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Assessing Potential Atmospheric CO2 Monitoring Sites for Improved Estimation of Southern Ocean CO2 Uptake

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The Southern Ocean plays a fundamental role in in the global carbon cycle and is estimated to absorb ~40% of anthropogenic carbon-dioxide (CO_2) emissions. Recent studies have highlighted the potentially large decadal variability of this uptake, and the uncertainties associated with estimates derived from different ocean carbon measurement technologies. The majority of these estimates of Southern Ocean CO_2 uptake are commonly derived from 'bottom-up' analyses of oceanic carbon measurements. An independent means of estimating air-sea CO_2 fluxes is provided by 'top-down' analyses, which employ inverse methods or data assimilation techniques combining atmospheric CO_2 measurements with numerical transport model analyses. Robust regional flux estimates from such top-down methods require an atmospheric observational network with sufficient spatial coverage. At present, however, long-term measurements of atmospheric CO_2 are only available at a limited number of sites in the Southern Ocean region. Given this sparse atmospheric sampling there is an urgent need for expansion of the current Southern Ocean atmospheric CO_2 measurement network.

The British Antarctic Survey has identified a number of locations (including the sub-Antarctic and South Atlantic Islands of Tristan da Cunha, South Georgia and the Falklands) where new systems for long-term observations of CO_2 could be established. In this analysis we present results from a set of Observing System Sampling Experiments (OSSEs) using the GEOS-Chem atmospheric transport model, in combination with the Local Ensemble Transform Kalman Filter method (Chen et al. 2021) to identify the effectiveness of these locations towards providing improved constraints on Southern Ocean air-sea fluxes. Our assessment of potential sampling sites is derived from metrics quantifying the uncertainty reduction of regional oceanic CO_2 flux estimates.

References

Chen et al. (2021) Variability of North Atlantic CO_2 fluxes for the 2000–2017 period estimated from atmospheric inverse analyses. Biogeosciences, 18 (15). pp. 4549-4570. ISSN 1726-4189.