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Past, present, and future changes in marine biogeochemistry in the Arabian Sea

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The work presented here aims at a better understanding of the Asian Monsoon system including the marine biogeochemistry in the Arabian Sea. Changes in the past as recorded in marine sediments, as simulated over the past 1000 years, and under forcing by anthropogenic CO_2 emissions by numerical model simulations are investigated. The investigation is based on three columns: a sediment core taken in the Arabian Sea (core SO130-275KL taken off Pakistan), a pre-industrial model run from 850 - 1850 with the Max Planck Institute's Earth System Model (MPI-ESM) including the marine and terrestrial carbon cycle and forced by solar variations and volcanic eruptions, and a continuation of this simulation to 2005 under the historical anthropogenic CO_2 forcing which allows a comparison with present day climatology.

In a first step we compare model results for a set of biogeochemical tracers within the water column and the sediment mixed with observations in the Arabian Sea. We further analyse correlations between Monsoon forcing (represented by zonal wind speed at 850 hPA, short wave radiation, Indian summer precipitation) and biogeochemical parameters, with particular focus on denitrification rates and fluxes to the sediment. This analysis is focused on three regions: off Somalia and off Oman for the summer monsoon, and the central Arabian Sea for the winter monsoon. For the summer monsoon, the highest correlation is found between zonal wind speed and calcite flux to the sediment off Somalia, for the winter monsoon the correlation is highest for short wave radiation in the central Arabian Sea. Time series of mixed layer depth and integrated primary production within the upper 100 m of the ocean from a CMIP5 historical experiment (1850-2005) show, at the location of the sediment core SO130-275KL, little correlation during the summer monsoon, but good correlation during the winter monsoon. As a result, the sediment core is more likely to document winter monsoon conditions.

Moreover, the model simulates denitrification in the oxygen minimum zones of the Indian Ocean as expected. More interesting, when comparing pre-industrial, present, and future states, it is shown that dentrification shows bipolar anomalies in the present state with a positive anomaly in the eastern Arabian Sea, and a negative anomaly in the western Arabian Sea. For 2100, when the model is forced by the RCP8.5 scenario, anomalies of denitrification are negative in the entire Arabian Sea.