Climate Dimensions of the
Water Cycle

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Weather and Climate Forecasts:
Tactical & Strategic Decision Making for Water Resources

Days

Emergency management

Tactical decisions

Weeks

Disruption planning

Balancing Resources

Stand-by Preparations

Seasons

Resource allocation

Drought management

Dam/reservoir Management

Years – Decade

Flood plain management

Water resource management

Energy demand

Century

Infrastructure

Strategic planning

Capacity building

Technology Development

Land use planning

Risk

Forecast lead time

Adapted from Julia Slingo

Predictability, Prediction and Scenarios

Examples:
- 2004/2005 U.S. hurricane landfalls
- Heavy snowfall + cold last winter
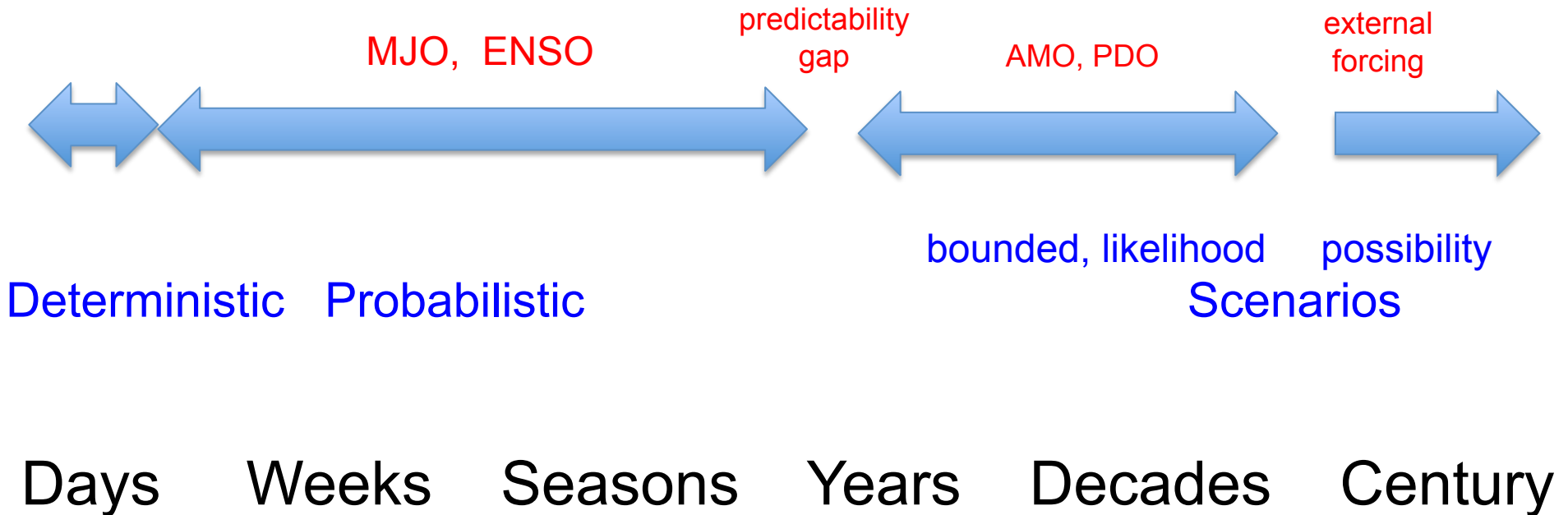- Russian heatwave/Pakistan flood

black swan

Examples:
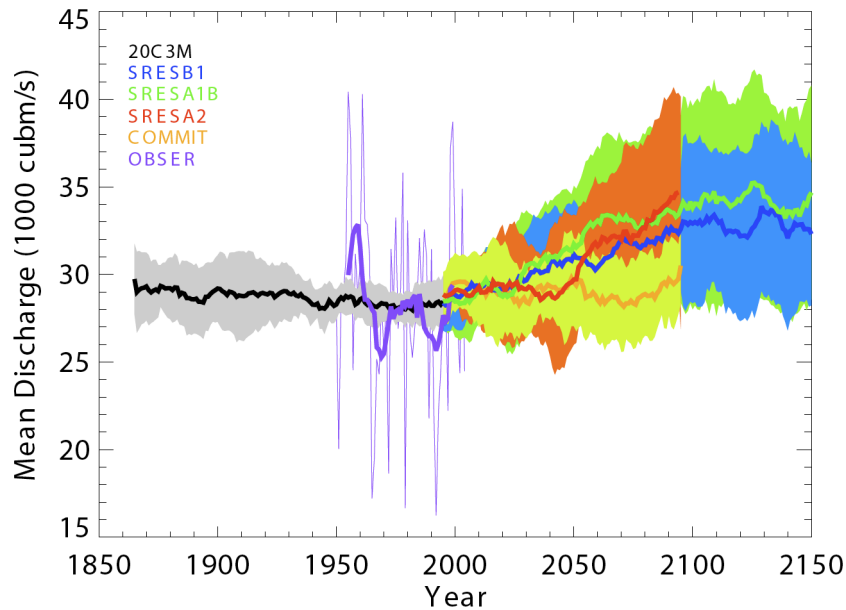- "Tipping points"
- Abrupt climate change

Dragon King

"Tell us what you DON'T know"

predictability gap

MJO, ENSO

AMO, PDO

external forcing

bounded, likelihood

possibility

Deterministic   Probabilistic

Scenarios

Days   Weeks   Seasons   Years   Decades   Century

(a) Multi-model Wet Season Ganges Discharge

20C3M
SRESB1
SRESA1B
SRESA2
COMMIT
OBSER

Nearly all CMIP3 scenarios considered show increased discharge for the Ganges
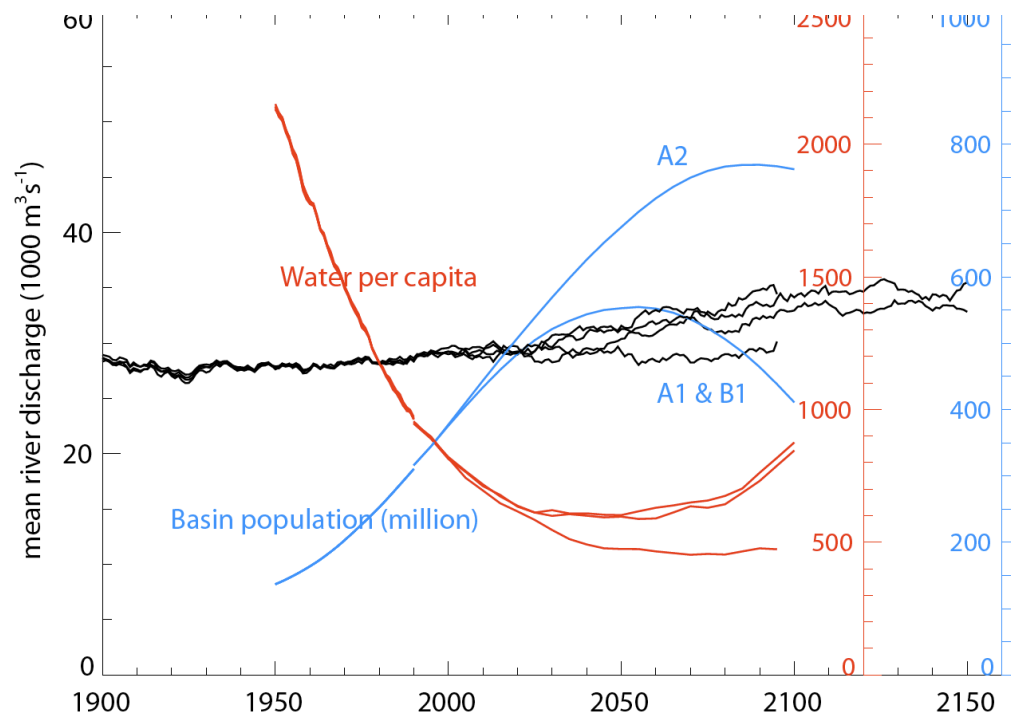
Owing to population increase, substantial reduction in per capita water availability

Water per capita

A2

A1 & B1

Basin population (million)

Webster and Jian (2011)

Creative construction of future scenarios

CMIP century scale simulations are designed for assessing sensitivity to greenhouse gases using emissions scenarios

They are not fit for the purpose of inferring decadal scale or regional climate variability, or assessing variations associated with natural forcing and internal variability. Downscaling does not help.

We need a much broader range of scenarios for regions (historical data, simple models, statistical models, paleoclimate analyses, etc).

Permit creatively constructed scenarios as long as they can't be falsified as incompatible with background knowledge

Regional approach to scenario development

Climate dynamics analysis of historical black swan events

SCENARIOS

A   B

C   D

20 YEARS FROM NOW...
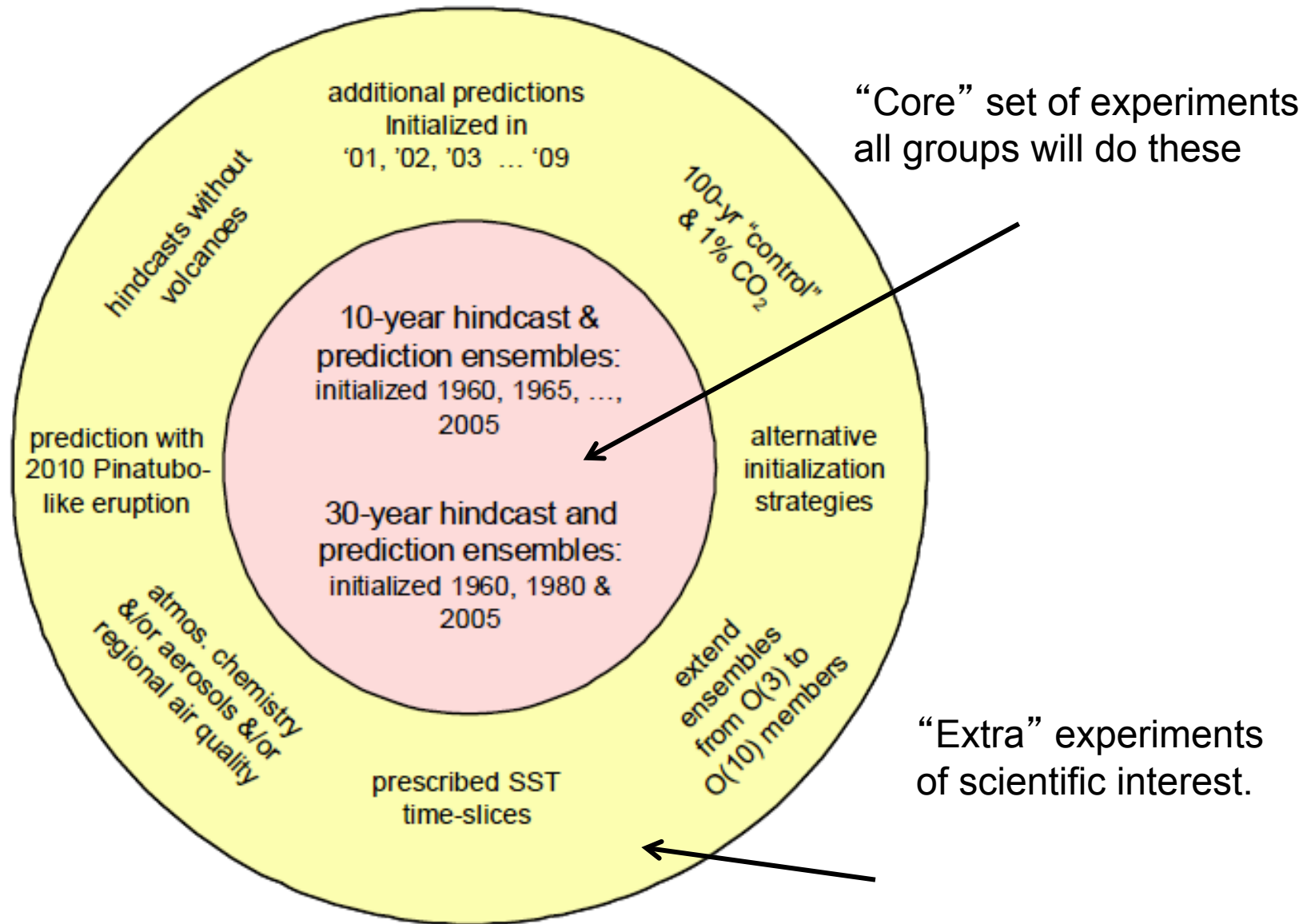
Experimental Design for CMIP5 (AR5) Decadal Runs
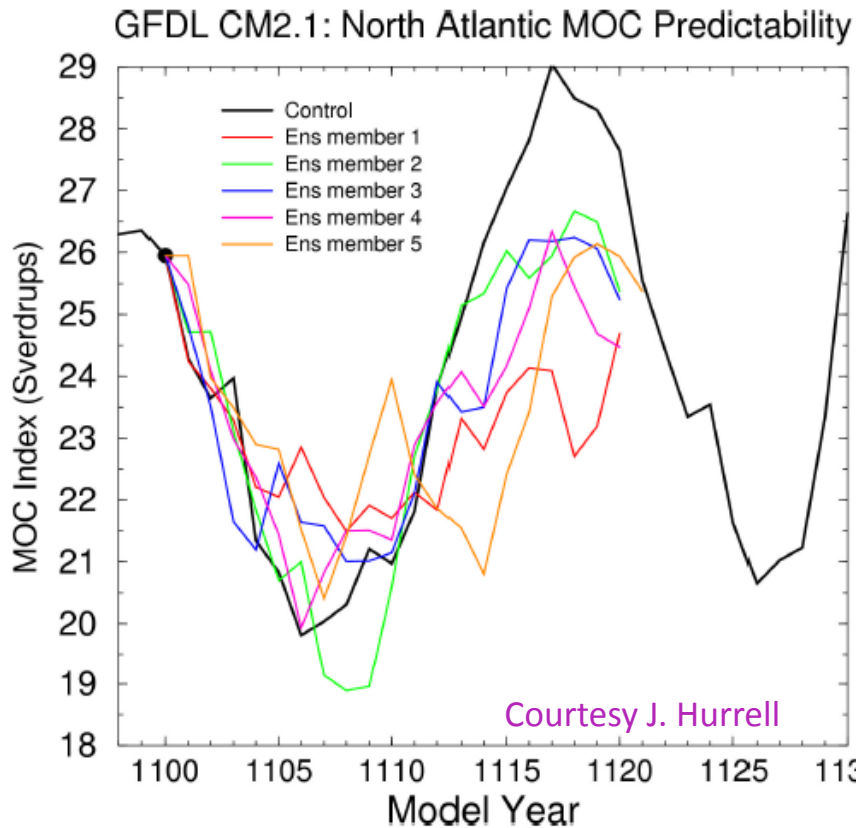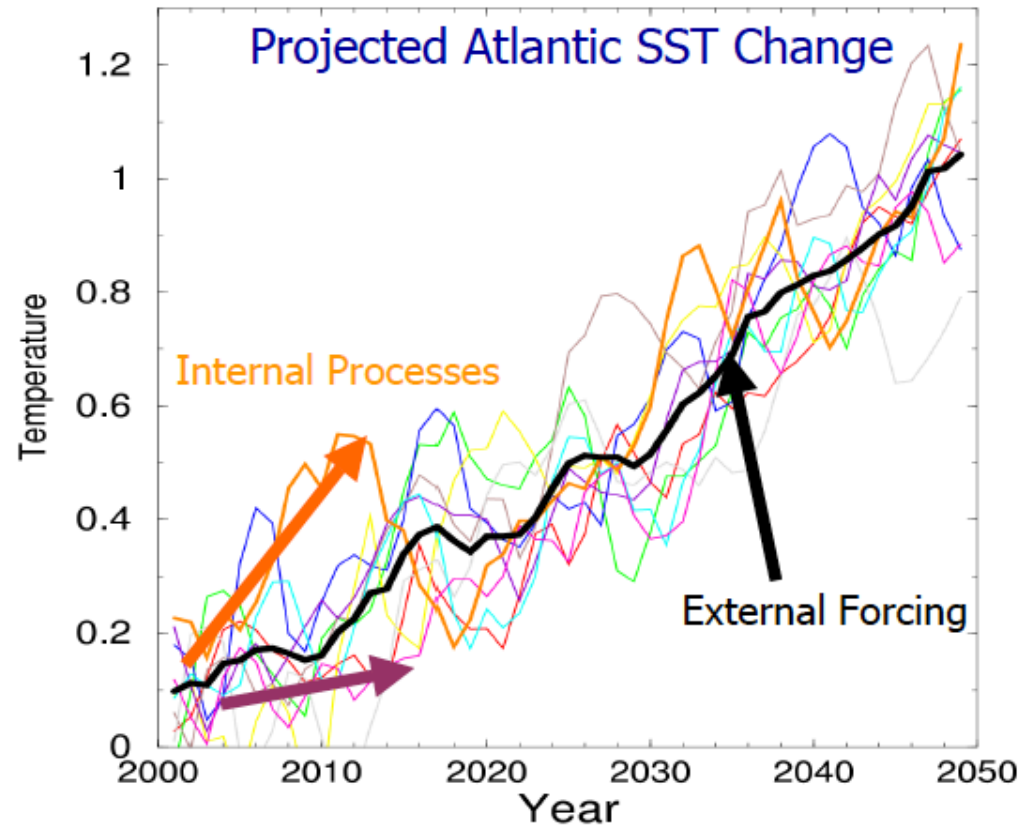

Figure 2. Schematic summary of CMIP5 decadal prediction experiments.

Decadal Predictability & Prediction:
GFDL Climate Model

GFDL CM2.1: North Atlantic MOC Predictability

Legend:
- Control
- Ens member 1
- Ens member 2
- Ens member 3
- Ens member 4
- Ens member 5

MOC Index (Sverdrups) vs Model Year

Courtesy J. Hurrell

Projected Atlantic SST Change

Internal Processes

External Forcing

Temperature vs Year

The MOC is predicable at a lead of one to two decades in perfect model studies

Initial condition uncertainty and natural internal variability dominates simulations on decadal time scales
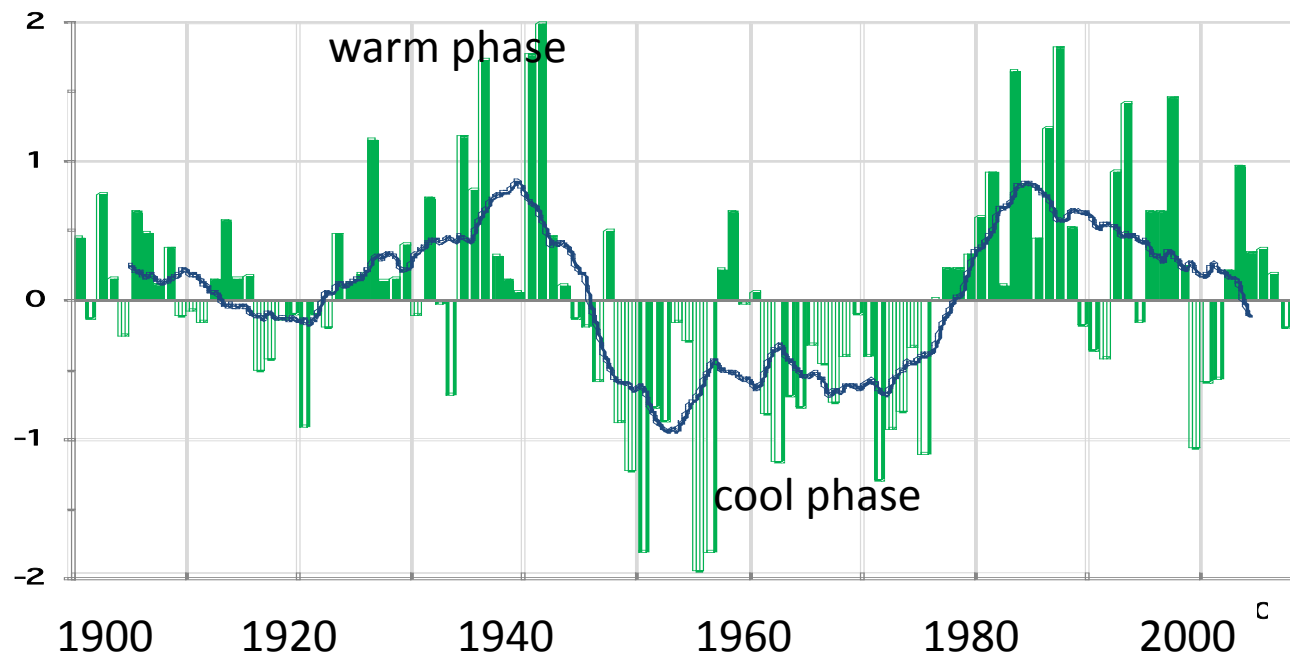
Major modes of decadal scale internal variability
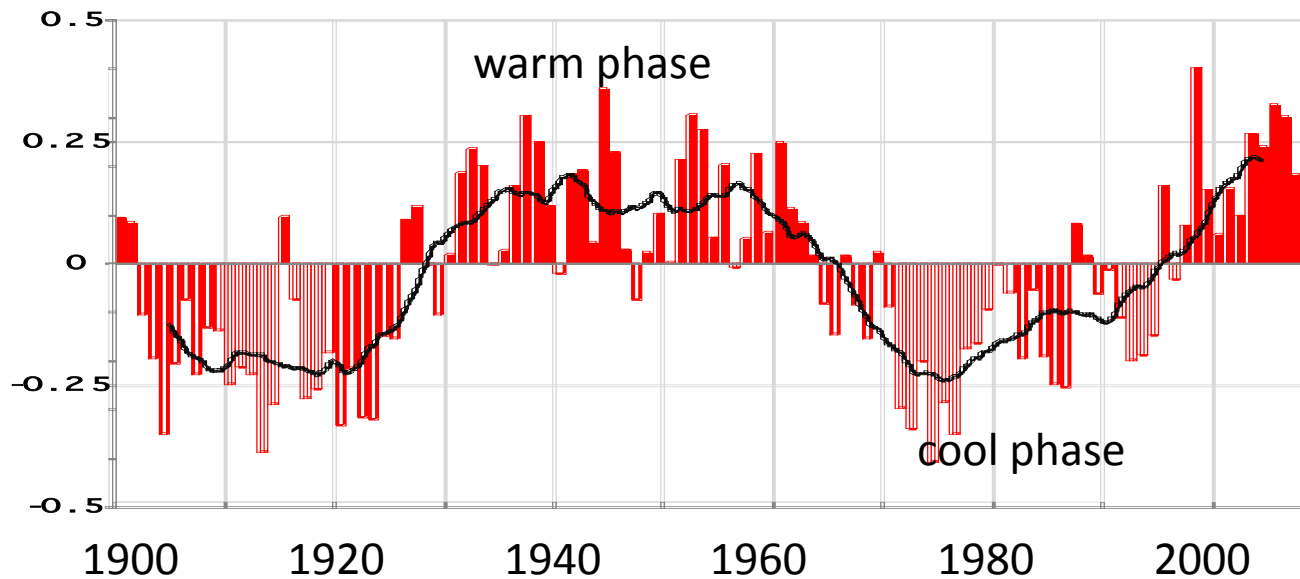
Atlantic Multidecadal Oscillation (AMO)
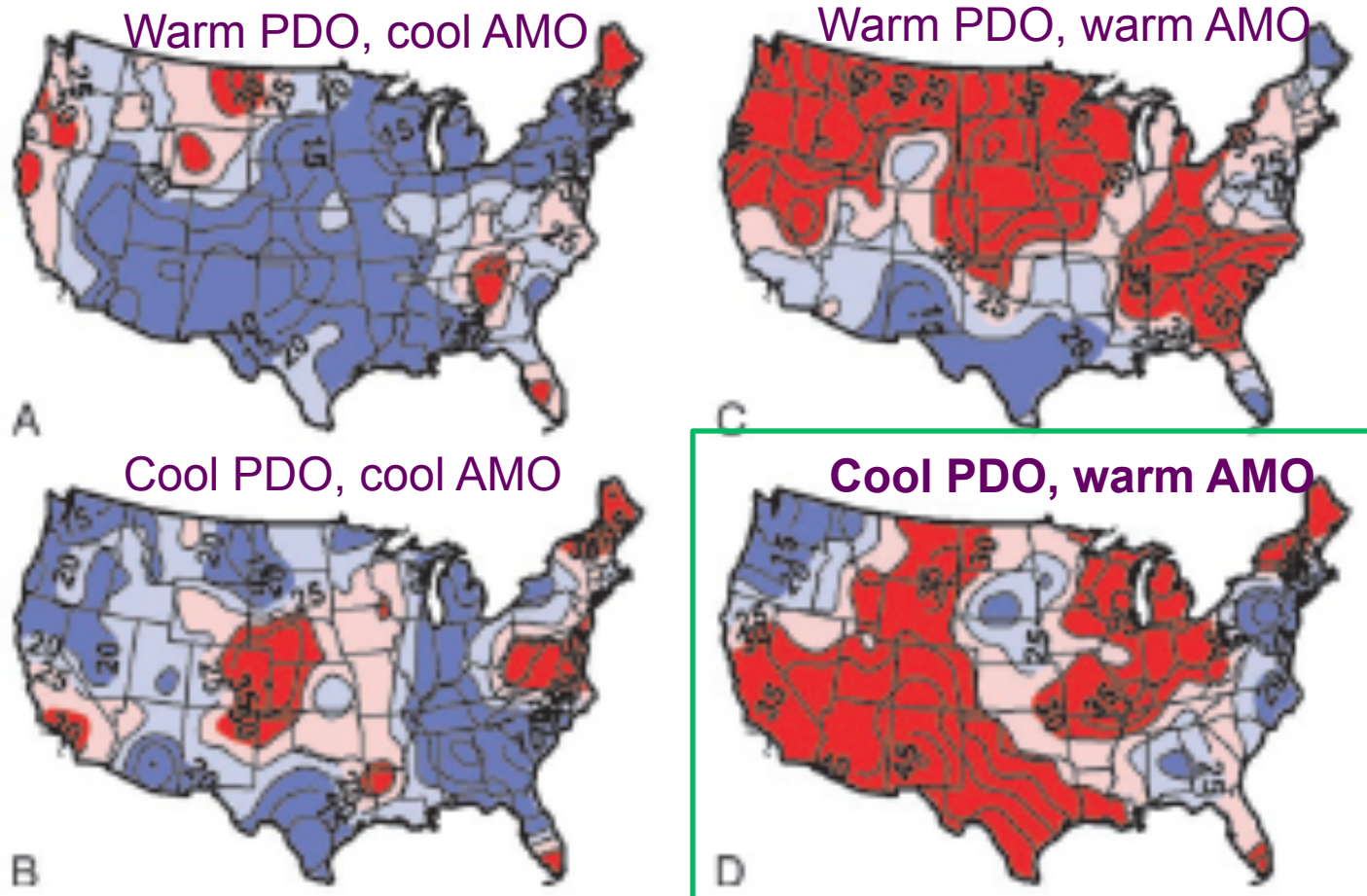
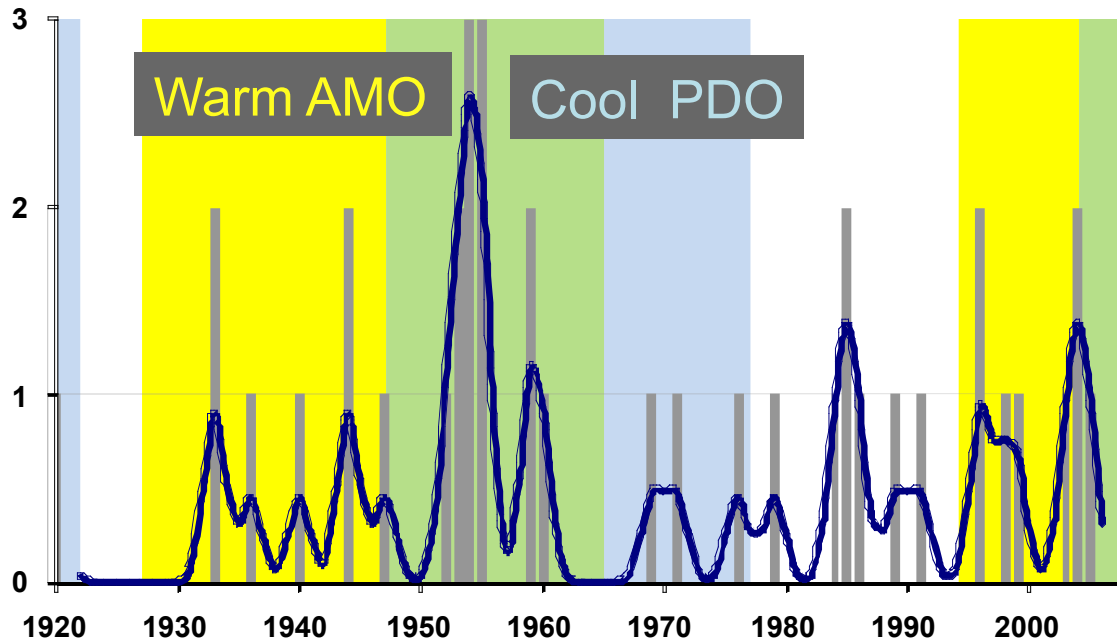In warm phase since 1995

Past analogue period: 1946 - 1964

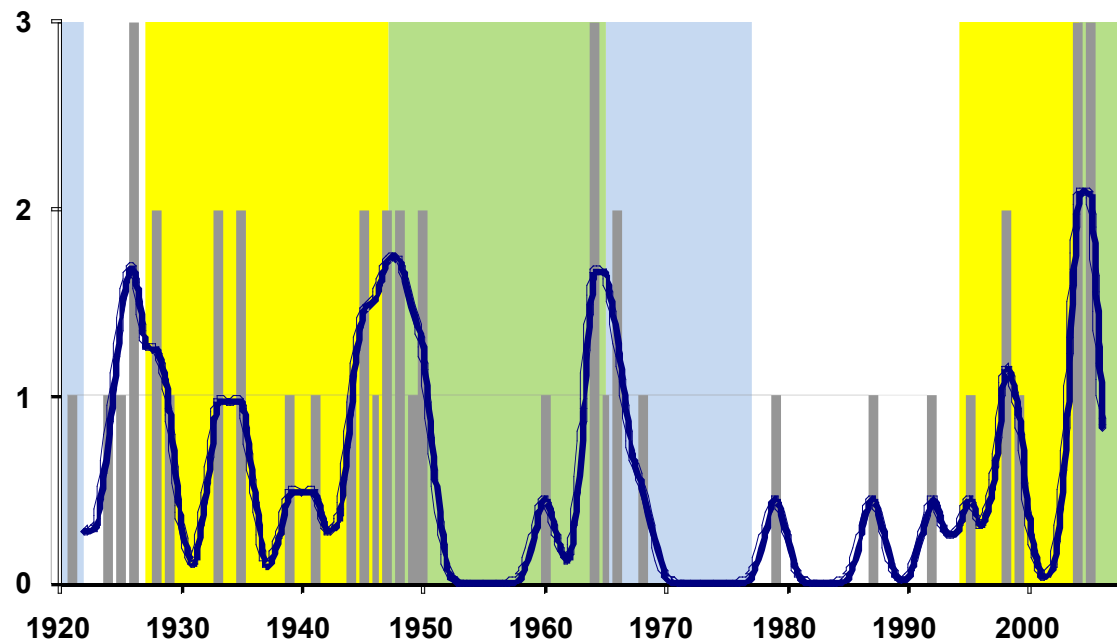**Pacific Decadal Oscillation (PDO)**

Entering cool phase

Impact of AMO, PDO on 20-yr drought frequency (1900-1999)

Warm PDO, cool AMO

Warm PDO, warm AMO

Cool PDO, cool AMO

Cool PDO, warm AMO

PNAS

Landfalling Hurricanes

Warm AMO   Cool PDO

Atl coast: more in warm AMO, cool PDO

Fl coast: more in warm AMO

2004: El Nino Modoki
2005: Very high AMO

Scenarios: 2025

Most likely scenario:
- Warm AMO, cool PDO
- More La Nina events
- Decrease/flattening of the warming trend

Weather/climate impacts (analogue: 1950's):
- more rainfall in NW, mid Atlantic states
- less rainfall in SW, Great Lakes region, North Central plains
- more hurricane landfalls along Atlantic coast, fewer in FL

CMIP5 simulations will provide additional scenarios

Critical issue: predicting the next regime change (change point)

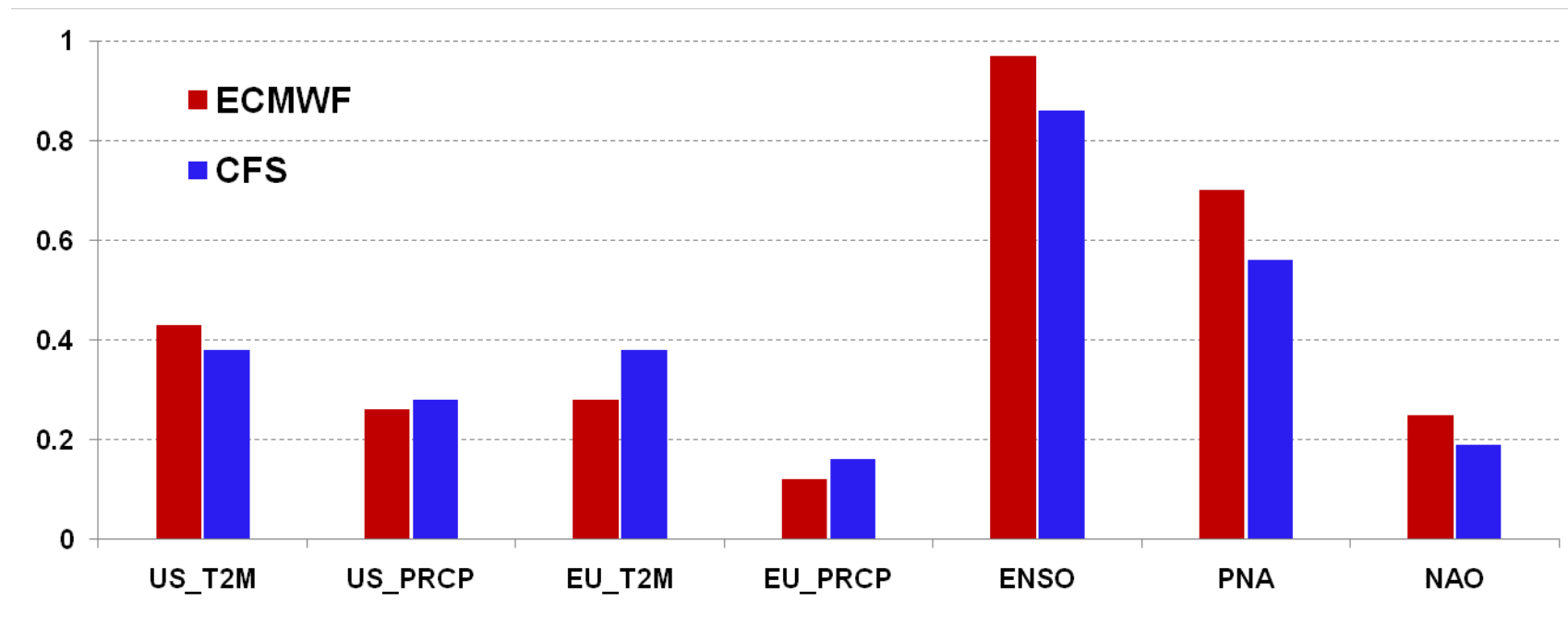# Subseasonal - Seasonal Predictability & Prediction

MJO • ENSO • NAO • PNA

ECMWF Syst 4 vs CFSv2 seasonal forecasts

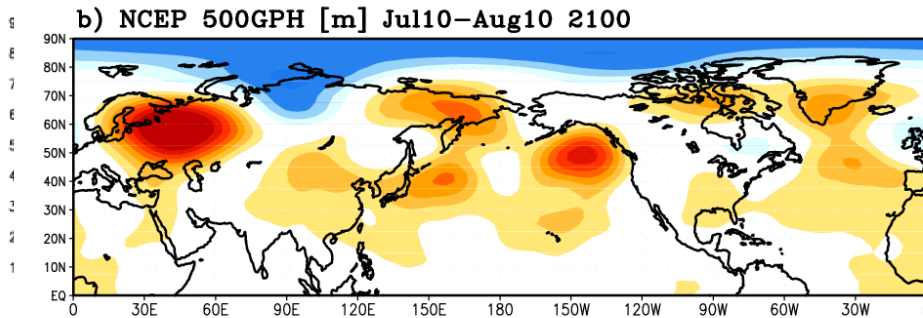28yr hindcast predictability for ensemble mean
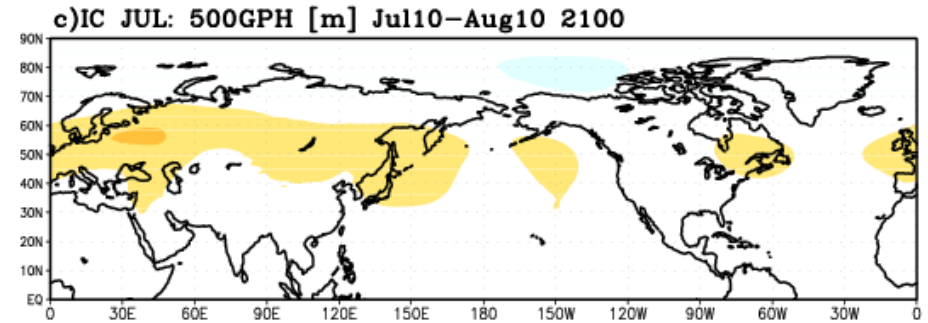
Nov initial condition for Dec, Jan, Feb

Kim, Webster, Curry 2011

Summer 2010: Russian heat wave & Pakistan floods

Observations

b) NCEP 500GPH [m] Jul10−Aug10 2100

Ensemble mean

c)IC JUL: 500GPH [m] Jul10−Aug10 2100

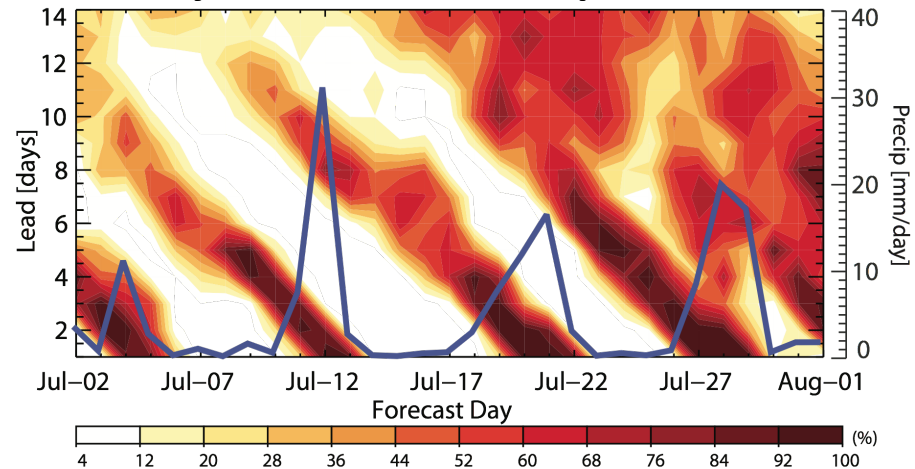**Best verifying ensemble member**

IC JUL(1st HIP): 500GPH [m] Jul10−Aug10 2100

−140 −120 −100 −80 −60 −40 −20 20 40 60 80 100 120 140
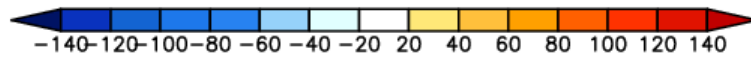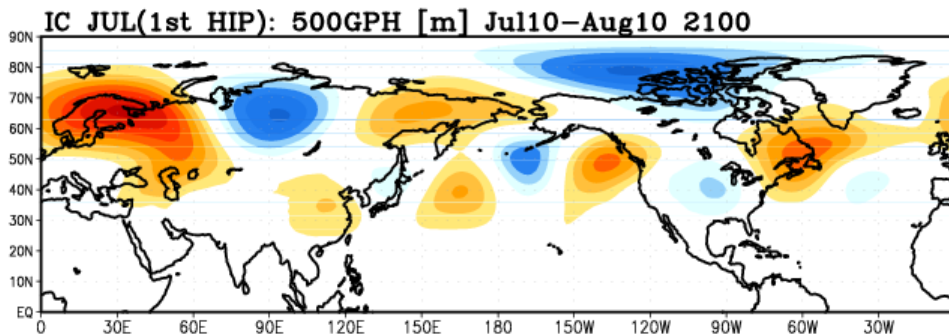
15 day rainfall ensemble predictions

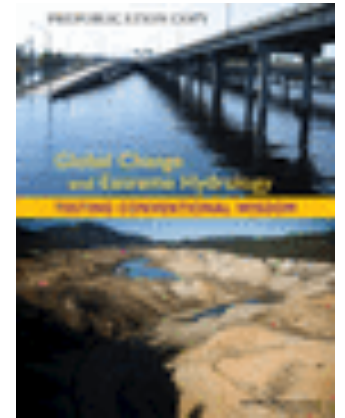

4 12 20 28 36 44 52 60 68 76 84 92 100 (%)

For ECMWF forecasts of Jul 10 – Aug 10 initialized Jul 1:
- the ensemble mean does not capture the event
- one ensemble member captured it very well (verified best Jul 1-10)

JC's recommendations

- Improve ocean observations for model initialization

- Subseasonal and seasonal predictions:

  - hybrid statistical/dynamical predictions

  - improve treatment of Arctic sea ice (wintertime snowfall)

  - regional climate dynamics/diagnostics

  - interpret ensembles to identify potential black swans

- Decadal and century timescales:

  - Broader range of CMIP scenarios to explore possible impacts of natural forcing changes (e.g. solar, volcanoes)

  - Improve understanding of historical/paleo regional climate dynamics and black swans

  - Creative, regional approach to scenario development, including population and land use changes and alternative policy scenarios

At odds with NRC report