Cooperation with Parties to the Convention - Italy

National Agency for New Technologies, Energy and the Environment of Italy (ENEA) regularly (once in five years) carries out modelling of atmospheric pollution levels of a wide range of pollutants over territory of Italy. These simulations are performed with the usage of Italian national model MINNI developed by ENEA. Results of these simulations are used by the authorities of the country to improve national environmental and human health protection policy.

In accordance with the agreement between ENEA and MSC-E model calculations of air concentrations of heavy metals (Pb, Cd, Hg, As, Ni, Cr, Cu, Zn, Se) were performed over the EMEP domain for 2015. 3D concentrations with spatial resolution of 50x50 km^2 and temporal resolution of 6 hours for the agreed area were produced (Fig. 1). For mercury concentrations of three forms (elemental, particulate, and gaseous oxidized forms) were prepared. It is planned that these calculation results are used as boundary conditions for MINNI model. The work was carried out under financial support of ENEA.

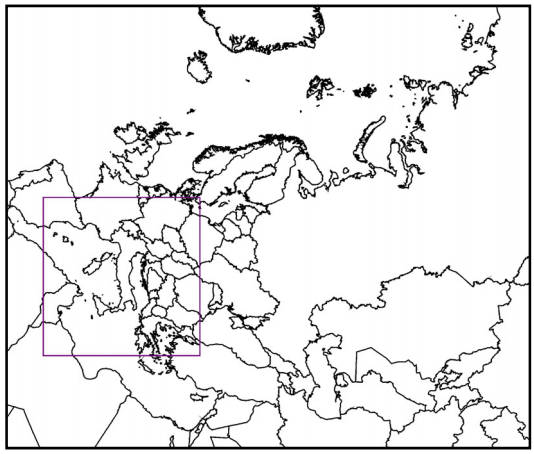

Fig. 1*. EMEP modelling domain and agreed area for Italy*

Modelling of atmospheric transport of heavy metals includes contributions to pollution levels from anthropogenic and secondary emissions within the EMEP domain, and transport from sources located outside the EMEP domain. Gridded emission data in the EMEP region is received from the EMEP Centre on Emission Inventories and Projections (CEIP) [http://www.emep-emissions.at/ceip/]. Emission data, used in modelling for 2015, are based on inventories for 2014, because the data for 2015 were not available in the CEIP database at the moment of the model calculations. Speciation of mercury emissions is based on global-scale mercury emission data for 2010 prepared under UNEP [*AMAP/UNEP*, 2013].

Secondary emission sources of heavy metals are represented by wind re-suspension of dust particles containing heavy metals (Pb, Cd, As, Ni, Cr, Zn, Cu, Se) and natural emission and re-emission of mercury. The modelling approaches to simulate natural emission of mercury and wind re-suspension of lead and cadmium are documented in the MSC-E reports [*Travnikov and Ryaboshapko,* 2002*; Ilyin et al.,* 2007]. Similar approach was applied for parameterization of re-suspension of other particulate heavy metals (As, Ni, Cr, Zn, Cu, Se).

Model calculations of considered pollutants were carried out over the EMEP domain, while air concentrations were extracted for the agreed area, which included Italy and some neighbouring territories. Modelling results were verified by comparing calculated air concentrations with the levels

observed in 2015. The observed air concentrations were derived from EMEP/CCC database (EBAS). It should be noted that at the moment of verification measurement information available in EBAS for 2015 was limited, because some of the countries did not report measurements from their stations. Besides, the stations are located mostly in the central and northern Europe and only few Spanish sites are situated in the agreed domain. Possible alternative data of the EU database AirBase were also not available for 2015.

Results of the verification of modelled air concentrations are summarized in Table 1. The statistical indexes, used in the verification, were as follows: mean relative bias (MRB), Pearson's correlation coefficient (R_c), Normalized root mean square error (NRMSE) and a share of model-measurement pairs of values differing from each other within 2-fold and 3-fold range (expressed as F2 and F3, respectively).

As seen from the table, the model is capable of calculating air concentrations of heavy metals with reasonable quality: MRB for different pollutants is within ±20% range, and spatial correlation coefficient varies from 0.56 (Ni) to 0.97 (Pb). Statistical indices for Se are not representative because they are based only on measurements from two stations. It is important to note, that quality of modelling results for so-called second-priority metals (As, Ni, Cu, Cr, Zn) is similar to that for metals targeted by the Protocol (Pb, Cd, Hg).

Table 1. *Statistical indexes of comparison between modelled and observed concentrations in air of the considered pollutants*

Pollutant	MRB(%)*	R_c**	NRMSE***	F2 (%)	F3 (%)	N
Heavy metals						
Pb	9.3	0.97	0.28	81.3	100.0	16
Cd	18.7	0.80	0.85	73.3	93.3	15
Hg	-7.5	0.74	0.11	100.0	100.0	9
As	-17.4	0.78	0.46	68.8	87.5	16
Ni	0.7	0.56	0.79	75.0	100.0	16
Cr	-15.7	0.74	0.54	69.2	84.6	13
Cu	-0.6	0.72	0.76	63.6	81.8	11
Zn	-19.5	0.83	0.80	37.5	43.8	16
Se	0.0	1.0	0.0	100.0	100.0	2

* mean relative bias, ** Pearson's correlation coefficient, *** Normalized root mean square error

More detailed information on verification of modelling results for each metal was submitted to ENEA.

Special attention was paid to analysis of spatial distribution of concentrations in air of second priority metals and model performance for these metals. Similar spatial distributions of mean annual air concentrations are noted for arsenic, nickel and chromium. For example, in the EMEP region relatively high (0.3-3 ng/m^3) calculated concentrations of arsenic are noted for regions where powerful emission sources are located, such as Poland, Slovakia, Italy, the United Kingdom, east of Ukraine and areas in central part of Russia (Fig. 2a). Besides, in the agreed area relatively high concentrations caused by significant contribution of secondary sources take place in the south-eastern part of Greece, south of France and Northern Africa (Fig. 2b). In addition to this, in case of chromium relatively high levels are also noted for central and southern regions of the European part of Russia.

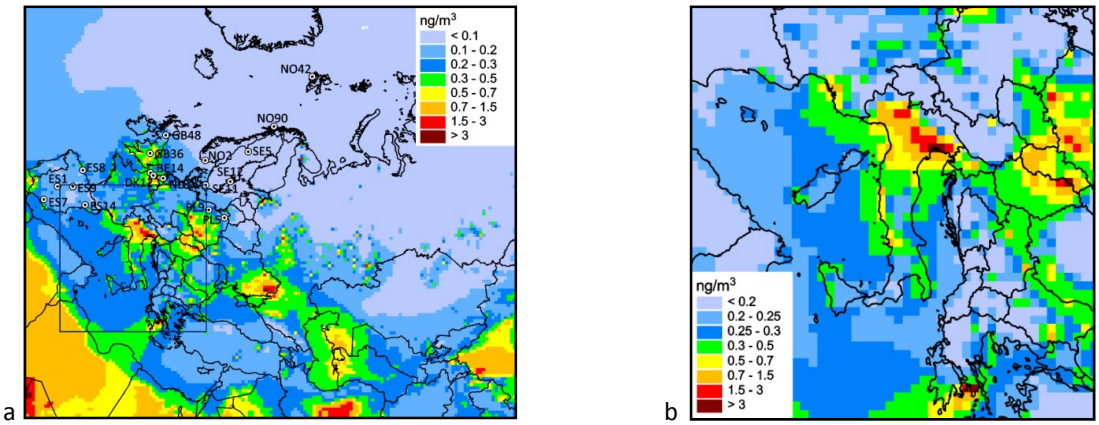

***Fig. 2**. Spatial distribution of annual mean concentrations of arsenic over EMEP domain (a) and over the region for MINNI modelling (b) in 2015*

Unlike arsenic, nickel and chromium, spatial distribution of air concentrations of zinc and copper has specific peculiarities. The most significant emissions and, consequently, pollution levels of zinc and copper take place in Germany (Fig. 3).

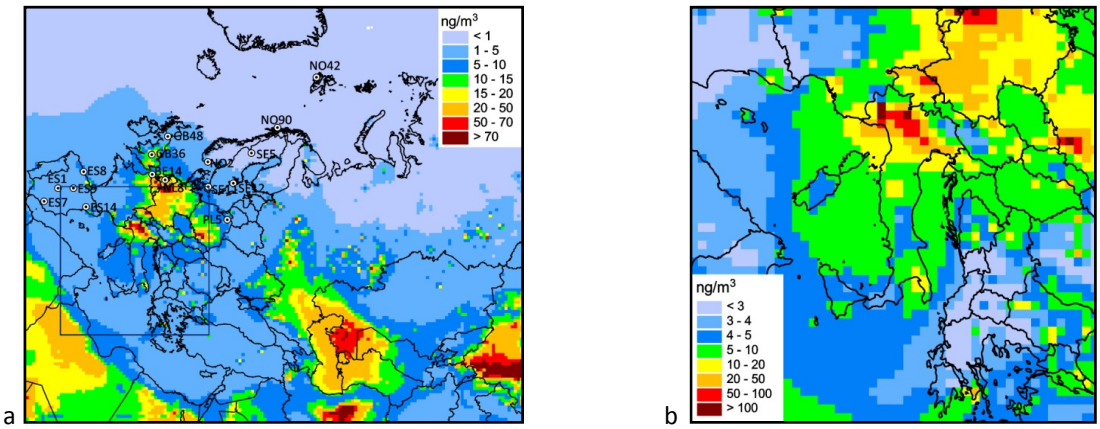

***Fig. 3**. Spatial distribution of annual mean concentrations of zinc over EMEP domain (a) and over the region for MINNI modelling (b) in 2015*

Data from 16 EMEP stations measuring arsenic in air in 2015 are involved into verification of the modelling results. Mean relative bias is about -17% which means some underestimation of the observed levels by the model in area covered by monitoring stations (Table 1). The most significant underestimation takes place for stations DK12, PL5, SE5, SE12 and the Norwegian stations (Fig. 4). For other stations the bias between observed and modelled levels lies within ±40%. Spatial correlation coefficient is about 0.8, which indicates that spatial variability is captured by the model.

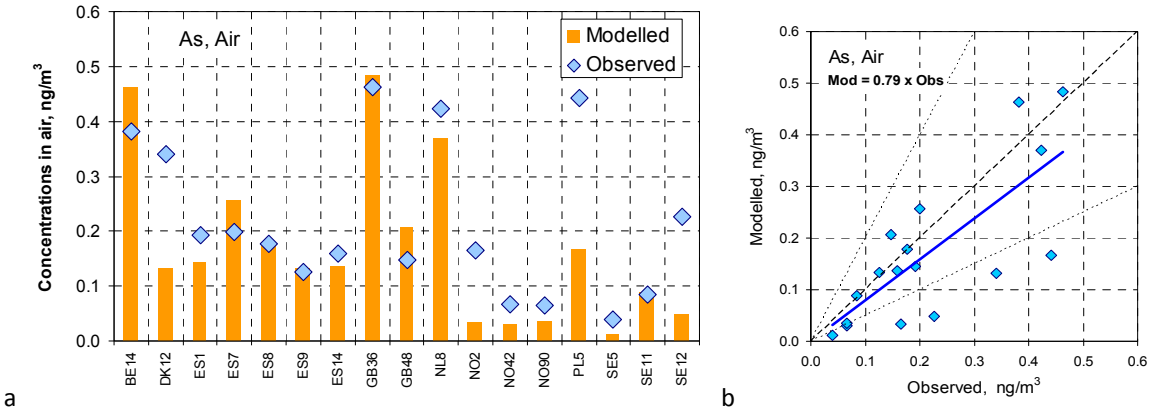

Fig. 4. *Annual mean modelled and observed concentrations of arsenic in air in 2015 at individual stations (a) and their scatter plot (b). Dashed line mean 1:1 ratio, and dotted lines mean 2-fold range*

For 2015 data on measured air concentrations are available from 16 stations. Average level of concentrations was predicted by the model with bias about 1% (Table 1). However, spatial correlation is not so high compared to other metals (0.56). It is explained by 3-fold underestimation of the levels observed at Spanish station ES7 (Fig. 5). If this station is ignored, the correlation coefficient would be 0.79. Some overestimation of Ni levels at stations SE14, PL5 and PL9 is caused by overestimated influence of anthropogenic component of air concentrations.

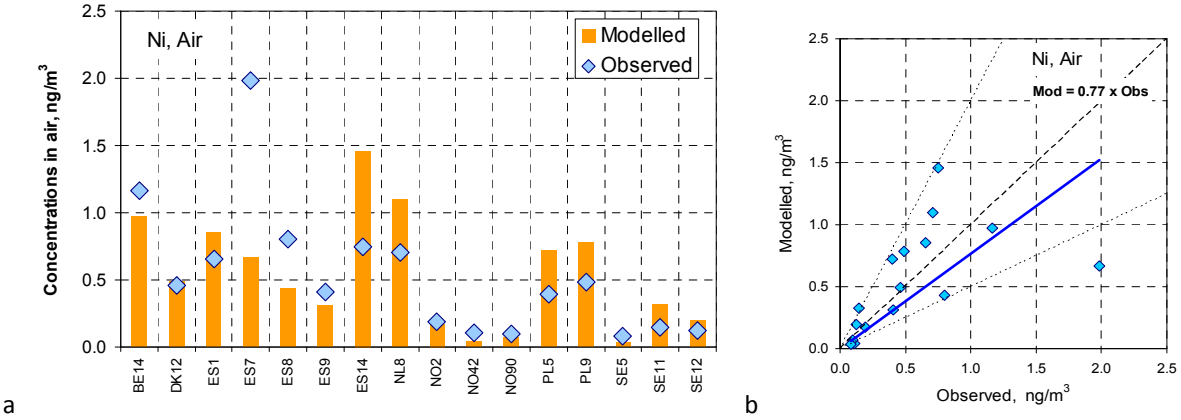

Fig. 5. *Annual mean modelled and observed concentrations of nickel in air in 2015 at individual stations (a) and their scatter plot (b). Dashed line mean 1:1 ratio, and dotted lines mean 2-fold range.*

Observed air concentrations of chromium in 2015 are available from 13 EMEP stations. Measured concentrations were somewhat (-16%) underestimated by the model (Table 1). The underestimation is caused mostly because of outlying measured values at station NO2, where the modelled value is 8-fold smaller than the observed one (Fig. 6). For most of other stations the bias between modelled and observed levels remains with ±50%.

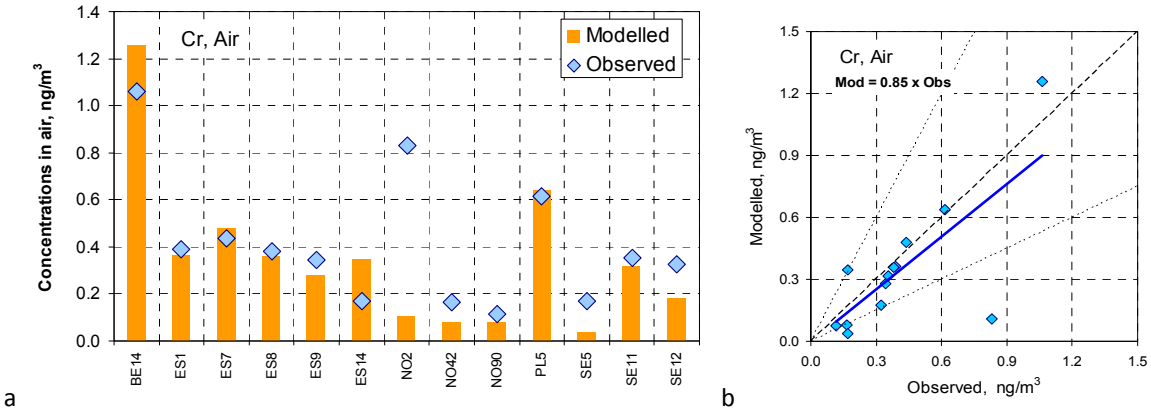

Fig. 6. *Annual mean modelled and observed concentrations of chromium in air in 2015 at individual stations (a) and their scatter plot (b). Dashed line mean 1:1 ratio, and dotted lines mean 2-fold range*

Data from 16 stations are involved into comparison of modelled and observed levels of zinc. On average the model underestimates observed zinc levels by about 20%. However, spatial differences in modelling performance are significant. Relatively good agreement between modelled and observed concentrations is seen for stations in the United Kingdom, Sweden and Benelux region (Fig. 7). At the same time large differences are noted for Spanish, Norwegian and Polish stations. For comparison, measured levels in 2014 at German stations vary from 6.3 to 18.4 ng/m^3, in France – from 7.2 to 16.1 ng/m^3. The corresponding median values are 13.6 and 9.5 ng/m^3. The only measured value for station in Slovenia is 8.1 ng/m^3.

Large differences in emission spatial distribution are reflected in distribution of calculated air concentrations in Europe: high concentrations in Germany and Poland are contrasting to low levels in Spain, France, southern and south-eastern parts of Europe. It is likely that the reason of these differences is connected with emission inventories in European countries. For example, according to the data provided by CEIP, around 90% of zinc emission in Germany is caused by automobile tyre and brake wear, while in other countries the role of this sector is much smaller. In order to identify reasons of mentioned discrepancies between modelled and observed levels of zinc, more detailed investigation is needed.

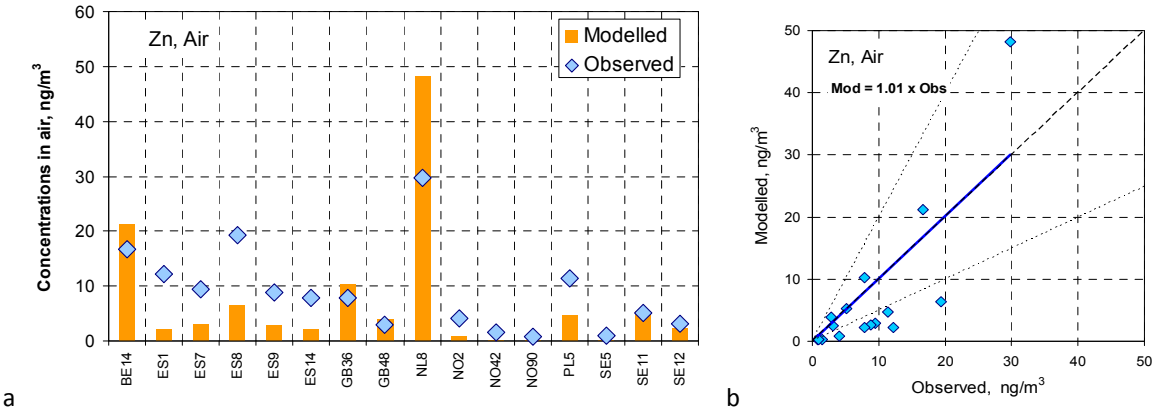

Fig. 7. *Annual mean modelled and observed concentrations of zinc in air in 2015 at individual stations (a) and their scatter plot (b). Dashed line mean 1:1 ratio, and dotted lines mean 2-fold range*

Information on measured concentrations of copper in air in 2015 is available from 11 stations. On average, the model managed to reproduce the concentrations: the mean relative bias is about -1% and

spatial correlation coefficient is 0.72 (Table 1). However, the relative differences between modelled and observed levels at particular stations vary significantly. The model underestimates observed levels at stations ES9, GB36 and Norwegian stations (Fig. 8). Some overestimation can be mentioned for station BE14, which is likely caused by overprediction of effect of secondary emissions in Benelux region. More than 90% of calculated concentration at station SE11 is contributed by anthropogenic sources. Therefore, significant (4-fold) overestimation at this station is likely explained by uncertainties of anthropogenic emissions.

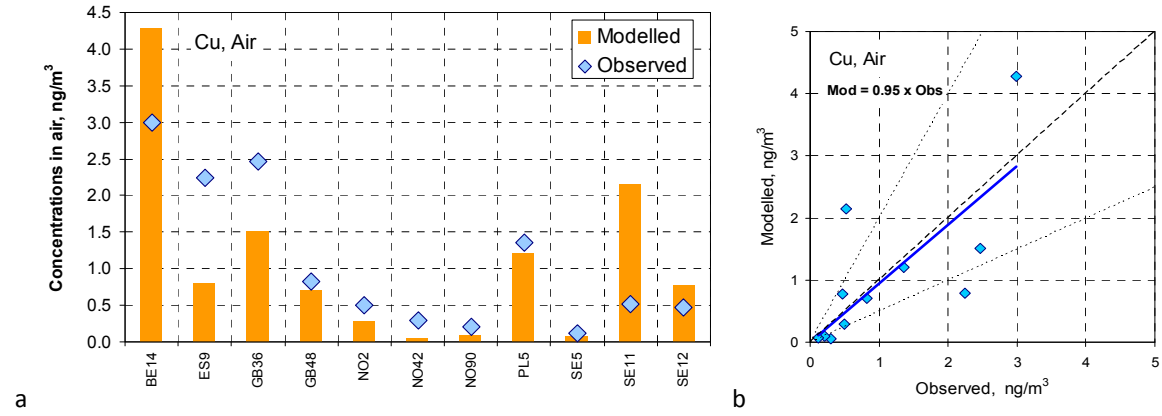

Fig. 8. *Annual mean modelled and observed concentrations of zinc in air in 2015 at individual stations (a) and their scatter plot (b). Dashed line mean 1:1 ratio, and dotted lines mean 2-fold range*

Information on selenium measurements in the atmosphere is very limited. Only two British stations provided observed air concentrations in 2015 within the EMEP region. The model reproduced these levels with negligible mean relative bias (Table 1). However, it should be noted that no strict conclusions could be derived from the comparison based on the measurement data from only two stations.

In general, concentrations of second-priority metals were simulated with satisfactory accuracy: the mean relative bias is within ±20% range and spatial correlation coefficient varies from 0.6 to 0.8. However, at some particular stations the differences between modelled and observed concentrations can be significant. More detailed analysis of emission data, monitoring information and modelling approaches, carried out in cooperation between EMEP centres and national experts, could favour improvement of quality of model assessment.

Information on pollution levels of heavy metals targeted by the Protocol is regularly reported to the EMEP countries. However, pollution levels of so-called second priority metals (As, Ni, Cr, Cu, Zn, Se) can also be of interest. In particular, for air concentrations of some of these metals (As and Ni) target values are established by EU Directive 2004/107/EC. Modelling of atmospheric transport and deposition of these metals is undertaken by various groups of scientist on regional [*González et al.,* 2012, *Chen et al.,* 2013, *Dore et al.,* 2014, *Adani et al*., 2015] and global scales [*Wai et al.*, 2016]. Information on lead, cadmium and mercury concentrations and deposition in 2015, described in Chapter 1, is supplemented with modelling results for the second priority metals. Annual mean levels of As, Ni, Cr, Cu, Zn, Se can be provided by the request.

References: EMEP Status Report 2/2017