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Air-sea CO2, O2 and N2O fluxes in the Namibian Upwelling System: a modelling approach

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Uncertainties exist in our understanding of the biogeochemical cycles of nitrogen and carbon, two key cycles for climate regulation via both greenhouse gases N2O and CO2. The role of the Benguela Upwelling System as a nitrogen source for the open ocean, via the turbulent instabilities and filament structures enriched in chlorophyll, is still to be investigated. The loss of nitrogen by denitrification and/or anammox with CO2, N2O and H2S gas emissions can also occur in this very productive zone in which dissolved oxygen concentrations may get very low.

A 3D coupled hydrodynamical (ROMS) and biogeochemical (BioBUS) model which takes into account these important processes is used in the Namibian Upwelling System, forced by climatological forcing. Air-sea gas fluxes are estimated based on Wanninkhof (1992)'s relationship for air-sea gas transfer velocity and QuickSCAT wind field. A significant evasion flux of CO2 out of the ocean occurs all year round, in the upwelling region between 20°S and 26°S with a marked spatial heterogeneity. The period of strong upwelling can induce outgoing CO2 fluxes up to 8.7 molCO2 m-2 yr-1 along the coast, while during the weak upwelling period the CO2 flux to the atmosphere remains close to 4.4 molCO2 m-2 yr-1. The whole studied domain represents a net annual source of CO2 for the atmosphere (3.5 molCO2 m-2 yr-1). Modelled oxygen concentrations vary between 4.5 ml.l-1 and 6 ml.l-1 over a year in Walvis Bay (23°S – 14°E) at the surface, and between 1.5 ml.l-1 and 3 ml.l-1 at 100 m depth. These estimations are in agreement with observations at the Walvis Bay station (23°S – 14°E). An important air-sea O2 flux to the ocean (up to 80 molO2.m-2.yr-1) is observed close to the coast as compared to offshore values ($\sim$1 molO2.m-2.yr-1). Due to denitrification on the continental shelf, the Walvis Bay area can potentially be a net source of N2O for the atmosphere. N2O concentrations are estimated from oxygen using different parameterisations. Our results show that the Walvis Bay area represents a net source of N2O for the atmosphere.