European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

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New Sensing Technologies for Indoor Air Quality Monitoring: Trends and Challenges

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MODEL ESTIMATES OF REGIONAL CLIMATE CHANGES AND ITS IMPACT ON THE AIR QUALITY OVER BULGARIA

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COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

EuNetAir European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

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1. CECILIA project

Extremely many scientific projects and related publications are aimed to assessment of the impact of climate changes on various areas of human activity and environment.

The EC project CECILIA (http://www.cecilia-eu.org/) is devoted to assessment of CC impacts on the environment in regional scales.

- **WP1&2 – intensive meteorological and climatic modelling**
- **WP3-6 – CC impact on water, agriculture, extreme events and others**
- **WP7 – CC impact on Air Quality**
  - **SEE on 10 km resolution**
  - **Regional Climate models used**
  - **3 time-slices: 1991-2000 (CR), 2041-2050 (NF), 2091-2100 (FF)**
  - **Fixed emissions (2000) and land-use**
  - **Boundary conditions from European scale modeling**

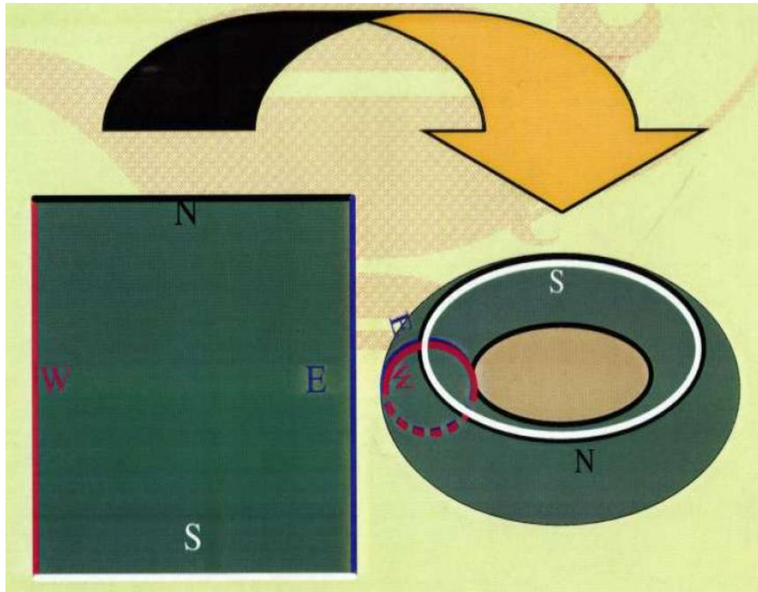
2. ALADIN Climate Model

Global Climate Models (GCM) – maximal resolution 20-30 km

Alternative: Regional Climate Models (RCM) – resolution 10 km and less.

- **ALADIN-Climate: created in a collaboration with MeteoFrance**
- **Nested by ARPEGE/IFS - GCM of MeteoFrance**

– Model description



ALADIN dynamics:

- **Spectral model on a torus (not on spere)**
- **Semi-Lagrangean advection scheme**

ALADIN physics (the same as ARPEGE):

- **Radiation scheme (Morcrette)**
- **Convective scheme (Bougeault)**
- **Precipitation (Ricard and Royer).**
- **Turbulence (Mellor and Yamada).**

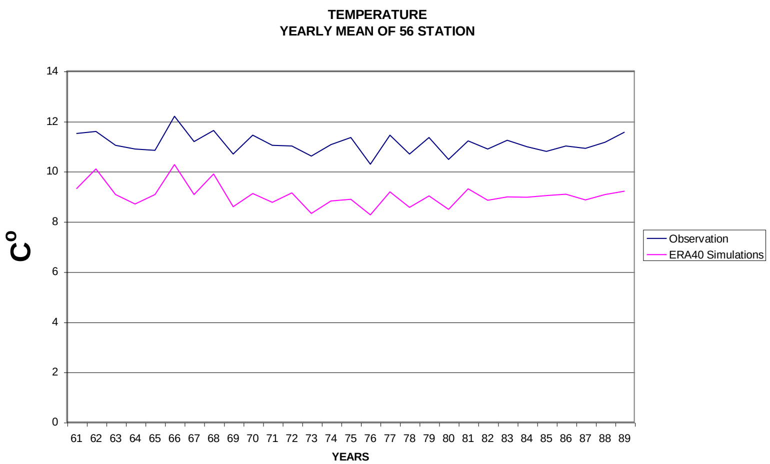
– Validation (verification)

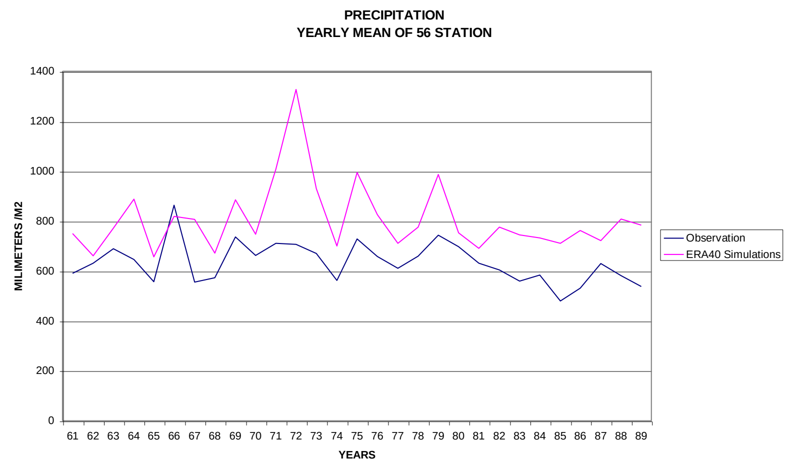
Period of simulation: 1961-2000,

Forcing (boundary conditions): ERA-40 meteorological data set

Measurement data for comparison: <u>Bulgaria</u>, temperature & precipitation

Quality of simulation:





ALADIN-Climate errors: 2° for temperature; 15% for precipitation

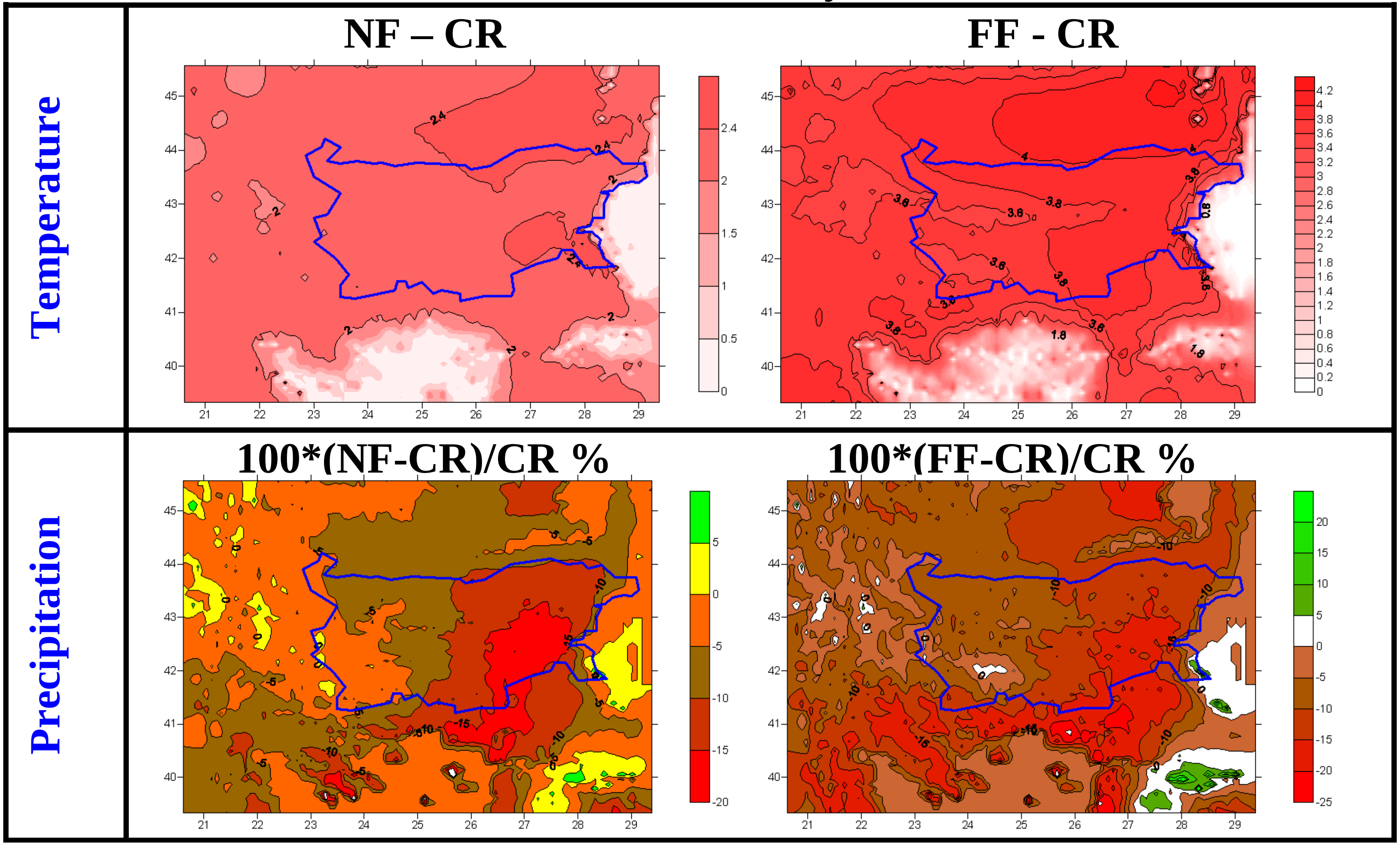
Curves parallel: i.e. systematic errors

GCM errors: 4° for temperature; 25% for precipitation

<u>The decrease of resolution to 10 km increase the quality of simulations.</u>

3. Modeled Climate Changes

Presented differences between Future (NF, FF) and Present (CR)
The differences will eliminate the systematic errors



4. AQ Modeling

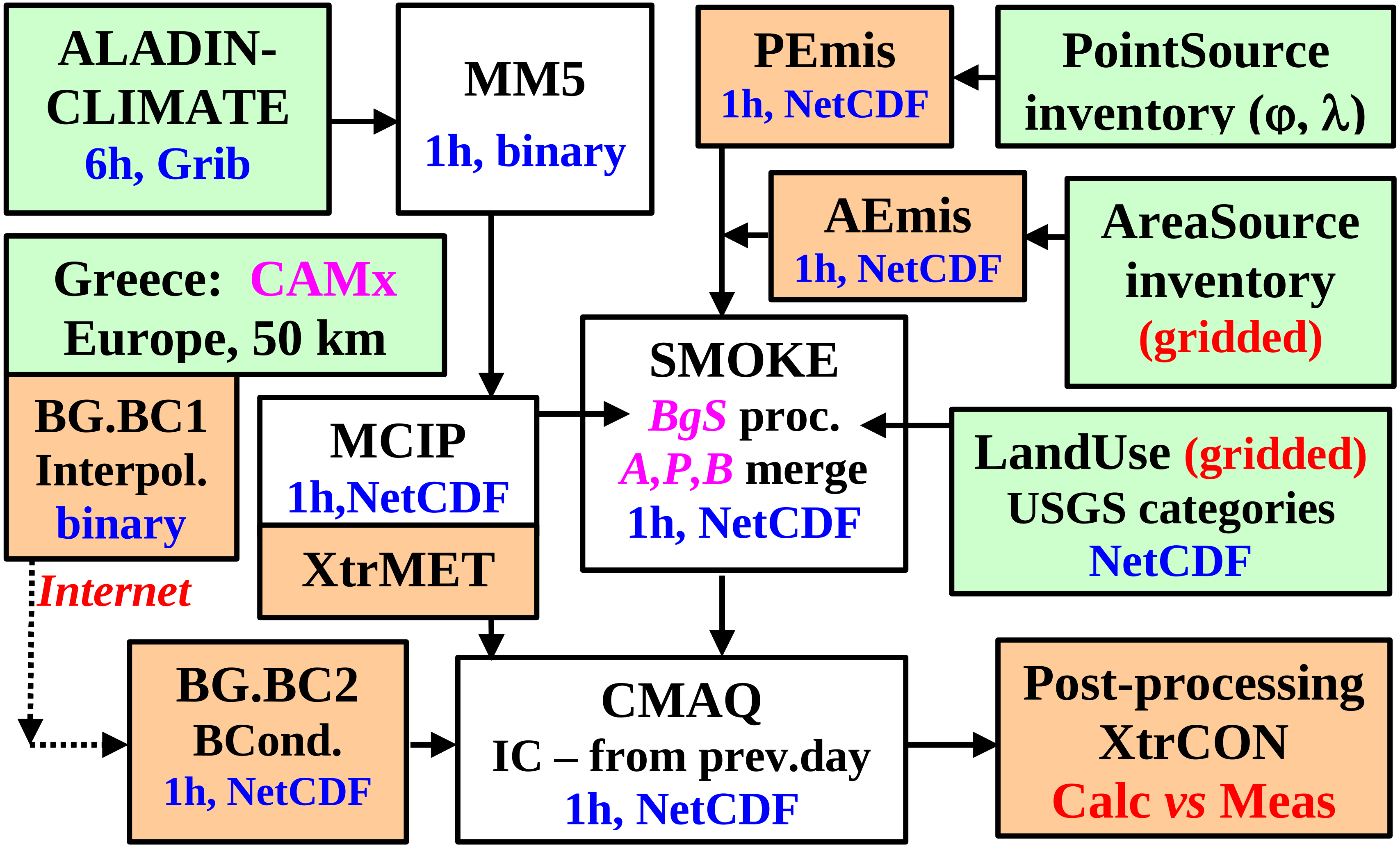
– Models used

Bulgarian Air Quality Impact group uses the US EPA Models-3 modeling system, consisting of

- **CMAQ - (Community Multi-scale Air Quality model), the chemical-transport model (CTM) of the System;**
- **MM5 - the 5th generation PSU/NCAR Meso-meteorological Model used as meteorological pre-processor to CMAQ, and**
- **SMOKE (Sparse Matrix Operator Kernel Emissions Modelling System) – emission pre-processor to CMAQ.**

A number of interfaces (scripts and Fortran codes) created as to link those models in a system with the different types input information.

– Data flow diagram



– AS, LPS, BgS emissions

Iinventory emissions (GEMS inventory - TNO)

Area emissions and LPS emissions

Fortran codes AEmis and PEmis created.

Input: gridded inventory, temporal and speciation profiles, predefined SNAP specific effective heights for LPS (650 m, 400 m, 400 m and 150 m)

Output: NetCDF files for 1-hour emissions for every day of the year

Pollutants: 22 (CO, NH3, NO, NO2, SO2, SULF, 10 VOCs, PMC, 5 PM2.5)

Biogenic emissions

SMOKE's *Biogenic Processing* used

Input: 1. gridded LandUse, USGS 1-km data base, 24/230 categories

2. meteodata – MCIP output

Output: NetCDF files for 1-hour emissions for every day of the year

CMAQ emission input

SMOKE's *MrgGrid Processing* used to merge Area and Biogenic emission files as a common NetCDF file, 1-hour basis, for every day of the year

– CMAQ calculation: IC and BC

Initial conditions: previous day's last hour concentrations (CMAQ option)

Boundary conditions (two-fold interface created, see data-flow scheme)

- Extraction from 50-km AUTH RegCM/CAMx data base
- Transformation to CMAQ pollutants and creation of BC input file
- All BC for all 3 periods (CR, NF, FF) extracted and saved

Output

NetCDF file on 1-hour basis for all fays of the year (14 layers)

Pollutants: 78 pollutants, from which:

- 52 gaseous
- 21 aerosols (Aitken and accumulation modes)
- 5 aerosol distributions (3 by number, 2 by aerosol area)

Archived: surface values for 17 most important pollutants (incl. O3, SOx….)

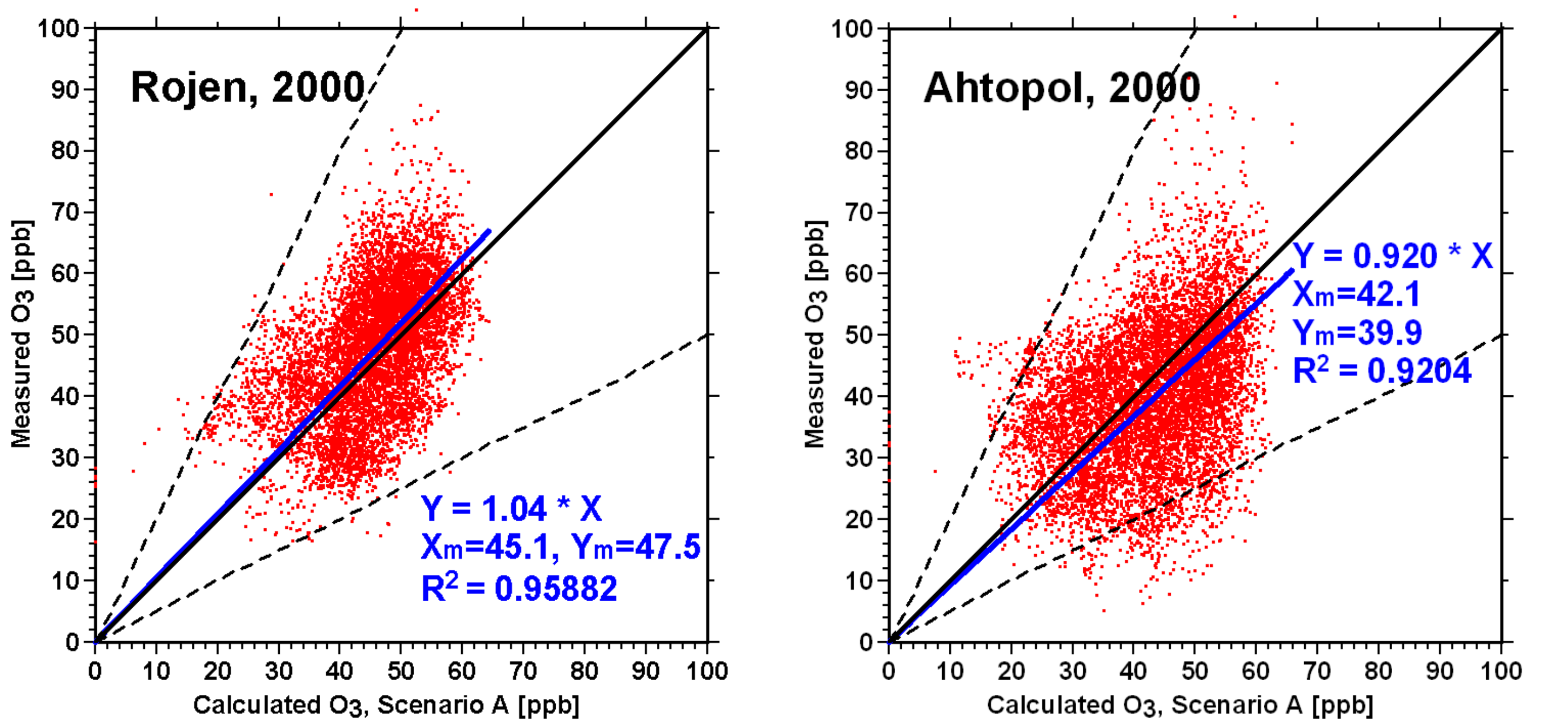
COST is supported
by the EU Framework Programme

ESF provides the COST Office
through a European Commission contract

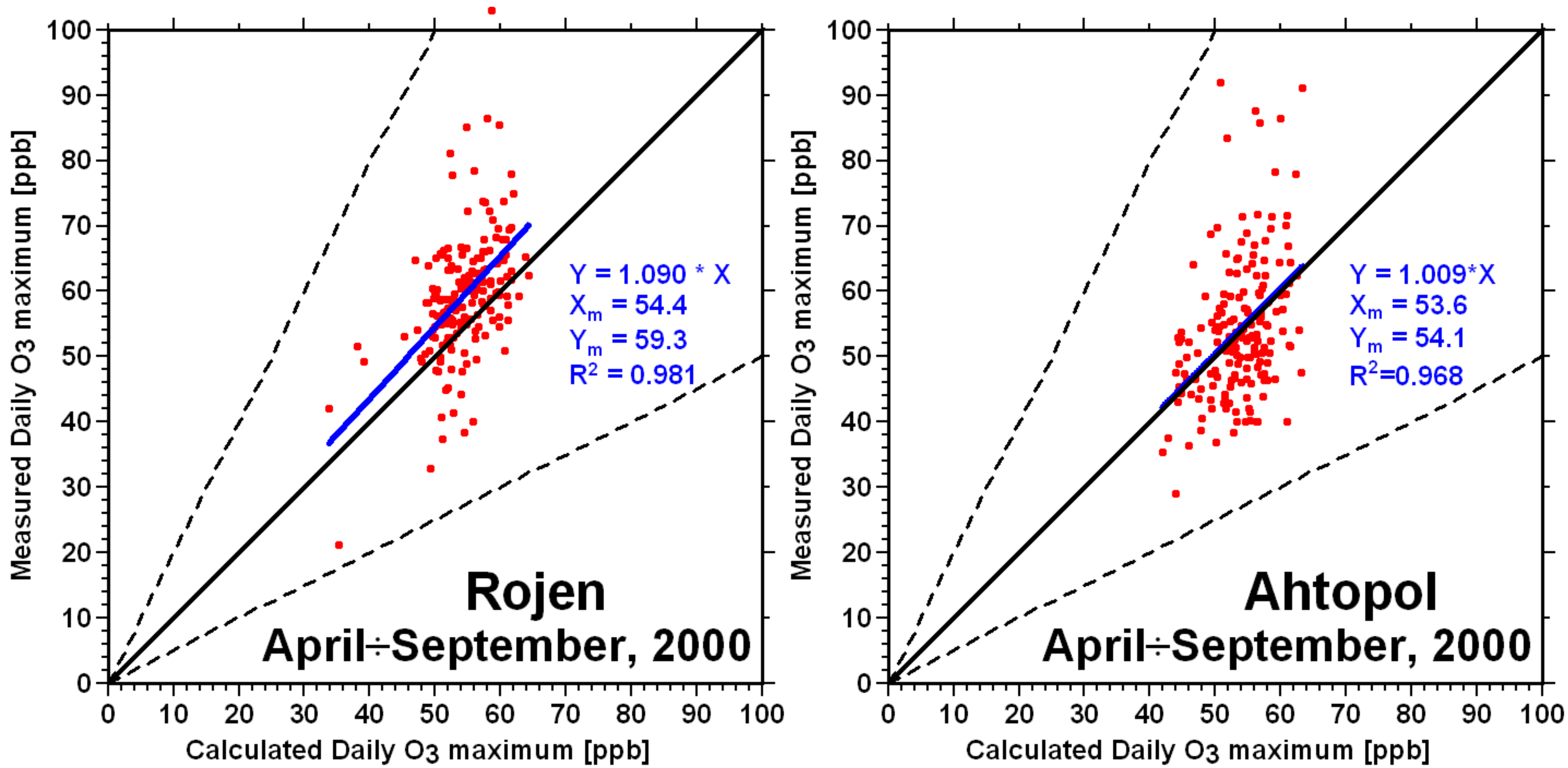
– Validation (verification)

Only OZONE measurements for 2000 available (hourly values)
2 measuring points: Rojen (Rodopi mountains) & Ahtopol (at Black sea)

Scattered diagrams:



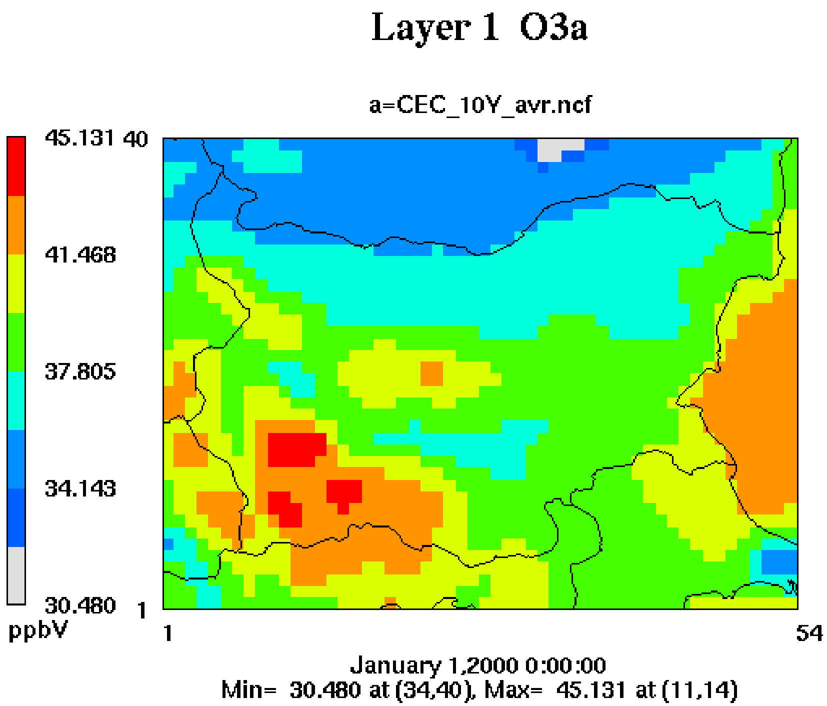
Scatter diagrams of ozone ADM (Calc.*vs*.Measur)

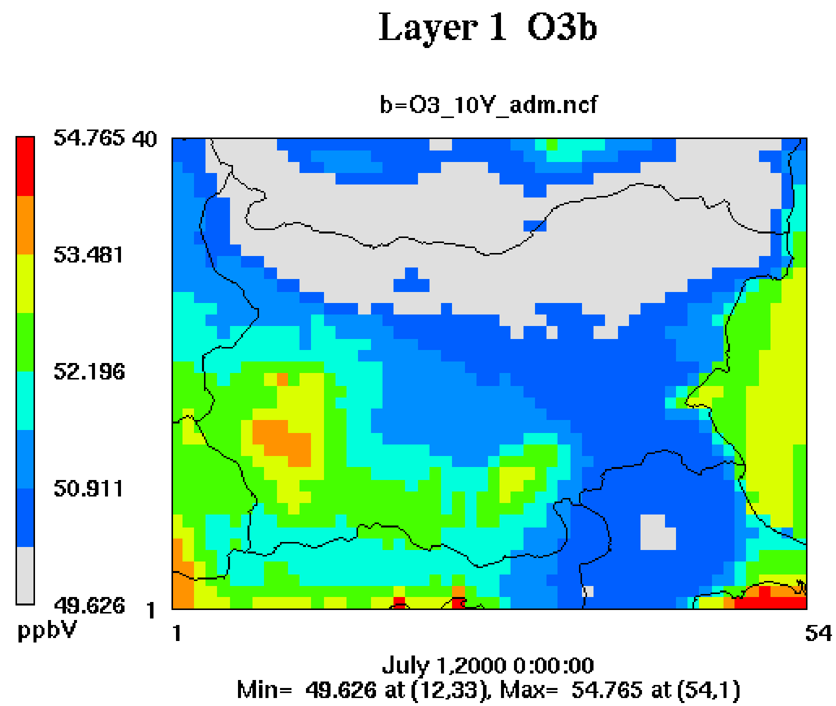


Conclusion: ALADIN/CMAQ is able to give good assessment of AQ

6. Current climatic AQ levels (CR simulation results)

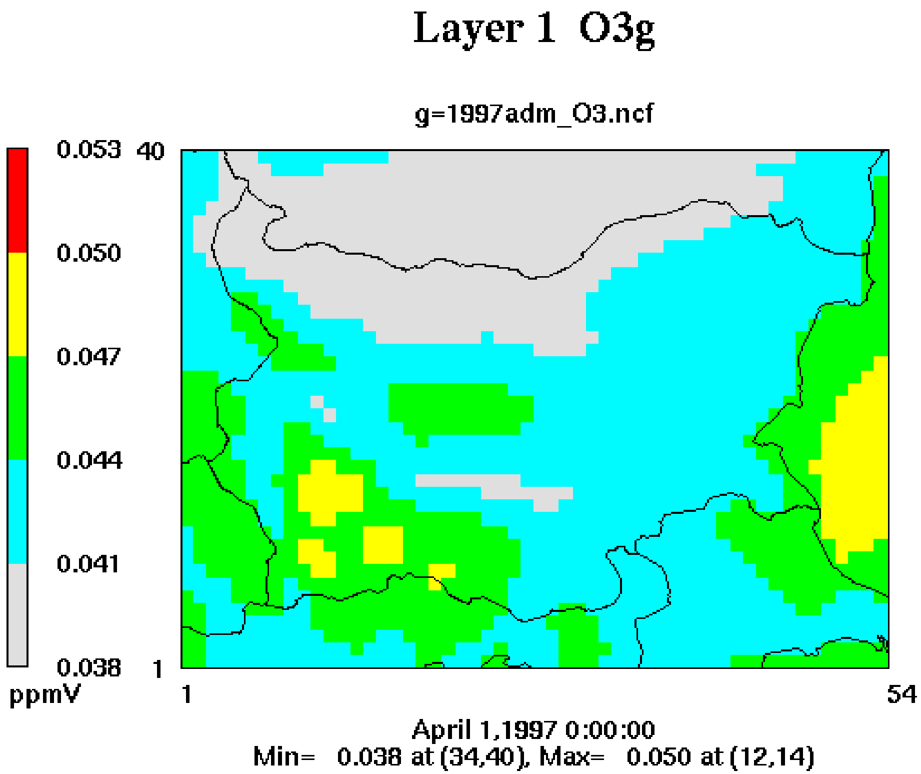
a) 10-year averaged ozone values

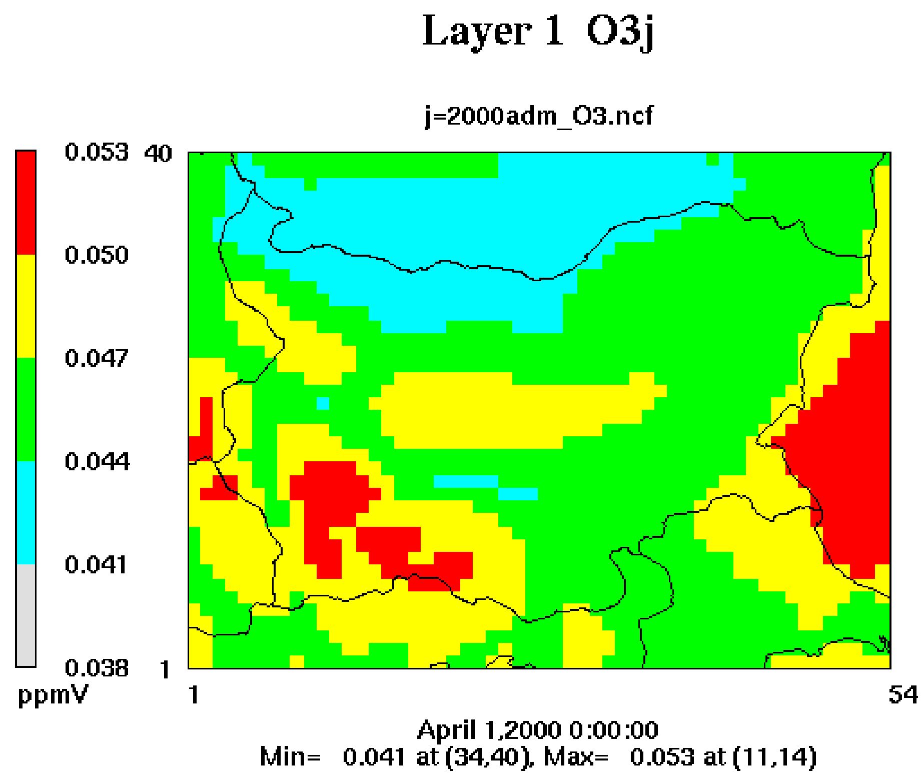




- **some resemblance between space patterns**
- **values are quite different**

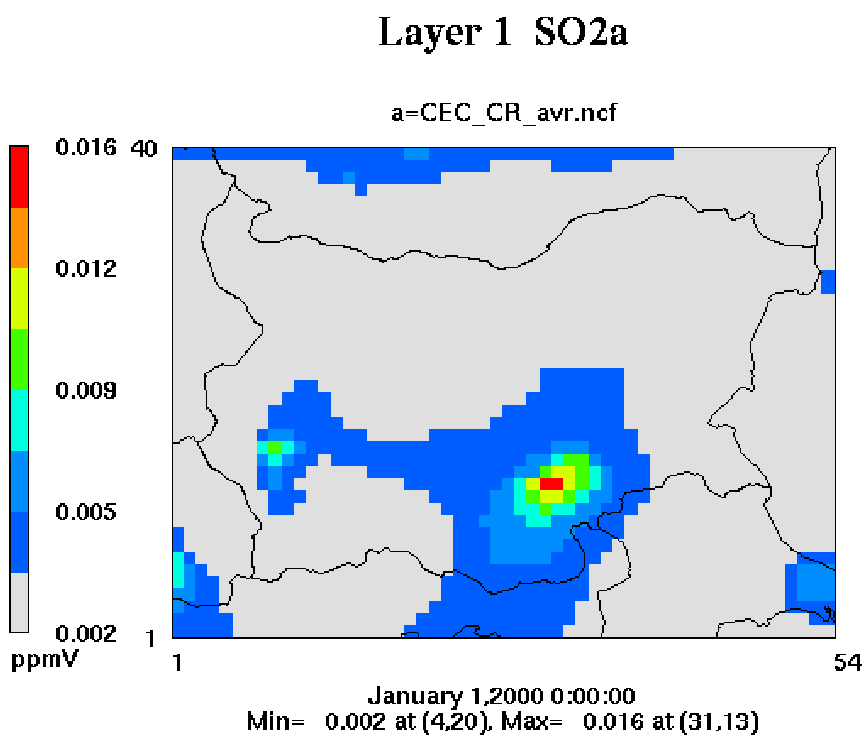
b) Inter-year variability of ozone ADM (years 1997 & 2000)

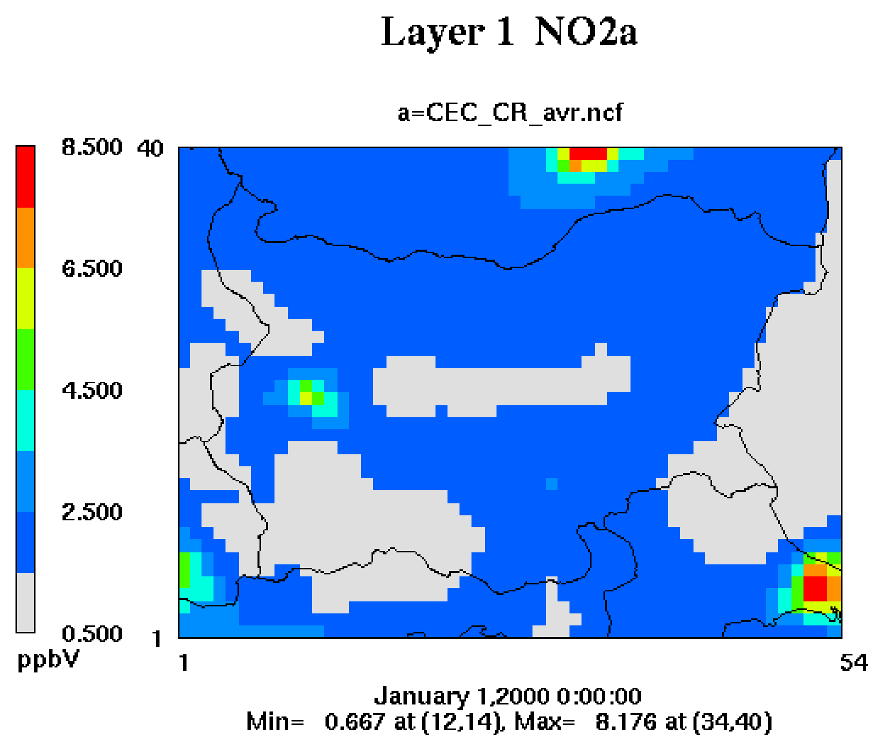




- **cold and wet summer of 1997**
- **dry and worm year 2000**

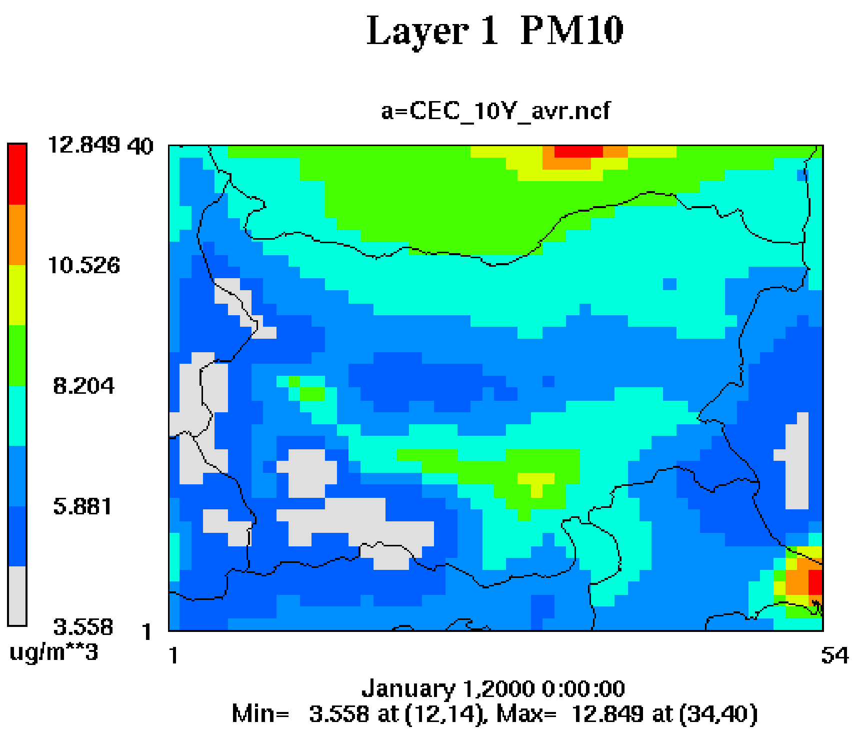
c) SO2 and NO2 climatic levels

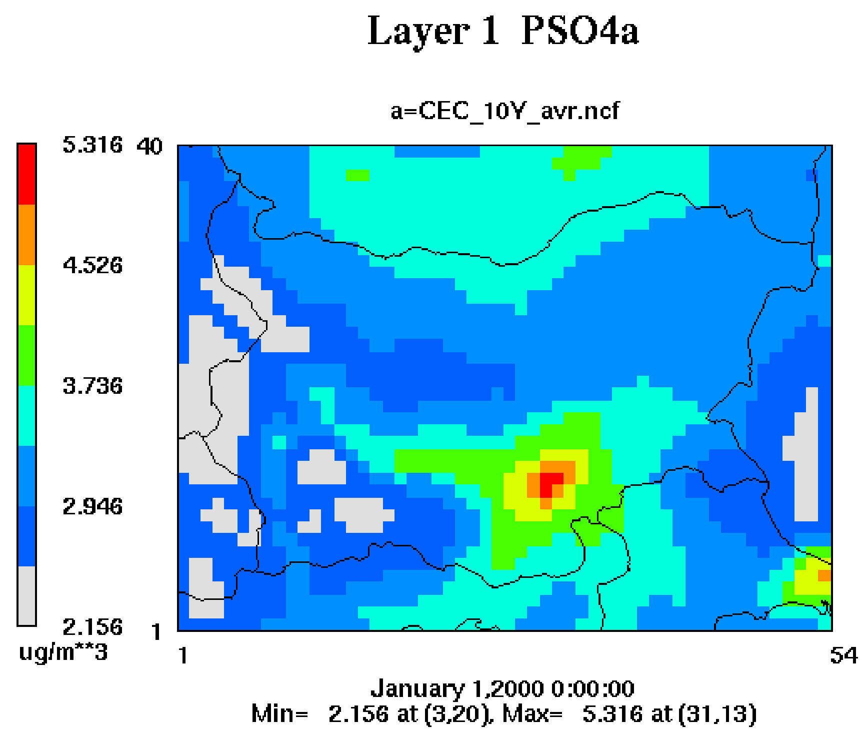




- **SO_2 – maxima around TPP "Mariza-Iztok" and TPP "Bobov dol"**
- **NO_2 – maxima around the most populated area: Sofia, Istanbul, Bucharest**
- **NO_2 – well expressed minima in mountain areas**

d) Particulate Matter



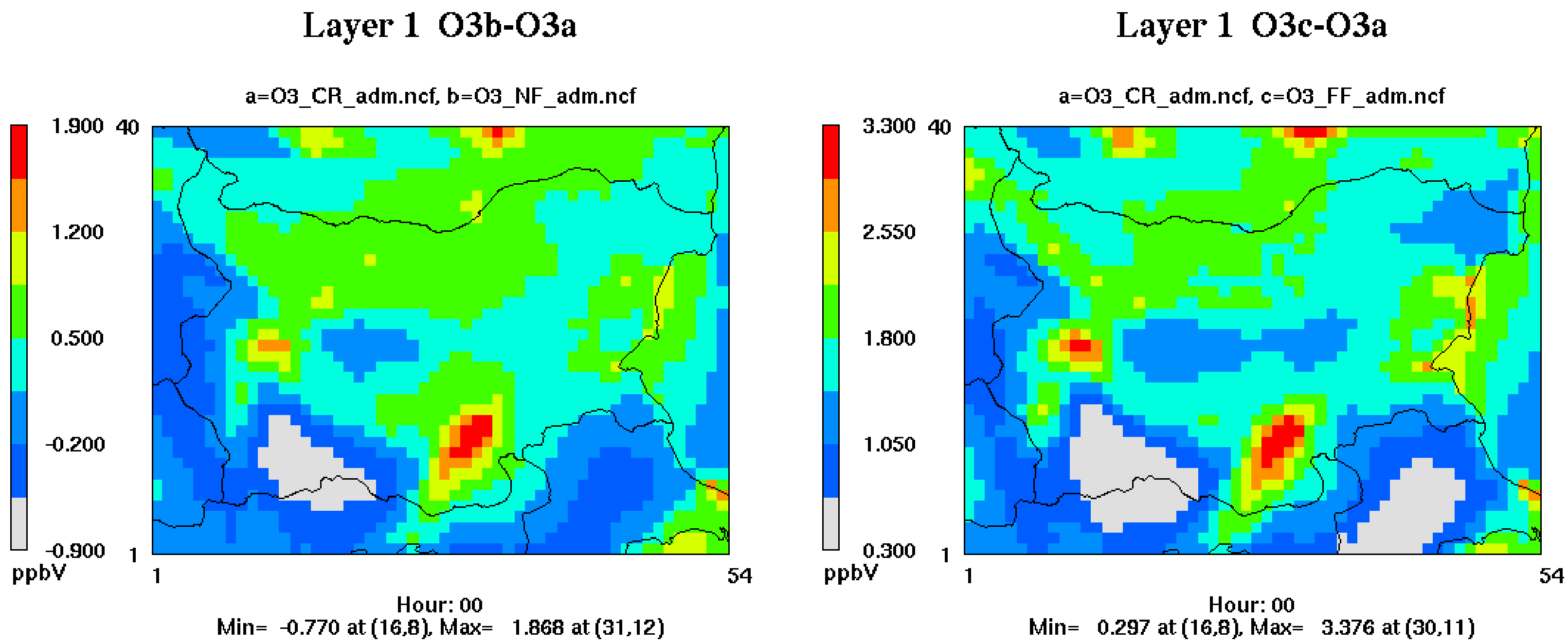


- **both fields are most or less similar that can be expected**
- **maxima again around the most powerful source – TPP "Maritza-Iztok"**
- **"Maritza-Iztok" maximum better expressed in PSO4 field**
- **minima in mountain areas, again**

7. Climate change impact on AQ

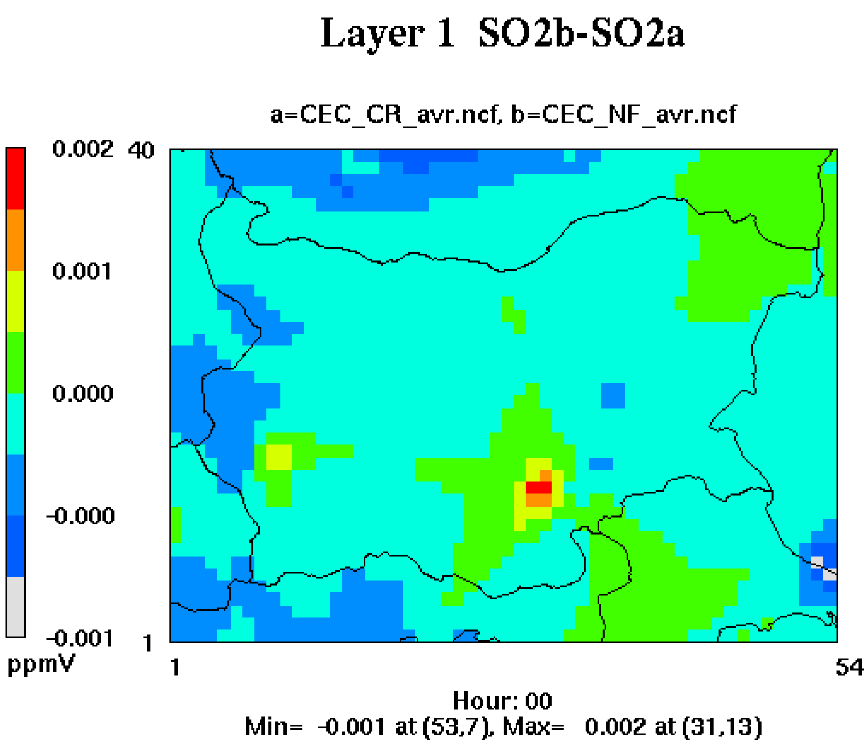
Methodology: Calculate differences between NF, FF and CR

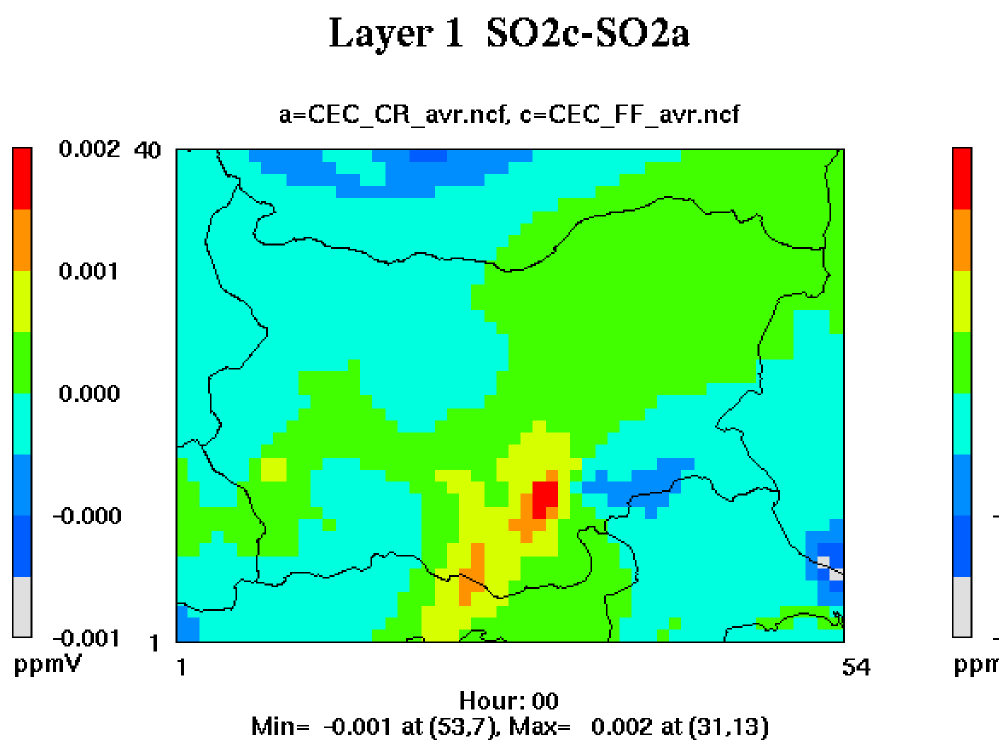
a) Ozone Averaged Daily Maxima



- **the difference "FF-CR" bigger than the difference "NF-CR"**
- **maximal difference ~3 ppb, 5-10 % of ADM maximums**
- **negative differences in mountain areas for "NF-CR"**
- **positive differences everywhere for "FF-CR"**

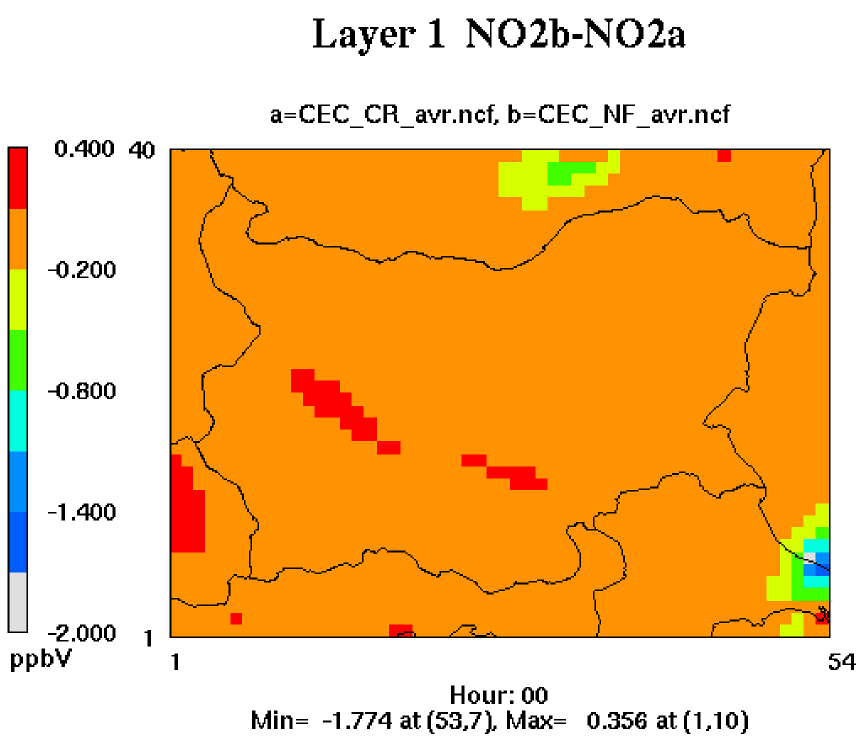
b) Sulfur dioxide concentrations (SO2)

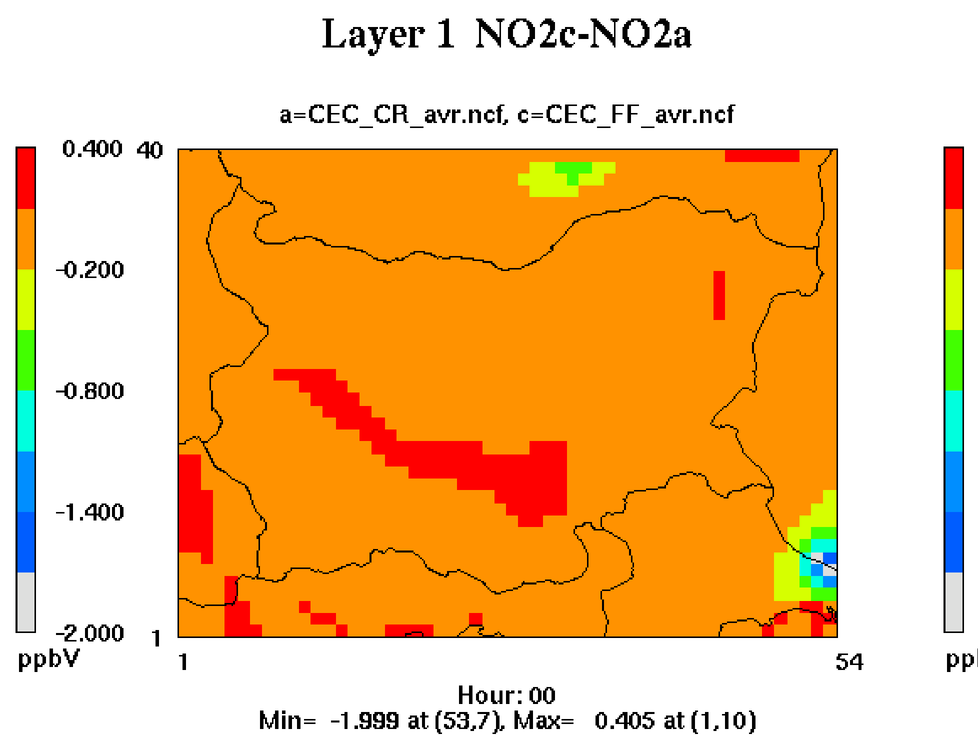




- **maximum about 2 ppb, i.e ~10 % of the maximal SO2**
- **maximums concentrated around the main SO2 pollution source.**
- **again, the difference "FF-CR" bigger than the difference "NF-CR"**

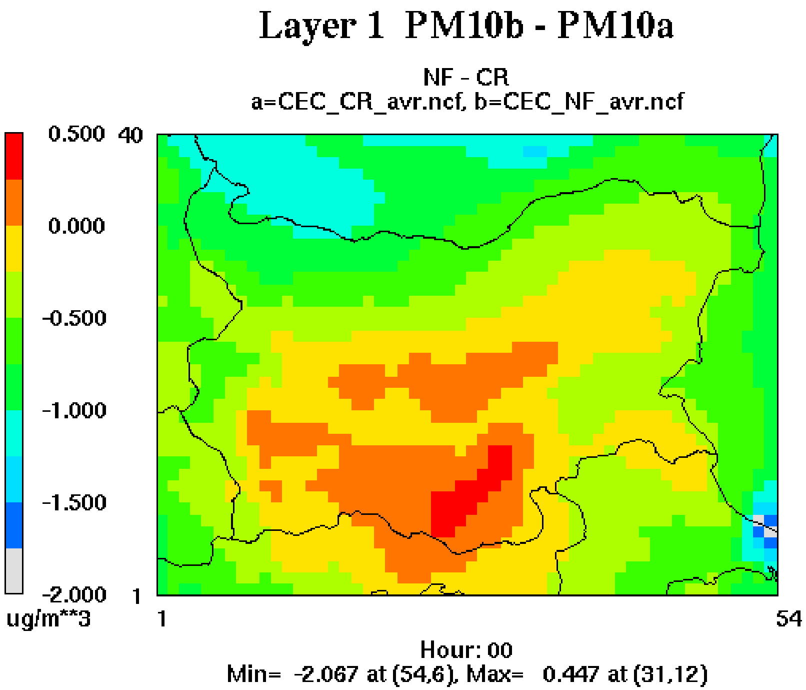
c) Nitrogen dioxide concentrations (NO2)

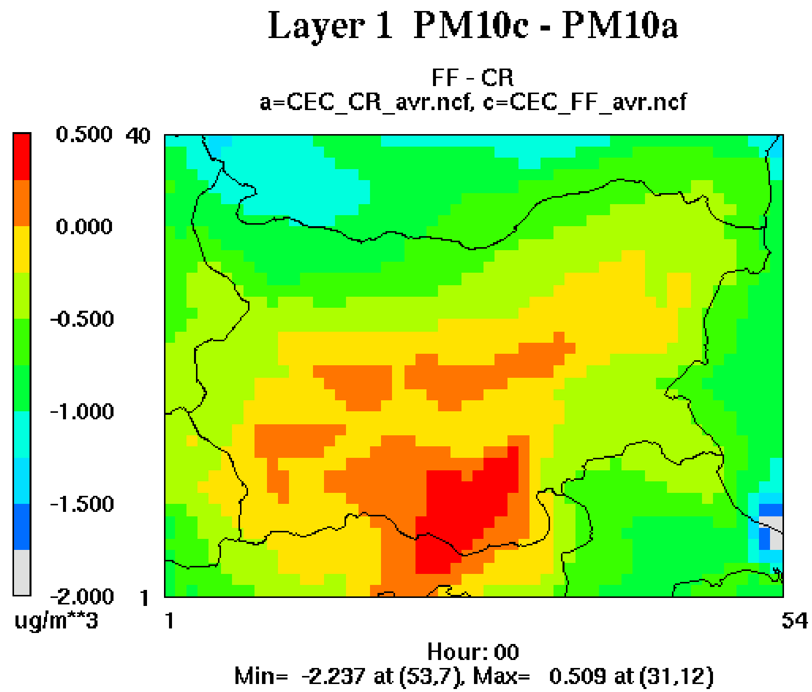




- **the pattern of the differences field is similar**
- **in prevailing part of the area differences close to 0**
- **differences “FF-CR” slightly higher than “NF-CR”**
- **maximal differences about 5%, rather small**

d) Particulate Matter (PM10)





- **positive differences in central and southern Bulgaria**
- **negative differences in northern part of the country**
- **maximal differences around TPP and its trail**
- **almost equal differences “NF-CR” and “FF-CR”**

8. Conclusion

- **The changes in AQ climatic values are rather small (5-10% of the maximal values).**
- **The maximal positive changes are located around the main pollution sources.**
- **In the remaining part of the domain there is decrease of pollution levels.**
- **The changes “FF - CR” are bigger than “NF - CR” (keeps the tendency)**
- **The behavior of the pollution levels CC reflects the behavior of the meteorological CC.**

Thank you!