**High-resolution Ocean Modelling for Coupled Seamless Predictions Workshop (HRCP)**
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# Multi-resolution simulations with the AWI Climate Model (AWI-CM)

## Abstract


- Our novel approach to gain higher resolution in oceanic key regions is to use a dynamical core (FESOM, the Finite Element Sea ice Ocean Model developed at Alfred Wegener Institute) supporting unstructured meshes
- FESOM is available in a coupled configuration with ECHAM6 (Max Planck Institute for Meteorology): the AWI Climate Model (AWI-CM)
- Several 100yr pre-industrial climate simulations are performed with a hierarchy of ocean model grids


## Hierarchy of model grids

- A benchmark set-up of AWI-CM with the REF87K grid (Fig.2) achieved a similar simulation realism regarding basic atmospheric and oceanic quantities when compared to state-of-the-art CMIP5 models (*Sidorenko et al. (2015)* and *Rackow et al. [in review]*)

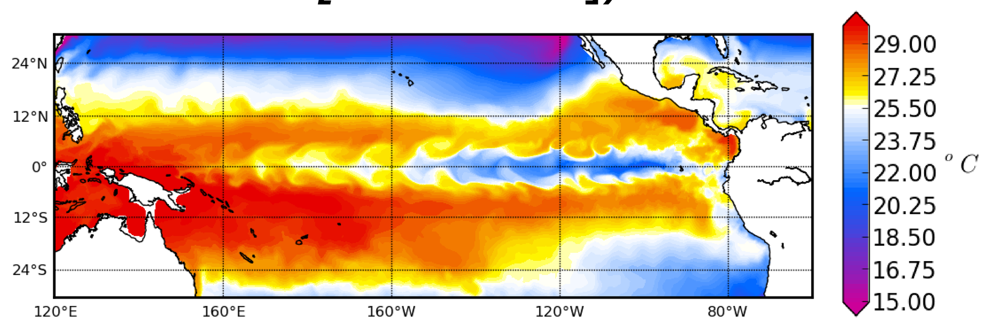
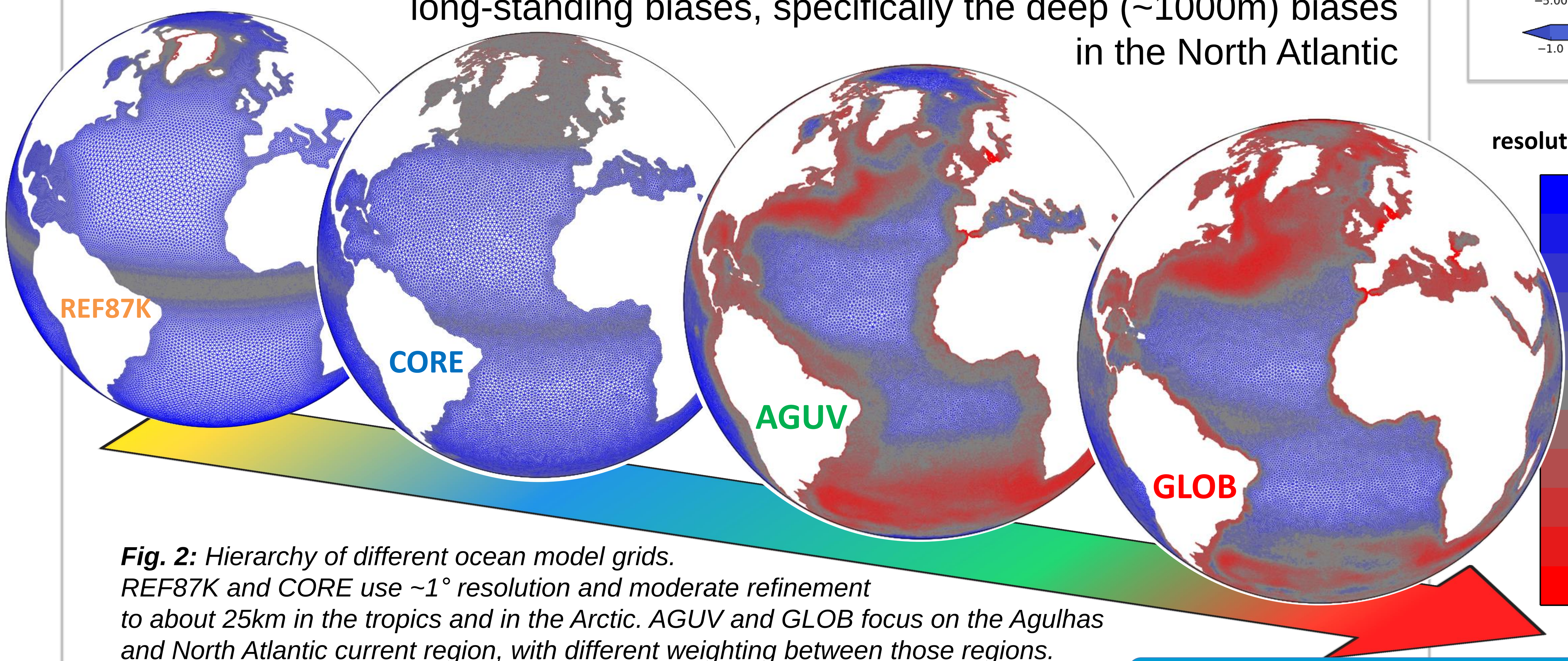


***Fig. 1:*** *Simulated Tropical Instability Wave (TIW) activity in the equatorial Pacific with mesh REF87K*

- The flexible layout of AWI-CM allows to use eddy-resolving resolutions in key ocean areas (**1/12°** corresponding to 9-10km). The goal is to reduce long-standing biases, specifically the deep (~1000m) biases in the North Atlantic



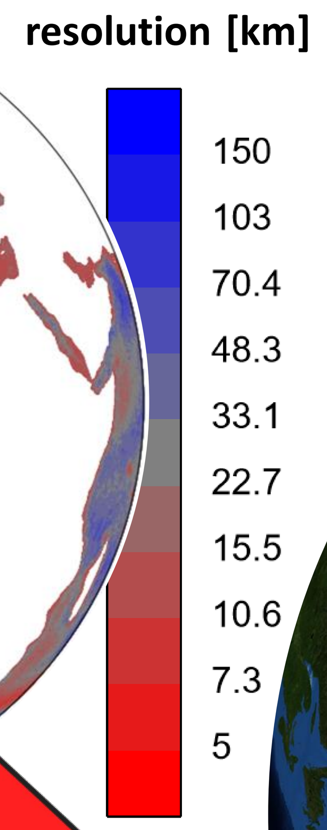




***Fig. 2:*** *Hierarchy of different ocean model grids. REF87K and CORE use ~1° resolution and moderate refinement to about 25km in the tropics and in the Arctic. AGUV and GLOB focus on the Agulhas and North Atlantic current region, with different weighting between those regions.*

## Configuration & throughput

| | grid points (2D) | #CPUs FESOM | #CPUs ECHAM | time step FESOM | time step ECHAM | coupling interval | throughput (sim. years per day) |
|---|---|---|---|---|---|---|---|
| T127-GLOB | 830,000 | 1920 | 1152 | 10 min | 3.3 min | 1h | **6.4 years/day** |
| T127-AGUV | 810,000 | 2304 | 1152 | 7.5 min | 3.3 min | 1h | **6.2 years/day** |
| T127-CORE2 | 127,000 | 192 | 576 | 15 min | 3.3 min | 1h | **5.6 years/day** |
| T63-REF87K | 87,000 | 384 | 192 | 30 min | 7.5 min | 1h | **21.8 years/day** |

***Table 1:*** *Model settings and throughput for the four different AWI-CM configurations. The atmospheric resolution is T127 except for the coarsest setup with REF87K (T63).*

## Deep ocean bias reduction

- 100-yr simulations show improvements with increasing resolution in North Atlantic deep-ocean hydrography:

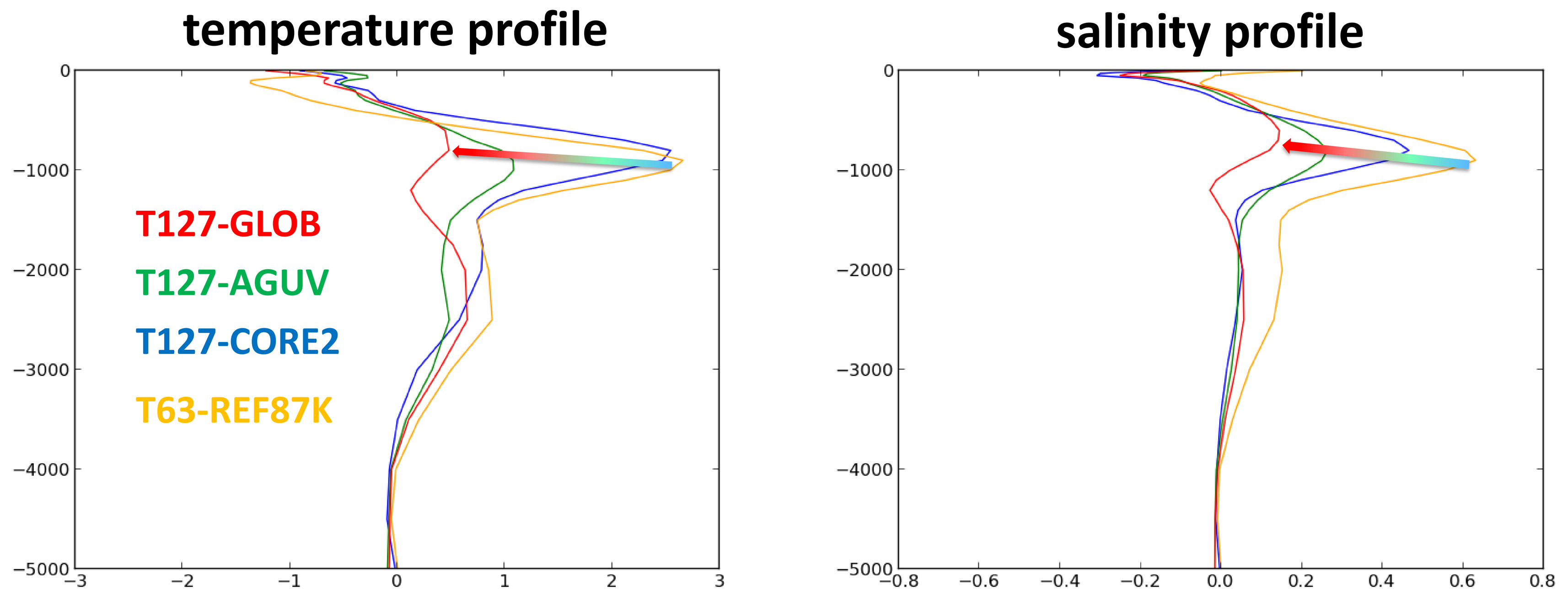



***Fig. 3:*** *Global profiles of potential temperature and salinity for years 71—100 of the pre-industrial simulations . Shown is the difference to the WOA2005 climatology.*

***Fig. 4:*** *Difference of **(left)** potential temperature and **(right)** salinity at 1000m to the WOA2005 climatology. The years 91-100 are used. The North Atlantic biases identified in the bench-mark version of AWI-CM successively decrease with increasing spatial resolution.*

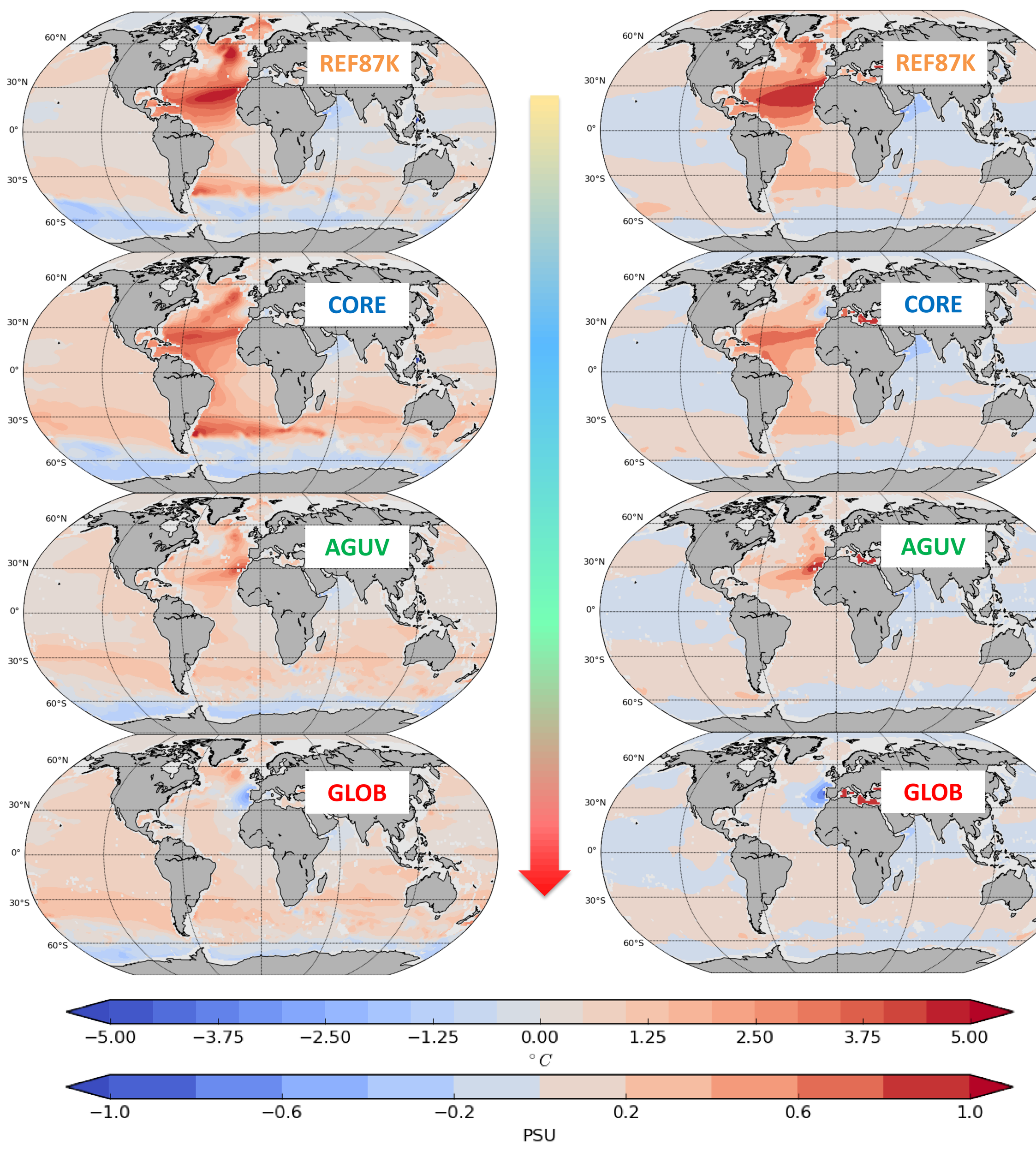
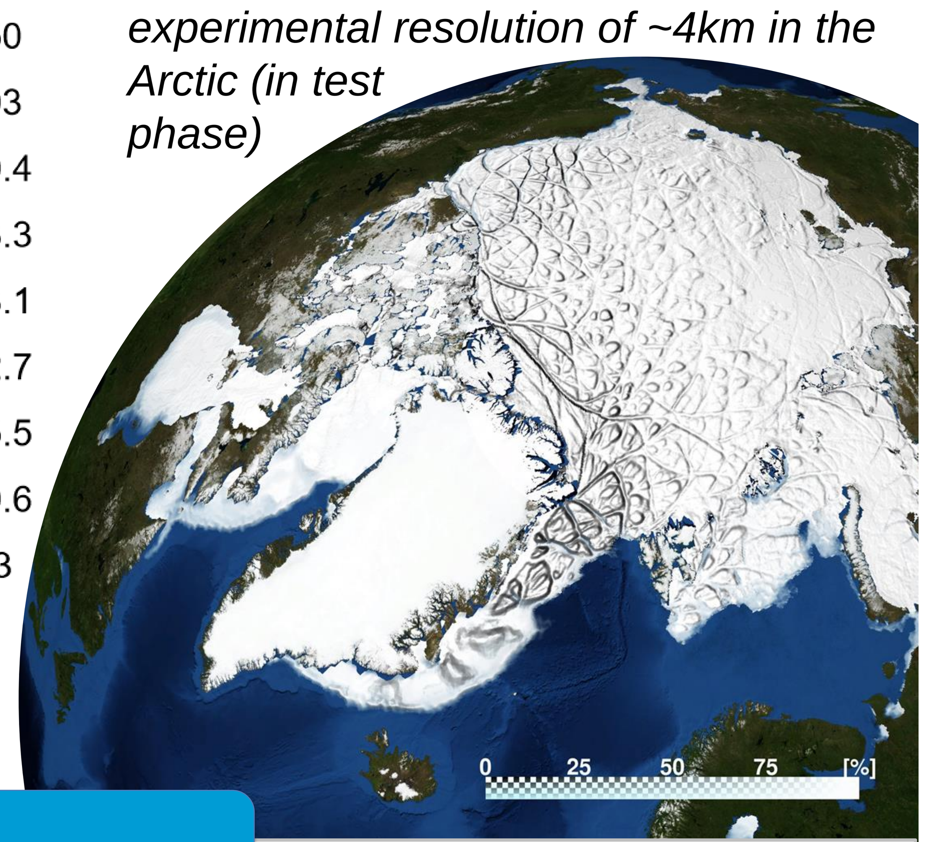



***Fig. 5:*** *Simulated sea ice area (opacity) and thickness (height) at experimental resolution of ~4km in the Arctic (in test phase)*



## Outlook

- FESOM2 (finite volume discretisation) is ~3 times faster than FESOM 1.4. Planned to be ready for use in CMIP6.
- It is not straightforward *a priori* how to design unstructured meshes in an optimal way for CMIP-type simulations.
- At high resolution of ~4km (Fig. 5), linear kinematic features appear in the modeled sea ice cover. Leads are known to have a strong impact on heat fluxes and biology.

**References**
- **Sidorenko, D. , Rackow, T. et al. (2015)**: Towards multi-resolution global climate modeling with ECHAM6-FESOM. Part I: model formulation and mean climate. *Clim. Dyn. Vol. 44, Issue 3, pp 757—780 , doi:* 10.1007/s00382-014-2290-6
- **Rackow, T. et al. (in review)**: Towards multi-resolution global climate modeling with ECHAM6-FESOM. Part II: climate variability.

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