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High resolution climate simulations with the AWI Climate Model (AWI-CM)

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The ocean component of AWI-CM (FESOM) uses unstructured meshes, which allows the use of variable resolutions without traditional nesting. Due to the flexibility of unstructured meshes, one needs to carefully design meshes so that the variable resolution can most efficiently improve the simulated results with the least possible computational cost. We propose a new approach to set up variable resolution, which uses the satellite-observed sea surface height variability to determine the regions where high resolution should be assigned. This approach is verified using both idealized experiments and ocean simulations. It will also become one of the standard mesh design methods for general FESOM users. The added value of the use of the high resolution ocean model is demonstrated by two different FESOM ocean setups (LR and HR) coupled with the atmospheric model ECHAM6. LR (low resolution) employs a coarse mesh with nominal resolution of about 100 km in the global ocean, about 25 km north of 50°N, about 35 km in the equatorial band, and moderate refinement along the coasts. HR (high resolution) uses a locally eddy-resolving mesh. Its design relies on the AVISO satellite altimetry product. The coarsest resolution on this mesh is set to ∼60 km, and the finest resolution is ∼10 km. The refinement was determined by a low-pass filtered SSH variance (SSHV) pattern derived from the AVISO data. Fine resolution is obtained in regions with high SSHV, including the pathways of main currents - the Gulf Stream, Kuroshio, Antarctic Circumpolar Current (ACC) and Agulhas Current. The HR mesh contains about 1.3 million surface grid nodes, which is close to the number of nodes on a 1/4° Mercator mesh (only wet nodes are dealt with on unstructured meshes). This mesh size ensures reasonably fast simulations with available computational resources. The AWI-CM simulations with the two global ocean setups were carried out in the framework of the PRIMAVERA EU project according to the HighResMIP protocol. The ocean model was initialized with 1950-1954 mean winter EN4 data. Afterwards, 50 years of coupled spin-up with constant 1950 forcing was performed. After the spin-up, both LR and HR were run with CMIP5 20th century forcing from 1950 till 2005, followed by the CMIP5 RCP8.5 scenario from 2006 till 2100.
The results clearly demonstrate the added value of HR simulations for both the ocean and atmospheric climate. Biases are strongly reduced almost over the entire globe. The most remarkable reduction in 2m temperature can be seen in the equatorial Pacific, in the Kuroshio current region, and over Southeast Asia.