

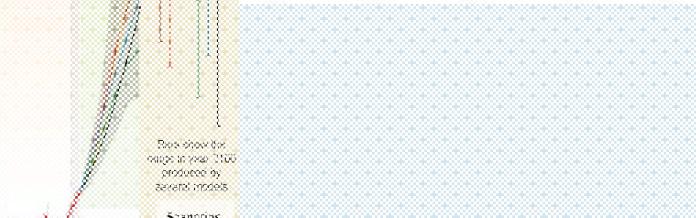
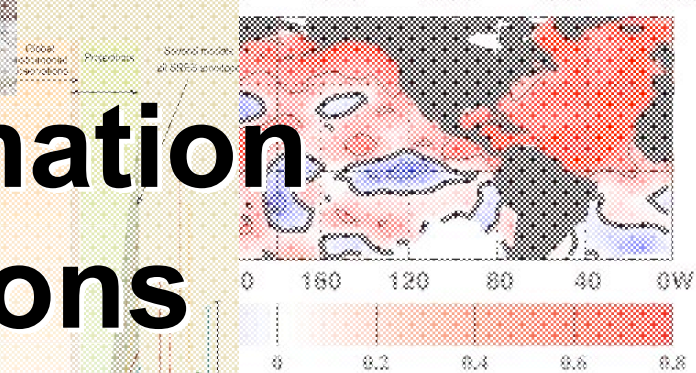
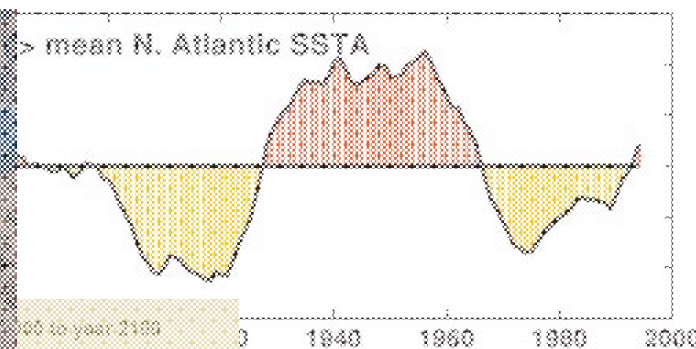
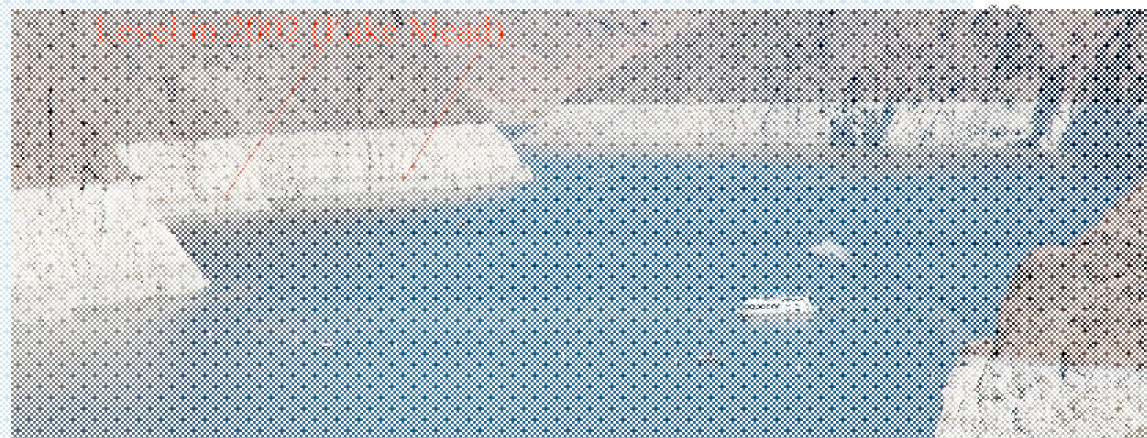
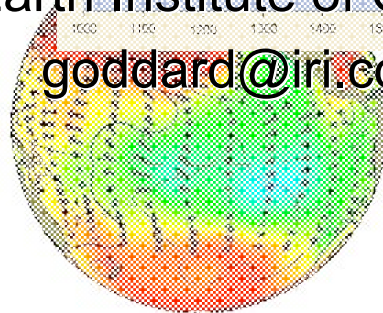
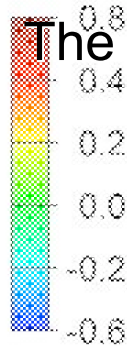
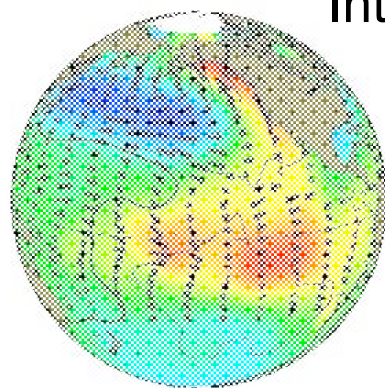
Decadal Information for Applications

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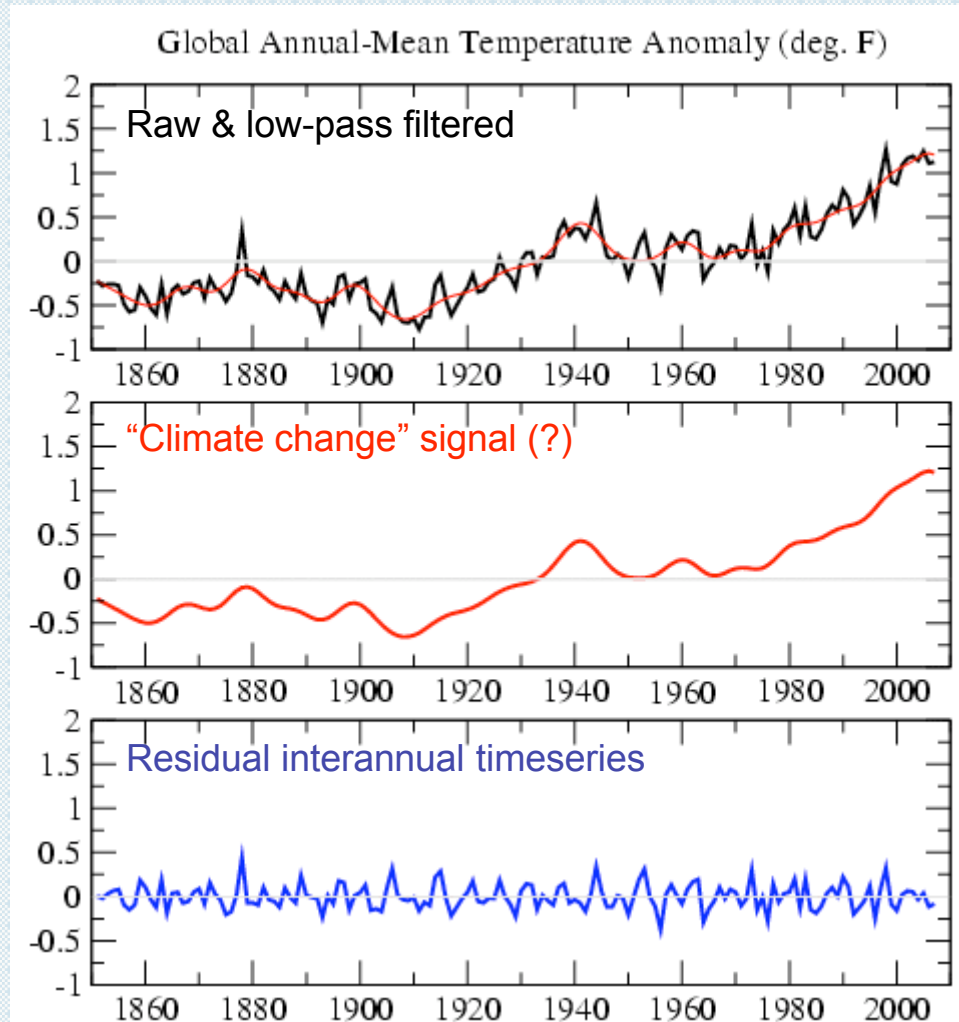


Outline

- Perception – CC v CV
- Potential Uses
- Current predictions – CC and CV
 - Verification/judgment issues
- Example from SE South America

Climate Variability & Change Globally

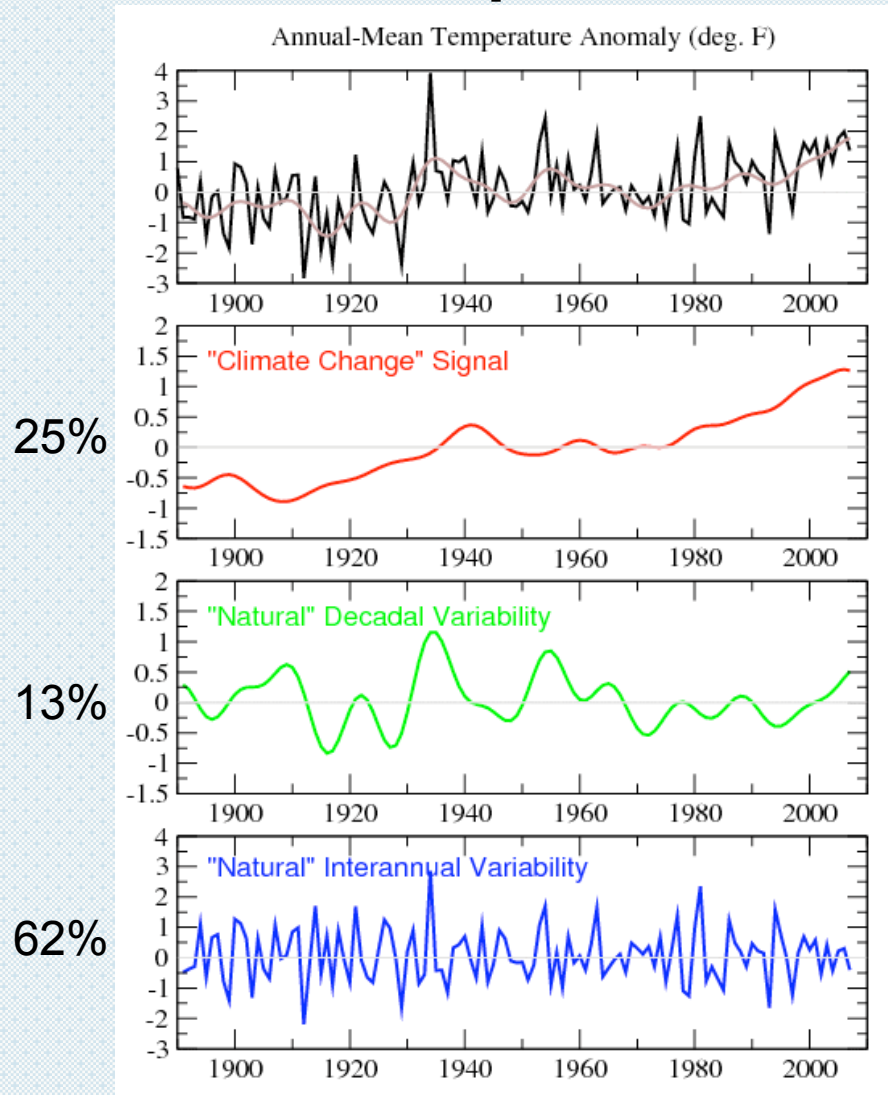
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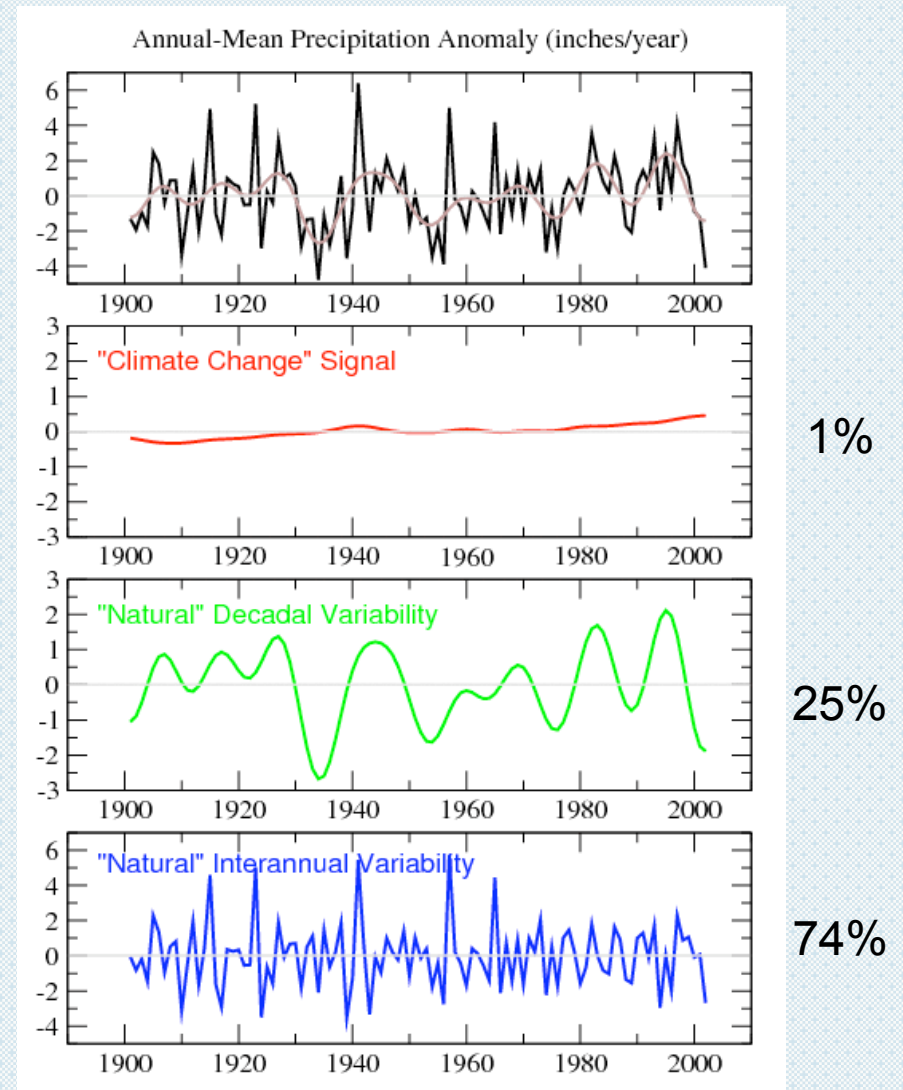
- Crude estimate that low-frequency globally-averaged temperature represents the 'externally-forced signal'
- Residual inter-annual "noise" is MUCH smaller
- Are the 'wiggles' in the decadal-smoothed globally-averaged timeseries predictable?

Climate Variability & Change in CO

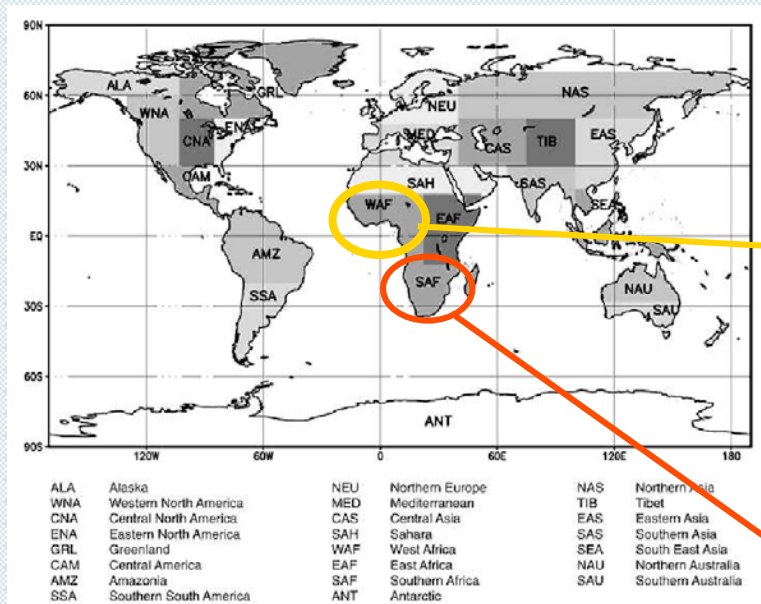
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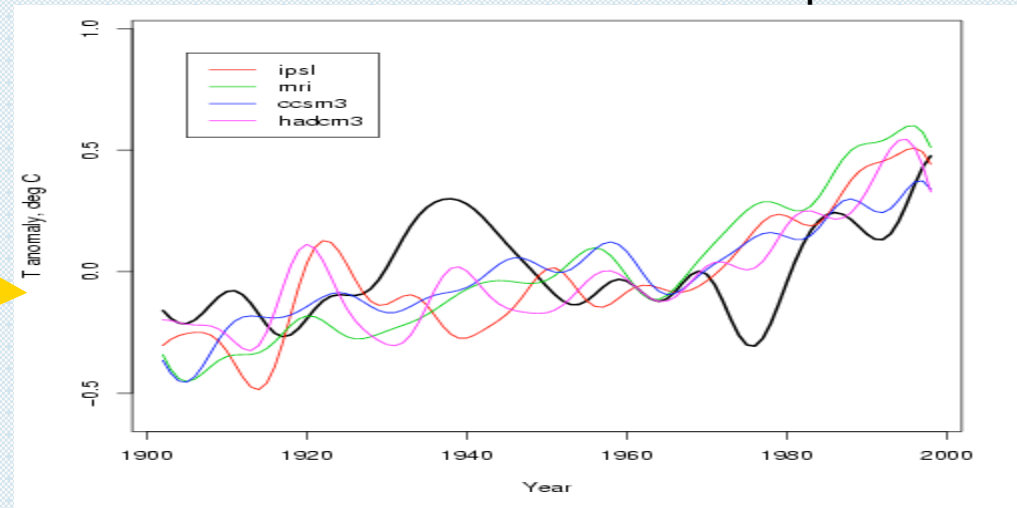
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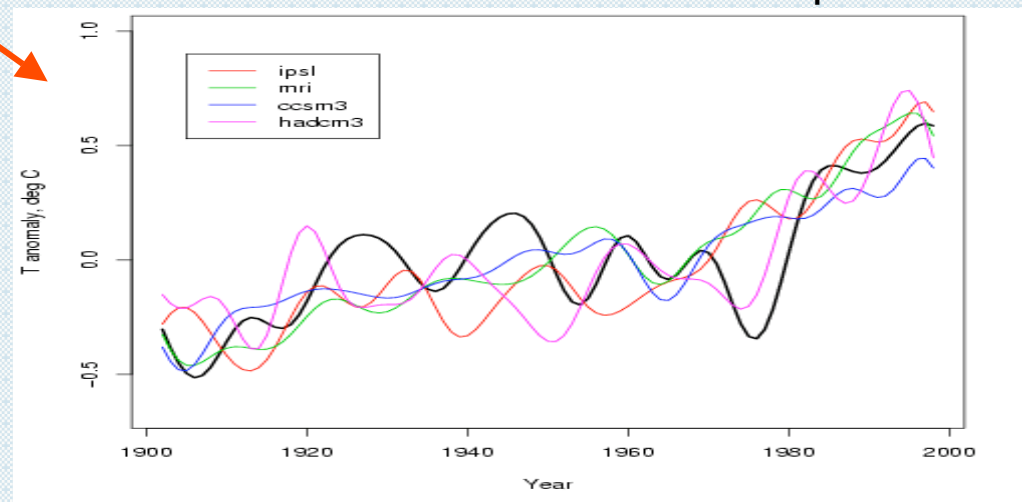
Regional Scale Decadal Predictions



Western Africa : Annual-Mean Temperature



Southern Africa : Annual-Mean Temperature



Climate Change Projections
cannot deliver predictions
of decadal variability

Potential Users(/uses)

- Global temperature
 - Public, media, policy: *attribution for any deviation from monotonic linear upward trend*
 - Regional temperature
 - Long-term agricultural planning (viticulture, pine plantations)
 - Regional precipitation
 - Guidelines for reservoir operations and management policies; interstate compacts (regional water managers, hydropower plants)
 - Infrastructure design and economic analysis (reservoirs, well fields, water & wastewater treatment plants, dikes, etc.)
 - Regional extremes (e.g. hurricanes)
 - Re-insurance
 - Regional ocean climate
 - Fisheries, ecosystem management
- ➔ Major issue: Tolerance for uncertainty??

Outcomes from one mtg on Decadal Climate Predictions (Use)

3-23-07 Seattle, WA (following CPASW)

Attending: Andy Wood, Nate Mantua, Brad Udall, Kathy Jacobs, Dan Vimont, Dave Meko, Matt Switanek, Dennis Lettenmaier, Art Miller, Levi Brekke, Ben Kirtman, Jim Kinter, Ed Sarachik

GENERAL OBSERVATIONS/RECOMMENDATIONS - subset

- Not understanding DV is obstacle to improving ENSO predictions and identifying impacts of CC
- Need **information on phase changes of DV** – predictability means useful skill. On the other hand, predictions of phase changes are useful only if persistent.
- **Nowcasts are important** – again, more important if conditions are persistent.
- Lack of verifiable cases is a problem, but shouldn't be an excuse. Some managers perceive that even a 5% improvement in predictive capacity can be useful.
- Evidence of **increasing interest and sophistication of users**. With increasing climate change, there will be more interest from the stakeholders in supporting this activity. (The near-crisis on the Colorado River represents a significant opportunity to argue for this type of research.)
- Drought is important without climate change and is even more important with it. Decadal variability is the key motivator in the Atlantic re hurricanes. Insurance companies are interested.
- Anthropogenic forcing may be a key contributor to decadal predictability. Sophisticated **users do distinguish between different sources of predictability** – for example, some will care whether a prediction is based on anthropogenic forcing or from a naturally occurring process in the climate system.

Outcomes from one mtg on Decadal Climate Predictions (Use)

(Cont.)

RESEARCH QUESTIONS/AGENDA(?) - subset

- **Identification**
 - Characterization of variability at different timescales (amplitude and timescale)
 - Connection between regional climate variability and large-scale modes of climate variability
- **Understanding**
 - Connecting empirical relationships (identified above) to physical mechanisms
 - Seasonality of impact
- **Mechanisms (relevant to local & regional impacts)**
 - Persistence (e.g. Role of land-surface in drought; cloud feedbacks, etc.)
 - Which local and large-scale mechanisms/modes impact various decision makers' concerns (fire, water, fisheries)
- **Simulation**
 - Examine ability of models to actually reflect decadal variability [on regional scales]
- **Predictability (Actual)**
 - Is predictability possible if phenomenon is understood but mechanisms are not?
 - Connection between droughts and decadal predictions
- **Other**
 - Facilitating effective interdisciplinary research

Predictions? / Projections?



Improved Surface Temperature Prediction for the Coming Decade from a Global Climate Model

DOI: 10.1126/science.1139540
, 796 (2007); **317** *Science*

Doug M. Smith,* Stephen Cusack, Andrew W. Colman, Chris K. Folland,
Glen R. Harris, James M. Murphy

nature

Vol 453 | 1 May 2008 | doi:10.1038/nature06921

LETTERS

Advancing decadal-scale climate prediction in the North Atlantic sector

N. S. Keenlyside¹, M. Latif¹, J. Jungclaus², L. Kornblueh² & E. Roeckner²

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“... new modeling system that **predicts both internal variability and externally forced changes** and hence forecasts surface temperature with substantially improved skill throughout a decade, both globally and in many regions.”

nature

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LETTERS

Advancing decadal-scale climate prediction in the North Atlantic sector

N. S. Keenlyside¹, M. Latif¹, J. Jungclauss², L. Kornblueh² & E. Roeckner²

“...over the next decade, the current Atlantic **meridional overturning circulation will weaken to its long-term mean...** Our results suggest that global surface temperature may not increase over the next decade, as **natural climate variations ... temporarily offset the projected anthropogenic warming.**”

Verification



“How can we communicate the quality of the predictions in a way that is meaningful to those that might use them?”

Smith et al (2005)

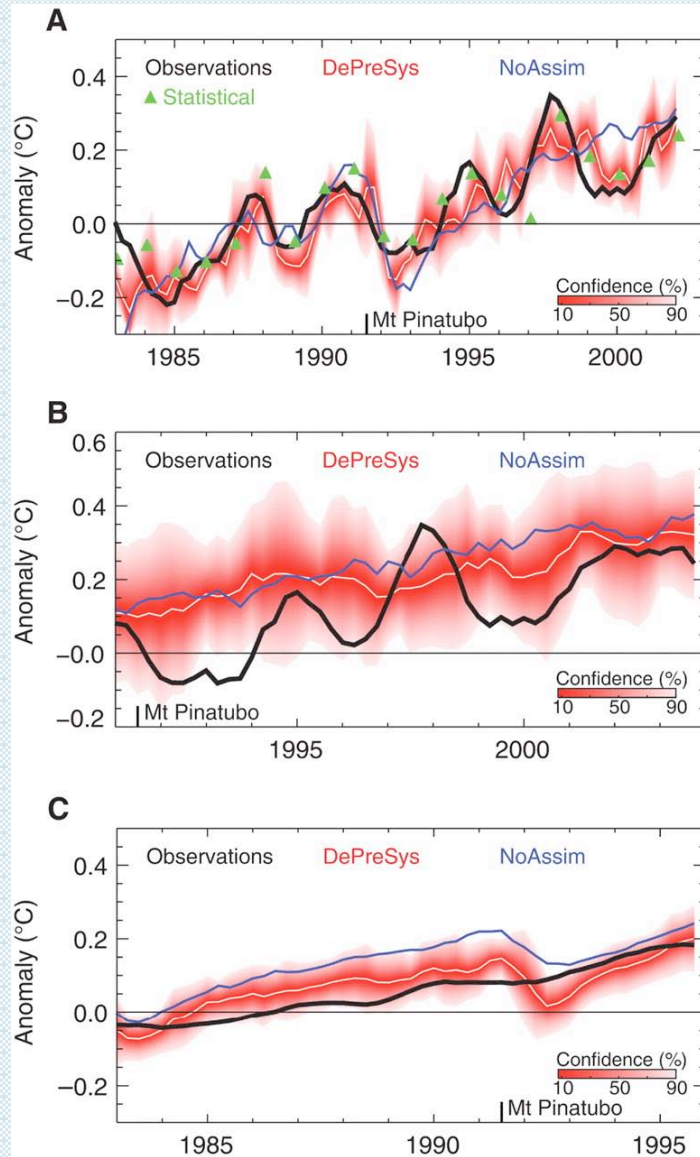


Figure 2

PROs

- View of increasing uncertainty at longer time horizons, as well as over long-time average
- Improved projections relative to original system

CONs

- Global average
- Little to no evidence of [predictable] LF climate *variability* at long lead
- Only 4 ensemble members

Smith et al (2005)

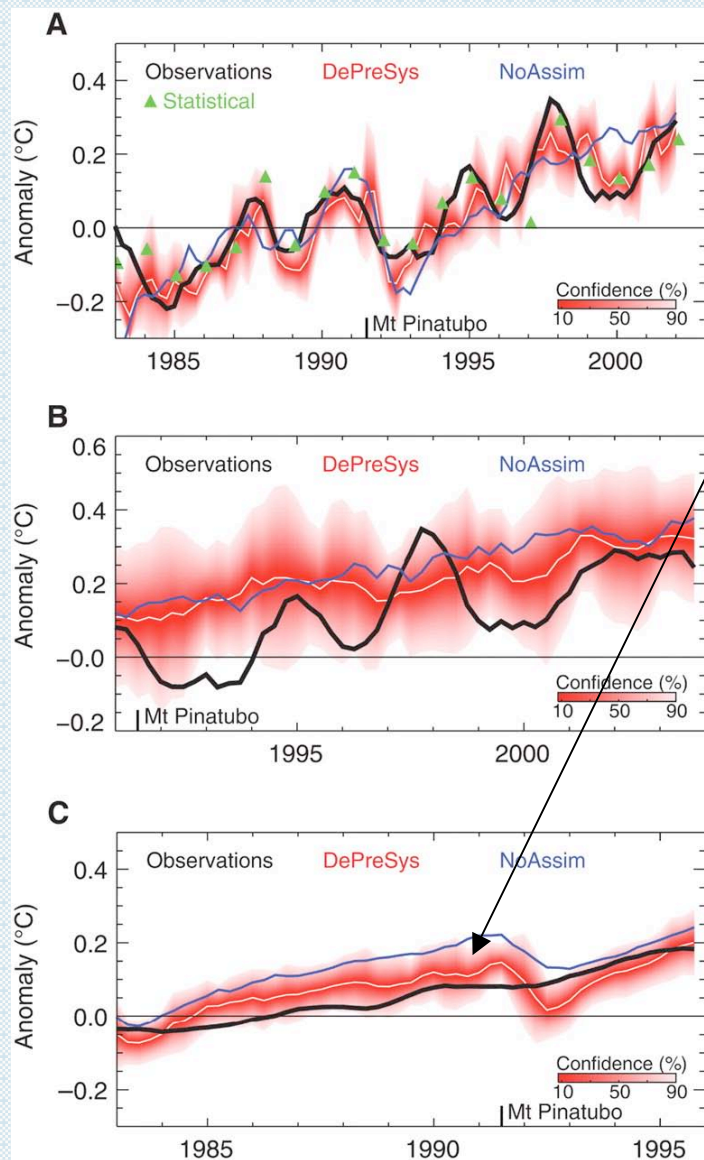


Figure 2

Added PRO:

View of **change in uncertainty with time scale**

- 1) Uncertainty in decadal-average
- 2) Uncertainty through a decade due to interannual variability
- 3) Realization of natural variability through decade

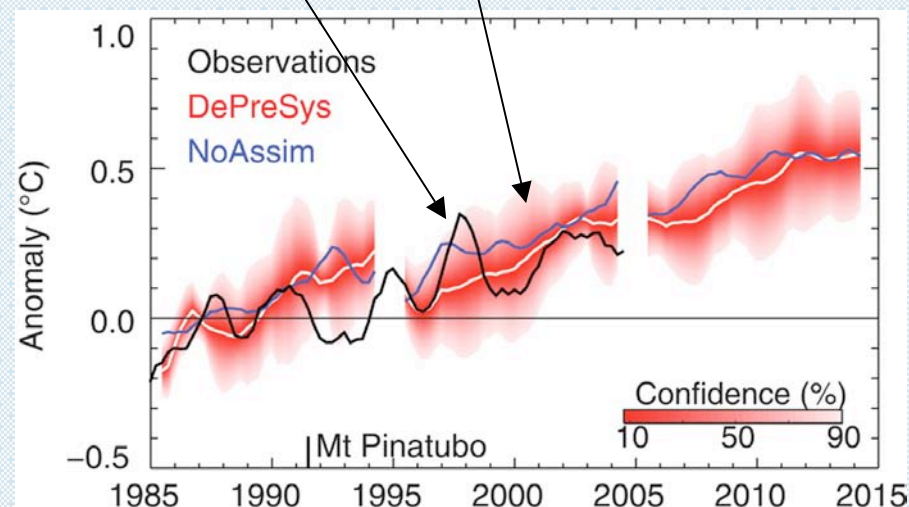


Figure 4

Smith et al (2005)

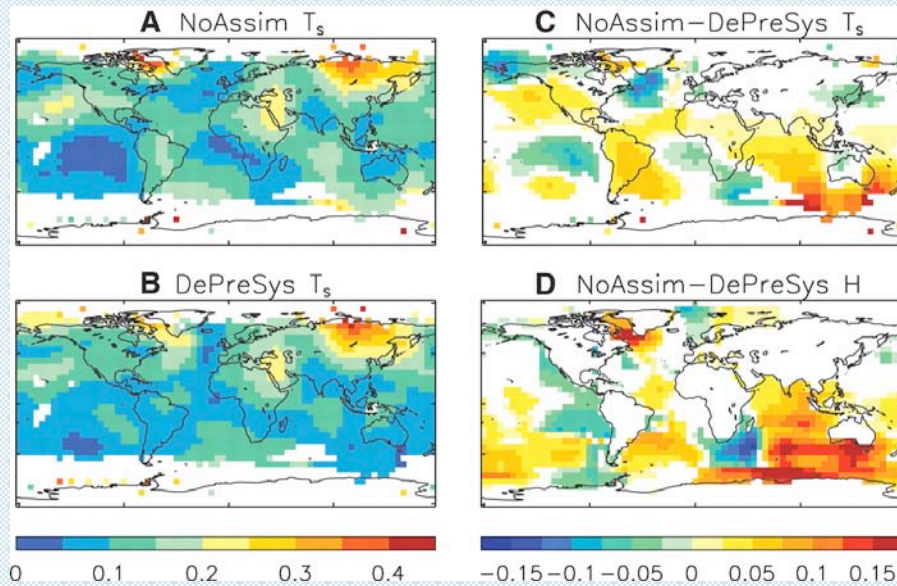
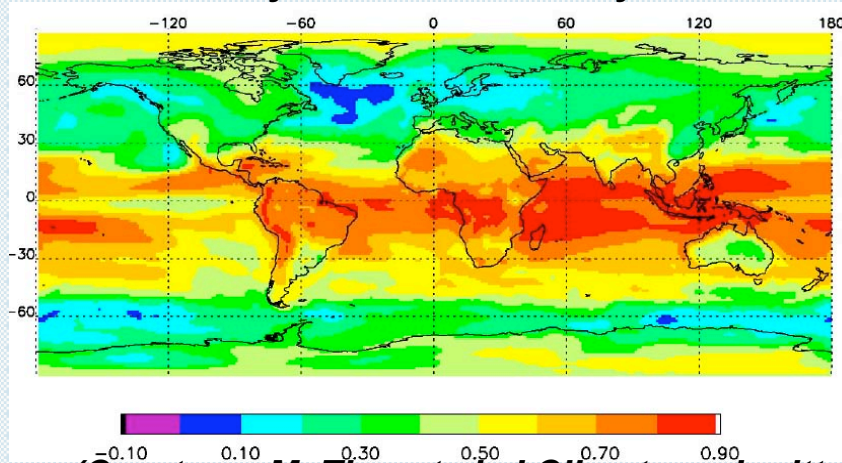


Figure 5

Ratio of Externally-forced to Internally-Forced Variance



(Courtesy: M. Ting et al, J.Climate, submitted)

Regionality?

- T_s projections improved over many regions

Climate variability?

- T_s projection worse over N.Atlantic
- Much improvement in regional T is associated with improvement in regional H , which bears striking resemblance to regions where T is dominated by externally-forced signal.

Keenlyside et al (2008)

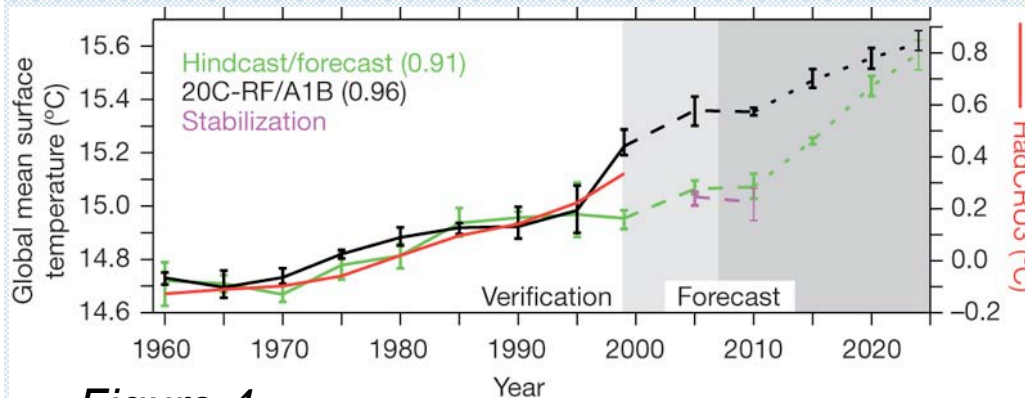


Figure 4

“... the initialized prediction indicates a slight cooling relative to 1994-2004 levels, while the anthropogenic-forcing-only simulation suggests a near 0.3 K rise.”

PRO:

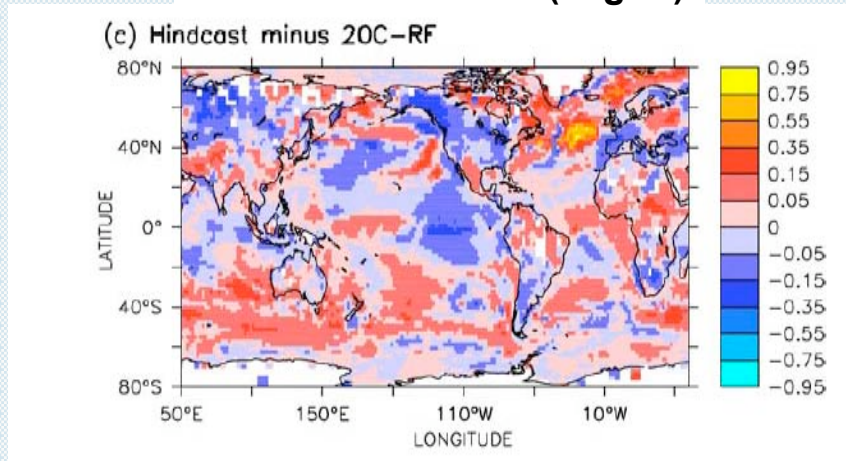
- Focus on mode(s) of natural climate variability

CONS:

- Statements/conclusions seem at odds with evidence (ie. fcst evolution)
- Uncertainty given by spread of 3 ensemble members
- Demonstration of natural climate variability (AMOC) not obvious

Keenlyside et al (2008)

Difference in RMSE (deg. K)



Supp. Figure 2c

Regionality?

- New method seems to have greater errors in most places, especially the N. Atlantic
- What does improved performance in eastern Pacific suggest for ENSO variability?

Maximum MOC Strength

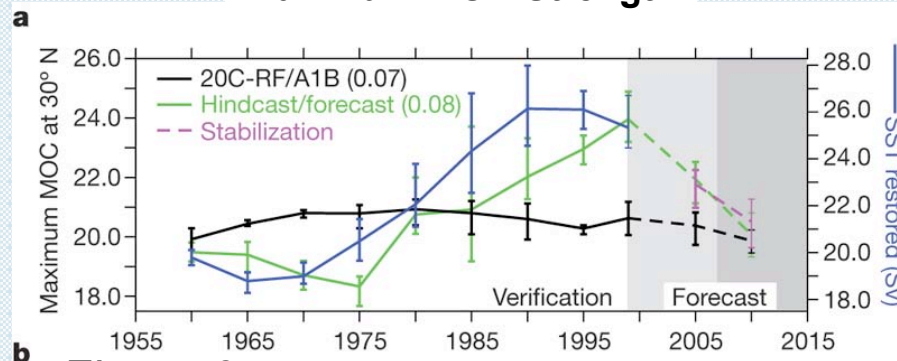


Figure 3a

Climate variability?

- Lack of verifying observations, so don't really know truth
- But – according to available truth, hindcast has no skill

Predictions? / Projections?

Projections?

- Yes – seems possible to provide better estimates of near-term anthropogenic climate change (at least T), due largely to correcting biases in ICs

Predictions?

- Not yet – Some evidence of potential predictability (perfect model/ICs) and slight evidence of real experimental predictability, *but* very little available at regional scales (and nothing yet demonstrated for precipitation).

Example: Hydropower in SE S.America

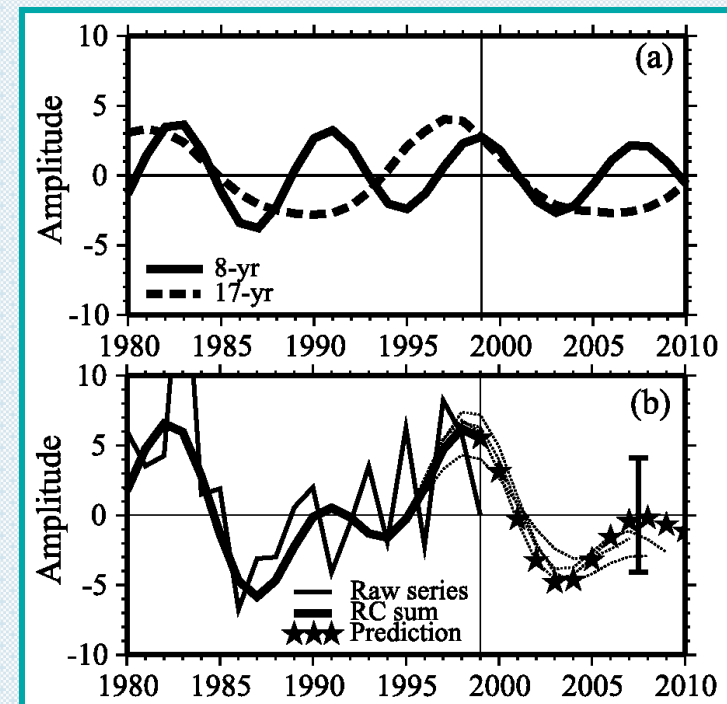
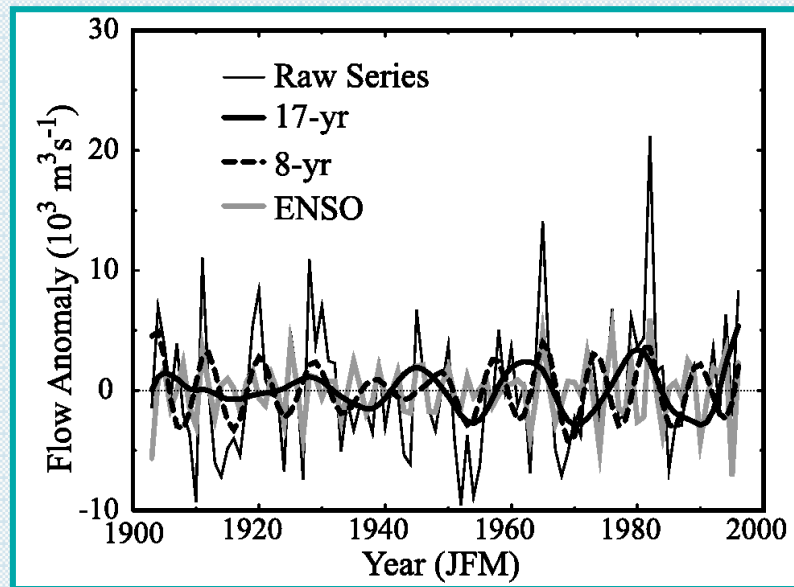
1) Improving year-to-year management:

How do decadal fluctuations modulate ENSO impacts in the region?

2) Long-term planning of water & energy contracts (typically 5-10 years):

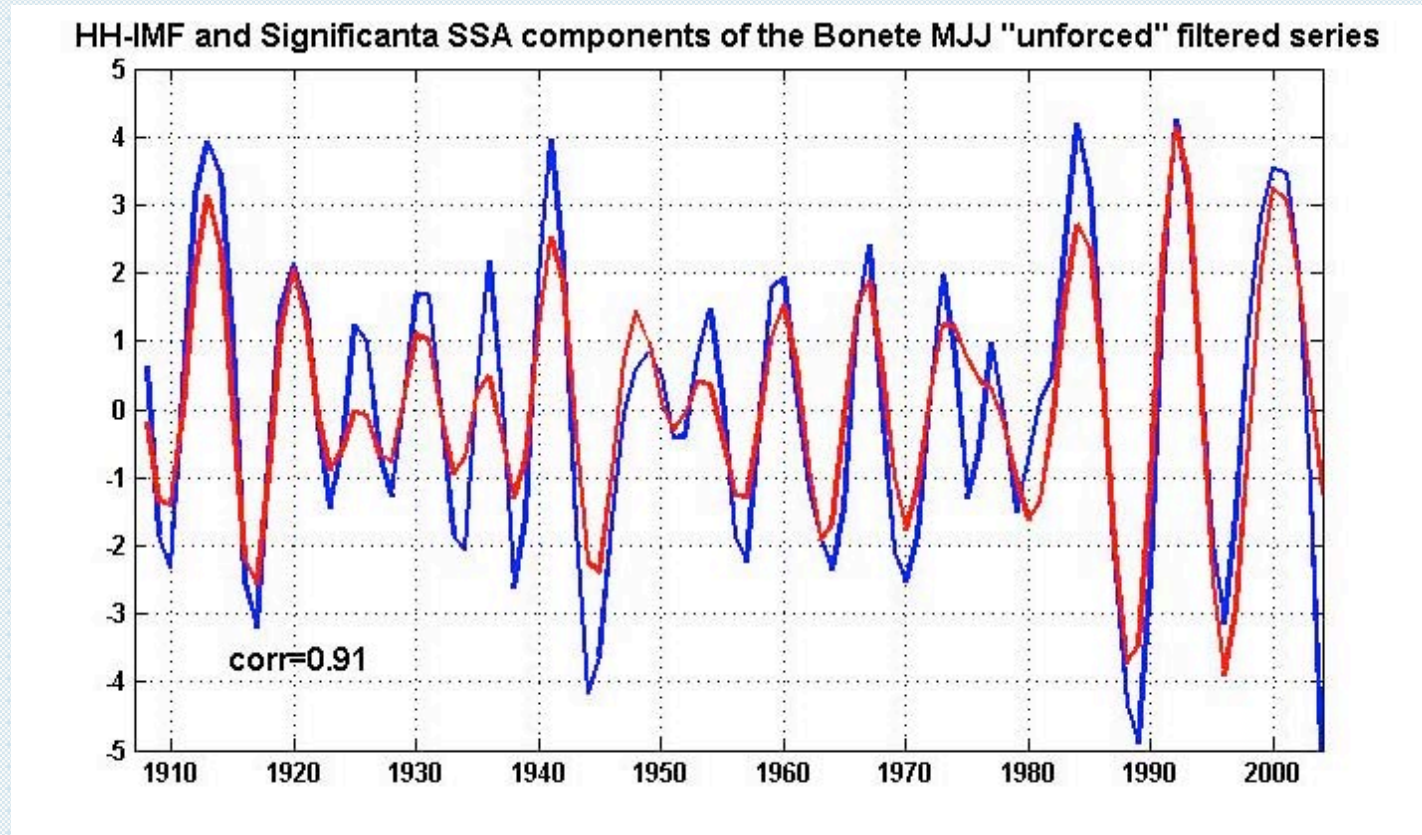
Can mean conditions for next 5-10 years be predicted within 'some level of confidence'?

Forward projection of *periodic* components: Paraná streamflow



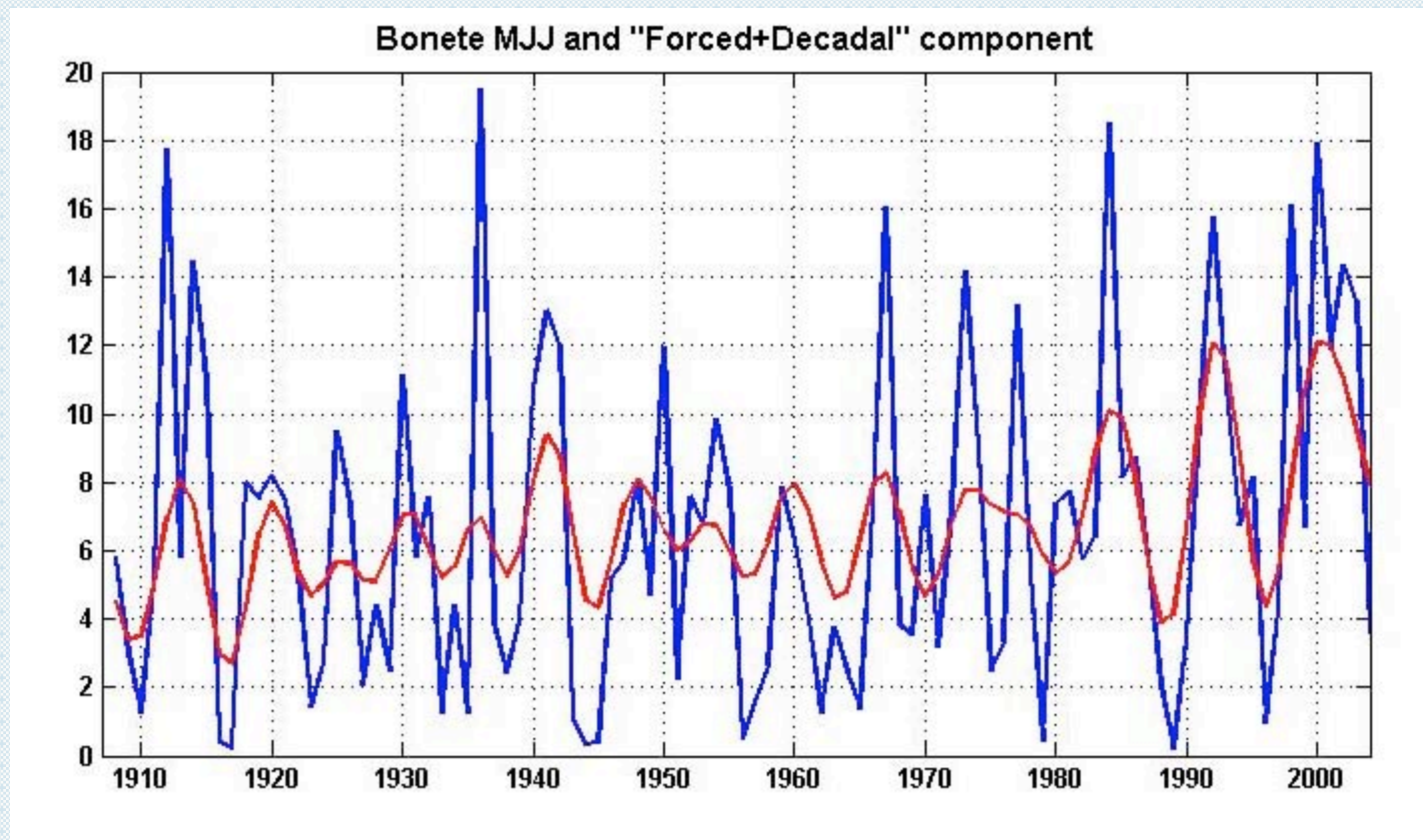
- Data: 100 years of station streamflow.
- Spectral decomposition, identification of significant periodicities, via SSA.
- ENSO removed, leaving components with periods $\sim 8, 17$ yr. These were attributed to influences of NAO, regional dynamics (SACZ/LLJ), respectively.
- Hindcast verification suggested useful (categorical) predictive skill.
- Linear prediction yielded forecasts of declining flows (stars in (b), right). These subsequently verified (Robertson, pers. comm.).

Streamflow & Hydropower for SE S.America



Different methods for time series analysis find dominant mode at about 9-year frequency. That mode, determined by different methodologies, is most robust in phasing and amplitude when 'externally-forced' variability and ENSO are first removed.

Streamflow & Hydropower for SE S.America



- Have information on 8-9 year 'period' component, plus anthropogenic signal, and a strong relationship with ENSO
- How to characterize uncertainty over next year? Next 3-4 years?

SUMMARY

- In almost all cases, **regional** climate predictability will be necessary for applications
- Careful **estimates of uncertainty** are key to appropriate use of information – expected error, relevant to timescale, consideration of characteristics of variability *within* time span of prediction/projection.
- A skillful decadal forecast (CC+CV) should be able to discriminate the climate of one decade from another (at least more often than not).
- In the absence of forecast skill, information on variability characteristics of past climate provides some benefit

Near-term Climate Change & Water Mgmt.

“As in the seasonal forecast case, ... decision making as long been done without [climate prediction] information, the **use of such information will require guidance**. In the case of climate change and water infrastructure, the increased future uncertainty should lead to an **increased discount rate** used in decision-making, which then **shrinks the planning time frame from a typically 30-40 years to say 20 years**. Thus, decadal prediction is extremely relevant. Yet, when you speak to water managers, they're typically using operational guidelines that were developed in the 60s and haven't changed since. So, we really need an understanding that climate change should lead to incremental decisions and frequent updating, ie, a complete change in how water planning and management is currently practiced. The current high profile of climate changes makes this a teachable moment. The availability of skillful decadal predictions would provide a huge incentive to make this much needed change in an intelligent way.”

- Casey Brown, IRI