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**

1. Overview

2. Climate Predictability

3. Atmosphere-Ocean Interactions

4. Land-Atmosphere Interactions

5. Operational Climate Prediction, Monitoring, and Analysis

6. Climate-Based Hydrologic Forecasting and Water Resources Application

7. Program Management

---

**Pathway**

**Research**

Define needs

Feedback on performance

**Synthesis Implementation Testbed**

**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

- **Land-atmosphere coupling** (e.g., soil moisture feedback, snow)
  - Sub-seasonal to seasonal

- **Atmospheric dynamics** (e.g., orographic response, LLJs, MJO, annular modes)
  - Sub-Seasonal

- **Predictability** (e.g., droughts, monsoons, extreme weather)

- **Land-Ocean coupling** (e.g., monsoons, diurnal cycle)
  - Subseasonal to seasonal
  - Seasonal to interannual

- **Ocean-Atmosphere coupling** (e.g., ENSO)
Slowly evolving lower boundaries: Sea surface Temperatures
Slowly evolving lower boundaries:

Soil moisture

Power spectrum of Precipitation

Power spectrum of Soil moisture

Land processes

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
Inter-ENSO event variability

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
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

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

(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
WC  Warm Pacific, Cold Atlantic
CC  Cold Pacific, Cold Atlantic
Impact of Soil Moisture Feedbacks on JJA Precipitation

Interactive soil moisture

No soil moisture feedbacks

[Maps and legends showing different moisture conditions]
Extreme events
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
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