Project: **1144**

Project title: **Impact of climate change on South Asia extremes: A high-resolution regional Earth System Model assessment**

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Report period: **2020-01-01 to 2020-12-31**

The overall aim of the project is to setup a high-resolution Regional Earth System Model (RESM) for South Asia and the northern Indian Ocean and to study climate change consequences and extreme events in the present and future climate.

During the first stage of our Project we have configured and validated our RESM for the CORDEX South Asia domain and performed numerical experiments for the period 1951-2005 in order to investigate the impact of the variability of fully-coupled marine biogeochemistry (INDB experiment) upon the model results (both ocean and atmosphere) compared to the experiment where a simple Jerlov exponential light attenuation was implemented and no interactive phytoplankton's influence upon SWR attenuation in water was considered (INDJ experiment).

Our results have shown that the effect of taking into account spatial and temporal variability of a fully-coupled marine ecosystem upon SWR attenuation in water leads to a cooling of the ocean waters compared to a reference experiment where a constant attenuation coefficient was set equal to 0.06 m^{-1} corresponding to Jerlov 1A water type (Fig. 1).

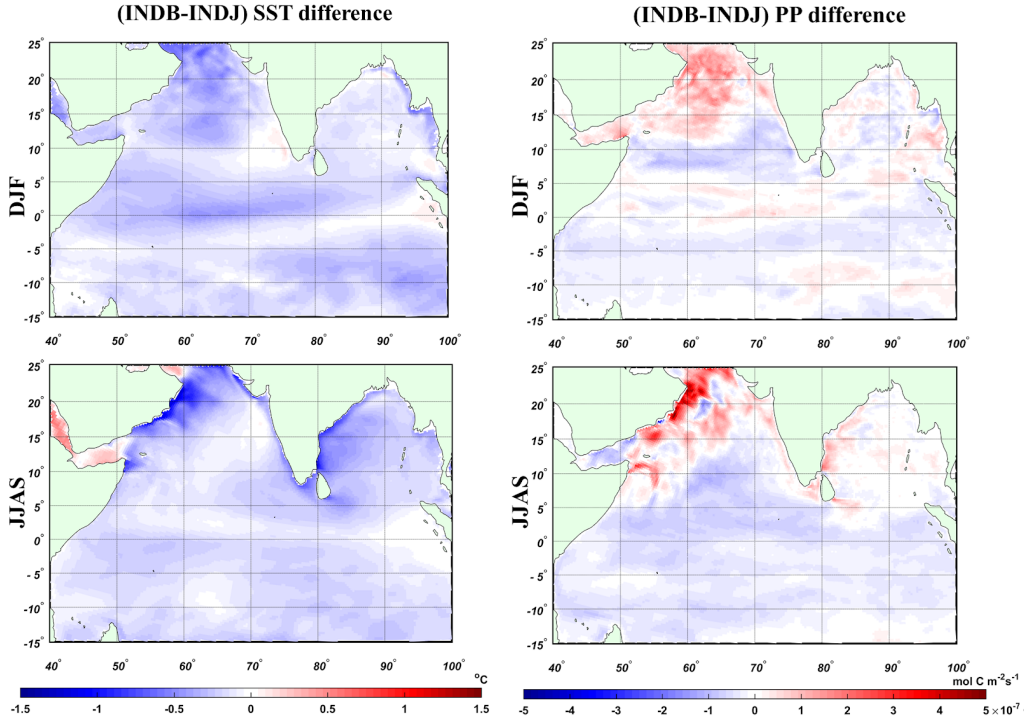

Fig. 1. Spatial distribution of the difference between model runs (INDB-INDJ) for SST and vertically-integrated primary production PP, both time-averaged seasonally (DJF, JJAS) for the period 1975–2004.

Another consequence is the enhanced ocean primary production in the Arabian Sea in the INDB experiment due to shallower upper-mixed layer. The shoaling of the upper-mixed layer is the result of enhanced vertical water temperature gradients due to the presence of phytoplankton in the upper layers, which absorbs more SWR and hinders its penetration in the deeper layers (Fig. 2). We can conclude that the higher phytoplankton primary production in the INDB (Fig. 1) is the effect of the decreased mixed-layer thickness which allows phytoplankton to prevail longer in the euphotic layer. This effect is more pronounced to the north of 10° N where the thermocline is relatively deep in INDJ and a reduction of the mixed-layer depth in INDB is most effective. In regions where the thermocline is generally shallower (to the south of 10° N) this effect is of minor importance as light is less limiting there.

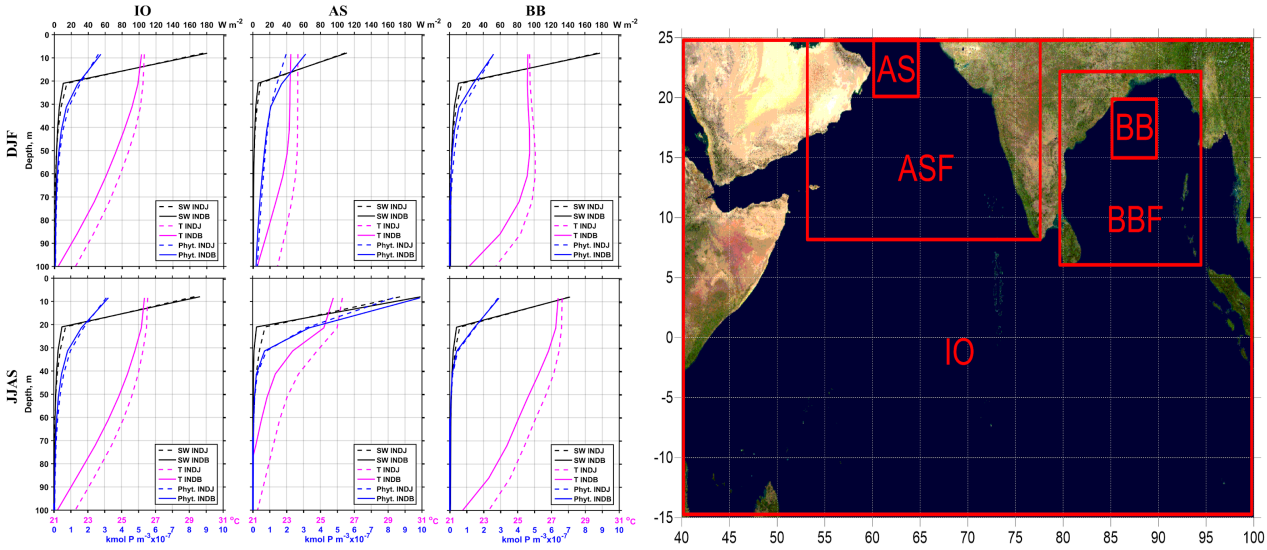

Fig. 2. Left - Vertical profiles of spatially-averaged short-wave radiation (SW), water temperature (T) and phytoplankton concentration (Phyt) in the INDJ and INDB experiments in 3 different areas shown at the Right Figure. DJF and JJAS designate for winter and summer seasons, both time-averaged for the period 1975–2004.

The variable marine biogeochemistry and its feedback also affects the amount of precipitation in the model, in particular during the monsoon season. The associated SST cooling leads to a reduction of the precipitation but affects it in different ways. In the Arabian Sea, the reduction of the transport of humidity across the equator leads to a reduction of the large-scale precipitation in the eastern part of the basin, reinforcing reduction of the convective precipitation. In the Bay of Bengal, the interactive feedback increases the large-scale precipitation, contouring the decrease of convective precipitation (Fig. 3). Thus, the main impacts of including the biogeochemical variability feedback in the Indian Ocean include the enhanced phytoplankton primary production, a shallower thermocline and decreased SST, with cascading effects upon the model ocean physics which further translates into altered atmosphere dynamics.

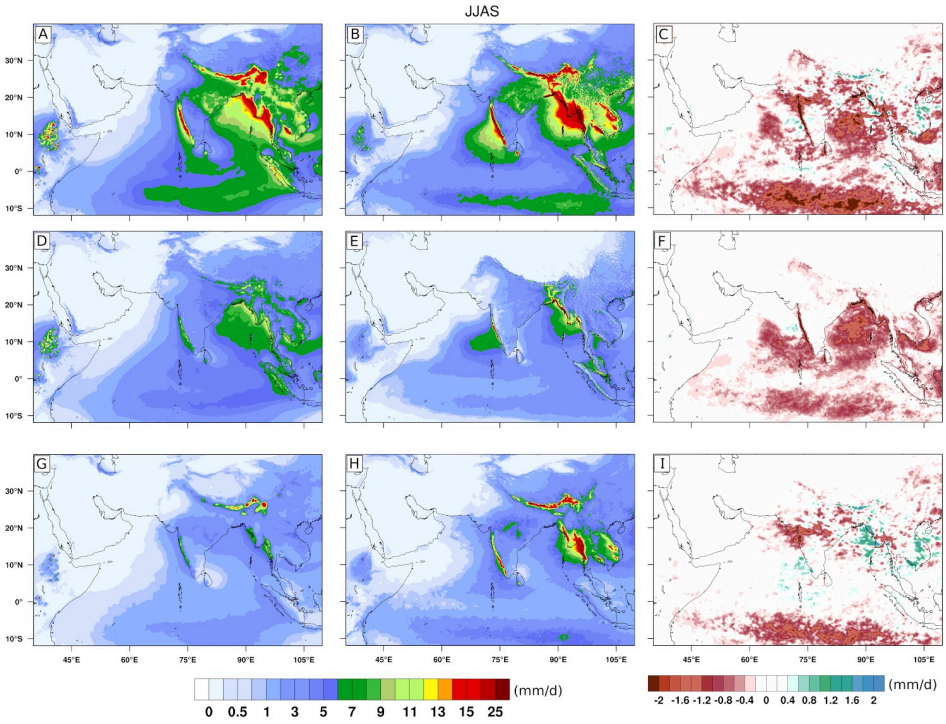

Fig. 3. JJAS precipitation for ERA5 (left column), INDJ experiment (middle column), and the differences between INDB and INDJ (right column) for total precipitation (upper panels); convective precipitation (middle panels), and large-scale precipitation (lower panels).

References

Sein, D. V., Dvornikov, A. Y., Martyanov S. D., Cabos, W., Ryabchenko V. A., Kumar, P., Jacob, D. (2020) Impact of the marine biogeochemical variability and its feedback on simulated South Asia climate. Journal of Advances in Modeling Earth Systems (under review)