Biogenic carbon emissions and climate impact dynamics

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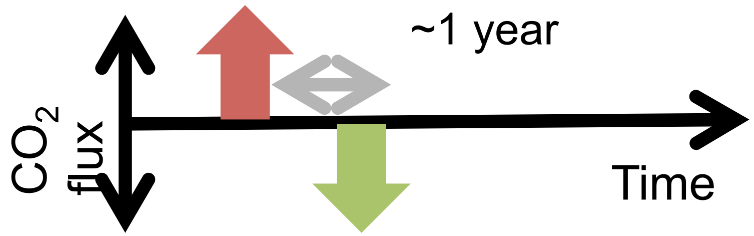
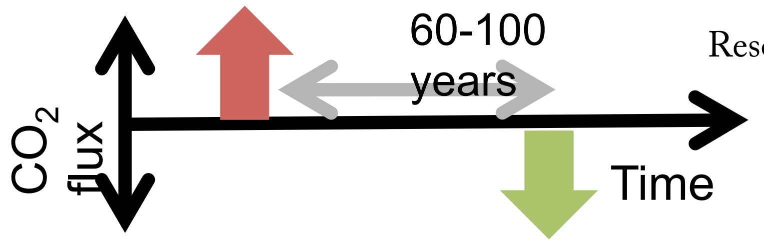
Carbon neutrality and climate neutrality



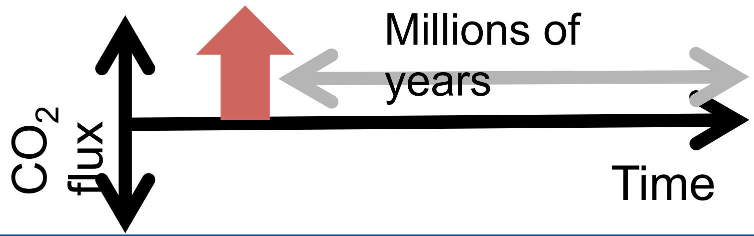
Sugar Cane
Resource turnover time <1yr

Carbon Neutral: Yes
Climate Neutral: Yes



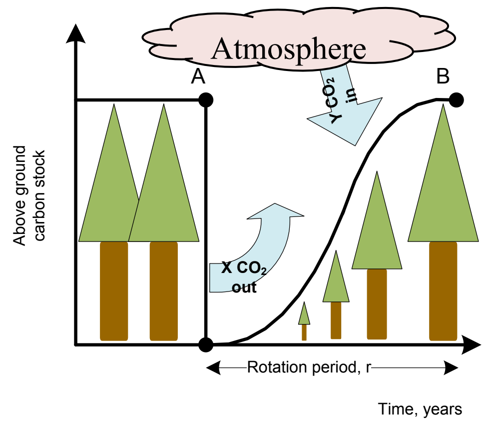
Forests,
Resource turnover time = 60-100 yrs

Carbon Neutral: Yes
Climate Neutral: ???



Fossil fuels

Carbon Neutral: No
Climate Neutral: No



"…there is a time lag between combustion and regrowth, and while the CO_2 is resident in the atmosphere it leads to an additional forcing"

Myhre et al., 2013: Anthropogenic and Natural Radiative Forcing, IPCC 5th Assessment Report Chapter 8

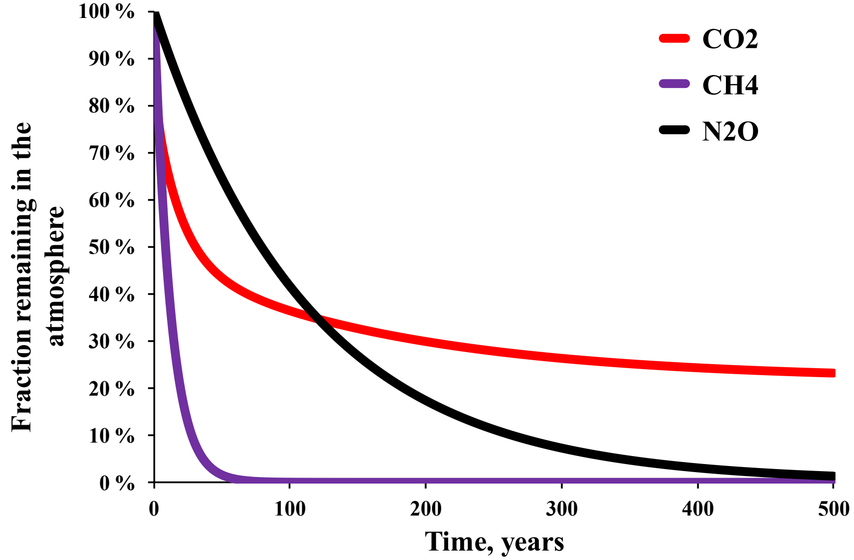
GHGs in LCA

1. The amount of emissions are listed in LCI (e.g., g of CH_4 per functional unit)

2. Each emission is characterized with the corresponding GWP and then summed together as CO_2-equivalents

3. N.B. Removal processes that decrease the concentration of the gas (e.g., CO_2 absorption by the oceans) are not reported in LCI but are embedded in the GWP

	GWP	
	TH = 20	TH = 100
CO_2	1.00	1.00
CH_4	84	28
N_2O	264	265



GLOBAL CHANGE BIOLOGY BIOENERGY
GCB Bioenergy (2011), doi: 10.1111/j.1757-1707.2011.01102.x

CO_2 emissions from biomass combustion for bioenergy: atmospheric decay and contribution to global warming

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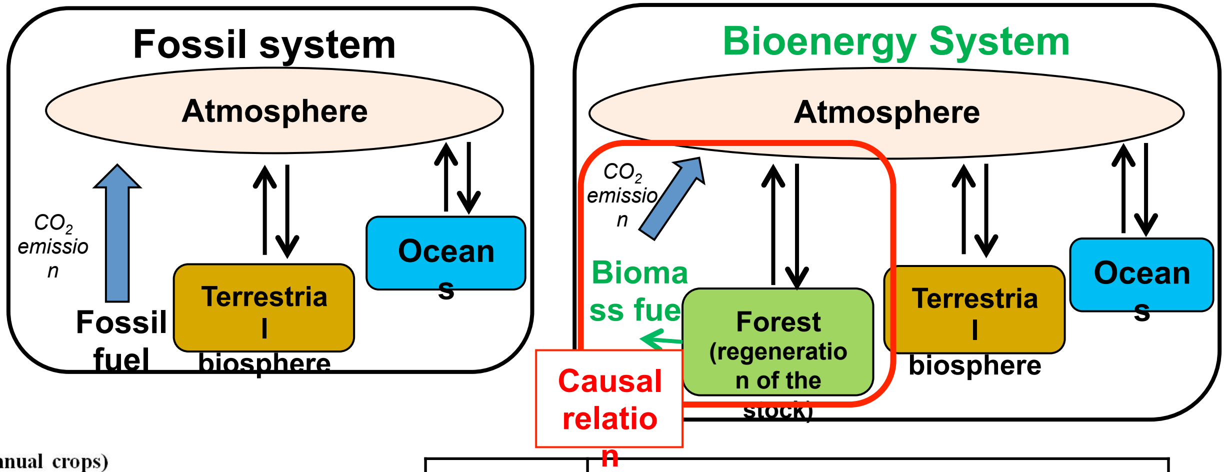
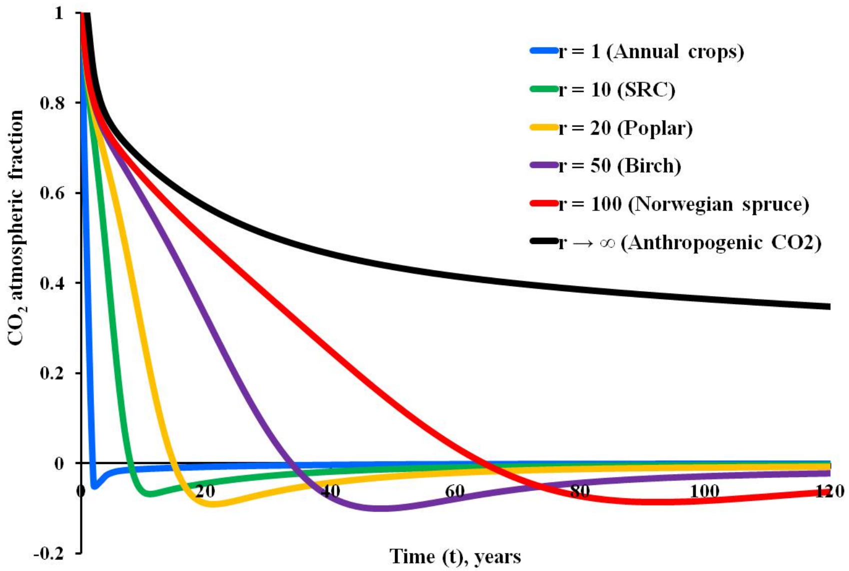
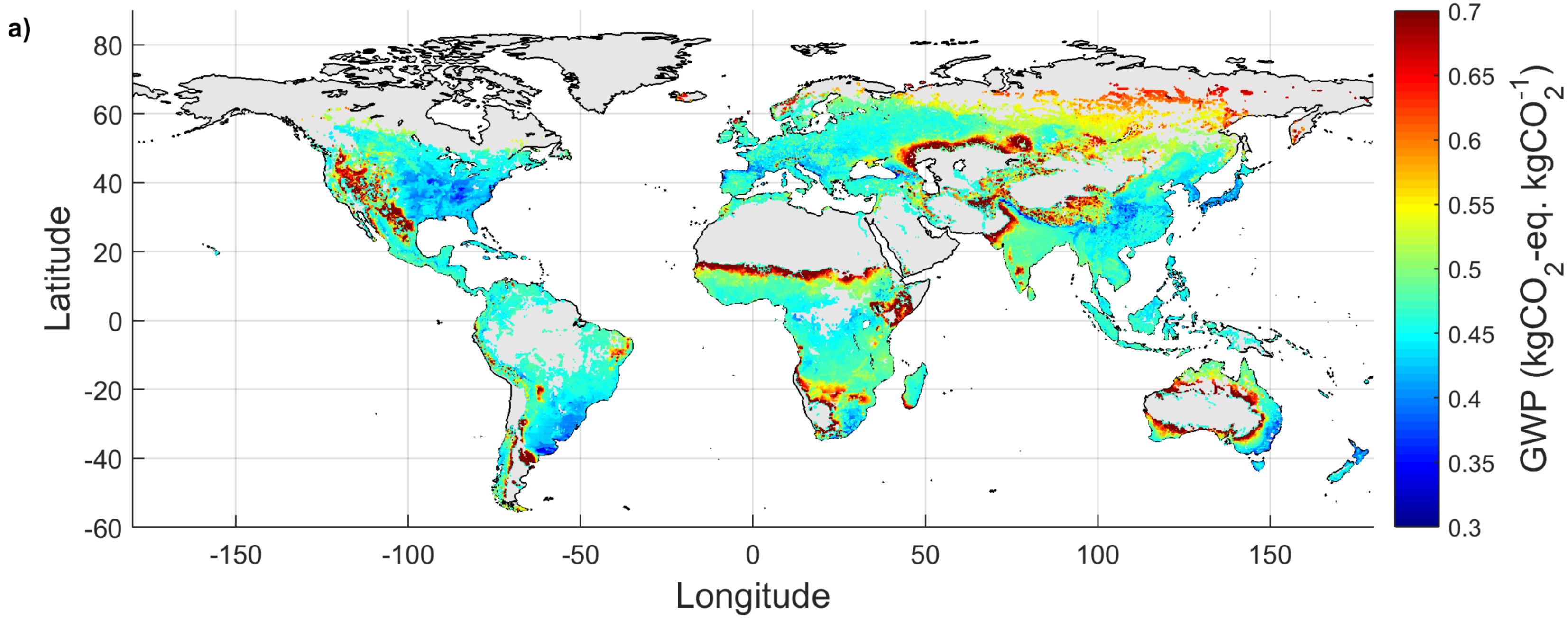




Rotation (years)	GWP TH = 20	GWP TH = 100	GWP TH = 500
1	0.02	0.00	0.00
10	0.22	0.04	0.01
20	0.47	0.08	0.02
40	0.80	0.16	0.03
50	0.87	0.21	0.04
60	0.90	0.25	0.05
80	0.94	0.34	0.06
90	0.95	0.39	0.07
100	0.96	0.43	0.08

GWP100 for CO_2 emissions from (secondary) forest bioenergy at 0.25° resolution



Global average: 0.49 ± 0.03 $kgCO_2$-eq./$kgCO_2$ (mean ± σ)

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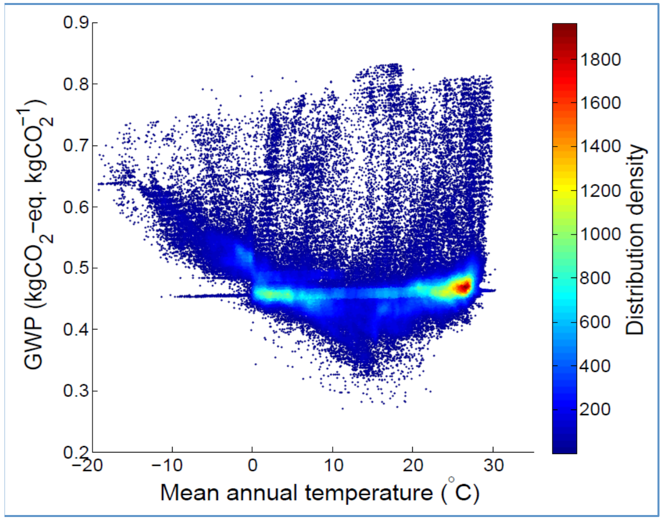
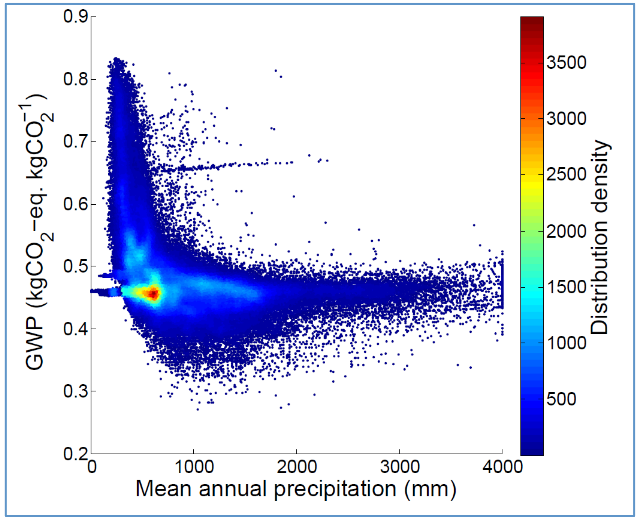
GWP100 aggregated at national level

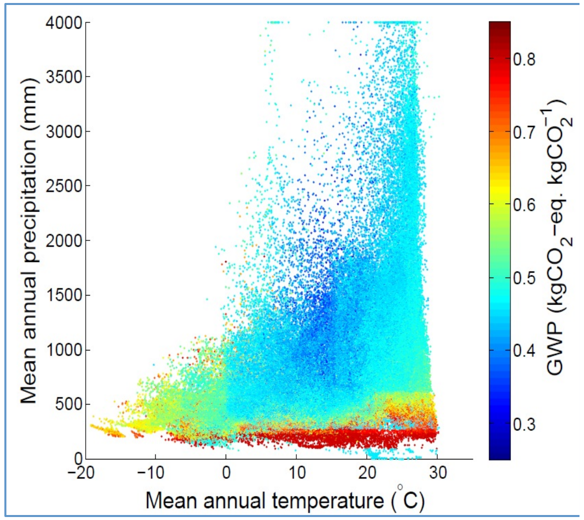
		GWP 100					
		50% Forest residue extracted				All res.	No res.
COUNTRY	Grids	Mean	σ	5th %ile	95th %ile	Mean	Mean
Afghanistan	854	0.54	0.11	0.37	0.78	0.46	0.72
Albania	42	0.43	0.02	0.36	0.46	0.36	0.56
Algeria	342	0.47	0.03	0.42	0.78	0.40	0.61
Andorra	1	0.46	0.00	0.46	0.46	0.39	0.59
Angola	1521	0.48	0.05	0.39	0.78	0.39	0.65
Argentina	4020	0.49	0.10	0.33	0.83	0.41	0.64
Armenia	46	0.45	0.05	0.37	0.64	0.39	0.59
Australia	7151	0.53	0.11	0.31	0.83	0.44	0.72
Austria	151	0.46	0.07	0.40	0.75	0.40	0.59
Azerbaijan	105	0.47	0.06	0.36	0.66	0.40	0.61
Bahamas	3	0.44	0.00	0.44	0.45	0.37	0.58
Bangladesh	185	0.47	0.01	0.45	0.50	0.38	0.65
Belarus	431	0.45	0.01	0.43	0.47	0.39	0.56
Belgium	53	0.45	0.02	0.42	0.49	0.38	0.57
…							

Cherubini F., M. Huijbregts, G. Kindermann, R. Van Zelm, M. Van Der Velde, K. Stadler, A.H. Strømman, Global spatially explicit CO_2 emission metrics for forest bioenergy, Under Review

GWP100 sensitivity to local climate conditions







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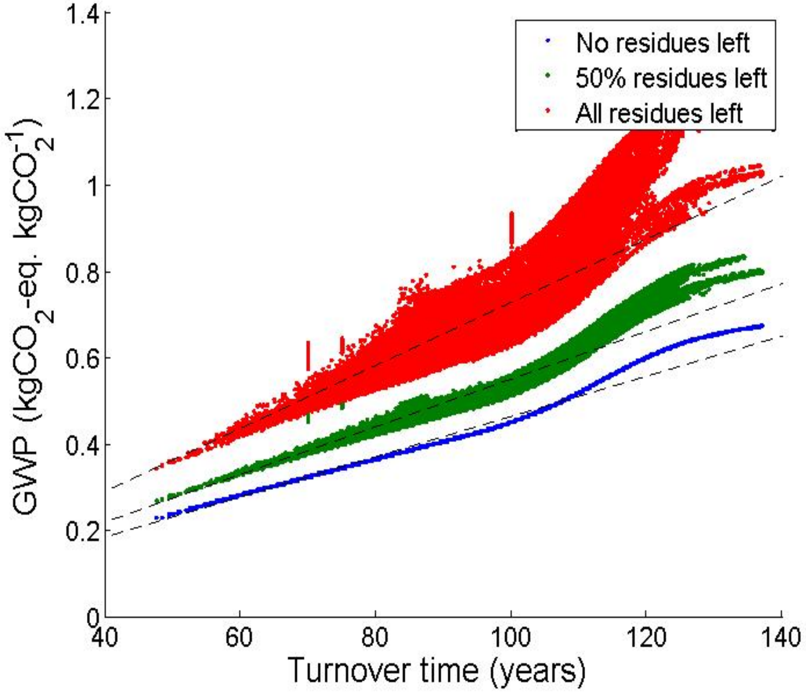
GWP100 sensitivity to rotation period (R) of the forest plantation and to residue extraction rates



	0% Residue extraction rate	50% Residue extraction rate	100% Residue extraction rate
Equation	GWP = 0.0073·R	GWP = 0.0055·R	GWP = 0.0046·R
R^2	0.738	0.835	0.863
RMSE	0.0073	0.030	0.022

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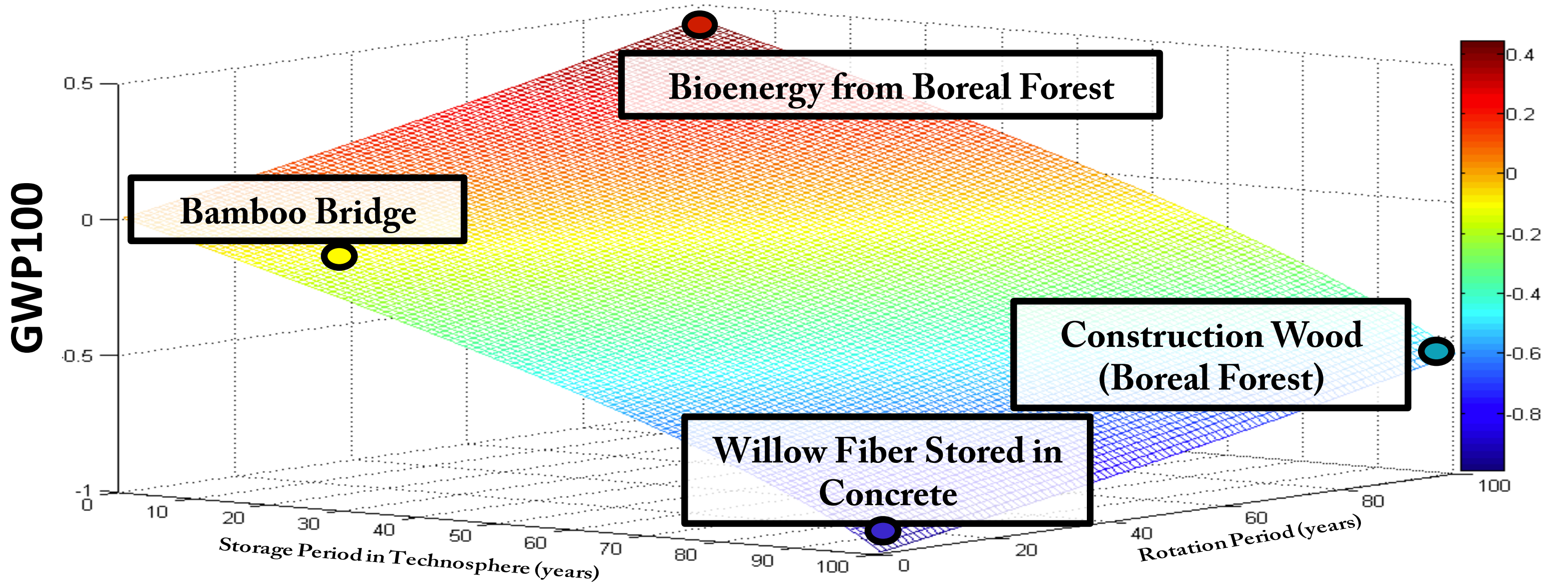
F.A.Q. 1: What about biomass stored in products before the release of C to the atmosphere?

Guest, G., et al. (2013). "Global Warming Potential of Carbon Dioxide Emissions from Biomass Stored in the Anthroposphere and Used for Bioenergy at End of Life." Journal of Industrial Ecology 17(1): 20-30.

GWP100 as a function of storage time and rotation period



GWP ≈ 0 if storage period is about half of the rotation period

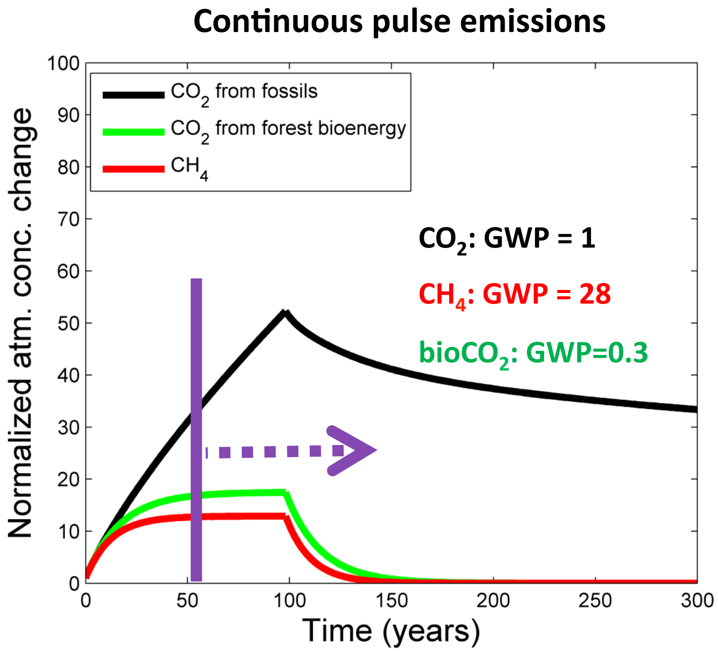
F.A.Q. 2: Is bioenergy climate neutral (GWP=0) if we assume that CO_2 emissions are offset by sequestration in other stands?

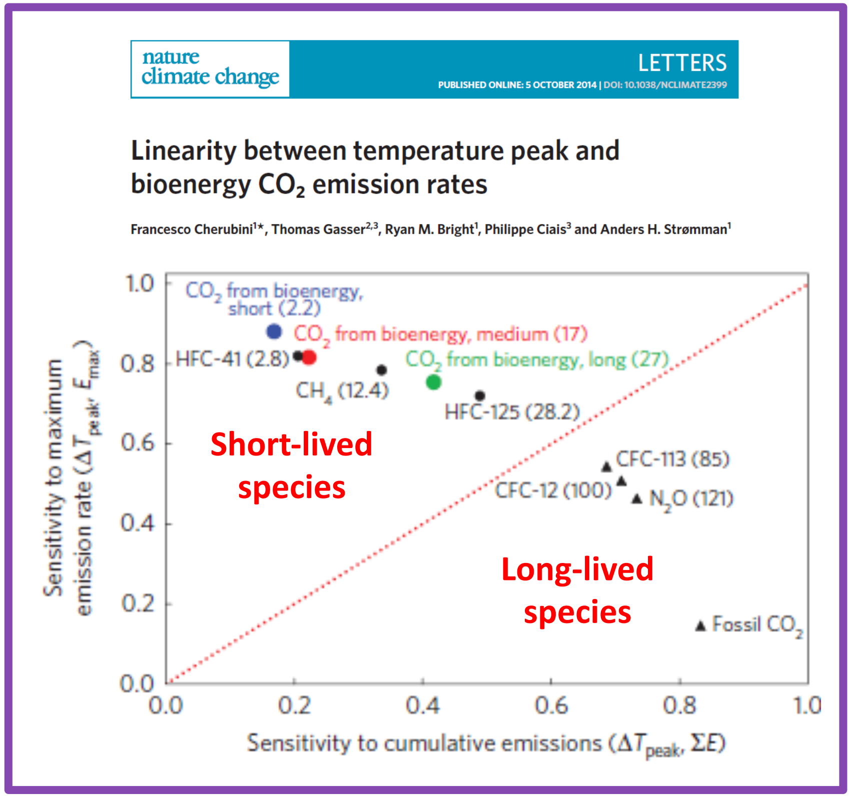
Argument (landscape approach): CO_2 emitted from wood harvested in stand A is offset by the sequestration going on in the other stands

1. Conceptual contradictions with LCA:
   - Inconsistent definition of system boundaries
   - CO_2 emissions from the same feedstocks would have different climate impacts depending on where the emissions occur
   - A reduction in CO_2 sequestration corresponds to an emission
   - One can easily argue that the same principle is valid for fossil CO_2

2. A technical contradiction with LCA…

F.A.Q. 2: Is bioenergy climate neutral (GWP=0) if we assume that CO_2 emissions are offset by sequestration in other stands?





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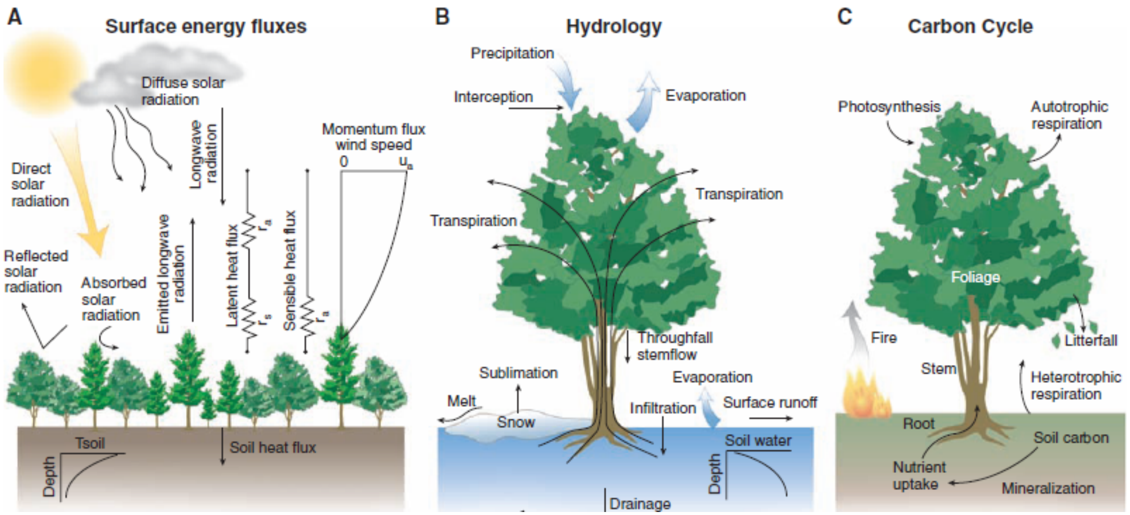
F.A.Q. 3: Are changes in climate change drivers other than C important?



Bonan, G. B. (2008). "Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests." Science 320(5882): 1444-1449.

"Ignoring biophysical interactions could result in millions of dollars being invested in some mitigation projects that provide little climate benefit or, worse, are counter-productive"

Jackson, R. B., et al. (2008). "Protecting climate with forests." Environmental Research Letters 3(4): 044006.