Improving the Representation of Turbulence and Clouds in Coarse-Grid Cloud Resolving Models

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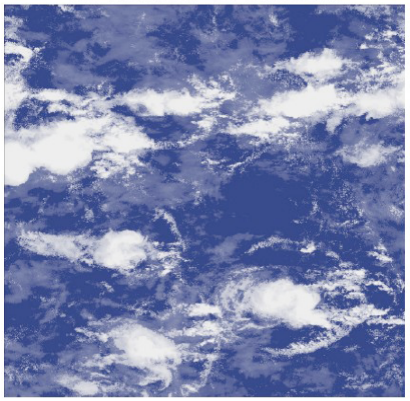
Who I am

- PhD student at University of Utah (2010)
- M.S. from Florida State University (2005)
- B.S. from Embry-Riddle Aeronautical University (2002)
- From the sticks (Kentucky, yeeeee-haw!)
- Medium-core outdoors enthusiast
- Enjoy the cheaper things of life (beer, food, ice cream, etc.)

A Tale of Two Simulations

LES "visible image" 180 km x 180 km



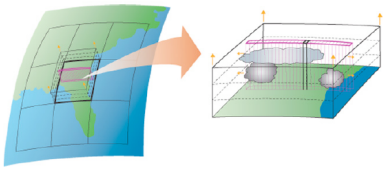
Expensive Simulation

"Grad Student Salary" Simulation

Clouds In Climate Models

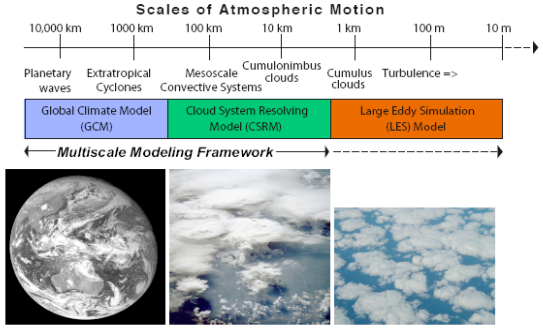
- Importance of clouds in the climate system cannot be overemphasized
- General circulation models have horizontal grid spacings ~ 100 km
- Convection cannot be resolved at these coarse grid spacings
- Superparameterization attempts to explicitly represent the subgrid scale features

Multiscale Modeling Framework



What Could Go Wrong?

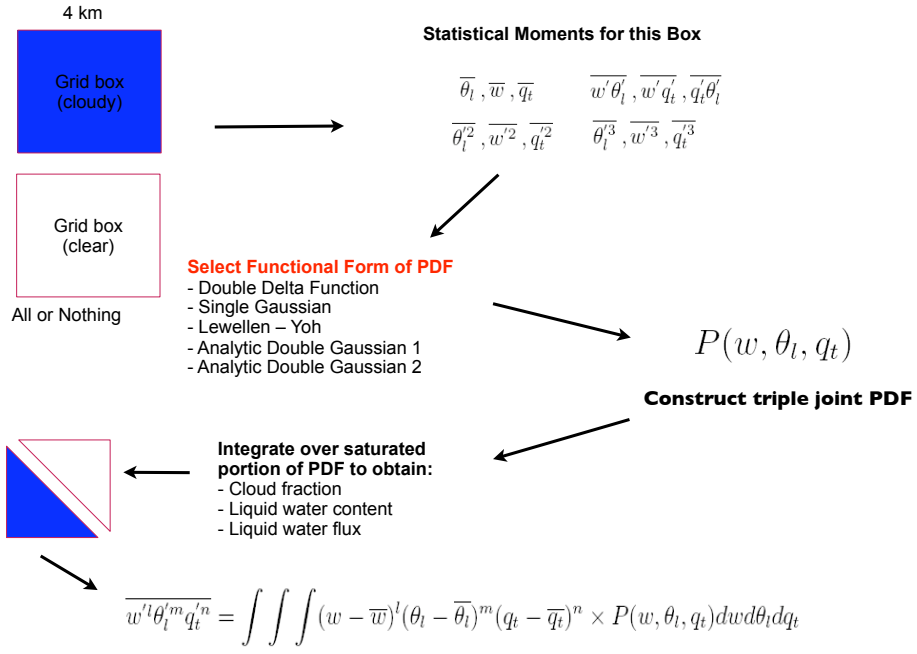
- Current computation limits what embedded CRMs can resolve
  - Embedded CRM currently has horizontal resolution of 4 km
- All scales of motion are NOT being resolved



Improved Parameterizations for Coarse Grid CRMs

- Shallow convection not represented with 4 km horizontal grid spacing
  - Embedded CRM in MMF (SAM) uses the "all or nothing approach"
- Improved parameterization should meet the following two criteria
  - Should be a unified parameterization
  - Should NOT be computationally expensive
- Focus on coarse grid CRMs. Possibly beyond...

Assumed PDF method



$$\overline{w'^l \theta_l'^m q_t'^n} = \int\int\int (w - \overline{w})^l (\theta_l - \overline{\theta_l})^m (q_t - \overline{q_t})^n \times P(w, \theta_l, q_t) dw d\theta_l dq_t$$

PDF Testing

- Extensive testing of assumed PDF performed (paper to be submitted this month)
  - Double Delta Function
  - Single Gaussian
  - Lewellen-Yoh
  - Analytic Double Gaussian I
  - Analytic Double Gaussian II
  - "All or Nothing Approach" (Single Delta Dirac)
- Range of grid volumes tested (0.2 to 204.8 km)
- Three cases tested from high resolution benchmarks
  - BOMEX (shallow convection)
  - Statocumulus to cumulus transition
  - Giga-LES (large domain deep & shallow convection, mesoscale organization)

Future Work

- Currently implementing Assumed PDF Method (Analytic Double Gaussian 1) into SAM
- Requires diagnostic/prognostic equations for the input moments
- Once complete, rerun the 100 m benchmarks at coarse resolution (3.2 km)
- Test in the MMF