CAM 4 Update

Phil Rasch

- CAM3.5, almost done
  - Inclusion of new aerosol distributions
  - Tuning for 1870.
  - Hindcast to see transient simulation character
  - First hints at climate sensitivity!
- The parameterizations that are in CAM3.5 may not be in CAM4!
- Post CAM3.5 already developing very rapidly

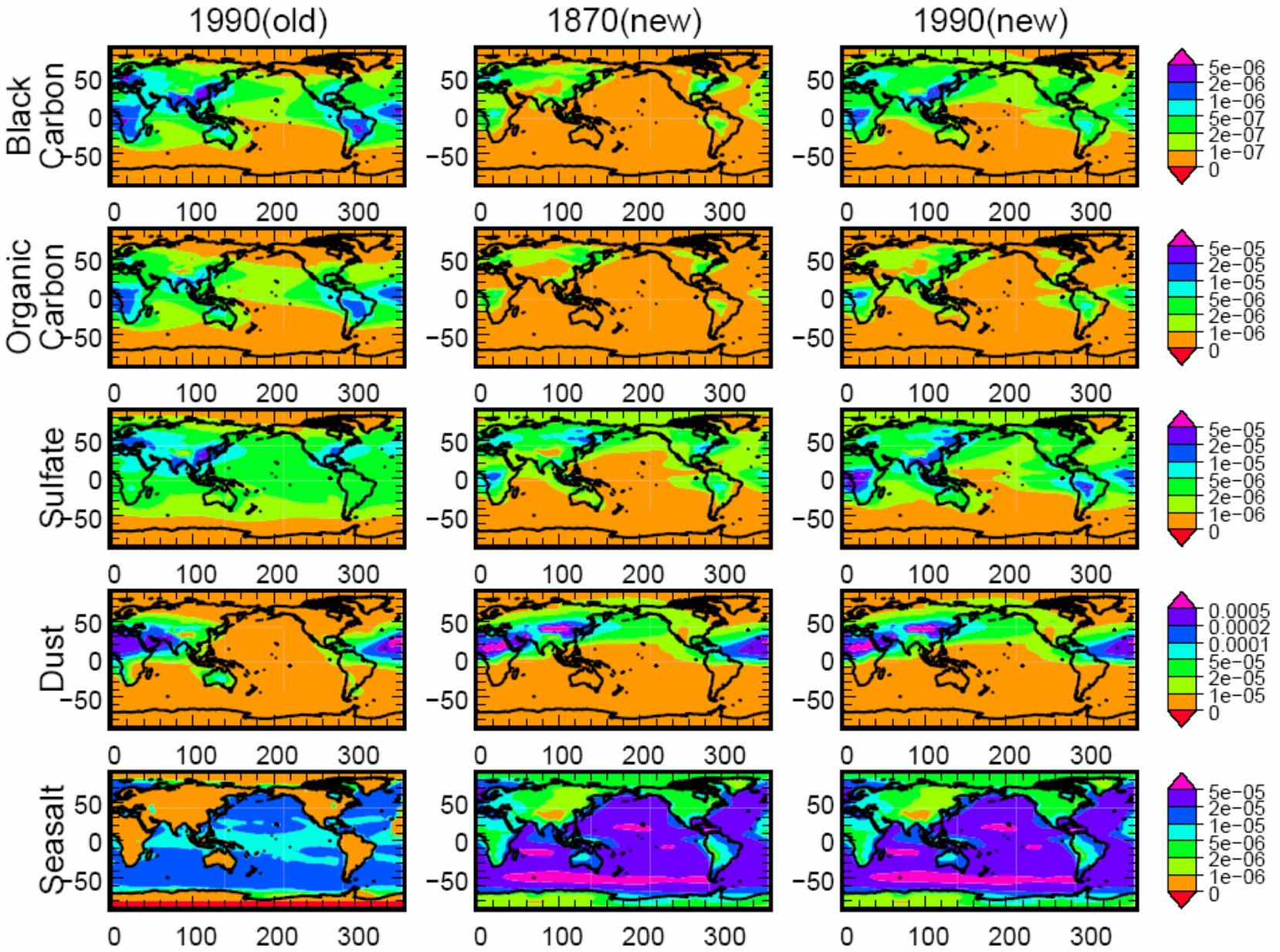
Outline of presentation

- Part 1: Briefing on
  - revisions that are "almost ready"
  - advances that are a bit less certain but still likely
  - A mention of things in which progress is "murky"
- Part 2: A mention of topics of interest to AMWG
  - Peter Hess
  - Andrew Gettelman
  - Jim Hack

Parameterizations that are maturing and ready for group assessment!

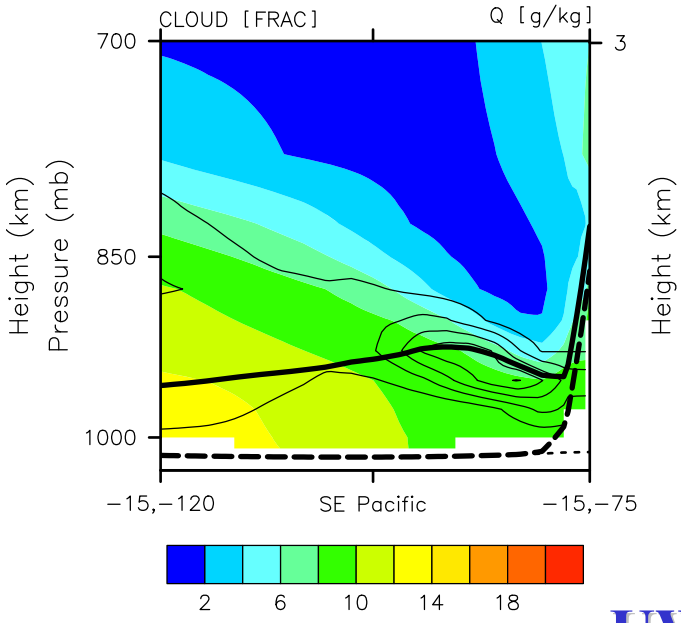
- Aerosol formulation: (in collaboration with Chem/Climate WG)
  - merger of CGD & ACD bulk aerosol formulation (these aerosols will be used for transient simulations with CCSM3.5). This is an interim solution, pending successful integration of PNNL codes (Liu/Ghan hope for first implementation in 4-8 weeks)!
  - Complete the integration with new microphysics & Ghan droplet activation
- Formal Assessment of UW PBL and Shallow convection schemes
- Formal Assessment of Morrison/Gettelman microphysics
- Formal Assessment of gravity wave and orographic wave breaking formulations
- Formal Assessment of Hybrid Isentropic coordinates

New Aerosols
(Hess, Rasch, Mahowald, Barth, Bond, Bundy, Vitt)



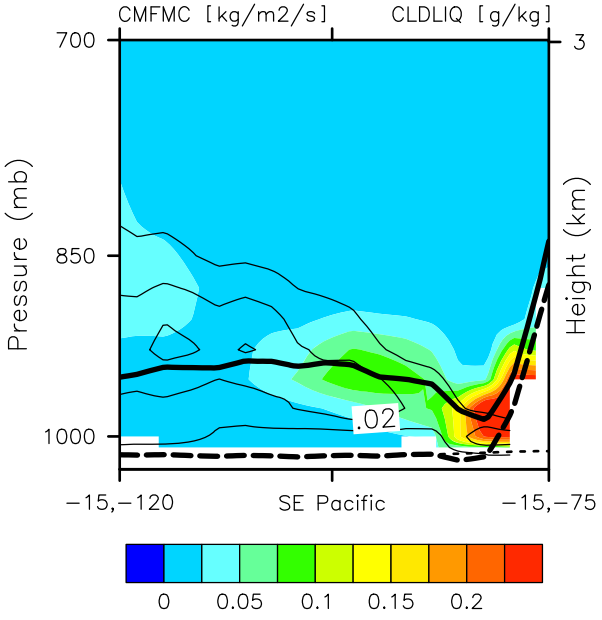
UW PBL and Shallow Convection (Bretherton & Park)

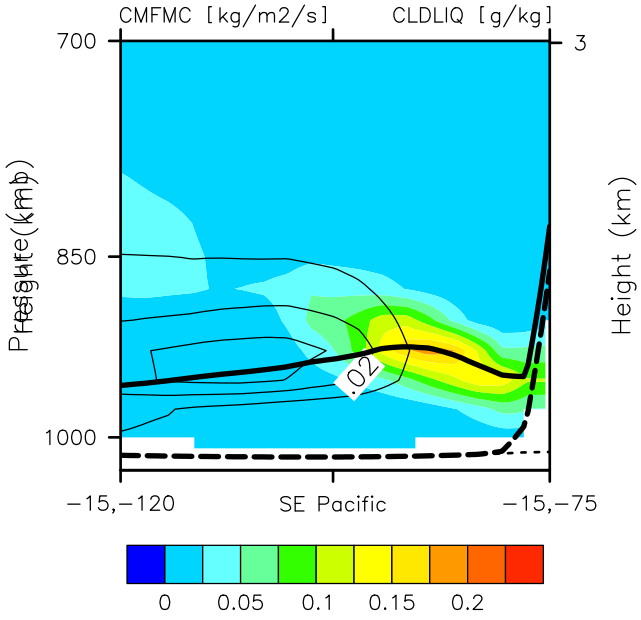
- New physics
- More realistic
- Remove previous parameterizations dependence on vertical resolution



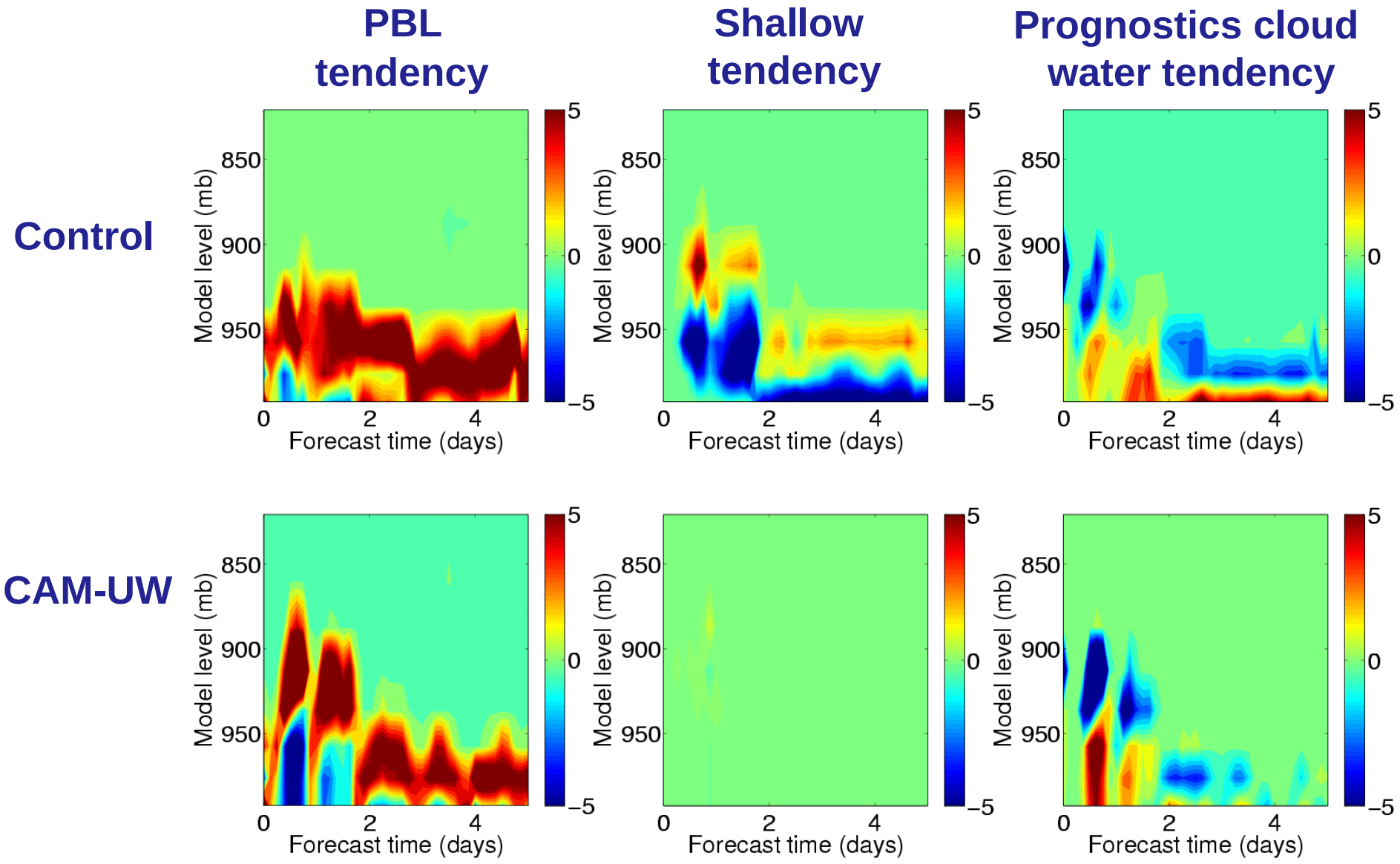
Control

UW

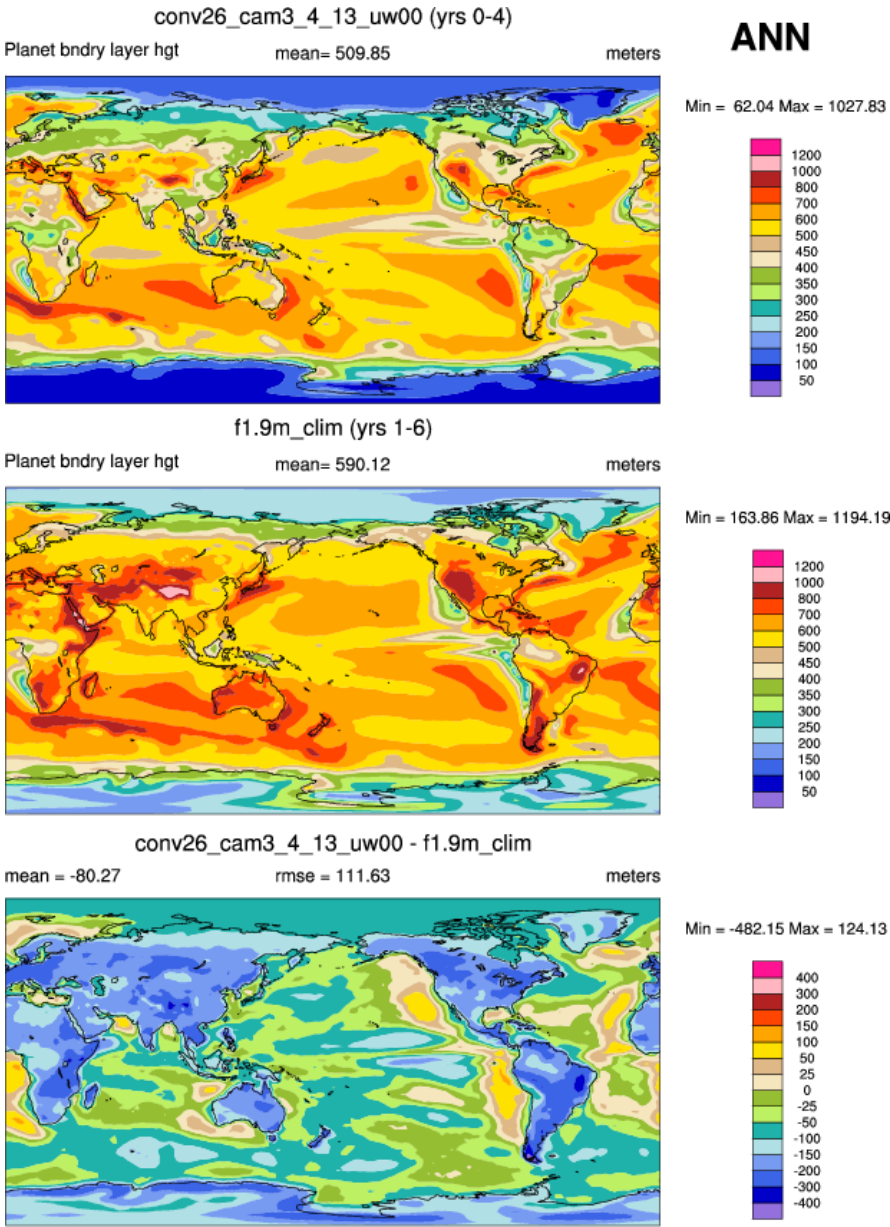




Stratocumulus regime (Physics terms)

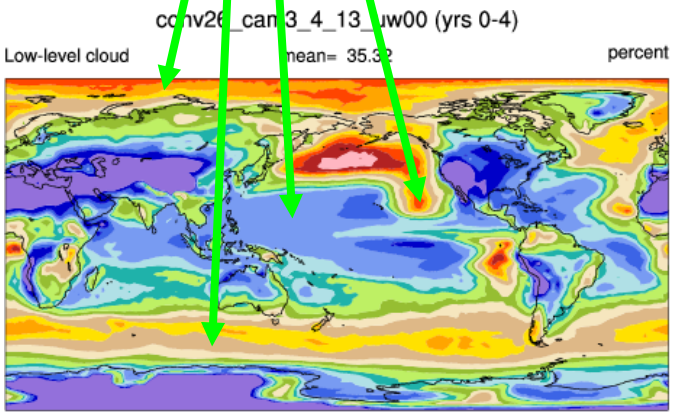


UW Parameterization
PBL Height Change



Notice these features!

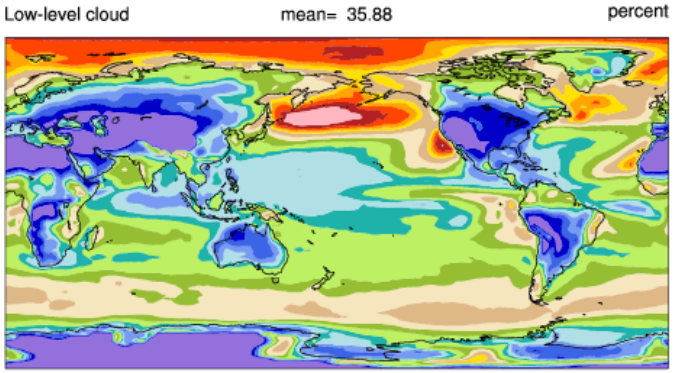
UW Parameterization
Low Cloud Fraction



JJA

Min = 0.00 Max = 93.25

95 90 85 80 75 70 60 50 40 30 25 20 15 10 5



Min = 0.00 Max = 94.54

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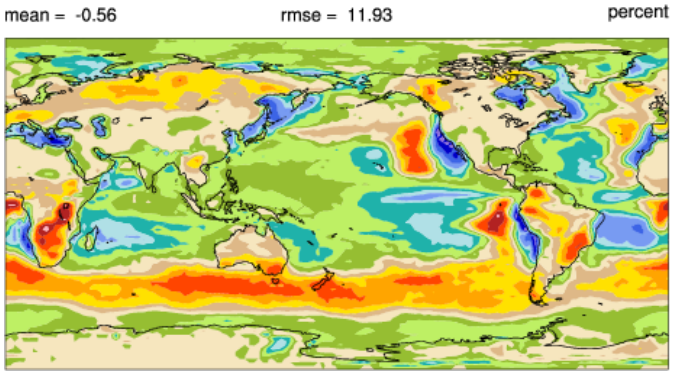
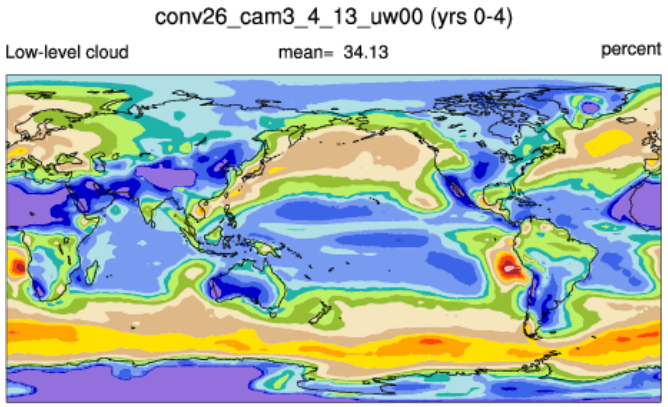


Min = -71.09 Max = 45.03

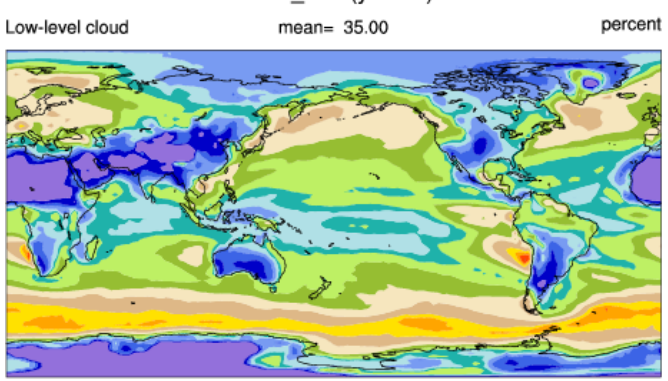
50 40 30 20 15 10 5 0 -5 -10 -15 -20 -30 -40 -50



DJF

Min = 0.00 Max = 91.56

95 90 85 80 75 70 60 50 40 30 25 20 15 10 5



Min = 0.00 Max = 85.69

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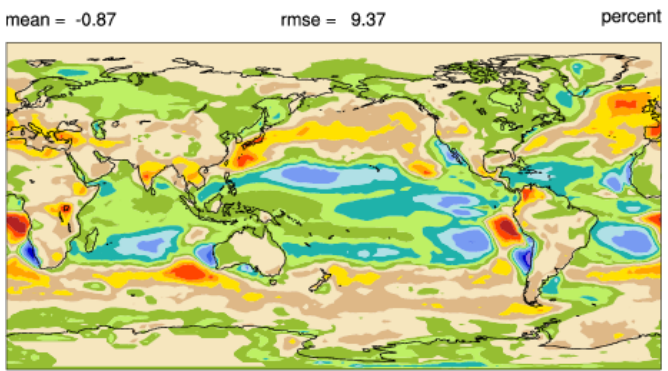
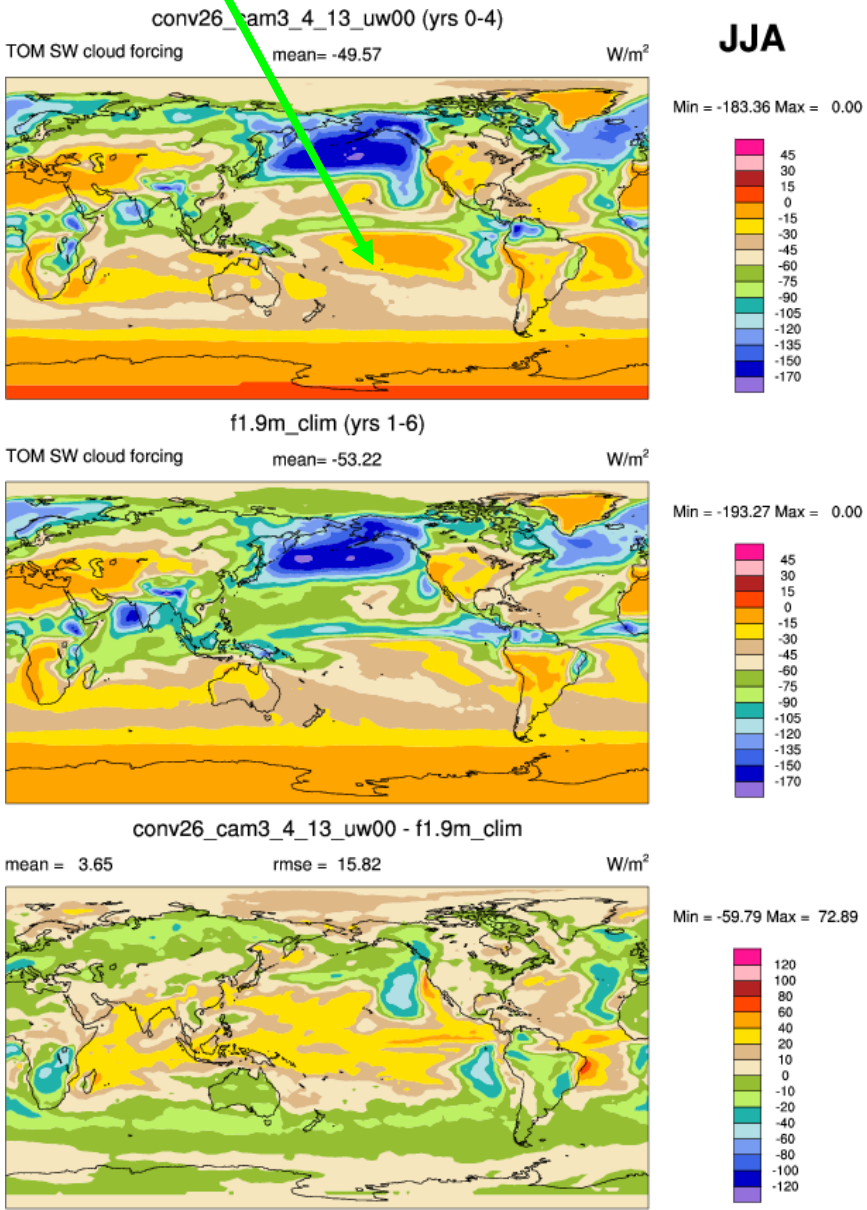


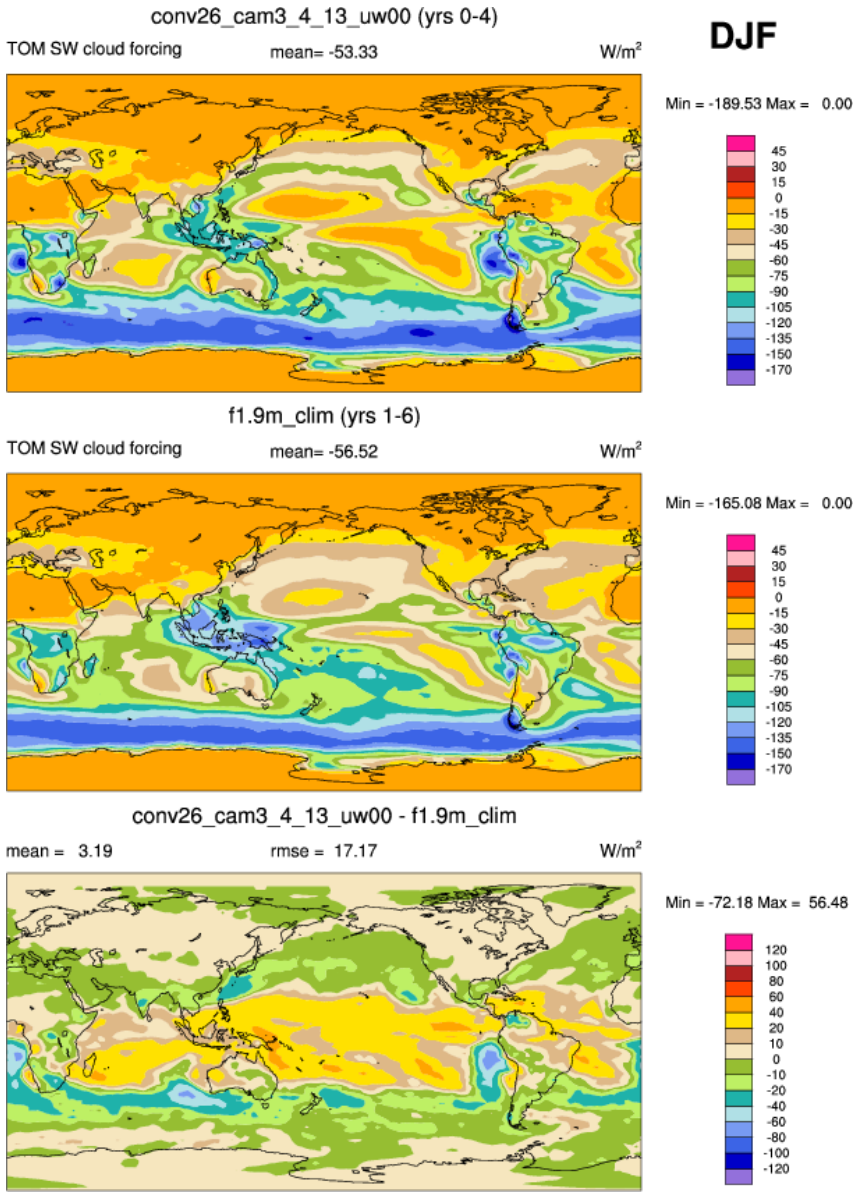
Min = -61.33 Max = 39.09

50 40 30 20 15 10 5 0 -5 -10 -15 -20 -30 -40 -50

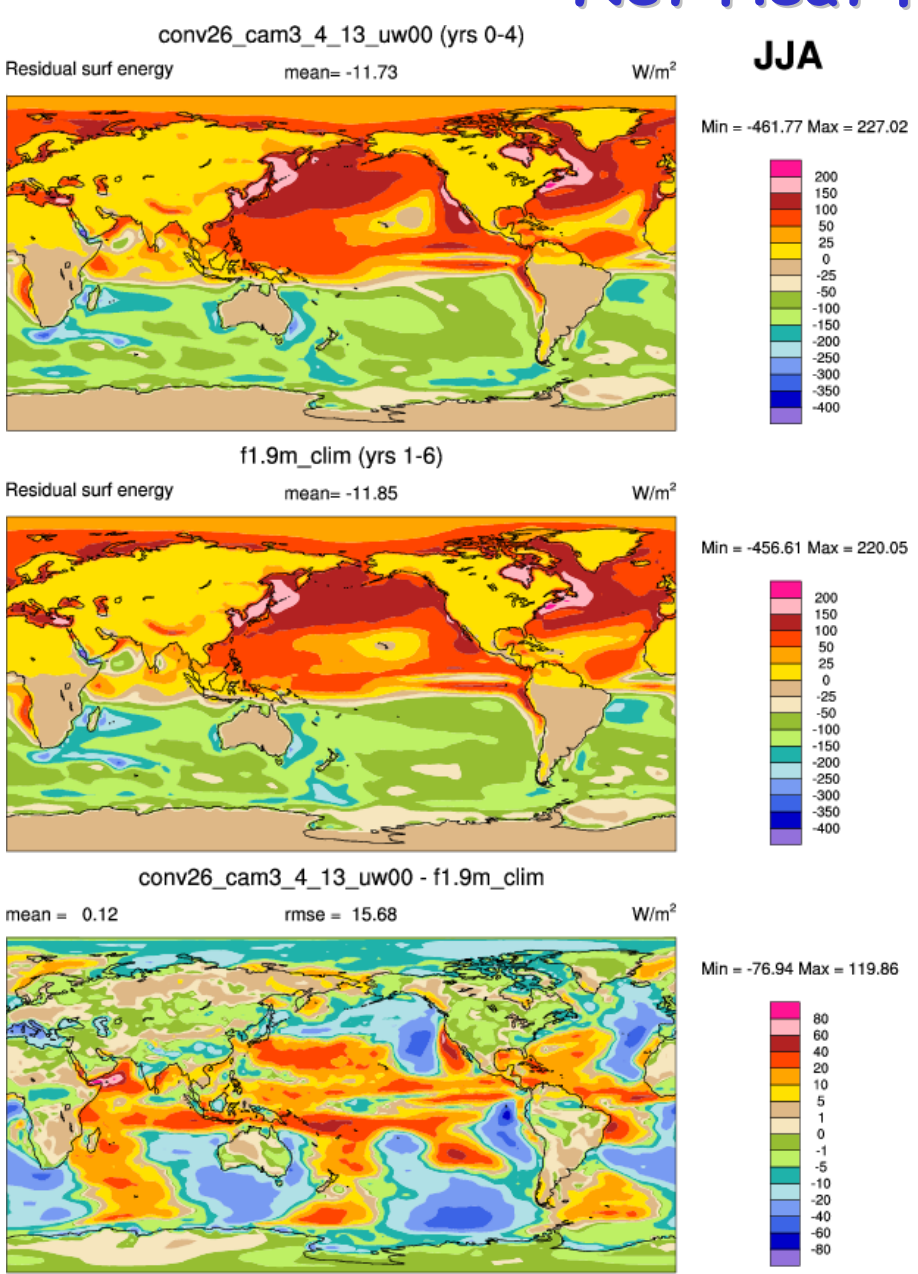
Notice these features!

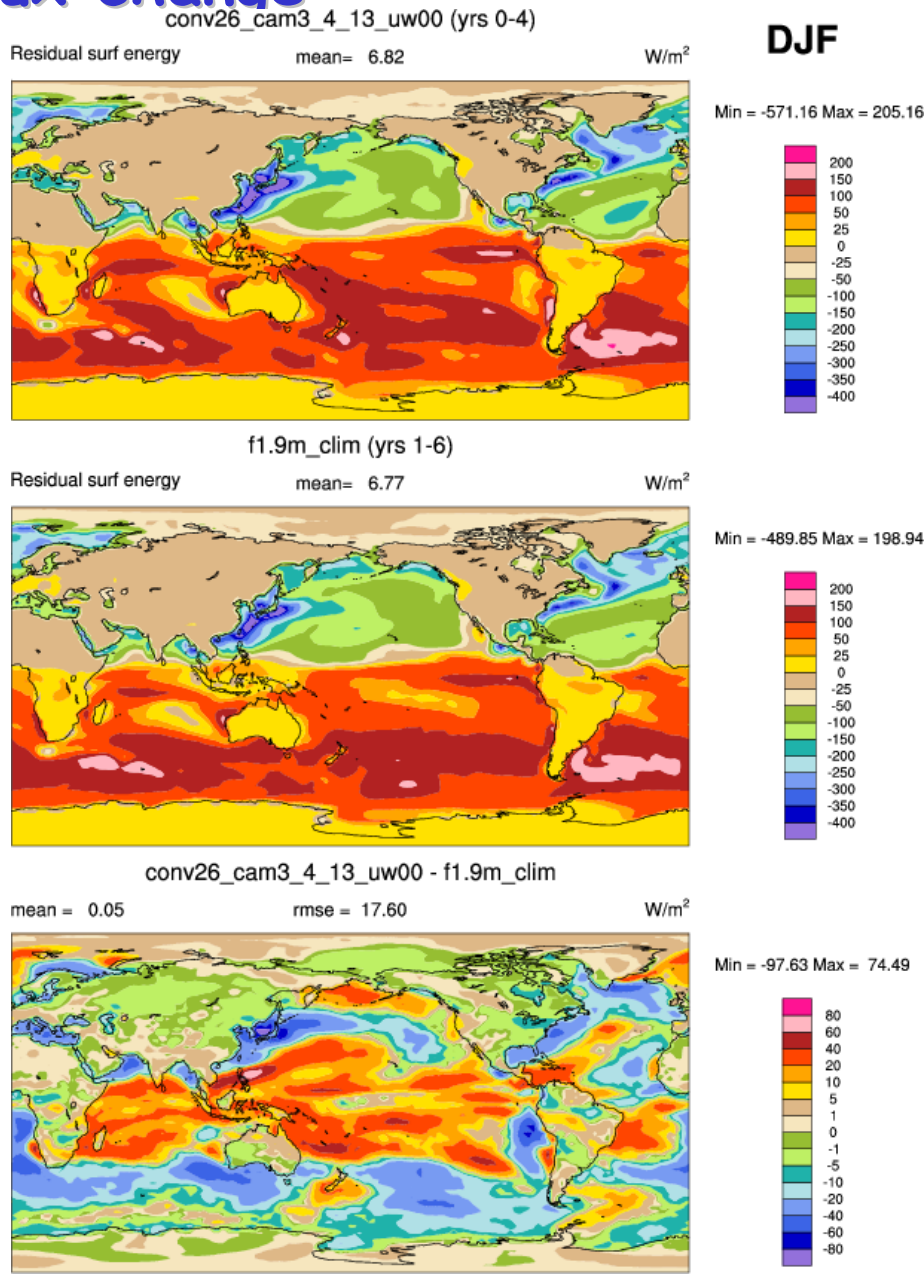
UW Parameterization
Shortwave Cloud Forcing Change



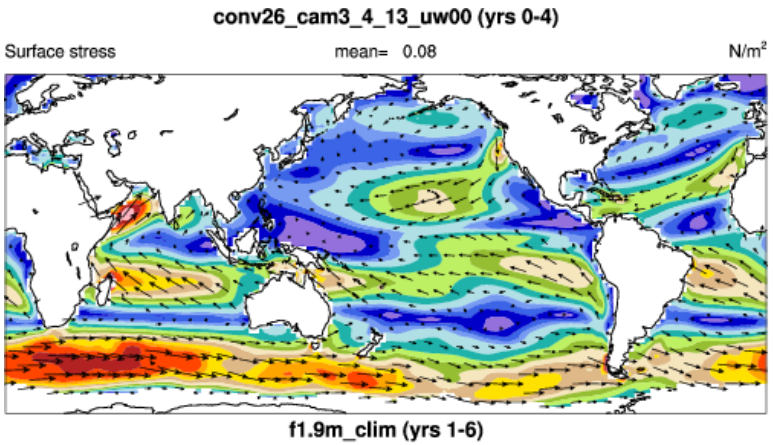


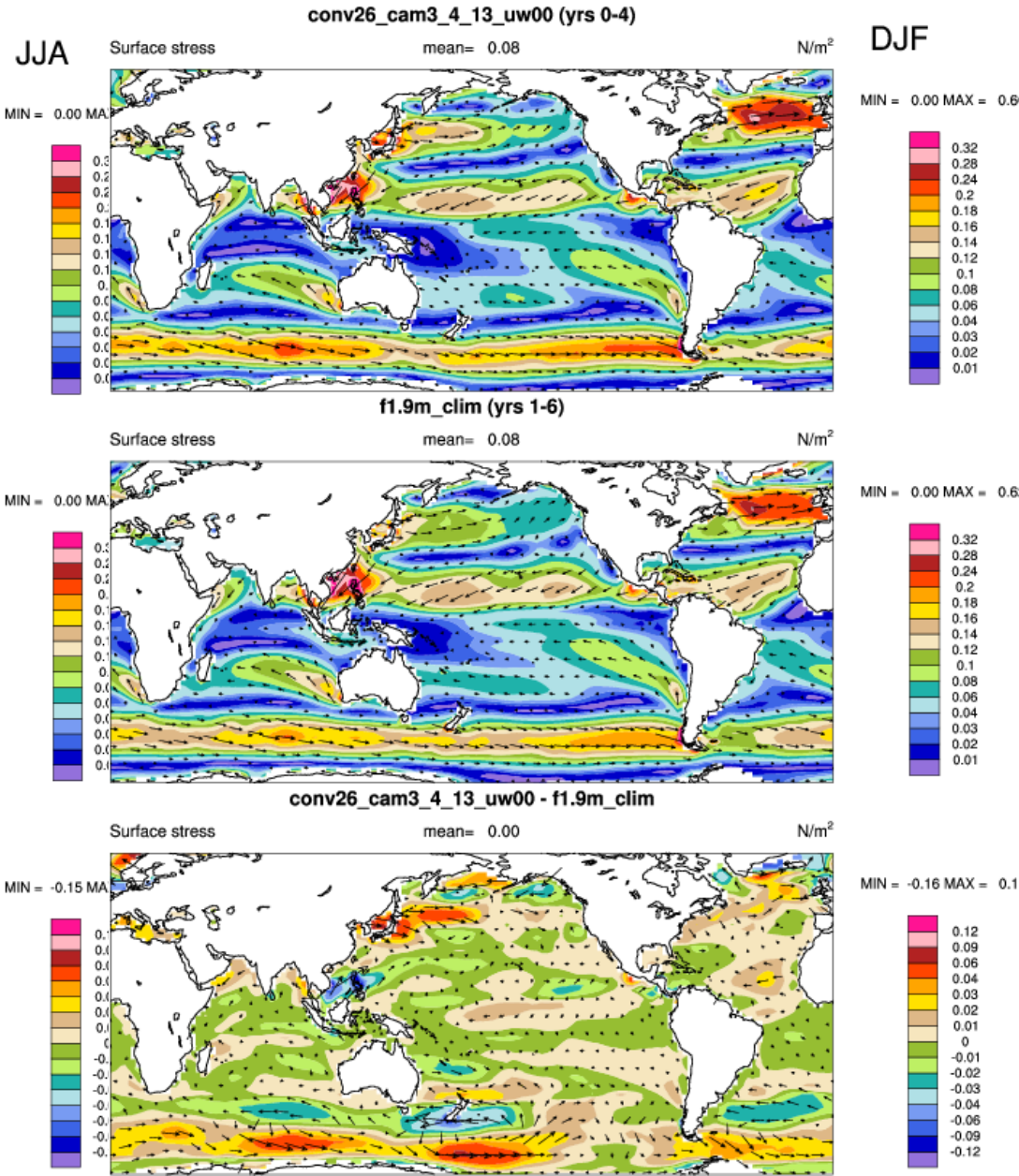
UW Parameterization
Net Heat Flux change



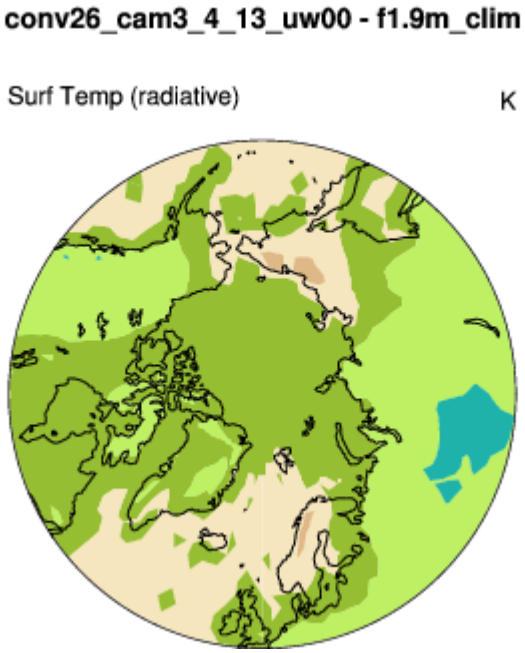


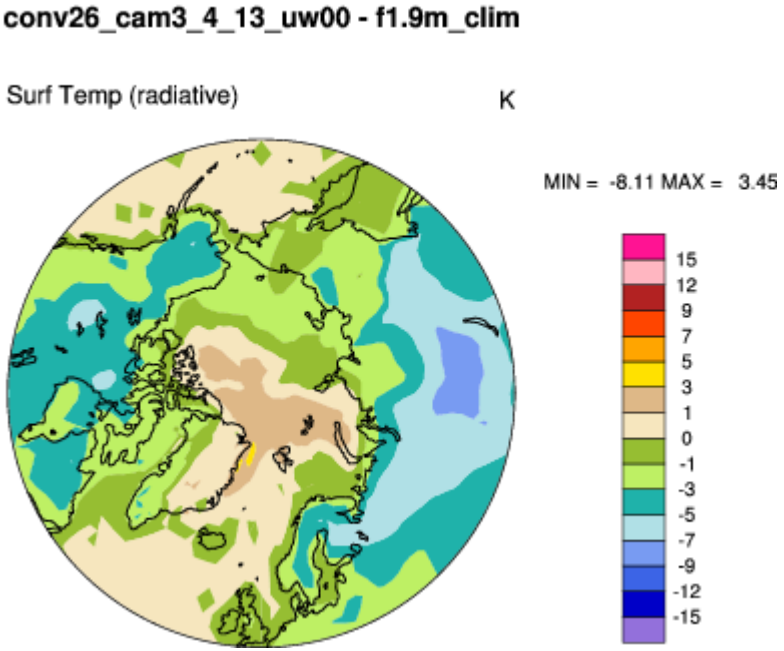
UW Parameterization
Surface Stress





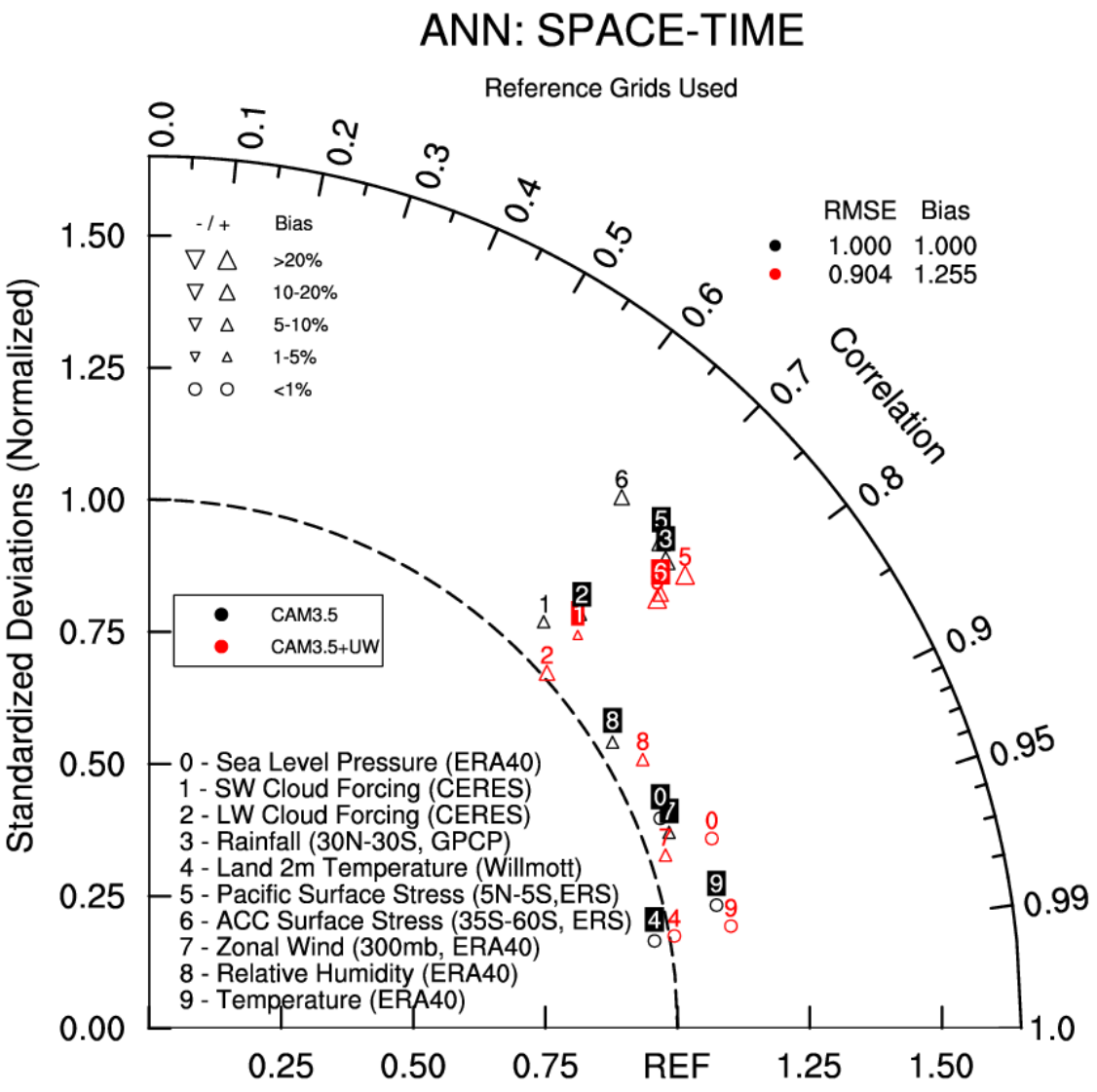
UW Parameterization
Surface Temperature Change





Taylor Diagram new model vs CAM3.5

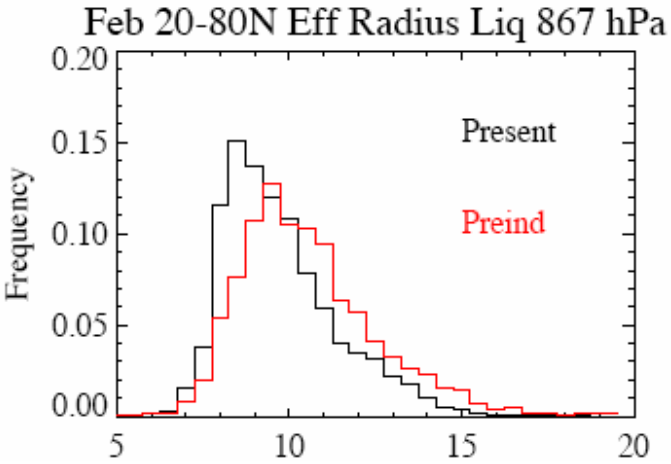
- Perhaps one more minor tuning then time for a coupled run!
- (Feedback from CCSM community)
- Further improvements at least within the PBL scheme are likely during the summer!
  - Svensson, Holtslog,

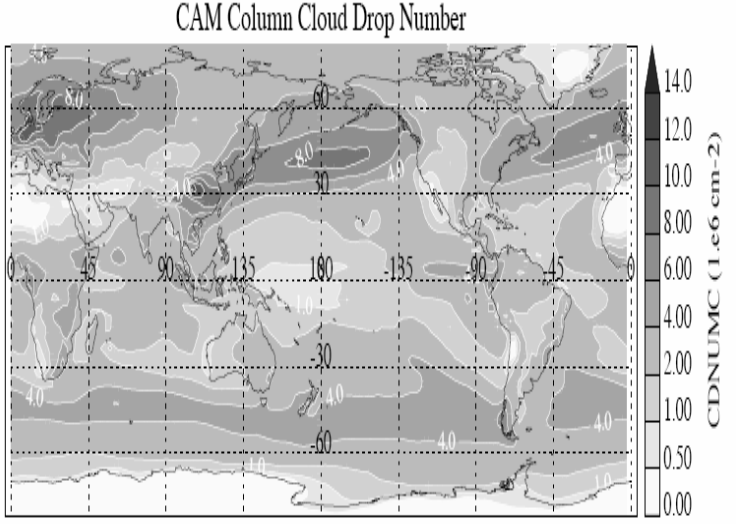


New microphysics (Morrison, Gettelman, Ghan)

- predicts drop number
  - with cloud drop activation provides (indirect effect)
  - Capability for indirect effect is a blessing and curse!
- modern representation of microphysics
  - Including mixed phase processes
- More realistic

Indirect effects of aerosols in CAM: PDF of N. Hemisphere (20-80N) Effective Radius of Liquid Cloud Drops for Present day and Pre-industrial Aerosol Loading at ~850hPa

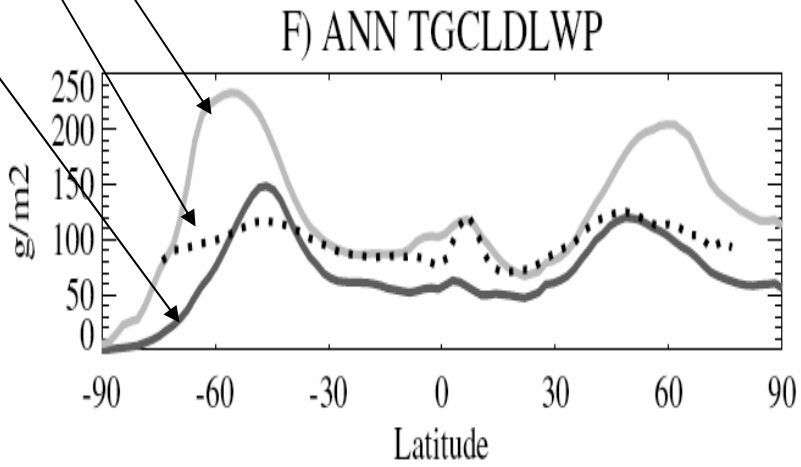




control

retrieval

new



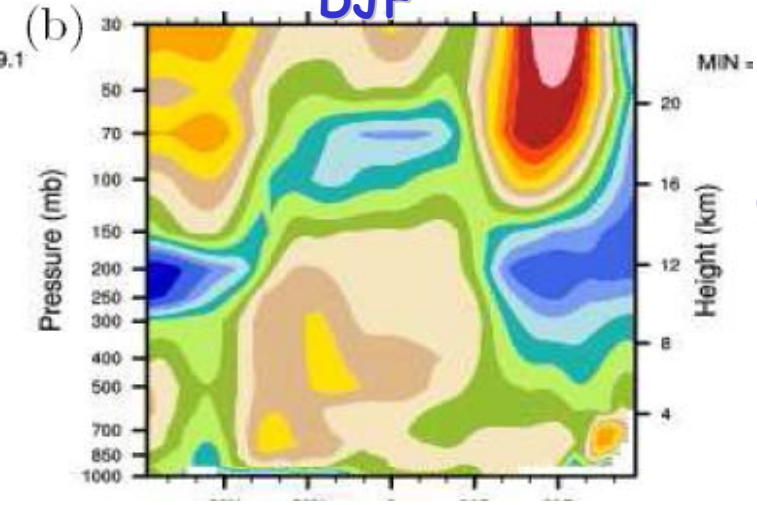
New Hybrid Terrain following/isentropic (Chen & Rasch)

- Removes known computational artifacts in sigma coordinate models
- Significant reduction in a systematic bias present in 22 of 23 models in IPCC AR4

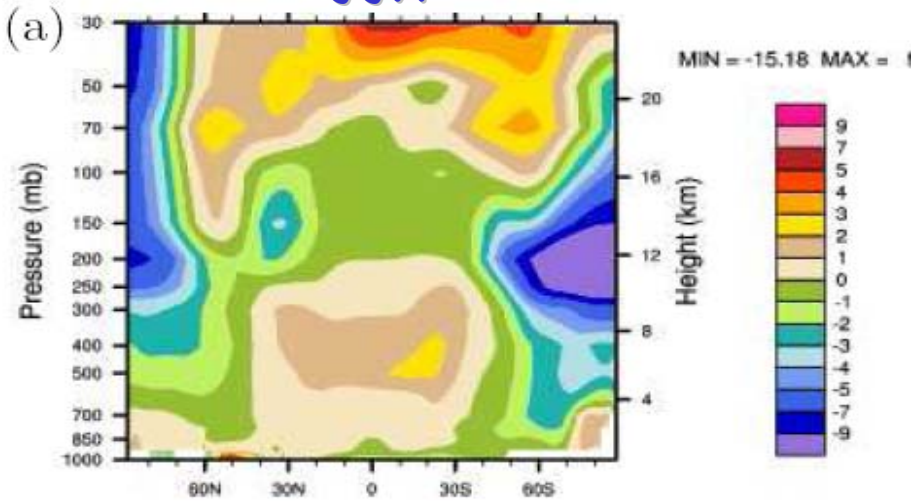
Zonal average temperature

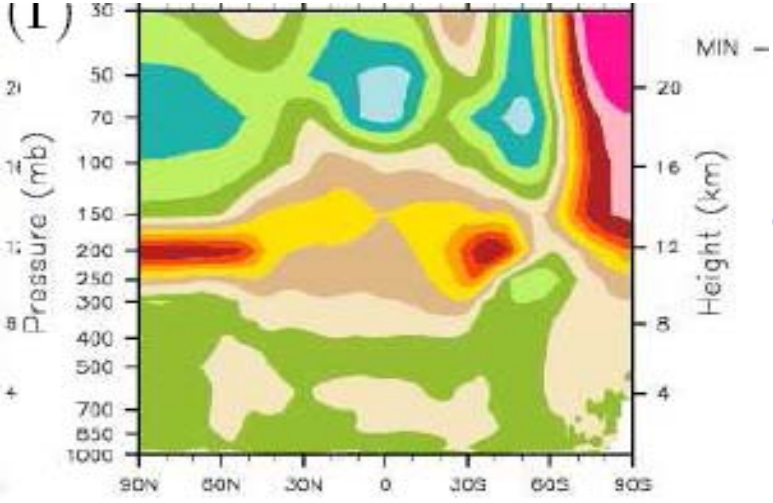
DJF

JJA

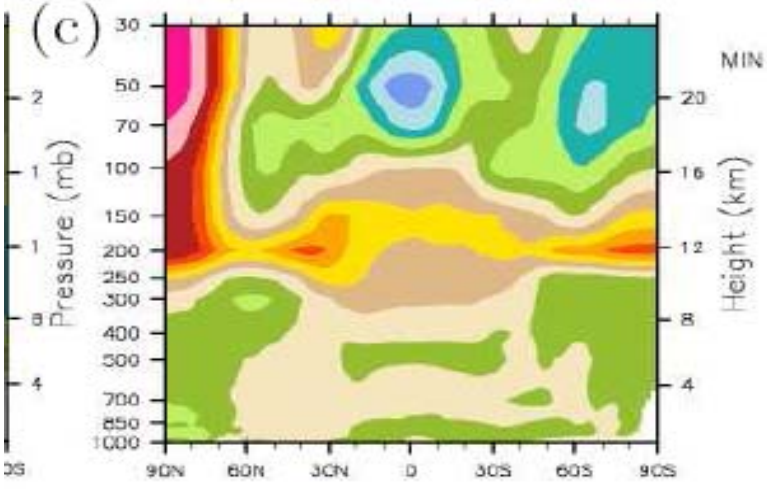


Diff Control Vs ERA



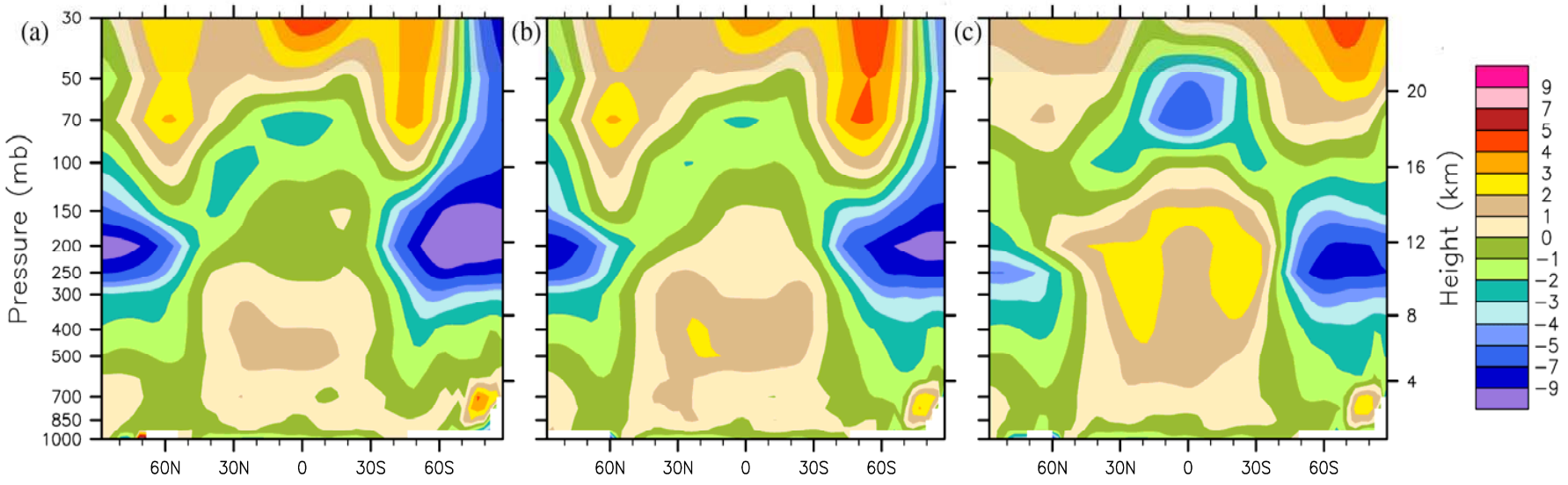


Diff New Model Vs Control



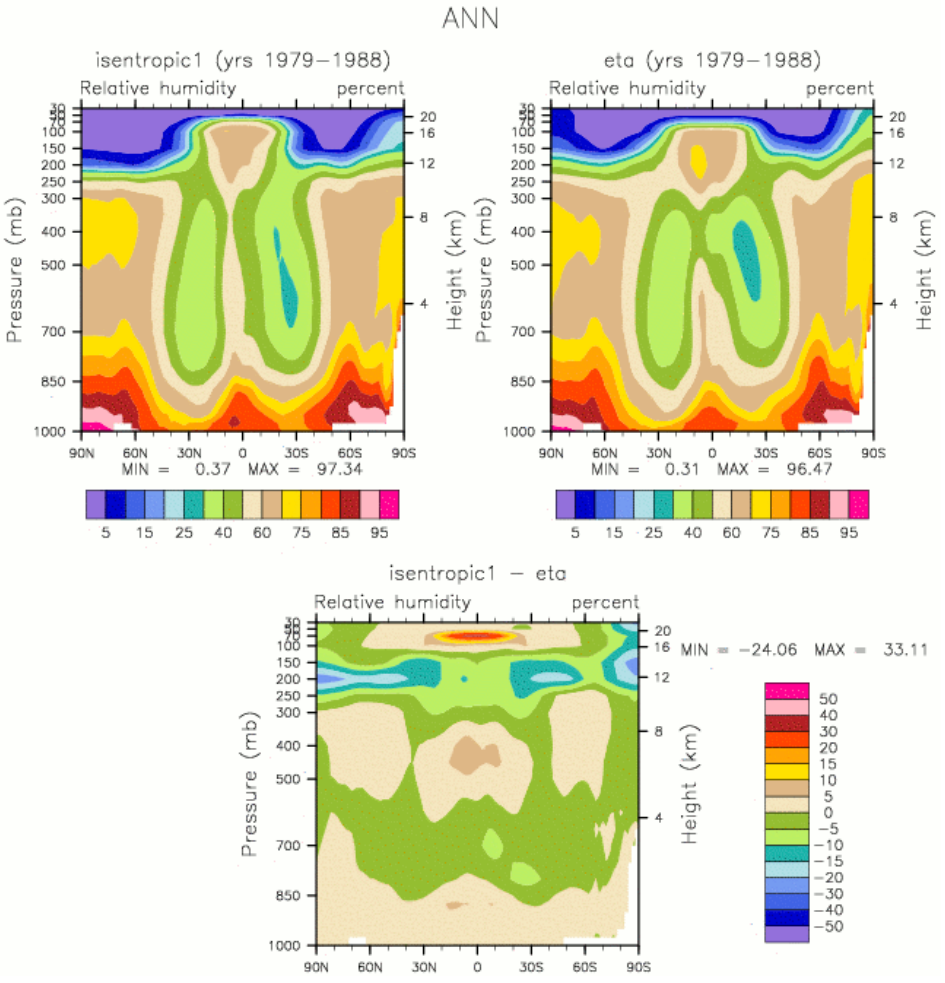
Ann Avg Temperature diff vs ERA15

T42-ERA FV-ERA IFV-ERA



Hybrid Isentropic formulation

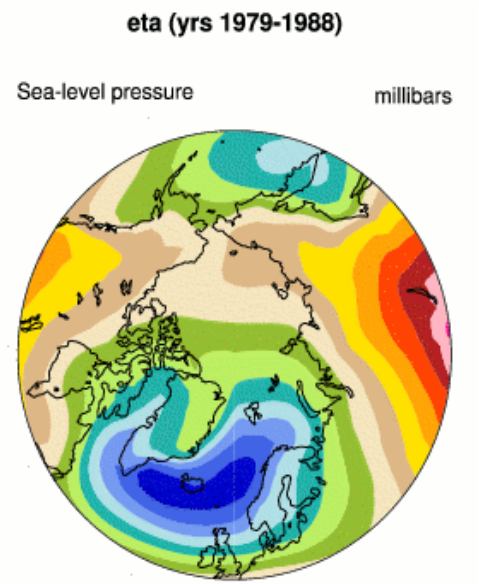
- Reduces other problems as well
  - Reduce Water vapor in UTLS
  - Increase it in middle troposphere (less mixing)
  - Clouds
  - Transport in UTLS region
  - Surface Pressure patterns (see next slide)



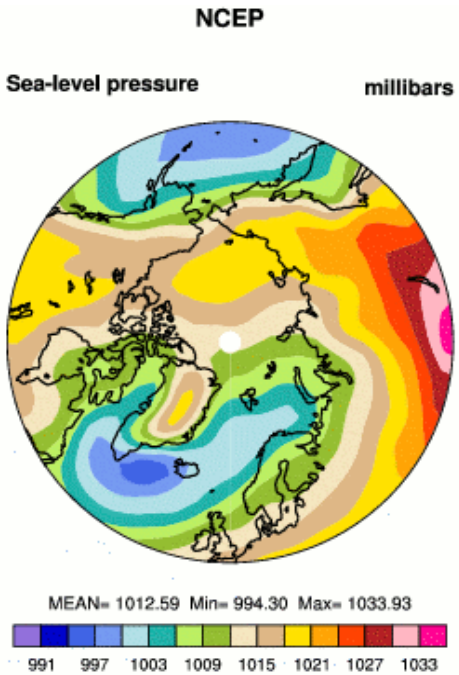
Isentropic Coords (continued)

- Substantial changes to
  - Surface pressure biases
  - Stationary waves
  - Zonal wind

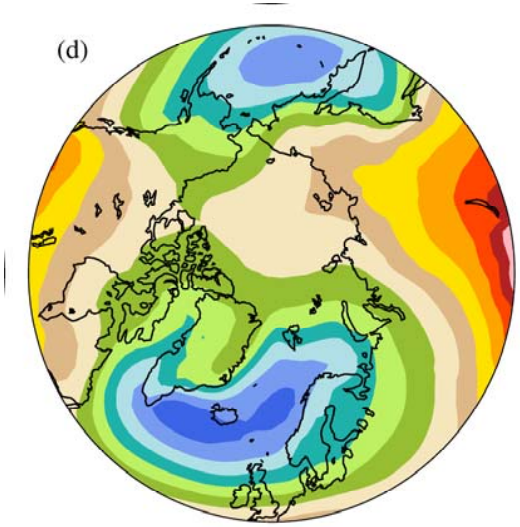
Control



Obs



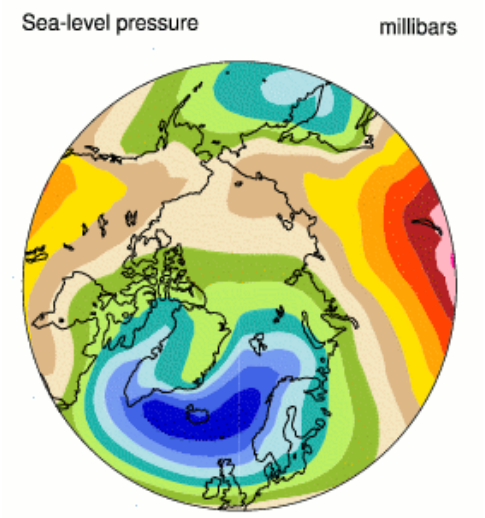
Isentropic model



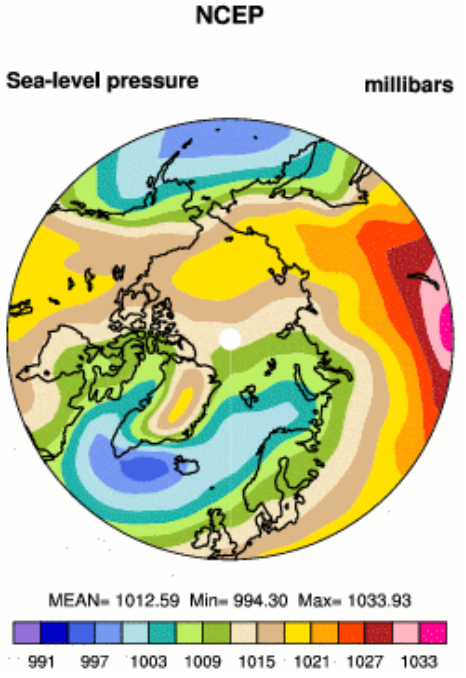
Changes to Mountain drag (Sassi and Boville)

- Substantial changes to
  - Surface pressure biases
  - Stationary waves
  - Zonal wind

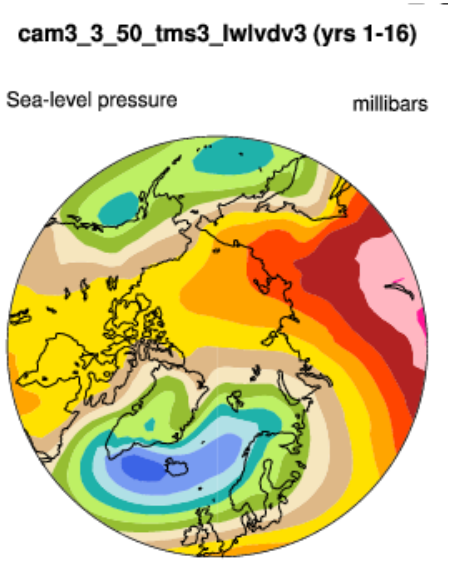
Control



Obs



Mountain Drag



So…..

- How carefully do we tune prior to putting these 5 parameterizations together?
- My vote is to not tune individual stages too carefully! Every "n" steps push model back to real world, and then do a coupled run.

Next Steps

(likely changes, but final outcome uncertain)

- Explore horizontal and vertical resolution sensitivities
- Improved ice, (Morrison, Gettelman, Mitchell, Liu)
- Ghan aerosol formulation desirable, interim aerosol solution (by Rasch, Mahowald, Hess, Barth, Bond) is the backup
- Radiation
  - AER RRTM
  - BUGSrad
  - ??

Next Steps (very uncertain)

- subgridscale water variability -> Cloud Fraction
  - sub-column generator
  - radiation --> heating & photolysis
  - microphysics
- alternate deep convection schemes
  - Bretherton shallow -> Deep
  - More variations on ZM?
  - Emanuel

Summary

- It is very likely that this version of CAM will be have the largest number of changes implemented between one generation and the next of any model since very earliest generation of CCM
- Probably more involvement by the outside community than any previous model.
- Many many changes still remain to be implemented and assessed, but I am very optimistic that this will be a remarkable improvement in our model.