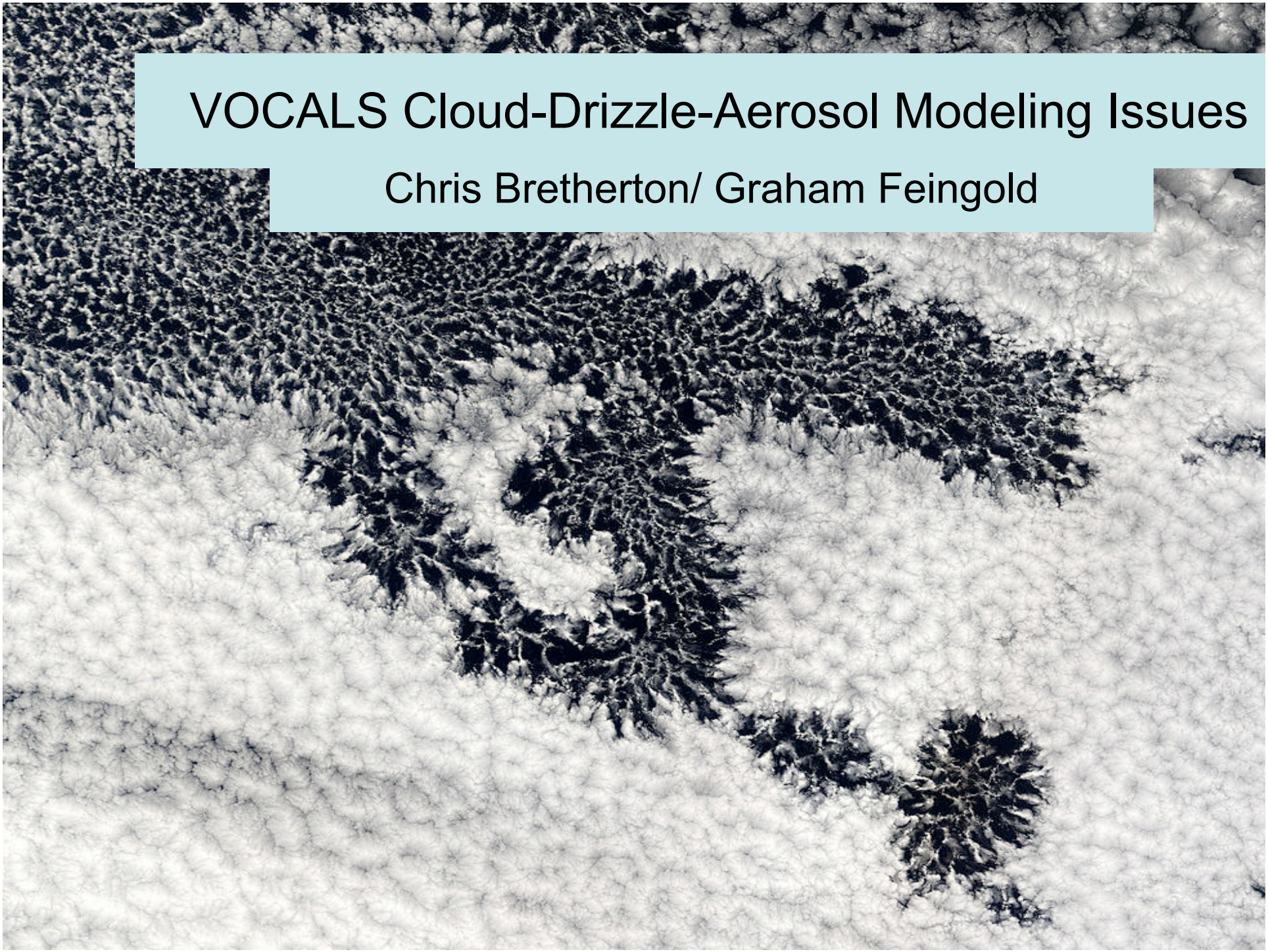
VOCALS Cloud-Drizzle-Aerosol Modeling Issues

Chris Bretherton/ Graham Feingold



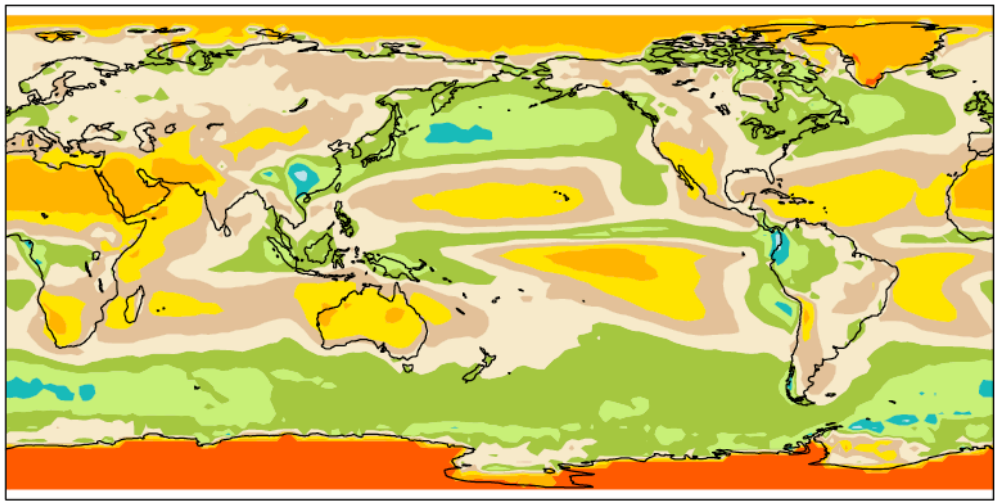
Model readiness/strategies for C-D-A goals

- Can AGCMs simulate stratocumulus-topped boundary layers well enough for better microphysics to matter?
- Can AGCMs simulate the SEP diurnal cycle and synoptic variability of subsidence and Sc?
- Are AGCM microphysical and cloud fraction parameterizations adequate for Sc drizzle?
- Can LES with bulk or bin microphysics simulate the transition in mesoscale structure in POCs that we think is associated with low N_d and more drizzle?
- Can LES make useful quantitative predictions of cloud LWP/area/drizzle over the full diurnal cycle?
- Are we ready for to model the C-D-A data we can hope to get from REx? What data would we need to make a good POC test case for a large-domain LES?

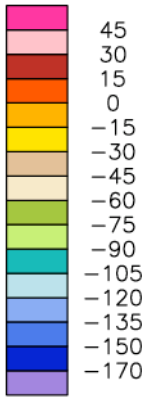
AGCMs can (imperfectly) simulate Sc-topped boundary layers

CERES

TOA SW cloud forcing mean= −48.59 W/m²



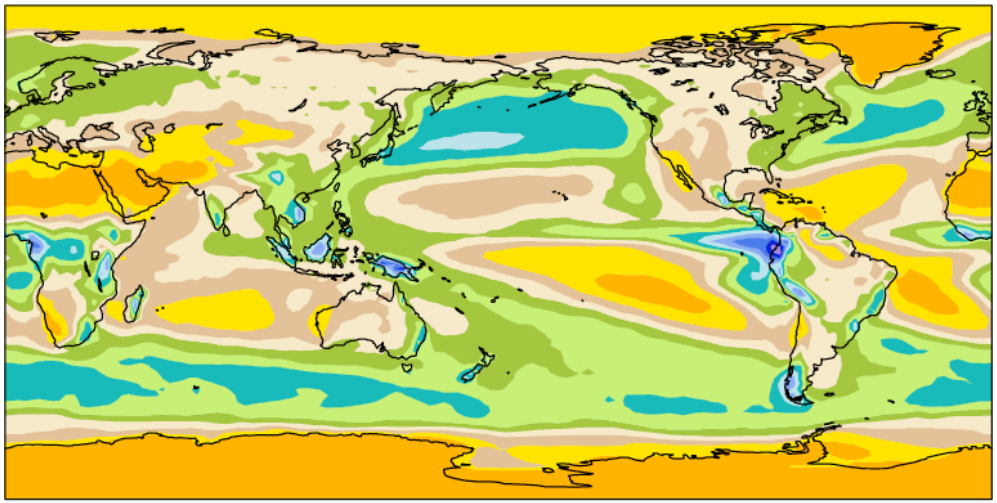
Min = −110.85 Max = 15.74



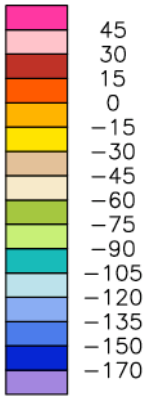
S027 (yrs 1-5) CAM-UW

ANN

TOA SW cloud forcing mean= −56.53 W/m²



Min = −184.68 Max = −1.47



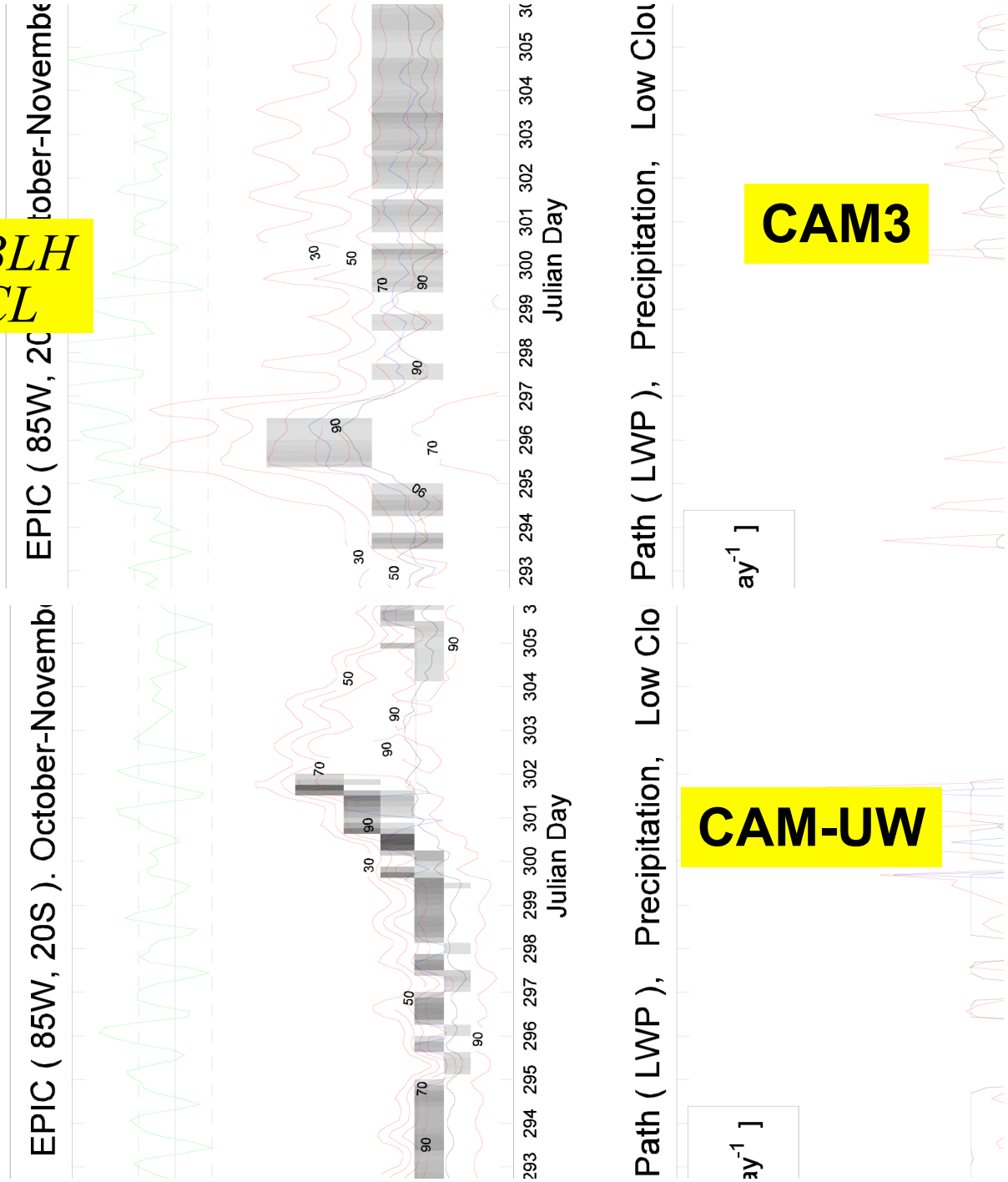
Park/Breth UW

AGCMs do simulate SEP diurnal cycle

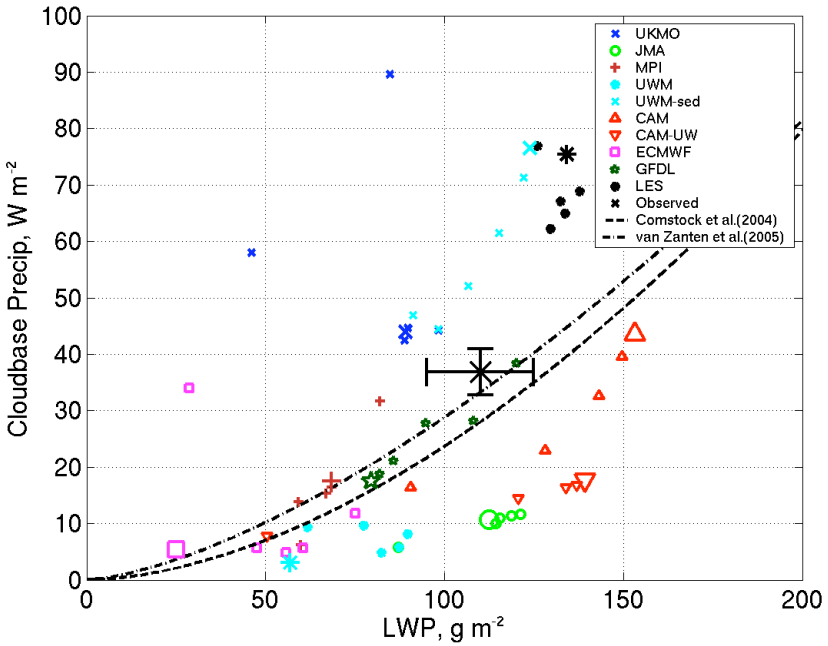
50 [hPa day^{-1}] ↕

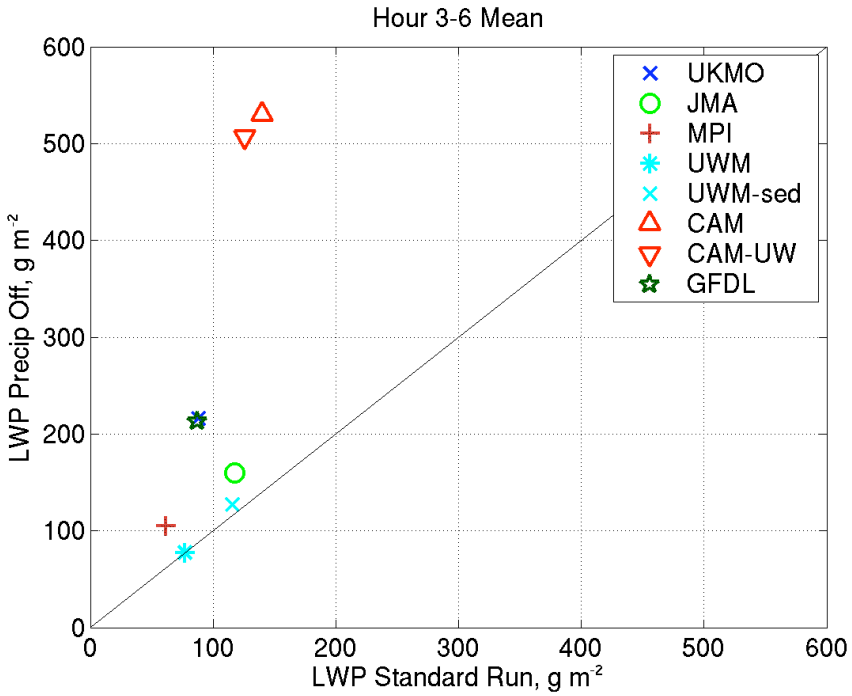
$\omega_{\sigma = 0.86}$ $PBLH$
RH LCL

Park and Breth, UW



GCSS DYCOMS RF02 intercomparison: GCM Sc microphys in ballpark but lots of scatter





As in regional/global models, SCM cloud thickness significantly reduced by drizzle

Do comparisons in forecast/analysis (not climate) mode

Bacmeister:

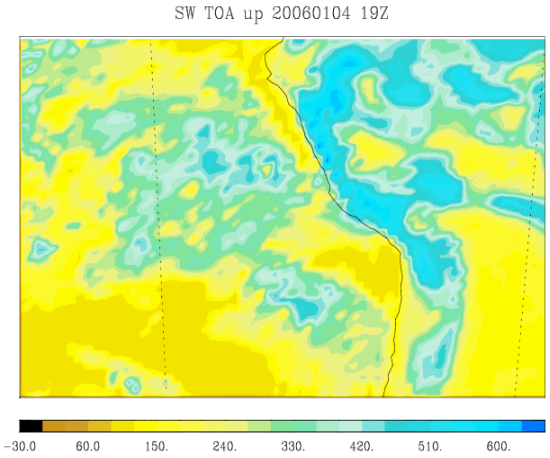
SEP Cloud fields and cloud processes in analyses should be examined in detail – including day-to-day variations, vertical structure, PBL and cloud physics tendencies. Analysis tendencies/increments may provide information about deficiencies in physics.

An analysis system could provide a testbed for parameterizations of cloud processes - including aerosol indirect effects:

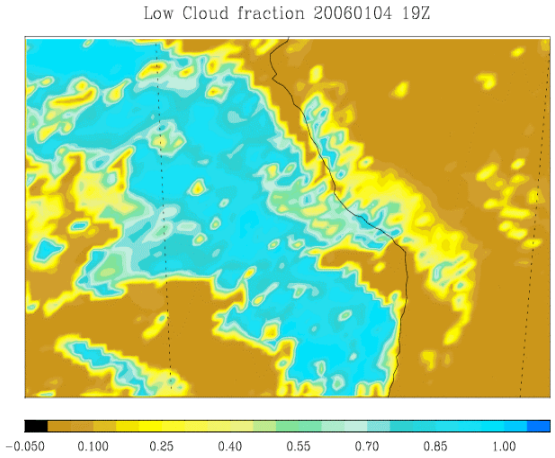
- Possibly “fairer” test than unconstrained climate run.
- Meaningful direct comparisons with high-frequency satellite or in-situ data, e.g., CloudSat, VOCALS REx.

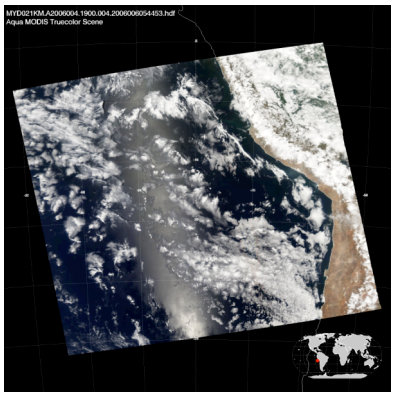
GEOS5 Analyzed cloud fields compared with MODIS images

Jan 4 2006 1930Z



Wm^{-2}





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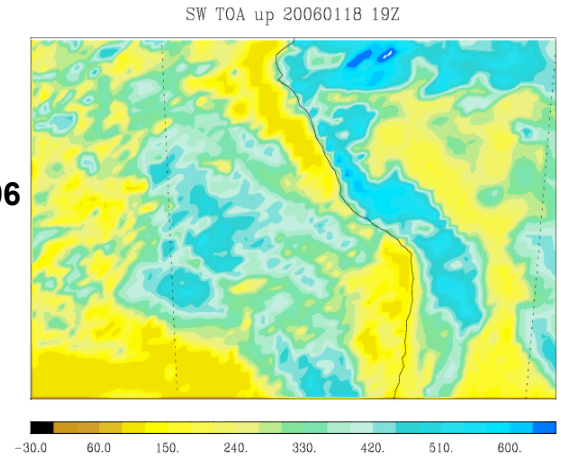
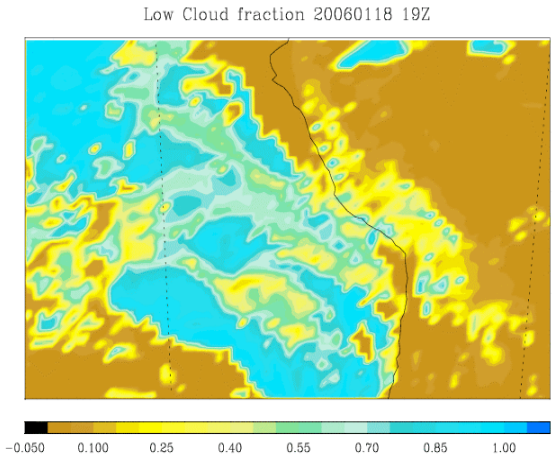
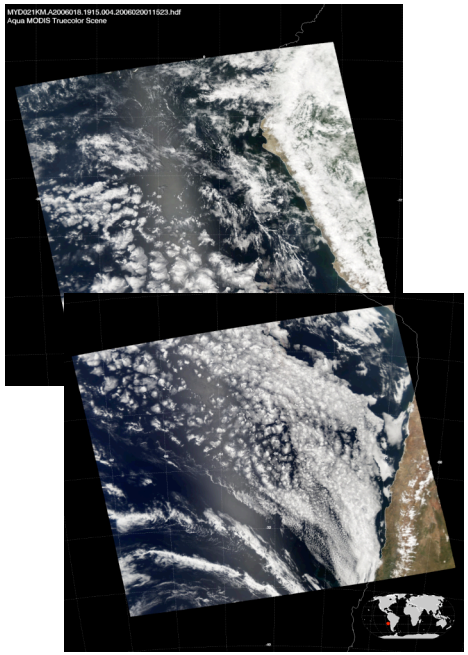


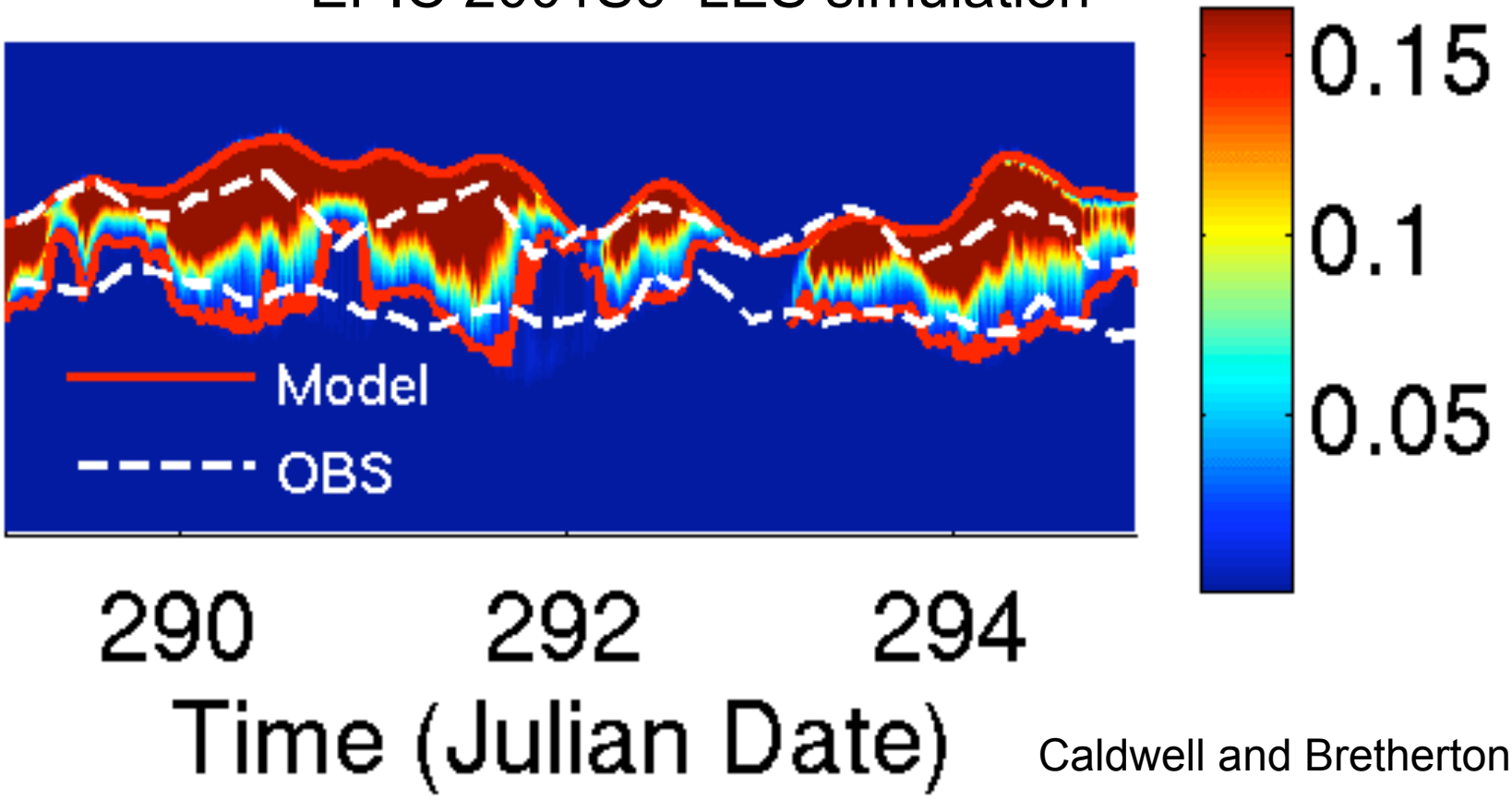
Wm^{-2}



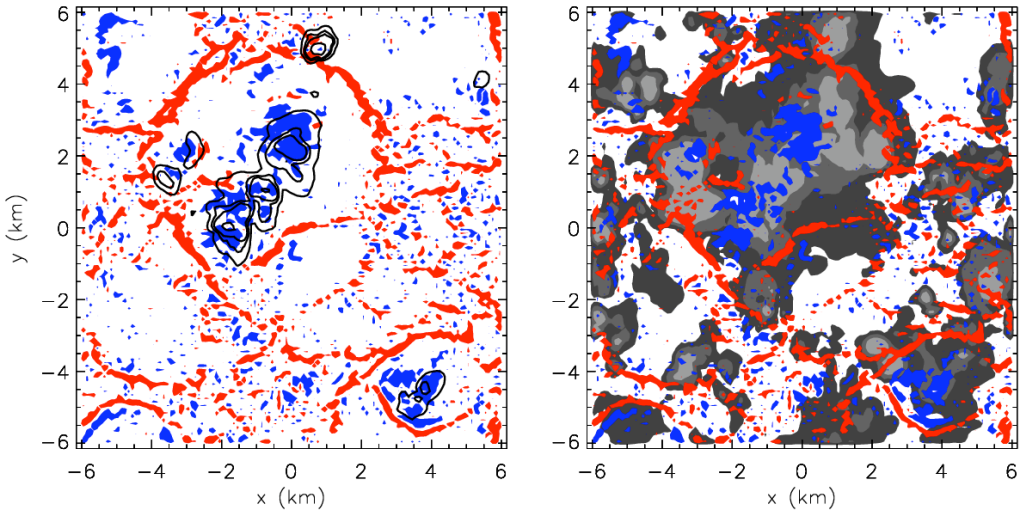


LES models can simulate SEP diurnal cycle
...but not without challenges

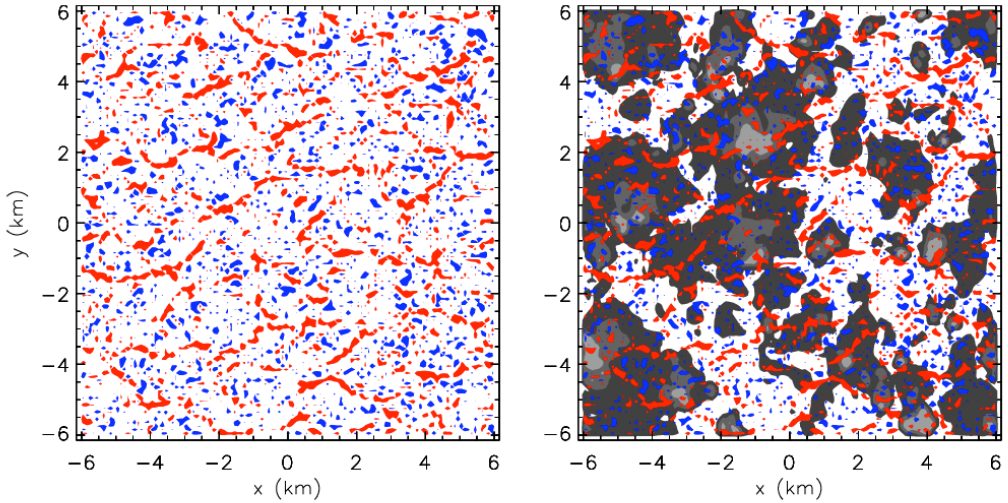
EPIC 2001Sc LES simulation



Caldwell and Bretherton



Na=25/cc: drizzle, open cells



Na=100/cc: no drizzle: open cells less prominent

Feingold

Thoughts

- Many climate/regional models do capture stratocumulus well enough for addressing cloud-drizzle-aerosol processes, and have skill with the SEP diurnal cycle.
- LES are able to reproduce a transition to open-cell structure (POCs) associated to drizzle when cloud-droplet concentrations are low.
- However, which models have skill in predicting Sc properties in specific places on specific days, and their relationship to synoptic aerosol and dynamical variability, is much less clear. This is a critical issue for comparing models with REx observations.