INTEGRATED ASSESSMENT MODELS: NORDIC ASSESSMENTS OF AIR POLLUTION

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NordicWelfAir

OUTLINE

- Overview- the assessment system developed at Aarhus University.
- Examples from a number of Danish/Nordic projects (e.g. funded by NKL).
- On-going research on health assessments within the NordicWelfAir.
- Finally - ideas for future research needs.....

Hønefoss
NordicWelfAir/NordForsk

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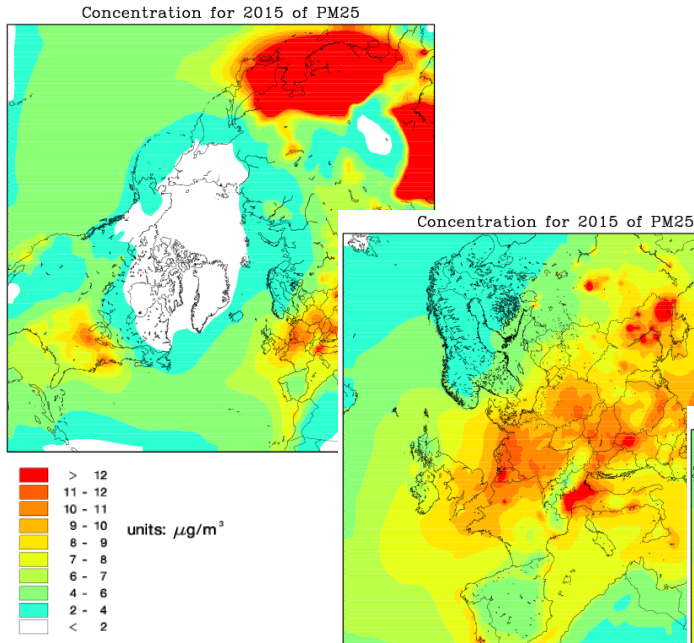
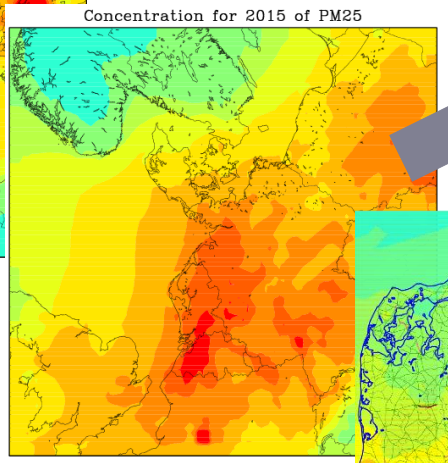
Multiscale modelling:

The integrated THOR system

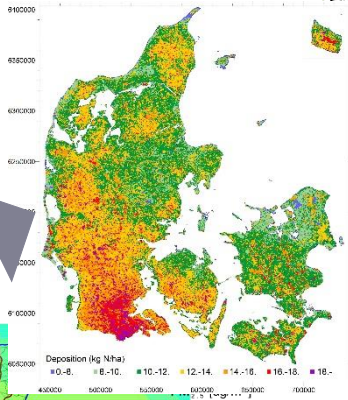




The hemispheric DEHM model

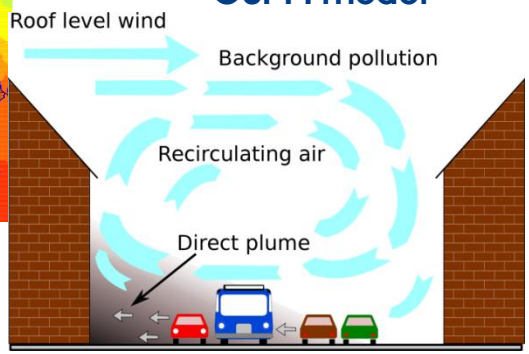
Rural branch

OML model

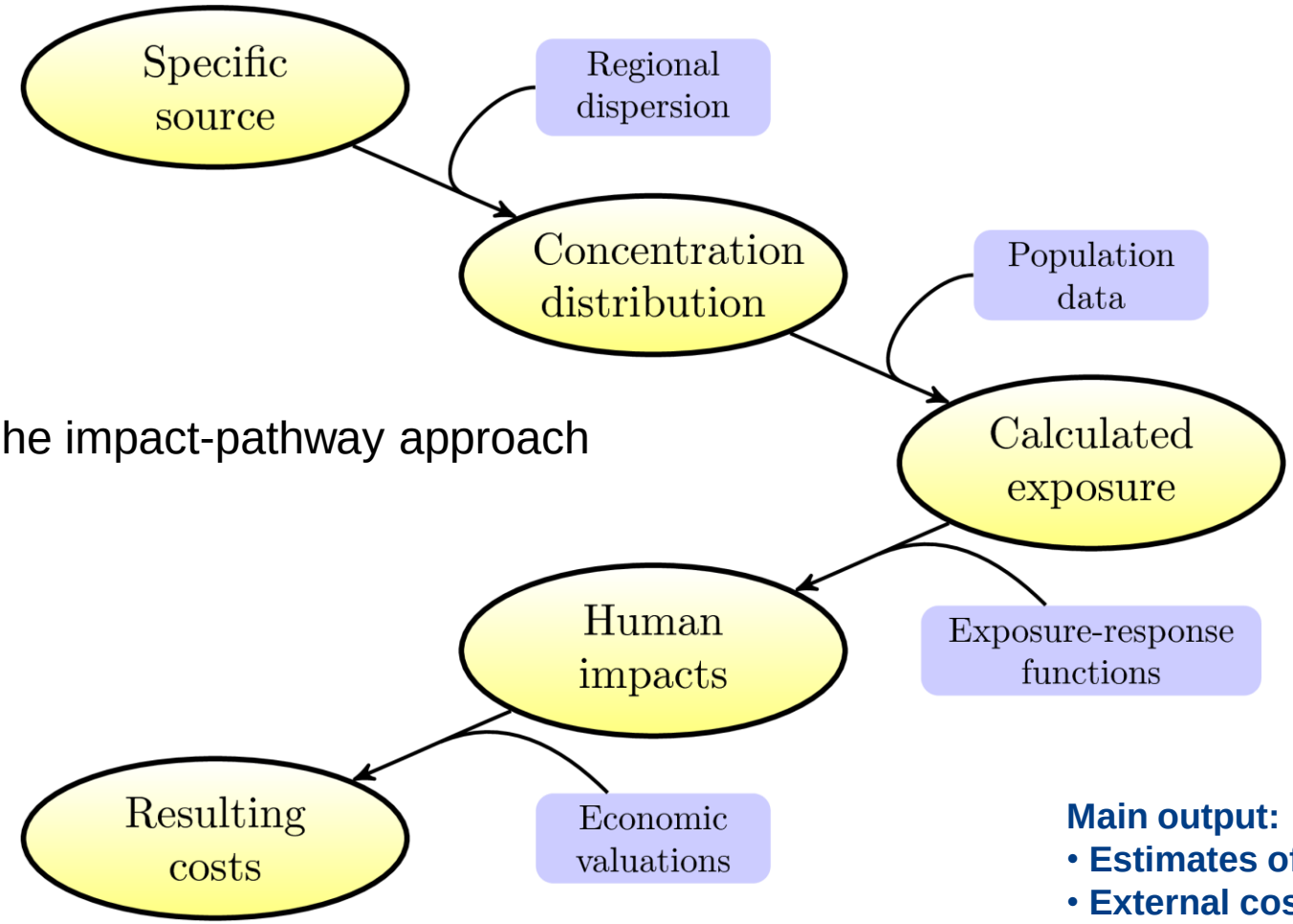


The background UBM model

The street scale OSPM model



The EVA System – Economic Valuation Of Air Pollution:



The impact-pathway approach

Main output:
- **Estimates of health impacts**
- **External cost**
- **Cost pr. kg emitted**

Brandt et al., 2013; Geels et al., 2015, 2020 (in prep.); Im et al., 2018, 2019.

World Health Organization
REGIONAL OFFICE FOR Europe

NordicWelfAir

This publication arises from the HRAPIE project and has received funding from the European Union.

Health risks of air pollution in Europe – HRAPIE project

Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide

DOI 10.1007/s00038-015-0690-y

ORIGINAL ARTICLE

Quantifying the health impacts of ambient air pollutants: recommendations of a WHO/Europe project

Marie-Eve Héroux · H. Ross Anderson · Richard Atkinson · Bert Brunekreef · Aaron Cohen · Francesco Forastiere · Fintan Hurley · Klea Katsouyanni · Daniel Krewski · Michal Krzyzanowski · Nino Künzli · Inga Mills · Xavier Querol · Bart Ostro · Heather Walton

Health effect endpoint	Pollutant	Range	Ages	RR per 10ug/m3	Valuation [DKK/2016]
Acute mortality	O_3	>35 ppb	all	1,0029	31.600.000
Acute mortality	NO_2 (1h max)	no thresh.	all	1,0027	31.600.000
Acute mortality	$PM_{2.5}$	no thresh.	all	1,0123	31.600.000
Acute mortality	SO_2	no thresh.	all	0,072%	31.600.000
Acute mortality infants	$PPM_{2.5}$	no thresh.	Infants	1,0400	47.400.000
Chronic mortality	$PM_{2.5}$	no thresh.	>30	1,062	1.115.000 pr YOLL
Chronic mortality	NO_2	>20ug/m3	>30	1,0550	1.115.000 pr YOLL

+ Background health data (Statistics Denmark).

YOLL: "Years Of Life Lost"

Danish example:
External costs related to air pollution in the Municipality of Copenhagen

- Source contribution to total $PM_{2.5}$, NO_2 etc. in Copenhagen -> health effects (ca. 460 premature deaths) and **costs.**

Tabel 6.2. Eksterne omkostninger i Københavns Kommune pga. de lokale emissionskilder i Københavns Kommune fordelt på stoffer og underopdelt på hovedemissionskategorier.

Mio. DKK

SNAP kode	Emissionssektor	Total	SO_2	O_3	NO_2	$PPM_{2.5}$	SIA+SOA+SS
SNAP01	Kraftvarme- og fjernvarmeværker, herunder affaldsforbrændingsanlæg	67	3	-2	57	8	0
SNAP02	Ikke-industriel forbrænding	265	1	0	11	253	0
SNAP03	Fremstillingsvirksomhed og bygge- og anlægsvirksomhed	9	1	0	6	2	0
SNAP04	Industrielle processer	8	2	0	0	6	0
SNAP05	Udledninger i forbindelse med udvinding, behandling, lagring og transport af olie og gas	4	0	0	0	4	0
SNAP06	Anvendelse af produkter	38	0	0	0	37	0
SNAP07	Vejtransport	335	0	-11	247	99	0
SNAP08	Ikke-vejgående maskiner (militær, tog, skibe, fly, arbejdsmaskiner)	81	1	-3	64	19	0
SNAP09	Affaldsbehandling, eksklusiv affaldsforbrænding	44	3	0	2	39	0
SNAP3BDF	Landbrug	0	0	0	0	0	0
Total	Københavns Kommune (alle kilder i kommunen)	855	11	-17	388	468	0
SNIP	International skibstrafik Øresund (< 25 km)	44	0	-2	43	3	0
Subtotal	Kilder uden for Københavns Kommune (DK, udland, ekskl. SNIP)	7.904	17	127	1.173	1.329	5.262
Total	Total (inkl. kilder i Kbh. Kommune og alle andre kilder på den nordlige halvkugle)	8.803	28	108	1.604	1.801	5.262
Total	% due to emissions in CPH	10%	38%	-16%	24%	26%	0%

Mainly wood stoves

Traffic

Examples – Nordic studies

- Future projections: climate -> emissions -> health impacts (Geels et al. 2015 and policy note).
  - Will be updated in more detail in the new EU-funded EXHAUSTION project (lead by CICERO).

- Nordic anthropogenic emissions -> contribution to air pollution and premature mortality across the Nordic/Arctic area (Im et al. 2019).

- New projections of shipping emissions -> contribution to air pollution and premature mortality across the Nordic/Arctic area (Geels et al. in prep).

NORDICWELFAIR - OVERALL AIM:

To further understand the link between

- air pollution levels and chemical composition and health effects

- distribution of related health impacts, socio-economics and welfare in the Nordic countries

Can only be solved through an interdisciplinary approach!

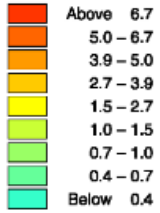

Colourbox


Colourbox

Request to modelers:
High resolution – decadal long – simulations for the Nordic area ....

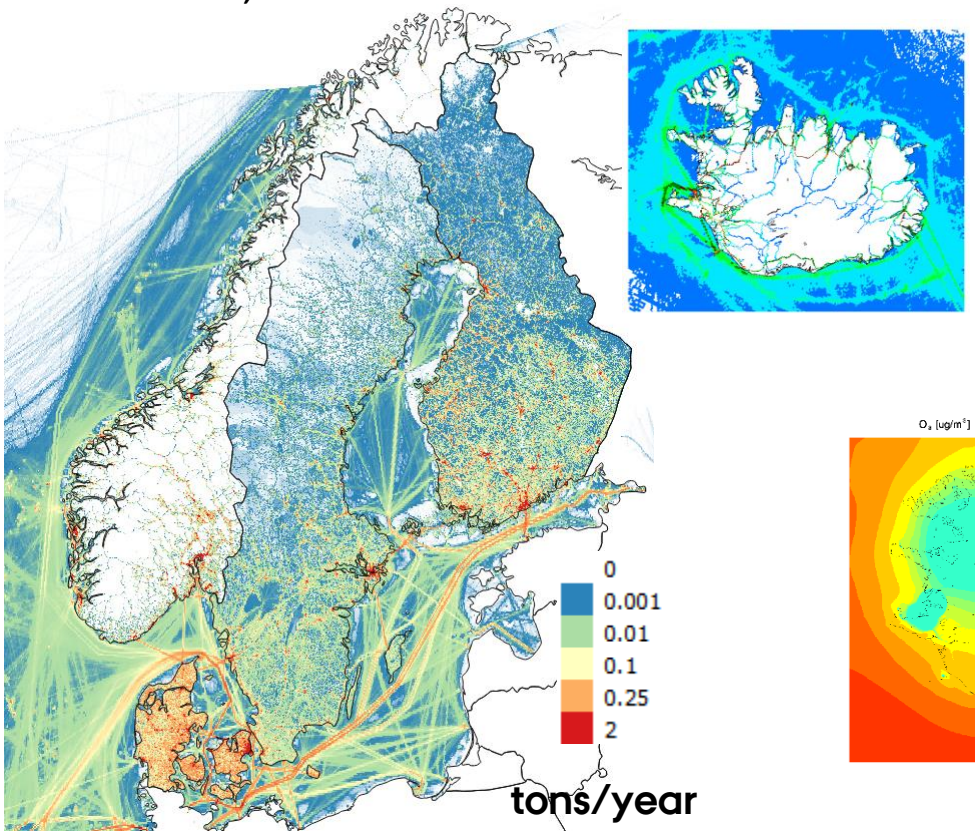
NordicWelfAir: 1 km x 1 km; 1979-2018

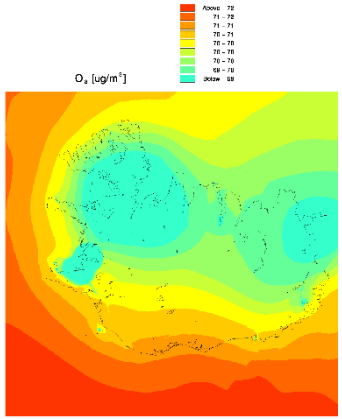
UBM model

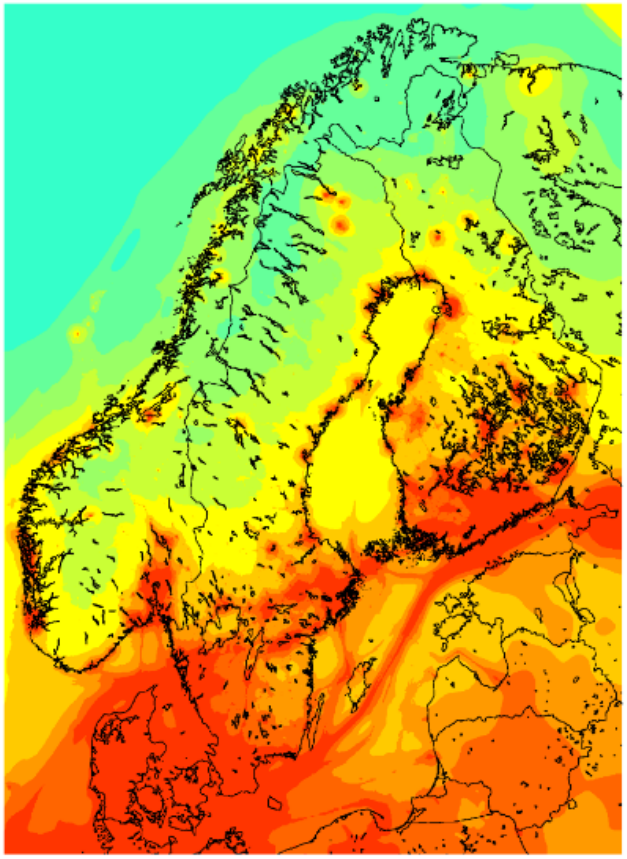


NO_2 [ug–NO_2/m^3]

All sectors, PM2.5







NordicWelfAir:

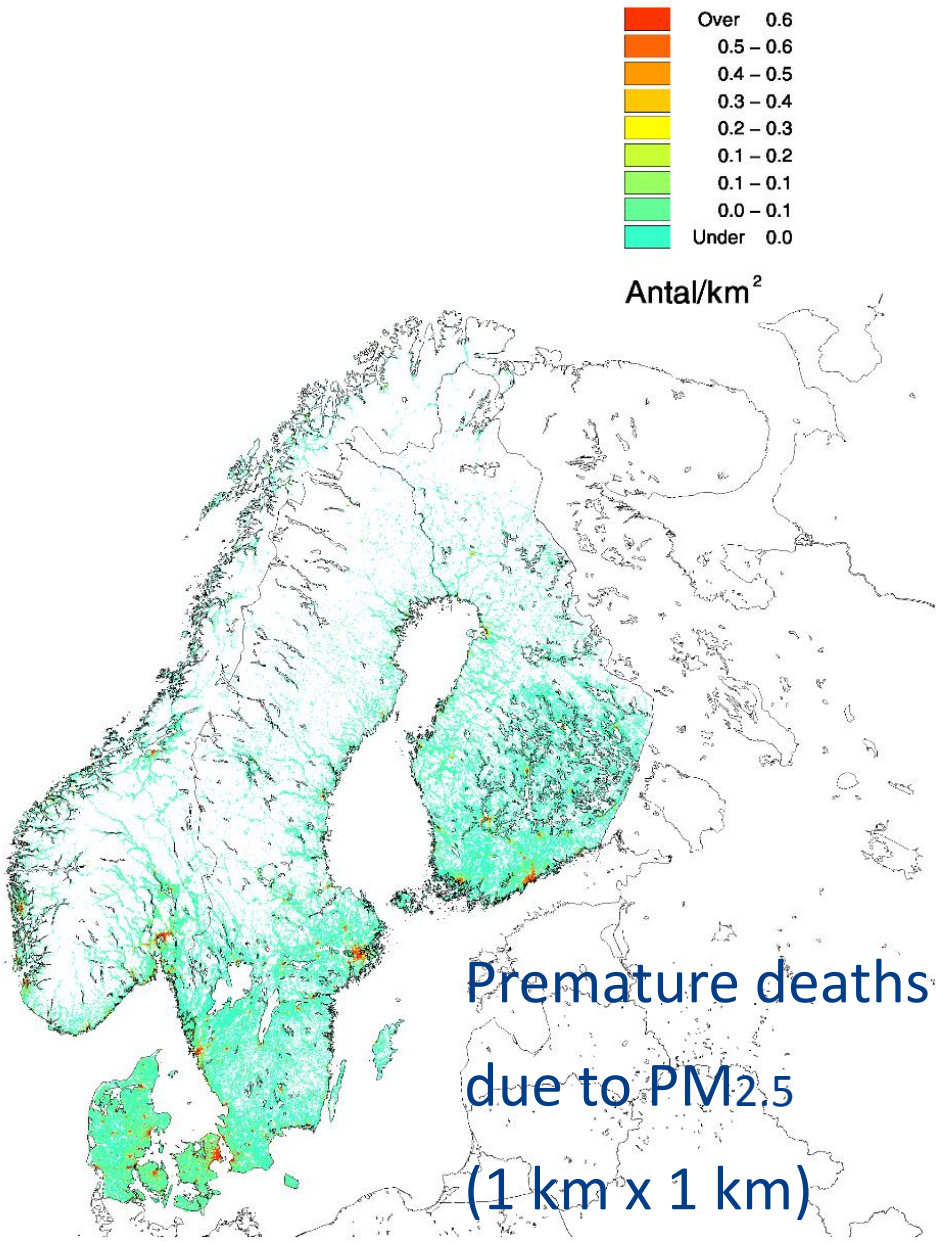
Predicted health impacts in the continental Nordic countries, using the EVA model – spatial distribution

In 2015:

Total population 26.1 million

Ca. 12.000 premature deaths due to air pollution

($PM_{2.5}$, O_3, NO_2, SO_2)



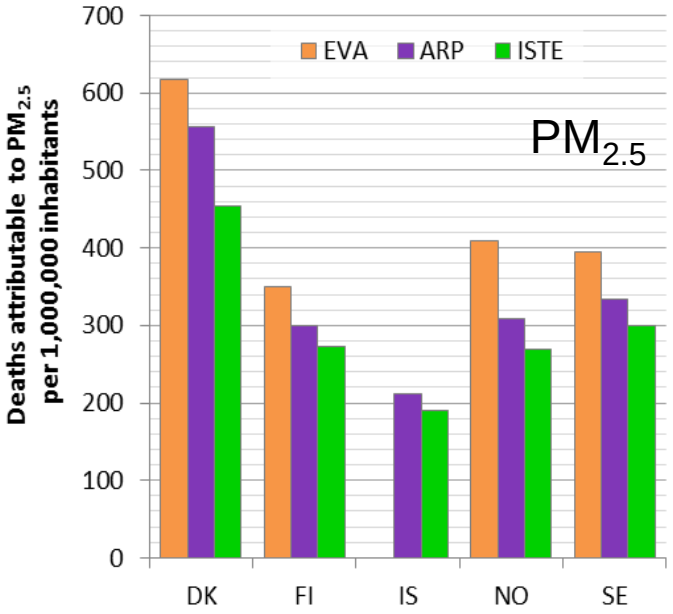
Premature deaths due to $PM_{2.5}$ (1 km x 1 km)

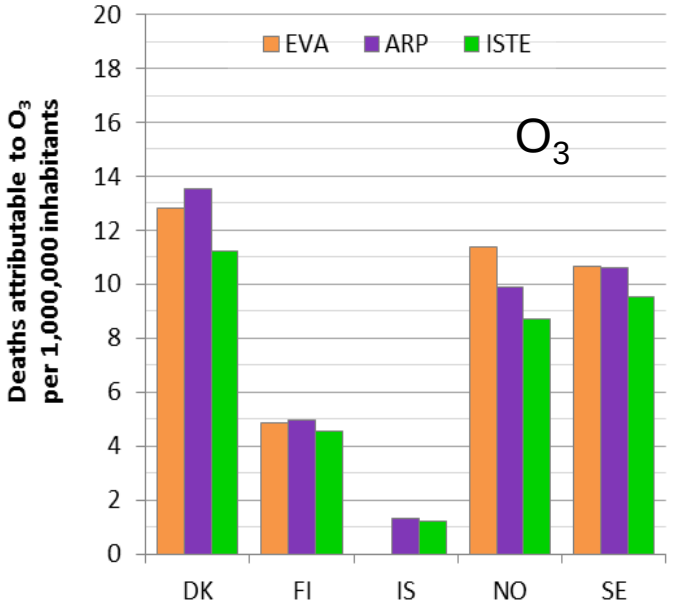
Aarhus University
Department of Environmental Science

Comparing different assessment models used in the Nordic:

EVA (Economic Valuation of Air Pollution/AU)
ARP (ALPHA RiskPoll/IVL)
ISTE (Health impacts of air pollution/THL)

In total 9000-12.000 premature deaths/2015.





Deaths attributable to air pollution in Nordic countries: cross evaluation of methodological approaches Heli Lehtomäki[1,2], Shilpa Rao[3], Camilla Geels[4,5], Katarina Yaramenka[6], Stefan Åström[6,7], Mikael Skou Andersen[4], Jørgen Brandt[4,5], Lise M. Frohn[4], Ulas Im[4,5], Otto Hänninen[1] – in prep.

Ideas for future research needs.....

- **Health:** new RR; additional components: (e.g. BC, UFP); threshold for effects reasonable (now 20 ug/m^3 NO_2)?
- Next step in exposure modelling -> personal exposure? Do we then have the dose-response functions needed?
  Activity pattern ..?

Colourbox

Ideas for future research needs.....

- **Residential wood combustion**: Remaining emissions source that will cause most of the $PM_{2.5}$ and ~all BC by 2030 in the Nordic countries!

  - No substantial improvement in sight: modern stoves + user education not good enough; end-of-pipe and gasification-based technologies too expensive, laborious, boring

  - How to get rid of RWC (at least in cities)? Regulate? Trust on individuals' wise choices?

  - Better understanding of the dynamics of people's preferences and choices: How to communicate the negative impacts of RWC, *how to regulate and not be hated …*



Ideas for future research needs.....

- **Assessments of the climate policy impacts on air pollution and effects ...** (New goals setup by the current government in DK: 70% reductions by 2030; respectively in FI: "carbon neutral" by 2035)!!!
  - Studies with different activity/energy pathways, incl. minimized (biomass) combustion, different agricultural practices etc. – collaboration with energy/land-use modelers
  - Integration with climate assessments; BC + co-emitted, carbon stocks, different temperature response time horizons (not only 100 years)
- *There is a need for science based advice on the optimal pathway to a fossil free society ....*

Ideas for future research needs.....

- Include other **environmental impacts** (e.g. N dep. and O_3 effects): requires new research:
  - valuation of e.g. terrestrial nature in terms of ecosystem services (biodiversity loss, lost benefits etc.)..
  - what environmental metrics should we use for e.g. N dep.?

- *Can provide important science based advise on how to protect nature and prioritize the use of land (e.g. production vs recreation) .*

- Holistic approach - Must go across the existing different directives (e.g. air quality, water framework, habitat).

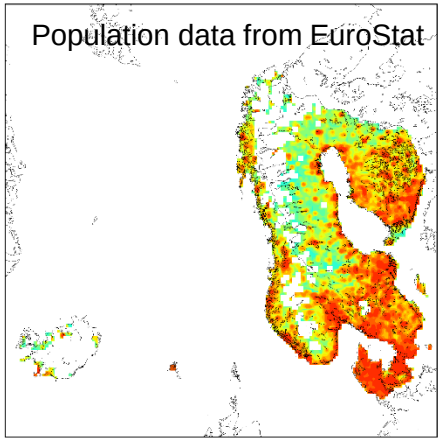
Thank you!

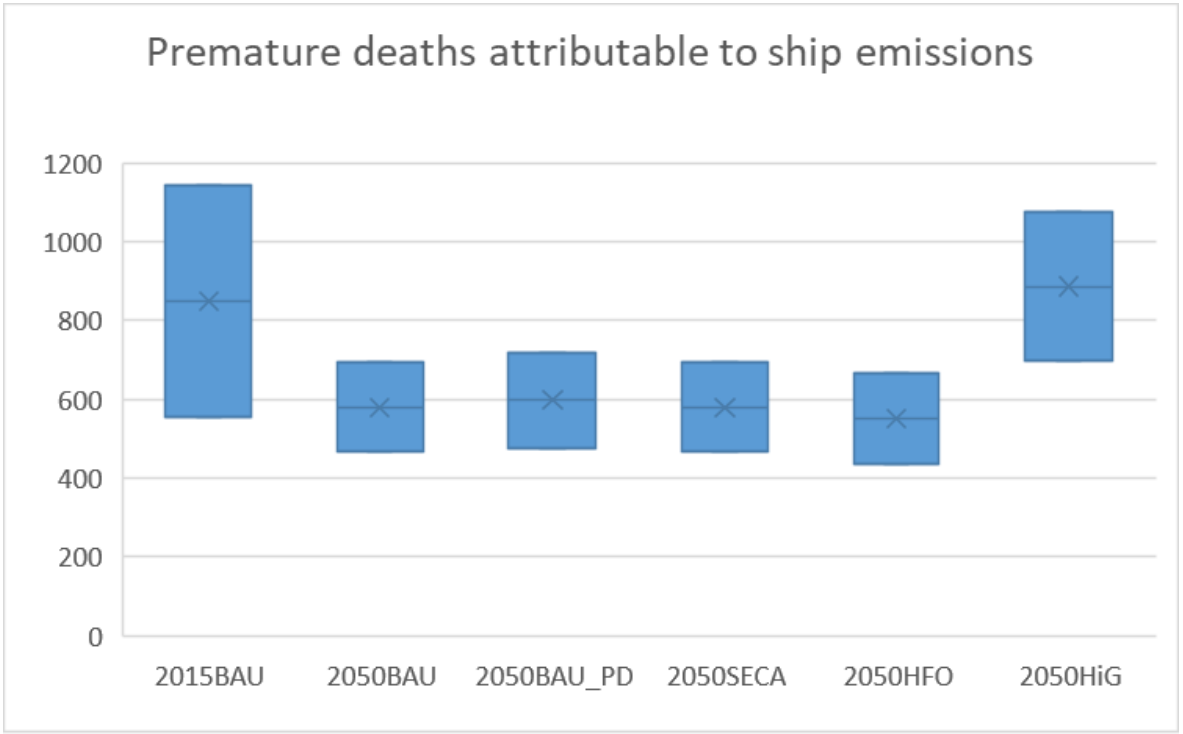
Aarhus University
Department of Environmental Science

Example:

Emissions From Ships And The Impacts On Human Health And Environment In The Nordic/Arctic – Now And In The Future (EPITOME)

Only the Nordic population





Exposure to heat and air pollution in EUrope – cardio-pulmonary impacts and benefits of mitigation and adaptation (EXHAUSTION)

o	Group	Impact category		Pollutant	Range	Ages	RR per 10ug/m3	Background	ER per ug/m3	For EVA template	
										ER	AGES
1	A*	Acute mortality		O3	>35 ppb	all	0.0029	0.97%	0.000003	2.81E-06	
2	A*	Acute mortality		NO2(1h)	no thresh.	all	0.0027	0.97%	0.000003	4.29E-06	
3	A*	Chronic mortality PM, gross		PM2.5	no thresh.	>30	0.062	Lifetables	0.001058	1.058E-03	>30
									0.000932	9.32E-04	>30
		Hospital admissions (HA):									
4	A*	Cardiovascular HA	incl stroke	PM2.5	no thresh.	all	0.0091	0.0212	0.000019	1.93E-05	
5	A*	Cardiovascular HA	excl stroke	O3	>35 ppb	>65	0.0089	0.0711	0.000063	6.33E-05	>65
6	A*	Respiratory HA		PM2.5	no thresh.	all	0.0190	0.0145	0.000027	2.75E-05	
7	A*	Respiratory HA		O3	>35 ppb	>65	0.0044	0.0442	0.000019	1.95E-05	>65
8	A*	Respiratory HA		NO2(24h)	no thresh.	all	0.0180	0.0145	0.000026	2.60E-05	
11	A	Acute mortality		PM2.5	no thresh.	all	0.0123	0.97%	0.000012	1.19E-05	
12	A	Mortality, correction		PM2.5	no thresh.	all	0.0620	Lifetables	-0.000126		
		Hospital admissions (HA):									
13	A	Cardiovascular HA	excl stroke	O3	10-35 ppb	>65	0.0089	0.0711	0.000063	6.33E-05	>65
14	A	Respiratory HA		O3	10-35 ppb	>65	0.0044	0.0442	0.000019	1.95E-05	>65
20	B*	Acute mortality infants		PPM2.5 (from PPM10)	no thresh.	Infants, post	0.0400	0.001	0.000004	6.15E-06	<1
21	B*	Chronic mortality, NO2		NO2(annual)	>20ug/m3	>30	0.0550	Lifetables	0.000939	6.25E-04	>30
22	B*	Bronchitis (KOL)	children	PM2.5 from PM10	no thresh.	6-18	0.0480	0.186000	0.000893	1.37E-03	6-18
23	B*	Bronchitis (KOL)	adults	PM2.5 from PM10	no thresh.	>18	0.1170	0.003900	0.000046	7.02E-05	>18
									0.069064		
24	B*	RAD		PM2.5	no thresh.	all	0.0470	14.69444	0.069024	6.90E-02	
25	B*	WLD		PM2.5	no thresh.	20-65	0.0460	0.00853	0.000039	3.93E-05	20-65
26	B*	Asthma symptoms	children	PM2.5 from PM10	no thresh.	5-19	0.0280	9.40%	0.000263	4.05E-04	5-19
27	B*	MRAD		O3	>35 ppb	all	0.0154	0.021369863	0.000033	3.29E-05	
40	-	Acute mortality		SO2	no thresh.	all	0.072%	0.97%	0.000001	6.968E-07	
41		Lung cancer morbidity		PM2.5	no thresh.	above 30	0.14	0.00116	0.000016	1.62E-06	

HEALTH ENDPOINTS - VALUATION

› VSL:	€4.2 mill.	(Navrud, 2016)
› VSL-infants:	€6.4 mill.	
› VOLY:	€149,594	(derived from VSL)
› *Morbidity:*		
› Lung cancer:	€72,697/case	(SDU, 2016)
› COPD	€39.445/case	(Jensen, 2006)
› Cardiovascular HA	€15,999/case	(DRG, 2016)
› Respiratory HA	€9,940/case	(DRG, 2016)
› Asthma symptoms	€1,325/case	(Mossing/Nielsen)
› Work loss day	€273/case	Rowe, 1995
› Restricted activity day	€148/case	Pearce, 1999
› Cough/asthma child	€162/case	(Drug agency)