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Revealing the fate of tropical forests through Earth observation data

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Ecosystems Session

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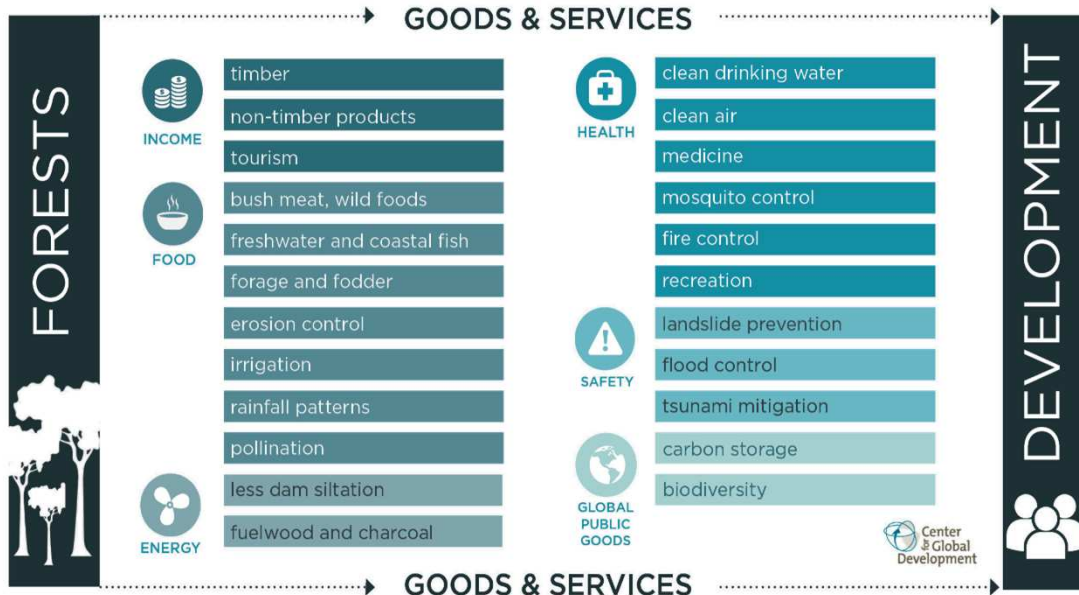
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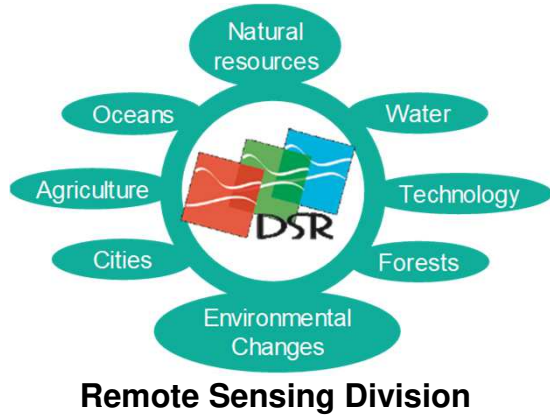
Why should we care about the fate of tropical forests?

- 1) We should identify ways to manage these systems aiming at maintaining ecoclimatic stability and social-economic development.
- 2) We should understand the complex role of these forests on the Earth system by measuring and modelling processes and feedbacks to assess their vulnerability and implications of perturbations for climate, ecosystems and humans.



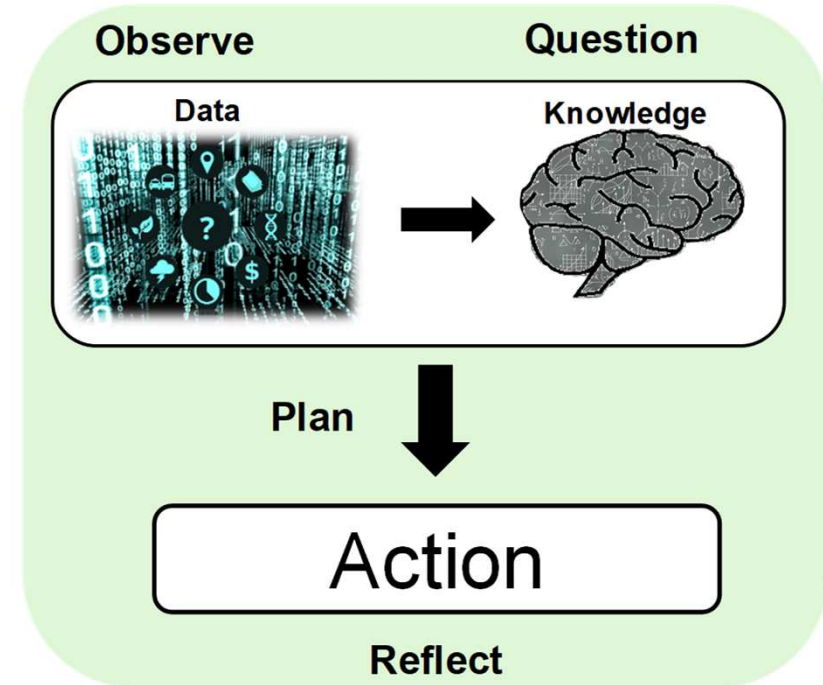


How do we tackle these two issues?



TREES Objectives:

To produce and share high-level knowledge and information from Earth Observation data for supporting policies towards tropical sustainable development.





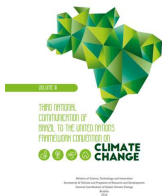
Who would benefit from our information?

UNFCCC: The Paris agreement 2015

Volunteer submission of the Brazilian Nationally Determined Contribution (NDC)

- Reducing by 43% (1.2 GtCO₂e in 2030) carbon emission below the 2005 reference level.

National GHG emission report



National REDD+ strategy



Sendai framework for disaster risk reduction (2015-2030)

Priorities for action

1. Understanding disaster risk
2. Strengthening disaster risk governance to manage disaster risk reduction

Targets

1. Reduce number of affected people
2. Reduce economic losses
3. Reduce damage to infrastructure

UNISDR strategy



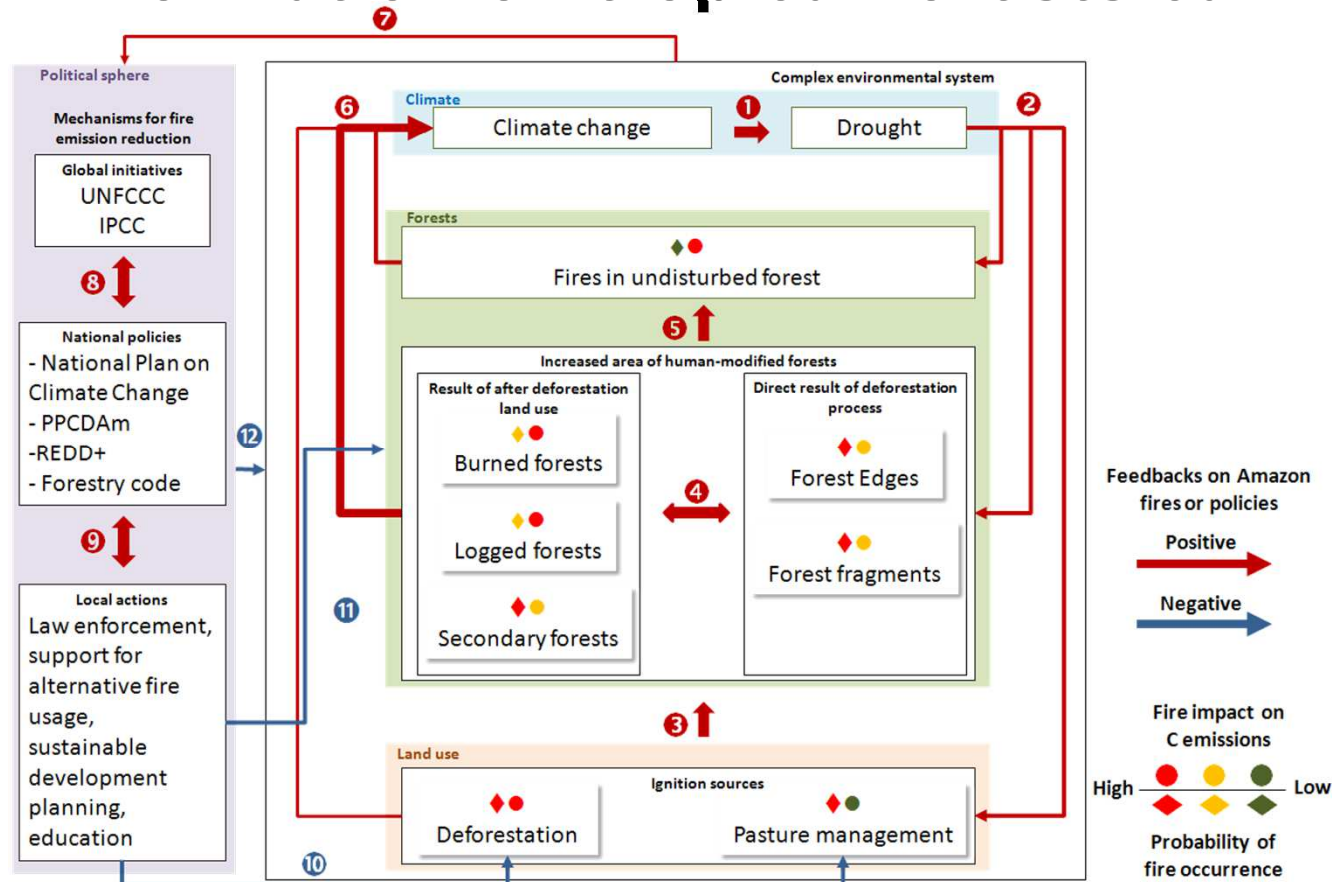
Sustainable development goals (2015-2030)



National Actions

1. National Policy on Climate Change (Law 12,187/2009)
2. Law on the Protection of Native Forests (Law 12,651/2012, Forest Code)
3. Law on the National System of Conservation Units (Law 9,985/2000)
4. REDD+ activities: reducing emissions from deforestation and forest degradation

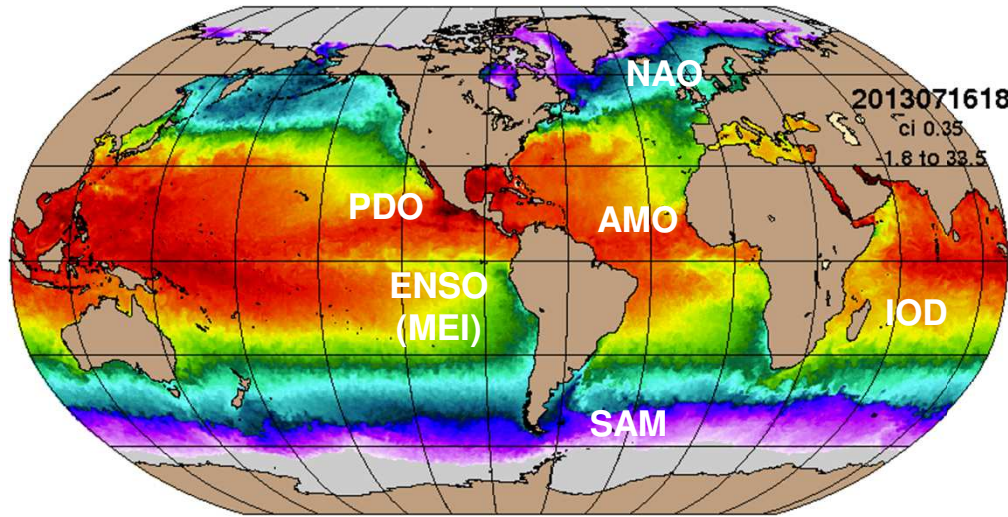
What type of information on tropical forests can we provide?



Aragão *et al.* 21st Century drought-related fires counteract the decline of Amazon deforestation carbon emissions. *Nature Communications* (2018)

Oceanic temperature variability influences Amazon droughts

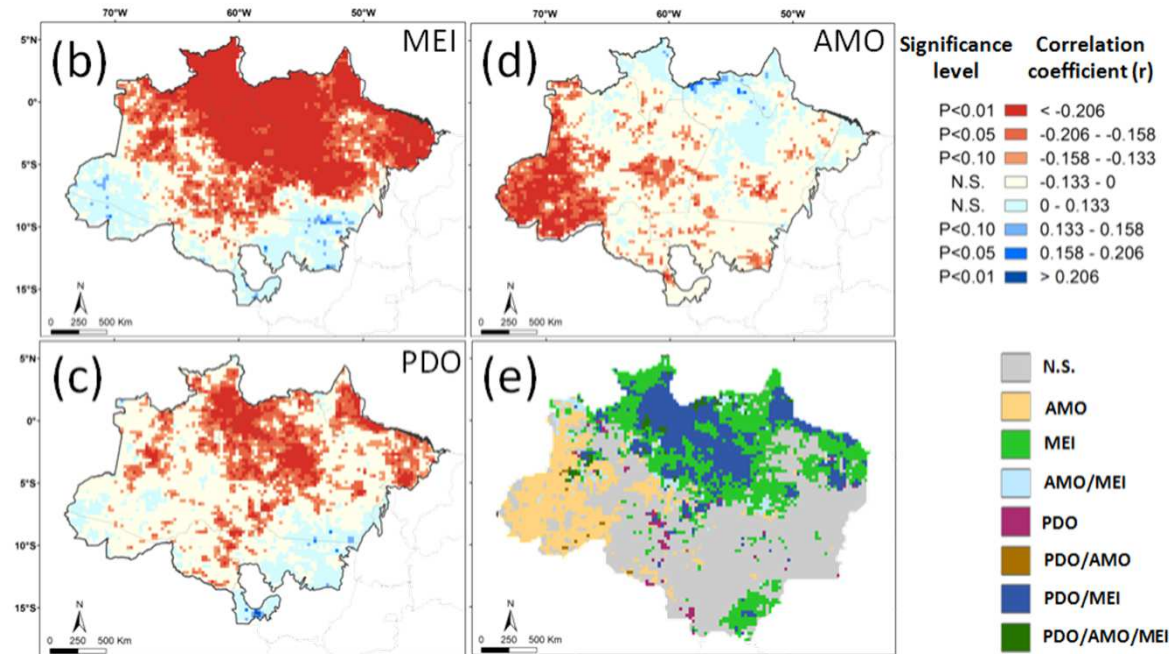
SST Jul 13, 2013 00Z 91.0



Major atmospheric patterns in their regions of origin: ENSO (El Niño/ Southern Oscillation), the Pacific Decadal Oscillation (PDO), the North Atlantic Oscillation (NAO), the Arctic Oscillation/ Northern Annular Mode (AO/ NAM), the Southern Annular Mode (SAM), the Indian Ocean Dipole (IOD), and the Atlantic Multi-Decadal Oscillation (AMO).

Naval Research Laboratory (NRL)

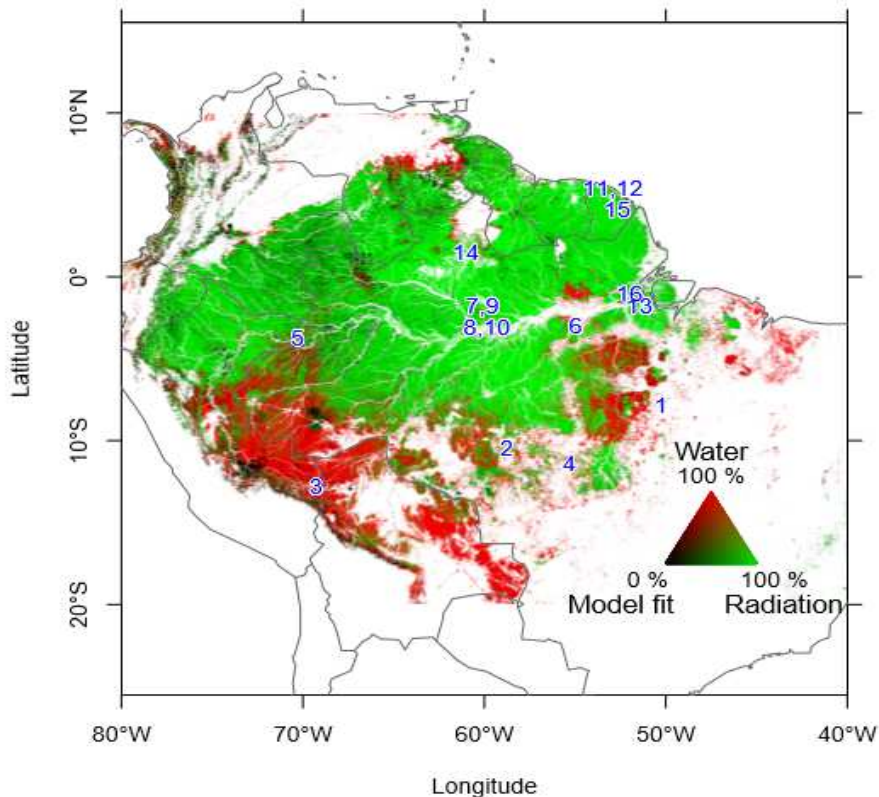
Drought footprint is variable but predictable depending on configuration of oceanic temperatures



Aragão et al. Nature Communications (2018)

Most of the Amazon is not adapted to water stress

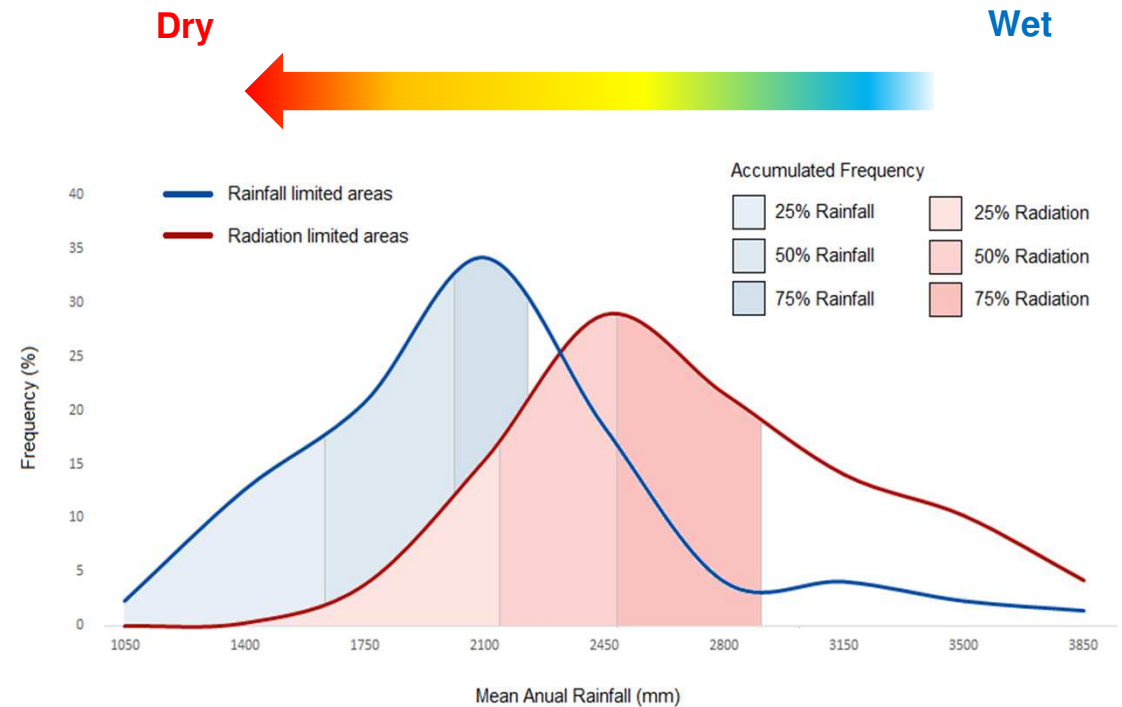
Climate controls on leaf growing season



Wagner et al. *PLOS ONE* (2017)

Is Amazonian C sink sustainable under increased drought frequency?

Is most of the Amazon biome susceptible to cavitation under a drier climate?



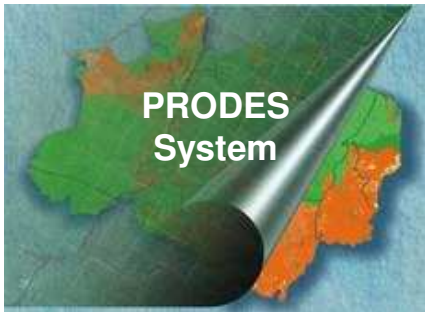
Bertani et al. *Remote Sensing* (2017)



Can we contribute to climate change mitigation?

The REDD+ context

Long-term deforestation monitoring (Reporting area)



Brazilian FREL 2014



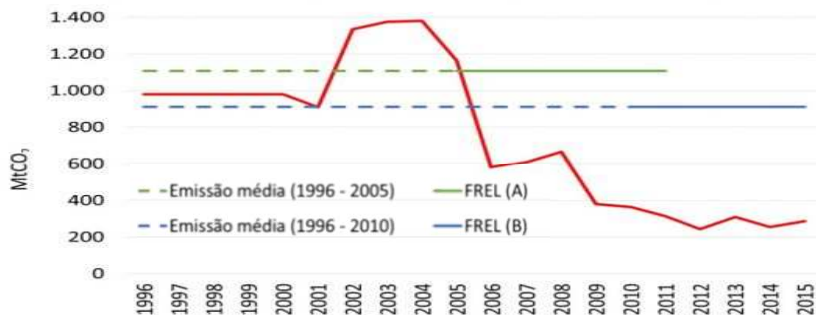
Real time deforestation monitoring (Law enforcement)



FCCC Technical Assessment



Forest Reference Emission Level 2014 (FREL)

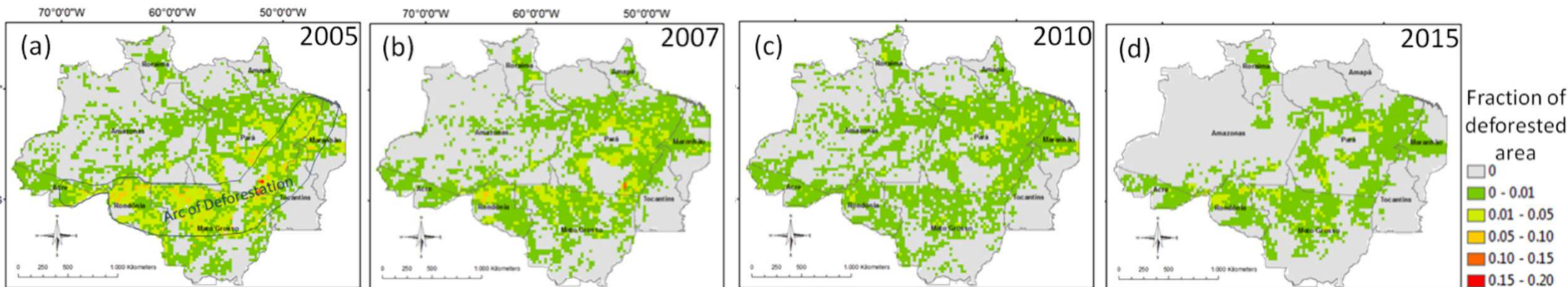


Technical Assessment (UNFCCC)

- **Conservative – exclusion of degradation**
- 1) Continue monitoring degradation (displacement emissions).
- 2) Include emissions from degradation in future FREL submissions, when new adequate data is available.

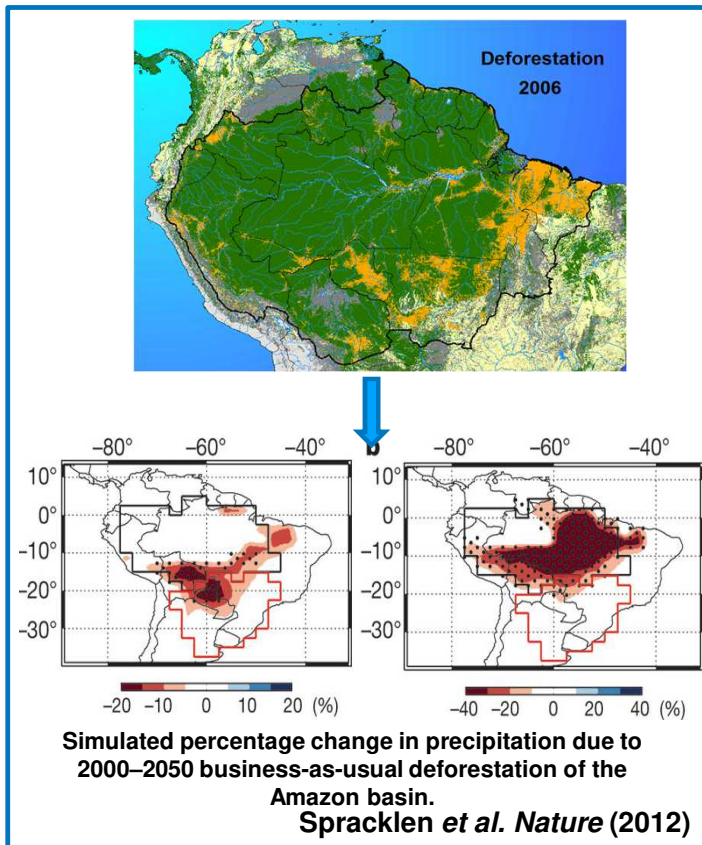
...but what happens to already deforested landscapes exposed to climate extremes?

Annual deforestation

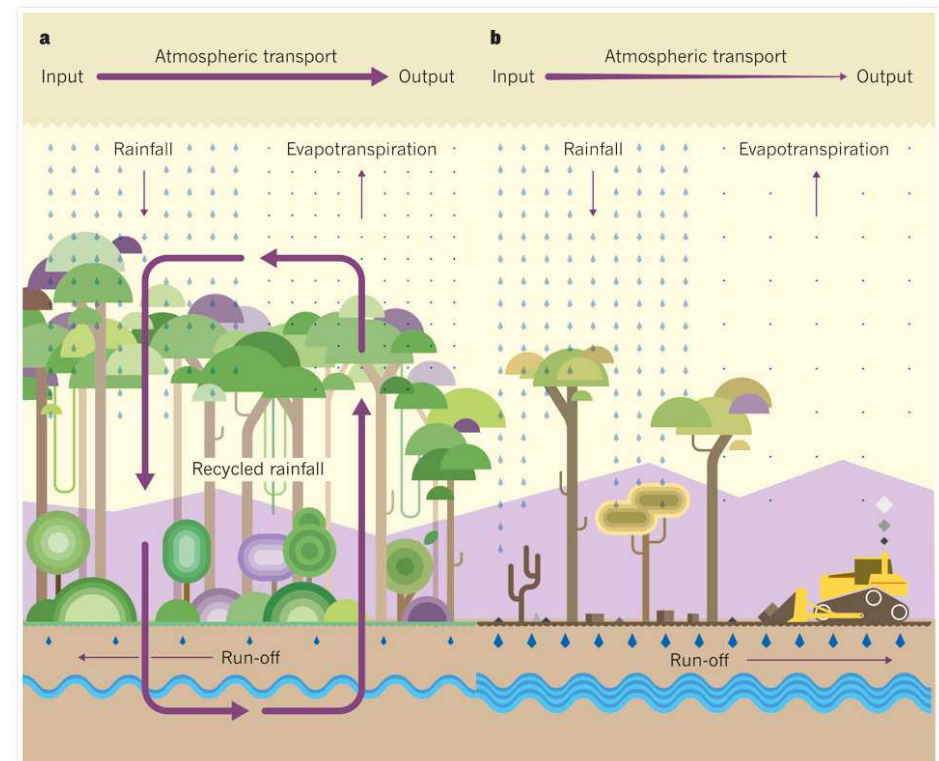


With increased deforested area rainfall decreases

Future implications and limitations



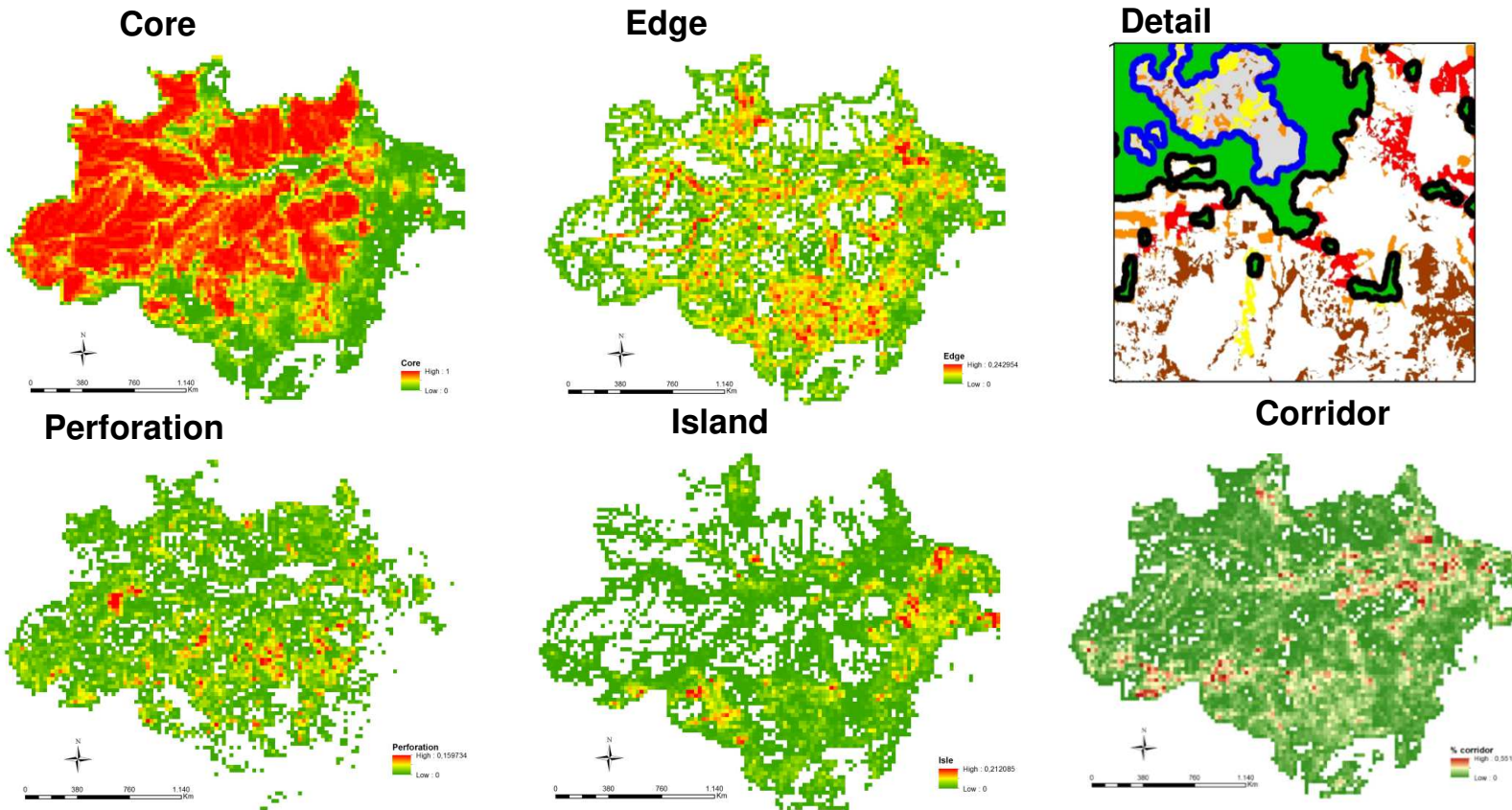
Plausible Mechanism



Aragão. The Rainforest's Water Pump. *Nature* 489, 217-218 (2012)



With increased deforested area fragmentation increases



TREES mapping

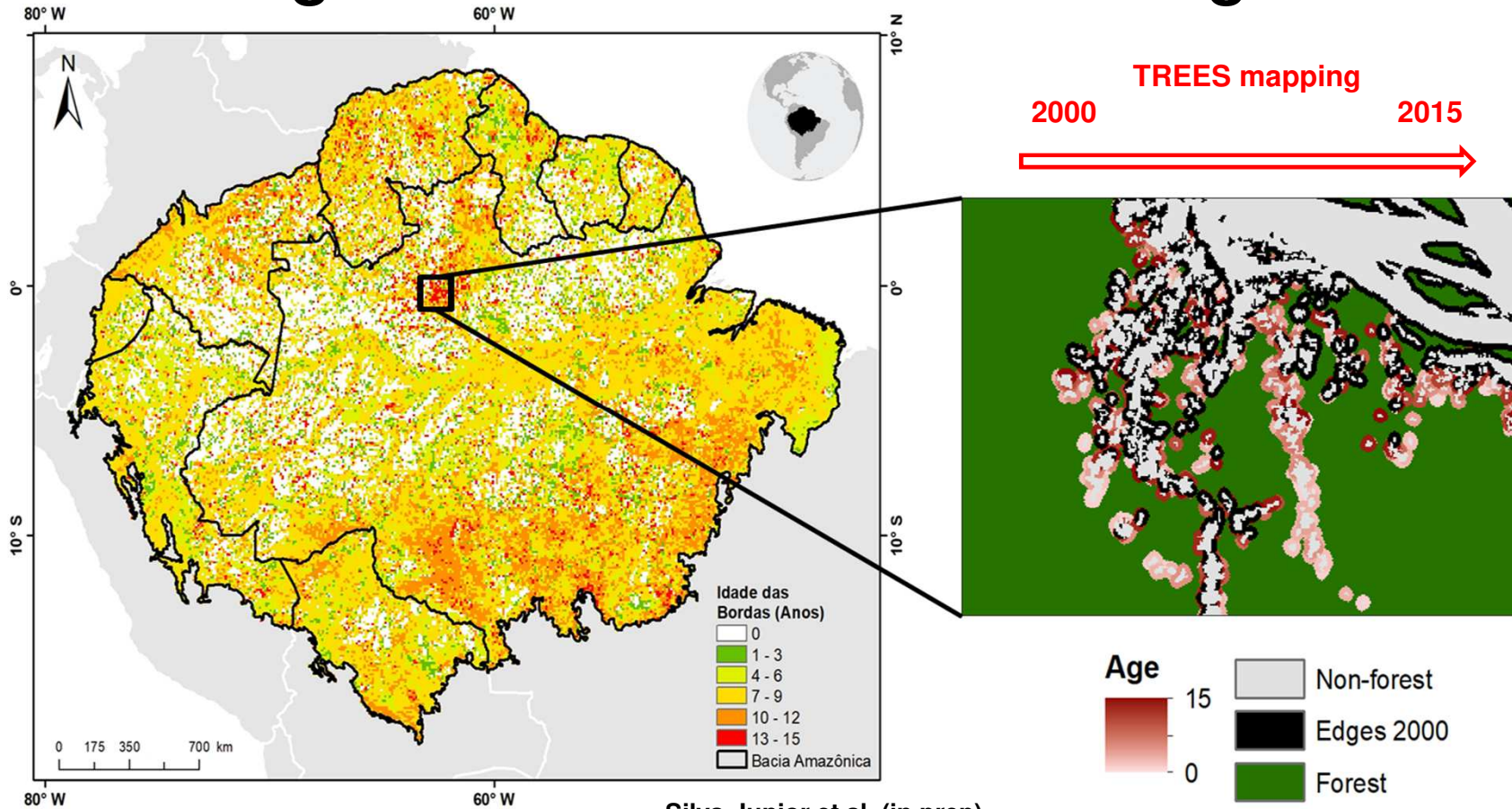
2003 → 2016

TOTAL	
Core	2,285,645.3 (71.9%)
Edge	164,595.0 (5.2%)
Perf.	58,442.8 (1.8%)
Bridge	341,869.9 (10.8%)
Loop	160,964.7 (5.1%)
Branch	64,280.2 (2%)
Islet	101,440.5 (3.2%)
Total	3,177,238.5 (100%)

Vedovato et al. Regional Environmental Changes (2016)

Fragmentation creates forest edges

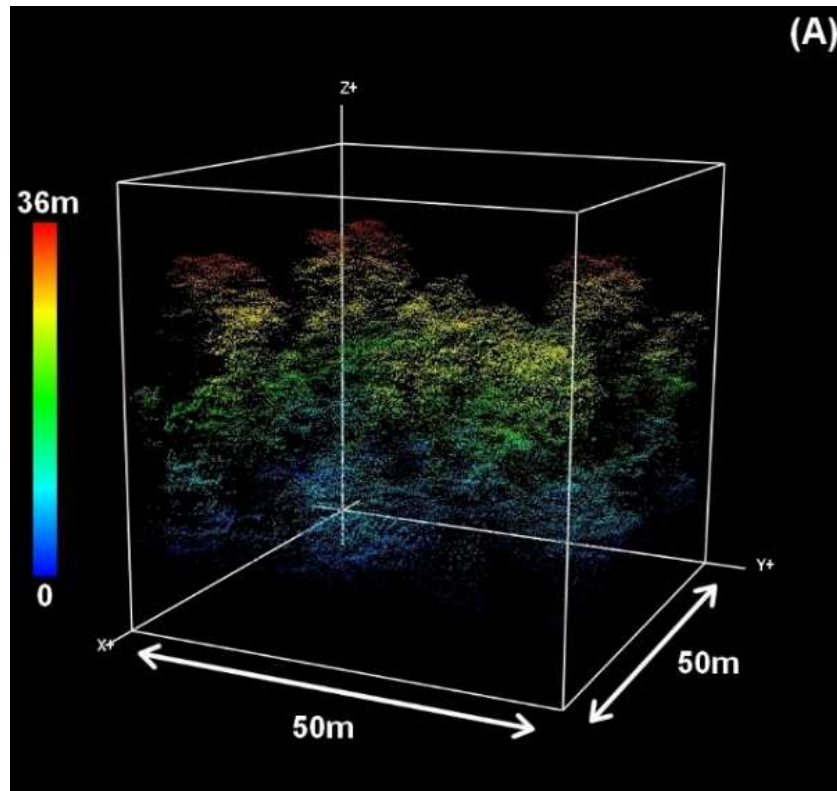
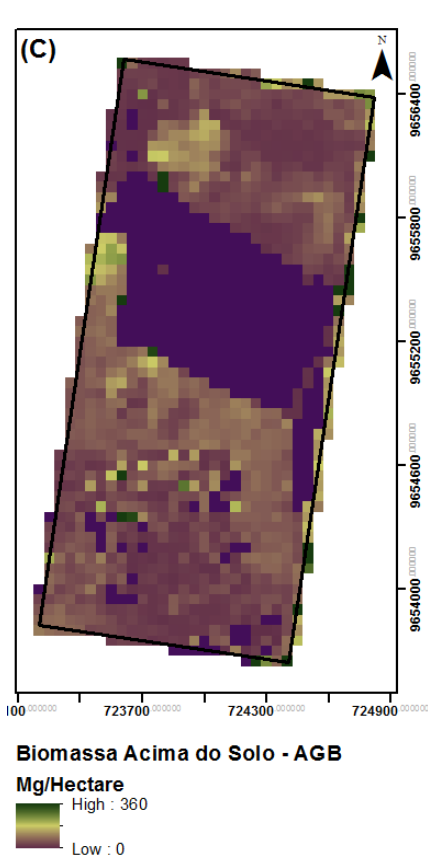
Age of Forest Edges (Year 2015)





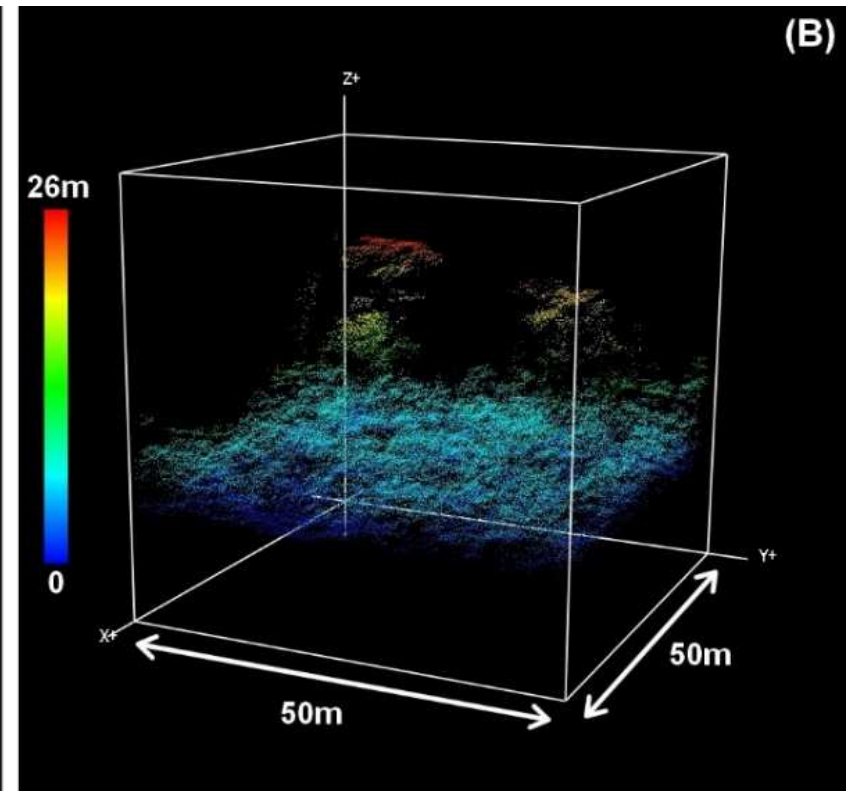
Fragmentation creates forest edges causing biomass loss

LIDAR



Forest

Silva-Junior, Aragão et al. (in prep)

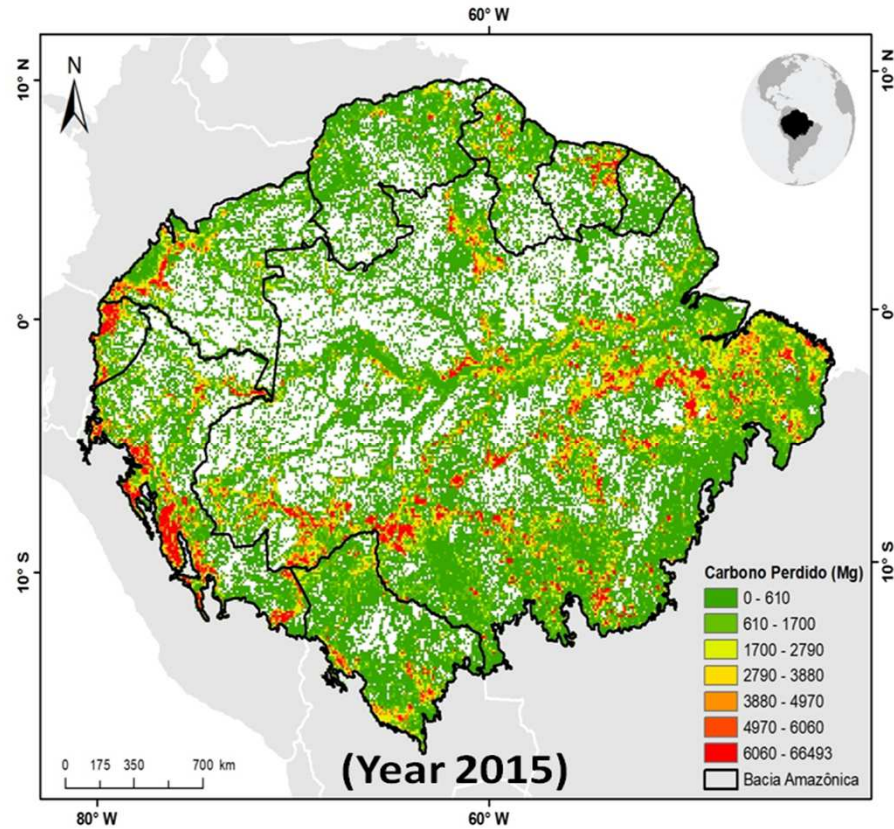


Edge

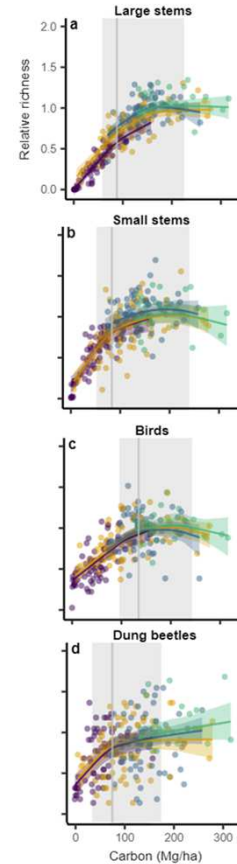
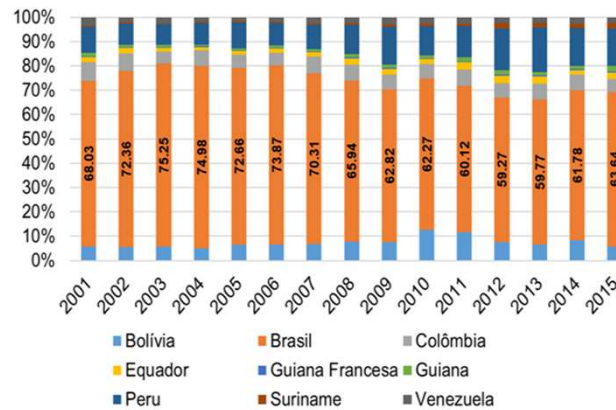
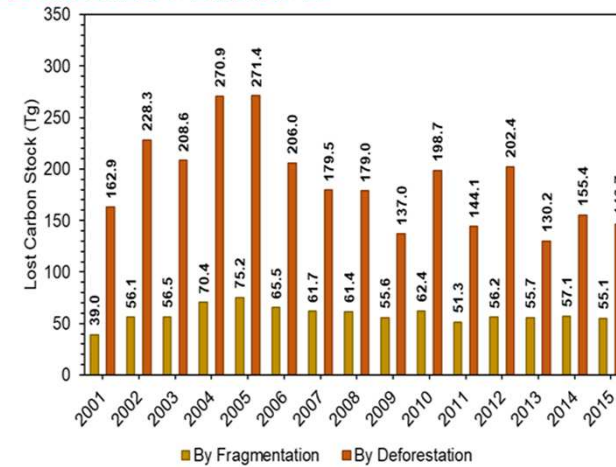
Indirect impact of deforestation on C stocks through edge effect

Loss of Carbon Stocks Between 2001 and 2015

Implications for diversity

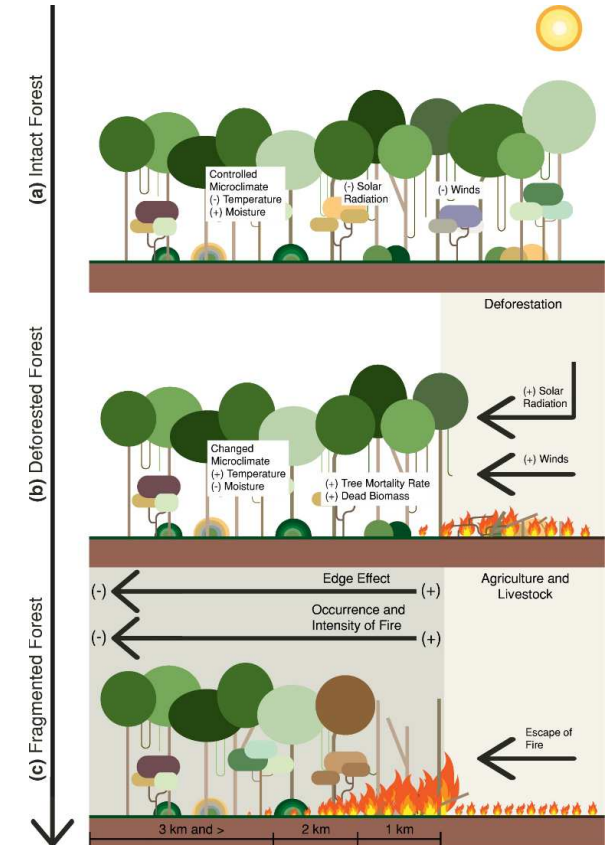
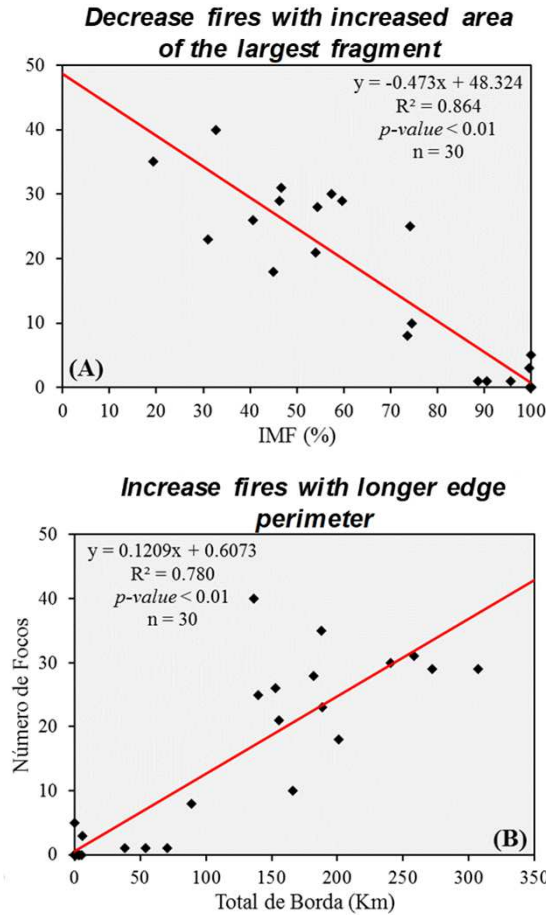
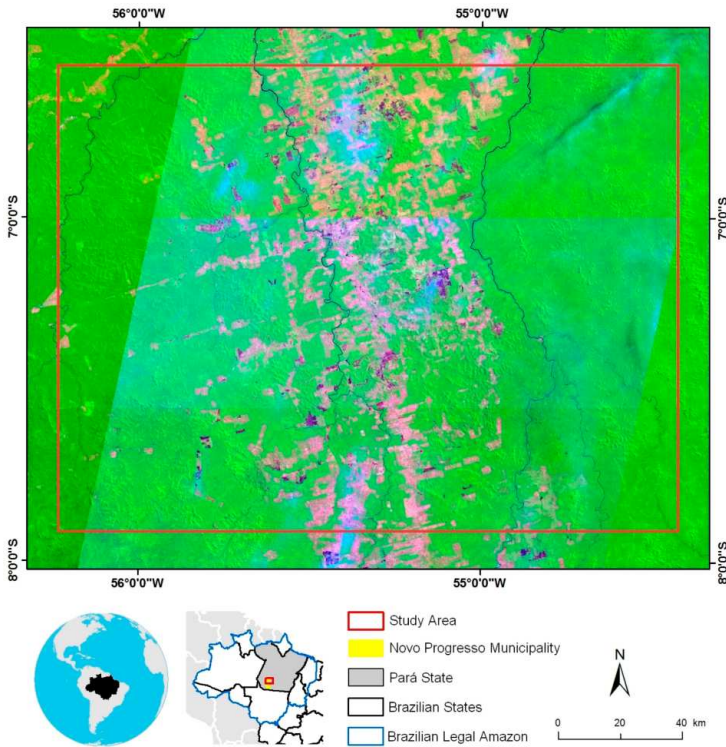


Silva-Junior et al. (in prep)



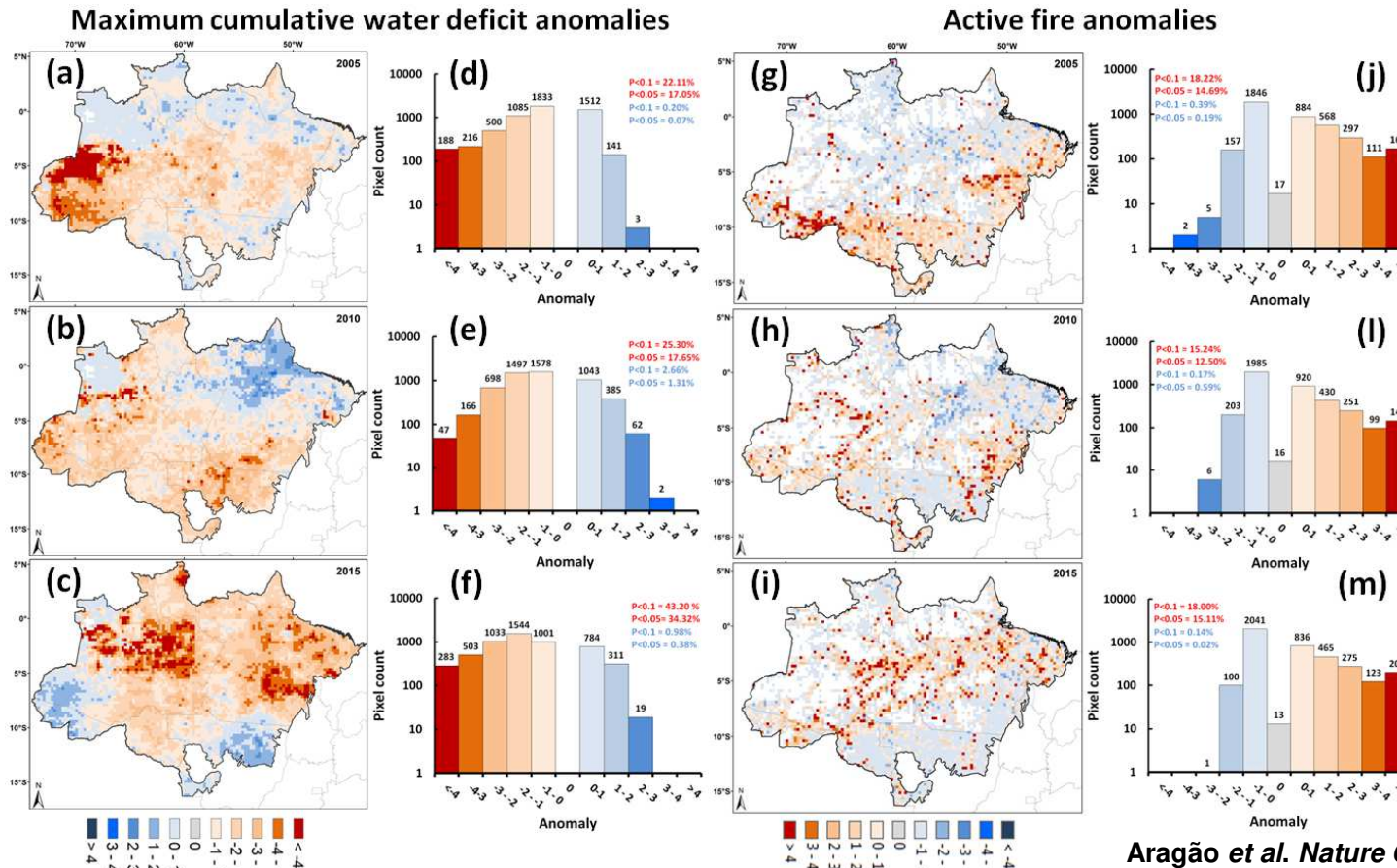
Ferreira et al. Nature Climate Change(2018)

Fragmentation increases fire incidence



Silva-Junior et al. *Forests* (2018)

Fires increase with droughts in fragmented landscapes

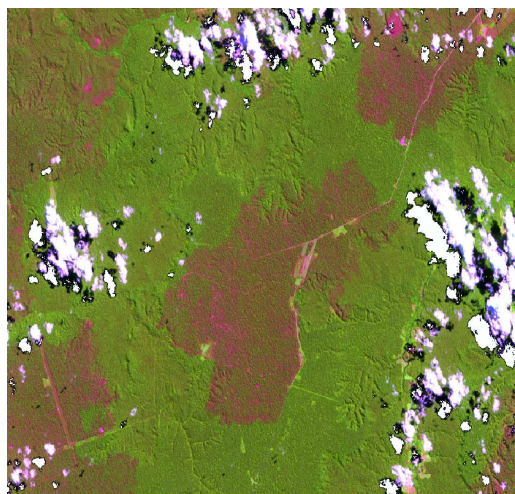


Aragão et al. Nature Communications (2018)

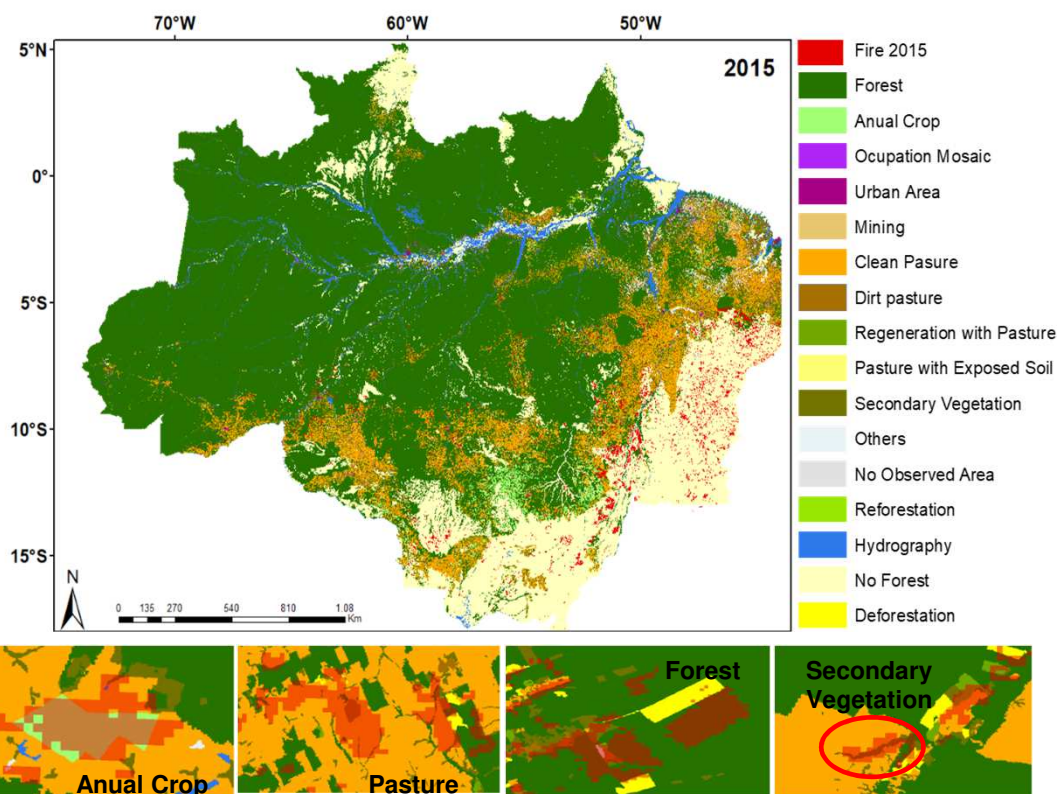


...but what is the extent of forest fires and their impacts on C emissions?

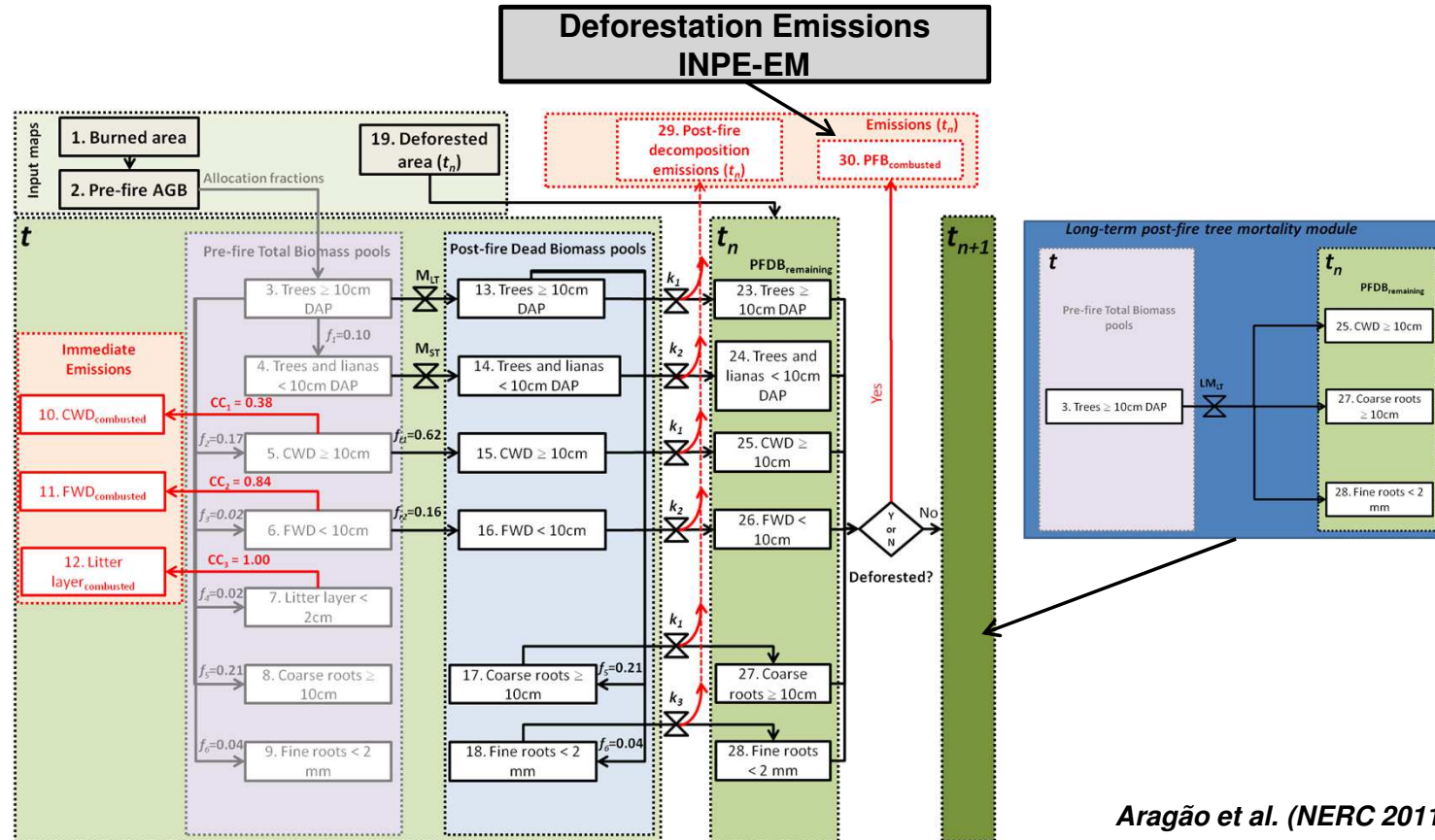
FATE-AMZ Program
Fire Associated Transient Emissions
2005 **2015**



Lorena, Aragão et al. (in prep)



The FATE-AMZ bookkeeping model

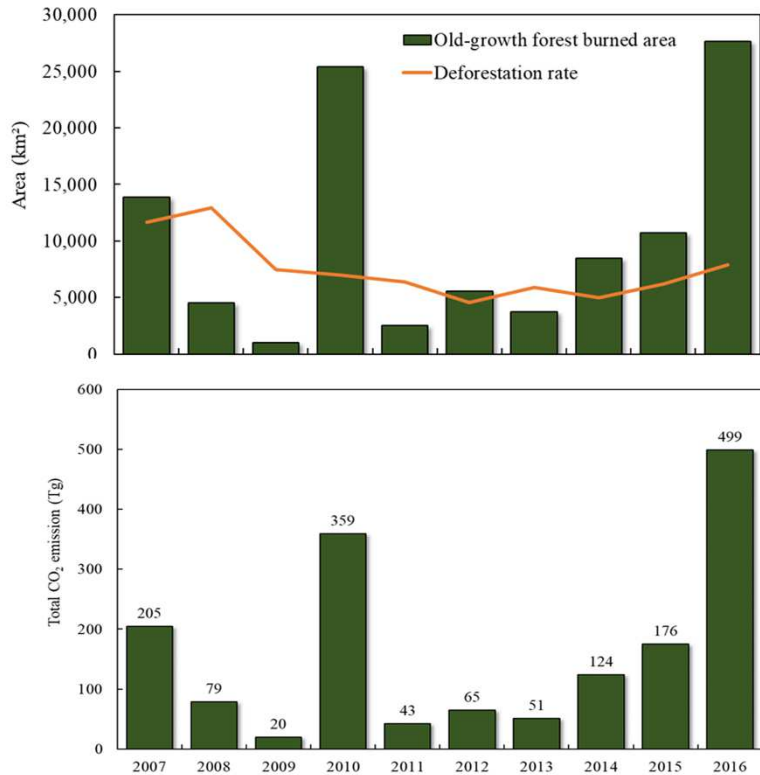


Aragão et al. (NERC 2011/CNPq 2013)

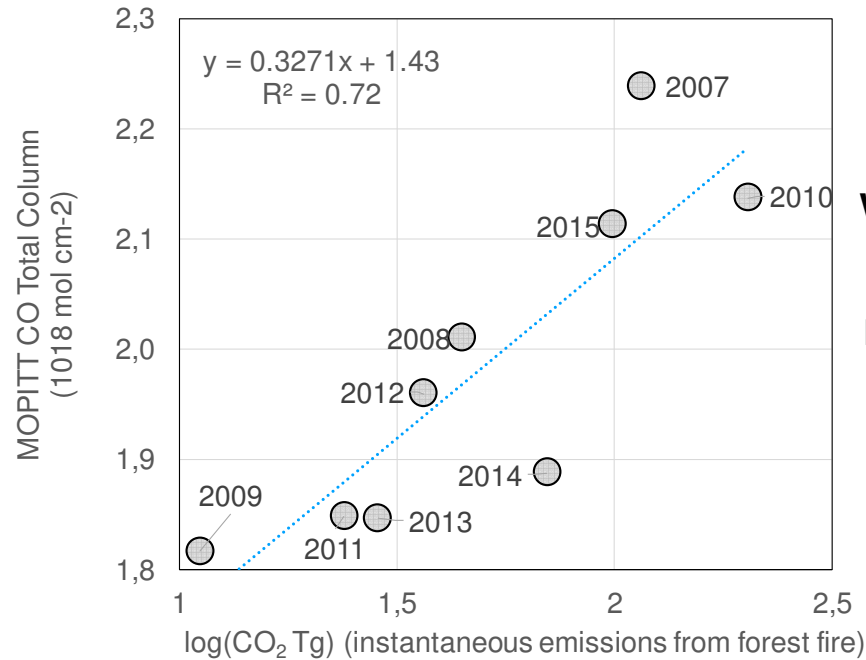


Burned area and emissions from old-growth forests

In 60% of the years burned area extent has surpassed deforested area in Amazonia



MOPITT-TERRA - Measurements Of Pollution In The Troposphere



Brazilian NDC
1.3 GtCO₂e in 2025

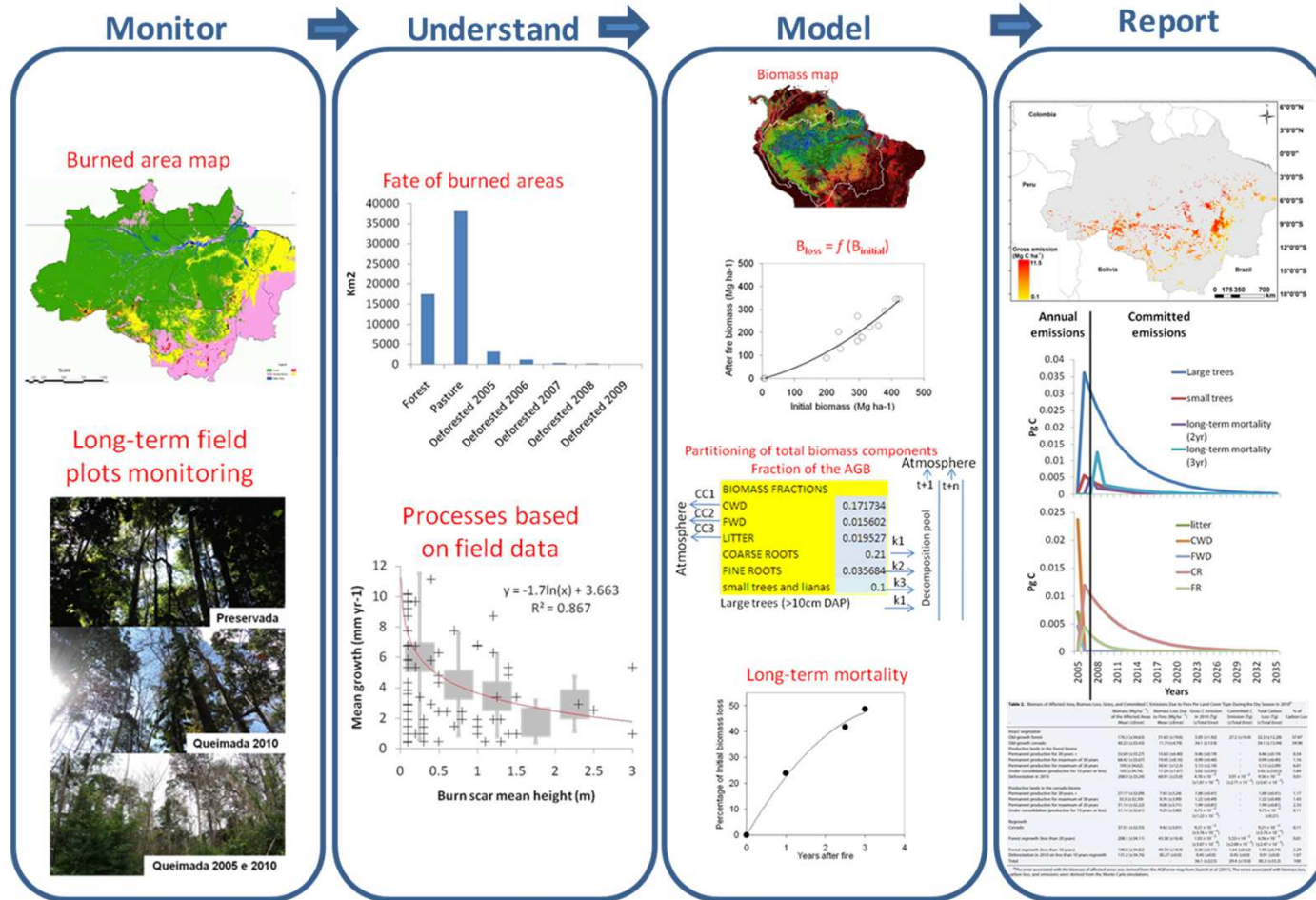
Wildfires = 0.499 GtCO₂e yr⁻¹ in 2016

Edge effect = 0.129 GtCO₂e yr⁻¹ in 2015

Tg = 10¹²g
Gt = 10¹⁵g



A consistent way to report C emissions from forest degradation: The FATE-AMZ program





Conclusions

- 1) With continuous land cover change and the risk of intensification of droughts, Amazonia may gradually lose its full functionality.**
- 2) Contrarily to the climate system, which has great inertia to respond to changes, human system can be manipulated through coherent planning and implementation of policies.**
- 3) We now have enough understanding of the Earth system to produce robust information on essential metrics for decision making and to propose effective solutions. For instance, full package for reporting emissions from degradation.**



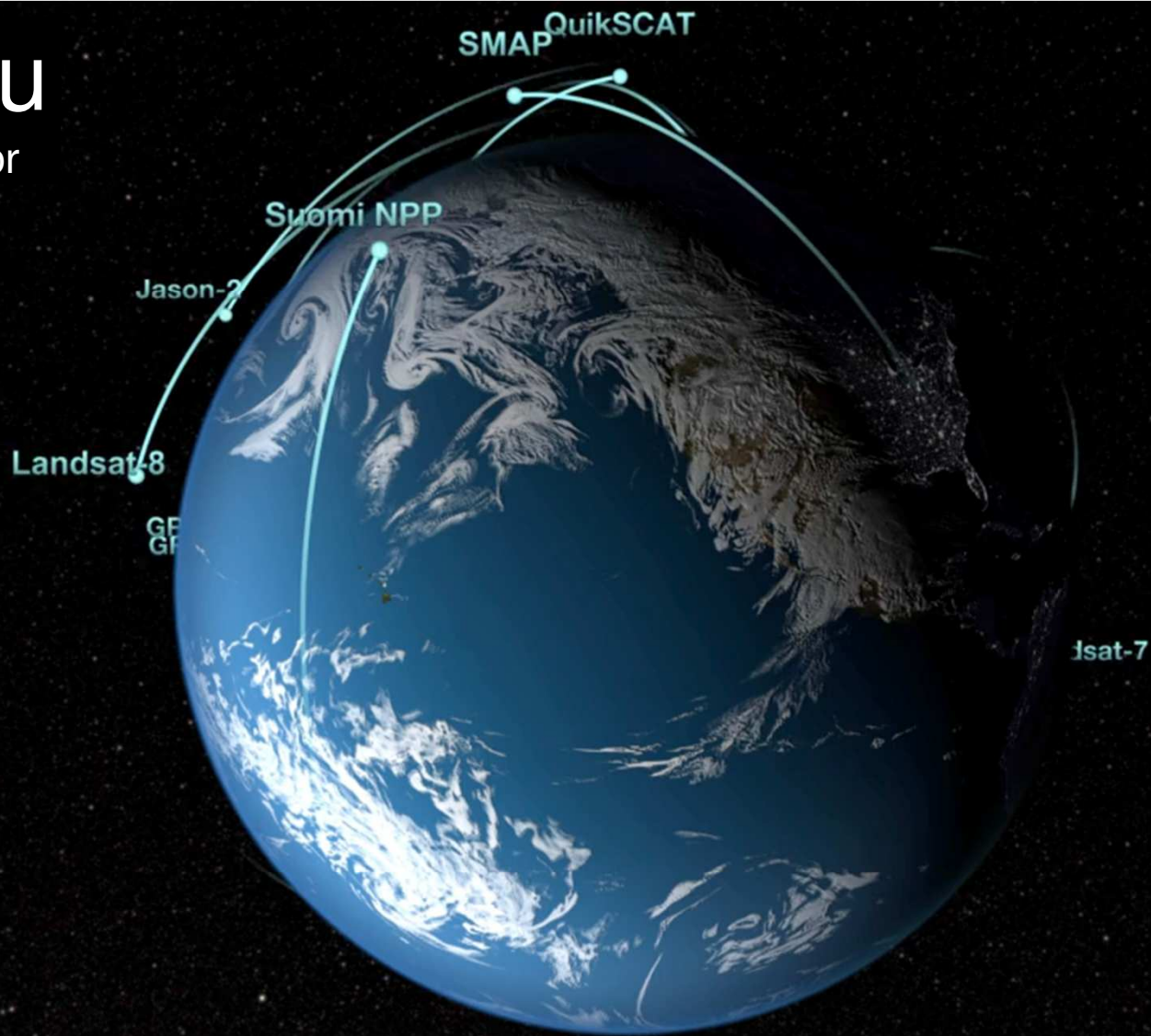
Conclusions

- 4) **Effective policies can reduce economic costs (e.g. health) and create opportunities in forestry (restoration) and other sectors, such as the increased productivity of agricultural lands in Amazonia with the current control of deforestation.**
- 5) **Continuously build collaborations for sharing experiences and standardize methods among tropical nations.**
- 6) **Clear communication about the knowledge built is a key element for the successful reversal of the observed trends**



Thank you

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Source: NASA

