An assessment of the AMO and PDO representations in the CMIP6 decadal predictions

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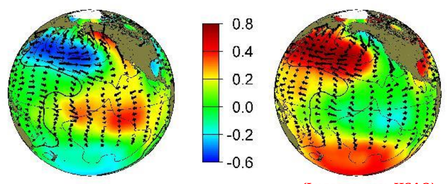
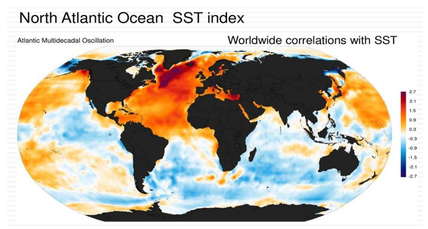
Background/Motivation

- The Atlantic Multidecadal Oscillation (AMO) and Pacific Decadal Oscillation (PDO) are potential drivers of Indian Summer Monson Rainfall (ISMR) variability, with the positive AMO (PDO) phase enhancing (suppressing) precipitation over the Indian subcontinent.



(Image source: JISAO)



(Image source: wikipedia)

- The current climate models have good skill in predicting sea surface temperature (SST) and surface air temperature over the globe at lead one year, lead 2-5 years and lead 6-10 years but display poor skill in predicting ISMR beyond a season.

- The seasonal prediction skill of ISMR in models mainly arises from the predictability of the interannual modes of variability such as El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Atlantic Niño. On the decadal timescales, the skilful predictions of the global decadal climate modes are very important for accurate ISMR predictions.

- The near-term climate prediction known as the decadal prediction is an emerging field in climate science, which addresses the gap between the shorter term seasonal forecasts and long-term climate change projections. In the present study, the prediction skill of AMO and PDO in all the available retrospective decadal predictions from the state-of-the-art climate models of the Coupled Model Intercomparison Project (CMIP) Phase 6 (CMIP6) is assessed.

Data and Methods

- The decadal hindcasts from component A of CMIP6 DCPP (dcppA-hindcast) are used in this study. The dcppA-hindcast consists of multi-model ensembles of decadal retrospective forecasts/hindcasts forced by prescribed CMIP6 historical external forcings and initialized at yearly intervals, for a duration of 10 years, from 1960/1961 onwards.

- The SST (tos), sea level (zos) and surface eastward and northward wind components (uas and vas) variables of the CMIP6 dcppA-hindcasts are used in this study.

- The decadal hindcast anomalies ($Y'_{i\tau}$) are computed by subtracting the climatology at each forecast lead year ($\overline{Y}_\tau$), as per the WCRP standard approach to compute the decadal prediction anomalies

$$Y'_{i\tau} = Y_{i\tau} - \overline{Y_\tau}$$
$$\overline{Y_\tau} = \frac{1}{n}\sum_{i=1}^{n} Y_{i\tau}$$

where Y is the ensemble mean prediction, Y' is the decadal forecast anomaly with respect to the forecast average $\overline{Y}$, i is the starting year and τ is the forecast lead year, n=1,2,3,…,10.

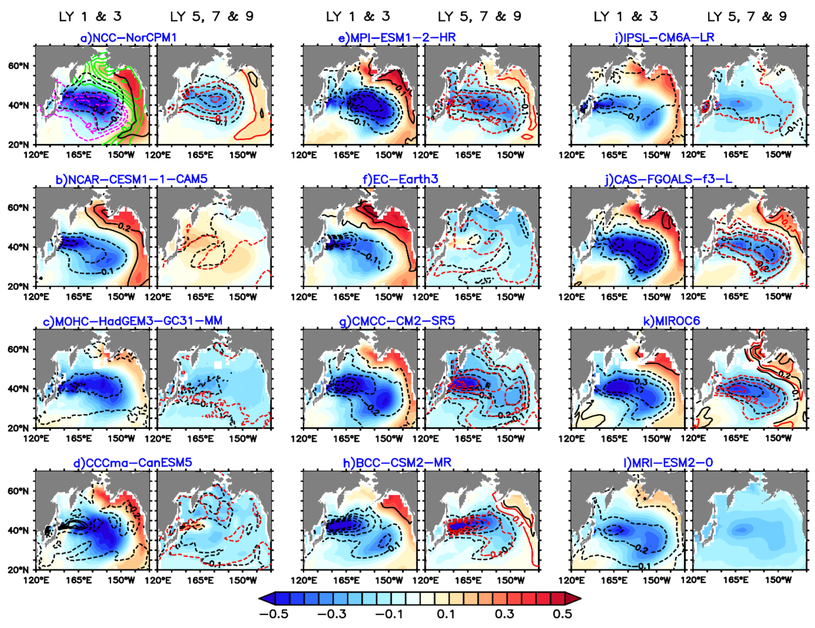
- The predictive skill of the models is measured by anomaly correlation coefficients (ACCs) and mean squared skill score (MSSS) between ensemble mean predictions and reanalysis/observations.

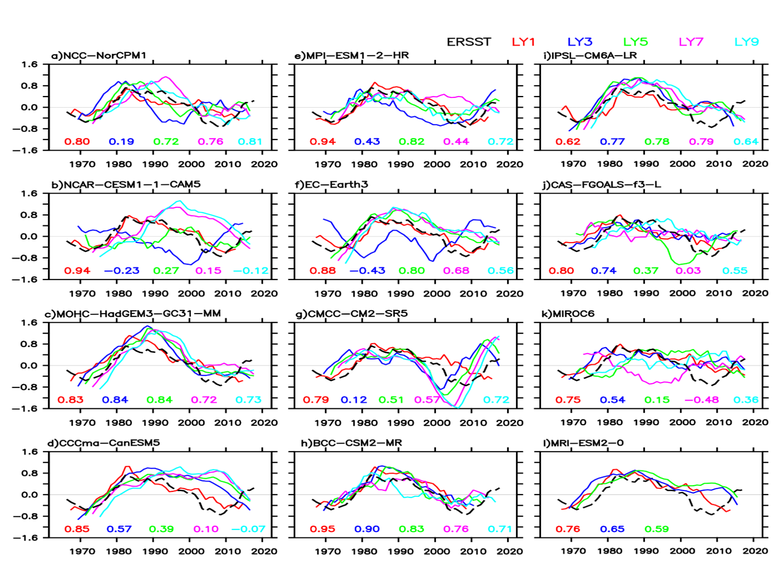
- The PDO pattern presented is the leading mode of the empirical orthogonal function (EOF) of spatial detrended SST anomalies over the north Pacific poleward of 20°N and the PDO index is the principal component of the leading EOF of north Pacific detrended SST anomalies (Mantua et al. 1997).

- The AMO index is computed as the area averaged detrended SST anomalies over the North Atlantic i.e., 80°W-0°E, 0°N-65°N (e.g. Enfield et al. 2001; Deepa and Gnanaseelan 2021). AMO pattern is derived by regressing the detrended annual mean SST anomalies over the North Atlantic onto the AMO index.

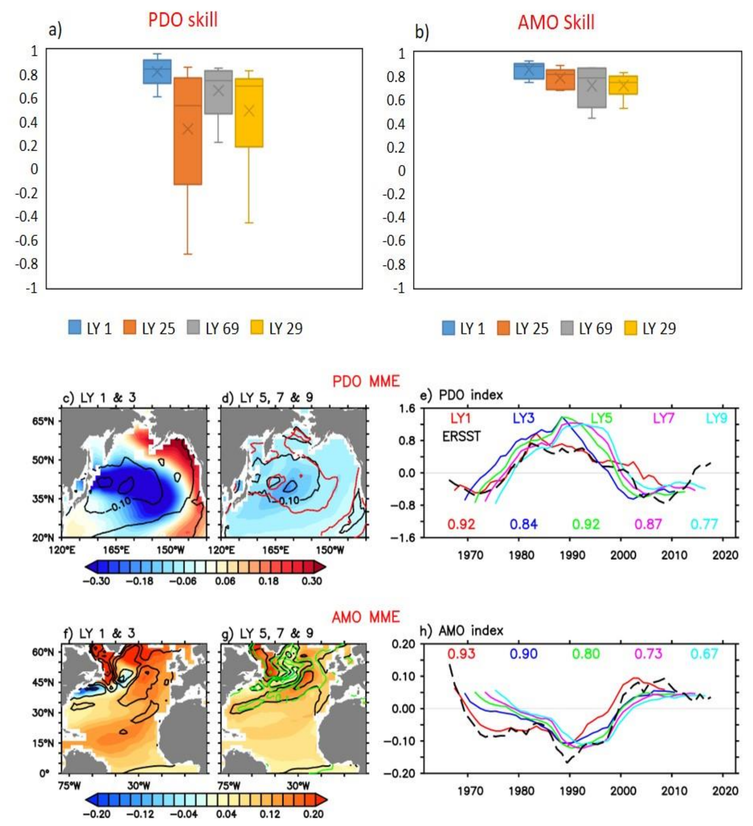
Discussion

The PDO pattern and index in ERSST and CMIP6 decadal hindcasts at different leads

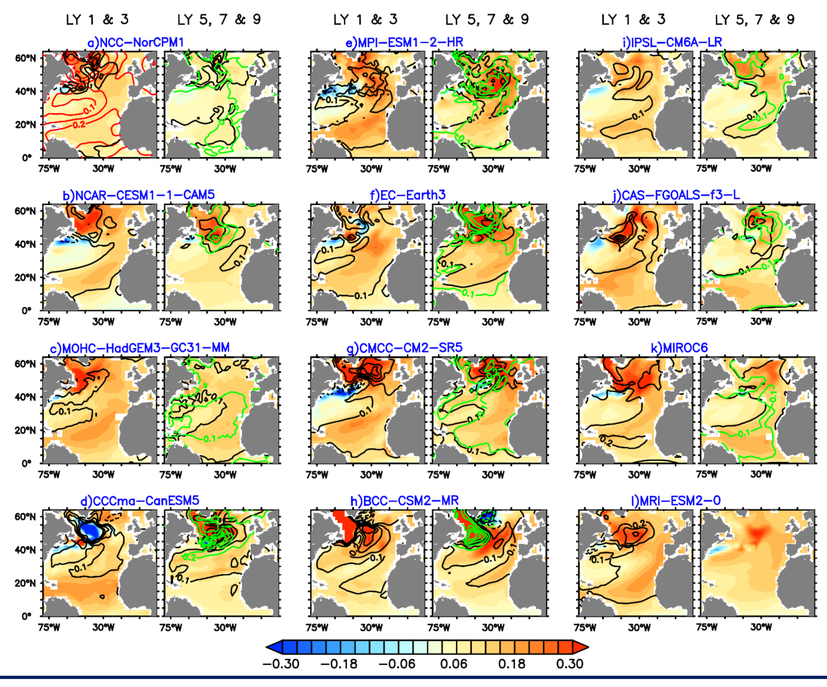


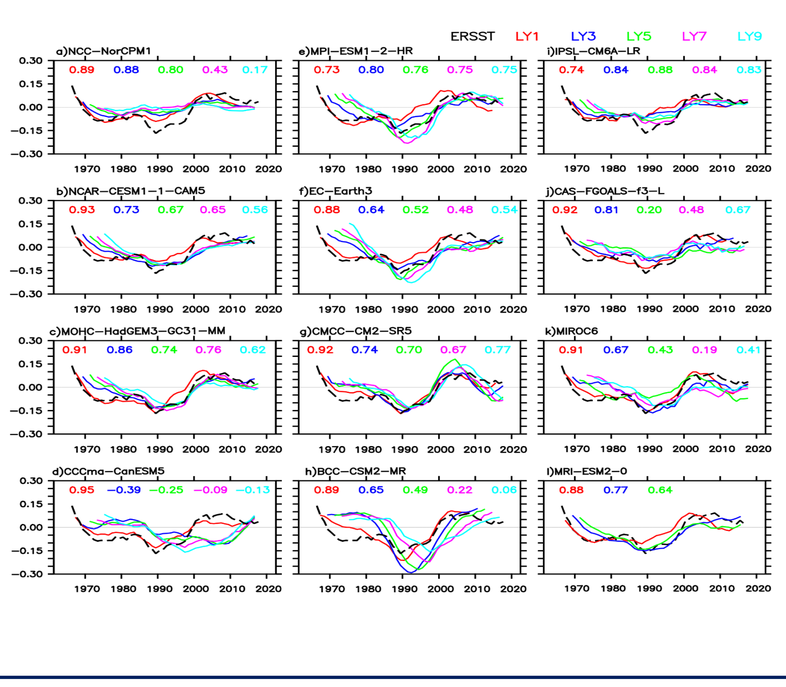


In general, the models are skilful in predicting AMO up to a decade, whereas only few models skilfully predict PDO.

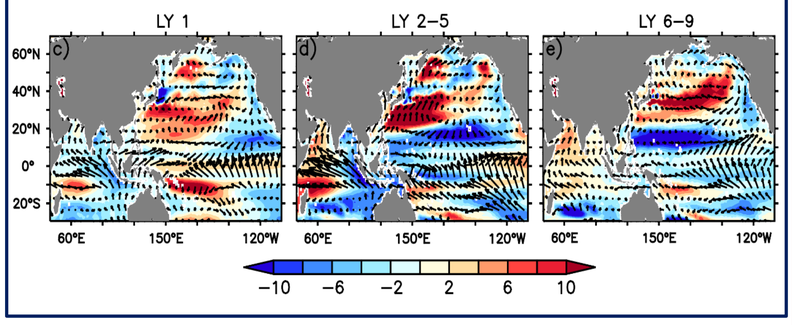


The AMO pattern and index in ERSST and CMIP6 decadal hindcsts at different leads

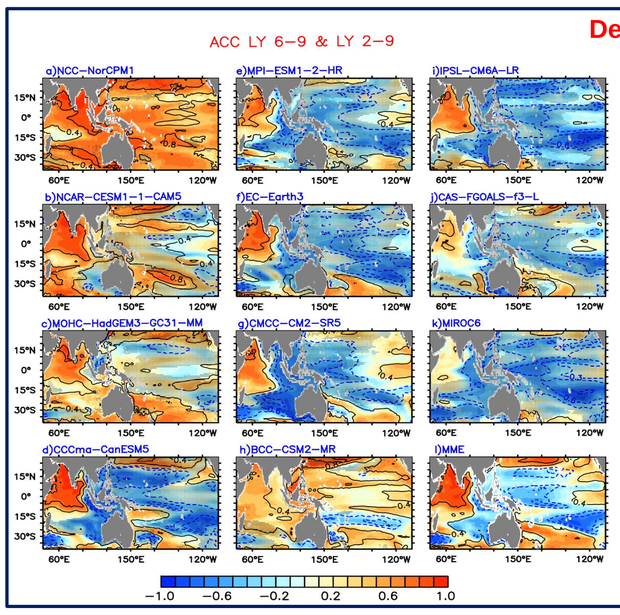


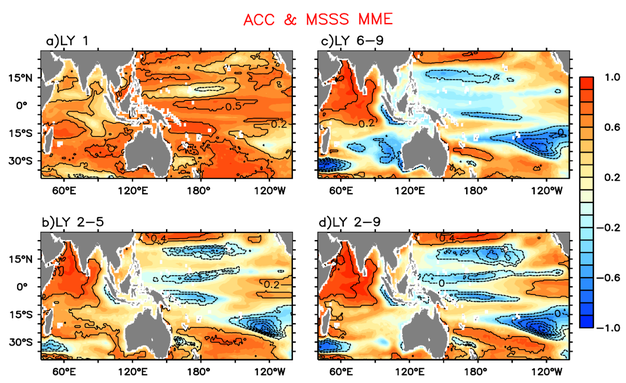


Regression of sea level anomalies and surface winds on the AMO index in the multi-model ensemble (MME)



Decadal prediction skill of SLA





- The models are skilful in predicting the sea level over the tropical Indo-Pacific for the lead year 1 and thereafter the skill persists mainly over the western Indian Ocean regions.

- Most of the models exhibit significant skill in the Arabian Sea region at higher leads including 2-5 years and 6-9 years.

- In association with the AMO related teleconnections, skilful representations of strong cross equatorial flow and convergence of southerly winds towards the Arabian Sea region are noted in the CMIP6 predictions.

- The better representation of AMO in the models has primarily contributed to the skilful sea level predictions over the Arabian Sea region.

Reference

Deepa J.S, Gnanaseelan C. (2024) On the skill of Indo-Pacific decadal sea level predictions and its connection with skilful AMO and PDO predictions, Climate Dynamics, 62, 10363-10380, DOI:10.1007/s00382-024-07456-z

Acknowledgements

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