Influence of LRT in a regional AQ model

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- grid
- emissions

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BelEUROS overview

- 3D grid model developed by RIVM (NL) for modelling of ozone
- in Belgium implemented in 2001
- since 2005 extended by VITO for modelling of primary and secondary particulate matter

- Meteo: ECMWF (T, rH, CC, Pr, WV, WD + mixing layer height)
- Emissions: Emission mapping tool E-map: EMEP/CORINAIR or IIASA + regional emission inventories for Flanders
- Chemistry: gas phase CACM or CB-IV-99 (+ aerosolmodule MADRID
- Resolution: horizontal: 60km/15km/7.5km; vertical: 4 (14) layers
- Boundary conditions: climatology or “nesting” into TM4 fields (TEMIS)

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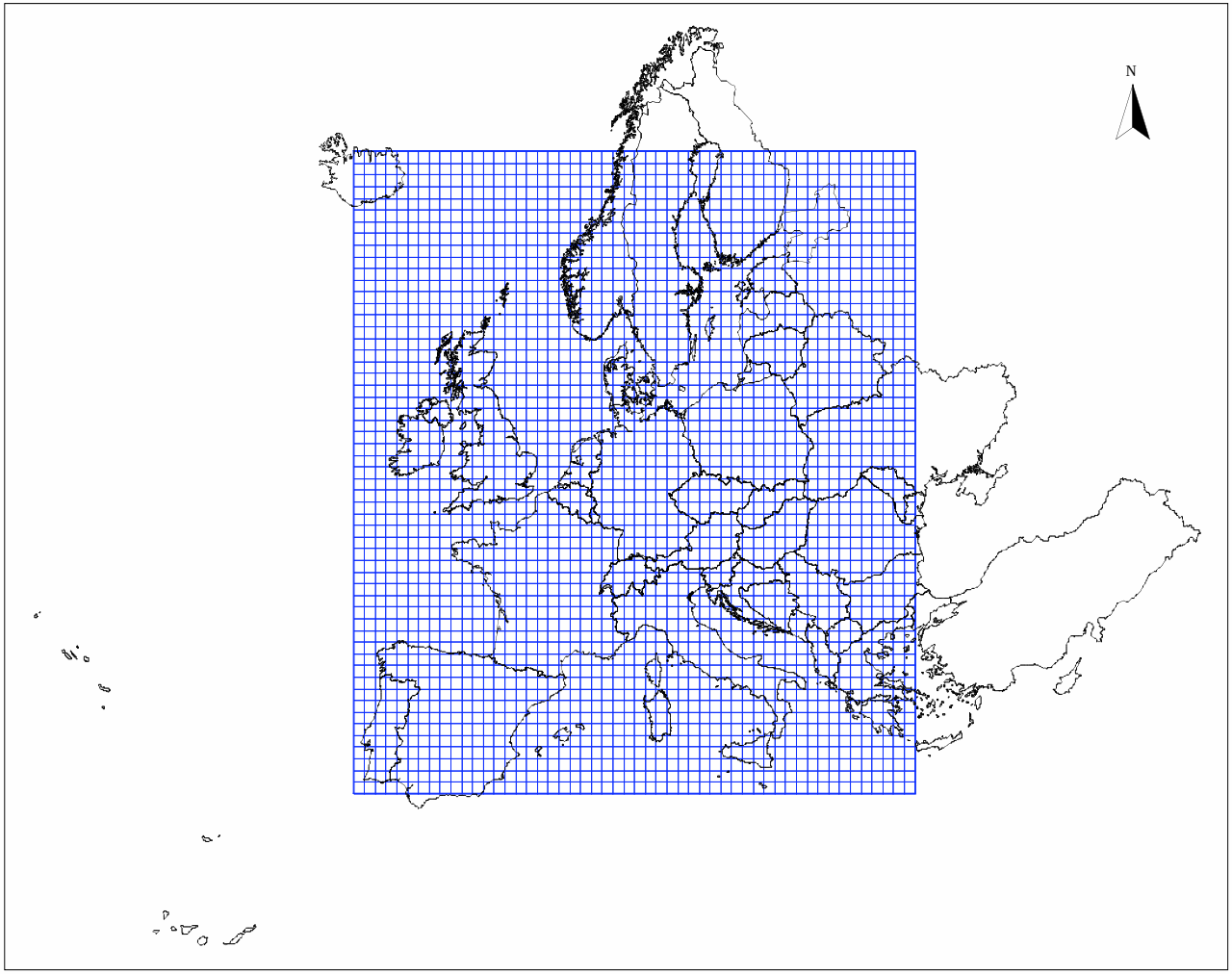
Overview of the BelEUROS-modelling system
- base grid: 60x60 km -



Figuur: Basisrooster van 0,55° x 0,55°.

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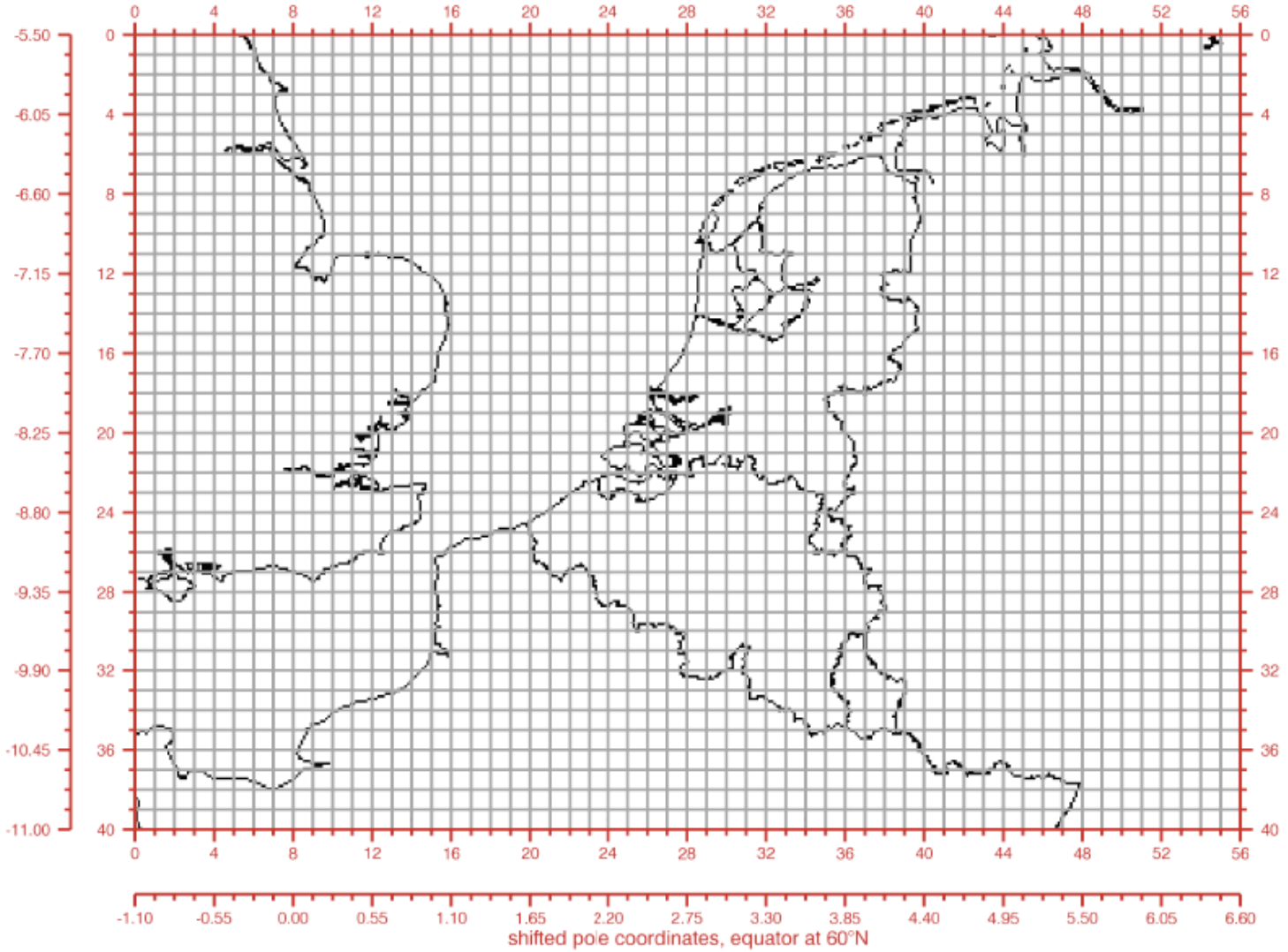
Overview of the BelEUROS-modelling system
- refined grid: 15x15 km or 7.5x7.5 km -



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Emission data

- **6 categories of pollutants**

NO_x	VOC	SO_2	NH_3	$PM_{2.5}$	$PM_{10-2.5}$

- **11 emission sectors (SNAP-sectors)**

electricity production	non-ind. combustion	industrial combustion	production processes
extr. & distr. foss. fuels	use of solvents	road traffic	other mobile sources
waste treatment	agriculture	nature	

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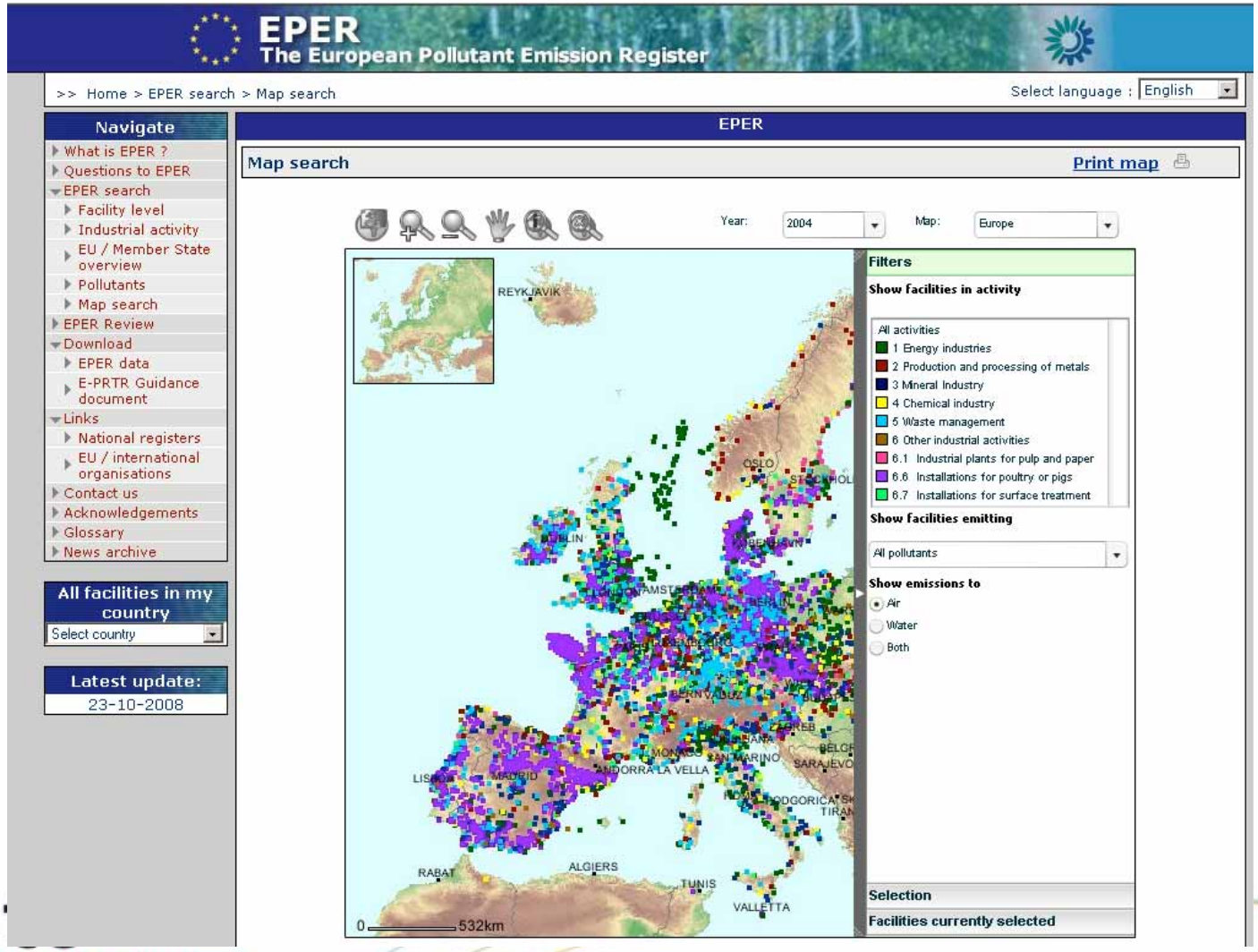
TEM

Methodology of E-map

1. Distinction between point sources and surface sources

Point source emissions: EPER data base



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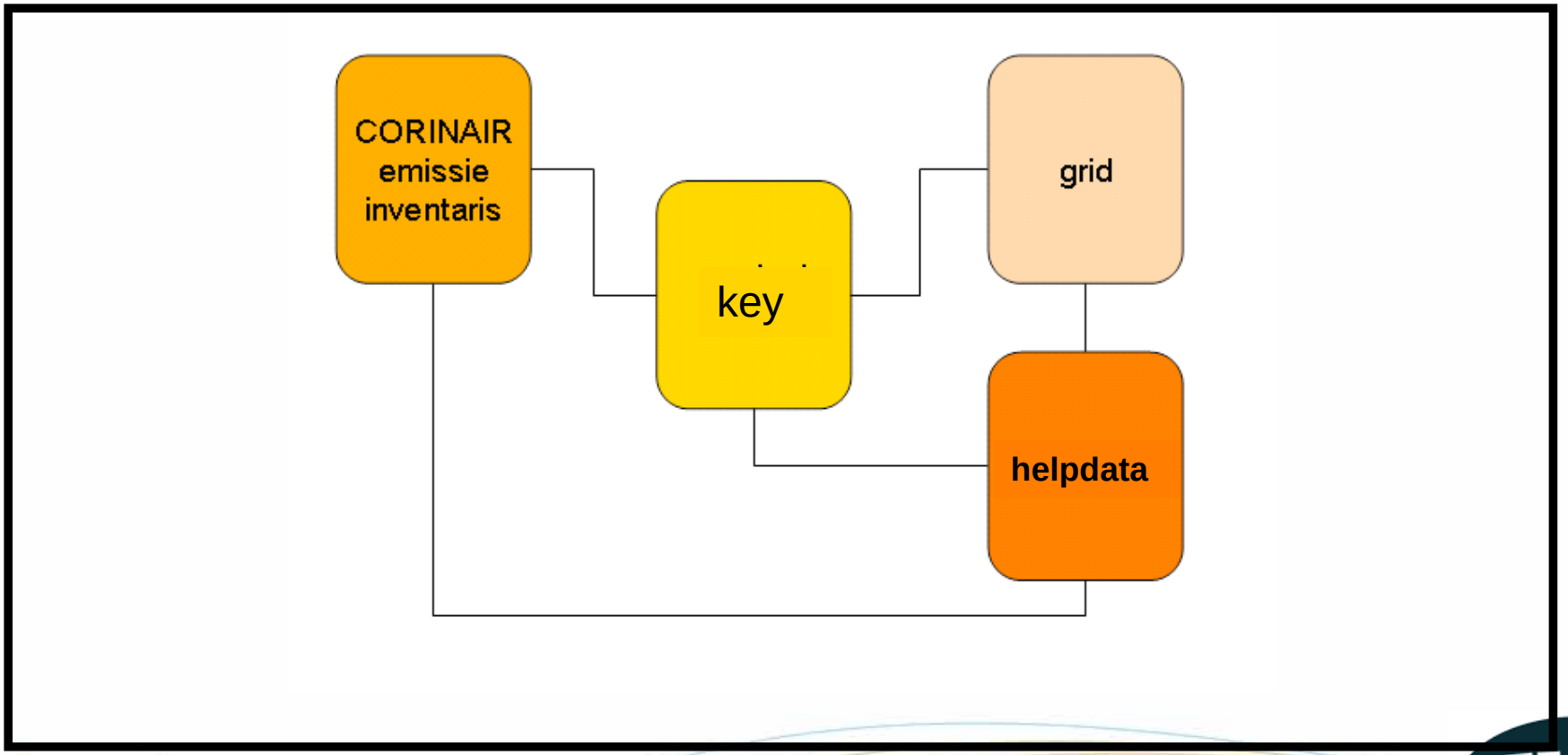
Methodology of E-map

2.) Surface sources: Disaggregation of national emission totals (after substraction of poi sources) b.m.o. surrogate variables (helpdata)

surrogate data: e.g. road maps, shipping lanes, population density, …

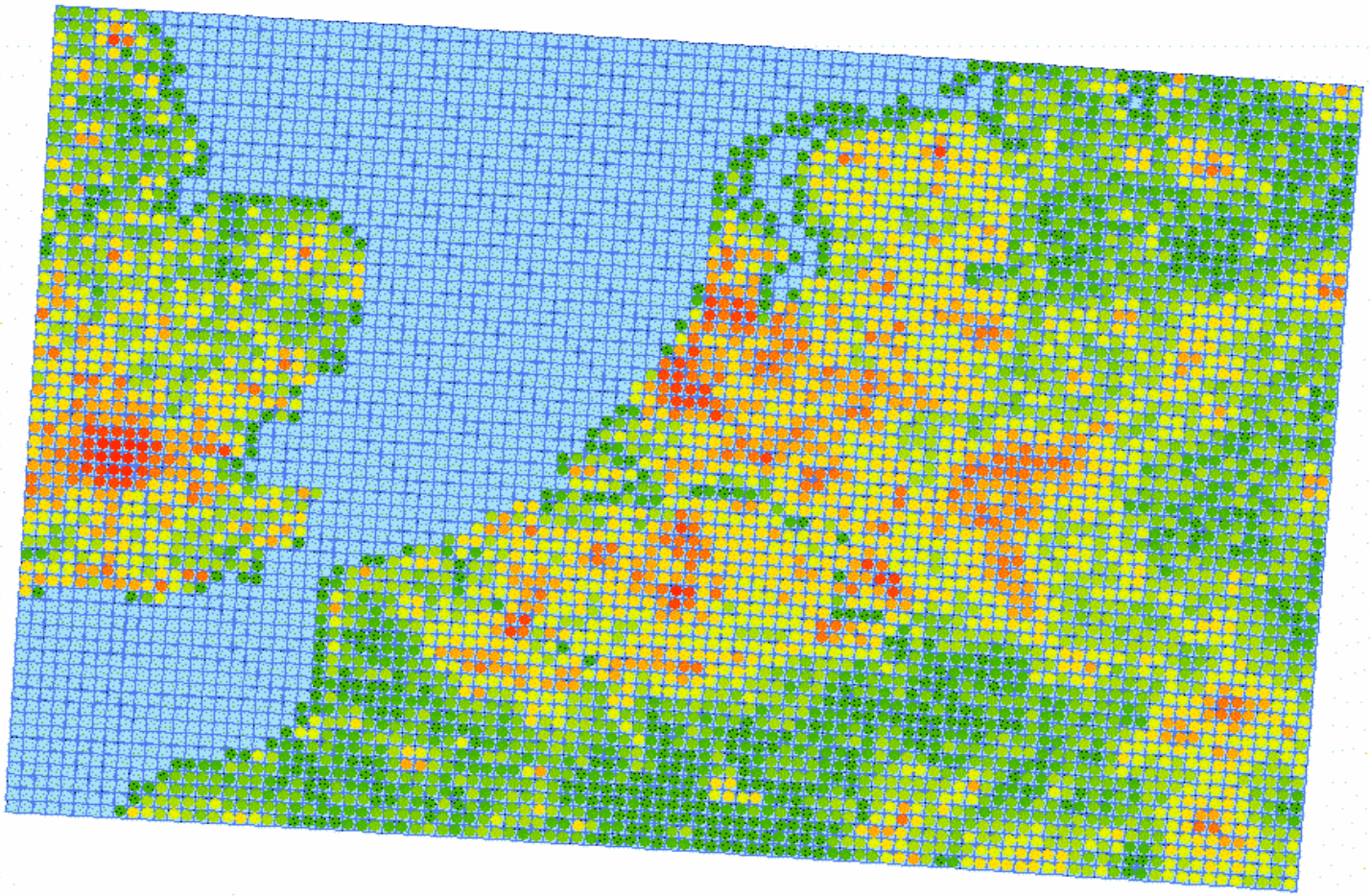
Specific key by pollutant and by sector



Methodology of E-map

NOx-emissions for S2 (non-industrial combustion)
in the grid refinement area of BelEUROS

surrogate data: population data and CORINE land use classes for urban areas

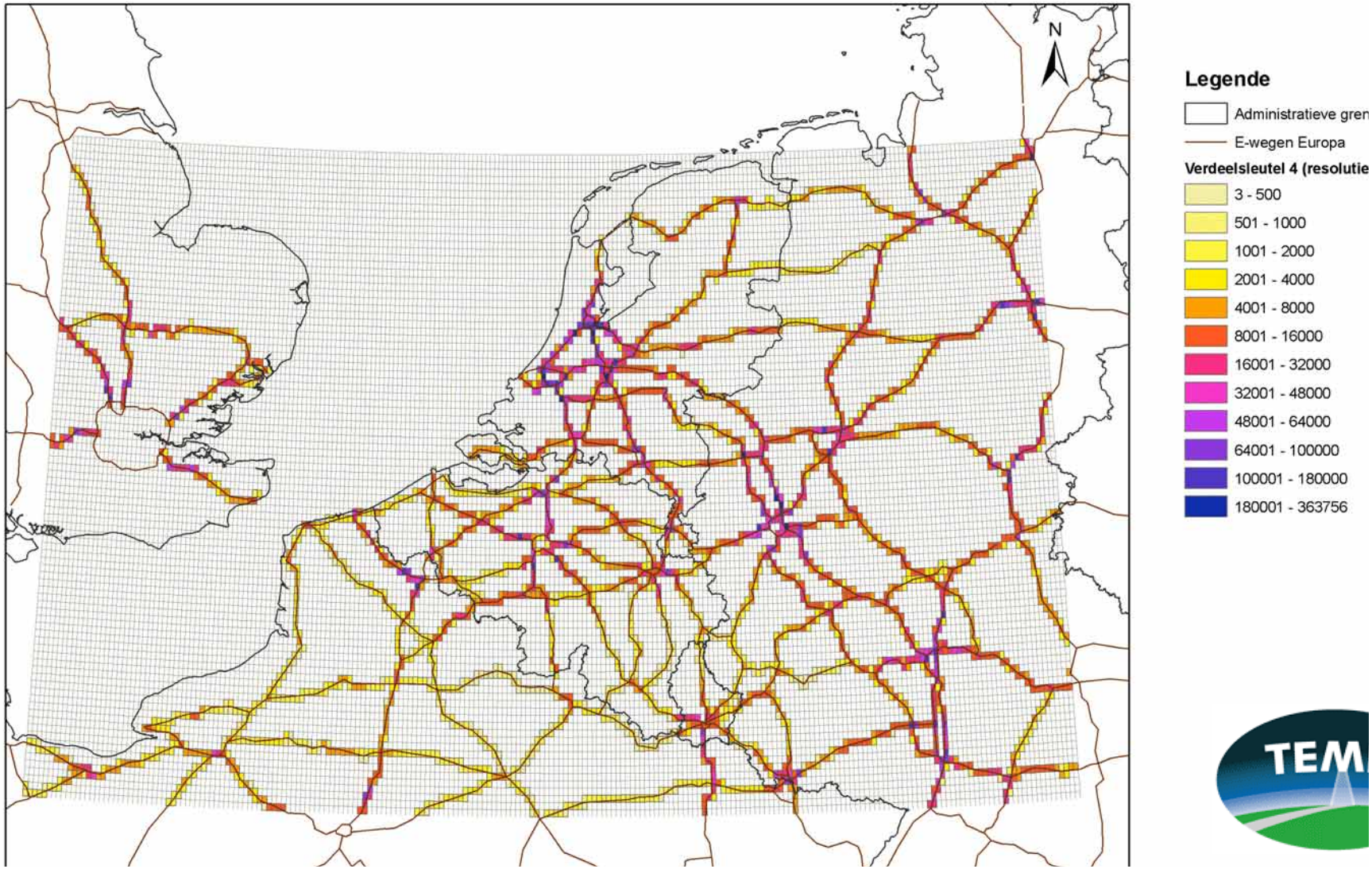


Methodology of E-map

Sector 7 road transport:

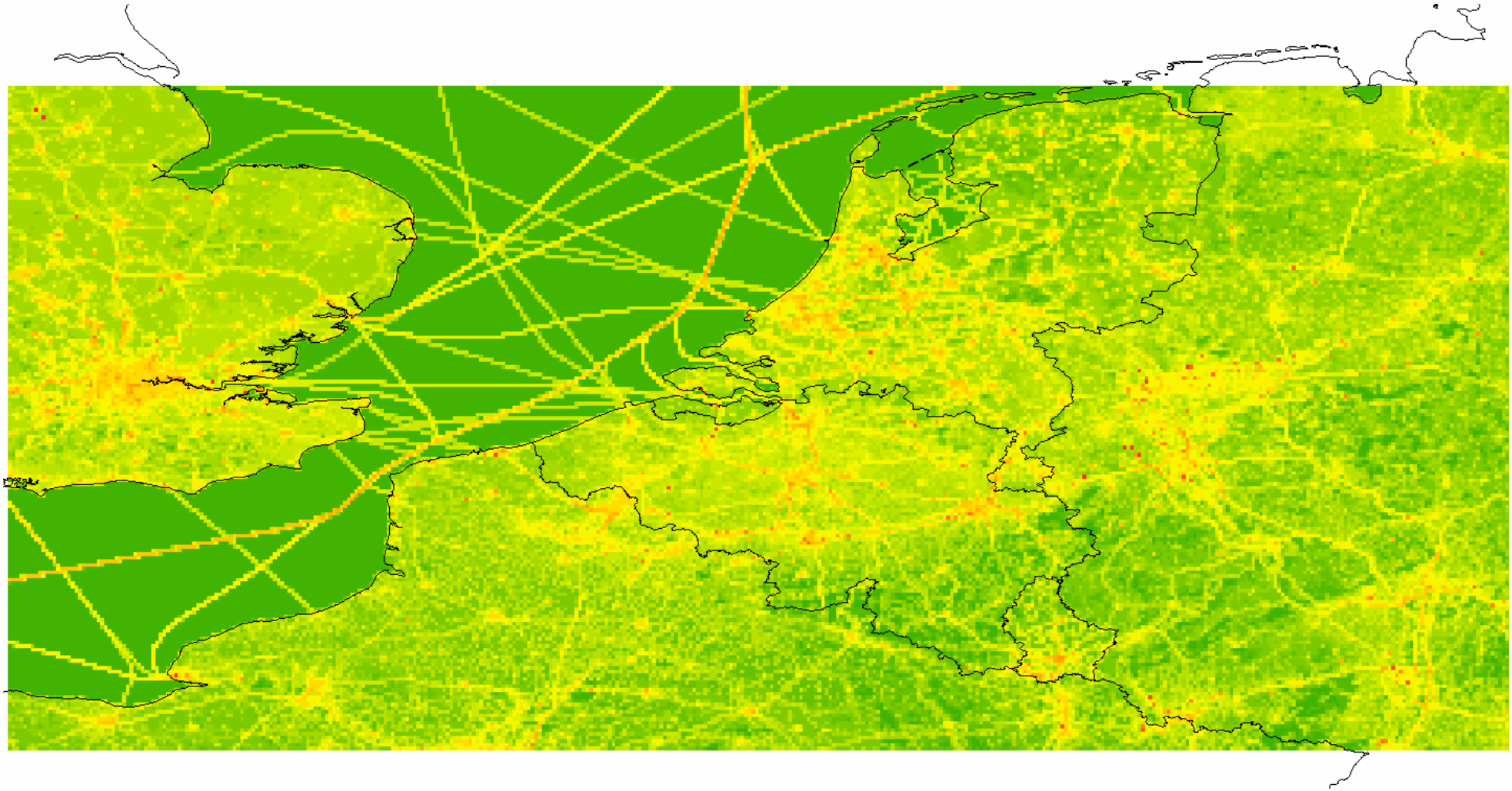
Distinction between motorways, main roads and urban roads (TREMOVE)

Distribution key for motorways for NOx emissions



Methodology of E-map

Summing up the emissions of all sectors: total NOx of all sectors emissions with high resolution of approx. up to 5 km

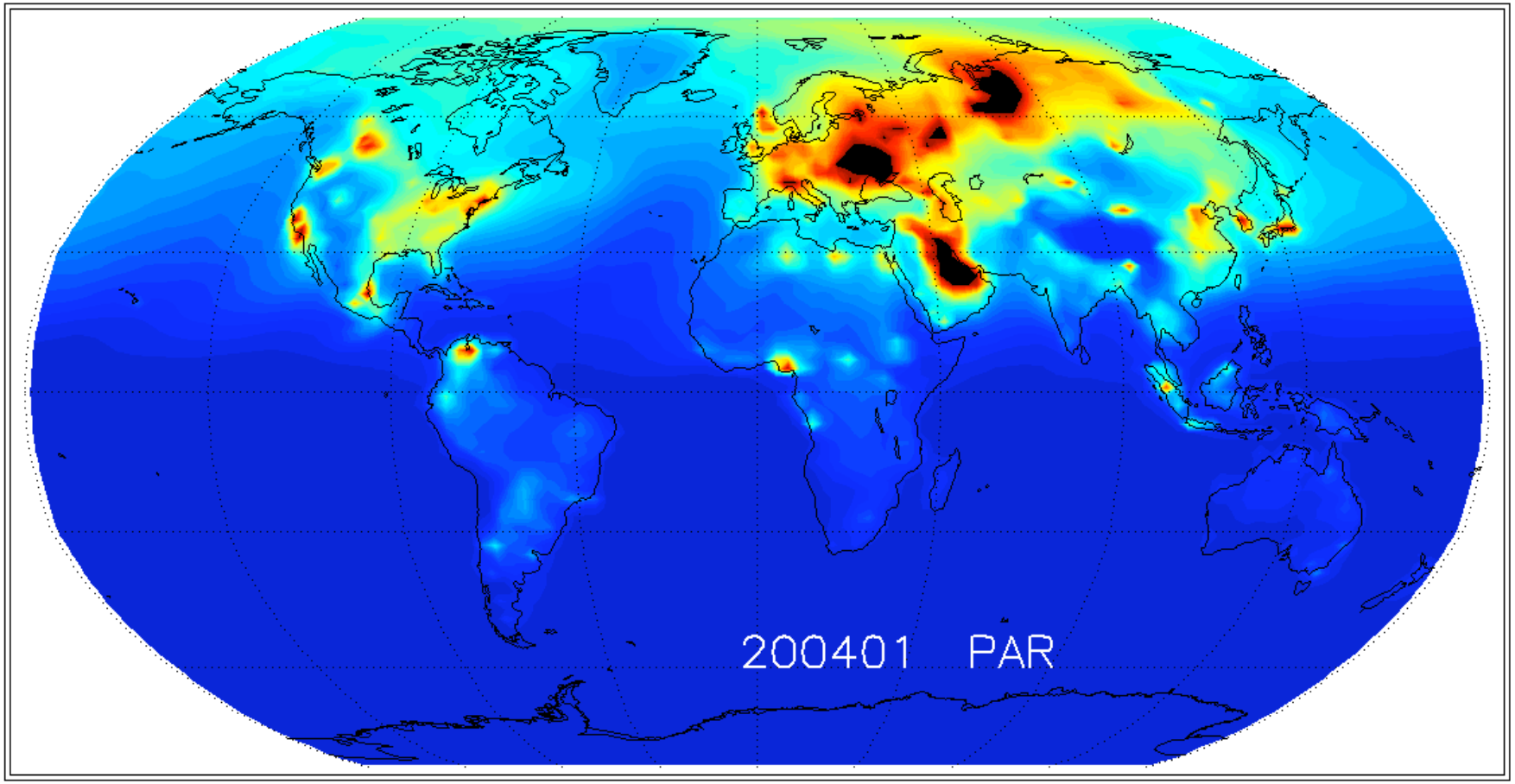


Results reached in TEMIS

Improvement of boundary conditions for the BelEUROS-mode

- For the retrieval of boundary conditions for BelEUROS: Nesting into the TM4 model
- Retrieval of 3-D concentration fields of all chemical species of the CB-IV mechanism from the TM4 model and interpolation to the lateral grid cells of BelEUROS

Results – improved boundary conditions
TM4 concentration field for “PAR”



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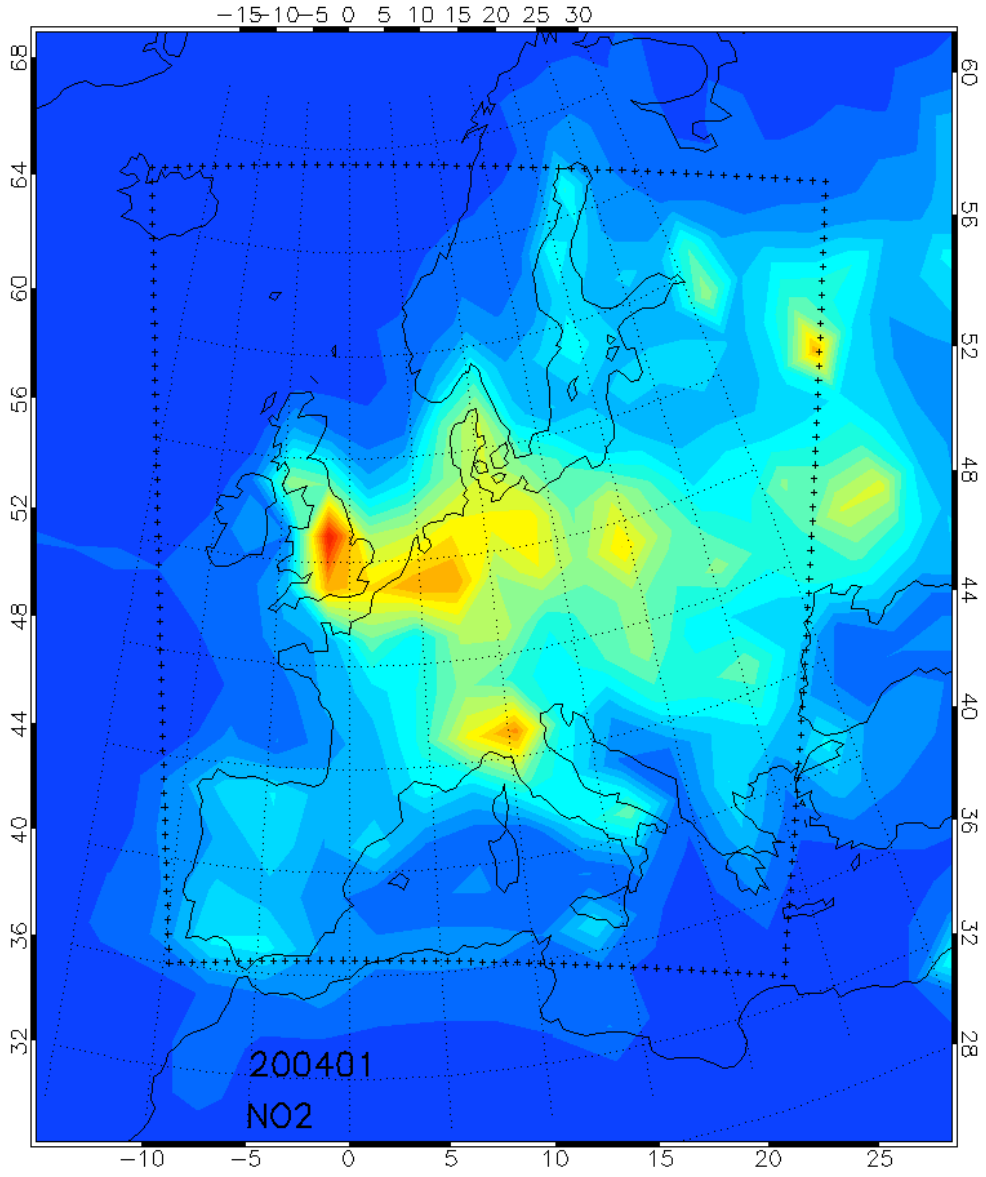
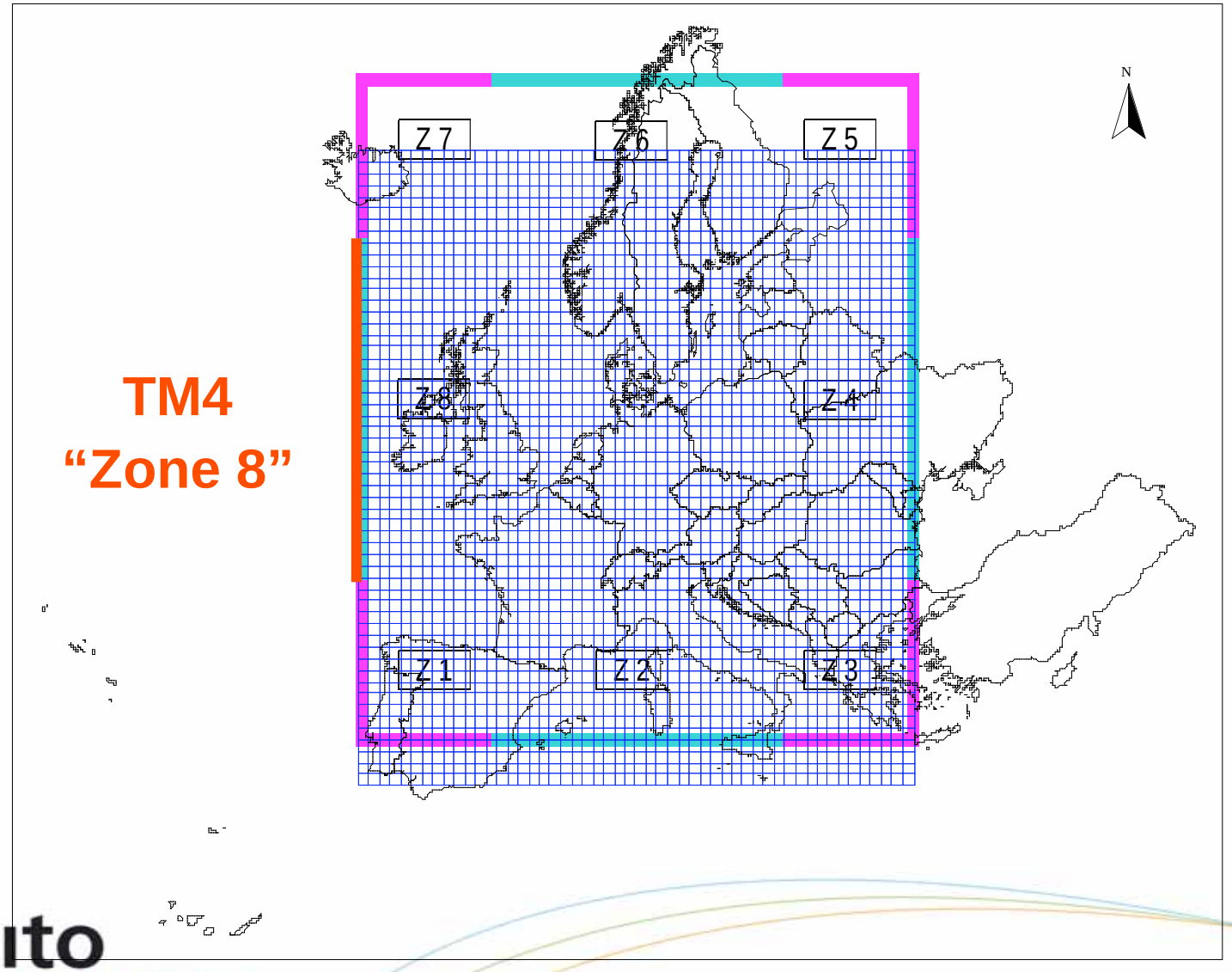
Results – improved boundary conditions
- Nesting into TM4 -



Nesting of BelEUROS into TM4 concentration fields; dotted line shows the border o the BelEUROS domain

Results – Analysis of boundary conditions

TM4
“Zone 8”



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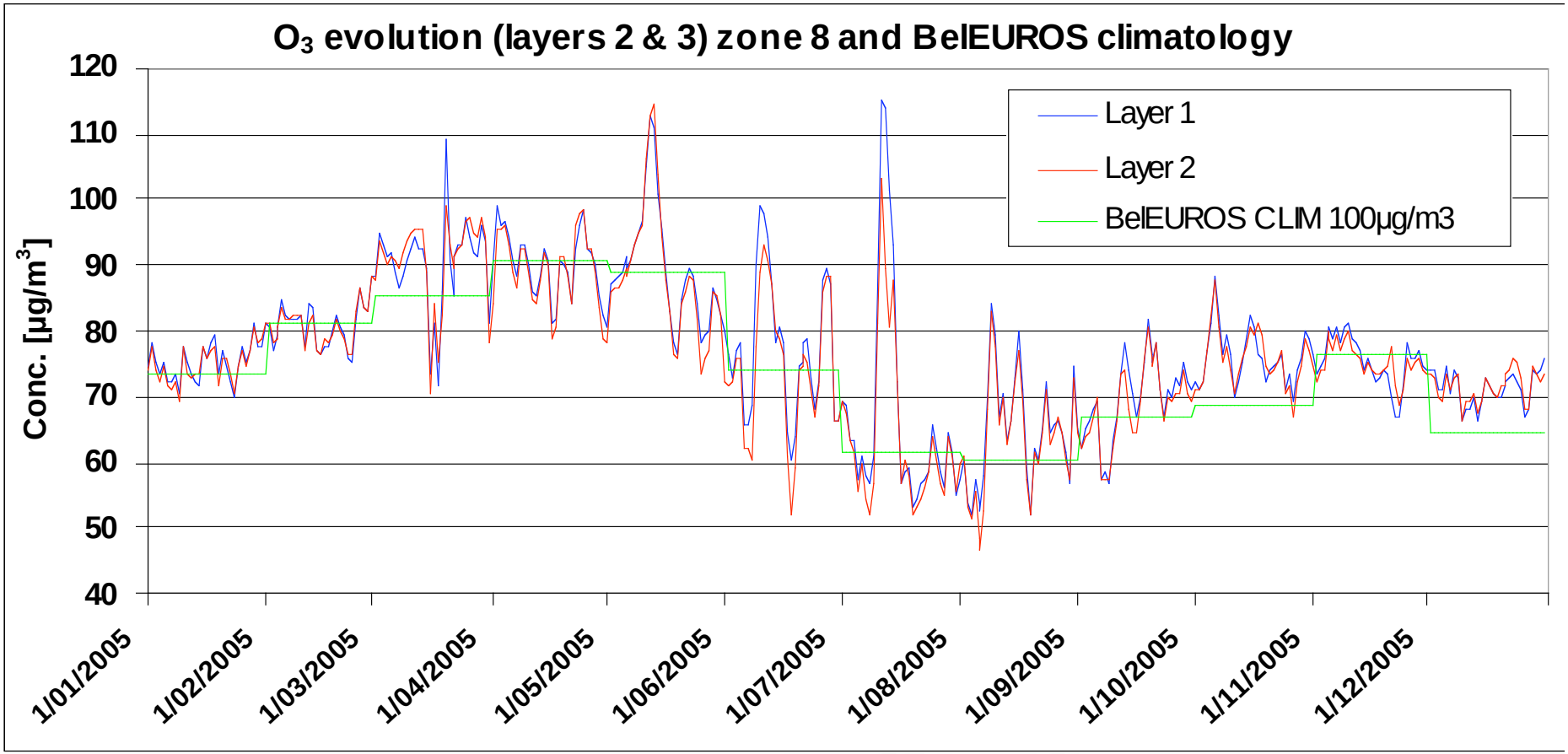
Results: Improved BC

Analysis of ozone concentrations at the Western boundary of the BelEUROS domain simulated by TM4 and climatological values



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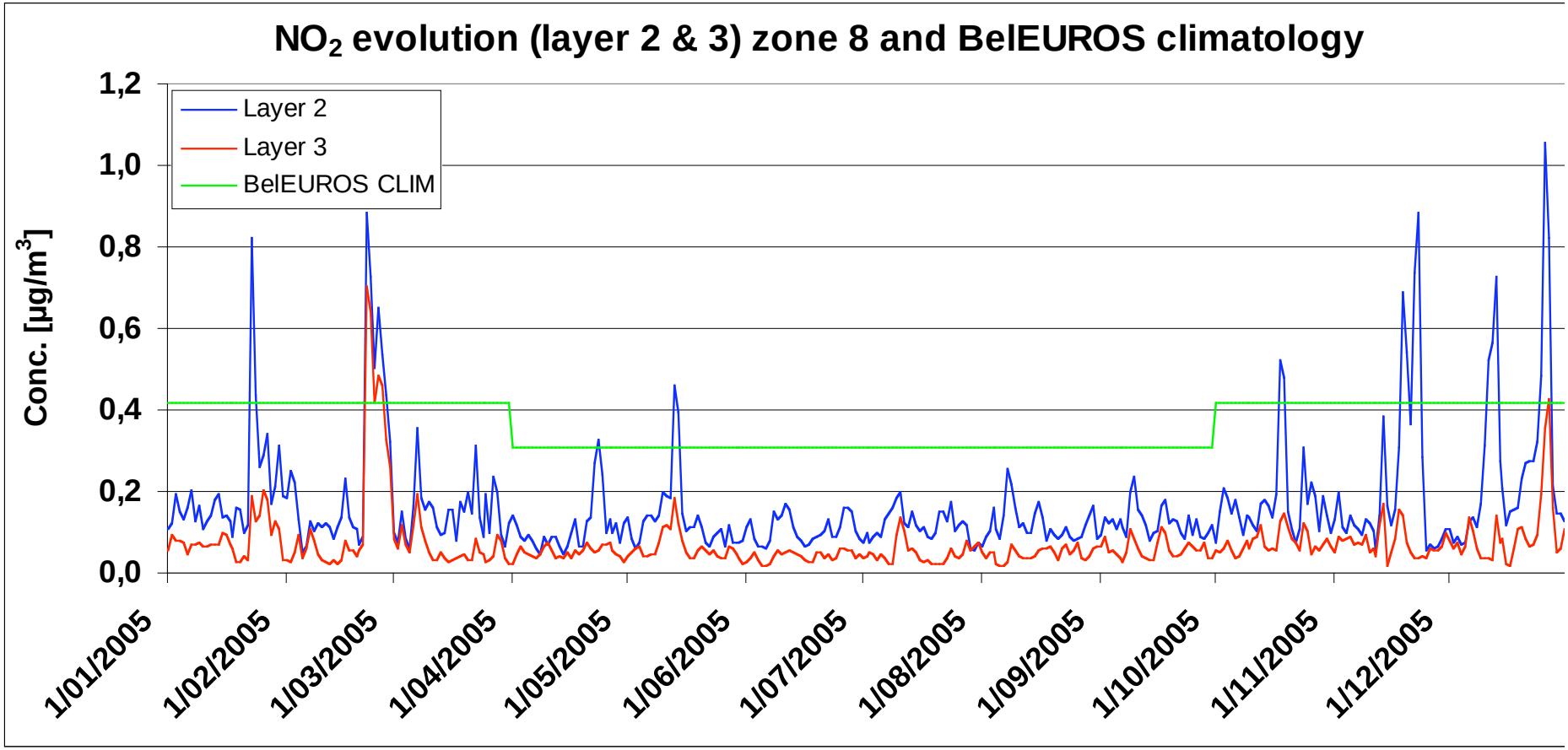
Results: Improved BC

Analysis of NO_2 concentrations at the Western boundary of the BelEUR domain as simulated by TM4 and climatological values



BelEUROS climatology for NO_2 higher than TM4; peaks (transport events) are missing

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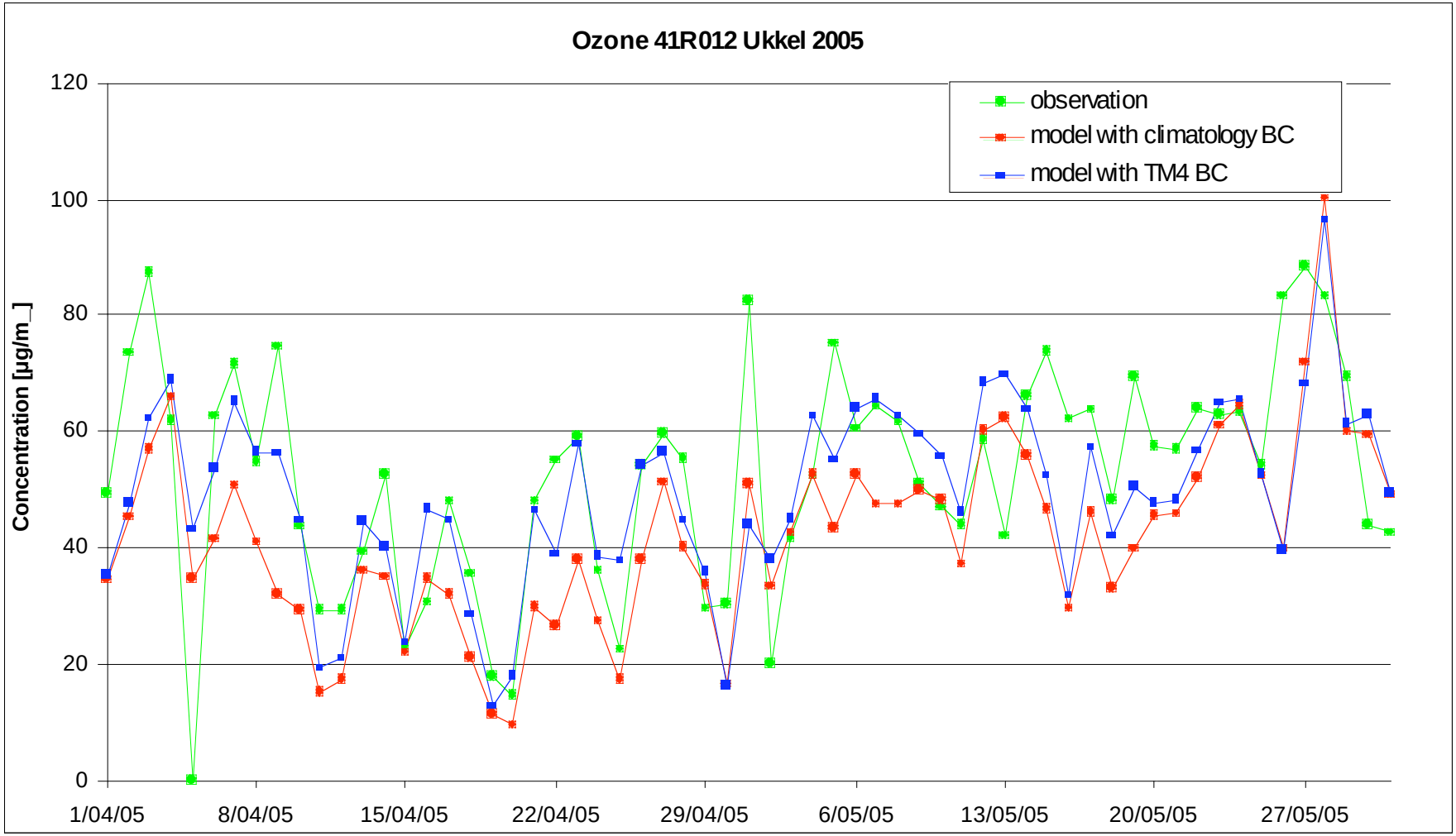
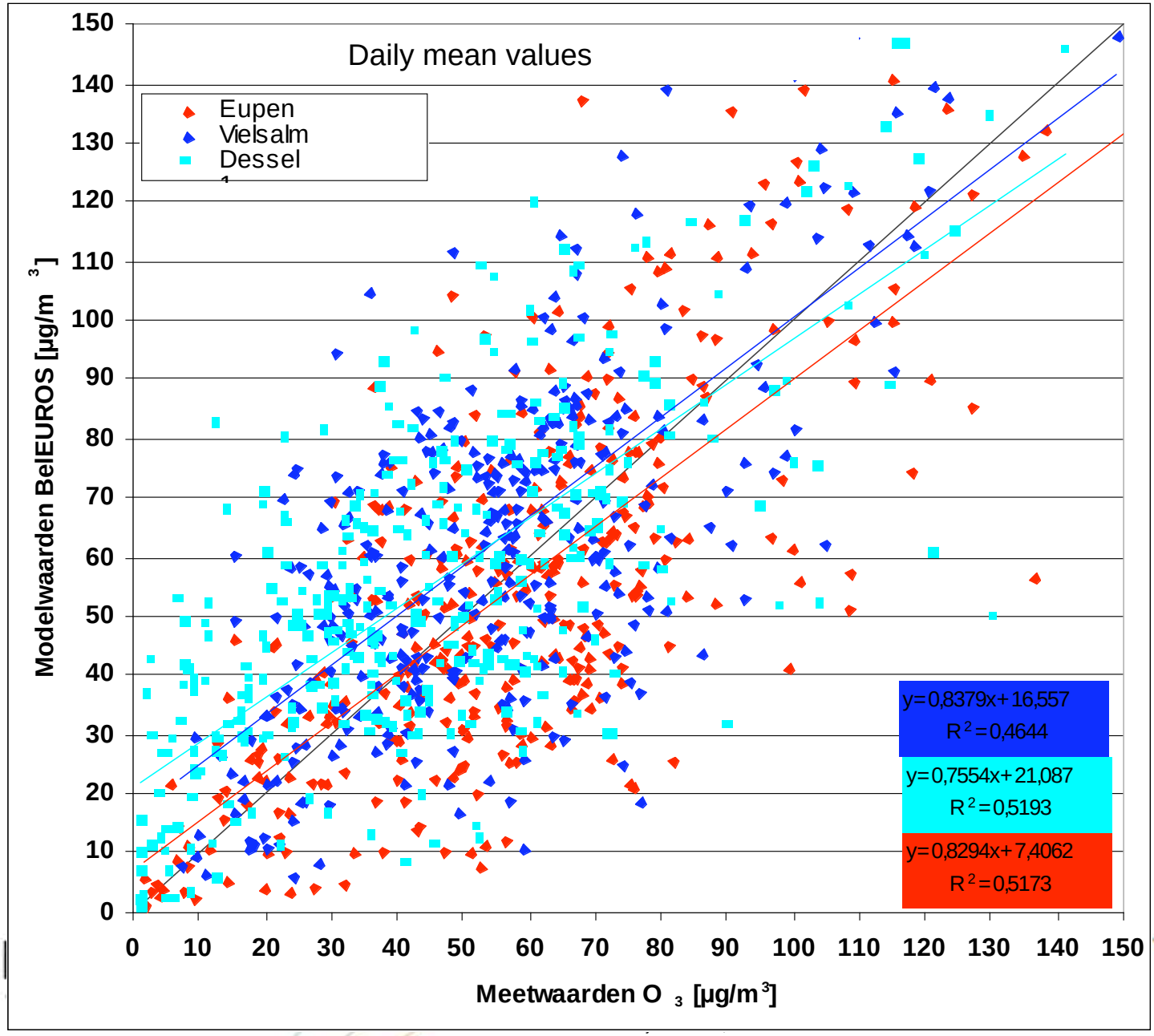
Results: Improved BC - validation



Bias: -27,1 % (Clim.); -9,1 % (TM4)

Validation: Photochemical pollutants – O_3 daily means



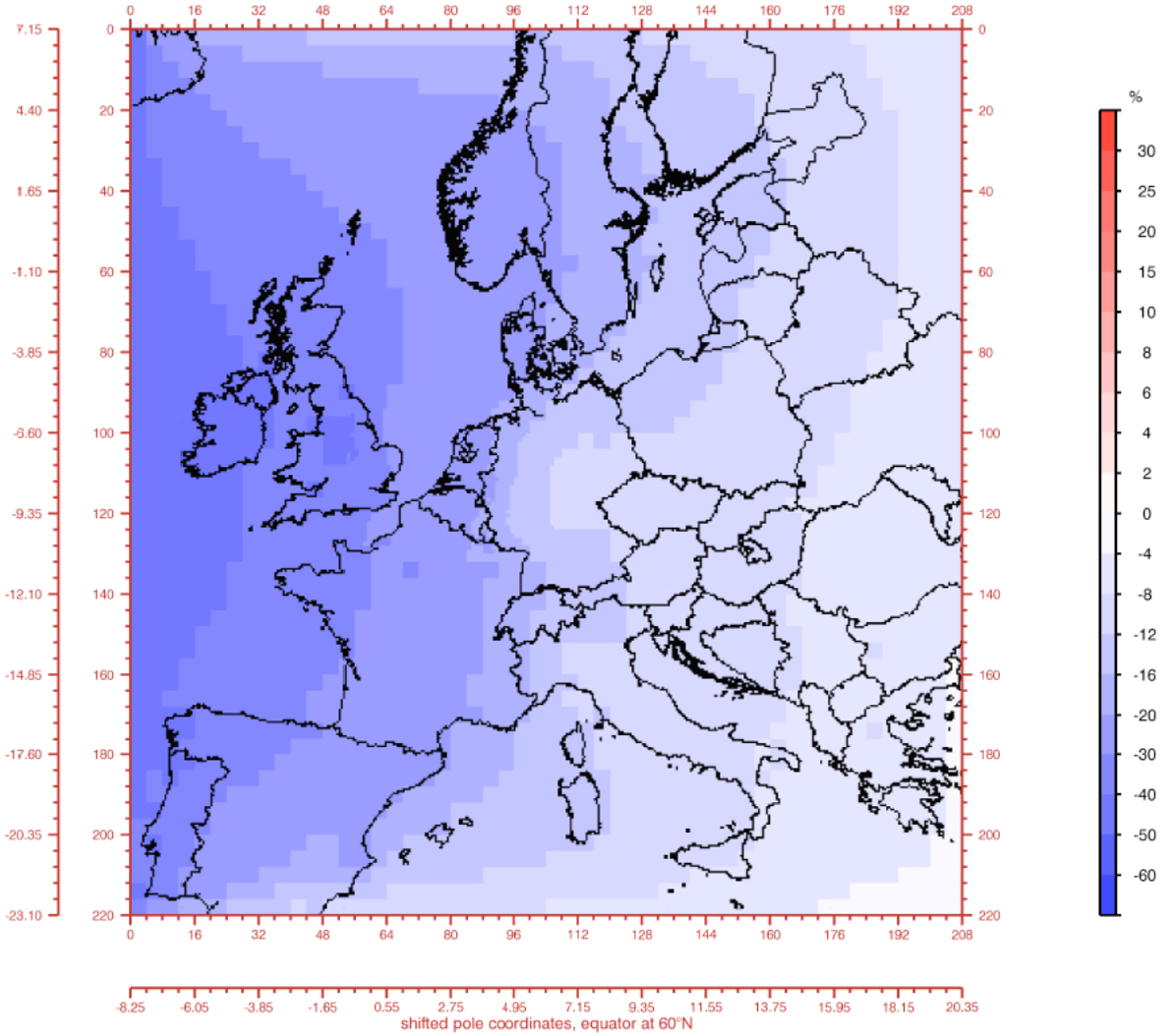
Validation of the spatial distribution for O_3 (annual mean concentration)

BelEUROS 2006 (model)

RIO-corine 2006 (interpolated measuremen

Results: Sensitivity study: Contribution of LRTAP

Impact of transatlantic O_3 transport on European O_3-levels



relative difference (annual mean) betwee calculation with ozon BC and calculation with 50 % lower ozon transport from the western boundary

correct estimation o boundary O_3 important! -> use of Earth Observation data!

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Results: Contribution of LRTAP

Impact of transatlantic O_3 transport on European air quality (O_3)

Reduction of western boundary ozone [%]	Ozone reduction in Belgium		
	mean winter	yearly mean	Max. 1h summer
25	23,3	11,7	6,4
50	42,9	22,3	11,8
100	69,5	39,5	18,5
"100"	93,2	46,8	25,6

Highest influence of boundary ozone in Belgium in the winter, lowest influence on summer ozone peaks

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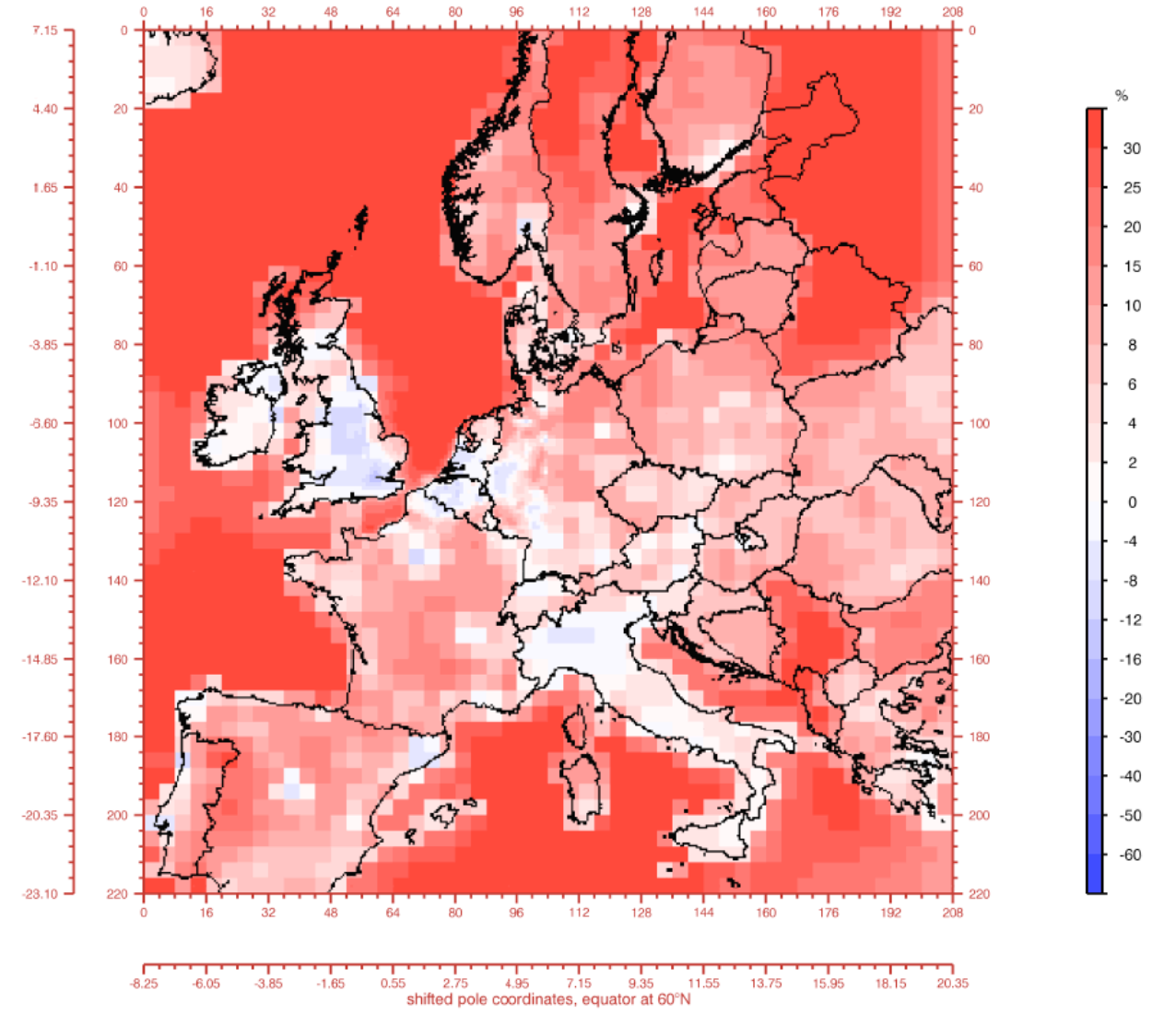
Results: Contribution of LRTAP

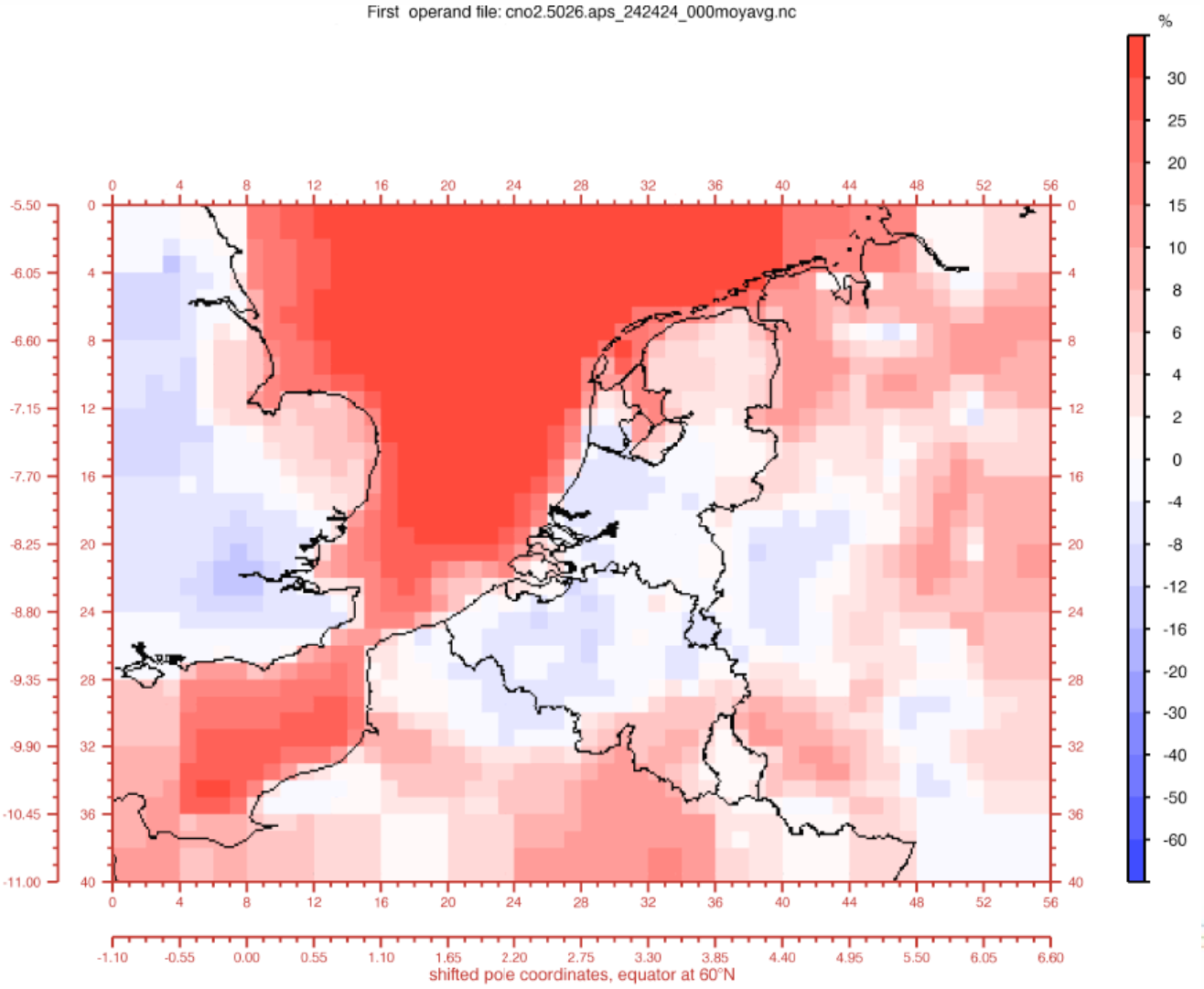
Impact of transatlantic O_3 transport on European NO_2-levels



Relative change in annual mean NO_2-concentration when reducing O from western boundary by 50 %

Results: Contribution of LRTAP

Impact of transatlantic O_3 transport on European NO_2-levels



Flanders: 6.5 % o annual mean NO_2 concentration due to O_3 background by changing the NO/NO_2-ratio; increasing O_3 background can lead to non-attainment of EU limit value for NO in urban areas; us of EO-data!

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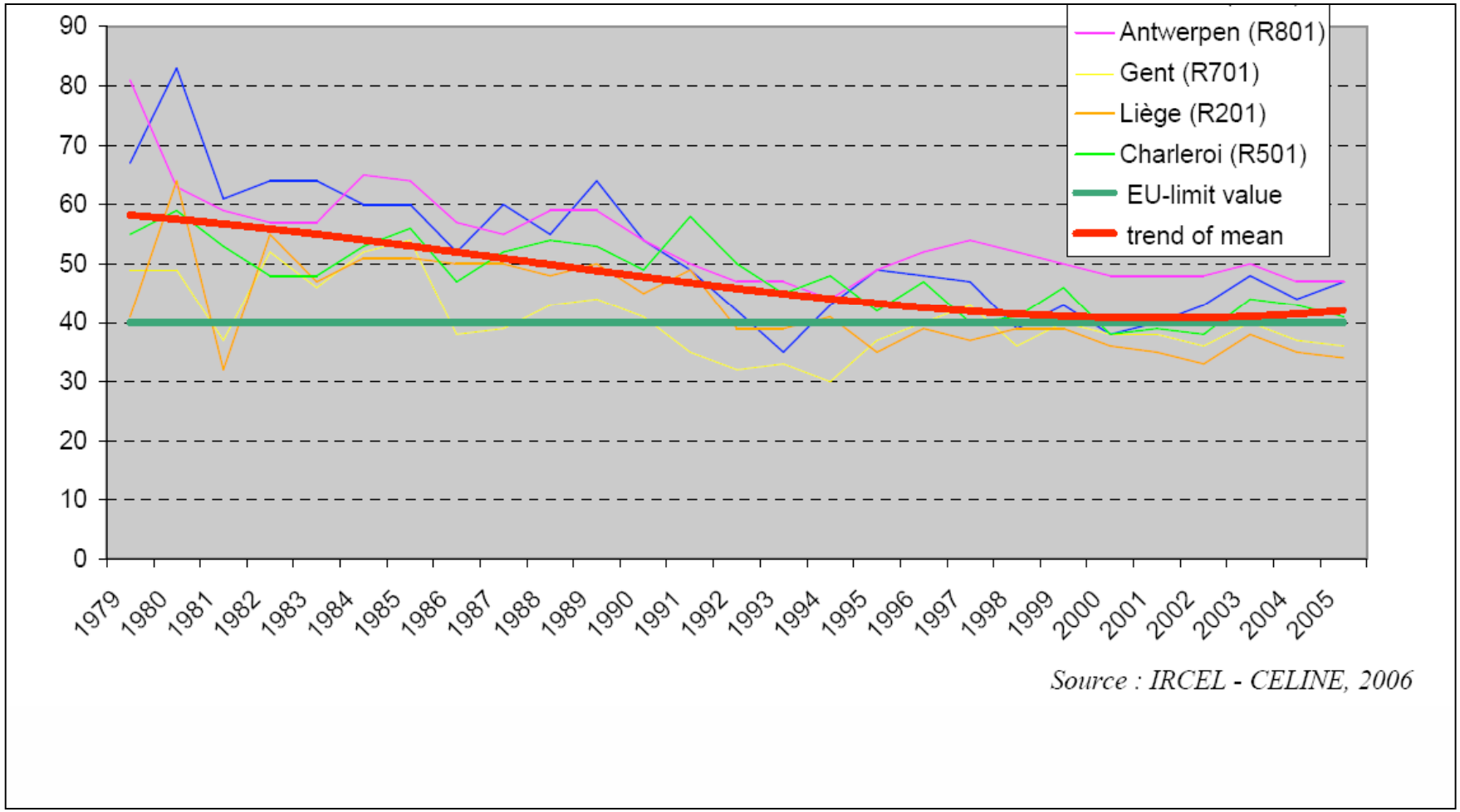
Results: Relevance of LRTAP on regional AQ



Since 2001 increase in NO_2-concentrations, among others due to higher NO_2/NO-ratio in traffic emissions and higher O_3-background

→ problems to attain EU limit value!

→ necessity to assess O_3 background as correct as possible

Conclusions

1) Nesting of BelEUROS into TM4 concentration fields results in more realistic representation of long range transport of air pollutants in BelEUROS simulations.
2) This improved the model performance for O_3 and NO_2 simulations.
3) Sensitivity study showed a high impact of transatlantic O_3-transport or annual mean O_3- and NO_2-concentrations in Europe.
4) The measured and forecasted increase of the northern hemispheric O background can lead to an increase of O_3- and NO_2-concentrations, esp. in urban areas, leading to problems attaining EU limit values.
5) For a correct estimation of the O_3 background a further improvement c model boundary conditions using Earth Observation data is desirable.

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Acknowledgement

- Thanks to Bas Mijling and Ronald van der A (KNMI) for providing us with the TM4 concentration fields
- Thanks to ESA for financial support within the TEMIS project

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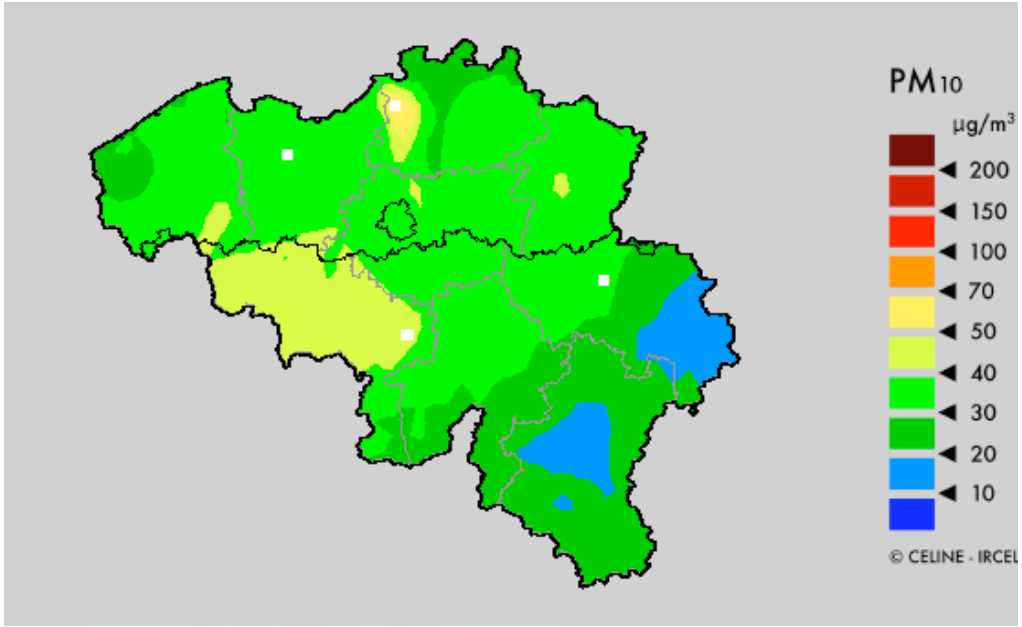
Outlook

- Further improvement of boundary conditions for the BelEUROS model:
  - nesting of the fine particulate matter version of BelEUROS into TM4 concentration fields ($PM_{2.5}$, NH_4^+, SO_4^{2-}, NO_3^-)
  - using Aerosol Optical Depth (AOD) data for improved boundary conditions, taking LRT of fine particulate matter into consideration
  - using tropospheric ozone data for improved boundary conditions and LRT of ozone

Outlook

Daily forecast of PM_{10} concentrations for the Belgian Interregional Environment Agency: These forecasts only use local information and suffer from the lack of information on long range transport of PM_{10}

» **Improvement of PM_{10} forecasts** using AOD observations from satellites, especially for taking e.g. Sahara dust, forest fires and biomass burning into consideration



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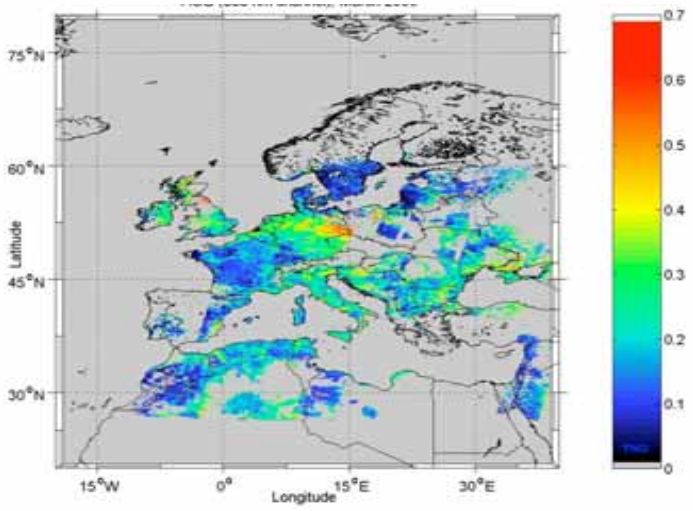
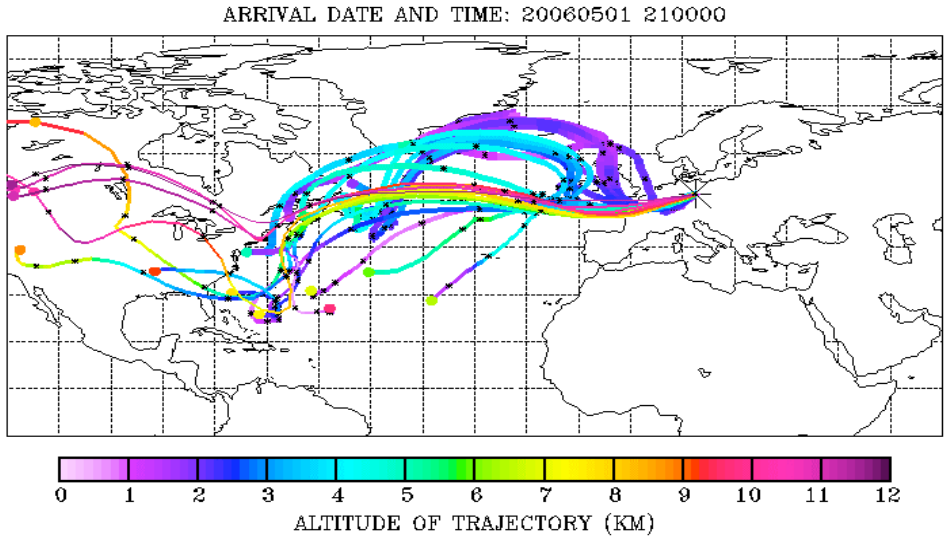
Outlook

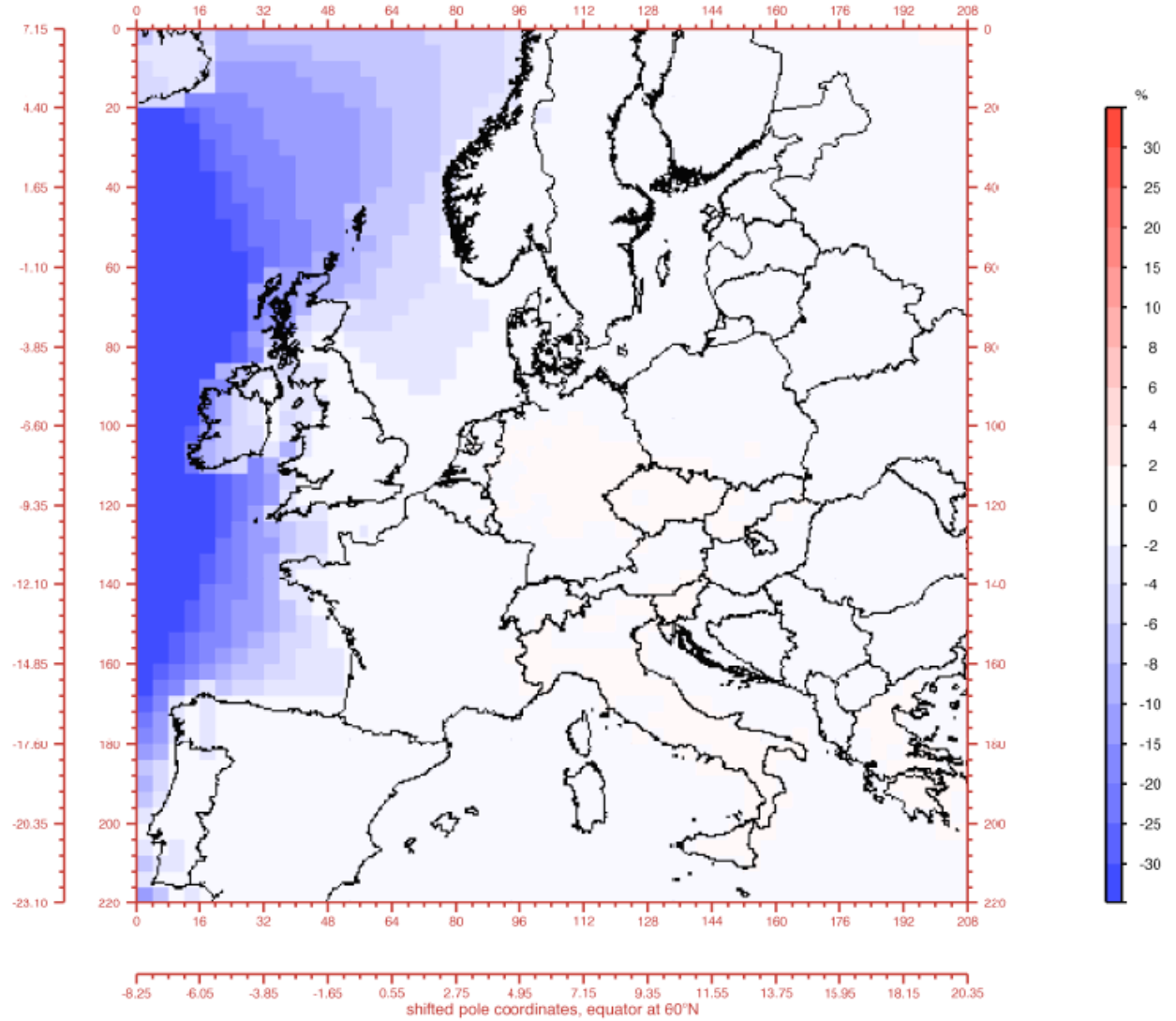
- Detection of upcoming PM clouds:
  - Combination of forecast model with trajectory model and AOD data
  - combine AOD EO data with forecasted back trajectories by e.g. Flextra/Flexpart
  - This would permit the detection of upcoming PM clouds





Results: Contribution of LRTAP

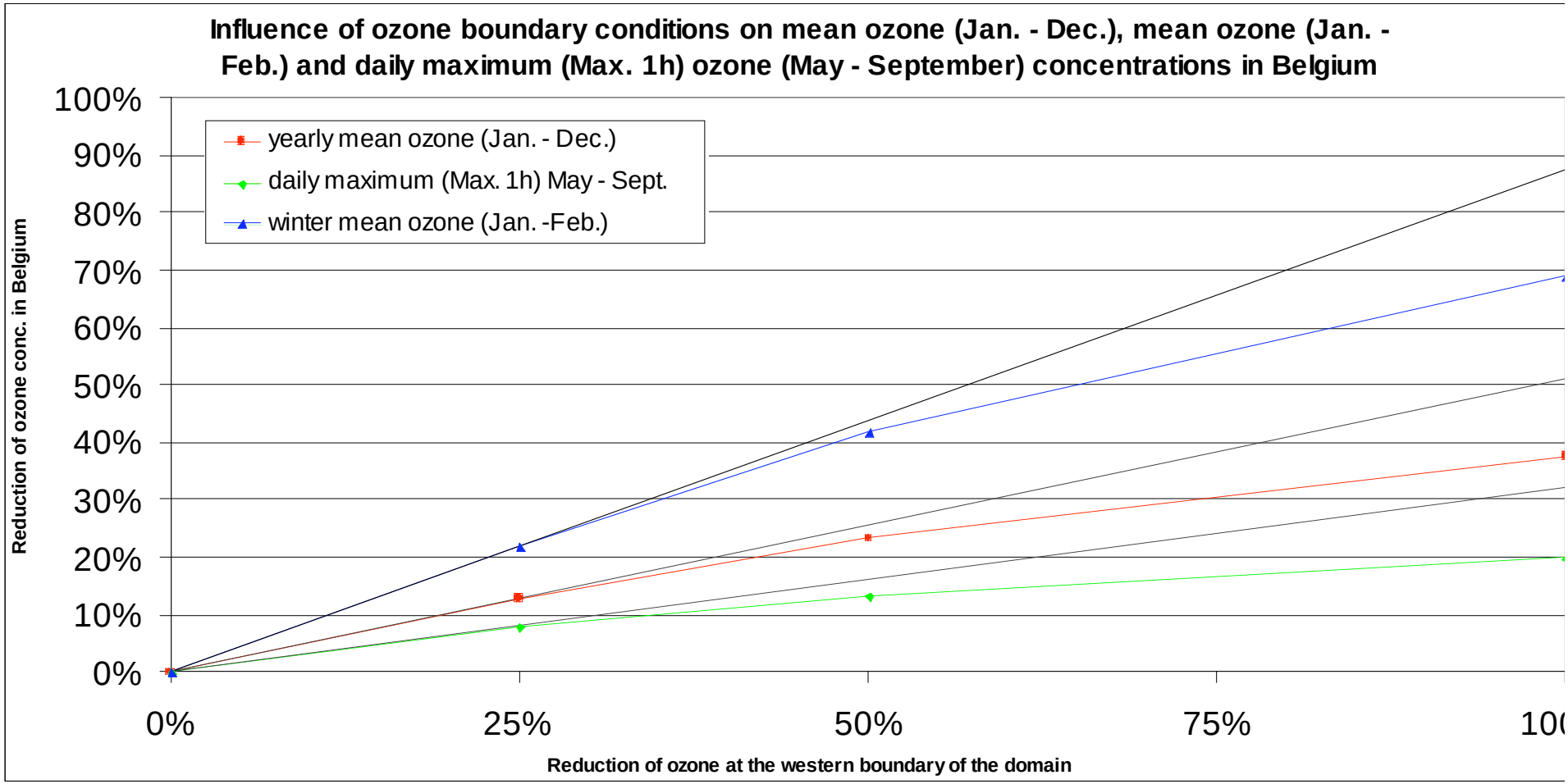
Impact of transatlantic NO_2 transport on European NO_2-levels



Belgium: influence of transatlantic NO tranport on NO_2-levels in Belgium i very limited

Results: Contribution of LRTAP

Impact of transatlantic O_3 transport on European air quality (O_3)



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Results: Contribution of LRTAP

Reduction of western boundary ozone [%]	NO_2 change in Flanders		NO_2 change in Wallonia	
	mean winter	yearly mean	mean winter	yearly mea
25	-2,4	-1,2	+0,7	+1,2
50	-5,9	-3,4	+0,7	+1,4
100	-21,6	-11,7	-7,6	-3,3

Reduction of BC Ozone leads to a shift of the NO/NO_2-ratio towards NO, especially during wintertime in areas dominated by anthropogenic (NO) emissions.

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