Ocean climate indices and Total Solar Irradiance: causality over the past few decades and revision of indices uncertainties

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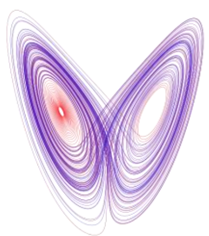
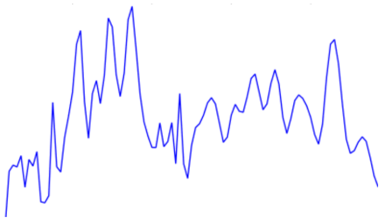
Causality. Method of Conditional Dispersions (MCD)

Assumption: We have 2 time series produced by dynamical systems (e.g. Sun and Ocean Climate)





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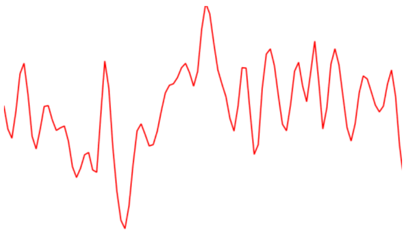
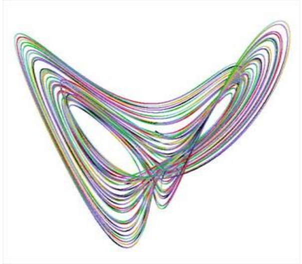
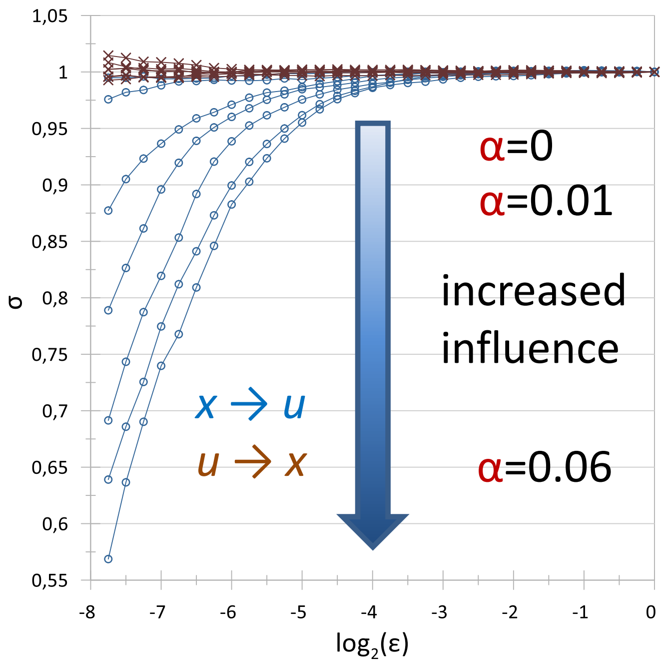




Does one dynamical system cause another?
MCD (Čenys et al., 1991) can answer

MAIN IDEA
We detect connections between Sun and Climate using nonlinear dynamics method



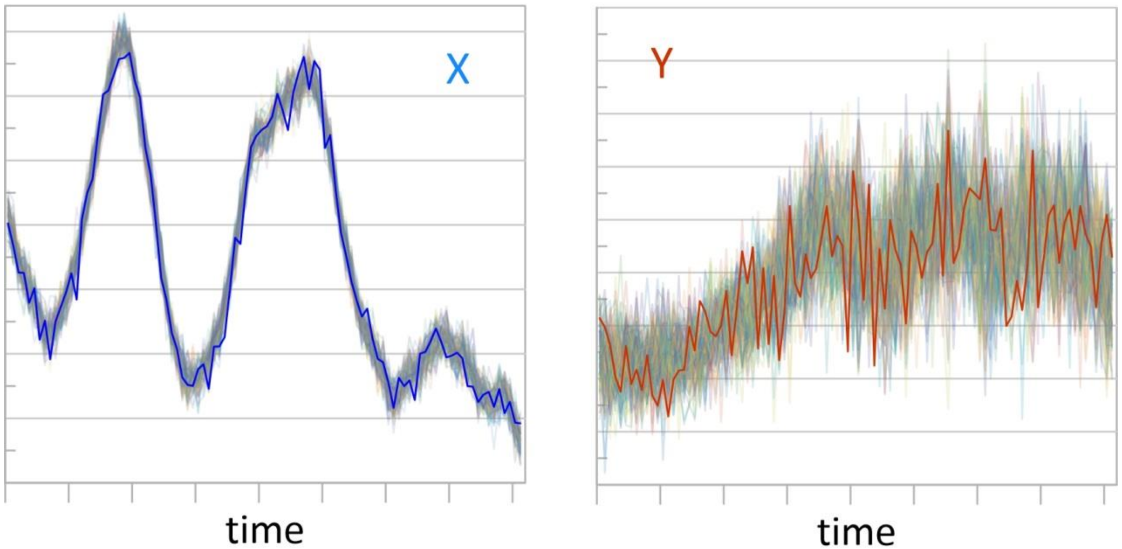
Henon maps

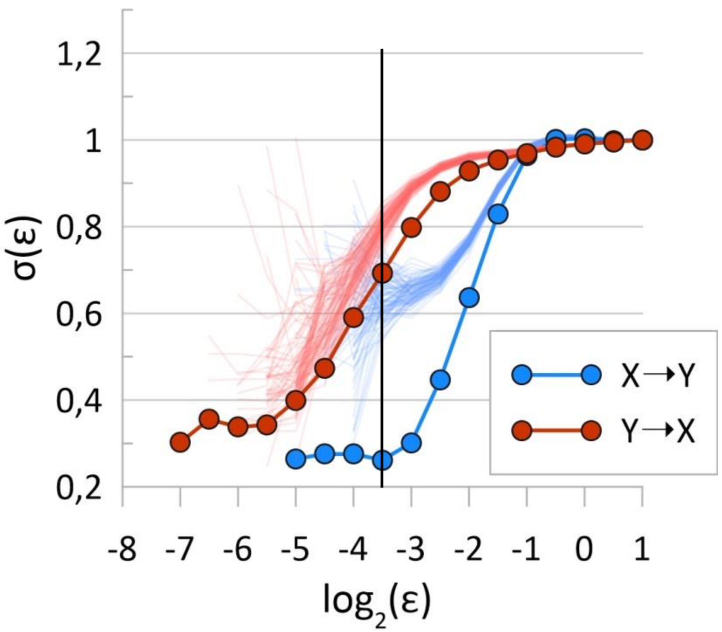
$$\begin{cases} x_{n+1} = 1 + y_n - 1.4x_n^2 \\ y_{n+1} = 0.3x_n + \alpha(v_n - y_n) \end{cases}$$

$$\begin{cases} u_{n+1} = 1 + v_n - 1.4u_n^2 \\ v_{n+1} = 0.3u_n \end{cases}$$

Lower steep curve means dependency

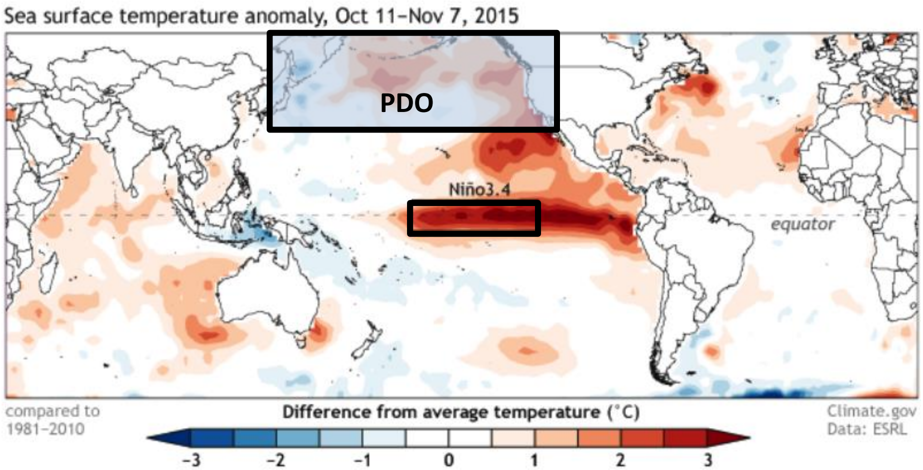
Error estimation using the Monte Carlo method





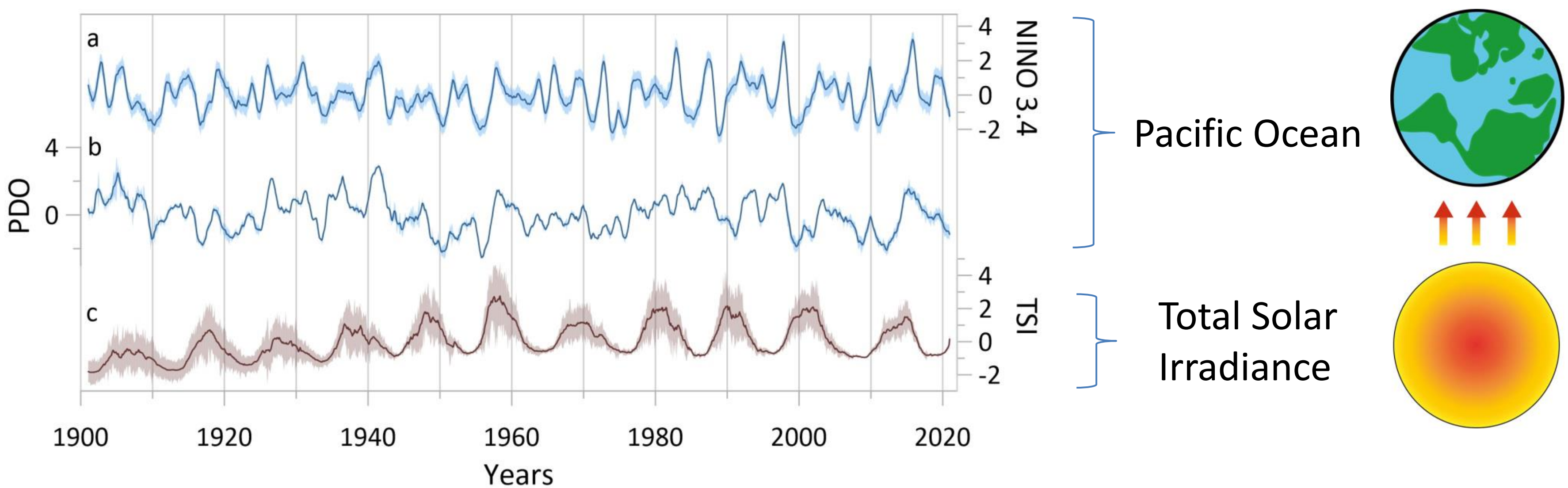
1) Add Gaussian noise to each time series
2) Get 100 noisy time series
3) Apply the MCD to 100 noisy pairs of time series
4) Determine the confidence interval for the conditional variance curve using 100 results of the MCD

Ocean Climate indices



NINO 3.4	Sea surface temperature
PDO	Sea surface temperature

Normalized and filtered time series with uncertainties



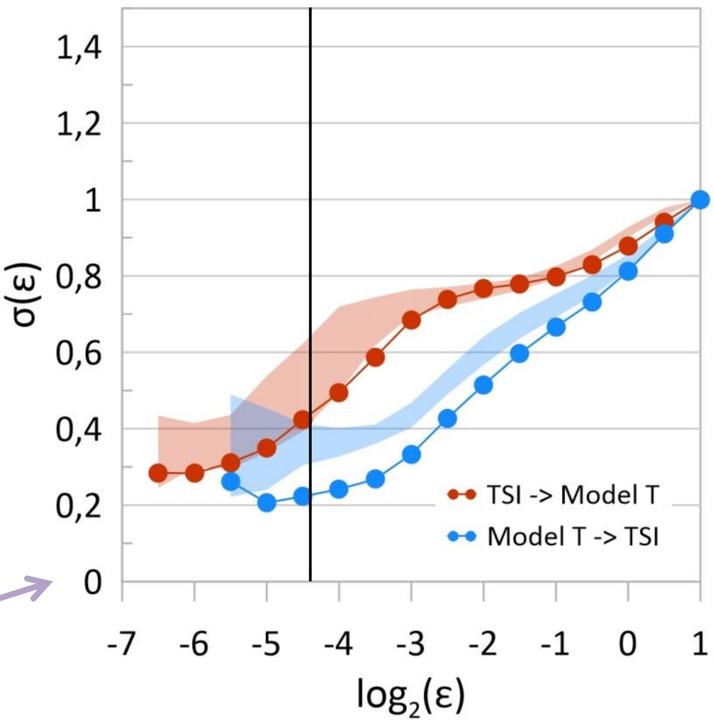
Ocean-Atmosphere model. MCD Calibration

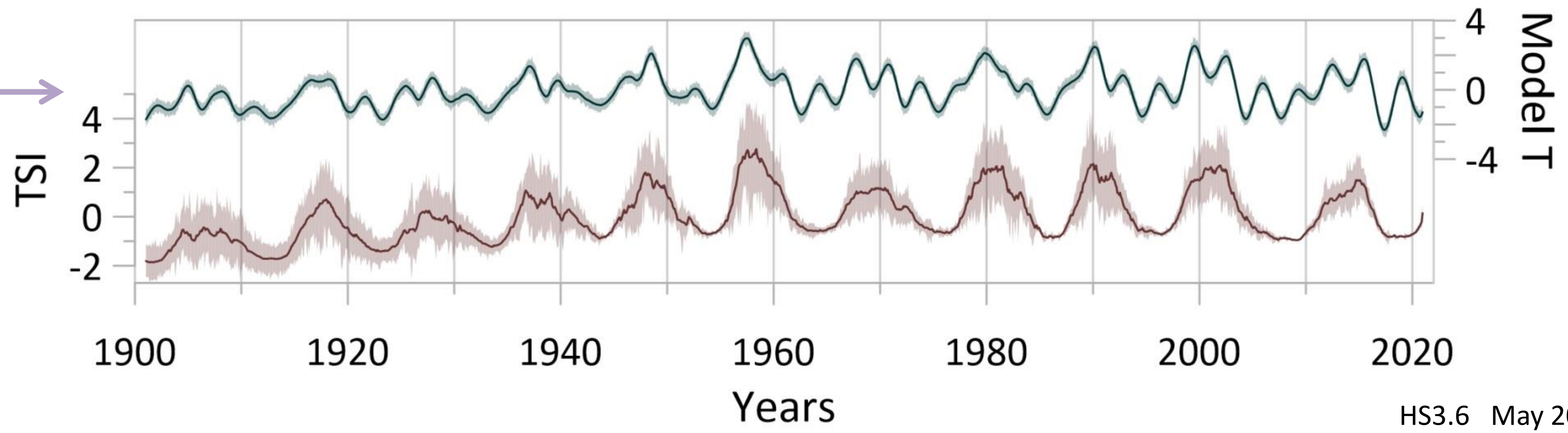
Conceptual Ocean – Atmosphere model
(Jin, 1997)

$$\frac{dT}{dt} = RT + \gamma h - e_n(h + bT)^3 + S * TSI$$

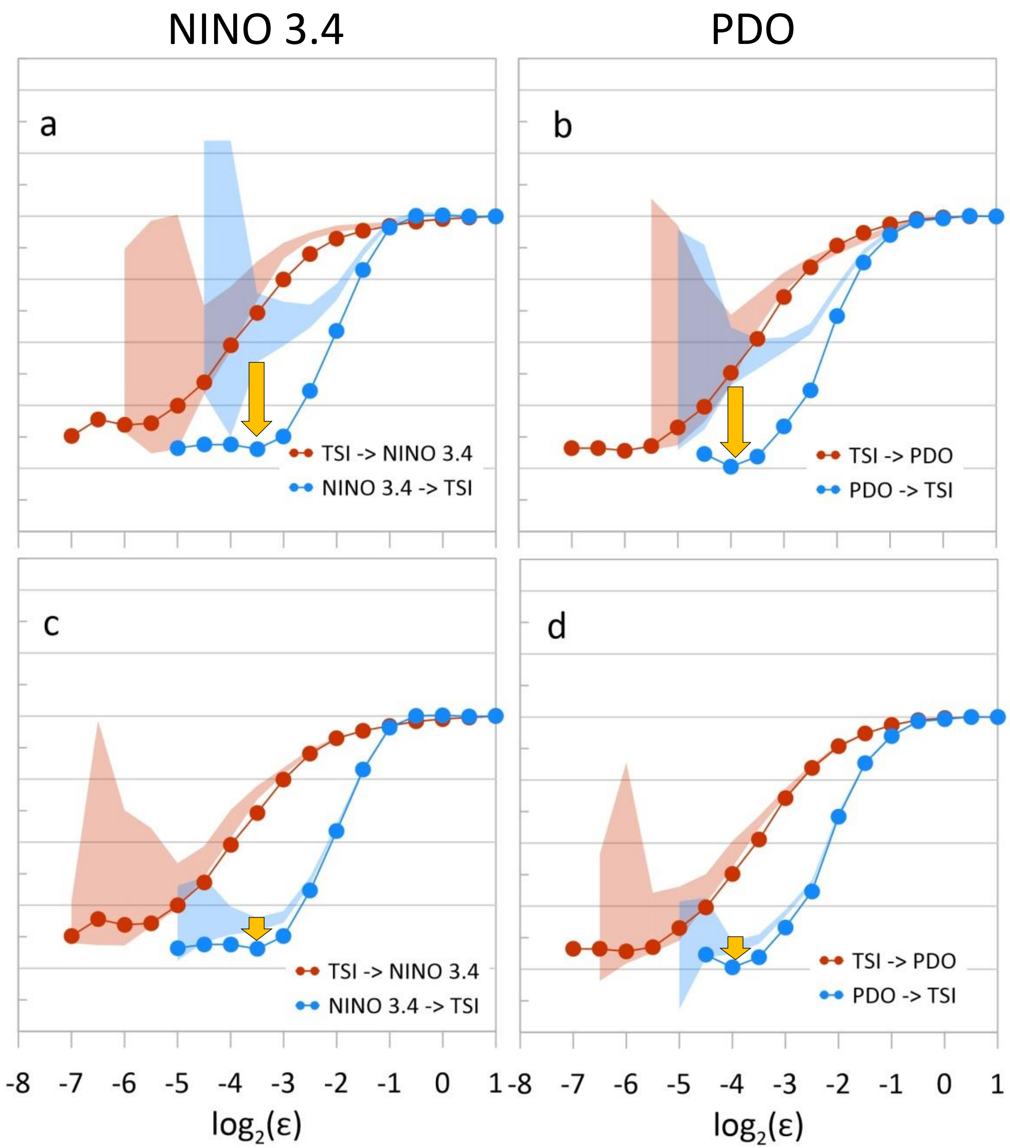
$$\frac{dh}{dt} = -rh - \alpha bT$$

1) We added forcing *TSI*
2) We added Gaussian noise to obtained model time series Model T
3) MCD has shown that *TSI cause* Model T





Causality between climate indices and TSI



With noise

1) NINO 3.4 and PDO depend on TSI
2) We can evaluate climate indices uncertainties using causality as a criteria

With noise/10

Conclusions

- We estimated the causal relationship between TSI and climate indices NINO 3.4, PDO over the past century using the method of conditional dispersions (Čenys et al., 1991). The method reveals that NINO 3.4 and PDO depend on TSI;

- We use the conceptual ocean-atmosphere model (Jin,1997) with TSI added as a forcing to calibrate the method;

- MCD approach can be used to evaluate climate indices uncertainties by detecting connections between time series with added Gaussian noise.

Thank you for your attention!

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