AfriSAR: the campaign and a tomographic analysis

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The AfriSAR campaign – Gabon Forest

- ## Why this campaign?
  - Collect data to support the development of the BIOMASS mission [1]
  - Concept verification, algorithms development for geophysical estimation, …
  - Associated campaign for TOTAL : potential of radar and optical acquisitions for hydrocarbon exploration and environmental protection

- ## Where?
  - Gabon (Africa)
  - Map large areas of tropical forests
  - 100t-500t/ha biomass range

Gabon

- ## How?
  - Airborne acquisitions (and ground measurements)
  - Radar (L and P band)
  - Hyperspectral (VNIR and SWIR)

[1] : Le Toan *et al.* 'The BIOMASS Mission : Mapping global forest biomass to better understand the terrestrial carbon cycle', Remote Sensing of Environment, 2011.

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The AfriSAR campaign – Gabon Forest

- Who?

ESA sponsored campaign
- ONERA SETHI (France) and DLR F-SAR (Germany)
- Ground measurements by University College London (Simon Lewis) and CESBIO
- Great scientific support from local agencies (AGEOS: Gabon space agency; ANPN: Gabon National Park Agency)

On ONERA side
- Additional funding from CNES
- TOTAL

Collaboration with NASA (UAVSAR + LVIS)

The AfriSAR campaign – Gabon Forest

- When?

Different seasons
- o July 2015 – SETHI – ONERA - Dry season
- o February 2016 – FSAR – DLR - Wet season
  - UAVSAR + LVIS acquisitions (NASA)

→ Influence of the disturbances on the estimation techniques
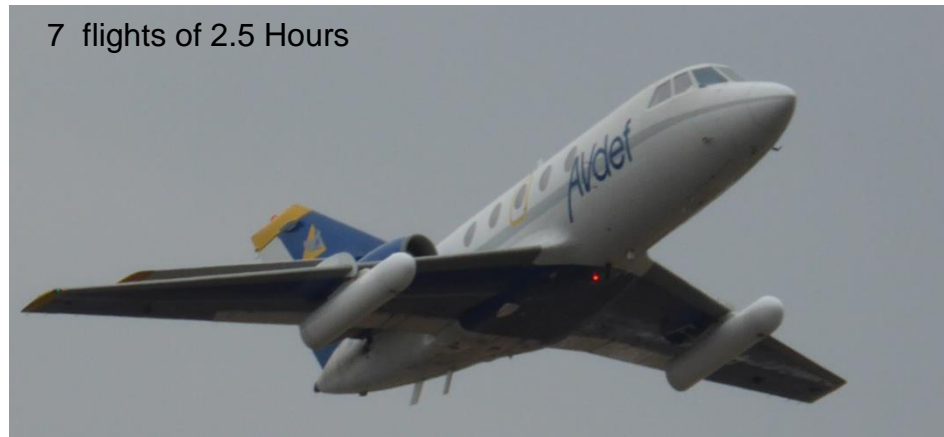- o Season
- o Weather
- o Soil moisture
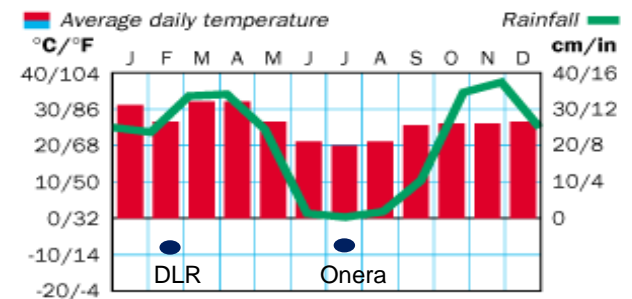
The AfriSAR campaign – Gabon Forest

4 trihedrals (2.275m) deployed on the airport

7 flights of 2.5 Hours

A large team
10 ONERA , 4 AvDEF, 1 ESA, 2 CESBIO + ANPN + AGEOS + DLR

Radar configuration

Geometry	
Flight ground altitude	**20000 ft or 6096m**
Aircraft speed	100 – 150m/s
First recorded distance	6600m
Full resolution recorded distance	8000m
Pulse duration	30 µs
Radar setting	
Mode	P + L
Side	Left looking
PRF	5 kHz
Sampling frequency	500 MHz
P Band	
Range of frequency	**410-460 MHz**
Bandwidth	**50 MHz**
Polarisation mode	**HH, HV, VH, VV**
Effective PRF	1250Hz
Antenna beamwidth (site)	100°
Antenna beamwith (azimuth)	60°
Transmitted power	500W
Antenna boresight	45°
Effective Swath	[5863m 25°-55°]
Range of incidence angle	25°-55°
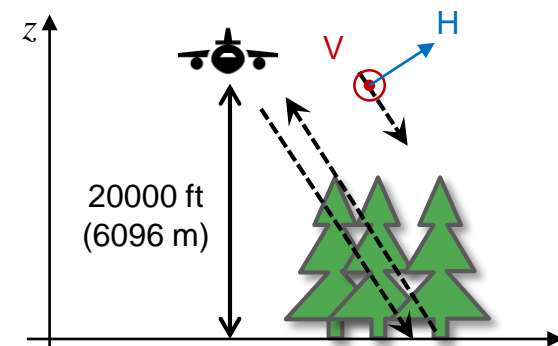
Same configuration as DLR F-SAR

Acquisition Geometry

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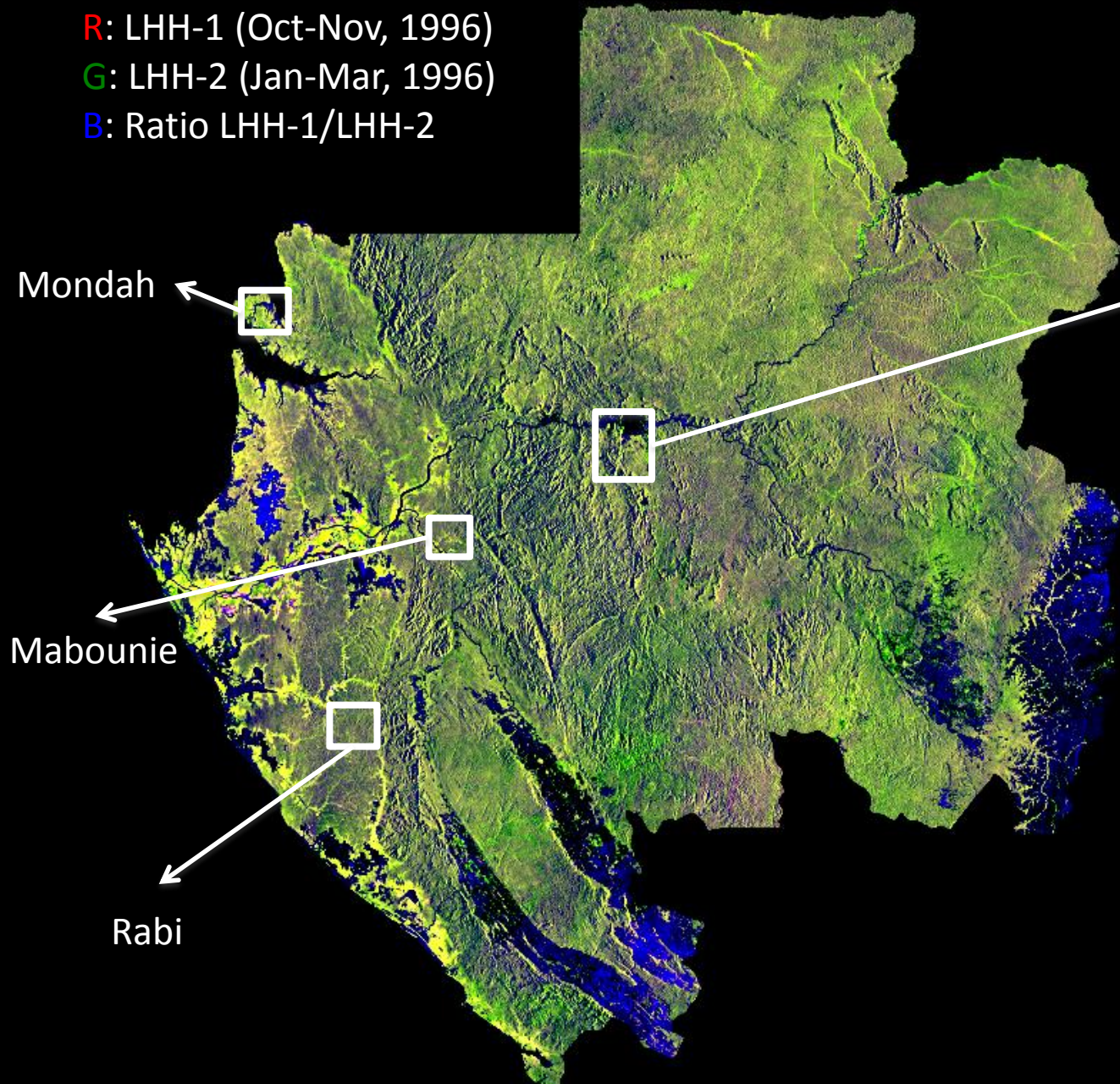
TOTAL
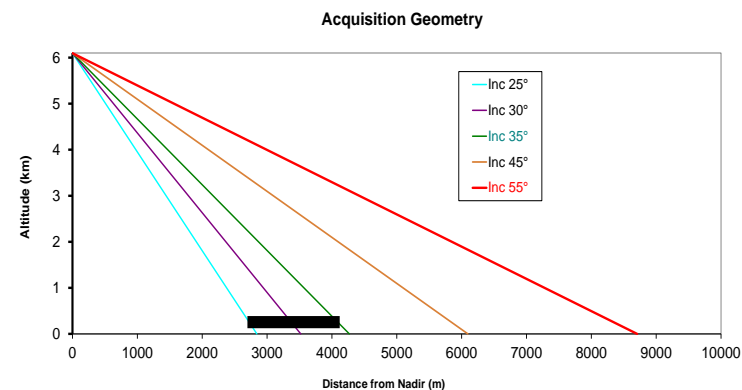
JERS LHH MOSAIC of GABON

R: LHH-1 (Oct-Nov, 1996)
G: LHH-2 (Jan-Mar, 1996)
B: Ratio LHH-1/LHH-2

Sites for AfriSAR
Airborne Campaign

Mondah

Main Study Area
La Lopé National Park

Mabounie

Rabi

The sites: La Lopé - National Park

- Patchy forests and savannas
    - Marked topography
    - Plots: 100t/ha to 500t/ha
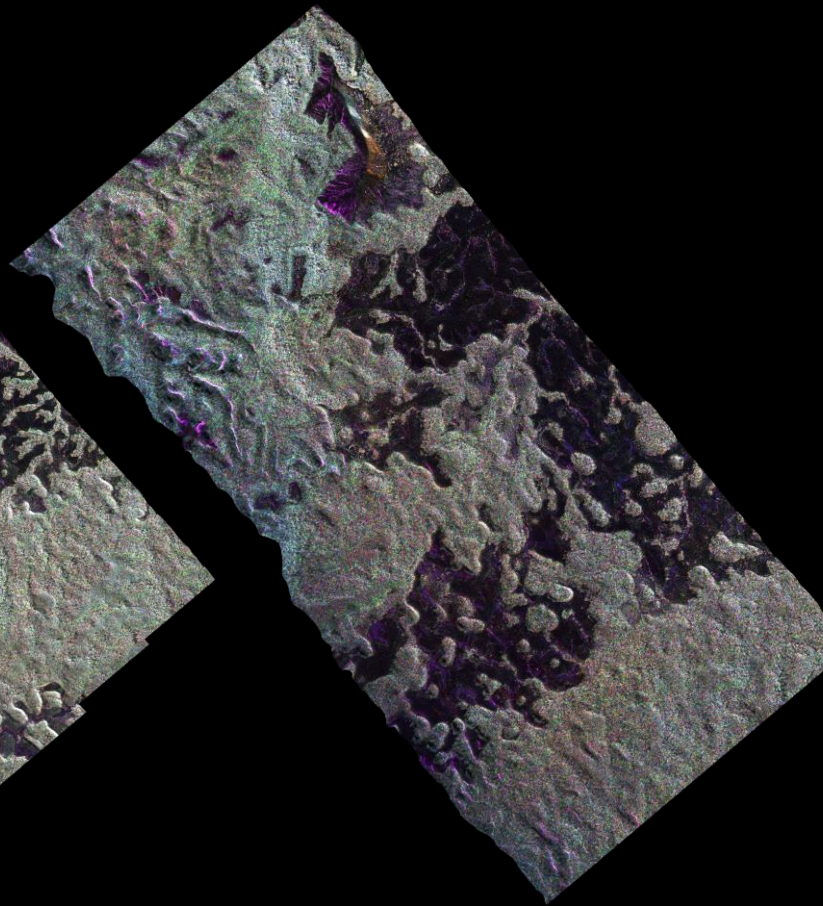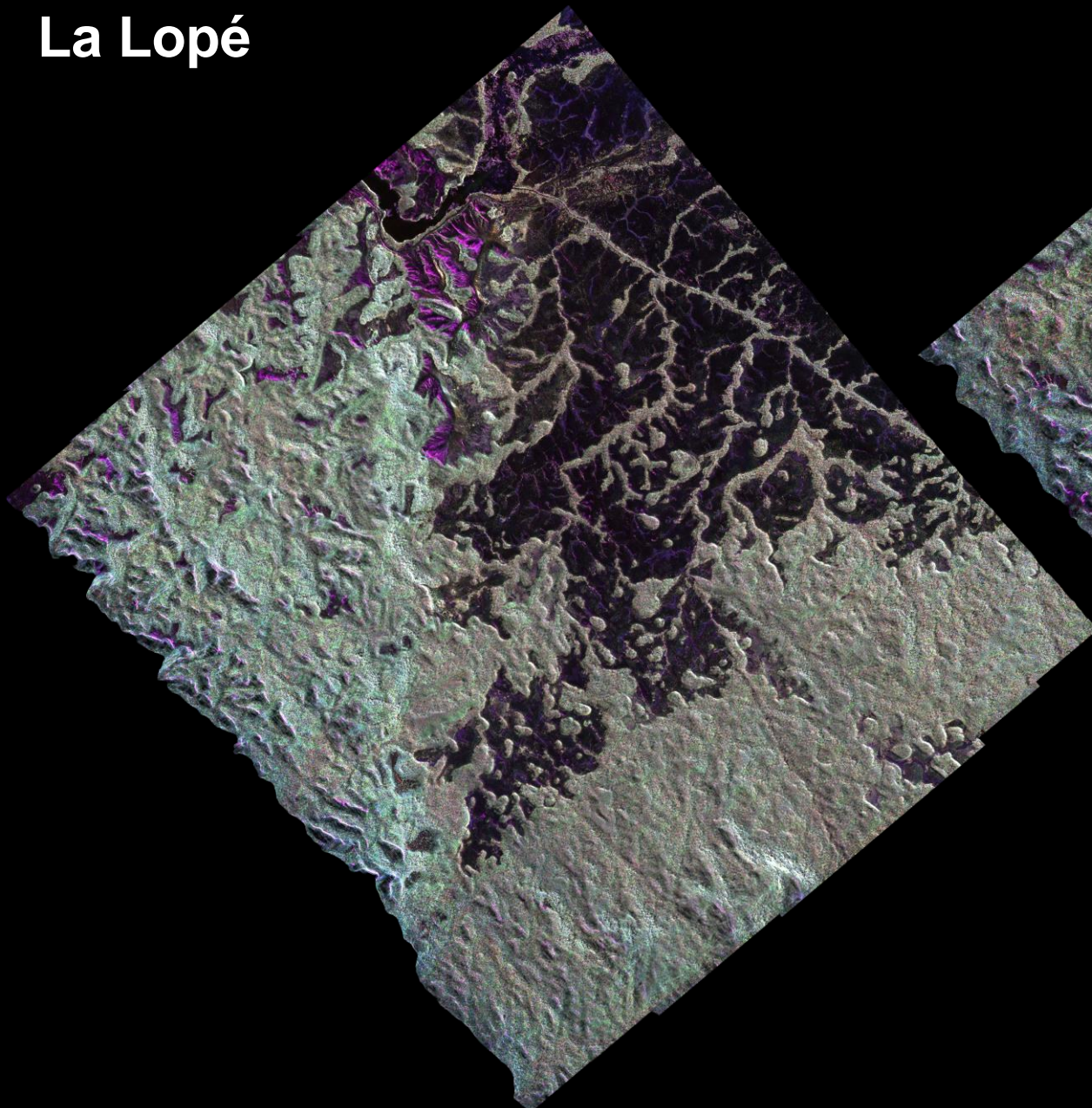   - Selected with the help of ANPN (National Park Agency – Lee White)
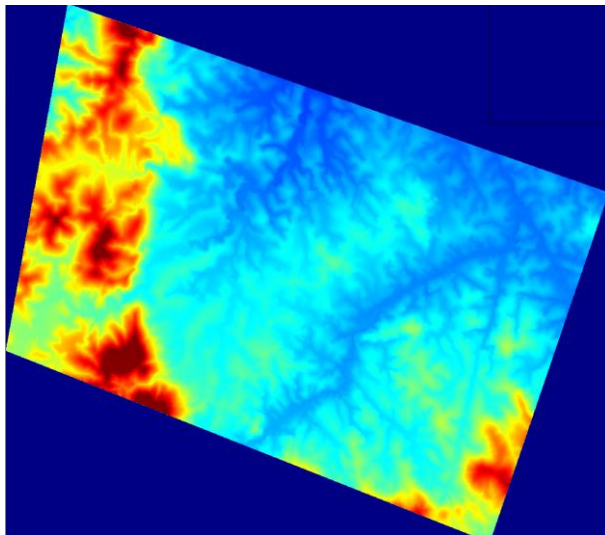

Photos: CESBIO

La Lopé

P band
HH – HV – VV

Tomo-Stack –
10 swaths – M2

Mosaic – 6 shifted swaths

9

La Lopé site: LIDAR

Digital Terrain Model
(ground height)

Canopy Height Model
(vegetation height)

150m   500m

0m   50m
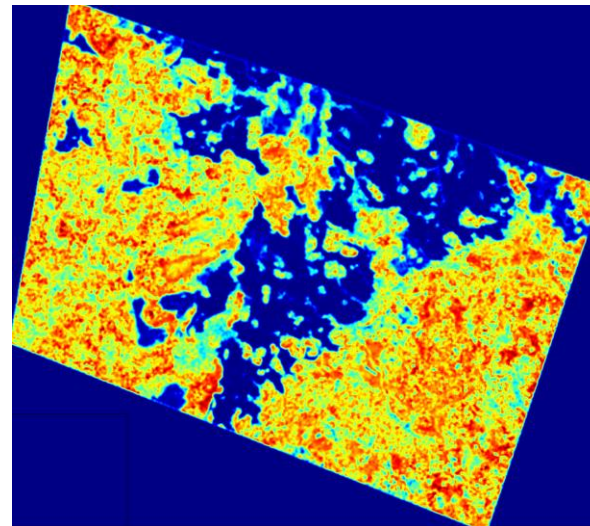
- LIDAR data provided by S. Saatchi – JPL
- Date: 2013

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Tomographic analysis from SETHI acquisitions over La Lopé

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Tomography SAR

P band acquisitions

Vegetation profile

Backscattered power
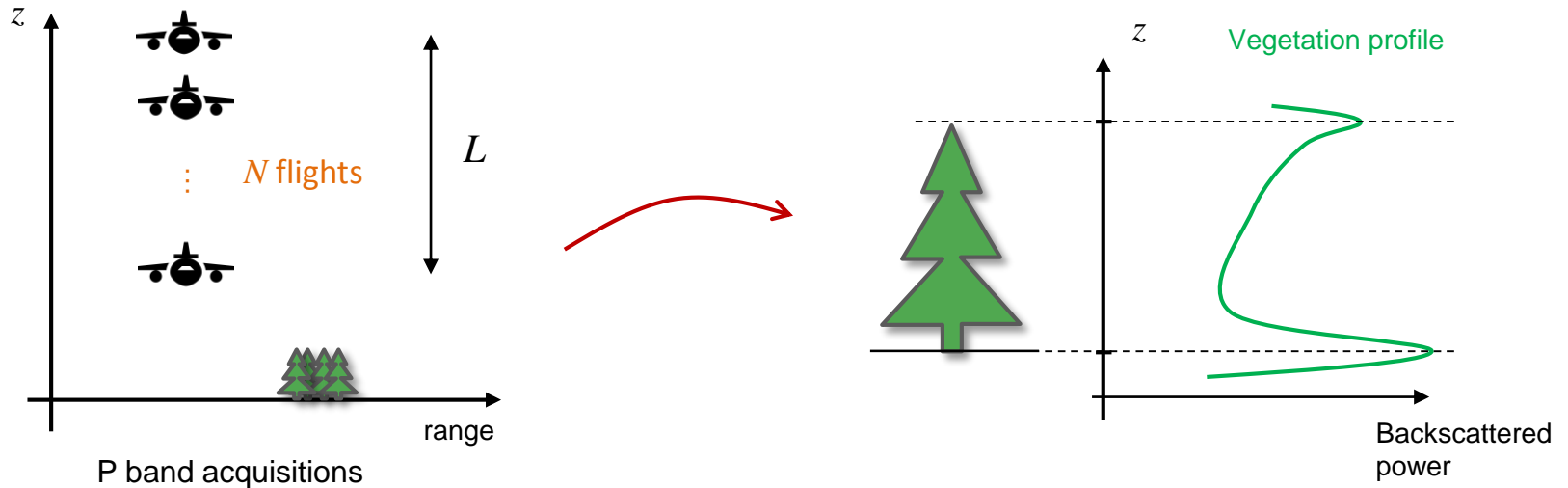
Tomography SAR :
Use information collected by sensors at different altitudes to estimate a vegetation profile *

* power of the backscattered response of the scatterers as a function of their height

→ Estimation of the ground and the canopy height
→ Analysis of vegetation and ground properties

La Lopé TomoStack

10 flights → L = 160m synthetic vertical antenna

ID	Flight ID : 20150705-B	AfriSAR 3
ID	05/07/2015 (B)	
1	TomoSAR	Lope-M2-20950-P+L (0m)
2	"	Lope-M2-20685-P+L (-80m)
3	"	Lope-M2-20750-P+L (-60m)
4	"	Lope-M2-20880-P+L (-20m)
5	"	Lope-M2-20980-P+L (+10m)
6	"	Lope-M2-21080-P+L (+40m)
7	"	Lope-M2-21145-P+L (+60m)
8	"	Lope-M2-21210-P+L (+80m)
9	"	Lope-M2-20685-P+L (-80m)
10	"	Lope-M2-20980-P+L (+10m)
11	Calibration	Libreville- Cal-20060-P+L

10 flights

z

160m
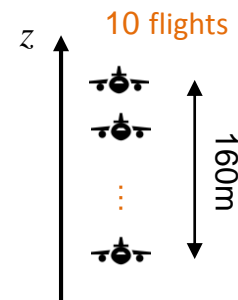
Resolution for tomography : ~6m at -3dB in near range for Capon
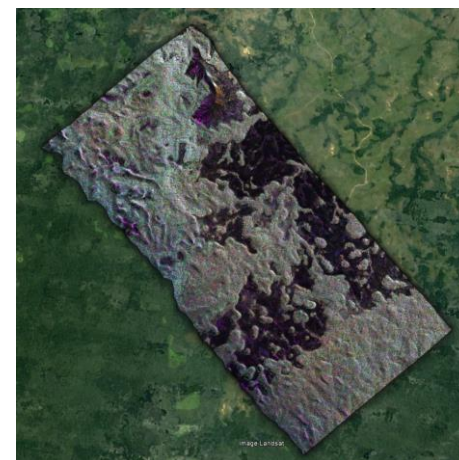
La Lopé - TomoStack

- Preparing the TomoStack:
  - Standard SAR processing (projection into the master trajectory -> flight 10)
 - Use of a Digital Elevation Model (DEM) for topography calibration
    Here: TanDEM-X* DEM

    * Satellite data (X-band) : little penetration in the vegetated cover

Phase correction of the TomoStack

- **Phase screens** [1]
  - ○ Residual phases on the data
  - ○ Mostly dued to misknowledge on the trajectory of the flights
  - ○ Can provoke defocusing and strong side lobes in the tomographic profiles
  - → Need to be corrected

  Correction procedure :
  - • Estimation of the phase screens for each flight (based on phase linked approach [2])
  - • Correction of the data

- **Tomographic estimators on the corrected data stack**
  - ○ Here : Capon estimator [3] for the vegetation profile
  - ○ Classic non parametric estimator
  - ○ Resolution at -3dB : ~6m (near range)

Estimated phase screen on image 1
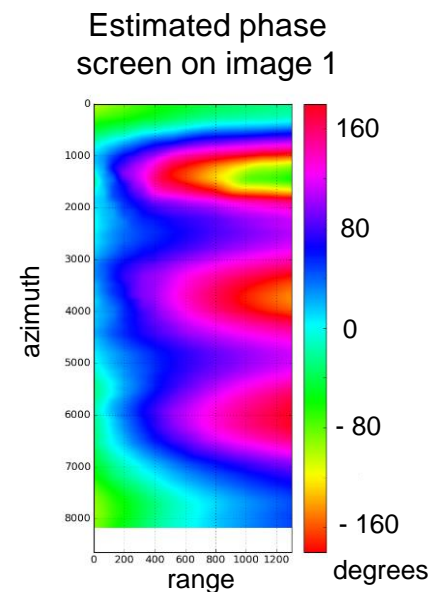
[1] : Tebaldini and Monti Guarnieri, IEEE TGRS, 2010
[2] : Tebaldini *et al*, IEEE TGRS, 2016
[3] : Stoica and Moses, Introduction to Spectral Analysis, Englewood Cliffs, NJ: Prentice Hall, 1997

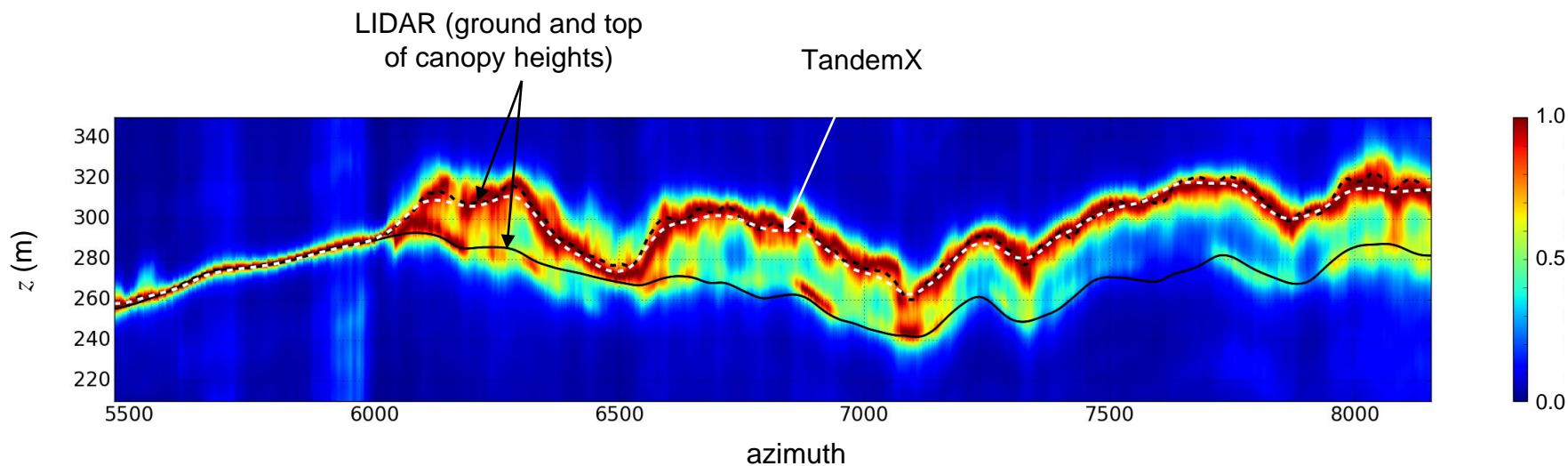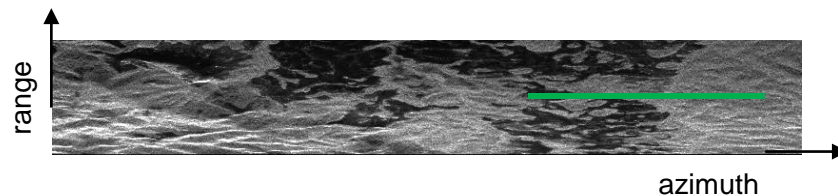# Tomographic analysis
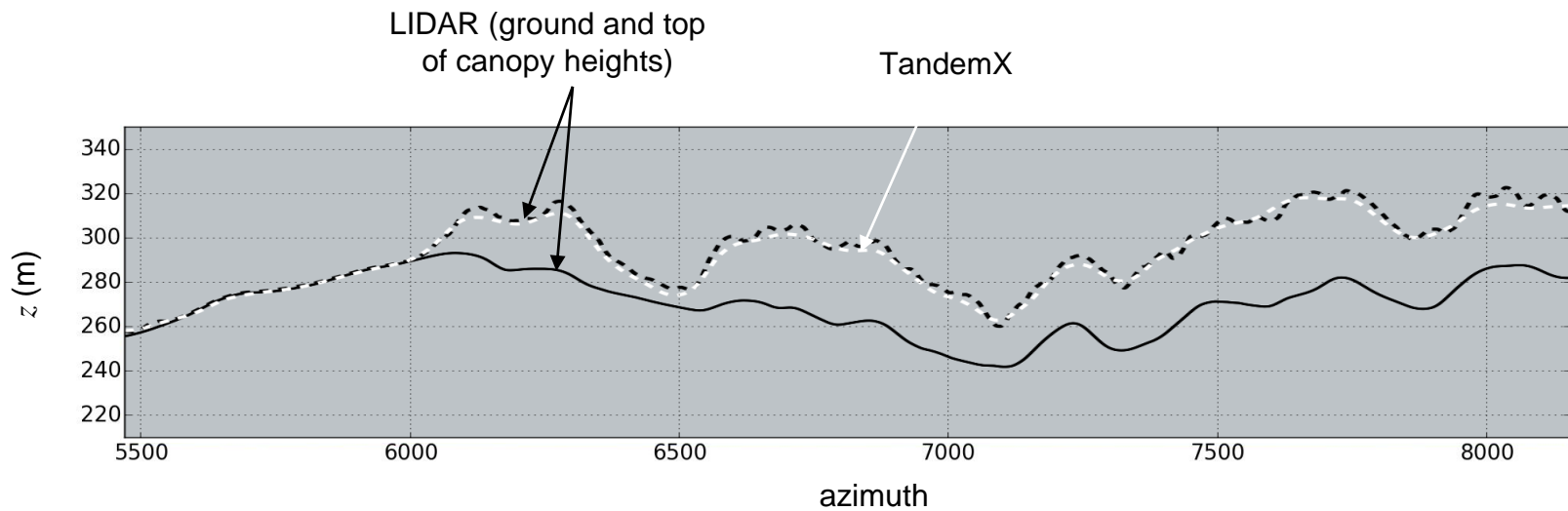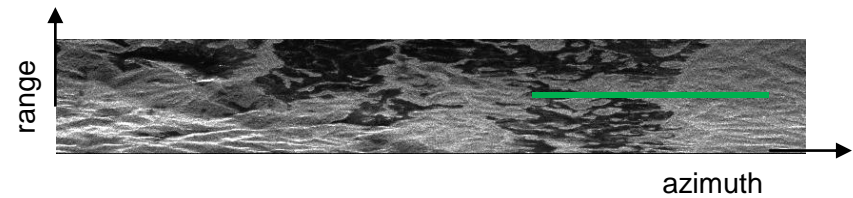
Examples of results:

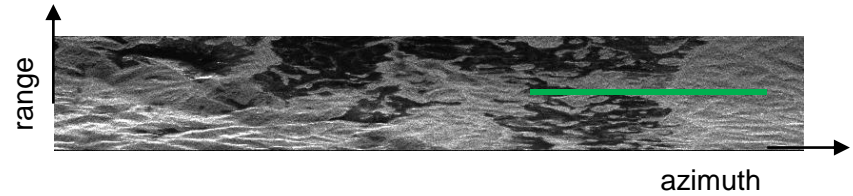LIDAR (ground and top of canopy heights)

TandemX
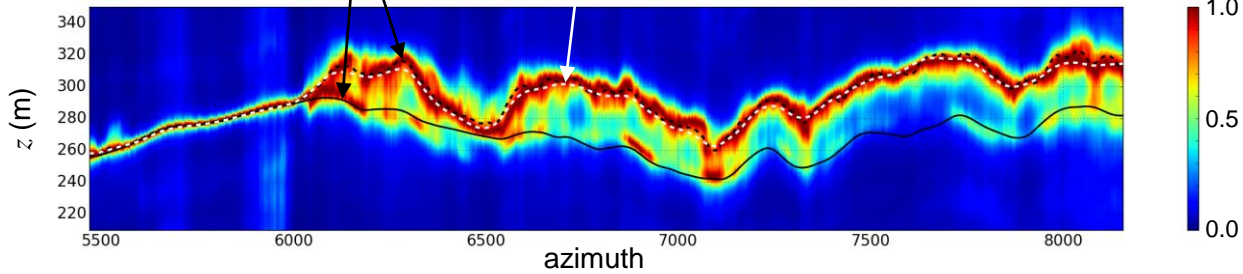
Sliding windows: 33x33 pixels

Tomographic analysis

Examples of results:

Capon
(normalized profiles)

LIDAR (ground and top of canopy heights)

TandemX

z (m)

azimuth

Polarisation mode : HV

Sliding windows: 33x33 pixels

Tomographic analysis
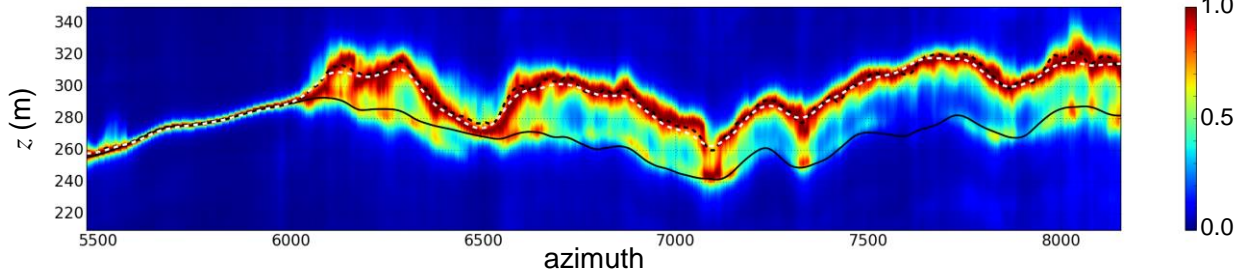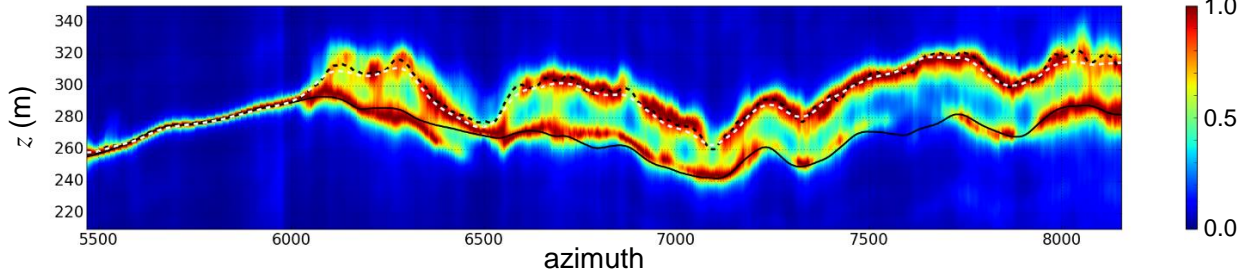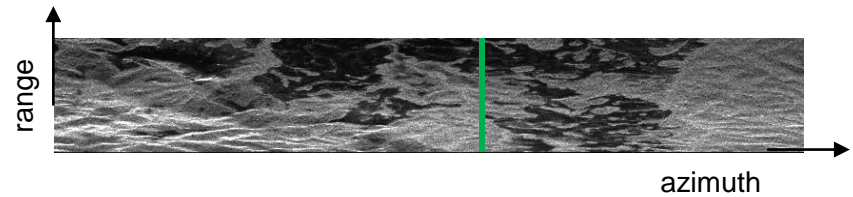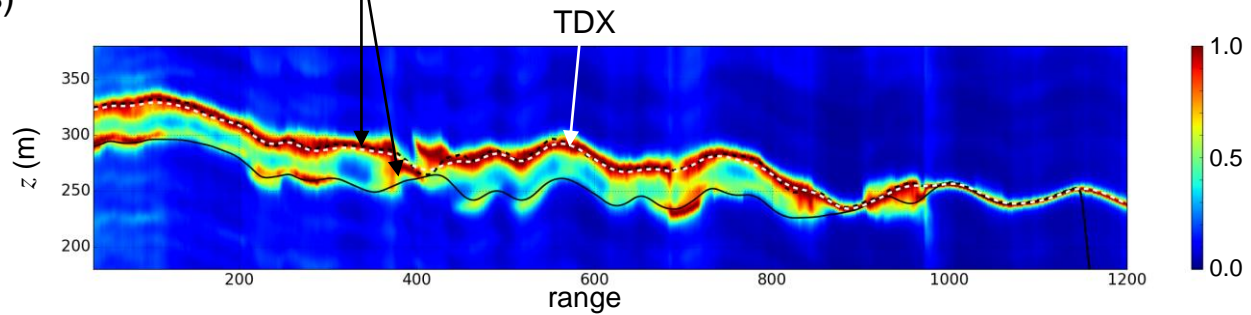

Examples of results:

Capon
(normalized profiles)

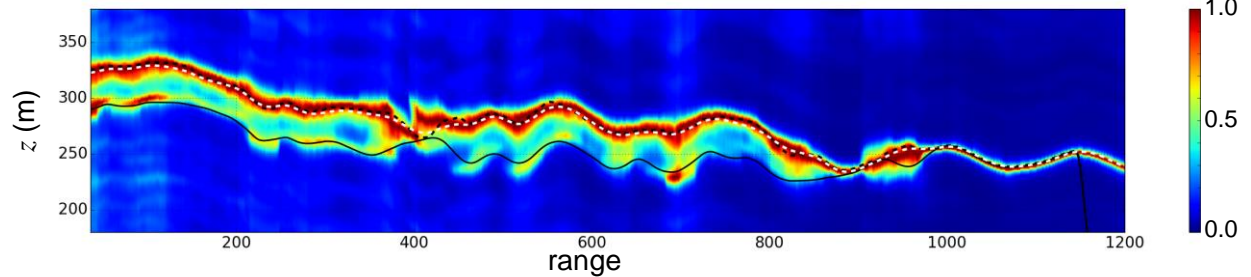LIDAR (ground and top of canopy heights)

TDX

HV

VV

HH

Tomographic analysis

Examples of results:

Capon
(normalized profiles)

LIDAR (ground and top of canopy heights)

TDX

HV

VV

HH

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Identification of ROI

P band
HH – HV – VV

Labels on map: MIX2bCa, LPG01_2, LPG01_1, MIX1a, OKO2a, OKO1a, COL3a, SAV2a, COL1a, COL2a, SAV1a, MAR2a, MAR1a

Image Landsat / Copernicus

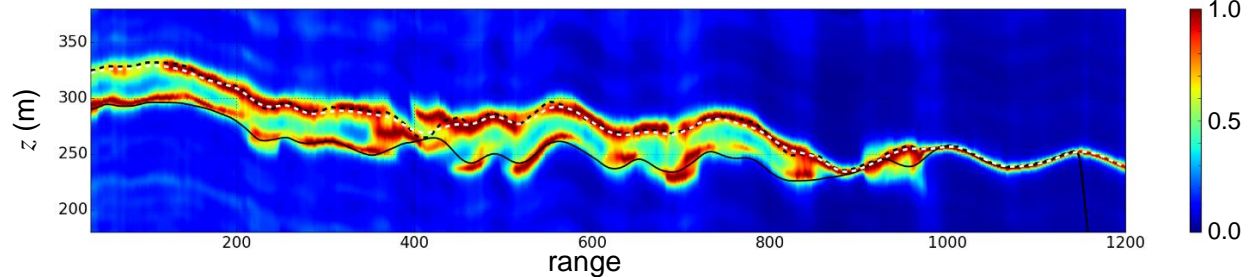100m
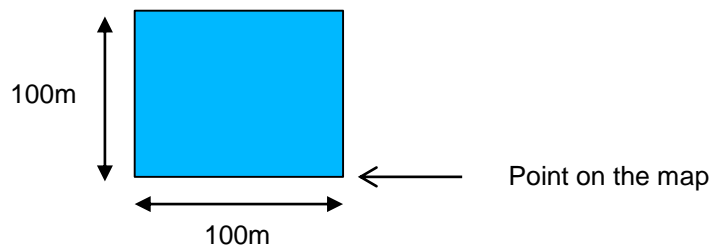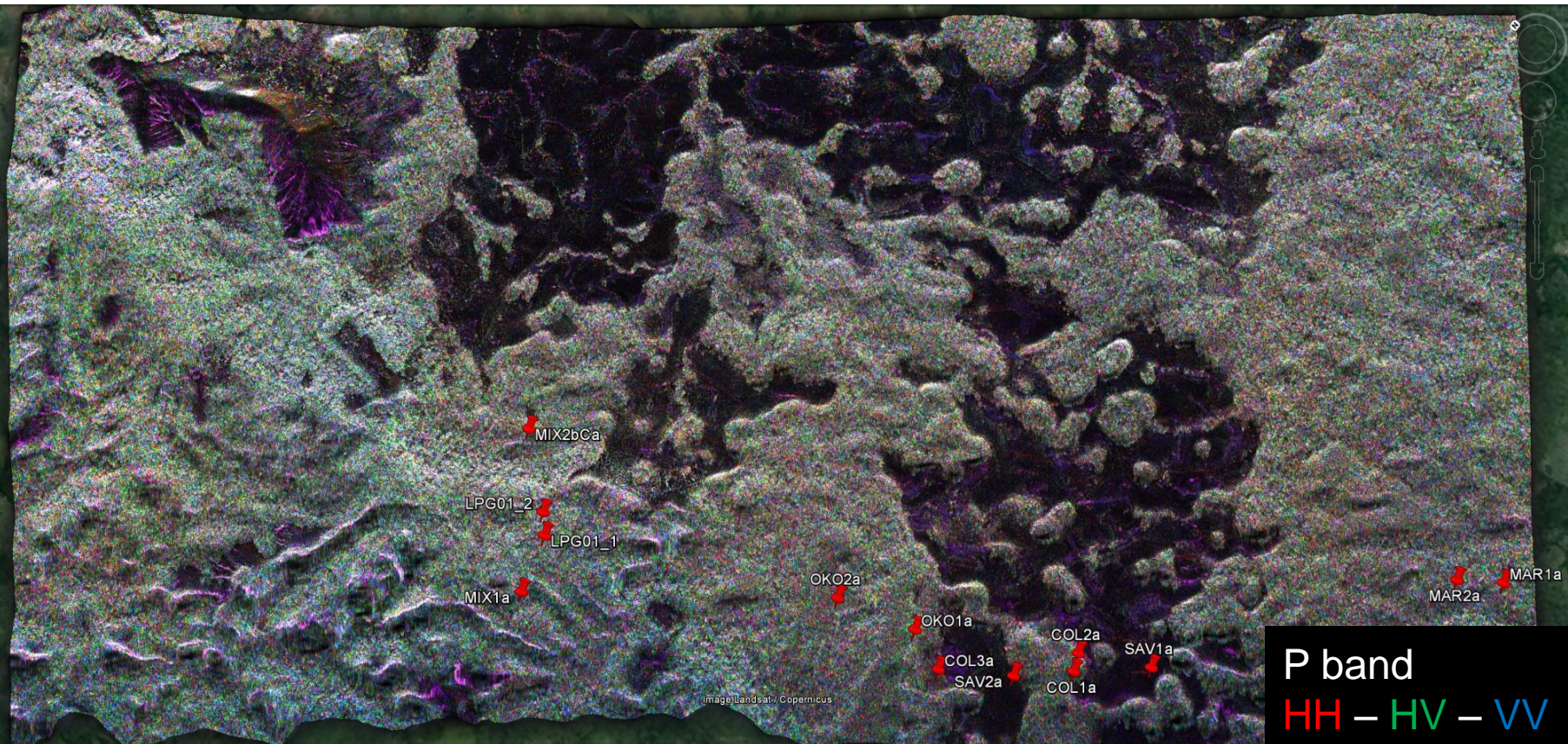
100m

← Point on the map

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Tomographic analysis on ROI

SAV1

Savanna region
Low vegetated areas
Almost flat area

COL3

Colonizing forest
(savanna borders)
Very young forest
Flat area

OKO2

Mono-specy: Okoumé
Homogeneous high trees
Former plantation
Flat area

MIX1
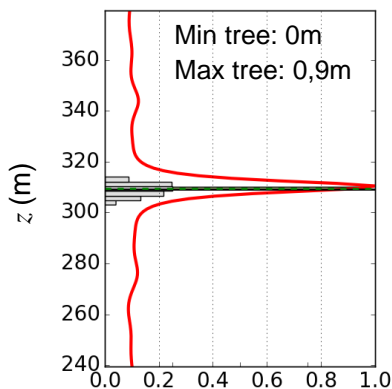

Multiple species
Multiple growing states
Moderate slope
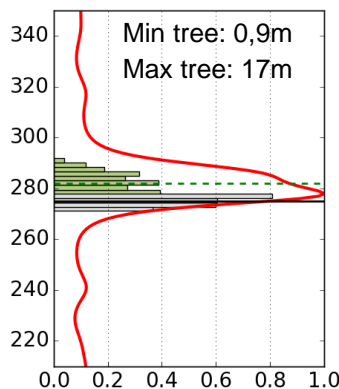
Photos :
Afrisar report
+ CESBIO

SAV1

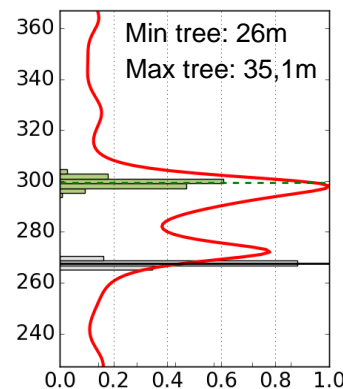Savanna region
Low vegetated areas
Almost flat area

COL3

Colonizing forest
(savanna borders)
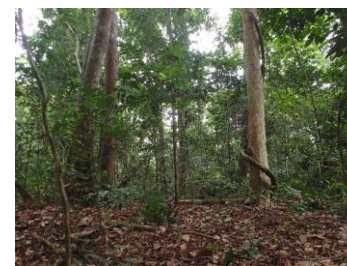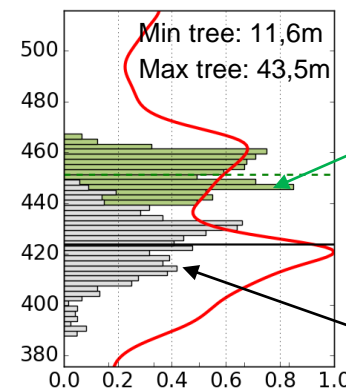Very young forest
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OKO2

Mono-specy: Okoumé
Homogeneous high trees
Former plantation
Flat area

MIX1

Multiple species
Multiple growing states
Moderate slope

Photos :
Afrisar report
+ CESBIO

Capon normalized profiles HV

Conclusion on the tomographic analysis

- The profiles are well correlated to the LIDAR data (ground and canopy heights)

- There is a definite sensitivity of the profiles to the type of forest and the histogram of height (given by LIDAR)
  - Future work will include exploration of the effect of topography

- Qualitative results for the moment
  - Future work will include estimation of the ground and canopy heights

TOTAL

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Thank you for your attention

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