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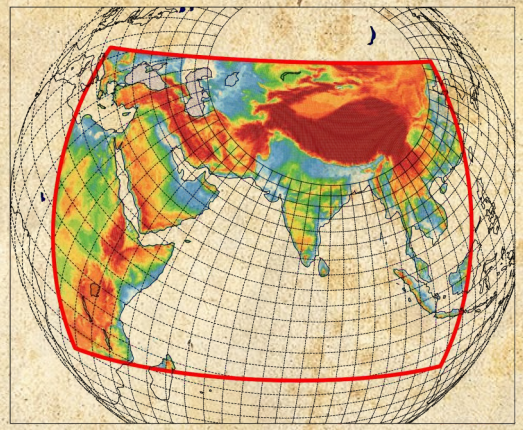

Projected climate change in the South Asia and northern Indian Ocean by the end of the 21st century as obtained from a Regional Earth System Model

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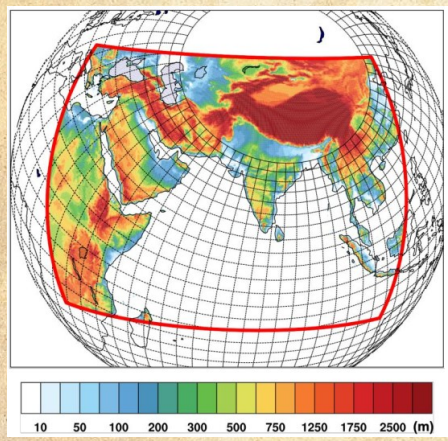
The model

We have implemented a new version of the high-resolution Regional Earth System Model (RESM) ROM for South Asia and the northern Indian Ocean.

The model includes ocean, atmosphere, hydrological cycle and marine biogeochemistry components. Such a modeling system is required for the study of extreme events in the atmosphere and the ocean in the India region, for seasonal and decadal predictions, climate change projections and advanced monsoons modeling.



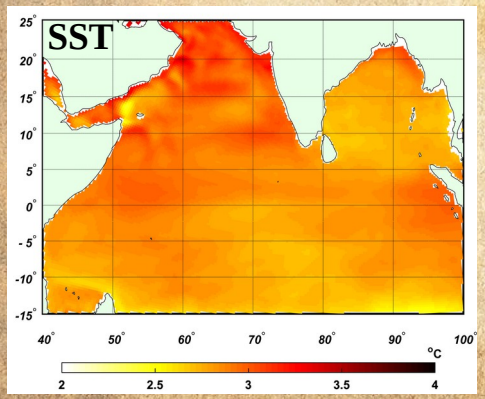
The oceanic component of ROM is the Max Planck Institute Ocean Model (MPIOM: Marsland et al., 2002; Jungclaus et al., 2013), which is coupled to the REgional atmospheric MOdel (REMO: Jacob, 2001a, 2001b) Via the OASIS coupler.

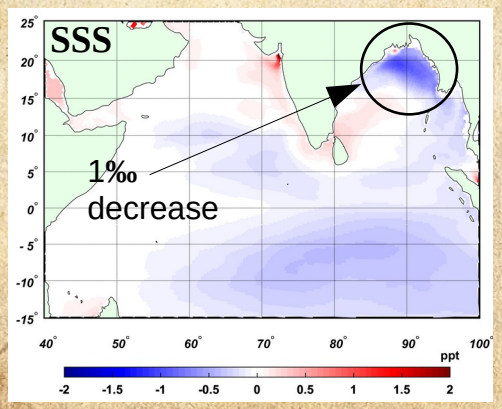
ROM also includes as modules the Hamburg Ocean Carbon Cycle model (HAMOCC: Ilyina et al., 2013), and the Hydrological Discharge model (HD: Hagemann and Dumenil, 1998). MPIOM provides the possibility to refine the grid resolution in the region of interest and to avoid the lateral boundary conditions in the ocean while performing calculations.

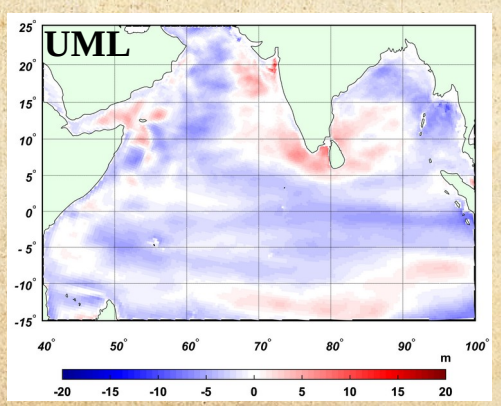
Another feature of the ROM system is that the coupling between the ocean and the atmosphere is implemented only at the chosen subdomain. At the same time, outside this region MPIOM calculates heat, freshwater, and momentum fluxes from atmospheric fields taken from the same global model used for REMO boundary conditions. A detailed description of ROM can be found in [Sein et al., 2015, doi:10.1002/2014MS000357].

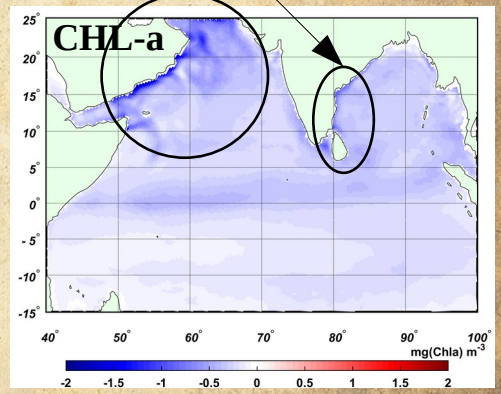
For this study we performed calculations for the 1920-2099. After 30 years adjustment period, from 1950 to 2005 the model was driven with ERA-Interim forcing. For the future period (2006-2100), the calculation was performed according to the RCP-8.5 scenario. Next, we will compare two climatic periods, the past climate (1975-2004) and the future one (2070-2099).

Differences between past (1975-2004) and future (2070-2099) climate









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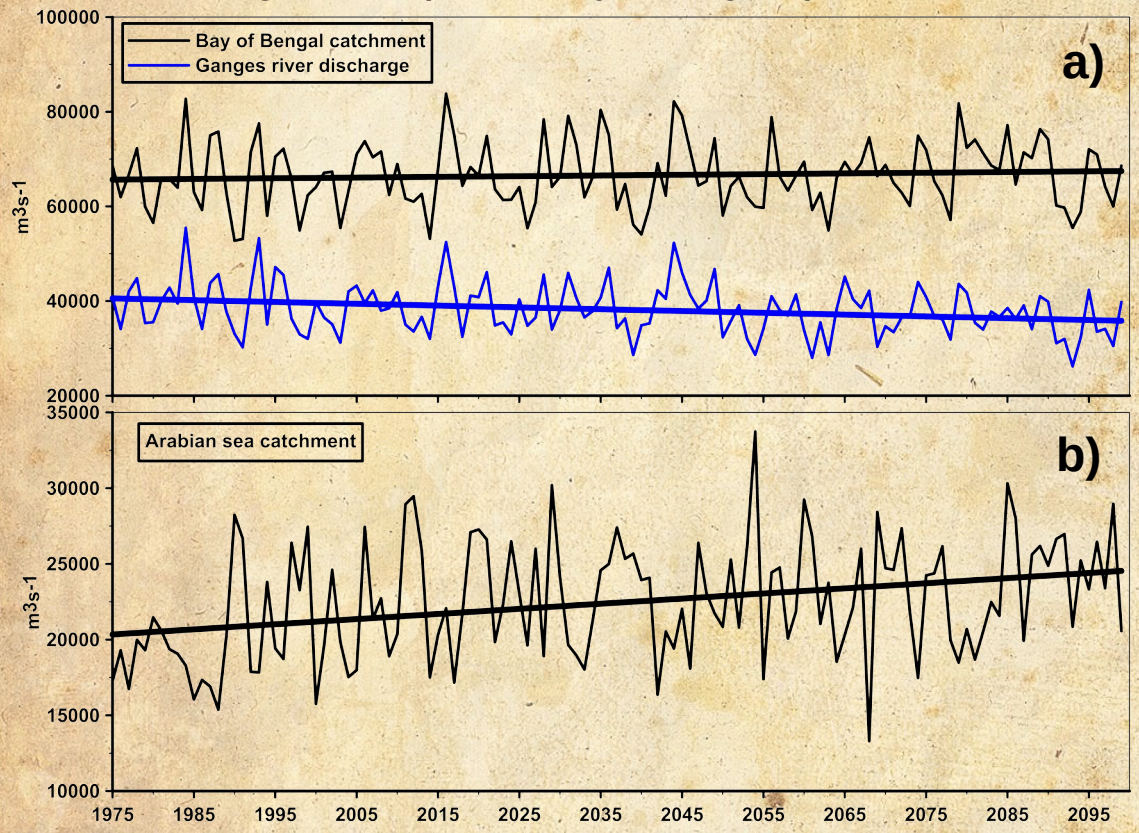
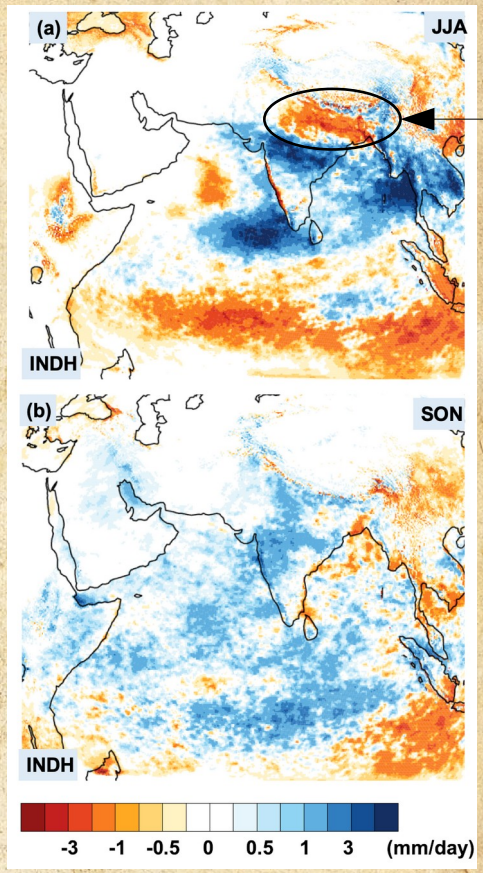
Changing the regime of precipitation and river runoff

Interannual variability of the mean annual total river runoff according to the modeling results: a) for the Bay of Bengal, b) for the Arabian Sea.



basin	period	runoff $m^3 \cdot s^{-1}$	Δ $m^3 \cdot s^{-1}$
Arabian sea	1975-2004	20143	3539
	2070-2099	23682	
Bay of Bengal	1975-2004	65207	2390
	2070-2099	67597	
Ganges and Brahmaputra rivers	1975-2004	39517	-3161
	2070-2099	36356	

Change in total seasonal precipitation in calculations according to the SSP5-8.5 scenario, future climate (2070-2099) minus the past (1975-2004) JJA — summer, SON - autumn



decrease precipitation in future

There is a strong decrease in the amount of precipitation in the future climate (up to 3-4 mm/day) over the northeastern part of India and over Nepal in the summer (JJA). At the same time, an increase in the amount of precipitation is observed over the central part of India, in the Andaman Sea, over Thailand and Myanmar. Thus, despite the decrease in the runoff of the Ganges and Brahmaputra rivers, the total continental runoff into the Bay of Bengal turns out to be higher in the future climate (2070-2099) relative to retrospective calculations (1975-2004) due to the runoff of smaller rivers.

Conclusions

Comparison of past and future climate simulations showed significant future SST increases, reaching 3ºC on average over the area under consideration.

The salinity of the ocean's upper layer will decrease by 1‰ on average, which indicates a change in the precipitation-evaporation balance in the future climate.

The model simulations also showed that in the future the average annual value of the UML thickness in the considered area will decrease, on average by 5 m.

Simulations also show a widespread decrease of the chlorophyll-a concentration in the surface layer in the future, especially pronounced in the northern and western parts of the Arabian Sea in spring and summer, respectively.

Analysis of the summer monsoon index in South Asia (WYM) has shown a significant weakening of monsoon activity in the future climate (2070-2099): summer monsoons in the area will weaken, and their duration will decrease. However, comparing the past and future climate, the surface average wind speed practically does not change.

We have determined that in the future climate (2070-2099) the intensity of atmospheric precipitation will exceed the precipitation intensity obtained in retrospective calculations (1975-2004) from June to September. It coincides with the beginning of the summer monsoon period according to the WYM index for the future climate.

The model solution according to the SSP5-8.5 scenario showed a decrease in the amount of precipitation in the future climate (on average, up to 3-4 mm/day) over the northeastern part of India and over Nepal in summer. At the same time, over the central part of India, in the Andaman Sea, over Thailand and Myanmar, there will be an increase in the amount of precipitation. Due to the redistribution of the amount of precipitation over the mainland part of the considered area, the river runoff will not change uniformly. The total continental runoff into the Bay of Bengal increases in the future, but the runoff in the Ganges delta will be greatly weakened. Thus, despite the decrease in the runoff of the Ganges and Brahmaputra rivers, the total continental runoff into the Bay of Bengal turns out to be higher in the future climate (2070-2099) relative to retrospective calculations (1975-2004) due to the runoff of smaller rivers.

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