Climate Predictability
(CPPA Sci & Impl Plan, Chapter 2)

E. Hugo Berbery, Siegfried Schubert,
Dave Gutzler, Wayne Higgins

CPPA Objectives

Improve operational intra-seasonal to interannual hydroclimatic predictions for the Americas with quantified uncertainties sufficient for making informed decisions

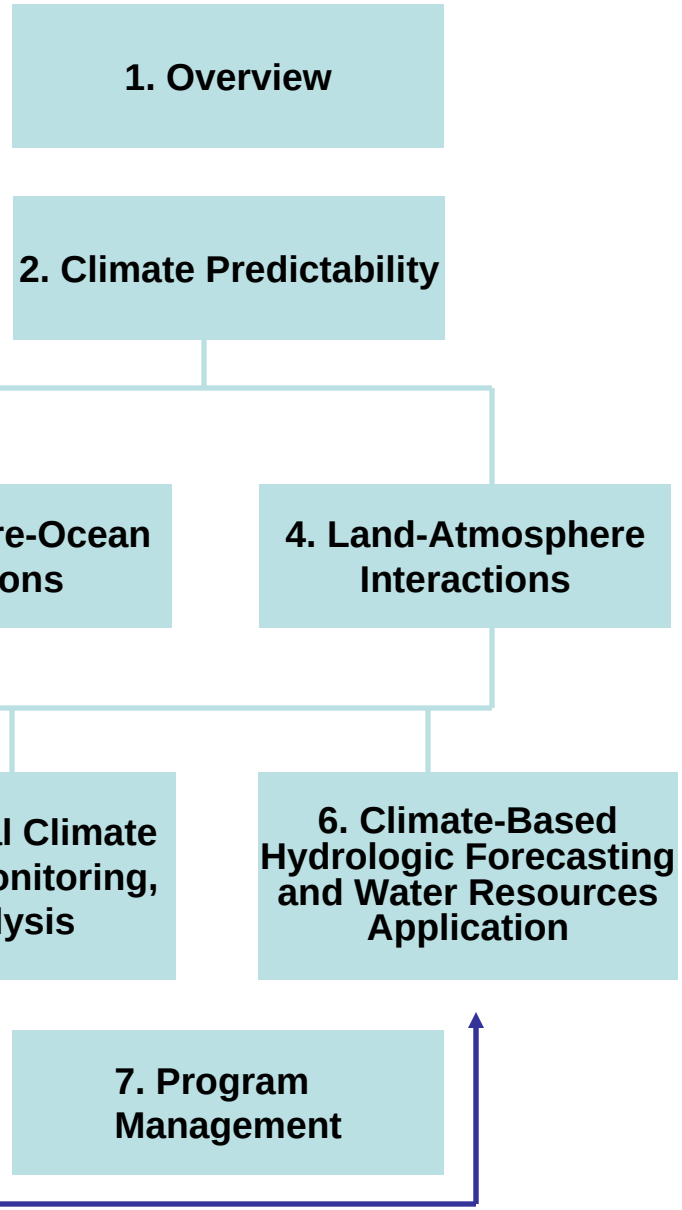
Quantify the sources and limits of predictability of climate variations on intra-seasonal to interannual time scale

Improve predictive understanding and model simulations of ocean, atmosphere and land-surface processes, including the ability to quantify uncertainty

Advance NOAA's operational climate forecasts, monitoring, and analysis systems by transferring research to operation

Develop climate-based hydrologic forecasting capabilities for decision support and water resource applications

Science Plan



Pathway

Research

Synthesis Implement-ation Testbed

Define needs Feedback on performance

Operation

Chapter contents:

- Science background
- Science priorities
- Implementation strategies
- Deliverables

Chapter 2: Climate Predictability

To develop and demonstrate a capability to make reliable monthly to seasonal predictions of precipitation and land-surface hydrologic variables through improved understanding and representation of ocean, land, and atmospheric processes in climate prediction models

Chapter 2: Climate Predictability

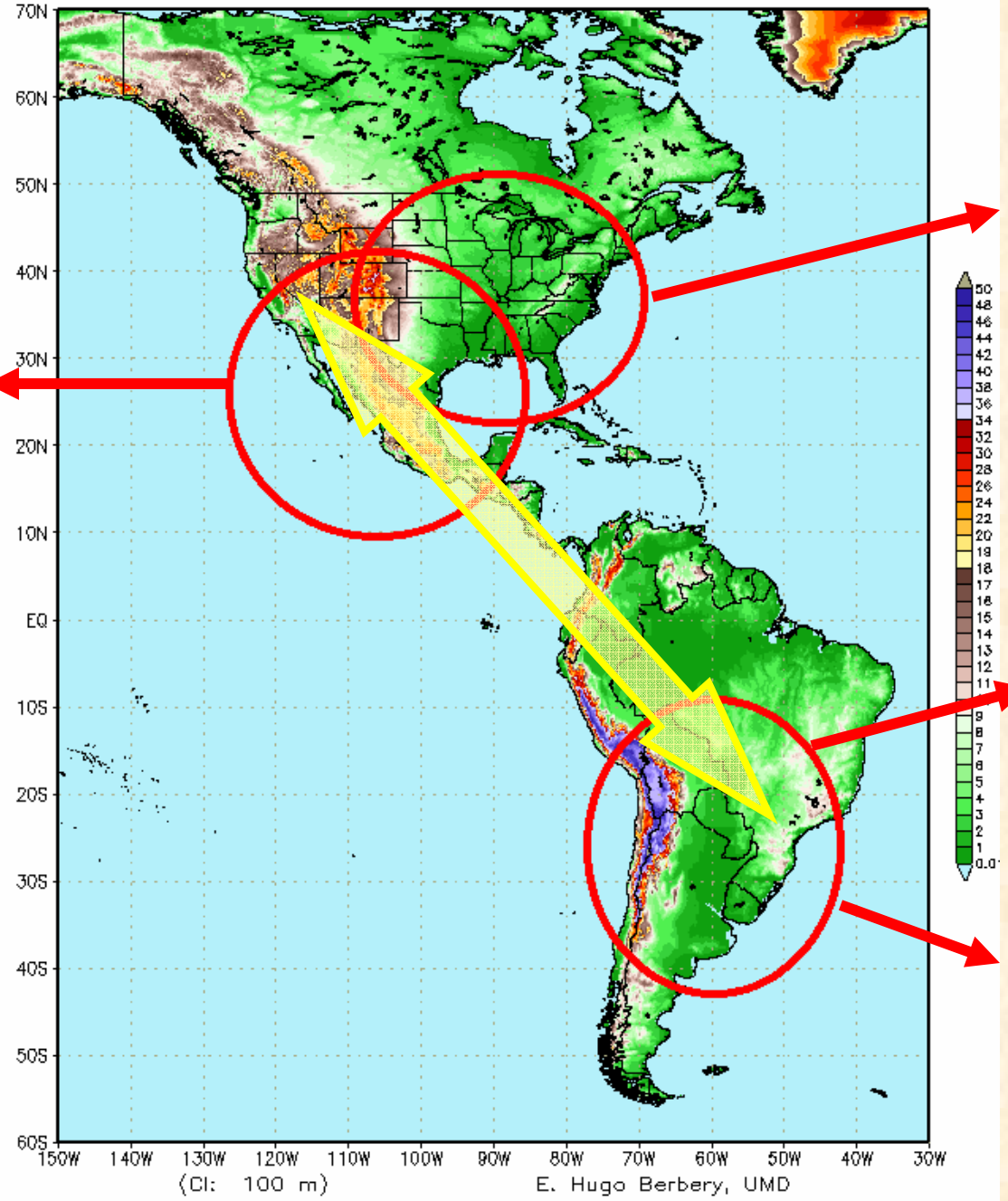
- Understand the contributions of land and ocean memory
- Modeling of coupled ocean-atmosphere processes
- Modeling of coupled land-atmosphere processes
- Atmospheric response to boundary forcings
- Modeling and prediction of precipitation processes (hydroclimatological focus)

Outline

- Chapter 2: Phenomena and research paths
- Warm season: The American monsoons
- Droughts
- Cold season hydroclimate
- Extreme weather
- Some predictability issues

North American Monsoon

Complex terrain



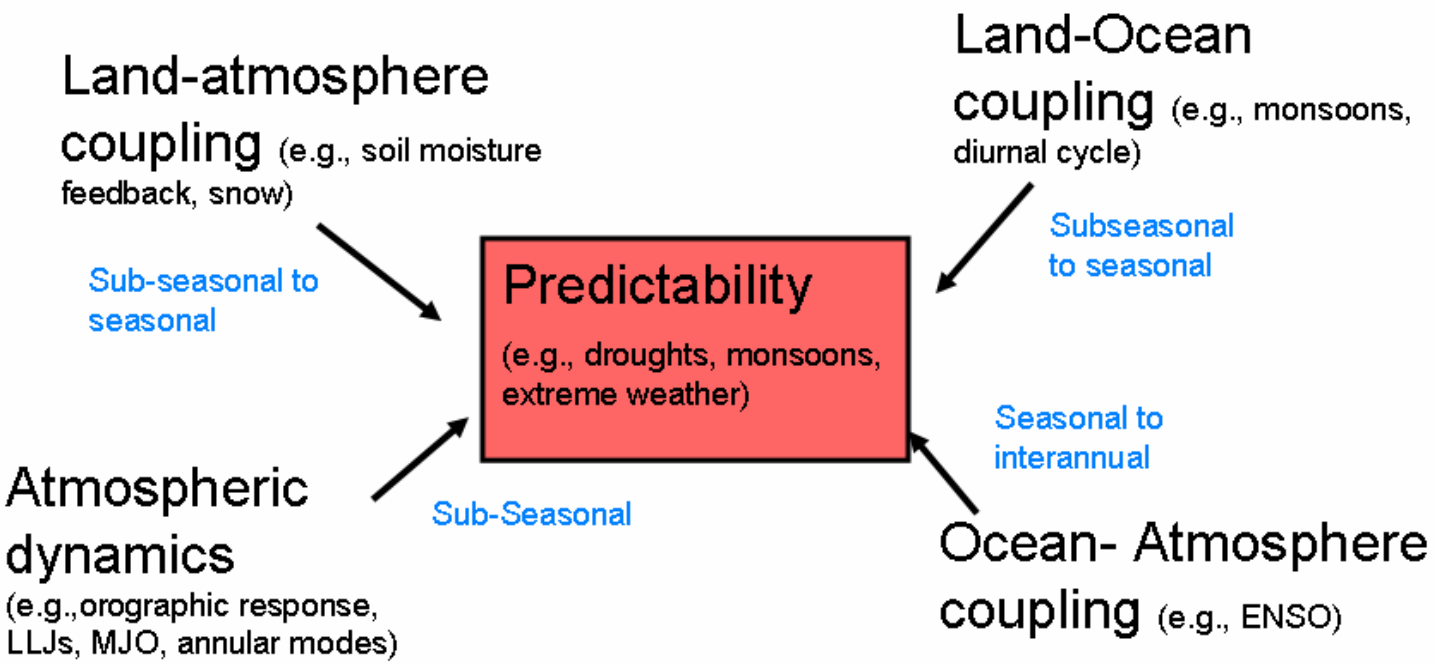
Great Plains Hydroclimate

South American Monsoon

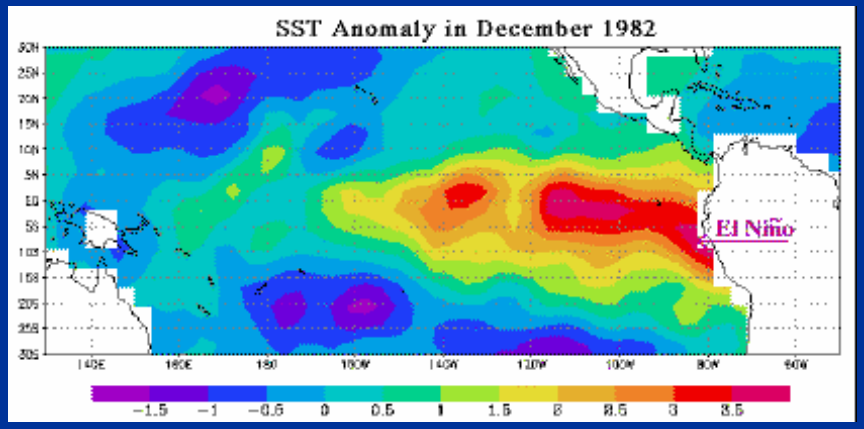
La Plata Basin

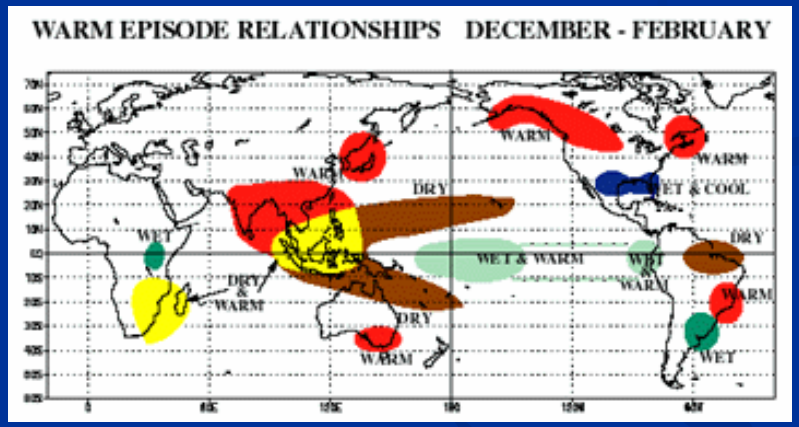
Summer Monsoons
LLJs
MCCs
Impact on large basins
LS-A feedbacks

Climate Predictability on Intraseasonal to Interannual Time Scales



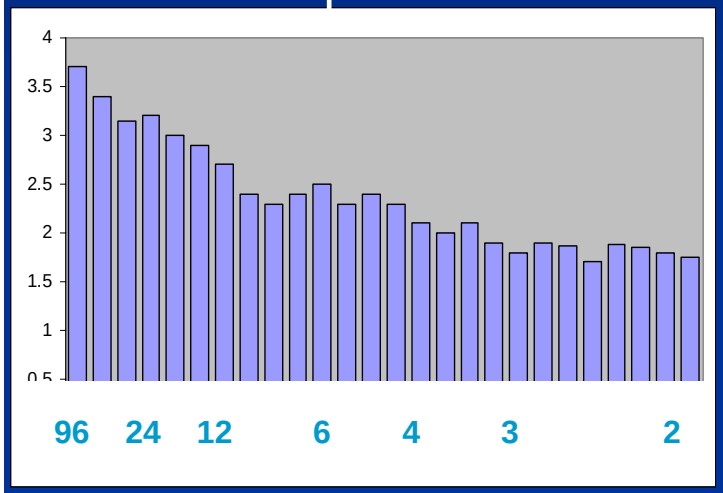
Slowly evolving lower boundaries:
Sea surface Temperatures





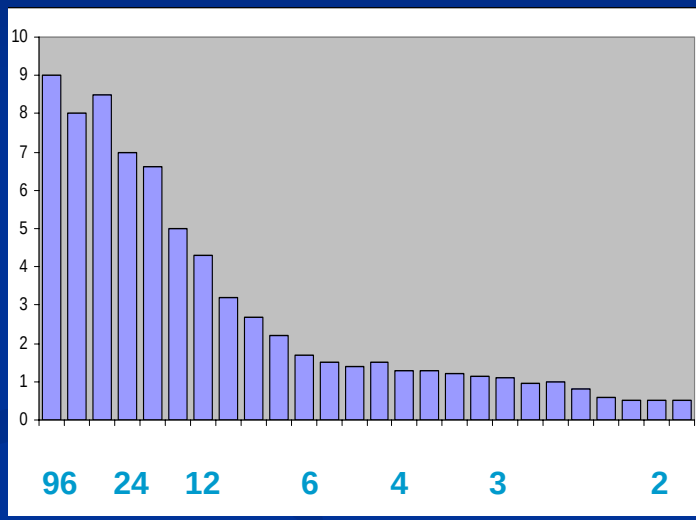
Slowly evolving lower boundaries:
Soil moisture

Power spectrum of Precipitation



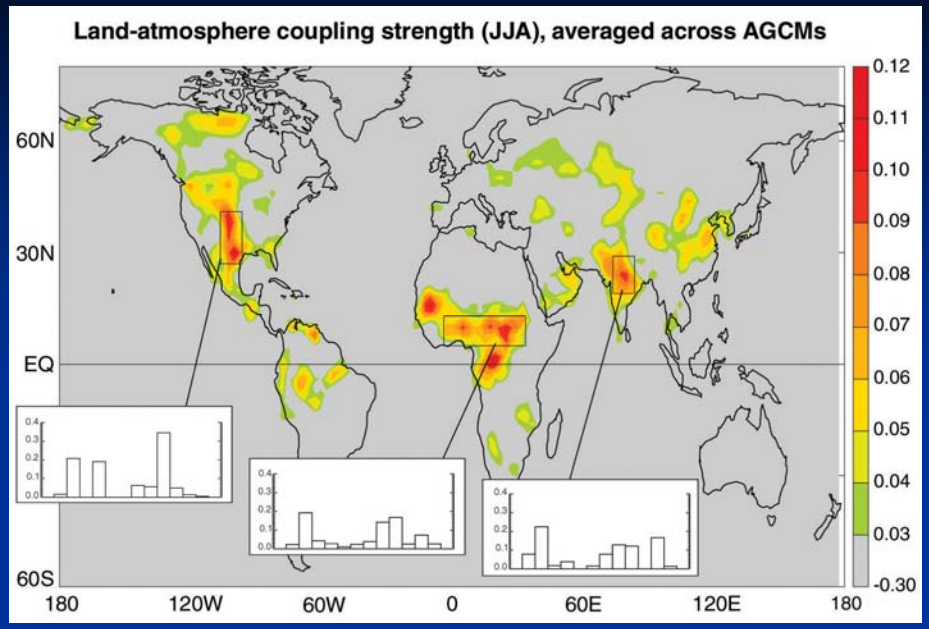
Land processes

Power spectrum of Soil moisture

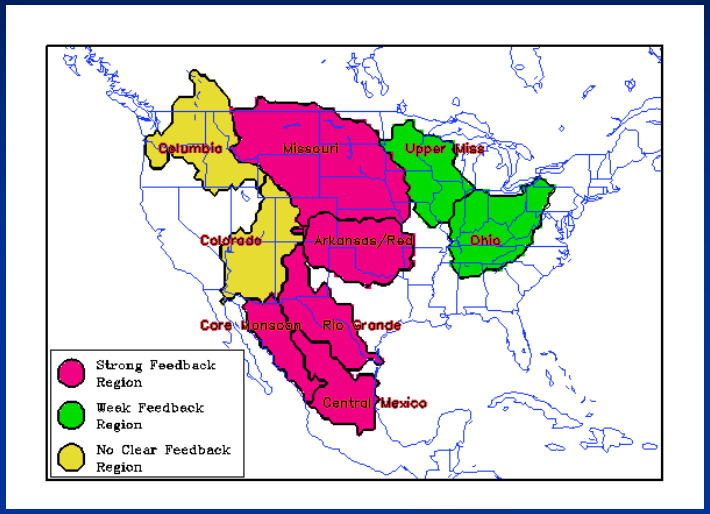


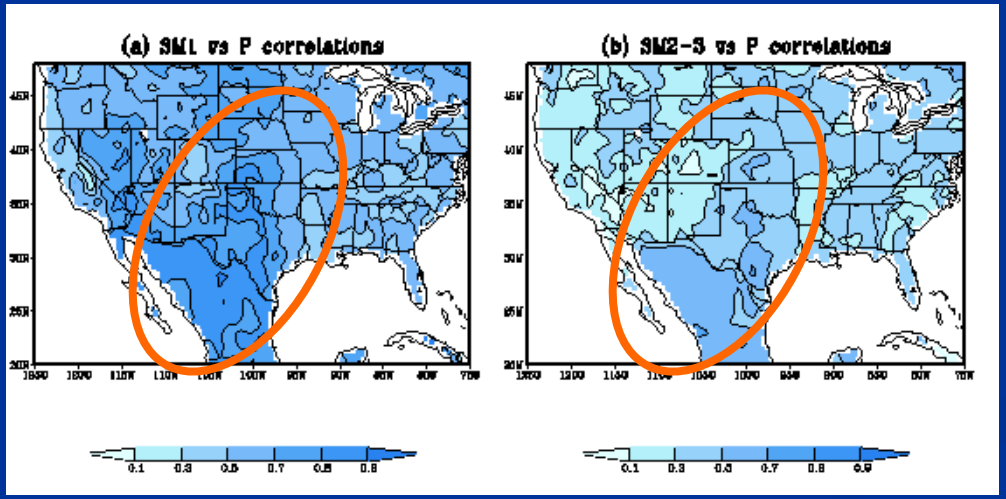
Land-Atmosphere Coupled Models

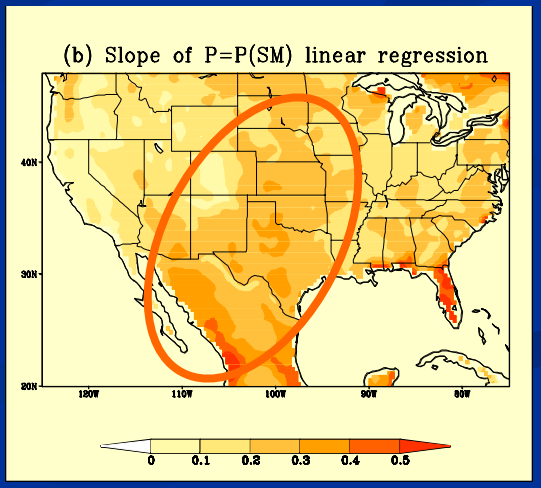
Hotspots



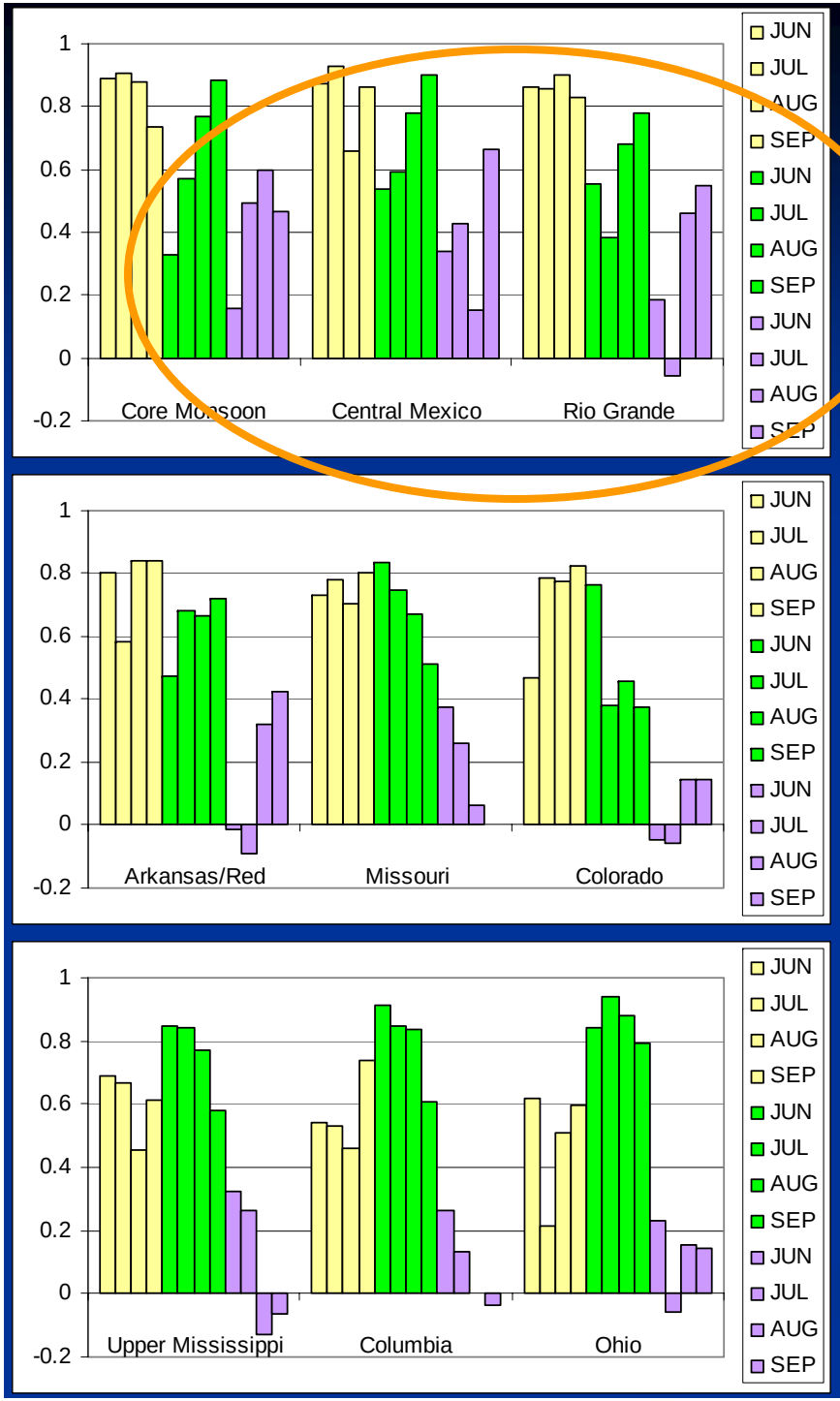
Models - Koster et al. 2004







NARR - Luo et al. 2006

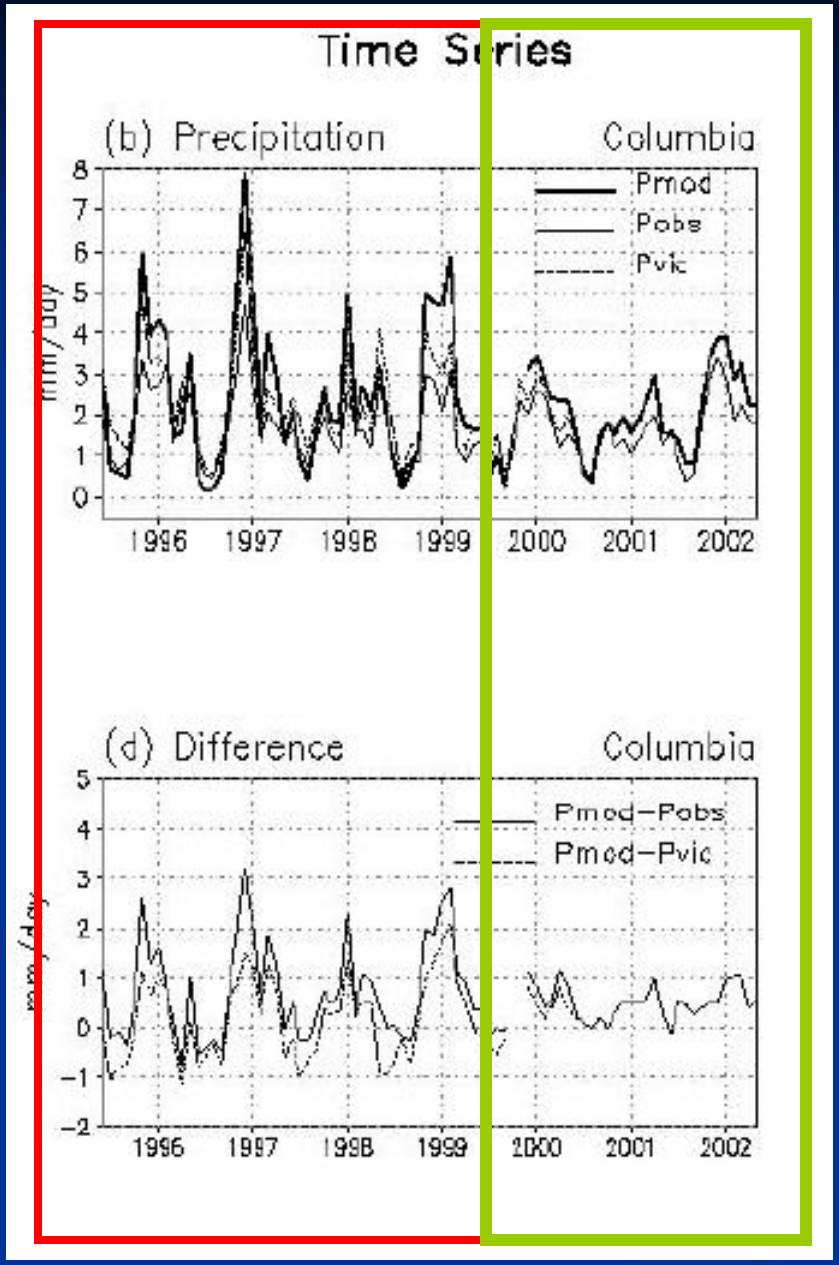


Process studies

LSA Interactions

Soil moisture persistence

“Predictive skill”



Assimilation of land data

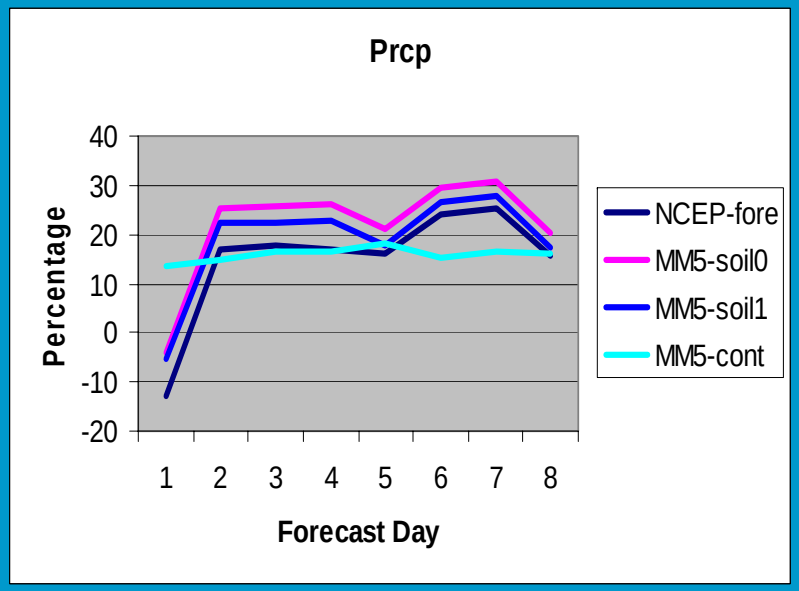
Time series of Pobs and Pmod
Area averaged over the Columbia basin

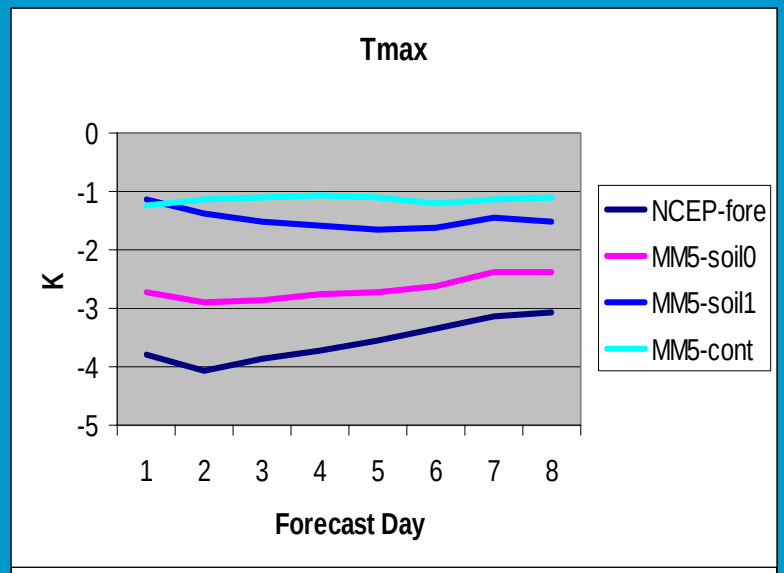
Eta model operational forecasts

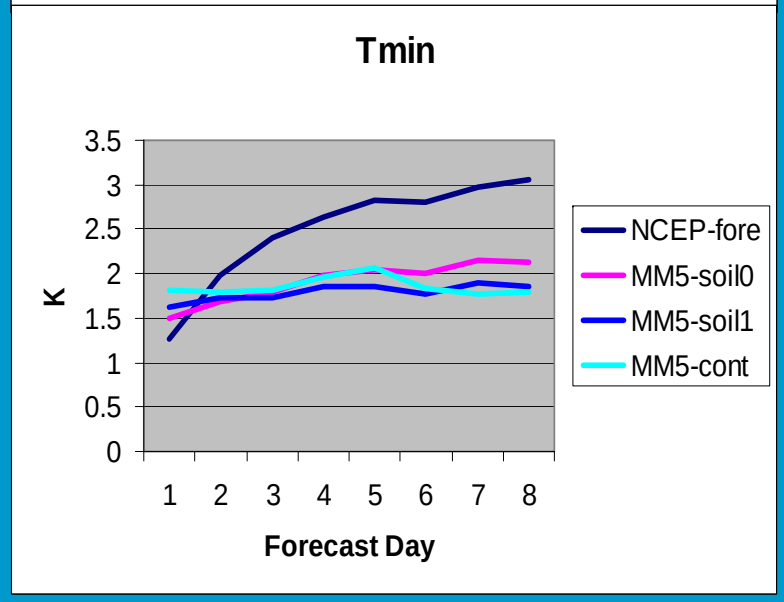
Cold Season hydroclimate

- SSTs
- Topography
- Snow

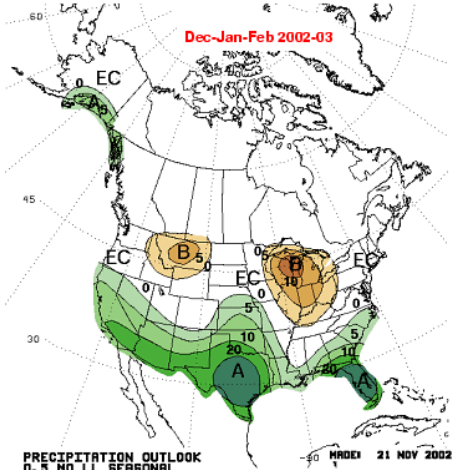
Mean Bias


Prcp
Percentage
40
30
20
10
0
-10
-20
1
2
3
4
5
6
7
8
Forecast Day
NCEP-fore
MM5-soil0
MM5-soil1
MM5-cont

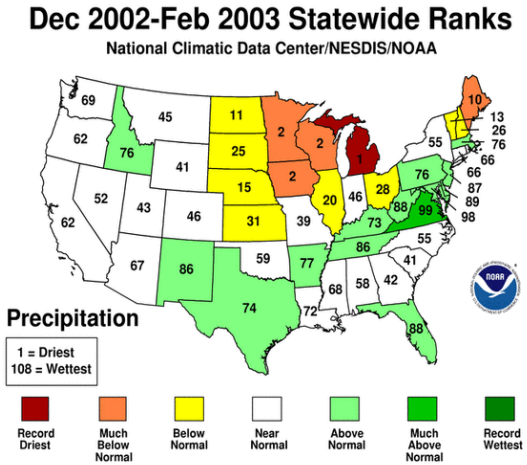

Tmax
K
0
-1
-2
-3
-4
-5
1
2
3
4
5
6
7
8
Forecast Day
NCEP-fore
MM5-soil0
MM5-soil1
MM5-cont

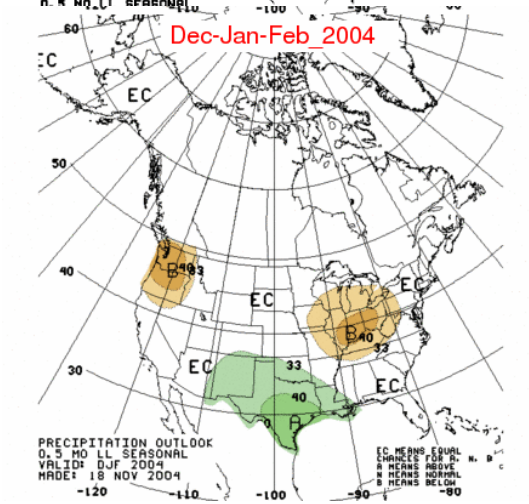

Tmin
K
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
Forecast Day
NCEP-fore
MM5-soil0
MM5-soil1
MM5-cont

Inter-ENSO event variability

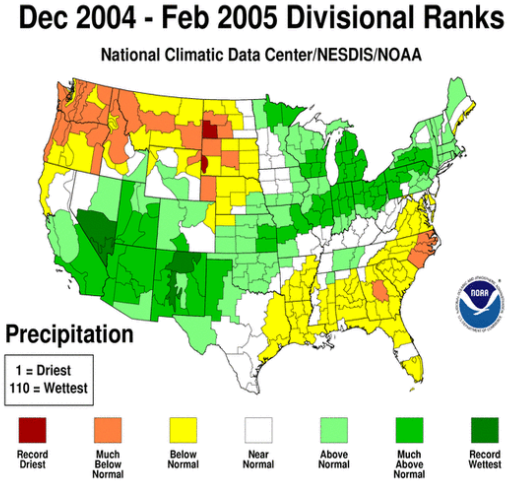


2002/03





2004/05



We need to understand and exploit the variable response to tropical SST forcings

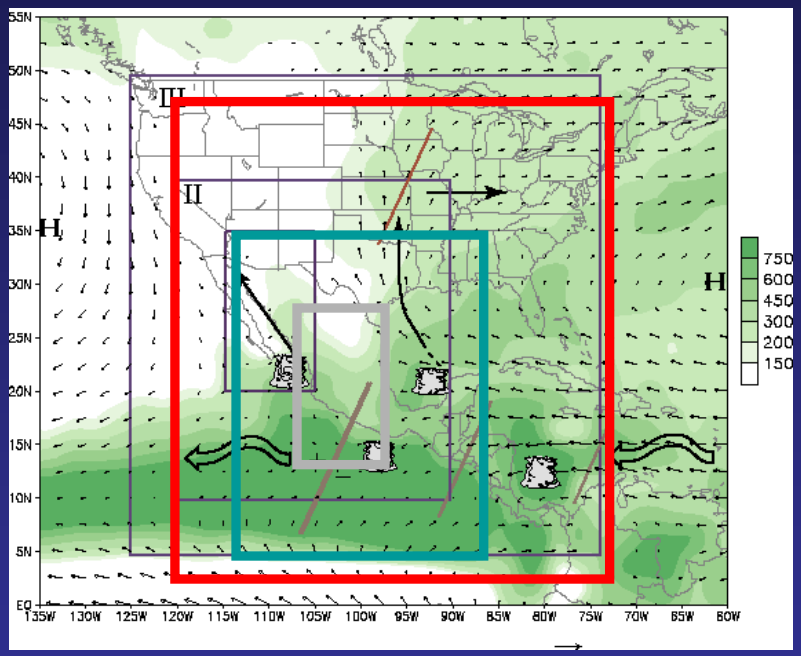
A long-term deliverable from CPPA

Warm Season Hydroclimate

- The North American Monsoon – NAME
- The South American Monsoon - MESA

NAME and MESA and internationally coordinated, joint CLIVAR-GEWEX process study programs aimed at improving warm season precipitation forecasts over the America

NORTH AMERICAN MONSOON EXPERIMENT (NAME)

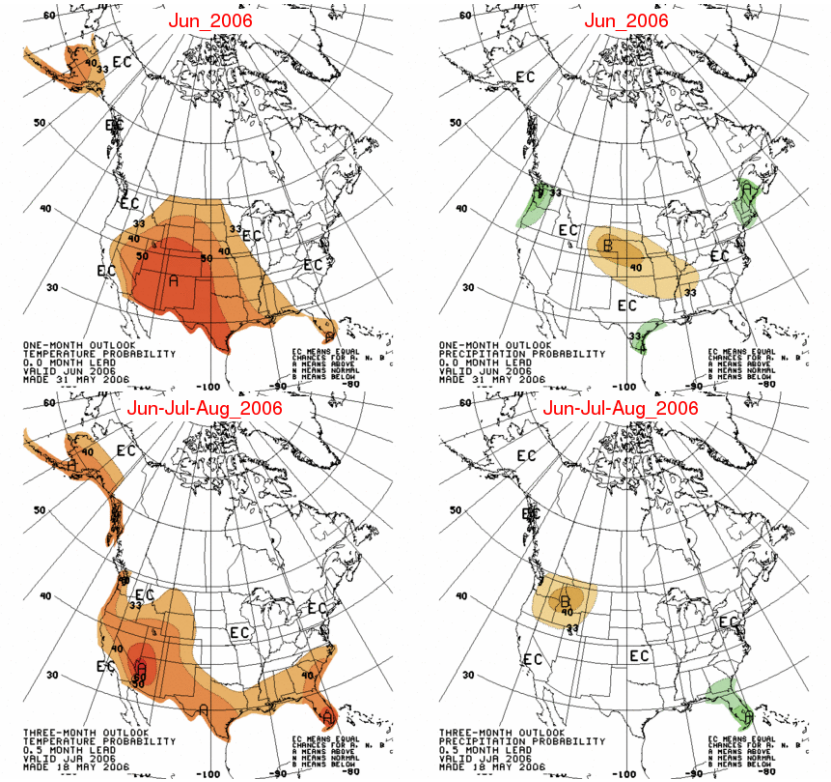


HYPOTHESIS:

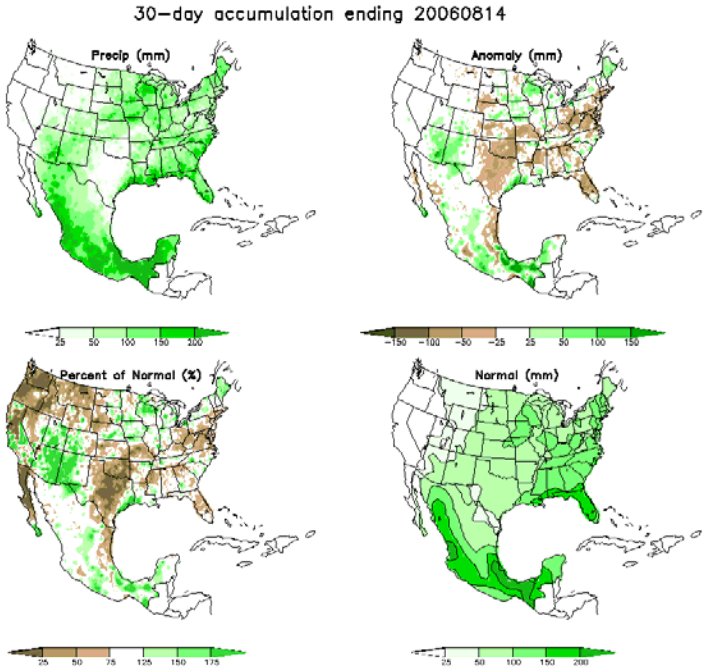
The NAMS provides a physical basis for determining the degree of predictability of warm season precipitation over the region.

Monsoon Prediction

CPC monthly/seasonal outlook issued May 2006



Observed patterns



30-day accumulation
ending 14 Aug 06 [from CPC]

A very strong monsoon so far, especially in SW United States
Was there antecedent guidance? A long-term deliverable from CPPA

MONSOON EXPERIMENT IN SOUTH AMERICA (MESA)

An internationally coordinated, joint CLIVAR – GEWEX program aimed at providing:

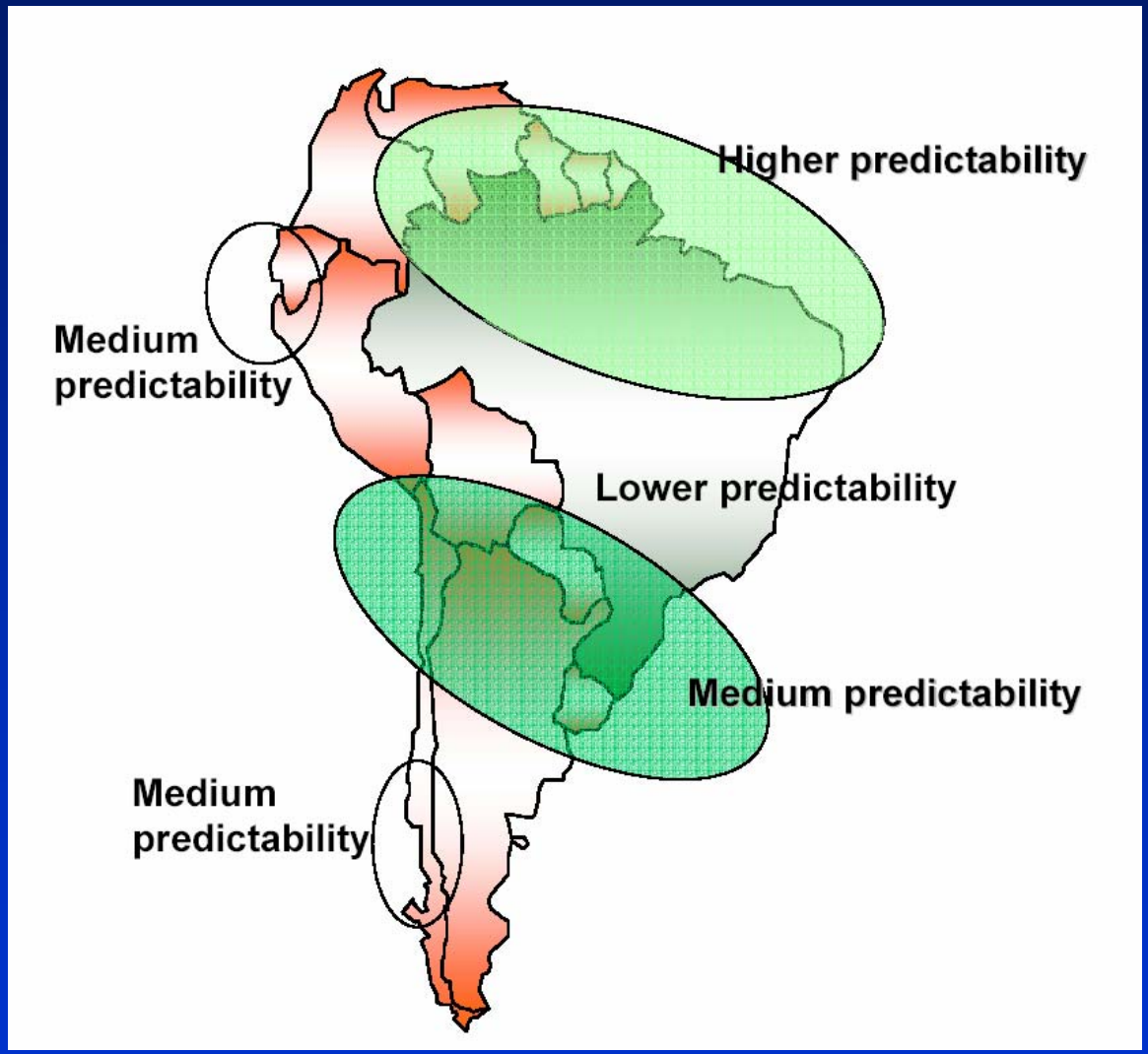
1. A better understanding of the South American monsoon system and its ***variability***,

2. A better understanding of ***the role of that system in the global water cycle***

3. Improved observational data sets, and

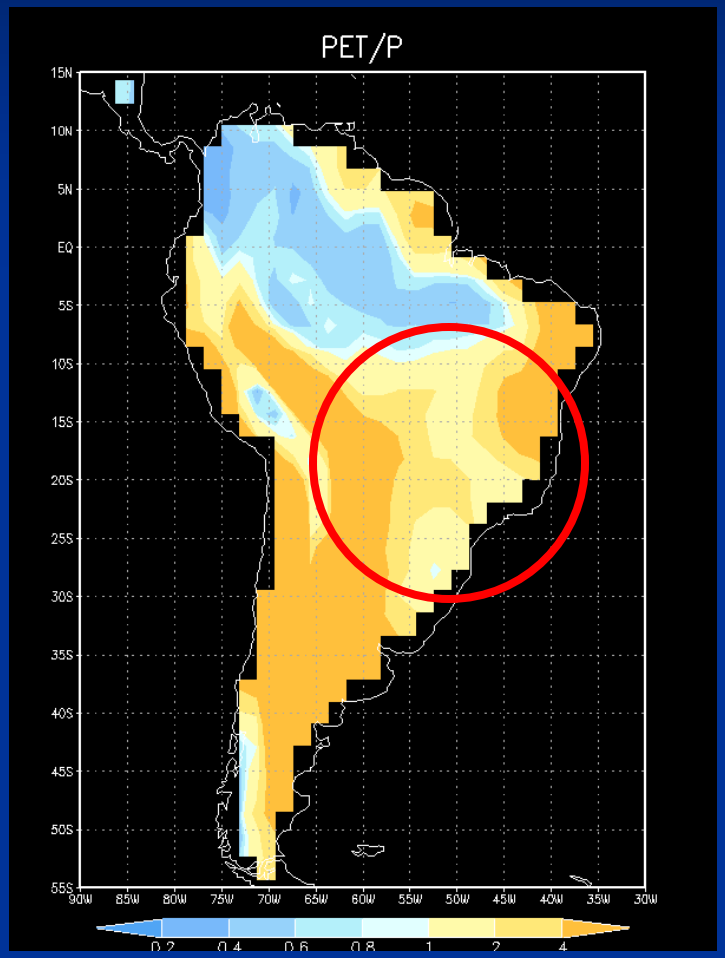
4. Improved simulation and ***prediction of the monsoon and regional water resources***

Regions with lower, medium and higher predictability at seasonal and interannual time scales (Source: J. Marengo, CPTEC/INPE).

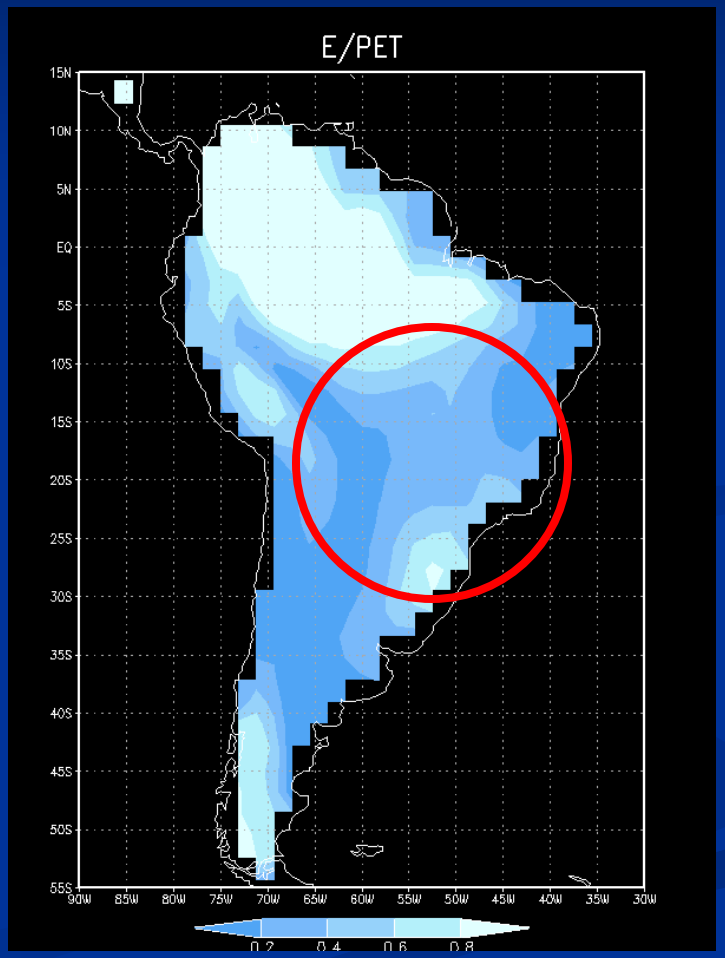


Transition region – a necessary condition to have hotspots

E_p/P



E/E_p



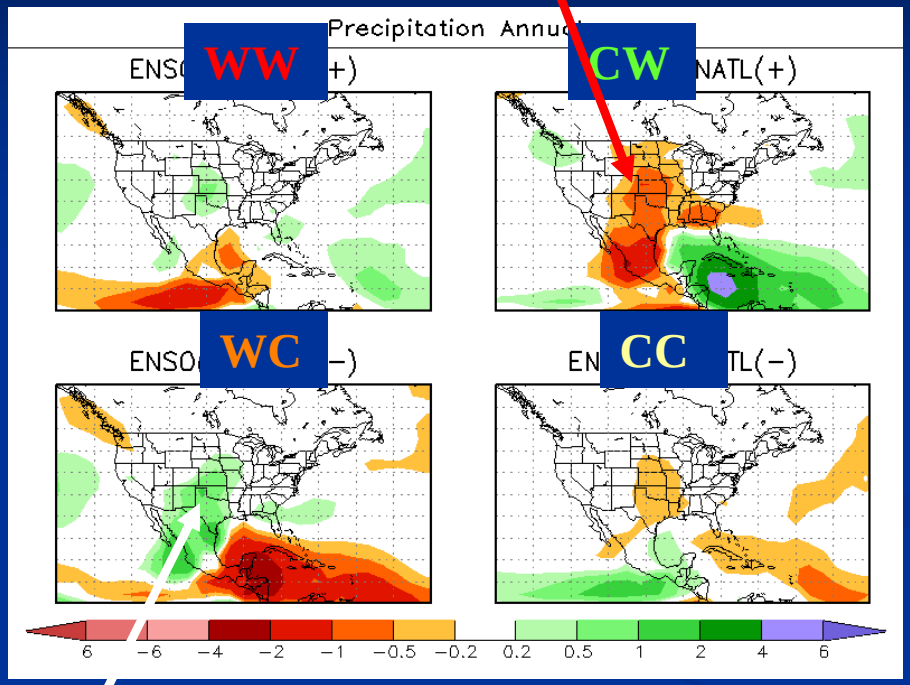
(Estimated from NCEP-NCAR Global Reanalysis)

Collini et al 2006

Droughts

Annual Mean Precipitation Responses

Major drought



Wet conditions

mm/day

WW Warm Pacific, Warm Atlantic

CW Cold Pacific, Warm Atlantic

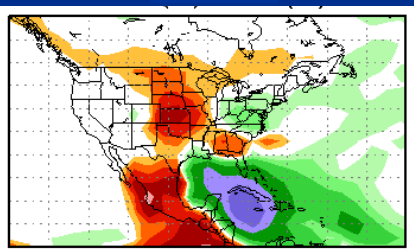
CC Cold Pacific, Cold Atlantic

WC Warm Pacific, Cold Atlantic

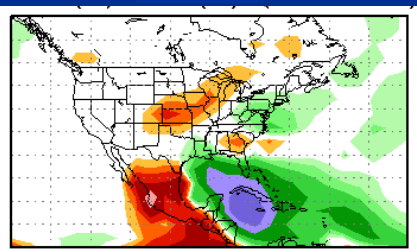
Impact of Soil Moisture Feedbacks on JJA Precipitation

Interactive soil moisture

CW

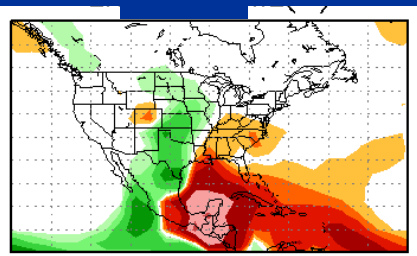


CW

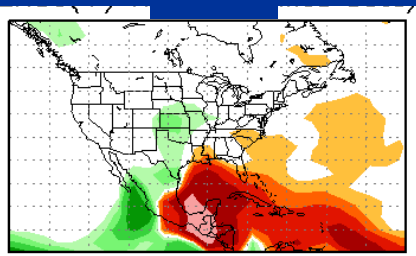


No soil moisture feedbacks

WC

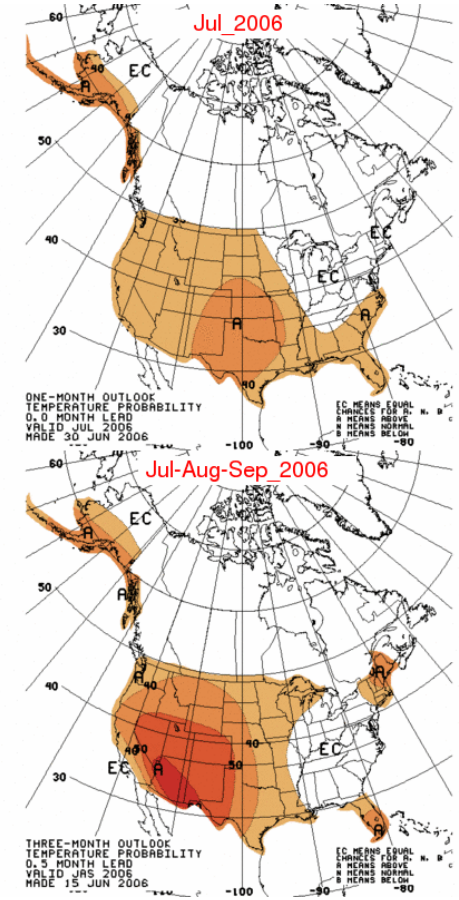


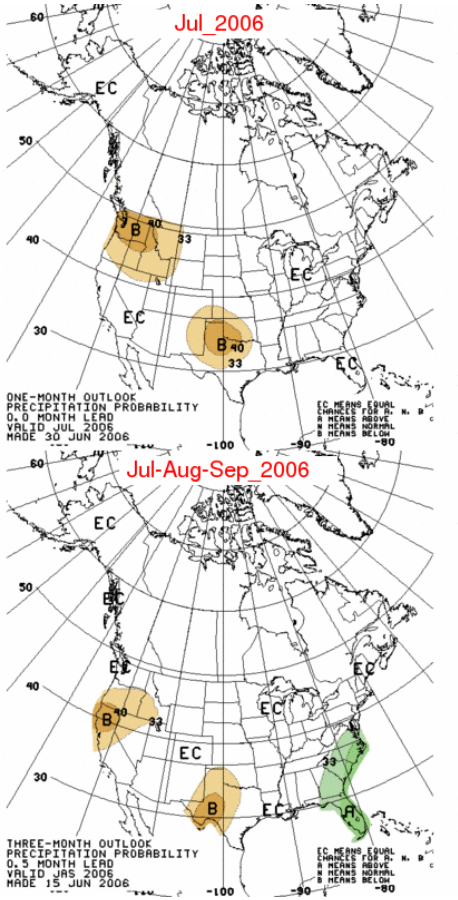
WC



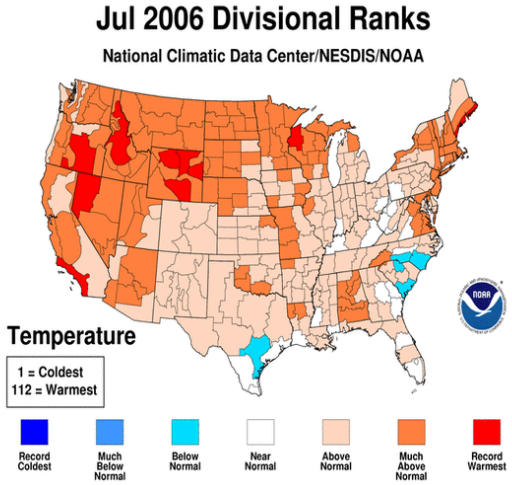
Extreme events

CPC monthly/seasonal outlook issued June 2006

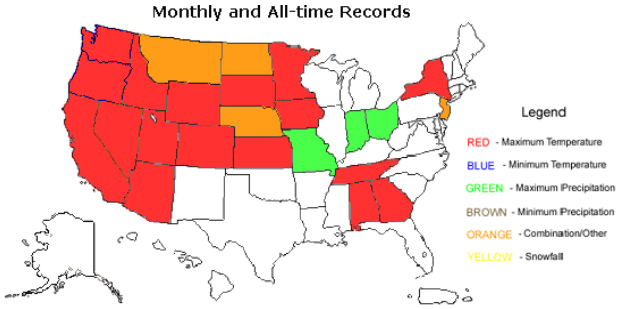




Extreme Events July 2006

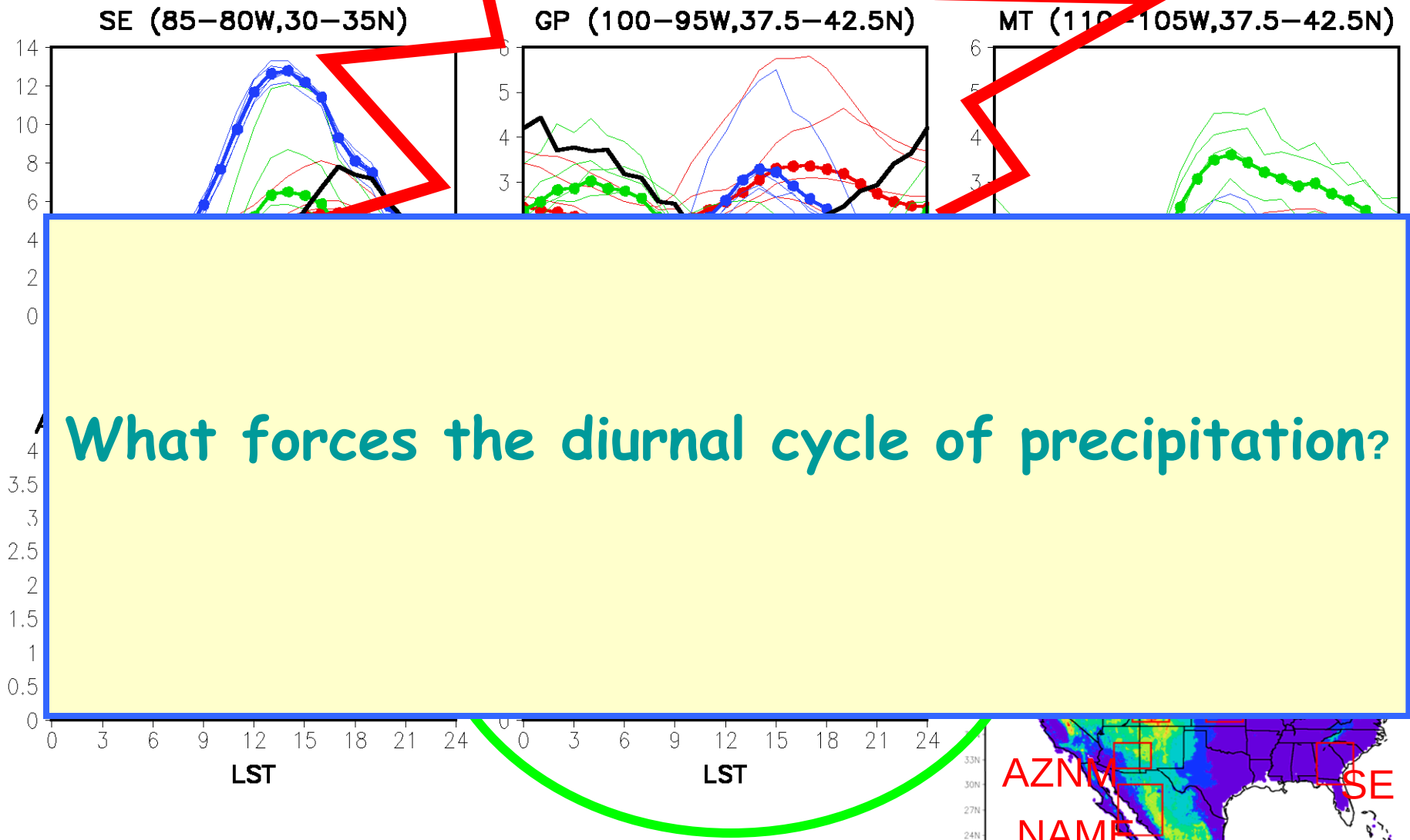


Locations of all-time records July 2006 [from NCDC]



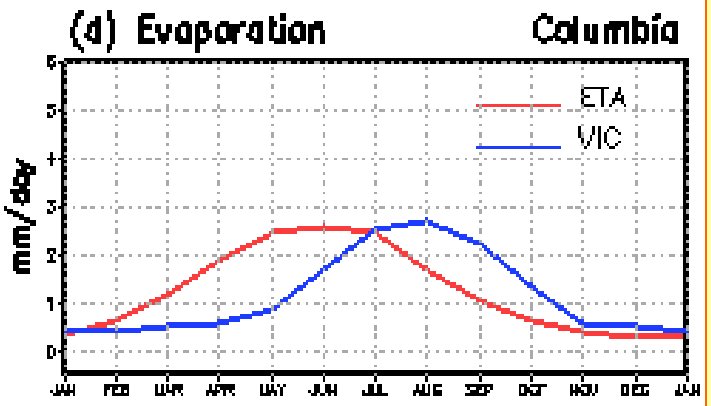
Are extreme events like the July heat wave potentially predictable?
A long-term deliverable from CPPA

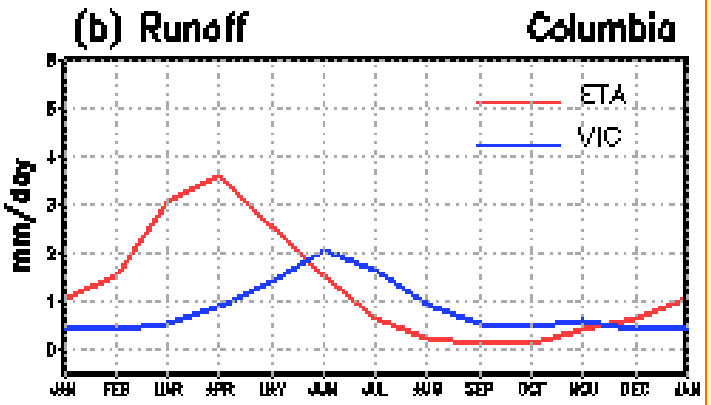
Diurnal Cycle of Rainfall in Global Models

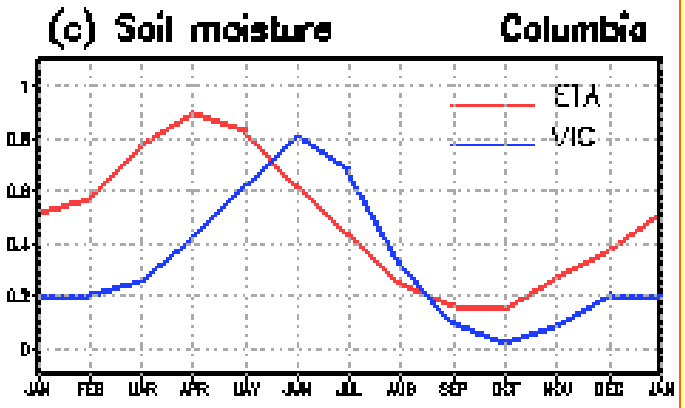


What forces the diurnal cycle of precipitation?

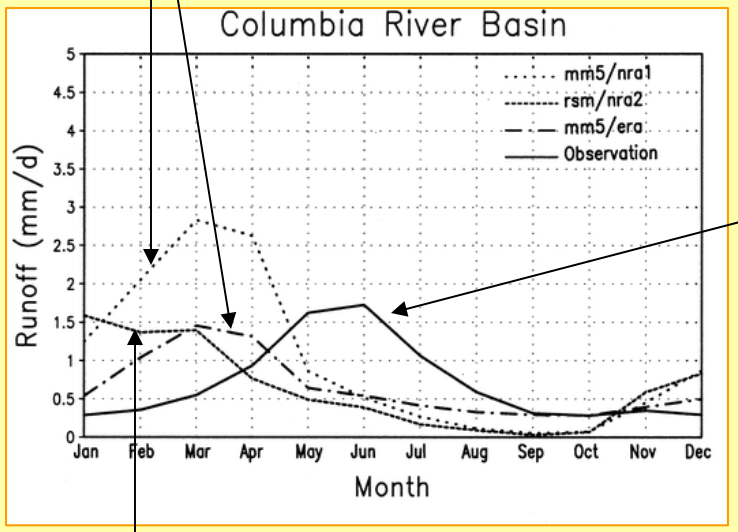
Siegfried Schubert, Myong-In Lee







MM5



Obs

RSM

From Leung et al. 2003

From Luo et al. 2005

Implementation for Climate Predictability

- **Atmospheric response to boundary conditions**
- Numerical experimentation to explore relative contributions of oceanic and land processes to predictability
- Empirical studies to examine complex interactions between SSTs, land processes, and rainfall anomalies

- **Coupling between atmosphere, land and ocean**
- Empirical and modeling (global coupled models and regional models) studies to explore mechanisms linking land and ocean variability in the Pan American region
- Improve representation of land surface effects
- Improve representation of air-sea-land interaction processes

Climate Predictability on Intraseasonal to Interannual Time Scales

Science Background

- Science Objectives and Priorities
  - Drought predictability
  - Predictability of the American monsoons
  - Extreme weather events
  - Cold season hydro-climate predictability
- Implementation Strategies
  - The role of atmosphere-land interactions
  - The role of atmosphere-ocean interactions
  - The role of land-ocean interactions (monsoon systems)
  - The role of atmospheric dynamics
    orographic systems, teleconnections, MJO, LLJs, weather
  - Predicting extremes (droughts, floods, hurricanes, blizzards)
- critical gaps - diurnal cycle, annual cycle, monsoon onset, land- atmosphere coupling strength, roles of the different ocean basins, weather/climate link, simulating key teleconnections including impact of MJO, impact of global warming
- Observations
- Process studies, field studies
- Deliverables