Table S-1: Model treatment of OA/OC and aerosol schemes.

	Submitted OC or OA	SOA treatment	Aerosol parametrization
SPRINTARS	OA	SOA included in OA	An aerosol module in SPRINTARS predicts mass mixing ratios of the main tropospheric aerosols: carbonaceous (BC and organic matter; OM), sulfate, soil dust, and sea salt, and the precursor gases of sulfate, i.e. sulfur dioxide (SO2) and DMS. SPRINTARS is coupled with the radiation and cloud/precipitation schemes in the GCM for calculating the direct, semi-direct, and indirect effects of aerosols. In the calculation of the direct effect, the refractive indices depending on wavelengths, size distributions, and hygroscopic growth are considered for each type of aerosol. The aerosol semi-direct effect is also included as a consequence of a link between the GCM and aerosol module. Number concentrations for cloud droplets and ice crystals are prognostic variables as well as their mass mixing ratios, and changes in their radii and precipitation rates are calculated for the indirect effect. More detailed descriptions of SPRINTARS can be found in Takemura et al. (2000) for the aerosol transport, Takemura et al. (2002) for the aerosol direct effect, and Takemura et al. (2005)for the aerosol indirect effect on water and ice clouds.
OsloCTM3	OC	SOA not included in OC	Bulk parameterization of carbonaceous aerosols with conversion from hydrophobic to hydrophilic mode determined by latitudinally and seasonally varying aging timescales (Skeie et al., 2011). Coupled sulfur cycle/oxidant chemistry scheme (Berglen et al. 2004).
GOCART	OC	---	Aerosol particle sizes from 0.01 to 10 µm are included with parameterized hygroscopic growth, which depends on the ambient relative humidity (RH) and aerosol type. The only wet phase chemistry in GOCART is SO2+H2O2 → sulfate, where H2O2 is a prescribed field from the GEOS-Chemistry Climate Model.
C-IFS	OC	---	The MACC aerosol scheme is a bulk scheme with 3 size bins for desert dust and sea-salt, organic and black carbon as well as sulphate and SO2 (Morcrette et al., 2009).
CHASER-T42	OC	---	The chemical component of CHASER calculates aerosols in cooperation with SPRINTARS, and considers chemical processes/interactions of aerosols including nitrate formation based on ISORROPIA as well as sulfate formation. An aerosol module in SPRINTARS predicts mass mixing ratios of the main tropospheric aerosols, see the aerosol parametrization for SPRINTARS above for further details.
CHASER-T106	OC	---	(as above)
CAMchem	OA	SOA included in OA	CAM4-chem uses a bulk aerosol scheme for black carbon, organic carbon, sulfate, ammonium and ammonium nitrate. Sea salt and dust each have 4 size bins and emissions are calculated online. SOA are derived using the 2-product model approach using laboratory-determined yields for SOA formation from photooxidation of monoterpenes, isoprene and aromatics.
GEOS5	OA	---	GEOS5 considers two OA tracers (i.e. hydrophilic and hydrophilic) and convert hydrophoblic OA to hydrophilic OA in 2.5 days. Aerosol particle sizes from 0.01 to 10 µm are included with parameterized hygroscopic growth, which depends on the ambient relative humidity and aerosol type. The only wet phase chemistry in GEOS5-GOCART is SO2+H2O2 → sulfate, where H2O2 is a prescribed field from the GEOS-Chemistry Climate Model.
GEOSCHEM ADJOINT	OC	---	sulfate, sulfate on surface of sea-salt aerosol, inorganic nitrate, inorganic nitrates on surface of sea-salt aerosol, ammonium, hydrophilic BC, hydrophobic BC, hydrophilic OC, hydrophobic OC, dust (4 bins), accumulation mode sea salt, coarse mode sea salt
EMEPrv48	OC	---	Two size-modes for particles, although our definitions of particle-size depend a little on the compound.

Table S-2: BC burden (BD) changes and direct radiative forcing (DRF), global, annual mean, when reducing emissions by 20 % within the indicated region. DRF was calculated using full 4D AFE profiles. Burden is given in mgm^{-2} and radiative forcing is given in mWm^{-2}.

	NAM		EUR		SAS		EAS		RBU		MDE	
Model	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**
OsloCTM3	-1.3	-2.2	-1.3	-2.7	-7.1	-11.0	-7.7	-12.4	-0.3	-0.5	-0.25	-0.44
GEOS5	-1.8	-3.1	-1.5	-2.3	-9.5	-17.9	-10.3	-17.3	-0.5	-0.8	---	---
CHASERT42	-3.1	-4.6	-3.2	-4.7	-15.9	-26.4	-16.2	-24.4	-0.7	-1.0	-0.0	0.3
CHASERT106	-2.5	-3.2	-2.7	-3.3	-12.3	-17.6	-13.2	-16.1	---	---	---	---
GOCART	-2.1	-3.5	-2.2	-3.3	-13.4	-30.9	-14.2	-26.3	-0.6	-0.0	-0.3	-0.5
SPRINTARS	-1.5	-2.5	-2.0	-3.6	-14.7	-22.4	-14.9	-20.9	-1.5	-2.55	-1.4	-2.5
CAMchem	-1.4	-1.9	-1.7	-2.3	-7.9	-11.9	-8.9	-11.9	-0.4	-0.5	-0.2	-0.2
C-IFS	-1.5	-1.8	-1.2	-1.5	-7.1	-9.7	-6.7	-7.8	---	---	---	---
GEOSCHEM	-1.5	-2.4	-1.4	-1.9	-9.1	-18.4	-9.8	-15.9	-0.4	-0.5	-0.2	-0.4
EMEPrv48	---	---	---	---	---	---	---	---	---	---	---	---
Mean	**-1.9**	**-2.8**	**-1.9**	**-2.8**	**-10.8**	**-18.5**	**-11.3**	**-17.0**	**-0.6**	**-0.8**	**-0.4**	**-0.6**
Median	**-1.5**	**-2.5**	**-1.7**	**-2.7**	**-9.5**	**-17.9**	**-10.3**	**-16.1**	**-0.5**	**-0.5**	**-0.2**	**-0.4**
Std.dev.	**0.6**	**0.9**	**0.6**	**0.9**	**3.2**	**6.6**	**3.2**	**5.7**	**0.4**	**0.8**	**0.4**	**0.9**

Table S-3: OA burden (BD) changes and direct radiative forcing (DRF), global, annual mean, when reducing emissions by 20 % within the indicated region. DRF was calculated using full 4D AFE profiles. Burden is given in mgm^{-2} and radiative forcing is given in mWm^{-2}.

	NAM		**EUR**		**SAS**		**EAS**		**RBU**		**MDE**	
Model	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**
OsloCTM3	-5.7	0.9	-6.3	0.8	-39.3	7.1	-35.1	5.0	-2.8	0.3	-0.6	0.1
GEOS5	-6.8	1.1	-6.5	0.9	-64.4	11.5	-53.56	7.36	-1.1	0.0	---	---
CHASERT42	-16.7	3.2	-11.5	1.9	-118.5	21.6	-65.4	10.3	-2.5	0.4	-1.2	0.2
CHASERT106	-11.8	2.3	-8.8	1.5	-82.1	15.0	-50.0	7.6	---	---	---	---
GOCART	-5.0	0.8	-4.1	0.5	-48.6	8.6	-39.6	5.6	-1.5	0.2	-0.5	0.1
SPRINTARS	-6.8	1.3	-6.0	1.0	-48.8	9.1	-41.4	6.6	0.7	-0.2	-1.5	0.2
CAMchem	-5.1	0.9	-4.6	0.7	-30.4	5.5	-23.0	3.2	-0.4	0.0	0.0	-0.0
C-IFS	-3.7	0.7	-3.0	0.5	-32.1	5.8	-20.3	3.0	---	---	---	---
GEOSCHEM	-3.9	0.6	-4.0	0.5	-35.0	6.3	-30.2	4.2	-1.0	0.1	-0.5	0.1
EMEPrv48	-11.2	2.0	-8.5	1.4	-35.1	7.0	-29.0	4.5	---	---	---	---
Mean	**-7.3**	**1.3**	**-6.1**	**0.9**	**-55.5**	**10.1**	**-39.8**	**5.9**	**-1.2**	**0.1**	**-0.7**	**0.1**
Median	**-5.7**	**0.9**	**-6.0**	**0.8**	**-48.6**	**8.6**	**-39.6**	**5.6**	**-1.1**	**0.1**	**-0.6**	**0.1**
Std.dev.	**4.0**	**0.8**	**2.5**	**0.6**	**27.3**	**5.0**	**13.9**	**2.2**	**1.1**	**0.2**	**0.5**	**0.1**

Table S-4: SO_4 burden (BD) changes and direct radiative forcing (DRF), global, annual mean, when reducing emissions by 20 % within the indicated region. DRF was calculated using full 4D AFE profiles. Burden is given in mgm^{-2} and radiative forcing is given in mWm^{-2}.

	NAM		**EUR**		**SAS**		**EAS**		**RBU**		**MDE**	
Model	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**	**BD**	**DRF**
OsloCTM3	-34.7	7.5	-23.8	4.5	-42.6	9.9	-78.1	16.1	-13.2	2.3	-33.6	6.4
GEOS5	-27.2	6.3	-18.6	3.6	-61.3	13.5	-78.1	15.8	-12.0	2.3	---	---
CHASERT42	-67.1	17.8	-43.5	10.1	-111.2	27.1	-142.2	32.7	-19.2	4.7	-89.4	19.0
CHASERT106	-45.2	12.8	-34.0	8.0	-79.5	20.1	-91.7	21.8	---	---	---	---
GOCART	-28.2	6.2	-29.6	5.0	-30.8	7.5	-115.7	21.3	-19.1	2.8	-36.7	6.7
SPRINTARS	-47.3	13.0	29.8	6.9	-64.7	16.5	-140.4	35.5	-12.5	2.7	-58.7	12.7
CAMchem	-31.2	8.4	-23.9	5.4	-52.5	13.1	-81.2	16.8	-12.4	2.9	-55.7	10.9
C-IFS	-40.5	10.5	-19.7	4.4	-57.1	13.7	-88.0	20.0	---	---	---	---
GEOSCHEM	-19.9	4.7	-20.2	3.8	-24.4	6.1	-82.1	16.4	-11.7	2.3	-47.6	8.8
EMEPrv48	-29.1	7.2	-24.2	5.3	-43.0	10.8	-60.4	12.5	-24.1	4.5	---	---
Mean	**-37.9**	**9.7**	**-20.4**	**5.7**	**-58.2**	**14.2**	**-99.7**	**21.8**	**-14.2**	**2.9**	**-53.6**	**10.8**
Median	**-34.7**	**8.4**	**-23.8**	**5.0**	**-57.1**	**13.5**	**-88.0**	**20.0**	**-12.5**	**2.7**	**-51.6**	**9.9**
Std.dev.	**13.3**	**4.0**	**19.3**	**2.0**	**24.7**	**6.1**	**24.7**	**6.9**	**3.1**	**0.8**	**18.4**	**4.3**

Table S-5: Indication of which model groups performed which experiments.

	Base	***NAMreduced***	***EURreduced***	***SASreduced***	***EASreduced***	***RBUreduced***	***MDEreduced***
OsloCTM3	X	X	X	X	X	X	X
GEOS5	X	X	X	X	X	X	
CHASERT42	X	X	X	X	X	X	X
CHASERT106	X	X	X	X	X		
GOCART	X	X	X	X	X	X	X
SPRINTARS	X	X	X	X	X	X	X
CAMchem	X	X	X	X	X	X	X
C-IFS	X	X	X	X	X		
GEOSCHEM	X	X	X	X	X	X	X
EMEPrv48	X	X	X	X	X	X	

	NAM	EUR	SAS	EAS	RBU	MDE	ARC
NAMreduced	-406 ± 62	-132 ± 53	-32 ± 64	-44 ± 34	-81 ±43	-60 ±29	-93 ±58
EURreduced	-32 ±18	-768 ± 139	-30 ± 45	-77 ± 53	-289 ±107	-189 ± 73	-122 ± 52
SASreduced	-59 ± 51	-43 ± 49	-1639 ± 395	-331 ± 149	-40 ± 45	-258 ± 102	-41 ± 42
EASreduced	-83 ± 38	-40 ± 26	-95 ± 51	-564 ± 91	-83 ± 39	-37 ± 24	-66 ± 39
RBUreduced	-49 ± 36	-235 ± 61	-30 ± 117	-142 ± 61	-564 ± 126	-92 ± 71	-168 ± 56
MDEreduced	-80 ± 242	-103 ± 158	-511 ± 787	-241 ± 239	-166 ± 193	-2676 ± 166	-93 ± 206

Table S-6: Table of source-receptor relationships for radiative forcing from BC (numbers behind Fig. 9 (e) and 9 (f)), with source regions given as rows and receptor regions as columns. Values are multi-model medians and one standard deviation, and the unit is $mWm^{-2}Tg^{-1}$.

	NAM	EUR	SAS	EAS	RBU	MDE	ARC
NAMreduced	78 ± 49	12 ± 13	1.5 ± 5.0	2.1 ± 2.1	5.3 ± 4.7	3.6 ± 4.6	2.5 ± 2.1
EURreduced	2.6 ± 4.7	105 ± 60	6.7 ± 6.6	6.7 ± 4.6	22 ± 15	25 ± 16	3.8 ± 1.9
SASreduced	3.0 ± 2.6	2.7 ± 2.5	254 ± 139	18 ± 19	1.7 ± 1.4	12 ± 9	0.8 ± 0.7
EASreduced	3.3 ± 2.5	1.3 ± 1.9	3.8 ± 6.8	73 ± 30	5.1 ± 2.4	2.3 ± 1.6	1.0 ± 0.8
RBUreduced	2.0 ± 16	31 ± 17	2.1 ± 19.5	10 ± 6	57 ± 23	8.1 ± 8.8	4.9 ± 2.3
MDEreduced	4.4 ± 133.1	23 ± 52.8	73 ± 102	19 ± 8	16 ± 45	303 ± 117	2.2 ± 33.0

Table S-7: Table of source-receptor relationships for radiative forcing from OA (numbers behind Fig. 9 (c) and 9 (d)), with source regions given as rows and receptor regions as columns. Values are multi-model medians and one standard deviation, and the unit is $mWm^{-2}Tg^{-1}$.

	NAM	**EUR**	**SAS**	**EAS**	**RBU**	**MDE**	**ARC**
NAMreduced	37 ± 11	8.9 ± 5.7	0.6 ± 1.7	1.3 ± 1.2	2.9 ± 2.1	1.9 ± 2.3	1.8 ± 0.8
EURreduced	1.5 ± 0.9	85 ± 30	7.3 ± 4.5	6.6 ± 3.0	20 ± 9.1	29 ± 10.6	2.9 ± 1.2
SASreduced	1.8 ± 1.6	1.7 ± 1.6	171 ± 58	15 ± 14	1.2 ± 0.9	12 ± 8	0.5 ± 0.4
EASreduced	4.4 ± 2.1	2.3 ± 1.3	3.2 ± 4.8	50 ± 11	4.9 ± 2.2	1.3 ± 1.3	1.2 ± 0.9
RBUreduced	1.8 ± 1.1	15 ± 6	2.7 ± 4.8	11 ± 4.4	50 ± 13	6.9 ± 6.1	5.1 ± 1.9
MDEreduced	3.5 ± 1.4	12 ± 5	66 ± 27	16 ± 7	11 ± 5	198 ± 57	1.5 ± 0.6

Table S-8: Table of source-receptor relationships for radiative forcing from SO_4 (numbers behind Fig. 9 (a) and 9 (b)), with source regions given as rows and receptor regions as columns. Values are multi-model medians and one standard deviation, and the unit is $mWm^{-2}Tg^{-1}$.

Table S-9: As Table 4, but for the four HTA1 regions. Response to Extra-Regional Emission Reductions (RERER), averaged over the 10 participating models. A high RERER value means that the given region is very sensitive to extra-regional emission reductions. The top table shows RERER for column aerosol burdens, the bottom table shows RERER for DRF calculated using vertically, spatially and temporally resolved AFE profiles.

Burden	**NAM**	**EUR**	**SAS**	**EAS**
BC	0.57 ± 0.09	0.58 ± 0.06	0.23 ± 0.06	0.28 ± 0.05
OA	0.57 ± 0.14	0.63 ± 0.07	0.20 ± 0.07	0.33 ± 0.04
SO_4	0.51 ± 0.10	0.71 ± 0.05	0.50 ± 0.05	0.35 ± 0.03
DRF	**NAM**	**EUR**	**SAS**	**EAS**
BC	0.71 ± 0.09	0.72 ± 0.07	0.29 ± 0.04	0.41 ± 0.05
OA	0.58 ± 0.15	0.65 ± 0.08	0.20 ± 0.04	0.37 ± 0.08
SO_4	0.47 ± 0.09	0.68 ± 0.05	0.35 ± 0.04	0.35 ± 0.07