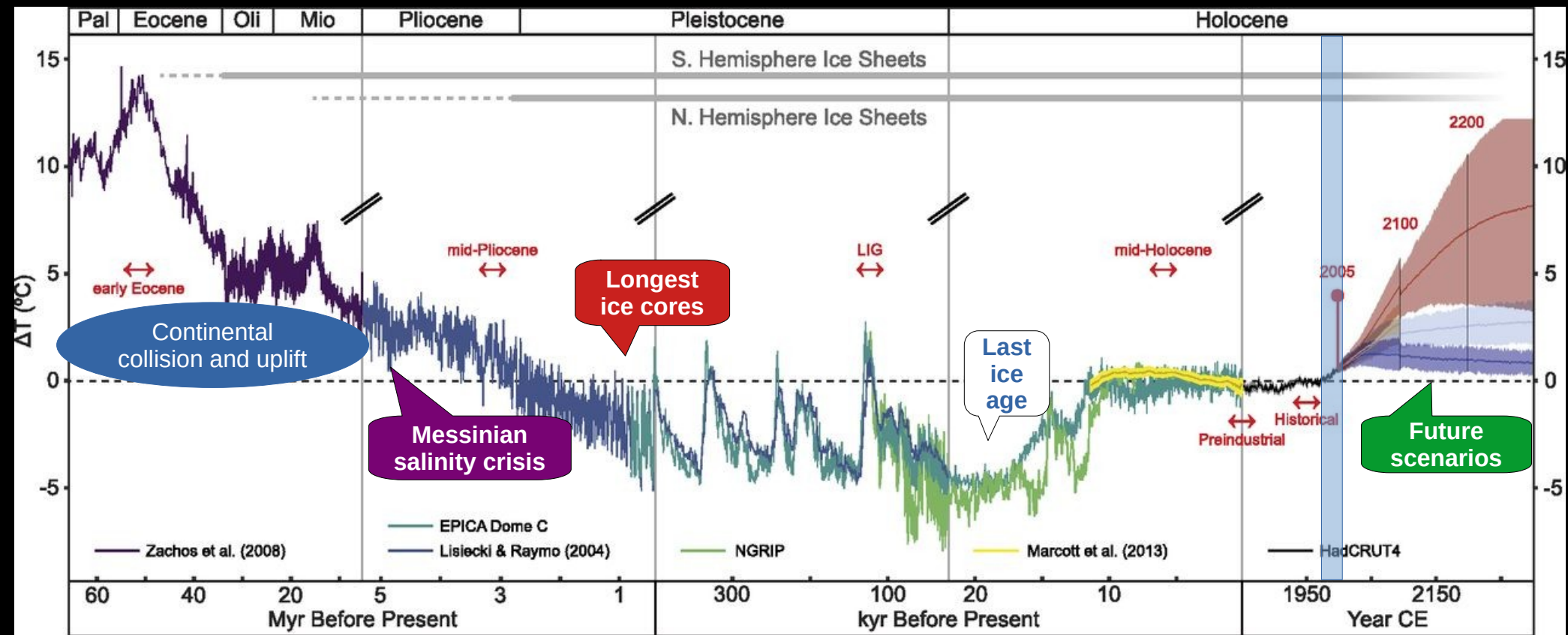


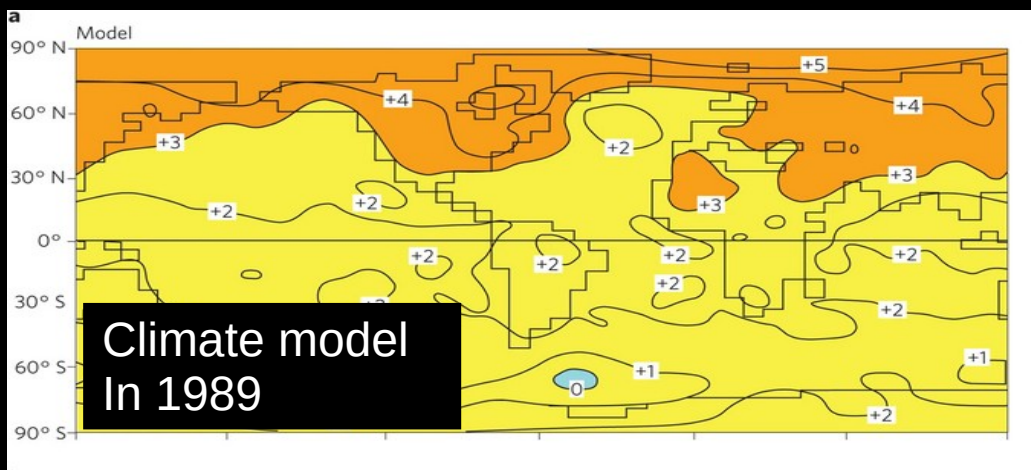


Simulating the Earth System with *EC-Earth*

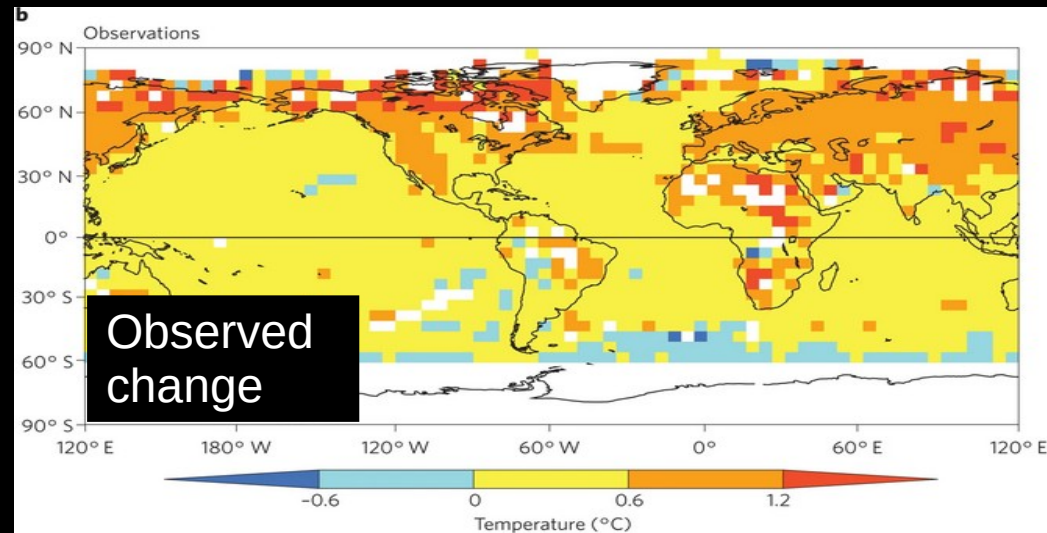
Joakim Kjellsson, Rossby Centre, SMHI
with Klaus Wyser (SMHI), Qiong Zhang (Stockholm University)

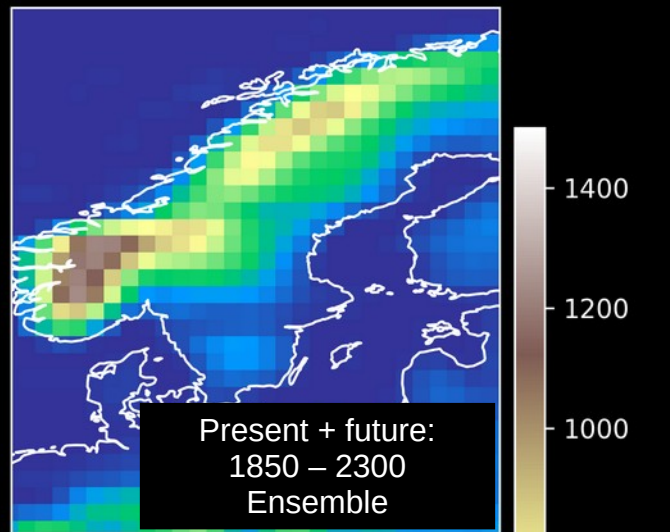
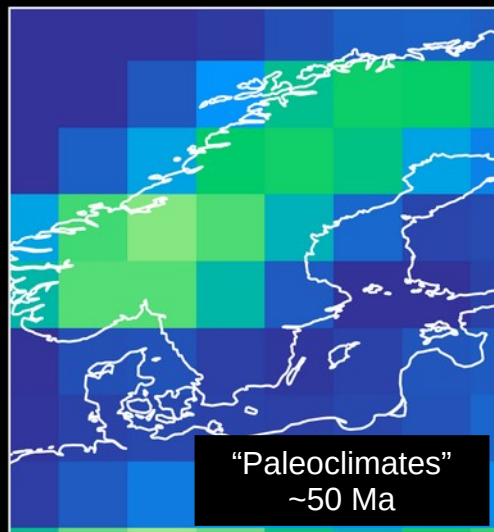
Models could predict warming patterns in the 1980's

What is new since then?

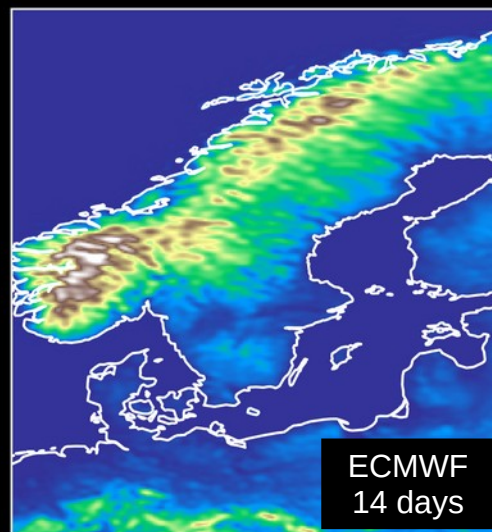
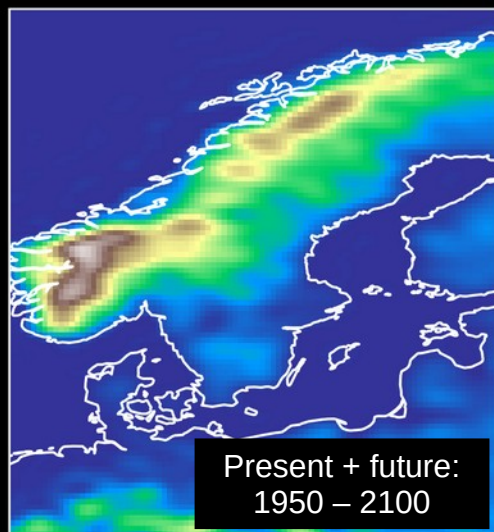


Stouffer & Manabe (2017)

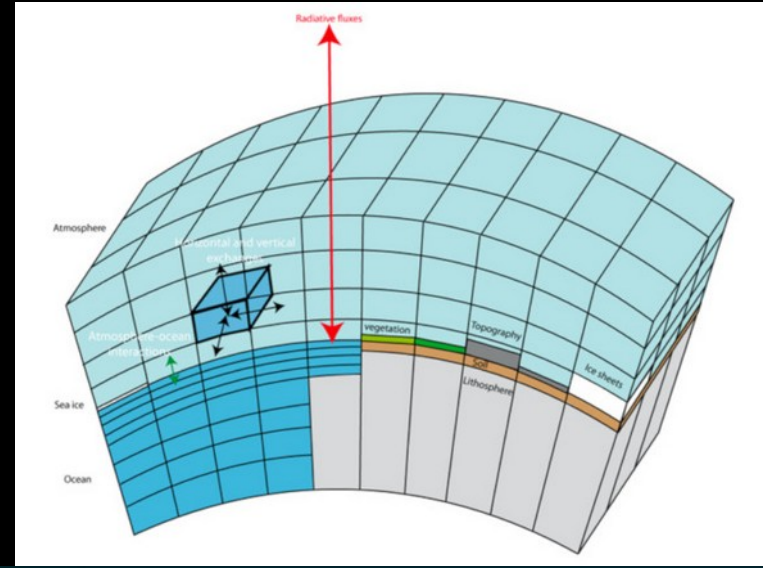
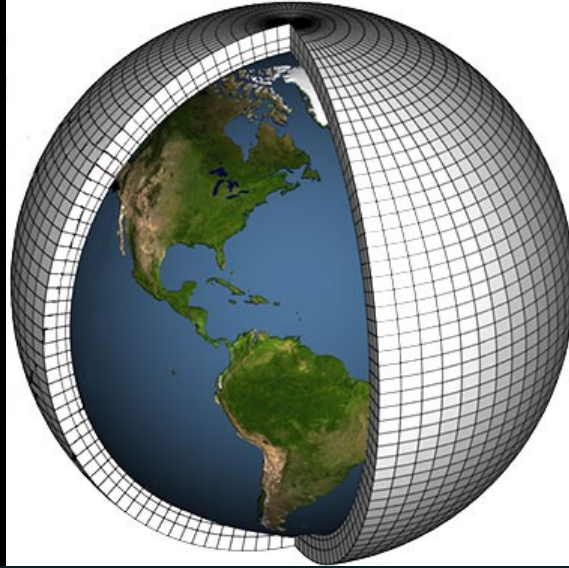




Topography in EC-Earth4



Atmosphere + Ocean: Solve Navier-Stokes equations for momentum on rotating sphere.



1950s
Radiative transfer

1967
Water-vapour changes

1975
Oceans and sea ice

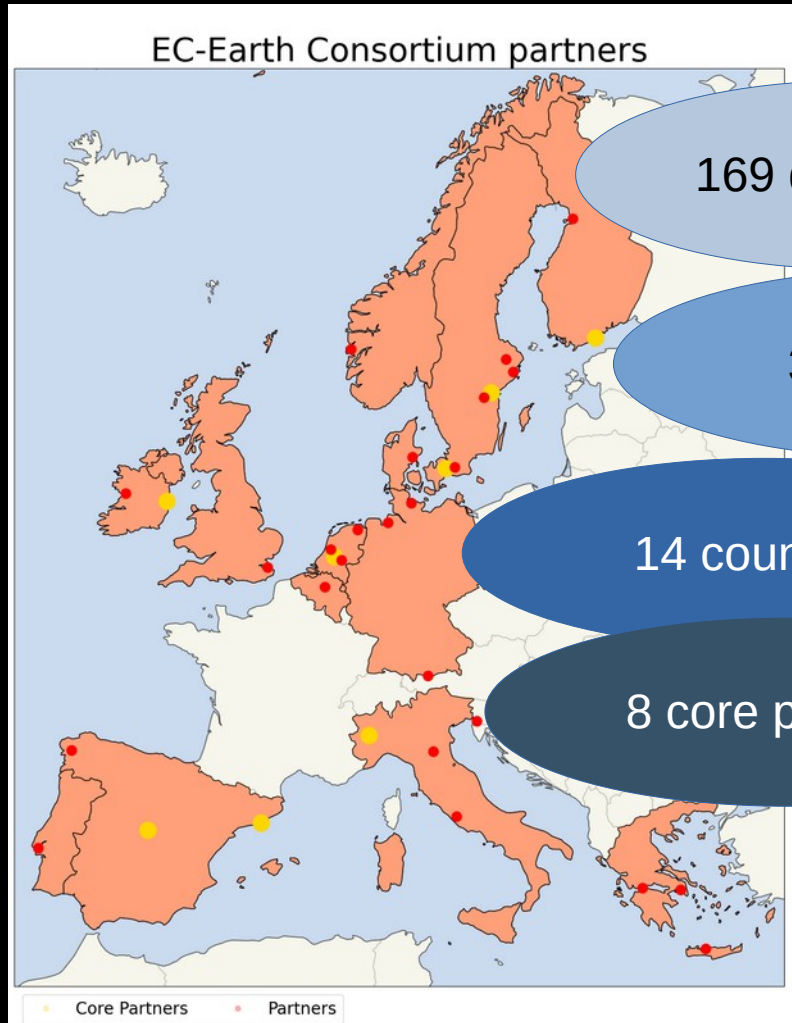
1980
Realistic geography

1980s
Changes to cloud cover

1990s
Aerosols

2000s
Dynamic vegetation

2010s
Atmospheric chemistry



169 developers

39 institutes

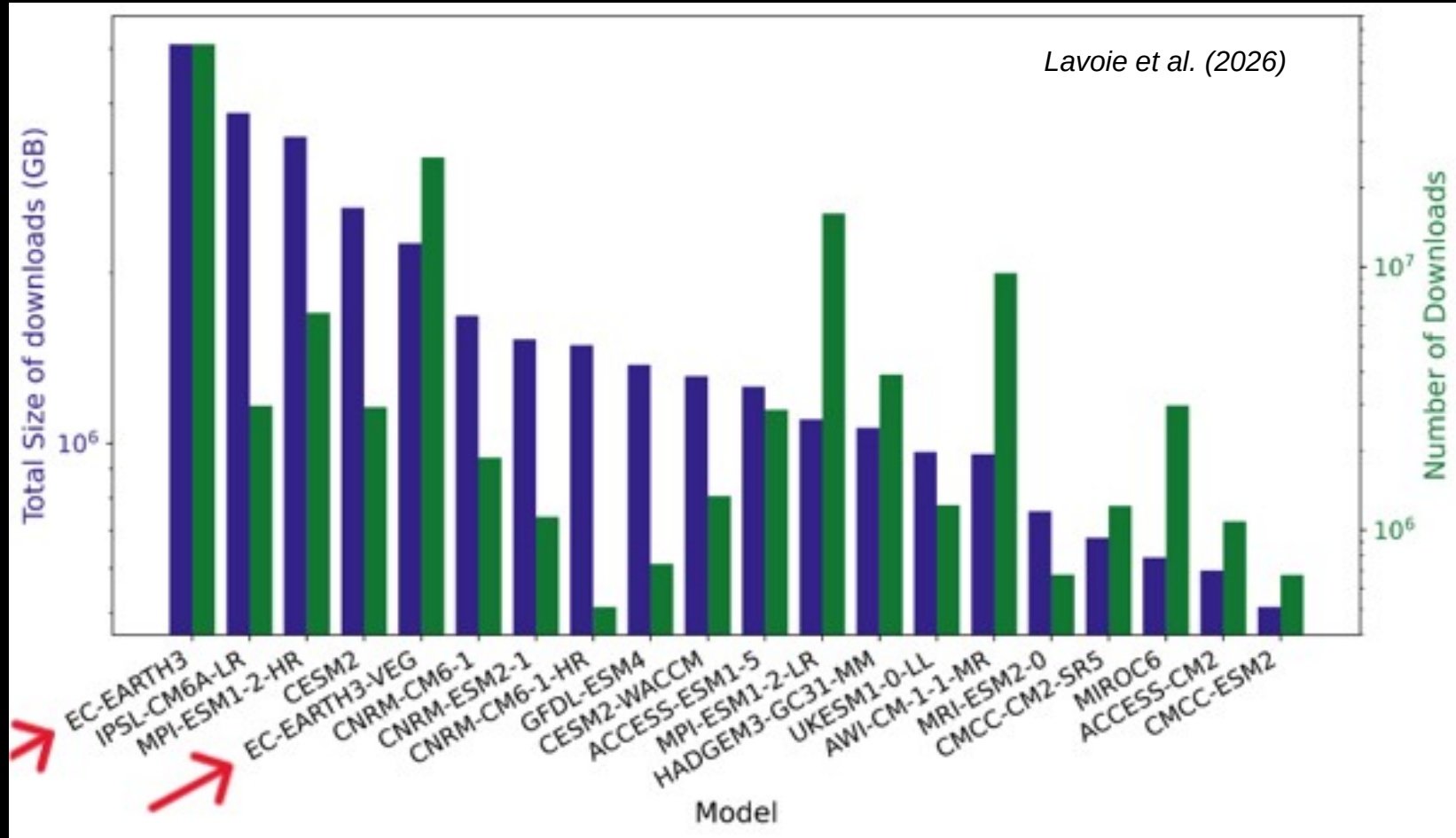
14 countries

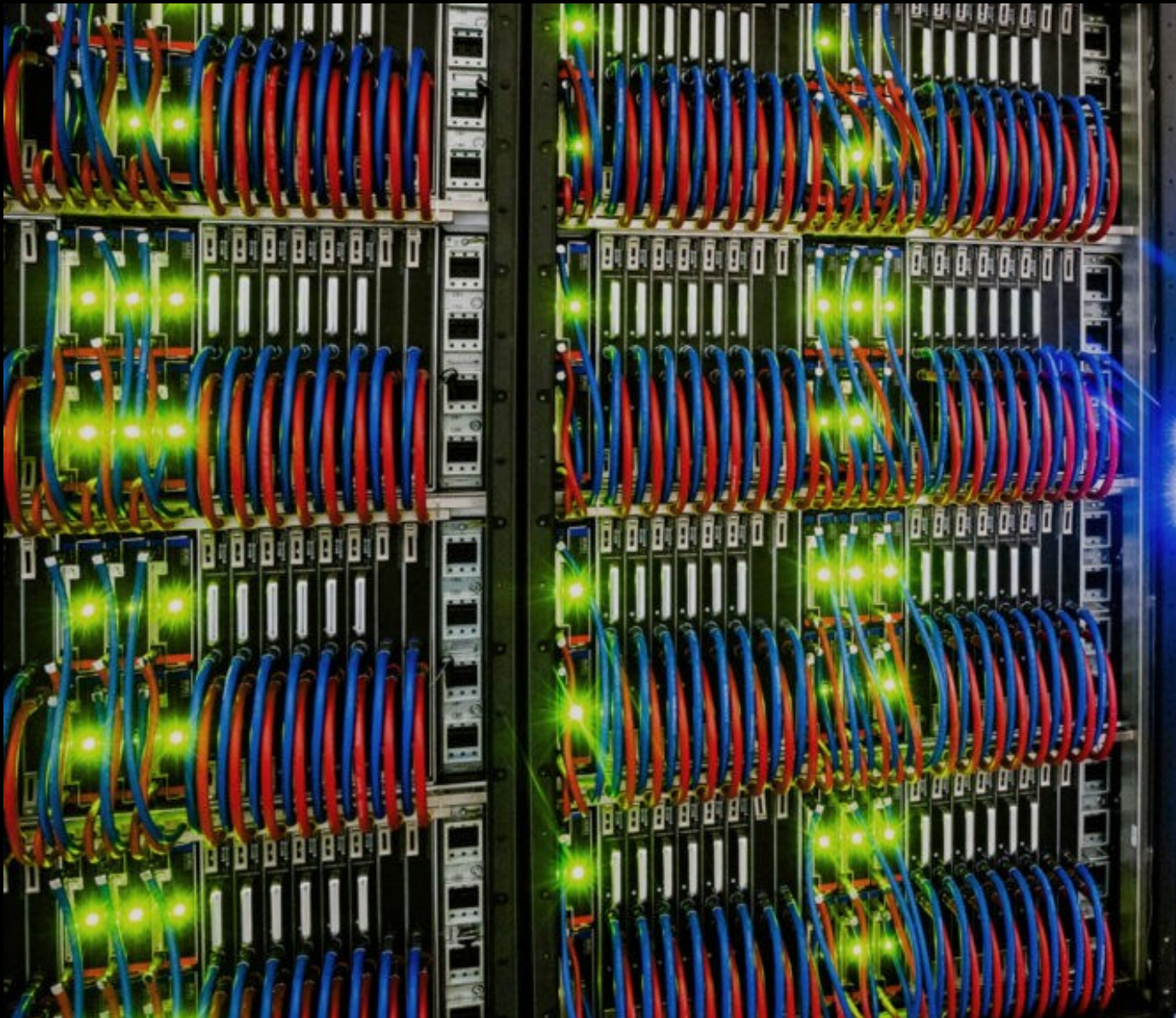
8 core partners

EC-Earth

- European state-of-the-art ESM.
- 15 years old.
- Link forecasting and climate modelling communities.
- Submodels (Fortran or C++). CPU only.
- Scripts in Python.
- License: EC-Earth consortium + ECMWF.
- Input data @ NSC.

EC-Earth3 was the most downloaded of all models in CMIP6!

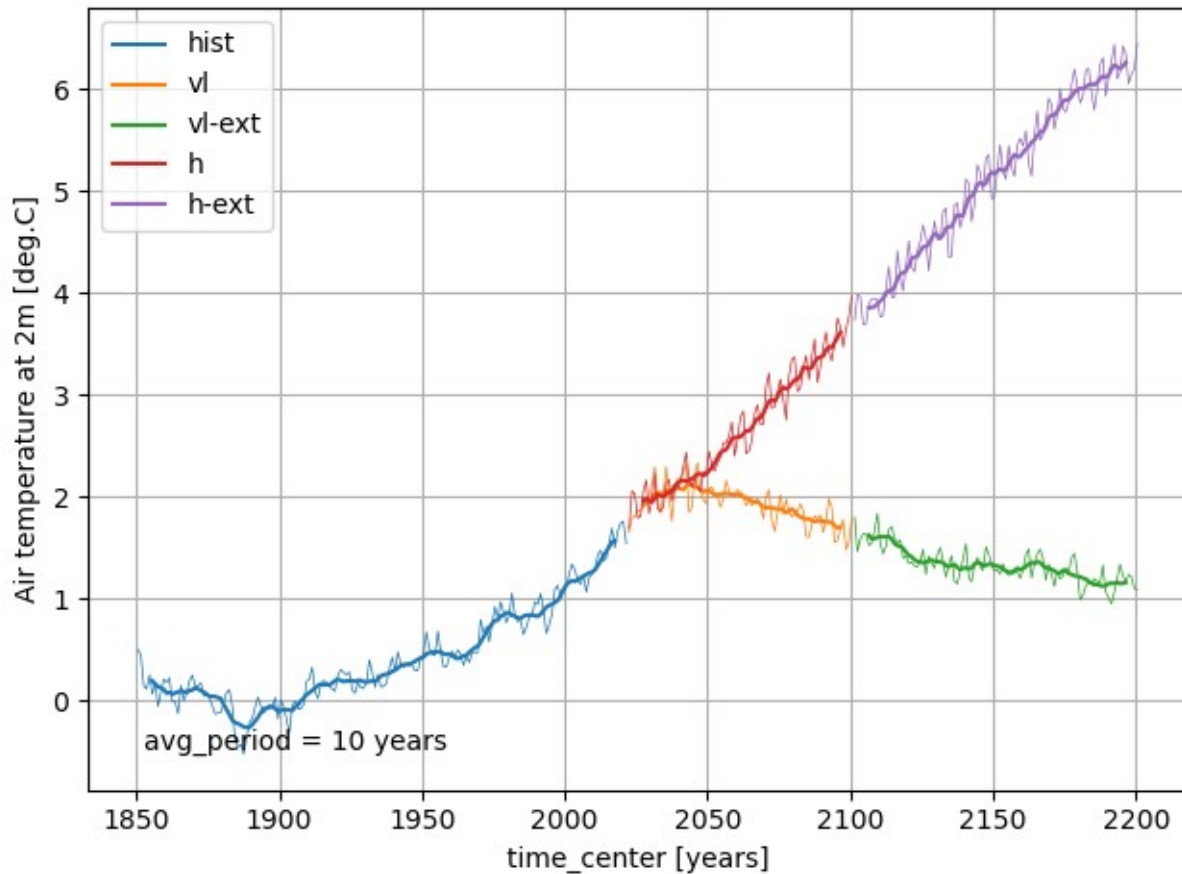




- NSC-Freja 
- NSC-Tetralith 
- NAISS-Arrhenius 
- ECMWF-HPC2020 
- BSC-MareNostrum5 
- CSC-LUMI 
- DKRZ-Levante 



Present + future scenarios with EC-Earth3 ~16 SYPD @ NAISS-Arrhenius (688 cores)

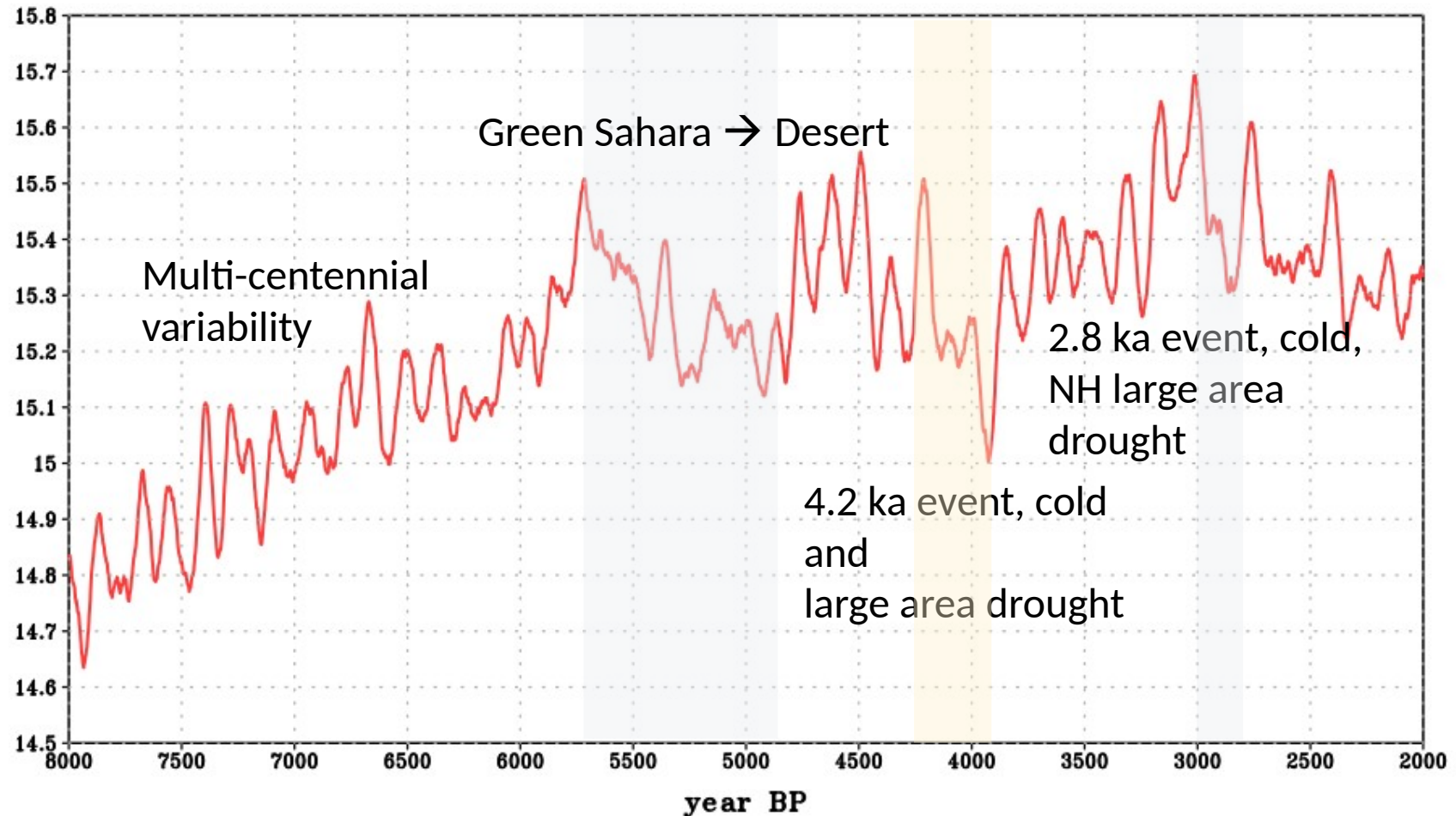


Klaus Wyser
(SMHI)

Mid-Holocene with EC-Earth3

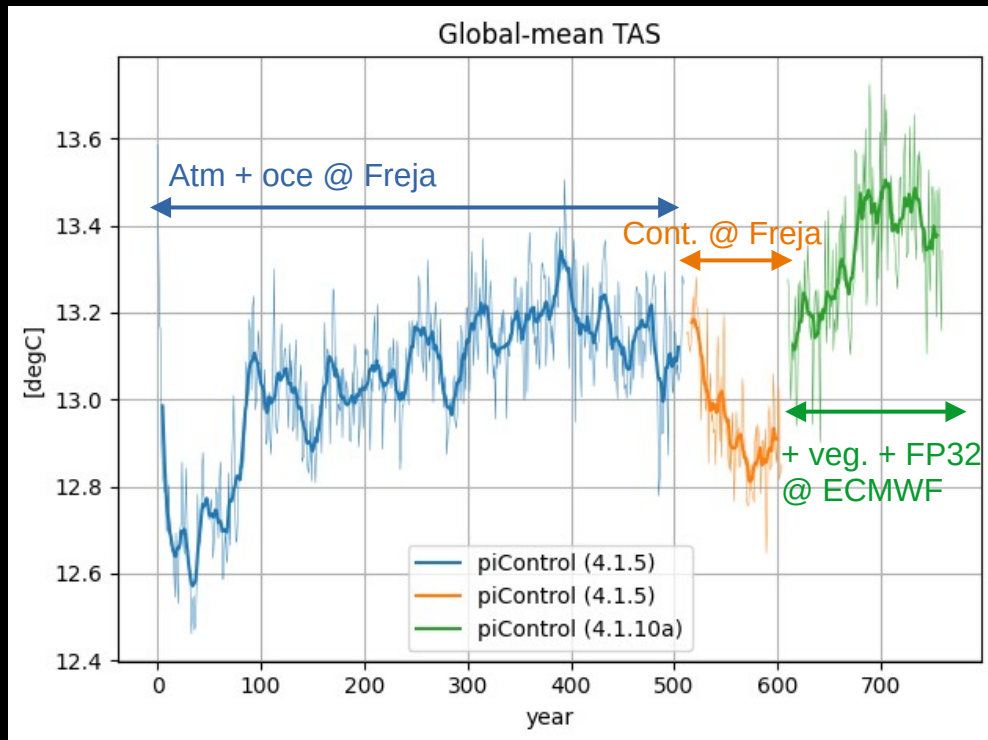
~ 20 SYPD @ NSC-Tetralith (480 cores)

Qiong Zhang (Stockholm Uni.)



Equilibration of EC-Earth4-ESM-1

Currently ~12 SYPD @ ECMWF-HPC2020 (1536 cores)

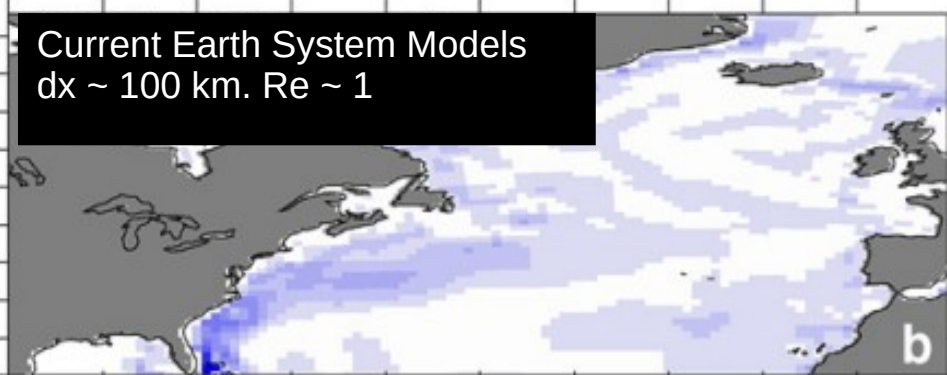


- Lots of bug fixes and HPC improvements
- Atmosphere in FP32
- Longer time step in ocean
- Parallel I/O for atmosphere
- Interactive aerosol chemistry
- Open source (soon)
- Git

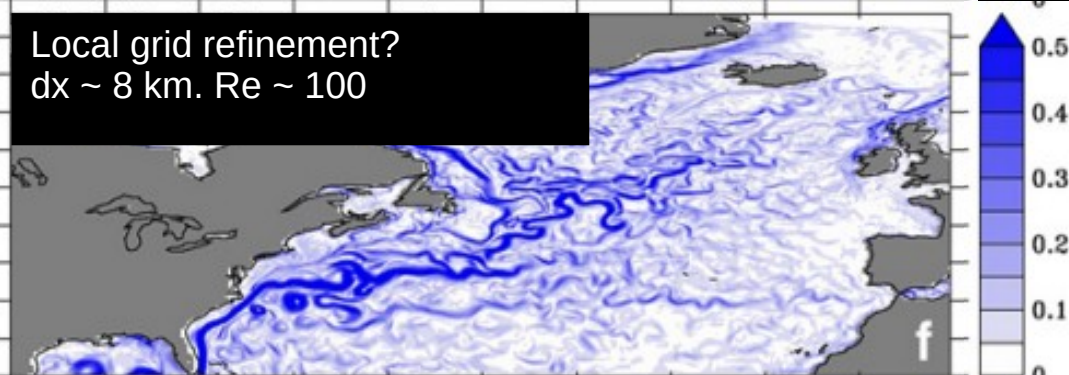
EC-Earth 4.1.10 (Sep 2026) ported to Arrhenius

The ocean is highly turbulent Current Earth System Models are very laminar!

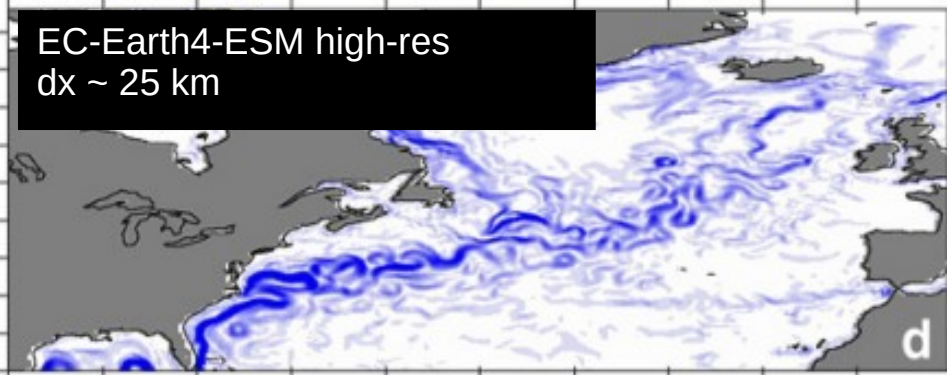
Current Earth System Models
dx ~ 100 km. Re ~ 1



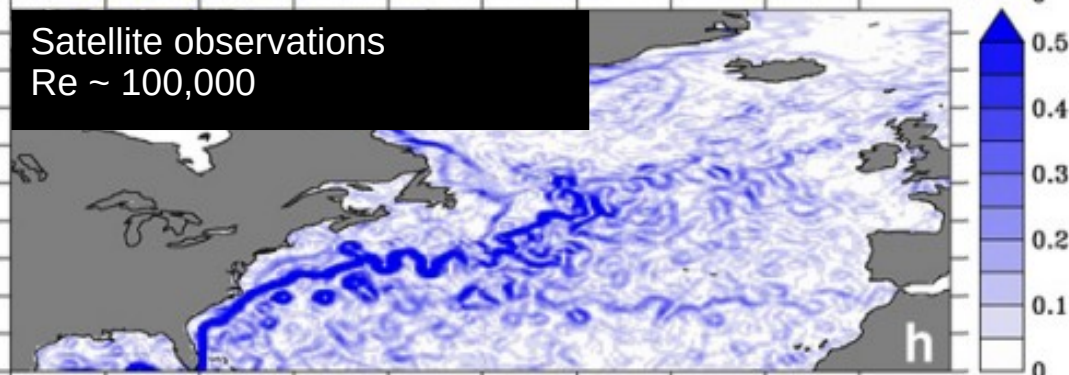
Local grid refinement?
dx ~ 8 km. Re ~ 100



EC-Earth4-ESM high-res
dx ~ 25 km



Satellite observations
Re ~ 100,000

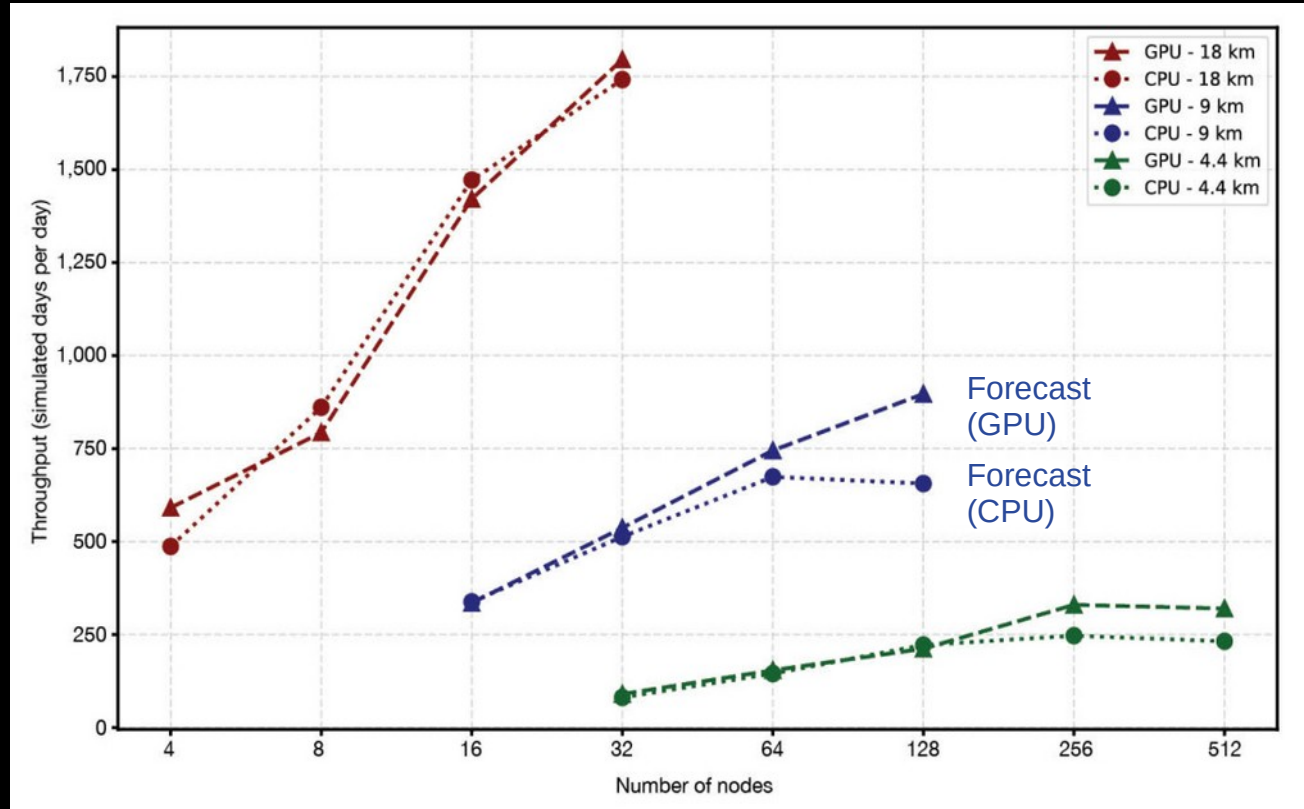


Marzocchi et al. (2015)

Ongoing GPU port of ECMWF forecast model to GPU @JUPITER (NVIDIA GH200)

Michael Lange (ECMWF)

- GPU-ready EC-Earth is years away
- Source-2-source translation - exists!
- Full re-write in GT4Py - not likely!
- Agentic “shadow” in C++/Kokkos - maybe?



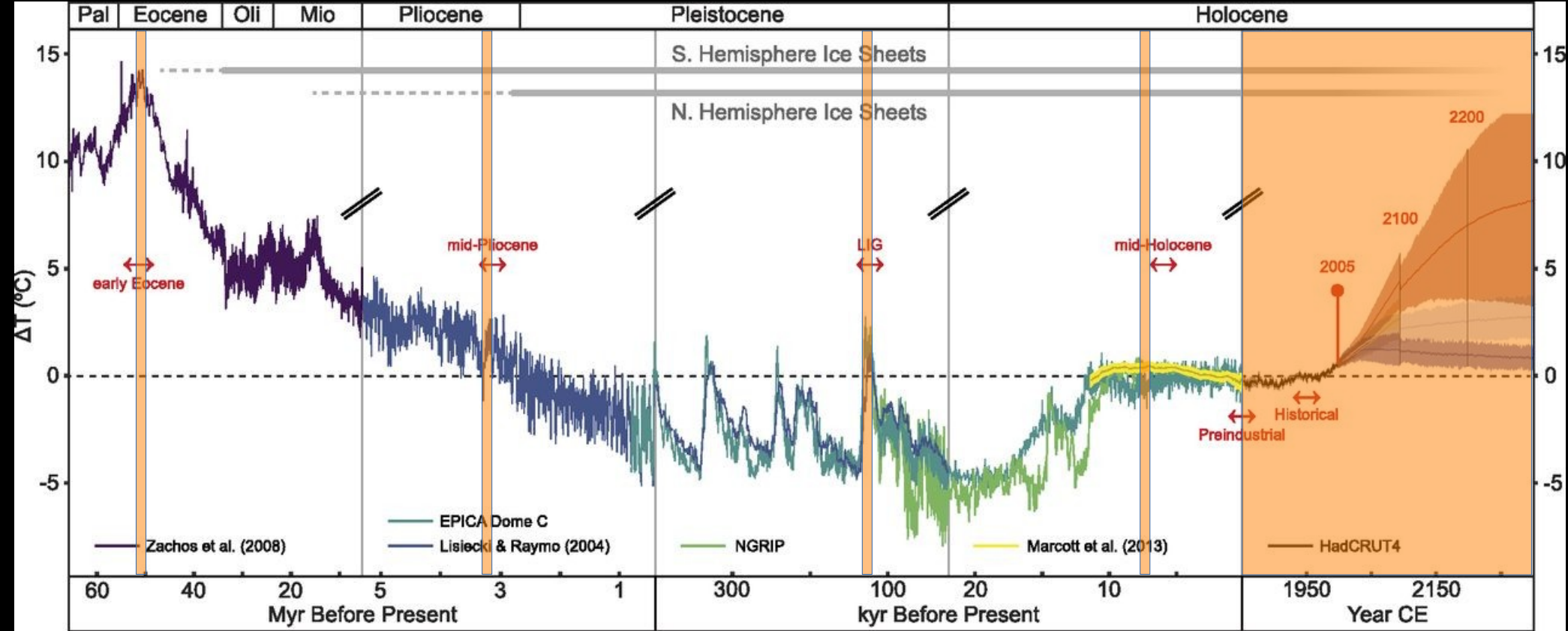
We are bound to CPUs for the coming years

Component	FP32	GPU port	Vendor
Atmosphere	99.9%	New version available	NVIDIA + AMD
Ocean	Mostly	No I/O, no ice, no river (2027?)	NVIDIA
Vegetation	?	?	?
Coupler	?	Planned	?
Ice sheets	?	?	?
I/O server	Yes	Merge with coupler	?

Code freeze in 2026 – Use for several years!

EC-Earth5 on GH200?

EC-Earth-ESM: Simulate the Earth System across climate states



European consortium. From weather prediction to climate modelling.
Heavy use on NAISS + EuroHPC resources