

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2022-15

Anonymous Referee #2

Referee comment on "Interannual variability in the Australian carbon cycle over 2015–2019, based on assimilation of Orbiting Carbon Observatory-2 (OCO-2) satellite data" by Yohanna Villalobos et al., Atmos. Chem. Phys. Discuss.,
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Villalobos et al. (2022) describes a regional inversion for Australia over the period from 2015 to 2019, expanding on work presented in Villalobos et al. 2020 and 2021. The inversion assimilates measurements from the OCO-2. The CMAQ atmospheric transport model was used to simulate transport and dispersion, driven by meteorological data from the WRF model. The CABLE model was used to provide estimates of biospheric terrestrial fluxes, forced with Australian regional drivers and observations from the BIOS3 set-up. Prior fossil fuel emissions were obtained from ODAIC, with missing sectors taken from EDGAR product, and diurnal factor from Nasser (2013). Ocean fluxes were obtained from the CAMS global model (Chevallier 2019), fire fluxes from GFED version 4.1. CAMS was also used to provide information on initial and boundary conditions.

Validation was carried out by comparing posterior concentrations to those measured at TCCON sites and ground-based in-situ measurements. Fluxes were compared to those from nine other atmospheric inversions and their ensemble.

To understand the association between bio-climatic factors and CO₂ fluxes, rainfall was obtained from Australian Water Availability Project (AWAP), Bureau of Meteorology (BOM) and temperature from ERA5 ECMWF atmospheric reanalyses. EVI was used as a proxy for vegetation greenness and activity. Fluxes between the posterior fluxes and bio-climatic factors were assessed. Some evidence supported the hypothesis that the Australian savanna ecosystem during 2015/2016 period following higher than average rainfall was a carbon sink on average. But there is still a large amount of uncertainty in these estimates as the validation of the posterior fluxes against the available modelled biogenic fluxes and posterior concentrations compared with situ measurements did not improve greatly compared with the prior flux and concentration estimates.

I would support the publication of this paper, but suggest some additional discussion be

added to the manuscript so that the reader can better understand why the comparison of modelled concentrations with in situ measurements is poor, and what would be required in order to obtain the validation of the inversion results for terrestrial Australia, which would then allow for more robust conclusions to be drawn regarding the source and sink status of biomes in Australia using the posterior fluxes from OCO-2 inversions.

Main Comments:

The objective of the paper was to assess the interannual variability in CO₂ fluxes in relation to bio-climatic factors. This is often the objective of many papers based on eddy-covariance site measurements, where fluxes are directly measured. There is an absence in the paper in discussion around how findings from eddy-covariance measurements taken during this period compares with fluxes estimated from OCO-2 inversion and other inversions, where fluxes are indirectly obtained. The paper would also be improved if some discussion were included on what is known about interannual variability of CO₂ fluxes in other savanna ecosystems in response to bio-climatic factors. E.g. Williams et al. (2008), Archibald et al. (2009), and Merbold et al. (2011).

As already discussed by the first reviewer, it would be helpful to understand how the boundary conditions contributed to the posterior solution, and what sort of magnitude of correction was made to these concentrations by the inversion. Another issue that is discussed by the authors is that during this period, Australia experienced some of the worst wild fires on record. Was there any special treatment applied to the OCO-2 measurements to filter out periods when the transport model would like have performed very poorly, such as during these fires?

As shown in the results, for several of the biomes and periods the inversion did not improve on the prior concentrations, and in fact made the agreement between the in situ measurements and modelled concentrations worse. The authors discuss the challenge of validating the posterior estimates from the inversion, given that many of the in-situ sites were coastal sites where OCO-2 retrievals were not obtained. Given that it may be a large challenge to obtain reliable retrievals of OCO-2 fluxes over the ocean, what suggestions do the authors have to improve validation over continental Australia?

Minor Comments:

Line 574: "constraint" should be "constrained"

Line 637: Duplication of "In summary"

References

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