Climate Variability and Climate Change
Seeking the Meaning for Water Resources Management

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Climate and Water Resources:
   Ensure long-term strategies robust
   Promote enhanced year-to-year management

1. Infrastructure e.g. Reservoirs
   Needs knowledge of climate 10-30 years +

2. Year-on-year Management
   Seasonal climate monitoring and forecast

3. Quantitative analyses to find the best balance in a changing climate, mix of long-term and short-term interventions (Brown and Lall, 2006)
2. Year-on-year Management

*Climate information is a contribution*
Climate Science:
- We are better able to understand, monitor and predict year-to-year climate fluctuations
- A key area is how to translate this into information that best leads to action

Understanding

Monitoring

Prediction

CMAP rainfall – merge of station, satellite, model
Exploring the management of Angat Dam, Philippines using monitored and forecast monthly inflows (Most value with relatively low annual storage to inflow ratios)
National Water Resources Board (NWRB) specific guidance to the reservoir managers with regard to water releases for each user within a particular period. The MWSS manages water for Metro Manila, and is part-owner of the dam since it contributed one-third of the construction costs. Two private concessionaires have contracts with MWSS to handle Metro Manila’s water distribution. The National Irrigation Administration (NIA) manages the irrigation system in Bulacan province. NIA does not directly represent farmers, but collects irrigation service fees, and is the main entity lobbying for farmers’ interests in Angat. The National Power Corporation (NPC), which actually operates the dam, generates and distributes hydropower through the Luzon grid at levels that depend upon the allocation of water between NIA and MWSS.

Collaborations to develop new best practices

Here Includes

Water Resources Board
Philippines Met Service
Irrigation Administration
Power Corporation
Reliable Seasonal Climate Forecasts are possible in many tropical locations

Skill of Oct-Dec rainfall Predictions from a GCM
Red = Positive skill
From General Circulation Model (GCM) to Reservoir Inflow Forecast

The GCM gives a large-scale climate forecast Oct-Feb

Then apply a statistical transformation to predict Oct-Feb reservoir inflow
Angat Watershed

Angat Reservoir

Hydropower (200 MW)

Bustos Dam

Hydropower (Auxiliary) – 48 MW)

La Mesa Dam

Metro Manila (97%)

Bulacan Irrigation (31000 ha)

Manila Bay
Estimating Improved Hydropower Production using Monitored and Forecast Information - Output from software illustrated in previous slide

Lall and Arumugam, 2006
Statistical Downscaling of GCM Forecasts
Results of SE Asia Climate Community
Circle size = prediction skill for March-May

Seasonal total  Number of dry days

From ASMC/IRI workshop for ASEAN countries, May 2007
Dynamical Climate Model at High Resolution over Java
Predicts spatial variations in drought in Dec-Feb El Nino seasons

Model Predicted rainfall anomalies in El Nino years

Top: spatially coherent dry anomaly in Sep-Nov of El Nino years.

Bottom: dry anomaly on north coast, but wet anomaly on south coast, in Dec-Feb of El Nino years.

(Qian et al., in preparation)
Water Resources: Infrastructure and Management

1. Infrastructure e.g. Reservoirs
   *Needs knowledge of climate 10-30 years +*

2. Year-on-year Management
   *Climate information is a contribution*

3. Quantitative analyses to find the best balance
Multi-decadal variability is now recognized as a natural part of the climate system.

There is growing understanding of its sources and statistical properties.

Motivates finding best ways to incorporate statistics for long-term planning.
NAO and its relation to the Morocco rainfall regions

Solid line is 10-year low pass filter (LF)

Residual is treated as year-to-year variability (HF)

Oct-Apr NAO rainfall time-series for the five sub-regions of Morocco

Ward et al 1999
Precipitation MINUS Evaporation Change by 2021-2040: Model

Figure 6: The change in annual mean precipitation minus evaporation from the GFDL CM2.1 model for the period from 2021-2040 minus 1950-2000. Units are in mm per month.

(pers comm, Richard Seager, LDEO, 2007)
Projected precipitation changes 21st Century

Stippled areas: more than 90% of models agree on the direction of change

White areas: fewer than 66% of models agree

IPCC
NAO trends

Middle panel is model driven with observed changes in GHGs, ozone, aerosols, vegetation, solar irradiance, SST, sea-ice

Scaife et al., 2008, J. Climate
Update on observed NAO: returns closer to pattern of 1970s?

Developing information to support South Florida Water Management District

Models simulate low frequency statistical properties to guide management strategies

Power Spectrum

Kwon and Lall, 2006
Next 10-30 years

1. Available historical records suggest what range of climate to plan for?

2. How much additional uncertainty to add?

3. Is there a best estimate tendency based on available evidence?
   (global change projections and physical interpretation)
Summary

1. Climate change motivates better management of drought and floods now

2. Water resources: Combining Infrastructure and Management

3. Uncertainty evaluations for infrastructure – incorporating natural and anthropogenic influences

4. Weather insurance could play increasing role
Evaporation MINUS Precipitation for NAO positive
NAO correlation with Surface Temp

Temp influence widespread
Fig. 5. Changes in the frequency of heavy precipitation events in (top left) NAO+. (right) CTL simulations, and (bottom left) observations. The fractional change in occurrence of above 90th percentile 5-day events is plotted. The calculation of 90th percentiles and winters used are consistent with previous figures. Gridded observations of precipitation data were calculated for this study: 5-day mean winter (DJF) precipitation station data were gridded onto the model grid using an angular distance weighting method (Alexander et al. 2006). Provided there were at least two stations within the “correlation decay distance” then values were calculated for each grid box.
We also note that projected climate change signals in winter extremes for the twenty-first century (e.g., Frei et al. 2006 for precipitation) are of the same order of magnitude as the changes found here from the NAO between the 1960s and 1990s. This emphasizes the need to accurately model low-frequency NAO variability in the numerical models used for regional climate prediction. An important part of the evaluation of regional

It is important that we determine the source of observed NAO changes. The results presented here do not in themselves have any bearing on the extent to which changes in the NAO are natural or anthropogenic, although the recent downturn in the winter NAO from strong positive values in the early to mid-1990s to near-average values a decade later suggests that a significant part of the increase from 1965 to 1995 may be due to natural climate variability. If so, attribution of changes in regional, seasonal climate extremes needs to be carried out much more thoroughly than hitherto, taking into account the details of atmospheric circulation changes in given seasons. Furthermore, if the NAO increase between the 1960s and 1990s is natural in origin, future decades could easily see a reversal of regional trends in European winter climate because NAO effects can dominate the effects of global warming on Europe in winter, even on multidecadal time scales.

decrease of the winter NAO. Alternatively, if the overall NAO increase since the 1960s is anthropogenic in origin, then the rapid changes in Eurasian winter climate and its extremes over the last few decades could continue in the future. In this case, current climate prediction models severely underestimate future changes in European winter precipitation and temperature change because they have great difficulty in producing the observed rate of increase in the NAO.
Water and economic development: The role of variability and a framework for resilience

Casey Brown and Upmanu Lall

A water resources index that measures the benefits of increased storage infrastructure

Next step: In a changing climate, what is the best balance between management and infrastructure