Norwegian Meteorological Institute

LRTAP Long-range Transboundary Air Pollution

Activities on monitoring and modelling of acidification, eutrophication and photo-oxidants, progress and plans

Hilde Fagerli + many more

EMEP 37th Steering Body meeting, Geneva, 9-11th September 2013

Norwegian Meteorological Institute

Contributors

EMEP/MSC-W: M. Schulz, M. Gauss, A. Benedictow, J.E. Jonson, S. Tsyro, A. Nyiri, D. Simpson, B. M. Steensen, H. Klein, A. Valdebenito, P. Wind, A. Kirkevåg, J. Griesfeller, J. Bartnicki, D. Olivie, A. Grini, T. Iversen, Ø. Seland, V.S. Semeena, H. Fagerli

EMEP/CCC: W. Aas, A-G. Hjellbrekke

EMEP/CEIP: K. Mareckova, R. Wankmuller

NILU: P. Schneider, S. Solberg, T. Svendby, L. Liu

CCE/RIVM: M. Posch

CEH: M. Vieno, S. Reis

UW: M. Kryza, M. Werner, K. Walaszek

Outline

- EMEP model development and performance changes
- Trend analysis for (1990)-2000-2010 period
- EMEP simulations on different scales
- Climate air-quality interactions
- Plans

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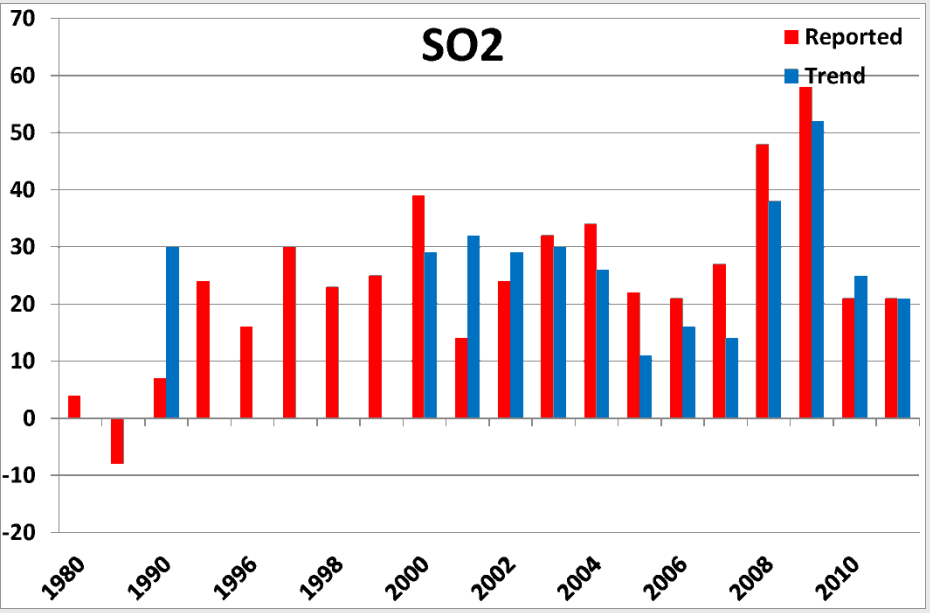
EMEP model development and performance changes – historic recap

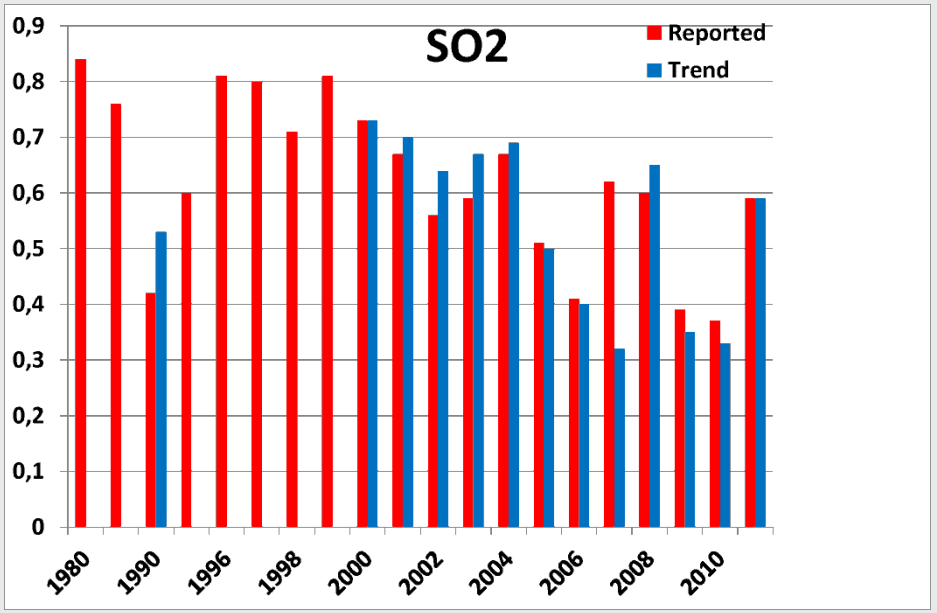
- Release of EMEP open source code March 2013
- Overview of main changes since 2003 (version rv1.7) via 10 different versions to rv4.4 used for this report.
- **Did the model get better?**
  - The model ‘system’:
    - Emissions
    - Meteorology
    - EMEP model and different inputs
  - Comparison to observation data base that also has changed

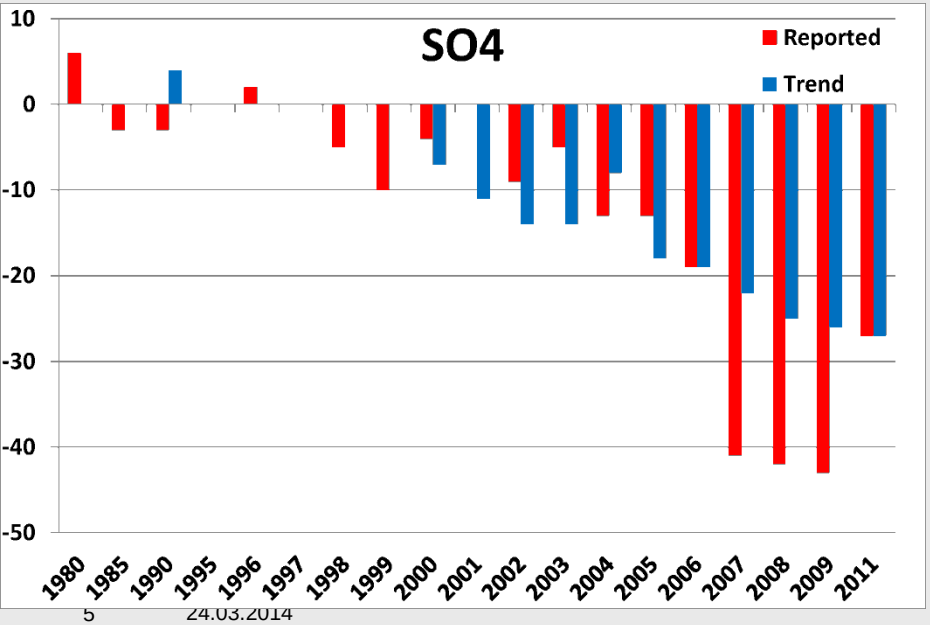
- The most updated EMEP model, with the most updated emissions and meteorology compared to ***reported results***

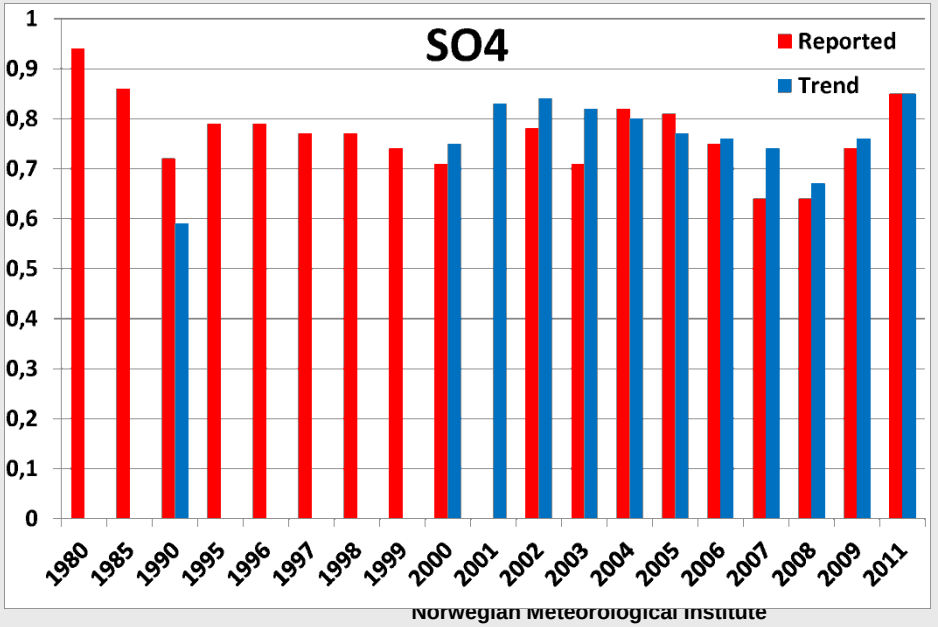
Bias (%)



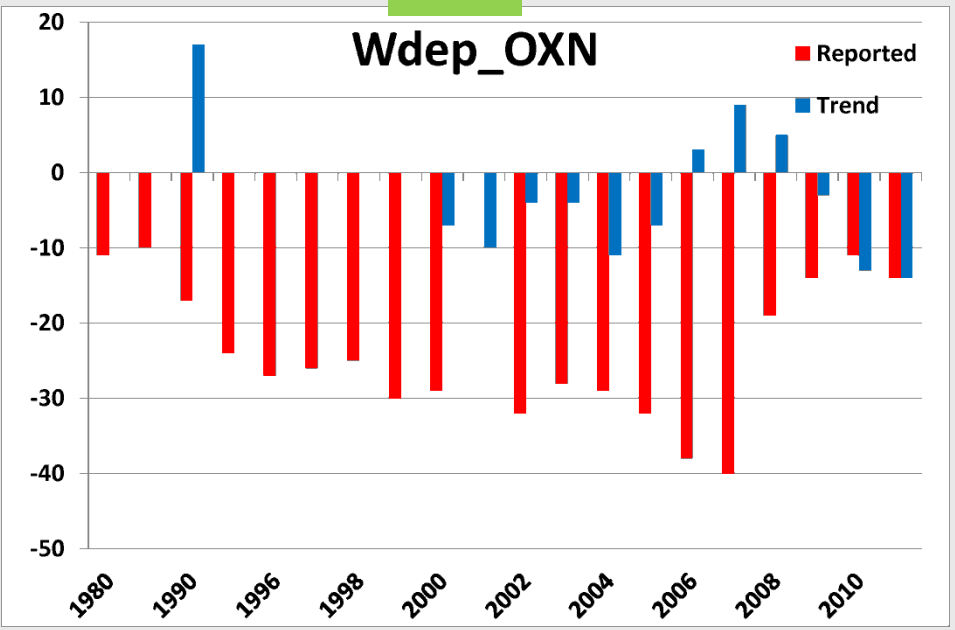
Correlation



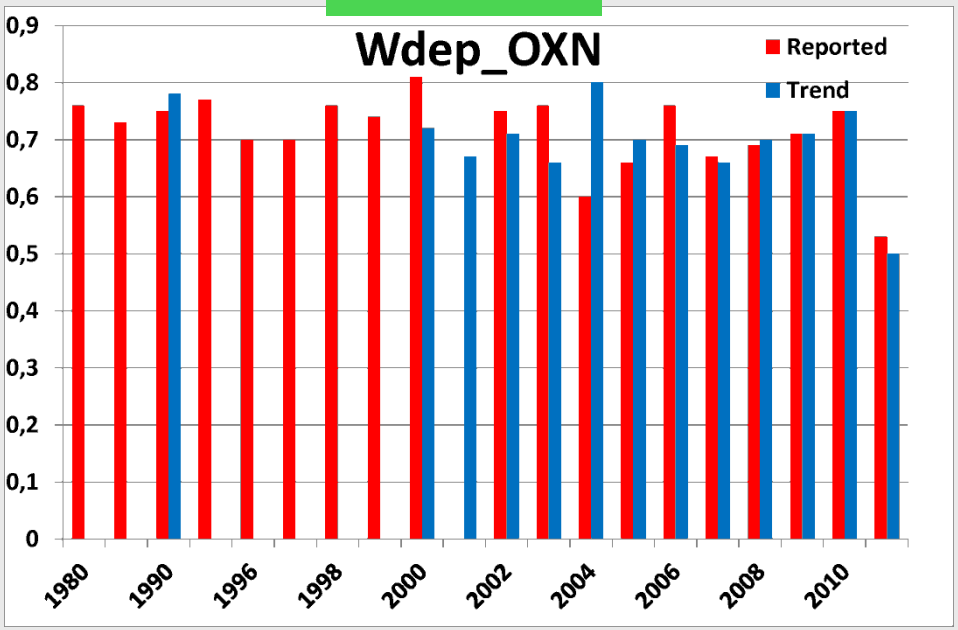




Bias



Correlation



- The latest model is generally better than older ones considering all pollutants together
- Model changes not always correlated

EMEP MSC-W Model Training Course
24-26 April 2013, Oslo, Norway

- 25 Participants : UK, Hungary, Belgium, Poland, Norway, Estonia, Croatia, Austria, JRC/Italy

  (no visa or travel permit: Congo, France)

- Presentations on Aerosol and Chemistry, Emissions,Computer requirements, Grid flexibility, Nesting, IFS Meteorology, WRF Coupling, Plume rise, Outputs&Formats, Products, Plotting tools, IT infrastructure at MSCW and Home Exercises

- Training Course presentations on https://wiki.met.no/emep/page1/emepmscw_opensource

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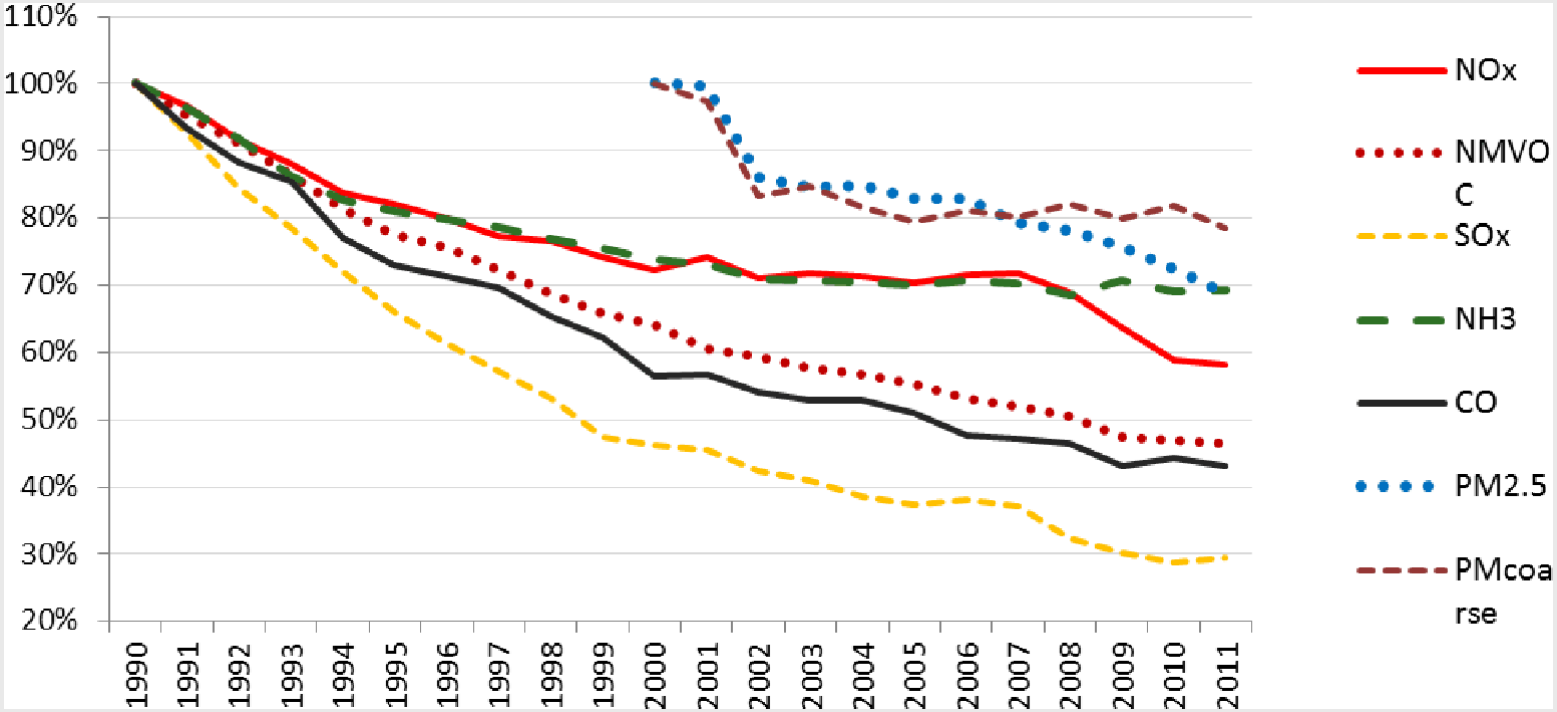
EMEP MSC-W Model Training Course, summarising …

- EMEP Open source code 2013 rv 4.3, Released April 2013
  https://wiki.met.no/emep/page1/emepmscw_opensource
- Available MSCW support on documentation, grids, nesting,emissions and ECMWF meteorology clarified
- WRF offers now a flexible meteo source => Group ?
- Boundary conditions from standard EMEP simulations could be a future product for national model use
- User forum, FAQ, email list will be renewed
- Course should be repeated, probably bi-annually

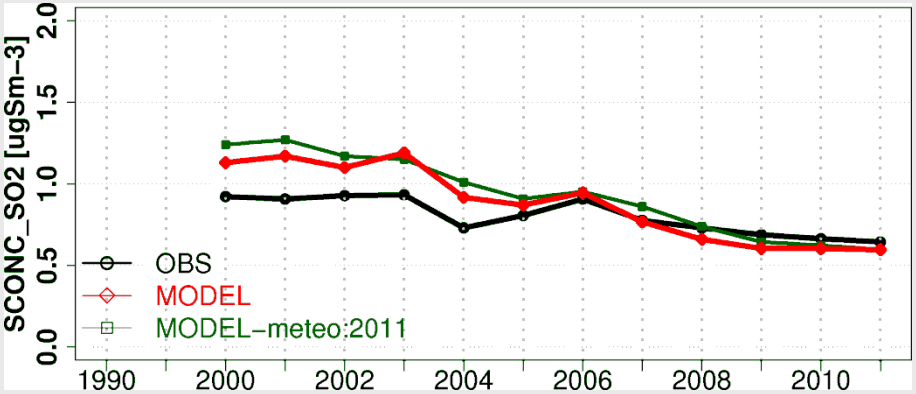
Reported Emission Trends 1990-2010

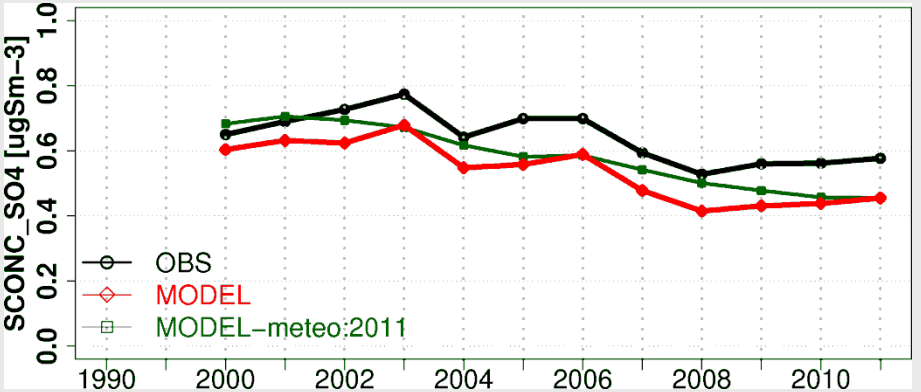


Emission trends (%) in the EMEP area 1990-2011 (no ship emissions)

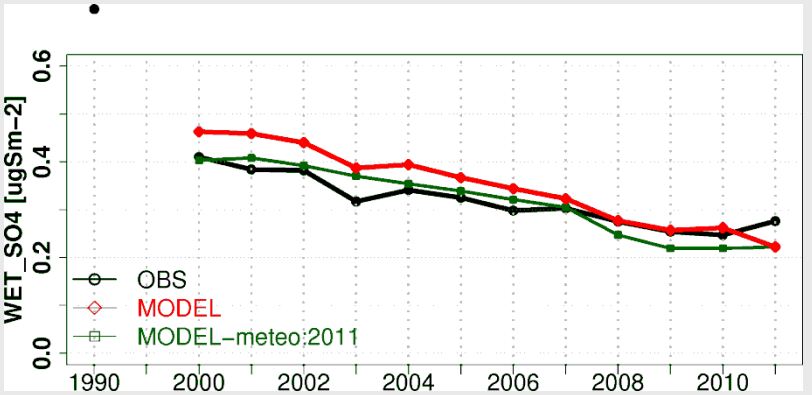
Agreement between emission based modelling and independent measurements
Provide the most convincing argument for having achieved air pollution abatement

10 Year Trend of European Mean Sulfur components

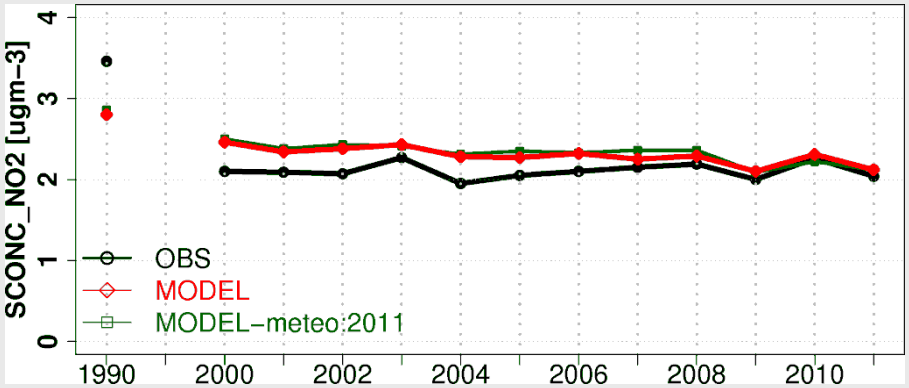


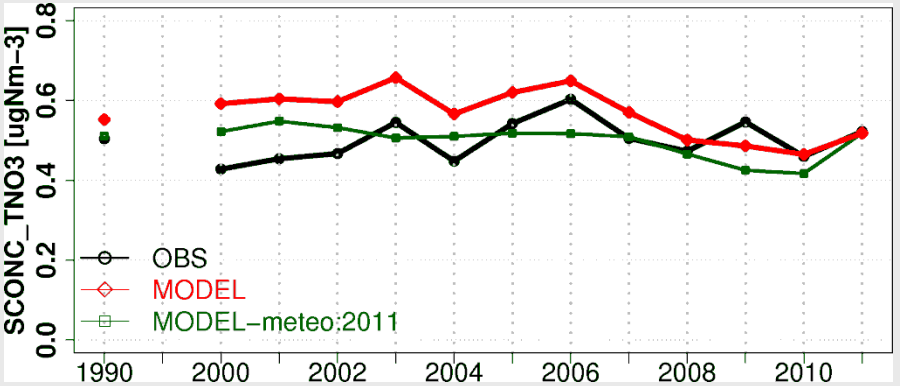


- Downward trend of about 20-40%, slightly more than in Tørseth et al. (but Different stations)
- Bias in SO4 constant
- Modelled SO2 and S wet dep decrease faster in model

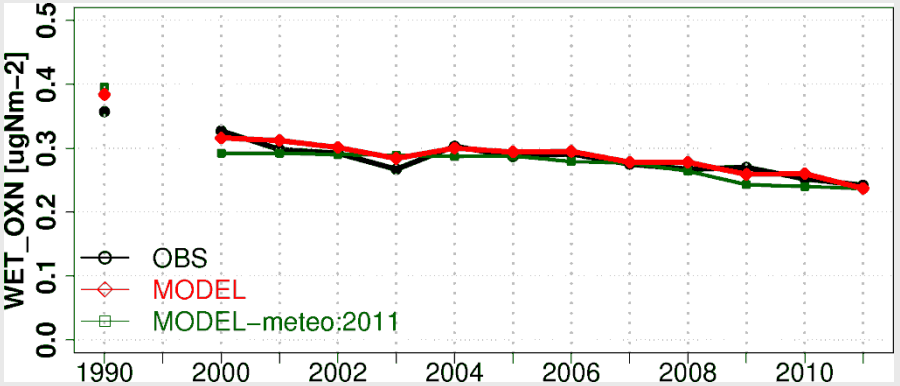


10 Year Trend of European Mean oxidized N components



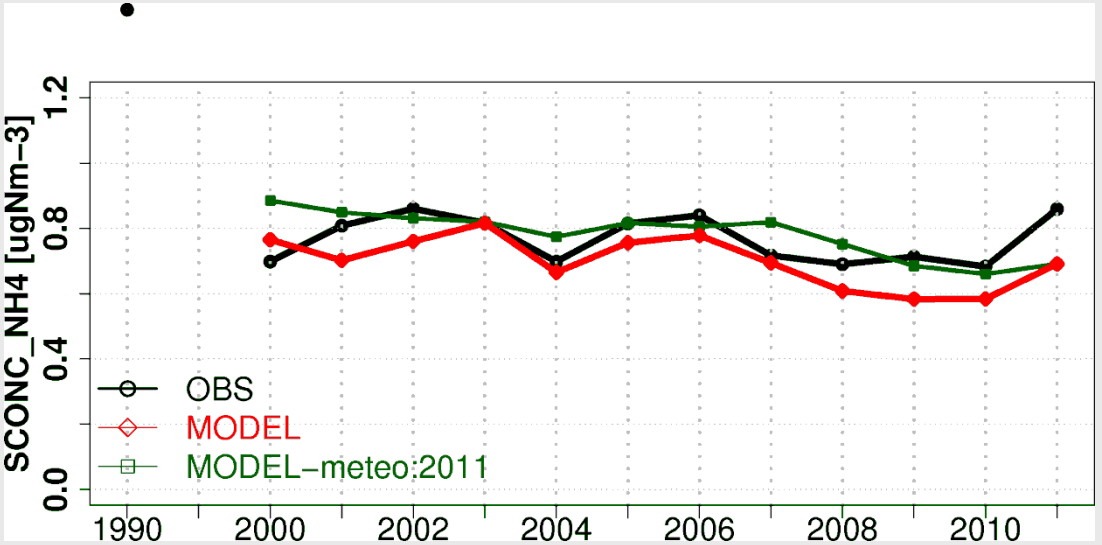


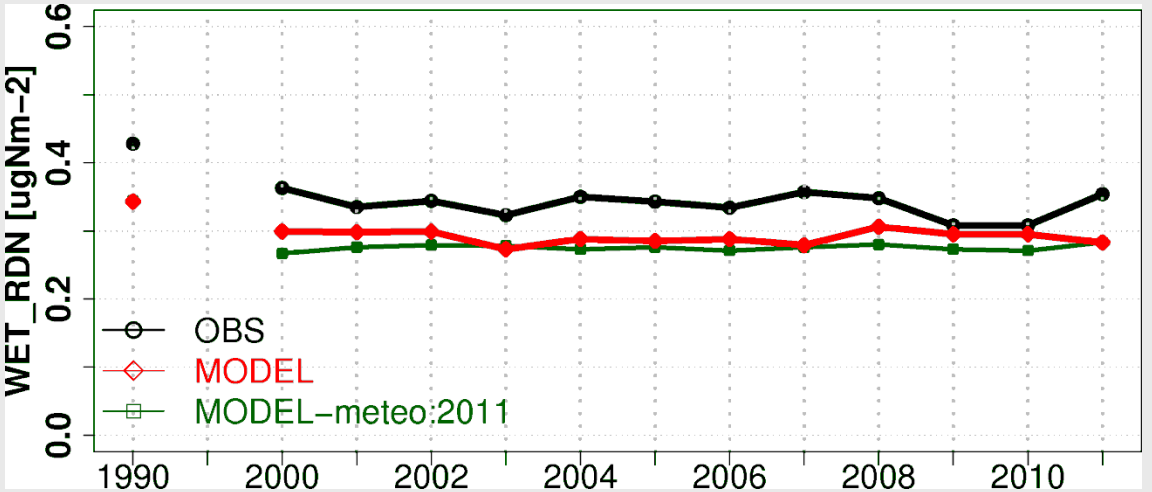
- Weak downward trend for NO2 and wet dep of N (consistent with Tørseth et al.)
- Absent trend for TNO3



10 Year Trend of European Mean reduced Nitrogen components

- Weak downward trend of Ammonium, more in the model
- No trend in red N wet dep





Suggestions for further EMEP trend work (jointly with TFMM)

- Can model reproduce the trends? Are trends the same in the different seasons?
- What is the role of changing chemical regimes?
- What is the effect of boundary conditions (hemispheric contribution)?
- Develop consistent data set for the two recent decades:
  - Identify inconsistencies due to changed instrumentation, protocols, personnel etc
  - Identify sites that are influenced by ‘new’ local emission patterns
  - Develop techniques to cope with a changing network structure
- Look at representativeness w.r.t. emissions, divide into different regions

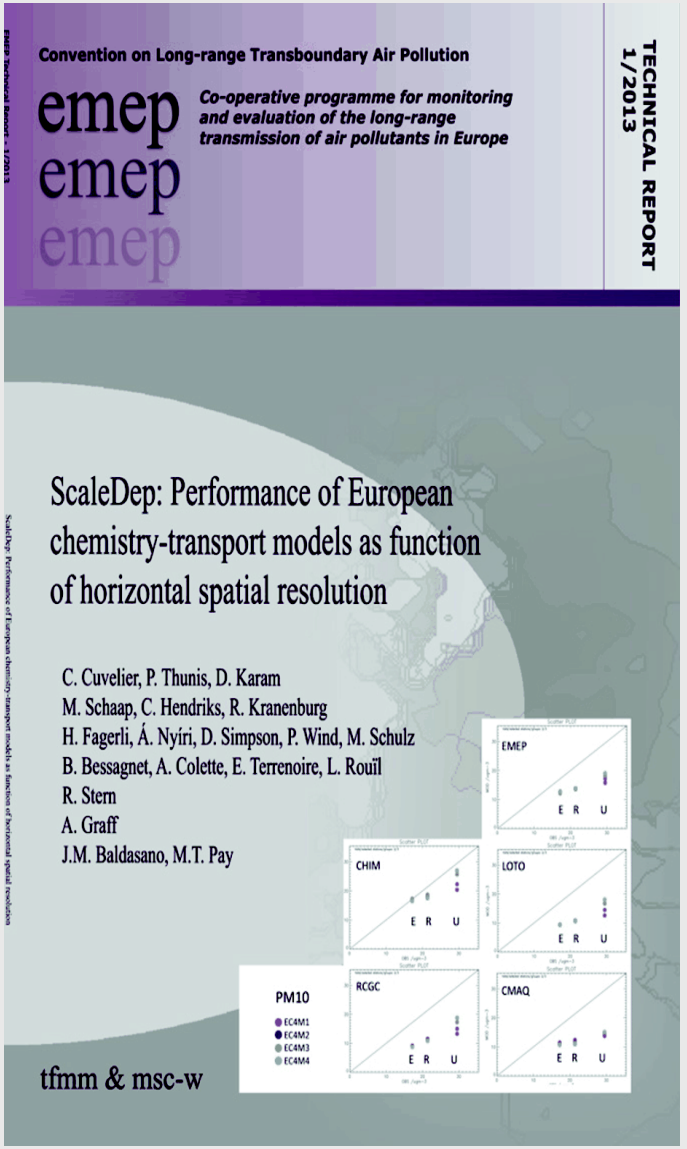
Towards a finer scale EMEP grid

- EB 2012 decided to change the grid projection (lat,lon), resolution (0.1 x 0.1) degree) and domain
- EMEP Technical Report 1/2013, TFMM & MSC-W

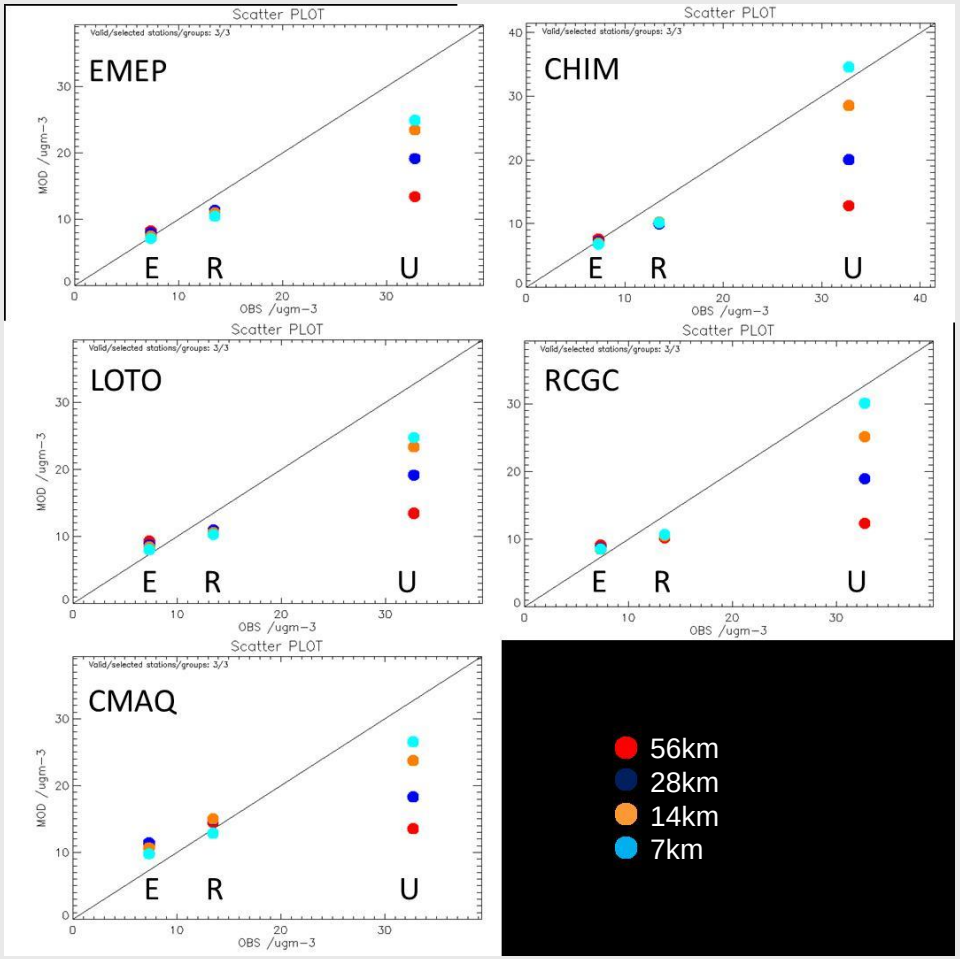
ScaleDep: Performance of European

Chemistry-transport models as a function

Of horizontal spatial resolution



Annual average NO2 concentrations per station type. E=EMEP, R=RURAL, U=URBAN



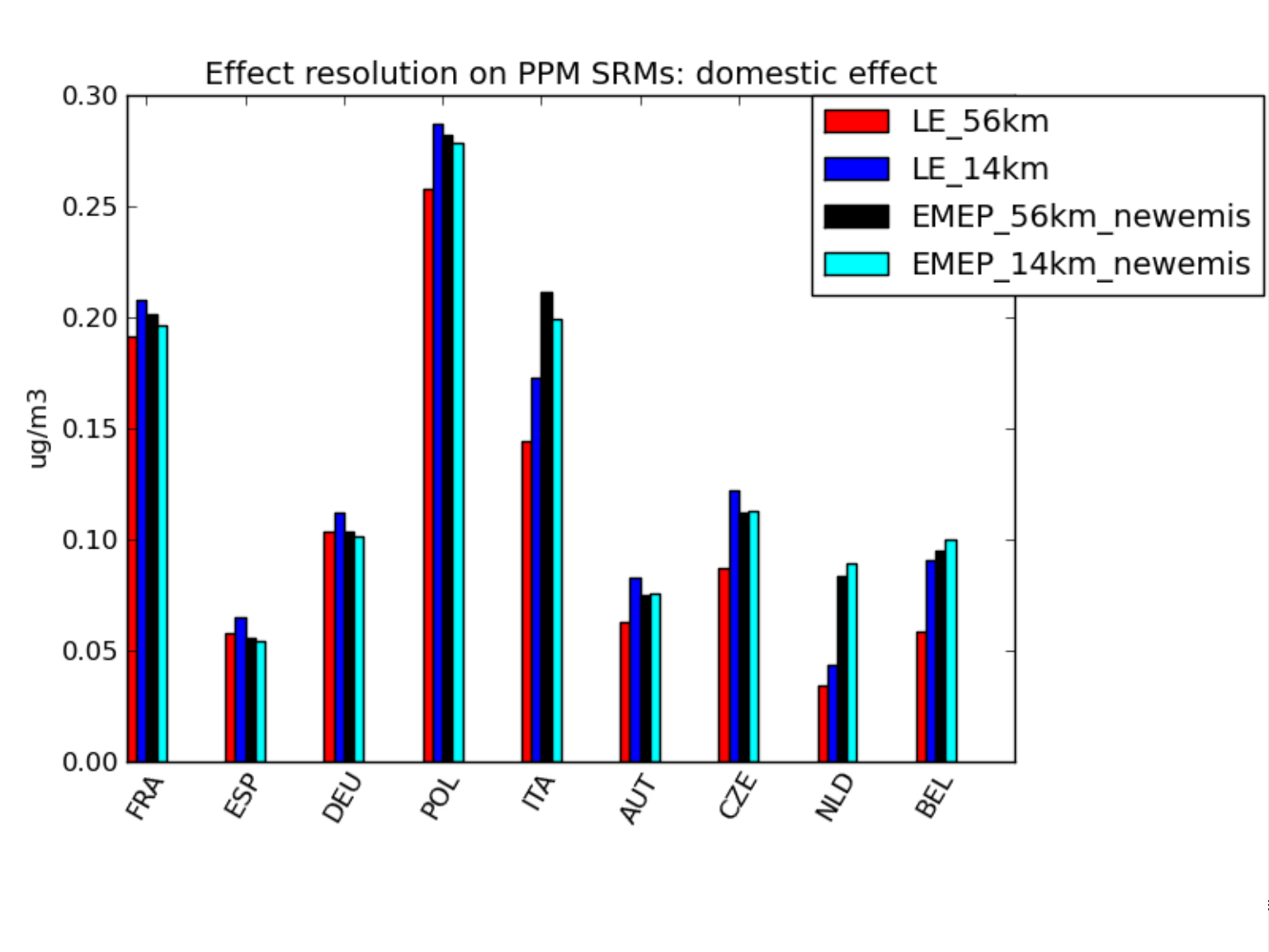
Critical load exceedances in different resolutions

Table 4.1: Ecosystem area exceeded and average exceedance (AAE) for acidity and nutrient N critical loads in the EU28 region and in the whole of Europe using depositions modelled on the TNO56 and TNO14 grid, using meteo and emissions from 2009. Corresponding results from this years report of 2011 conditions are given for comparison.

Region	Grid	Acidity Critical Loads		Nutrient N Critical Loads	
		Area exc. (%)	AAE (mol $ha^{-1}a^{-1}$)	Area exc. (%)	AAE (mol $ha^{-1}a^{1}$)
EU28	TNO56	8.54	30.0	65.4	260.0
	TNO14	8.18	28.2	64.4	243.7
	EMEP-2011	6.8	19.9	63.4	230.5
Europe	TNO56	5.90	18.6	58.8	193.6
	TNO14	5.78	17.4	58.1	184.1
	EMEP-2011	4.8	12.9	59.5	180.0

Somewhat lower impacts for critical load exceedances for nitrogen in ~14km grid than ~50km

Preliminary results: Source-receptor matrices in different resolutions for PPM (EMEP and LOTOS-EUROS)



Simulations Overview 2012/13 in support of GP and TSAP

- Gothenburg protocol and Thematic Strategy of Air Pollution revision required at different stages EMEP model runs (always asap)
- Multiple Emission Scenarios from TFIAM and CIAM where tested in combination with base runs
- Future Source Receptor runs at 14/28/56 km resolution
- We were glad to have a new super computer at MetNo …

Short Name	Description	Purpose
GP_2005 GP_2020 GP_CLE_2010 GP_CLE_2020 GP_CLE_2030	TNO28 & PS EMEP grids Meteo 2006-2010 UNECE GP emissions = TSAP revision work	Scenario runs Gothenburg Protocol Guidance Document
TSAP SR 2020	TNO28 0.5x0.25 Meteo 2006-2010 SR for 55 countries NOx,SO2,NH3,PM,VOC 1400 runs, 5 base runs	TSAP revision GAINS input Scale Dependency
TSAP SR 2020 Fine/coarse grid	TNO14 and TNO 56 Meteo 2009 SR for 55 countries NOx,SO2,NH3,PM,VOC 600 runs, 10 base runs	TSAP revision GAINS input Scale Dependency

Short Name	Description	Purpose
TSAP 2020 Ozone boundary conditions	TNO28 0.5x0.25 Meteo 2006-2010 9 ozone perturbations +1.5 to -4 ppb	TSAP revision GAINS input Future Hemispheric Impact
TSAP scenarios Jan 2012	TNO28 0.5x0.25 Meteo 2006 MCE 2020/2030/2050 nonEU 2020/2030/2050 REF 2005/2010/2020/ 2025/2030/2050	TSAP revision
TSAP scenarios Sep 2012	TNO28 0.5x0.25 Meteo 2006-2010 MCE 2050 REF 2000/2005/2020	TSAP revision
TSAP scenarios March 2013	TNO28 0.5x0.25 Meteo 2006-2010 P12_[A5/COB/MFR]2025 REF 2005	TSAP revision

Links between air quality and climate

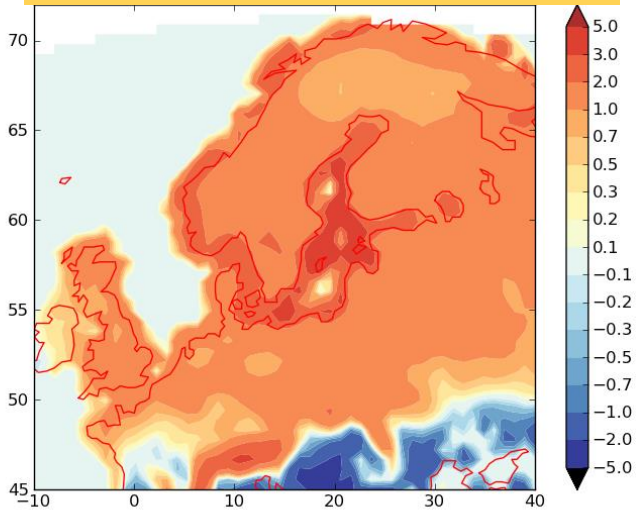
- The effect of a changing climate on air pollution
- SLCF

- Numerous international projects: ECLAIRE,ECLIPSE,IMPACT2C, PEGASOS, ENSCLIM, MD-CH4

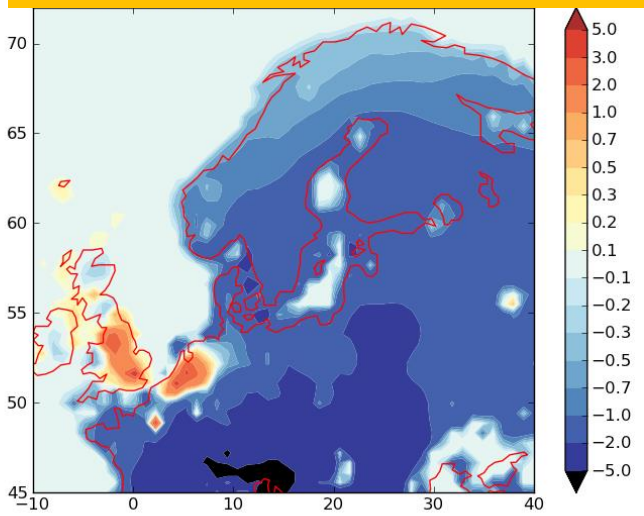
Changes in risks to northern European forests

Effect of climate on ozone

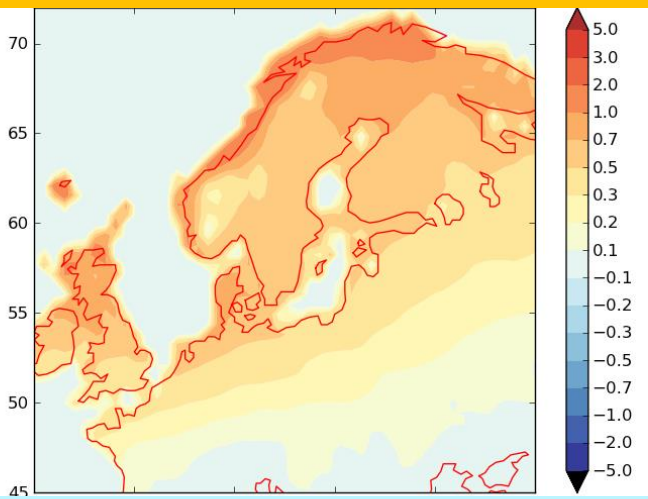
Effect of climate on POD1



Effect of emissions on POD1

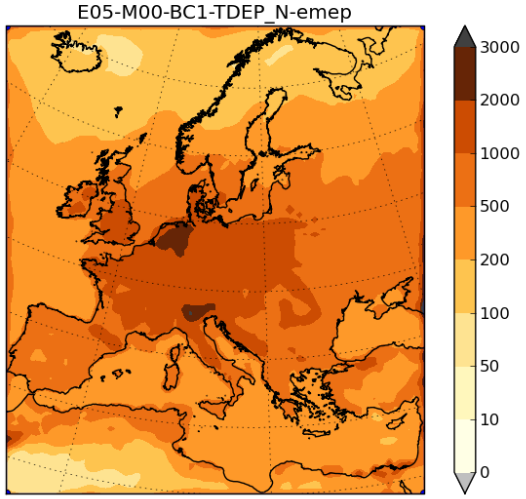


Effect of arctic shipping emissions on POD1

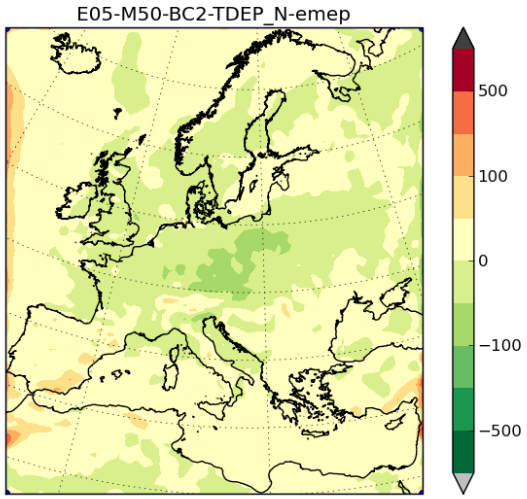


Tuovinen, Hakola,Karlsson, Simpson . Climate Change, Air Pollution and Global Challenges, Volume 13: Understanding and Perspectives from Forest

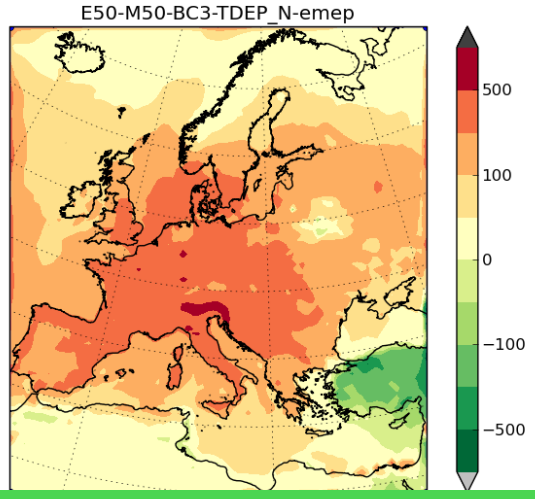
Changes in nitrogen deposition, 2000-2050



Base case (1990-2009)

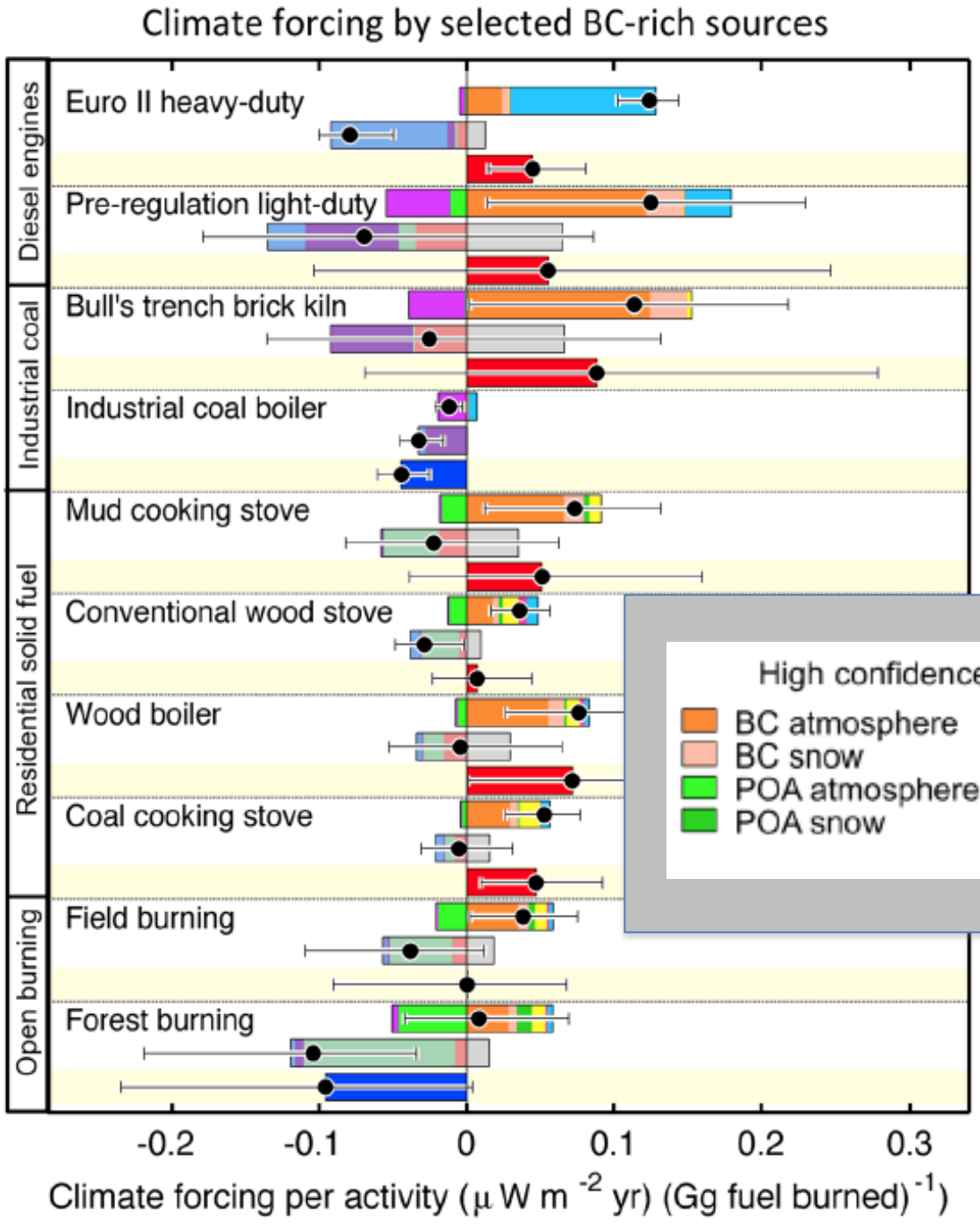


Effect of climate



Effect of climate & emissions

- Climate penalty for N dep
- Large difference between models
- NH3 emissions projected to remain practically unchanged – unknown impacts from changing temperature on NH3 and soil NO

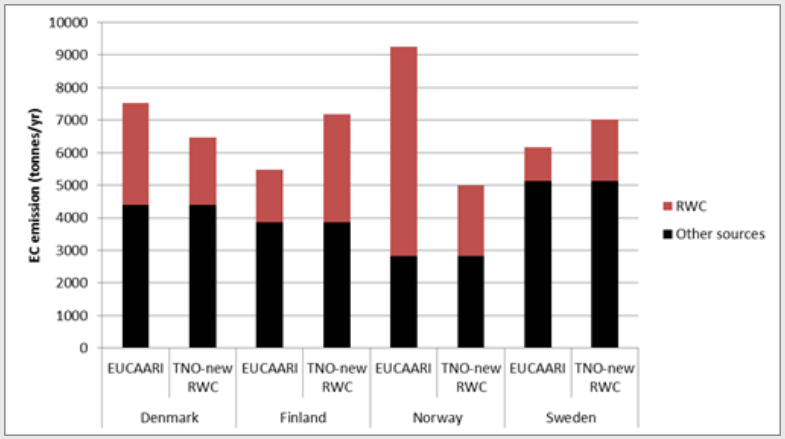


Where to act on Black Carbon?

Exemplary figure from Bond et al, JGR-Atmospheres, 2013 "Bounding the role of black carbon in the climate system"

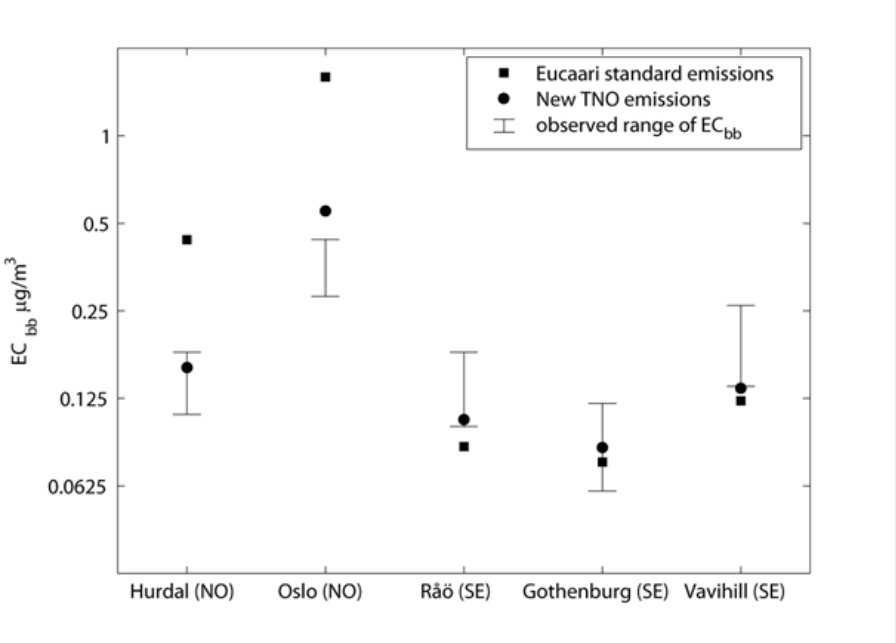
Comparing modelled EC to measured EC/BC – focus on residential wood burning (Genberg et al. ACP 2013)

- 8 sites, bias within 20%
- **Revised residential wood burning emissions (TNO):**



Large changes for some countries, especially Norway!

- **Revision seems to give better modelling results:**



ECLIPSE

- Radiative forcing and climate response due to short-lived species, including dependence on location

- Present day emissions, one year response of emissions in 1) Europe, 2) SE Asia, 3) Shipping, 4) Rest -> RF

- Climate response 2010 -> 50 year simulations with reductions in each region separately

Species: BC,OC,SO2,NO2,CO,VOCs,NH3

Plans

- **Provide data and tools to Parties so that they are able to do their own/complementary assessments/policies:**
  - Concentrations, depositions (incl. high resolution), SR, trends. Boundary conditions
  - Country reports + easier access to country data
  - Annual release of EMEP open source model
  - Bi-annual training course. Discussion platform

  ➢ New web interface to EMEP with better access to products

- **Contribute to assessments for GP, TFs,HTAP, WGE,EU TSAP, AMAP, HELCOM, OSPAR**
  - Database of simulations
  - Report on estimates and analysis of transboundary pollution to the Arctic

Plans (2)

- **Prepare for and evaluate results of the EMEP model in the new grid:**
  - Input generation (emissions, meteorology,..), Model performance, Trends, Source-receptor relationships
  - ➢ Report on the new grid (with TFMM, Parties, CEIP)

- **Trend analysis and model evaluation/comparisons** (with TFMM, CCC, Parties)
  - Co-operation with national experts

- **Keep the EMEP model state-of-the-art**

Plans (3)

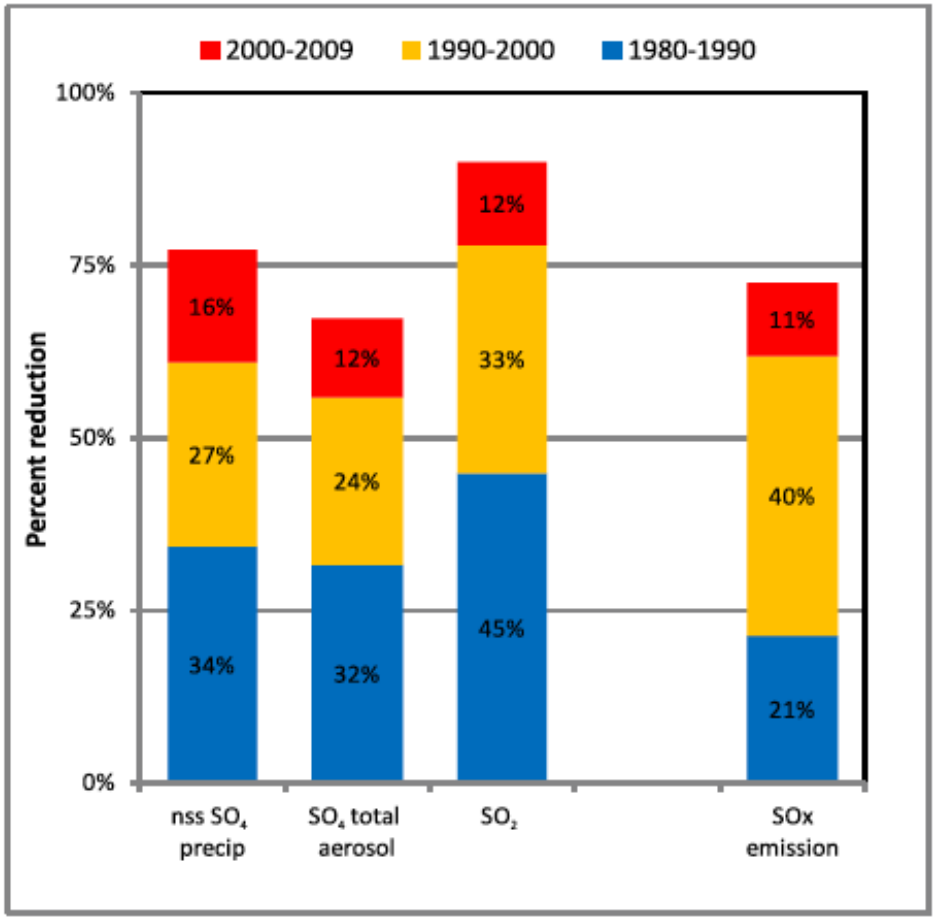
- **Investigate the role of climate sensitive emissions (nitrogen oxide, ammonia, VOC's, methane) for future effectiveness of the Gothenburg protocol** (ECLAIRE)
  - Report on effectiveness of the GP protocol in a changing climate

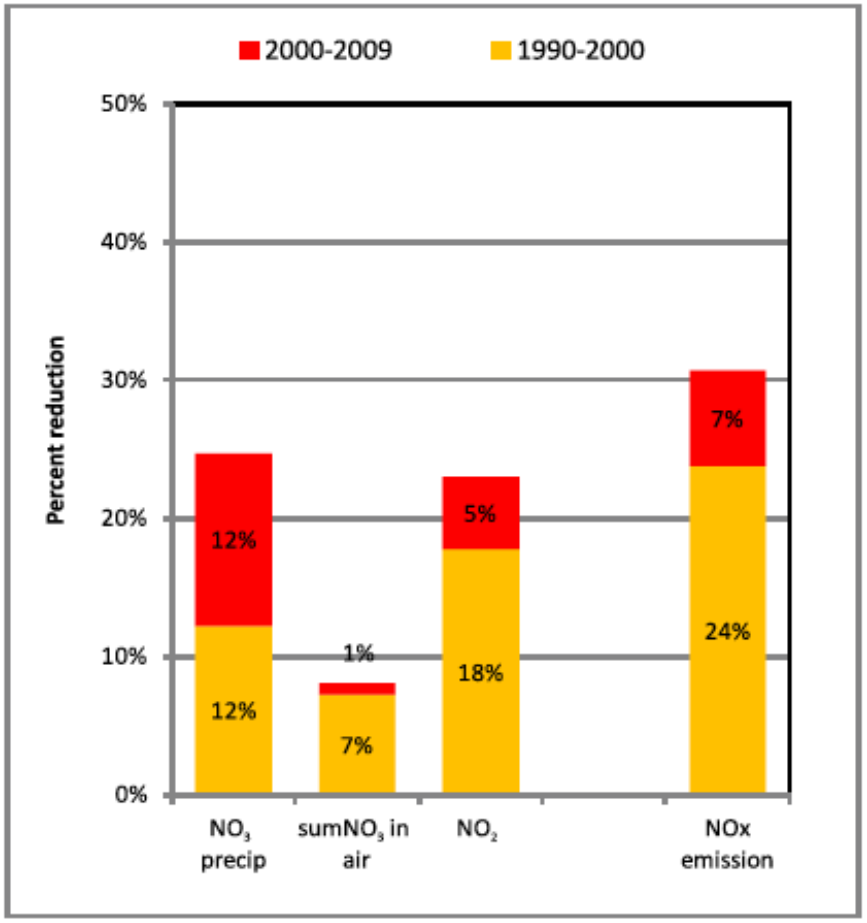
- **Calculate SLCP forcing for Gothenburg protocol implementation.** *Evaluate BC uncertainty. (ECLIPSE)*
  - Report on SLCP forcing originating in the EMEP area (for black carbon, methane, ozone)

Plans

- Provide data and tools to Parties so that they are able to do their own/complementary assessments/policies:
- Contribute to assessments for GP, TFs,HTAP, WGE,EU TSAP, AMAP, HELCOM, OSPAR
- Prepare for and evaluate results of the EMEP model in the new grid
- Trend analysis and model evaluation/comparisons
- Keep the EMEP model state-of-the-art
- Investigate the role of climate sensitive emissions (nitrogen oxide, ammonia, VOC's, methane) for future effectiveness of the Gothenburg protocol
- Calculate SLCP forcing for Gothenburg protocol implementation.

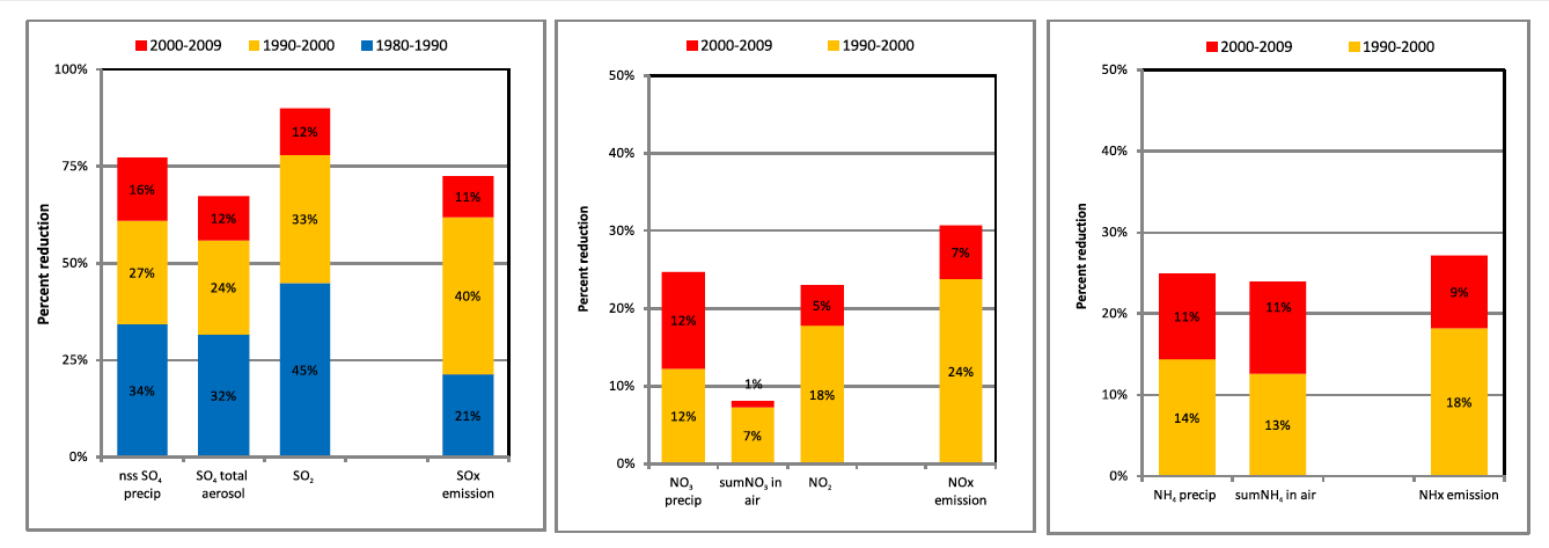
Trends N and S
Measurements versus Emissions





14 sites used for consistent sulfur trends
All sites used for nitrogen trends

Torseth et al. 2012


2000-2009
1990-2000
1980-1990
Percent reduction
100%
75%
50%
25%
0%
16%
27%
34%
12%
24%
32%
12%
33%
45%
11%
40%
21%
nss SO4 precip
SO4 total aerosol
SO2
SOx emission
2000-2009
1990-2000
Percent reduction
50%
40%
30%
20%
10%
0%
12%
12%
1%
7%
5%
18%
7%
24%
NO3 precip
sumNO3 in air
NO2
NOx emission
2000-2009
1990-2000
Percent reduction
50%
40%
30%
20%
10%
0%
11%
14%
11%
13%
9%
18%
NH4 precip
sumNH4 in air
NHx emission

Eclaire – impacts of climate change

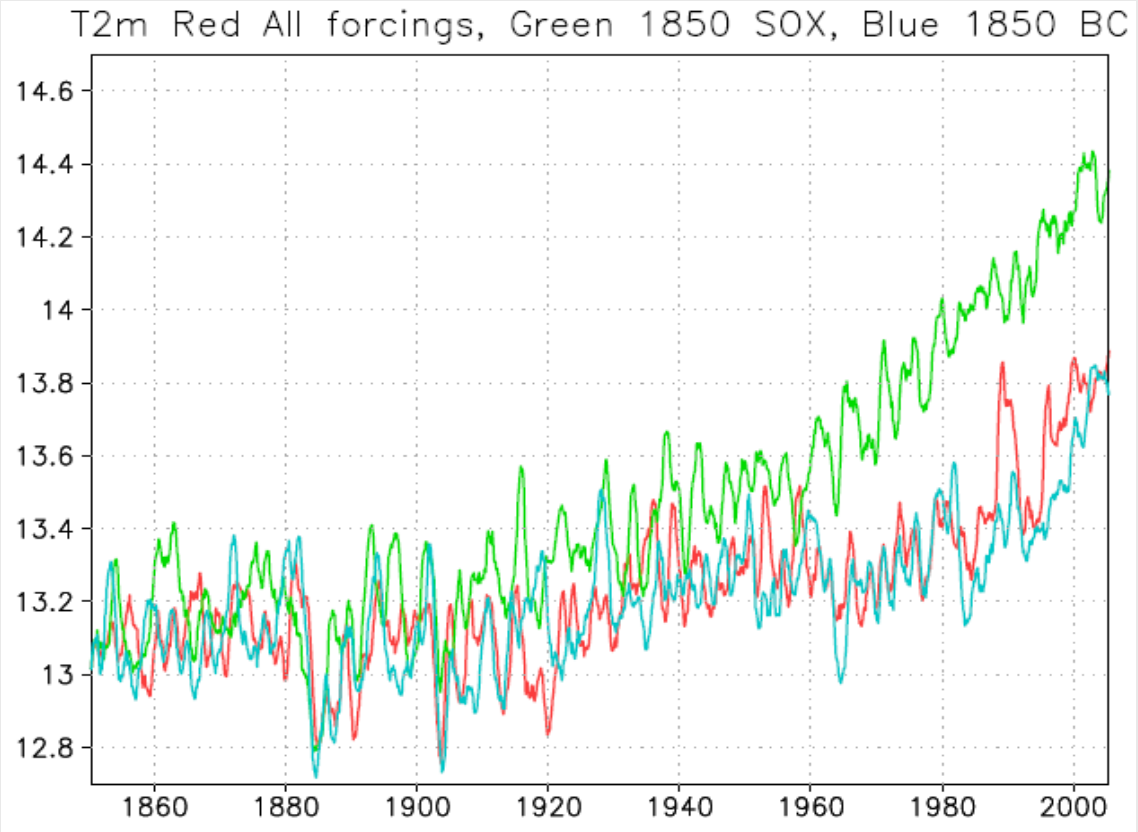
- Activities:
  - Long-term (1900-2050) calculations, O3 and S, N-dep results delivered to ecosystem models.
  - Multi-model intercomparison, 2009, TNO-lead.
  - EnsClim (with NMR): effects of climate change, boundary conditions, and emissions, from current (1990-2009) to future conditions (2040-2059).
- Based upon:
  - IIASA/ECLAIRE emissions, 2005, 2050.
  - SMHI climate-model simulations (RCA3)
  - For EnsClim, hemispheric boundary conditions from DMU (DEHM).

Temperature response to SO2 and EC emissions with NorESM

1. Simulation with all forcings included, 1850-present
2. As (1) but with BC emissions kept constant at year 1850 levels
3. As (1) but with SO_x emissions kept constant at year 1850 levels

Temperature response to SO2 and EC emissions with NorESM (2)

Global Mean T



1850 SOx
All forcings
1850 EC

PEGASOS, Figure from Øyvind Seland

Cooling due to SOx increase
Slight warming due to EC increase

! Bond el al 2013 suggest underestimation of global BC emissions of ~factor of two

Scientific work needed to support the UNECE convention wrt BC mitigation

- Contribute to continued joint, international scientific assessments of BC effects;
  Quantify BC climate forcing, health effects, the role of co-emitted species
- Clarify uncertainties and misunderstandings, answer to frequently asked questions on climate and air quality benefits
  Report on regional forcing and effectiveness of measures, including the Arctic
- Monitor over time BC-related atmospheric parameter in the atmosphere through measurements and modelling
  Implement measurement strategy, method harmonization, supersites development
- Provide emission-to-impact modelling
  for sectors/scenarios/countries/regions