Persistent Regime Modes Of Mid-Latitude Variability And Scale Interactions

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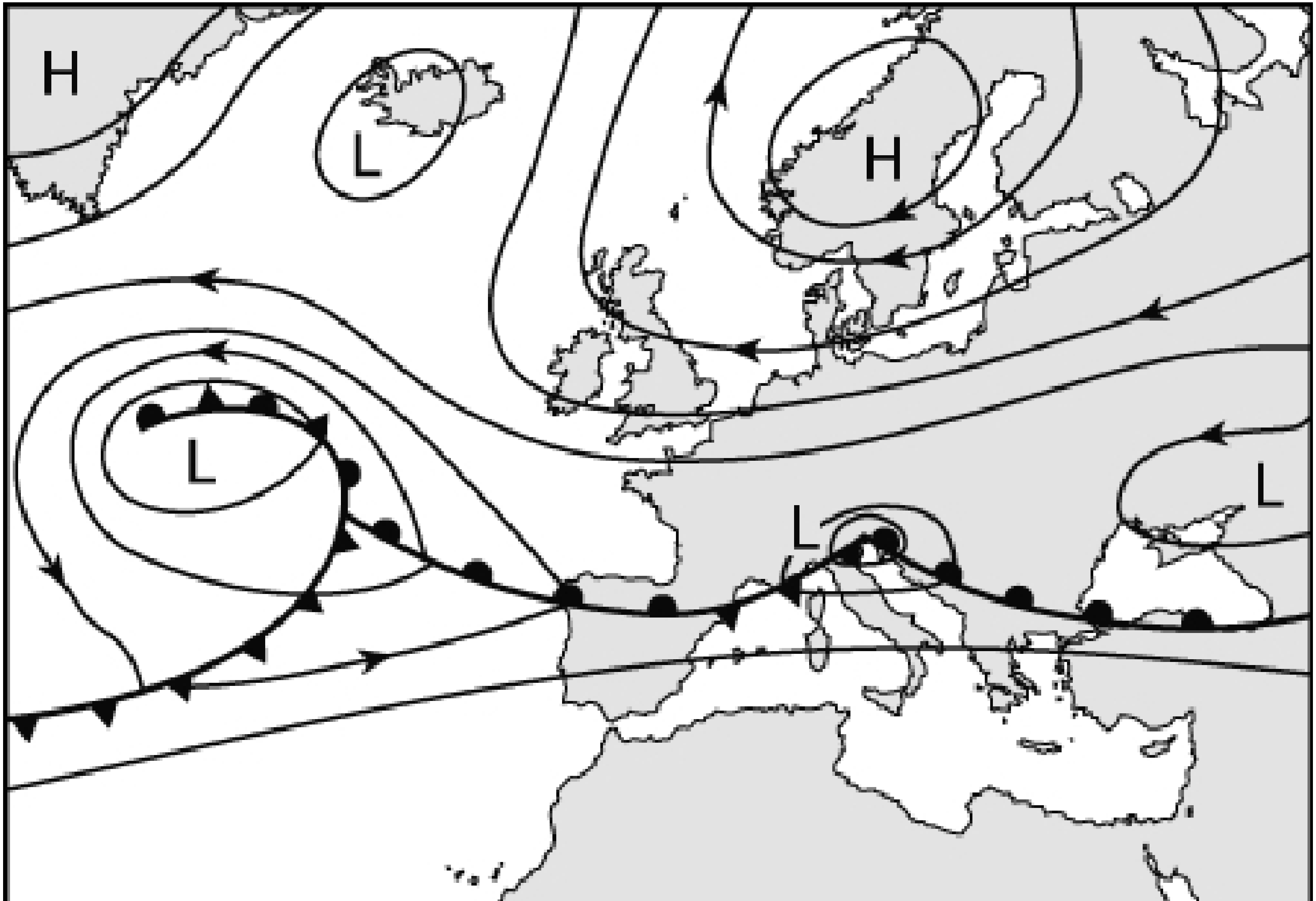
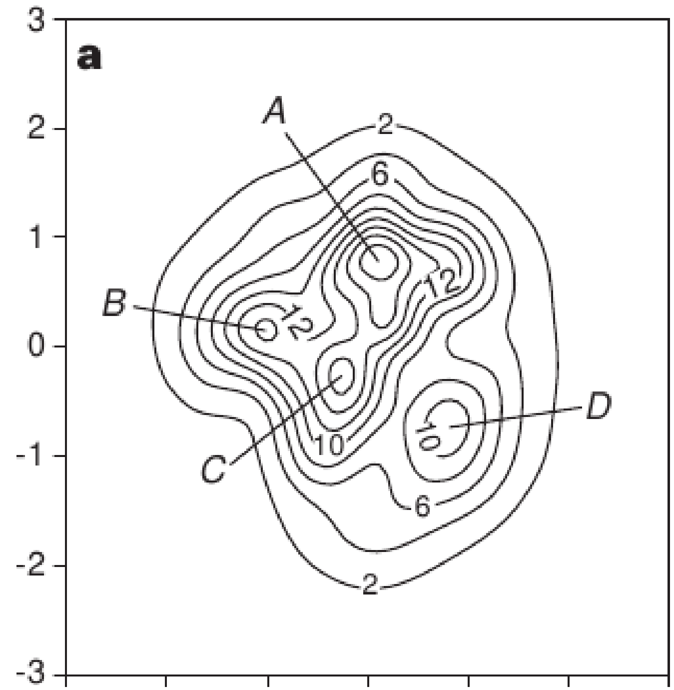
Outline

- Motivation
- Space-Time Clustering
- NH metastable regimes
- Dynamical processes
- SH attribution
- Summary

Motivation

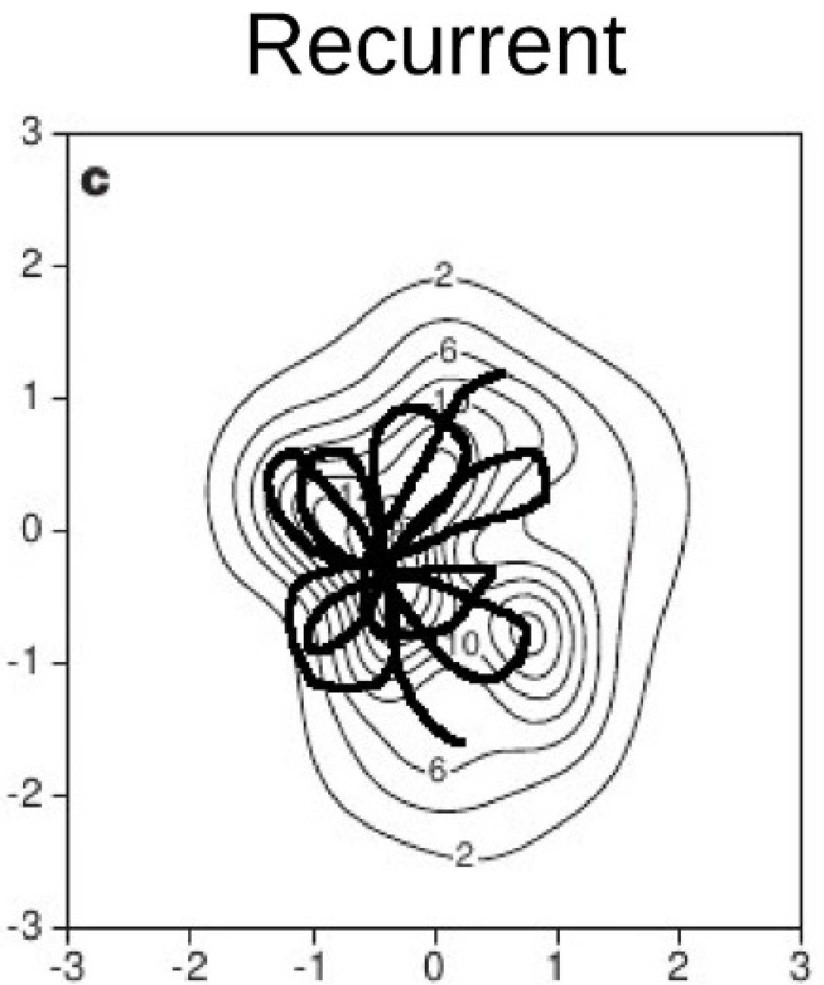


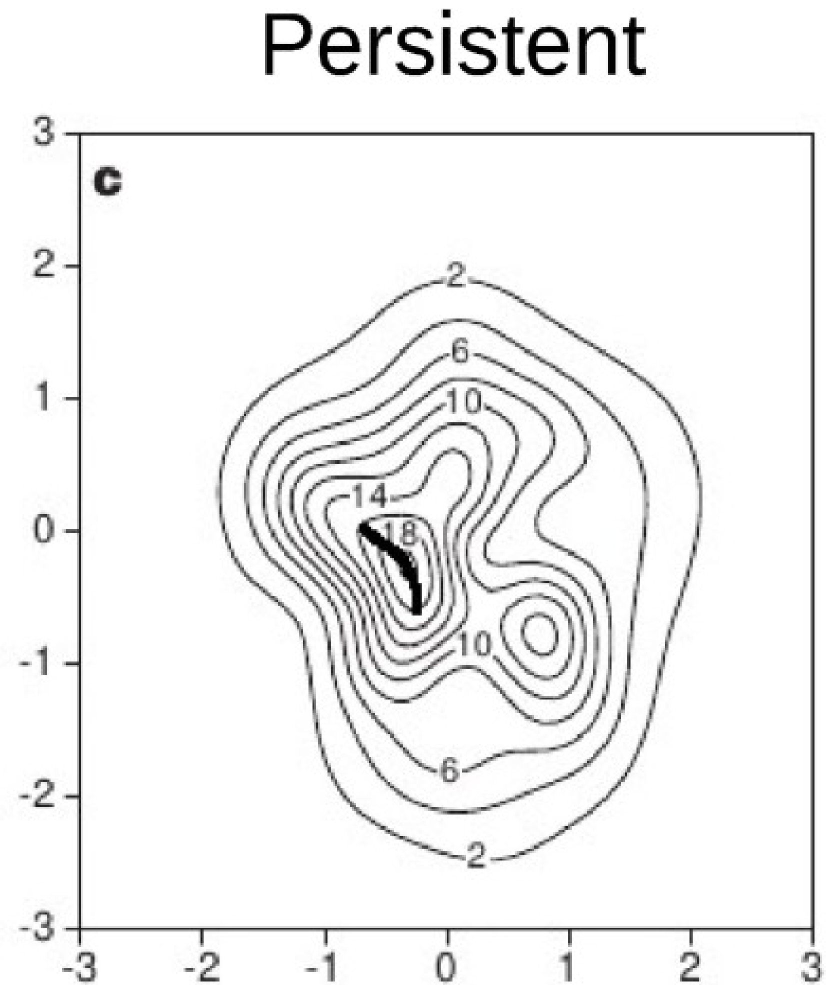
Motivation



Corti et al. 1999

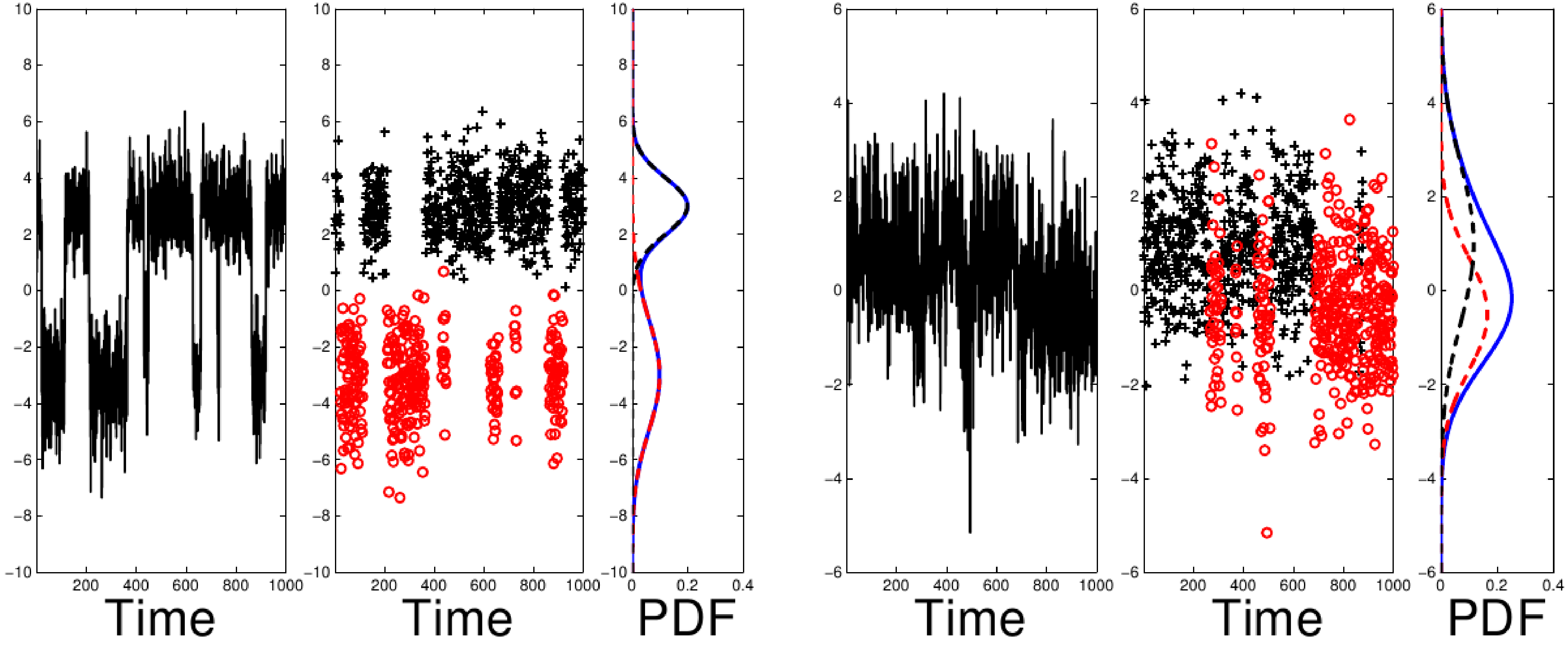
Motivation





Hannachi et al. 2015

Space-Time Clustering



Franzke et al. 2008

Space-Time Clustering

Finite Element, Bounded Variation,
Vector Autoregressive Factor
FEM-BV-VARX method:

$$\mathbf{x}_t = \mu_t + \mathbf{A}_q(t)\phi_1(x_{t-\tau}, \ldots, x_{t-m\tau}) + \mathbf{B}(t)\phi_2(u_t) + \mathbf{C}(t)\epsilon_t$$

Horenko 2010, O'Kane et al. 2013, Franzke et al. 2015

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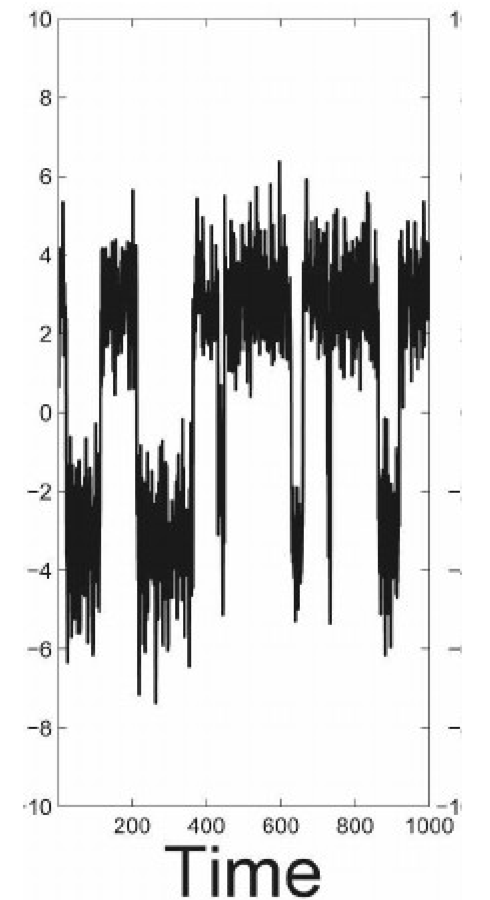
Conditional Mean



Horenko 2010, O'Kane et al. 2013, Franzke et al. 2015

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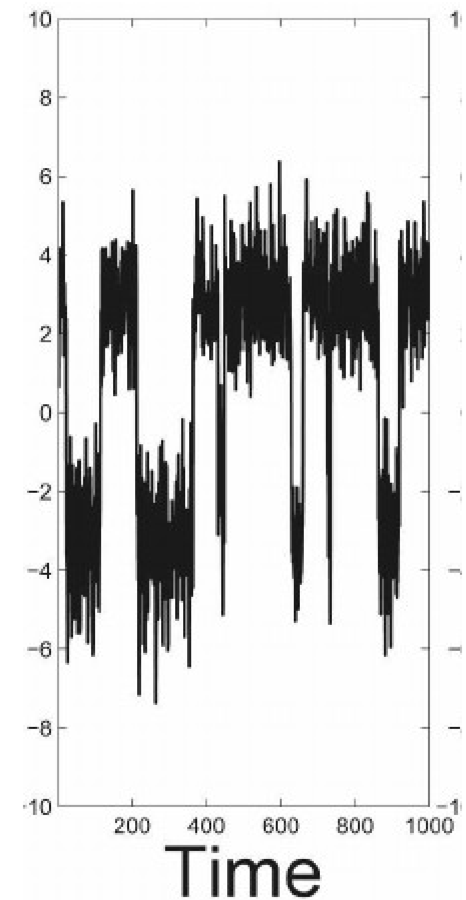
Vector Autoregressive Components



Horenko 2010, O'Kane et al. 2013, Franzke et al. 2015

Space-Time Clustering

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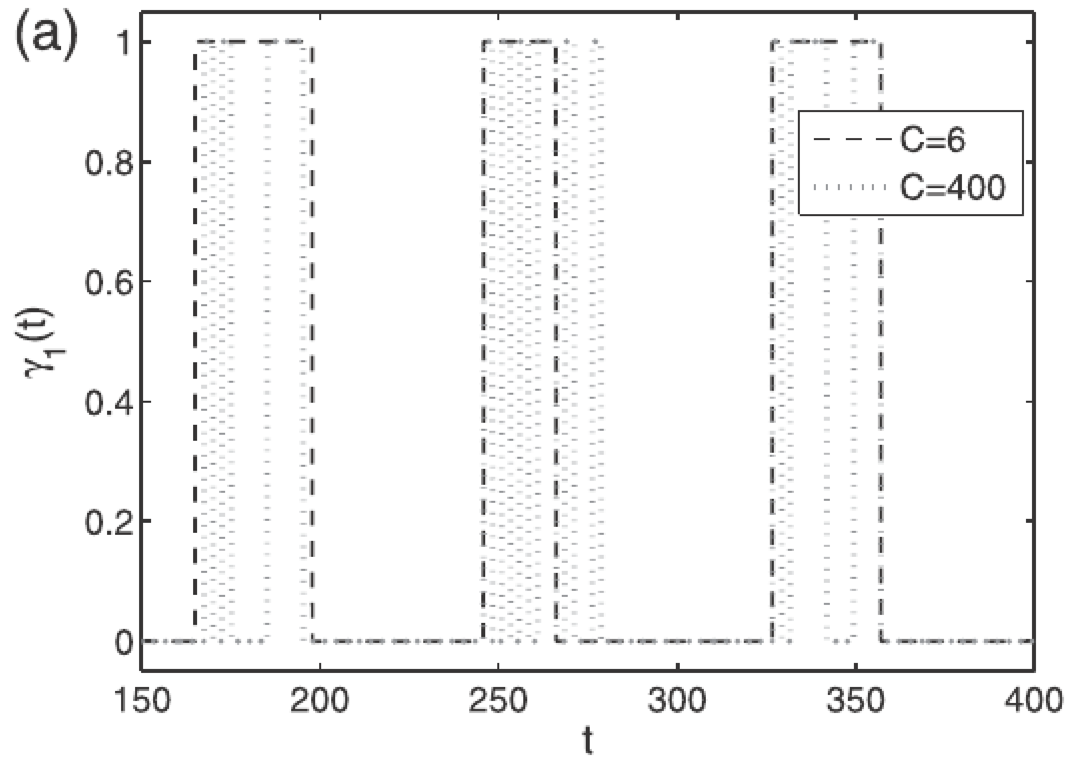
External Factor Component

Horenko 2010, O'Kane et al. 2013, Franzke et al. 2015

Space-Time Clustering

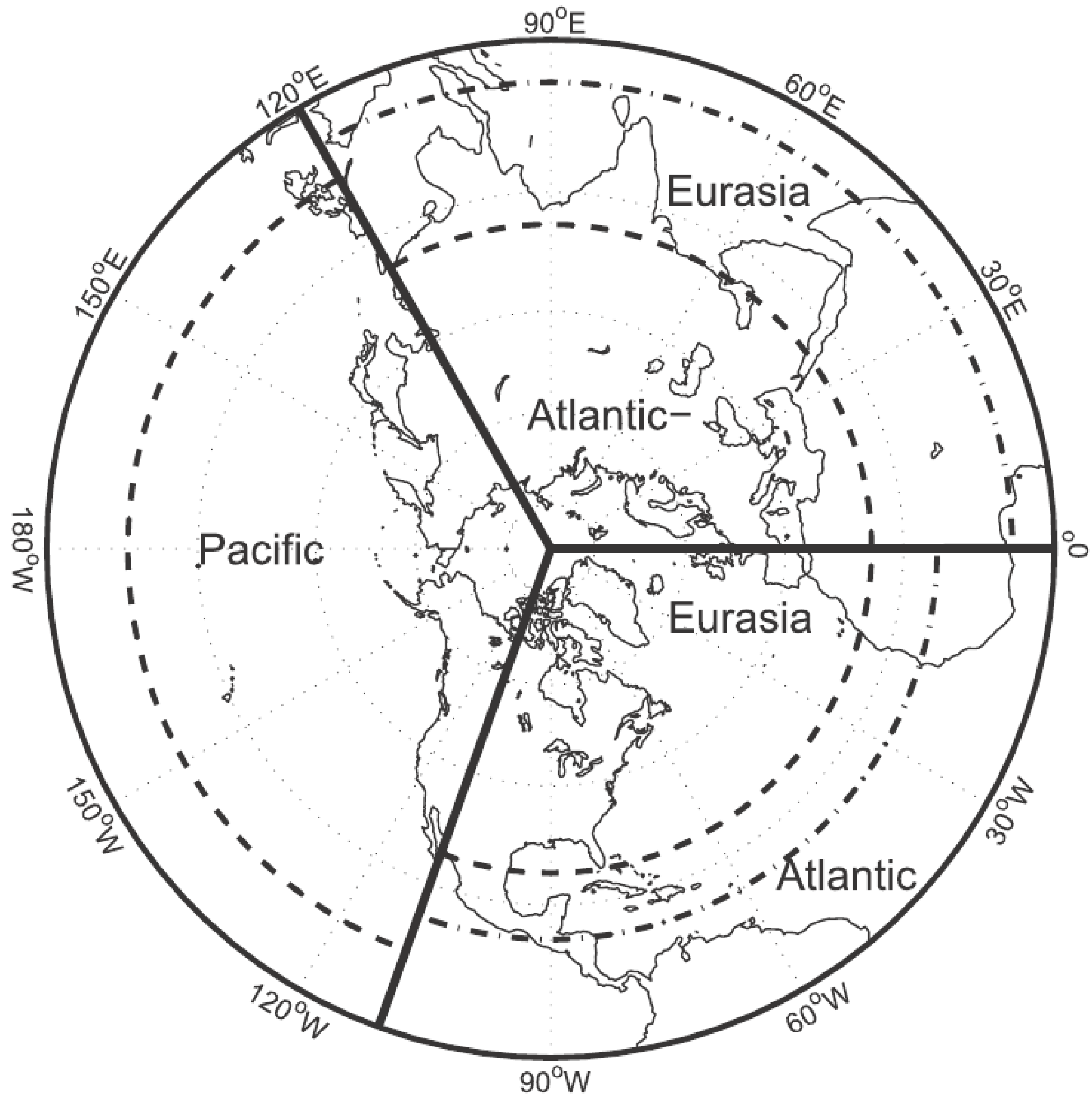


Imposing persistency by enforcing a maximum number of switches

$$|\gamma_i|_{\mathrm{BV}(0,T)} = \sum_{t=0}^{T-1} |\gamma_i(t+1) - \gamma_i(t)| \leq C,$$

Horenko 2010, O'Kane et al. 2013, Franzke et al. 2015

NH Metastable Regimes



Risbey et al. 2015

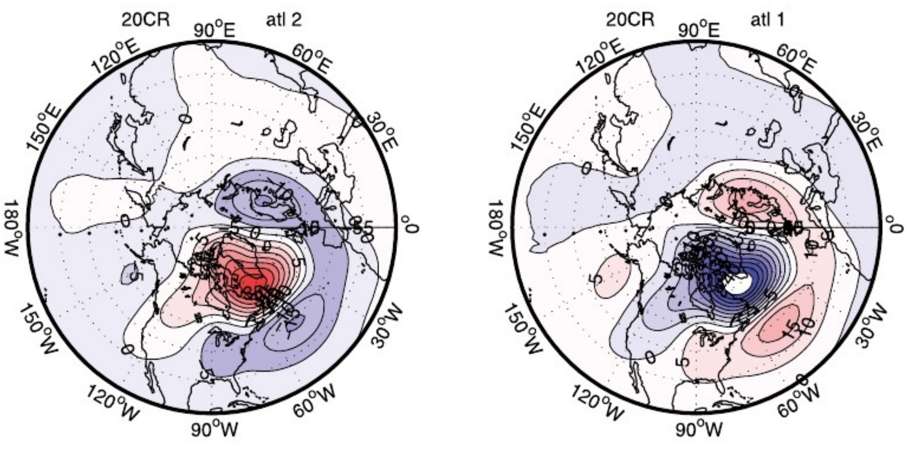
NH Metastable Regimes

TABLE 1. Periods used for the FEM-BV-VARX analysis for the given reanalysis.

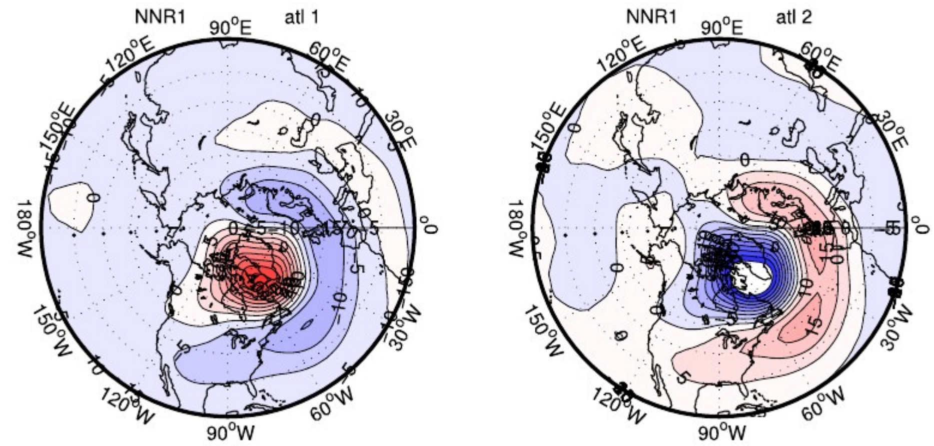
Expt	Reanalysis	Period
1	20CR	1871–2009
2	20CR	1948–2009
3	NNR1	1948–2009
4	NNR1	1979–2009
5	CFSR	1979–2009

Risbey et al. 2015

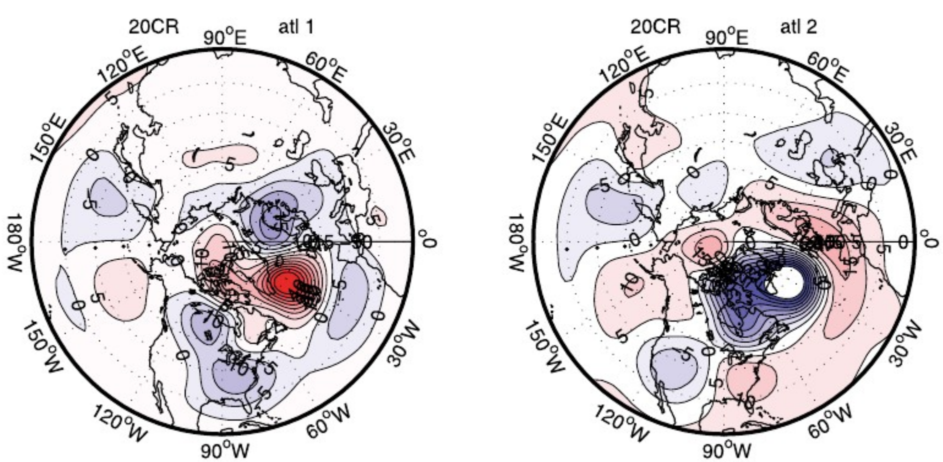
North Atlantic Regimes



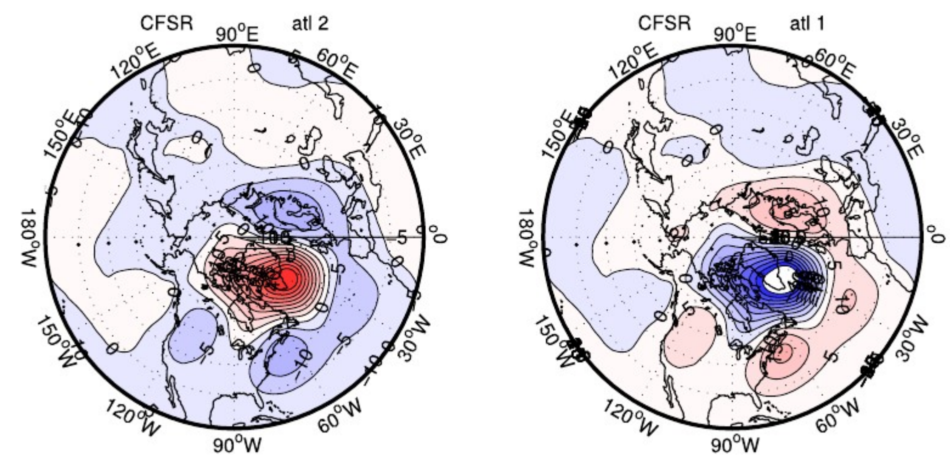
(a) 20CR 1871–2009



(c) NNR1 1948–2009



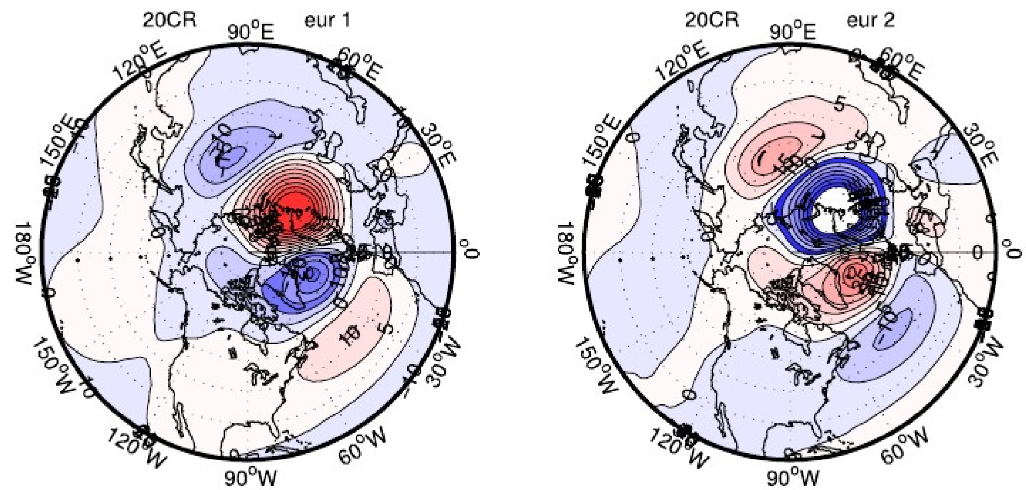
(b) 20CR 1948–2009



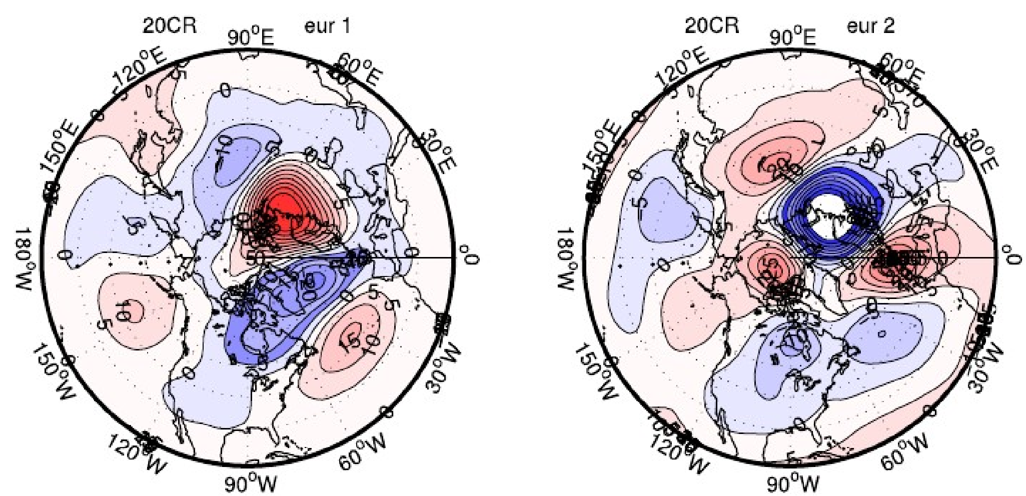
(d) CFSR 1979–2009

Risbey et al. 2015

Eurasian Regimes



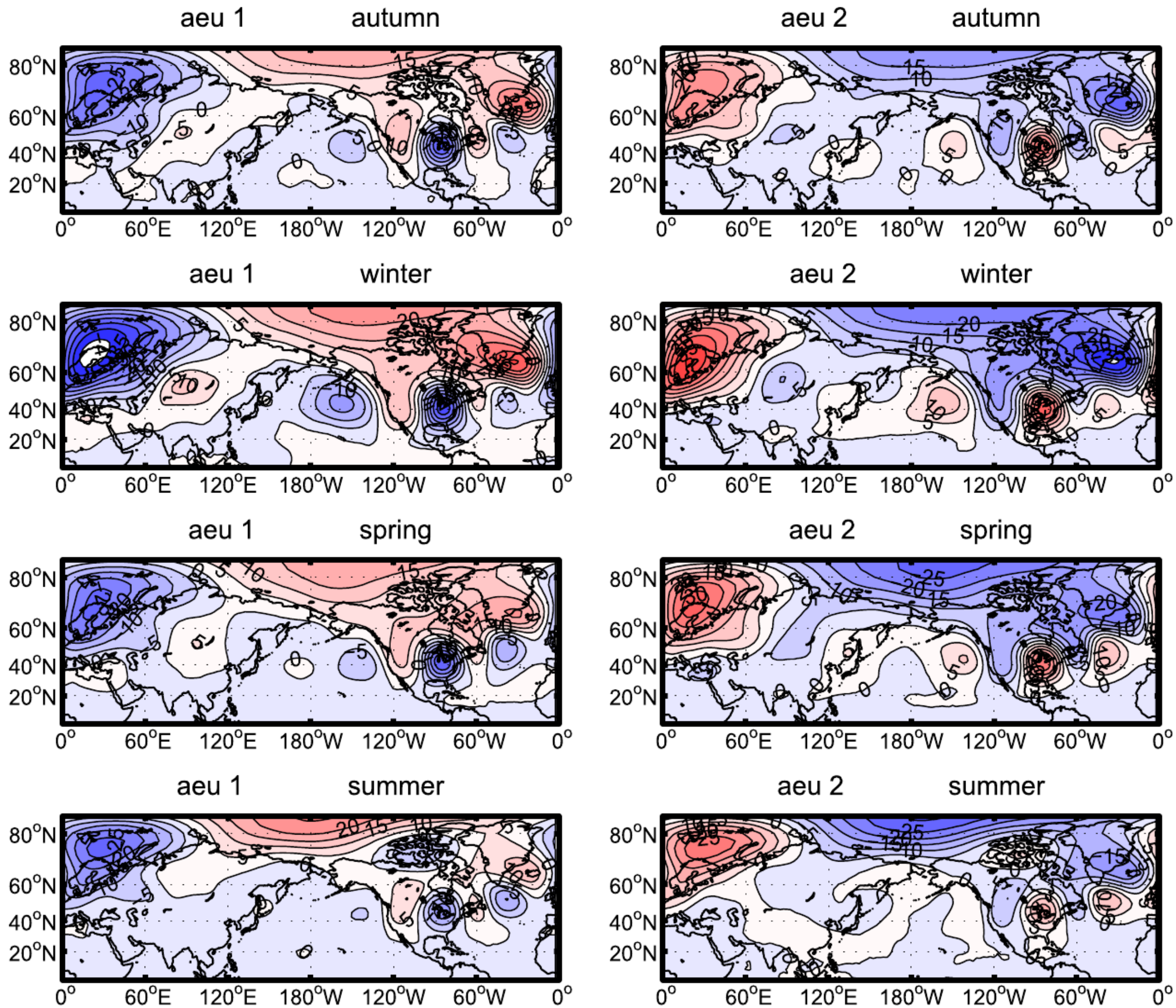
(a) 20CR 1871–2009



(b) 20CR 1948–2009

Risbey et al. 2015

Atlantic-Eurasian Regimes

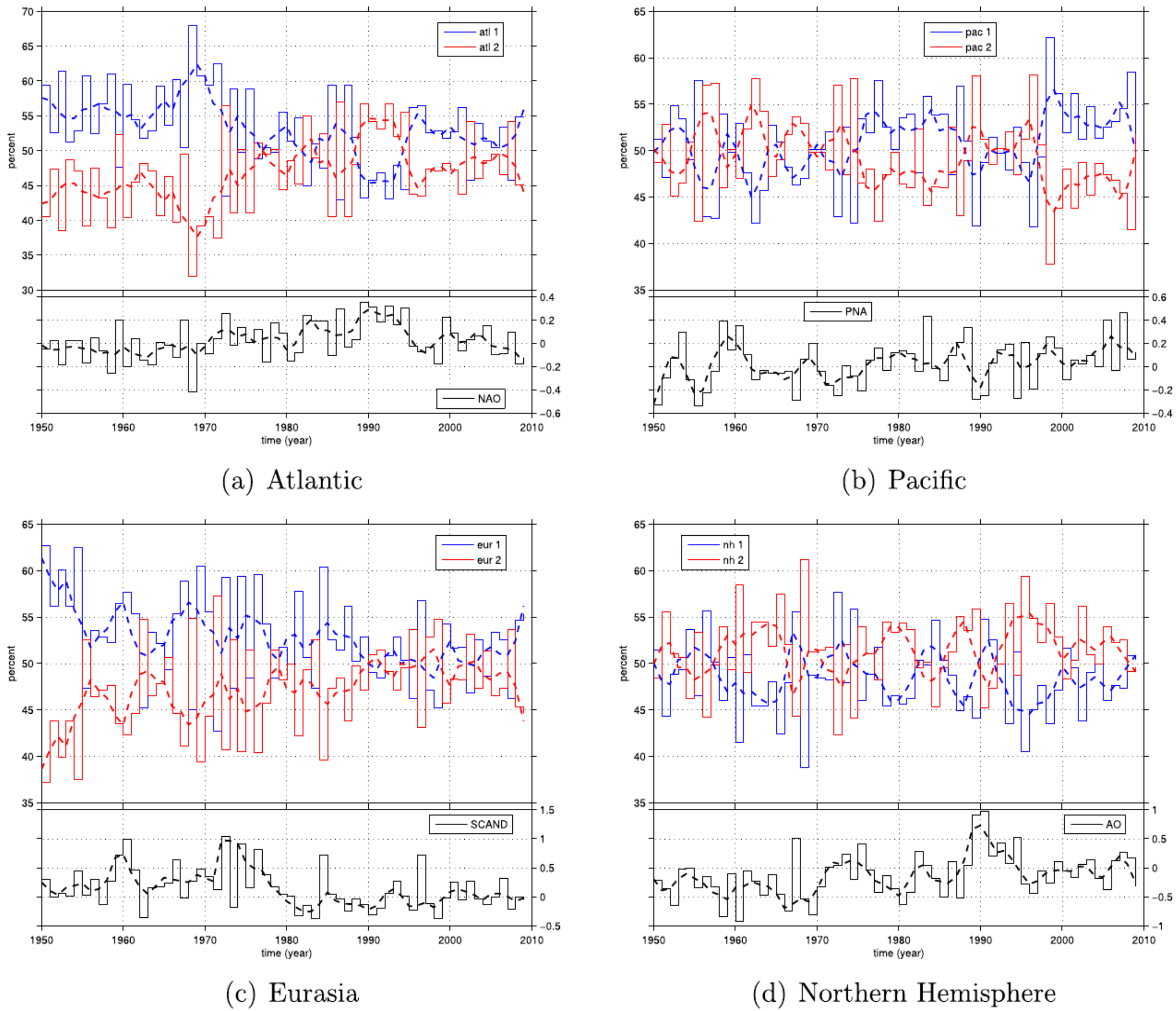


Risbey et al. 2015

Interannual Regime Variability

Corr=0.76

0.41

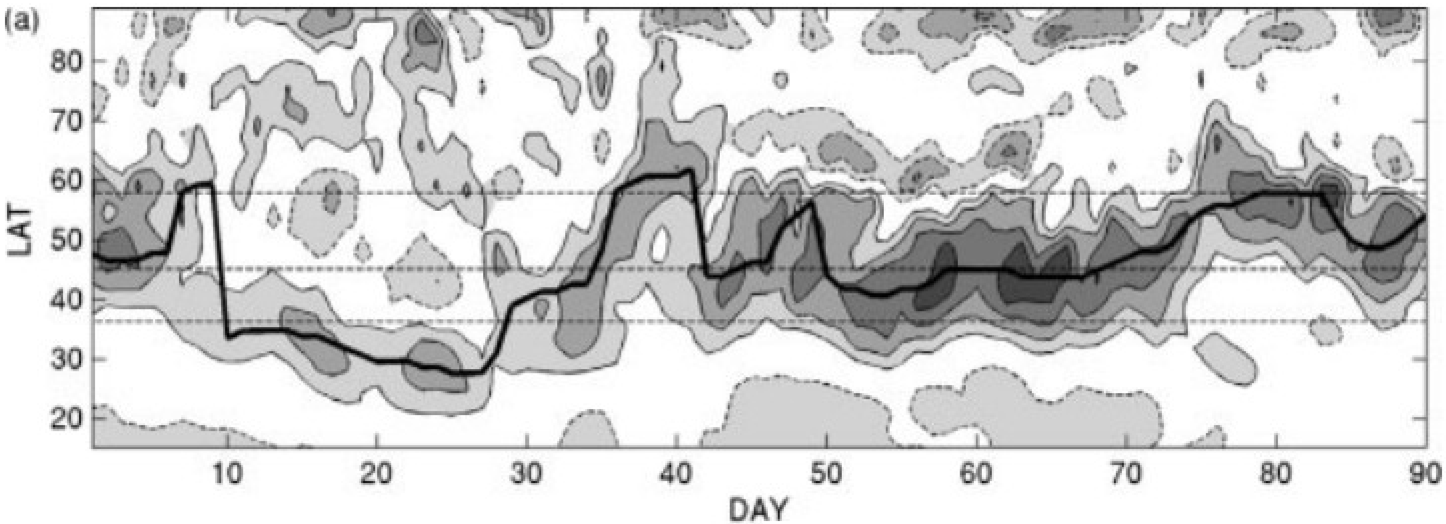


0.57

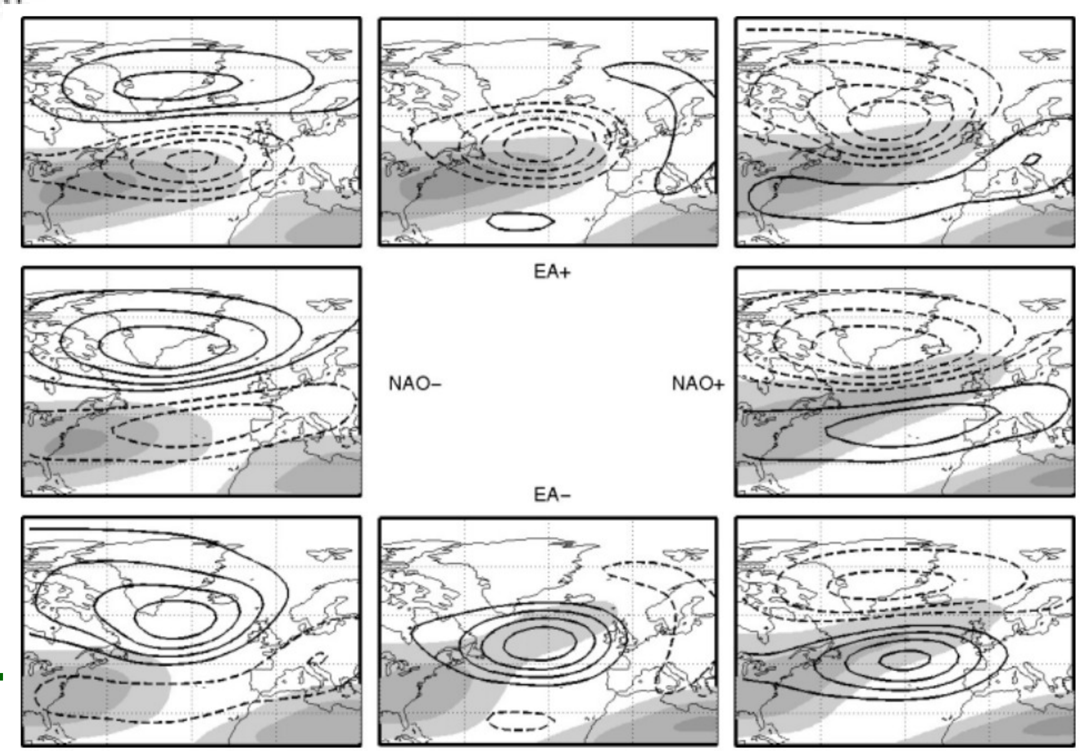
0.35

Risbey et al. 2015

North Atlantic Jet Stream

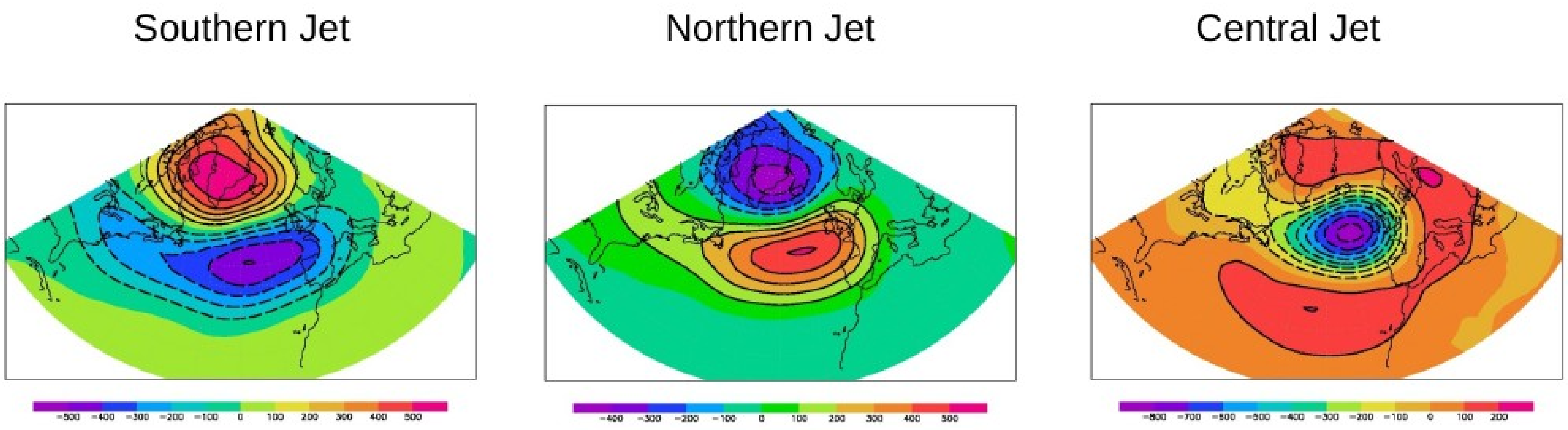


Jet Latitude Index



Woollings et al. 2010

North Atlantic Jet Stream

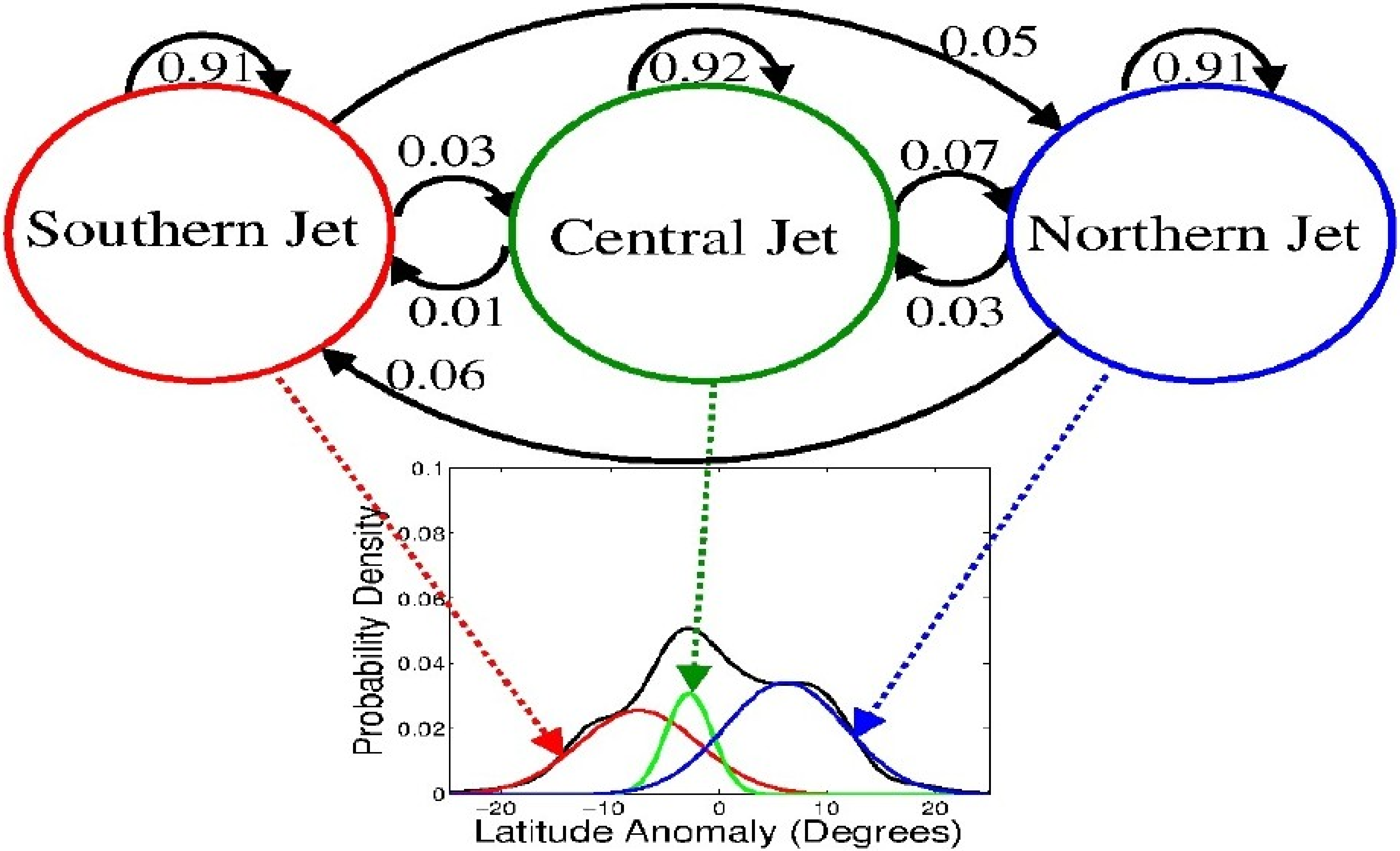


Anomalous 500 hPa Geopotential Height (Annual cycle subtracted)

Mixture of NAO and EA teleconnection Patterns (Woollings et al. 2010)

Franzke et al. 2011

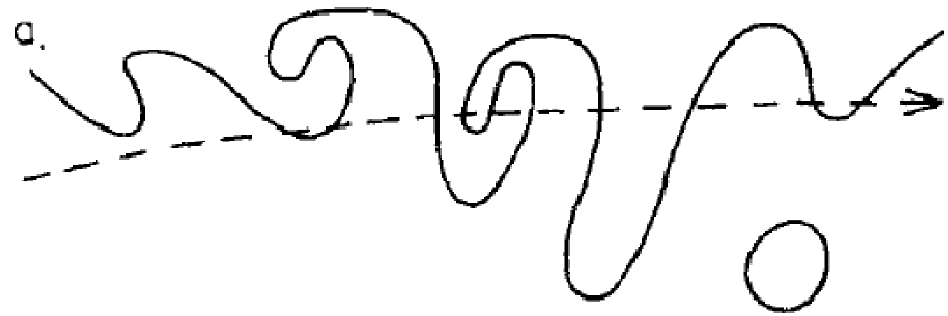
North Atlantic Jet Stream



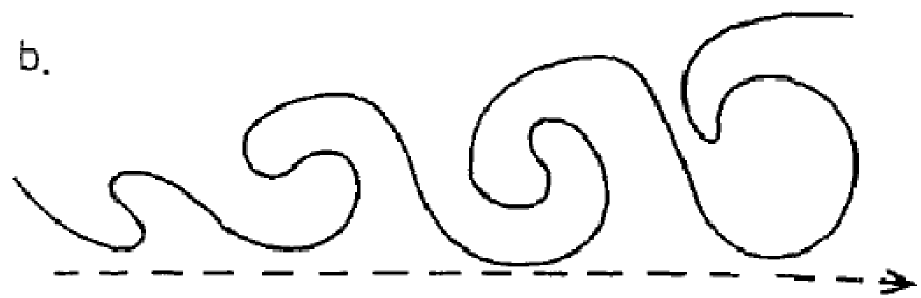
Franzke 2015

North Atlantic Jet Stream

LC1 (Anticyclonic)



LC2 (Cyclonic)



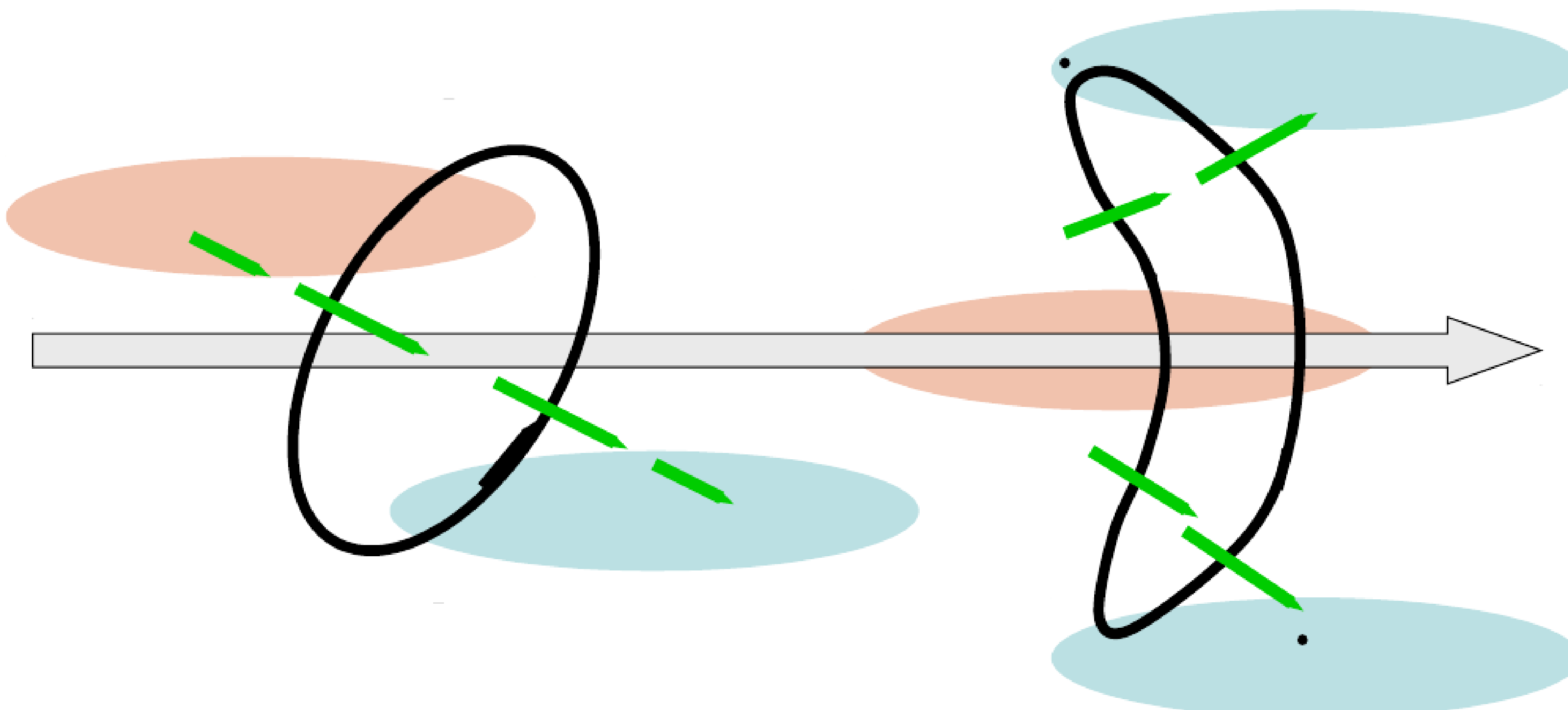
Side of jet determines shear, and so
also the direction of wave-breaking

North Atlantic Jet Stream

E Vectors ~ wave activity flux

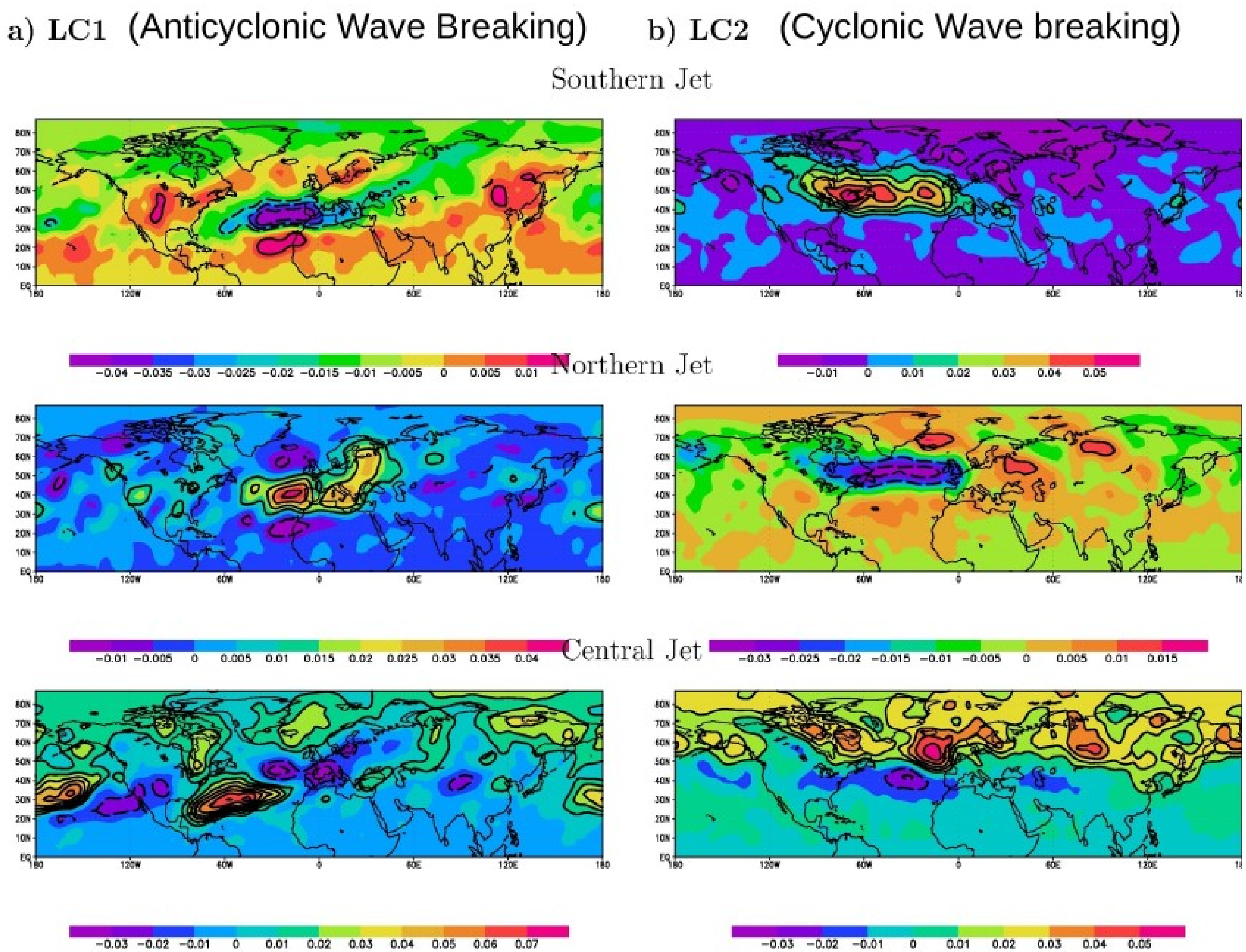
Divergence : Accelerates westerlies

Convergence : Decelerates westerlies



Hoskins et al 83

North Atlantic Jet Stream

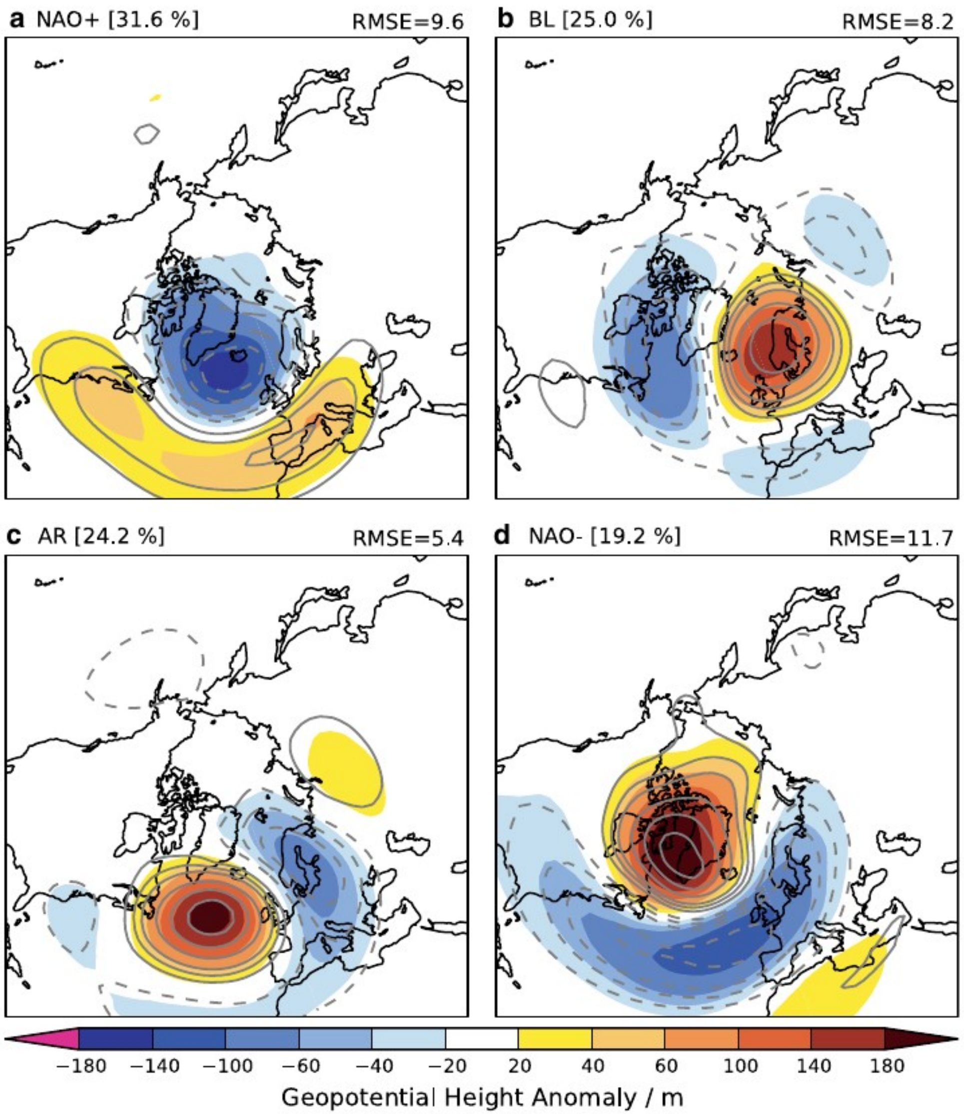


Rossby Wave Breaking; ECMWF reanalysis

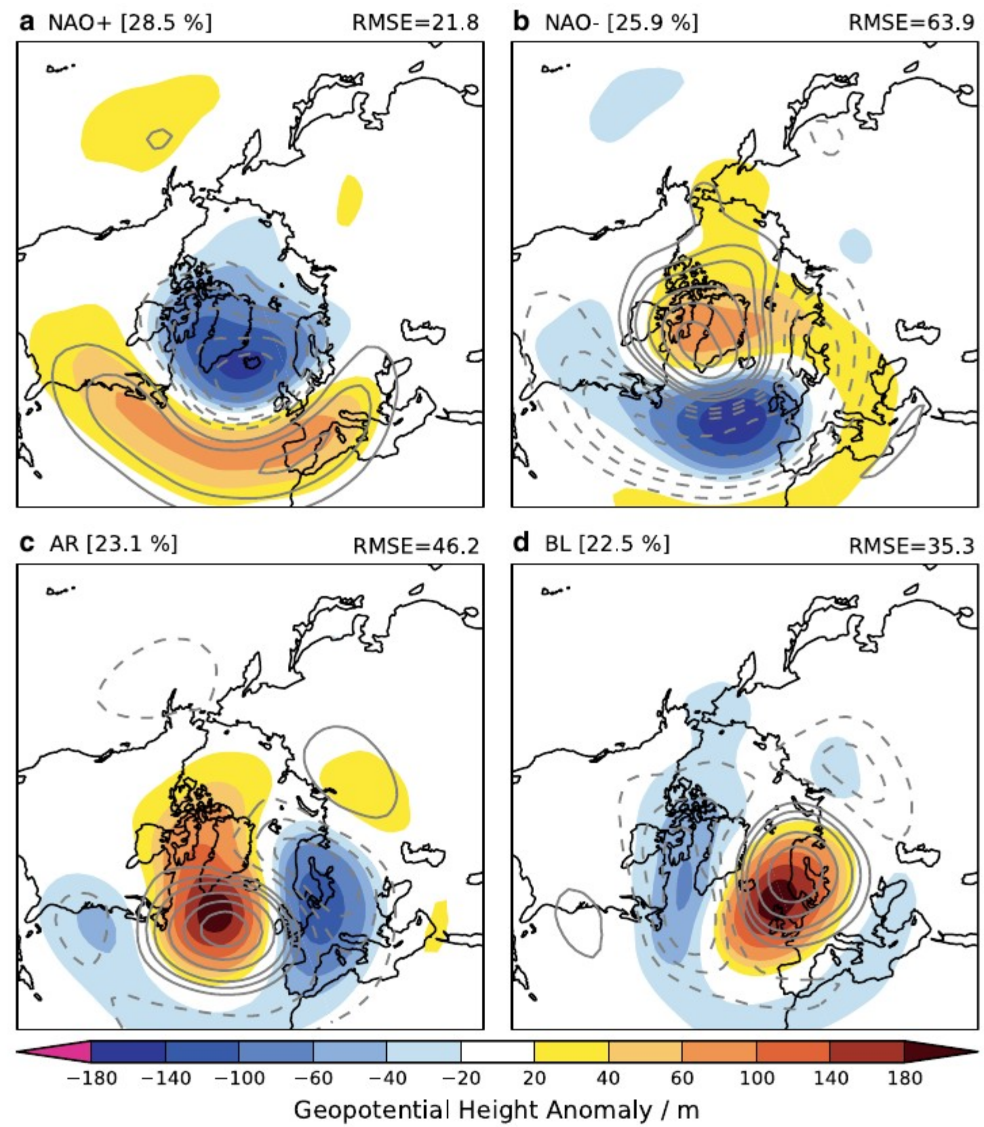
Franzke et al. 2011

Regime Simulations

T1279



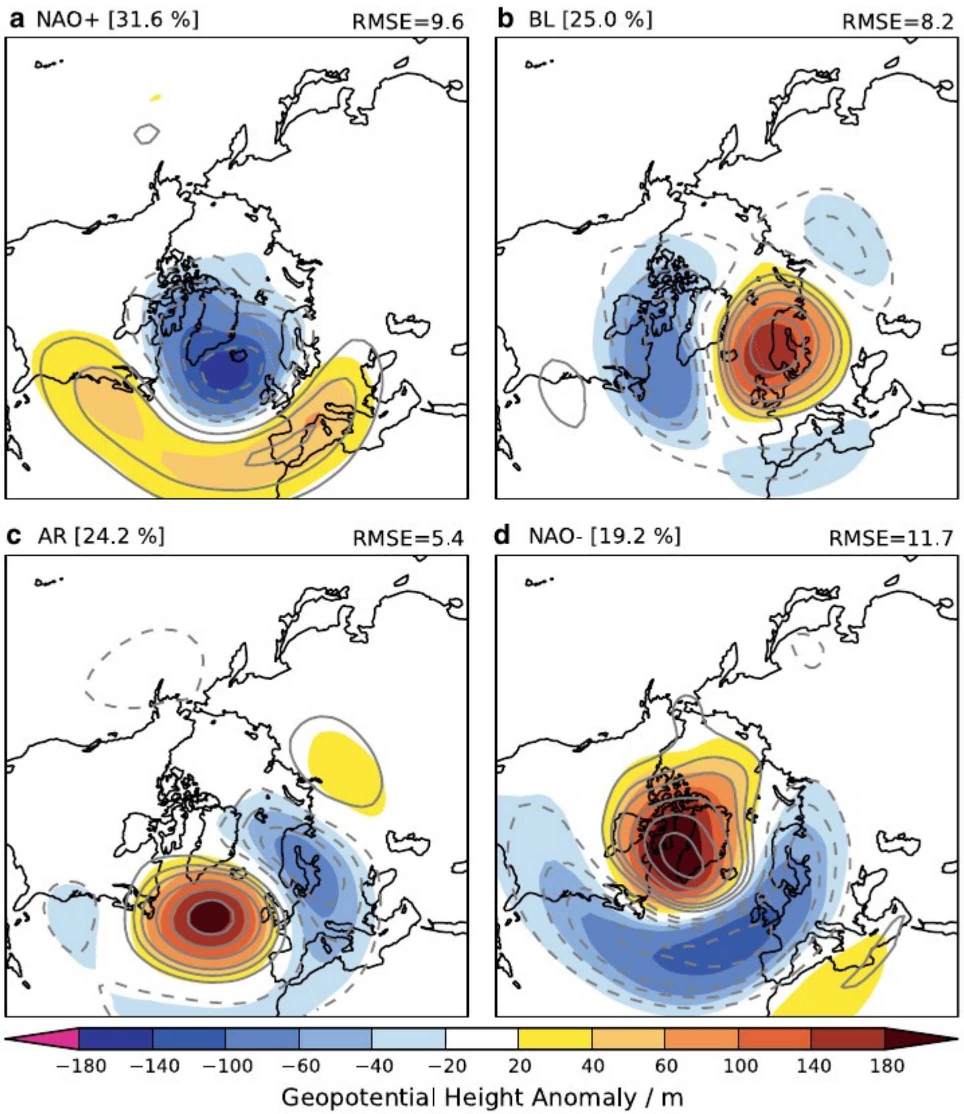
T159



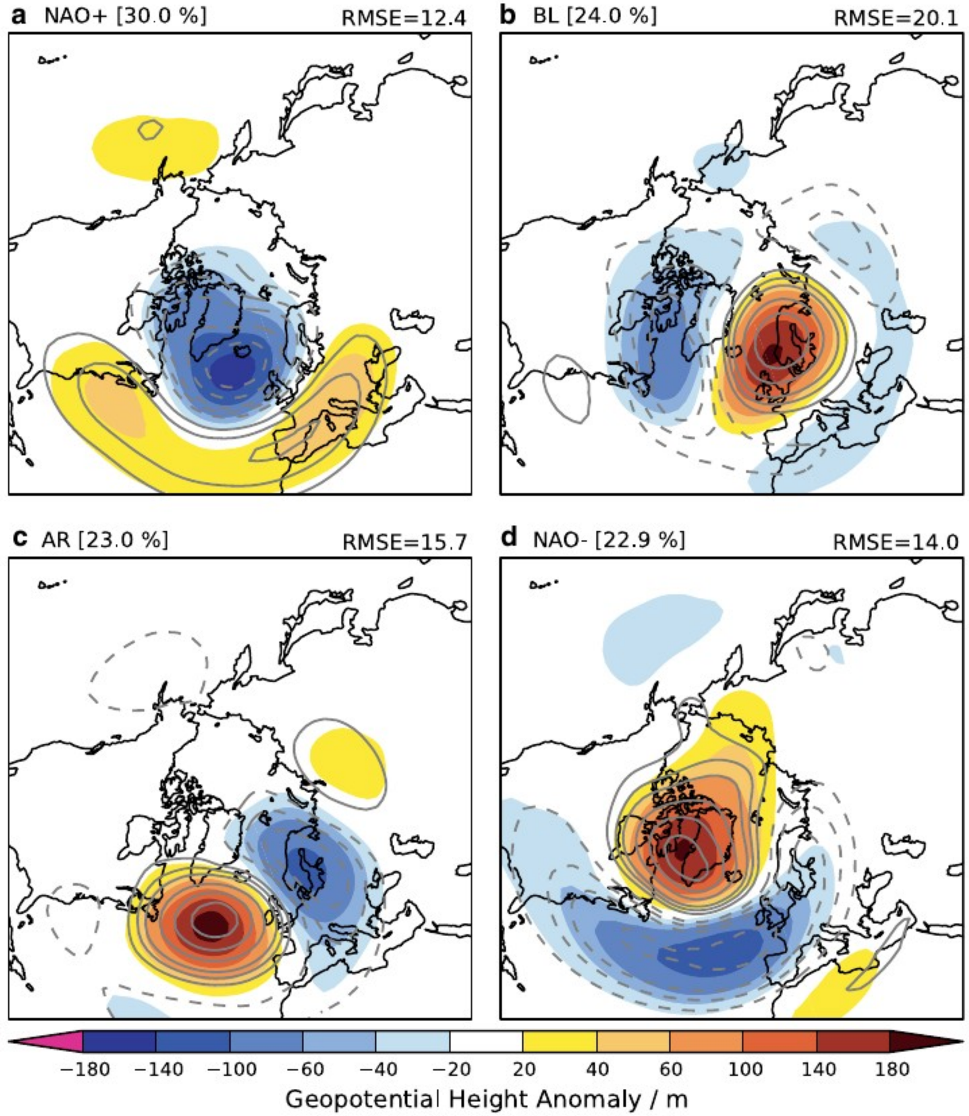
Dawson and Palmer 2014

Regime Simulations

T1279



T159, Stochastic Physics



Dawson and Palmer 2014

Attribution of Secular Changes

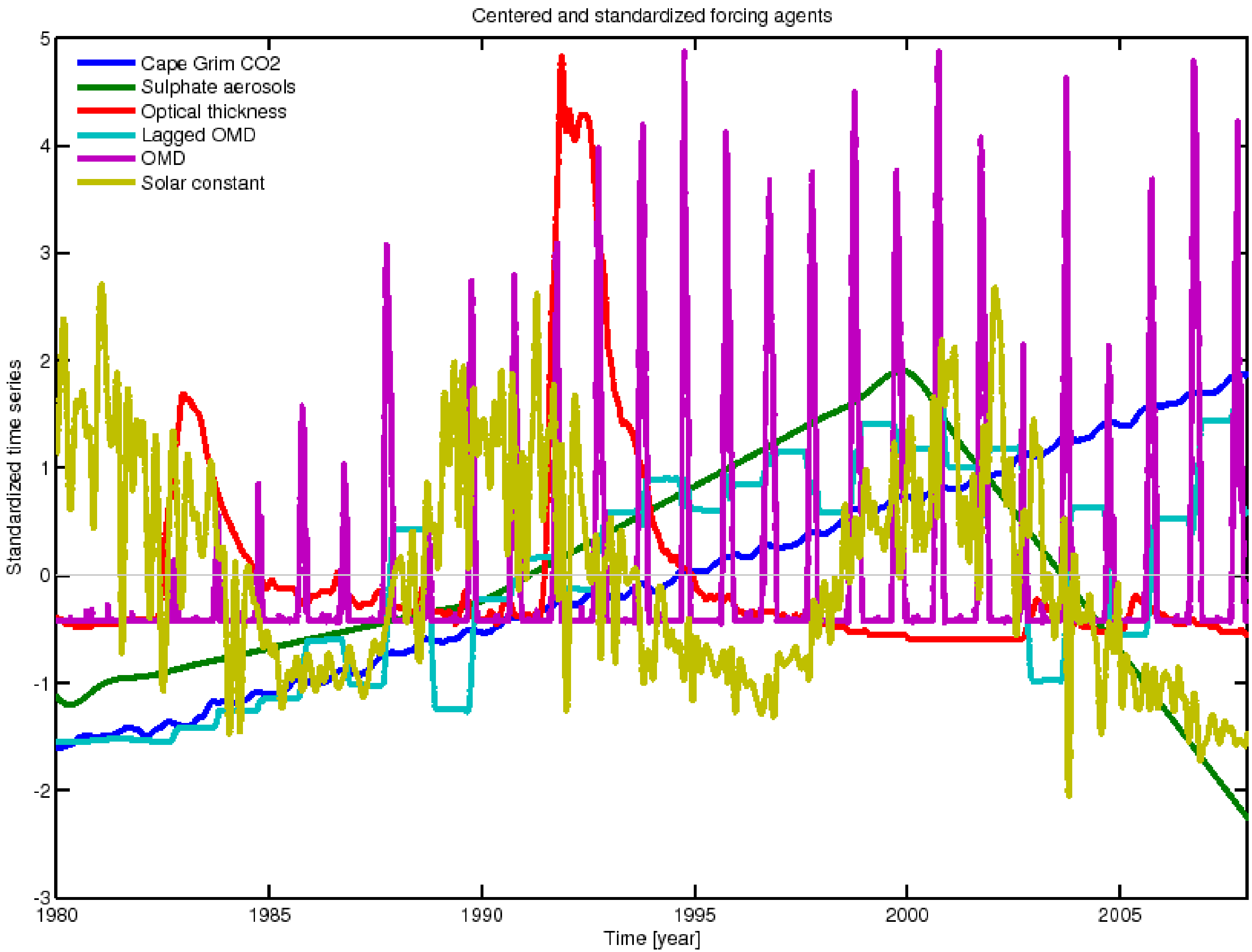
Finite Element, Bounded Variation, Vector Autoregressive Factor
FEM-BV-VARX method:

$$\mathbf{x}_t = \mu_t + \mathbf{A}_q(t)\phi_1(x_{t-\tau}, \ldots, x_{t-m\tau}) + \mathbf{B}(t)\phi_2(u_t) + \mathbf{C}(t)\epsilon_t$$

External Factor Component

Franzke et al. 2015

SH Secular Circulation Trends

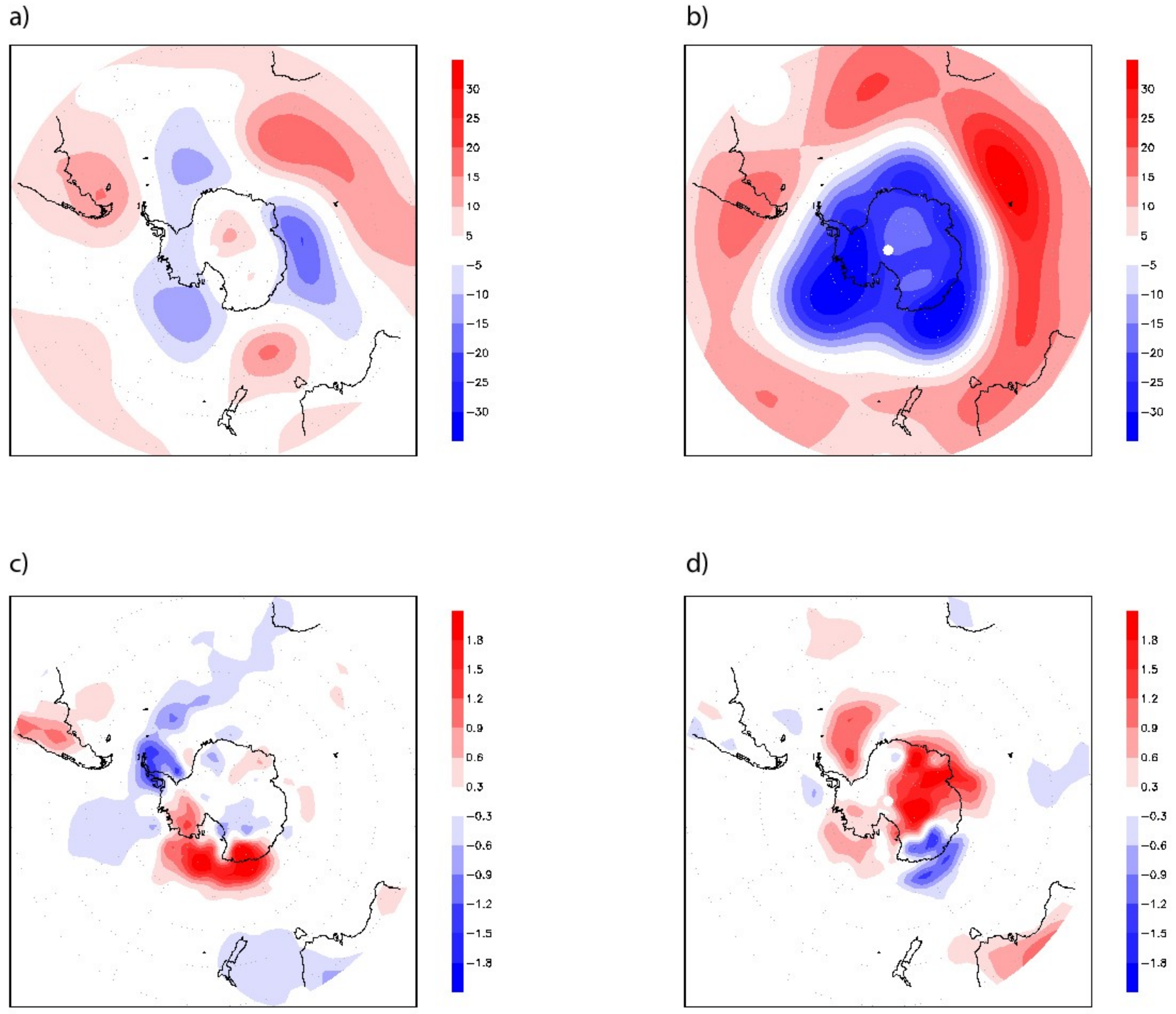


Franzke et al. 2015

SH Secular Circulation Trends

500 hPa Geopotential

Surface Air Temperature



Franzke et al. 2015

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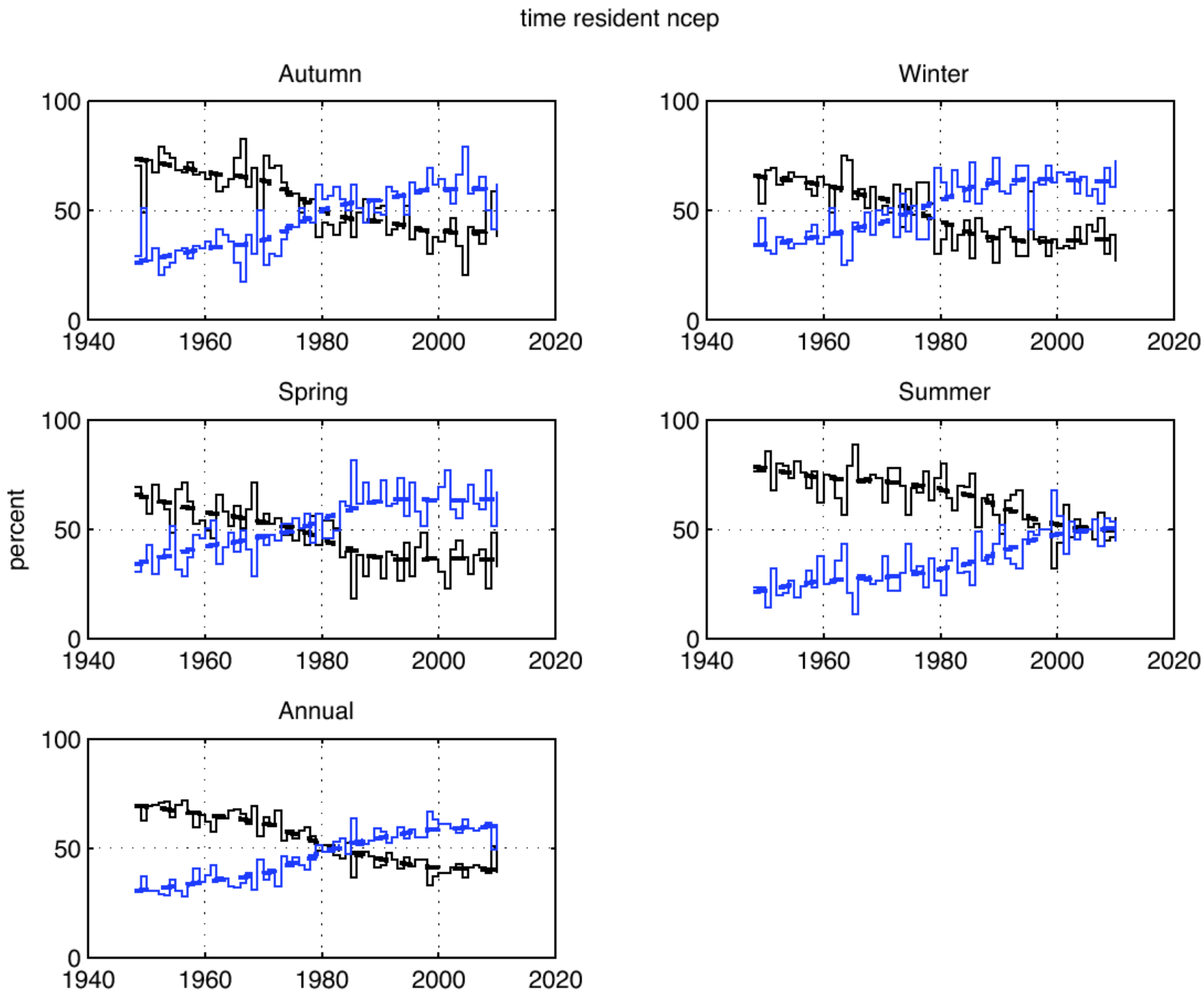


Franzke et al. 2015

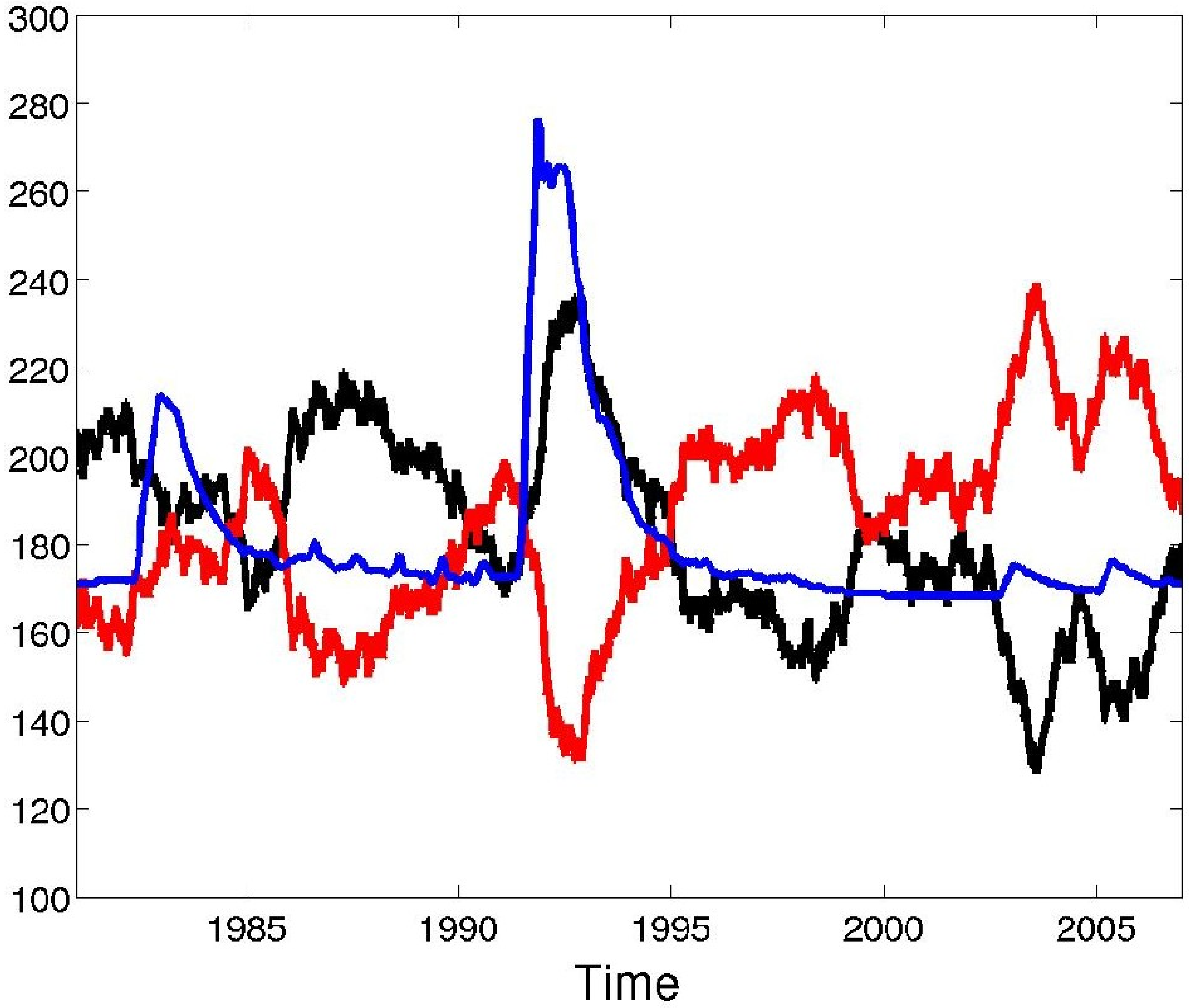
SH Secular Circulation Trends

Attribution Results:

- CO_2 AIC_{min}= 63053
- Akaike weight value reveals strong statistical support of CO_2 compared to stratospheric Ozone: w_i=3.1083e^{-18}
- → Recovery of ozone has less relevance to changes in Southern Hemisphere extratropical circulation than projected in many modelling studies (e.g. Barnes et al., 2013; Shindell et al., 2004)

Franzke et al. 2015

SH Secular Circulation Trends



Franzke et al. 2015

Summary

- Space-Time Clustering
  - Non-Stationary clustering approach
  - In NH all important teleconnection have been found
- Attribution of secular changes
  - In SH CO_2 is more important than Ozone → Recovery of Ozone hole might have less relevance than previously claimed

References

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