An Investigation of regional correlation gradients between the North Atlantic Oscillation and solar energy resources in Ireland and the UK

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Introduction

Large-scale integration of renewable energy sources requires better assessments of their spatio-temporal variability. Here we focus on regional-scale differences in the correlations between solar short-wave (SW) radiation and the North Atlantic Oscillation index (NAO; Figure 1). We demonstrate that this pattern is influenced by local orography.

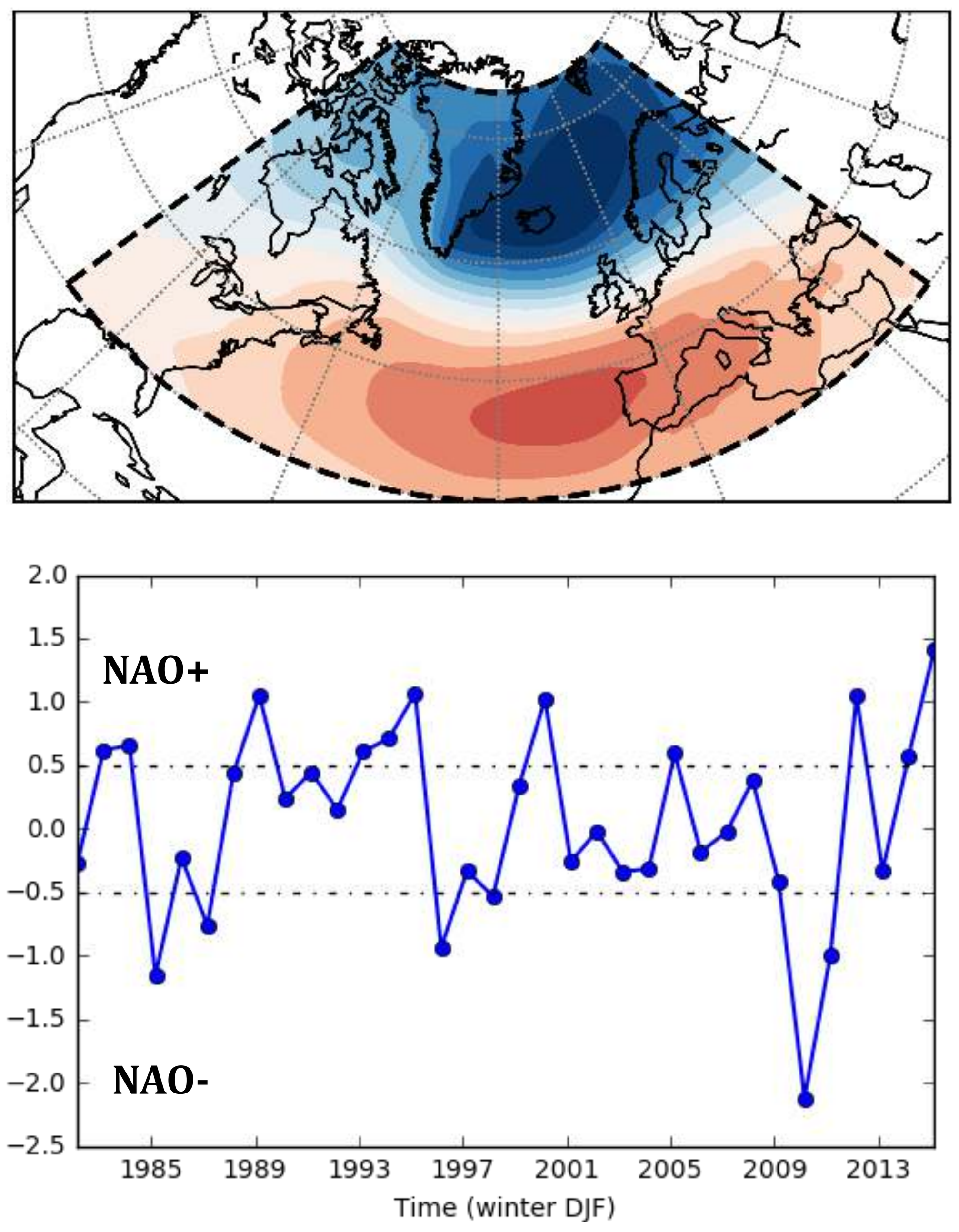


Figure 1: North Atlantic Oscillation sea-level pressure pattern (upper) and variability of the index (lower). The NAO index oscillates between positive (NAO+) and negative (NAO-) values, reflecting changes in mean monthly atmospheric pressure patterns.

Data

Data from the following sources were used:

1. NOAA's Climate Prediction Center NAO pattern indices, for the winter season (December-January-February) for the time-period of analysis (1982-2015).

2. Met Éireann's MÉRA Climate Reanalysis' [1] SW solar radiation data for the winter season and same period.

3. European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT): Surface incoming shortwave radiation, from EUMETSAT's first generation satellite.

Methods

The solar data (MÉRA & satellite) were normalized against their respective climatological monthly mean before being aggregated into winter season means.

Results

Correlation Scores

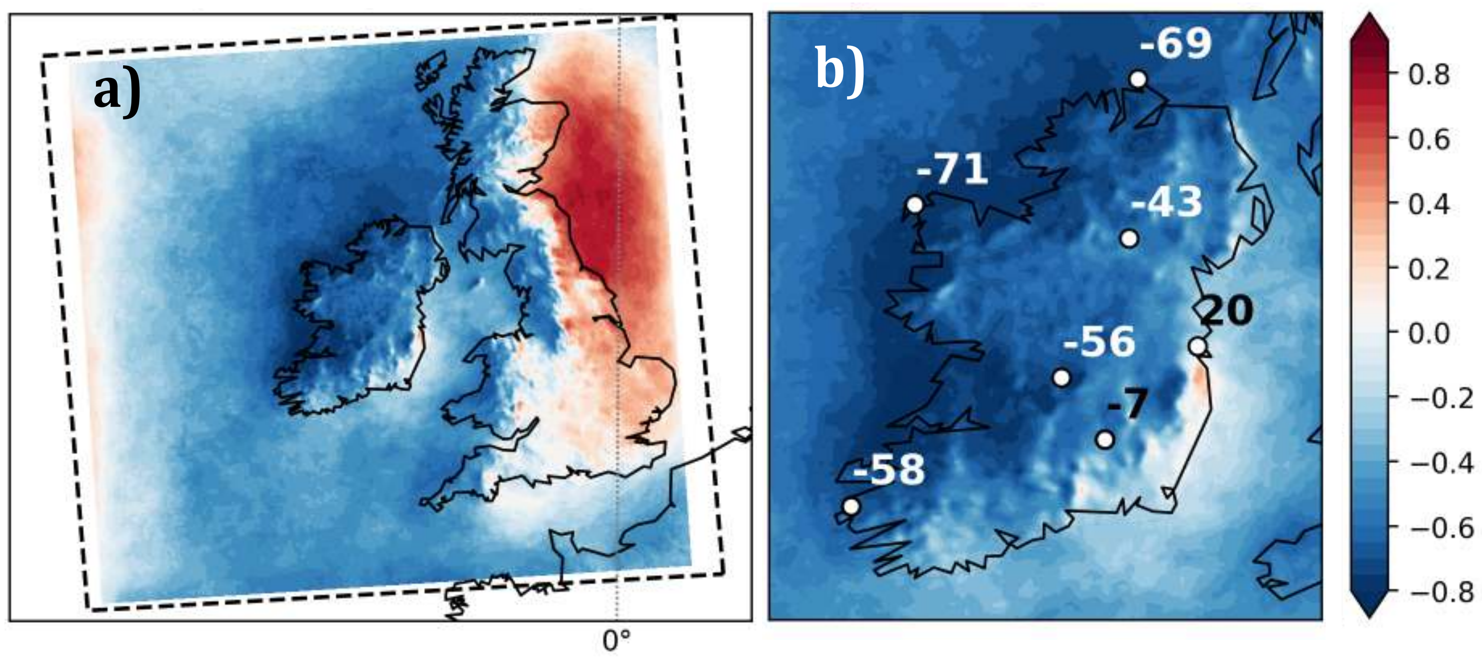


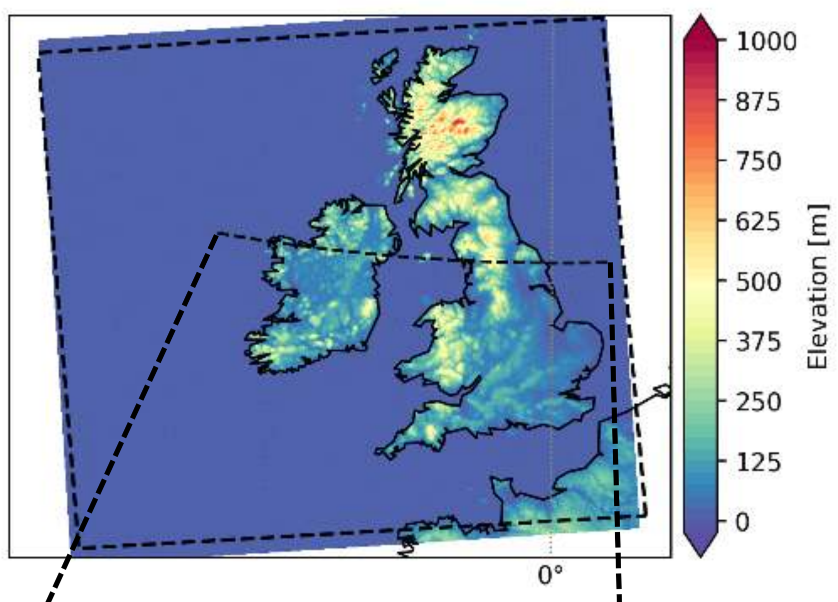
Figure 2: Spearman correlation scores using MÉRA's SW radiation for the period 1982-2015. Plots show the scores between radiation and the NAO index for the whole domain a) and for the island of Ireland b). The later includes the correlation scores (R x 100) for station observations.

In the UK, correlations between winter SW radiation and the NAO index exhibits a strong zonal gradient (Figure 1 a).

A similar but weaker correlation gradient was found for Ireland, with highly negative correlations along the Alantic seaboard (Figure 1 b), and weak to no correlations in southeast Ireland.

Spatial variability across latitude transects

Figure 3: Elevation mask for the studied domain, from MÉRA .



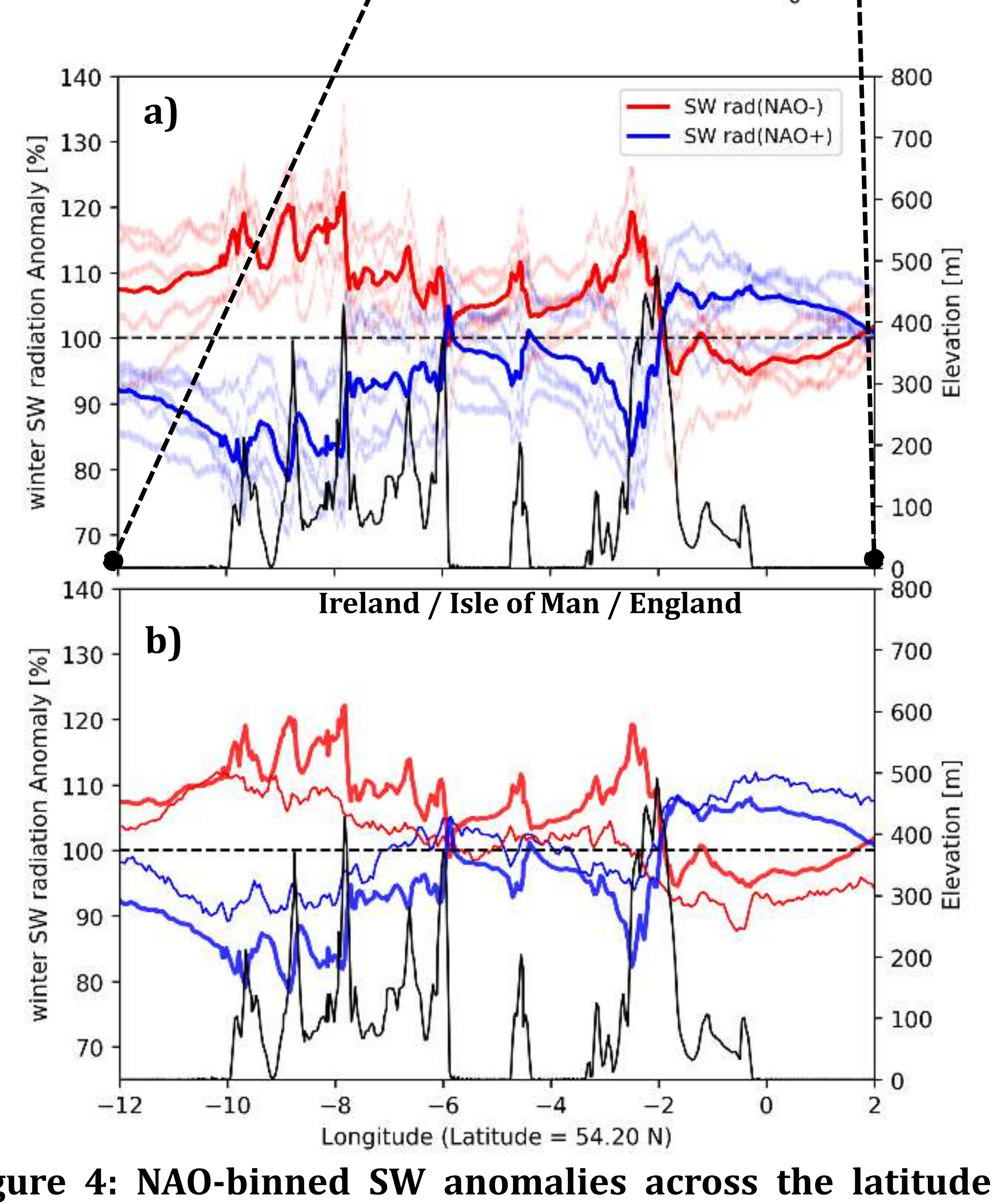
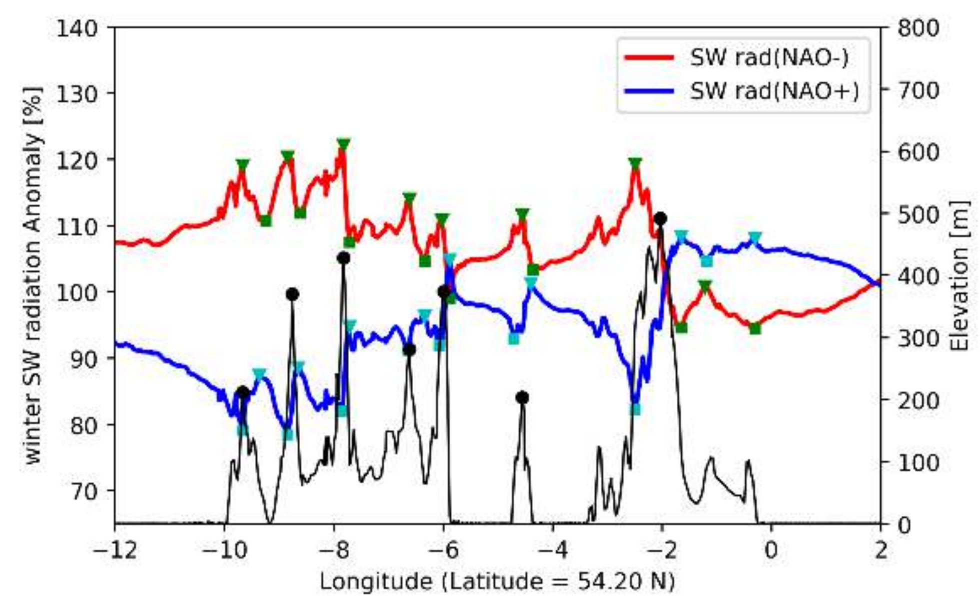


Figure 4: NAO-binned SW anomalies across the latitude of 54.20 N. Red (blue) refers to NAO- (NAO+) SW anomalies. Plot a) was produced using MÉRA, and contains the average radiation (bold) for each NAO phase and the average radiation for individual winters, used to compose the mean. Plot b) includes satellite data (thin lines) for comparison with the MÉRA (bold) derived SW anomalies. Both plots show the elevation across that latitude (black line).

Peak lag analysis

Figure 5: Local minima (squares) and maxima (triangles) peaks of SW anomalies & orographic peaks (black ball markers), for average NAO- (red) and NAO+ (blue) conditions. The thin black line represents the elevation of the land masses (MÉRA data).



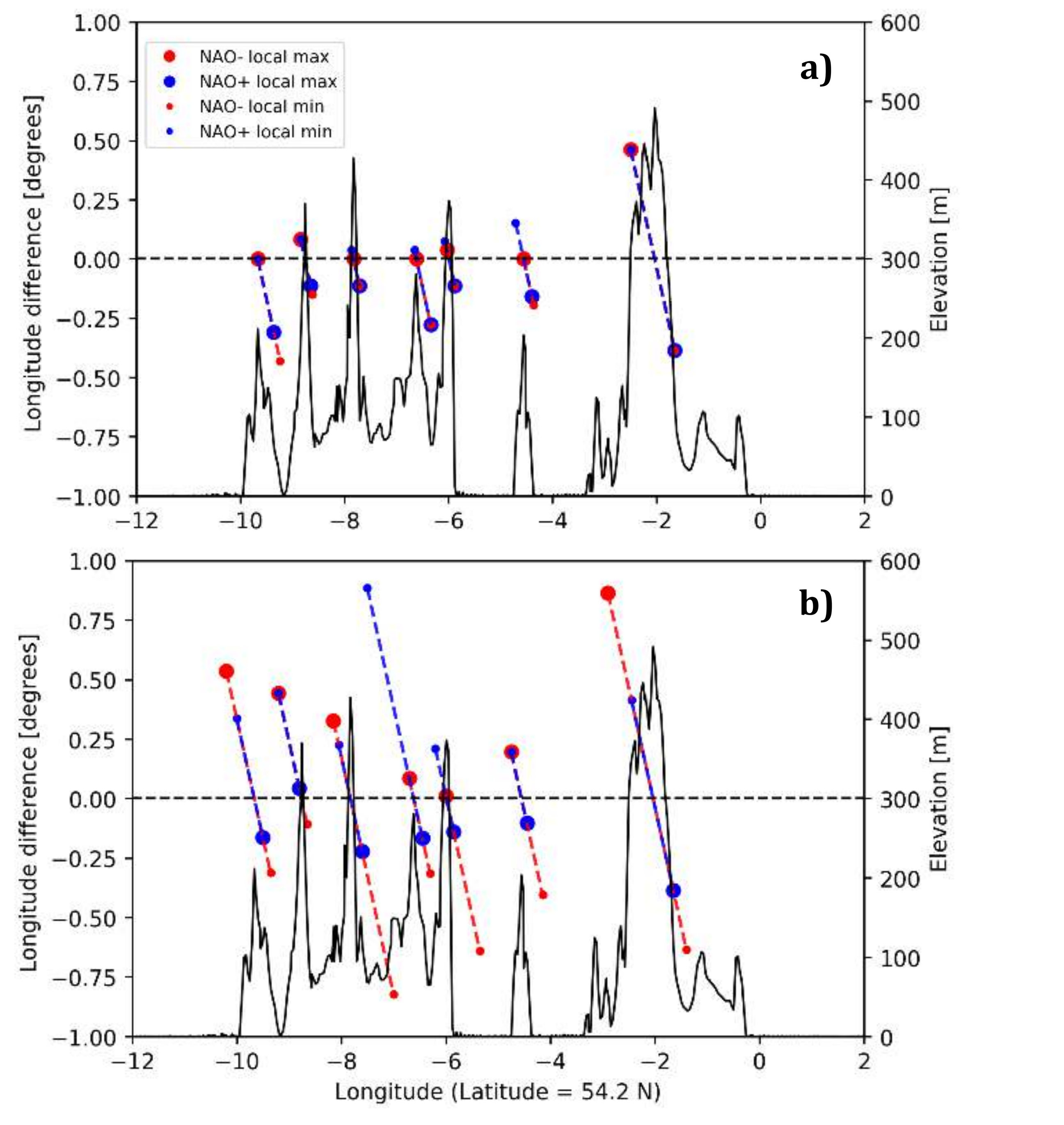


Figure 6: Longitude difference between NAO-binned peak SW anomalies, across the latitude of 54.20 N. Red (blue) ball markers refer to local peaks associated with NAO- (NAO+) conditions, with the small (big) markers representing local minima (maxima) in SW anomalies. Figure 6 a) is based on MÉRA. Figure 6 b) is based on independent satellite-derived SW data.

Conclusions

- Winter solar radiation variability is strongly linked to the NAO, but considerable spatial variation in the correlation signal exists across the land masses of Ireland and Britain (Figure 2).
- This spatial variation is predominantly west-east oriented (Figure 4) and at local scales is reinforced by the existence of topographic cross barriers (Figure 6).
- Extended analysis (not shown) suggests that these local and regional gradients can be explained by the NAO's modulation of wind speeds and directions and its interaction with orographic features.
- Findings may inform local- and regional-scale renewable energy generation balancing.

References

[1] *Gleeson et al., 2017, Adv. Sci. Res.*

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