Using decadal observations from the three main ARM sites to evaluate model simulated aerosol-cloud processes

S. Menon (smenon@lbl.gov), I. Sednev (isednev@lbl.gov)

Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Summary

We use the GISS GCM to perform global climate simulations to constrain simulated aerosol-cloud processes. The ARM Climate Research Facility (ACRF) long-term site's Climate Modeling Best Estimate (CMBE) products from SGP, NSA and TWP are used to evaluate simulated total cloud cover (CC) and liquid water path (LWP) for 1996-2007. The sensitivity of CC and LWP to cloud nucleation and autoconversion (Qaut) are examined for:

Sim DIE: Standard model with all indirect effects (cloud nucleation scheme from Lohmann et al. (2007, ACP) and Qaut from Beheng (1994, Atmos. Res));

Sim DIEM: Similar to Sim DIE but cloud nucleation is from Abdul-Razak and Ghan (2001, JGR) and the aerosol model used includes microphysics (Bauer et al. 2008, ACP) rather than the standard mass only model used for Sim DIE;

Sim DIEQs: Similar to Sim DIE but with the Qaut from Seifert and Beheng (2001, Atmos. Res.) The indirect effect (based on differences between present-day and pre-industrial aerosol emissions) predicted are -0.88, **-0.36** and **-0.68** Wm^{-2}, for Sim DIE, DIEM and DIEQs, respectively. These differences are due to differences in the nucleation and Qaut scheme used.

Based on the limited comparison of present-day simulations (Year 2000) with observations as shown, the model largely overestimates LWP at TWP sites, especially Sim DIEQs and underestimates it over the SGP sites. Over the NSA site the winter LWP amount is underestimated. For CC, the model is comparable to observations, except for the under-prediction over the SGP site. Additional diagnostics from the CMBE data and the TWP ICE campaign are being compared to evaluate the over-estimation of LWP. Global LWP values are comparable to observations (*Lohmann et al., ACP, 2007) except for the LWP from Sim DIEQs.

Annual global values

Variable	Obs*	DIE	DIEM	DIEQs
Ocn LWP (gm^{-2})	**50-84**	**68.3**	**67.8**	**114**
CC (%)	**62-67**	**60.5**	**60.3**	**61.8**
SW Cloud Rad. Forcing (Wm^{-2})	**-50.0**	**-48.3**	**-48.3**	**-53.0**

Regional values

	Obs	DIE	DIEM	DIEQs
LWP JJA/DJF				
NSA	**87.5/16.0**	**67.9/2.90**	**95.4/4.22**	**175/7.32**
SGP	**22.5/40.4**	**7.53/14.8**	**5.28/7.67**	**7.54/23.4**
TWP	**18.3/26.6**	**99.8/93.5**	**109/105**	**128/100**
CC JJA/DJF				
NSA	**66.8/83.0**	**70.2/93.5**	**73.7/93.8**	**77.6/92.5**
SGP	**42.0/56.3**	**9.14/28.7**	**8.23/27.8**	**8.36/32.6**
TWP	**47.2/70.9**	**46.8/64.7**	**47.5/64.8**	**49.1/65.2**

(JJA=Jun-Aug and DJF= Dec-Feb)

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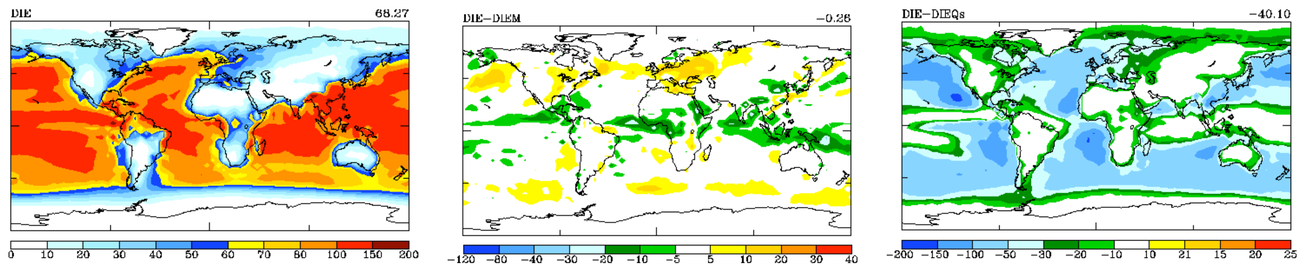
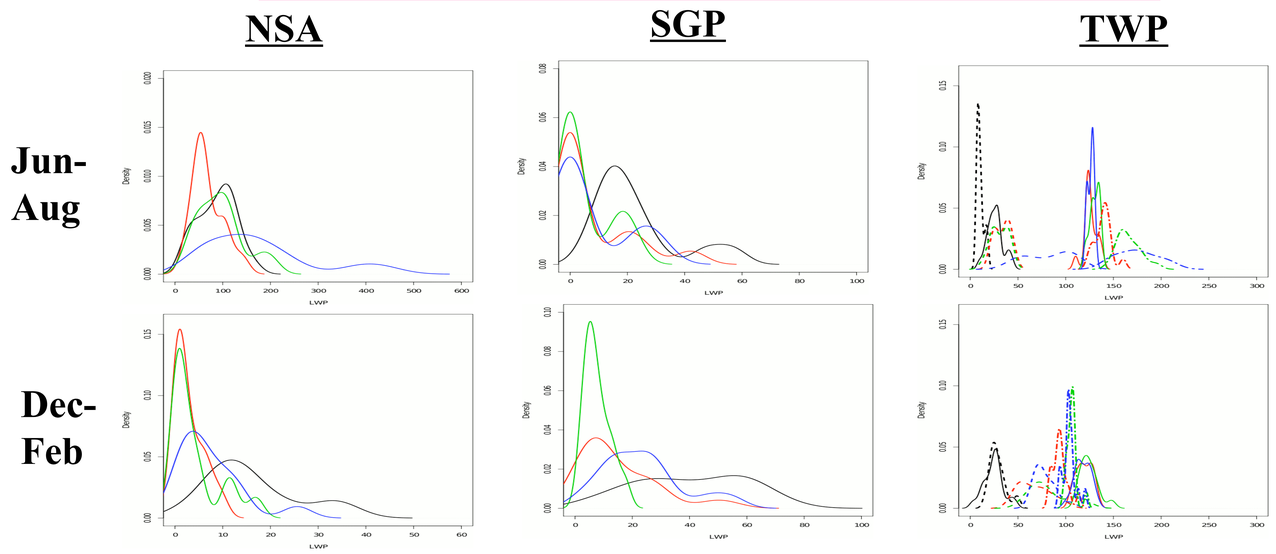
Liquid water path (gm^{-2})

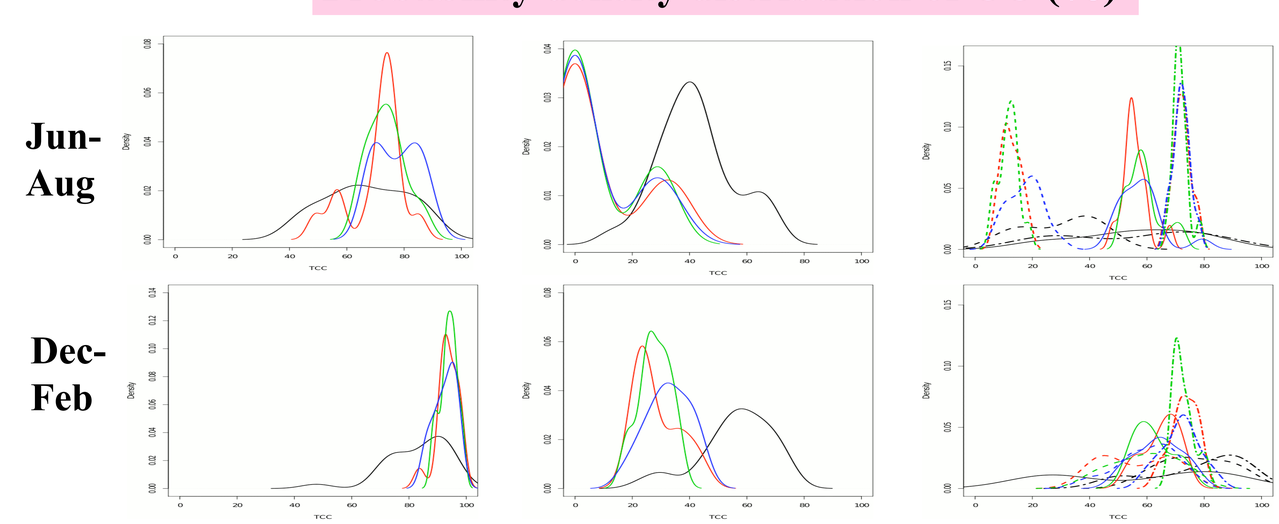


Global annual LWP for Sim DIE and differences in LWP for Sim (DIE-DIEM) and Sim (DIE-DIEQs). Mean values are on r.h.s. of graph. For Sim DIEQs, LWP values are fairly similar to that obtained for the standard Qaut scheme that is an increasing function of condensate only. Clearly, Qaut schemes need to account for aerosol-cloud interactions, and present schemes as implemented cannot represent regional LWP distributions reasonably even if global averages are within values retrieved from observations.

Probability density distribution of LWP (gm^{-2})



Probability density distribution of CC (%)



Legend: ARM site (black); Sim DIE (red), Sim DIEM (green),Sim DIEQs (blue). For TWP sites, C1 C2 and C3 are represented by two-dash, solid and dashed lines, respectively, otherwise colours are as before.