Improving the Prediction of Arctic Oscillation by the Interannual Increment Approach

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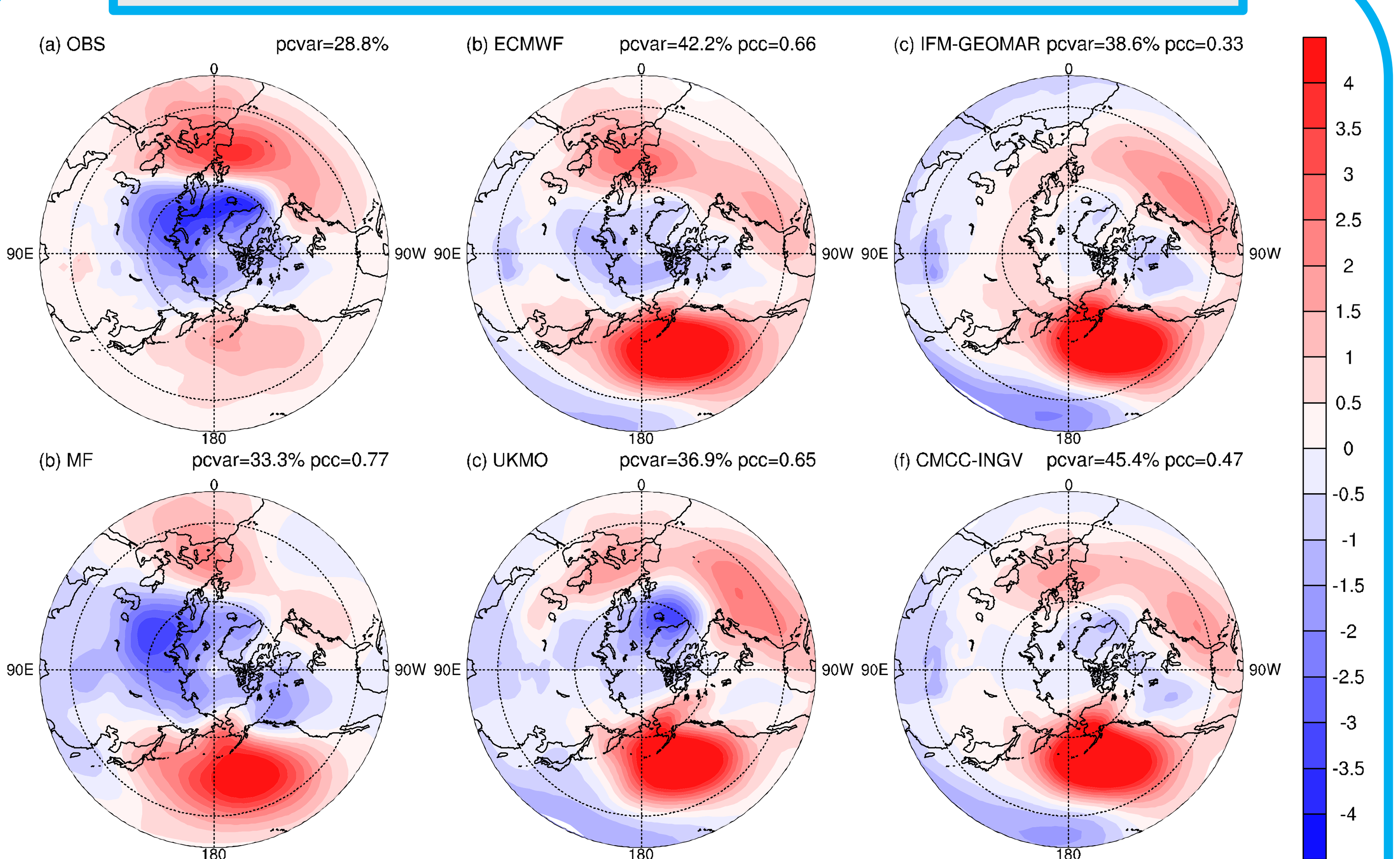
a. Introduction

The main advantage of the interannual-increment approach is that the year-to-year increment (calculated by the value of current year minus the value of preceding year) amplifies the signals of interannual variability of predictors and/or predictant. To date, this approach has been utilized in many studies.

In this study, efforts have been made to improving the prediction of Arctic Oscillation (AO) by the interannual-increment approach.

b. AO Prediction of ENSEMBLE



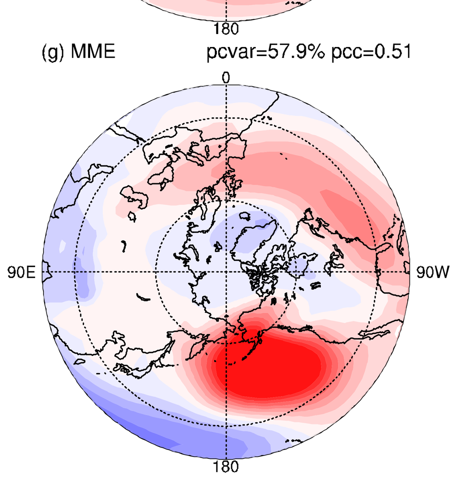


Fig. 1: The spatial patterns of the leading EOF mode of DJF sea level pressure anomalies (hPa) of north 20°N during 1961−2006 derived from observation (a) and ENSEMBLE (b-g). The pcvar and pcc represent the percent variance and spatial correlation coefficient of the leading EOF modes between observation and ENSEMBLE models, respectively.

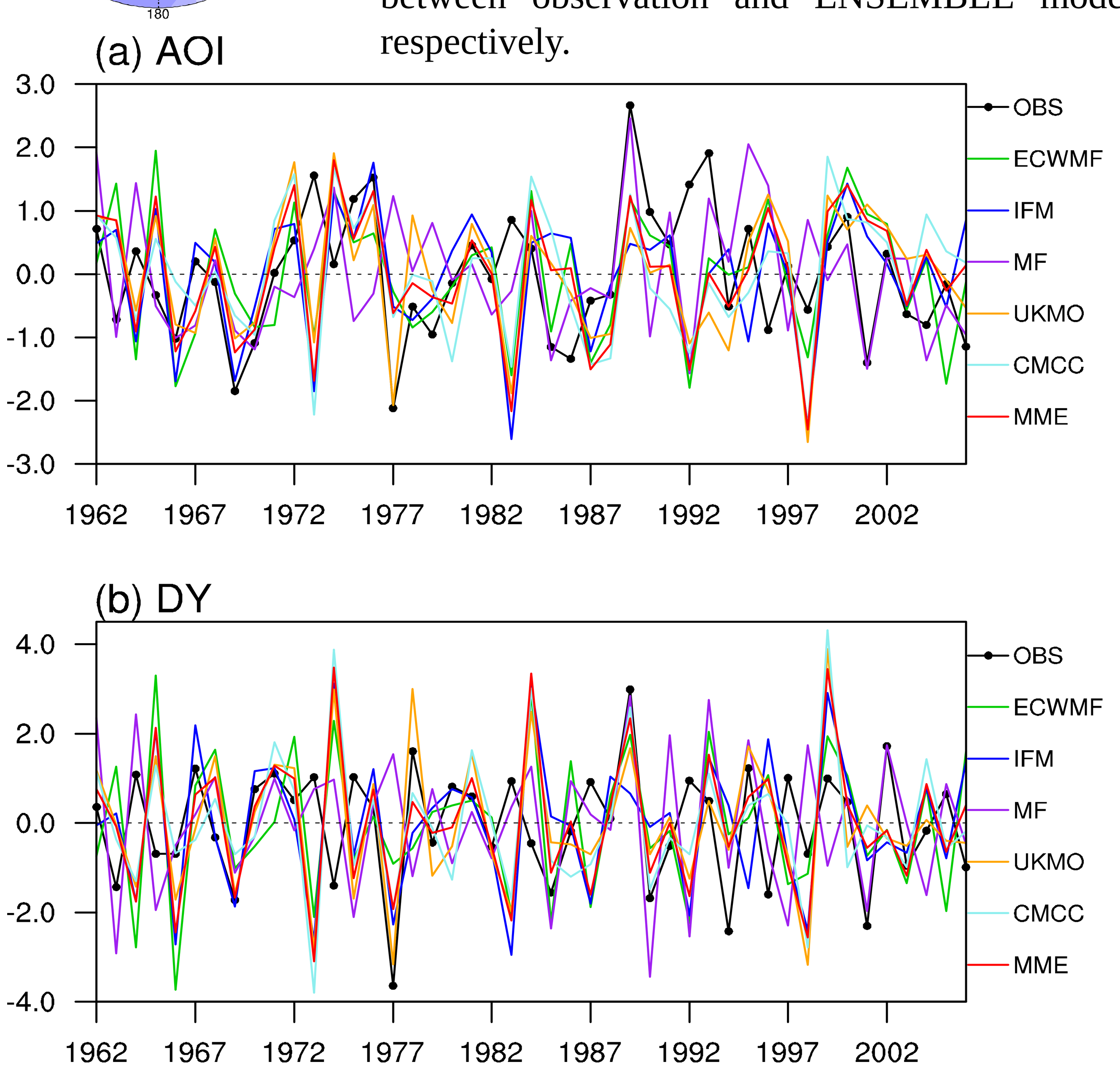


Fig. 2: The normalized DJF AOI (a) and DY of AOI (b) during 1962−2006 derived from observation and ENSEMBLE models, which are obtained by projecting the observed AO spatial pattern.

The ENSEMBLE model have bad performance in predicting the spatial pattern and interannual variation of AO, which demands improvements.

c. Improvement

Preceding sea ice and concurrent SST are used as the predictors to improved the AO prediction for their significant impact on DJF AO. The dynamical-statistical model for DY_AOI prediction is established based on a multivariable regression method, as follows:

$$DY\_AOI_{predicted} = aDY\_SICI + bDY\_SSTI$$

$$AOI_{improved} = DY\_AOI_{predicted} + AOI_{obs\text{-}preceding}$$

Predictor1 — Preceding Sea Ice

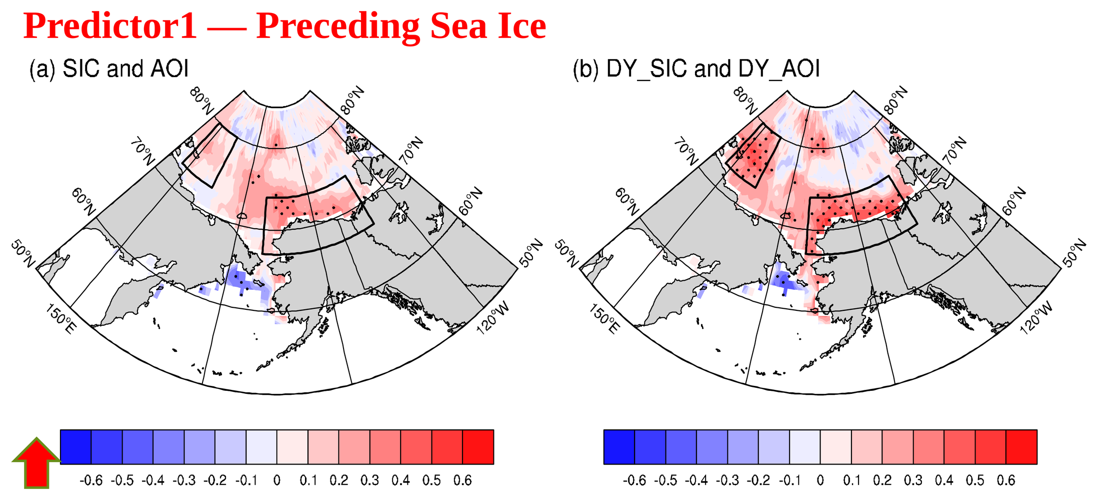


Fig. 3: (a) The correlation coefficients between the preceding SON **sea ice** concentration and DJF AOI derived from observation during 1961/62−2005/06. (b) As in (a), but for the DY of sea ice and the DY of AOI. The dotted areas indicate statistical significance at the 95% confidence level, based on a Student's t test.

Predictor2 — Concurrent SST

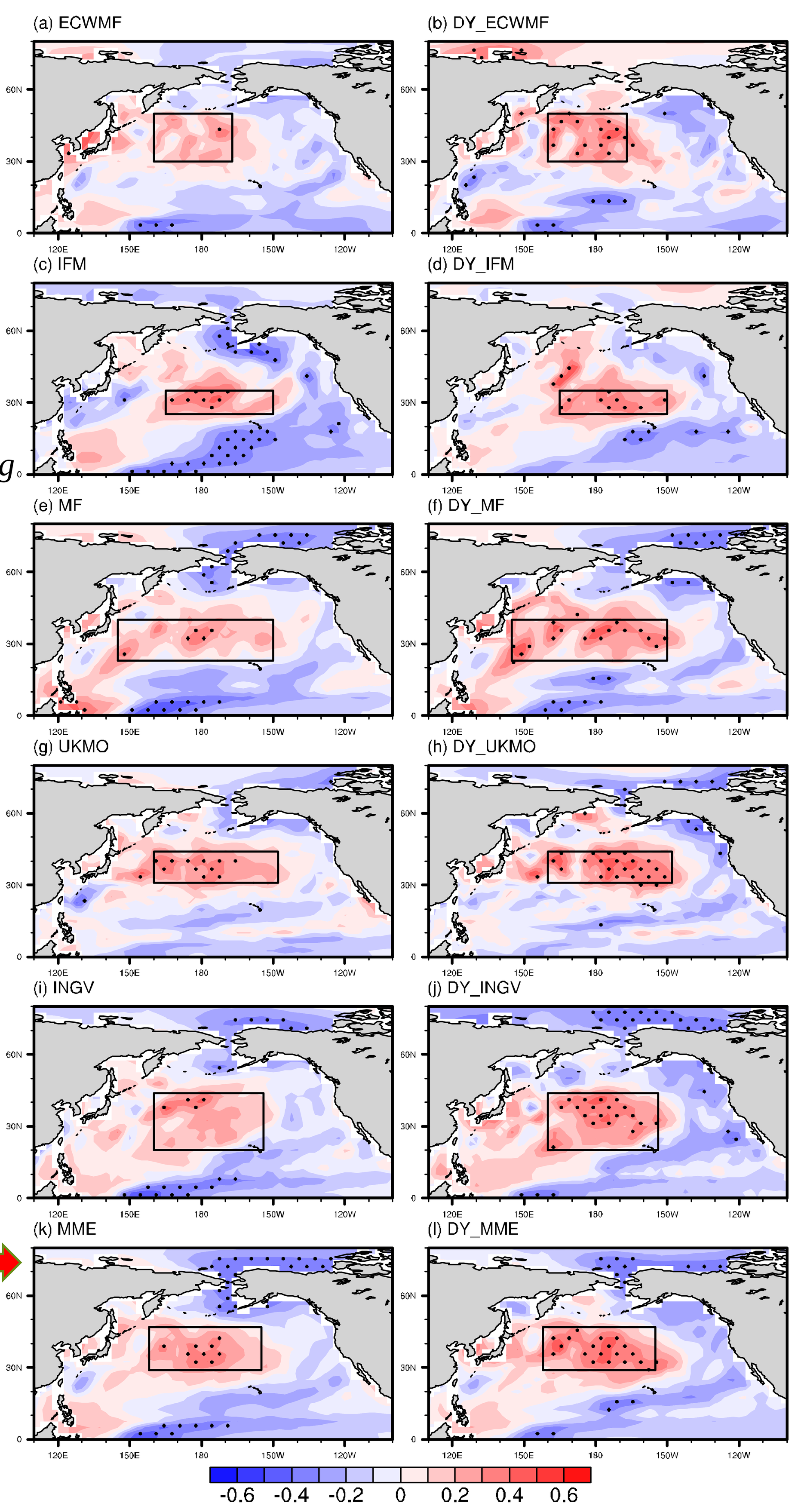


Fig. 4: (left) The correlation coefficients between the observed DJF AOI and ENSEMBLE-predicted **SST** during 1962−2006. (right) As in (left), but for the DY of SST and the DY of AOI. The dotted areas indicate statistical significance at the 95% confidence level, based on a Student's t test.

d. Results

Cross-validation

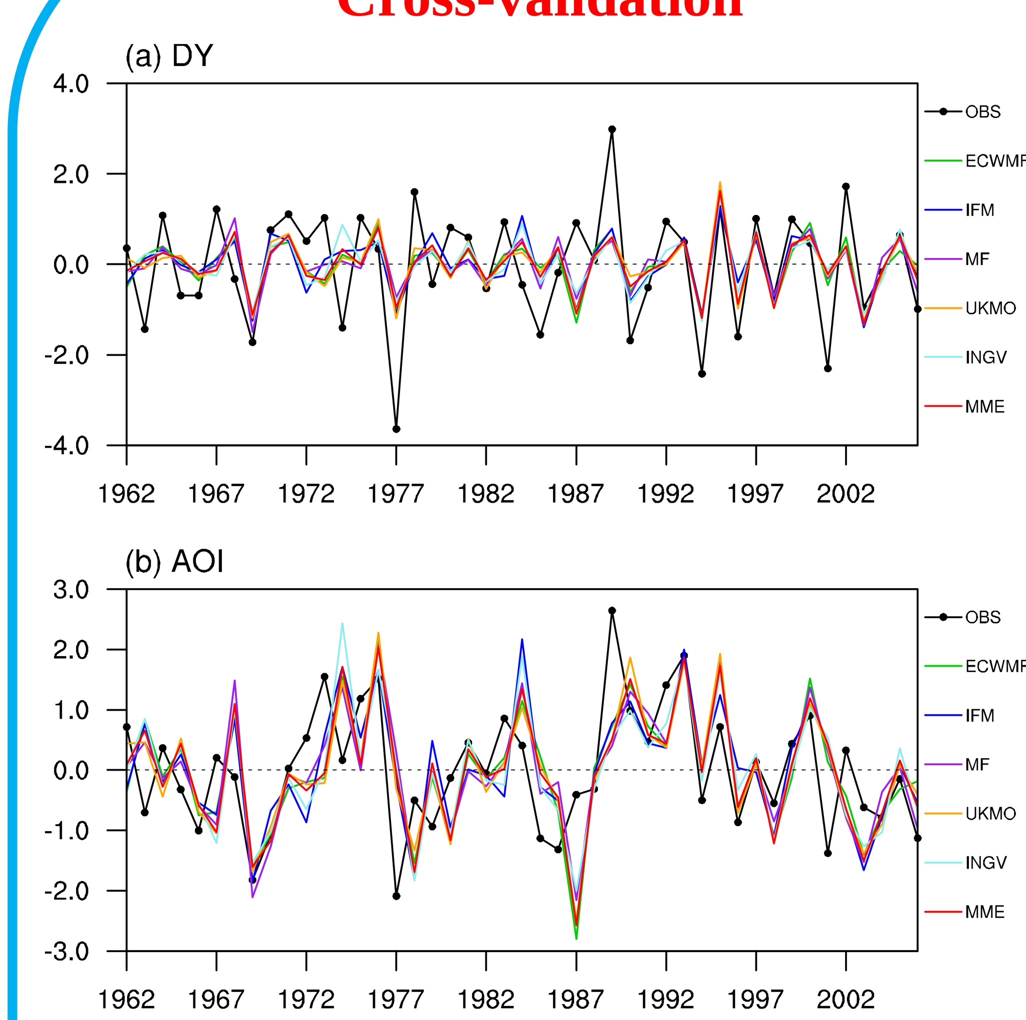


Fig. 5: Predicted and observed (a) DY of AOI and (b) AOI for 1962−2006, in which the predicted DY using the dynamic and statistical prediction model in the cross-validation.

Table 1 The correlation coefficients between the observed and predicted AOI, DY_AOI by the improved scheme (raw model) during 1962−2006 along with the improvement of RMSE in parentheses. Significance level at 95% (blue) and 99%(red) are based on a Student's *t* test with effective degrees of freedom.

ENSEMBLE Model	Cross-Validation AOI	Cross-Validation DY_AOI	RMSE AOI	RMSE DY_AOI
ECWMF	0.54(0.20)	0.60(0.02)	17%	46%
IFM	0.51(0.29)	0.57(0.31)	9%	38%
MF	0.54(0.33)	0.59(0.30)	8%	40%
UKMO	0.54(0.22)	0.60(0.31)	16%	40%
INGV	0.48(-0.05)	0.52(-0.11)	22%	50%
MME	0.51(0.36)	0.55(0.33)	3%	37%

Hindcast

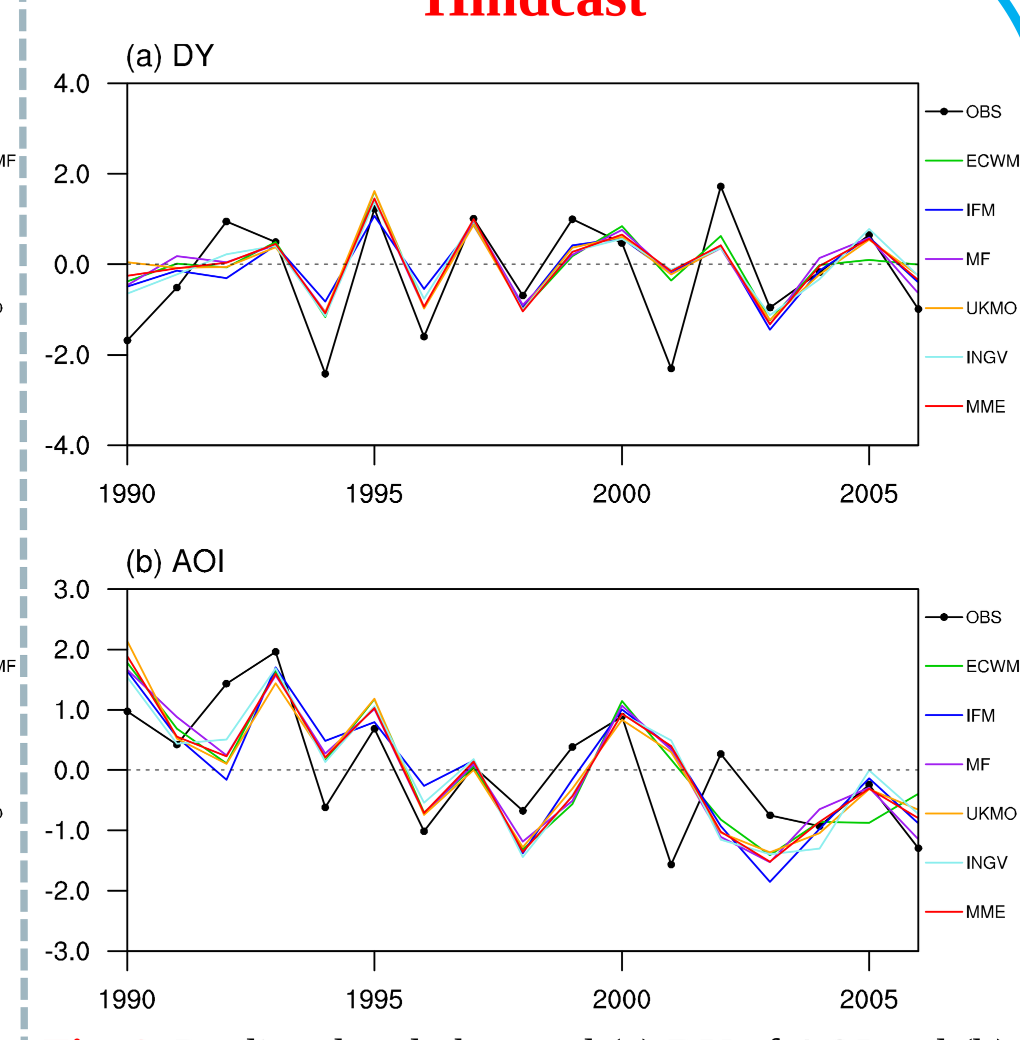


Fig. 6: Predicted and observed (a) DY of AOI and (b) AOI for 1990−2006, in which the predicted DY using the dynamic and statistical prediction model in the hindcast.

Table 2 The correlation coefficients between the observed and predicted AOI, DY_AOI by the improved scheme (raw model) during 1990−2006 along with the improvement of RMSE in parentheses. Significance level at 95% (blue) and 99%(red) is based on a Student's *t* test with effective degrees of freedom.

ENSEMBLE Model	Hindcast AOI	Hindcast DY_AOI	RMSE AOI	RMSE DY_AOI
ECWMF	0.66(0.09)	0.76(0.26)	41%	58%
IFM	0.62(0.08)	0.73(0.35)	26%	37%
MF	0.67(0.31)	0.76(0.40)	31%	53%
UKMO	0.65(-0.07)	0.72(0.34)	35%	39%
INGV	0.67(0.10)	0.79(-0.08)	30%	54%
MME	0.66(0.15)	0.75(0.39)	29%	42%

The dynamical-statistical model demonstrates a considerable capability for improving the AOI prediction of ENSEMBLE, with most the improved correlation coefficients significant at 99% confidence level and the large reduce of RMSE in cross-validation and hindcast.

e. Conclusion

The good performance of this dynamical-statistical model indicates a capability of the interannual-increment approach for interannual prediction of the AO. Thus, the dynamical-statistical model combine interannual-increment approach gives a new clue for AO prediction and the short-term climate prediction.

Reference: Zhang, D., Huang, Y., & Sun, B. (2019). Verification and improvement of the capability of ENSEMBLES to predict the winter Arctic Oscillation. *Earth and Space Science*, 6 https://doi.org/10.1029/2019EA000771