Land Carbon Modeling for the Global Carbon Budget
Friedlingstein et al. (2025), "Global Carbon Budget 2024", Earth System Science Data
(https://doi.org/10.5194/essd-17-965-2025)

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Science Question

- How can we accurately (and annually) assess the global carbon cycle and anthropogenic CO2 emissions in support of climate policies?
- In particular, how can we quantify global and national land-use emissions and the land sink?

Analysis

- Land-Use Harmonization 2 dataset (LUH2) – a global dataset of historical and future land-use change and management that has contributed annually-updated land-use forcing data to GCB for 10 years. Uses Landsat data on forest area change and Landsat-based products to inform land-use changes in regions of importance for the carbon budget.
- EDv3.0 model – an ecosystem demography model included for the second time in the GCB as one of 20 DGVMs used to compute land carbon sinks and emissions. ED followed TRENDY protocol and passed all criteria of model inclusion. Uses GEDI and ICESat-2 data. Includes all gross transitions of LUH2)

Results

- Net land use emissions (E_{LUC}) (1.0 Gt C/yr in 2023) have a statistically significant decrease of about 0.2 GtC per decade, but are still too high to be offset by current levels of reforestation and afforestation.
- The net land sink (S_{LAND} - E_{LUC}) in 2023 was 1.1 GtC /yr, which is the lowest estimate since 2015. This reduced sink is primarily driven by a response of tropical land ecosystems to the onset of the 2023–2024 El Niño event, combined with large wildfires in Canada in 2023.

Significance

- Although developed for use in global-scale climate models, the LUH2 dataset is becoming more relevant for national-scale reporting for carbon budgets
- ED simulations demonstrate capability for global-scale land carbon modeling and potential for incorporating GEDI and ICESat-2 observations to improve future GCB estimates.

Acknowledgements
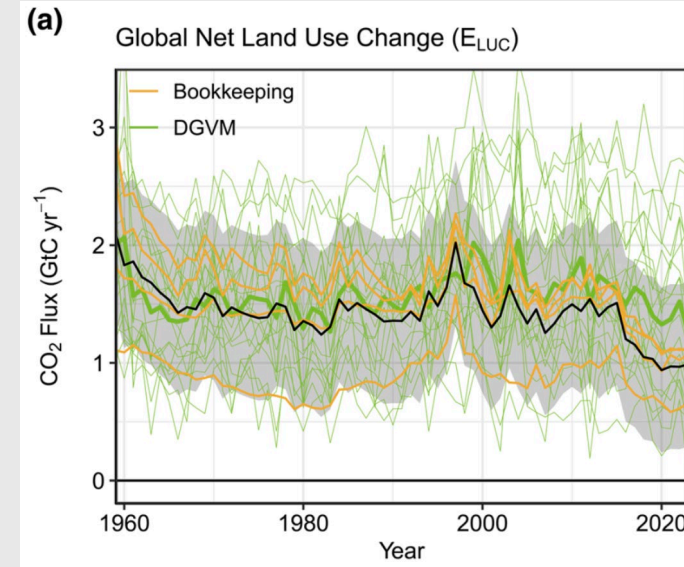
Figure (a)

Net global CO2 emissions from land-use change, via book-keeping models (yellow), budget estimate (black) and DGVMs (green).

Figure (d)

The Land sink (SLAND) estimated by DGVMs including ED.