Climate predictions with MIROC6

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1. Introduction

Recently, a Japanese modeling community has cooperatively developed a new ocean–atmosphere coupled model called MIROC6 (Tatebe et al., 2019). There are two major updates from MIROC5: a finer atmospheric vertical resolution with a higher model top and incorporation of a shallow convective parameterization. Overall reproducibility of mean climate and internal climate variability on intraseasonal to decadal timescales in MIROC6 is improved over MIROC5.

We performed decadal predictions using MIROC6, which contribute to the Decadal Climate Prediction Project (DCPP) for the CMIP6. In this study, we address whether a climate model with a better representation of climate and/or initial conditions constrained by more observations lead to the improvement in seasonal to decadal prediction skill.

2. Prediction system

		MIROC6	MIROC5
Atmosphere	Horizontal resolution	T85	T85
	Vertical levels	81 levels	40 levels
Ocean	Horizontal resolution	360 x 256	256 x 224
	Vertical levels	63 levels	50 levels

	CMIP6 → MIROC6		MIROC5 ← CMIP5	
	seasonal-decadal MIROC6	Hist	decadal MIROC5-DP	seasonal MIROC5-SP
Assimilation method	IAU (anomaly)		IAU (anomaly)	IAU (anomaly)
Assimilation variables	TO, SO, SIC		TO, SO	TO, SO
Issuing date, duration	Every Nov. 1st between 1960-2015, 10year	Every Nov. 1st between 1960-2008, 10year	Every Jan. 1st between 1960-2008, 10year	Every Nov. 1st between 1980-2015, 1year
Ensemble	10	50	3 (jul, oct, jan) x 2 = 6	8
Atmospheric Initial condition	JRA55	No replacement	No replacement	NCEP/NCAR

- Drifts are removed by transforming raw outputs into anomalies with respect to the lead time-dependent forecast climatology
- Larger ensembles are prepared for a few selected cases:
  40 for 2008-10 (26 months) and 50 members for 2019-2020 (10 years)
- For evaluation, in addition to the anomaly correlation coefficient (ACC), "partial ACC" proposed by Smith et al. (2019) is used to evaluate the impact of initialization:

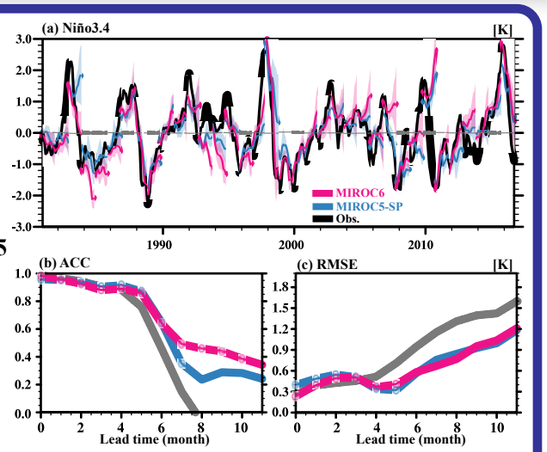
$$O' = \widetilde{O'} + O'_{res} \qquad Y' = \widetilde{Y'} + Y'_{res}$$

Observed (O') and ensemble mean initialized forecast anomalies (Y') are decomposed into components that can be explained by linear regression with the ensemble mean of uninitialized experiments and the residuals.

3. Results

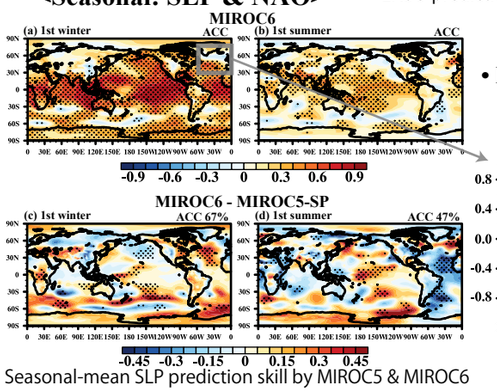
<Seasonal: ENSO>

- Significant skill up to about 1 year ahead
- Improved over MIROC5 likely due to a better ENSO reproducibility



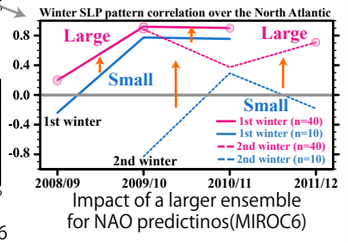
ENSO prediction skill by MIROC5 & MIROC6

<Seasonal: SLP & NAO>



Seasonal-mean SLP prediction skill by MIROC5 & MIROC6

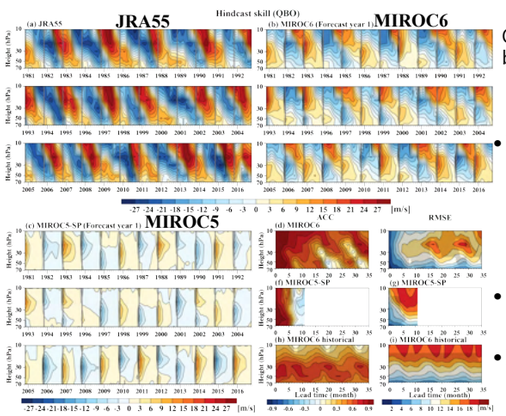
- Improved over MIROC5 for the 1st winter



Impact of a larger ensemble for NAO predictinos(MIROC6)

- NAO prediction skill is also improved, but ACC itself is low (~0.3): "signal-to-noise paradox" applies to MIROC6
- A larger ensemble improves the skill for both 1st and 2nd winter NAO

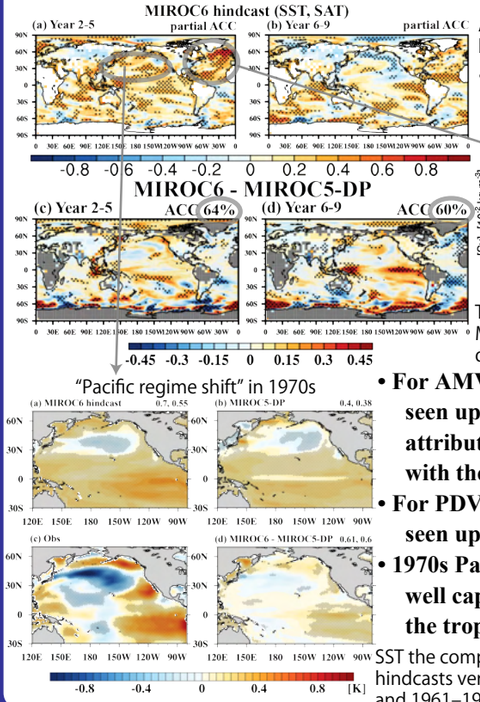
<Interannual: QBO>



QBO prediction skill by MIROC5 & MIROC6

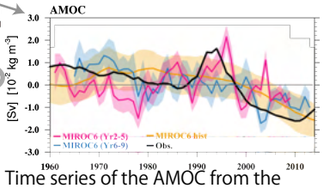
- Initial anomalies just decay in MIROC5, whereas MIROC6 reasonably reproduces the phase propagation
- Significant skills up to 3 years ahead (ACC>0.8)
- Note a forced component
- QBO prediction skill does not contribute toNAO prediction skill in MIROC6: the model fails to reproduce its teleconnection

<Decadal: PDV & AMV>



Annual-mean SAT/SST prediction skill by MIROC5 & MIROC6

- Improved over MIROC5 up to Yr7-10



Time series of the AMOC from the MIROC6 & observations of the potential density of deep Labrador Sea

"Pacific regime shift" in 1970s

SST the composite difference between Year 2-5 hindcasts verifying during the periods 1979–1992 and 1961–1973

- For AMV, the impact of initialization is seen up to Yr3-6, which may be attributed to predictability associated with the initialization of the AMOC
- For PDV, the impact of initialization is seen up to Yr2-5
- 1970s Pacific regime shift is particularly well captured by MIROC6 including the tropics

4. Conclusions

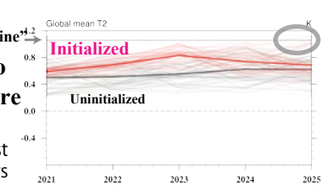
Decadal predictions with MIROC6 are performed:

- ENSO hindcast skills (particularly major events) are improved
- QBO is predictable up to 3 years ahead (ACC>0.8) owing to a better reproducibility in MIROC6 (and initialization)
- NAO hindcast skill is also improved, though the ACC itself is relatively low. A larger ensemble (40 members) improves the skill forboth 1st and 2nd winter NAO.

(• Barents-Kara, Hudson Bay, and Sea of Okhotsk sea ice in the 1st winter and sea ice around the Arctic pole in the 1st September is improved)

- MIROC6 hindcast has a larger fraction of areas with better skill both for ACC and RMSE at all lead times compared to the MIROC5-DP
- AMV: the impact of initialization over subpolar gyre region seen up to Yr4-7 -> success in the initialization of AMOC
- PDV: the impact of initialization up to Yr2-5. 1970s Pacific regime shift is particularly improved, including the tropics

*We are planning to increase the ensemble to 50 members: initialization experiments are under way.



Global-mean SAT in the latest MIROC6 forecast with 50 members

Kataoka .et al. (2019) Seasonal to Decadal Predictions With MIROC6: Description and Basic Evaluation. JAMES, 12, e2019MS002035. https://doi.org/10.1029/2019MS002035.

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