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K&C Phase 4 – Status report

Measuring above ground biomass and changes over Brazilian tropical secondary forests and savanna woodlands (Cerrado) using L-band SAR data

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Science Team meeting #23
Hatoyama, Japan, January 18-20, 2017

The importance of tropical secondary forests ...

... establishing on abandoned farmland

- act as a carbon sink: on average accumulating above-ground biomass ~5 Mg ha^{-1} yr^{-1} and important at recovering biodiversity
- Amazon: ~ 1/3 deforested land supporting secondary forests at some stage in the 1990s and 2000s (Lucas et al., 2000; Carreiras et al., 2006)
- **however**, still high uncertainty in terms of contribution of its dynamics to the global carbon cycle (South America, 50%; Pan et al., 2011)

Project outline and objectives

Assess the sensitivity of L-band SAR data to forest above ground biomass in a range of lower-carbon tropical regions in **Brazil** : **secondary forests** and savanna woodlands (***Cerrado)***

Value of L-band data for measuring forest above ground biomass:

- sensitivity up to ~ 100 t/ha (saturation level at this frequency)
- developing forest monitoring systems (activity data + emission factors) in regions with lower biomass density

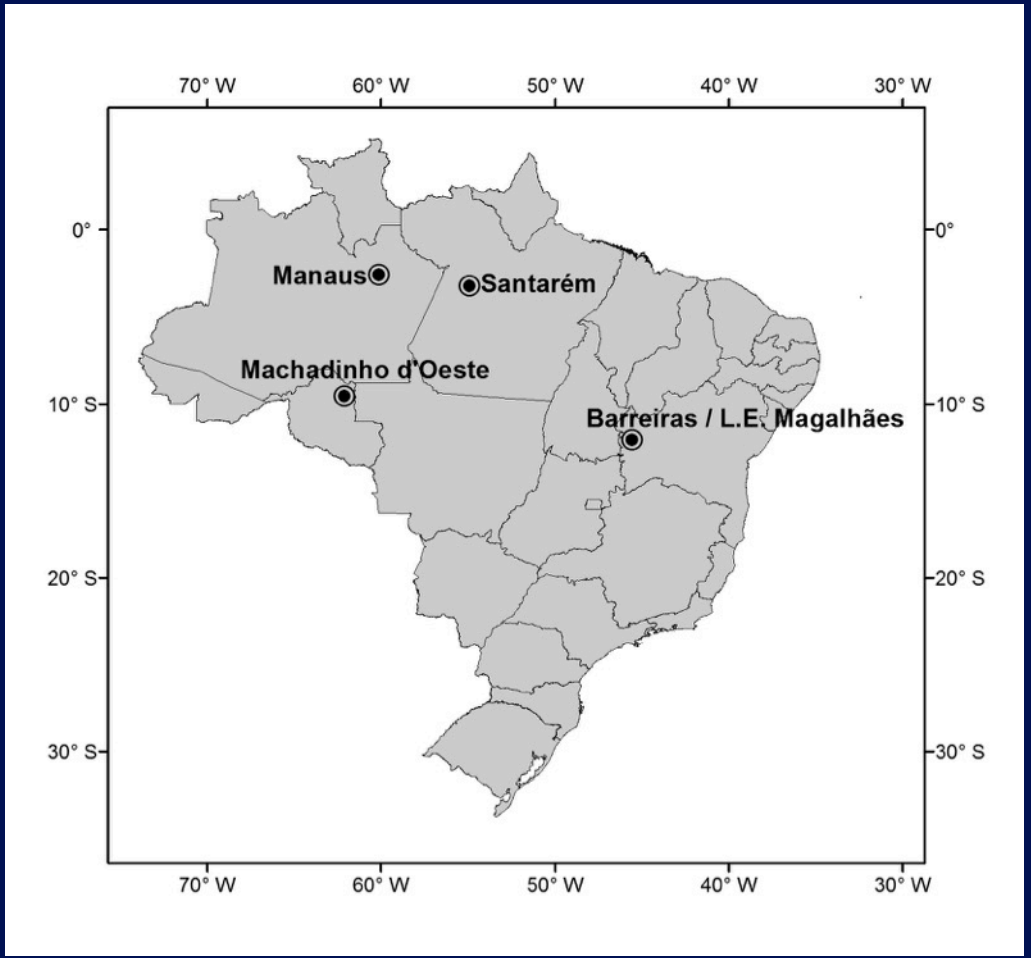
Support of K&C Thematic Drivers

- changes in forest biomass have an impact in terms of **climate**:
  - deforestation: source of carbon to the atmosphere
  - forest growth: carbon removal from the atmosphere

- uncertainties in these biomass-related fluxes in terms of the global carbon budget -> currently estimated as the residual term (exception: Pan et al., 2011, using observational data)

- accurate maps of secondary forests and *Cerrado* biomass and change
  - reduce uncertainty carbon accounting (**UNFCCC**)

Study areas



Secondary forests

- Manaus (Amazonas)
- Santarém (Pará)
- Machadinho d‘Oeste (Rondônia)

Savanna woodland (*Cerrado*)

- Barreiras (Bahia)
- Luis Eduardo Magalhães (Bahia)

Preliminary results

What is the capability of optical and L-band SAR data to discriminate the age of tropical secondary forests?

- access to time series maps of non-forest, secondary forest and mature forest spanning three decades (1980s - …) over the three sites
- precise location of areas with secondary forests of known age
- ALOS PALSAR 2007-2010 catalogue
  - dual-pol (HH+HV) level 1.1
- Landsat 5 TM surface reflectance data 2007-2010
  - USGS

Preliminary results

1st : Mapping mature forest (MF), non-forest (NF) and secondary forest (SF) (2007-2010)

- 6 predictors
  - HH, HV (ALOS PALSAR)
  - TM3, TM4, TM5, TM7 (Landsat 5 TM)

- algorithm: non-parametric Random Forests (Breiman, 2001) in classification mode

2010		# observed				
OA 95%		MF	NF	SF	Total	CE (%)
# predicted	MF	0.5412	0.0000	0.0418	0.5830	7.17
	NF	0.0000	0.2299	0.0008	0.2307	0.36
	SF	0.0086	0.0033	0.1744	0.1863	6.39
	Total	0.5498	0.2332	0.2170	1.0000	
	OE (%)	1.57	1.40	19.64		

OA - overall accuracy, OE - omission error, CE - commission error

- class-specific errors < 20%
- > errors in MF and SF

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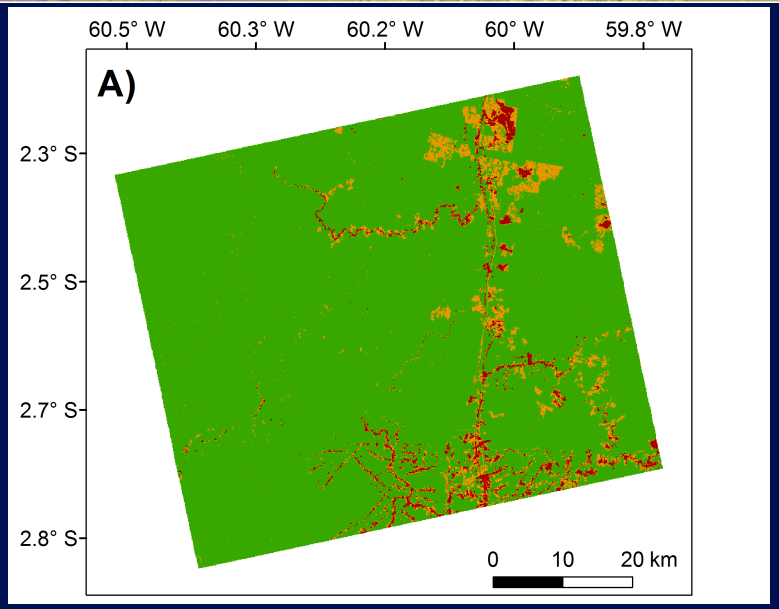
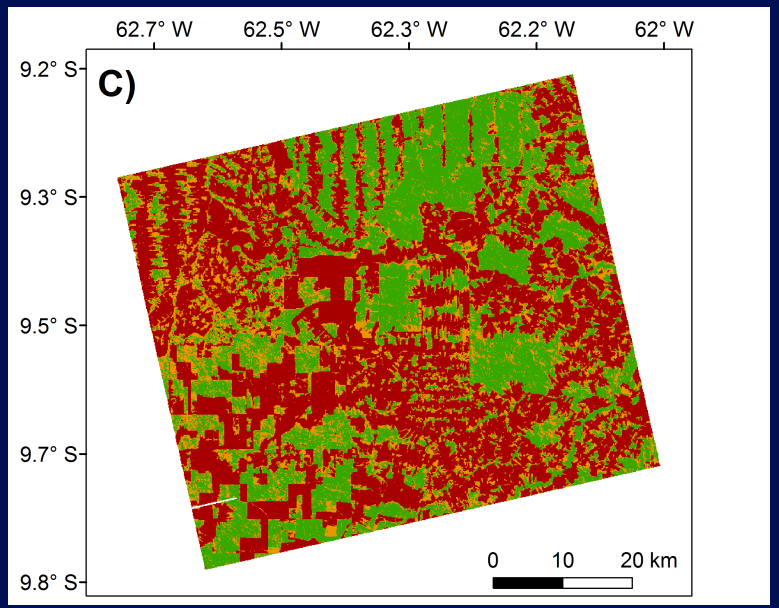
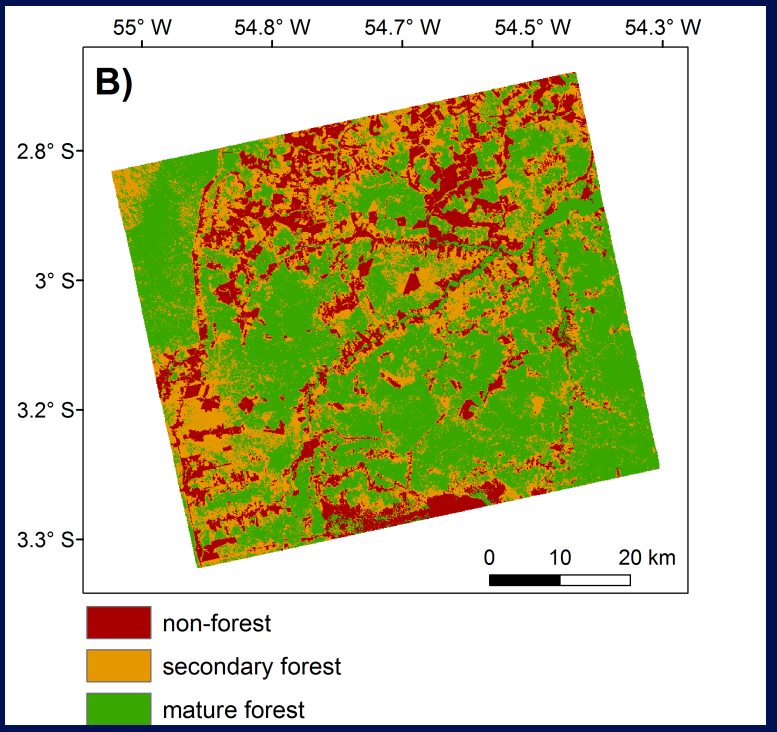




Preliminary results



A) Manaus B) Santarém

C) Machadinho d'Oeste

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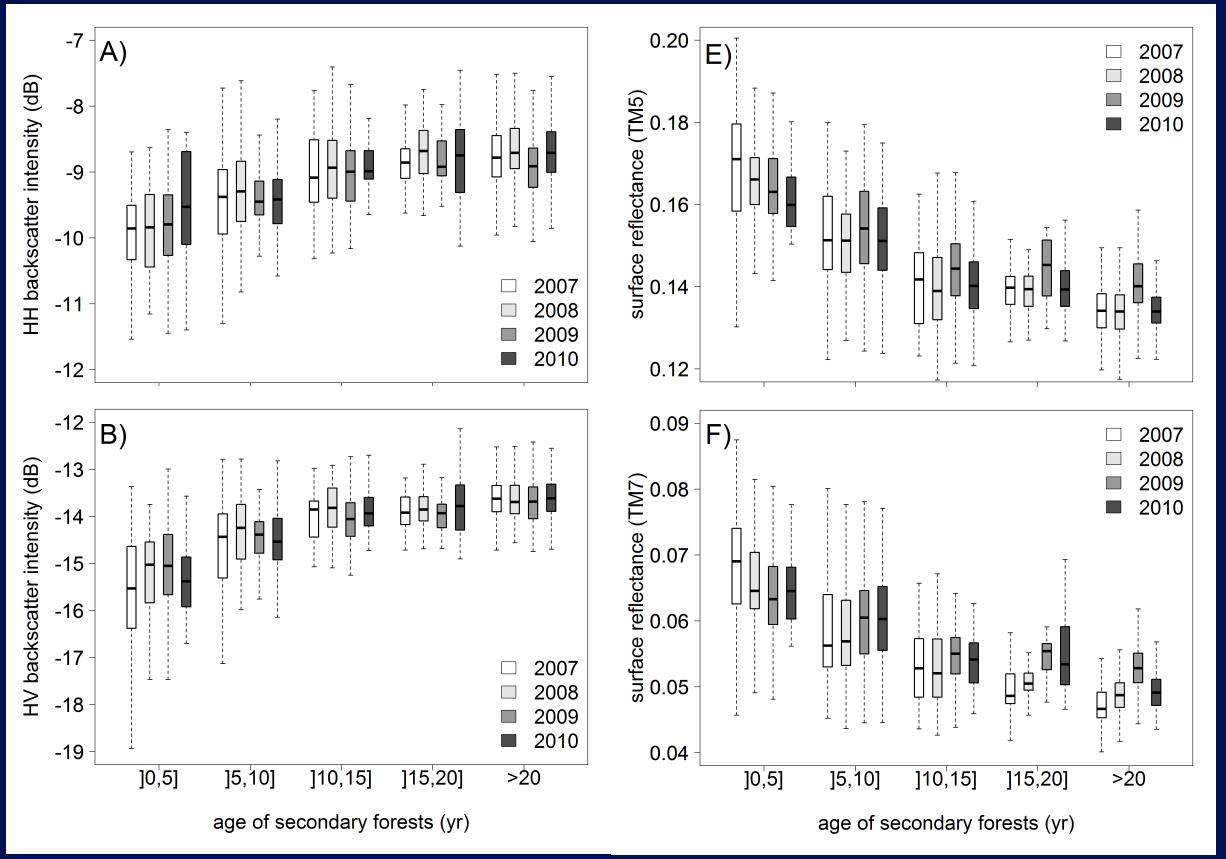
Preliminary results

2nd : Discriminating and mapping the age of secondary forests (ASF) (2007-2010)

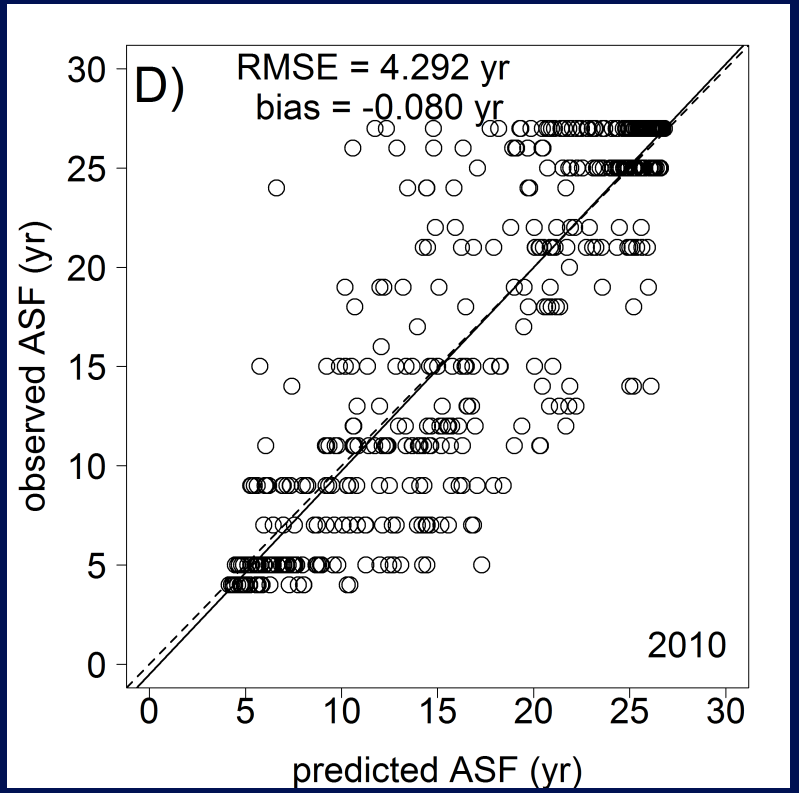


Preliminary results

- algorithm: non-parametric Random Forests (Breiman, 2001) in regression mode
- 6 predictors
  - HH, HV (ALOS PALSAR)
  - TM3, TM4, TM5, TM7 (Landsat 5 TM)
- asymptotic regression model to estimate saturation value

$$ASF_{pre} = b_0 + b_1(1-\exp(-\exp(b_2)\, ASF_{obs}))$$

[20.0-24.5] years



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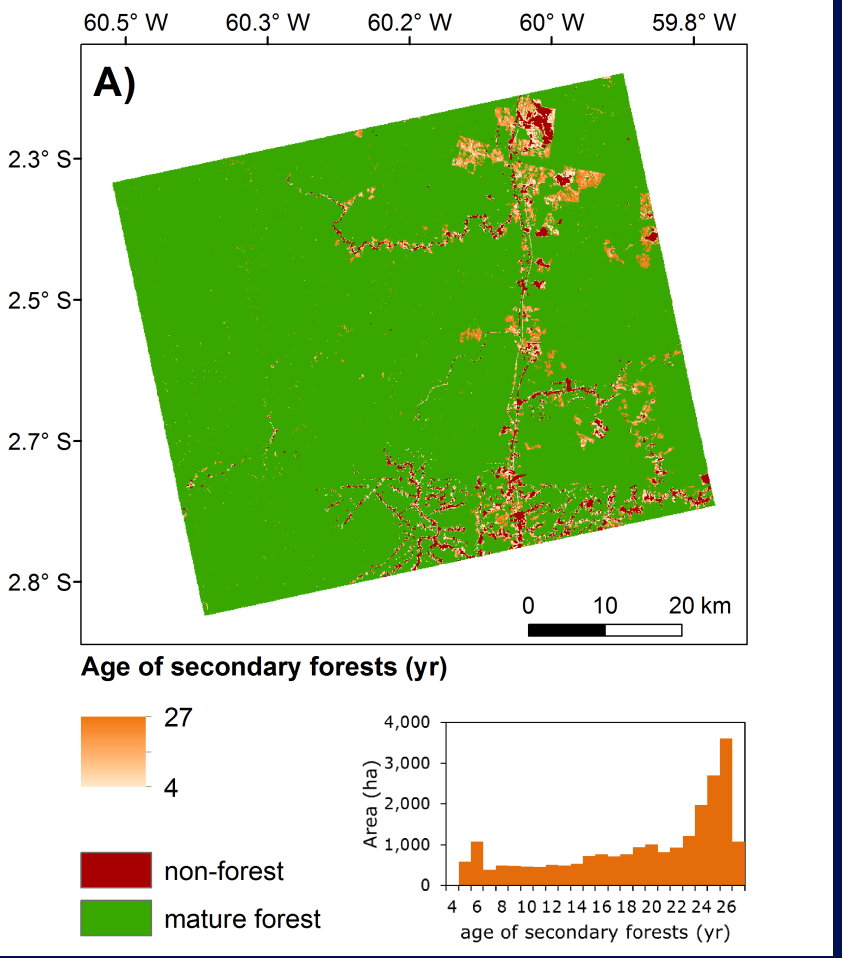
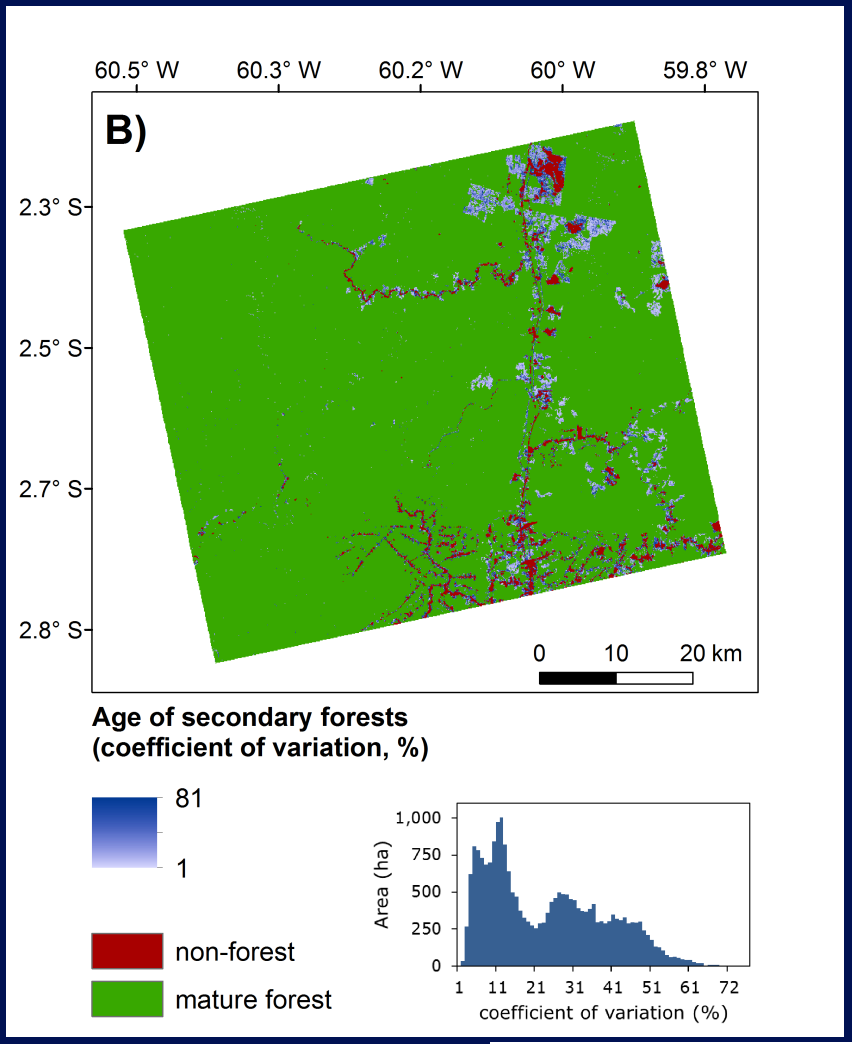
Manaus





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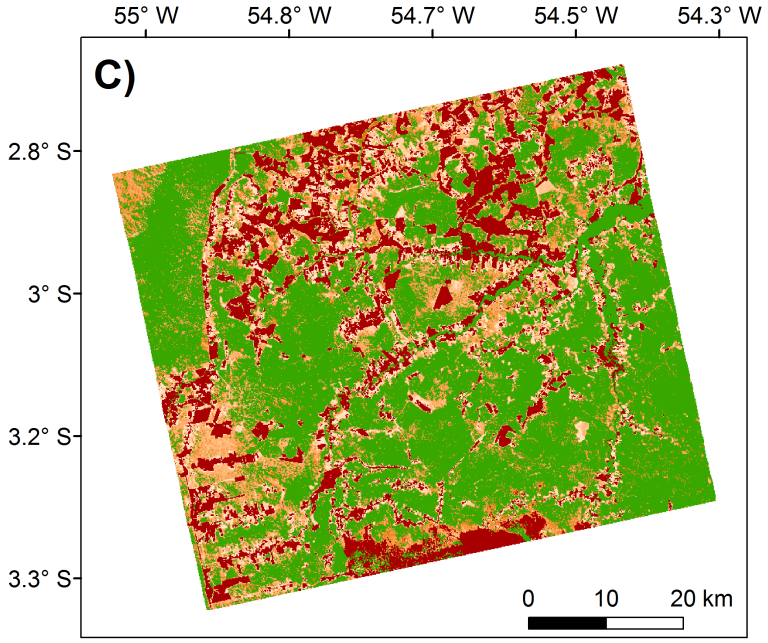
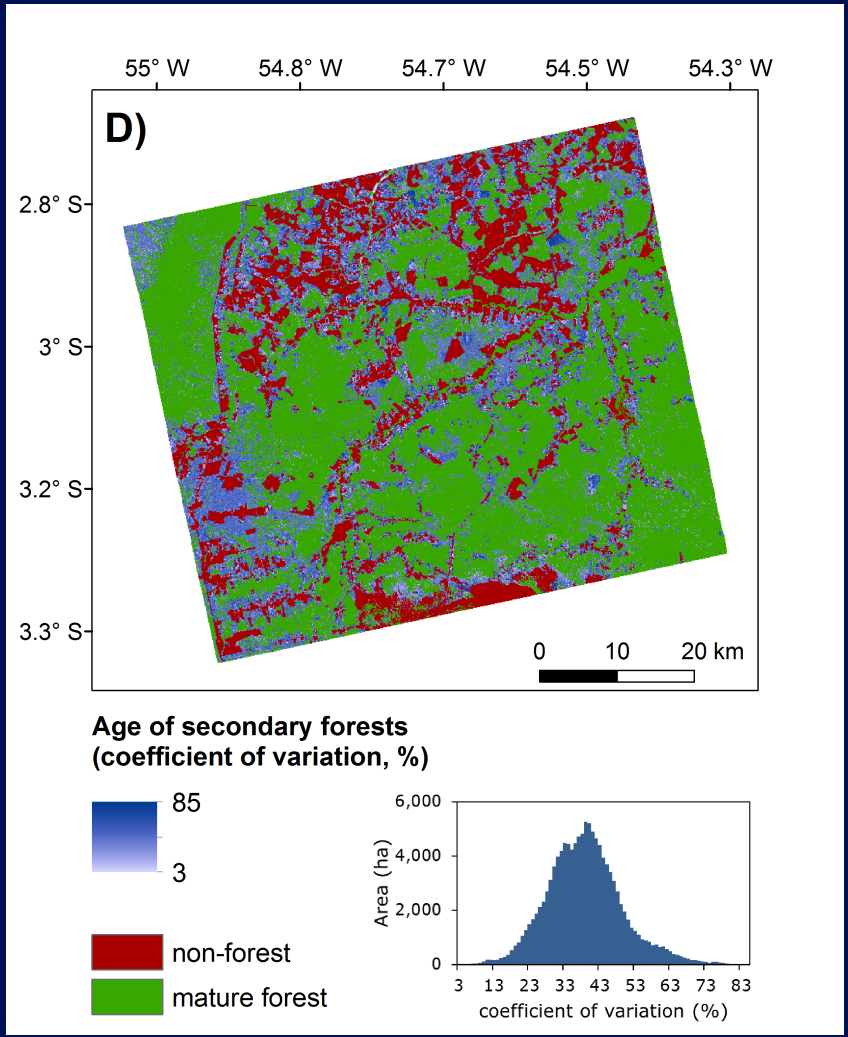
Preliminary results

Santarem





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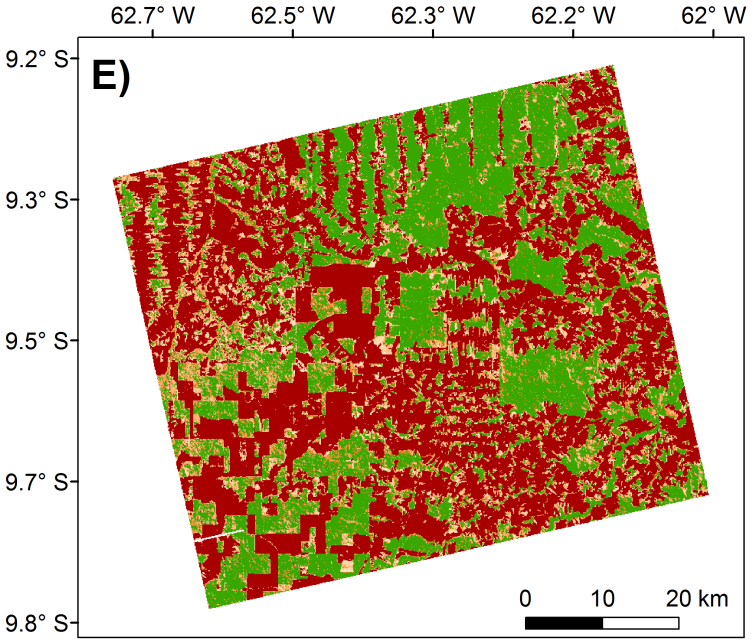
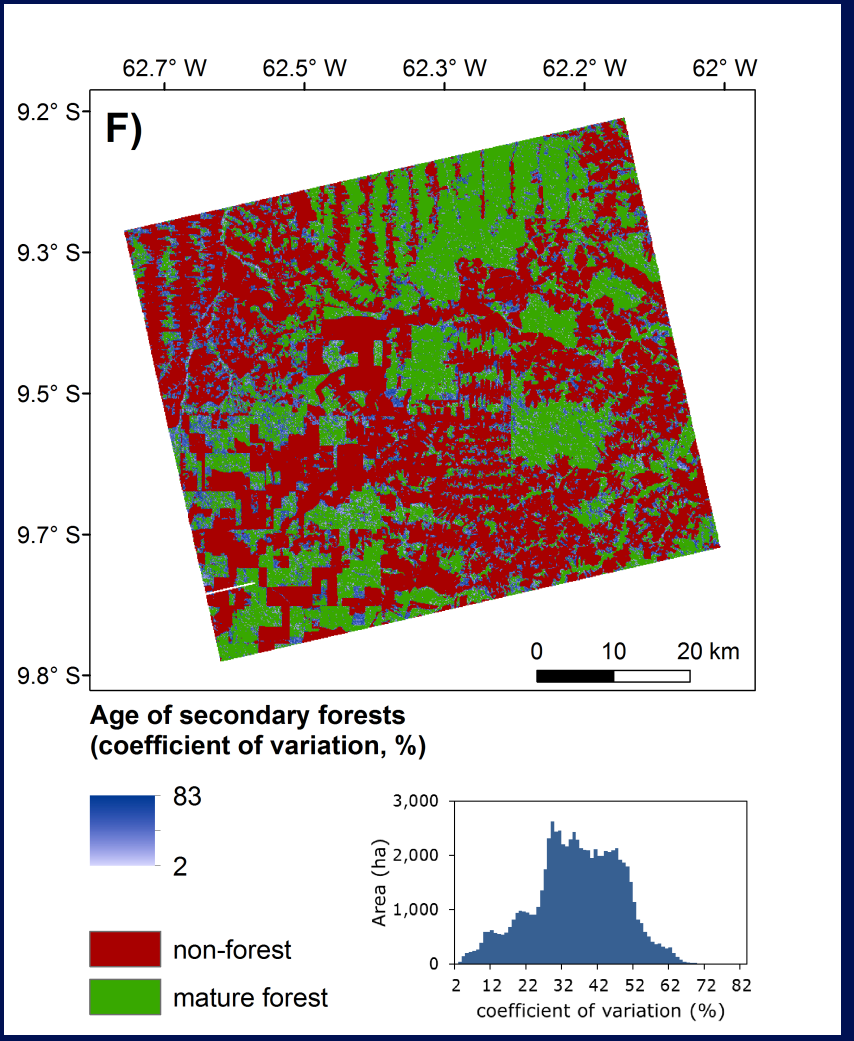
Preliminary results

Machadinho d'Oeste





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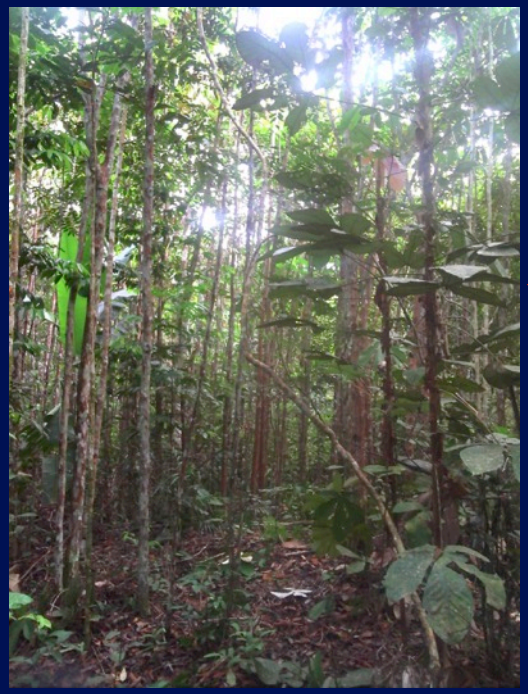
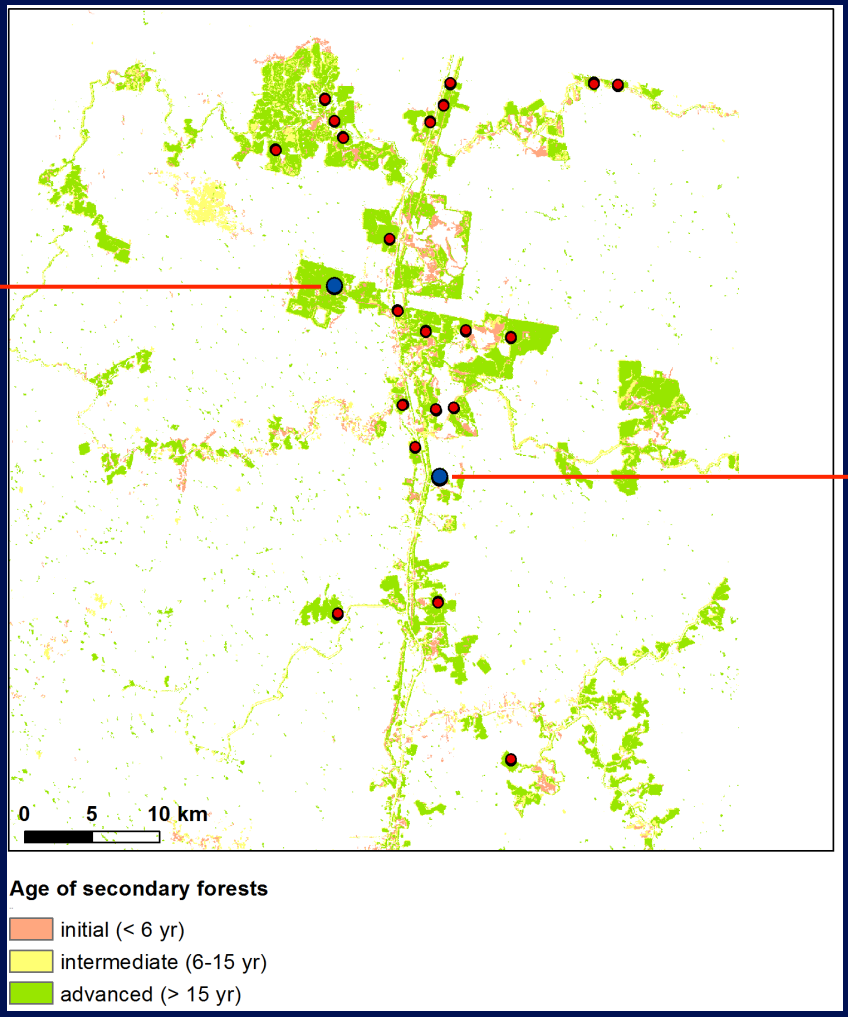
Data sharing

Manaus, August 2014, 23 plots measured in secondary forests



Adv22_18
19 years old



Adv12_2
22 years old

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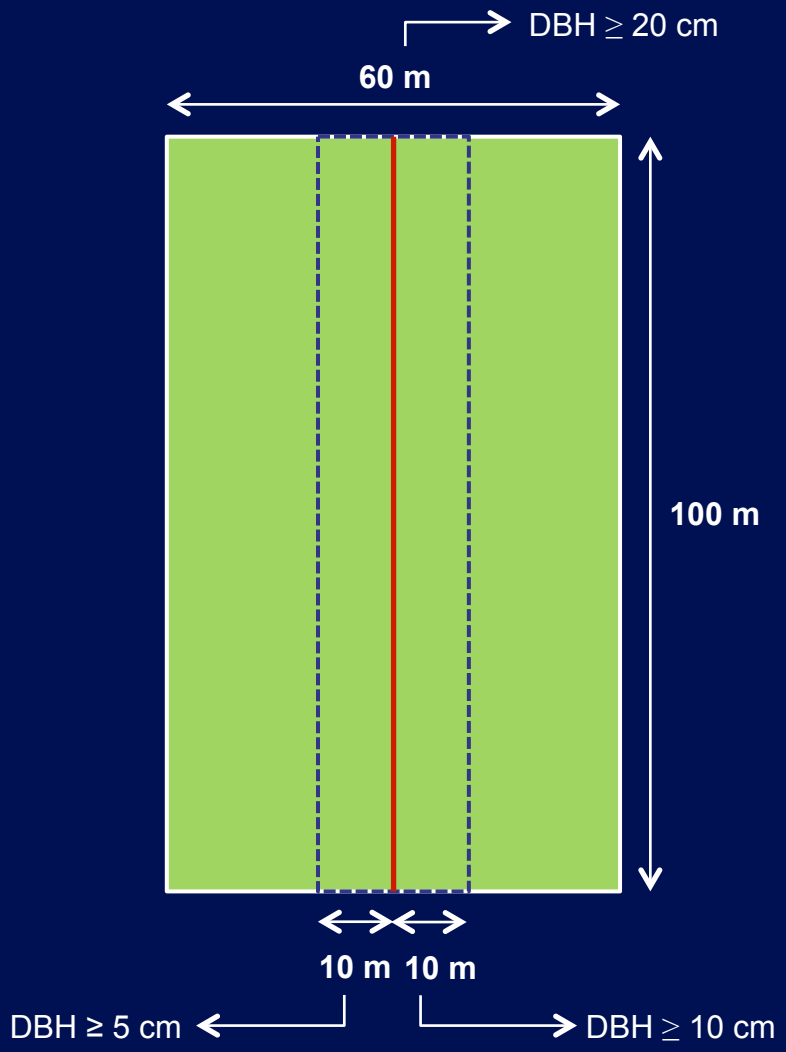
Data sharing



Test the impact of:

Minimum measured DBH

Plot size

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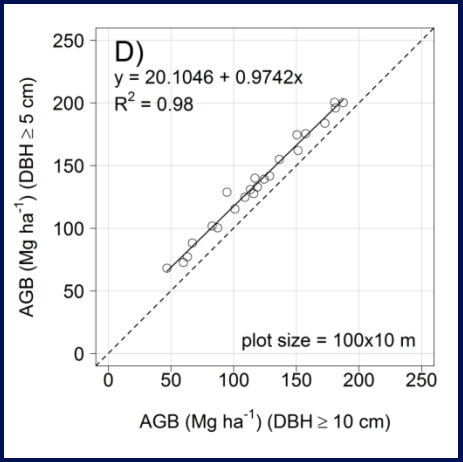
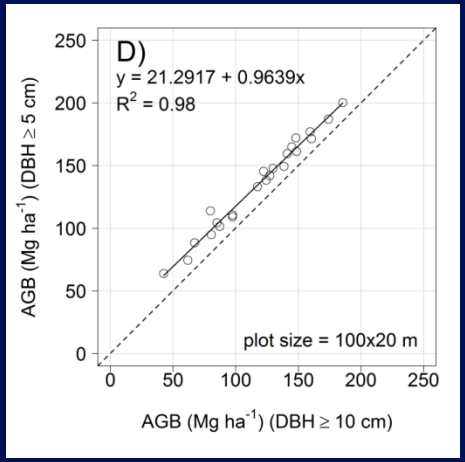
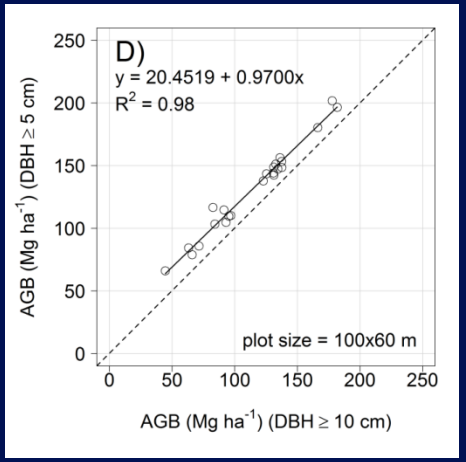
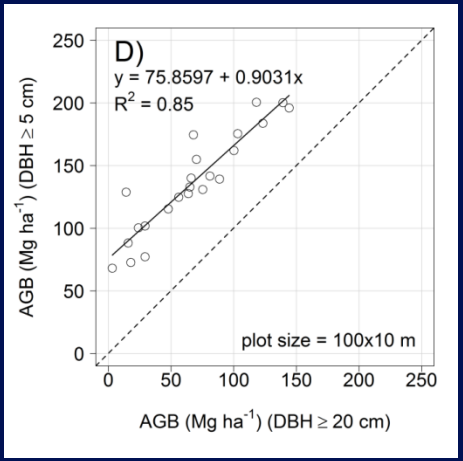


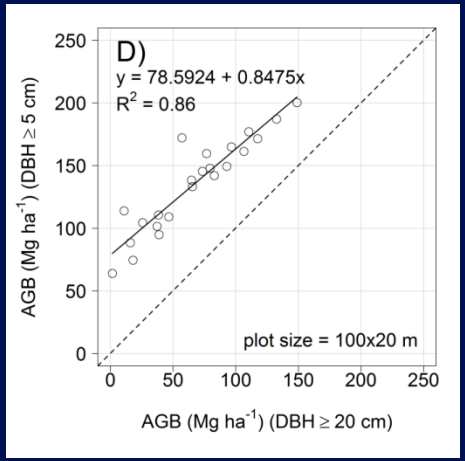


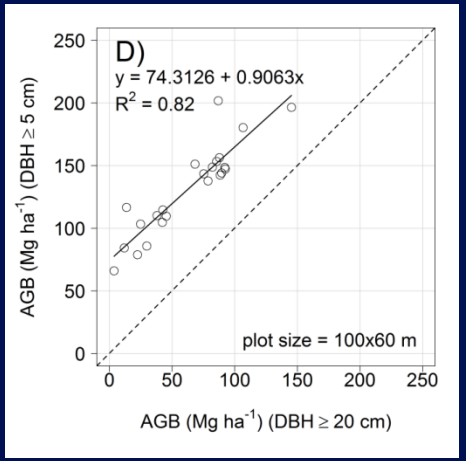


not measuring trees with DBH 5-10 cm:

- ~20 Mg ha^{-1}
- ~15% average AGB







not measuring trees with DBH 5-20 cm:

- ~75 Mg ha^{-1}
- ~55% average AGB

The slope of these relationships is not significantly different from 1 ($\alpha = 0.05$)

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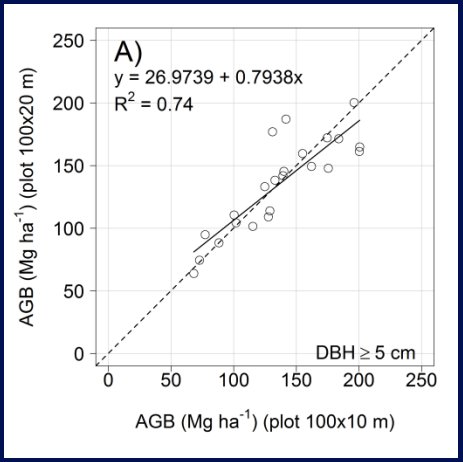
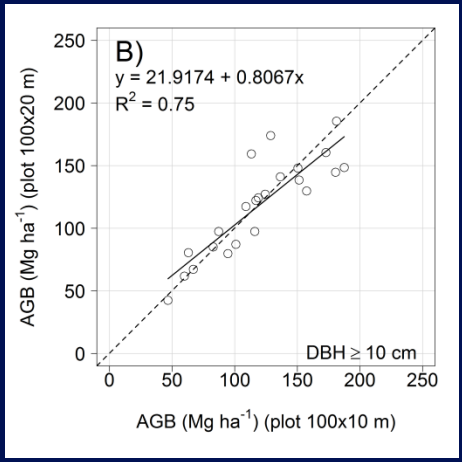
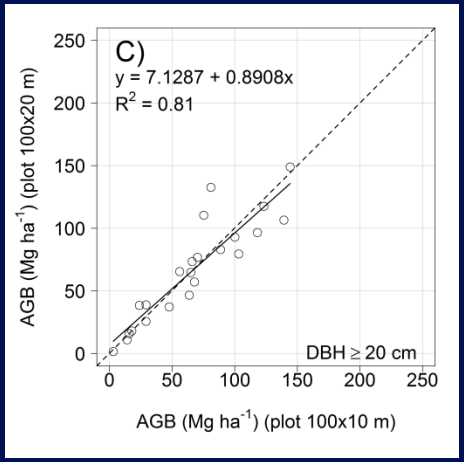
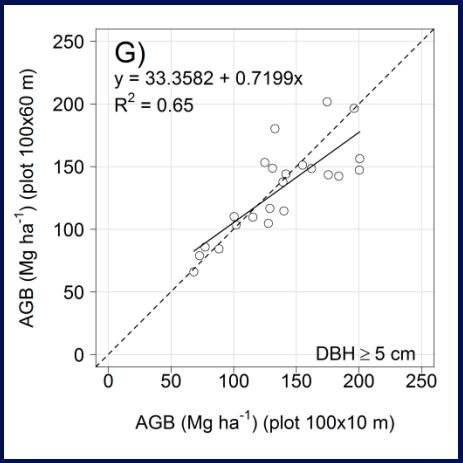
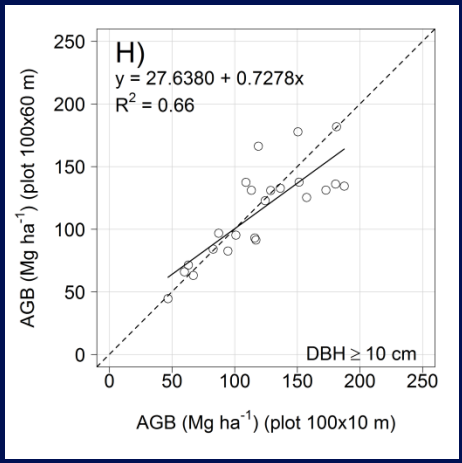
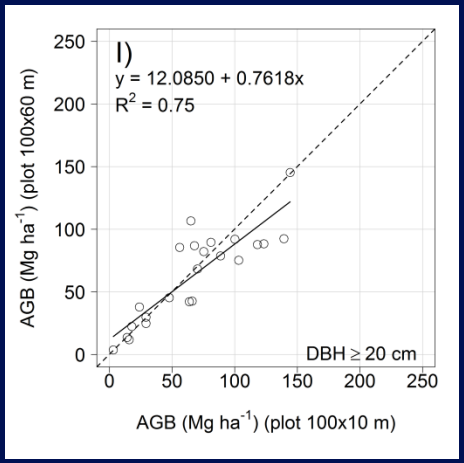




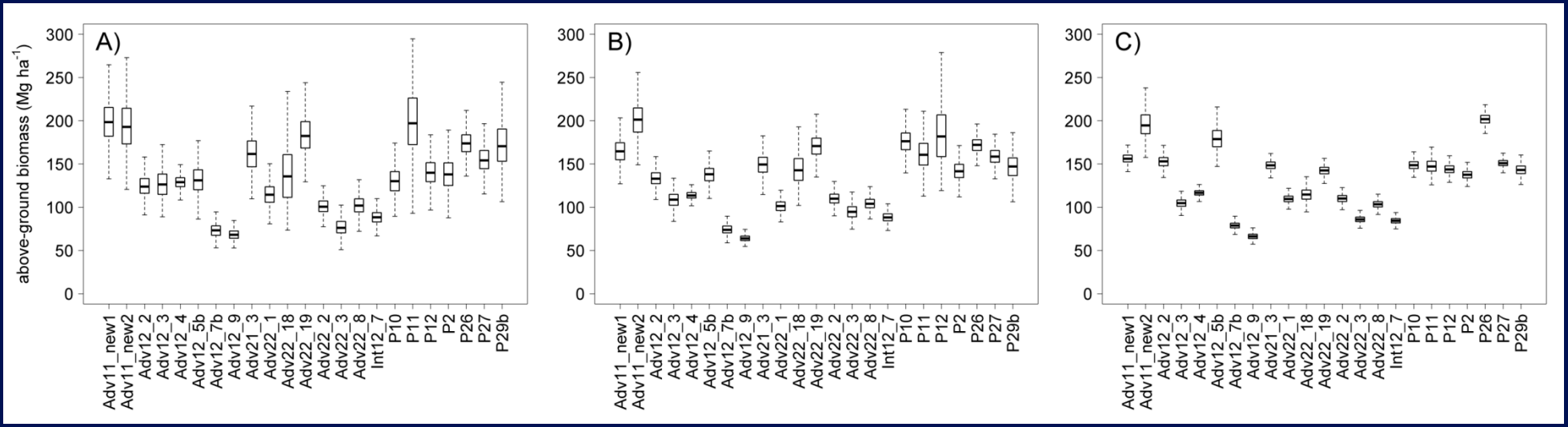






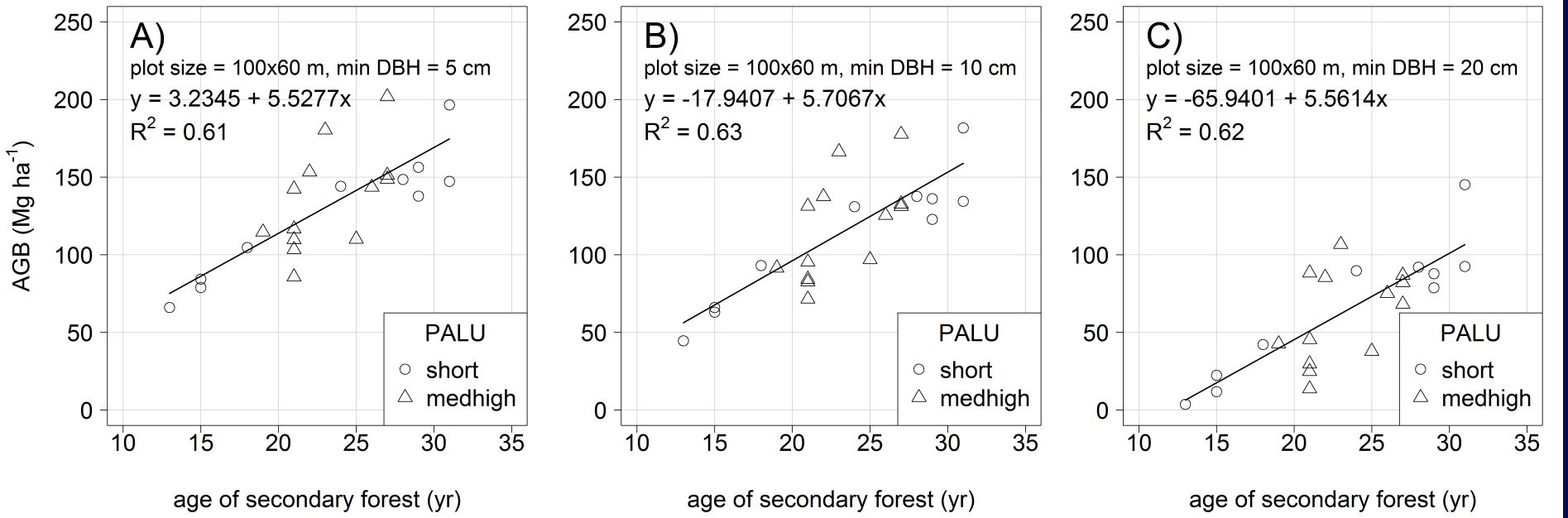


Data sharing



- distribution of above-ground biomass (AGB) values at A) 100x10 m^2, B) 100x20 m^2 and C) 100x60 m^2 plots using a minimum measured diameter at breast height of 5 cm, using 1000 bootstrap samples
- decreased variability around AGB estimates with increased plot size

Data sharing



- above-ground biomass (AGB) as a function of age of secondary forest and for a range of minimum measured diameter at breast height
- period of active land use (PALU): short (≤ 2 yr) and medium-high (>2 yr).
- AGB accumulation rate ~5.5 Mg ha^{-1} yr^{-1} but period of active land use apparently not having an impact on accumulation rate

Project milestones

- Initial maps of AGB of secondary forests and savanna woodlands (*cerrado*) and their changes (mid-2016)

- Validation of above-ground biomass maps of secondary forests and savanna woodlands (*cerrado*), associated error analysis and final map products, including error maps (late 2017)

Deliverables

- Above-ground biomass map of secondary forests over areas of approximately 200x200 km around each regrowth hotspot site (Manaus, Santarém and Machadinho d'Oeste)
- Above-ground biomass map of Cerrado in the eastern part of the municipalities of Barreiras and Luis Eduardo Magalhães, Bahia State
- Change maps for these regions and assessment of their implications for carbon and biodiversity

Carreiras, J.M.B., Jones, J., Lucas, R.M. and Shimabukuro, Y.E. (2017). Mapping major land cover types and retrieving the age of secondary forests in the Brazilian Amazon by combining single-date optical and radar remote sensing data. *Remote Sensing of Environment* (under review).

PALSAR/PALSAR-2 data access

- ALOS PALSAR and ALOS-2 PALSAR-2 over secondary forest and cerrado sites downloaded
- Also, downloaded ALOS-2 PALSAR-2 strip data over the same sites to upscale to larger areas
- Data made available by JAXA is enough to complete the project

Acknowledgements

- JAXA K&C 4: PIKC1621
- JAXA ALOS 4th RA: PI1208
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- UK NERC National Centre for Earth Observation (NCEO)
- United States Geological Survey (USGS)

Thank you!!!
Questions?