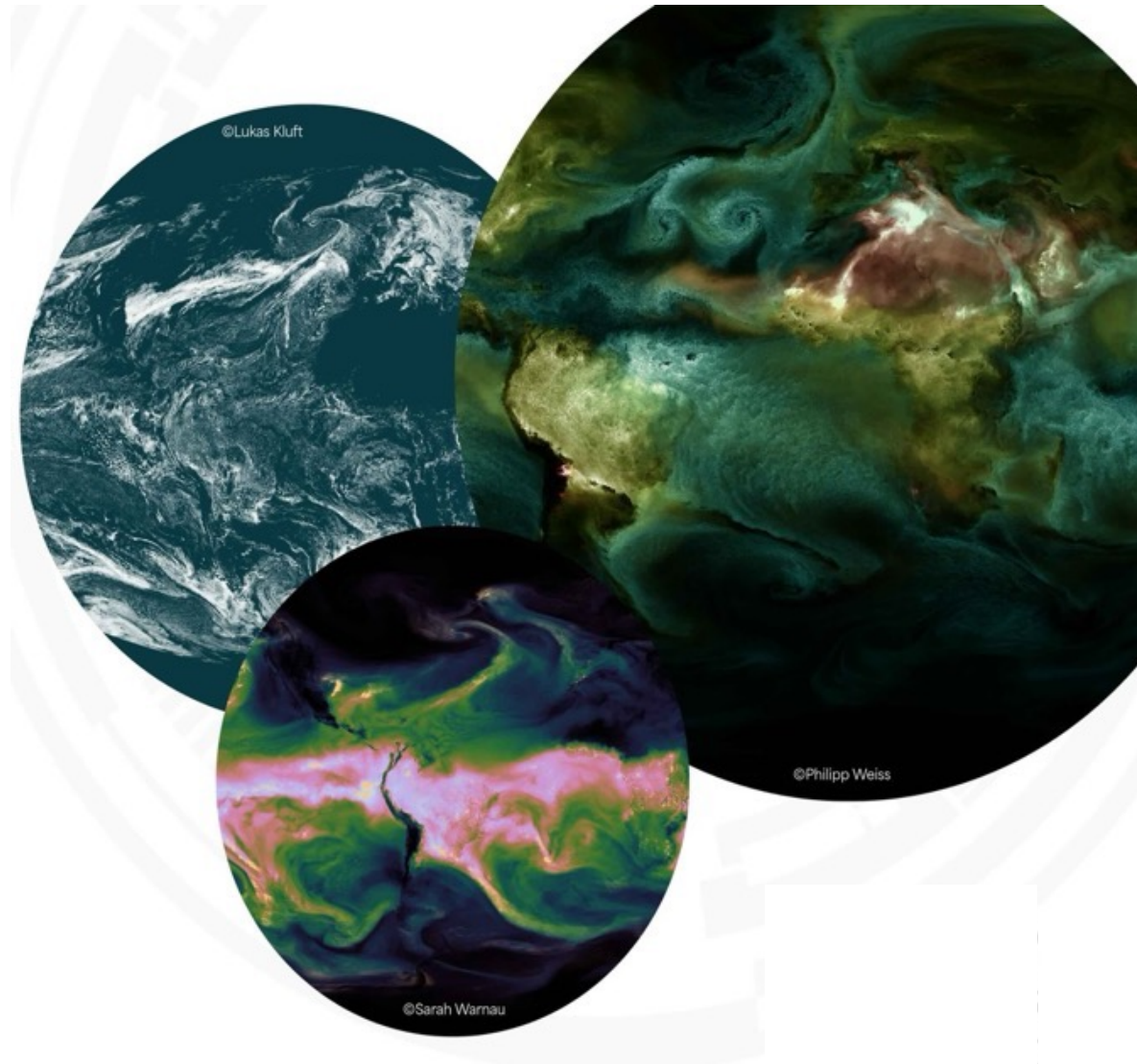


The Digital Earth Lighthouse Activity: March 2025 Update



Andrew Gettelman, U. Colorado
Pier Luigi Vidale, NCAS/U. Reading



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Digital Earth Lighthouse Activity

Cross-Cutting WCRP Activity supporting development of integrated interactive digital information systems providing global and regional information, including both natural and human systems

Areas of activity

- **Fully coupled km-scale regional and global models:** Foster a global research network in km-scale modeling of the Earth system and individual components (**km-scale** = $\Delta x < 10\text{km}$)
- **Data-Fusion for climate:** Establish an active community for *climate data assimilation* and *data driven modeling* (e.g. Machine Learning/AI methods), expanding on numerical weather prediction and re-analysis
- **Beyond the Physical Earth System:** Include human interactions on and impacts to human systems in ESMs

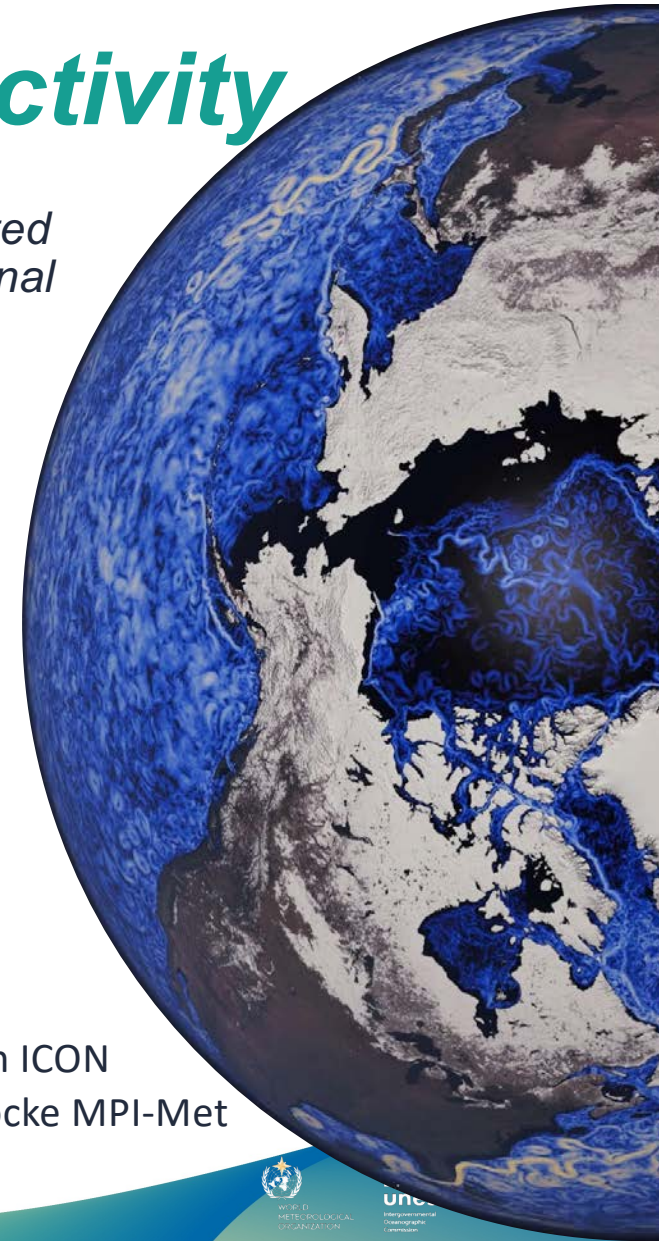
1.2km ICON
D. Klocke MPI-Met

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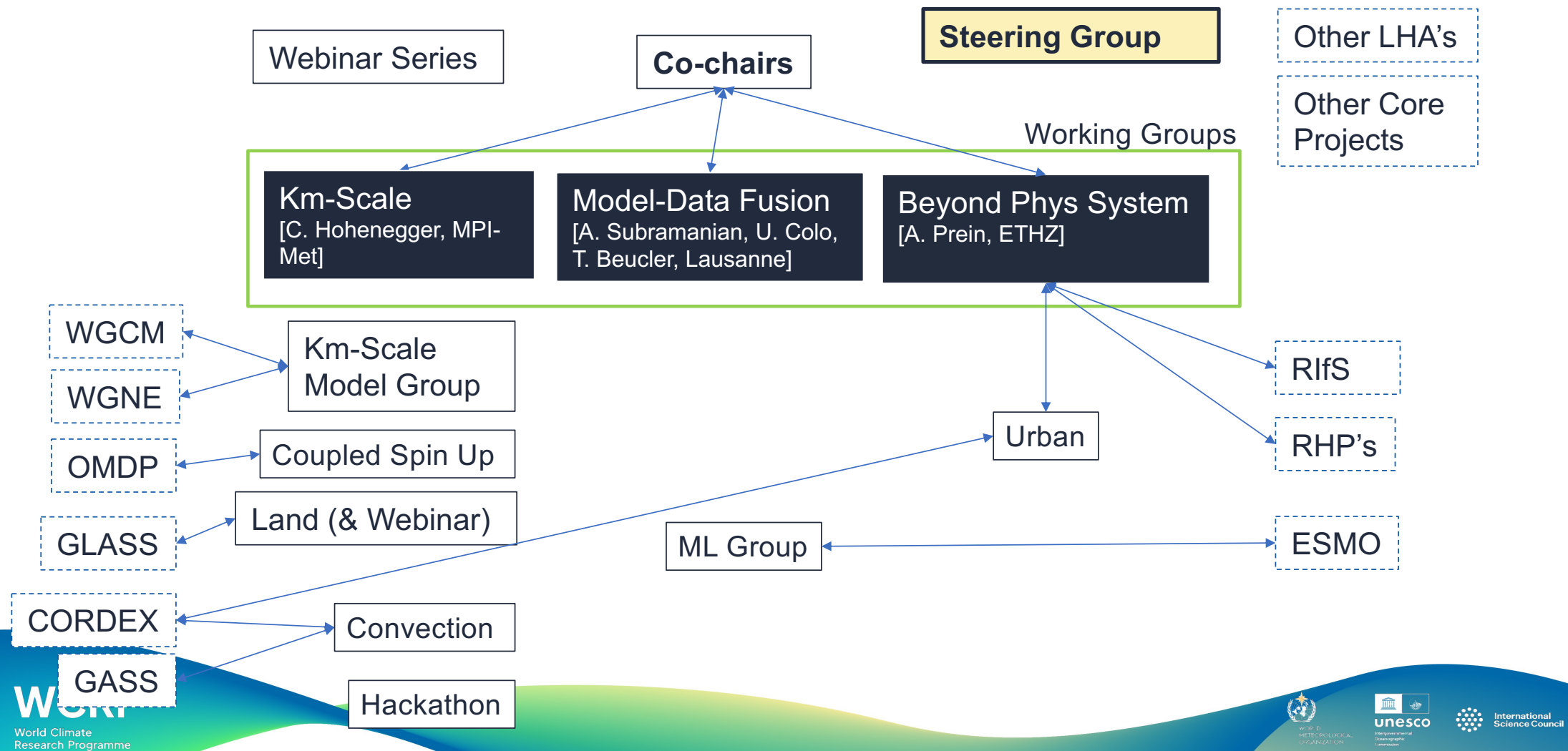


United Nations
World Meteorological
Organization



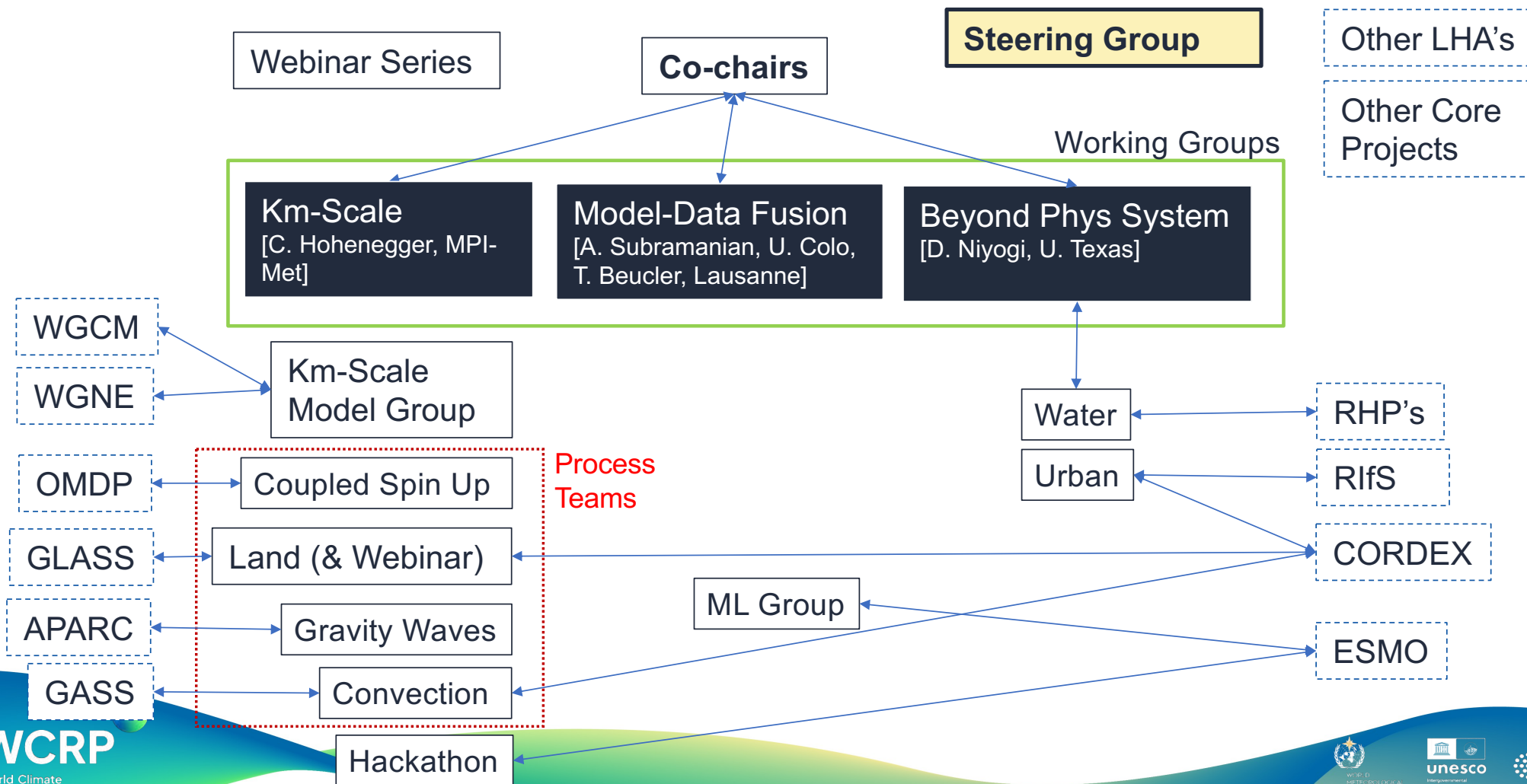
Digital Earth LHA Structure

2024



Digital Earth LHA Structure

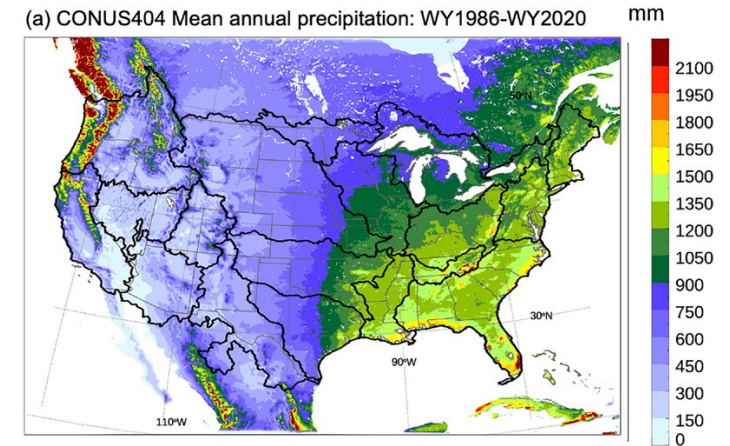
2025



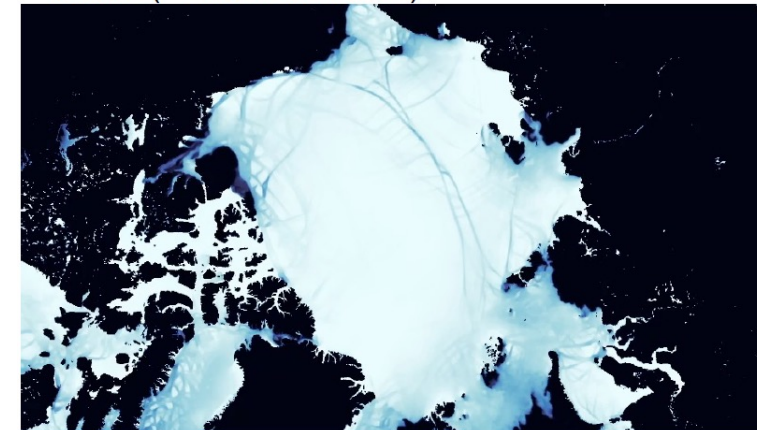
Regional & Global Km-Scale Models

- CORDEX Regional Climate Models @ km-scale (FPS)
- ~10 global km-scale atmosphere models
 - >1yr simulations with ~3km atmospheres (7 models)
- Several km-scale coupled models developed
 - Testing down to 1km global!
- Science use cases needing global models:
 - Small scale impacts on general circulation, Teleconnections
 - Coupling across 'spheres' (e.g. ocean – atmosphere)

Regional Climate Model (4km)
Rasmussen et al 2023, BAMS



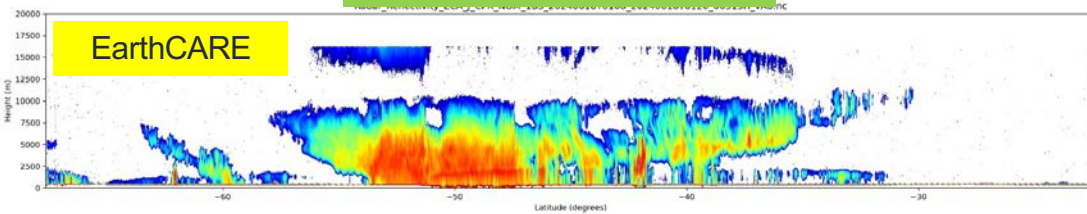
Simulated sea ice leads/cracks in the Arctic Ocean (FESOM at 4-5km)



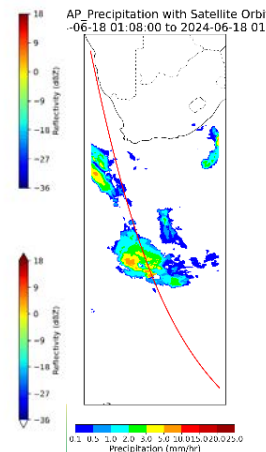
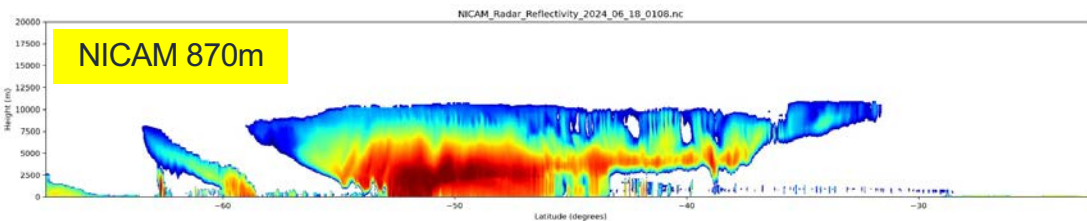
Racknow, ECMWF, Koldunov, AWI : NextGEMS Coupled Ocean/Ice (5km) & Atmos (9km)

Radar reflectivity

EarthCARE



NICAM 870m





DE km-scale Modeling Science Initiatives

- Nurture the development of **process comparisons/teams**
 - Km-scale **Land-Atmosphere** interactions
 - **Convective organization** team re-forming
 - **Gravity waves** may be forming with APARC
- **Km-scale model working group** (regional and global): with WGNE
- **Seminar Series** on km-scale modelling
- Participating in **conferences/workshops**
 - Hosting/supporting meetings/sessions where necessary
- Global **‘pan-hackathon’ for km-scale modelling** in Spring 2025
 - Multiple models, sharing tools and workflows, data sets
 - Increase ability of users to analyse km-scale models
 - Bring analysis capabilities and data to users worldwide

All these activities are for global AND regional models

Km-Scale Model Working Group

Model/Center	Name	Location
ICON	Cathy Hohenegger	Germany (Chair)
MetOffice	Huw Lewis	UK
NCAR/Earthworks	Bill Skamarock	USA
DOE-E3SM	Hassan Beydoun	USA
NASA-GEOS	Bill Putman	USA
NOAA-GFDL	Lucas Harris	USA
NICAM	Daisuke Takasuka	Japan
COSMO (Regional)	Nikolina Ban	Austria
MCV	Xingliang Li	China
ECMWF-IFS	Benoit Vanniere	UK

Km-Scale Model Working Group

- Meeting regularly every ~ 4-6months
- Typically: updates on latest developments/ or discussion of a particular issue
- September 17th : discussed ‘clumsy’ nature of convection @ km scale
- Next meeting was in April
- One key topic: organized convection at km-Scale

The World Climate Research Programme Global km-scale Hackathon



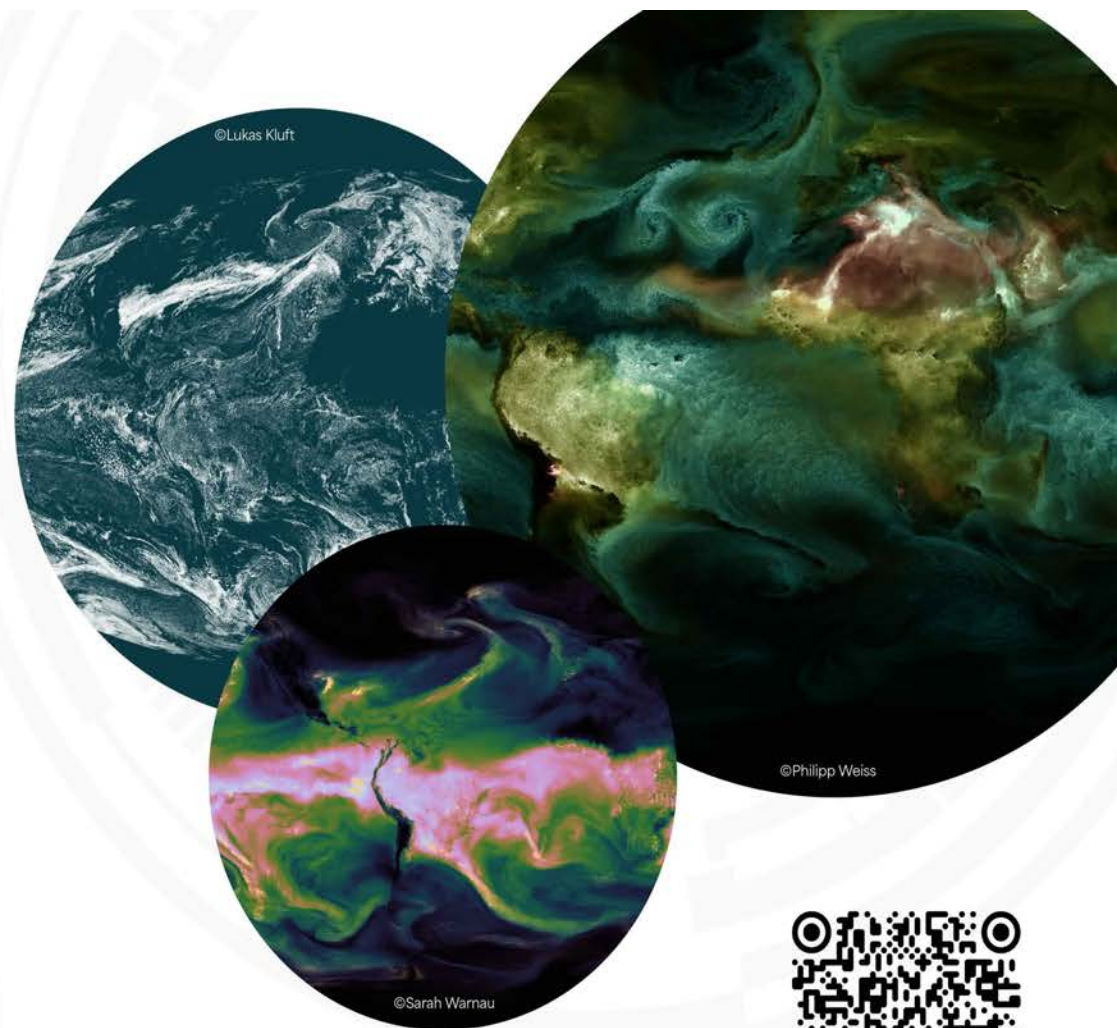
When: 12-17 May 2025

Where: 11 regional nodes worldwide

Join us and contribute to strengthening collaborations in weather and climate research, driving advances in storm-resolving models for better predictions!

Organisers: WCRP Digital Earths Lighthouse, in collaboration with other international partners and initiatives

Our partners:



For more information, visit our website:



Physical to Virtual Data Fusion for Climate

Chairs: A. Subramanian (Univ. Colorado), T. Beucler (Laussane univ.)

- Data Assimilation for Climate
 - Co-hosted several workshops (Boulder 2022, Boston 2024)
 - Connecting with coupled DA efforts lead by WWRP DAOS
 - Climate DA: participating in investigations of ML based DA, currently it does NOT outperform traditional methods
- Machine Learning and Data Driven Modeling
 - Coordinating efforts for Climate (with ESMO): joint group
 - Connecting to WWRP PDEF who are starting a new ML effort for NWP
 - ML Exploration in all aspects of ‘digital earth’
 - Urban Digital Twin group at UT-Austin has produced a ML Hindcast Dataset, we are helping to advertise it for community use.
 - Bi-monthly webinars and WG meetings will start soon
 - Several DE members attending GRC- AI/ML meeting in summer 2025



Human Systems: Beyond the Physical

Chair: D. Niyogi (U. Texas)

- Core competencies of Earth System Models: Water, Energy, Land
 - Emerging efforts with: Hydrology, Energy Systems, Crops
 - Example: GEWEX Regional Hydroclimate Project (RHP) for the US (H2US)
- Humans dominate in Urban environments
 - Urban Digital Twin effort started: data sets, academic/city twins(Dev Niyogi, U. Texas)
 - Olympic Weather Forecast (w/ WMO)
 - Connecting with CORDEX Urban FPS
 - Also WWRP Urban warning systems project



Collaborations Across WCRP and Beyond

- Integrate km-scale working group with other DE efforts
 - Already engaged with WGNE
- ‘Integrated’ with other community km-scale efforts: EVE, DYAMOND
- Discussing joint process teams with CORDEX – FPS
 - Joint meeting with CORDEX being discussed for 2025
- Supporting regional km-scale modeling (e.g. hackathon)
- Active model engagement with process focused groups (GASS, GLASS)
 - Need to push forward convective team
- Coordinate ML efforts with ESMO
- Connecting Urban efforts with CORDEX: maybe others?



Plans/Priorities for 2025-2026

- Ongoing activities
 - Webinars, Km-scale WG (with WGNE/ESMO), Coupled spin up
 - Land-Atmos group (with GLASS)
 - Urban group
- Pan-Hackathon, May 2025 (ESMO, DYAMOND, EVE, etc.)

Km Scale modeling

- Process teams: Land (GLASS), Convection (with GASS), GW (APARC)
- Possible process meeting with CORDEX

Model-data fusion

- ML working group (with ESMO)
- Possible ML meeting in 2026

Human Systems

- Several Urban Digital Twins Sessions planned at other meetings
- Exploring use cases for human systems beyond Urban group
 - Regional Hydroclimate Projects, re-engage with ISIMIP

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Suggestions, Issues & Challenges

- AI/ML: what is the DE-LHA Role?
 - Collaborating with other AI efforts, may be focused on specific areas (e.g. DA)
 - PL Vidale delivering a keynote on km-scale at EXCLAIM symposium in Zürich, June 2025: multiple round tables on relative roles of ML and "physics-based" models
- Potential Meetings for 2026
 - Another general meeting on km-scale modeling?
 - Discussing a meeting with CORDEX on km-scale processes
- Are we achieving our 'goals'?
 - LHA is a 10 year effort. We are 3-4 years into it. → need a roadmap so that what it develops ends up benefiting / merging into core programmes
 - Accelerating progress on km-scale and integrating it across WCRP (good)
 - Data assimilation/AI and beyond the physical system are slower
- Do we work to formalize working groups (by engaging specific members?)
- Suggestions?

Thank You

