9.
Sulfur Dioxide
(SO_2)

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Sulfur dioxide (SO_2) is not a greenhouse gas but is a precursor of atmospheric sulfuric acid (H_2SO_4) as an aerosol. SO_2 is oxidized by hydroxyl radicals (OH) to form sulfuric acid, although this reaction is much slower than the corresponding one between NO_2 and nitric acid. Nevertheless, SO_2 dissolves easily in suspended droplets in the atmosphere, unlike NO_x. Sulfuric acid aerosol is produced by SO_2 oxidation through photochemical gas-to-particle conversion.

Sources of SO_2 include fossil fuel combustion by industries and power generation, and oxidation of dimethylsulfide (DMS) from oceans (IPCC, 1990). Major sinks of SO_2 are the formation of sulfuric acid and deposition onto wet surfaces. For SO_2, removal by dry deposition is more important than for NO_2 because of its high degree of solubility. Anthropogenic SO_2 has caused acid rain and deposition throughout industrial times. SO_2 has a large variability in space and time because of its short lifetime and localized anthropogenic sources.

Observation stations that submitted data for SO_2 to the WDCGG are shown in Figure 9.1 and listed in Table 9.1. All of the 31 contributing stations are located in Europe. Figure 9.2 illustrates annual mean concentrations of SO_2 for individual stations in colours that change with the concentration. Please note that data for SO_2 is reported in various units, i.e., ppb, $\mu g/m^3$, mg/m^3, $\mu gS/m^3$, and mgS/m^3, and that it can be converted to a single unit of ppb as follows:

X_p [ppb] = $(R * T / M / P_0) * 10^3 * X_g$ [$\mu g/m^3$]

X_p [ppb] = $(R * T / M / P_0) * 10^6 * X_g$ [mg/m^3]

X_p [ppb] = $(R * T / M_S / P_0) * 10^3 * X_g$ [$\mu gS/m^3$]

X_p [ppb] = $(R * T / M_S / P_0) * 10^6 * X_g$ [mgS/m^3]

where R is the molar gas constant, which is 8.31451 [J/K/mol],
T is the temperature assuming 25 °C or 298.15 [K] for all of the reports,
M is the molecular weight of SO_2, which is 64.0648,
M_S is the atomic weight of S, which is 32.066, and
P_0 is the standard pressure, which is 1013.25 [hPa].

Generally, SO_2 concentrations are higher in southern regions than in northern regions. The annual mean concentrations in the central and eastern part of Europe were lower in 1997 than in early 1990s. Few data have been reported from the western and northern part of Europe, but it is likely that SO_2 concentrations are lower in these regions than in the southeastern part.

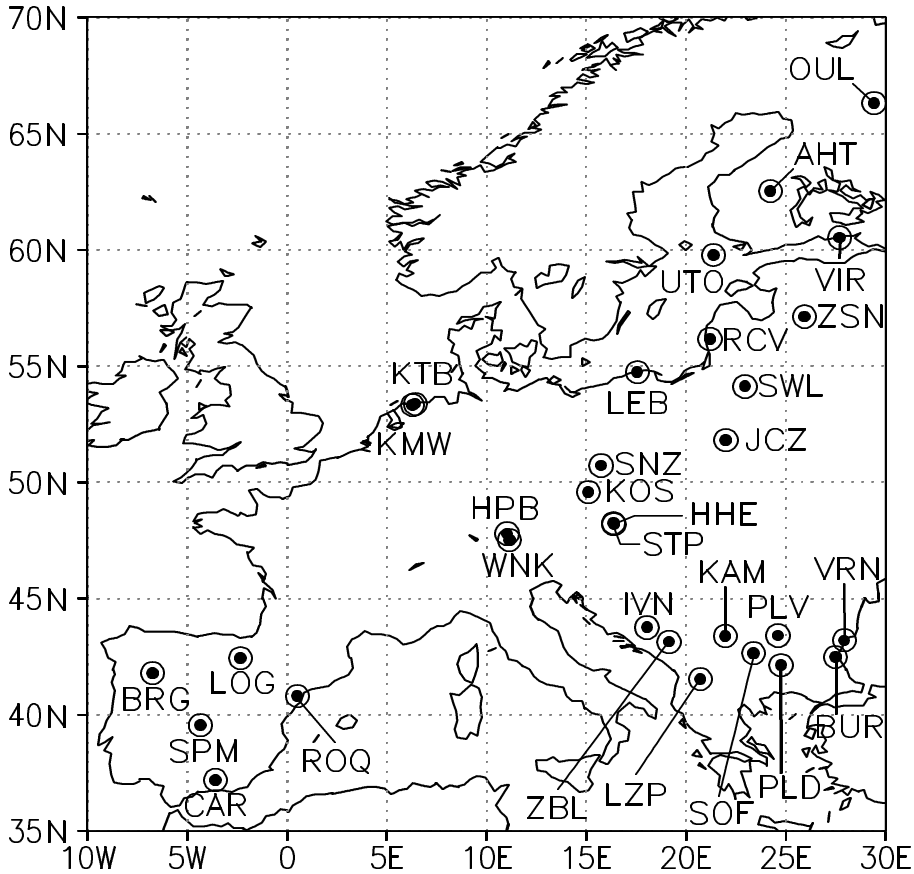

Fig. 9.1 Location of observation stations.

Table 9.1 List of observation stations for sulfer dioxide (SO_2) in alphabetical order.

Index	Station	Country/Territory	Organization
AHT	Ahtari, Myllymaki	FIN	Finnish Meteorological Institute
BRG	Braganca	PRT	Instituto Nacional de Meteorologia e Geofisica
BUR	Burgas	BGR	National Institute of Meteorology and Hydrology
HHE	Hohe Warte/WIEN	AUT	Central Institute for Meteorology and Geodynamics
HPB	Hohenpeissenberg	DEU	Deutscher Wetterdienst (DWD)
IVN	Ivan Sedlo	BIH	Federal Hydrometeorological Institute
JCZ	Jarczew	POL	Institute of Meteorology and Water Management
KAM	Kamenicki Vis	YUG	Federal Hydrometeorological Institute
KTB	Kloosterburen	NLD	Air Research Laboratory
KMW	Kollumerwaard	NLD	Air Research Laboratory
KOS	Kosetice	CZE	Czech Hydrometeorological Institute
CAR	La Cartuja	ESP	Instituto Nacional de Meteorologia
LZP	Lazaropole	MCD	Hydrometeorological Institute
LEB	Leba	POL	Institute of Meteorology and Water Management
LOG	Logrono	ESP	Instituto Nacional de Meteorologia
OUL	Oulanka, Kuusamo	FIN	Finnish Meteorological Institute
PLV	Pleven	BGR	National Institute of Meteorology and Hydrology
PLD	Plovdiv	BGR	National Institute of Meteorology and Hydrology
ROQ	Roquetas	ESP	Instituto Nacional de Meteorologia
RCV	Rucava	LVA	Environmental Pollution Observation Centre
SPM	San Pablo de los Montes	ESP	Instituto Nacional de Meteorologia
SNZ	Sniezka	POL	Institute of Meteorology and Water Management
SOF	Sofia	BGR	National Institute of Meteorology and Hydrology
STP	Stephansplatz/WIEN	AUT	Central Institute for Meteorology and Geodynamics
SWL	Suwalki	POL	Institute of Meteorology and Water Management
UTO	Uto, Korppoo	FIN	Finnish Meteorological Institute
VRN	Varna	BGR	National Institute of Meteorology and Hydrology
VIR	Virolahti, Koivuniemi	FIN	Finnish Meteorological Institute
WNK	Wank	DEU	Fraunhofer Institute for Atmos. Env. Res.
ZBL	Zabljak	YUG	Federal Hydrometeorological Institute
ZSN	Zoseni	LVA	Environmental Pollution Observation Centre

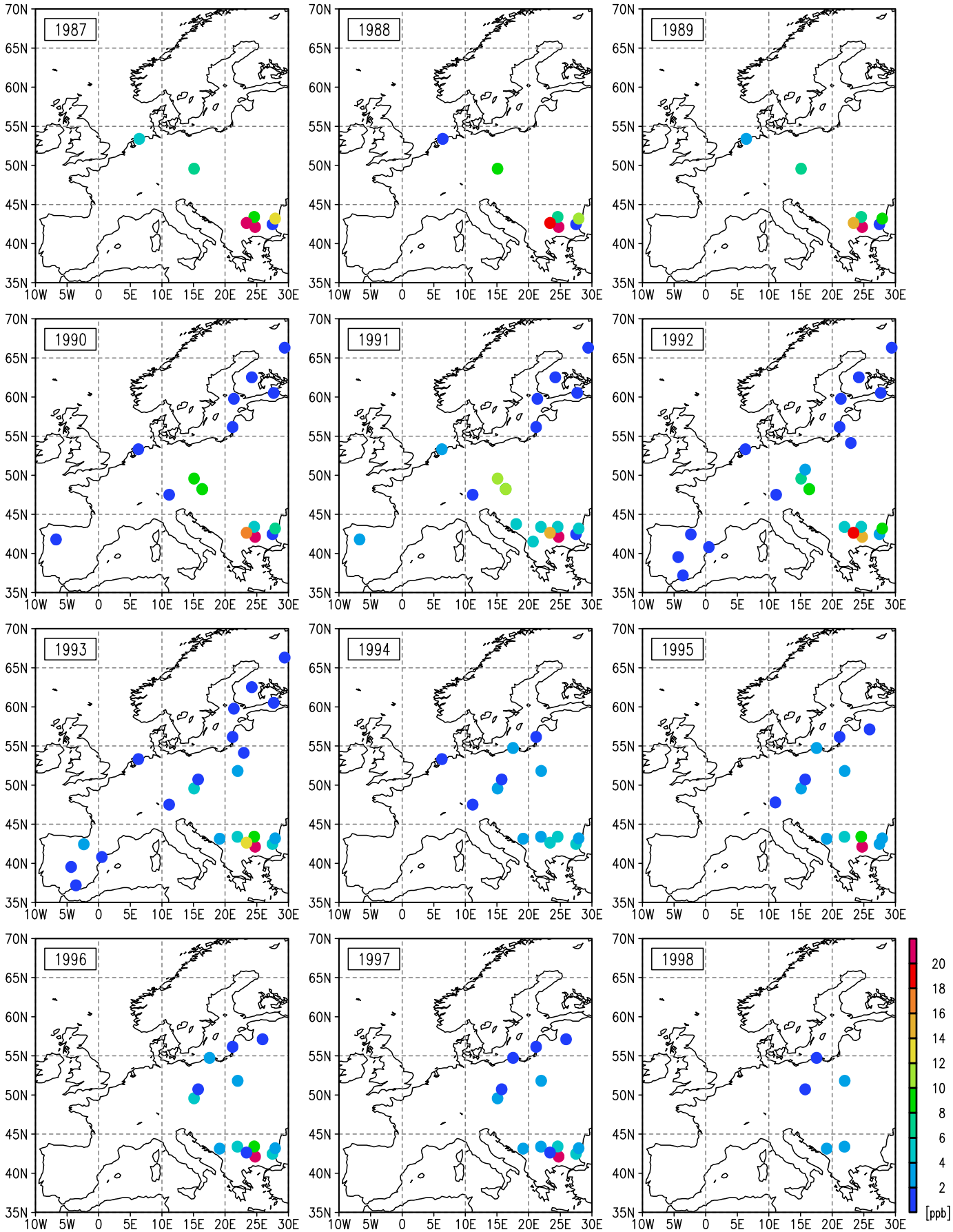

Fig. 9.2 Annual mean concentrarions of SO_2 for individual stations in colors that change with concentrations.