COSMO overview

Christoph Gebhardt (COSMO, DWD)

COSMO “Consortium for small-scale modeling”

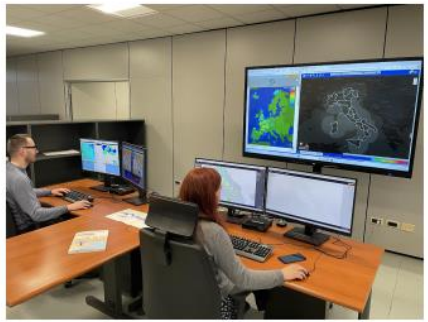
- 7 active national meteorological services as partners
- ~~7~~ 8 additional partners and military services
- Close cooperation with
  - KIT (ICON-ART)
  - CLM (regional climate modelling)

Agenzia ItaliaMeteo

Agenzia ItaliaMeteo (AIM) is the designated **National Meteorological and Climate Agency for Italy**, established by national law L. n. 205/2017.

AIM is a **public entity** with organizational, accounting, and budgetary autonomy, responsible at the national level for **informative, technical-scientific, and operational activities** in the fields of meteorology and climatology.

The agency is headquartered in Bologna.

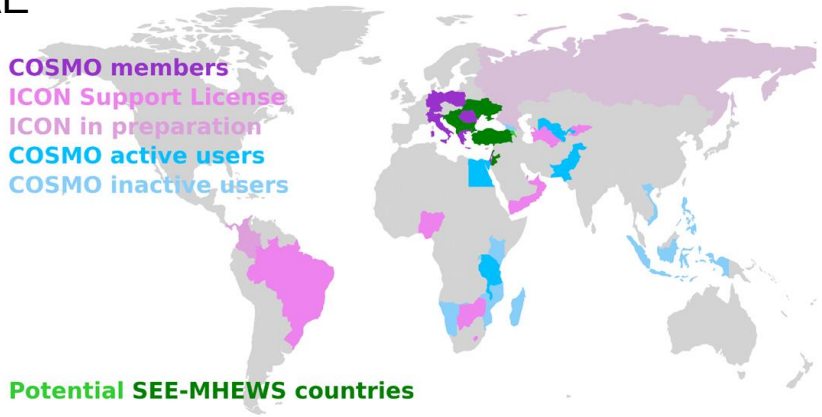


The role of the Agenzia ItaliaMeteo Agency in the meteorological modeling

- AIM has set up meteorological modelling **coordination groups** to coordinate meteorological modelling efforts at a national level
- AIM is **responsible for maintaining and developing the NWP system based on ICON** to support Italian stakeholders, particularly the National Department of Civil Protection
- AIM **promotes the use of the ICON** model in universities and other Italian operational and research institutions

ICON open source / COSMO support licenses

- Two new open source releases of ICON in April and October 2025
- www.icon-model.org
- ICON support licenses provided by COSMO consortium
  - running ICON: Brazil (Navy), Qatar, Oman, UAE
  - signed by: Botswana, Kyrgyzstan, Lesotho, Nigeria, Turkmenistan, Yemen, Zimbabwe
  - further countries are processing the contract
  - South-East European Multi-Hazard Early Warning Advisory System
    → providing access to ICON forecasts performed by IMS at ECMWF computer



Activities of COSMO members beyond priority projects etc.

- Extension of HiHydroSoil data set
- GLORI
- ‘headache problem’ – cases of excessive precipitation in convection-permitting LAMs
- Reanalysis activities

Extension of HiHydroSoil v2.0 data set

- The HiHydroSoil v2.0 data set (by FutureWater) represents the first global high-resolution dataset (250m) that directly provides physical soil parameters
- Tested for use in ICON (Jürgen Helmert, DWD)
- Extension of the existing data set by soil properties from ISRICS SoilGrids data set required

Table 1. Input variables for deriving soil hydraulic properties

Name	Variable	Unit
bdod	Bulk density of the fine earth fraction	cg/cm^3
cec	Cation Exchange Capacity of the soil	cmol+/kg
clay	Proportion of clay particles (< 0.002 mm) in the fine earth fraction	‰
soc	Soil organic carbon content in the fine earth fraction	dg/kg
phh20	Soil pH	pH x 10
silt	Proportion of silt particles (≥ 0.002 mm and ≤ 0.05 mm) in the fine earth fraction	‰
sand	Proportion of sand particles (> 0.05 mm) in the fine earth fraction	‰

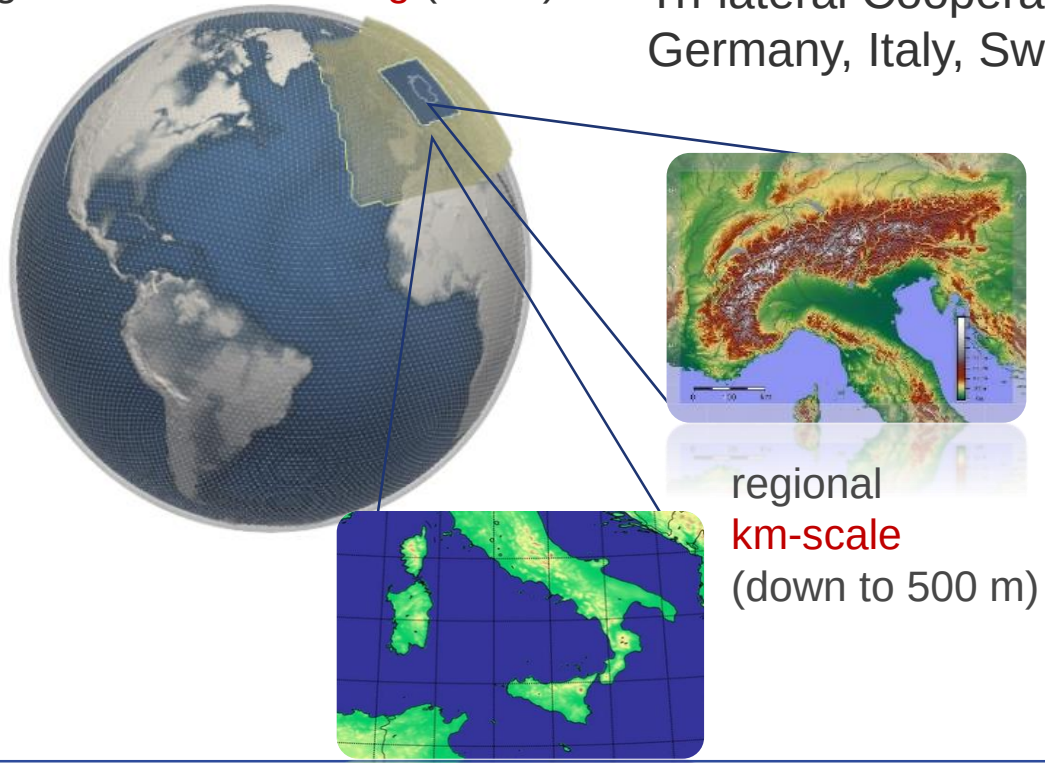
Table 2. Standard soil depths

Name	Standard depth	Thickness of layer
sd1	0-5 cm	5 cm
sd2	5-15 cm	10 cm
sd3	15-30 cm	15 cm
sd4	30-60 cm	30 cm
sd5	60-100 cm	40 cm
sd6	100-200 cm	100 cm

- Advantages for the simulation land-atmosphere interactions (ICON-NWP) and more accurate and consistent modeling of mineral dust emissions (ICON-ART)
- Contract signed with FutureWater to extend HiHydroSoil v2.0, funded by COSMO license fees

The GLORI Digital Twin

global storm-resolving (~3km)



Tri-lateral Cooperation
Germany, Italy, Switzerland

regional
km-scale
(down to 500 m)

global-to-regional short-range high resolution Digital Twin

configurable & on-demand

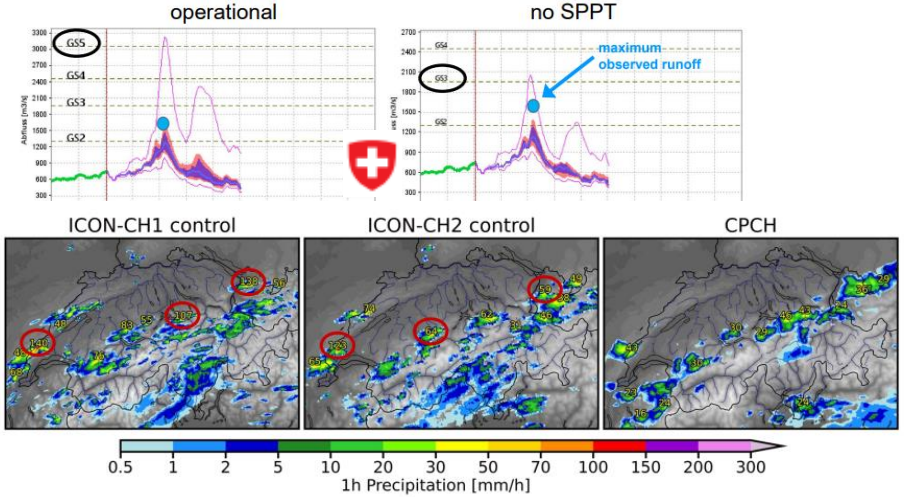
GLORI4DE
GLORI for DestinationEarth

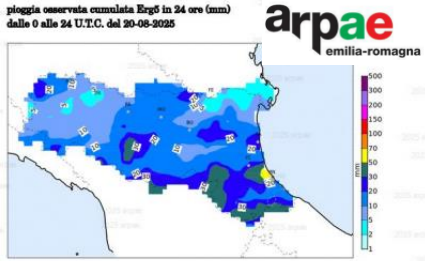
Interoperability with DestinE

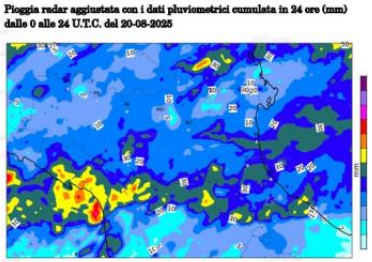
Link to ICON@500m, which is operational at DWD since 27th Feb 2025

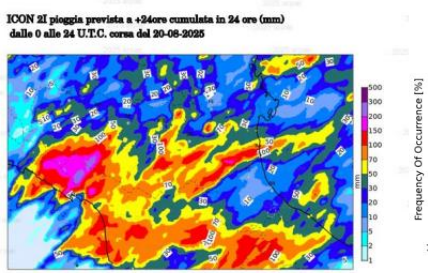
‘Headache problem’

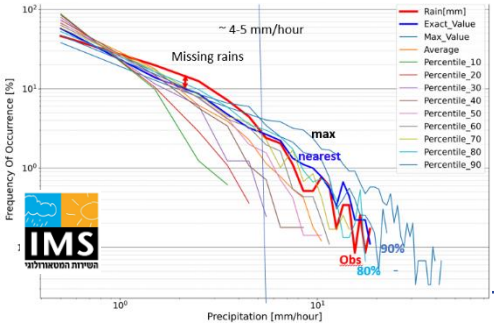
- several cases of excessive precipitation amounts with convection-permitting forecasts for MeteoSwiss, IMS, ARPAe, DWD → detrimental impact on weather warnings and hydrological forecasts
- tuning of physics could partially mitigate the problem, but there are still forecast busts
- targeted activity in COSMO











Re-analysis

DWD *(Arianna Valmassoi a.o.)*

- ICON-DREAM: global EnVar, 2010 – 2024 available, working on back-extension (& forth ext.)
- ICON-FORCE: ICON-D2-KENDA, for AI training dataset, all obs, 2015 – 2024;
  - LHN reprocessed specifically for the reanalyses using all the available data

ARPAE *(Antonio Giordani)*

- planned: I-DREAM-IT: ICON-2I-KENDA, for AI training dataset, all obs, 2010 – 2025;
  - Conventional obs in LETKF, and LHN

Meteo-Swiss *(Daniel Leuenberger a.o.)*

- REA-L-CH1: re-analysis light: deterministic downscaling of ERA5, 2005 – 2025
  - LHN using a new, homogeneous radar-gauge product
  - Purpose: Wind climatology (climate division) & AI training dataset

Potential Reanalysis framework in COSMO

(Arianna Valmassoi, Marco Arpagaus, Thomas Gastaldo, Christoph Gebhardt, Christoph Schraff)

- Facilitate the production and/or the joint use of (common) regional reanalyses within COSMO
- The aim of to both support climate services and the development of data-driven methods based on AI/ML
- Facilitate the sharing of observations needed by our reanalyses
- Share reanalysis production framework
- Required: *Accessible data storage* for sharing observations as well as boundary and initial conditions

COSMO & AI

- strategy is needed and discussed
- How to cooperate, adapt, and define our role in a fast evolving environment of AI developments?
- Future: AI only, NWP only, hybrid approaches? A scientific question, but not only scientific
- How to invest resources? How to distribute available resources…if you can afford to distribute?
- AI in/as COSMO or new partnerships (EUMETNET-AI, ML pilot project)?
- No clear answers available these day
- Status:
  - New approaches such as AI represent progress and are motivating in this sense
  - Question of resources and external demands are challenging
  - Maintaining & fostering flow of information, communication and cooperation is essential
  - We are not alone with such questions

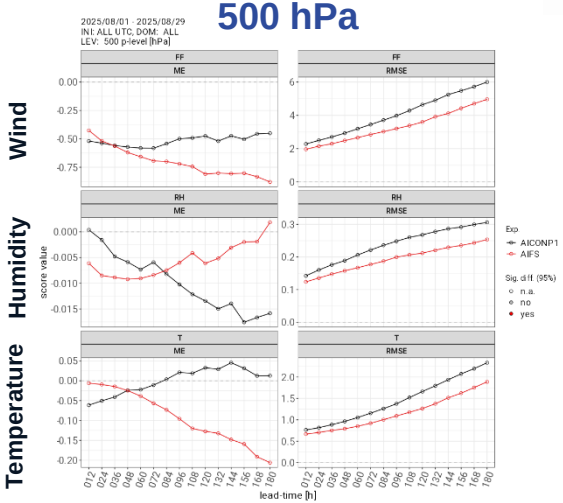
ACCORD

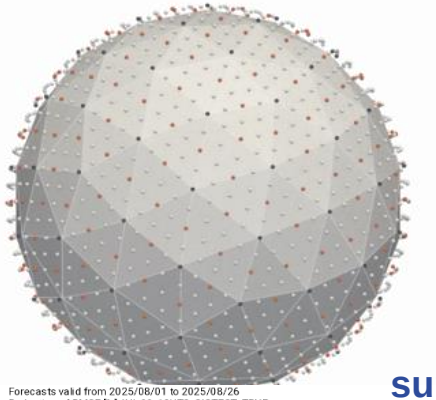
A Consortium for COnvection-scale modelling Research and Development

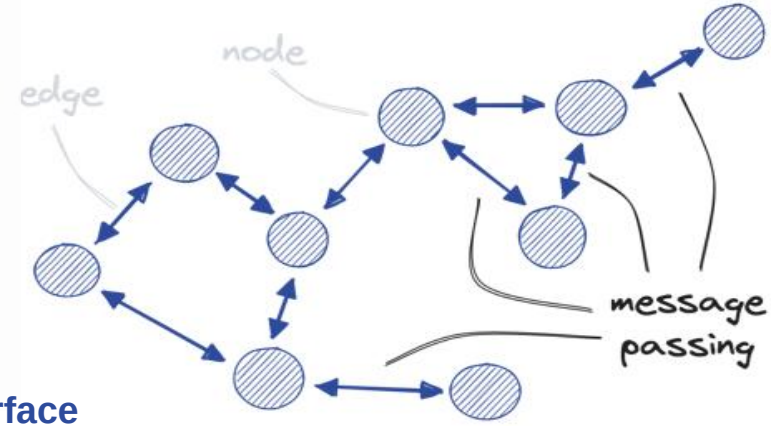
AI/ML in the ACCORD 2026-2030 Scientific Strategy

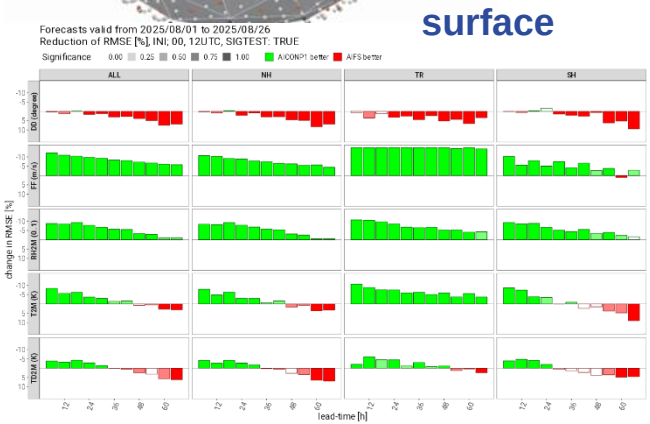
Claude FISCHER, ACCORD/PM, COSMO General Meeting, Basel, 02/09/2025

AICON
graph neural network forecasting model









Technically operational
at DWD since
3rd September 2025

…see national poster

COSMO presentations at EWGLAM 2025

- *Chiara Marsigli: “Ensemble activities in COSMO”*
- *Michael Baldauf: “Further developments in the Discontinuous Galerkin based dynamical core for ICON”*
- *Flora Gofa: “COSMO verification activities” (online)*
- *Christoph Schraff: “Update on data assimilation in COSMO” (online)*
- *Jürgen Helmert: „Surface activities in the COSMO Consortium”*
- *Matthias Raschendorfer: “Some recent development for ICON physics“*
- *Jürgen Helmert: "Advancing ancillary parameters and soil processes for numerical weather prediction at DWD”*
- *Jan-Peter Schulz: “Land surface atmosphere interactions simulated by the ICON atmospheric model”*
- *Thomas Gastaldo: “High-Resolution data assimilation with ICON and KENDA at Agenzia ItaliaMeteo and Arpae” (poster)*
- *Xu Xu: “High-resolution data assimilation in global and regional ICON for the GLORI Digital Twin”*