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On the analysis of impact of chemistry, transport and emission sources on tropospheric ozone production in model SMOG

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Motivation

- A common problem of almost all urban areas in Europe is air-pollution resulting from the cycle of photooxidation reactions - summer photochemical smog with the tropospheric ozone (O3) as the main part. The smog episodes occur in summer months as a consequence of the high emission intensity of ozone precursors and specific meteorological conditions with the impact of solar radiation.
- To accept some appropriate measures that can prevent the high O3 concentration episodes it is necessary to know appropriate contribution of different sources, with respect to their type, height, distance etc. With respect to nonlinearity of the reactions and complexity of the problem this is not so easy task as, for example, it was for much easier sulphur dioxide pollution problem.

Goals

- To study the contribution of individual parts of emission plumes – so called “puffs” – to the places of interest.
- To estimate the role of emission intensity of individual sources, chemistry along the trajectory from the sources and mixing of pollutants from individual sources as well.
- To show how the different types and individual emission sources in particular can affect the O3 ground concentration.
- To study the contribution of biogenic emissions to the anthropogenic sources in the places of interest.
- To estimate the role of emission intensity of biogenic sources in plume of photochemical smog from urban areas.
- To show the overall efffect in appropriate period how the biogenic emissions can impact long term averages and behaviour.

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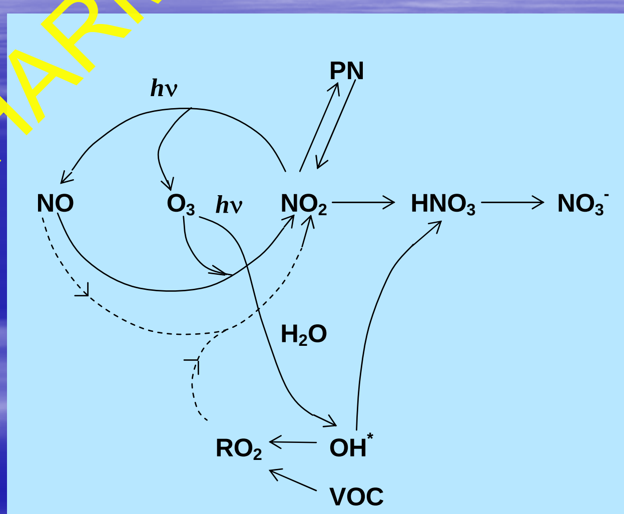
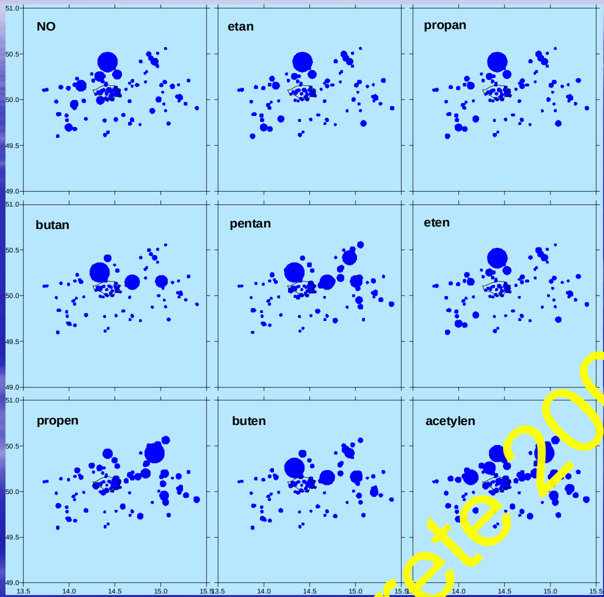
- VOC`s splitted on source level to the individual groups of organics

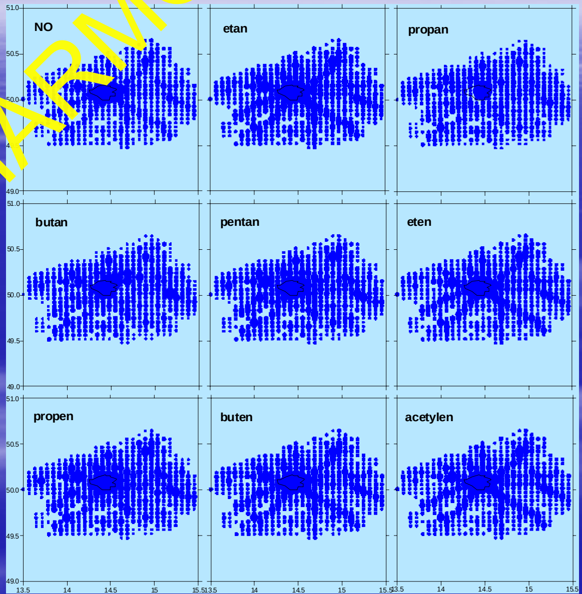
Scheme of chemical reactions



REZZO 1,2 – point sources



REZZO 1,2 – area sources



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- wet deposition: HNO_3, NO_3^-, PN

Model system couple ETA-SMOG

trajectories based on ETA NWP model (meteorological preprocessor):

- Semi-staggered Arakawa E-grid
- 0.25°x 0.25° horizontal resolution (rotated)
- 32 model layers
- centre of domain 50°N, 15°E,
- +/- 20° longitude, +/- 15° latitude

Other Choices

- ETA (NCEP) - SMOG
- MM5 (NCAR, PSU) – CAMx
- METRAS (Uni. of Hamburg) - SMOG
- ALADIN/LACE (METEO France, CHMI) – SMOG

QUANTIFY

- RegCM – CAMx
- ALADIN/CLIMATE – CAMx

EC FP6 Integrated Project

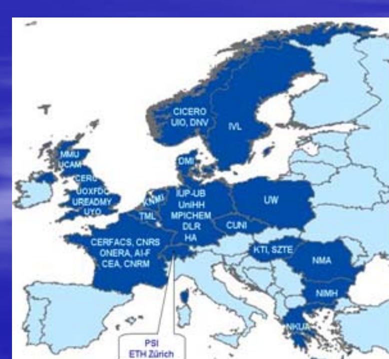
QUANTIFY

Coordinated by Robert Sausen
DLR-Institut für Physik der Atmosphäre
Oberpfaffenhofen, Germany
http://www.pa.op.dlr.de/quantify/

QUANTIFY - Quantifying the Climate Impact of global and European Transport Systems

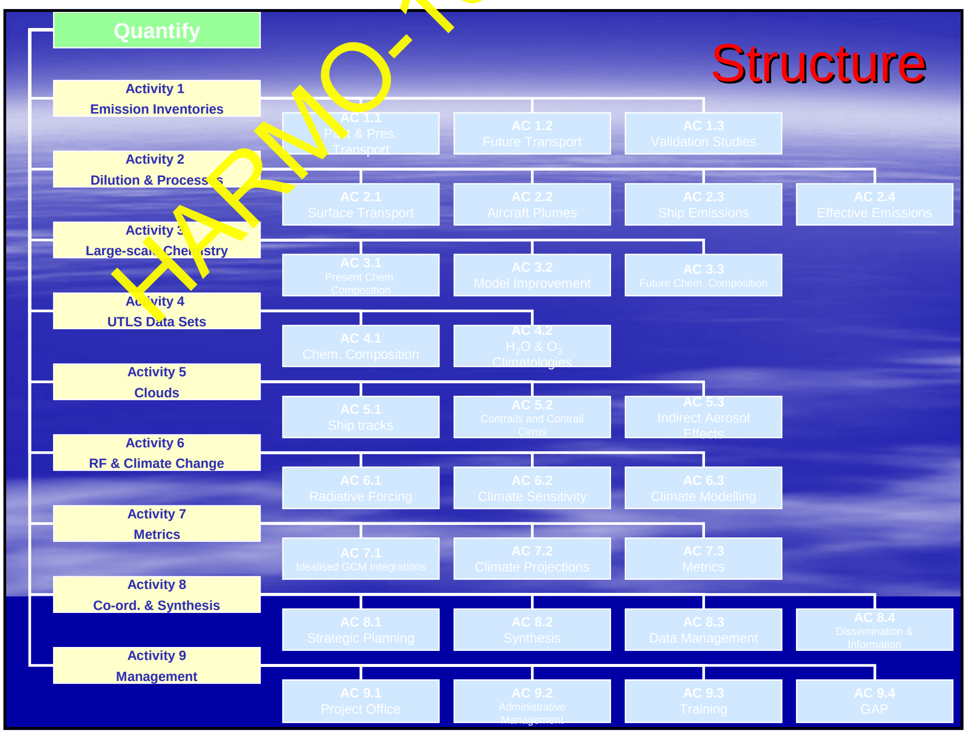
Objective:	To quantify the climate impact of the global and European transport systems for the present situation and for different scenarios of future development.

Participants:	35 from 16 countries
Start:	March 2005
Finish:	February 2010
Funds:	8.0 M€
Total costs	12.0 M€



Impact of traffic emissions on climate

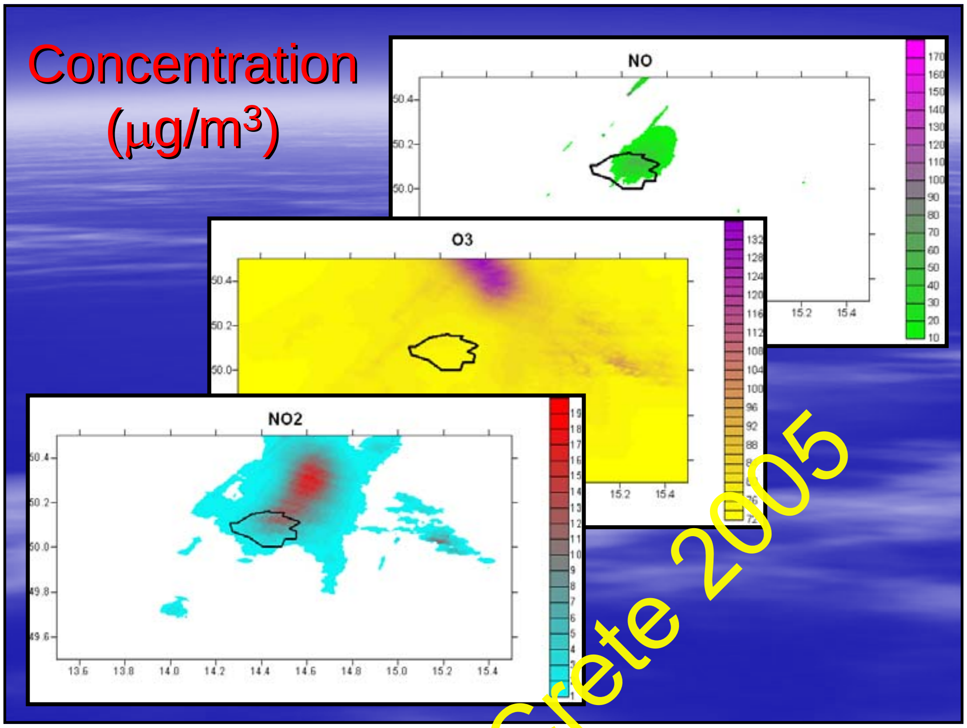
- Change of the radiative forcing by
  - the emission of greenhouse gases, including long-lived species like CO_2 and N_2O, but also of water vaour;
  - the emission ozone precursors;
  - the emission of particles and their precursors;
  - triggering additional clouds (e.g., contrails contrail cirrus) and by modifying natural clouds (e.g., ship tracks).

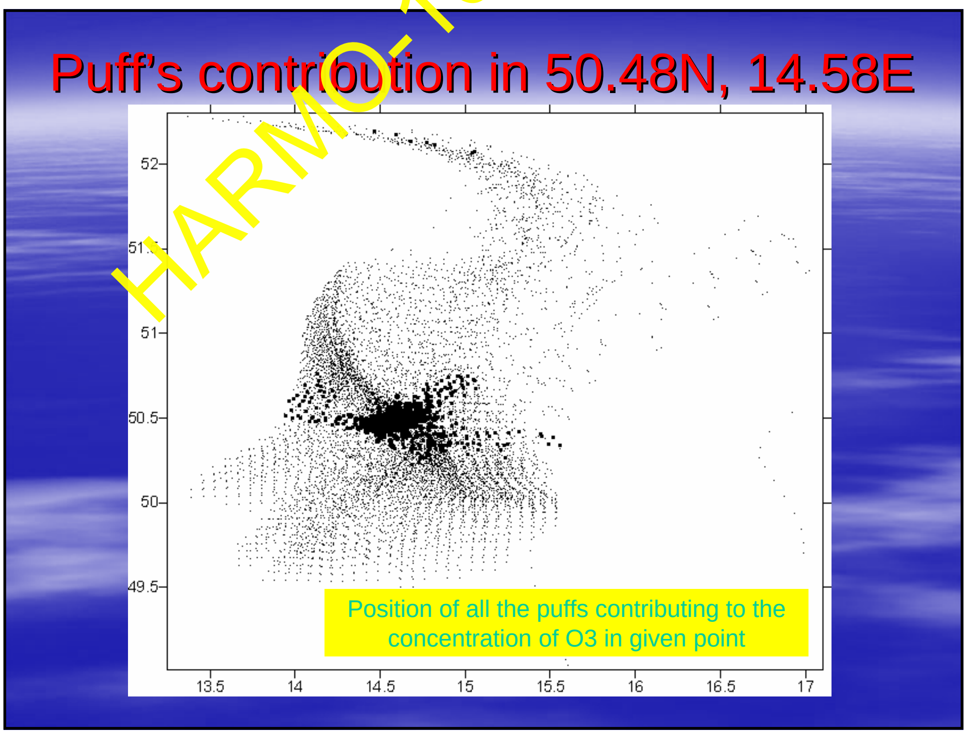


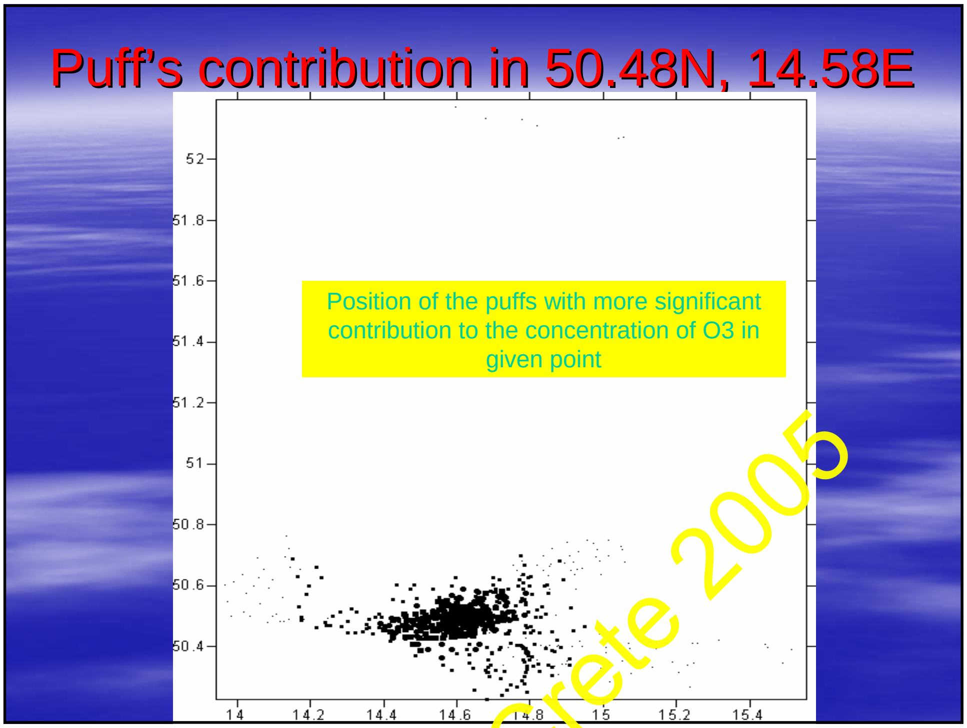
Further information

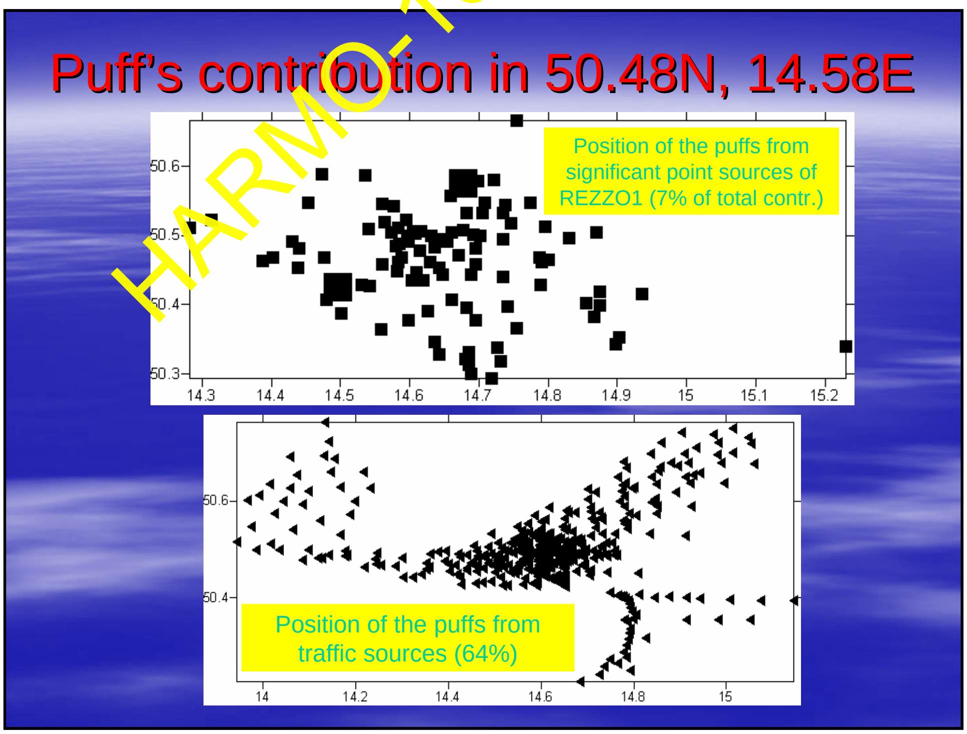
- http://www.pa.op.dlr.de/quantify/
- (http://www.quantify.eu/)

Example of results for Prague plume on 19 September 2003 – about 3000 sources

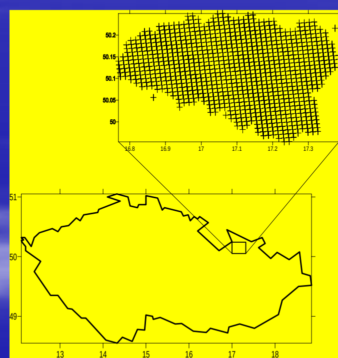

Concentration
(µg/m³)
NO
O3
NO2


Puff's contribution in 50.48N, 14.58E
52
51
50.5
50
49.5
13.5
14
14.5
15
15.5
16
16.5
17
Position of all the puffs contributing to the concentration of O3 in given point


Puff's contribution in 50.48N, 14.58E
Position of the puffs with more significant contribution to the concentration of O3 in given point
52
51.8
51.6
51.4
51.2
51
50.8
50.6
50.4
14
14.2
14.4
14.6
14.8
15
15.2
15.4


Puff's contribution in 50.48N, 14.58E
Position of the puffs from significant point sources of REZZO1 (7% of total contr.)
50.6
50.5
50.4
50.3
14.3
14.4
14.5
14.6
14.7
14.8
14.9
15
15.1
15.2
Position of the puffs from traffic sources (64%)
50.6
50.4
14
14.2
14.4
14.6
14.8
15

Example of results for remote area of Hruby Jesenik June 2002

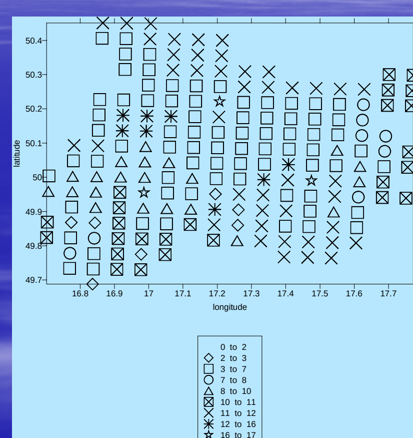


Biogenic emissions

Example of estimate

- based on land use distribution below

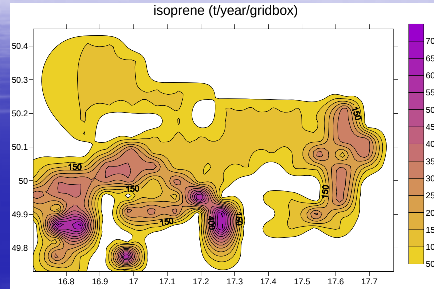
0	WITHOUT DATA
2	MIXED FOREST
3	CONIFEROUS FOREST
7	FOREST AND CULTIVATED AREAS (FIELDS)
8	FOREST AND MEADOWS
10	AGRICULTURAL AREA WITH PREVAILING ARABLE LAND
11	MIXED AGRICULTURAL AREA WITH ARABLE LAND MEADOWS
12	AGRICULTURAL AREA WITH PREVAILING MEADOWS
16	BUILT-UP AREAS (INDUSTRIAL AREAS OR SETTLEMENT)

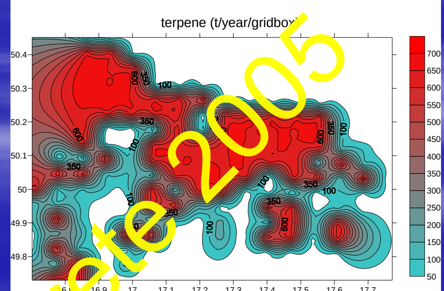


Biogenic emissions

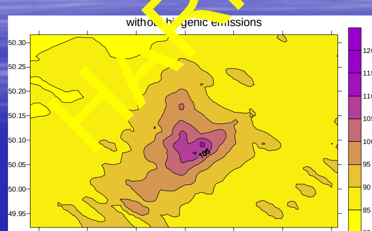
Example of estimate

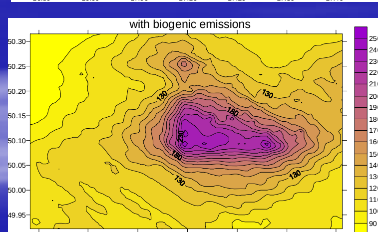
- for monoterpene and izoprene
- dependent on temperature and radiation (solar zenith angle and cloudness) – typical conditions

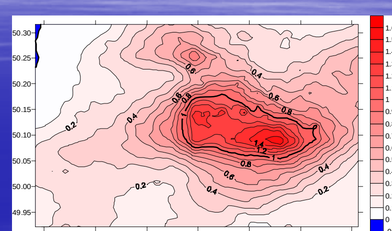




Impact of biogennic emissions



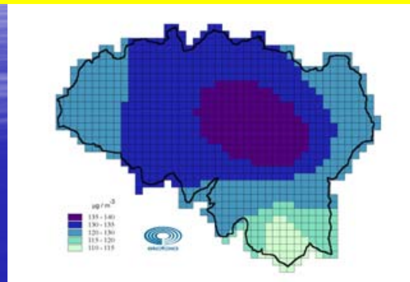




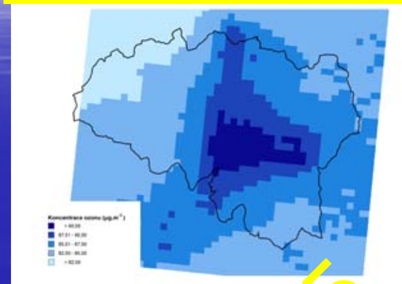
One day surface ozone concentration in mg/m3 based on simulation with and without biogenic emission

Full June 2002 simulation

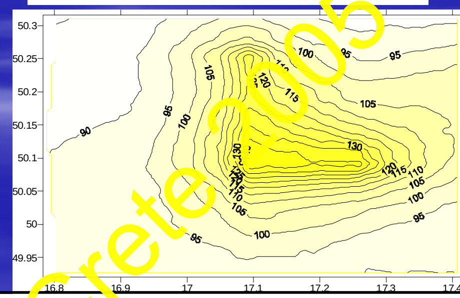
Monthly surface ozone concentration in μg/m³ based on measurement



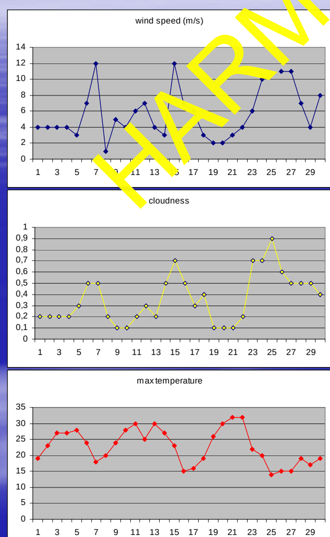
Monthly surface ozone concentration in μg/m³ based on simulation without biogenic emission

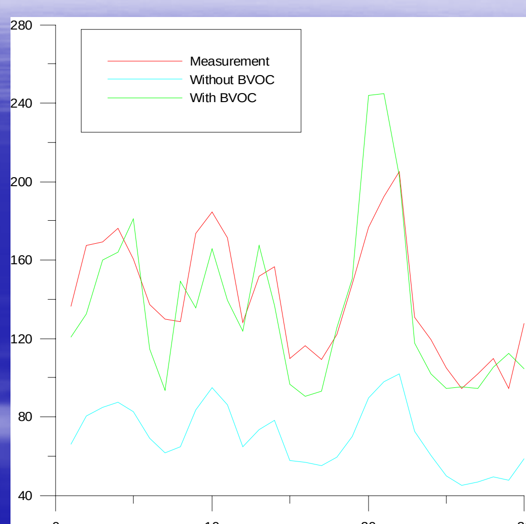


Monthly surface ozone concentration in μg/m³ based on simulation with biogenic emission



Full June 2002 simulation





Daily surface ozone concentration in μg/m³ for measurement point Cervenohorske sedlo

Conclusions

- both traffic and biogenic emissions play an important role in ozone formation
- information on puff's origin (individual emission source) on the output
- with analysis of ozone precursors contributions as well the possibility to identify emission sources where appropriate measures could be applied to reduce emission impact
- significant improvement of the comparison with measurement – impact of the biogenic emission more important than information on longer transport

Acknowledgement

This work is supported in framework of the following projects: "Mathematical modelling of air quality with applications in risk management (1ET400300414) of National Programme on "Information Society", EC project MAGMA EVG3-2002-00502 and project of The Czech Ministry of Environment VaV/740/2/01.