Modeling of atmospheric chemistry and transport from global to local scales

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COSMO-User-Seminar
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http://www.staff.uni-mainz.de/kerkweg/MACCHIATO
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STARTING POINT

- ECHAM5/MESSy
  - global general circulation model
  - grid space > 100 km
  - chemistry
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STARTING POINT

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  - global general circulation model
  - grid space > 100 km
  - chemistry

- Measurements
  - local
  - influenced by local effects (e.g. orography)
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STARTING POINT

- **ECHAM5/MESSy**
  - global general circulation model
  - grid space > 100 km
  - chemistry

- **Measurements**
  - local
  - influenced by local effects (e.g. orography)

=> a dynamical regional model including chemistry is required
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STARTING POINT

- regional model: COSMO
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- regional model: COSMO
- chemistry: MESSy (= Modular Earth Submodel System)
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STARTING POINT

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=> COSMO/MESSy
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=> COSMO/MESSy

consistent chemistry?
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=> COSMO/MESSy

consistent chemistry? Build model chain!
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=> COSMO/MESSy

consistent chemistry? Build model chain!

ECHAM5/MESSy => COSMO/MESSy

=> COSMO/MESSy => COSMO/MESSy
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ECHAM5 – MESSy - COSMO

- “zooming” option for Atmospheric Chemistry GCM for field-campaign planning and analysis
- COSMO with gas-phase (and aerosol) chemistry for regional chemical weather forecast
- consistent model system on different scales (global – regional – local) for process studies
- Impact of climate change on specific regions (downscaling)
- supported model system (community effort ...
1. Motivation
2. What is MESSy?
3. Status of COSMO/MESSy
4. Online Coupling
5. Summary and Outlook
1. Motivation

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What is MESSy?

- Interface with infrastructure to couple 'processes' (= submodels) to a base model (e.g. a GCM or COSMO)
- Set of processes coded as switchable submodels
- Coding standard

process oriented approach of MESSy

transparent control of feedback mechanisms
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**MESSy submodels**

<table>
<thead>
<tr>
<th>MESSy1.1</th>
<th>MESSy1.2</th>
<th>MESSy1.3</th>
<th>MESSy1.4</th>
<th>MESSy1.5</th>
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<td>D14CO</td>
<td>MESSy1.3</td>
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<td>- PDEF</td>
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<td>NCREGRID</td>
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</tr>
</tbody>
</table>
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The MESSy interface

- **Base Model Layer**: power supply
- **Base Model Interface Layer**: multiple socket outlet
- **Submodel Interface Layer**: connector
- **Submodel Core Layer**: the machinery...
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The MESSy interface

Standardisation on the lowest possible level ...

- INFRA-STRUCTURE LEVEL
  - SWITCH / CALL
  - MEMORY / OUTPUT
  - TRACER
  - RE-GRIDDING
  - TOOLS...

- INTERFACE LEVEL
  - process specific interface

- PROCESS LEVEL
  - INTENT(IN)
  - INTENT(OUT)
  - subroutines as 'operators'
    in smallest meaningful entity
    (box, column, column-vector, ...)

- LANGUAGE LEVEL
  - Fortran90/95 ISO/IEC 1539:1991

user interface: namelists

"science code"
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The infrastructure submodels are implemented:

- **SWITCH/CONTROL**
- **TIMER**
- **CHANNEL / memory management**
  - COSMO memory allocation via CHANNEL
  - COSMO output via CHANNEL
  - COSMO restart via CHANNEL
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Status of COSMO/MESSy

- **TRACER:**
  - transport of tracers (horizontal/vertical diffusion, advection, ...)
  - convection not (yet) implemented
  - ongoing work: integration not yet mass conserving
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OUTLINE

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- Boundary condition updates required more often than for pure meteorological models (e.g. photochemistry)
- exchange of much more fields required (chemical species)
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=> the data amount (number of files and size of files) becomes huge
=> **ONLINE COUPLING** of model instances
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Online Coupling

ECHAM5/MESSy
Online coupling between ECHAM5/MESSy and COSMO-EU/MESSy.
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Online Coupling

Online data exchange ECHAM5 -> COSMO

ECHAM5/MESSy

COSMO-EU/MESSy

Online data exchange COSMO -> COSMO

COSMO-DE/MESSy
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Online Coupling

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ECHAM5/MESSy

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COSMO 1km/MESSy
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Online Coupling

ECHAM5

COSMO 1

COSMO 2

COSMO 11

COSMO 3

COSMO 31

COSMO 32

COSMO 321

...
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The vision of “ONLINE-COUPLING”
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MACCHIATO as a project contains a lot of model development.

MESSy provides the possibility to add processes and diagnostic tools to COSMO without changing COSMO after the MESSy interface is included once.

Output of variables not included in the grib tables of COSMO is possible via the MESSy interface.

The MACCHIATO Project
Summary

- MACCHIATO as a project contains a lot of model development.
- The model chain ECHAM5/MESSy => COSMO/MESSy => COSMO/MESSy => ... will provide a tool for consistently calculating atmospheric chemistry across all scales.
The MACCHIATO Project

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Summary and Outlook

Technical Workpackages:

- MESSy infrastructure in COSMO: COSMO/MESSy
Technical Workpackages:

- MESSy infrastructure in COSMO: COSMO/MESSy  done
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Summary and Outlook

Technical Workpackages:

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Summary and Outlook

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Summary and Outlook

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Summary and Outlook

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Summary and Outlook

Scientific Workpackages:
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Summary and Outlook

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Summary and Outlook

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  - The performance of COSMO/MESSy will be evaluated with observations of chemically passive tracers (e.g. CO)
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  - The chemistry of COSMO/MESSy will be evaluated with observations of chemically active tracers (e.g. O3, NOx, HCHO)
- Investigation of the dynamical and chemical aspects of chemical plumes
- Case study of regional air pollution with the COSMO/MESSy
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Thank you for listening!
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The MESSy interface
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Status of Online Coupling

- meteorological online coupling of ECHAM5/MESSy -> COSMO/MESSy “nearly finished”

- chemical online coupling of ECHAM5/MESSy -> COSMO/MESSy prepared but not yet tested

- meteorological and chemical online coupling of COSMO/MESSy -> COSMO/MESSy prepared but not yet tested