Influence of transatlantic NO_2- and O_3-transport on air quality in Europe

Felix Deutsch, Koen De Ridder,

Jean Vankerkom, Clemens Mensink

VITO - Flemish Institute for Technological Research,
Centre for Integrated Environmental Studies, Mol, Belgium

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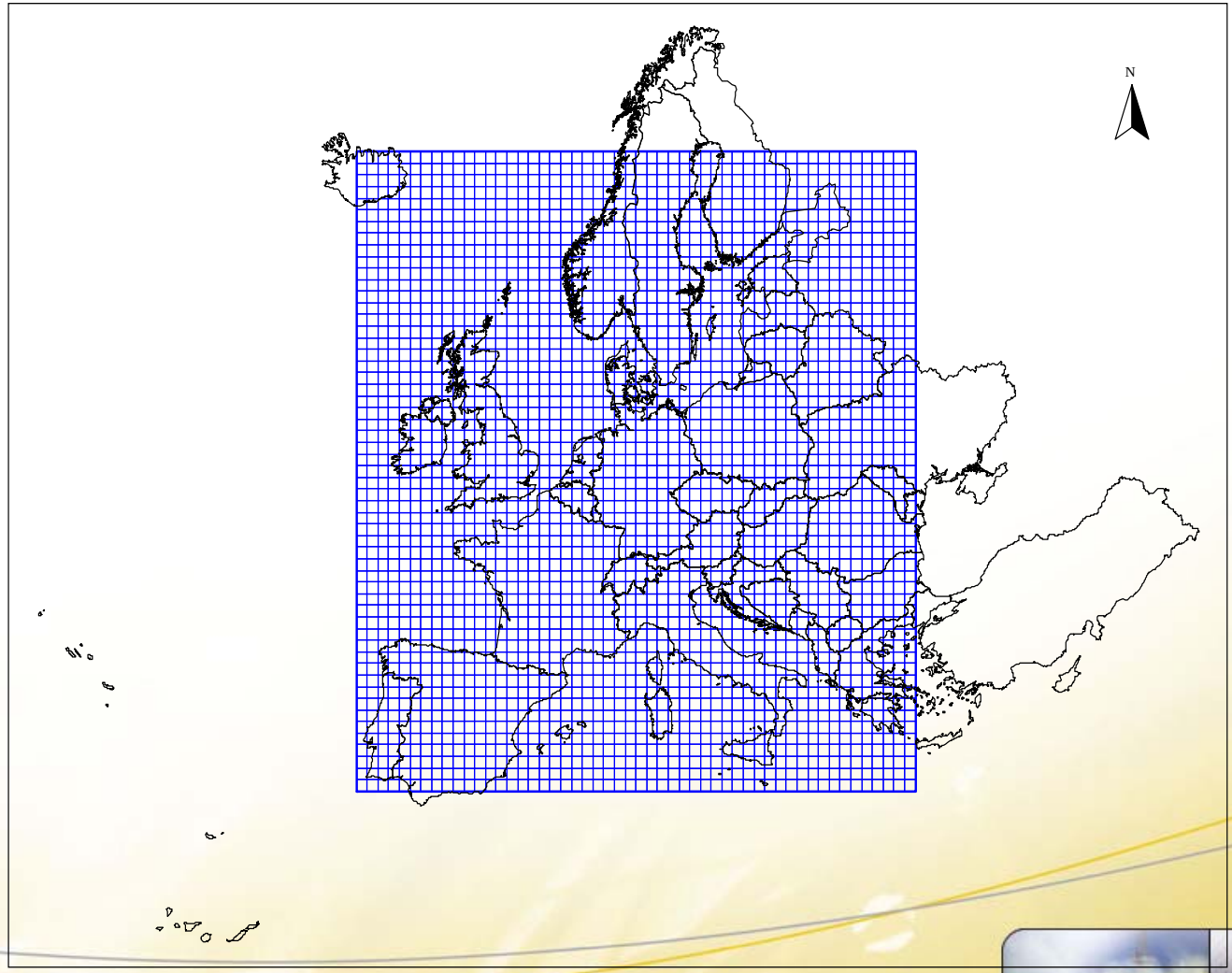
Short overview of BelEUROS

- EUROS created by RIVM (Netherlands) for modelling of ozone
- in Belgium implemented in 2001 for ozone
- in 2004/2005 EUROS extended by VITO with two modules for modelling primary and secondary particulate matter (PM_{10}, $PM_{2.5}$)

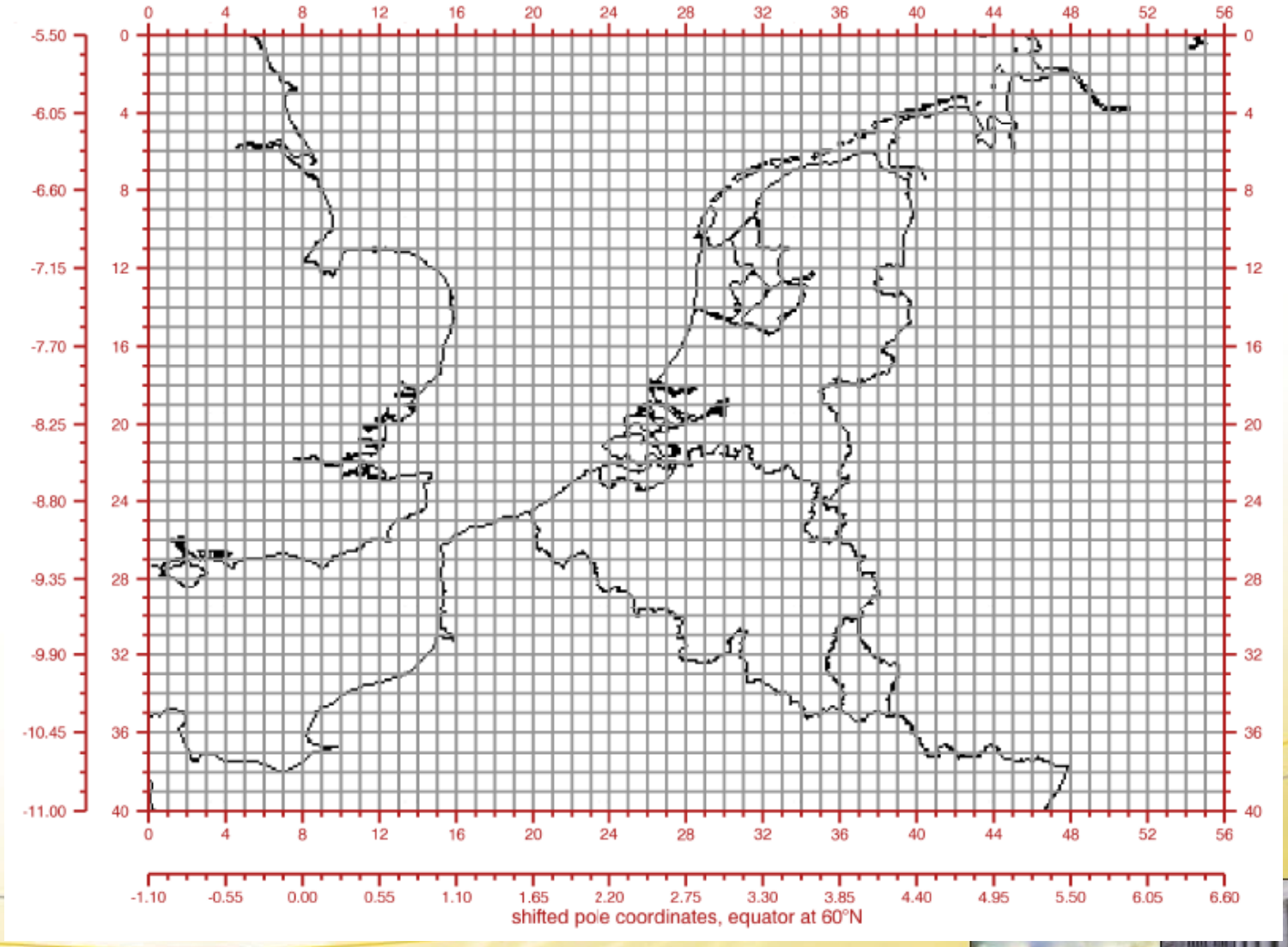
- Meteo: ECMWF (T, rH, wv+wd, CC, PR, mixing layer height)
- Emissions: EMEP/CORINAIR; additionally local emission inventories with higher resolution, e.g. for Belgium
- Chemistry: for O_3, NO_x: Carbon Bond IV (CB-IV) gas phase mechanism, for PM_{10}, $PM_{2.5}$: CACM + aerosol module MADRID 2
- Resolution: horizontal: 60 km/15 km or 7.5 km;
  vertical: 4 layers (chemistry), 14 layers: advection

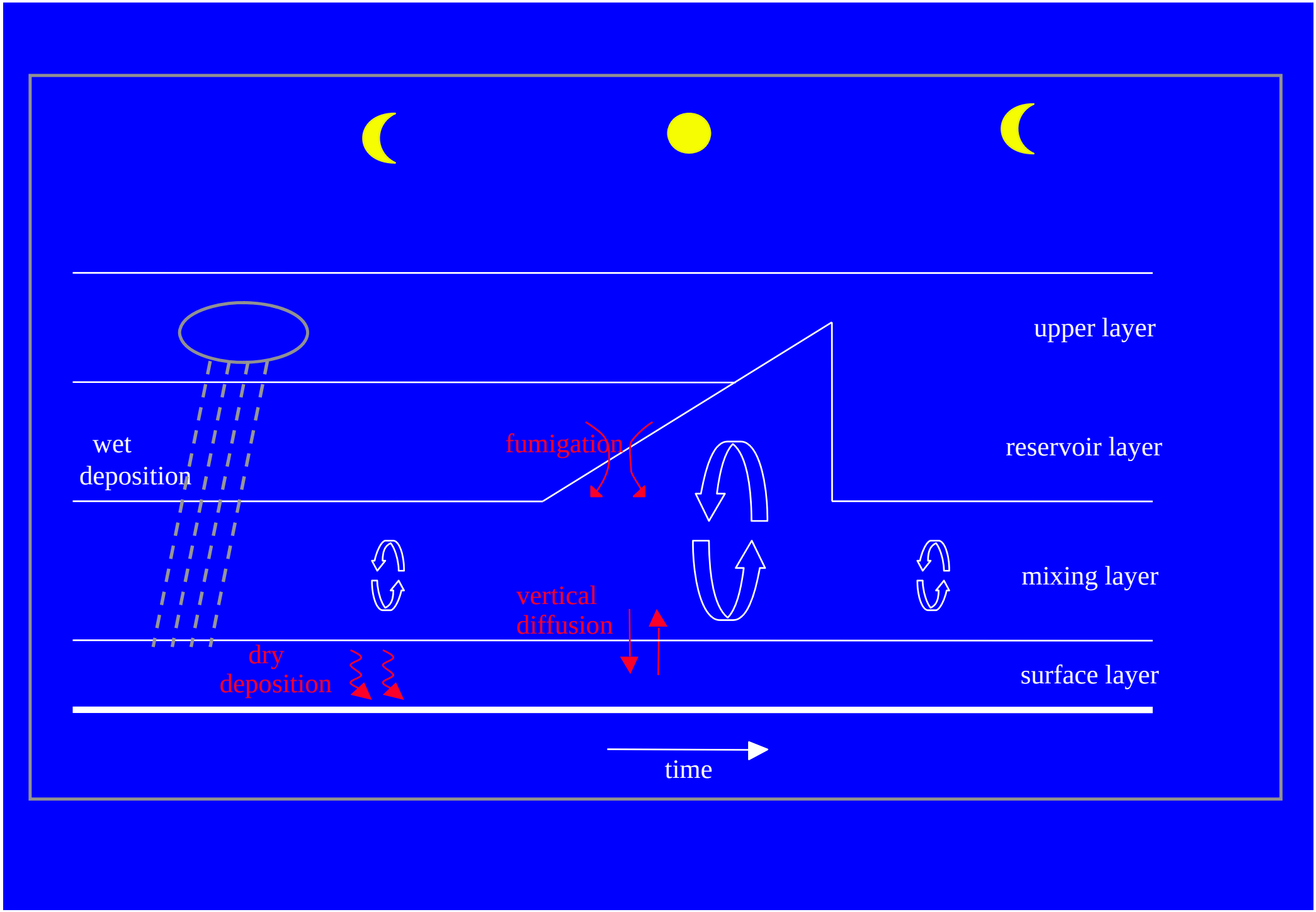
Overview of the BelEUROS-modelling system
- base grid -



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

Refined grid: resolution 15 km x 15 km (or 7.5 km x 7.5 km)




upper layer
reservoir layer
mixing layer
surface layer
wet
deposition
fumigation
vertical
diffusion
dry
deposition
time

Overview of the BelEUROS-modelling system - emissions -

- **6 pollutants**

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

- **8 emission sectors**

traffic	residential sources	refineries	agriculture
combustion	industry	solvents	nature

Results

required input data:

- meteorology: 3-D fields of wind speed & direction, temperature, humidity, cloud cover, precipitation, mixing height (ECMWF)
- emissions: per pollutant (NO_x, VOCs, …) and per sector (traffic, industry, biogenic)

but additionally

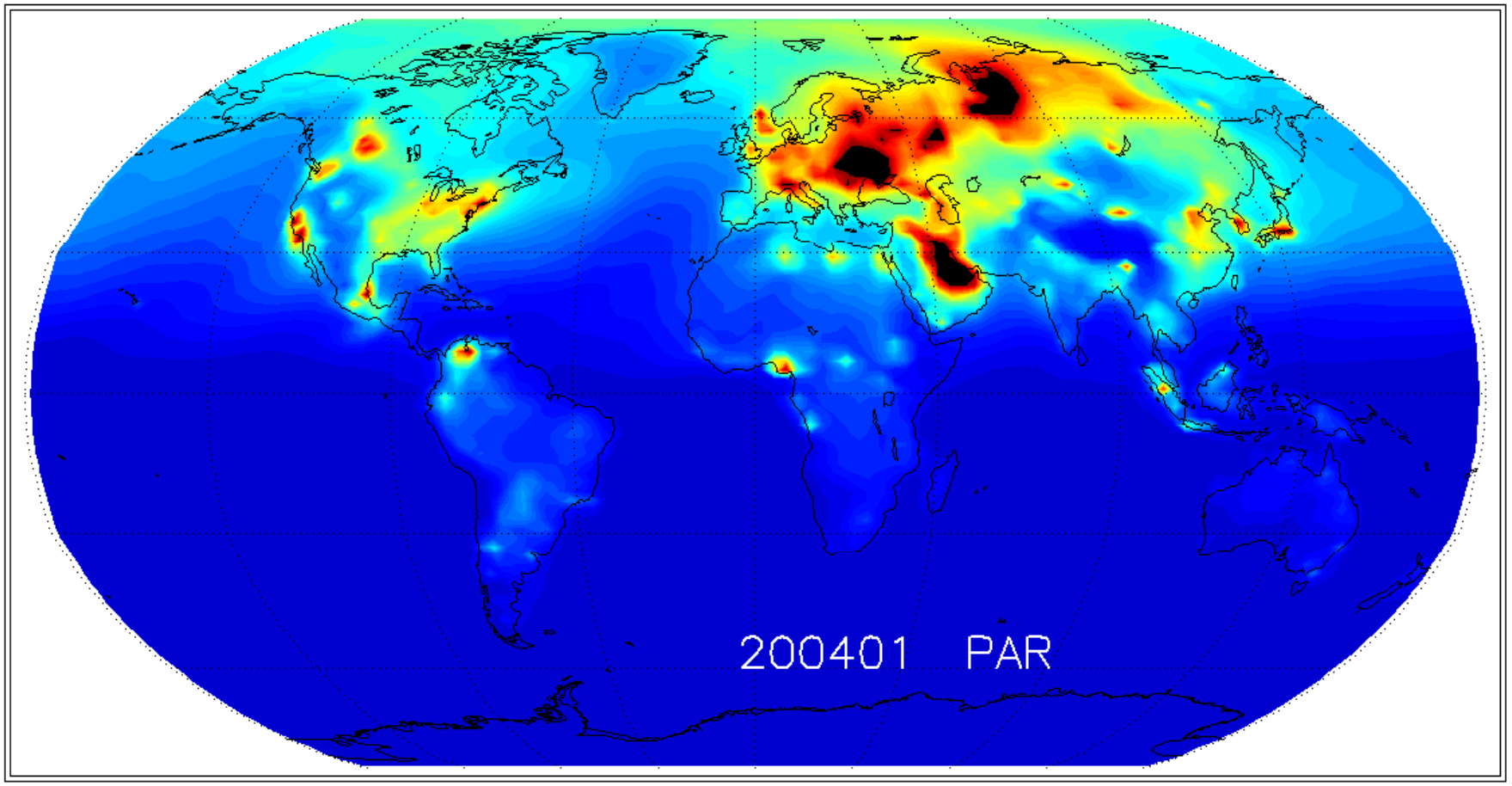
- **boundary conditions: concentrations of O_3, NO_2 and all other chemical species at the boundaries of the model domain (up to now climatological values)**; these lateral boundary values were specified as long-term (monthly) mean concentrations), but no actual concentrations for a certain period

Results

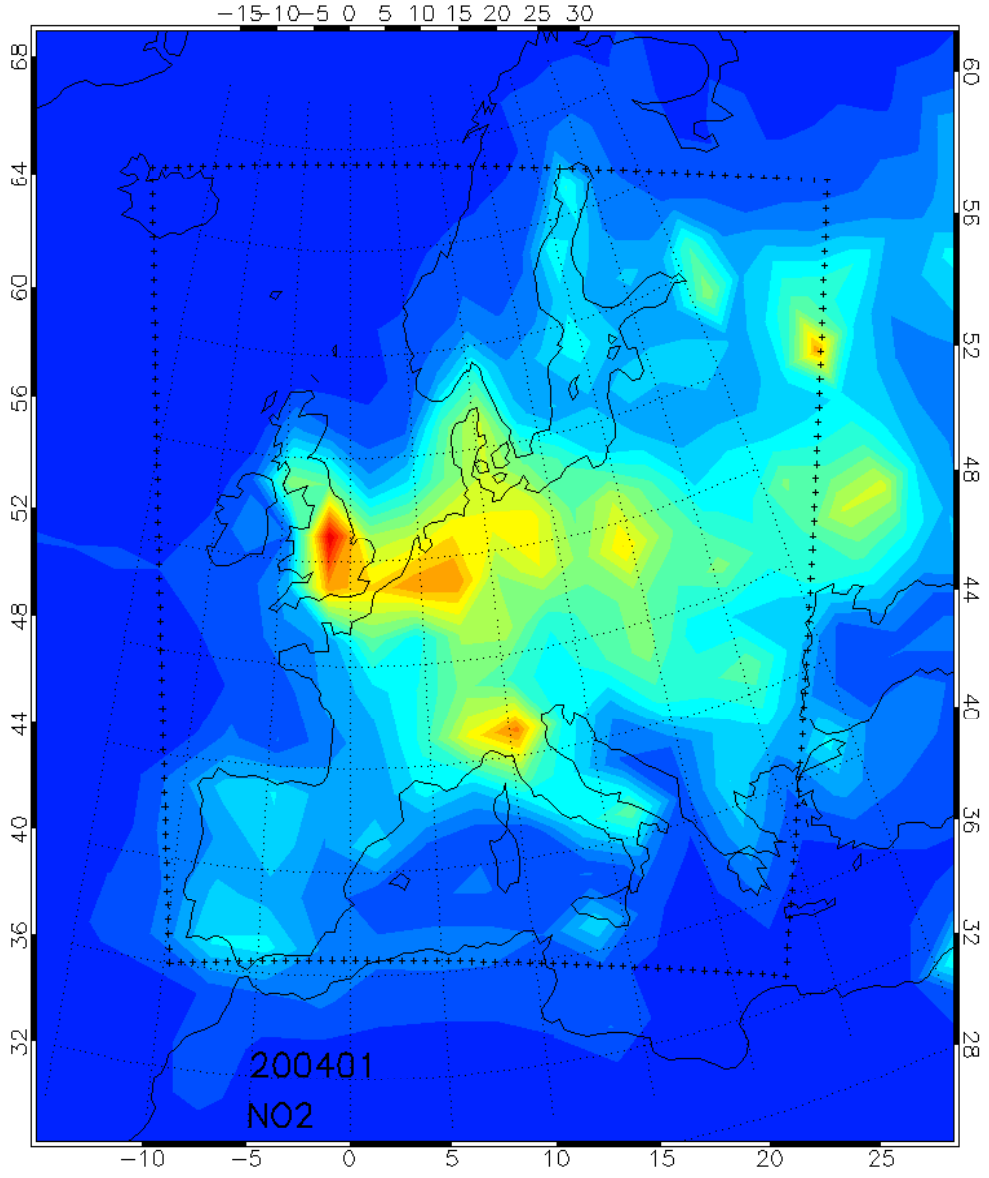
Methodology for improved boundary conditions for the BelEUROS-model

- Retrieval of 3-D concentration fields of all chemical species of the CB-IV mechanism from the global TM4 model and interpolation to the lateral grid cells of BelEUROS to replace the climatologies

Results – improved boundary conditions
TM4 concentration field

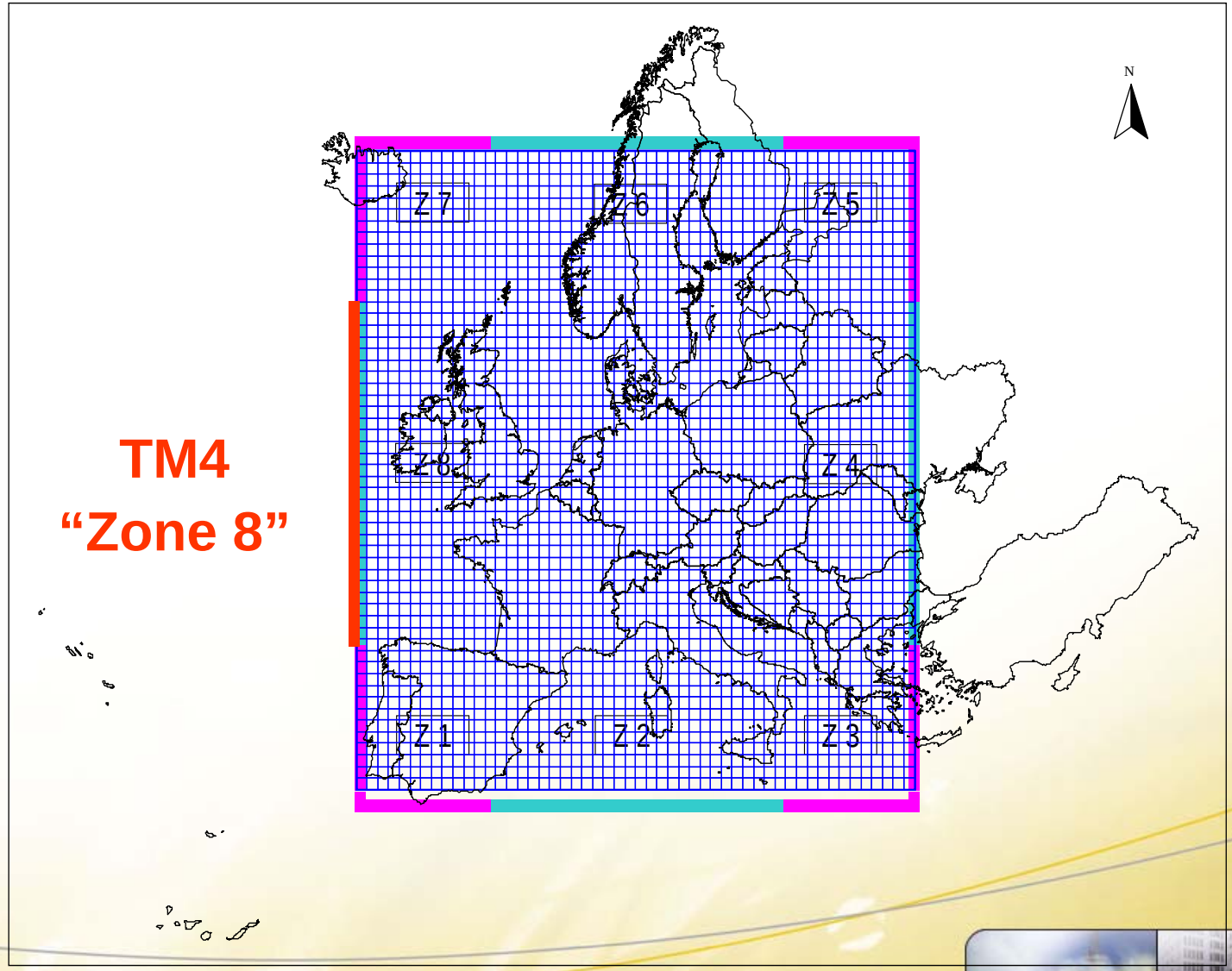


Results – improved boundary conditions



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

Results – improved boundary conditions

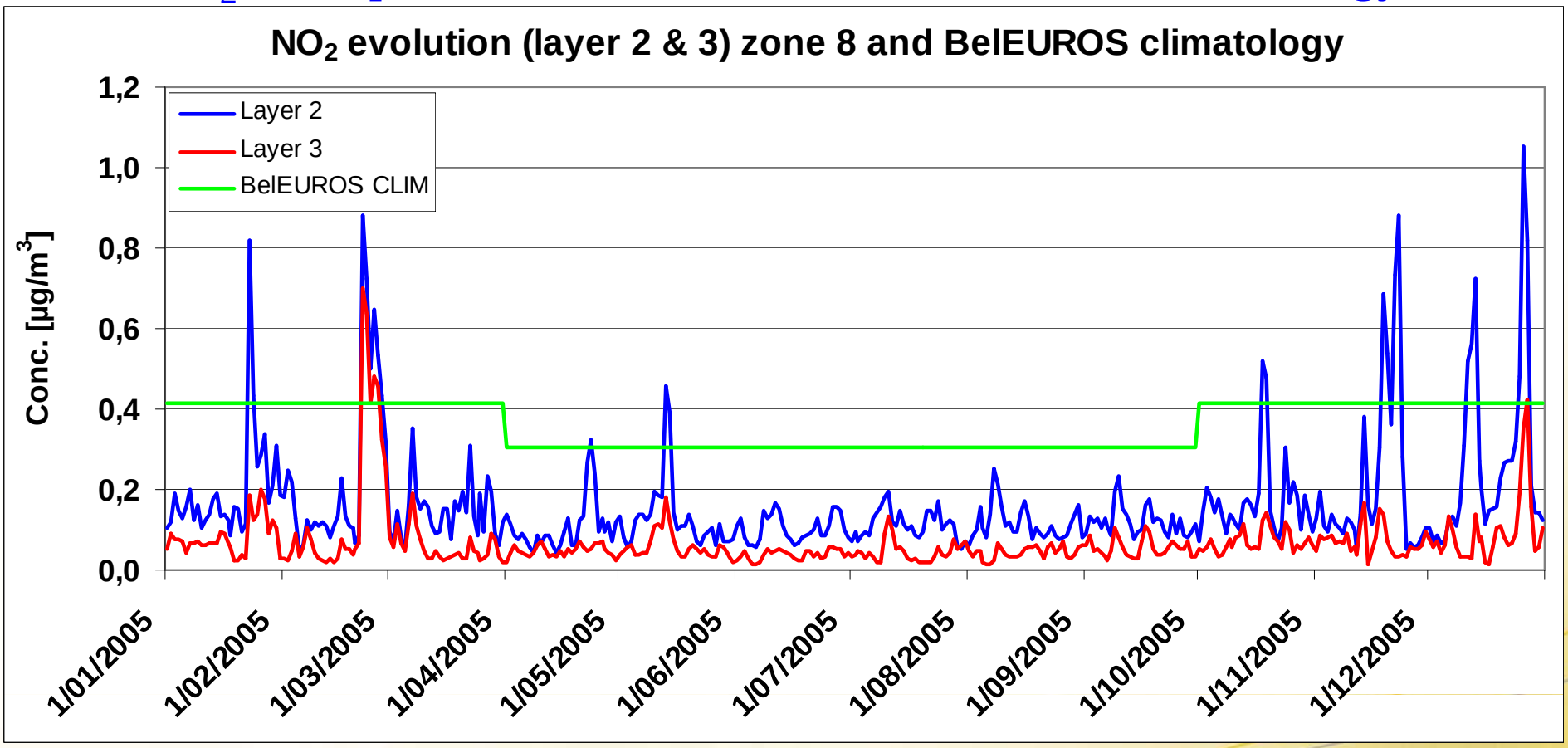


TM4
"Zone 8"

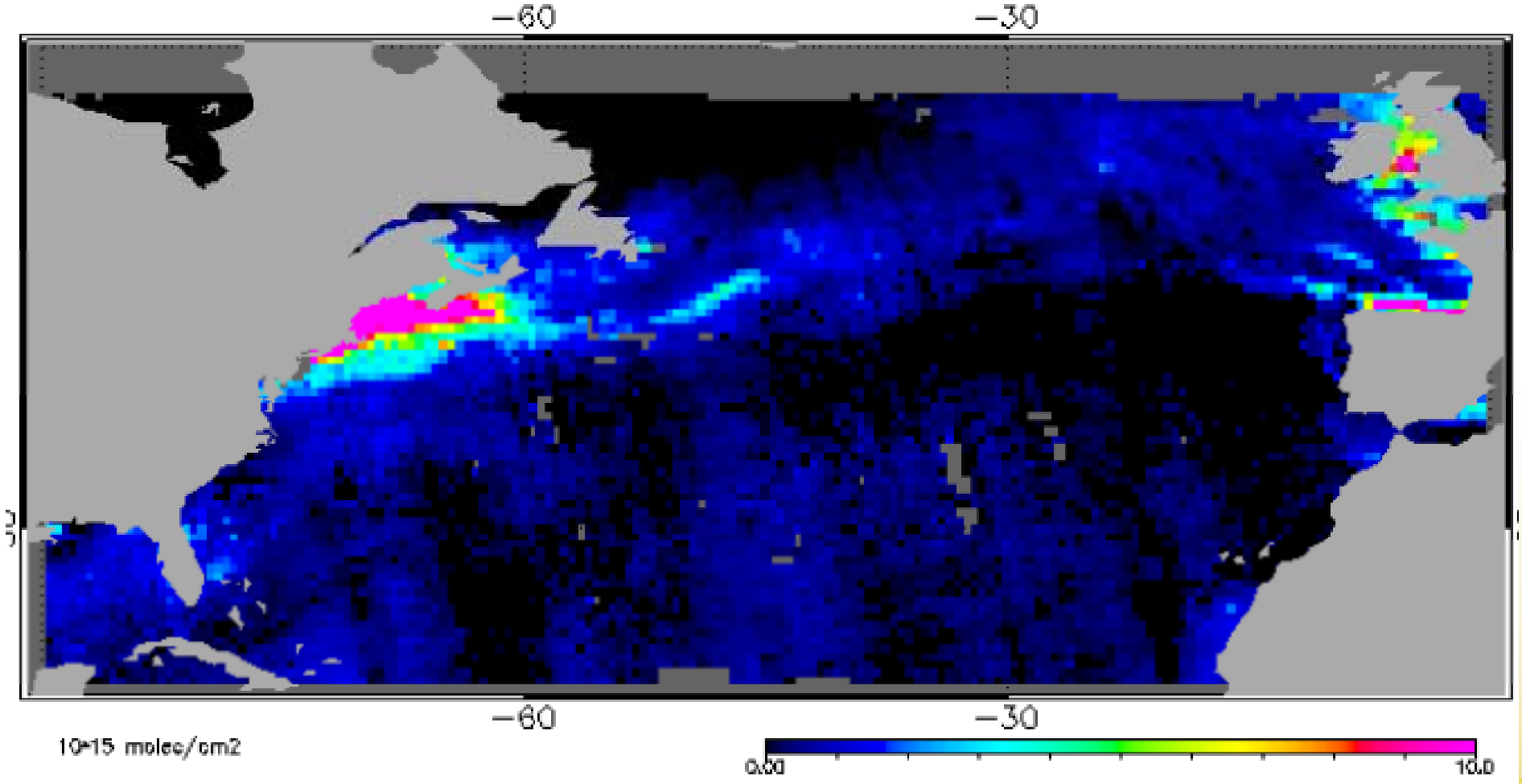
Figuur: Basisrooster van 0,55° x 0,55°.

Results: Improved BC

NO_2: Comparison of TM4 BC and BelEUROS climatology



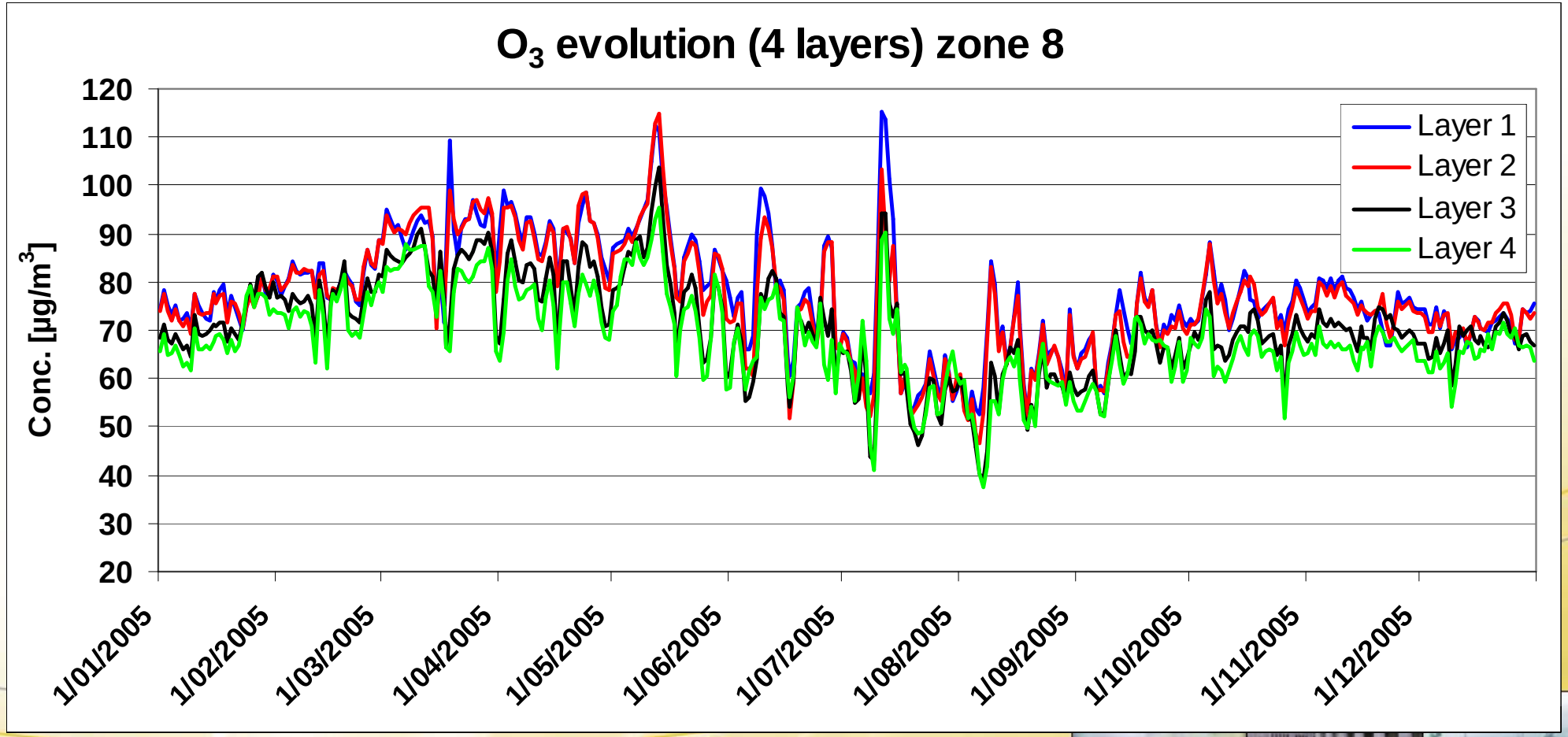
BelEUROS climatology for NO_2 slightly higher than TM4; peaks (transport events) are missing



Tropospheric column density of NO2 on 25th of December 2005 from OMI observations (Mijling et al., 2007)

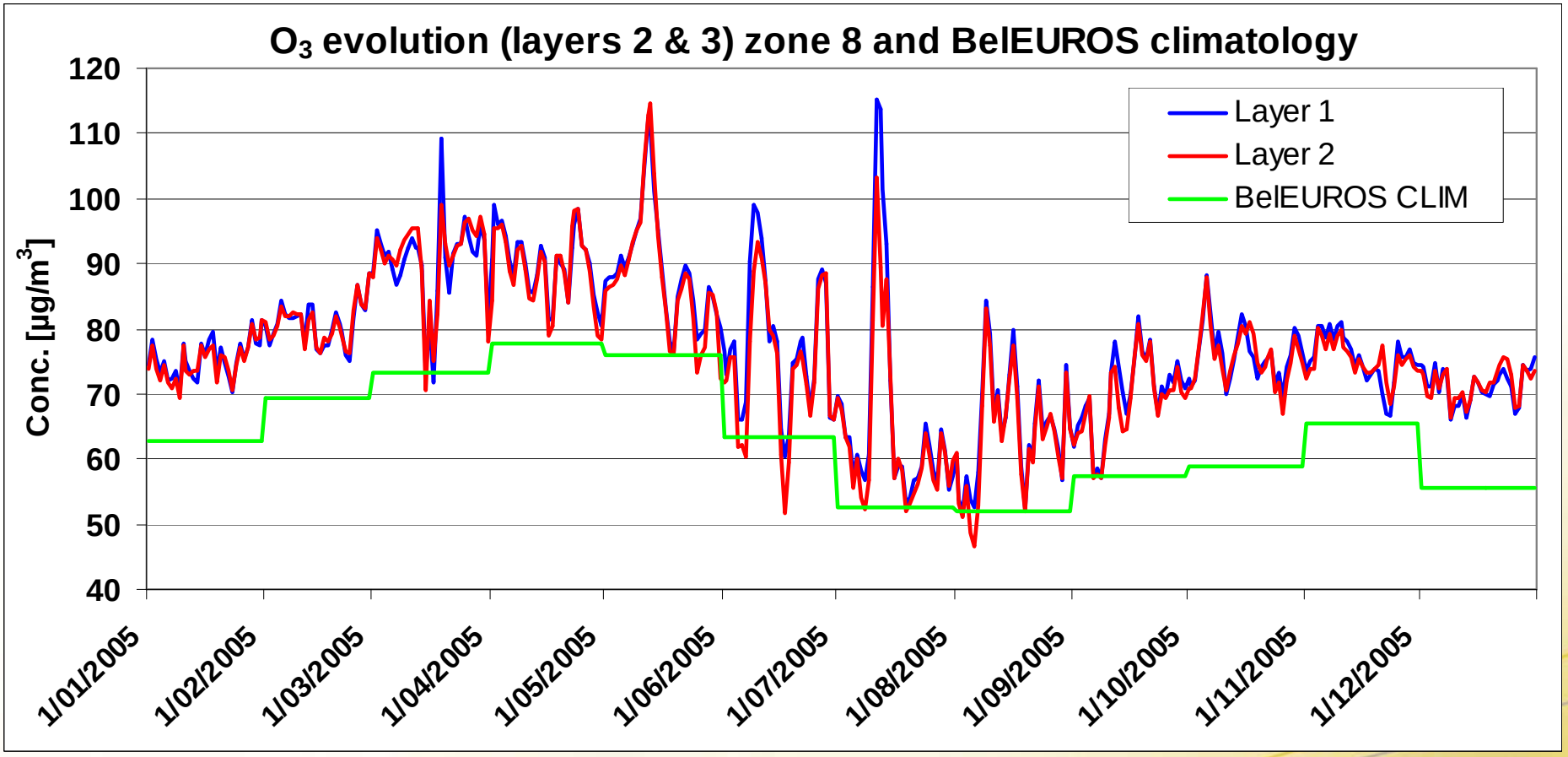
Results: Improved Boundary Conditions

Ozone concentrations at the Western boundary of the BelEUROS domain simulated by TM4



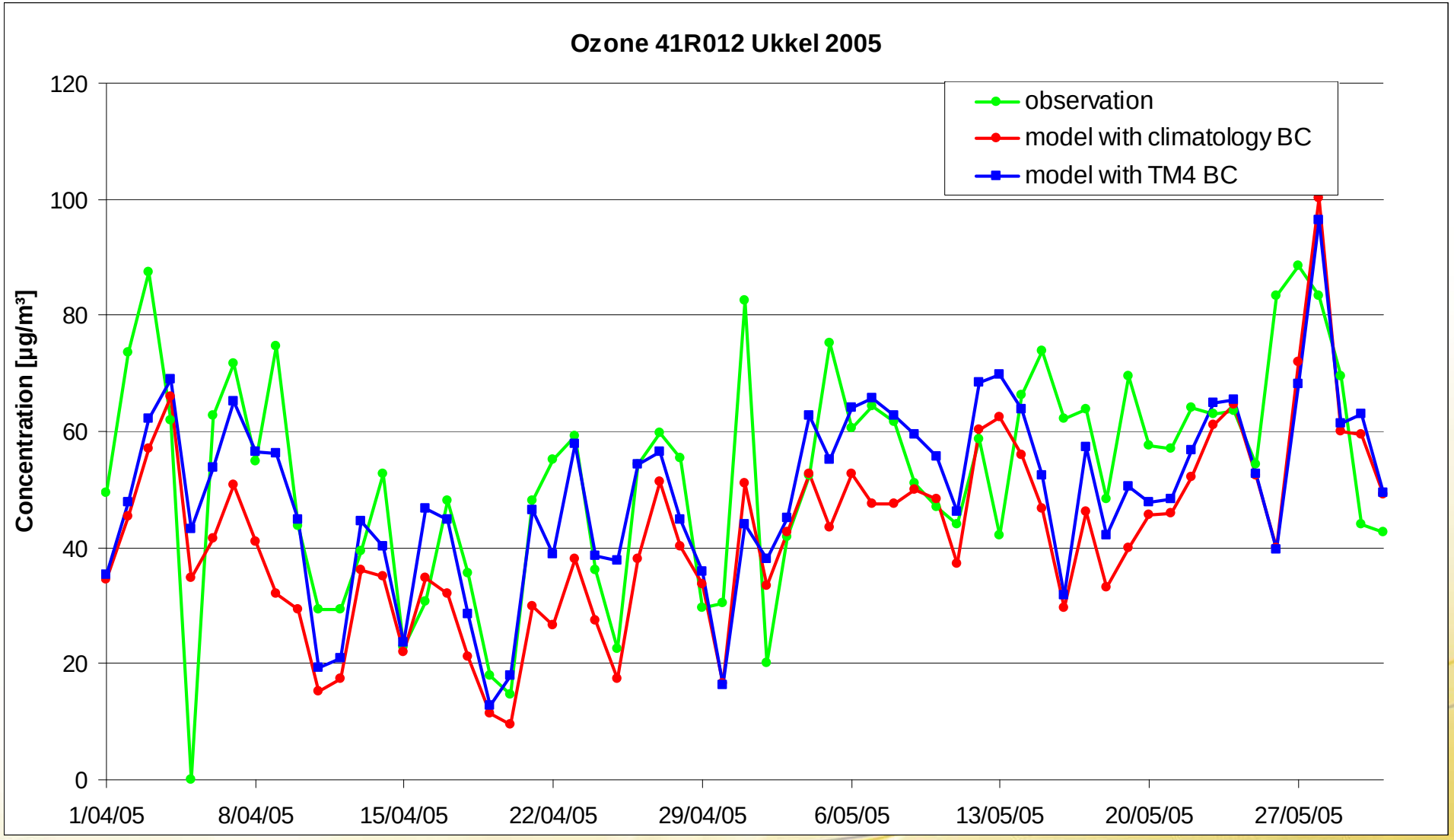
Results: Improved BC

Ozone: Comparison of TM4 BC and BelEUROS climatology



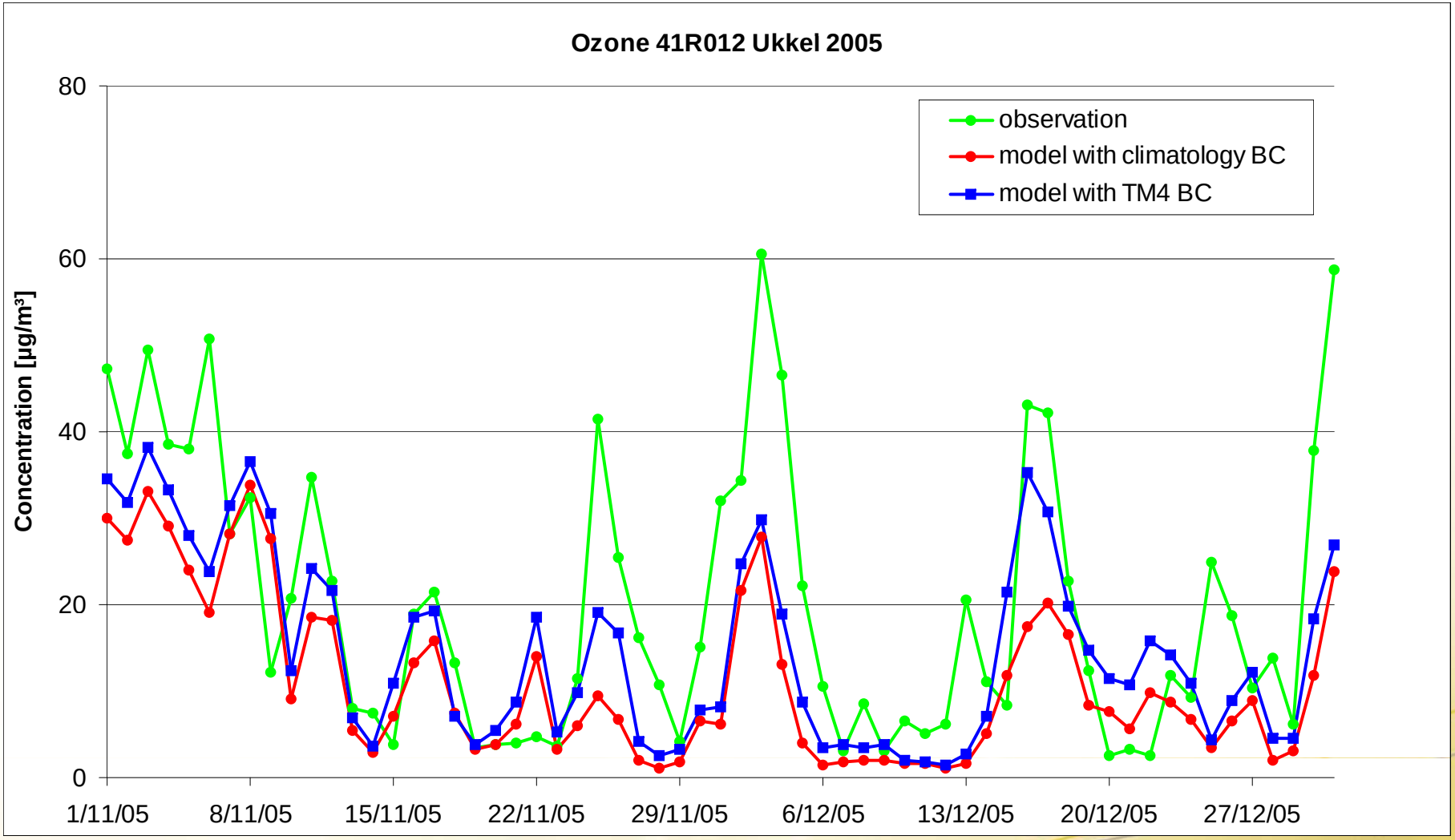
BelEUROS climatology for the mixing layer for O_3 lower than TM4

Results: Improved BC



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

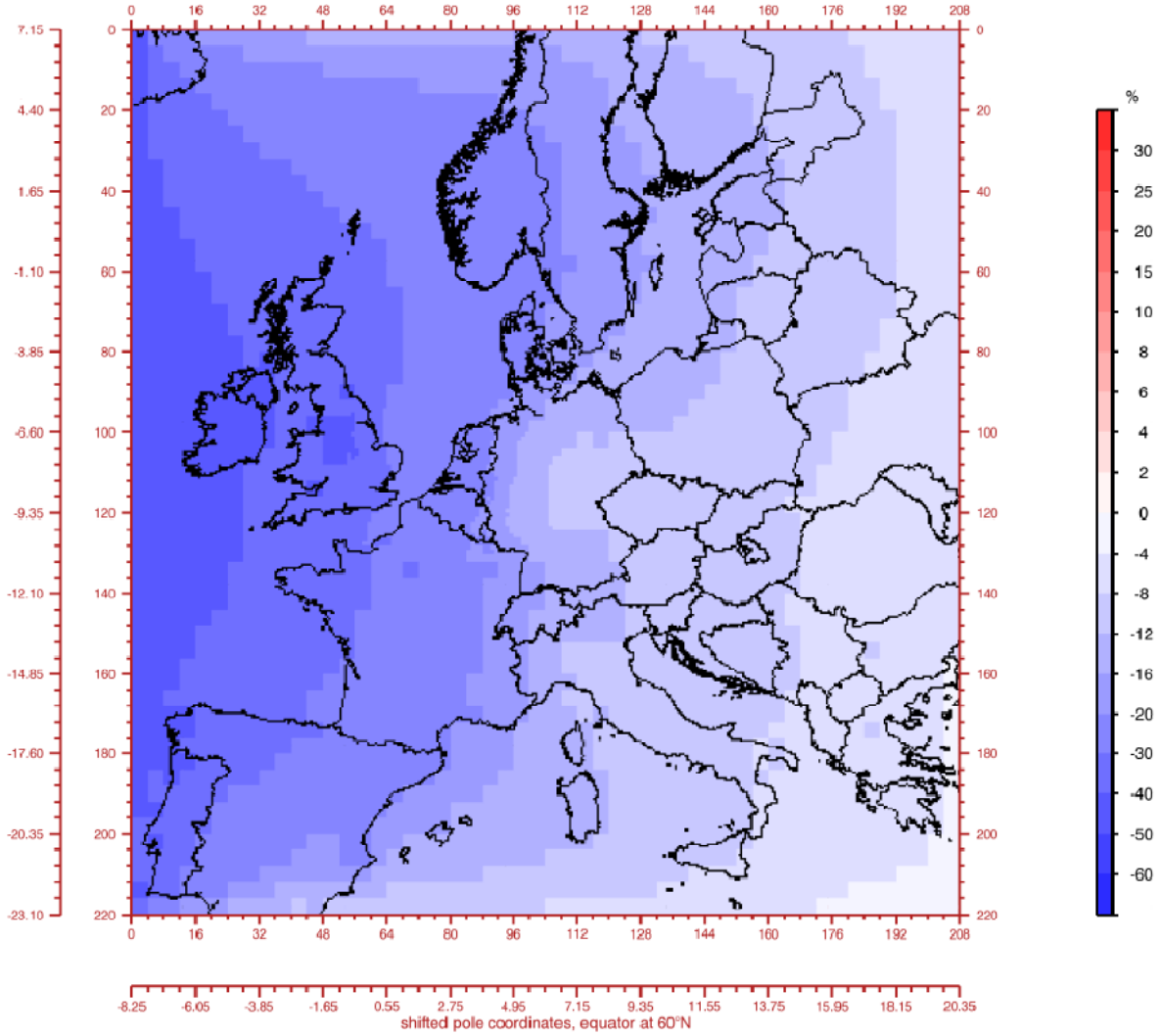
Results: Improved BC



Bias: -44,9 % (Clim.); -24,5 % (TM4)

Results: Contribution of LRTAP

Impact of transatlantic O_3 transport on European O_3-levels



relative difference between calculation with and without ozone transport from the western boundary;

Belgium: 37 % annual mean contribution

Results: Contribution of LRTAP

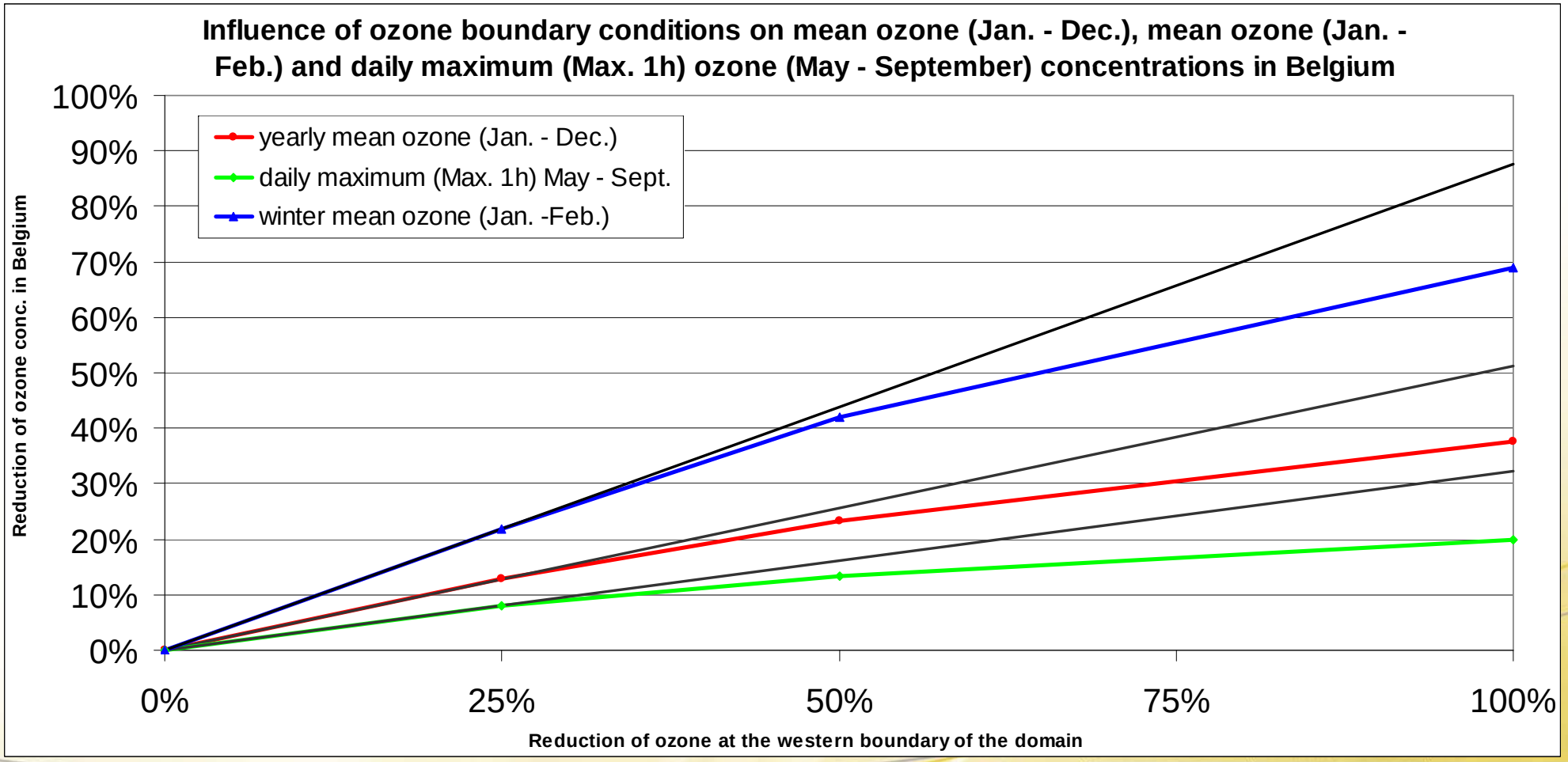
Impact of transatlantic O_3 transport on European air quality (O_3)

Reduction of western	Ozone reduction in Belgium		
boundary ozone [%]	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

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

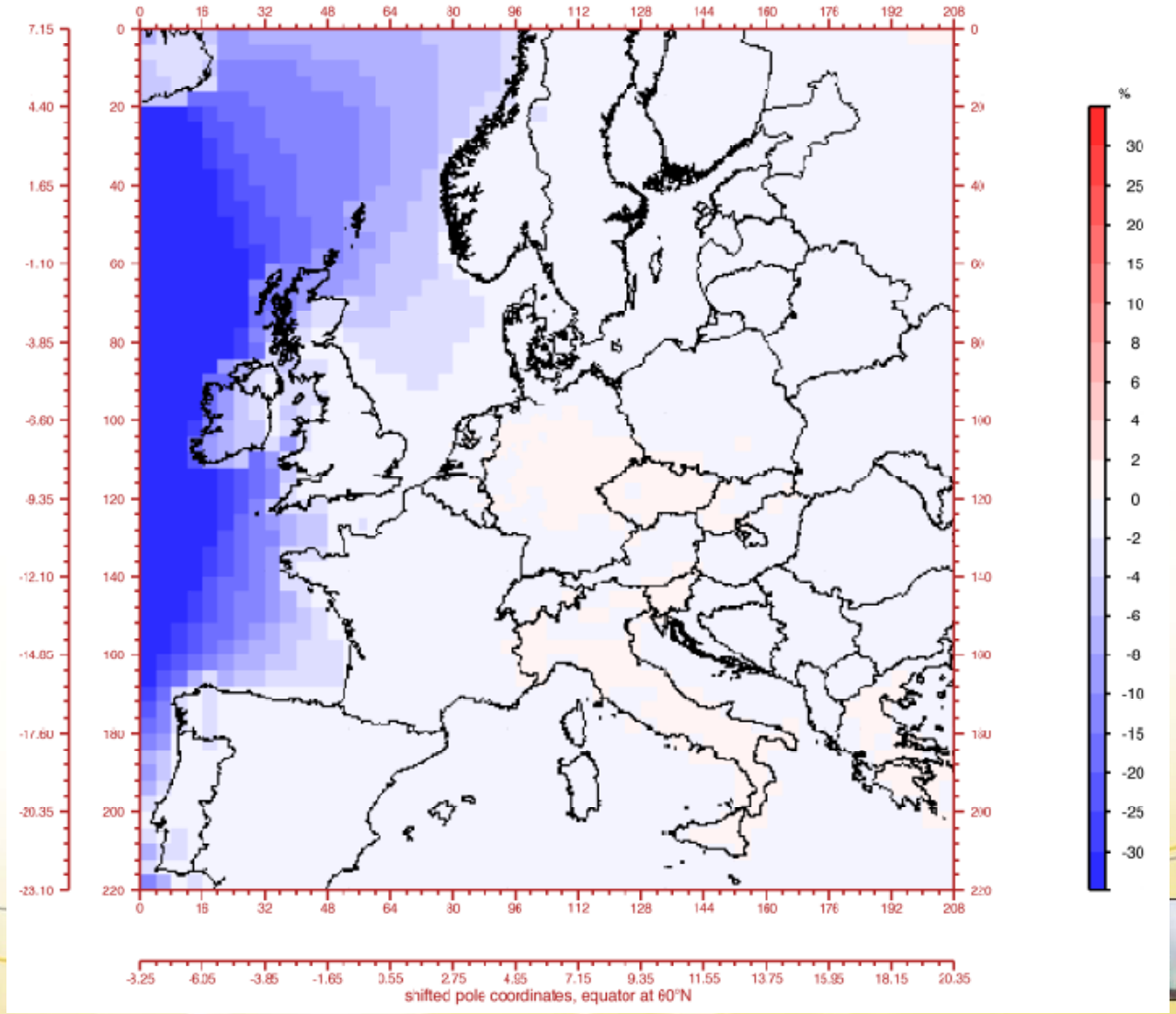
Results: Contribution of LRTAP

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

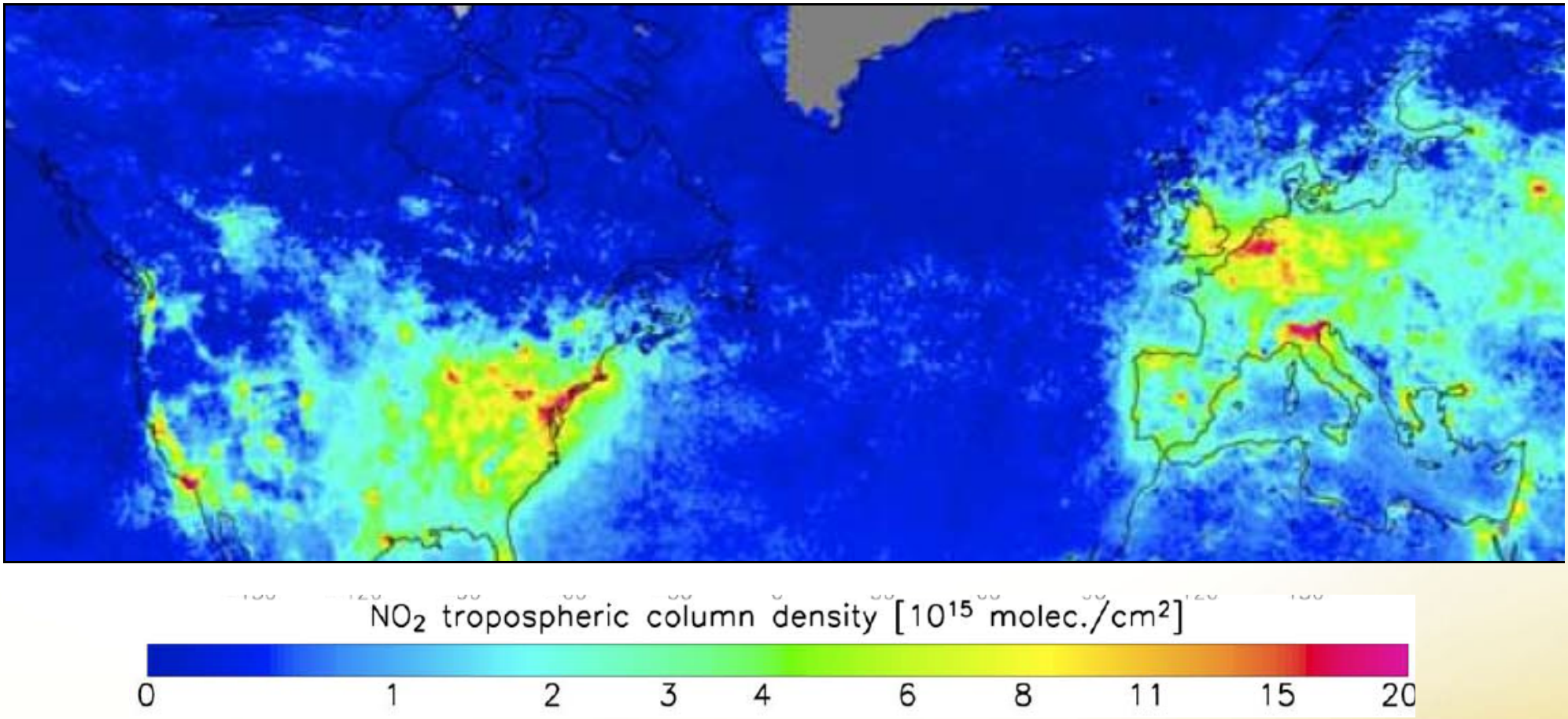


Results: Contribution of LRTAP

Impact of transatlantic NO_2 transport on European NO_2-levels

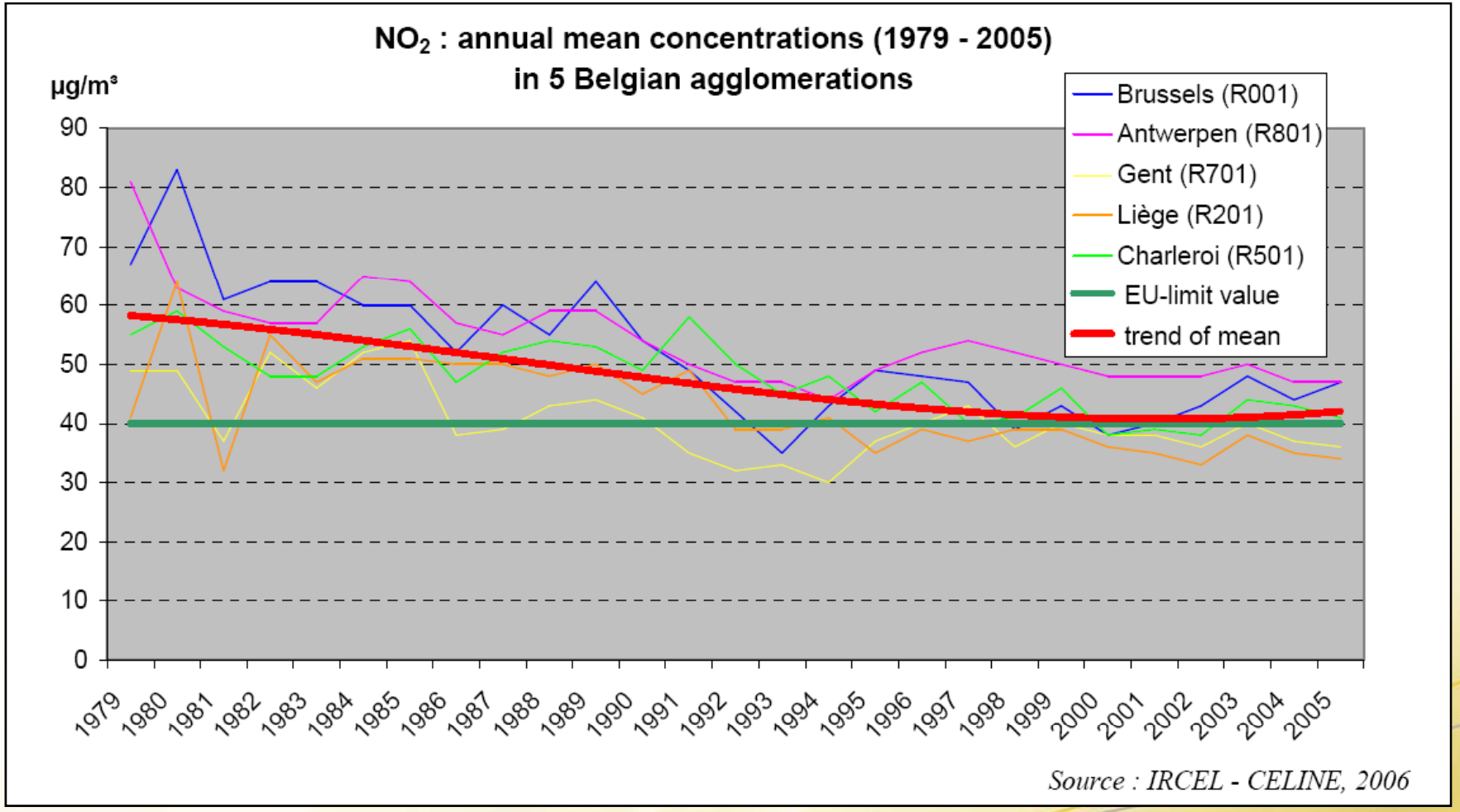


Belgium: influence of transatlantic NO_2-tranport on NO_2-levels in Belgium is very limited



Mean tropospheric NO2 column for the year 2004 from SCIAMACHY (KNMI/IASB/ ESA); from www.temis.nl

Results: Contribution of LRTAP



Conclusions

1) Nesting of the components of the ozone chemistry of BelEUROS into TM4 concentration fields resulted in more realistic representation of long range transport of air pollutants in BelEUROS simulations.

2) This improved the model performance, especially on ozone simulations in winter/spring/autumn.

3) Calculations showed a high impact of transatlantic O_3-transport on annual mean O_3 concentrations in Europe.

4) Transatlantic NO_2-transport can have an impact on NO_2 concentrations during episodes, but the influence on annual mean values is very limited.

Outlook

- Impact of O_3 – transport on NO_2 concentrations is still to be investigated.
- Model performance is expected to benefit from a further improvement of boundary conditions by using Earth Observation data, also for the fine particulate matter species
- 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

Acknowledgement

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- Thanks to ESA for financial support within the TEMIS project