Impact Of Temporal Decorrelation At P-Band On Forest Canopies In Equatorial Africa

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Temporal and weather effects on canopy scattering in tropical forests at P-Band

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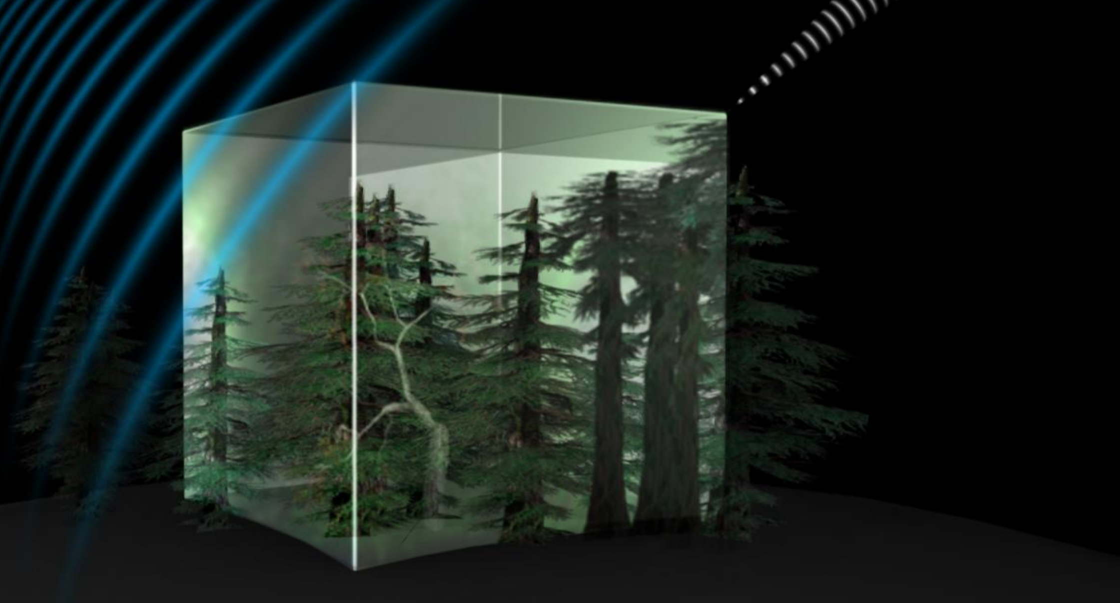
BIOMASS (ESA)

P-Band SAR

Selected as next ESA Earth Explorer Core Mission

Currently in Phase-B

Launch expected in 2021-22



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Mission Objectives

- to determine the distribution of aboveground biomass in the world’s forests
- to measure annual changes in this stock over the period of the mission.

The BIOMASS Tomographic phase

- One year duration
- Global coverage
- 7 passes per illuminated sites
- 3 day repeat pass time
- Vertical resolution ≈ 23 m

Temporal decorrelation: TropiSCAT

Multiple flight tracks are usually collected by flying multiple passes

$\Rightarrow$ The illuminated scene is required to be stable over time

Q1): what is the impact of varying weather conditions?

Q2): can we assess canopy-only temporal decorrelation based on existing data?

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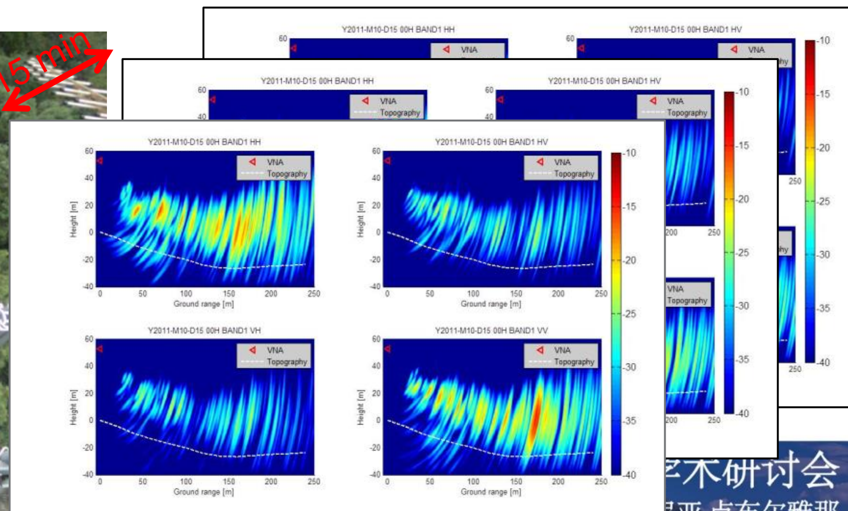
Temporal decorrelation: TropiSCAT

TropiSCAT – ESA – 2011

⇔ a static ground-based radar observing a tropical forest

- Located in French Guyana – same site as TropiSAR
- Team members from ONERA, CNES, CESBIO, POLIMI
- 20 antennas installed on top of the Guyaflux tower (55 m)
- Fully polarimetric (HH, HV, VH and VV)
- Vertical resolution capabilities
- One image every 15 minutes over a time span of one year

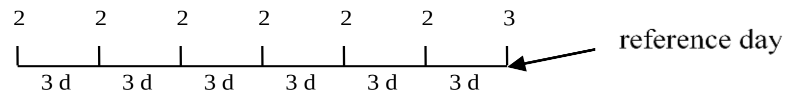
⇒ Access to the vertical structure of temporal decorrelation



Methodology

Simulating BIOMASS repeat-pass tomography:

- Two antennas per day every 3 days at 06:00 am
- 7 – day tomogram is compared against a reference from “instantaneous” tomography



- The dataset covers the time span starting from December 6, 2011 to February 29, 2012
- 63 7-day tomograms under various weather conditions

N = 5 7-day Tomograms

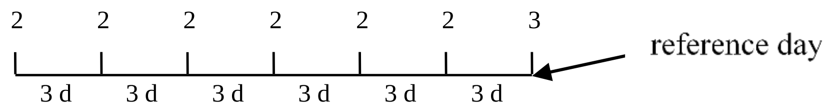
N = 25 7-day Tomograms

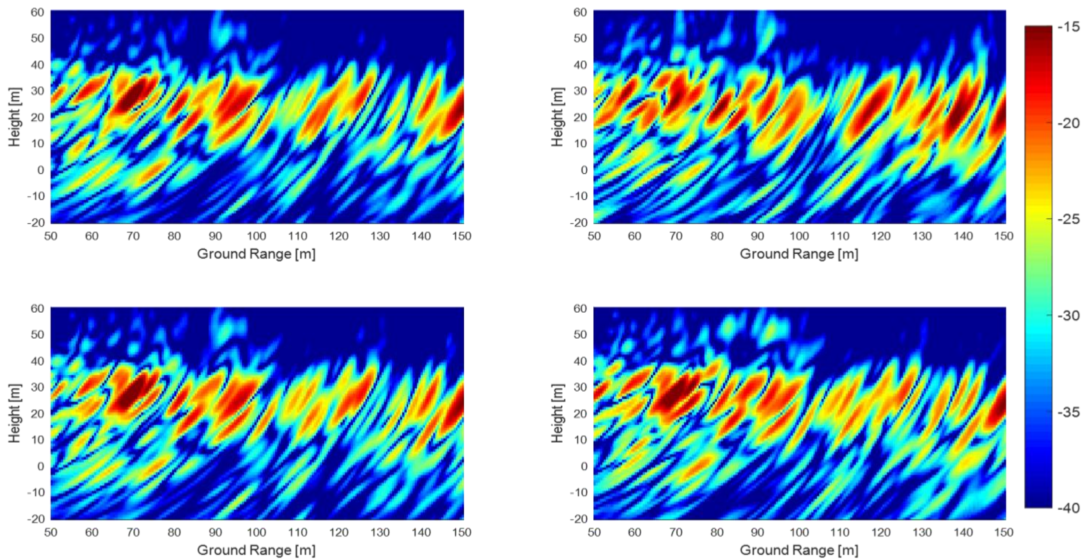
N = 27 7-day Tomograms

N = 9 7-day Tomograms

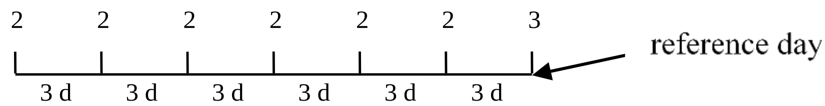
Y. Bai et al., “An empirical study on the impact of changing weather conditions on repeat-pass SAR tomography”, JSTARS, Apr. 2018.

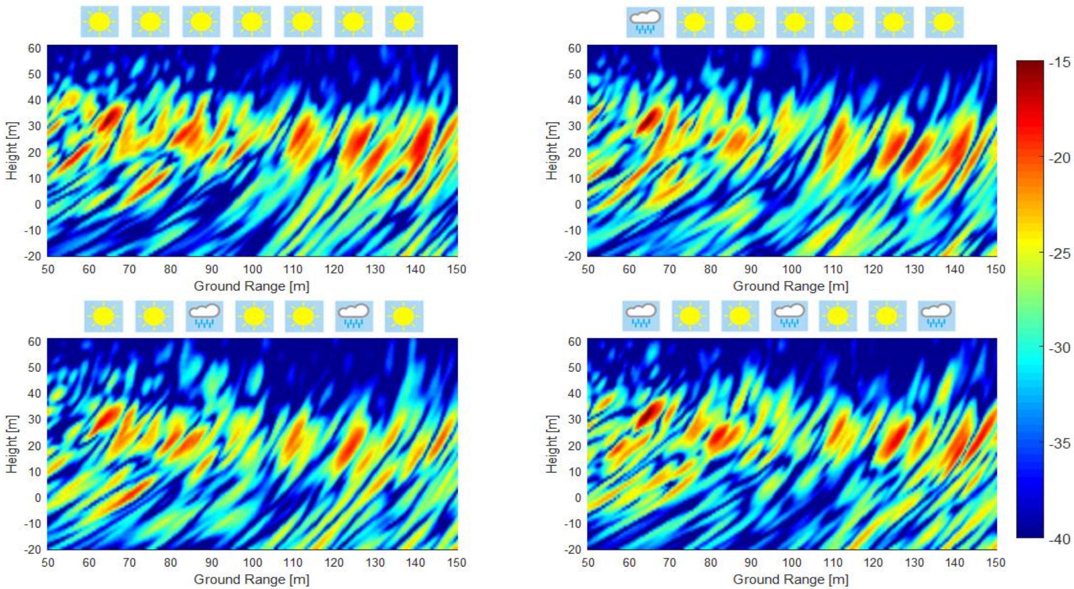
Reference tomograms





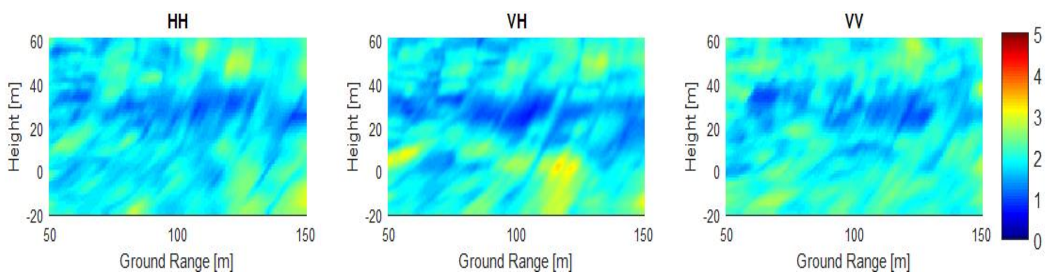
7-day tomograms





Results and Discussion

- The intensity of scattering elements within the canopy layer is more stable than intensity of scattering elements at ground level. This is consistent with the findings in (Hamadi et al., 2015), which showed that higher coherence is obtained when considering only the canopies.
- A possible physical explanation is that terrain scattering is more affected by changing moisture conditions. However, it is also to be remarked that terrain scattering is particularly weak in TropiSCAT data, since the terrain is back-sloping w.r.t. the Radar.
- The variation of the tomographic signal at canopy level can be assessed as about 1 – 1.5 dB (1 sigma), which would entail a biomass retrieval error of around 50-80 Mg/ha at the Paracou test site using tomography



$$\sigma_{rel} = 10 \cdot Log_{10}\left(1 + \frac{Std(P_7^i)}{Mean(P_7^i)}\right)$$

Temporal decorrelation: TropiSCAT

Multiple flight tracks are usually collected by flying multiple passes

⇒ The illuminated scene is required to be stable over time

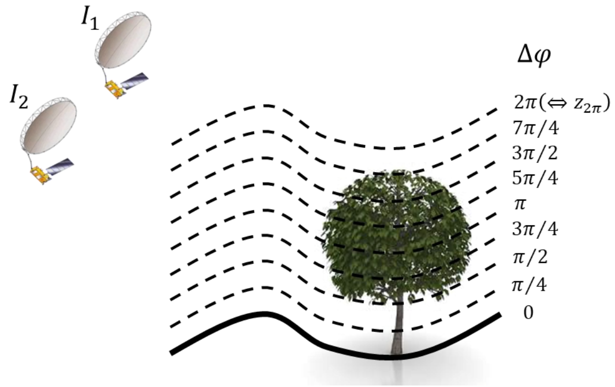
Q1): what is the impact of varying weather conditions?

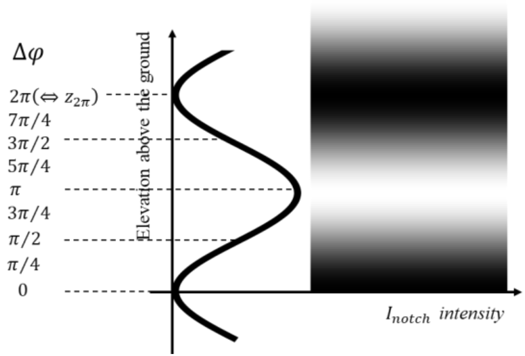
Q2): can we assess canopy-only temporal decorrelation based on existing data?

Methodology: ground-notching

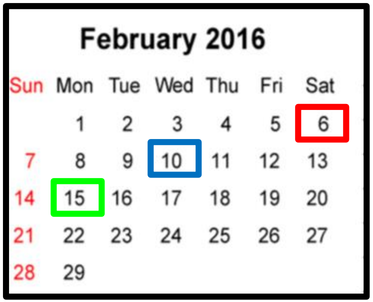
- The extraction of volume-only contributions from single-baseline data is here implemented using Interferometric ground notching (Mariotti et al, 2018).
- Ground rejection is achieved by taking the difference between two phase-calibrated, ground-steered, SAR SLC images, in such a way as to produce a third image where ground scattering contributions are canceled out.

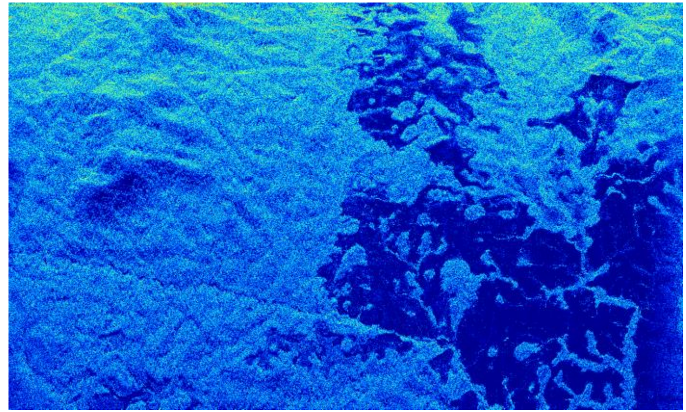
$$I_{notch} = I_1 - I_2$$





Data-set: La Lopé – AfriSAR





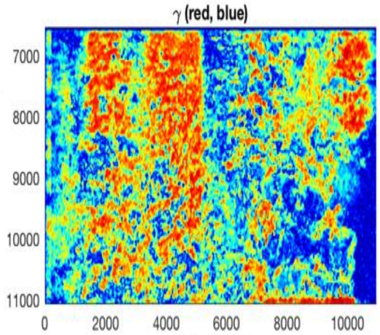
Campaign	AfriSAR 2016
System	E-SAR - DLR
Site	Lope, Gabon
Scene	Tropical forest
Carrier Frequency	P-Band
Tree height	≈ 30-50 m

Selected pairs:

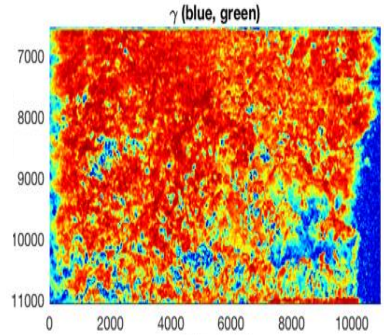
- four interferometric pairs at 0, 4, 5, and 9 days,
- three pairs acquired on the same day on three different days.
- All pairs are characterized by a vertical baseline of about 10 m, which corresponds to a height of ambiguity of about 250 m an off-nadir angle of 35°.

Canopy temporal decorrelation

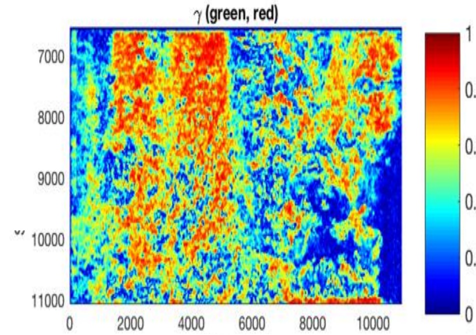
Feb 6 vs Feb 10

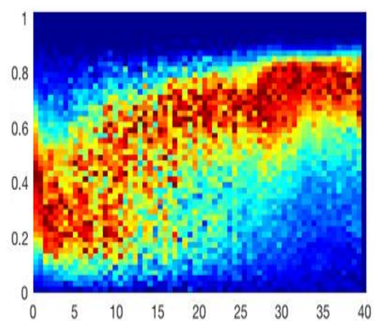


Feb 10 vs Feb 15

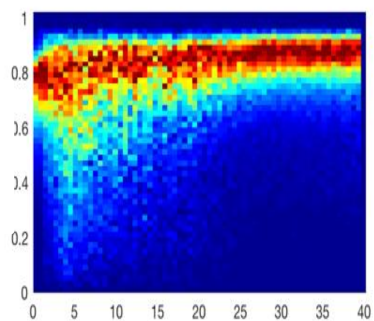


Feb 6 vs Feb 15





Forest height



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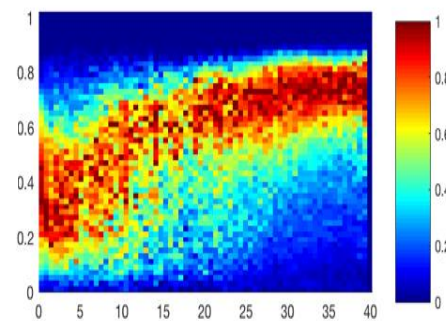
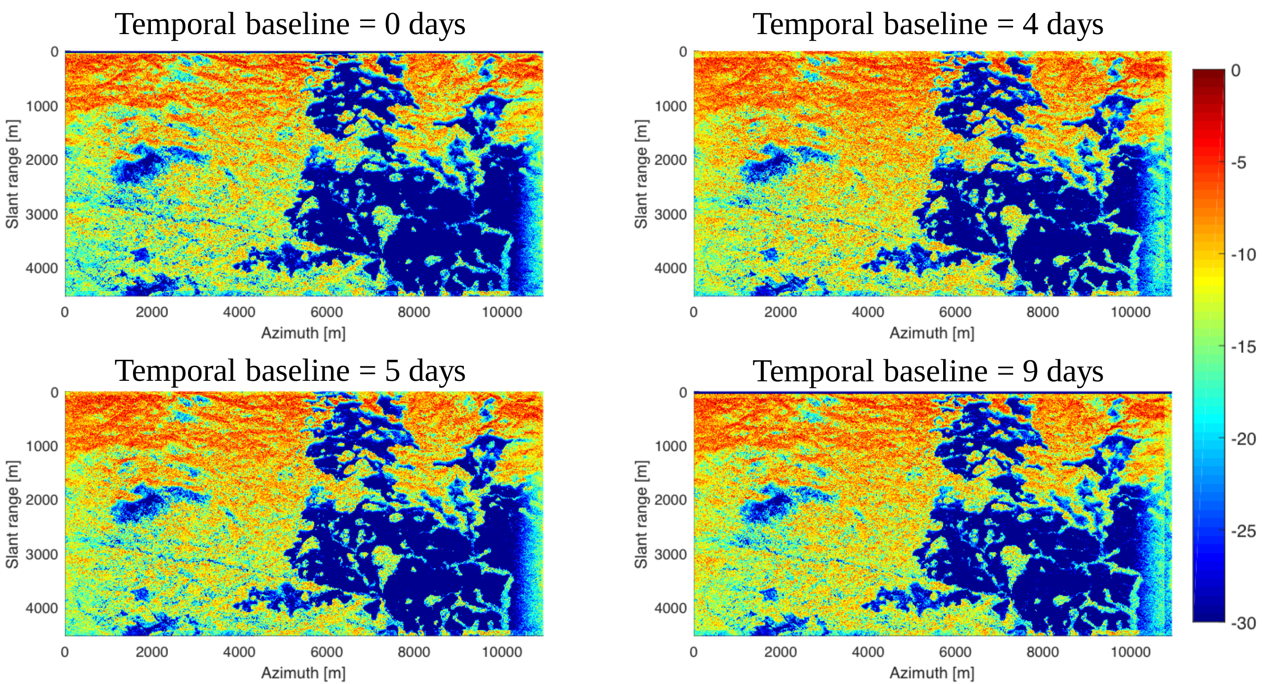
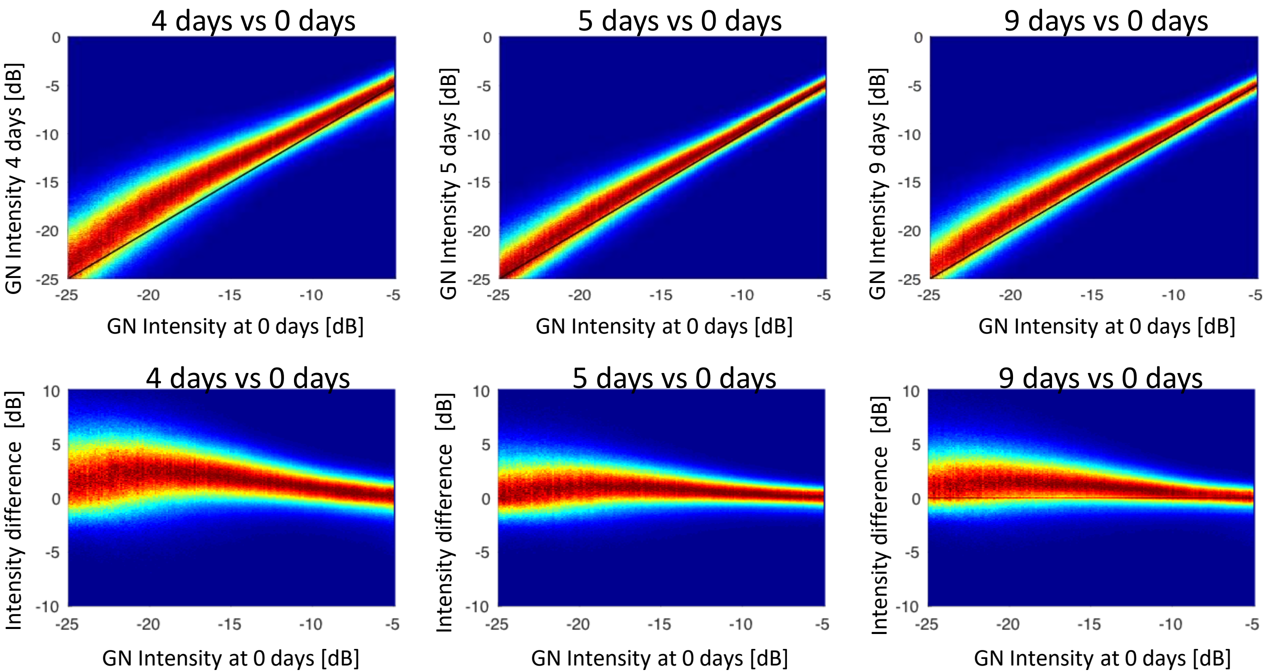


Forest height

Ground-notched intensities

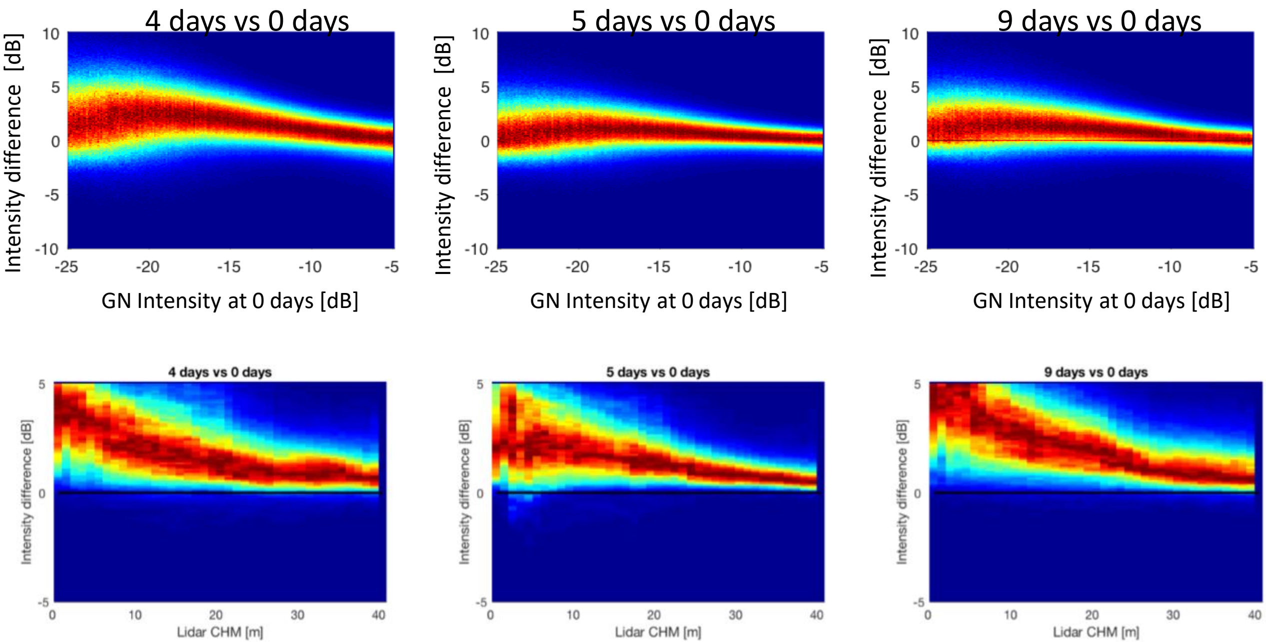


Ground-notched intensities



- Temporal decorrelation produces an intensity increase for low-intensity areas (<-10 dB)
- All pairs tend to yield the same intensity for high-intensity areas ⇔ densely forested areas appear to be more stable

AfriSAR Lopé



- Temporal decorrelation produces an intensity increase for low-intensity areas (<-10 dB)
- All pairs tend to yield the same intensity for high-intensity areas to within less than 1 dB ⇔ densely forested areas appear to be more stable

Conclusions

Weather effects - TropiSCAT:

- The intensity of scattering elements within the canopy layer is more stable than intensity of scattering elements at ground level.
- The variation of the tomographic signal at canopy level can be assessed as about 1 – 1.5 dB (1 sigma), which would entail a biomass retrieval error of around 50-80 Mg/ha at the Paracou test site using tomography

Temporal decorrelation - AfriSAR Lopé:

- It was observed that ground-notched intensities at different days tend to ground-notched intensity at 0 days in areas where the signal is brighter.
- The measured variation for AfriSAR Lopé was less than 1 dB on bright areas
- This finding indicates that temporal decorrelation impact mostly on low vegetation (which is associated to lower backscatter), whereas the signal appears to be definitely more stable on densely forested areas that produce higher backscatter.

Papers

Y. Bai, S. Tebaldini, D. H. T. Minh and W. Yang, "An Empirical Study on the Impact of Changing Weather Conditions on Repeat-Pass SAR Tomography," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 11, no. 10, pp. 3505-3511, Oct. 2018.

Y. Bai, X, Yang, et al. , “Progresses on SAR remote sensing of tropical forests: forest biomass retrieval and analysis of changing weather conditions”, prepared for Dragon 2018

Y. Bai, M. M. d'Alessandro, S. Tebaldini and M. Liao, "Analysis of P-band Repeat-pass Sar Tomography Under Changing Weather Conditions," *IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium*, Valencia, 2018, pp. 9034-9037.

Y. Bai, M. M. d'Alessandro, S. Tebaldini and W. Yang, "A study on temporal decorrelation at P-Band on forest canopies in equatorial Africa

" *Living Planet Symposium 2019, Milan*.

Y. Bai, M. M. d'Alessandro, S. Tebaldini and M. Liao, "Analysis of temporal decorrelation of forest canopies in equatorial Africa at P-band", submitted to JSTARS