WGCM 2022 Status Germany

Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen

Alfred Wegener Institut für Polar und Meeresforschung, Bremerhaven

Max Planck Institut für Meteorologie, Hamburg

Deutscher Wetterdienst, Offenbach

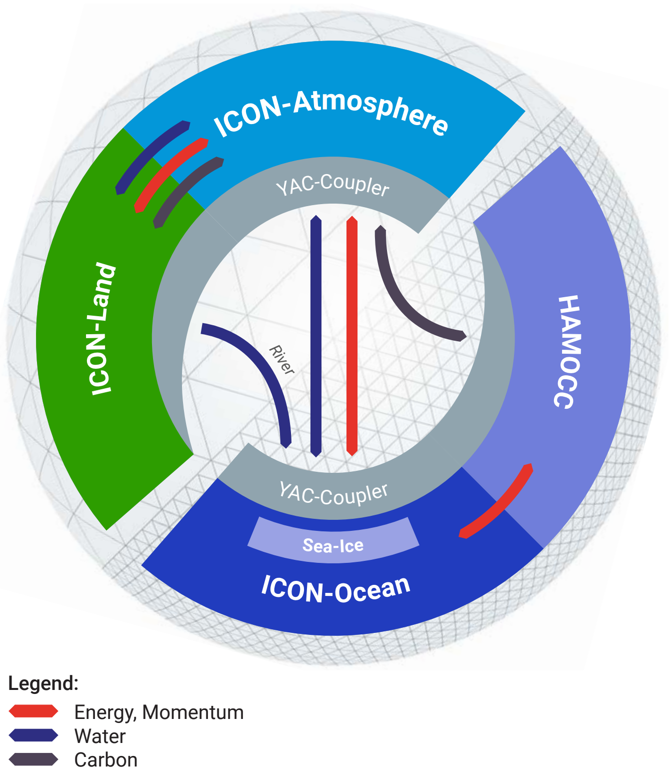
Karlsruhe Institut für Technologie, Karlsruhe

Deutsches Klima Rechenzentrum, Hamburg

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

contact: johann.jungclaus@mpimet.mpg.de

ICON-ESM as successor of MPI-ESM



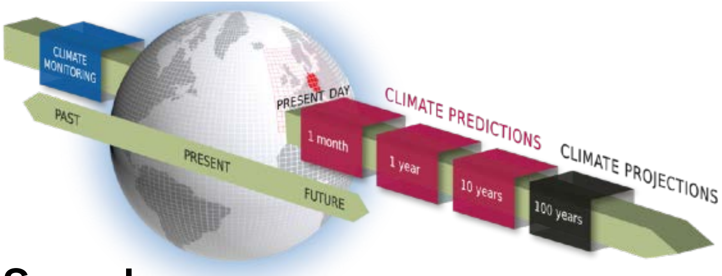
Processes, sub-models and interfaces:

- Atmosphere (ICON-A):
  - Energy fluxes
  - Water cycle and water mass exchange
  - Energy momentum
- Ocean (ICON-O):
  - Sea surface temperature
  - Sea ice
  - Surface ocean velocity
- Land (JSBACH+HD):
  - Energy and energy momentum (between atmosphere and land)
  - Runoff to the ocean

Giorgetta et al., 2018; Jungclaus et al., 2022, Korn et al., 2022

ICON Seamless

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD
MAX-PLANCK-INSTITUT FÜR METEOROLOGIE
KIT Karlsruher Institut für Technologie



ICON-Seamless =
Model and Data Assimilation for

- ✓ Numerical Weather Prediction (NWP)
- ✓ Climate Prediction (Seasonal, Decadal)
- ✓ Climate Projections

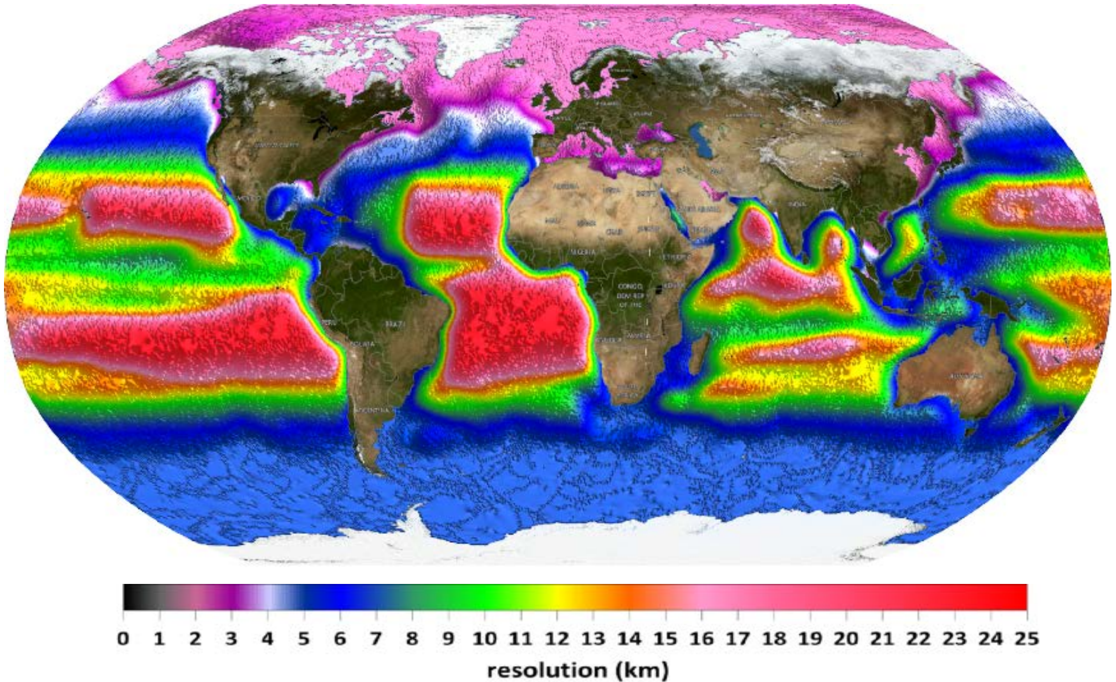
- One consistent model including Atmosphere (ICON-NWP), Ocean (ICON-O), Land (ICON-Land), ICON-ART
- Configurations for different application scenarios well balanced and compatible

Time Line / Milestones

- ICON-Seamless *experimental versions running 2022*
- *Seasonal and Decadal* Prediction pre-operational *by 2024*
- Unified *ICON-Land* for NWP and climate time scales experimental version by 2025
- Regional coupled model ICON-LAM by 2025
- *CMIP7*

AWI-CM/ESM in CMIP7 and European projects

- Pushing the boundaries for earth system modeling (AWI-ESM) regarding components: ice shelf cavities, ice sheets, ocean biogeochemistry, high resolution focused on polar regions
- Pushing the boundaries for coupled atmosphere-land-ocean-sea ice modeling (AWI-CM3: OpenIFS/IFS FESOM2) regarding resolution:

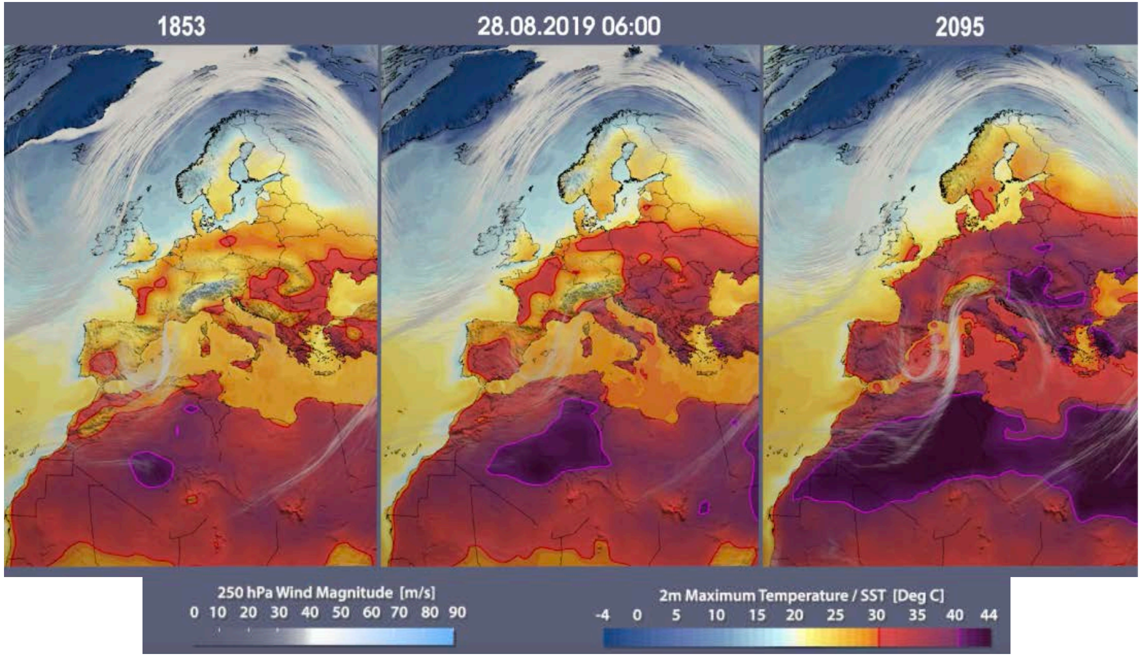


- AWI-CM-XR: The Big 4 (globally 3-4 km atm./ocean) – see NextGEMS slide
- AWI-CM-HR: DECK, ScenarioMIP
- AWI-ESM-MR: DECK, ScenarioMIP, PMIP

Envisaged CMIP7 ocean resolution AWI-CM-HR:
13 Mio. surface nodes;
atmosphere resolution: 30 km
5 SYPD possible

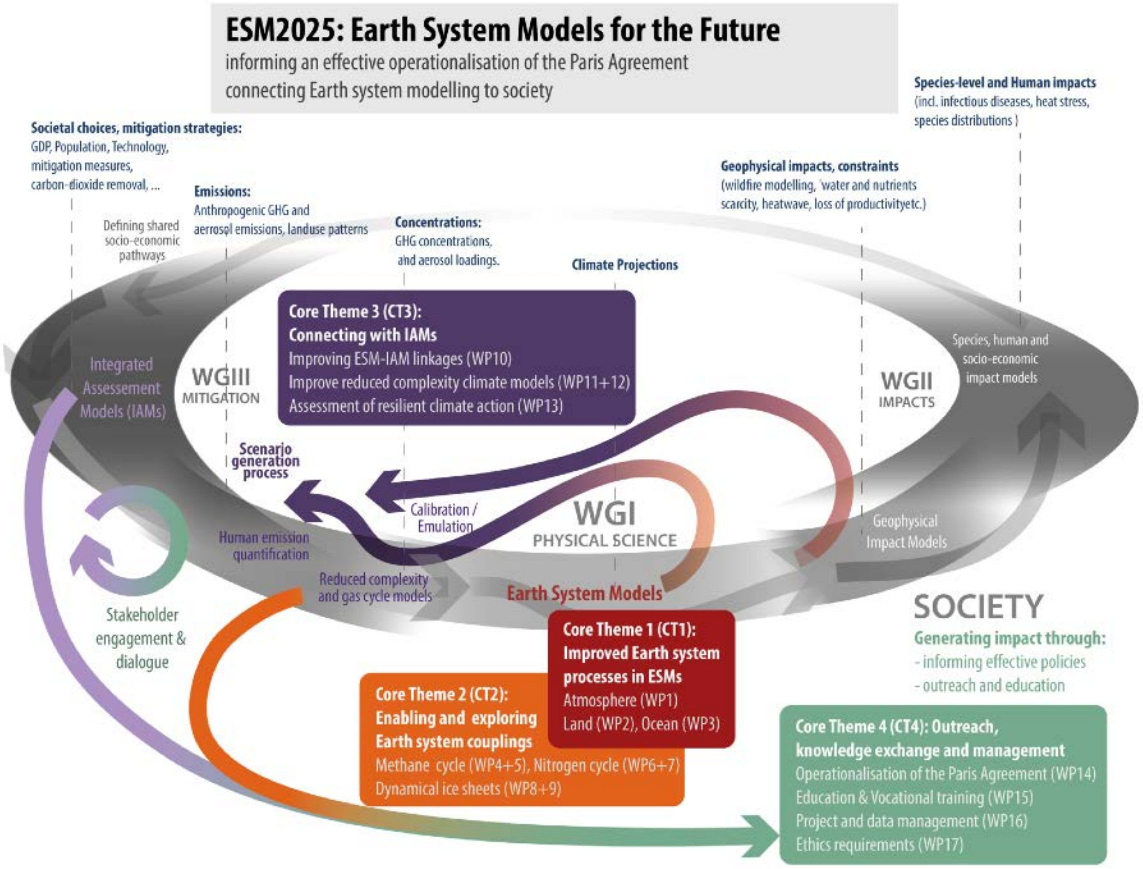
Storyline attribution and projection

- Use spectral nudging with coupled models
- Understand extreme events in a warming world
- Make climate change more tangible



Sanchez-Benitez et al., *J. Climate* (2022)

EU Project ESM2025



H2020 **ESM2025**

- Improving processes realism in ESMs (ICON-ESM)
- Enabling and exploring new couplings between Earth system components
- Connecting with IAMs
- Applications: e.g., operationalisation of the Paris Agreement

Physics-aware ML based Earth system modelling

ERC Synergy Grant USMILE(USMILE)

V. Eyring, M. Reichstein, G. Camps-Valls & P. Gentine

CMIP7: Development of an EMAC successor based on the ICON/MeSSy system

Projects on km-scale modelling

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DKRZ DEUTSCHES KLIMARECHENZENTRUM

The Big 4: nextGEMS, WarmWorld, EERIE, DestinE (Climate DT)

Hypothesis I: Representing critical processes by the laws of physics rather than parametrisations provides a step change in the trustworthiness of climate change projections.

Hypothesis II: Driving impact models with km-scale models will be a game changer for applications

And we will have technically much advanced models!

Check for updates

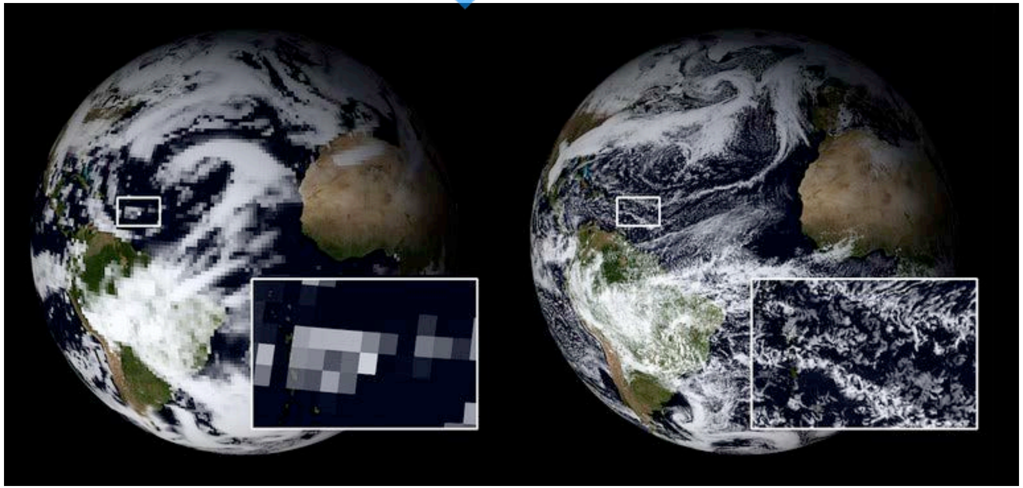
editorial

Think big and model small

It is now possible to model the climate system at the kilometre scale, but more work and resources are needed to harvest the full potential of these models to resolve long-standing model biases and enable new applications of climate models.

Editoral, Nature Climate Change (2022)

NextGEMS



ICON @ 80km and 5km

- two prototype storm-resolving ESMs (**ICON-A/O**, IFS/**FESOM**
- produce multi-decadal projections of future climate change

AWI-CM-XR: OpenIFS/FESOM: globally 3-4 km atm./ocean

ICON-ESM: ICON-A/ICON-O: globally 1.25-5 km atm./ocean

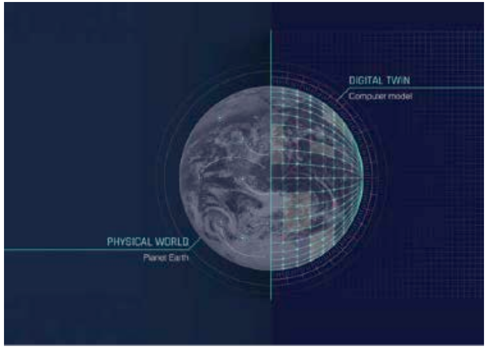
Projects supporting modelling

“accelerating the development of a new generation of high resolution weather and climate models: with expertise in earth system modelling, software design and high performance computing, ESiWACE is supporting scientists on the path to exascale computing.”

- “Better”: defining and testing the configurations of the two model systems used: ICON and IFS-FESOM.
- “Faster”: transforming the ICON code base into an open, scalable, modularized and flexible code.
- “Easier”: develop novel methods to make climate information visible, accessible, and interoperable.
- “Smarter”: involve the applied math and informatics communities to improve workflow and model performance

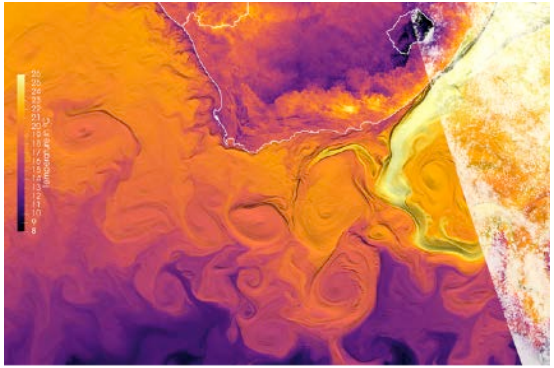
Destination Earth Climate Adaptation Twin

"Build a high precision digital model of the Earth to model, monitor and simulate natural phenomena and human activities"



Building on NextGEMS experience, the core of the Climate Change Adaptation Digital Twin will be constituted by the ICON "Sapphire" ESM and ECMWF's Integrated Forecasting System (IFS) coupled to the NEMO ocean and AWI's FESOM ocean model

First 1.25-km global coupled ICON



MPI-M and DKRZ have succeeded at meeting a "grand challenge" formulated a decade ago: developing a global climate model that resolves convective-scale motions. These first successful runs are launched on roughly one third of DKRZ's "Levante" CPU partition capacity (2520 compute nodes with two CPUs 256 GB main memory), with a throughput of 2.5 simulated days per day.

Value of storm-resolving models (NextGEMS)

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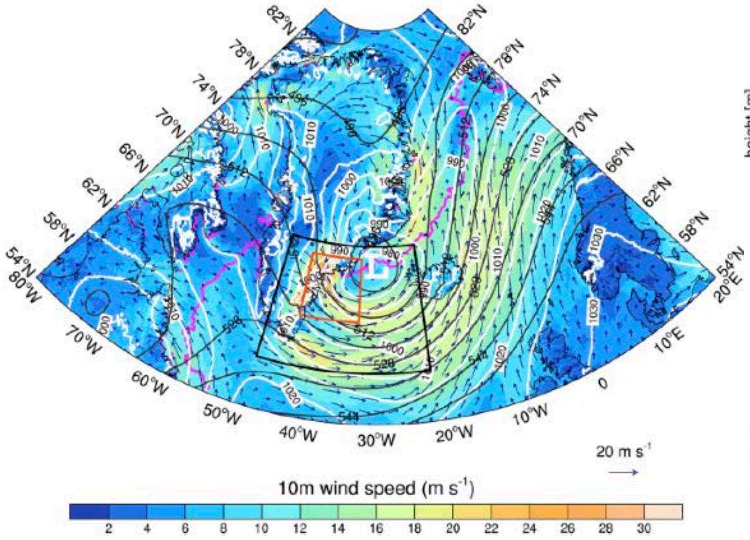
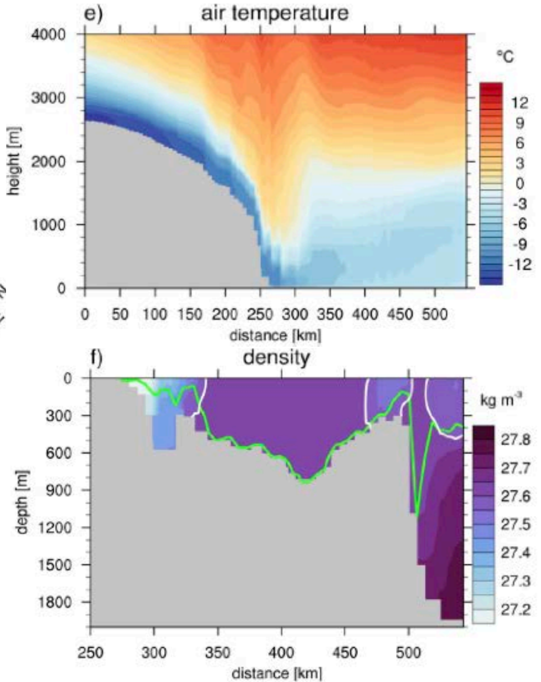
Air-Sea Interactions and Water Mass Transformation During a Katabatic Storm in the Irminger Sea

O. Gutjahr[1,2], J. H. Jungclaus[2], N. Brüggemann[1,2], H. Haak[2], and J. Marotzke[2,3]





- Process study on katabatic wind event,
- formation and propagation of a Polar Low,
- enhanced deep water formation in the ocean,

connecting km-scale processes with the regional and global scale

Gutjahr et al., JGR-O, 2022