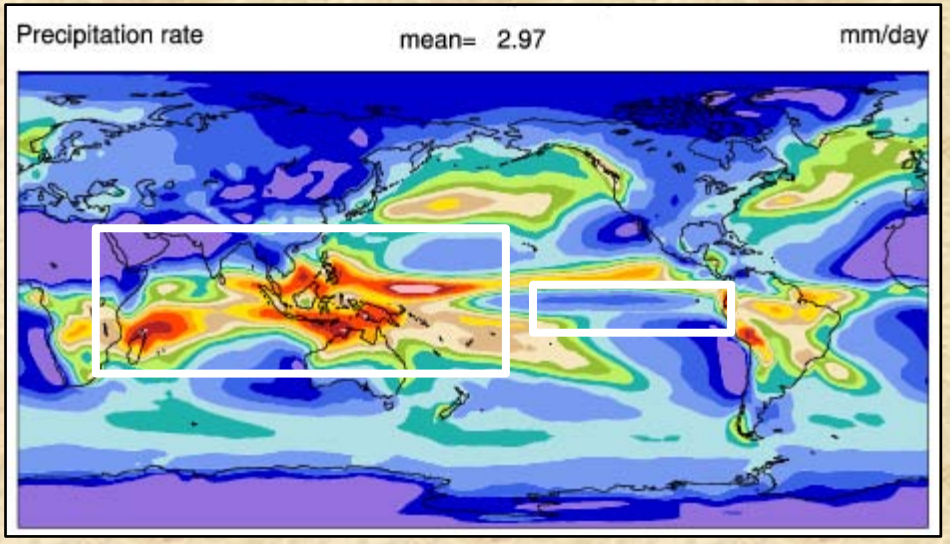


Precipitation Climatology. DJF.

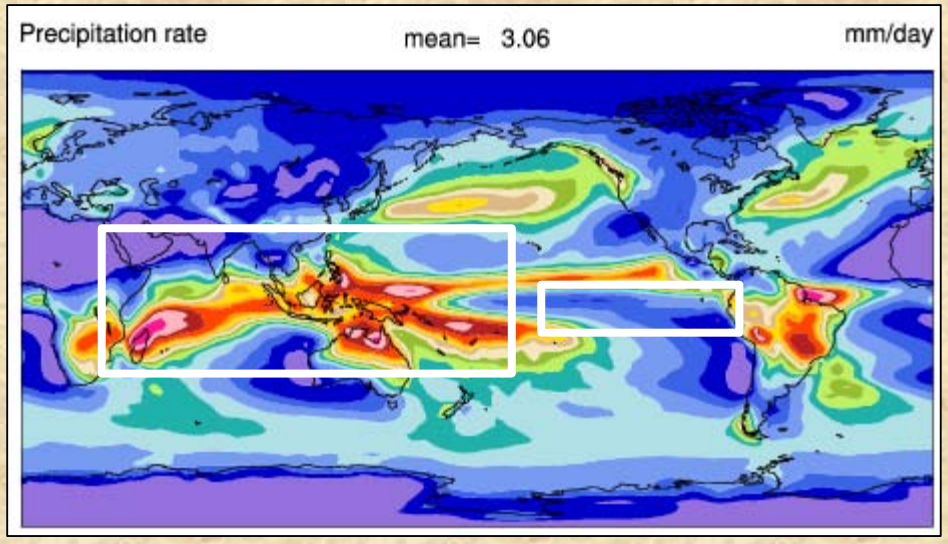
OBSERVATION



CAM5

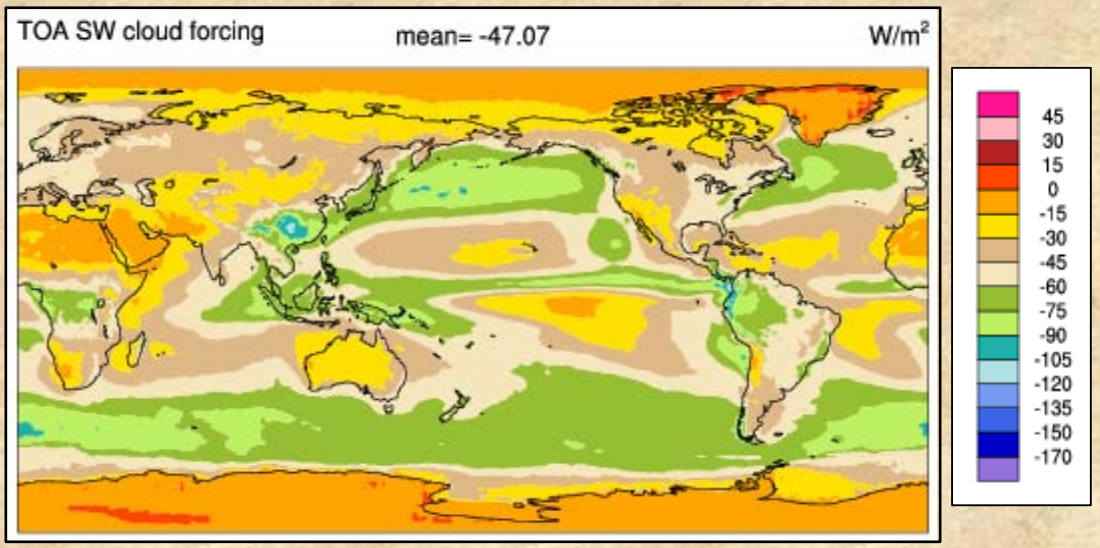


UNICON

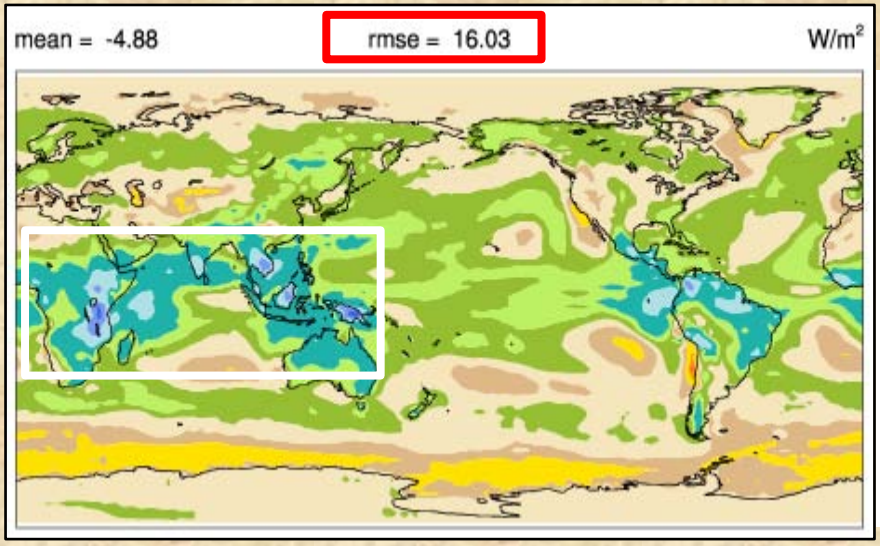


Δ SW Cloud Radiative Forcing. ANN.

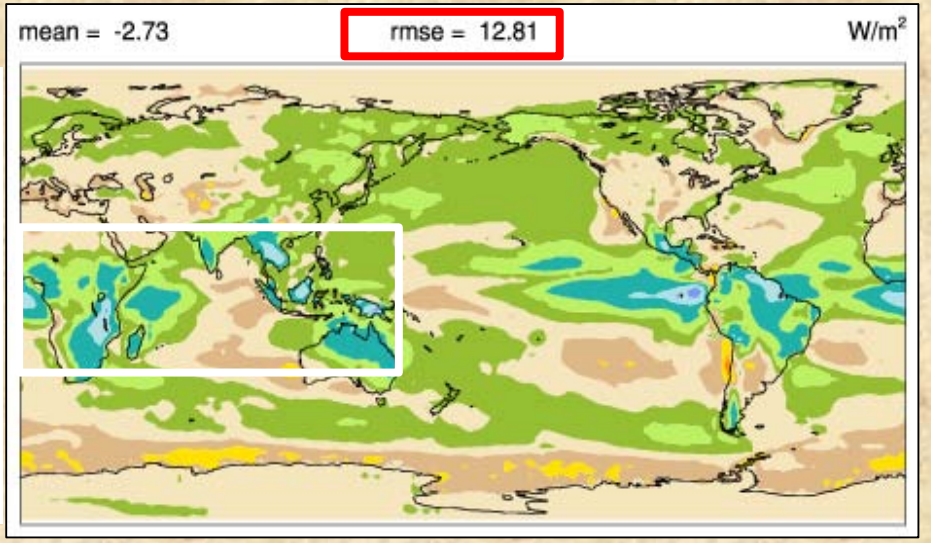
OBSERVATION



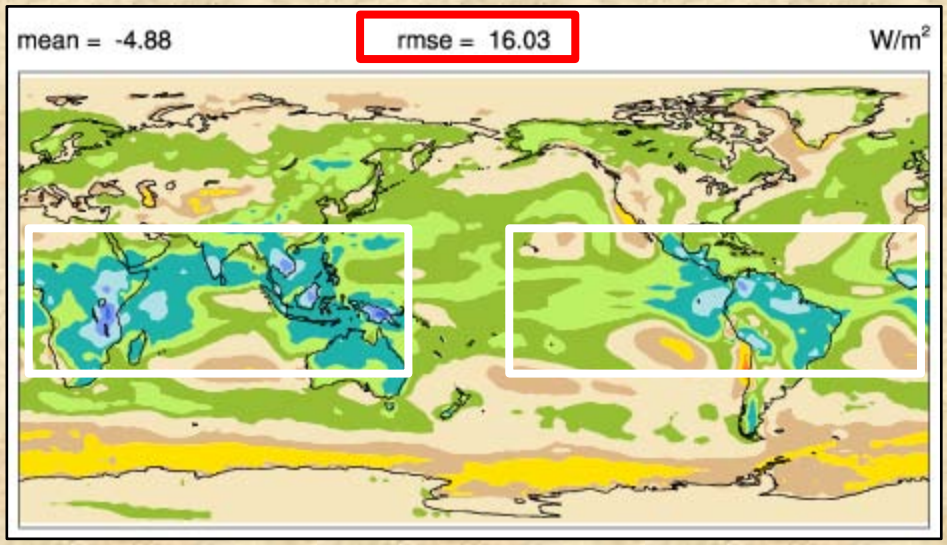
CAM5



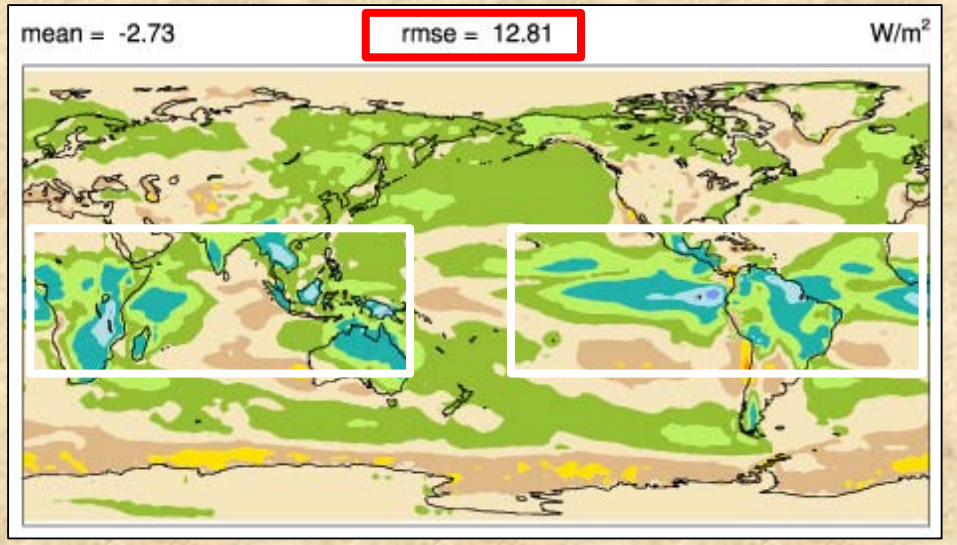
UNICON



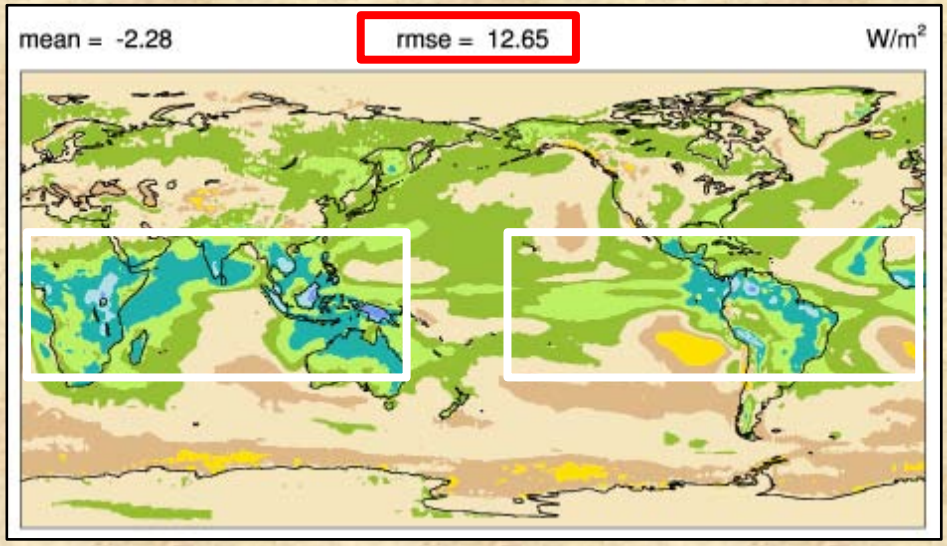
CAM5 : 2-Degree



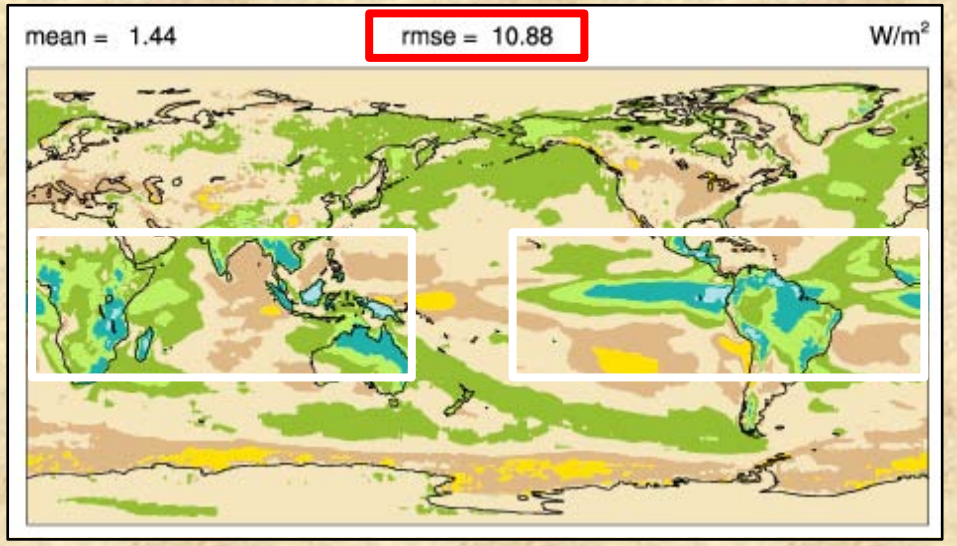
UNICON : 2-Degree



CAM5 : 1-Degree

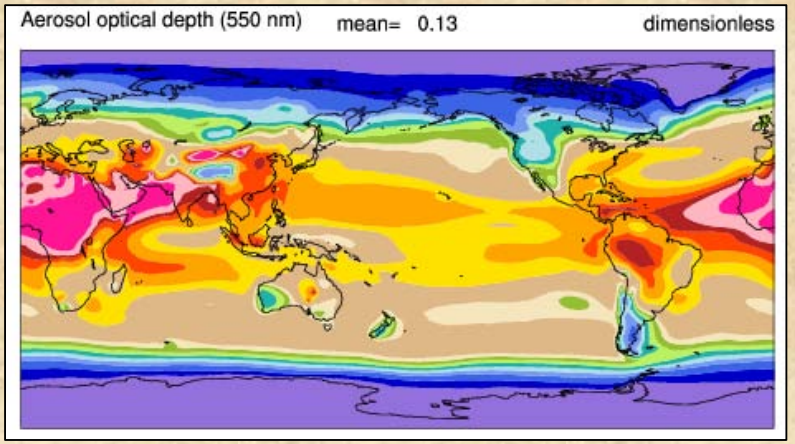


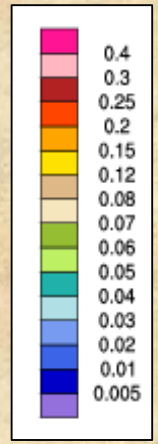
UNICON : 1-Degree



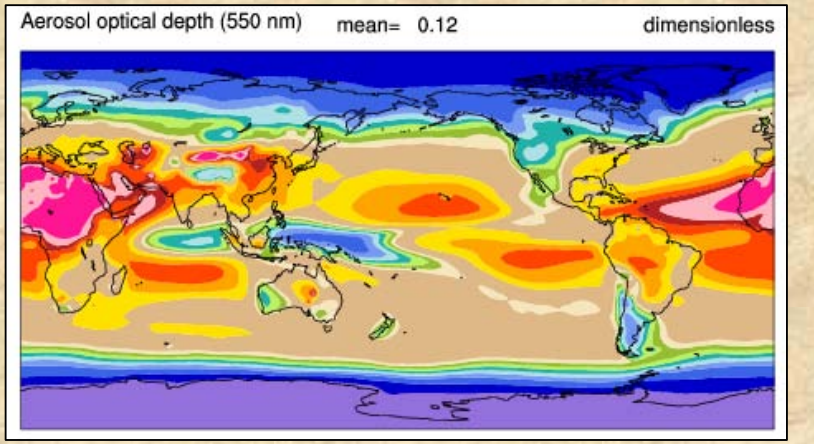
Aerosol Optical Depth. ANN.

UNICON

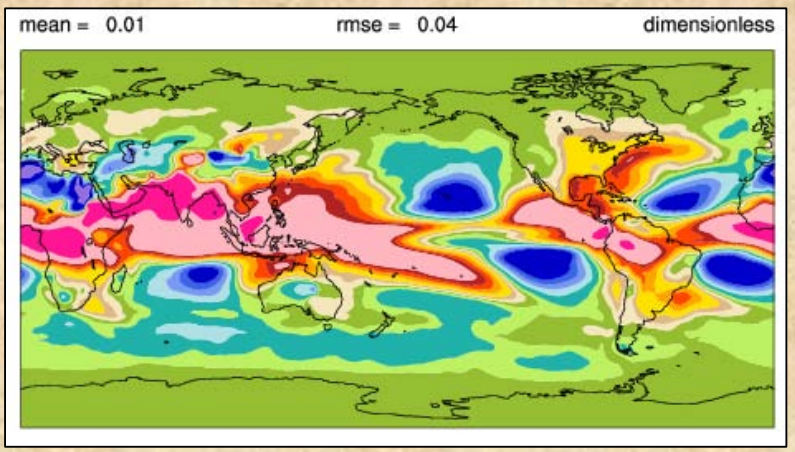


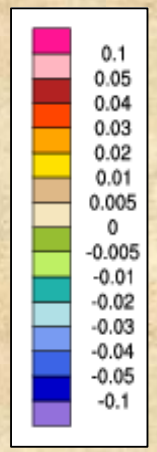


CAM5

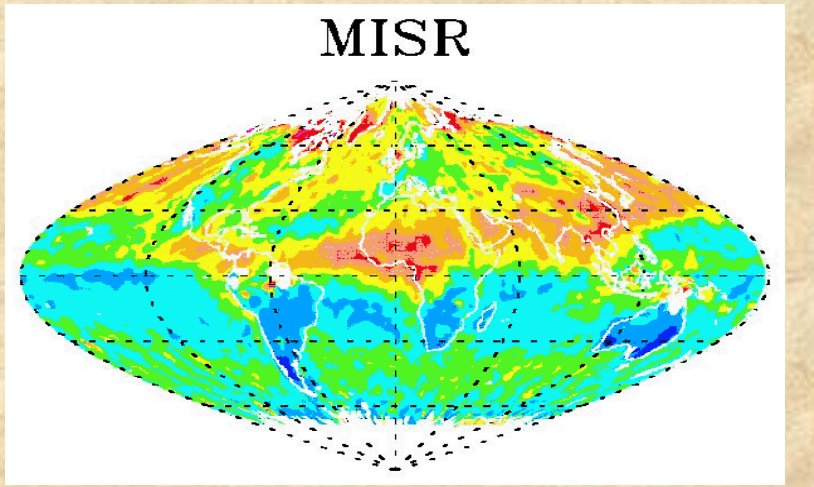


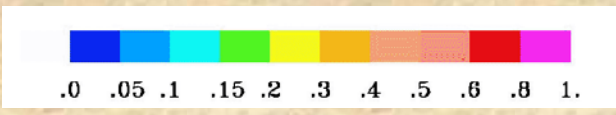
UNICON – CAM5



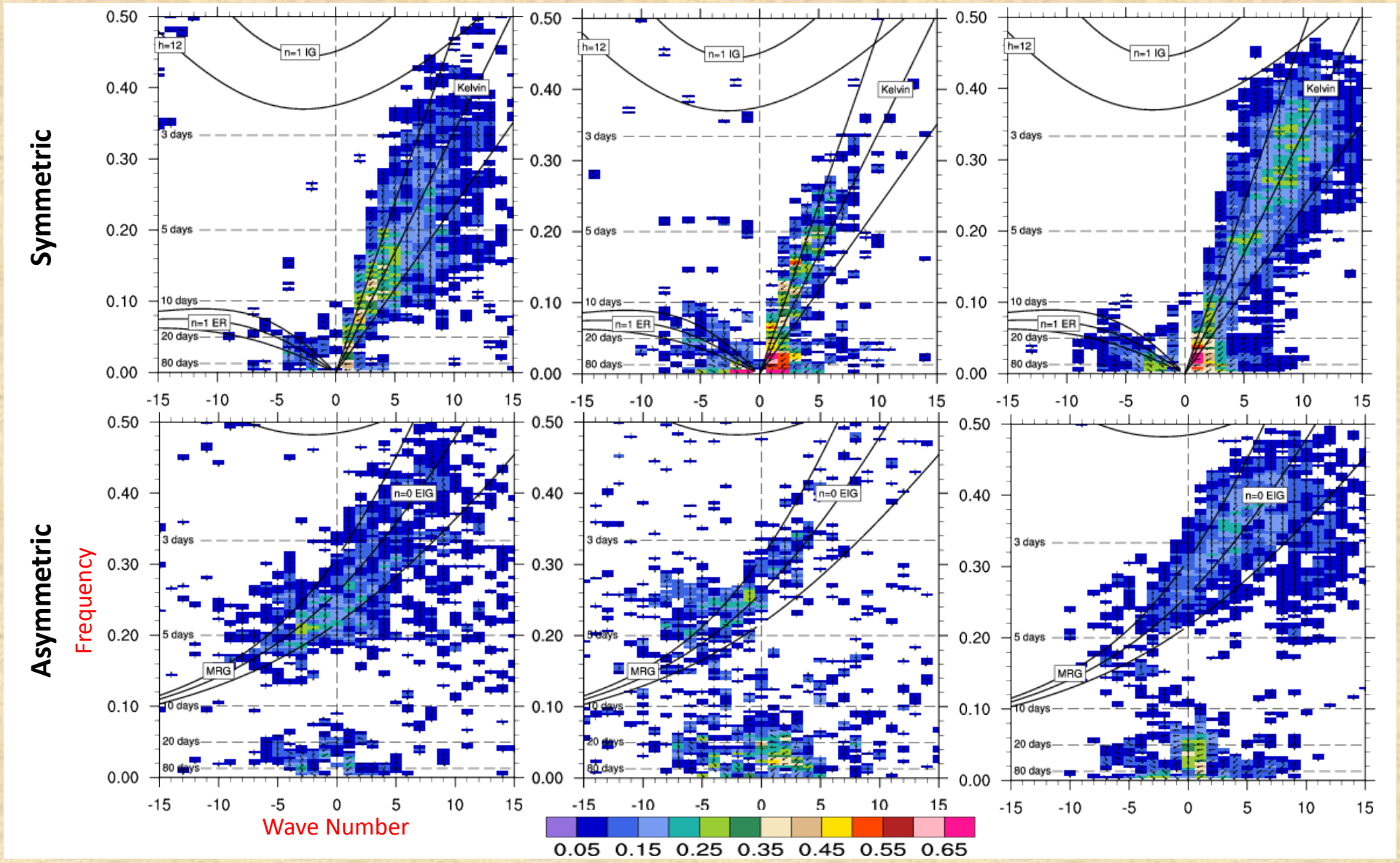


MISR

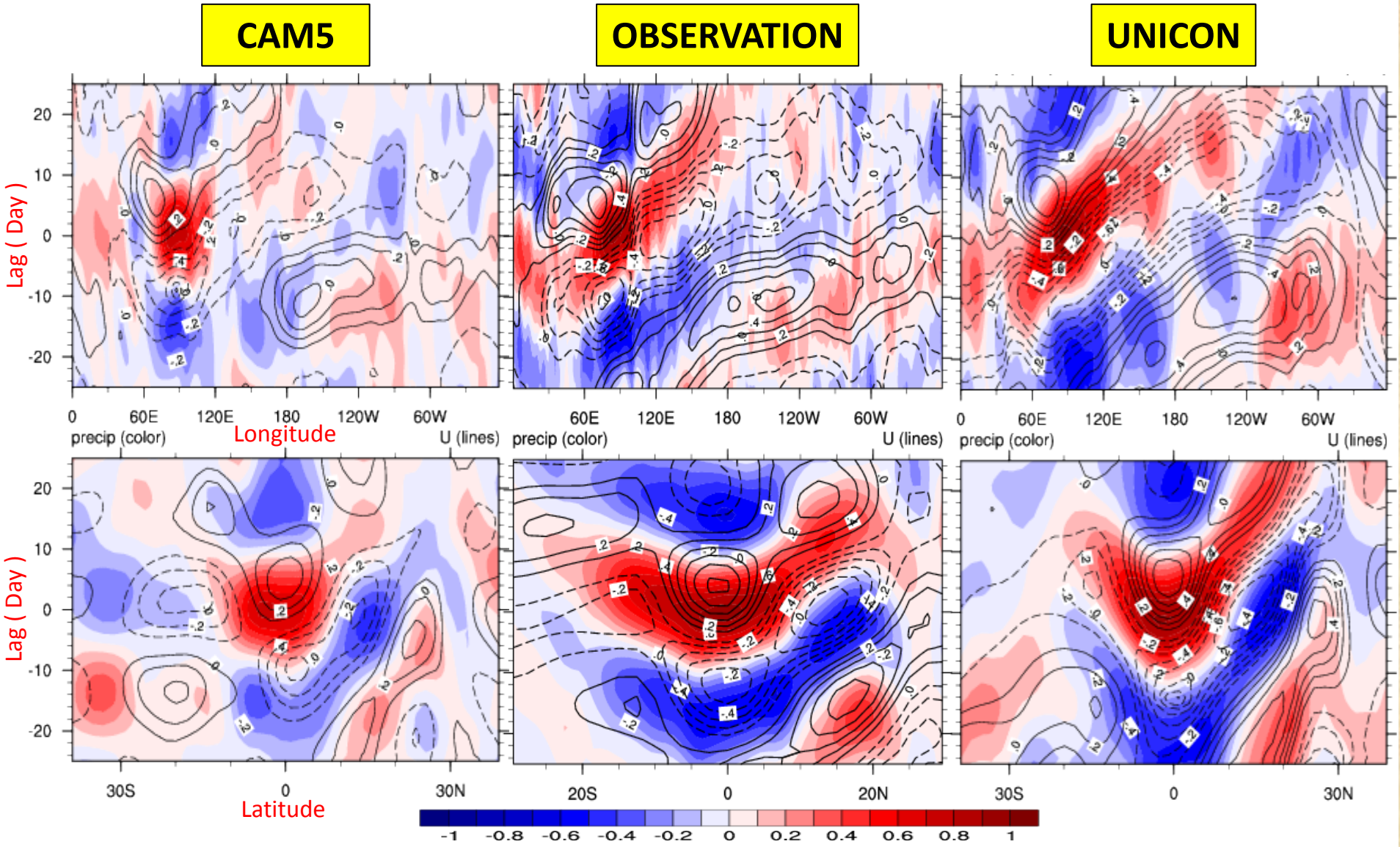




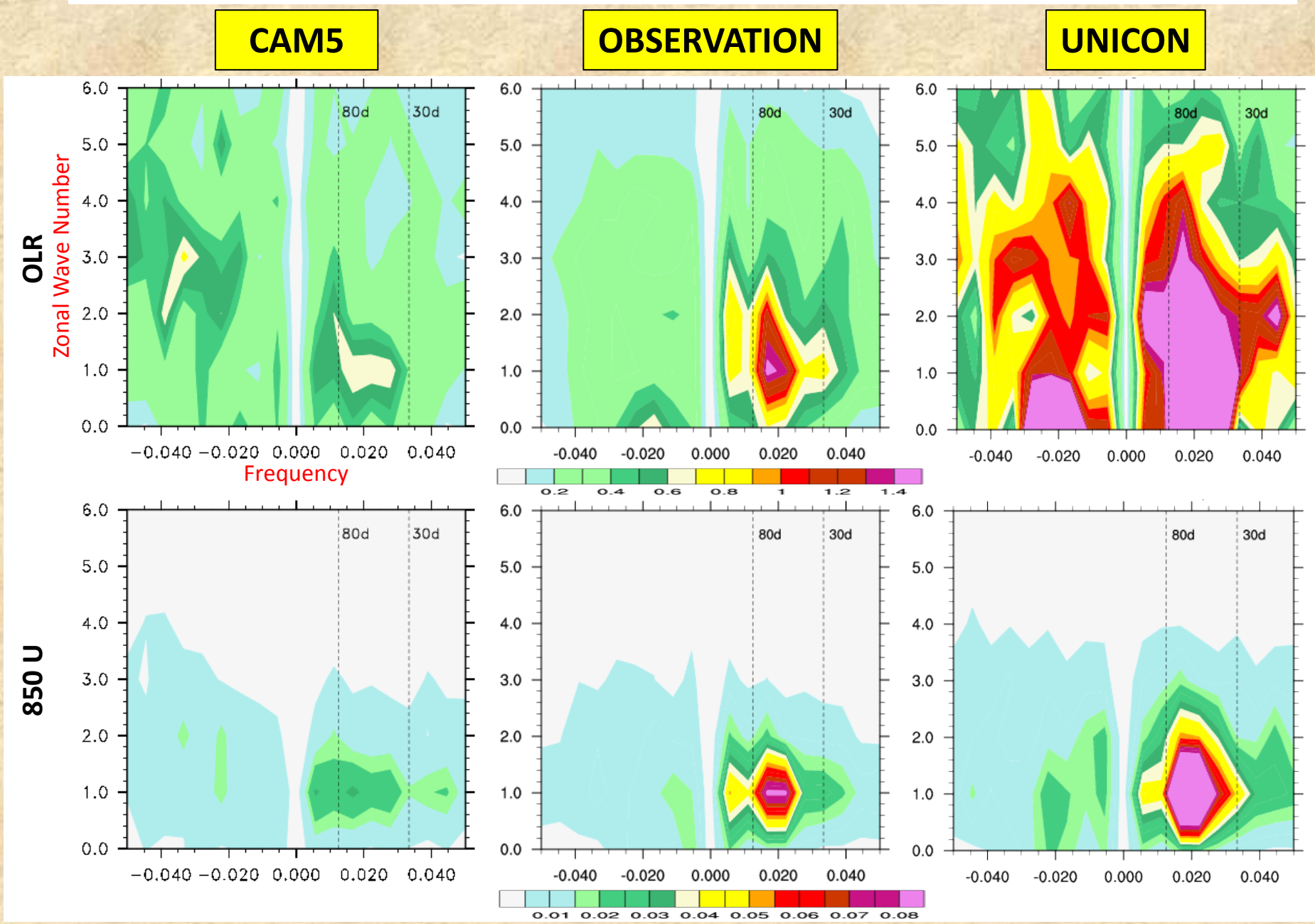
Madden-Julian Oscillation. Cross-Spectra (OLR,U850).



Madden-Julian Oscillation. Summer. Indian Ocean. Lag-Correlation of PRECT (Color) and U850 (Line).

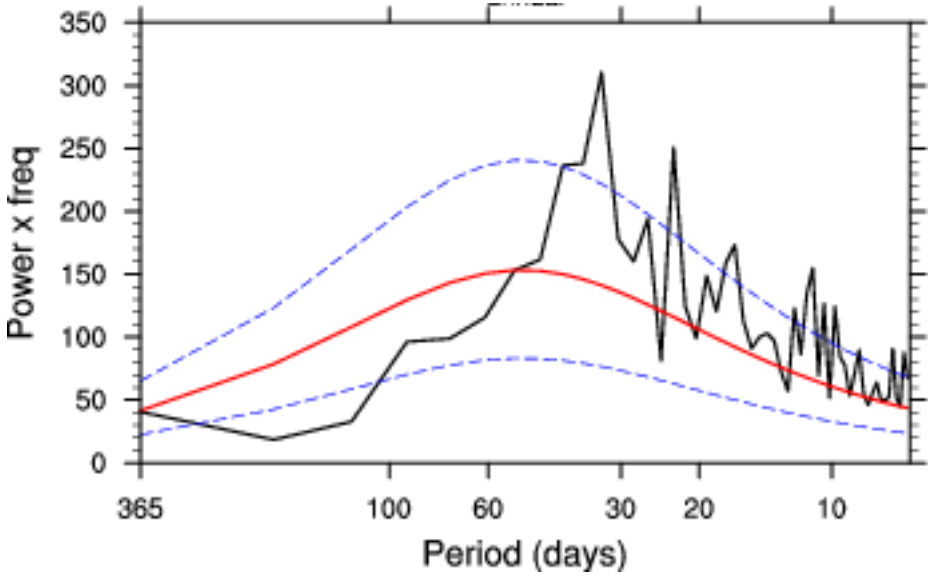


Madden-Julian Oscillation. Summer. Power Spectra.



Power Spectra of Daily OLR. Indian Ocean. ANN.

OBSERVATION



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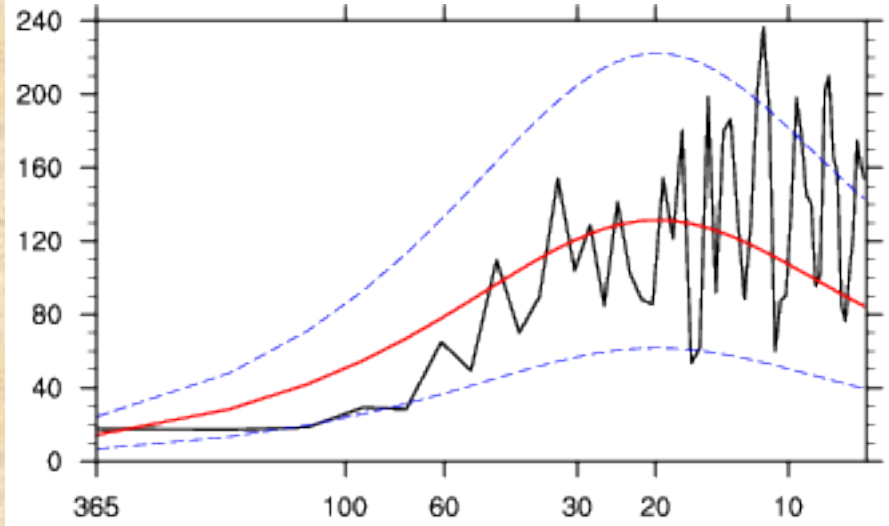
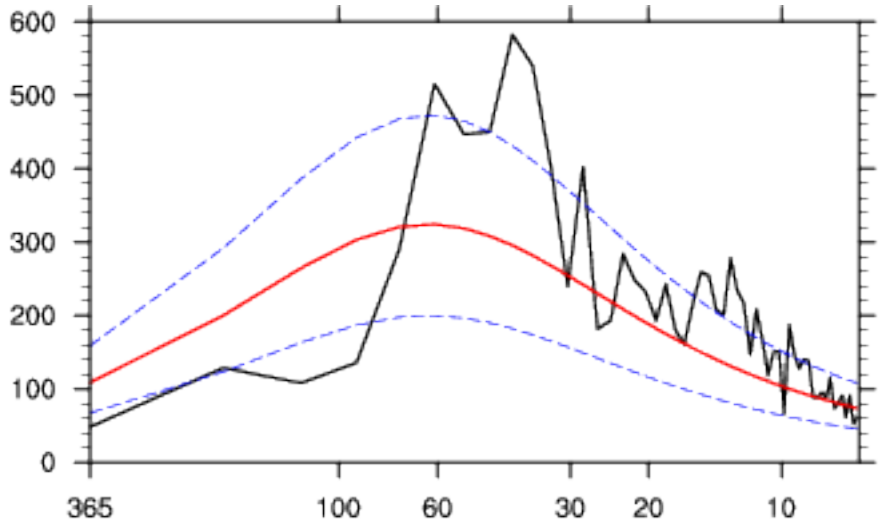


UNICON

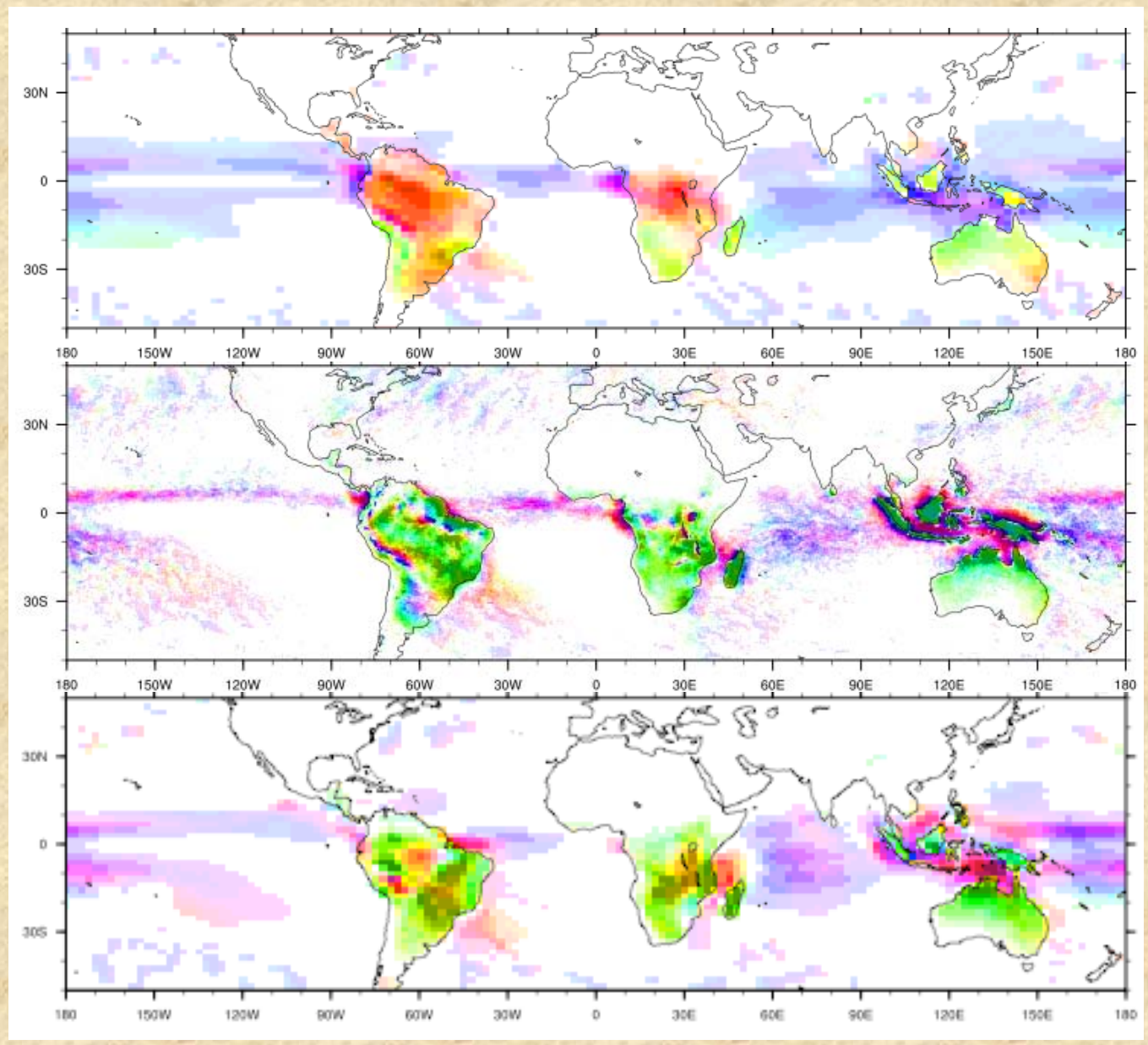


Diurnal Cycle of Precipitation. DJF.

CAM5

OBS

UNICON



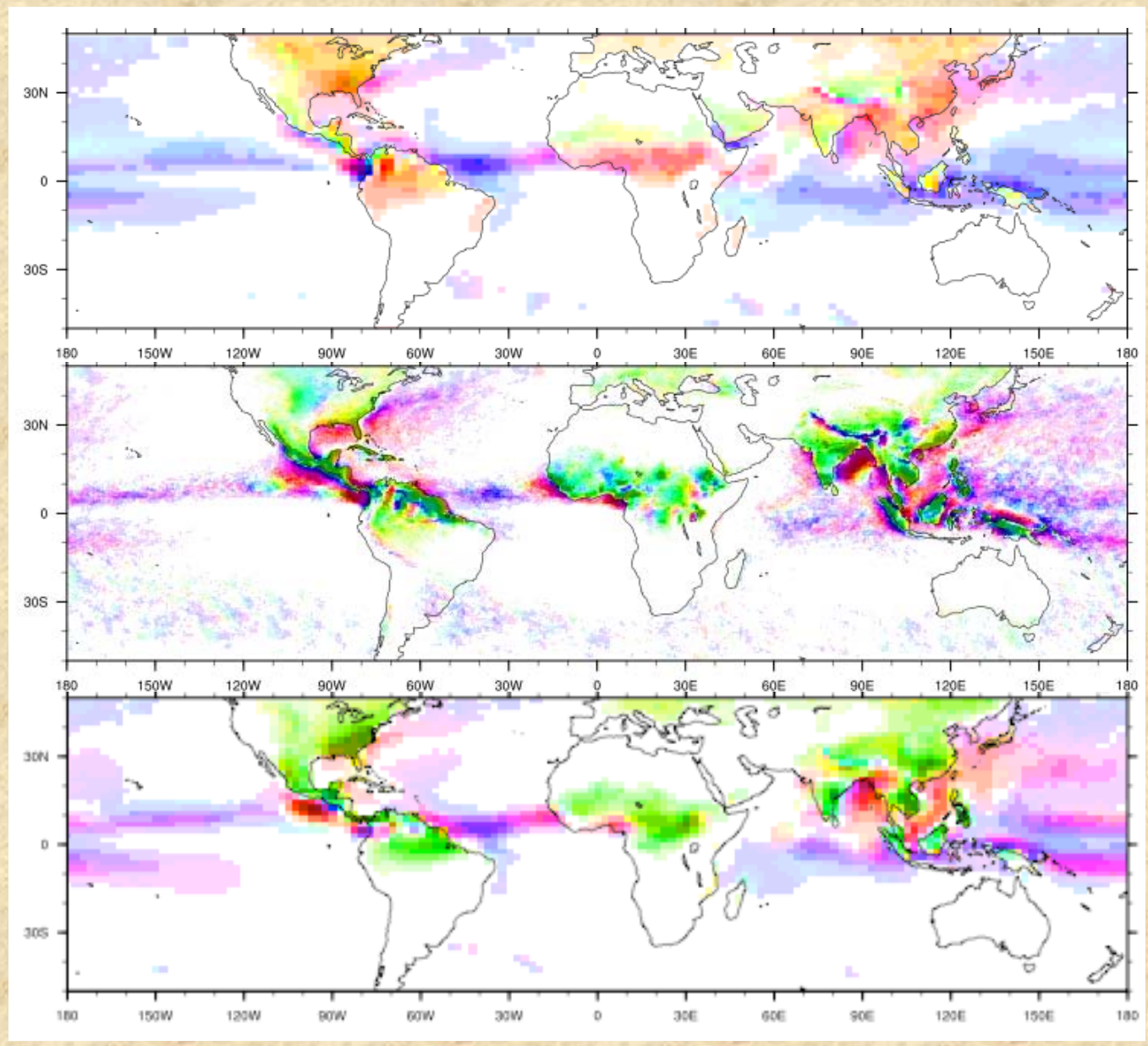
Local Hour of Max Precip

Diurnal Cycle of Precipitation. JJA.

CAM5

OBS

UNICON



Local Hour of Max Precip

SUMMARY

- UNICON is a new sub-grid vertical transport scheme by non-local asymmetric turbulent eddies and a scale-adaptive parameterization well harmonized with CAM5 moist turbulence scheme without double-counted transport.

- UNICON simulates all shallow-deep, dry-moist, and forced-free convection within a single framework in a seamless, consistent and unified way without relying on any equilibrium assumptions.

- UNICON simulates both the '*climatology*' and '*variability*' (e.g., MJO and diurnal cycle of precipitation) reasonably well.

- On-going work and future plans
  - Papers describing UNICON are in preparation (*A Unified Convection Scheme I.II.III. S. Park. 2012*).
  - Constrain several key parameters (a_u, R_u, c_0, c_ε, c_δ) from OBS/LES.
  - Test in "coupled / high-resolution (both in $\Delta x \bullet \Delta y$ and Δz)" configuration.
  - Develop and implement a *new* microphysics.