Comparison of NASA GCE-CRM and SCM-CAM5 (SCAM) with ARM data

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Abstract

We studied the responses of the low-level warm clouds to increased aerosol loading in the GCE cloud resolving model (CRM) and the single column version of the CAM5 model (SCAM) using the ARM observations at the SGP site under different background aerosol concentrations in May, 2011. The CRM shows increased LWP with increased aerosol loading when the background aerosol concentration is relatively small but decreased LWP when the background aerosol concentration is large. The SCAM always shows increased LWP as the aerosol loading increases and the response of LWP to the increased aerosol loading is more than that in the CRM. The increased LWP to the increased aerosol loading in the SCAM under high background aerosol concentration may be attributed to its coarse resolution and the lack of the detailed microphysics at the cloud top. The two models also show very different responses of the precipitation which requires further investigation.

Model Set-up

We used both a Cloud-System Resolving Model and the single column CAM5 model.

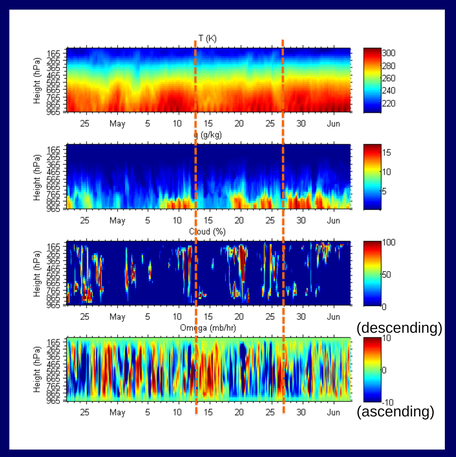
Cloud-System Resolving Model

- The Goddard Cumulus Ensemble (GCE) model (Tao et al., 2003) is used for the CRM.
- The GCE model adopts the double-moment bulk representation of Saleeby and Cotton (2004) to represent microphysical processes. This has the important feature that it follows microphysical processes such as sedimentation and evaporation accurately.
- Grid points: 256X256X144; Horizontal resolution: 50m; Vertical resolution: varied, from ~50m near surface and stretched to ~400m the top.

Singe column CAM5.3

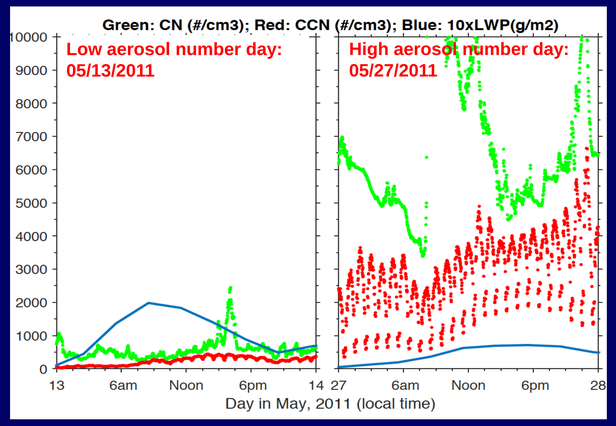
- Two-momentum scheme for ice and water (Morrison and Gettelman [2008], version 1.5), MAM3 aerosols.
- Grid points: 30 layers.

ARM Observations at the SGP Site



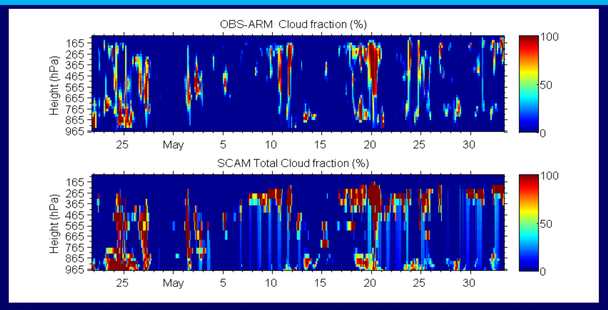
- We used the forcing data derived from the Midlatitude Continental Convective Clouds Experiment (MC3E) which was conducted during April to June 2011 near the ARM Southern Great Plains (SGP) site.
- We picked two days, May 13th and 27th, 2011, both with low level clouds for simulation.

Observed CN/CCN/LWP

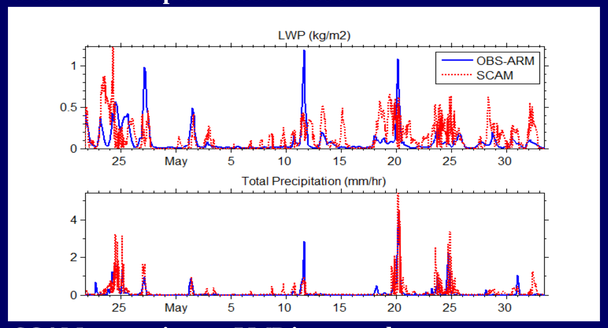


- Note that LWP (g/m2) is increased by a factor of 10 to use the same y-axis.
- Relevant CN number (green) is from 400 to 800 #/cc on May 13th, from 4000 to 8000 on May 27th.
- Relevant CCN number at 1%ss (red) is 100-400 on May 13th , 2000-4000 on May 27th
- On both days, CCN:CN ~ 1:2.

Results from SCAM

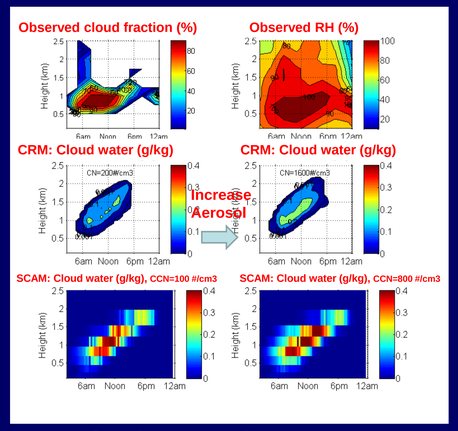


- Top graph shows the observed cloud fractions and bottom graph shows simulated cloud fraction from SCAM.
- SCAM overestimates cloud fractions for low clouds , high clouds and deep convective clouds.

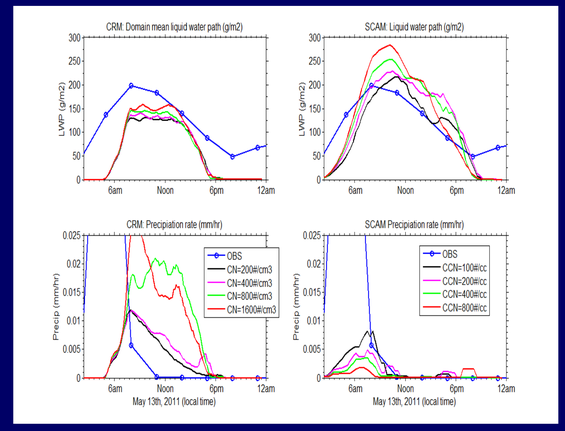


- SCAM overestimates LWP in general.
- SCAM and observations match reasonably well on days with strong precipitation rates.
- SCAM tends to overestimation on days with weak precipitation rate.

Comparison of CRM and SCAM on 05/13/2011

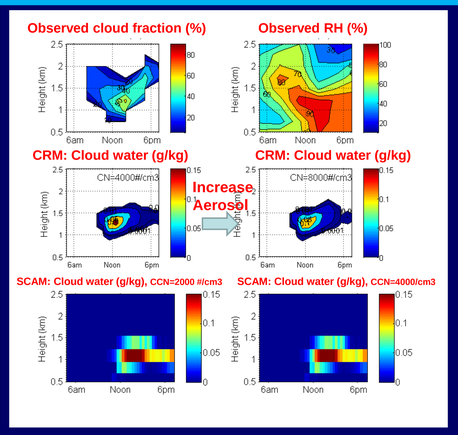


- Results of CRM and SCAM on 05/13/2011 with low background aerosol number.
- CRM and SCAM both show increased cloud water with increased aerosol numbers.
- CRM also shows slight increased cloud top heights.

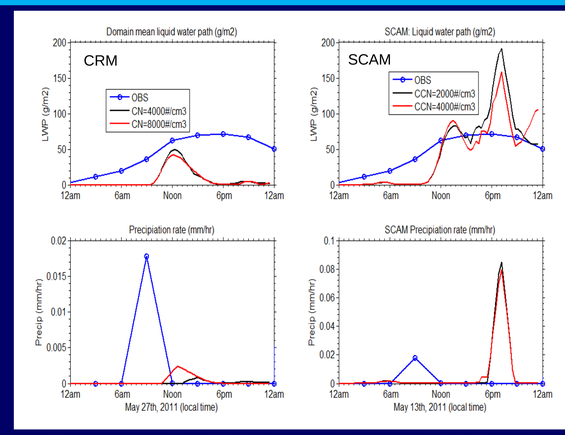


- SCAM simulated larger LWP and smaller precipitation rate
- Both models fail to show strong precipitation around 6am (could be due to the sampling difference, one vs. regional mean?)

Comparison of CRM and SCAM on 05/27/2011



- Results of CRM and SCAM on 05/27/2011 with high background aerosol number.



- Near noon, the CRM shows decreased LWP with increased aerosol numbers while SCAM shows increased LWP with increased aerosol numbers.

Summary and Conclusions

Relative changes of LWP and Precipitation rate to the relative changes of aerosol/cloud drop numbers		
05/13/2011	CRM	SCAM
$\lambda = \frac{dln(LWP)}{dln(Na)}$	+0.10	+0.20
$s = -\frac{dln(Precip)}{dln(Nd)}$	-0.24	+1.0
05/27/2011		
$\lambda = \frac{dln(LWP)}{dln(Na)}$	-0.20	+0.02
$s = -\frac{dln(Precip)}{dln(Nd)}$	<0	N/A

1. On 05/13/2011 when the background aerosol number is low, both models predict increased LWP with increased aerosol number, but SCAM is more sensitive.
2. On 05/27/2011 when the background aerosol number is high, the two models have opposite LWP response to the increased aerosol loading due to representation of the evaporation of drops due to entrainment.
3. The response of the precipitation rates are more complex and needs further investigation.