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Water mass analysis of effect of climate change on air-sea CO_2 fluxes. The Southern Ocean.

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The impact of climate change on the air-sea CO_2 exchange has been proven to be strongly regional dependent, but the exact mechanisms are still poorly constrained. Here, we propose to explicit the role of the ocean dynamics on the air-sea CO_2 fluxes into a water mass framework. As a case study, we choose the Southern Ocean because its circulation redistributes water mass contents (heat, salt, dissolved carbon) from one basin to another thus playing a major role in the climate system. In a water mass framework, we investigate how increasing atmospheric CO_2 and resulting climate change affect both air-sea CO_2 fluxes and outcrop surface areas of water masses. Using a global model of marine biogeochemistry embedded in a climate model, we perform two 140-year transient CMIP5 simulations, in which only atmospheric CO_2 or both atmospheric CO_2 and climate change affect the ocean carbon cycle. We find that air-sea CO_2 flux patterns are organized along with density gradients at preindustrial state and display specific water mass responses to atmospheric CO_2 and climate change. Experiments reveal that these sensitivities rely on the water mass intrinsic geochemical and climate sensitivities (sensitivity to atmospheric CO_2 and climate change, respectively). The water mass intrinsic geochemical sensitivity depends on its buffering ability. Under changing climate, stratification induces a southward shift of the density gradient resulting in propagation of the lighter water masses. This change of the water mass patterns favor both the CO_2 uptake and the negative climate sensitivity of lighter water masses to the detriment of the others resulting in a weakening of the Southern Ocean CO_2 sink.