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Was Australia a sink or source of carbon dioxide in 2015? Data assimilation using OCO-2 satellite data

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Estimates of the net CO₂ flux at a continental scale are essential to building up confidence in the global carbon budget. In this study, we present the assimilation of the satellite data from the Orbiting Carbon Observatory-2 (OCO-2) (land nadir and glint data) to estimate the Australian CO₂ surface fluxes for 2015. We used the Community Multiscale Air Quality (CMAQ) model and a four-dimensional variational scheme. Our preliminary results suggest that Australia was a slight carbon sink during 2015 of -0.15 ± 0.11 PgC y⁻¹ compared to the prior estimate of 0.13 ± 0.55 PgC y⁻¹. The monthly seasonal cycle shows there was not a good agreement between the prior and posterior fluxes in 2015. Our monthly posterior estimates suggest that from May to August, Australia was a sink of CO₂ and that from October to December, it was a source of CO₂ compared to the prior estimates, which showed an opposite sign. To understand these results more deeply, we aggregated the CO₂ surface fluxes into six categories using Land Cover Type Product the Moderate Resolution Imaging Spectroradiometer (MODIS) and divided them into two areas (north and south). Our posterior fluxes aggregated in the southern and northern Australia indicates that most of the uptake of CO₂ is driven by grasses and cereal crops. Grasses and cereal crops in these two regions represent -0.11 ± 0.027 and -0.06 ± 0.05 PgC/y respectively. In the southern region, the monthly time series of this category shows that this uptake occurs mainly from June to September, whereas in the north, it occurs from January to March. We evaluate our posterior CO₂ concentration against The Total Carbon Column Observing Network (TCCON) and in-situ measurements. We use the TCCON stations from Darwin, Wollongong, and Lauder (in New Zealand). Amongst the in-situ measurements, we considered stations located at Gunn Point (near Darwin), Cape Grim (in Tasmania) and Iron Bark and Burncluith (in Queensland). Analysis of the monthly biases indicates that CO₂ concentration simulated by posterior fluxes are in better agreement with TCCON data compared to in-situ measurements. In general, monthly mean biases in TCCON Darwin are improved by almost 70 per cent. Lauder and Wollongong stations are strongly affected by ocean fluxes which have small prior uncertainty in this inversion. Biases are hence not much improved here. We verify this by relating bias to wind direction. If the winds come from the ocean, fluxes over Australia are less constrained by OCO-2 data. Biases against in situ data are generally not improved by assimilation, suggesting either problems with the transport model or an inability for OCO-2 data to constrain fluxes at scales relevant to these measurements.