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SUMMARY

Sulphur dioxide emissions for Northern Asia has been estimated one the basis of fossil fuel combustion figures and other available information. These have been combined with emission surveys for Europe and North America, in a common grid with elements 300 x 300 km^2.

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CIRCUMPOLAR SO_2 EMISSION SURVEY

1 INTRODUCTION

In order to carry out model calculations of the atmospheric transport of sulphur compounds into the Arctic, emission estimates are needed for the Northern hemisphere down to ca 30^0N, in individual grid squares of 300x300 km^2.

The survey is based on available data for SO_2 emission rates in Europe (1) and North America (2), and other relevant information. The latter is used particularly to estimate emissions which occur close to the Arctic Ocean. In the following, each area will be discussed separately.

2 EUROPE

The EMEP survey (1) cover the whole of Europe, including an estimated 68% of the emissions in the USSR. Most of the data are for 1976-1977. Recently, however, updated emission data have been received for Portugal, Spain, France, Belgium, Luxembourg, the Netherlands, Switzerland, Austria, Federal Republic of Germany, United Kingdom, Denmark, Norway, Sweden and Finland. In addition the following countries have presented national emission figures to the ECE for 1980: Romania, USSR, Czechoslovakia, Hungary, Italy and Poland.

This information has been used to adjust the 1978 emission survey, with two exceptions: Emissions of the SO_2 in Romania has been estimated from fossil fuel consumption figures (3), and the distribution of SO_2 emissions in the USSR has been changed following the evaluation of emissions in the northern parts of USSR.

The EMEP grid squares are 150x150 km^2 and the emission figures were transferred to the 300x300 km^2 grid simply by assuming uniform emission intensity in the 150x150 km^2 squares.

2.1 GREENLAND

Total consumption of liquid fuel was 170.000 t in 1981 (3). This figure probably includes mainly gas oil (diesel) and gasoline. The proportions are not known, but the sulphur content of diesel oil may be assumed to $\leq$ 0.3%, hence the emissions are less than 500 t SO_2-S/a.

2.2 SPITSBERGEN

There are coal-fired power generation plants in the mining communities Longyearbyen, Barentsburg and Pyramiden. All use local coal, with a sulphur content of ~1.4% S. The Longyearbyen plant has a capacity of 2x5 MW (7). This corresponds to a fuel consumption of 7 t/h. Assuming 70% of maximum production gives a SO_2 emission of 600 t SO_2-S/a. The total emission of sulphur dioxide from stationary sources in Spitsbergen may be estimated to between 1000 and 2000 t SO_2-S/a.

3 NORTH AMERICA

Emissions of SO_2 (and NO_2) for individual states and provinces in USA and Canada are available from the USA-Canada bilateral memorandum of intent (2). Transferring these emission figures to grid squares was carried out subjectively, using a geographic atlas to pinpoint smelters and population centres.

3.1 ALASKA

The population is about 350.000. The two largest towns are Anchorage (46.000) and Fairbanks (16.000). The degree of urbanisation is low, and the emissions have been estimated to ~5000 t SO_2-S/a. Emissons in connection with oil extractionon the North Slope has been estimated to 450 t SO_2-S/a.

3.2 CANADA - NORTHWEST TERRITORIES

Emissions of SO_2 were 1545 t SO_2/s in 1974 (5).

4 USSR

According to information given to ECE, the total emissions of SO_2 in 1980 were 25 million tonnes, corresponding to 12.5 million tonnes as sulphur. In 1975 the emissions were 12 million tonnes as S (1). The breakdown of emissions in source categories was given for 1974 as follows (4):

SO_2 emission in 1974 (thousand tonnes)

Power stations	11.800
Non-ferrous metallurgy	4.300
Iron and steel metallurgy	1.700
Chemical industry	1.900
Others	6.500
	25.200

Of particular interest in this connection is the large emissions from non-ferrous metallurgy, an important fraction of which is associated with copper-nickel smelters in Nor'ilsk and on the Kola peninsula. The production of non-ferrous metals in the USSR were as follows (3):

	1974	1980	
Copper (primary)	110.000	1150.000	tonnes
Nickel	104.000	154.000	"
Lead	475.000	525.000	"
Zinc	680.000	785.000	"

The copper and nickel deposits in the Soviet Union are similar to the deposits in Canada. Nickel occurs as the sulphide pentlandite together with copper ferrosulphide and magnetic iron sulphide (pyrrhotite). Relatively large emissions occur in the initial roasting and smelting processes. In

1974 the primary copper and nickel productions in Canada were 821.000 and 269.000 tonnes, respectively (5). The associated SO_2 emissions were 3.15 million tonnes of SO_2. Assuming that the extraction processes are similar in the USSR, and that the emission factor for the extra copper production is 2 kg SO_2/kg copper produced, leads to inferred total SO_2 emissions from copper and nickel extraction of approximately 3.1 million tonnes. The largest copper-nickel smelter complex is at Nor'ilsk, not far from the outlet of R. Jenisej into the Kara Sea. Copper-nickel smelters are also located on the Kola peninsula (Nickel-Zapolyarni and Monchegorsk), and in Sverdlovsk. Copper is mined and processed at various other sites also (Djerkasgan, Balkasj, Fergana).

A suggested breakdown could be as follows:

	Nor'ilsk	Kola	Ural	Oth. USSR
Copper production (tonnes)	330	80	160	580
Nickel " "	108	35	21	-
Sulphur dioxide emissions	1250	300	450	1150

The remaining ca 1.4 million tonnes of SO_2 emissions from non-ferrous metallurgical industry (allowing for production increases since 1974) may be associated with lead and zinc production, which is mined in Leninogorsk, Tekeli, and various other locations in the Oriental region. Another interesting area is the Kolyma valley in the far northeastern part of Siberia; which contain lead ores, rich in tin and gold content. A recent survey of snow chemistry in the USSR identified this area with concentrations of sulphate exceeding 84 μ eq/l - figure 1 (6).

It is reasonable to assign 0.4 million tonnes of SO_2 emissions due to non-ferrous metallurgy to this area, and to locate the remaining ca 1 million tonnes at Nor'ilsk (0.2 M tonnes) and in Leninogorsk, Djeskasgan and Novokusnetsk.

Coal deposits in the Arctic are located at Inta and Vorkuta in the Pechora basin, at Nor'ilsk, Sangas and near Jakutsk and at Susuman and in the Kolyma Valley. Brown coal is found at Tiksi and Jakutsk.

The coal at Inta has a sulphur content of 3% (4). No data on sulphur contents are available for the other deposits.

Coals from Inta and Vorkuta are presumably used in thermoelectric plants located in Kola, White Sea, Pechora, and Yamal. The population in these districts is 3.5 million, or 1.3% of the total population of USSR.

Assuming that the electricity consumption per capita is higher by a factor of two than the USSR average, and a conversion efficiency of 31%, yields an annual consumption of 14 million tonnes of Inta/Vorkuta Coals, resulting in 0.84 million tonnes of SO_2 emissions. A further 0.4 million tonnes of SO_2 should be added to account emisisons of SO_2 related to other uses of fossil fuels, e.g. house heating, industrial heat consumption, transport, etc. The population in the Jakutsk autonomous region is only about 700.000, and the emissions from fossil fuel consumption (including electricity generation) should not exceed 0.2-0.3 Mt SO_2/a.

In the preparation of the EMEP emission survey (1) it was assumed that 2/3 of the USSR emissions occurred within the EMEP grid.

However, of the 4 million tonnes of SO_2-S assumed to be emitted outside the EMEP grid, 1.9 million tonnes of SO_2-S are associated with non-ferrous metallurgy. The remaining 2.1 million tonnes must have been assessed too low in view of the important Karaganda-Kusbas heavy industries, and the Fergana, Irkutsk, and Petrovsk industrial regions. The boundary of the EMEP grid transects the industrial region along the Ural, and a substantial part of the SO_2 emissions from this region occur outside the EMEP grid. The emission of sulphur dioxide from the part of USSR within the EMEP grid can be assumed to be about 6 Mt s/a. The emissions in the individual grid squares have been estimated to conform with this new assessment. A redistribution of emissions in the USSR within the EMEP grid follows also from the positioning of emissions in Kola, Archangelsk and Inta.

5 THE FAR EAST

Japan, Korea, and parts of China also fall within the circumpolar emission grid. For completeness, emissions in these countries have been estimated from fossil fuel consumption figures and assumed sulphur contents of these.

	Solid fuel consumption mill. tonnes	%S	Liquid fuel mill. tonnes	%S	Estimated emissions mill. t SO_2-S
Japan	88	1	277	1.6	3.9
N. Korea	42	2.5	3	1.7	1.09
S. Korea	21	1.5	34	1.9	0.77
China	433	2.5	114	0.6	11.2

The emissions have been subjectively located in grid squares within the densely populated and industrialized parts of the countries.

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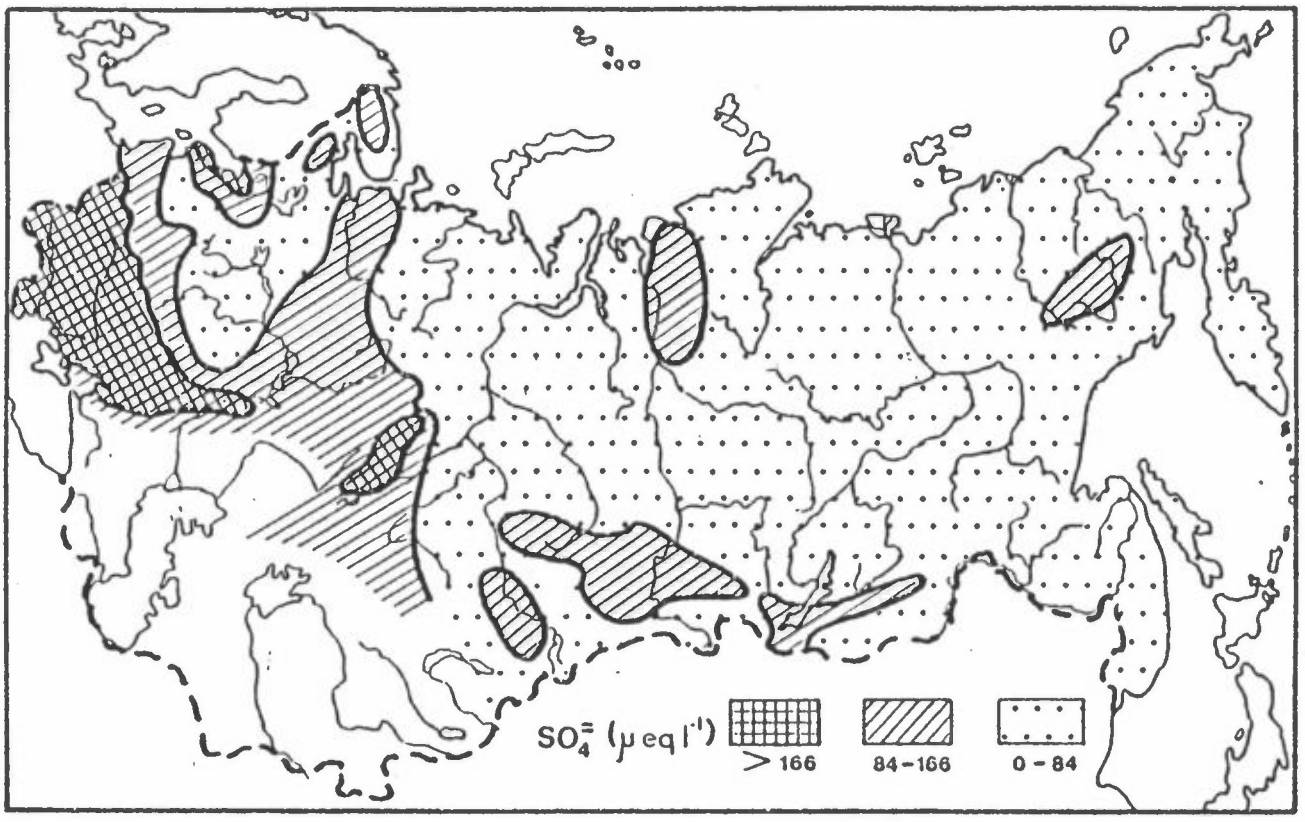

Figure 1: Spatial distribution of sulphate in snow samples collected during spring 1982 in the Soviet Union (after Belikova et al., 1984).

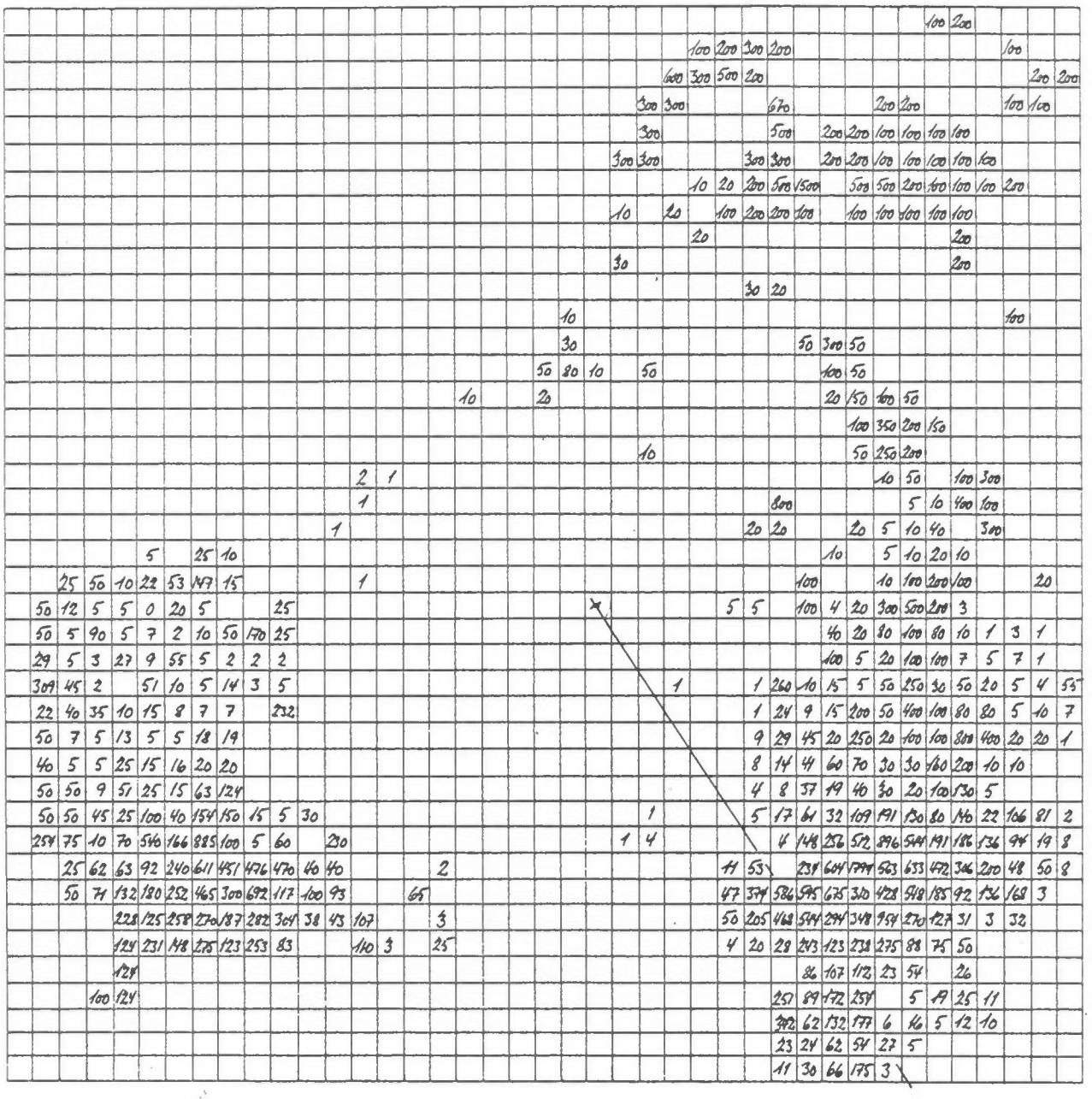

Figure 2: Estimated SO_2 emissions for individual grid squares.
Unit: 10^3 tonnes/a (as S).

Figure 3: The area covered by the grid.

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Utslipp av SO_2 i de nordlige delene av Asia er anslått på grunnlag av oppgaver over forbruk av fossilt brensel og andre opplysninger. Disse er sammenstilt med utslippsoppgaver for Europa og Nord-Amerika i et felles rutenett med rutestørrelse 300 x 300 km^2.

TITLE

ABSTRACT (max. 300 characters, 7 lines)
Sulphur dioxide emsission for Northern Asia has been estimated on the basis of fossil fuel combustion figures and other available information. These have been combined with emission surveys for Europe and North America, in a common grid with elements 300 x 300 km^2.

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