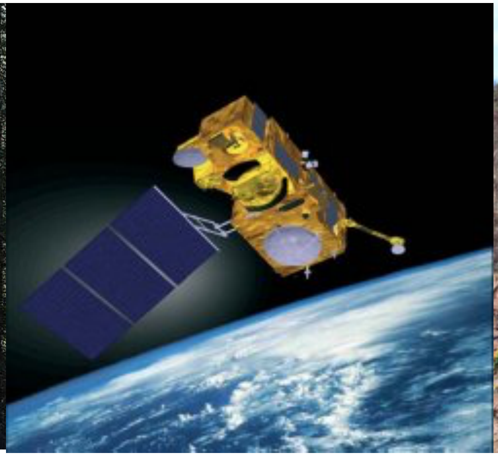
Estimating Biomass using SAR Altimetry data onboard the Copernicus Sentinel-3 Mission: the ALBIOM Project

Maria Paola Clarizia[1], *Leila Guerriero*[2], *Nazzareno Pierdicca*[3], *Jennifer Reynolds*[1], *Alireza Taravat*[1], *Giuseppina De Felice-Proia*[2], *Cristina Vittucci*[2], *Davide Comite*[3], *Marco Restano*[4] *and Jérôme Benveniste*[5]

1: Deimos Space UK; 2: Tor Vergata University, Italy; 3: University of La Sapienza, Italy; 4: SERCO, ESA-ESRIN, Italy; 5: European Space Agency, ESA-ESRIN, Italy






ALBIOM: ALtimetry for BIOMass

Project Type

- ESA-funded under the EO for Society Permanent Open Call
- Kickoff: November 2019

Goal

Derivation of forest biomass from SAR altimeter data from the Copernicus Sentinel-3 mission

Motivation

- Forest Biomass is **an Essential Climate Variable** (ECV);
- **Its mapping is crucial** for conservation of biodiversity, sustainable management of forests, enhancement of forest carbon stocks…
- The **existing satellites are still inadequate to guarantee a frequent and accurate mapping** and monitoring of forest biomass

Methodology

1. Assessment of global biomass monitoring status and user needs;
2. **Sensitivity Analysis** of the altimeter data wrt biomass;
3. **Development of a S3 altimeter backscattering simulator** over forested areas;
4. **Development of suitable inversion algorithms** to estimate biomass from S3 Data;
5. Generation of **biomass estimation prototypes** over specific areas of Tropical and Boreal Forests

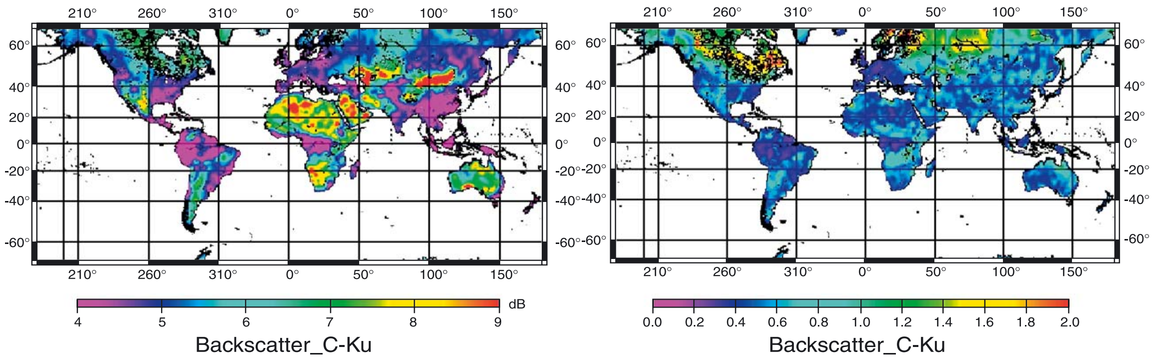
Consortium

Deimos Space UK

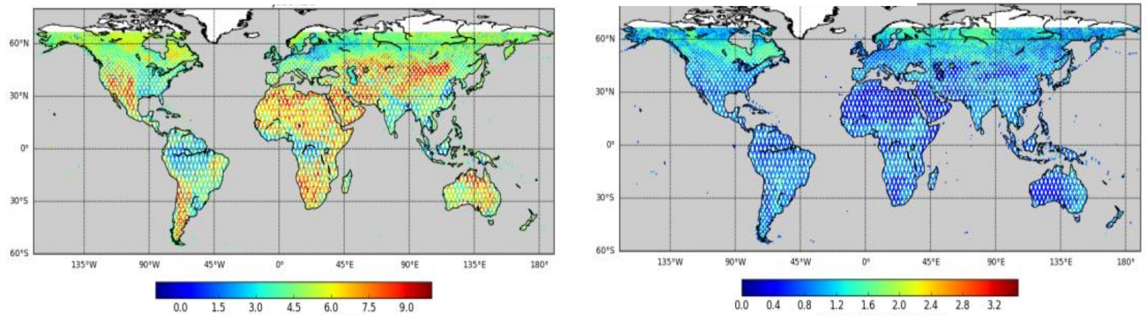
University of La Sapienza, Italy

Tor Vergata University, Italy

Past Studies on Vegetation From Altimetry

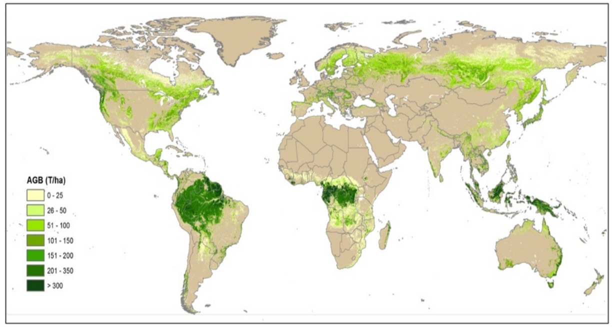


Mean (left) and std dev (right) of backscatter C – ku from Topex-Poseidon (1993 - 2002) From *[Papa et al., 2003]*

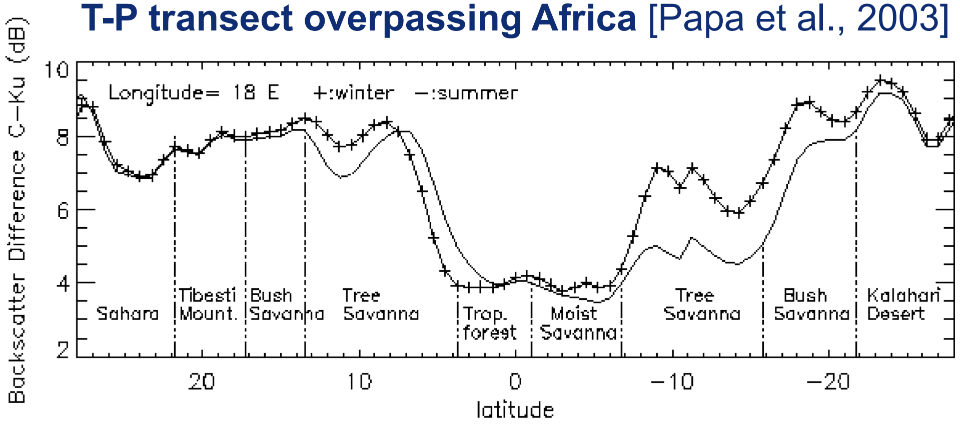


Mean (left) and std dev (right) of backscatter C – ku from Jason-2 (2008 - 2016)
From [Blarel et al., 2016]

Global Map of Above Ground Biomass



C band and ku band backscatter difference from a T-P transect overpassing Africa [Papa et al., 2003]



Background

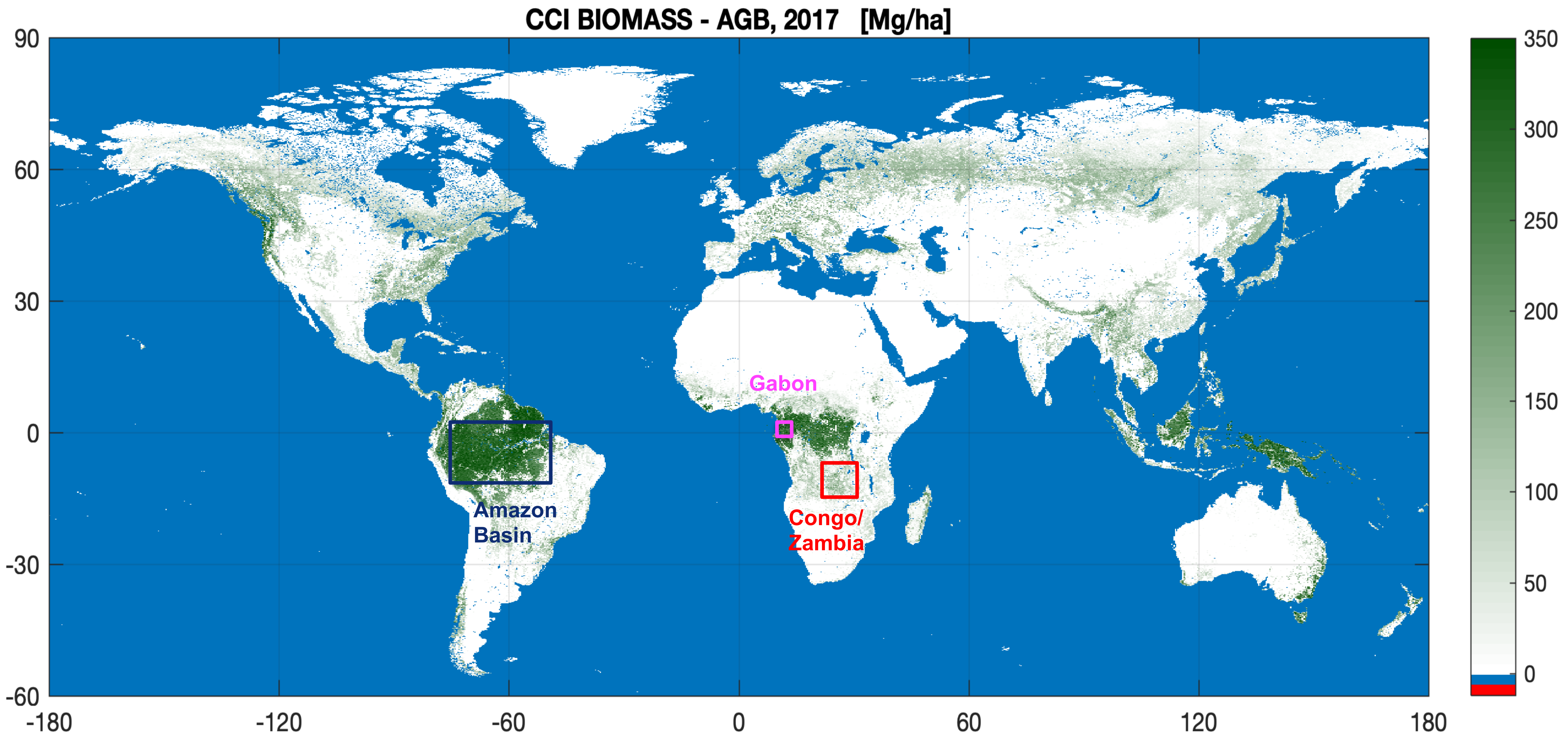
Previous studies have demonstrated the **correlation between radar altimetry backscatter over land and a variety of land parameters,** including vegetation parameters

ALBIOM Innovation

It's the first time that a biomass retrieval is attempted from Sentinel-3 altimetry data;

For the first time a Sentinel-3 SAR altimeter backscattering simulator over vegetated areas will be developed

Main Study Areas



Methodologies

Sensitivity Analysis

- Multivariate correlation Analysis of Level 2 radar backscatter coefficients from different retrackers (Ocean, Offset Centre of Gravity, Ice…) versus biomass, and also other land parameters (e.g. topography, Land cover, soil moisture, precipitation…);
- Analysis of L1 altimetry waveforms: Quality Control Filter on Waveforms/data, and waveform reprocessing using the ESA GPOD SAR Versatile Altimetric Toolkit for Ocean Research and Exploitation (SARvatore);

Simulation Approach

- Modelling the coherent and incoherent surface scattering from the soil, and the volume scattering, with the most suitable EM approximation depending on scatterer shape, dimensions and frequency;
- Identification of driving vegetation parameters in the altimetric backscattering, and validation through experimental data.

Algorithm Approach

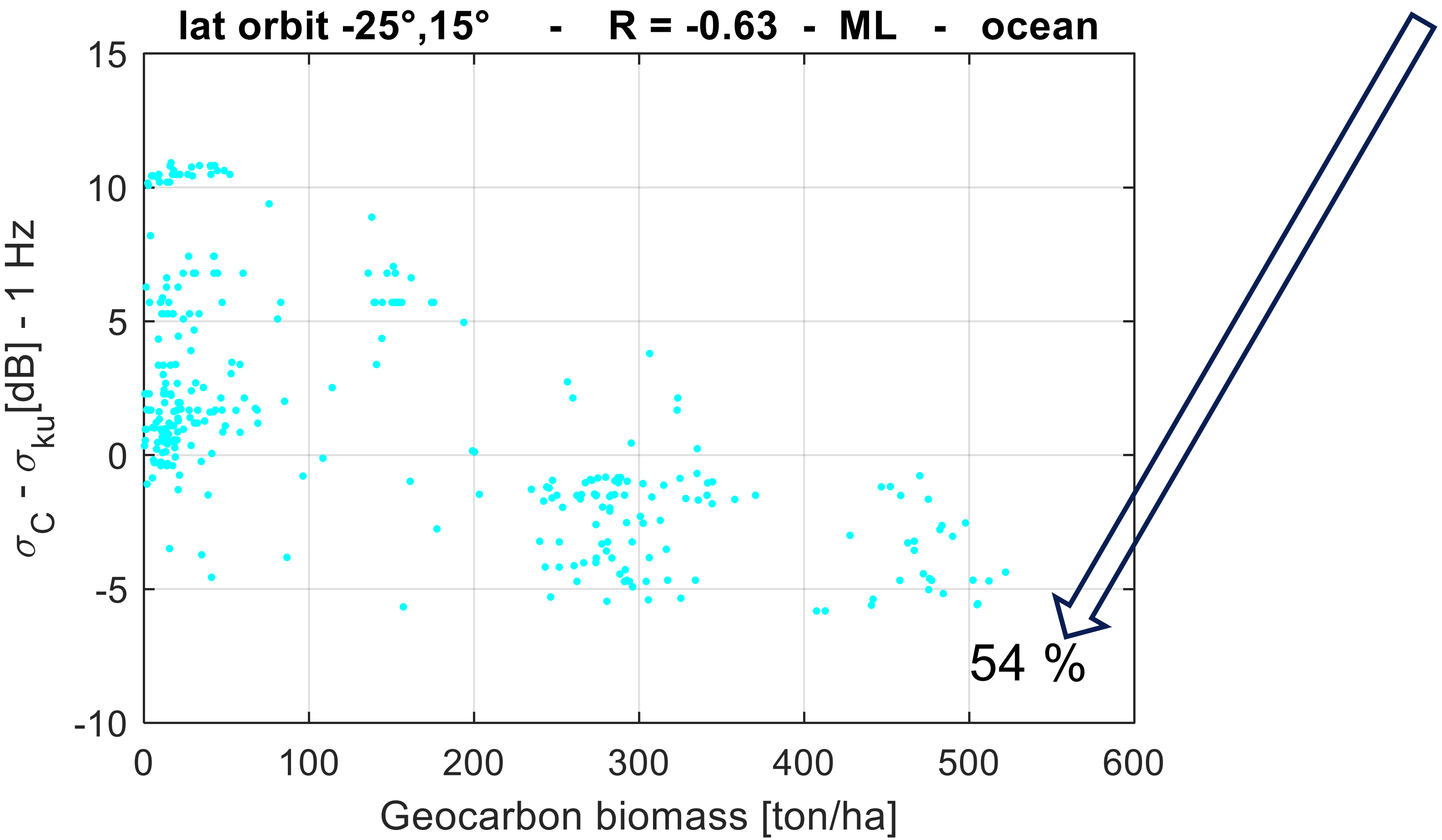
- Development of a simpler semi-empirical model function, with inputs given by the most suitable observable(s) from S3 data plus auxiliary data (topography, soil moisture…), by combining the simulator outputs and the results of the sensitivity analysis;
- Development of a more complex approach using Artificial Neural Networks (ANNs)

Sensitivity to biomass: Preliminary Results

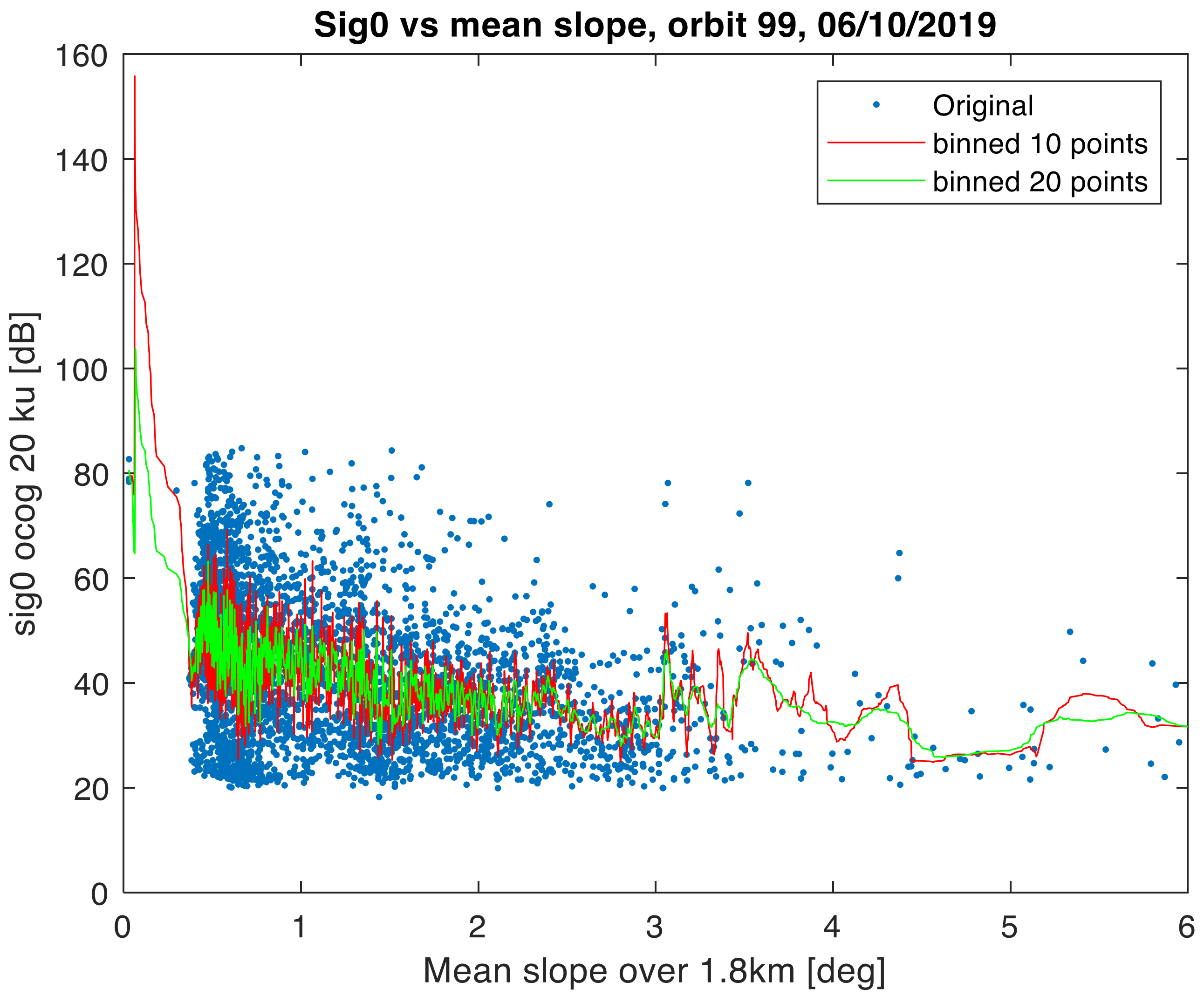
Difference between Normalised Radar Cross Section (NRCS) computed for C band and for Ku band,– 1 Hz data, orbit no. 99, Central Africa

OCEAN tracker, along-track smoothing using a 20 sample running average

Percentage of available values over the orbit

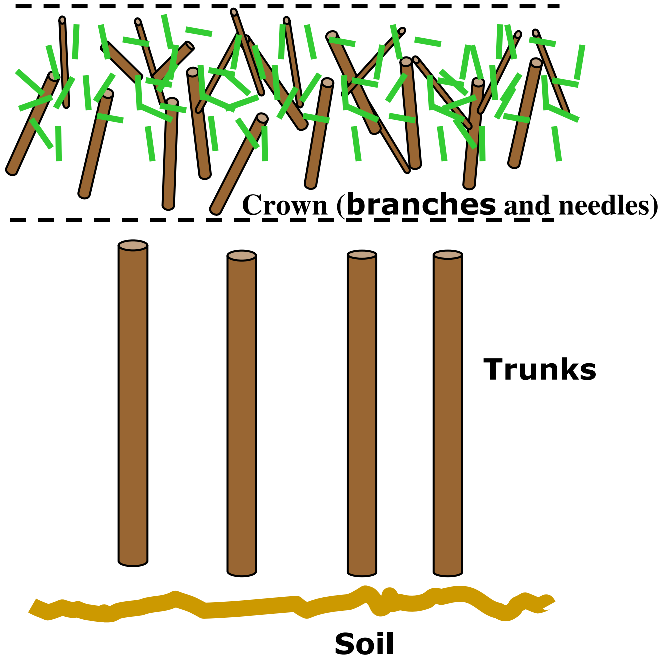


Effect of topography

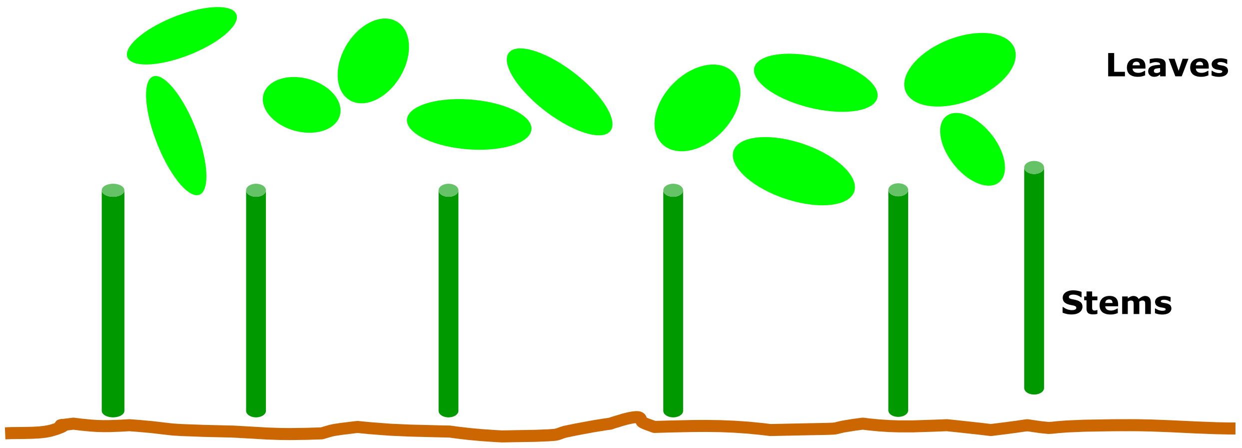


- An example of a 20 Hz backscatter coefficient obtained from the Offset Centre of Gravity (OCOG) retracker, versus collocated biomass;
- **The observable decreases for increasing surface mean slope derived from SRTM 90m DEM**
- **A decrease in the order of almost ~17 dB can be appreciated over the interval 0-3 deg mean slope**
- It is clear that the topography affects the signal in a manner comparable to biomass
- **A retrieval algorithm will need to take topography (and possibly other land parameters) into account**

Tor Vergata Model for Backscattering Simulations



Examples of vegetation as represented by the model



Volume scattering and Surface scattering

σ_{vol} **:**

Leaves, Needles

- Rayleigh Gans
- Physical Optics

$\sigma_{soil\ inc}$: IEM,SPG,GO

$\sigma_{soil\ coh}$: Coherent contribution (Comite et al., 2019)

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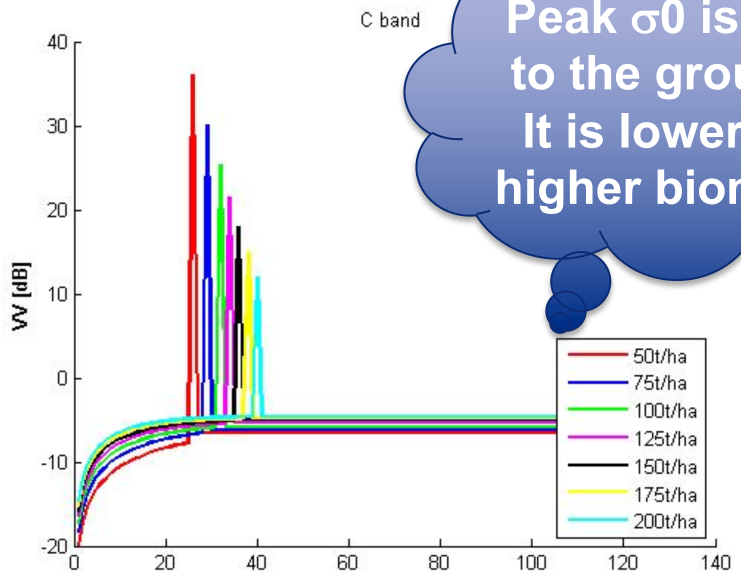
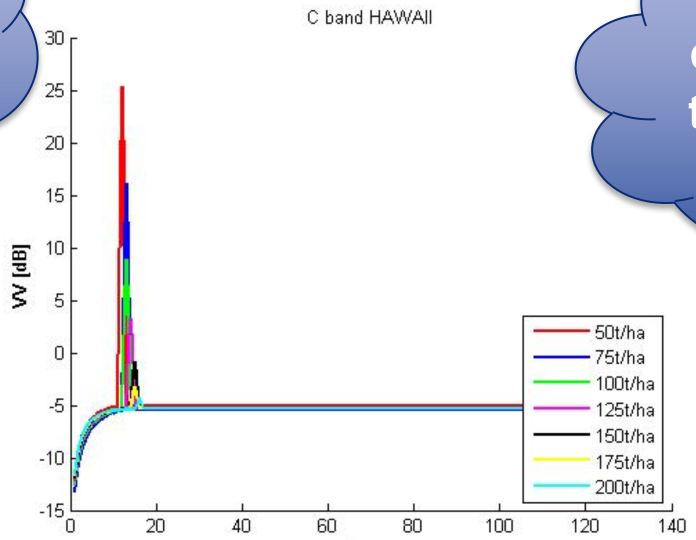
Backscatter Simulations – Preliminary Results

C-band

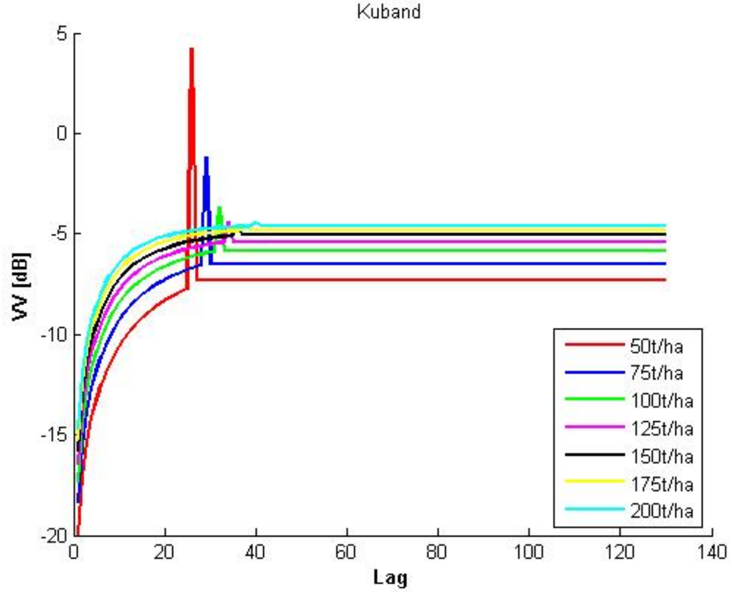


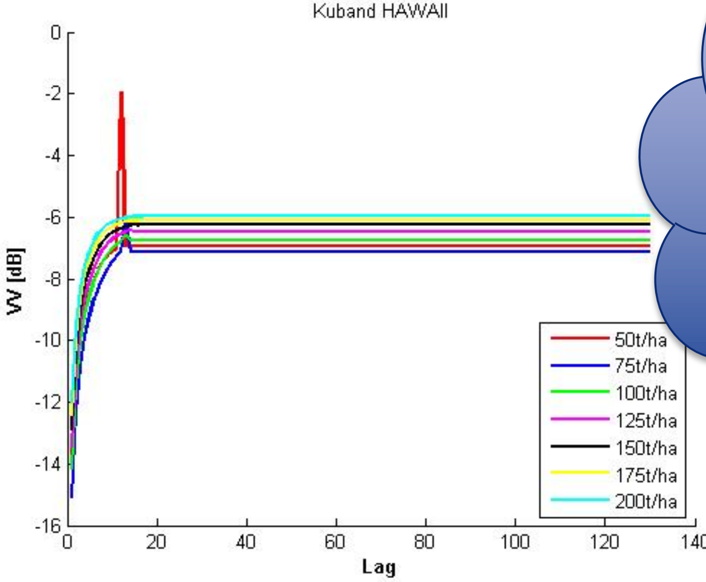
Peak σ0 is due to the ground. It is lower for higher biomass



Peaks moves to the left due to larger and shorter trees wrt to left case (for the same biomass)

Ku-band





Peak σ0 is related to biomass and forest type (allometric equation)
Peak position is related to forest type (allometric equation)

"Keep Home" Message

- **ALBIOM will derive a forest biomass product from Sentinel-3 SAR altimetry data**, using a modelling component and an algorithm component;
- Preliminary investigations indicate that **the land backscatter coefficient is influenced by biomass**, but…
  - The influence varies depending on the geographical location;
  - The signal is also affected by other land parameters, and certainly by topography
  - Some of the radar waveforms falls out of the tracking window: these need to be automatically detected and filtered out

Future Work

- **Consolidate sensitivity analysis:**
  - Filter out the "bad" data, i.e. data contaminated by water, or too noisy, or where signal is out of the tracking window;
  - Choose between existing L2 backscatter coefficients, or define our own observable from the L1 waveforms;
  - Evaluate whether it's better to work with 20 Hz or 1 Hz data
  - Implement a multivariate regression of observable as a function of biomass and surface slope as a minimum
- **Continue the model development**
  - Consolidate the vegetation model for the altimetric backscattering, determine the driving land parameters, and validate with experimental data
- **Begin the algorithm development**
  - Develop and test a simple model function for retrieval, and prepare for the more complex ANN approach

Thank you for having viewed the slides!

For further info on the ALBIOM Project you could:

Write to me: maria-paola.clarizia@deimos-space.com

Or visit https://eo4society.esa.int/projects/albiom/