Spatially Explicit Sources and Sinks of Carbon from Deforestation, Growth and Degradation in the Tropics

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Outline

- Aboveground carbon loss
  - Remote sensing based stratification and deforestation combined with GLAS biomass
  - IPCC good practices
  - Results
- Aboveground carbon density loss and gain
  - "Direct" carbon density change
    - Change point analysis of biomass time series
    - Based on GLAS and MODIS biomass
  - Results

Stratification Based Biomass Loss

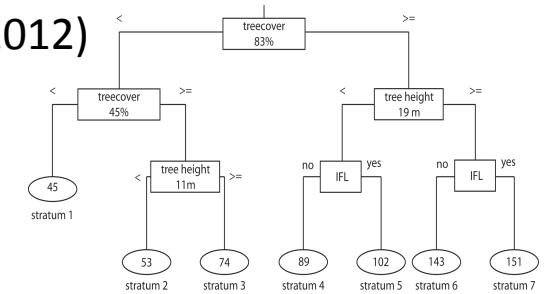
$$Emissions = AD * EF$$

$$AGCloss = \sum AD_i * EF_i$$

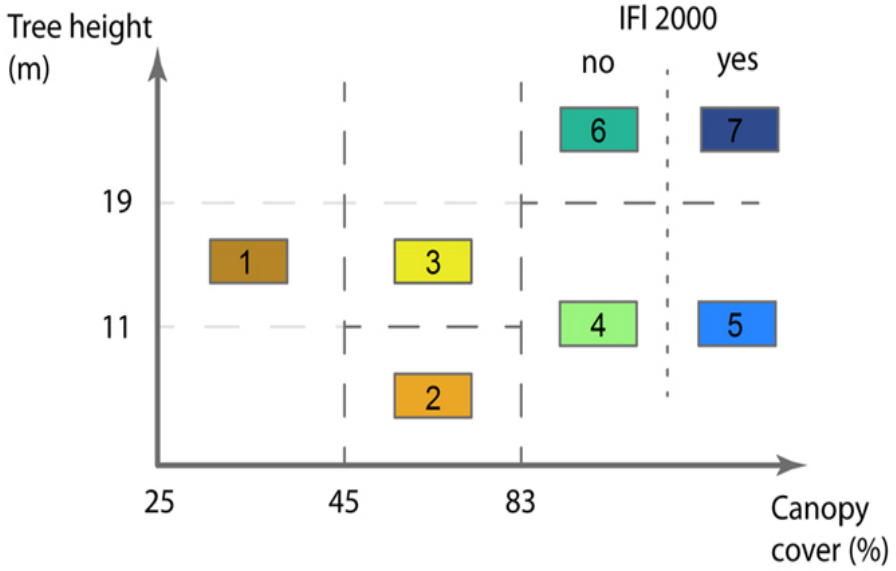
- Forest cover loss map (AD)
  Hansen et al. 2013

- Forest cover stratification for year 2000 (prior to disturbance)
  - Canopy cover
  - Tree height
  - IFL (intact forest)

- Mean carbon density estimate for each forest stratum (EF) (Baccini et al. 2012)

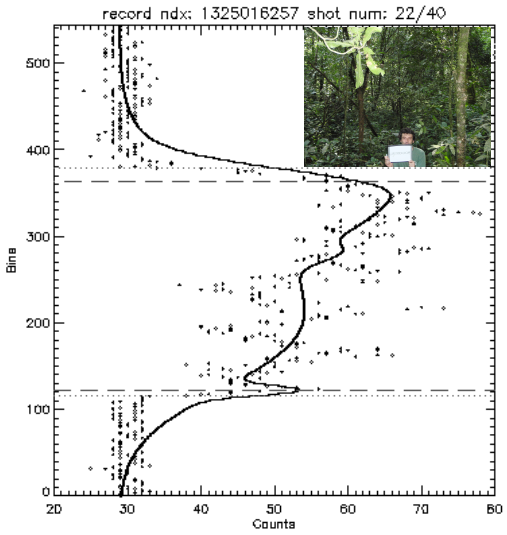


Tree based strata AGC density values (MgC/ha)

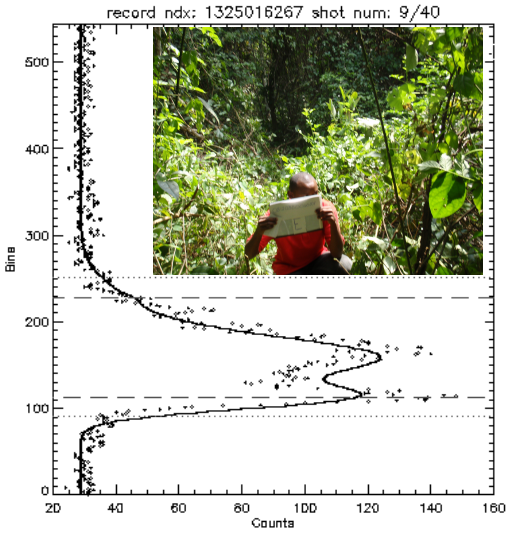


1 – low cover
2 – medium cover short
3 – medium cover tall
4 – dense cover short
5 – dense cover short intact
6 – dense cover tall
7 – dense cover tall intact

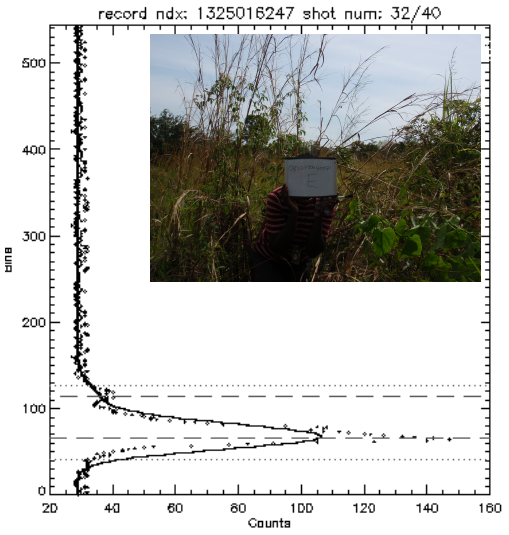
GLAS Co-located Field Measurements



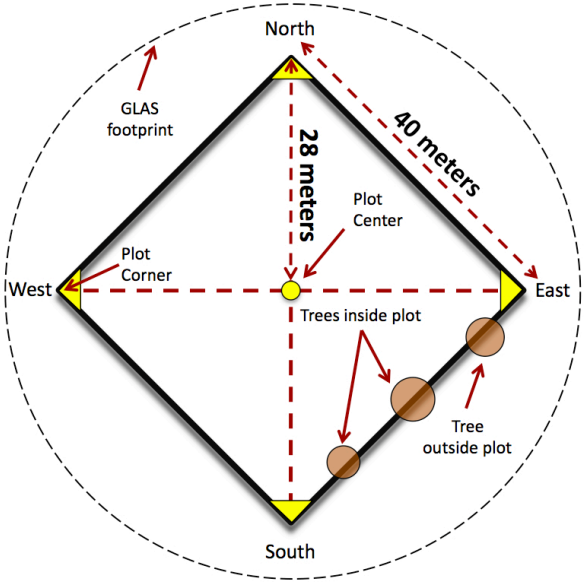
Biomass = 205 (t/ha)



Biomass = 78 (t/ha)



Biomass = 30 (t/ha)

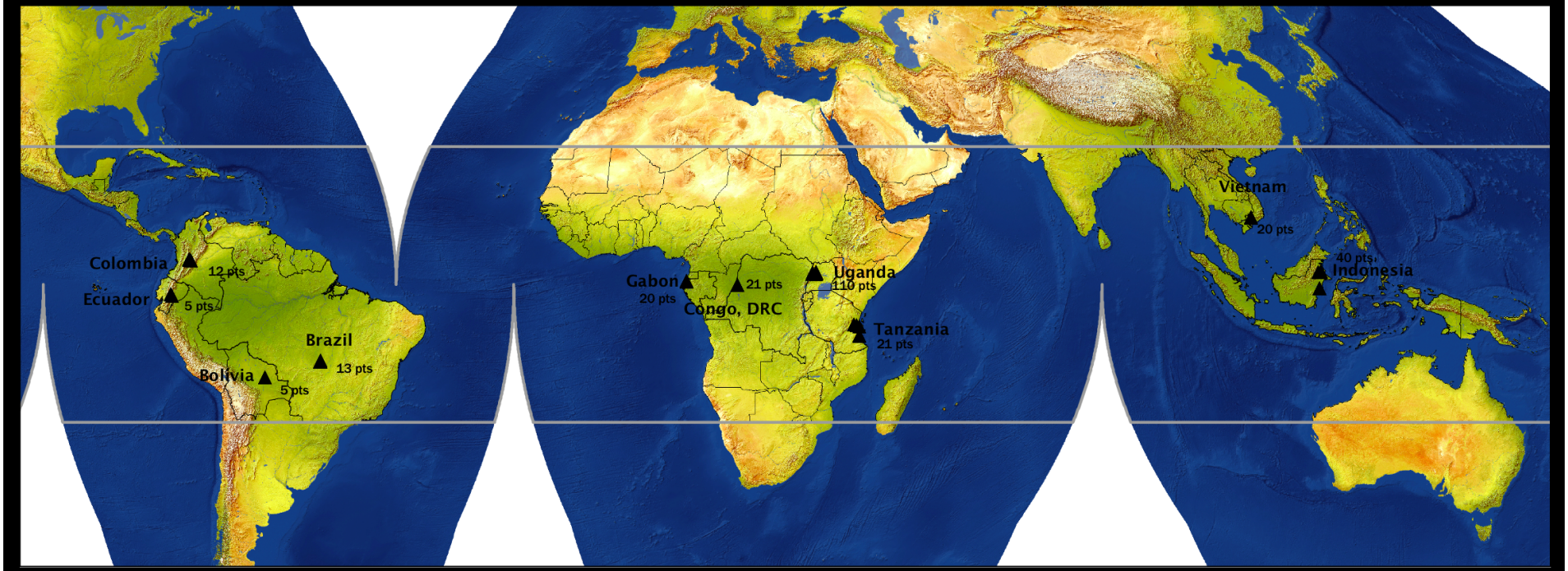


Attributes of Budongo_ForestPlots

FID	Shape	ID	plot_id	Plot	Country_Co	GPS_lat	GPS_lon	Biomass
0	Point	143	08120280029857	29857	800	2.1812	31.75978	59.692494
1	Point	141	08120280029858	29858	800	2.17958	31.75955	35.817075
2	Point	142	08120280029859	29859	800	2.17806	31.75935	37.378829
3	Point	138	08120280029860	29860	800	2.17181	31.75848	72.939635
4	Point	137	08120280029861	29861	800	2.17028	31.75828	37.492761
5	Point	112	08112880029862	29862	800	2.16245	31.75718	36.310185
6	Point	116	08112880029863	29863	800	2.16091	31.75694	36.58397
7	Point	113	08112880029864	29864	800	2.15935	31.75671	38.610336
8	Point	117	08112880029865	29865	800	2.15781	31.7565	35.746995
9	Point	114	08112880029866	29866	800	2.15623	31.75631	28.751374
10	Point	115	08112880029867	29867	800	2.15469	31.75607	35.632561
11	Point	118	08112880029868	29868	800	2.15314	31.07588	35.769245
12	Point	134	08120180029881	29881	800	2.11412	31.75065	62.794605
13	Point	130	08120180029882	29882	800	2.1126	31.75038	43.535527
14	Point	133	08120180029883	29883	800	2.11104	31.75018	88.086729

Field observation network & calibration

>300 locations > 30,000 trees measured



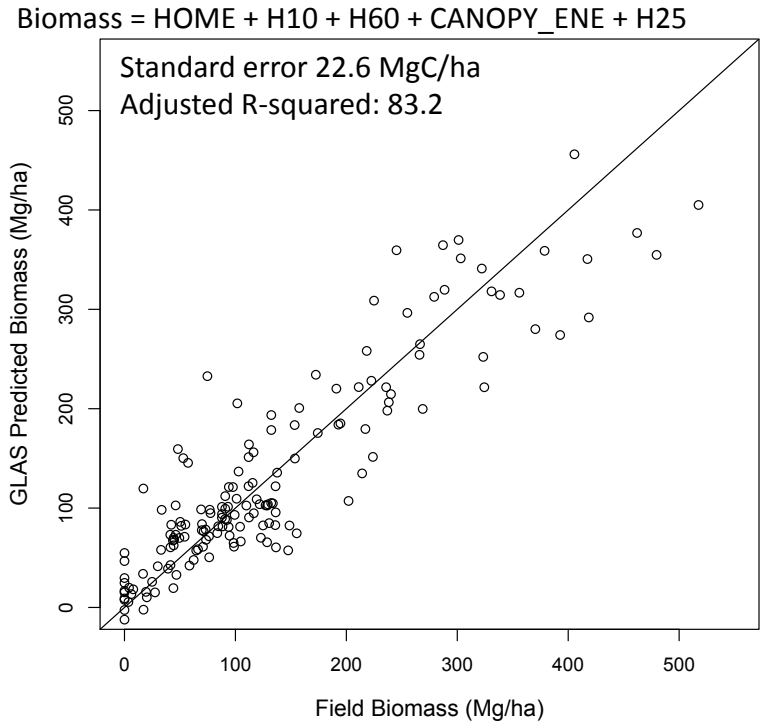
- Columbia
- Ecuador
- Bolivia
- Brazil

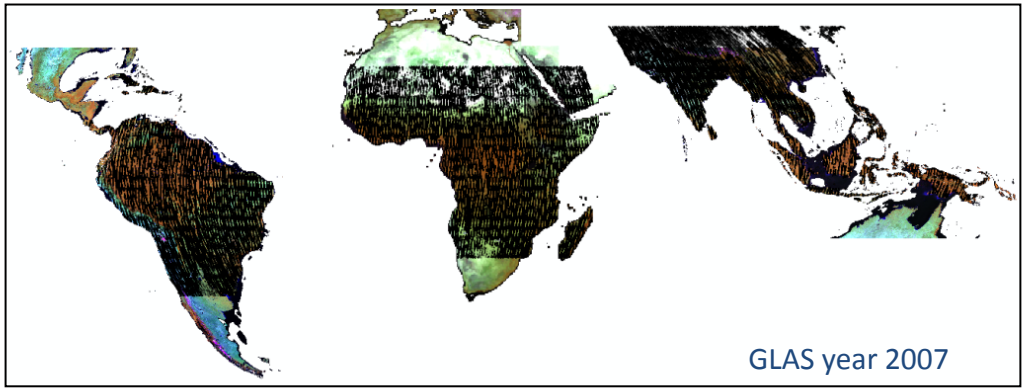
- Gabon
- DRC
- Uganda
- Tanzania

- Vietnam
- Cambodia
- Indonesia

Aboveground Biomass from LiDAR (GLAS)

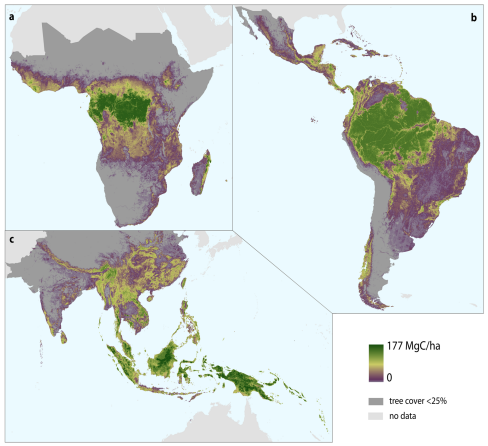
- Biomass estimates at each GLAS location
- Height and metrics from GLAS waveform





Results – Stratification Based

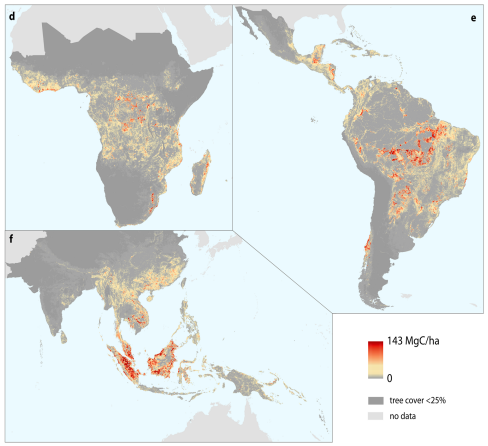
Biomass strata map



Forest area change (AD)
Hansen et al 2013

$$AGCloss = \sum AD_i * EF_i$$

Biomass loss map



	Period (2000s)	Annual gross loss (TgC/yr)					
		AGC		AGC + BGC			
		current study		Harris et al. 2012		Achard et al. 2014	
		estimate	range	median	range	average	range
Africa	00-05	234	190 - 278	116	54 - 218	148	44 - 221
	05-10			-	-		
	10-12			-	-	-	-
Latin America	00-05	442	409 - 475	440	309 - 674	465	323 - 650
	05-10			-	-		
	10-12			-	-	-	-
South and Southeast Asia	00-05	346	314 - 378	257	208 - 345	267	236 - 367
	05-10			-	-		
	10-12			-	-	-	-
Pan-tropical total	00-05	1022	958 - 1086	813	570 - 1220	880	602 - 1237
	05-10			-	-		
	10-12			-	-	-	-

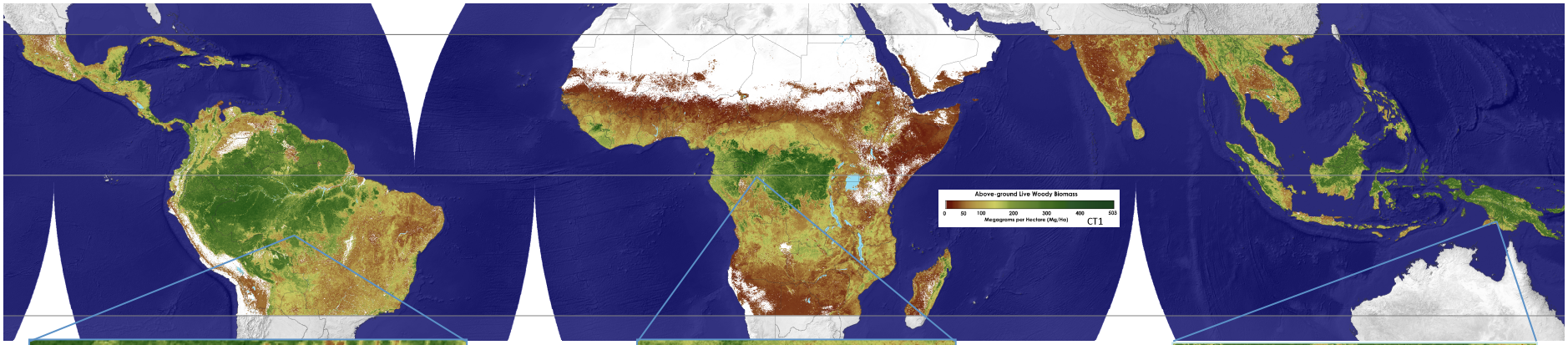
“Direct” Biomass loss and gain

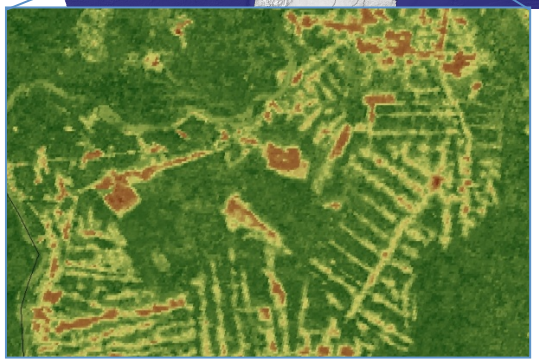
Baccini et al. 2012

Error 25 Mg C ha^{-1}

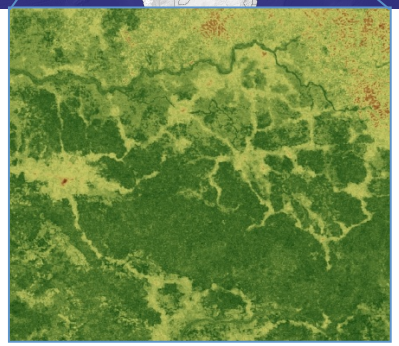
Error 19 Mg C ha^{-1}

Error 24 Mg C ha^{-1}

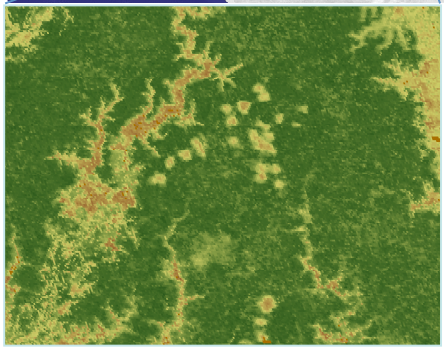




Amazon Basin detail from the map



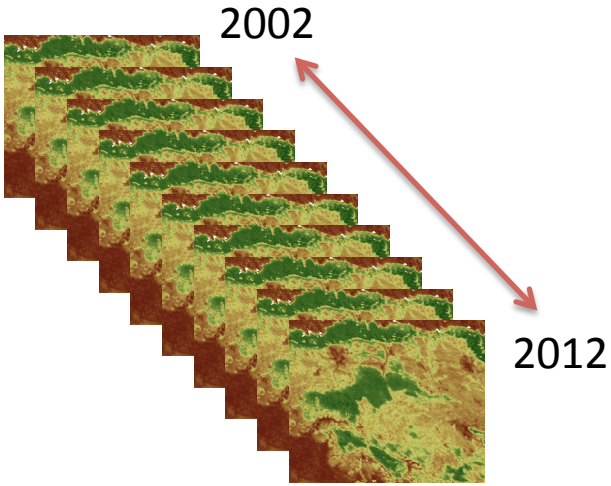
DRC detail from the map

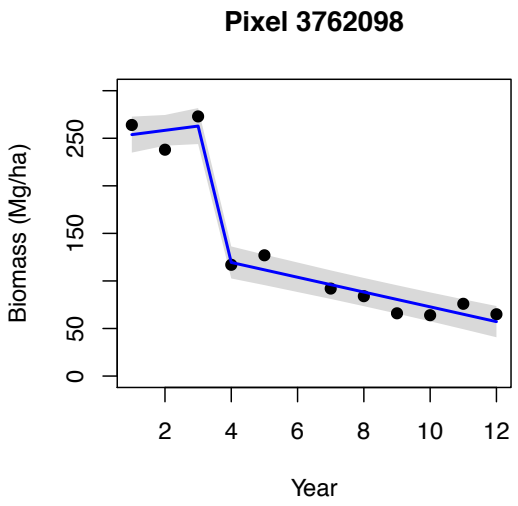


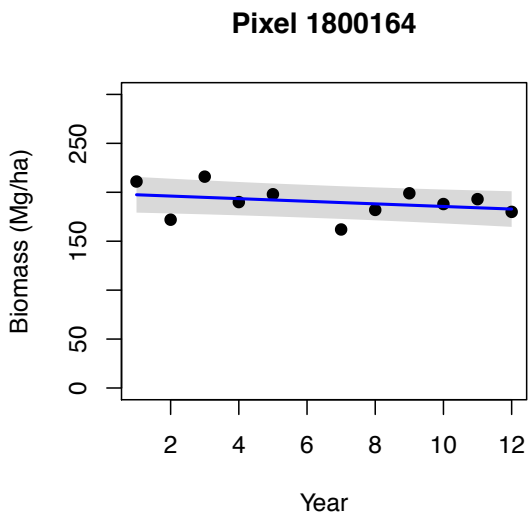
PNG detail from the map

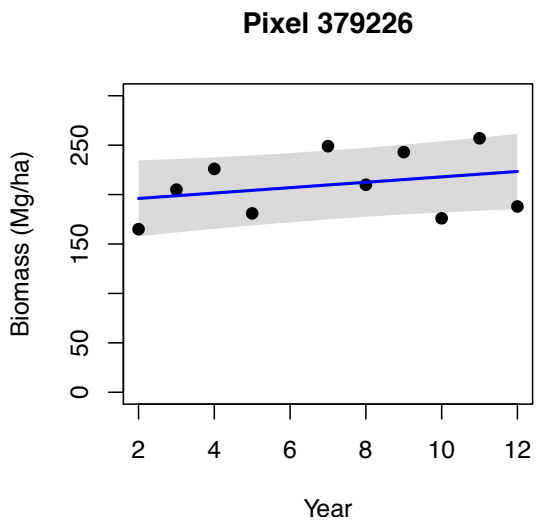
Carbon density trajectories over time and space

- Time series approach based on “change point” analysis
- For each 500 m x 500 m pixel we identify the trajectory of carbon density

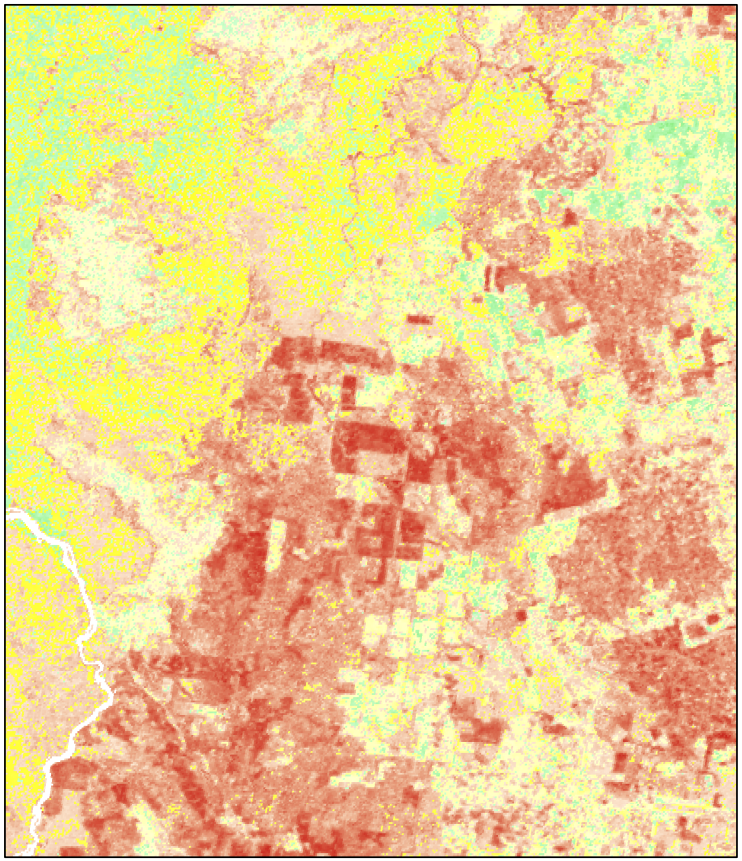




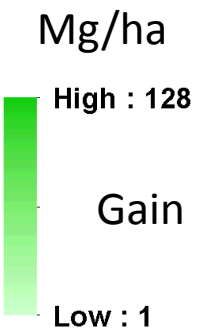


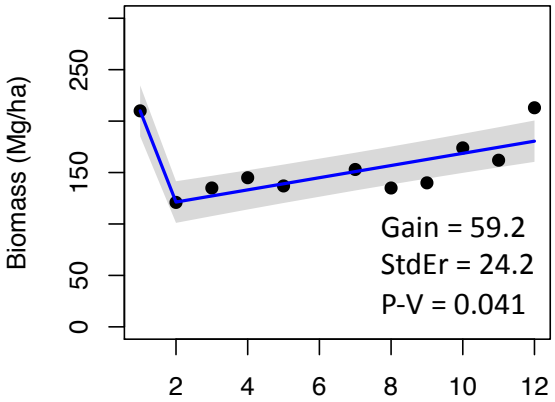


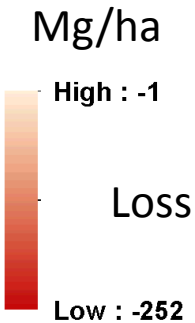
Continuous spatially explicit carbon density change

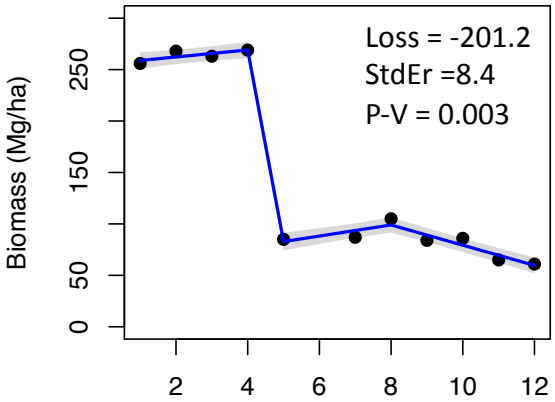


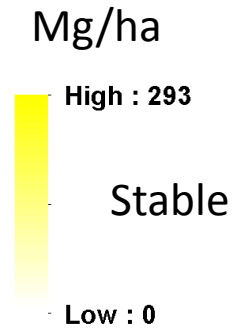
190 km x 215 km

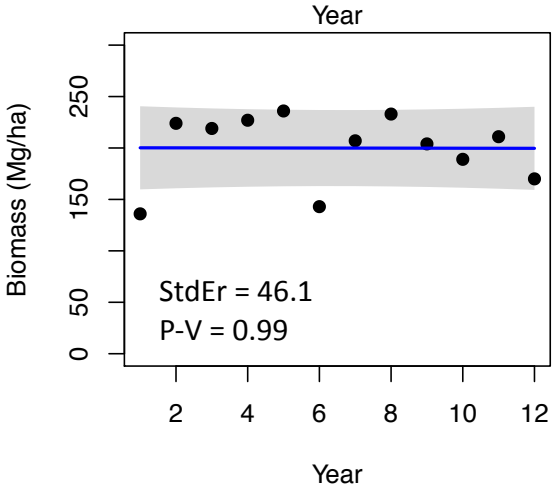






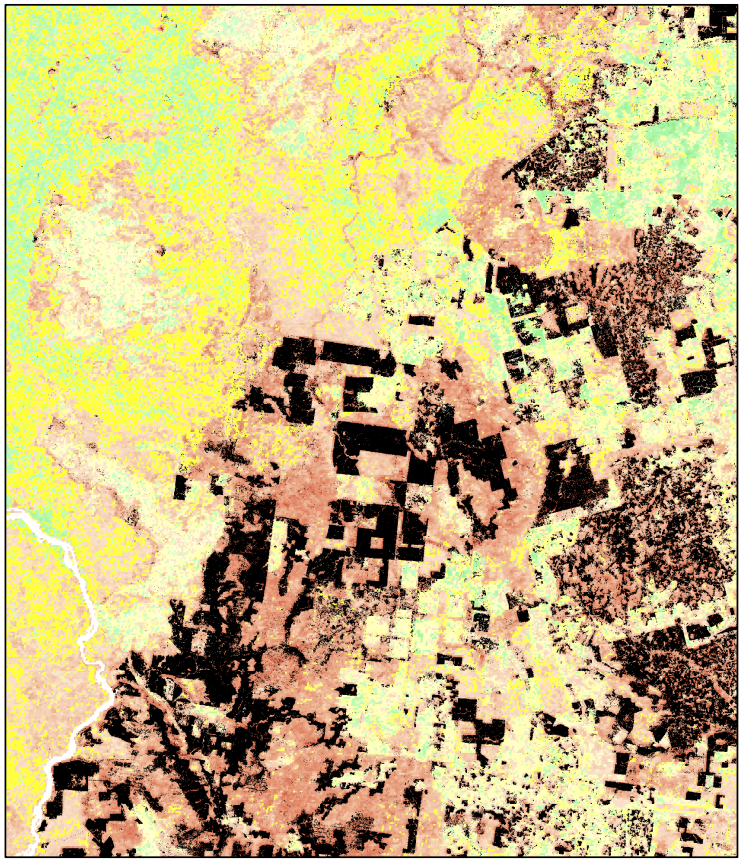






Consistent with deforestation and sensitive to “degradation” ?

Deforestation Landsat baased (30 m resolution)
Hansen et al. 2014



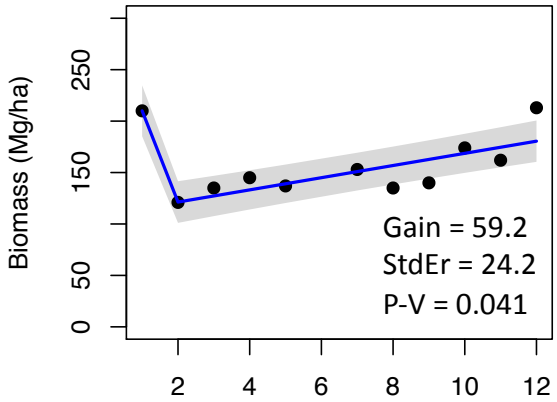
190 km x 215 km

Mg/ha

High : 128

Gain

Low : 1

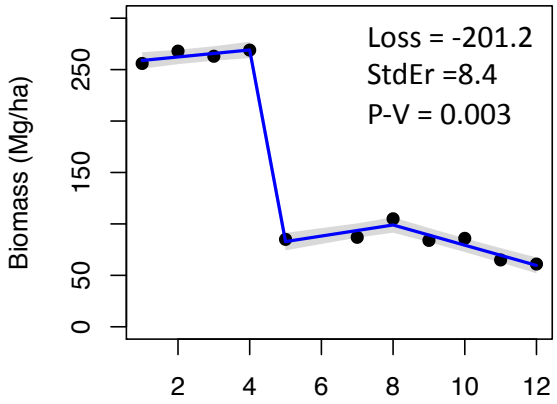


Mg/ha

High : -1

Loss

Low : -252

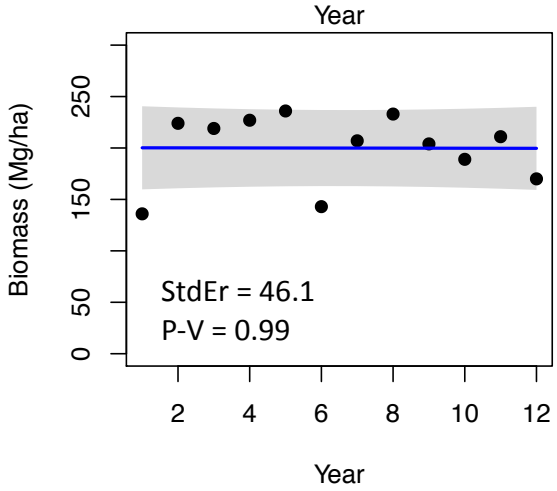


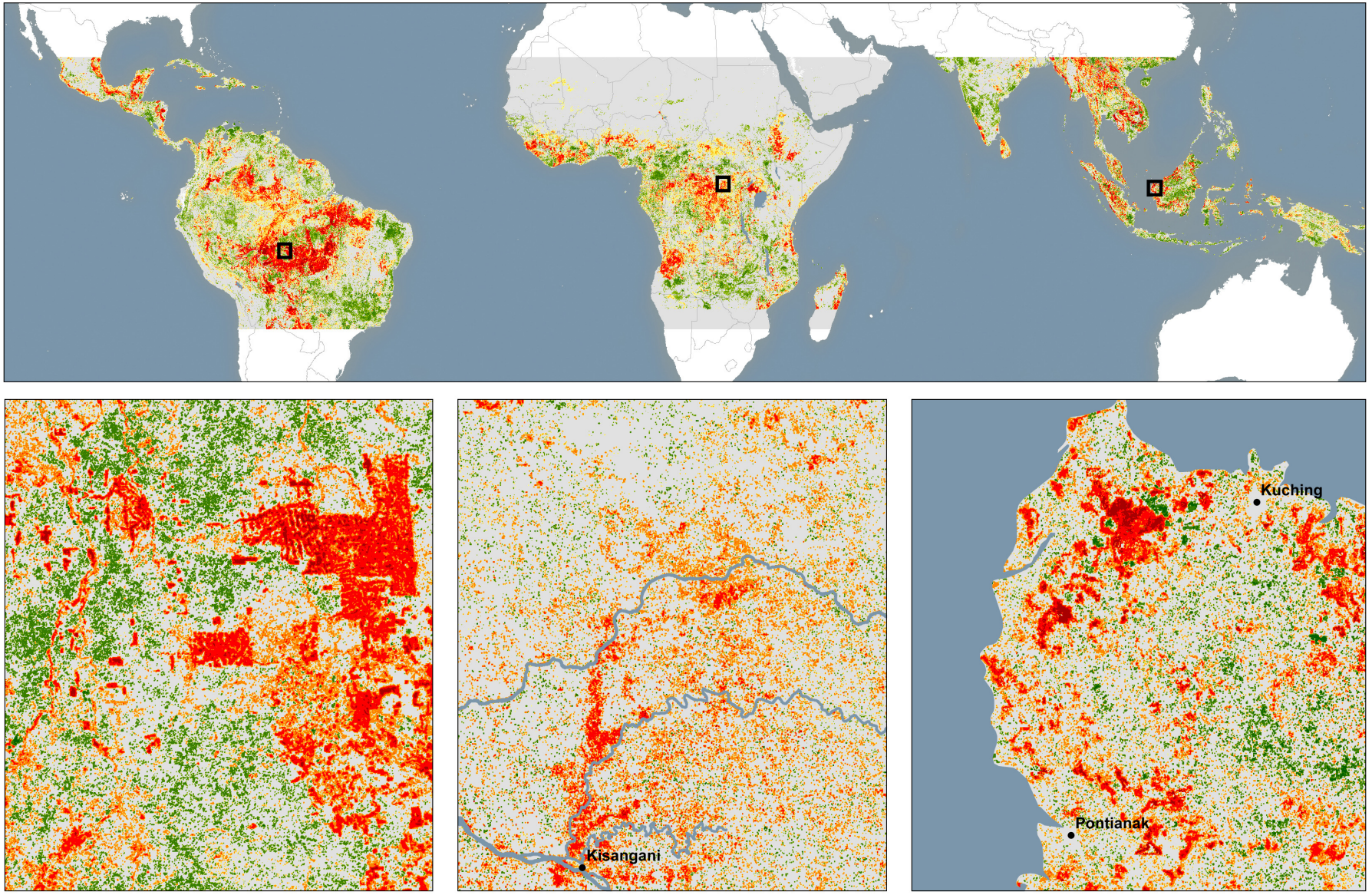
Mg/ha

High : 293

Stable

Low : 0




Kisangani
Kuching
Pontianak
0
50
100 km
Carbon Loss/Gain 2002-2012
<-250
-50
0
50
>150
tonnes per hectare

Summary

- Stratification approach, simple, scalable, endorsed by IPCC
- “Direct” approach globally consistent, continuous, no need for strata and land cover change products
- Sensitive to losses (deforestation, degradation, natural disturbance) and gain (growth, reforestation, and afforestation)
- Fewer inputs resulting in smaller uncertainty
- Difficult to provide attribution (Deforestation or Degradation?). Do we need to?

Thank you!