ACME

Accelerated Climate Modeling for Energy

ACME v0

David C. Bader, Julie McClean ,Mark Taylor, Mathew Maltrud, Kate Evans, Milena Veneziani, James Hack, Marcia Branstetter, Salil Mahajan, Qi Tang, and Detelina Ivanova.

June 5, 2017

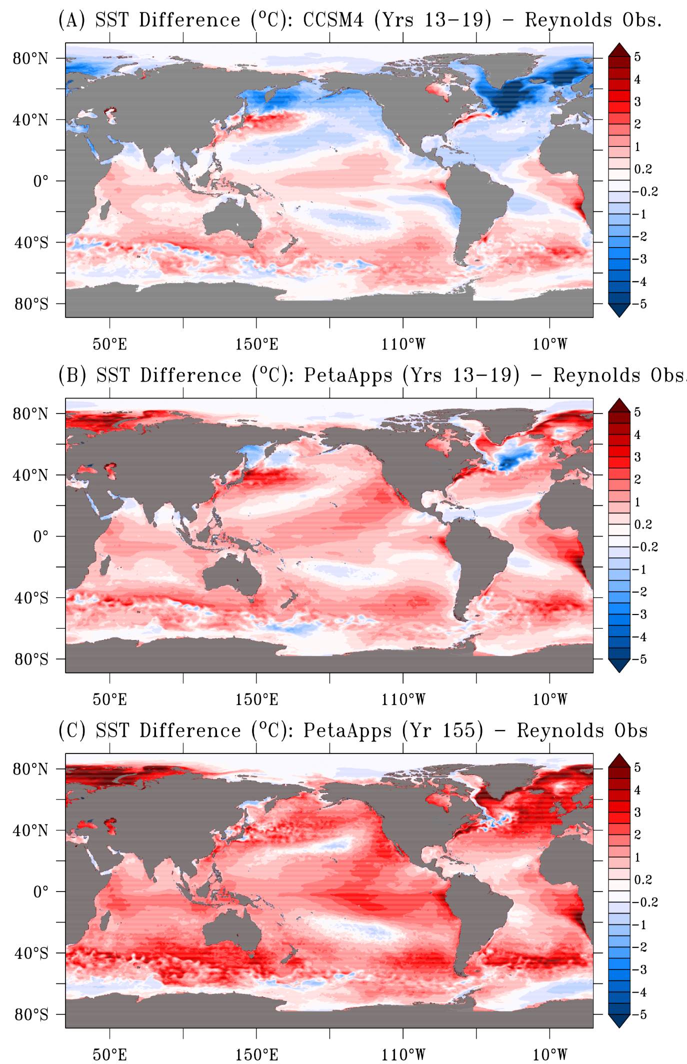
Phase 1 – Grand Challenge Project

- **Motivation** – determine source of problems in Atlas and PetaApps and fix for future high resolution simulations
  - a. Initialization method
  - b. Grid /Dycore; does isotropic grid improve simulation – particularly polar vortex problem
  - c. Atmospheric Physics – CAM4 vs CAM5
- **Experimental plan**
  - Initialize from POP/CICE with CORE forcing for three configurations T341/CAM4 and CAM4-SE runs (year 1973) and CAM5-SE (v0.1)
  - Examine the effects of initialization through comparison of CCSM4 run with Atlas and PetaApps runs.
- ***Independently, NCAR/CESM ran similar simulation to v0.1***

Sensitivity to Initial Conditions: CCSM3.5 1990 Controls

ATLAS: 0.1° POP/CICE & 0.25° CAM/CLM
PetaApps: 0.1° POP/CICE & 0.5° CAM/CLM

SST Biases:



(A) ATLAS SST – Reynolds SST (Yrs 13-19)
Initialized from 2 yr CCSM4 using 0.1° POP/CICE and 0.5° CAM/CLM. (McClean et al., 2011, OM)

(B) PetaApps SST – Reynolds SST (Yrs 13-19).
Initialized from multi-century CCSM3 Pre-industrial control interpolated to high resolution grid. (Kirtman et al., 2012, Clim. Dyn.)

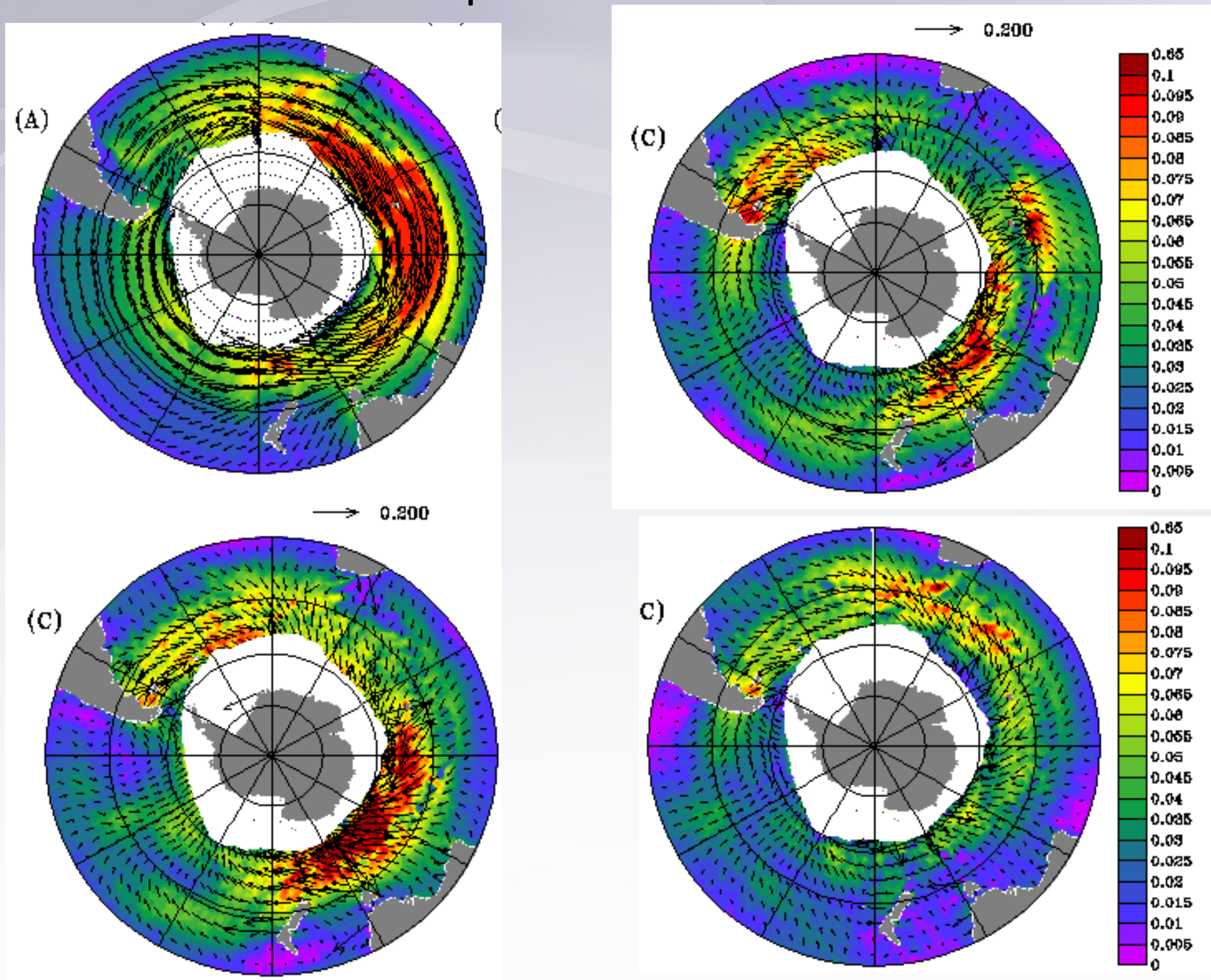
(C) PetaApps SST – Reynolds SST (Yr 155)

PetaApps output courtesy, B. Kirtman (U. Miami)

Southern Hemisphere Winter Wind Stress Biases

Quick-Scat

CAM4-Spectral



CAM4-SE

CAM5-SE

Conclusions from Phase 1

- Dynamical Cores using isotropic grids (spectral and spectral element) are superior to spherical coordinate grids at high resolution
- Cloud responses are similar in the spectral and spectral element models at the same resolution using the same tuning constants
- Scientific and computational arguments informed the decision to use the spectral element as the default ACME dynamical core

Phase 2 – ACME v0

- Use an existing climate model to provide a baseline for comparisons with next generation ACME simulations.
- In particular, focus on simulations where oceanic and atmospheric mesoscale phenomena with scales of 10s and 100s of kilometers, respectively, are largely resolved.

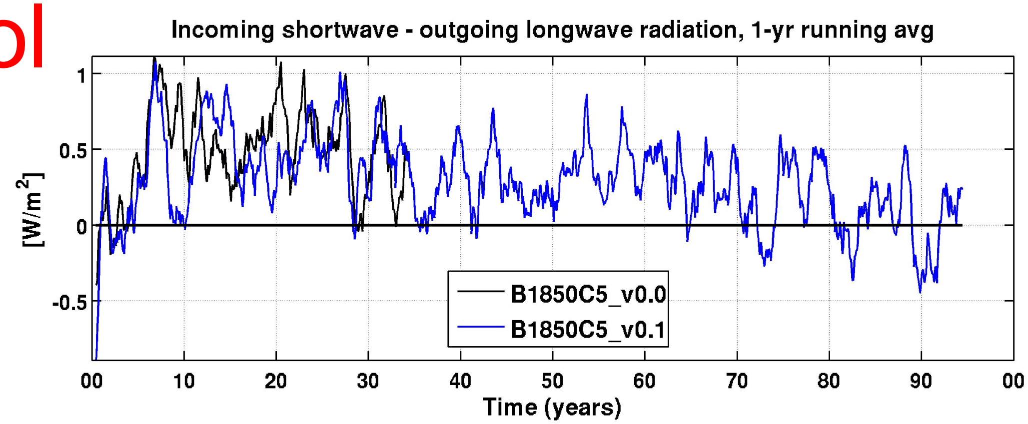
ACME v0.1

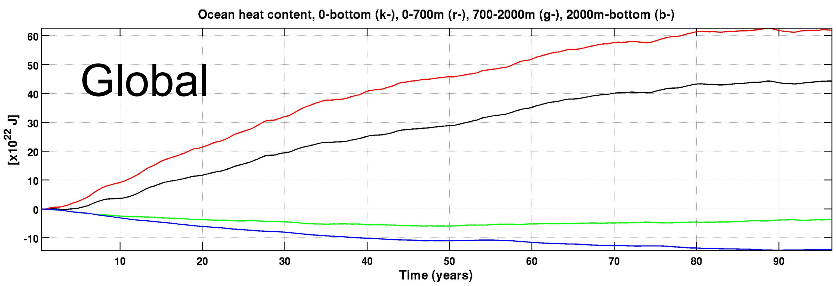
ACME v0.0 shut down after discovery of RRTM look-up table bug that resulted in ~1 W/m^2 shortwave error

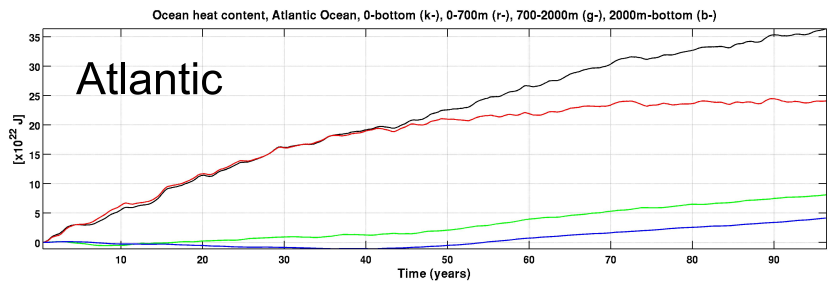
Atmosphere retuned after coupling to restore energy balance.

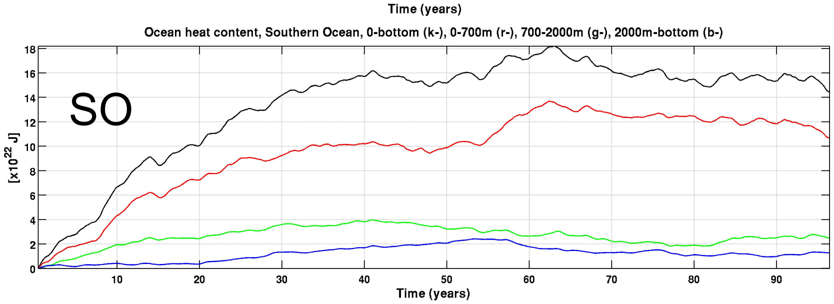
ACME V0.1: High-Resolution 1850 Pre-Industrial Control

TOA net radiation (Wm^{-2})









Annual time series of global, Southern Ocean, & Atlantic Ocean heat content (J) relative to year 1 annual average.

Black: total depth, red: 0=700 m
Green: 700-2000m; blue: 2000-bottom

Nine Additional Runs

- Climate change response – ensemble of three (McClean, et al presentation Spring 2016 meeting)
  - initialized from three different POP/CICE states from same CORE.v2 forced simulation
  - Approximate Present Day Forcing – ca 2000 climatological GHG and aerosol precursors
- Initialization error vs bias trade-offs – ensemble of three (rest of this presentation)
  - New run with APD forcing using an initial state run identical to that of the 1850 run (1970-1973 CORE forced ice/ocean simulation).
  - Branch at year 20 of the 1850 simulation; force with the (APD) forcing
  - Branch at year 90 of the 1850 simulation; force with the (APD) forcing
- Impact of coupling shock and bias formation in initializing climate change simulations
  - initialized from three different POP/CICE states from same CORE.v2 forced simulation. Modified AMIP forcing 1950-1970
  - Approximate Present Day Forcing initiated after 20 years – ca 2000 climatological GHG and aerosol precursors