CAM-CLUBB-SILHS simulations of the diurnal cycle of precipitation over CONUS

Vincent Larson, Peter Bogenschutz, Andrew Gettelman, Brian Griffin

2017 ASR Meeting

A major goal of the CMDV-MCS project is to produce a version of ACME that propagates MCSs eastward over CONUS

This will require an intensive and targeted effort.

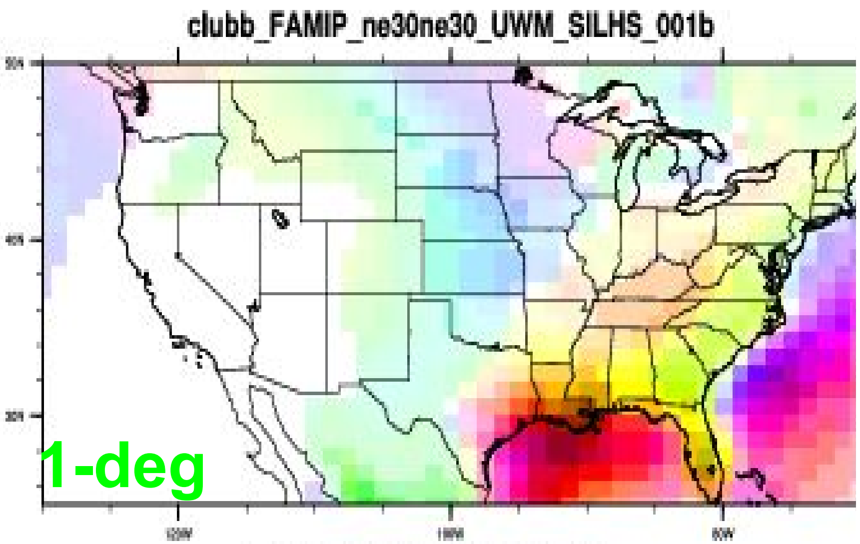
Where do we stand now?

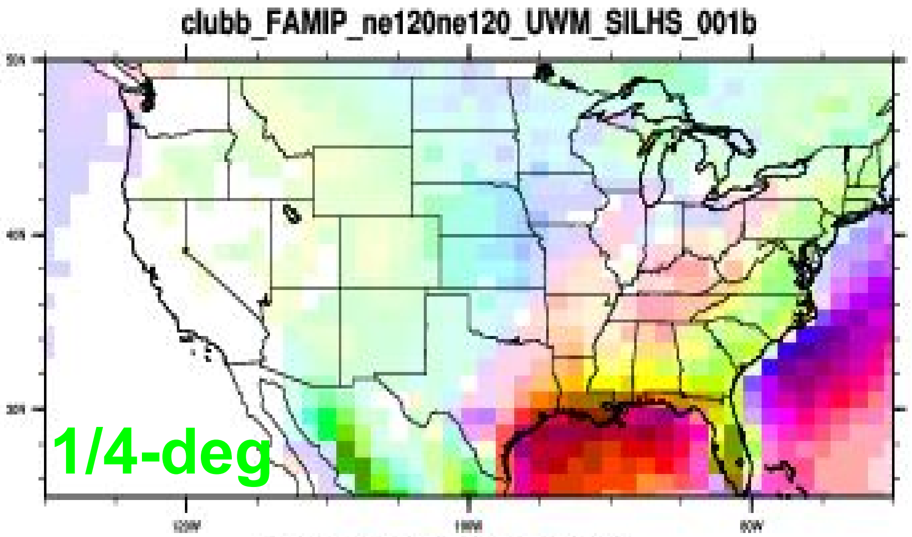
Let’s look at a simulation from a climate model that lets CLUBB go deep.

Model configuration of our CAM-CLUBB-SILHS-MG2 simulations:

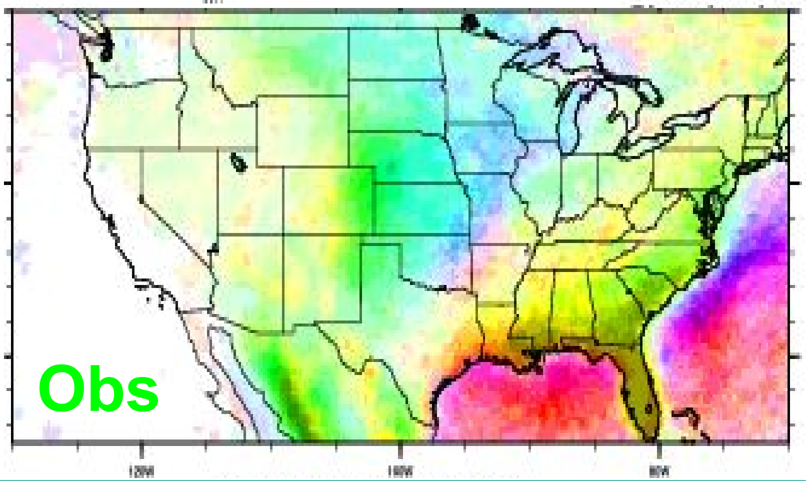
Cloud parameterization	CLUBB (ZM is disabled)
Microphysics	MG2
Interface between clouds and microphysics	SILHS
Resolution	Uniform 1 degree (“lo res”) or quarter-degree (“hi res”)
Physics (aerosol and radiation) time step	30 min (1 degree) or 15 min (¼ degree)
CLUBB and MG2 time step	5 min for both resolutions
Ocean boundary condition	AMIP (prescribed, time-varying SST)

Diurnal cycle of rain in JJA shows hints of the correct pattern, but the signal is weak:





Precip shows nighttime max over central US



How could we improve the diurnal cycle in the future?

Perhaps tweaking CLUBB’s “cold-pool physics” would help.

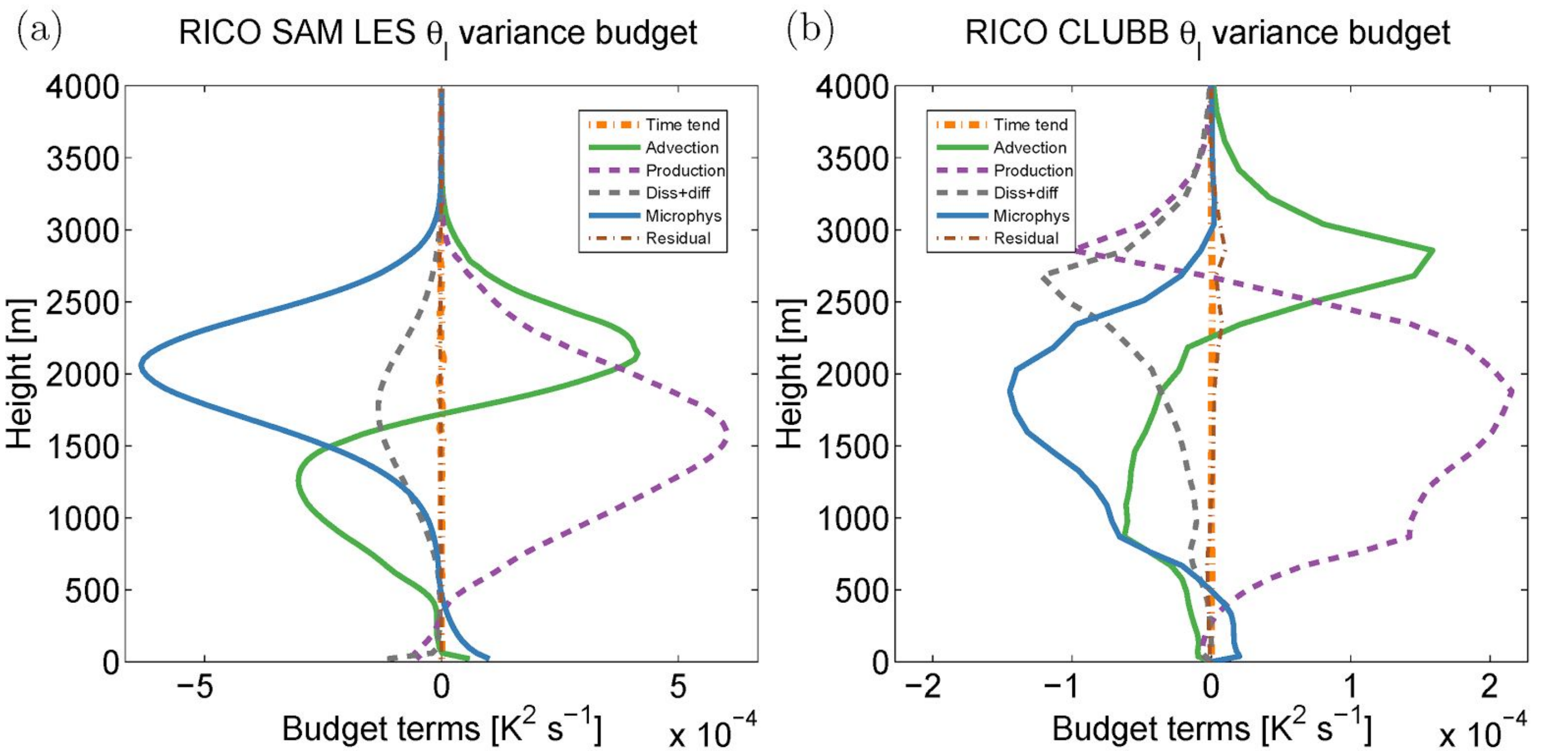
CLUBB (but not ACMEv1) now includes microphysical effects on variances:

$$\frac{\partial \overline{\theta_1'^2}}{\partial t} = \underbrace{-\frac{1}{\rho_s}\frac{\partial \rho_s \overline{w}\,\overline{\theta_1'^2}}{\partial z} - \frac{1}{\rho_s}\frac{\partial \rho_s \overline{w'\theta_1'^2}}{\partial z}}_{\text{advection}} \underbrace{-2\,\overline{w'\theta_1'}\frac{\partial \overline{\theta_1}}{\partial z}}_{\text{production}}$$

$$\underbrace{+\varepsilon_{\theta_1\theta_1}}_{\text{diss+diff}} \underbrace{+2\,\overline{\theta_1'\left.\frac{\partial \theta_1}{\partial t}\right|'_{\text{mc}}}}_{\text{microphysics}}, \text{ and}$$

Griffin and Larson (2016)

With the right correlations, evaporation can increase sub-cloud temperature variance, i.e. generate cold pools:



Griffin and Larson (2016)

CLUBB doesn't include an explicit parameterization of spatial organization, but neither does "org"

The org of Mapes and Neale (2011) changes the feedbacks and timing of convection, but whether the convective structure is a squall line or supercell is neither an input or output.

Rather, org is a "time-lagged but positive feedback on deep convection development" (Mapes and Neale 2011).

This time-lagged feedback can be parameterized in a PDF framework as well.

How could we diagnose problems in ACME's ability to propagate MCSs?

Problems may occur far upstream of the ARM site in Oklahoma.

We need to be able to compare with a benchmark, i.e. the "correct" answer. I.e., should we compare with re-analysis data, a WRF regional simulation, and/or a variable-resolution ACME simulation?

We need to be able to look at mechanisms in detail.

We need to be able to modify the model code and re-run quickly.

Should we set up one or more cases using CAPT or nudging?

A short case would be quick to run.

Re-analysis or a high-res simulation would tell us the “correct” solution.

Conclusions

- CLUBB now has some cold-pool physics in it, but to generate cold pools, CLUBB needs to have rain fall in cool air.

- To understand why eastward propagation of MCSs is weak, we need some good test cases.