

ANNEX S

Sulfur Dioxide Emissions

Sulfur dioxide (SO₂) emitted into the atmosphere through natural and anthropogenic processes affects the Earth's radiative budget through photochemical transformation into sulfate aerosols that can (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) affect cloud formation; and (3) affect atmospheric chemical composition (e.g., stratospheric ozone, by providing surfaces for heterogeneous chemical reactions). The overall effect of SO₂ derived aerosols on radiative forcing is believed to be negative (IPCC 1996). However, because SO₂ is short-lived and unevenly distributed through the atmosphere, its radiative forcing impacts are highly uncertain. Sulfur dioxide emissions have been provided below in Table S-1.

The major source of SO₂ emissions in the United States was the burning of sulfur containing fuels, mainly coal. Metal smelting and other industrial processes also released significant quantities of SO₂. As a result, the largest contributors to U.S. emissions of SO₂ were electric utilities, accounting for 63 percent in 2000 (see Table S-2). Coal combustion accounted for approximately 94 percent of SO₂ emissions from electric utilities in the same year. The second largest source was industrial fuel combustion, which produced 4 percent of 2000 SO₂ emissions. Overall, SO₂ emissions in the United States decreased by 23 percent from 1990 to 2000. The majority of this decline came from reductions from electric utilities, primarily due to increased consumption of low sulfur coal from surface mines in western states.

Sulfur dioxide is important for reasons other than its effect on radiative forcing. It is a major contributor to the formation of urban smog and acid rain. As a contributor to urban smog, high concentrations of SO₂ can cause significant increases in acute and chronic respiratory diseases. In addition, once SO₂ is emitted, it is chemically transformed in the atmosphere and returns to earth as the primary contributor to acid deposition, or acid rain. Acid rain has been found to accelerate the decay of building materials and paints, and to cause the acidification of lakes and streams and damage trees. As a result of these harmful effects, the United States has regulated the emissions of SO₂ under the Clean Air Act. The EPA has also developed a strategy to control these emissions via four programs: (1) the National Ambient Air Quality Standards program,¹ (2) New Source Performance Standards,² (3) the New Source Review/Prevention of Significant Deterioration Program,³ and (4) the sulfur dioxide allowance program.⁴

References

EPA (2001) *National Air Pollutant Emissions Trends Report, 1900-2000*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

¹ [42 U.S.C § 7409, CAA § 109]

² [42 U.S.C § 7411, CAA § 111]

³ [42 U.S.C § 7473, CAA § 163]

⁴ [42 U.S.C § 7651, CAA § 401]

Table S-1: SO₂ Emissions (Gg)

Sector/Source	1990	1995	1996	1997	1998	1999	2000
Energy	20,136	16,247	16,641	17,052	17,157	16,517	15,435
Stationary Combustion	18,407	14,724	14,726	15,104	15,192	14,540	13,496
Mobile Combustion	1,339	1,189	1,612	1,636	1,655	1,668	1,626
Oil and Gas Activities	390	334	304	312	310	309	314
Industrial Processes	1,306	1,117	958	993	996	992	1,031
Chemical Manufacturing	269	260	231	235	237	238	243
Metals Processing	658	481	354	369	367	363	373
Storage and Transport	6	2	5	5	5	5	5
Other Industrial Processes	362	365	354	371	376	376	392
Miscellaneous*	11	9	15	14	11	11	19
Solvent Use	0	1	1	1	1	1	1
Degreasing	0	0	0	0	0	0	0
Graphic Arts	0	0	0	0	0	0	0
Dry Cleaning	NA	0	0	0	0	0	0
Surface Coating	0	0	0	0	0	0	0
Other Industrial	0	0	1	1	1	1	1
Non-industrial	NA						
Agriculture	NA						
Agricultural Burning	NA						
Waste	39	43	29	30	31	31	32
Waste Combustion	39	42	28	29	30	30	31
Landfills	0	0	1	1	1	1	1
Wastewater Treatment	0	1	0	0	0	0	0
Miscellaneous Waste	0	0	0	0	0	0	0
Total	21,481	17,408	17,629	18,076	18,185	17,541	16,499

Source: (EPA 2000)

* Miscellaneous includes other combustion and fugitive dust categories.

NA (Not Available)

Note: Totals may not sum due to independent rounding.

Table S-2: SO₂ Emissions from Electric Utilities (Gg)

Fuel Type	1990	1995	1996	1997	1998	1999	2000
Coal	13,807	10,526	11,073	11,444	11,313	10,729	9,728
Petroleum	580	375	417	466	691	580	464
Natural Gas	1	8	6	5	5	6	8
Misc. Internal Combustion	45	50	48	51	52	53	54
Other	NA	NA	4	4	110	112	80
Total	14,432	10,959	11,549	11,971	12,171	11,479	10,333

Source: (EPA 2000)

Note: Totals may not sum due to independent rounding.