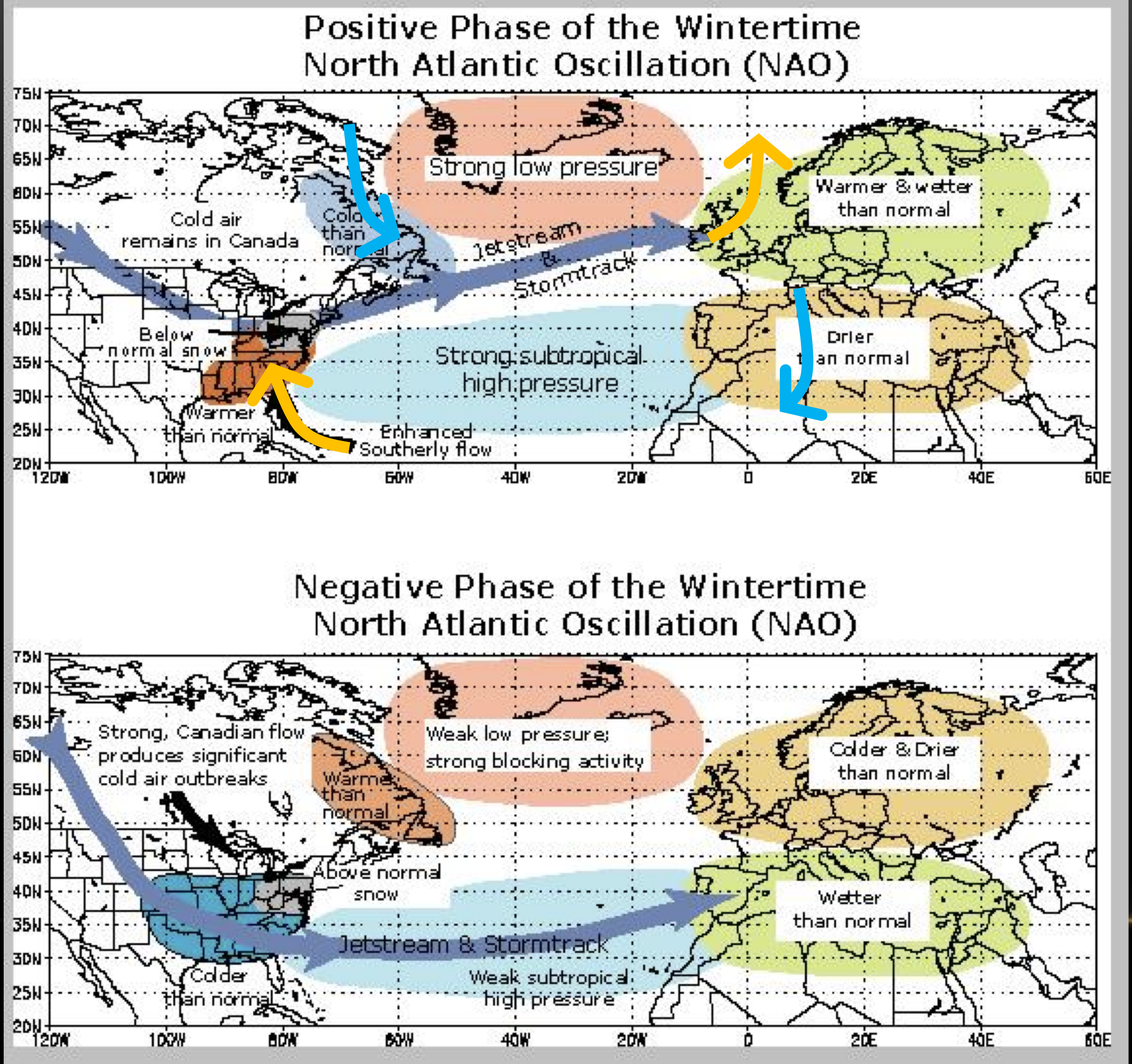
NAO Impacts and Application

The NAO Impacts

- The NAO is associated with changes in temperature and precipitation from eastern North America to western and central Europe (Walker and Bliss 1932, van Loon and Rogers 1978, Rogers and van Loon 1979).
- The NAO accounts for about half of the year-to-year variability in winter surface temperature over Northern Europe [Rodwell et al., 1999] and a third of the variability in northern hemisphere surface temperature [Hurrell, 1996].

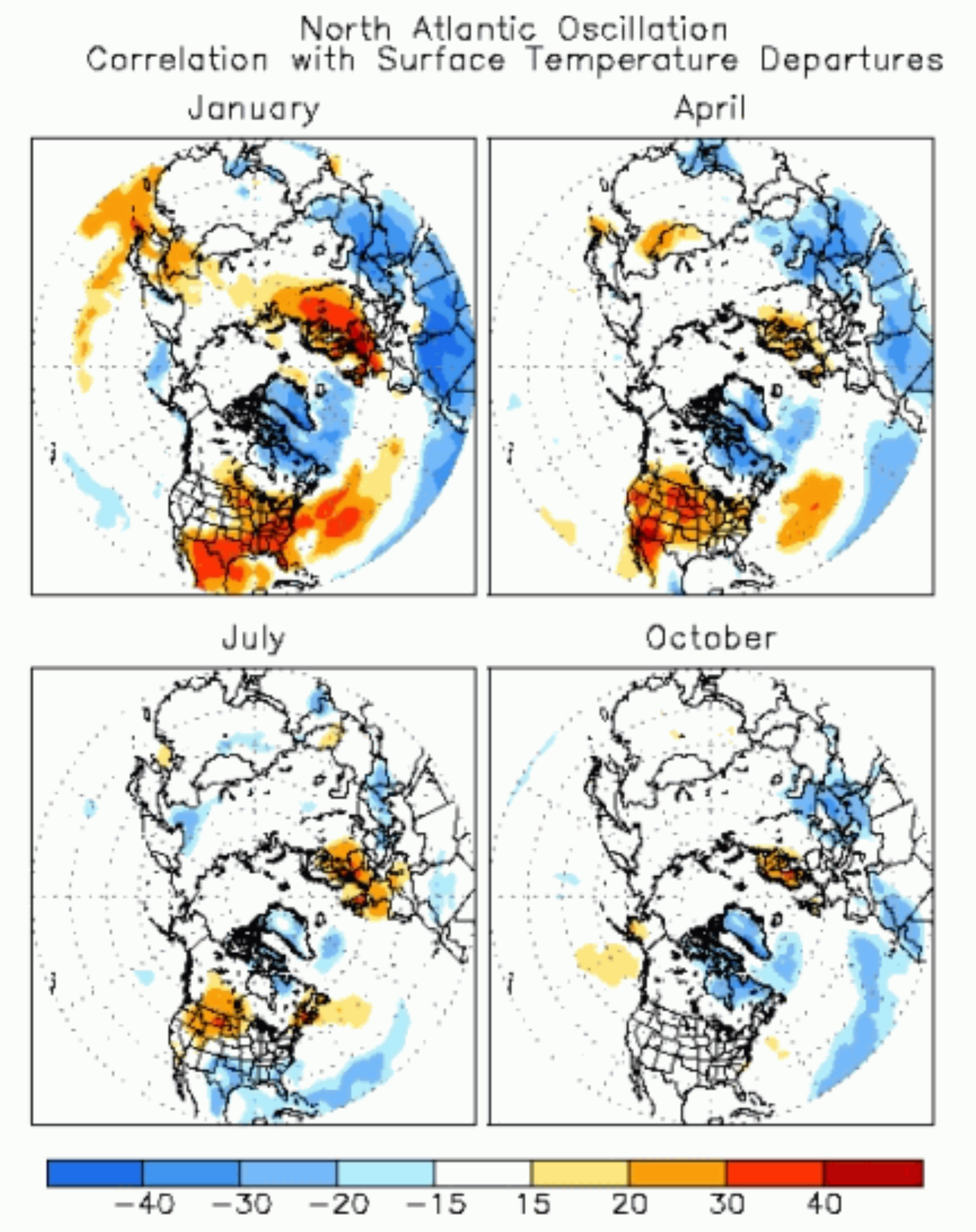


T and precipitation anomalies associated with the NAO can be largely explained by advection and the changes in the storm track.

Blue arrows: cold advection

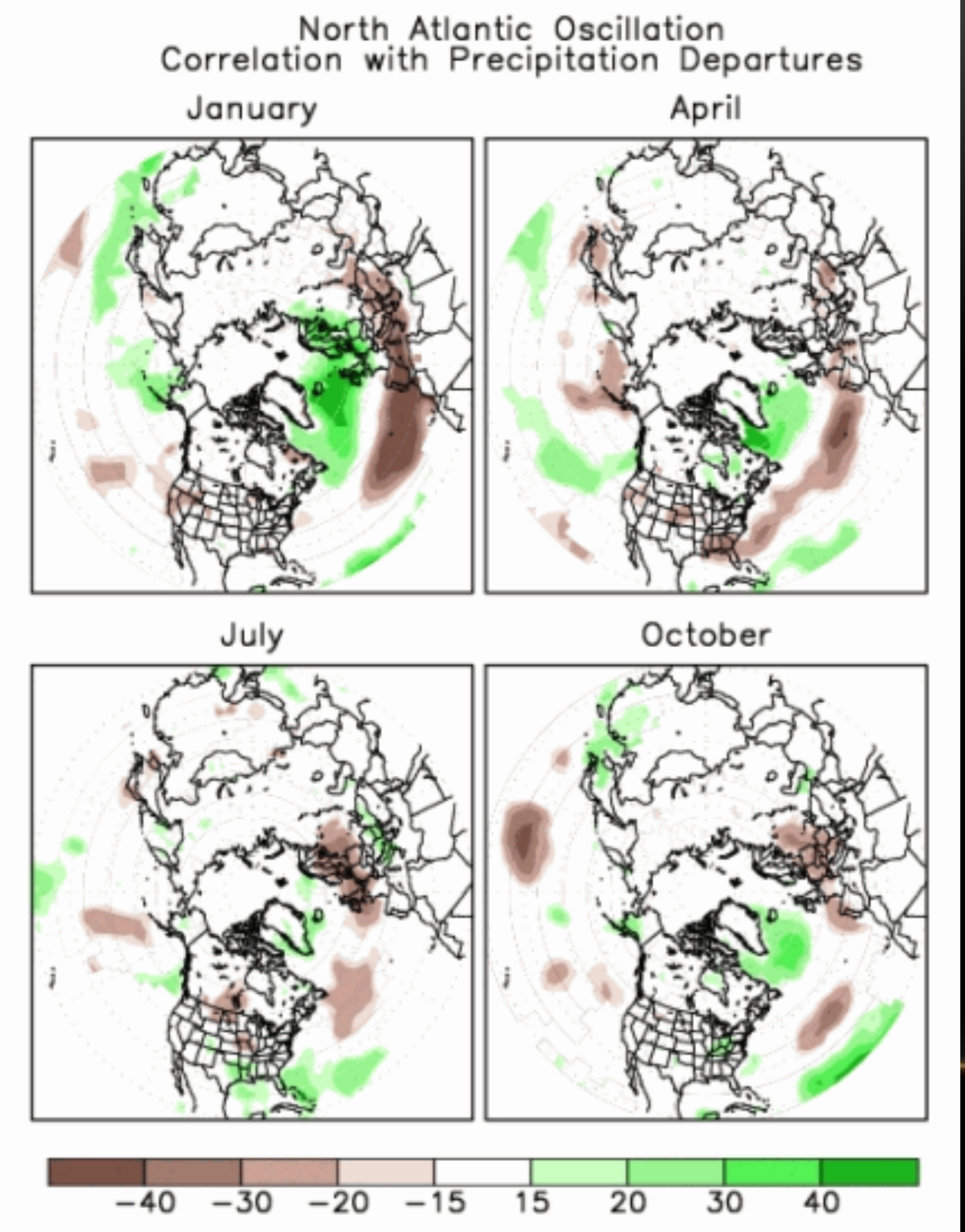
Orange arrows: warm advection

http://www.weather.gov/images/iwx/webpages/climate/la_nina/NAOImpacts.jpg



- Temperature anomalies over eastern North America and western Europe have a quadrupole structure.
- Strongest anomalies occur in the northern winter.

CPC: https://www.cpc.ncep.noaa.gov/data/teledoc/nao_tmap.shtml

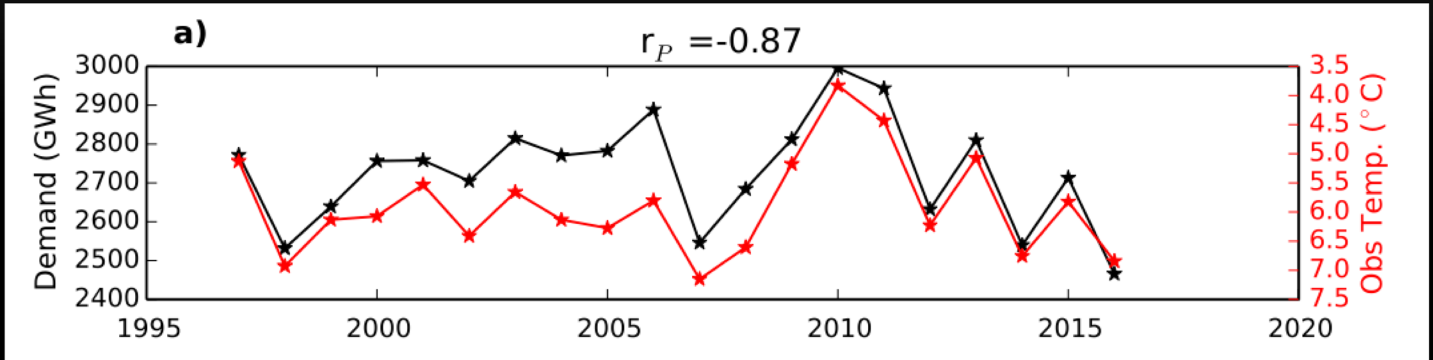


CPC: https://www.cpc.ncep.noaa.gov/data/teledoc/nao_pmap.shtml

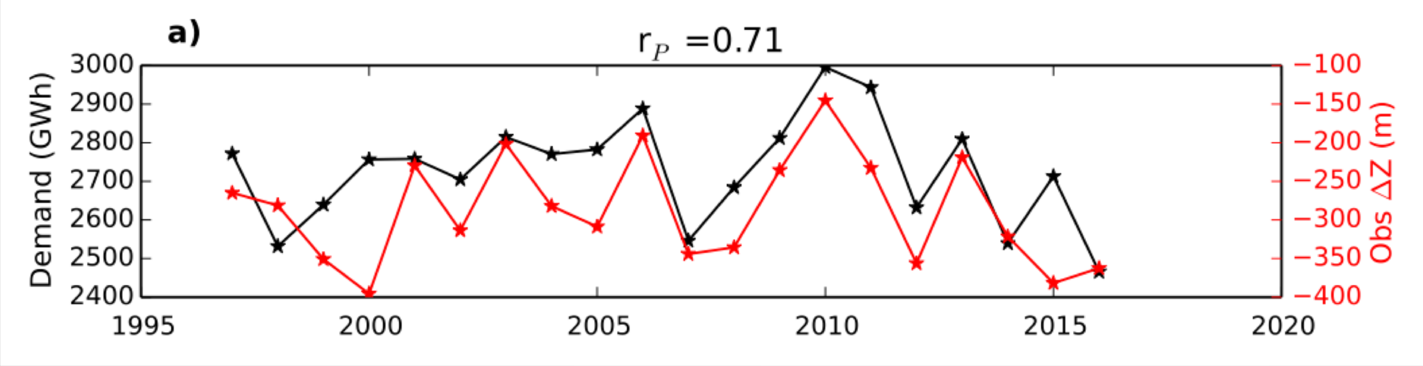
Skillful seasonal prediction of winter gas demand Thornton et al. 2019

- Residential properties are predominantly heated using gas central heating systems in Britain.
- Ensuring a reliable supply of gas is vital in protecting vulnerable sections of society from the adverse effects of cold weather.
- The North Atlantic oscillation (NAO) is the dominant mode of winter variability in this region and it modulates the surface climate conditions, including temperature, wind speed and storminess.

weather-driven component of Britain's winter gas demand



Time series of the winter mean gas demand (black) and winter mean temperature (red) in Great Britain (GB).



Time series of the winter mean GB gas demand and ΔZ (the winter mean Z500 North–South height difference).

- The winter mean gas demand is strongly correlated to the winter mean T and a circulation index.
- The atmospheric circulation index is more skillfully predicted by dynamical models than T, it is thus a better predictor of gas demand.

Thornton et al. 2019

Prediction of Winter Mean Gas Demand

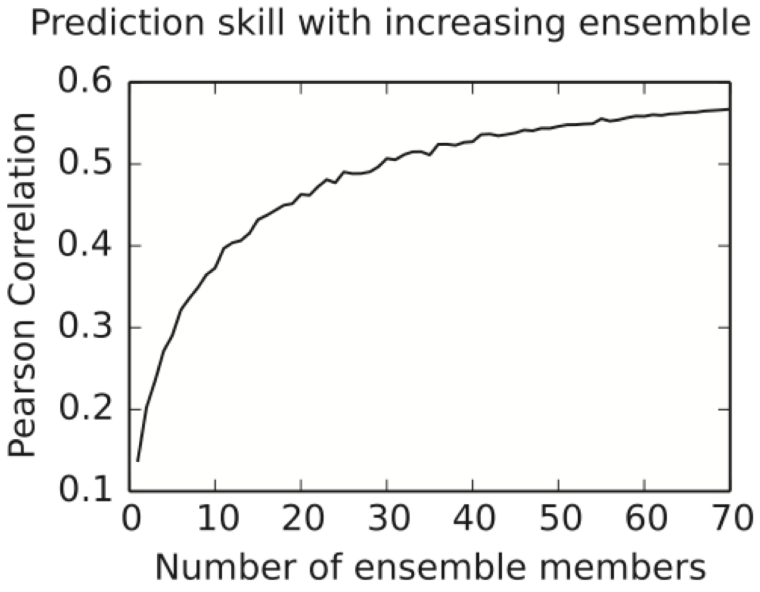


Figure 8. The impact of ensemble size on hindcast skill, when predicting winter mean gas demand using winter mean ΔZ. The skill is measured using the Pearson correlation coefficient. 1000 samples of the correlation have been generated by randomly sampling the ΔZ ensemble members each winter, to give alternative hindcast ensemble mean timeseries. The mean correlation of the bootstrap samples is shown. For a sample size of 20, statistical significance at the 5% level using a 1-sided Fisher Z test, is achieved with a correlation of at least 0.379.

A large ensemble size is required to achieve skillful prediction of gas demand, due to the known signal to noise problem of seasonal forecasting in the Atlantic sector.

Skilful and reliable probabilistic forecasts of the risk of above median, above upper tercile and the correct tercile of winter mean demand are possible.

Thornton et al. 2019

Impact of the North Atlantic Oscillation on Renewable Energy Resources

- Renewable energy has been invested by many nations as part of the mitigation and adaptation strategies to climate change and to achieve energy independence.
- Resource evaluation is necessary for the success of investments on renewable energy. Since the life span of most renewable energy plants is up to several decades, estimations of the interannual variability are important for successful assessment and management of renewable energy installations (Jerez et al. 2013).
  - Renewable Energy Resources include wind, precipitation and surface solar radiation
- Renewable energy like solar, hydropower and wind power are weather/climate-dependent. Impacts of climate modes on the wind field, cloudiness, and precipitation affect the renewable energy potential.
- Dynamical downscaling driven by reanalysis can provide useful information for regional resource evaluation related to renewable energy (Jerez et al. 2013).

NAO Impacts on 10-m Wind Speed in Southwestern Europe (NAO- minus NAO+)

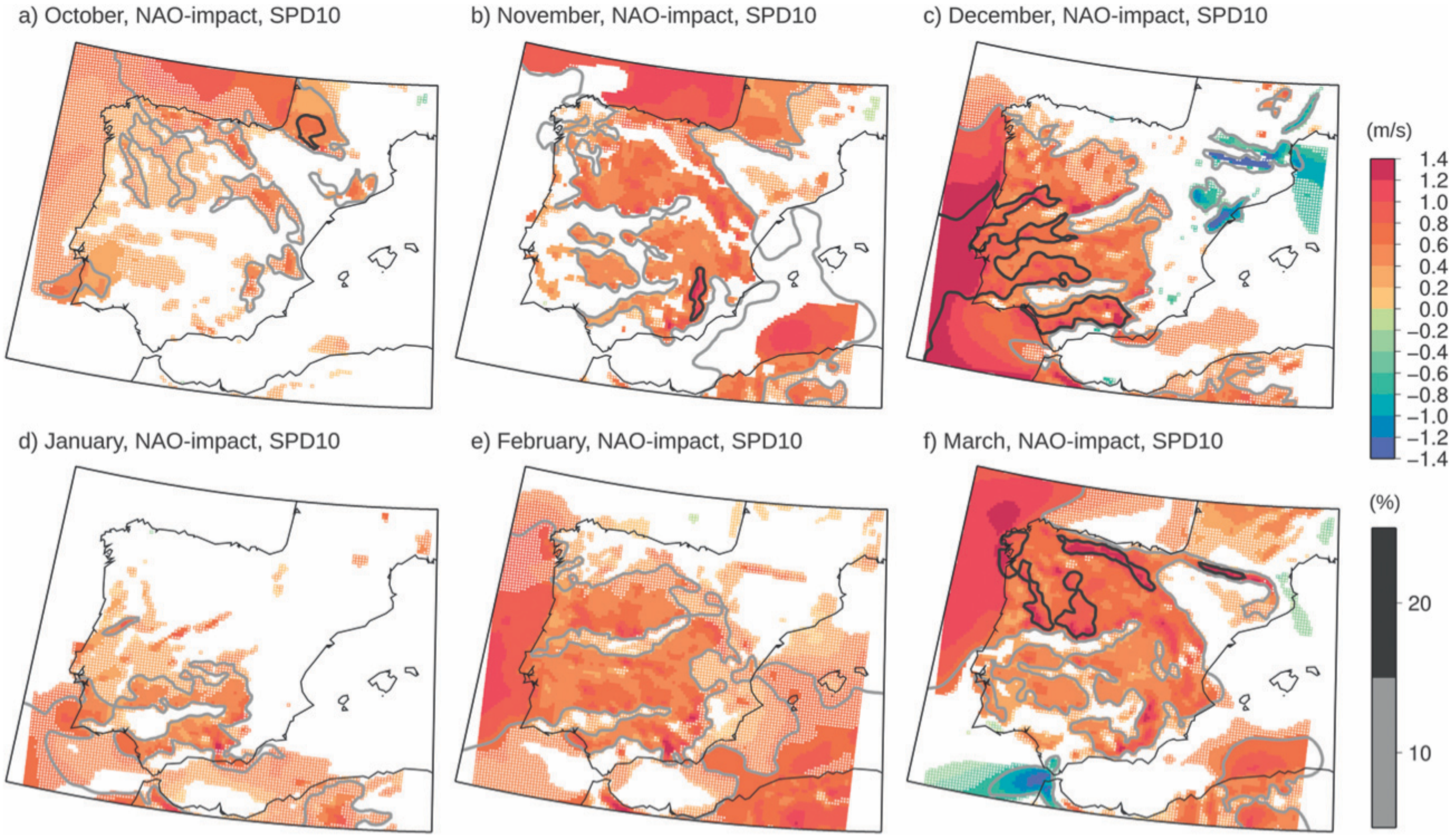


FIG. 2. NAO impact on SPD10: differences in mean SPD10 ($m\,s^{-1}$) between negative and positive phases of NAO, statistically significant at the 10% level and supported by significant temporal correlations between the SPD10 and NAO series. Gray-shaded contours depict the differences expressed as a percentage. The superimposed white dots indicate a signal-to-noise ratio that is below 0.75.

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NAO Impacts on Surface shortwave downward radiation in Southwestern Europe

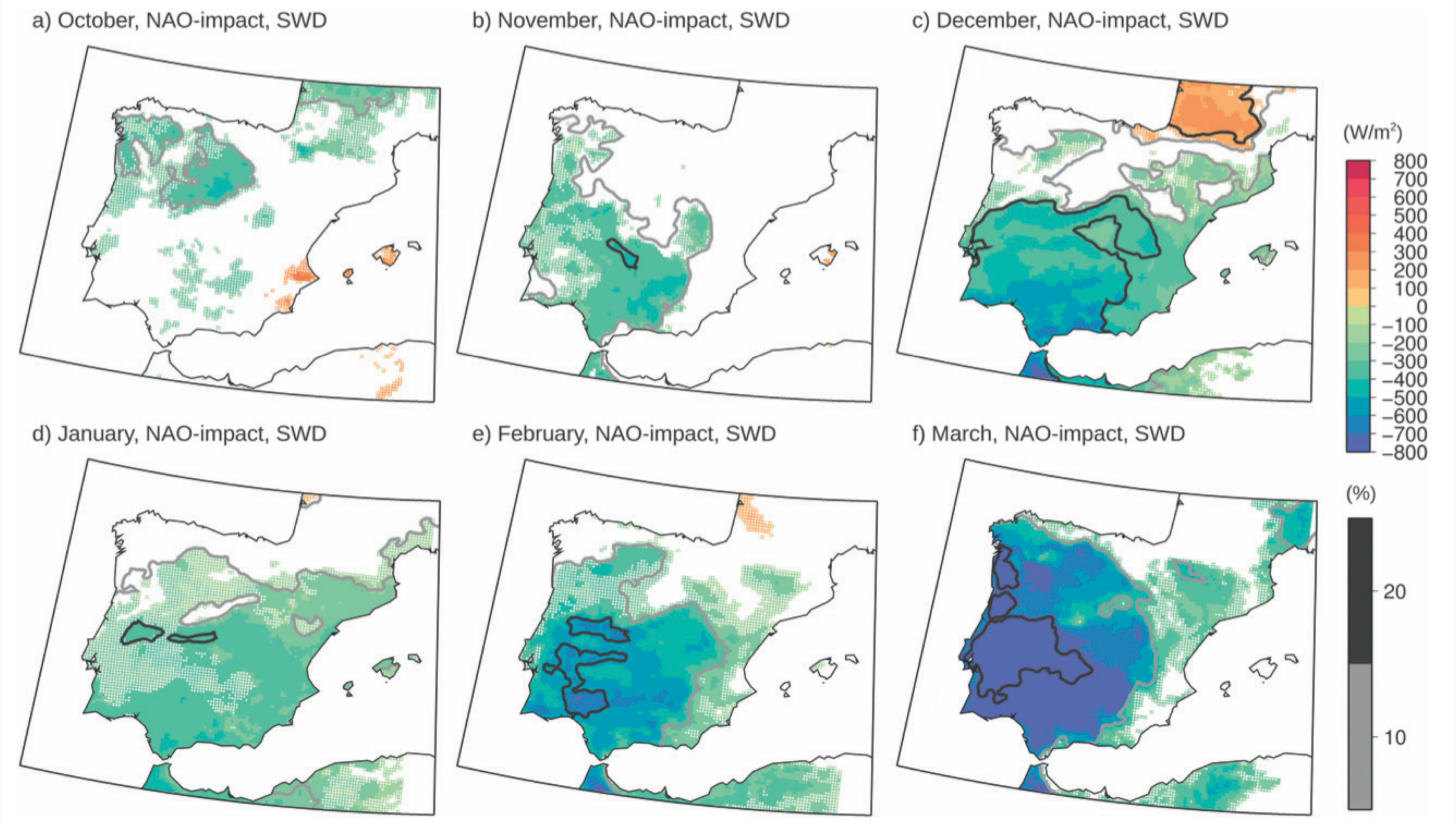

FIG. 10. As in Fig. 2, but for SWD ($W\,m^{-2}$).

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NAO Impacts on Precipitation in Southwestern Europe

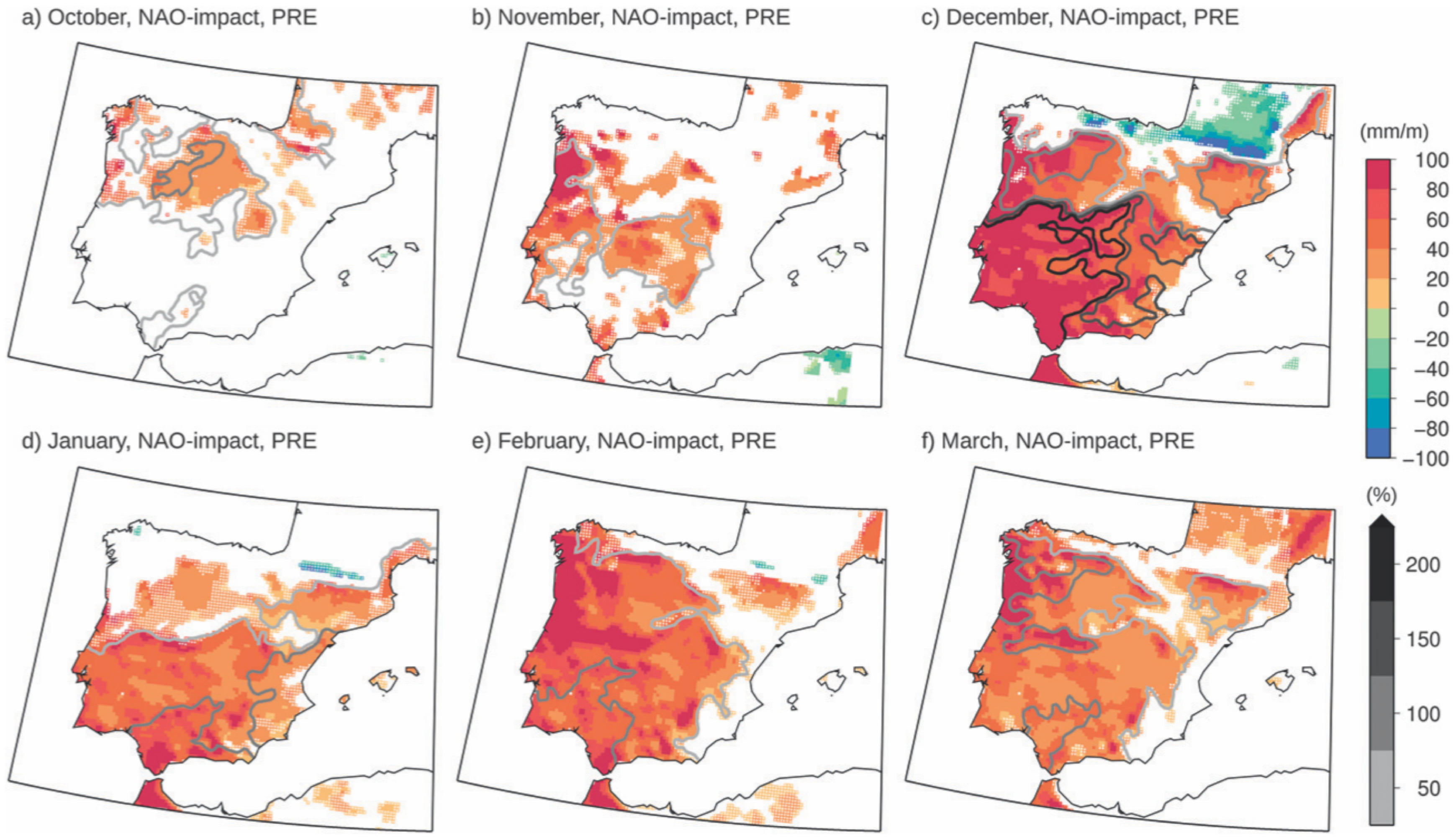

FIG. 6. As in Fig. 2, but for PRE (mm month^{-1}).

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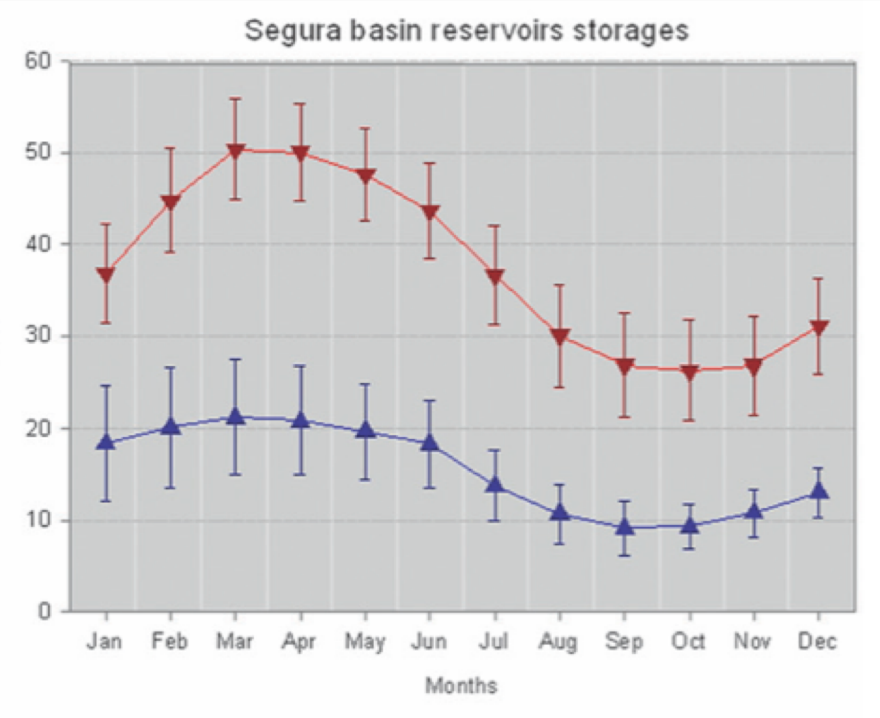
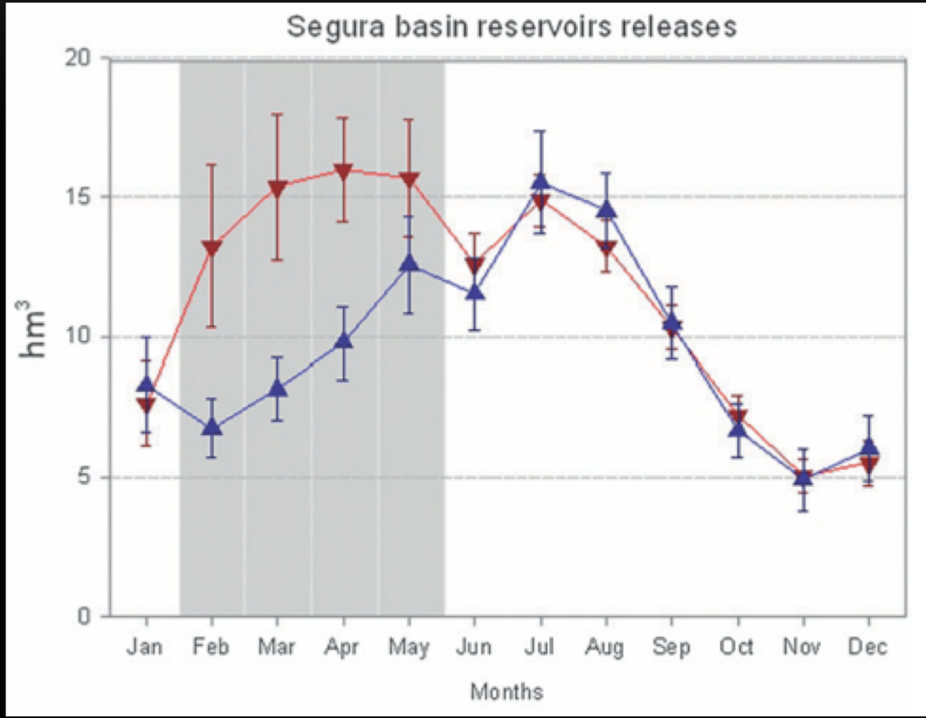
Average reservoir storage (left) and release (right)





- Clear differences in the reservoir storage exist between the NAO+ (blue) and NAO- (red) years. The largest differences occur in late winter and early spring and the impacts of NAO propagate throughout the year.
- For NAO-, a significant winter peak in the inflow to the reservoirs leads to the largest releases during that season. In contrast, the water released by dams is reduced during NAO+ to increase the water storage in order to guarantee the supply in summer.

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hydropower power generation in Spain

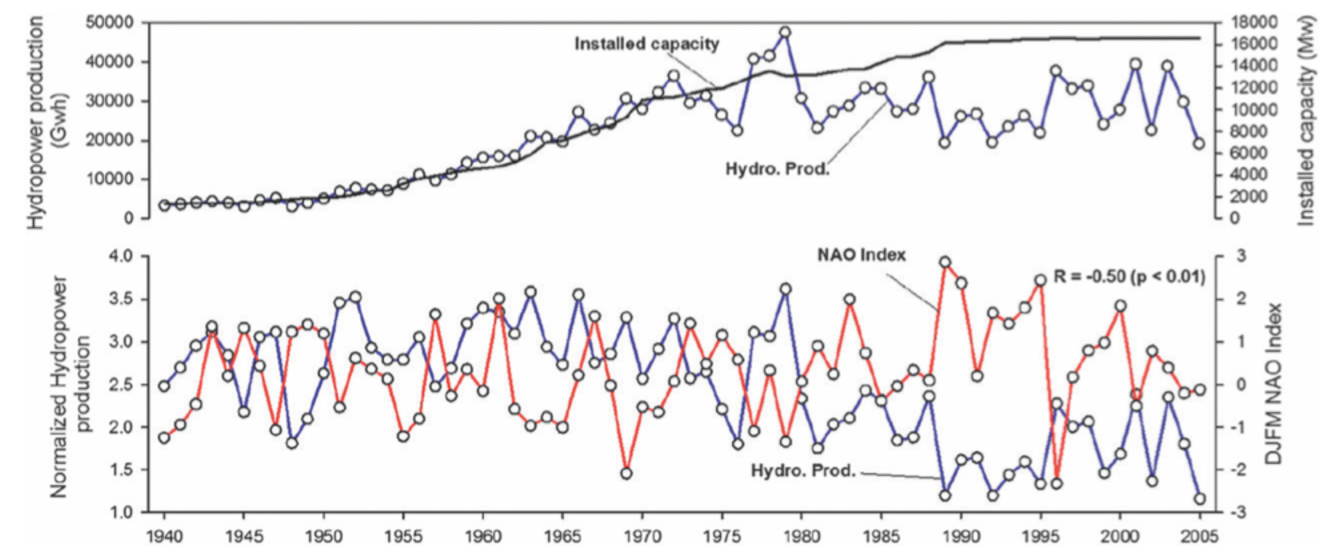

FIG. 9. (top) Evolution of annual hydropower power generation (blue; GW h) in Spain and the total hydropower power installed capacity (black; MW). (bottom) Evolution of the normalized hydropower power generation (i.e., the annual hydropower power generation divided by the installed capacity) (blue; GW h MW^{-1}) and the winter NAO index (red). The correlation coefficient R between both series is also shown.

- Top: annual hydropower power generation (blue) and total hydropower power installed capacity (black).
- Bottom: normalized hydropower power generation (i.e., the annual hydropower power generation divided by the installed capacity) (blue) and the winter NAO index (red).

- The annual hydropower power generation has a significant negative correlation with the winter NAO variability (-0.5)

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- The CPC's page on the North Atlantic Oscillation : https://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml
- Jerez, S., Trigo, R. M., Vicente-Serrano, S. M., Pozo-Vázquez, D., Lorente-Plazas, R., Lorenzo-Lacruz, J., Santos-Alamillos, F., & Montávez, J. P. (2013). The Impact of the North Atlantic Oscillation on Renewable Energy Resources in Southwestern Europe, *Journal of Applied Meteorology and Climatology*, *52*(10), 2204-2225.
- Thornton, H E, *et al* 2019: Skilful seasonal prediction of winter gas demand. *Environ. Res. Lett.* **14** 024009