How do biophysical climate effects of deforestation influence tropical vegetation carbon loss ?

Yue Li[1], James T. Randerson[1]

and the BGC Team

1 Department of Earth System Science, University of California, Irvine

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yue.li@uci.edu
@YueLi_LA

Research summary

Objective:

- Deforestation leads to a direct tropical forest biomass loss.
- Regional biophysical climate effects of deforestation may contribute to additional vegetation carbon losses
- Here we quantify the extra carbon loss from the biophysical changes across different tropical continents

Approach:

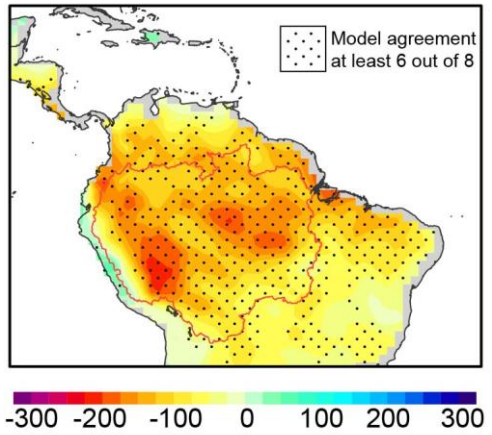
- We quantified rainfall and temperature change from deforestation using data from the LUMIP experiments (Lawrence et al., 2016)

- We converted the biophysical changes to carbon using the temperature and rainfall relationships that describe the spatial pattern of tropical aboveground vegetation carbon

$$Biomass = a * MAP + b * MAT + \varepsilon$$

	a*100	b	R^2	γ_{MAP}	γ_{MAT}
ESA CCI (Obs)	6.6	-0.58	0.47	8.1% $(100\ mm)^{-1}$	-0.7% ^oC
CMIP6 mean	4.6	-0.19	0.71	7.5% $(100\ mm)^{-1}$	-0.3% ^oC

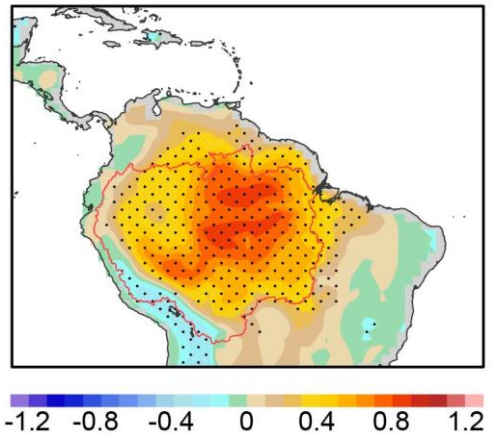
A



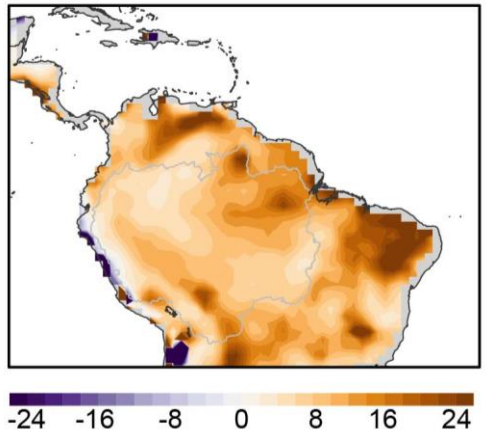
Biophysical effects of deforestation on:

A Rainfall (MAP, mm yr^{-1})
B Temperature (MAT, ^oC)
C Vegetation carbon (%)

B



C



Results:

- Amplification of the deforestation losses by means of biophysical feedbacks varied by continent
- Carbon losses from the biophysical response contributed to an additional 18% biomass loss in the Amazon, 11% in the Congo and 1% in tropical Asia.

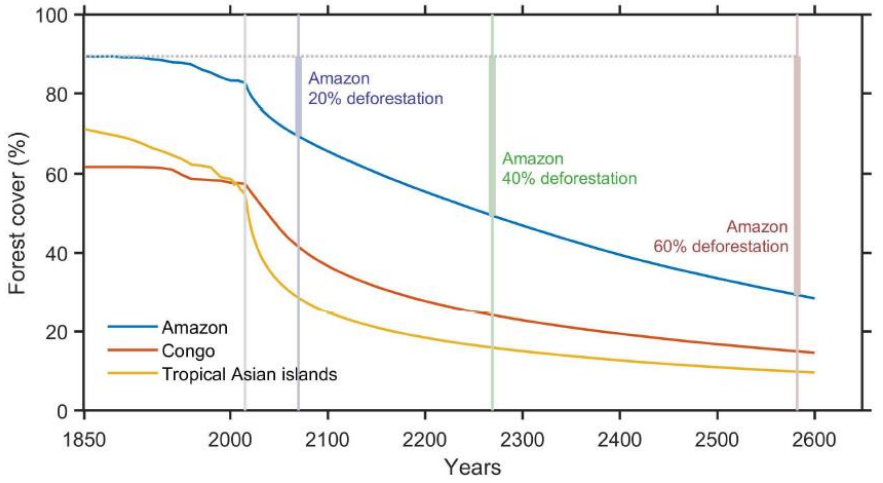
Future research

Objective:

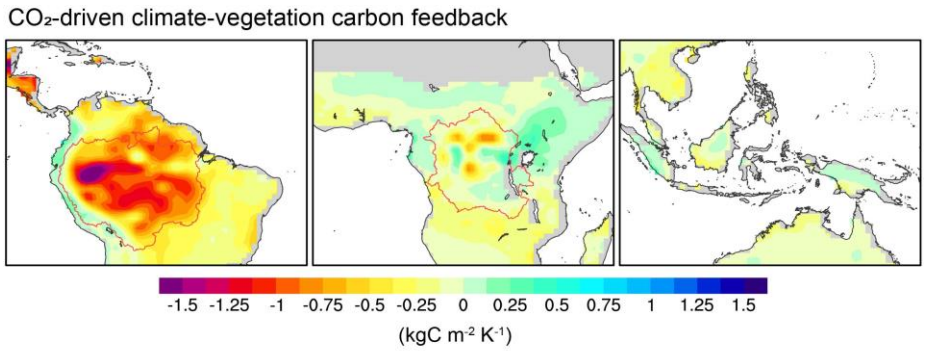
- Explore deforestation interactions with plant physiological responses to increasing CO_2

Approach:

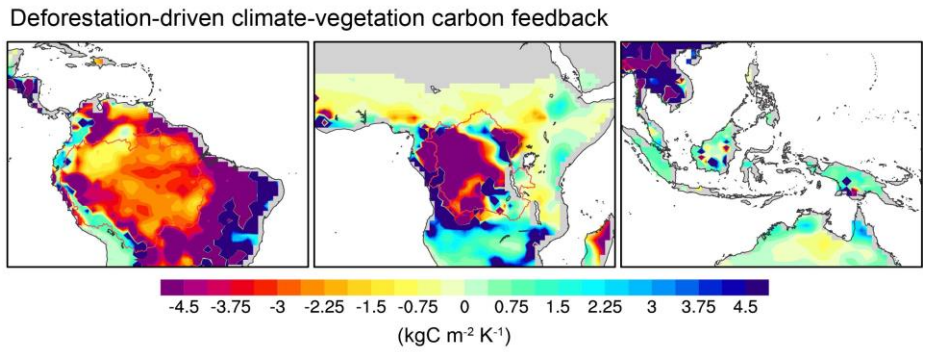
- Simulate the deforestation scenario in the tropics using a cellular automata model
- Perform transient simulations by adding deforestation into the C4MIP 1%COU, 1%BGC simulations



Simulated transient tropical deforestation scenario



γ from 1%COU & 1% BGC



γ from LUMIP-based biophysical climate × Observation-based sensitivity

Relation to white paper

Gaps in Current Research

Earth system feedback from vegetation cover change

Land-atmosphere interactions

- Evaluated the CESM simulated deposition in mineral aerosols in a coupling manner
  (Li Y, et al. Deforestation strengthen dust transport from North Africa to the Amazon, submitted to *Journal of Climate*)

- Quantified the deforestation-driven climate carbon feedback
  (Li Y, et al. Biophysical climate effects of deforestation accelerate tropical vegetation carbon loss, in prepare)

Short-term Research Goal

Investigate biophysical response to vegetation cover

Evaluate plant physiological and land surface responses to changing atmospheric CO2

- Evaluating the deforestation interaction with the plant physiological response to increasing CO_2

Long-term Research Goal

- More deep understanding on the land-atmosphere interaction processes (between vegetation and fire/aerosols/nutrients transport)