GlobBiomass WP5000
Regional Case Study Mexico

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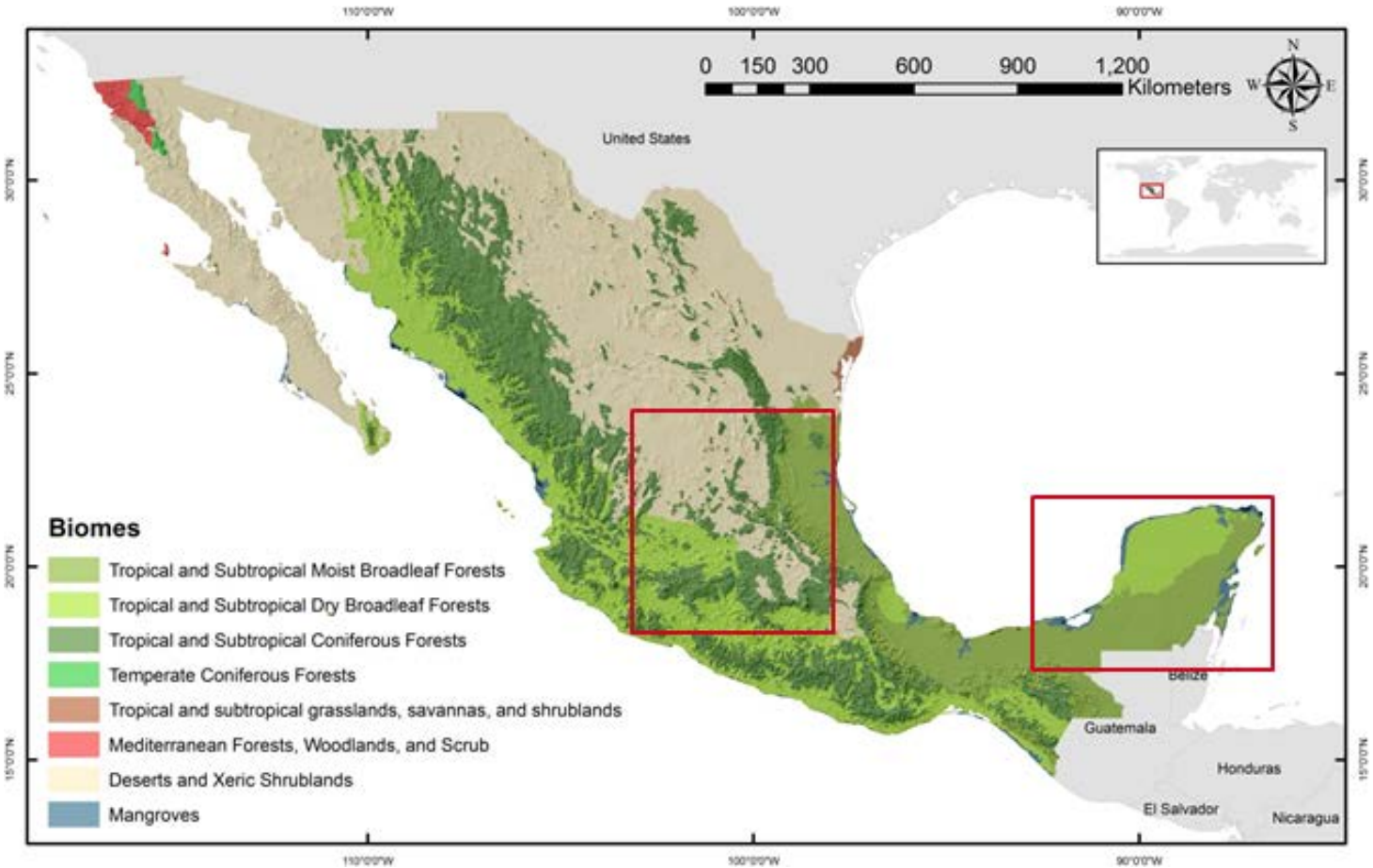
GlobBiomass User Workshop
September 2017
FAO, Rome

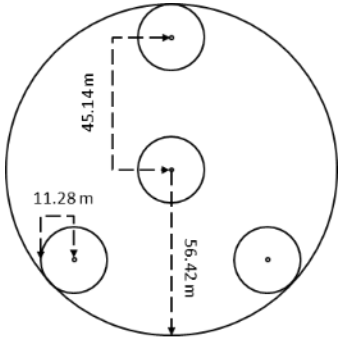
Study areas


0 150 300 600 900 1,200
Kilometers
N
S
W
E
United States
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Biomes
Tropical and Subtropical Moist Broadleaf Forests
Tropical and Subtropical Dry Broadleaf Forests
Tropical and Subtropical Coniferous Forests
Temperate Coniferous Forests
Tropical and subtropical grasslands, savannas, and shrublands
Mediterranean Forests, Woodlands, and Scrub
Deserts and Xeric Shrublands
Mangroves

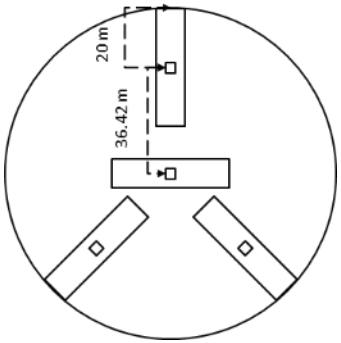
In-situ AGB data (INFyS)

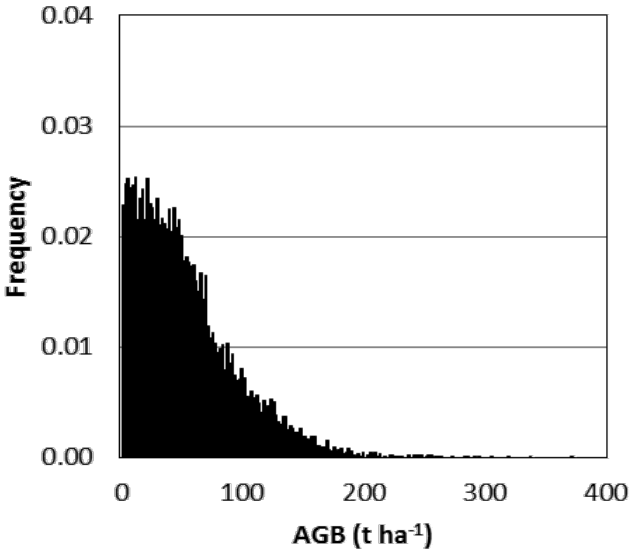
- Circa 26,000 primary sampling units (1 ha) with 4 x 400 m^2 subplots measured by CONAFOR (2004 to 2012)
- Approximately 6,000 available for the study areas
- Independent Validation dataset (not used for training the algorithm): 15% of the INFyS data
- A total of 339 biomass allometric equations and 214 species-specific wood densities were used by CONAFOR to estimate AGB

Forest and arid vegetation



Tropical forest and Mangroves





Spatial Datasets

DATASET	Spatial resolution	Number of Looks	2005	2010	2015
ALOS PALSAR	25 m	16	x	x	
ALOS-2 PALSAR-2*	25 m	16			x
Landsat PTC*	30 m	N/A	x	x	x
Landsat 7 ETM+ SR	30 m	N/A	x	x	
Landsat 8 OLI SR	30 m	N/A			x
SRTM Plus (NASA V3)	30 m	N/A	x	x	x
Sentinel-1 Dual Polarisation IW Mode	5 m x 20 m	5x1 (4.9 ENL)			x

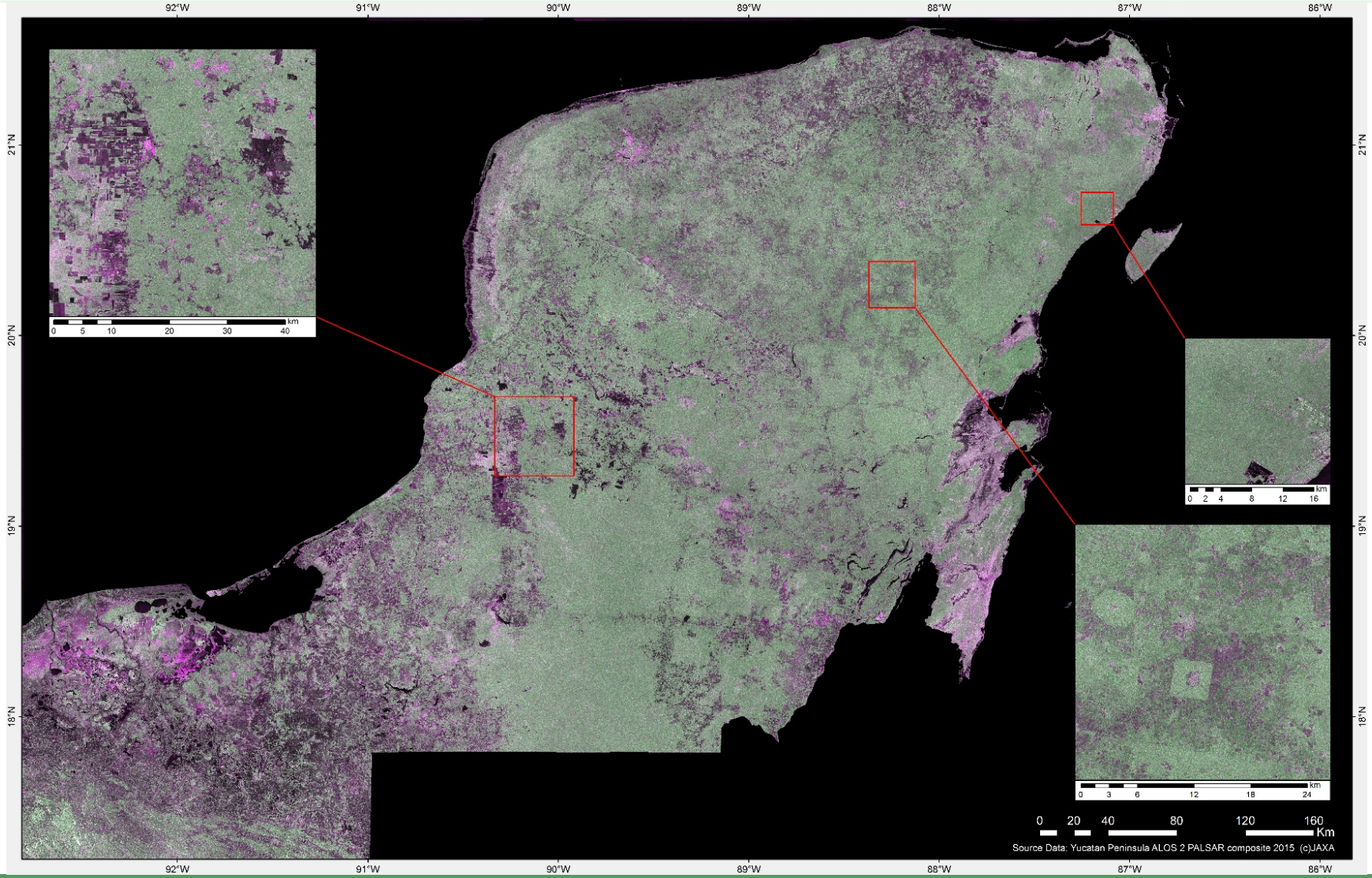
Spatial Datasets

- Sentinel-1 annual composites (±1 year)
  - Composites generated using Google Earth Engine (GEE) Playground
  - Ground Range Data (Thermal noise removal, radiometric calibration, terrain correction using SRTM 30)
  - Pixel value corresponds to the 50% percentile of the annual observations. Values clamped to 1st and 99th percentile to preserve the dynamic range against anomalous outliers
- Landsat 7/8 Surface Reflectance (SR) annual composites (±1 year)
  - Composites generated using Google Earth Engine (GEE) Playground
  - Exclusion of pixels based on QA layers (i.e. cloud pixels, etc)
  - Pixel value corresponds to the 50% percentile of the annual observations (median)

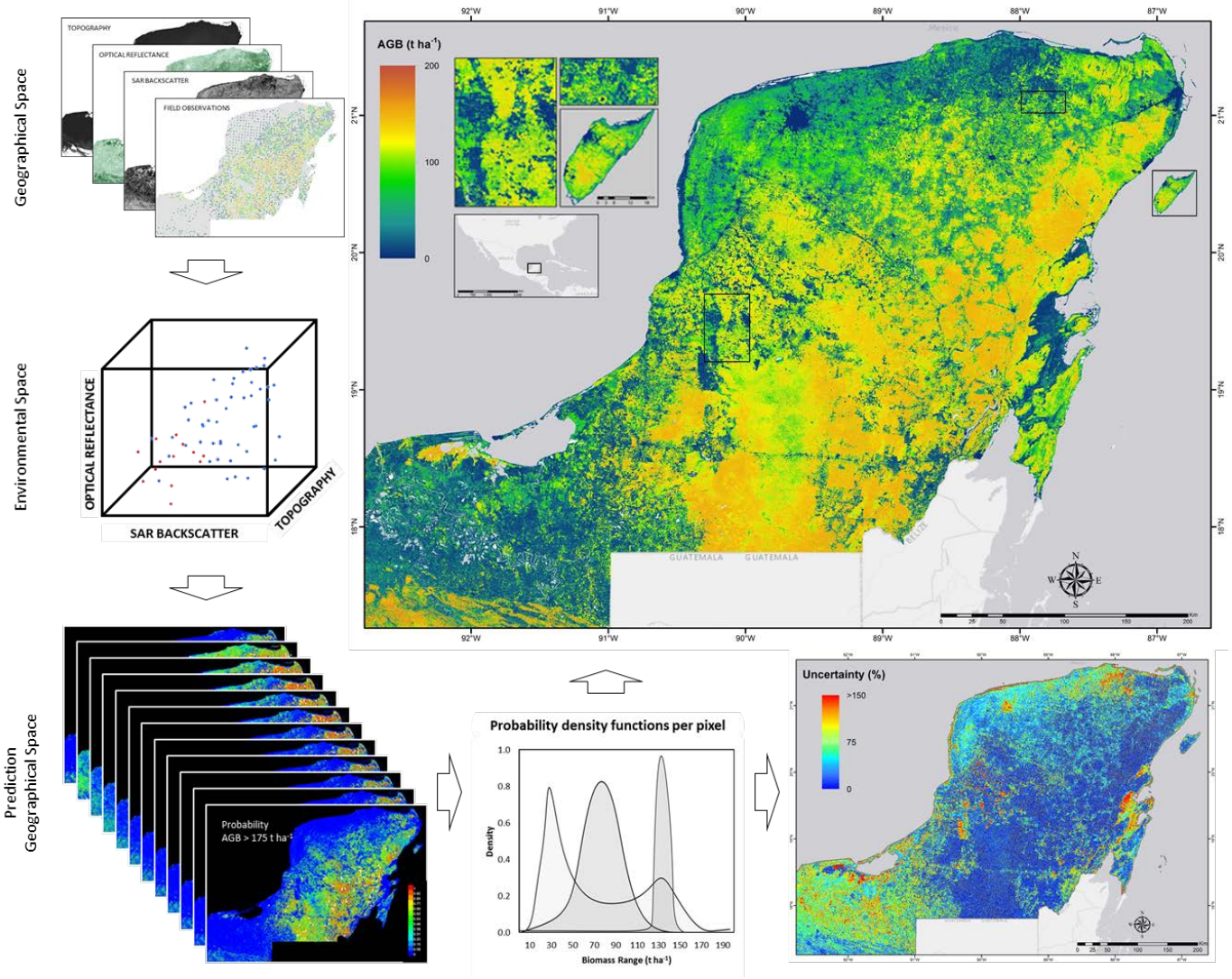
Spatial Datasets

- ALOS PALSAR / ALOS-2 PALSAR-2 Mosaics
  - Standard SAR pre-processing (Shimada et al., 2014): Calibration, multi-looking (output of 16 looks), projection, ortho-rectification, slope correction using SRTM DEM and an additional destriping process (Shimada and Isoguchi, 2002)
  - Multi-channel filtering (7x7 window) using annual mosaics to reduce speckle
  - Correction of remaining striping effects (due to image acquisition in different soil moisture conditions) using previous/later year and linear regression from non-affected neighbouring stripes
  - Reprocessed version of PALSAR-2 2015 released on 27.04.2017
- Additional Spatial Datasets
  - Landsat Tree cover (Hansen et al. 2013)
  - Global Surface Water dataset (Pekel et al., 2016)
  - Land Use and Vegetation series III (2002-2005) , IV (2007-2008), & V (2013-2015)

Spatial Datasets



MaxEnt



Maximum Entropy Classifier

Maximum probability weighted mean

$$\widehat{AGB} = \frac{\sum_{i=1}^{N} P_i^n AGB_i}{\sum_{i=1}^{N} P_i^n}$$

Prediction Error

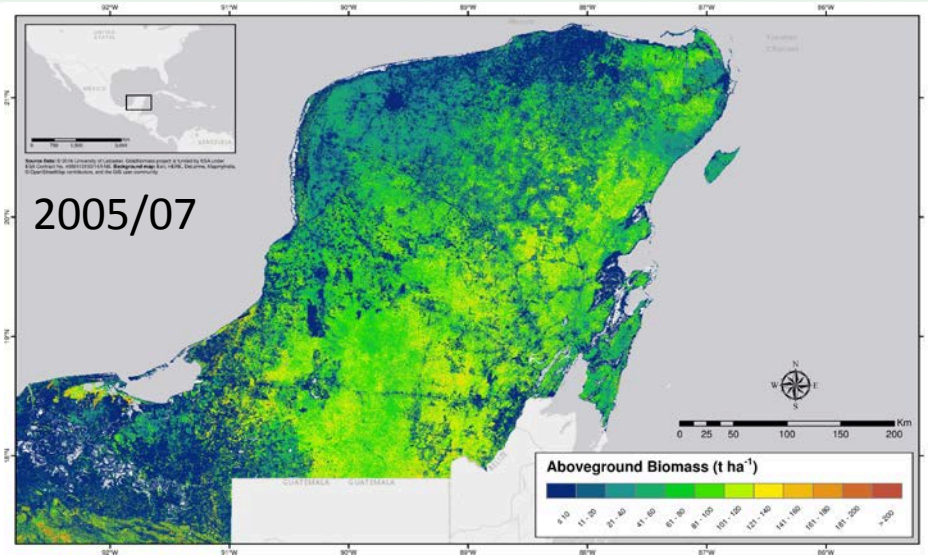
$$\varepsilon_{prediction} = \sigma_{\widehat{AGB}} / \widehat{AGB}\, x100$$

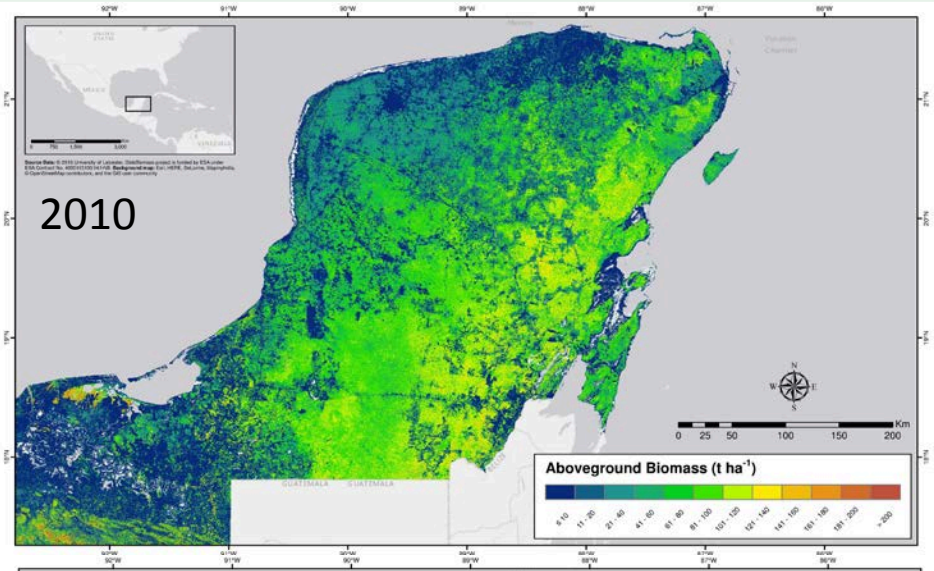
$$\sigma_{\widehat{AGB}} = \sqrt{\frac{\sum_{i=1}^{N} (AGB_i - \widehat{AGB})^2 P_i}{\sum_{i=1}^{N} P_i}}$$

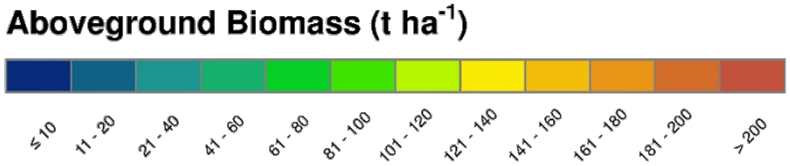
Error Propagation

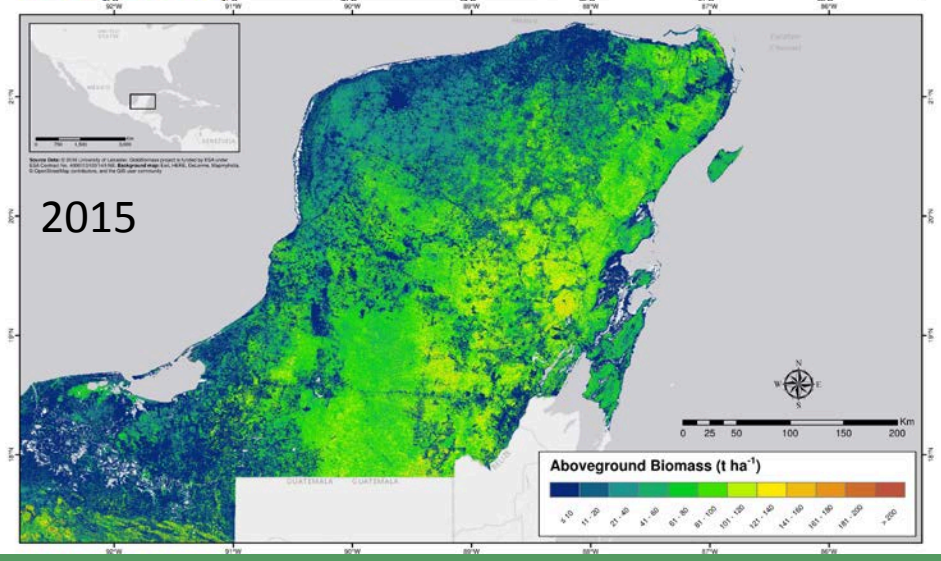
$$\varepsilon_{AGB} = (\varepsilon_{measurement}^2 + \varepsilon_{allometry}^2$$

Biomass maps



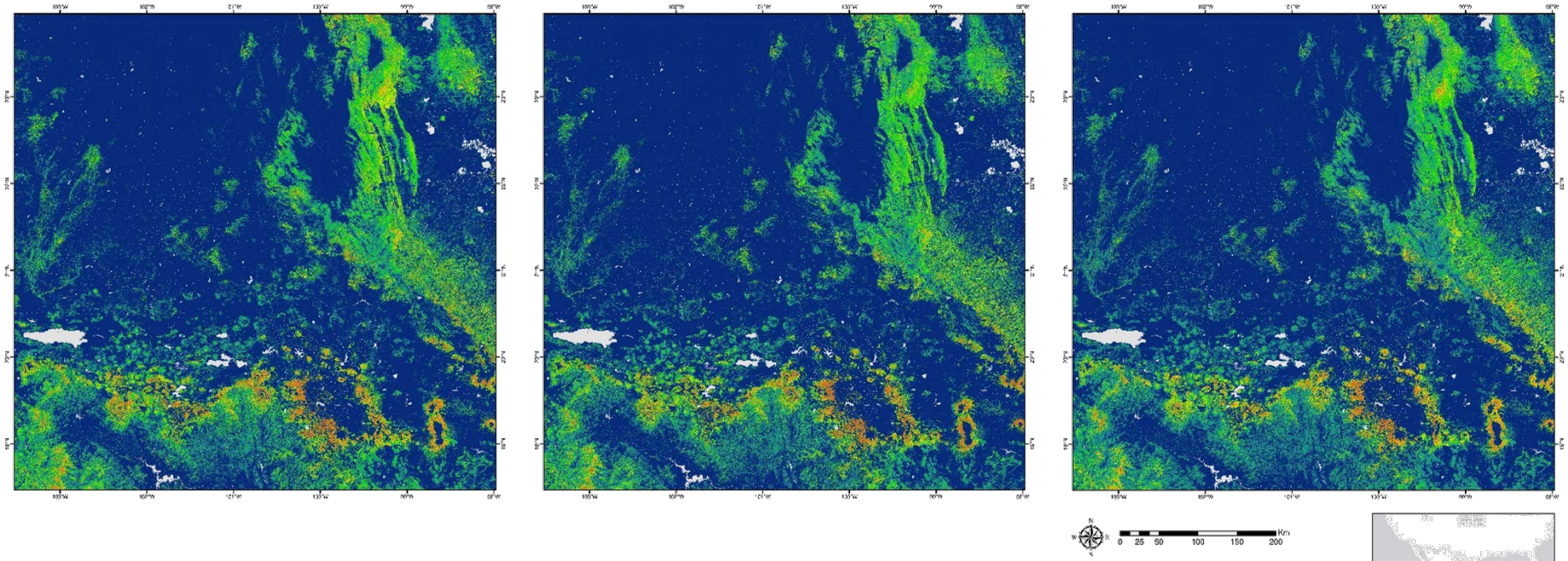




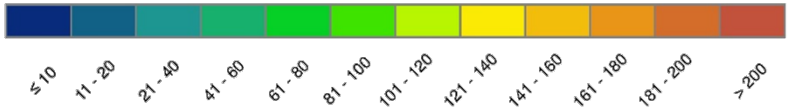


Central Mexico

2005/07 2010 2015

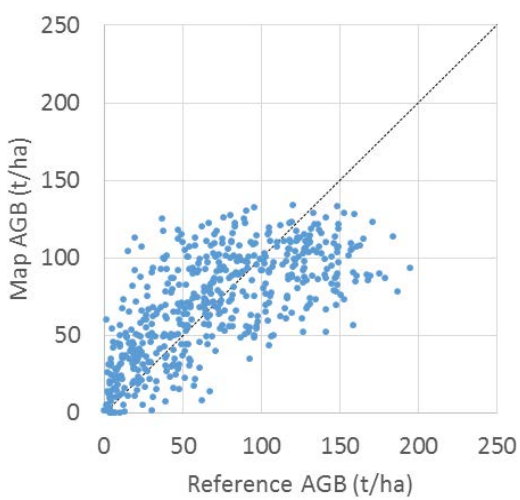


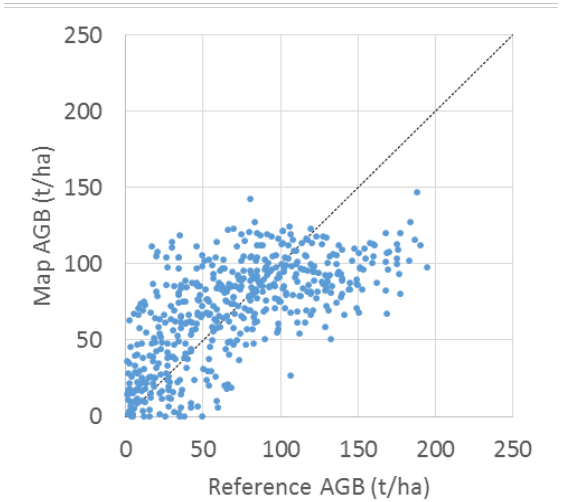
Aboveground Biomass (t ha^{-1})

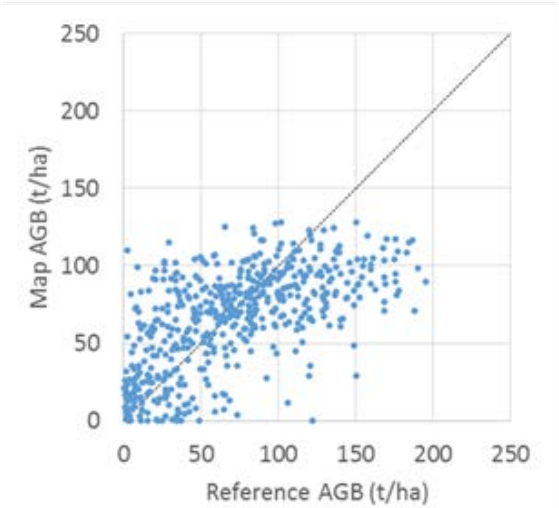


Yucatan Peninsula

2005-07				2010				2015			
AGB Ranges	RMSE (t/ha)	SD (t/ha)	Bias (t/ha)	AGB Ranges	RMSE (t/ha)	SD (t/ha)	Bias (t/ha)	AGB Ranges	RMSE (t/ha)	SD (t/ha)	Bias (t/ha)
0-30	28.8	20.7	20.0	**0-30**	33.2	26.0	20.7	**0-30**	34.9	27.3	21.8
30-60	33.0	28.3	17.0	**30-60**	33.4	29.8	15.2	**30-60**	31.0	28.8	11.6
60-90	24.5	22.8	9.1	**60-90**	23.1	22.3	6.3	**60-90**	21.4	21.4	-0.2
90-120	29.1	23.3	-17.3	**90-120**	25.0	21.0	-13.5	**90-120**	31.7	23.8	-20.9
120-150	41.5	20.6	-36.0	**120-150**	45.8	17.5	-42.3	**120-150**	51.5	23.3	-45.9
> 150	71.4	21.5	-68.1	**> 150**	67.2	15.9	-65.3	**> 150**	74.9	20.8	-72.0
Overall	**34.1**	**34.1**	**-0.3**	**Overall**	**35.2**	**35.2**	**-1.3**	**Overall**	**37.6**	**37.2**	**-5.2**





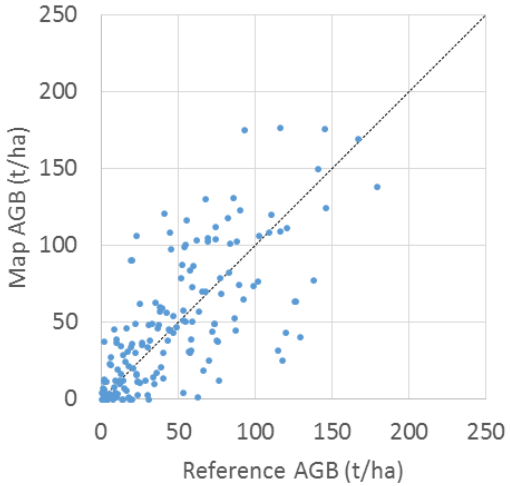


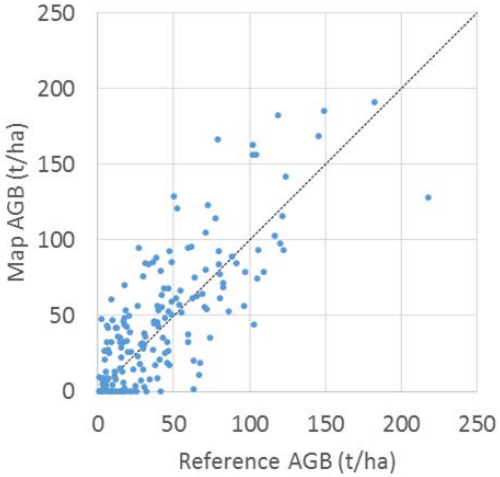
Central Mexico

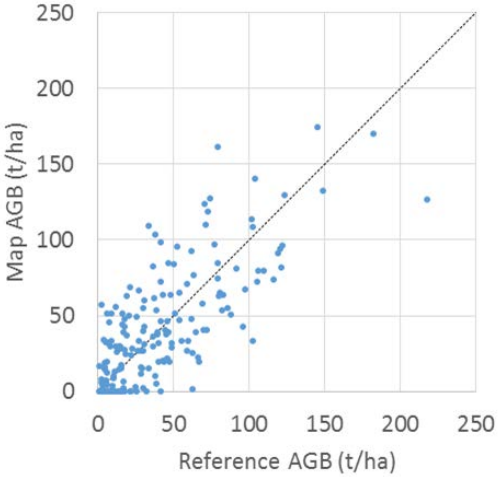
2005-07			
AGB Ranges	RMSE (t/ha)	SD (error) (t/ha)	Bias (t/ha)
0-30	21.32	20.37	6.30
30-60	28.69	28.00	6.26
60-90	34.88	34.73	-3.22
90-120	49.31	48.92	-6.24
120-150	54.77	39.07	-38.38
> 150	29.13	21.59	-19.56
Overall	**31.31**	**31.30**	**0.89**

2010			
AGB Ranges	RMSE (t/ha)	SD (error) (t/ha)	Bias (t/ha)
0-30	20.69	19.49	6.95
30-60	29.64	28.54	8.03
60-90	34.09	33.93	-3.33
90-120	41.86	41.83	1.69
120-150	24.33	24.07	3.57
> 150	63.87	49.31	-40.59
Overall	**28.15**	**27.75**	**4.77**

2015			
AGB Ranges	RMSE (t/ha)	SD (error) (t/ha)	Bias (t/ha)
0-30	19.98	18.72	6.99
30-60	27.68	27.62	1.75
60-90	36.87	36.59	-4.58
90-120	35.81	28.12	-22.18
120-150	26.10	23.07	-12.21
> 150	64.97	39.72	-51.42
Overall	**27.37**	**27.36**	**0.61**

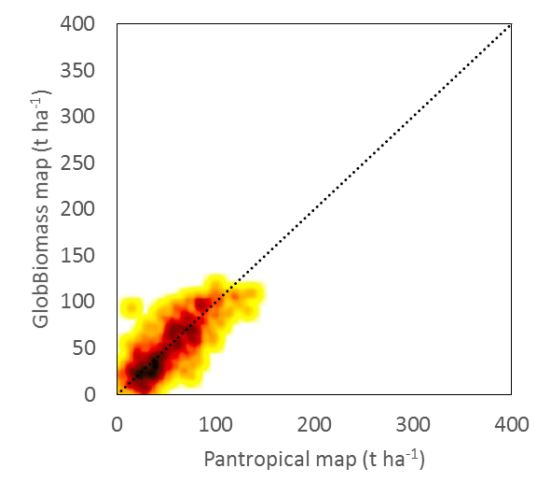




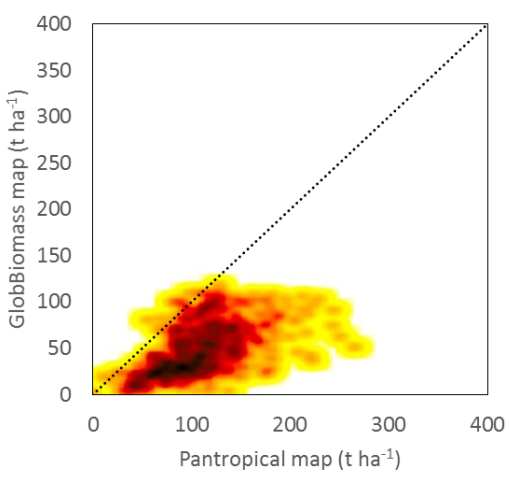


Comparison to pantropical maps

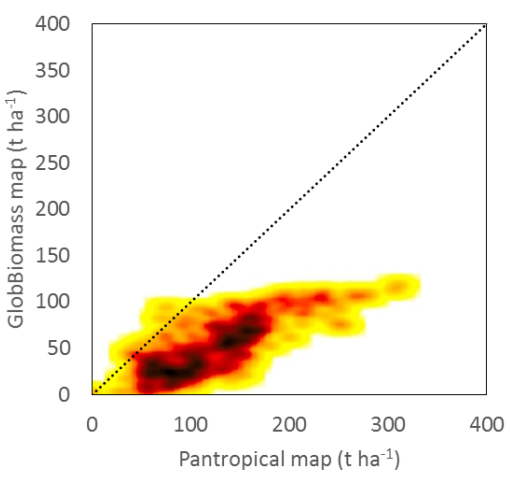
Avitabile (2016)

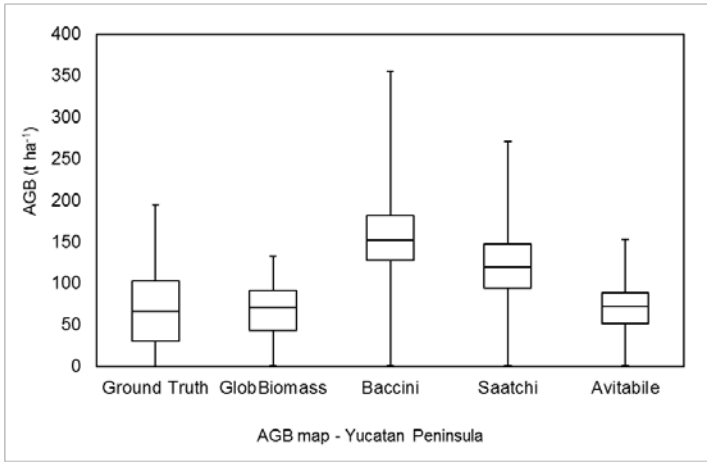


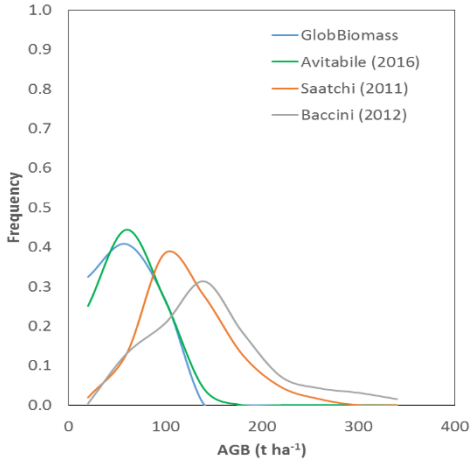
Saatchi (2011)



Baccini (2012)







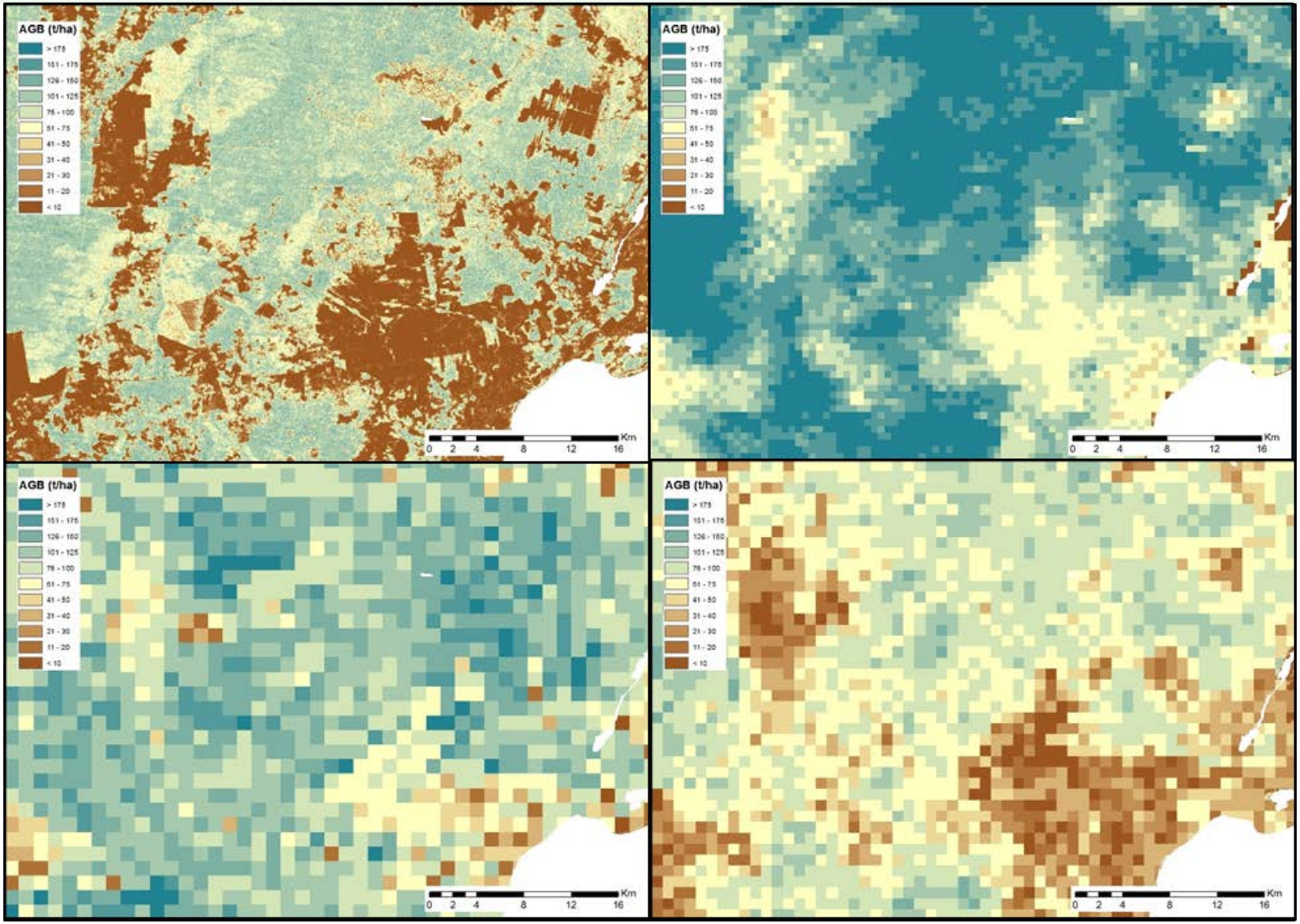
Comparison to pantropical maps

GlobBiomass

Baccini (2012)

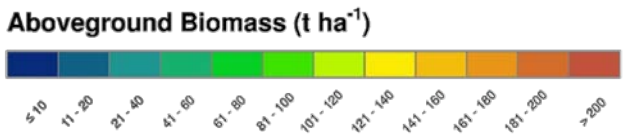
Saatchi (2011)

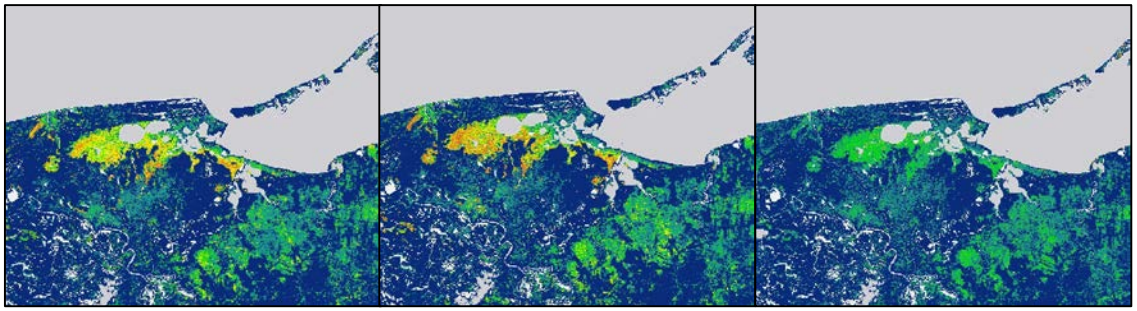
Avitabile (2016)



Known issues

- *Residual scan line corrector (SLC) effects due to the use of Landsat 7 & PTC*
- Land cover product (INEGI – LUV) used to mask urban areas excludes some vegetation around and within those areas
- No forest mask, but the estimation area is constrained to areas with at least 1% tree cover according Landsat PTC
- Co-registration issues recently found in a couple of tiles from ALOS PALSAR mosaics in Yucatan peninsula
- Problems with mangroves





AGB-Change maps

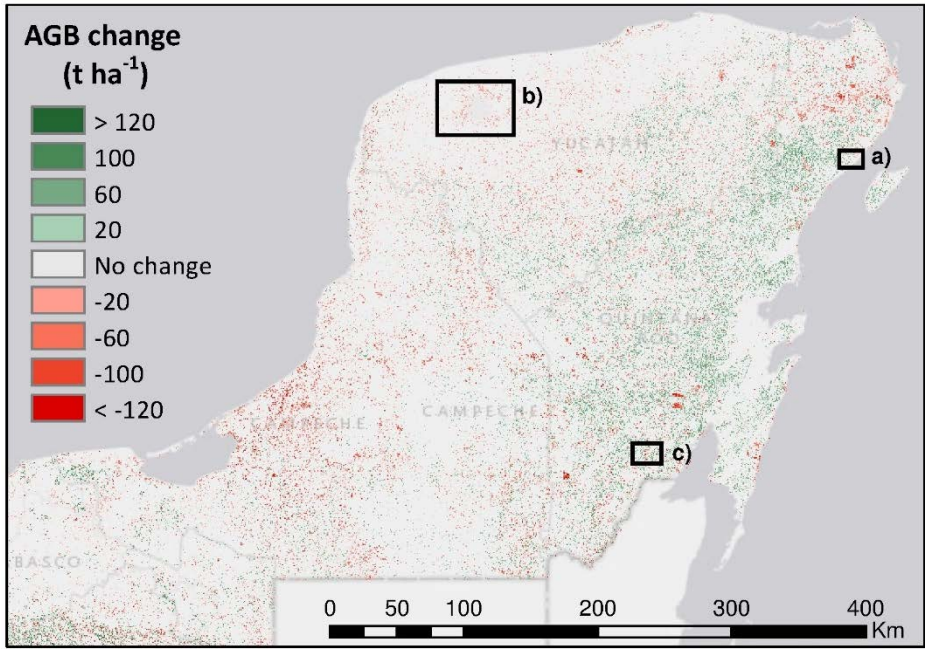
- Objective
  - Change maps between epochs (2005/07 - 2010, 2010 – 2015, 2005/07 – 2015)
- Challenges (ATBD document)
  - Random variation due to system noise and, for radar images, speckle
  - Environmental changes that affect biomass estimates
  - Sudden high-intensity change due to deforestation and fire
  - Lower intensity, possibly progressive change caused by forest degradation
  - Biomass changes due to forest growth

AGB-Change maps

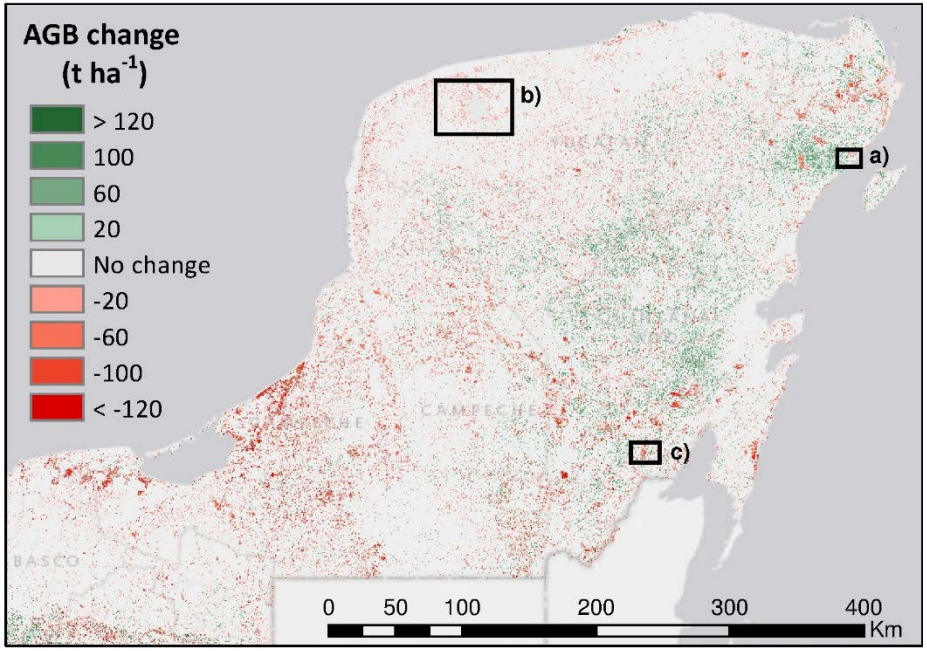
- Based on independent validation (by AGB range) or uncertainty characterization at pixel level
- An interval around the AGB estimation is generated ($AGB_{t1} \pm SD_{t1}$, and $AGB_{t2} \pm SD_{t2}$)
- AGB change is defined as $AGB_{t2} - AGB_{t1}$
- AGB change is accepted under these conditions:
  - AGB Loss: Loss is more than 1SD or 2SD
  - AGB Gain: Gain is more than 1SD or 2SD
- Outputs:
  - Gain/loss class layer
  - Magnitude of change layer (± t ha^{-1})
  - Uncertainty of change layer (t ha^{-1} or %)*

AGB-Change maps

2005/07-2010



2005-2015



AGB-Change maps

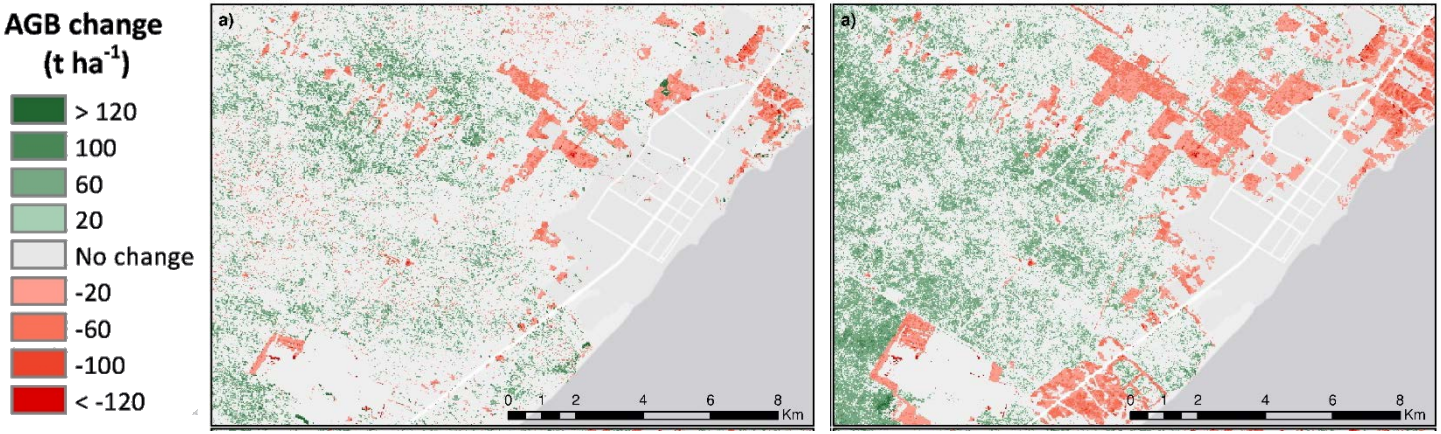
2005/07

2010

2015

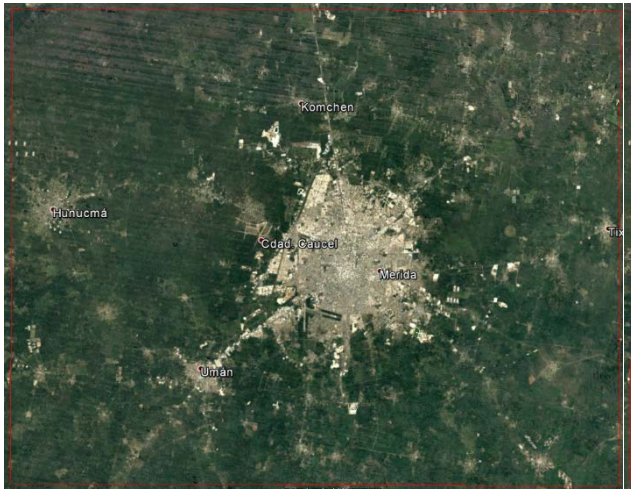
2005/07-2010

2005-2015

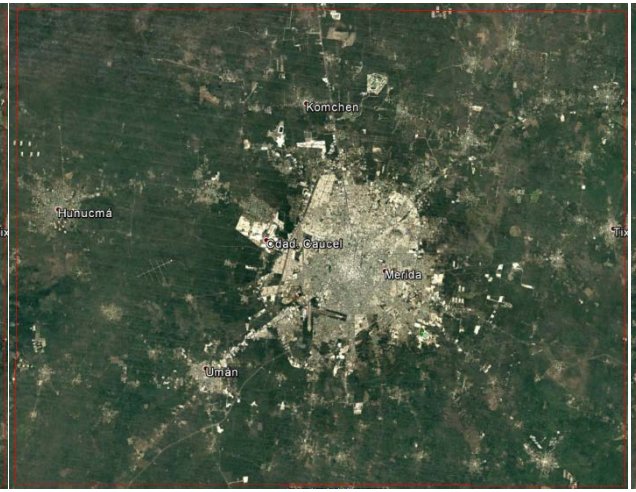


AGB-Change maps

2005/07



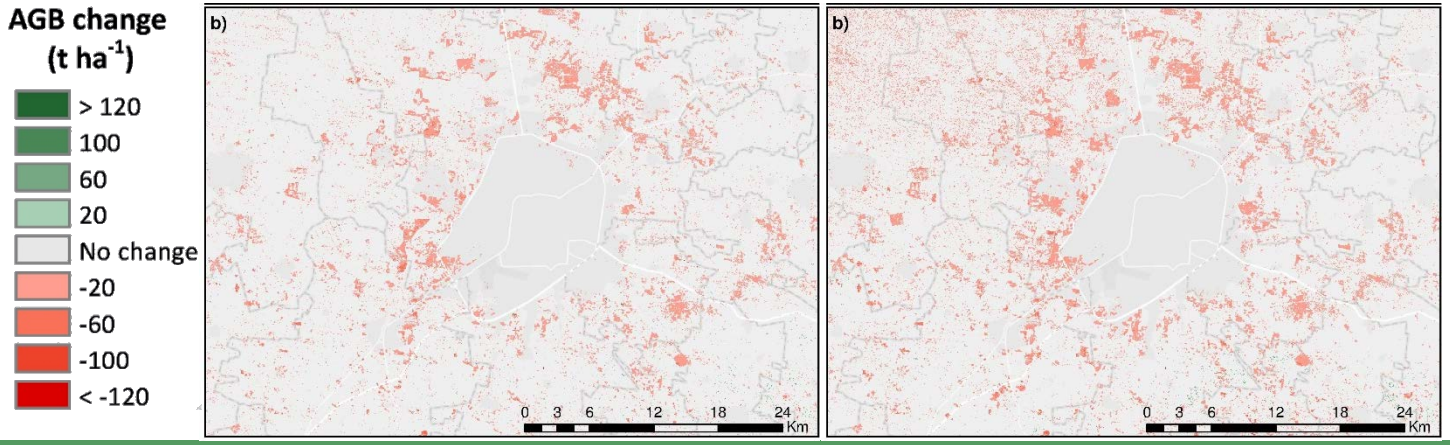
2010



2015

2005/07-2010

2005-2015



AGB-Change maps

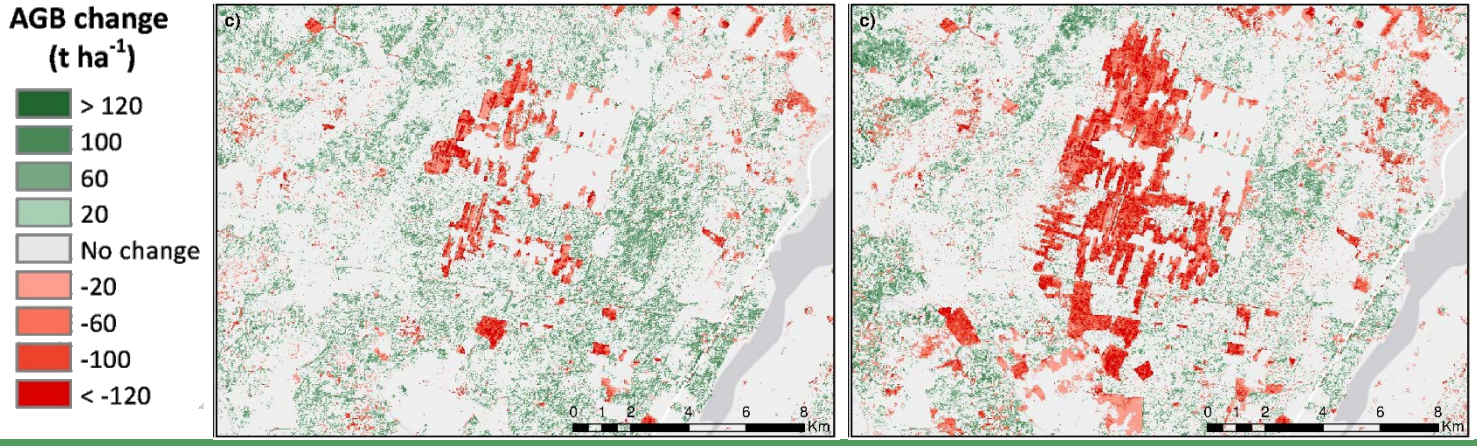
2005/07

2010

2015

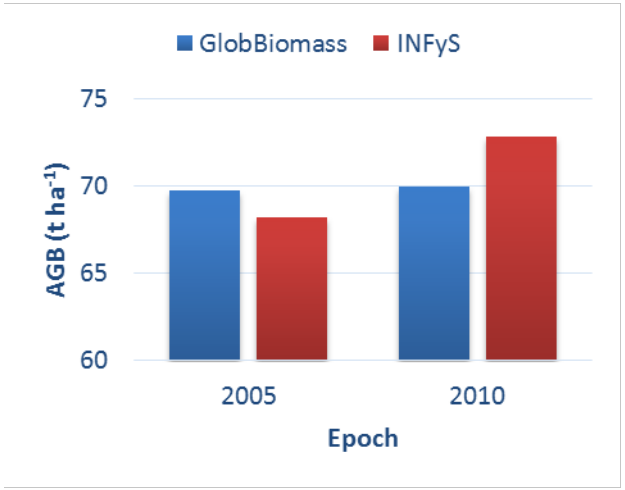
2005/07-2010

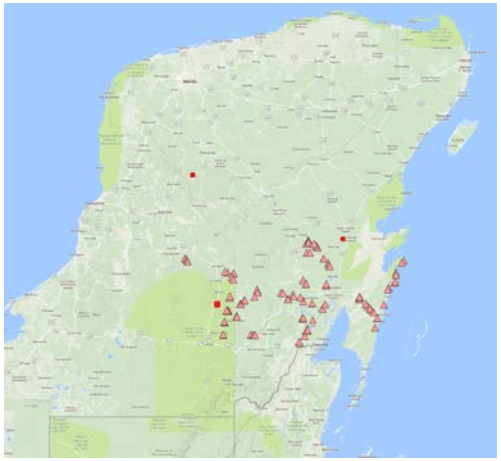
2005-2015



Validation AGB change products

- State level data
  - Assess change at large scales
- High resolution imagery
  - Useful to validate complete or nearly complete removal (i.e. deforestation) or gain (re- and afforestation) of AGB.
- Long term ground measurements
  - Useful to validate a reduction/gain of AGB (degradation/growth)
  - Long term plots annually measured on Yucatan 2007-2015 (Rutgers University).
  - Intensive carbon monitoring sites (CEC, CONAFOR, USAID, etc), Mexican Carbon Program, etc





Conclusions

- AGB maps for 2005/07, 2010 & 2015 are available
- Due to signal saturation, the maps underestimate AGB at high AGB levels while AGB is overestimated at low AGB levels
- Previous assessments present substantial differences in the amount and spatial distribution of AGB in the Mexico
- AGB change products based on the characterization of the uncertainty are promising, but validation is still ongoing
- The BIOMASS mission (P-band) will provide first data on high biomass tropical forests. However, Mexico will suffer from the loss of coverage due to the US Department of Defence Space Objects Tracking Radar (SOTR) stations (Joao et al., 2017)

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GLOBBIOMASS

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Grazie