Panel Discussion: Model Biases and Challenging Issues

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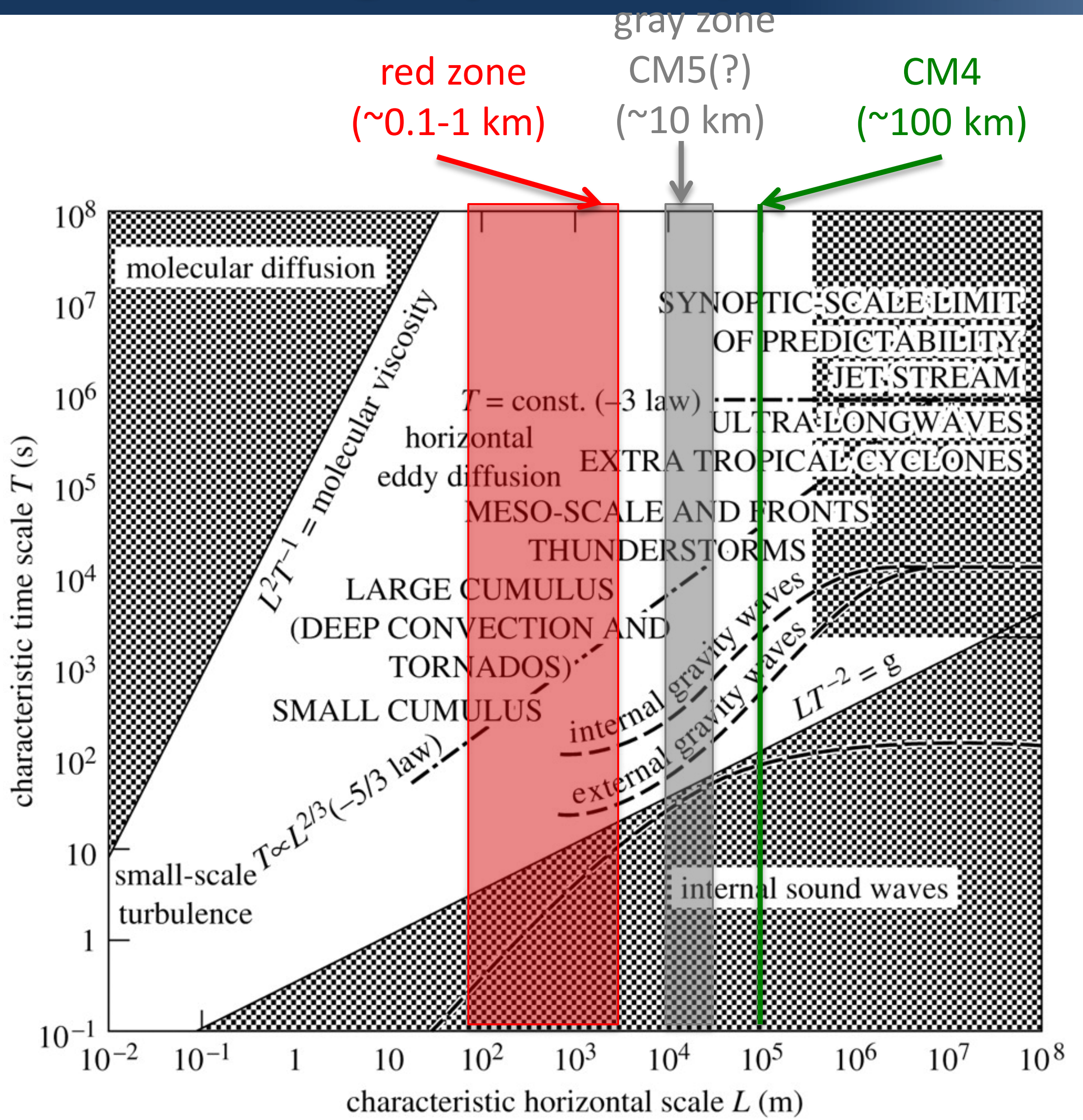
Challenge: Atmospheric physics parameterization in the gray-zone (~10 km)

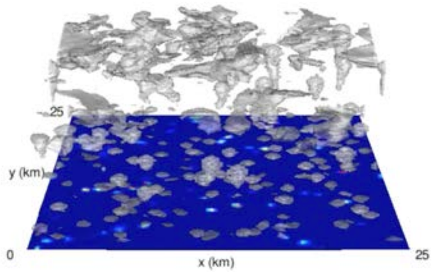


Following Smagorinsky (1974)

A modeling system for gray-zone physics development

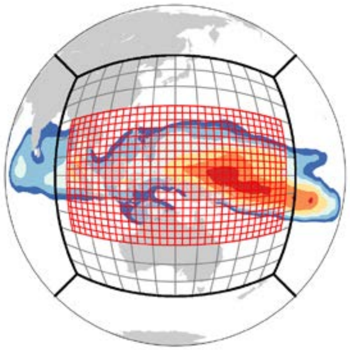
Tier 1: Cloud-Resolving Models

(~0.1 to 10 km)



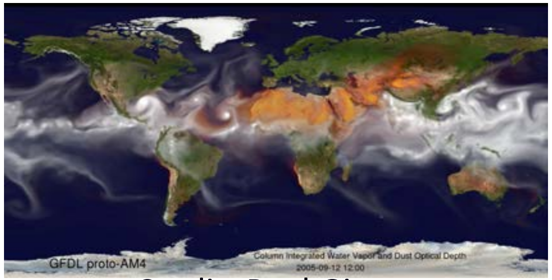
Credit: Nadir Jeevanjee

Tier 2: Variable-Resolution Global Model (~1 to 10 km, with 3X regional refinement)



Credit: Lucas Harris and Kun Gao

Tier 3: Uniform-Resolution Global Model (~1 to 100 km)



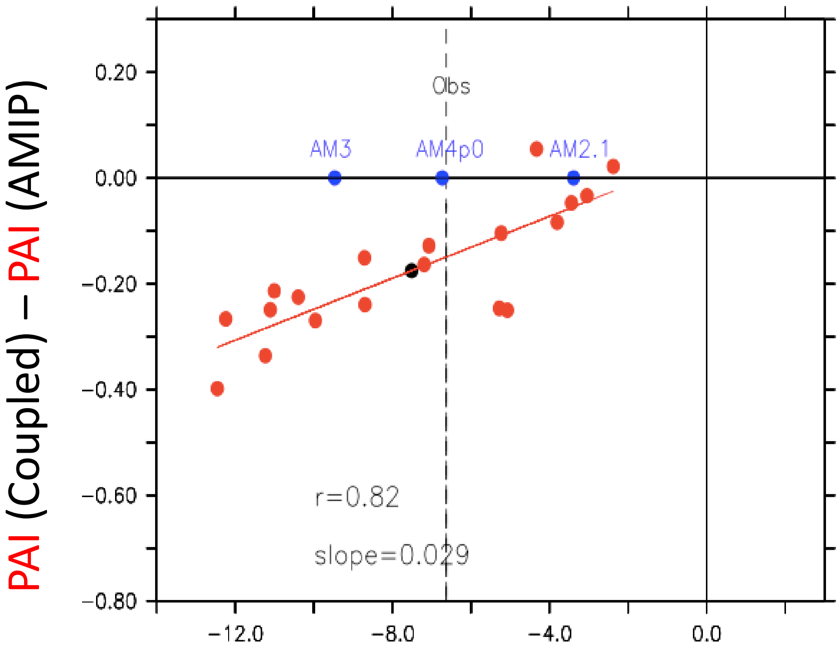
Credit: Paul Ginoux

To make the most out of this modeling system

- Formulation All models will be based on the same FV3 dynamical core and the same set of physics parameterizations.
- Analysis More emphasis will be put on process-level diagnostics (collaboration with NOAA Model Diagnostics Task Force) and extreme weather events.
- Science Key questions to be addressed:
  - Role of deep convection in cloud feedback
  - Transition from shallow to deep convection
  - Tropical transients
  - PDF of resolved motion.
  - …

Double ITCZ bias diagnosed from AMIP simulations

Each red dot is CMIP5 model



NH-SH tropical asymmetry in TOA SW (AMIP)

PAI = measure of double ITCZ bias

AMIP bias in SW absorption (not AMIP bias in PAI itself) is correlated with increase in PAI bias when model is coupled

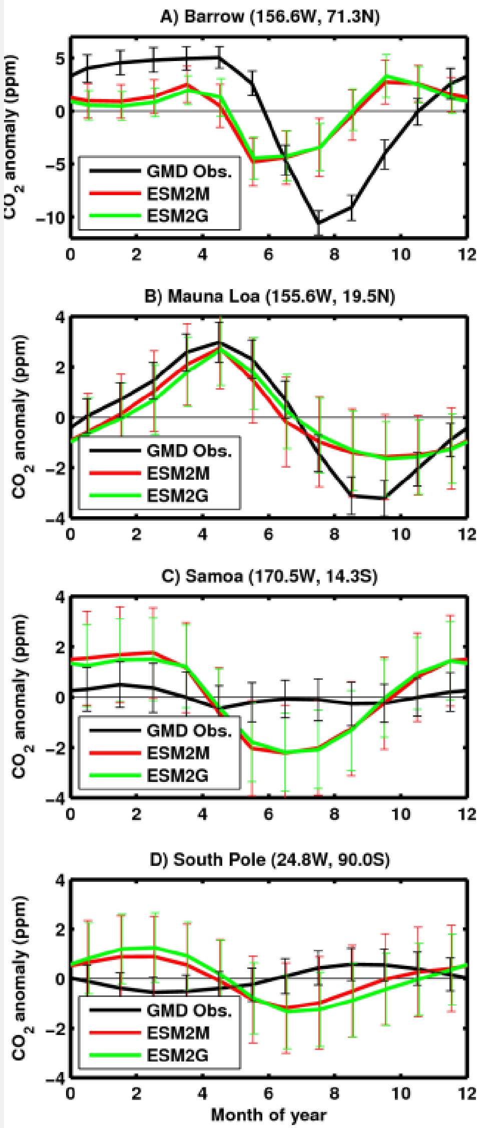
Baoqiang Zhang, Ming Zhao, Isaac Held, Chris Golaz, GRL 2017

How to Attribute CO_2 Mean and Variability Biases In the Face of Diverse and Complex Drivers?

Problem: NOAA/GFDL Coupled Carbon-Climate Model

Dunne et al. J Climate 2013: GFDL's ESM2 global coupled climate-carbon Earth System Models Part II: Carbon system formulation and baseline simulation characteristics.

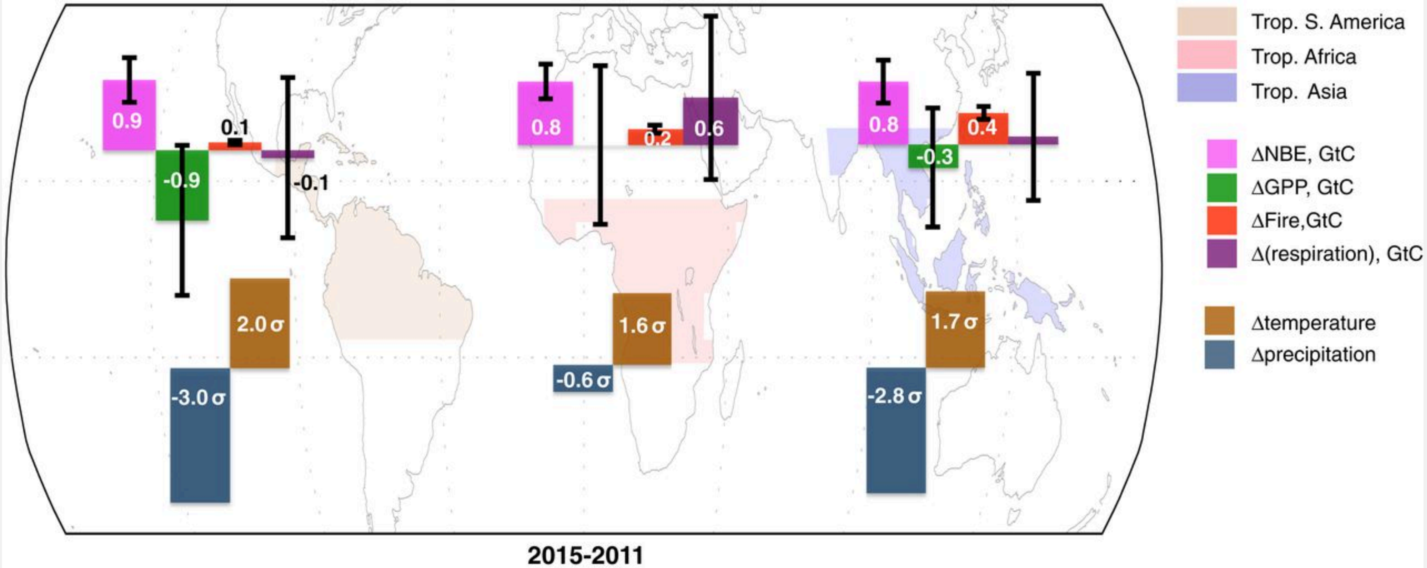
Fig. 12. Seasonal cycle in surface atmospheric CO_2 anomalies from detrended NOAA/Global Monitoring Division (GMD) observations (black), ESM2M (red), and ESM2G (green).



Partial Solution?: NASA Carbon Monitoring System

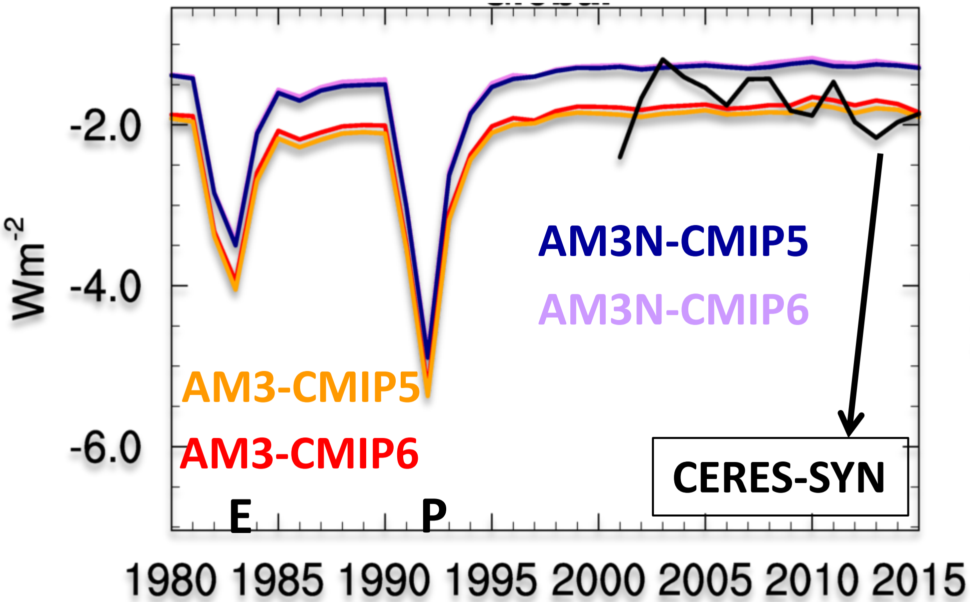
Liu et al. Science 2017: Contrasting carbon cycle responses of the tropical continents to the 2015–2016 El Niño

Fig. 2 Carbon flux, temp., and precip. anomalies in 2015 relative to 2011.



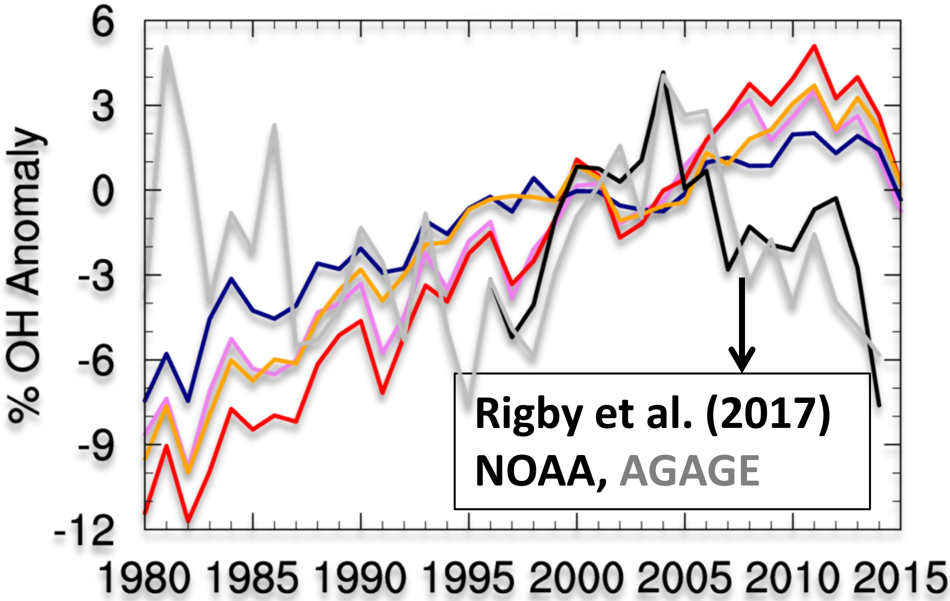
Uncertainties in Atmospheric Composition and Climate: Focus on model, input or both?

Shortwave Radiation Flux Change at Top-of-Atmosphere due to Aerosols



model structure > short-lived pollutant emission inventories

Global Mean Hydroxyl (OH) Radical



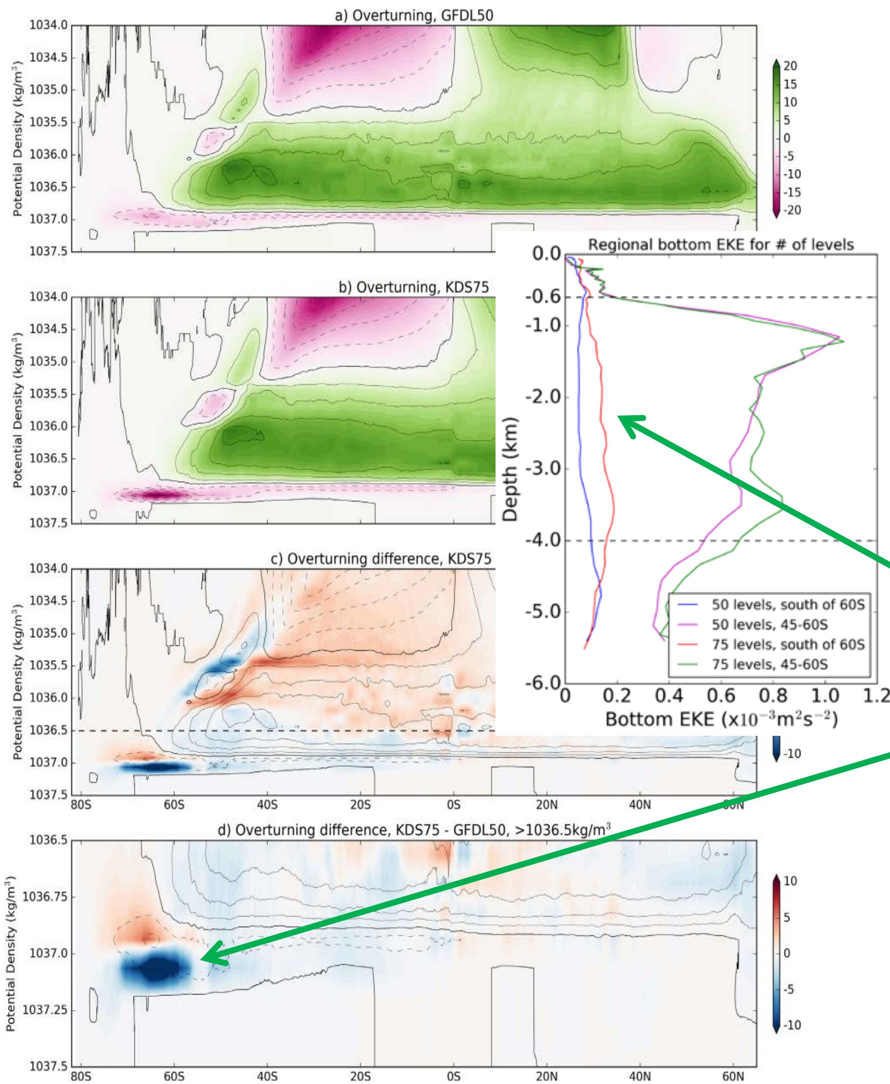
model structure ≈ short-lived pollutant emission inventories

Model Versions: AM3 (Donner et al. 2011; Naik et al. 2013), AM3N (Paulot et al. (2016)
Short-lived Pollutant Emissions: CMIP5 (Lamarque et al. 2010), CMIP6 (Hoesly et al., 2017)

Simulations courtesy F. Paulot and D. Paynter

Vertical ocean resolution & Antarctic Bottom Water

Stewart, Hogg, Griffies, Heerdegen, Ward, Spence, England, *Ocean Modelling* 2017



Vertical resolution needs to be sufficient to resolve vertical structure of baroclinic modes admitted by the horizontal grid.

Stewart et al algorithm for vertical grid in z-level ocean models → 50 levels for 1st mode, 75 for 2nd mode, etc.

Better resolving vertical structure of baroclinc modes (here 1st & 2nd), enhances the deep circulation as well as flow off the shelves.

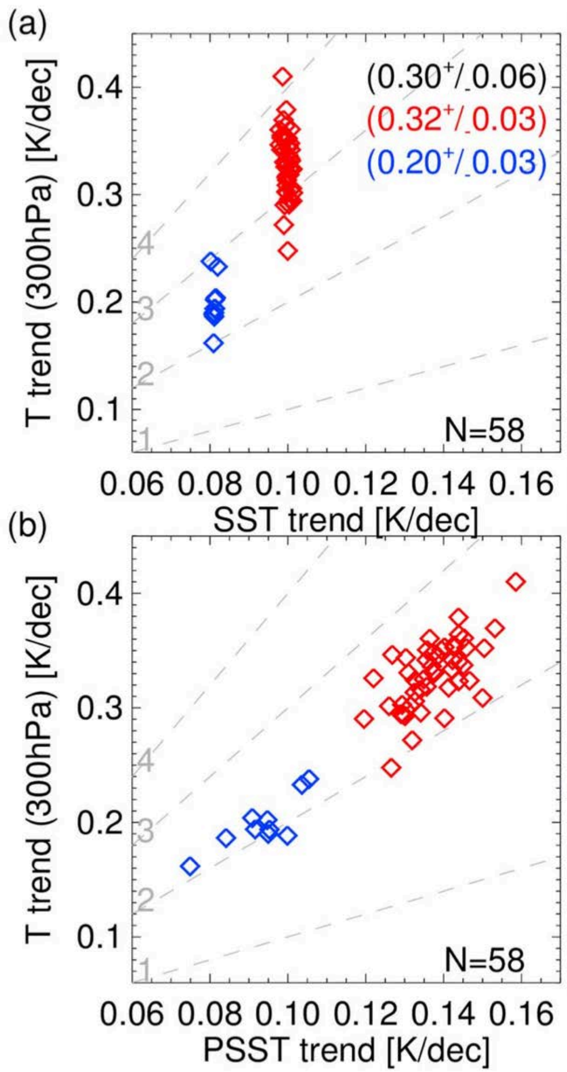
Simulations here compares 50 & 75 level version of the CM2.6 ocean-ice configuration with CORE-NYF forcing run for 65 years.

Twice bottom EKE south of 60S at depth of continental slopes.

Significant enhancement (~8Sv) in AABW cell as well as other slope features.

Vertical Resolution Hypothesis for more energetic deep flows: The key is not the vertical resolution close to topography, because that is no better in the 75 level model. **Rather, the key is the resolution of diabatic processes in the mixed layer and resolution of vertical structure of baroclinic modes.**

Temperature trends 1980's-2008



AR5 AMIP (="observed Sea Surface Temperatures")
(Each marker is one model run; 3 ensembles per model.)

-> Range of **300hPa Tropical Temperature trends: Roughly factor 3!**
(-> Long standing debate of moist adiabatic warming profile is not just a matter of MSU/sonde data!)

Cause: **Location of deep convection relative to SST**.
"Precipitation-weighted SST" trends explain spread in air temperature trends:

- Subtle differences in SST data (red="Hurrell", blue ="HadISST1").
- Large stochastic spread (more ensemble members).
- Systematic model differences to SST pattern forcing -> implications for coupled runs?

[Fueglistaler/Radley/Held, GRL, 2015]