

Cost-efficient reduction of population exposure caused by primary PM_{2.5} emissions in Finland (#66)

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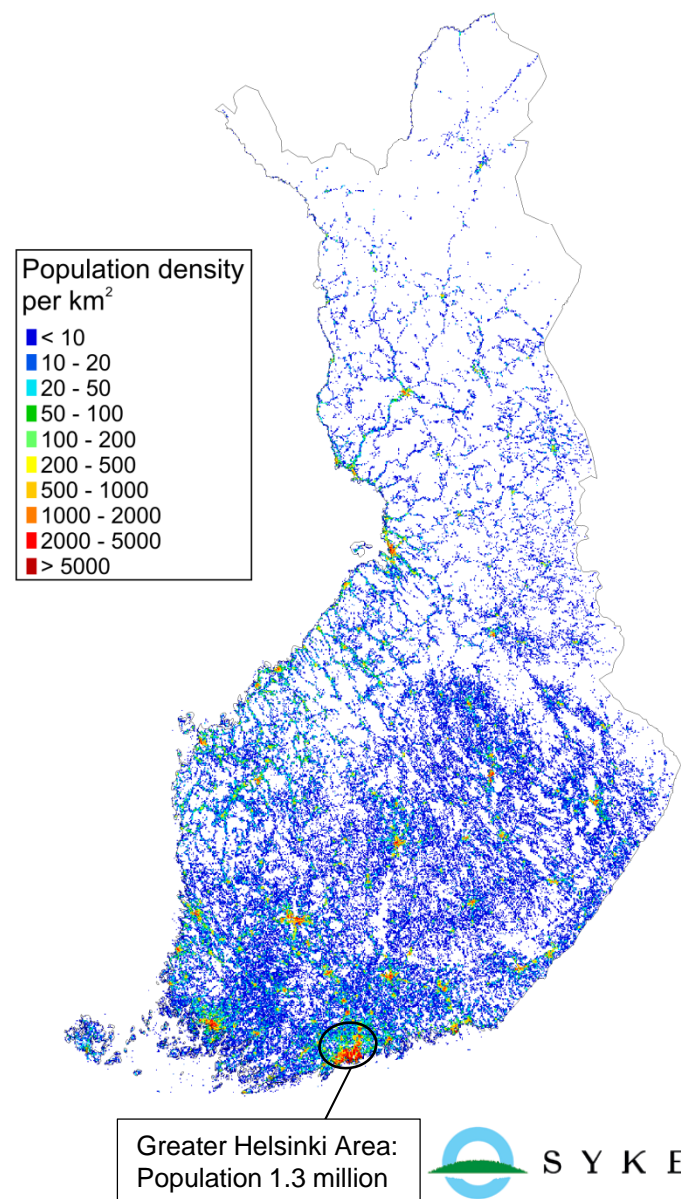
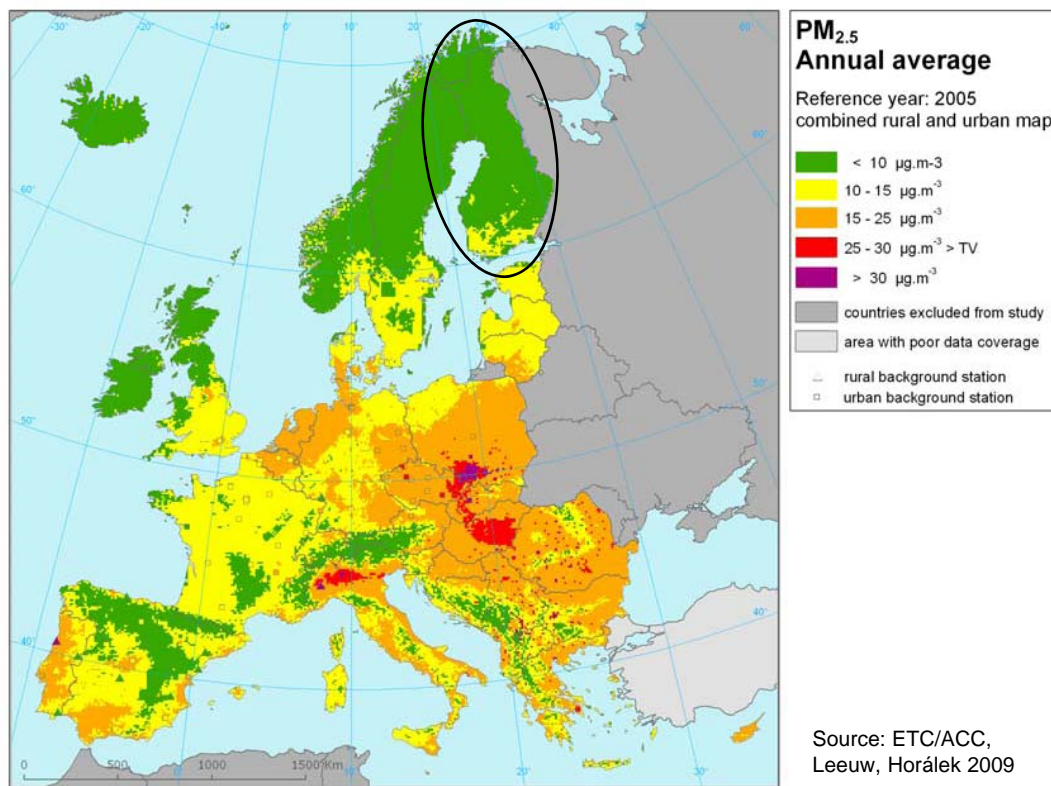
- Primary PM_{2.5} emissions in Finland 1984-2020
- Primary PM_{2.5} reduction potential and cost-efficiency in 2020 for:
 - Reduction of emissions
 - Reduction of population exposure

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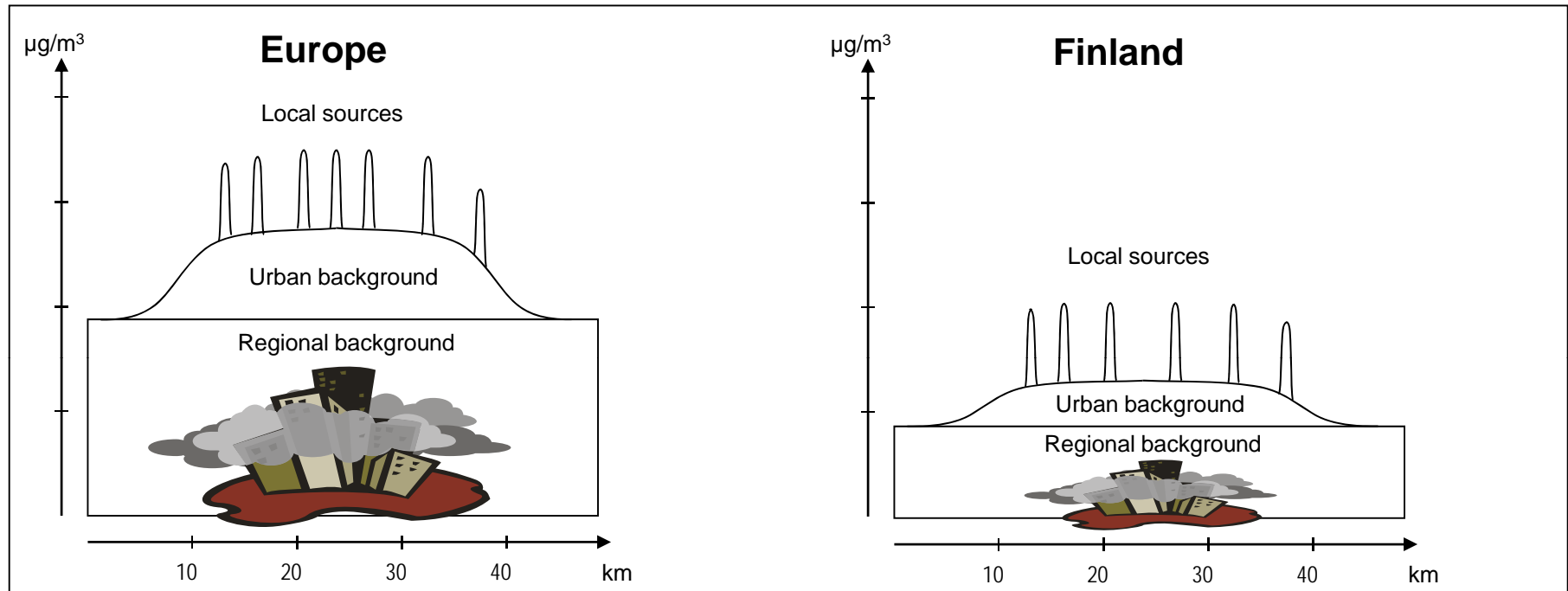
Fine particulate matter (PM_{2.5}) in Finland

Finland:

- Land area 340 000 km², population 5.4 million, low population density
- Low annual average concentrations of PM_{2.5}



Components of PM concentrations in Europe vs Finland



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Modeling resolutions and components of PM concentrations:

- 50km: Regional background (Urban background)
- 10km: Regional/Urban background
- 1km: Urban background / Local sources

In Finland vs Central Europe:

- lower regional/urban background
- strong local sources (e.g. domestic wood combustion, traffic spring/winter suspension)

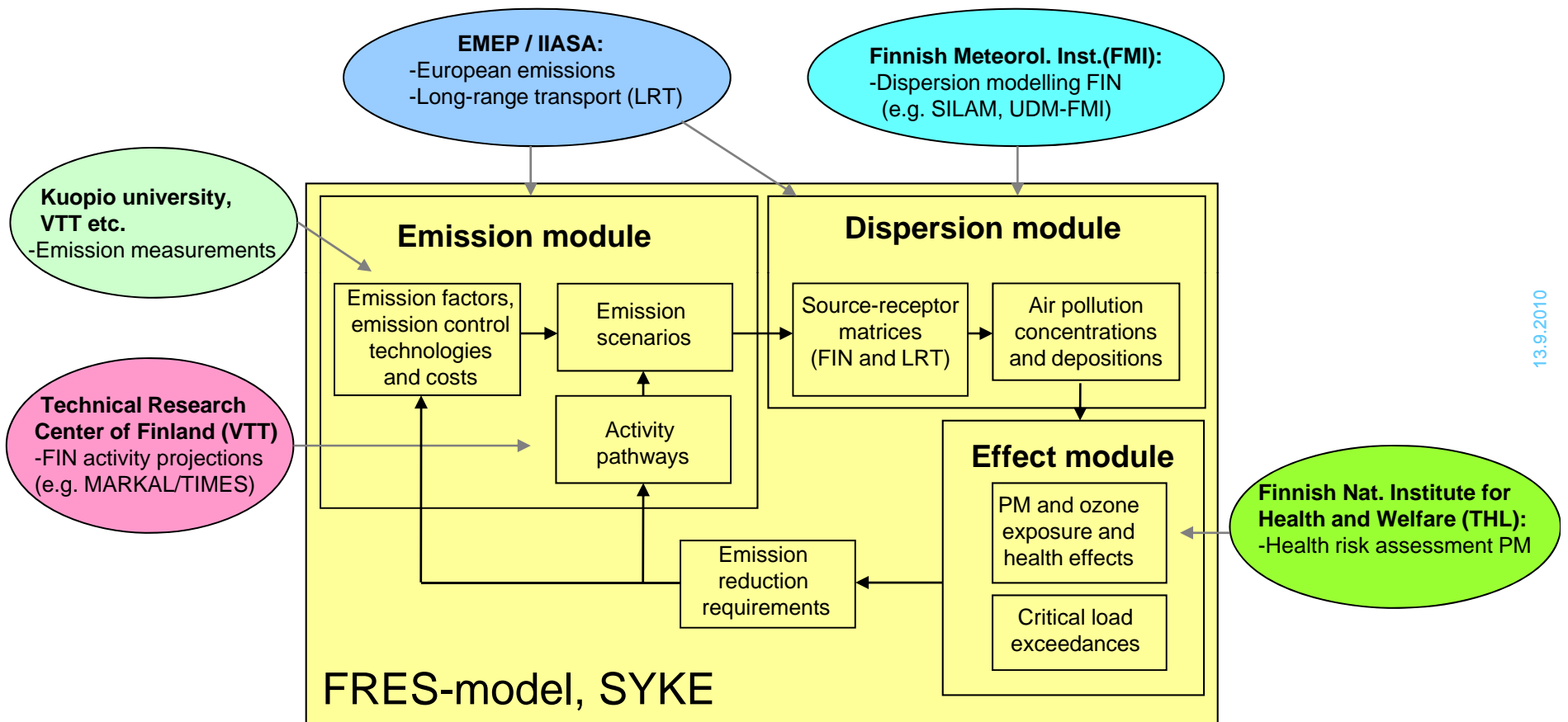
Contribution to average winter/autumn concentrations 20% in Helsinki
(Saarikoski et al. *Water Air Soil Pollut* 2008 191:265-277)

Major source for PM_{10} , significant also in $\text{PM}_{2.5}$ in spring/winter time
(Vallius et al. *Sci Total Environ* 2005; Pakkanen et al. *Atm Environ* 2001)

Methodology

Finnish Regional Emission Scenario (FRES) model

part of the Finnish Integrated Assessment Modeling (IAM) framework

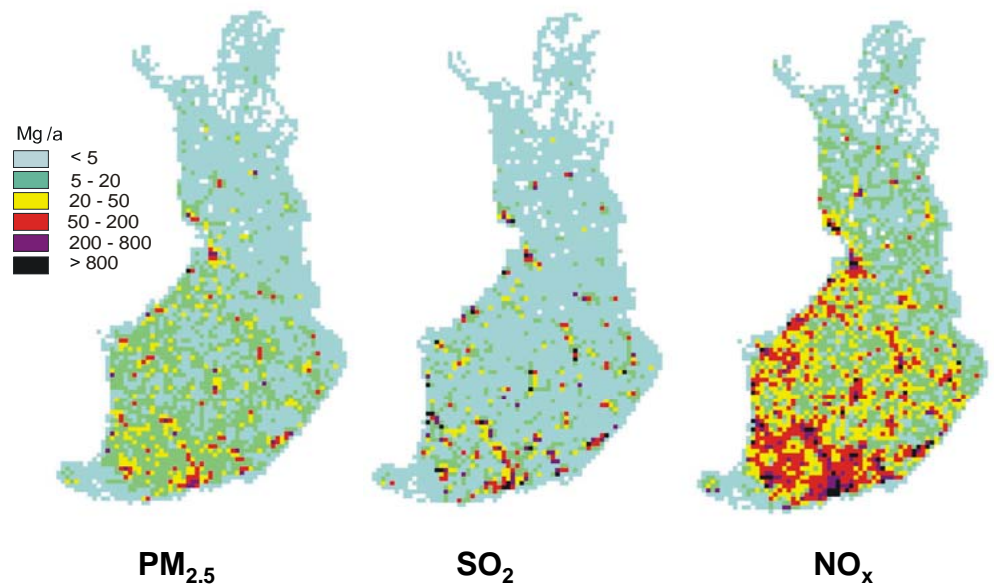


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Finnish Regional Emission Scenario (FRES) model

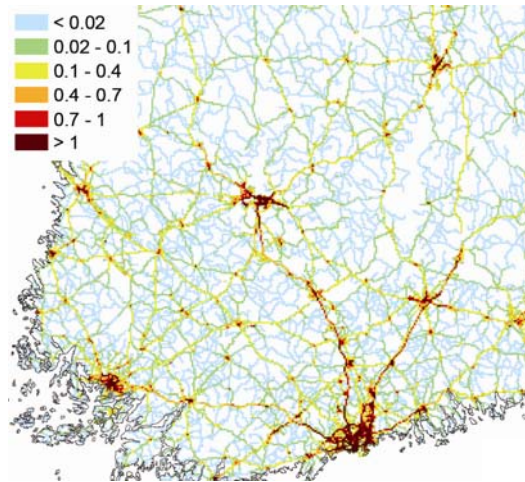
www.environment.fi/syke/pm-modeling

- Anthropogenic emissions 1990, 2000, 2005, 2010, 2020, 2030, 2050 (several projections)
- Comprehensive and congruent calculation for primary PM and gases
 - primary PM (TSP, PM_{10-2.5-1-0.1}, chemical composition, incl. BC/OC/sulfates)
 - SO₂, NO_x, NH₃, NMVOCs
 - GHGs
- Abatement technologies and costs
- Aggregation: 154 sectors, 15 fuels (GAINS compatible)
- Large point sources (>200), small point sources (> 200), area emissions (1 × 1km²)
- Several emission heights
- Dispersion with s-r matrices (10 × 10km² and 1 × 1km²)
- LRT from EMEP
- Databases of population and critical loads

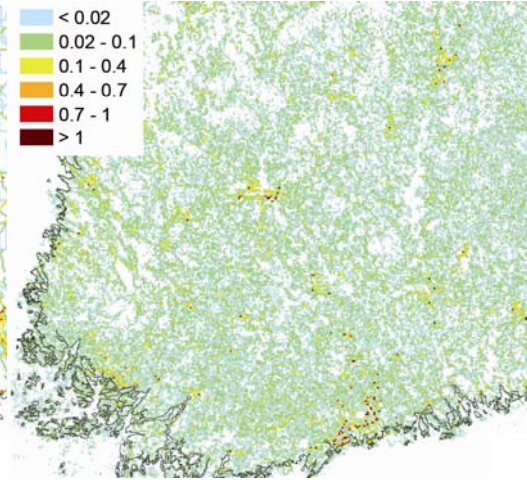


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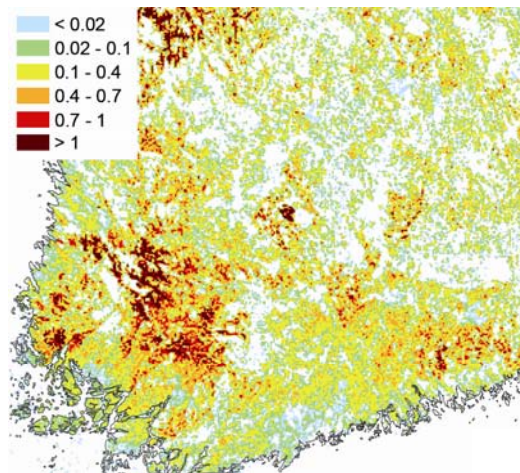
Emissions – 1 km / 1 hour resolution



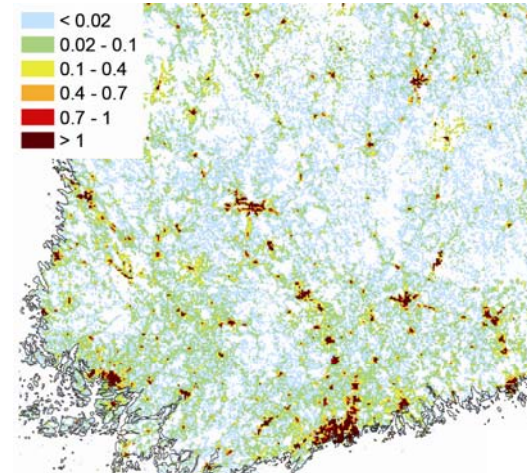
Road traffic (PM_{2.5})



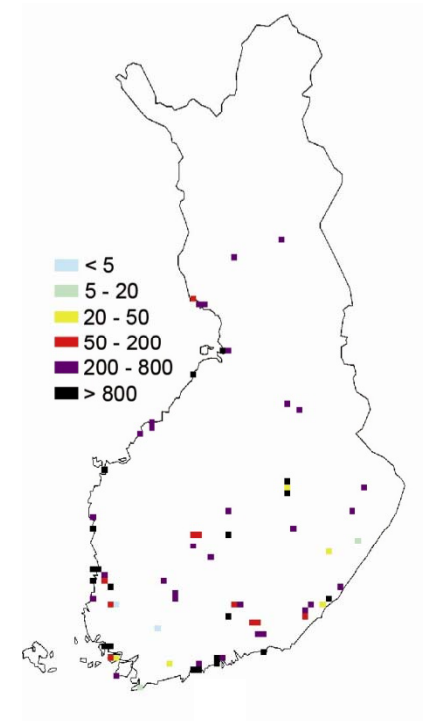
Domestic combustion (PM_{2.5})



Agriculture (NH₃)



Other area (PM_{2.5})



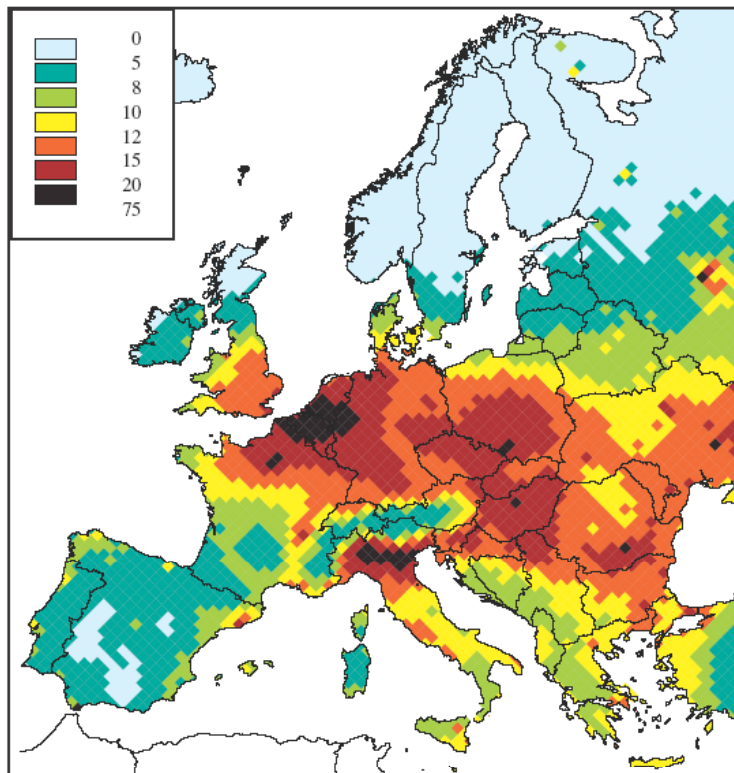
Large point sources (SO₂)

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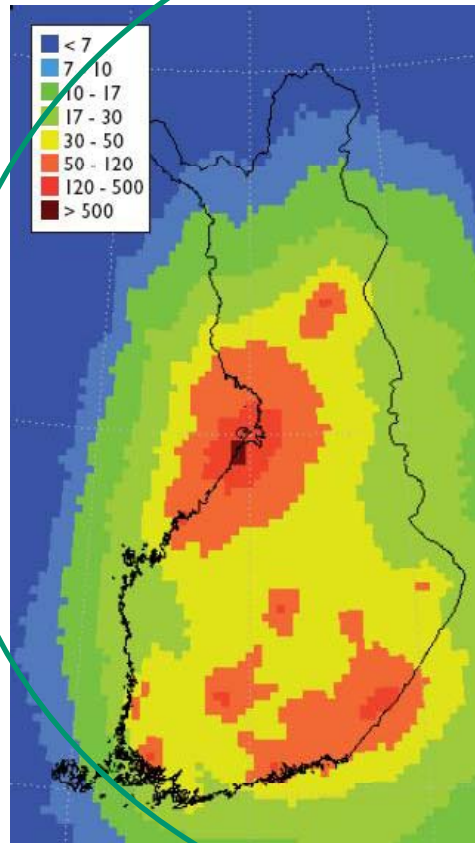
Dispersion/impacts – Various tools

1. Long-range transport impacts with EMEP 50 km resolution
2. Finnish high-stack PM emissions with 10 km resolution
3. Finnish near-ground PM emissions with 1 km resolution

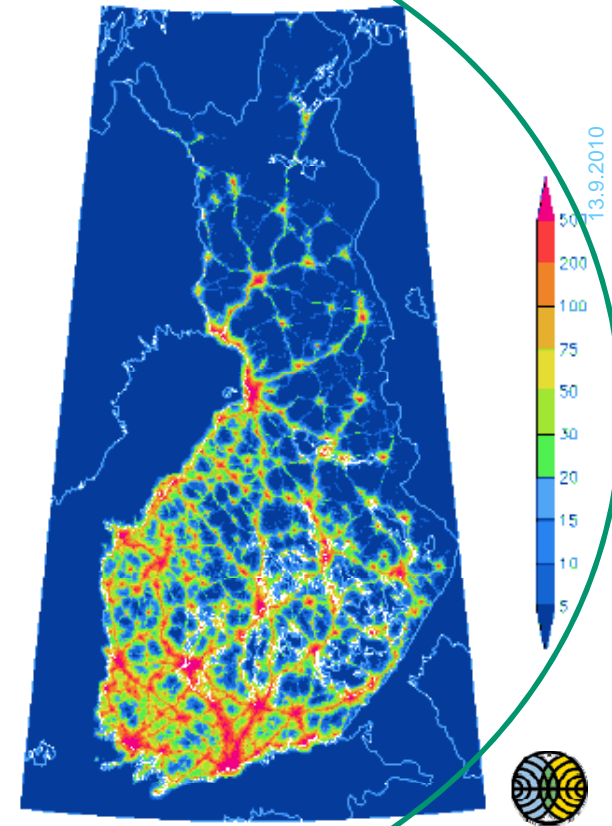
1. EMEP source-receptor matrices (SRM) 50 x 50 km



2. Lagrangian SILAM based SRM 10 x 10 km



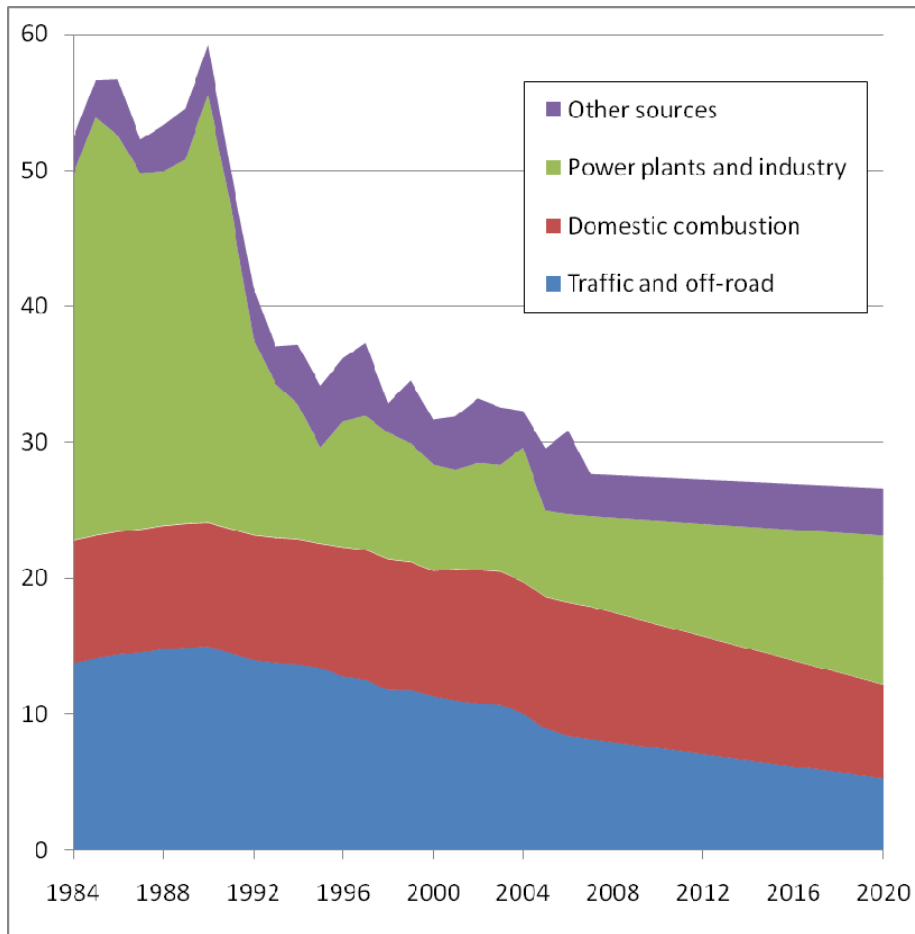
3. Gaussian UDM-FMI based SRM 1 x 1 km



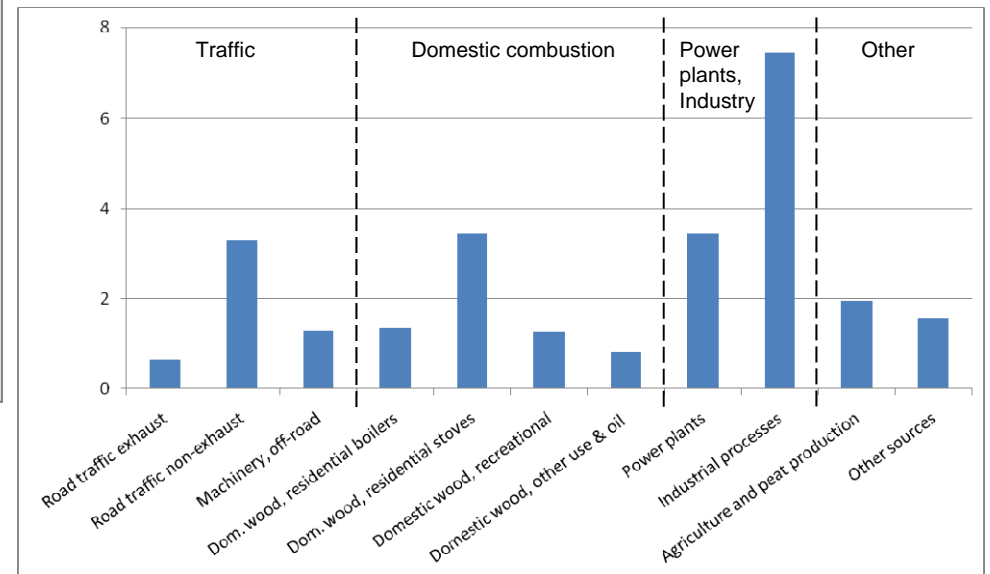
Results

Primary PM_{2.5} emissions in Finland 1984 - 2020

PPM2.5 emission 1984-2020 (kilotons/a)

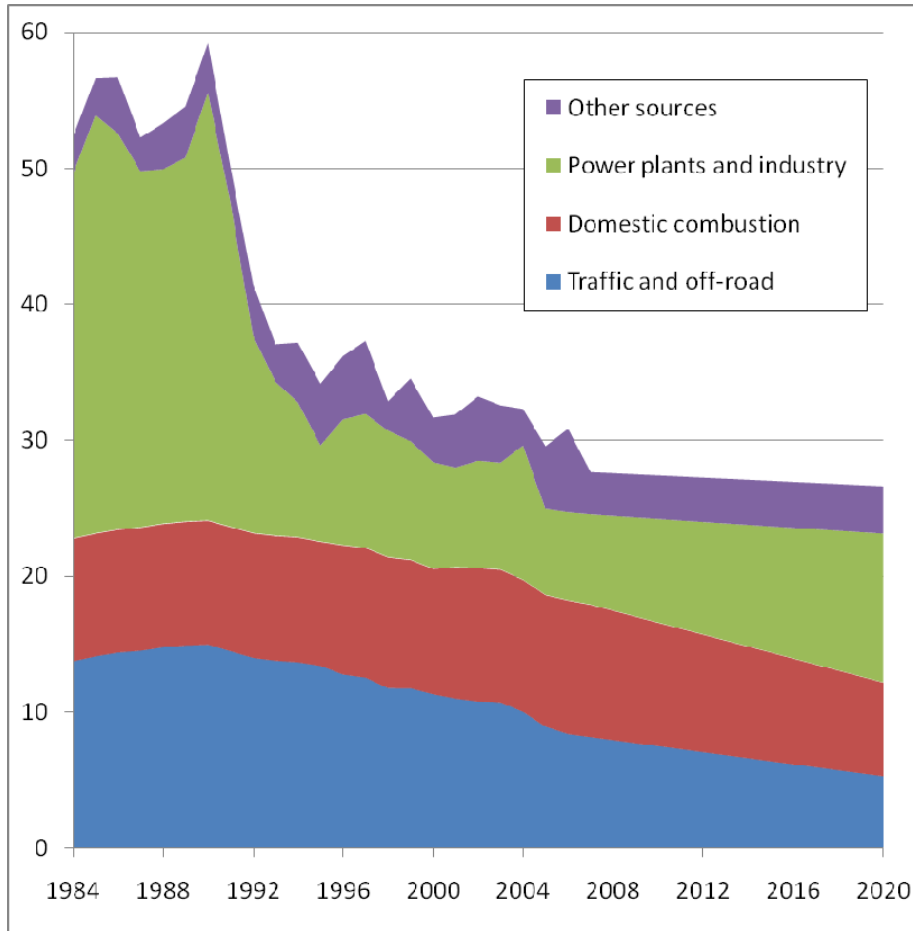


PPM2.5 emission 2020 (kilotons/a)

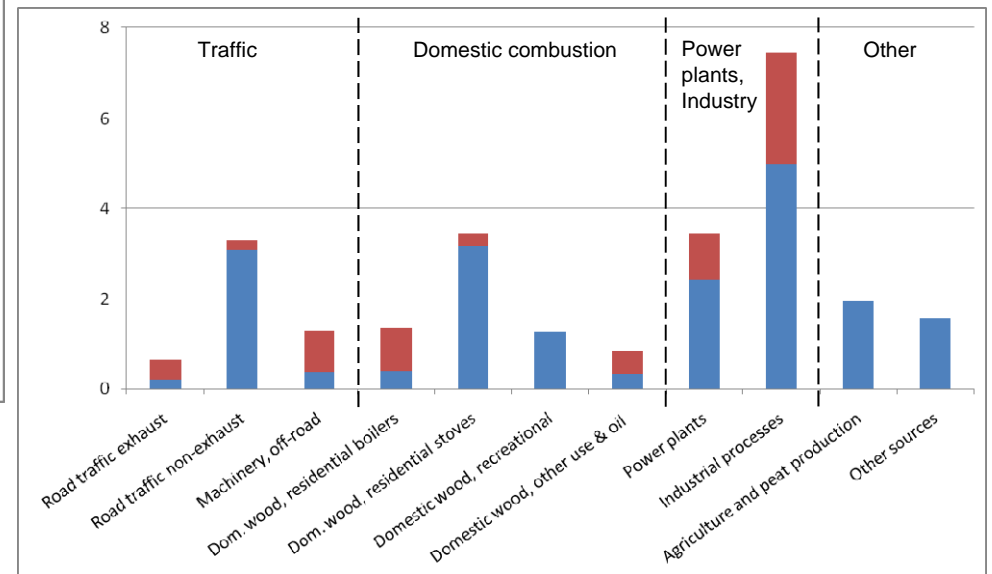


Primary PM_{2.5} emissions in Finland 1984 - 2020

PPM2.5 emission 1984-2020 (kilotons/a)

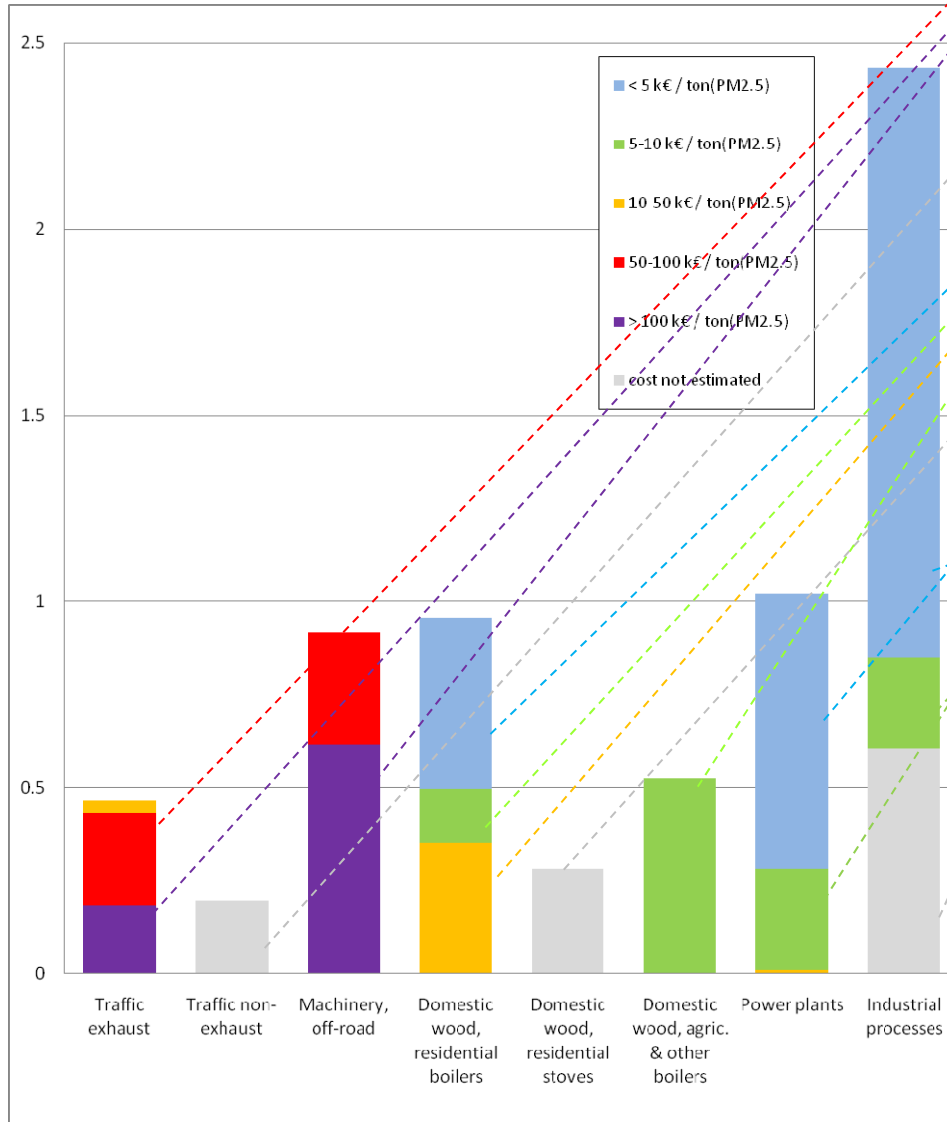


PPM2.5 emission and reduction potential 2020 (kilotons/a)



PPM_{2.5} emission, reduction potential and cost-efficiency

Emission reduction potential in 2020 (axis: kilotons(PM_{2.5})/a) and cost-efficiency per reduced emission (colors: 1000 €/ ton(PM_{2.5}))



Euro 5/6 to all vehicles

Street cleaning ? / Dust suppression ?

End-of-pipe measures (ESP)

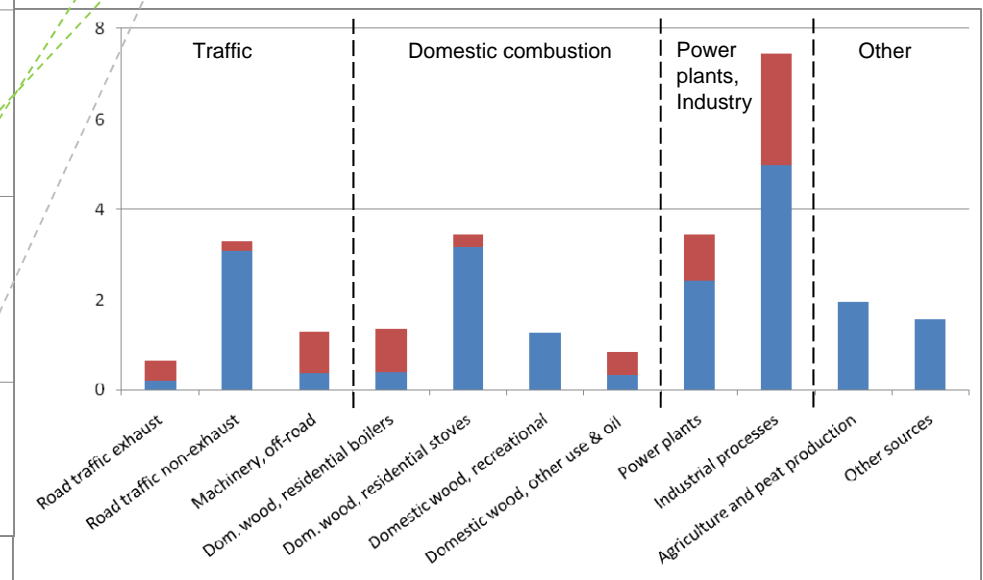
Accelerated change for low-emission stoves

Fabric filters in solid fuel plants >50MW

Fabric filters in solid fuel plants 10-50MW
 ESPs in solid fuel plants <10MW
 ESPs in HFO plants

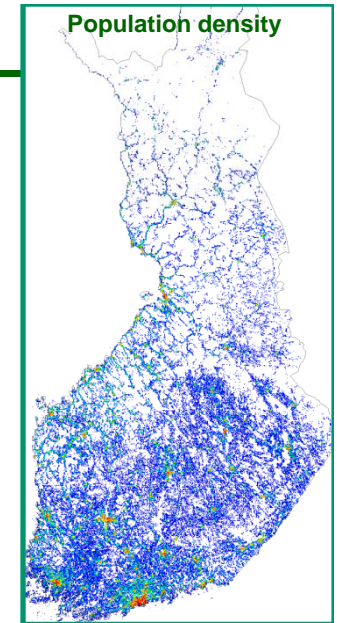
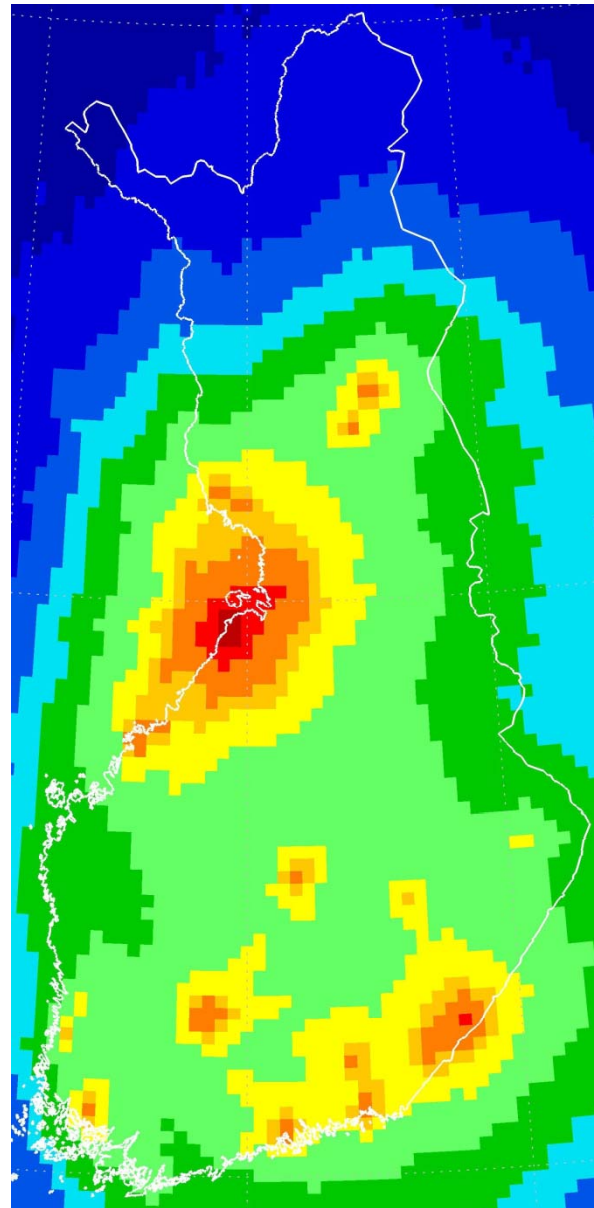
Fabric filters in few individual industry plants

PPM_{2.5} emission and reduction potential 2020 (kilotons/a)

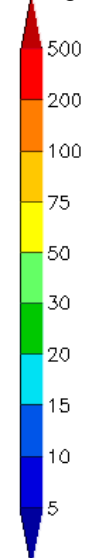


Modeled PM_{2.5} concentrations in 2020 – Power plants and industry

- Largest emissions from industrial processes – not located near major cities
- High-stack-emissions – efficient mixing – minor impact on concentrations
- Highest impacts on annual concentrations below 1 µg/m³ from industrial process plants, not in high population density areas



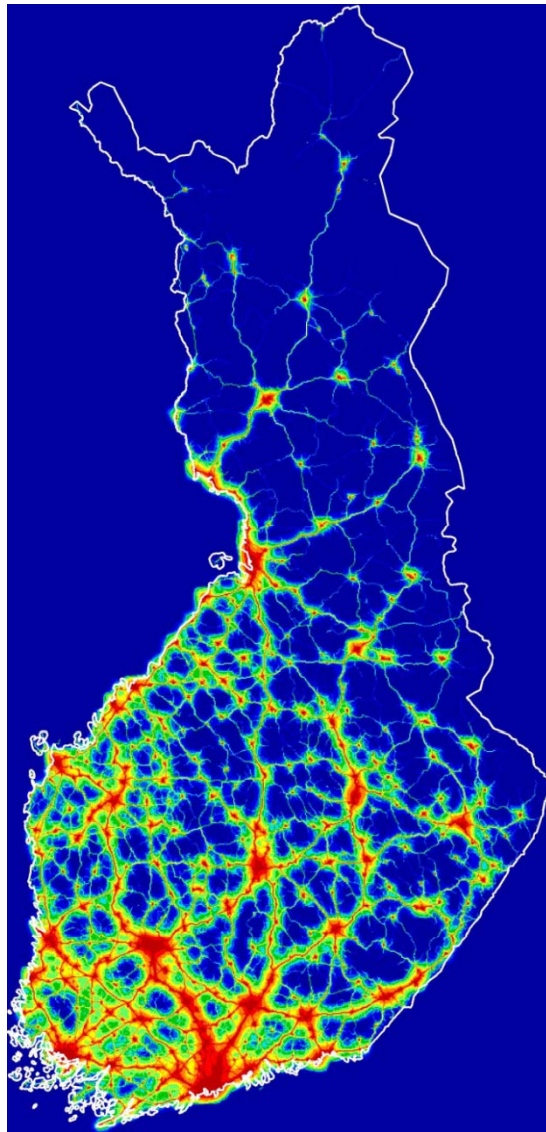
ng/m³ 13.9.2010



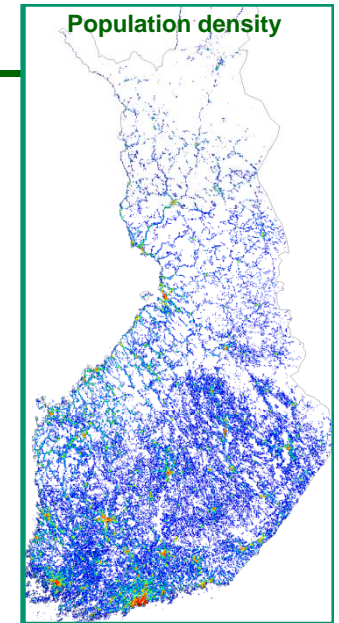
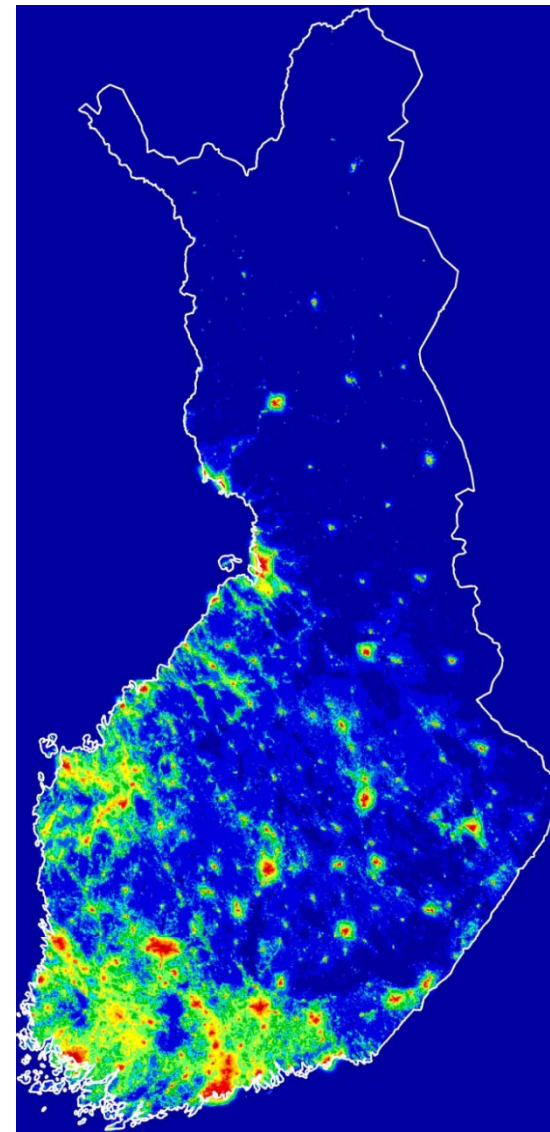
Modeled PM_{2.5} concentrations in 2020 – Traffic sources

- Emissions to great extent in urban areas and along highways – near high population densities
- Low-altitude-emissions – high impact on concentrations
- Impact on annual concentrations 1 to 6 µg/m³ in many locations

Road traffic



Machinery and off-road



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ng/m³

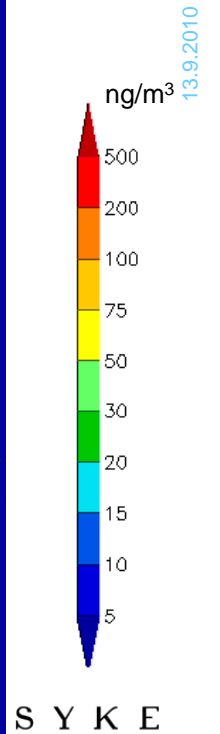
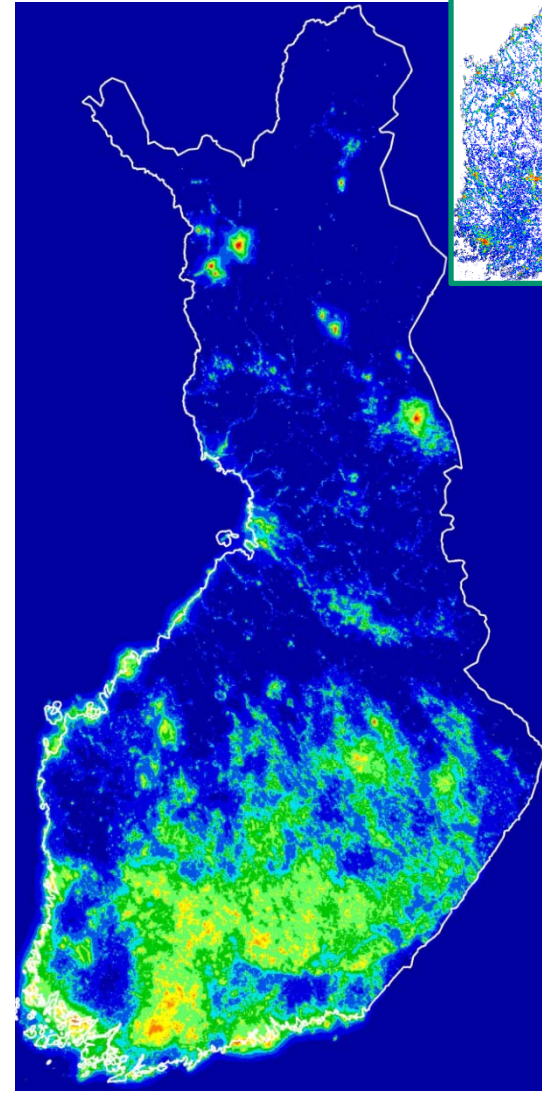
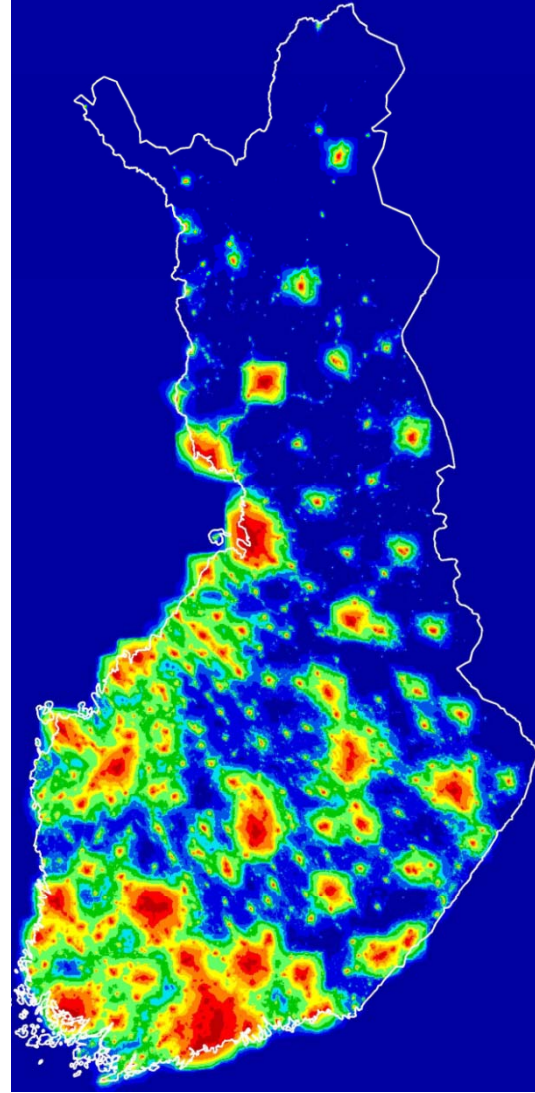
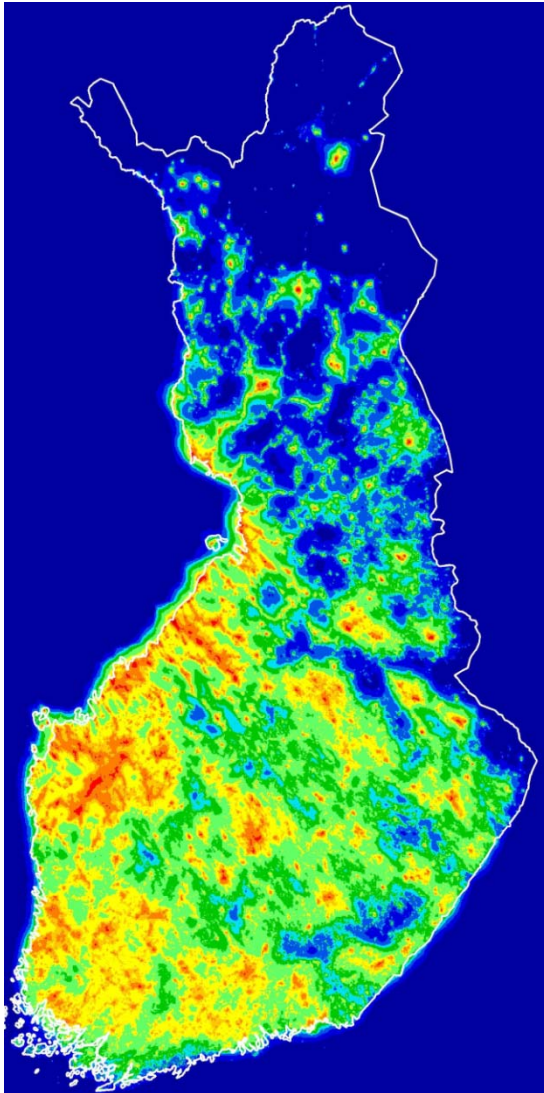
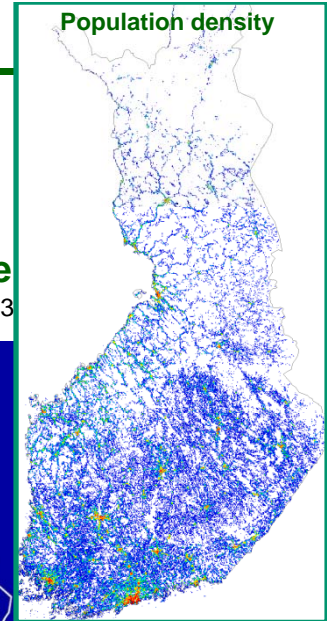
500
200
100
75
50
30
20
15
10
5

Modeled PM_{2.5} concentrations in 2020 – Domestic wood combustion

Residential – primary heating
(small boilers) below 1 µg/m³

Residential – supplementary heat.
(stoves) below 2 µg/m³

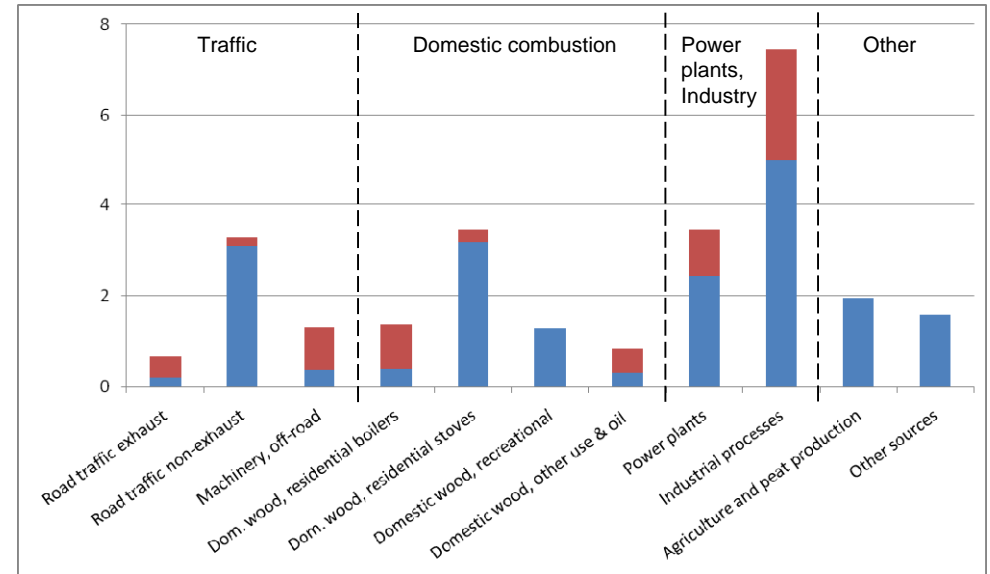
Recreational wood use
(stoves) below 0.5 µg/m³



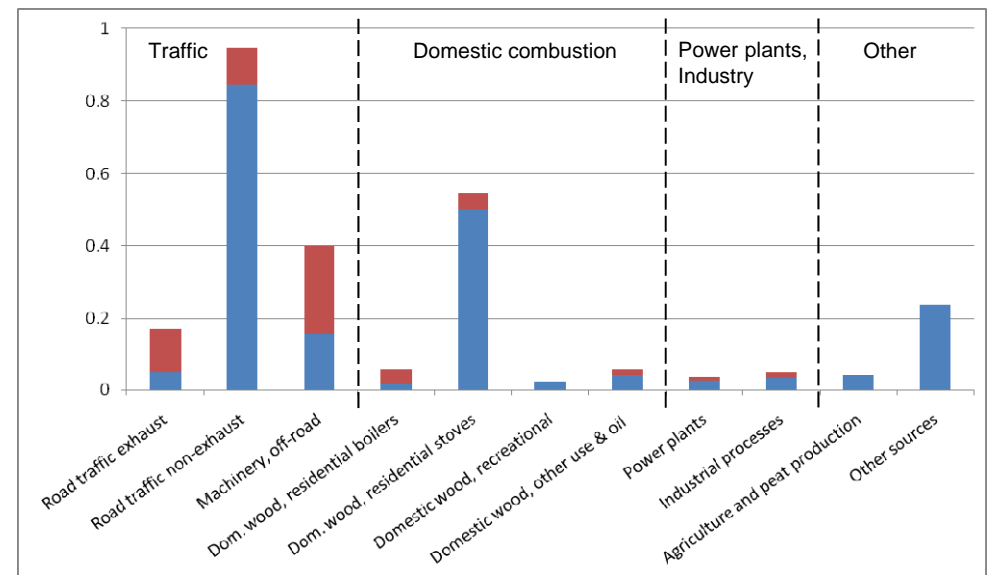
PPM_{2.5} emission, pop. exposure and red. potential 2020

- Strongly different emission – exposure relationships for different emission sources categories (high-stack / near-ground, urban / non-urban)
- Traffic non-exhaust and residential wood stoves biggest sources of population exposure to primary PM_{2.5} in Finland in 2020
- Reduction potential of population exposure largest for traffic sources

PPM_{2.5} emission and reduction potential 2020 (kilotons/a)

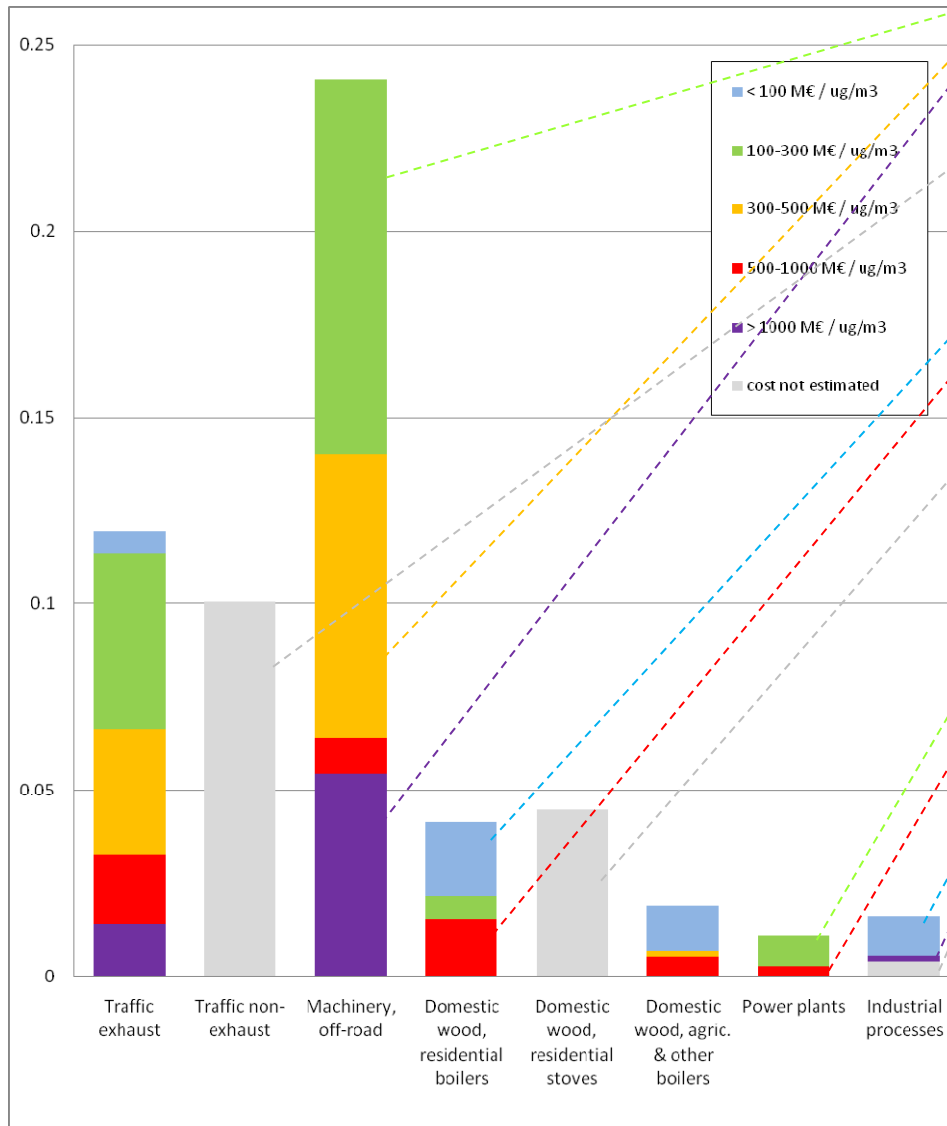


Population exposure caused by PPM_{2.5} and red. pot. 2020 (µg/m³)



PPM_{2.5} pop. exposure, reduction pot. and cost-efficiency

Population exposure reduction potential in 2020 (axis: $\mu\text{g}/\text{m}^3$) and cost-efficiency per reduced pop. exposure (colors: M€ / $\mu\text{g}/\text{m}^3$)



Euro 5/6 to all vehicles

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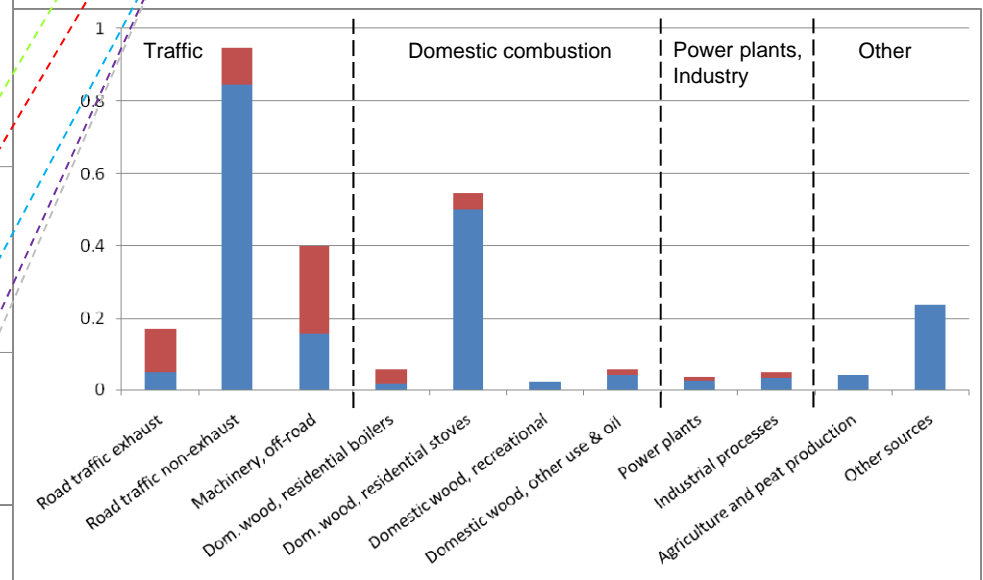
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Population exposure caused by PPM_{2.5} and red. pot. 2020 ($\mu\text{g}/\text{m}^3$)



Conclusions

In the future (2020) for primary PM_{2.5}

- Biggest cost-efficient **emission reduction potential** in **power plants and industry**
- However, only modest reductions of population exposure can be achieved with the emission abatement in power plants and industry
- **Population exposure reduction potential** high on accelerated **renewal of traffic vehicle fleet**
- **Traffic non-exhaust** and **residential wood stoves** the biggest sources to cause population exposure
 - Modest and uncertain emission reduction potential
 - Future challenge to develop efficient technologies for PM_{2.5} reduction

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Foto: M. Räisänen

Thank You

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Foto: M. Räsänen

