LONG RANGE TRANSPORT OF HEAVY METALS FROM POLAND COMPUTED BY AN EULERIAN MODEL

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INTRODUCTION

The modeling activity on the long range transport of air pollutants has been mainly focused on sulfur and nitrogen oxides for the past several years. Compared to sulfur and nitrogen, much less development can be noticed in modeling long range transport of heavy metals. The existing models were designed either for computing transport of heavy metals into the Baltic and the North Sea (Grasl et al., 1989; Krell and Roeckner, 1988; Jaarsveld et al., 1986), or to the Arctic (Pacyna and Ottar, 1985; Pacyna et al., 1985, 1989). Except Jaarsveld's climatologic approach and the stochastic model of Krell and Roeckner, the above models are of Lagrangian type based on the trajectory computations. Another climatologic model (Alcamo et al., 1990) was designed to compute long range transport of heavy metals in Europe but because of the resolution of the climatologic data, there might be some difficulties to run it for the transport period shorter than one year.

The main purpose of developing the model presented in this paper is the computation of the transboundary atmospheric transport of heavy metals in Europe. This model can be applied both for the episodes and annual transport of metals. Also, because of the Eulerian approach and positive definite pseudo-spectral (PDPS) numerical algorithm which does not produce negative values, it can be potentially used for modeling atmospheric transport of mercury, the case when re-emission becomes a serious limitation for the applications of the trajectory models.

In this study, the model was used to compute long range atmospheric transport of As and Pb emitted from the sources located in Poland. It has been run for four months of 1985: January, April, July and October which represented four seasons of 1985. The main goals of these runs were: (1) organize a computer tool for estimating atmospheric transport of heavy metals from Poland, and (2) to investigate the influence of seasonal variation of the meteorological conditions on the transport pattern.

MODEL DESCRIPTION

Atmospheric long range transport of As and Pb from Poland is simulated by the two-dimensional Eulerian model. Basic transport equation for As and Pb takes into account emission, advection, and dry plus wet deposition of the metals. It has the same form for As and Pb:

$$\frac{\partial c_i}{\partial t} + u\frac{\partial c_i}{\partial x} + v\frac{\partial c_i}{\partial y} = -(\frac{v_{di}}{h} + \frac{P\,W_i}{h})\,c_i + (1-\alpha_i)\,Q_i \qquad (1)$$

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where subscripts i=1,2 refer to As and Pb variables, respectively. In equation (1): $c_i = c_i(x,y,t)$ is the concentration; $u(x,y,t)$ and $v(x,y,t)$ are the components of the 925 hPa wind field; v_{di} is the dry velocity deposition; h=$h(x,y,t)$ is the mixing height; P is the precipitation amount for the last 6 hours; W_i is the scavenging ratio; Q_i is the emission and α_i is a part of the emission which is deposited at the same grid where emission occurs. The values of the dry deposition velocity, scavenging ratio and α are given in Table 1.

Table 1. Parameter values for As and Pb.

Metal	Parameter		
	$v_d\ (m\,s^{-1})$	W (*unitless*)	α (*unitless*)
As	0.002	500000	0.10
Pb	0.002	500000	0.15

The velocity and precipitation fields are updated every 6 hours during the model runs. Mixing height is kept constant for 24 hours and updated at 1200 GMT.

The advéctive part of the transport equation (1) is solved by means of the PDPS method (Bartnicki, 1986; 1989). The advantage of PDPS method over the pseudospectral approach is the elimination of artificial negative values from the solution. This method is also more accurate compared to another positive definite schemes, like for example, Spline, Smolarkiewicz, Finite Element and Flux Corrected algorithms (Bartnicki et al.,1990).

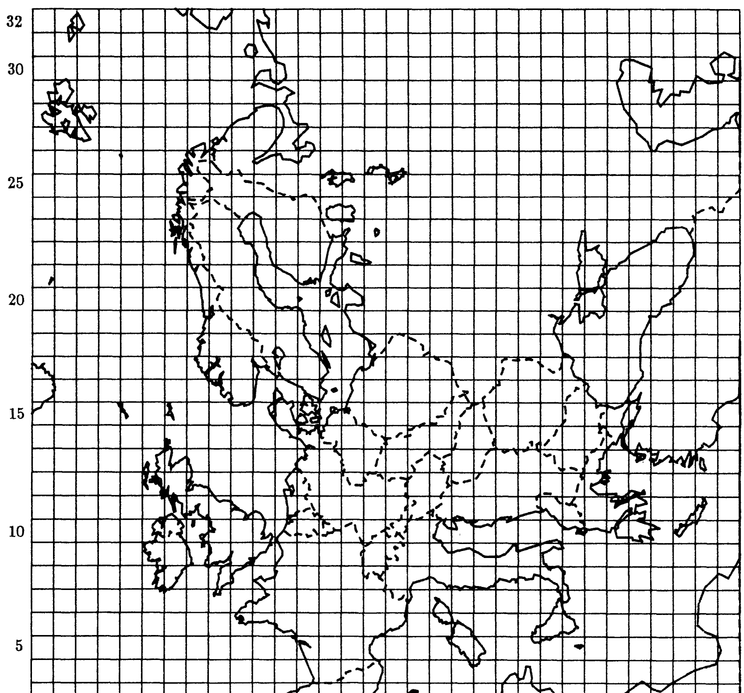

Fig. 1. Area of the model computations.