Numerical Model Training Course 2023

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The *Numerical Model Training Course 2023* for the ICON model took place from March 27$^{\text{th}}$ to 31$^{\text{st}}$. The organization team from DWD received further support from the COSMO partner weather services and members of the CLM community.

The application areas of the ICON model range from numerical weather prediction (NWP) and regional climate simulations (CLM - Climate Limited Area Model) to the prediction of trace substance dispersion with ICON-ART. Therefore, national meteorological services, universities and research institutions are among the ICON users and the target groups of the training course. Each morning, lectures on the physical basics of the ICON model, data output of the DWD and technical details of ICON were scheduled (see Fig. 1). In the afternoon, practical exercises allowed participants to learn how to run ICON simulations.

Numerical Model Training 2023: Program Overview *(Times in CEST)*

	Monday 27.03.	Tuesday 28.03.	Wednesday 29.03.	Thursday 30.03.	Friday 31.03.
9:00 – 9:45		Dynamics *G. Zängl*	Microphysics *A. Seifert*	Gravity Wave Drag *M. Köhler*	Soil & External Parameters *J. Helmert*
9:45 – 10:30		Advection *D. Reinert*	Clouds & Convection *A. de Lozar*	Data Provision *H. Riede*	Lake & Sea Ice *D. Mironov*
10:30 – 11:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00 – 11:45		Nesting & ICON-LAM *D. Reinert*	Turbulent Diffusion *M. Raschendorfer*	Radiation *M. Ahlgrimm*	Exercise: Installation
11:45 – 12:30		Physics Overview *L. Schlemmer*	Turbulent Transfer *M. Raschendorfer*	ICON-ART *A. Hoshyaripour*	Exercise: Installation Wrap-up
12:30 – 13:00	Registration	Lunch Break	Lunch Break	Lunch Break	
13:00 – 13:30	Introduction & Getting Started I *D. Rieger & F. Prill*				
13:30 – 14:00		Group Picture			
14:00 – 14:45	Getting Started II *F. Prill*	Exercise II	Exercise III	Exercise IV	
14:45 – 15:30	Exercise I	Exercise II	Exercise III	Exercise IV	
15:30 – 16:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
16:00 – 16:45	Exercise I	Exercise II	Exercise III	Exercise IV	
16:45 – 17:30	Exercise I	Exercise II	Exercise III	Exercise IV	
17:30 –		Icebreaker			

Figure 1: Timetable for the Model Training 2023.

After the cancellation of the Numerical Model Training 2020 at short notice due to Covid 19, only a substitute online training with shortened exercises took place since then. The interest in the first face-to-face course after four years therefore was very high. To meet this demand, three parallel exercise groups were planned already at an early stage. These groups covered NWP for universities (*Academia*), regional climate simulations (*CLM*) and NWP for national weather services (*MetServices*).

In total, we welcomed 71 participants in Offenbach (see Fig. 2). The fact that WMO supported several African national meteorological services resulted in an international course with participants from Austria, Brazil,

Burkina Faso, France, Germany, Israel, Italy, Kenya, Mauritius, Mozambique, Niger, Oman, Seychelles, South Africa, Switzerland, Tanzania, United Arab Emirates and Zimbabwe.

Figure 2: Participants of Numerical Model Training 2023.

For the first time, the training was held at the headquarters in Offenbach, with exercises in the conference areas *Blue* and *Green* as well as in the *Gartensaal*. The lectures were streamed from conference area *Blue* to the other rooms.

The participants had to bring their own notebooks for the exercises. The *Academia* and CLM course were performed on the HPC `levante` at the German Climate Computing Center (DKRZ) while the *MetService* course was run on ECMWF's ATOS system.

In the scope of the training course, the ICON Tutorial was also revised and published. The ICON Tutorial is updated with each training course and is now the most comprehensive model documentation available for the ICON model.It is available for download on `https://www.dwd.de/EN/ourservices/nwv_icon_tutorial/nwv_icon_tutorial_en.html`

The exercises of the *Academia* group, designed and conducted by F. Prill, D. Reinert, and D. Rieger (DWD), cover a wide range of ICON functionalities. These exercises continue the successful ICON training that has been developed over the past ten years. A crucial innovation is the use of Jupyter Notebooks for the *Academia* exercises, which in the meantime have established themselves as the "de-facto standard" in e-learning. The initial steps consisted of idealized simulations that otherwise serve as tests with reference solution for numerical weather prediction models. By adding higher resolution simulation areas, so-called nests, the participants got to know a basic functionality of ICON, which is also used operationally, e.g. with the ICON-EU-Nest. The next step was a global three-day forecast, started from DWD analysis. Based on this, the participants extended the setup of ICON to generate initial and boundary data for a simulation with ICON as a local model (limited-area mode, LAM). In the third exercise block the LAM simulation for a higher resolution area over Germany was conducted. In the last part of the *Academia* exercises, the participants, mostly PhD students and postdocs who want to use and further develop ICON in their projects, were able to make changes to the source code of ICON to compute and output a new diagnostic.

The CLM portion of the course was designed and delivered by the CLM community. The course provided an introduction to the *Starter Package for ICON-CLM Experiments* (SPICE). SPICE is a runtime environment for performing regional climate simulations with ICON-CLM. SPICE was developed within the CLM

community. Participants learned how to install and configure SPICE and how to use it to run simulations. In special exercises the participants learned which steps are necessary to perform a simulation for a different time period, a different area and with different boundary conditions. Furthermore, it was explained how to create a simulation with convection allowing resolution. Boundary data were provided by a previously created experiment with coarser resolution. Analyzing the results with the evaluation tool *EvaSuite* included in SPICE has been explained as well. In the final exercise, participants were able to begin configuring the model for their target region and use case.

For the first time, tailored exercises with the ICON model were offered for the group of national meteorological services. These exercises and corresponding materials have been developed by a group of COSMO scientists: U. Schättler and J.-N. Welß from DWD, S. Dinicila, S. Gabrian and R. Dumitrache from NMA, W. Interewicz and D. Wojcek from IMGW and A. Shtivelman from IMS. Several online meetings have been held in the weeks before the NWP Model Training to coordinate and discuss the necessary work. The first task for the participants was to generate a grid and external parameters for their own model area using the DWD's grid generator web service. The preprocessing step (interpolation of global ICON data to a regional grid) and the execution of an ICON-LAM simulation were then performed by all of them on a provided grid under the guidance of the tutors. Subsequently, these steps then had to be transferred to the self-generated grid in the individual participants target area. Exercises for visualizing the model results rounded off the practical learning content. On the last afternoon, colleagues from ECMWF offered online lectures and exercises on ECMWF's scheduler `ecflow`. This enables the automated execution of all steps that were started by hand during this week, which is necessary for an operational prediction. All computer simulations were performed on DWD training accounts on ECMWF's HPC (ATOS).

The final exercise block, common to all groups, provided an overview of how to install ICON on an HPC system. This exercise was designed and performed by U. Schättler.

We would like to express our sincere thanks to all colleagues who supported us in the preparation and execution. Special thanks go to ECMWF for their support with ecflow and the HPC system.