First Global Mapping Approaches

GlobBiomass - 1st Users Workshop

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GAMMA Remote Sensing & CESBIO

Product specification and algorithm design

The development of one or multiple global biomass algorithms is part of WP3000: define methods leading to an improved global map of AGB (*), taking into account regional approaches and the scientific basis of the algorithms. The development shall take into account the Product Specification Document derived from user requirements (WP1000) and the available ground and space data (WP2000).

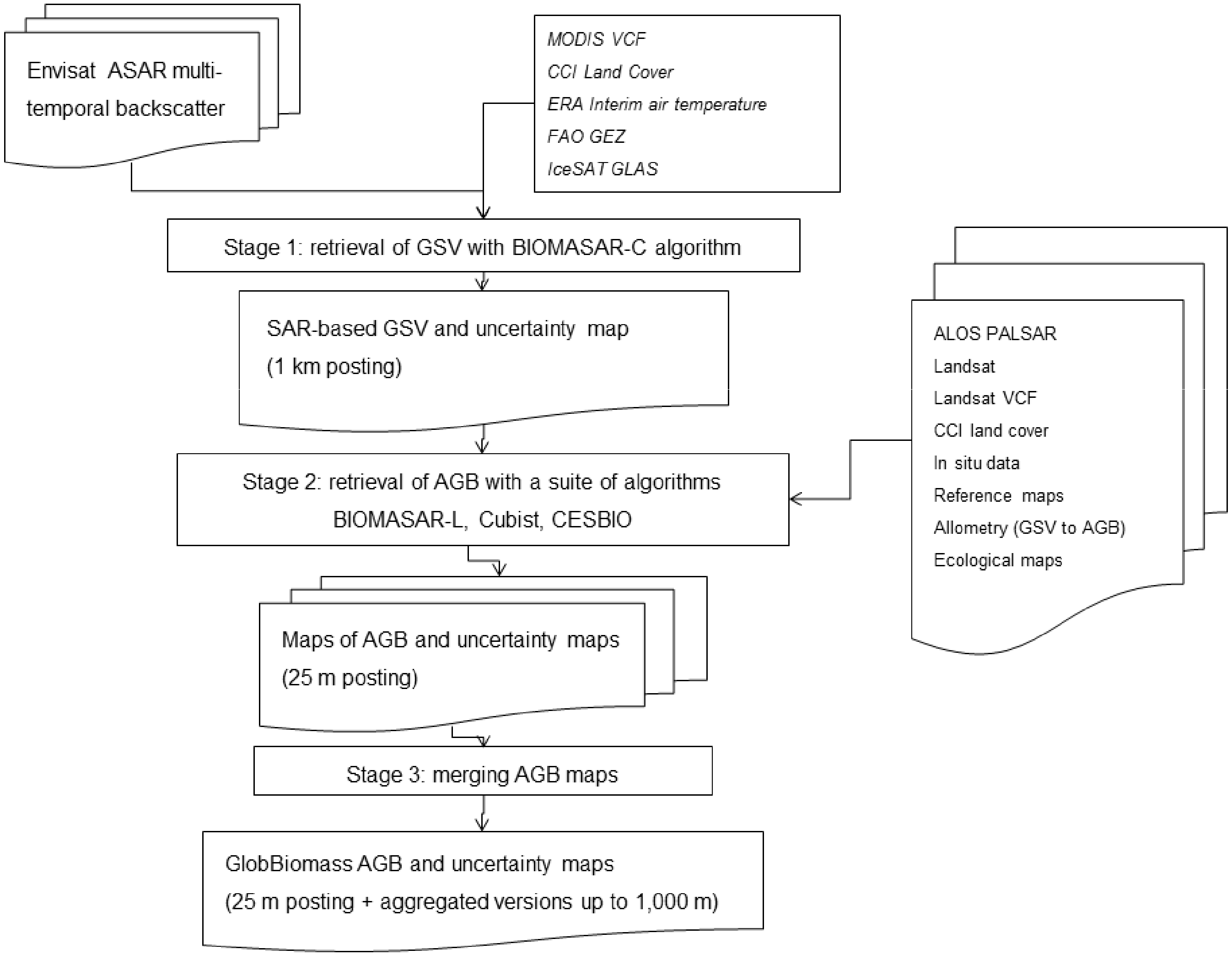
(*) spatial resolution < 500 m and an error expected of max 30%.

Some considerations on biomass estimation

- There is no remote sensing observable that can give us biomass directly
- The remote sensing observations in theory most suitable for estimating biomass globally are either publically unavailable or not yet available
- Models inverting EO to biomass are always approximations

What can we do then? Try to extract as much “biomass”-related information as possible from (i) EO datasets publically available that may relate to biomass and (ii) methods designed to perform globally

The GlobBiomass global biomass mapping approach

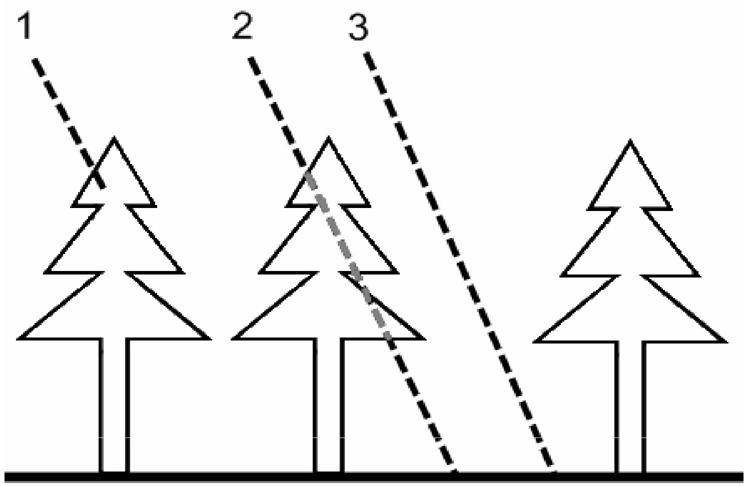


Strengths and bottlenecks of this approach

- ✓ Use of physically-based models relating SAR data to “biomass” variables
- ✓ No or little in situ data required for model training (but reference data required for calibrating)
- ✓ Parallel development of retrieval approaches

- ➢ Is C-band sufficiently reliable to derive unbiased biomass? Is one L-band image sufficiently reliable to derive biomass fulfilling the requirements set for this project?
- ➢ Are the models selected perfoming globally?
- ➢ Does the retrieval perform well when no in situ data are used for training?
- ➢ Several retrievals work with GSV. How to best link with AGB?
- ➢ What are the (best) decision rules to select one retrievalapproach instead of the others?

The forest backscatter model



1) volume scattering from canopies
2) surface scattering attenuated by canopies
3) scattering from forest floor though canopy gaps

Water Cloud with gaps:

$$\sigma^0_{for} = \sigma^0_{gr} T_{for} + \sigma^0_{veg} \left(1 - T_{for}\right)$$

Transmissivity as function of canopy density, *η*, and height, *h*, linked to GSV or AGB:

$$T_{for} = (1 - \eta) + \eta e^{\frac{-2\kappa_e h}{\cos\theta}} = \exp(-\beta V) = \exp(-cB)$$

β – transmissivity coefficient, κ – extinction coefficient, c – attenuation coefficient

Model training and inversion

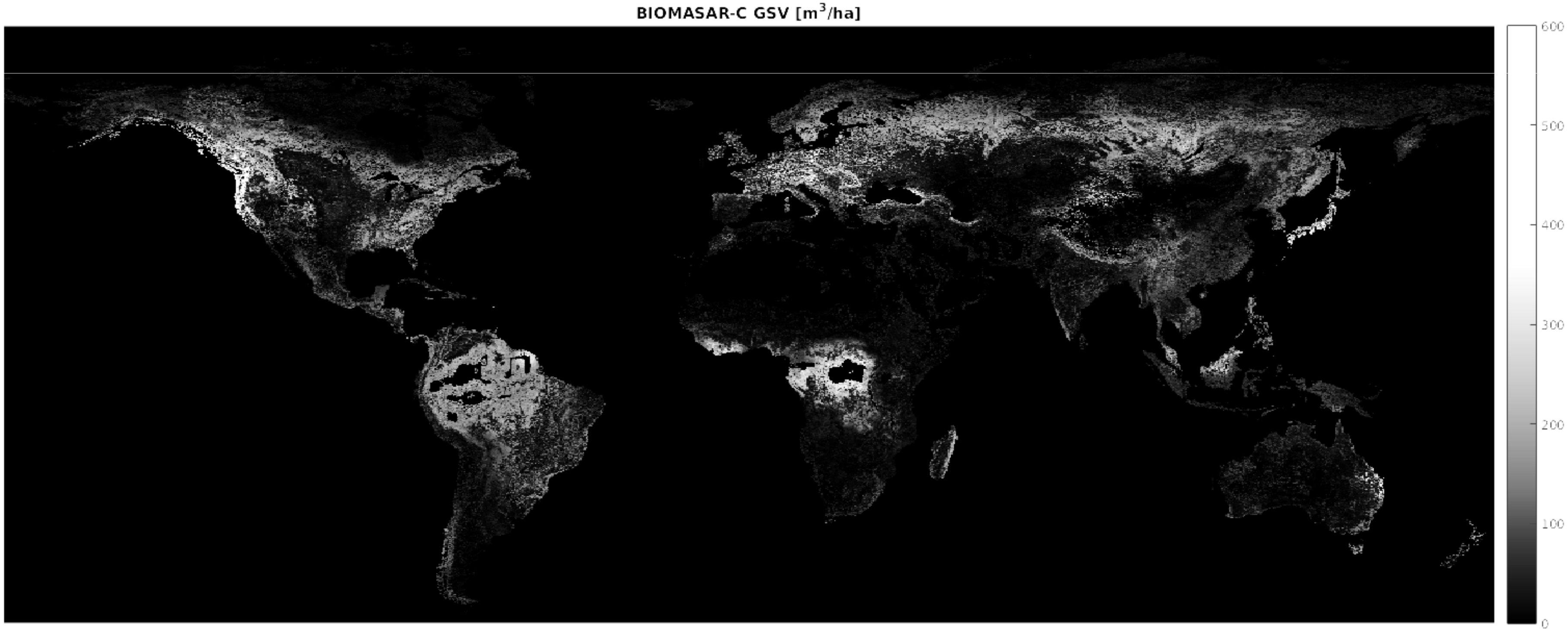
- Need to estimate the model parameters σ^0_{gr} σ^0_{veg} and attenuation
- It is highly desirable to have the estimation adaptive at pixel level
- In BIOMASAR-C and –L, the estimation of σ^0_{gr} σ^0_{veg} is supported by VCF products and other auxiliary datasets required to constraining the estimation to physically plausible values. In CESBIO method, currently in situ data are considered.
- The coefficient of attenuation is currently set to a constant value in BIOMASAR-C and –L. An e.m. model-based approach is used by CESBIO
- Inversion is straightforward
- Multi-temporal combination of biomass estimates from individual observations necessary at C-band

  - Nice and easy but ….

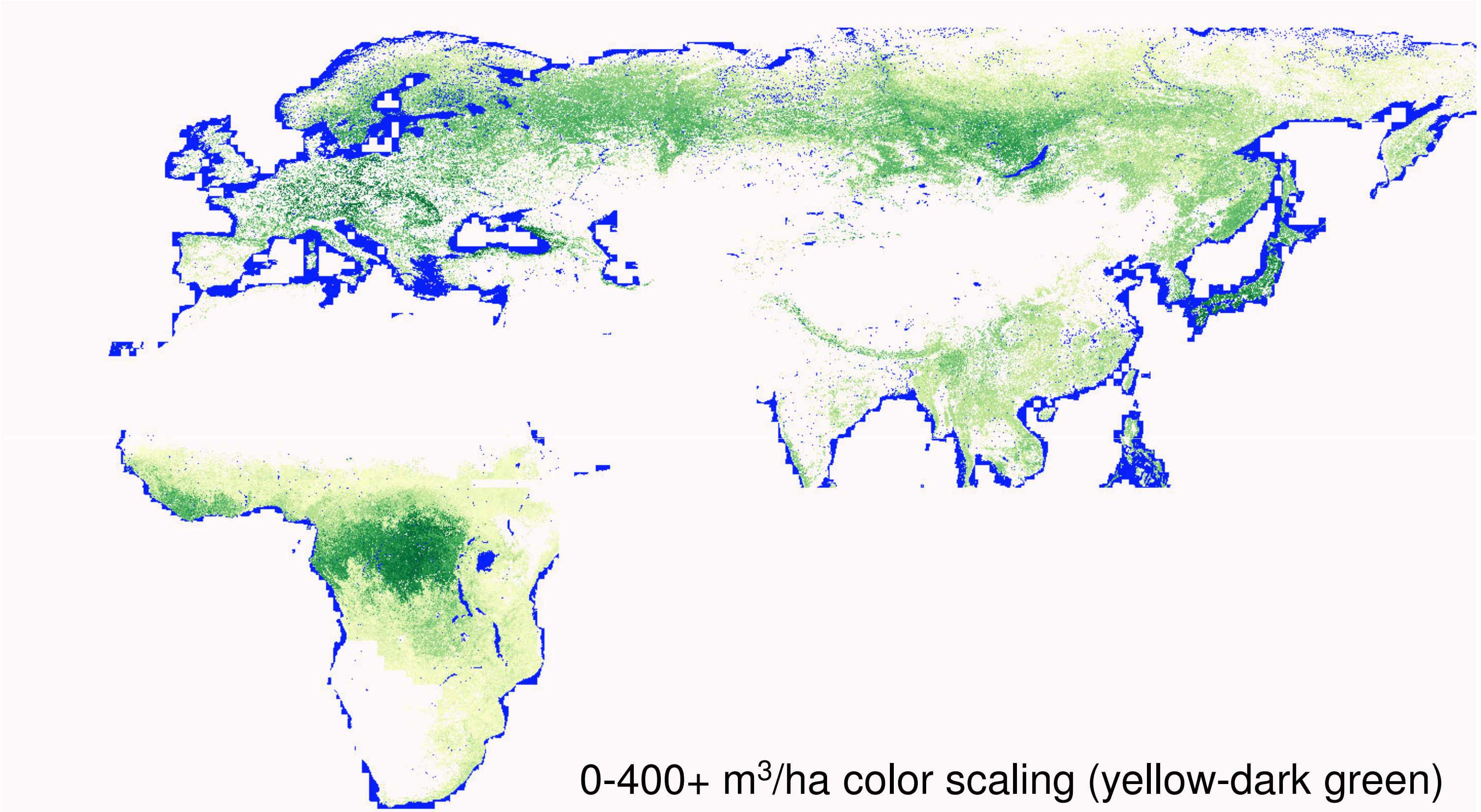
- The automatic estimation of model parameters of BIOMASAR can fail
- In situ data are not available in sufficient manner everywhere to traing the model precisely
- The assumption of constant attenuation must be reconsidered
- Shall we link methods or results? If so, how to cope with the different nature of the output by each algorithm?

BIOMASAR-C

- Global GSV map produced from hypertemporal observation (17 months) of the SAR backscatter by Envisat ASAR around the year 2010. Pixel size: 0.01 deg.
- Spatial distribution of biomass well captured. Validated at regional level > 10°N
- Limitations: Underestimation in fragmented landscapes and in high-biomass forest (>250 m^3/ha)



Stage 2 retrieval – Rescaling with Cubist



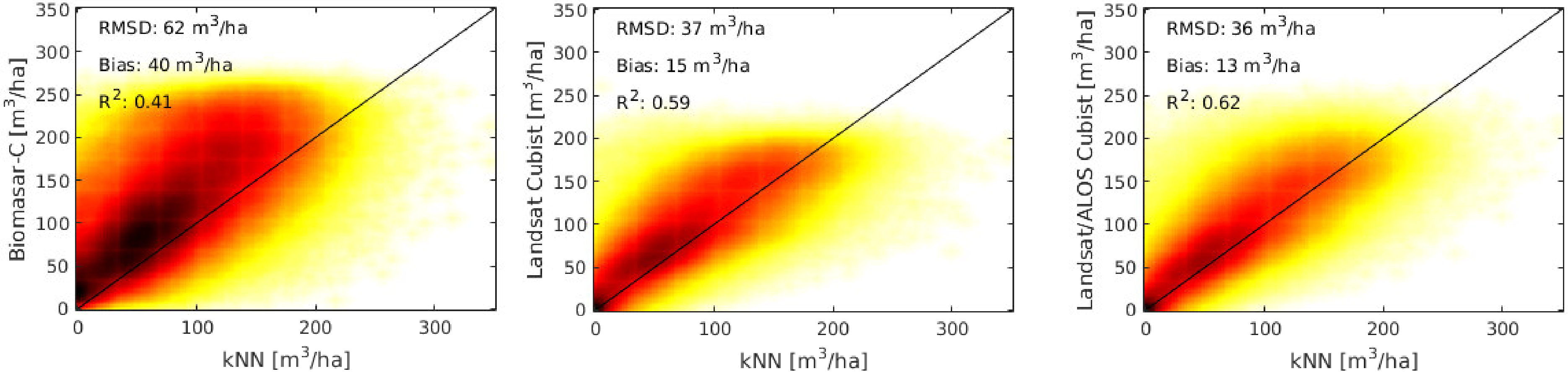
0-400+ m^3/ha color scaling (yellow-dark green)

1) Develop models (Cubist) at 1 km scale linking BIOMASAR-C GSV (response) and Landsat/PALSAR imagery (predictors) – per PALSAR orbit and 1°x1° tile

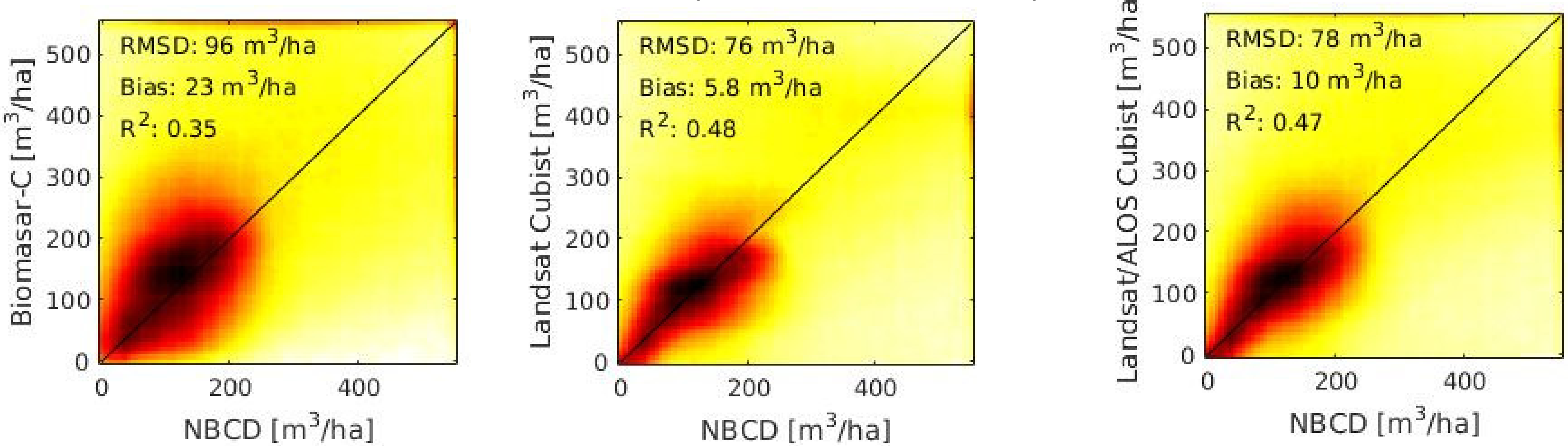
2) Predict GSV at full resolution of PALSAR/Landsat imagery

Results with the rescaling method

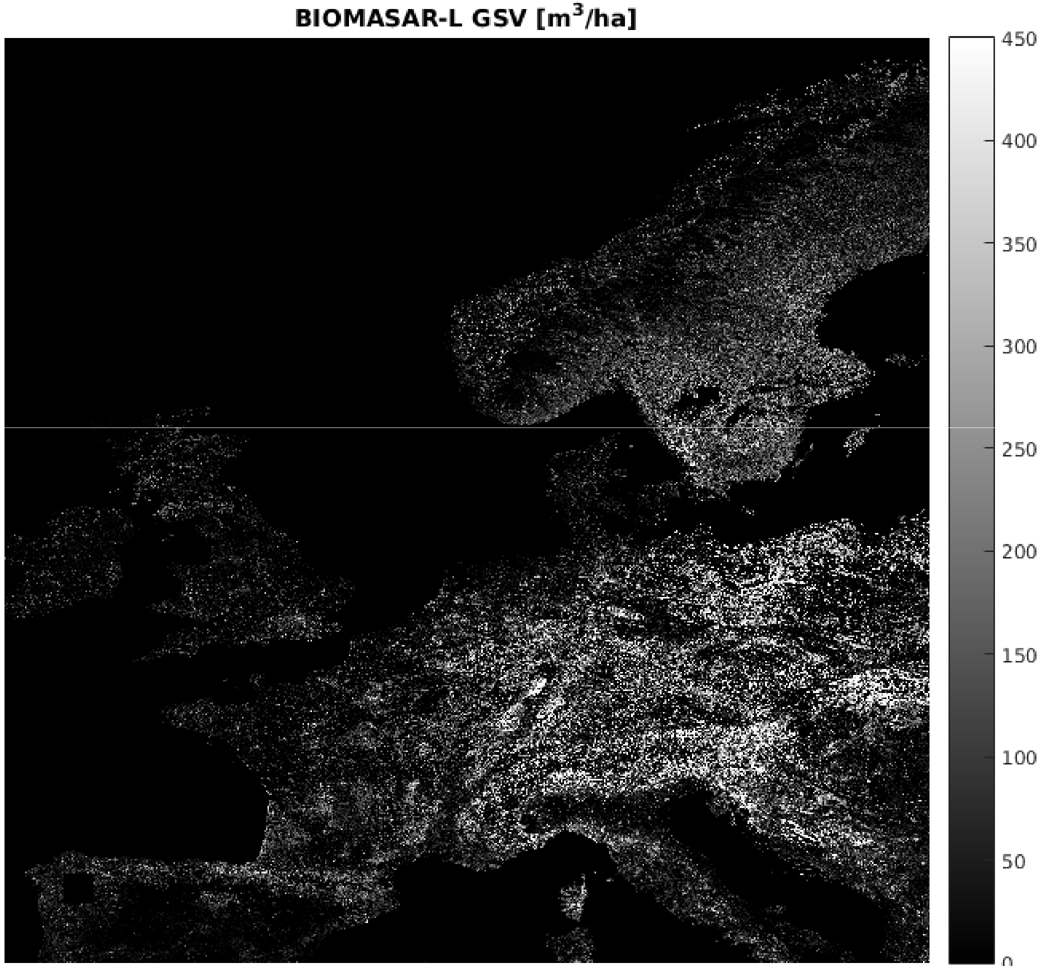
Sweden (kNN as reference)



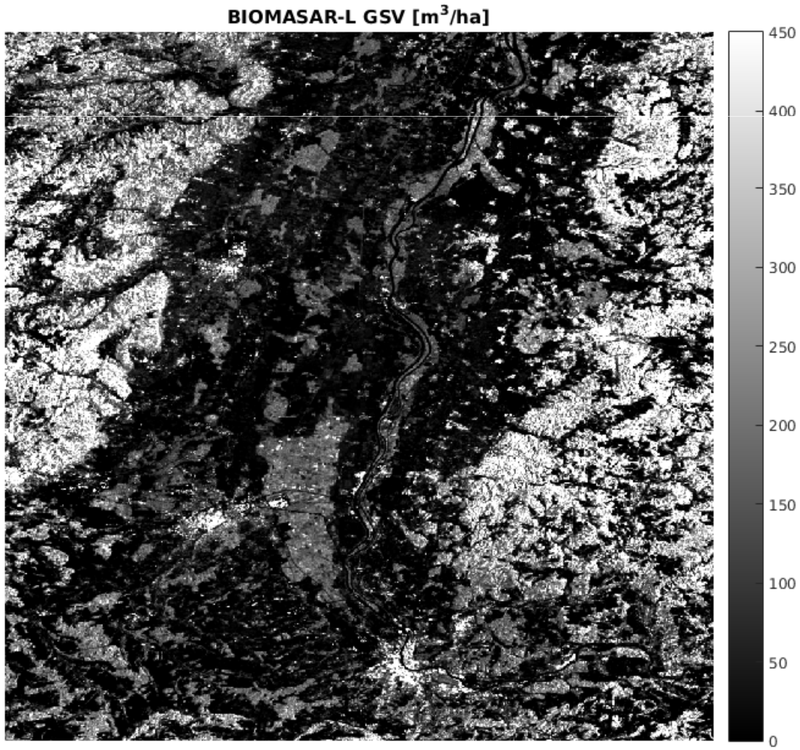
USA (NBCD as reference)



Stage 2 retrieval – BIOMASAR-L

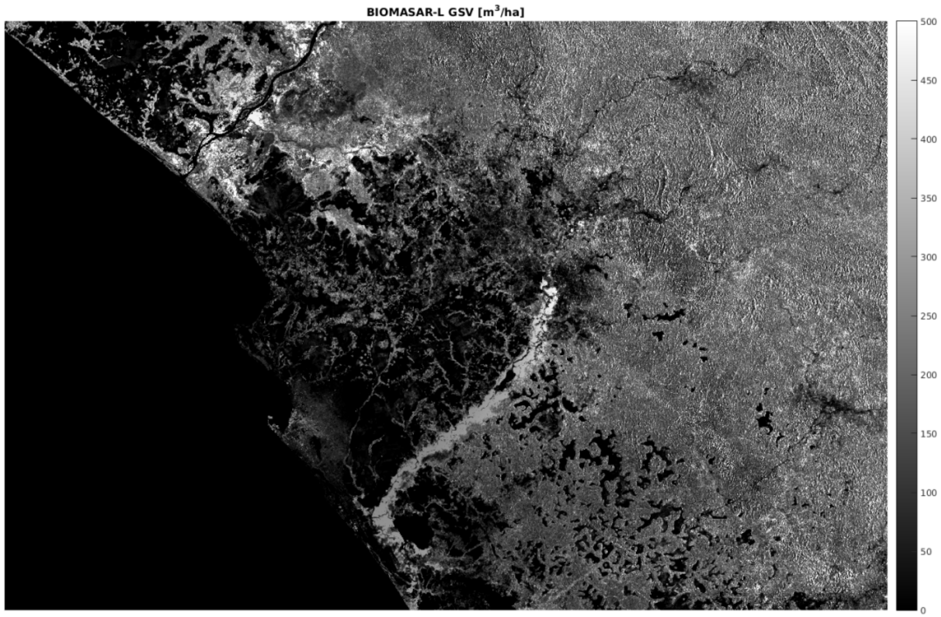


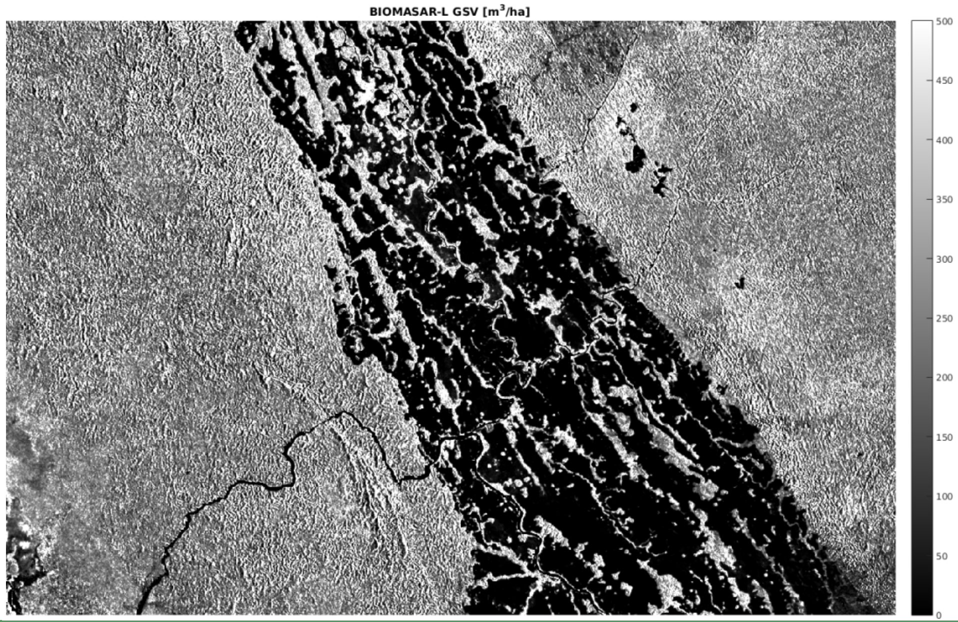
Europe



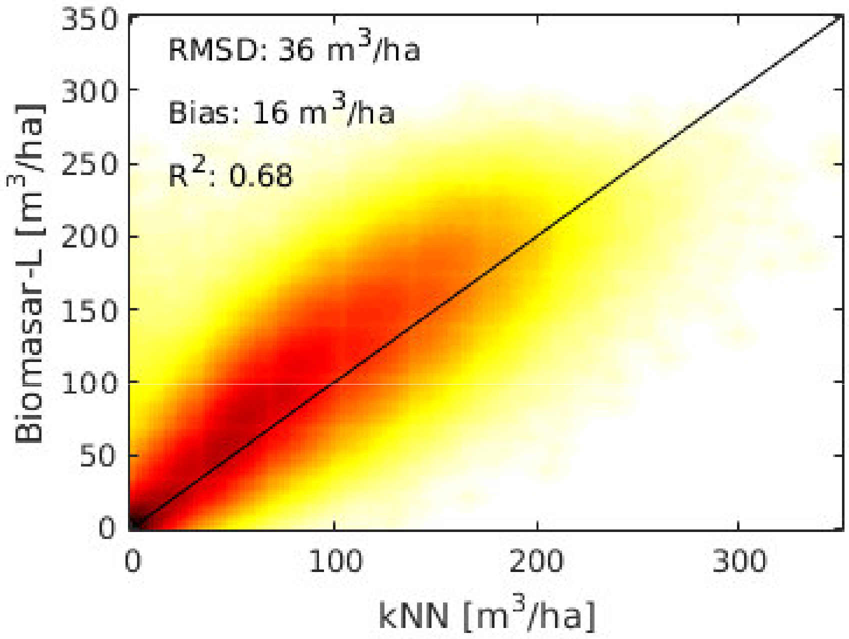
Gabon/Congo


BIOMASAR-L GSV [m³/ha]
500
450
400
350
300
250
200
150
100
50
0


BIOMASAR-L GSV [m³/ha]
500
450
400
350
300
250
200
150
100
50
0


BIOMASAR-L GSV [m³/ha]
500
450
400
350
300
250
200
150
100
50
0

Results with BIOMASAR-L



Sweden

Accuracy assessment based on:

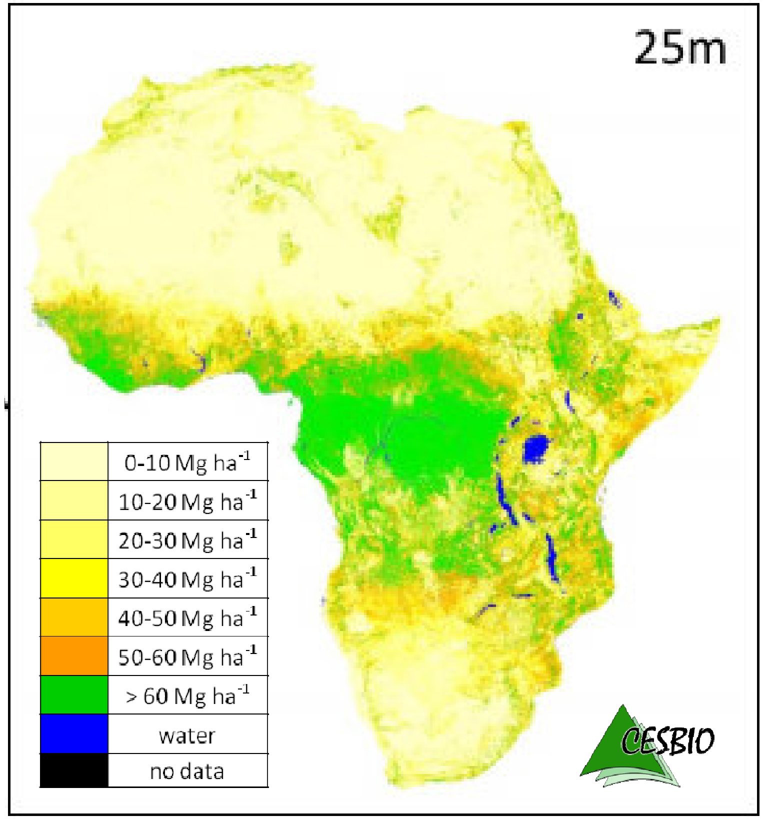
1) Plot data (where available)

2) Regional maps (bias?)

CESBIO method for low biomass forests

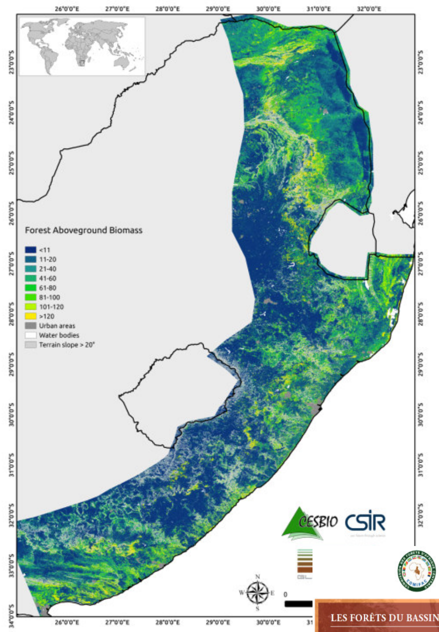
Use of ALOS-PALSAR for low biomass forests (AGB< 150 t/ha)

- Mapping of woody savanna in Africa: Cameroon, Congo basin, South Africa, Africa
- Currently starting validation in Australia
- Looking for collaboration for training/validation in Brasilian Cerrado



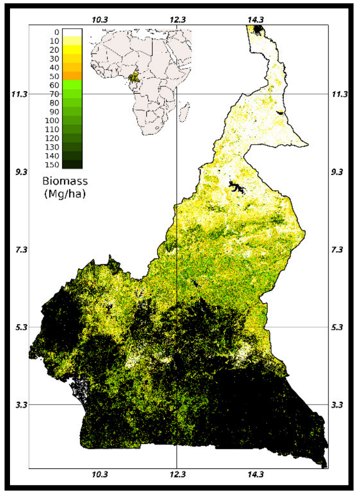
AGB map S. Africa

Globbiomass regional site



AGB map Cameroon

REDDAF



LES FORÊTS DU BASSIN DU CONGO

État des Forêts 2013

CHAPITRE 1

ÉVOLUTION DU COUVERT FORESTIER DU NIVEAU NATIONAL AU RÉGIONAL ET MOTEURS DE CHANGEMENT

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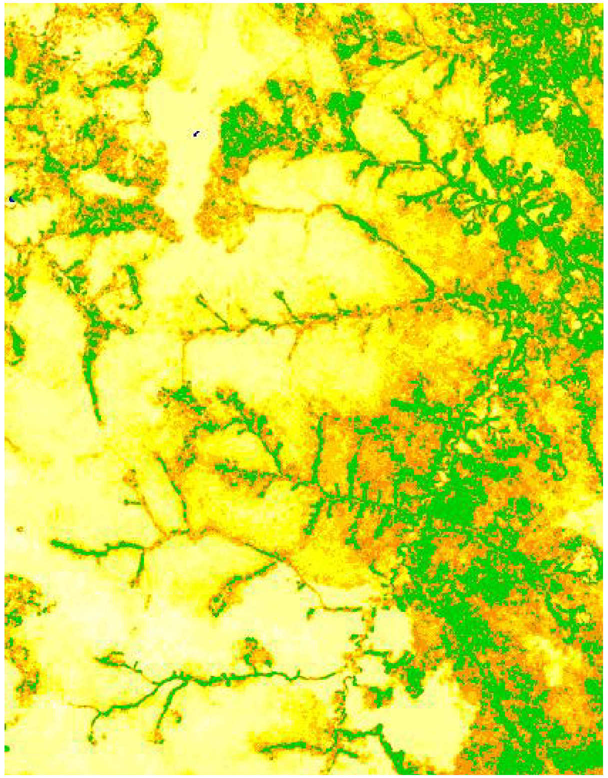
Avec la contribution de : Peter Potapov, Svetlana Turubanova, Alice Altstatt, Louis-Vincent Fichet, Gernot Ramminger, Sharon Gomez, Guillaume Cornu, Lucas Bourbier, Quentin Jungers, Pierre Defourny, Thuy LeToan, Manuela Hirschmugl, Gabriel Jaffrain, Camille Pinet, Cédric Lardeux, Anoumou Kemavo, Philippe Dorelon, Donata Pedrazzani, Fabian Enßle, Joerg Seifert-Granzin, Landing Mane, Ludovic Nkok Banak, Anton Vrieling, Stéphane Mermoz

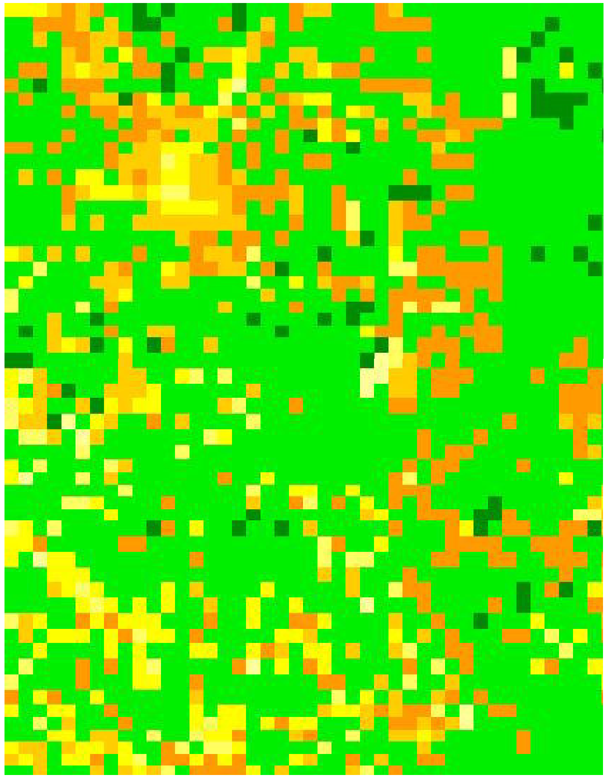
[1]CCR, [2]University of Maryland, [3]SIRS, [4]IRD, [5]GAF AG, [6]Astrium, [7]CIRAD, [8]Eurosense, [9]Norut, [10]UCL

Comparison with existing maps

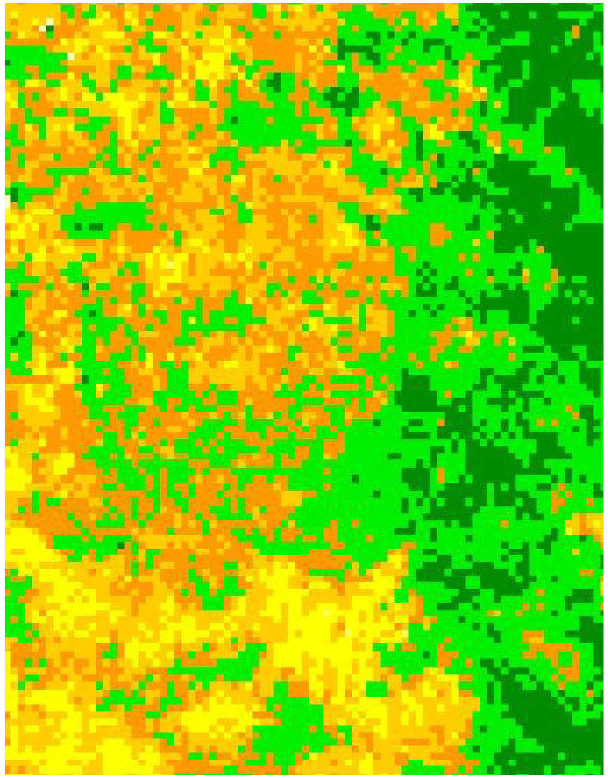
This study



Saatchi et al., 2011



Baccini et al., 2012

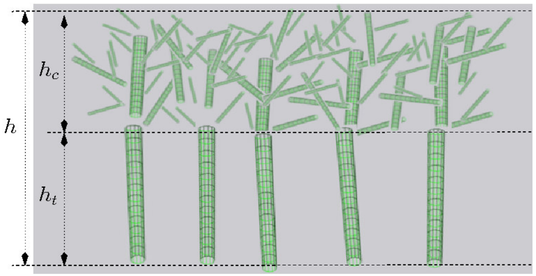


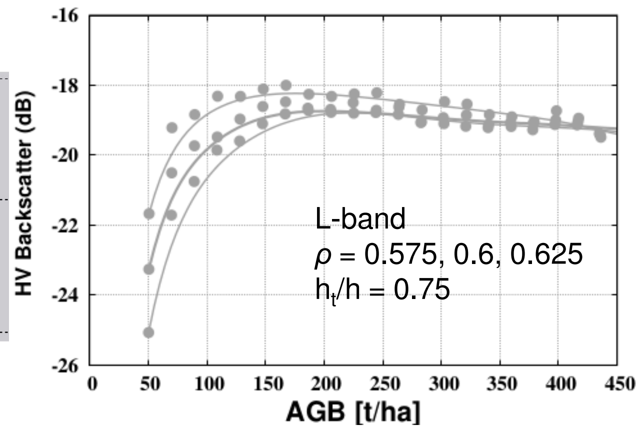
- 0-10 Mg ha^{-1}
- 10-20 Mg ha^{-1}
- 20-30 Mg ha^{-1}
- 30-40 Mg ha^{-1}
- 40-50 Mg ha^{-1}
- 50-60 Mg ha^{-1}
- 60-100 Mg ha^{-1}
- > 100 Mg ha^{-1}
- water
- no data

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

CESBIO method for high AGB and dense forests under test

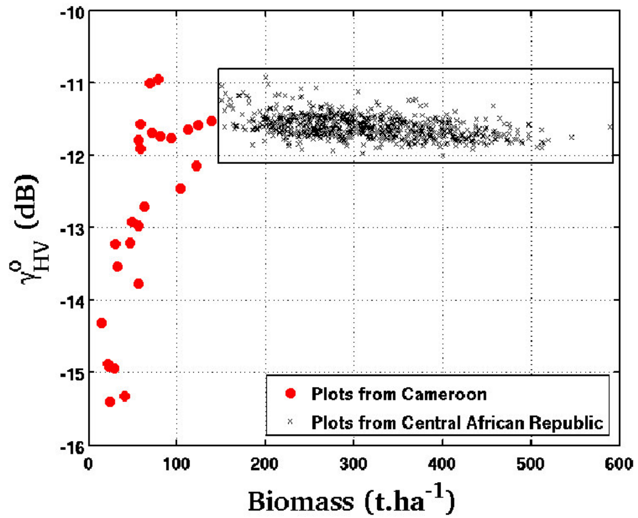
1. Using electromagnetic modeling to simulate the radar backscatter from a forest canopy described as a structured ensemble of dielectric scatterers (cylinders for stem, branches, ellipsoids for leaves)

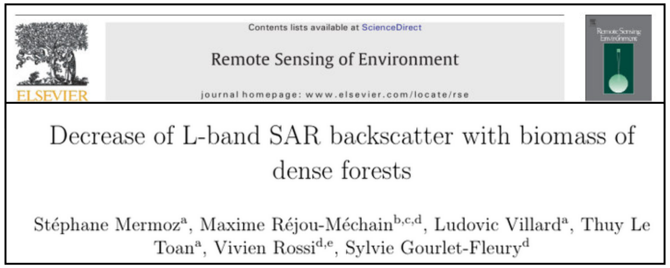




Example of a simulation of the effect of wood density ρ (linked to tree species)

2. Experimental data in Central African Republic




Contents lists available at ScienceDirect

Remote Sensing of Environment

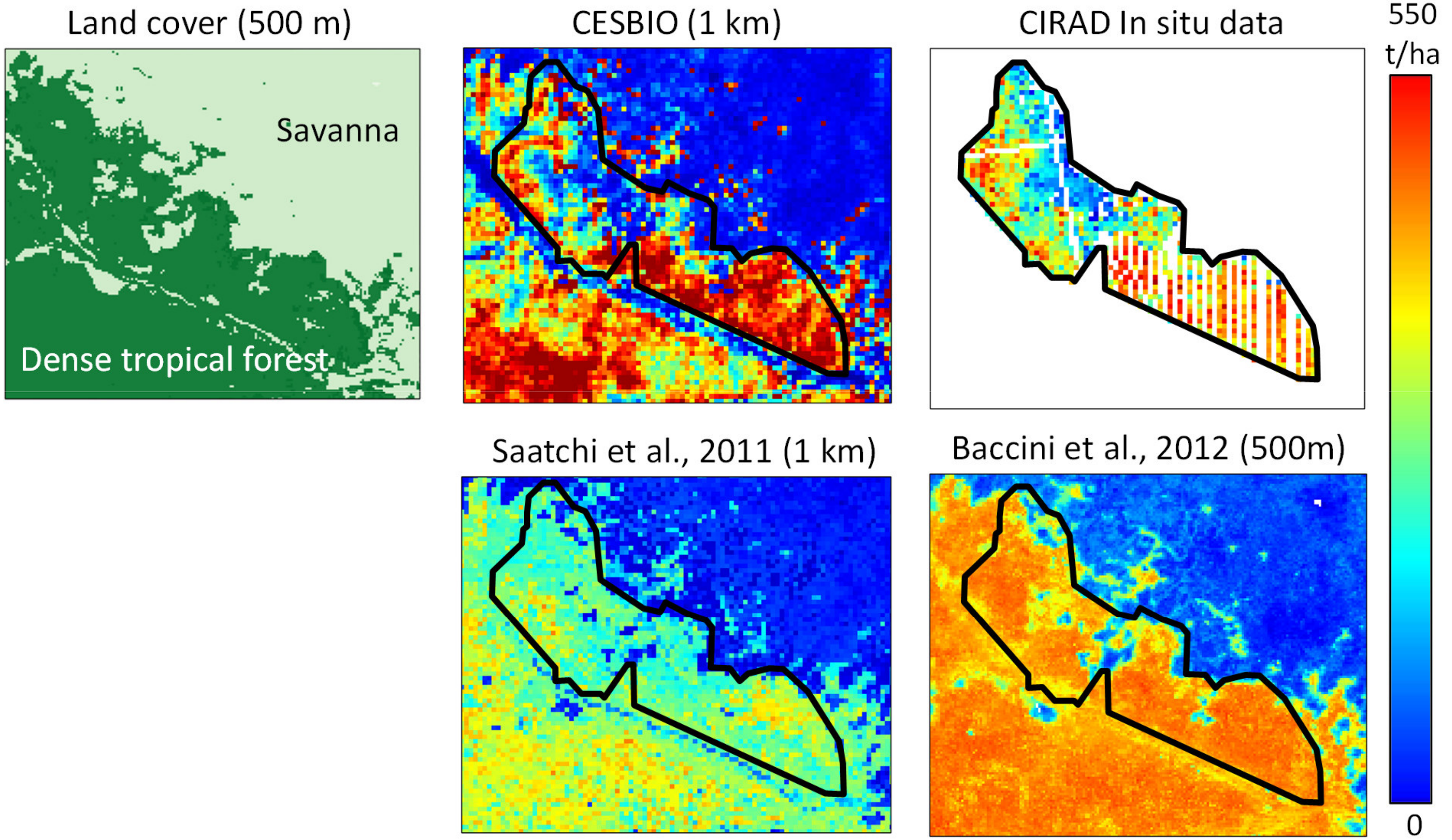
journal homepage: www.elsevier.com/locate/rse

ELSEVIER

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

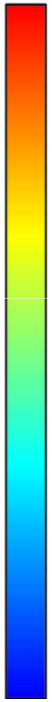
Stéphane Mermoz[a], Maxime Réjou-Méchain[b,c,d], Ludovic Villard[a], Thuy Le Toan[a], Vivien Rossi[d,e], Sylvie Gourlet-Fleury[d]

Comparison with 1 km in situ data



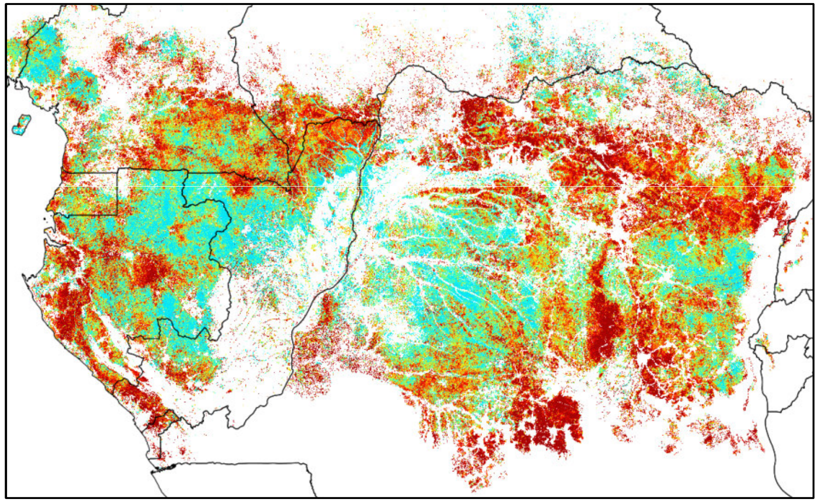
Mapping of high AGB forests at low resolution (500 m) using the HV decreasing trend-A test to be pursued

AGB
500 t/ha

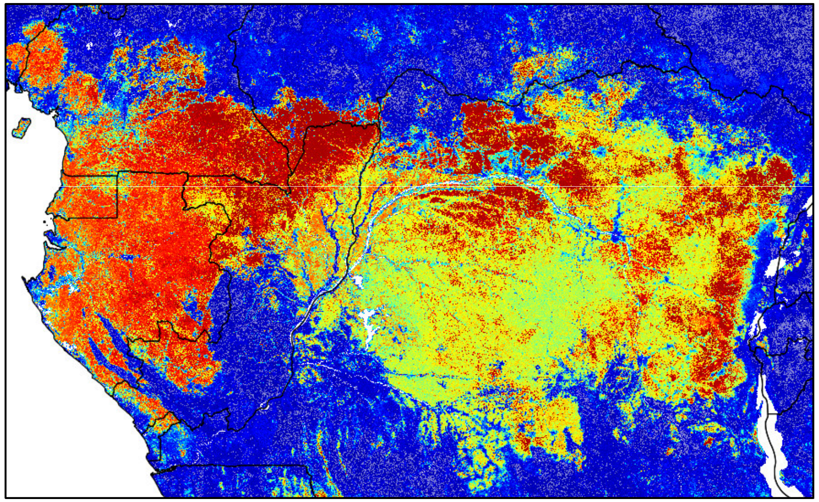


0

AGB map at 500 m - Cesbio



AGB map at 1 km – Avitabile et al.



Outlook

1. Comparison CESBIO and Gamma maps
   – Assessment of validity of model training framework of each stage 2 retrieval approach presented
     - If BIOMASAR-L, Cubist and CESBIO method perform differently → why?
     - Is upscaling affected by the issues of the C-band based estimates?
     - Is BIOMASAR-L training assumption incorrect?
     - Is the performance of CESBIO affected by the number of in situ observations?
     - Is the estimation of attenuation in BIOMASAR and CESBIO ill-posed?
     - How to deal with the decrease of L-band backscatter in high biomass areas?
     - How to harmonize Gamma's GSV and CESBIO's AGB estimates
2. Integrate CESBIO and Gamma
   – Shall we integrate algorithm or maps?
   – Which rules shall be followed?

› There is a lot of work ahead of us. Development and testing will be pursued until summer and iterations on biomass estimation will be undertaken until end of 2016 when the global biomass dataset shall be released.