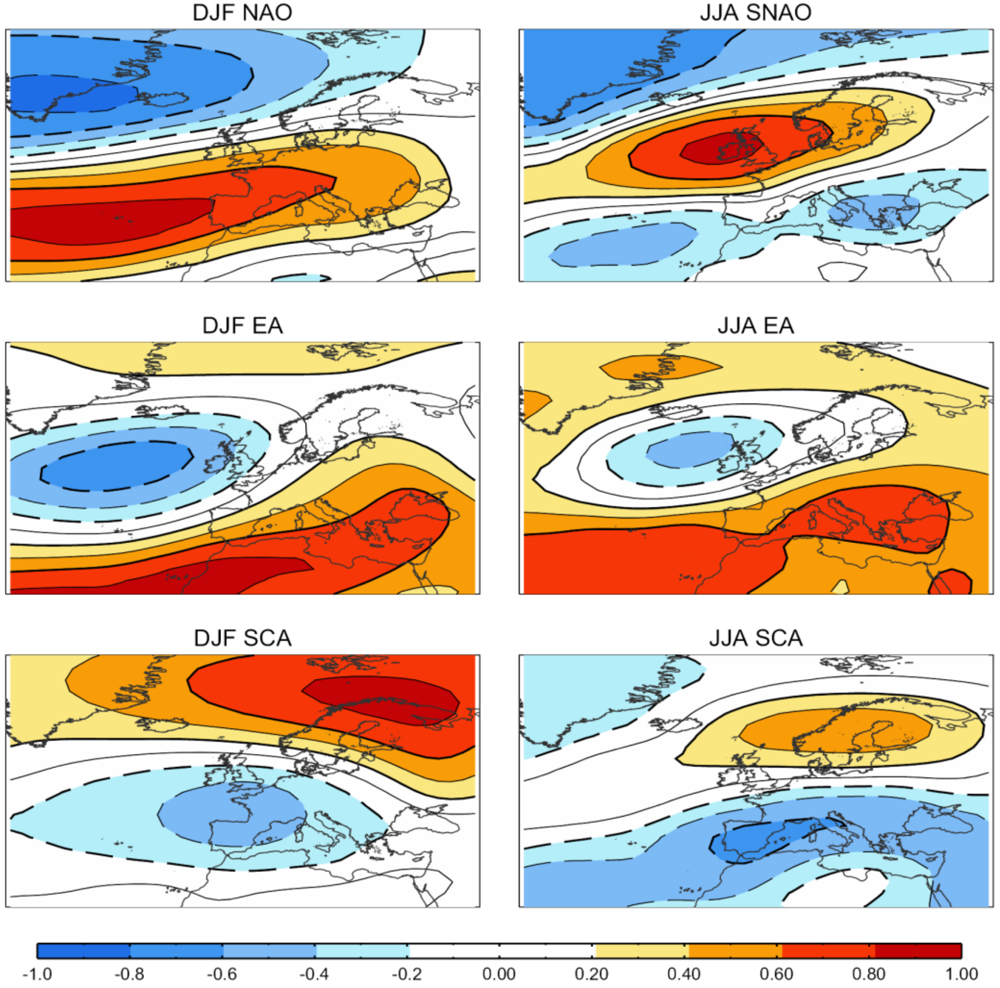
Examining the NAO-EA relationship and jet variability sin 1685

Javier Mellado-Cano , David Barriopedro , Ricardo García-Herrera Ricardo M. Trigo, Armand Hernández

Historical Climatology. CL1.20 Scheduled for a live chat on Monday, 04 May 2020, 16:15-18:00

European Atmospheric circulation



Main modes of atmospheric variability over the Euro-Atlantic sector for winter (December-to-February, left panels) and summer (June-to-August, right panels), as shown by correlation maps between the seasonal time series of the indices and geopotential height at 500 hPa for the 1951-2018 period

Main **large-scale atmospheric circulation driver** of **European climate** variability

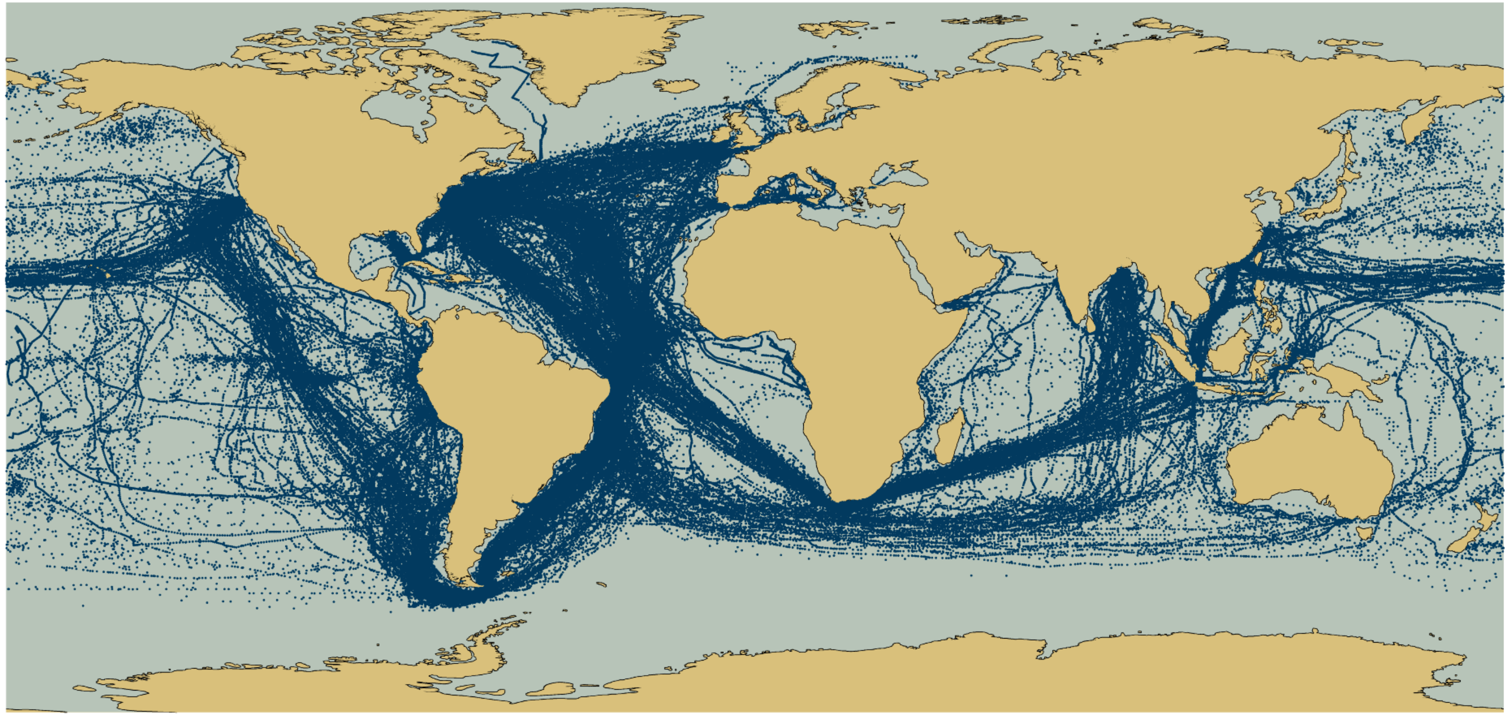
- The North Atlantic Oscillation (NAO) is the main pattern of atmospheric variability
- The East Atlantic pattern (EA) is the second pattern of climate variability

Longest instrumental-based reconstruction :
NAO ---18th century
EA --- mid 19th century

Can we extend beyond the instrumental period these índices?

Ship’s logbooks

- **Ships’ logbooks** provide **enough number** of wind direction **observations** in many parts of the world.
- These **observations** allow allow the **construction** of **almost continuous** time series of **atmospheric circulation beyond the instrumental period**.



Wind direction observations from ICOADS for the period 1663-1857 in blue dots.

Over the **Euro-Atlantic sector**: Mellado-Cano et al. 2019 developed the **Directional Indices (1685-2014)**

Open Access | Published: 07 November 2019

New observational insights into the atmospheric circulation over the Euro-Atlantic sector since 1685

Javier Mellado-Cano, David Barriopedro, Ricardo García-Herrera & Ricardo M. Trigo

Climate Dynamics **54**, 823–841(2020) | Cite this article

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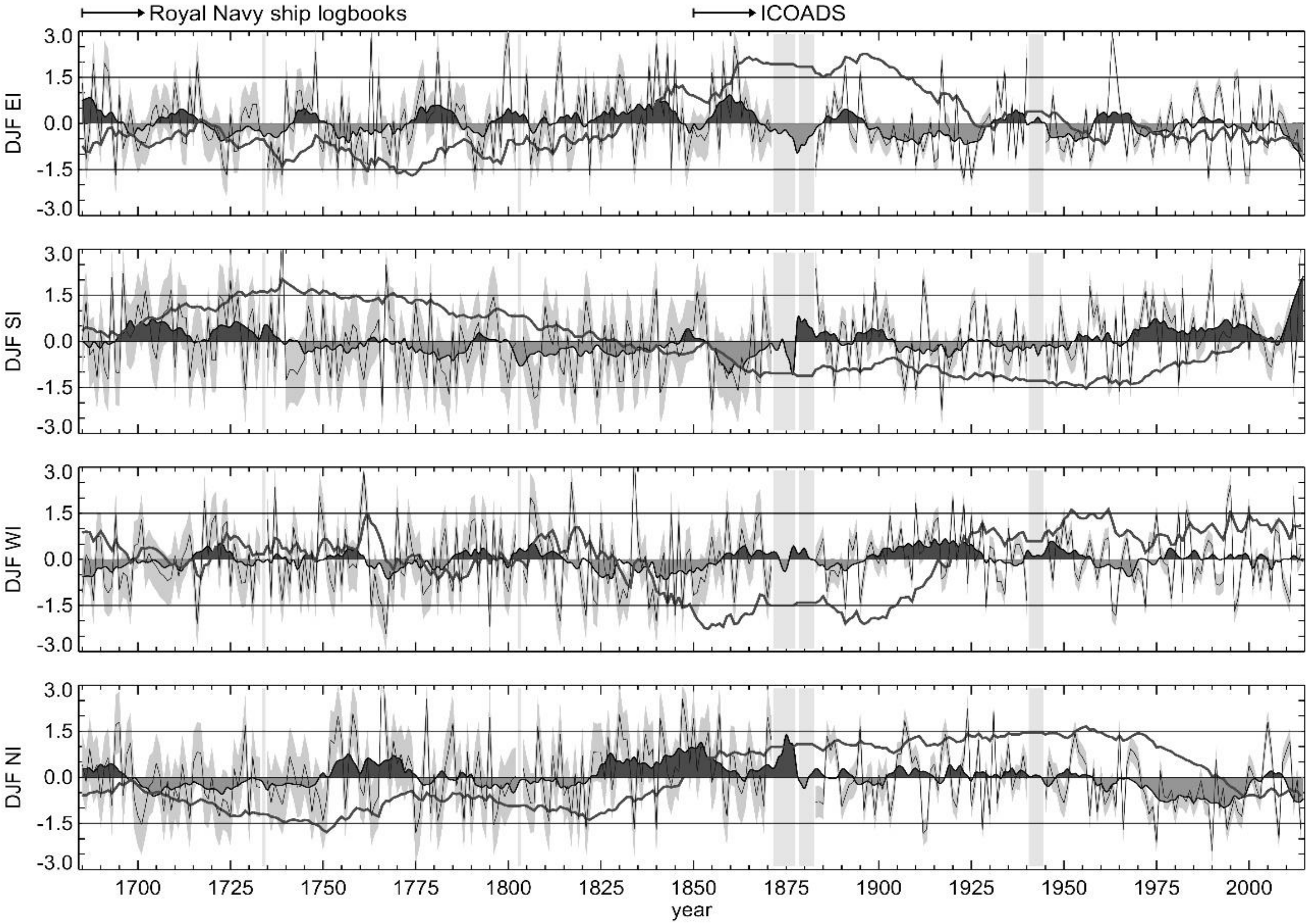
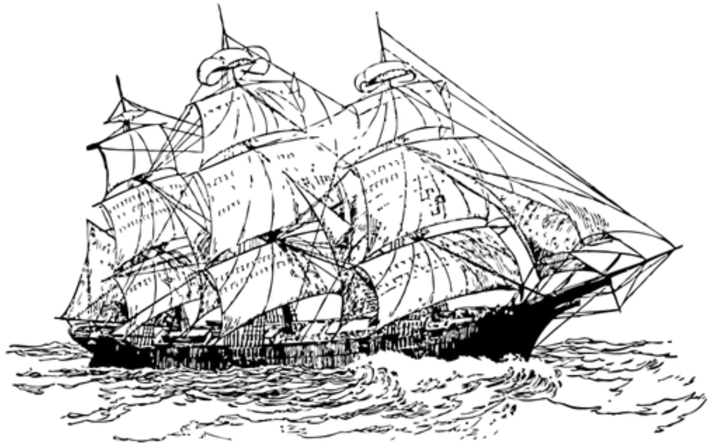
Directional Indices



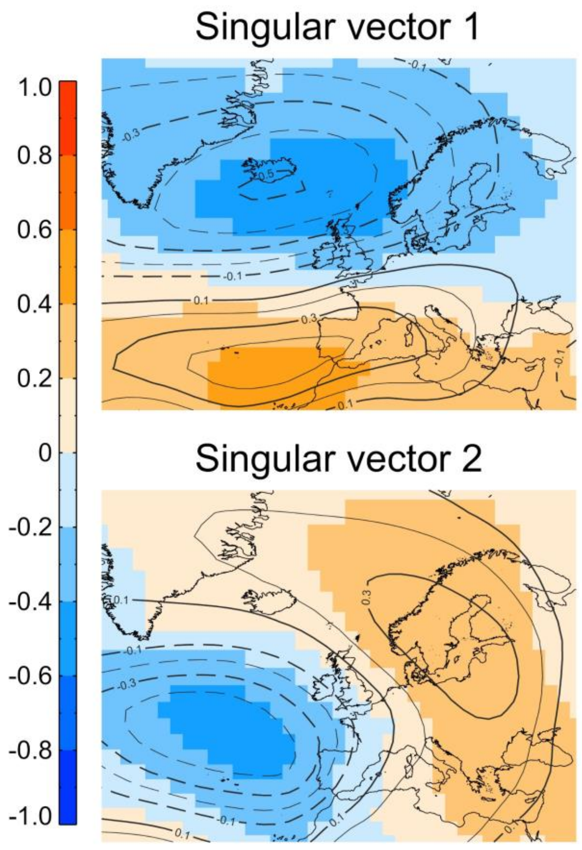
Standardized winter series of DIs for 1685-2014 (gray line) with errors (shadow) and the 11-year running average (black line) superimposed, with dark/light grey shading highlighting periods above/below the 1685-2014 average.

DIs are the **longest instrumental time series** of atmospheric circulation available **to date**



A Singular Value Decomposition (SVD) analysis was applied to the 1685-2014 winter time series

NAO and EA obtained from DIs



Regression coefficient distribution between the singular vectors from the SVD analysis and SLP (colors) and Z500 (contours) computed for the period 1901-2010.

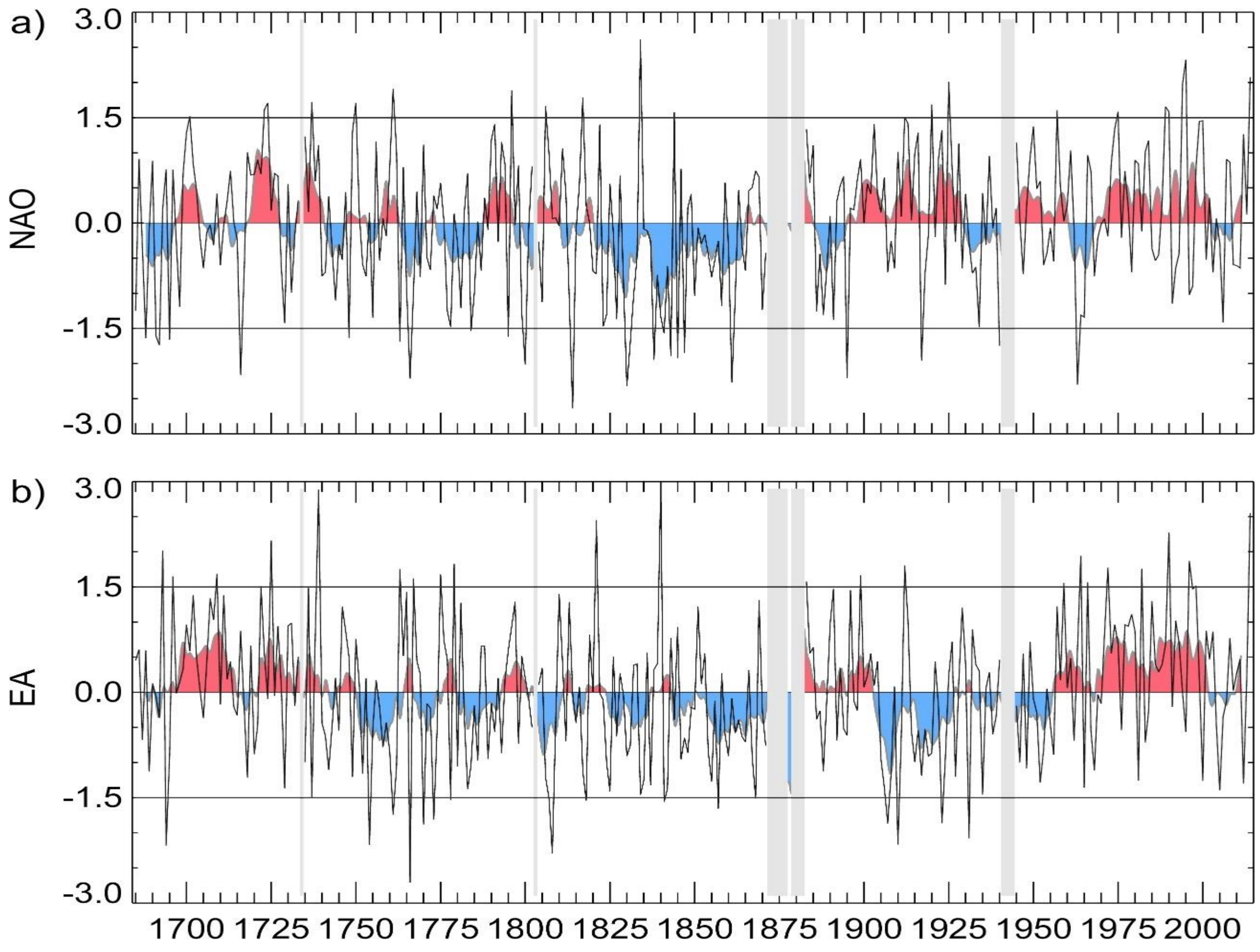
SV1 similar to **NAO**

SV2 similar to **EA**

Indices	Overlapping period	SVD1 / SVD2
NAO		
CPC NOAA	1950-2014	**0.60** / -0.2
Hurrell et al. 1995	1901-2014	**0.48** / -0.19
Jones et al. 1997	1824-2014	**0.67** / -0.05
Luterbacher et al. 2002	1685-2001	**0.61** / -0.04
EA		
CPC NOAA	1950-2014	**0.32 / 0.55**
Comas-Bru and Hernández (2018)	1950-2014	0.20 / **0.74**
2nd EOF SLP ERA-20C	1901-2010	-0.21 / **0.57**
Comas-Bru and Hernández (2018)	1852-2014	0.28 / **0.47**

All NAO (EA) indices display significant correlations at $p<0.01$ with the first (second) singular vector of the DIs and insignificant or very weak correlations with the second (first) one

Examining the NAO-EA relationship



Winter standardized series of: a) NAODI; b) EADI for 1685-2014 (in SD, black line) and a 7-year running mean (grey line), with red (blue) shading indicating periods above (below) the 1685-2014 mean. Vertical grey shading identifies periods of missing data.

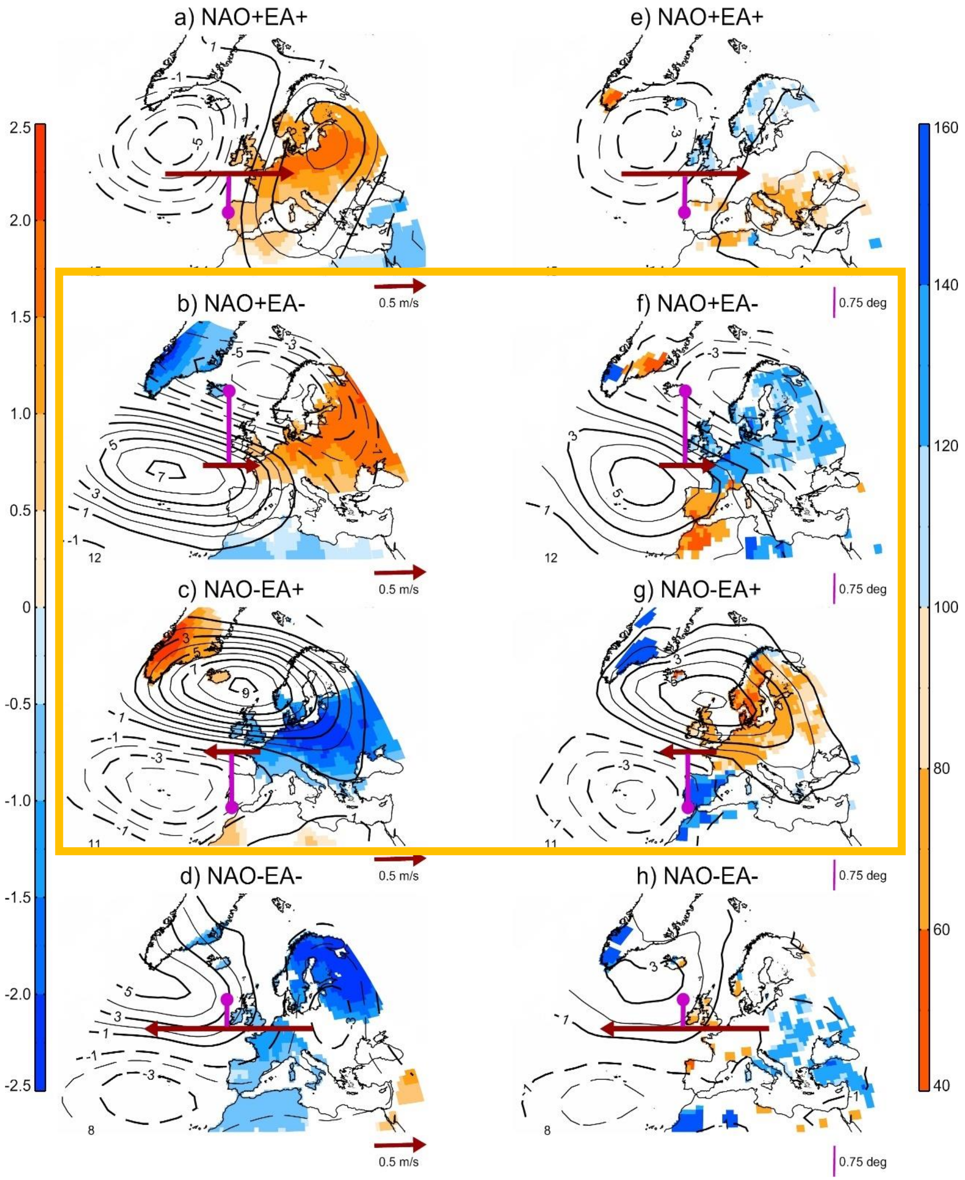
- **Longest** time series of the **East Atlantic pattern** currently **available**
- **EA**$_{DI}$ is the **dominant pattern** in **nearly 50%** of the winters, indicating that the **last** three **centuries cannot be** properly **described** by the state of the **NAO**$_{DI}$ **alone**

NAO

EA

Both are **required** for a properly **characterization** of **European past climate**

Examining the NAO-EA relationship



Preserves the pressure dipole but with differences in the location, intensity and spatial extension of the centers of action.

- **Opposite phase:** zonality-oriented dipole

Winter composites of: a-d) near-surface temperature (shading) and geopotential height at 500 hPa (contours) anomalies; e-h) precipitation (shading) and SLP (contours) anomalies for different combinations of NAO_{DI} and EA_{DI} indices.

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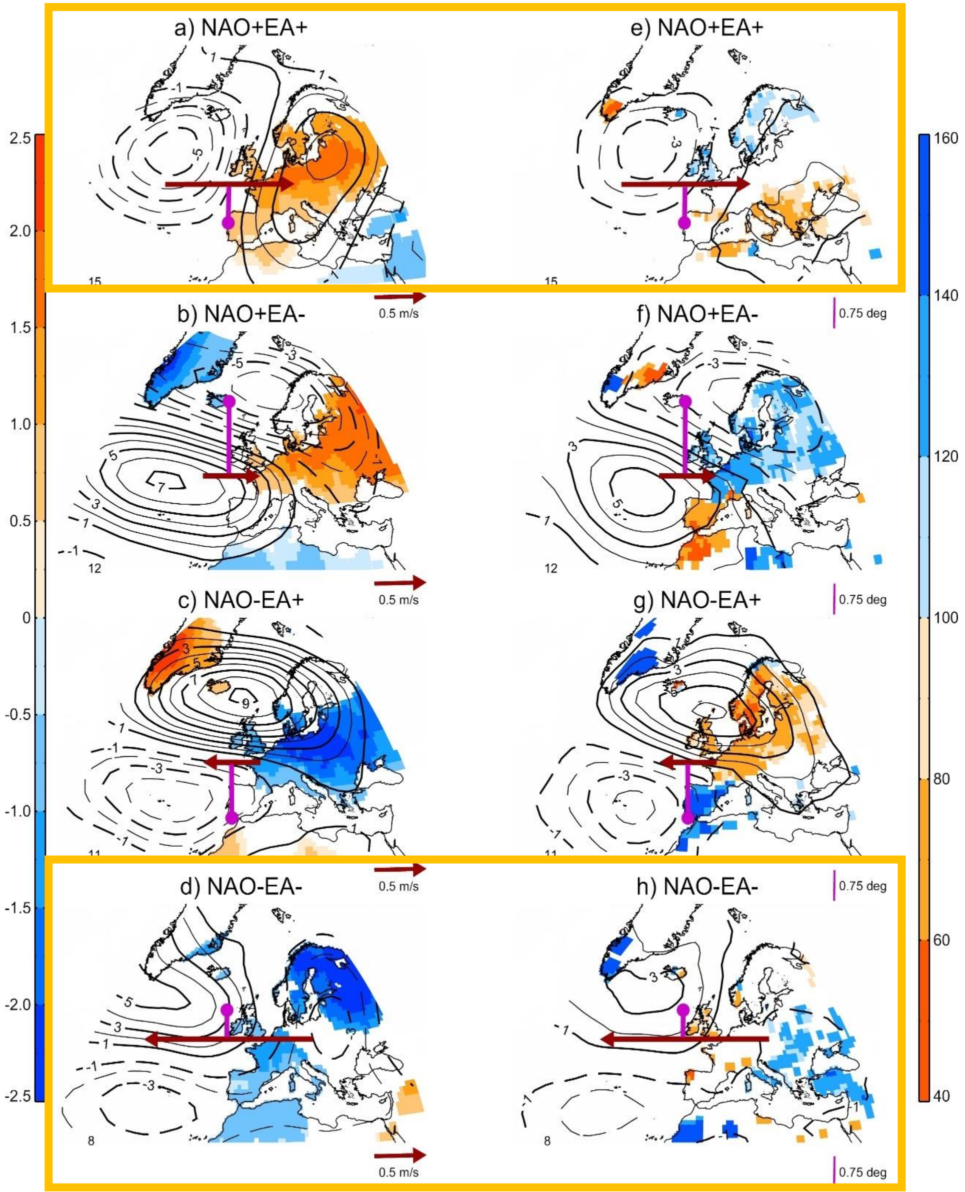

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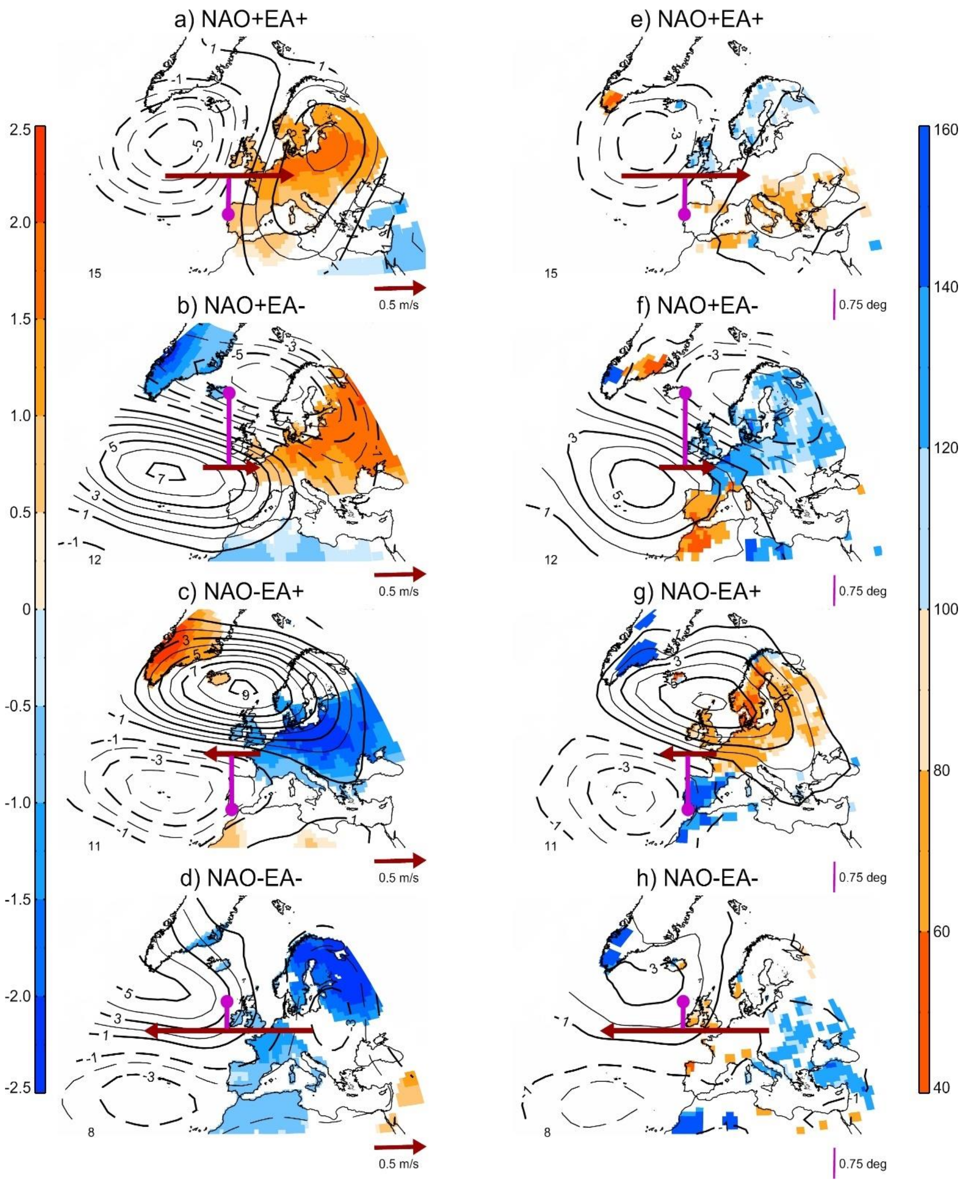

Preserves the pressure dipole but with differences in the location, intensity and spatial extension of the centers of action.

- **Temperature:** largely determined by the **NAO**
- **Precipitation:** overall **more sensitive** to the concomitant **state of NAODI and EADI**

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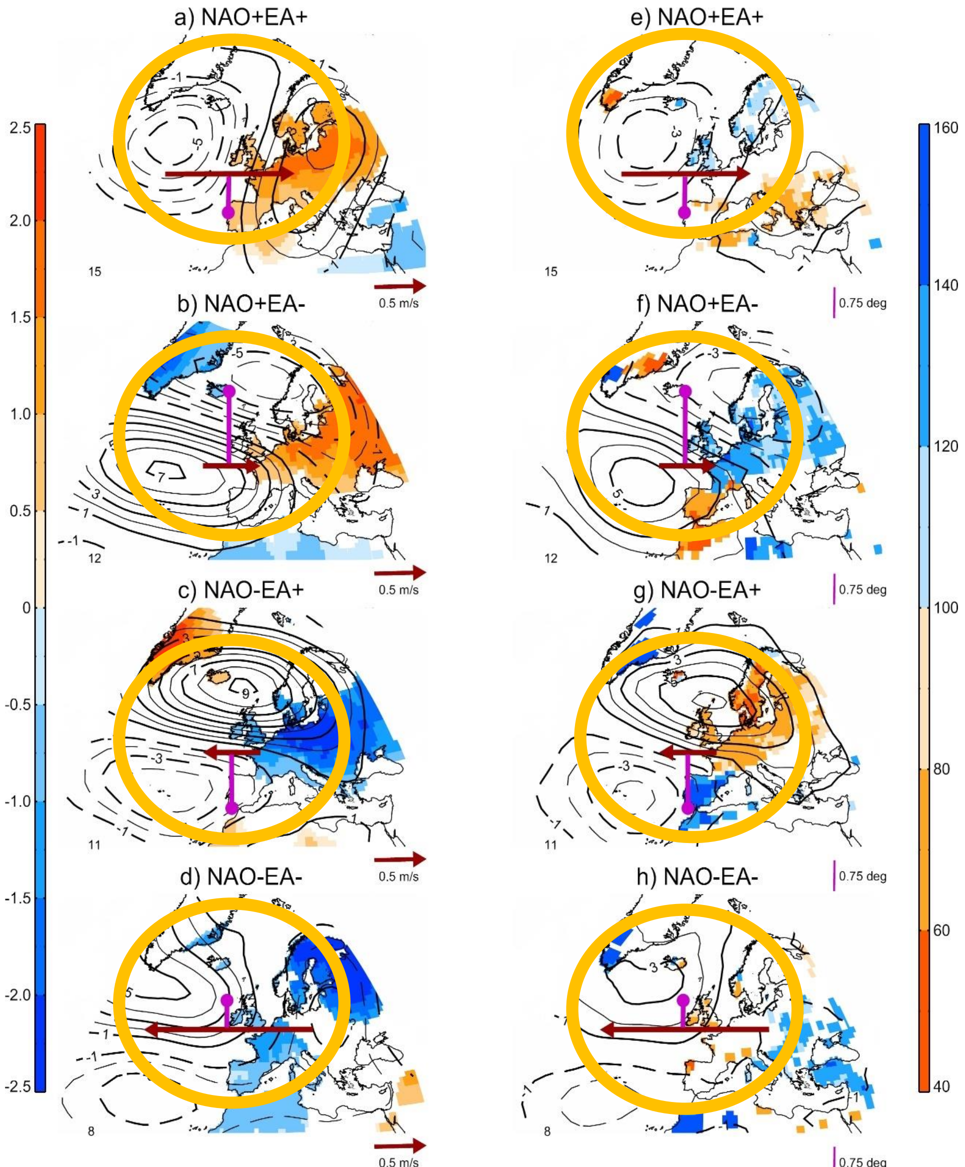

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- **Different jet speed/latitude** anomalies for each combination

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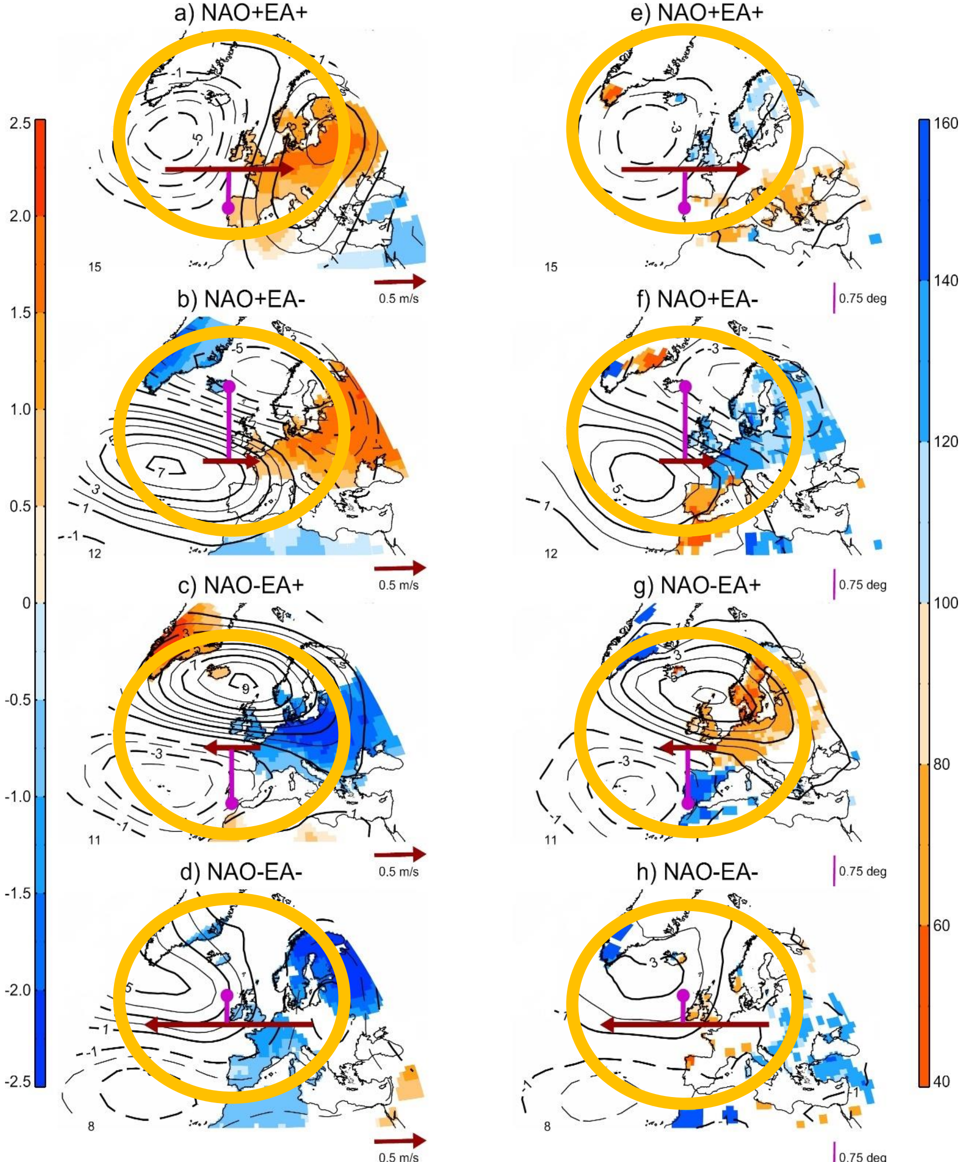

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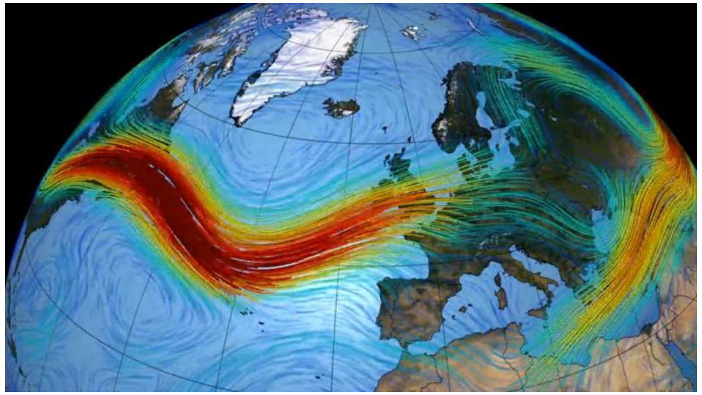

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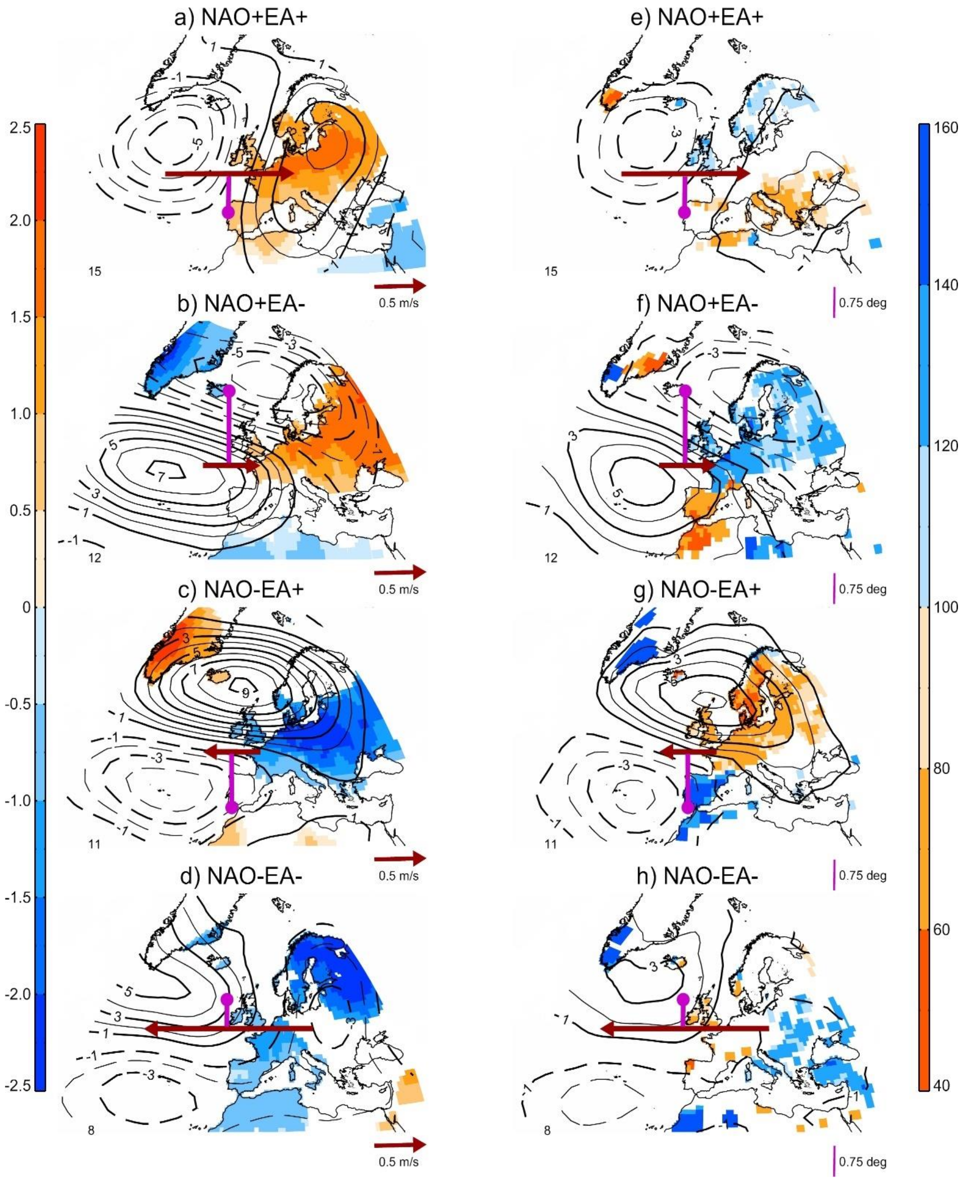

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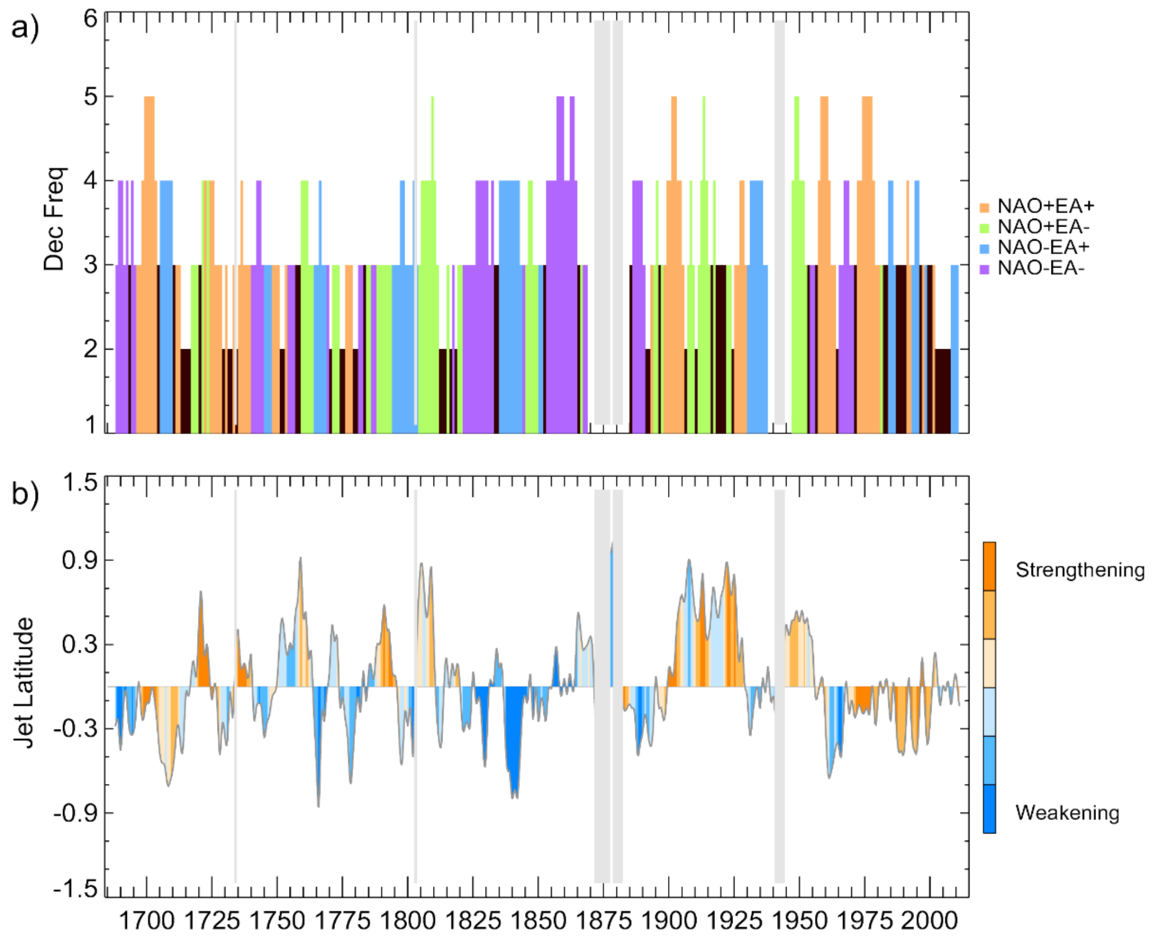

Frequency and type of the dominant winter NAO/EA combination for each 11-year period of the 1685-2014 period; b) Reconstructed jet speed anomaly (in SD with respect to 1685-2014) with a 7-year running mean (grey line). The corresponding 7-year running mean of the jet latitude anomalies are shown in color, with red (blue) shading denoting a northward (southward) migration of the jet.

Longest timeseries of the concomitant state of **NAO/EA and the jet stream variability**

- 1720-1740: NAO+EA+. Stronger jet
- 1825-1875: NAO-EA- exception of 1840s (EA+)

Precisely NAO índices from some authors have disagreements during this decade (Cornes et al. 2013; Luterbacher et al. 2001)

Summary

- ✓ **DIs-based indices** are optimal indicators of **instrumental NAO and EA series**, also **capturing their main signatures** on European temperature and precipitation.

- ✓ The results **highlight** the **role** of **EA** in **shaping the North Atlantic action centers** and the **European climate responses to NAO.**

- ✓ The combined influence of these indices on the Euro-Atlantic climate is explained by **additive (canceling)** effects of **NAO and EA** on the **speed (latitude) of the North Atlantic jet stream** and their different degrees of influence.

- ✓ The **so-inferred anomalies of the jet stream** are related to **transitions** in the **NAO/EA phase space**, **which** have been recurrent and e**xplain non-stationary NAO signatures.**

- ✓ **Reconstructions** of atmospheric circulation and **European past climate cannot be properly described** by the **NAO alone.**

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Examining the North Atlantic Oscillation, East Atlantic pattern and jet variability ...

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Examining the North Atlantic Oscillation, East Atlantic pattern and jet variability since 1685

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https://doi.org/10.1175/JCLI-D-19-0135.1
Published Online: 27 June 2019

LINK

SUPPORT MATERIAL

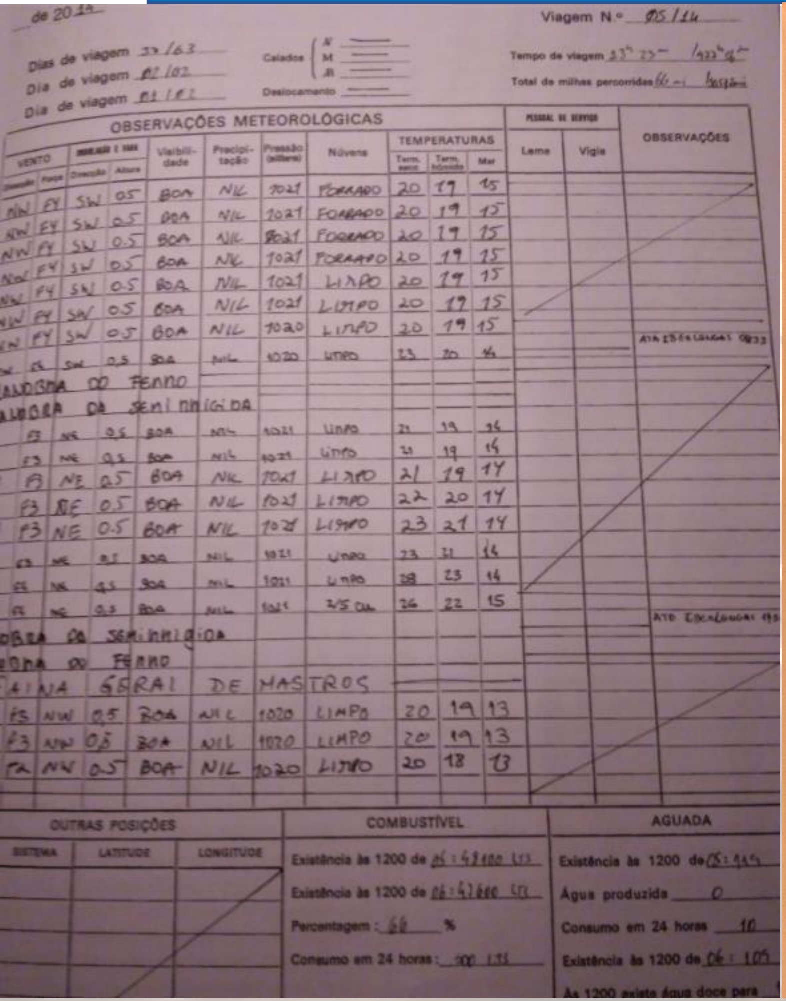
Ship’s logbooks

Ships’ logbooks: first-hand well-dated daily information

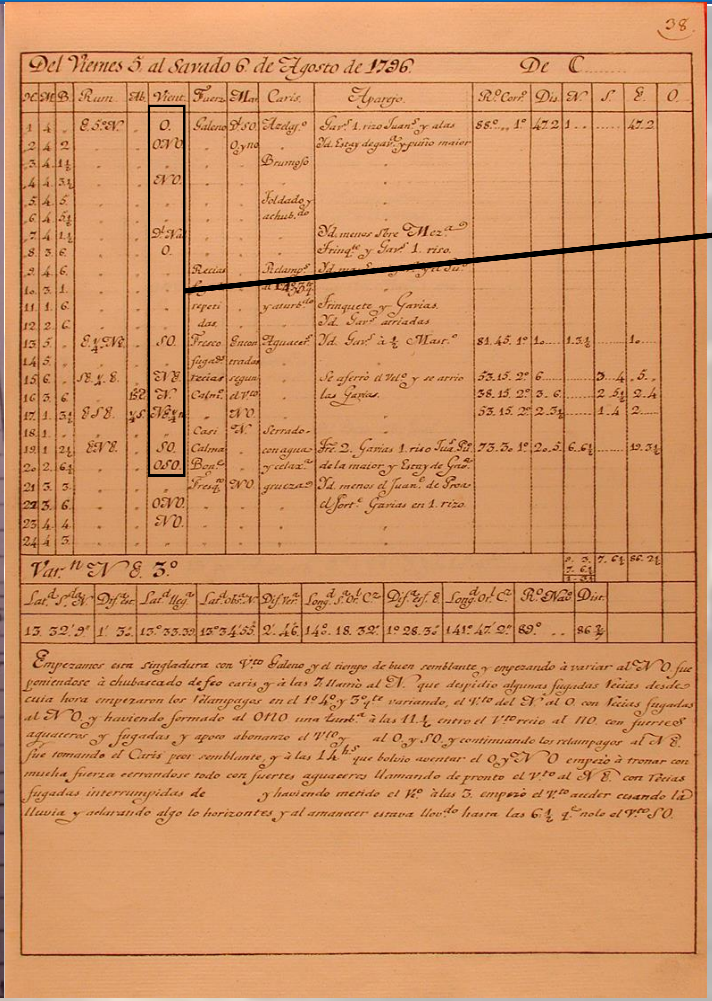
Wind direction, an instrumental observation: 1) measured with a 32-point compass; 2) no need of subjective judgments or re-scaling

Example of a compass from a ship (2017)

Ships' logbooks



Example of Creoula's logbook
(2015)



Example of a Spanish Logbook
(1796)

Wind direction has been used to **improve** the **knowledge** of **climate** in the past

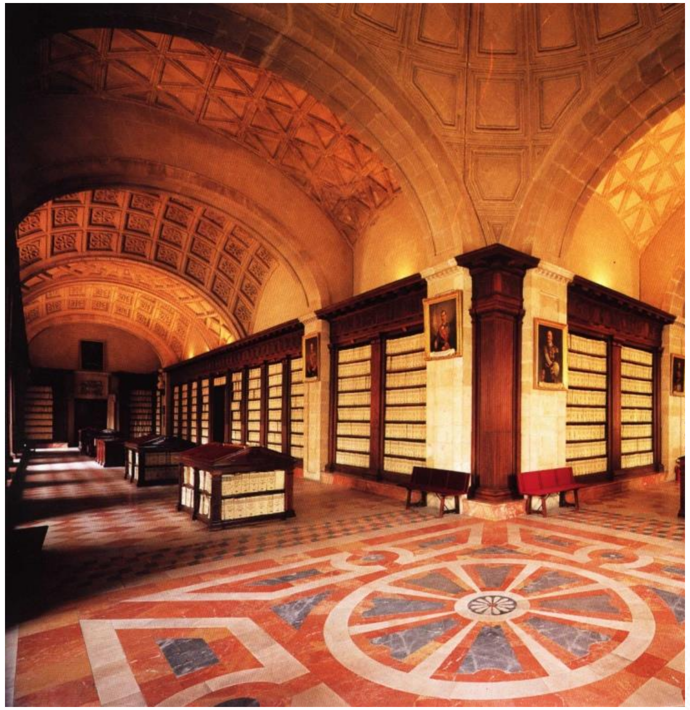
- Barriopedro et al. 2014 (Clim Dyn)
- Ayre et al. 2015 (RMetS)
- Gallego et al. 2015 (QJRMS)
- Ordoñez et al. 2016 (Journal of Clim)
- Gallego et al. 2017 (Scientific report)
- Vega et al. 2017 (Journal of Clim)

Data

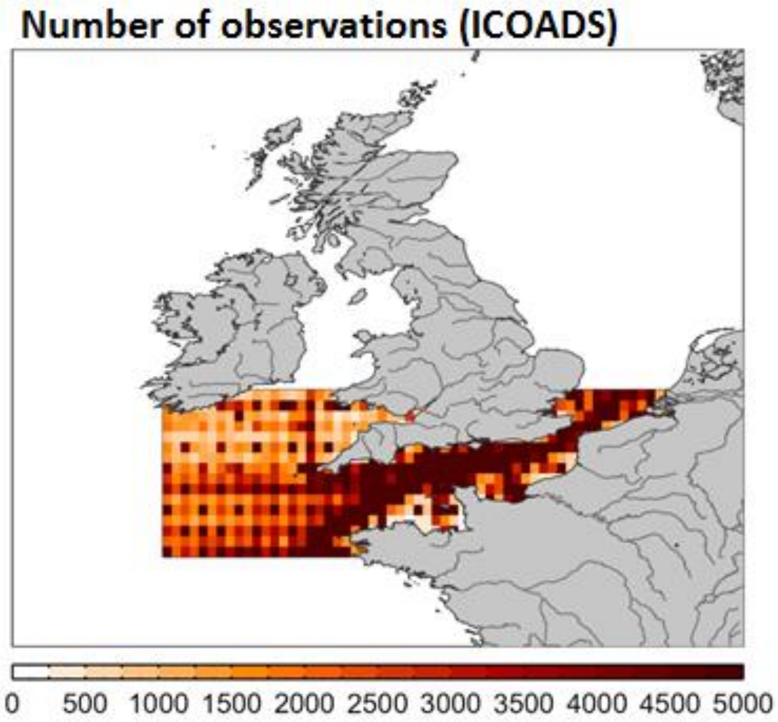
- **1685-1870**: **Royal Navy ships' logbooks** from the archives of the British National Maritime Museum and the UK National Archives (74.363 daily wind records in the English Channel)

- **1750-2014**: **ICOADS v3.0** (Freeman et al. 2016) dataset (455 million records around the world)

1685 ⟷ 2014



British National Maritime Museum



Daily data from ICOADS in the English Channel

Eddy-driven jet stream

- Latitude and speed of the Eddy-driven jet stream are identified from daily ERA-20C as follows:

  - For each grid point, the **daily mean zonal wind is averaged for the 700,825 and 925 hPa** pressure levels and the **low-pass filtered (>10-day)** to remove the features associated with individual synoptics systems.

  - The **resulting field** is then **zonally averaged over the Atlantic sector** ([0-60ºW] , neglecting winds poleward of 75ºN and equatorward 15ºN.

  - The **jet speed** is defined as the **maximum westerly wind speed** of the resulting latitudinal profile, while the **latitude** is defined by the **location** of this maximum.