Knowledge Transfer and the Community Climate System Model

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Outline

- **The CCSM program**
- **The CCSM community: CCSM as an axis for KT**
- **Scientific challenges aligning MMAP & CCSM research**
- **Interaction of the CCSM and MMAP teams**

Ties to Knowledge Transfer plan:

3. Opportunities and challenges
   - Capabilities of the prototype MMF
   - Inertia of established modeling centers
4. Goals and objectives
   - Enable improved climate models
   - Provide improved tools for the simulation of global clouds
7. Metrics?

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The CCSM Program

Scientific Objectives:

- Develop a comprehensive climate model to study the Earth's Climate.
- Investigate seasonal and interannual variability in the climate.
- Explore the history of Earth's climate.
- Estimate the future of the environment for policy formulation.

Recent Accomplishments:

- Release of a new version (CCSM3) to the climate community.
- Studies linking SST fluctuations, droughts, and extratropical variability.
- Simulations of last 1000 years, Holocene, and Last Glacial Maximum.
- Creation of largest ensemble of simulations for the IPCC AR4.

http://www.ccsm.ucar.edu

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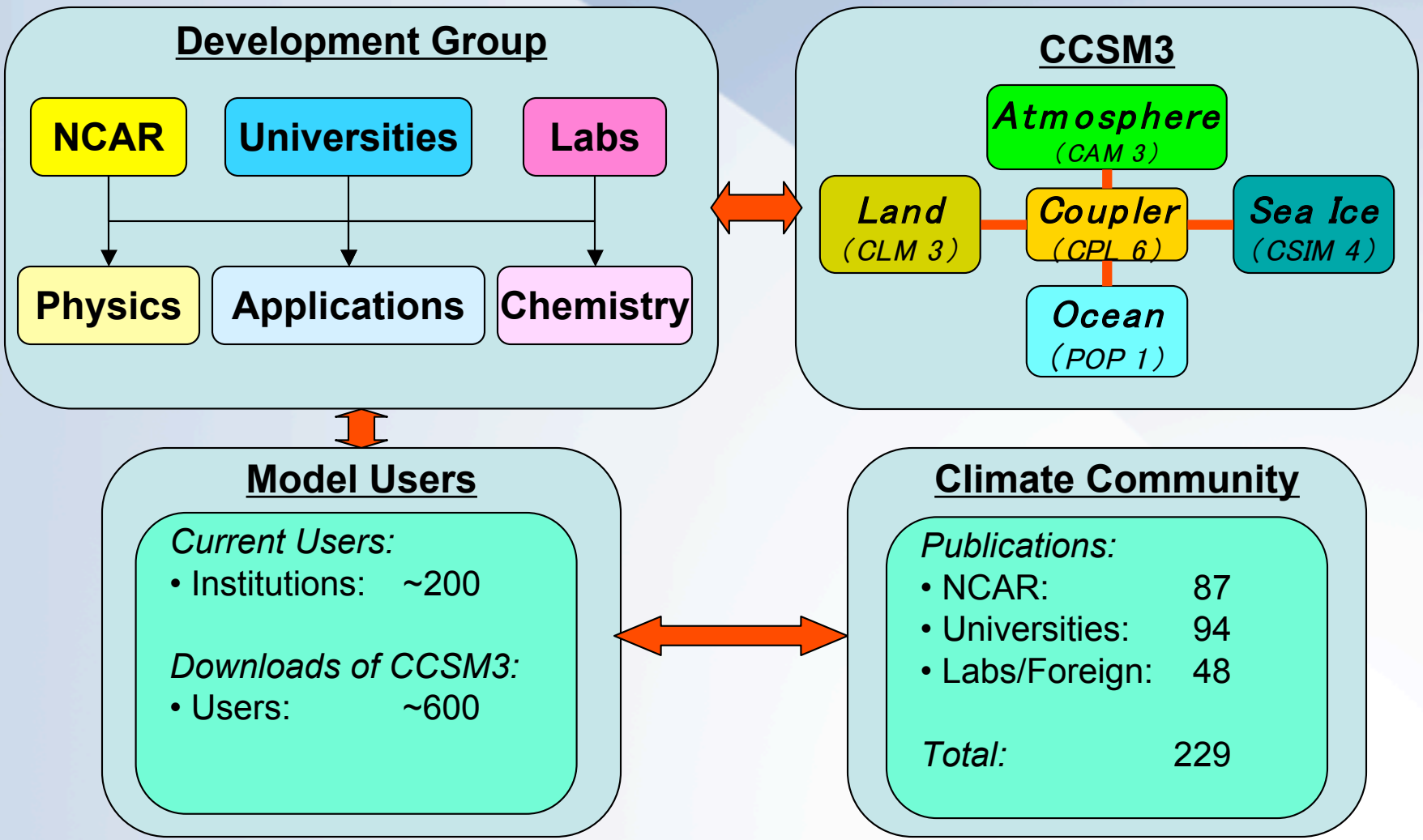
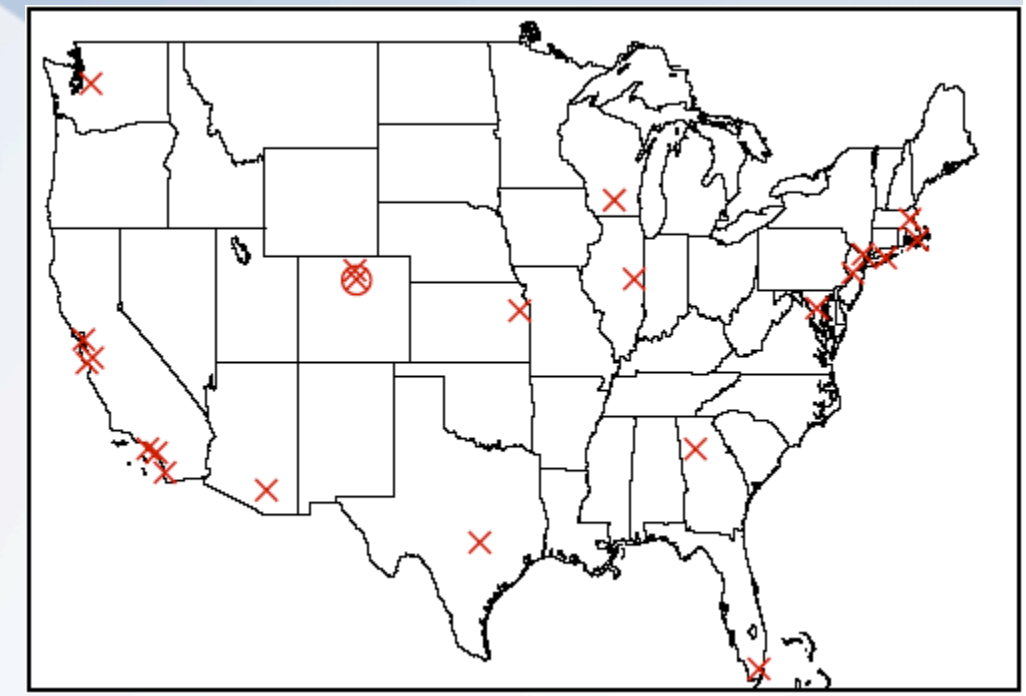
The CCSM Community



University Developers of CCSM

Twenty-two U.S. institutions including:

- Carnegie Institution
- Center for Ocean-Land-Atmosphere Studies
- Colorado State University
- Georgia Institute of Technology
- Lamont Doherty Earth Observatory/Columbia
- Massachusetts Institute of Technology
- Princeton University
- Scripps Institution of Oceanography
- State University of New York / Stony Brook
- University of Arizona
- University of California, Berkeley
- University of California, Irvine
- University of California, Los Angeles
- University of California, Santa Cruz
- University of Colorado
- University of Illinois
- University of Kansas
- University of Miami
- University of Texas
- University of Washington
- University of Wisconsin
- Woods Hole Oceanographic Institute

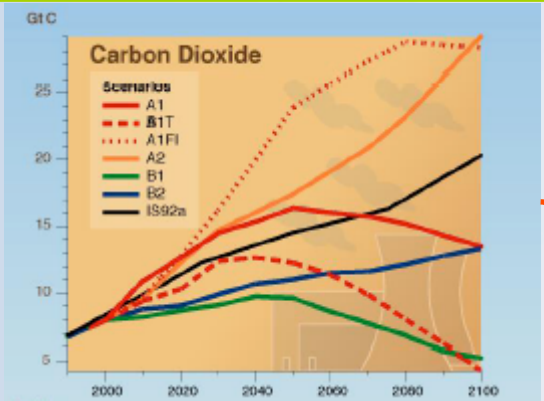


Development with our lab partners

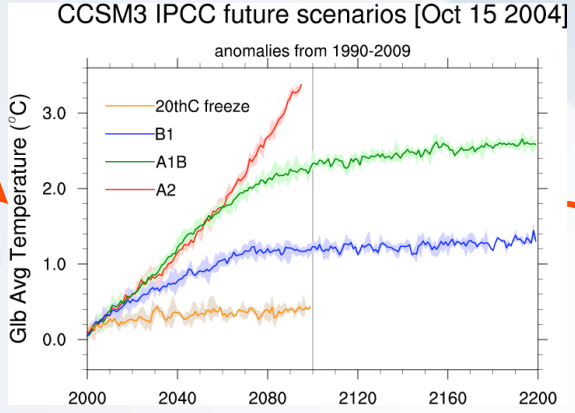
- **DOE:**
  - Major components of CCSM: POP and CSIM
  - Extensions to include BGC and chemistry
  - Software Engineering (esp. CAM)
- **NASA:**
  - Earth System Modeling Framework (ESMF)
  - Finite Volume Dynamical Core
- **NOAA:**
  - Implementation of GM eddy parameterization
  - KPP development
  - Anisotropic viscosity
  - Ocean Climate Process Teams + GFDL MOU

Climate Simulations for the IPCC AR4

IPCC Emissions Scenarios



Climate Change Simulations



Results:
- 10,000 simulated years
- Largest submission to IPCC
- 100 TB of model output

IPCC 4th Assessment

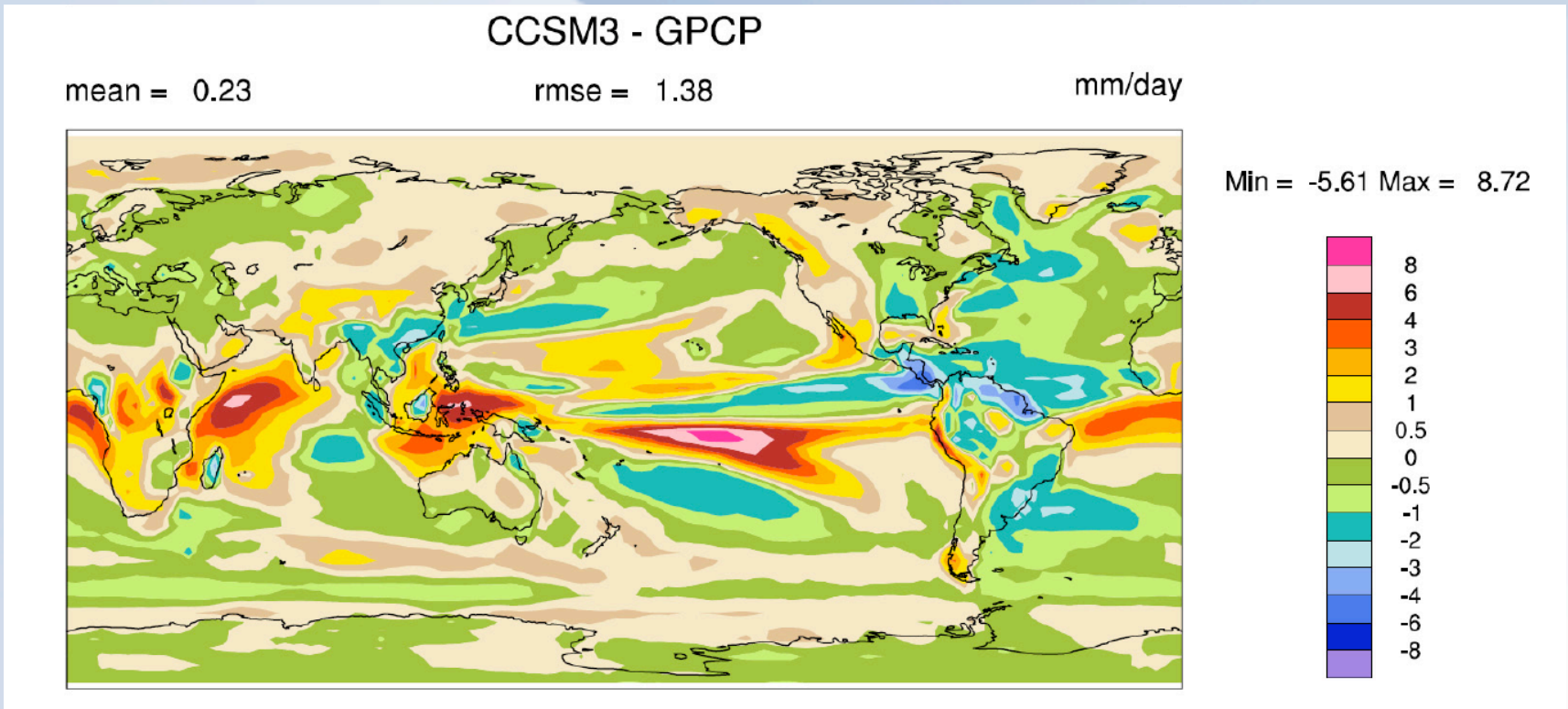
Alignment of MMAP and CCSM research aims

- **Traditional parameterization approaches introduce significant systematic errors in climate models.**

- **It is clear that we need a new basis for investigating cloud/climate interactions:**
  - Theory is not providing much guidance.
  - Intercomparison of traditional models is not yielding common and unique directions for parameterization improvement.

- **The synergistic opportunities for MMAP:**
  - Develop benchmark models for cloud/climate studies.
  - Use these to develop process-grounded parameterizations.
  - Make progress on long-standing debates regarding cloud/climate feedbacks.

Structure of Tropical Convective Activity



Collins et al, 2006

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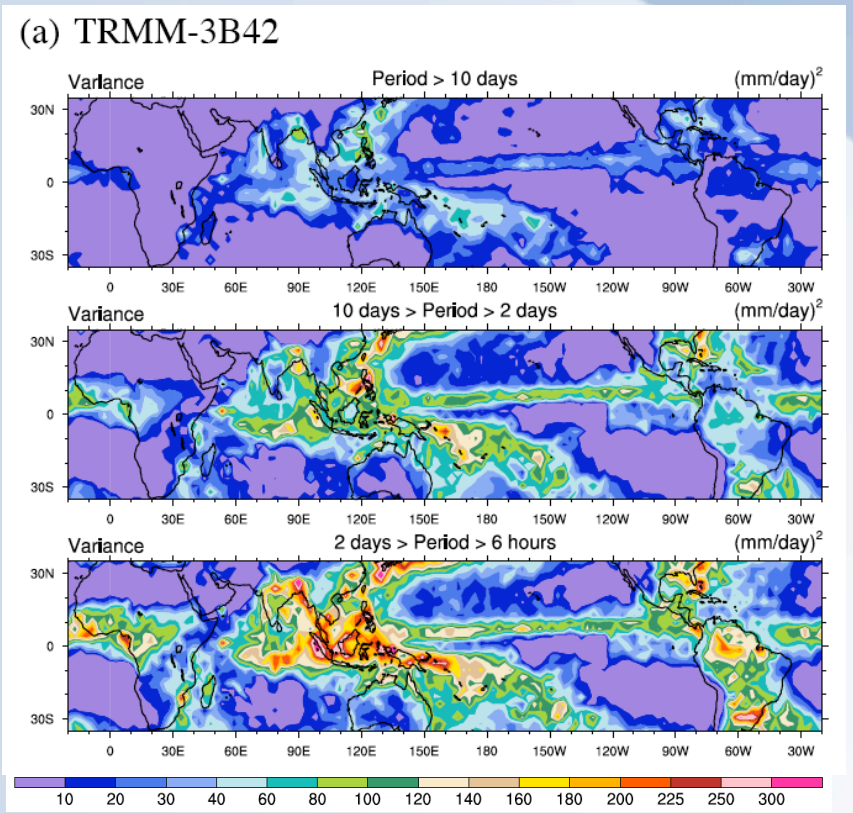
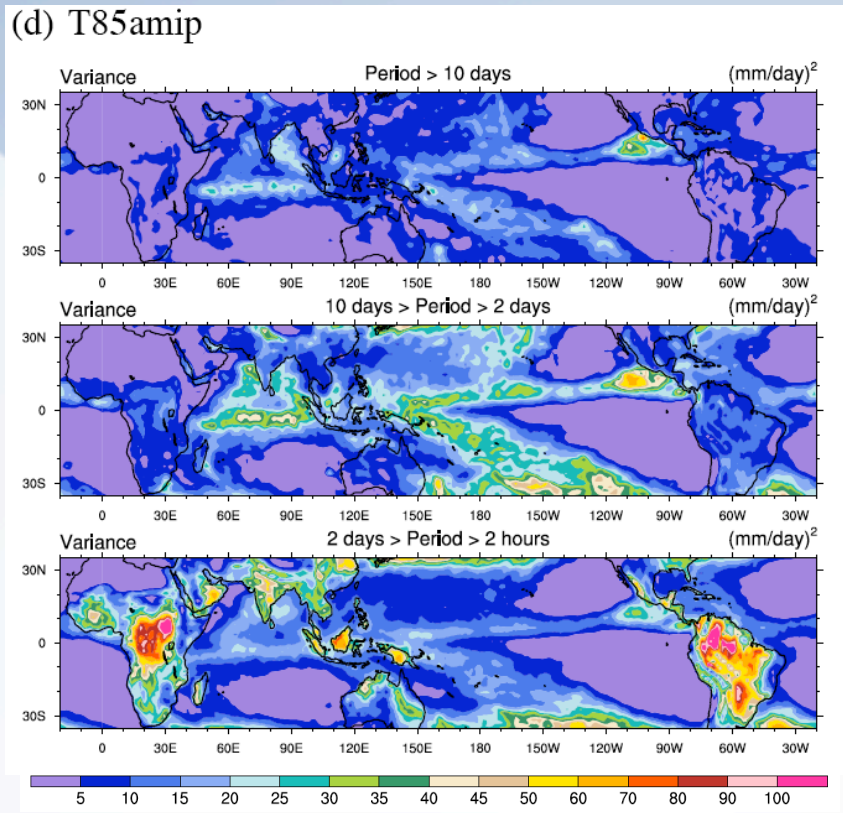
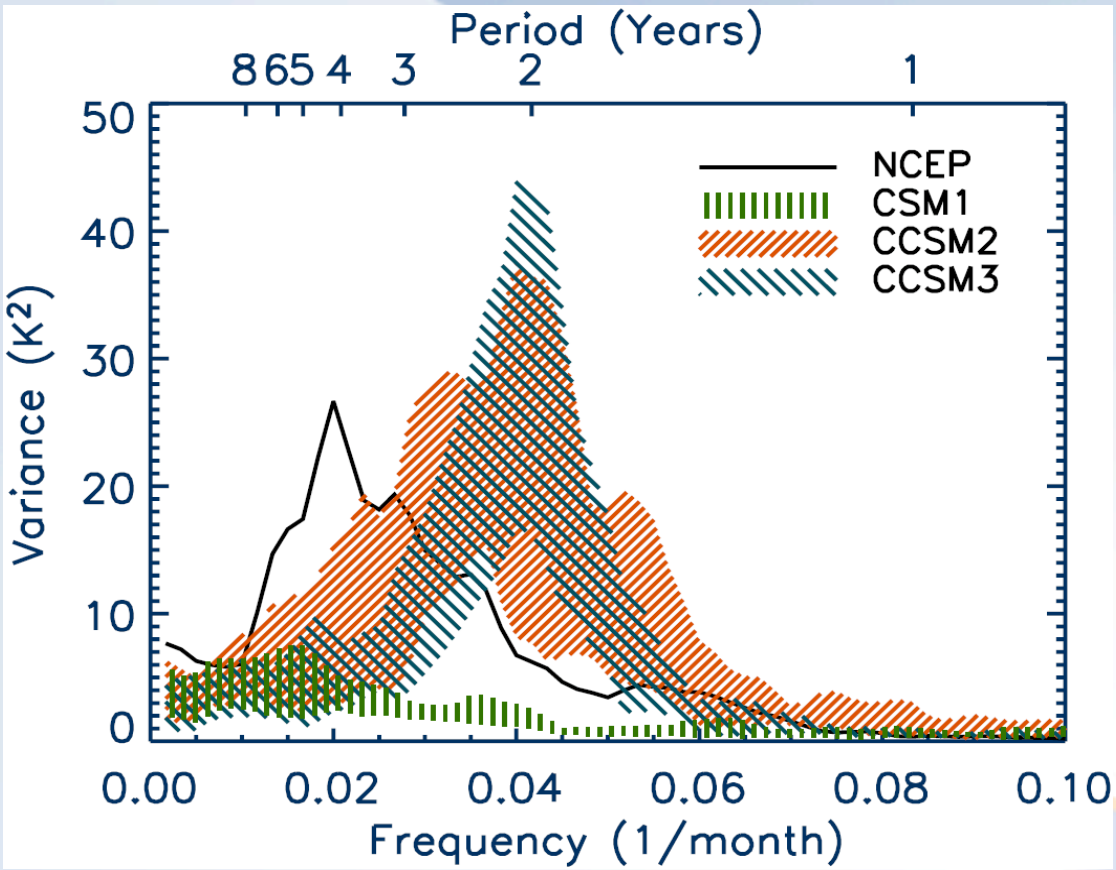
Variance in Precipitation





Rasch et al, 2006

ENSO Power Spectra



Gent and Kiehl, 2004; Collins et al, 2006

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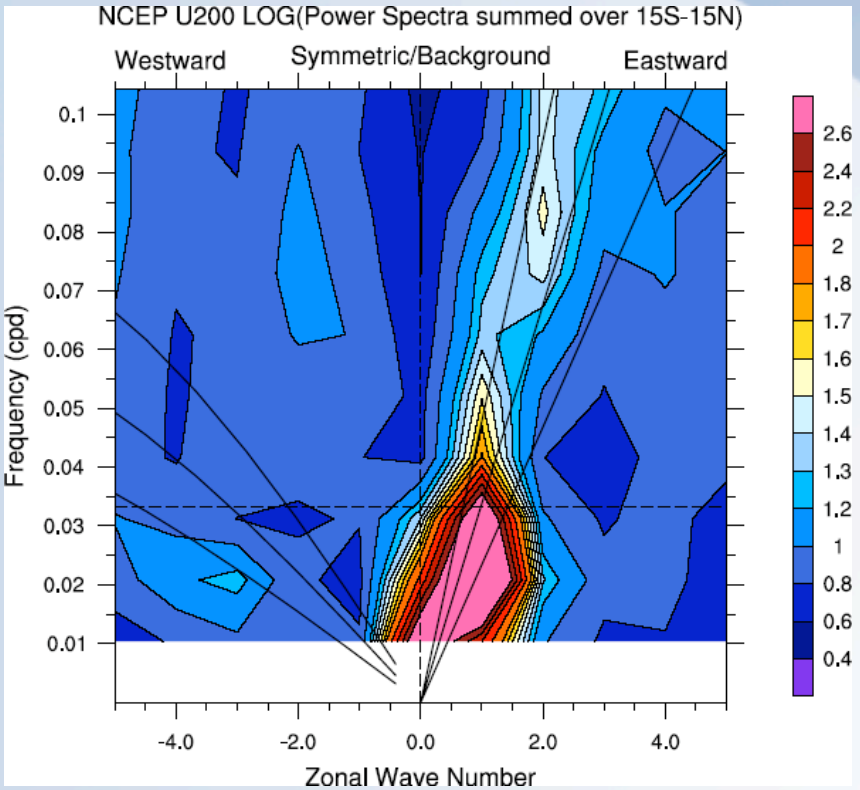
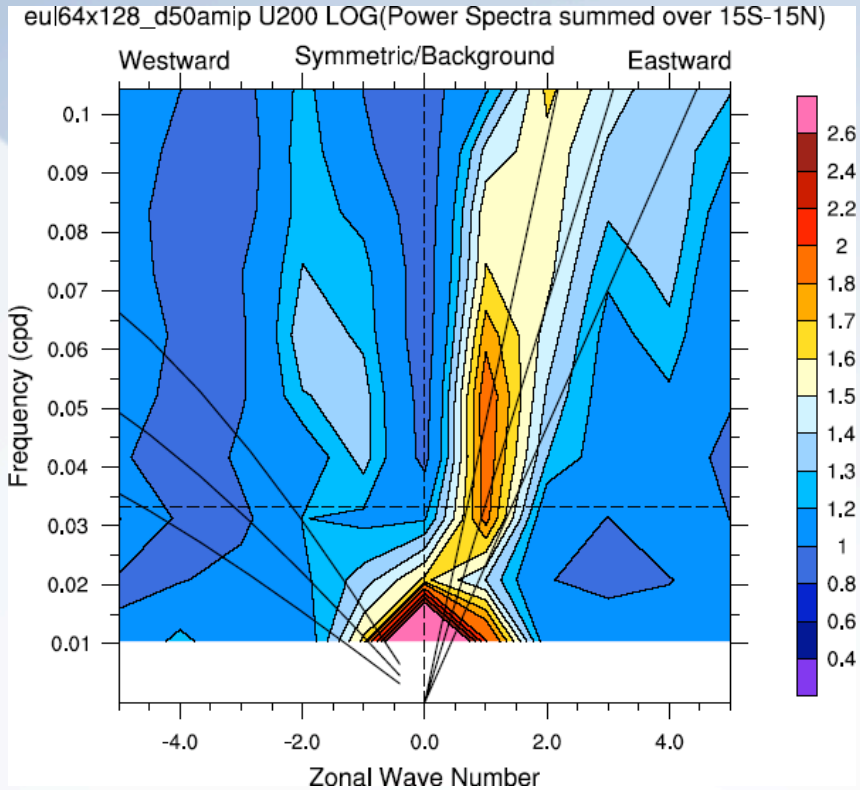
MJO Propagation





Collins et al, 2006

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Why do CCSM Scientists *Need* MMAP

- **New strategies for near-term objectives (IPCC AR5):**
  - Reduction in tropical biases in the physical climate
  - Development of an Earth System Model (ESMs)
- **Long-term objectives for IPCC AR6:**
  - Emphasis on “ultra”-high-resolution (10-20 km) ESMs
  - Increased focus on small-scale climate change
- **Two-track strategy for model development:**
  - “Bread and butter”
  - “Blue sky”

Initial Interactions of MMAP and CCSM

- **Starting point: the Atmospheric Model Working Group**
- **New AMWG processes for facilitating interactions:**
  - Metrics-based development
  - White paper for community engagement in development
  - Open scientific and implementation planning
- **New CCSM processes for facilitating interactions:**
  - Broad-based scientific and implementation planning
  - Broad-based discussion of scientific requirements
- **New directions for CCSM:**
  - Nested regional climate modeling

Implementation Plan for CCSM/MMAP Interactions

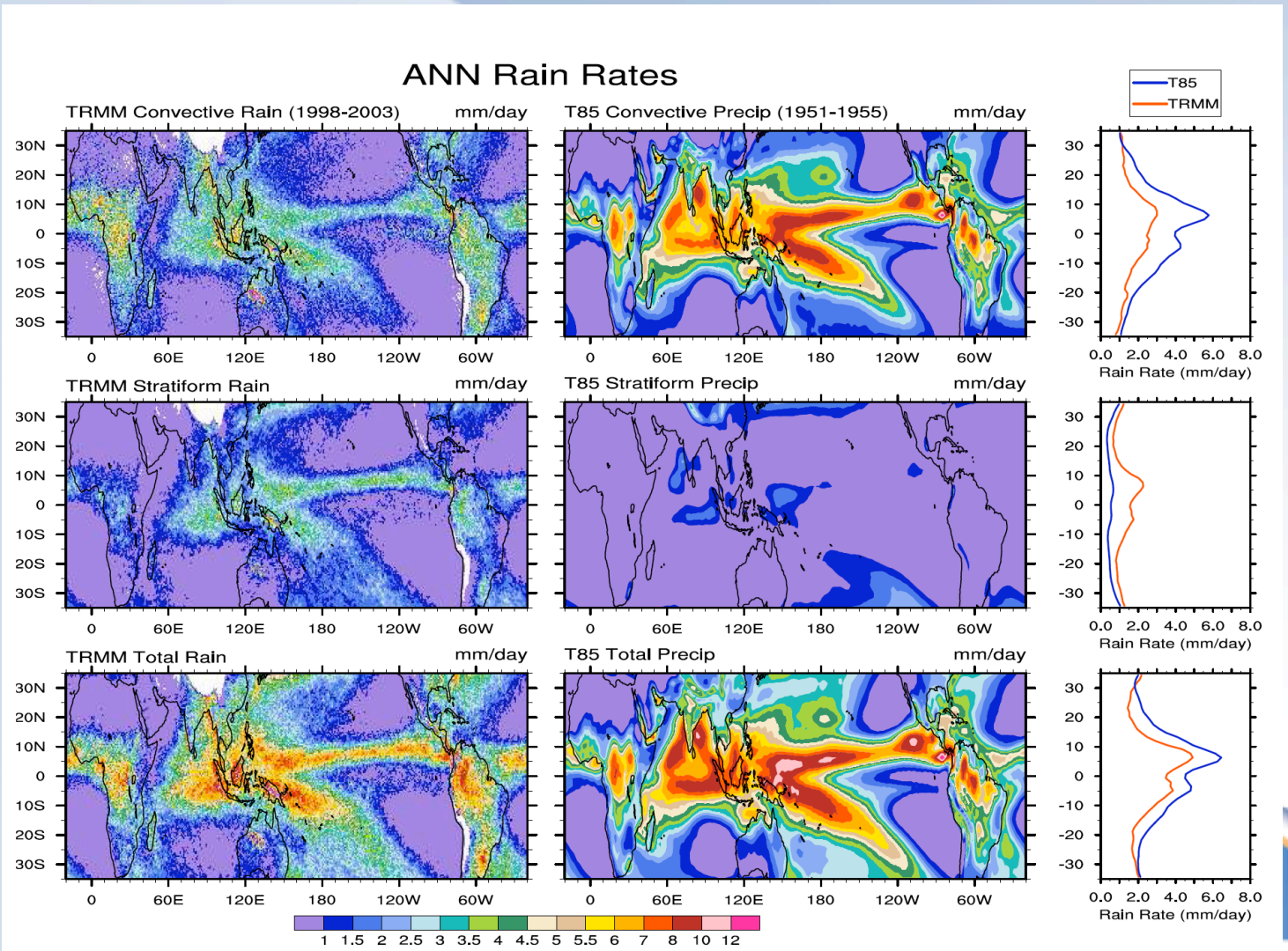
Plan:

- Year 1: Make prototype of MMF available to modeling centers
- Year 3: Make improved parameterizations available to centers

Challenges:

- What are the metrics for success of the new parameterizations?
- How can we best engage the larger modeling communities?
- Do we want to aim for “grand-challenge” climate experiments?
- Do we want to aim for “grand-challenge” assessment questions?
  - Diversity in cloud feedbacks?
  - Diversity in climate feedbacks?
  - Relationship of sub-grid processes to regional and global climate change?

Partitioning of Stratiform & Convective Rain



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