ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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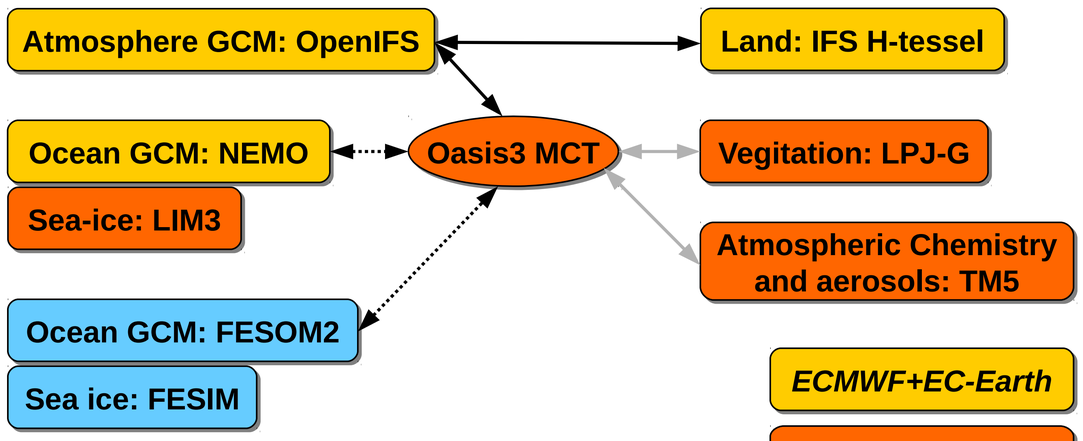
OpenIFS – FESOM2.0 coupled model

Goal and model setup

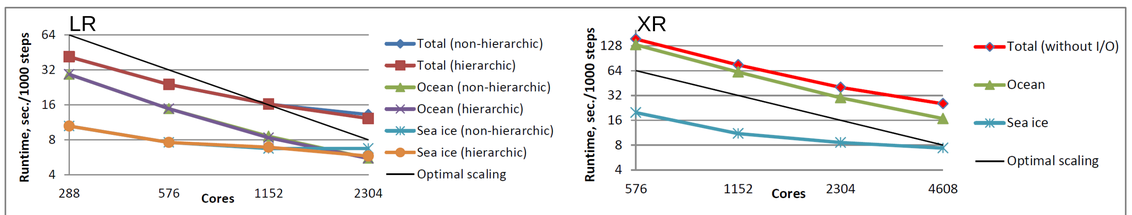
- Provide high resolution atmosphere for coupling with FESOM2
- Potential alternative ocean model for EC-Earth 4?
- Starting from EC-Earth OpenIFS development branch
- Adding in FESOM2 as additional ocean model



- Uses OpenIFS CY40r1v2[1]
- Thus far: development not fed back to EC-Earth project
- Separate repository at DKRZ gitlab

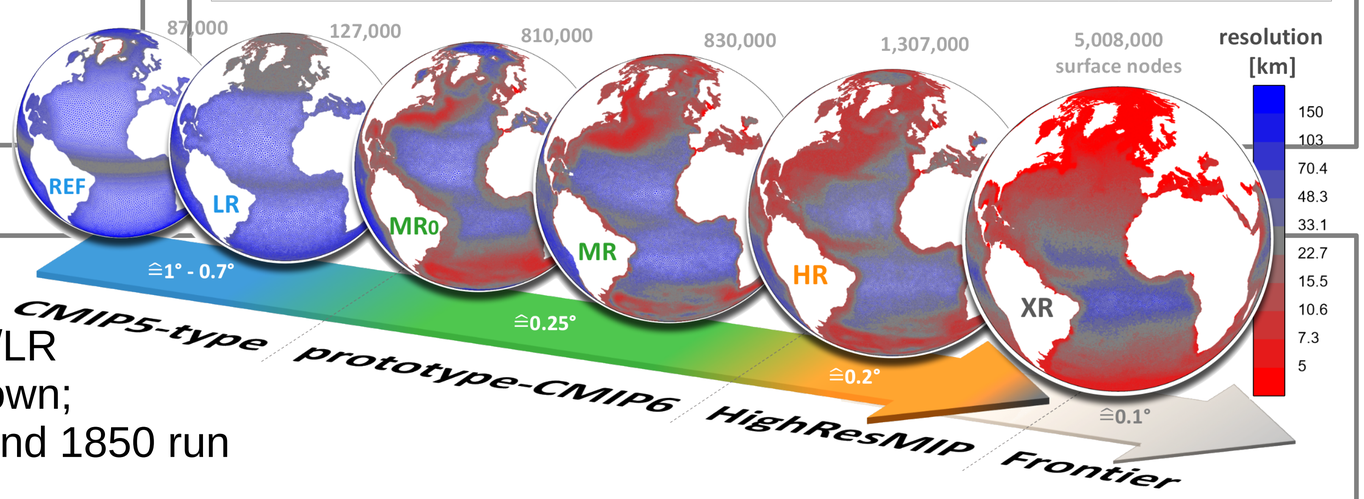
FESOM 2.0

- **F**inite volum**E** **S**eaice **O**cean **M**odel (FESOM2.0)
- Development: FEOM[2] → FESOM1.4[3] → 2.0[4]
- Unstructured triangular mesh
- Flexible mesh generation
- Resolution in e.g. dynamically active regions, study areas, coastlines, tropics, etc.
- Saving computational resources



FESOM2 computational scalability on typical meshes

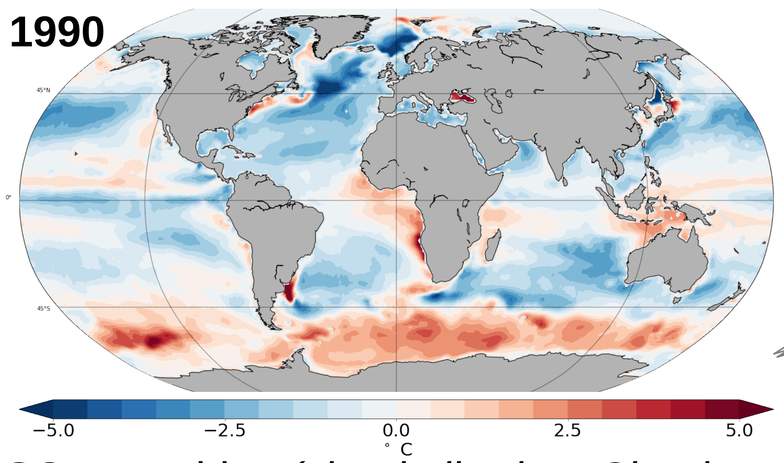
Mesh	LR	HR	XR	A1km
Resolution (Km)	25-100	10-80	4-40	1-30
Surface nodes	127k	1.3m	5.0m	14.0m
CPUs	0.28-0.4k	2.4-4.6k	1.7-18.0k	7.0-55.0k
SYPD	90-170	24-40	2-40	2-16

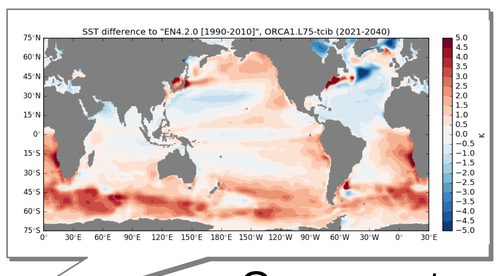


Simulation results

- OpenIFS-FESOM2 (OF-CM) results on T255L91/LR
- 50y runs; Means of last 20y – PHC3 SST are shown;
- Runs with constant ghg and solar forcing; 1990 and 1850 run

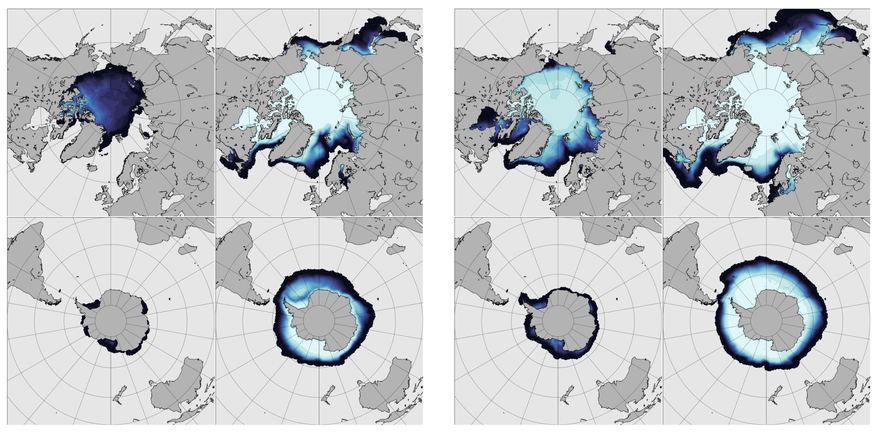
1990





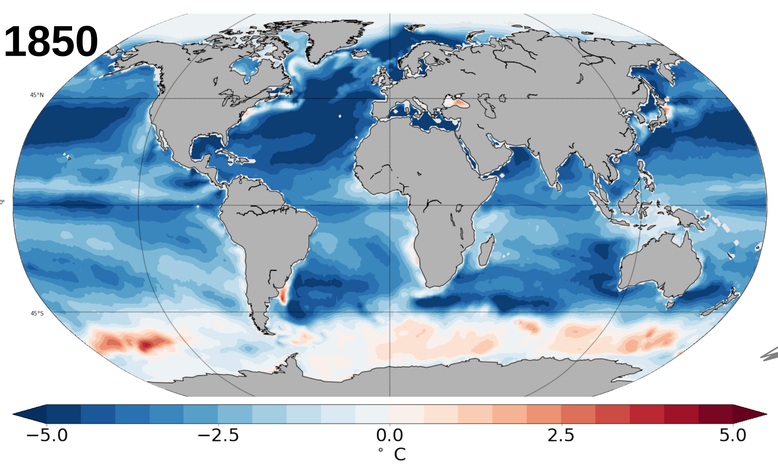
Compare to EC-Earth

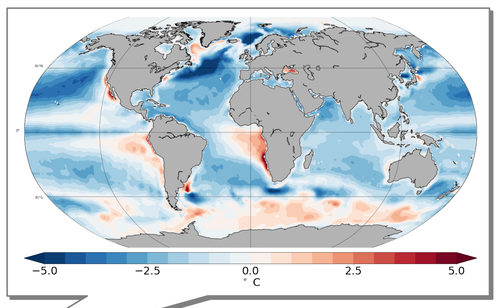
- SO warm bias *(cloud albedo + Cloud condensation nuclei/marine aerosols)*
- Gulf Stream separation shifted northwards *(low resolution)*
- warm western continental boundaries *(weak upwelling)*
- FESOM2 is colder than NEMO by ~ 0.5°C *(strong mixing)*
- sea ice regions show warm bias / low EOS ice concentrations
- 1850 pre-industrial control run too cold



Sea ice concentrations at end of local summer / winter with const. 1990 and 1850 forcing

1850





Compare to ECHAM6-FESOM2.0

Outlook

→ Improving cold bias by tuning mixing
→ Coupling OpenIFS cycle 43
→ Use in ESM-project *
→ Higher resolution for both atmosphere and ocean T255L91/LR → T511/MR
→ Lower res. for palo climate applications

Longer term:

→ Studying model bias origins
→ Atm. chemistry and dynamic vegetation
→ Final goal: FESOM2-based ESM for CMIP7

References
[1] Carver et al, 2018, "The ECMWF OpenIFS numerical weather prediction model release cycle 40r1: description and use cases", in preparation to be submitted to GMDD.
[2] Danilov, S., Kivman, G., & Schröter, J. (2004). A finite-element ocean model: principles and evaluation. Ocean Modelling, 6(2), 125-150.
Wang, Q., Danilov, S., Sidorenko, D., Timmermann, R., Wekerle, C., Wang, X., ... & Schröter, J. (2014).
[3] Wang, Qiang, Sergey Danilov, and Thomas Jung. "FESOM1. 4: Formulation of an unstructured-mesh ocean general circulation model." 2014.
[4] Danilov, S., Sidorenko, D., Wang, Q., and Jung, T.: The Finite-volumE Sea ice–Ocean Model (FESOM2), Geosci. Model Dev., 10, 765-789, 2017.

* ESM-Project: https://www.esm-project.net/

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