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Chikira-Sugiyama cumulus scheme in CAM5: Preliminary results

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Because of ongoing troubles with our RAID
and the NERSC computer system, my slides are incomplete.



- Chikira-Sugiyama cumulus scheme (Chikira and Sugiyama 2010) was implemented in CAM5 (CESM1.2.1).

Outline of Chikira-Sugiyama (CS) scheme

1. Based on plume-entraining model
2. Entrainment rate vertically varies depending on buoyancy and vertical velocity of updraft air parcel following Gregory (2001).
3. Multiple cloud types classified according to updraft vertical velocity at cloud base
4. Cloud base mass flux is determined by convective kinetic energy closure (Xu 1993; Pan and Randall 1998)

*Empirical triggering schemes are never used.

*Originally implemented in MIROC5

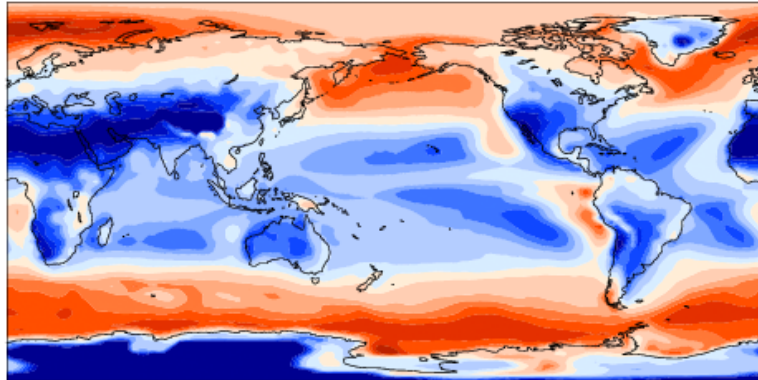
- In CAM5, aerosols are prognostic variables. The cumulus scheme should transport aerosols. But prognostic aerosols are not supported yet.
- Tuning exercise is still ongoing.

Experimental design

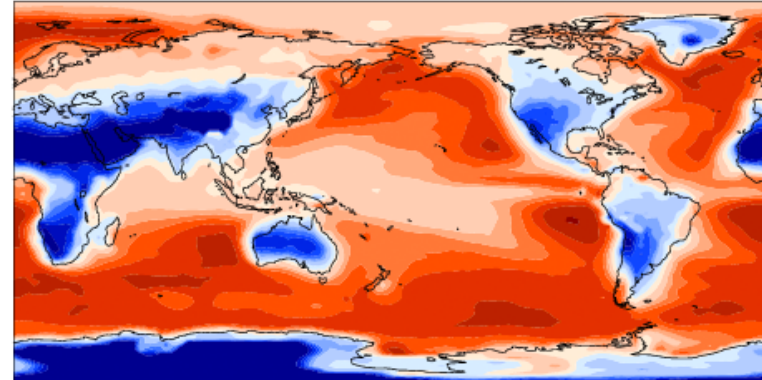
- Prescribed aerosols
 - Climatological SSTs
 - Integration: 1 year (spin up) + 5 years
 - Horizontal resolution: 2.5 deg x 1.9 deg (LON x LAT)
1. CAM5 Default (Zhang-McFarlane scheme + UW shallow convection scheme)
 2. CAM5 with CS scheme (UW shallow convection scheme turned off)
 3. CAM5 with CS scheme + UW shallow convection scheme
 4. CAM5 with CS scheme + PBL and shallow convection schemes replaced by CLUBB (third order turbulence closure scheme)

Annual mean low level cloud amount [%]

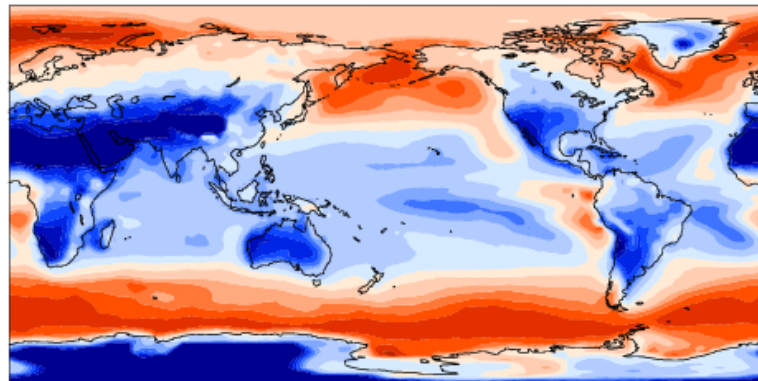
CAM5 Default



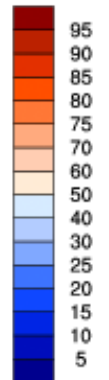
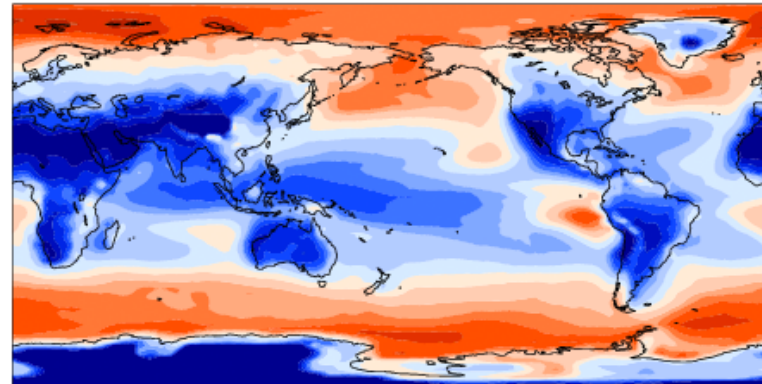
CS



CS + UW shallow conv.

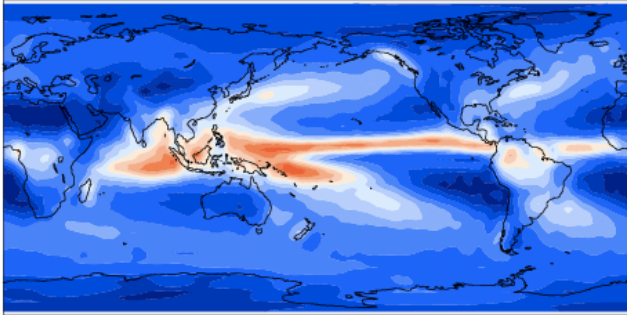


CS + CLUBB

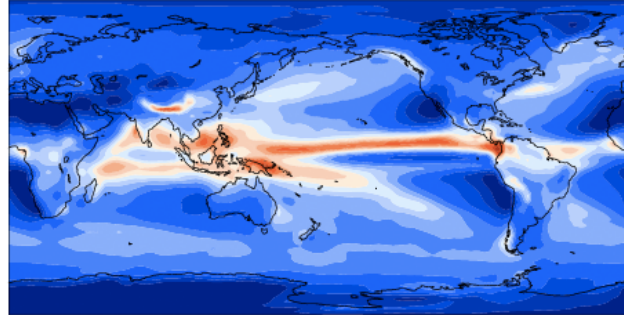


Annual mean precipitation [mm/day]

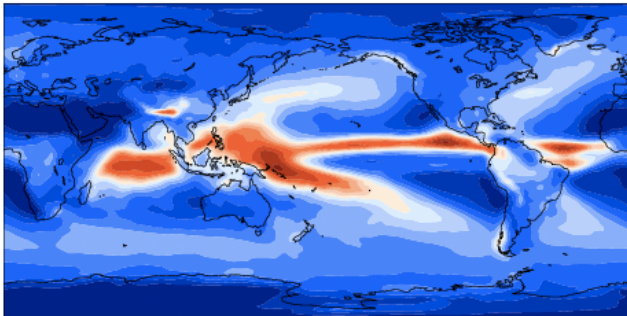
CMAP (1979-1998)



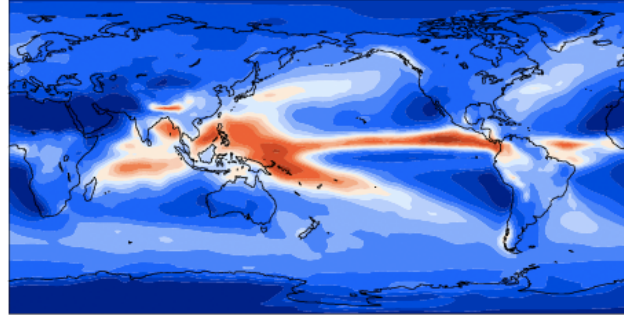
CAM5 Default



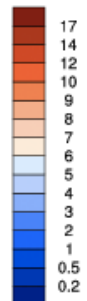
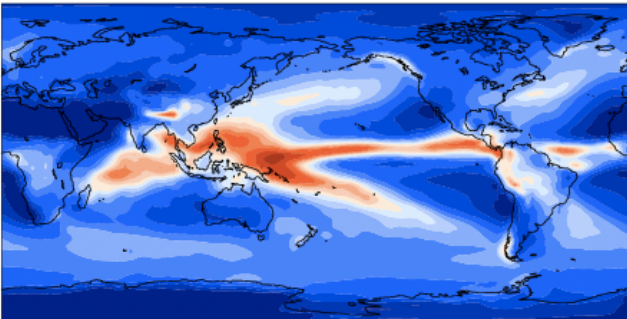
CS



CS + UW shallow conv.



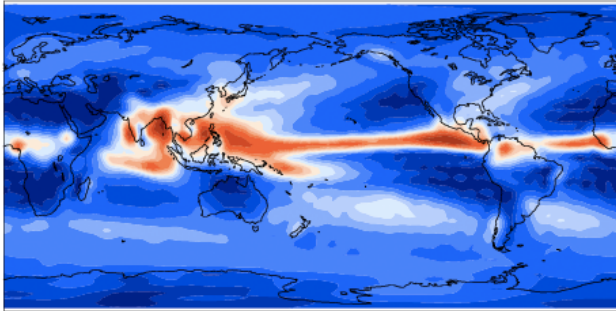
CS + CLUBB



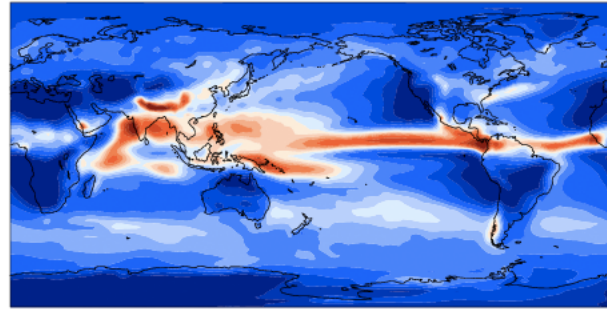
Tuning must be done to reduce too much precipitation.

JJA precipitation [mm/day]

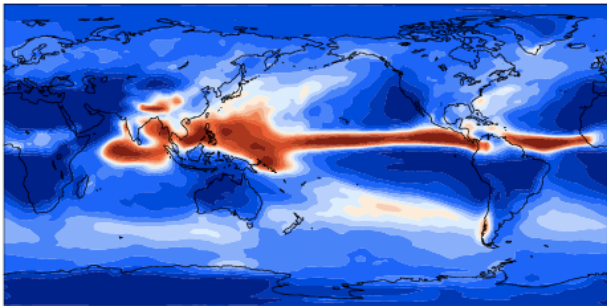
CMAP (1979-1998)



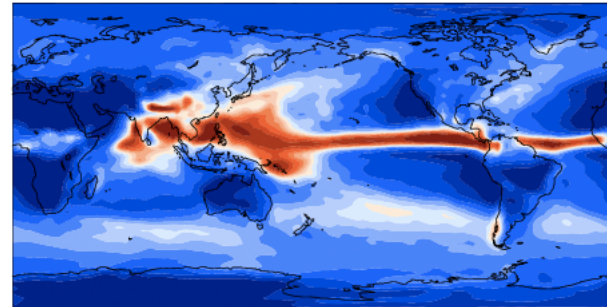
CAM5 Default



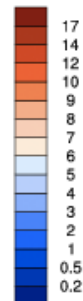
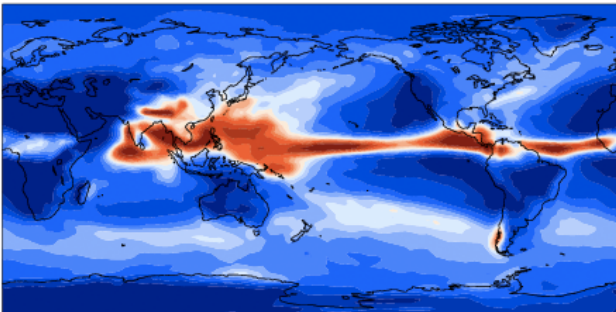
CS



CS + UW shallow conv.



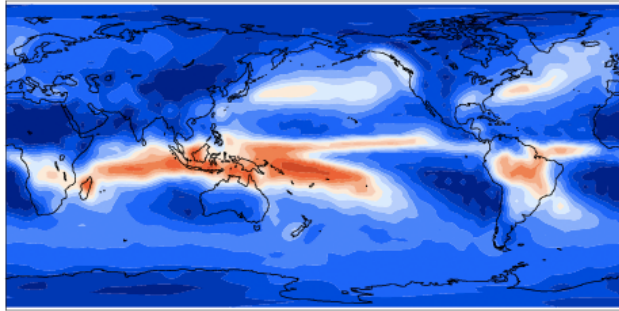
CS + CLUBB



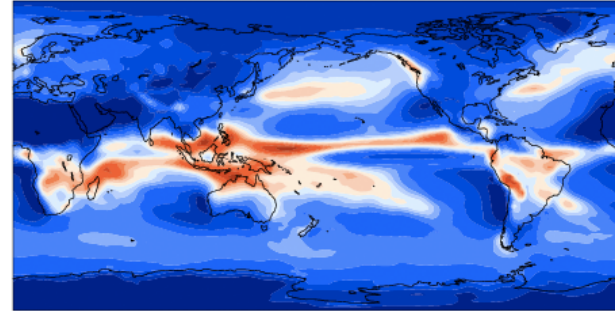
Precipitation over the Western Pacific is better represented.

DJF precipitation [mm/day]

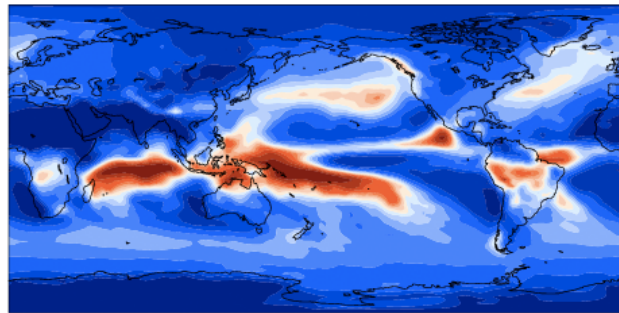
CMAP (1979-1998)



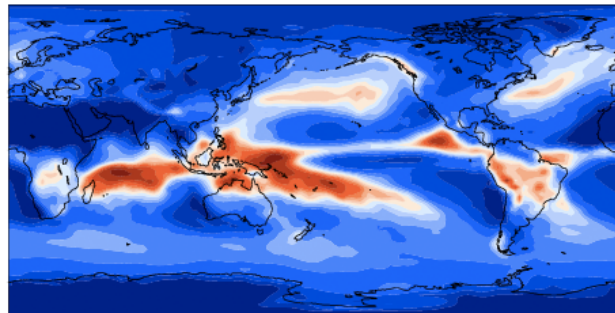
CAM5 Default



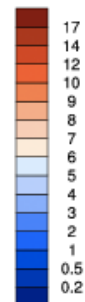
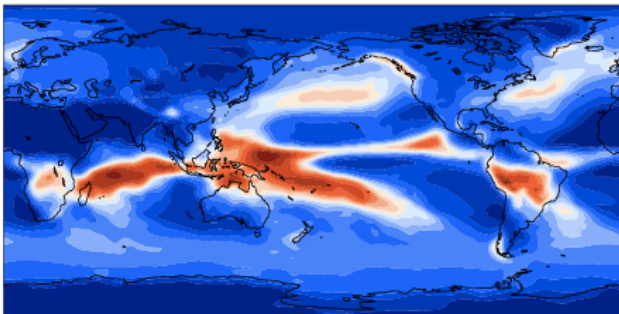
CS



CS + UW shallow conv.



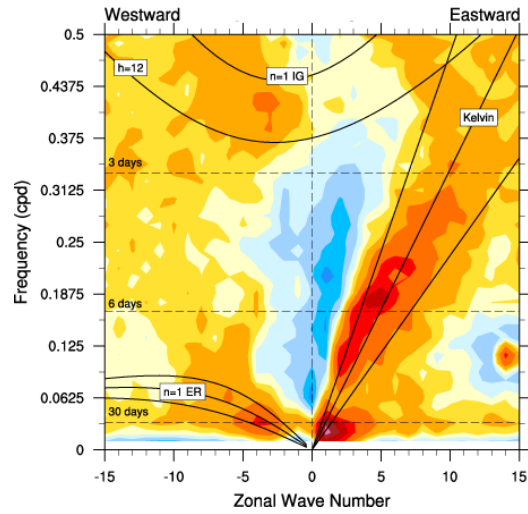
CS + CLUBB



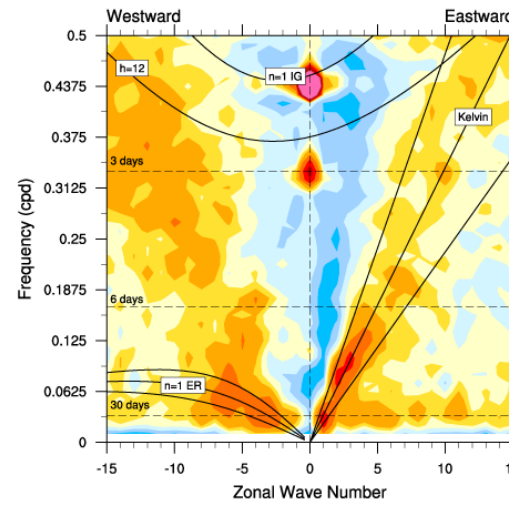
SPCZ is better represented

Wheeler-Kiladis diagram for OLR (Symmetric; 15S-15N)

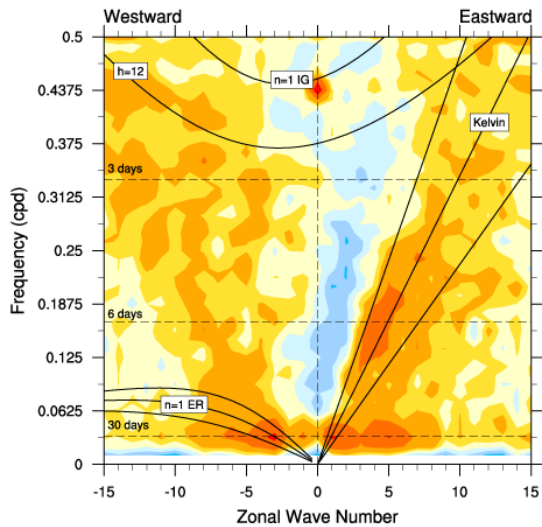
NOAA OLR (1986-2003)



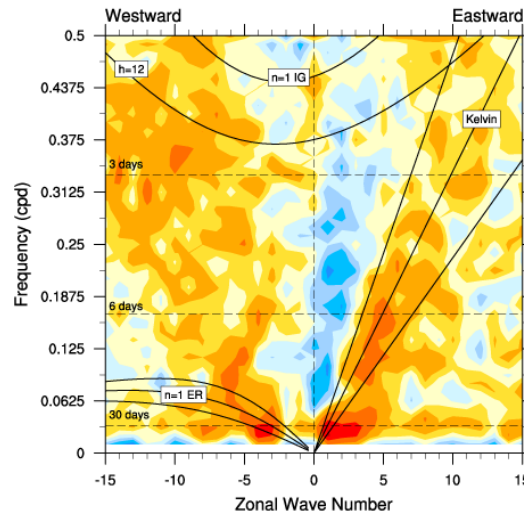
CAM5 Default



CS



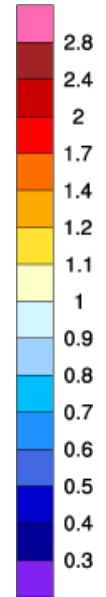
CS + UW shallow conv.



CS + CLUBB



Picture unavailable

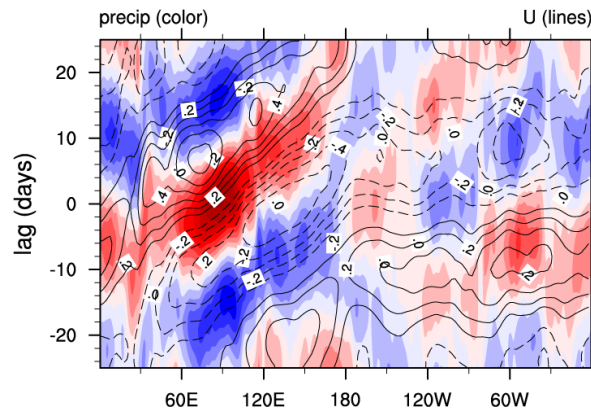


Lag correlation for 90E, 0N (Winter)

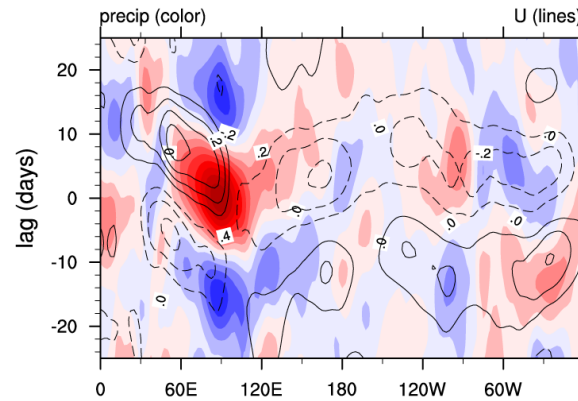
Color: Precipitation

Contours: U850

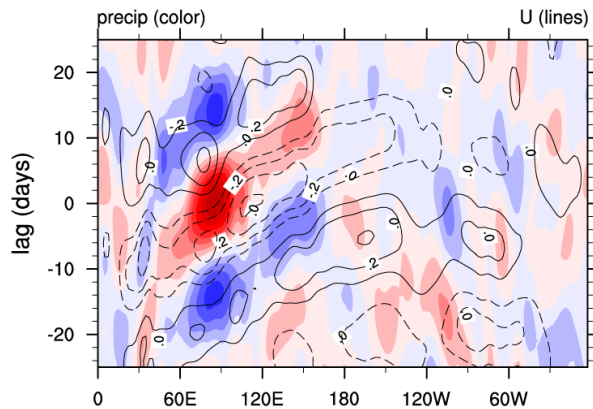
GPCP + ERA Interim (1996-2007)



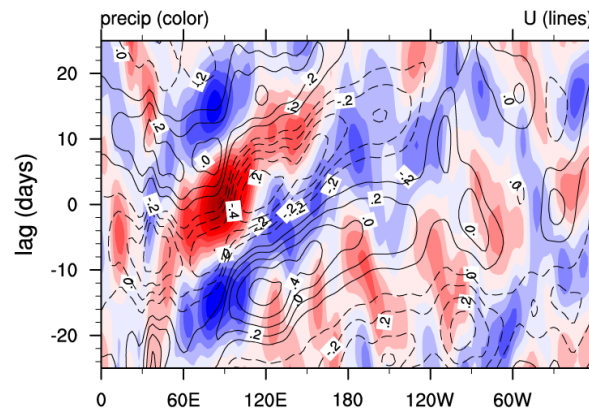
CAM5 Default



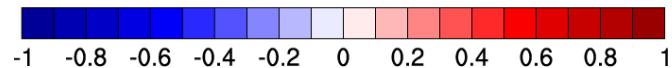
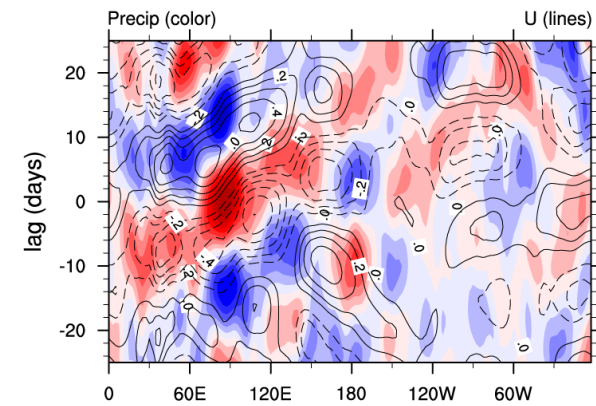
CS



CS + UW shallow conv.



CS + CLUBB



Summary

- The results look promising in terms of both climatology and variability.
- The best result is obtained with the combination of CS and UW shallow convection schemes.
- Tuning must still be done to reduce too much precipitation.
- Prognostic aerosols will be supported in the near future.

Ongoing work – Unified Parameterization (UP)

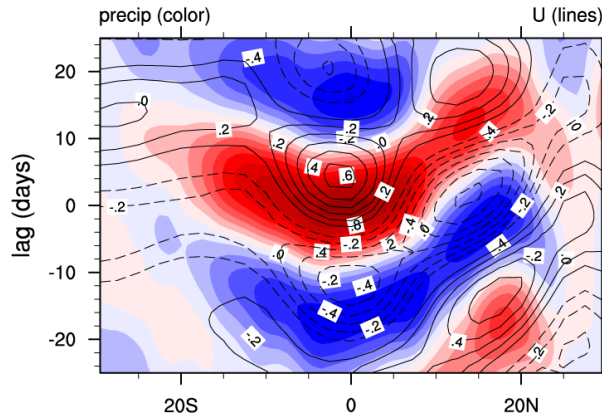
- Implementation of UP (Arakawa and Wu 2013) in the CS scheme is ongoing.
- UP is designed for schemes with a single cloud type and no downdraft. But the CS scheme handles multiple cloud types and downdraft.
- With multiple cloud types and downdraft, the problem becomes much more complicated.
- I have been working on generalizing UP for multiple cloud types and downdraft and I obtained a solution which Dr. Arakawa agreed with.
- Its implementation still needs to be done.

Lag correlation for 90E, 0N (Summer)

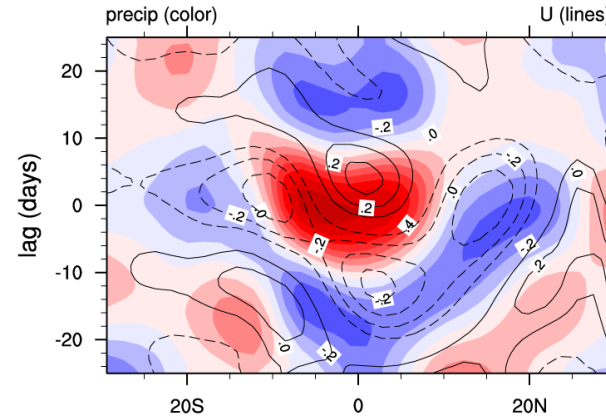
Color: Precipitation

Contours: U850

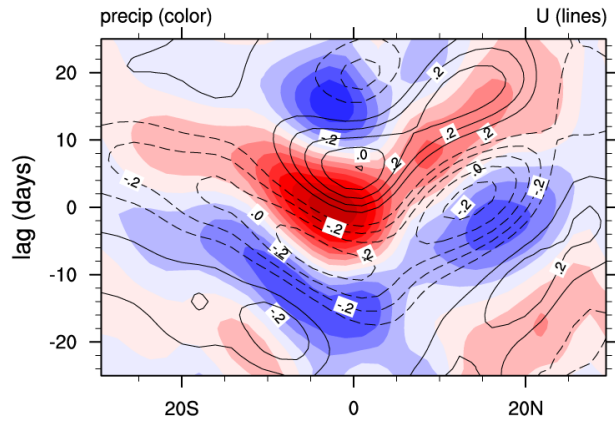
GPCP + ERA Interim (1996-2007)



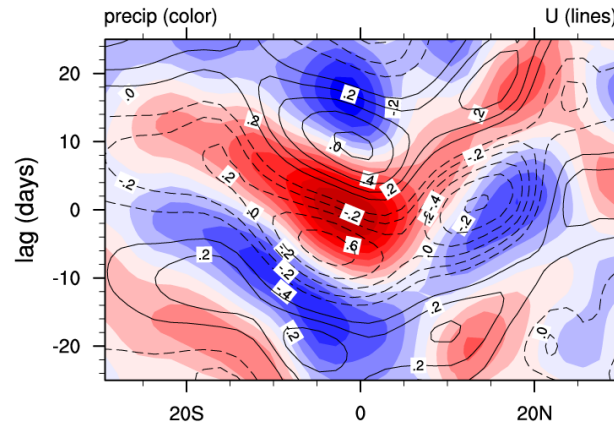
CAM5 Default



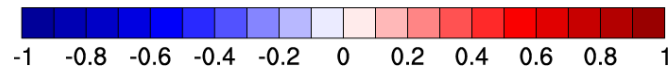
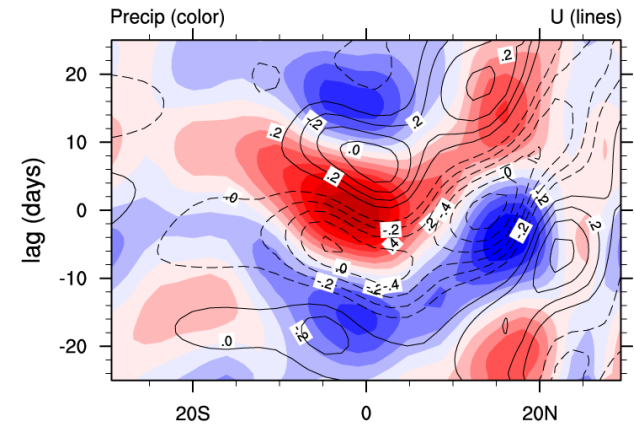
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CS + UW shallow conv.

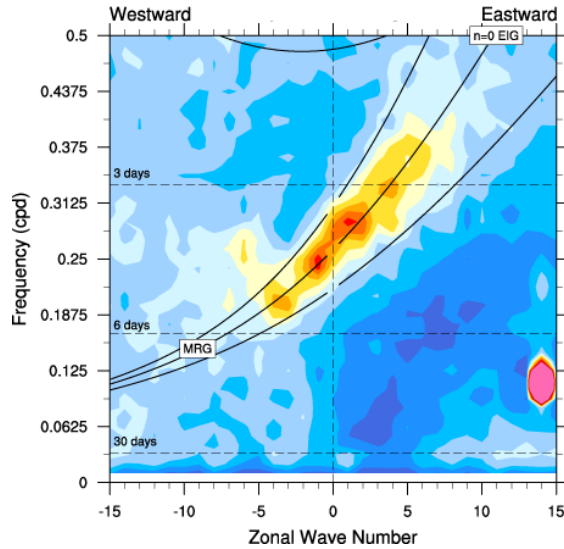


CS + CLUBB

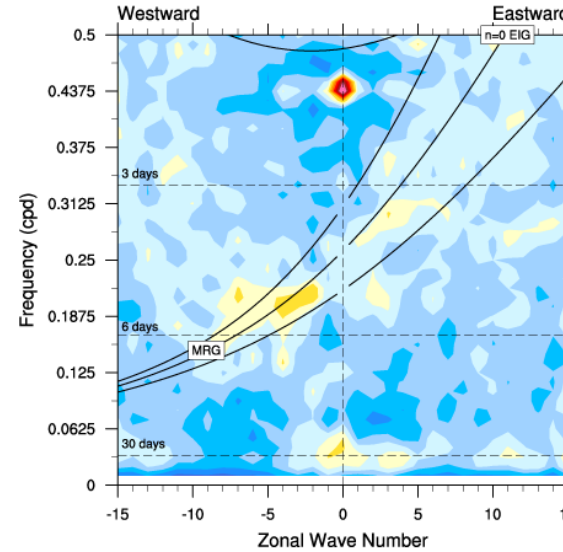


Wheeler-Kiladis diagram for OLR (Anti-Symmetric; 15S-15N)

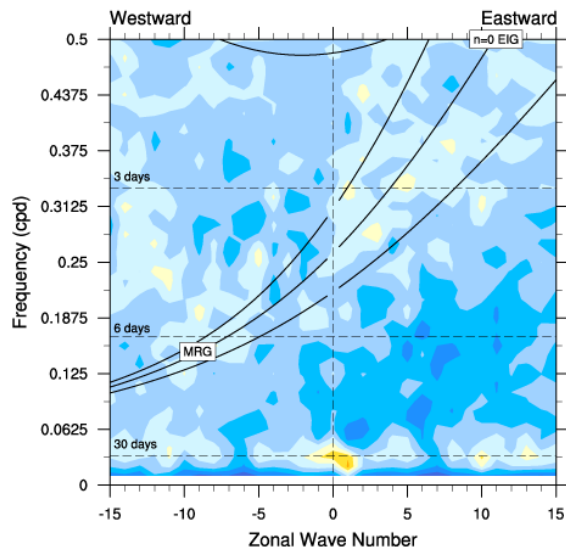
NOAA OLR (1986-2003)



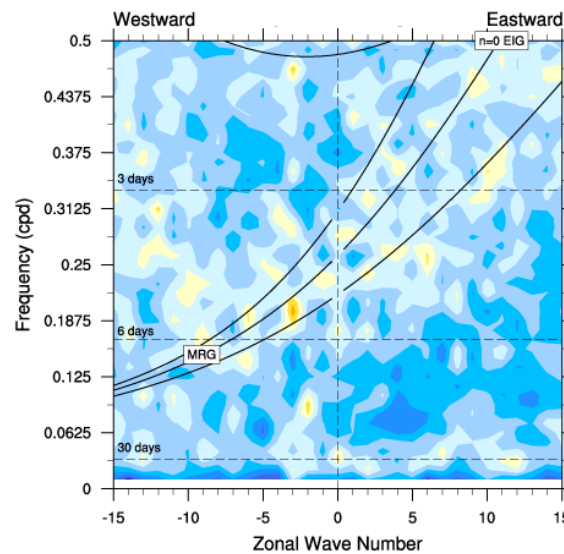
CAM5 Default



CS



CS + UW shallow conv.



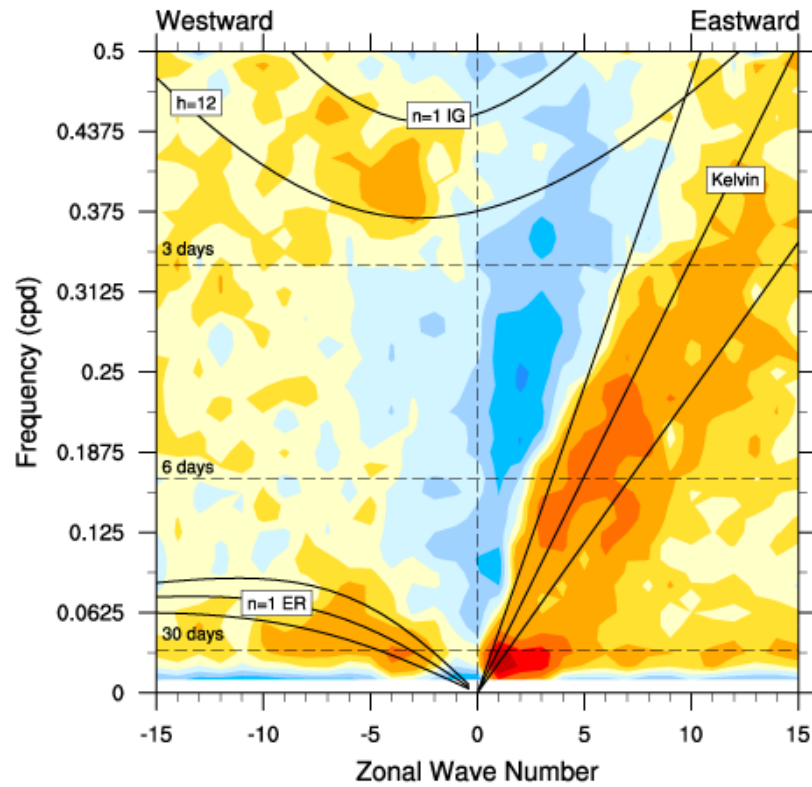
CS + CLUBB



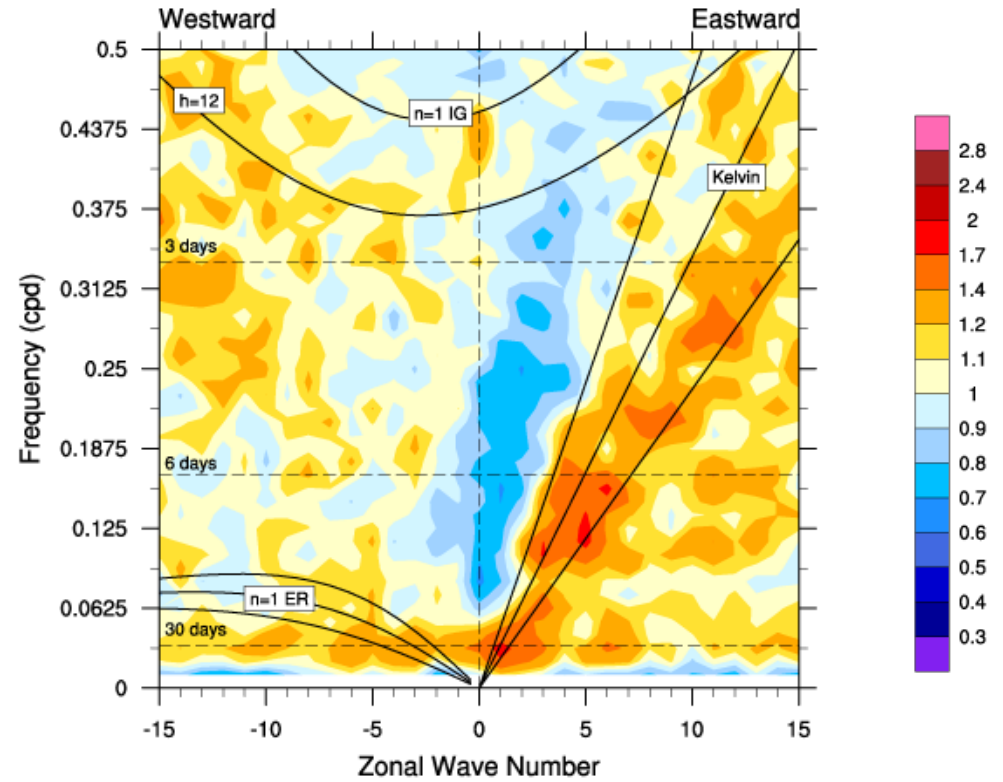
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Wheeler-Kiladis diagram for precipitation (Symmetric; 15S-15N)

TRMM 3B42

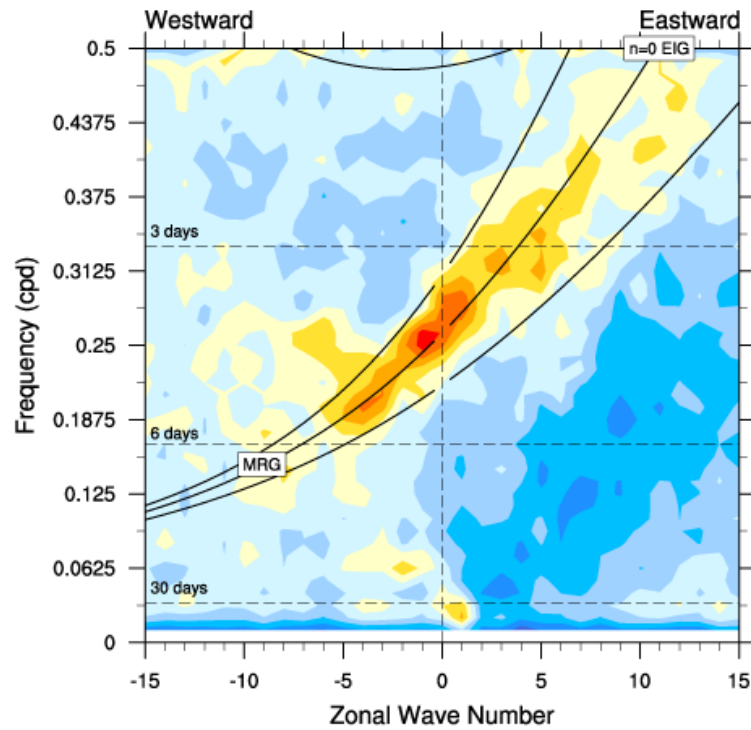


CS + CLUBB



Wheeler-Kiladis diagram for precipitation (Anti-Symmetric; 15S-15N)

TRMM 3B42



CS + CLUBB

