FINNISH REGIONAL EMISSION SCENARIO (FRES) MODEL

Niko Karvosenoja*, Kaarle Kupiainen, Antti Tohka and Mikko Savolahti
Finnish Environment Institute, P.O.Box 140, FIN-00251 Helsinki, Finland *niko.karvosenoja@ymparisto.fi

1. FRES model development

National integrated assessment modeling (IAM) of air pollution in Finland has been used in the 1990s assessing acidification and supporting policy-making (Johansson 1999). At that time employed emission inventories were relatively rough and compiled on case-by-case basis.

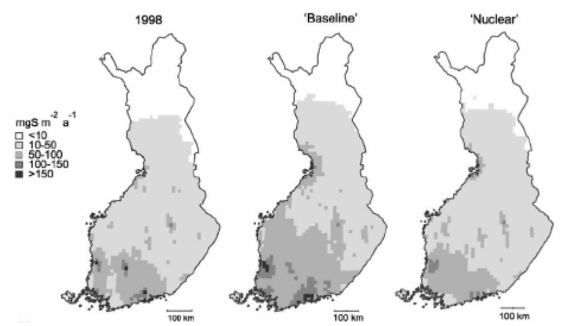
The development of a comprehensive emission model to work as a part of the IAM system started in the late 1990s. The first version of the Finnish Regional Emission Scenario (FRES) model described the emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and non-methane volatile organic compounds (NMVOCs) from approx. 250 point sources and area sources at municipality level (448 municipalities in Finland). The current version additionally consists of primary particulate matter in different size fractions (TSP, PM_{10}, $PM_{2.5}$, PM_1, $PM_{0.1}$), and chemical compositions (BC, OC, sulphates, minerals, heavy metals, dioxins, furans). Furthermore, area sources are described at 1 × 1 km spatial resolution (Figure 2). (www.environment.fi/syke/pm-modeling)

2. IAM studies with the FRES model

FRES model has been used to estimate future emissions and impacts of different activity pathways. The studies presented here have been carried out in two phases: (1) as a part of the environmental impact assessment (EIA) of the Finnish climate strategies and (2) in the national IAM of PM project KOPRA (www.environment.fi/default.asp?node=12463&lan=en).

2.1. EIA of the Finnish climate strategy

The EIA of the Finnish climate strategies (2000-2001) concentrated primarily on acidification and ground-level ozone assessment with different activity pathways in 2010 and 2020. The FRES emissions of SO_2, NO_x, NH_3 and NMVOC were used as input to the acidifying deposition and ozone formation models (Syri et al. 2002). The resulting acidic depositions and ozone concentrations were combined with the data of ecosystem critical loads and critical ozone levels (AOT40 and WHO guidelines), respectively (Figure 1).



(a) (b) (c)

Figure 1. Sulphur deposition caused by Finnish emissions (a) in 1998 and (b) in 2020 in the Baseline pathway and (c) Nuclear GHG action pathway (Syri et al. 2002)

2.2. KOPRA IAM of PM project

KOPRA project (2002-2005) focused on the development of PM assessment framework. Emission scenarios for PM and gases in 2010 and 2020 were developed and feasible emission reduction potentials and costs, as well as emission uncertainties were estimated (Karvosenoja et al. 2007, Karvosenoja et al. 2008). Atmospheric modeling with 10 × 10 km spatial resolution and health risk assessment were carried out by Finnish Meteorological Institute and National Health Institute, respectively. In order to assess health effects of future pathways, PM dispersion was estimated based on the application of source-receptor transfer matrices that were developed based on the base year atmospheric modeling and incorporated in FRES model (Figure 3) (Rypdal et al. 2007).

2. Future work

The analysis of KOPRA project dispersion modeling and emission - population relationships revealed the need for finer resolution dispersion estimates in the vicinity of low-emission sources, such as traffic and domestic combustion. The ongoing PILTTI project (2006-2008) (http://www.ymparisto.fi/default.asp?contentid=202713&lan=fi&clan=en) aims to develop 1 × 1 km resolution PM transfer matrices for the total area of Finland.

In addition to primary PM source-receptor matrices available in the FRES model, matrices for gas-to-particle sulphate and nitrate secondary PM, as well as for sulphur and nitrogen deposition will be available during 2008.

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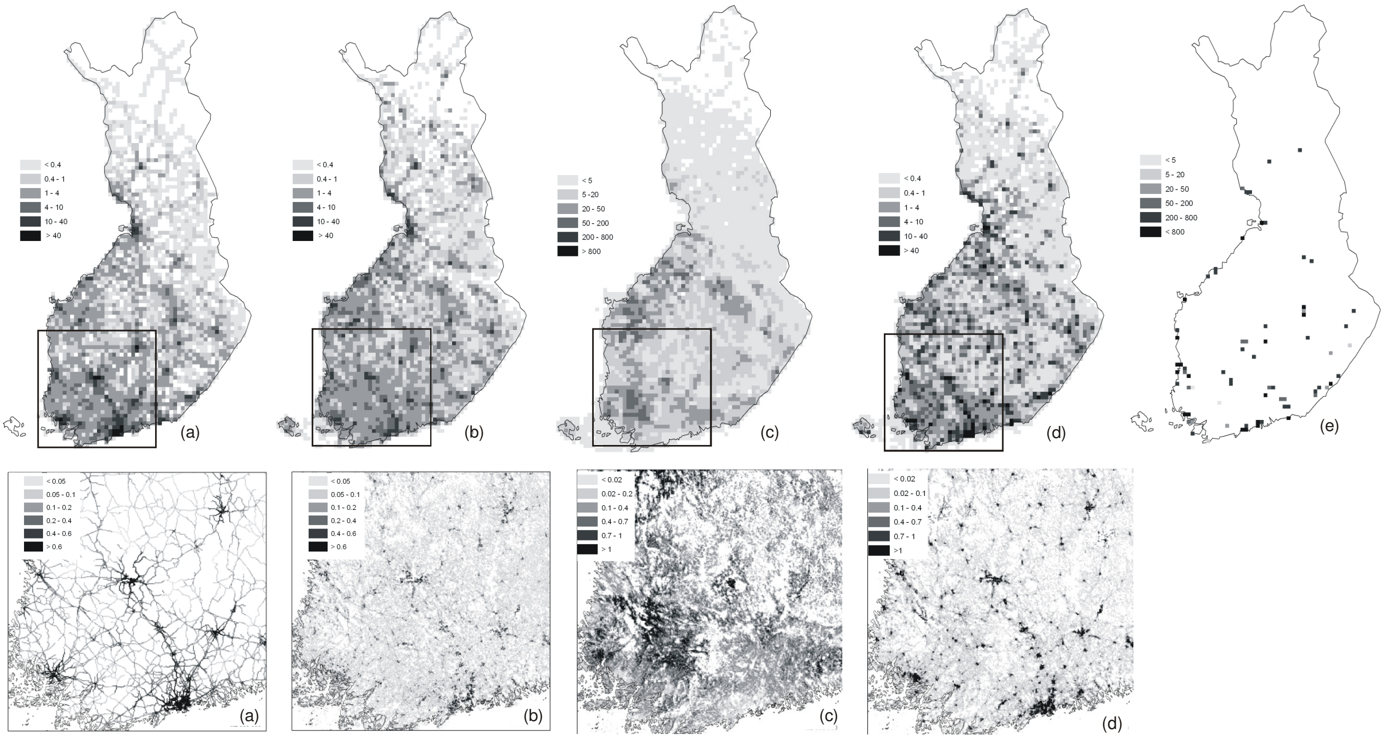

Figure 2. The spatial emission distribution of (a) road traffic, (b) residential wood combustion, (c) agriculture, (d) other area sources and (e) point sources in 2000 presented in $10 \times 10 km^2$ and (a) – (d) in $1 \times 1 km^2$. Unit Mg(PM2.5) a^{-1}, except (c) $Mg(NH_3)$ a^{-1} and (e) $Mg(SO_2)$ a^{-1}. (Karvosenoja et al. 2005)

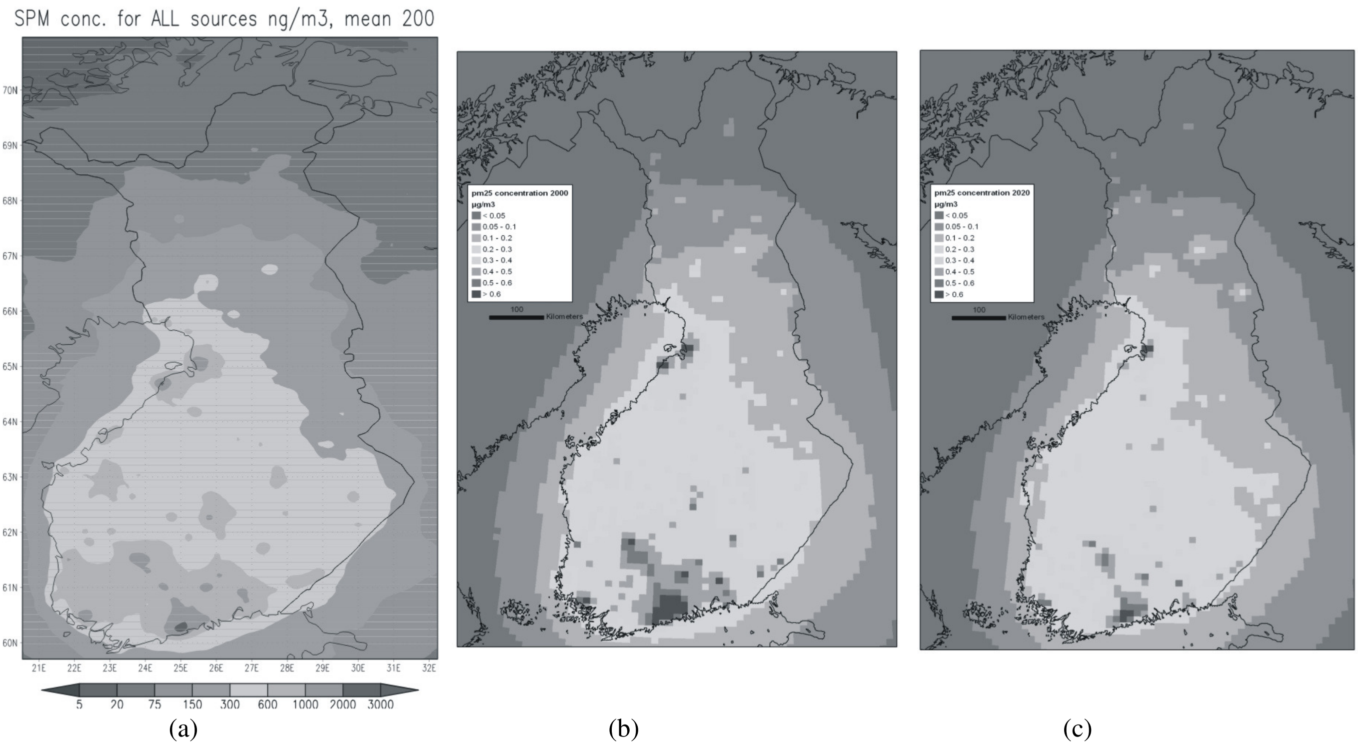

Figure 3. $PM_{2.5}$ concentrations caused by Finnish emissions based on (a) SILAM dispersion modeling in 2000, (b) source-receptor transfer matrices in 2000 and (c) transfer matrices in 2020 (Rypdal et al. 2007)