Long-term variability of moisture transport over Europe as inferred from ships' logbook records

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1. Introduction

• The strength and direction of near-surface winds over the oceans are a key component of the hydrological cycle and its variability, determining moisture fluxes and precipitation signatures over land.

• The marine meteorological observations in old ships' logbooks provide first-hand, well-dated daily information since the 17th century with which to improve our understanding of climate variability and change.

• We present a monthly index (the Westerly Index, WI) based on the persistence of the westerly wind over the English Channel for 1685-2012 using only marine meteorological observations [1].

2. The Westerly Index

• Period: 1685-1849 (Royal Navy Ships' Logbooks) + 1851-present (CLIWOCv1.5 & ICOADSv2.1) ⇨ ~3.450.000 wind records.

•WI [1]: persistence (% of days per month) of westerly wind (225º-315º) over the English Channel (cf. [-10, 5]ºE, [48,52]ºN).

• The WI provides the longest instrumental record of atmospheric circulation currently available (*Figure 1*).

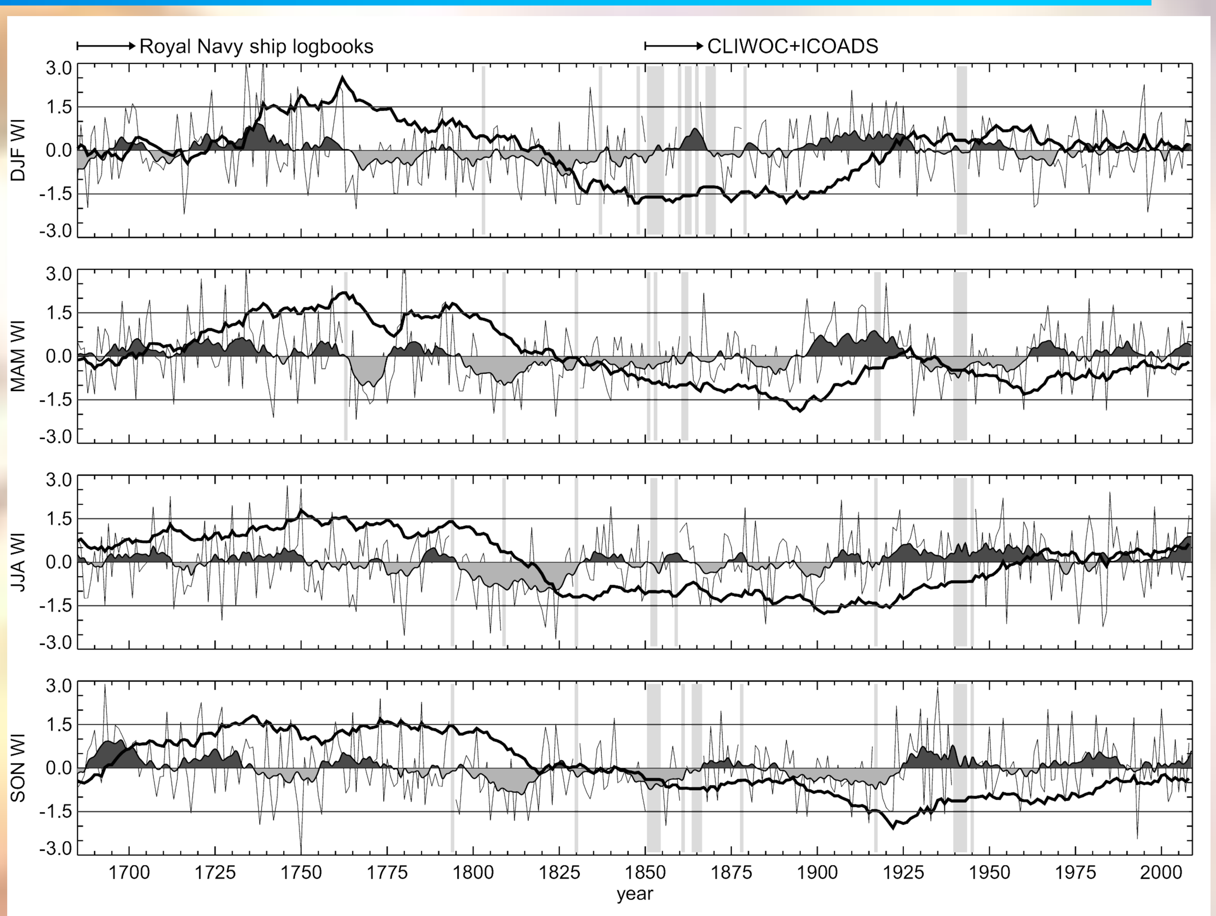


Figure 1. Standardized seasonal series of WI (1685-2008), 11-year running average (shading) and cumulative normalized anomalies (thick). Vertical gray bars indicate periods of missing data.

3. Associated impacts

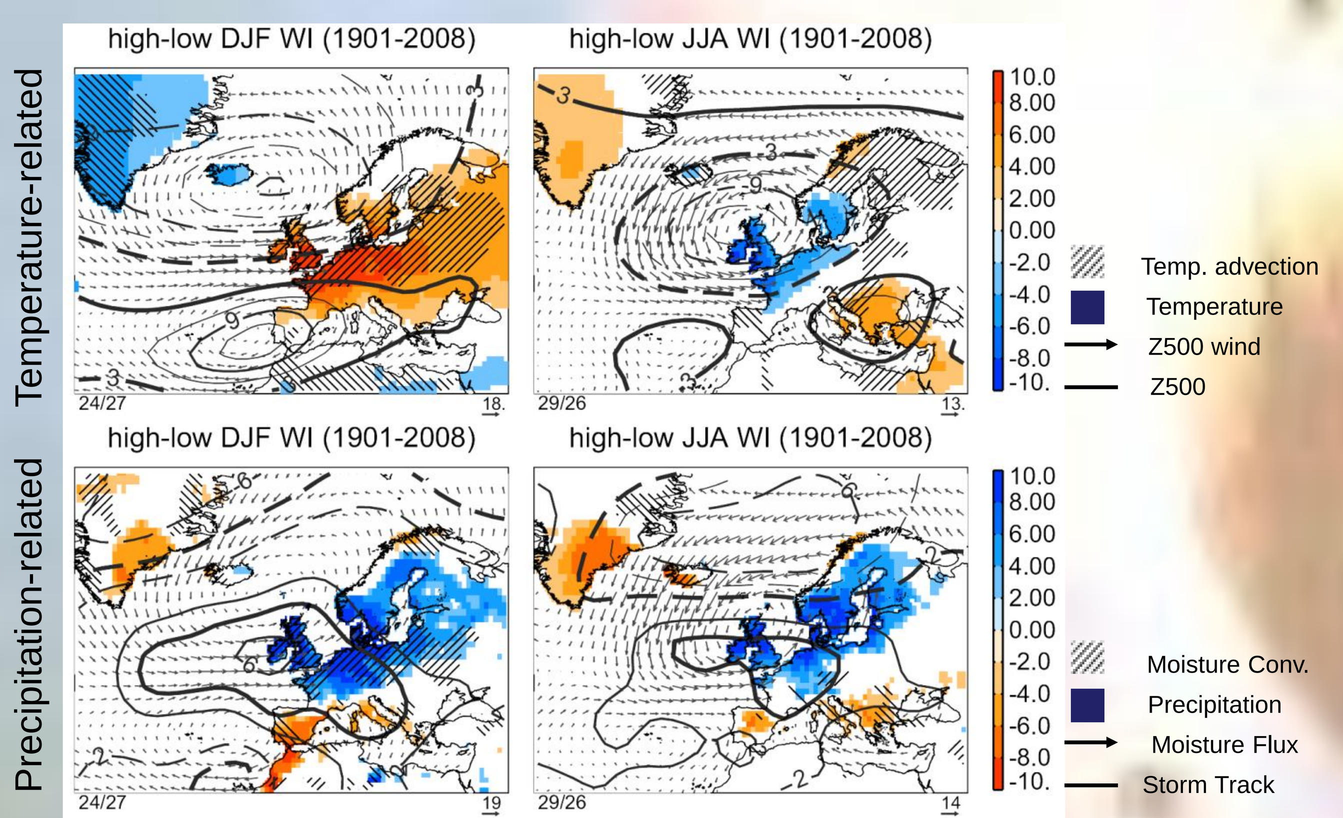


Figure 2. Scaled seasonal composites (dimensionless) for high (> 0.75 SD) minus low (< - 0.75 SD) WI during 1901-2008.

WI as a valuable indicator of European climate

• WI signatures (*Figure 2*): 1) low-high meridional pressure dipole; 2) warm Northern Europe & cold Greenland temperatures, with opposite patterns in summer; 3) increased (reduced) year-round precipitation over Northern Europe (Mediterranean & Greenland) associated with anomalies in moisture transport over the eastern Atlantic.

WI & NAO as complementary circulation indices

• European drought variability is well explained by the WI and the North Atlantic Oscillation (NAO) index. WI (NAO) is a better indicator of water-balance anomalies in Northern (Southern) Europe (*Figure 3*) [2].

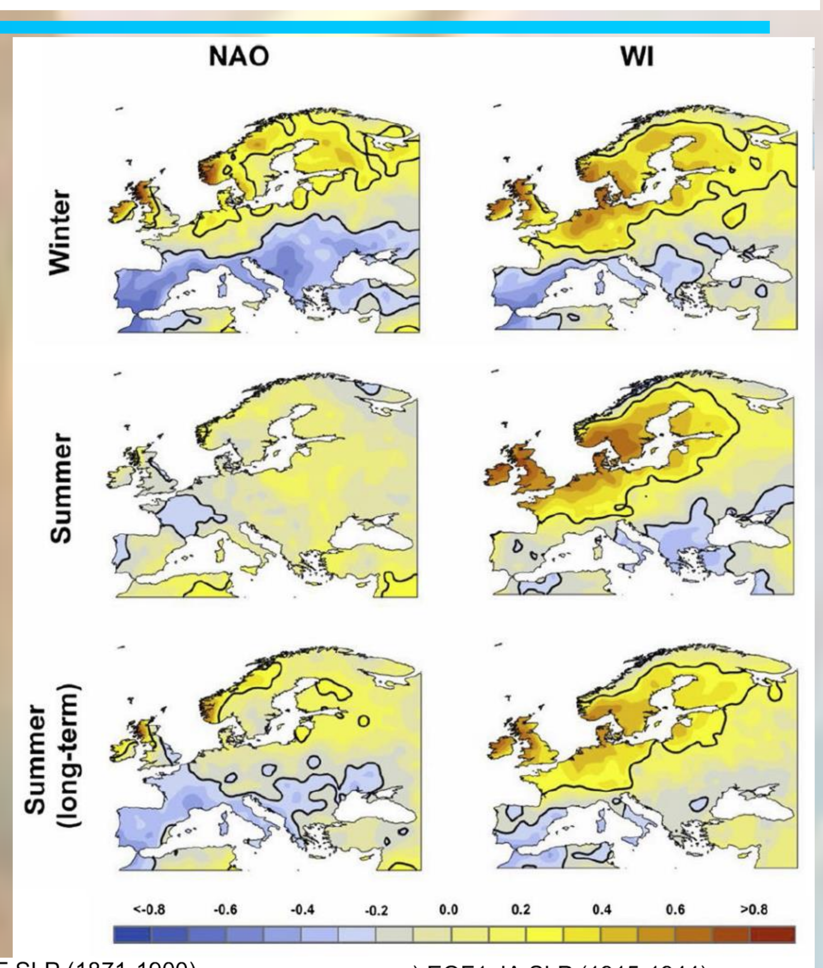


Figure 3. Correlation coefficients (1951-2008) between SPEI and circulation indices at seasonal and long-term (9-month) scales. Black line denotes significance ($p < 0.05$).

Non-stationarity

• There are several multidecadal periods of weakened correlation between WI and NAO (e.g., 1855-1895 in winter, 1830-1860 in summer) during the industrial era. They are associated with non-stationary teleconnections over the North Atlantic (i.e., changes in the centers of variability, *Figure 4*).

• Comparisons with long instrumental NAO-like indices extending back to the 17th century suggest that similar situations occurred in the pre-industrial era.

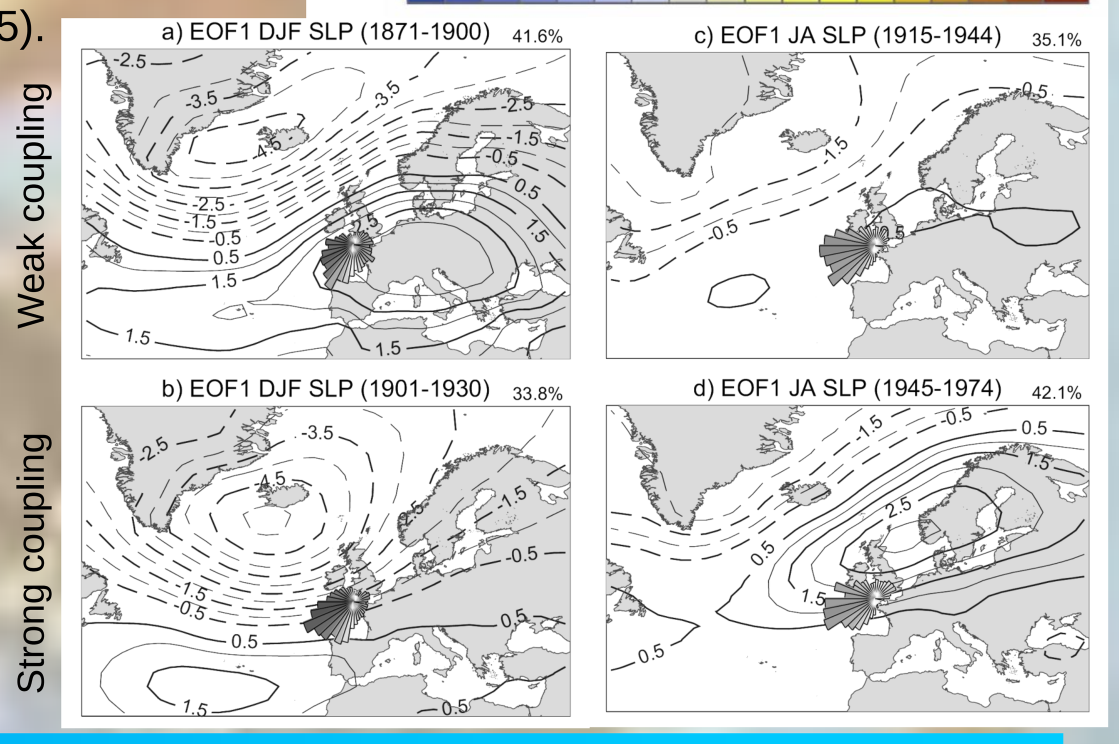
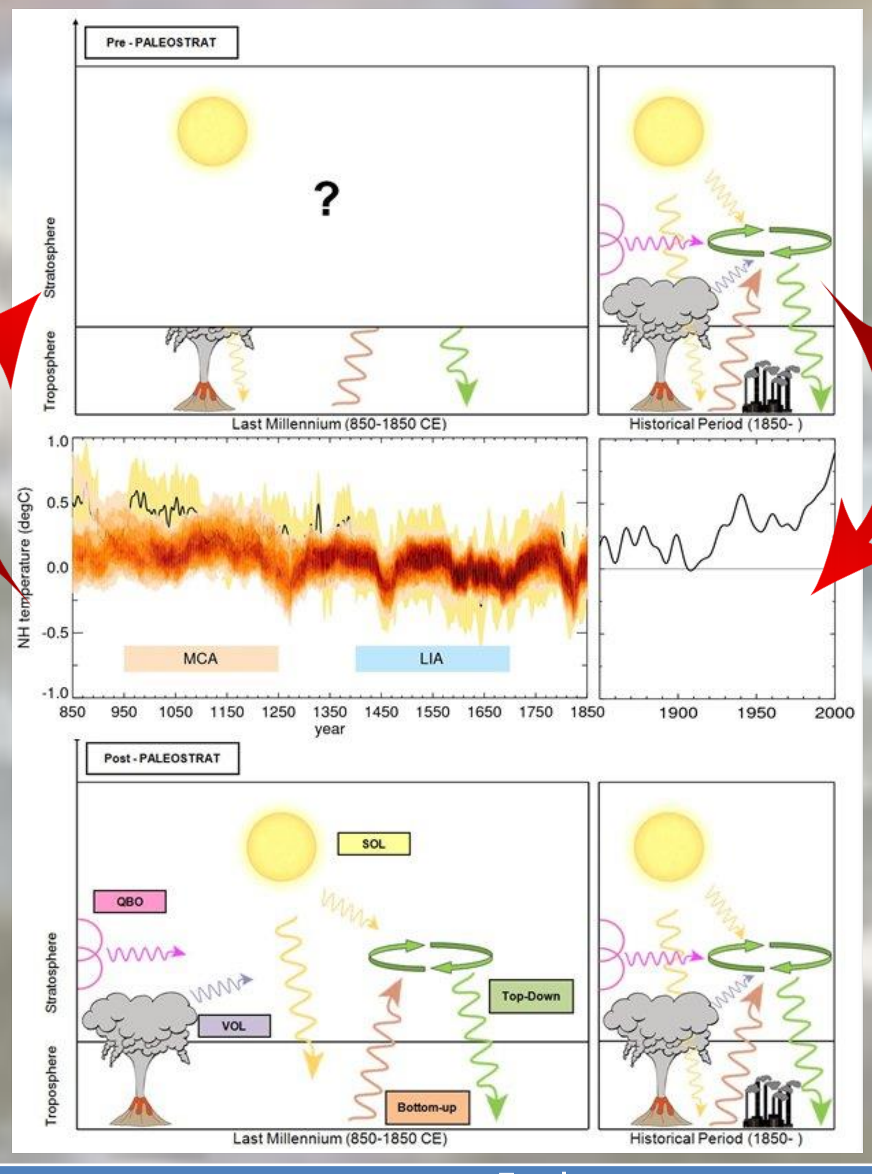


Figure 4. Seasonal mean SLP (hPa) regressed onto the first EOF for the 30-year periods of maximum and minimum correlation between WI and the winter and high-summer NAO within the 1871-2008 period.

4. PALEOSTRAT project

Paleo ⇨Stratosphere

- Set up external forcings
- Run LM simulations with high- and low-top models
- Administrate the database
- Characterize multidecadal and centennial variability.
- Describe the responses to external forcings.
- Isolate climatic signals and explore non-linear interactions



Stratosphere ⇨Paleo

- Quantify the internal vs externally-forced variability on the climate of the LM.
- Evaluate the role of the stratosphere in driving regional responses.
- Pin down the origin of discrepancies between models and reconstructions
- Improve the representation of external forcings.

	Forcing				
Simulation	Antropogenic	Orbital & Solar	Land Use / Change	Volcanic	Chemistry
Control (1000 yrs)	Fixed (1850)	Fixed (1850)	Fixed (1850)	No	Specified (1850)
Basic (850-1850 CE)	PMIP	PMIP	PMIP	Neely et al.	Specified (1850)
New (850-1850 CE)	PMIP	PMIP	PMIP	Neely et al. + Aerosol Model	Interactive

• To better understand the lack of stationary relationships, model simulations accounting for all sources of tropospheric variability are required, including the stratosphere, which plays a decisive role in shaping the extratropical atmospheric circulation through the stratosphere-troposphere coupling [3].

• PALEOSTRAT (PALEOmodelization from a STRATospheric perspective) [4] provides a novel and synergistic view of the paleoclimate and the stratosphere (*Figure 5*) in order to: 1) better understand the role of the stratosphere in the climate responses to internal and external forcings (e.g., [5]) and, 2) improve current understanding of the Last Millennium (LM, 850-1850 CE, [6]).

• This will be addressed by a suite of LM coupled simulations with an Earth System Model, which only differ in the representation of the stratosphere, the external forcings and the implementation of volcanic aerosols (*Figure 5*).

• PALEOSTRAT will allow investigating the impact of the stratosphere on the climate of the LM, the internal variability (e.g., NAO) at long time-scales and the responses of the Earth's System hydrological cycle to different forcings (e.g., volcanic and solar).

• The model output will be available to the scientific community, including PMIP (PAGES), SPARC (WCRP) and CMIP (IPCC).

Figure 5. Current knowledge on the role of the stratosphere in climate for the LM (left panels) and the instrumental period (right panels), and before (top panels) and after (bottom panels) PALEOSTRAT. Boxes highlight the main objectives. The Table describes the LM simulations.

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