Weather Forecast Evaluation of CAM4

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Outline

- Simulations
- Why does CAM4 have a low bias in clear-sky longwave radiation?
- Why does CAM4 underestimate the impact of high clouds on outgoing longwave radiation in the extratropics?
- (Satellite simulator aside:
  - ISCCP simulator v4.0 is available
  - COSP v1.0 will be available very shortly)

Simulations

- Weather forecast simulations are started every day in the period January – February 2006 with the ECMWF operational analysis
- Two model versions are examined:
  - CAM3.6 (CAM3_5_35) which has CAMRT + MG Microphysics + HB PBL + Hack ShCu
  - CAM4 (CAM3-6-16dev07) which has RRTM + MG Microphysics + UW PBL/ShCu + Ice Supersaturation (+ Cloud Macrophysics?)

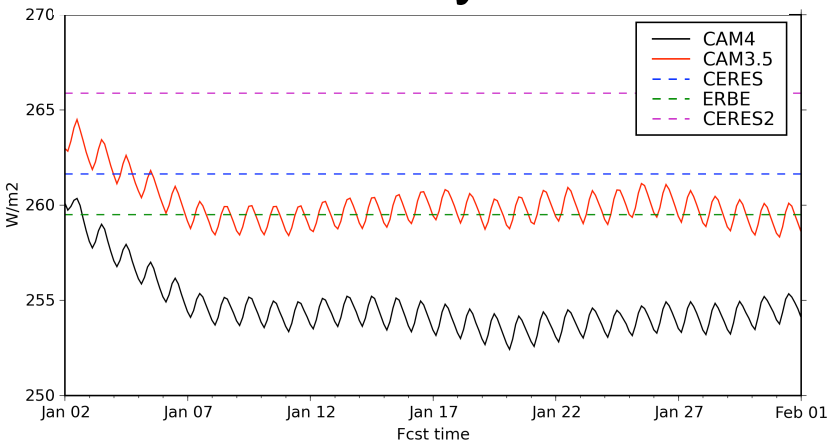
Question: Why does CAM4 have a low bias in clear-sky outgoing longwave radiation?

Answer: This result from drifts in middle & lower tropospheric water vapor (moist) and temperature (cold) which are particularly prominent in tropical regions adjacent to the deep convection regions.

Possible Causes: Overactive shallow and deep convection? Bad interactions between shallow and deep convection?

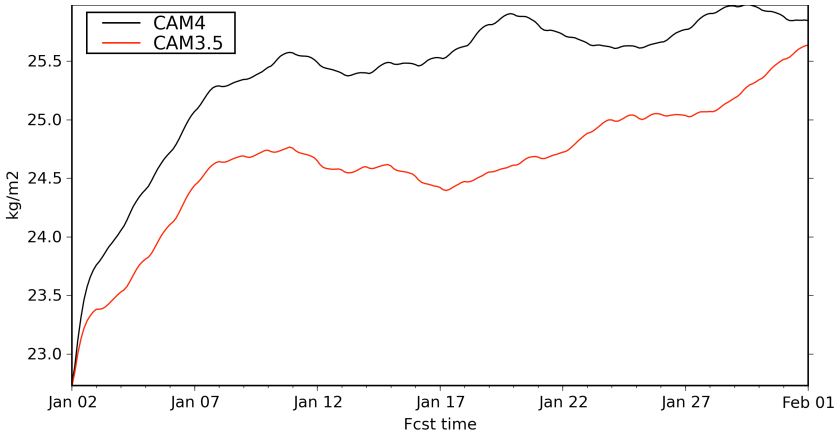
Drifts in Global Means

Clear Sky OLR

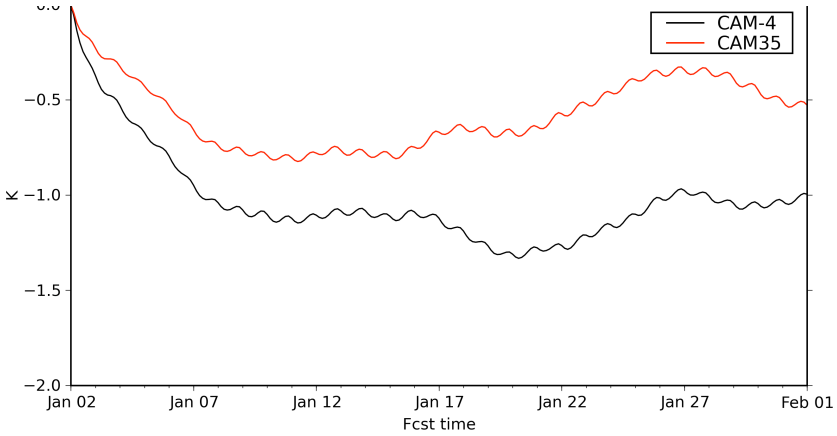


- *With ECMWF analysis, CAMRT or RRTM produces a global mean clear-sky longwave within the range of observational estimates at the start of the forecast*
- *Difference in initial value is consistent with offline comparisons of CAMRT and RRTM*
- *Drift to 'climate' occurs over ~5 days is well correlated with moist and cold drifts*

Column Water Vapor

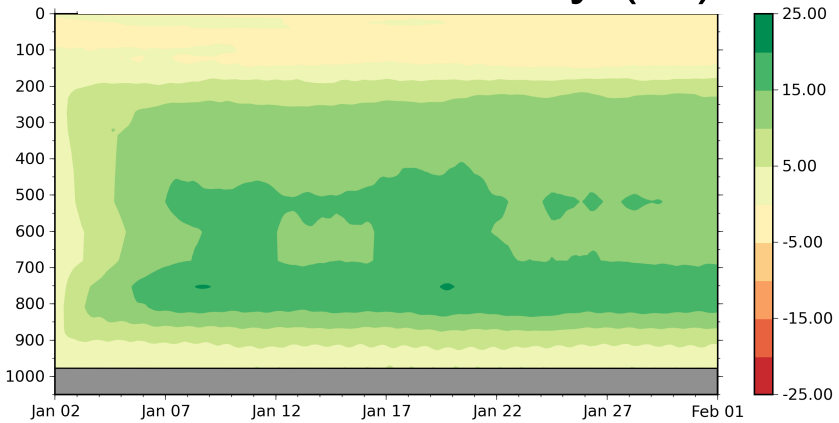


Temp beneath 300 hPa



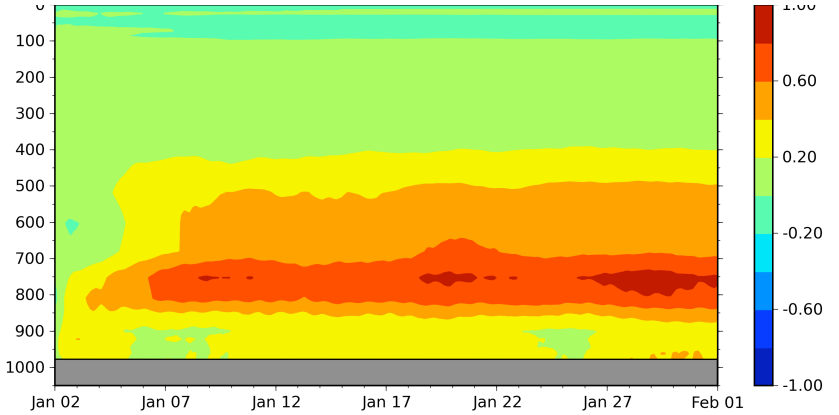
Vertical Profiles of CAM4's Drift

Relative Humidity (%)

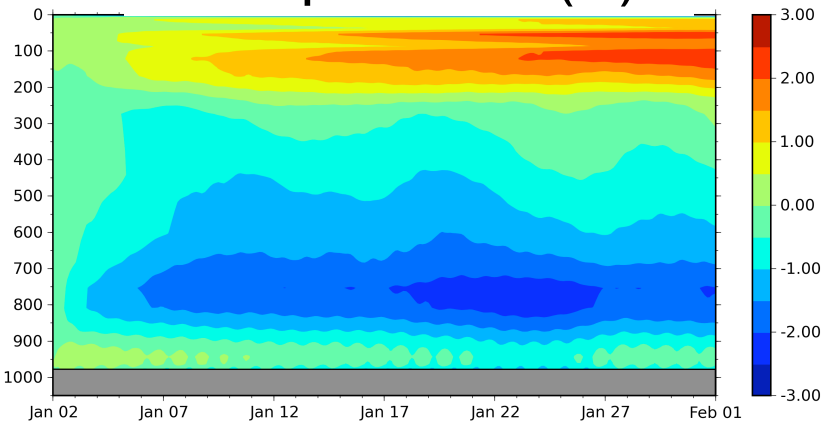


- *Relative to the ECMWF analysis, CAM4 has a tropospheric moist bias of 10-15%*
- *The moist bias is largest near 800 hPa where there is also a cold bias of 2K*
- *CAM3.6 drifts have similar structure but smaller amplitude*
- *Do CAM4's automatic figures show this drift?*

Mixing Ratio (g kg^{-1})

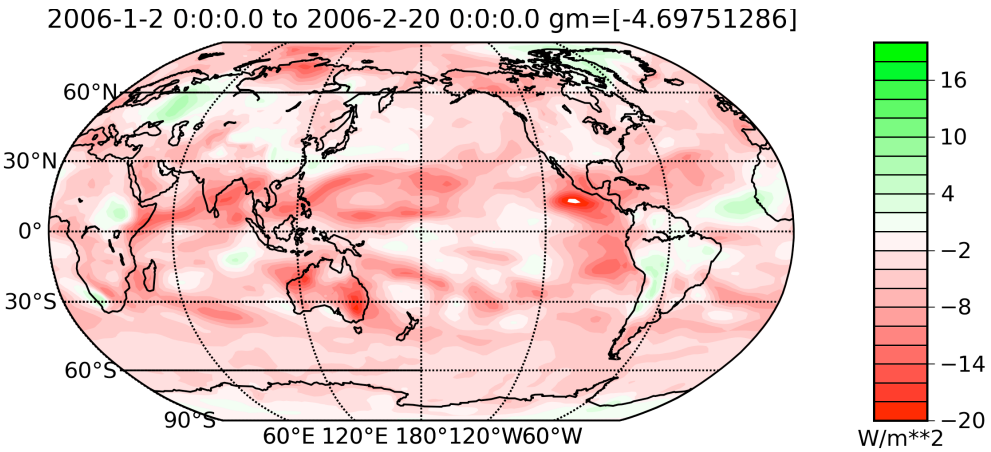


Temperature (K)



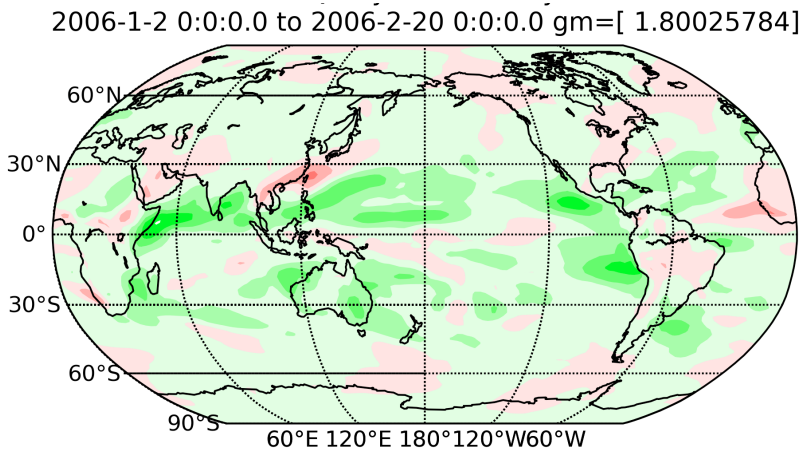
A Map of CAM4's Drift

Clear-sky OLR Drift

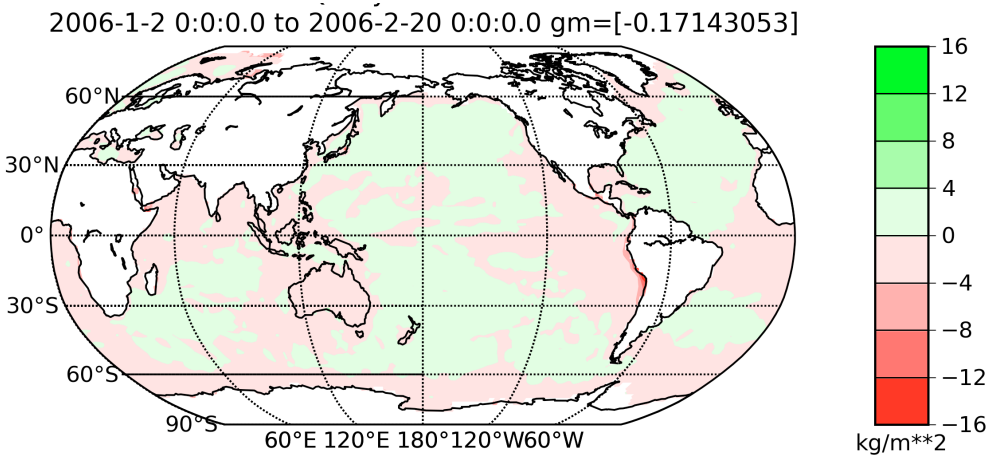


- *Clear-sky longwave drifts are largest in the winter hemisphere of the tropics and co-located with large drifts in column water vapor*
- *ECMWF is slightly dry relative to SSM/I Wentz retrievals, whereas the CAM drift relative to ECMWF is much larger*

Column Water Vapor Drift



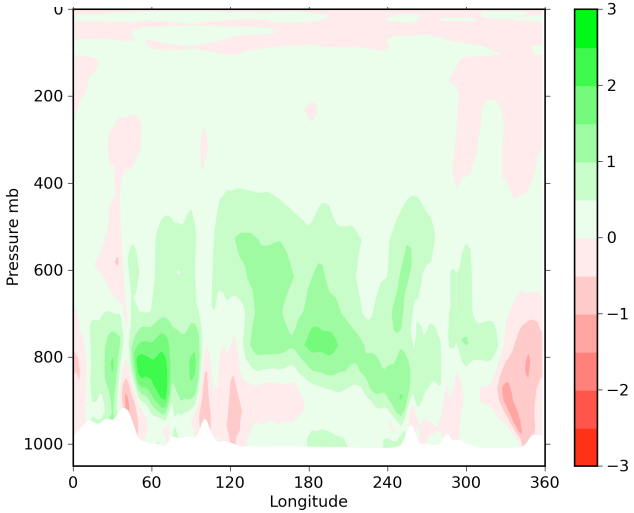
ECMWF Analysis Minus SSM/I



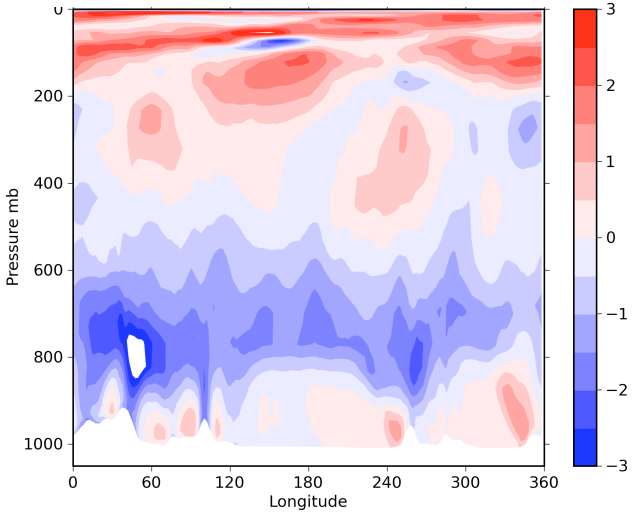
What Causes These Biases?

0-30N Cross-section

Q Drift (g kg^{-1})



T Drift (K)



- *ARM radiosondes at Darwin partially confirm the vertical structure of these biases (not shown), although Darwin is not the center of action for these biases*

- Temperature and moisture biases are most strong at 800 hPa – too frequent middle-level convection?
- Interactions between shallow and deep convection? Precipitation has large biases in many of these regions
- Shallow convection implicated from S.E. Pacific drift?

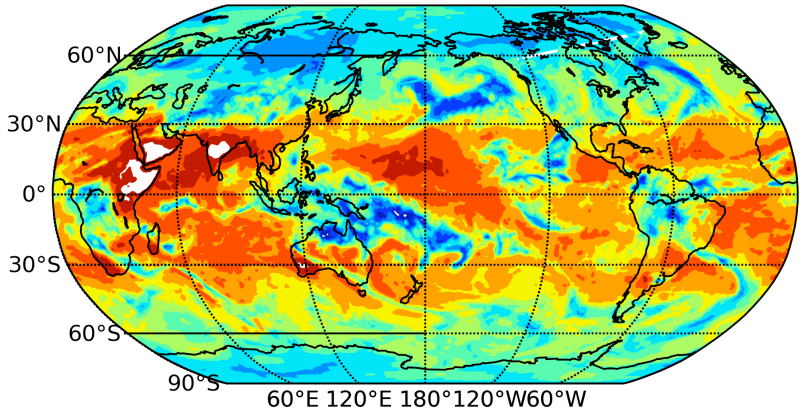
***Question:* Why does CAM4 underestimate the impact of high clouds on outgoing longwave radiation in the extratropics?**

Answer: It appears to result from too low ice cloud fractions in the extratropics.

Possible Causes: A poor ice cloud fraction parameterization?

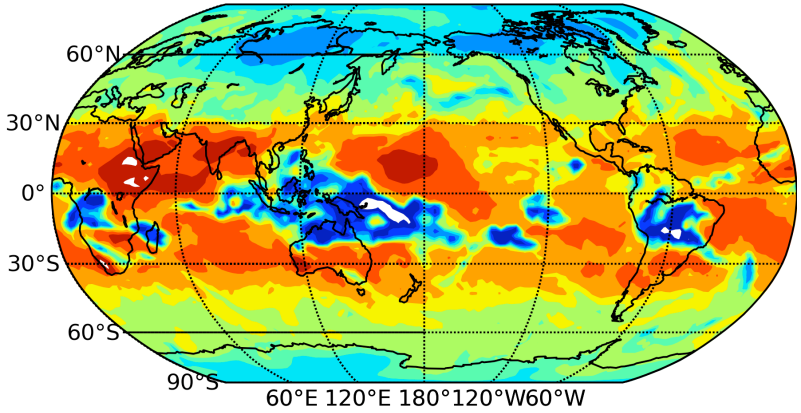
OLR Snapshot: 12Z, January 27, 2006

CERES

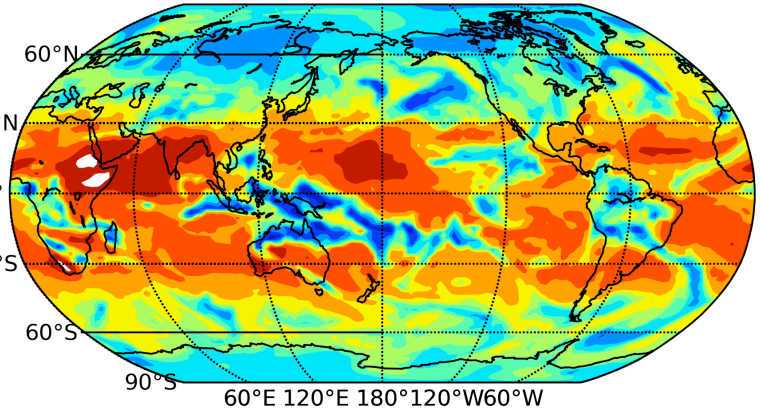


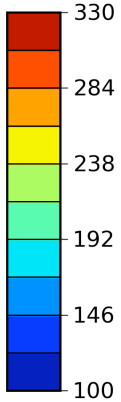
- *A sixty-hour CAM forecast does a reasonable job positioning midlatitude and even some tropical systems*
- *CAM4's midlatitude systems lack a strong OLR signature*
- *CAM4's tropical systems have a bit too strong OLR signature*

CAM4



CAM3.6

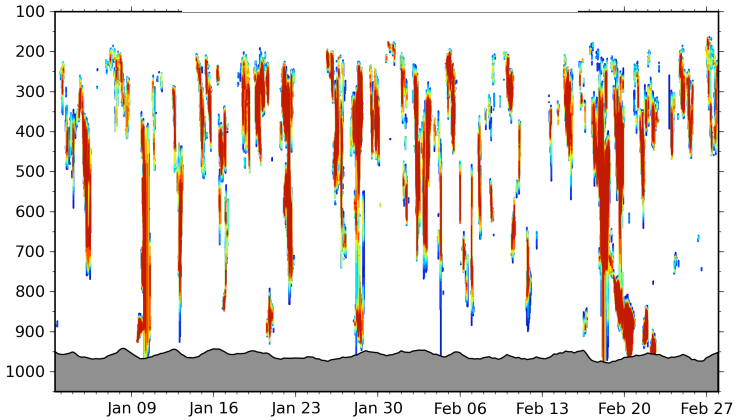




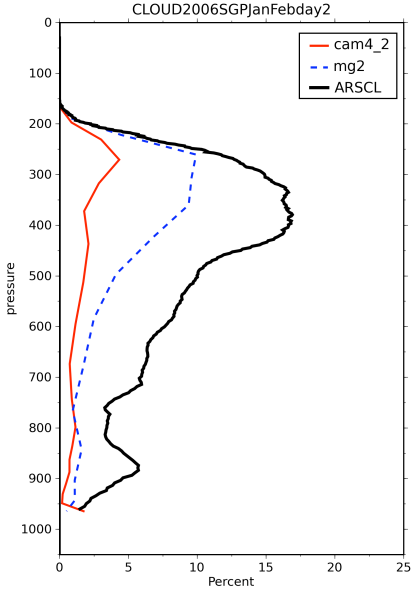
W m^{-2}

Cloud Fraction Profile at SGP

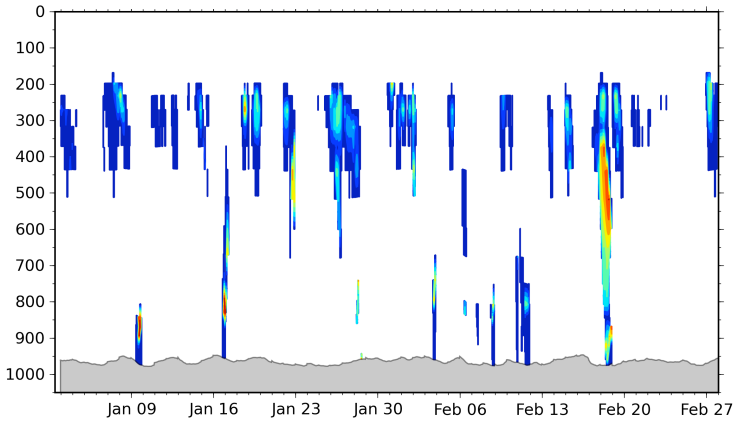
ARM



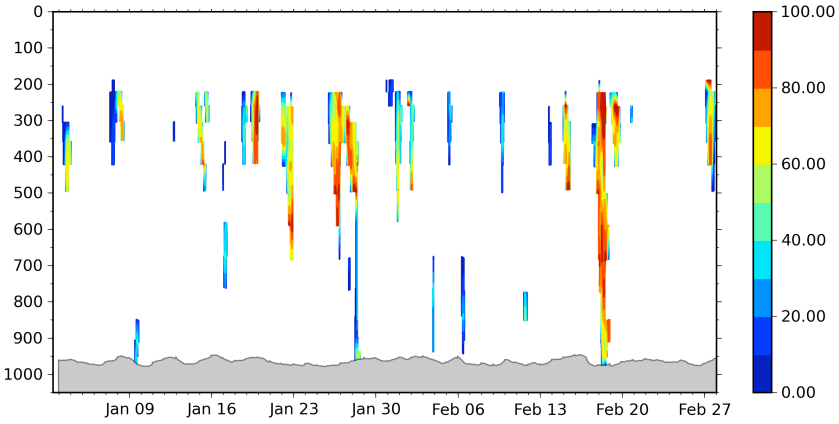
- *CAM4 underestimates strongly high cloud fraction and has much less cloud than CAM3.6*
- *Ice water content changes appear to be secondary*



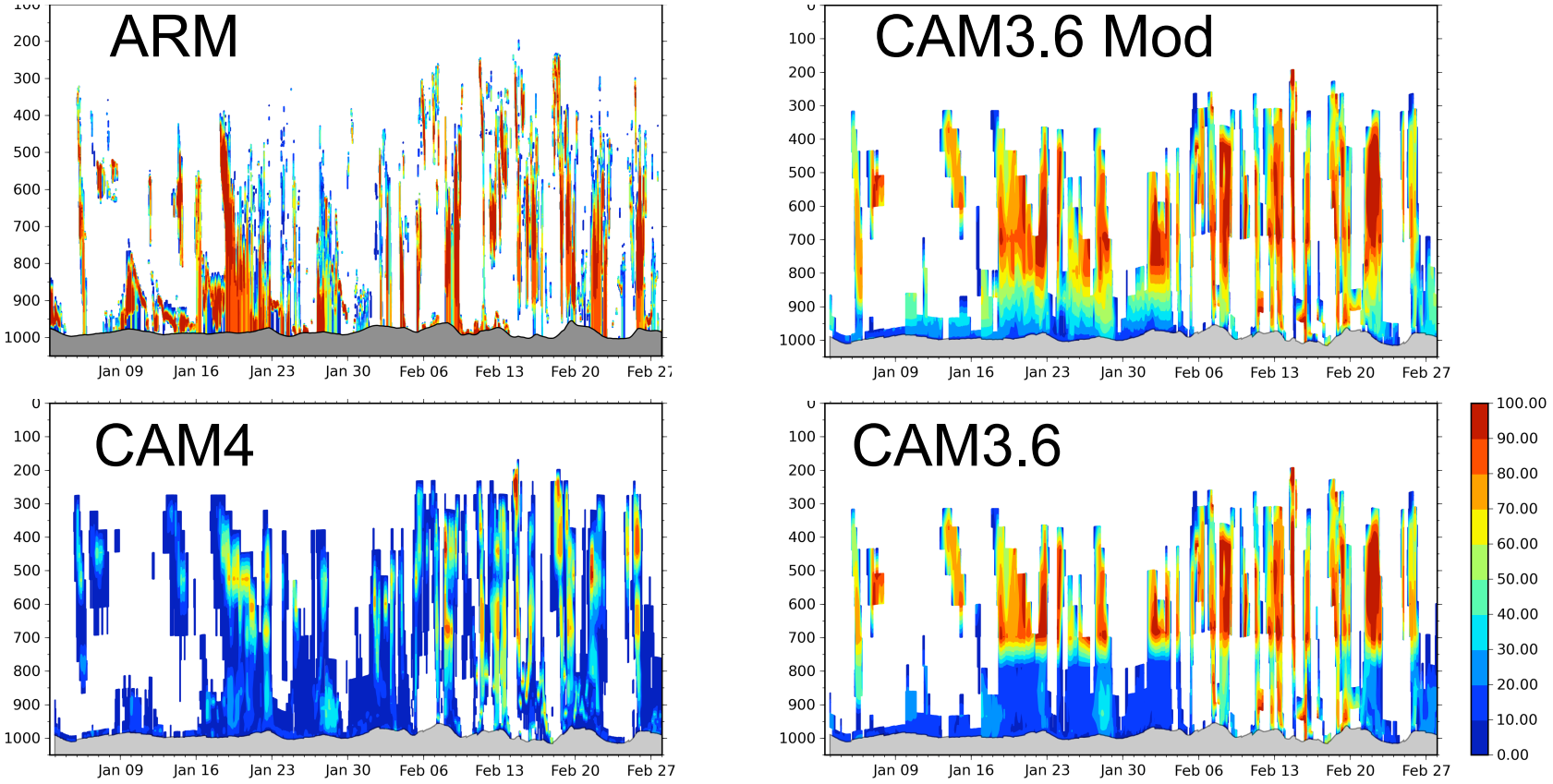
CAM4



CAM3.6

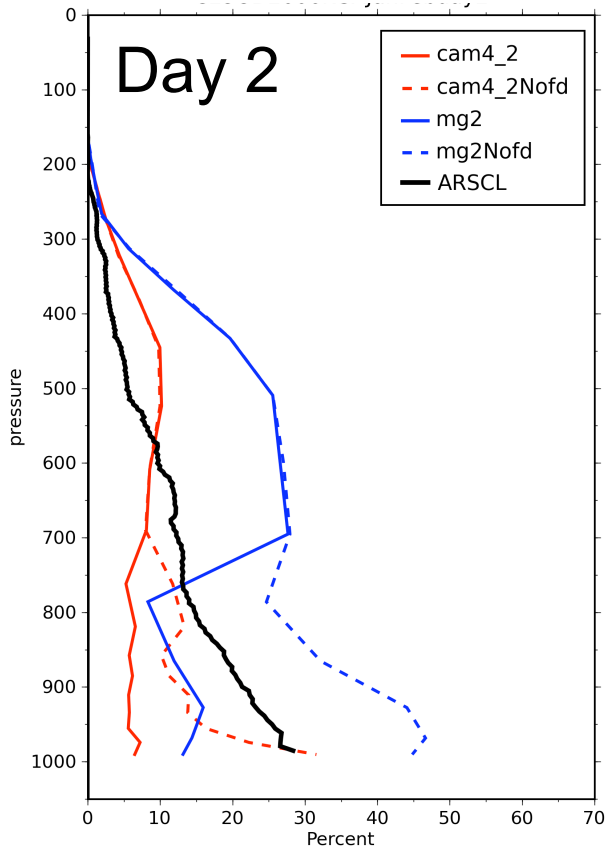


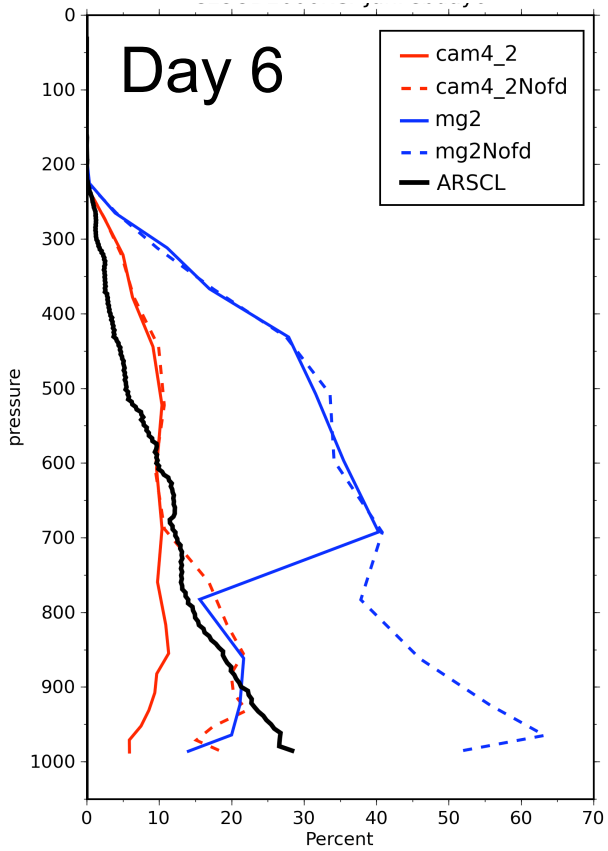
Cloud Fraction Profile at Barrow



- *CAM4 underestimates high and low cloud fractions*
- *CAM3.6 has an artificial break at 750 hPa due to 'freeze-dry' which can be made to appear less artificial*
- *Freeze dry compensates for the lack of clear-sky occurrences*

Cloud Fraction Drift at Barrow





- *CAM3.6 overestimates clouds at high levels and has a larger drift than CAM4*
- *Freeze-dry plays a more important role in CAM3.6 but in both models reduces a drift towards increased low-level clouds*

Summary

- Clear-sky longwave biases appear to be due to drifts in temperature and water vapor and not the fault of the radiation code
- Underestimates in longwave cloud forcing do result from both too small clear-sky fluxes and too large cloudy-sky fluxes
- The lack of extratropical longwave cloud forcing is partially due to underestimates in the area of high clouds