The online coupled meso scale climate-chemistry model MCCM – a modeling tool for short as well as for climate periods

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Overview

- Introduction to the modeling system MCCM
- Short outline about the type of applications
- Examples and results
- Summary
**Online coupled meso scale climate chemistry model**

<table>
<thead>
<tr>
<th>Meteorological part</th>
<th>Chemistry part</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Based on MM5</td>
<td>- RADM2 / RACM chemistry</td>
</tr>
<tr>
<td>- Non-hydrostatic</td>
<td>- KPP preprocessor for chemical mechanisms</td>
</tr>
<tr>
<td>- Nesting capability</td>
<td>- Photolysis model</td>
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<tr>
<td>- Soil and snow model</td>
<td>- Aerosol module (SORGAM)</td>
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<td></td>
<td>- Biogenic emission module</td>
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</table>

**Output:**
Fields of temperature, humidity, cloud water and ice, rain water, snow, photolysis frequencies, concentrations of chemical compounds in the gas and particle phase, snow height …
Mesoscale-Climate-Chemistry-Model (MCCM)

- Observations
- Orography
- Land use
- Soil Texture
- Anthropogenic
- Emissions
- Global Weather
- forecast models
- Global
- Climate Models

Analysis

Interpolation

Meteorological Data Assimilation

Biogenic Emissions

MCCM (MM5/chem)

Meteorology, Climate, Aerosols, Air Chemistry, Soil-Vegetation

Simulation of Air Quality

Simulation of Regional Climate

- Air Pollution Control Strategies
- Critical Levels and Loads
- Climate Changes and Air Quality
- Extreme Events
- Soil-Vegetation-Atmosphere Feedback Effects

Runoff / Routing Model (e.g. WASIM)
Detailed hydrological Model
Dynamic Vegetation Model (MOBILE)
Bio-Geo-Chemistry Model
Micro-scale Model (e.g. GRAL)

Regional

Local

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Chemistry Mechanisms

- **RADM2 (Stockwell et al. 1990)**
  63 chemical species, 21 photolysis reactions and 136 chemical reactions of higher order

- **RACM (Stockwell et al. 1997)**
  77 chemical species, 23 photolysis reactions and 214 chemical reactions of higher order

- **RACM-MIM (Geiger et al. 2003)**
  84 chemical species, 23 photolysis reactions and 221 chemical reactions of higher order
  (based on MIM-Isoprene-Mechanism; this mechanism reflects an advanced description of the chemistry of biogenic ozone precursors like isoprene and others)
Applications

- Evaluation studies about chemical schemes and numerical methods (→ Bavaria)

- Short time simulations, validation, comparison, strategies and scenarios of air quality studies (→ Mexico City, Santiago de Chile, Munich, Augsburg, Berlin)

- Long time simulations with the background on annual thresholds (→ Alpine region)

- Operational forecast for $O_3$ and $PM_{10}$ (→ Southern Germany, Bavaria, Southern Austria)

- Climate-chemistry simulations for present and future climate (→ Southern Germany, Mexico)
Evaluation Studies - Chemical Mechanisms

Domain D3 (6km-drid) * Comparison: Simulations - Measurements * Station Erlangen

O\textsubscript{3} [ppb]

Setup: 54-18-6-2 km grid
2 month period
Southern Germany

PhD thesis / Edwin Haas 2007
Evaluation Studies - Advection Schemes

D3: Quantile-Quantile-Plot

- ▲ MPDATA
- ● BOTTM
- ▲ BOTTP

Simulations [ppb]

Measurements [ppb]

Station Andechs
Station Ansbach
Station Neustadt an der Donau
Station Neu-Ulm
Station Augsburg
Station Erlangen
Station München-Johanneskirchen
Station Regensburg

Setup:
- 54-18-6-2 km grid
- 10 days period
- Southern Germany

PhD thesis / Edwin Haas 2007

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COST-728 / NetFAM workshop Copenhagen, Denmark, 21-23 May 2007
Air Quality Studies - Scenarios

O₃-concentrations in 2010

Setup: 18-6-2 km grid
       days period
       Mexico City

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Air Quality Studies - Scenarios

O$_3$-Difference in 2010

<table>
<thead>
<tr>
<th>Longitude (°W)</th>
<th>Latitude (°N)</th>
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<tbody>
<tr>
<td>19.2</td>
<td>19.4</td>
</tr>
<tr>
<td>19.4</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Setup: 18-6-2 km grid days period Mexico City

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Air Quality Studies - Emission Strategies

Setup: 27-9-3-1 km grid
4 days period
Southern Germany

O₃ change

NO₂ change
Air Quality Studies - Methodology

Source-receptor analysis for NO$_2$ within the conurbation of Munich

Setup:
- 54-18-6-2 km grid
- 5 days period
- Southern Germany

Biogenic sources
Solvents
Agricultural
Other industrial sources
Others incl. domestic heating
Point sources
Traffic

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Operational Forecast e.g. PM$_{10}$

1 day forecast: 8th Oct. 2005
Domain 1: 60 km
Domain 2: 15 km

Setup:
- 60-15 km grid
- 3 days forecast
- Germany

Measurements: 8th Oct. 2005
(Source: UBA)

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Climate-Chemistry Simulations – Air Quality

Threshold exceedances in the future

Setup: 60-20 km grid
2x10 years period
Southern Germany

Distribution of daily $O_3$ maximum

1991-2000
2031-2039
Summary

- Meso-scale Climate-Chemistry Model (MCCM) ……
  - based on a well known and validated meteorological model (Æ MM5)
  - performs with validated chemistry mechanisms
  - short- and long term simulations, assessment of emission strategies, forecast, climate impact assessment
  - Regional and urban areas (e.g. alpine environments; urbanized conglomerations)
Remarks and Outlook

- Modeling tools are only a part of an integrative description of the air quality.
- Models results are only as good as its input data.
- Model diversity against community model.

Focus on climate-chemistry simulations with emphasis on urban conglomerations.
- Model coupling within the compartments of the bio-, hydro- and atmosphere.
Thank you for your attention