Norwegian Meteorological Institute
met.no

Activities on acidification, eutrophication and photo-oxidants

Progress and plans

MSC-W: H. Fagerli, A. Benedictow, H. Berge, M. Gauss, J.-E. Haugen, T. Iversen, J.E.Jonson, A. Kirkevåg, A. Nyíri, Ø. Seland, D. Simpson, S. Tsyro, A. Valdebenito, S. Valiyaveetil, P. Wind

CCC: W. Aas, A.-G. Hjellbrekke, A. M. Fjæraa

CEIP: K. Mareckova, R. Wankmüller

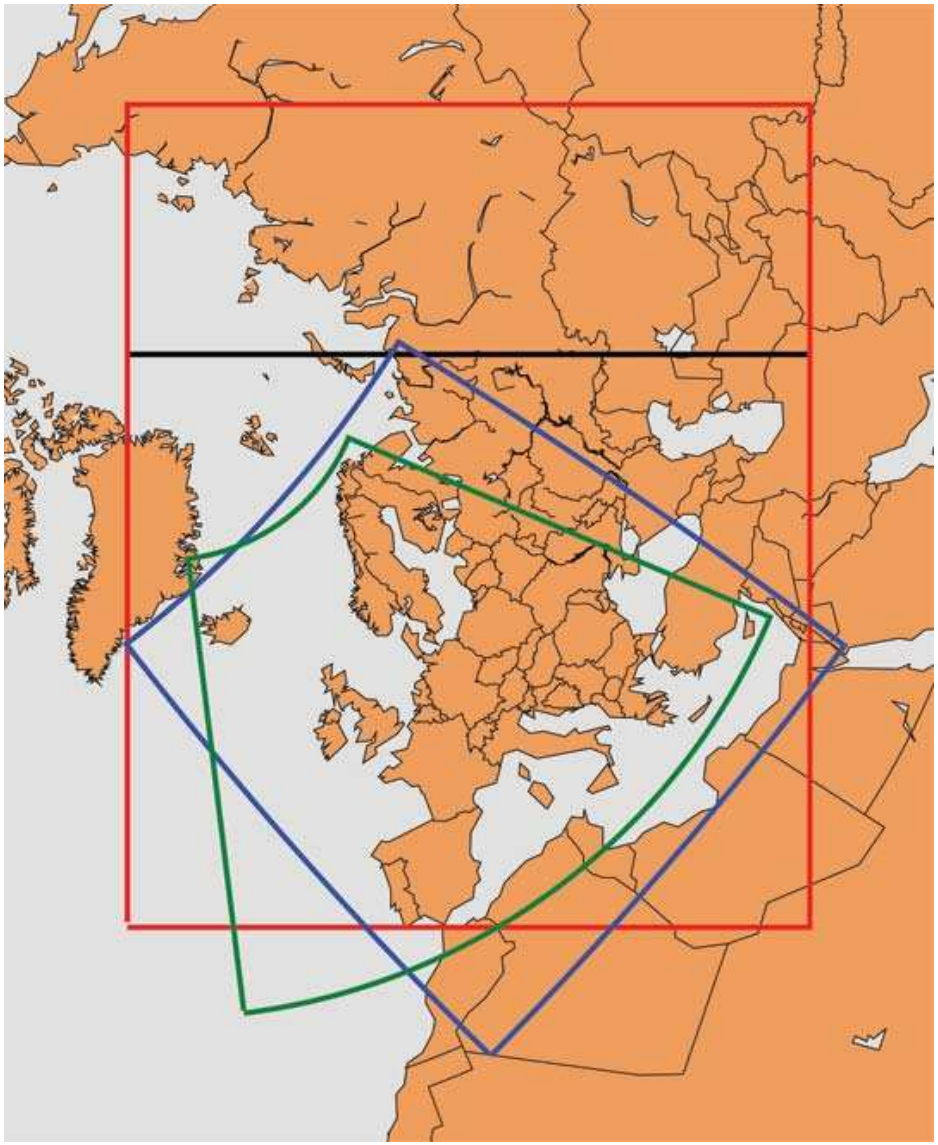
EMEP 34th Steering Body meeting, Geneva, 13-15th September 2010

Outline

- Status calculations for 2008 in the extended EMEP domain
- First steps towards investigating AQ-climate interactions
- EMEP model development
- Plans for 2010-2011

Model calculations and source-receptor calculations for 2008

- Calculations were done covering a large part of the EECCA countries
- Several model updates preceded the calculations
- The meteorological driver has been changed to ECMWF-IFS
- Flexibility in the EMEP model
  - use with future climate data
  - GMES operational services



Factors contributing to (reported) change from year to year

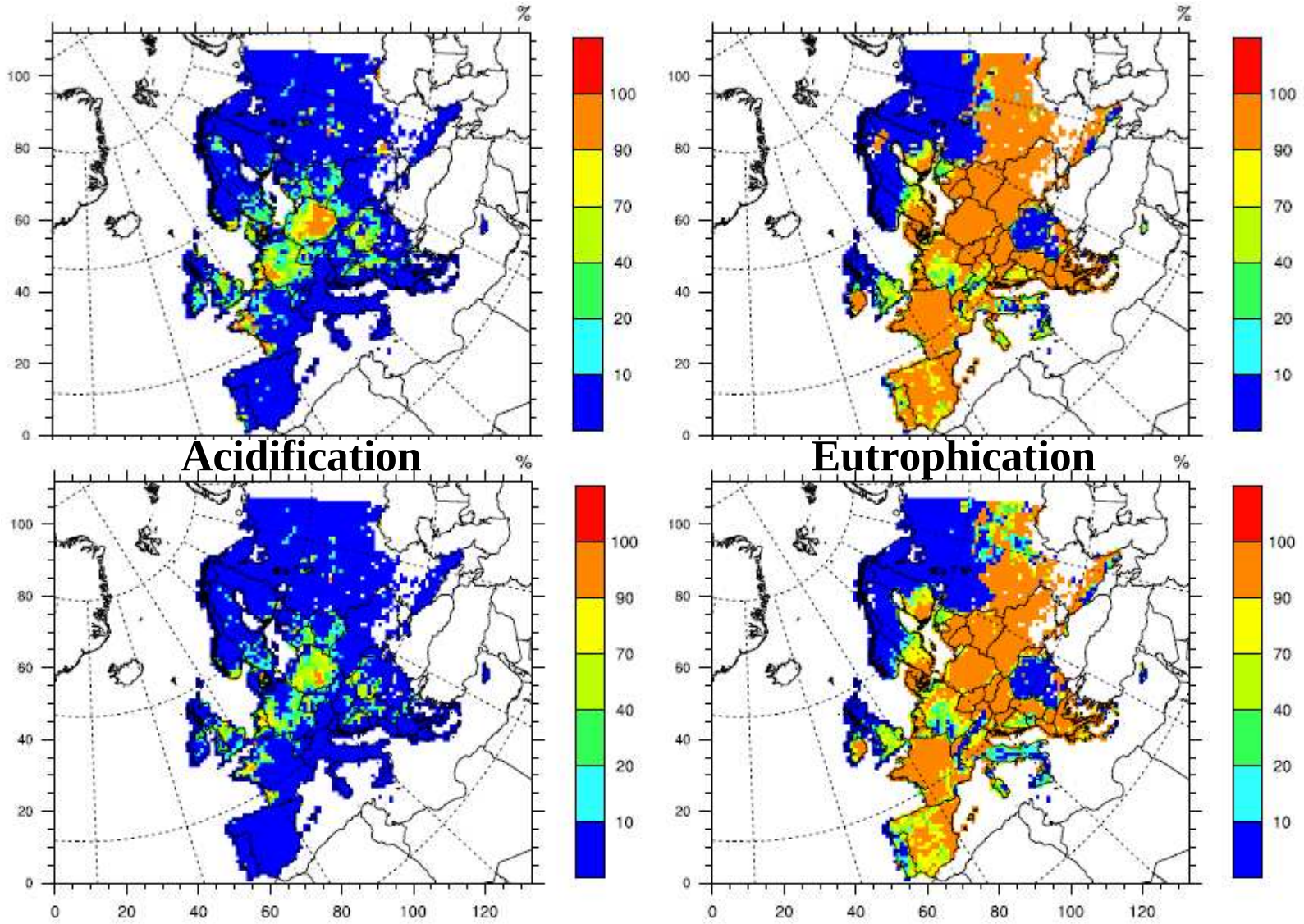
- Inter-annual meteorological variability
- Change in surface properties and external forcings
- Changes in emissions

- Model version (EMEP and NWP)
  - continuous model improvement vs. *consistent* trend calculations

Critical load exceedances : area at risk

2007

2008



From 2007 to 2008 …

- Emission change (CEIP) :
  - SOx: -8.1%
  - NOx: -0.03%
  - NH_3: -1.7%
  - NMVOCs: +2.4%
  - CO: -1.6%

- Response (MSC-W) :
  - oxidized sulphur deposition: -7.9% (mainly caused by emis. change)
  - oxidized nitrogen deposition: +0.05% (mainly caused by met. change)
  - reduced nitrogen deposition: -0.4% (ditto)

Choice of a suitable numerical weather prediction model (NWP)

- How good is the NWP? (verification of model meteorology, continuity)

This is the important criterion!

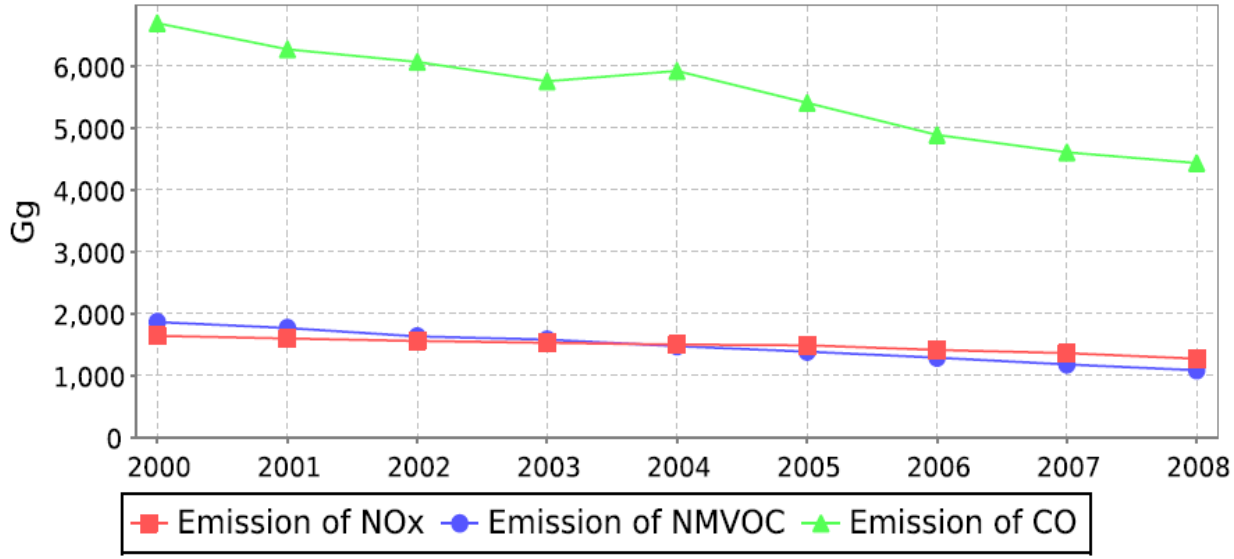
- How good is the Unified EMEP model with this NWP? (evaluation against EMEP measurements)

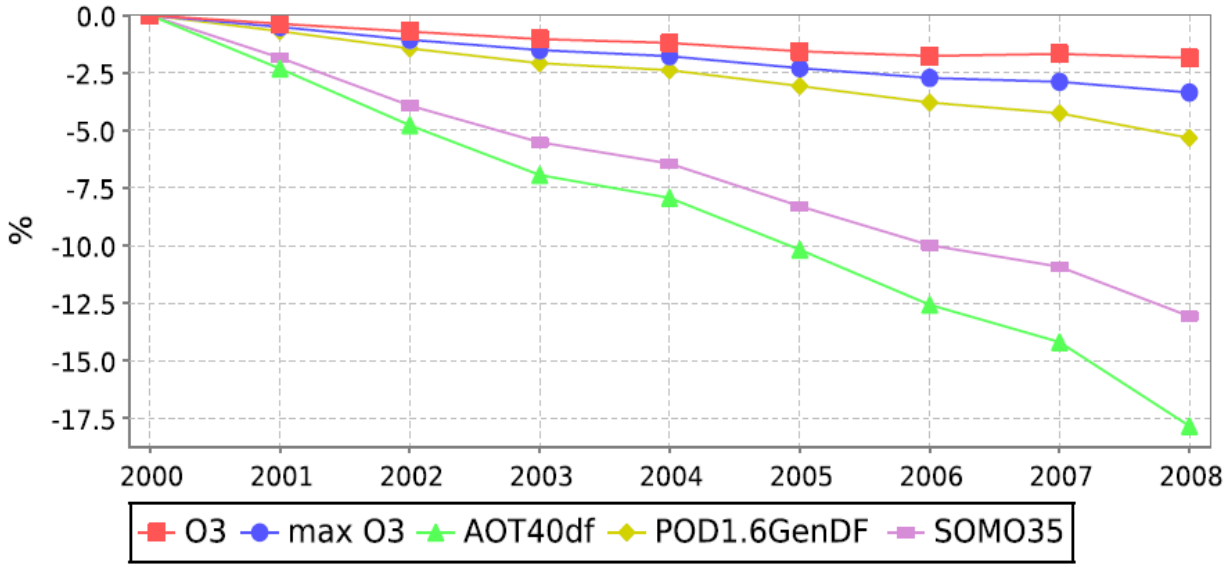
Trends

- Trends in Europe during the last 10 years tend to be small
- Often masked by inter-annual meteorological variability
- This year the trend figures in country notes show results from a multi-year model run with fixed meteorology (=2008)
- Changes should reflect changes in emissions only

Trends in country X

Emissions…





… and response

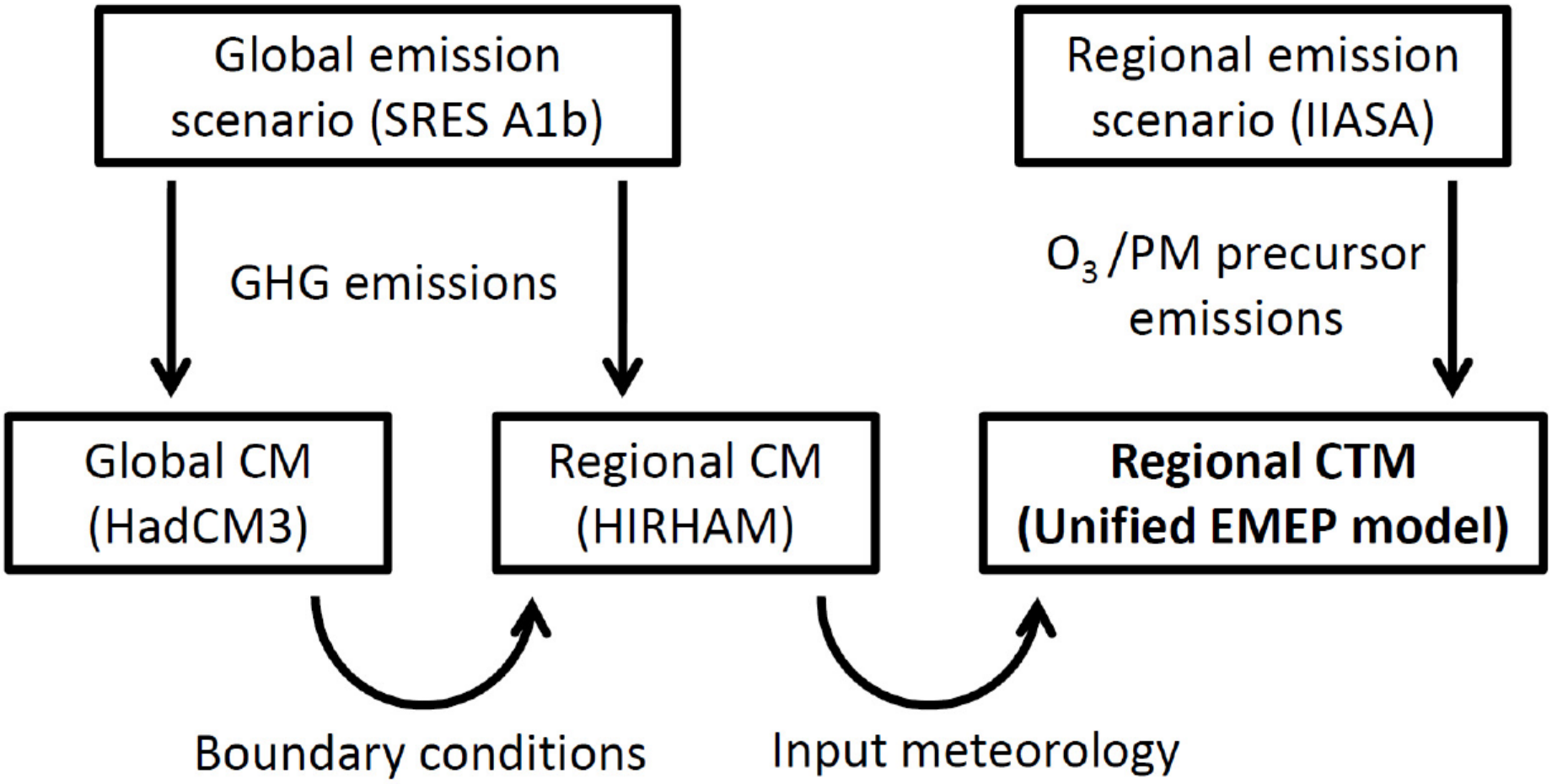
Climate-AQ interactions

Examples of climate-AQ interactions

(e.g. Jacob and Winner, 2009; Isaksen et al., 2009)

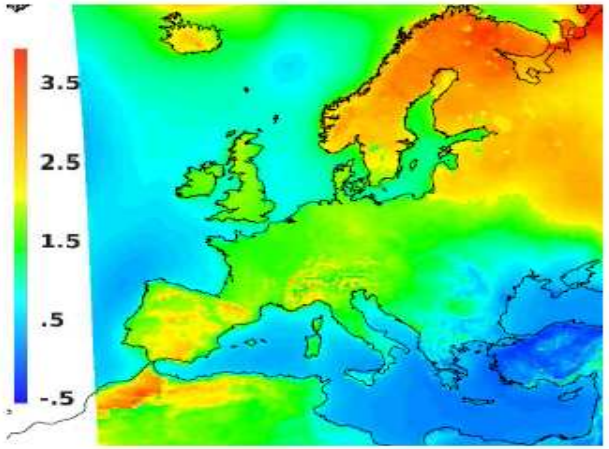
- Higher temperature → ozone increase in polluted areas
  → more sulfate (more SO_2 oxidation)
  → less nitrate (more evaporation)
  → forest fires (sources of CO, PM, …)
- Higher humidity → decrease in background ozone
- Changes in precipitation *frequency* → changes in PM
- PM → clouds/precipitation, radiative forcing (dir/indir)
- Changes in PBL height and convection → changes in mixing
- Change in temperature, soil moisture
  → changes in biogenic emissions, uptake, deposition

HIRHAM calculations, future climate

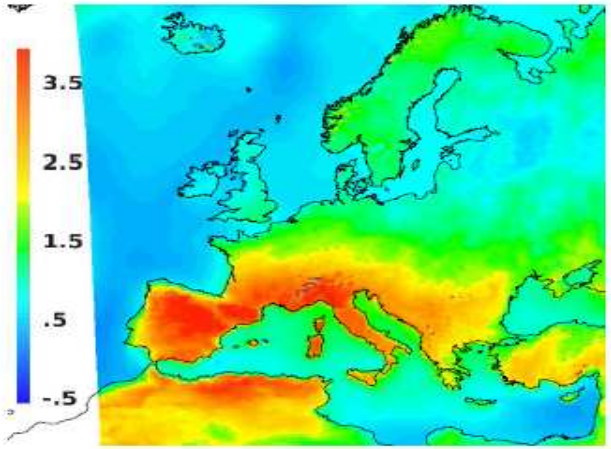


Climate change 2000s to 2040s

Winter

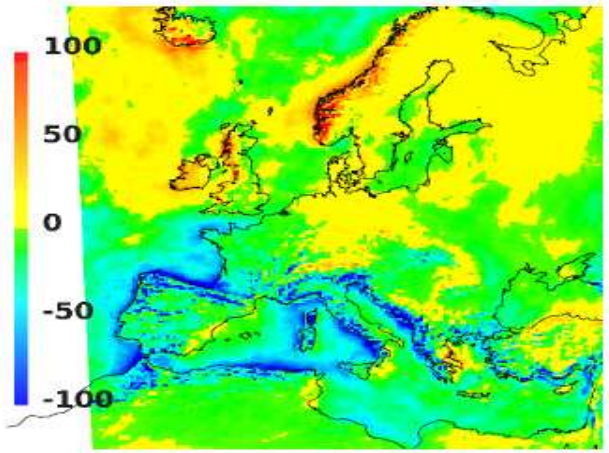


(a) Δ Temperature DJF

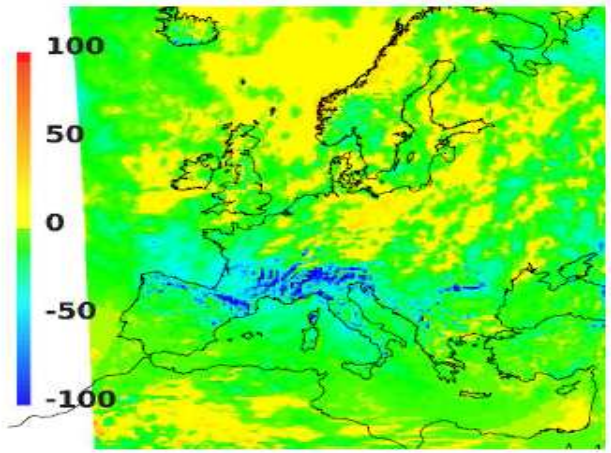


(b) Δ Temperature JJA

Summer



(c) Δ Precipitation DJF



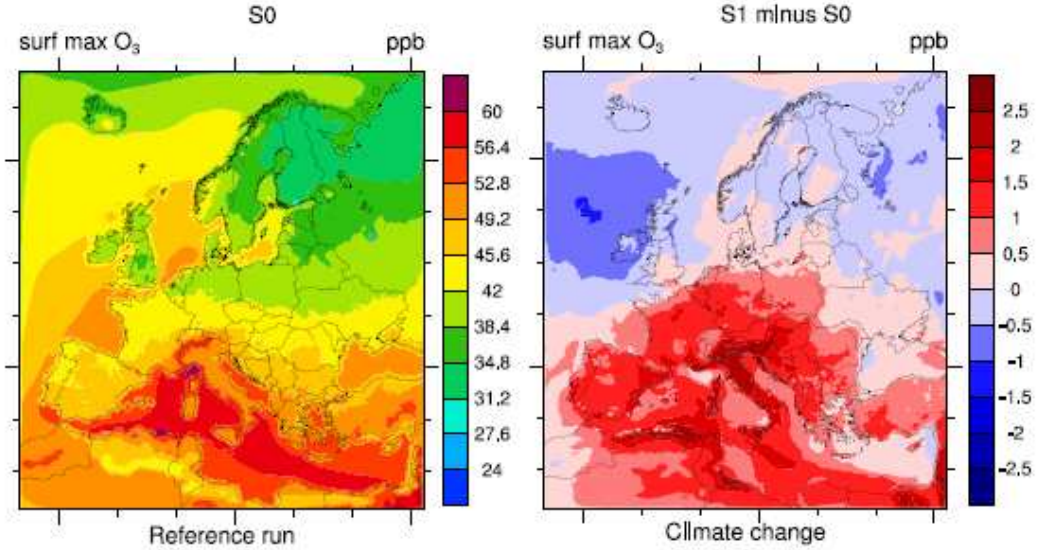
(d) Δ Precipitation JJA

Change in T (a,b) and surface precipitation (c,d) between the 2000s and the 2040s for the JJA and the DJF seasons. Units: Kelvin for temperature and mm/year for surface precipitation.

Changes in ozone

Left: Daily maximum surface ozone, 2000-2010.

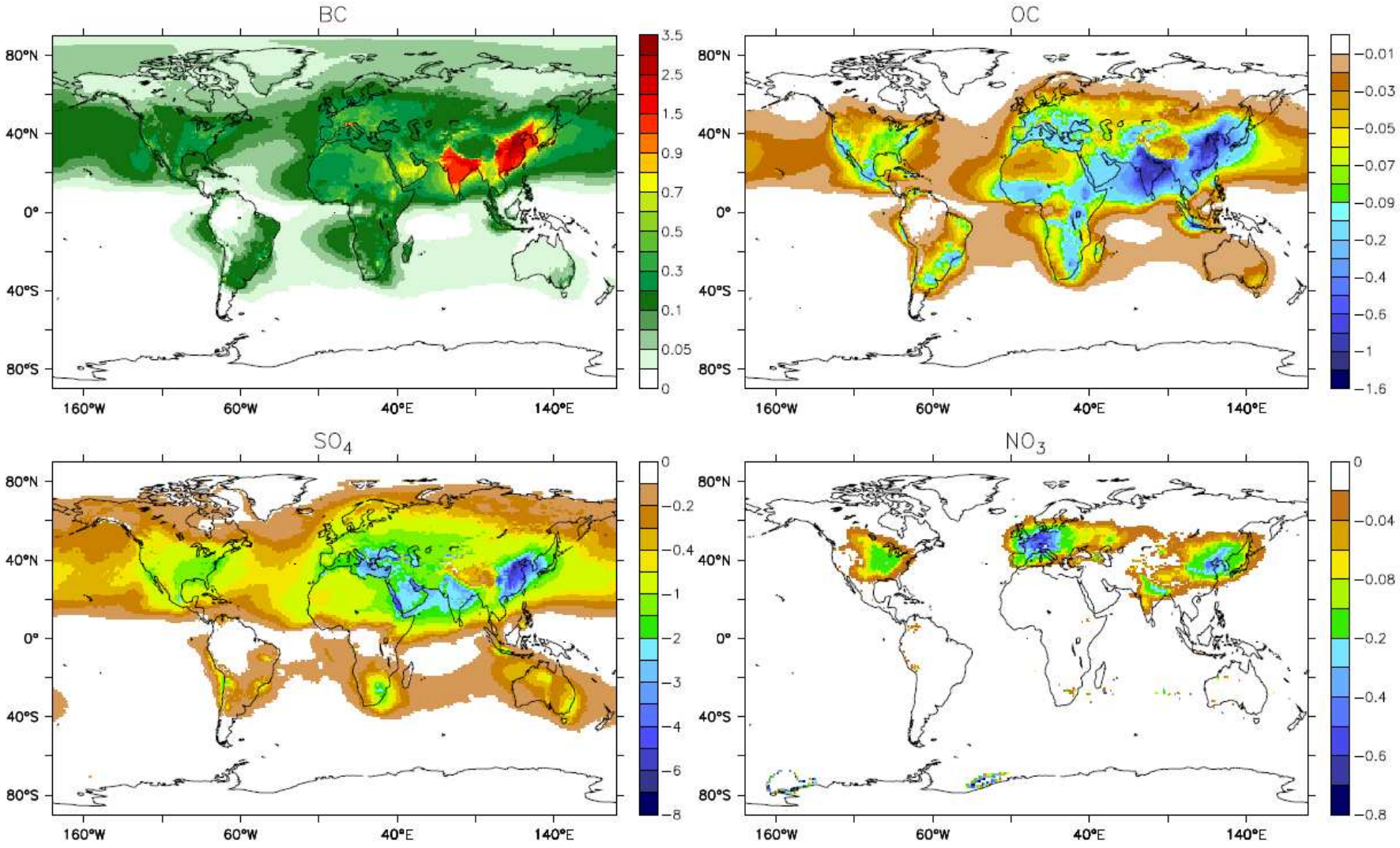
Right: Change until 2040-2050, Effect of climate change only.



Short-lived climate forcers and their near-term radiative forcing(RF)

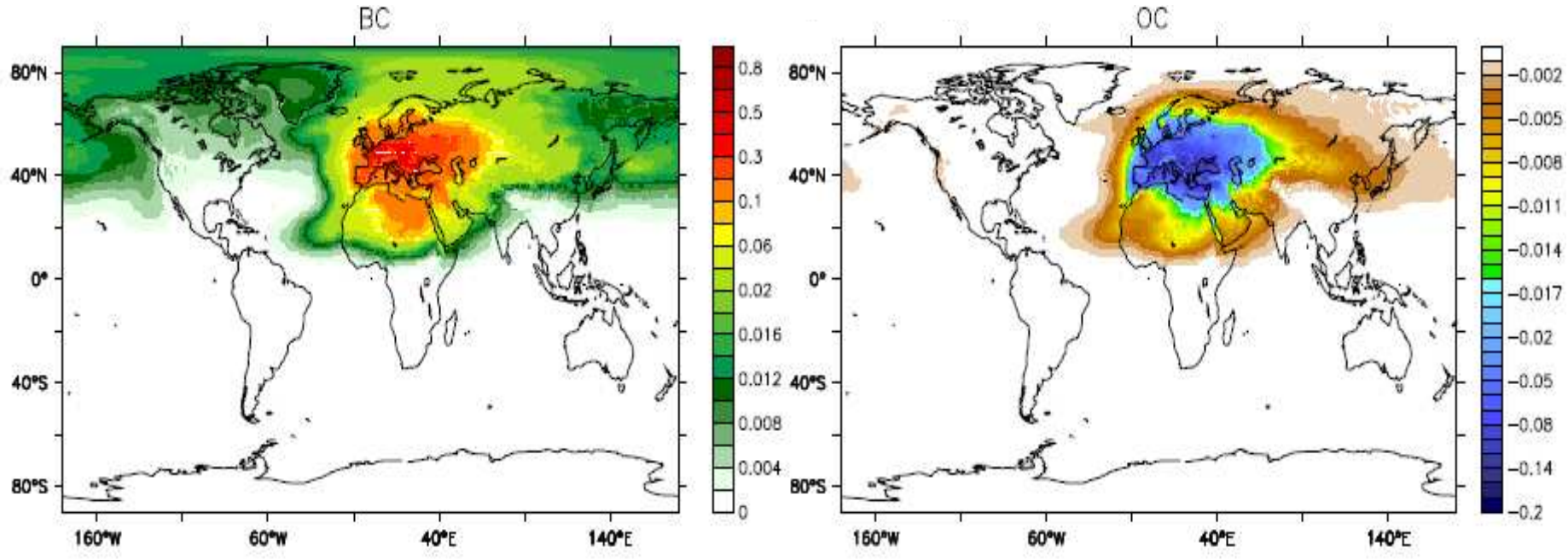
1. Global source receptor calculations with the Unified EMEP model (MSC-W)
2. Contributions from individual EMEP countries to aerosol columns are multiplied by ”normalized RF” to get contributions to RF (CICERO, Univ. Oslo, MSC-W)
3. Contribution from each EMEP country to RF to be implemented as a new parameter in the GAINS model (CIAM)

Radiative forcing due to BC, POC, SO_4 and NO_3



Tropospheric columns multiplied by normalized radiative forcing. Unit: Wm^{-2}.

Example: Contribution from all EMEP countries on global RF due to BC and POC



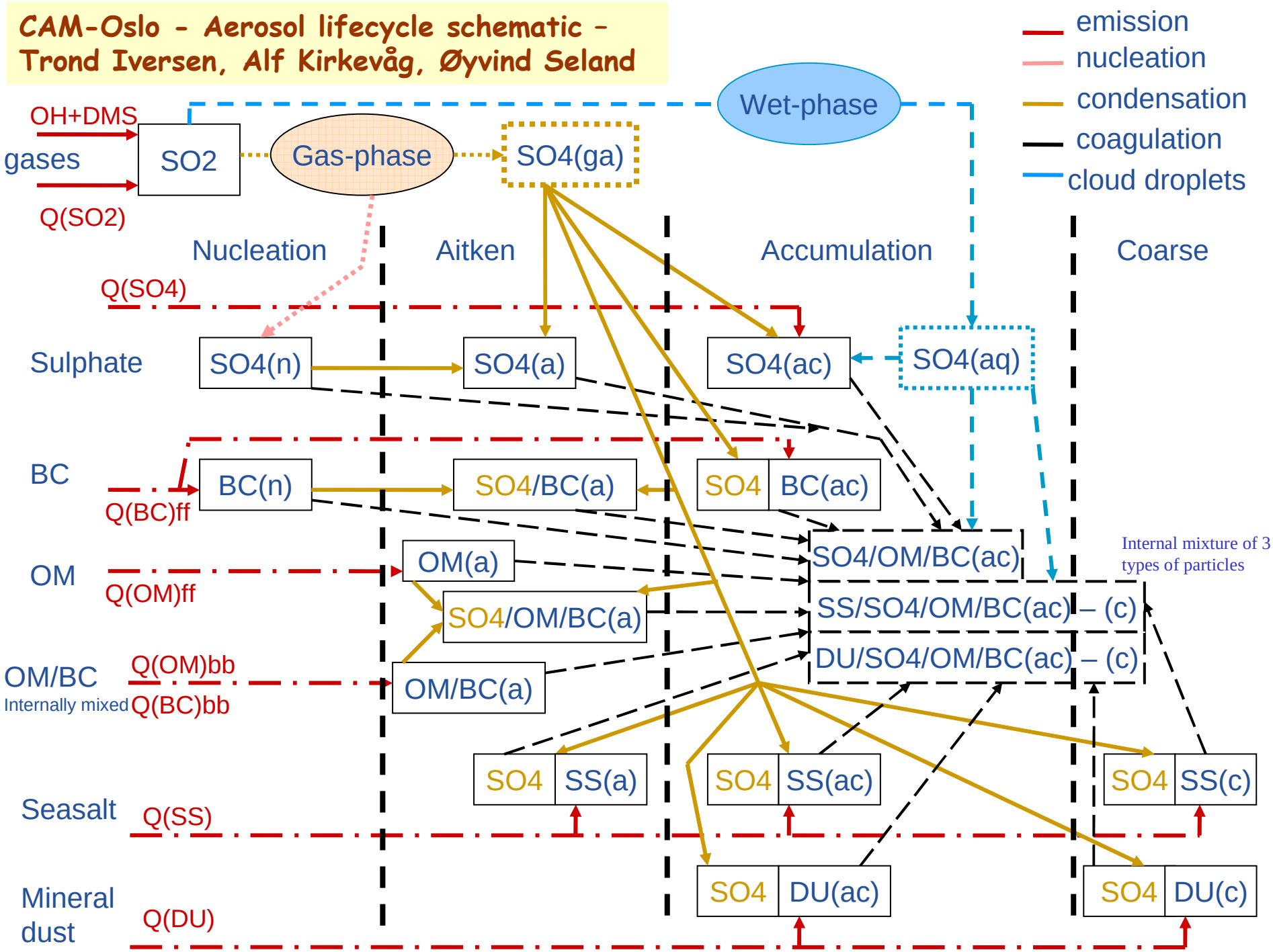
Calculated RF due to BC and POC caused by emissions from all EMEP countries. Unit: Wm^{-2}.

The Norwegian Earth System Model

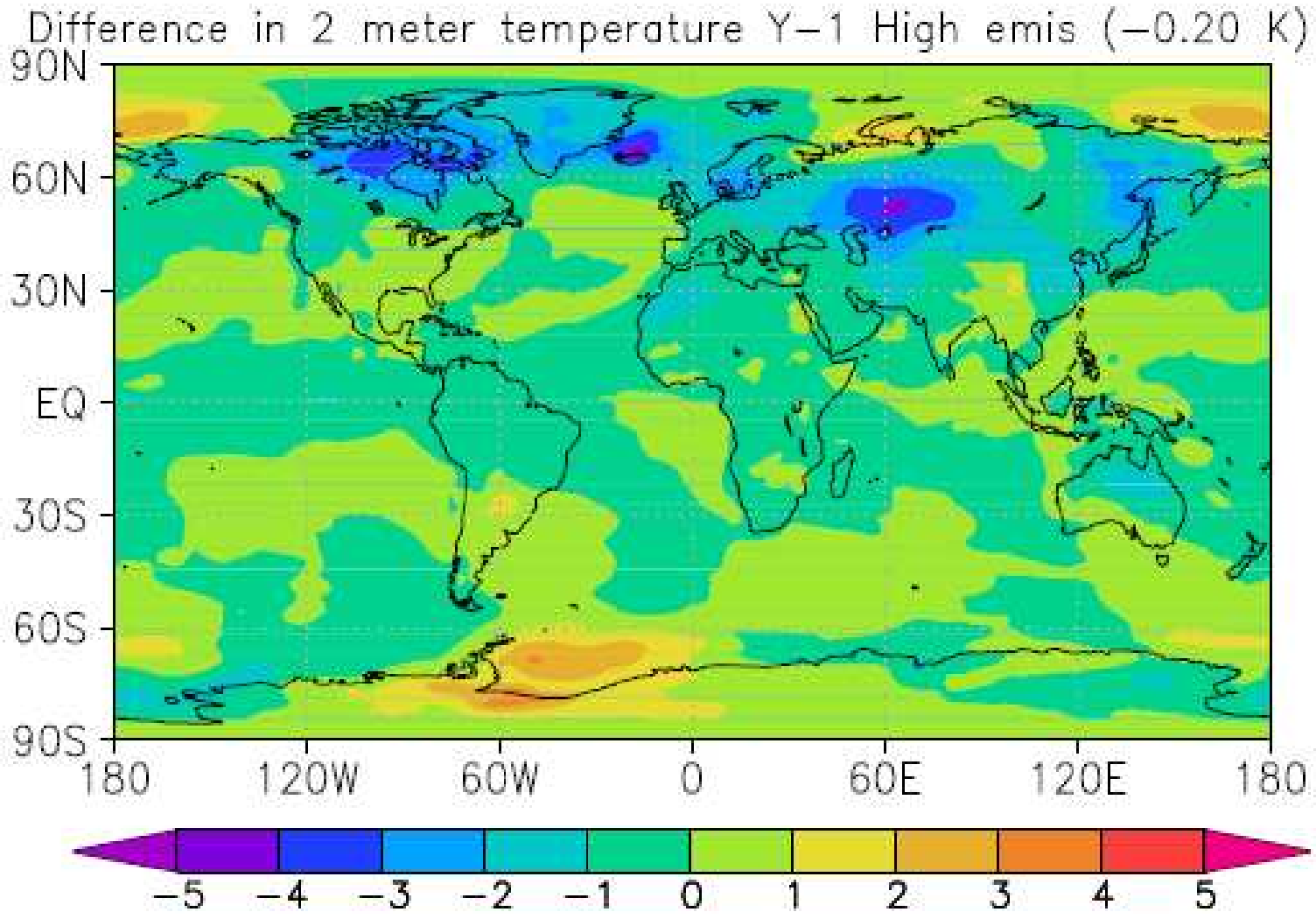
(met.no, Bjerknes Centre, Univ. Oslo, Nansen Centre, and Cicero)

- Based on NCAR's Earth System Model CCSM5
- Carbon cycle: HAMOCC5 (MPI, Hamburg)
- Ocean model: from Bergen Climate Model
- Aerosols and cloud-aerosol interactions: 'CAM-Oslo'
- Being implemented: Photo-oxidants

- Advantage: Two-way coupling between climate and air pollution


CAM-Oslo - Aerosol lifecycle schematic -
Trond Iversen, Alf Kirkevåg, Øyvind Seland
emission
nucleation
condensation
coagulation
cloud droplets
Wet-phase
OH+DMS
gases
SO2
Gas-phase
SO4(ga)
Q(SO2)
Nucleation
Aitken
Accumulation
Coarse
Q(SO4)
Sulphate
SO4(n)
SO4(a)
SO4(ac)
SO4(aq)
BC
BC(n)
SO4/BC(a)
SO4 BC(ac)
Q(BC)ff
OM
OM(a)
SO4/OM/BC(ac)
Internal mixture of 3 types of particles
Q(OM)ff
SO4/OM/BC(a)
SS/SO4/OM/BC(ac) – (c)
DU/SO4/OM/BC(ac) – (c)
OM/BC
Internally mixed
Q(OM)bb
Q(BC)bb
OM/BC(a)
SO4 SS(a)
SO4 SS(ac)
SO4 SS(c)
Seasalt
Q(SS)
Mineral dust
Q(DU)
SO4 DU(ac)
SO4 DU(c)

NorESM: Temperature impact from volcano emissions



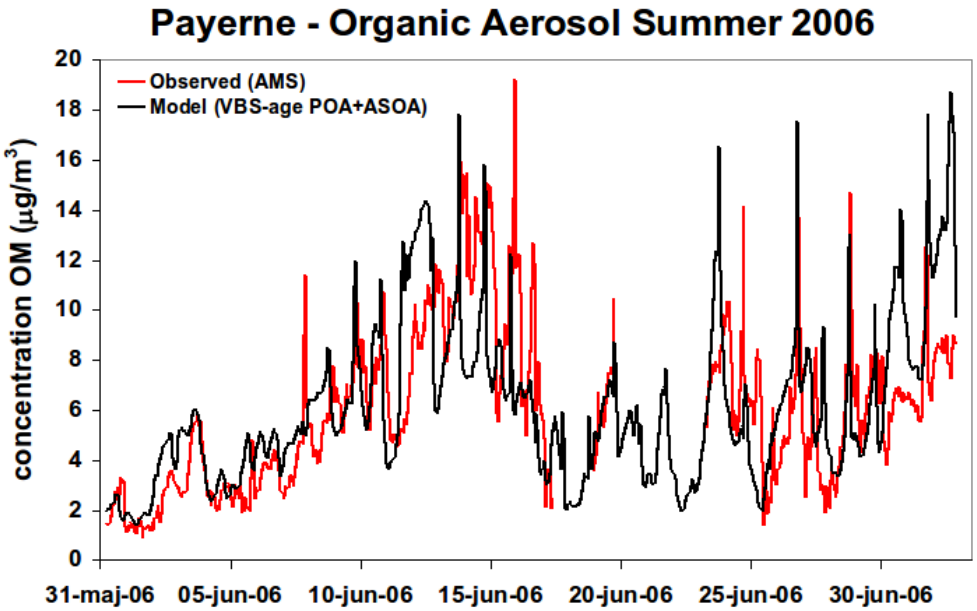
Keeping the Unified EMEP model ‘state-of-the-art’

EMEP model updates (selection)

- update of the chemical scheme
- co-deposition scheme (accounting for effects of ammonia compounds on SO_2 deposition)
- new roughness length in order to remedy overestimation of friction velocity over forests
- new scheme for calculating mixing heights and turbulent diffusivity in stable conditions
- pollution from forest and vegetation fires has been included (GFED-2, GFED-3)
- convection has been implemented in a research version of the Unified EMEP model
- new ammonia emission module, covering a large part of Central and Northern Europe

Organic Aerosol Modelling

- SOA still 'difficult'
- Many unknowns
- Several SOA schemes implemented
- Progress through EMEP, EUCAARI campaigns + SCARP project

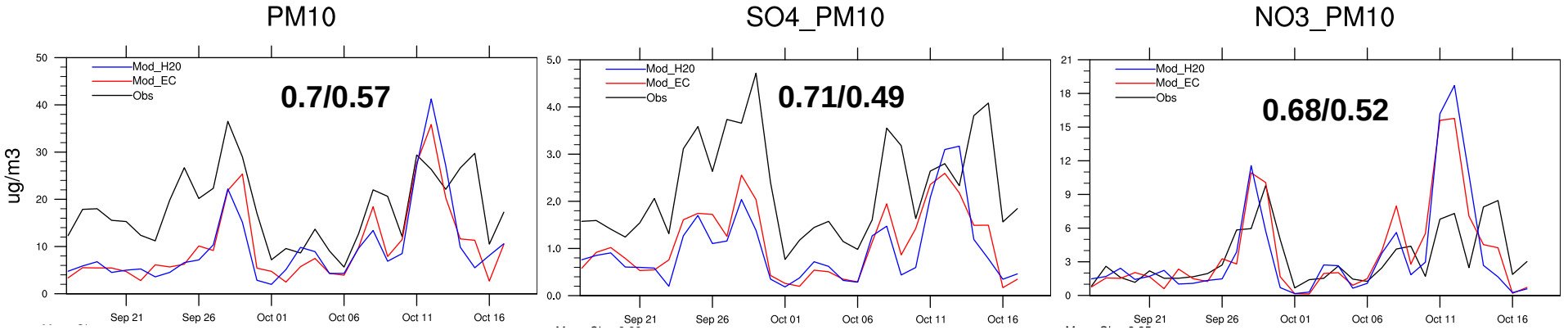


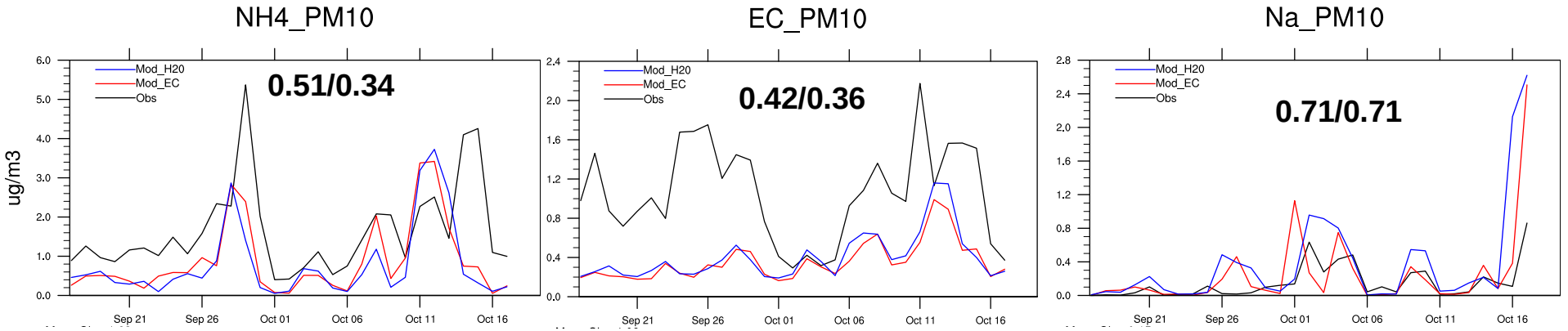
(Bergström et al., IAC, 2010)

- Plan: use measurements to constrain SOA parameters

Melpitz DE44: PM10

ECMWF – red
HIRLAM - blue



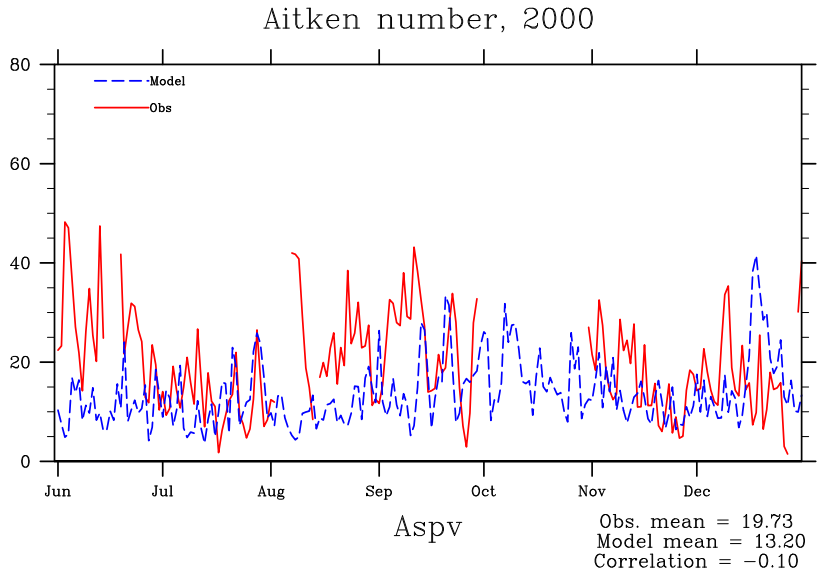


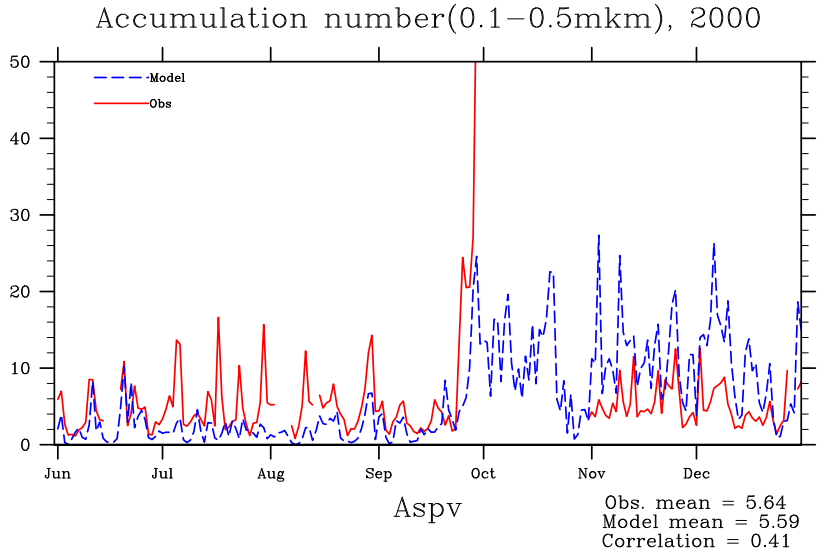
Model underestimation (exc. NO3, Na), more so using HIRLAM

ECMWF – better correlations, slightly higher concentrations

Most of episodes are reproduce with both met, models

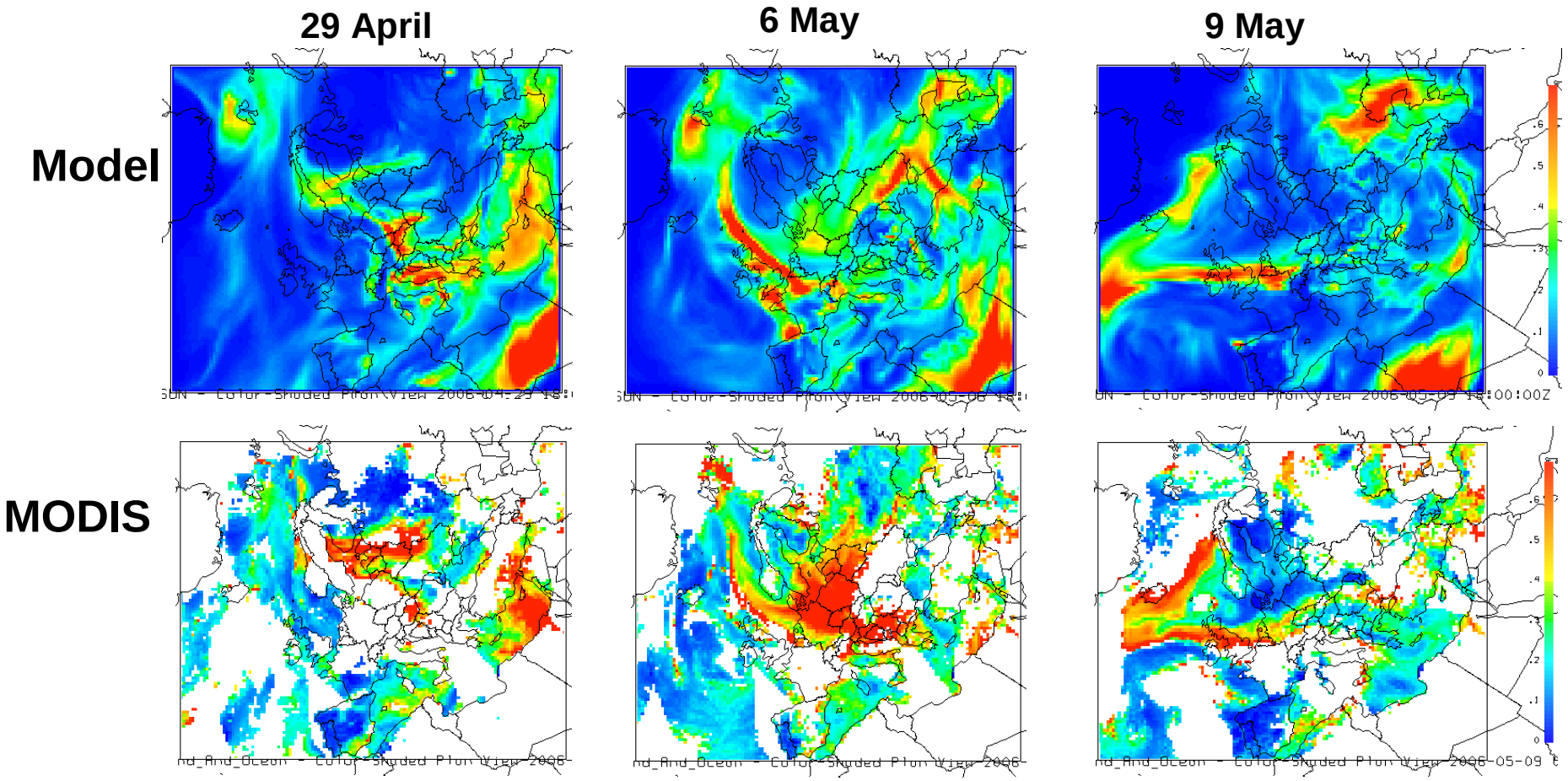
- **The official version of the Unified EMEP model calculates PM mass (i.e. the total of all PM components)**
- **A research version of the model includes the size-resolved aerosol dynamics model 'MONO32', which calculates aerosol number concentrations in 4 size modes**





Aerosol model vs. MODIS:
Aerosol Optical Depth

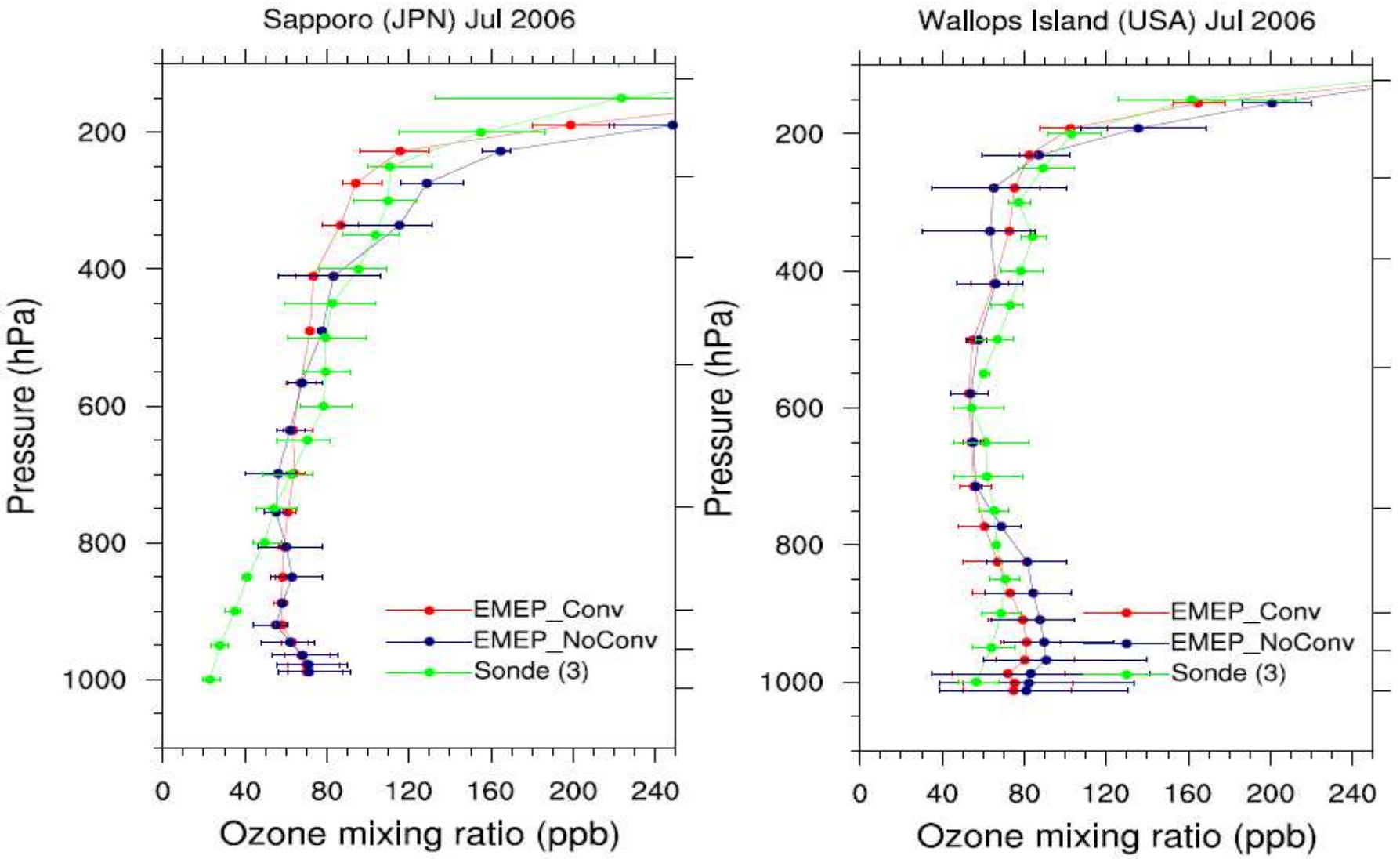
<u>Case study</u> – agricultural fires in Eastern Europe and Russia, spring 2006



Further development is envisaged of the size-resolved aerosol model, facilitated by the availability of:

- **recent emission estimates of particle number**
- **measurements of particle number size distribution**
- **progress in modelling of aerosol processes**

Global modeling: Sonde comparisons



Future plans (1/2)

- Investigate contribution from European emissions of short-lived climate forcers to radiative forcing: include ozone;
- work on air quality and climate interactions: use CMIP5 for meteorological input, use different emission scenarios;
- investigate transport of particles to the Arctic, including the entire hemisphere; assess model performance using available campaign measurement data and measurements from the HTAP database;
- investigate the response of biogenic emissions and uptake by vegetation to climate change;
- apply the Norwegian Earth System Model (NorESM) to calculate dynamical responses to radiative forcing.

Future plans (2/2)

- Participate in the model intercomparison exercise performed in TFMM using data from the intensive EMEP measurement periods;
- continue the development of the secondary organic aerosols (SOA) module in the EMEP model using EMEP intensive measurements (2009) and other data (MSC-W, CCC);
- explore the use of particle-dynamics models within the Unified EMEP model; use recent estimates of particle number emissions;
- further develop the global version of the Unified EMEP model; refine the convection parameterization; use improved emission estimates from different world regions (MSC-W, MSC-E).