This is a Correspondence submitted to Nature GeoScience following the undermentioned paper: Gabriel Chiodo, Jessica Oehrlein, Lorenzo M. Polvani, John C. Fyfe & Anne K. Smith, Insignificant influence of 11-year solar cycle on the North Atlantic Oscillation, Nature Geoscience, volume 12, pages 94–99 (2019). This is a non-peer reviewed preprint.

Title:Solar signals in observation indeed implied enhanced predictability since 1977

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The sun NAO connection attracted enough attention over the last few decades and explored in various modelling as well as observational studies. A modelling work[1] using UK Met Office Unified Model analysed the regional impact of the solar 11-year cycle on NAO, during boreal winter and found an in-phase relationship. It was interesting to study the robustness of such a proposed association between the sun and NAO[1]. Various studies already addressed and explored that issue in detail using observation[2,3,4]. Those noted that such in-phase connection is clearly noticed since 1977, though inconsistent over the last 150 years[6] and suggested variations in earlier periods[5]. Solar lag connections in observation were also seen sensitive to the period chosen (earlier or later)[4], though strongest around the North Atlantic in lag year-1 and year-2 in later decades of the last century ([4], their Fig.5)

Here we show the sun-NAO connection indeed suggested enhanced predictability since 1977 in observation for zero lag case. This is established by using two different data sources and for two different meteorological parameters (HadSLP2/ HadSLP2r_lowvardata for Sea Level Pressure (SLP) and NCEP reanalyses for geopotential height) (Fig.1). It also consulted different methodology, one is Compositing technique and the other Multiple Linear Regression (MLR) technique with AR(1) noise model[7]. Fig.1 showed few results, but we have increased confidence that using various other observational/ reanalyses data and applying other methodologies will also indicate a similar solar signature since 1977.

The modelling work of Chiodo et al. (2019) however could not capture any robust connection between the sun and NAO. Following the above discussion of an overall 150-years period using observation, such a result is not unlikely. Also, for models, the peak and trough of various climate modes are not synchronised with observed climate modes of variability[8,10]. The decadal signature part for some climate features is well presented in models, in general; but unfortunately, those do not match with observed peak and trough[9]. Thus, interactions among various modes and related teleconnections may not be well captured[10], so as the temporal and spatial pattern of regional variations (as elaborately discussed for ISM[8,9] and Nino3.4[8,10]). Those were explored for CMIP5 models which had observed solar, volcanic and greenhouse gas forcing.

Such deviations are likely to be present for other parameters as well e.g., SLP around Iceland and Azore (and hence on the signature of NAO). The outputs from various targeted experiments as described in Chiodo et al. (2019) will also have similar biases, e.g., unsynchronised ENSO indices, ISM etc. and very likely to miss many teleconnections those influence NAO. Thus, their detected solar signature around the north Atlantic, if matches with observations, deserve attention, but could be a coincidental match. It may not have confidence in what they claim in this paper.

Hence, the above discussion does not agree with the statement, ‘the solar signal over this period might have been a chance occurrence due to internal variability, and hence does not imply enhanced predictability.’ **Observation and Reanalyses data indeed suggests**

clear enhanced predictability, though present since 1977. A hypothesized mechanism is proposed relating to change in the observed sun-NAO behaviour since 1977 ([4], their Fig.3). However, those hypotheses are yet to be verified and need exploring further by modelling work. Recent research[4,10] discussed the importance of taking proper account of atmospheric mean background state to understand the Sun-NAO connection better.

References:

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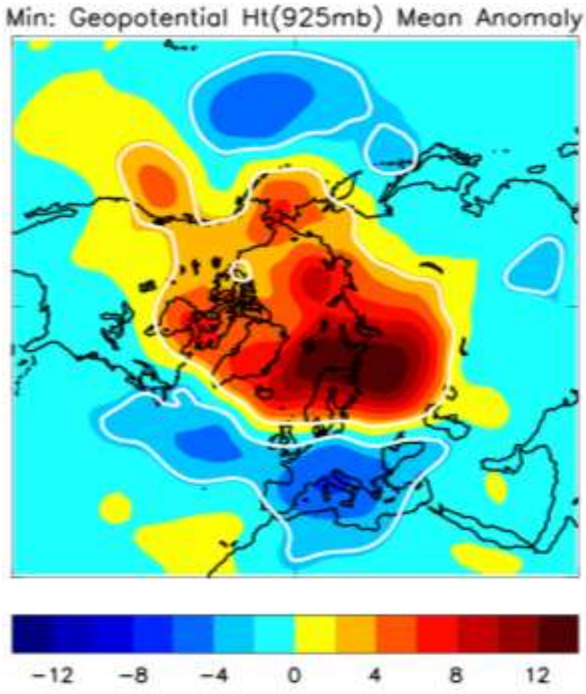
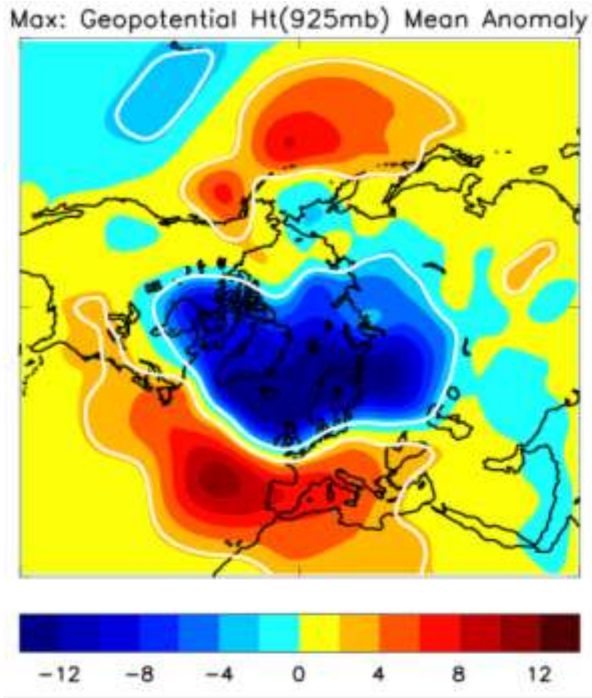
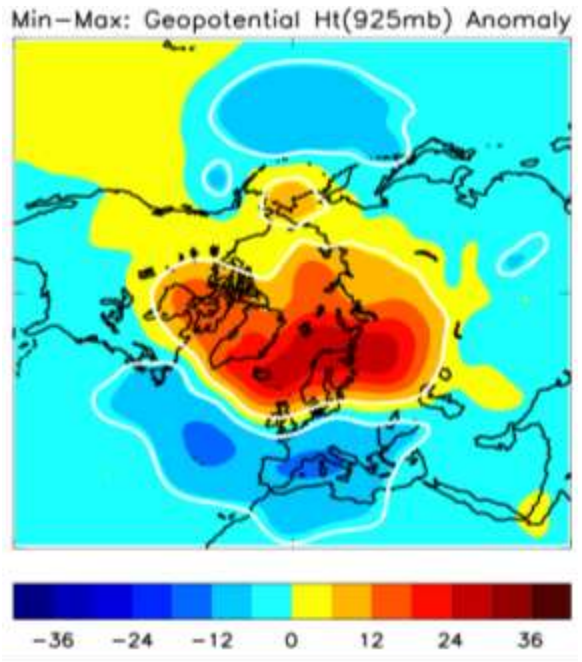
a)


Min: Geopotential Ht(925mb) Mean Anomaly
−12 −8 −4 0 4 8 12

b)


Max: Geopotential Ht(925mb) Mean Anomaly
−12 −8 −4 0 4 8 12

c)


Min−Max: Geopotential Ht(925mb) Anomaly
−36 −24 −12 0 12 24 36

d)

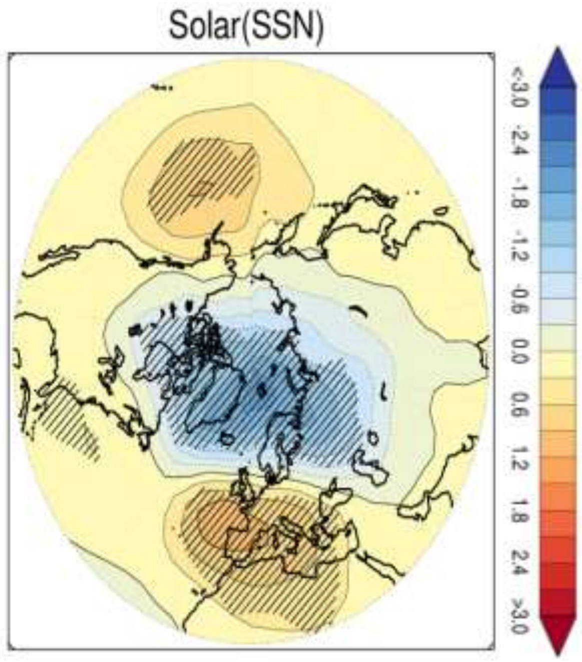

Solar(SSN)
<-3.0 -2.4 -1.8 -1.2 -0.6 0.0 0.6 1.2 1.8 2.4 >3.0

Fig.1. Solar signal (using Sunspot Number (SSN)) in 925 mb Geopotential Height (m) (a,b,c, using Compositing technique[7]) and Hadley SLP data (hPa)(d, using MLR technique[7]) since 1970s. For Compositing, Min (Max) years are defined when SSN is below (above) average; significant level at 95% are shown by white contour. For MLR, amplitude of components of SLP variability (Max-Min, hPa) due to the sun is presented and significant level at 95% are marked by hatching. Note ‘c’ is for Min-Max, while ‘d’ is for Max-Min. Both (c,d) shows positive NAO pattern for high sun. For Compositing, results are similar with or without detrending the data beforehand; though results for detrended data are presented. For MLR, other independent factors used are linear trend, ENSO, Aerosol Optical Depth (for volcano) and QBO (30 hPa).