Model Intercomparison of Indirect Aerosol Effects

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Bottom line:

Modeling aerosol indirect effects on clouds remains poorly quantified in part because better measurements of cloud liquid path and aerosol abundance are needed, and better treatment of precipitation efficiency is needed.

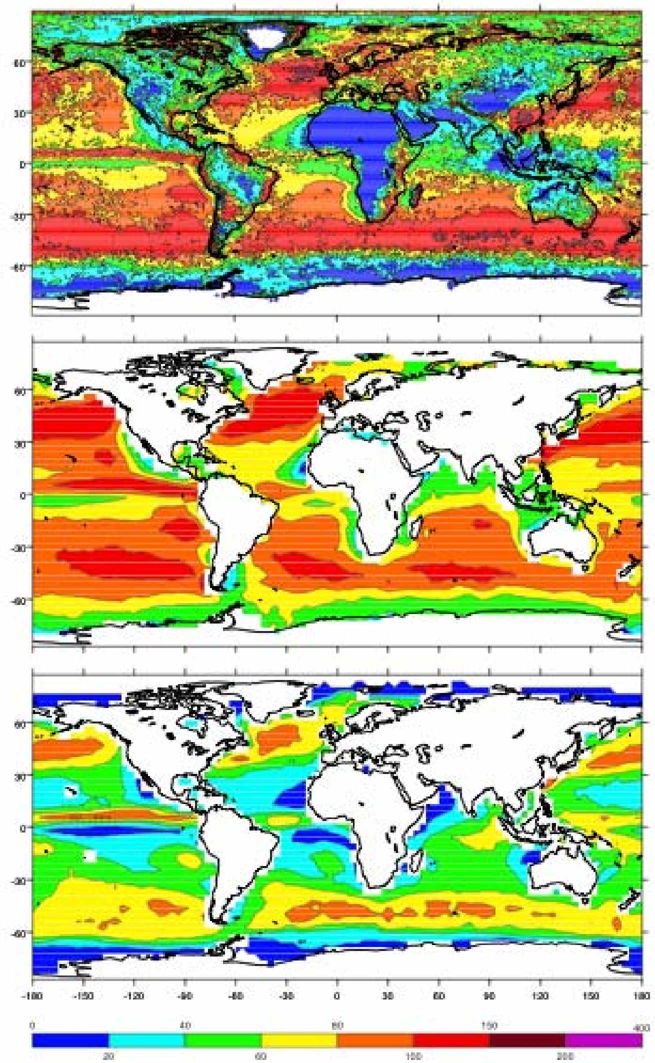
A set of controlled experiments was used to compare models and to define which aspects of models need better quantification

- **Each experiment allows more and more flexibility to choose the model group's own methods**
  - **First model runs are with a specified distribution aerosols; a specified affect of aerosols on droplet number and no effect of aerosols on precipitation efficiency**
  - **Final model runs with common aerosol sources, but each group chooses their own preferred method for aerosol/cloud interactions including precip efficiency**

Why is the aerosol/cloud problem difficult? Satellite observations are not accurate enough to constrain clouds in climate models:

Observed cloud liquid water path (g/m^2) is poorly known so it is difficult to improve the models.

Clouds reflect 54 W/m^2, so a small change from aerosols can have a large forcing impact

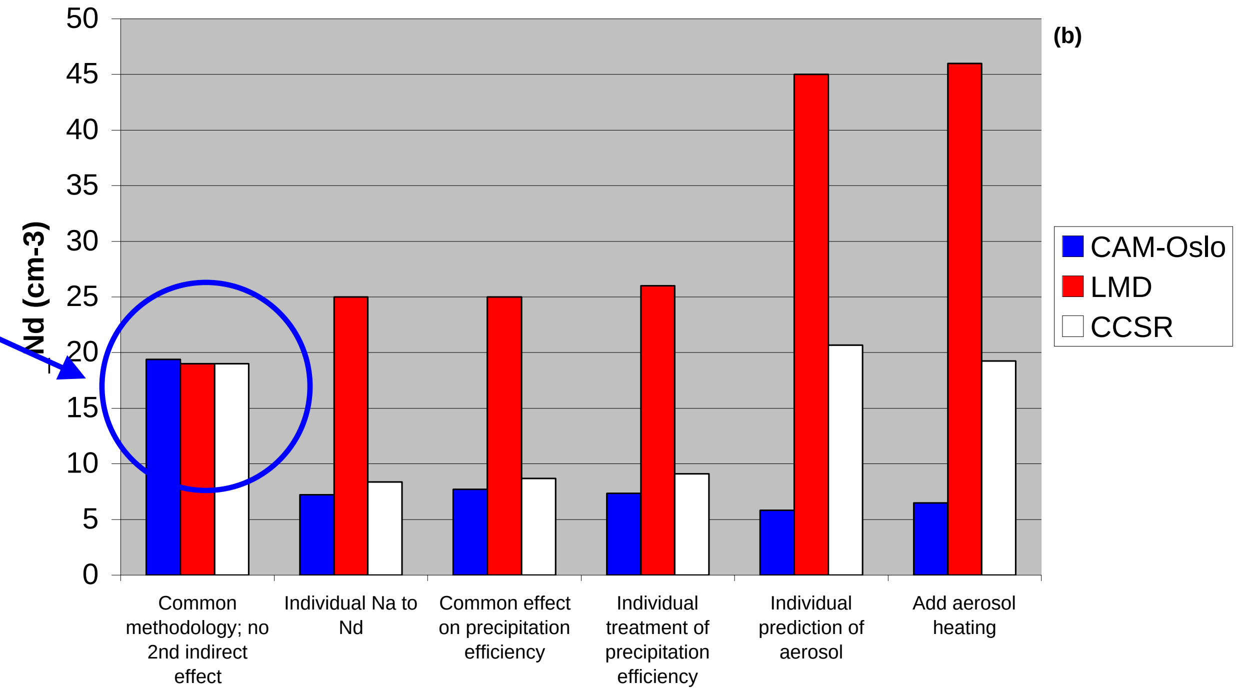


MODIS:
Mean LWP = 66.8 g/m2

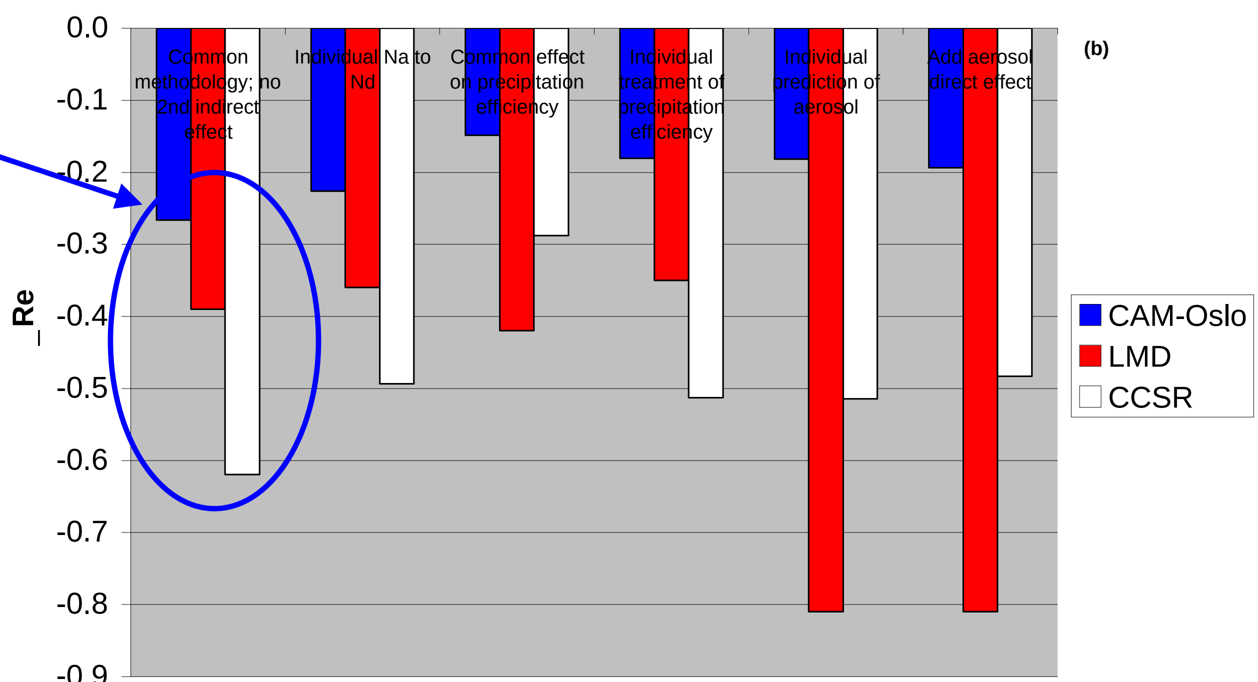
SSMI:
Greenwald et al.
Mean LWP = 78.7 g/m2

SSMI:
Weng and Grody,
Mean LWP = 47.9 g/m2

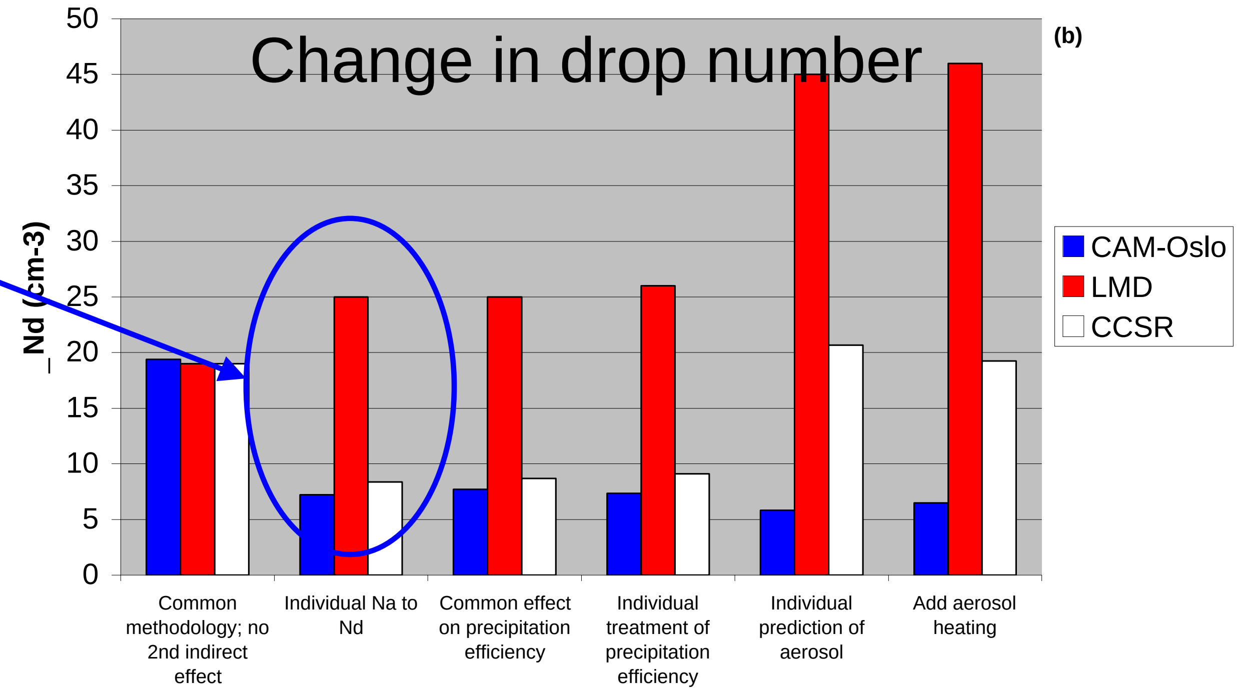
Droplet number concentration is nearly the same in the first experiment



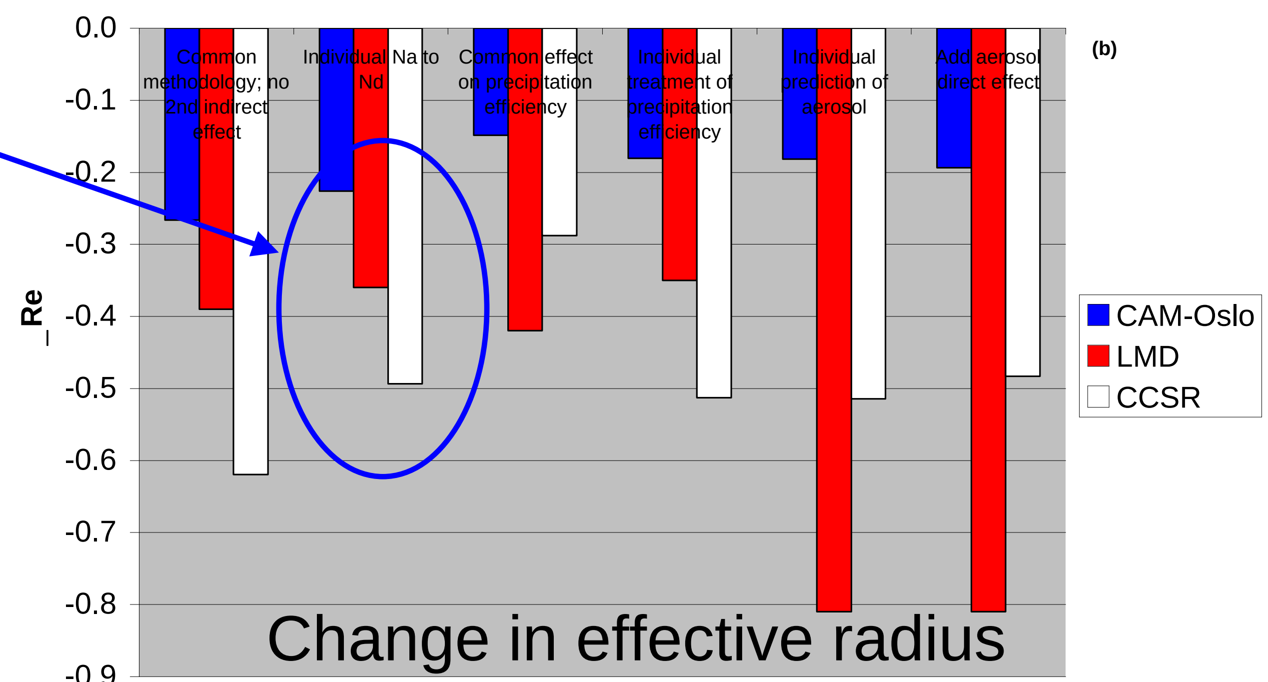
Differences in predicted radius change associated with different amounts of liquid water



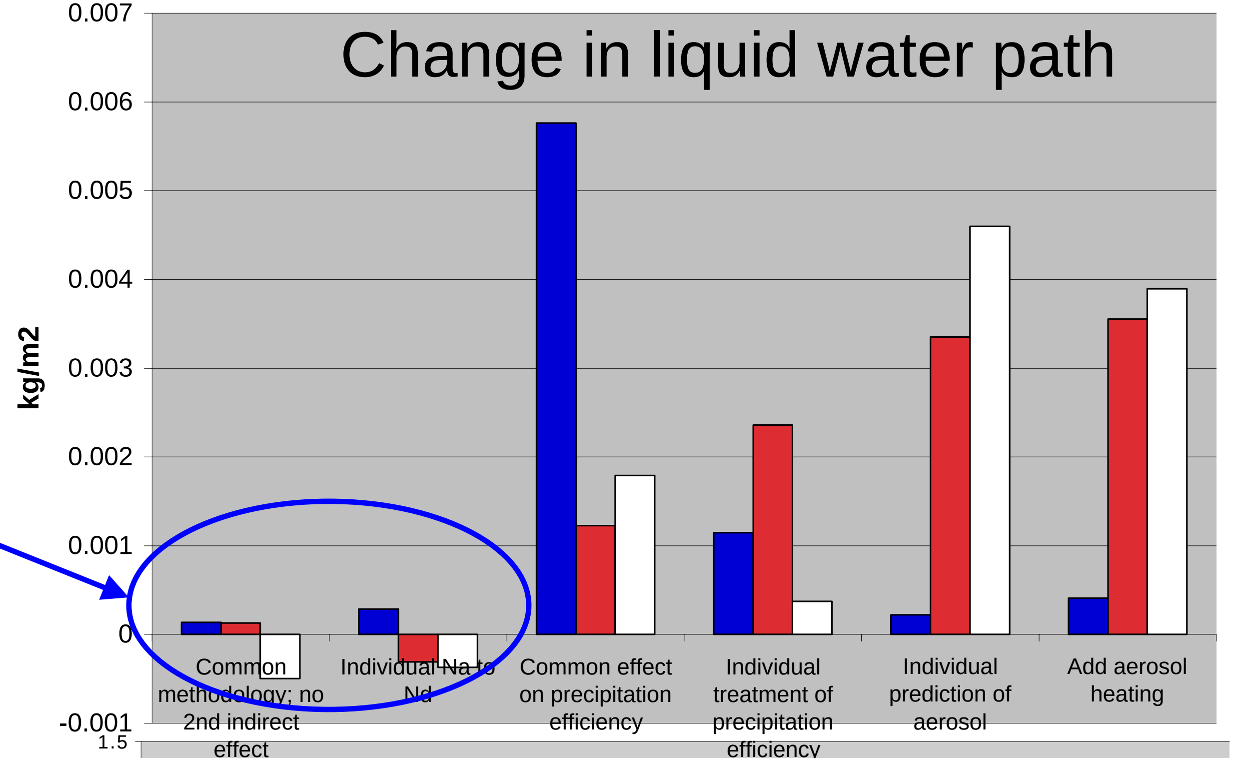
Each model uses their own parameter-ization



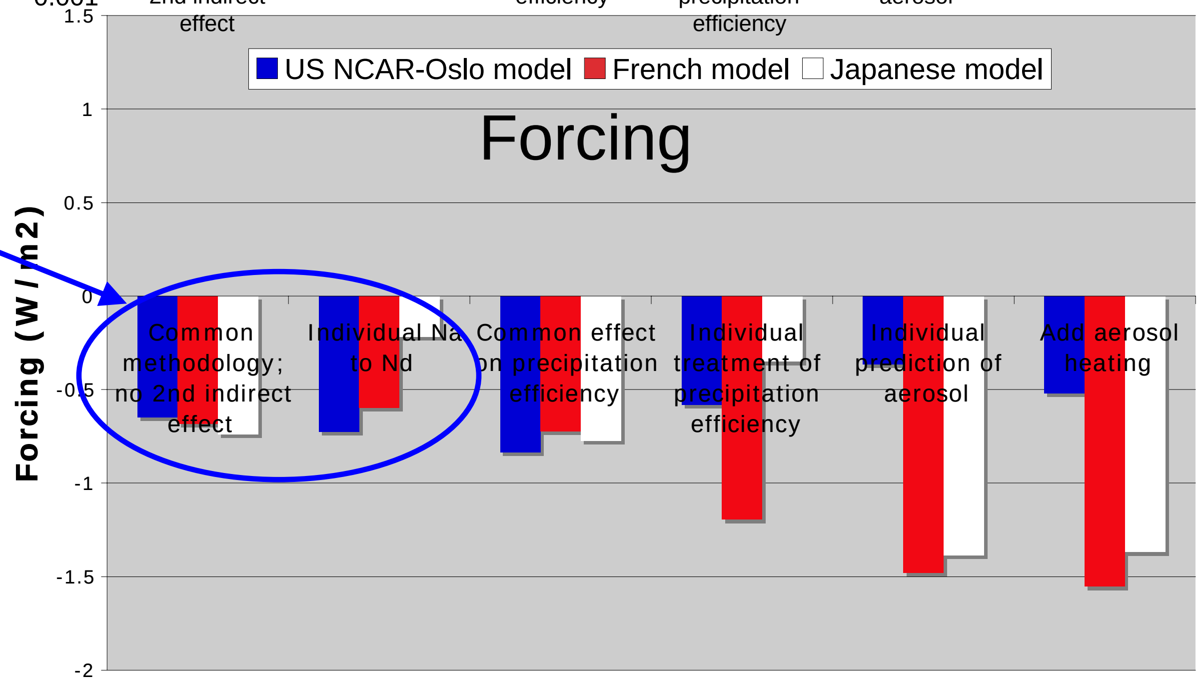
Introduces somewhat smaller changes in droplet radius



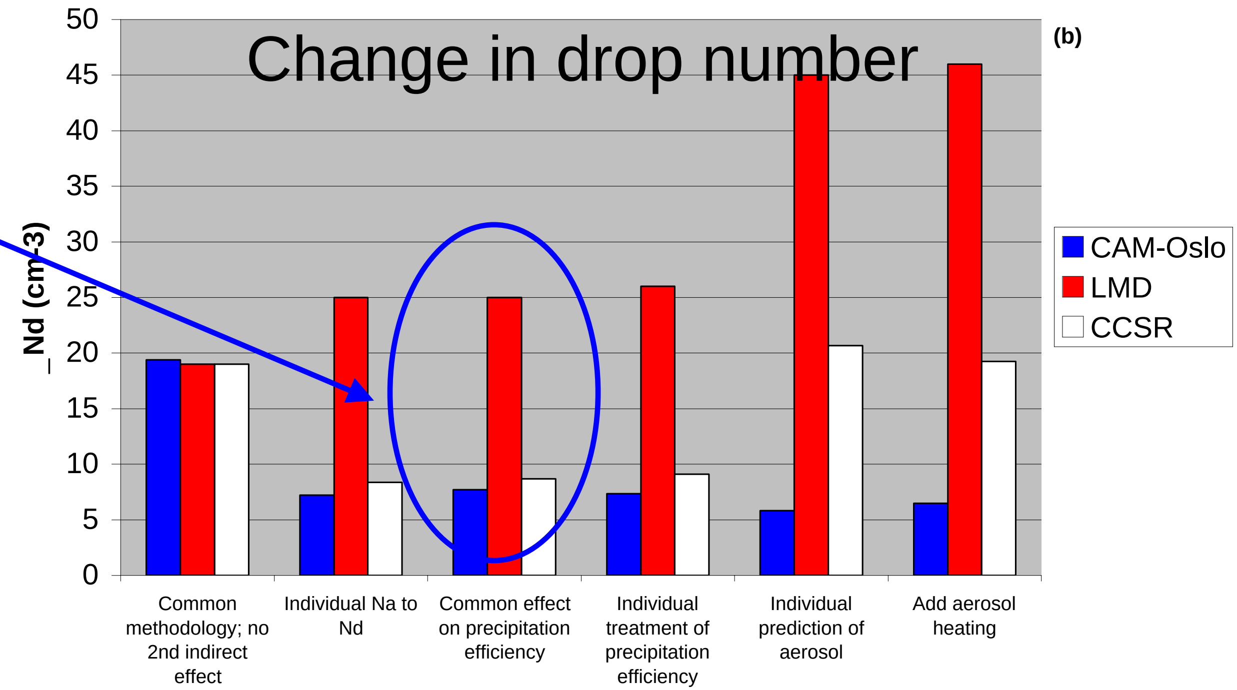
No change in LWP since no change in precipitation efficiency



Forcing is nearly identical in 1st experiment, while differences in 2nd are due to param. differences of 1st indirect effect

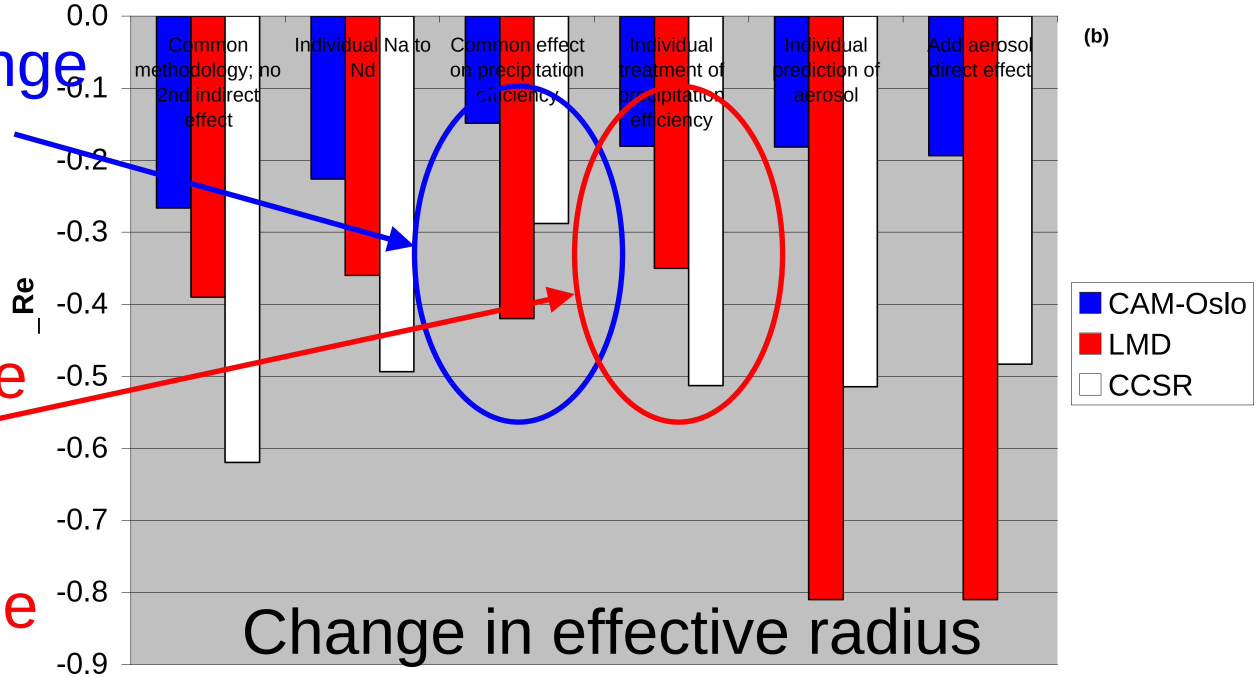


Effect of aerosols on precipitation efficiency introduced



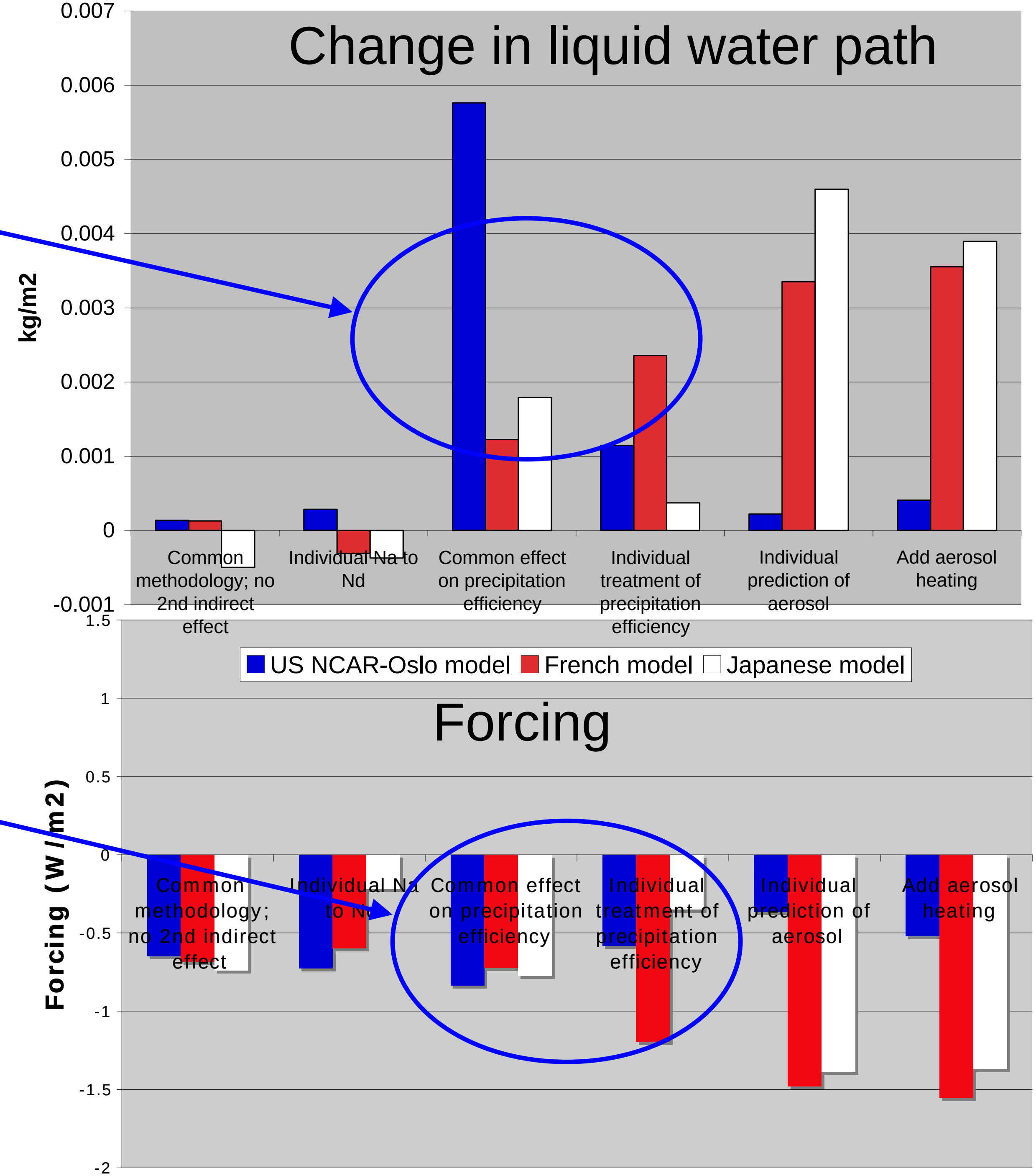
Effective radius change is due to changes in liquid water content

Effective radius change responds differently when no common autoconversion scheme



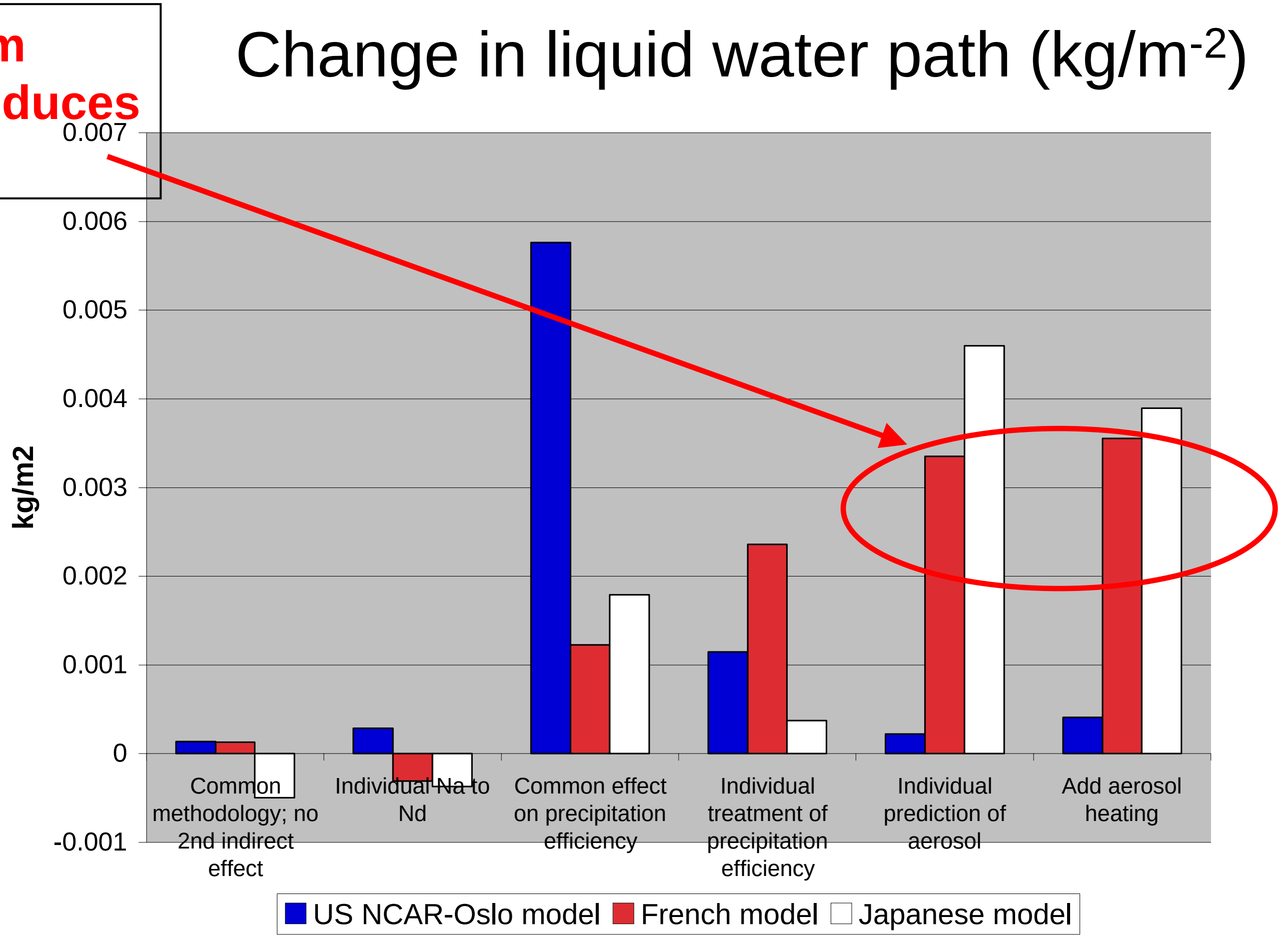
Large changes in LWP when introduce effective of aerosols on precipitation efficiency

Differences in forcing are significant



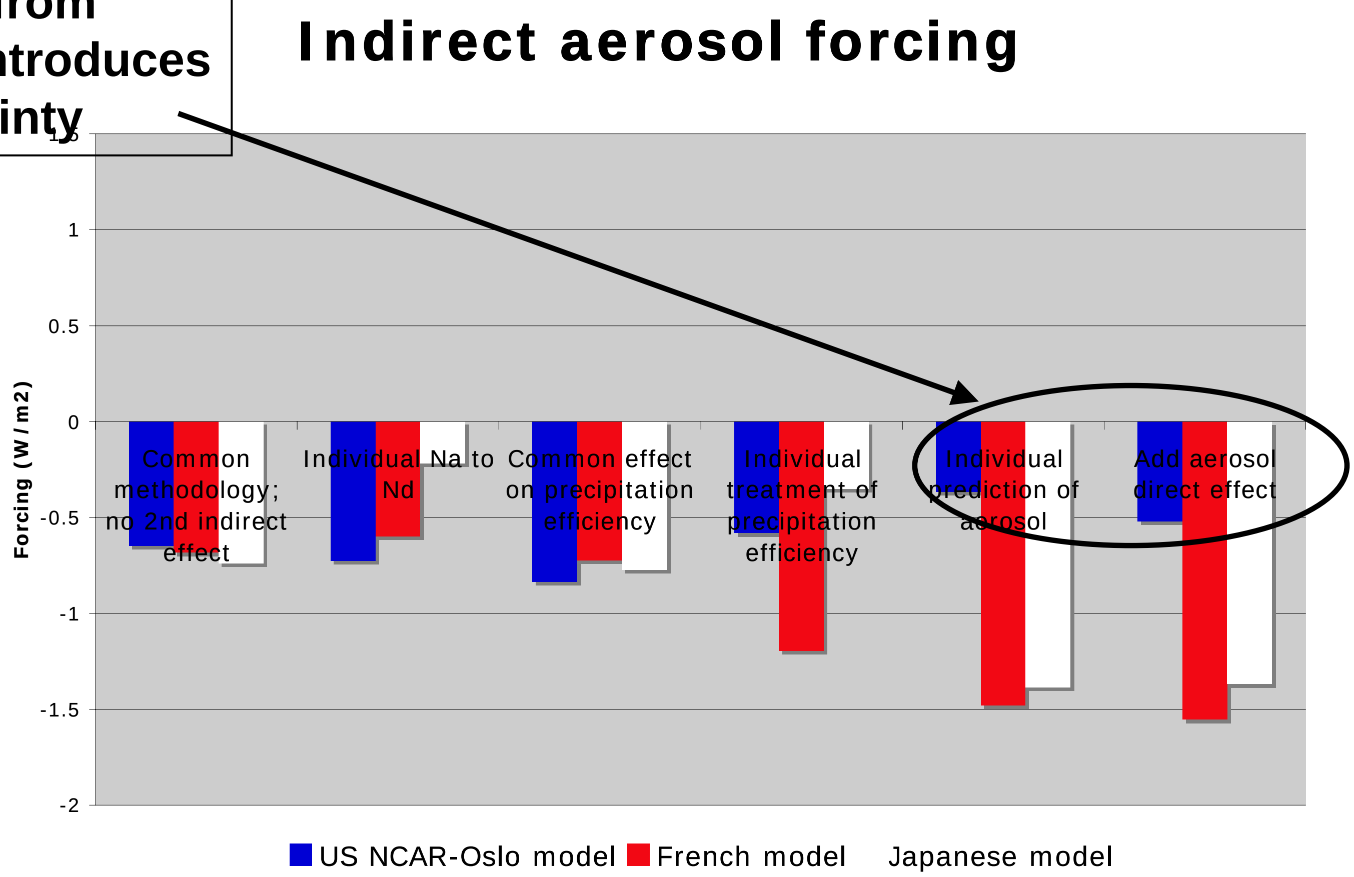
The larges differences are introduces when models attempt to predict aerosols:

Modeling aerosols from common sources introduces large uncertainty



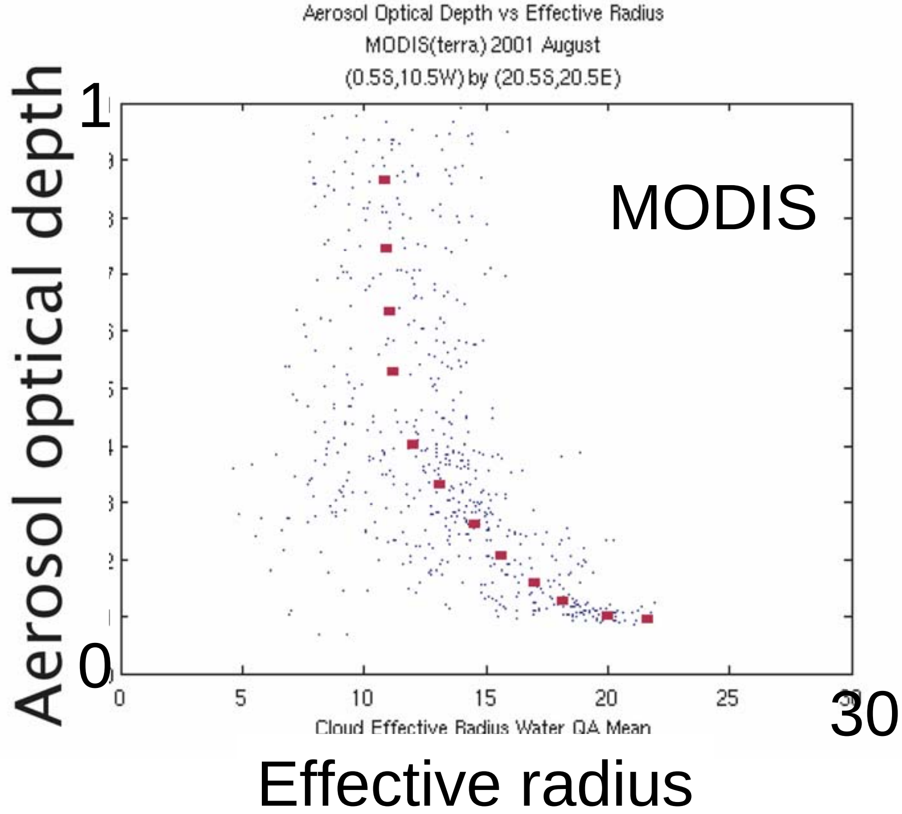
These uncertainties translate into the largest uncertainties in indirect forcing

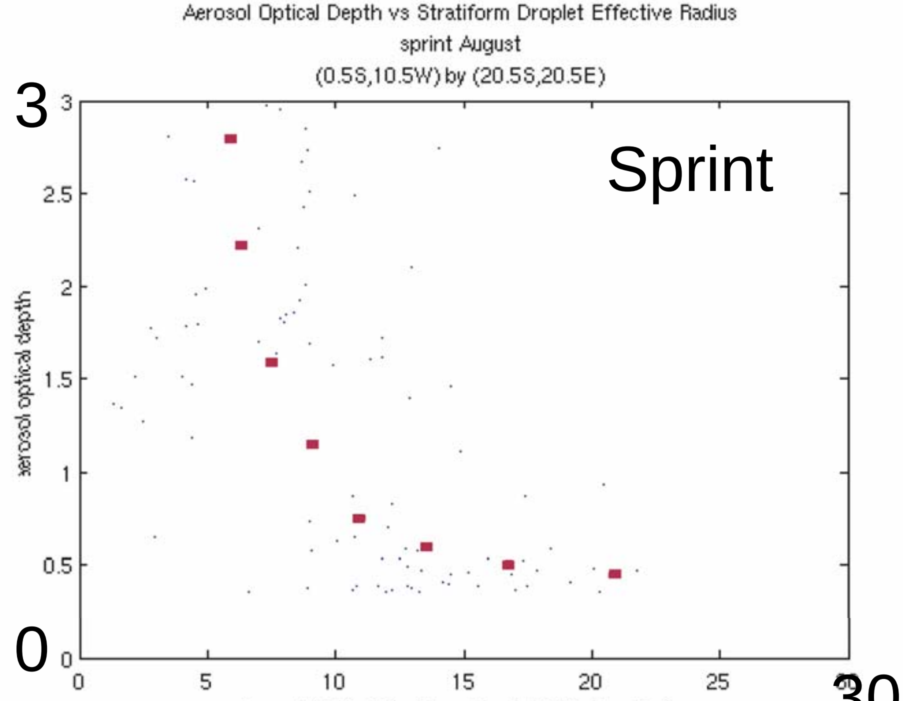
Modeling aerosols from common sources introduces even larger uncertainty

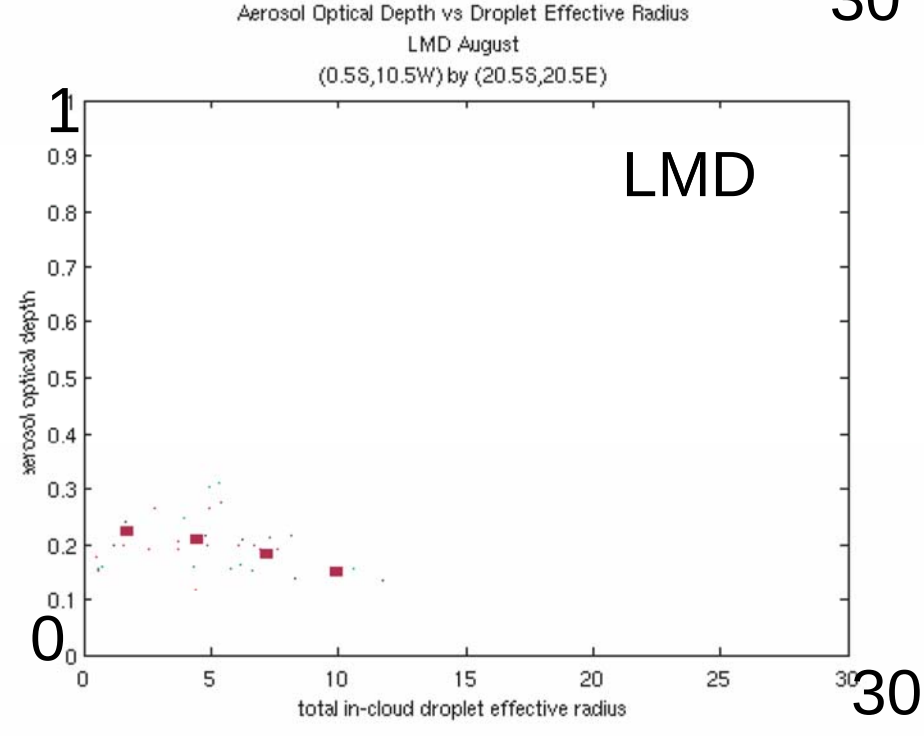


Can we differentiate which model is right?

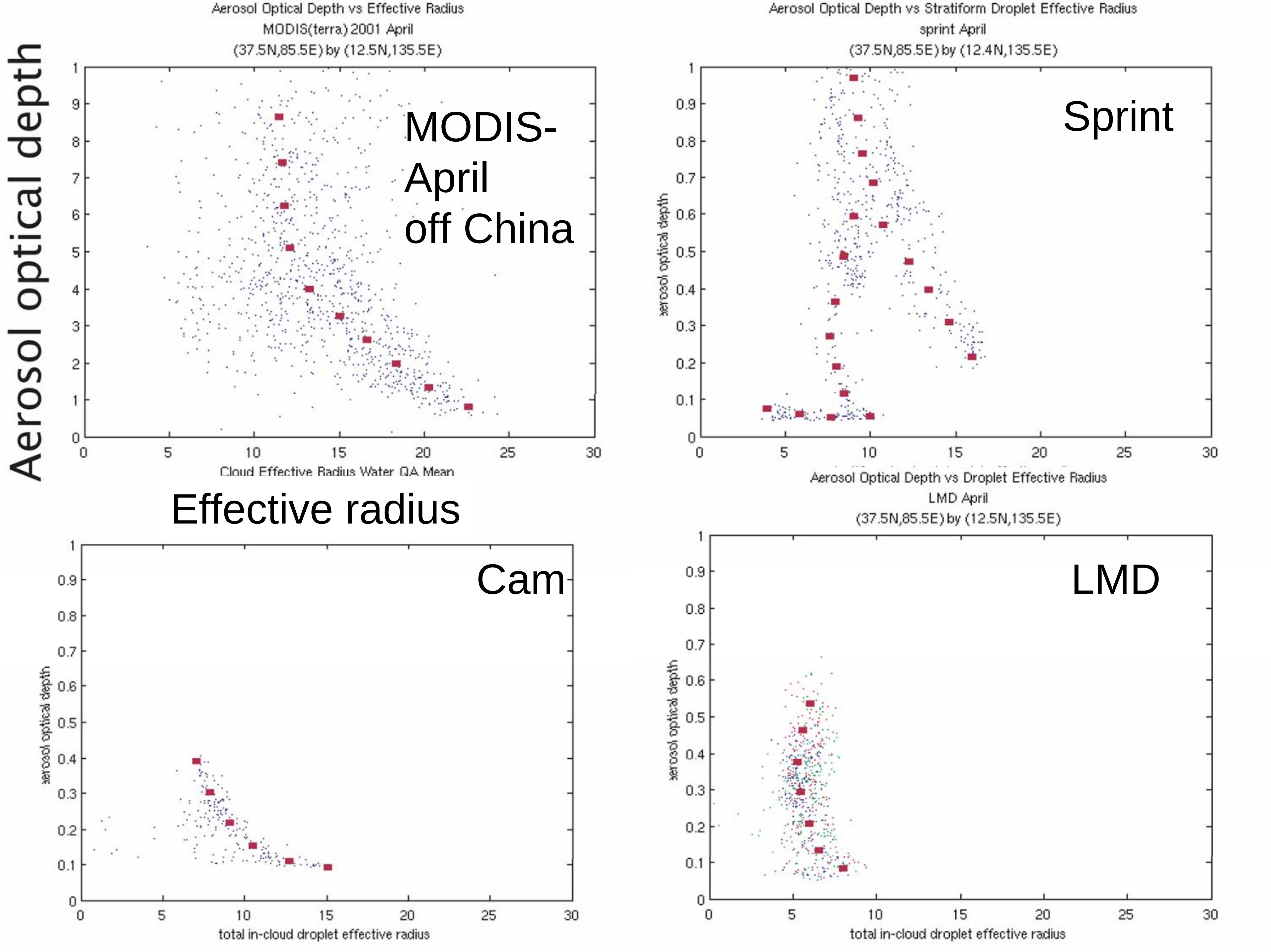
- Strategy:
  - Compare model effective radius vs aerosol optical depth from MODIS and models
  - Examine different regions
  - Current model results: monthly average (over 5 years simulations)
  - MODIS data: daily product







Comparison of aerosol optical depth vs effective radius off of Africa in August (biomass)



Aerosol optical depth
Effective radius
Aerosol Optical Depth vs Effective Radius
MODIS(terra) 2001 April
(37.5N,85.5E) by (12.5N,135.5E)
MODIS-
April
off China
Cloud Effective Radius Water QA Mean
Aerosol Optical Depth vs Stratiform Droplet Effective Radius
sprint April
(37.5N,85.5E) by (12.4N,135.5E)
Sprint
aerosol optical depth
Cam
aerosol optical depth
total in-cloud droplet effective radius
Aerosol Optical Depth vs Droplet Effective Radius
LMD April
(37.5N,85.5E) by (12.5N,135.5E)
LMD
aerosol optical depth
total in-cloud droplet effective radius

Next steps

- We need to develop the right observations and use these to improve and constrain the models (aerosol optical depth vs effective radius?).

- Could re-run intercomparison giving modelers a new ISCCP simulator that gives “proper” effective radius and cloud optical depth as satellite would sample them

- Better quantification of the vertical aerosol distribution (Calypso) and cloud distribution and water path (Cloud Sat) could be used to improve the models