

Centro Euro-Mediterraneo  
per i Cambiamenti Climatici

# Coupling among atmospheric blocking, the North Atlantic Oscillation, and the Atlantic jet stream

Paolo Davini<sup>1,4</sup>, Chiara Cagnazzo<sup>2</sup>, Rich Neale<sup>3</sup>, Joe Tribbia<sup>3</sup>

<sup>1</sup> Centro Euro-Mediterraneo per i Cambiamenti Climatici, Bologna, Italy. (paolo.davini@cmcc.it)

<sup>2</sup> ISAC-CNR, Roma, Italy

<sup>3</sup> National Center for Atmospheric Research, Boulder, Colorado, USA

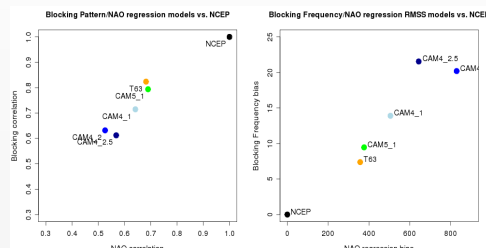
<sup>4</sup> Università Ca' Foscari, Venezia, Italy



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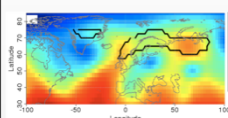
## Main Remarks

- Over the Atlantic basin, **atmospheric blocking**, **low-tropospheric jet** and the **North Atlantic Oscillation (NAO)** emerge to be tightly associated.
- In any climate models analysed, **biases in the blocking representation** are reflected by biases in the NAO pattern.
- Some modelled NAO, even though it possesses similar geographical pattern, **can represent a zonal mode of variability that differs from the one seen in the reanalysis.**
- Underestimation of European blocking and overestimation Low Latitude Blocking.**



**Figure 7:** Left: Blocking spatial correlation (model vs NCEP/NCAR Reanalysis) vs. NAO spatial correlation (model vs NCEP/NCAR Reanalysis). Right: The same as left, but for RMS for blocking frequency (y-axis) and NAO linear regressions on Z500 anomalies (x-axis).

## 1. Introduction



**Figure 1:** Z500 field on the 3 Feb 2012 (colours) and blocked areas (contours).

Atmospheric blocking describes a mid-latitude weather pattern where a **quasi-stationary high-pressure system** modifies the westerly flow, "blocking" the eastward movement of the migratory cyclones (Rex, 1950a).

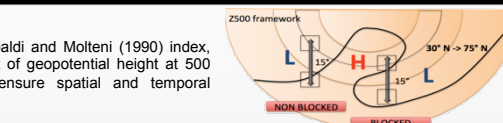
Wintertime blocking may lead to extreme events (Trigo et al, 2004), as the **huge and lasting snowfall** occurred in Southern and Eastern Europe this early February.



## 2. Data and Method

**Blocking:** bidimensional extension of the Tibaldi and Molteni (1990) index, based on reversal of the meridional gradient of geopotential height at 500 hPa. Further constraints are applied to ensure spatial and temporal persistence (Davini et al, 2012).

**North Atlantic Oscillation (NAO),** Hurrell et al, 2003: First EOF of the monthly mean Z500 over the Atlantic sector (90W-40E, 20-85N). NAO is hereafter represented as linear regression on the Z500 anomalies.

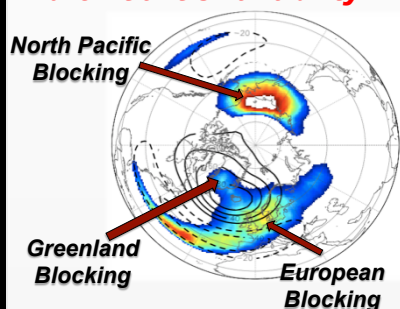


**Jet Latitude Index (JLI),** Woollings et al, 2010: the daily latitude where the maximum of the zonally averaged zonal wind between 60W and 0 is located. Values are averaged between 925 and 700 hPa and a 5 days running mean is applied.

A series of different AMIP simulations from CMCC and NCAR for the winter (DJF) of 1980-2000.

Models analysed are **CMCC-CMS (T63L95)** and **CAM4 (1deg)** and **CAM5 (1deg)** with different horizontal resolutions.

## 3. Blocking climatology and the Euro-Atlantic variability



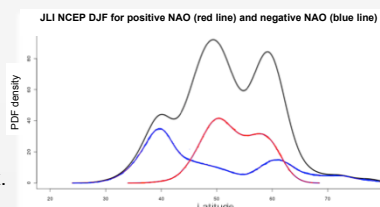
Blocking frequency is dominated by high latitude blocking over **Pacific (NPB)** and **Greenland (GB)**. **European Blocking (EB)** area is evident and Low Latitude Blocking events over Central Atlantic emerge clearly (see Davini et al, 2012 for details).

**Figure 2:** Blocking frequencies (colours) as percentage of blocked days in the DJF NCEP Reanalysis 1980-2000 as shown by the Davini et al (2012) index. Black contours show the NAO linear regression on Z500 anomalies of the Atlantic EOF1.

**NAO patterns are anti-correlated with GB** (-0.45 on daily basis, see also Woollings et al, 2008) while EB is not.

**JLI PDF: the negative NAO phase is associated with equatorward displaced jet.**

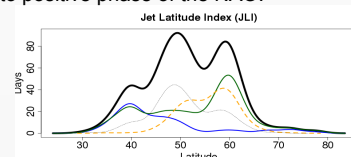
**Positive NAO phase cannot distinguish between the central or the poleward peak.**



**Figure 3:** JLI PDF for NCEP/NCAR Reanalysis in DJF 1980-2000 (black). Blue and red line represent JLI for positive and negative NAO phase (terciles of the NAO PDF).

## 4. Blocking and JLI coupling

**Greenland Blocking** is associated to **negative NAO phase** and **equatorward displaced jet**. European blocking is linked to poleward displaced jet but not to positive phase of the NAO.



**Figure 4:** JLI PDF in NCEP/NCAR Reanalysis in DJF 1980-2000. Blue, green and yellow line represent JLI when blocking is occurring over Greenland, Europe and Iberian Wave Breaking sector respectively. Dotted line represents when no blocking is occurring in the 3 sectors.

Europe	Greenland	Iberian Wave Breaking (IWB)
15W-20E 47.5N-62.5N	70W-20W 62.5N-72.5N	30W-10W 37.5N-47.5N

This suggests that the bimodal oscillation of the NAO is connected to the occurrence of the Greenland Blocking and to the associated equatorward displacements of the jet.

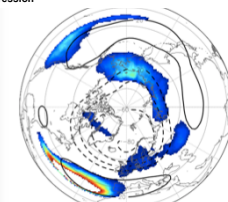
The **variability of the Euro-Atlantic sector** needs the inclusion of the **European Blocking** to be properly described.

## 5. Models

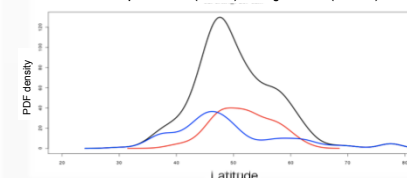
### CAM 4

Too zonal NAO, unimodal Atlantic jet.

CAM4 DJF blocking frequency and NAO linear regression



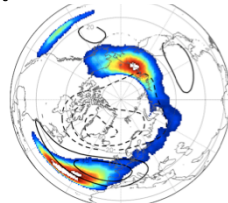
JLI CAM4 DJF for positive NAO (red line) and negative NAO (blue line)



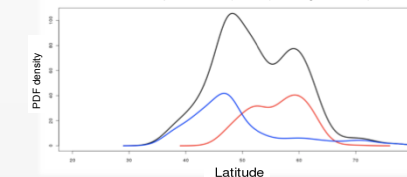
### CAM 5

Good NAO pattern, but bimodal JLI variability. The NAO is representing a 10° northward variability.

CAM5 DJF blocking frequency and NAO linear regression



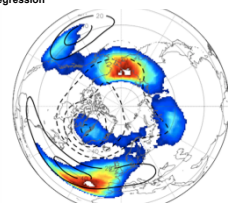
JLI CAM5 DJF for positive NAO (red line) and negative NAO (blue line)



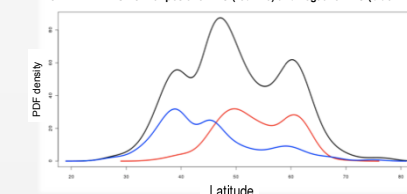
### CMCC-CMS

Too zonal NAO pattern but trimodal JLI variability.

CMCC-CMS DJF blocking frequency and NAO linear regression



JLI CMCC-CMS DJF for positive NAO (red line) and negative NAO (blue line)



**Figure 5:** As Fig 2, but for top to bottom respectively, CAM4, CAM5 and CMCC-CMS

**Figure 6:** As Fig 3, but for CAM4, CAM5 and CMCC-CMS