The influence of water temperature-phytoplankton feedback in a Regional Earth System Model upon the hydrography and biogeochemistry of the northern Indian Ocean

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Within the Coordinated Regional Climate Downscaling Experiment (CORDEX) framework, a high-resolution Regional Earth System Model (RESM) was used to understand the effects of various parameterizations of the attenuation of short-wave radiation (SWR) penetrating into the ocean. The RESM comprises of the Max Planck Institute Ocean Model and the Hamburg Ocean Carbon Cycle model (MPIOM/HAMOCC) coupled via the OASIS coupler to the Regional atmosphere Model (REMO), and the Hydrological Discharge model (HD). Two runs of the RESM for the historical period 1950-2017 were performed. In the first run, the model utilized a simple light attenuation parameterization based on the Jerlov water types when the attenuation coefficient varies spatially depending on the water type but does not vary in time. In the second run, the feedback between the ocean and atmosphere through the marine ecosystem was implemented by using the parameterization of light attenuation coefficient as the function of not only water attenuation itself but also phytoplankton concentration, which was implemented in both the physical and biogeochemical model blocks. The obtained model results correspond well to the observed climatic characteristics. In the calculation with phytoplankton-dependent light attenuation parameterization, the average SST was lower than in the case of Jerlov-based parameterization. The greatest difference in SST (more than 1 °C) occurs in the spring and summer periods during the phytoplankton bloom. The SST differences in autumn and winter are less pronounced and do not exceed 0.2 °C and 0.6 °C, respectively. Also, during the period of intensive heating (spring and summer) the SWR in the ocean upper layers calculated by the feedback-based model run is more strongly absorbed in these layers and, as a result, a significant cooling of subsurface layers (25-200 m) occur (up to 1-1.5 ° C). The phytoplankton primary production and its dispersion in the feedback-based model run turned out to be higher, especially during the periods of winter and summer blooms, and the surface concentration of dissolved nitrates was lower than in the reference run (Jerlov-based parameterization) almost the whole year.

The work was supported by the Russian Science Foundation (Project 19-47-02015) and by the grant DST/INT/RUS/RSF/P-33/G of the Department of Science and Technology, Govt. of India.