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Contrasting sea-air CO_2 exchanges in the western Tropical Atlantic Ocean

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The western Tropical Atlantic Ocean is a biogeochemically complex region due to the structure of the surface current system and the large freshwater input from the Amazon River coupled with the dynamics of precipitation. Such features make it difficult to understand the dynamics of the carbon cycle, leading to contrasting estimates in sea-air CO_2 exchanges in this region. Here we demonstrate that these contrasting estimates occur because the western Tropical Atlantic Ocean can be split in three distinct regions regarding the sea-air CO_2 exchanges. The region under the North Brazil Current domain, acting as a weak annual CO_2 source to the atmosphere, with low interannual variability. The region under the North Equatorial Current influence, acting as an annual CO_2 sink zone, with great temporal variability. The third region is under the Amazon River plume influence, and has greater interannual variability of CO_2 exchanges, but it always acts as an ocean CO_2 net sink. Despite this large spatial variability, the entire region acts as a net annual CO_2 sink of -1.6 ± 1.0 mmol m^{-2} day^{-1}. Importantly, the Amazon River plume waters drive 87% of the CO_2 uptake in the western Tropical Atlantic Ocean. In addition, we found a significant increase trend in sea surface CO_2 partial pressure in North Brazil Current and North Equatorial Current waters. Such trends are greater than the increase in atmospheric CO_2 partial pressure, revealing the sensitivity of carbon dynamics in these regions against a global climate change scenario. Since several studies have put efforts to elucidate the snapshots sea-air CO_2 exchanges, we have expanded our knowledge about their spatial and temporal dynamics. Our findings shed a comprehensive light on the risk of extrapolation in estimating sea-air CO_2 exchanges from regional snapshots. Hence, in addition to pointing out questions that still need to be answered on the CO_2-carbonate system our study may be useful for the sampling design of future studies in this region. This should significantly improve the performance of complex coupled ocean-biogeochemical models to provide more robust information about the natural behaviour and changes that the western Tropical Atlantic Ocean is experiencing.