

## K&C Phase 4 – Status report

**Use of ALOS PALSAR in forest carbon assessment**

**Forest Cover Change and Biomass Mapping**

*Thuy Le Toan, Stephane Mermoz, Alexandre Bouvet,  
Ludovic Villard*

**CESBIO  
Toulouse, France**

Science Team meeting #22  
Hatoyama, Japan, January 18-20, 2017

## Project Objective

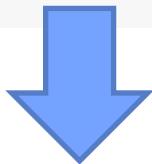
To demonstrate the feasibility of forest information generated from ALOS-PALSAR to support Carbon Cycle Science, International Conventions (REDD+) and Climate Change in 3 projects:

1. Forest biomass mapping at regional and national scale
2. Detection of forest disturbances (degradation, deforestation, regrowth)
3. Use of forest biomass map to improve carbon model

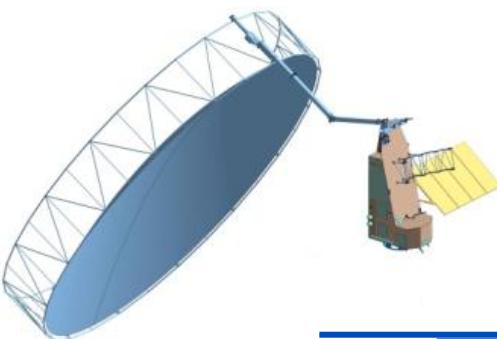
.... and

To consolidate methodology for **forest cover change and biomass mapping**

High temporal resolution SARs

**Sentinel-1**

Low frequency SARs

**BIOMASS****ALOS, NISAR, SAOCOM..****NRT Deforestation****Forest Cover Change  
Above Ground Biomass**

1. **Carbon Cycle:** Forest Carbon flux: national, regional, global
2. **International Convention:** REDD+: national  
→ Climate Change

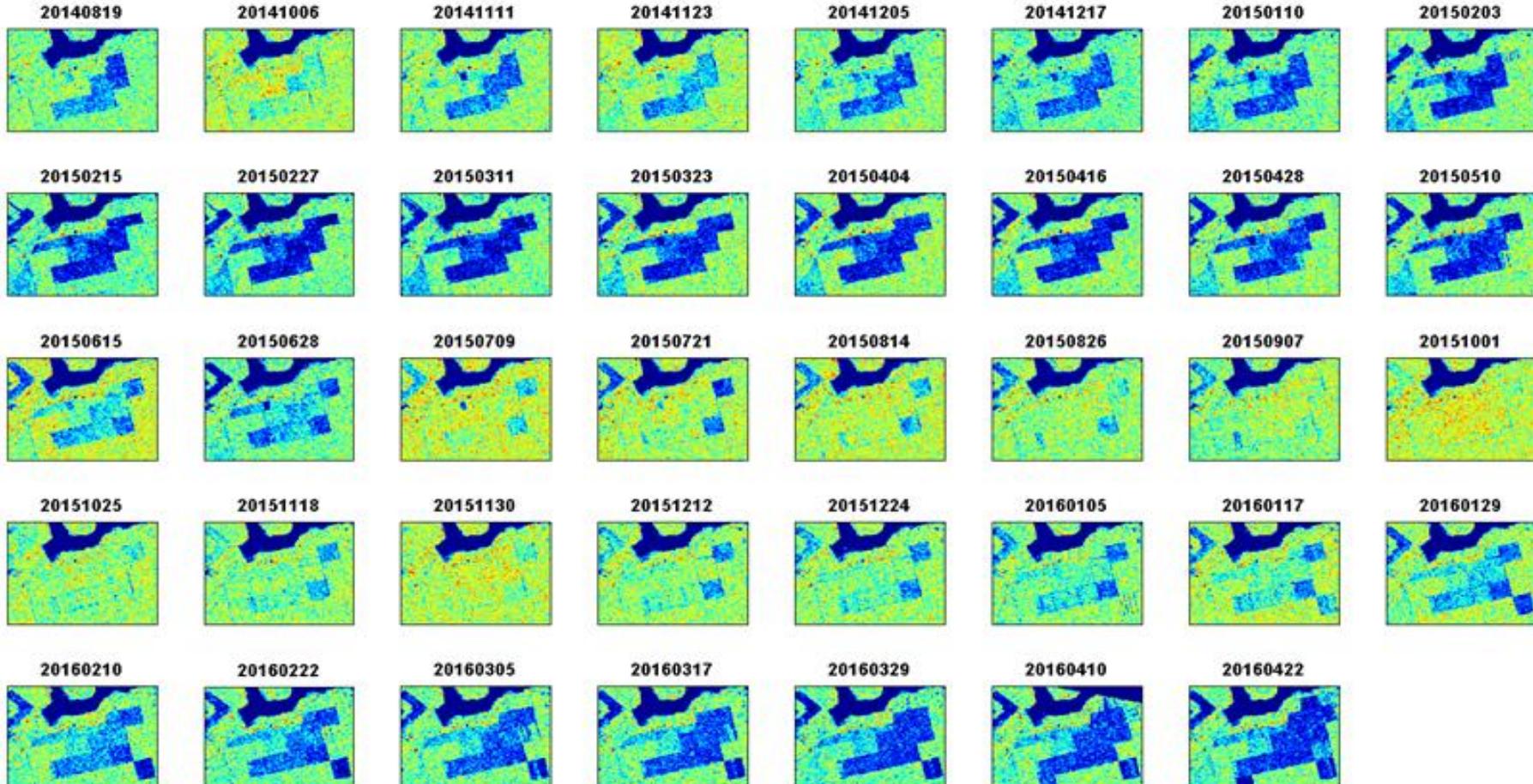
ALOS

K&C Initiative  
An international science collaboration led by JAXA

# Detection of disturbances

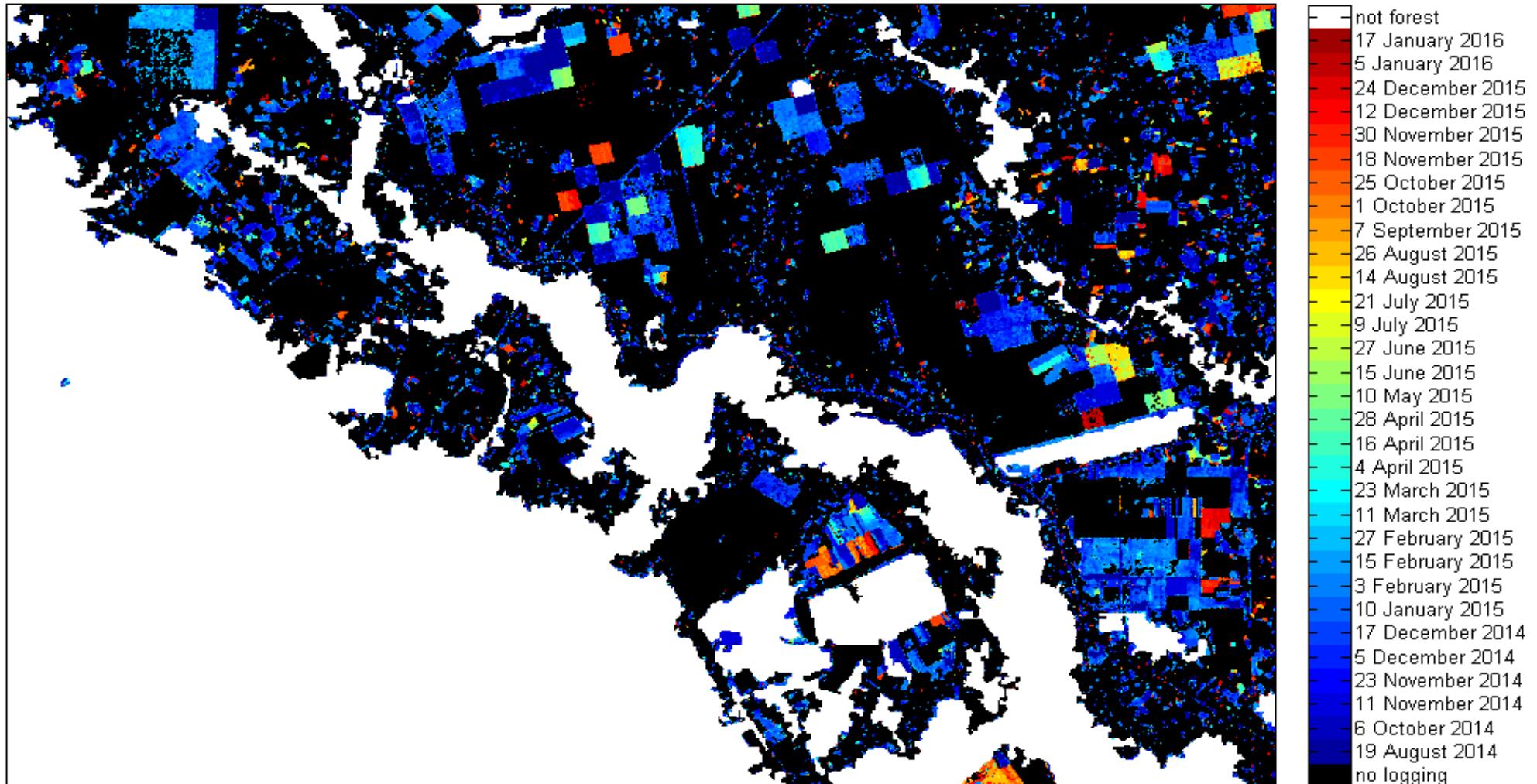
## Early forest logging monitoring with Sentinel-1 at 20m

19-08-2014

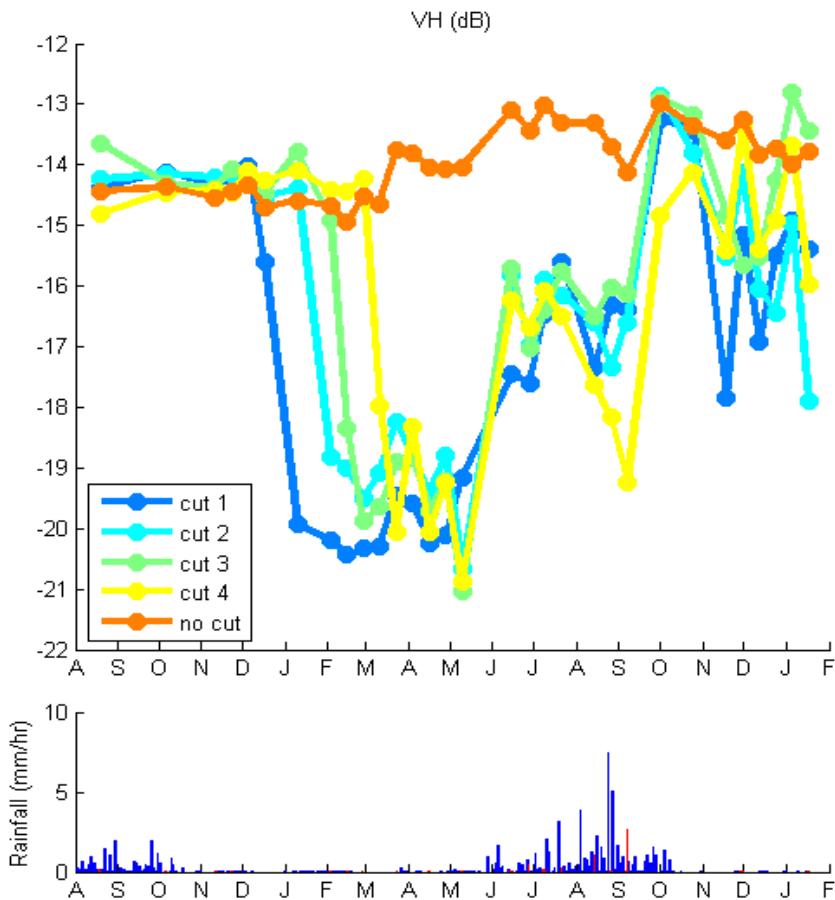


22-04-2016

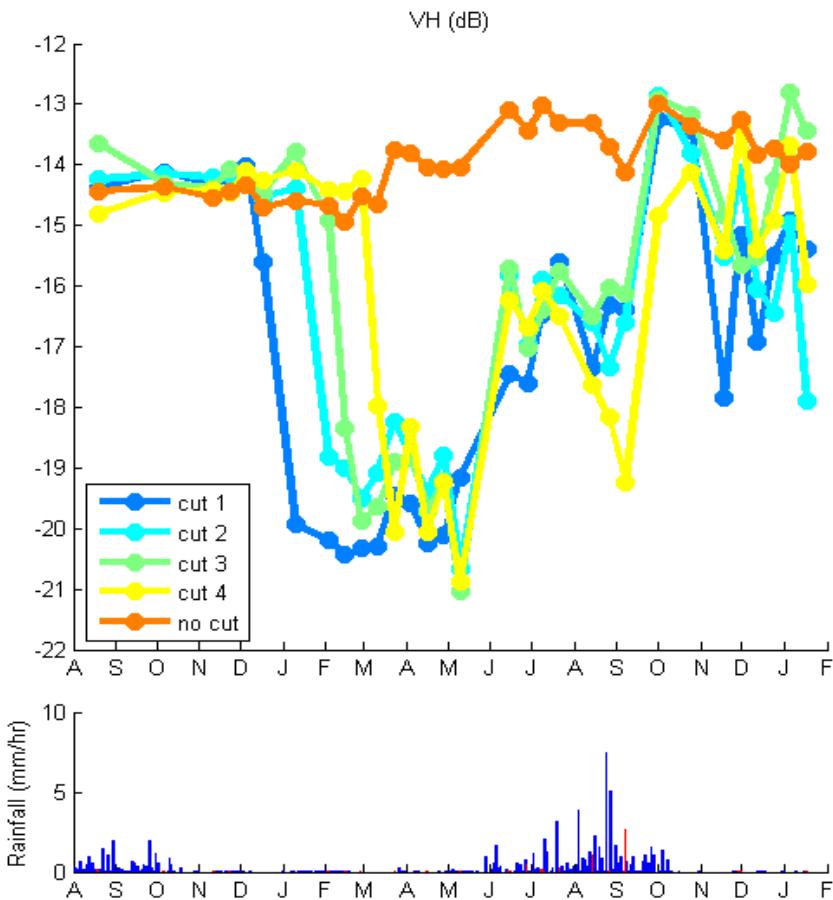
## Logging date map using Sentinel-1



## Sentinel-1 VH backscatter



## Sentinel-1 VH backscatter

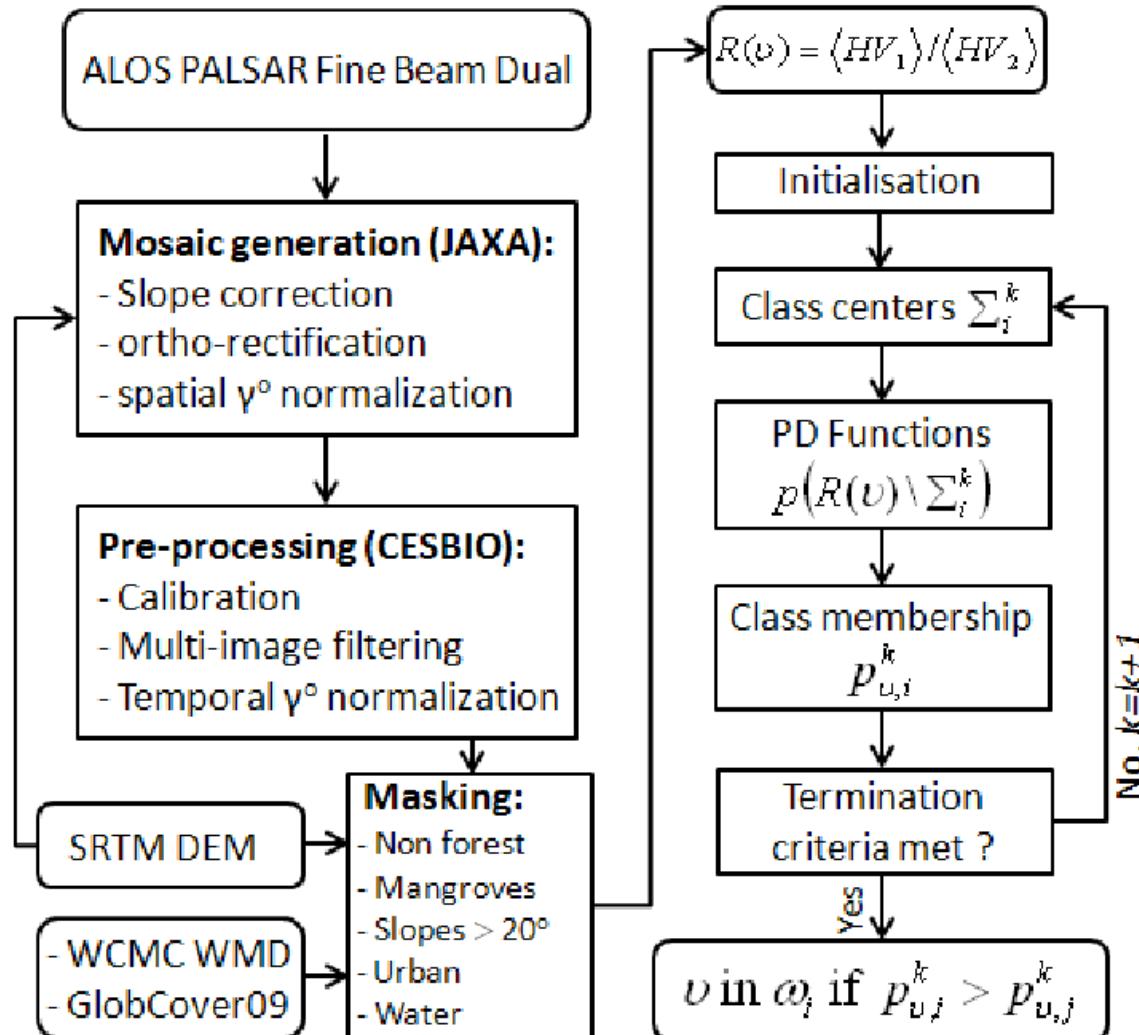


Early detection of logging/deforestation is possible with Sentinel-1 every 6/12/24 days, except during rainy season

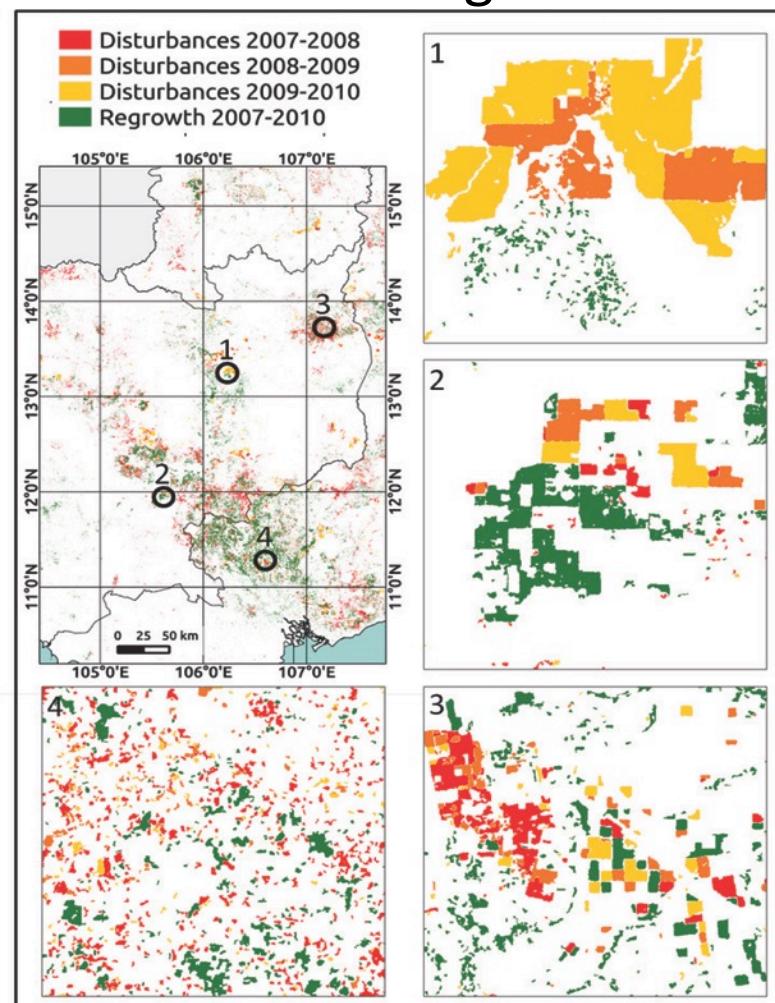
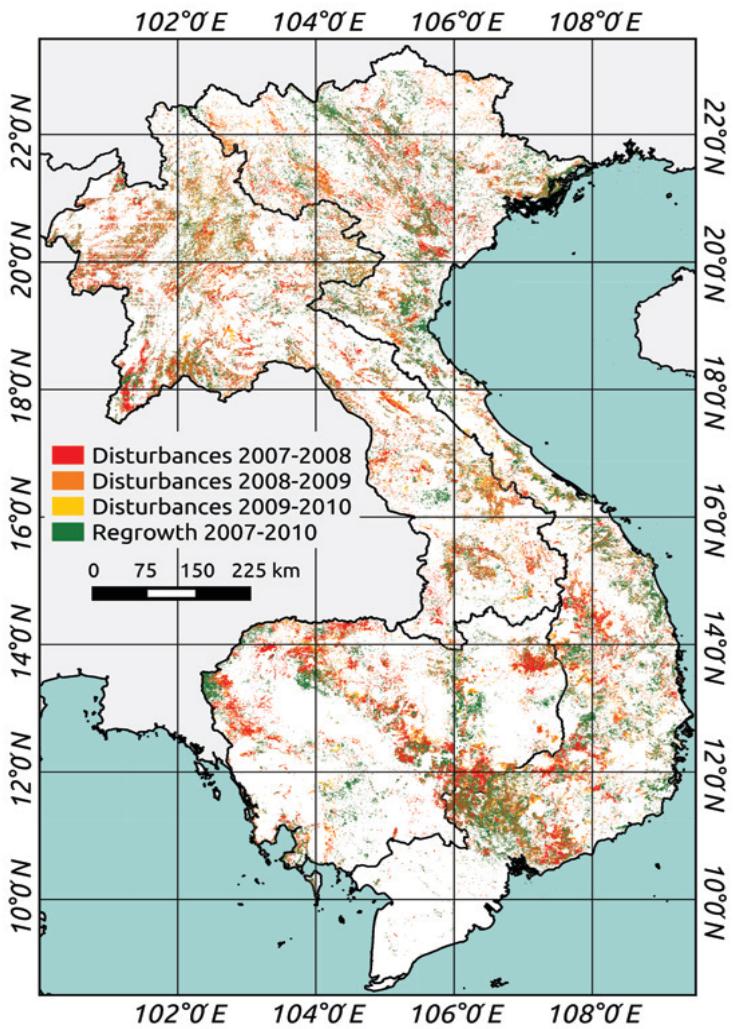
## ALOS

- Monitor deforestation during rainy season
- Monitor forest regrowth

## Forest change detection methodology using ALOS



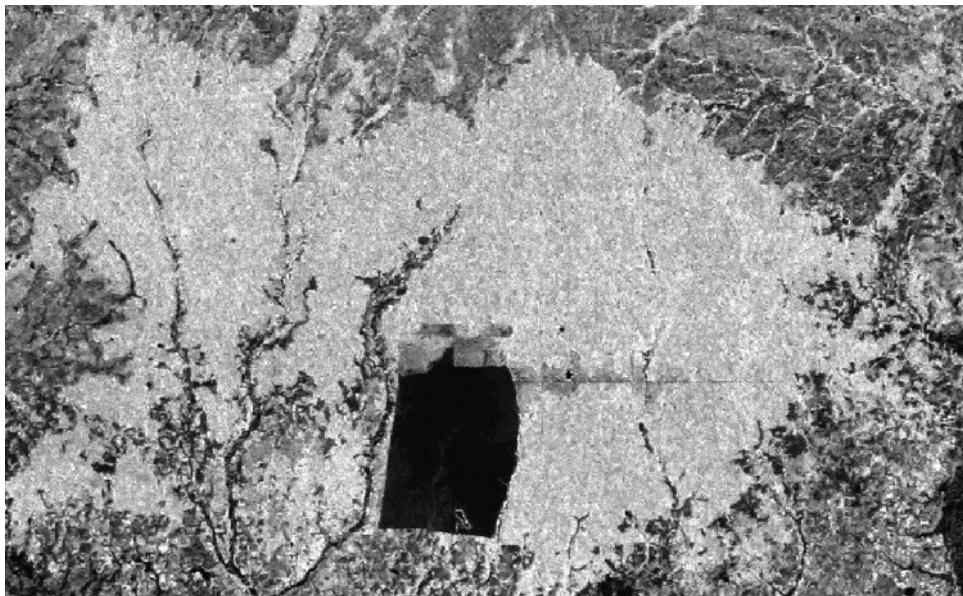
## ALOS-PALSAR for monitoring disturbances and regrowth



Mermoz & Le Toan, Remote Sensing 2016

## 2010-2015 backscatter change

ALOS 2010

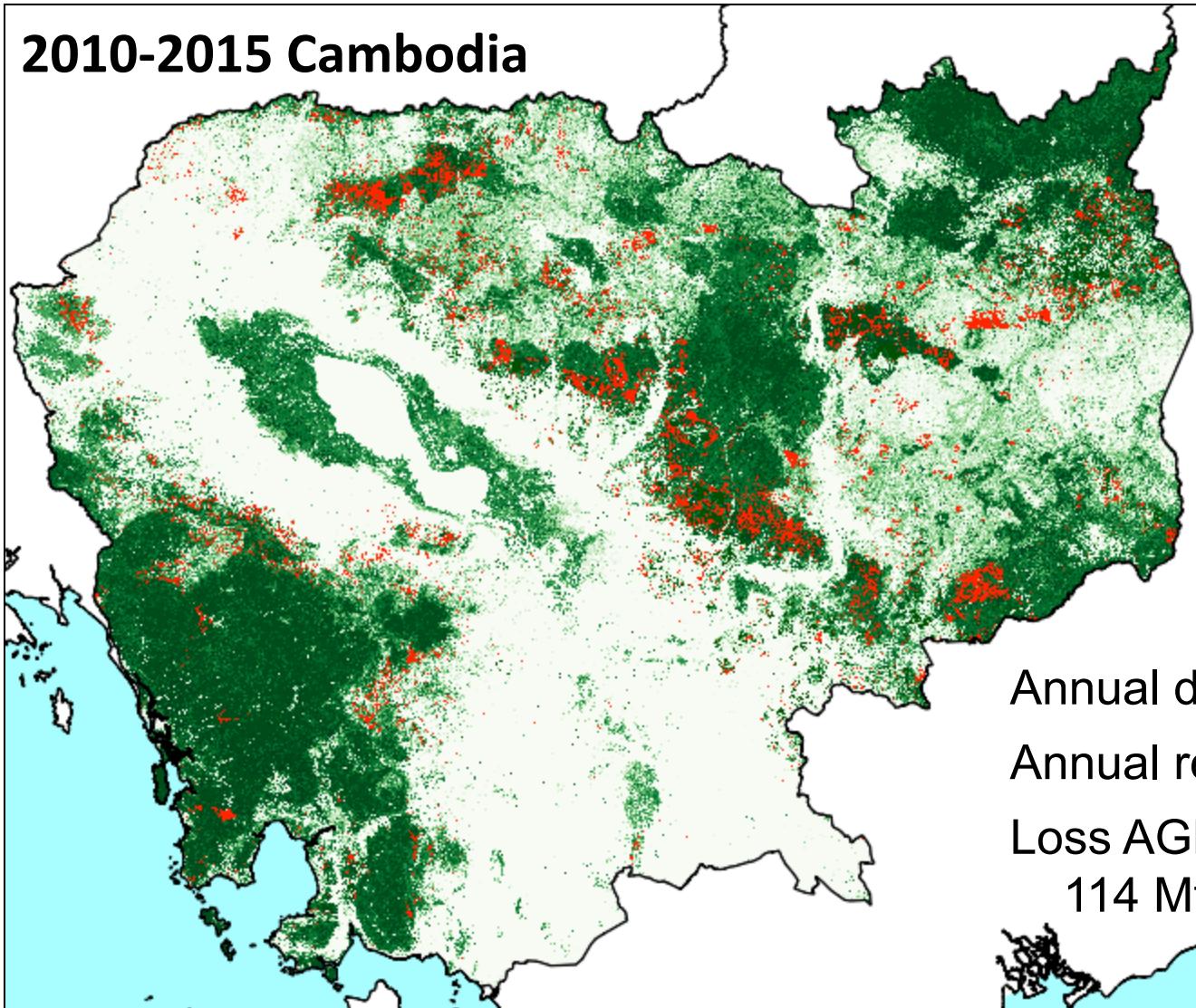


ALOS 2015



Regrowth in 5 years

**2010-2015 Cambodia**



**Using ALOS &  
ALOS-2 data**

Red: loss in forest cover

Annual disturbance rate = -1.45%

Annual regrowth rate = 0.42%

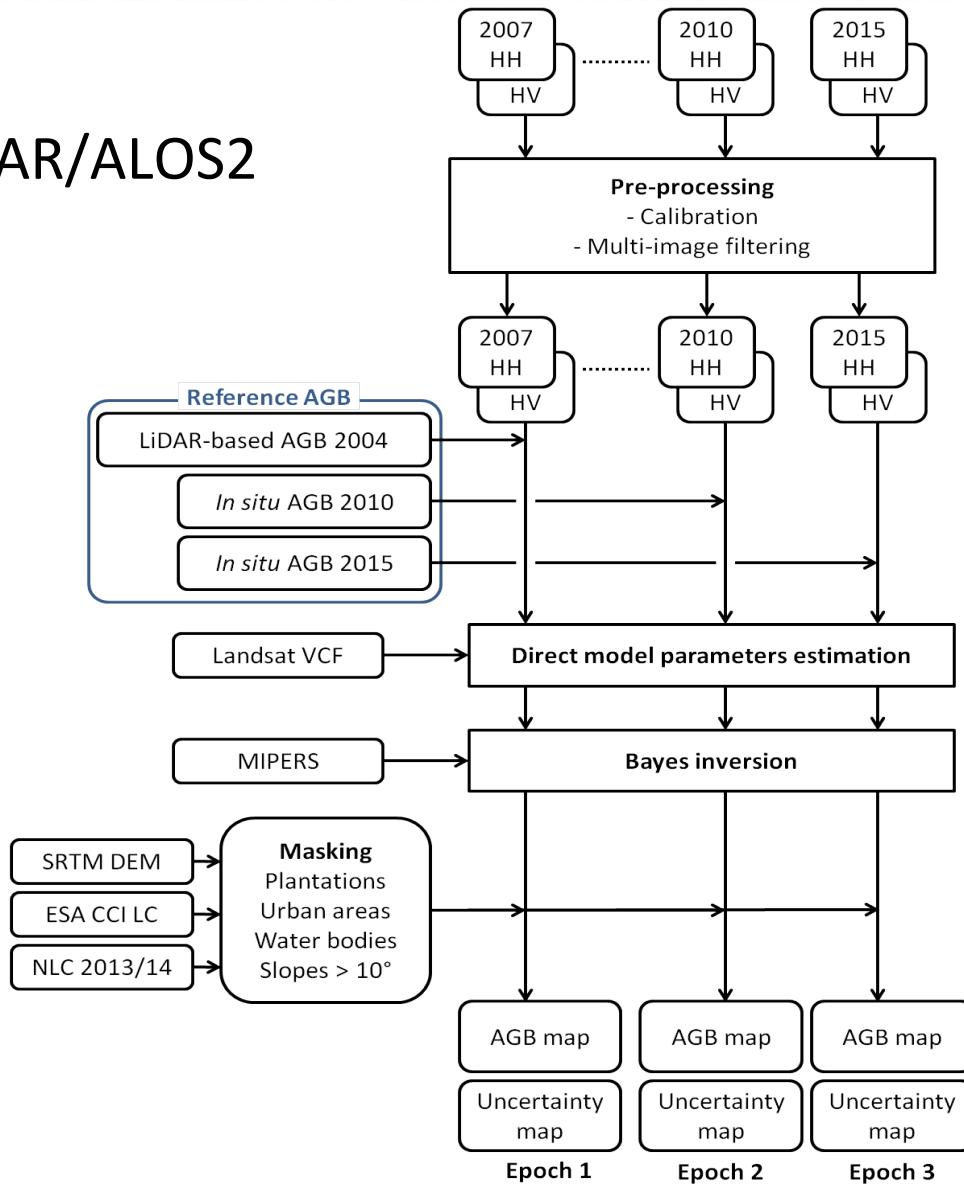
Loss AGB = 134 Mt (Saatchi) /  
114 Mt (Baccini)

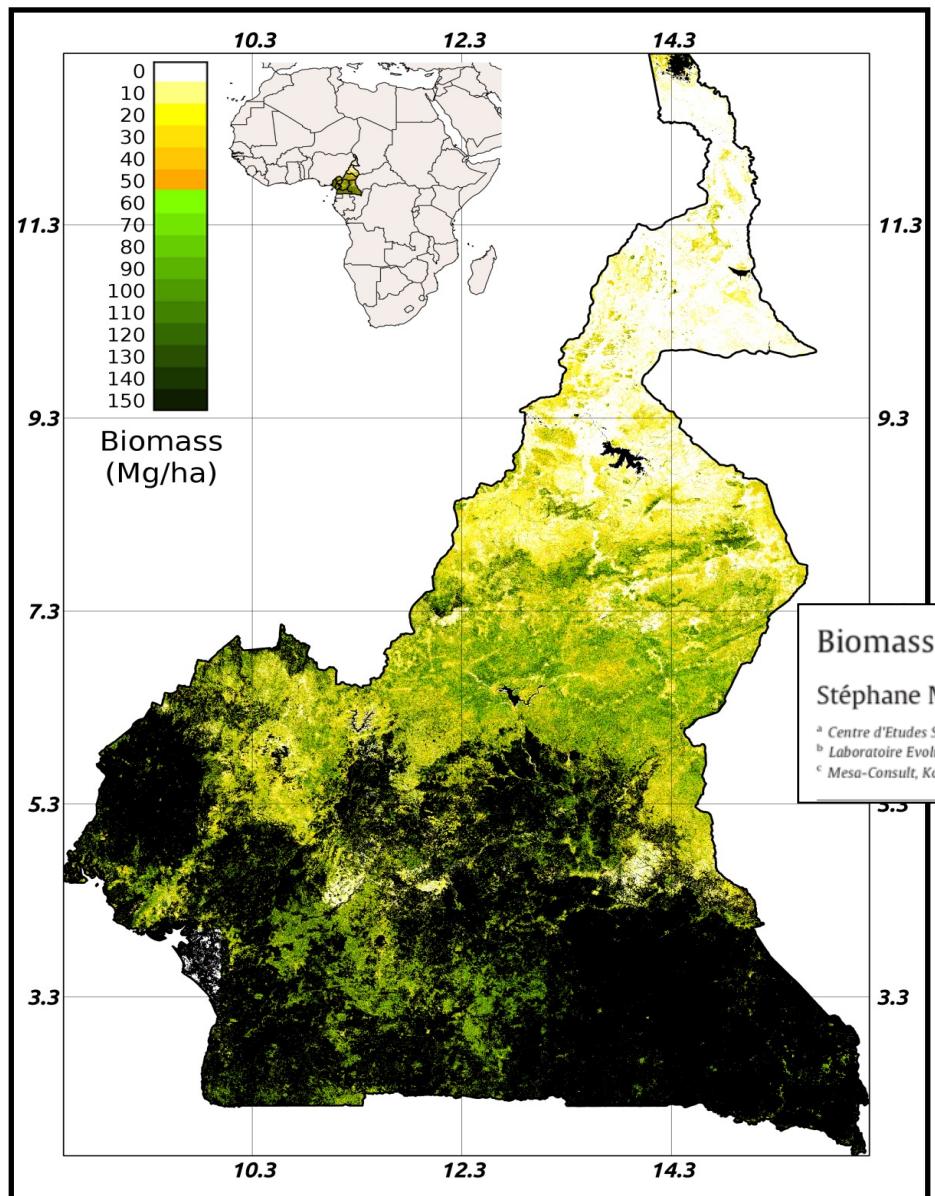
ALOS

K&C Initiative  
An international science collaboration led by JAXA

# Biomass mapping

# CESBIO Algorithm using PALSAR/ALOS2 for Biomass mapping (GlobBiomass project)





## Biomass mapping at national scale

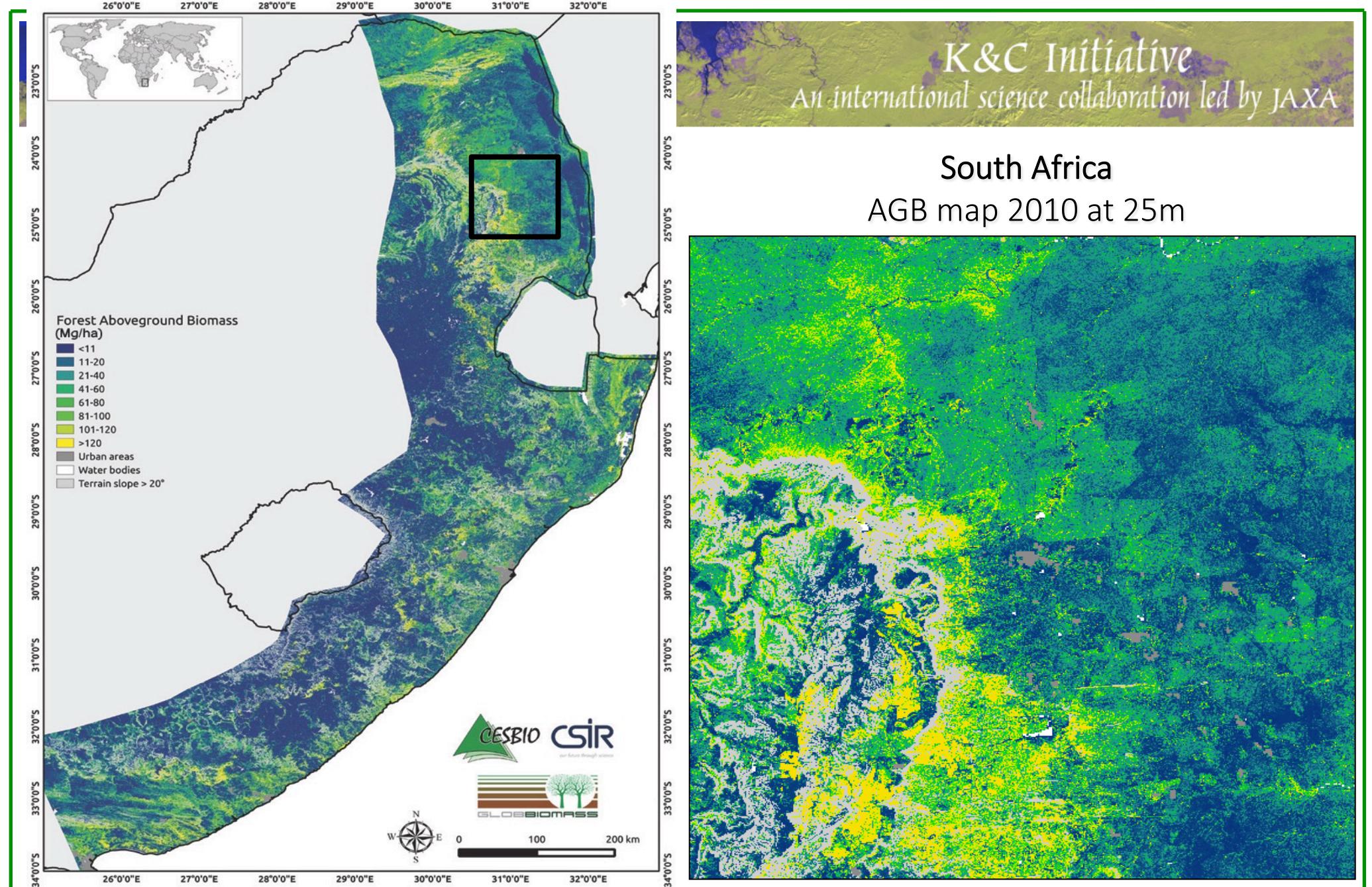
### Cameroon

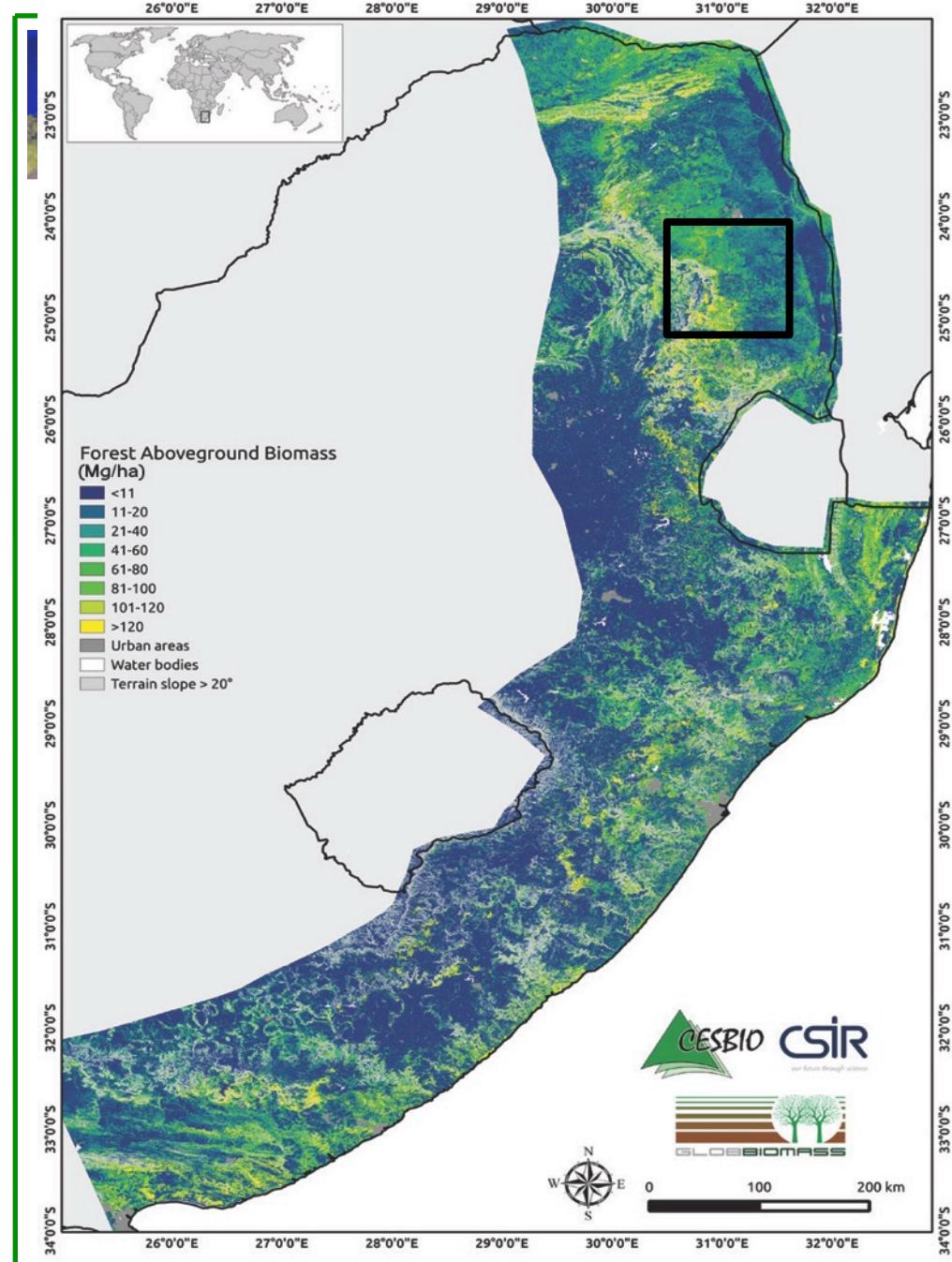
Biomass assessment in the Cameroon savanna using ALOS PALSAR data

Stéphane Mermoz <sup>a,\*</sup>, Thuy Le Toan <sup>a</sup>, Ludovic Villard <sup>a</sup>, Maxime Réjou-Méchain <sup>b</sup>, Joerg Seifert-Granzin <sup>c</sup>

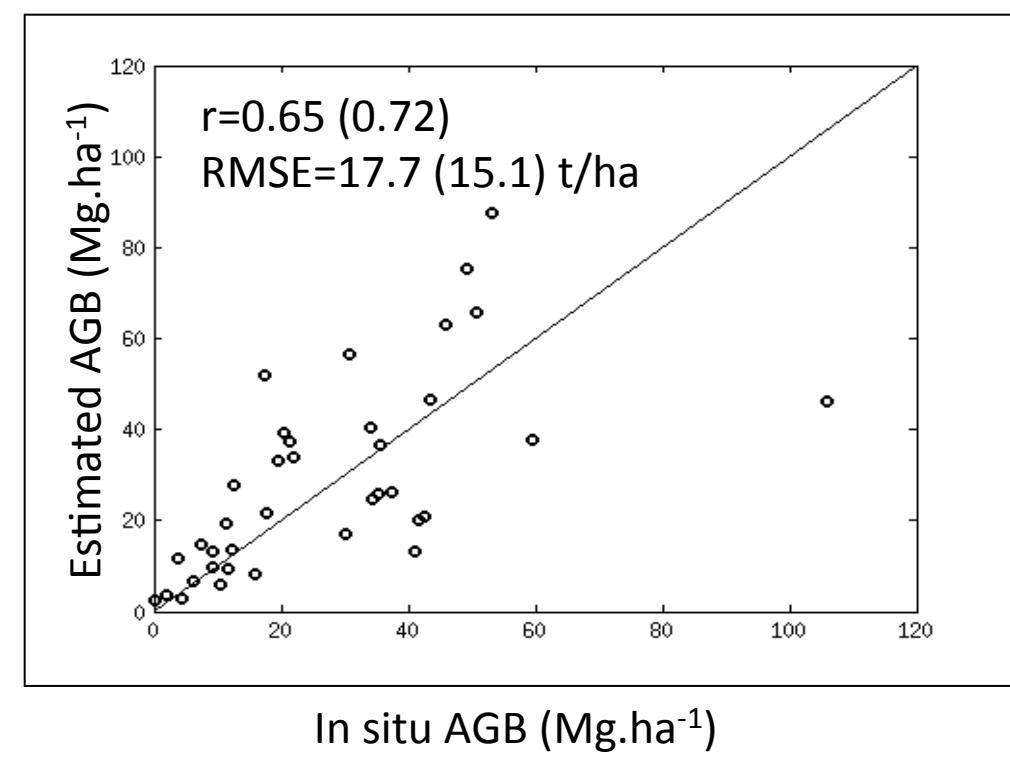
<sup>a</sup> Centre d'Etudes Spatiales de la BiOosphère, UMR CNRS 5126, University of Paul Sabatier, Toulouse, France  
<sup>b</sup> Laboratoire Evolution et Diversité Biologique, UMR CNRS 5174, University of Paul Sabatier, Toulouse, France  
<sup>c</sup> Mesa-Consult, Konstanz, Germany





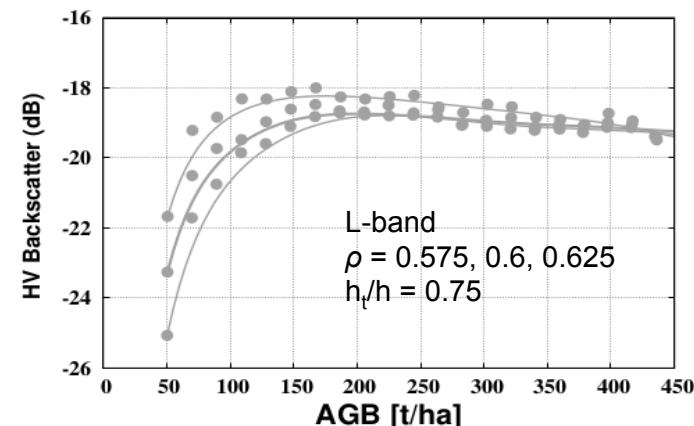
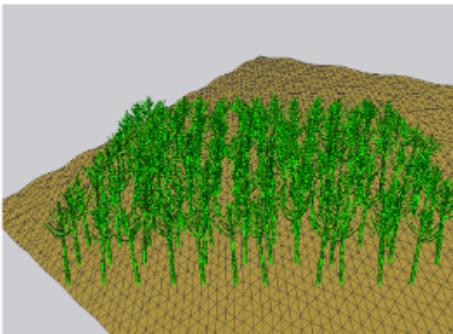
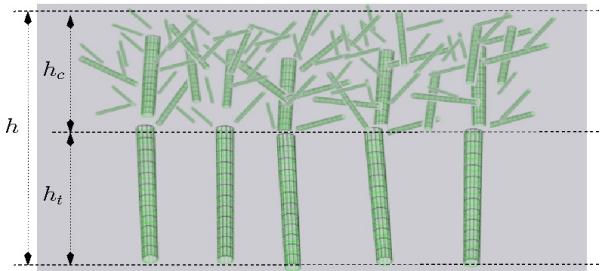


South Africa  
AGB map 2010 at 25m

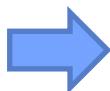
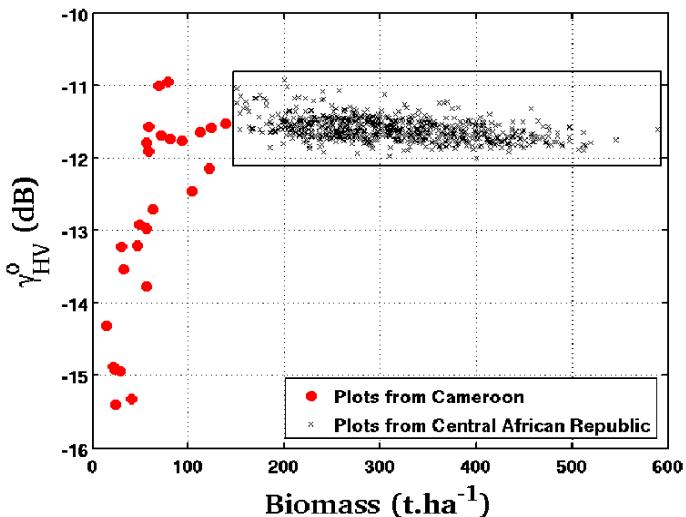


# CESBIO method for high AGB and dense forests

## 1..Electromagnetic modelling



## 2. Experimental data in Central African Republic



*Example of a simulation of the effect of wood density  $\rho$  (linked to tree species)*

Contents lists available at ScienceDirect

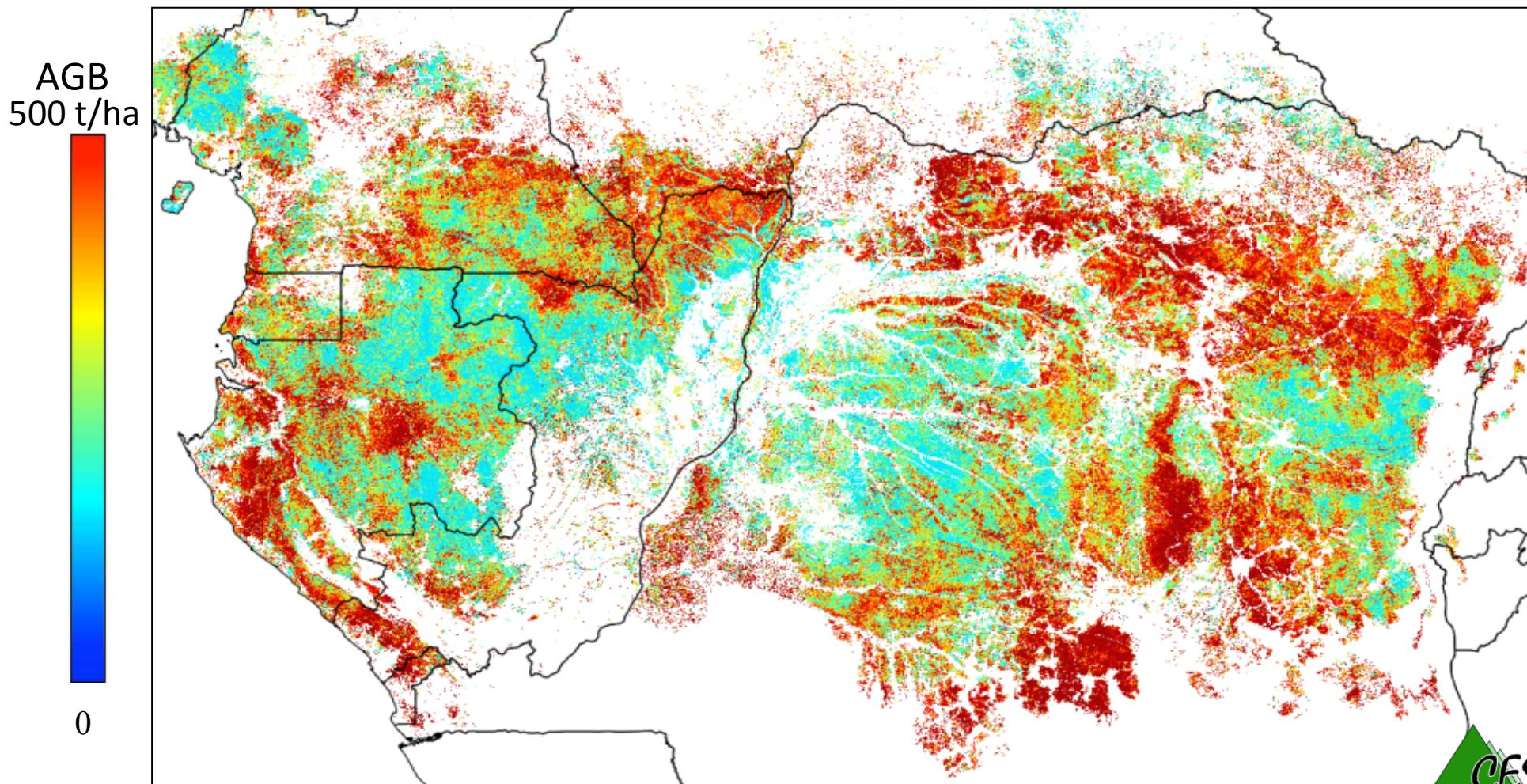
 Remote Sensing of Environment

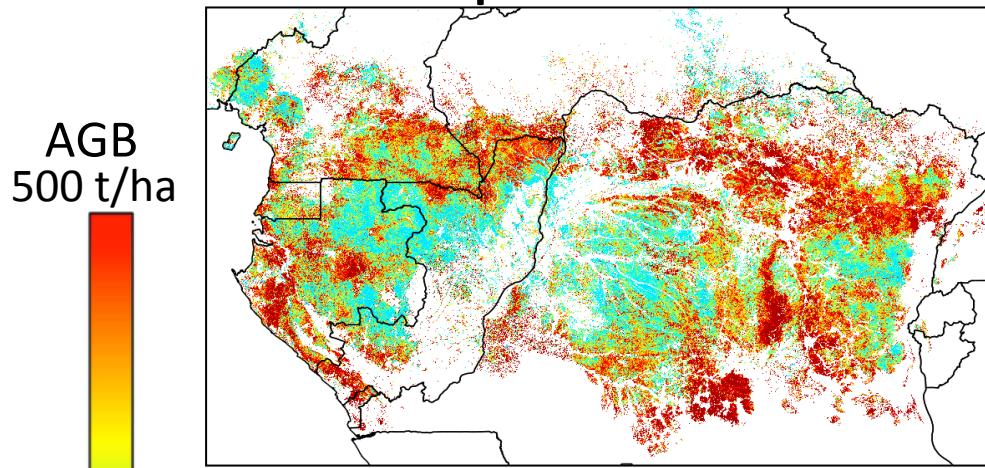
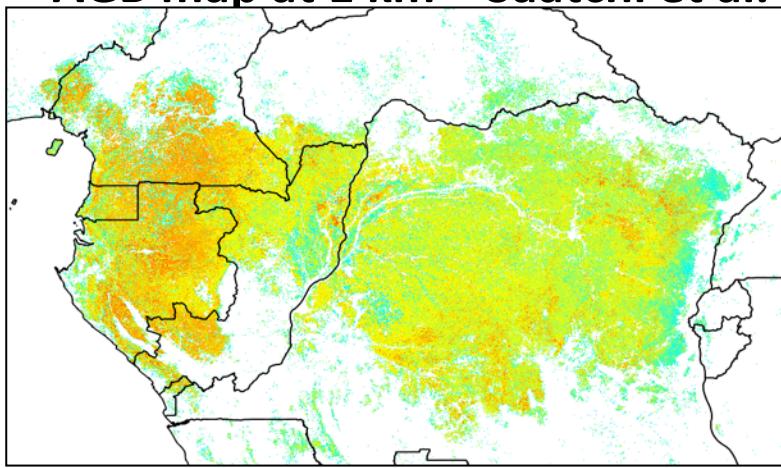
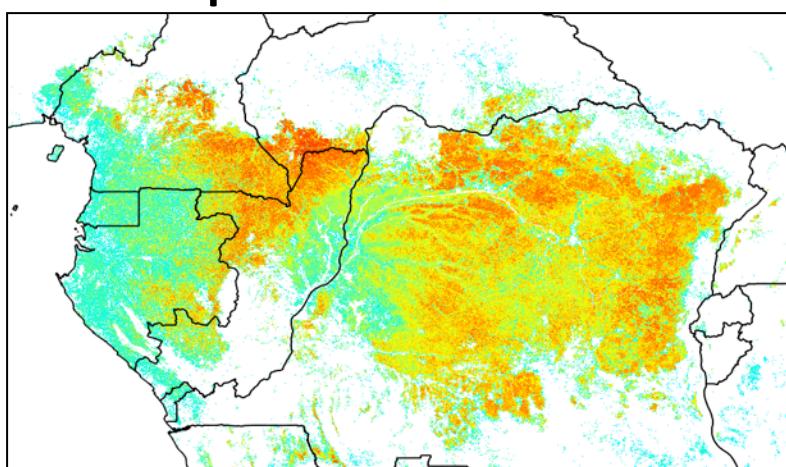
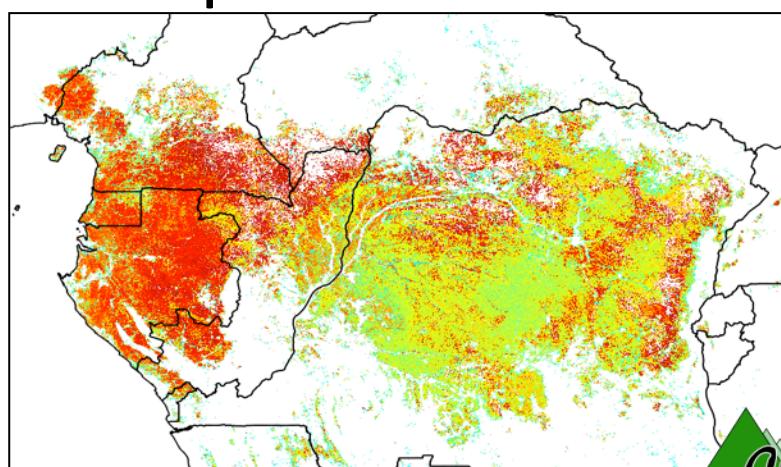
journal homepage: [www.elsevier.com/locate/rse](http://www.elsevier.com/locate/rse)

Decrease of L-band SAR backscatter with biomass of dense forests

Stéphane Mermoz<sup>a</sup>, Maxime Réjou-Méchain<sup>b,c,d</sup>, Ludovic Villard<sup>a</sup>, Thuy Le Toan<sup>a</sup>, Vivien Rossi<sup>d,e</sup>, Sylvie Gourlet-Fleury<sup>d</sup>

## Mapping of high AGB forests at low resolution (500 m) Congo basin

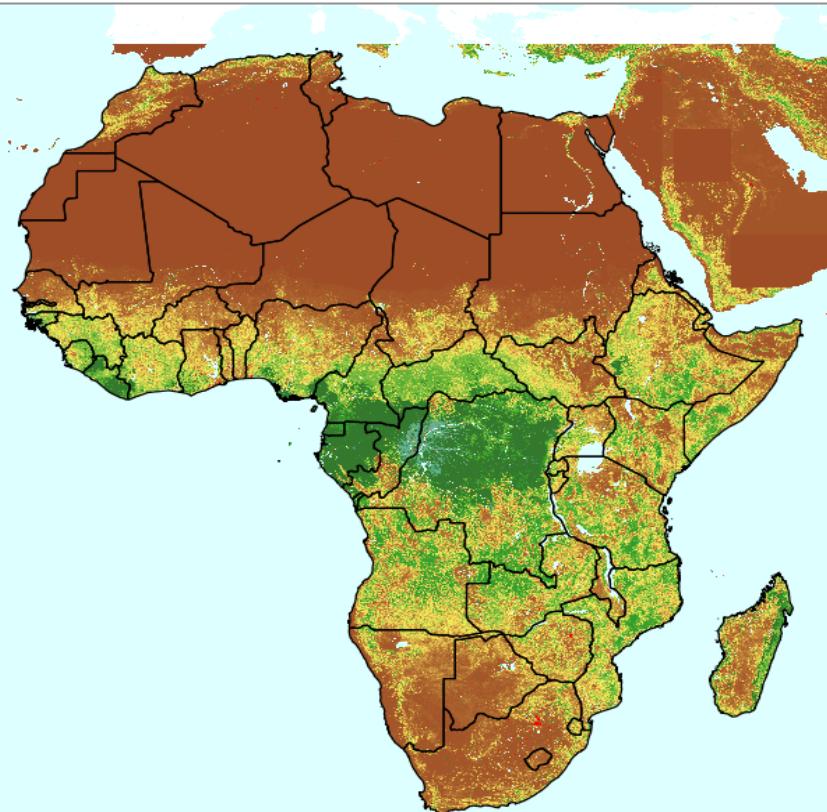
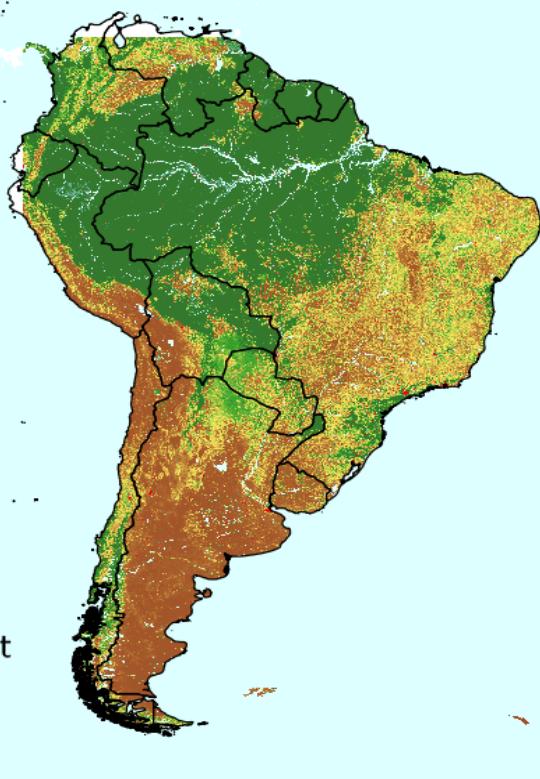


**AGB map at 500 m - Cesbio****AGB map at 1 km – Saatchi et al.****AGB map at 500 m – Baccini et al.****AGB map at 1 km – Avitabile et al.**

## Biomass mapping at global scale

### CESBIO Biomass map using ALOS-PALSAR (2010)

Spatial resolution 25 m, and 500 m for dense tropical forest

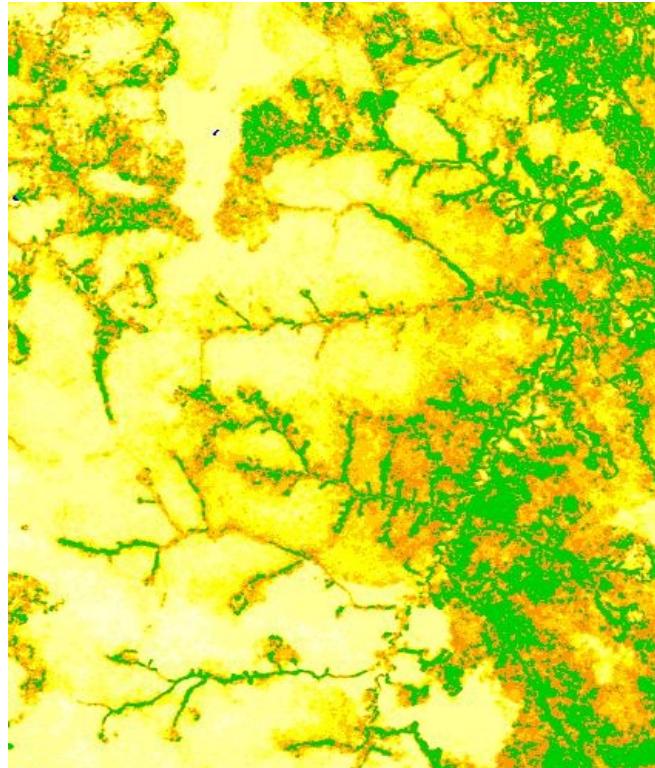


Africa

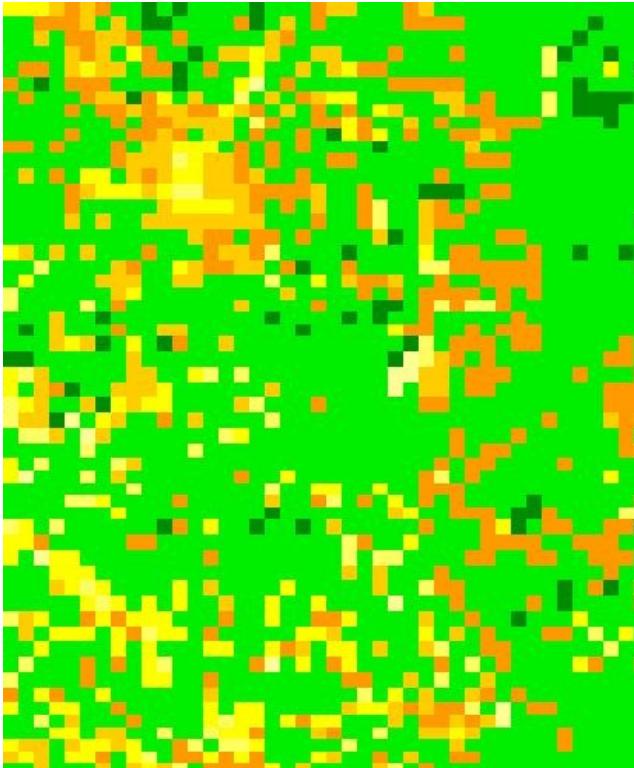
**Bouvet, A. Mermoz,, Le Toan T. S., Villard, L., Mathieu, R., Naidoo, L.. (2016, under review),** An above-ground biomass map of African savannahs at 25 meters resolution derived from ALOS PALSAR. *Remote Sensing of Environment*

## Comparison with existing maps

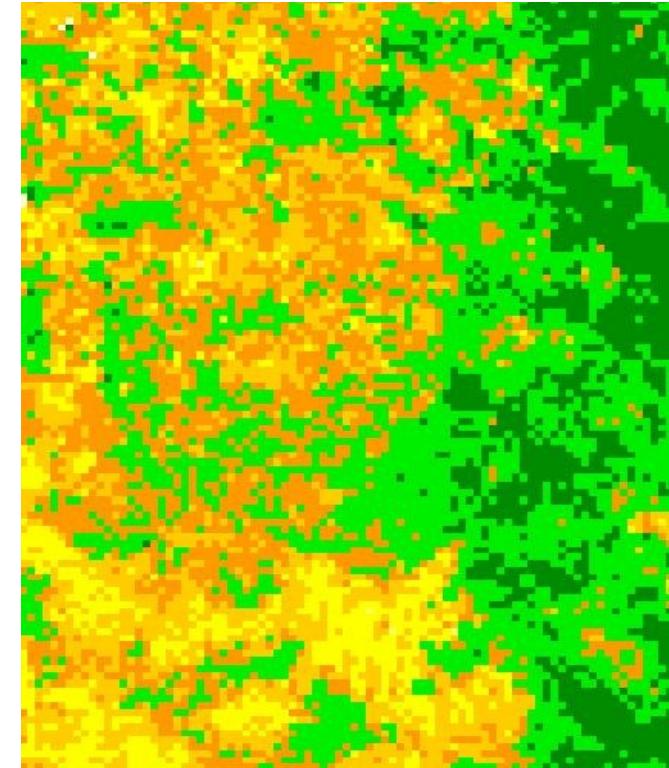
This study



Saatchi et al., 2011

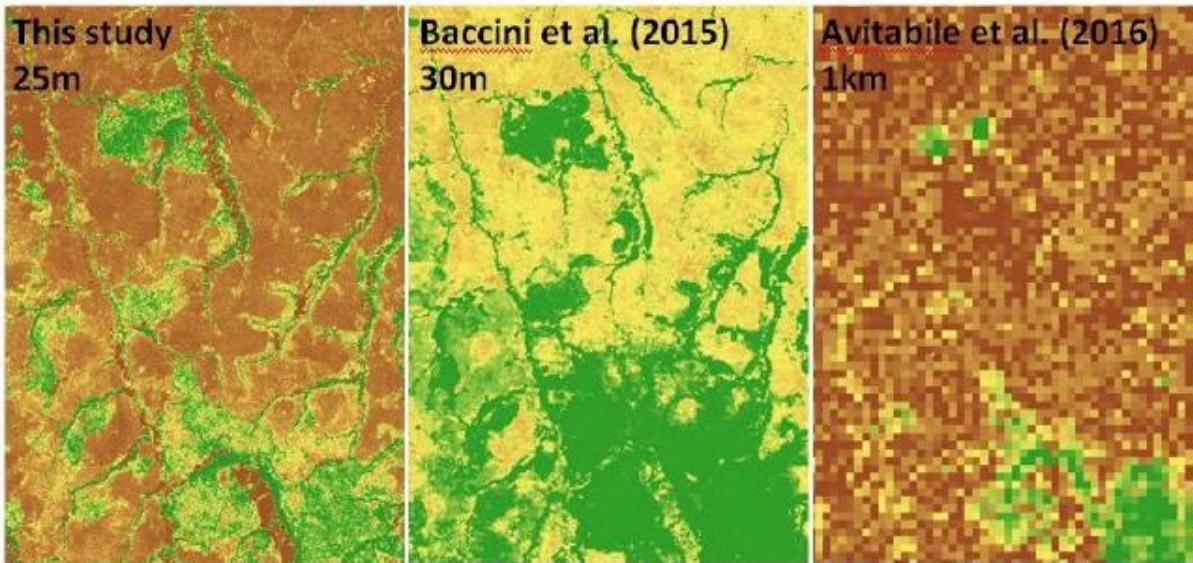


Baccini et al., 2012



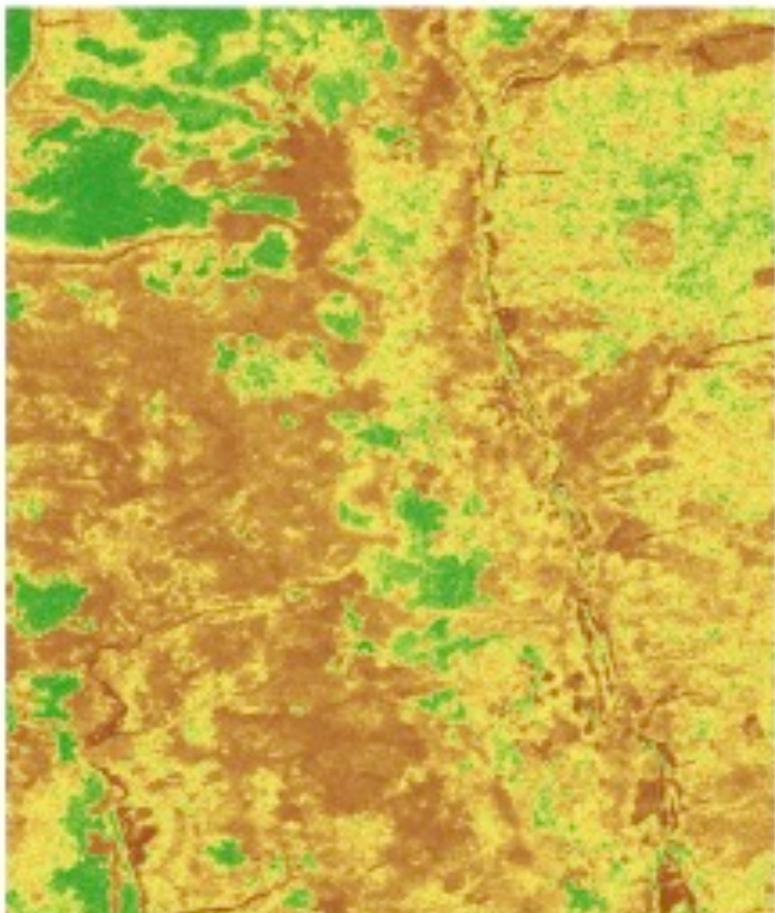
	0-10 Mg ha <sup>-1</sup>
	10-20 Mg ha <sup>-1</sup>
	20-30 Mg ha <sup>-1</sup>
	30-40 Mg ha <sup>-1</sup>
	40-50 Mg ha <sup>-1</sup>
	50-60 Mg ha <sup>-1</sup>
	60-100 Mg ha <sup>-1</sup>
	> 100 Mg ha <sup>-1</sup>
	water
	no data

Subset from tile: Latitude: 10°S to 5°S  
Longitude: 20°E to 25°E

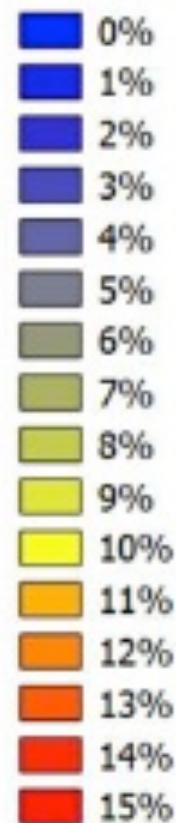
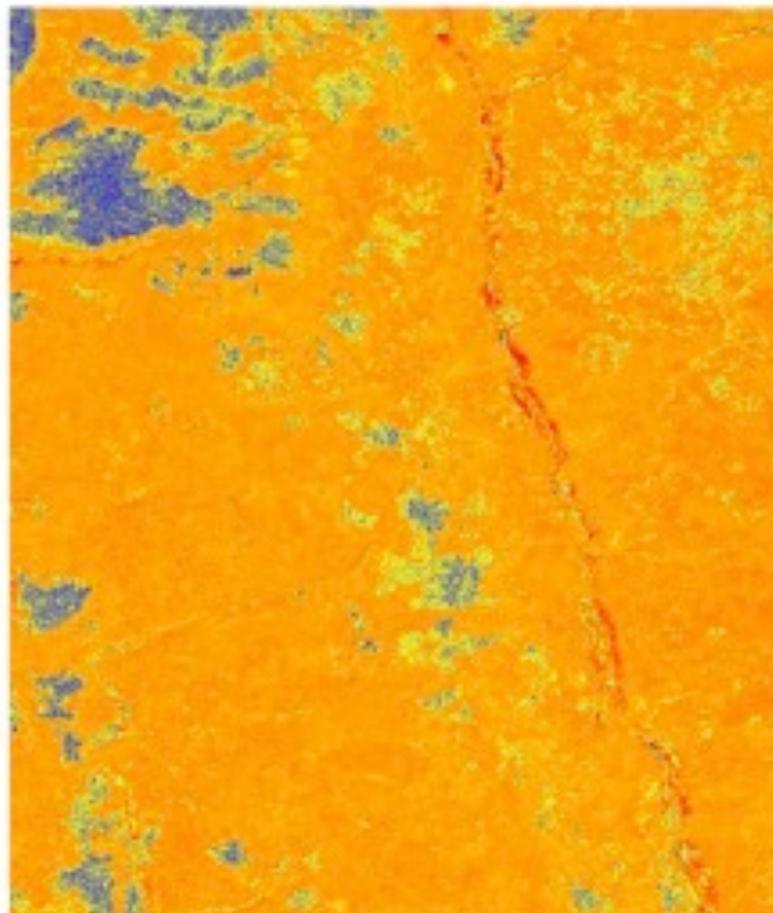


## Error estimation

Estimated AGB

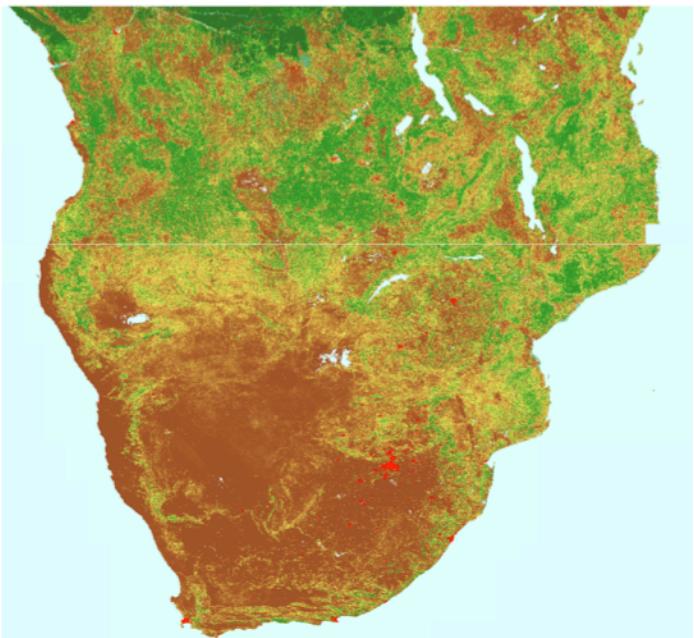


Percent precision error



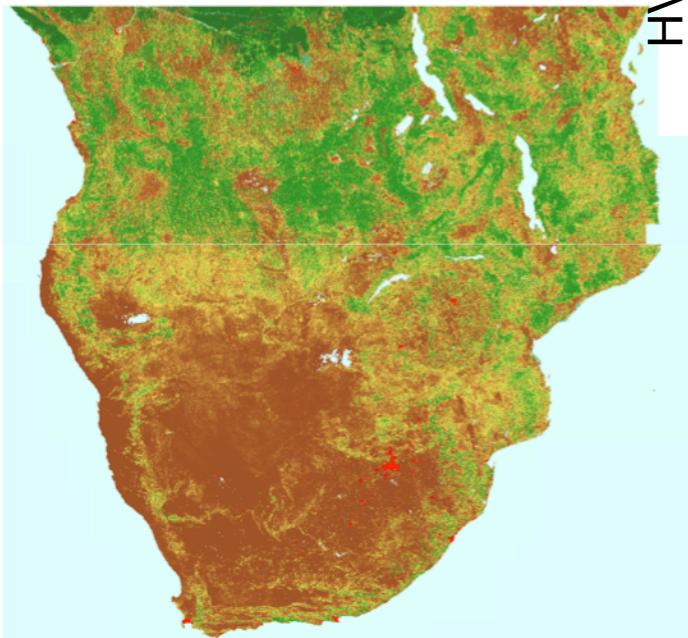
Current work:

AGB 2010

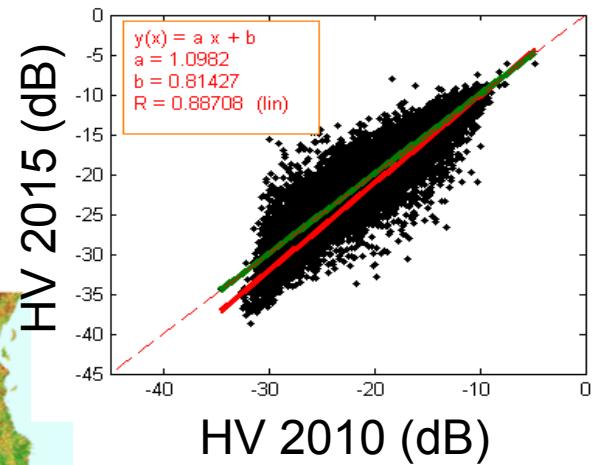


From ALOS mosaics

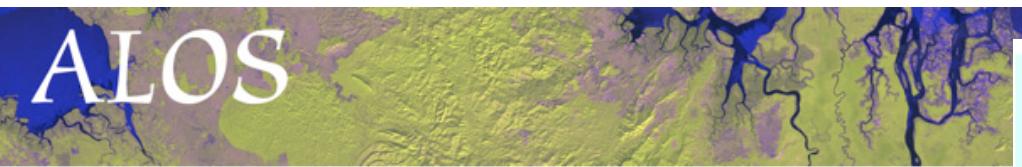
AGB 2015



From ALOS2 mosaics



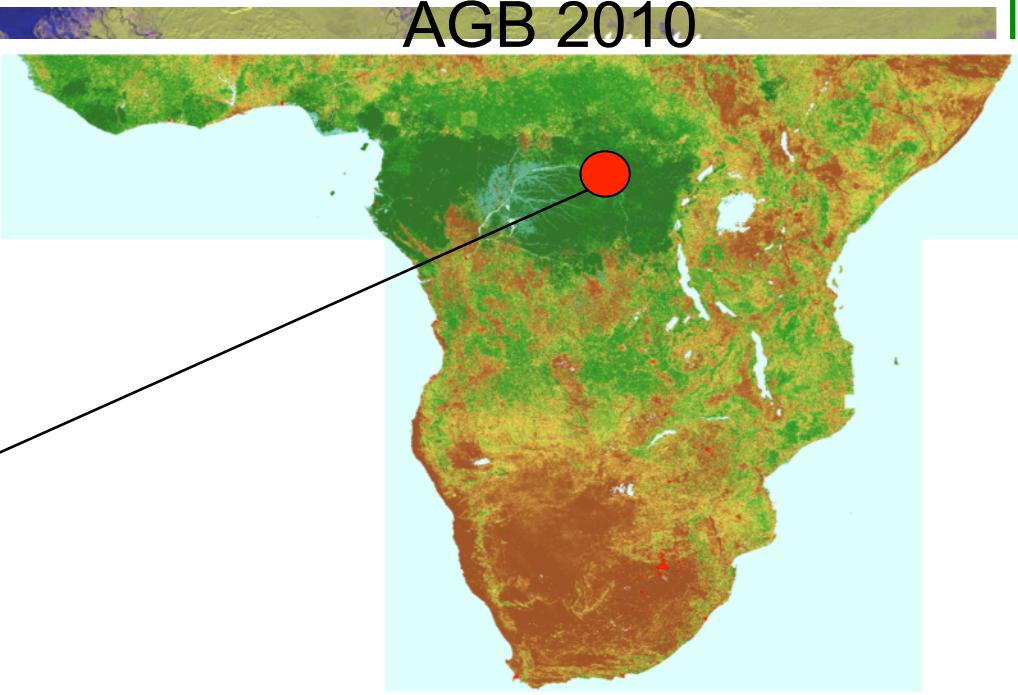
**ALOS**



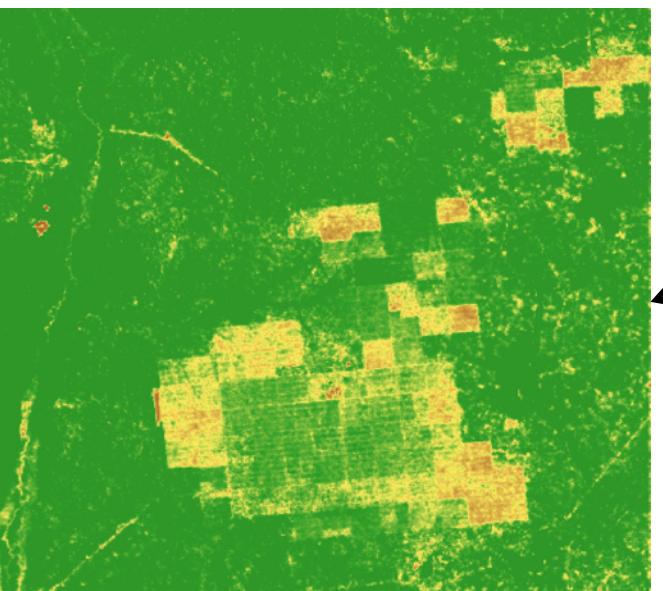
RD Congo  
2.3N, 22.9<sup>E</sup>  
20x20km



**AGB 2010**



**AGB 2015**



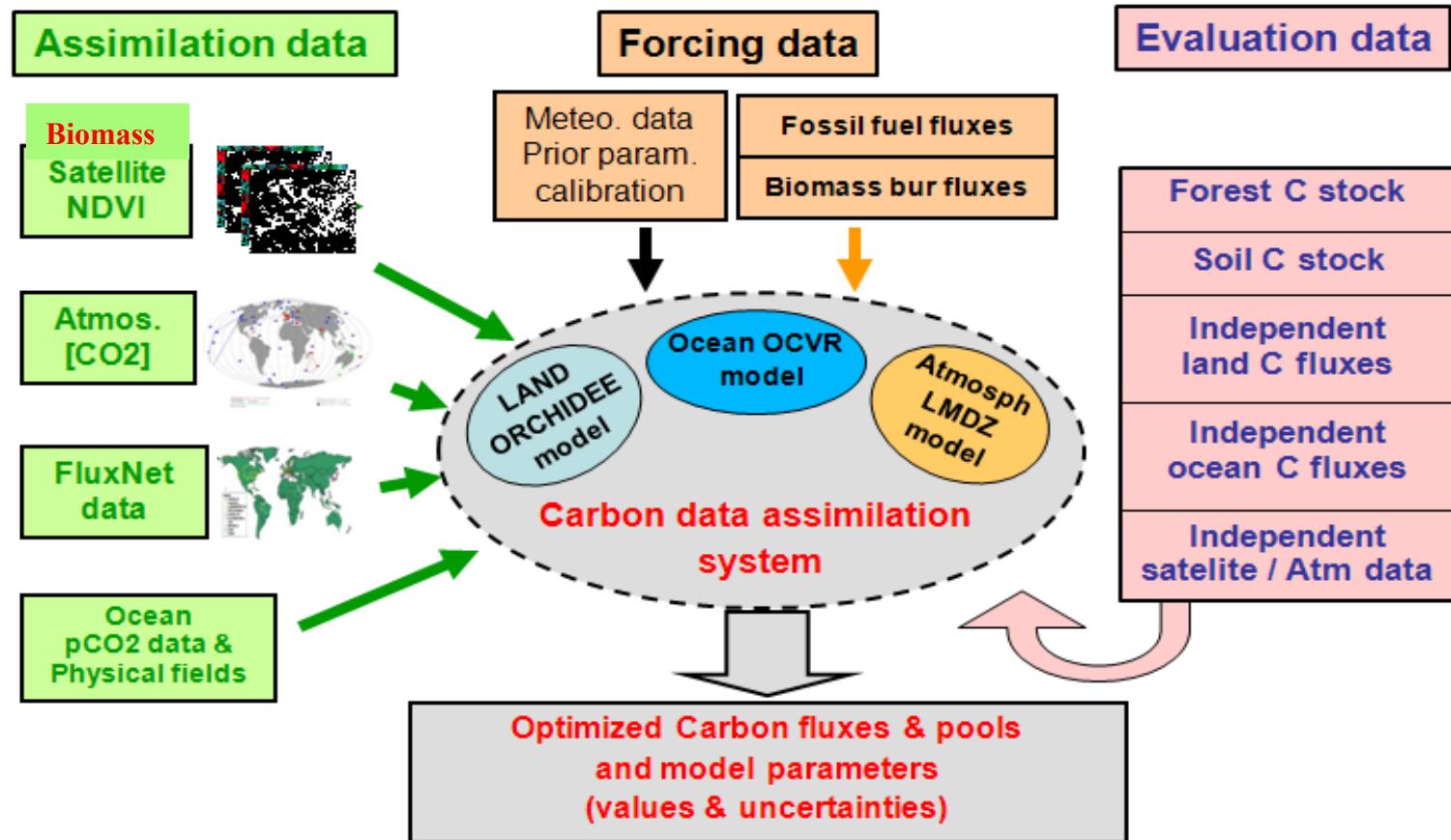
# Use of biomass map to optimise a carbon model

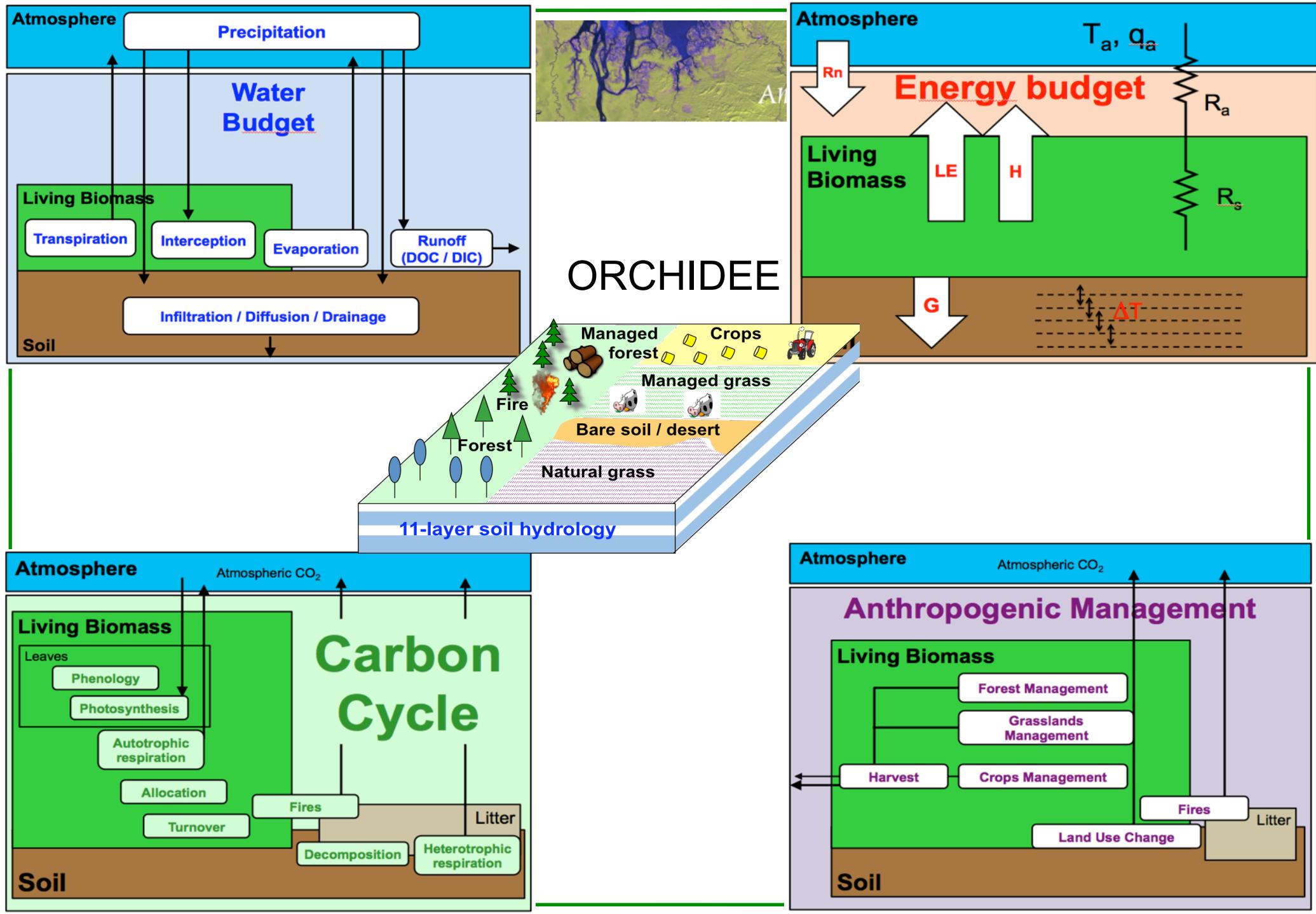
**Cecile Dardel, Philippe Peylin, Philippe Ciais,**  
**LSCE, France**

**Thuy Le Toan, Alexandre Bouvet, Stephane Mermoz**  
**CESBIO, France**

# ORCHIDEE Land Model in Earth System model

LSCE, France



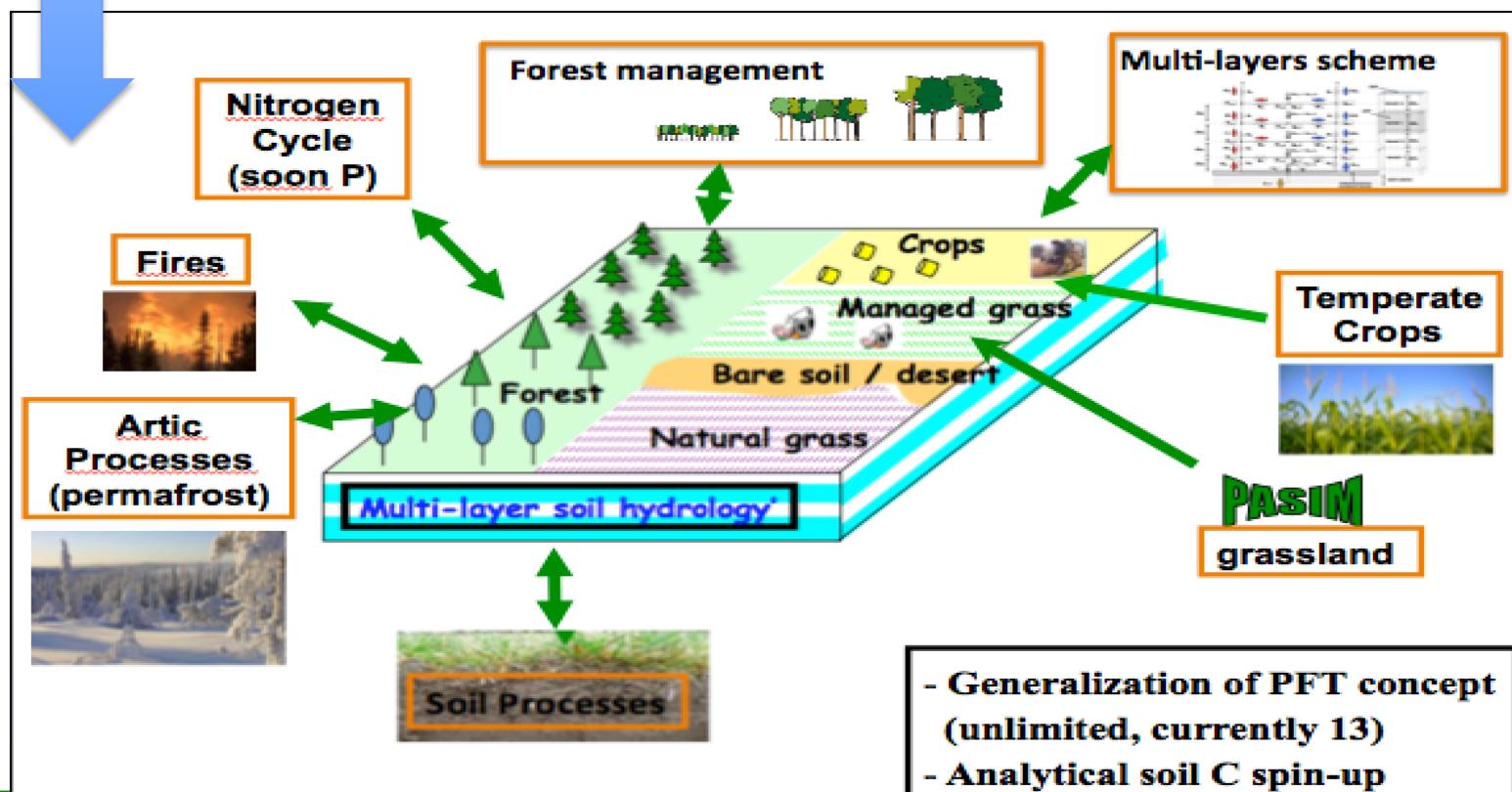
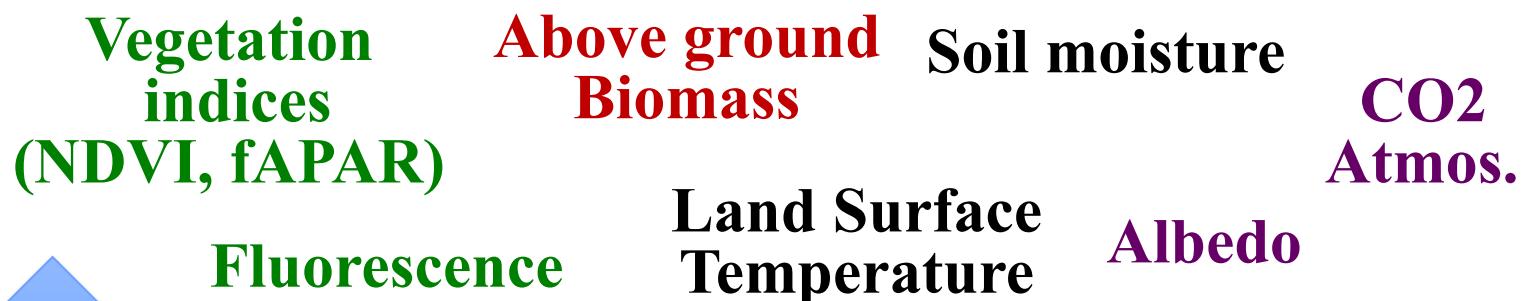


Satellite  
Observations

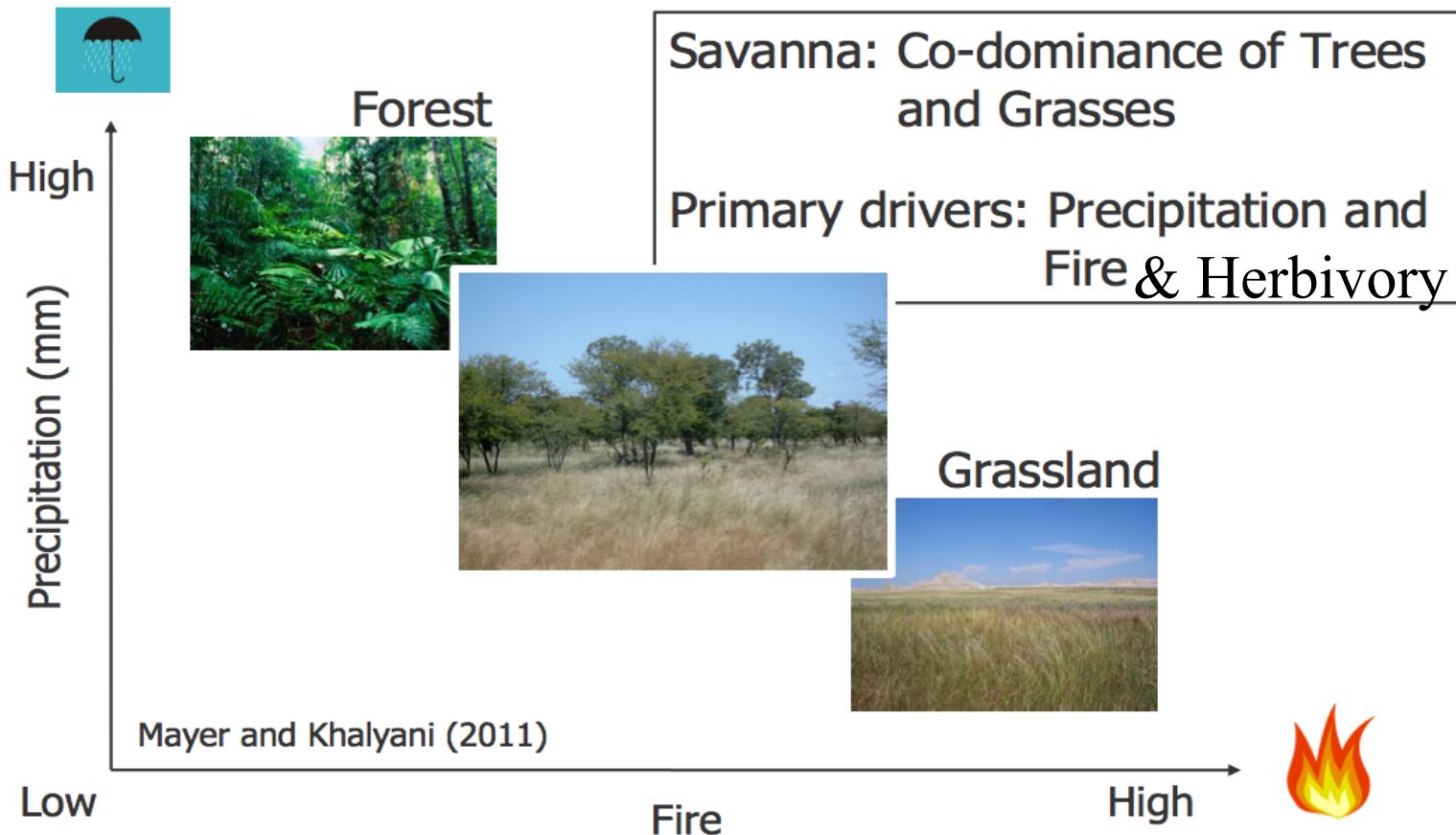


Data  
Assimilation  
(Parameter correction)

ORCHIDEE



# Current work using Biomass map of Africa: Forest-Savanna Transition



## Assimilation of satellite observations

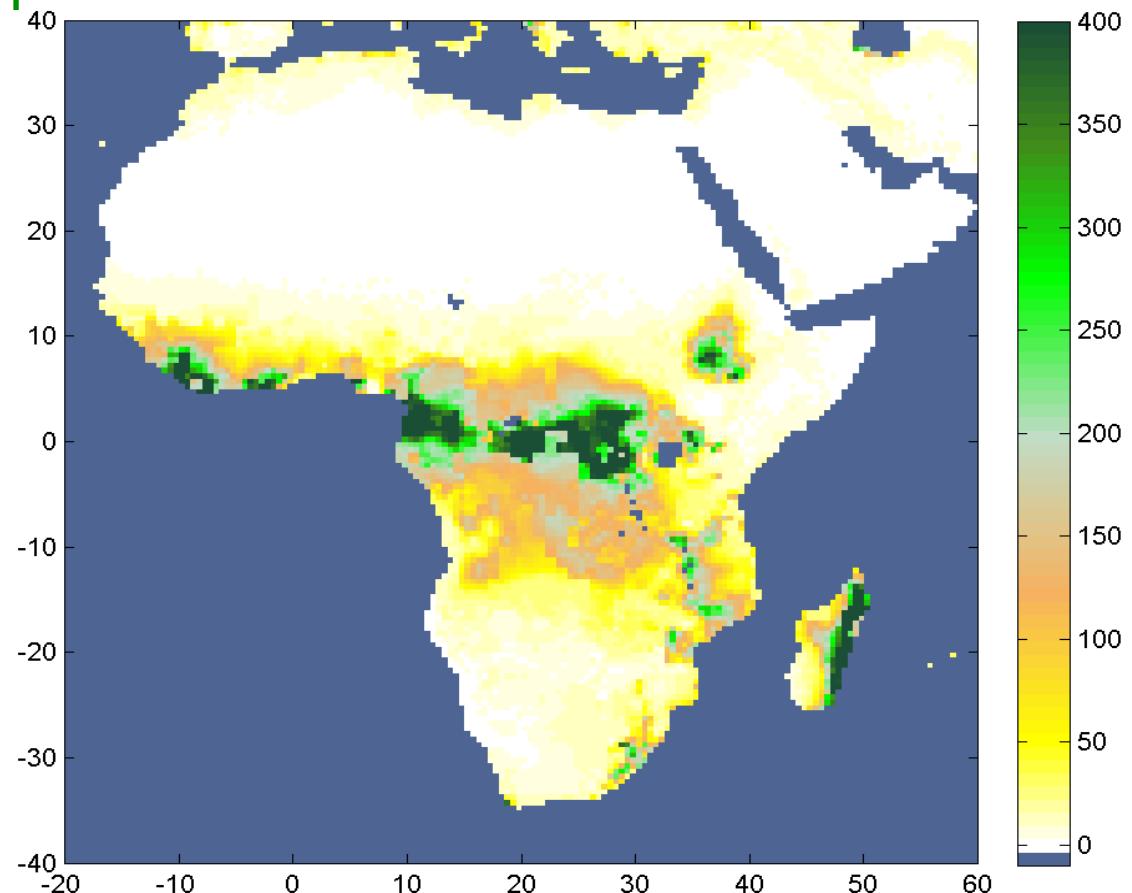
Goals: to improve

- The terrestrial carbon budget
- Estimation of uncertainties
- Climatic Predictions
- Processus Understanding

## Goals :

- 1. Test** the model (vegetation types boundaries ; carbon and biomass fluxes)
- 2. Improve** the model (parameters, fires ; mortality ; existing PFTs...)
- 3. Assimilation** of biomass data
- 4. Perform future simulations** (IPCC scenarios)

## ORCHIDEE initial AGB simulation (t/ha)



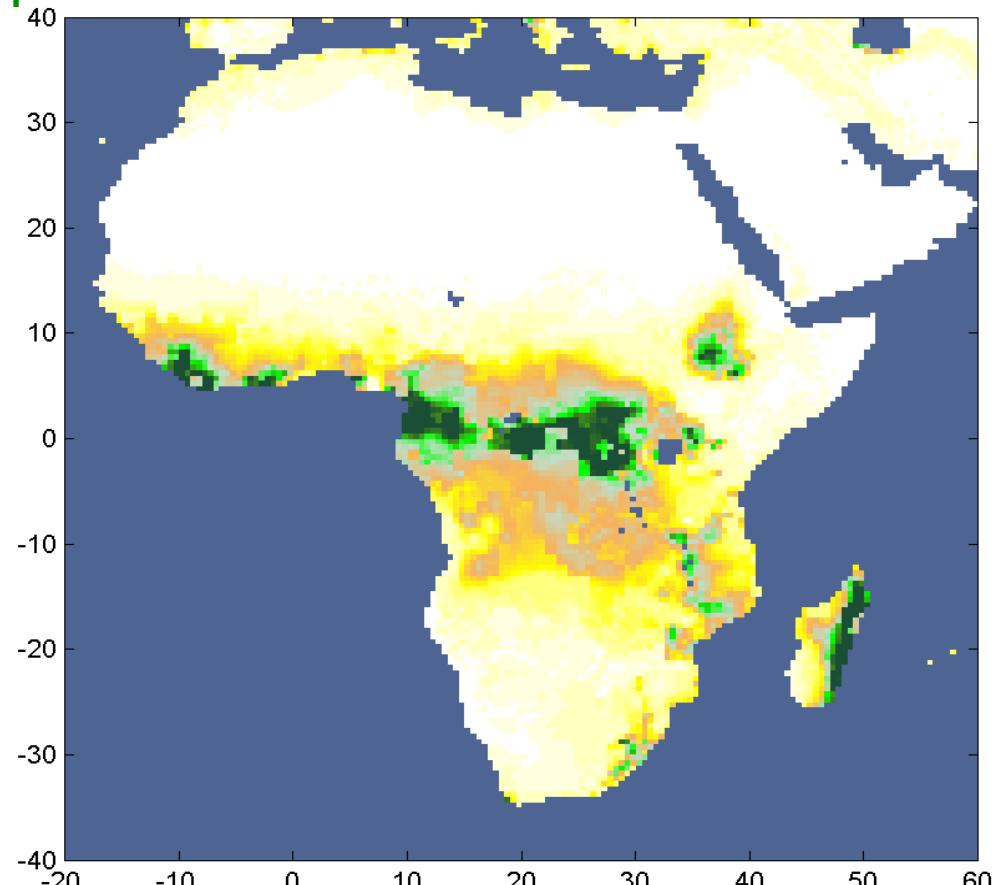
Simulation: 1850-2200

Spatial resolution:  $0.5 \times 0.5^\circ$

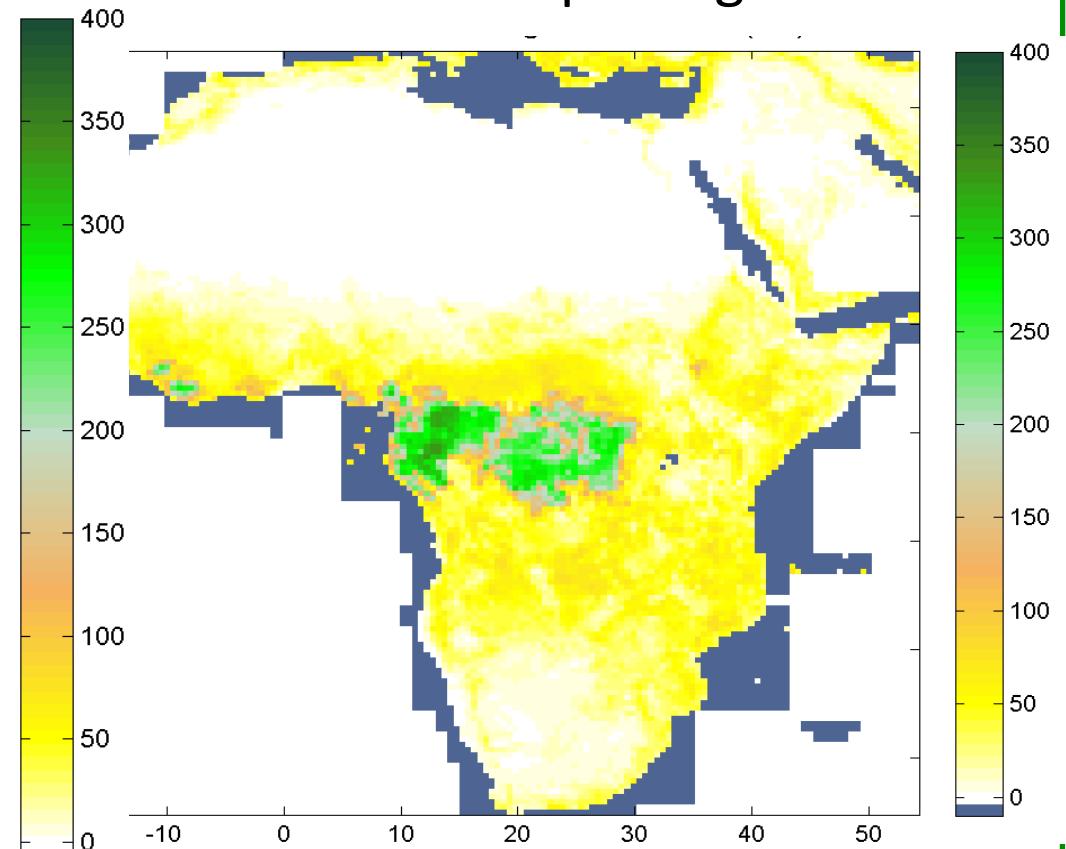
Yearly output

Climatic data: GSWP3

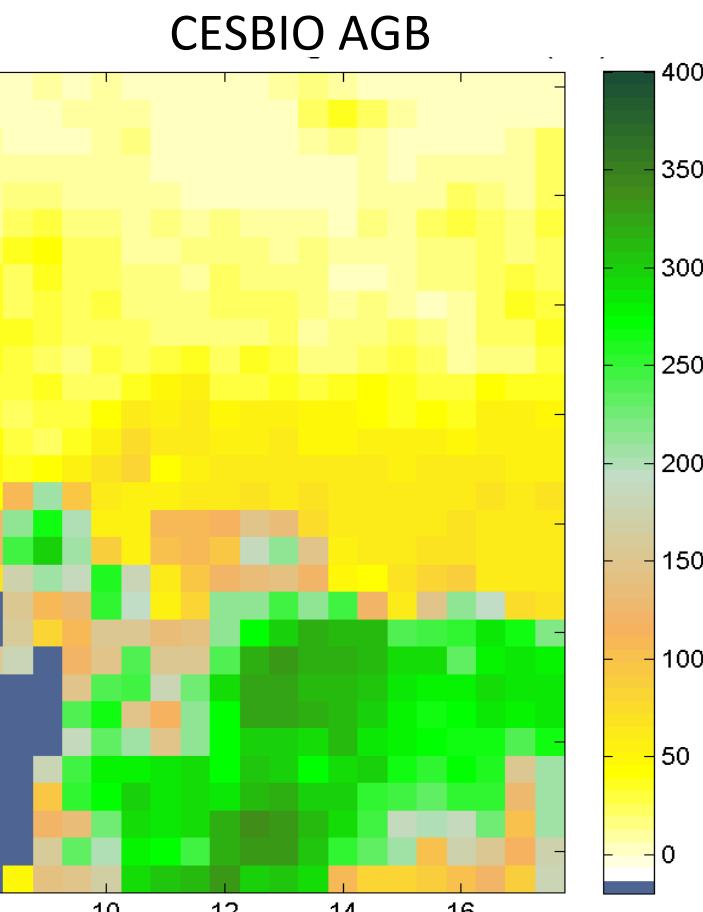
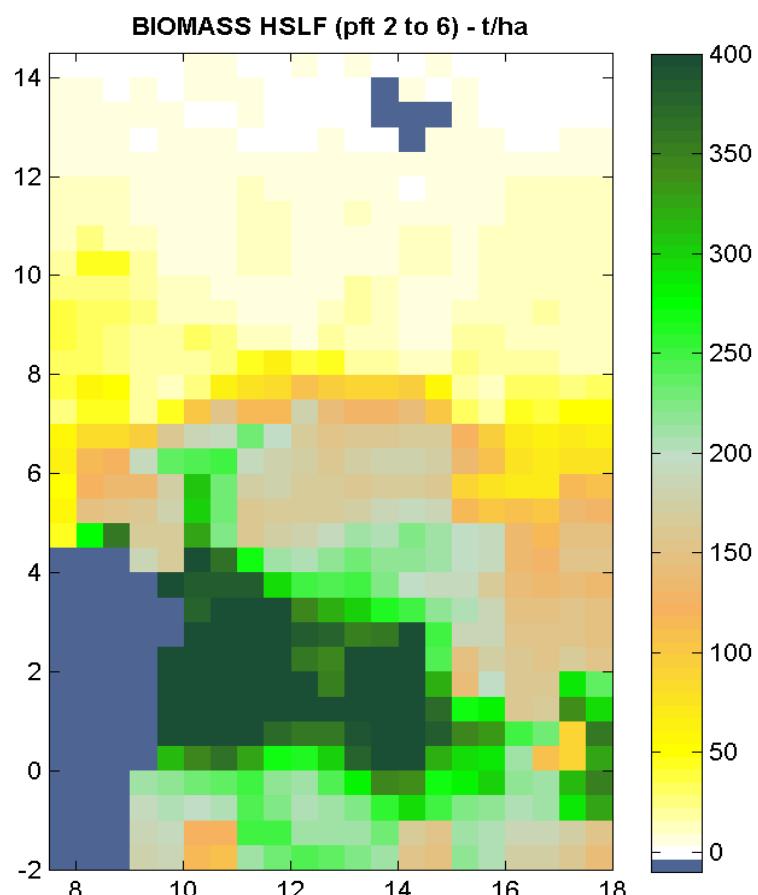
ORCHIDEE initial AGB simulation

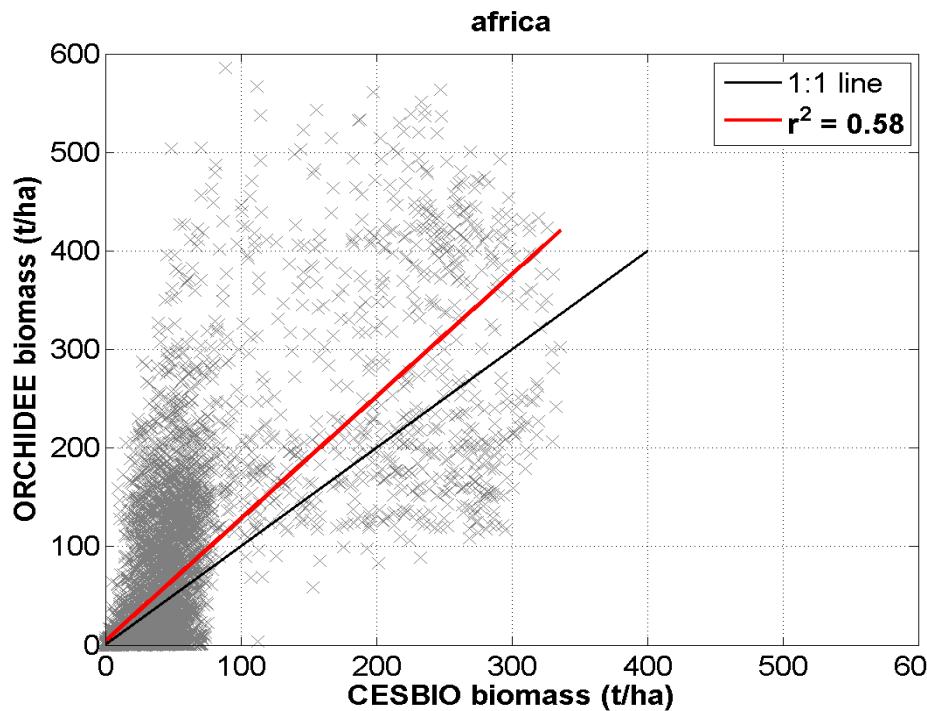


CESBIO AGB map using ALOS



## Comparison North Cameroon





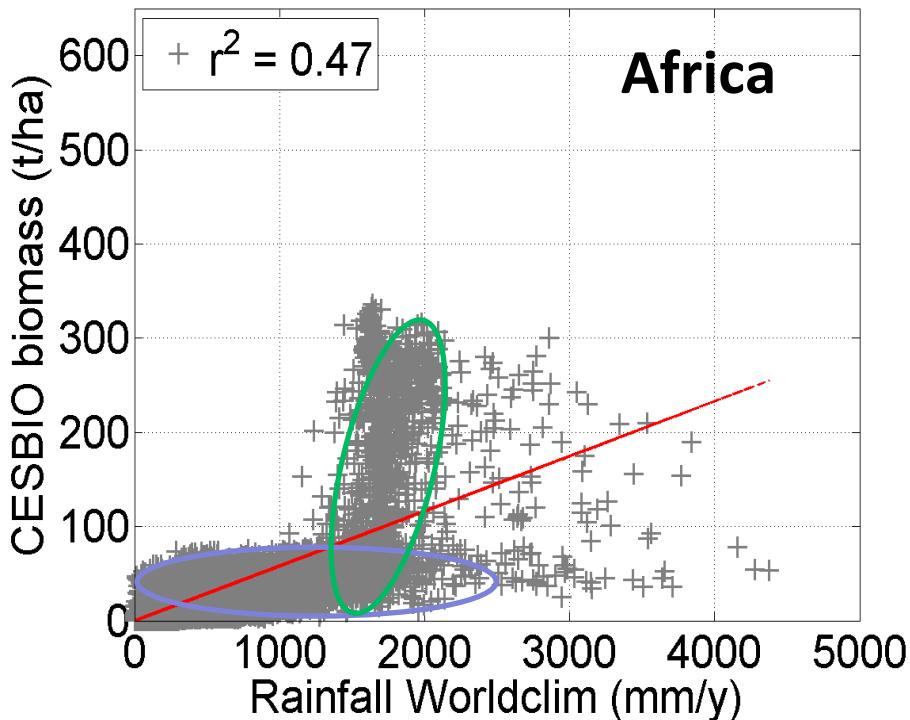
## Over estimation of AGB by ORCHIDEE

Possible causes:

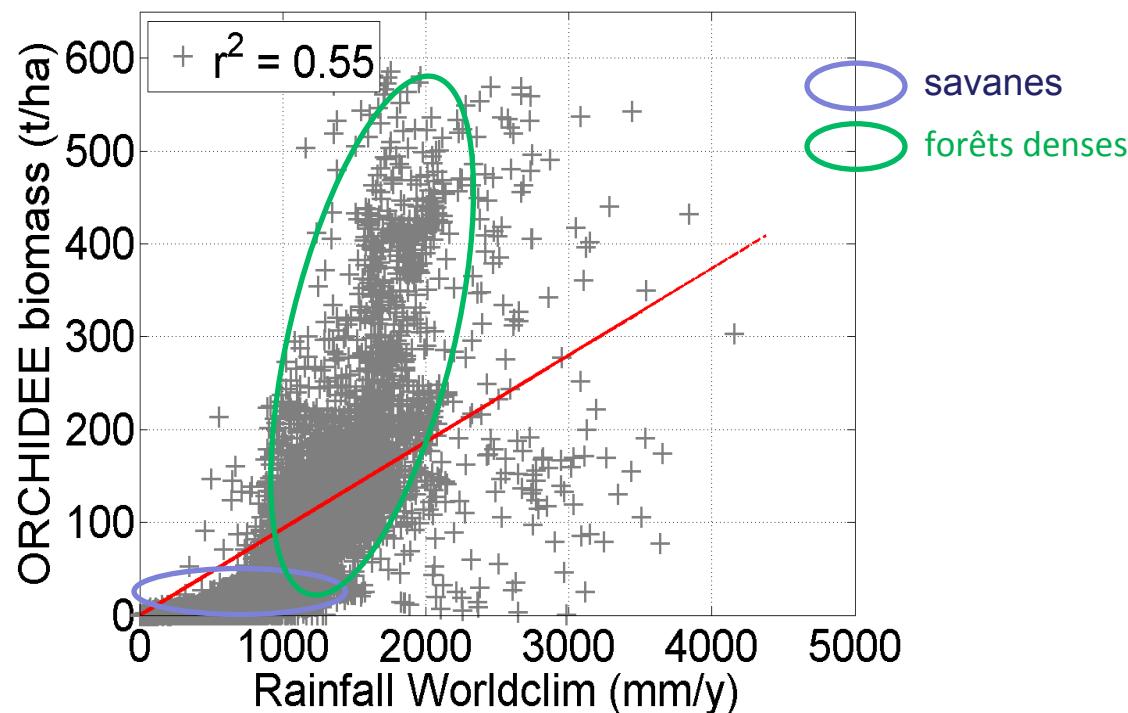
- Anthropogenic impacts not included
- Over estimation of tree productivity:  
Carbon allocation to be improved
- Under estimation of mortality
- Fire impacts
- .....

## Detection of problems in the DGVM module

CESBIO biomass vs Worldclim rainfall



ORCHIDEE biomass vs Worldclim rainfall



- ALOS AGB shows relations between rainfall and AGB: dichotomy between savanna and dense forest
- ORCHIDEE reproduce the same type of relations (but AGB to be improve)

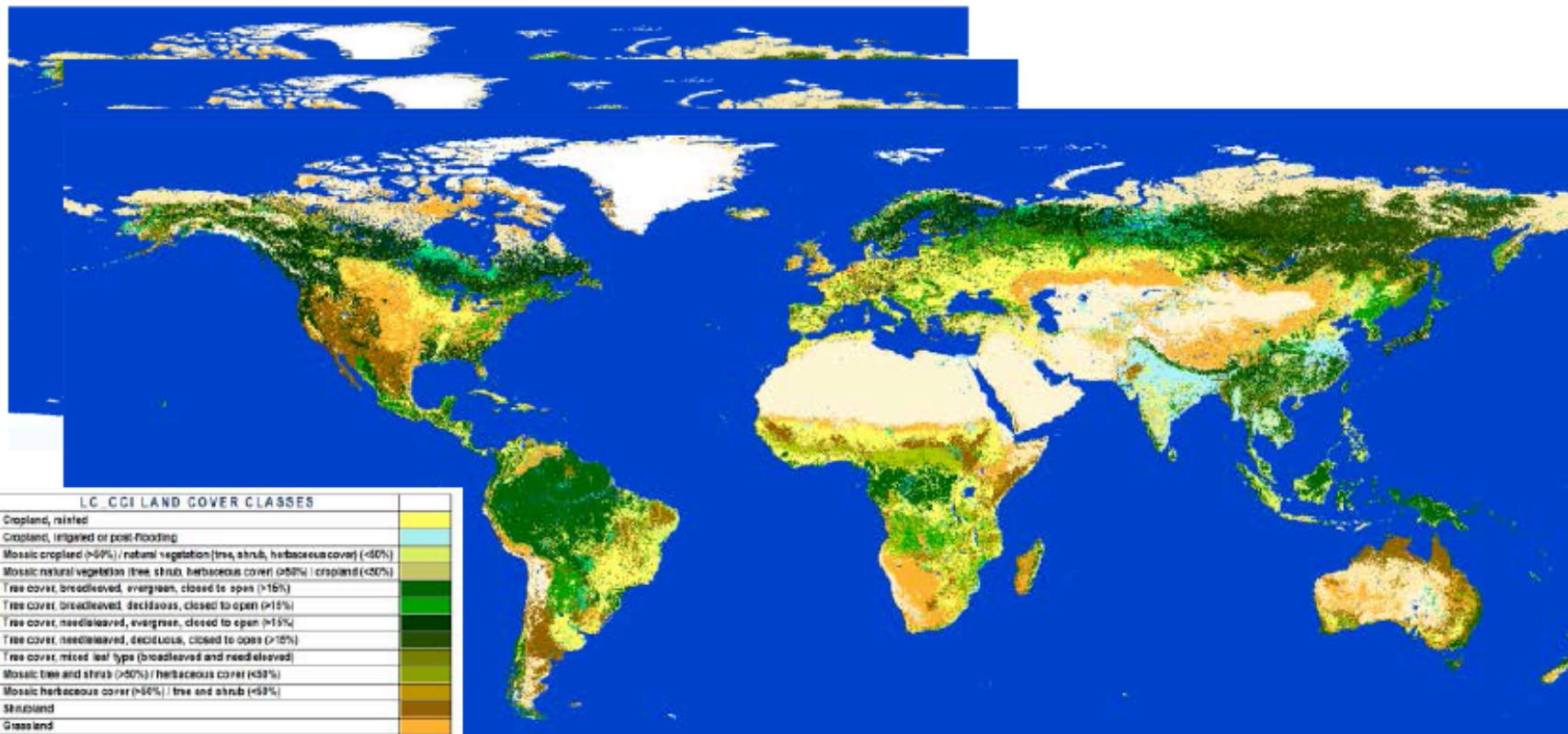
## Use of CCI-Land Cover Product as forcing data



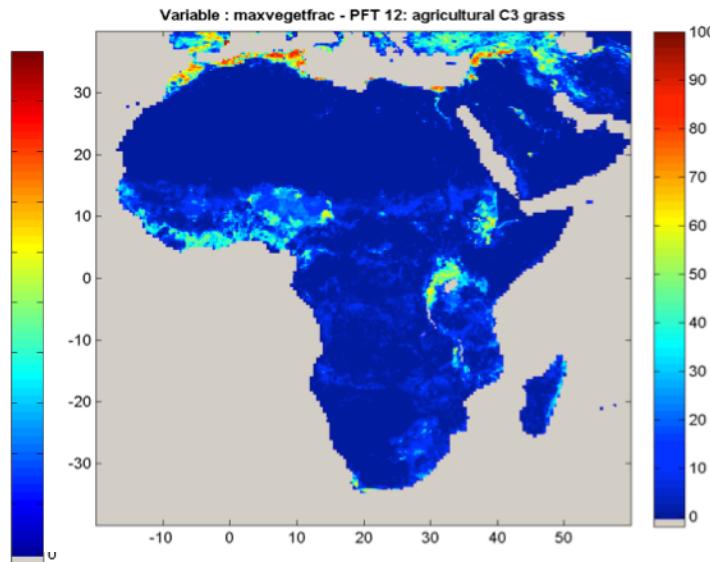
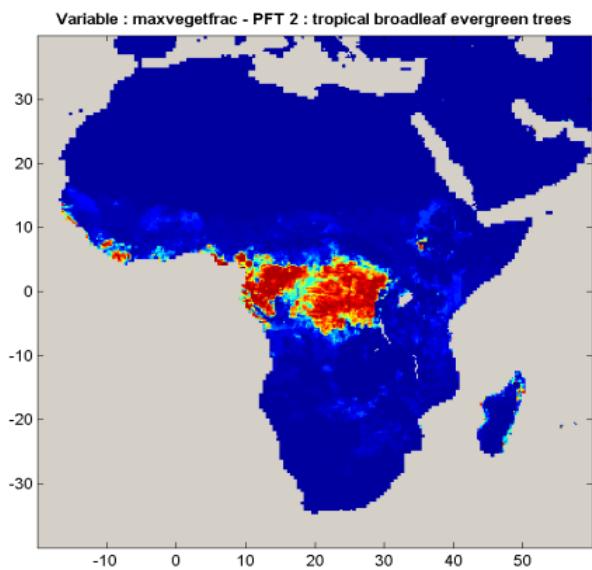
### CCI-LC products



3 LC state products for the 2000, 2005 and 2010 epochs

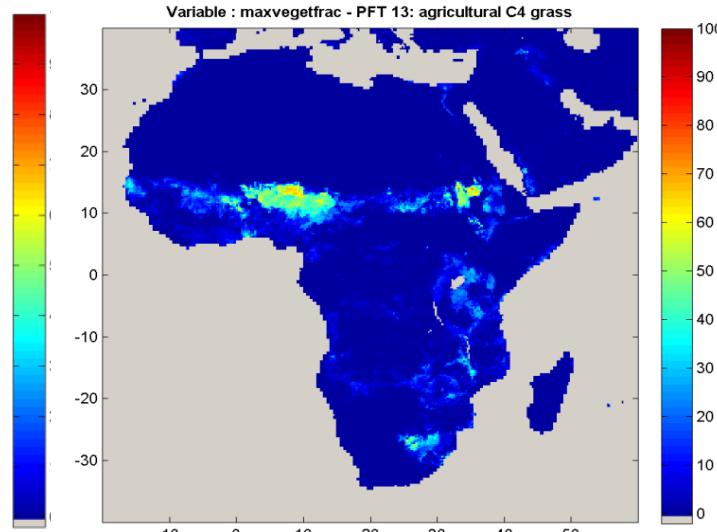
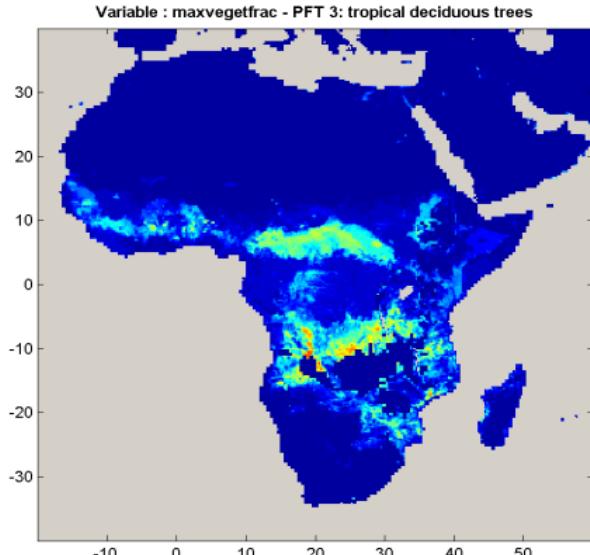


2: tropical  
broadleaf  
evergreen trees



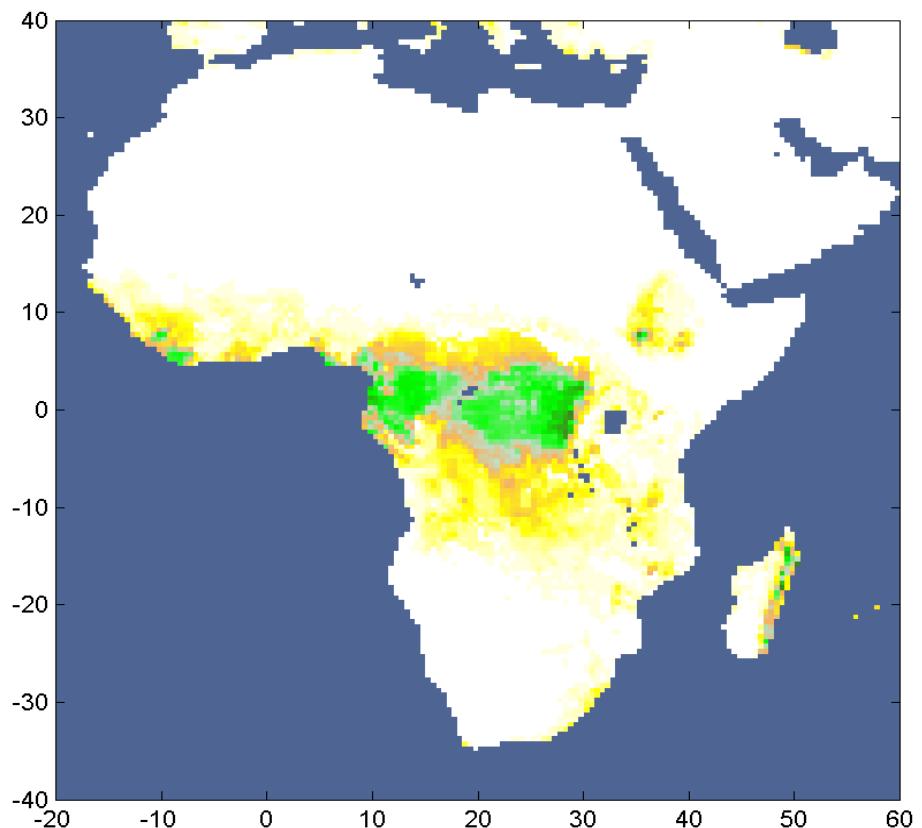
12: agricultural C3  
grasses

3: tropical  
raingreen  
(deciduous) trees

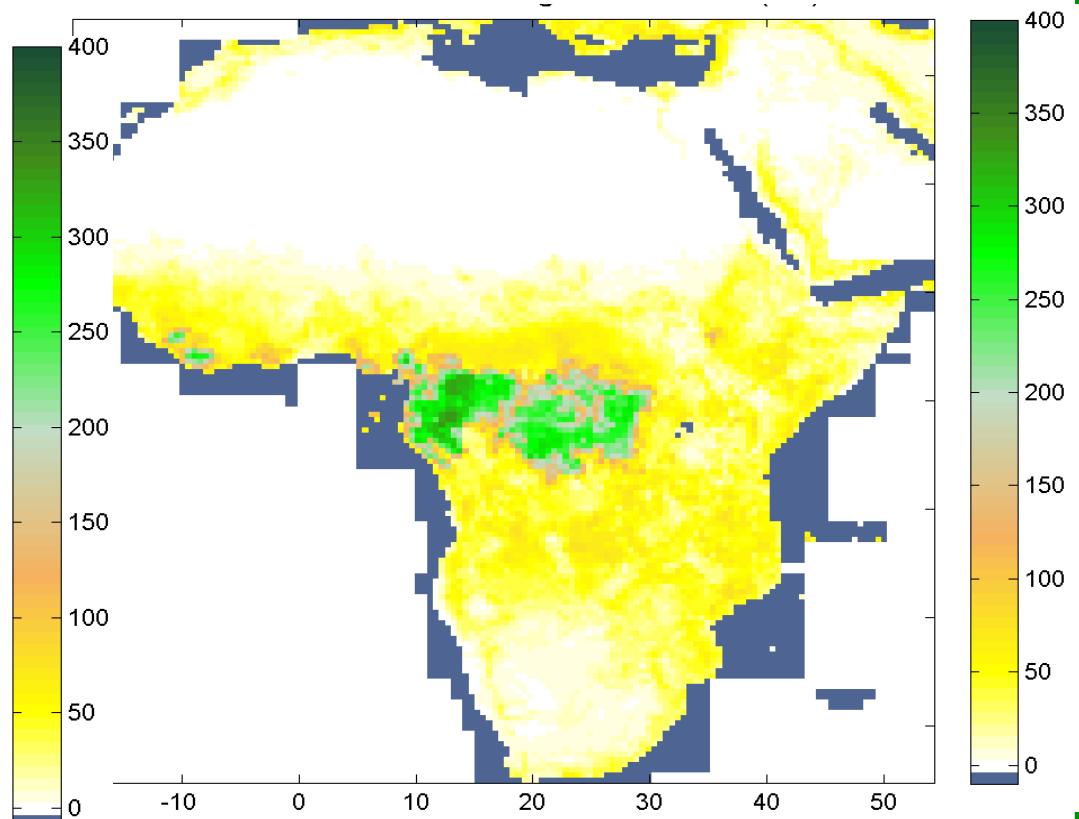


13: agricultural c4  
grasses

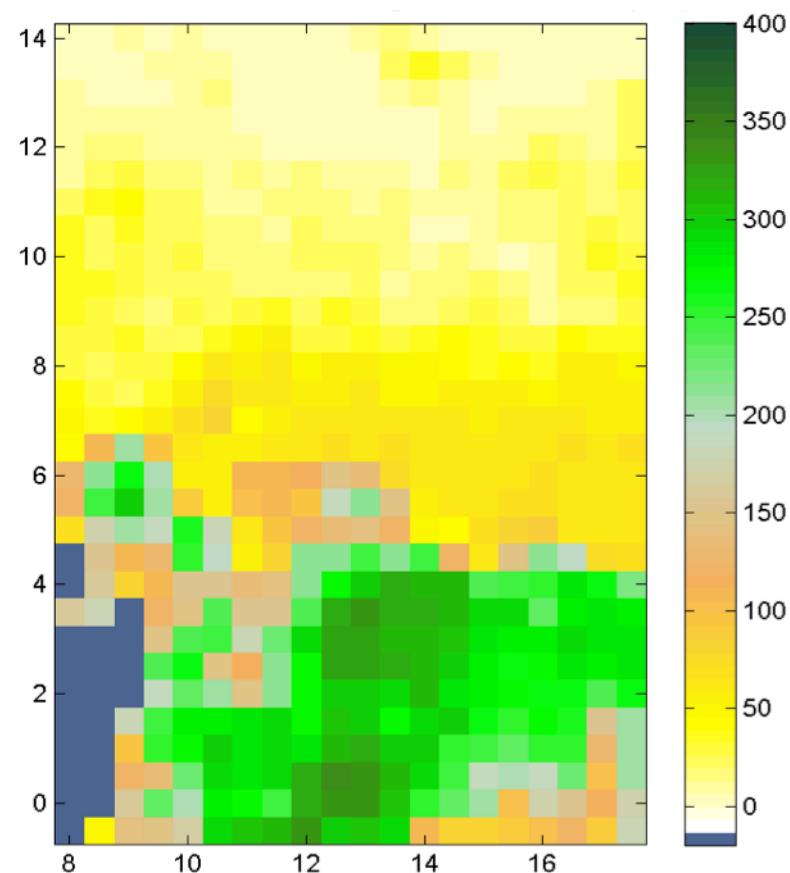
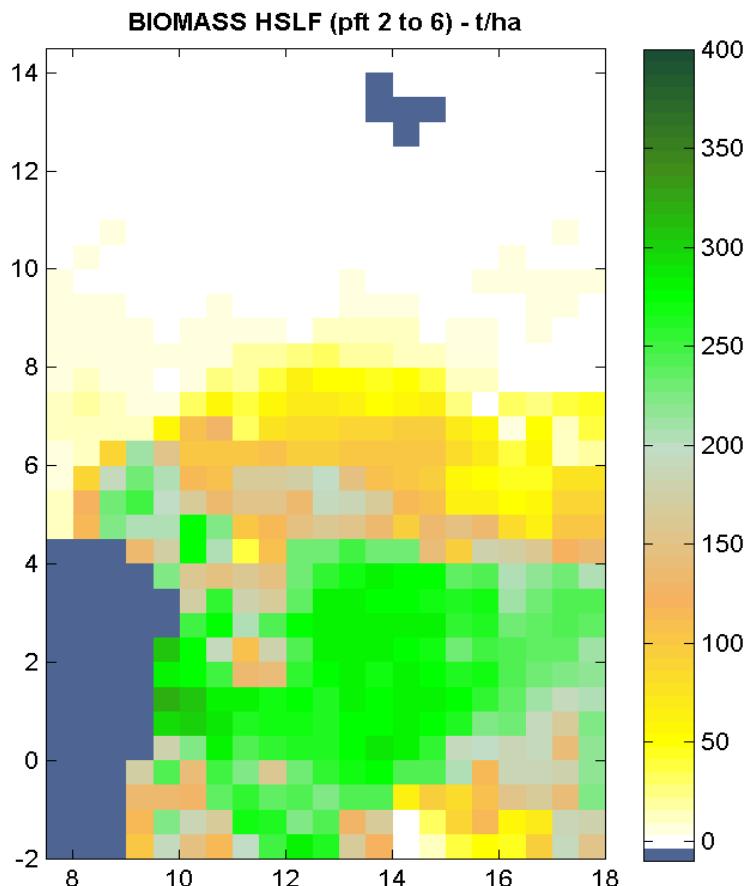
ORCHIDEE AGB simulation



CESBIO AGB map using ALOS



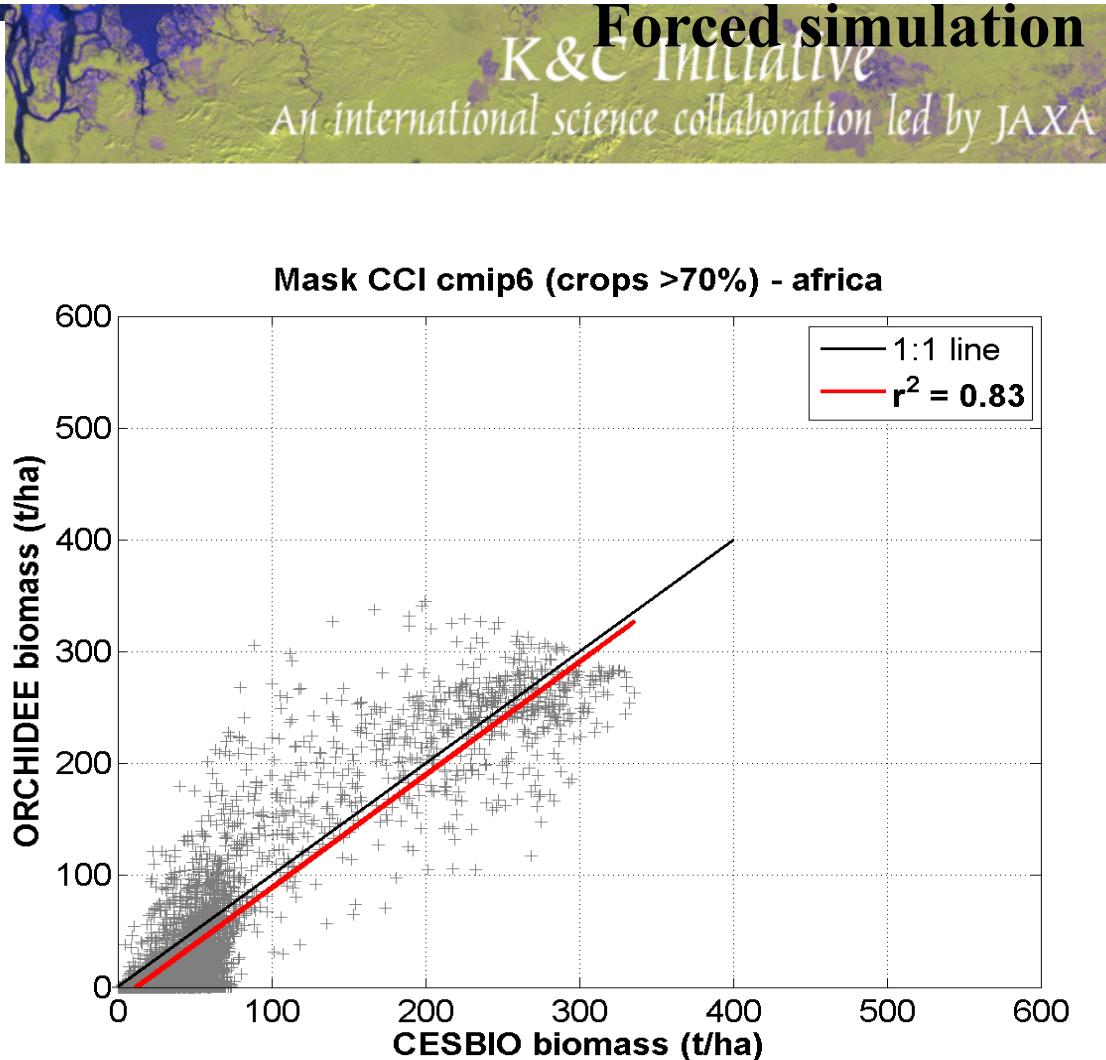
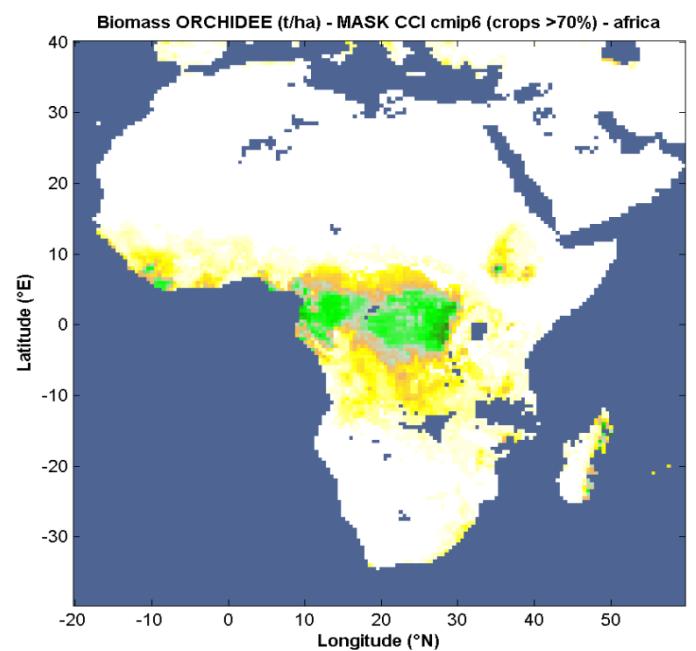
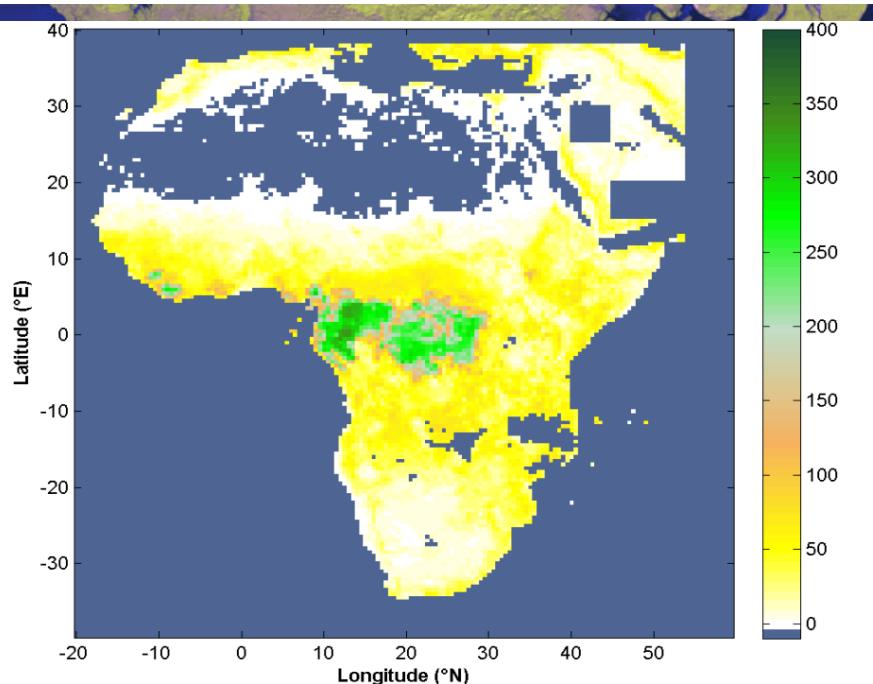
## North Cameroon



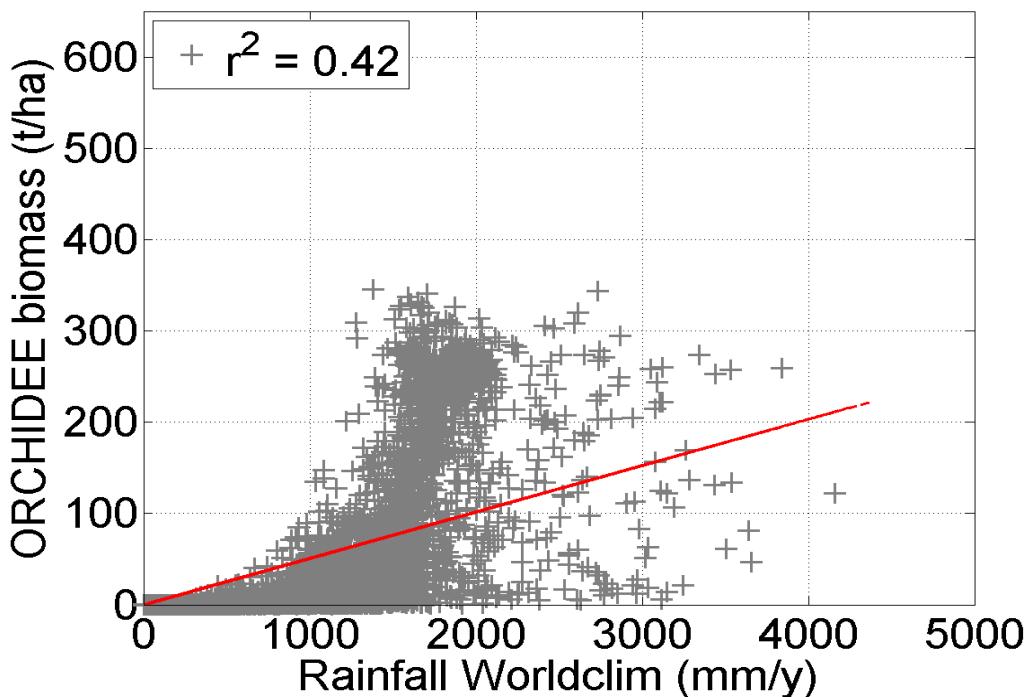
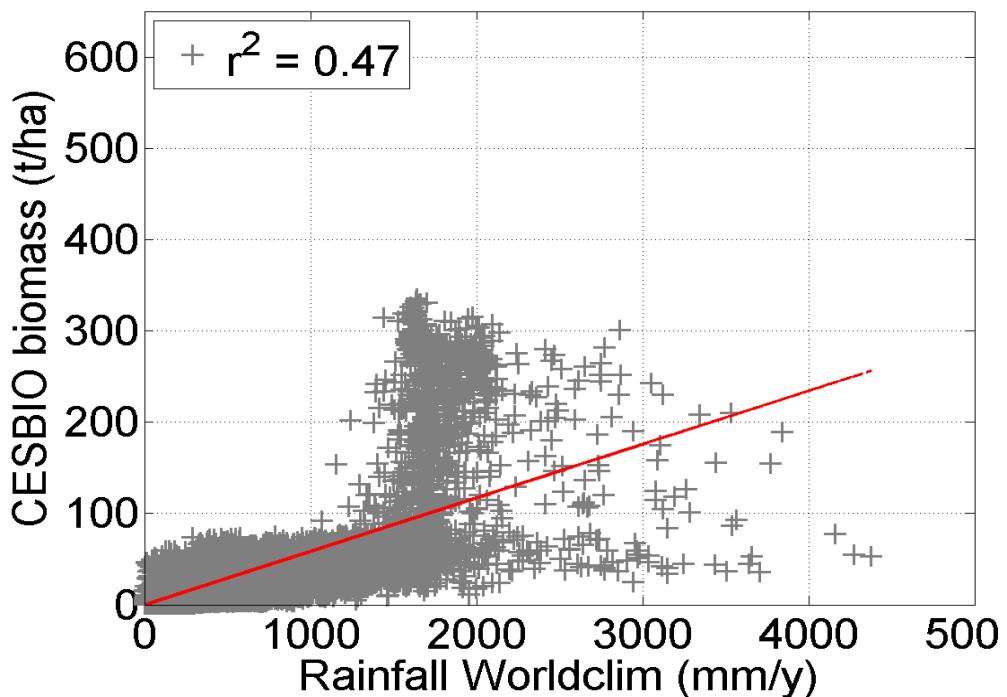
# Forced simulation

K&C Initiative

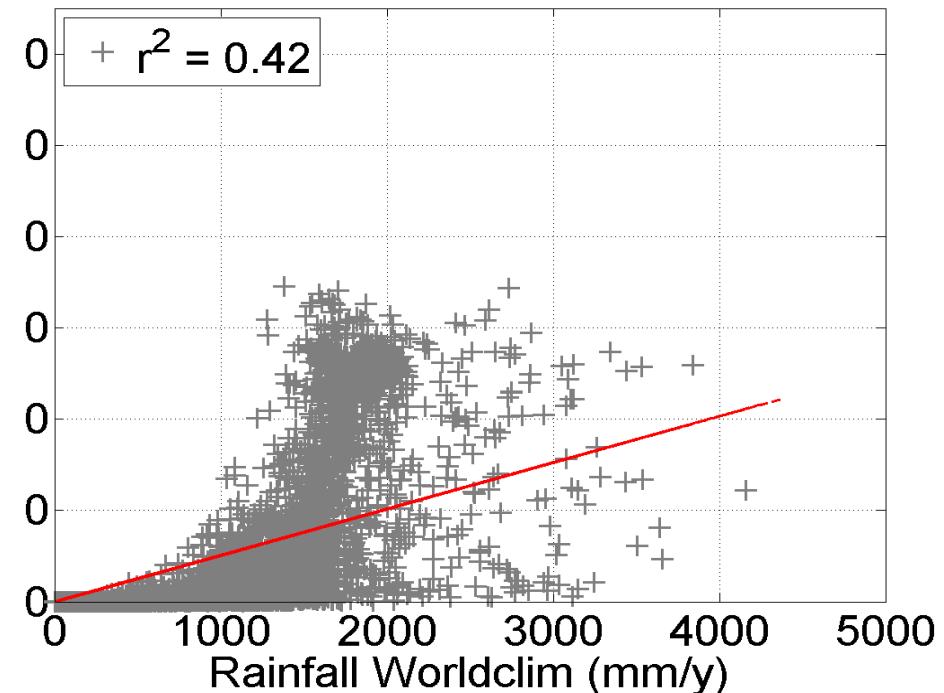
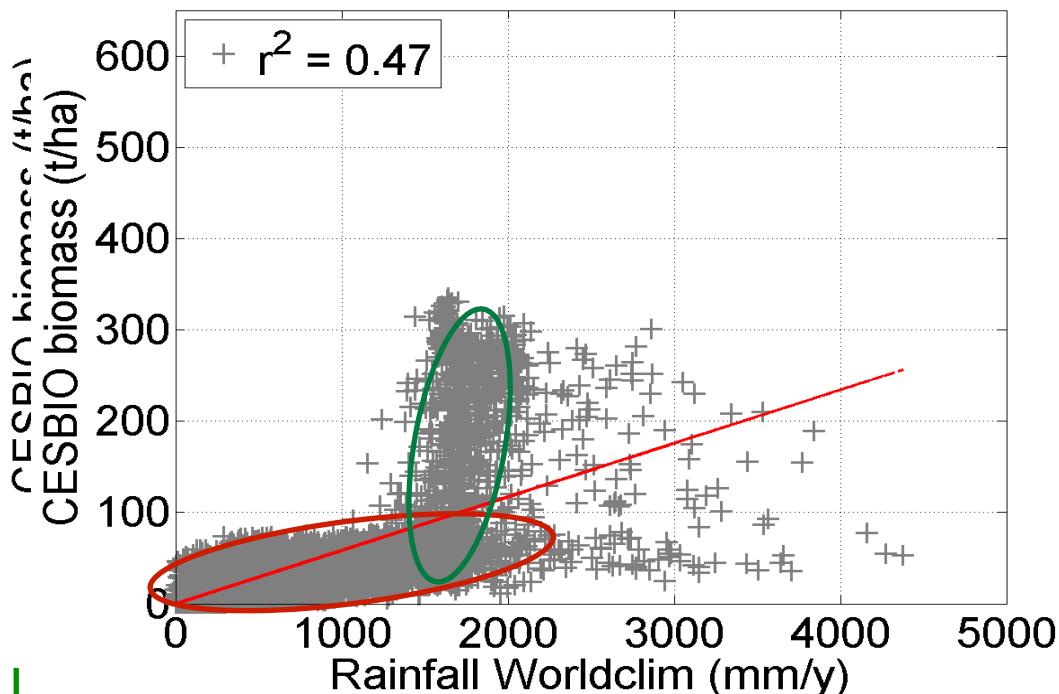
An international science collaboration led by JAXA



## Rainfall as the main AGB driver ?



## Rainfall as the main AGB driver ?



→ Impacts of different climatic change scenarios

Works in progress

## Work to be done

1. Continue 2015 ALOS2 analysis
2. Validation of the South America map
3. Continue improving the Carbon model for Carbon fluxes estimation

## Data sharing

- Reference data for disturbances : Vietnam 2010, Cameroon; Gabon 2015

## Deliverables

Africa 2010: (50 m, 500 m in tropical forests)

Africa 2015 (50 m, 500 m in tropical forests))

**Thank you!**

ありがとう