Utility of stochastic decadal simulations in water resource planning

Arthur M. Greene, Lisa Goddard,
Paula Gonzalez

International Research Institute for Climate and Society (IRI)

Columbia University, New York, NY USA

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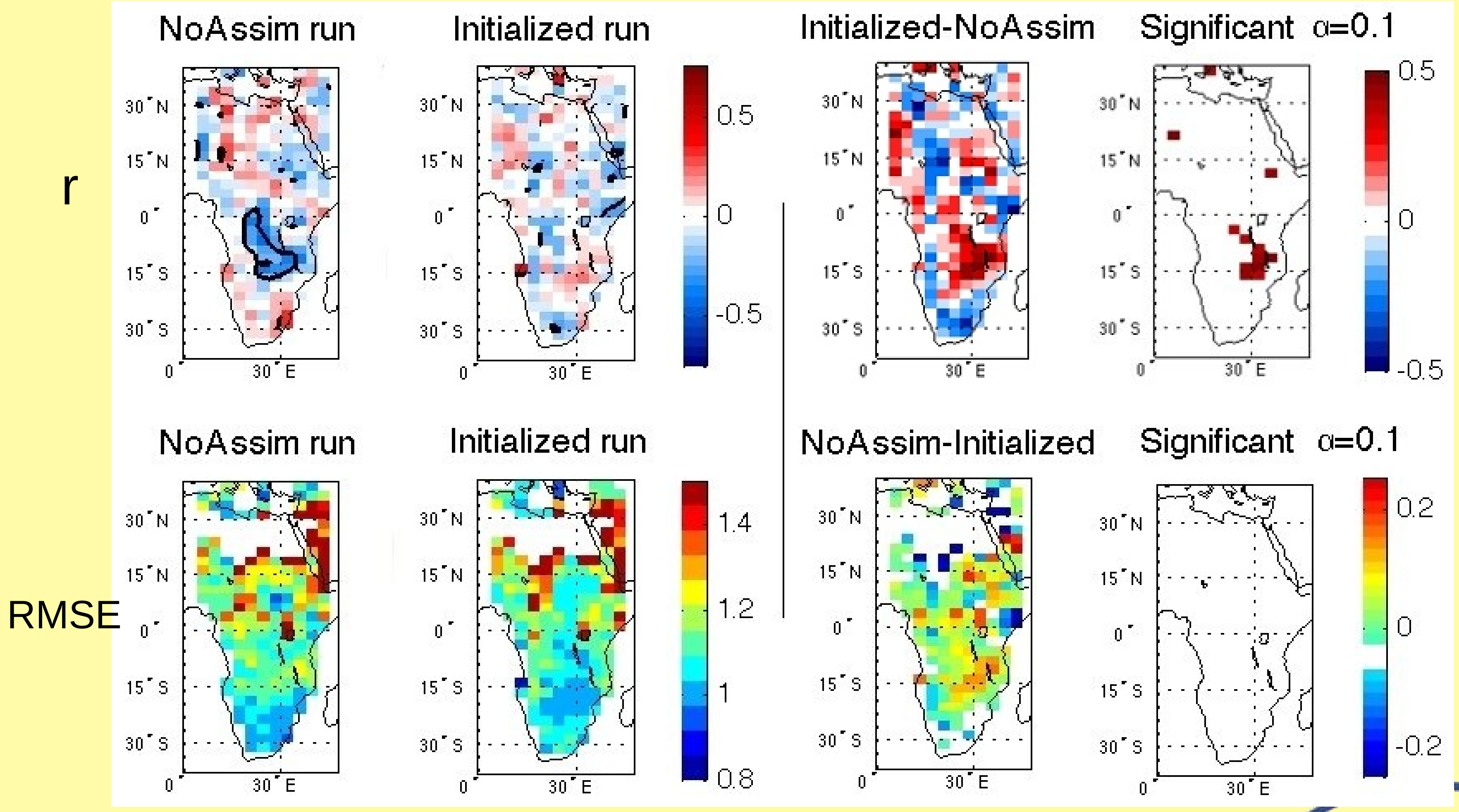
In a nutshell…

- Skillful decadal forecasts, particularly at regional scales (and over land), still lie in the future.
- A potentially useful alternative: Synthetic data sequences, conditioned by observations and including a regional climate change component.
- Issues in simulation design
- Case Study: Berg River, Western Cape province, South Africa

State-of-the-art initialized precipitation forecasts



Data courtesy Doug Smith (see Smith et al., Science 2007)

Verification: Average of 2-5 yr lead forecasts for annual mean precipitation, using GPCC

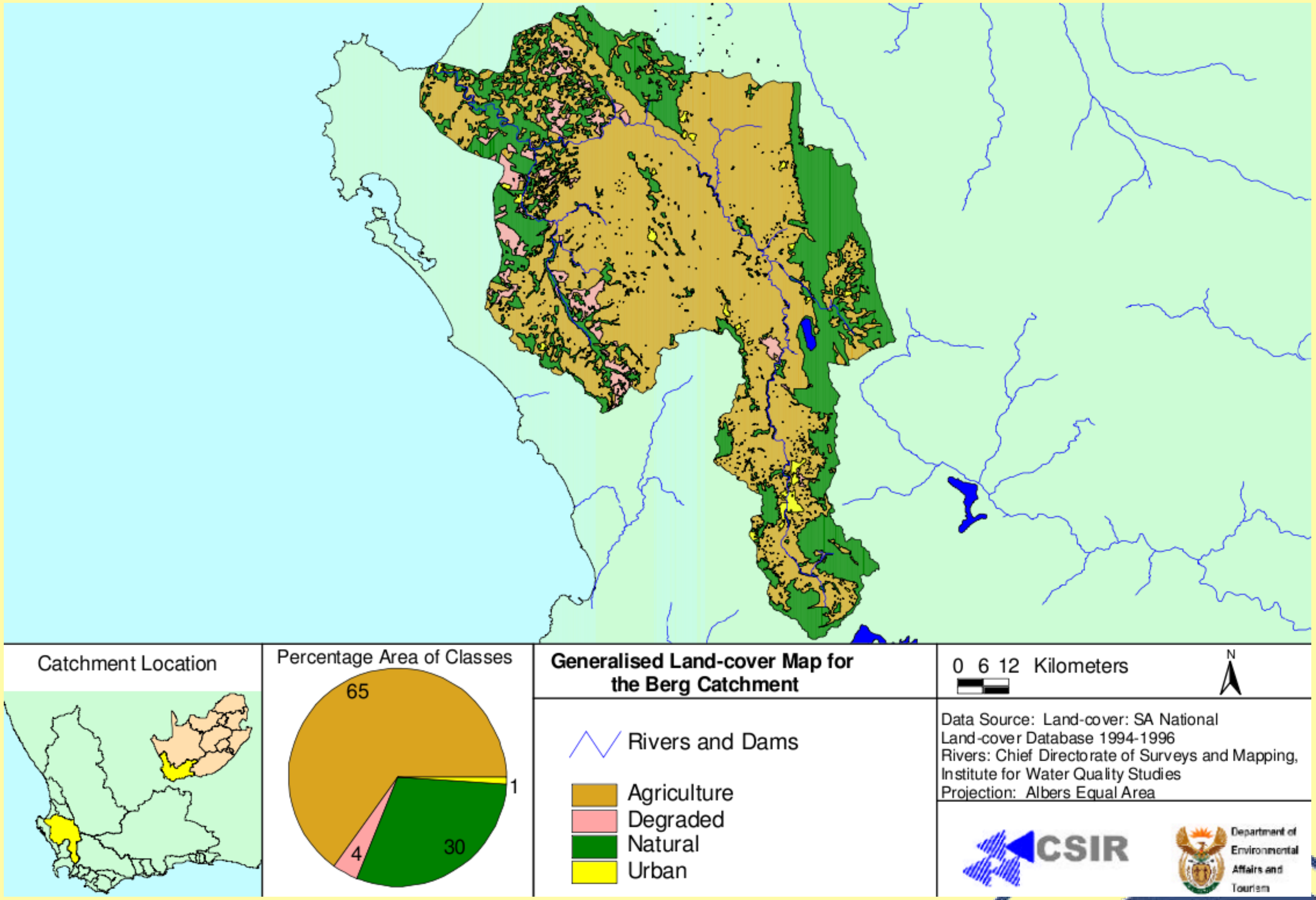
Simulations should be useful for southernmost Africa.

Simulation design issues

- Projection of regional climate change
  - Sensitivity estimation (long-range)
  - Role for IPCC models…
- Stationarity assumptions
  - Second moments
  - Serial autocorrelation (→ low-frequency variability)
  - Seasonal cycle, daily statistics
  - Local/regional covariation – spatial scale of decadal “footprint”
- Description of uncertainty
  - Arises at many levels: intermodel, scenario, estimation…
  - Not solely a matter of amplitude, but also temporal behavior
- Multivariate model
  - May be required by downstream modeling framework
  - Training data must conform…

Case study: Berg river watershed, W. Cape Province, S. Africa

- Length: ~300km
- Catchment: 7715 km^2
- Headwaters in the Drakenstein Mts., ~1000 m.a.s.l.
- precip, temperature gradients with elevation
- Principal H_2O source for Cape Town, including commercial, industrial
- Economically significant agricultural resource
- Extant hydrology, economic models
- Availability of data, models provides an excellent testbed



Simulation scheme

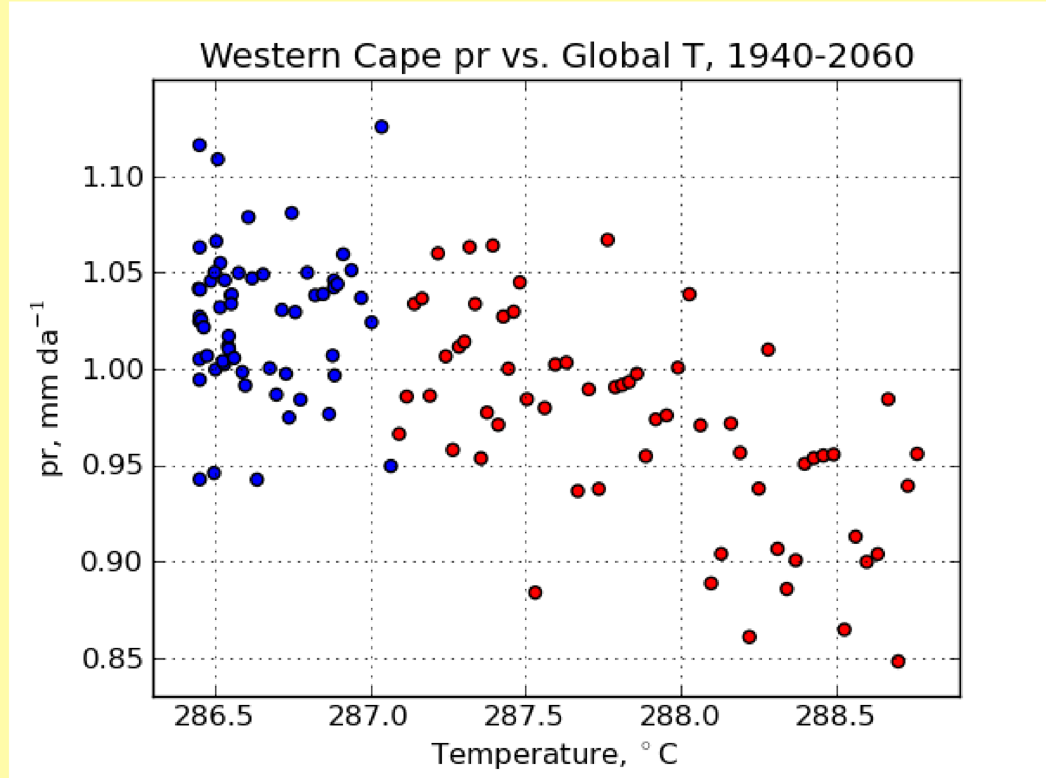
- Forced trends from IPCC (A1B)
- Low-frequency (annual–superannual) variability simulated with VAR(1) model
- Subannual variations generated by resampling observations

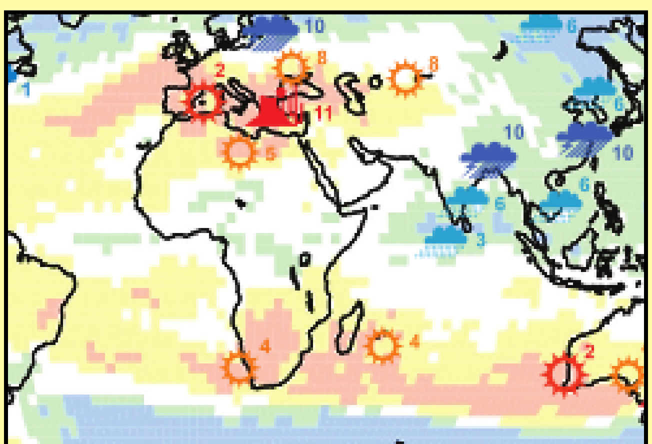
Climate change: Which century to trust?

pr sensitivity (to global mean temperature change): Weak in 20c, decidedly negative in 21c.

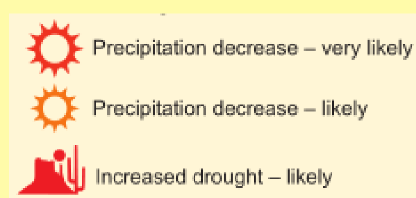
Because (a) consensus among the IPCC models is strong, and (b) region lies at the poleward margin of the dry subtropics, 21c sensitivity is utilized.

Consequence: Simulated precipitation decreases by about 10% by mid-century (annual mean).





IPCC, 2007



VAR and simulation statistics

Intervariable correlation

Observations

	pr	Tmax	Tmin
pr	1.000		
Tmax	-0.447	1.000	
Tmin	0.068	0.733	1.000

Simulation

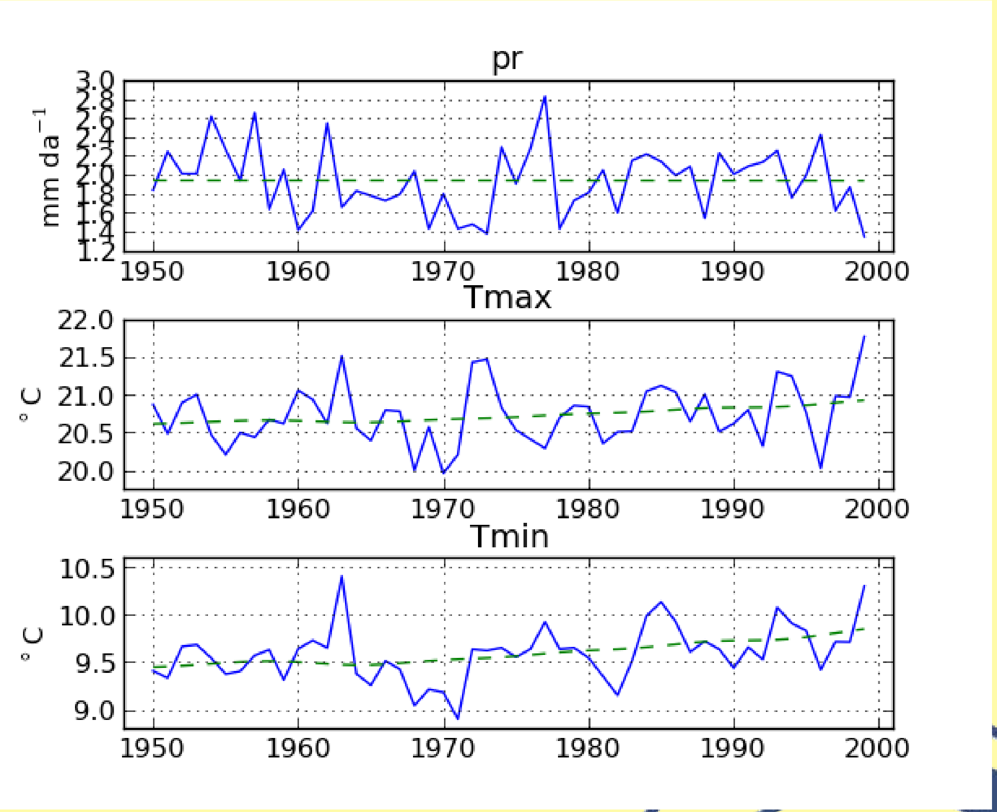
	pr	Tmax	Tmin
pr	1.000		
Tmax	-0.445	1.000	
Tmin	0.068	0.733	1.000

Serial autocorrelation

	pr	Tmax	Tmin
Obs	0.004	0.168	0.297
Sim	-0.008	0.176	0.303

Tmin significant at 0.05,
Tmax not quite…

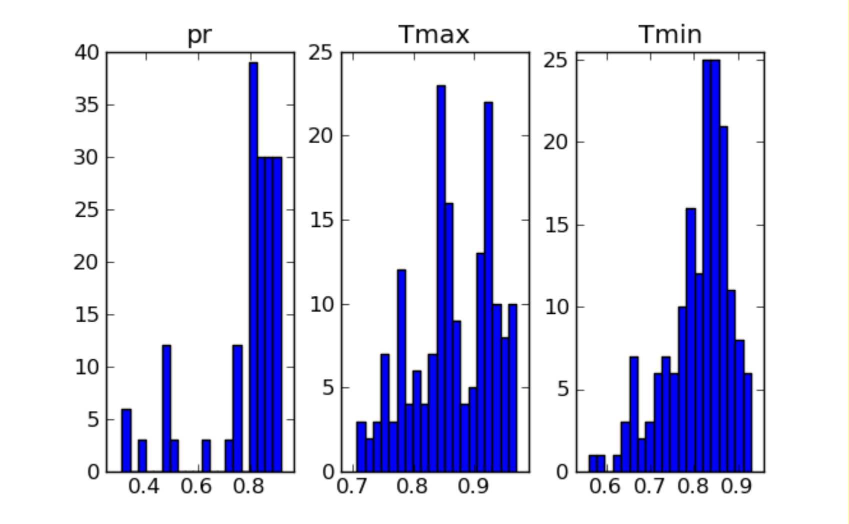
Annualized data (171-station means)



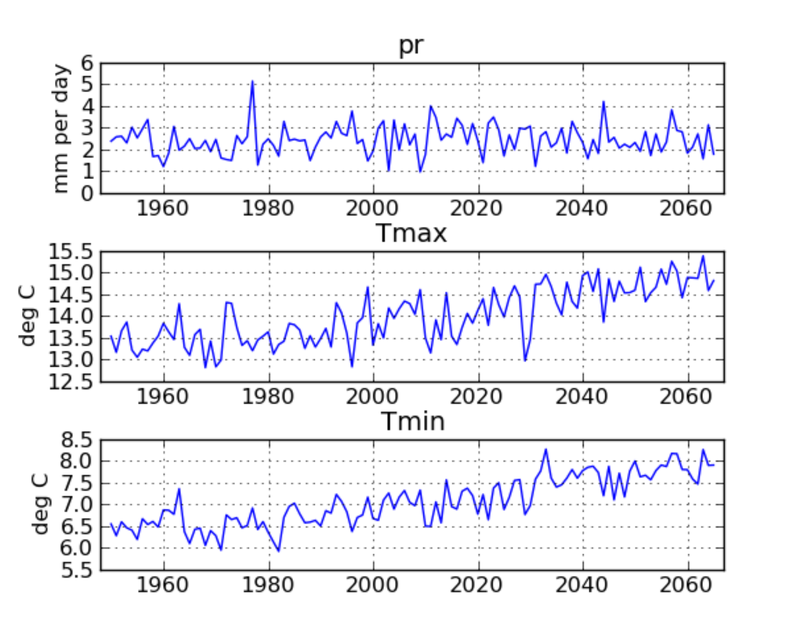
Propagation of simulations to the local level

- Individual station records well-correlated with "regional" signal: Catchment behaves coherently.
- Downscaled to station level via linear regression.
- Each year's subannual variations taken from a randomly resampled year in the observations.

Station correlations with regional signal



Station-level simulation; T trends are local



Concluding remarks

- In principle similar to the weather generator idea, but certain considerations may be particularly relevant:
  - Secular (i.e., climate change) trends
  - Decadal variations that are not "random," and relationship with the large-scale decadal modes (AMO, PDO, SAM…)
- Here a VAR(1) model is utilized; a wide range of models may be required, given the potential variety of regional behaviors.
- Anthropogenically-induced changes in variance, other higher-order features, abrupt climate changes, not considered.
- Uncertainty owing to differences in model formulation not treated here, but these will affect the trend – not the focus for this study.
- Simulations are presently being run in the first "downstream" (hydrology) model: Agricultural Catchments Research Unit (ACRU) model, University of Natal. Stay tuned!

-~- The End -~-

amg@iri.columbia.edu