IMPLIED OCEAN HEAT TRANSPORTS IN THE STANDARD AND SUPER-PARAMETERIZED CAM 3.0

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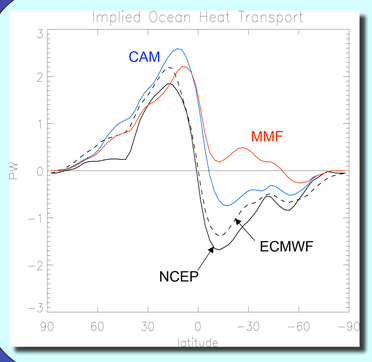
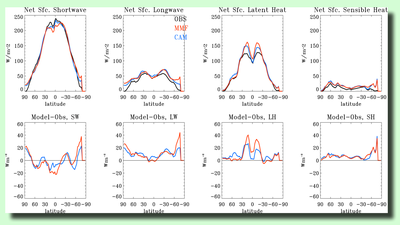


- WHY: 1) Evaluate AGCM readiness for coupling to an ocean model, 2) Identify errors in AGCM
- HOW: Integrate oceanic net surface energy budget from South Pole to North Pole.
- WHAT: 1) CAM 3.0, 2) MMF - CAM 3.0 with cloud resolving model in place of cumulus parameterization; 14-year AMIP runs

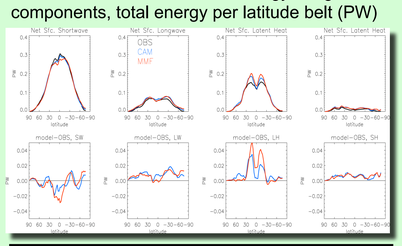
Surface Energy Budget Components

Zonal Means

Zonal mean oceanic surface energy budget components, fluxes (Wm^{-2})

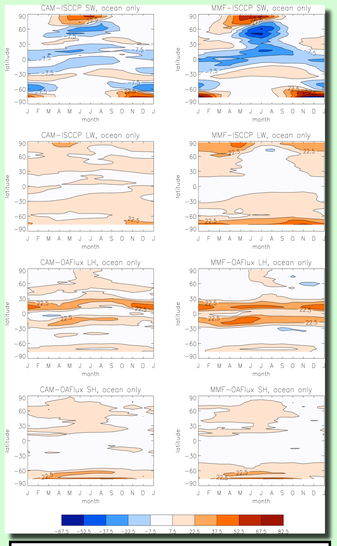


Zonal mean oceanic surface energy budget components, total energy per latitude belt (PW)



- Surface shortwave and latent heat fluxes are the two largest components and error sources of the surface energy budget.
- Largest errors are concentrated in the tropics and subtropics.

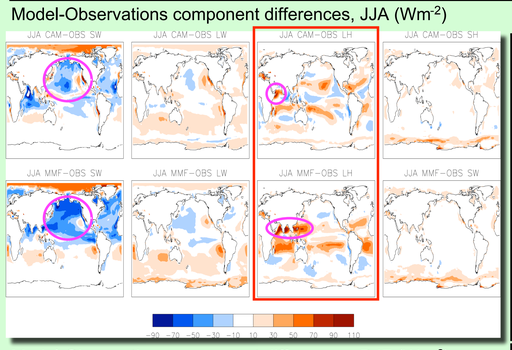
Annual cycle of zonal mean oceanic surface energy budget terms (Wm^{-2})



- Tropical surface shortwave errors migrate with the ITCZ, suggesting too much ice aloft, especially in the MMF.
- Latent heat flux errors are slightly higher in the MMF, but do not migrate with the ITCZ as they do in the CAM, suggesting exaggerated land influences in the MMF.

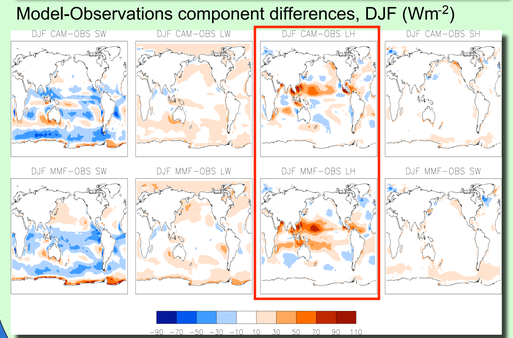
Geographic Biases

Model-Observations component differences, JJA (Wm^{-2})



- CAM surface SW errors concentrated in Indian Ocean. MMF errors most extensive in Pacific and ITCZ.
- Positive LW errors are concentrated in marine SC regions and indicate too much upward LW, likely due to do insufficient marine Sc clouds.
- MMF latent heat flux biases extend from Indian to Pacific Oceans.

Model-Observations component differences, DJF (Wm^{-2})



- SW biases are greatest in CAM in Southern Hemisphere storm belt.
- CAM, MMF LH biases are similar, and slightly greater in the MMF.

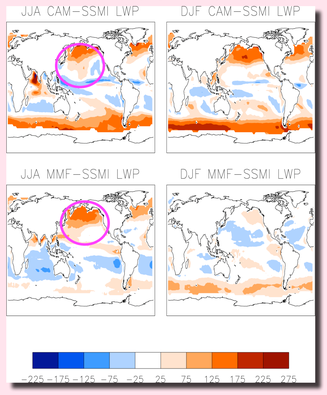
NOTE: circumstantial evidence suggests that the cyclic boundary condition on the MMF's embedded CRM may result in overly active and deep tropical convection, consistent with the observed surface energy biases.

Note: LH notations are discussed in Winds, Evaporation, Latent Heating section at right.

Clouds and Surface Shortwave Fluxes

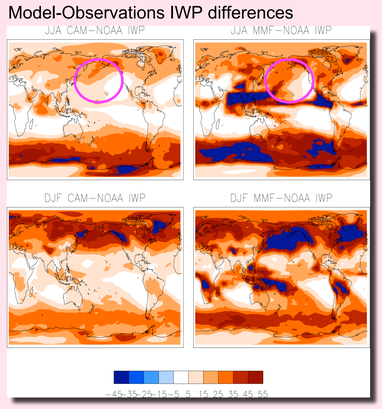
Clouds: Global view

Model-Observations LWP differences



- Boreal summer north Pacific liquid water path similar in CAM and MMF, so cannot explain SW biases.
- Note high JJA LWP values in Indian Ocean for CAM. In the MMF, high LWP is shifted northward to the Asian monsoon region.

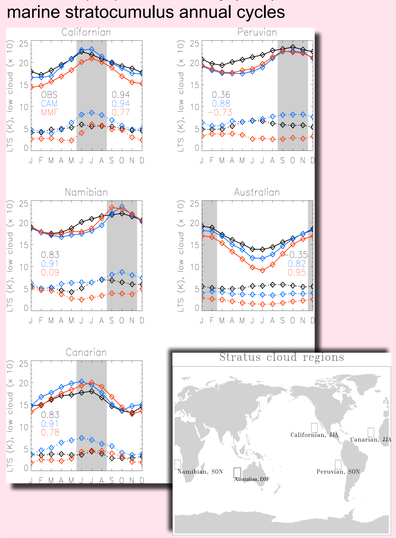
Model-Observations IWP differences



- Compared to AMSU-derived IWP values, each model produces too much ice, especially poleward of winter hemisphere storm tracks.
- MMF also produces too much ice in tropical convection, a possible symptom of the cyclic boundary condition on the CRM.
- IWP data source: NOAA Microwave Surface and Precipitation Products System (MSPPS).

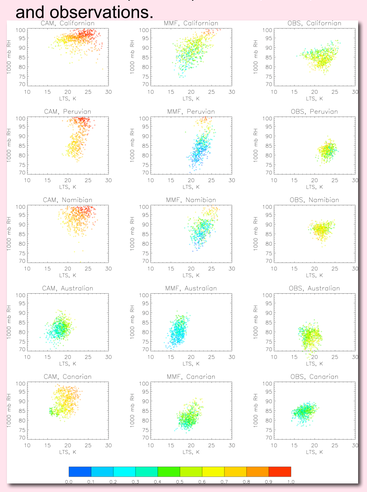
Marine Stratocumulus Clouds

Lower Tropospheric Stability (LTS) and marine stratocumulus annual cycles



- Both models reproduce the observed LTS annual cycle (solid lines).
- Wide disagreement exists on low cloud fraction (CF; dashed lines).
- LTS-CF correlations are lowest for the MMF, except in the Australian region.
- CF in CAM is parameterized. MMF simply operates on large-scale conditions.

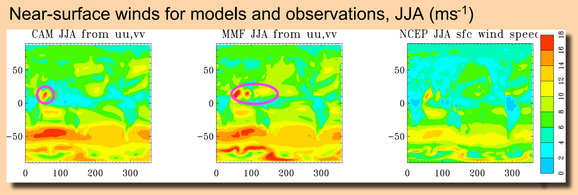
LTS, 1000mb relative humidity, and cloud fraction (crosses) in CAM, MMF, and observations.



- As expected, CAM CF is primarily sensitive to LTS.
- MMF low cloud amounts are less than those in CAM, and are most sensitive to low-level relative humidity.
- In nature, the LTS-RH-CF relationship seems to vary from region to region.

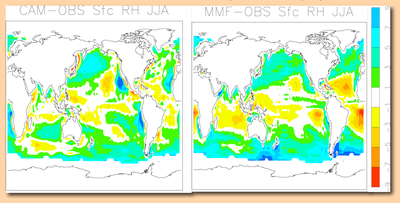
Wind, Evaporation, and Latent Heat Fluxes

Near-surface winds for models and observations, JJA (ms^{-1})



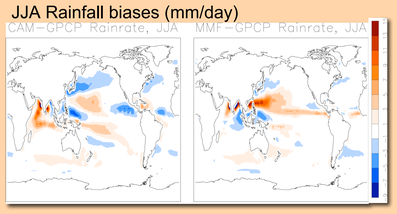
- MMF JJA near-surface winds are most excessive in the tropical Indian and Pacific Oceans.

JJA Surface relative humidity biases (%)



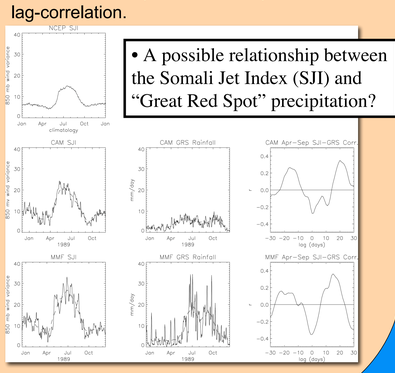
- CAM and MMF Asian monsoon-region LH biases (red boxes, left-most panel) arise from excessive winds. Biases are greater in MMF.
- MMF LH biases in sub-tropical trade wind regions result from low RH biases and slightly excessive winds.

JJA Rainfall biases (mm/day)



- LH, RH, and wind biases give some insight into the MMF's Pacific precipitation bias.
- Precip bias appears to have its origins in the Somali jet region for both CAM and MMF.

Somali Jet winds, W.Pac rainfall, and their lag-correlation.



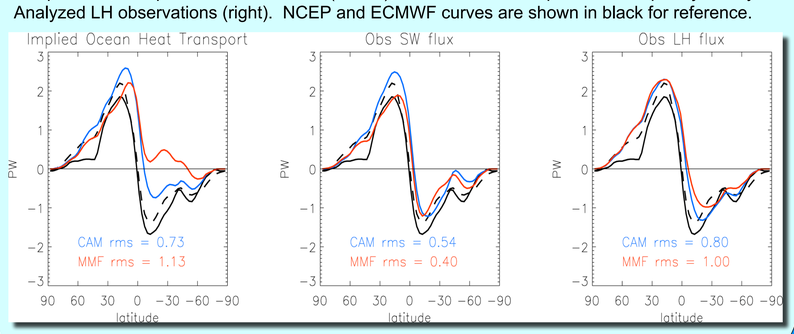
- A possible relationship between the Somali Jet Index (SJI) and "Great Red Spot" precipitation?

Note: Lag-correlation performed on departures from smoothed curve

Conclusions

- Surface shortwave and latent heat flux biases are primarily responsible for errors in implied ocean heat transports.
- SHORTWAVE BIASES:
  - MMF has not been tuned to reduce TOA net radiation biases.
  - Adjusting ice-snow conversion rate or effective ice radius is most direct route to improvement.
  - MMF produces realistic Marine Sc clouds, but too few of them. The negative biases appears to arise from anomalously low surface relative humidity in marine Sc regions.
- LATENT HEAT FLUX BIASES
  - Arise from varying combinations of wind and relative humidity biases.
  - Excessive LH fluxes over Somali Jet may be related to MMF "Great Red Spot" precipitation.

Implied Transports from simulated surface energy budget components (left), simulated components, except ISCCP surface SW (center), and simulated components except Objectively Analyzed LH observations (right). NCEP and ECMWF curves are shown in black for reference.



Depiction of potential model improvements as SW & LH biases are improved.