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Contemporary stratification constrains future anthropogenic carbon and excess heat uptake in the northern limb of the Southern Ocean

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The Southern Ocean is a major sink of anthropogenic carbon and excess heat. The Earth system model projections of these sinks provided by the CMIP5 and CMIP6 scenario experiments show a large model spread contributing to the large uncertainties in climate sensitivity and remaining carbon budgets for ambitious climate targets. A recent study identified an emergent coupling between anthropogenic carbon and excess heat uptake, highlighting that the passive-tracer behavior of these two quantities is dominant under high-emission scenarios. This coupling indicates that the use of a single observational constraint might be sufficient to reduce projection uncertainties in both anthropogenic carbon and excess heat uptake. In the northern limb of the Southern Ocean (30°S-55°S) where the subduction of intermediate and mode water is known to drive carbon and heat uptake, we find that the variations in model´s contemporary water-column stability over the first 2000 m is highly correlated to both its future anthropogenic carbon uptake and excess heat uptake efficiency. Using observational data, we reduce the uncertainty of future estimates of (1) the cumulative anthropogenic carbon uptake by up to 53% and (2) the excess heat uptake efficiency by 28%. Our results show that improving the representation of water-column stratification in Earth system models should be prioritized to improve future anthropogenic climate change projections.