

# Supporting Information:

## Constraining the date of a seasonally ice-free Arctic using a simple model

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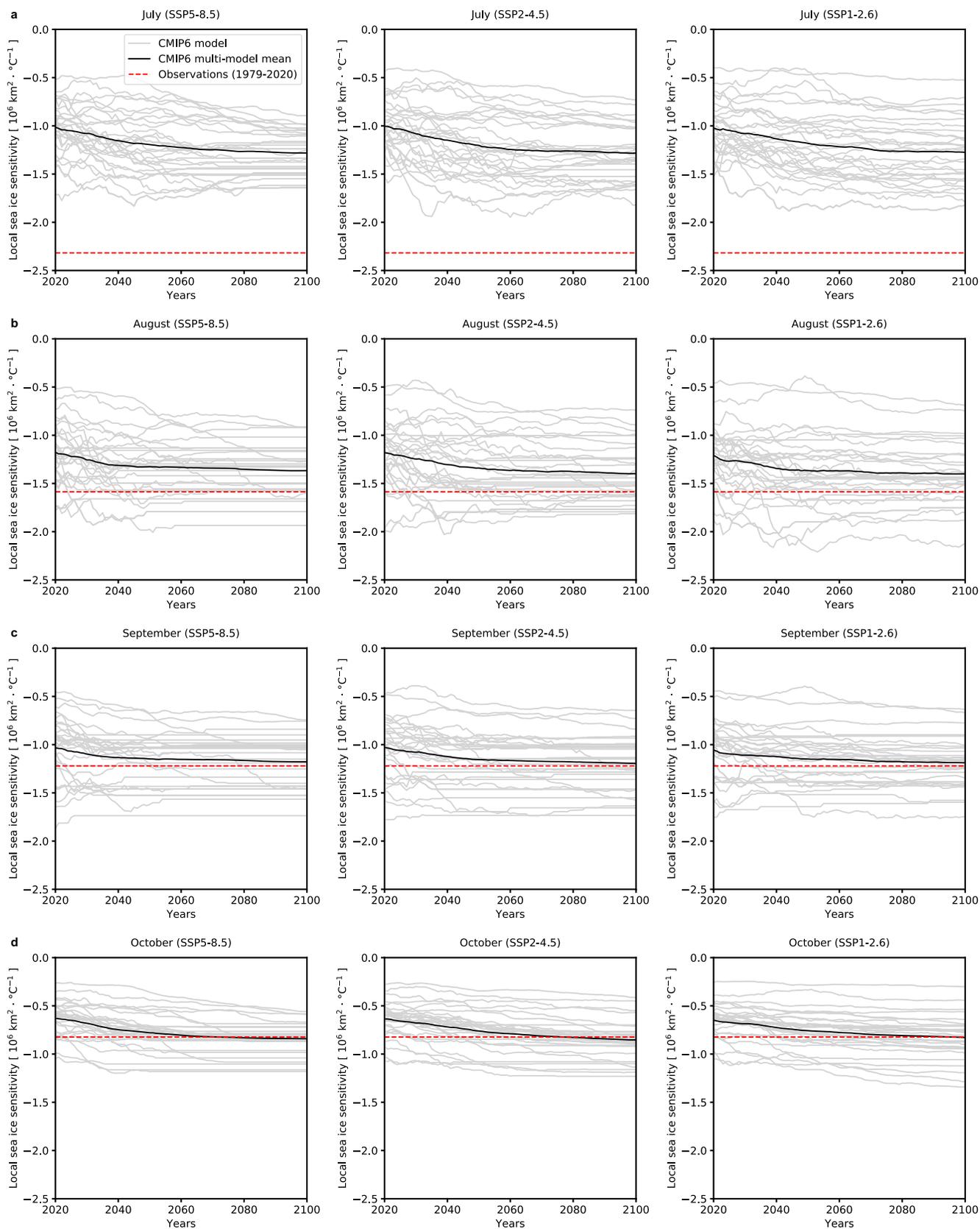
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	Model Name	Ensemble Member
1.	ACCESS-CM2	rlilp1f1
2.	ACCESS-ESM1-5	rlilp1f1
3.	BCC-CSM2-MR	rlilp1f1
4.	CAMS-CSM1-0	rlilp1f1
5.	CanESM5	rlilp1f1
6.	CESM2	r4ilp1f1
7.	CESM2-WACCM	rlilp1f1
8.	CNRM-CM6-1-HR	rlilp1f2
9.	CNRM-CM6-1	rlilp1f2
10.	EC-Earth3	rlilp1f1
11.	EC-Earth3-Veg	rlilp1f1
12.	EC-Earth3-Veg-LR	rlilp1f1
13.	FGOALS-f3-L	rlilp1f1
14.	FGOALS-g3	rlilp1f1
15.	FIO-ESM-2-0	rlilp1f1
16.	GFDL-ESM4	rlilp1f1
17.	HadGEM3-GC31-LL	rlilp1f3
18.	INM-CM4-8	rlilp1f1
19.	INM-CM5-0	rlilp1f1
20.	IPSL-CM6A-LR	rlilp1f1
21.	MIROC6	rlilp1f1
22.	MIROC-ES2L	rlilp1f2
23.	MPI-ESM1-2-HR	rlilp1f1
24.	MPI-ESM1-2-LR	rlilp1f1
25.	MRI-ESM2-0	rlilp1f1
26.	NESM3	rlilp1f1
27.	NorESM2-LM	rlilp1f1
28.	NorESM2-MM	rlilp1f1
29.	UKESM1-0-LL	rlilp1f2

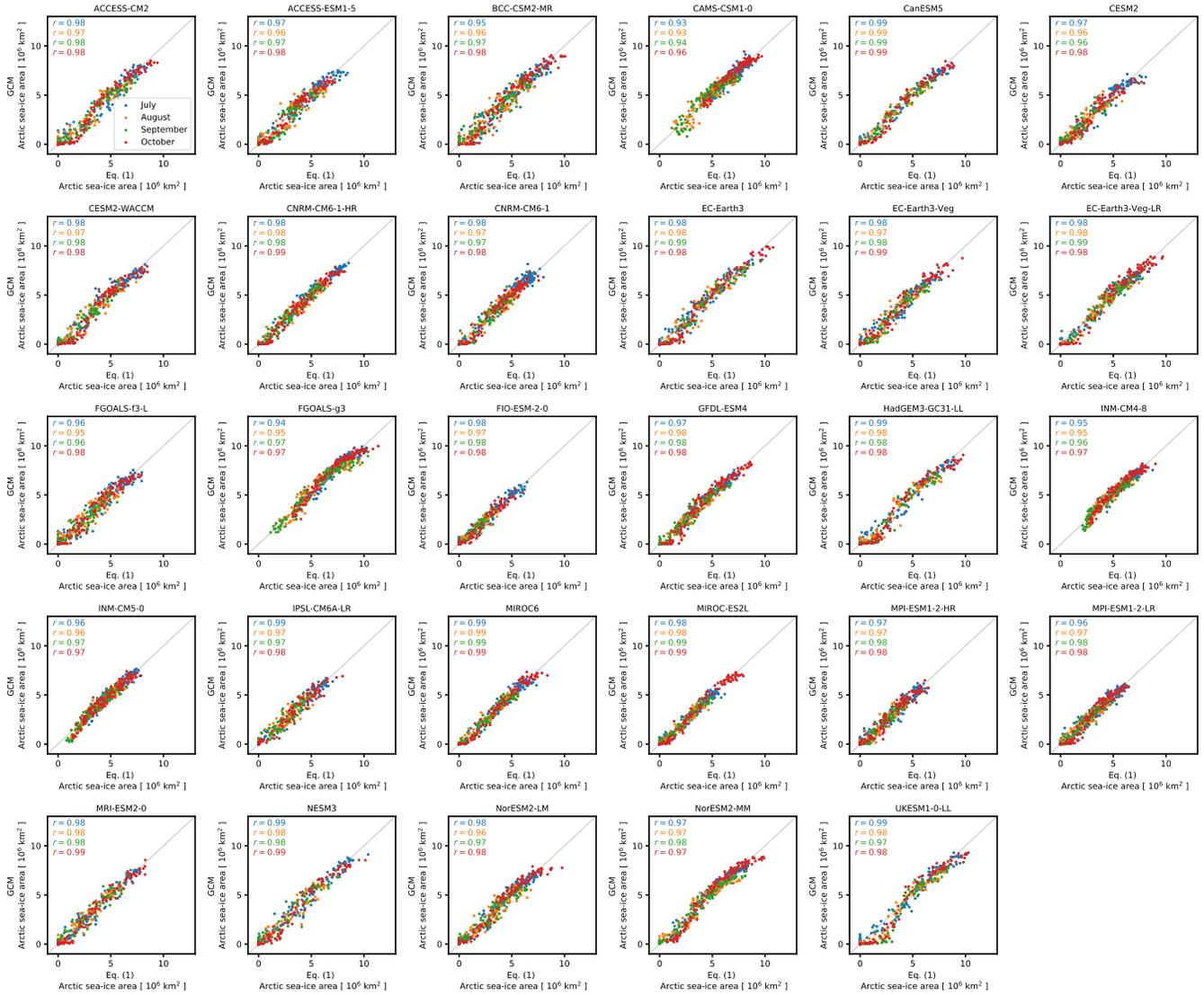
Supplemental Table 1: List of the coupled GCMs and ensemble member used for each Historical, SSP1-2.6, SSP2-4.5, and SSP5-8.5 simulation.

Month	SSP5-8.5	SSP2-4.5	SSP1-2.6
July	15 years	34 years	N/A
August	18 years	21 years	N/A
September	20 years	22 years	30 years
October	18 years	21 years	N/A

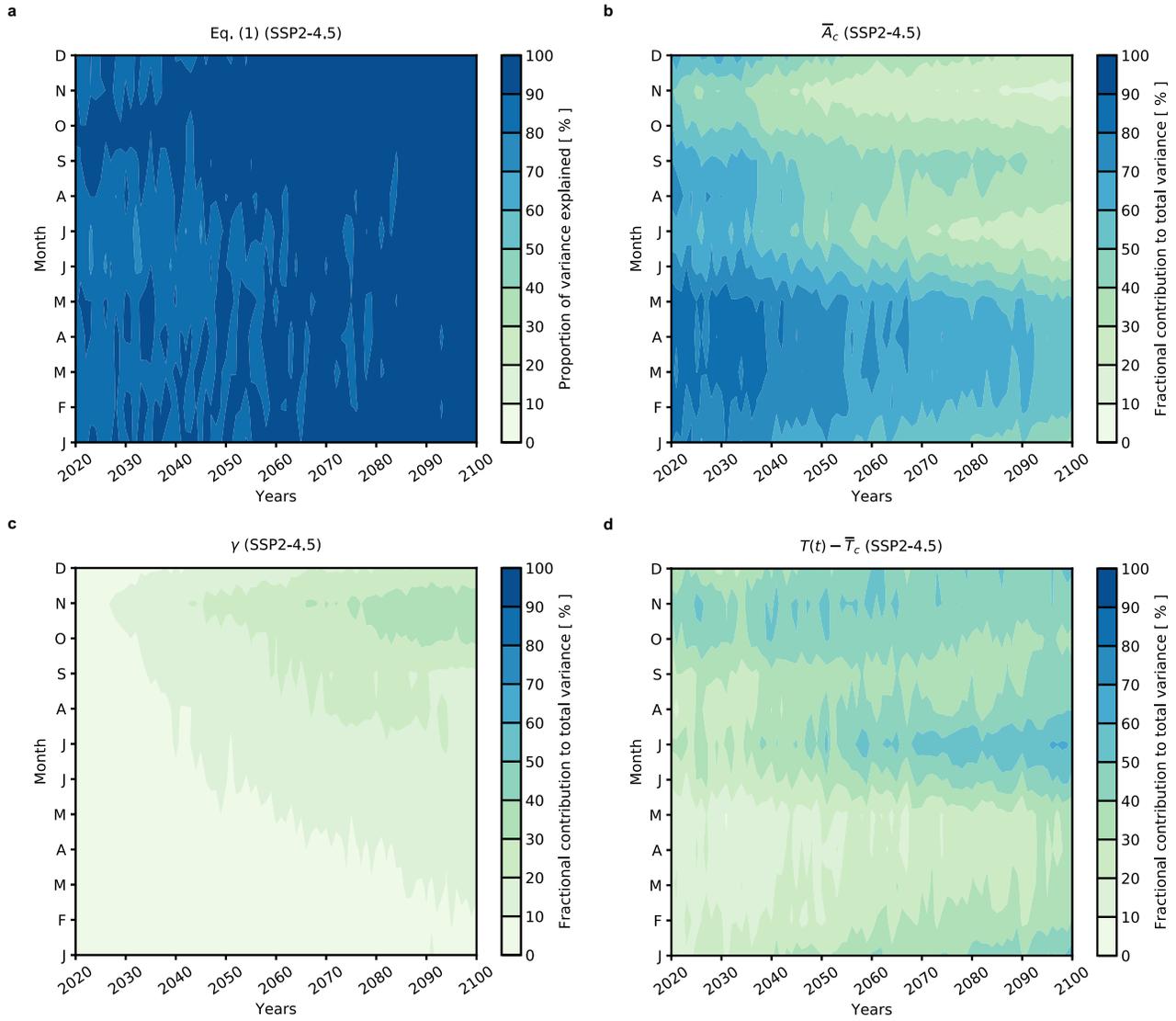
Supplemental Table 2: Internal variability range denoting the range of years when ice-free conditions in the Arctic appear as estimated from the 50-member CanESM5 large ensemble. The range denotes the 3- $\sigma$  spread (0.14% and 99.86%) for each month and each forcing scenario. For SSP1-2.6, July, August, and October are not included as most ensemble members do not experience ice-free conditions.



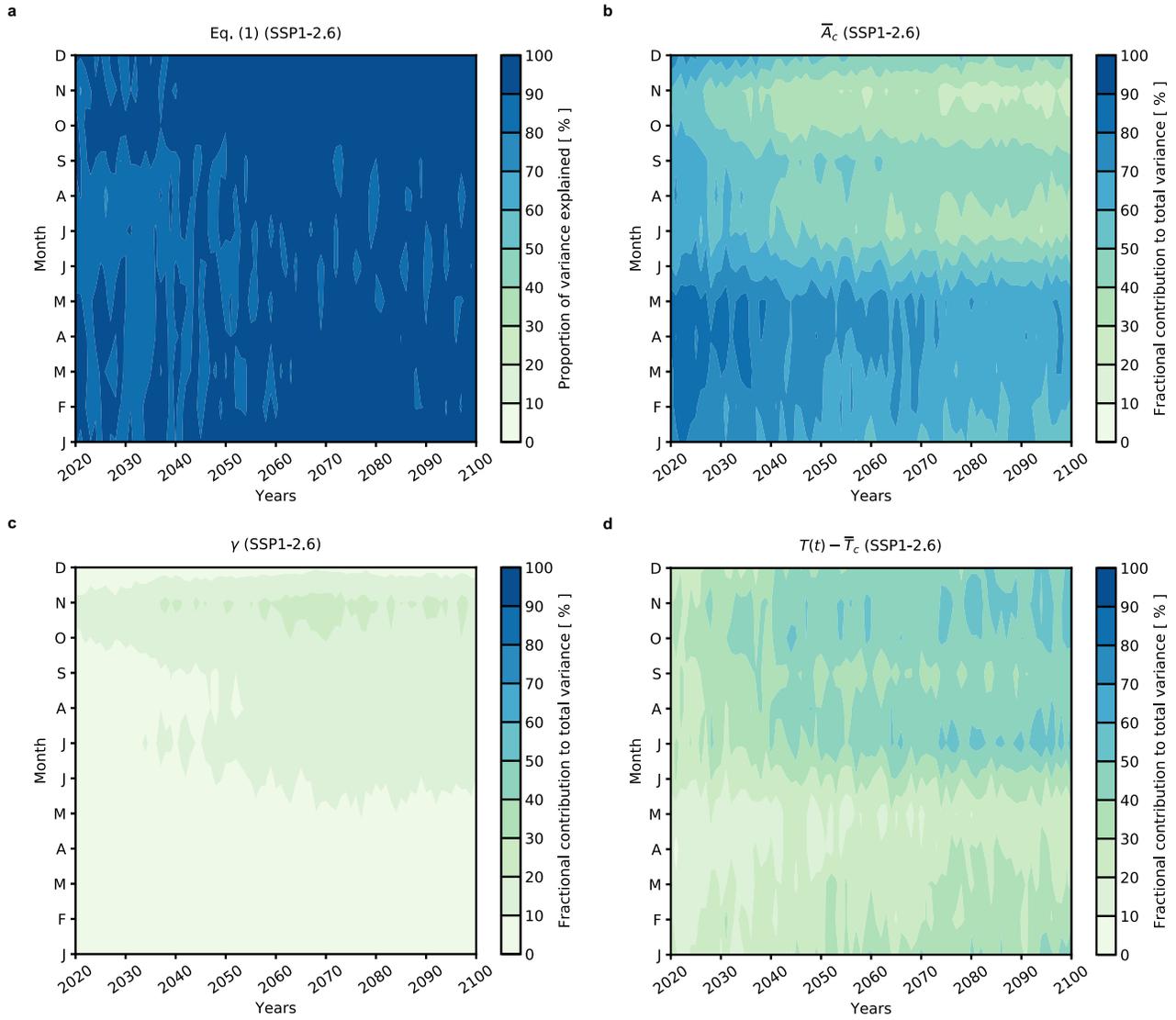
**Supplemental Figure 1: Evolution of the local sea ice sensitivity.** The local sea ice sensitivity for 29 different coupled GCMs computed using total least squares from 1979 up to each year using the month of (a) July, (b) August, (c) September, and (d) October. The black line in each panel denotes the multi-model mean and the grey lines represent individual GCMs. The red dashed line denotes observations from 1979–2020.



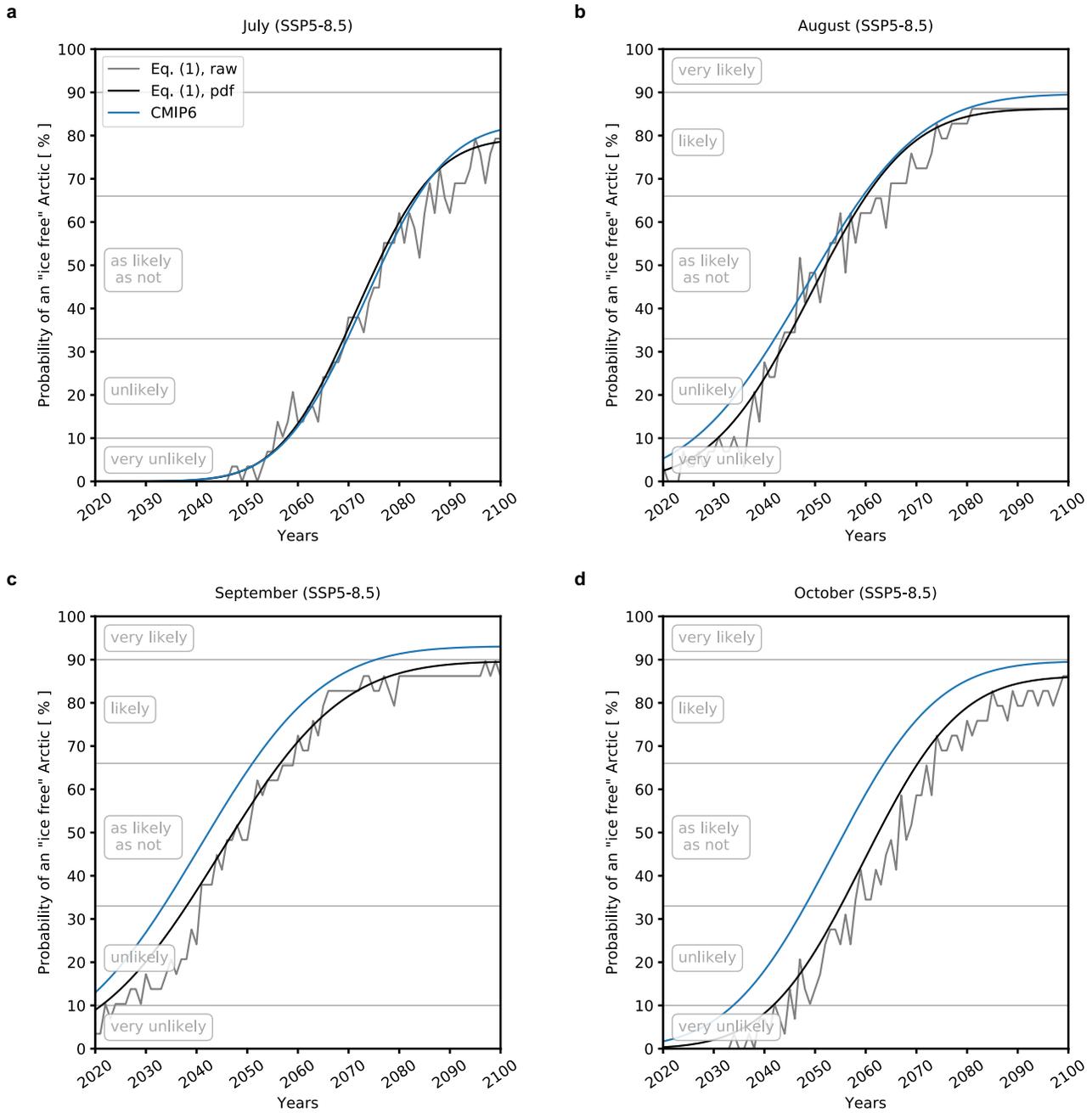
Supplemental Figure 2: **Comparison of Arctic sea-ice area from each GCM and Eq. (1).** Arctic sea-ice area from 29 different coupled GCMs (y-axis) and calculated using Eq. (1) (x-axis) in July (blue), August (orange), September (green), and October (red). All plots use Historical and SSP5-8.5 simulations from 1979–2100.



Supplemental Figure 3: **Partitioning intermodel variance in projections of Arctic sea-ice area in SSP2-4.5.** (a) The proportion of the inter-model variance ( $r^2$ , where  $r$  is the Pearson correlation coefficient) in monthly Arctic sea-ice area from CMIP6 models that is accounted for by Eq. (1) as a function of month and year. Fractional contribution of (b)  $\bar{A}_c$ , (c)  $\gamma$ , and (d)  $T(t) - \bar{T}_c$  to total variance as a function of month and year.



Supplemental Figure 4: **Partitioning intermodel variance in projections of Arctic sea-ice area in SSP1-2.6.** (a) The proportion of the inter-model variance ( $r^2$ , where  $r$  is the Pearson correlation coefficient) in monthly Arctic sea-ice area from CMIP6 models that is accounted for by Eq. (1) as a function of month and year. Fractional contribution of (b)  $\bar{A}_c$ , (c)  $\gamma$ , and (d)  $T(t) - \bar{T}_c$  to total variance as a function of month and year.



Supplemental Figure 5: **Comparison of GCM and Eq. (1) probabilities.** Cumulative probability density function showing the year when the Arctic will experience ice free conditions in (a) July, (b) August, (c) September, and (d) October. The black line represents Eq. (1), which is identical to Fig. 4, and the blue line is the unconstrained CMIP6 output. The grey line shows the cumulative GCM frequencies.