EGU General Assembly, 4-8 May 2020
Online

Session OS1.10: Understanding the Indian Ocean's past, present, and future

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

Stanislav D. Martyanov,
Dmitry V. Sein,
Vladimir A. Ryabchenko,
Anton Y. Dvornikov,
Pankaj Kumar

Methods

The REgional atmosphere MOdel REMO with 50km horizontal resolution is coupled to the global ocean-sea ice model MPIOM and marine biogeochemistry model HAMOCC with increased resolution over the Indian Ocean (up to 20 km). Hereafter this coupled system will be called ROM (Fig. 1). The models are coupled via the OASIS coupler. The global Hydrological Discharge model HD, which calculates river runoff (0.5 degree horizontal grid resolution), is coupled to both the atmosphere and ocean components.

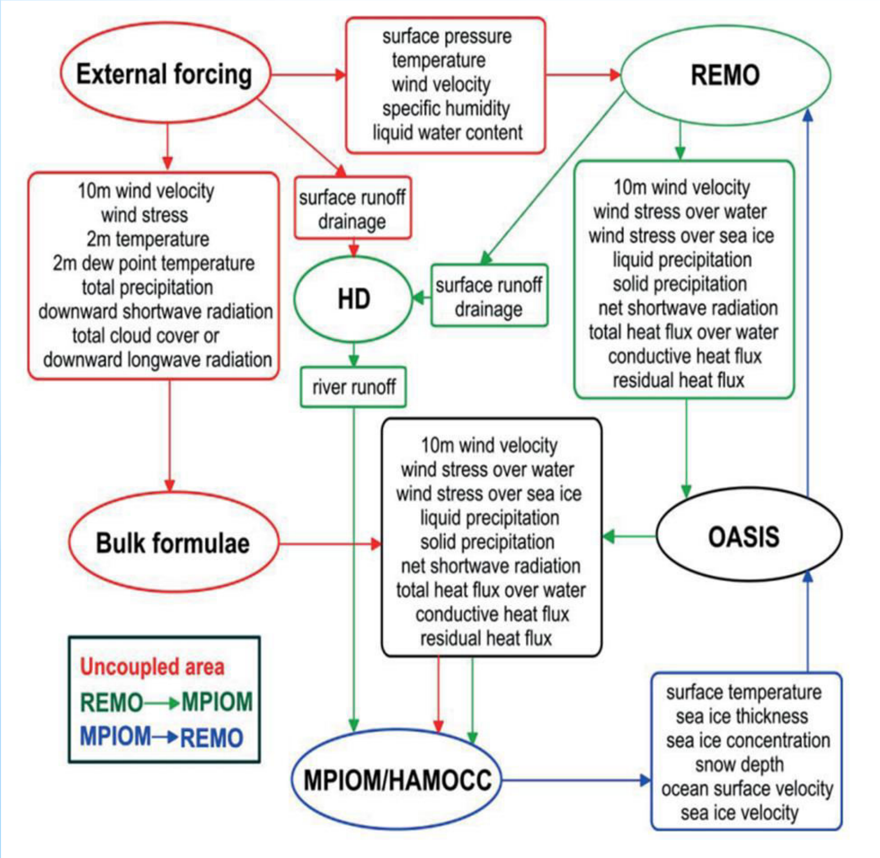


Fig. 1. Coupling scheme of the ROM modeling system.

Red color denotes the prescribed forcing used as lateral boundary conditions for REMO and as surface forcing for MPIOM in the uncoupled area.
The workflow of heat, momentum, and mass fluxes from the atmosphere (REMO) to the ocean (MPIOM) in the coupled area is marked with green.
The data flow from MPIOM to REMO is marked with blue.

CORDEX South Asia Domain

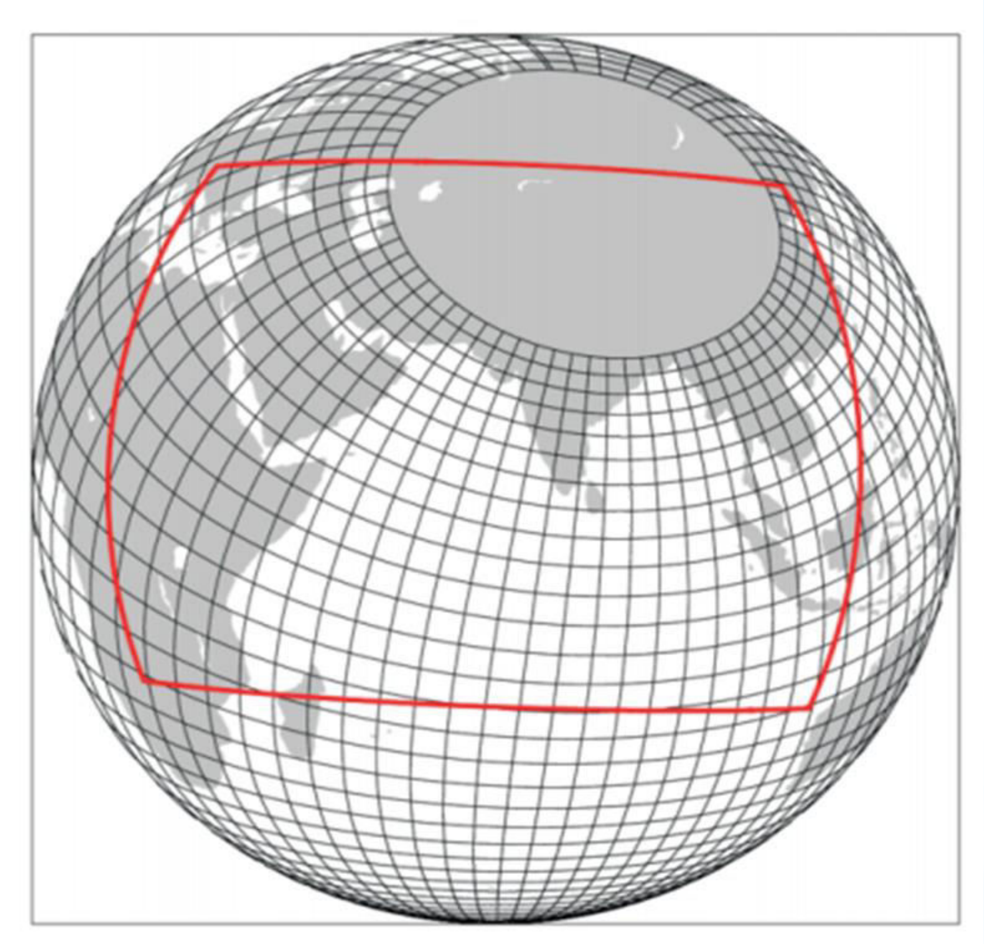


Fig.2. CORDEX South Asia Domain

Exchange of fields between ocean and atmosphere takes place every three hours.

Exchange between REMO/MPIOM and HD model is done once per day.

Lateral atmospheric and upper oceanic boundary conditions outside the REMO domain were prescribed using ERA-Interim reanalysis.

Light attenuation parameterizations

Two runs of the RESM for the historical period 1950-2017 were performed.

In the first run (labeled as 718 herein), 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 (Jerlov, 1976). This light attenuation parameterization was used both for the evolutionary equation for water temperature and in the HAMOCC biogeochemical module.

In the second run (labeled as 719 herein), 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 (see Groger et al, 2013 for details of the parameterization).

Therefore, in the 719th experiment the presence of phytoplankton in the water reduces the amount of SWR penetrating into the water column thus affecting its temperature and, through water temperature, the heat flux between the ocean and the atmosphere

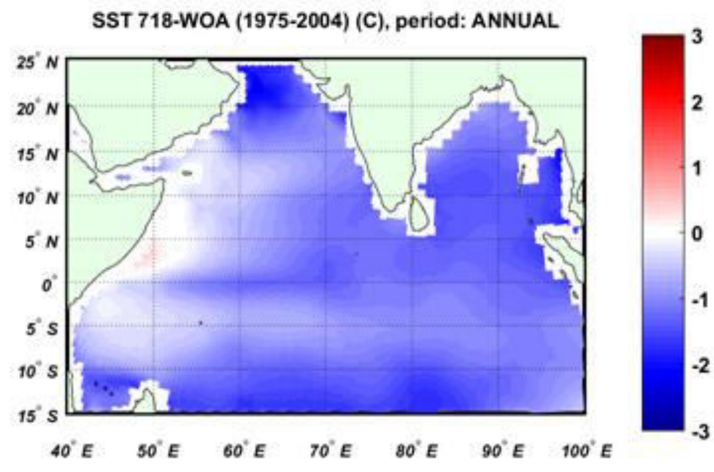
Results

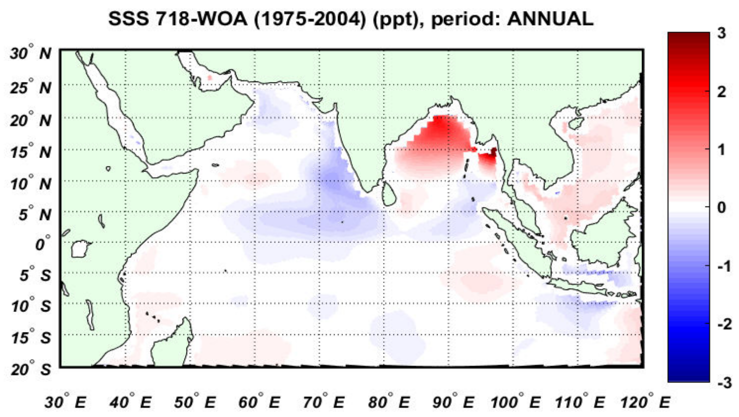
To verify the model, we used the monthly-averaged climatic fields of temperature, salinity, dissolved nitrates and dissolved phosphates taken from the World Ocean Atlas 2013 (WOA13), as well as the satellite data (SeaWiFS and MODIS-Aqua) on the monthly-averaged chlorophyll concentration.

According to Indian Meteorological Department, we distinguished the following seasonal periods for the verification procedure based on the monsoon activity in the northern part of the Indian Ocean:

- DJF: December–February (winter season, NE winds);
- MAM: March–May (pre-monsoon season);
- JJAS: June–September (monsoon season, SW winds);
- ON: October-November(post-monsoon season);
- ANN: annual.

These periods were used for the time-averaging of the model results and observations.



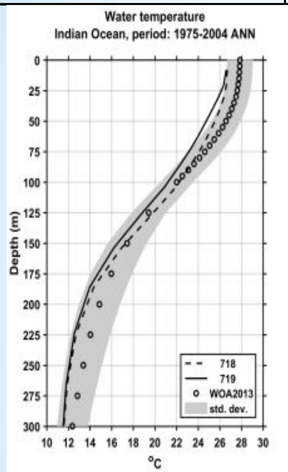
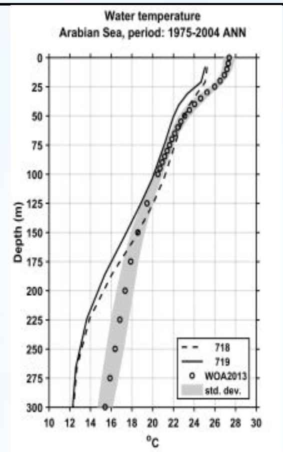
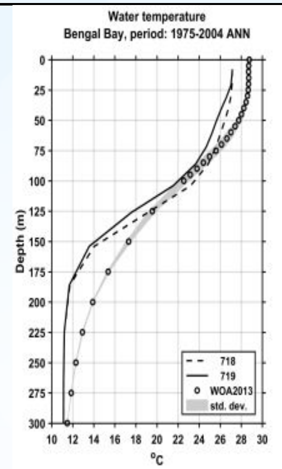
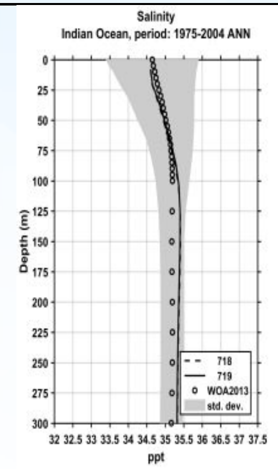
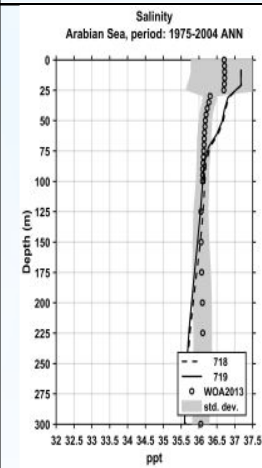
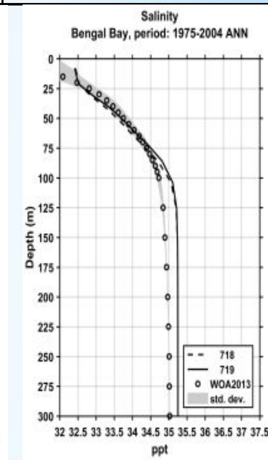


Verification against WOA13: SST and SSS

Spatial distribution of the difference between model run (718) and WOA13 for SST and SSS.

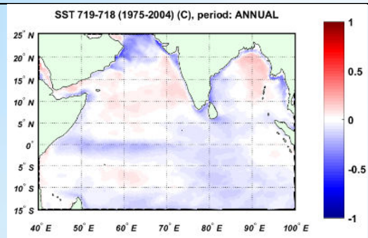
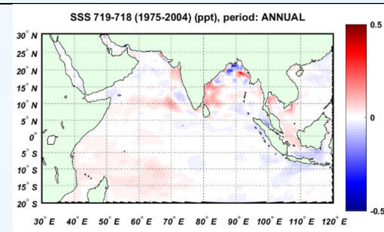
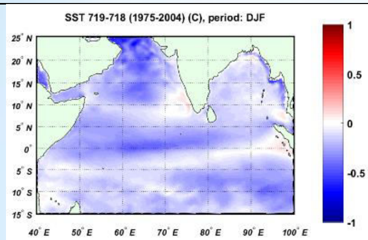
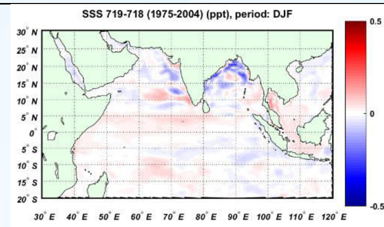
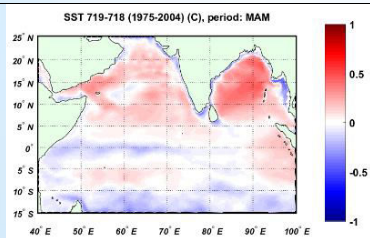
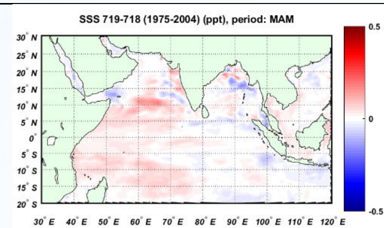
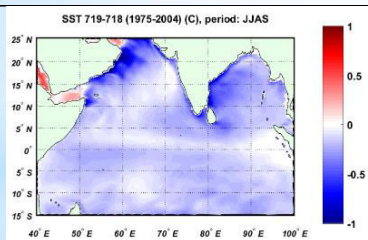
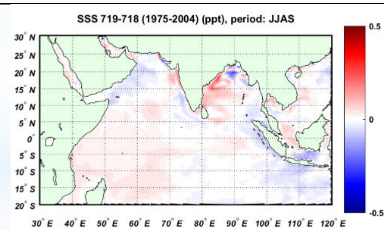
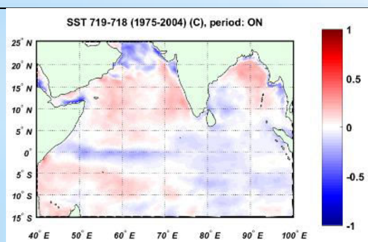
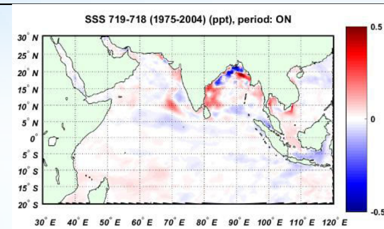
SST and SSS are time-averaged annually for the period 1975–2004.

Vertical distribution of water temperature and salinity

	Water temperature			Water salinity		
	Indian Ocean	Arabian Sea	Bengal Bay	Indian Ocean	Arabian Sea	Bengal Bay
ANN						

Vertical profiles of water temperature and salinity time-averaged annually for the period 1975–2004.

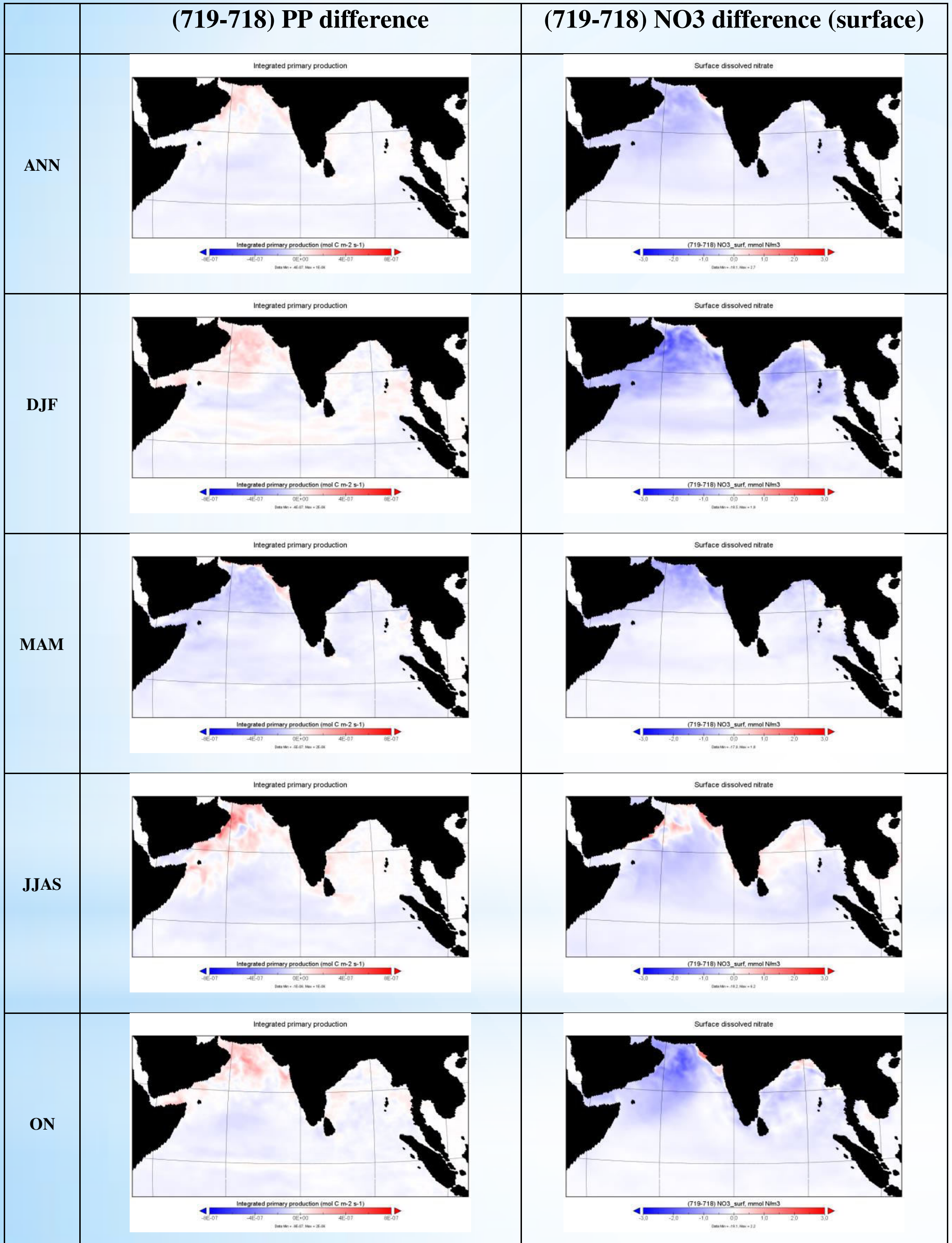
Legend: 718 and 719 denote the model runs; WOA13 denotes the climatic data from the World Ocean Atlas 2013; std. dev. denotes the standard deviation of the WAO13 data

	(719-718) SST difference	(719-718) SSS difference
ANN		
DJF		
MAM		
JJAS		
ON		

Difference between two different model runs (718 and 719)

Spatial distribution of the difference between model results (719-718) for SST and SSS.

SST and SSS are time-averaged annually (ANN) and seasonally (DJF, MAM, JJAS, ON) for the period 1975–2004.



Difference between two different model runs (718 and 719)

Spatial distribution of the difference between model results (719-718) for depth-integrated PP (left column) and NO3 in the surface layer (right column).

PP and NO3 are time-averaged annually (ANN) and seasonally (DJF, MAM, JJAS, ON) for the period 1975–2004.

Conclusion

The obtained model results correspond relatively 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.

The phytoplankton primary production 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 in that case 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.