Carbon emissions and uptake from vegetation change in the tropics (CARBICS)

Nicolas Labrière, Jérôme Chave, Jean-Pierre Wigneron

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Of carbon …

⇒ Vegetation in the tropics is increasingly exposed to direct and indirect anthropogenic pressure
⇒ Fire is at the core of several disturbance processes

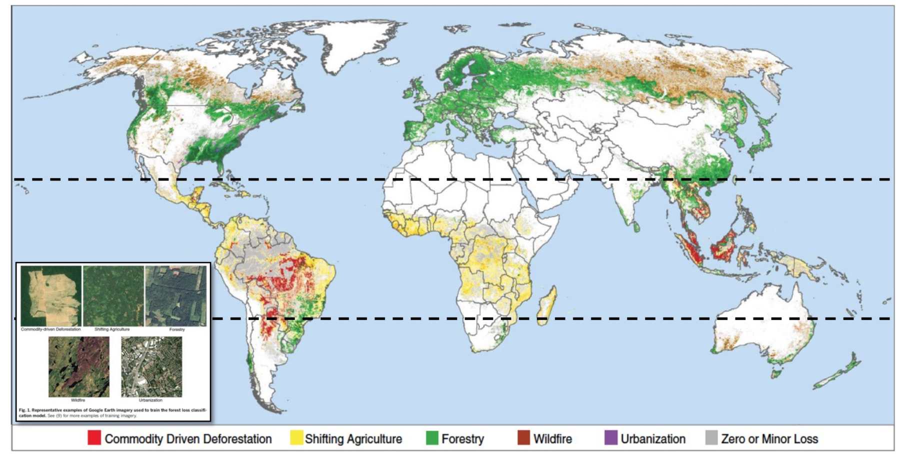

Fig. 2. Primary drivers of forest cover loss for the period 2001 to 2015. Darker color intensity indicates greater total quantity of forest cover loss.

… and water

⇒ Passive microwave systems such as SMOS have interesting capabilities for AGB retrieval
⇒ SMOS L-VOD is a strong candidate to study AGB dynamics

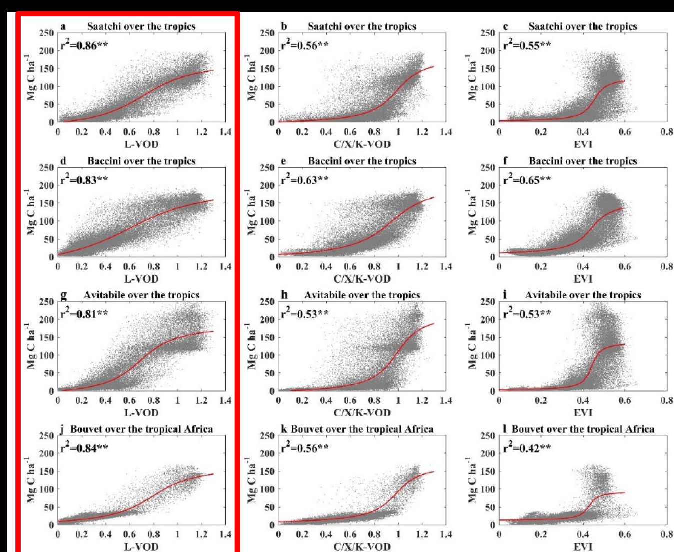

Fig. S5. Scatterplots between benchmark AGC density (Mg C ha^{-1}) maps and yearly

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Curtis *et al.* 2018 *Science* **361**, 1108–1111; Fan *et al.* 2019 *Nature Plants* **5**, 944–951

Objectives

(1) Decompose "observed" changes in aboveground C stocks across the tropics over the last decade into different processes to better apprehend their relative contributions over time and space

(2) Better identify the socio-ecological causes of those emissions and uptake, which could subsequently guide policy making

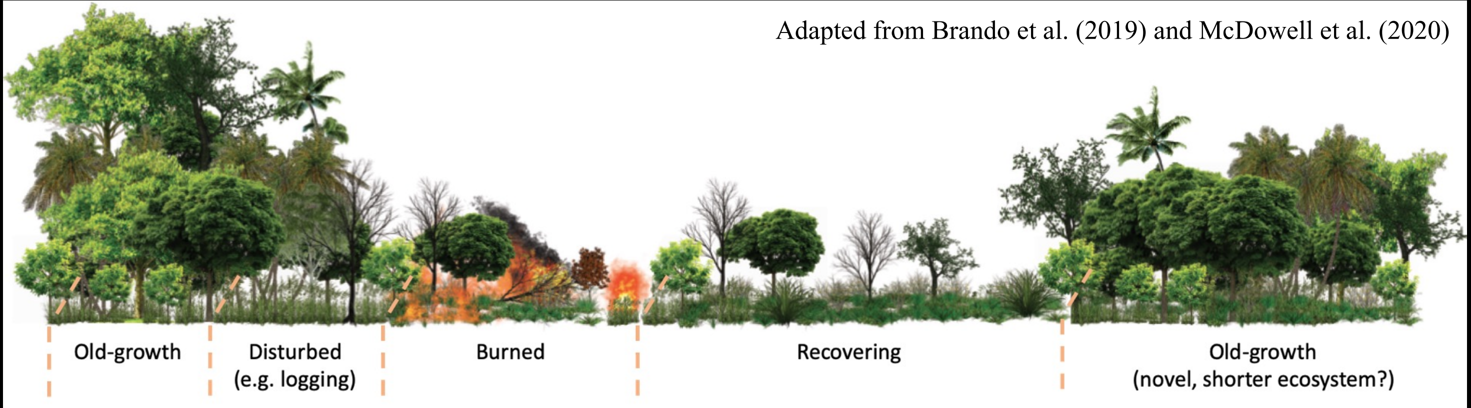
Research questions

(1) How did emissions from vegetation burning change in the tropics over the last decade?

(2) How do those emissions compare with non-fire mediated emissions from vegetation loss and degradation?

(3) How do carbon stocks recover after scarce *vs.* frequent fires?

(4) Are there differences in carbon uptake from vegetation recovering from fire *vs.* non-fire mediated disturbances?

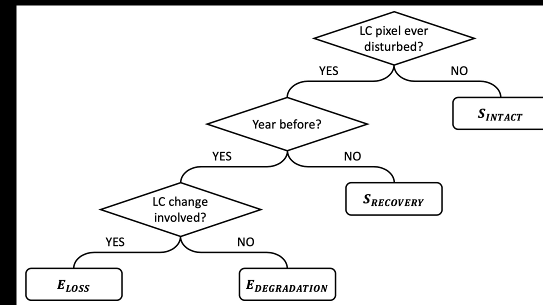


Brando *et al*. 2019 *Annual Review of Earth and Planetary Sciences* **47**, 555–581; McDowell et al. 2020 *Science* **364**, eaaz9463

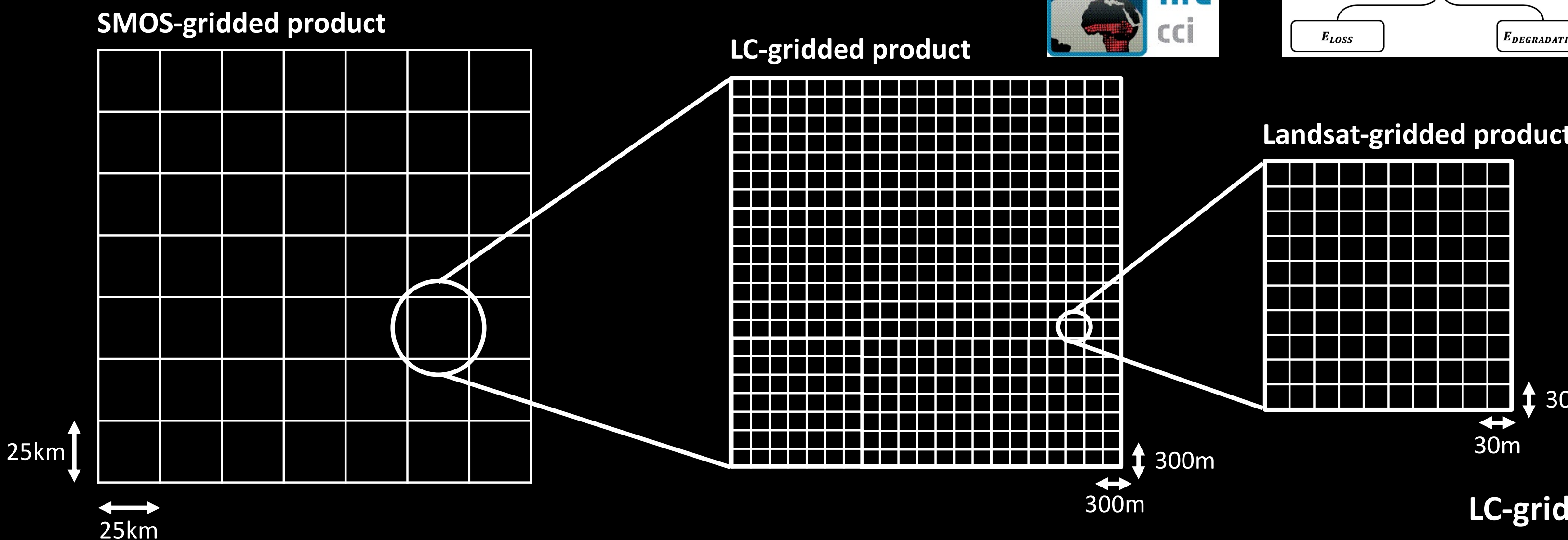
A "bookkeeping-like" approach

⇒ Locally-calibrated
⇒ Spatially explicit

biomass cci | land cover cci | fire cci



GLOBAL FOREST WATCH

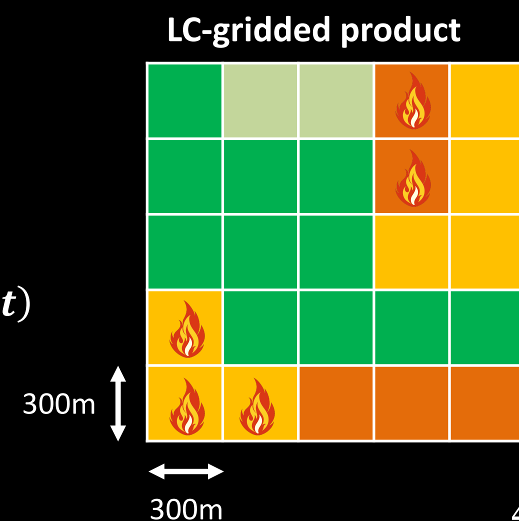


$$AGC(X,Y,t) = AGC(X,Y,t-1) + S_{INTACT}(X,Y,t) - E_{MANAGED}(X,Y,t)$$

$$\Delta AGC(X,Y,t) = S_{INTACT}(X,Y,t) - E_{MANAGED}(X,Y,t)$$

$$E_{MANAGED}(X,Y,t) = E_{LOSS}(X,Y,t) + E_{DEGRADATION}(X,Y,t) - S_{RECOVERY}(X,Y,t)$$

$$E_{LOSS}(X,Y,t) + E_{DEGRADATION}(X,Y,t) = E_{FIRE}(X,Y,t) + E_{NON-FIRE}(X,Y,t)$$



Houghton *et al.* 2012 *Biogeosciences* **9**, 5125–5142; Yue *et al.* 2020 *Nature Communications* **11,** 3170

Acknowledgements

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Thank you for your attention

$S_{RECOVERY}$

Following Chazdon et al. (2016), we will use recovery functions in the form of Michaelis-Menten equations to estimate the aboveground carbon density of LC pixel (x, y) as a function of its age since last disturbance:

$$\boldsymbol{AGCD_{RECOVERY}(x,y,t) = \frac{AGCD_{MAX} \times age(x,y,t)}{\tau + age(x,y,t)}},$$

with $AGCD_{MAX}$ corresponding to the mean AGCD (obtained from local lookup tables) for the “undisturbed” land cover closest to the LC pixel under consideration within SMOS pixel (X, Y), and τ the age needed to recover half of $AGCD_{MAX}$. Building on previous research, τ is set to 20 years (Chazdon et al., 2016; Poorter et al., 2016).

The carbon uptake from recovering vegetation within SMOS pixel (X, Y) for year t is the sum of uptakes from the q LC pixels (x, y) classified as “recovering”:

$$\boldsymbol{S_{RECOVERY}(X,Y,t) = \sum_{i=1}^{q} (AGCD_{RECOVERY}(x_i,y_i,t) - AGCD_{RECOVERY}(x_i,y_i,t-1)) \times \mathcal{A}_{RECOVERY}(x_i,y_i,t)},$$

with $\mathcal{A}_{RECOVERY}$ corresponding to the area of the LC pixel with recovering vegetation.

E_{LOSS}

$E_{LOSS}(X, Y, t)$, the carbon emissions resulting from land cover change within SMOS pixel (X, Y) for year t, will depend on the prior and subsequent land covers of LC pixels affected by land cover change between year $t-1$ and year t. Here, we will mobilize the "mean AGCD per land cover" lookup tables we have attached to each SMOS pixel (X, Y). Provided r LC pixels (x, y) experienced land cover change between year $t-1$ and year t, the local AGCD values per land cover will be used as follows to compute $E_{LOSS}(X, Y, t)$:

$$\boldsymbol{E_{LOSS}(X, Y, t) = \sum_{i=1}^{r} (AGCD_{LOSS}(x_i, y_i, t-1) - AGCD_{LOSS}(x_i, y_i, t)) \times \mathcal{A}_{LOSS}(x_i, y_i, t)},$$

with $\mathcal{A}_{LOSS}$ corresponding to the area of the LC pixel having experienced disturbance-related land cover change.

$E_{DEGRADATION}$

$E_{DEGRADATION}(X, Y, t)$, the carbon emissions resulting from degradation (here defined as disturbances that do not lead to land cover change) within SMOS pixel (X, Y) for year t, depends on the land cover of LC pixels affected by such disturbances and the relative extent of these disturbances. For each SMOS pixel (X, Y), we will build land cover-specific linear regressions to model $AGCD$ (obtained from biomass reference maps) as a function of percent tree cover (PTC) and percent non-tree vegetation (PNV), both retrieved from the MODIS MOD44B Vegetation Continuous Fields (VCF) yearly products available at 250m spatial resolution:

$$\boldsymbol{AGCD_{DEGRADATION}(x, y, t) = \alpha + \beta \times PTC(x, y, t) + \gamma \times PNV(x, y, t)}$$

We will therefore complement the lookup table attached to each SMOS pixel with values of inferred parameters α, β and γ per land cover. Provided s LC pixels (x, y) experienced degradation between year $t-1$ and year t within SMOS pixel (X, Y), $E_{DEGRADATION}(X, Y, t)$ will be computed as follows:

$$\boldsymbol{E_{DEGRADATION}(X, Y, t) = \sum_{i=1}^{s} \left(AGCD_{DEGRADATION}(x_i, y_i, t-1) - AGCD_{DEGRADATION}(x_i, y_i, t)\right) \times \mathcal{A}_{DEGRADATION}(x_i, y_i, t)},$$

with $\mathcal{A}_{DEGRADATION}$ corresponding to the area of the LC pixel having experienced degradation.