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Supplement of

An assessment of Antarctic sea-ice thickness in CMIP6 simulations with comparison to the satellite-based observations and reanalyses

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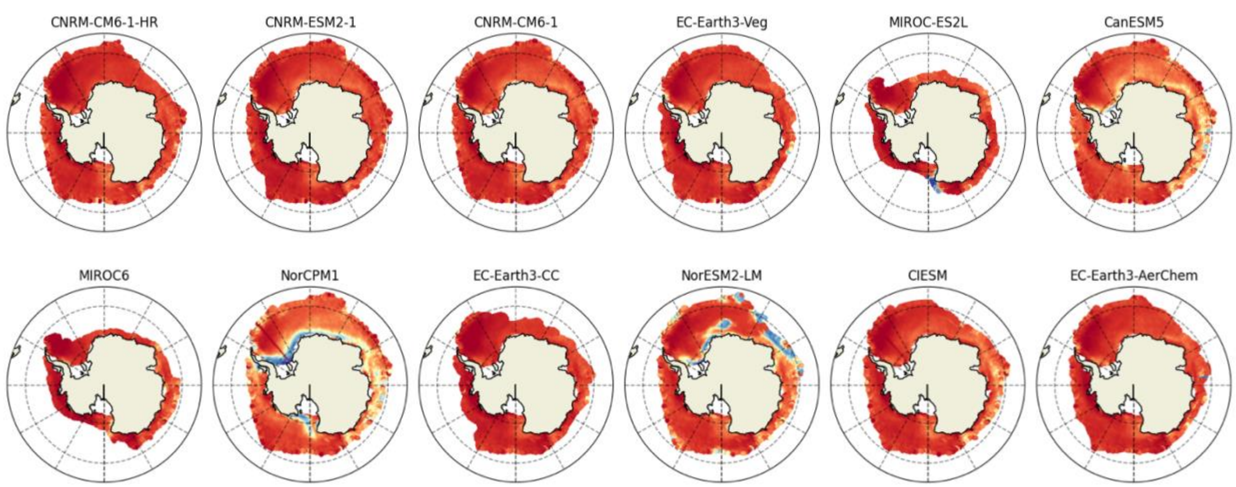
Introduction

The data files used in the supporting document are derived using Python. The format of the datasets was netcdf (.nc) format. The visualization generated is in the form of images (.png) format.

The spatial biases are calculated in Python by subtracting the reference dataset for respective months from the CMIP6 modeled data. (Fig. S1-S3)



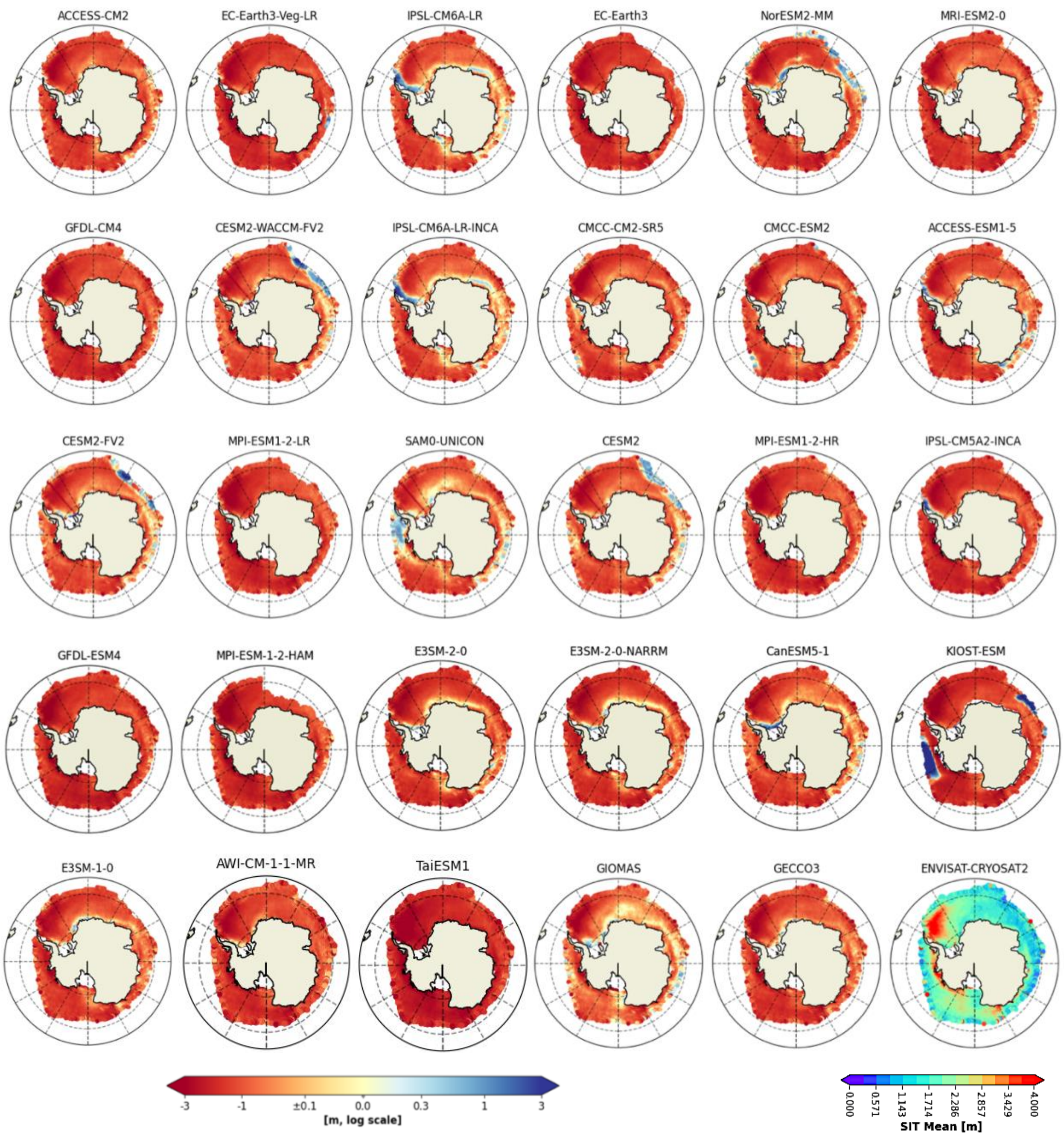
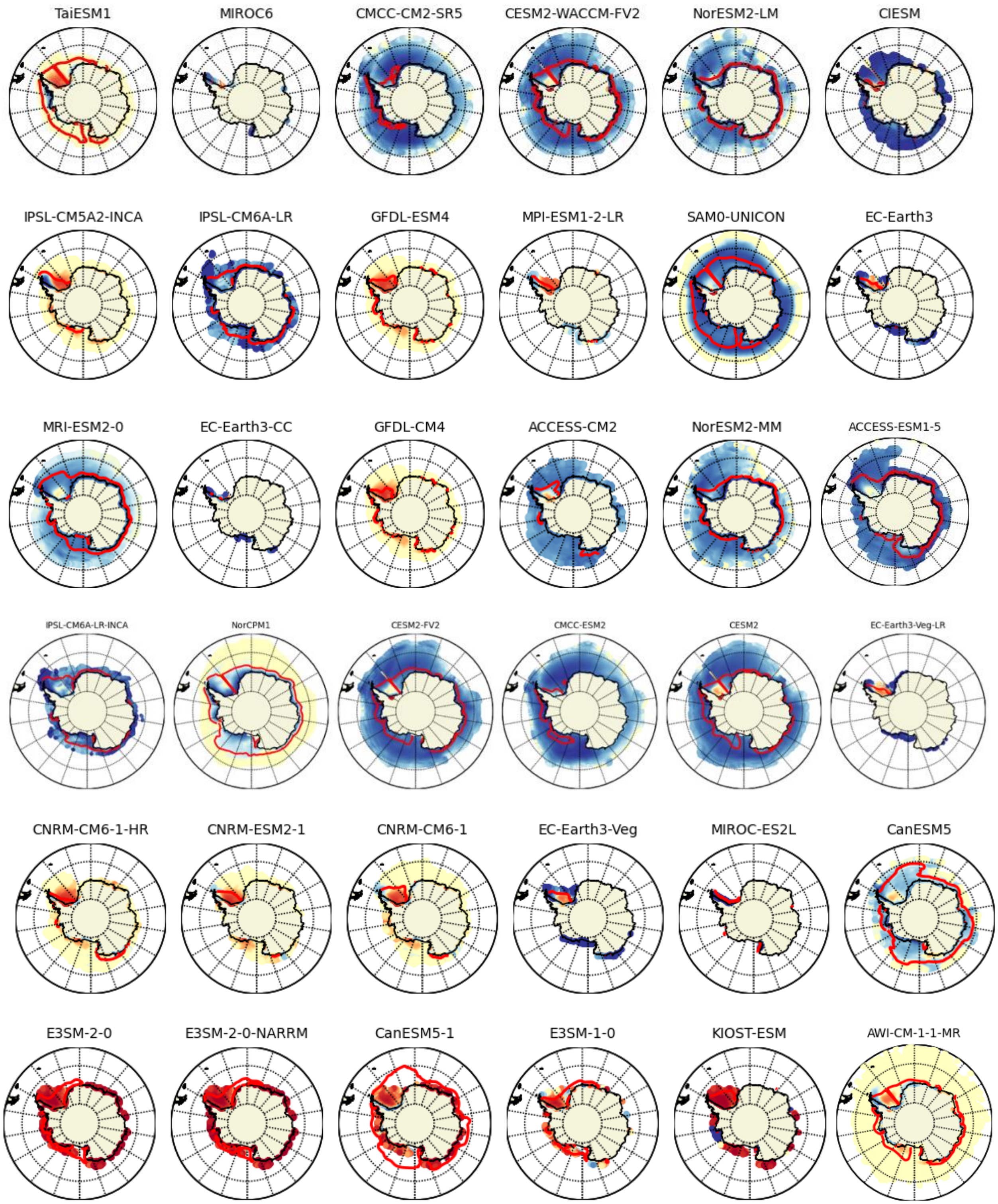


Figure S1: Spatial Biases of SIT from 2002 to 2014 (September) from 39 CMIP6 models and Reanalyses from the reference dataset: ENVISAT-CS-2. Last figure shows the time averaged SIT for ENVISAT-CS-2.


TaiESM1
MIROC6
CMCC-CM2-SR5
CESM2-WACCM-FV2
NorESM2-LM
CIESM
IPSL-CM5A2-INCA
IPSL-CM6A-LR
GFDL-ESM4
MPI-ESM1-2-LR
SAM0-UNICON
EC-Earth3
MRI-ESM2-0
EC-Earth3-CC
GFDL-CM4
ACCESS-CM2
NorESM2-MM
ACCESS-ESM1-5
IPSL-CM6A-LR-INCA
NorCPM1
CESM2-FV2
CMCC-ESM2
CESM2
EC-Earth3-Veg-LR
CNRM-CM6-1-HR
CNRM-ESM2-1
CNRM-CM6-1
EC-Earth3-Veg
MIROC-ES2L
CanESM5
E3SM-2-0
E3SM-2-0-NARRM
CanESM5-1
E3SM-1-0
KIOST-ESM
AWI-CM-1-1-MR

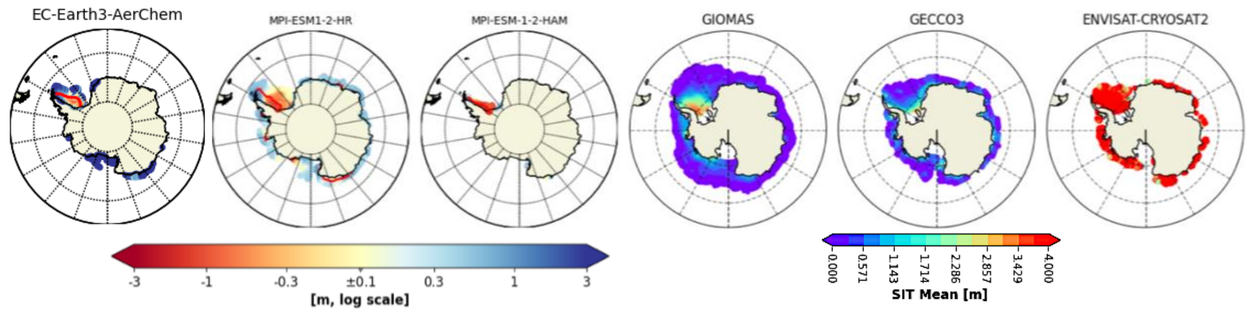
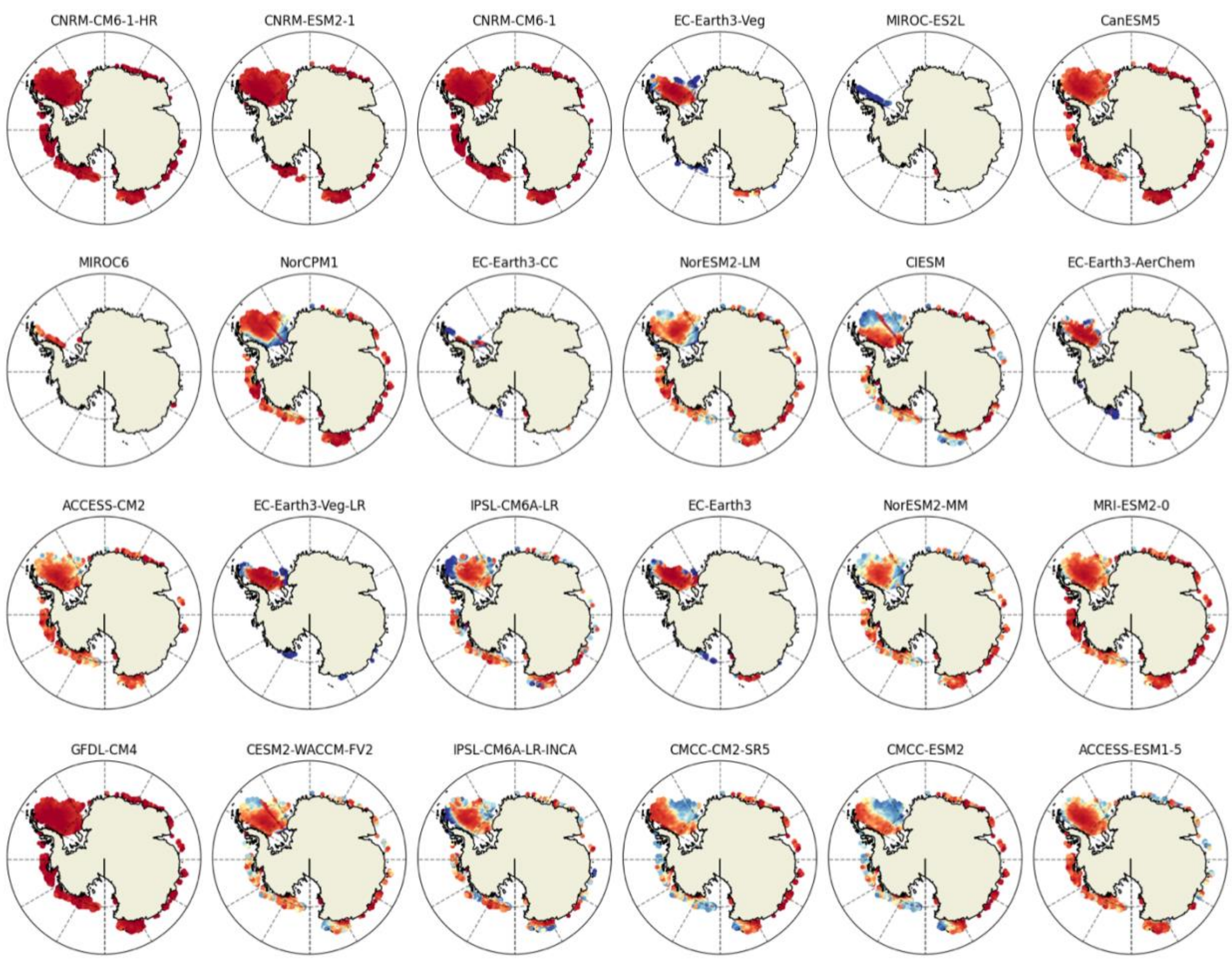


Figure S2: Spatial Biases of SIT averaged over 2002 to 2014 (February) for 39 CMIP6 models from the reference dataset: GIOMAS. The last three plots show the time averaged SIT for the three sea-ice products. The red contours represent the sea-ice edge (15%SIC).



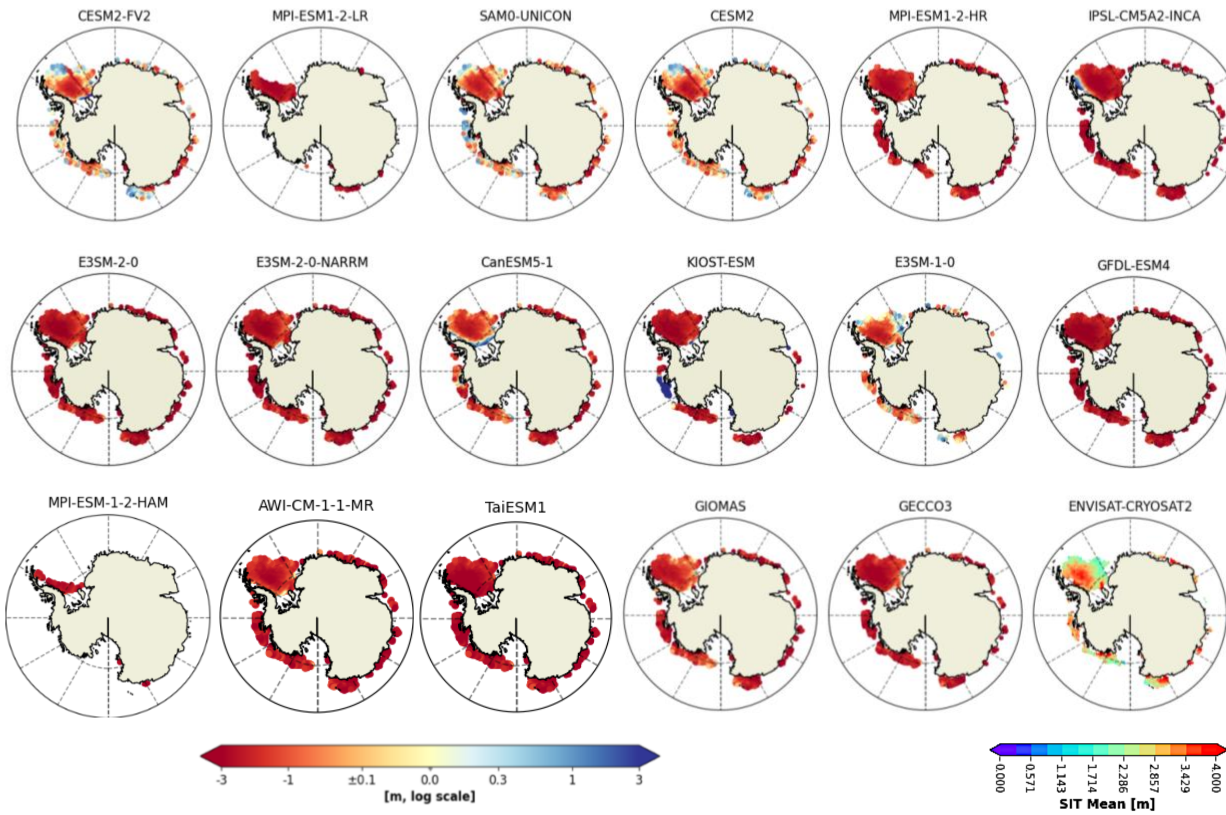


Figure S3: Spatial Biases of SIT from 2002 to 2014 (February) from 39 CMIP6 models and Reanalyses from the reference dataset: ENVISAT-CS-2. Last figure shows the time averaged SIT for ENVISAT-CS-2.

Tables

Source	Spatial Resolution	Temporal Resolution	Variable used	References
SATELLITE PRODUCTS: Envisat *(Radar Altimeter 2 (RA2))* and CryoSat-2 *(Synthetic-Aperture Interferometric Radar Altimeter (SIRAL))*. Based on Ku-band frequencies.	50 km	2002-2012 (Envisat) Since 2010 (CryoSat-2)	Sea-ice Thickness	(Hendricks et al., 2018)

SEA-ICE ESTIMATES AND REANALYSES: Global Ice-Ocean Modeling and Assimilation System *(GIOMAS)*	0.8 degrees	2002-2014	Effective Sea-ice Thickness ("*heff"*)	(Zhang and Rothrock, 2003)
German contribution to the Estimating the Circulation and Climate of the Ocean project (GECCO3)	0.4 degrees	2002-2014	Effective Sea-ice Thickness ("*heff"*)	(Köhl, 2020)

Table S1: Table showing observation dataset details.

Model Name	Atmospheric Model	Ocean Model	Sea-Ice Model	References
ACCESS-CM2	MetUM-HadGEM3-GA7.1	ACCESS-OM2	CICE5.1.2	Dix et al., 2019
ACCESS-ESM1-5	HadGAM2 [250km]	ACCESS-OM2 (MOM5) [100km]	CICE4.1 [100km]	Ziehn et al., 2020
AWI-CM-1-1MR	ECHAM6.3.04p1	FESOM 1.4.	FESOM 1.4.	Semmler et al., 2018
CanESM5	CanAM5	NEMO3.4.1	LIM2	Swart et al., 2019
CanESM5-1	CanAM5	NEMO3.4.1	LIM2	Swart et al., 2019
CESM2	CAM6 [100km]	POP2 [100km]	CICE5.1 [100km]	Danabasoglu et al., 2020
CESM2-FV2	CAM6 [100km]	POP2 [100km]	CICE5.1 [100km]	Danabasoglu et al., 2020
CESM2-WACCM-FV2	WACCM6	MAM4	CICE5.1	Danabasoglu et al., 2020, Gettelman et al., 2019
CIESM	CIESM-AM	CIESM-OM	CICE4	Lin et al., 2020
CMCC-CM2-SR5	CAM5.3	NEMO3.6	CICE4.0	Lovato et al., 2020
CMCC-ESM2	CAM5.3	NEMO3.6	CICE4.0	Cherchi et al., 2019
CNRM-CM6-1-HR	Arpege 6.3 [100km]	Nemo 3.6 [25km]	Gelato 6.1 [25km]	Voldoire, 2019
CNRM-ESM2-1	Arpege 6.3 [250km]	Nemo 3.6 [100km]	Gelato 6.1 [100km]	Roland, 2018
CNRM-CM6-1	Arpege 6.3	Nemo 3.6	Gelato 6.1	Voldoire, 2018
E3SM-1-0	EAM	MPAS-Ocean	MPAS-Seaice	Bader et al., 2019
E3SM-2-0	EAMv2	MPAS-Ocean	MPAS-Seaice	Golaz et al., 2022
E3SM-2-0-NARRM	EAMv2	MPAS-Ocean	MPAS-Seaice	Tang et al., 2023
EC-Earth3	IFS cy36r4	NEMO3.6	LIM3	Massonnet et al., 2020
EC-Earth3-AerChem	IFS cy36r4	NEMO3.6	LIM3	van Noije et al., 2021
EC-Earth3-CC	IFS cy36r4	NEMO3.6	LIM3	Döscher et al., 2022

EC-Earth3-Veg	IFS cy36r4 [100km]	NEMO3.6 [100km]	LIM3 [100km]	Earth E.C., 2019
EC-Earth3-Veg-LR	IFS cy36r4	NEMO3.6	LIM3	Wyser et al., 2020
GFDL-CM4	GFDL-AM4.0.1	GFDL-OM4p25	GFDL-SIM4p25	Held et al., 2019
GFDL-ESM4	GFDL-AM4.1	GFDL-OM4p5	GFDL-SIM4p5	Krasting et al., 2018
IPSL-CM5A2-INCA	LMDZ	NEMO-OPA	NEMO-LIM3	Boucher et al., 2020
IPSL-CM6A-LR-INCA	LMDZ	NEMO-OPA	NEMO-LIM3	Boucher et al., 2021
IPSL.IPSL-CM6A-LR	LMDZ [250km]	NEMO-OPA [100km]	NEMO-LIM3 [100km]	Lurton et al., 2020
KIOST-ESM	GFDL-AM2.0	GFDL-AM2.0	GFDL-AM2.0	Kim et al., 2019
MIROC6	CCSR AGCM [250km]	COCO4.9 [100km]	COCO4.9 [100km]	Tatebe et al., 2019
MIROC6-ES2L	CCSR AGCM [500km]	COCO4.9 [100km]	COCO4.9 [100km]	Shiogama et al., 2019
MPI-ESM-1-2-HAM	ECHAM6.3	MPIOM1.63	UNNAMED (thermodynamic (Semtner zero-layer) dynamic (Hibler 79)	Mauritsen et al., 2019
MPI-ESM1-2-HR	Same as above	Same as above	Same as above	Gutjahr et al., 2019
MPI-ESM1-2-LR	Same as above	Same as above	Same as above	Mauritsen et al., 2019
MRI-ESM2-0	MRI-AGCM3.	MRI.COM4.4	MRI.COM4.4	Yukimoto et al., 2019
NorCPM1	CAM-OSLO4.1	MICOM1.1	CICE4	Counillon et al., 2016
NorESM2-LM	CAM-OSLO	MICOM	CICE	Seland et al., 2020
NorESM2-MM	CAM-OSLO	MICOM	CICE	Seland et al., 2020
SAM0-UNICON	CAM5.3 with UNICON	POP2	CICE4.0	Park et al., 2019
TaiESM1	TaiAM1	POP2	CICE4	Lee et al., 2020

Table S2: Details of the specifications of 39 CMIP6 models used in the study (for TaiESM1 we suspect that SIT values in 'cm' were erroneously stored as 'm'; hence converted)

	February			September		
Models	**STD**	**RMSD**	**Corr**	**STD**	**RMSD**	**Corr**
ENV-CS2	1.021	0	1	1.269	0	1
ACCESS-CM2	0.777	0.326	0.903	0.534	0.642	0.847
NorCPM1	0.779	0.352	0.794	0.944	0.647	0.76
MPI-ESM-1-2-HAM	0.095	0.207	0.948	0.33	0.744	0.855
NorESM2-LM	1.507	0.498	0.789	1.267	0.769	0.613
MIROC6	0.135	0.193	0.982	0.34	0.652	0.777

MRI-ESM2-0	0.785	0.387	0.907	0.592	0.648	0.82
GFDL-ESM4	0.13	0.535	0.592	0.351	0.739	0.833
IPSL-CM5A2-INCA	0.323	0.502	0.471	0.503	0.725	0.702
EC-Earth3-CC	0.366	0.199	0.887	0.349	0.745	0.754
GFDL-CM4	0.117	0.544	0.517	0.379	0.716	0.862
NorESM2-MM	1.08	0.393	0.903	0.818	0.678	0.716
EC-Earth3-AerChem	0.626	0.217	0.81	0.489	0.709	0.792
CMCC-CM2-SR5	1.238	0.507	0.892	0.714	0.636	0.793
MPI-ESM1-2-HR	0.205	0.26	0.94	0.42	0.734	0.811
SAM0-UNICON	1.028	0.426	0.865	0.813	0.58	0.813
ACCESS-ESM1-5	1.012	0.39	0.896	0.704	0.655	0.758
CESM2-WACCM-FV2	1.281	0.57	0.693	0.966	0.707	0.677
EC-Earth3-Veg-LR	0.708	0.227	0.798	0.461	0.723	0.775
CESM2-FV2	1.417	0.655	0.655	1.134	0.779	0.607
EC-Earth3	0.634	0.226	0.823	0.446	0.725	0.777
CESM2	1.084	0.499	0.849	0.74	0.605	0.817
IPSL-CM6A-LR	1.603	0.395	0.809	0.914	0.59	0.8
MPI-ESM1-2-LR	0.185	0.262	0.93	0.362	0.755	0.834
CMCC-ESM2	1.233	0.494	0.891	0.679	0.626	0.811
CIESM	0.927	0.281	0.838	0.456	0.697	0.813
CNRM-ESM2-1	0.05	0.209	0.74	0.05	0.209	0.74
CNRM-CM6-1	0.066	0.219	0.748	0.066	0.219	0.748
EC-Earth3-Veg	0.184	0.101	0.808	0.184	0.101	0.808
MIROC-ES2L	0.127	0.049	0.978	0.127	0.049	0.978
CanESM5	0.264	0.155	0.846	0.264	0.155	0.846
E3SM-2-0-NARRM	0.14	0.221	0.674	0.342	0.327	0.863
CanESM5-1	0.313	0.159	0.808	0.382	0.302	0.858
E3SM-1-0	0.249	0.096	0.919	0.306	0.331	0.886
KIOST-ESM	1.885	0.955	0.271	1.771	0.744	0.322
E3SM-2-0	0.592	0.225	0.642	0.494	0.327	0.862
TaiESM1	0.296	0.146	0.644	0.613	0.515	0.788
GIOMAS	0.675	0.487	0.041	0.515	0.699	0.226
GECCO3	0.876	0.478	-0.033	0.46	0.702	0.32

Table S3: Table showing spatial correlations, RMSDs and Standard Deviations for Sea-ice Thickness.

	February			**September**		
Models	**STD**	**RMSD**	**Corr**	**STD**	**RMSD**	**Corr**
ENV-CS2	0.592	0.000	1	0.760	0.000	1
ACCESS-CM2	0.301	0.263	0.567	1.070	0.536	0.77

NorCPM1	1.532	0.788	0.793	2.203	1.431	0.809
MPI-ESM-1-2-HAM	0.227	0.113	0.791	0.953	0.432	0.73
NorESM2-LM	1.357	0.325	0.547	1.417	0.528	0.687
MIROC6	0.057	0.120	0.578	0.673	0.393	0.596
MRI-ESM2-0	0.890	0.302	0.84	1.168	0.543	0.842
GFDL-ESM4	0.032	0.328	0.492	0.144	0.485	0.813
IPSL-CM5A2-INCA	1.933	1.228	0.375	3.234	2.280	0.657
EC-Earth3-CC	0.105	0.110	0.881	0.449	0.397	0.699
GFDL-CM4	0.008	0.337	0.423	0.042	0.548	0.848
NorESM2-MM	0.696	0.282	0.628	1.041	0.533	0.708
EC-Earth3-AerChem	0.338	0.143	0.772	0.682	0.383	0.752
CMCC-CM2-SR5	0.484	0.309	0.445	0.949	0.444	0.782
MPI-ESM1-2-HR	0.099	0.166	0.686	0.287	0.441	0.765
SAM0-UNICON	1.211	0.431	0.793	2.000	1.288	0.812
ACCESS-ESM1-5	1.045	0.349	0.695	1.557	0.869	0.657
CESM2-WACCM-FV2	1.520	0.665	0.57	2.007	1.049	0.753
EC-Earth3-Veg-LR	0.367	0.141	0.693	0.663	0.392	0.732
CESM2-FV2	1.868	0.845	0.531	2.284	1.216	0.713
EC-Earth3	0.437	0.146	0.727	0.657	0.395	0.727
CESM2	0.922	0.315	0.688	1.722	0.867	0.82
IPSL-CM6A-LR	0.895	0.263	0.767	1.442	0.741	0.743
MPI-ESM1-2-LR	0.457	0.153	0.707	1.168	0.491	0.794
CMCC-ESM2	0.385	0.307	0.459	0.907	0.408	0.807
CIESM	0.147	0.274	0.291	1.107	0.535	0.782
CNRM-ESM2-1	0.032	0.129	0.553	0.287	0.172	0.848
CNRM-CM6-1	0.050	0.130	0.602	0.333	0.159	0.873
EC-Earth3-Veg	0.120	0.063	0.76	0.295	0.187	0.804
MIROC-ES2L	0.012	0.031	0.343	0.203	0.181	0.614
CanESM5	0.223	0.084	0.837	0.541	0.240	0.872
E3SM-2-0	1.32	0.201	0.576	1.648	0.935	0.869
E3SM-2-0-NARRM	0.356	0.218	0.613	1.374	0.932	0.865
CanESM5-1	0.322	0.117	0.818	0.585	0.288	0.866
E3SM-1-0	0.472	0.197	0.832	1.216	0.788	0.882
KIOST-ESM	1.350	0.634	0.287	1.640	1.479	0.394
TaiESM1	0.589	0.285	0.597	1.499	1.256	0.791
GIOMAS	0.432	0.287	0.102	0.334	0.418	0.301
GECCO3	0.566	0.292	-0.074	0.297	0.424	0.368

Table S4: Table showing spatial correlations, RMSDs and Standard Deviations for Sea-ice Volume. The STD and RMSD values are of scale 10^9m.

	February			September		
Models	**STD**	**RMSD**	**Corr**	**STD**	**RMSD**	**Corr**
NSIDC	0.200	0.000	1	0.288	0.000	1
ACCESS-CM2	0.130	0.121	0.488	1.031	0.742	0.787
NorCPM1	0.590	0.312	0.86	1.331	0.933	0.901
MPI-ESM-1-2-HAM	0.107	0.134	0.151	1.141	0.901	0.617
NorESM2-LM	0.171	0.116	0.551	0.676	0.458	0.742
MIROC6	0.015	0.126	0.05	0.555	0.461	0.39
MRI-ESM2-0	0.383	0.213	0.836	1.139	0.778	0.901
GFDL-ESM4	0.037	0.115	0.52	0.218	0.131	0.848
IPSL-CM5A2-INCA	0.608	0.480	0.464	3.415	2.705	0.797
EC-Earth3-CC	0.016	0.126	0.097	0.526	0.396	0.588
GFDL-CM4	0.009	0.125	0.466	0.061	0.195	0.866
NorESM2-MM	0.162	0.110	0.613	0.711	0.478	0.772
EC-Earth3-AerChem	0.076	0.124	0.287	0.687	0.483	0.717
CMCC-CM2-SR5	0.106	0.114	0.459	0.761	0.511	0.81
MPI-ESM1-2-HR	0.051	0.121	0.277	0.320	0.162	0.825
SAM0-UNICON	0.542	0.267	0.824	1.250	0.899	0.887
ACCESS-ESM1-5	0.339	0.195	0.684	1.047	0.758	0.779
CESM2-WACCM-FV2	0.387	0.237	0.723	1.175	0.866	0.864
EC-Earth3-Veg-LR	0.077	0.124	0.285	0.681	0.480	0.724
CESM2-FV2	0.394	0.235	0.719	1.195	0.862	0.874
EC-Earth3	0.085	0.125	0.302	0.661	0.470	0.691
CESM2	0.332	0.203	0.693	1.189	0.871	0.864
IPSL-CM6A-LR	0.186	0.108	0.713	0.953	0.629	0.786
MPI-ESM1-2-LR	0.211	0.174	0.293	1.510	1.156	0.748
CMCC-ESM2	0.097	0.114	0.454	0.769	0.517	0.811
CIESM	0.065	0.125	0.225	1.050	0.802	0.785
CNRM-ESM2-1	0.047	0.055	0.534	0.435	0.294	0.856
CNRM-CM6-1	0.068	0.055	0.59	0.483	0.322	0.879
EC-Earth3-Veg	0.044	0.058	0.389	0.336	0.222	0.805
MIROC-ES2L	0.002	0.061	0.045	0.227	0.184	0.48
E3SM-2-0	0.218	0.139	0.71	1.064	0.857	0.956
E3SM-2-0-NARRM	0.218	0.142	0.718	0.105	0.855	0.957
CanESM5-1	0.198	0.758	0.862	0.501	0.346	0.89
E3SM-1-0	0.164	0.143	0.7	0.828	0.756	0.899
KIOST-ESM	0.207	0.135	0.668	0.103	0.848	0.944
CanESM5	0.191	0.073	0.847	0.512	0.346	0.887
TaiESM1	0.436	0.225	0.768	1.195	0.855	0.874
GIOMAS	0.213	0.000	0.761	0.190	0.000	0.943
GECCO3	0.187	0.000	0.682	0.090	0.000	0.936

Table S5: Table showing spatial correlations, RMSDs and Standard Deviations for Sea-ice Area. The STD and RMSD values are of scale 10^9m.

References for Supporting Material:

Bader, David C.; Leung, Ruby; Taylor, Mark; McCoy, Renata B.: *E3SM-Project E3SM1.0 model output prepared for CMIP6 CMIP*, Version *YYYYMMDD*[1], *Earth System Grid Federation,* https://doi.org/10.22033/ESGF/CMIP6.2294, 2019.

Cherchi, A., Fogli, P. G., Lovato, T., Peano, D., Iovino, D., Gualdi, S., Masina, S., Scoccimarro, E., Materia, S., Bellucci, A., and Navarra, A.: Global Mean Climate and Main Patterns of Variability in the CMCC-CM2 Coupled Model, *Journal of Advances in Modeling Earth Systems, 11(1), 185–209*. https://doi.org/10.1029/2018MS001369, 2019.

Counillon, F., Keenlyside, N., Bethke, I., Wang, Y., Billeau, S., Shen, M.-L., and Bentsen, M.: Flow-dependent assimilation of sea surface temperature in isopycnal coordinates with the Norwegian Climate Prediction Model, *Tellus A, 68,* https://doi.org/10.3402/tellusa.v68.32437, 2016.

Danabasoglu, G., Lamarque, J.F., Bacmeister, J., Bailey, D.A., DuVivier, A.K., Edwards, J., Emmons, L.K., Fasullo, J., Garcia, R., Gettelman, A. and Hannay, C.: The community earth system model version 2 (CESM2), *Journal of Advances in Modeling Earth Systems*, *12*(2), p.e2019MS001916, 2020.

Döscher, R., Acosta, M., Alessandri, A., Anthoni, P., Arsouze, T., Bergman, T., Bernardello, R., Boussetta, S., Caron, L.P., Carver, G. and Castrillo, M.: The EC-Earth3 earth system model for the coupled model intercomparison project 6*, Geosci Model Dev 15: 2973–3020*, 2022.

Gettelman, A., Mills, M.J., Kinnison, D.E., Garcia, R.R., Smith, A.K., Marsh, D.R., Tilmes, S., Vitt, F., Bardeen, C.G., McInerny, J. and Liu, H.L.: The whole atmosphere community climate model version 6 (WACCM6). *Journal of Geophysical Research: Atmospheres*, *124*(23), pp.12380-12403, 2019.

Golaz, J.C., Van Roekel, L.P., Zheng, X., Roberts, A.F., Wolfe, J.D., Lin, W., Bradley, A.M., Tang, Q., Maltrud, M.E., Forsyth, R.M. and Zhang, C.: The DOE E3SM model version 2: Overview of the physical model and initial model evaluation. *Journal of Advances in Modeling Earth Systems*, *14*(12), p.e2022MS003156, 2022.

Gutjahr, O., Putrasahan, D., Lohmann, K., Jungclaus, J. H., von Storch, J.-S., Brüggemann, N., Haak, H., and Stössel, A.: Max Planck Institute Earth System Model (MPI-ESM1.2) for the High-Resolution Model Intercomparison Project (HighResMIP), *Geoscientific Model Development, 12(7), 3241–3281,* https://doi.org/10.5194/gmd-12-3241-2019, 2019.

Held, I.M., Guo, H., Adcroft, A., Dunne, J.P., Horowitz, L.W., Krasting, J., Shevliakova, E., Winton, M., Zhao, M., Bushuk, M. and Wittenberg, A.T.: Structure and performance of GFDL's CM4. 0 climate model. *Journal of Advances in Modeling Earth Systems*, *11*(11), pp.3691-3727, 2019.

Kim, YoungHo; Noh, Yign; Kim, Dongmin; Lee, Myong-In; Lee, Ho Jin; Kim, Sang Yeob; Kim, Daehyun.: KIOST KIOST-ESM model output prepared for CMIP6 CMIP, Version YYYYMMDD[1], *Earth System Grid Federation,* https://doi.org/10.22033/ESGF/CMIP6.1922, 2019.

Lin, Y., Huang, X., Liang, Y., Qin, Y., Xu, S., Huang, W., Xu, F., Liu, L., Wang, Y., Peng, Y. and Wang, L.: Community integrated earth system model (CIESM): description and evaluation. *Journal of Advances in Modeling Earth Systems*, *12*(8), p.e2019MS002036, 2020.

Lurton, T., Balkanski, Y., Bastrikov, V., Bekki, S., Bopp, L., Braconnot, P., Brockmann, P., Cadule, P., Contoux, C., Cozic, A. and Cugnet, D.: Implementation of the CMIP6 forcing data in the IPSL-CM6A-LR model. *Journal of Advances in Modeling Earth Systems*, *12*(4), p.e2019MS001940, 2020.

Massonnet, F., Ménégoz, M., Acosta, M., Yepes-Arbós, X., Exarchou, E., and Doblas-Reyes, F. J.: Replicability of the EC-Earth3 Earth system model under a change in computing environment, *Geoscientific Model Development, 13(3), 1165–1178,* https://doi.org/10.5194/gmd-13-1165-2020, 2020.

Mauritsen, T., Bader, J., Becker, T., Behrens, J., Bittner, M., Brokopf, R., Brovkin, V., Claussen, M., Crueger, T., Esch, M. and Fast, I.: Developments in the MPI‐M Earth System Model version 1.2 (MPI‐ESM1. 2) and its response to increasing CO2. *Journal of Advances in Modeling Earth Systems*, *11*(4), pp.998-1038, 2019.

Park, S., Shin, J., Kim, S., Oh, E., and Kim, Y.: Global Climate Simulated by the Seoul National University Atmosphere Model Version 0 with a Unified Convection Scheme (SAM0-UNICON), *Journal of Climate, 32,* https://doi.org/10.1175/JCLI-D-18-0796.1, 2019.

Seland, Ø., Bentsen, M., Seland Graff, L., Olivié, D., Toniazzo, T., Gjermundsen, A., Debernard, J.B., Gupta, A.K., He, Y., Kirkevåg, A. and Schwinger, J.: The Norwegian Earth system model, NorESM2–evaluation of theCMIP6 DECK and historical simulations. *Geoscientific Model Development Discussions*, *2020*, pp.1-68, 2020.

Tang, Q., Golaz, J.C., Van Roekel, L.P., Taylor, M.A., Lin, W., Hillman, B.R., Ullrich, P.A., Bradley, A.M., Guba, O., Wolfe, J.D. and Zhou, T.: The fully coupled regionally refined model of E3SM version 2: Overview of the atmosphere, land, and river results. *Geoscientific model development*, *16*(13), pp.3953-3995, 2023.

Tatebe, H., Ogura, T., Nitta, T., Komuro, Y., Ogochi, K., Takemura, T., Sudo, K., Sekiguchi, M., Abe, M., Saito, F. and Chikira, M.: Description and basic evaluation of simulated mean state, internal variability, and climate sensitivity in MIROC6. *Geoscientific Model Development*, *12*(7), pp.2727-2765, 2019.

Vancoppenolle, M., Fichefet, T., Goosse, H., Bouillon, S., Madec, G., and Maqueda, M. A. M.: Simulating the mass balance and salinity of Arctic and Antarctic sea ice. 1. Model description and validation, *Ocean Modelling*, 27(1-2), 33-53, 2009.

van Noije, T., Bergman, T., Le Sager, P., O'Donnell, D., Makkonen, R., Gonçalves-Ageitos, M., Döscher, R., Fladrich, U., von Hardenberg, J., Keskinen, J.-P., Korhonen, H., Laakso, A., Myriokefalitakis, S., Ollinaho, P., Pérez García-Pando, C., Reerink, T., Schrödner, R., Wyser, K., and Yang, S.: EC-Earth3-AerChem: A global climate model with interactive aerosols and atmospheric chemistry participating in CMIP6, *Geoscientific Model Development, 14(9), 5637–5668.* https://doi.org/10.5194/gmd-14-5637-2021, 2021.

Weaver, R., Morris, C., and Barry, R. G.: Passive microwave data for snow and ice research: Planned products from the DMSP SSM/I system, *Eos, Transactions American Geophysical Union, 68(39), 769-777,* 1987.

Wyser, K., van Noije, T., Yang, S., von Hardenberg, J., O'Donnell, D., and Döscher, R.: On the increased climate sensitivity in the EC-Earth model from CMIP5 to CMIP6, *Geoscientific Model Development, 13(8), 3465–3474,* https://doi.org/10.5194/gmd-13-3465-2020, 2020.

Yukimoto, S., Kawai, H., Koshiro, T., Oshima, N., Yoshida, K., Urakawa, S., Tsujino, H., Deushi, M., Tanaka, T., Hosaka, M., Yabu, S., Yoshimura, H., Shindo, E., Mizuta, R., Obata, A., Adachi, Y., and Ishii, M.: 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(5), 931–965,* https://doi.org/10.2151/jmsj.2019-051, 2019.

Ziehn, T., Chamberlain, M. A., Law, R. M., Lenton, A., Bodman, R. W., Dix, M., Stevens, L., Wang, Y.-P., Srbinovsky, J., Ziehn, T., Chamberlain, M. A., Law, R. M., Lenton, A., Bodman, R. W., Dix, M., Stevens, L., Wang, Y.-P., and Srbinovsky, J.: The Australian Earth System Model: ACCESS-ESM1.5, *Journal of Southern Hemisphere Earth Systems Science, 70(1), 193–214,* https://doi.org/10.1071/ES19035, 2020.