UCD DUBLIN

electricity research centre

Effects of the NAO and other atmospheric teleconnection patterns on wind resources in Western Europe

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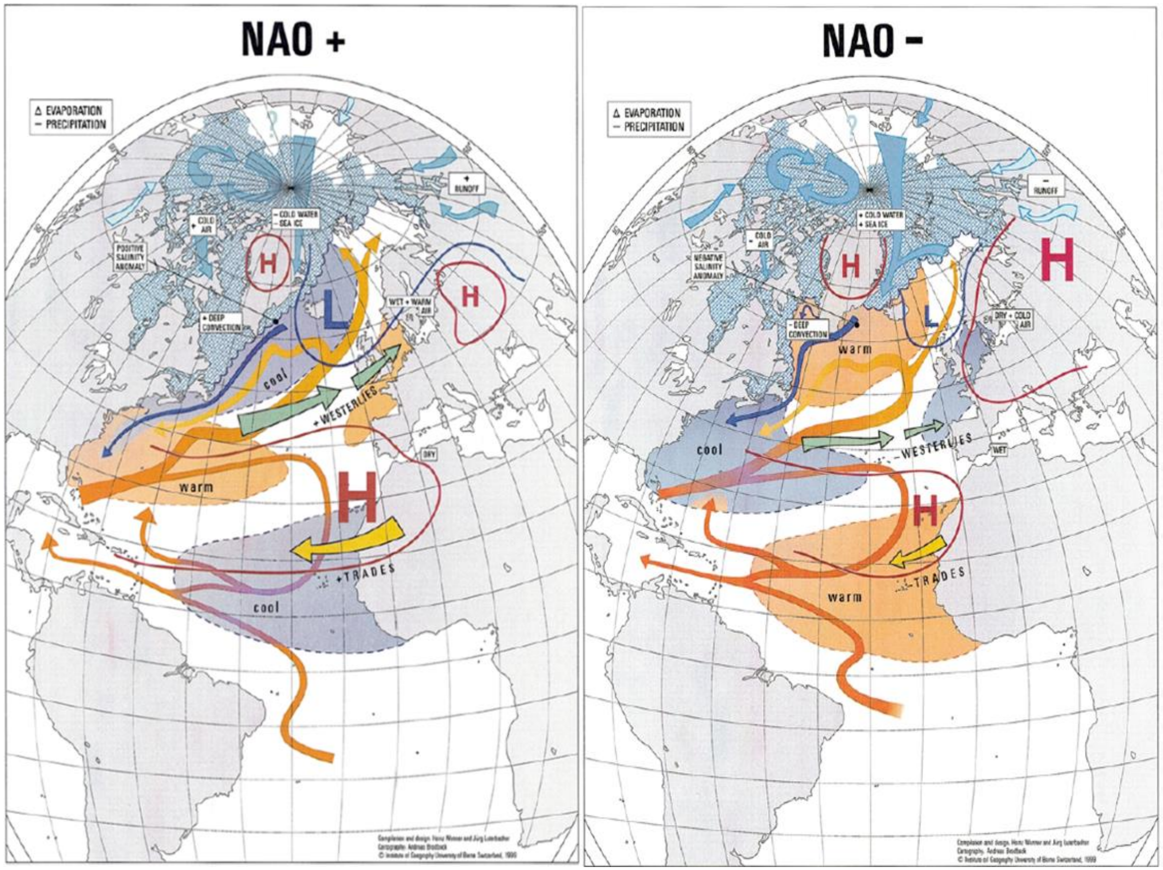
Department of Jobs, Enterprise and Innovation
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

The North Atlantic Oscillation

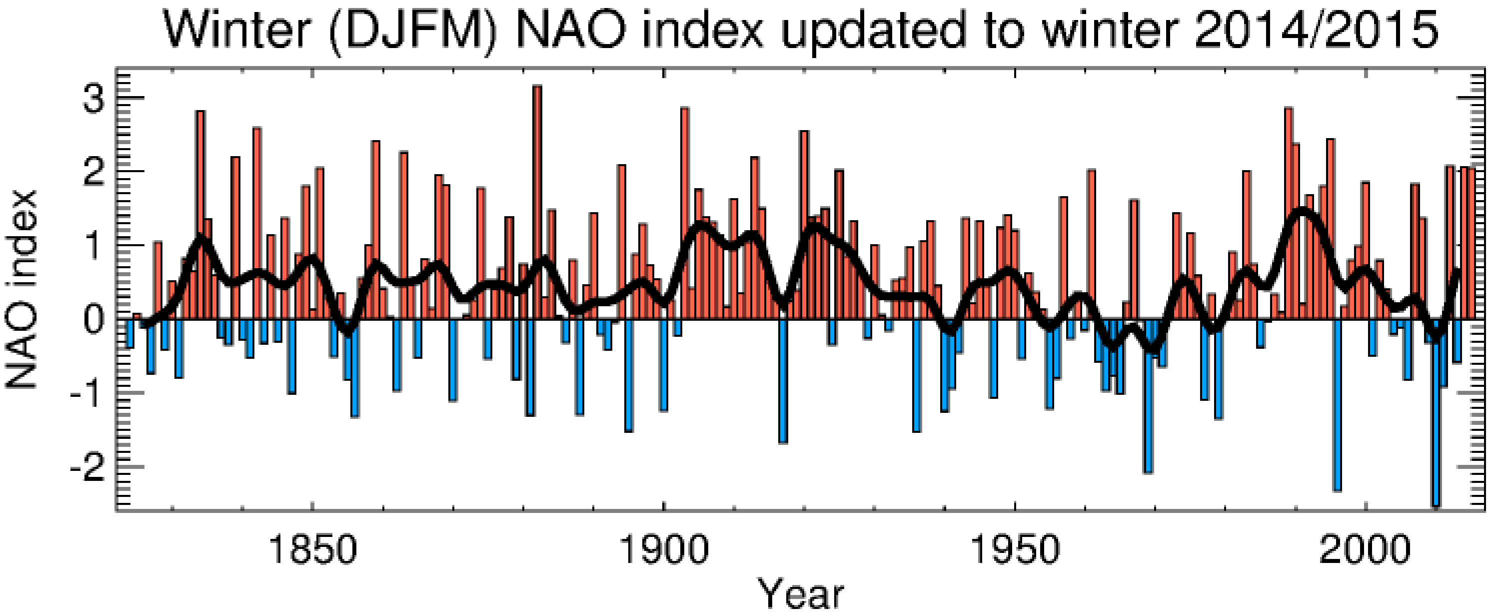


- NAO is responsible for large part of the variability of winter climate in the North Atlantic
- The NAO can be defined as a large scale oscillation of atmospheric mass
- The strength of the pressure gradient between the two centres of action varies

(From Wanner et al., 2001)

The North Atlantic Oscillation

- Definition:
  - Difference between the normalised sea level pressure over Gibraltar and the normalised sea level pressure over Southwest Iceland
  - PC time series of the first EOF of SLP

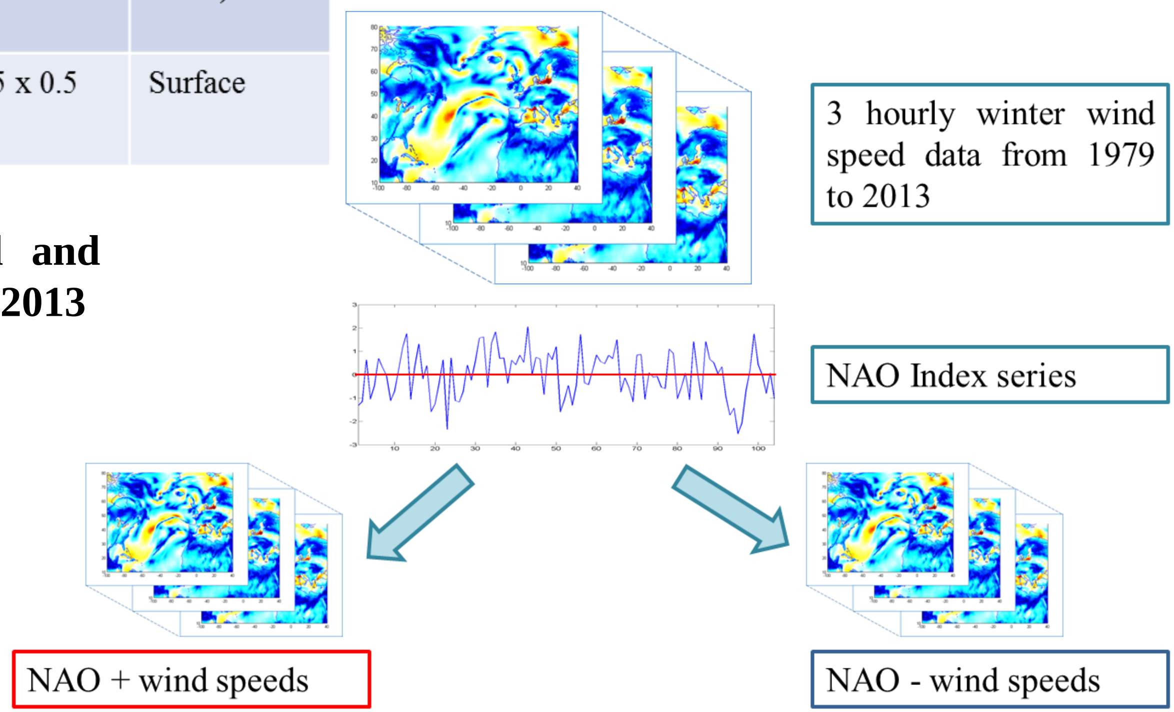


Data and Methods

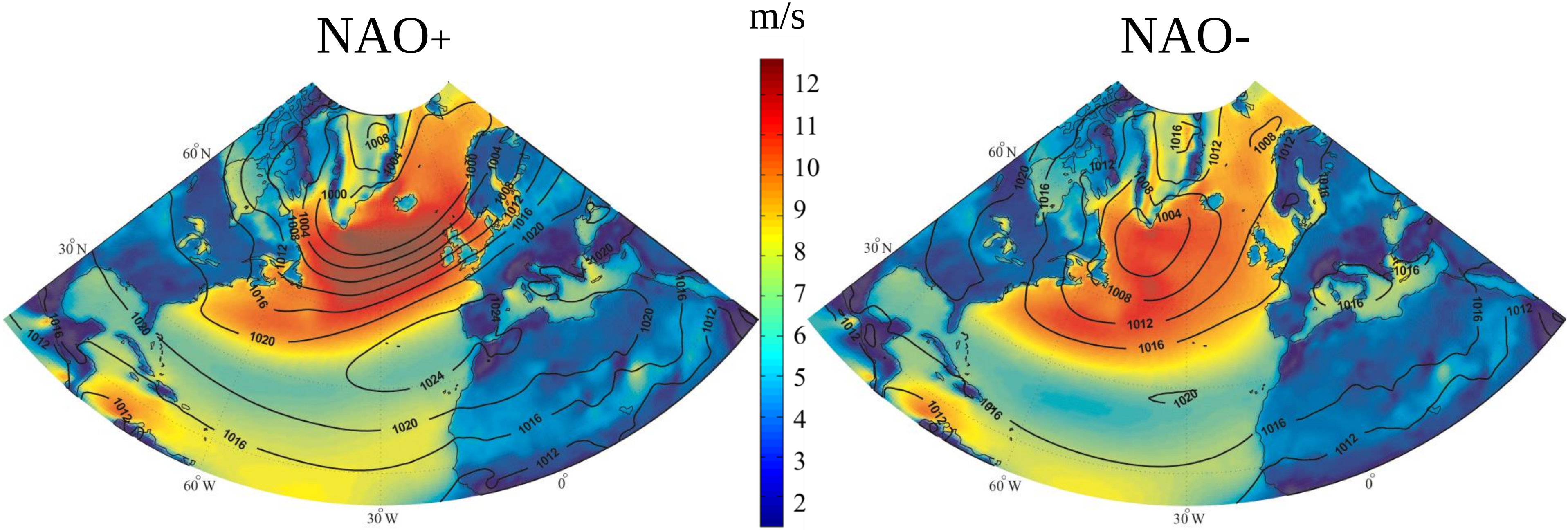
- **ERA-Interim (ECMWF)**

Variable	Time span	Temporal resolution	Spatial resolution	
U and V components (DJF)	1979 – 2013	6 hourly analysis + 3 hourly forecast	0.5 x 0.5 horizontal	10 m height (from 31 levels)
SLP (DJF)	1979 - 2013	Monthly	0.5 x 0.5	Surface

- **Met Éireann: hourly wind speed and direction observations from 1979 to 2013**

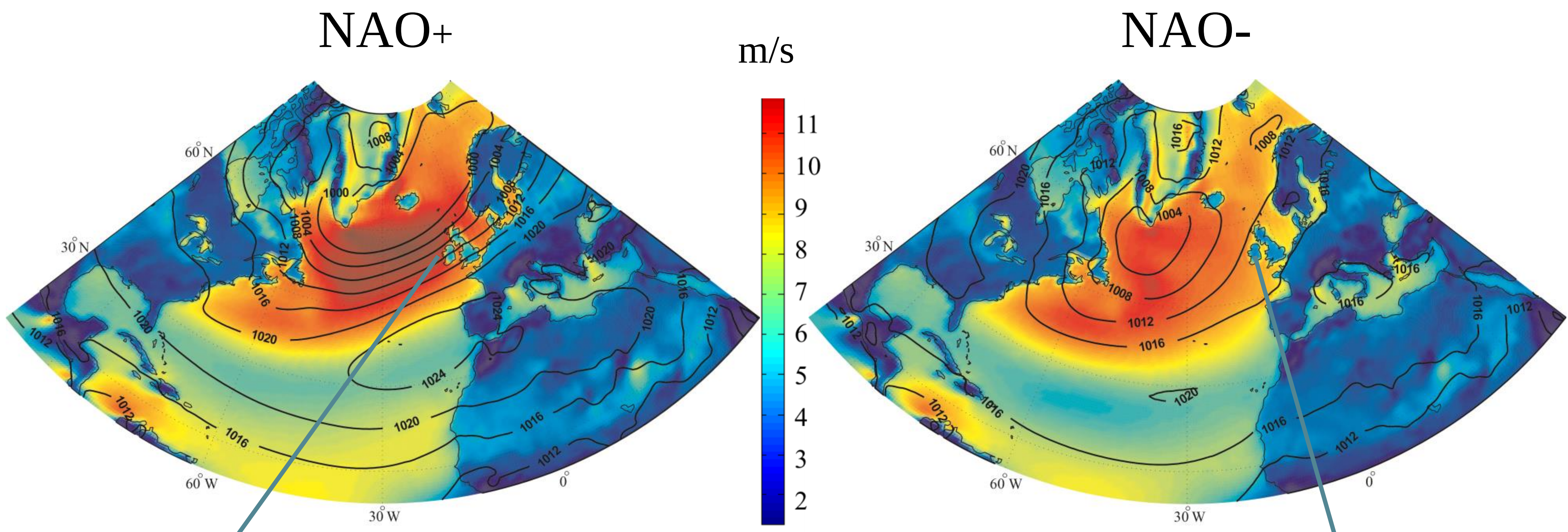


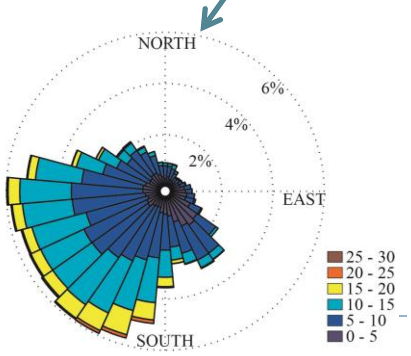
Wind speeds and directions



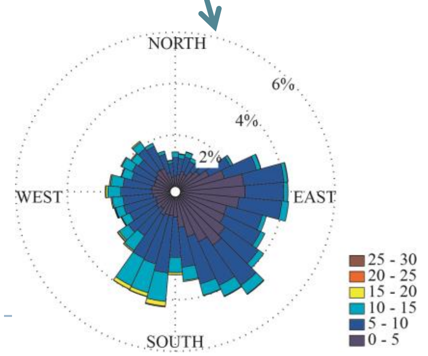
Based on DJF wind speeds from the ERA-Interim reanalysis (1979 - 2013)

Wind speeds and directions





Met Éireann observation data from Belmullet station (1979 - 2013)



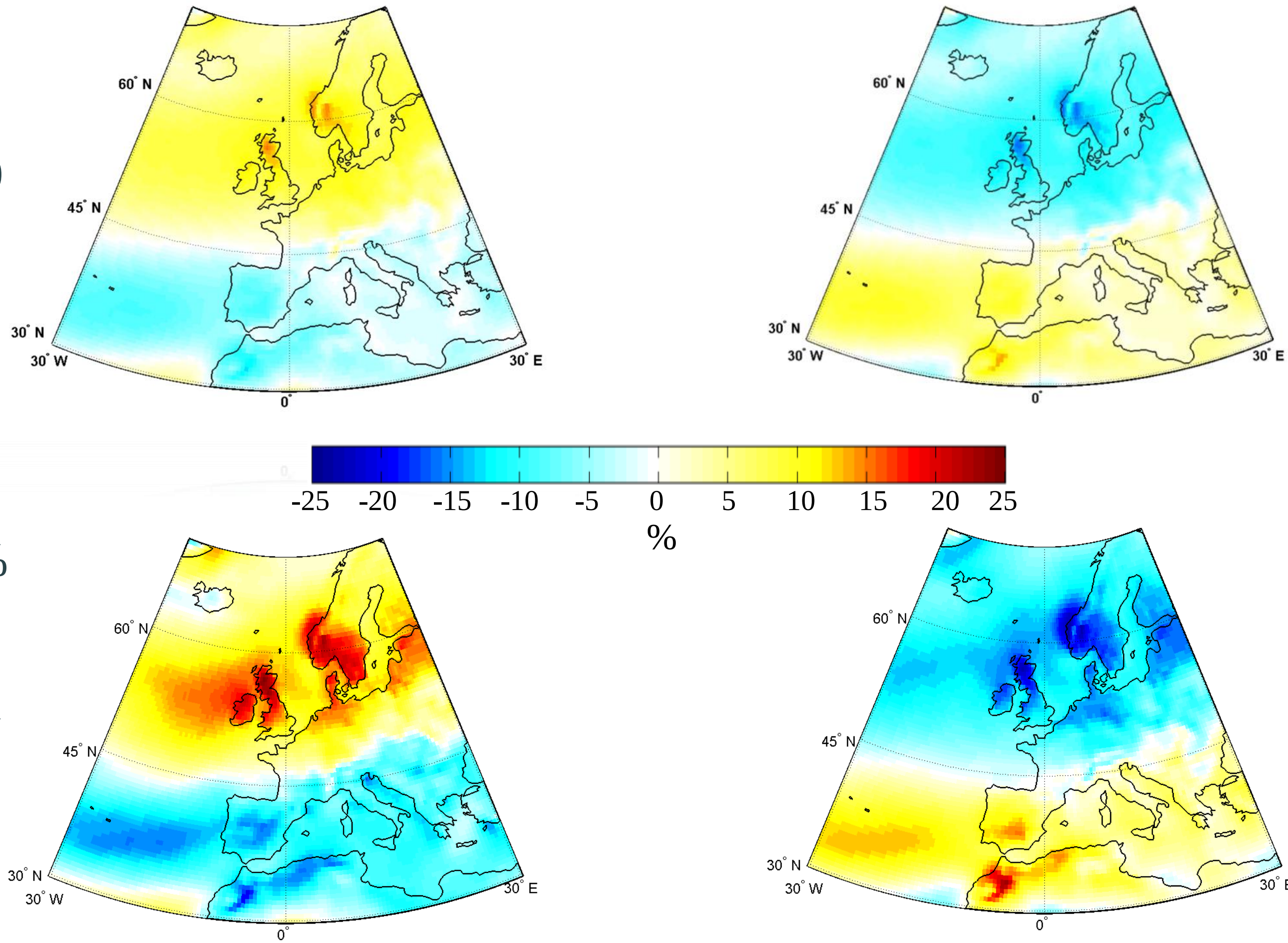
Wind speed anomalies

52.5 % NAO+

NAO- 47.5 %

NAO > 0

NAO < 0



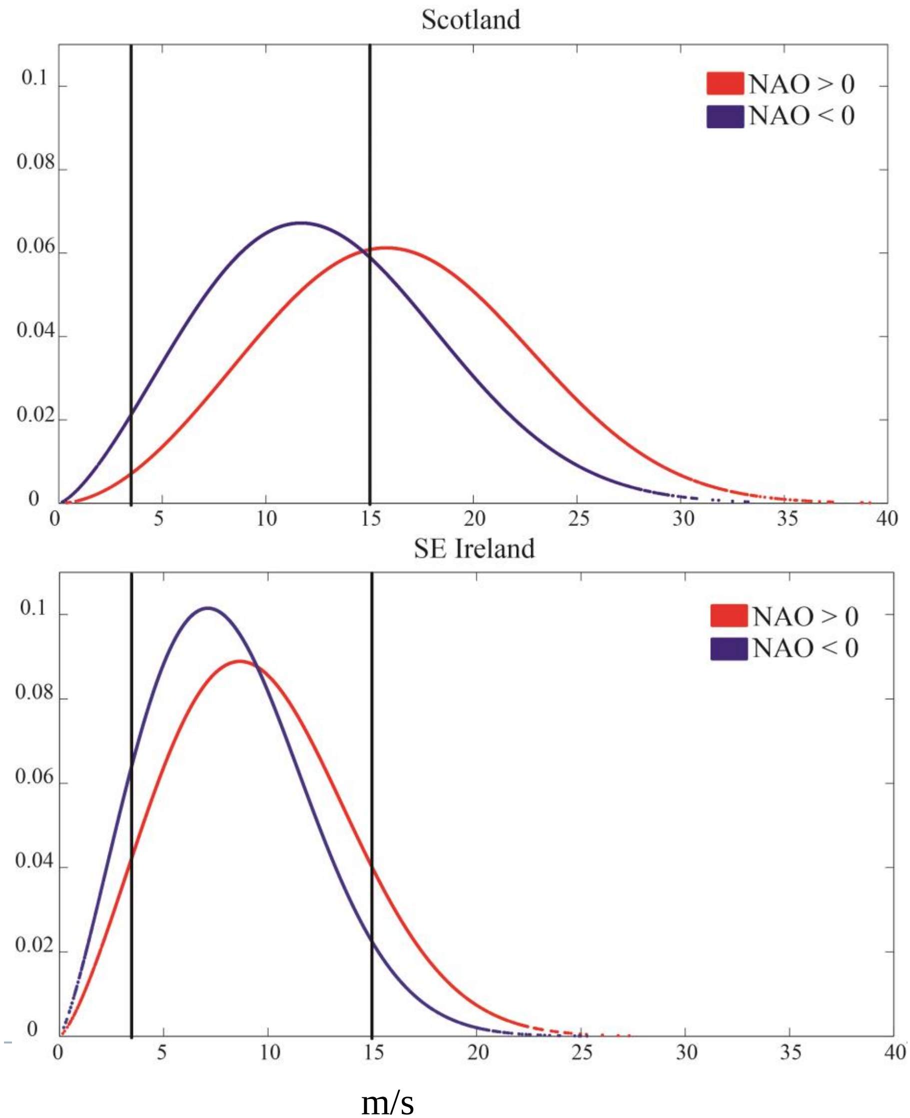
14.4 %

21.8 %

NAO > 1

NAO < -1

Weibull distributions



Scotland:

λ NAO positive = 18.38

λ NAO negative = 14.60

k NAO positive = 2.85

k NAO negative = 2.42

South East Ireland:

λ NAO positive = 10.9

λ NAO negative = 9.21

k NAO positive = 2.37

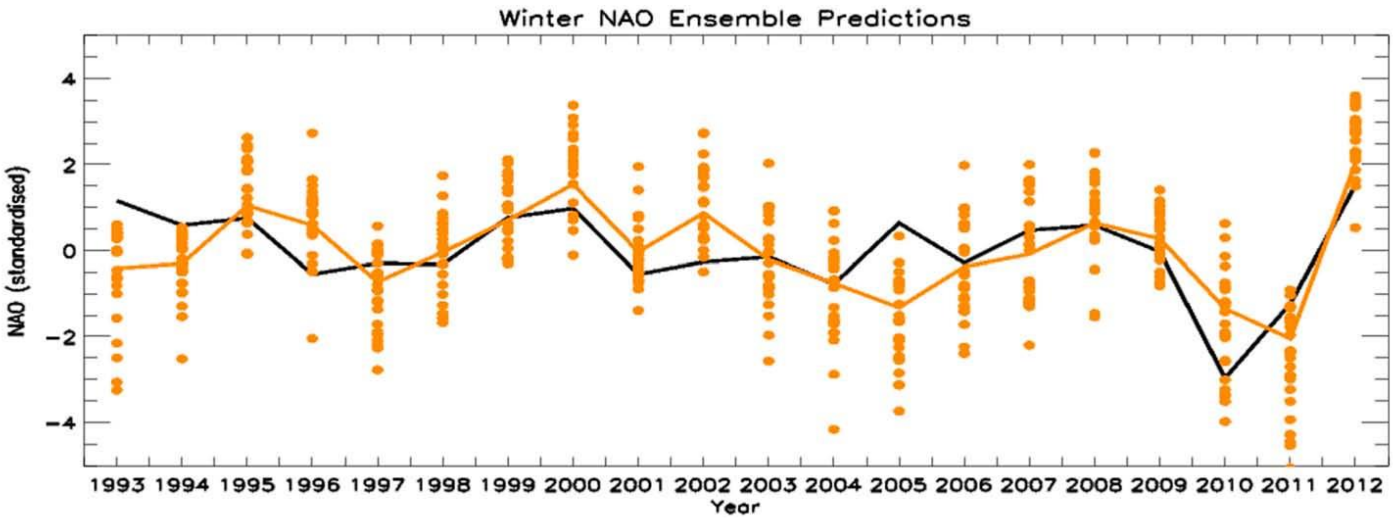
k NAO negative = 2.26

Predictability of the NAO

- 0.62 correlation between model and observation
- 1 to 4 months lead times

Sources of predictability:

- ENSO
- Ocean temperatures
- Arctic Sea Ice
- QBO



From *Scaife et al. (2014)*

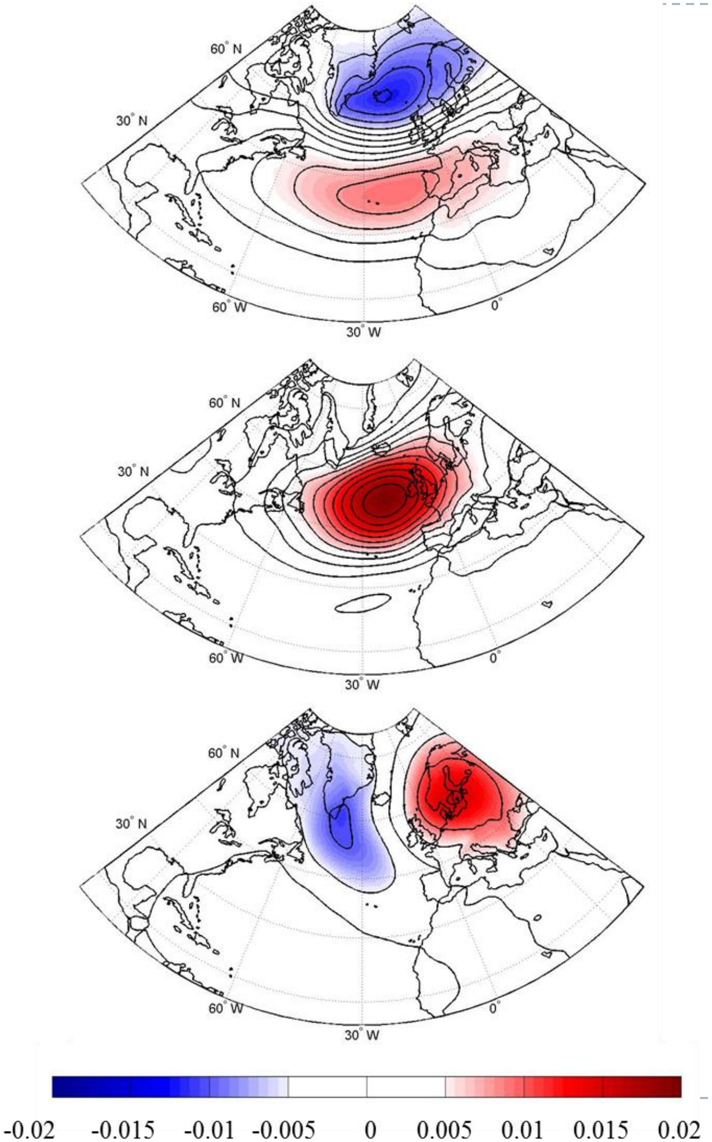
Collaboration with ESRI

- Curtis, J., M. Lynch and L. Zubiate (2015): Caron dioxide emissions from electricity: the influence of the North Atlantic Oscillation. *Applied Energy (2016), pp. 487-496 DOI information: 10.1016/j.apenergy.2015.09.056*
  - 3 % decline in emissions at 2 GW installed capacity and 9 % decrease at 4 GW installed capacity

- Curtis, J., M. Lynch and L. Zubiate (2015): The impact of the North Atlantic Oscillation on electricity markets: A case study on Ireland (*in review*)
  - NAO+: lower prices but higher CF results in increased revenue for generators

Other patterns

(Based on Moore et al., 2012)



1st EOF: **North Atlantic Oscillation (NAO)**

41.6 %

2nd EOF: **East Atlantic Pattern (EA)**

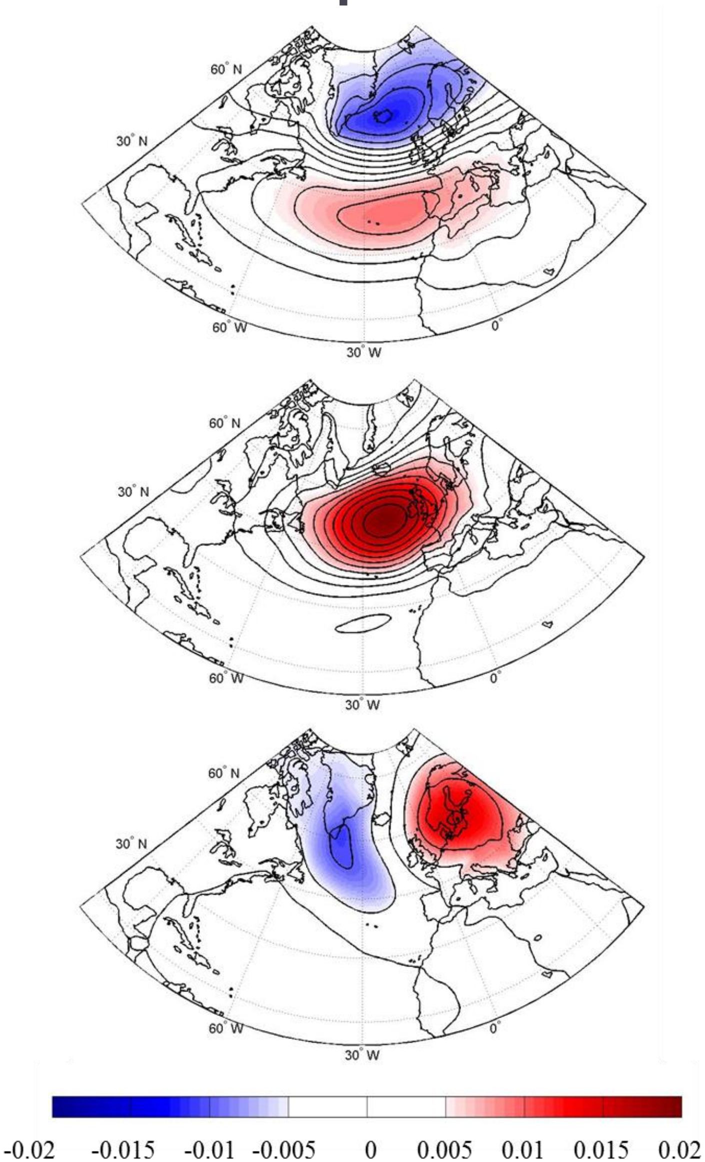
15.7 %

3rd EOF: **Scandinavian Pattern (SCA)**

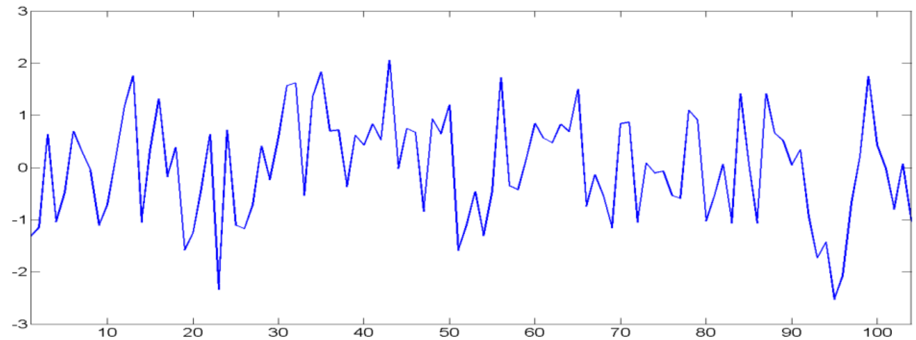
13.5 %

Dataset: DJF SLP ERA-Interim
Period: 1979-2013

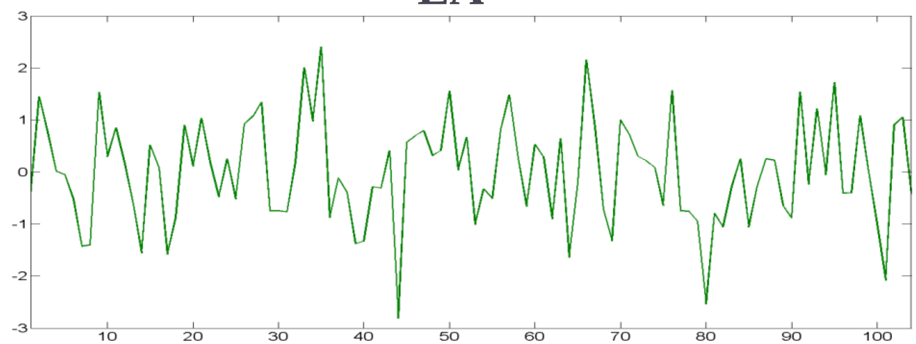
Other patterns



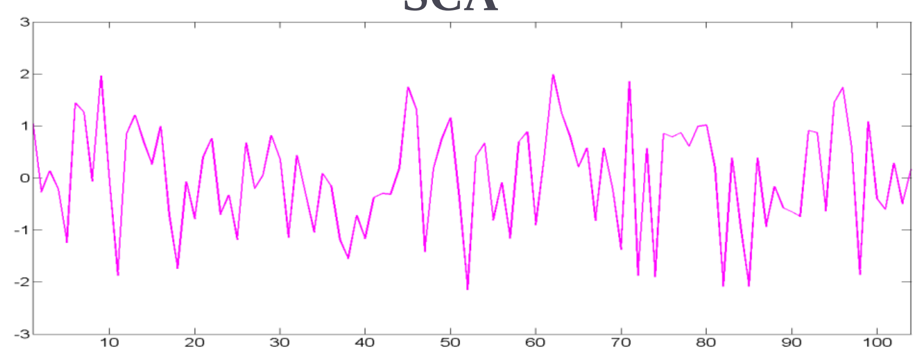
NAO



EA



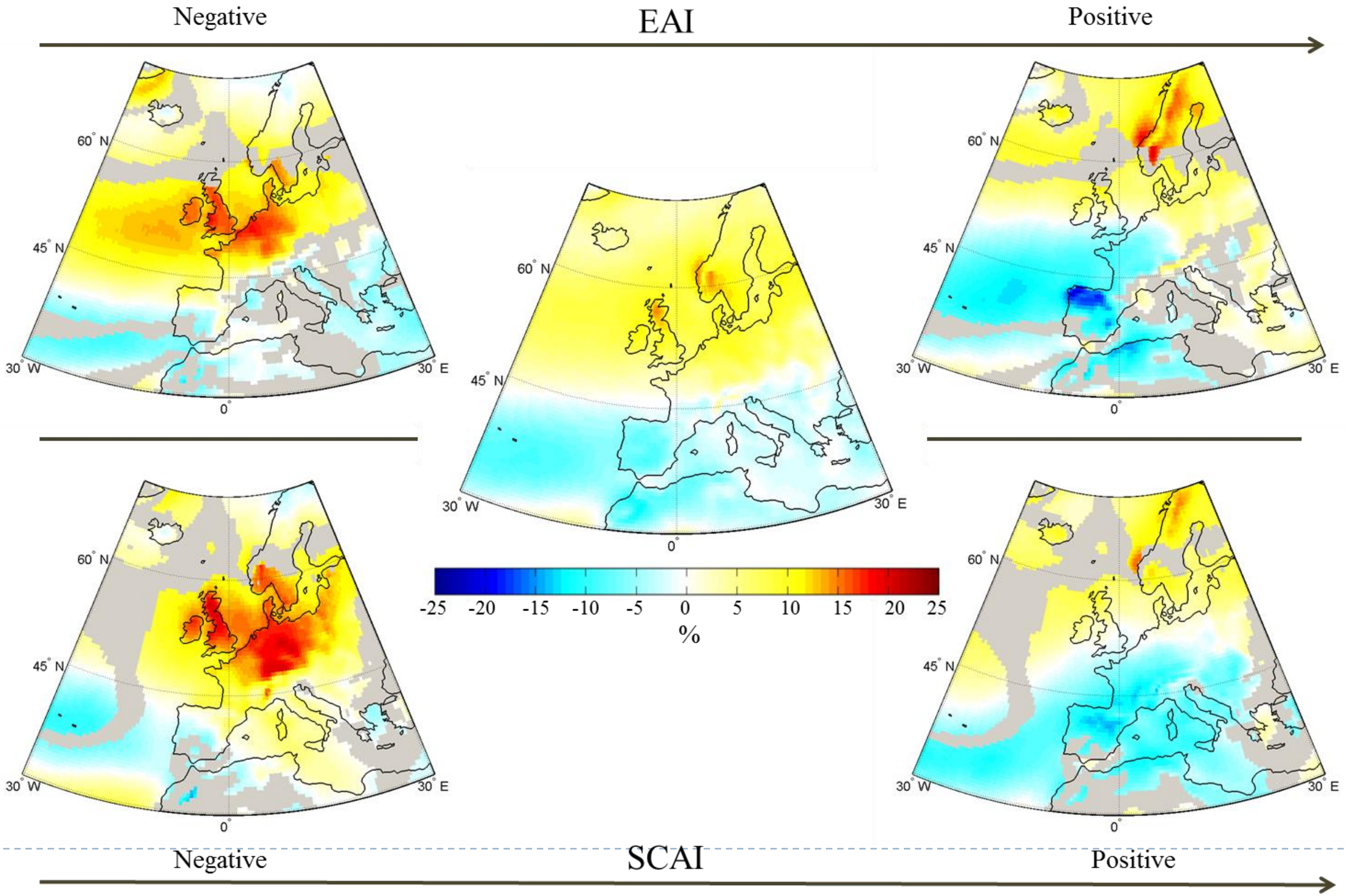
SCA



Dataset: DJF SLP ERA-Interim

Period: 1979-2013

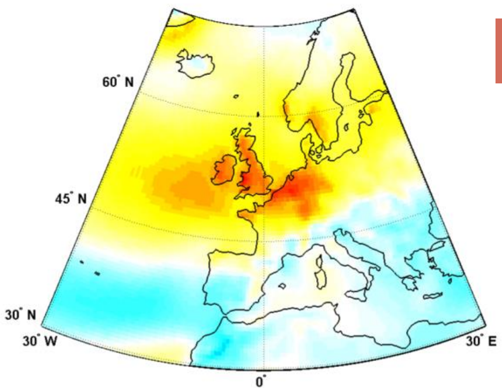
Wind speed anomalies NAO+



Power output NAO+

Data: 1999-2009 power output from EirGrid

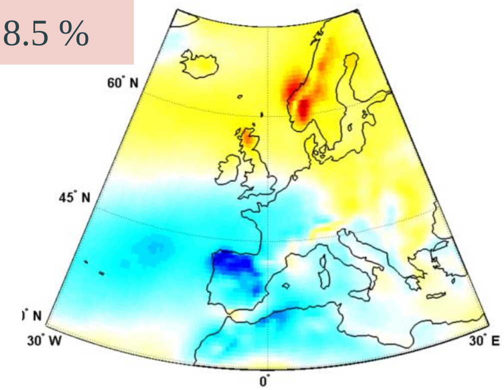
Negative EAI Positive

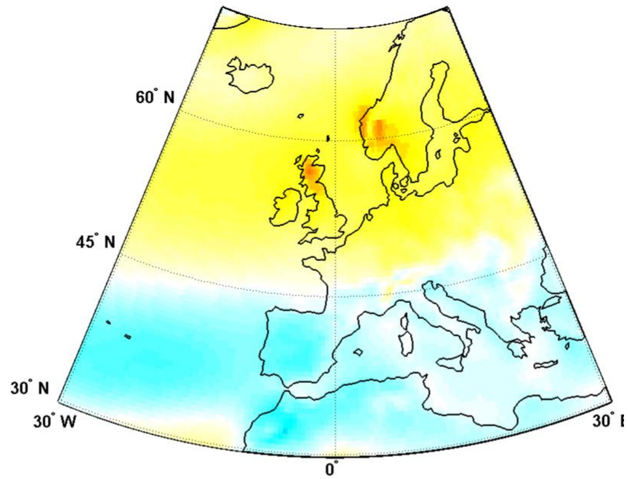


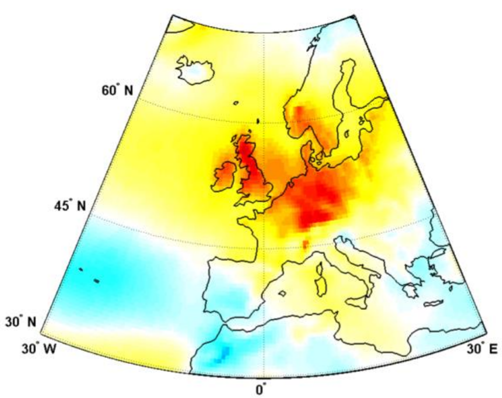
17.2 %

12.8 %

8.5 %

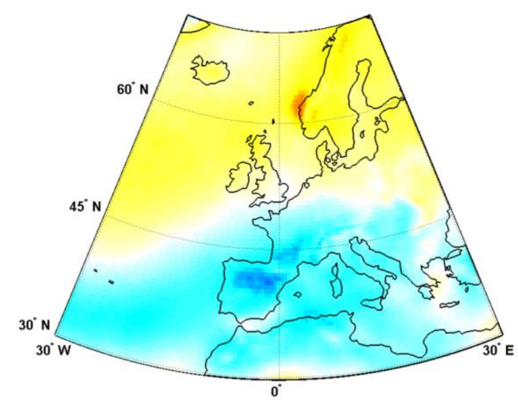






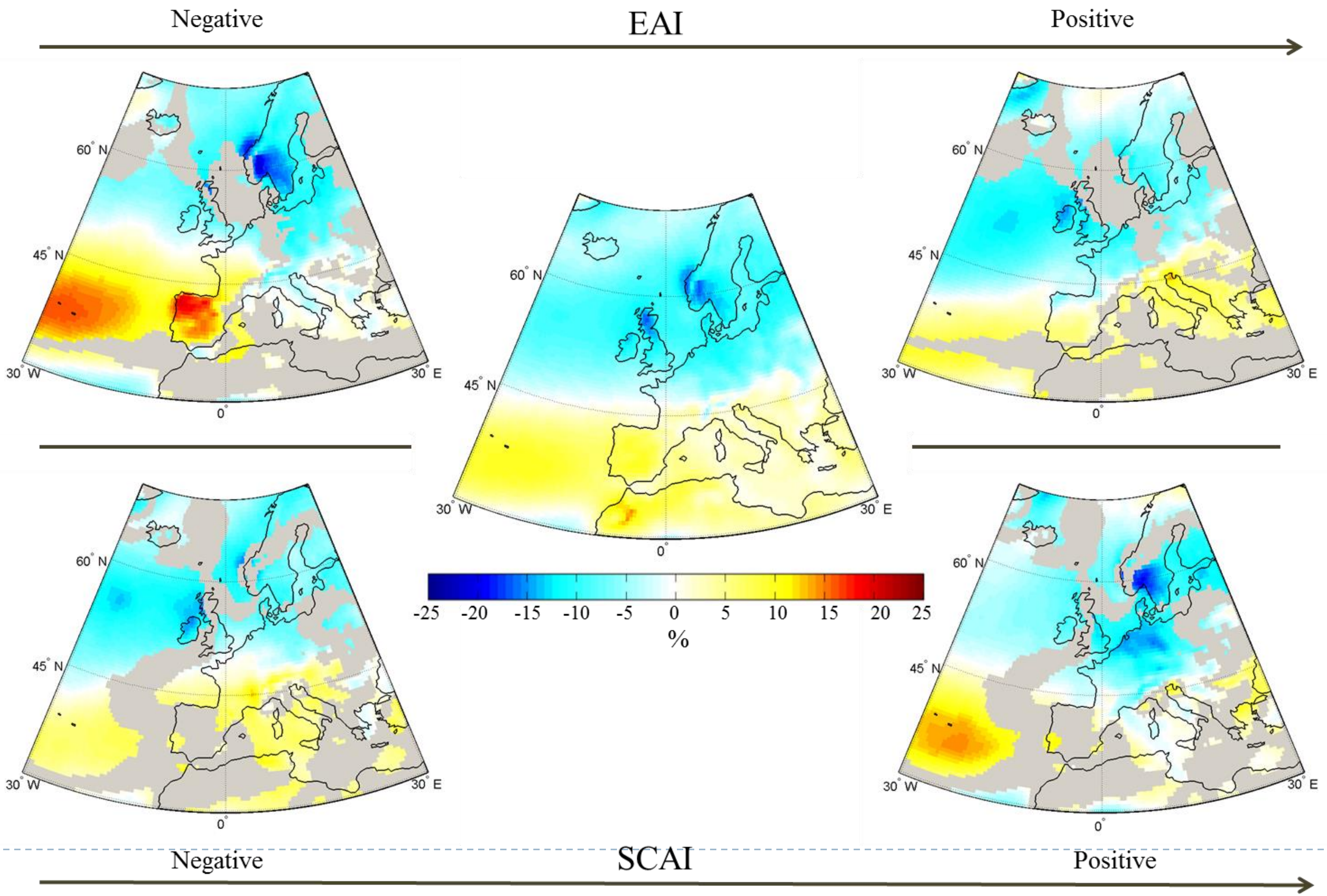
23.3 %

3.5 %



Negative SCAI Positive

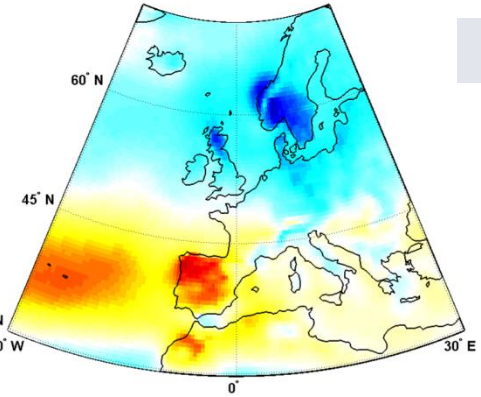
Wind speed anomalies NAO-



Power output NAO-

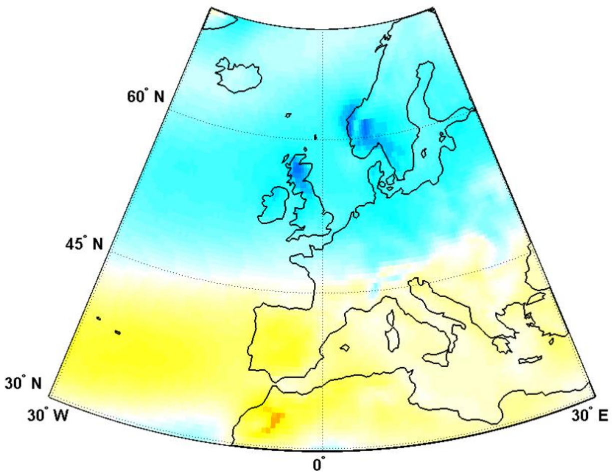
Data: 1999-2009 power output from EirGrid

Negative EAI Positive

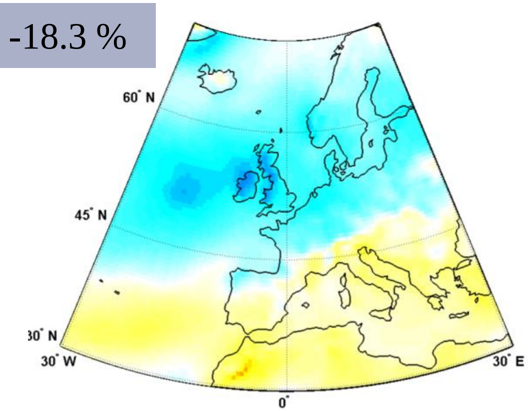


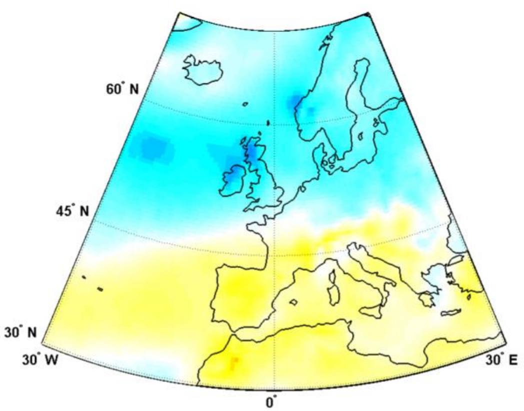
-9 %

-14.6 %



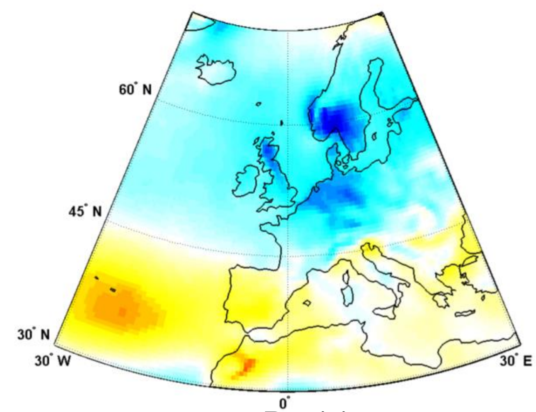
-18.3 %





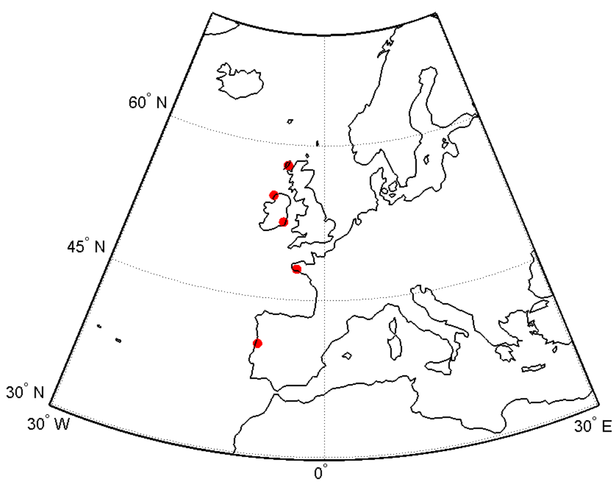
-16.5 %

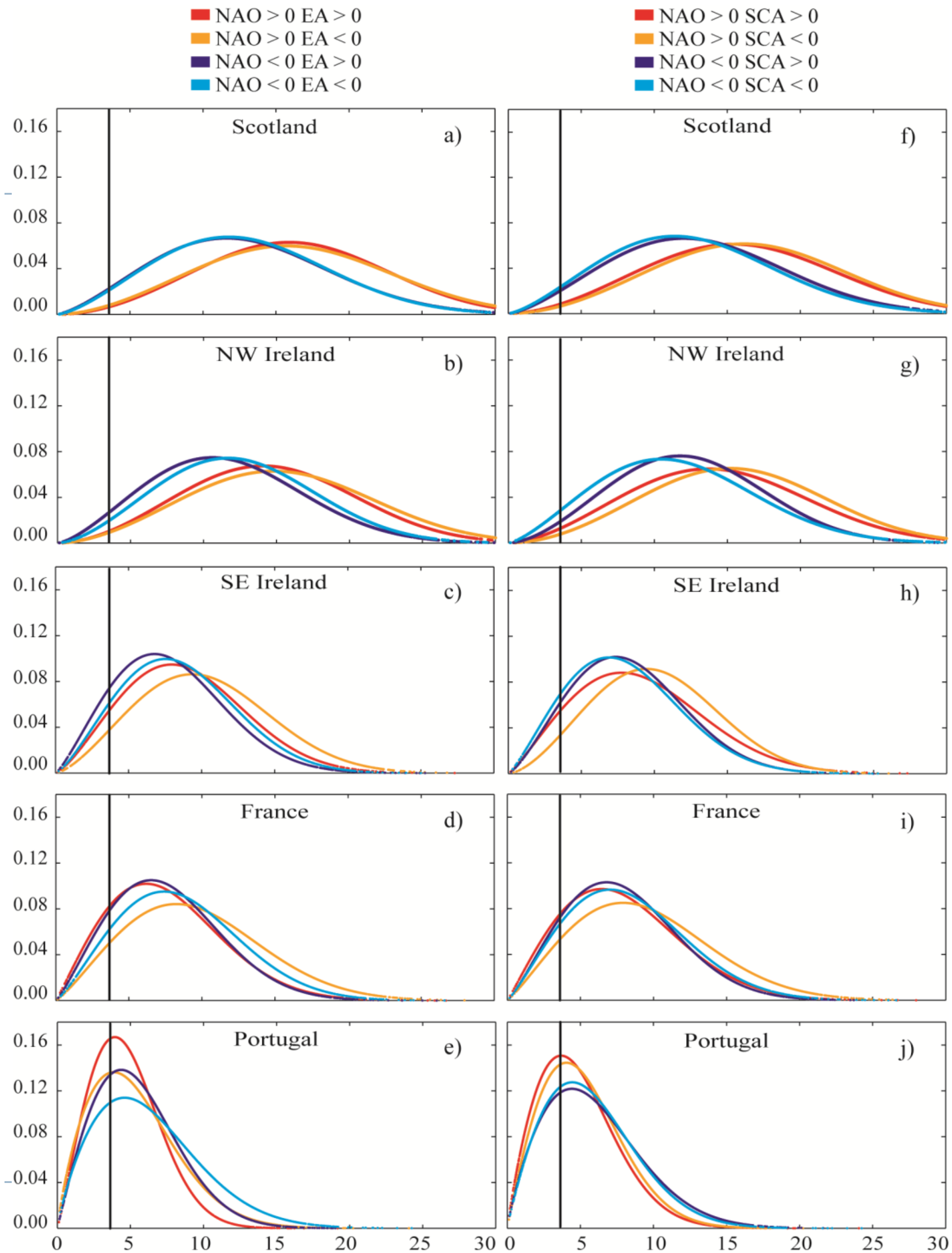
-9.2 %



Negative SCAI Positive

Weibull distributions for NAO/EA and NAO/SCA combinations



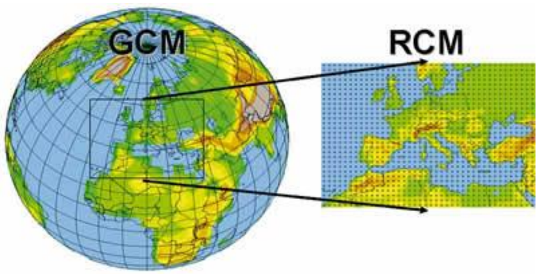


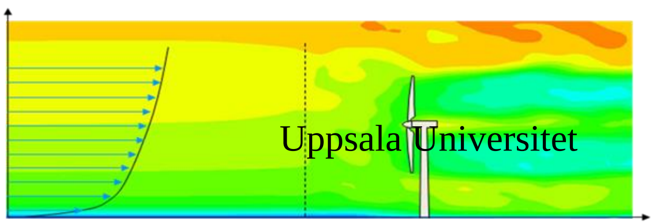
Conclusions

- The effect of the NAO on wind resources varies regionally
- In some regions (e.g. Scotland) wind speeds show a quasi-stationary relationship with NAO
- In other regions (e.g. SE Ireland), the EA and the SCA have a significant impact on winter wind distributions
- The sensitivity and behaviour of wind speeds to the NAO, the EA and the SCA gradually changes from North to South
- Given the high spatial variability, this analysis could benefit from higher resolution wind data

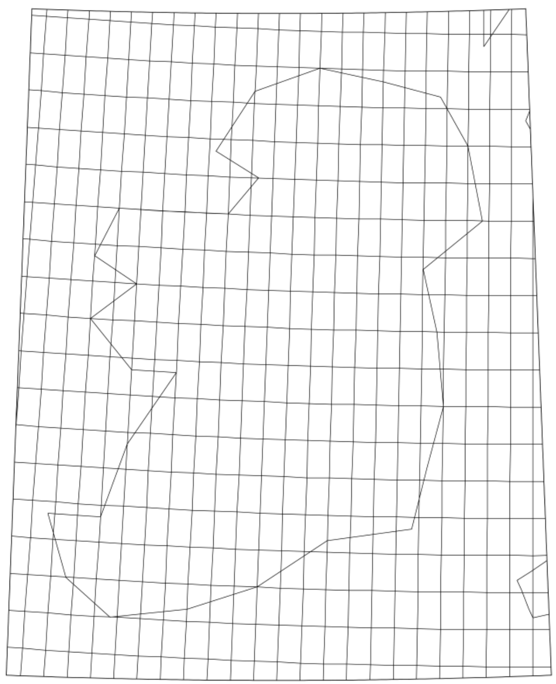
WRF Downscaling

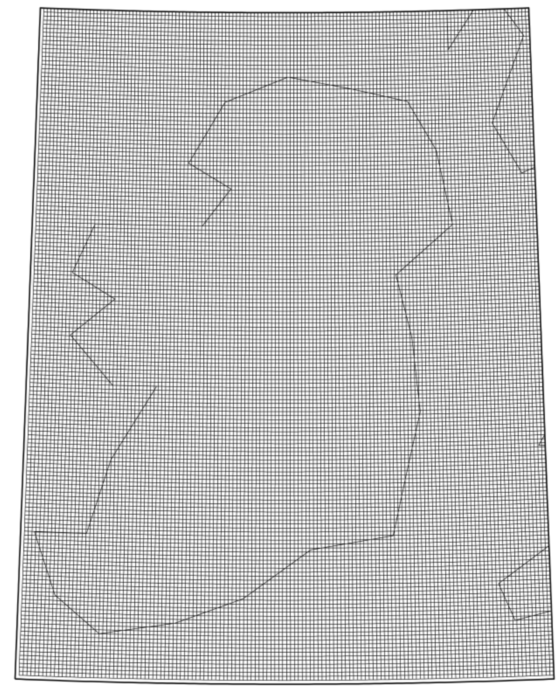
- WRF (Weather Research and Forecasting)
- Downscaling of wind speeds to 3x3 km grid to observe effects at local scale
  - Topography
    - 2' geo data resolution
  - Vertical profile
    - Cubic spline interpolation





WRF Downscaling





- 0.25° horizontal resolution
- 60 vertical levels
- 6-hourly temporal resolution

- 3 Km horizontal resolution
- 31 vertical levels
- 1-hourly temporal resolution
- Time series of selected variables at 60 s resolution

Work in progress

- Validating WRF output at the moment
- Replicate the spatial analysis of the influence of the three main large-scale atmospheric patterns on new dataset
- Estimate the effects on winter power output

Thank you!