Summary: Prescribed Aerosol

Current Differences between Prescribed Aerosol and Predicted Aerosol Runs

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Prescribed Aerosol

- Model Tag: pmam03_cam5_0_54 + fixed SST + no deposition fluxes to the surface (now being re-examined in CAM5.1.06)
- Two microphysical and radiation calls can be done independently.
  - One with predicted aerosols and the other one with prescribed aerosols.
- Our goal is to produce a very similar climate to the predicted aerosol simulation using prescribed aerosols.
  - Control: Predicted Aerosol are archived (aerosol number and mass)
  - Prescribed run: Read-in archived aerosols, use in radiative transfer calculation and cloud microphysics
  - We preprocess archived aerosol data using the "***time-diddling***" scheme by K. Taylor (just like SST). Thus, the monthly mean values of aerosol mass and number are consistent even after time-interpolation with monthly mean values.

Prescribed Aerosol to Microphysics

- Let "X" be an aerosol property (mass, or number)
- Case 0: $X = X_{ucs}$ Results are not shown here.
- Case 1: $X = X_{cs}*f_{lcloud}+X_{ucs}*(1-f_{lcloud})$
- Case 2: $X = X_{cs}*f_{lcloud}+(X_{ucs}-X_{cs})*(1-f_{lcloud})$
  - X: Final values provided to microphysics
  - X_{cs}: Conditionally sampled aerosol properties *when clouds present* (mass and number)
  - X_{ucs}: Unconditionally archived aerosol properties
  - f_{lcloud}: liquid cloud fraction
  - X_{cs}: $f_{lcloud} > 0.0$
- Case 3: $X = X_{cs}*f_{lcloud}+(X_{ucs}-X_{cs})*(1-f_{lcloud})$
  - Conditionally sampled aerosols depend on liquid cloud fraction we used for sampling.
  - X_{cs}: $f_{lcloud} > 0.1$

Prescribed Aerosol

- Case 0:
  - Our first naive attempt produced too many liquid droplets and larger cloud liquid water path than runs with predicted aerosols.
  - Droplet ~ 24% difference
  - likely due to the time averaged aerosols producing too high drop activation in cloudy environments.

- Cases1 -3 are on our web: http://climate.pnl.gov/sitemap/cam/cam_public/camruns_public.php
  - C01: Case 1
  - C02: Case 2
  - C03: Case 3
  - All the results are 5-year averages.

Difference: Prescribed - Predicted

FSTOM

Case 1	**-2.1W/m^2**
Case 2	0.7W/m^2
Case 3	0.4W/m^2

SWCF

Case 1	**-2.3W/m^2**
Case 2	1.0W/m^2
Case 3	0.5W/m^2

AODVIS

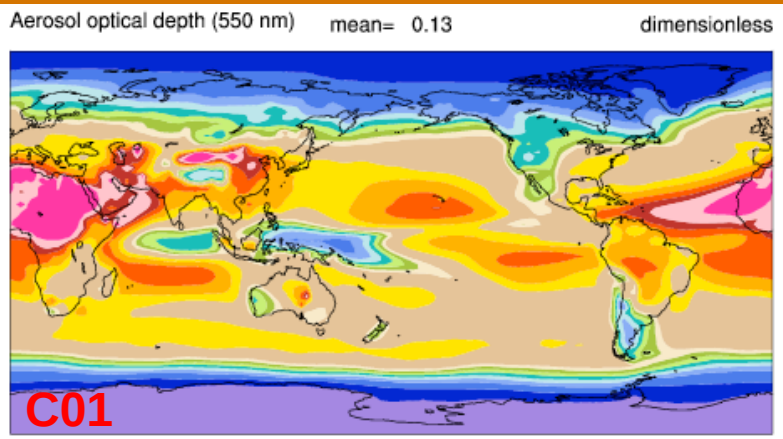
Case 1	**0.005**
Case 2	0.005
Case 3	0.005

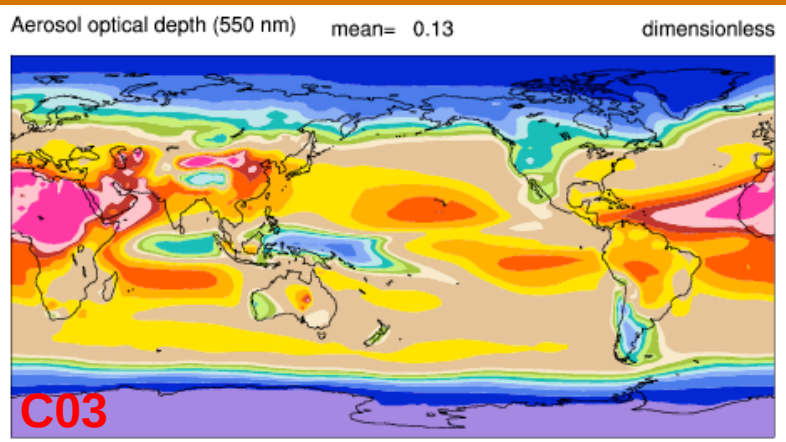
LWCF

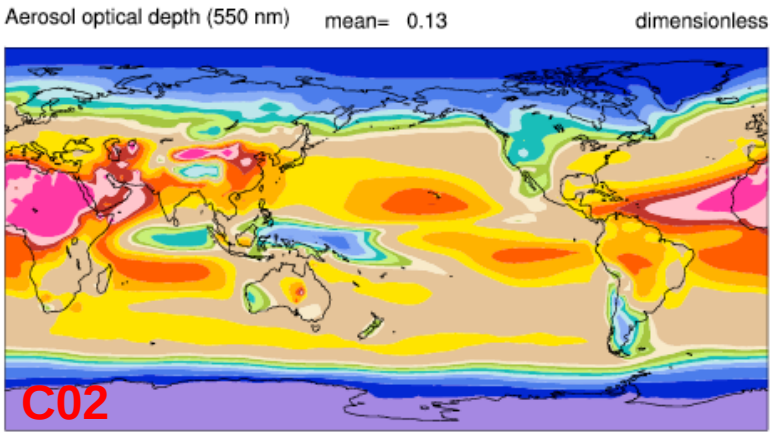
Case 1	**0.3W/m^2**
Case 2	0.2W/m^2
Case 3	0.1W/m^2

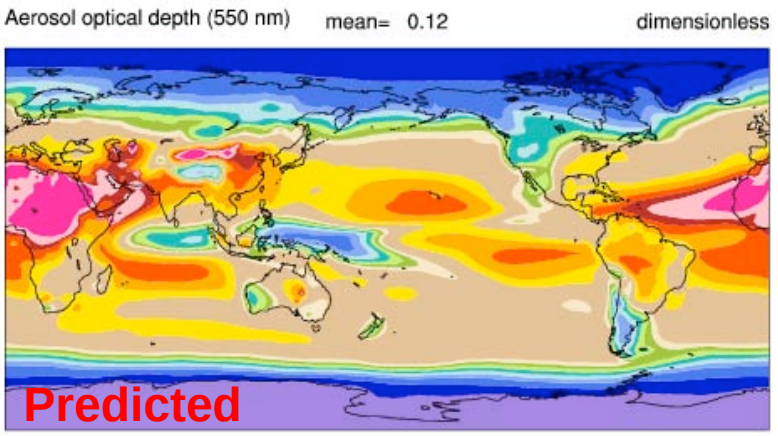
Residual fluxes at the top of the model are mainly caused by cloud not by AOD.

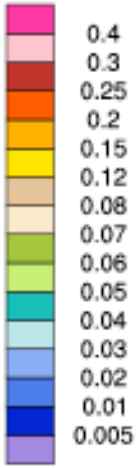
Difference: AODVIS (Annual)











- AOD is very well simulated.

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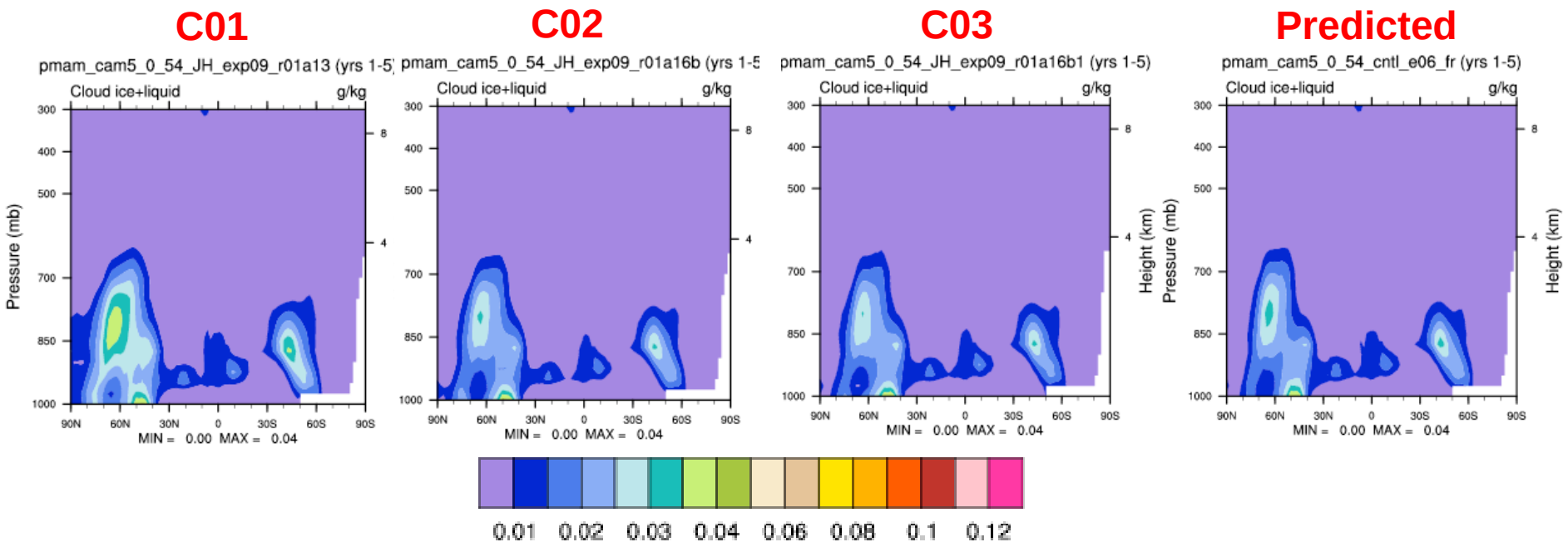
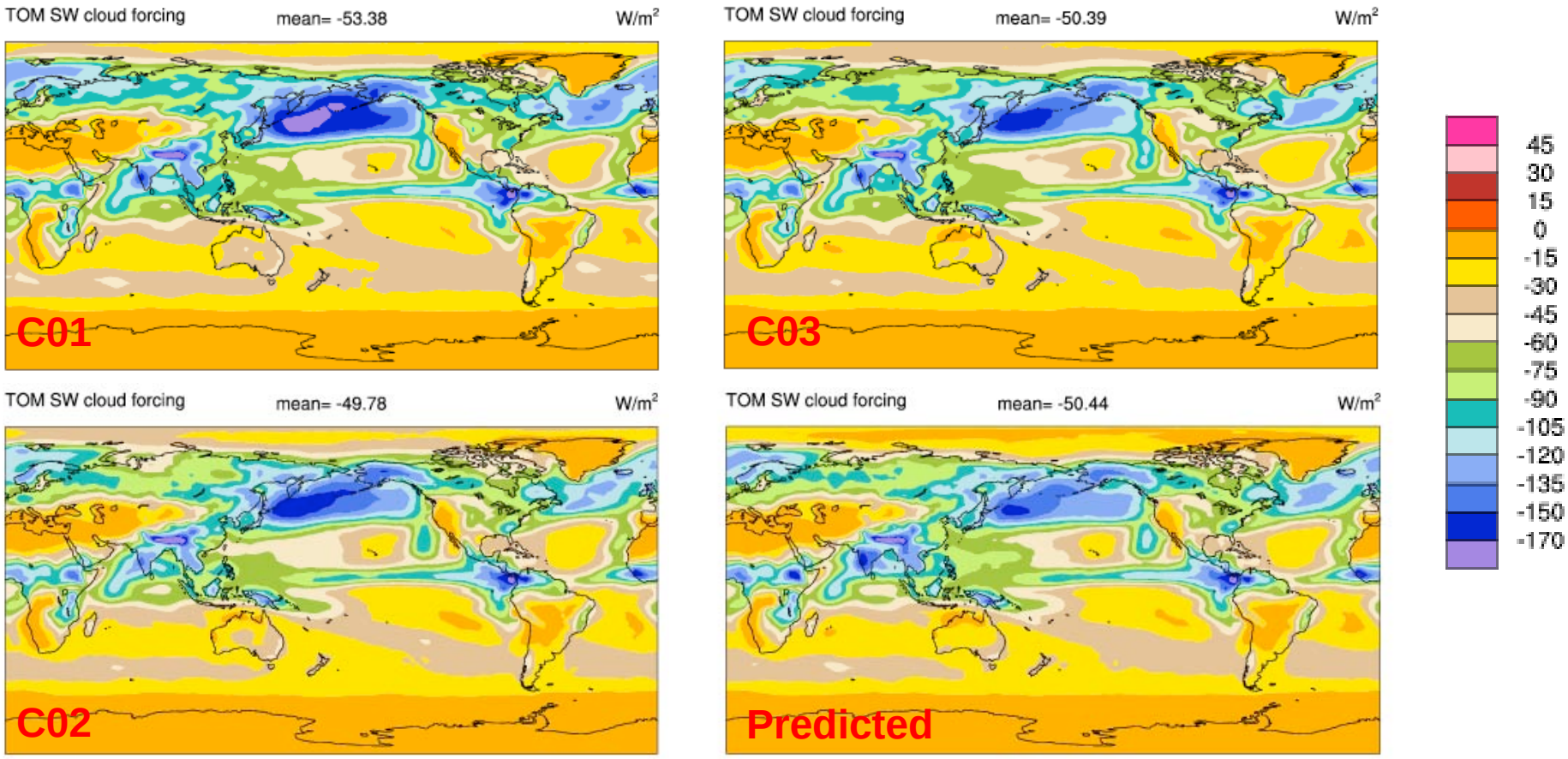
Difference: CWAT (JJA)



- Annual mean agrees better than northern summer case.
- Cloud water is quite well simulated in various settings
  - C02 & C03 are much improved.

Difference: SWCF (JJA)



- Regional difference.
- C03 agrees better with predicted aerosols run.

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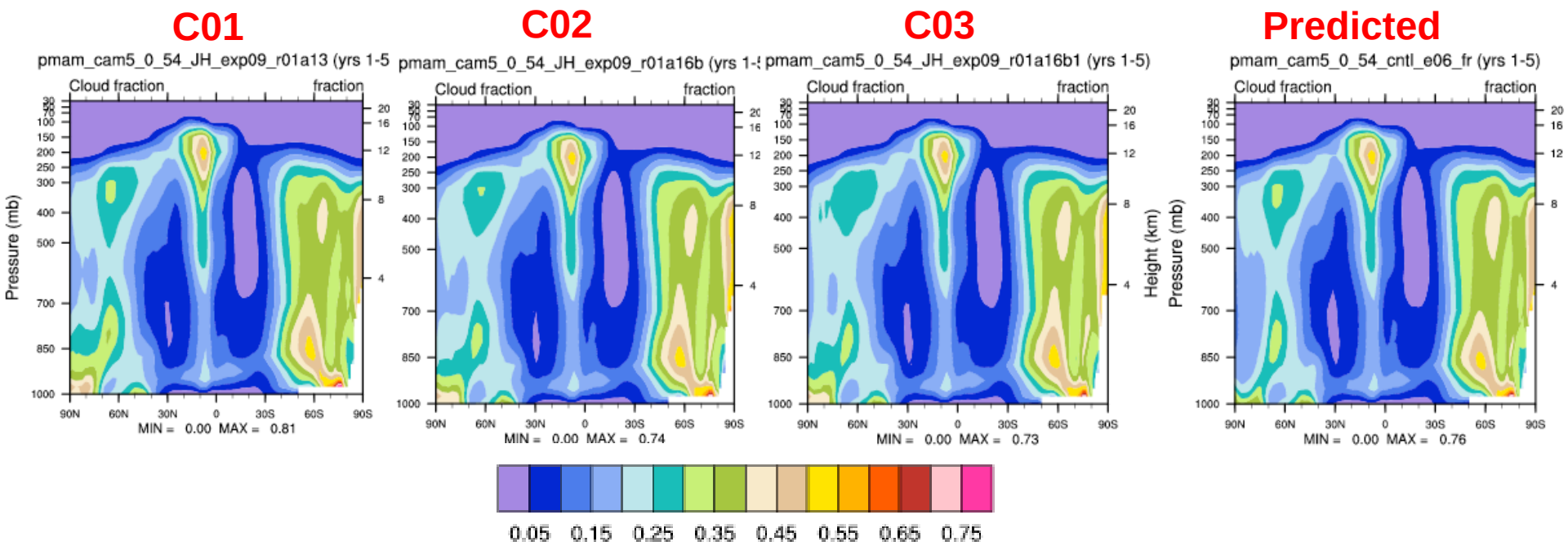
Difference: Cloud fraction (JJA)



- One of the largest difference is found in cloud fraction during **northern summer season** over **the Arctic**.

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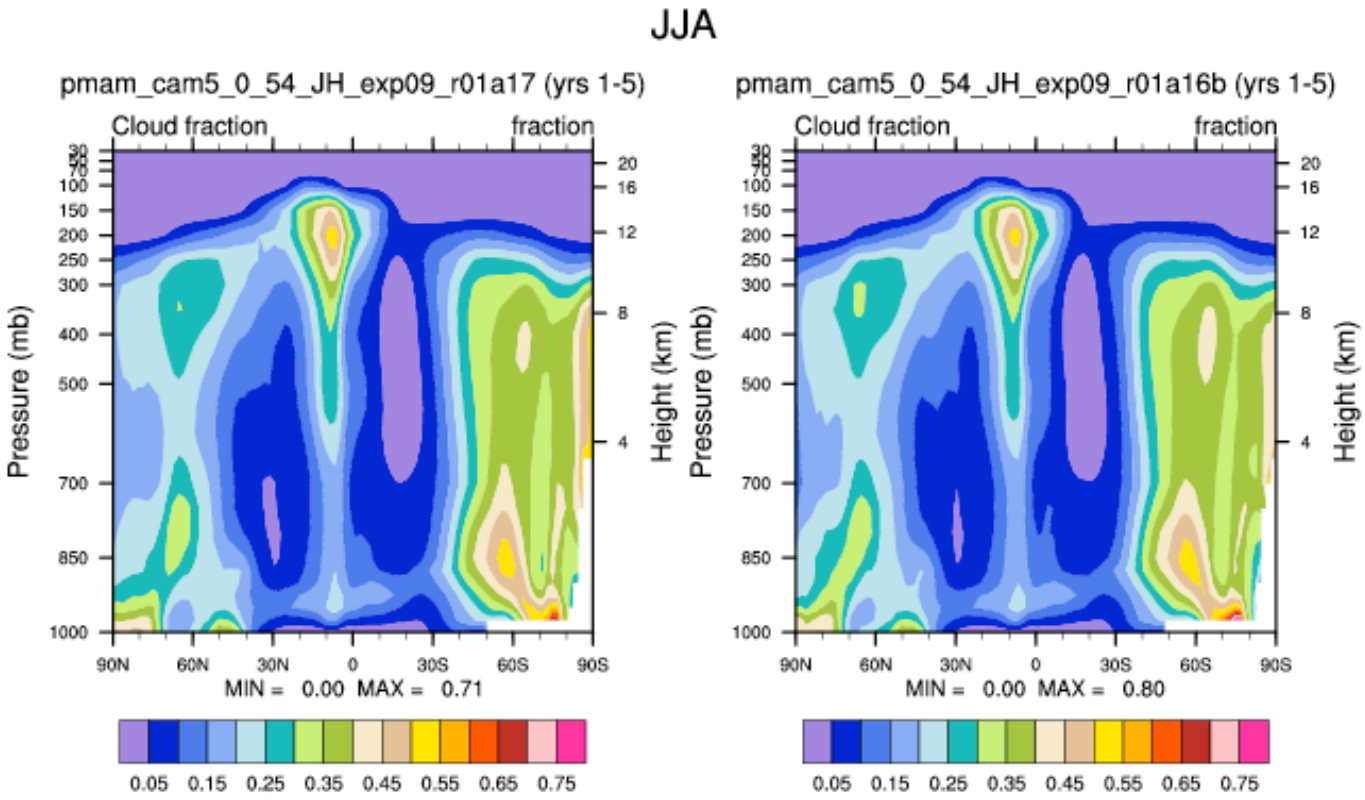
Deposition fluxes to the surface



- All the previous experiments were done without **deposition fluxes** to the surface
  - Figure above tested now uses the deposition fluxes (shown above, compared to Case 1).
  - Impacts are not critical in AMIP-style runs, but this can be critical in fully coupled runs (not tested yet).

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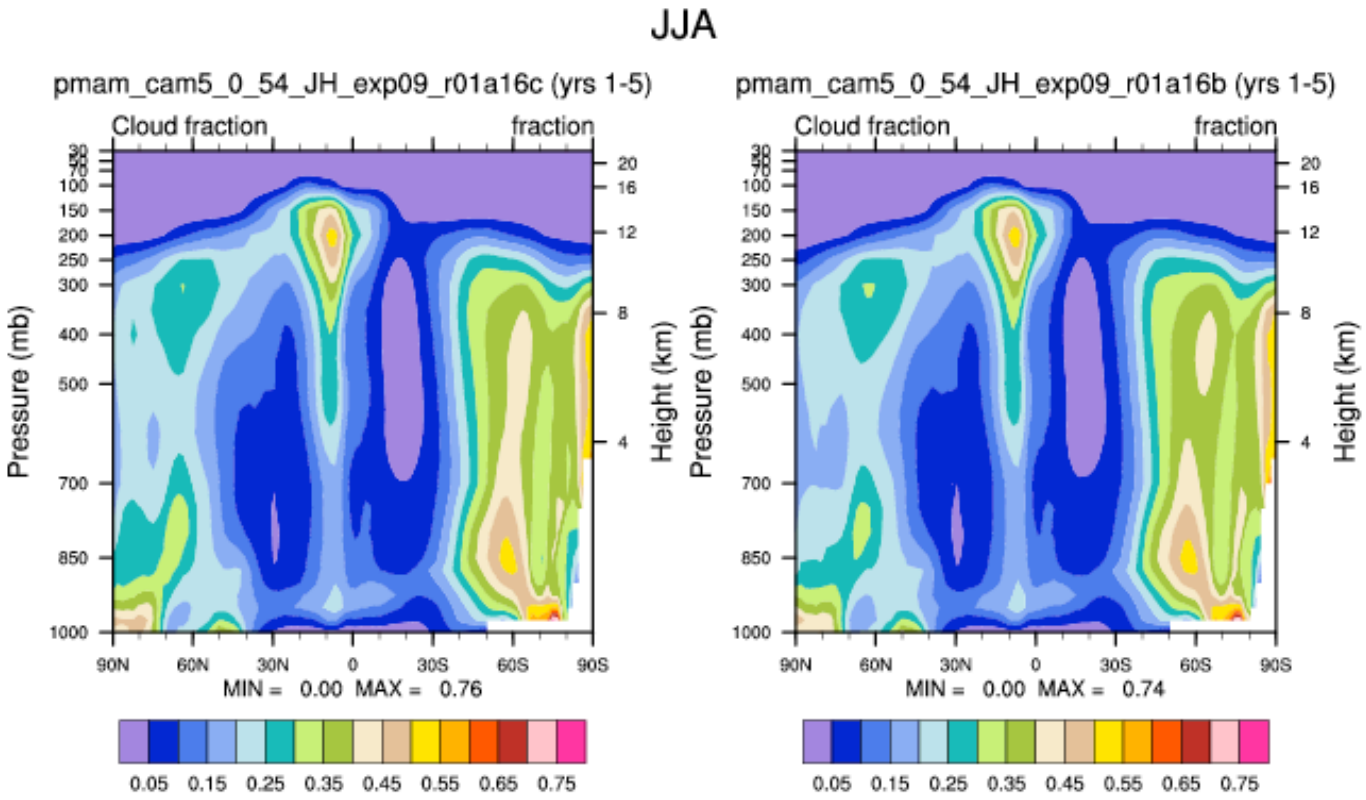
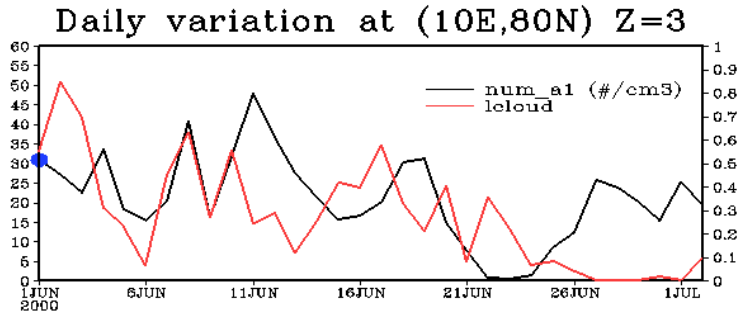
5-year climatology of prescribed aerosols

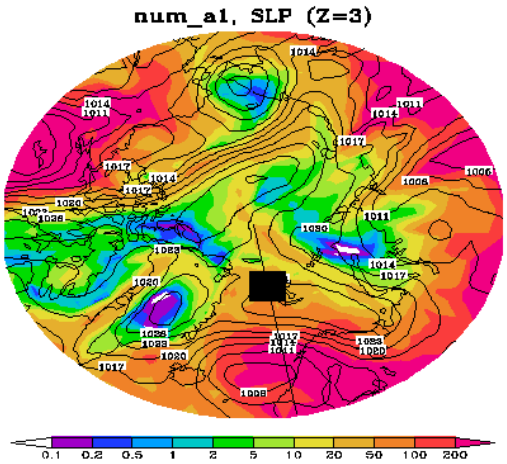


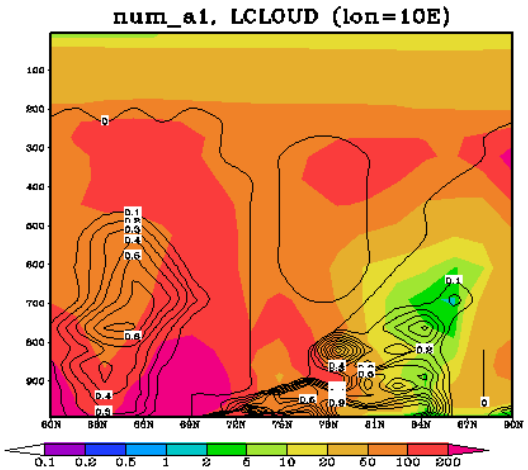
- In real case, 5- or 10-year mean aerosol mass and numbers are used.
  - Slightly more clouds are simulated (against Case 1).

Why did we produce such different Arctic summer clouds?

- ***Unrealistically low aerosol numbers and mass*** in the predicted aerosol runs
  - Unrealistic values of aerosols < 0.1/cm^3 or are simulated in the Arctic during northern summer
  - The monthly prescribed aerosols, do not show these low aerosol numbers.
  - As soon as we have more aerosols, more cloud will be created. We think it will reduce descrepancy between prescribed and predicted aerosols.







- Aerosol deposition, especially wet deposition is the key removal process.

Three paths forward

(We never did this kind of careful evaluation of “interactive versus prescribed” aerosols with CAM3 or CAM4)

1. Continue to search for a better solution in present model
2. Test the current solution
   - But recognize the Arctic summer cloud and resulting difference in radiation properties are changed. This could influence our results especially in the fully coupled run.
   - We are running SOM to examine “climate sensitivity”.
   - If it is promising, we’ll try a fully coupled run.
3. Explore current solution with modified cloud/aerosols
   - Modifications to cloud processes (LLNL/PNNL)
   - Modifications to aerosols (PNNL)