Application of GEM-AQ model to long-term Air Quality Simulation Over Europe

Contribution to Eurodelta Projects

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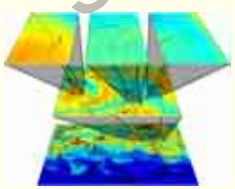

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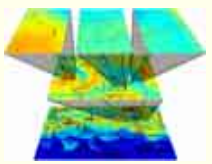
Multiscale Air Quality Modelling Network (www.magnet.ca)

Outline

- Harmonisation and intercomparison of advanced “on-line” numerical models
- GEM-AQ modelling system description
- Experiment setup
- Results
- Conclusions

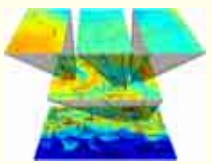
„Harmonisation”

- For simple models:
  - model formulation (similar assumptions)
  - treatment of the atmospheric processes (similar parameterisations)
- For advanced numerical models, with complex physics and chemistry - very difficult issue
  - large domain - to get area of influence
  - meteorological data
  - harmonised emissions
  - initial and boundary conditions



„Intercomparison”

- Model evaluation - comparison with measurements:
  - high resolution simulation
  - comparison with hourly measurements (not statistics)
  - station type (urban, suburban, rural)
- Model intercomparison:
  - difficult to interpret even if the same emission data are used
  - the intercomparison method
  - impossible without measurements

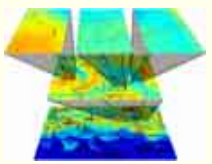


On-line modelling - purpose

- Reproduce the variability of atmospheric constituents with possibly good accuracy for episodic and not-episodic situation
  - maximum and minimum values, diurnal cycle
- Understanding dependence of chemical processes on meteorological situation
  - stable warm high, frontal passages, breeze regime

On-line modelling

- Strength
  - detailed connection between chemistry and meteorology
  - no need to store and interpolate the meteorological data
  - meteorological parameters available for chemistry every time-step
- Limitations
  - computationally expensive
  - meteorology must be recalculated in EACH simulation
  - necessary to analyse ALSO meteorological output



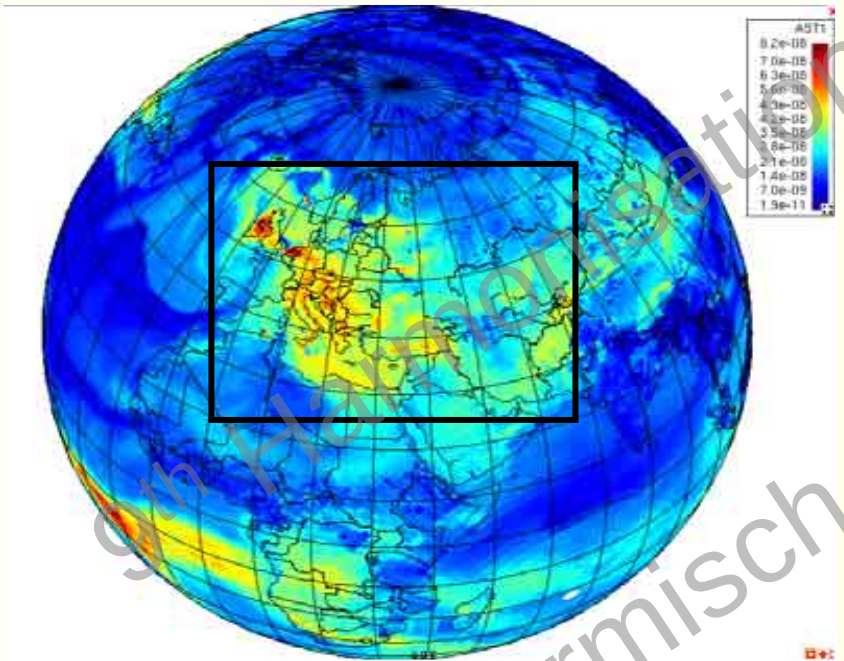
On-line modelling

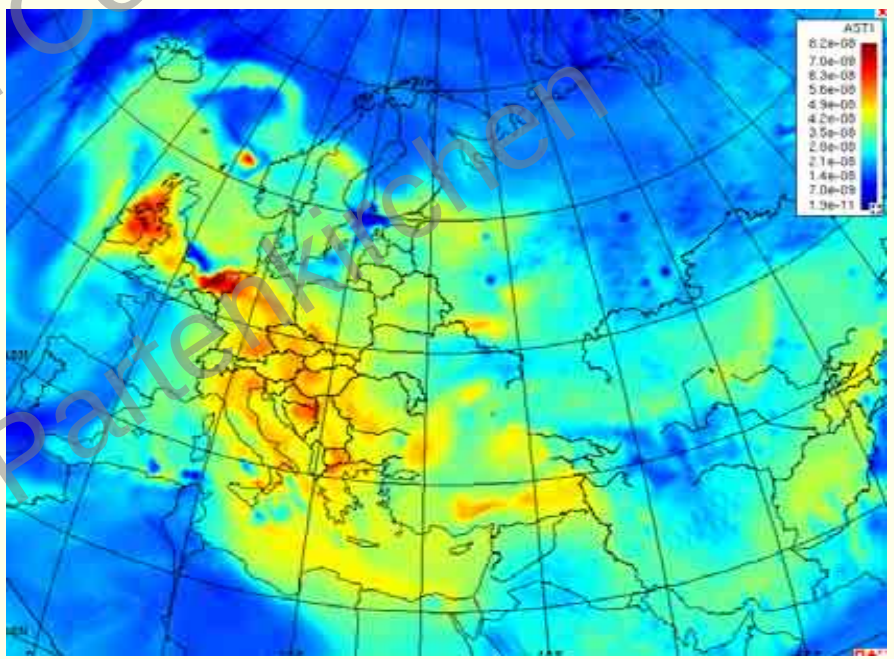
- ☺ detailed connection between chemistry and meteorology:
  - studying atmospheric processes connected with air quality
  - „chemical weather” operational forecast
- ☹ due to the computational requirements inefficient for:
  - long-term emission scenarios
  - „regulatory” purposes

Air Quality modelling over Europe

- The (questionable) quality of initial and boundary conditions for regional and local scale runs
- Issues:
  - how important is transport over North Atlantic for background ozone concentrations ?
  - influence of precursors transported in plumes during long-range transport events

Air Quality modelling over Europe





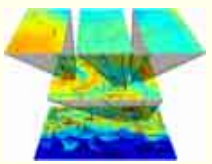
MULTISCALE AIR QUALITY MODELLING SYSTEM **GEM-AQ / MC2-AQ**

Joint project between

- **Institute of Environmental Engineering Systems**
  Warsaw University of Technology
- **York University, Toronto, Canada**
  Department of Earth and Space Science and Engineering
  Multiscale Air Quality Modelling Network (www.maqnet.ca)
  (sponsored by the Canadian Foundation for Climate and Atmospheric Sciences www.cfcas.org)

GEM – Host Meteorological Model

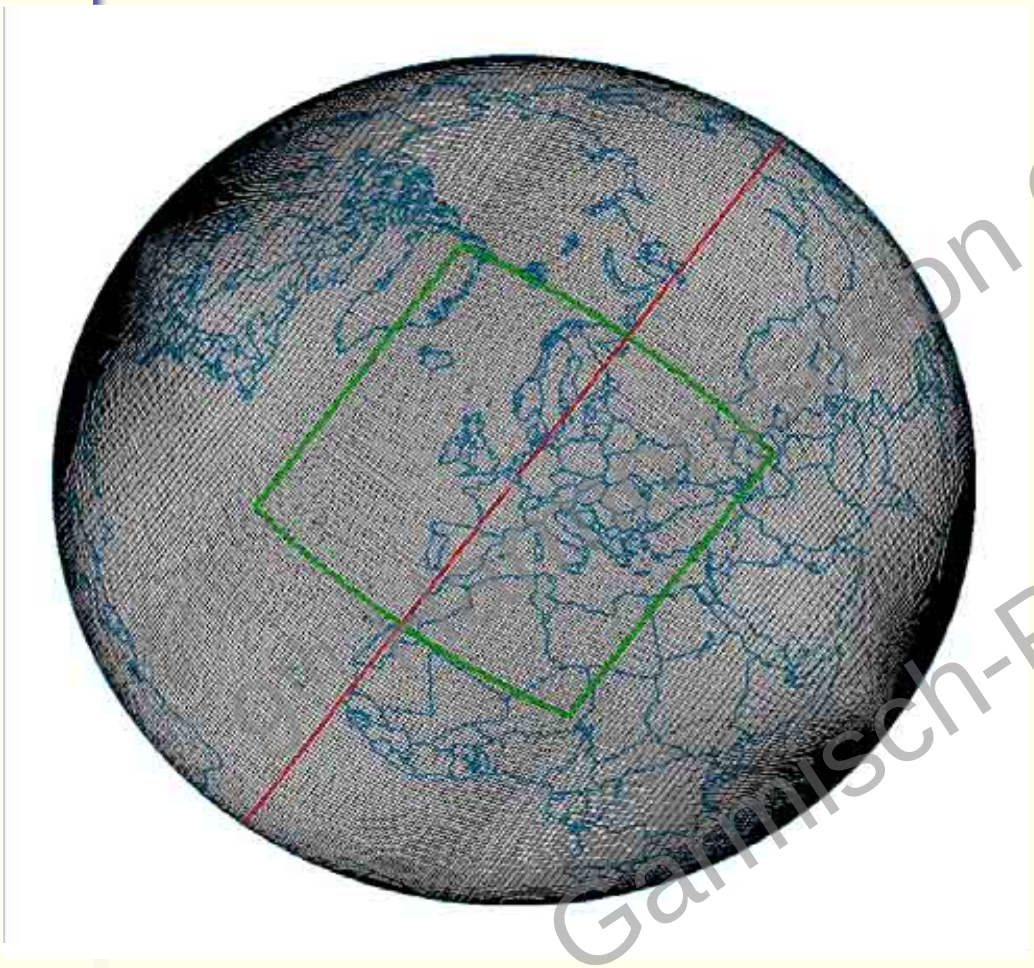
- Global Environmental Multiscale model
  (Côté at al. 1998)
  - Operational execution on 0.9ºx0.9º global grid
  - 3D-VAR continuous objective analysis
    (Gauthier et al.)
  - 5 and 10 day weather forecasts – global
  - 48 hour regional forecast over North America
  - Vertical resolution 28 hybrid levels
  - Top at 10 mb … research version up to 0.1 mb
  - Coupled with full physics



Air Quality Module

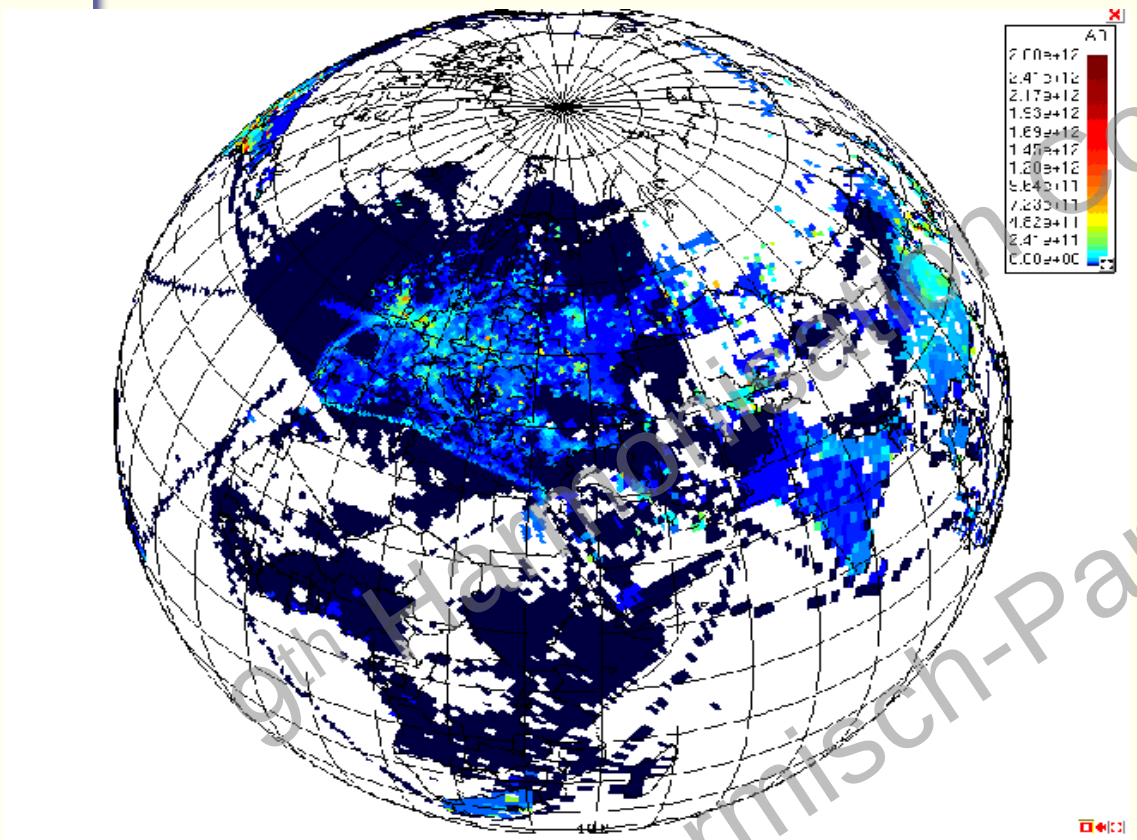
- Gas phase chemistry
- Biogenic emissions
- Anthropogenic emissions
- Aerosol chemistry and physics
- Dry and wet removal
- Wet chemistry

Model grid definition



- global variable grid
  - 320x190 grid points
  - 0.5 deg resolution over Europe (100 x 100 grid points)
- hybrid vertical levels
  - model top - 10 mb
  - 28 levels

Emission data

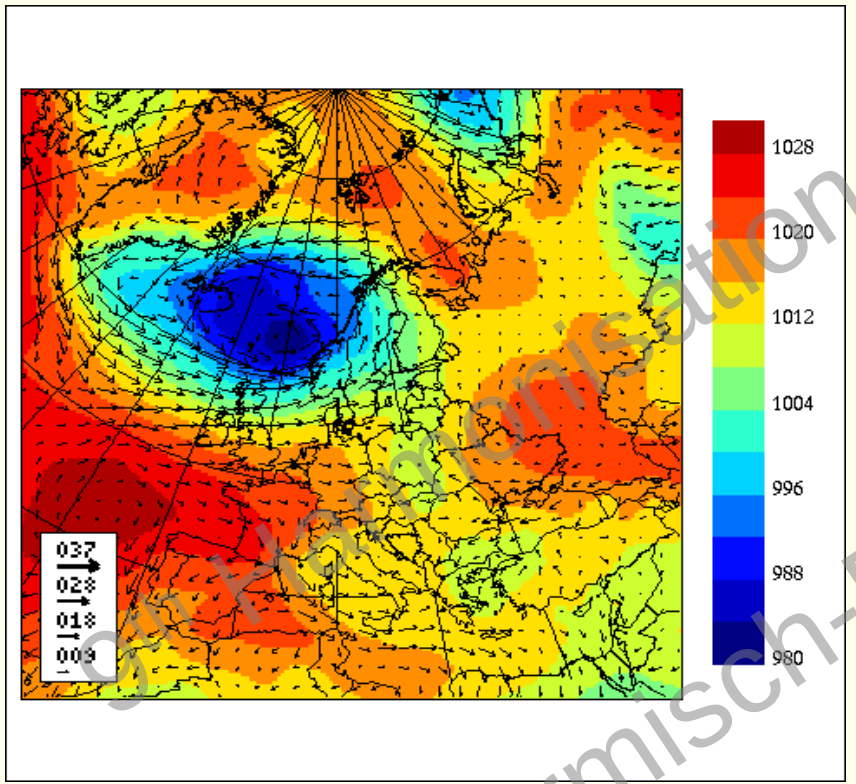


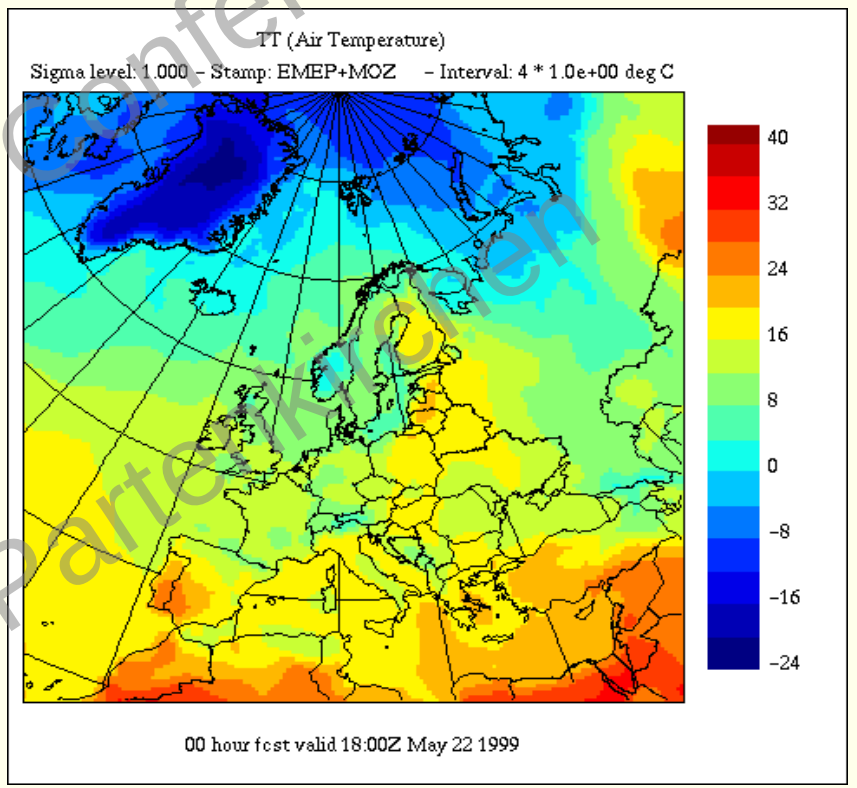
- EMEP emission inventory combined with EDGAR/GEIA global inventory
- Time variation: within EMEP area time factors provided in CityDelta project applied

Modelling strategy

- GEM-AQ simulation (global model)
  - CMC OA every 24 hours
  - variable grid centered over Europe
  - global CTM 3D fields for chemical IC
- Tree 5-day case studies (1999)
  - 25 -29 of May
  - 1 - 5 of August
  - 8 - 12 of September
- 2-day spin up for each simulation

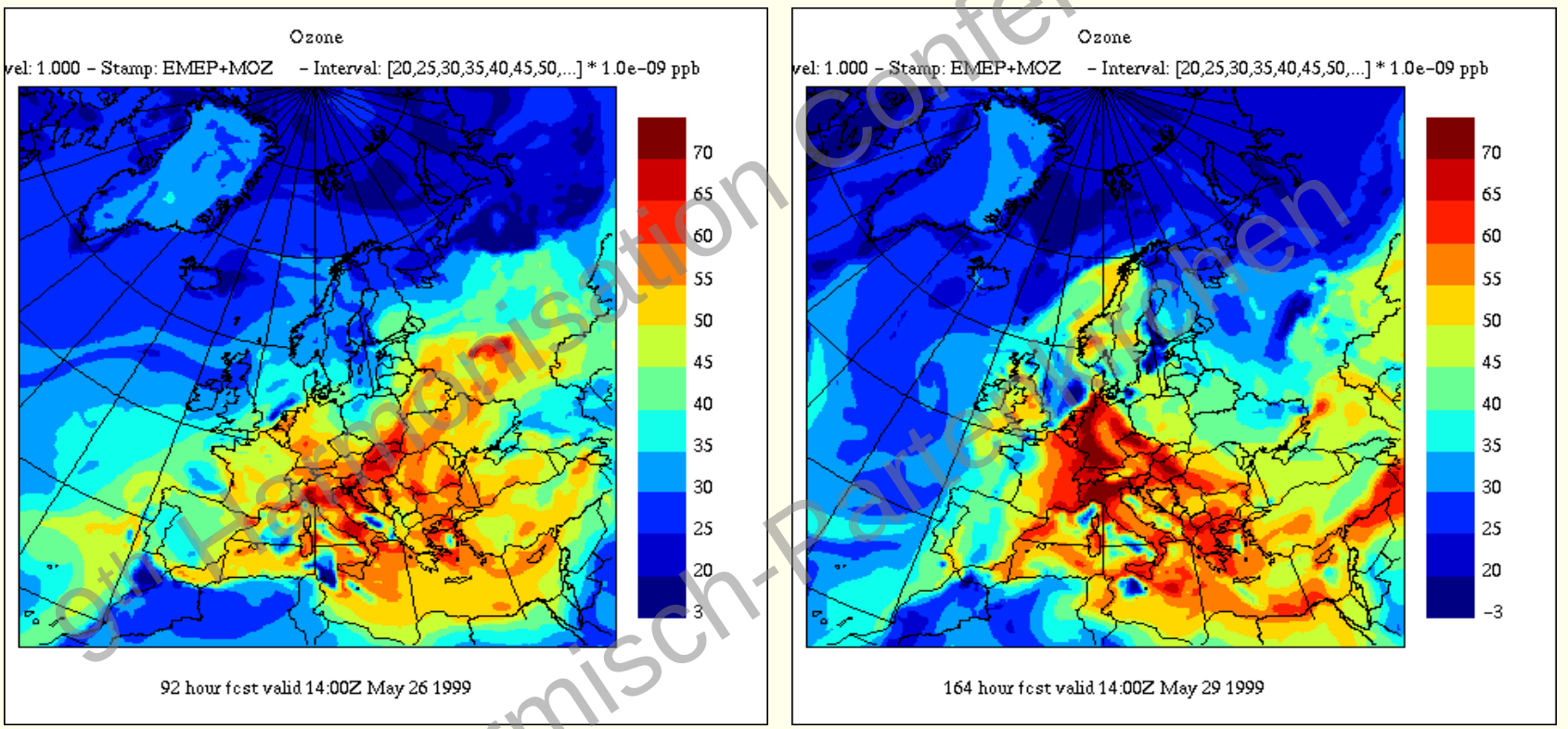
Meteorology - 25 of May 1999





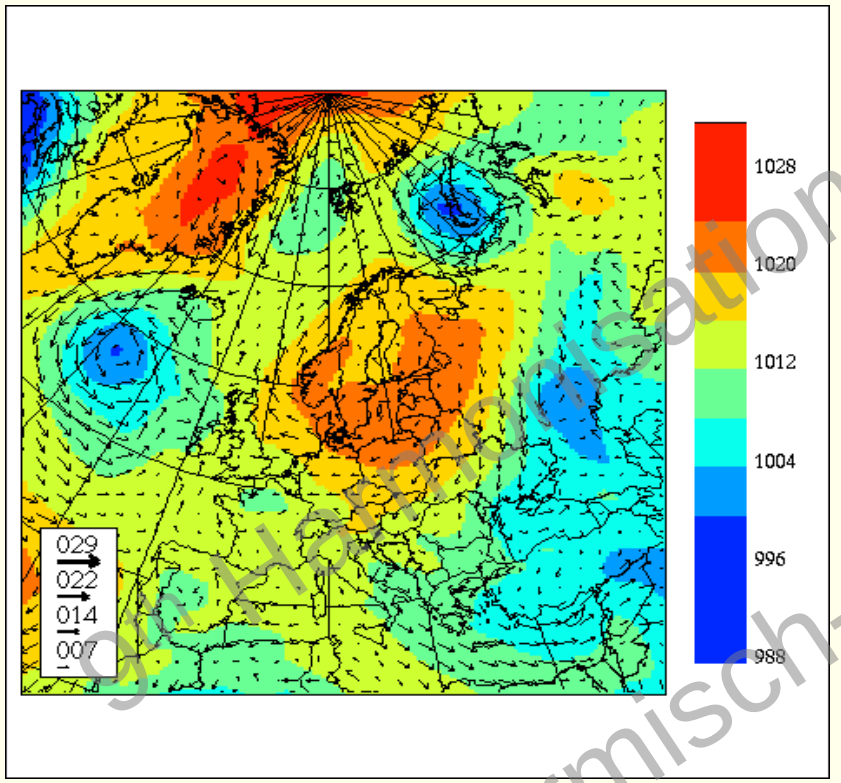
Pressure, wind and temperature field

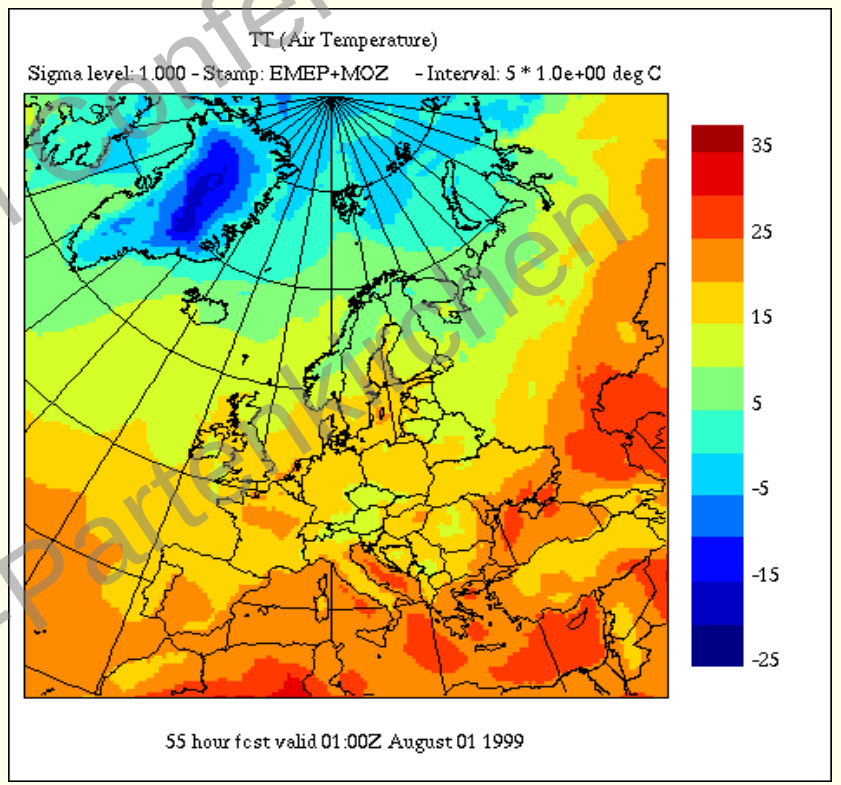
Ozone episode: 25 - 29 of May



Ozone field (ppb), 14 UTC 26 & 29 of May

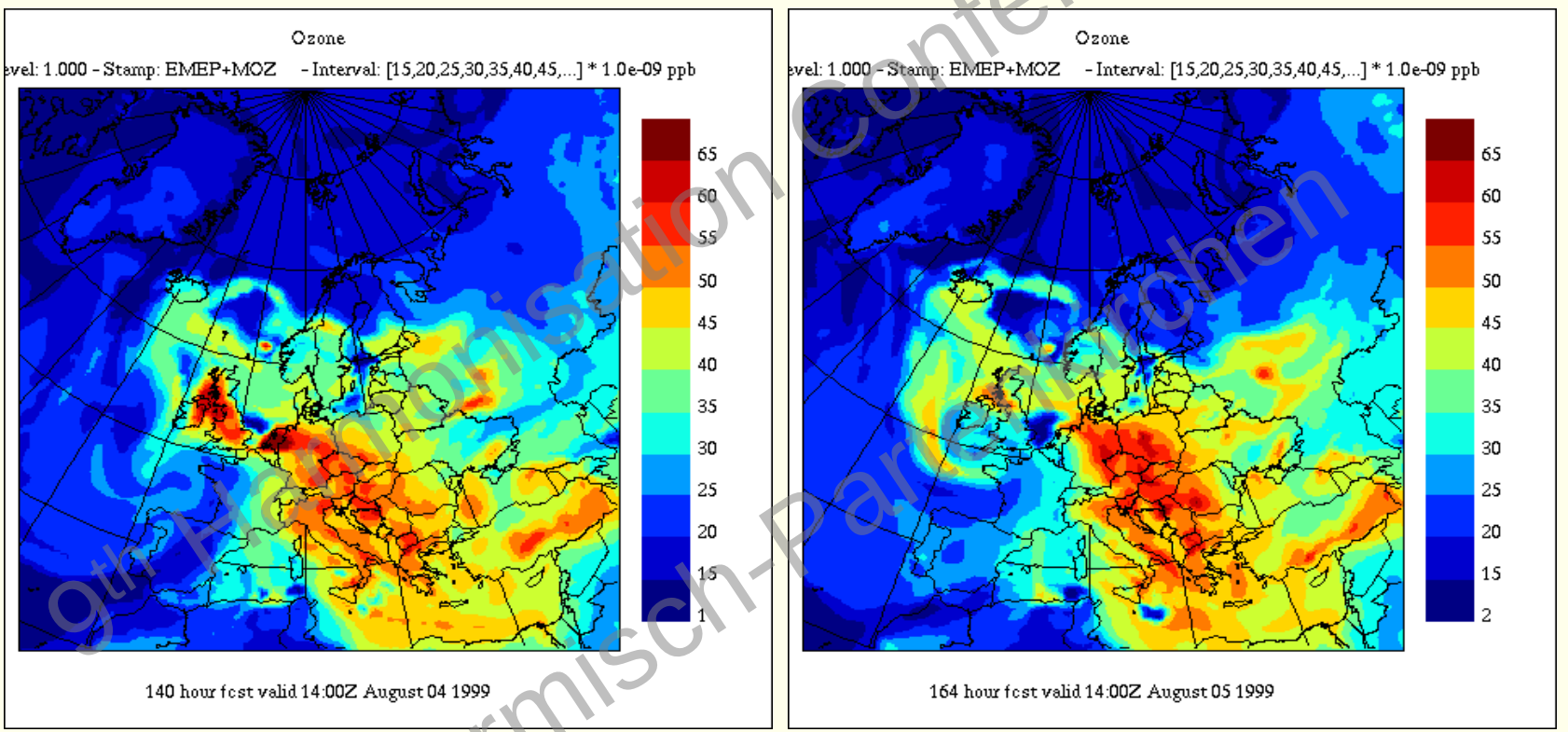
Meteorology - 1 of August 1999





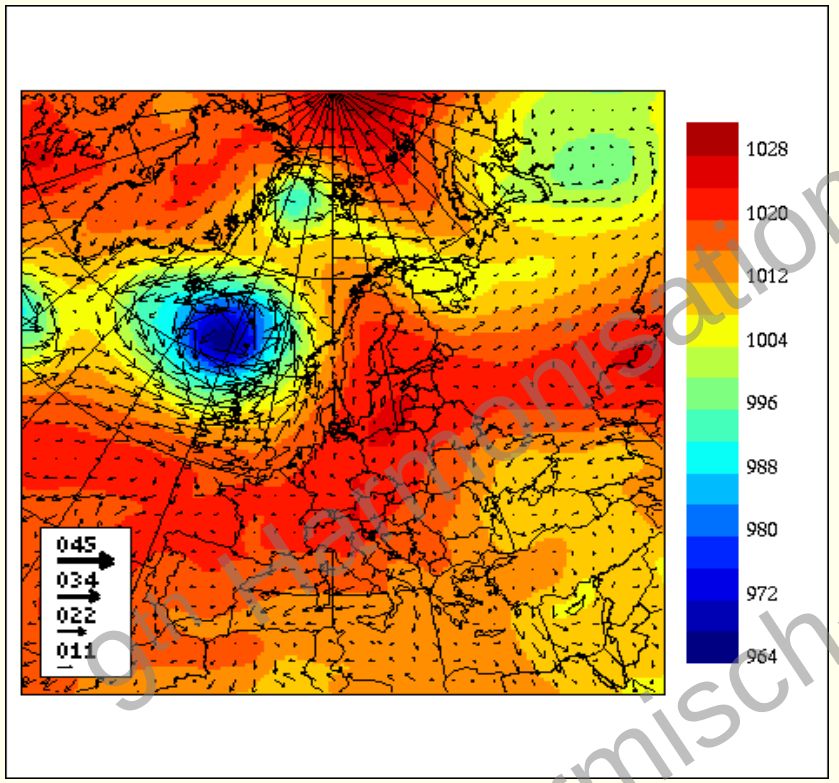
Pressure, wind and temperature field

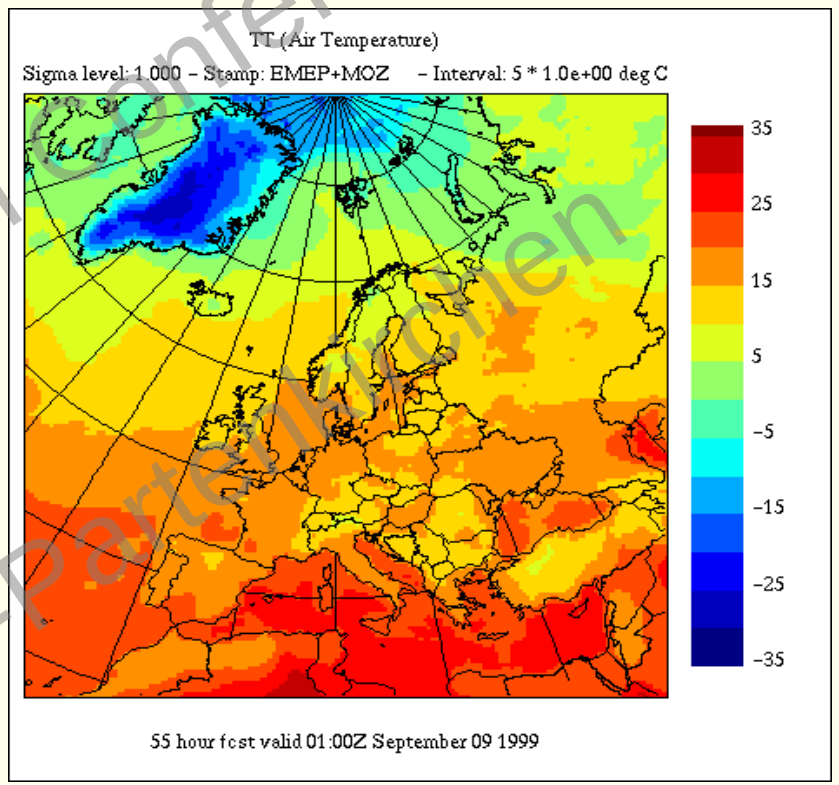
Ozone episode: 1 - 5 of August



Ozone field (ppb), 14 UTC 4 & 5 of August

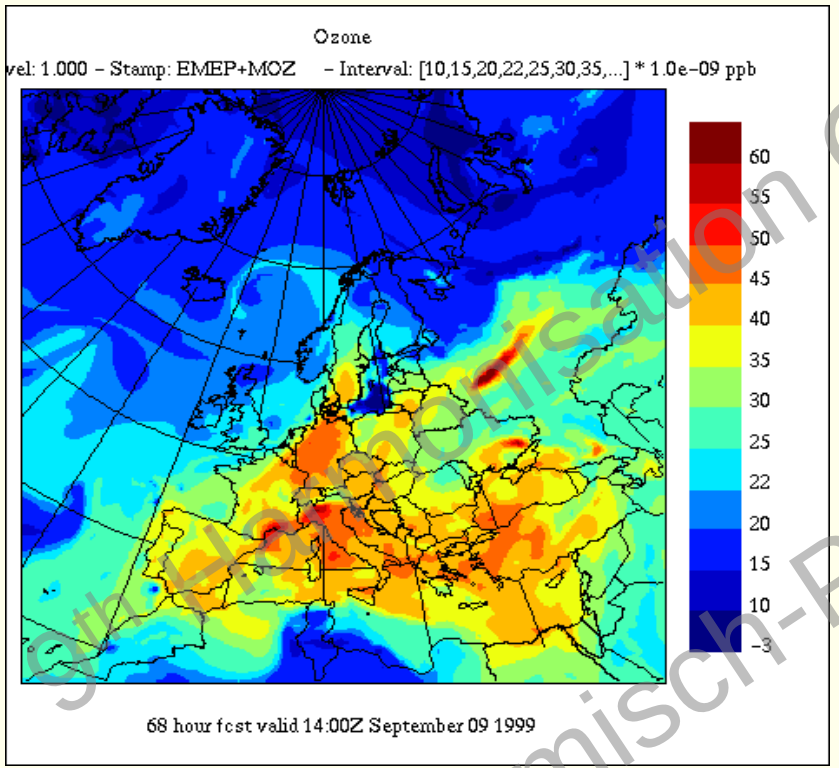
Meteorology - 8 of September 1999

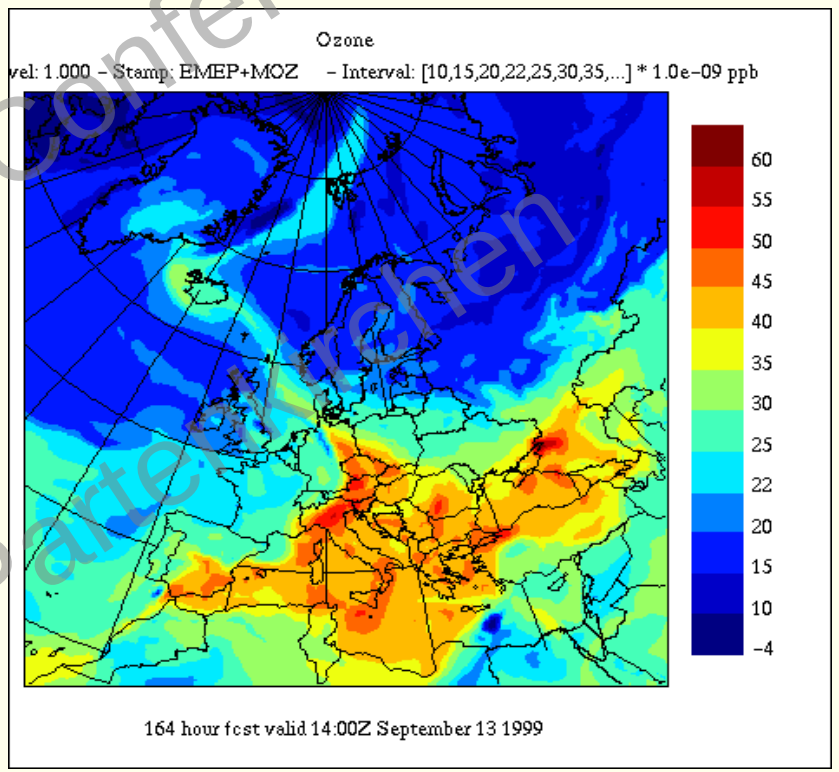




Pressure, wind and temperature field

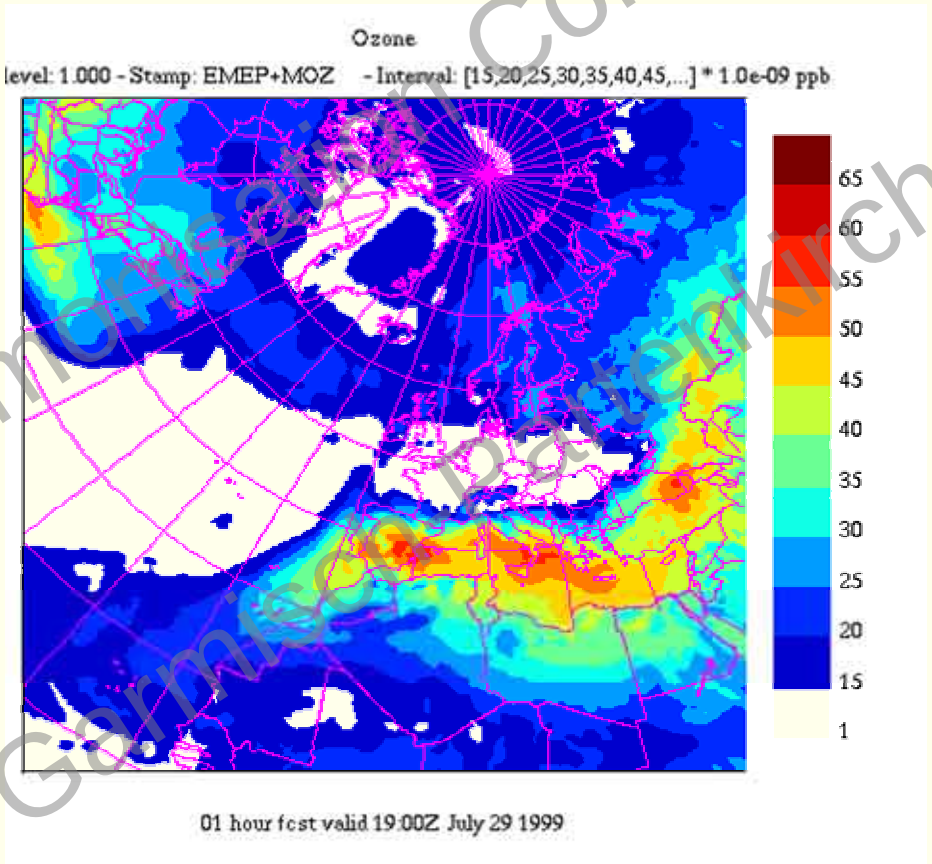
Ozone episode: 8 -12 September



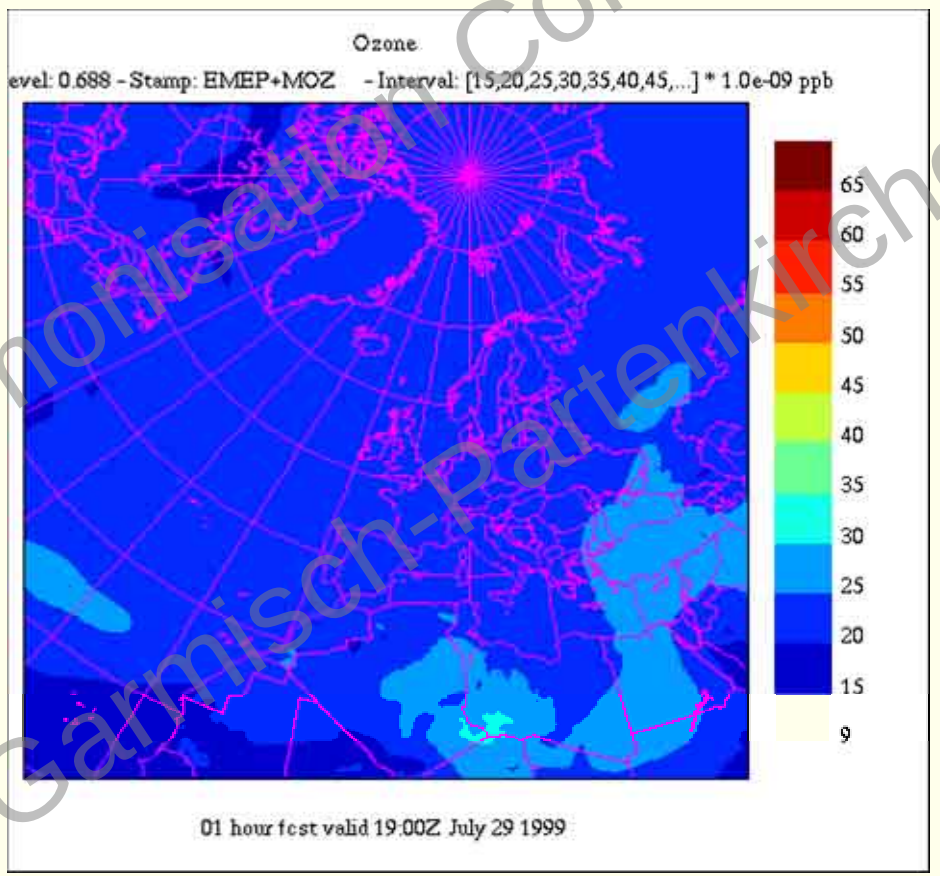


Ozone field (ppb), 14 UTC 9 & 13 of September

Ozone transport over Atlantic August case study - surface



Ozone transport over Atlantic August case study - 3000 m



Conclusions

- On-line model: studying and understanding linkage between chemistry and meteorology
- Global model:long range transport over Atlantic Ocean - detection of polluted plums coming from North America
- Reproducing with reasonable accuracy the chemical constituents variability (connected with both local production and long range transport)

Conclusions

- „Chemical weather” over Europe is connected with meteorological situation
- Transport over Atlantic Ocean and over North Sea is driven by frontal systems associated with low pressure development
- Use of an on-line chemical weather forecast system allows for detailed analysis of transport and transformation of chemical species in the atmosphere

Conclusions

- Towards data assimilation:
  - Assimilation of CO from MOPITT
  - Assimilation of tropospheric ozone from
    - GOME
    - Surface networks
  - Assimilation of aerosols
    - AVHRR, MODIS (optical depth)
    - CALIPSO lidar - backscatter
    - AERONET and AEROCAN networks

Future work

- Establishing the influence of precursors transported in air masses on air quality over Europe
  - MC2-AQ simulation over Europe
  - EMEP grid definition
  - EMEP emission fields
  - Chemical boundary conditions:
    - from GEM-AQ simulation
    - “clean air mass” - very low concentration of chemical species