Examine the sensitivity of climate system to aerosol/cloud interactions and autoconversion in CAPT framework

- Focus on cloud fields and radiative fluxes.
- In additional to the default parameterization and scheme used in CAM3, apply another 4 different parameterizations for cloud drop nucleation and 4 different autoconversion schemes.

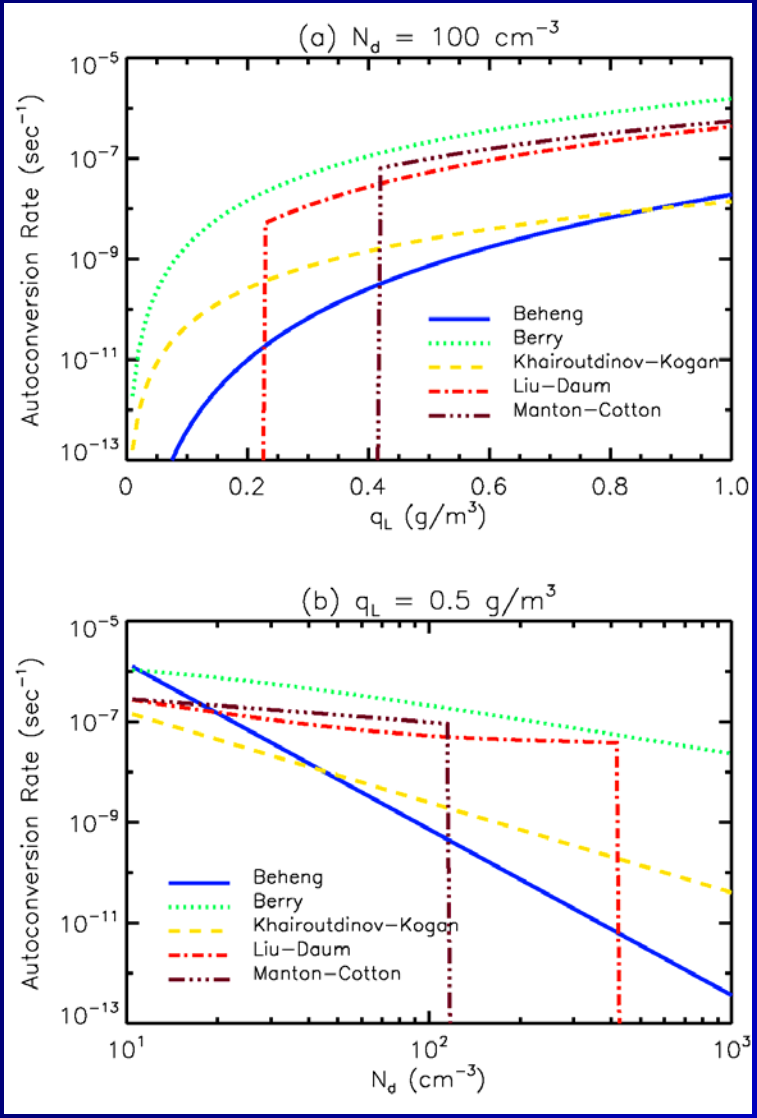
  Cloud drop nucleation:

  (1) Abdul-Razzak and Ghan, 2002; (2) Nenes and Seinfeld, 2003; (3) Ming et al., 2006; and (4) Chuang et al., 2002

  Autoconversion:

  (1) Beheng, 1994; (2) Berry, 1968; (3) Khairoutdinov-Kogan, 2000; and (4) Liu-Daum, 2004
- Also examine the new cloud microphysics package developed by Morrison-Gettelman.
- 30 sensitivity simulations have been accomplished. Each run contains 32 3-day forecasts during May 2003 IOP.
- Progress update will be mainly focused on the sensitivity of simulated cloud fields to the autoconversion schemes.

Autoconversion schemes used in GCMs



Beheng (1994)

$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = 6\times10^{25}\; n^{-1.7}\; \rho_a^{3.7}\; N_c^{-3.3}\; q_l^{4.7}$$

Berry (1968)

$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = \frac{\rho_a\, q_l^2}{1.2\times10^{-4} + \dfrac{1.596\times10^{-12}\; N_c}{D_o\;\rho_a\;q_l}}$$

Khairoutdinov-Kogan (2000, CAM-MG)

$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = 1350\; q_l^{2.47}\; N_c^{-1.79}$$

Liu-Daum (2004)

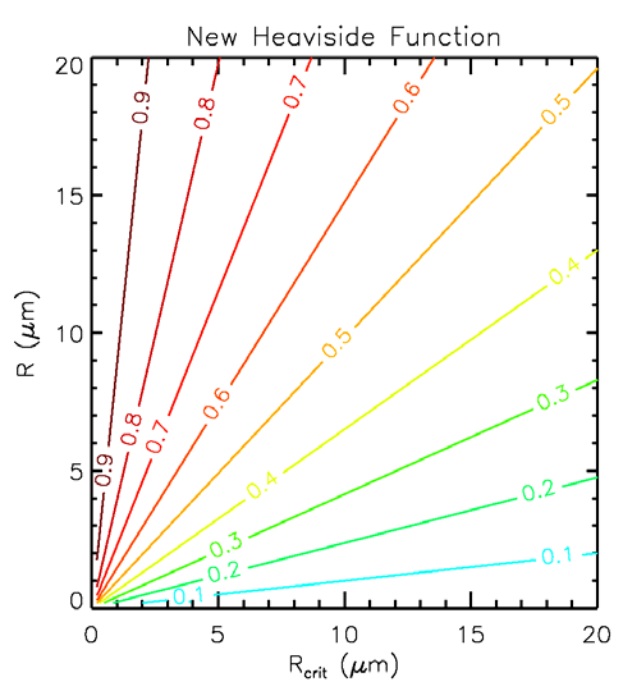
$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = \kappa_2 \left(\frac{3\,\rho_a}{4\,\pi\,\rho_w}\right)^2 \beta_6^6\, \frac{q_l^3}{N_c}\, \mathrm{H}(R_6 - R_{6c})$$

Manton-Cotton (1977, CAM3 Default)

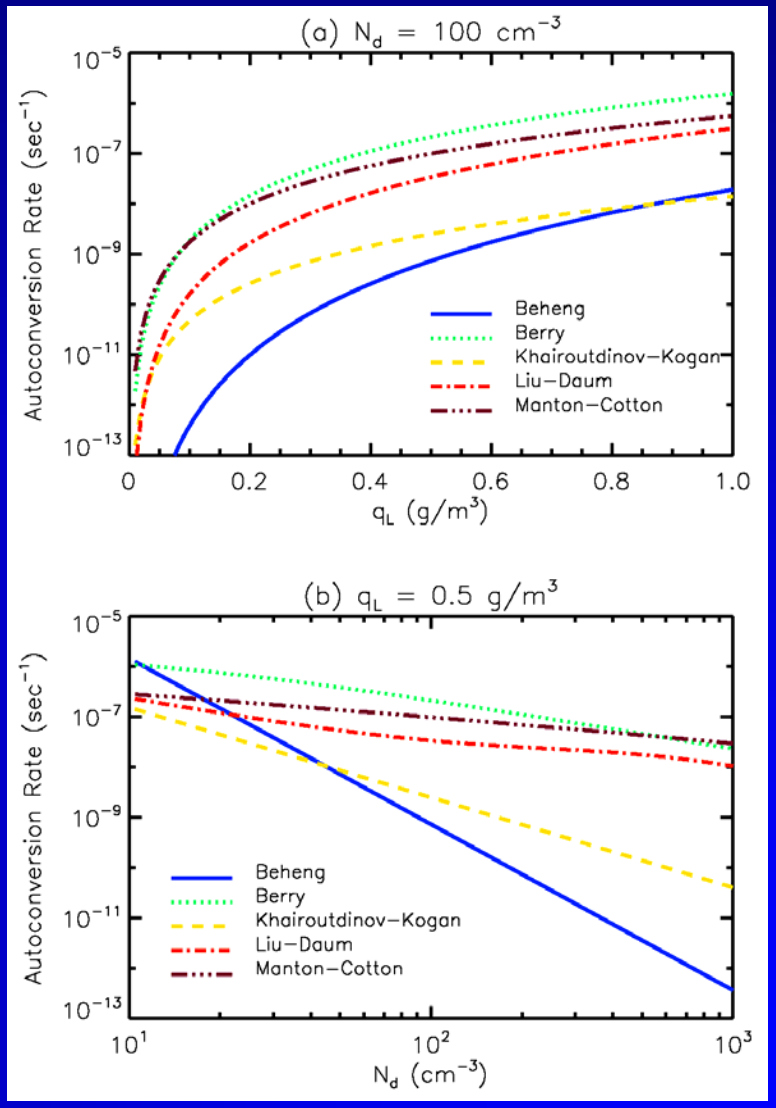
$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = C_{l,aut}\; q_l^2\, \frac{\rho_a}{\rho_w} \left(\frac{q_l\;\rho_a}{\rho_w\, N_c}\right)^{1/3} \mathrm{H}(r_{3l} - r_{3lc})$$

Autoconversion schemes applied to CAM3.5.08 with modified Heaviside function

Modified Heaviside function

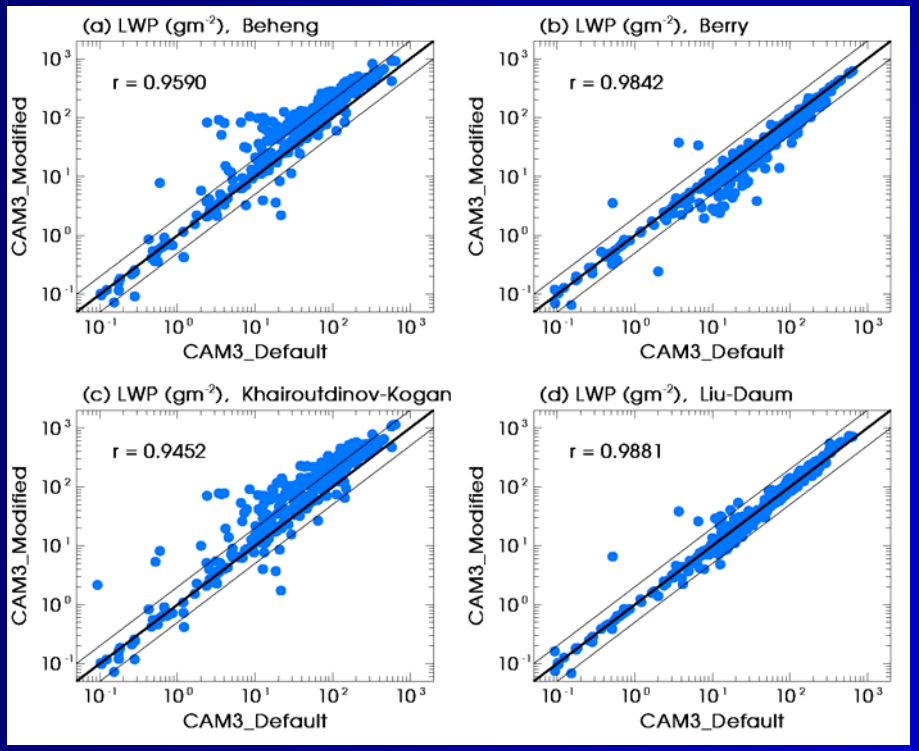


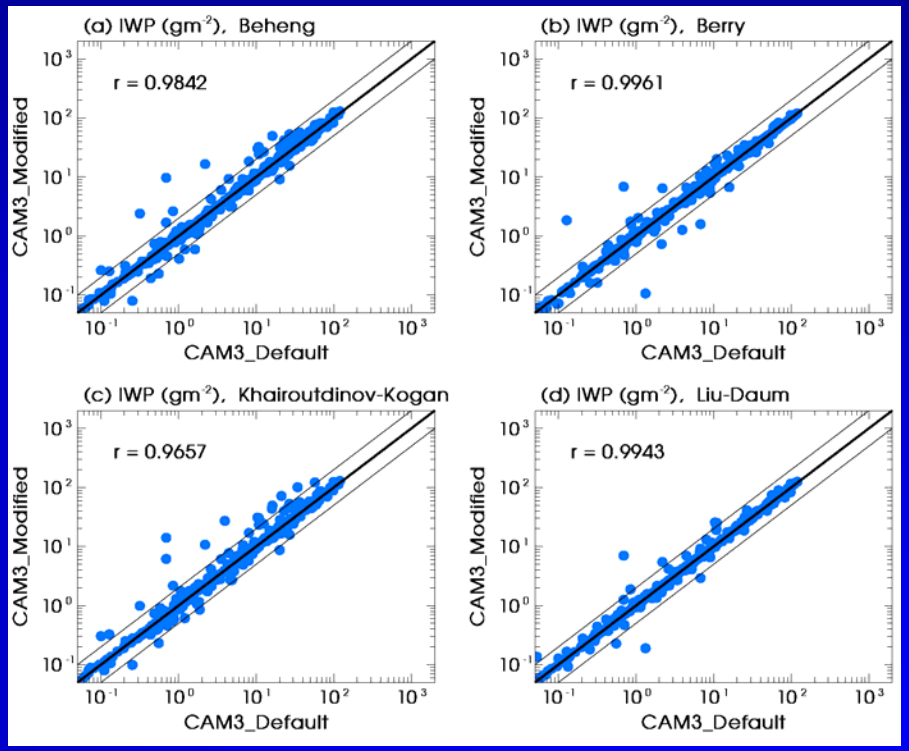
$$\mathrm{H}(R, R_c) = (R + 0.01R_c) / (R + R_c)$$



LWP and IWP :
Comparison among different autoconversion schemes

Scatter plot between modified and default (Manton-Cotton) schemes with prescribed Ndrop

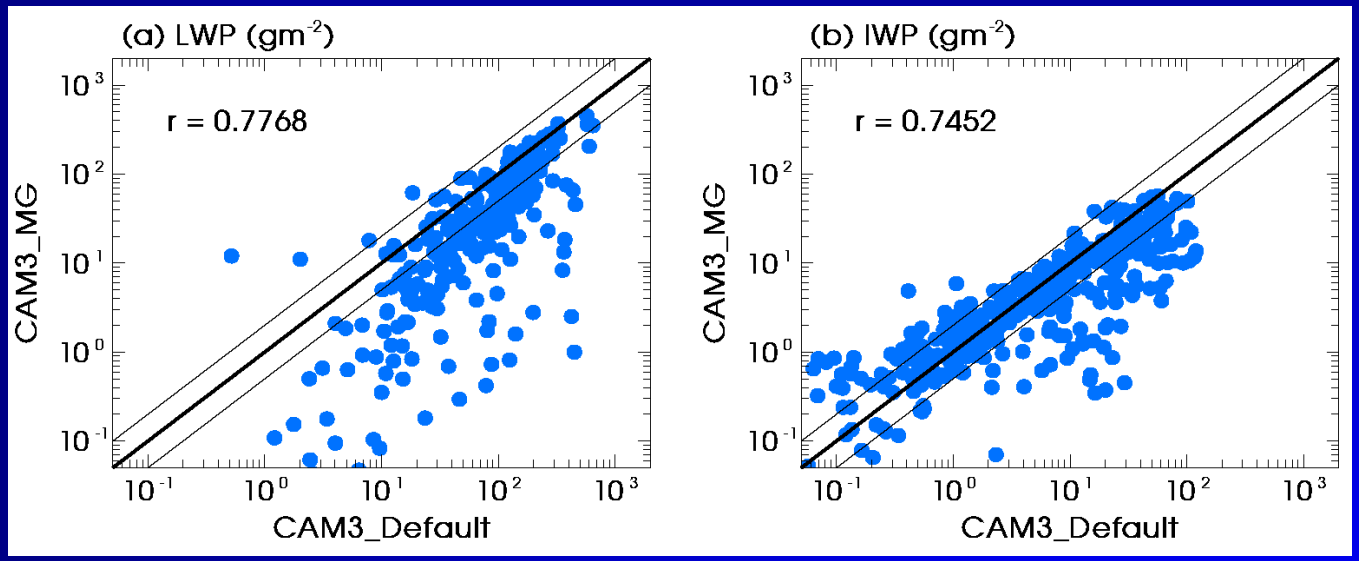




Composite of 6-12 hr forecasts

LWP and IWP :
Comparison between different microphysics packages

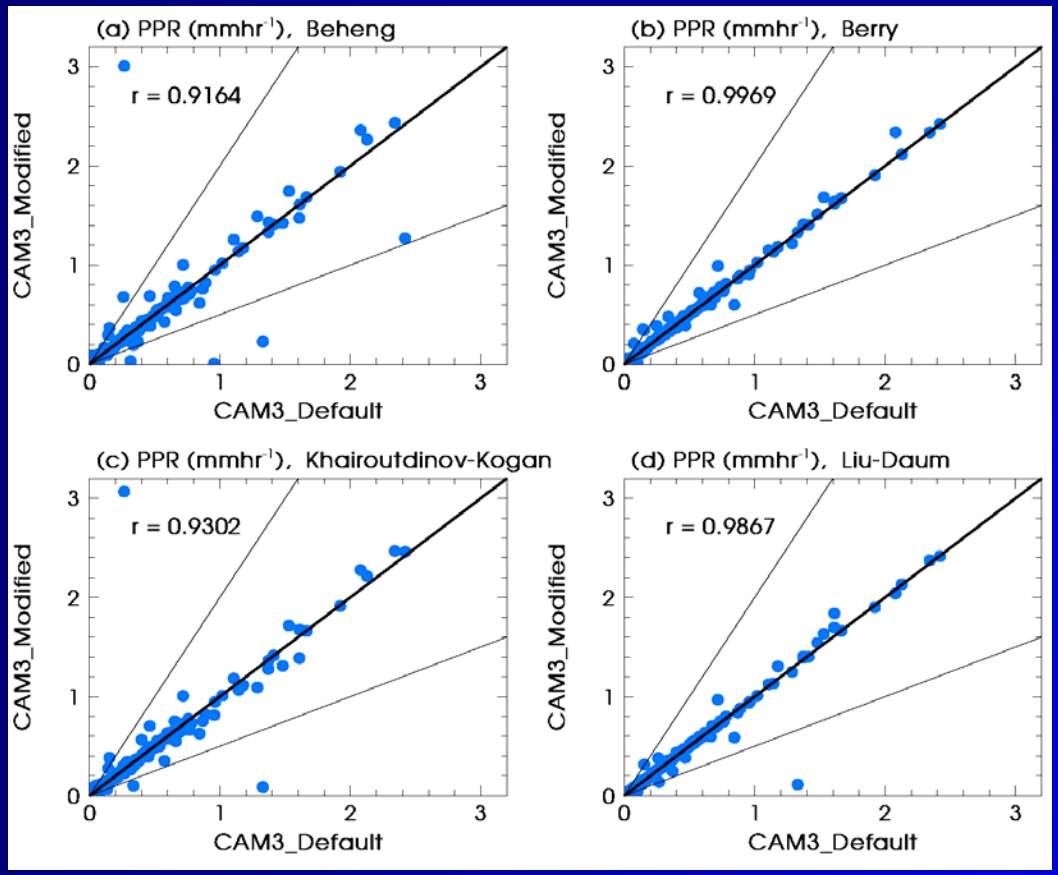
Scatter plot between Morrison-Gettelman and default cloud microphysics package



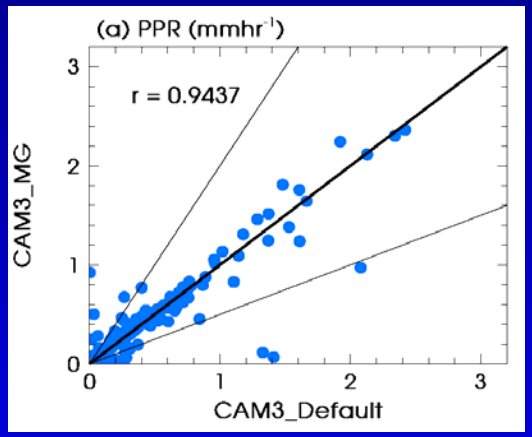
Composite of 6-12 hr forecasts

Precipitation Rate:
CAM3 with different schemes and cloud microphysics

Modified and default (Manton-Cotton) schemes with prescribed Ndrop

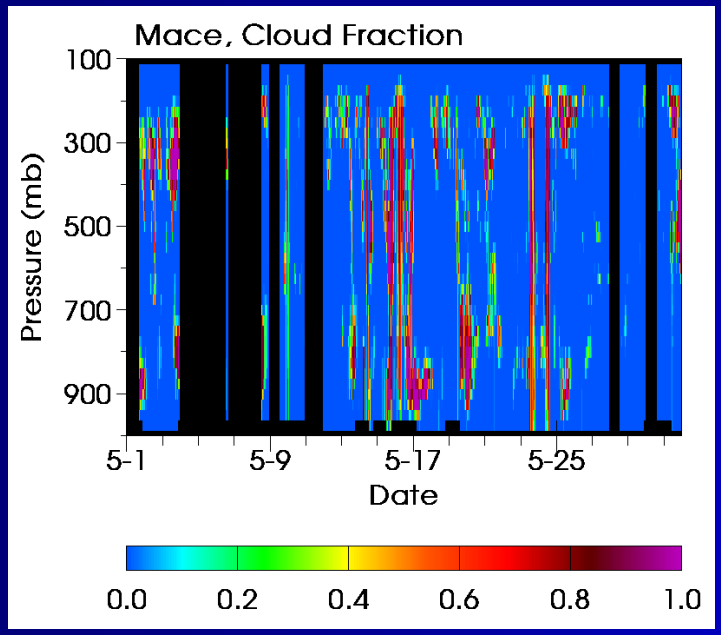


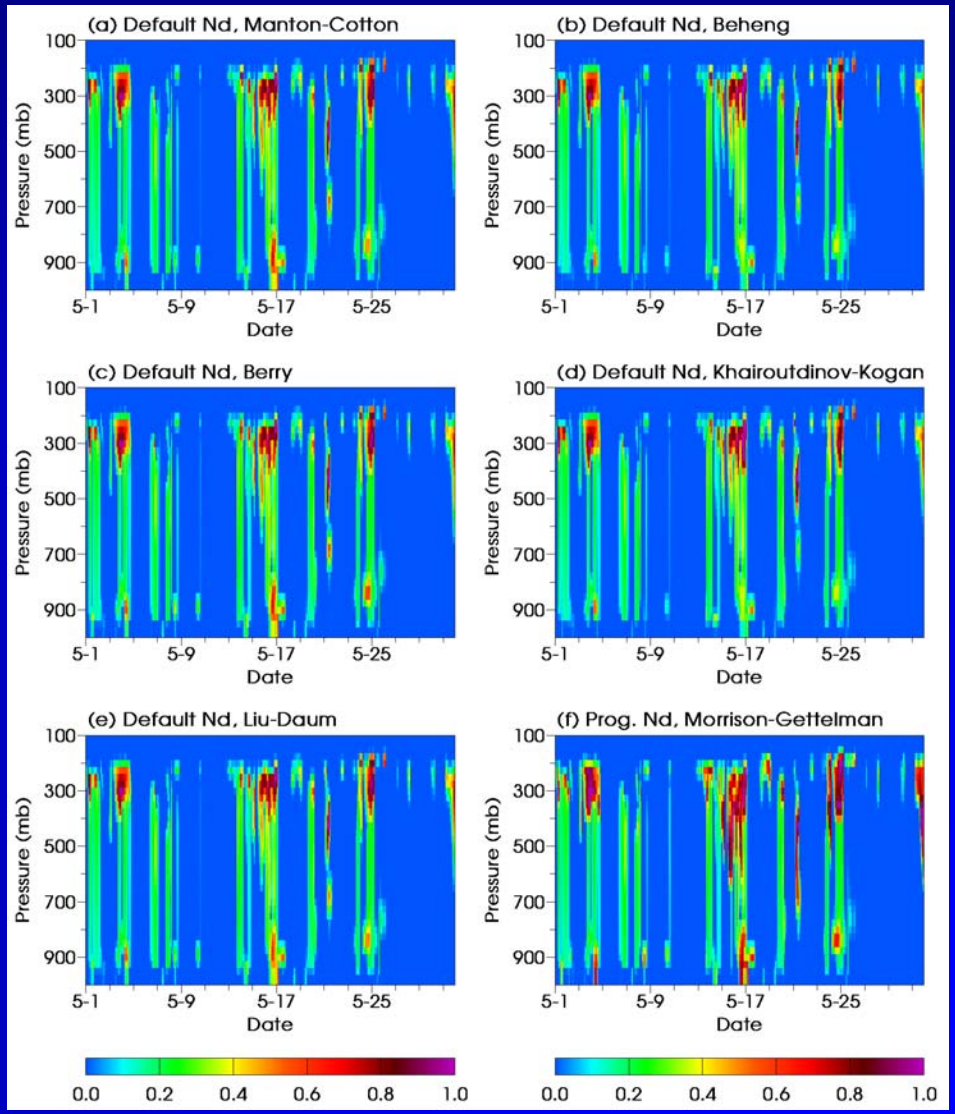
Morrison-Gettelman and default cloud microphysics package



Composite of 6-12 hr forecasts

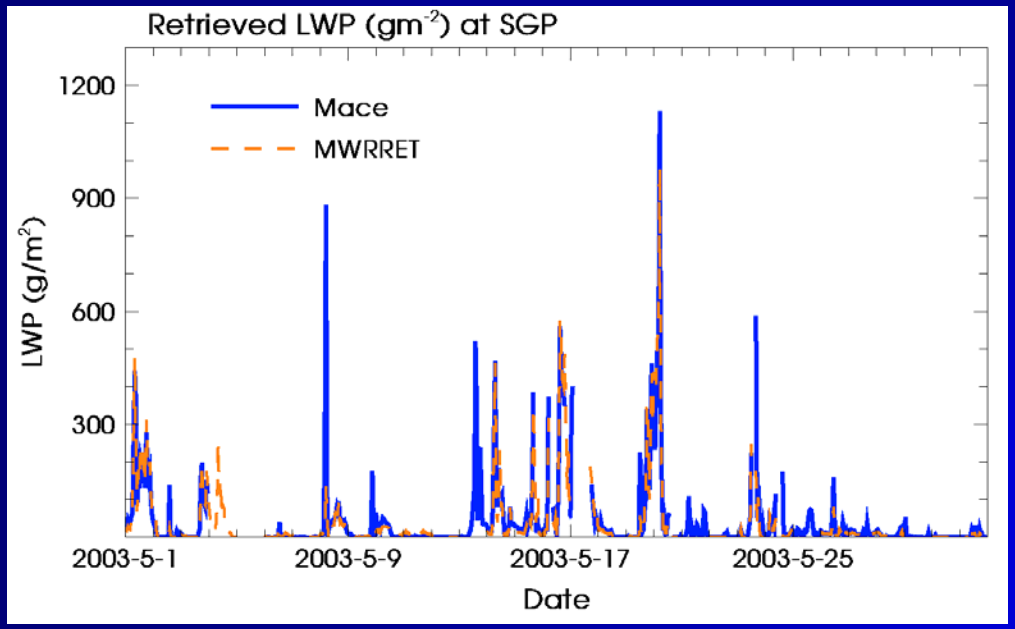
Comparison of CAM3 Cloud Fraction with ARM Cloud Microphysics Product

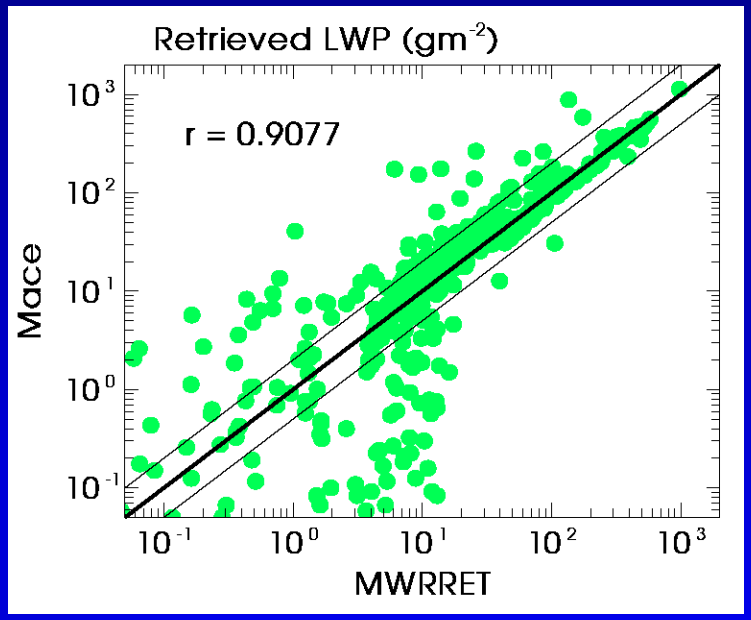




Data consistency from different retrievals

LWP, Microphysics Product (G. Mace) vs. MWRRET (D. Turner)

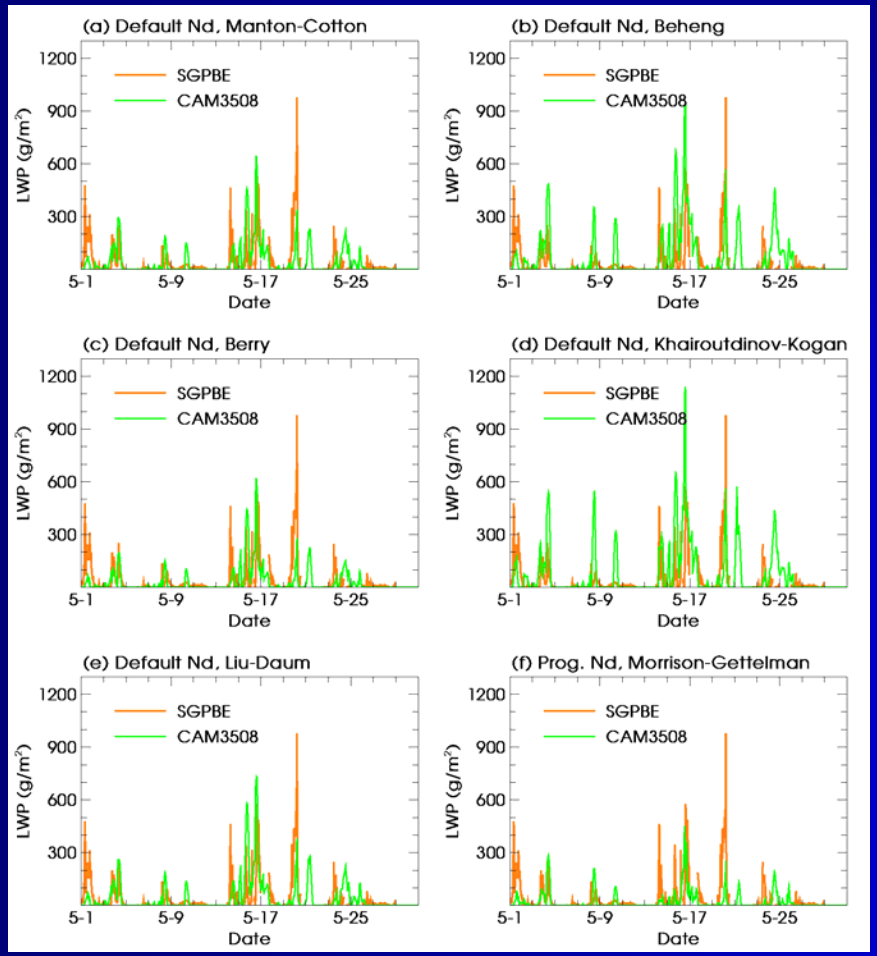




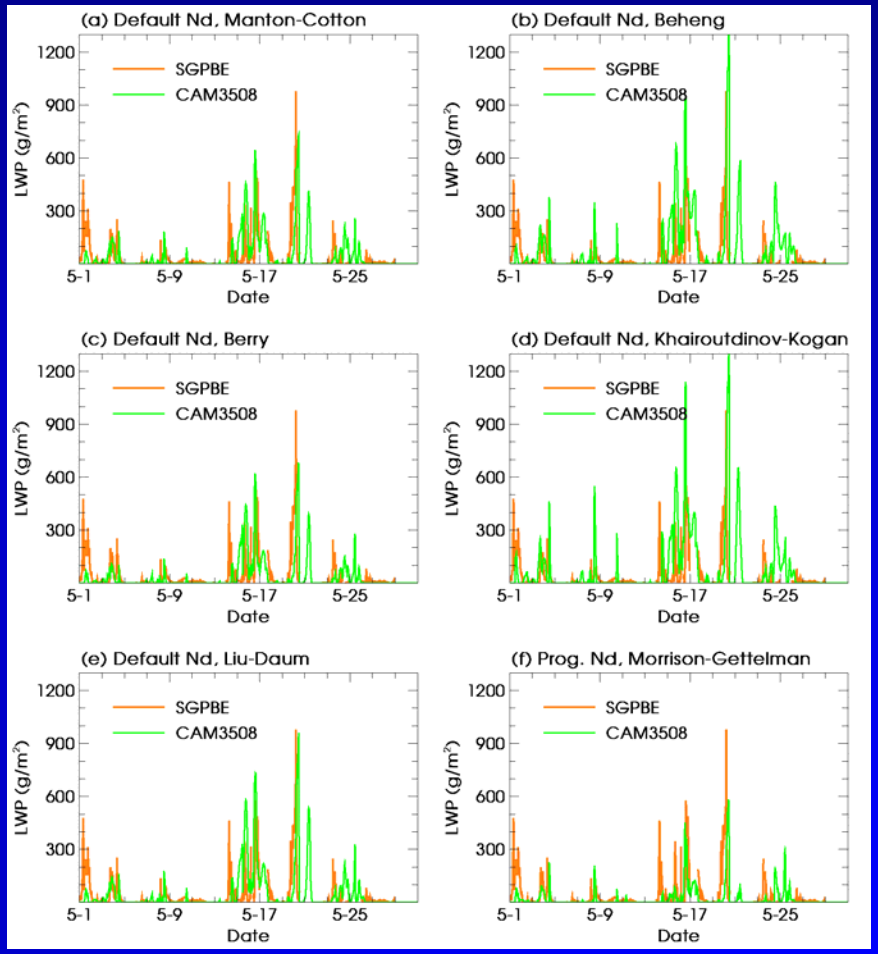
- Both are based on microwave radiometers. Retrieved LWP is in a better agreement for larger values of LWP.
- New algorithm was used for MWRRET. “Perhaps the most accurate possible retrievals of LWP from the MWR that is possible”?

Comparison of CAM3 LWP with MWRRET

LWP, SGPBE, h6-30

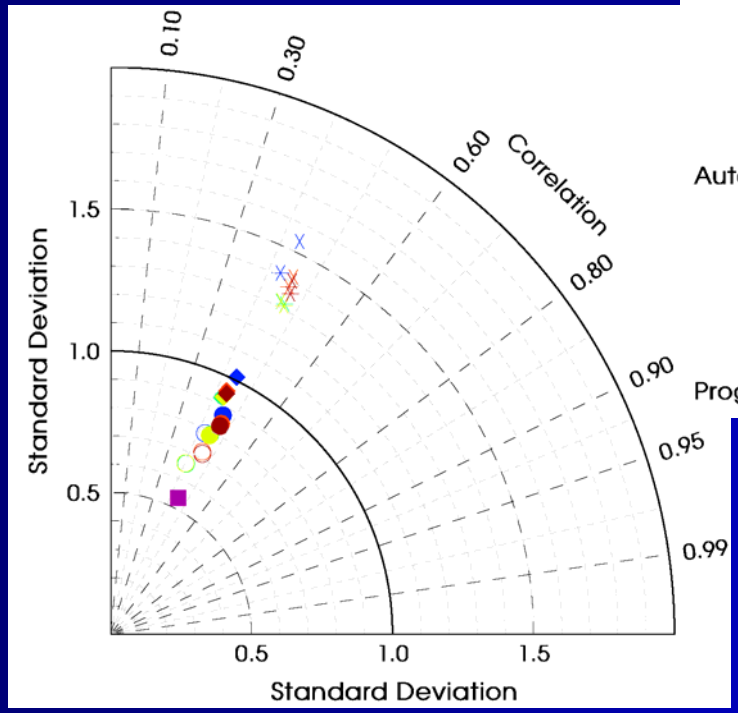


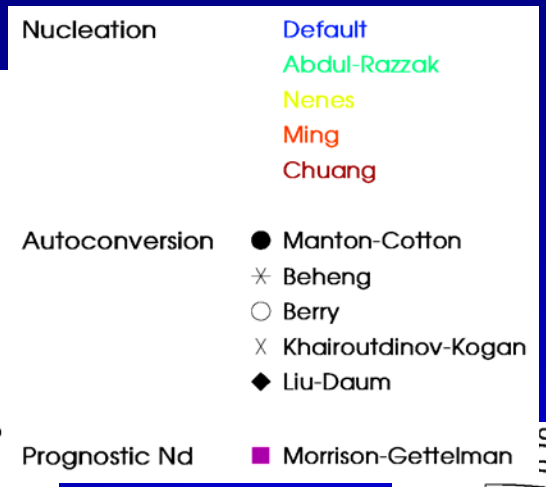
LWP, SGPBE, h12-36



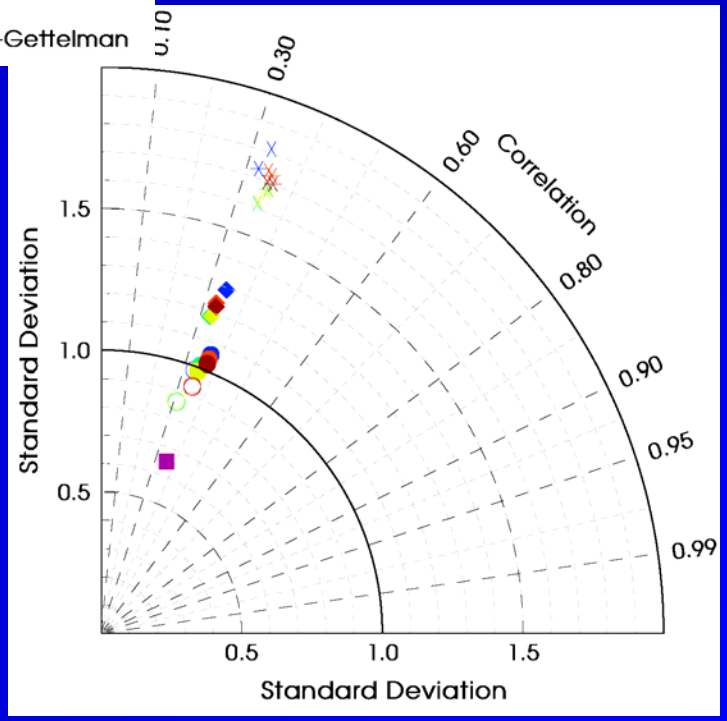
Taylor diagram :
Display pattern similarity between a model and observation

LWP, SGPBE, h6-30





LWP, SGPBE, h12-36



Comparison of CAM3 precipitation rate with measurements

PPR, Xie, h6-30