

Supplementary Information for

Future changes in the wintertime ENSO-NAO teleconnection under greenhouse warming

Xin Geng¹, Jong-Seong Kug², Yu Kosaka³

¹ *CIC-FEMD/ILCEC, Key Laboratory of Meteorological Disaster of Ministry of Education (KLME), Nanjing University of Information Science and Technology, Nanjing, China*

² *School of Earth and Environmental Sciences, Seoul National University, Seoul, South Korea*

³ *Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan*

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Introduction

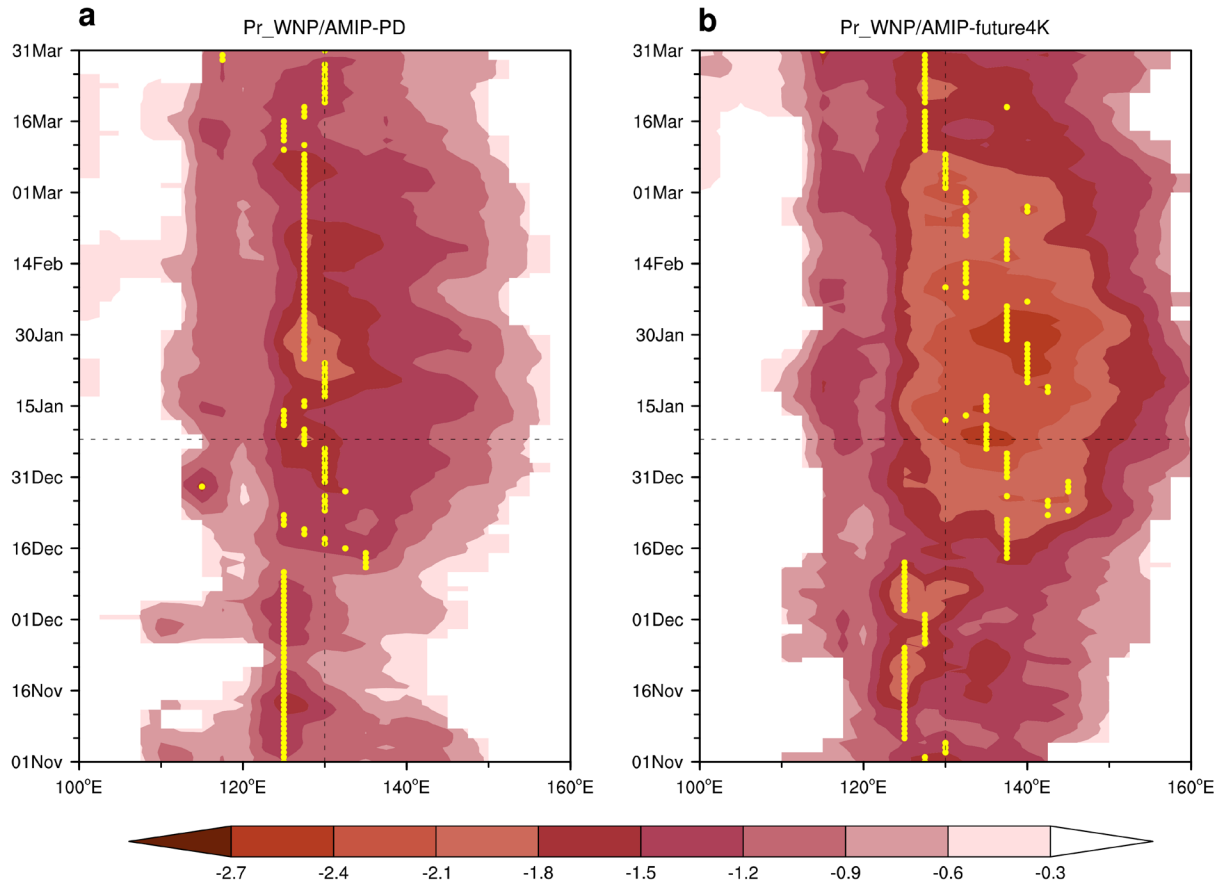
This document contains four Supplementary figures and one Supplementary table with legends. The context and relevance of these items are mentioned in the main text where appropriate.

**Corresponding author address:*

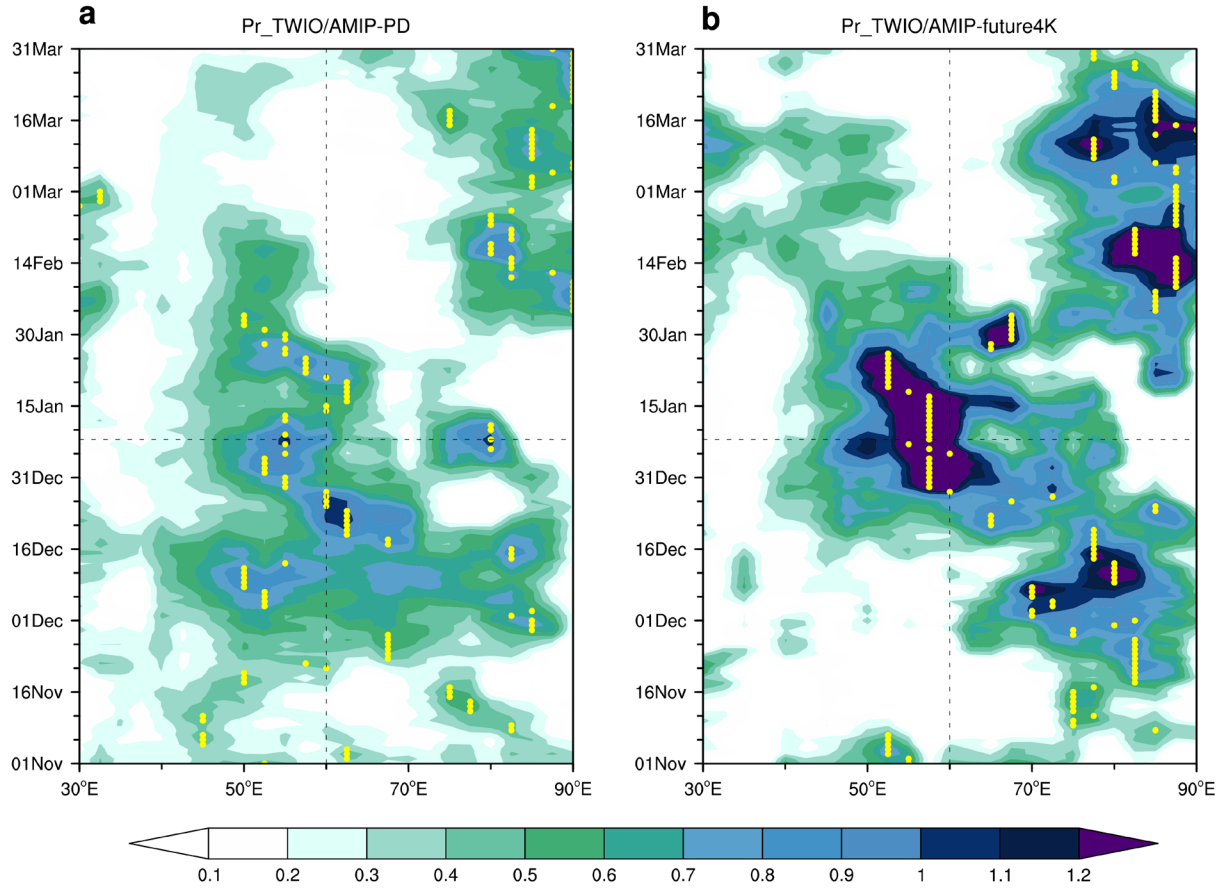
Dr. Jong-Seong Kug

School of Earth and Environmental Sciences, Seoul National University, Seoul, South Korea.

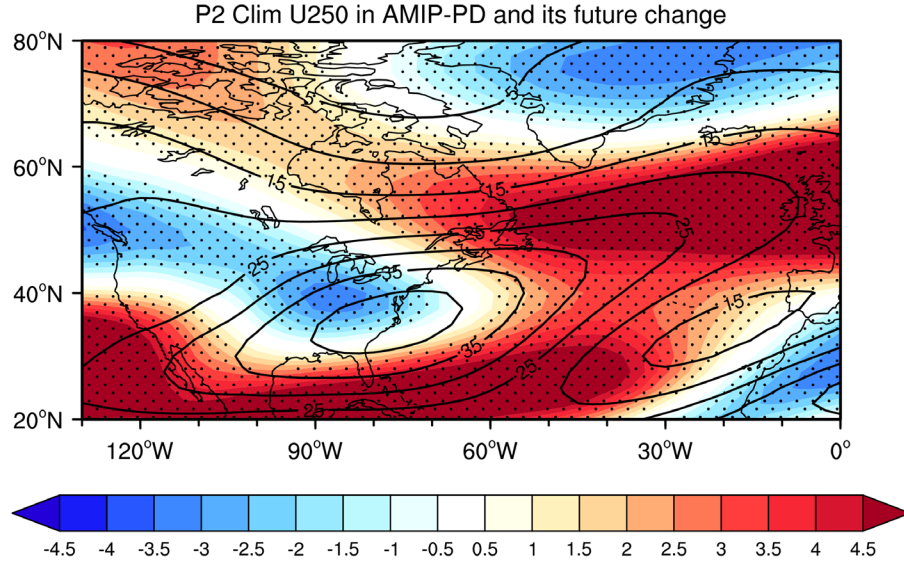
E-mail: jskug1@gmail.com



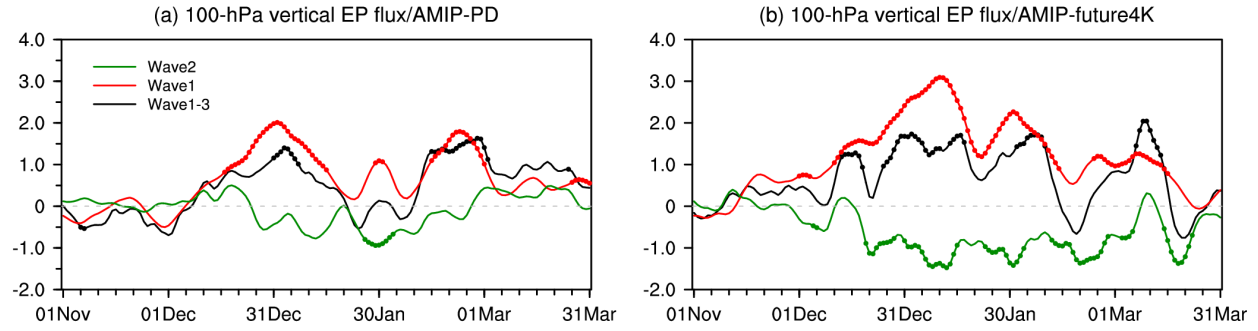
Supplementary Figure 1 Regression coefficients of the western North Pacific meridional mean (0° – 20° N) daily precipitation anomalies with respect to the DJF Niño-3.4 index for the MME of (a) AMIP-PD and (b) AMIP-future4K simulations. Note that only the significant values at the 90% confidence level are displayed. The yellow dot represents the zonal location of the maximum regression coefficient at each certain day. The horizontal black dashed line separates the whole winter period into early winter (P1) and late winter (P2). The vertical black dashed line marks 130° E longitude for better comparison.



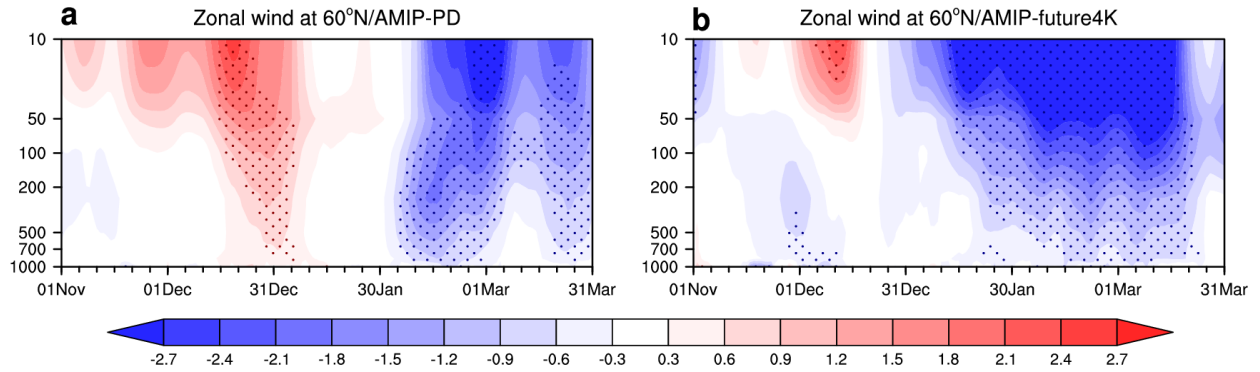
Supplementary Figure 2 Regression coefficients of the tropical western Indian Ocean meridional mean (5°S–5°N) daily precipitation anomalies with respect to the DJF Niño-3.4 index for the MME of (a) AMIP-PD and (b) AMIP-future4K simulations. Note that only the significant values at the 90% confidence level are displayed. The yellow dot represents the zonal location of the maximum regression coefficient at each certain day. The horizontal black dashed line separates the whole winter period into early winter (P1) and late winter (P2). The vertical black dashed line marks 60°E longitude for better comparison.



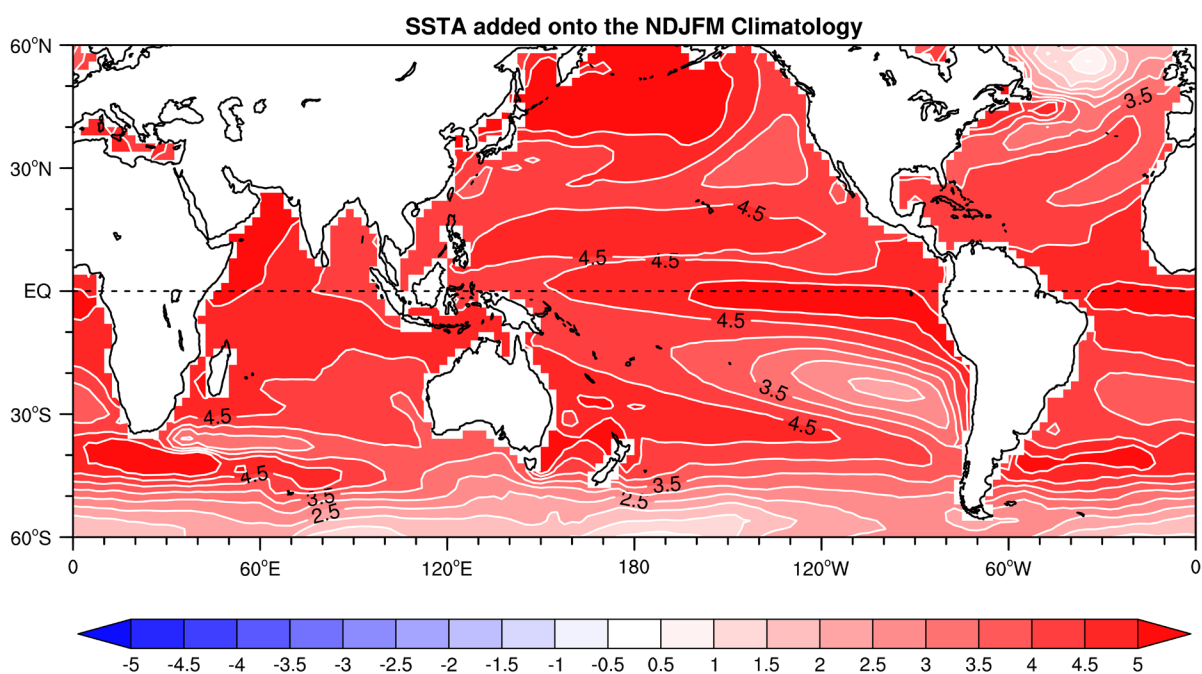
Supplementary Figure 3 Spatial pattern of climatological 250-hPa zonal wind (contours in ms^{-1}) during P2 for the MME of the AMIP-PD simulations. The shadings (units: ms^{-1}) show the P1 climatological 250-hPa zonal wind differences between the MME of the AMIP-future4K and AMIP simulations. The dots denote the zonal wind differences that are significant at the 90% confidence level.



Supplementary Figure 4 Temporal evolution of the ENSO-regressed vertical component of 100-hPa EP flux averaged in 40° – 70° N for the MME of the AMIP-PD and AMIP-future4K simulations. The dots indicate the anomalies significant at the 90% confidence level.



Supplementary Figure 5 Regression coefficients of the wintertime daily zonal wind anomalies (shadings in ms-1) at 60°N with respect to the DJF Niño-3.4 index from 1000 to 10 hPa for the MME of the “high-top” models of the (a) AMIP-PD and (b) AMIP-future4K simulations. The dots denote the corresponding anomalies are significant at the 90% confidence level.



Supplementary Figure 6 The wintertime (NDJFM) mean SST anomaly (shadings and contours in K) added onto the climatology to force the AMIP-future4K simulations.

Supplementary Table 1 Seven CMIP6 AMIP and AMIP-future4K simulations used in the study.

Model	Institution	Model Top	Ensemble Variant Label
BCC-CSM2-MR	BCC	1.459 hPa (Low-top) ¹	r1i1p1fl
CanESM5	CCCma	1 hPa (High-top) ²	r1i1p2fl
CESM2	NCAR	2.26 hPa (Low-top) ³	r1i1p1fl
HadGEM3-GC31-LL	MOHC	85km (High-top) ⁴	r5i1p1f3
IPSL-CM6A-LR	IPSL	0.01 hPa (High-top) ⁵	r1i1p1fl
MIROC6	MIROC	0.004 hPa (High-top) ⁶	r1i1p1fl
MRI-ESM2-0	MRI	0.01 hPa (High-top) ⁷	r1i1p1fl

Supplementary References

1. Wu, T. *et al.* The Beijing Climate Center Climate System Model (BCC-CSM): the main progress from CMIP5 to CMIP6. *Geoscientific Model Development* **12**, 1573–1600 (2019).
2. Swart, N. C. *et al.* The Canadian Earth System Model version 5 (CanESM5.0.3). *Geoscientific Model Development* **12**, 4823–4873 (2019).
3. Danabasoglu, G. *et al.* The Community Earth System Model Version 2 (CESM2). *Journal of Advances in Modeling Earth Systems* **12**, e2019MS001916 (2020).
4. Andrews, M. B. *et al.* Historical Simulations With HadGEM3-GC3.1 for CMIP6. *Journal of Advances in Modeling Earth Systems* **12**, e2019MS001995 (2020).
5. Boucher, O. *et al.* Presentation and Evaluation of the IPSL-CM6A-LR Climate Model. *Journal of Advances in Modeling Earth Systems* **12**, e2019MS002010 (2020).
6. Tatebe, H. *et al.* Description and basic evaluation of simulated mean state, internal variability, and climate sensitivity in MIROC6. *Geoscientific Model Development* **12**, 2727–2765 (2019).
7. Yukimoto, S. *et al.* The Meteorological Research Institute Earth System Model Version 2.0, MRI-ESM2.0: Description and Basic Evaluation of the Physical Component. *Journal of the Meteorological Society of Japan. Ser. II* **97**, 931–965 (2019).