Introduction

The regional COSMO-Model together with the preprocessing package is a state of the art, unified, nonhydrostatic model system for simulating the processes of the atmosphere. The model has been originally developed by DWD and the COSMO Consortium. Later on a climate mode (CLM) for regional climate simulations has been provided by the CLM Community with extensions necessary for climatological applications. Today, the COSMO / COSMO-CLM (CCLM) is a unified model system for numerical weather prediction (NWP) and regional climate modelling (RCM). Different operational configurations are used by different national weather services and regional climate research units.

Furthermore, it can be extended to online-coupled aerosol- and air chemistry simulations using the ART-system (Aerosol and Reactive Trace gases), which is then called COSMO-ART. This model system has been developed at the Institute for Meteorology and Climate Research at the Karlsruhe Institute of Technology (KIT). It allows the online calculation of reactive trace substances and their interaction with the state of the atmosphere and includes the feedback between chemistry, natural and anthropogenic aerosol, clouds and radiation. COSMO-ART can also be used to simulate the dispersion of volcanic ash, pollen grains or accidental releases. The model system can be applied for research purposes but also in the operational forecast mode.

The official version of COSMO contains an accelerated version of the dynamical core written in C++ instead of Fortran which can accelerate the execution of the COSMO model significantly on CPU machines. Furthermore, it allows to run on clusters and supercomputers with graphics processing units (GPUs).

Also, the COSMO-Model system allows for coupling of the Community Land Model via the OASIS coupling software, as an alternative and more accurate (but more expensive) soil- and vegetation model to the standard TERRA module.

The course is targeted towards users from universities and research institutions (PhD-students, post-docs, etc.) and COSMO members. We invite students and scientists interested to work or already working with COSMO / COSMO-CLM / COSMO-ART to participate in this Training Course. Par-
Participants already working with the COSMO-Model system are invited to bring and present a poster describing their work.

Note that a separate course for new users from other National Weather Services (NWS) who are running the model operationally — COSMO licensees or developing countries — is tentatively planned later in 2017. The date is not yet fixed but will be somewhere in October / November 2017. A separate announcement will follow later this year.

Lectures on the different components of the model (dynamics and numerics, physical parameterizations, data assimilation) will be offered by the model developers with emphasis on standard applications. Practical exercises will give the opportunity to compile the programs, run the model and analyse the output of NWP and RCM runs using standard scripts.

The practical exercises are offered in parallel for two different groups:

1. NWP research applications,
2. climate research applications,

The course duration is 1 week (basic training) plus 2 extra days for the more specialized topics:

- The first week of the course **(Mar 27th 13:30 to 31th 12:30 MEZ)** is devoted to provide basic training on the theory and usage (practical exercises) of the model in NWP and RCM mode as well as for idealized cases (ITC).

- Extra lessons will be given for **COSMO-ART** on the following **Monday to Tuesday, April 3rd 09:00 to 4th 18:30 MEZ**. This course is designed for NWP or OPERATIONAL applications. In several theoretical lectures an overview on the physical and chemical processes included in COSMO-ART will be presented. The trainees will learn how to install and run the model system COSMO-ART during practical exercises.

- There will perhaps also be an introductory course on the compilation and use of the new accelerated dynamical core on **Monday and Tuesday, April 3rd to 4th**. This tutorial will teach how to compile and run COSMO with this version of the dynamical core activated. Furthermore it will give an overview of the C++ code and enable to make basic modifications and additions, which might be required within PhD projects or other applications of the COSMO model. **The course will be held if enough registrations for it are received until mid of December.**

- (No lessons on the Community Land Model in RCM mode this time. The next course will be hopefully offered in 2018.)

- Participants of the extra **ART** or **Community Land Model** courses should have a good knowledge in running the model system. Otherwise, it is strongly recommended to attend the basic training in the first week.

Those interested in parts of the training are invited to register for these parts only.
Location

The Training Course will take place at the DWD Training Center in Langen, Germany. For more information on the Training Center see http://www.dwd.de/btz (click on the British flag to see the English page).

Registration

The deadline for registration is February 3rd, 2017.

A Registration Form is accessible from the web page http://www.clm-community.eu → Events → Training → click on ‘‘Registration to ...’’.

Please note that the NWP- and RCM practical exercises during the first week will be at the same time, so it is only possible to attend one of them. Therefore you have to choose between these three options in the registration form. Similarly, the extra COSMO-ART- and Community Land Model-lessons and -exercises on Monday and Tuesday of the second week are at the same time, too.

Two computer-pools are available, but due to limited capacities, the number of participants to this course is restricted. Therefore we might be forced to put people on a waiting list. Should this be the case, you will be notified as soon as possible.

Accommodation

Please note that the guesthouse at the BTZ is no longer available from 2016 on. All participants have to be accommodated in hotels in Langen or Offenbach and have to book their rooms themselves.

For example, the “Achat Comfort Hotel Frankfurt Airport” in Langen is close by the Training Center. Here and in other hotels we organized block reservations. Please refer to:

http://www.clm-community.eu → Events → Training → click on ‘‘Room reservations for COSMO/CLM/ART Training Course’’.

Financial Support

Generally, no financial support is available for the participants, with one exception.

Participants from COSMO members (National Weather Services) may submit a COSMO activity proposal.

Please try to secure the necessary funds from your institution as soon as possible, so that there is enough time for a smooth travel preparation.

Visa

Depending on your country of origin, you might need a visa to enter Germany. If this is the case, we can support you by providing an invitation letter.

The deadline for this is January 11th, 2017.
If you need such a letter, please follow the respective link on the above registration web page and enter the required personal data into the form.

These are:

1. Full name
2. Sex
3. Date of birth
4. Place of birth
5. Full office address
6. Email
7. Fax
8. Passport number
9. Date of arrival in Germany
10. Date of departure from Germany

Consider to start the visa process as early as possible, because the German embassies might be closed before and after New Year’s Day for several weeks, depending on local celebrations and holidays.

**Contents of the Training**

**Theory Lessons (THE) — preliminary planning**

1. Model Overview
   - Components of the COSMO-Model system
   - The Software Package: Availability and User Support
   - Necessary computing environment
   - Necessary data to operate the model

   Schättler

2. Dynamics and Numerics
   - Continuous and discretized model equations
   - Time splitting
   - Grid definition
   - Boundary conditions
   - The Runge-Kutta time step and available spatial discretizations
   - Advection algorithms (semi-Lagrange, Bott, etc.)
   - Stability analysis for Leapfrog and Runge-Kutta time stepping

   Will / Baldauf

3. Physical Parameterizations
   - Cloud Microphysics and (subgrid-scale) cloudiness
   - Radiation
   - Turbulence
   - Surface layer scheme
   - Convection
   - Subgrid Scale Orography scheme
   - Soil
   - Lakes
   - Sea Ice

   Blahak
   Reinhardt
   Raschendorfer
   Raschendorfer
   Mironov
   Schulz
   Helmert
   Mironov
   Mironov

4. Verification for NWP

   N.N.
5. Data Assimilation for NWP
   - Nudging for the Atmosphere
   - Sea Surface Temperature Analysis
   - Snow Analysis
   - Soil Moisture Analysis
   - Latent Heat Nudging

6. Dynamics on long time scales
   - Concept of regional climate modelling
   - Difference NWP and RCM mode
   - Model developments for RCM applications
   - Uncertainty and model errors on long time scales

7. Evaluation of CLM runs

8. Aerosol, Clouds and Radiation (Monday and Tuesday 2\textsuperscript{nd} week)
   - Overview on the physical and chemical processes included in COSMO-ART
     B. Vogel
   - Emissions
     Kraut
   - Gas phase chemistry
     H. Vogel
   - Aerosol dynamics
     B. Vogel
   - Radiation and clouds
     Rieger, Schadt
   - External parameter, boundary and emission conditions (INT2LM-ART)
     Rieger

\textbf{Practical Exercises — preliminary planning}

All exercises will be offered separately for the NWP- and the RCM-applications as well as for running idealized cases, COSMO-ART, and Community Land Model. The NWP- and RCM- exercises will be in the first week at the same time, so it is not possible to attend all of them. The same holds for COSMO-ART and Community Land Model. Exercises on idealized cases are separate during the first week.

1. Installation of the model system
   - Installation of the source code
   - Installation of the Grib and the NetCDF libraries
   - Creating the binaries for INT2LM and the COSMO Model
   - Defining the model domain and getting external parameters

2. Preparing external, initial and boundary data
   - Job organization and run-Scripts
   - External data
   - Namelist input for INT2LM

3. Running the COSMO-Model in NWP- / Climate-Mode
   - Job organization
   - Namelist input for the COSMO Model
   - Basic configurations for NWP
   - Case studies / experiments
4. Visualization and analysis of GRIB / NetCDF Files
   - Graphics
   - Visualization of Grib data
   - Visualization and analysis of NetCDF data (CDO, NCO, ETOOL)

5. Troubleshooting in NWP- / climate mode

6. Individual exercises

7. Running idealized cases

8. Running COSMO-ART (Monday and Tuesday 2nd week)
   - Dispersion of material released by a single source, e.g. volcano, power plant etc.
   - Dispersion of primary aerosol like sea salt, mineral dust, and pollen grains
   - Simulations with gas phase chemistry and interaction with aerosol
   - Impact of aerosol on radiation and clouds
   - Preprocessing of input data ⇒ Running INT2LM-ART

The timetable will be very similar to last year’s timetable, which is given below.

**Lecturers**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Michael Baldauf</td>
<td>DWD FE 13</td>
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<tr>
<td>Susanne Brienen</td>
<td>DWD KU 11</td>
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<td>Isabel Kraut, KIT</td>
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<td>Dmitrii Mironov</td>
<td>DWD FE 14</td>
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<td>Thorsten Reinhardt, AGeoBw</td>
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<td>Burkhardt Rockel, Helmholtz-Zentrum Geesthacht</td>
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<td>Ulrich Schättler, DWD FE 13</td>
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<td>Jan-Peter Schulz, DWD FE 13</td>
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<td>Merja Tölle, Uni Giessen</td>
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<td>Heike Vogel, KIT IMK-TRO Karlsruhe</td>
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<td>Ulrich Blahak, DWD FE 13</td>
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<td>Jürgen Helmert, DWD FE 14</td>
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<td>Matthias Raschendorfer, DWD FE 14</td>
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<td>Daniel Rieger, KIT</td>
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<td>Tobias Schadt, KIT</td>
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<td>Christoph Schraff, DWD FE 12</td>
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<td>Christian Steger, DWD KU 11</td>
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<td>Bernhard Vogel, KIT IMK-TRO Karlsruhe</td>
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<td>Andreas Will, BTU Cottbus</td>
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Further Informations

Web page

http://www.clm-community.eu → Events → Training.

Language and Prerequisites

The lessons, presentations and exercises will be held in English language. All slides will be in English. We expect a certain familiarity with

- Unix / Linux basic commands (cd, ls, grep, find, chmod, ssh, scp, . . .),
- text editors (vi, emacs),
- shell-scripts (ksh, bash),
- FORTRAN 90,
- basic knowledge in geophysical fluid dynamics,
- basic knowledge in analytical and discrete mathematics (3D analysis, linear algebra).

Concerning Unix / Linux beginners, you can find links to introductory materials on the web page.

Materials

All material will be made available on the web page, including:

- Slides of all presentations
- Model Documentation
- Tutorials

So long as the materials from the upcoming training are not available, you can take a look to last years presentations at the bottom of the page:

http://www.clm-community.eu → Events → Training.

The basic informations and descriptions of model physics and dynamics will be very similar.

Contact

For questions on organizational matters, you can write an email to: COSMO-CCLM.Training@dwd.de

For urgent questions concerning the COSMO / CLM / ART lectures and exercises, please contact

- NWP related: Ulrich Schättler ulrich.schaettler@dwd.de
- RCM related: Susanne Brienen susanne.brienen@dwd.de
- ART related: Bernhard Vogel bernhard.vogel@kit.edu
- Community Land Model related: Edouard Davin edouard.davin@env.ethz.ch
<table>
<thead>
<tr>
<th>Time</th>
<th>Monday 27.03.2017</th>
<th>Tuesday 28.03.2017</th>
<th>Wednesday 29.03.2017</th>
<th>Thursday 30.03.2017</th>
<th>Friday 31.03.2017</th>
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<tbody>
<tr>
<td>09:00 − 10:30</td>
<td><strong>Dynamics and Numerics</strong>&lt;br&gt;Baldauf</td>
<td><strong>Data Assimilation for NWP</strong>&lt;br&gt;Schraff</td>
<td><strong>Dynamics on long timescales</strong>&lt;br&gt;Will</td>
<td><strong>Troubleshooting in NWP Mode</strong>&lt;br&gt;Practical Exercises III</td>
<td><strong>Phys. Parameterizations V</strong>&lt;br&gt;External Parameters&lt;br&gt;Soil; Lakes; Sea Ice&lt;br&gt;Helmert</td>
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<td>10:30 − 11:00</td>
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<td>11:00 − 12:30</td>
<td><strong>Physics I</strong>&lt;br&gt;Convection&lt;br&gt;Köhler</td>
<td><strong>Phys. Parameterizations II</strong>&lt;br&gt;Radiation&lt;br&gt;Subgrid Scale Orograph&lt;br&gt;Reinhardt, Schulz</td>
<td><strong>Phys. Parameterizations IV</strong>&lt;br&gt;Turbulence, Surface Transfer&lt;br&gt;Raschendorfer</td>
<td><strong>Verification for NWP</strong>&lt;br&gt;Fundel</td>
<td><strong>Evaluation of climate runs</strong>&lt;br&gt;Anders</td>
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<td>12:30 − 13:00</td>
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<td>13:00 − 15:00</td>
<td>Model Overview&lt;br&gt;Phys. Parameterizations III&lt;br&gt;Microphysics&lt;br&gt;Blahak</td>
<td>Running in NWP Mode&lt;br&gt;Starter Package III&lt;br&gt;Phys. Parameterizations III&lt;br&gt;Microphysics</td>
<td>Verifications for NWP&lt;br&gt;Verification for NWP&lt;br&gt;Fundel</td>
<td><strong>Aerosols and Chemistry</strong>&lt;br&gt;Dynamics; COSMO-ART&lt;br&gt;Vogel</td>
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<td>15:00 − 15:30</td>
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<td>15:30 − 17:00</td>
<td><strong>Installation of the Model System</strong>&lt;br&gt;Starter Package I&lt;br&gt;Visualization of GRIB files I</td>
<td><strong>Visualization of NetCDF files I</strong>&lt;br&gt;Postprocessing and Visualization of NetCDF files I</td>
<td><strong>Idealized Test Cases I</strong>&lt;br&gt;Practical Exercises I&lt;br&gt;Make your own COSMO forecast</td>
<td><strong>Practical Exercises IV</strong>&lt;br&gt;Individual Exercises/Own Projects</td>
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<td>17:00 − 18:30</td>
<td><strong>External, initial and boundary data</strong>&lt;br&gt;Starter Package II&lt;br&gt;Visualization of GRIB files II</td>
<td><strong>Postprocessing and Visualization of NetCDF files II</strong>&lt;br&gt;Idealized Test Cases II</td>
<td><strong>Practical Exercises II</strong>&lt;br&gt;Make your own COSMO forecast</td>
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<td>18:30 − 21:00</td>
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Theoretical lessons (THE)<br>Regional Climate Mode (RCM) specific THE<br>Pract. exerc. for NWP<br>Pract. exerc. for RCM
<table>
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<tr>
<th>Time</th>
<th>Monday 03.04.2017</th>
<th>Tuesday 04.04.2017</th>
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</table>
| 09:00 – 10:30| Emissions K. Deetz  
Gas Phase Chemistry H. Vogel  
Introduction General Code Flow | Aerosol Dynamics S. Gruber  
Aerosols and Radiation K. Deetz  
Setup on GPU |
| 10:30 – 11:00| Coffee Break                                                                     |                                                       |
| 11:00 – 12:30| Installing and Running COSMO-ART H. Vogel  
Configuration | Aerosols and Clouds S. Gruber  
External Parameters (INT2LM_ART) K. Deetz  
STELLA Example |
| 12:30 – 13:00| Lunch Break                                                                      |                                                       |
| 13:00 – 15:00| Special course COSMO-ART  
Compilation | Special course COSMO-ART  
Add a new diagnostic to the Dycore |
| 15:00 – 15:30| Coffee Break                                                                      |                                                       |
| 15:30 – 17:00| Special course COSMO-ART  
Hands-on compiling | Special course COSMO-ART: Troubleshooting  
Reserve, Q&A, Tooling |
| 17:00 – 18:30| Special course COSMO-ART  
Hands-on compiling | Special course COSMO-ART  
Reserve, Q&A, Tooling |

**COSMO-ART specific THE**  
**Pract. exerc. for COSMO-ART**  
**Accelerated Dynamical Core**  
**Hands-on and practical exercises**