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Present and future aerosol impacts on Arctic climate change in the GISS-E2.1 Earth system model

Ulas Im et al.

Correspondence to: Ulas Im (ulas@envs.au.dk)

Measurement Techniques

Black carbon

Measurements of elemental carbon (EC, which is a "type" of BC) uses a thermal/ or thermal-optical method (Chow et al, 1993) after collecting particulate matter on a Quartz filter for the EMEP, IMPROVE (including Fairbanks), and CABM datasets (Torseth et al, 2012; EMEP manual, 2014; Huang et al, 2006; Sharma et al, 2017; Huang et al, 2020). This method determines the total carbon in the particulate material and then splits this measurement into OC and EC based on an optical correction via thermal-optical protocol or only using stepwise temperature to separate OC from EC (Huang et al., 2020). These are reported for $PM_{2.5}$ and PM_{10} in the EMEP dataset, and for total suspended particles (TSP) in the Alert (CABM) dataset for the years 2005-2011. From 2011 to present, the Alert measurements of EC are for PM_1. Alert sampling frequency is a weekly integration. The overall uncertainty for Alert EC measurements is approximately upto 30%, and the IMPROVE EC measurements have 0.002 μg C m^{-3} method detection limit.

Measurements of equivalent black carbon (eBC, which is another "type" of BC) can be done via aethalometer (e.g. complementary measurements at Alert and at Zeppelin), or via particle soot absorption photometer (PSAP, Bond et al, 1999) at Gruvebadet, Zeppelin, and at Utqiagvik (Barrow), and these are for PM_1. Both use the light absorption method where the change in light transmission through the filter over time is related to the concentration of eBC. These eBC measurements from different instruments may be systematically offset unless scaled by a third type of measurement (e.g., Continuous Soot Monitoring System, COSMOS; Kondo et al, 2011). While each of these BC measurement methods are different, and none of them fully represent BC, they have been shown to provide a range of the "true" BC concentrations, and typically agree with each other within a factor of two (2021 AMAP SLCF report, chapter 4).

Sulfate

For the IMPROVE and CABM networks, water soluble inorganic ions, like $SO4^{2-}$, are measured with ion chromatography. The particulates are caught on nylon filters, then the samples are dissolved in deionized water, separated by ion chromatography and detected by changes in conductivity (Harris, 2003). For EMEP SO_4^{2-} measurements are made daily, particulate matter is collected for 24 hours on Teflon filters kept at ambient conditions. The samples are prepared via water extraction after ultrasonic treatment. The reported concentrations are blank corrected, and the method has a detection limit of 0.01-0.02 μg S m^{-3}. At Gruvebadet lab, SO_4^{2-} is by TECORA SKYPOST sampler, with a PM_{10} particle size cutoff. FTFE filters. These SO_4^{2-} measurements have up to 20% analytical uncertainty (2021 AMAP SLCF report, chapter 4).

Organic carbon

As mentioned above, OC is also measured via a thermal/or thermal- optical method (Chow et al, 1993; Huang et al., 2006; Huang e al., 2020) after being collected on a quartz filter, using the same thermal/ or thermal-optical instrumentation as EC in the IMPROVE, NAPS, EMEP and CABM measurement networks. These OC measurements have approximately 20% uncertainty (Sharma et al, 2017).

Table S1. Arctic monitoring stations and the observed aerosol species used in model evaluation

Stations	Latitude	Longitude	Aerosol Species
Alert (B1, O1, S1)	82.47	-62.5	BC, OC, $SO4^{2-}$
Denali (B2, O2, S2)	63.11	-151.19	BC, OC, $SO4^{2-}$
Fairbanks (B3, S3)	64.84	-147.72	BC, $SO4^{2-}$
Gates of the Arctic (B4, O3, S4)	67.91	-153.46	BC, OC, $SO4^{2-}$
Gruvebadet (B5)	79.00	12.00	BC
Hurdal (B6, O4, S5)	60.44	11.07	BC, OC, $SO4^{2-}$
Karasjok (S6)	69.47	25.51	$SO4^{2-}$
Karvatn (B7, O5, S7)	62.78	8.88	BC, OC, $SO4^{2-}$
TrapperCreek (B8, O6, S8)	62.32	-150.23	BC, OC, $SO4^{2-}$
Utqiagvik (B9, S10)	71.29	-156.79	BC, $SO4^{2-}$
Villum Research Station (B10, S11)	81.60	-16.67	EC, $SO4^{2-}$
ZeppelinMountain (B11, S12)	78.91	11.89	BC, $SO4^{2-}$

Table S2. Arctic Aeronet stations used in model evaluation

Stations	Latitude	Longitude
Andenes (A1)	69.28	16.01
ARM_Oliktok_AK (A2)	70.50	210.12
Barrow (A3)	71.31	203.34
Bonanza Creek (A4)	64.74	211.68
Helsinki (A5)	60.20	24.96
Hornsund (A6)	77.00	15.54
Hyytiala (A7)	61.85	24.30
Iqaluit (A8)	63.75	291.46
Ittoqqortoormiit (A9)	70.48	338.05
Kangerlussuaq (A10)	67.00	309.38
Kuopio (A11)	62.89	27.63
Narsarsuaq (A12)	61.16	314.58
Opal (A13)	79.99	274.06
Pearl (A14)	80.05	273.58
Resolute_Bay (A15)	74.71	265.03
Sodankyla (A16)	67.37	26.63
Thule (A17)	76.52	291.23
Tiksi (A18)	71.59	128.92
Yakutsk (A19)	61.66	129.37
Yellowknife_Aurora (A20)	62.45	245.62

Table S3. Model evaluation over the individual monitoring stations for black carbon (BC). Statistics used are mean bias (*MB*), mean gross error (*MGE*), normalized mean bias (*NMB*), normalized mean gross error (*NMGE*), root mean square error (*RMSE*), and Pearson's correlation (*r*).

Station	*MB*	*MGE*	*NMB*	*NMGE*	*RMSE*	*r*	Simulation
Alert	-0.04	0.04	-0.95	0.96	0.05	0.01	Eclipse_AMIP
Alert	-0.04	0.04	-0.96	0.96	0.05	0.43	Eclipse_AMIP_NCEP
Alert	-0.04	0.04	-0.95	0.95	0.05	0.13	Eclipse_CplHist1
Alert	-0.04	0.04	-0.95	0.95	0.05	0.37	Eclipse_CplHist2
Alert	-0.04	0.04	-0.95	0.95	0.05	0.30	Eclipse_CplHist3
Alert	-0.04	0.04	-0.94	0.94	0.05	0.09	CMIP6_Cpl_Hist
Denali	-0.06	0.06	-0.73	0.74	0.11	0.70	Eclipse_AMIP
Denali	-0.05	0.05	-0.62	0.66	0.09	0.77	Eclipse_AMIP_NCEP
Denali	-0.05	0.06	-0.70	0.72	0.11	0.60	Eclipse_CplHist1
Denali	-0.05	0.05	-0.68	0.70	0.11	0.60	Eclipse_CplHist2
Denali	-0.05	0.05	-0.68	0.70	0.10	0.71	Eclipse_CplHist3
Denali	-0.05	0.05	-0.65	0.69	0.10	0.65	CMIP6_Cpl_Hist
Fairbanks	-0.02	0.14	-0.19	1.28	0.33	-0.09	Eclipse_AMIP
Fairbanks	0.03	0.16	0.31	1.50	0.49	-0.08	Eclipse_AMIP_NCEP
Fairbanks	0.00	0.16	0.04	1.50	0.46	-0.09	Eclipse_CplHist1
Fairbanks	-0.02	0.14	-0.16	1.31	0.32	-0.10	Eclipse_CplHist2
Fairbanks	-0.01	0.15	-0.06	1.39	0.39	-0.09	Eclipse_CplHist3
Fairbanks	0.00	0.16	-0.04	1.44	0.40	-0.10	CMIP6_Cpl_Hist
GatesoftheArctic	-0.05	0.05	-0.74	0.77	0.13	0.84	Eclipse_AMIP

GatesoftheArctic	-0.05	0.05	-0.68	0.69	0.12	0.74	Eclipse_AMIP_NCEP
GatesoftheArctic	-0.04	0.04	-0.66	0.66	0.12	0.80	Eclipse_CplHist1
GatesoftheArctic	-0.04	0.04	-0.64	0.65	0.11	0.84	Eclipse_CplHist2
GatesoftheArctic	-0.04	0.04	-0.64	0.66	0.12	0.76	Eclipse_CplHist3
GatesoftheArctic	-0.04	0.04	-0.59	0.61	0.14	0.53	CMIP6_Cpl_Hist
Gruvebadet	-0.04	0.04	-0.93	0.93	0.06	0.43	Eclipse_AMIP
Gruvebadet	-0.05	0.05	-0.94	0.94	0.06	0.42	Eclipse_AMIP_NCEP
Gruvebadet	-0.04	0.04	-0.93	0.93	0.06	0.34	Eclipse_CplHist1
Gruvebadet	-0.04	0.04	-0.91	0.91	0.05	0.23	Eclipse_CplHist2
Gruvebadet	-0.05	0.05	-0.94	0.94	0.06	0.43	Eclipse_CplHist3
Gruvebadet	-0.04	0.04	-0.87	0.87	0.05	0.25	CMIP6_Cpl_Hist
Hurdal	-0.06	0.06	-0.43	0.44	0.07	0.64	Eclipse_AMIP
Hurdal	-0.06	0.06	-0.45	0.46	0.08	0.63	Eclipse_AMIP_NCEP
Hurdal	-0.06	0.06	-0.45	0.45	0.08	0.62	Eclipse_CplHist1
Hurdal	-0.06	0.06	-0.42	0.46	0.08	0.54	Eclipse_CplHist2
Hurdal	-0.06	0.06	-0.45	0.45	0.08	0.66	Eclipse_CplHist3
Hurdal	-0.03	0.04	-0.21	0.28	0.05	0.61	CMIP6_Cpl_Hist
Karvatn	-0.02	0.03	-0.35	0.52	0.04	-0.09	Eclipse_AMIP
Karvatn	-0.02	0.02	-0.29	0.41	0.03	0.36	Eclipse_AMIP_NCEP
Karvatn	-0.02	0.03	-0.36	0.47	0.03	-0.05	Eclipse_CplHist1
Karvatn	-0.02	0.03	-0.28	0.50	0.03	-0.13	Eclipse_CplHist2
Karvatn	-0.02	0.03	-0.37	0.47	0.03	0.08	Eclipse_CplHist3
Karvatn	-0.02	0.02	-0.31	0.43	0.03	0.04	CMIP6_Cpl_Hist

TrapperCreek	-0.03	0.04	-0.61	0.69	0.05	0.69	Eclipse_AMIP
TrapperCreek	-0.02	0.04	-0.42	0.66	0.05	0.72	Eclipse_AMIP_NCEP
TrapperCreek	-0.03	0.04	-0.57	0.70	0.05	0.57	Eclipse_CplHist1
TrapperCreek	-0.03	0.04	-0.54	0.70	0.06	0.47	Eclipse_CplHist2
TrapperCreek	-0.03	0.04	-0.52	0.69	0.05	0.62	Eclipse_CplHist3
TrapperCreek	-0.03	0.04	-0.46	0.76	0.07	0.53	CMIP6_Cpl_Hist
Utqiagvik	-0.02	0.03	-0.74	0.90	0.04	-0.23	Eclipse_AMIP
Utqiagvik	-0.02	0.03	-0.67	0.88	0.04	-0.12	Eclipse_AMIP_NCEP
Utqiagvik	-0.02	0.03	-0.67	0.94	0.04	-0.23	Eclipse_CplHist1
Utqiagvik	-0.02	0.03	-0.69	0.92	0.04	-0.21	Eclipse_CplHist2
Utqiagvik	-0.02	0.03	-0.69	0.93	0.04	-0.21	Eclipse_CplHist3
Utqiagvik	0.00	0.03	0.10	0.83	0.04	-0.04	CMIP6_Cpl_Hist
ZeppelinMountain	-0.02	0.02	-0.83	0.83	0.03	0.38	Eclipse_AMIP
ZeppelinMountain	-0.02	0.02	-0.84	0.84	0.03	0.48	Eclipse_AMIP_NCEP
ZeppelinMountain	-0.02	0.02	-0.80	0.81	0.03	0.32	Eclipse_CplHist1
ZeppelinMountain	-0.02	0.02	-0.81	0.82	0.03	0.40	Eclipse_CplHist2
ZeppelinMountain	-0.02	0.02	-0.81	0.82	0.03	0.39	Eclipse_CplHist3
ZeppelinMountain	-0.02	0.02	-0.74	0.77	0.03	0.23	CMIP6_Cpl_Hist

Table S4. Model evaluation over the individual monitoring stations for organic carbon (OC). Statistics used are mean bias (*MB*), mean gross error (*MGE*), normalized mean bias (*NMB*), normalized mean gross error (*NMGE*), root mean square error (*RMSE*), and Pearson's correlation (*r*).

Station	*MB*	*MGE*	*NMB*	*NMGE*	*RMSE*	*r*	Simulation
Alert	-0.13	0.14	-0.83	0.88	0.16	0.01	Eclipse_AMIP
Alert	-0.13	0.13	-0.83	0.84	0.15	0.24	Eclipse_AMIP_NCEP
Alert	-0.12	0.13	-0.79	0.81	0.15	0.04	Eclipse_CplHist1
Alert	-0.12	0.13	-0.79	0.82	0.15	0.11	Eclipse_CplHist2
Alert	-0.12	0.12	-0.79	0.81	0.15	0.21	Eclipse_CplHist3
Alert	-0.11	0.12	-0.72	0.77	0.14	0.09	CMIP6_Cpl_Hist
Denali	-0.20	0.44	-0.31	0.66	1.59	0.69	Eclipse_AMIP
Denali	0.03	0.46	0.05	0.69	1.34	0.77	Eclipse_AMIP_NCEP
Denali	-0.10	0.49	-0.15	0.74	1.68	0.59	Eclipse_CplHist1
Denali	-0.07	0.48	-0.11	0.73	1.76	0.52	Eclipse_CplHist2
Denali	-0.05	0.45	-0.07	0.68	1.55	0.67	Eclipse_CplHist3
Denali	0.17	0.56	0.26	0.84	1.74	0.62	CMIP6_Cpl_Hist
GatesOfTheArctic	-0.28	0.38	-0.44	0.59	0.68	0.90	Eclipse_AMIP
GatesOfTheArctic	-0.18	0.30	-0.29	0.47	0.55	0.93	Eclipse_AMIP_NCEP
GatesOfTheArctic	-0.16	0.30	-0.25	0.46	0.52	0.94	Eclipse_CplHist1
GatesOfTheArctic	-0.13	0.23	-0.20	0.37	0.41	0.96	Eclipse_CplHist2
GatesOfTheArctic	-0.12	0.26	-0.19	0.41	0.43	0.95	Eclipse_CplHist3
GatesOfTheArctic	-0.06	0.38	-0.10	0.59	1.01	0.84	CMIP6_Cpl_Hist

Hurdal	-0.60	0.73	-0.52	0.64	0.98	-0.50	Eclipse_AMIP
Hurdal	-0.65	0.77	-0.57	0.67	0.98	-0.26	Eclipse_AMIP_NCEP
Hurdal	-0.59	0.69	-0.51	0.61	0.93	-0.54	Eclipse_CplHist1
Hurdal	-0.58	0.72	-0.50	0.63	0.92	-0.48	Eclipse_CplHist2
Hurdal	-0.66	0.74	-0.57	0.65	0.97	-0.49	Eclipse_CplHist3
Hurdal	-0.44	0.65	-0.39	0.57	0.87	-0.62	CMIP6_Cpl_Hist
Karvatn	-0.67	0.67	-0.82	0.83	0.89	-0.24	Eclipse_AMIP
Karvatn	-0.64	0.66	-0.79	0.80	0.88	-0.25	Eclipse_AMIP_NCEP
Karvatn	-0.68	0.68	-0.83	0.83	0.89	-0.35	Eclipse_CplHist1
Karvatn	-0.66	0.67	-0.81	0.82	0.88	-0.23	Eclipse_CplHist2
Karvatn	-0.68	0.69	-0.84	0.84	0.89	-0.20	Eclipse_CplHist3
Karvatn	-0.62	0.63	-0.76	0.77	0.85	-0.36	CMIP6_Cpl_Hist
TrapperCreek	0.06	0.32	0.13	0.73	0.71	0.74	Eclipse_AMIP
TrapperCreek	0.33	0.49	0.76	1.12	1.17	0.80	Eclipse_AMIP_NCEP
TrapperCreek	0.14	0.39	0.32	0.88	0.86	0.63	Eclipse_CplHist1
TrapperCreek	0.20	0.44	0.45	1.00	1.05	0.52	Eclipse_CplHist2
TrapperCreek	0.23	0.41	0.53	0.92	0.99	0.68	Eclipse_CplHist3
TrapperCreek	0.50	0.61	1.13	1.39	1.97	0.63	CMIP6_Cpl_Hist

Table S5. Model evaluation over the individual monitoring stations for sulfate ($SO4^{2-}$). Statistics used are mean bias (*MB*), mean gross error (*MGE*), normalized mean bias (*NMB*), normalized mean gross error (*NMGE*), root mean square error (*RMSE*), and Pearson's correlation (*r*).

Station	*MB*	*MGE*	*NMB*	*NMGE*	*RMSE*	*r*	Simulation
Alert	-0.34	0.37	-0.72	0.77	0.48	0.38	Eclipse_AMIP
Alert	-0.37	0.37	-0.77	0.78	0.49	0.50	Eclipse_AMIP_NCEP
Alert	-0.34	0.36	-0.72	0.76	0.48	0.44	Eclipse_CplHist1
Alert	-0.34	0.35	-0.72	0.75	0.47	0.48	Eclipse_CplHist2
Alert	-0.34	0.36	-0.72	0.75	0.47	0.46	Eclipse_CplHist3
Alert	-0.32	0.34	-0.68	0.72	0.45	0.51	CMIP6_Cpl_Hist
Denali	-0.15	0.17	-0.46	0.53	0.24	0.38	Eclipse_AMIP
Denali	-0.16	0.17	-0.50	0.52	0.23	0.67	Eclipse_AMIP_NCEP
Denali	-0.14	0.16	-0.45	0.50	0.23	0.48	Eclipse_CplHist1
Denali	-0.14	0.16	-0.43	0.49	0.23	0.46	Eclipse_CplHist2
Denali	-0.14	0.16	-0.42	0.48	0.22	0.51	Eclipse_CplHist3
Denali	-0.09	0.14	-0.28	0.43	0.20	0.54	CMIP6_Cpl_Hist
Fairbanks	0.00	0.19	0.02	1.04	0.24	-0.36	Eclipse_AMIP
Fairbanks	0.02	0.20	0.09	1.07	0.25	-0.28	Eclipse_AMIP_NCEP
Fairbanks	0.00	0.19	0.03	1.05	0.24	-0.35	Eclipse_CplHist1
Fairbanks	0.01	0.19	0.06	1.02	0.23	-0.34	Eclipse_CplHist2
Fairbanks	0.01	0.19	0.06	1.02	0.23	-0.31	Eclipse_CplHist3
Fairbanks	0.08	0.23	0.46	1.22	0.27	-0.32	CMIP6_Cpl_Hist
GatesoftheArctic	-0.25	0.26	-0.64	0.66	0.36	0.53	Eclipse_AMIP

GatesoftheArctic	-0.26	0.26	-0.65	0.66	0.36	0.64	Eclipse_AMIP_NCEP
GatesoftheArctic	-0.25	0.26	-0.64	0.66	0.37	0.49	Eclipse_CplHist1
GatesoftheArctic	-0.24	0.25	-0.61	0.63	0.36	0.48	Eclipse_CplHist2
GatesoftheArctic	-0.25	0.25	-0.63	0.64	0.36	0.52	Eclipse_CplHist3
GatesoftheArctic	-0.20	0.22	-0.51	0.55	0.31	0.64	CMIP6_Cpl_Hist
Hurdal	-0.55	0.57	-0.60	0.62	0.72	0.28	Eclipse_AMIP
Hurdal	-0.54	0.55	-0.59	0.59	0.65	0.69	Eclipse_AMIP_NCEP
Hurdal	-0.55	0.58	-0.60	0.63	0.72	0.29	Eclipse_CplHist1
Hurdal	-0.52	0.55	-0.57	0.60	0.69	0.34	Eclipse_CplHist2
Hurdal	-0.54	0.57	-0.59	0.62	0.72	0.27	Eclipse_CplHist3
Hurdal	-0.49	0.53	-0.53	0.57	0.68	0.29	CMIP6_Cpl_Hist
Karasjok	-0.48	0.52	-0.58	0.61	0.67	0.24	Eclipse_AMIP
Karasjok	-0.50	0.50	-0.60	0.60	0.63	0.55	Eclipse_AMIP_NCEP
Karasjok	-0.46	0.49	-0.55	0.58	0.65	0.28	Eclipse_CplHist1
Karasjok	-0.47	0.48	-0.56	0.57	0.65	0.29	Eclipse_CplHist2
Karasjok	-0.46	0.48	-0.55	0.57	0.64	0.34	Eclipse_CplHist3
Karasjok	-0.38	0.42	-0.46	0.50	0.59	0.35	CMIP6_Cpl_Hist
Karvatn	-0.16	0.26	-0.29	0.49	0.39	0.39	Eclipse_AMIP
Karvatn	-0.19	0.20	-0.35	0.38	0.30	0.76	Eclipse_AMIP_NCEP
Karvatn	-0.19	0.25	-0.35	0.47	0.38	0.44	Eclipse_CplHist1
Karvatn	-0.16	0.24	-0.31	0.46	0.37	0.45	Eclipse_CplHist2
Karvatn	-0.18	0.24	-0.34	0.45	0.36	0.50	Eclipse_CplHist3
Karvatn	-0.13	0.23	-0.24	0.42	0.35	0.48	CMIP6_Cpl_Hist

TrapperCreek	-0.16	0.17	-0.49	0.52	0.25	0.52	Eclipse_AMIP
TrapperCreek	-0.17	0.17	-0.52	0.52	0.23	0.75	Eclipse_AMIP_NCEP
TrapperCreek	-0.16	0.17	-0.49	0.50	0.24	0.61	Eclipse_CplHist1
TrapperCreek	-0.15	0.17	-0.46	0.51	0.24	0.51	Eclipse_CplHist2
TrapperCreek	-0.15	0.16	-0.46	0.49	0.23	0.60	Eclipse_CplHist3
TrapperCreek	-0.11	0.14	-0.32	0.42	0.21	0.60	CMIP6_Cpl_Hist
Tustervatn	-0.22	0.29	-0.39	0.52	0.40	0.37	Eclipse_AMIP
Tustervatn	-0.26	0.27	-0.46	0.47	0.35	0.72	Eclipse_AMIP_NCEP
Tustervatn	-0.25	0.29	-0.44	0.52	0.42	0.36	Eclipse_CplHist1
Tustervatn	-0.23	0.29	-0.40	0.51	0.40	0.38	Eclipse_CplHist2
Tustervatn	-0.24	0.28	-0.43	0.50	0.40	0.41	Eclipse_CplHist3
Tustervatn	-0.18	0.26	-0.32	0.46	0.38	0.40	CMIP6_Cpl_Hist
Utqiagvik	-0.25	0.29	-0.61	0.70	0.37	0.16	Eclipse_AMIP
Utqiagvik	-0.23	0.28	-0.56	0.68	0.35	0.24	Eclipse_AMIP_NCEP
Utqiagvik	-0.24	0.29	-0.59	0.69	0.37	0.13	Eclipse_CplHist1
Utqiagvik	-0.24	0.29	-0.59	0.69	0.37	0.15	Eclipse_CplHist2
Utqiagvik	-0.25	0.28	-0.60	0.68	0.36	0.22	Eclipse_CplHist3
Utqiagvik	-0.20	0.26	-0.48	0.63	0.33	0.27	CMIP6_Cpl_Hist
VillumNord	-0.26	0.30	-0.64	0.72	0.41	0.41	Eclipse_AMIP
VillumNord	-0.28	0.30	-0.68	0.72	0.41	0.49	Eclipse_AMIP_NCEP
VillumNord	-0.26	0.29	-0.63	0.72	0.41	0.41	Eclipse_CplHist1
VillumNord	-0.26	0.29	-0.64	0.70	0.40	0.48	Eclipse_CplHist2
VillumNord	-0.26	0.29	-0.64	0.70	0.40	0.50	Eclipse_CplHist3

VillumNord	-0.24	0.27	-0.59	0.67	0.38	0.51	CMIP6_Cpl_Hist
ZeppelinMountain	0.04	0.11	0.29	0.80	0.16	0.34	Eclipse_AMIP
ZeppelinMountain	0.03	0.08	0.18	0.62	0.11	0.59	Eclipse_AMIP_NCEP
ZeppelinMountain	0.05	0.11	0.39	0.80	0.15	0.49	Eclipse_CplHist1
ZeppelinMountain	0.05	0.11	0.37	0.79	0.15	0.47	Eclipse_CplHist2
ZeppelinMountain	0.05	0.10	0.33	0.74	0.15	0.52	Eclipse_CplHist3
ZeppelinMountain	0.08	0.12	0.56	0.89	0.17	0.52	CMIP6_Cpl_Hist

Table S6. Model evaluation over the individual Aeronet monitoring stations for aerosol optical depth at 550 nm. Statistics used are mean bias (*MB*), mean gross error (*MGE*), normalized mean bias (*NMB*), normalized mean gross error (*NMGE*), root mean square error (*RMSE*), and Pearson's correlation (*r*).

Station	*MB*	*MGE*	*NMB*	*NMGE*	*RMSE*	*r*	Simulation
Andenes	-0.02	0.05	-0.22	0.49	0.06	0.03	Eclipse_AMIP
Andenes	-0.03	0.04	-0.30	0.36	0.04	0.35	Eclipse_AMIP_NCEP
Andenes	-0.04	0.05	-0.43	0.46	0.05	0.04	Eclipse_CplHist1
Andenes	-0.03	0.04	-0.32	0.43	0.05	0.22	Eclipse_CplHist2
Andenes	-0.01	0.05	-0.13	0.47	0.06	-0.09	Eclipse_CplHist3
Andenes	-0.03	0.04	-0.29	0.36	0.04	0.20	CMIP6_Cpl_Hist
ARM_HyytialaFinland	0.00	0.06	0.00	0.65	0.07	-0.73	Eclipse_AMIP
ARM_HyytialaFinland	-0.02	0.04	-0.23	0.46	0.04	-0.51	Eclipse_AMIP_NCEP
ARM_HyytialaFinland	-0.02	0.05	-0.21	0.55	0.05	-0.68	Eclipse_CplHist1
ARM_HyytialaFinland	-0.02	0.05	-0.18	0.62	0.05	-0.88	Eclipse_CplHist2
ARM_HyytialaFinland	-0.03	0.04	-0.30	0.42	0.04	-0.46	Eclipse_CplHist3
ARM_HyytialaFinland	-0.02	0.04	-0.20	0.44	0.04	-0.73	CMIP6_Cpl_Hist
Barrow	-0.08	0.08	-0.55	0.58	0.10	0.34	Eclipse_AMIP
Barrow	-0.09	0.09	-0.62	0.63	0.11	0.44	Eclipse_AMIP_NCEP
Barrow	-0.09	0.09	-0.65	0.66	0.12	0.22	Eclipse_CplHist1
Barrow	-0.09	0.09	-0.64	0.66	0.11	0.35	Eclipse_CplHist2
Barrow	-0.08	0.09	-0.62	0.63	0.11	0.28	Eclipse_CplHist3
Barrow	-0.08	0.08	-0.56	0.59	0.11	0.02	CMIP6_Cpl_Hist

Bonanza_Creek	-0.08	0.09	-0.57	0.61	0.16	0.13	Eclipse_AMIP
Bonanza_Creek	-0.08	0.08	-0.56	0.57	0.15	0.52	Eclipse_AMIP_NCEP
Bonanza_Creek	-0.10	0.10	-0.67	0.70	0.17	0.00	Eclipse_CplHist1
Bonanza_Creek	-0.10	0.10	-0.66	0.66	0.17	0.28	Eclipse_CplHist2
Bonanza_Creek	-0.09	0.09	-0.64	0.66	0.17	0.31	Eclipse_CplHist3
Bonanza_Creek	-0.09	0.09	-0.59	0.62	0.17	0.09	CMIP6_Cpl_Hist
Helsinki	0.00	0.06	-0.05	0.64	0.08	-0.51	Eclipse_AMIP
Helsinki	-0.02	0.04	-0.25	0.47	0.05	-0.35	Eclipse_AMIP_NCEP
Helsinki	0.00	0.07	0.02	0.75	0.10	-0.54	Eclipse_CplHist1
Helsinki	-0.03	0.04	-0.27	0.39	0.04	-0.14	Eclipse_CplHist2
Helsinki	-0.02	0.05	-0.19	0.50	0.05	-0.68	Eclipse_CplHist3
Helsinki	-0.01	0.06	-0.10	0.59	0.07	-0.66	CMIP6_Cpl_Hist
Hornsund	-0.04	0.04	-0.38	0.42	0.05	0.40	Eclipse_AMIP
Hornsund	-0.05	0.05	-0.48	0.48	0.06	0.31	Eclipse_AMIP_NCEP
Hornsund	-0.04	0.05	-0.43	0.49	0.06	0.07	Eclipse_CplHist1
Hornsund	-0.04	0.05	-0.39	0.48	0.06	0.14	Eclipse_CplHist2
Hornsund	-0.03	0.04	-0.31	0.41	0.06	0.25	Eclipse_CplHist3
Hornsund	-0.04	0.05	-0.43	0.48	0.06	-0.07	CMIP6_Cpl_Hist
Hyytiala	-0.02	0.04	-0.23	0.44	0.05	-0.31	Eclipse_AMIP
Hyytiala	-0.03	0.05	-0.26	0.50	0.06	-0.50	Eclipse_AMIP_NCEP
Hyytiala	0.00	0.06	-0.03	0.61	0.10	-0.32	Eclipse_CplHist1
Hyytiala	-0.02	0.03	-0.22	0.35	0.04	0.09	Eclipse_CplHist2
Hyytiala	-0.03	0.04	-0.32	0.44	0.05	-0.09	Eclipse_CplHist3

Hyytiala	-0.02	0.05	-0.18	0.49	0.06	-0.31	CMIP6_Cpl_Hist
Iqaluit	-0.01	0.04	-0.10	0.42	0.06	0.01	Eclipse_AMIP
Iqaluit	-0.02	0.05	-0.20	0.49	0.07	0.07	Eclipse_AMIP_NCEP
Iqaluit	-0.03	0.04	-0.35	0.45	0.06	-0.13	Eclipse_CplHist1
Iqaluit	-0.02	0.04	-0.18	0.47	0.06	0.18	Eclipse_CplHist2
Iqaluit	-0.02	0.05	-0.21	0.52	0.07	-0.17	Eclipse_CplHist3
Iqaluit	-0.02	0.04	-0.22	0.39	0.06	0.14	CMIP6_Cpl_Hist
Ittoqqortoormiit	-0.01	0.02	-0.20	0.24	0.02	0.71	Eclipse_AMIP
Ittoqqortoormiit	-0.03	0.03	-0.35	0.35	0.03	0.72	Eclipse_AMIP_NCEP
Ittoqqortoormiit	-0.03	0.04	-0.43	0.49	0.04	-0.07	Eclipse_CplHist1
Ittoqqortoormiit	-0.03	0.03	-0.41	0.44	0.03	0.02	Eclipse_CplHist2
Ittoqqortoormiit	-0.02	0.03	-0.34	0.39	0.03	0.43	Eclipse_CplHist3
Ittoqqortoormiit	-0.02	0.03	-0.26	0.35	0.03	0.01	CMIP6_Cpl_Hist
Kangerlussuaq	0.03	0.05	0.37	0.64	0.09	0.50	Eclipse_AMIP
Kangerlussuaq	0.01	0.04	0.08	0.49	0.05	0.22	Eclipse_AMIP_NCEP
Kangerlussuaq	-0.02	0.03	-0.32	0.36	0.03	0.04	Eclipse_CplHist1
Kangerlussuaq	-0.02	0.02	-0.24	0.29	0.03	0.35	Eclipse_CplHist2
Kangerlussuaq	-0.01	0.03	-0.07	0.41	0.04	0.40	Eclipse_CplHist3
Kangerlussuaq	0.00	0.03	-0.05	0.38	0.03	0.06	CMIP6_Cpl_Hist
Kuopio	-0.04	0.04	-0.41	0.44	0.05	-0.19	Eclipse_AMIP
Kuopio	-0.04	0.04	-0.43	0.46	0.05	-0.18	Eclipse_AMIP_NCEP
Kuopio	-0.04	0.04	-0.46	0.46	0.05	-0.16	Eclipse_CplHist1
Kuopio	-0.04	0.04	-0.40	0.41	0.05	0.23	Eclipse_CplHist2

Kuopio	-0.04	0.04	-0.40	0.41	0.05	-0.06	Eclipse_CplHist3
Kuopio	-0.04	0.04	-0.40	0.41	0.05	0.10	CMIP6_Cpl_Hist
Narsarsuaq	-0.01	0.02	-0.10	0.24	0.02	-0.22	Eclipse_AMIP
Narsarsuaq	0.00	0.02	-0.03	0.30	0.03	-0.18	Eclipse_AMIP_NCEP
Narsarsuaq	-0.02	0.03	-0.23	0.35	0.03	-0.99	Eclipse_CplHist1
Narsarsuaq	-0.01	0.02	-0.14	0.23	0.02	-0.79	Eclipse_CplHist2
Narsarsuaq	-0.02	0.02	-0.33	0.33	0.03	-0.15	Eclipse_CplHist3
Narsarsuaq	0.02	0.04	0.34	0.52	0.06	-0.03	CMIP6_Cpl_Hist
OPAL	-0.03	0.03	-0.41	0.45	0.04	0.57	Eclipse_AMIP
OPAL	-0.03	0.03	-0.44	0.46	0.04	0.30	Eclipse_AMIP_NCEP
OPAL	-0.03	0.04	-0.47	0.57	0.05	-0.39	Eclipse_CplHist1
OPAL	-0.03	0.04	-0.44	0.49	0.04	0.23	Eclipse_CplHist2
OPAL	-0.03	0.04	-0.45	0.50	0.04	0.18	Eclipse_CplHist3
OPAL	-0.02	0.04	-0.29	0.56	0.05	-0.69	CMIP6_Cpl_Hist
PEARL	-0.03	0.03	-0.41	0.42	0.04	0.54	Eclipse_AMIP
PEARL	-0.03	0.04	-0.43	0.51	0.05	0.04	Eclipse_AMIP_NCEP
PEARL	-0.03	0.04	-0.47	0.50	0.05	-0.01	Eclipse_CplHist1
PEARL	-0.03	0.03	-0.44	0.46	0.04	0.19	Eclipse_CplHist2
PEARL	-0.03	0.03	-0.35	0.42	0.04	0.12	Eclipse_CplHist3
PEARL	-0.03	0.04	-0.35	0.49	0.05	-0.28	CMIP6_Cpl_Hist
Resolute_Bay	-0.04	0.04	-0.46	0.47	0.06	0.39	Eclipse_AMIP
Resolute_Bay	-0.04	0.04	-0.43	0.43	0.05	0.56	Eclipse_AMIP_NCEP
Resolute_Bay	-0.04	0.05	-0.49	0.50	0.06	0.24	Eclipse_CplHist1

Resolute_Bay	-0.04	0.04	-0.48	0.48	0.06	0.45	Eclipse_CplHist2
Resolute_Bay	-0.04	0.04	-0.45	0.47	0.05	0.48	Eclipse_CplHist3
Resolute_Bay	-0.03	0.04	-0.36	0.40	0.05	0.05	CMIP6_Cpl_Hist
Sodankyla	-0.03	0.05	-0.35	0.55	0.05	-0.60	Eclipse_AMIP
Sodankyla	-0.03	0.04	-0.38	0.50	0.05	-0.62	Eclipse_AMIP_NCEP
Sodankyla	-0.04	0.05	-0.48	0.54	0.06	-0.93	Eclipse_CplHist1
Sodankyla	-0.03	0.06	-0.36	0.68	0.06	-0.81	Eclipse_CplHist2
Sodankyla	-0.03	0.04	-0.36	0.50	0.05	-0.76	Eclipse_CplHist3
Sodankyla	-0.03	0.04	-0.40	0.45	0.05	-0.29	CMIP6_Cpl_Hist
Thule	-0.04	0.04	-0.43	0.49	0.05	0.07	Eclipse_AMIP
Thule	-0.04	0.04	-0.47	0.51	0.05	0.36	Eclipse_AMIP_NCEP
Thule	-0.04	0.05	-0.52	0.56	0.05	0.05	Eclipse_CplHist1
Thule	-0.04	0.04	-0.48	0.51	0.05	0.20	Eclipse_CplHist2
Thule	-0.03	0.04	-0.41	0.49	0.05	0.15	Eclipse_CplHist3
Thule	-0.03	0.04	-0.35	0.49	0.05	-0.26	CMIP6_Cpl_Hist
Tiksi	-0.14	0.14	-0.67	0.67	0.23	0.00	Eclipse_AMIP
Tiksi	-0.15	0.15	-0.72	0.72	0.24	-0.02	Eclipse_AMIP_NCEP
Tiksi	-0.16	0.16	-0.78	0.78	0.24	0.30	Eclipse_CplHist1
Tiksi	-0.16	0.16	-0.76	0.76	0.24	0.03	Eclipse_CplHist2
Tiksi	-0.14	0.14	-0.68	0.68	0.23	0.00	Eclipse_CplHist3
Tiksi	-0.15	0.15	-0.74	0.74	0.23	0.67	CMIP6_Cpl_Hist
Yakutsk	-0.13	0.13	-0.66	0.66	0.15	0.44	Eclipse_AMIP
Yakutsk	-0.11	0.11	-0.55	0.56	0.14	0.45	Eclipse_AMIP_NCEP

Yakutsk	-0.12	0.12	-0.60	0.62	0.15	0.38	Eclipse_CplHist1
Yakutsk	-0.13	0.13	-0.66	0.66	0.15	0.49	Eclipse_CplHist2
Yakutsk	-0.12	0.12	-0.65	0.65	0.15	0.34	Eclipse_CplHist3
Yakutsk	-0.10	0.11	-0.54	0.57	0.14	0.36	CMIP6_Cpl_Hist
Yellowknife_Aurora	-0.07	0.10	-0.46	0.63	0.17	-0.35	Eclipse_AMIP
Yellowknife_Aurora	-0.07	0.10	-0.47	0.61	0.17	-0.09	Eclipse_AMIP_NCEP
Yellowknife_Aurora	-0.10	0.10	-0.62	0.62	0.18	-0.27	Eclipse_CplHist1
Yellowknife_Aurora	-0.08	0.09	-0.51	0.60	0.16	0.14	Eclipse_CplHist2
Yellowknife_Aurora	-0.09	0.10	-0.55	0.63	0.18	-0.30	Eclipse_CplHist3
Yellowknife_Aurora	-0.08	0.11	-0.51	0.67	0.18	-0.31	CMIP6_Cpl_Hist

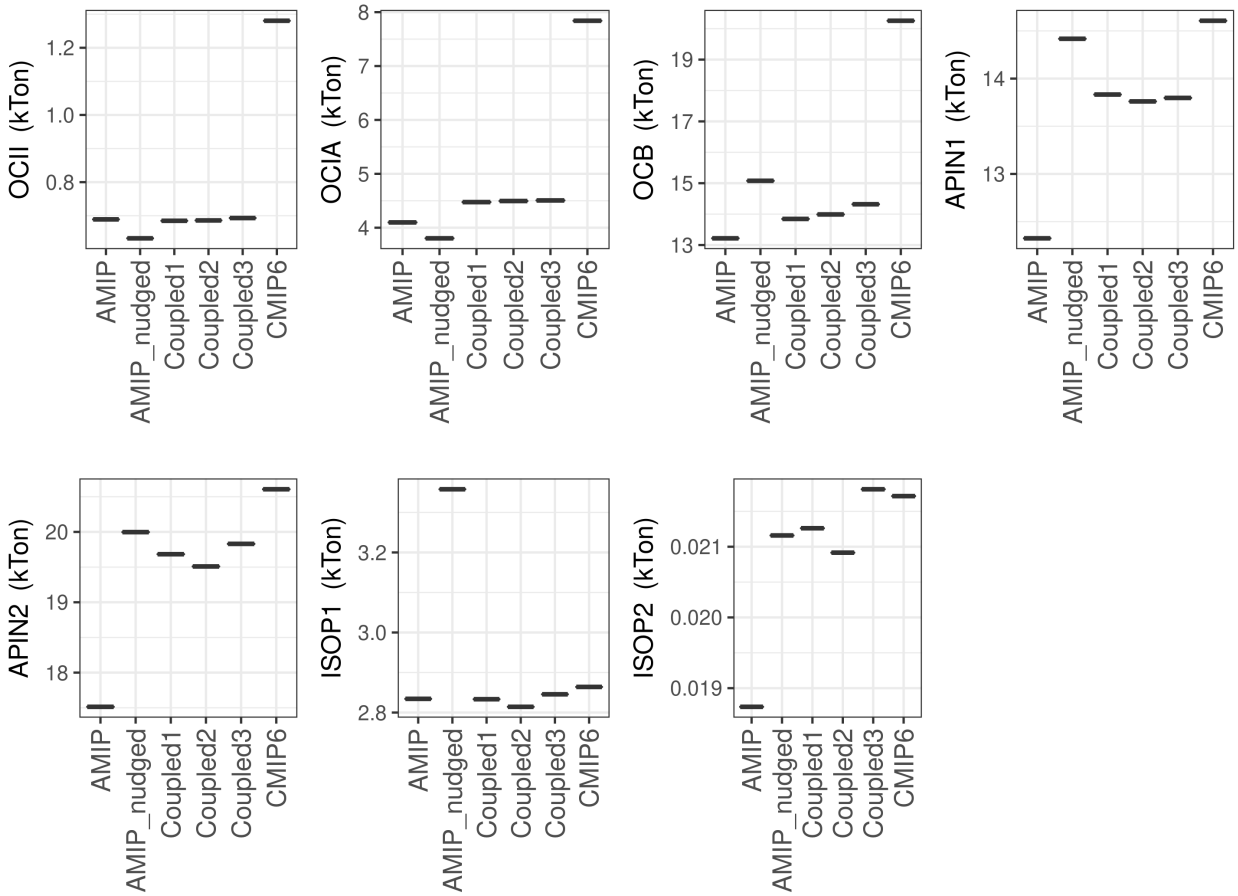

Figure S1. Present day SOA burdens in the Eclipse and CMIP6 ensemble.

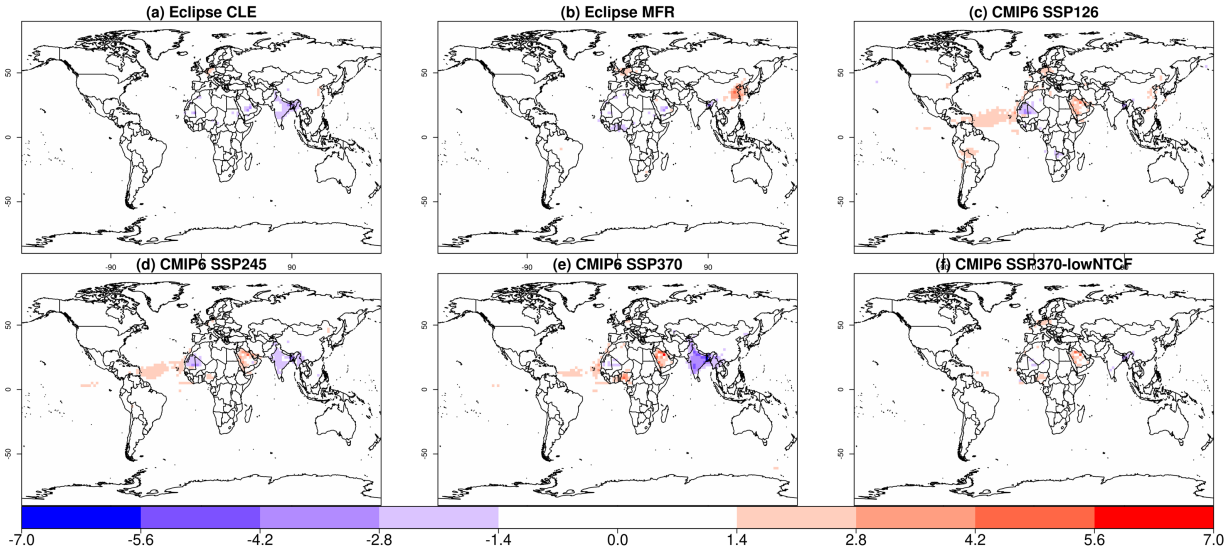

Figure S2. Spatial distribution of the statistically significant annual mean global RF_{ARI} (W m^{-2}) changes between the 1990-2010 mean and the 2030-2050 mean as calculated by the GISS-E2.1 ensemble.

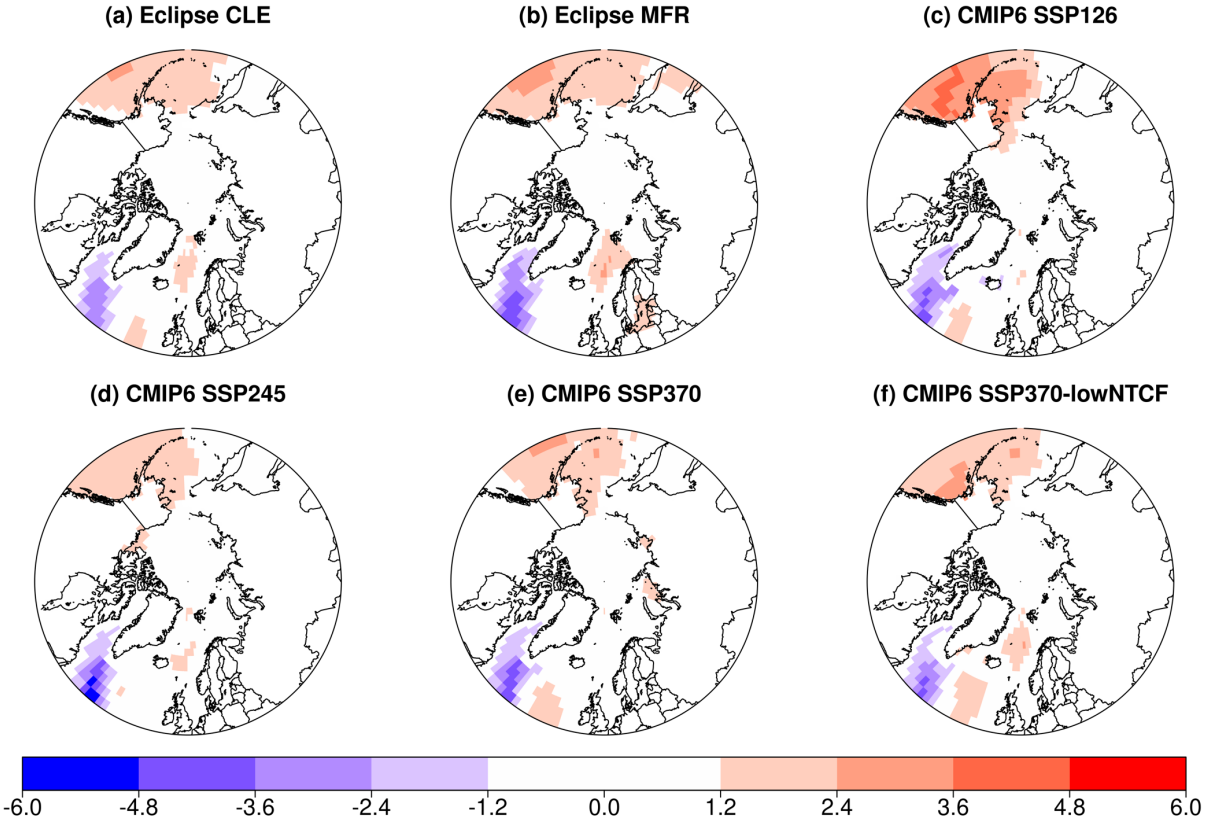

Figure S3. Spatial distribution of the annual mean Arctic sea surface temperature (°C) change between the 1990-2010 mean and the 2030-2050 mean as calculated by the GISS-E2.1 ensemble.

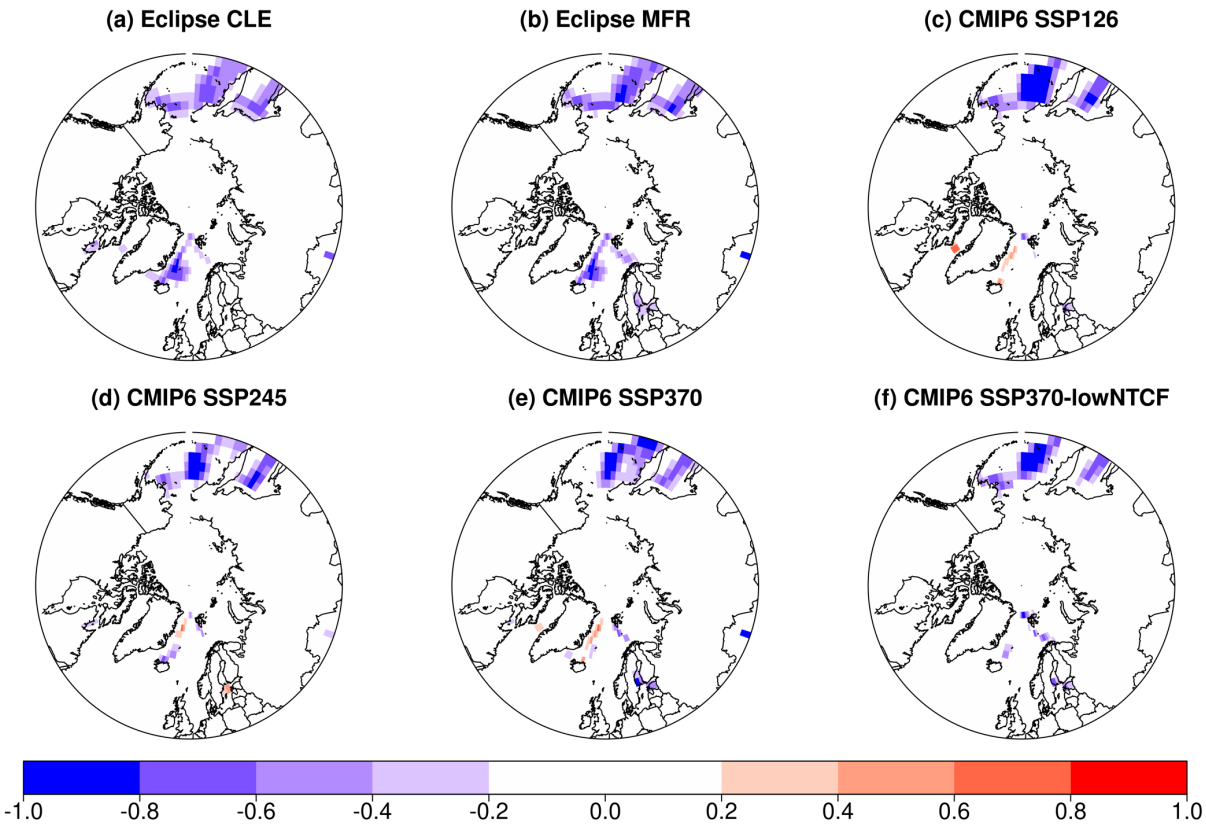

Figure S4. Spatial distribution of the March Arctic sea-ice fraction change between the 1990-2010 mean and the 2030-2050 mean as calculated by the GISS-E2.1 ensemble.

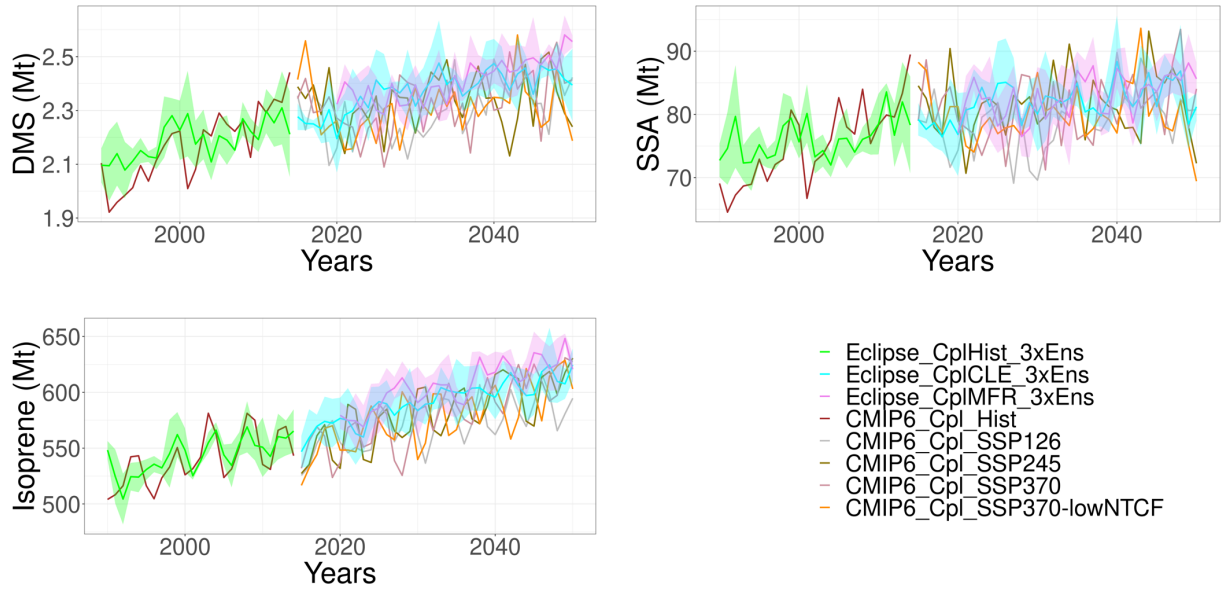

Figure S5. Arctic DMS and sea-salt and global isoprene emissions anomalies in 1900-2050 based on the 1990-2010 mean, simulated by the Eclipse and CMIP6 ensembles.

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