Prescribed-Aerosol Functionality for the CAM5 Single Column Model

Presented at the 2014 AMWG Meeting
Boulder, CO
by

Bereket Lebassi-Habtezion and Peter Caldwell
Lawrence Livermore National Lab

02/10/2014

Background

- By default, initial and advected aerosol profiles in SCAM5 are zero
  - This makes SCAM runs bizarre/unrealistic (green line in Fig below)
- Several fixes exist (but none are publicly released yet):
  1. Specifying droplet concentration at observed values
  2. Specifying aerosol concentration at observed values
  3. Using the 'prescribed aerosol' climatology built for the global model

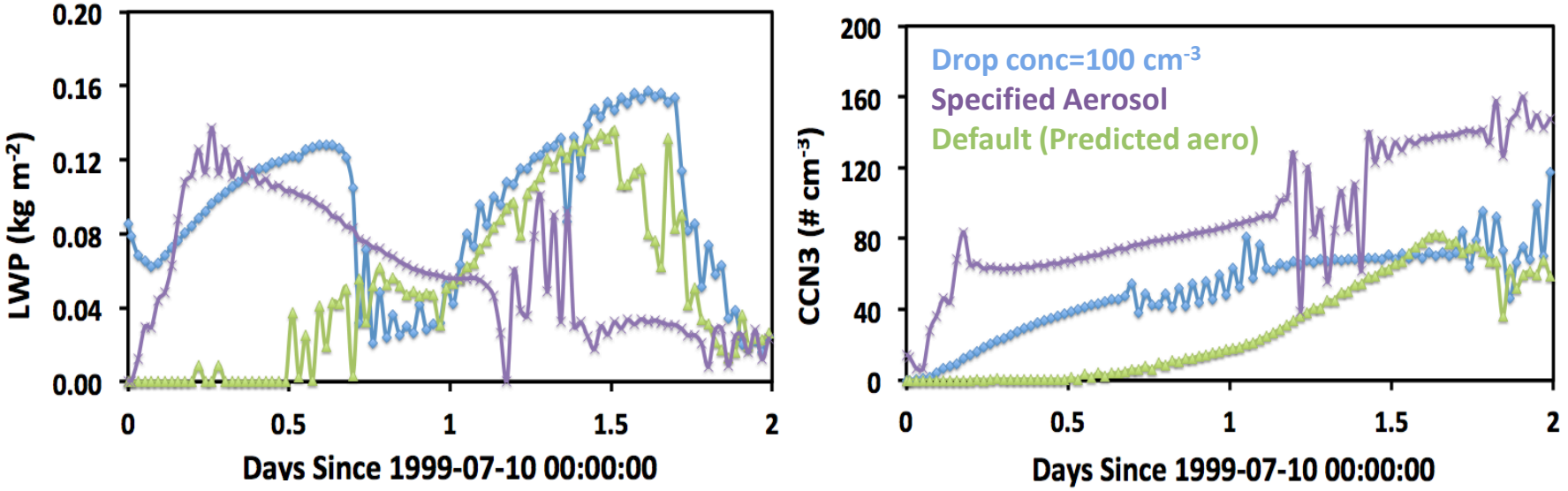


Fig 1: Liquid Water Path (LWP) (left) and Cloud condensation nuclei at 0.1% super saturation (*CCN3) (right) from DYCOMS RF01 SCAM runs*

Goal: A Default Aerosol Treatment for SCAM

The fixed droplet concentration and specified aerosol methods require special knowledge of observed conditions so can't be applied generally. Also:

- fixed droplet concentration also can't be used for aerosol studies
- specified aerosol currently has a bug

The goal of this presentation is to assess whether existent prescribed aerosol functionality can serve as the default aerosol method for SCAM

Description of Prescribed Aerosol Method

The approach is:

1. Monthly-mean climatological aerosol properties are read from a predicted-aerosol run
2. Mean interstitial aerosol properties are scaled by a draw from a lognormal distribution
   - random sampling is needed to reproduce the polar clouds of predicted-aerosol runs
   - The same random draw is used for 24 hrs
3. The resulting prescribed aerosol values are used for microphysics and radiation

Potential Issues:

1. There is a bug in the random # generator
2. Since SCAM runs are short, results are heavily affected by random sampling

Issues with the Random # Generator

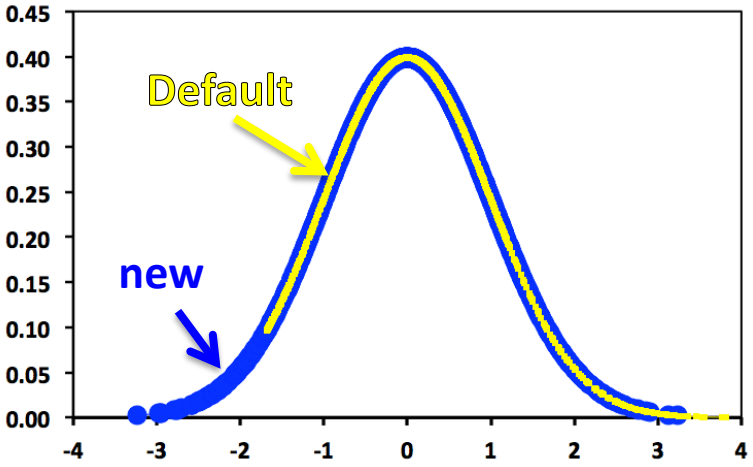


Fig 2a: PDF of random #s taken from the default and new implementations. Normally-distributed data is generated as a step in producing the log-normal data used by the model.

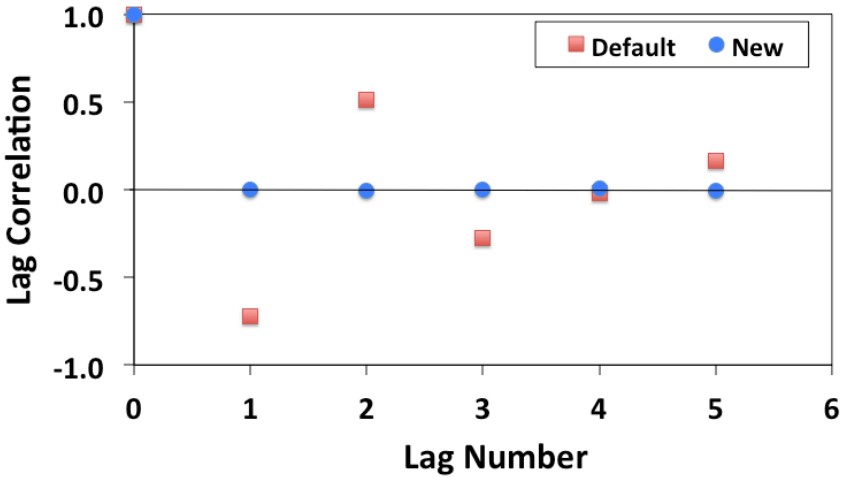


Fig 2b: The dependence of the random numbers generated in a one year Single Column model run with the default CAM (Red) and CAM with new setup (Blue).

Problems:

1. In the CAM5.3 release, the random # generator never samples the negative tail of the distribution
2. Subsequent samples are strongly anti-correlated

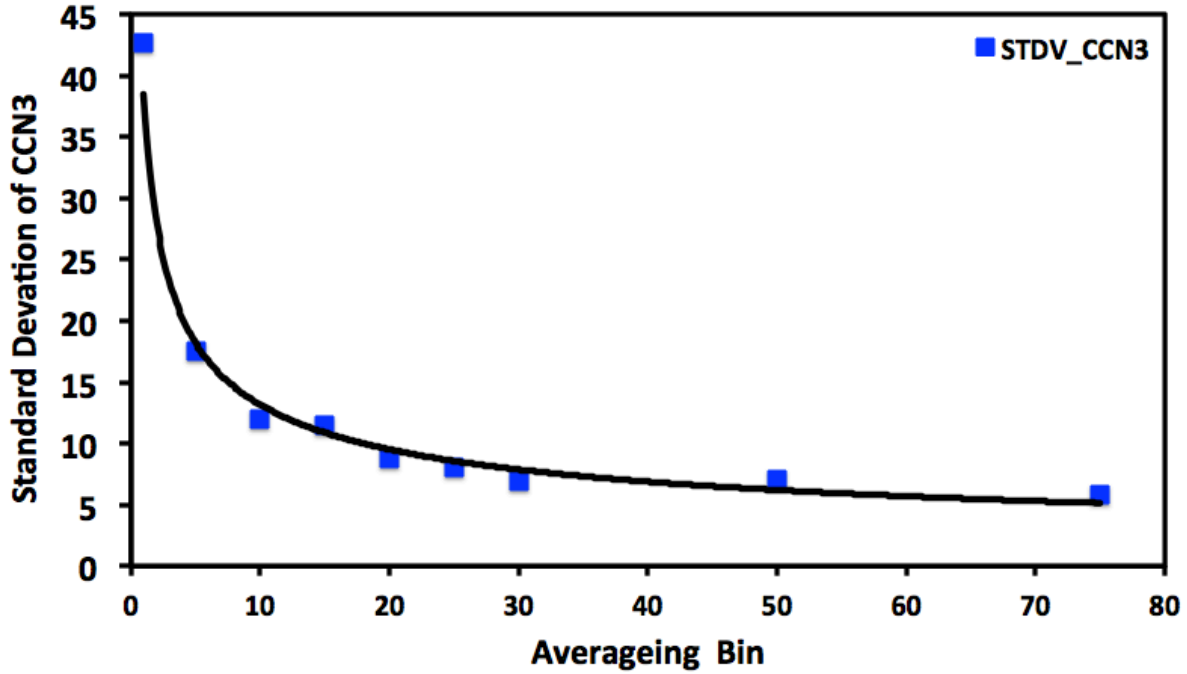
We understand these issues and a fix is forthcoming

Robust Results from Random Samples

Random sampling means that SCAM simulations using prescribed aerosol see unintended/unusual aerosol values. This can be fixed via:

1. turning off random sampling so climatological means are always used
2. using ensembles of simulations

Turning off random sampling causes the same problems with polar clouds found in the global model, so we use ensembles.



- You need about 75 ensemble runs to get a convergence within standard deviation of about 5

Fig 3: Standard deviation of CCN3 for RICO for a total of 150 ensemble runs averaged by bins of 5, 10, 15, 20, 25 and 30, 50 and 75

Results from RICO

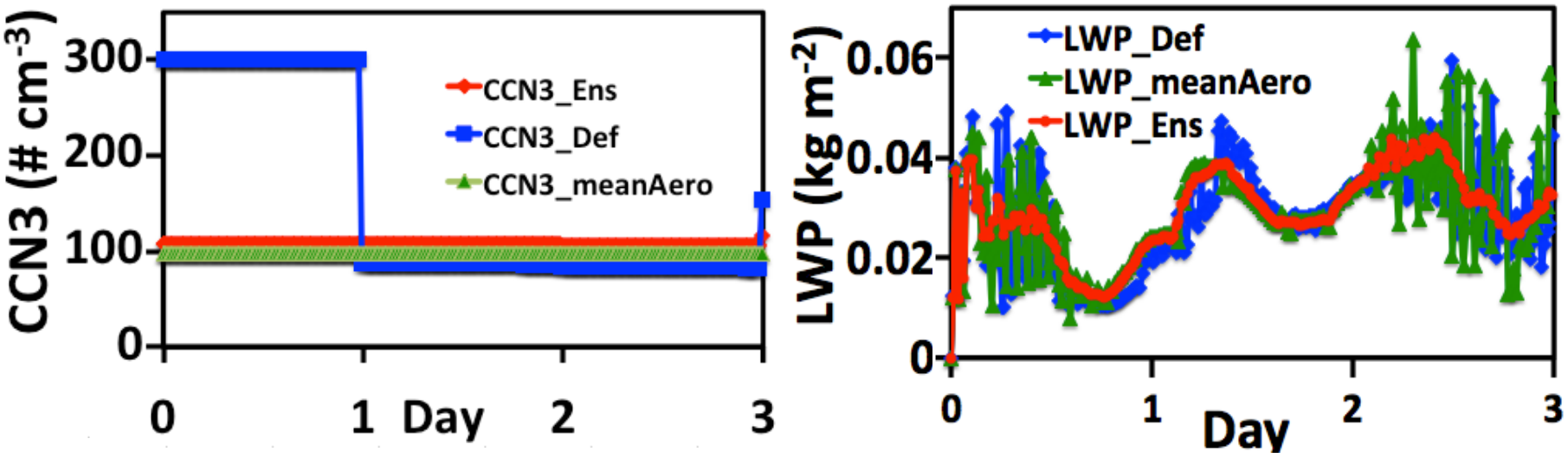


Fig 5: CCN3 and LWP of RICOa SCAM run with one ensemble member using default sampling (blue), with 150 ensemble members and the new sampling scheme (red) and using the mean climatological aerosol (green)

- The impact of daily random draws and anti-correlation between consecutive samples is clear in CCN3.
- The random # bug does not seem to have a major effect on model behavior
  - Also found in global simulations (on the next slide)
- Using an ensemble or turning off random sampling gives the same results

Global Annual Mean Differences (5yrs)

1. Difference between Predicted and Default

RESTOM	SWCF	LWCF	AODVIS
0.012	0.295	-0.045	-0.007

2. Difference between Default and Prescribed_New

RESTOM	SWCF	LWCF	AODVIS
0.09	-0.066	-0.028	0.000

- The changes in the annual mean global model run differences are small

Conclusions

- There is a bug in prescribed-aerosol but it doesn't have much impact and a fix is on the way
- Prescribed aerosol seems to work properly for SCAM, but its use of random numbers requires modification
  - We advocate using ensembles with 75 members
  - Outside polar regions, setting the random # to 0 would also work