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Emission metrics for quantifying regional climate impacts of aviation

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Table S1: Global and regional aviation emissions used in this study. Emissions are for year 2006 and from the AEDT inventory (Wilkerson et al., 2010). Also included is the accumulated flight distance in each region.

Source Region	BC (kg yr^{-1})	NOx (kgN yr^{-1})	OC (kg yr^{-1})	SO2 (kg yr^{-1})	CO2 (kg yr^{-1})	Flight distance (km)
Global	5.9E+06	8.1E+08	6.4E+06	2.3E+08	5.9E+11	6.7E+10
SAF	4.0E+05	5.6E+07	3.6E+05	1.4E+07	3.8E+10	2.5E+09
NAM	2.2E+06	2.9E+08	2.0E+06	8.2E+07	2.2E+11	1.8E+10
EAS	9.8E+05	1.6E+08	1.1E+06	3.8E+07	1.0E+11	4.6E+09
EUR	1.5E+06	2.2E+08	2.1E+06	5.8E+07	1.5E+11	8.9E+09
SPO	4.6E+05	7.1E+07	4.8E+05	1.8E+07	4.6E+10	2.4E+09
SAS	2.5E+05	4.1E+07	2.3E+05	9.5E+06	2.5E+10	1.6E+09

Table S2: Radiative forcing (Wm^{-2}) by component, source region and latitude band for input to the emission metric calculations.

Component	Source region	Radiative forcing (Wm^{-2})				
		Global	90°S-28°S	28°S-28°N	28°N-60°N	60°N-90°N
Contrail-Cirrus	Global	4.6E-02	1.8E-03	2.8E-02	1.6E-01	2.1E-02
	SAF	3.5E-03	4.7E-04	6.5E-03	9.7E-05	9.0E-10
	NAM	1.8E-02	-1.5E-10	7.8E-03	7.5E-02	5.5E-03
	EAS	4.2E-03	-4.8E-10	4.3E-03	1.0E-02	1.2E-03
	EUR	9.5E-03	2.0E-10	1.2E-04	4.9E-02	7.0E-03
	SPO	2.7E-03	7.3E-04	4.9E-03	-1.0E-06	2.5E-11
	SAS	1.6E-03	-2.0E-10	3.0E-03	6.1E-04	9.3E-09
NOx-ozone	Global	1.9E-02	4.8E-03	2.0E-02	3.6E-02	2.3E-02
	SAF	2.0E-03	1.4E-03	2.9E-03	1.0E-03	2.5E-04
	NAM	5.3E-03	7.0E-05	4.0E-03	1.4E-02	8.4E-03
	EAS	4.0E-03	3.6E-04	4.8E-03	6.9E-03	3.8E-03
	EUR	3.0E-03	4.7E-05	1.3E-03	9.0E-03	8.2E-03
	SPO	3.1E-03	2.5E-03	4.8E-03	7.8E-04	-5.1E-05

	SAS	1.6E-03	7.0E-05	2.2E-03	2.4E-03	6.6E-04
BC	Global	5.7E-04	9.7E-05	5.2E-04	1.3E-03	6.6E-04
	SAF	5.4E-05	2.8E-05	8.2E-05	2.6E-05	9.9E-06
	NAM	1.9E-04	1.8E-06	1.3E-04	5.9E-04	2.7E-04
	EAS	1.0E-04	9.0E-06	1.1E-04	2.0E-04	1.0E-04
	EUR	1.1E-04	1.4E-06	4.7E-05	4.0E-04	2.2E-04
	SPO	5.6E-05	4.9E-05	8.5E-05	1.3E-05	7.3E-06
	SAS	5.0E-05	3.8E-06	6.4E-05	7.7E-05	3.3E-05
OC	Global	-4.6E-05	-4.7E-06	-4.9E-05	-9.9E-05	-2.1E-05
	SAF	-4.4E-06	-1.4E-06	-7.3E-06	-1.6E-06	-2.5E-07
	NAM	-1.5E-05	-6.4E-08	-1.3E-05	-4.1E-05	-7.8E-06
	EAS	-7.7E-06	-4.0E-07	-1.0E-05	-1.2E-05	-2.9E-06
	EUR	-1.0E-05	-5.3E-08	-5.3E-06	-3.8E-05	-8.8E-06
	SPO	-5.1E-06	-2.5E-06	-8.5E-06	-8.7E-07	-2.1E-07
	SAS	-3.6E-06	-1.4E-07	-5.4E-06	-4.2E-06	-8.3E-07
Sulfate	Global	-3.2E-03	-2.2E-04	-3.5E-03	-6.5E-03	-2.0E-03
	SAF	-3.0E-04	-9.9E-05	-5.0E-04	-1.1E-04	-1.8E-05
	NAM	-1.1E-03	3.6E-06	-1.0E-03	-3.0E-03	-8.5E-04
	EAS	-5.8E-04	-3.2E-06	-7.5E-04	-9.7E-04	-2.7E-04
	EUR	-5.5E-04	1.0E-06	-2.9E-04	-1.9E-03	-7.8E-04
	SPO	-3.3E-04	-1.1E-04	-5.8E-04	-4.1E-05	7.2E-06
	SAS	-2.7E-04	-2.9E-06	-3.8E-04	-3.5E-04	-7.8E-05
NOx-nitrate	Global	-3.2E-04	-5.6E-07	-2.8E-04	-9.7E-04	-4.1E-05
	SAF	-1.2E-05	-1.9E-07	-1.7E-05	-1.9E-05	-4.8E-08
	NAM	-9.4E-05	5.8E-10	-8.0E-05	-2.8E-04	-1.3E-05
	EAS	-3.2E-05	6.0E-09	-2.4E-05	-1.1E-04	-6.1E-06
	EUR	-1.1E-04	-3.9E-09	-6.7E-05	-4.2E-04	-1.9E-05
	SPO	-5.9E-06	-3.5E-07	-8.3E-06	-8.5E-06	-1.8E-08
	SAS	-4.1E-05	1.7E-09	-5.7E-05	-6.4E-05	-3.2E-07
NOx-methane	Global	-9.3E-03	-6.8E-03	-1.1E-02	-8.6E-03	-6.1E-03
	SAF	-1.1E-03	-8.3E-04	-1.4E-03	-1.0E-03	-7.4E-04
	NAM	-2.7E-03	-2.0E-03	-3.3E-03	-2.5E-03	-1.8E-03
	EAS	-1.7E-03	-1.2E-03	-2.0E-03	-1.5E-03	-1.1E-03
	EUR	-1.5E-03	-1.1E-03	-1.8E-03	-1.4E-03	-9.7E-04
	SPO	-1.4E-03	-9.0E-04	-1.5E-03	-1.1E-03	-8.1E-04
	SAS	-7.0E-04	-4.5E-04	-7.4E-04	-5.6E-04	-4.0E-04

Table S3: Regional climate sensitivities (RCS) used in the emission metric calculations [K (W m^{-2})$^{-1}$] (Shindell & Faluvegi, 2009).

Sulfate, OC, nitrate, methane, contrail-cirrus		Forcing region			
		90°S-28°S	28°S-28°N	28°N-60°N	60°N-90°N
Response region	90° S-28° S	0.19	0.05	0.02	0
	28° S-28° N	0.09	0.24	0.1	0.02
	28° N-60° N	0.07	0.17	0.24	0.06
	60° N-90° N	0.06	0.16	0.17	0.31
NOx-induced ozone change		Forcing region			
		90°S-28°S	28°S-28°N	28°N-60°N	60°N-90°N
Response region	90° S-28° S	0.19	0.13	-0.06	-0.03
	28° S-28° N	0.09	0.26	0.09	0.02
	28° N-60° N	0.07	0.15	0.2	0.06
	60° N-90° N	0.06	0.13	0.05	0.07
BC		Forcing region			
		90°S-28°S	28°S-28°N	28°N-60°N	60°N-90°N
Response region	90° S-28° S	0.19	0.06	0.02	0
	28° S-28° N	0.09	0.17	0.07	0.02
	28° N-60° N	0.07	0.24	0.14	0.08
	60° N-90° N	0.06	0.31	0.15	-0.08

Table S4 Relative uncertainties adopted in the Monte Carlo analysis.

	Relative uncertainty (1 SD)	Source
BC	39%	AeroCom multi-model mean (Myhre et al., 2013a)
SO_2 (sulfate)	34%	AeroCom multi-model mean (Myhre et al. 2013a)
OC	33%	AeroCom multi-model mean (Myhre et al. 2013a)
NOx (nitrate)	50%	AeroCom multi-model mean (Myhre et al. 2013a)
NOx	73%	IPCC AR5, WG1 Ch.8 SM (Myhre et al., 2013b)
CO2	6%	IPCC AR5, WG1 Ch.8 SM (Myhre et al. 2013b)

Table S5: Global and regional GWP and GTP of contrail-cirrus for time horizons 20 and 100 years, calculated per km accumulated flight distance. The GTPs are calculated using the impulse response function by Boucher and Reddy (2008) and values are given relative to CO_2 using CO_2 parameters from Joos et al. (2013).

		GWP		GTP	
Component	Source region	H=20	H=100	H=20	H=100
Contrail-cirrus	Global	27	7.5	8	1.1
	SAF	55	15	17	2.2
	NAM	41	11	12	1.6
	EAS	36	10	11	1.4
	EUR	42	11	13	1.6
	SPO	44	12	13	1.7
	SAS	40	11	12	1.6

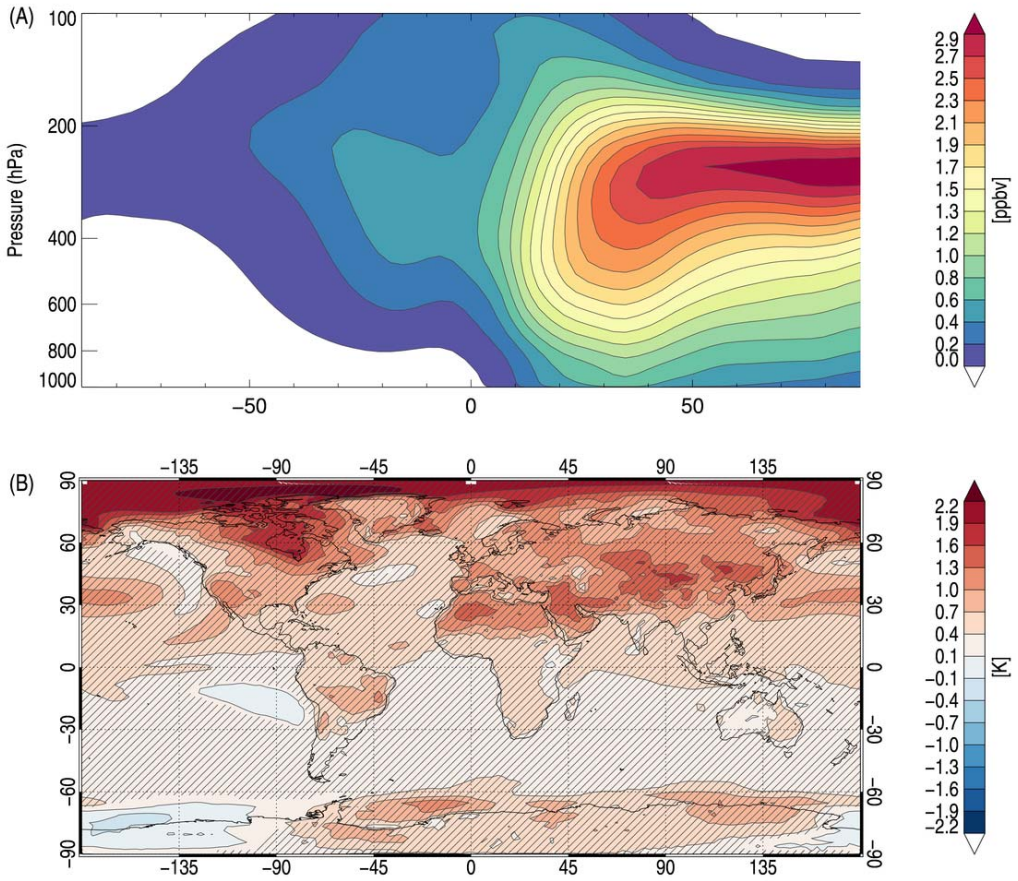
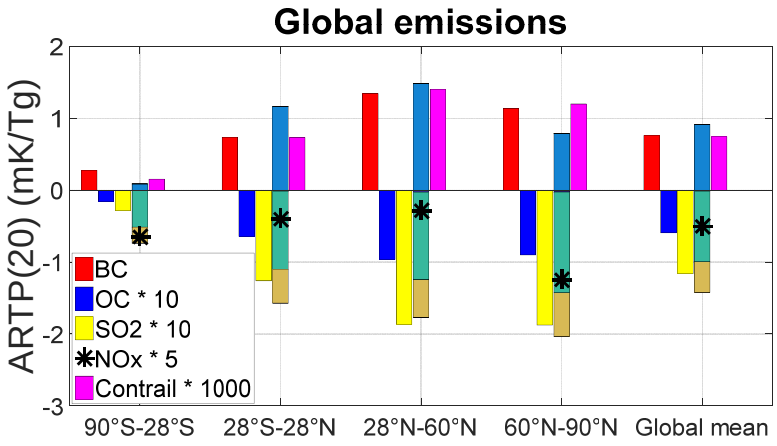


Figure S1: (A) Zonal, annual mean ozone concentration change from OsloCTM3 caused by global aviation NOx emissions and (B) annual mean surface temperature response to the aviation ozone perturbation (scaled by a factor 40) as simulated by CESM1.2. Hatching indicates statistical significance at the 0.05 level.



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49 *Figure 2: ARTP(20) for BC, OC, SO_2, NOx and contrail-cirrus for global aviation emissions.*
50 *NOx is comprised of contributions from ozone (light blue), methane (teal green), methane-induced*
51 *ozone (dark yellow) changes and nitrate aerosols (dark blue). The asterisk indicate the net NOx*
52 *effect.*

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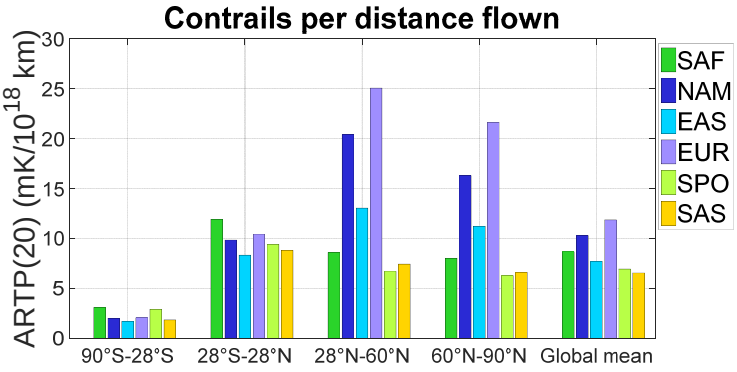

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56 *Figure S3: ARTP(20) of aviation-induced contrail-cirrus calculated per accumulated km flight*
57 *distance.*

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