Working Group on Effects (WGE)

MSC-E took part in the annual Task Force meeting of ICP-Vegetation of WGE held in March 2016 in Dubna, Russia. The Task Force was informed about long-term trends of lead, cadmium and mercury in the EMEP region and about comparison of modeled values with observed concentrations in mosses.

Monitoring of concentrations in mosses is valuable source of supplementary information to characterize pollution levels. Compared to station-based monitoring, they are relatively cheap and are carried out over vast territories. Since mosses used in monitoring do not have roots they accept both nutrients and pollutants from the atmosphere. However, besides atmospheric deposition, concentration of pollutants in mosses depends on a number of other environmental factors, such as proximity to sea coast, surrounding land-cover, altitude etc. That is why monitoring data in mosses are more difficult to interpret compared to station-based measurements.

Regular moss surveys are carried out in the EMEP region once in five years. For the analysis of long-term trends the surveys held in 1990, 1995, 2000, 2005 and 2010 were used [*Harmens et al*., 2010, *Harmens et al*., 2013, *Steinnes at al*., 2011]. The data, collected and stored under the ICP-vegetation supervision, were provided to MSC-E for joint analysis of the results of atmospheric modeling and monitoring of heavy metals in mosses.

Information on measurements of lead and cadmium from all five moss survey was available from 10 countries (Finland, Sweden, Norway, Austria, the Czech Republic, Slovakia, Switzerland, Estonia, Iceland, Poland). For mercury the long-term trends were analyzed for the surveys for 1995, 2000, 2005 and 2010 because of lack of measurement data. Concentrations in mosses and total deposition cannot be compared directly. Therefore, for comparison of long-term trends these values were normalized. Reductions of lead concentrations in mosses and deposition for 1990-2010 were 82 and 79%, respectively (Fig. 1). The corresponding values for cadmium were 53% (concentrations in mosses) and 56% (deposition). Reduction of mercury from 1995 to 2010 was much lower: 16% for concentrations and 14% for deposition. Both model results and observations in mosses indicate some increase between 2005 and 2010.

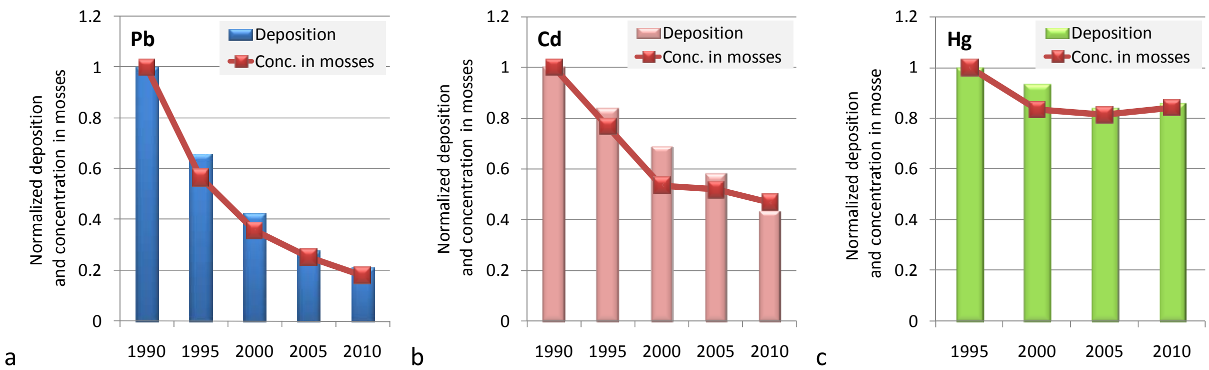

Fig..1. *Normalized modeled deposition and observed concentrations in mosses of lead (a), cadmium (b) and mercury (c) in the EMEP region in 1990-2010*

In particular countries magnitudes of reductions may differ from the mean values. For most countries reduction of lead and cadmium levels of modeled deposition and observed concentrations in mosses was similar (Table 1). However, there are some exceptions, for example, reduction of cadmium levels in France or Bulgaria. These situations require special investigation in cooperation with experts from the ICP-Vegetation.

Table 1. *Reduction (%) of calculated total deposition of heavy metals and their concentrations in mosses in the EMEP countries*

	Lead		Cadmium		Mercury	
	TD*	MC**	TD	MC	TD	MC
1990-2010						
Austria	77.6	83.8	39.2	57.6	-	-
Czech Republic	77.9	84.1	48.8	53.8	-	-
Estonia	78.4	82.6	62.6	54.5	-	-
Finland	82.2	80.0	66.2	55.0	-	-
Iceland	45.1	50.3	27.5	89.1	-	-
Norway	80.5	83.4	52.7	37.6	-	-
Slovakia	67.0	79.2	60.2	42.3	-	-
Sweden	81.3	83.3	56.8	44.6	-	-
Switzerland	83.1	86.5	49.2	59.3	-	-
1995-2010						
Bulgaria	55.1	38.8	51.7	0.6	-	-
France	74.2	62.4	55.3	17.6	-	-
1990-2005						
Germany	70.8	71.2	42.5	30.5	-	-
Latvia	73.4	62.1	44.1	2.1	-	-
Lithuania	73.1	55.5	48.1	63.2	-	-
United_Kingdom	74.3	60.1	46.8	77.3	-	-
Austria	-	-	-	-	10.4	38.0
Czech_Republic	-	-	-	-	29.8	40.3
Finland	-	-	-	-	5.7	16.0
Norway	-	-	-	-	11.5	4.2

* TD – total calculated deposition; ** MC – measured concentrations in mosses; '-' – no data

Special attention has been paid to investigation of spatial distribution of long-term pollution reductions in the EMEP domain. For example, in the Scandinavian region (Norway, Sweden, and Finland) country-averaged trends of modeled deposition and observed concentrations in mosses are very similar (Fig. 2). However, spatial distributions of long-term changes of these two parameters, expressed in terms of reduction between 1990 and 2010, do not fully coincide. Modeled and observed reductions demonstrate general south-to-north gradient (Fig. 3). However, the reduction of the observed concentrations in mosses is more mosaic compared to that of modeled deposition. Most likely, the differences in spatial distributions are caused by the fact that measurement in mosses may be influenced by local conditions, which are not fully resolved by the regional-scale model.

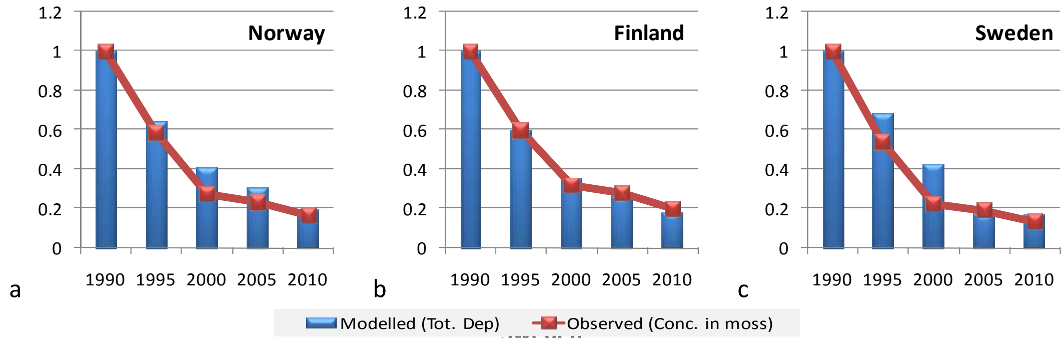

Fig. 2. *Normalized modeled deposition and observed concentrations in mosses of lead in Norway (a), Finland (b) and Sweden (c) in 1990-2010*

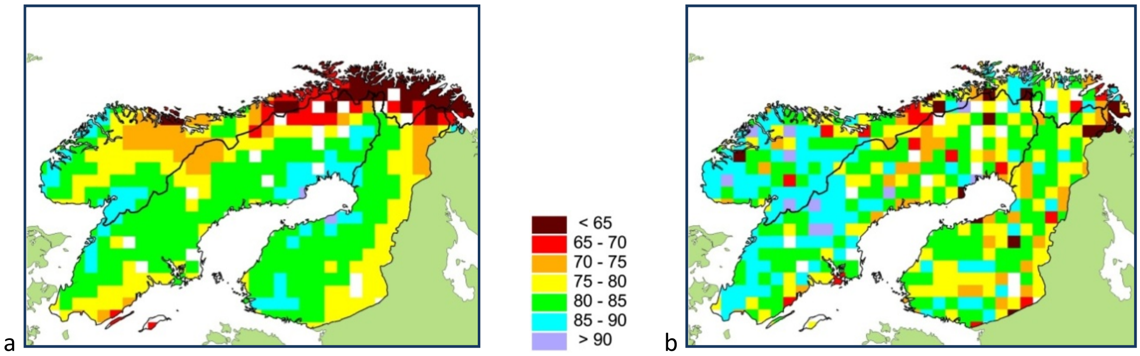

Fig. 3. *Spatial distribution of reductions of calculated total deposition (a) and concentrations in mosses (b) between 1990 and 2010 in Scandinavian region*

Measurements of heavy metals in mosses are characterized by wide spatial coverage and dense spatial resolution and could complement station-based EMEP monitoring data. Data on spatial distribution of lead, cadmium and mercury concentrations in mosses as well as on their long-term trends are used in verification of modeling results and assessment of heavy metal pollution in the EMEP region.

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