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IMPACT OF THE BULGARIAN POWER PLANTS ON THE SULPHUR POLLUTION OF SOUTH-EASTERN EUROPE

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Abstract. The Regional Air Pollution Information and Simulation model (RAINS) is developed at the International Institute for Applied Systems Analysis (IIASA), Austria. The European implementation of the RAINS model is a scientific background for important EU decisions. It has been used to support the negotiations on an updated Sulphur Protocol under the Convention on Long-range Transboundary Air Pollution (UN/ECE,1994). The version RAINS-Europe 7.2 is used to consider sulphur deposition over Europe focusing on different scenarios for development of the Bulgarian electricity sector for years 1995-2010. The advisability of updating the RAINS database and developing model versions with more precise space resolution is demonstrated.

Keywords: air pollution, transboundary pollution, EMEP, RAINS.

INTRODUCTION

The main activity considering the transboundary air pollution in Europe is the so-called EMEP programme: a co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe[1]. The only way of evaluating the transboundary air pollution is first to estimate the emissions and then to model their transport taking into account the meteorological conditions. Measurements of air concentrations and depositions can not be of direct benefit in transboundary air pollution evaluation, but they are very useful for testing the models by which the transboundary air pollution is evaluated. Model validation is made in the frame of EMEP program as well as in other international programmes like ETEX and ATMES.

The major output products of the EMEP programme are the so-called "country-to-country" matrixes. They give the final evaluation how much an European country pollutes another one country. The deposition budget matrixes show how much of the pollutant emitted from a country is deposited over the territory of another one country, and the same for the all couples of European countries. A part of the country-to-country deposition budget matrix for oxidised sulphur for 1994 is presented in Table 1. It includes three Balkan countries: Albania (AL), Bulgaria (BG) and Greece (GR).

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Table 1. Deposition budget matrix for oxidised sulphur, 1994 (units: 100t sulphur). Preliminary result (for scientific research only)

		e m i t e r s												
		AL	AT	BE	BG	DK	FI	FR	DE	GR	HU	IS	IE	IT	LU
	AL	62	0	0	24	0	0	2	7	27	8	0	0	49	0
	AT	1	50	11	5	1	0	70	211	3	50	0	1	98	1
r	BE	0	0	187	0	0	0	109	84	0	1	0	2	3	2
e	BG	11	2	1	881	1	0	5	32	20	57	0	0	29	0
c	DK	0	0	7	0	65	0	9	109	0	2	0	2	1	0
e	FI	0	0	4	2	10	125	6	74	0	8	0	1	3	0
i	FR	0	3	113	3	2	0	1311	227	0	10	0	8	131	10
v	DE	0	14	253	5	26	0	474	4253	2	31	0	11	79	19
e	GR	34	1	1	336	0	0	4	22	227	23	0	0	69	0
r	HU	2	16	5	21	1	0	24	135	4	707	0	0	62	1
s	IS	0	0	0	0	0	0	2	3	0	0	2	1	0	0
	IE	0	0	3	0	0	0	10	9	0	0	0	103	0	0
	IT	5	11	7	19	1	0	137	100	9	49	0	1	1639	1
	LU	0	0	3	0	0	0	15	7	0	0	0	0	0	4

The values at the main diagonal are the deposition over the country caused by their own emissions. These type of assessments are used to assist policy advisors in preparation of international agreements – protocols for reduction of emission of different pollutants.

AN OVERVIEW OF THE RAINS MODEL

The RAINS model was developed at IIASA as a tool for integrated assessments of alternative scenarios for reduction of the pollution in Europe[2]. The model incorporates databases on energy consumption (use of fuel) for different regions in Europe, distinguishing 21 categories of fuel use in 6 economic sectors. Emissions of SO_2, NO_x, NH_3 and VOC are estimated by the CORINAIR inventory of the European Environmental Agency. Emission reduction measures and technologies and their cost are represented in order to consider different possibilities for emission reduction and to assess their costs. Important input information is the so-called "meteorological" or "source-receptor" matrixes. They describe the dispersion of emission from a point (a model grid cell) to other points (model grid cells). They are derived by EMEP transboundary air pollution model based on 10 years meteorological data. Possessing the emissions for the consider period of time according to some scenario and the most likely meteorological conditions according to the meteorological matrixes, RAINS model predicts the expected deposition of the considered pollutant over Europe. Another type of input information is about ecosystem's sensitivity presented as critical loads as well as critical levels.

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By comparison of critical loads and expected deposition a degree of ecosystem protection could be established.

A RAINS' *scenario* consists of *energy pathway* and *emission abatement strategy*. The *energy pathway* stands for quantity and type of fuels used in different economic sectors for the considered time period. The *emission abatement (control) strategy* stands for packages of emission control measures applied to the different emission source categories (economic sector/fuel). The main function of the model is to analyse different scenarios. It predicts the emissions of the considered pollutants, deposition field over Europe, degree of ecosystems protection and costs necessary for the applied control measures. There is a second "optimisation" option of RAINS. A desired field of deposition or a field of percent of "protected" ecosystems could be defined as a target for the optimisation. The model determines where and by what control measures the emissions have to be reduced in order to achieve the target by minimum costs.

SOME SCENARIOS FOR SO_2 DEPOSITION IN 2010 FOCUSING ON DIFFERENT EMISSION CONTROL MEASURES IN BULGARIAN POWER PLANTS (BPP)

The version RAINS-Europe 7.2 has been used to consider some scenarios for possible emission control measures in BPPs. The Official Energy Pathway (OEP96) for all European countries is assumed in the all scenarios. The emission abatement (control) strategies are build up from the following three basic possibilities:

- no emission control, i.e. emission abatement measures are not applied,
- maximum technical feasible emission reduction is applied,
- standards from the 2nd Sulphur Protocol are applied.

The deposition of SO_2 in 2010 according to 4 of the considered scenarios are shown in the figures. The scenarios themselves are briefly described above the pictures.

RESULTS AND DISCUSSION

The space resolution of 150×150 km on the presented fields is determined by the grid step of the EMEP model by which the meteorological matrixes have been calculated. The expected deposition according the model and to the information set in its databases, if emission control measures are not applied at all, including in BPPs, is presented in Fig.1*a*.

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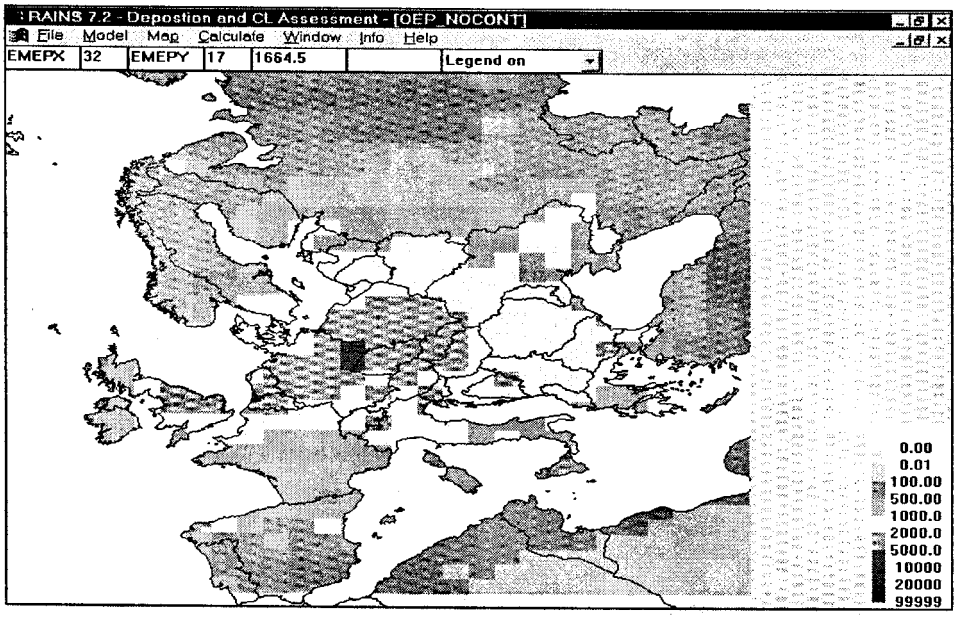

Fig.1*a*. Sulphur deposition (mg/m².year) in 2010 according to the scenario OEP_nocontrol: Official energy pathway (OEP96) for all countries; no control for all countries / sectors / fuels

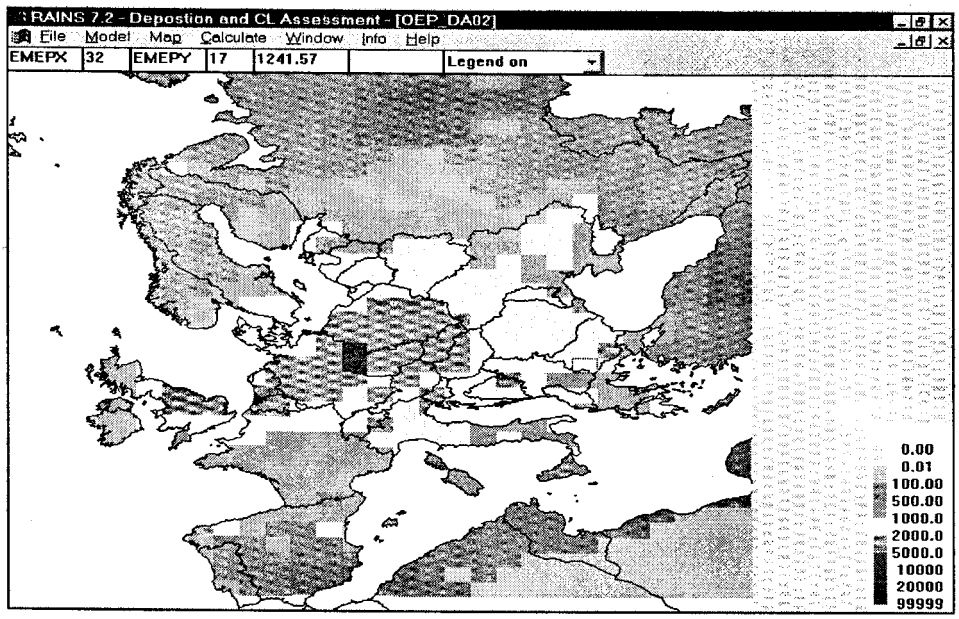

Fig.1*b*. Sulphur deposition in 2010 according to the scenario OEP_da02: Official energy pathway (OEP96) for all countries; no control for all countries / sectors / fuels, except for Bulgarian power plants, where the standards from the 2nd Sulphur Protocol are applied

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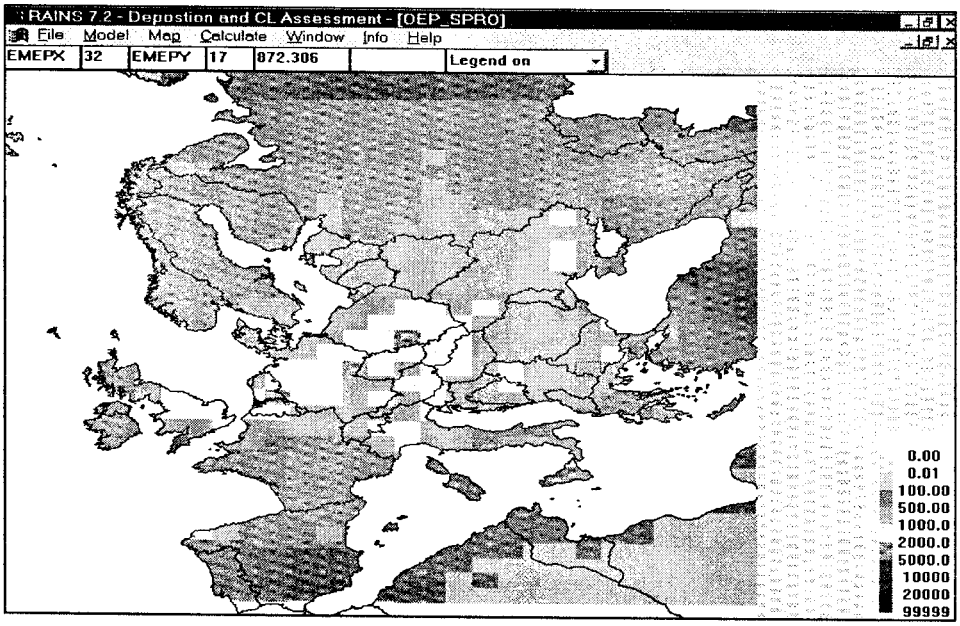

Fig.2*a*. Sulphur deposition in 2010 according to the scenario OEP_spro: OEP96 for all countries; emission and fuel standards from the 2nd Sulphur Protocol

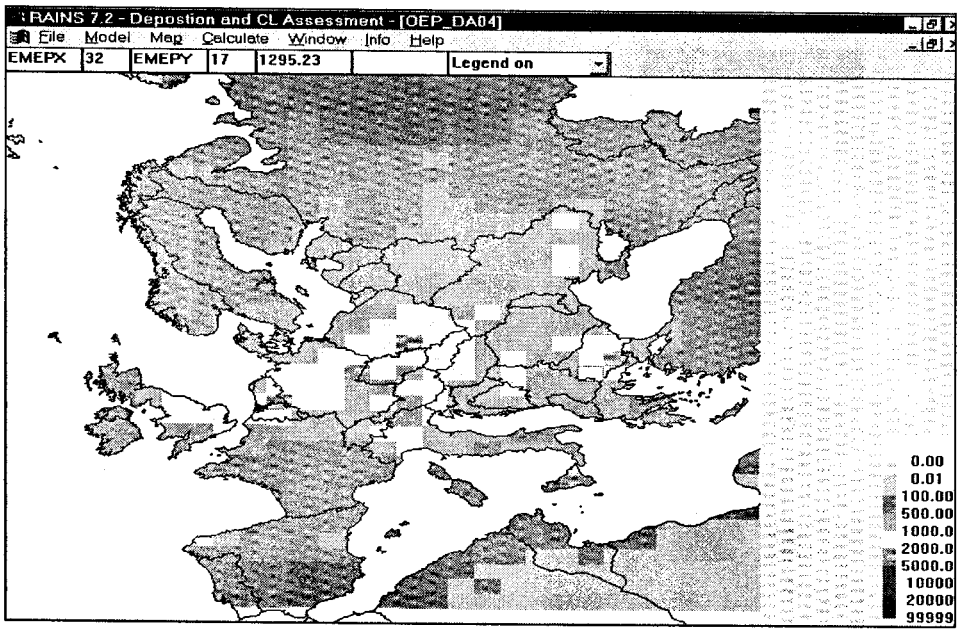

Fig.2*b*. Sulphur deposition in 2010 according to the scenario OEP_da04: OEP96 for all countries; emission and fuel standards from the 2nd Sulphur Protocol for all countries / sectors / fuels, except for Bulgarian power plants, where no control is applied

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If the control measures according to the 2nd Sulphur Protocol[3] are applied in Bulgarian power plants the depositions are expected to decrease (Fig.1*b*). They would become: less than 2000 mg/m^2.year in north-eastern part of Bulgaria; less than 1000 in North-Western part of European Turkey, in Northern Greece, in FYR Macedonia, Southern Serbia; less than 500 in north-western corner of Asian Turkey. If all European countries satisfy the requirements of the 2nd Sulphur Protocol, the depositions over almost the whole Balkan region are expected to be less than 1000, excluding some areas in Bulgaria, Northern Serbia and Bosnia (see Fig.2*a*). In that case, if the BPPs would not reduce their sulphur emissions (see Fig.2*b*), the depositions over some Bulgarian regions would remain more than 2000, more than 1000 over almost the whole Bulgaria and over some regions of Serbia and Romania, and more than 500 over some part of Greece and Turkey.

Obviously the considered approach and the models like RAINS are a powerful tool for analyses of transboundary air pollution problems. The main open questions in this field for the Balkan region are:

- The space resolution of the RAINS model as well as that of the EMEP models is insufficient. This problem concerns not only the presentation of the results (Figs 1, 2), but the accuracy of the model's calculations. In a mountain region as Balkans, a smaller space step of models is obligatory.
- The databases' information about fuel used, their characteristics, cost of emission abatement measures is nor updated nor precise enough, especially for countries in transition.

Regional Balkan activities like to EMEP and RAINS, with more precise space resolution and actual databases are necessary.

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