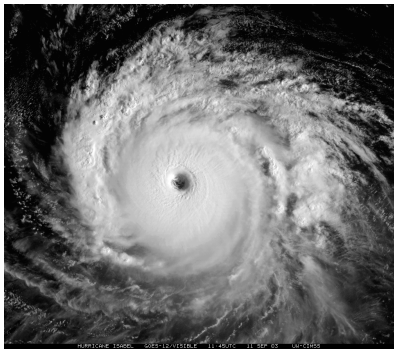

Stony Brook University

Reduced Complexity Frameworks In CAM

Kevin A. Reed

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Stony Brook University, Stony Brook, New York

Collaborators…

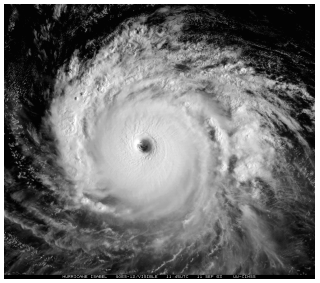
Brian Medeiros[2] , Adam Herrington[1], Daniel Chavas[3] and Christiane Jablonowski[4]

[1]*Stony Brook University, Stony Brook, NY*

[2]*National Center for Atmospheric Research, Boulder, CO*

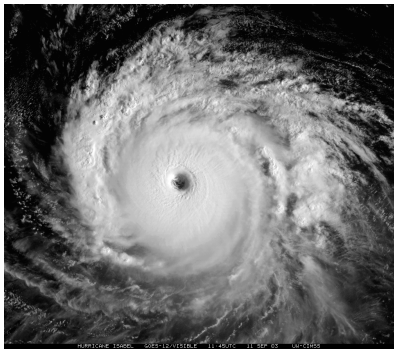
[3]*Purdue University, West Lafayette, IN*

[4]*University of Michigan, Ann Arbor, MI*

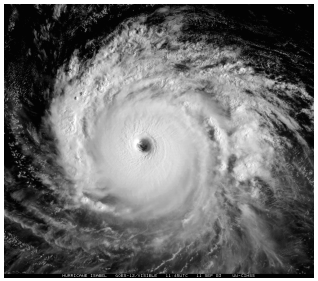


General Design of Simulations

- National Center for Atmospheric Research's (NCAR) Community Atmosphere Model version 5 (CAM 5).
- Generally, two dynamical core options, FV or SE with 30 vertical levels is used at the horizontal resolutions of:
  - $\Delta x = 1.0°$; ne=30; ~100 km
  - $\Delta x = 0.25°$; ne=120; ~25 km
- Idealized simulations with simplified boundary conditions and/or physics forcings.
  - Typically built off aquaplanet configuration
- Full physics with Atmospheric Model Intercomparison Project (AMIP) protocols for 1980-2005.
  - Prescribed observed SSTs, ozone, CO_2, solar forcing, etc.

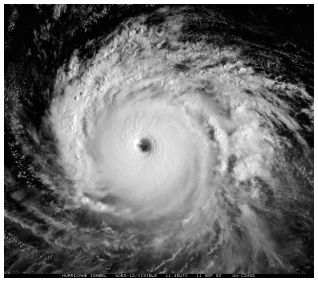


Idealized Tropical Cyclones



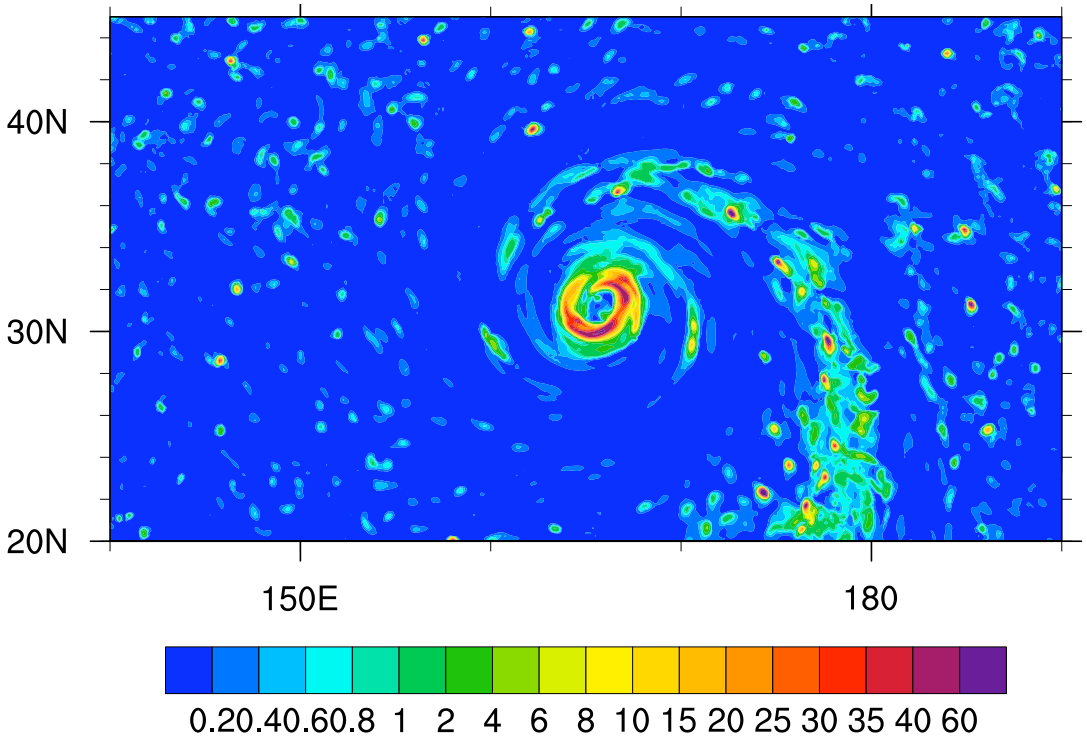
Tropical Cyclone Test Case

- Develop an analytic initialization technique of a single, initially weak vortex in CAM aquaplanet.
- The vortex is built upon prescribed analytic 3D moisture, pressure, temperature and velocity fields that are embedded into tropical environmental conditions.
- Vortex is in hydrostatic and gradient wind balance, with v_0 = 20 m/s and RMW = 250 km.
- Vortex characteristics:
  - Surface vortex
  - Warm-core
- Favorable environment set by observations from *Jordan 1958*, with 29ºC SST.

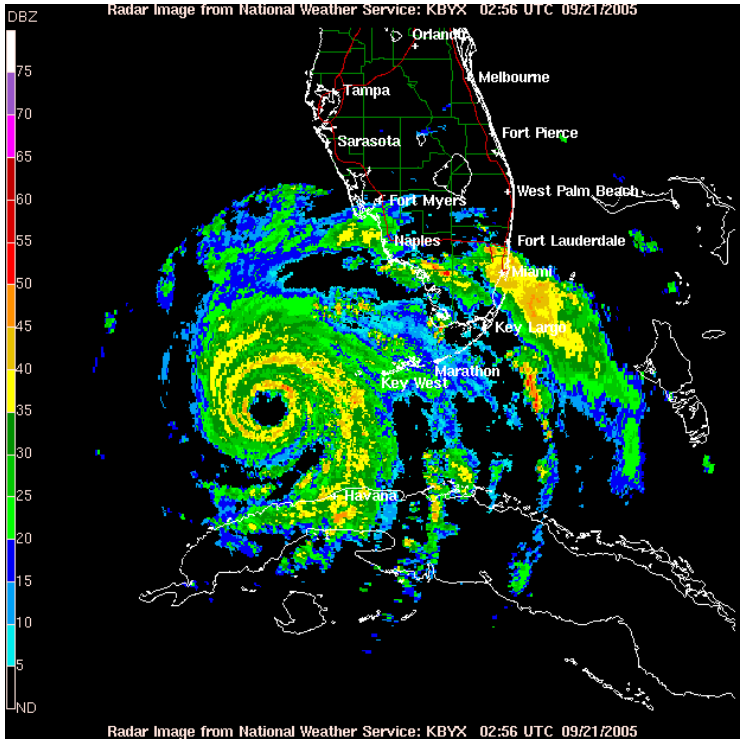


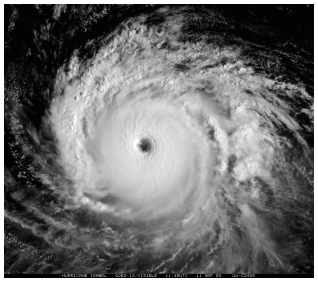
Intercomparison: Physical Realism

Total Precipitation Rate FV Simulation (0.125° ≈ 14 km)

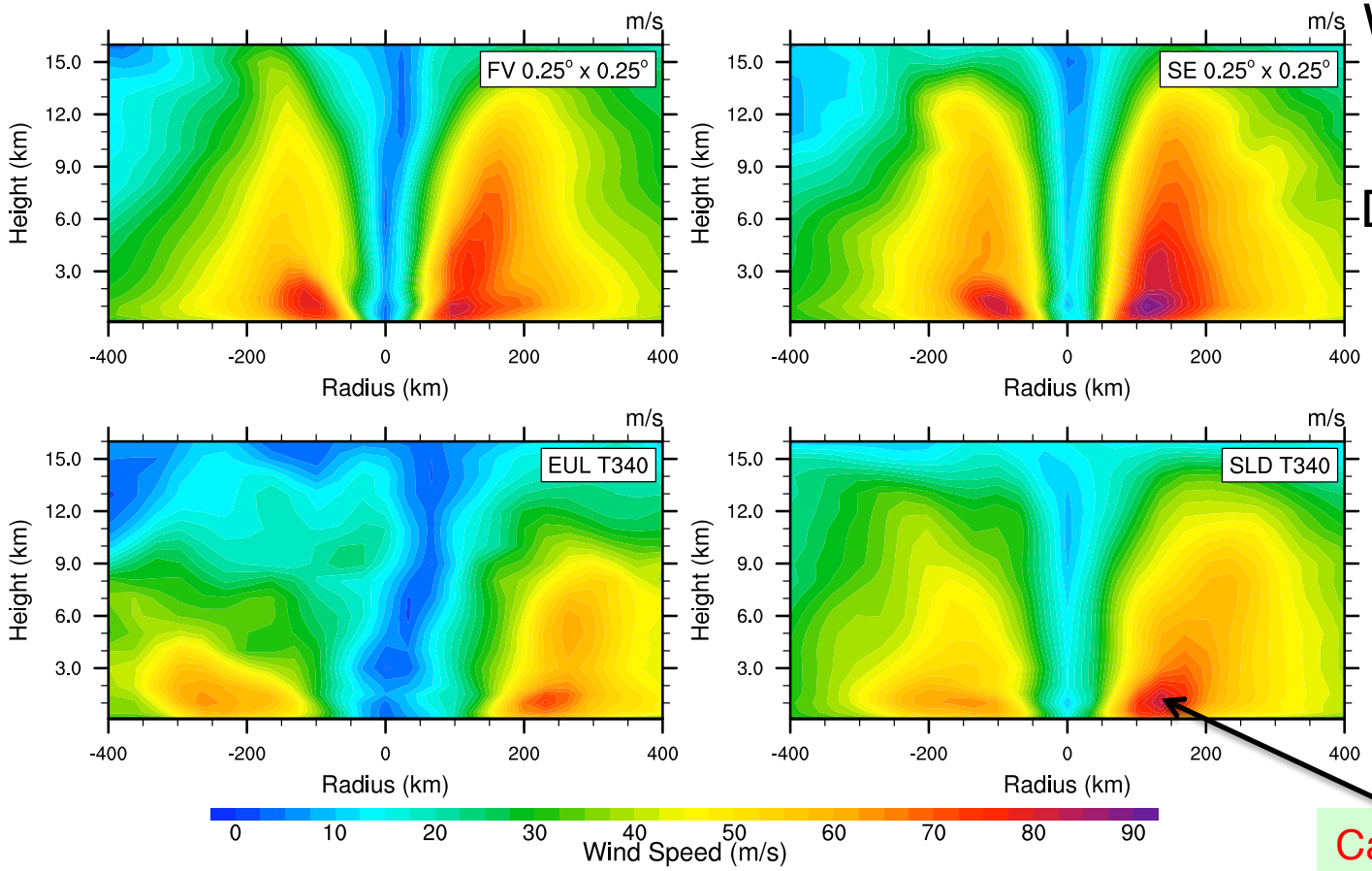


Radar Image of Hurricane Rita (2005)





Intercomparison: Full Physics Simulations



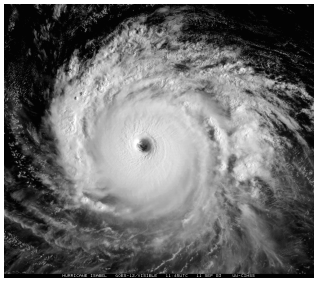
Wind Speed (m/s) At Day 10

Differing strengths and shapes:

FV & SE at 0.25° (≈ 28 km)

EUL & SLD at T340 (≈ 39 km)

Category-4 cyclone

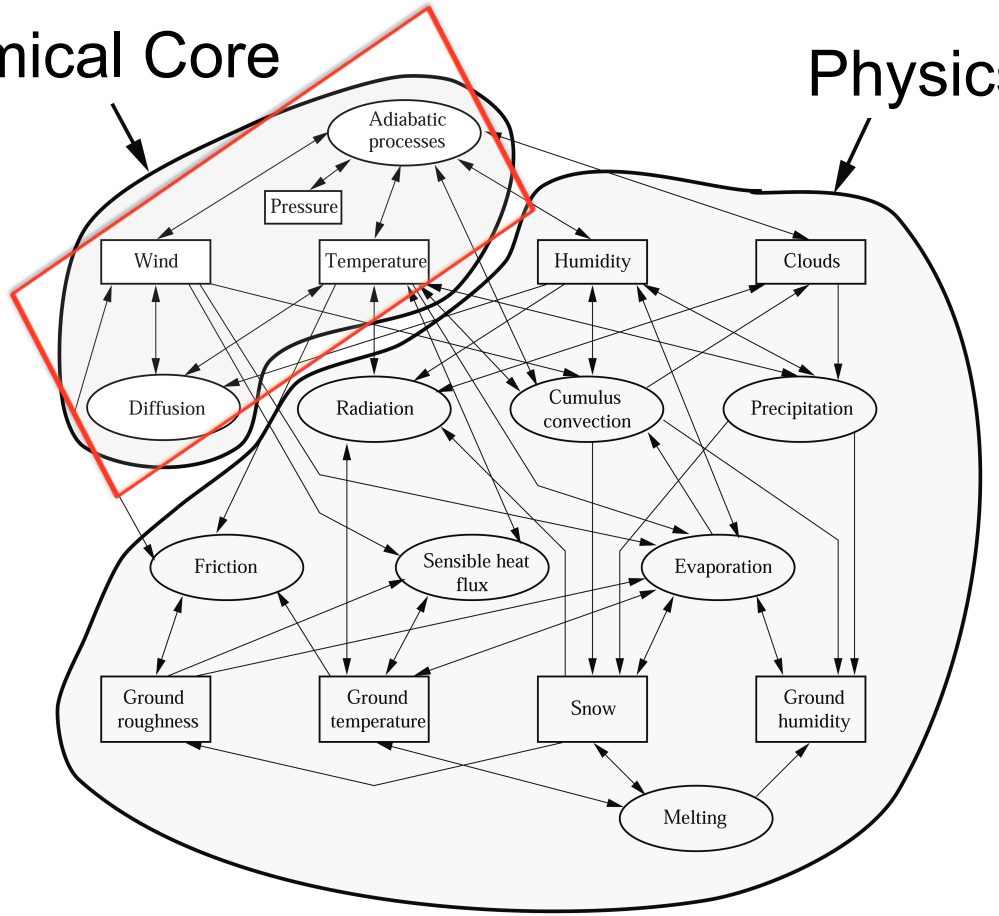


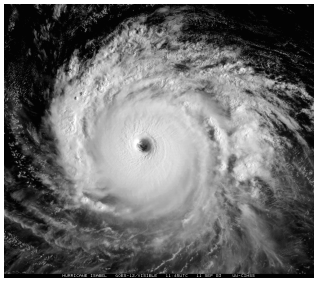
Impact of Dynamical Core

Process

Variable

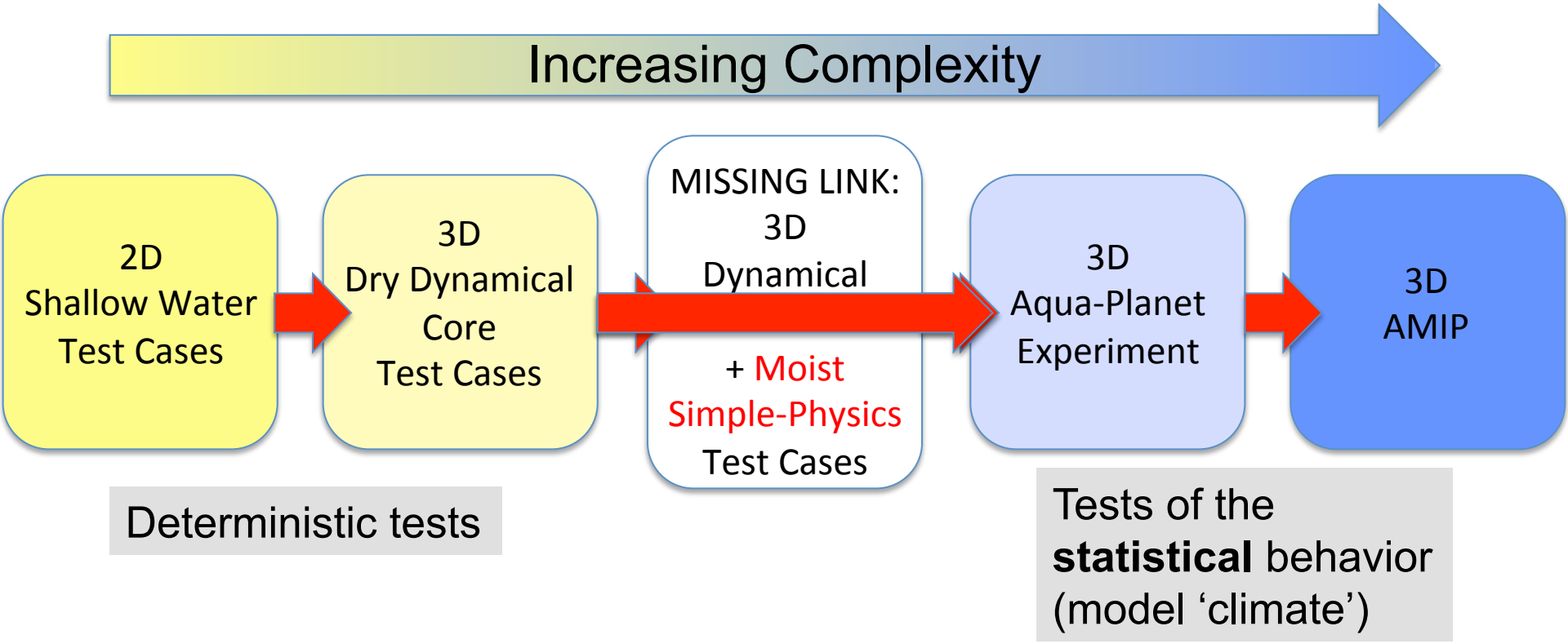
Interaction

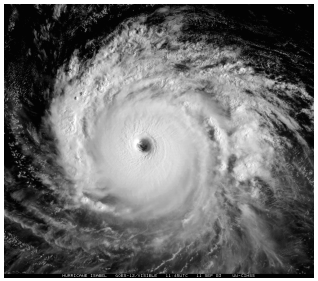




How Do We Evaluate GCMs?

- Utilize a test hierarchy



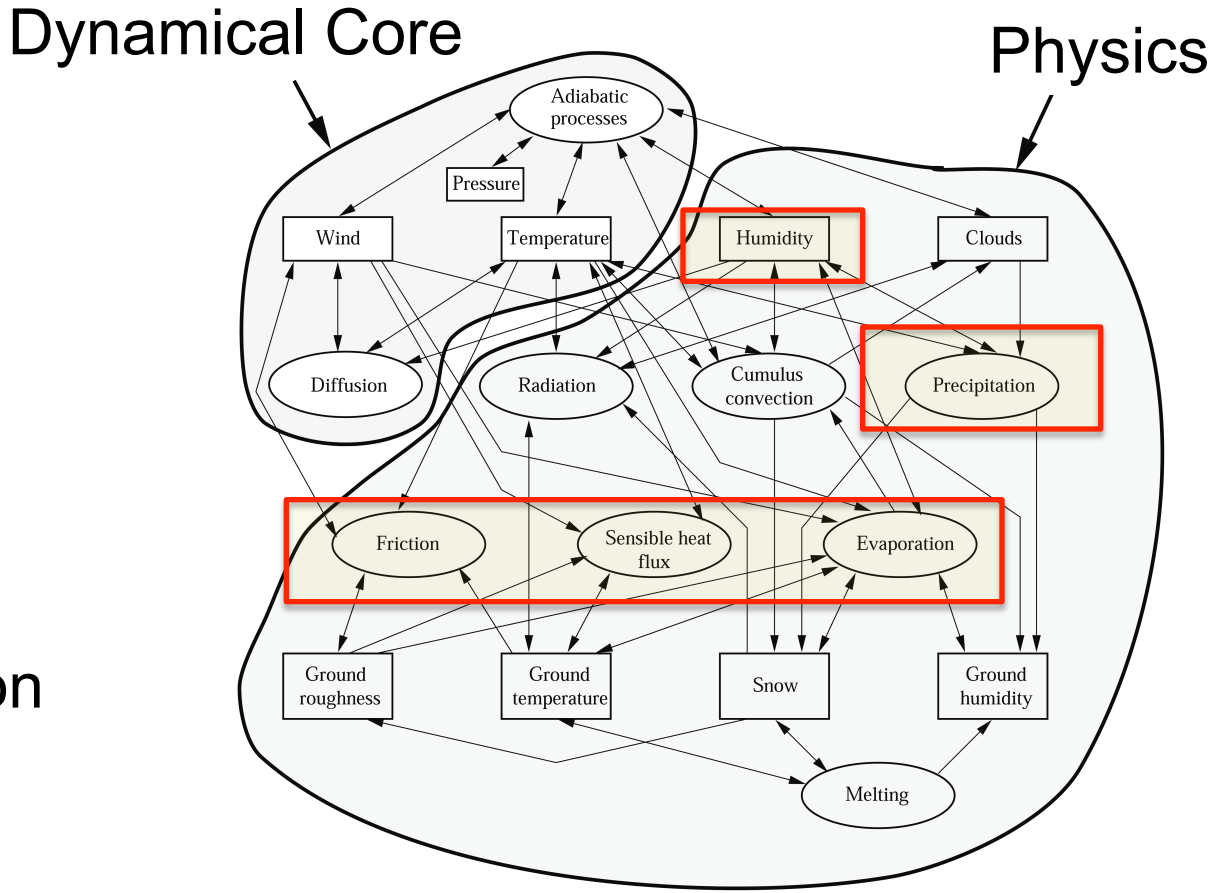


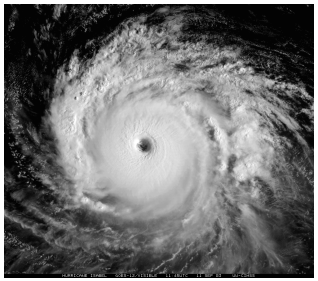
Simple-Physics

Process

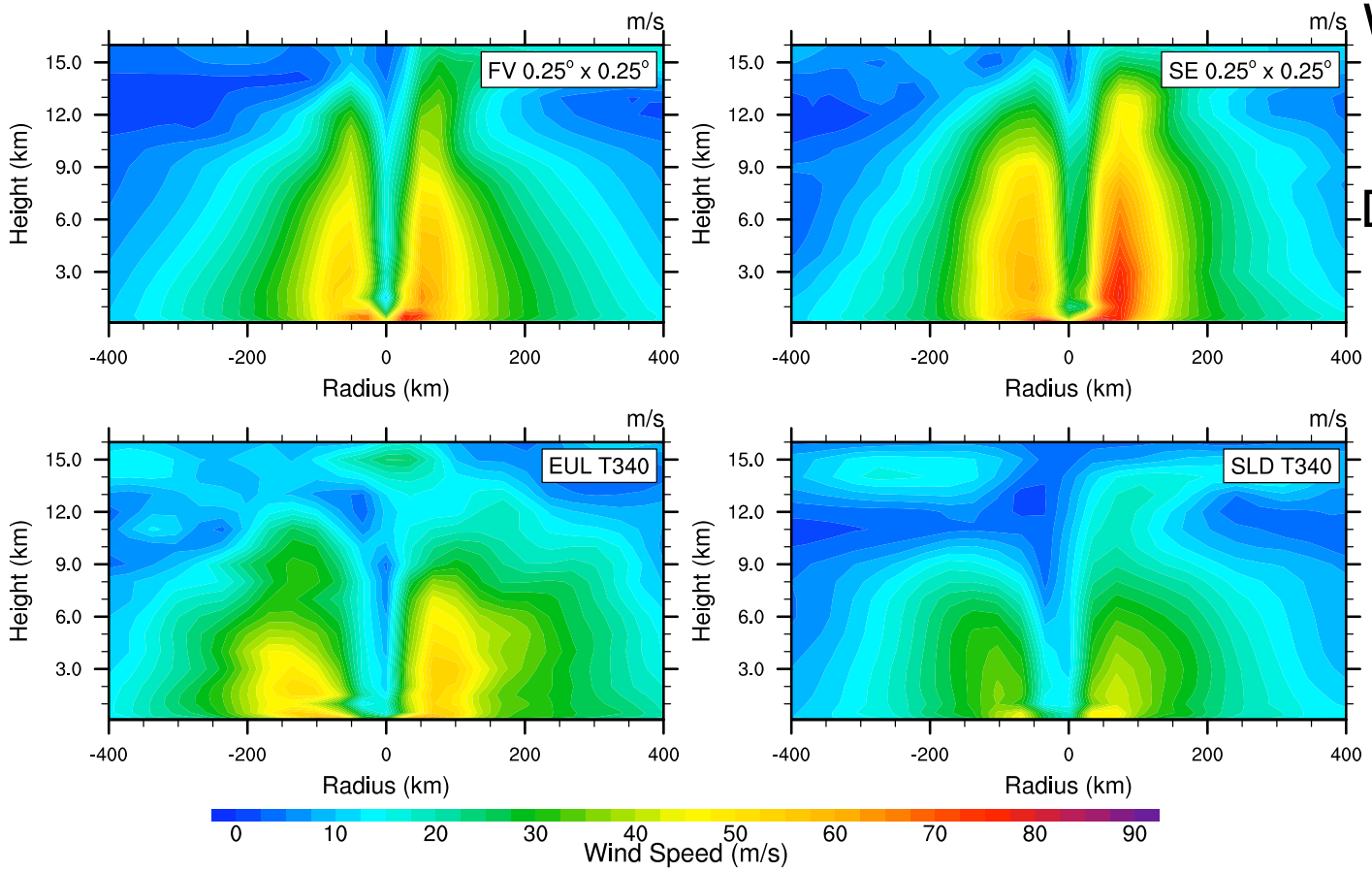
Variable

Interaction





Simple-Physics Dynamical Core Comparison



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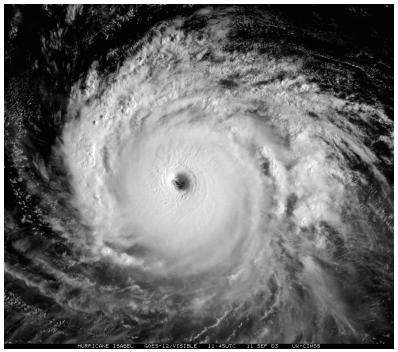
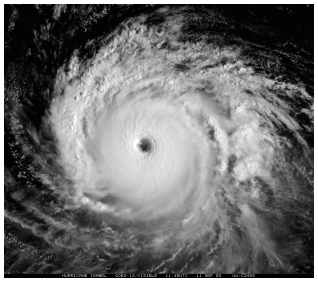
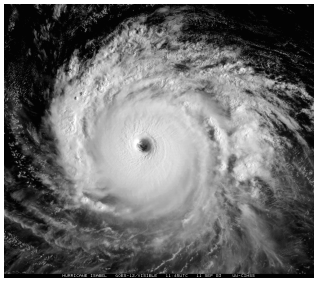


Radiative Convective Equilibrium



Design of Experiments

- NCAR's Community Atmosphere Model version 5 (CAM 5).
- The SE dynamical core with 30 vertical levels is used at the horizontal resolutions of:
  - ne=30 (~100 km)
  - ne=120 (~25 km)
- Full physics in Aquaplanet mode is used, with a simplified ocean covered Earth and constant SST of 29^{o} C.
- No rotation or uniform rotation effects (i.e., 10 deg. N).
- Diurnally varying, spatially uniform insolation (~340 W/m^2).
- No direct and indirect effects of aerosols.
- Tuning parameters are set to ne=30 configuration for all simulations.
- Such a setup mimics similar simulations with limited-area or cloud-resolving models, but at a relatively lower resolution.



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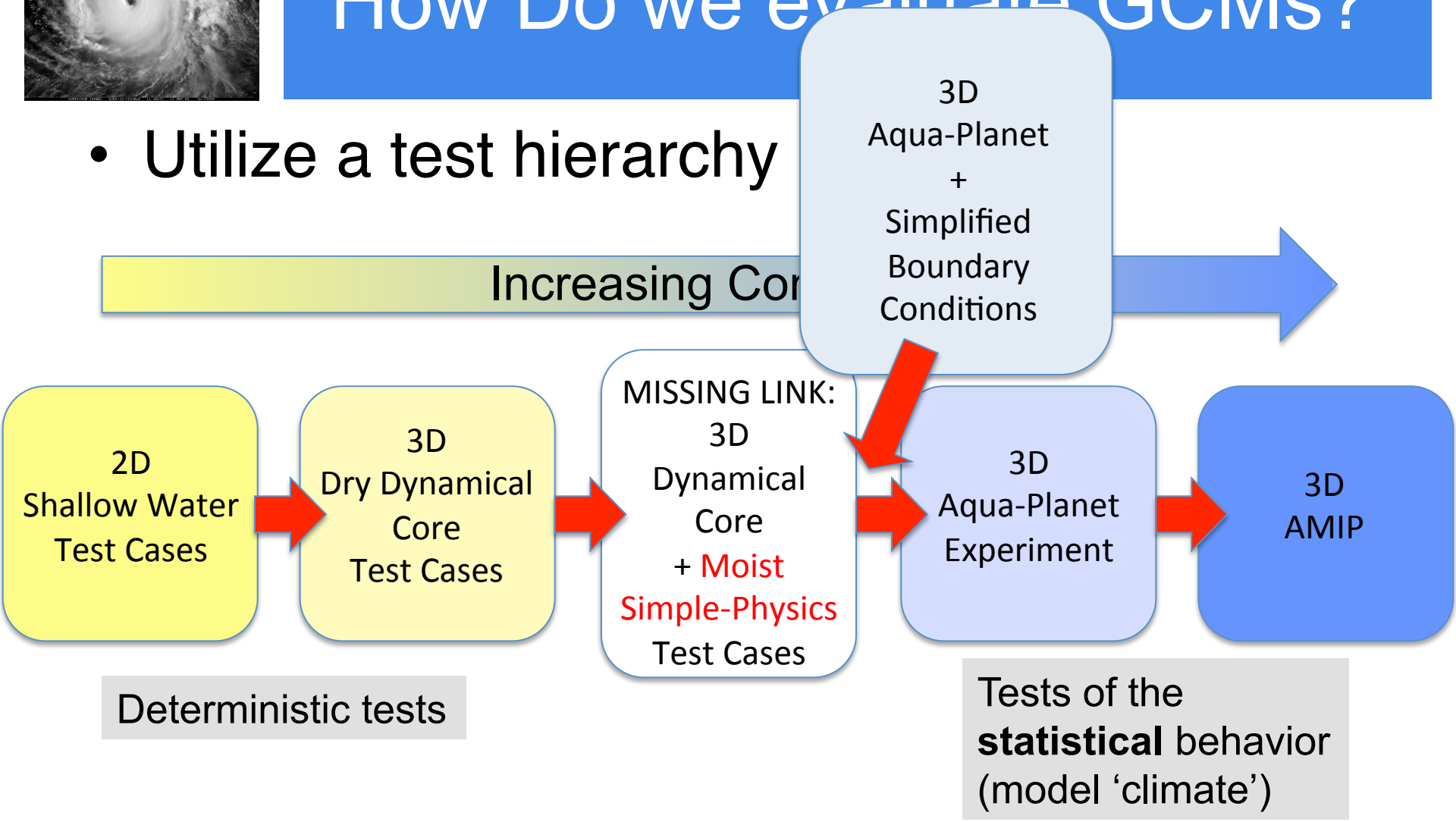
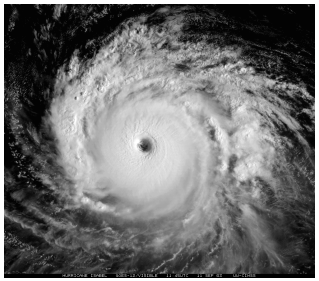
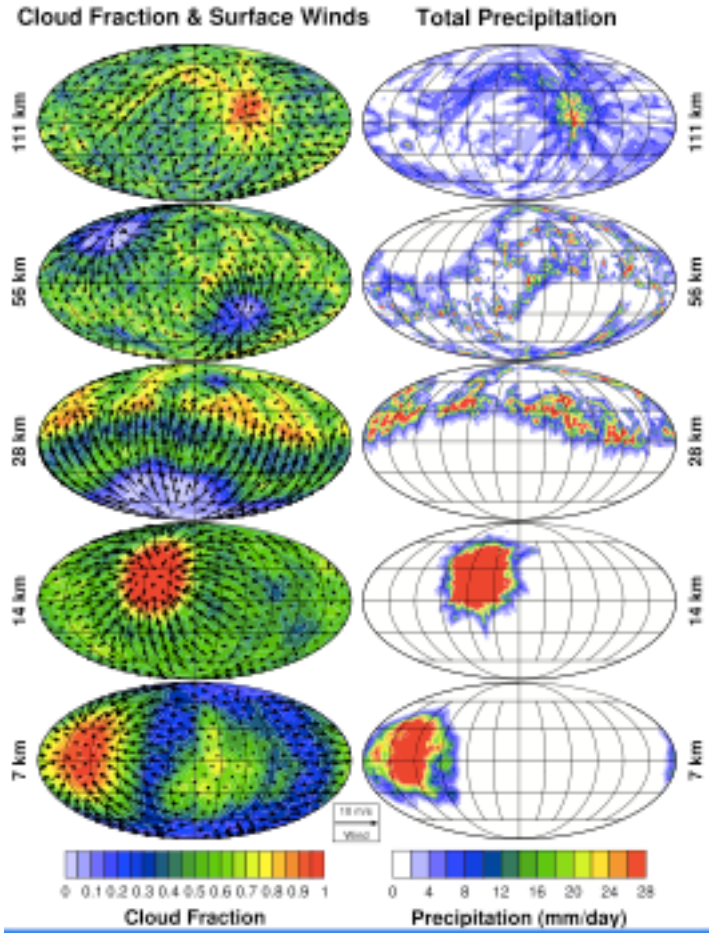
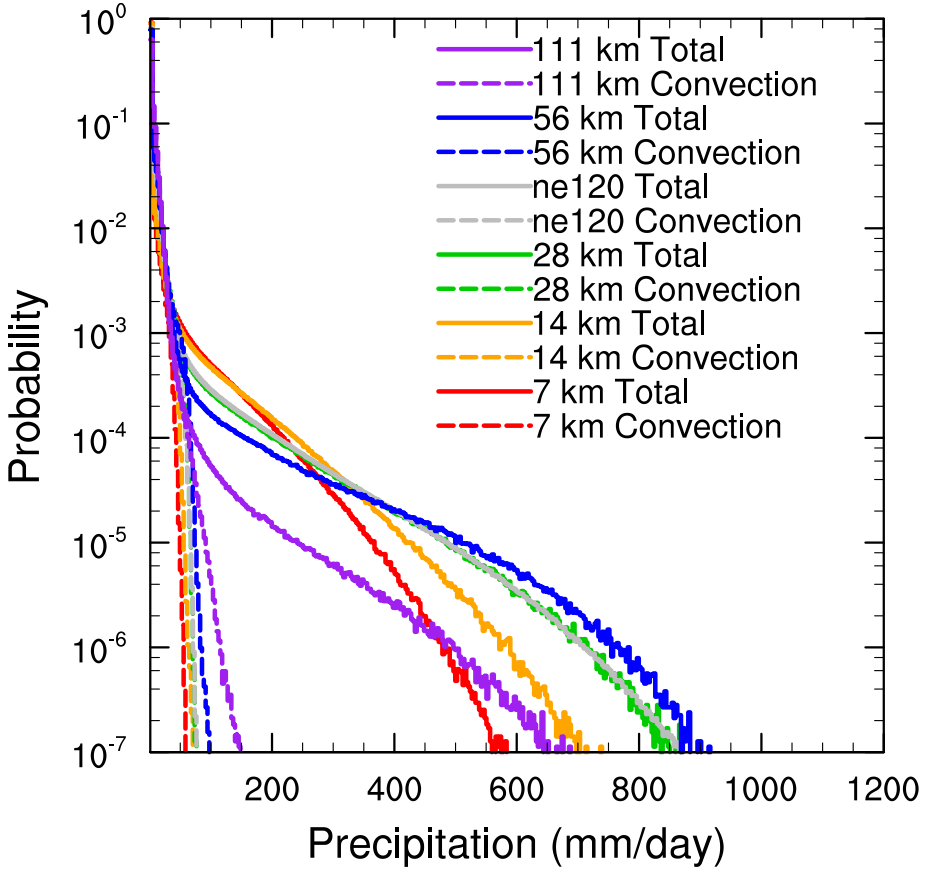
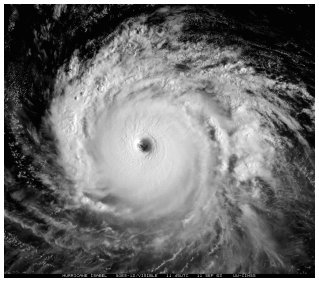




Reduced Planet RCE: Resolution Dependence – Scale Awareness







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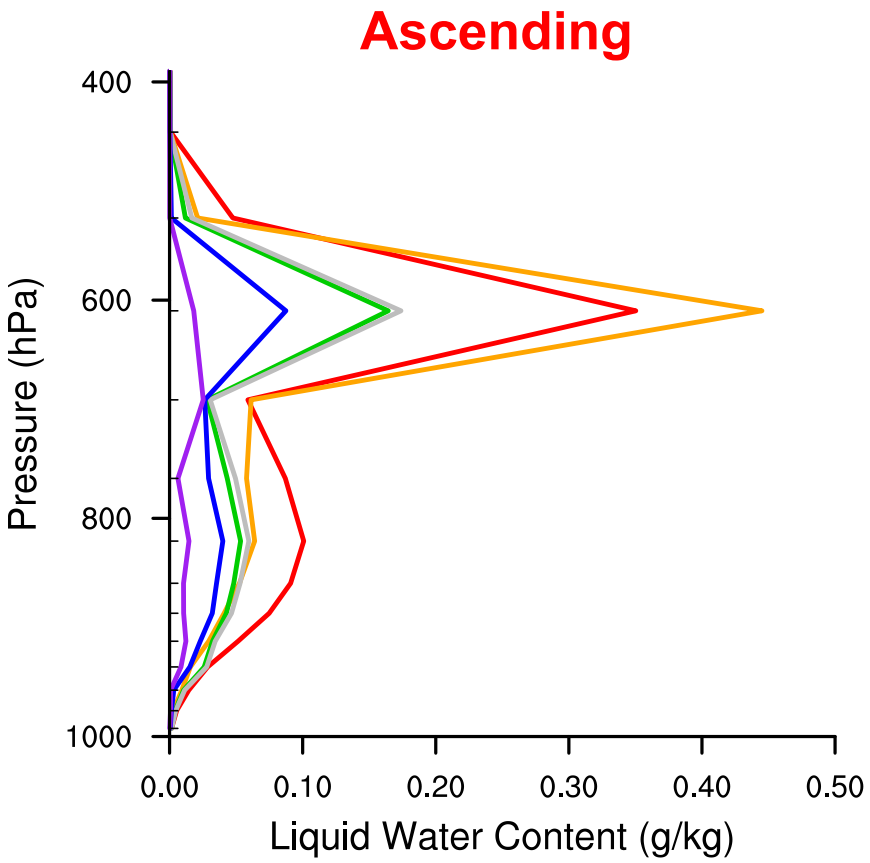
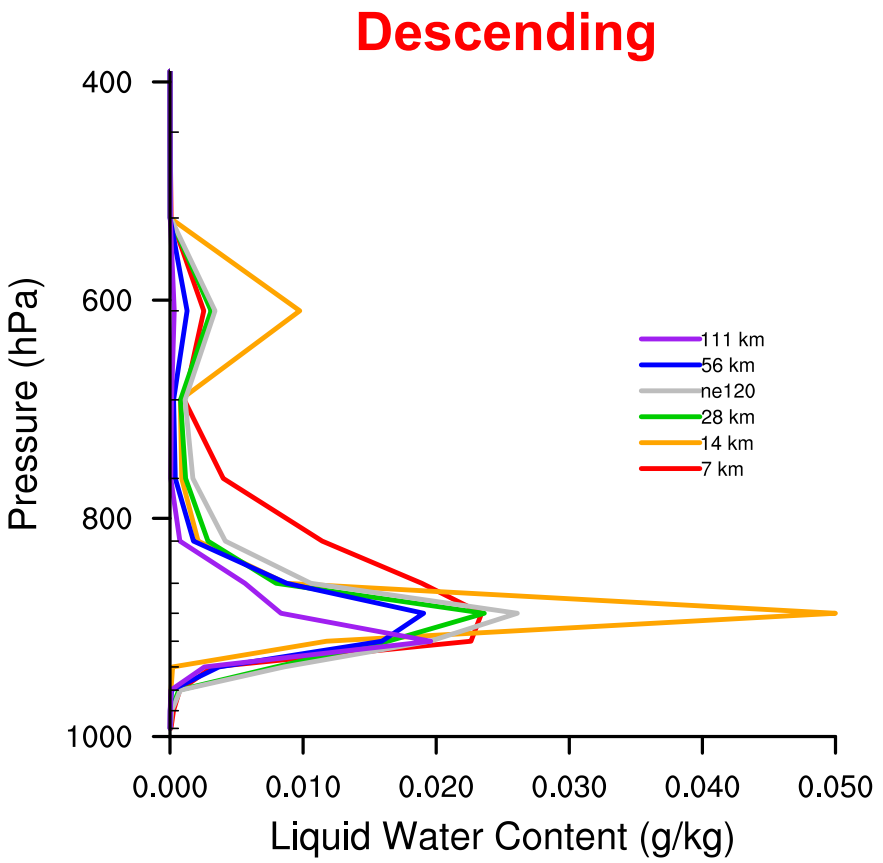
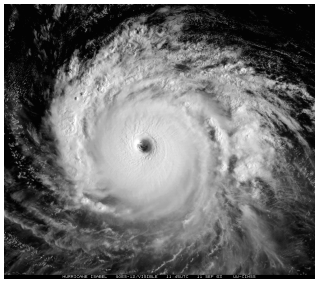
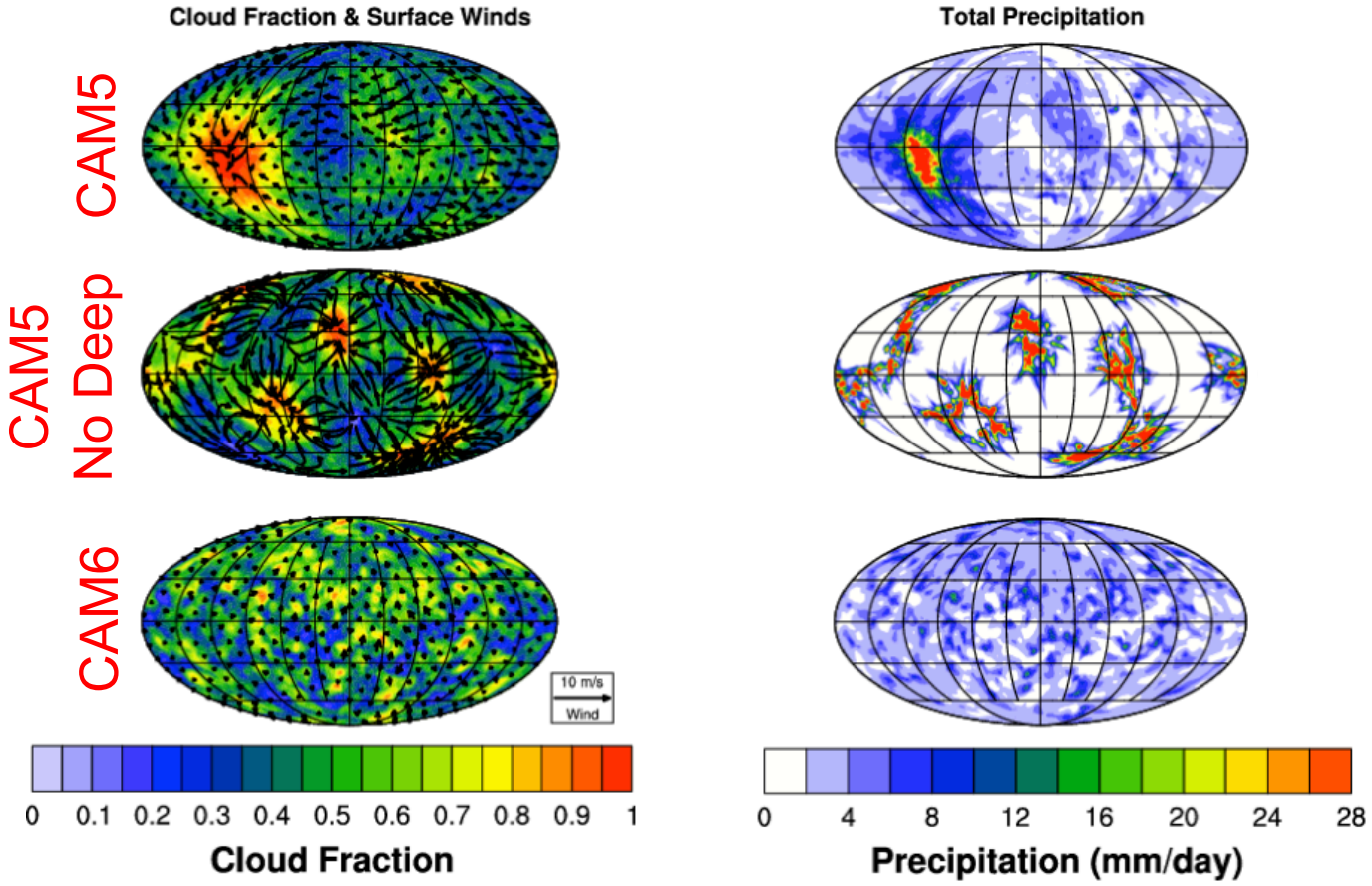
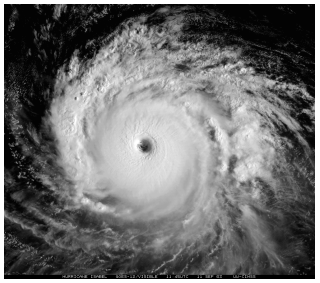




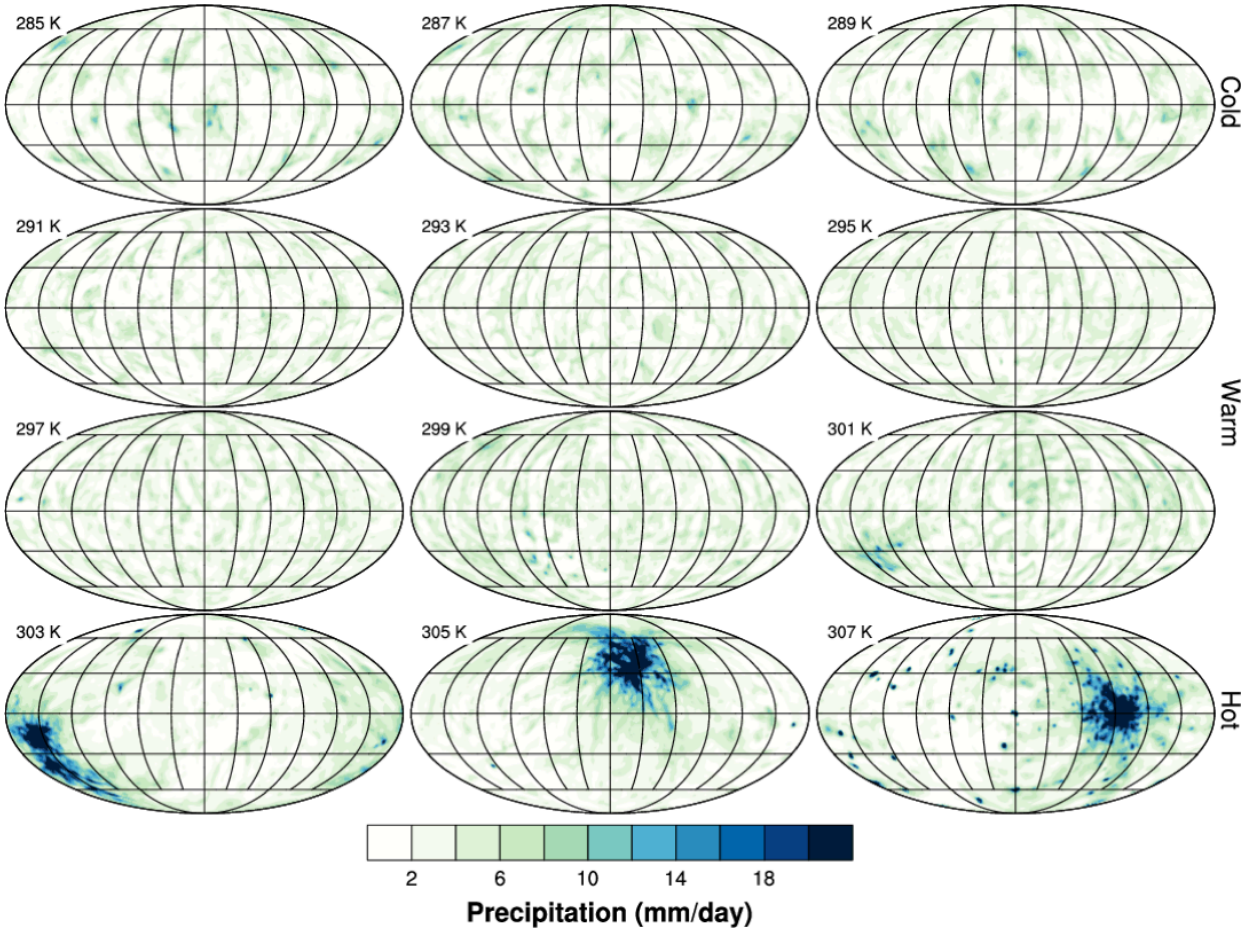


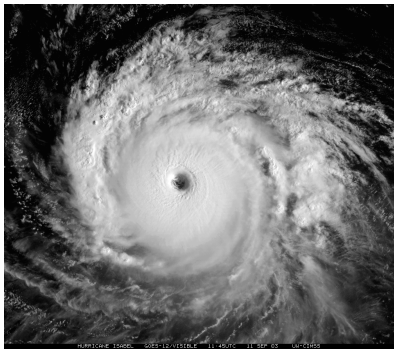
Investigate Convection Parameterizations Choices



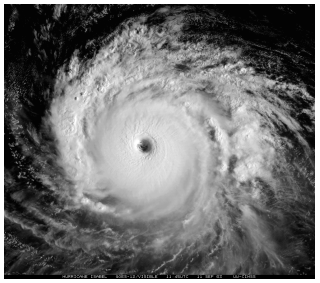


SST Sensitivity

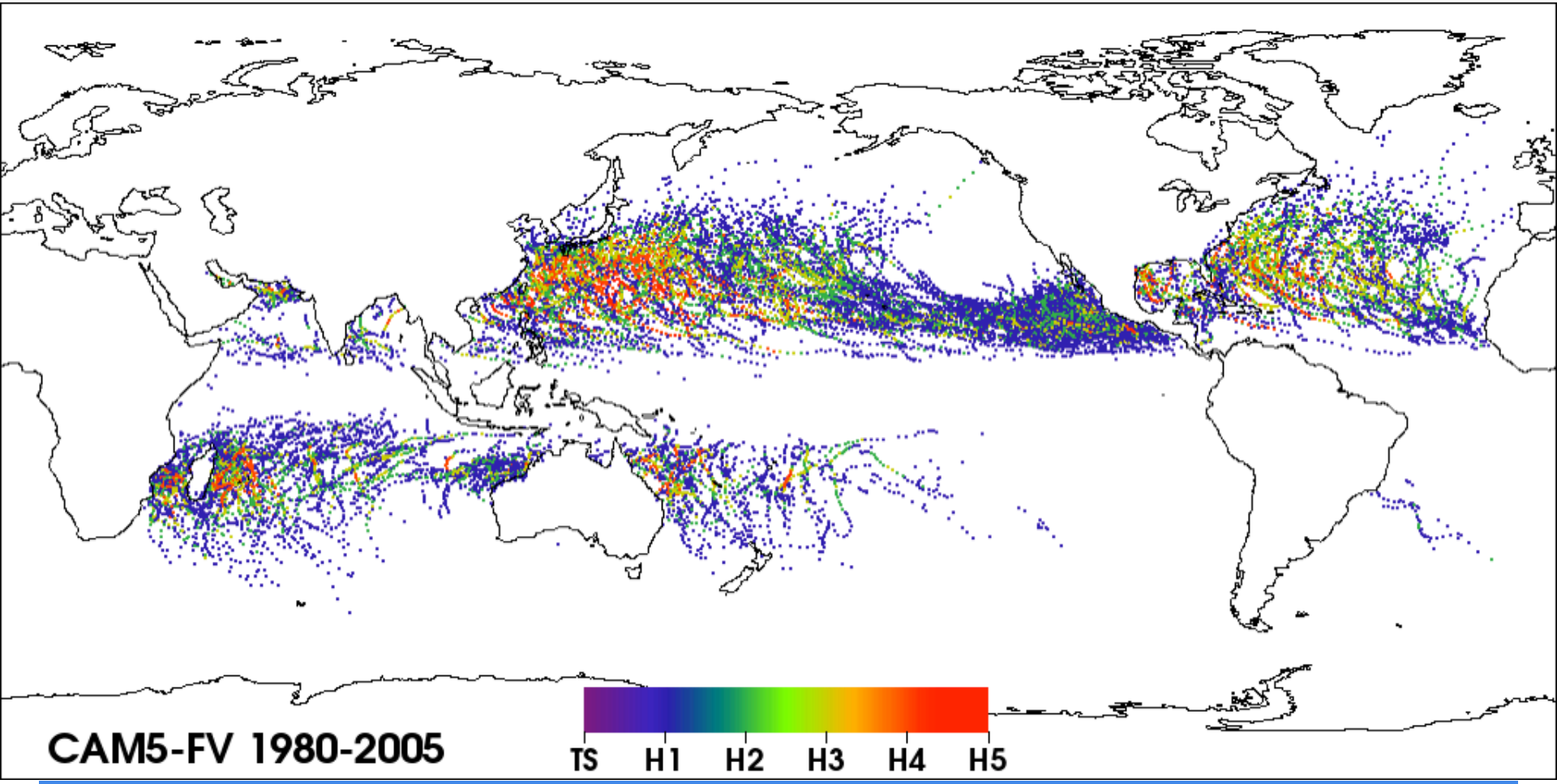


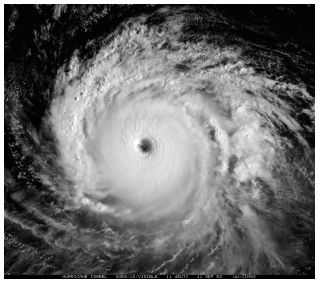


High-Resolution AMIP Comparison

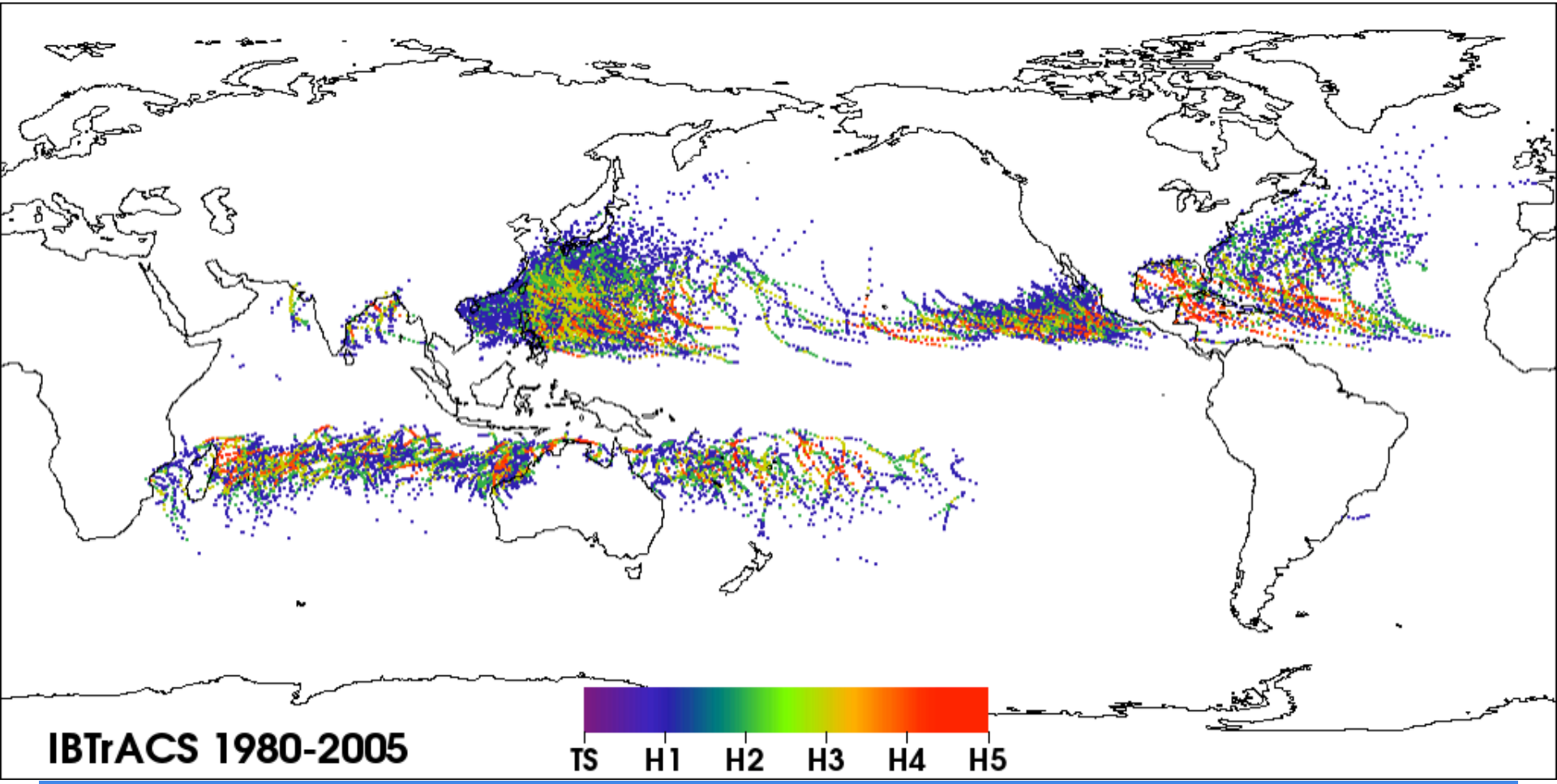


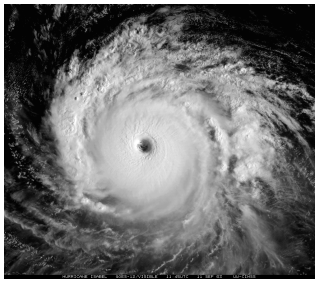
CAM5-FV AMIP Storm Tracks



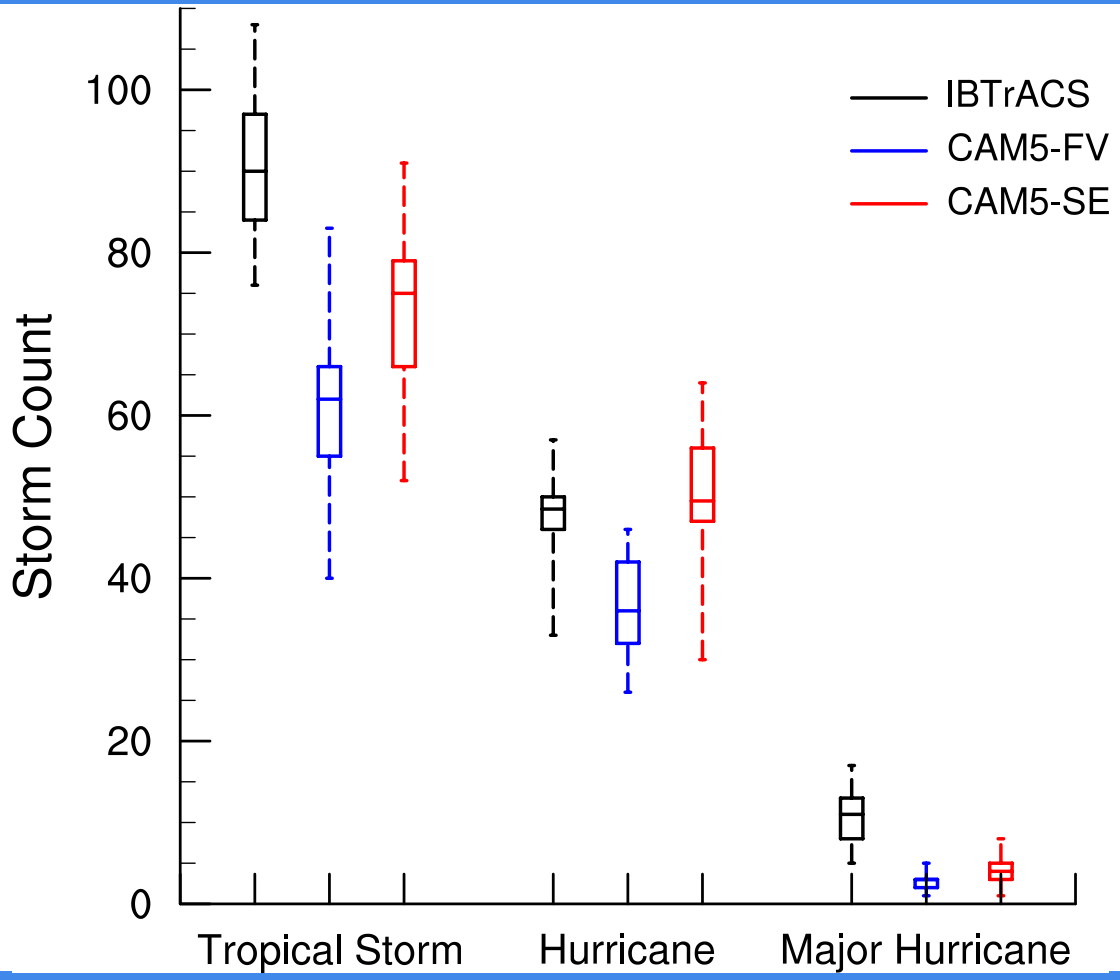


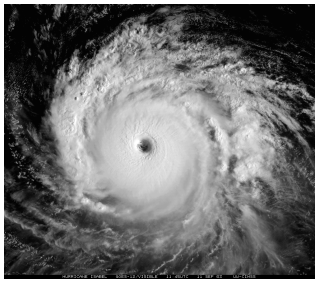
Observations





Impact of Dynamical Core





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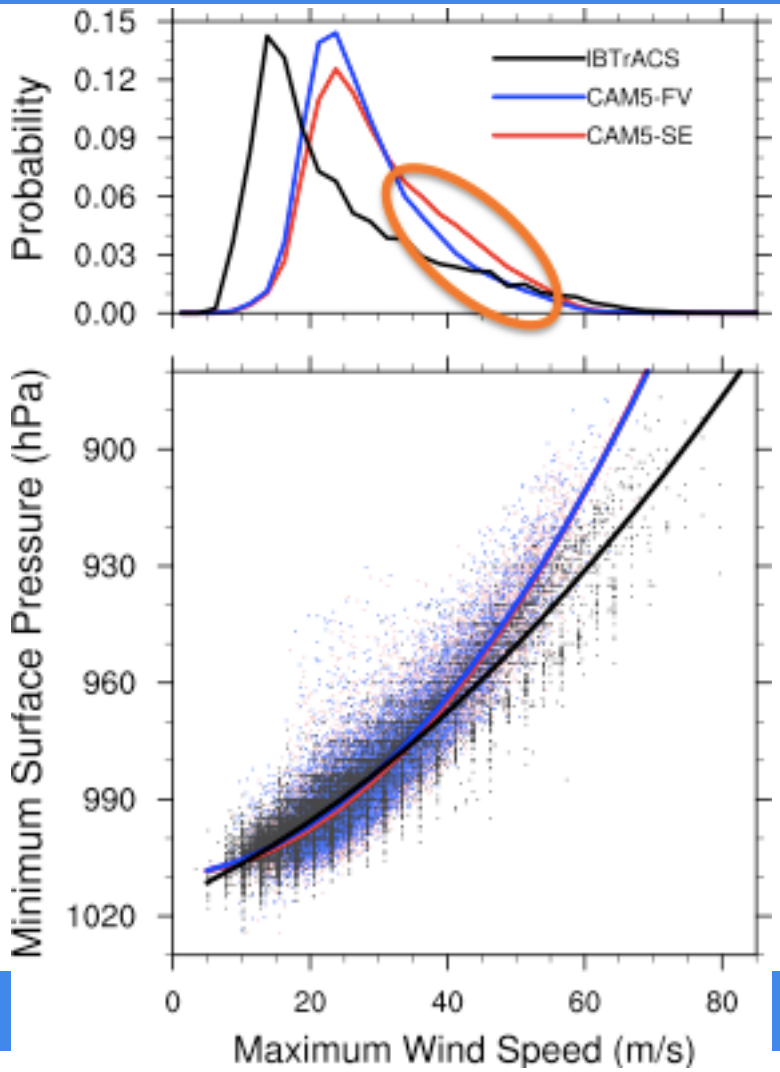
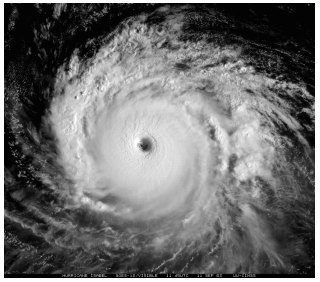


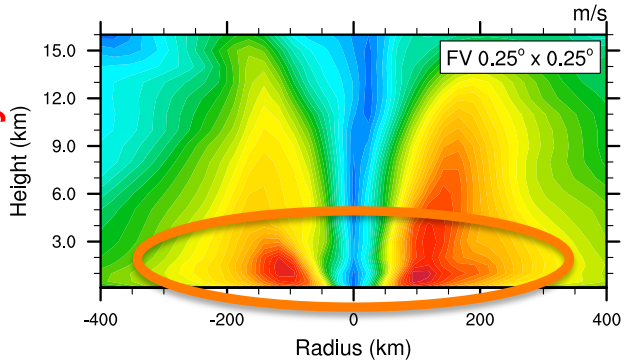


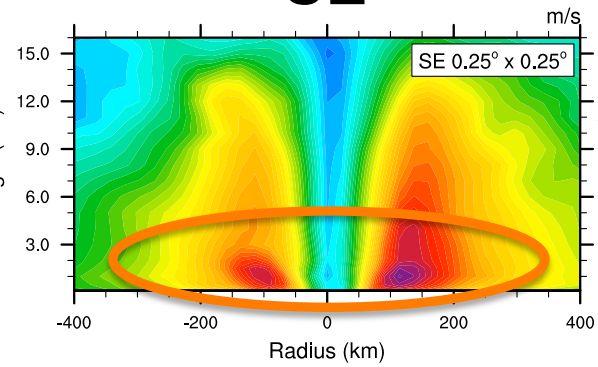
Consistent with the Idealized Simulations

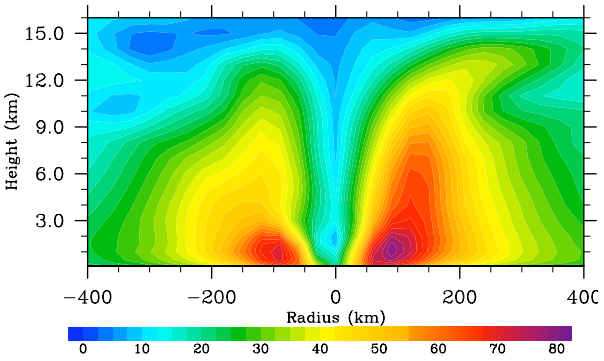
Idealized **AMIP**

FV SE FV

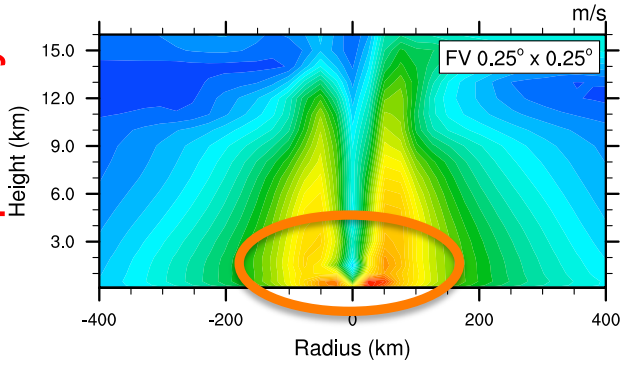
Full Physics

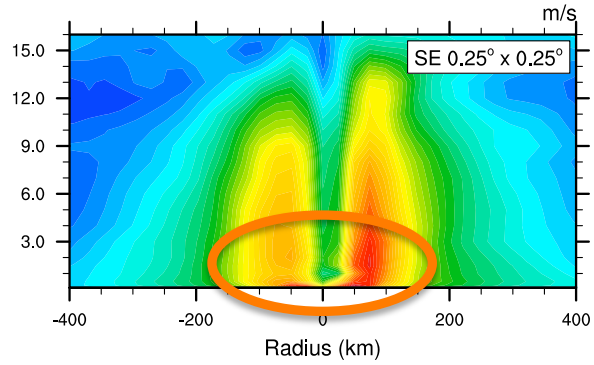


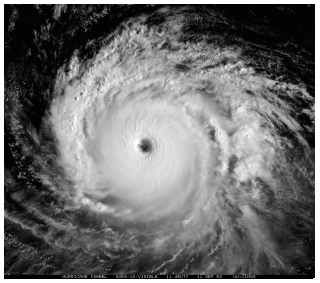




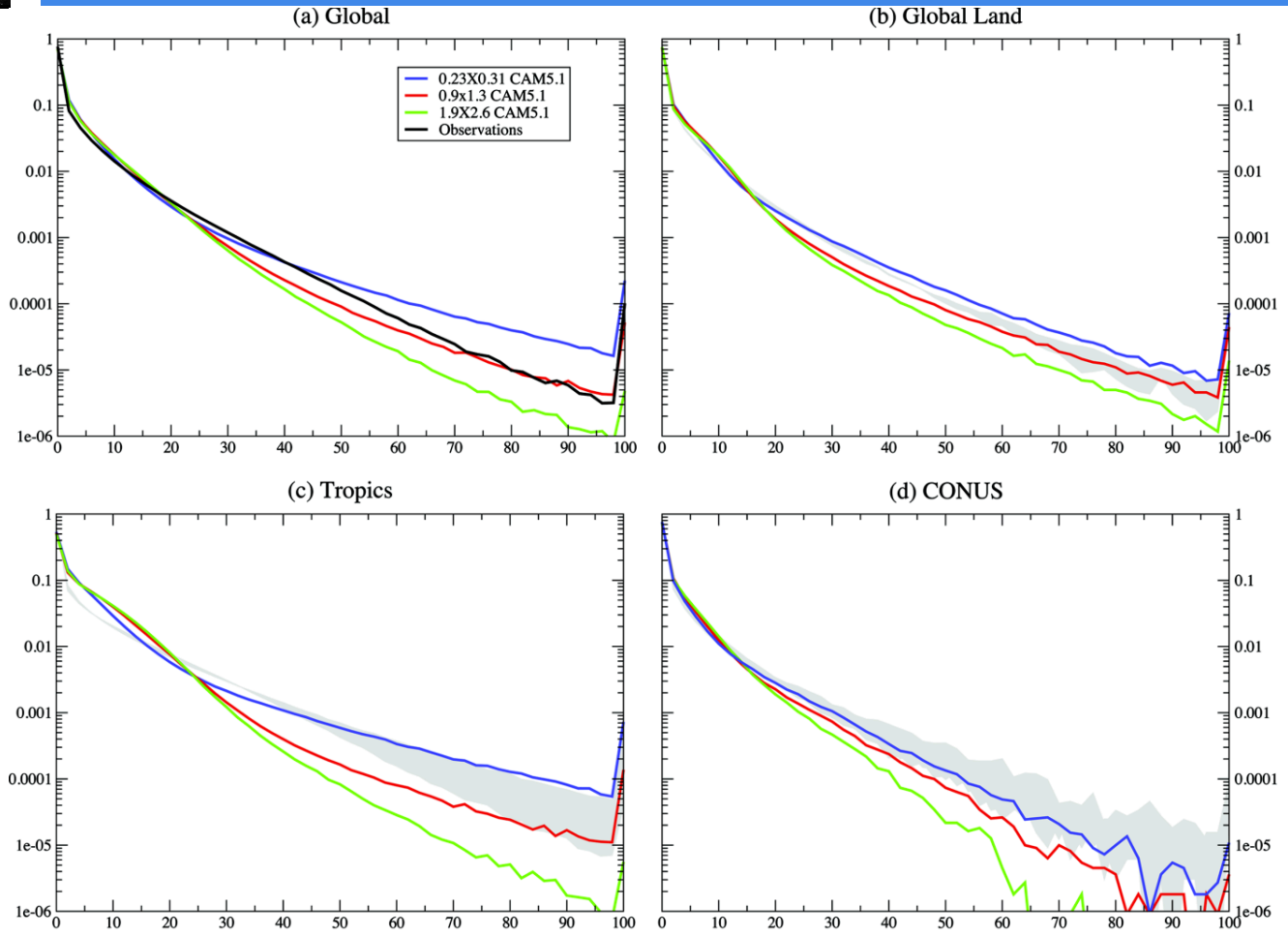
Simple Physics



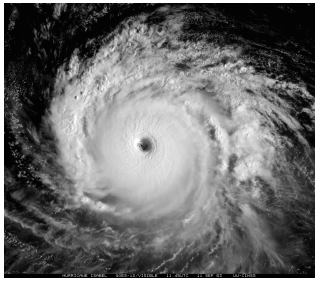




AMIP - Precipitation Distribution



mm/day



Final Thoughts

- The choice of dynamical core has significant impact on the evolution and strength of tropical cyclones (but likely all types of extreme events) and reduced complexity configurations offer a real opportunity to explore this.
- Horizontal resolution has an obvious impact on precipitation extremes and a radiative convective equilibrium configuration can be useful to explore this scale sensitivity (and perhaps inform model design choices).
- We do lack a global radiative convective equilibrium benchmark for GCMS (similar to aquaplanet configurations). *Perhaps one should be developed?*
- A hierarchical approach is crucial to understanding the simulation of extremes in high-resolution GCMs.

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