Effects of large scale atmospheric circulation patterns on winter wind power output in Western Europe

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Introduction

- The North Atlantic Oscillation (NAO) is a large scale atmospheric pattern; the NAO index is defined as the difference in normalised monthly sea level pressure (SLP) between the Azores and Iceland
- The NAO is responsible for large part of the winter climate variability in Western Europe
- 2010 poor wind year was due to very negative NAO index values
- Besides the NAO, other large scale Sea Level Pressure (SLP) patterns play a role in determining the winter climate in Europe; the East Atlantic (EA) pattern and the Scandinavian pattern (SCA)
- Recent advances in the intraseasonal prediction of NAO will allow for improved prediction of near surface wind speeds (*Scaife et al. 2014*)

Objectives

- **Explore the effect of the EA and SCA on the NAO – wind speed relationship**
- **Quantify the wind speed anomalies due to these modes and their geographical variation**
- **Assess the impact of the wind speed anomalies on wind power output**

Methodology

Data

- Monthly mean ERA-Interim SLP
- 3-hourly 10 m wind speeds from ERA-Interim (0.5 degree resolution)
- 15 minute power output data from EirGrid, 12 wind farms from 99-09 with a total capacity of 83 MW

Methods

- Calculate and validate NAO, EA and SCA indices
- Separate 3-hourly data into monthly combinations of indices
- Calculate wind speed anomalies relative to the long term mean (104 winter months from 1979 to 2013)
- Calculate capacity factor deviations relative to the 33 winter month average (from 1999 to 2009) in selected Irish wind farms

Power Output

- Average capacity factor is **45 %** for the NAO+ winter months, **36 %** for the NAO- months
- No power production time is 9 % on average when NAO is positive and 12 % when NAO is negative
- Wind farms in the North West of Ireland show slightly higher differences between NAO+ and NAO- in terms of capacity factor

Results

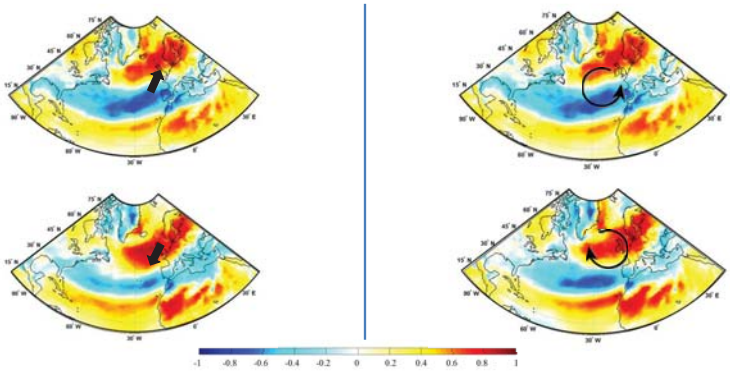

Fig. 1 NAO-Wind speed correlation for NAO and EA with same (top) and opposite (bottom) sign

Fig. 2 NAO-wind speed correlation for NAO and SCA with same (top) and opposite (bottom) sign

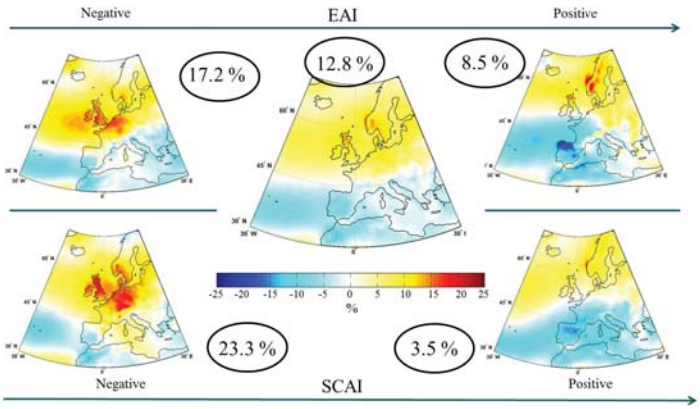

Fig. 3 Maps showing wind speed anomalies for NAO+ cases. Labels indicate capacity factor anomalies based on 12 wind farms in Ireland

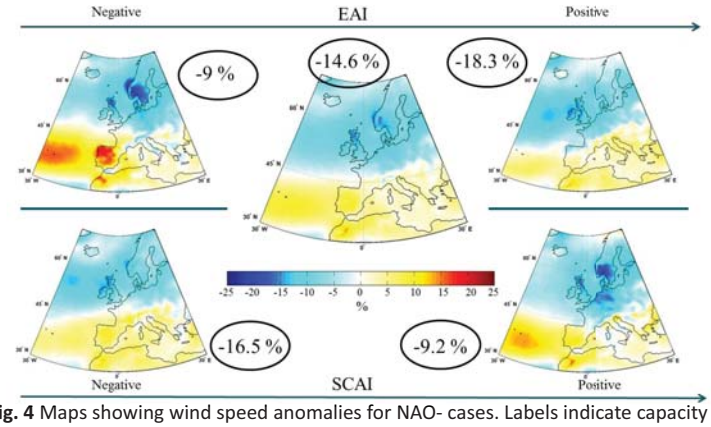

Fig. 4 Maps showing wind speed anomalies for NAO- cases. Labels indicate capacity factor anomalies based on 12 wind farms in Ireland

Conclusions

- **EA and SCA modulate the correlation between the NAO and the winter wind speeds by forcing a migration of the NAO dipole**
- **The effect of NAO on wind speed is regionally variable depending on the sensitivity to the other two patterns**
- **EA and SCA negative enhance NAO+ related anomalies in Ireland, while EA+ and SCA- do the same for NAO- anomalies**
- **Consideration of these 3 patterns has allowed us to identify regions with more and less stationary NAO-wind speed relationships**

Acknowledgement

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