## Supporting Information for "Antarctic Sea Ice Area in CMIP6"

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Table S1. CMIP6 models that have sea ice data concentration available at the time of writing from the historical simulations, label of 'first' ensemble member, number of ensemble members with sea ice data in historical and SSP2-4.5 experiments, and availability of pre-industrial control (piC) simulations, availability of variable 'sivol' for historical simulations, and DOI for historical simulations. Expansions of institution acronyms are available at https://wcrp-cmip.github.io/CMIP6\_CVs/docs/CMIP6\_institution\_id.html.

ACCESS-CM2 rliiplfl 2 1 yes yes 10.22033/ESGF/CMIP6.4271   ACCESS-ESM1-5 rliiplfl 3 3 yes yes 10.22033/ESGF/CMIP6.4272   AWI-CM-1-1-MR rliiplfl 5 1 yes no 10.22033/ESGF/CMIP6.359   BCC-CSM2-MR rliiplfl 3 1 no yes 10.22033/ESGF/CMIP6.2948   BCC-ESM1 rliiplfl 3 0 no yes 10.22033/ESGF/CMIP6.2949   CAMS-CSM1-0 rliiplfl 3 2 yes yes 10.22033/ESGF/CMIP6.7627   CESM2 rliiplfl 11 1 yes yes 10.22033/ESGF/CMIP6.10298   CESM2-WACCM rliiplfl 3 1 yes yes 10.22033/ESGF/CMIP6.11298   CNRM-CM6-1 rliiplfl 1 0 yes yes 10.22033/ESGF/CMIP6.4066   CNRM-CM6-1 rliiplfl 1 yes yes 10.22033/ESGF/CMIP6.4066   CNRM-ESM2-1 rliiplfl 25 10 yes no 10.22033/ESGF/CMIP6.4067   CNRM-ESM2-1 rliiplfl <th>Model name</th> <th>First variant</th> <th>Historical</th> <th>SSP2-4.5</th> <th>pre-industrial control</th> <th>sivol</th> <th>URL/DOI</th>	Model name	First variant	Historical	SSP2-4.5	pre-industrial control	sivol	URL/DOI
ACCESS-ESM1-5rilipfin33yes10.2033/ESGF/CMIP6.4272AWI-CM-1-I-MRrilipfin51yesno10.2033/ESGF/CMIP6.359BCC-CSM2-MRrilipfin30noyes10.2033/ESGF/CMIP6.2948BCC-ESM1rilipfin32yes10.2033/ESGF/CMIP6.2949CAMS-CSM1-00rilipfin32yes10.2033/ESGF/CMIP6.7954CESM2rilipfin111yes10.2033/ESGF/CMIP6.7627CESM2rilipfin131yes10.2033/ESGF/CMIP6.10071CESM2-WACCMFP2rilipfin10yes10.2033/ESGF/CMIP6.10071CESM2-WACCM-FQ2rilipfin10yes10.2033/ESGF/CMIP6.10071CESM2-WACCM-FQrilipfin10yes10.2033/ESGF/CMIP6.10071CNRM-CM6-1rilipfin10yes10.2033/ESGF/CMIP6.4066CNRM-CM6-1rilipfin11yes10.2033/ESGF/CMIP6.4067CNRM-ESM2-1rilipfin21yes10.2033/ESGF/CMIP6.4067CARSM5rilipfin11yes10.2033/ESGF/CMIP6.4067EC-Earth3rilipfin1413yes10.2033/ESGF/CMIP6.4070EC-Earth3-Vegrilipfin11yes10.2033/ESGF/CMIP6.3355FIO-ESM-2-0rilipfin11yes10.2033/ESGF/CMIP6.355FIO-ESM-2-0rilipfin11yes10.2033/ESGF/CMIP6.3594GFD-ESM-4rilipfin <td>ACCESS-CM2</td> <td>r1i1p1f1</td> <td>2</td> <td>1</td> <td>yes</td> <td>yes</td> <td>10.22033/ESGF/CMIP6.4271</td>	ACCESS-CM2	r1i1p1f1	2	1	yes	yes	10.22033/ESGF/CMIP6.4271
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EC-Earth3-Veg   r1i1p1f1   4   3   yes   yes   10.22033/ESGF/CMIP6.4706     FGOALS-f3-L   r1i1p1f1   1   no   yes   10.22033/ESGF/CMIP6.3355     FIO-ESM-2-0   r1i1p1f1   3   3   yes   yes   10.22033/ESGF/CMIP6.3355     GFDL-CM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8594     GFDL-ESM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8597     GISS-E2-1-G   r1i1p1f1   10   yes   yes   10.22033/ESGF/CMIP6.7127     GISS-E2-1-G-CC   r1i1p1f1   1   0   yes   yes   10.22033/ESGF/CMIP6.7127	EC-Earth3	r1i1p1f1	14	13	yes	yes	10.22033/ESGF/CMIP6.4700
FGOALS-f3-L   r1i1p1f1   1   no   yes   10.22033/ESGF/CMIP6.3355     FIO-ESM-2-0   r1i1p1f1   3   3   yes   yes   10.22033/ESGF/CMIP6.9199     GFDL-CM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8594     GFDL-ESM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8597     GISS-E2-1-G   r1i1p1f1   10   yes   yes   10.22033/ESGF/CMIP6.7127     GISS-E2-1-G-CC   r1i1p1f1   1   0   yes   yes   10.22033/ESGF/CMIP6.7127	EC-Earth3-Veg	r1i1p1f1	4	3	yes	yes	10.22033/ESGF/CMIP6.4706
FIO-ESM-2-0 r1i1p1f1 3 3 yes yes 10.22033/ESGF/CMIP6.9199   GFDL-CM4 r1i1p1f1 1 yes yes 10.22033/ESGF/CMIP6.8594   GFDL-ESM4 r1i1p1f1 1 yes yes 10.22033/ESGF/CMIP6.8597   GISS-E2-1-G r1i1p1f1 10 0 yes yes 10.22033/ESGF/CMIP6.7127   GISS-E2-1-G-CC r1i1p1f1 1 0 yes yes 10.22033/ESGF/CMIP6.7127	FGOALS-f3-L	r1i1p1f1	1	1	no	yes	10.22033/ESGF/CMIP6.3355
GFDL-CM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8594     GFDL-ESM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8597     GISS-E2-1-G   r1i1p1f1   10   0   yes   yes   10.22033/ESGF/CMIP6.7127     GISS-E2-1-G-CC   r1i1p1f1   10   0   yes   yes   10.22033/ESGF/CMIP6.7127	FIO-ESM-2-0	r1i1p1f1	3	3	yes	yes	10.22033/ESGF/CMIP6.9199
GFDL-ESM4   r1i1p1f1   1   yes   yes   10.22033/ESGF/CMIP6.8597     GISS-E2-1-G   r1i1p1f1   10   0   yes   10.22033/ESGF/CMIP6.7127     GISS-E2-1-G-CC   r1i1p1f1   1   0   yes   yes   10.22033/ESGF/CMIP6.7127	GFDL-CM4	r1i1p1f1	1	1	yes	yes	10.22033/ESGF/CMIP6.8594
GISS-E2-1-G   r1i1p1f1   10   0   yes   10.22033/ESGF/CMIP6.7127     GISS-E2-1-G-CC   r1i1p1f1   1   0   yes   yes   10.22033/ESGF/CMIP6.7127	GFDL-ESM4	r1i1p1f1	1	1	yes	yes	10.22033/ESGF/CMIP6.8597
GISS-E2-1-G-CC r1i1p1f1 1 0 yes yes 10.22033/ESGF/CMIP6.11762	GISS-E2-1-G	r1i1p1f1	10	0	yes	yes	10.22033/ESGF/CMIP6.7127
	GISS-E2-1-G-CC	r1i1p1f1	1	0	yes	yes	10.22033/ESGF/CMIP6.11762
GISS-E2-1-H r1i1p1f1 10 0 yes yes 10.22033/ESGF/CMIP6.7128	GISS-E2-1-H	r1i1p1f1	10	0	yes	yes	10.22033/ESGF/CMIP6.7128
HadGEM3-GC31-LL r1i1p1f3 4 1 no yes n/a	HadGEM3-GC31-LL	r1i1p1f3	4	1	no	yes	n/a
HadGEM3-GC31-MM r1i1p1f3 4 0 no no n/a	HadGEM3-GC31-MM	r1i1p1f3	4	0	no	no	n/a
INM-CM4-8 r1i1p1f1 1 1 yes no 10.22033/ESGF/CMIP6.5069	INM-CM4-8	r1i1p1f1	1	1	yes	no	10.22033/ESGF/CMIP6.5069
INM-CM5-0 r1i1p1f1 10 1 yes no 10.22033/ESGF/CMIP6.5070	INM-CM5-0	r1i1p1f1	10	1	yes	no	10.22033/ESGF/CMIP6.5070
IPSL-CM6A-LR r1i1p1f1 32 2 yes yes 10.22033/ESGF/CMIP6.5195	IPSL-CM6A-LR	r1i1p1f1	32	2	yes	yes	10.22033/ESGF/CMIP6.5195
MIROC-ES2L r1i1p1f2 3 1 yes no 10.22033/ESGF/CMIP6.5602	MIROC-ES2L	r1i1p1f2	3	1	yes	no	10.22033/ESGF/CMIP6.5602
MIROC6 r1i1p1f1 10 3 yes no 10.22033/ESGF/CMIP6.5603	MIROC6	r1i1p1f1	10	3	yes	no	10.22033/ESGF/CMIP6.5603
MPI-ESM-1-2-HAM rli1p1f1 2 0 yes yes n/a	MPI-ESM-1-2-HAM	r1i1p1f1	2	0	yes	yes	n/a
MPI-ESM1-2-HR r1i1p1f1 10 2 yes yes 10.22033/ESGF/CMIP6.6594	MPI-ESM1-2-HR	r1i1p1f1	10	2	yes	yes	10.22033/ESGF/CMIP6.6594
MPI-ESM1-2-LR r1i1p1f1 10 10 yes yes 10.22033/ESGF/CMIP6.6595	MPI-ESM1-2-LR	r1i1p1f1	10	10	yes	yes	10.22033/ESGF/CMIP6.6595
MRI-ESM2-0 r1i1p1f1 5 1 yes yes n/a	MRI-ESM2-0	r1i1p1f1	5	1	yes	yes	n/a
NESM3 r1i1p1f1 5 2 yes no 10.22033/ESGF/CMIP6.8769	NESM3	r1i1p1f1	5	2	yes	no	10.22033/ESGF/CMIP6.8769
NorCPM1 r1i1p1f1 30 0 yes no http://cera-www.dkrz.de/WDCC/meta/CMIP6/	NorCPM1	r1i1p1f1	30	0	yes	no	http://cera-www.dkrz.de/WDCC/meta/CMIP6/
CMIP6.CMIP.NCC.NorCPM1.historical							CMIP6.CMIP.NCC.NorCPM1.historical
NorESM2-LM r1i1p1f1 1 0 yes no http://cera-www.dkrz.de/WDCC/meta/CMIP6/	NorESM2-LM	r1i1p1f1	1	0	yes	no	http://cera-www.dkrz.de/WDCC/meta/CMIP6/
CMIP6.CMIP.NCC.NorESM2-LM.historical							CMIP6.CMIP.NCC.NorESM2-LM.historical
NorESM2-MM rli1p1f1 1 0 no no http://cera-www.dkrz.de/WDCC/meta/CMIP6/	NorESM2-MM	r1i1p1f1	1	0	no	no	http://cera-www.dkrz.de/WDCC/meta/CMIP6/
CMIP6.CMIP.NCC.NorESM2-MM.historical							CMIP6.CMIP.NCC.NorESM2-MM.historical
SAM0-UNICON r1i1p1f1 1 0 yes yes 10.22033/ESGF/CMIP6.7789	SAM0-UNICON	r1i1p1f1	1	0	yes	yes	10.22033/ESGF/CMIP6.7789
UKESM1-0-LL r1i1p1f2 12 5 yes yes 10.22033/ESGF/CMIP6.6113	UKESM1-0-LL	r1i1p1f2	12	5	yes	yes	10.22033/ESGF/CMIP6.6113

	CMIP3 and CMIP5 models included in this study.
CMIP3 models	CMIP5 models
bccr-bcm2-0	ACCESS1-0
cccma-cgcm3-1	ACCESS1-3
cccma-cgcm3-1-t63	BNU-ESM
cnrm-cm3	CCSM4
csiro-mk3-5	CESM1-BGC
gfdl-cm2-0	CESM1-CAM5
gfdl-cm2-1	CMCC-CM
giss-aom	CMCC-CMS
giss-model-e-r	CNRM-CM5
inmcm3-0	CSIRO-Mk3-6-0
ipsl-cm4	CanESM2
miroc3-2-hires	EC-EARTH
miroc3-2-medres	FGOALS-g2
miub-echo-g	FIO-ESM
mpi-echam5	GFDL-CM3
mri-cgcm2-3-2a	GFDL-ESM2G
ncar-ccsm3-0	GFDL-ESM2M
ukmo-hadcm3	GISS-E2-H
ukmo-hadgem1	GISS-E2-H-CC
	GISS-E2-R
	GISS-E2-R-CC
	HadGEM2-AO
	HadGEM2-CC
	HadGEM2-ES
	IPSL-CM5A-LR
	IPSL-CM5A-MR
	IPSL-CM5B-LR
	MIROC-ESM
	MIROC-ESM-CHEM
	MIROC5
	MPI-ESM-LR
	MPI-ESM-MR
	MRI-CGCM3
	NorESM1-M
	NorESM1-ME
	bcc-csm1-1
	bcc-csm1-1-m
	inmcm4

Table S2. CMIP3 and CMIP5 models included in this study.



Figure S1. (a-b) 1979-2014 sea ice area in (a) September and (b) February for individual CMIP6 models. Crosses show the 1979-2014 mean; thin coloured vertical lines around the mean show two standard deviations from that model's control run; and thick coloured vertical boxes show two standard deviations across ensembles with three or more members, corrected for small sample size, for 1979-2014, if available. Horizontal grey lines show the 1979-2014 mean of each observational product. The number of ensemble members for each model is noted on the x-axis. (c-d) 1979-2014 sea ice area standard deviation in detrended sea ice area in (c) September and (d) February, representing inter-annual variability. Horizontal grey lines show the standard deviation across 1979-2014 from the three observational products.

(a) Bootstrap

(f) AWI-CM-1-1-MR

(b) NASA-Team

(g) BCC-CSM2-MR

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(c) OSISAF

(h) BCC-ESM1

(k) CESM2-WACCM (I) CESM2-WACCM-FV2 (o) CNRM-ESM2-1 (p) CanESM5 (q) E3SM-1-0 (r) EC-Earth3 (s) EC-Earth3-Veg (t) FGOALS-f3-L (u) FIO-ESM-2-0 (y) GISS-E2-1-G-CC (v) GFDL-CM4 (w) GFDL-ESM4 (x) GISS-E2-1-G (z) GISS-E2-1-H (aa) HadGEM3-GC31-LL (ab) HadGEM3-GC31-MM (ac) INM-CM4-8 (ad) INM-CM5-0 (ae) IPSL-CM6A-LR (af) MIROC-ES2L (ag) MIROC6 (ah) MPI-ESM-1-2-HAM (ai) MPI-ESM1-2-HR (aj) MPI-ESM1-2-LR (ak) MRI-ESM2-0 (al) NESM3 (am) NorCPM1 (an) NorESM2-LM (ao) NorESM2-MM (ap) SAM0-UNICON (aq) UKESM1-0-LL Sea ice concentration (%) 80 20 40 60 100 Ó

Figure S2. Mean 1979-2014 September sea ice concentration for CMIP6 r1 models and observations.

March 11, 2020, 4:09pm

























(e) ACCESS-ESM1-5







(j) CESM2





March 11, 2020, 4:09pm

(a) Bootstrap

(f) AWI-CM-1-1-MR

(k) CESM2-WACCM

(p) CanESM5

(u) FIO-ESM-2-0

(b) NASA-Team

(g) BCC-CSM2-MR

(I) CESM2-WACCM-FV2

(q) E3SM-1-0

(v) GFDL-CM4

(w) GFDL-ESM4

(s) EC-Earth3-Veg

(i) CAMS-CSM1-0

(d) ACCESS-CM2

(o) CNRM-ESM2-1

(t) FGOALS-f3-L

(y) GISS-E2-1-G-CC

(e) ACCESS-ESM1-5

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:

(c) OSISAF

(h) BCC-ESM1

(m) CNRM-CM6-1

(r) EC-Earth3

(x) GISS-E2-1-G

(n) CNRM-CM6-1-HR





(j) CESM2



:

Figure S4. (a-aa) Mean 1979-2014 September sea ice volume per unit area for CMIP6 r1 models. (ab) The standard deviation of September sea ice volume per unit area across (a-aa).



:

(c) BCC-CSM2-MR

(h) CESM2

(d) BCC-ESM1

(i) CNRM-CM6-1

(e) CAMS-CSM1-0

(j) CNRM-ESM2-1

 $Figure \ S5. \quad {\rm As \ Fig. \ S4 \ but \ for \ February.}$ 

(a) ACCESS-CM2

(f) CESM2-WACCM-FV2

(b) ACCESS-ESM1-5

(g) CESM2-WACCM





Figure S6. Trends in Antarctic sea ice area over 1979-2018 for each month for observations and CMIP6 r1 models as marked, calculated from a least-squares linear regression. The shading on the bars corresponds to the confidence level, from the two-sided p-value for a hypothesis test whose null hypothesis is that the slope is zero, with t-distribution of the test statistic. Linear regressions are outlined in red if they are statistically significant at the 95 % confidence level, black otherwise.



Figure S7. Linear trend in September sea ice concentration over 1979-2018 for CMIP6 models and observations, with trends significant at the 95 % confidence level contoured in black. Green contours show 15 and 80 % sea ice concentration.

(a) Bootstrap

(b) NASA-Team



(d) ACCESS-CM2

(e) ACCESS-ESM1-5

(c) OSISAF



Figure S8. As Fig. S7 but for February.