ACME
Accelerated Climate Modeling for Energy

"Status and Future Roadmap – ACME Atmos"

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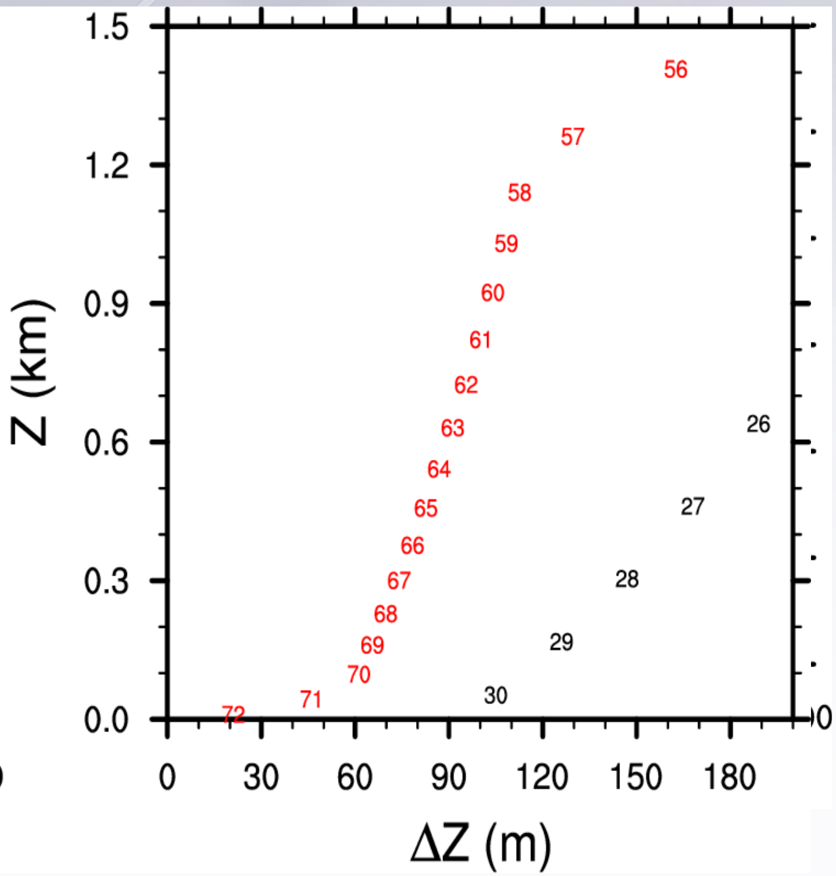
V1 Atmos – New Parameterizations

- Aerosols
  - MAM3 → MAM4
  - Revisions to convective transport, aerosol nucleation, and scavenging to transport more aerosols to high latitude
  - Aerosol resuspension → evaporating aerosols are to the coarse mode
  - Numerics of Aerosol Nucleation
  - Sea Spray Aerosol now contains an organic component
- Ice Microphysics
  - Nucleation
  - Conversion to precipitation
  - ~~Subgridscale vertical velocity~~
  - ~~Prexisting Ice~~
- ~~Elevation Class Decomposition (sub-columns for atmosphere and land~~)
- Simple Ozone (linearized production and loss)
- Shallow Convection/Turbulence → CLUBB
- Cloud Microphysics → Morrison Gettelman version 2 (MG2)

Deferred to Version 2

V1 Atmos – Better Resolved Hori. and Vert. Structures

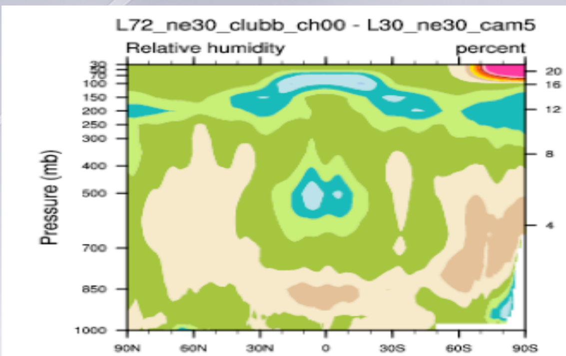
- 25km horizontal and 72 layers with top at ~ 60km



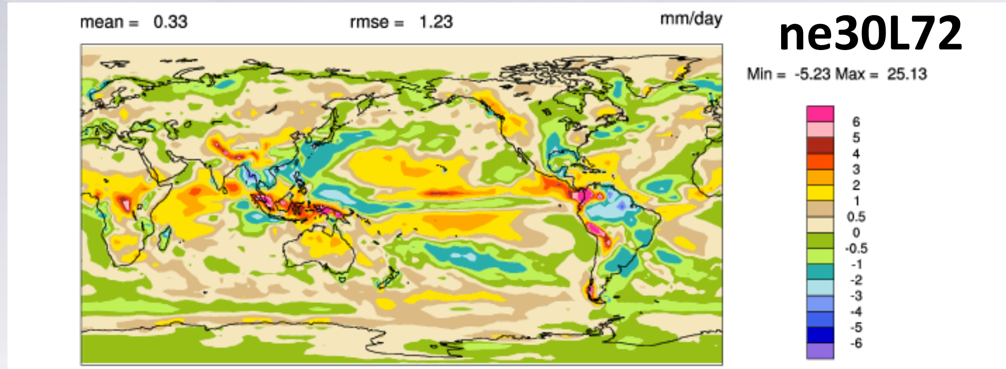
- Captures important dynamical features that cannot be resolved at typical GCM scales.
- Non-linear features governed by cloud, aerosol, dynamical interactions
- Better resolves features associated with water
  - Surface to troposphere water vapor gradients
  - Equator to pole water vapor gradients
  - Cloud thickness
  - Surface fog
  - Snow cover

Challenge: *Significant tuning required but little experience for a model at such high resolutions*

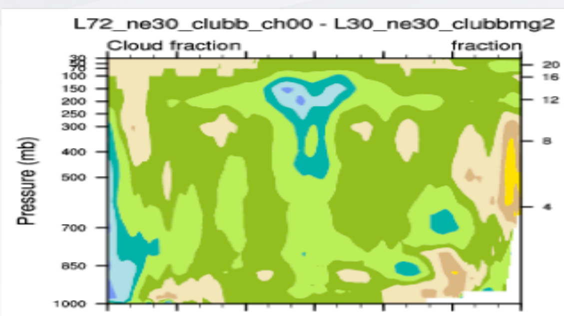
Changes in RH (ne30L72 - ne30L30)

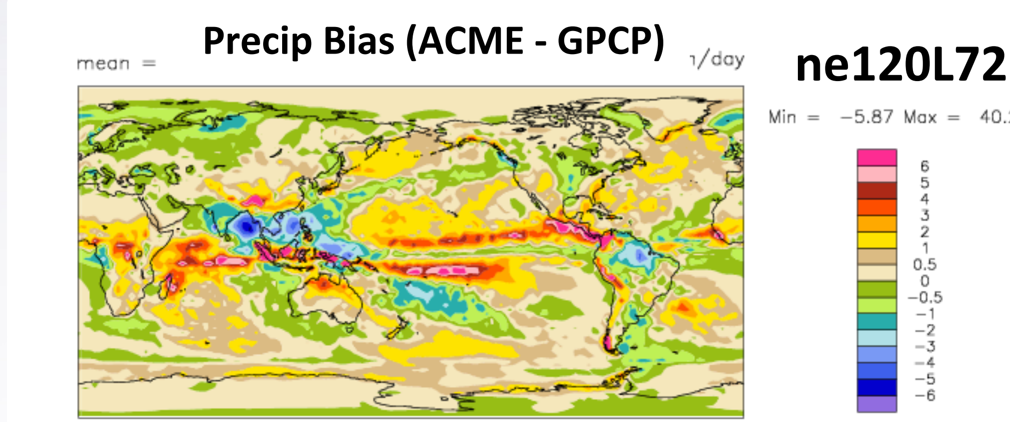


Precip Bias (ACME - GPCP)



Changes in Clouds (ne30L72 - ne30L30)

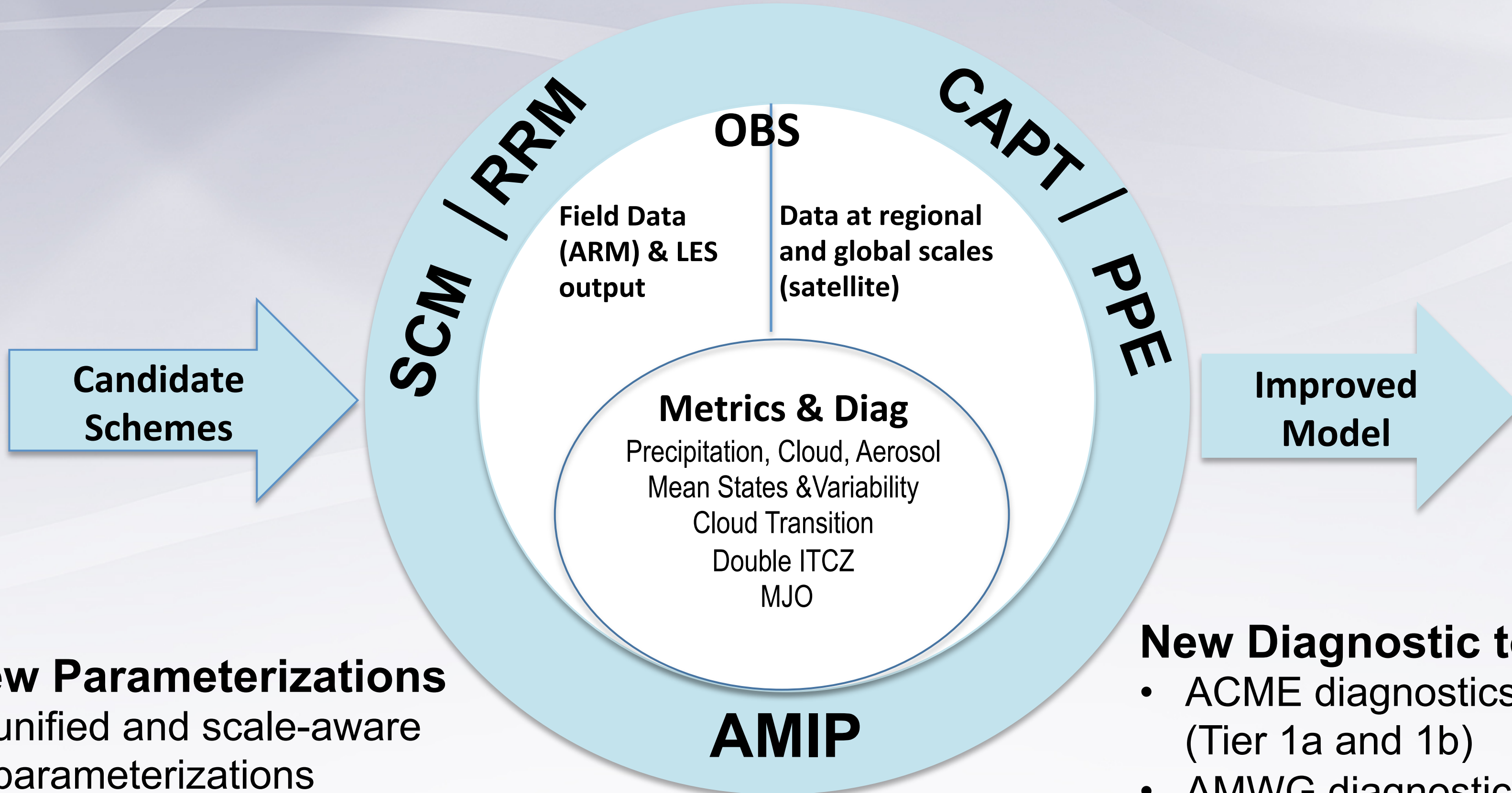




- Drier mid/upper troposphere
- Reduced cloud at all levels

- Larger precipitation bias in the tropical ocean
- **RESTOM > 7w/m2 in AV1C-00 before tuning**

Challenge: *How do you develop and test a model at a scale that you can barely afford to run?*



Observations

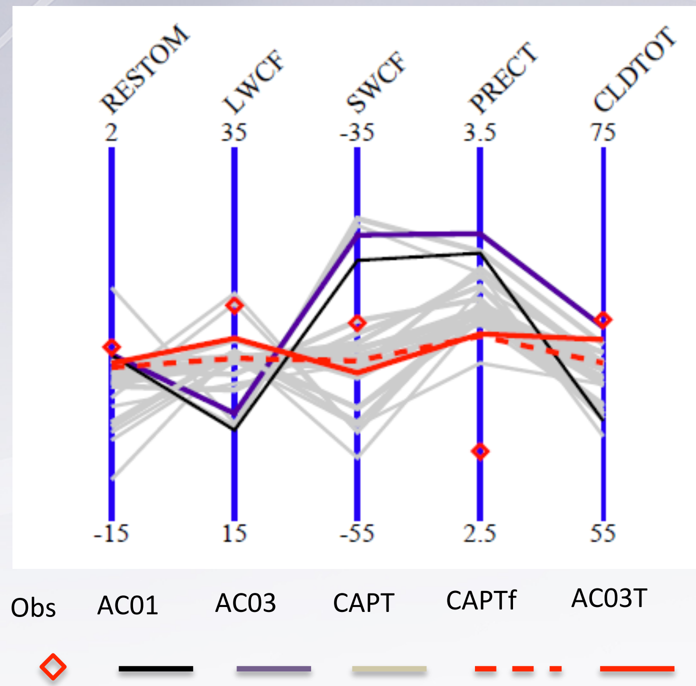
New Parameterizations

- unified and scale-aware parameterizations
- macrophysics/microphysics
- aerosols
- turbulence
- ....

New Diagnostic tools

- ACME diagnostics (Tier 1a and 1b)
- AMWG diagnostics with multiple view tool
- Simulators (COSP)
- ARM diagnostics & ARM Simulators

Short-term hindcasts and PPE used to effectively gauge the tuning response at high resolution



Global JJA mean stats from CAPT and AMIP runs. AC01 and AC03 use default. CAPTf and AC03T use same tuning parameters

- Biases associated with fast physics occur in only a few days
- Computational cost for a CAPT test is 1/25th or less compared to a typical AMIP test.
- Wall clock time as small as 1/100th with bundling; turnaround even quicker as short large jobs favored on LCs.

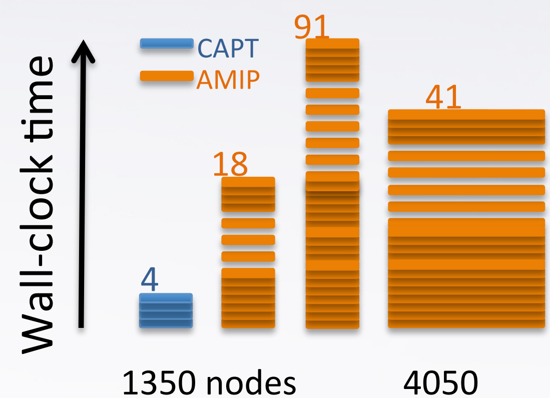
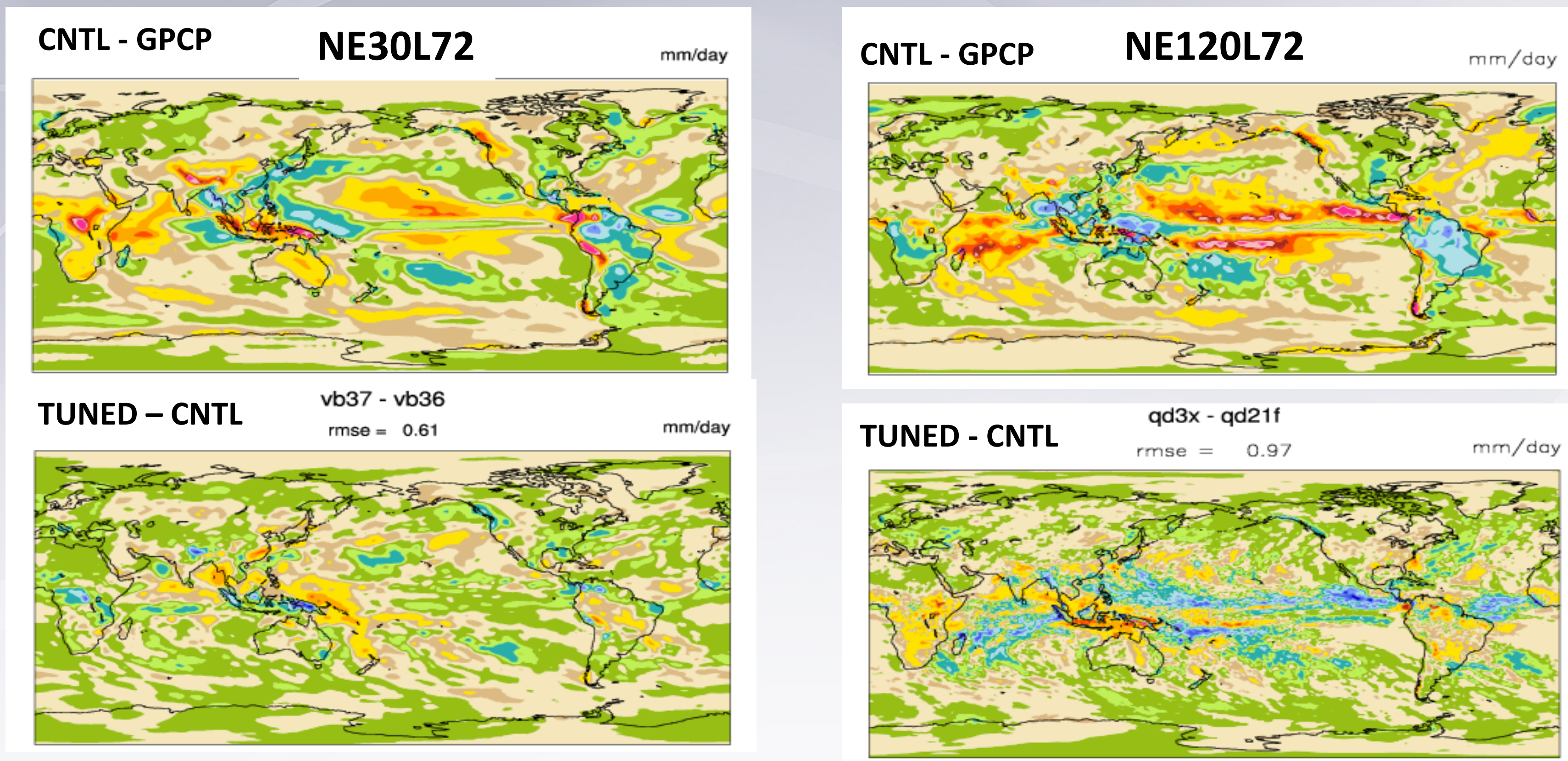


Illustration of wall-clock time for CAPT (5day) and AMIP (JJA or 15mon) simulations on Titan. One unit is 42 minutes.

Tuning has reduced many model biases



- Noticeable Improvements are seen in the tropics including maritime continent, TWP and the Amazon regions.
- Other improvements include reduced biases in mean precipitation, SLP in the NH, surface temp in SE US, cloud forcing distribution, Southern ocean wind stress, AIE, and QBO.
- RESTOM < 0.5 W/m2

Current status

- Extensive tuning has been conducted in the atmosphere group for both low and high resolution configurations in the past 4 months.
  - >**300** 1-yr or longer tuning simulations with ne30L72 done
  - Hundreds of 5 day hindcasts done for high resolution tuning and tests.
  - Total 256x12= **3072** 3-day PPE runs completed for providing guidance to the tuning (Perturb 18 parameters with 256 sampling points and 12 ensembles for each sampling point).
- Basic tuning has been completed for both the low and high resolution configurations
  - A well-tuned ne30L72 configuration with close to zero imbalance at TOA for F1850 was provided to the coupled and technical teams for their subsequent use.
  - A reasonable tuned configuration is ready for coupled testing.
- Ongoing efforts are to continue to reduce those outstanding biases identified from current tuning tests before model freezes. We have found ways to reduce these biases.
  - Southern ocean wind stress, AIE, regional bias in clouds and precipitation.
  - Other key tasks that have high priorities for the coupled tuning.

Roadmap for next 12 months (1 July 2016 – 30 June 2017)

- Better understand of the ACME v1 atmosphere model
  - Examine model behaviors in coupled simulations
  - Scientific analysis of model simulations
  - Document ACME v1 atmos in scientific papers
  - *Analysis for understanding of ACME V1 science problems*
- Enhance capabilities for model development and analysis
  - Complete Tier 1a and 1b diagnostics and make them fully functional
  - Develop and document scorecards
  - RRM for other regions of important to ACME
  - Enhance simulator package by adding the aerosol simulator and ARM simulator
- Start new developments for V2
  (depends on V2 science and outstanding issues)
  - **Address Climate Biases**
  - Improved convection (ZM will be updated or replaced). Account for organization, microphysics, convective gustiness, CIN, etc)
  - Improved treatment of clouds, aerosols and their interactions
  - The elevation class scheme
  - Revisions to atmosphere flow (topography, non-hydrostatic flow, etc)
  - Isotopes
  - SE

Extra Slides

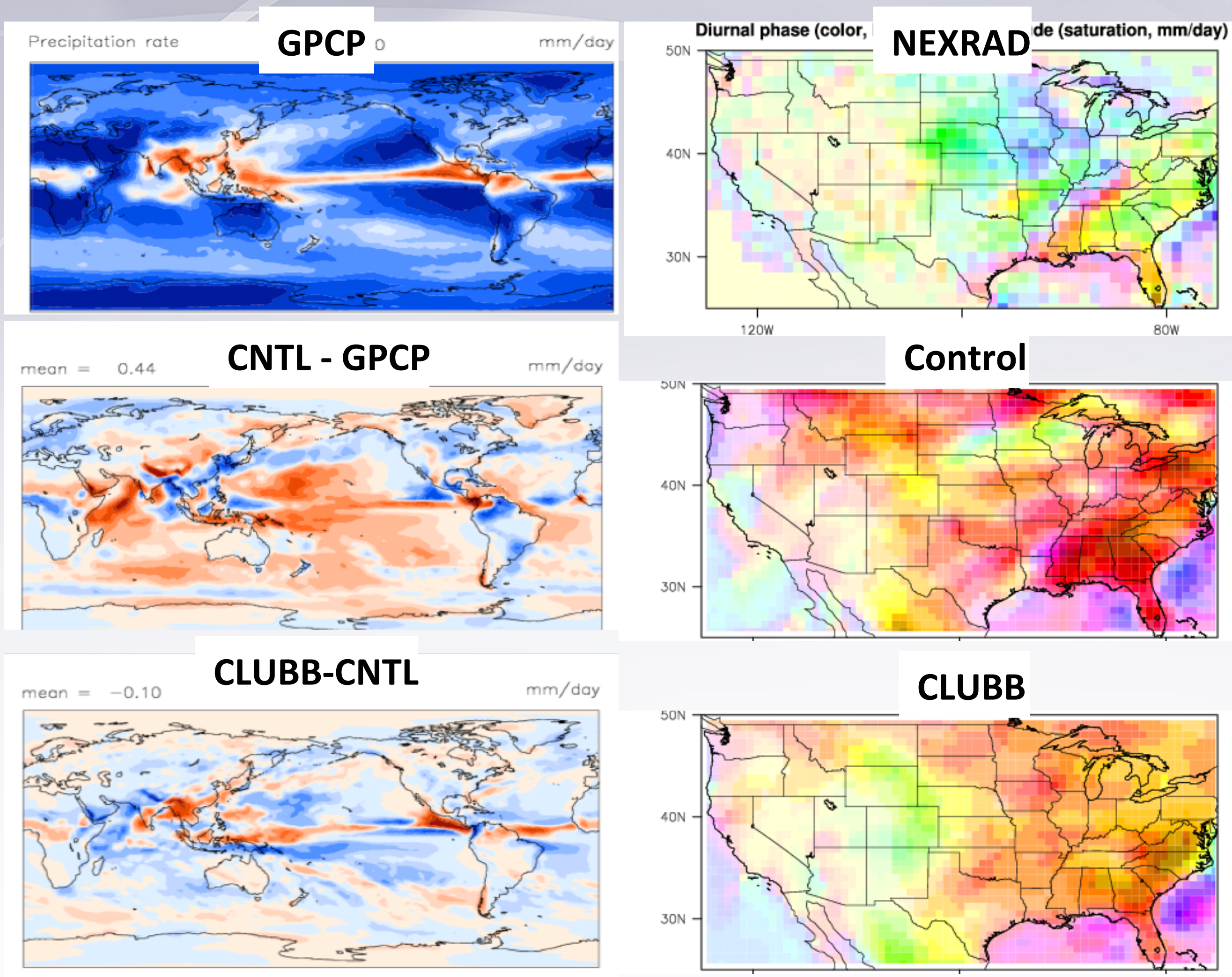
Thoughts on version two (1)

- Better parameterizations related to topography
  - Elevation Class decomposition in atmosphere and land model
  - Mountain stresses, gravity wave drag, flow around topography
- Updated convection
  - Organization, microphysics, interactions with surface heterogenieties, triggers
  - Stochastic elements in parameterizations
- Improved clouds (microphysics, macrophysics)
- Improved aerosols
  - Improved treatment of secondary organic aerosols
  - Reactive photochemistry for aerosols and Methane problems
  - Stratospheric aerosols, especially volcanos
- Improved internal consistency between convection, clouds, aerosols

Thoughts on version two (2)

- Improved physical/chemical/optical properties
  - Emission source types (e.g., biomass burning/fossil fuel/marine organics)
  - Shape
  - Shell-core treatments
- Numerical methods used to treat atmosphere flow, and physics
  - pressure gradient term
  - hybrid isentropic coordinate
  - non-hydrostatic model
  - Convergent, accurate, consistent numerics for physics
  - Improved thermodynamics
- TKE sensitive to radiative cooling

Improved Mean State and Variability with New Parameterizations Shown at ne30L30



- Significant improvements are seen in pr, cloud radiative forcing, diurnal variability, MJO, cloud transition, etc ...
- Issues with Kelvin wave, AIE, etc ...