



On the Signs of Lag-Time Effects in the Connectivity of Climate Networks Constructed with Surface Temperature Anomalies

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Outline



- Introduction to Climate Networks
- Methods: Identification of Lag Times
- Results
- Conclusion



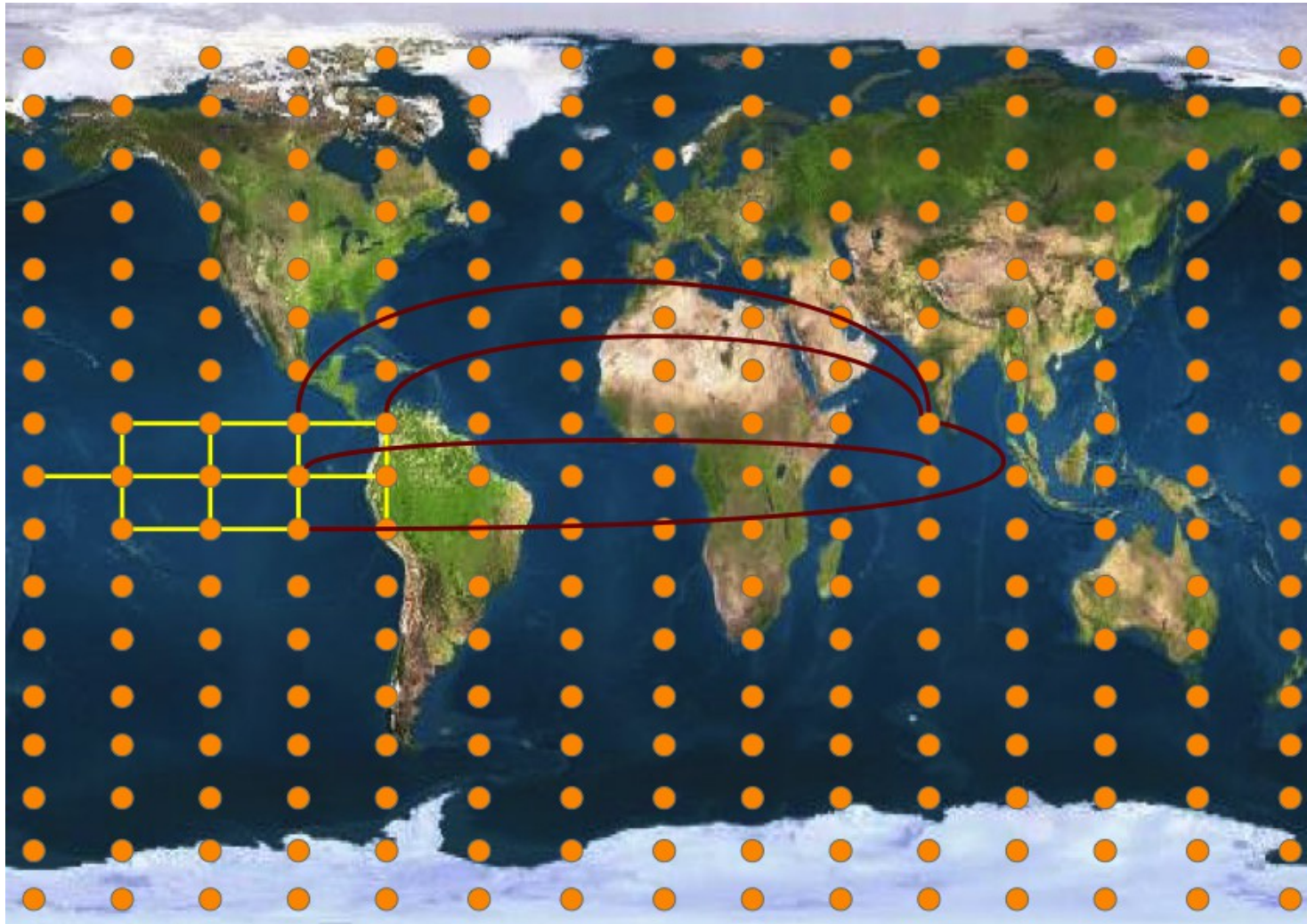
Introduction



- **Introduction to Climate Networks**
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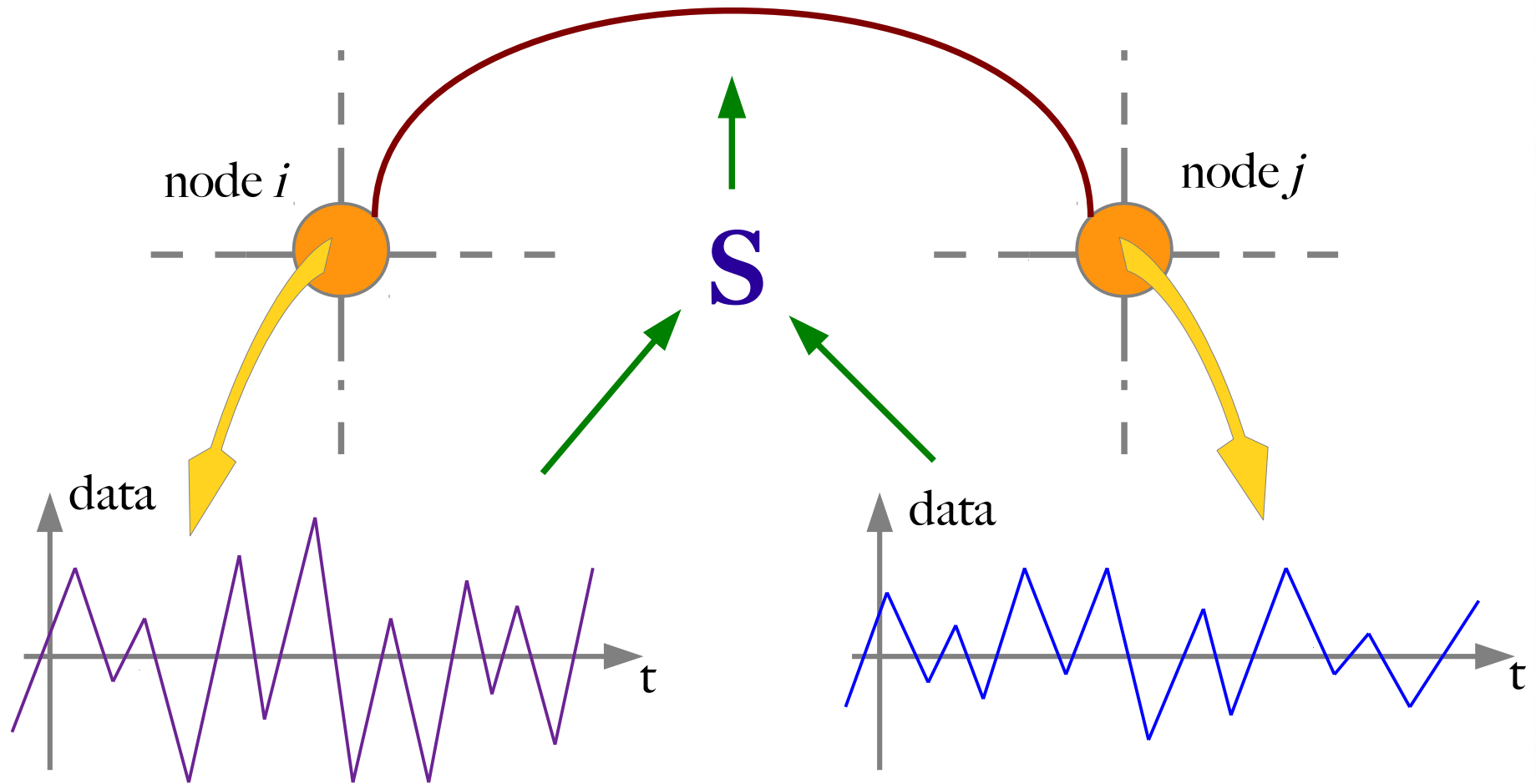


Climate Network





Building Climate Network



- Cross Correlation

$$CC_{ij} = \frac{1}{N_{months}} \sum_{t=1}^{N_{months}} a_i(t) a_j(t + \tau_{ij})$$

- Mutual Information

$$MI_{ij} = \sum_{m,n}^{N_{bins}} p_{ij}(m,n) \log_2 \left(\frac{p_{ij}(m,n)}{p_i(m) p_j(n)} \right)$$

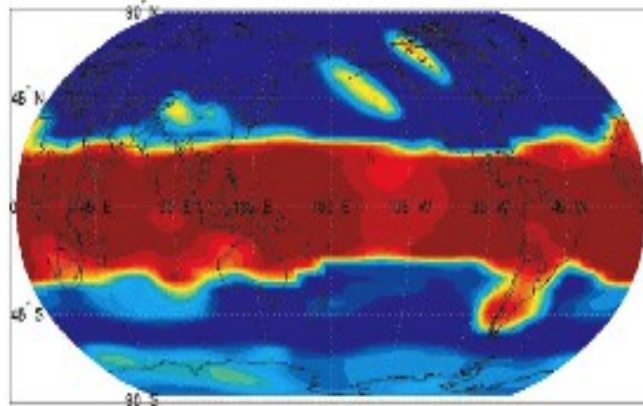
$$p_{ij}(m,n) = P(a_i(t) \in m; a_j(t + \tau_{ij}) \in n)$$

THEY CAN BE ESTIMATED ONLY

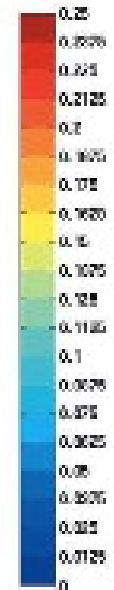
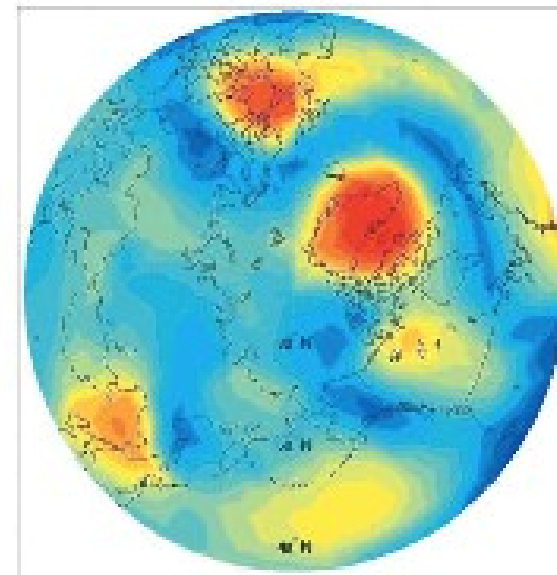
Previous Works

$$|ICCI| > 0.5$$

Weighted degree



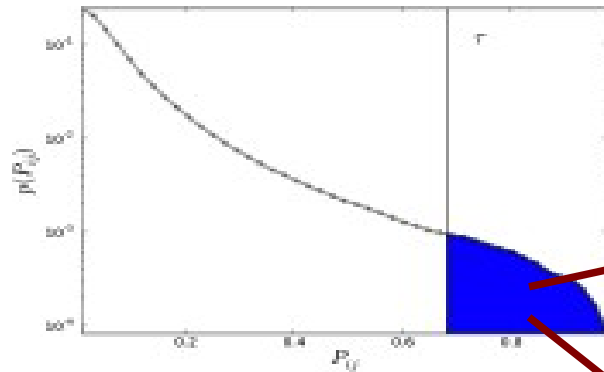
Weighted degree



A. Tsonis et al. (2006), *Am. Meteorol. Soc.*



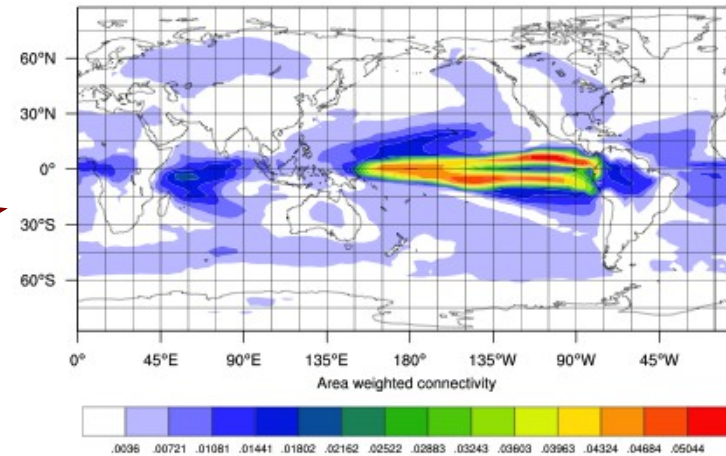
Previous Works



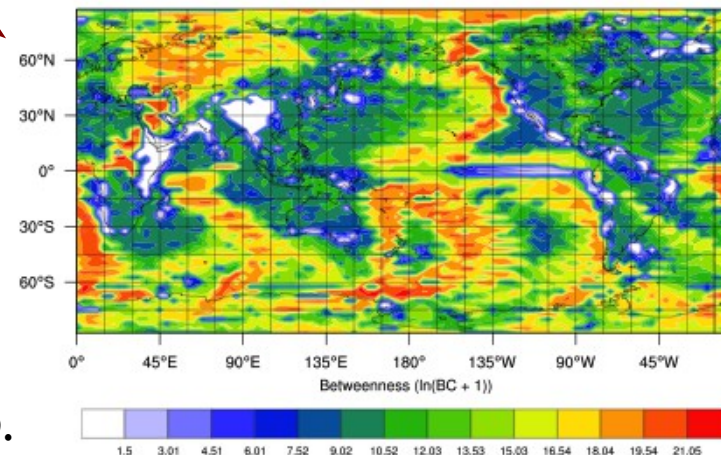
Correlation PDF

MONTHLY DATA

Weighted degree

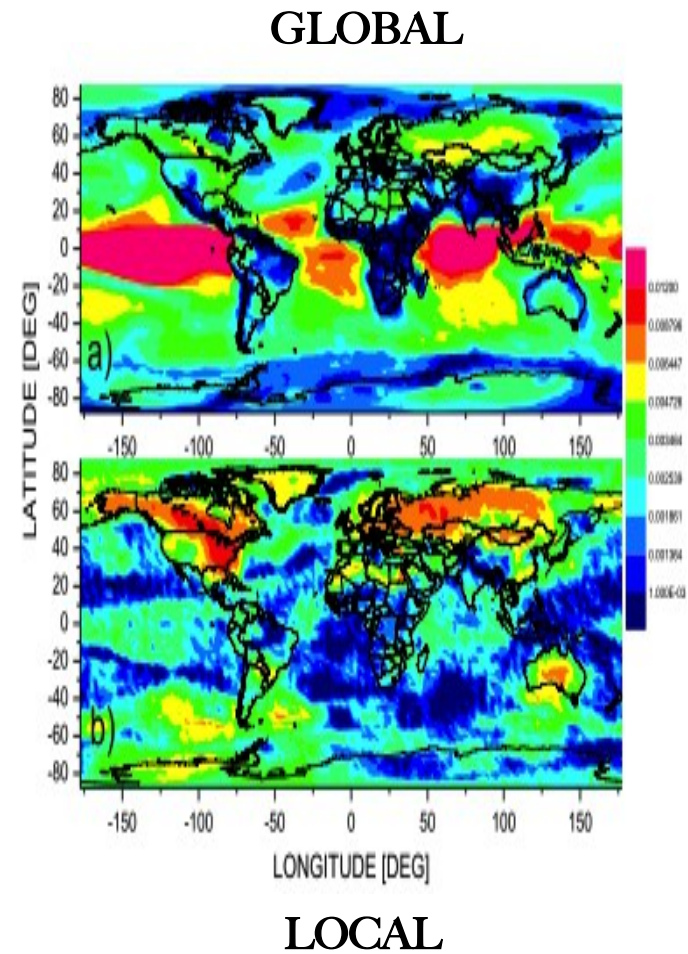


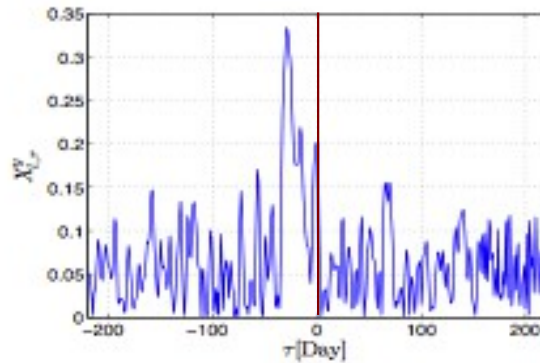
Betweenness



J. Donges et al. (2009), *Eur. Phys. J. Sp. Top.*

- A global threshold is fast and easy, but it does not take into account that there may be intrinsic differences in the time-series that could affect correlations
- A way to avoid this, it is to pass somehow to a *local* thresholding

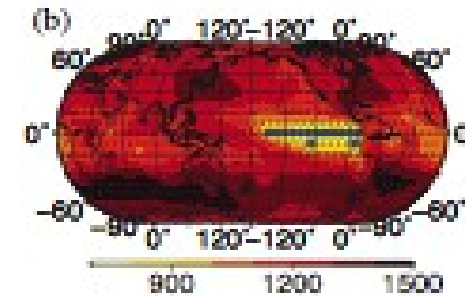




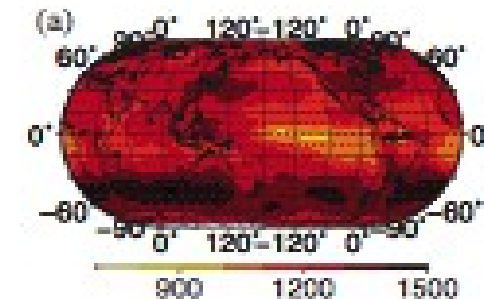
Lagged Correlation
between points

DAILY DATA

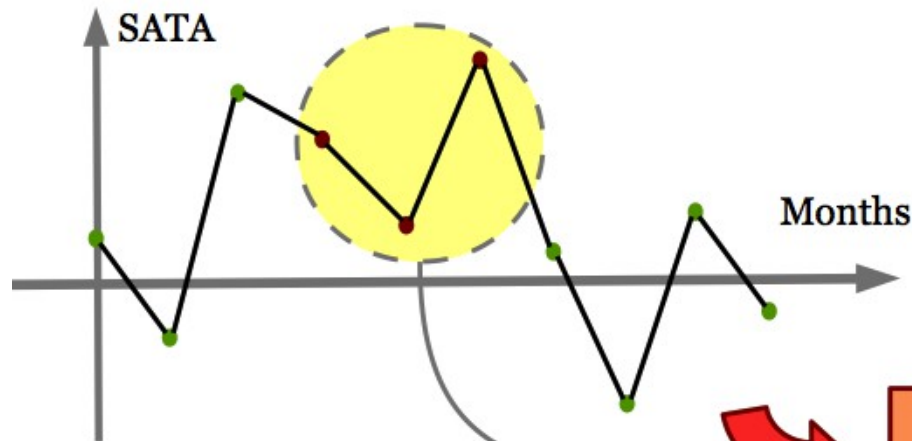
In-degree during El Niño



In-degree during not-El Niño

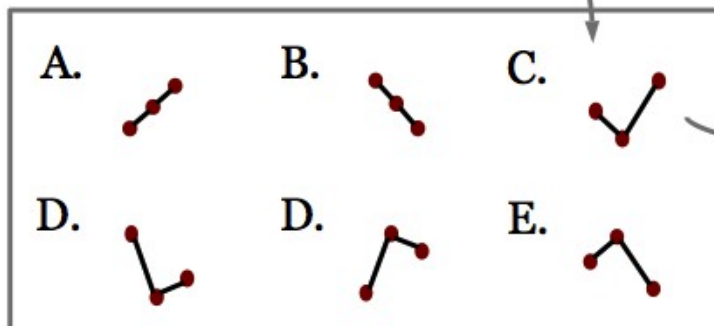


Ordinal Patterns



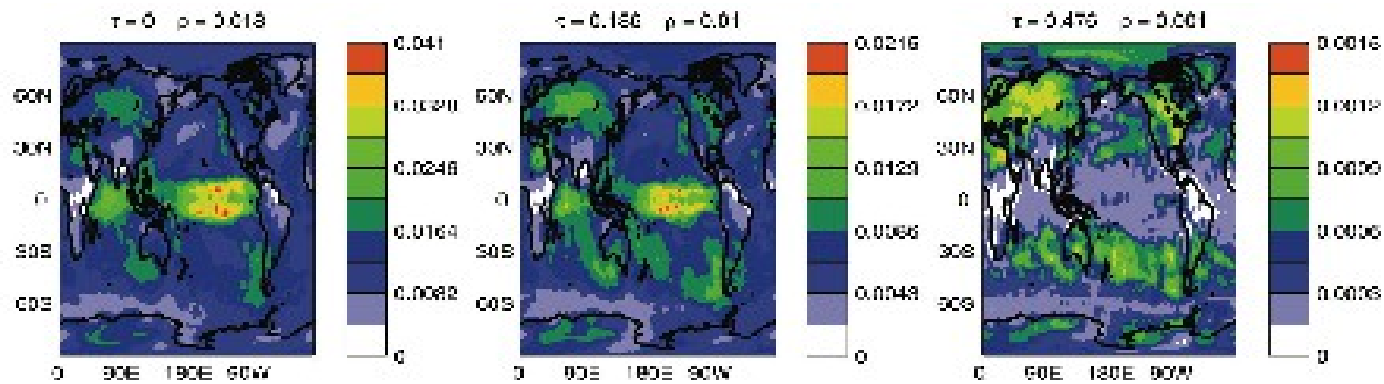
SYMBOLIC TIME-SERIES

... C, D, B, C, E, C, D ...

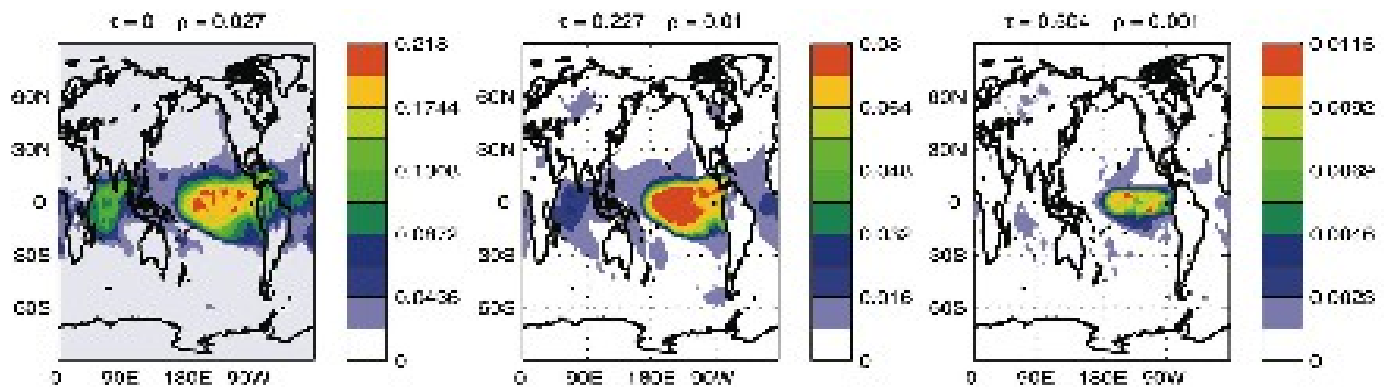


MUTUAL INFORMATION MIOP

Consecutive Months



Consecutive Years





Methods



- Introduction to Climate Networks
- **Methods: Identification of Lag Times**
- Results
- Conclusion



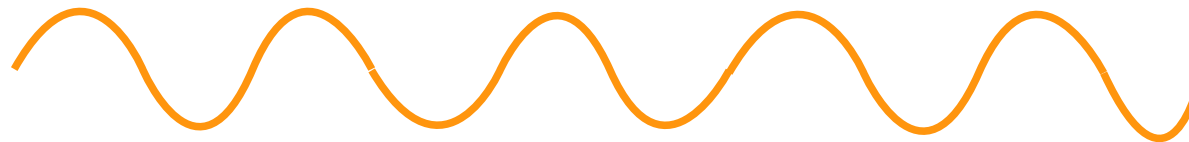
Surface Temperature Data



SAT data
of
Barcelona



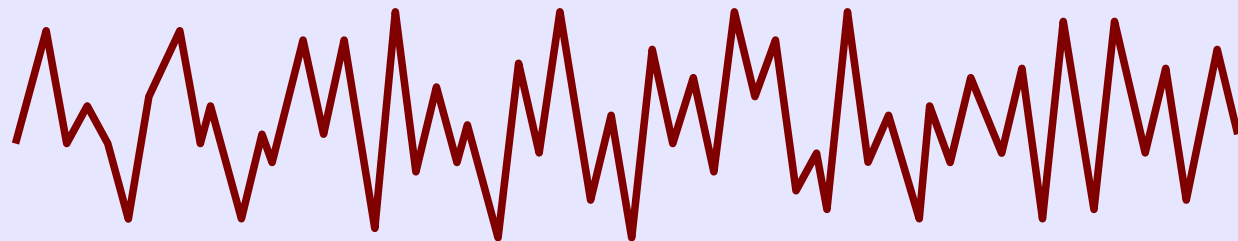
Solar
Cycle



-

=

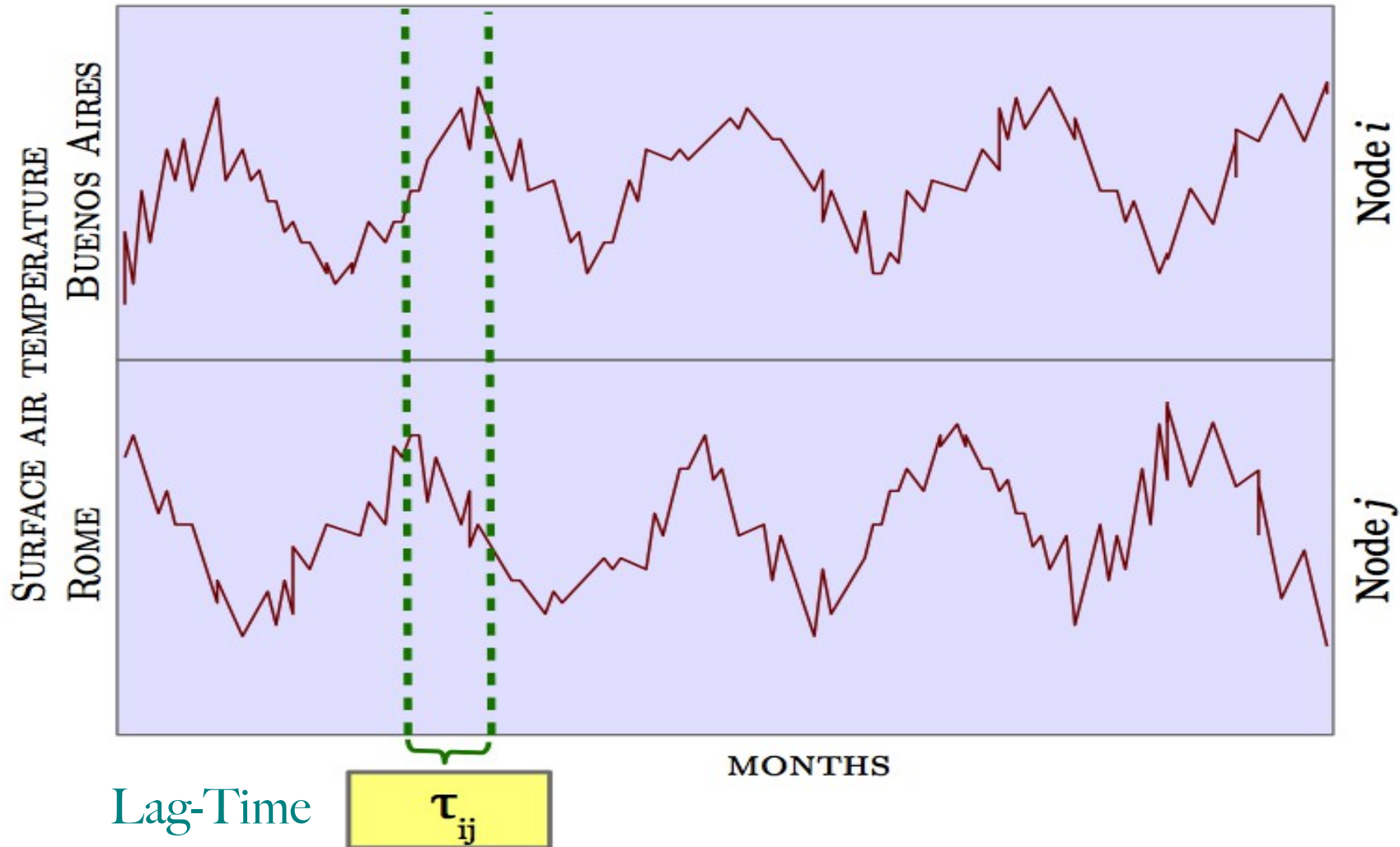
SAT
anomalies
(SATA)



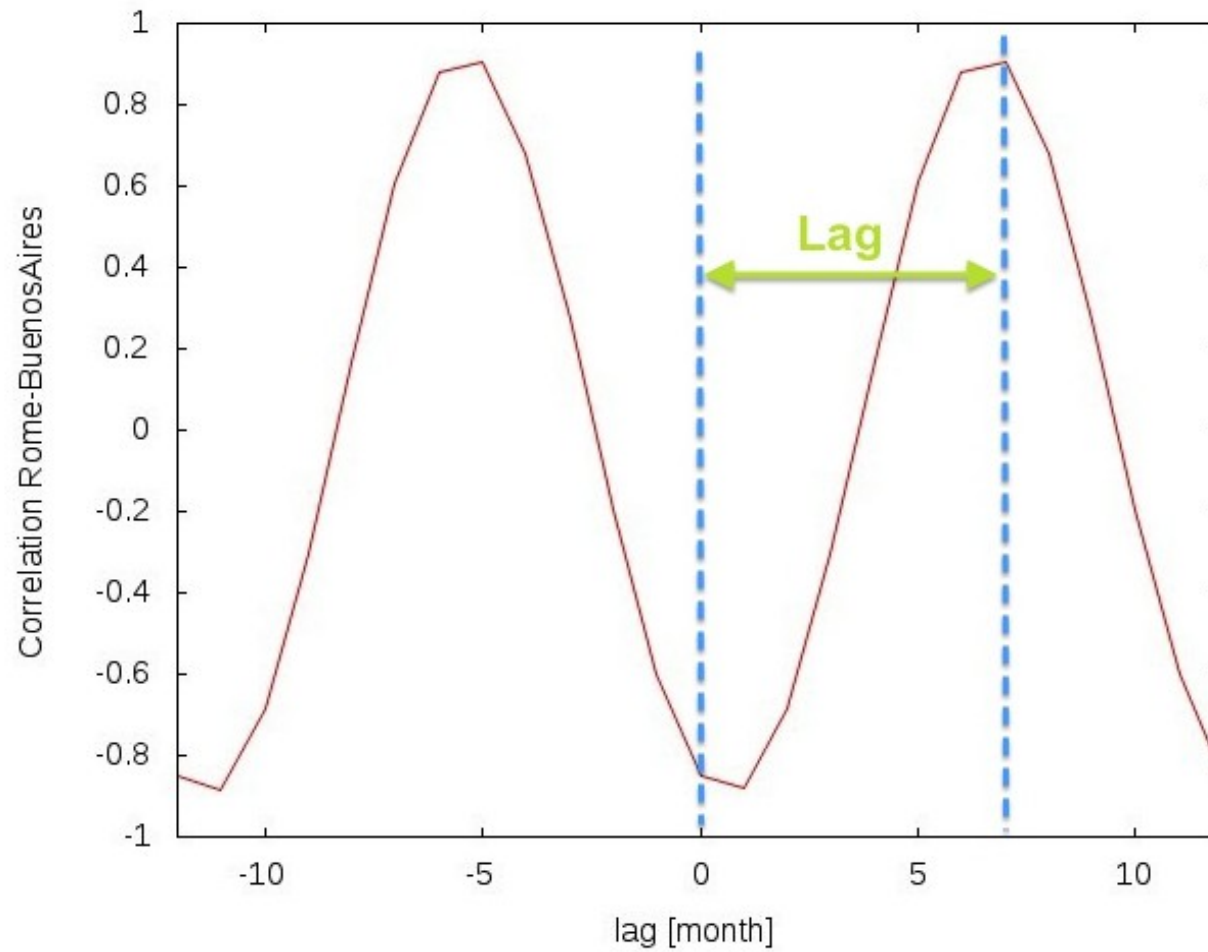
Question: Can we find any influence of the solar cycle in SATA?
Can the average connectivity be affected by this influence?



Lag-Time

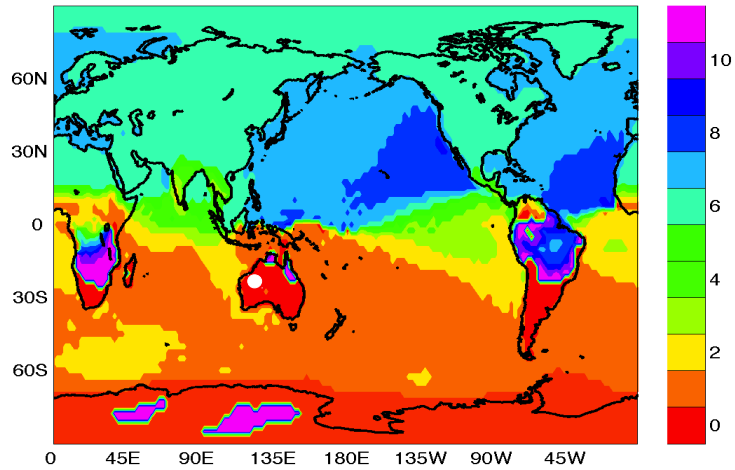


Lag-Time Measure

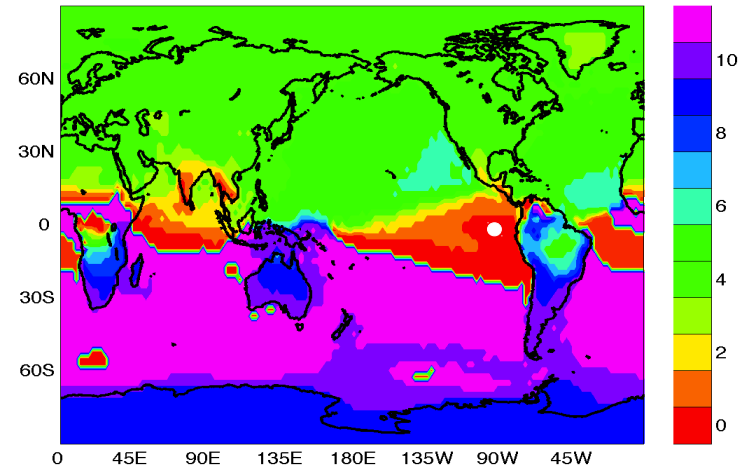




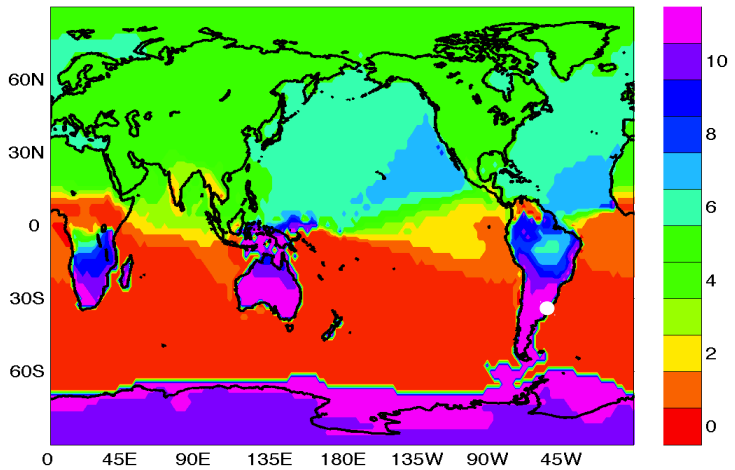
Lag-Time Maps



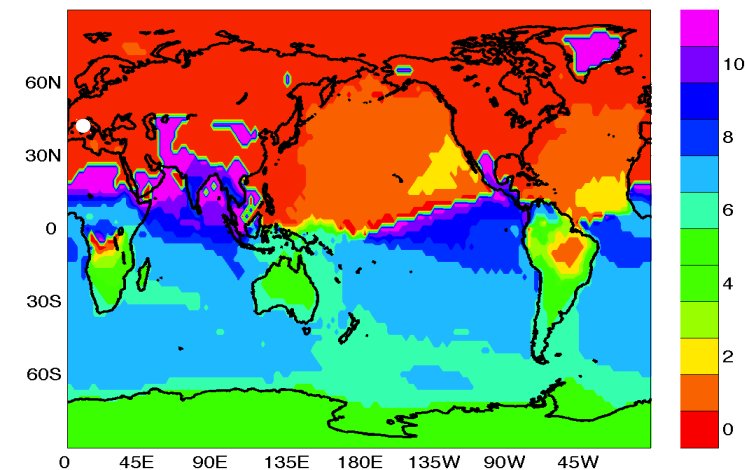
Australia



El Niño Basin



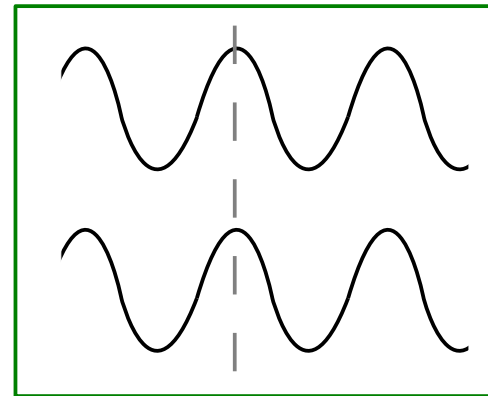
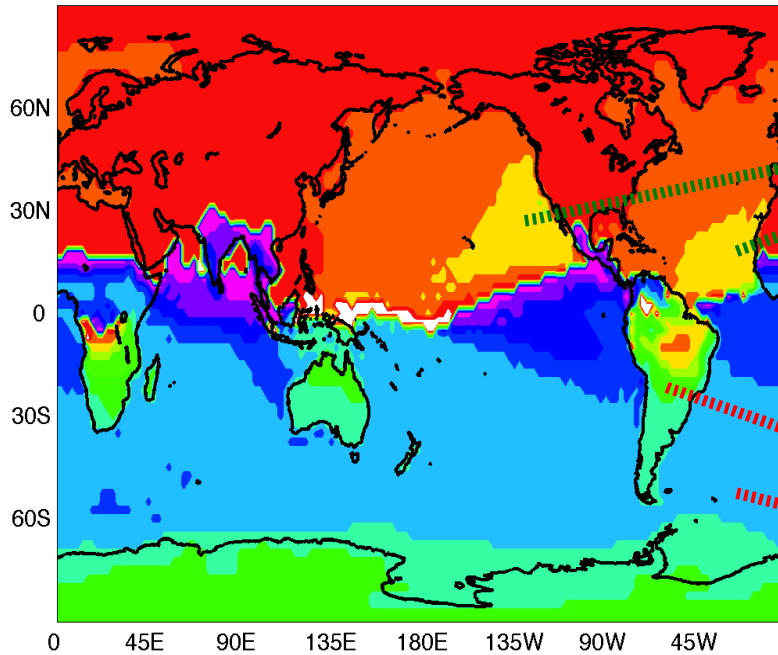
Buenos Aires



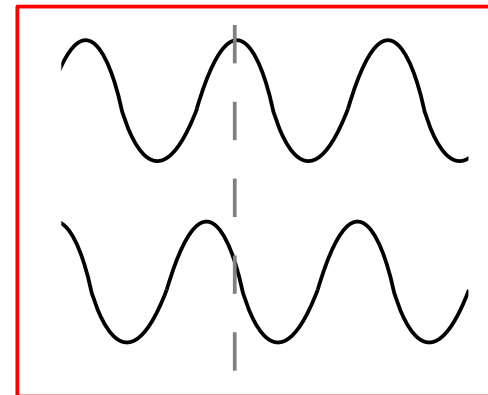
Rome



Synchronous Solar Cycles



ON PHASE

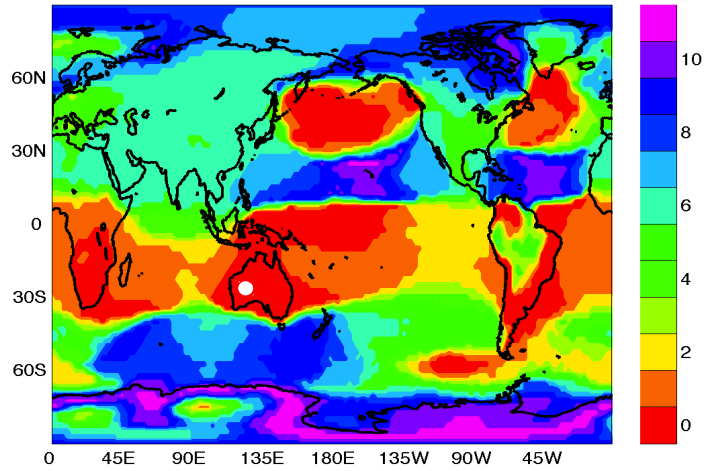


OUT OF PHASE

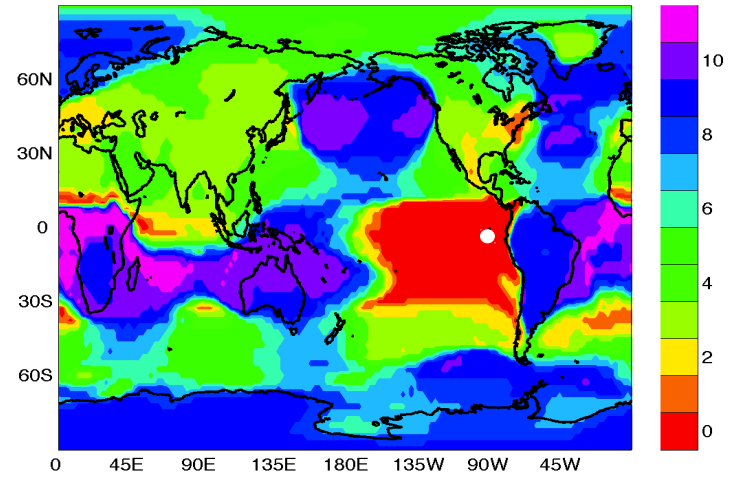
Climatic Regions of Synchronous solar cycle, can be identified by **persistence** of lag patterns



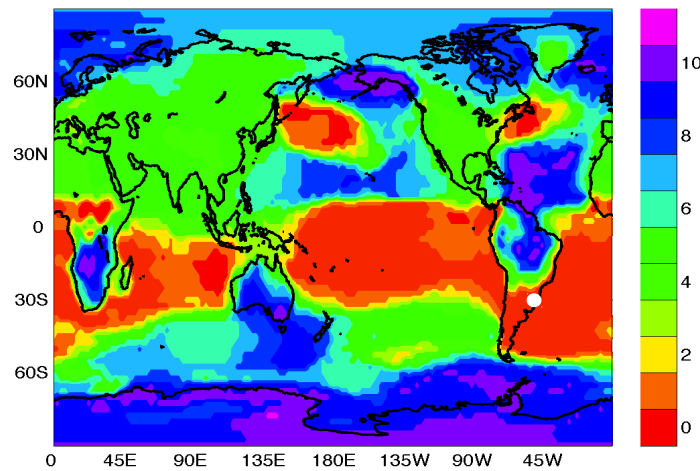
Geopotential Lags



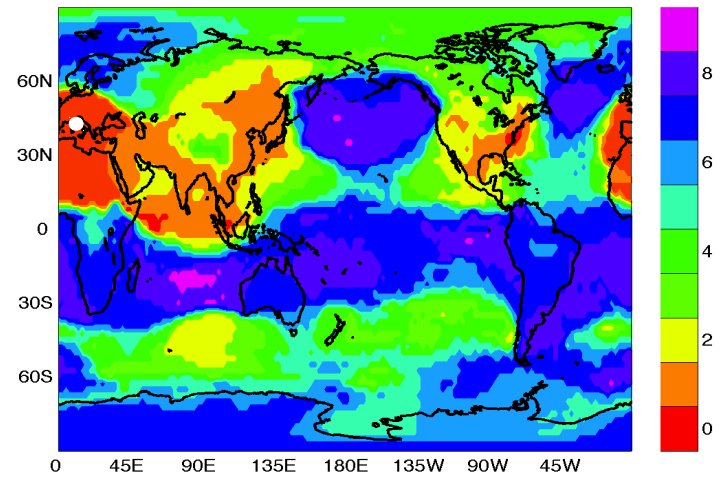
Australia



El Niño Basin



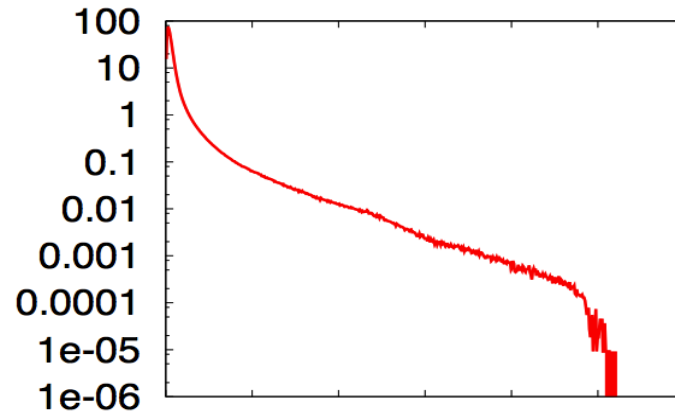
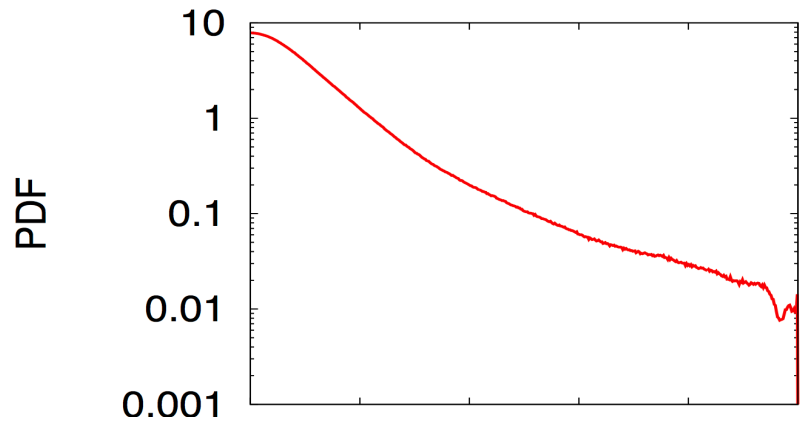
Buenos Aires



Rome

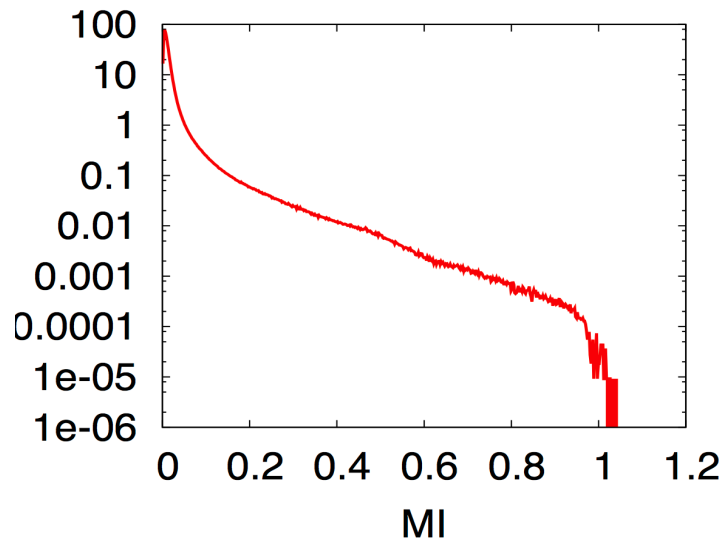
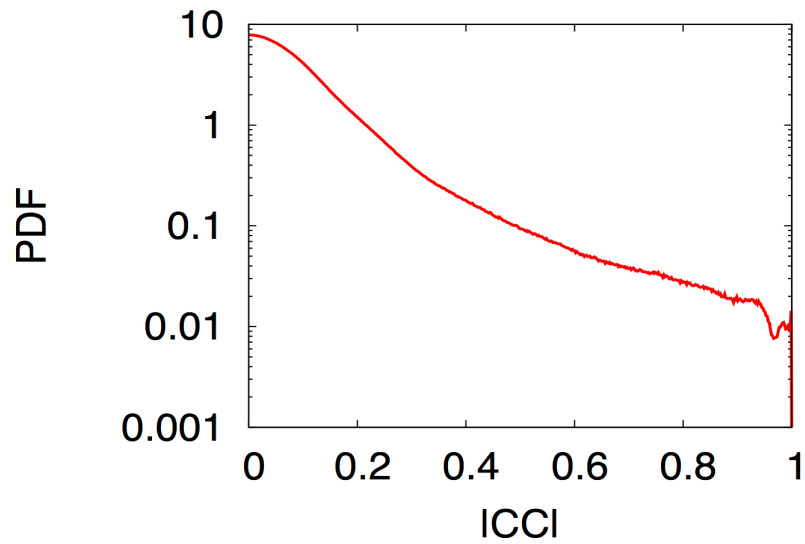


Histograms



No Lag

Lag





Results



- Introduction to Climate Networks
- Methods: Identification of Lag Times
- **Results**
- Conclusion



A wide point of view



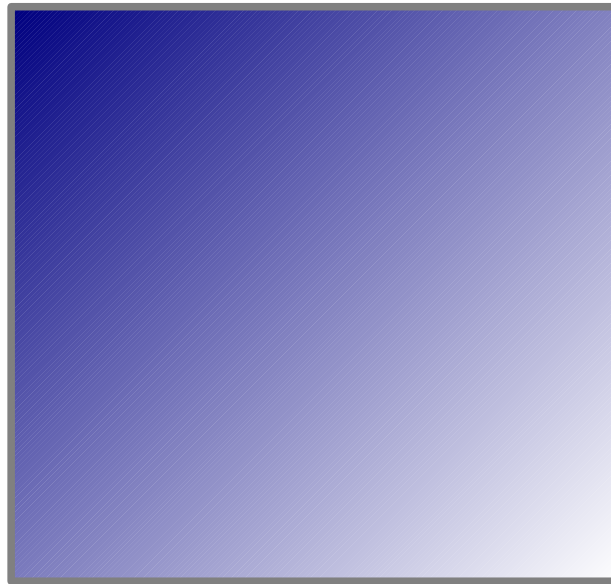
	CC	MI	MIOP(4)
Lagged series			
Not lagged series			



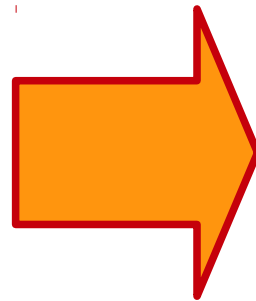
Pruning



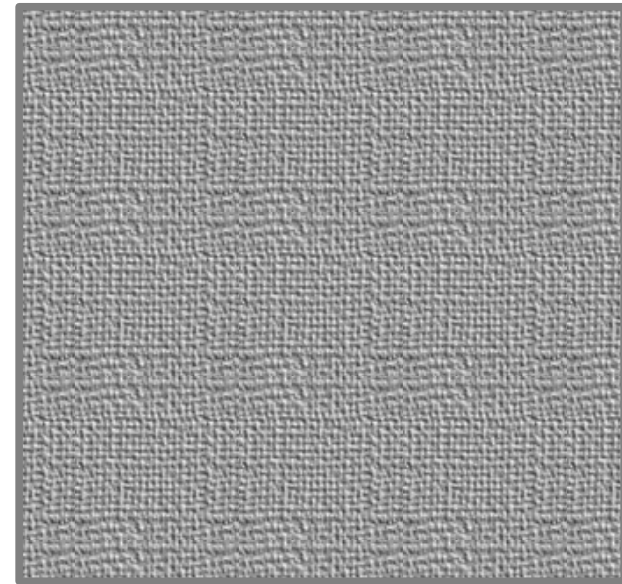
Similarity
Measures



Array of continuous
values



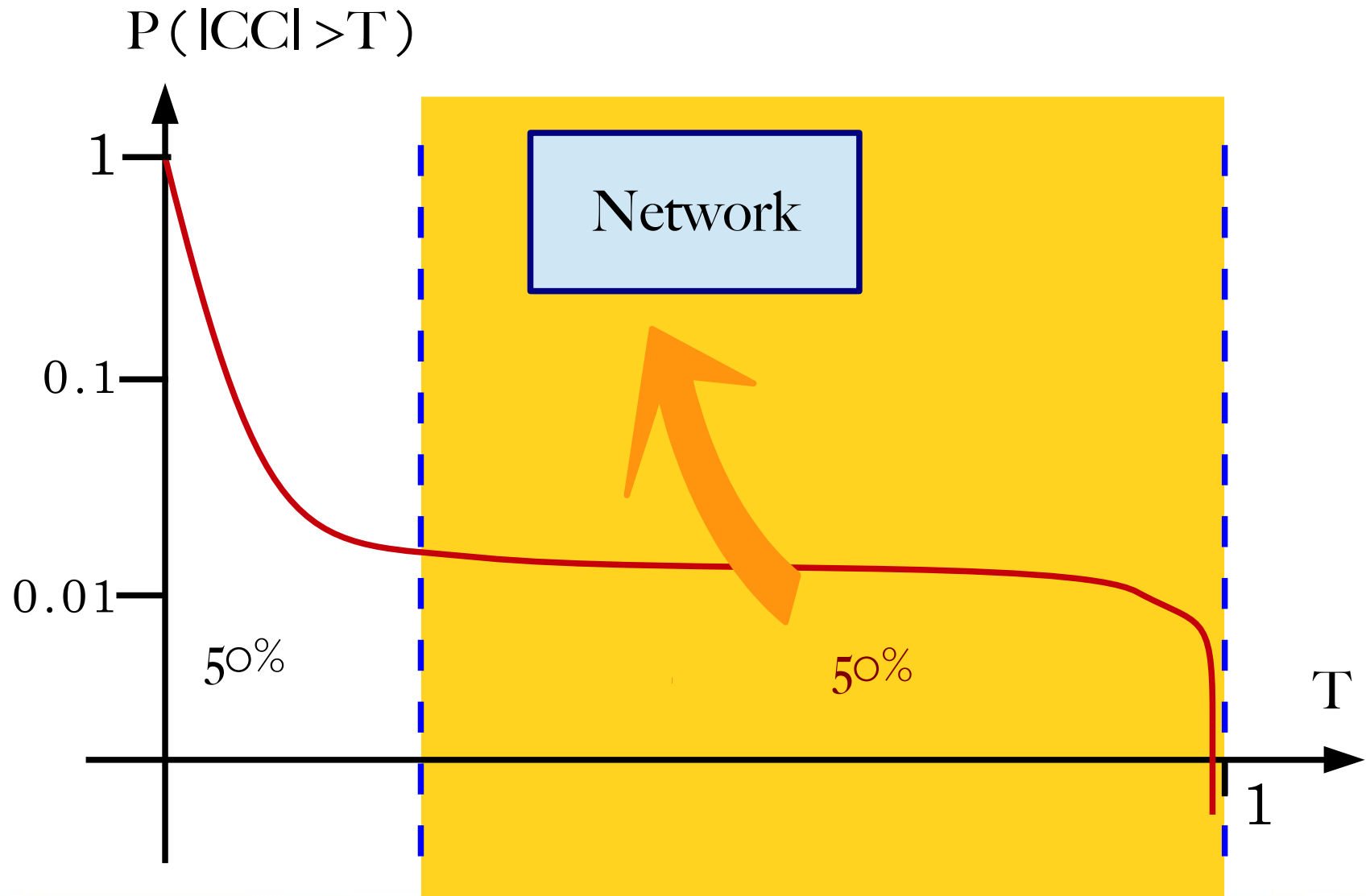
Adjacency
Matrix (a Network)



Binary Matrix



Classical Method





Results: Classic Way

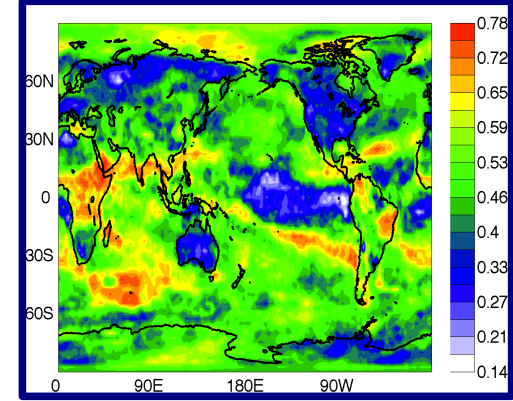
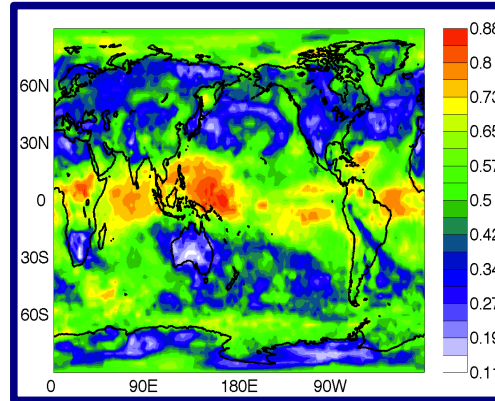
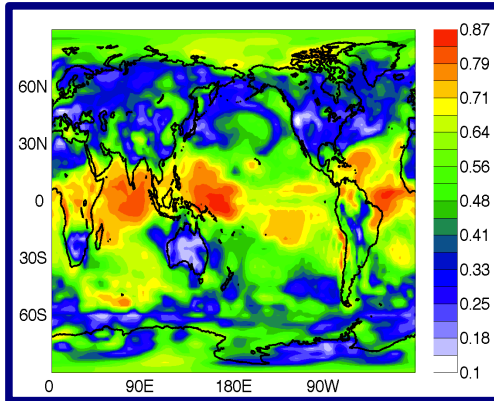


CC

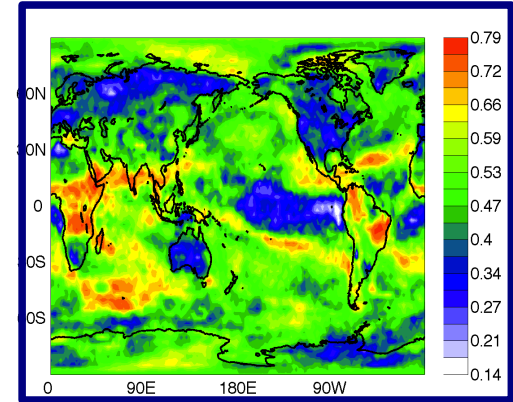
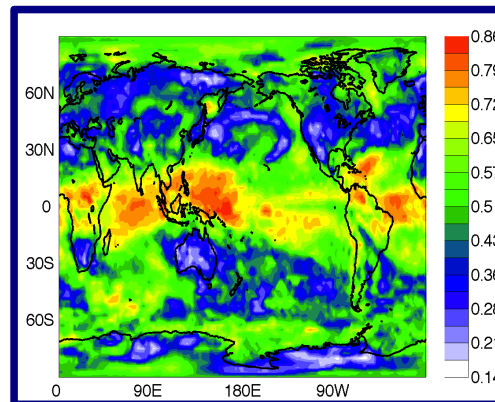
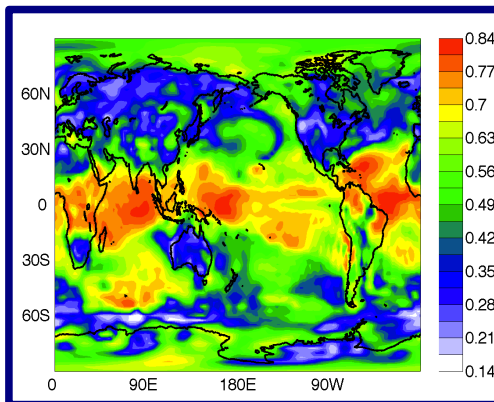
MI

MIOP

Lag



No Lag

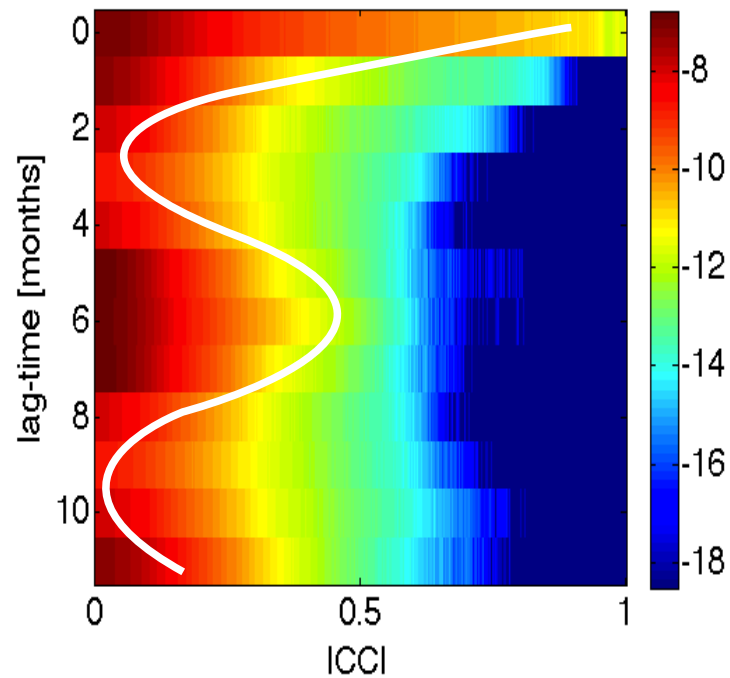




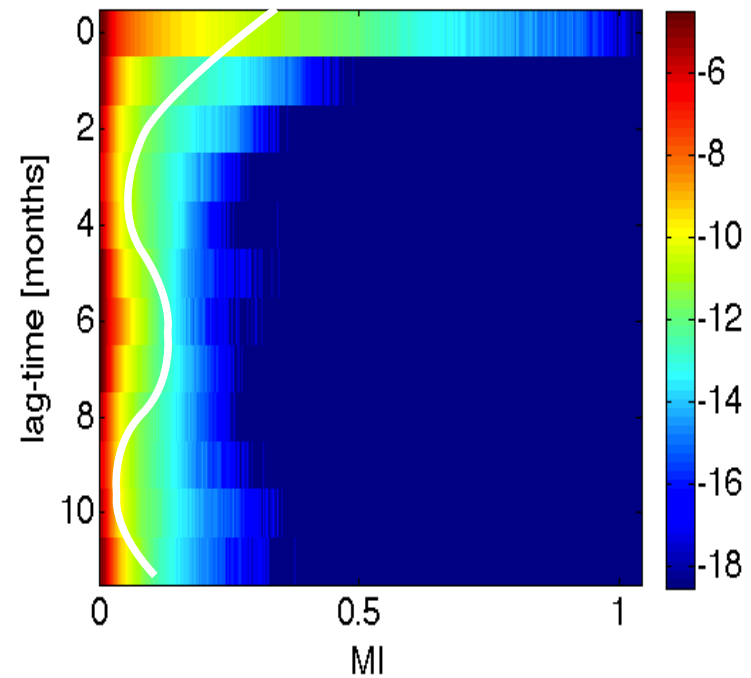
Local Links Abundance



Cross Correlation



Mutual Information

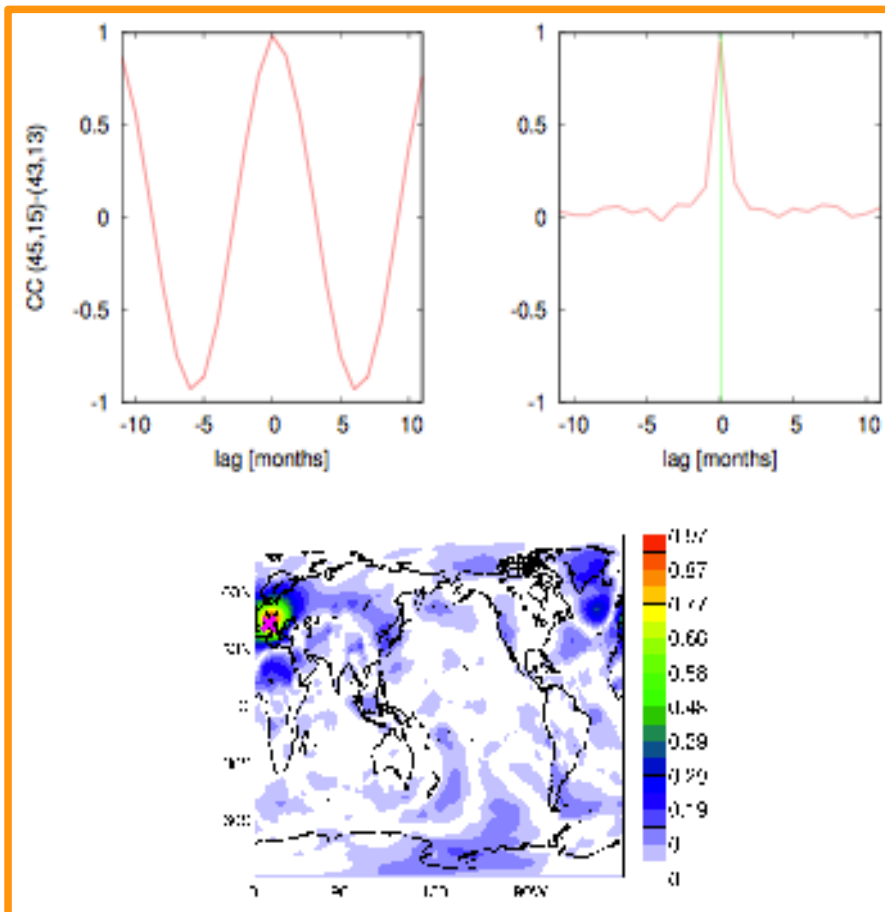




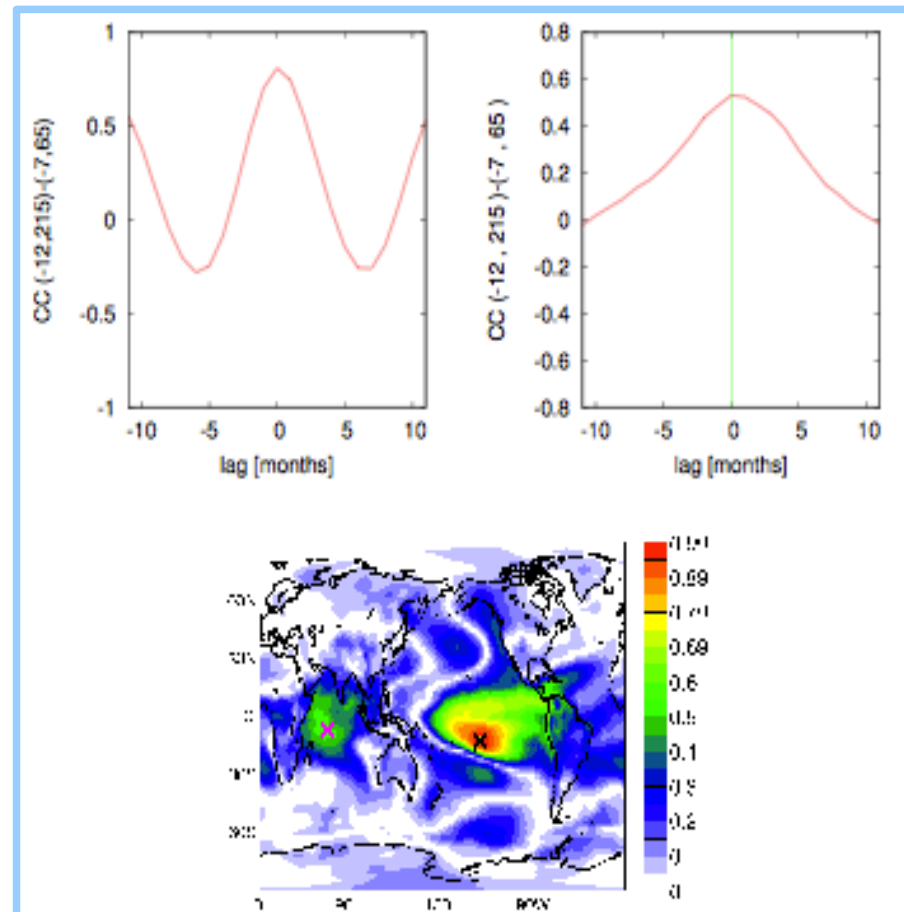
Zero Lag Links



Southern Europe

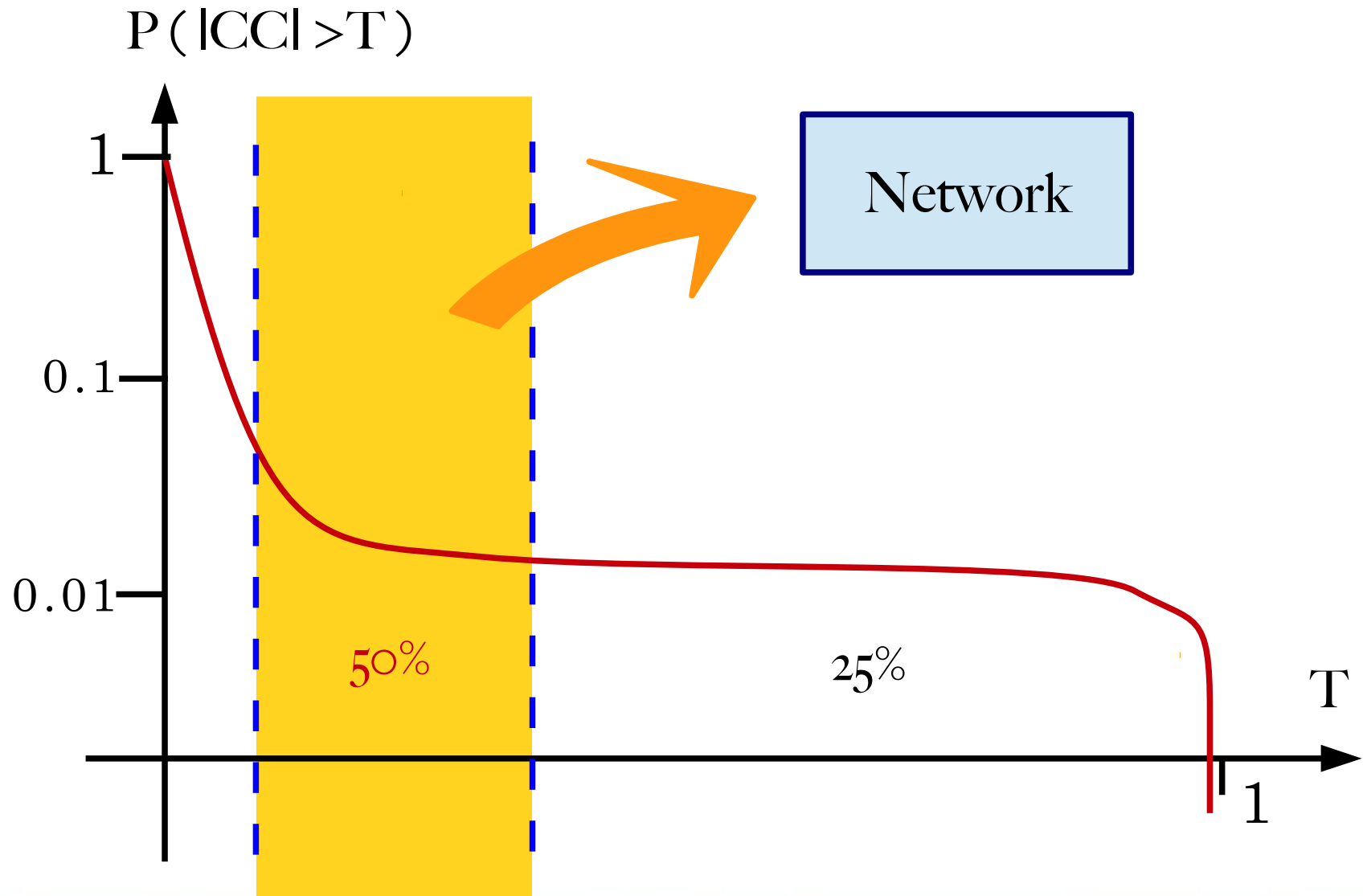


Equatorial Teleconnection





1st Pruning : Fixed Threshold





Results: Fixed Threshold

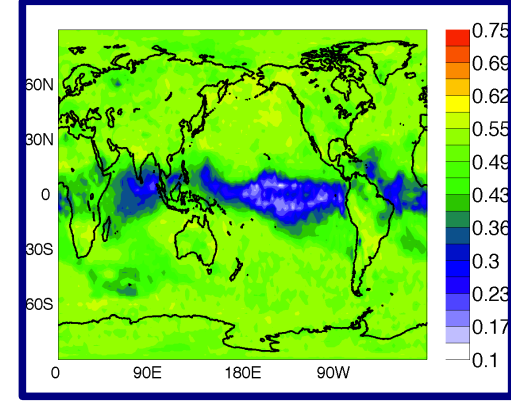
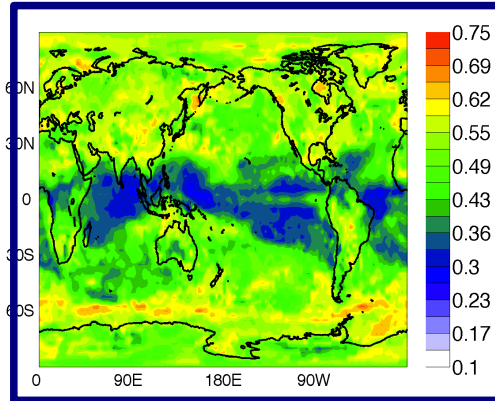
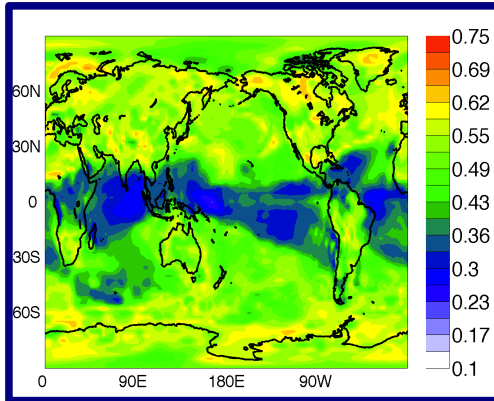


CC

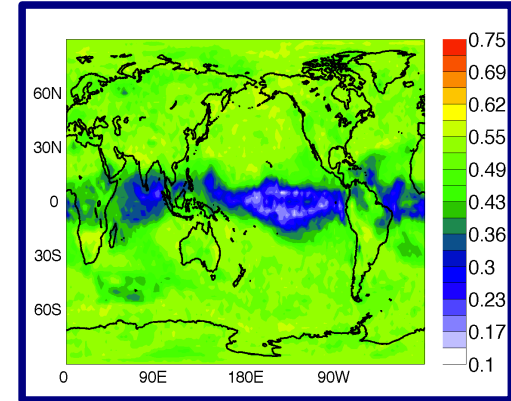
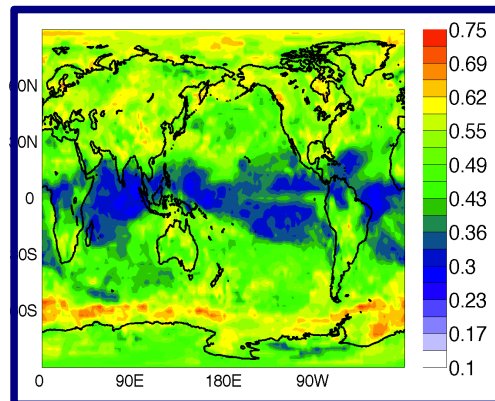
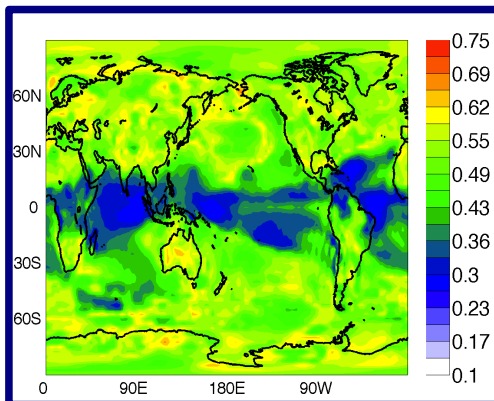
MI

MIOP

Lag

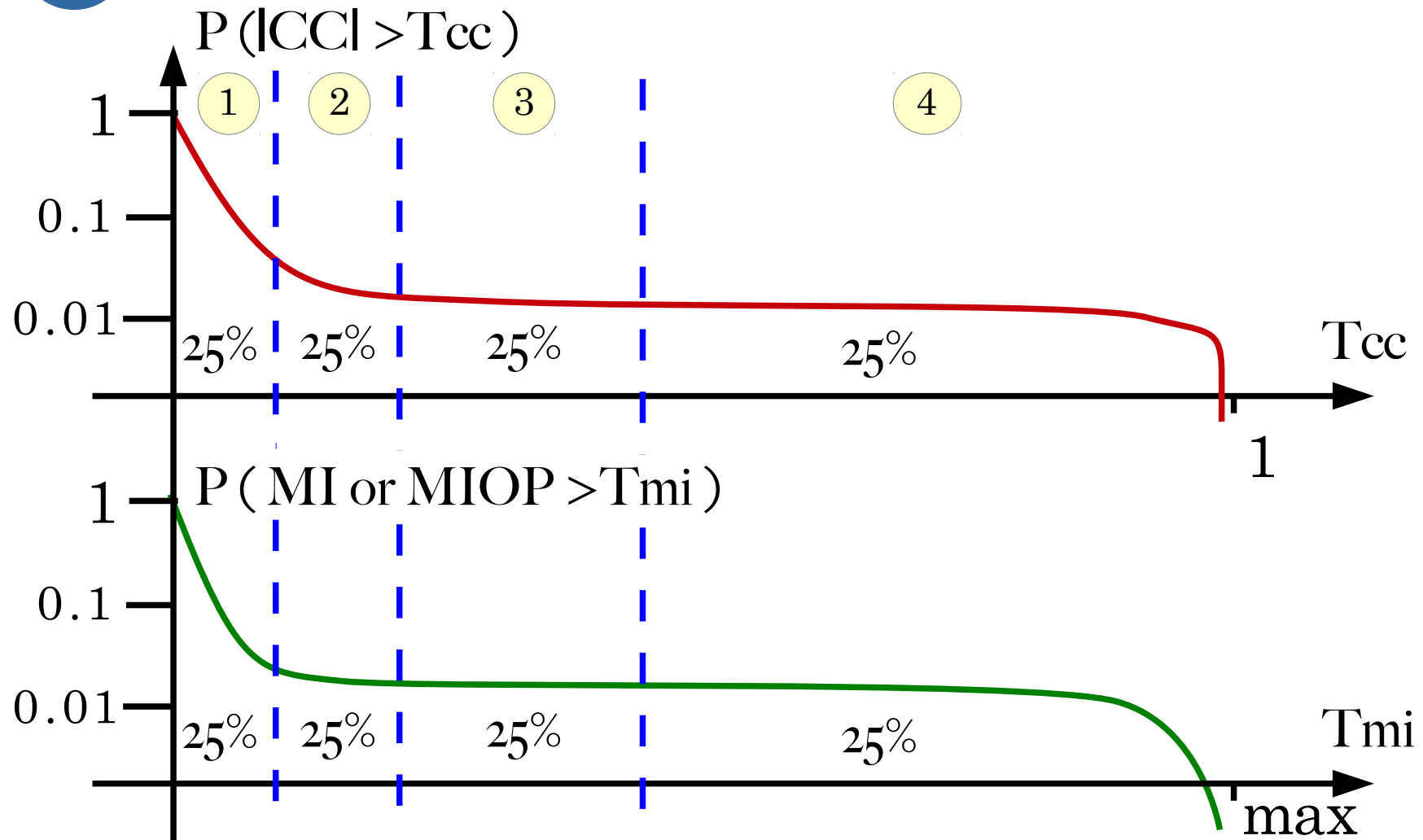


No Lag





2nd : Comparative Filtering



We discarded all MI/MIOP-4 and MI/MIOP-1 and MI/MIOP-2 unless that contemporary CC-3 or CC-4 (& vice versa)



Results: Comp. Filt.

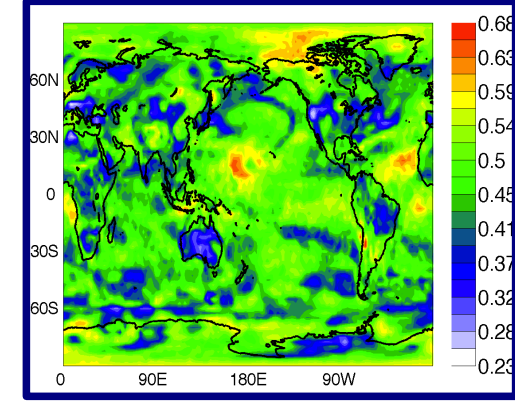
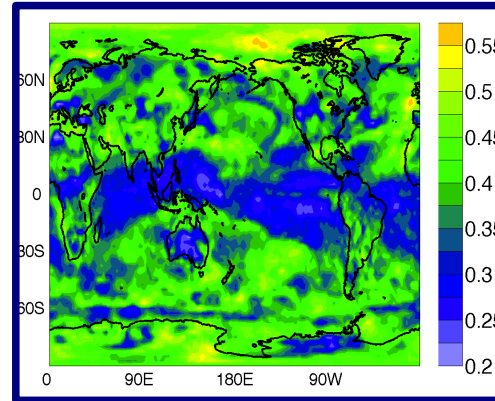
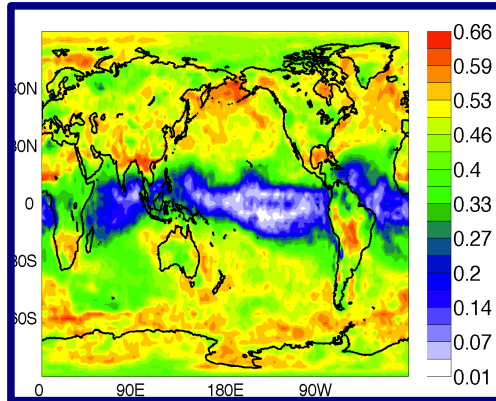


CC

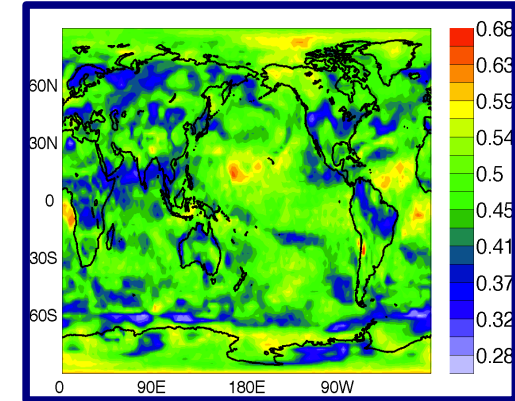
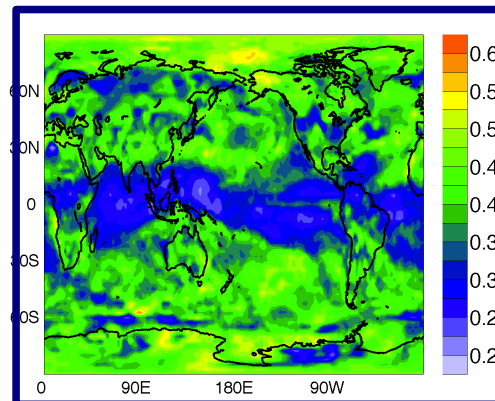
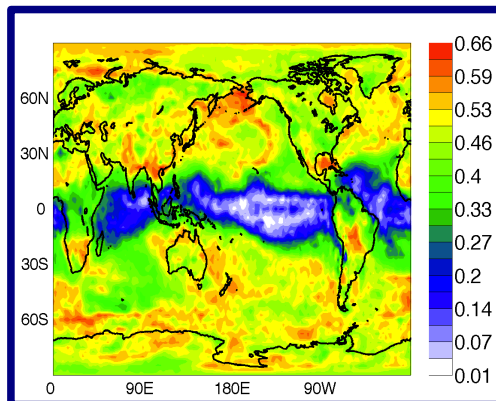
MI

MIOP

Lag



No Lag





Random Lags Comparison

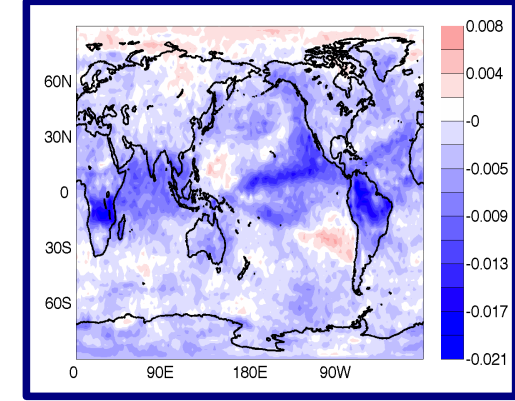
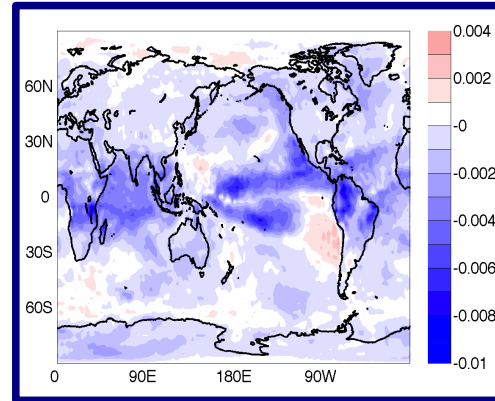
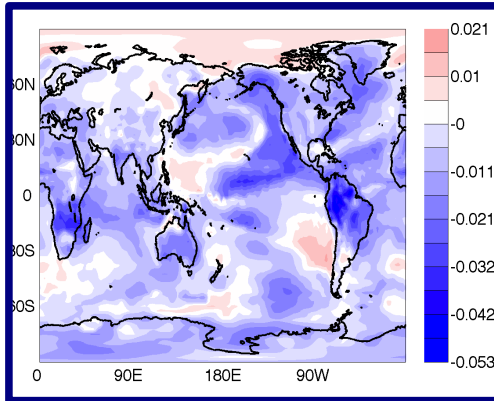


ΔCC

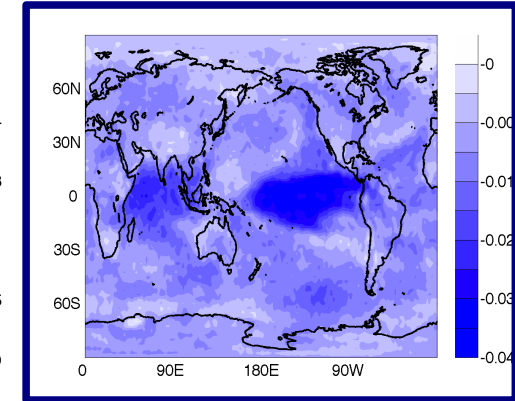
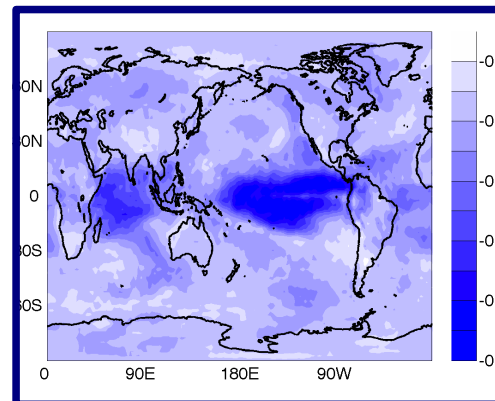
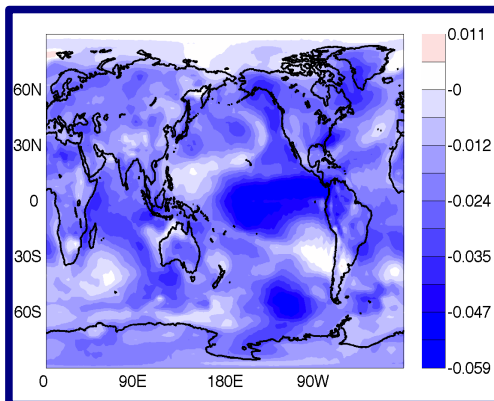
ΔMI

$\Delta MIOP(4)$

Lag

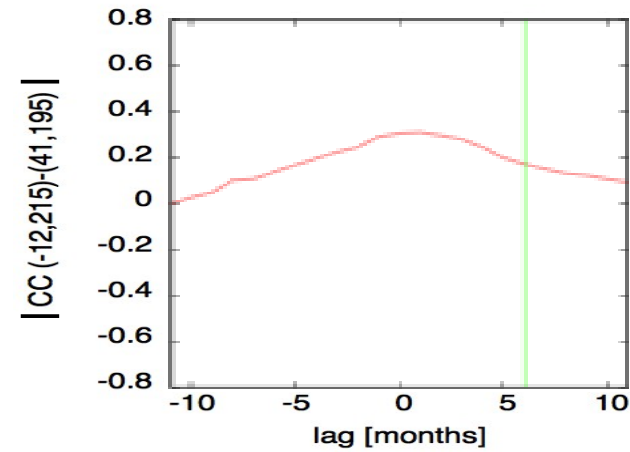
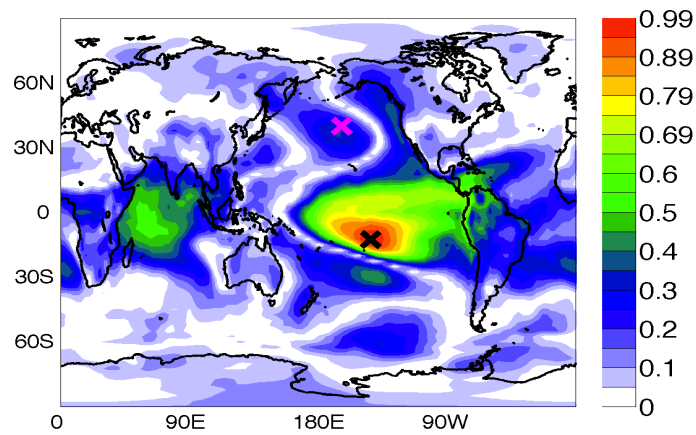
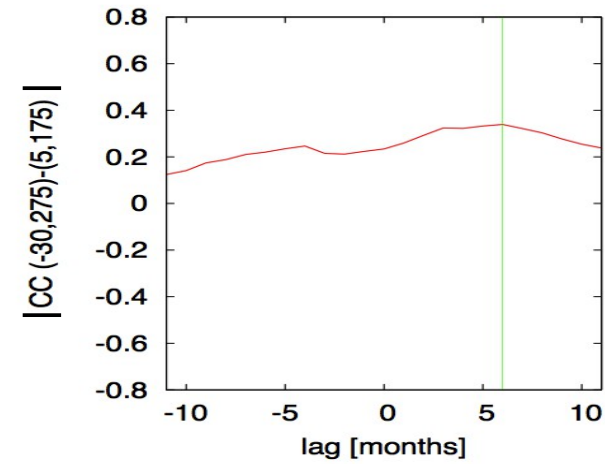
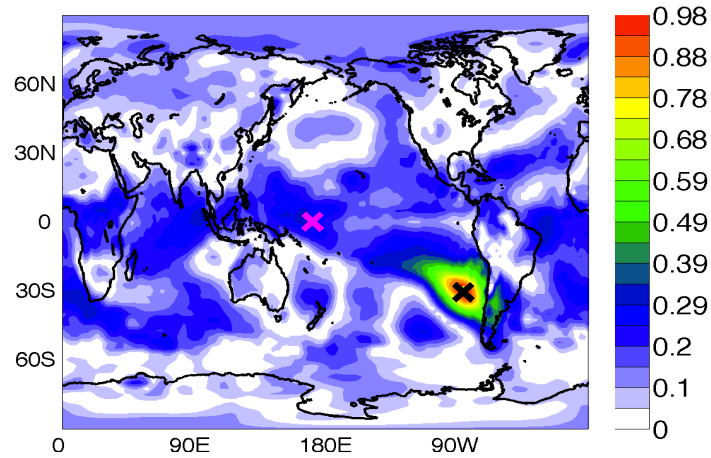


Ran. Lag





Correlations





Conclusions



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Conclusions



We do not see any clear influence of lag time introduction. Why?

- The changes act on little values of time-series statistical similarities and they are very slight.
- Moreover the changes seem not to be far away from a random enhancement, due to slow varying similarity measures with arbitrary lags.



THANK YOU!