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Generating near-term climate change scenarios for an arid region: a case study

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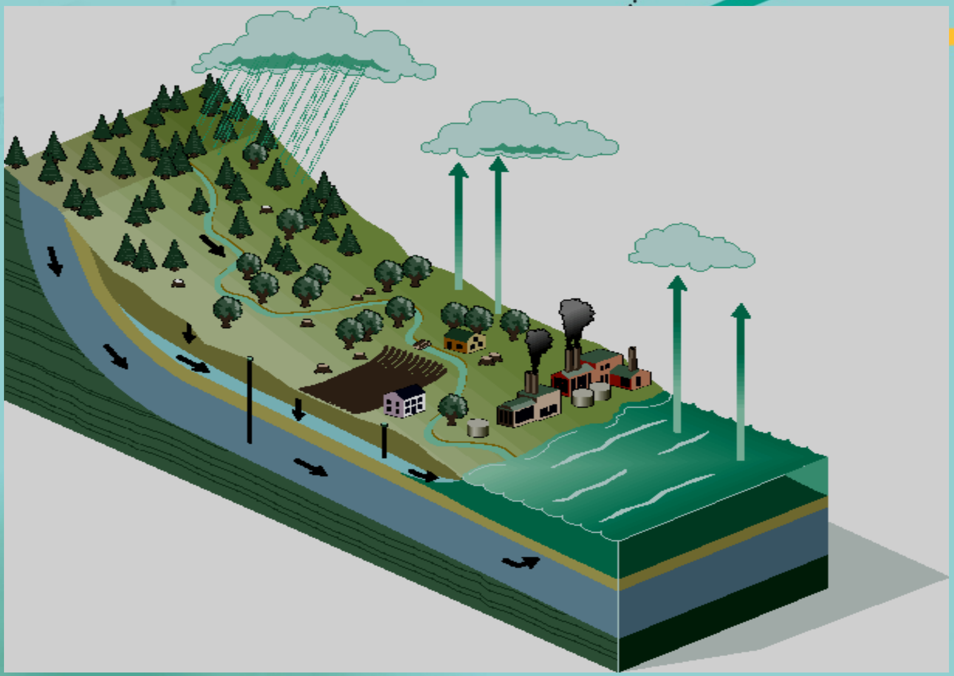
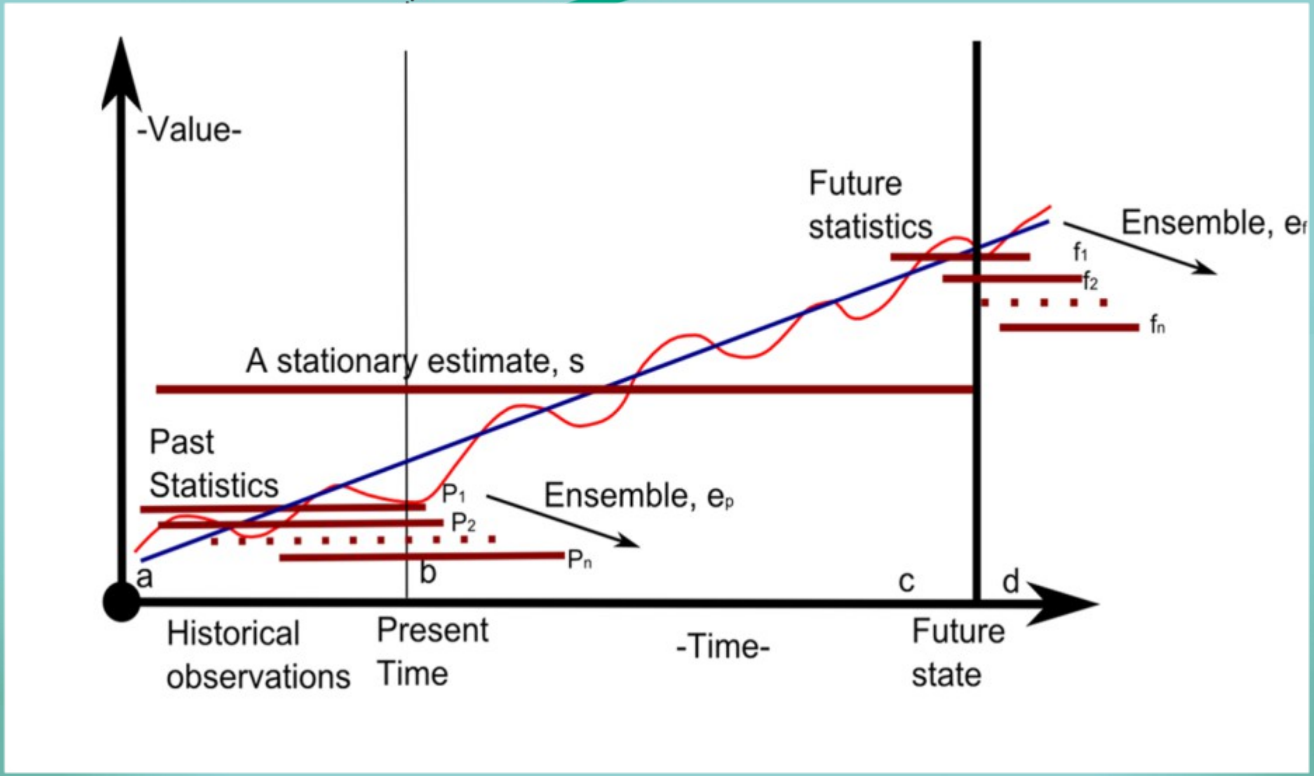
Questions we like to address in relation to future water resources



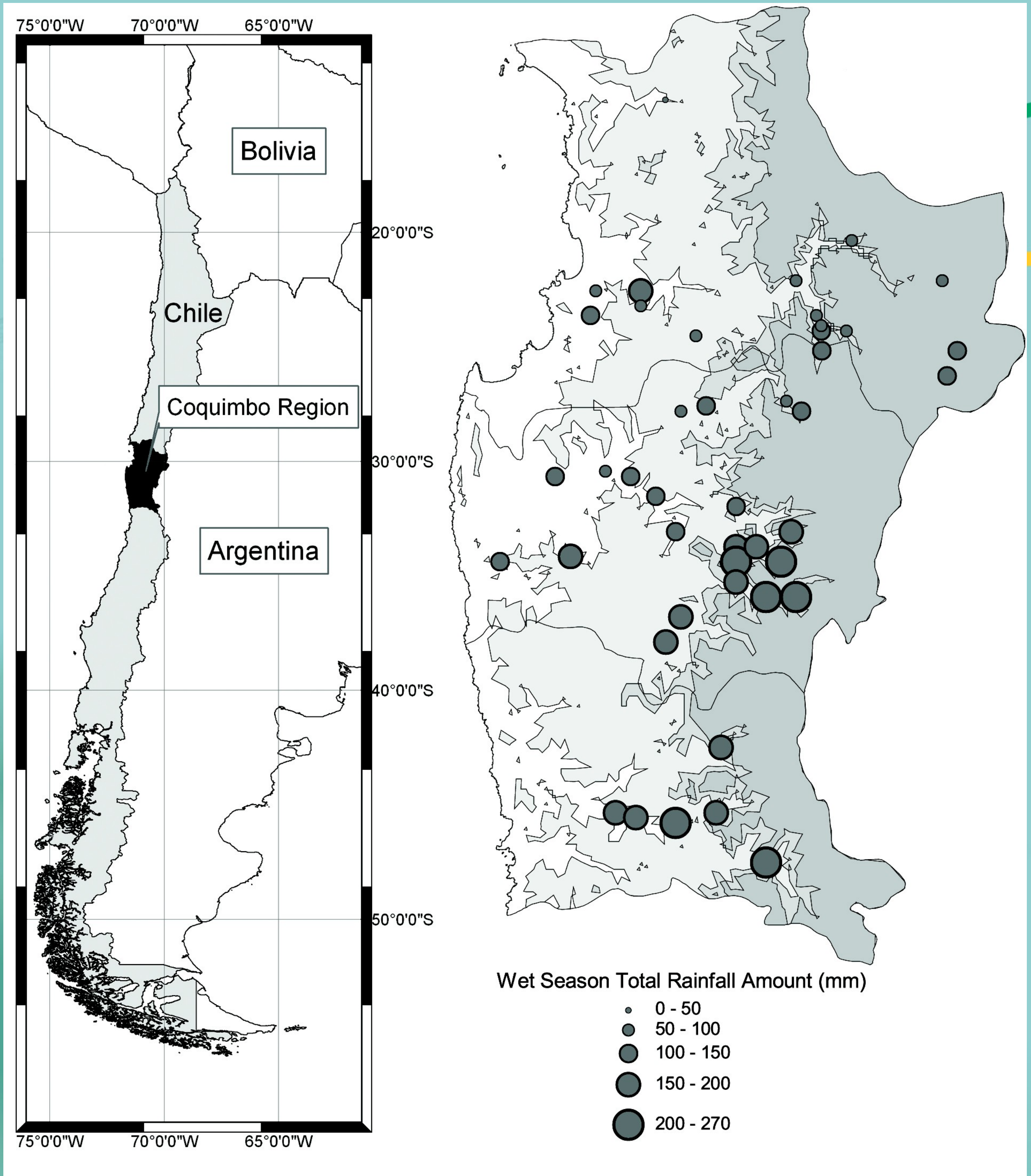
- Suficient water resources?
- What is the frequency of droughts?
- What about extreme events?

- Skillful <u>decadal forecasts</u>, particularly at regional scales (and over land), still lie in the <u>future</u>.
- A potentially useful alternative: <u>Synthetic data sequences</u>, conditioned by observations and including a regional climate change component.

Why do we need stochastic sequences?



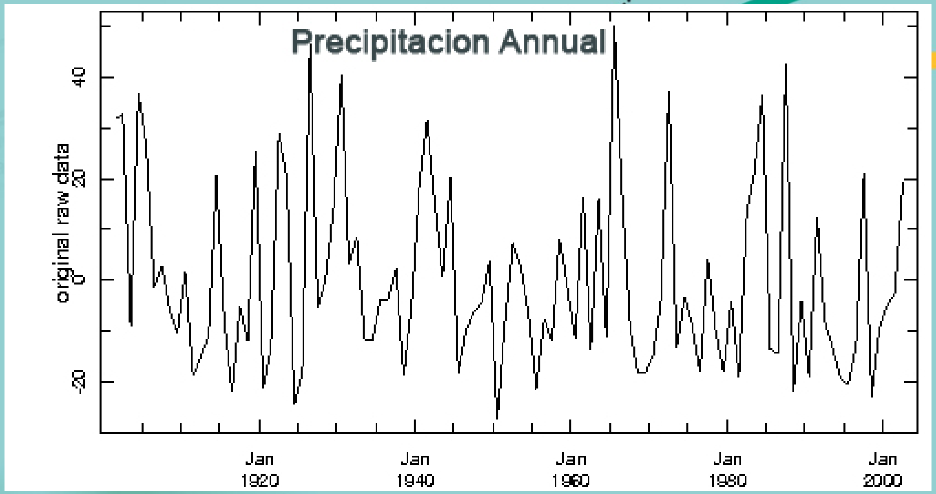
- No stationarity
- Statistics of "short stationary segments"
- Need for ensembles or stochastic sequences

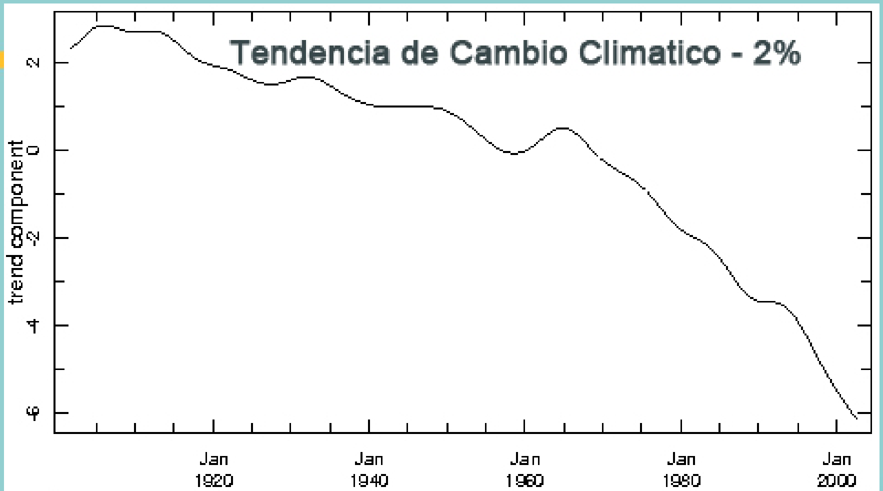


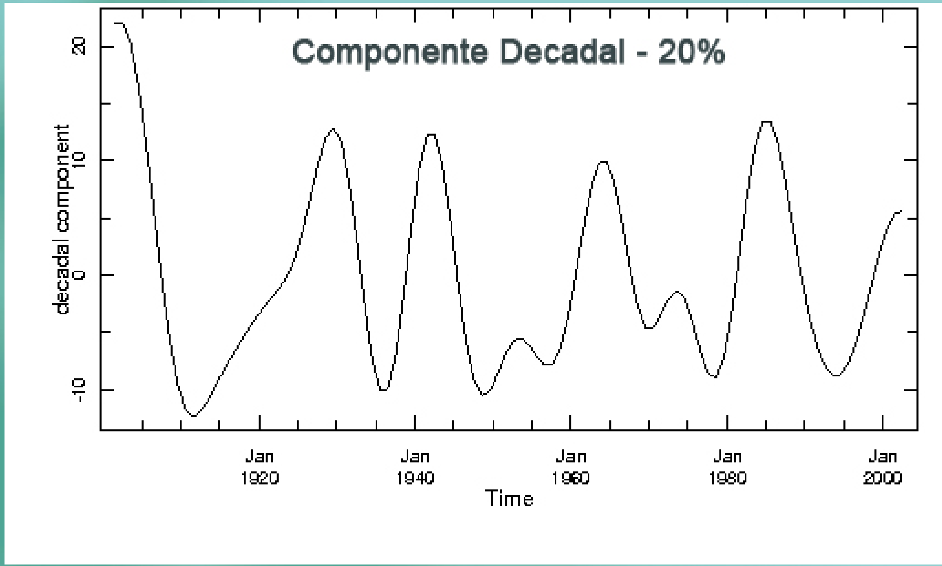
Station data

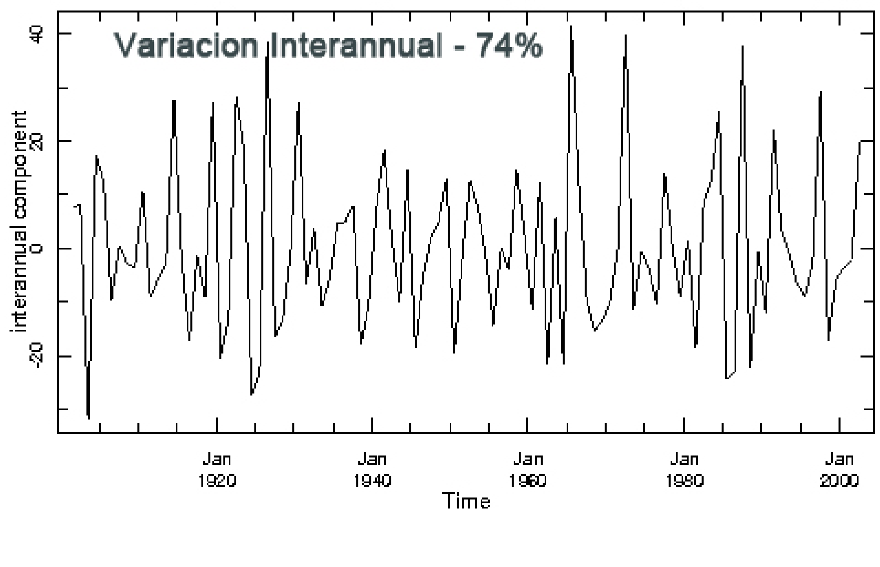
- 44 stations
- 1943-present
- Clear North-South and E-W gradient
- High coherence

What are the components of variability?



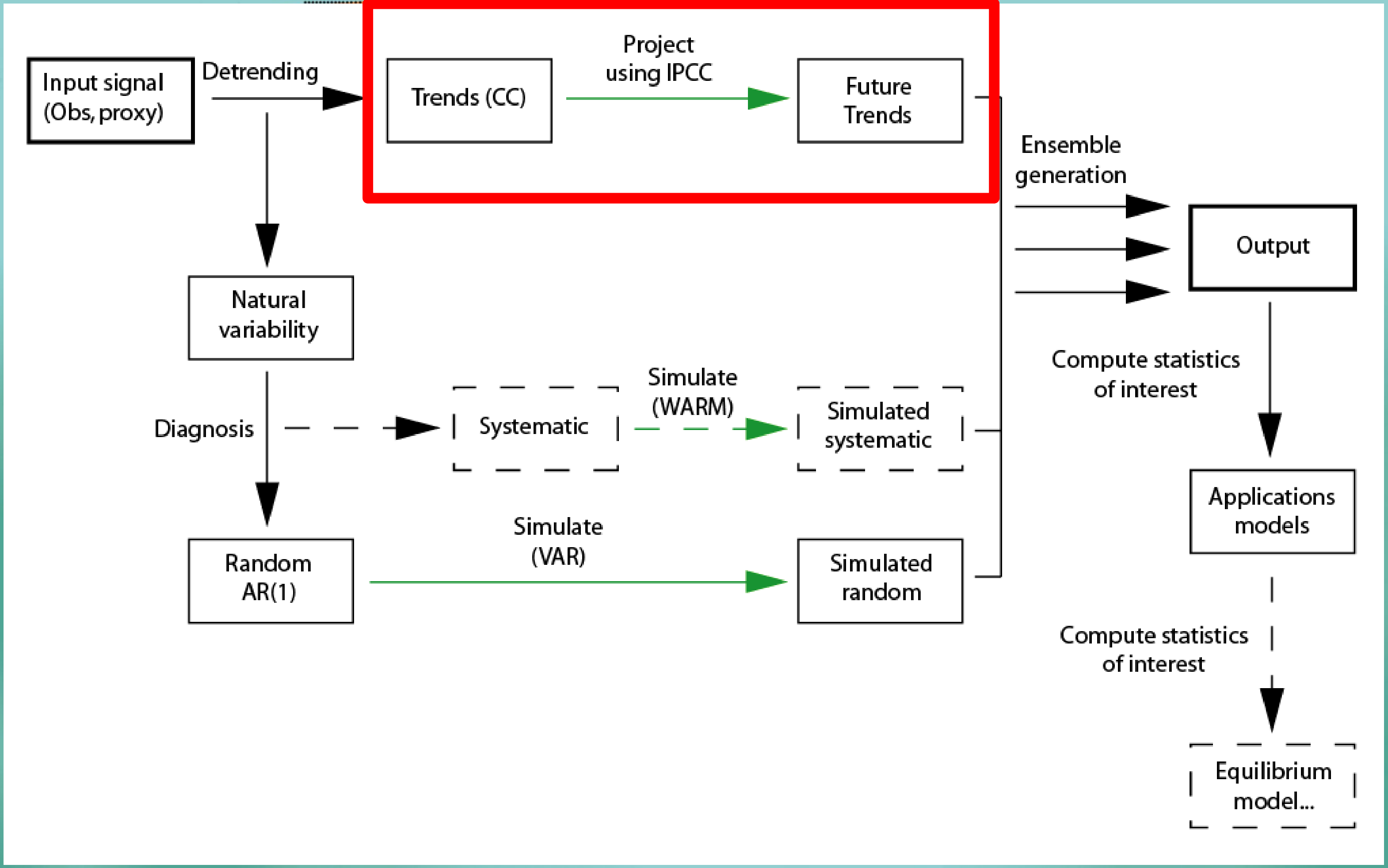




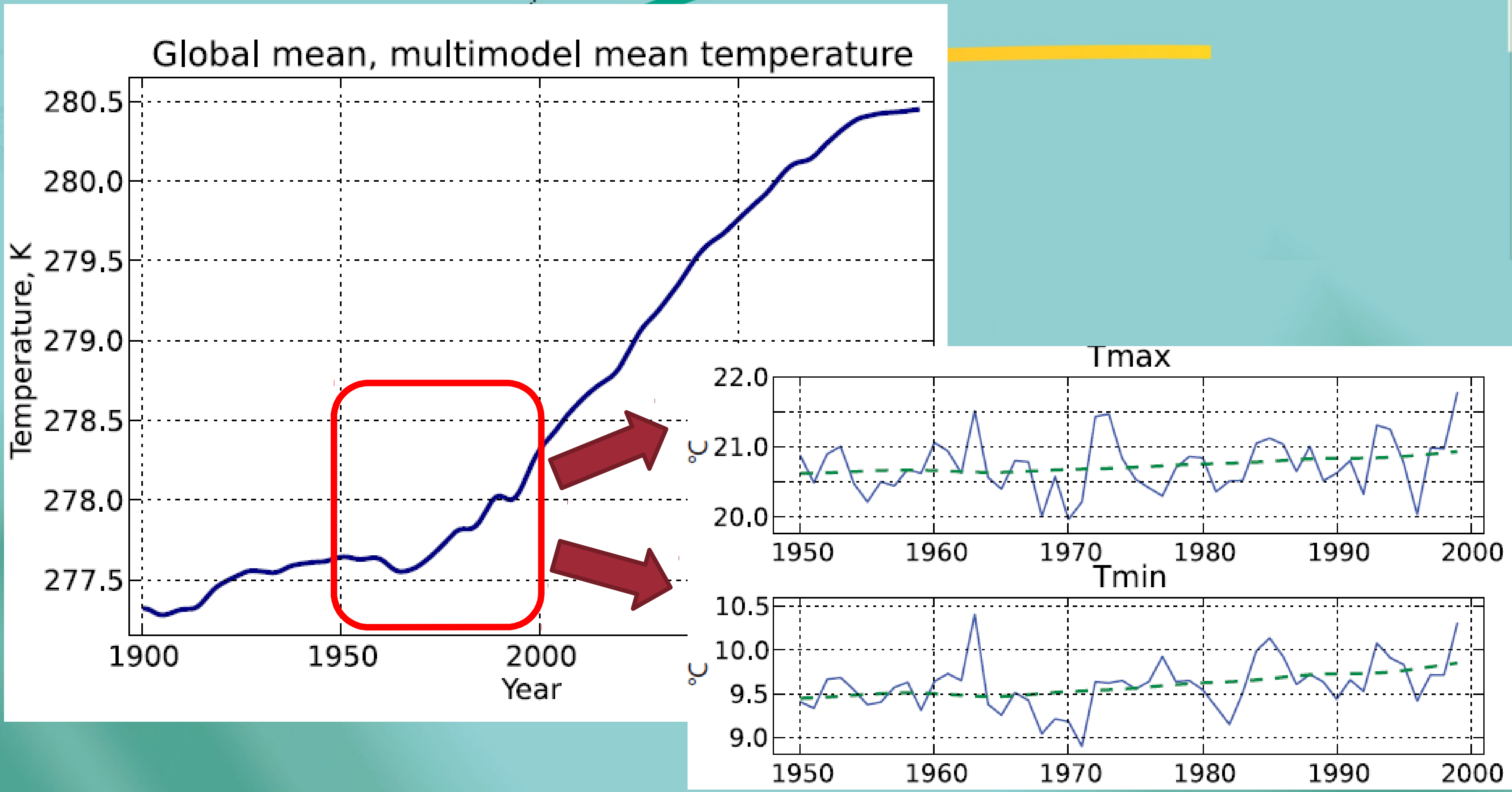


Methodology

Step 1: Selection of the CC component



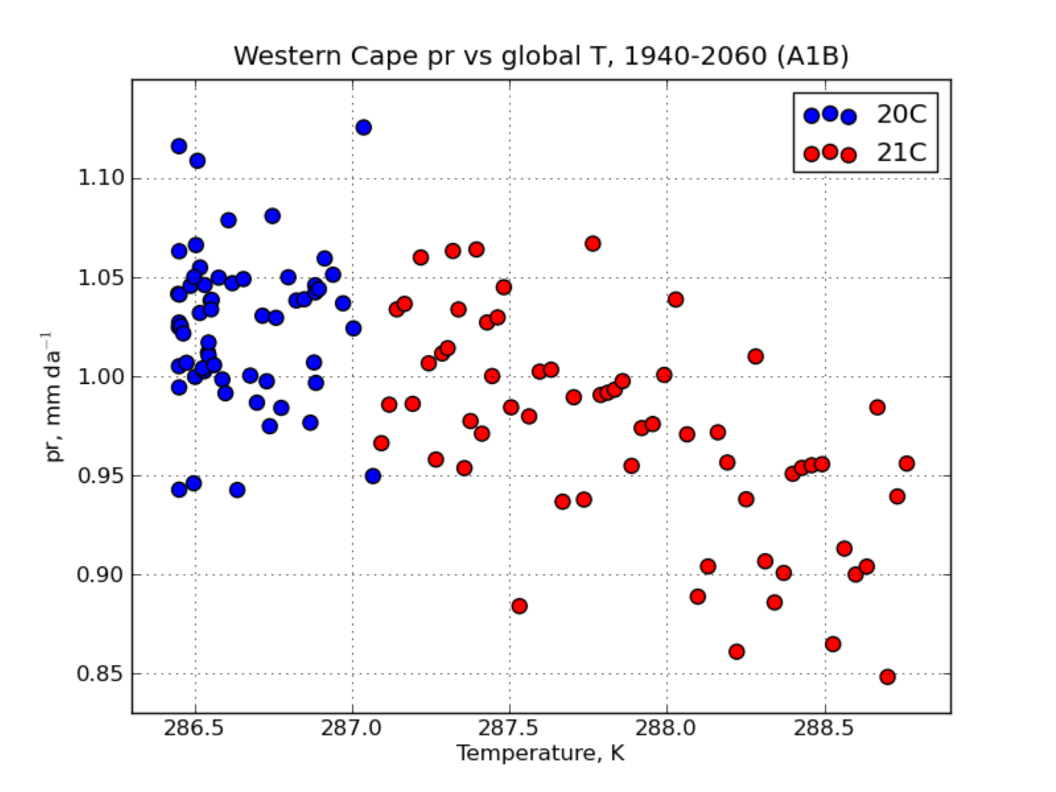
Climate change trends: Temperature

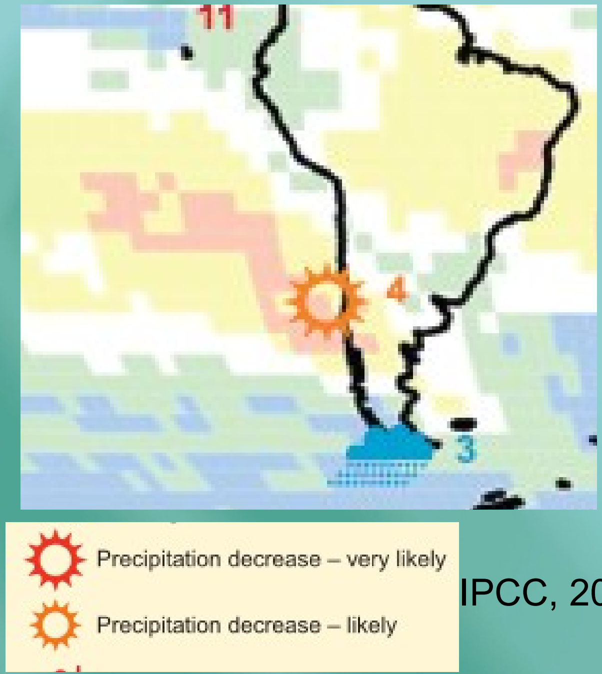


Climate change trends: Which century to trust?

Regional pr response to global mean temperature change: Weak in 20c, decidedly negative in 21c.

Because consensus among the IPCC models is strong 21c sensitivity is utilized.



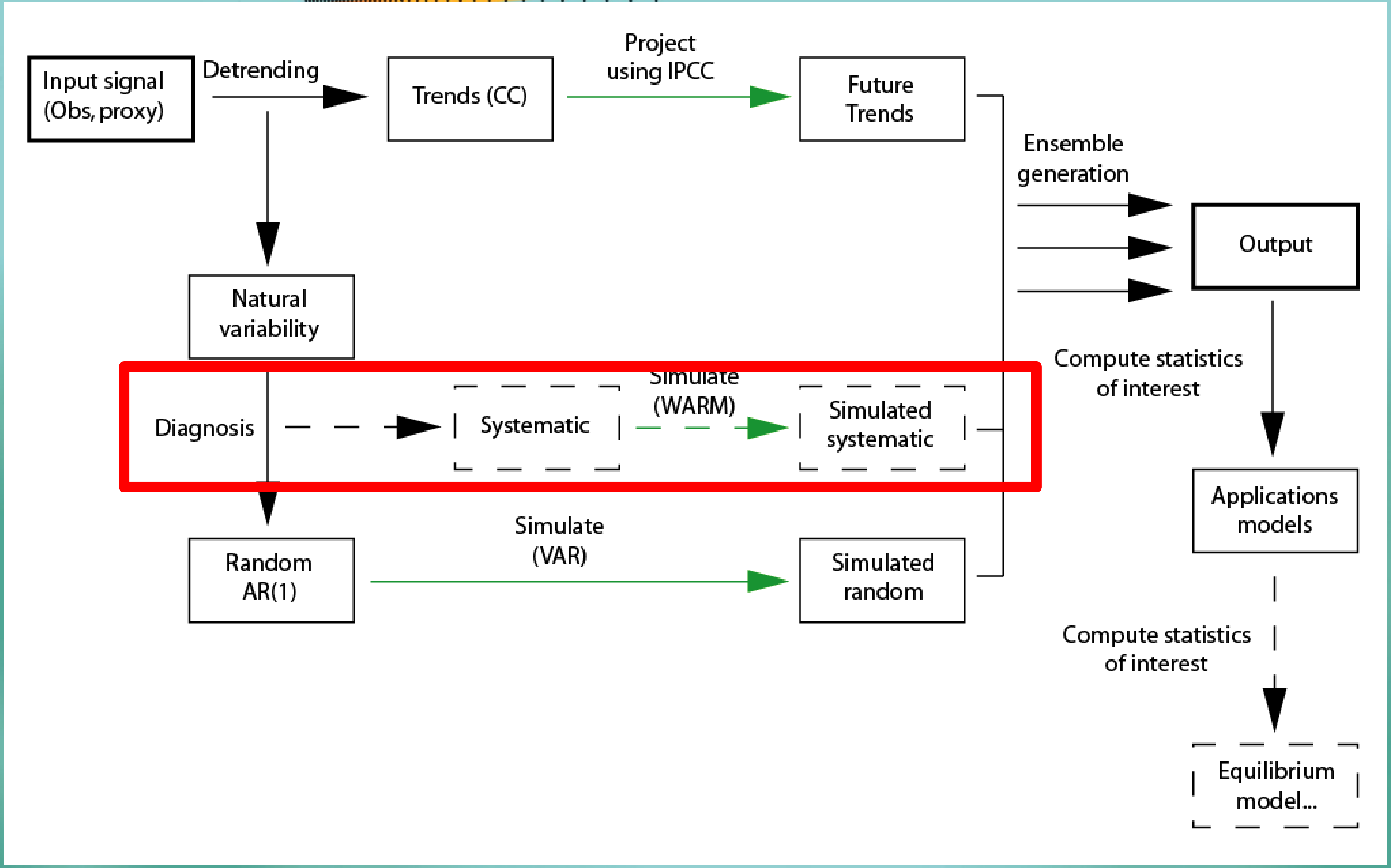


IPCC, 2007

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

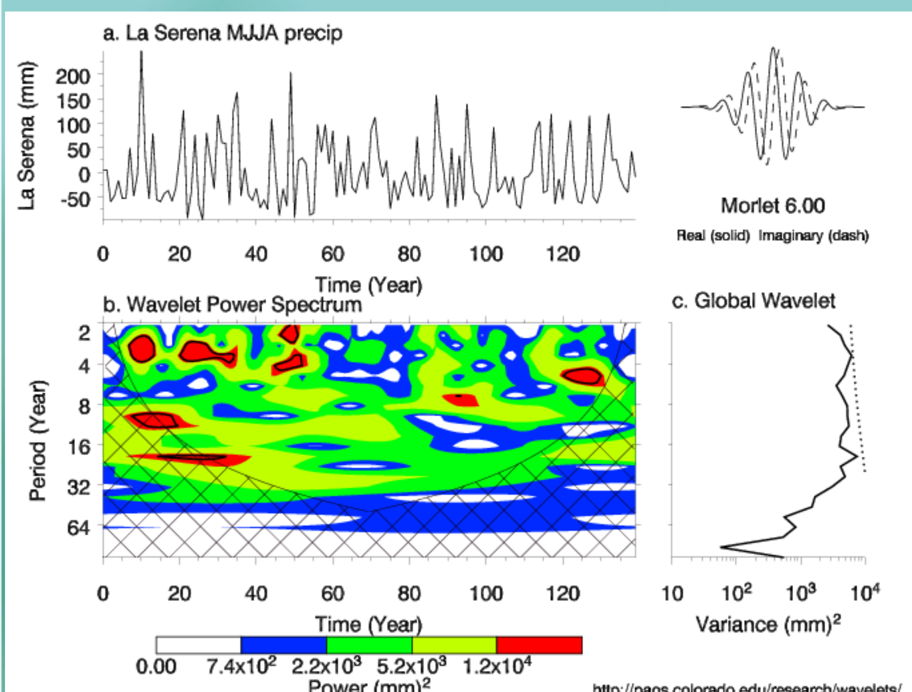
Methodology

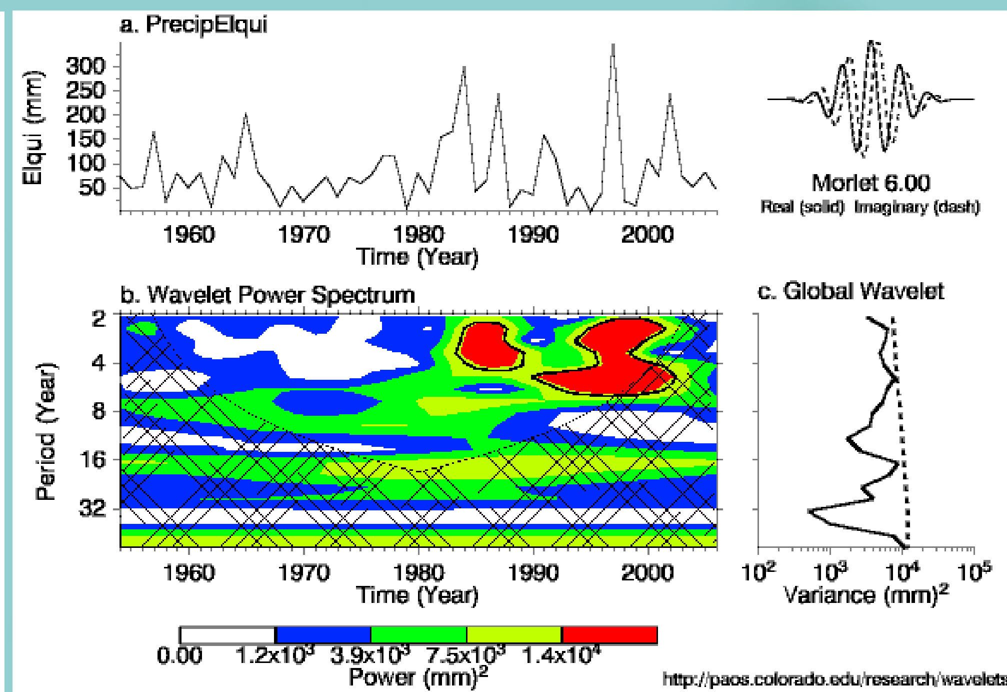
Step 2: Selection of the Decadal deterministic component



Do we find decadal patterns that are deterministic?

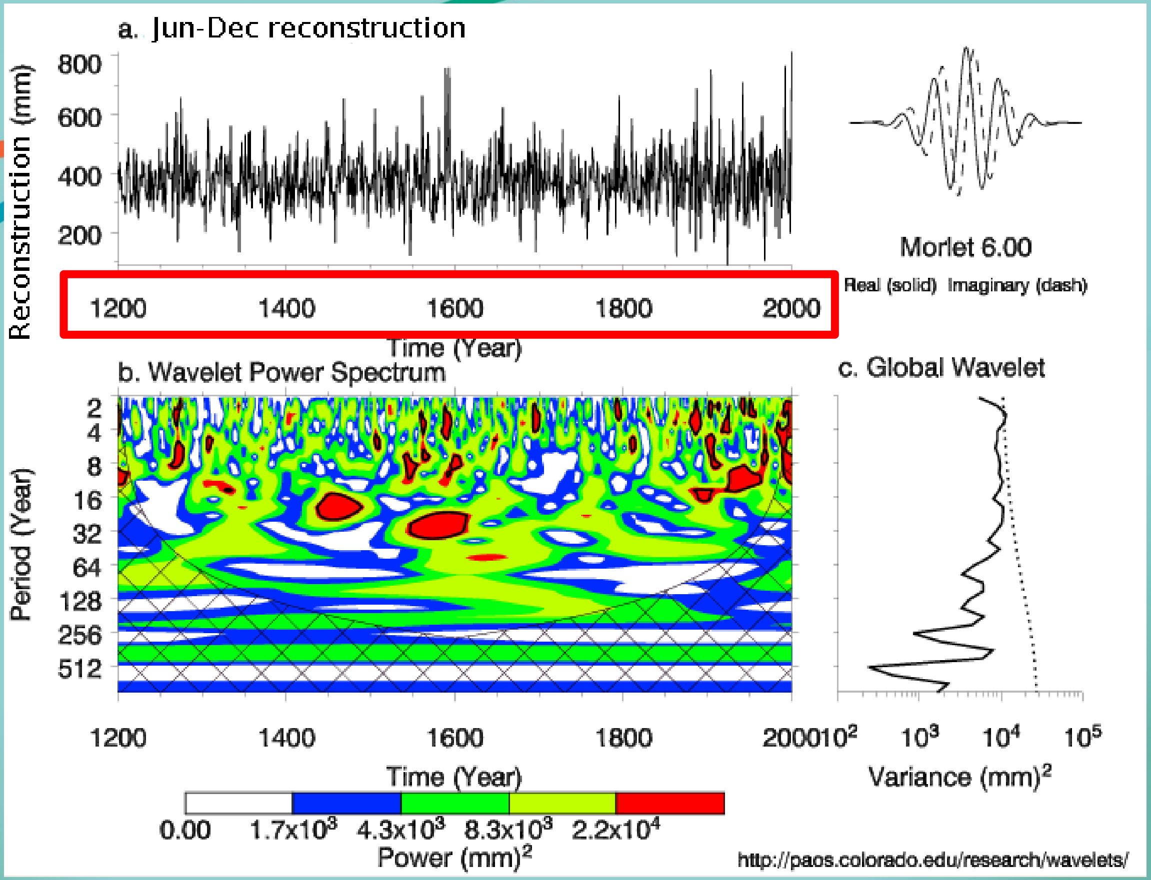
- (Schulz, Boisier and Aceituno, 2011) - Regarding the interannual variability, rainfall seems to be modulated to a large extent by ENSO, while the pronounced low-frequency changes during the past century appears to be linked to the Interdecadal Pacific Oscilation.





Wavelet spectra for the Coquimbo Region

PALEODATA

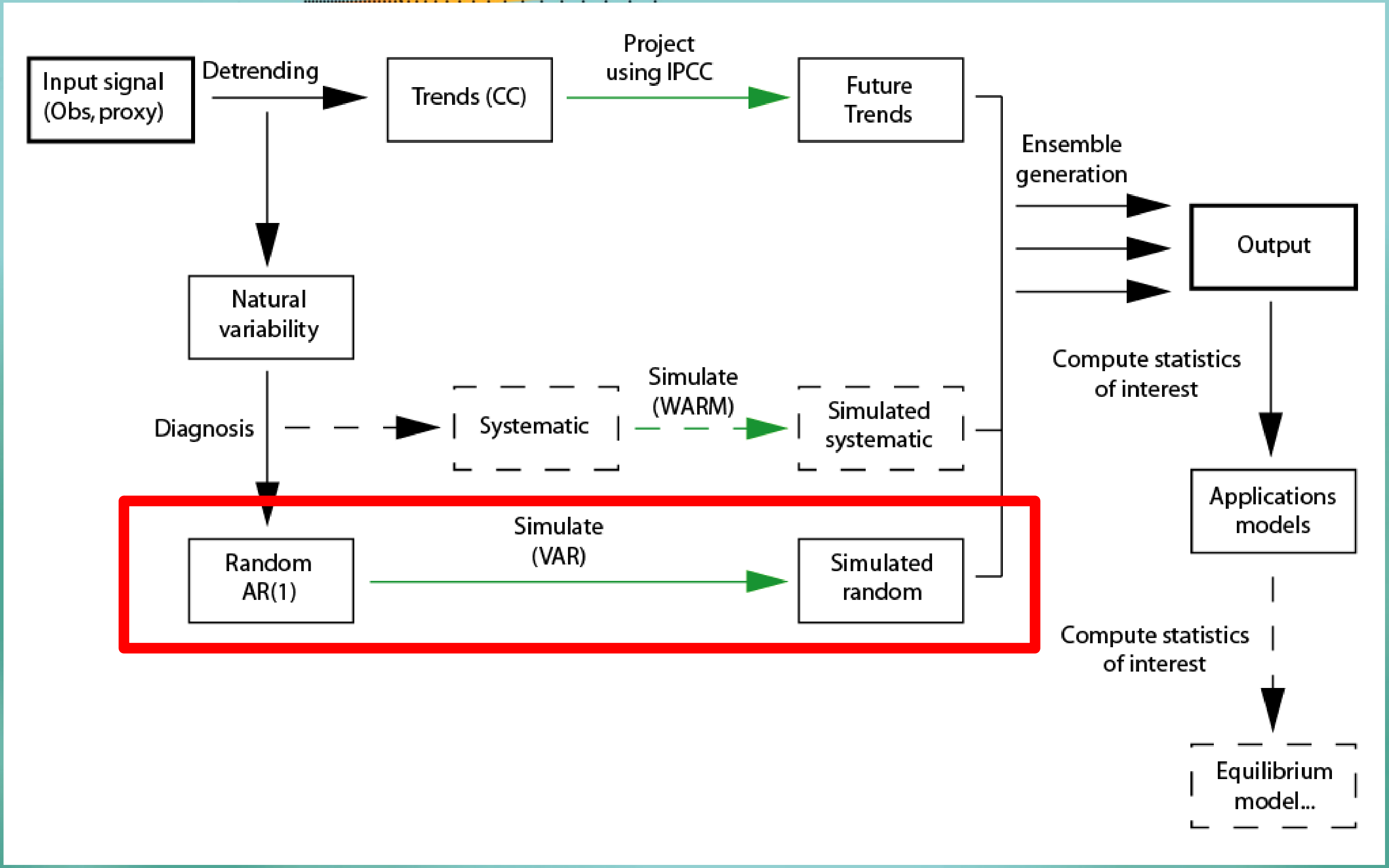


Wavelet spectra for tree-ring reconstruction of Jun-Dec precip for central Chile: Little consistent decadal signal

Simulations will then comprise just two components: Climate change trend and stochastic variations.

Methodology

Step 3: Selection of the Decadal stochastic component



Vector autoregressive (VAR) model

Formally, $\mathbf{y}_t = A\mathbf{y}_{t-1} + \mathbf{e}_t$, where

yt is a three-component vector (pr, Tmax, Tmin) at time t,

A is a (3 x 3) matrix of coefficients,

yt-1 is the same vector one time step (year) previous,

et is a white-noise process with covariance matrix Σ, which may have nonzero off-diagonal elements.

For our purposes, two data characteristics are of primary concern: Inter-variable correlation and serial autocorrelation in the individual variables.

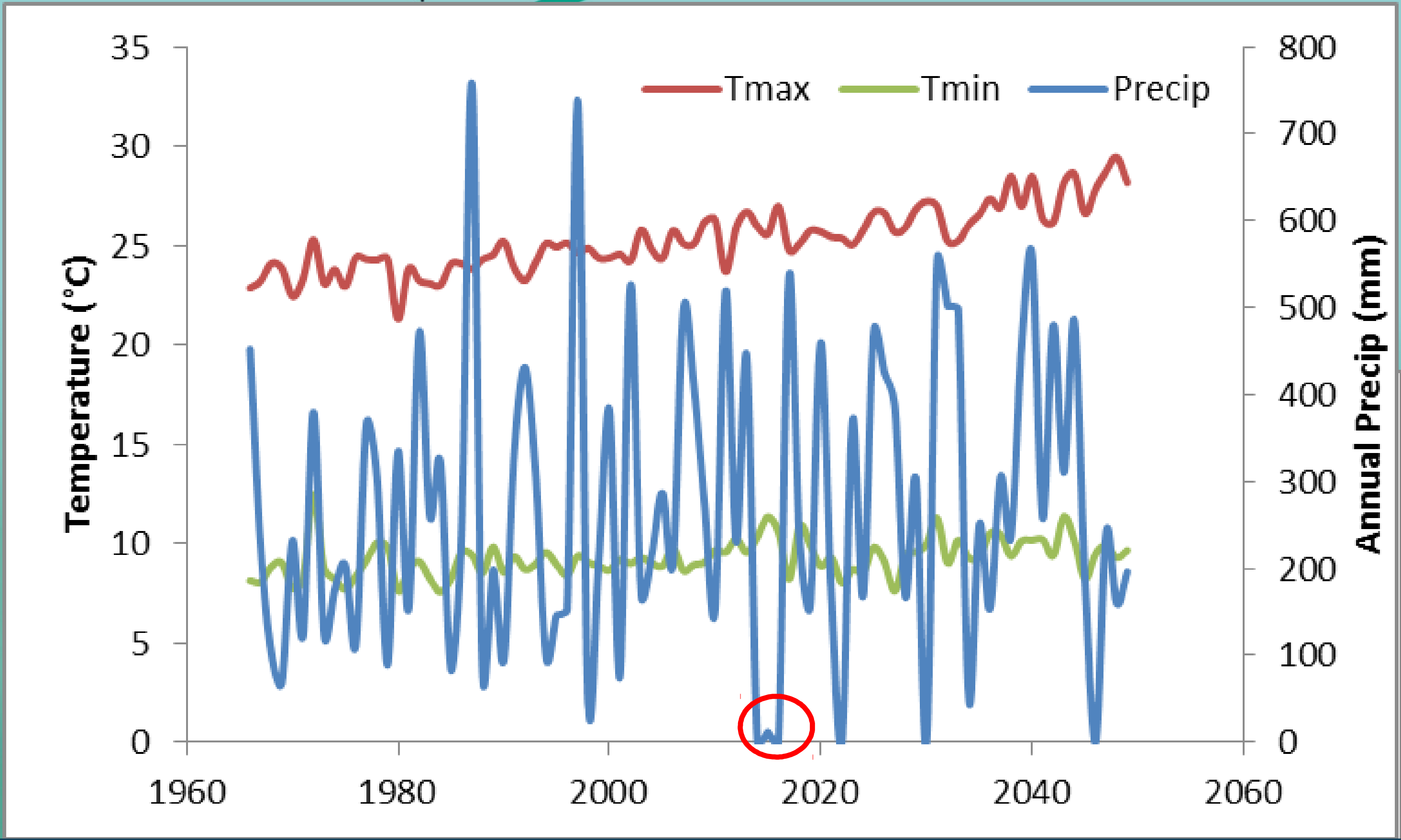
Simulation overview

- Multivariate setting: pr, Tmax, Tmin
- Obs: 50-60 yr of daily data (1943-2006) for 44 stations.
- Forced trends from IPCC (A1B)

  - For Tmax, Tmin, via 20C regression

  - For pr, via 21C regression
- No evidence for *systematic* low-frequency variation: Incorporate trend + stochastic components only.
- Low-frequency (annual–multidecadal) variability simulated with VAR(1) model.
- Subannual variations generated by block resampling of observations.

Downscaling of simulations to the local level



- Variables maintain their correlation and are consistent with past conditions
- Continuous time series visualize extreme events which differ from past ocurrences
- Allows to evaluate the probability of droughts and extreme events and evaluate the potential impact on water resources

Some concluding thoughts…

- Method can be thought of as a "decadal weather generator" incorporating a climate change component.
- For the decadal component a random model is utilized; Other models may also prove relevant.
- Uncertainty owing to differences in model formulation not treated.
- Relevant paleodata can augment the instrumental record.
- Simulations will be run through a hydrological model of the Elqui valley

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