Assessing the influence of NAO, EA and SC modes on carbon uptake by vegetation in Europe

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Forest ecosystems in Europe constitute an important global carbon sink, removing 7% to 12% of European anthropogenic carbon emissions. However, vegetation activity in Europe is highly variable at the inter-annual scale, particularly due to the impact of the most important large-scale circulation pattern for the Northern Hemisphere, the North Atlantic Oscillation (NAO). Understanding how climate variability in Europe affects net primary production, which is related to the availability of food, fuel and other resources, is particularly relevant for land management and environmental policy assessments.

The NAO controls storm track position, altering temperature and precipitation patterns, which are the main drivers of ecosystem activity. Recent studies have, however, shown the important contribution of other two major modes of climate variability in Europe, the East Atlantic (EA) and Scandinavian (SC) patterns, which modulate the non-stationary relationships between climate and the NAO. This work aims to assess how each of these three modes of variability impact carbon uptake by ecosystems in Europe.

1. Impacts of NAO, EA and SC on Net Primary Production (NPP)

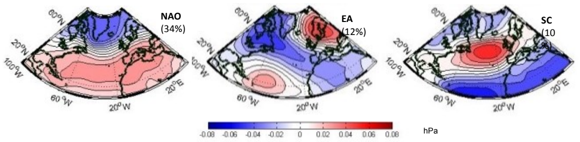

Fig. 1 Spatial distribution of the first three eigenvectors of Sea Level Pressure in the North Atlantic and the corresponding explained variance (in brackets) computed for the period 1979-2011.

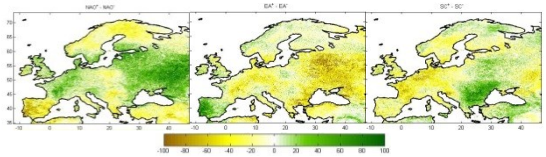

Fig. 2 Difference in annual NPP ($g.m^{-2}.m^{-1}$) between positive and negative winter phases of each mode, Positive values correspond to increased (decreased) NPP during positive (negative) phases of each mode in the period 2000-2011.

Figure 1 presents the spatial patterns of Sea Level Pressure (SLP) associated to each of the 3 main modes of climate variability in the North Atlantic. The difference in annual Net Primary Production during positive and negative <u>winter</u> phases of each mode is shown in Fig. 2.

A **dipole between the Iberian Peninsula and eastern Europe** is observed for winter NAO, coinciding with the centers of the response to winter EA (opposite signal). In **NAO^+ (EA^+) NPP is enhanced (decreased) in eastern Europe and decreased (enhanced) in the Iberian Peninsula.** SC pattern appears to influence particularly northwestern Europe and the Balkans.

DATA

- Annual **NPP** fields from MOD17A3 C5 dataset, at 1km resolution from 2000-2011.
- Net Photosynthesis (**PsN**) monthly fields from MOD17A2 dataset at 1km resolution from 2000-2011.
- Monthly indexes for **NAO**, **EA** and **SC** obtained from NOAA-CPC from 1950-2012.
- Monthly average air temperature (**T**) at 2m obtained from ERA-Interim, at 0.75º from 1979-2011.
- Monthly sea level pressure (**SLP**) obtained from NCEP/DOEII, provided at 2.5º from 1979-2011.
- Monthly precipitation (**P**) fields provided by GPCC at 1º from 1986-2011.

2. NPP response to combinations of the three modes

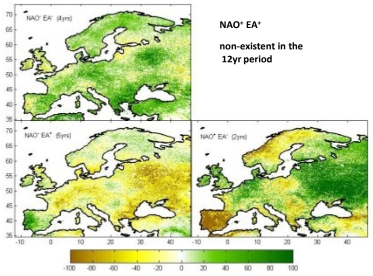

Fig. 3 NPP anomalies ($g.m^{-2}.m^{-1}$) associated to combinations of positive and negative phases of NAO and EA in 2000-2011.

Combinations of two phases (Fig. 3) lead do different NPP responses: **NAO^+EA^-** (and **NAO^-EA^+**) **enhance the dipole** pattern shown in Fig. 2a, while NAO^-EA^- leads to a fuzzier pattern of NPP anomalies.

EA and NAO with opposite sign strengthen the pattern of NAO influence on NPP

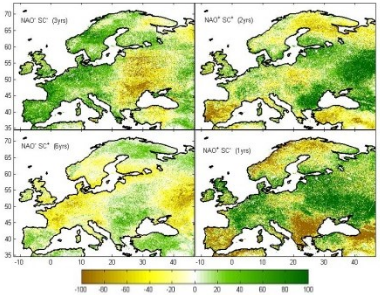

Fig. 4 NPP anomalies ($g.m^{-2}.m^{-1}$) associated to combinations of positive and negative phases of NAO and SC in 2000-2011.

SC displaces the regions with larger impacts from NAO

For **NAO** and **SC** (Fig. 4), the patterns are not as clear, however, remarkable differences are observed between the combinations of the two modes, particularly in **the Balkans** and northwestern Europe. **The eastern-European centre of the NAO dipole appears to be displaced by SC variability.**

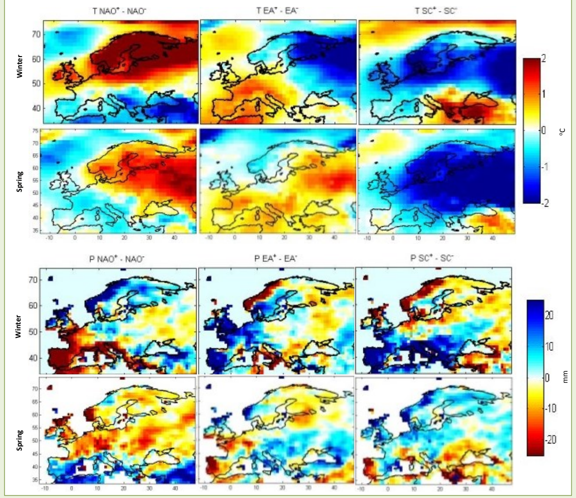

Fig. 5 Difference in winter and spring temperature (top) and precipitation (bottom) between positive and negative winter phases of each mode for the period 2000-2011.

The response in NPP the **Iberian Peninsula is driven mainly by precipitation changes in winter** between each NAO phase. In **eastern Europe, the patterns in annual NPP correspond to temperature changes in spring** due to NAO variability. However, the other two modes of variability **(EA and SC) also present strong relationships with PsN**, especially in **winter** and **spring** (Fig. 5). The patterns in temperature and precipitation for NAO, EA and SC phases indicate a complex interplay between the climatic impacts of the three modes and NPP response to different variables.

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