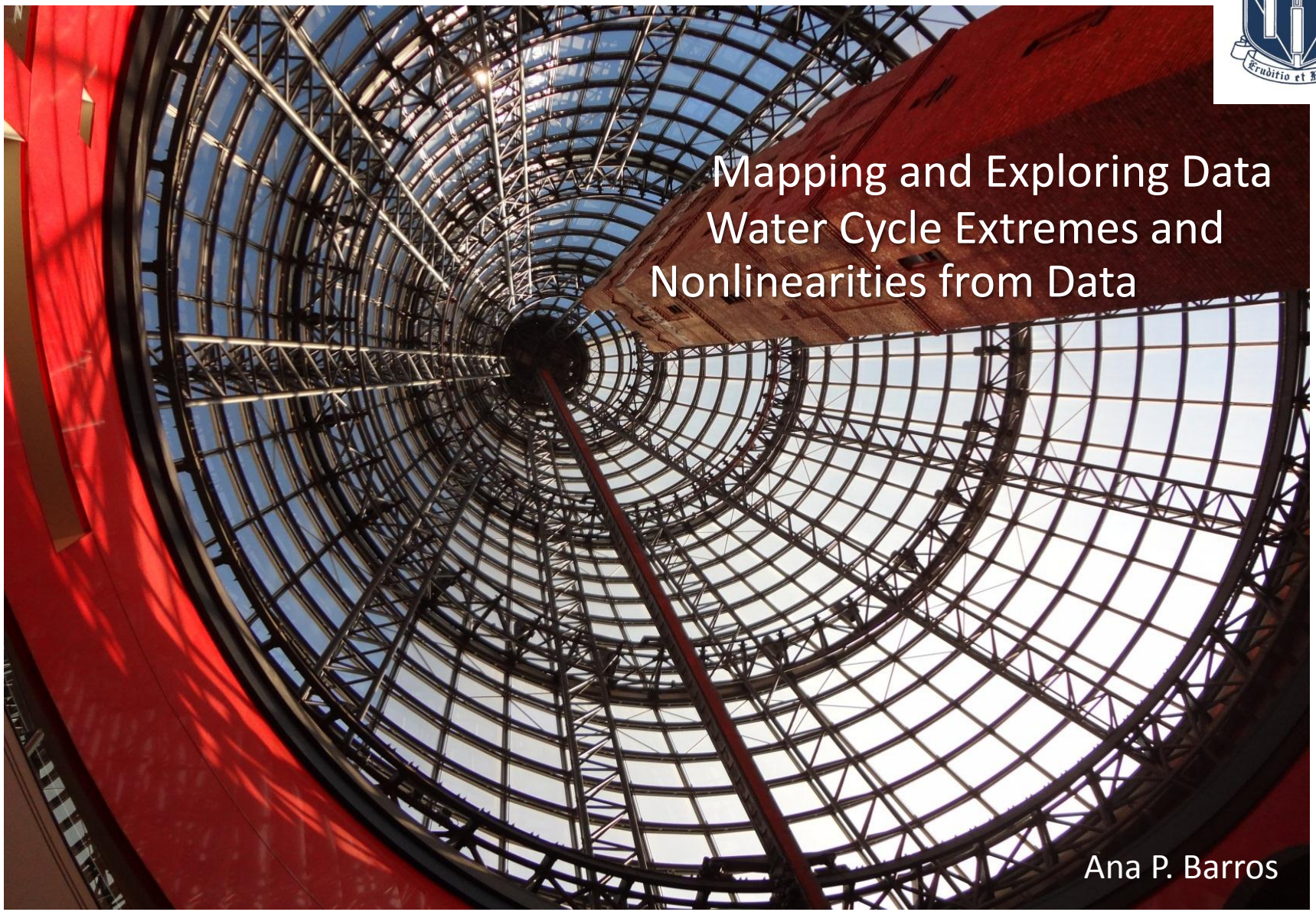


Mapping and Exploring Data Water Cycle Extremes and Nonlinearities from Data

Ana P. Barros

1st Workshop on Understanding Climate Change from Data, University of Minnesota, August 15-16 2011

Philosophy -> Method -> System -> Outcomes

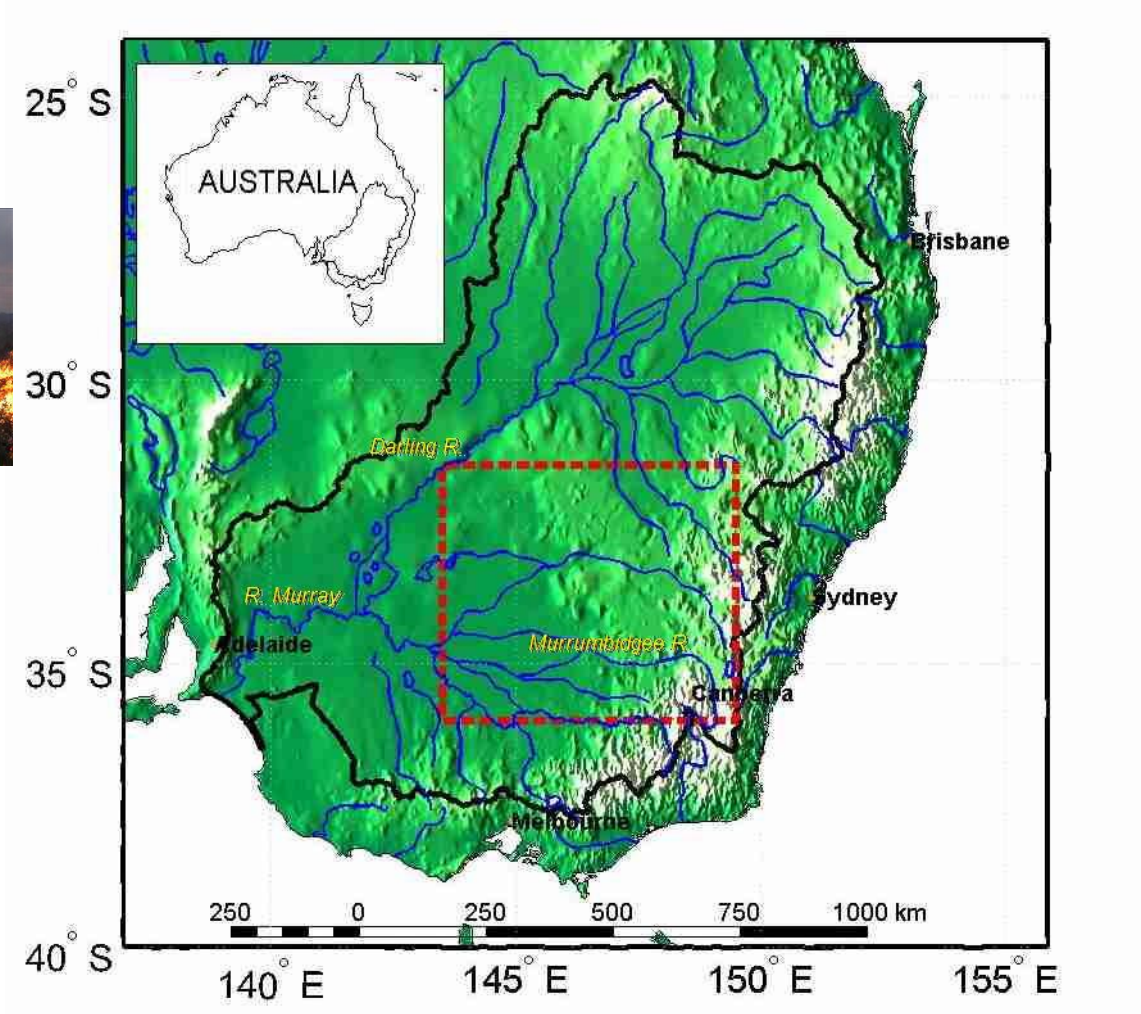
- **Exploratory Data Analysis** √
  - Detection and Attribution (**Understanding**)

- **Metrics**
  - Diagnostics
  - Impacts (Actionable Prognostics)

- **Predictability**
  - Physically-based Data-Driven Models
  - Modeling Myths (Black-Box/Data Assimilation)

Long-Lead Forecasts of Extreme Events for Water Resources Management

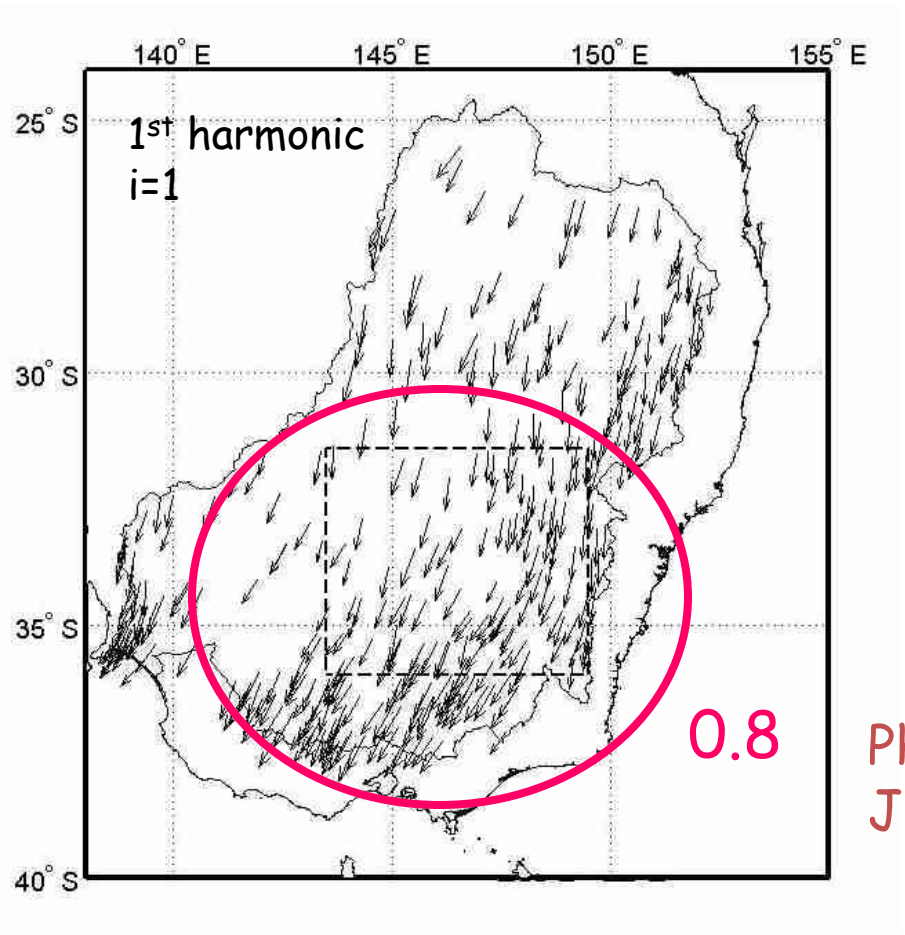
Drought Forecasting in the Murray-Darling Basin



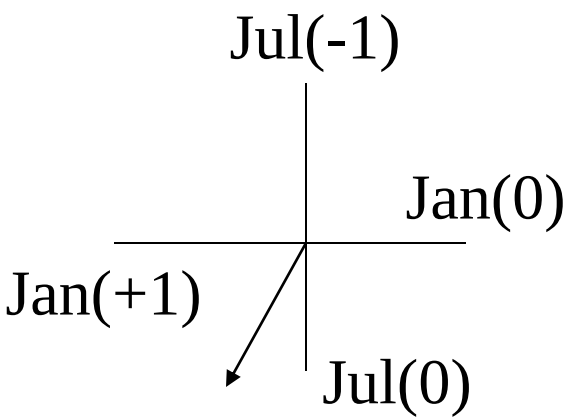
Ana Barros
Gavin Bowden*

Relationship with ENSO

Harmonic analysis of 24-month Log-Normal (LND) percentiles of precipitation composites for strong **ENSO years** (Troup SOI < -5) at 345 stations (100 years of data)



$$X = Xo + \Sigma\, C_i \cos(a - a_i)$$



Phase (a_1): **0-2** months after July of current EL Nino year

Barros and Bowden, 2008

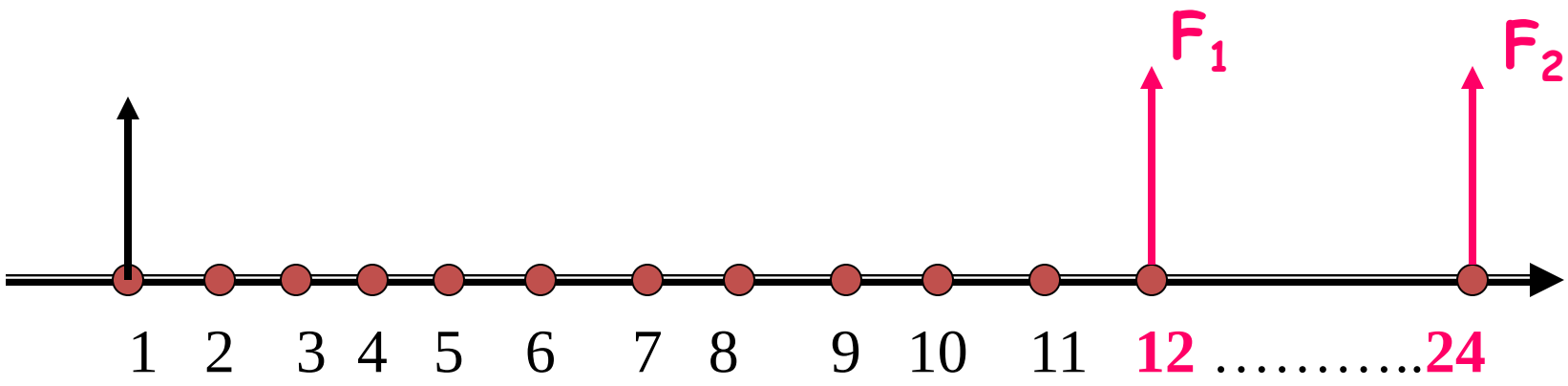
to achieve predictability

……. precursors of ENSO onset

- **SST anomalies** (SSTAs)
- **Zonal OLR monthly anomaly gradients** (NOAA,1979-2002,2.5^{o}x2.5^{o})
  (Barros and Bindlish 1998)
- **Zonal Windstress Anomalies** (Western Equatorial Pacific, COAPS)
  (Clark&Van Gorder 2001; Curties et al. 2002)

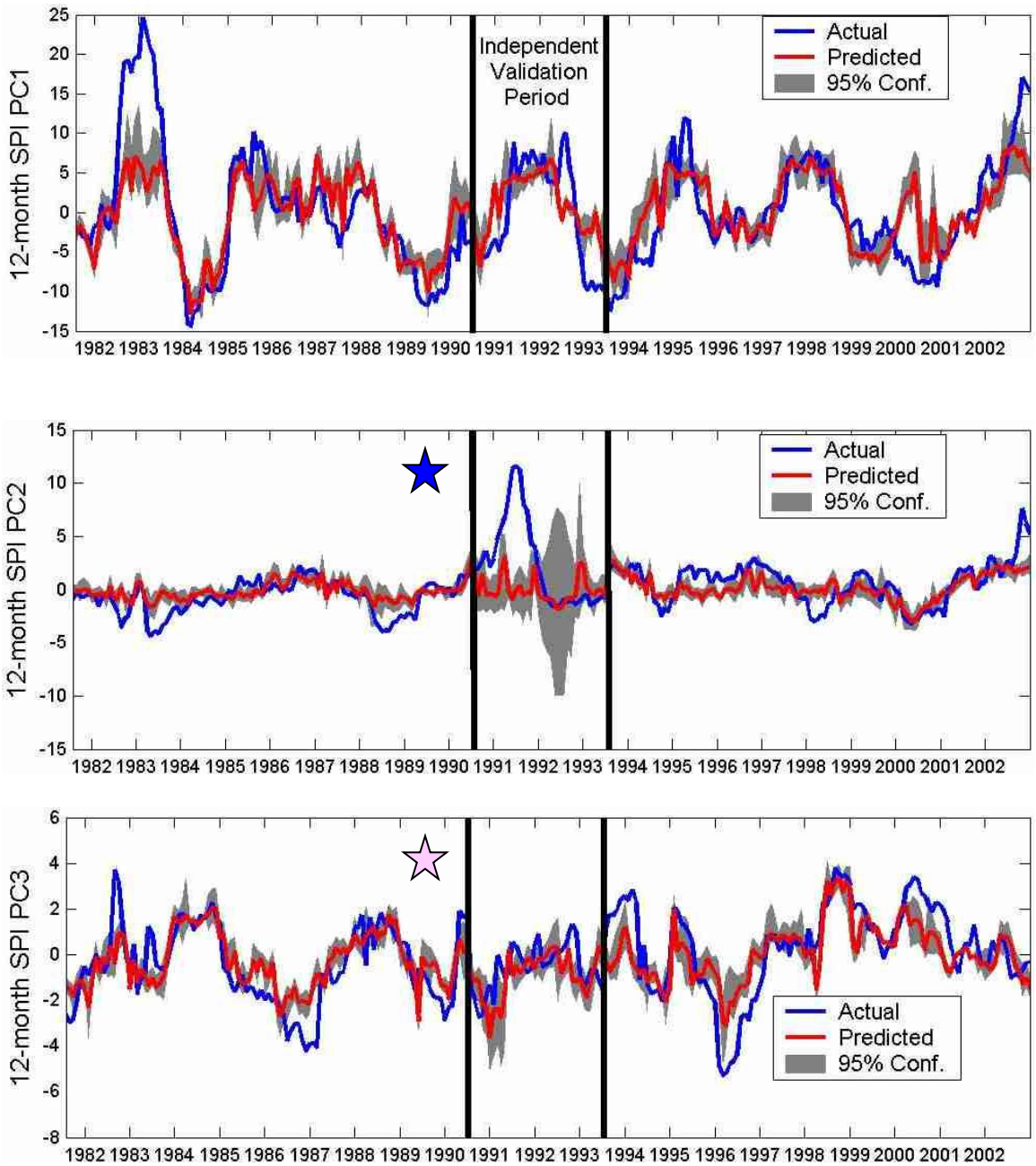
Goal

12 month lead-time areal mean SPI12



***Length of Record

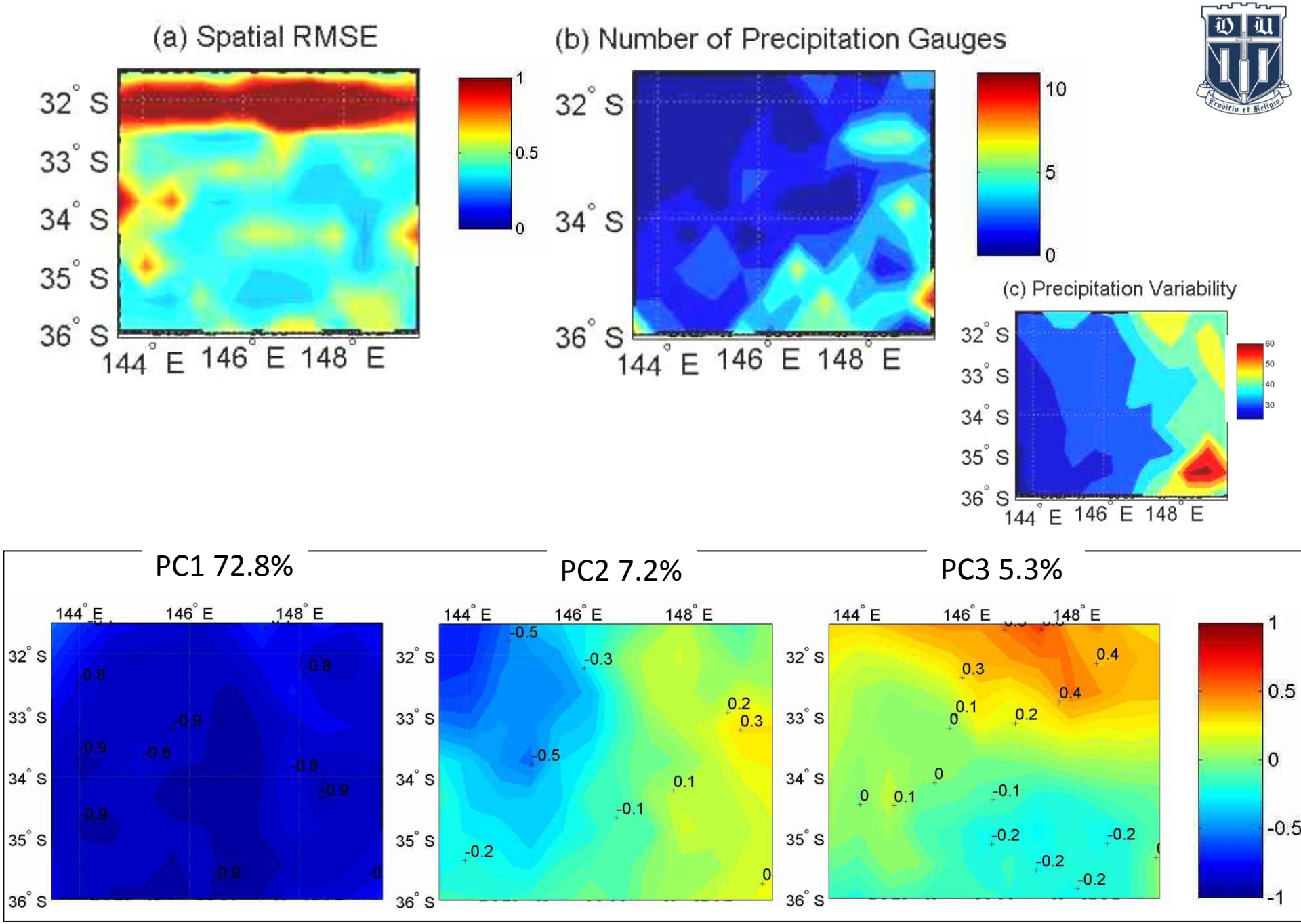
***Non-stationarity



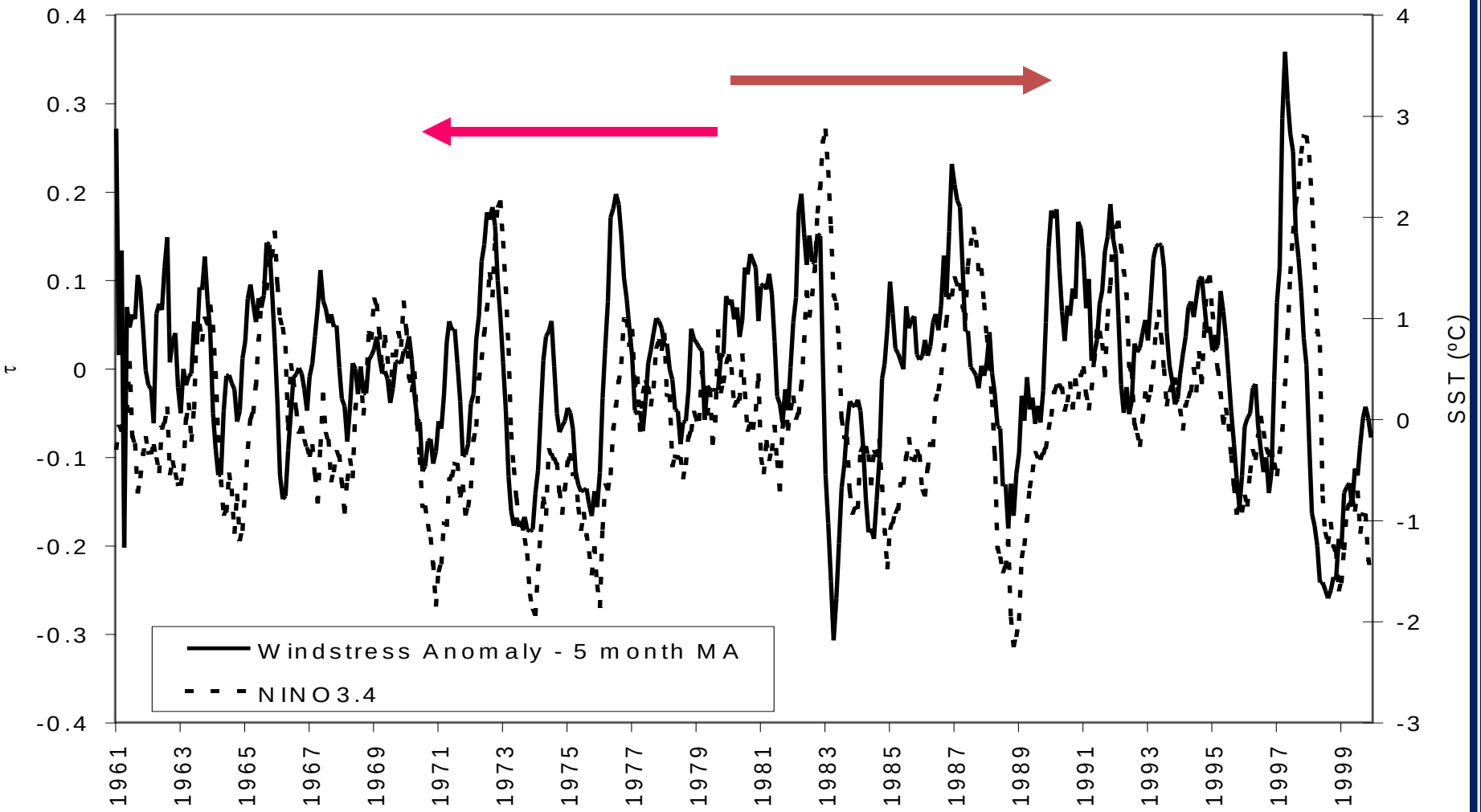
SOLO OUTPUTS

12-month SPI PC	**RMSE/R** Calibration Set	**RMSE/R** Validation Set
1	4.86 0.76	4.65 0.74
2	1.57 0.60	4.63 ★ 0.05
3	1.22 0.77	1.13 ☆ 0.37

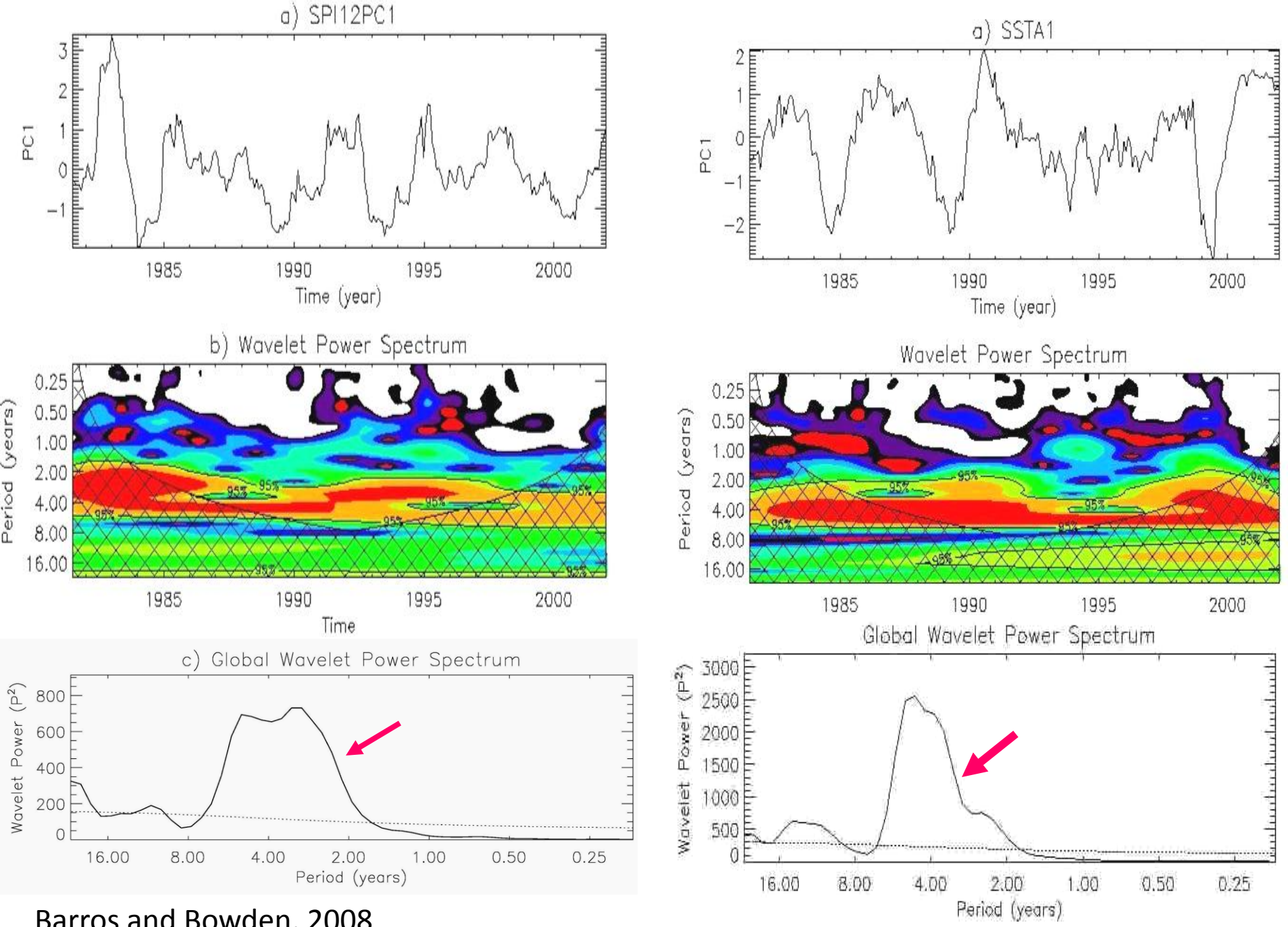
Barros and Bowden, 2008



Barros and Bowden, 2008



Barros and Bowden, 2008



Barros and Bowden, 2008

Summary

A question of pride and prejudice…

Can we afford not to explore such models?

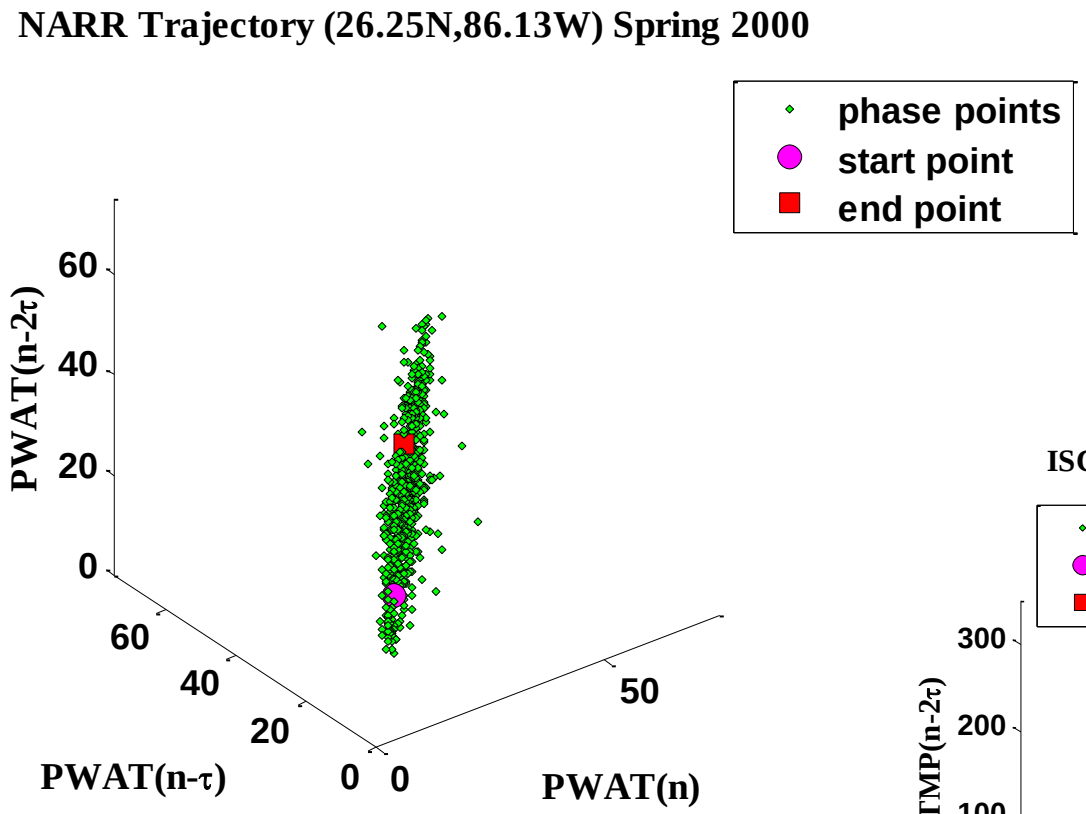
What is the right measure of drought in the context of desired (useful) predictability?

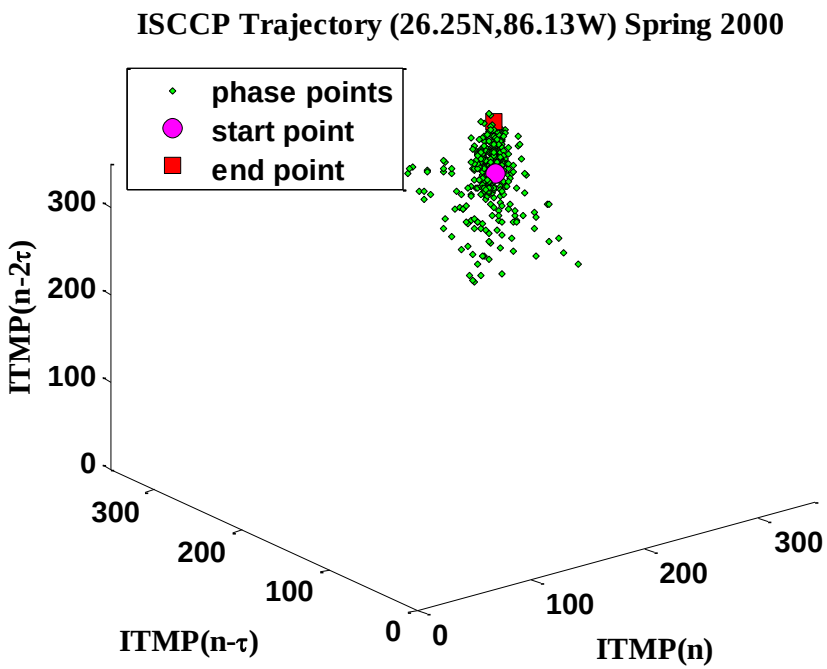
What is useful predictability?

How can we best use such studies……

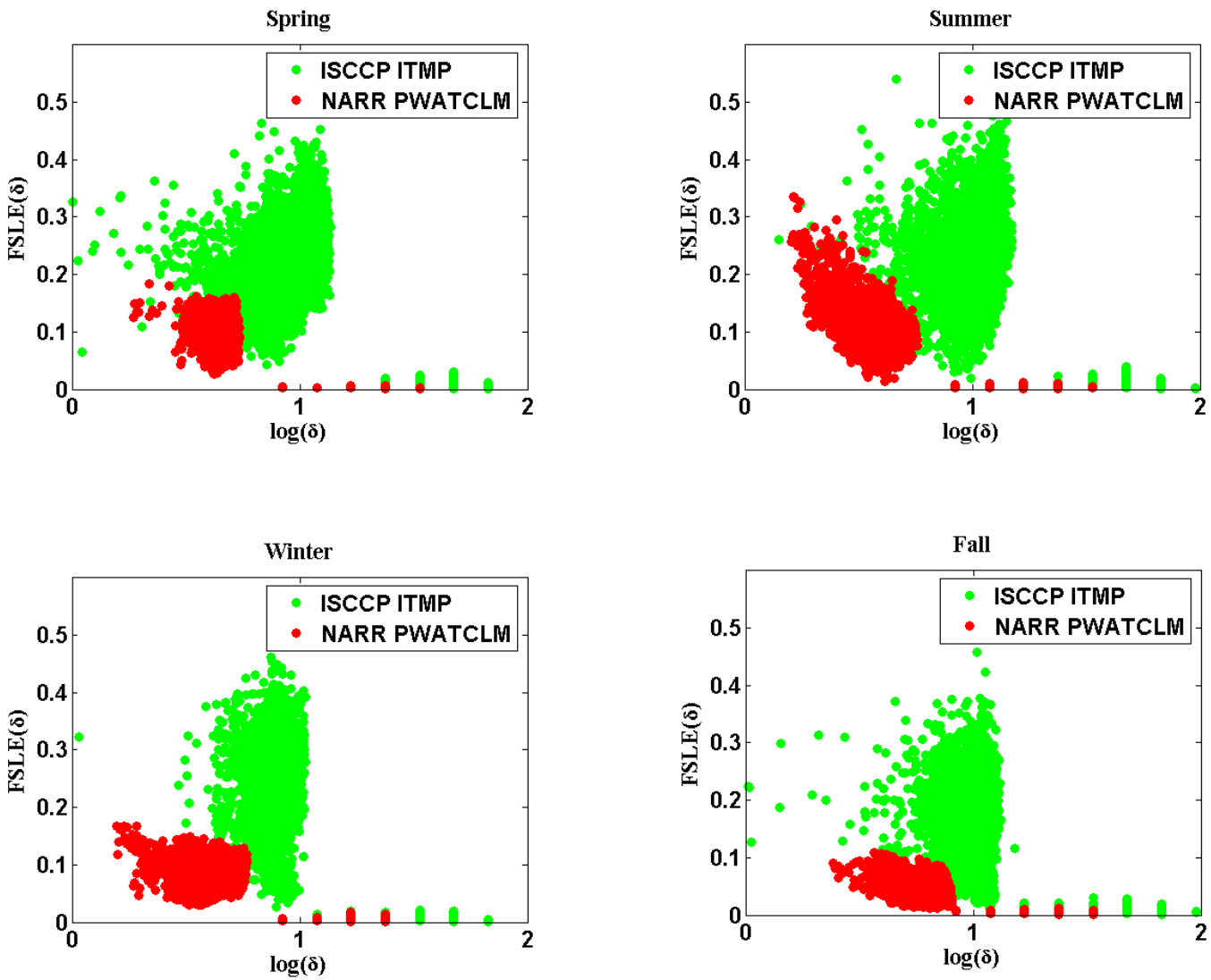
to assess data needs?
to test and improve physical models?
to learn?

Finite-Size Lyapunov Exponents (place-based)

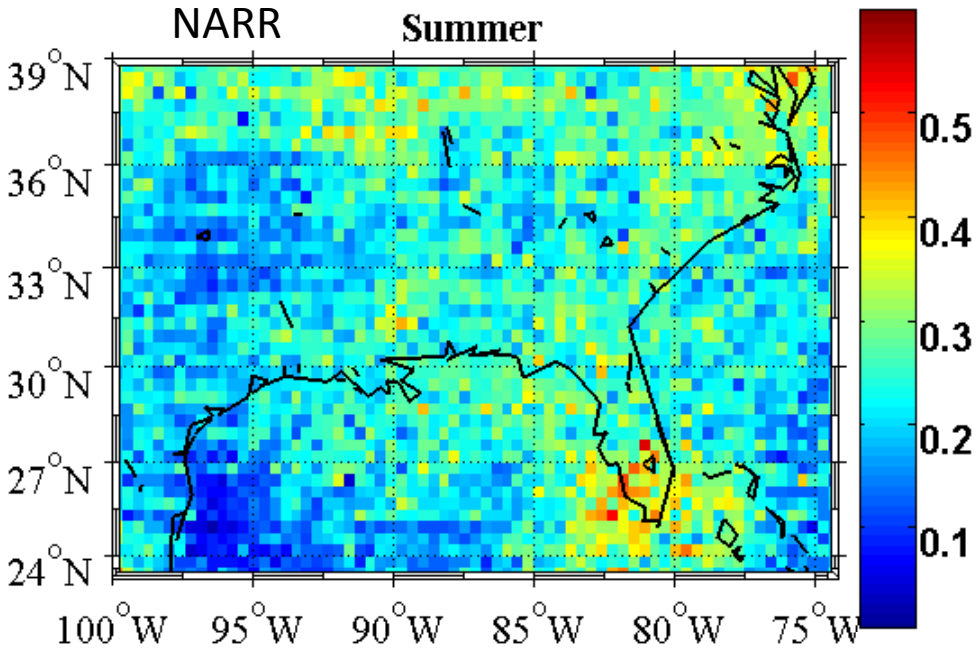


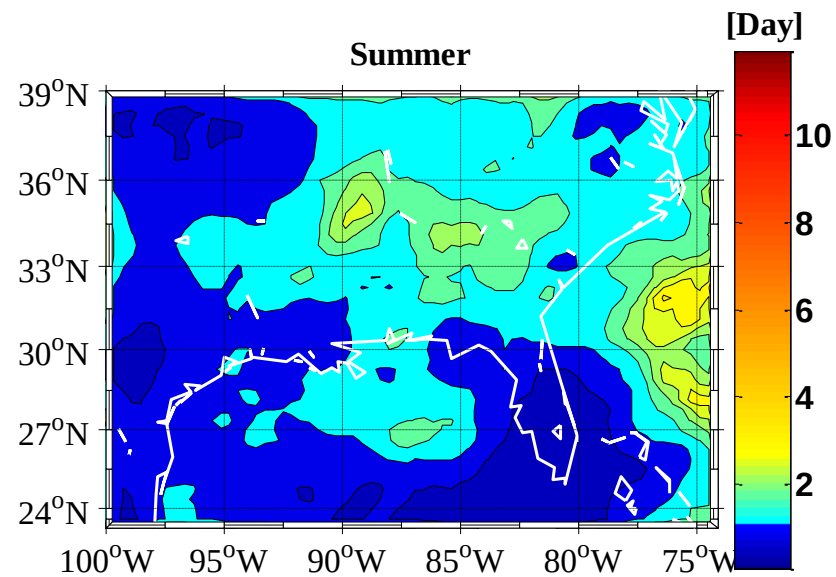


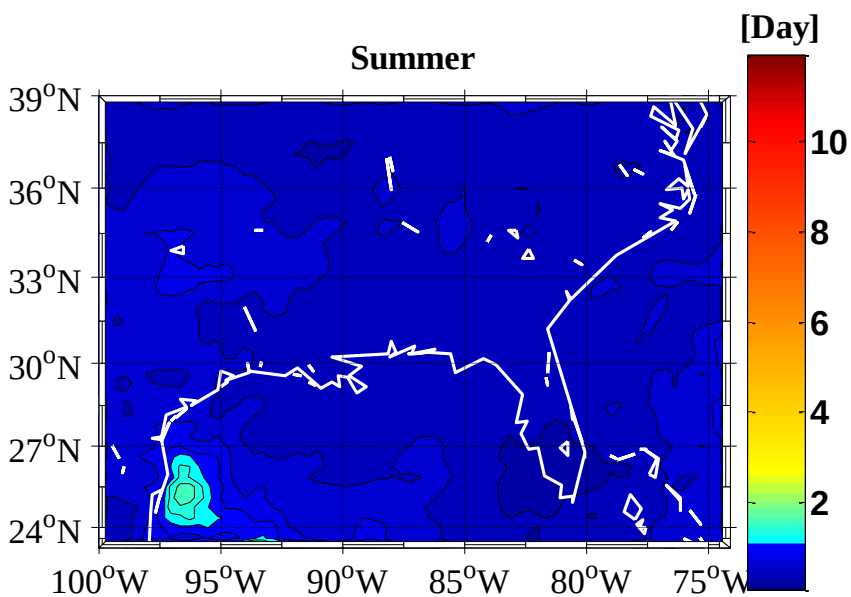
Tao and Barros 2009, Barros 2010

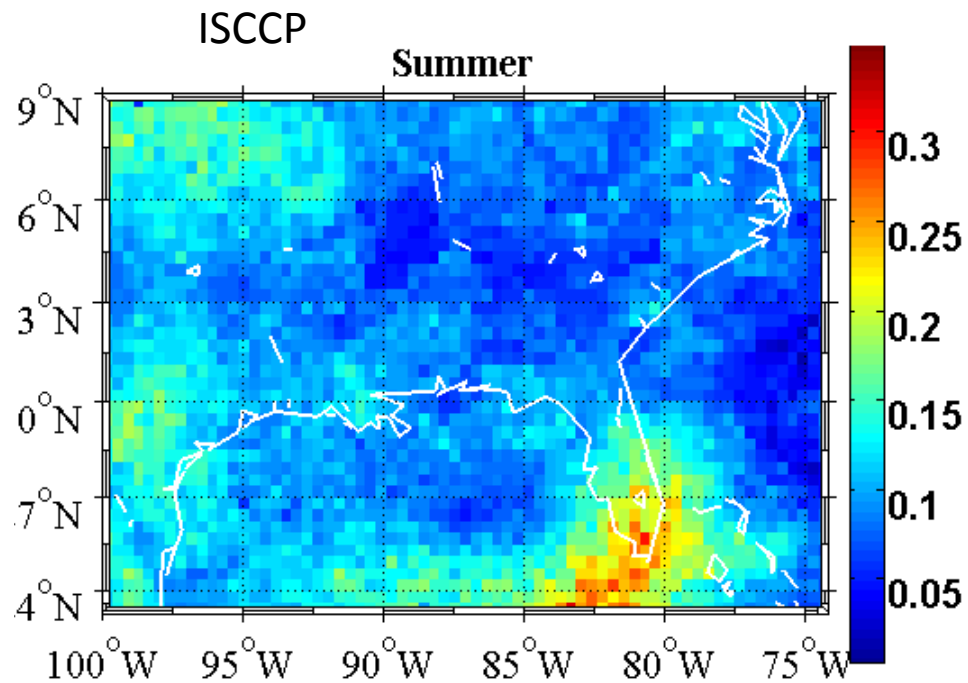


Tao and Barros,2009
Barros 2010







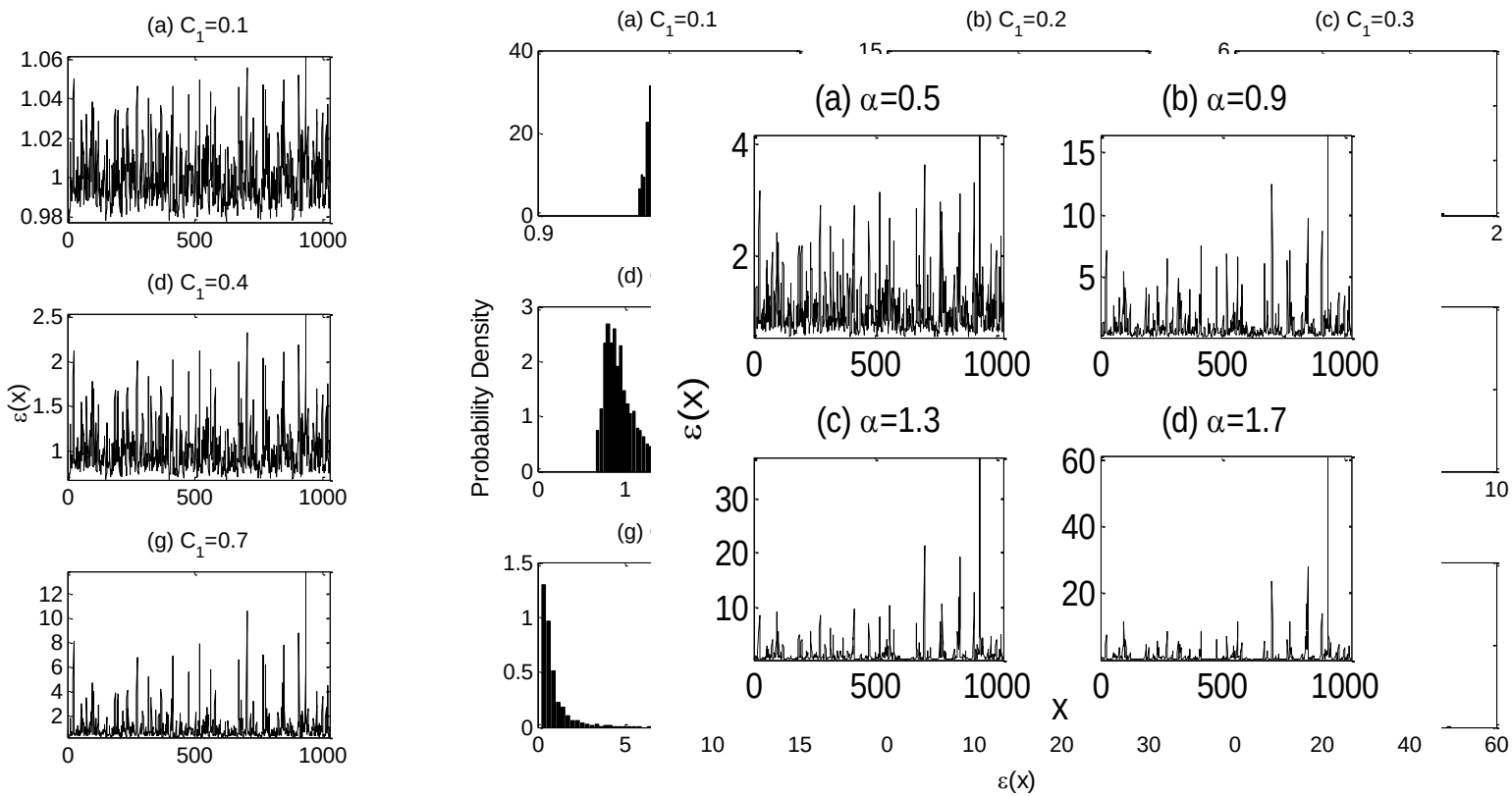


Tao and Barros, 2009

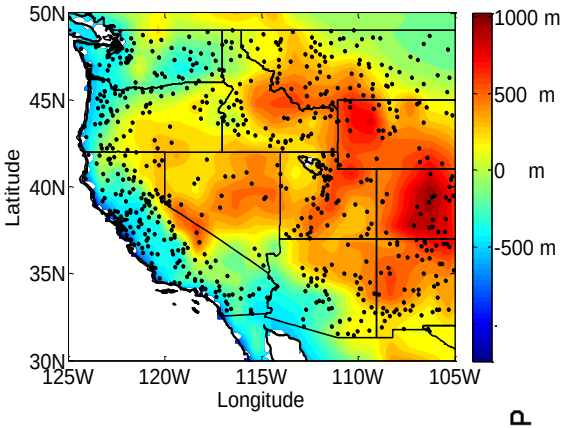
Multifractal Scaling

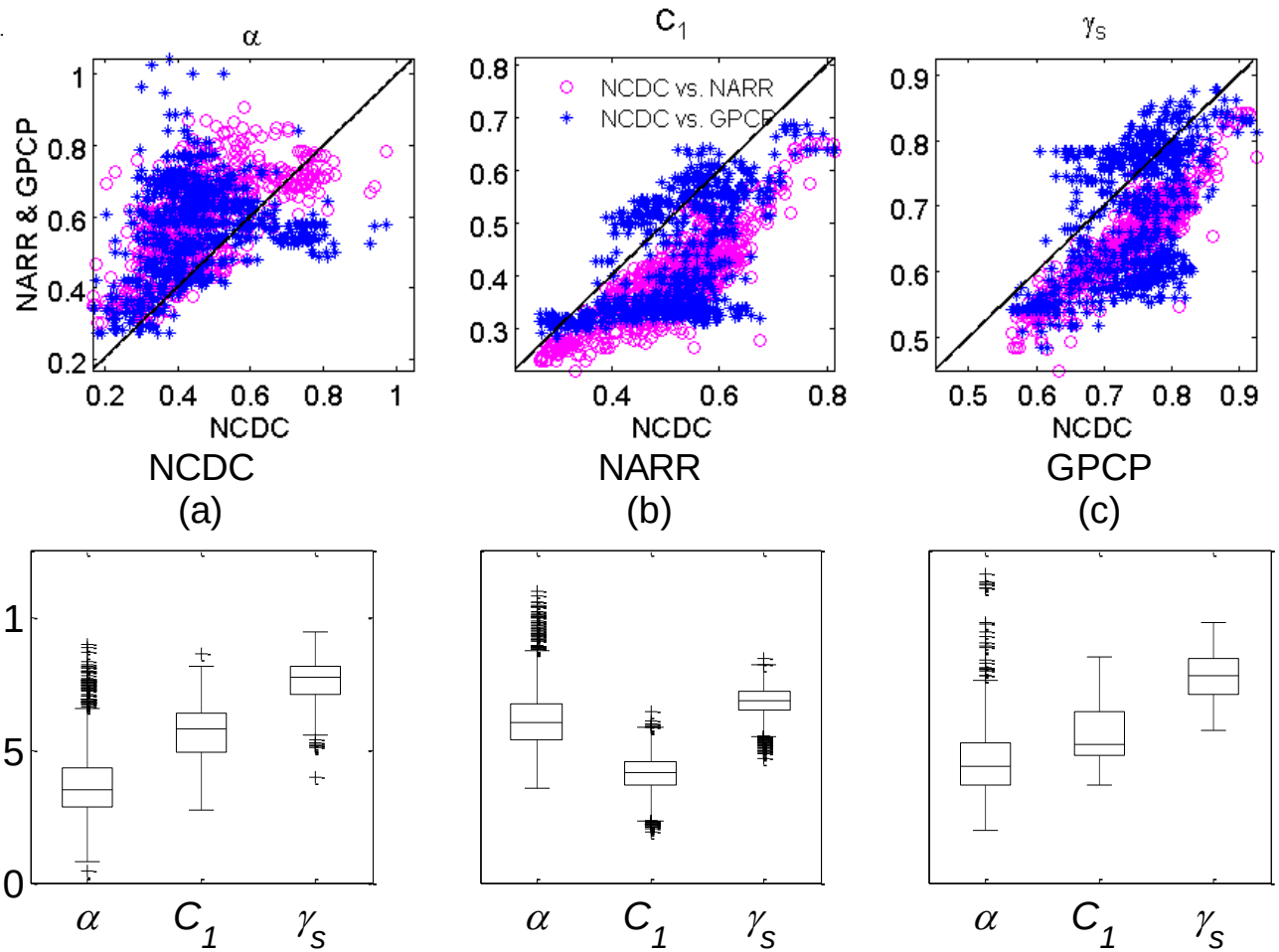
$$\Pr(\varepsilon_\lambda > \lambda^\gamma) \sim \lambda^{-c(\gamma)}$$

$$c(\gamma) = \begin{cases} C_1\left(\dfrac{\gamma}{C_1\alpha'} + \dfrac{1}{\alpha}\right)^{\alpha'}, & \alpha \neq 1 \\ C_1 \exp\left(\dfrac{\gamma}{C_1} - 1\right), & \alpha = 1 \end{cases}$$

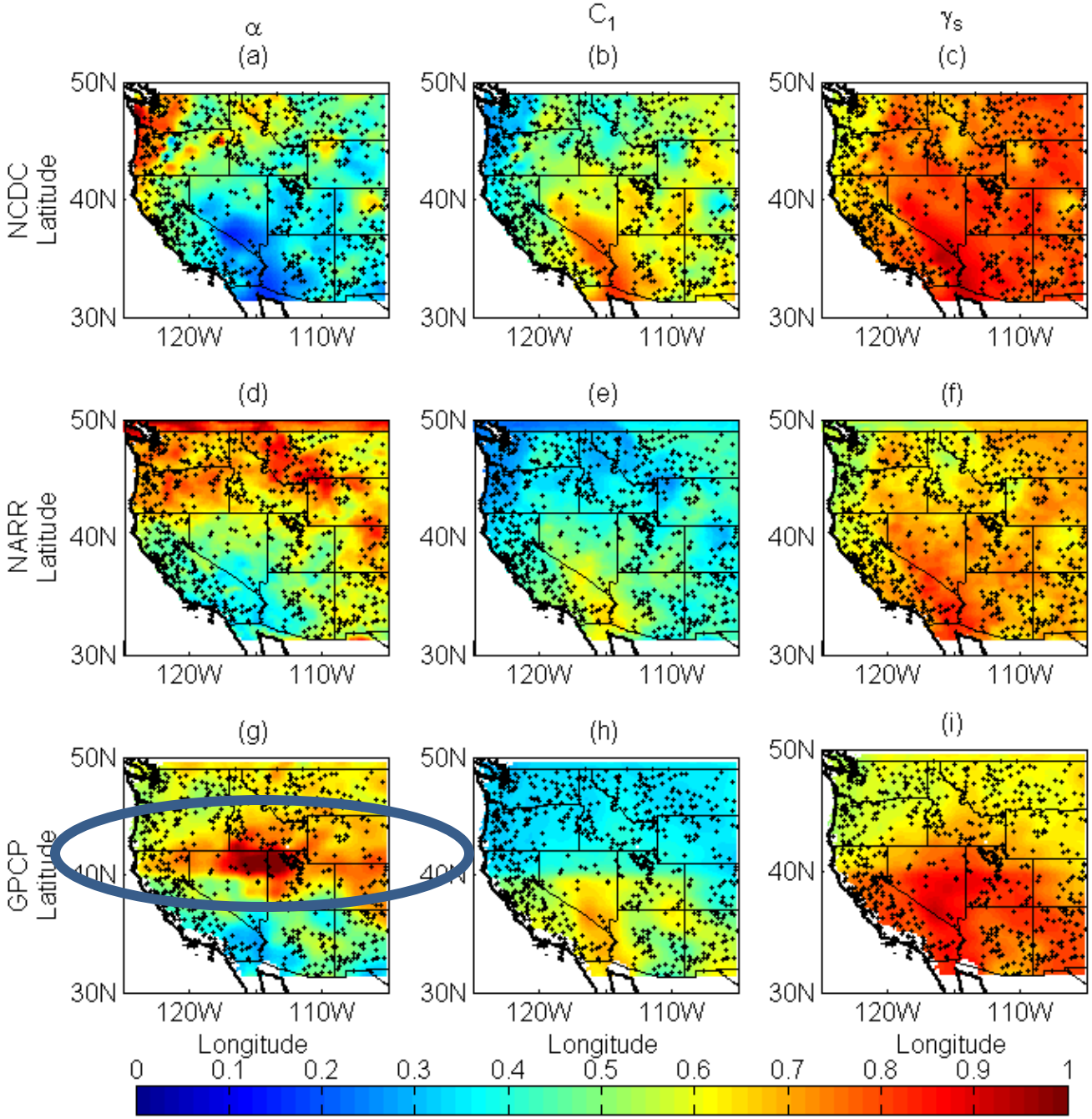


Sun and Barros, 2010



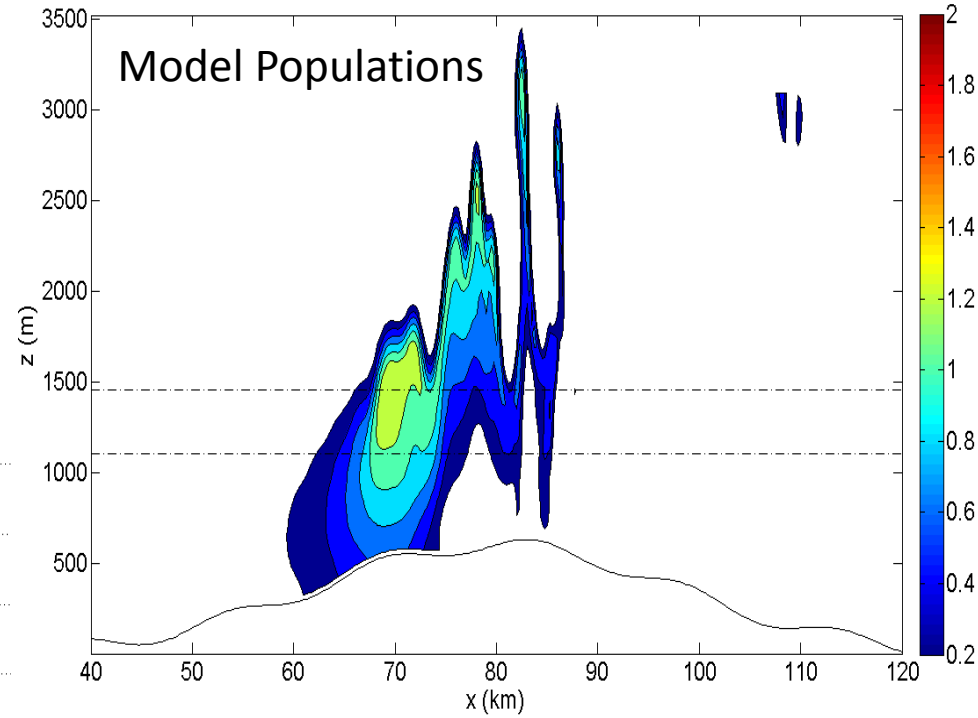


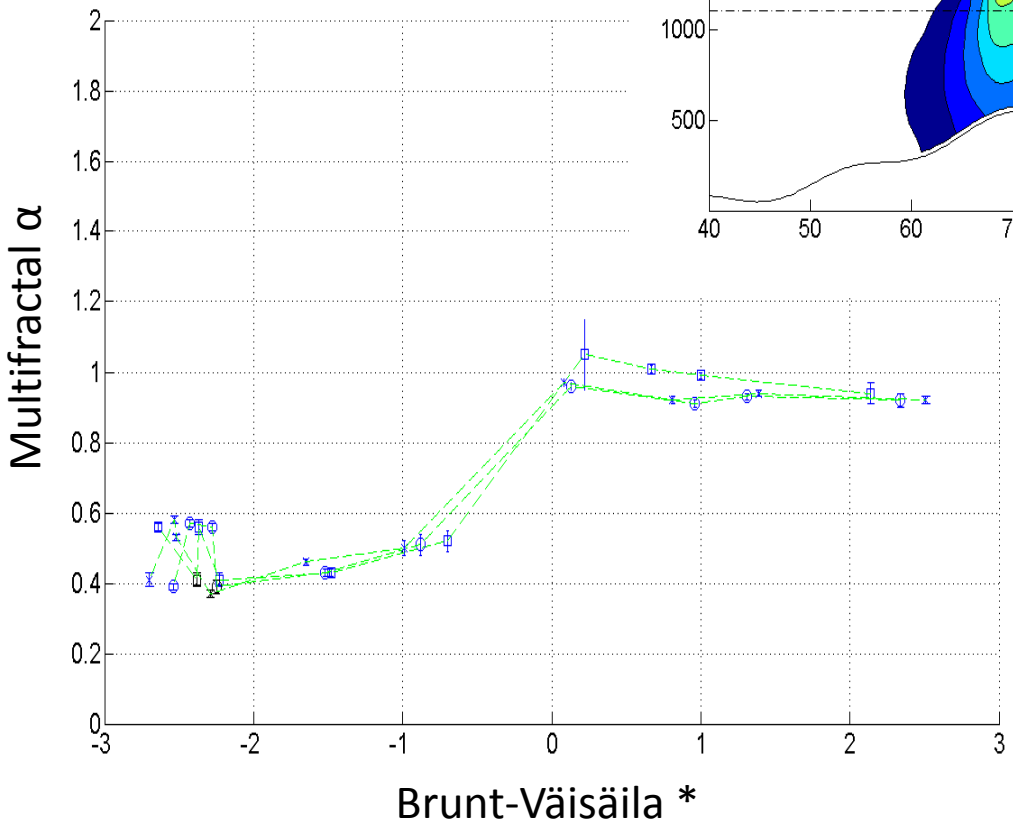
Sun and Barros, 2010



Sun and Barros,2010

HPC Opportunities "compression"



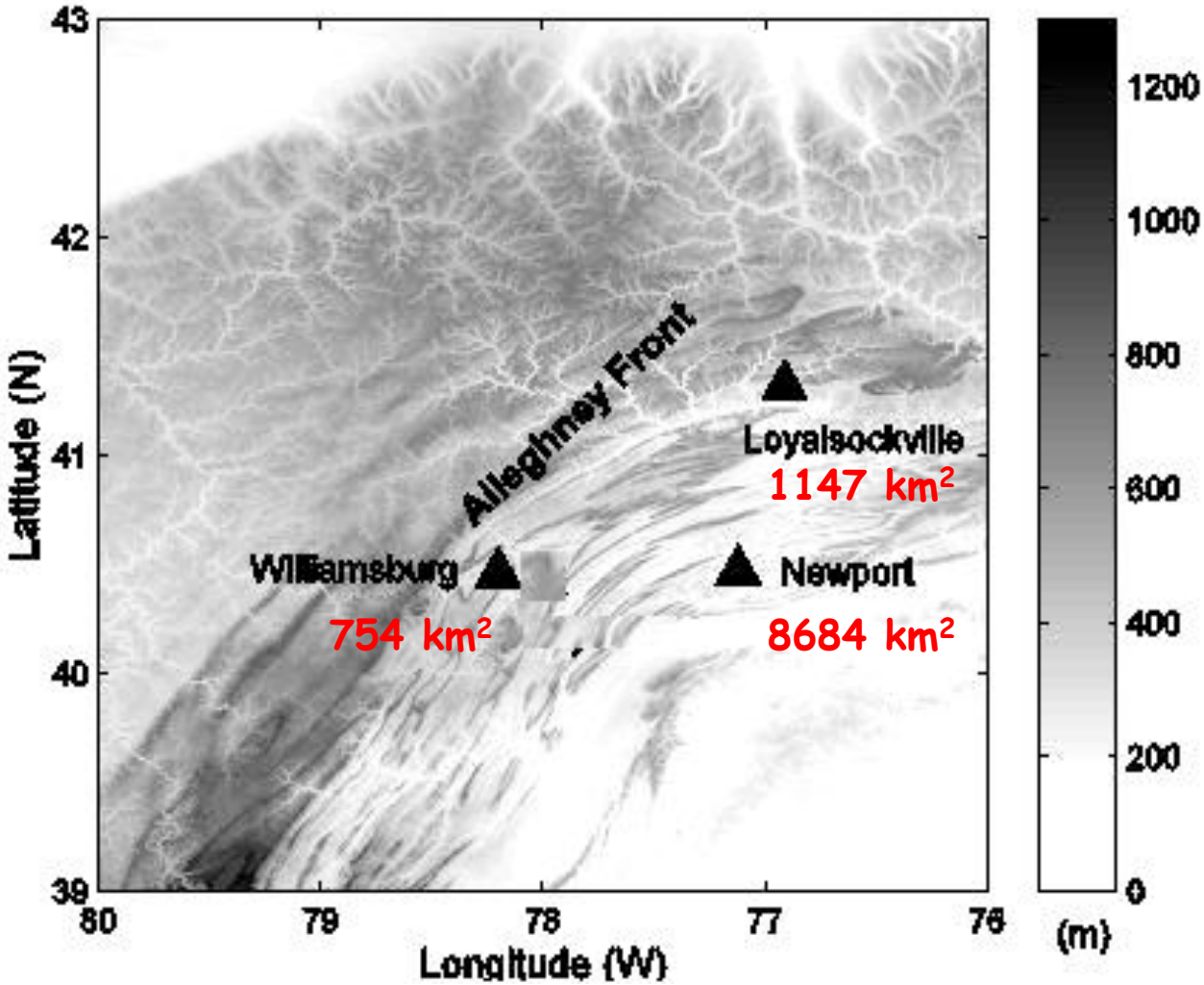


Using Multifractals to develop new *subgrid-scale parameterizations* of terrain-forced convection

Nogueira et al. 2011

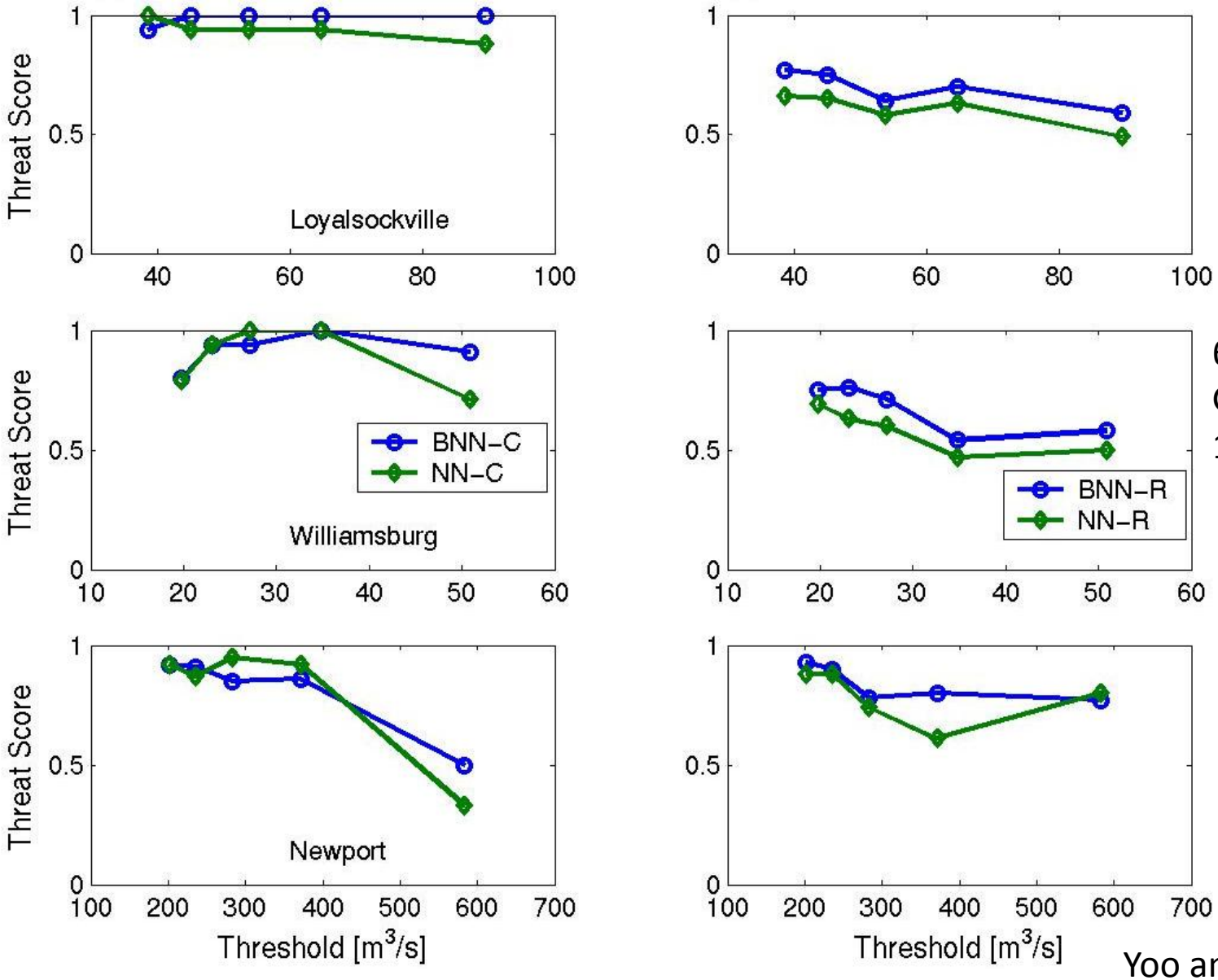
May 2004

Prediction in **U**ngauged **B**asins - PUB



Kim and Barros, 2001
Barros ,2005

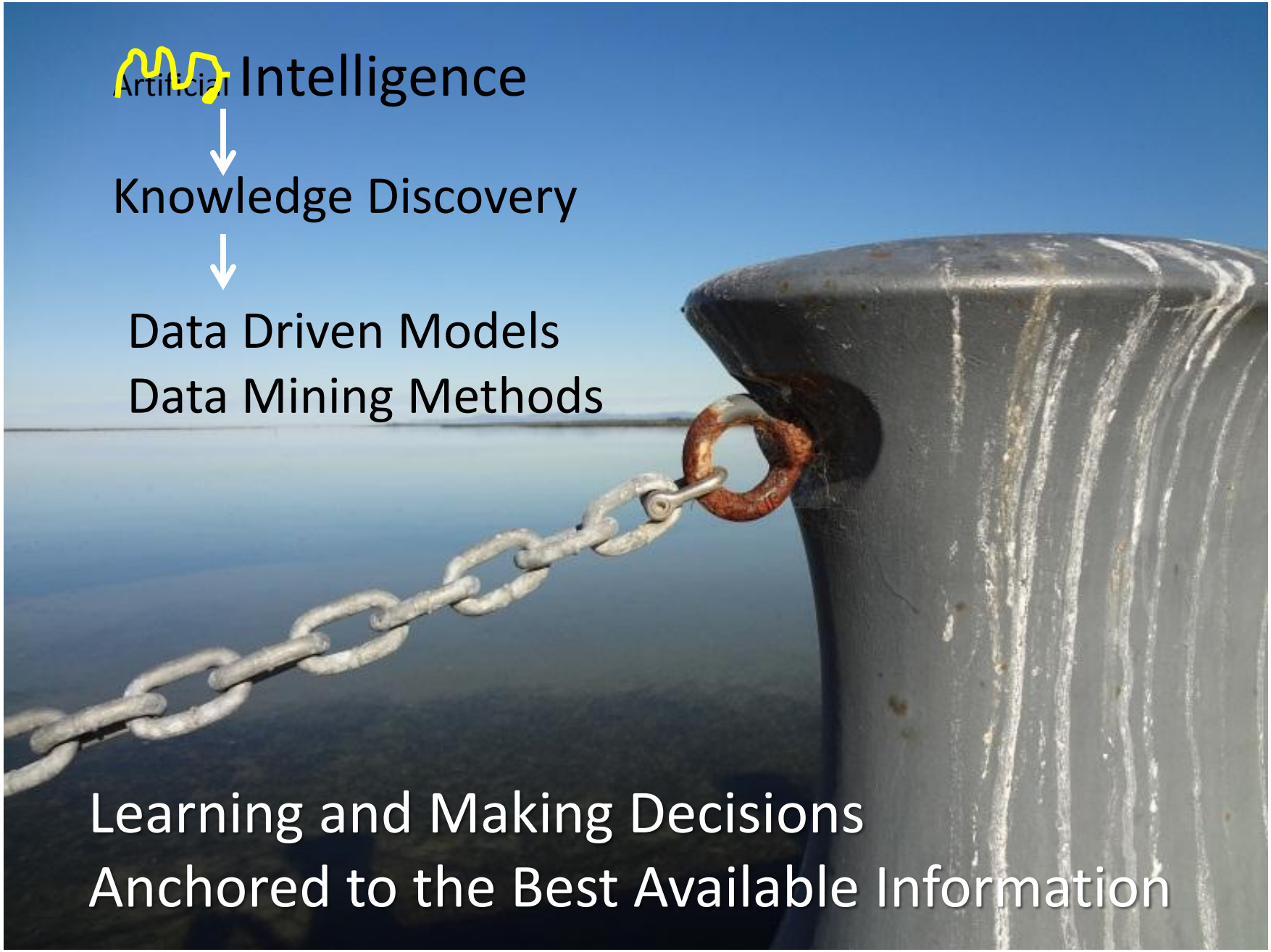
18-hr Forecasts over a 5-year period



6 radiosondes
GOES IR
160 raingauges

Yoo and Barros,2004

Barros,2005


Artificial Intelligence
Knowledge Discovery
Data Driven Models
Data Mining Methods
Learning and Making Decisions
Anchored to the Best Available Information