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Identifying the origins of the global carbon budget imbalance using oxygen

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Despite major advances in the estimation of all fluxes in the global cycles of carbon and oxygen, mathematical imbalances continue to arise when these fluxes are combined. Between 1997 and 2022, the global budget imbalances (BIM) for CO₂ and O₂ budgets – a quantification of the missing sources and/or sinks of CO₂ and O₂ – are -18 Tmol/yr and 41 Tmol/yr, respectively. The CO₂ BIM has tended to become increasingly negative over the last decade, while the O₂ BIM has tended to become increasingly positive. To identify the origins of the BIMs, we carried out a systematic analysis of the combination and permutation of all available individual flux estimates provided by a sub-set of contributors to the Global Carbon Budget 2023 update. We first examine the possibility that inaccuracies in the ocean air-sea fluxes contributes to the CO₂ and O₂ BIM. We show that the interannual variability of the air-sea O₂ flux required for a reduction of the O₂ BIM tends to be close to that simulated by several ocean models. An in-depth analysis of the Southern Ocean has confirmed their ability to simulate reasonable interannual variability in the air-sea fluxes of O₂ and CO₂. We conclude that in order to simultaneously reduce the negative trend in CO₂ BIM and the positive trend in O₂ BIM in the recent decade, a reduction in the increasing trend in the terrestrial CO₂ sink over the last decade is most likely required.