GLOBAL CARBON BUDGET



Carbon Budgets: On the role of ecosystems

Adam Schlosser – special thanks to David Kicklighter

XLIV MIT GLOBAL CHANGE FORUM GLOBAL NET ZERO EMISSIONS GOALS: CHALLENGES AND OPPORTUNITIES MARCH 23-24, 2022 MIT SAMBERG CONFERENCE CENTER, CAMBRIDGE, MA Changes in surface temperature





- Still warming... as warm as it was <u>125,000 years ago.</u>
- Warming rate acceleated over past few decades
- Warming eginning to follow the classic "COWL" (cooler ocean warmer land) pattern.



Carbon Dioxide concentrations and growth rates highest in millions of years

FAQ 5.4: What are Carbon Budgets?

The term carbon budget is used in several ways. Most often the term refers to the total net amount of carbon dioxide (CO_2) that can still be emitted by human activities while limiting global warming to a specified level.





Effect of a one year pulse of present-day emissions on global surface temperature

Carbon Dioxide strongest anticipated long-term actor in human-forced change



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Trends of the net land CO_2 sink and related vegetation observations during 1980–2019

- Land has been a consistent sink for CO₂ over the past few decades.
- Recent downward trend in the strength of the global land sink.
- Signs of weaking in (simulated) gross primary production





Interannual variation in detrended anomalies of the net land CO₂ sink and land surface air temperature:1980–2019

 Strong relation to ENSO and temperature anomalies



Friedlingstein et al. (2020) and



- In response to increasing CO₂ land dominates NH & ocean dominates SH in terms of uptake.
- Response to climate warming strong land response in tropics for CO₂ release. Weaker release response seen across oceans at high latitudes.
- In weakest mitigation scenarios (higher CO₂ concentrations) the reduced sink fraction of land and ocean systems is salient.





Change in carbon from 2015 to 2100 under SSP scenarios

- In response to increasing CO₂ land dominates NH & ocean dominates SH in terms of uptake.
- Across IPCC scenarios widespread uptake across high latitude NH lands and SH ocean.





Potential influence of climate-induced vegetation shifts on future land use and associated land carbon fluxes in Northern Eurasia

- Climate-induced vegetation shifts permit expansion of areas devoted to cellulosic biofuel production (25%) and pastures (21%)
- Reduce the expansion of areas devoted to food crop production by 10%.
- In both climate scenarios, vegetation shifts further reduce the areas devoted to timber production by 6–8% over this same time period.
- Fire associated with climate-induced vegetation shifts causes the region to become more of a carbon source than if no vegetation shifts occur.



Boulton et al., Nature Climate Change (2022)

Indications of weakened Amazon rainforest resilience since early 2000s

- Boulton et al. (2022) study focused on remotely sensed data on monthly "vegetation optical depth" (VOD).
- Study finds that lag-1 autocorrelation is strengthening – thus, a weaker rebound and less "resilience".
- Is the preponderance of weaker rebound found in "damaging" VOD events?
- Nevertheless continued Amazon deforestation, combined with a warming climate, raises the probability that this ecosystem will cross a tipping point into a dry state in the 21st century (IPCC AR6)



Climate tipping elements: What are they and how worried should we be?



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