



Supplement of

Large gain in air quality compared to an alternative anthropogenic emissions scenario

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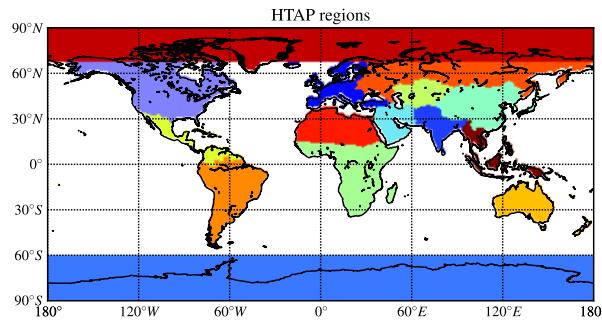


Figure S1. The HTAP source regions. Each region is represented by a different color see text for explanation of regions 2-17.

The globe was split in 16 socioeconomic regions according to the Hemispheric Transport of Air Pollution (HTAP) source regions. These regions are:

1. World (this region represents the whole globe).
2. Non-arctic/Antarctic Ocean.
3. U.S. and Canada (up to 66°North).
4. Western and Eastern E.U. and Turkey (up to 66°; polar circle).
5. South Asia: India, Nepal, Pakistan, Afghanistan, Bangladesh, Sri Lanka.
6. East Asia: China, Korea, Japan.
7. South East Asia.
8. Pacific, Australia and New Zealand.
9. Northern Africa, Sahara and Sahel.
10. Sub Saharan/ sub Sahel Africa.
11. Middle East: S. Arabia, Oman etc., Iran, Iraq.
12. Mexico, Central America, Caribbean, Guyana, Venezuela, Colombia.
13. South America.
14. Russia, Belarus, Ukraine.
15. Central Asia.
16. Arctic Circle (North of 66°N) and Greenland.
17. Antarctic.

Table S1. Global anthropogenic emissions of pollutants for the year 1980 in Tgy^{-1} used in TM4-ECPL model for CL simulation (NO_x is reported as N)

	Global	Europe	N. America	India	China
CO	585.16	86.15	128.56	59.40	113.56
NO_x	24.26	4.45	6.27	0.72	2.44
NH_3	29.06	3.51	3.02	4.48	4.89
OC	11.00	0.93	0.74	1.30	2.37
BC	4.52	0.55	0.44	0.37	1.06
SO_2	120.67	37.84	24.56	1.74	14.08

Table S2. a) Anthropogenic emission reductions (CL) compared to BA1980 accounting for increase in population and assuming constant per capita emissions as those of the year 1980. b) Emission reductions (CL) when in addition to the population increase (BA1980) the increase in energy use per capita is also taken into account per region (based on the World Bank statistics of 2010 versus 1980) and all energy is assumed to be produced from oil consumption.

a. Achieved emission reductions compared to no policy accounting for increased population								
CL/BA1980	N. America	Europe	India	China	S.E. Asia	Africa	Asia	Global
OC	0.48	0.59	0.84	1.01	1.52	0.81	0.93	0.85
BC	0.59	0.64	0.92	1.10	1.67	0.81	0.89	0.82
NO _x	0.66	0.62	1.55	1.59	1.91	0.45	1.00	0.77
CO	0.49	0.36	0.77	0.97	1.01	0.75	0.87	0.68
NH ₃	0.76	1.07	0.61	1.25	1.30	0.46	0.87	0.80
SO _x	0.45	0.24	2.35	1.25	2.09	0.40	1.03	0.56

b. Achieved emission reductions compared to no policy accounting for increased population and increased energy demand								
mean increase in energy use**	0.90	1.01	2.04	3.08	2.30	1.00&	2.50&	1.30
CL/energy-demand	N. America	Europe	India	China	S.E. Asia	Africa	Asia	Global
OC	0.54	0.59	0.41	0.33	0.66	0.81	0.37	0.65
BC	0.66	0.63	0.45	0.36	0.73	0.81	0.35	0.63
NO _x	0.74	0.61	0.76	0.52	0.83	0.45	0.40	0.59
CO	0.55	0.36	0.38	0.31	0.44	0.75	0.35	0.52
NH ₃	0.85	1.06	0.30	0.41	0.57	0.46	0.35	0.61
SO _x	0.50	0.23	1.15	0.40	0.91	0.40	0.41	0.43

** assuming increase in energy use per capita and that all is based on oil consumption, i.e. no renewable energy;
<http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE/countries/IW-B8-CN-IN?display=default> energy use as equivalent of oil consumption

& rough estimate

Table S3. Fractional changes in regional mean surface concentrations in 2010 for AE1980 and BA1980 compared to the CL simulation.

a. Anthropogenic Emissions fixed to 1980 (AE1980)								
AE1980/CL	Global	Europe	China	India	N. America	Africa	S.E. Asia	S. America
NO _x	0.95	1.30	0.53	0.55	0.98	1.02	0.60	0.99
SO ₂	1.19	2.82	0.60	0.30	1.49	0.97	0.50	1.65
O ₃	0.98	0.99	0.93	0.89	1.00	0.99	0.85	0.98
CO	1.06	1.39	0.94	0.89	1.19	0.99	0.94	1.00
SO ₄ ²⁻	1.19	2.54	0.65	0.47	1.43	1.22	0.57	1.43
OC	0.94	1.25	0.78	0.74	1.17	0.93	0.78	0.98
BC	0.93	1.33	0.69	0.67	1.12	0.88	0.62	0.88

b. Business As 1980 (BA1980) increase in population and constant per capita emissions as in 1980								
BA1980/CL	Global	Europe	China	India	N. America	Africa	S.E. Asia	S. America
NO _x	1.21	1.63	0.72	0.87	1.29	1.30	0.95	1.17
SO ₂	1.55	3.41	0.84	0.72	1.98	1.62	1.03	1.89
O ₃	1.05	1.07	1.03	1.03	1.08	1.10	1.00	1.05
CO	1.22	1.69	1.19	1.24	1.44	1.14	1.09	1.06
SO ₄ ²⁻	1.54	3.22	0.91	0.92	1.87	1.72	0.94	1.60
OC	1.10	1.54	1.01	1.19	1.43	1.07	0.90	1.06
BC	1.22	1.66	0.95	1.19	1.51	1.13	0.84	1.05

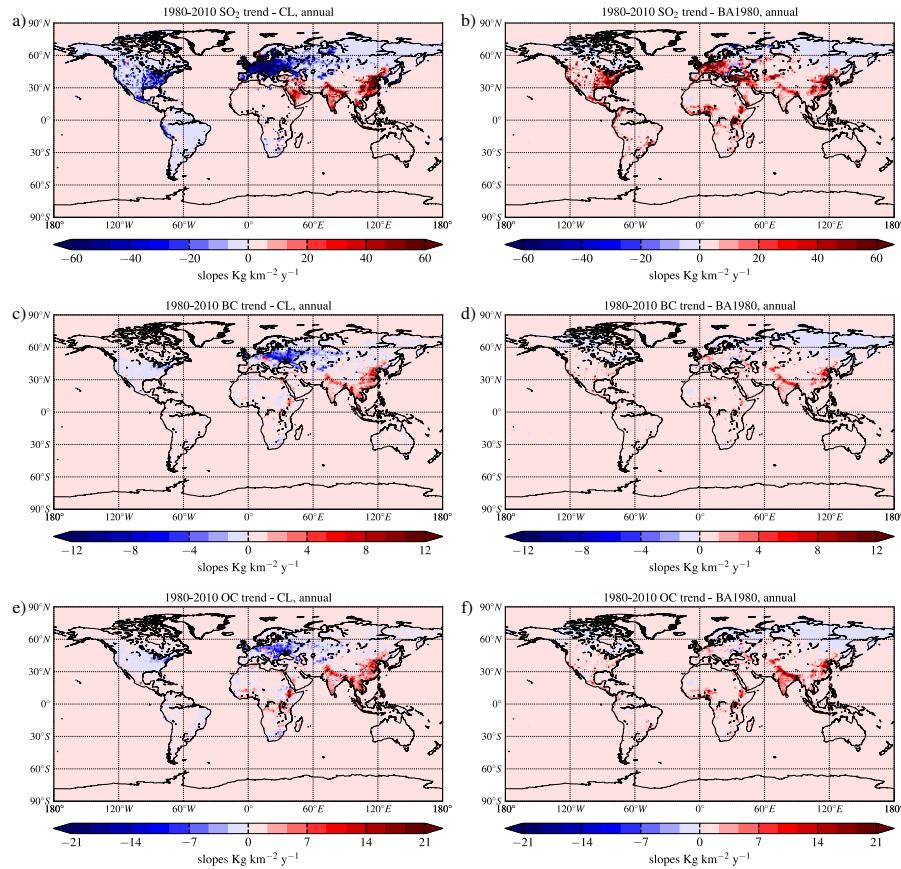


Figure S2. Distribution of annual mean anthropogenic emission trends for the period 1980-2010. Trends are calculated per grid box as mean over the period. Units are $\text{Kg km}^{-2} \text{y}^{-1}$ for NO_x in $\text{Kg(N) km}^{-2} \text{y}^{-1}$. Left column for CL scenario, right column BA1980 scenario. Top: CO, middle: NH_3 , bottom: NO_x .

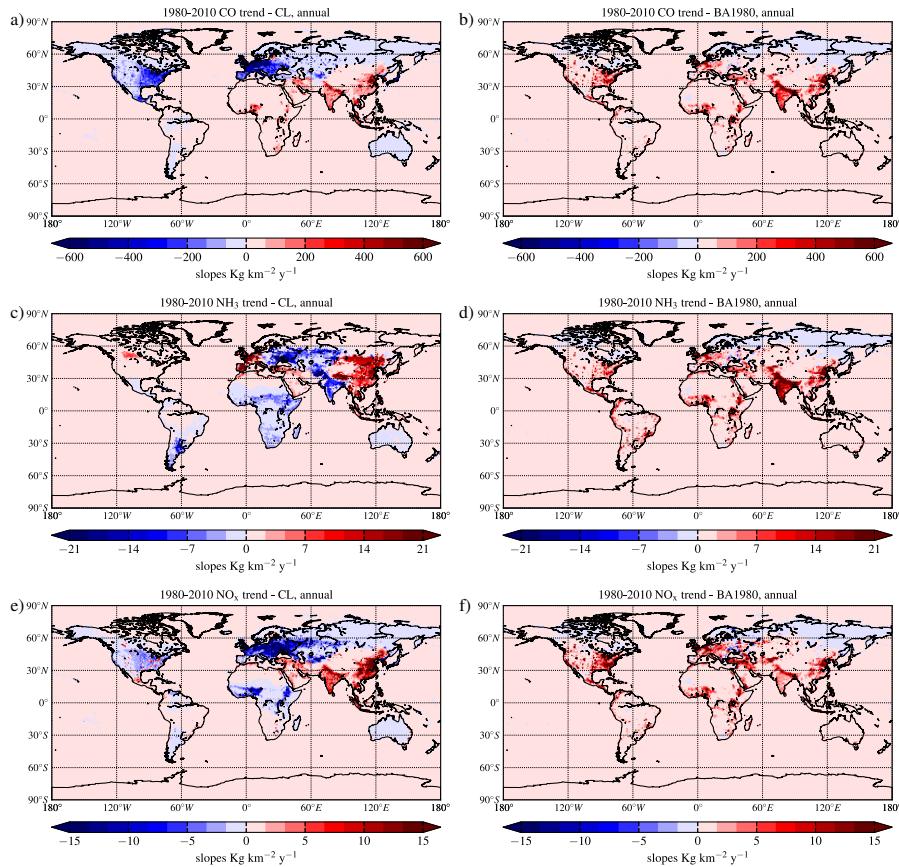


Figure S3. Distribution of annual mean anthropogenic emission trends for the period 1980-2010. Trends are calculated per grid box as mean over the period. Units are $\text{Kg km}^{-2} \text{y}^{-1}$. Left column for CL scenario, right column BA1980 scenario. Top: SO₂, middle: BC, bottom: OC.

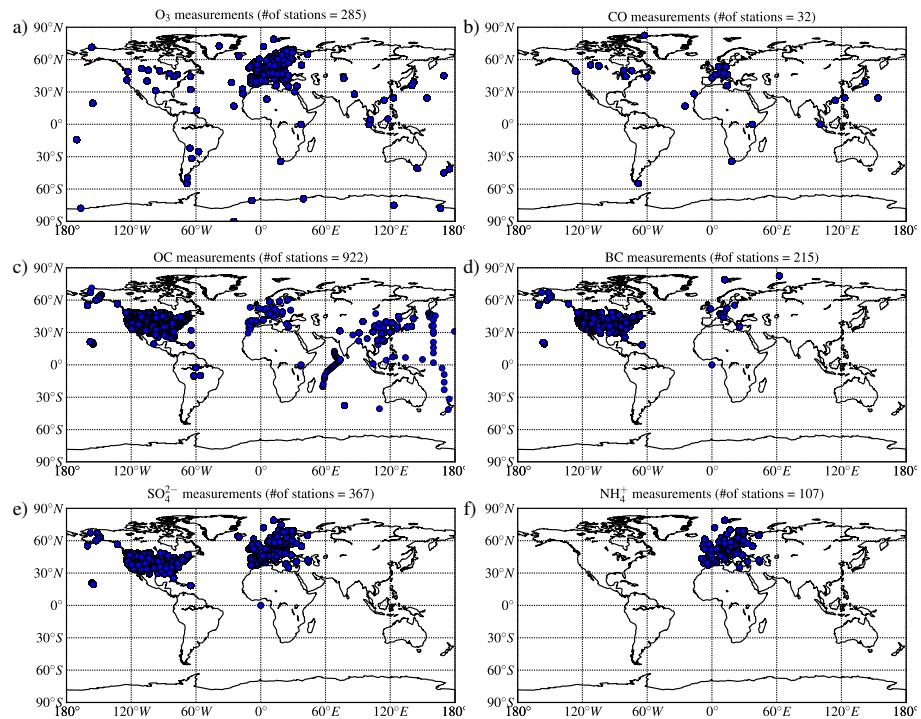


Figure S4. Location of surface stations used for model evaluation: a) for O_3 , b) for CO, c) for OC, d) for BC, e) for SO_4^{2-} , f) NH_4^+ . Number of stations used is provided in the title.

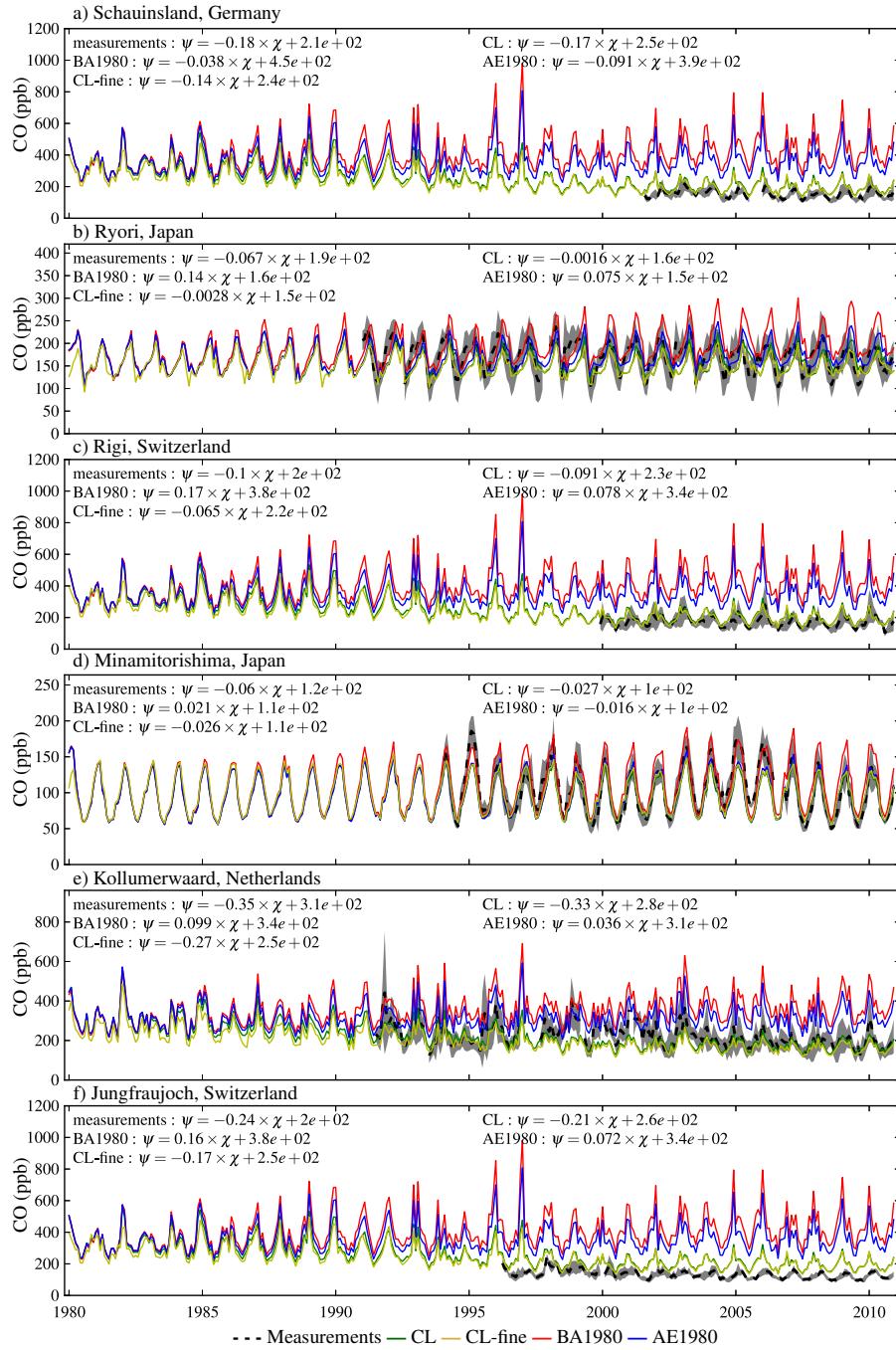


Figure S5. Comparison of the four simulations against CO observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

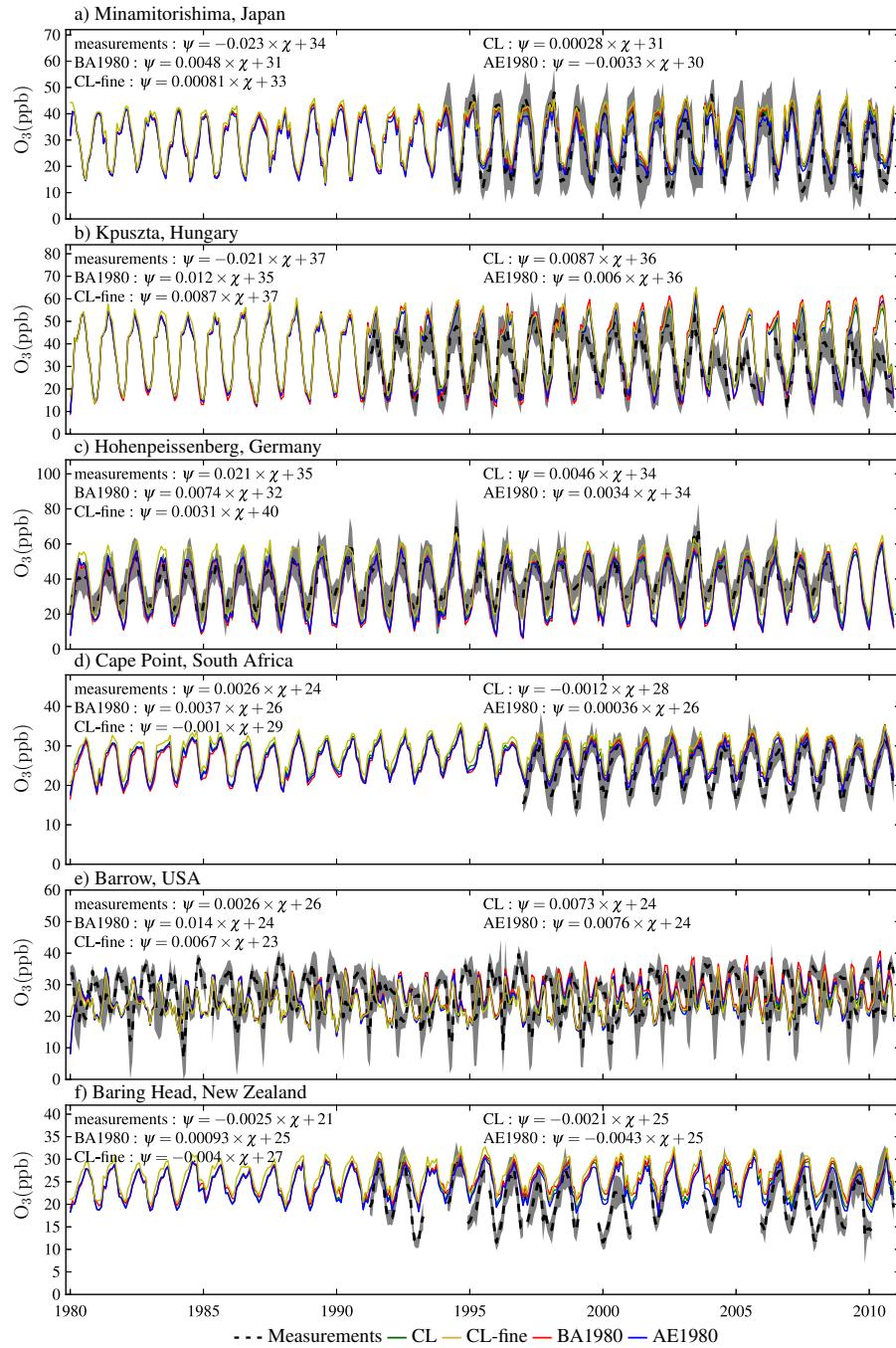


Figure S6. Comparison of the four simulations against O₃ observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

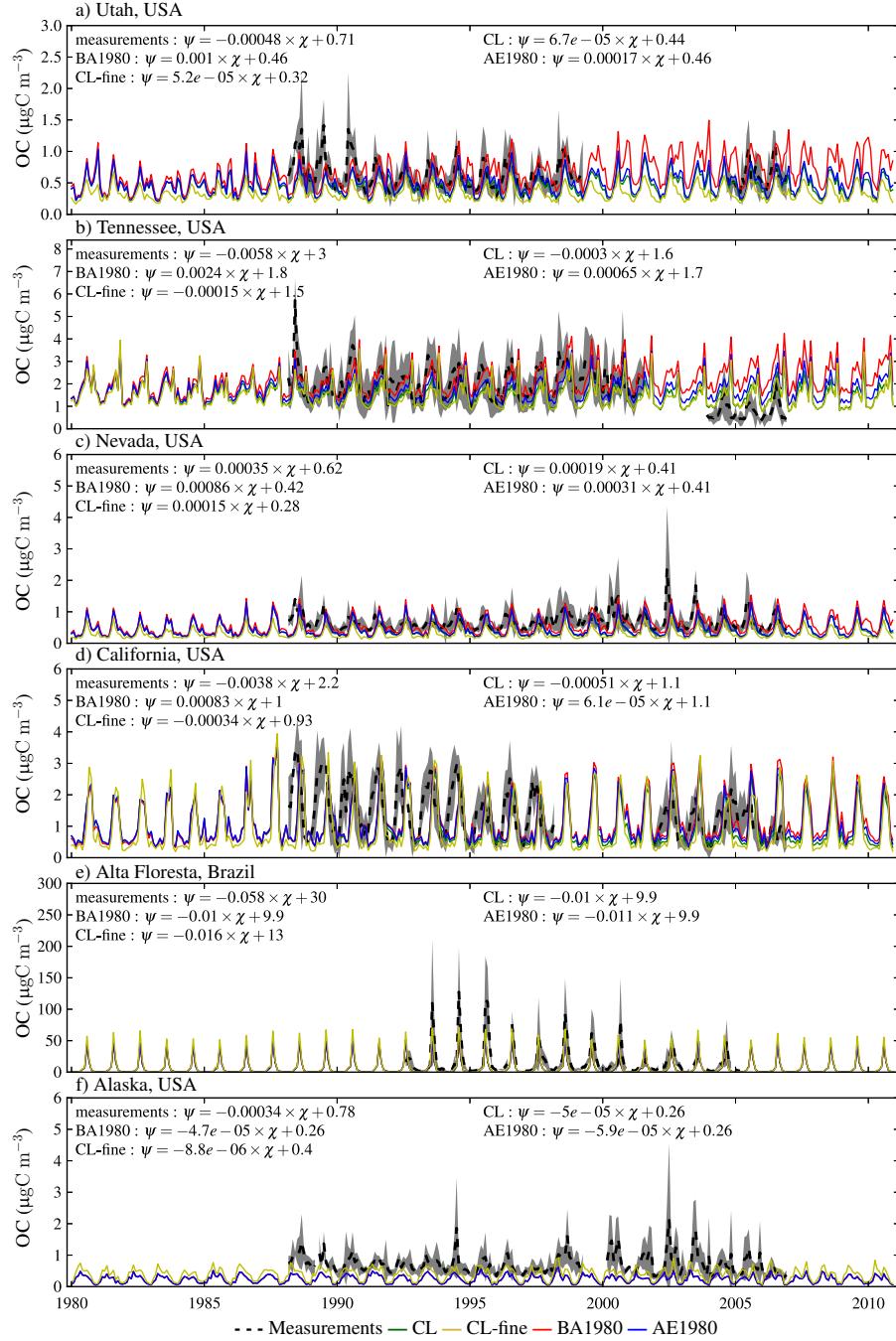


Figure S7. Comparison of the four simulations against OC observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

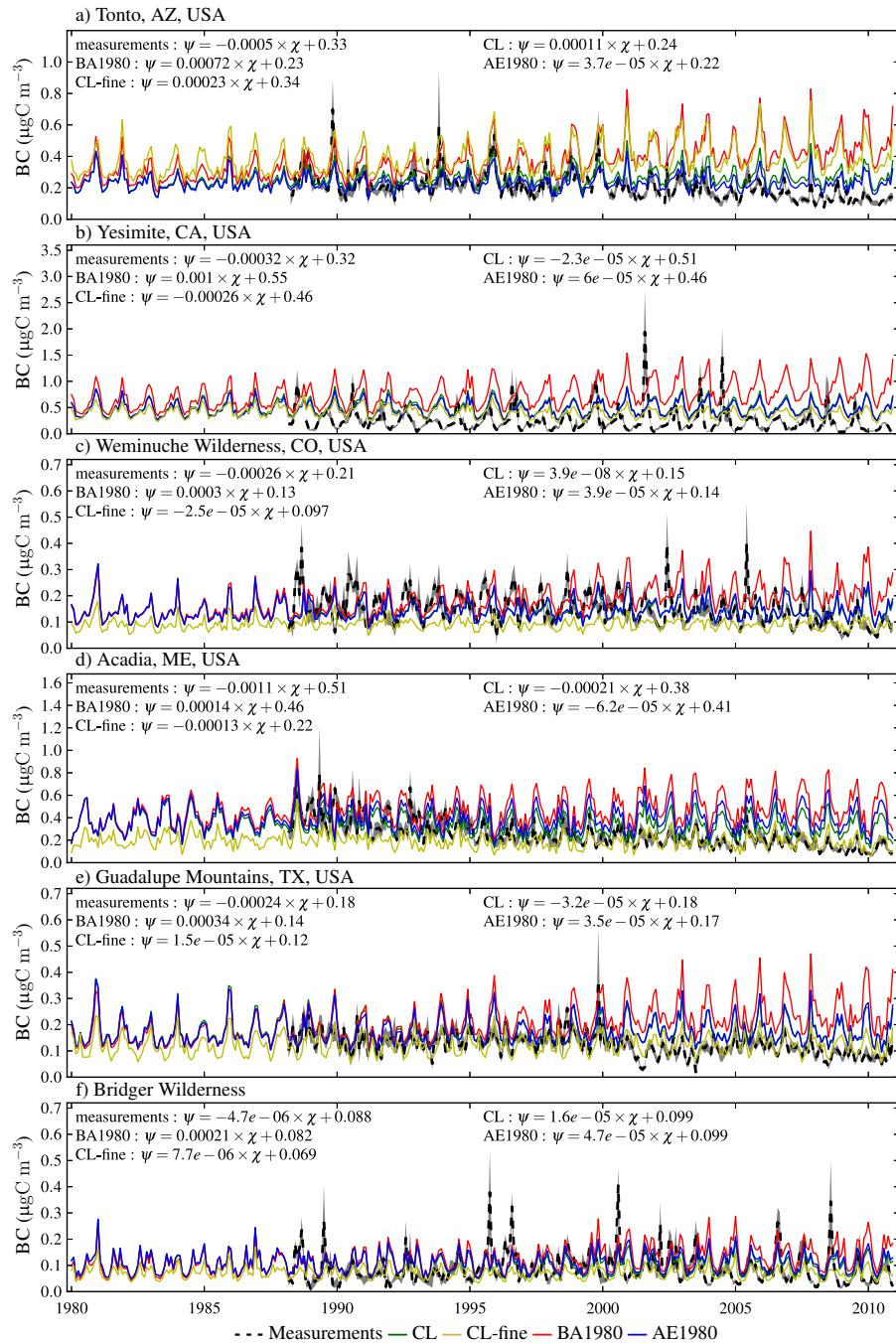


Figure S8. Comparison of the four simulations against BC observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

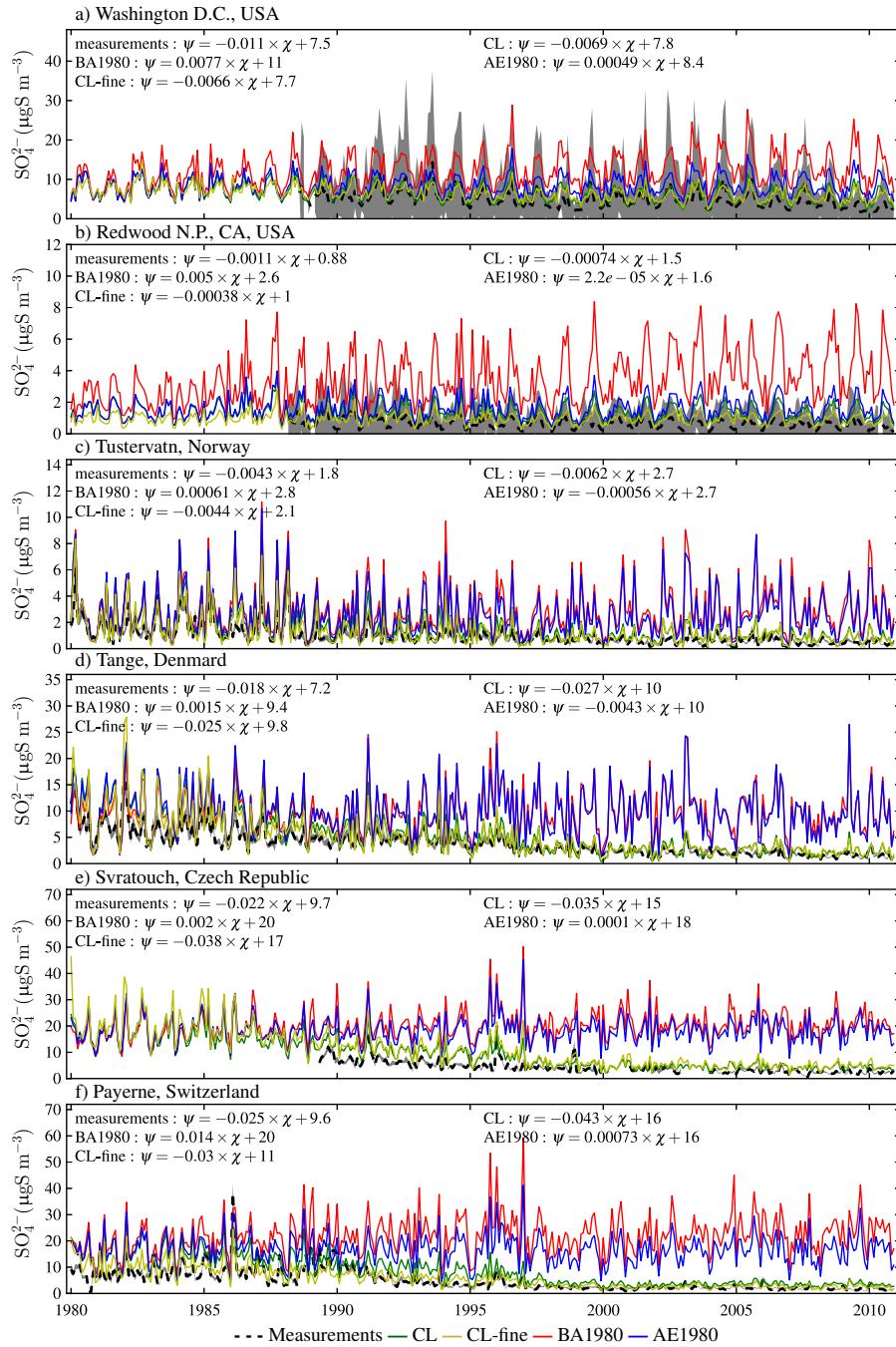


Figure S9. Comparison of the four simulations against SO_4^{2-} observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

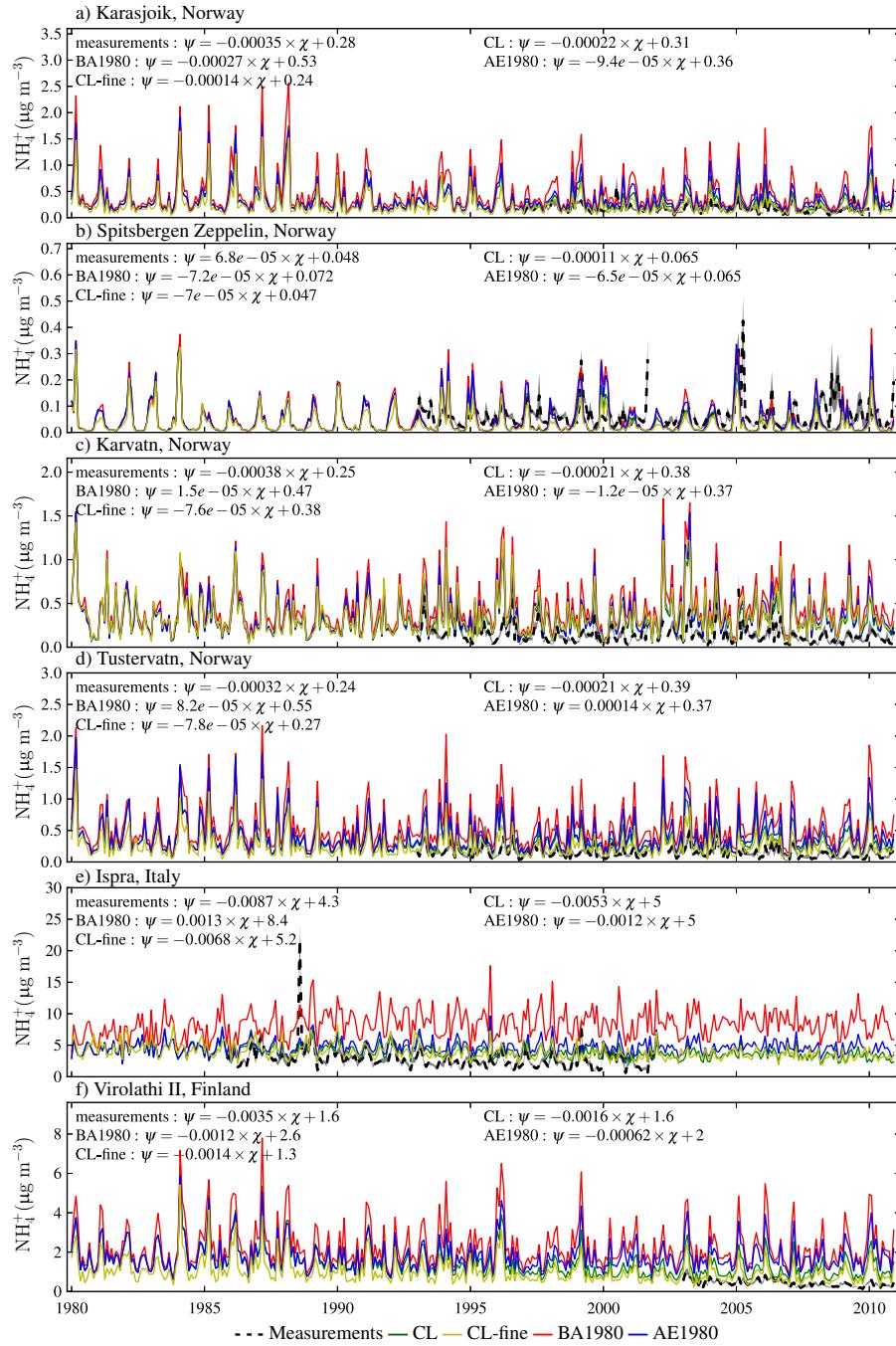


Figure S10. Comparison of the four simulations against NH_4^+ observations. The dashed line and shadowed areas indicate monthly mean surface observations and one standard deviation. Simulations are CL: current legislation (green); CL-fine: current legislation in the fine resolution of the model; BA1980: Business As in 1980, with constant anthropogenic emission rates per capita as in 1980 (red); AE1980: constant anthropogenic emissions as in 1980 (blue). Trends derived from the concentrations (ψ) as a function of the year (χ) are provided for the measurements and the four simulations inside the frames.

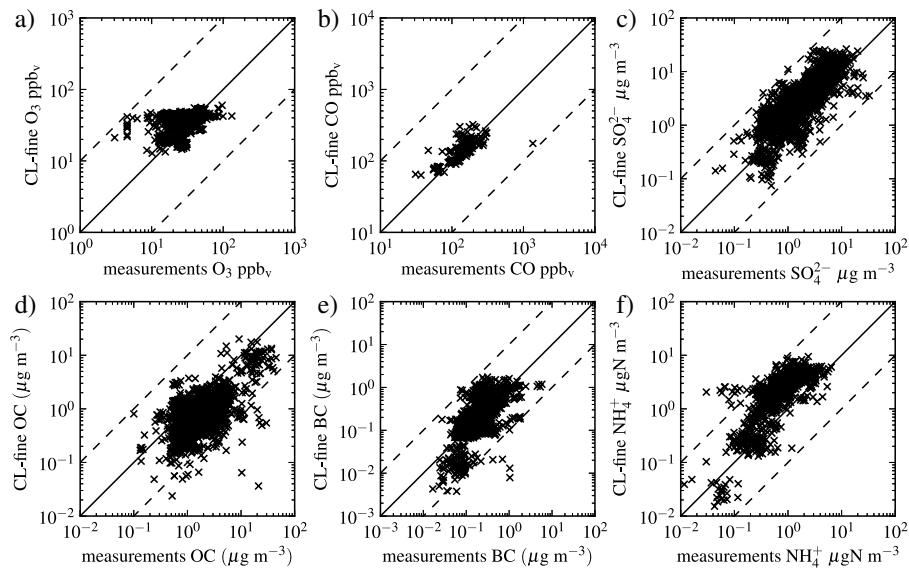


Figure S11. Comparisons of annually average surface model results ($3^\circ \times 2^\circ$ version) with observations (see Fig. S4 for station locations) a) for O₃, b) for CO, c) for SO₄²⁻, d) for OC, e) for BC, f) NH₄⁺. The continuous line shows the 1:1 slope and the dashed lines the 10:1 and 1:10 slopes