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Comparison of past and future simulations of ENSO in CMIP5/PMIP3 and CMIP6/PMIP4 models

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Table S1: Details of CMIP6/PMIP4 models included in this study: Model name, institution, reference, atmosphere resolution, ocean resolution.

Model name	Institution	References	Atmosphere resolution				Ocean resolution			
			Lon	Lat	Level	Top level	Lon	Lat	Level	Top grid cell
AWI-ESM-1-1-LR	Alfred Wegener Institute (AWI), Germany	Sidorenko et al. (2015) & Rackow et al. (2018); Danek et al. (2020a,b,c); Shi et al. (2020a,b,c,d)	192	96	47	80 km	126859 wet nodes		46	0-5m
CNRM-CM6-1	CNRM-CERFACS, France	Voldoire et al. (2019)	256	128	91	78.4 km	362	294	75	0-1m
CESM2	National Center for Atmospheric Research (NCAR), USA	Danabasoglu et al. (2020)	288	192	32	2.25 mb	320	384	60	0-10m
EC-EARTH3-LR	EC-Earth Consortium	Doescher et al. (in preparation)	320	160	62	5 hPa	362	292	75	0-1m
FGOALS-f3-L	Chinese Academy of Sciences (CAS), China	He et al. (2019)	360	180	32	2.16 hPa	360	218	30	0-10m
FGOALS-g3	Chinese Academy of Sciences (CAS), China	Li et al. (2020)	180	80	26	2.19 hPa	360	218	30	0-10m
GISS-E2-1-G	NASA Goddard Institute for Space Studies (GISS), USA	Kelley et al. (submitted)	144	90	40	0.1 hPa	360	180	40	0-10m
HadGEM3-GC31-LL	Met. Office Hadley Centre, UK	Williams et al. (2018)	192	144	85	85 km	360	330	75	0-1m
INM-CM4-8	Institute of Numerical Mathematics of the Russian Academy of Sciences, Russia	Volodin et al. (2018)	180	120	21	sigma= 0.01	360	318	40	0.001426 sigma
IPSL-CM6A-LR	Institut Pierre Simon Laplace (IPSL), France	Boucher et al. (2020)	144	143	79	40 km	362	332	75	0-2m
MPI-ESM1-2-LR	Max Planck Institute for Meteorology (MPI), Germany	Mauritsen et al. (2019)	192	96	47	0.01 hPa	256	220	40	0-12m

MIROC-ES2L	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (University of Tokyo), and National Institute for Environmental Studies, Japan	Hajima et al. (2020); Ohgaito et al. (in review)	128	64	40	3 hPa	360	256	63	0-2m
MRI-ESM2-0	Meteorological Research Institute (MRI), Japan	Yukimoto et al. (2019)	320	160	80	0.01 hPa	360	364	61	0-2m
NESM3	Nanjing University of Information Science and Technology, China	Cao et al. (2018)	192	96	47	1 Pa	384	362	46	0-6m
NorESM1-F	Bjerknes Centre for Climate Research, Norway	Guo et al. (2019)	144	96	32	3 mb	360	384	70	0-2.5m
NorESM2-LM	Bjerknes Centre for Climate Research, Norway	Seland et al. (2020)	144	96	32	3 mb	360	384	70	0-2.5m
UofT-CCSM-4	University of Toronto, Canada	Chandan and Peltier (2017)	288	192	26	2 hPa	384	320	60	0-10m

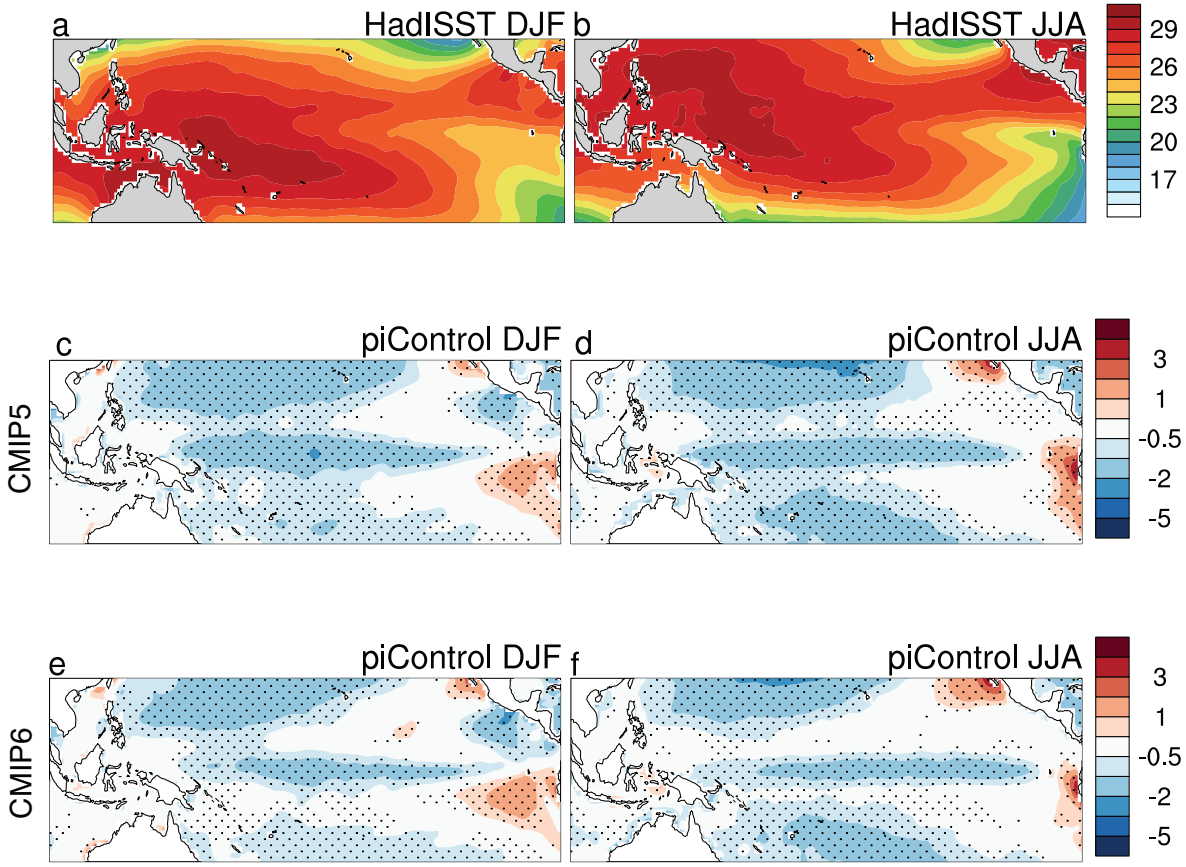

Figure S1: Sea surface temperature evaluation: Observed HadISST for (a) DJF and (b) JJA, CMIP5 *piControl* multi-model mean anomaly relative to HadISST for (c) DJF and (d) JJA and CMIP6 *piControl* multi-model mean anomaly relative to HadISST for (e) DJF and (f) JJA. Stippling indicates 2/3 of models agree on sign of anomaly. Units are °C.

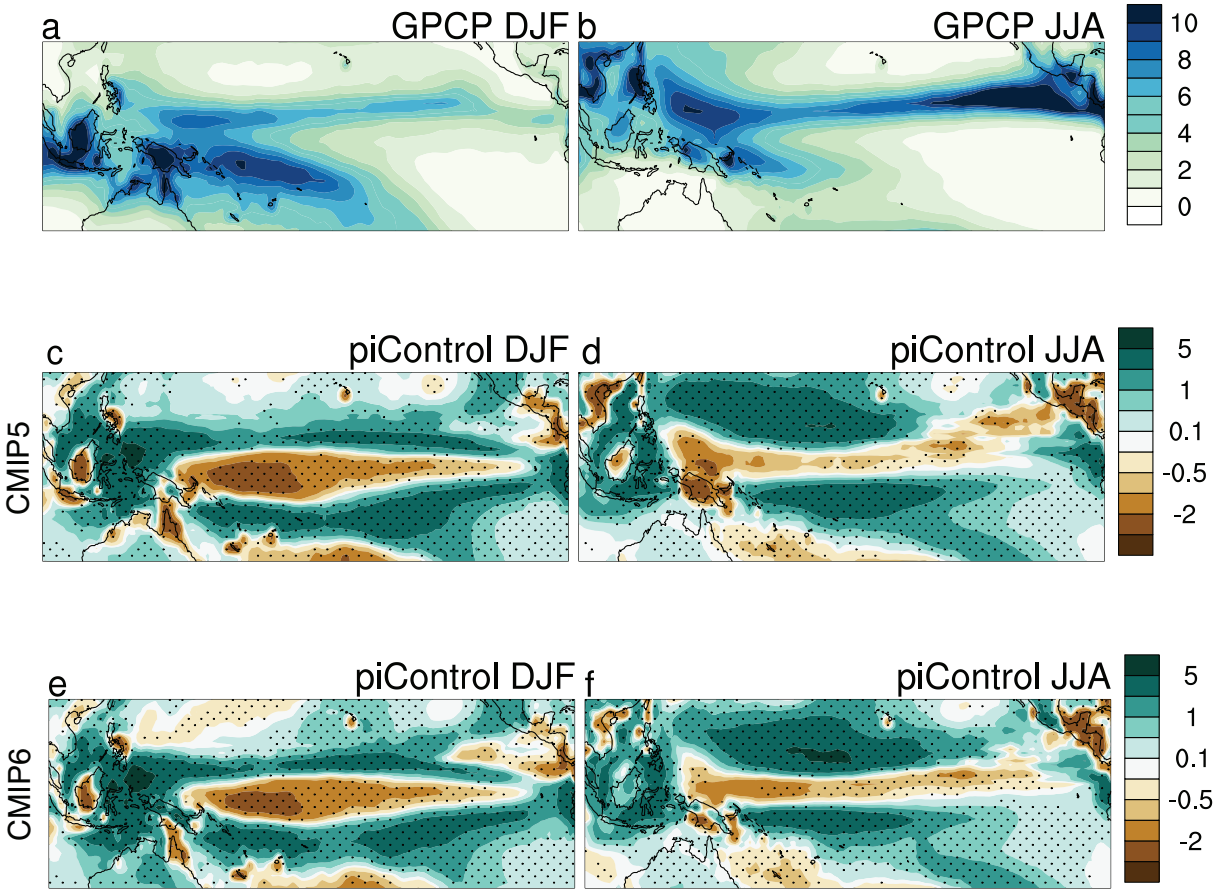

Figure S2: Precipitation evaluation: Observed GPCP for (a) DJF and (b) JJA, CMIP5 *piControl* multi-model mean anomaly relative to GPCP for (c) DJF and (d) JJA and CMIP6 *piControl* multi-model mean anomaly relative to GPCP for (e) DJF and (f) JJA. Stippling indicates 2/3 of models agree on sign of anomaly. Units are mm/day.

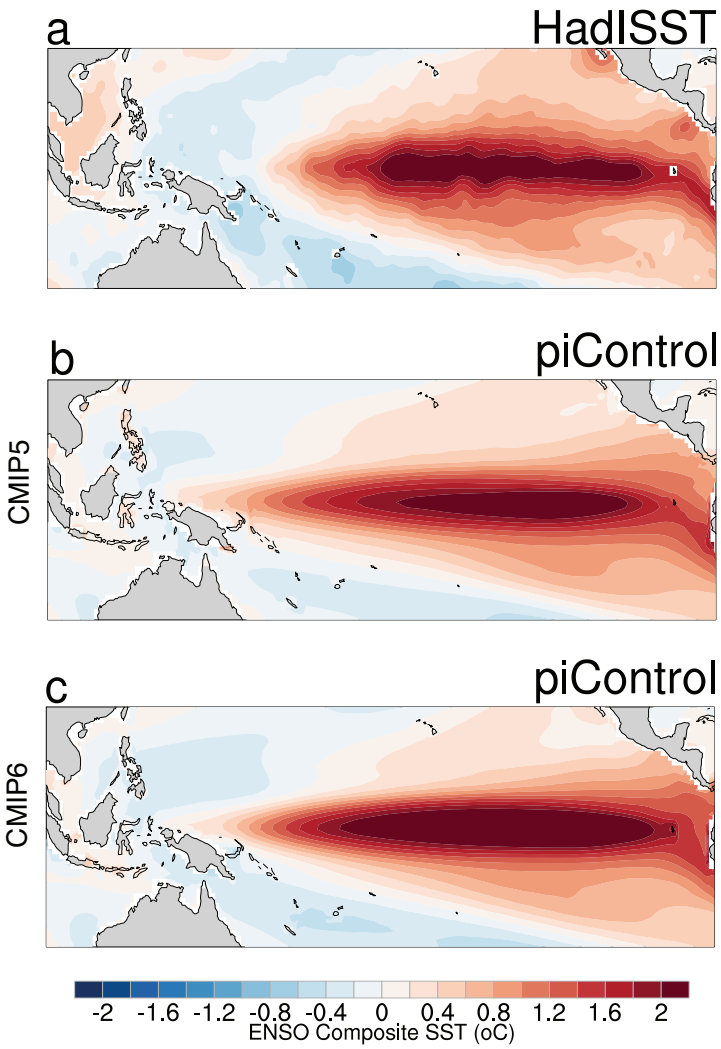

Figure S3: Evaluation of ENSO SST anomaly pattern: Composite El Niño minus La Niña sea surface temperature anomaly from (a) HadISST observations, (b) CMIP5 model ensemble average from piControl simulations and (c) CMIP6 model ensemble average from piControl simulations. Units are °C.

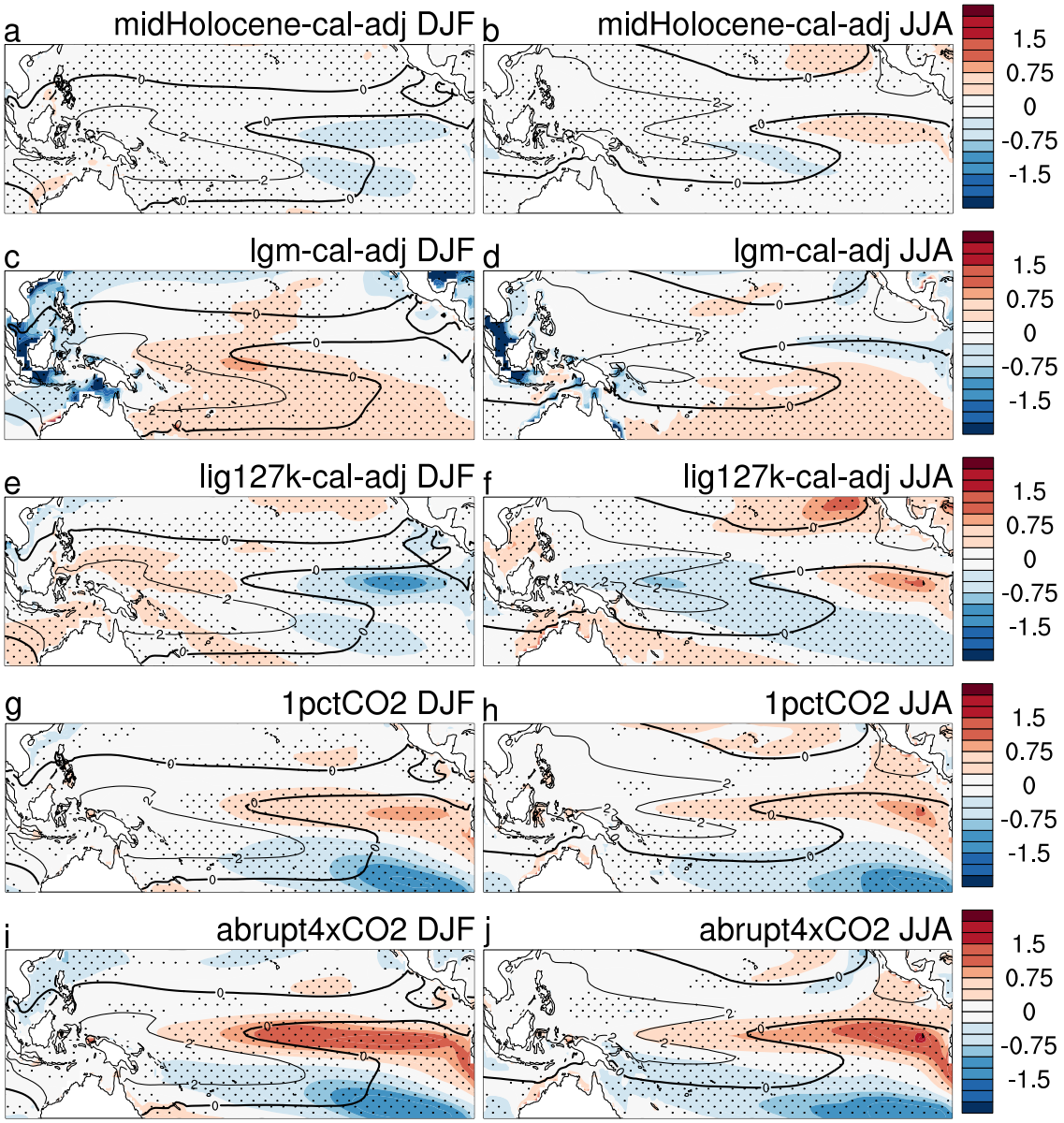

Figure S4: Ensemble mean seasonal changes in sea surface temperature in experiments minus pre-industrial control simulations as for Figure 6 but with tropical mean SST change (over 25°N-25°S, 100°E-80°W) subtracted. The ensemble mean temperature pattern in the pre-industrial control simulations is shown as black contours. Units are °C. Stippling indicates that more than 2/3 of the ensemble members agree on the sign of the change.

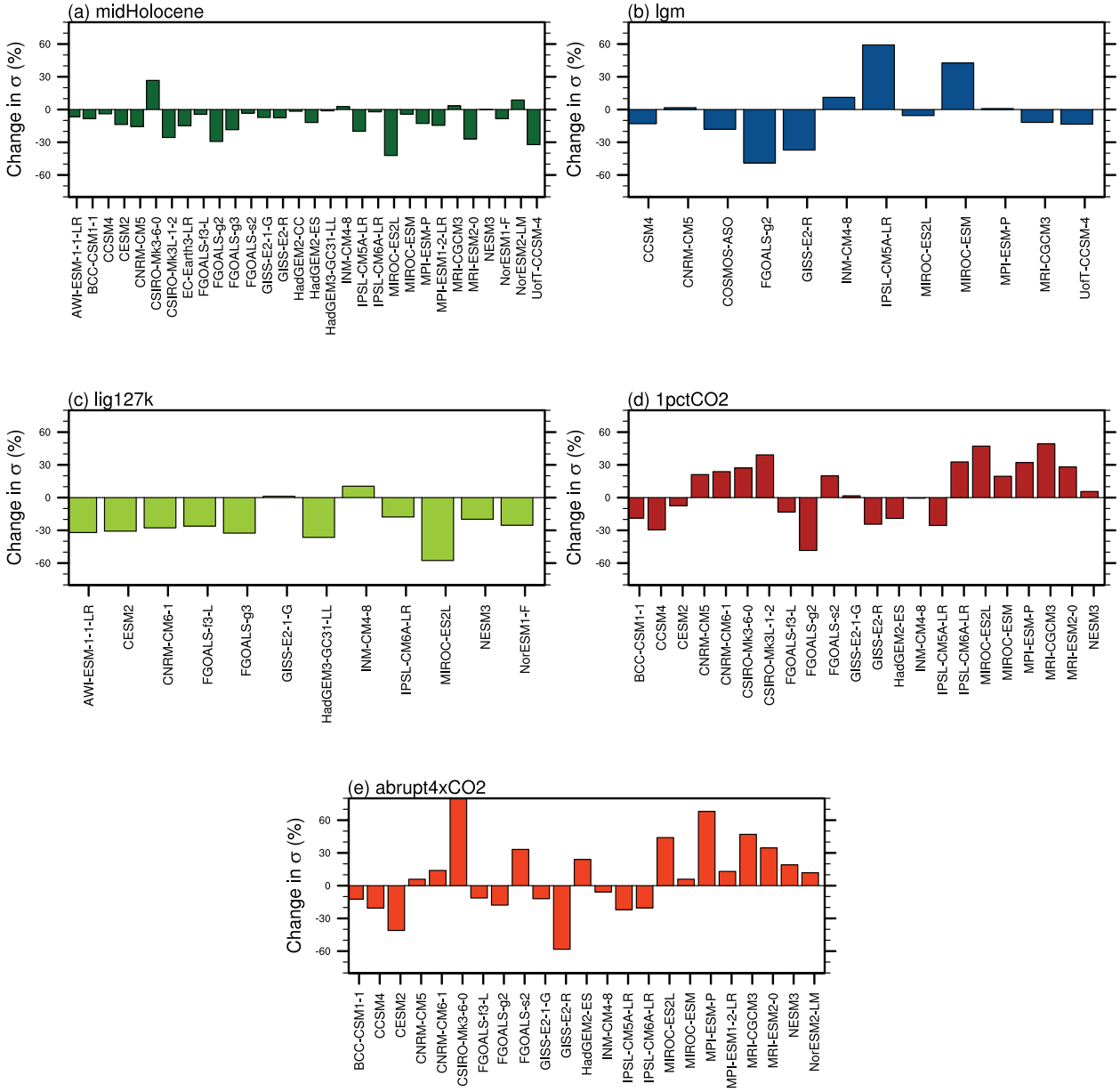

Figure S5: Change in amplitude of ENSO measured from standard deviation of 2-8 year bandpass filtered NINO3.4 index relative to *piControl* amplitude (%) in (a) *midHolocene*, (b) *lgm*, (c) *lig127k*, (d) *1pctCO2* and (e) *abrupt4xCO2*. Model names are given below plots. As in Figure 9 but using bandpass filtered NINO3.4 indices.

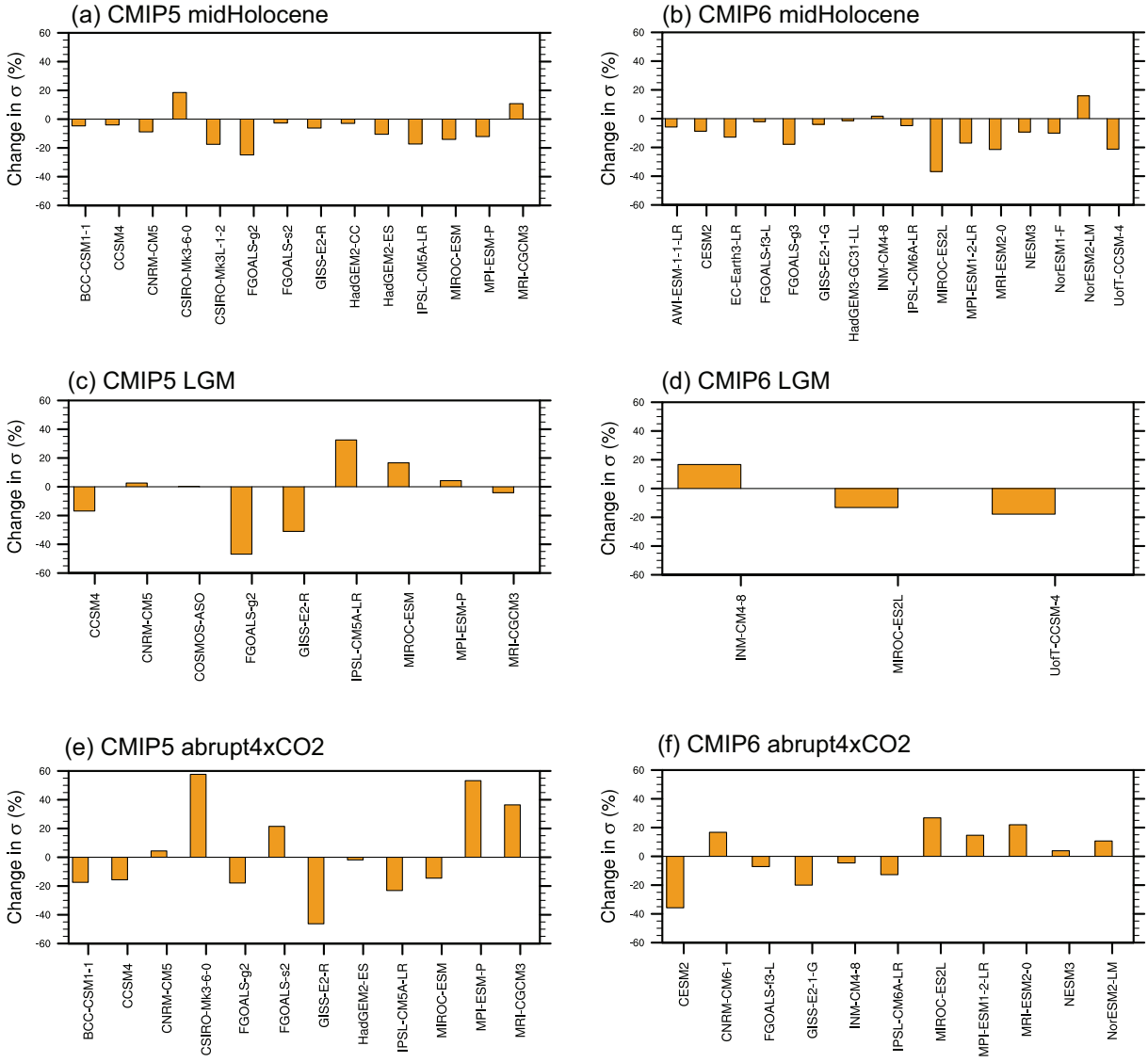

Figure S6: Change in standard deviation of NINO3.4 SST (%) relative to *piControl* for (a) CMIP5 *midHolocene* and (b) CMIP6 *midHolocene*, (c) CMIP5 *lgm* and (d) CMIP6 *lgm* and (e) CMIP5 *abrupt4xCO2* and (f) CMIP6 *abrupt4xCO2* experiments.

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