Supplementary materials for "Evaluation of preindustrial to present-day black carbon and its albedo forcing from ACCMIP (Atmospheric Chemistry and Climate Model Intercomparison Project)"

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The deviation of the simulated BC surface mass concentrations from the observations is computed with the log-mean normalized bias (LMNB) and log-mean normalized error (LMNE), which are defined as follows:

$$LMNB = \frac{\sum_{i=1}^{N} \log_{10}\left(\frac{C_{\mathrm{mod},i}}{C_{obs,i}}\right)}{N} \qquad LMNE = \frac{\sum_{i=1}^{N} abs\left[\log_{10}\left(\frac{C_{\mathrm{mod},i}}{C_{obs,i}}\right)\right]}{N} \tag{1}$$

where $C_{mod,i}$ is the modeled BC in month i, $C_{obs,i}$ is the observed BC in month i, and N is 12 for the total number of months in a year.

For BC snow concentrations, the LMNB and LMNE are computed using Eq (1), but, in this case, $C_{mod,i}$ or $C_{obs,i}$ are the modeled or observed data in a given region and "N" is the total number of observation data in that region.

If a model has LMNB of 0.3, it means that the model overpredicts, on average, within a factor of 2 ($=10^{0.3}$) of the observation.
If a model has LMNB of -0.6, it means that the model underpredicts, on average, within a factor of 4 ($=1/10^{-0.6}$) of the observation.
If a model has LMNE of 0.6, it means that the model predictions are, on average, within a factor of 4 ($=10^{0.6}$) of the observation.

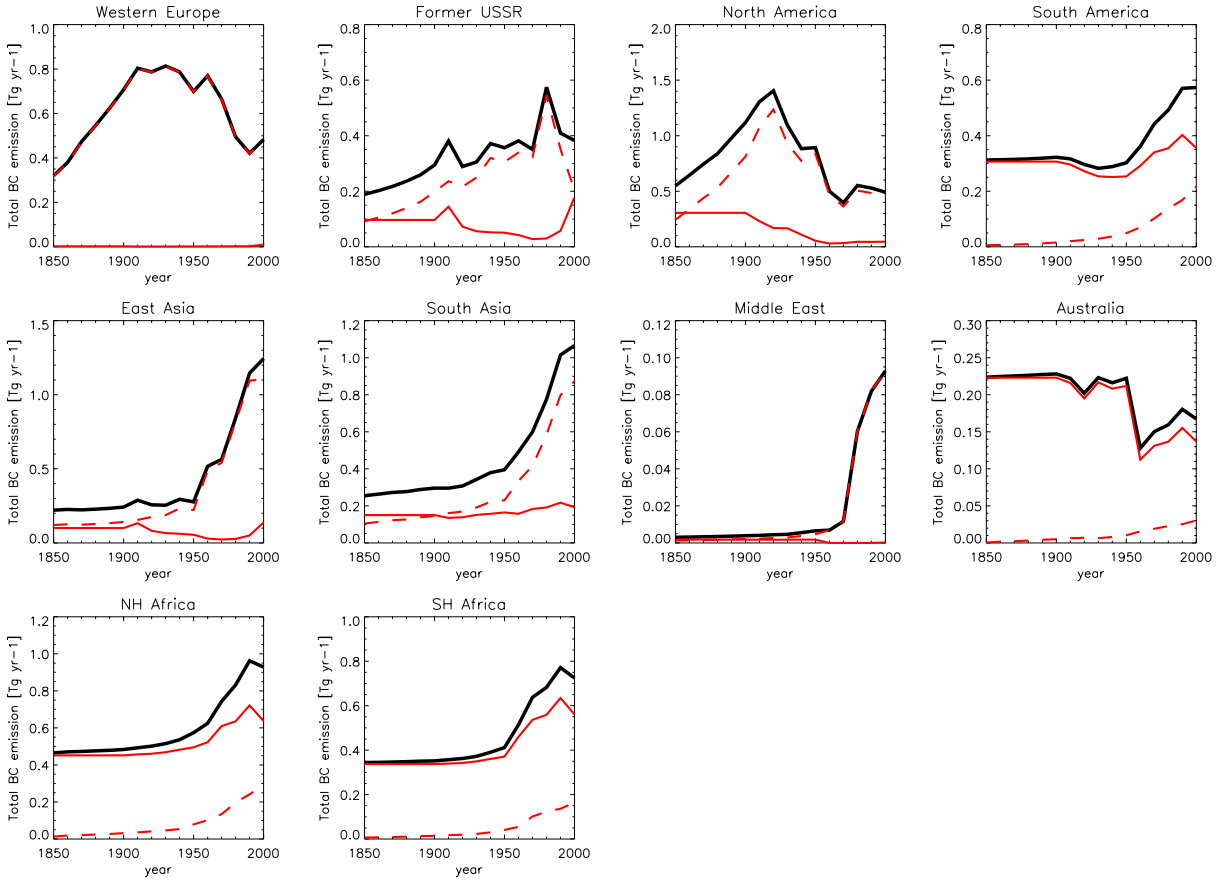
S-Table 1. Summary of statistical measures for BC mass concentration evaluation including correlation, log-mean normalized bias (LMNB) and log-mean normalized error (LMNE).

		GFDL-AM3	GISS-E2-R	NCAR-CAM3.5	NCAR-CAM5.1	HadGEM2	CICERO-OsloCTM2	MIROC-CHEM	GISS-E2-R-TOMAS
Correlation	Alert	-0.59	0.83	0.50	0.60	0.78	0.70	-0.61	0.78
	Ny-Ålesund	0.04	0.76	0.68	-0.09	0.69	0.55	0.11	0.86
	Barrow	-0.60	-0.48	-0.50	-0.11	0.85	-0.22	-0.59	-0.49
	Pallas (Pallastunturi)	-0.13	0.40	0.53	-0.30	0.44	0.26	-0.03	0.73
	Hyytiälä	0.43	0.69	0.56	-0.16	0.50	0.76	0.35	0.61
	Preila	0.24	0.63	0.31	-0.30	0.75	0.43	-0.57	0.61
	Mace Head	0.15	0.02	-0.18	-0.18	0.50	0.29	-0.64	-0.41
	Jungfraujoch	0.90	0.85	0.63	0.85	-0.58	-0.73	0.86	0.97
	Ispra	-0.57	0.46	-0.59	-0.79	0.92	0.87	-0.70	0.23
	Sable Island	0.17	0.08	0.09	-0.50	0.04	0.14	0.26	0.10
	Trinidad Head	0.67	0.11	0.26	0.70	0.68	0.13	-0.13	0.03
	Bondville	0.40	-0.49	-0.26	0.53	-0.65	0.42	0.66	-0.55
	Southern Great Plains	0.28	0.55	0.28	-0.05	-0.79	-0.48	0.81	0.56
	Mauna Loa	-0.05	0.91	-0.12	-0.30	0.79	0.84	-0.08	0.95
LMNB	Alert	-1.64	-0.74	-1.10	-2.20	0.35	-0.98	-1.34	-0.47
	Ny-Alesund	-0.85	-0.40	-0.47	-1.78	0.59	-0.58	-0.79	-0.08
	Barrow	-1.18	-0.41	-0.64	-1.34	0.47	-0.64	-0.88	-0.18
	Pallas (Pallastunturi)	-0.34	-0.04	-0.15	-0.72	0.42	-0.14	-0.27	0.09
	Hyytiälä	-0.08	0.04	-0.05	-0.29	0.22	-0.16	-0.19	0.14
	Preila	-0.15	-0.04	-0.24	-0.46	0.06	0.07	0.01	0.03
	Mace Head	-0.13	-0.01	-0.47	-0.60	0.06	-0.02	-0.15	0.14
	Jungfraujoch	0.90	0.69	0.91	0.81	1.05	1.07	0.96	0.74
	Ispra	-0.60	-0.41	-0.64	-0.73	-0.29	-0.48	-0.59	-0.33
	Sable Island	-0.18	-0.05	-0.02	-0.41	0.23	-0.19	-0.08	0.07
	Trinidad Head	-0.10	0.07	-0.09	-0.42	0.23	-0.14	-0.01	0.10
	Bondville	0.04	0.18	0.17	0.14	0.15	0.27	0.11	0.27
	Southern Great Plains	-0.14	-0.07	-0.08	-0.10	0.12	-0.19	-0.27	0.04
	Mauna Loa	0.02	0.09	0.12	-0.31	0.74	0.00	0.13	0.26
LMNE	Alert	1.64	0.74	1.10	2.20	0.37	0.98	1.34	0.48
	Ny-Alesund	0.85	0.40	0.48	1.78	0.59	0.59	0.79	0.20
	Barrow	1.18	0.60	0.65	1.34	0.47	0.64	0.95	0.48
	Pallas (Pallastunturi)	0.34	0.19	0.22	0.72	0.42	0.22	0.28	0.16
	Hyytiälä	0.09	0.06	0.07	0.29	0.22	0.16	0.19	0.14
	Preila	0.20	0.16	0.24	0.46	0.12	0.16	0.24	0.16
	Mace Head	0.17	0.16	0.47	0.60	0.14	0.14	0.37	0.19
	Jungfraujoch	0.90	0.69	0.91	0.81	1.05	1.07	0.96	0.74
	Ispra	0.60	0.41	0.64	0.73	0.29	0.48	0.59	0.33
	Sable Island	0.18	0.09	0.06	0.41	0.23	0.19	0.10	0.10
	Trinidad Head	0.12	0.22	0.15	0.42	0.23	0.22	0.23	0.21
	Bondville	0.07	0.18	0.17	0.14	0.17	0.27	0.11	0.27
	Southern Great Plains	0.14	0.09	0.10	0.12	0.17	0.19	0.27	0.06
	Mauna Loa	0.27	0.16	0.28	0.34	0.74	0.18	0.29	0.26

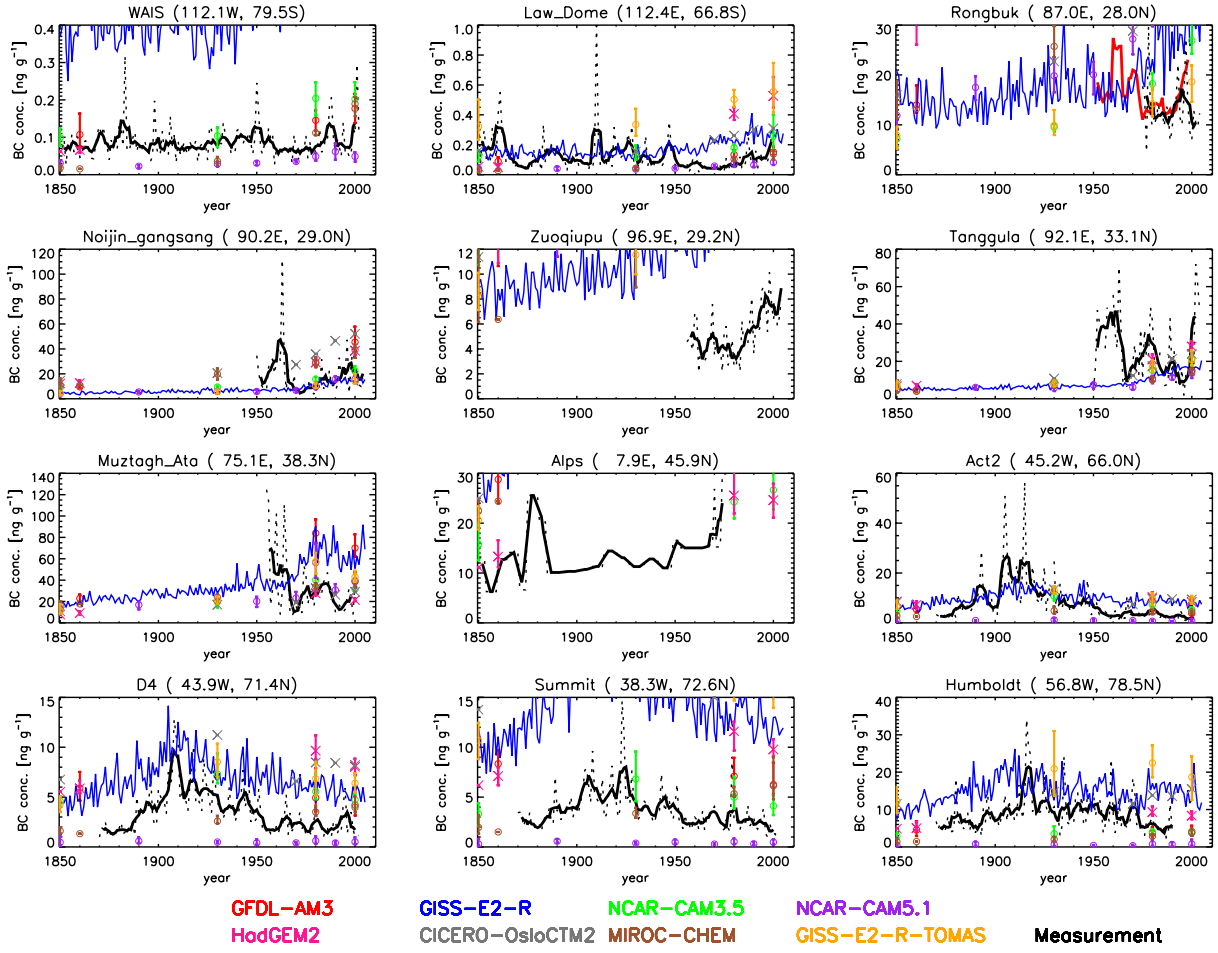
S-Table 2. Summary of statistical measures for the present-day BC in snow evaluation including LMNB and LMNE. Note that Canada sub-Arctic, Canadian Arctic, and Alaska N. slope regions in Fig.9 are lumped into Canada in here.

		GFDL-AM3	GISS-E2-R	NCAR-CAM3.5	NCAR-CAM5.1	HadGEM2	CICERO-OsloCTM2	MIROC-CHEM	GISS-E2-R-TOMAS
LMNB	Arctic ocean	-0.73	-0.59	-0.64	-1.34	-0.51	-0.33	-0.73	-0.45
	Greenland	0.62	0.73	0.74	-0.10	0.85	0.88	0.78	0.83
	Canada	-0.08	0.28	0.16	-0.42	0.41	0.34	0.08	0.44
	Russia	-0.35	-0.09	-0.16	-0.67	0.10	0.04	-0.20	0.02
	Tromso	0.19	0.22	0.11	-0.03	0.43	0.17	0.07	0.26
	Ny-Alesund	0.12	0.21	0.27	-0.25	0.78	0.44	-0.09	0.35
LMNE	Arctic ocean	0.75	0.02	0.02	0.04	0.02	0.02	0.03	0.02
	Greenland	0.71	0.79	0.79	0.56	0.87	0.89	0.84	0.87
	Canada	0.27	0.39	0.32	0.49	0.49	0.43	0.26	0.51
	Russia	0.43	0.31	0.31	0.75	0.27	0.30	0.34	0.28
	Tromso	0.23	0.24	0.18	0.13	0.43	0.21	0.15	0.26
	Ny-Alesund	0.18	0.24	0.27	0.31	0.78	0.44	0.20	0.35

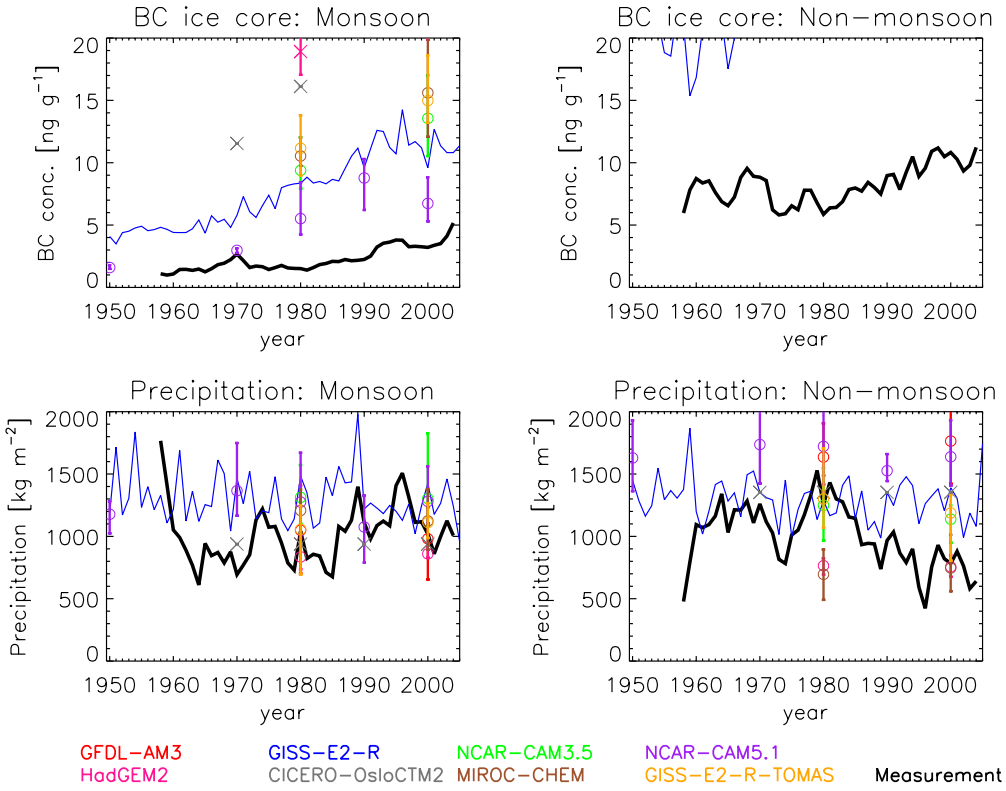
S - Figure1. Regional emission rate changes from 1850 to 2000. Black thick line is for total BC emissions, red solid line for biomass burning emissions and red dashed line for fossil fuel and biofuel emissions.



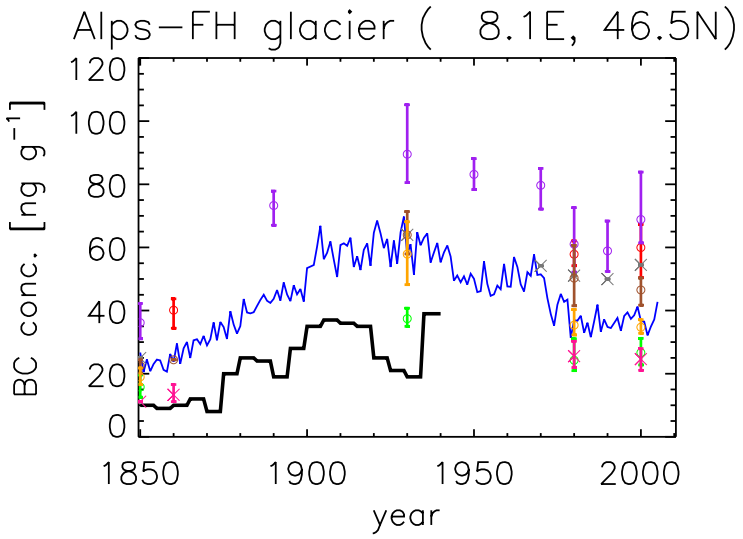
S- Figure 2. Same as Figure 11 but with Y-axis scale emphasizing observation values.



S- Figure 3. Same as Figure 13 but with Y-axis scale emphasizing observation values.



S-Figure 4. Comparison of the modeled BC concentrations with the Alps ice core from the Fiescherhorn (FH) glacier.



S- Figure 5. Spatial distribution of a ratio of BC emissions in 2000 to BC emissions in 1980.