C2: Emissions and exchange at local to global scale

- WP5 Past and future changes in air polution transported into Europe
- WP6 Emissions on regional to global scale
- WP7 European air pollution and deposition
- WP8 Assessing local and regional variation

WP5 Status

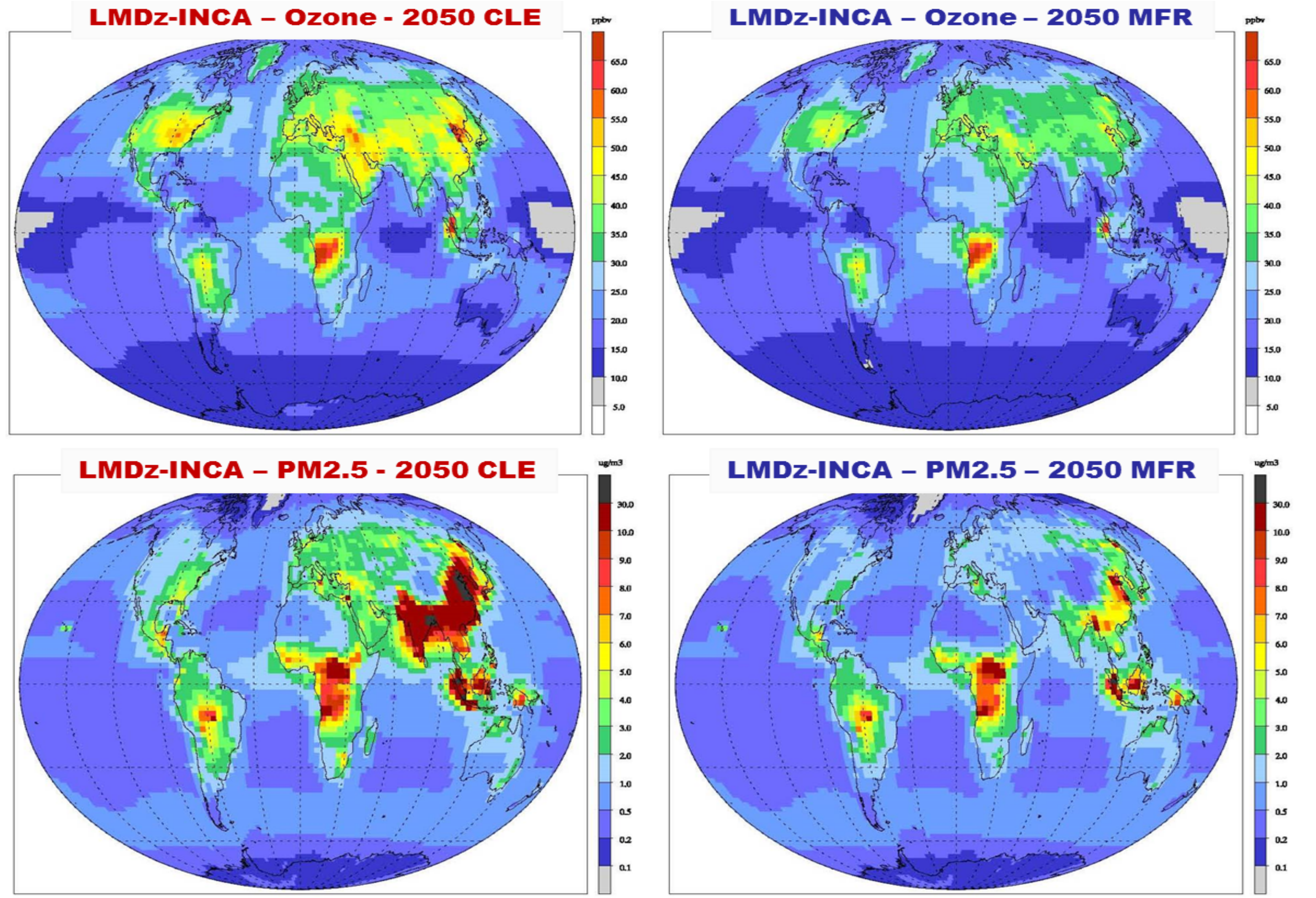
General: WP5 has strong overlap with HTAP activities – ongoing cooperation between many groups.

D5.1 .. D5.4 completed.

- Much work done on historical trends (also with TFMM, LRTAP, HTAP)...
- LMDZ-INCA-ORCHIDEE system substantially improved (BVOC, NHx)
  - → forecasts to 2100, AOD, Radiative forcing, ...

Future european pollutant boundary conditions (D5.4)

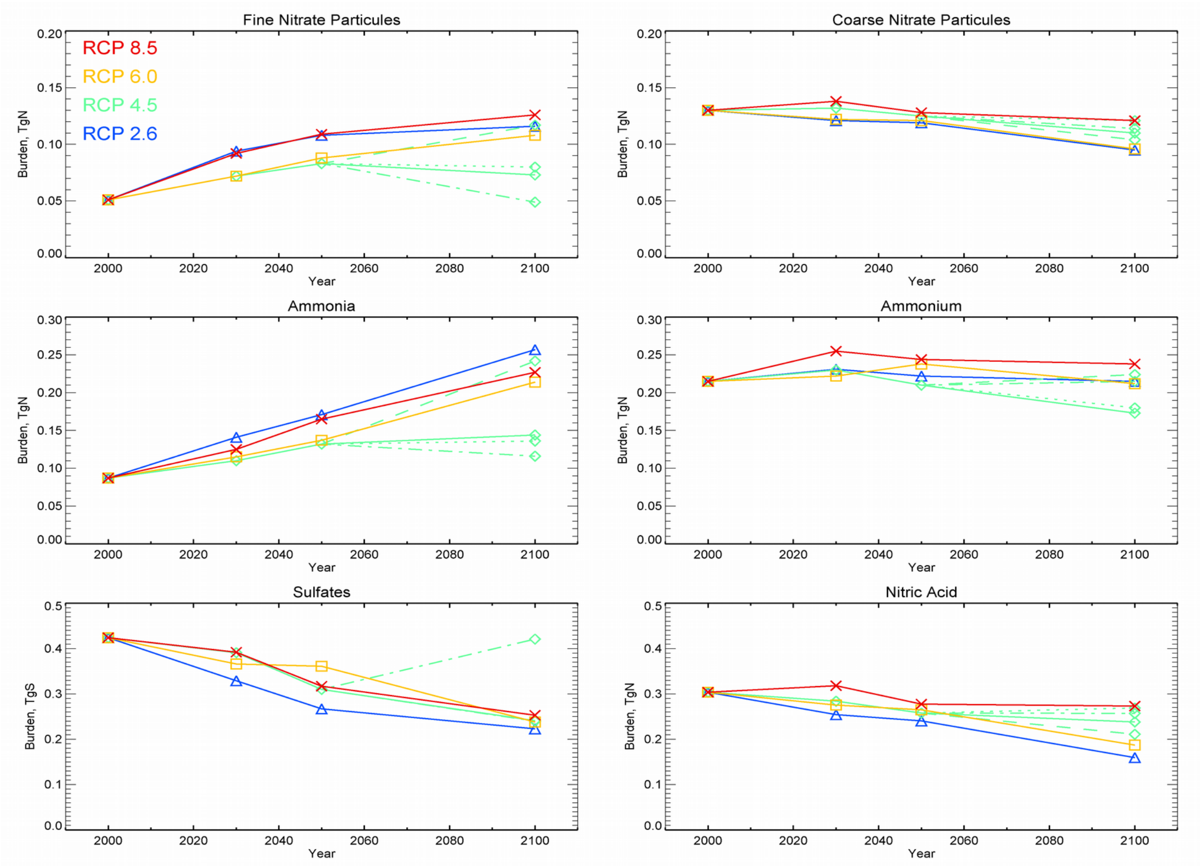
The two emission scenarios CLE and MFR have been used with the LMDz-INCA global model for the different time horizons (2005, 2010, 2030, and 2050 for scenario CLE and 2030, 2050 for scenario MFR). For each simulation NetCDF files have been prepared with key chemical species and aerosols to be used as boundary conditions for ECLAIRE regional model simulations



D. Hauglustaine, J. Lathière, P. Messina

Present and future nitrate aerosols and their direct radiative forcing of climate (D5.2) (1/2)

A new version of the LMDz-INCA model has been developed to include the NH_3 cycle and the ammonium nitrate and ammonium sulfate particles. The model has been used to investigate the future changes in nitrates and direct radiative forcing of climate based on snapshot simulations for the four Representative Concentration Pathway (RCP) scenarios and for the 2030, 2050 and 2100 time horizons. In all scenarios, the burden of fine nitrate particles increases and is mainly driven by the change in NH_3 emissions.



Evolution of the global burden of fine mode nitrates, coarse mode nitrates, ammonia, ammonium, nitric acid (TgN), and sulfates (TgS) for scenario RCP8.5 (red), RCP6.0 (yellow), RCP4.5 (green) and RCP2.6 (blue) between present-day and 2100.

Hauglustaine et al. (2014)

LSCE

WP5, D5.4 : evolution of Ozone

Future ozone is controlled by hemispheric emission developments – NOx, NMVOC and methane

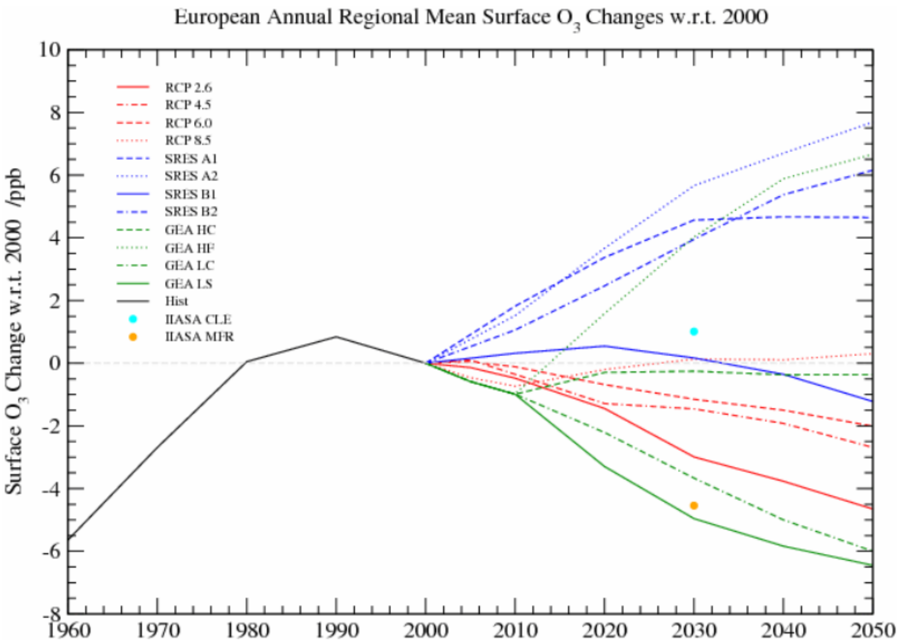


Fig: Ozone changes 1960 – 2050. ozone, Application of Wild et al (2013) method to HTAP ensemble, including IIASA CLE and MFR

WP6 Status

General:

- Much material in place.
- Many tests with LMDz-INCA.
- To be tested in EMEP

NH3 emissions

- 'Danish' work continues, climate and dynamic emissions
- EMEP work with Raia Massad started → 1st implementation of bi-directional in EMEP

BVOC emissions from LPJ-GUESS, ORCHIDEE

- Available for many years (including Paleo!)
- Isoprene emissions may increase of decrease in future
- Impact of CO2 inhibition

Soil-NO emissions

- LDNDC model 'ready'
- Awaiting European input data on agricultural management!
-

éclaire

D6.2 : Improved terrestrial (semi-) natural and agricultural emissions in response to integrated effects of climate change, change in atmospheric CO2 and N burden and land use/land management change

cnrs LSCE

Palmira Messina, Juliette Lathière, Didier Hauglustaine

First emissions module in ORCHIDEE was developed by Lathiere et al., (2006), based on Guenther et al., (1995)

$$F_{P,S} = \varepsilon_{P,S} \cdot LAI*SLW \cdot \gamma_{P,S} \cdot \gamma^{a}_{P,S} \cdot \gamma^{CO2}_{P,S}$$

$$\gamma_{P,S} = (1 - LDF)\,\gamma_{LI,TD} + LDF\,\gamma_{LD,TD}$$

ORCHIDEE emission module updates:

1. Including new species: α-pinene, β-pinene, limonene, myrcene, sabinene, camphene 3-carene, t-β-ocimene and bulk sesquiterpenes.

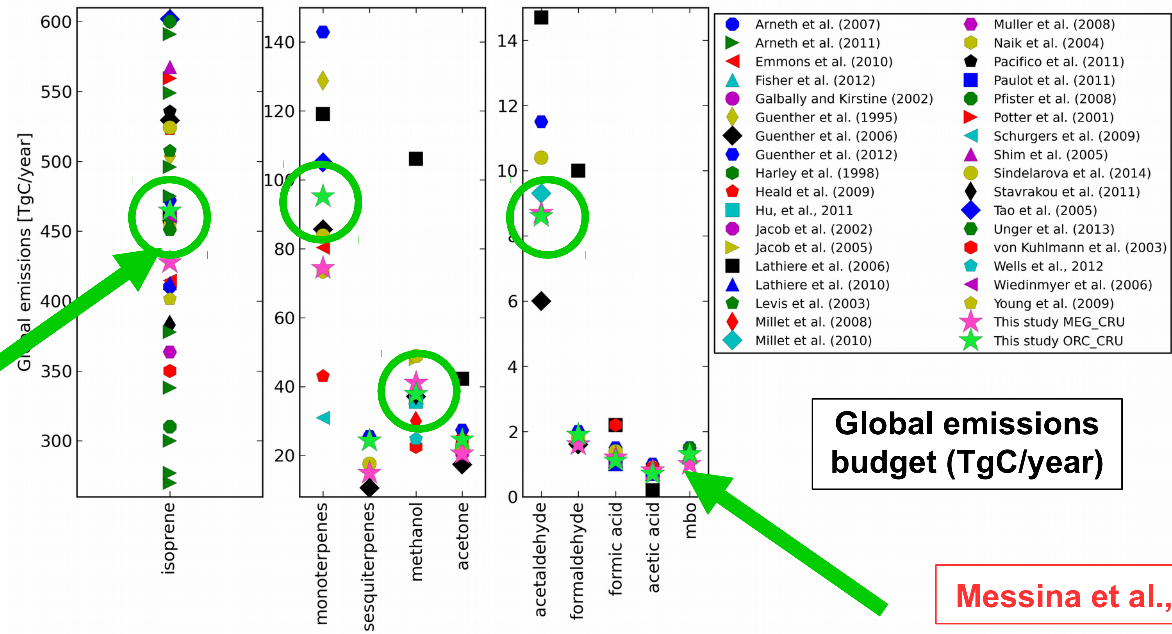
2. Updating Emission Factors for all emitted species and all Plant Functional Type.

3. For all compounds a **fraction** of **emission** is **now light-dependent**. The fraction depends on the compound, being for example 1 for isoprene, 0.8 for methanol, 0.6 for monoterpenes, 0.5 for sesquiterpenes, 0.2 for acetone.

4. Multi-layers radiation module based on Spitters, et al 1986a, 1986b.
BVOCs emissions are calculated for every LAI layer considering the sunlit and shaded leaf fractions and the light extinction and diffusion at different levels. Afterwards they are vertically integrated, providing a single value for each PFT and grid point.
Now it is more consistent with the vegetation model as we use the same approach employed in the calculation of photosynthesis.

5. Inclusion of **CO2 inhibition on isoprene** based on Possell et al., 2005 and Wilkinson et al. 2009.

Comparing ORCHIDEE results with other published BVOC estimates



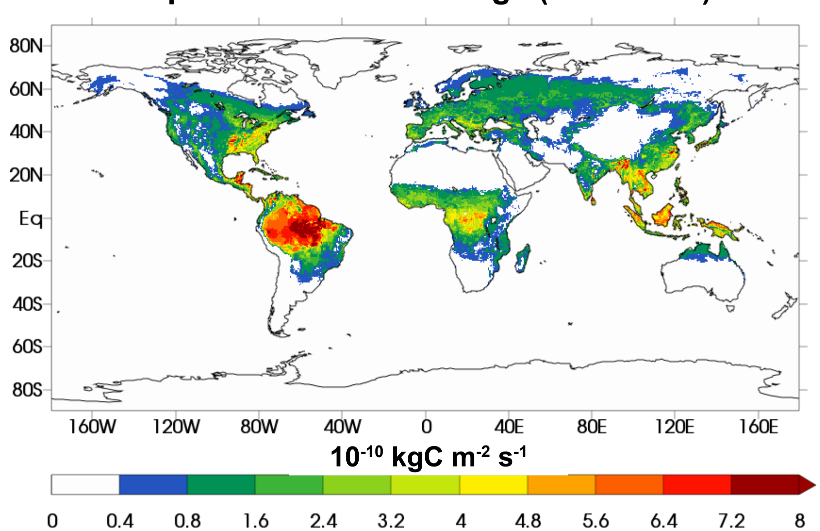
Global emissions budget (TgC/year)

Messina et al., in prep.

Global simulations: 2000-2009

CRU-NCEP Meteorological driving fields, 0.5° x 0.5° resolution

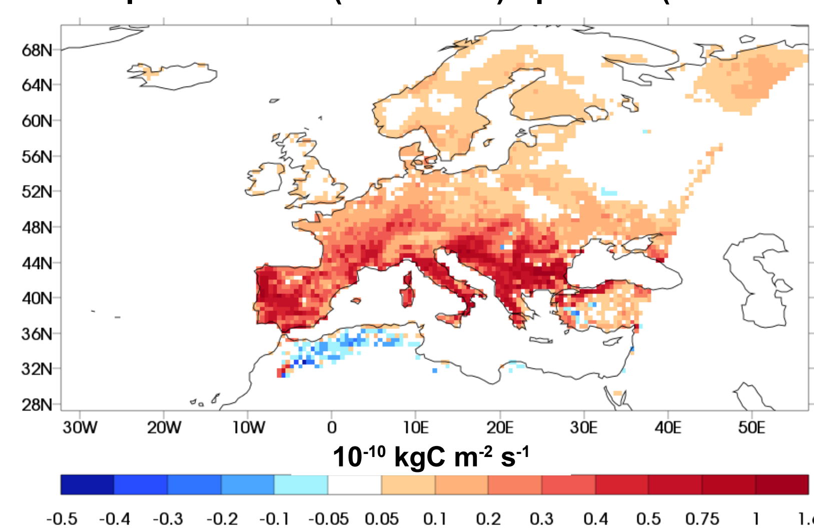
Isoprene: summer average (2000-2009)



European simulations: 1961-2100

ECLAIRE climate forcing scenario, 0.5° x 0.5° resolution

Isoprene: future (2041-2050) - present (1991-2000)



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University of Worcester

Dynamic NH_3 emissions in WRF-Chem and DEHM:

focus on **short-term variations in the NH_3 concentration**

A new version of the Dynamical Ammonia emission model covering all of Europe was finalized in 2014 (ECLAIRE D6.2) and has now been implemented in WRF-Chem and the Danish Eulerian Hemispheric Model (DEHM).

Results in an improved seasonal variation when compared to observed daily mean NH_3 conc.:

	# of obs	FAC2	MB	NMB	NMGE	RMSE	R
BASE	2020	0.38	0.93	1.10	1.28	1.76	0.55
DYNAMIC	2020	0.42	0.85	1.00	1.23	1.94	0.66

WRF-Chem vs. daily observations from 6 European sites (Harwell, Jarczew, Riso, Tange, Ulborg and Anholt) for 2012.

By Carsten Ambelas Skjøth, Malgorzata Werner and Camilla Geels

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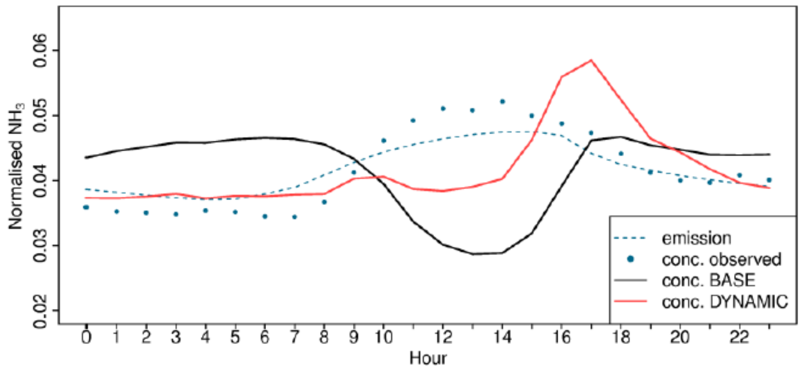
Dynamic NH_3 emissions in WRF-Chem and DEHM:

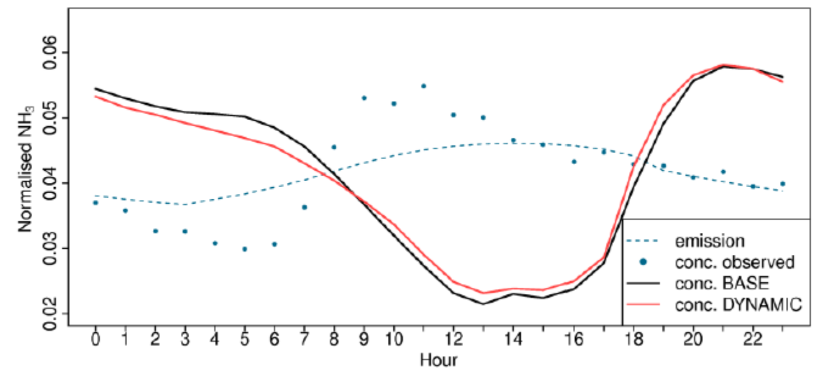
focus on **short-term variations in the NH_3 concentration**

But what about the sub-daily variations?

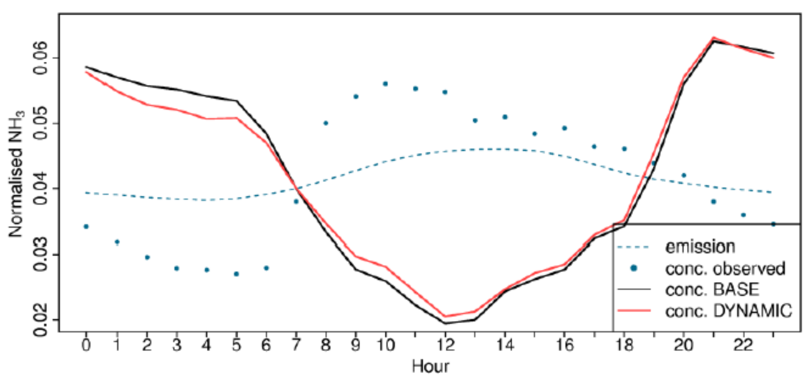
winter



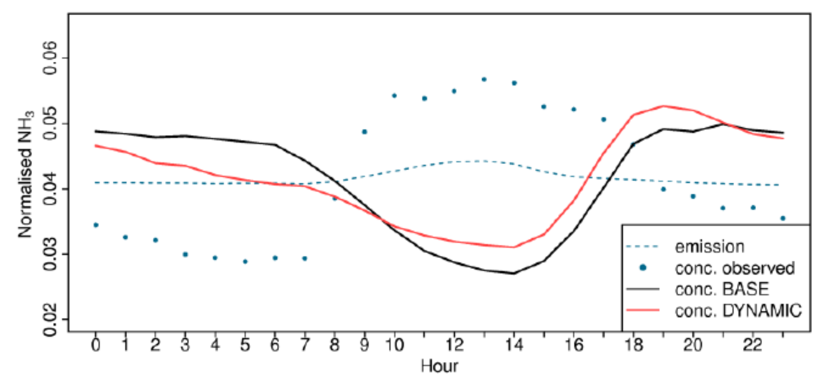
spring



summer



autumn



WRF-Chem vs. obs at the Harwell site: Normalized hourly emis. and conc.

WP7 European air pollution and deposition

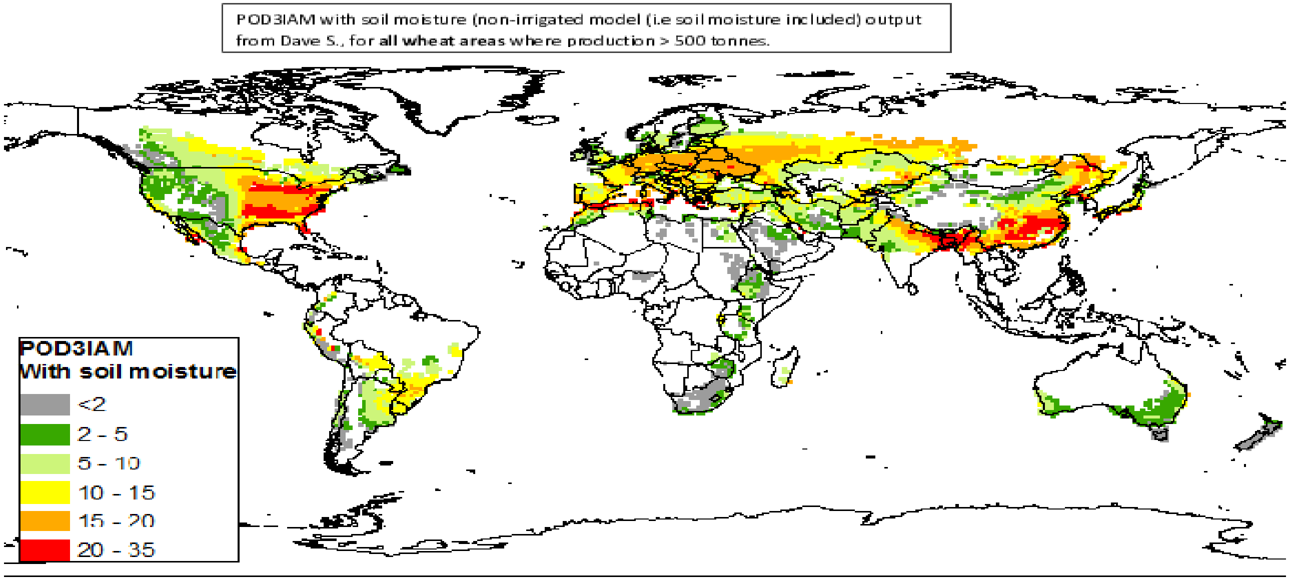
Status: DS is struggling…

- D7.2 Improved EMEP model with climate-change and canopy-chemistry capabilities (M40 → M45)
- D7.3 Report on effects of in-canopy BVOC and NO emissions on in-canopy O3 and POD estimates (M44)
- D7.5 Source-receptor matrices of APMs for current and future conditions (M36 → M45)

Activities:

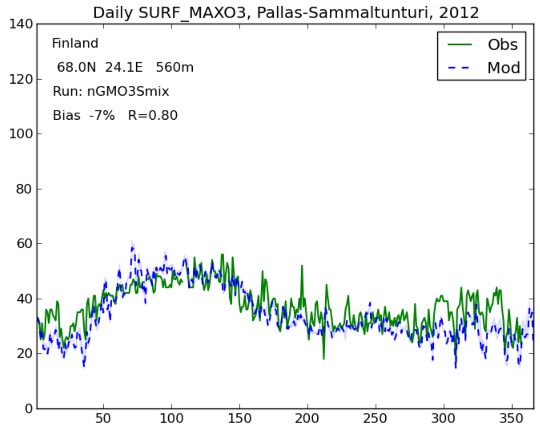
- Long-period runs – comparison with historical data (EMEP & MATCH)
- BVOC comparisons, with/without CO_2 effect (ORCHIDEE, LPJ-GUESS, ongoing)
- Implementation of Gamma methods for European scale (w. Raia et al.)
- ESX

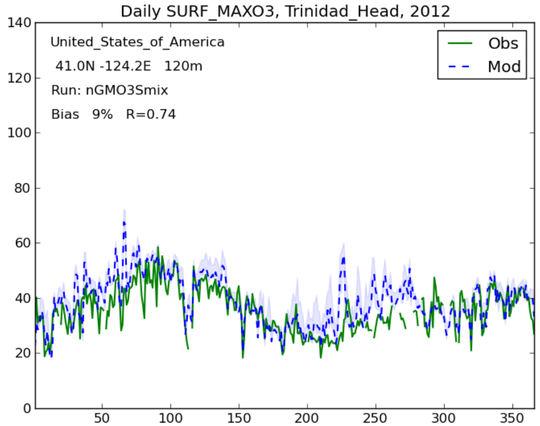
WP7 goes global for Gina..



- EMEP PODx modelling for global wheat impacts

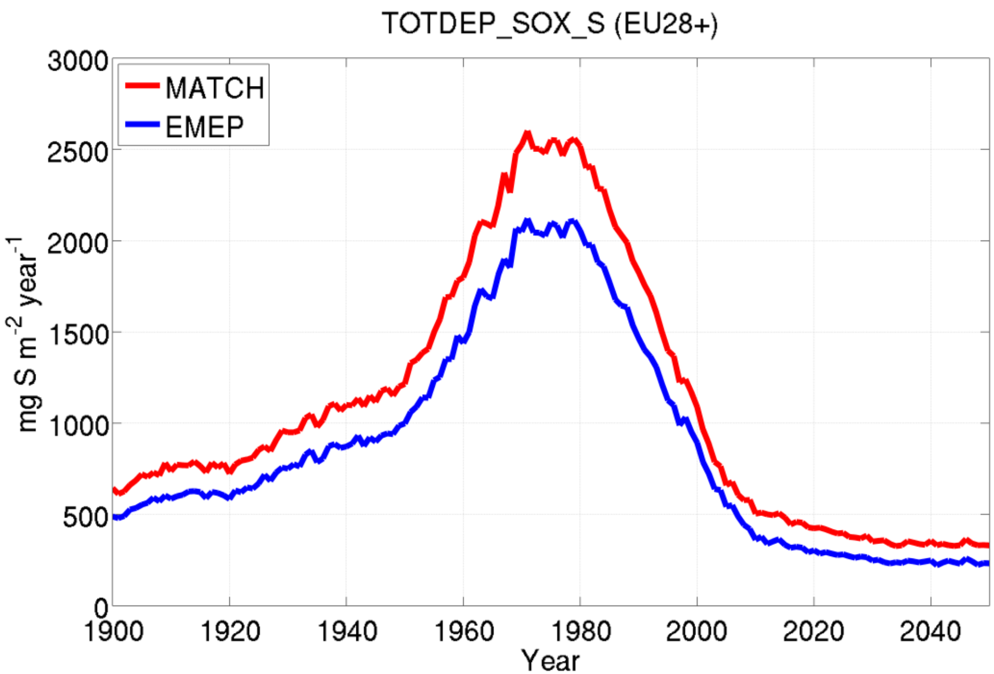
(Fig. From CEH/Gina)

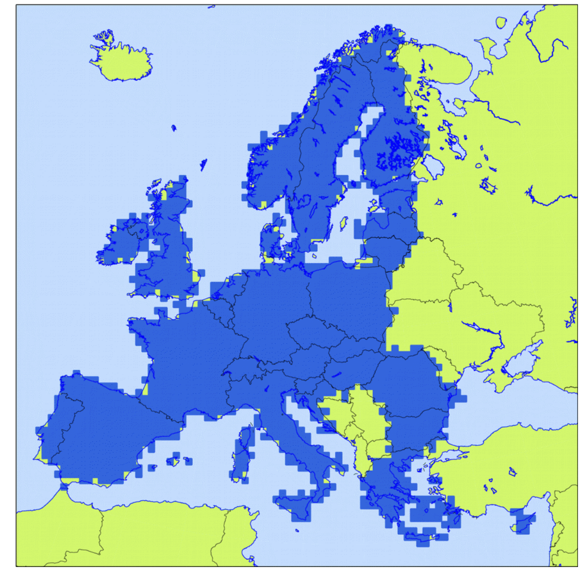


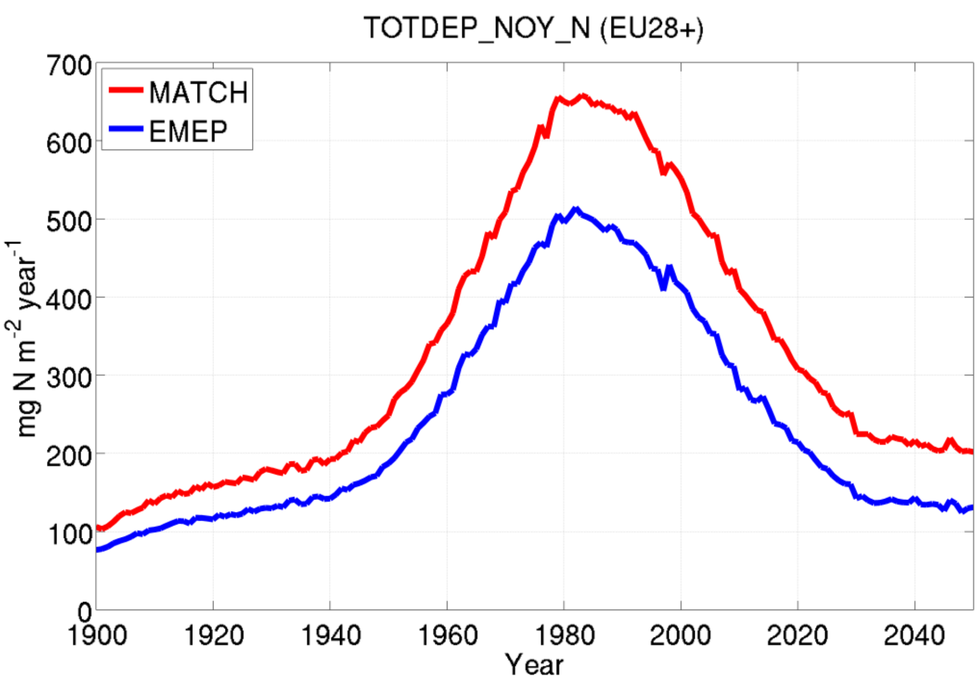


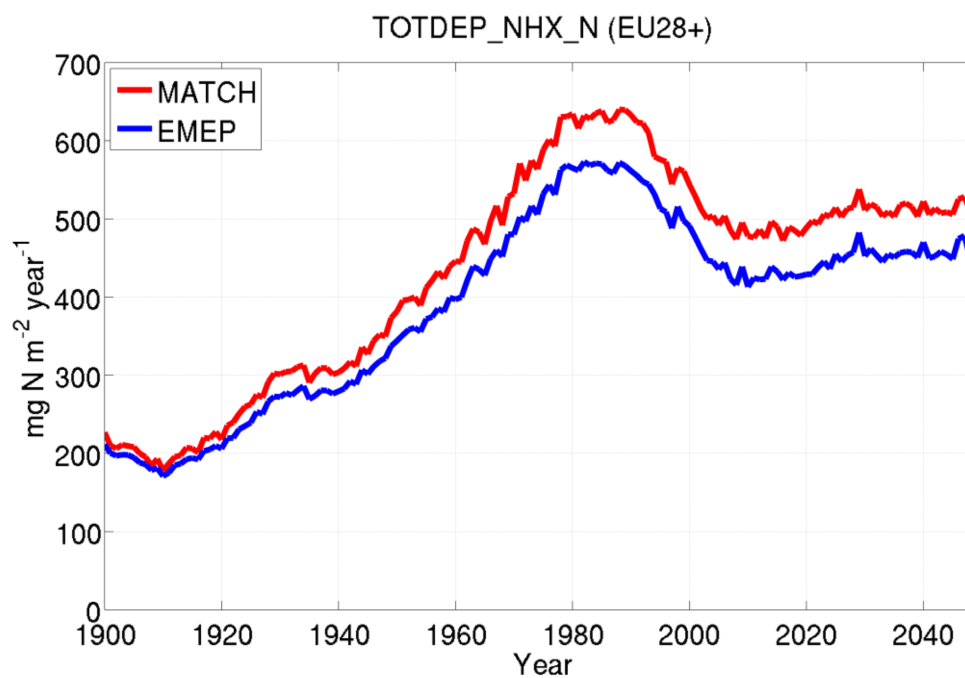
- Challenging!
- Improved treatment of aerosol surface area and N2O5 hydrolysis
-

Temporal trend (1900-2050) of sulphur and nitrogen deposition to EU28+



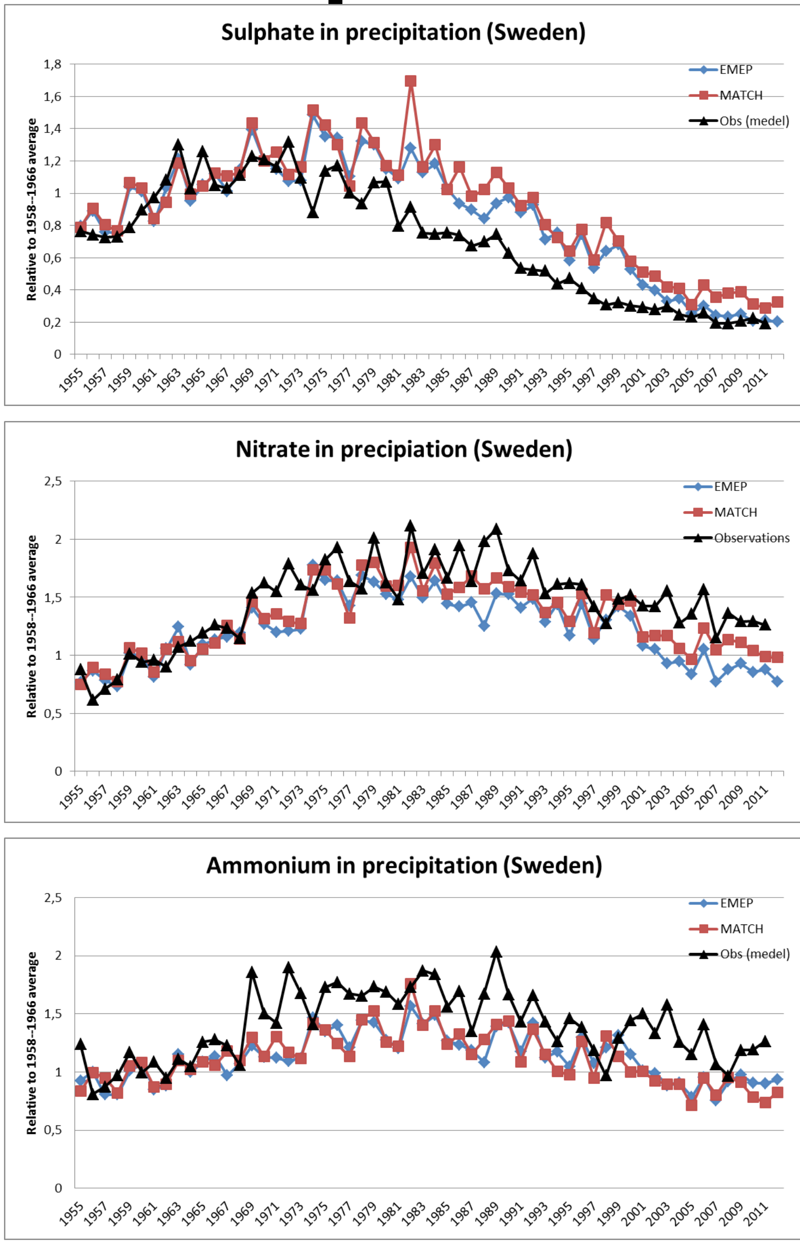




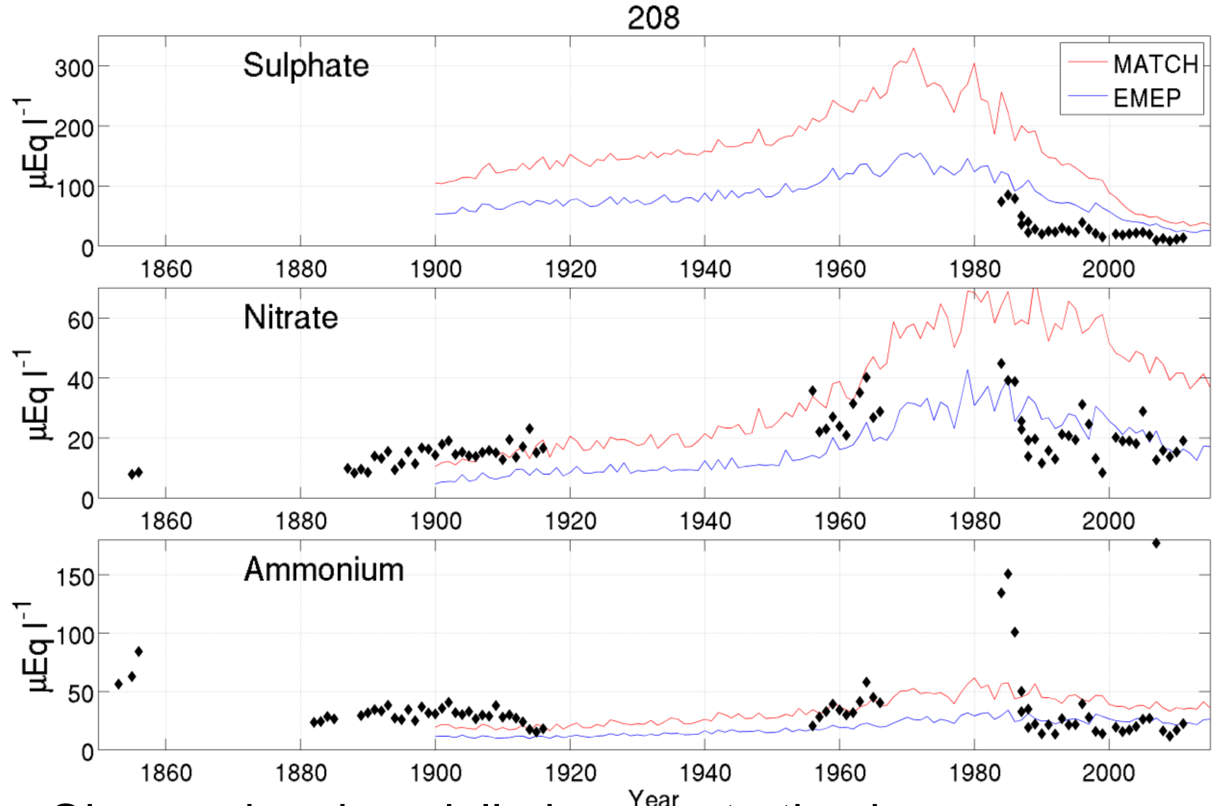


Comparison with observations

SMHI

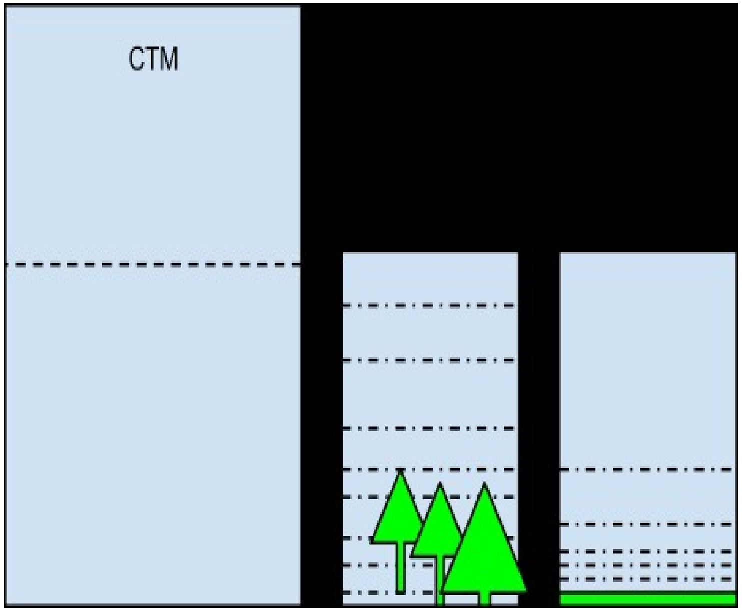


Relative trend in observed and modelled concentration in precipitation in Sweden 1955-2011.



Observed and modelled concentration in precipitation at Rothamstead, England 1853-2011.

ESX – 2014-2015 changes



Multiple vegetations enabled

- e.g. forest, shrubs
- Or oil-seed, siliques...

Within-layer integration improved (5-point Legendre Gaussian Q.)

Aerosol dynamics (MAFOR, thanks to M. Karl)

Improved BVOC chemistry

Lagrangian mode added

Wet deposition added

Mass balance checks and outputs

Many code improvements, bug-fixes, checks

WP8 Status

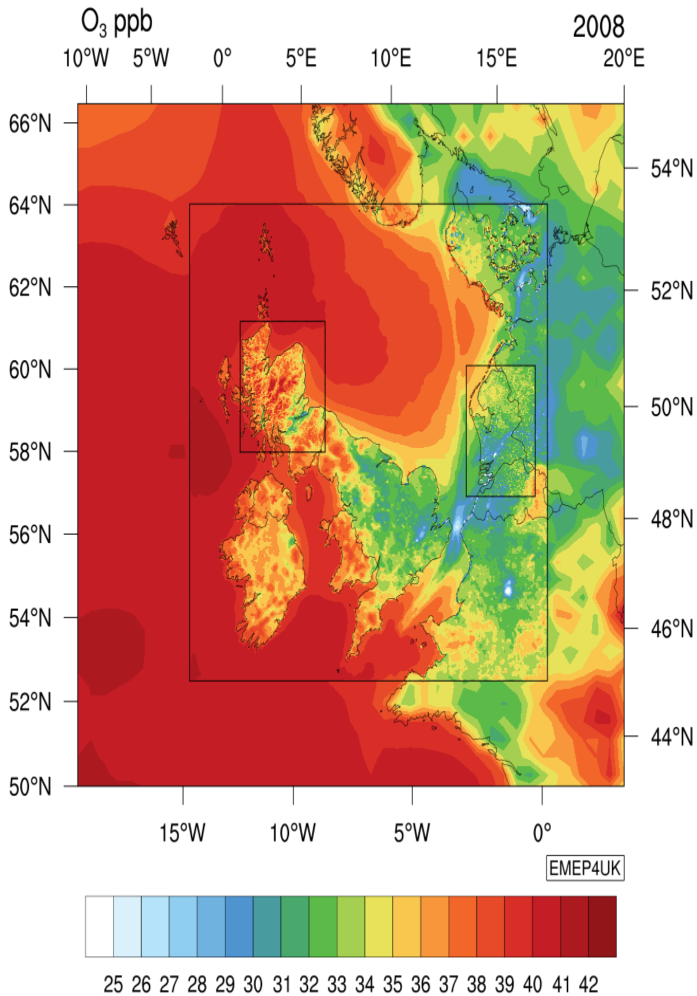
- It was not possible to complete the NitroScape work mainly as a result of problems with component models and the necessity to parameterise new simpler component models. However, a working version of the model has been made although there hasn't been time to apply it to the ÉCLAIRE landscapes

- The EMEP4UK simulations have been completed successfully and have provided the deposition and concentration data required by WP17 to estimate critical threshold exceedances

- Sub-grid parameterisations have been developed for concentrations of NH_3 and NO_2 at a 1 x 1 km^2 resolution that improve on the predictions of the EMEP model

WP8 Nitroscape (info. Jean-Louis Drouet)

- Theoretical framework – stabilised Testing
- Integration of FIDES-SurfATM – done (ESCAPADE project)
- FASSET – abandoned (see 4th GA)
- Applications – testing/calibration in France ongoing
- Applications for ECLAIRE landscapes – uncertain.



The EMEP4UK ECLAIRE model results

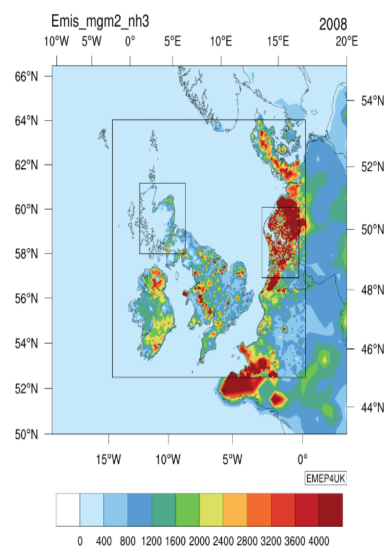
The EMEP4UK rv4.5 ECLAIRE model domain

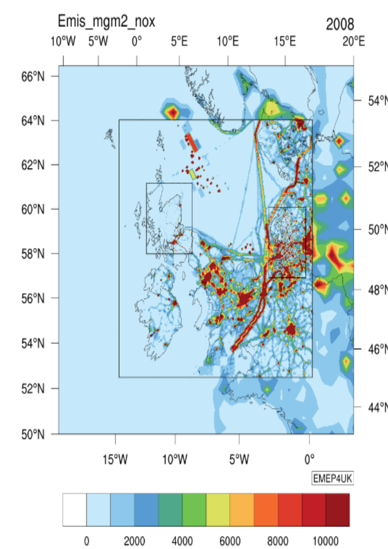
- EU domain 50 km x 50 km horizontal resolution (not all shown)
- UK+NL 5 km x 5 km horizontal resolution
- Scotland and Netherlands 1 km x 1km horizontal resolution

The emissions used are the TNO 2008 emissions + higher resolution for Scotland and the Netherlands (see figures below)

The metrological driver WRF has been updated to the version 3.6.1

The figure shows the 2008 annual average EMEP4UK calculated ozone surface concentration in ppb



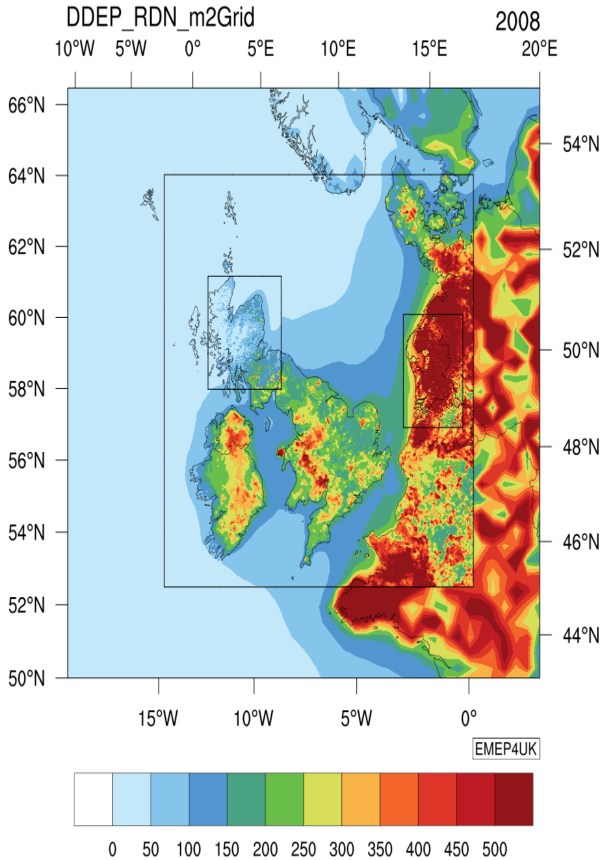


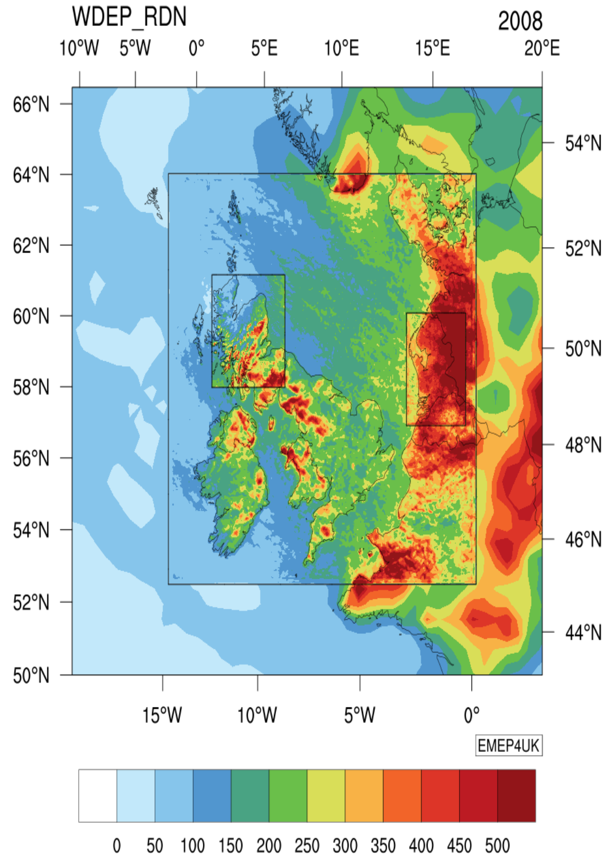
EMEP4UK references

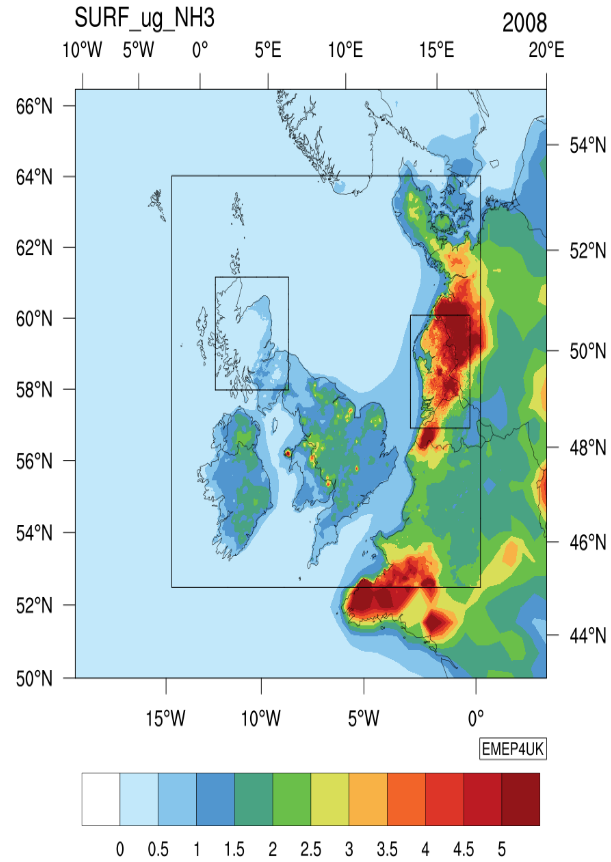
Vieno, M., Dore, A. J., Stevenson, D. S., Doherty, R., Heal, M. R., Reis, S., Hallsworth, S., Tarrason, L., Wind, P., Fowler, D., Simpson, D., and Sutton, M. A.: Modelling surface ozone during the 2003 heat-wave in the UK, Atmospheric Chemistry and Physics, 10, 7963-7978, DOI 10.5194/acp-10-7963-2010, 2010.

Vieno, M., Heal, M. R., Hallsworth, S., Famulari, D., Doherty, R. M., Dore, A. J., Tang, Y. S., Braban, C. F., Leaver, D., Sutton, M. A., and Reis, S.: The role of long-range transport and domestic emissions in determining atmospheric secondary inorganic particle concentrations across the UK, Atmos. Chem. Phys., 14, 8435-8447, 10.5194/acp-14-8435-2014, 2014

EMEP4UK rv4.5 WRF 3.6.1 – 2008 ECLAIRE model results

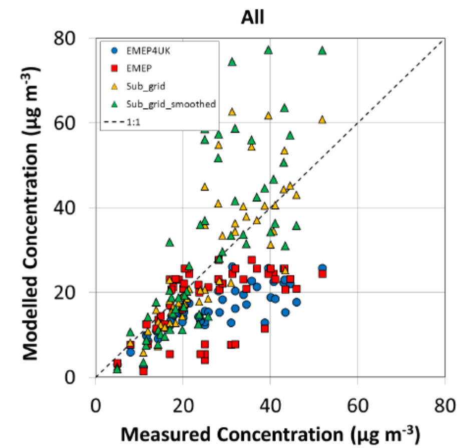






WP8 sub-grid modelling (Mark Theobald) - extended to NO2 (w.plume rise), dry/wet deposition

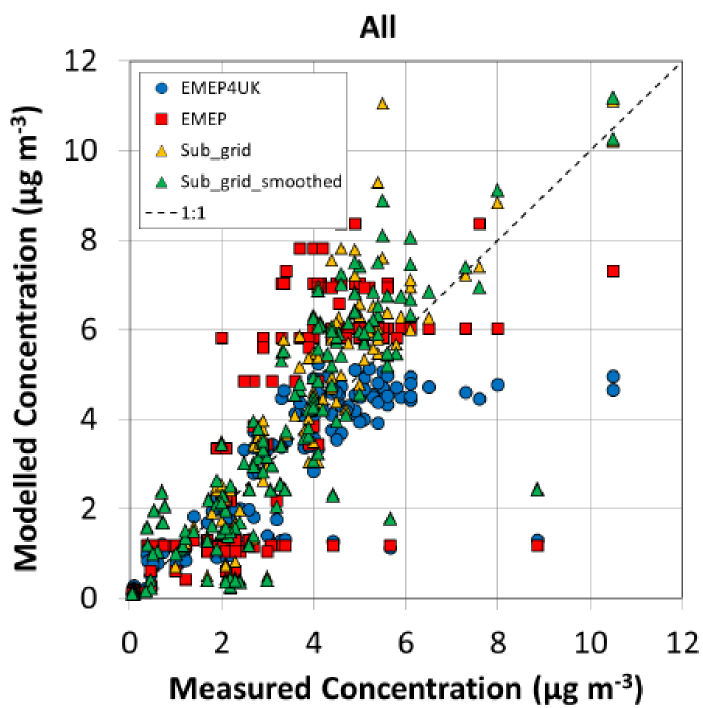
Effect on model validation (NO_2) – All data*



Model_name	FAC2	NMB	NMGE	RMSE	r	COE
EMEP	0.78	-0.31	0.37	12.6	0.52	-0.01
EMEP4UK	0.80	-0.40	0.4	12.9	0.79	-0.09
Sub_grid	**0.98**	**0.04**	**0.24**	**9.2**	**0.83**	**0.337**
Sub_grid_smoothed	0.89	0.19	0.38	14.24	0.77	-0.04

ish
e stations

Model Evaluation (NH_3 Concentrations) – All data



Model_name	FAC2	NMB	NMGE	RMSE	r	COE
EMEP	0.79	0.166	0.42	1.9	0.74	0.12
EMEP4UK	**0.87**	-0.15	**0.24**	**1.3**	0.79	**0.5**
Sub_grid	0.82	**0.10**	0.28	1.4	0.84	0.4
Sub_grid_smoothed	**0.87**	**0.10**	0.27	**1.3**	**0.86**	0.41

WP8 sub-grid Conclusions

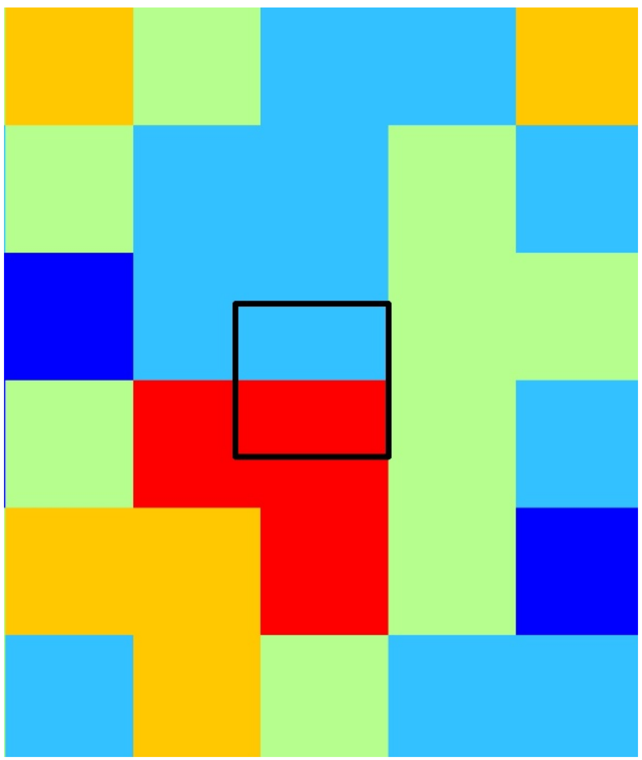
- *Sub-grid model for NO_2 developed by defining emission source squares as either ground-level or stack sources*
- *Evaluation of the sub-grid model for NH_3 and NO_2 concentrations shows that it improves on the performance of the EMEP model*
- *The sub-grid model is fairly insensitive to the meteorological data or the stack parameters used*
- *The sub-grid model for wet nitrogen deposition only performs slightly better than the EMEP model*

Scottish landscape emissions

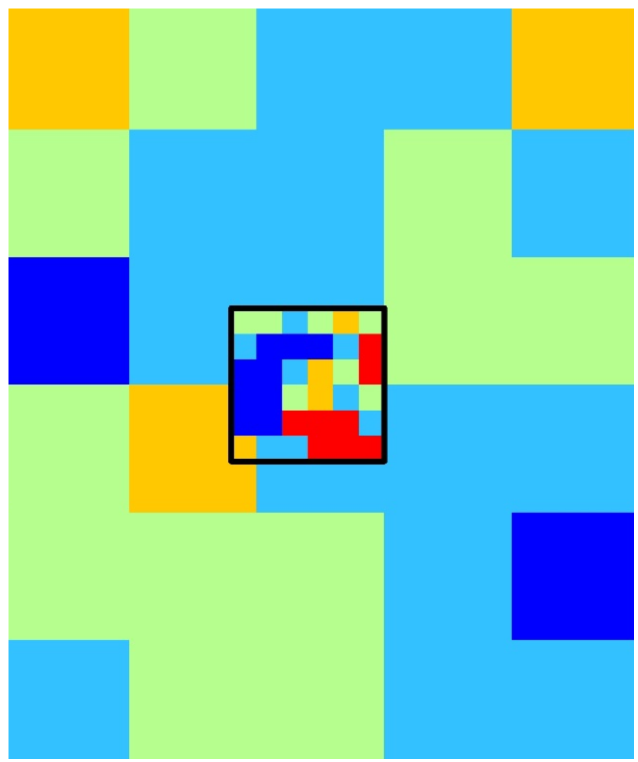
landscape data for the Scottish landscape all delivered, including emissions at 25 x 25 m, and with the landscape scale data aggregated to 1 km grid and embedded in the UK 1 km datasets (slide: Ulli)

- for EMEP4UK modelling; contributed sub-grid discussions and developments

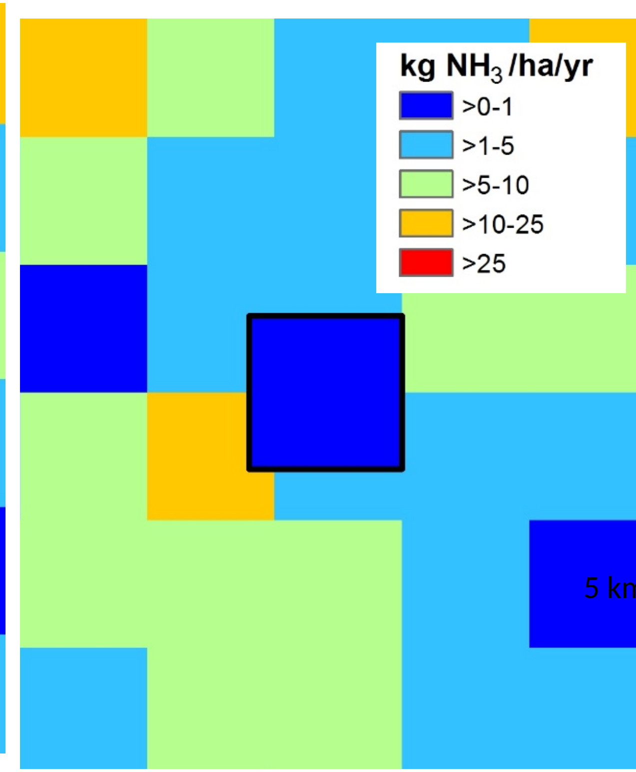
National scale map (based on parish data)



National scale with landscape (based on farm/field data)



National scale with landscape (landscape emissions removed)



ECLAIRE C2 Summary

- Mainly on-target – deliverables largely under control
- Some aspects suffer from 'end-of-chain' problems (LDNDC, EMEP)
- EMEP plans –
  - demonstrations with improved NH3 treatments (Gammas from Raia Massad, temperature effects, etc.)
  - But activity data will limit routine usage?
  - Runs with new BVOC from LPJ-GUESS, ORCHIDEE
  - Some technical challenges remain – ESX and improved modules for CTM models.

ECLAIRE C2 Summary

- Main policy messages
  - Ozone control requires hemispheric action, with methane as a 'win-win' target for air quality and climate
  - In general, warmer climates will give more soil-NO emissions and more monoterpene BVOC emissions
  - .. but isoprene BVOC emission changes are very uncertain, even with respect to the sign of the change.
  - Need better (dynamic, climate-sensitve) methodologies for NH3 emissions
  - N-deposition mainly under European control (90-95%)