Australia is already a net zero CO_2-e emitter – thanks to our forests and rangelands

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Many people and world governments believe rising greenhouse gas (GHG - mainly carbon dioxide - CO_2) levels in the atmosphere pose an unacceptable risk of 'dangerous' global warming/climate change. Accordingly, most nations (including Australia) have committed to lowering CO_2-e (equivalent) emissions within their jurisdictions to 'net zero' by 2050, or thereabouts. In fact a report on the ABC's News Web site (3 May 2022) claims that Tasmania has already achieved that objective – by a 'significant drop in native forest logging'.

In this essay I suggest that there is emerging strong, published evidence that - under the current enunciated position of the Australian Department of Industry , Science, Energy & Resources (DISER) - this country has most likely reached the goal of 'net zero CO_2 emissions' **already**. And it would require little additional effort, if any, to maintain this achievement to 2050 and beyond. Consider:

- Australia's Climate Council states that "Net zero emissions refers to achieving an overall balance between GHG emissions produced (added to) and GHG emissions taken out of (withdrawn from) the atmosphere". Analogously, France (host of the Paris Agreement - PA) will utilise sinks from its Land Use, Land Use Change & Forestry (LULUC&F) sector, as well as Carbon Capture and Storage, to balance emissions generated by those fossil fuels for which there are no alternative feedstocks. (See: https://unfccc.int/sites/default/files/resource/en_SNBC-2_summary_compl.pdf p.2; Fig.1 p.3). Australia and several other countries have also specifically nominated land based sinks in their Nationally Determined Contributions.
- In December 2020 Australia's DISER noted that *"for the Paris Agreement all net emissions from all lands (in Australia) will be accounted for – without restriction - using the independent monitoring systems of the national inventory.* (So) *through the national inventory there is complete coverage of the land sector in the Government's target acquittal".* [Emphases added]. See: DISER #588, p.13, 1st para. By way of contrast, for the Kyoto Protocol only about 1% of Australia's land mass was actually taken into account in determining net emissions from the LULUC&F sector (DISER #588, p.12, last para).
- It is impractical to carry out continental scale sampling of net CO_2-e emissions using ground based methodologies or computer models (e.g. FullCAM). Especially given the absence of appropriate means to validate the accuracy and precision of modelling outputs over such a huge area – combined with the complexity of the soils, vegetation, supported organisms, variable weather patterns and superimposed management. These factors all impact carbon fluxes and the utility of bottom-up biosphere models.
- The only possible way to sample these net emissions over the whole continent (769 m ha - inclusive of all our rangelands), with acceptable accuracy and precision, is via spectral sensors positioned on satellite platforms (e.g. GOSAT, OCO-2, TanSAT).
- In fact high spatial resolution CO_2 flux inversion systems are needed to support the global stocktake required by the PA and to complement the bottom-up emission inventories (https://doi.org/10.3390/rs13152996).
- Spectral sensors positioned on satellite platforms provide accurate data on the column averaged dry air mole fraction of CO_2 (XCO_2) measured from the top of the atmosphere to the earth's surface. The huge number of observations obtained integrate all sources and sinks (including many not recognised – e.g. deep drainage, run-off, erosion, respiration, litter decay, decomposers/termite activity) which contribute to the balance of the air column above the land beneath. They provide the robustness, spatial coverage and sampling intensity/frequency, as well as the accuracy and precision necessary to determine the Australia wide change in CO_2 content in natural systems. They also make it possible to estimate the distribution and magnitude of CO_2 in regions that have sparse *in situ* surface atmospheric monitoring (https://doi.org/10.5194/acp-21-6663-2021). Meanwhile, additional advances and rapid improvements in these remote sensing technologies can also be anticipated (https://doi.org/10.3390/rs13152996).

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- Published data in leading scientific journals (Table 1) for four different studies and three different satellite platforms (see above) together cover sampling 'years' from 2011 to 2017-18. These sampling periods include strong La Niña and El Niño episodes. The natural (managed land) CO_2 flux (withdrawal from the atmosphere above the Australian land mass over all retrieval platforms and sampling years, n=6) averaged c. 701 Mt CO_2-e per year. This average land sink is approximately 157 % of total human sourced emissions (≈ 446 Mt CO_2-e per year) released into the atmosphere over the 'years' sampled. [By way of contrast, the equivalent managed land sink in mainland USA (766 M ha) only corresponds to c.12 % of that nation's fossil fuel emissions].

Table 1. Natural CO_2 flux (withdrawal from the atmosphere above the Australian land mass) – expressed in common units (Mt CO_2-e/year) and based on retrievals from three different satellite platforms, combined with inversion procedures [See reference links for methods and attributed uncertainty estimates].

Reference	GOSAT	OCO-2	TanSat	Retrieval Year
Detmers et al. 2015	770	-	-	2010-11
Wang et al. 2019	958	806	-	2015
Chevallier et al. 2019	-	697	-	2017
Yang et al. 2021	-	205*	770	2017-18

GRAND MEAN (over all retrieval platforms and sampling years, n=6) ≈ 701 Mt CO_2-e /year

*This published value is included in the GM calculation, but appears to be an outlier, possibly related to the misapplication of the mass ratio between CO_2 and C (cf. Detmers et al. 2015 – as corrected 23 Jan 2017)

It has been suggested that any flux recorded in these lands cannot be included in our National Greenhouse Gas Inventory and PA accounts because this huge landscape is not identified or congruent with Intergovernmental Panel on Climate Change (IPCC) guidelines. This is not in accord with Ogle *et al.* (2018 - https://doi.org/10.1186/s13021-018-0095-3). These authors clearly show how the 'managed land' concept has now replaced (become a proxy for) the anthropogenic definitions associated with the Kyoto Protocol (First Commitment Period accounting). Hence:

"All governments using guidance from the IPCC are implicitly using the managed land proxy, and many of these governments may consider their entire territory as managed land". For example, for what is considered to be 'managed' and 'unmanaged' land in the USA see **Fig.4** in the previous Link. Note the title (read carefully) of this Ogle *et al.* 2018 paper is: 'Delineating managed land for reporting national greenhouse gas emissions and removals to the United Nations Framework Convention on Climate Change'. A final extract especially relevant to Australia follows:

"Among the nations providing information about application of the managed land proxy to subdivide forest land, grassland and wetlands into managed and unmanaged land, several have classified managed land simply by considering some land uses as managed and others as unmanaged. For example, Australia and Belarus consider all forest land, grasslands and wetlands as managed, while land in the 'other land' category (e.g., rock outcrops, glaciers, barren areas) is considered unmanaged". [Note: The UN Framework Convention on Climate Change/IPCC definition of a 'forest' is in effect inclusive of all vegetation classified as forest, woodland and medium/tall shrub-land in the Australian context].

Conclusion

To understand why Australia has seemingly achieved net zero CO_2 emissions (in terms of the PA) already, the following key points are relevant:

i. In future we will be accounting for all net emissions from all lands in the LULUC&F sector – without restriction - (as earlier noted only about 1% of the nation's land mass was included in accounts for the Kyoto Protocol).
ii. The only practical way to accurately sample all net emissions at a continental scale (769 M ha) is via inversions, based on satellite retrievals of the column averaged dry air mole fraction of CO_2 measured from

the top of the atmosphere to the land surface. The fact that we are an island continent adds to the integrity of the values reported (cf. European countries, for example, where a nation's air mass can change daily).

iii. Inversion studies suggest we are currently a net sink of around 255 Mt CO_2 per year – after averaging annualised results (including La Niña and El Niño 'years'), and deducting fossil fuel/cement generated emissions, for each respective year, from the total. All things being equal it is likely that net sinks of this order will be maintained through 2050 and beyond – as our woody vegetation continues to respond ('thicken up' *in situ*), and also through extending its range by invading many natural "remnant" grasslands.

These additional carbon sink responses in Australia's landscape reflect the vegetation's adaptation to lower fire frequencies as a result of changed management. For example, the introduction of domestic livestock has led to reductions in the regular/frequent burning regimes of previous millennia. The latter were instigated under now displaced (pre-European) indigenous management. This vegetation switch has been further promoted by tree clearing bans imposed in many jurisdictions, increased concentrations of CO_2 in the atmosphere, and the widespread availability of 4WD vehicles and efficient fire-fighting equipment since WWII. So in our land 'of droughts and flooding rains' even mega droughts are not constraining this long term woody plant (carbon sink) thickening/expansion.

iv. Australia is the 6th largest nation in area in the world (and in the main has a land mass covered by CO_2 absorbing perennial vegetation), yet it has far fewer people living in it than live in a single world 'maxi' city (e.g. Tokyo). Yearly fossil fuel emissions from anthropogenic sources in this country, either in terms of CO_2 or CO_2-e are thus more than offset by the ongoing capacity of our LULUC&F sector (≡ "all lands" – see 2nd dot point above) to absorb them.

v. Thus our nation, not just Tasmania, is a net zero CO_2-e emitter today – largely thanks to carbon sinks in our forest and rangeland communities. Rural landholders would be doing themselves and the Australian people a great service by publicising this fact at every opportunity.

Notes for rural landholders:

When CO_2 sinks are determined via information retrieved from satellites the individual landholder does not know his/her contribution to the total land sink that is being captured. The satellite information is validated/calibrated against ground station records. Confidence in the satellite inversion results would no doubt be further improved if more Total Carbon Column Observing Network (TCCON) ground calibration stations were distributed over Australia – they are presently located at Darwin and Wollongong - See: essd-11-935-2019.pdf. Australia's Terrestrial Ecosystem Research Network (TERN) has c.25 eddy covariance flux towers (many established in grazing lands with MLA support, *inter alia*). It may be possible to utilise such site data as additional calibration locations?

Importantly, where satellite based measurements are spatially filtered to include only data recorded near TCCON surface calibration sites (30+ located worldwide, including those in Australia) the resultant fluxes are found to converge to those based on surface measurements alone. A single OCO-2 footprint covers c.290 ha (c. 2,650,000 potential sampling points for the Australian land mass) with a 16-days revisit cycle. Spatial filtering of geo-referenced "agricultural (cropping/grazing) land" might also be targeted by individuals or government agencies e.g. if required for auditing (of CEAs/ACCUs and to avoid double counting sinks in national PA accounts). However, as a general principle no managed land should be excluded ('cherry picked') from any PA accounting to determine continental **Australia's** net CO_2 flux – accuracy and consistency of methodology across all jurisdictions (worldwide) demands it!

[All Web links included in this article were accessible on 6 May 2022]

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