News CLM Community

COSMO General Meeting 2025
03 September 2025
Basel, Switzerland

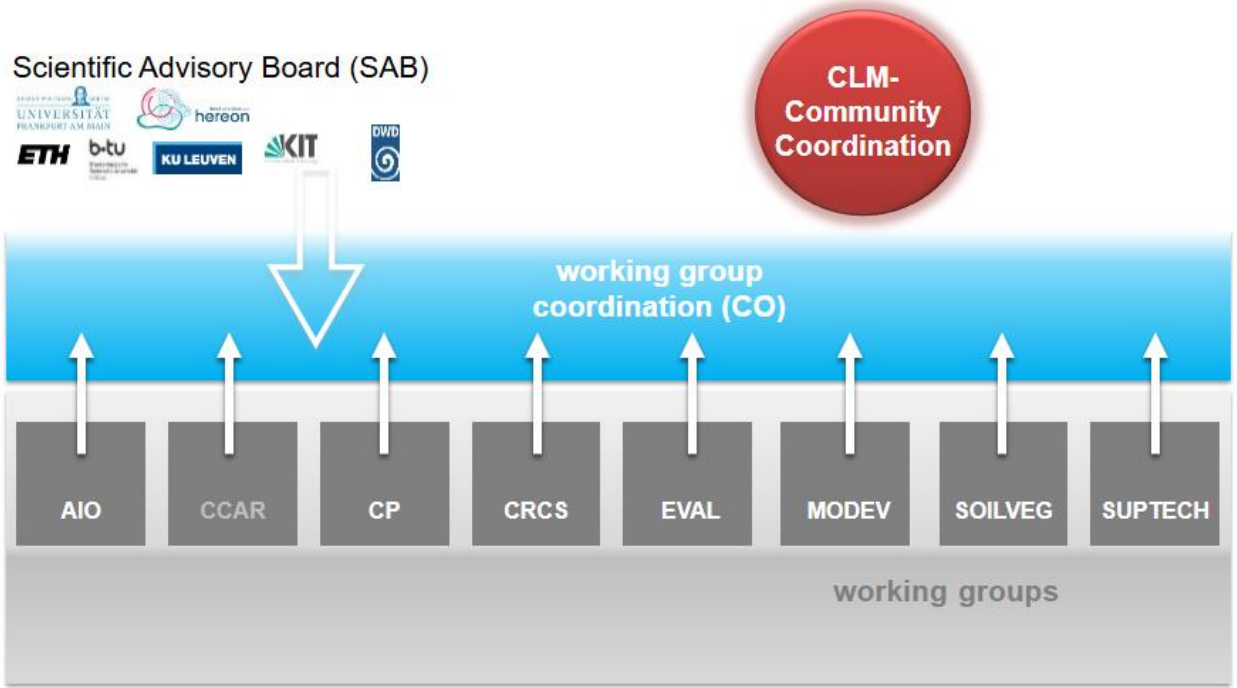
Outline

1. **Main working group activities last year**
2. ICON-CLM simulations for EURO-CORDEX
3. CLM Community numbers and meetings

CLM Community Overview

SAB Chair: Stefan Hagemann (Hereon)

DLR stepped back as core institution in 2024



WG SUPTECH

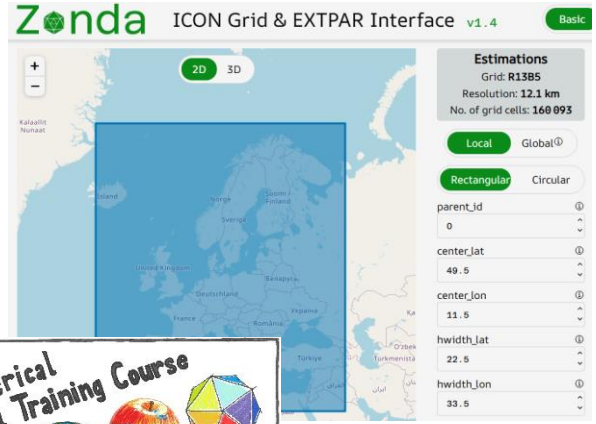
- **SPICE** (Starter Package for ICON-CLM Experiments):
  release of v2.3, documentation updated
- **Zonda** (new web interface for EXTPAR and ICON Grid Generator):
  contribution to tests
- **Training course** (exercises using ICON-CLM and SPICE):
  prepared and conducted in May 2025

Starter Package for
ICON-CLM Experiments (SPICE)

Installation and Setup Documentation

Version 2.3

DOI (SPICE in general): 10.5281/zenodo.10047046



WG EVAL

EvaSuite developing *(Evgenii Churiulin)*

- ***Project Transferred:*** Migrated to the CLM DKRZ GitLab for collaborative development
- ***Code Refactoring:*** Simplified code structure with added type hinting and comprehensive docstrings
- ***Visualization Update:*** Replaced legacy R-based visualizations with a modern Python-based plotting framework
- ***Testing:*** Developed automated unit tests for key functions to ensure robustness and maintainability
- ***Example Collection:*** Created dedicated example workflows for demonstration and user onboarding
- ***Robustness Improvements:*** Enhanced logging system and introduced advanced error checking mechanisms
- ***Open Source Ready:*** Prepared the codebase for public release, following best practices for accessibility and reproducibility

WG EVAL

COPAT2 manuscript *(Beate Geyer)*

Scientific Publication Progress:

- Drafted a manuscript for submission to Geoscientific Model Development (GMD)
- Drafted a list of datasets for submission to GMD

Title:

- Calibration of ICON-CLM for the CORDEX-EU Domain

Scope:

- Describes the setup, methodology, and results of calibrating the ICON-CLM regional climate model
- Focuses on the CORDEX-EU domain with emphasis on reproducibility and evaluation metrics
- Includes integration with EvaSuite for standardized evaluation workflows

Status:

- Manuscript in preparation, plan to finish it before CLM assembly 2025

Calibration of ICON-CLM for the CORDEX-EU domain

Beate Geyer[1], Angelo Campanale[2], Evgenii Churiulin[3], Hendrik Feldmann[3], Klaus Görgen[4], Stefan Hagemann[1], Ha Thi Minh Ho-Hagemann[1], Muhammed Muhshif Karadan[5], Klaus Keuler[5], Pavel Khain[6], Divyaja Lawand[5], Patrick Ludwig[3], Vera Maurer[7], Sergei Petrov[1], Stefan Poll[4], Christopher Purr[7], Emmanuele Russo[8], Martina Schubert-Frisius[9], Jan-Peter Schulz[7,2], Shweta Singh[7], Christian Steger[7], Heimo Truhetz[10], and Andreas Will[5]

[1]Institute of Coastal Systems, Helmholtz-Zentrum Hereon, Geesthacht, Germany
[2]CMCC Foundation - Euro-Mediterranean Center on Climate Change, Italy
[3]Institute of Meteorology and Climate Research Troposphere Research (IMKTRO), Karlsruhe Institute of Technology, Germany
[4]Institut für Bio- und Geowissenschaften (Agrosphere, IBG-3), Forschungszentrum Jülich, Germany
[5]Fachbereich für Atmosphärische Prozesse, Brandenburgische Technische Universität Cottbus-Senftenberg, Germany
[6]Israel Meteorological Service, Bet-Dagan, Israel
[7]Deutscher Wetterdienst, Offenbach am Main, Germany
[8]Institute for Atmospheric and Climate Science, ETH Zurich, Zürich, Switzerland
[9]GERICS, Helmholtz-Zentrum Hereon, Geesthacht, Germany
[10]Wegener Center for Climate and Global Change (WEGC) - University of Graz, Austria

WG SOILVEG: Activities

- **Urban modelling**
  - Strategic insights on urban climate modelling: Participation in Euro-CORDEX and the WCRP Flagship Pilot Study URB-RCC with a coordinated team from CMCC, KIT and KU Leuven
  - Implementation of ECOCLIMAP-SG in ICON (Schulz et al., DWD, CMCC), now testing and tuning
- **Irrigation**
  - Impact of spatial extension of irrigation in ICON-NWP (Roque and Valmassoi, Uni Bonn, DWD)
- **Land surface process studies and development**
  - Initialisation of snow in TERRA for seasonal prediction (group of Ahrens et al., GUF)
  - Studies on role of land surface in the climate system (groups of Seneviratne et al., Prein et al., ETHZ)

WG AIO: Regional Earth System Models (RESMs)

- Coupled to COSMO-CLM
  - ocean models NEMO 3.6, NEMO-MED12, MOM 5 (Hereon, GUF, IOW)
  - hydrological discharge model HD 5.2 (Hereon)
  - bio-geochemical model ECOSMO (Hereon)
  - community land model CLM 3.5.0 (FZJ)
  - the surface-subsurface hydrologic model ParFlow 3.13 (FZJ)
- Coupled to ICON-CLM
  - ocean NEMO 3.6 and hydrological discharge model HD 5.2 via OASIS3-MCT (Hereon)
  - ocean NEMO 4.2 via OASIS3-MCT (DWD)
  - ocean model ICON-O-LAM via YAC coupler (CMCC)
  - community land model eCLM vbeta-04 and ParFlow 3.13 via OASIS3-MCT (FZJ)
- Downscaled CMIP6 over the EURO-CORDEX
- CMORised model output data

Publications
see appendix

WG Convection-Resolving Climate Simulations (CRCS)

- Main joint activity in WG-CRCS (25plus WG members involved)
  - **Coordinated Evaluation of Convection Permitting Climate simulations with ICON-CLM for Germany (CECPI-Ger)**: Towards an optimized configuration for convection-permitting ICON-CLM climate runs
  - Methodologies: Coordinated Parameter Testing (COPAT), Linear Meta Model
  - Optimization of about 60 parameters with current ICON version in LAM setup over Germany
  - First optimized configuration (CEI195c) for single-moment scheme ready in February 2025 (start beginning of April 2024), for example: Reduction of 2m maximum air temperature biases; improvement of diurnal cycle, the 99th percentiles and spatial skill scores of precipitation, etc.; 11 highly sensitive parameters were identified; publications by Will et al. and Petrov et al. are under preparation
- Currently
  - Smaller Task Group continues towards optimized configuration with 2-moment MP scheme
  - Transient 150-year climate-mode ICON simulations at 3km over Germany in the BMBF UDAG project

WG Convection-Resolving Climate Simulations (CRCS)

- Other activities (non-comprehensive)
  - Provisioning of km-scale data from CORDEX-FPSCONV initiative via ESGF
  - Current FPSs with WG CRCS members' participation (e.g. FPS-URB)
  - Coupled RCSM runs from WG members under preparation (e.g., CMCC and FZJ)
  - Some WG CRCS members contribute to initiatives such as TEAMx
- Just started / Outlook
  - Establishment of Task Groups to test the new configuration e.g. over the Mediterranean and the Alps (with focus on specific processes)
  - Use of ICON-LAM km-scale operating environment on the new JUPITER GPU system at JSC in addition, e.g., to Levante for some WG CRCS simulations

Outline

1. Main working group activities last year
2. **ICON-CLM simulations for EURO-CORDEX**
3. CLM Community numbers and meetings

Planned Simulations CLM Community for EURO-CORDEX

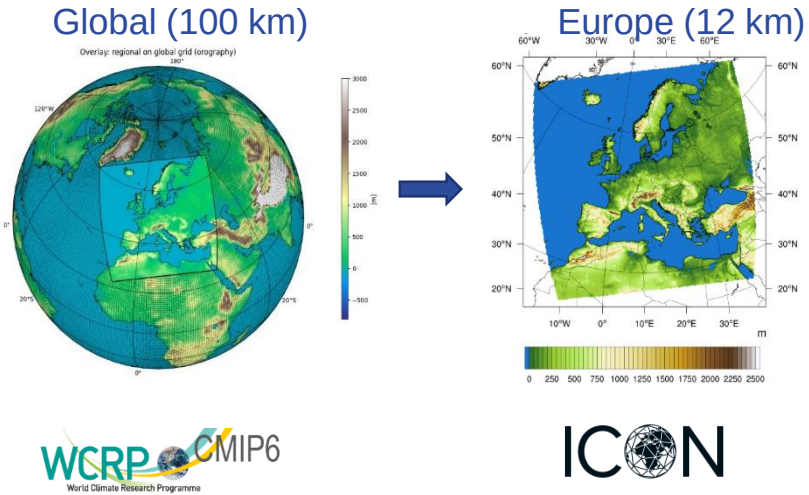
GCM / RCM	EC-Earth3-Veg r1i1p1f1	MPI-ESM1-2-HR r1i1p1f1	CNRM-ESM2-1 r1i1p1f2	NorESM2-MM r1i1p1f1	MIROC6 r1i1p1f1	CMCC-CM2-SR5 r1i1p1f1
COSMO-CLM	historical SSP1-2.6 SSP3-7.0 SSP5-8.5	historical SSP1-2.6 SSP3-7.0 SSP5-8.5		historical SSP1-2.6 SSP3-7.0	historical SSP1-2.6 SSP3-7.0	historical SSP1-2.6 SSP3-7.0
ICON-CLM	**historical** **SSP1-2.6** **(SSP2-4.5)** **SSP3-7.0** **(SSP5-8.5)**	**historical** **SSP1-2.6** SSP2-4.5 **SSP3-7.0** **(SSP5-8.5)**	**historical** **SSP1-2.6** **(SSP2-4.5)** **SSP3-7.0** **(SSP5-8.5)**	historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5	**historical** **SSP1-2.6** **(SSP2-4.5)** **SSP3-7.0** **(SSP5-8.5)**	historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5

Rot = UDAG Partner (KIT, BTU, Hereon)
Blau = DWD
Schwarz = CLM Community partners: CMCC, WegC, C2SM, IMWM; FZJ, LIST,

UDAG – 12 km simulations

- Provide regional climate projections based on current global climate models (CMIP6)
- "Dynamical Downscalling"
  - ICON-CLM replaces COSMO-CLM
  - 4 global models as driving models
  - Scenarios: SSP1-2.6 und SSP3-7.0

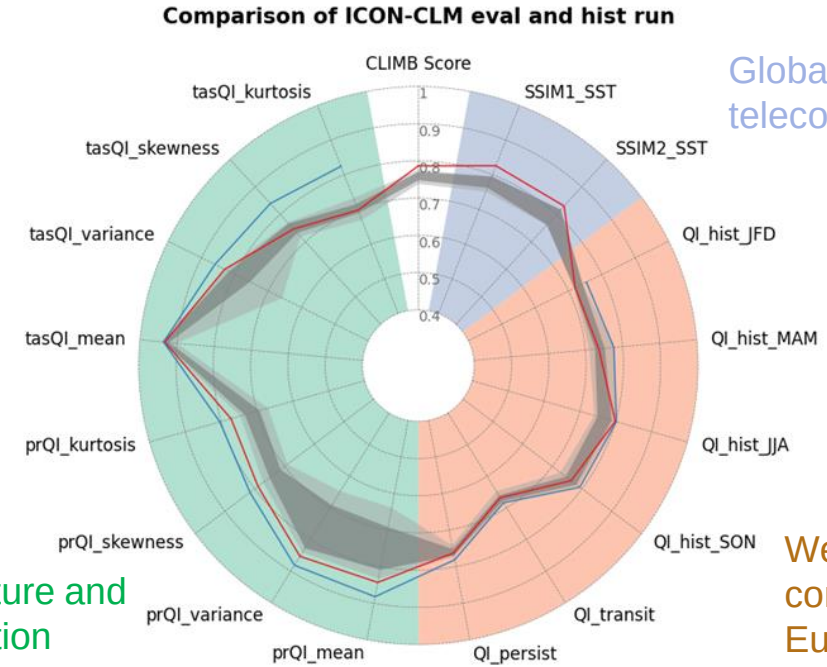
    (further scenarios depending on capacity)



GCM / RCM	EC-Earth3-Veg r1i1p1f1	MPI-ESM1-2-HR r1i1p1f1	CNRM-ESM2-1 r1i1p1f2	NorESM2-MM r1i1p1f1	MIROC6 r1i1p1f1	CMCC-CM2-SR5 r1i1p1f1
COSMO-CLM	historical SSP1-2.6 SSP3-7.0 SSP5-8.5	historical SSP1-2.6 SSP3-7.0 SSP5-8.5		historical SSP1-2.6 SSP3-7.0	historical SSP1-2.6 SSP3-7.0	historical SSP1-2.6 SSP3-7.0
ICON-CLM	Historical 2014 SSP1-2.6 2150 SSP2-4.5 2043 SSP3-7.0 2150 (SSP5-8.5) 2028	Historical 2014 SSP1-2.6 2100 SSP2-4.5 2100 SSP3-7.0 2100 SSP5-8.5 2100	Historical 2014 SSP1-2.6 2100 SSP2-4.5 2047 SSP3-7.0 2100 SSP5-8.5 2049	Historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5	Historical 2014 SSP1-2.6 2100 SSP2-4.5 2047 SSP3-7.0 2100 SSP5-8.5 2045	Historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5

Completed + CMORized
Completed
Running
Planned

Evaluation of 12km simulation



Global teleconnection

Grey area = CORDEX CMIP5
Blue line = ICON-CLM evaluation run
Red line = ICON-CLM MPI-ESM historical

Temperature and Precipitation distribution

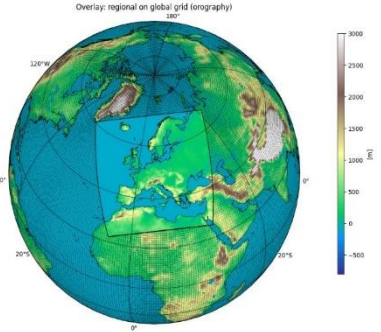
Weather condition in Europe

Harald Rybka et al. (DWD)

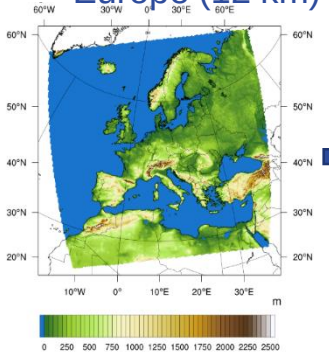
UDAG – 3 km simulations

➔ High-resolution simulations (3 km) for „Hydrological D-A-CH Region”:
Refinement of 12 Simulations to a convection-permitting scale (3 km)

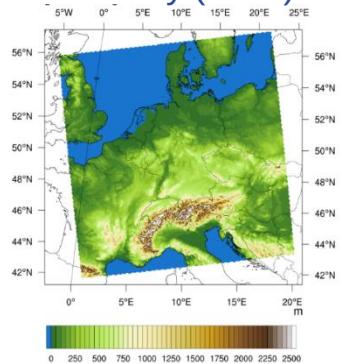
Global (100 km)



Europe (12 km)



Germany (3 km)



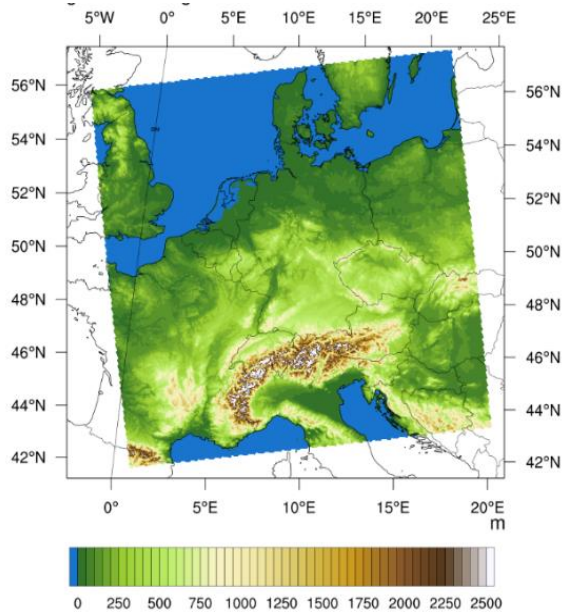
WCRP CMIP6
World Climate Research Programme

ICON

Setup of 3 km Simulation

- Based on latest NWP configuration
- Tuning Parameter:
  - Turbulence parameter
  - Cloud microphysics
- Development of a „Linear Meta-model“ to optimize the model setup
- Many test simulations to optimize the set up

Germany (3 km)



Status simulations @3km

GCM driven ICON-CLM@12km RCM	Processor (CPU/GPU)	ERA5 reanalysis	MPI-ESM1-2-HR	EC-Earth3-Veg	MIROC6
ICON-CLM@3km	CPU	Evaluation 2003	Historical 2014	Historical 2014	Historical 2000
	CPU and GPU		SSP1-2.6 2055	SSP1-2.6 2015	SSP1-2.6 2015
	CPU and GPU		SSP3-7.0 2072	SSP3-7.0 2015	SSP3-7.0 2015

Completed + CMORized
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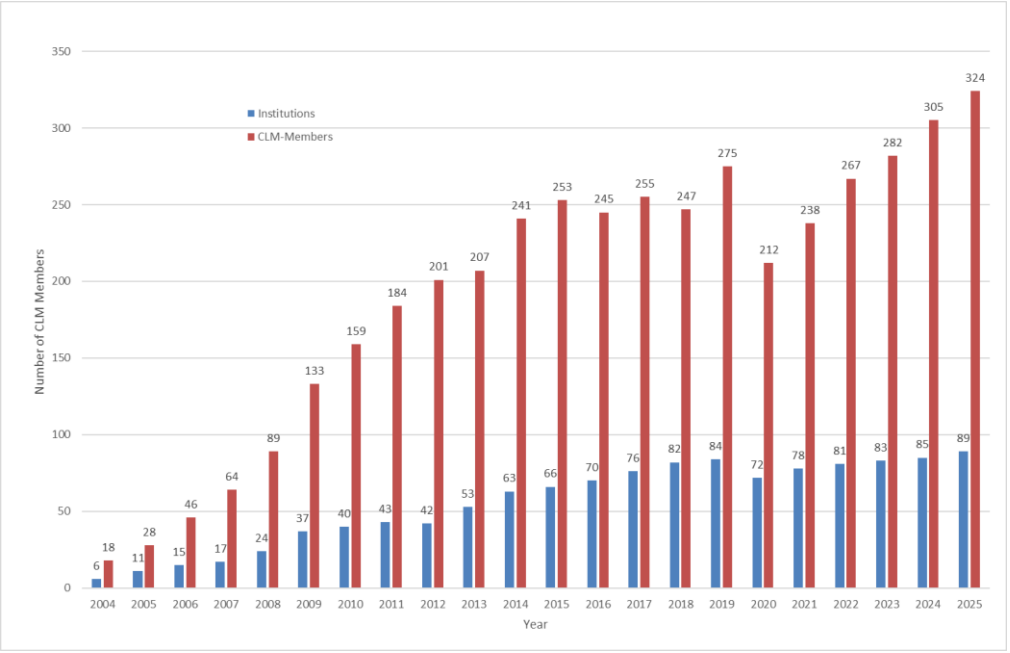
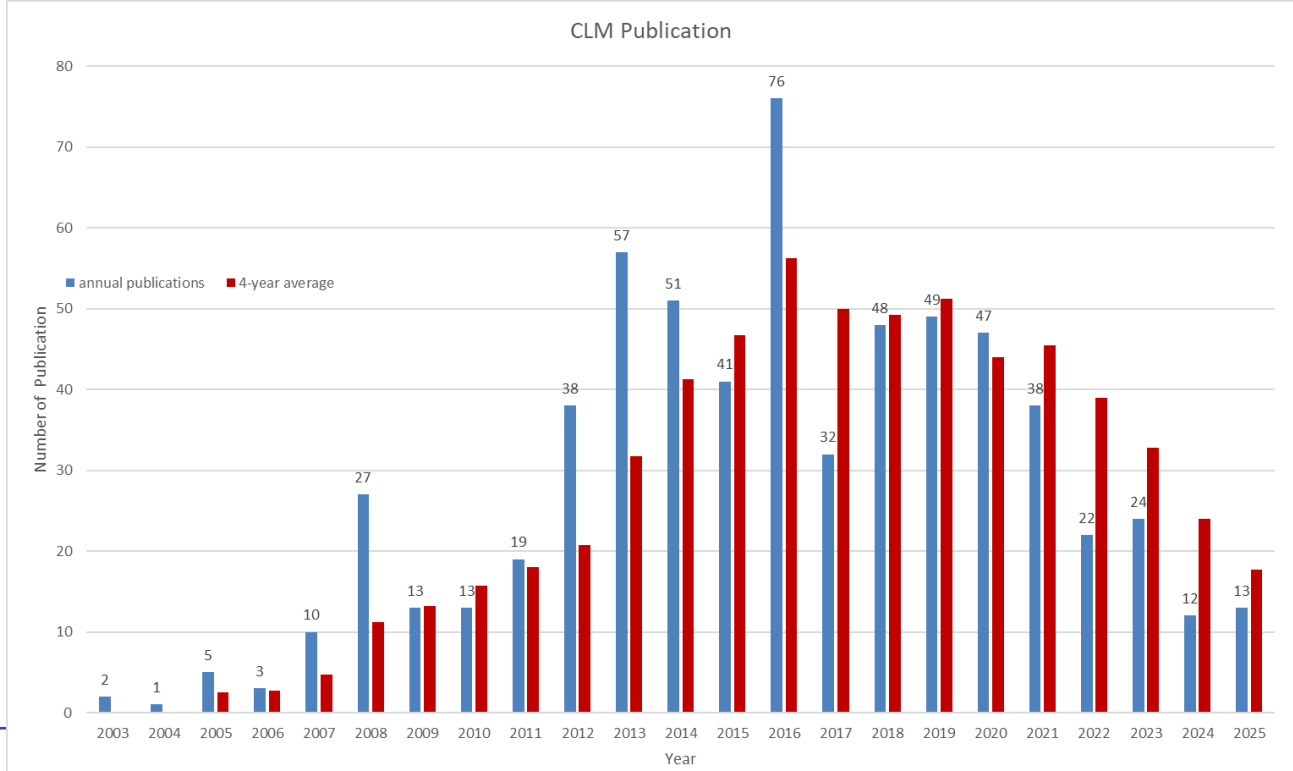
CLM Community members and institutions

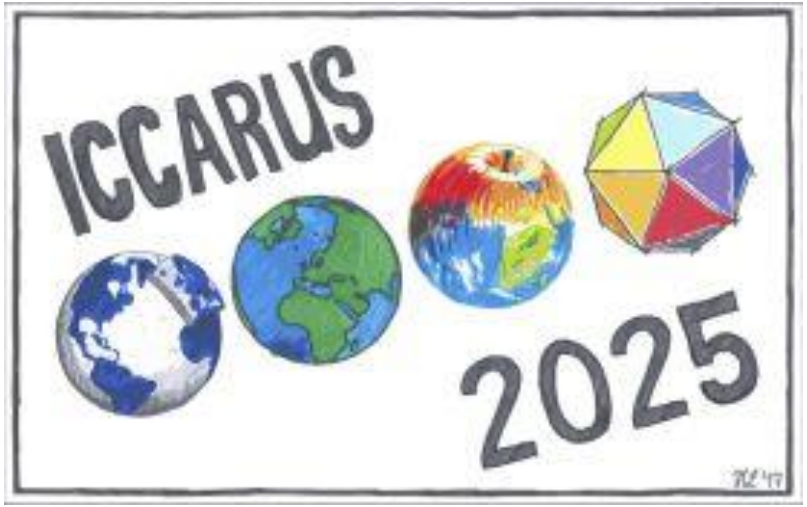


CLM Community development of publications



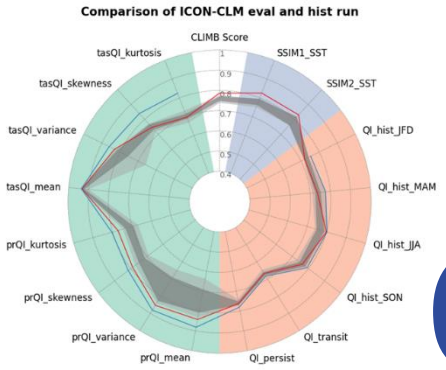
Meetings/Events 2025 + 2026

ICCARUS 2025:
10 - 14 March 2025, OF
ICON training course 2025:
12 – 16 May 2025, OF
CLM Community Assembly 2025:
23 – 26 September 2025, Graz
ICCARUS 2026:
16 -20 March 2026, OF
ICON training course 2026:
t.b.d.
CLM Community Assembly 2026:
22 – 25 September 2026, Lüneburg (t.b.c)



Take away messages

- CLM Community completed the transition from COSMO-CLM to ICON-CLM
- ICON-CLM simulations have in general better quality as COSMO-CLM simulations
- Recommend set ups for Europe @12 km and hydrological DACH region @3km (soon)
- Huge community effort to produce simulations for EURO-CORDEX. Many COSMO institutions/countries are involved (Italy, Poland, Switzerland, Israel)
- If other countries would also like to work in the field of regional climate modelling or require data for climate services, please contact Christian
- Simulations are on schedule and data will be published as soon as ESGF nodes are ready to take the data
- The new CORDEX-CMIP6 simulations will be the basis for climate services, climate adaptation and policy consultancy in Germany an many other countries in Europe



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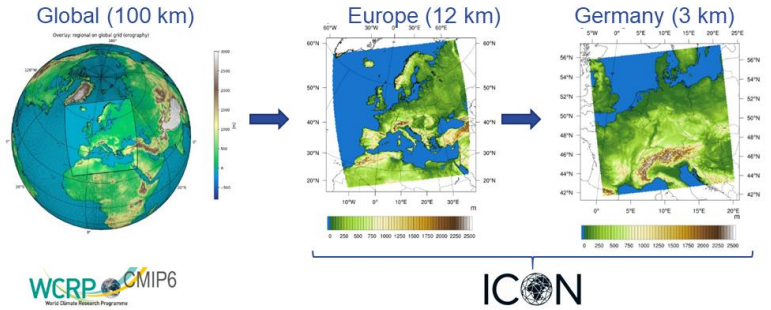
ICON-CLM	historical SSP1-2.6 (SSP2-4.5) SSP3-7.0 (SSP5-8.5)	historical SSP1-2.6 SSP2-4.5 SSP3-7.0 (SSP5-8.5)	historical SSP1-2.6 (SSP2-4.5) SSP3-7.0 (SSP5-8.5)	historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5	historical SSP1-2.6 (SSP2-4.5) SSP3-7.0 (SSP5-8.5)	historical SSP1-2.6 SSP2-4.5 SSP3-7.0 SSP5-8.5

Questions?



Starter Package for ICON-CLM Experiments (SPICE)

Installation and Setup Documentation

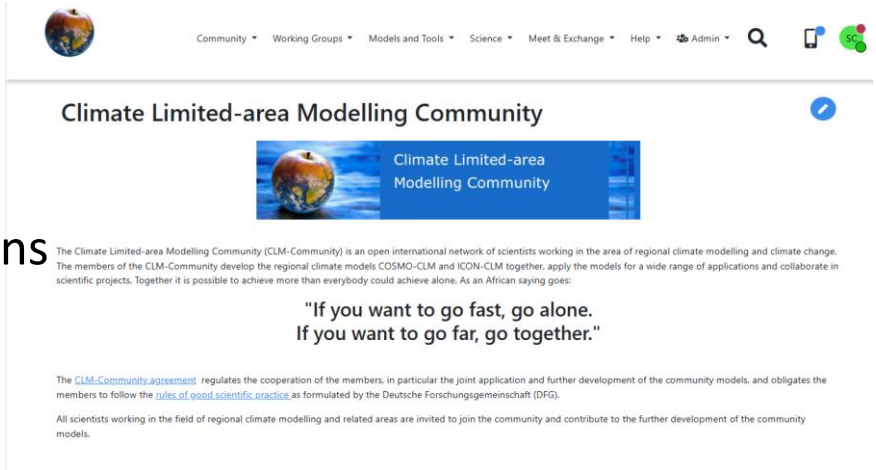
Version 2.3

DOI (SPICE in general): 10.5281/zenodo.10047046

WG SUPTECH

Further ongoing work:

- Community Website
- GitLab
- General Testsuite for new model versions
- User Management
- User Support
- Namelist-Tool
- Cmip2caf converter programs for input data
- CMORization tools



WG AIO: Regional Earth System Models (RESMs)

- Evaluation RESMs over the EURO-CORDEX domain
  - GCOAST-AHOI (Hereon): paper published (Ho-Hagemann et al., 2024)
  - IOW-ESM (IOW): paper published (Karsten et al., 2024)
  - ROAM-NBS (DWD): paper submitted (Maurer et al., 2025)
  - TSMP1 and TSMP2 (FZJ): paper in preparation (Poll et al.)
  - ICON-CLM + ICON-O-LAM (CMCC): paper in preparation (Campanale et al.)
- Downscaled CMIP6 over the EURO-CORDEX
  - Simulations are running and planned based on the balance matrix of the EURO-CORDEX initiative
- CMORised model output data
  - Join the EURO-CORDEX evaluation initiatives (on-going work)
  - Publish to the Earth System Grid Federation (ESGF) portal (planned)

Technical updates

- Porting of ICON-CLM to GPUs
  - Reduction of runtime by approx. 20 %
  - Minimal differences in 2m temperature between CPU and GPU (BIAS: -0.002K)
- Consolidation of output diagnostics in ICON and optimization in runtime environment SPICE
  - Storage of driving data for 3 km as lateral boundary frames
  - Calculation of potential evapotranspiration as ComIN plugin