Integrated assessment modelling at SYKE

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www.environment.fi/syke/gto

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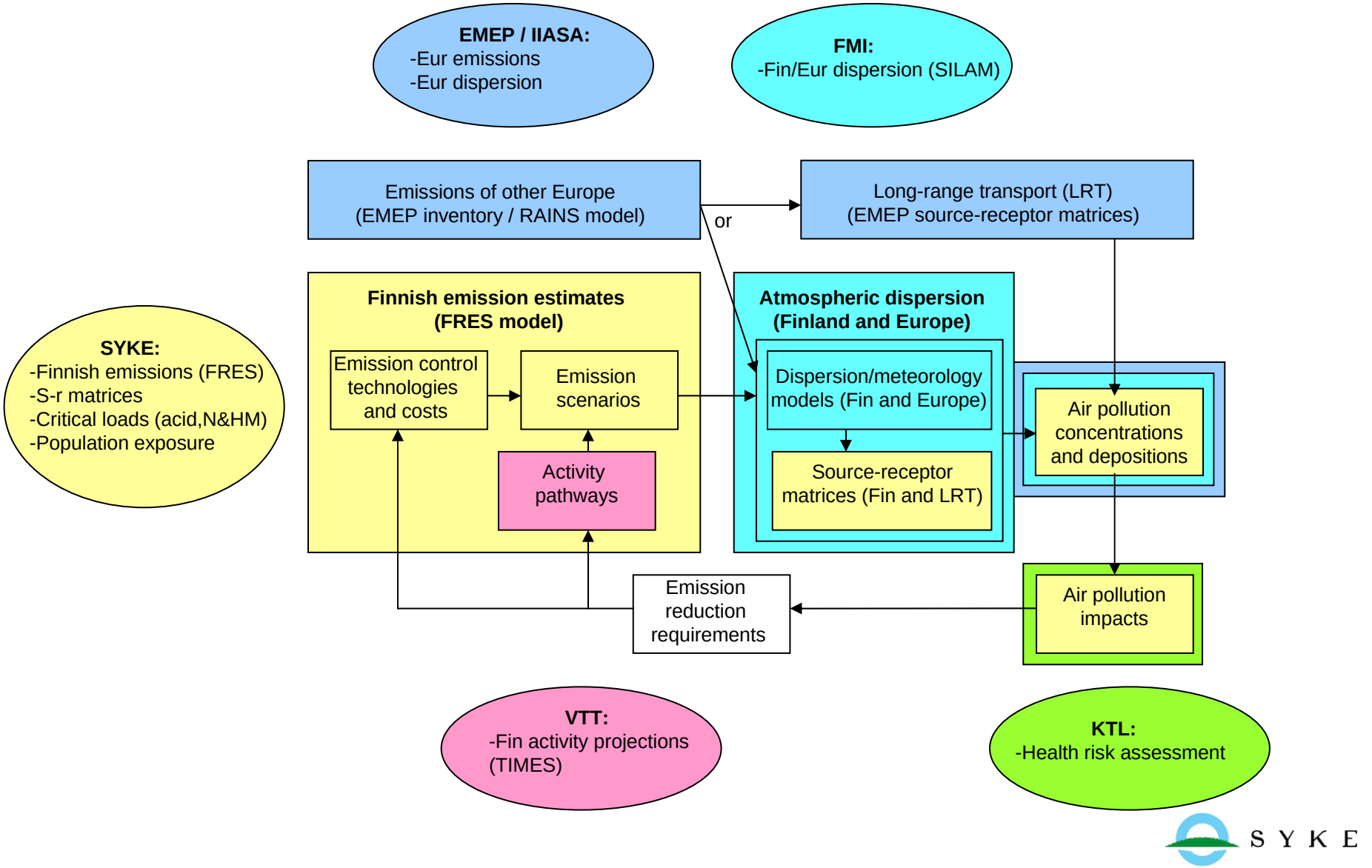
Main SYKE topics regarding N

- National Integrated Assessment model FRES
  - N, S, PM, emissions, scenarios and effects
  - Checking of RAINS data for Finland
- Calculation of critical loads for N
  - Mass balance and empirical CL
- N effects on ecosystems
  - INCA-N catchment modelling and scenario assessment (N-deposition, management, climate change)
  - N budgets, processes and trends of catchments and lakes
  - Baltic Sea research (N loading and coastal processes)
  - Biodiversity changes (mostly land-use)

Finnish IAM framework



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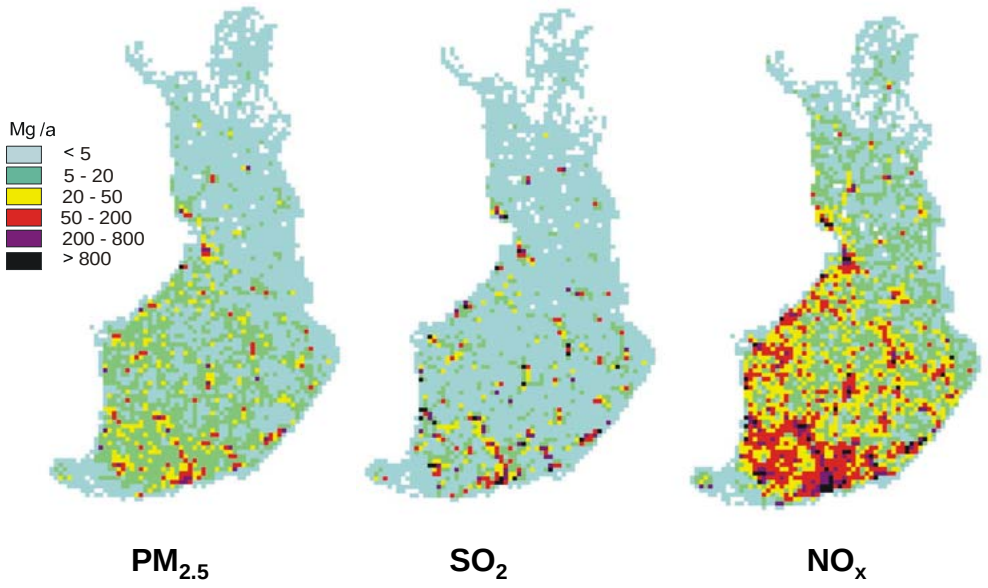
Finnish Regional Emission Scenario (FRES) model

www.environment.fi/syke/pm-modeling

- Anthropogenic emissions 1990, 2000, 2010, 2020, 2025 (several projections)
- Comprehensive and congruent calculation for primary PM and gases
  - •primary PM (TSP, PM10 - 2.5 - 1 - 0.1, chemical composition in size classes)
  - •SO_2, NO_x, NH_3, NMVOC
- Abatement technologies and costs
- Aggregation: 154 sectors, 15 fuels
- Large point sources (>200), area emissions (1 × 1km^2)
- Several emission heights
- Dispersion with s-r matrices
- LRT from EMEP



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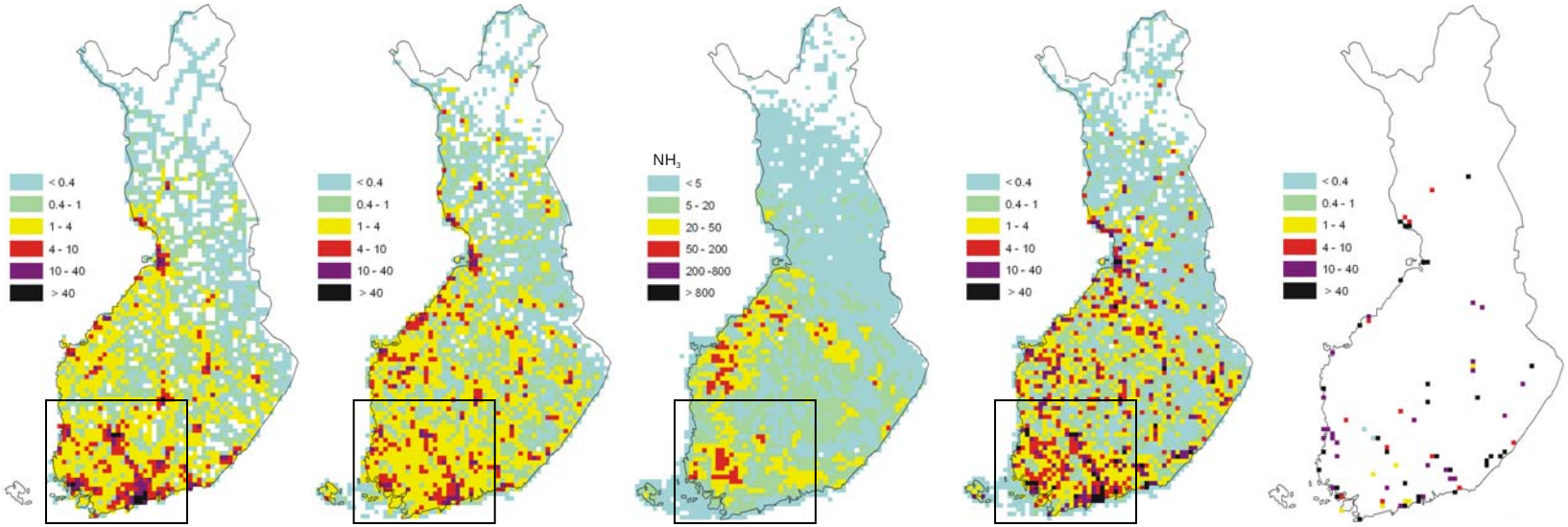
Links / similarities: FRES & Fin IAM vs. RAINS/GAINS

- Mainly **same air pollutants and impacts**
- FRES **source aggregation convergent** with RAINS classification (FRES more refined for some national key sectors, e.g. domestic wood combustion)
- Mainly **same source definitions** (exceptions, e.g. traffic resuspension)
- Mainly **same abatement technologies** for air pollution; efficiencies & costs based partly on RAINS, partly on national data (comparison studies)
- FRES **activity projections** as RAINS national pathways
- **LRT** based on RAINS / EMEP emissions and (optionally) EMEP matrices
- FRES main Finnish reference in RAINS **bilateral consultations**
- FRES people involved in **LRTAP** (TFIAM) and **CAFE** (CityDelta) processes
- Close **collaboration** between IIASA/SYKE scientists

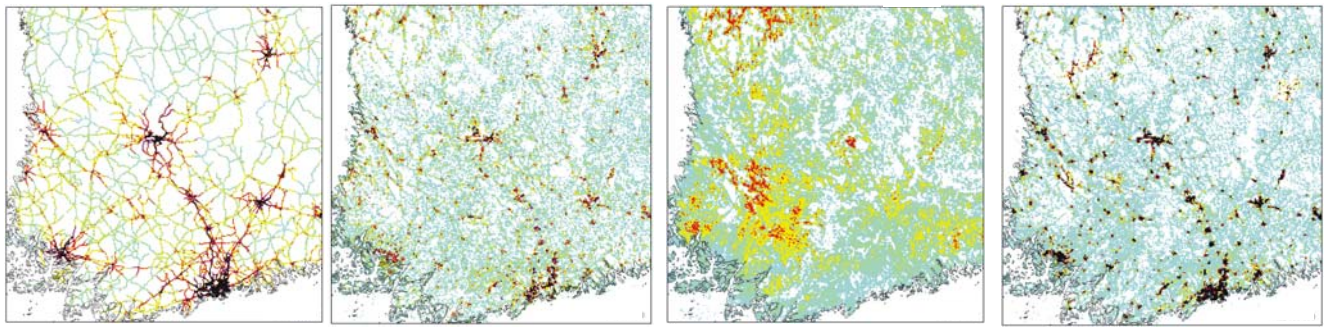
Finnish Regional Emission Scenario (FRES) model

www.environment.fi/syke/pm-modeling

- Emissions in 1 x 1 km^2 grid



Point sources



Road traffic (PM2.5)

Domestic combustion (PM2.5)

Agriculture (NH_3)

Other area (PM2.5)

Karvosenoja, Porvari, Raateland, Kupiainen, Johansson 2005

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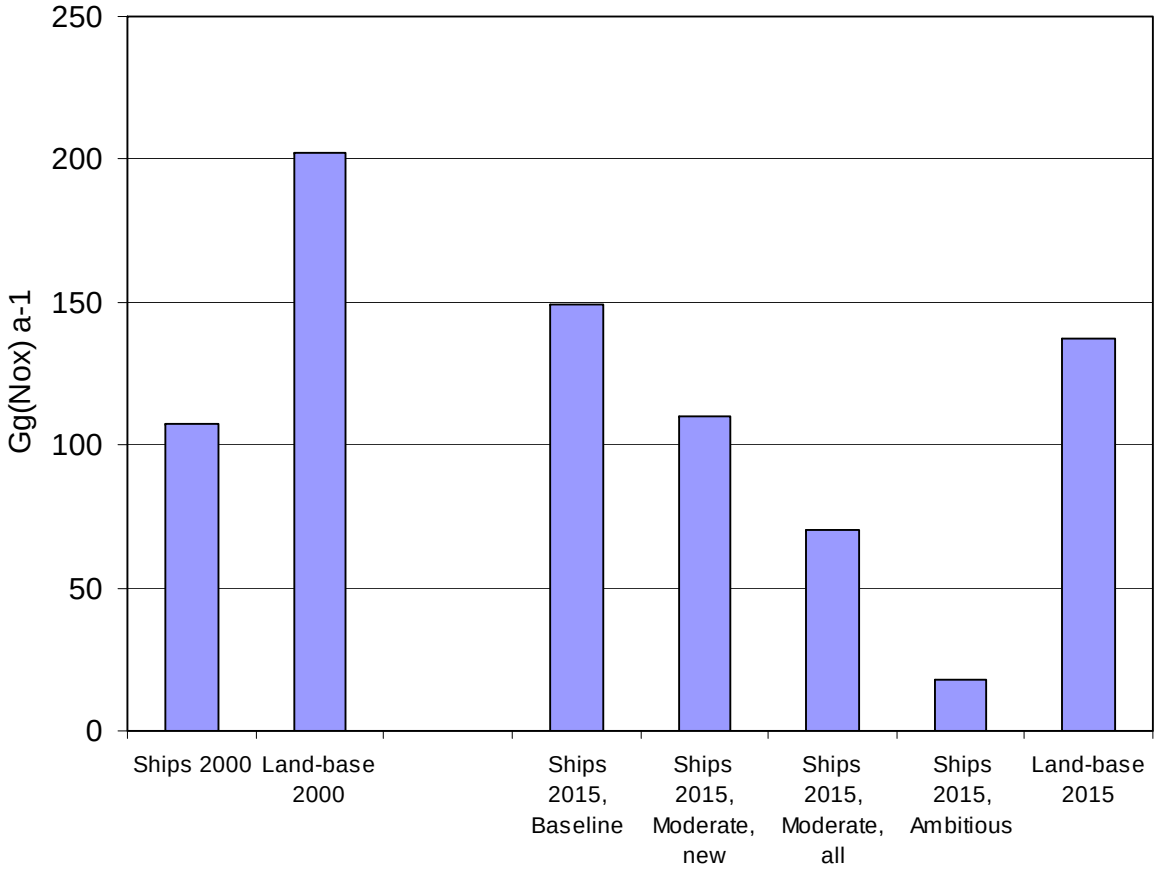
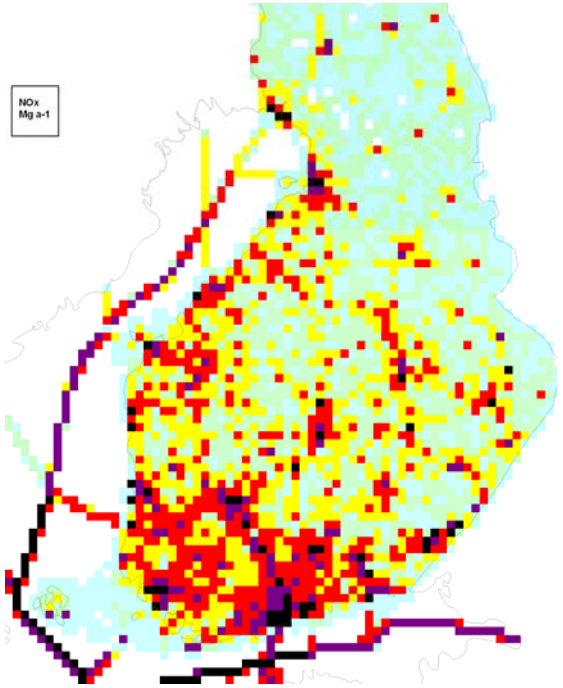
Finnish activity projections

- TIMES energy system model of VTT for energy projections
- LIPASTO traffic model of VTT
- Agriculture projections by Agricultural Research Centre
- Coordinated in national Climate Strategies by Ministry of Trade and Industry

Ship emissions at Northern Baltic Sea



Ship and land-based NOx emissions 2000



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Wahlström, Karvosenoja, Porvari 2006

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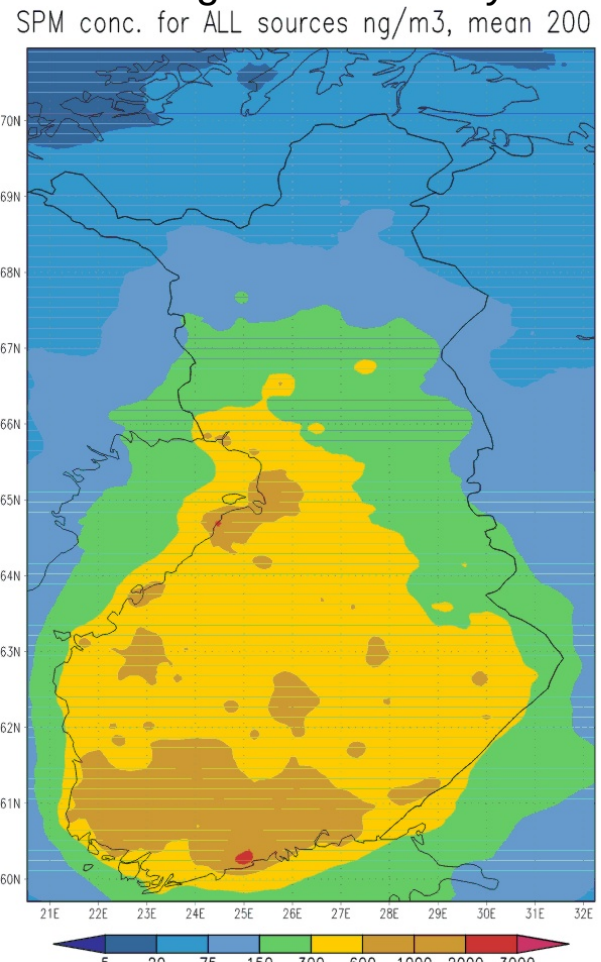
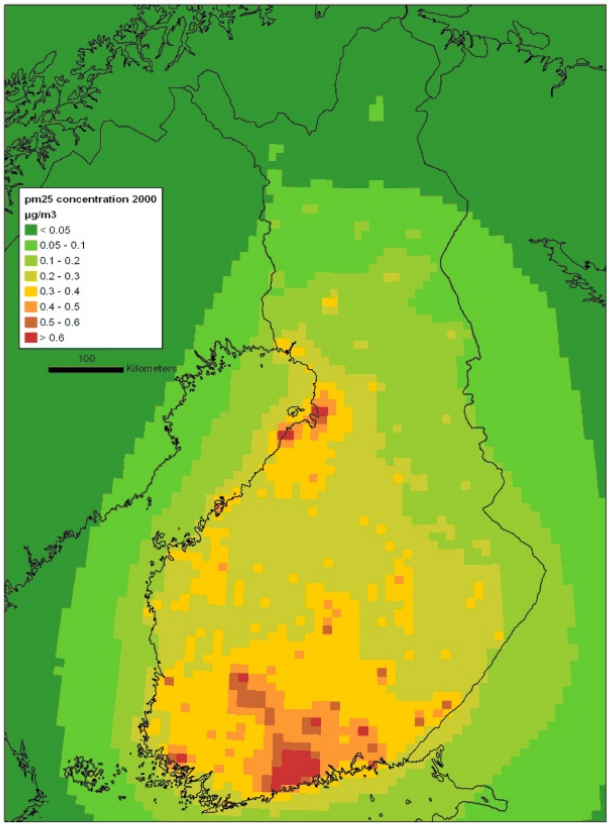
Source-receptor matrices based on SILAM/HIRLAM

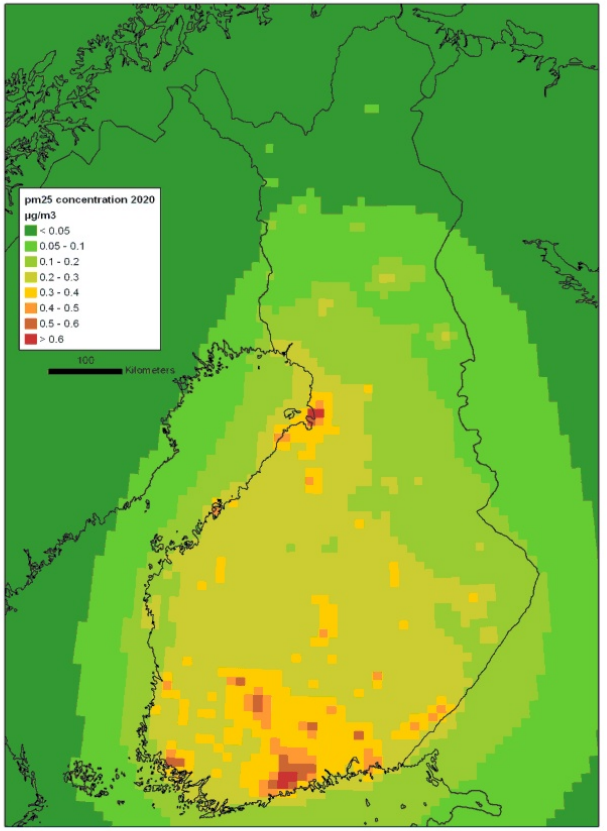
- Available: Primary PM10-2.5-1-0.1, Sulfate, S-deposition (resolution Fin10km / Eur30km)
- Yet to come: Nitrate, N-deposition;
- PILTTI project: Fin primary PM2.5 matrices for low-altitude sources in 1 km resolution
- ?: Organic secondary PM



2000, SILAM/HIRLAM modeled



2000
Matrices (based on SILAM/HIRLAM)



2020
Matrices (based on SILAM/HIRLAM)

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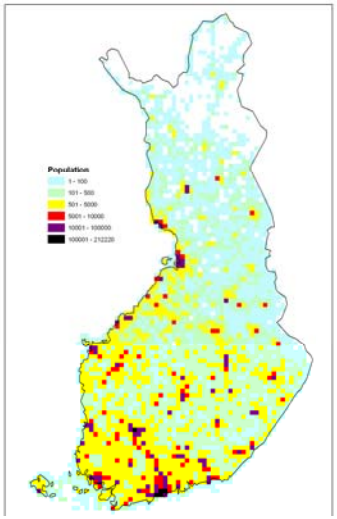
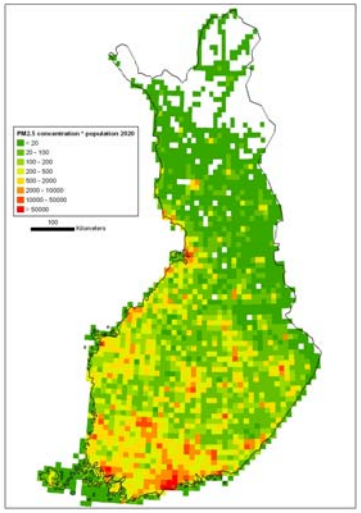
Impacts: PM

- Population exposure: concentration fields, population data (SYKE)

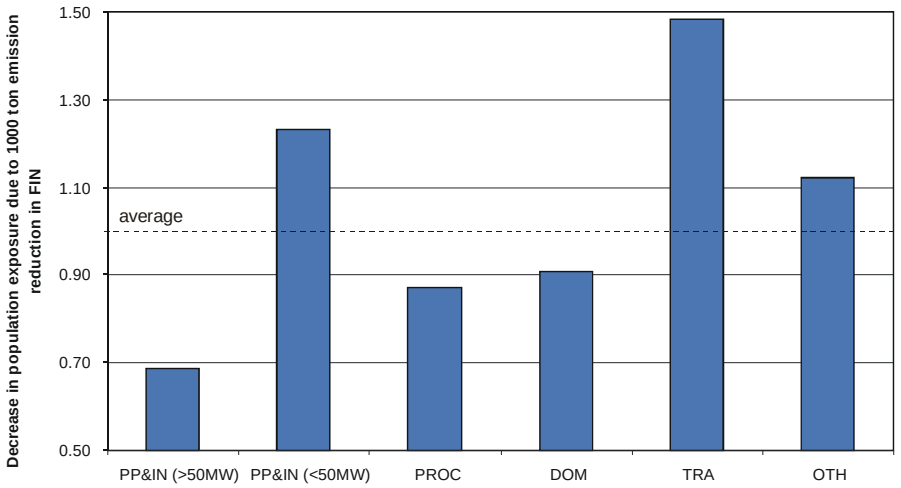


Population



Population exposure

Relative emission – exposure effects



Rypdal, Rive, Åström, Karvosenoja, Kupiainen, Bak, Aunan, Kukkonen, *En.Policy* 35:6309-6322

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- Health impacts and risks: Intake Fraction (iF) studies, harmfulness of PM properties (KTL)

Emission	Exposed population		
Emission in Finland	**Finnish**	**Other Europe**	**Total**
Area sources (solid fuel)	12	7	19
Domestic combustion	52	39	91
Traffic	49	27	76
Agriculture+peat	14	9	23
Large power plants	13	11	24
Large industrial plants	10	8	18
Total	**150**	**102**	**252**
Source in Europe, total	195	..	
All emission sources	**345**	**..**	

Premature deaths caused by primary PM2.5 (all PM equally toxic)

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Impacts: Critical loads

Receptor	Extent		Pollutant		Effect	Method	Update
	Area (km^2)	Sites	Dep.	Conc.			
Lakes	26 426	1 450	S, N		Acidification	SMB	*2001*
	17 000	820		Hg	Human health	SMB	*2005*
Forest soil	240 400	1 057 weath. sites	S, N		Acidification	SMB	*2001*
			N		Eutrophication	SMB	*2001*
			Pb, Cd		Ecosystem health	SMB	*2007*
Agricult. Soil			Pb, Cd		Ecosystem health	SMB	*2007*
Vege-tation	219 142	10 land use classes	N		Biodiversity	Empiric al CL	*2007*

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Applying empirical values of critical loads of N to land uses classes in Finland

- Harmonized land cover map for the bodies under the LRTAP convention (Cinderby 2007)
- Empirical critical loads of nitrogen Bern workshop 2002 (Achermann and Bobbink 2003)
- Assigning values suggested by Bern workshop to new harmonized LRTAP land cover map (Slootweg 2007)
- Empirical critical loads (Achermann and Bobbink 2003) were available for ten classes of land cover in Finland
- Some of these land cover classes with very little areal extent in Finland

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Eunis	Description	Area (%)
G3	Coniferouswoodland	30 %
G4	Mixed dec. & coniferous woodl.	26%
E5	Woodland fringes and clearings	13%
D1	Raised and blanket bogs	6%
F2	Arctic, alpine & subalpine scrubs	3%
G1	Broadleved deciduous woodland	2%
F4	Temperate shrub heathland	< 1%
E2.3	Moujntain hay meadows	< 1%
D2/4	Valley mires, poor fens	< 1%
A2.5	Coastal saltmarshes and reedbeds	< 1%

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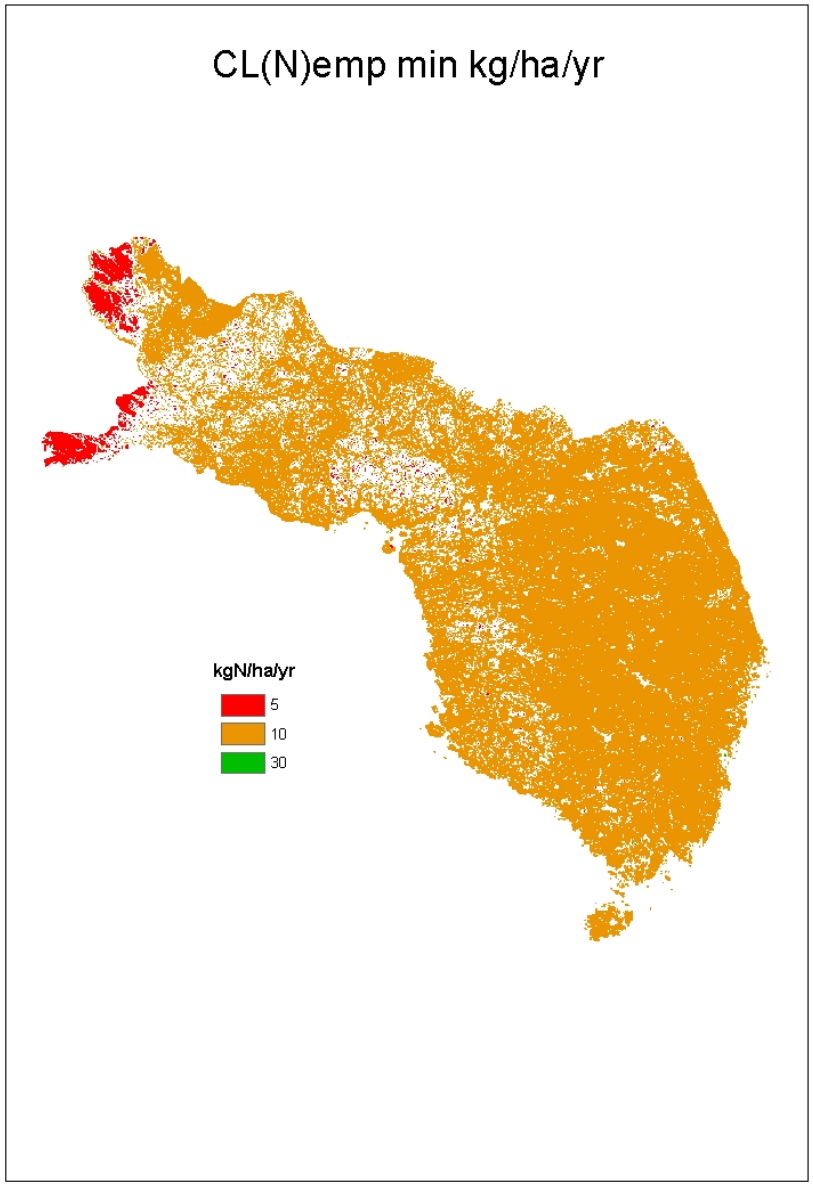

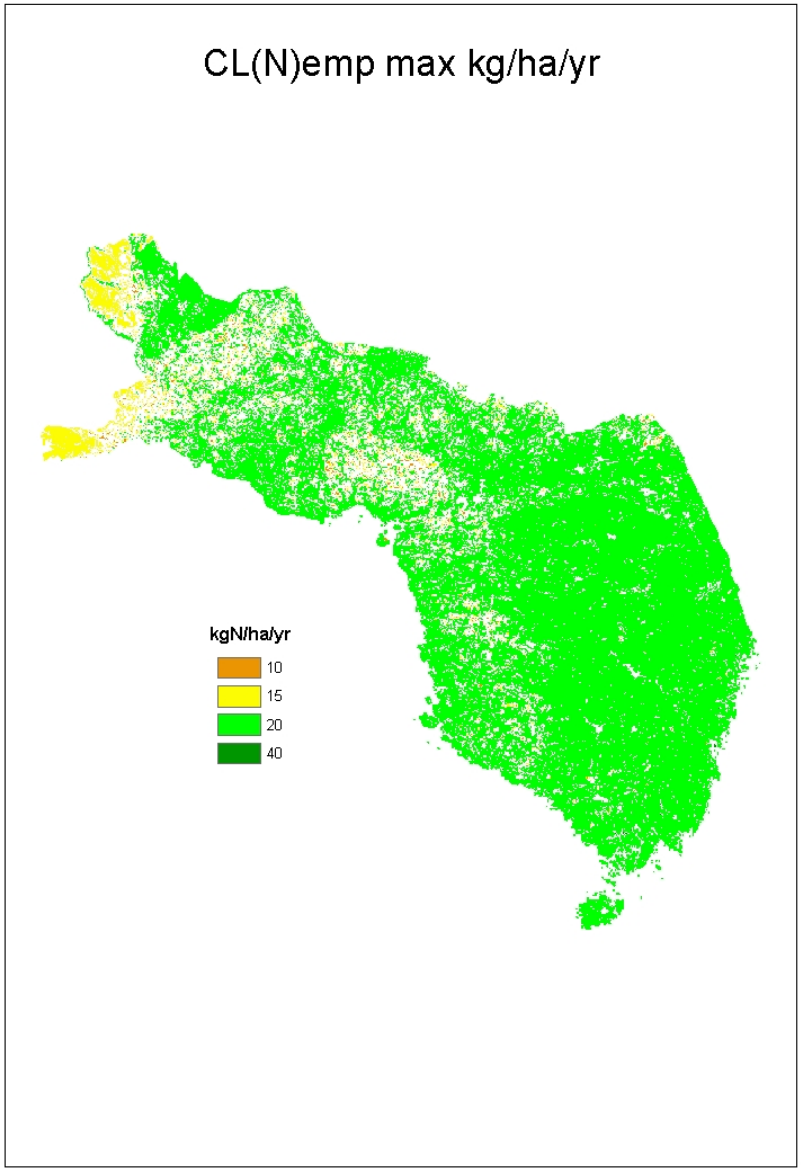

Empirical critical loads of nitrogen (kg N ha^{-1} yr^{--1}) per land use class

a) Minimum and b) Maximum values given for each land use class by Bobbink et al. 2002

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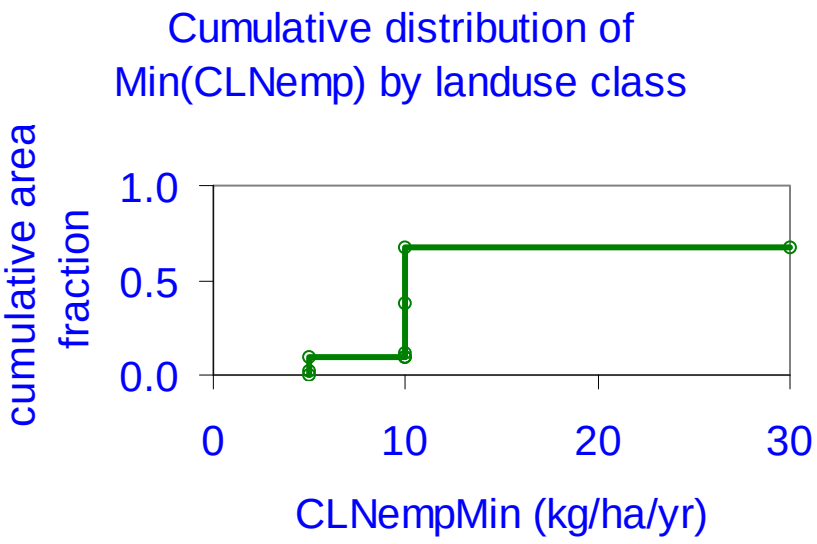

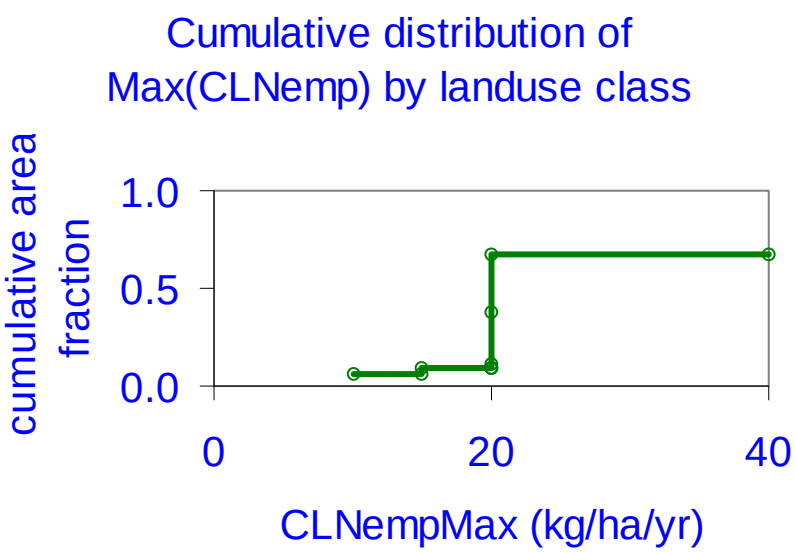

Cumulative distribution of empirical critical load of nitrogen CL N_{emp} (kg N ha^{-1} yr^{--1}) for ten classes of land use (LRTAP harmonized map) .

a) Minimum and b) maximum values given for each land use class by Bobbink et al. 2002

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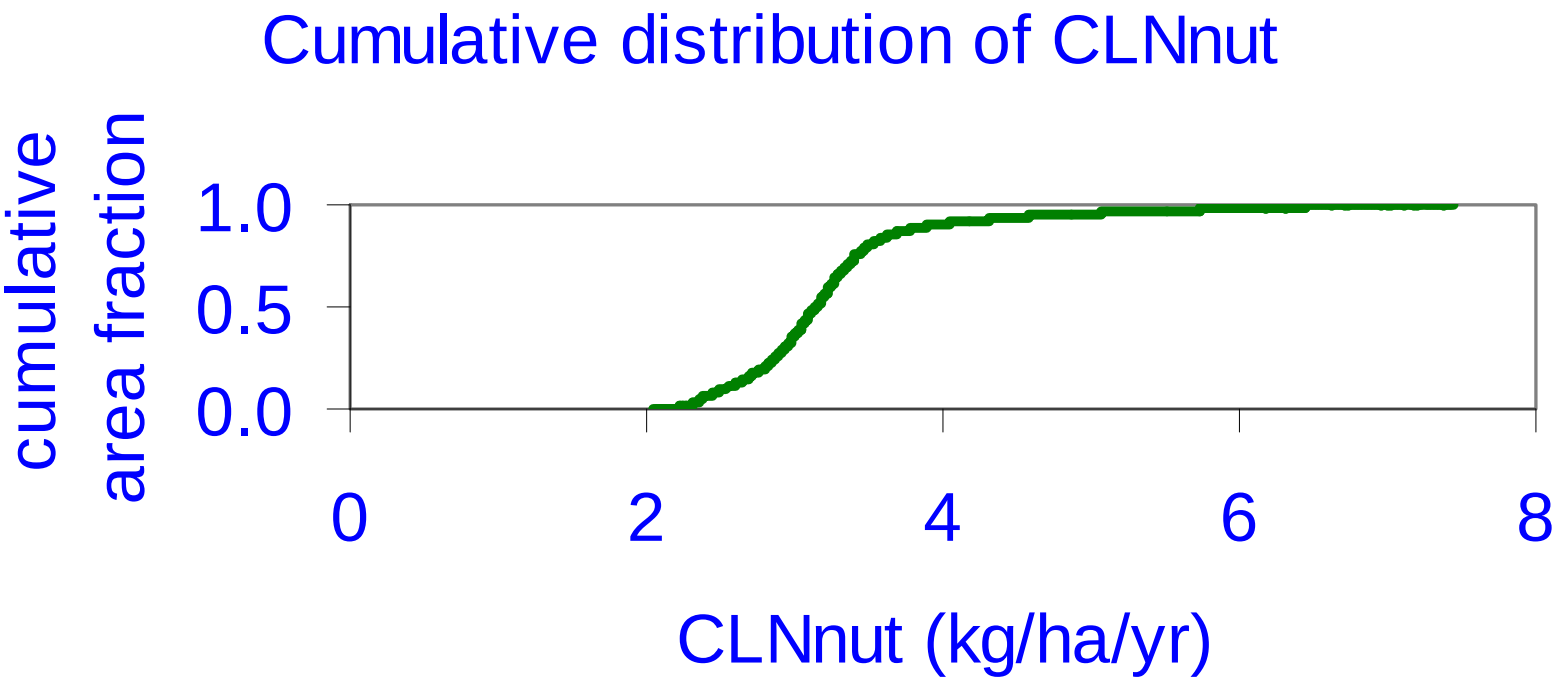

Cumulative distribution of mass balance critical load of nutrient nitrogen CL N_{nut} (kg N ha^{-1} yr^{--1})

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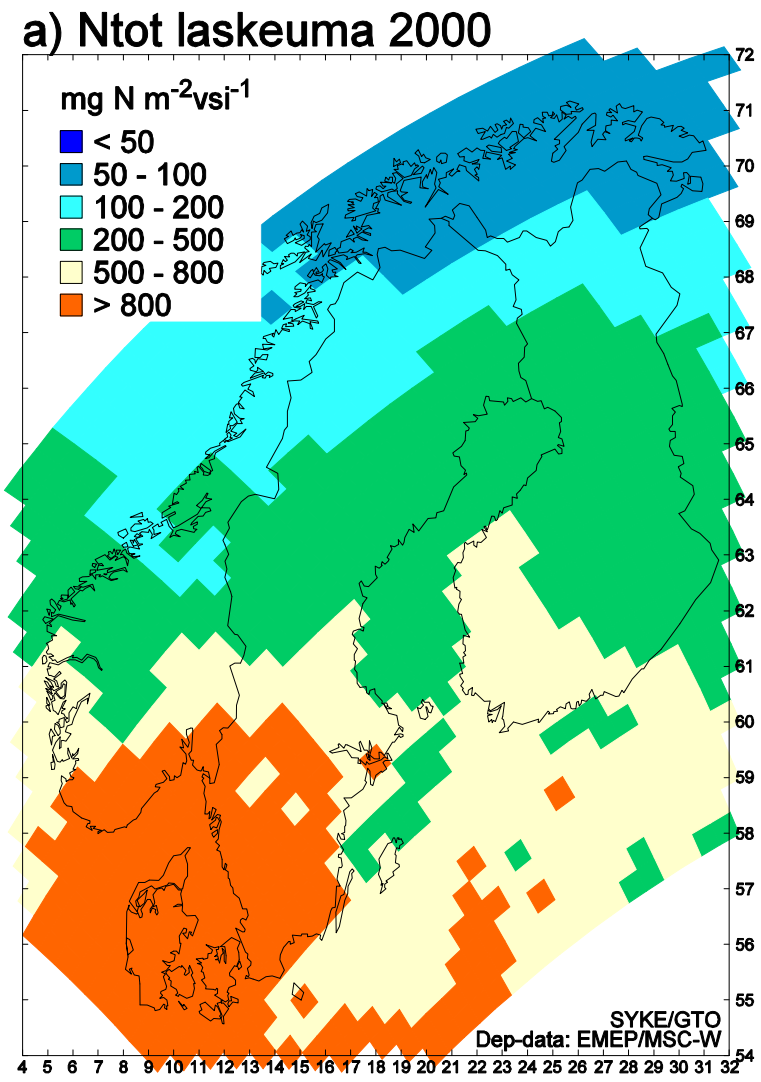

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Total deposition of nitrogen (mg N m^{-2} yr^{--1}) by EMEP MSC-W for the year 2000

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Conclusions

- with suggested empirical CL N, Finnish ecosystems appear less sensitive than with nutrient CL N, obtained by mass balance calculations

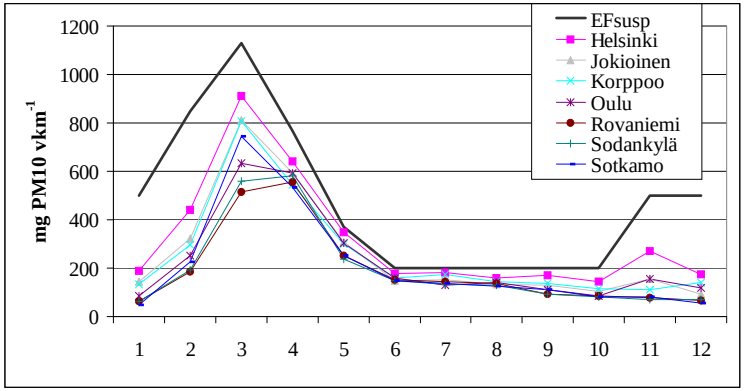
- there are indications that Nordic ecosystems indeed are sensitive to continued addition of low levels of nitrogen (Nordin et al. 2006)

- values by Nordin et al. (2006) used in Finnish submission of CL N values to ICP Modelling and Mapping (harmonised with Sweden)

Future issues (1)

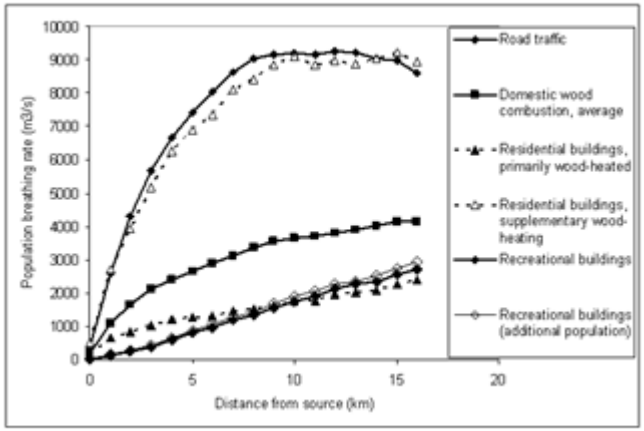
- Emissions
  - **PM**, (toxic pollution?)
  - Domestic **wood** comb., **small boilers** (1 – 50 MW), traffic **non-exhaust**
- Exposure
  - Low-emission-height sources, exposure **within 10 km**
  - S-r matrice development at **1 x 1 km²** for Finland (PILTTI)
- **Nitrogen** depositions and critical loads development

Traffic resuspension annual variation

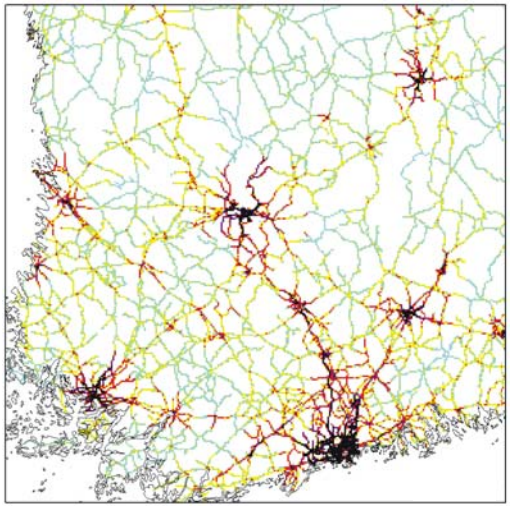


PILTTI project
- Health risks from nearby sources of fine particulate matter: domestic combustion and road traffic

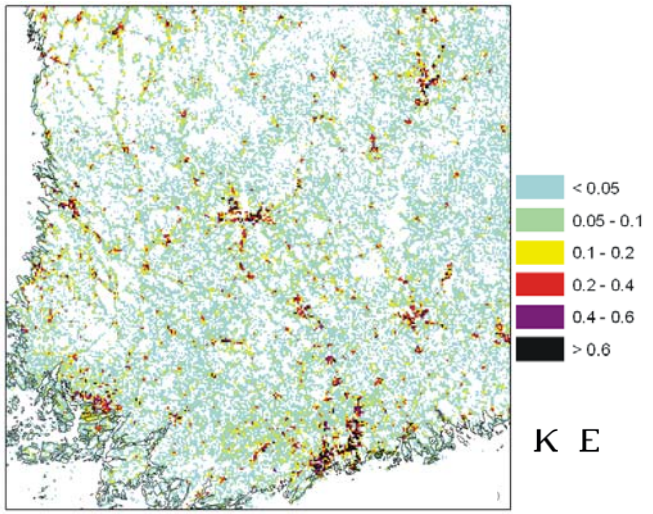
http://www.environment.fi/default.asp?contentid=202713&lan=en



Road traffic

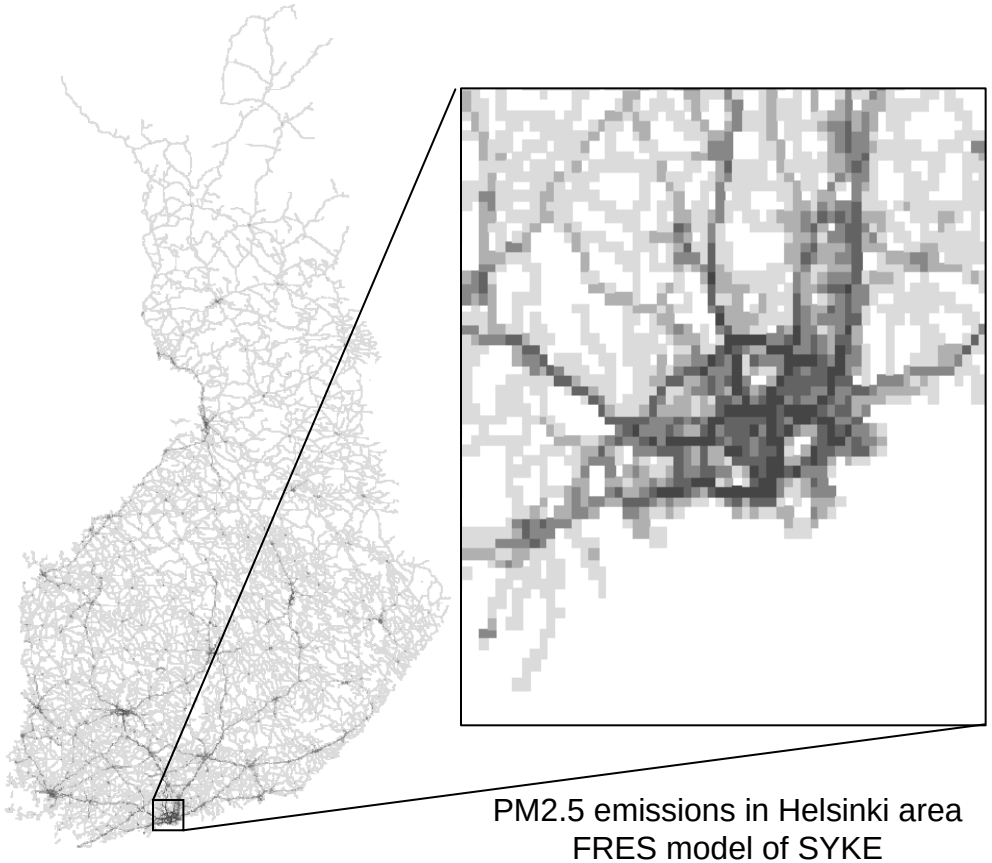


Dom. wood comb.

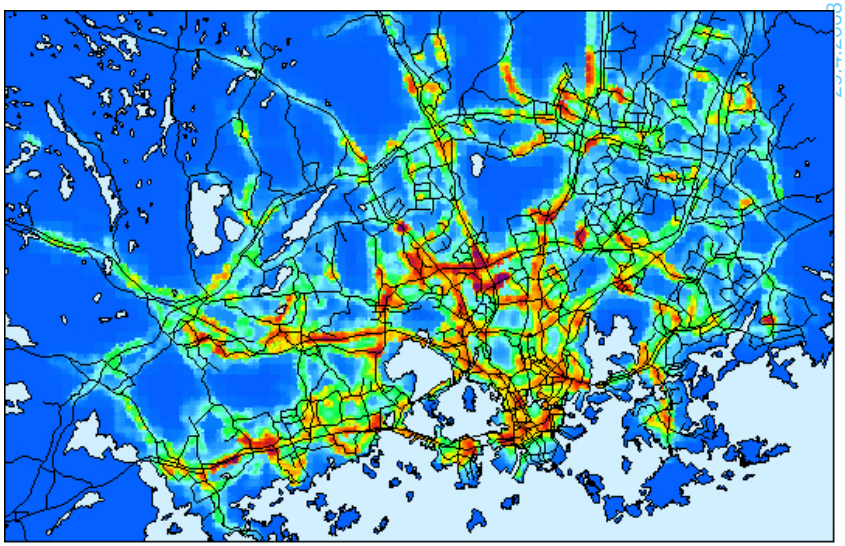


Future issues (2)

- Model integration
  - Extensions towards **climate change** assessment frameworks
  - More intense integration with **European scale** models, e.g. RAINS/GAINS (Project "Nordic low energy scenarios implemented in GAINS" 2007-2008 (SWE, FIN, NOR, DEN))
  - Collaboration with other **national scale** models (Project plans with other Nordic countries)
  - Integration with **local/urban scale** models



PM2.5 emissions in Helsinki area
FRES model of SYKE



PM2.5 concentrations in Helsinki area
Car-FMI model of FMI/YTV

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