The Digital Earth Lighthouse Activity

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

World Climate Research Program
Digital Earth Lighthouse Activity

Digital Earth Lighthouse Activity

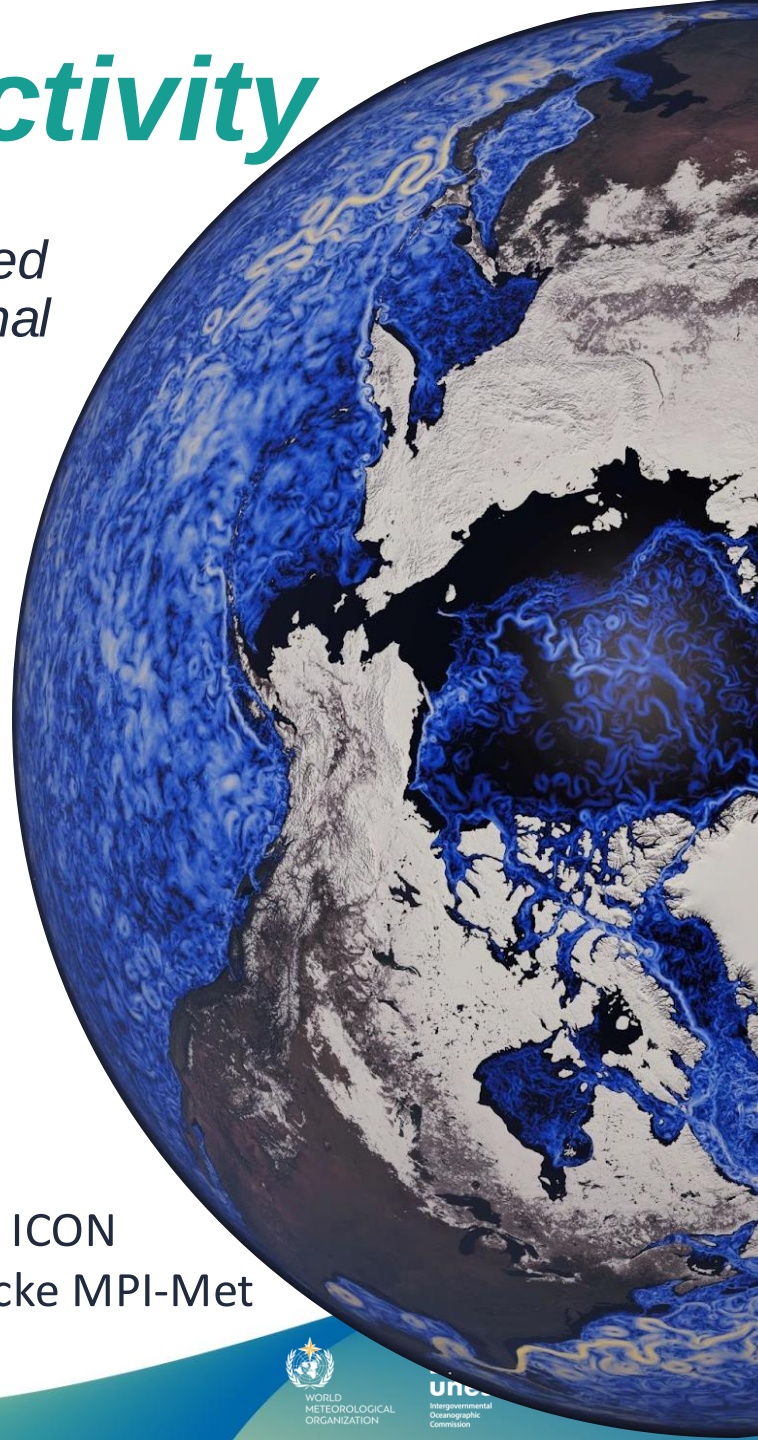
Cross-Cutting WCRP Activity supporting development of integrated interactive digital information systems providing global and regional information, including both natural and human systems

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 = Δx<10km)**

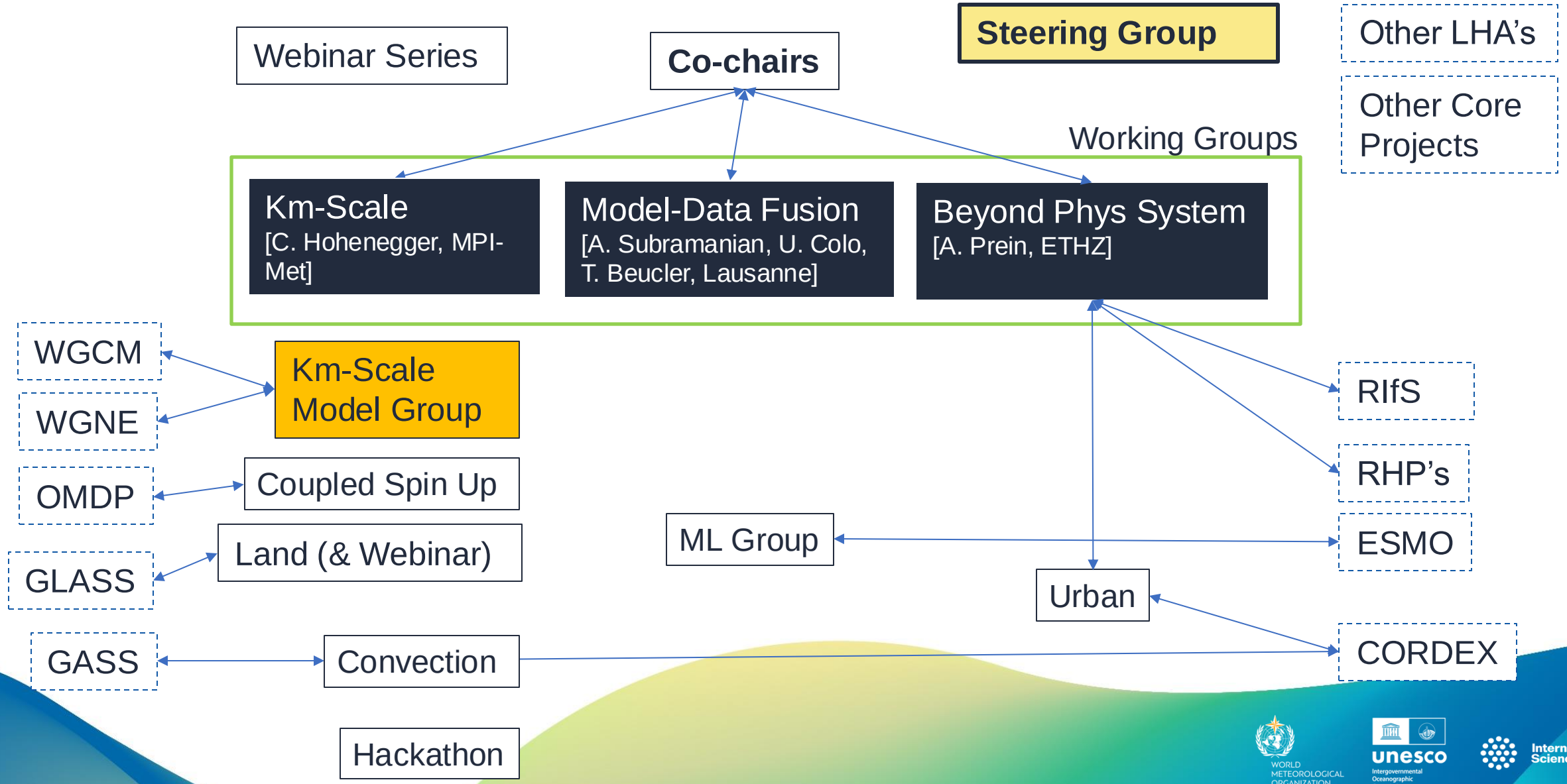
- **Data-Fusion for climate**: Establish an active community for *climate data assimilation* and *data driven modeling* (e.g. Machine Learning/AI methods), expanding on numerical weather prediction and re-analysis

- **Beyond the Physical Earth System**: Include human interactions on and impacts to human systems in ESMs



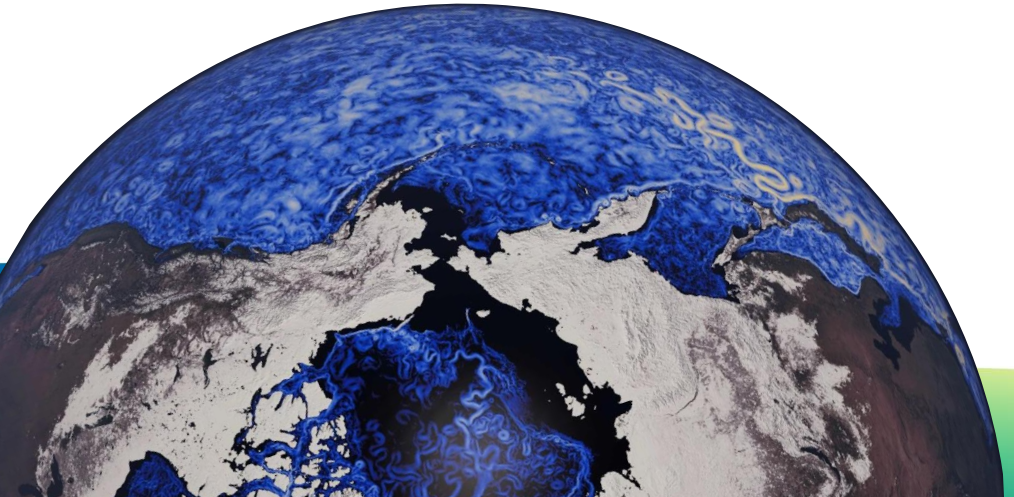
1.2km ICON
D. Klocke MPI-Met

Digital Earth LHA Structure



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)
- Km-scale land, sea ice and ocean models also exist
- Several km-scale coupled models developed
  - Testing down to 1km (24h, 1 ensemble member), even 300m
- Science use cases needing global models:
  - Small scale impacts on general circulation
  - Teleconnections
  - Coupling across ‘spheres’ (e.g. ocean – atmosphere)



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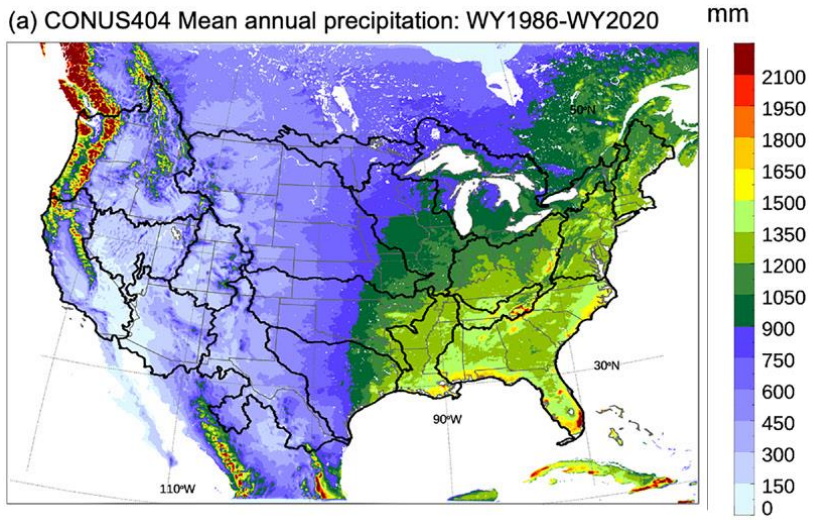
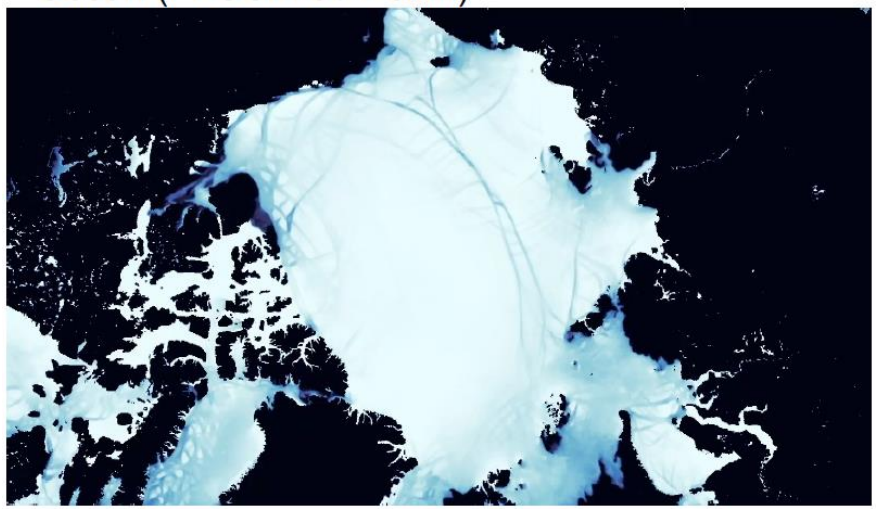
Regional Climate Model (4km)
Rasmussen et al 2023, BAMS



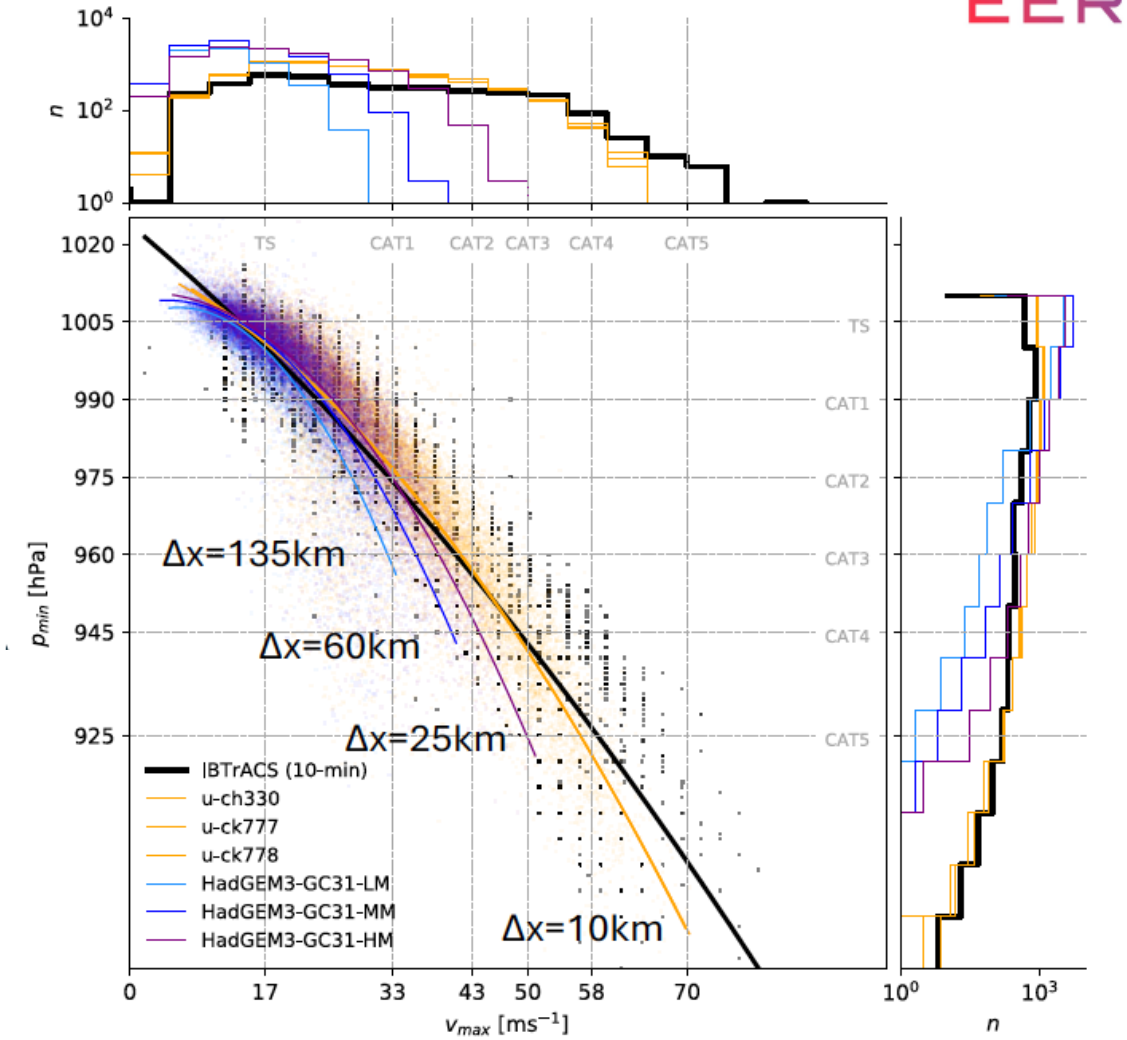
Simulated sea ice leads/cracks in the Arctic Ocean (FESOM at 4-5km)



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

Global Km-Scale Models

- Not just pretty pictures
- COUPLED Atmosphere-Ocean simulations @10km (30 yrs, multiple ensembles)
- Example: Tropical Cyclone pressure-wind relationship with resolution…



Vidale et al. 2024 in prep for J. Clim.

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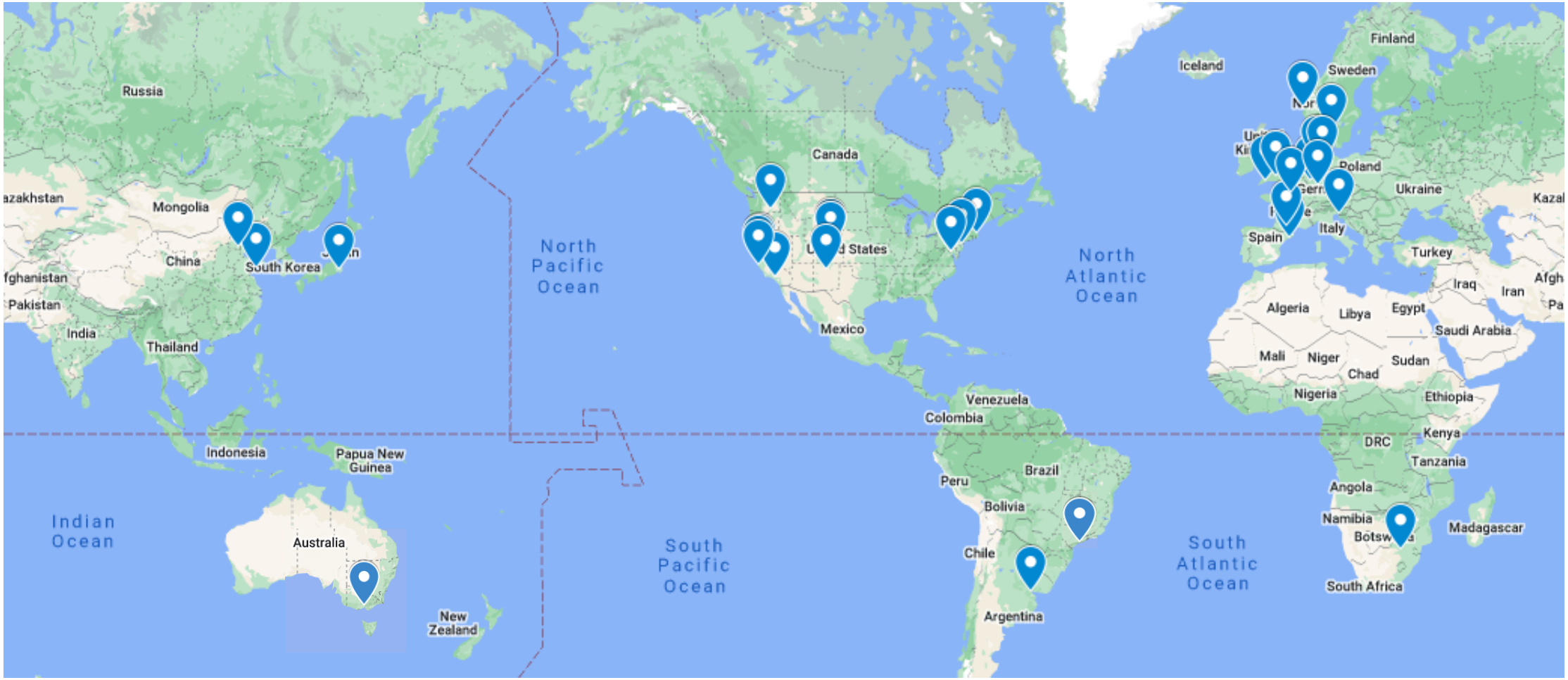
Km-Scale Model Efforts: Regional & Global



Discussions with 24 different efforts. 13 global, 11 regional

These are generally developers, not just users

DE km-scale Modeling Science Initiatives

- Nurture the development of **process comparisons/teams**
  - Km-scale **Land-Atmosphere interactions**
  - **Convective organization** team re-forming
- **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	Peter Caldwell	USA
NASA-GEOS	Bill Putman	USA
NOAA-GFDL	Lucas Harris	USA
NICAM	Daisuke Takasuka	Japan
CORDEX-Convection FPS	Nikolina Ban	Austria
MCV	Xingliang Li	China

Km-Scale Model Working Group

- Meeting regularly every ~ 4months
- Typically: updates on latest developments/ or discussion of a particular issue
- September 17th :discussed ‘clumsy’ nature of convection @ km scale
  - Presentations of analysis on organized convection
- Next meeting will be in January

Coupled Model Spin Up Group

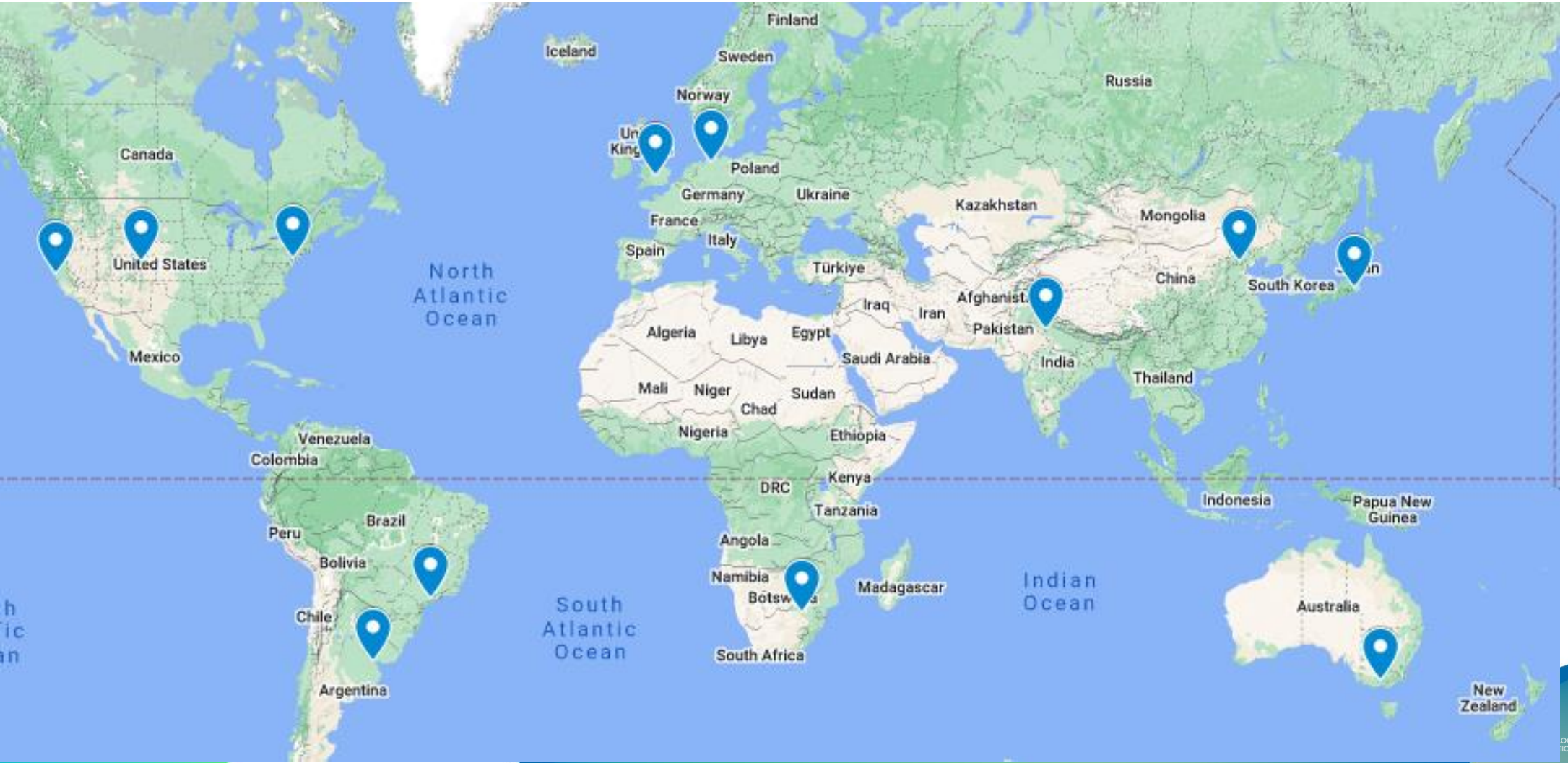
(led by B. Fox-Kemper, Brown Univ)

- What are the methods to spin up an ocean model in a coupled modeling system? Especially: higher resolution ($\Delta x<15km$) models.
- Survey sent to coupled model groups (especially higher resolution)
- 2nd round survey in development
- Review paper being discussed

Km-Scale Pan-Hackathon May 12-16th, 2025

Coordination: Gettelman (US-PNNL), Vidale (UK-Reading), Stevens (Germany-MPI Hamburg)

Planned Hackathon Node Locations (6 continents!)



Probable Nodes:

- Japan
- China
- Australia
- India
- S. Africa
- Europe (2)
- S. America (2)
- US (3)

Km-Scale Pan-Hackathon May 12-16th, 2025

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- Goal: Advance research with regional and global km-scale model output
- Multiple nodes, same week, sharing workflows and tools.
- Common and custom km-scale data sets:
  - Ask each node to host 1-2 common km-scale data sets (global) in specific formats
  - Other data can be stored (and shared) as well
  - Provide initial tools for using data, common software platforms (Jupyter Server)
  - Bringing other analysis workflows to each node (as tutorials)
- Progress
  - Technical meeting in October
  - Dry run probably in Jan-Feb (deploy common data set across nodes)
  - Nodes ‘self-organizing’

Physical to Virtual Data Fusion for Climate

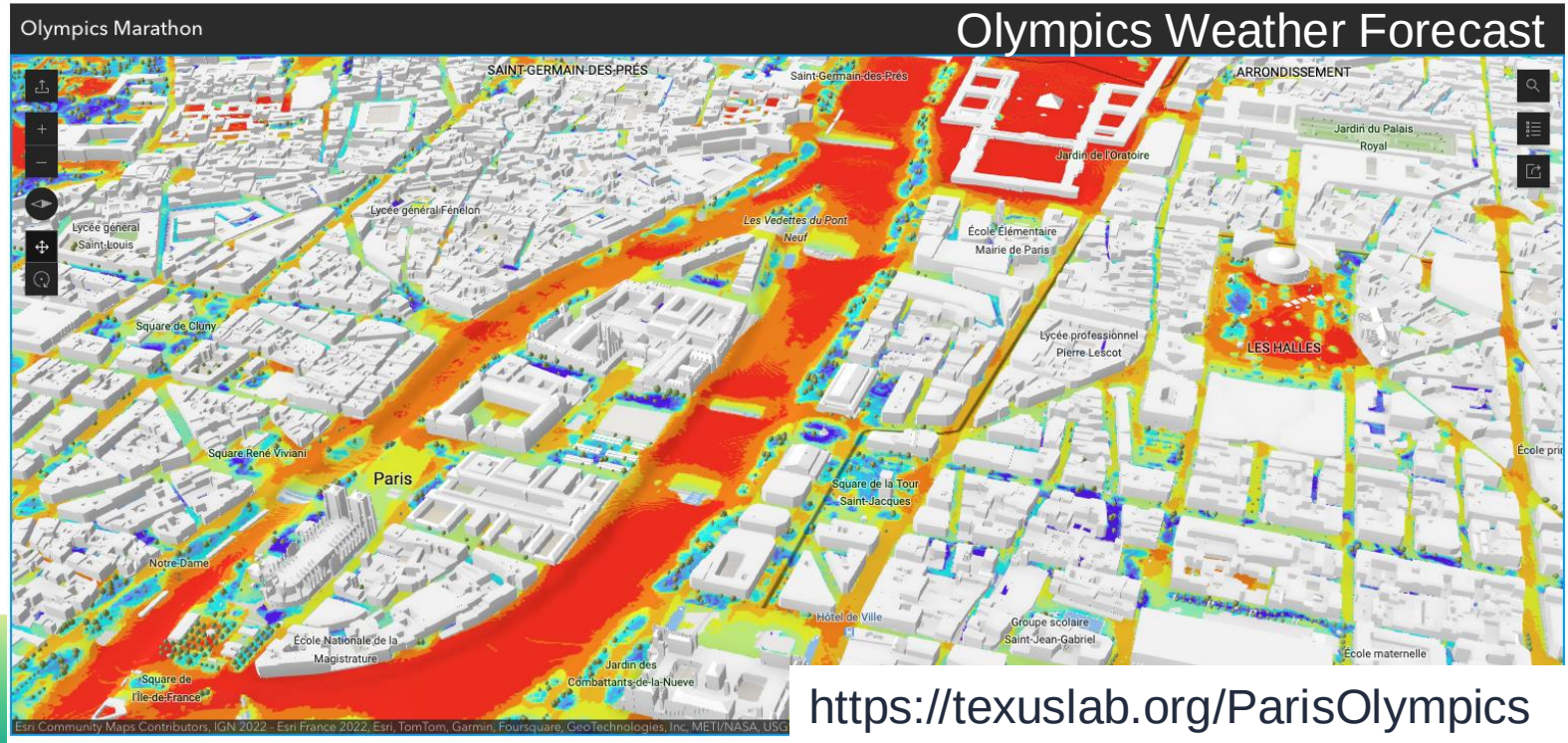
Chairs: A. Subramanian (Univ. Colorado), T. Beucler (Lausanne Univ.)

- Data Assimilation for Climate
  - Co-hosted several workshops have been held (Boulder 2022, Boston 2024)
  - Connecting with coupled DA efforts lead by WWRP DAOS
- 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’
    - Km-scale parameterization, Data Assimilation, Model emulation (for ensembles or ‘foundation modeling’), Downscaling
  - Exploring collaborations: Hackathon on km-scale modeling as ’training data’
  - Possible bi-monthly webinars and WG meetings starting in 2025
  - GRC in summer 2025, organize meeting in 2026

Human Systems: Beyond the Physical

- Digital Twins couple physical and human systems
- 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 (with WMO)
  - Connecting with CORDEX Urban FPS



https://texuslab.org/ParisOlympics

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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 and WWRP

DE–WGNE Collaboration Opportunities

- Are we missing people in the km-scale group? Is information moving back and forth to WGNE?
- Foster development of regional and global km-scale models
  - Metrics
  - Data sets at km-scale
- Pan-Hackathon: many nodes are also WGNE members
- Collaborate on process ‘teams’: deep convection at km scale
- Other opportunities?