Improving the Representation of SGS Turbulence and Clouds in Coarse-Grid CRMS

Or: What the heck does this mean???

Pete Bogenschutz
University of Utah

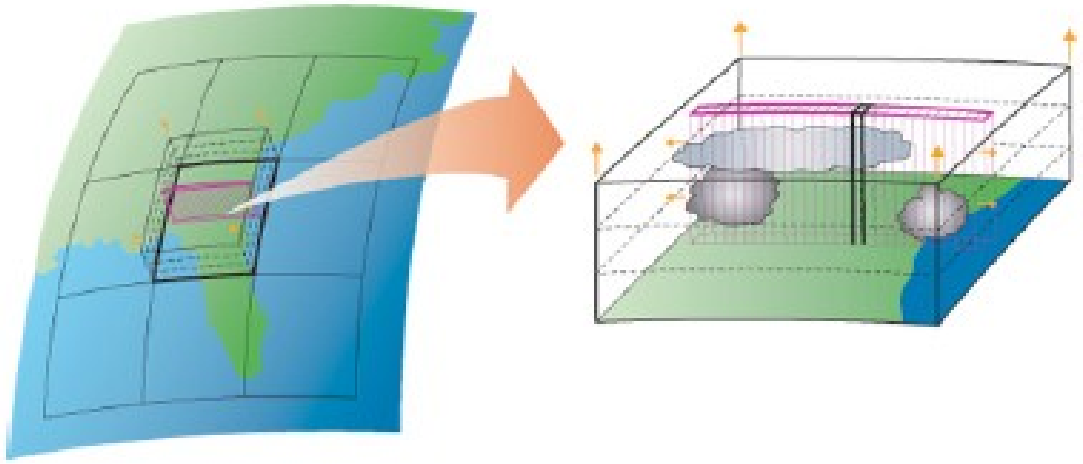
Fun Facts About Me

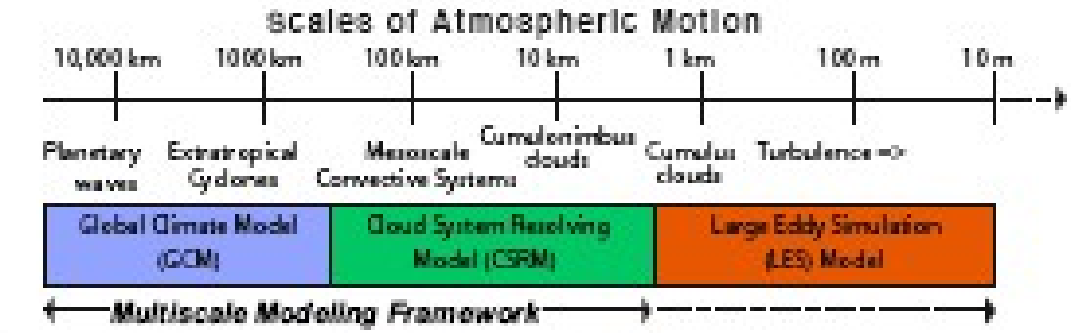
- PhD student at the University of Utah
- Working with Prof. Steven Krueger
- About to start my 12th year of college total (!!!!)
- Raised in Kentucky (yee-haw!), now living in Salt Lake City, via Florida for seven years
- Avid outdoors enthusiast (hiking, backpacking, camping, skiing, etc.)
- Connoisseur of all things cheap beer (PBR, nat. light, the beast etc.), cheap ice cream, fast food, and Bea Arthur

Research Interests

- Primarily interested in numerical modeling
- Florida State M.S. student: Mesoscale modeling (WRF) and object oriented verification
- PhD. Student: Large Eddy Simulation (LES) and Cloud Resolving Models (CRM)
  - University of Utah large Eddy Simulation (UU-LES)
  - System for Atmospheric Modeling (SAM)
  - Stratocumulus, shallow convection, deep convection

Multi-Scale Modeling Framework

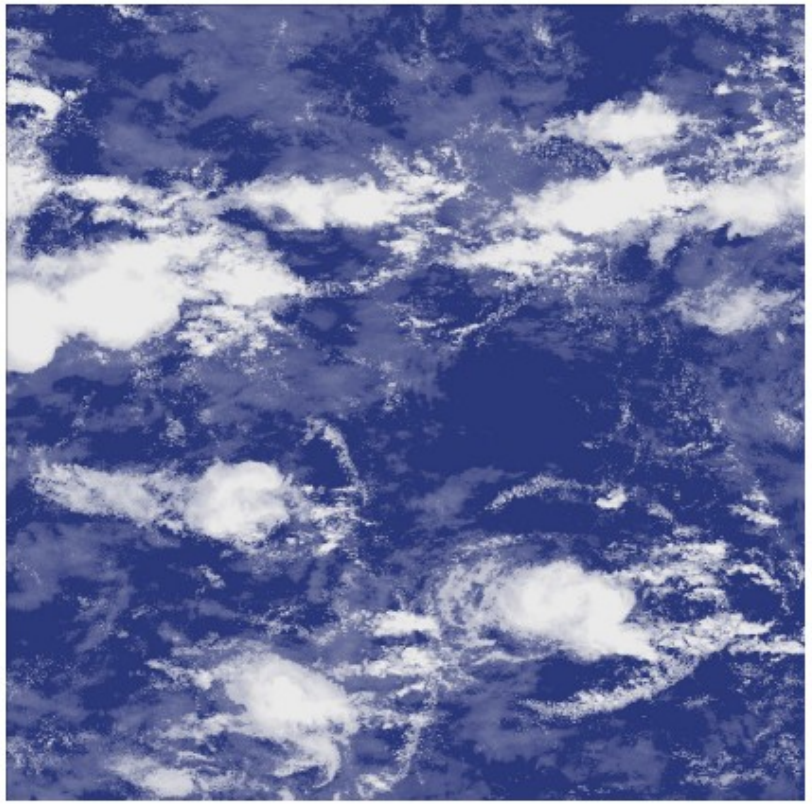




- CRMs and DCRMs are used in MMF, with horizontal grid sizes of 4 km or more
- In MMF, these are supposed to represent all types of cloud systems
- Many cloud-scale circulations are NOT resolved

But Wait...

LES "visible image" 180 km x 180 km



MISR visible image 380 km x 345 km
(west of Marshall Is., 11 March 2002)

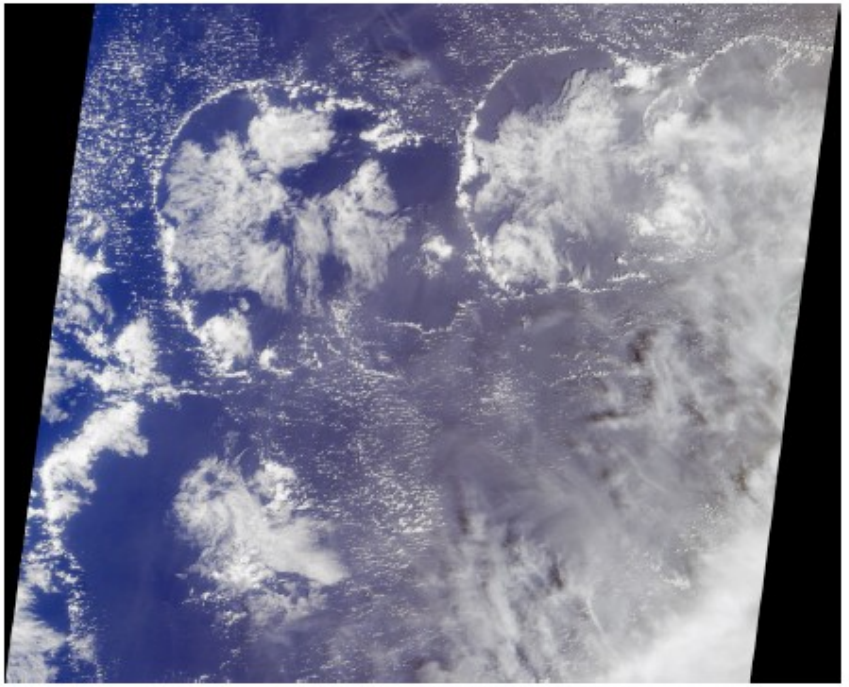


Image Credit: NASA/GSFC/LaRC/JPL, MISR Team

Why not just run CRMs at 100 m resolution????

Our Research Objective

- GOAL:
  - To simulate a range of cloud scales in an economical manner to advance the representation of cloud processes in climate models
- QUESTION:
  - How can we get a 1 km horizontal resolution case of deep and shallow convection to “look like” (or to “replicate”) a 100 m horizontal resolution case, in a fraction of the computation time?
- SOLUTION:
  - Improved SGS turbulence and cloud parameterizations!!!

SAM Super Run

- Using SAM, which is embedded into the CAM (Community Atmospheric Model) under the MMF approach
- Developed a “benchmark” case at 100 m resolution
  - Idealized GATE shear case (deep convection over ocean)
  - Domain of 2048 x 2048 x 256 points for 24 hours (2 s time step)
  - Ran on 2048 processors! (at SDSC)
- Data:
  - Each 3D volume = 16 GB
  - 3D volumes saved every 5 minutes of simulated time: 4608 GB

SGS Parameterization

- 1 km x 1 km “boxes” in the atmosphere are not always completely cloudy!!!
- Our method is based on the “assumed PDF method”
- Utilizes a three-dimensional PDF of vertical velocity, total water mixing ratio, and liquid water potential temperature
- Use results from GATE Super run to test assumed PDF method: Collected statistics for calculating moments needed to specify assumed PDFs for grid sizes of 800 m x 800 m x 100 m and multiples thereof

SAM Movies

- Added utility to create quick 2D movies
- Fields of 1 byte integers are collected throughout model simulation and converted to .gif images with quick post-processing code
- Current fields (x-y) include: Surface U & V winds, surface MSE, surface temperature, surface precip, cloud water path, ice water path
- Options for x-z or y-z movies available for tracers
- Email me for source code if interested! (P.bogenschutz@utah.edu)