Example 1: Atlantic tropical cyclones (TC)

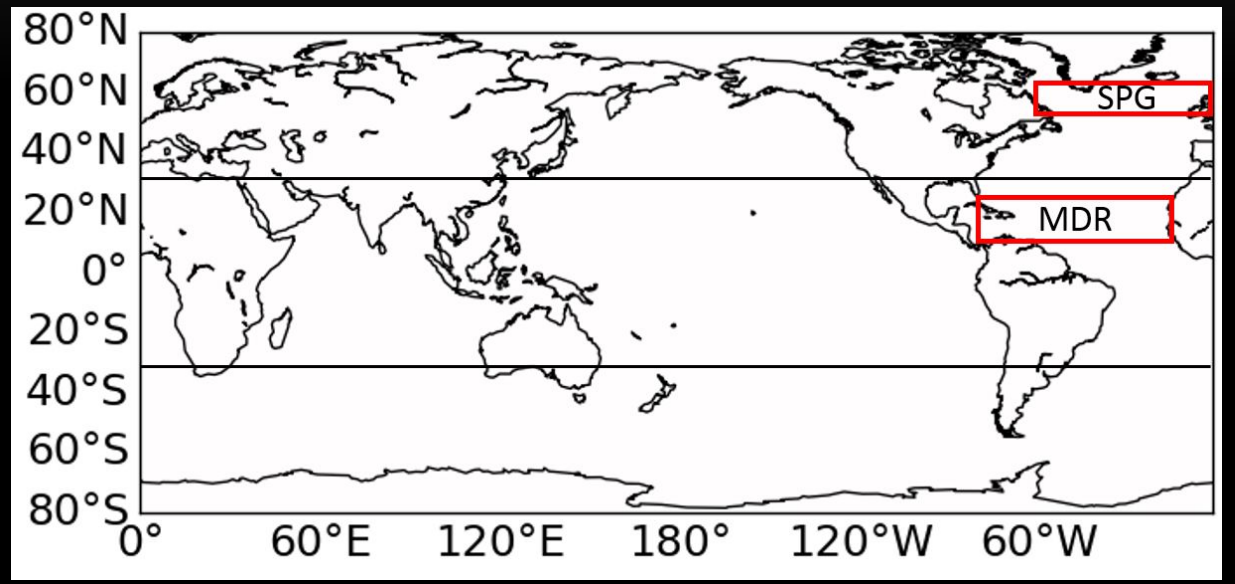
Hybrid Prediction

- TC indices (predictand; Jun-Nov):
  - basin-wide: TC frequency, hurricane (>= 64 knots) frequency, accumulated cyclone energy (ACE)
  - Landfalling: TC frequency, hurricane frequency
- A **Poisson** model for Atlantic TC activity (TC frequency, ACE, hurricane frequency, landfalling TC or hurricane frequency) is employed

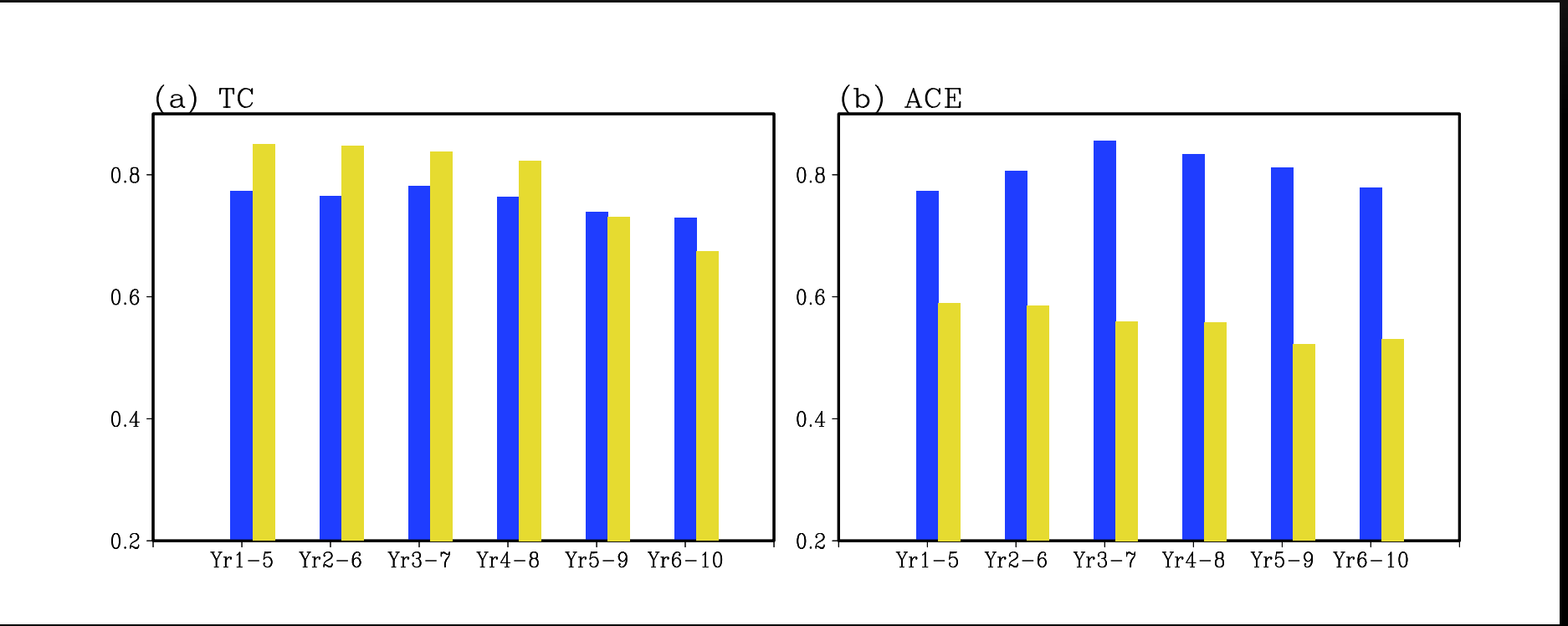
$$\lambda = \exp(a_0 + a_1 MDR + a_2 SPG)$$

where λ is a TC index, and there are two predictors derived from the predictions using a climate model, CESM.

  - MDR: the relative SST in Atlantic Main Development Region
  - SPG: subpolar SST index



ACC of TC frequency and ACE: Initialized vs. uninitialized Predictions

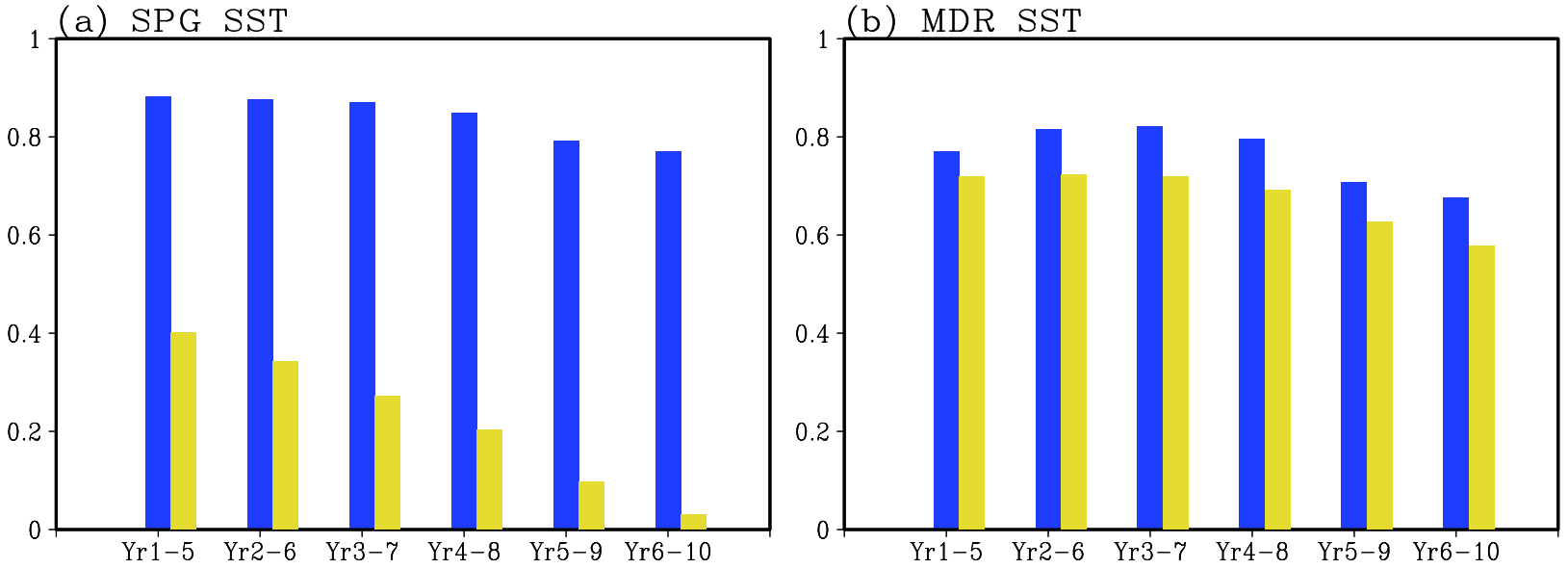


Blue: initialized prediction, with the SST predictors derived from CESM-DP

Yellow: uninitialized prediction, with the SST predictors derived from CESM-LE

- Initialization of the ocean and sea ice doesn't substantially affect the prediction of TC frequency, but significantly increases the skill of ACE prediction.

Predictive Skill of the Predictors (SPG and MDR)



Blue: initialized prediction, CESM-DP

Yellow: uninitialized prediction, CESM-LE

- Initialization (CESM-DP) significantly increases the skill of the SPG SST but doesn't substantially affect the MDR SST prediction.
- Ocean dynamics play an important role in the variability of the SPG SST while external forcing contributes to the variability of the MDR SST.

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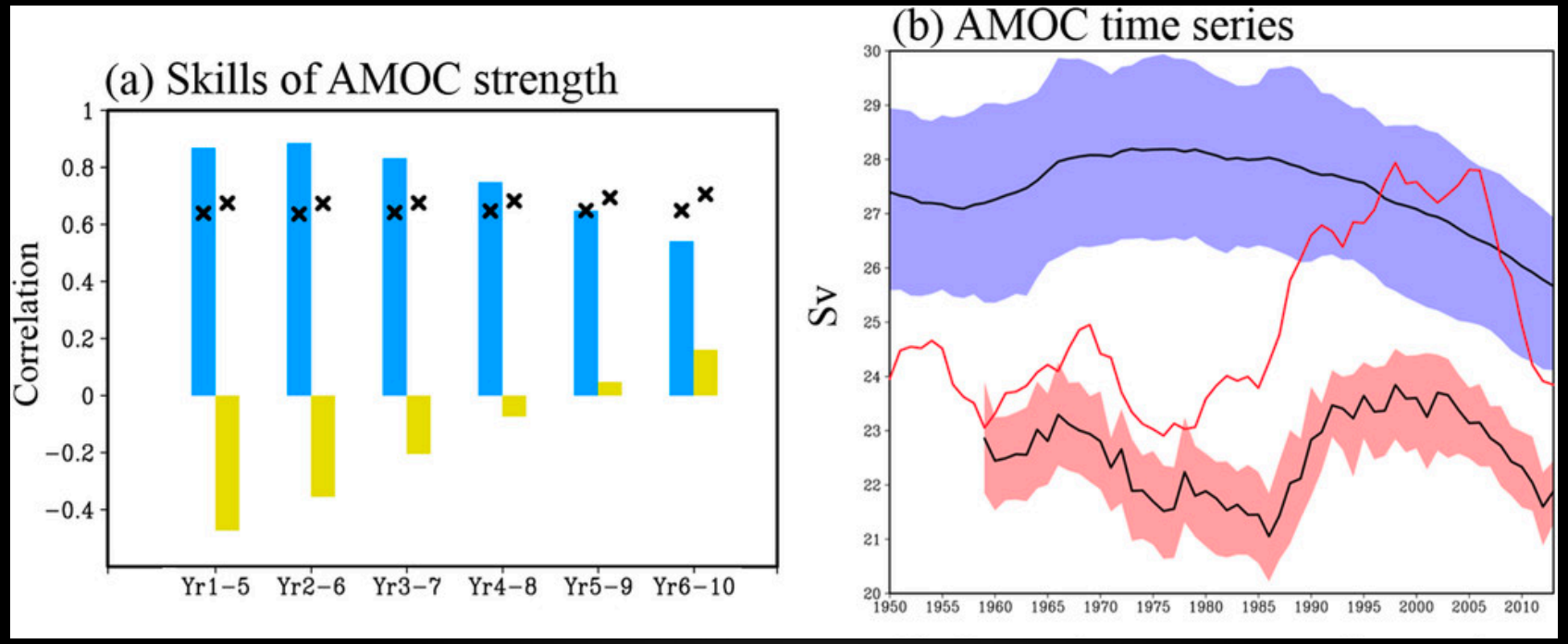
Ocean Initialization and AMOC

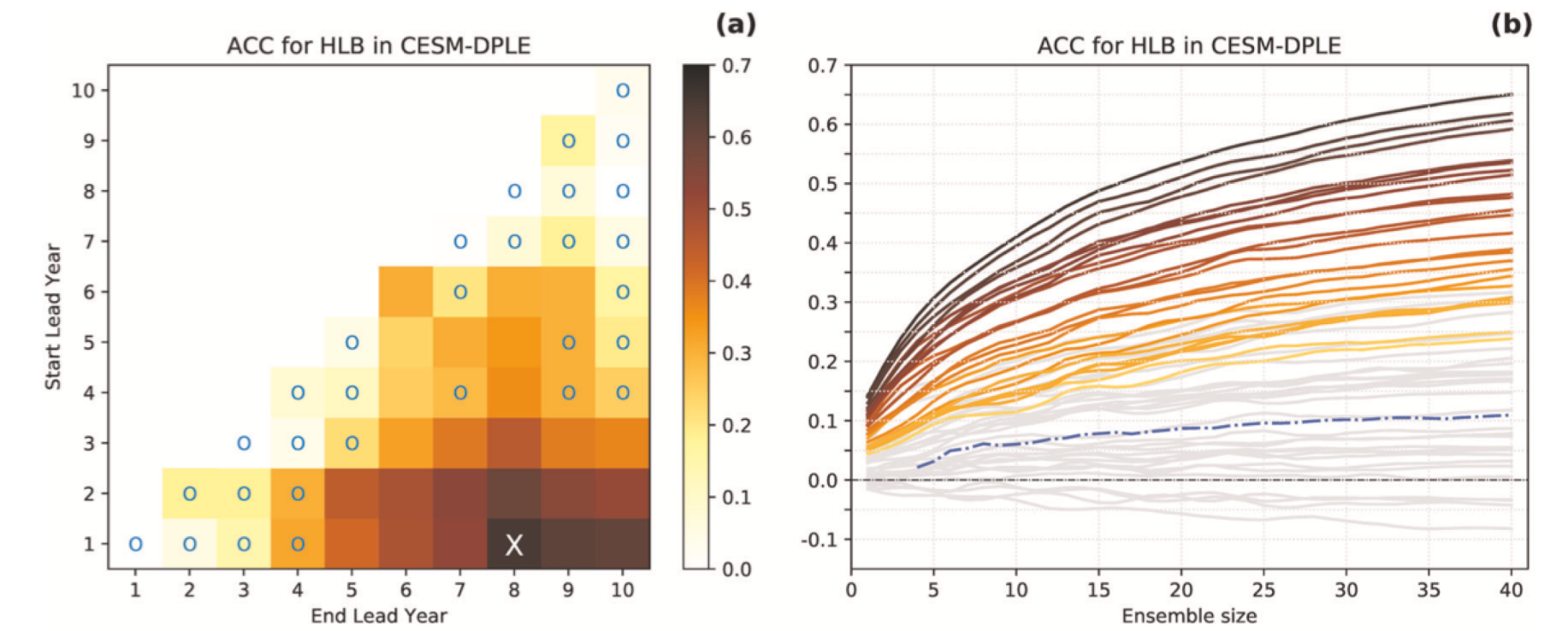
- Ocean initialization is critical for the skillful prediction of the AMOC.



(a) Forecast skills of the AMOC strength in the CESM-DP (blue bars) and the CESM-LE (yellow bars). (b) The 5-yr-mean AMOC strength time series in the ocean analysis (red), the initialized (CESM-DP at Yr 3–7) in black line with pink shading, and the uninitialized (CESM-LE) black line with purple shading.

Example 2: Decadal prediction of the North Atlantic Oscillation (NAO) and North Atlantic blocking

ACC of high-latitude blocking (HLB)



The anomaly correlation coefficient (ACC) is shown for all possible lead-year ranges. For example, for the initialization year 1992 the lead- year range LY[3–8] represents the average of the DJFM anomalies falling between December 1994 and March 2000.

Predictive skill for high-latitude blocking measured by the ACC. Each cell below the diagonal corresponds to a different lead-year range defined by the start lead-year (ordinate) and the end lead-year (abscissa). The cyan markers (o) indicate insignificant correlations. In b, the ACC is computed as a function of the ensemble size. Each line corresponds to a different lead-year range. Lines in color correspond to statistically significant correlations for the full ensemble (N = 40) following the same color code as in a and b. (From Fig. 2 in Athanasiadis et al. 2020)

- Skillful HLB predicted is achieved over various lead-year ranges, with the highest ACC of 0.65 for LY[1–8] (indicated by the “X” marker).
- Prediction skill increases with ensemble size)

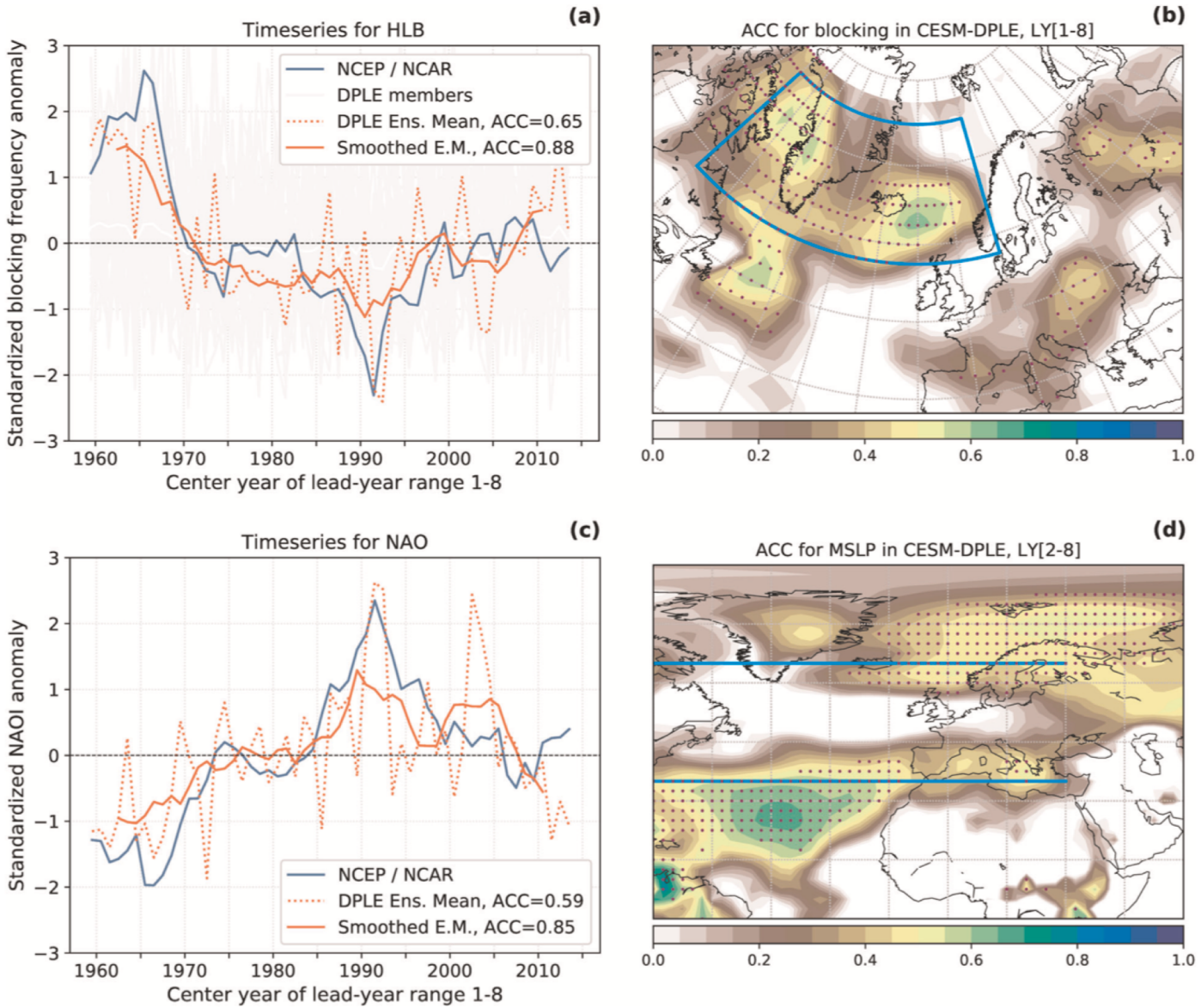


Fig. 3 Timeseries of high-latitude blocking and the NAO and the respective skill maps. On the left: predicted and observed standardized timeseries of HLB (**a**) and the NAO (**c**). The red, dotted lines show the CESM-DPLE ensemble mean for the lead-year range LY[1–8], while the solid, red lines represent a smoothed version of the former using centered 7-year running average. The blue lines show the observations (NCAR/NCEP reanalysis). As expected, the HLB and NAO timeseries are highly anticorrelated (−0.95 for NCEP/NCAR), while the respective anomaly correlation coefficients (ACC) are 0.65 and 0.59, both for the predicted timeseries without smoothing. On the right: mapping of the predictive skill (ACC) for blocking (**b**) and MSLP (**d**) winter-mean anomalies averaged over the same lead-year range LY[1–8]. The blue frame in **b** as in Fig. 1, while the blue lines in **d**, at 35 °N and 65 °N, relate to the definition of the NAO index (Methods). The dots on the maps indicate statistically significant correlations (Methods).

Prediction of HLB and NAO

- The high correlation between the observed and model time series comes from multi- decadal timescales.
  - The correlation increases significantly after smoothing the model time series.
- The HLB and the NAO timeseries are highly anticorrelated (−0.95 between the observed time- series).
- The low-frequency variability of HLB and the flipped-sign NAO resemble those of the Atlantic multi-decadal variability (AMV).

Athanasiadis et al. 2020

References

- Athanasiadis, P.J., Yeager, S., Kwon, YO. et al. Decadal predictability of North Atlantic blocking and the NAO. Nature npj Clim Atmos Sci 3, 20 (2020). https://doi.org/10.1038/s41612-020-0120-6
- Chang, C., & Wang, Z. (2020). Multiyear Hybrid Prediction of Atlantic Tropical Cyclone Activity and the Predictability Sources, *Journal of Climate*, *33*(6), 2263-2279.