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中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

PolTomSAR : Dragon4 id. 31470_2

3-D Geo-Physical Characterization of Vegetated Areas using SAR Polarimetry and Tomography (PolSAR, PolTomSAR)

J. Sun, L. Ferro-Famil, E. Chen, W. Hong, Z. Li, E. Pottier, S. Tebaldini, X. Li

IECAS

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POLITECNICO MILANO

IETR

INSTITUT D'ÉLECTRONIQUE ET DE TÉLÉCOMMUNICATIONS DE RENNES

26–30 June 2017 | Copenhagen, Denmark

2017年6月26-30日，丹麦 哥本哈根

TEAM COMPOSITION

Prof. Laurent FERRO-FAMIL

Prof. Eric POTTIER

IETR - University of Rennes 1 (F)

Prof. Stefano TEBALDINI

Prof. Fabio ROCCA

SAR lab- Politecnico di Milano (I)

Prof. Zengyuan LI

Prof. Wen HONG

Prof. Xinwu LI

Prof. Erxue CHEN

Institute of Forest Resources Information Techniques Chinese Academy of Forestry

Dr. Qiang XIN

Institute of Electronics, Chinese Academy of Science

Dr. Lu ZHANG

Center for Earth Observation and Digital Earth

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2017年“龙计划”四期

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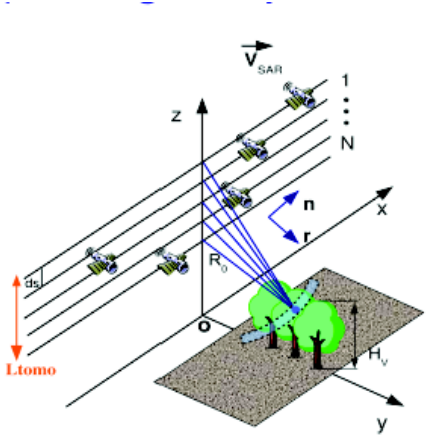
- **TomoSAR processing techiques for Spaceborne SAR missions**

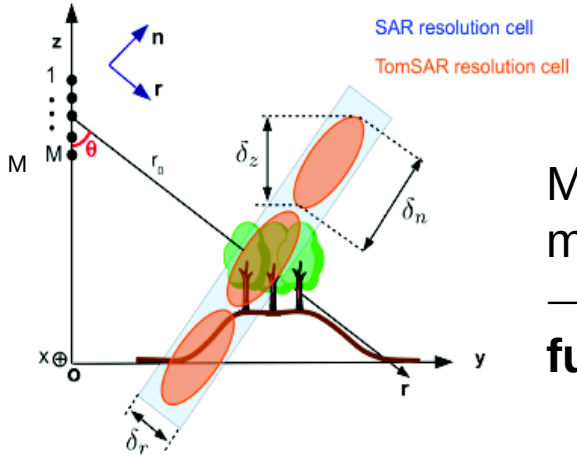
  → preparation of the SAOCOM-CS/PARSIFAL mission projects

- **Biomass estimation over tropical forests at P band**

  → preparation of the BIOMASS mission

- **Achievements and exchanges**

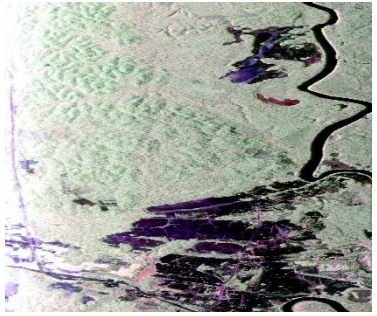


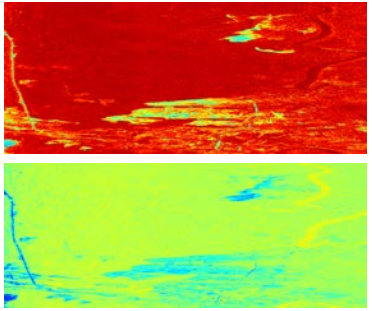


Mixed scattering mechanisms

→

full rank polarimetry





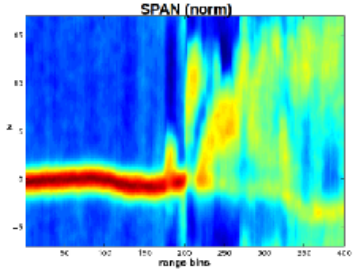
H

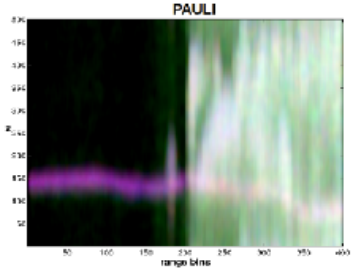
α

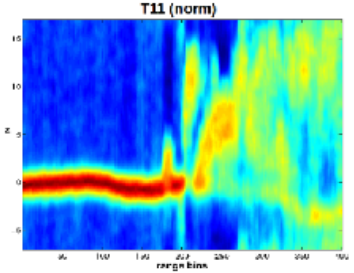
Intensity
σ(x,r)

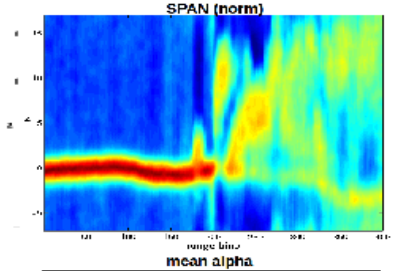
Rank 1 polarimetry (Pauli)
k(x,r)

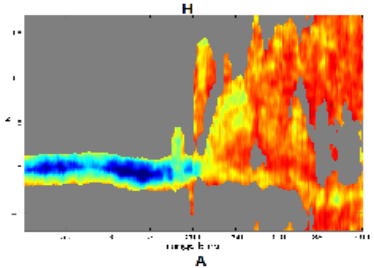
Full rank polarimetry
T(x,r)

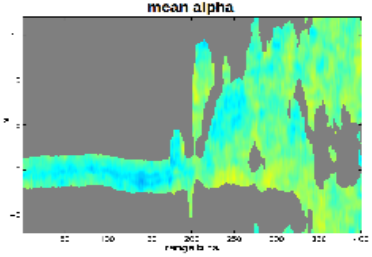


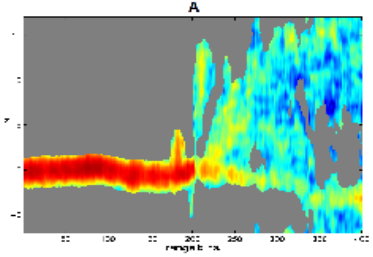












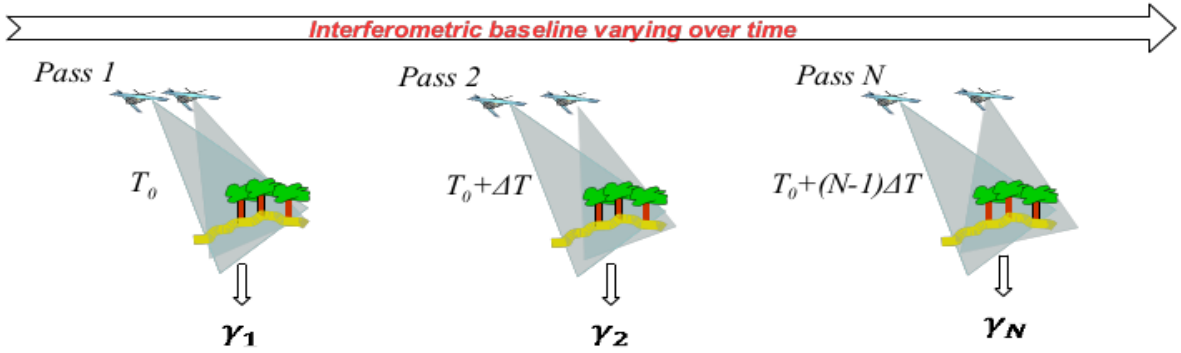
Dornstetten **airborne**

PolTomSAR data set

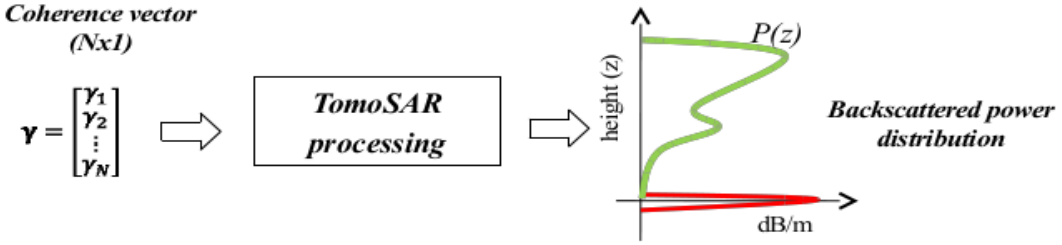
- DLR E-SAR
- L-Band
- 21 tracks: average baseline 20m
- Tomographic resolution
  $\delta_z = 2\text{m}$

Single pass systems:

- *Cartwheel*
- *Tandem-X*
- *Tandem-L*
- *SAOCOM*

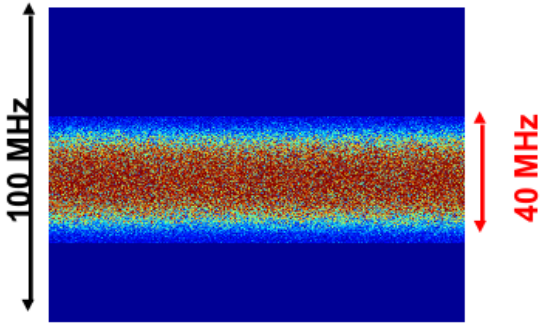


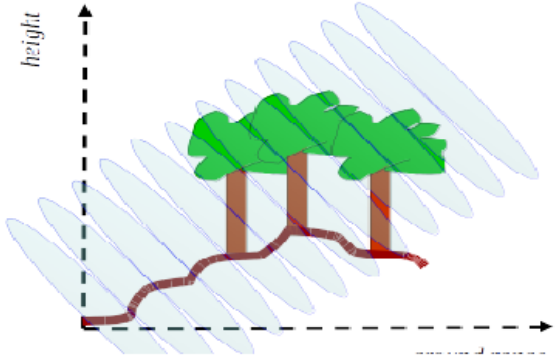
Processing:



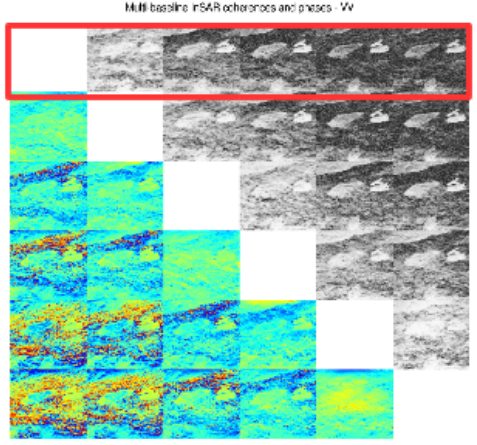
Interferometric pair are acquired nearly simultaneously
→ Intrinsically robust to temporal decorrelation:

Range resolution reduction





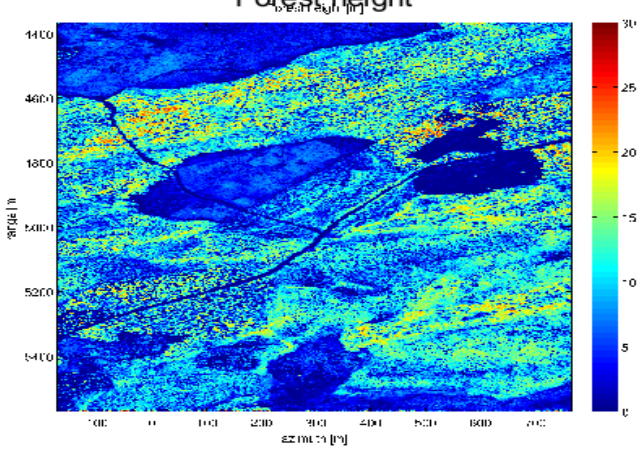
Loss of redundancy & information



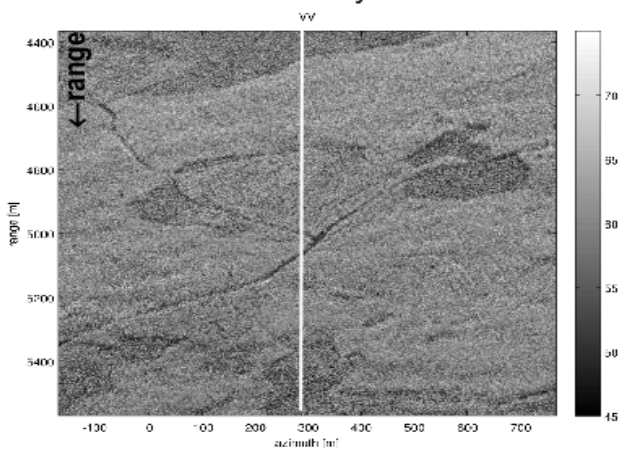
$\arg(\gamma_{ij})$

$|\gamma_{ij}|$

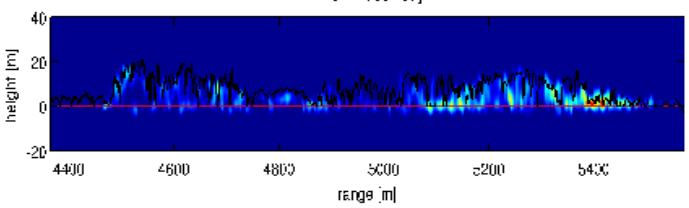
Forest height



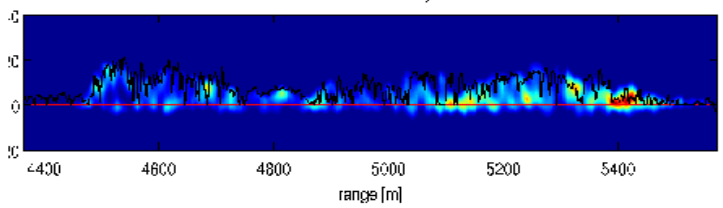
VV intensity



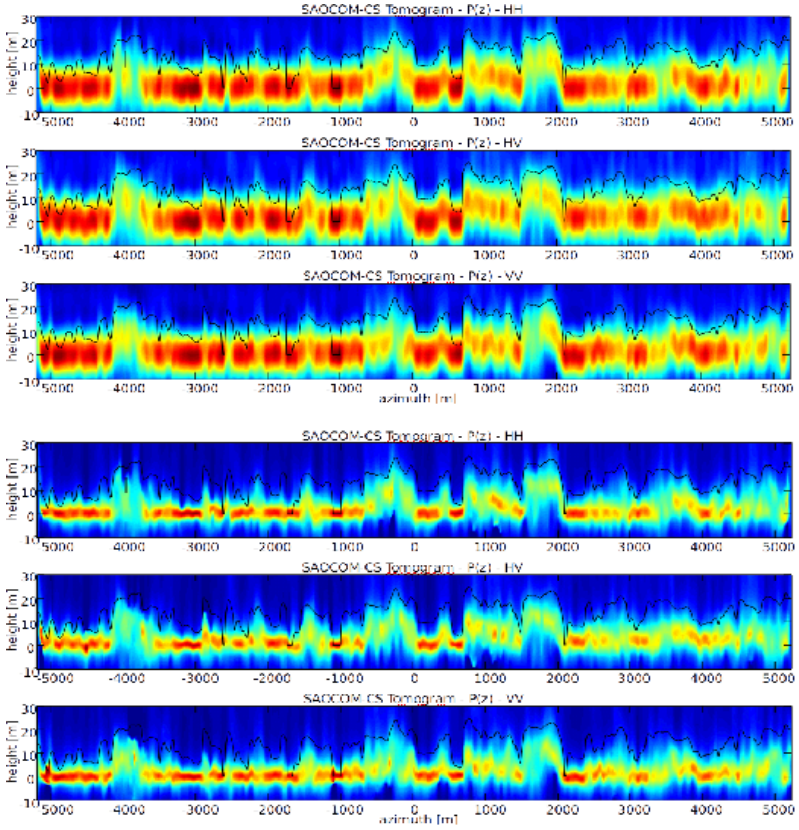
B_f = 100 MHz



B_f = 40 MHz



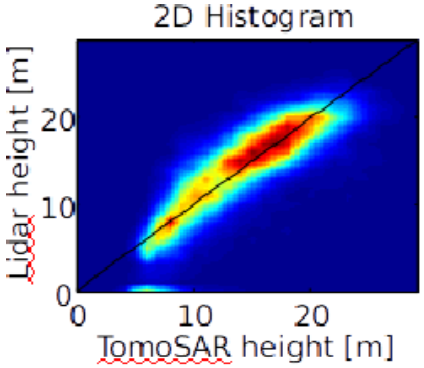
- Comparable performance for terrain topography and tree height

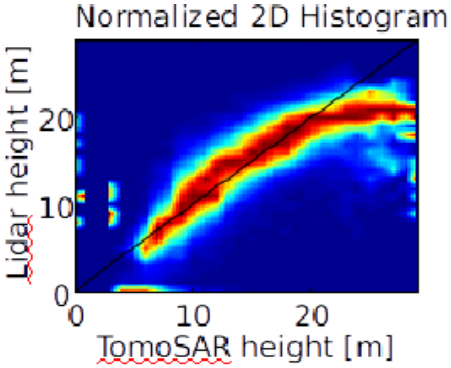


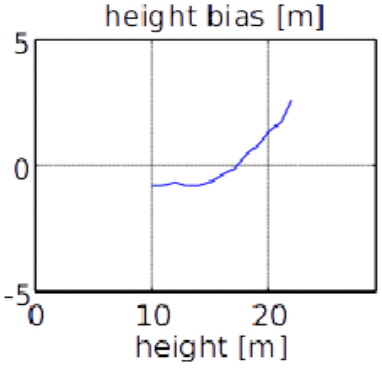
BEAMFORMER

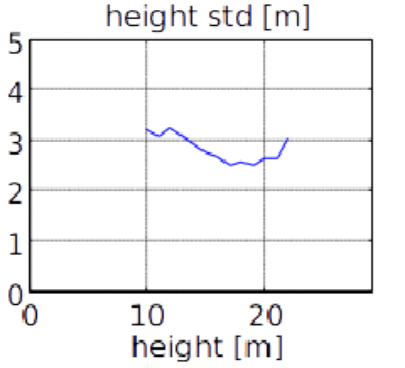
vs

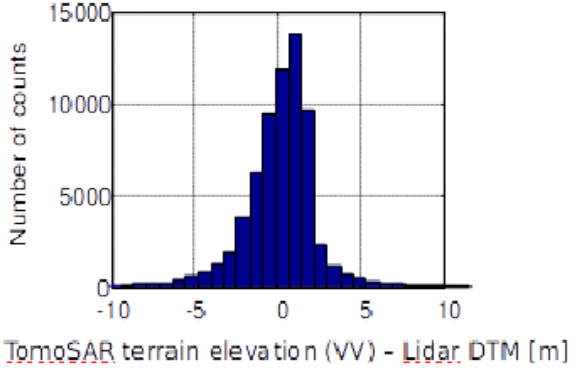
ADAPTED CAPON METHOD


2D Histogram
Lidar height [m]
TomoSAR height [m]
0
10
20


Normalized 2D Histogram
Lidar height [m]
TomoSAR height [m]
0
10
20


height bias [m]
height [m]
5
0
-5
0
10
20


height std [m]
height [m]
5
4
3
2
1
0
0
10
20


Number of counts
15000
10000
5000
0
-10
-5
0
5
10
TomoSAR terrain elevation (VV) - Lidar DTM [m]

M PolSAR images

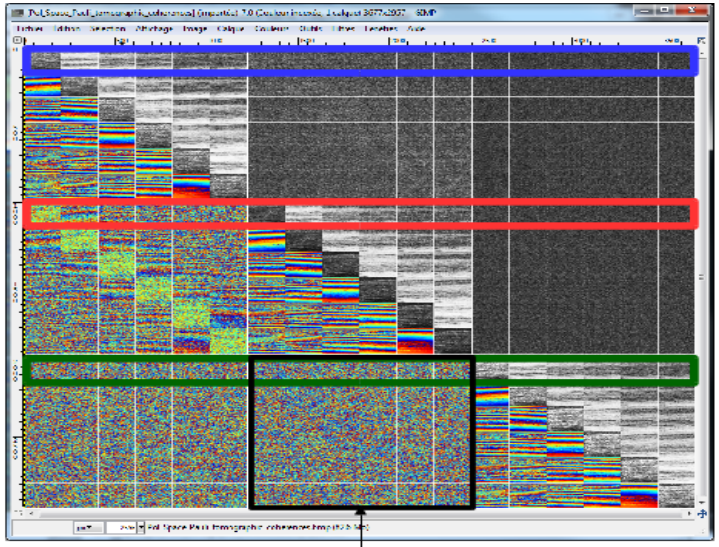
$$\mathbf{y}_{PS} = \begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \mathbf{y}_3 \end{bmatrix} \in \mathbb{C}^{3M}$$

$$\mathbf{R}_{PS} = \begin{bmatrix} \mathbf{R}_{11} & \mathbf{R}_{12} & \mathbf{R}_{13} \\ & \mathbf{R}_{22} & \mathbf{R}_{23} \\ & & \mathbf{R}_{33} \end{bmatrix}$$

$\gamma_{ij}(w_1, w_k)$

$\gamma_{ij}(w_2, w_k)$

$\gamma_{ij}(w_3, w_k)$



$\mathbf{R}_{ij} \in \mathbb{C}^{M \times M}$

Full rank analysis strategies

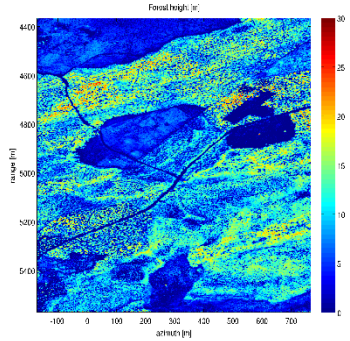
- Full-rank P-Capon (LFF et al. 2012)

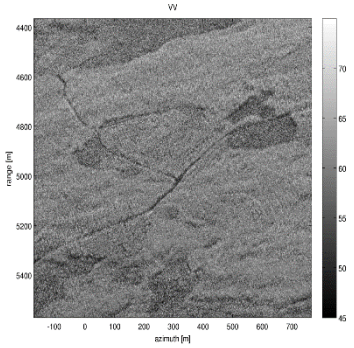
$$\mathbf{R}_{PS} \longrightarrow \sigma(z)\mathbf{T}(z)$$

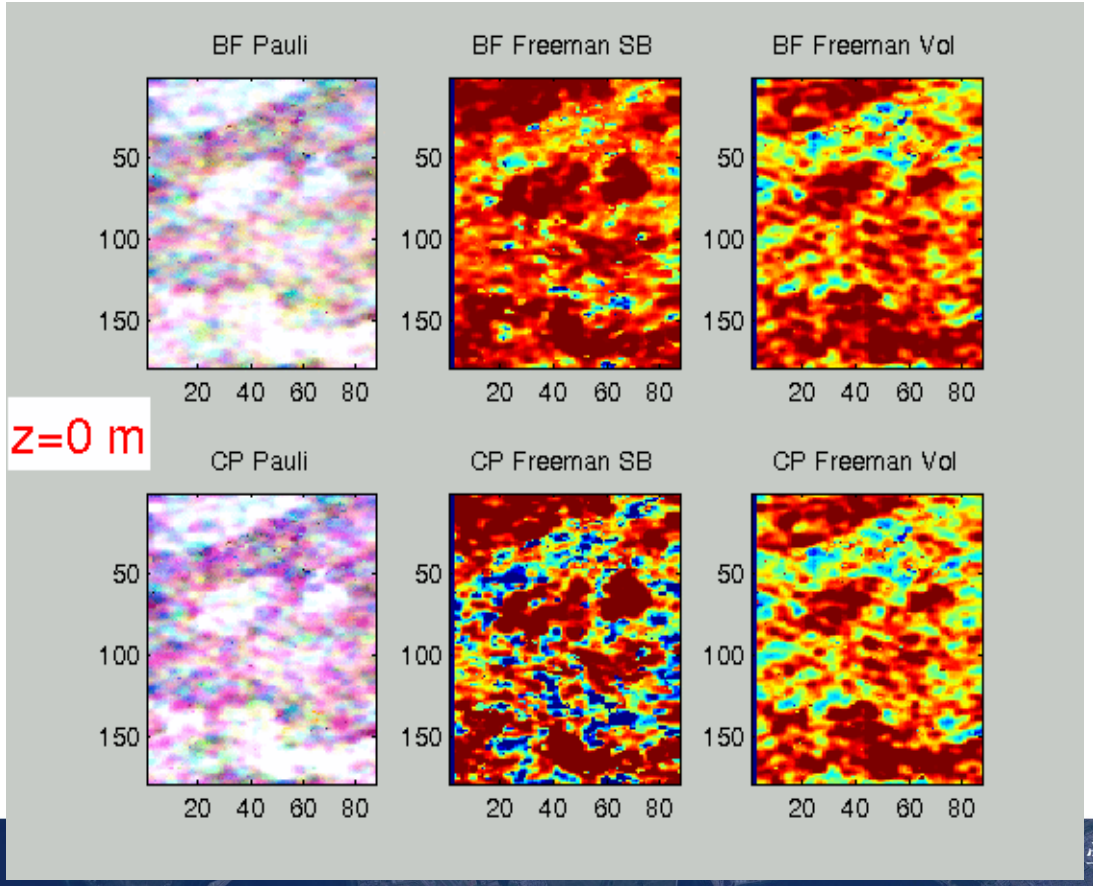
- SKP decomposition (Tebaldini 2009)

$$\mathbf{R}_{PS} = \sum_i \mathbf{T}_{P_i} \otimes \mathbf{R}_{S_i} \longrightarrow \sum_i \sigma_i(z)\mathbf{T}_{P_i}$$

Interpolation techniques:
see paper at IGARSS 2017

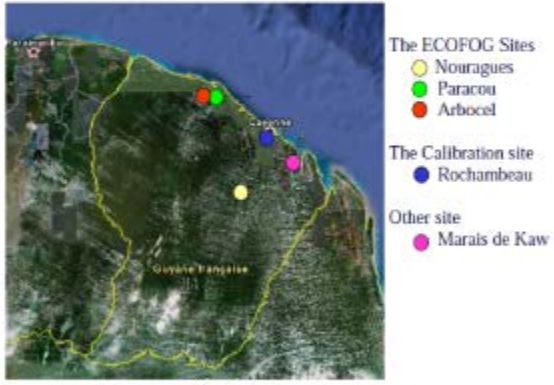

Forest height [m]
range [m]
azimuth [m]


VV
range [m]
azimuth [m]


BF Pauli
BF Freeman SB
BF Freeman Vol
z=0 m
CP Pauli
CP Freeman SB
CP Freeman Vol

Tropical forest Paracou test site

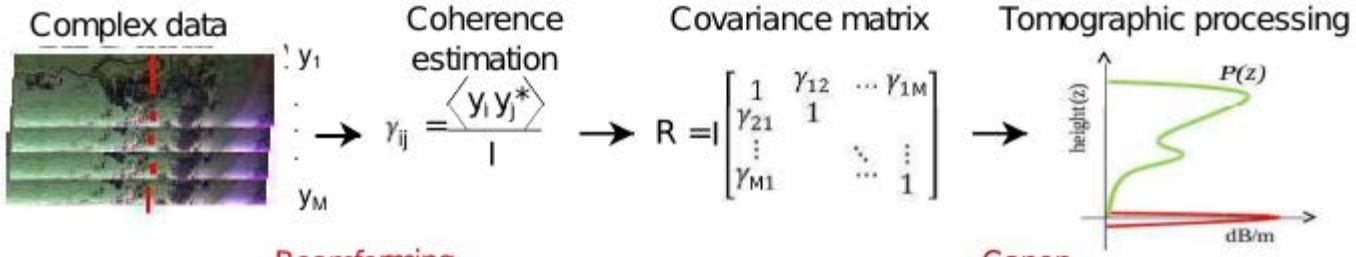
TropiSAR campaign

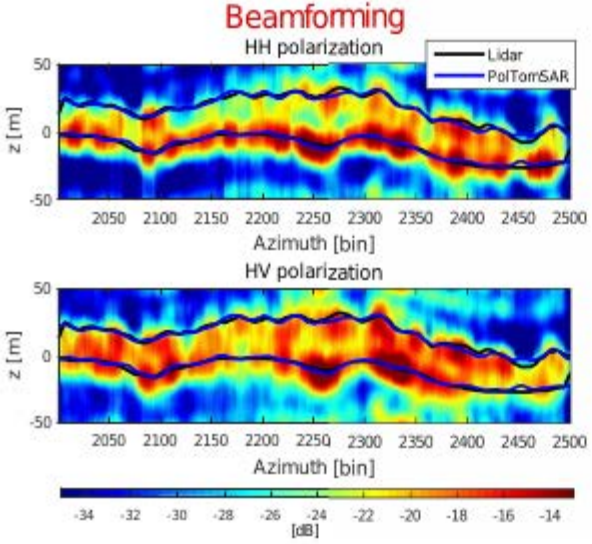


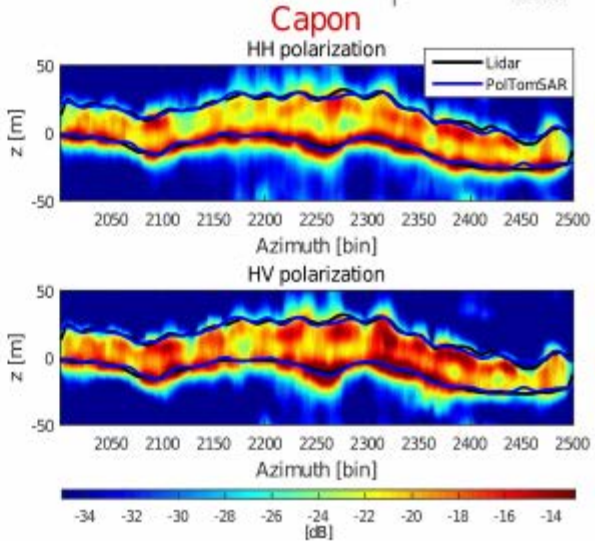
Paracou test site

- TropiSAR campaign, 2009
- ONERA SETHI
- P-Band
- Resolutions:
  - Azimuth: $\delta_a = 1.245m$
  - Range: $\delta_r = 1m$
  - vertical: $\delta_z = 20m$
- 6 tracks

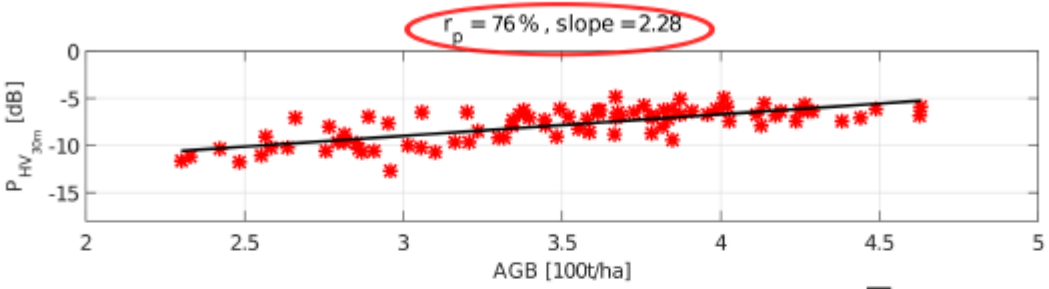
3-D characterization of a tropical forest cover

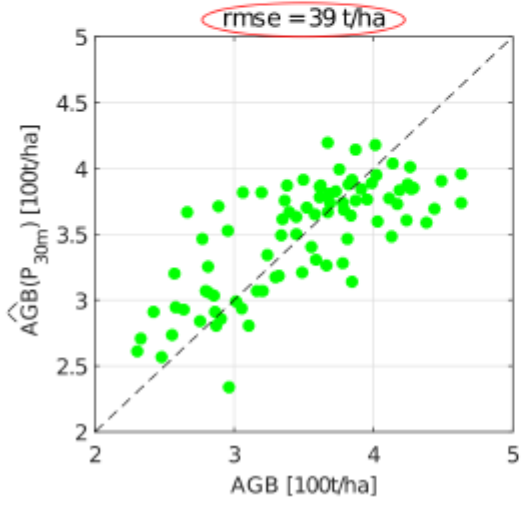


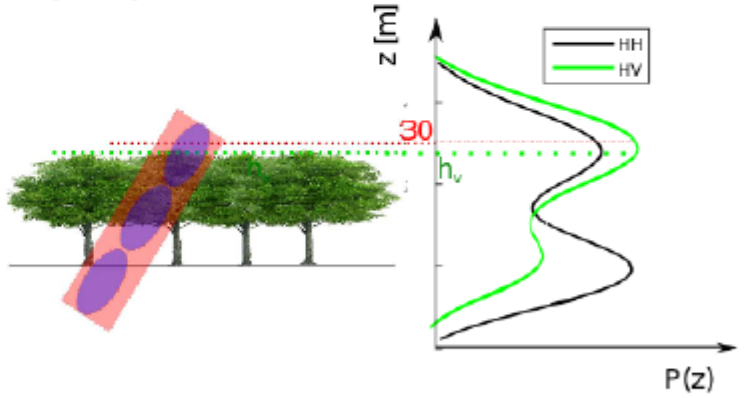




Tomogaphic biomass estimation [Ho Tong Minh 2013]: $\widehat{AGB} = \alpha_1 P_{HV_{30m}} + \alpha_2$





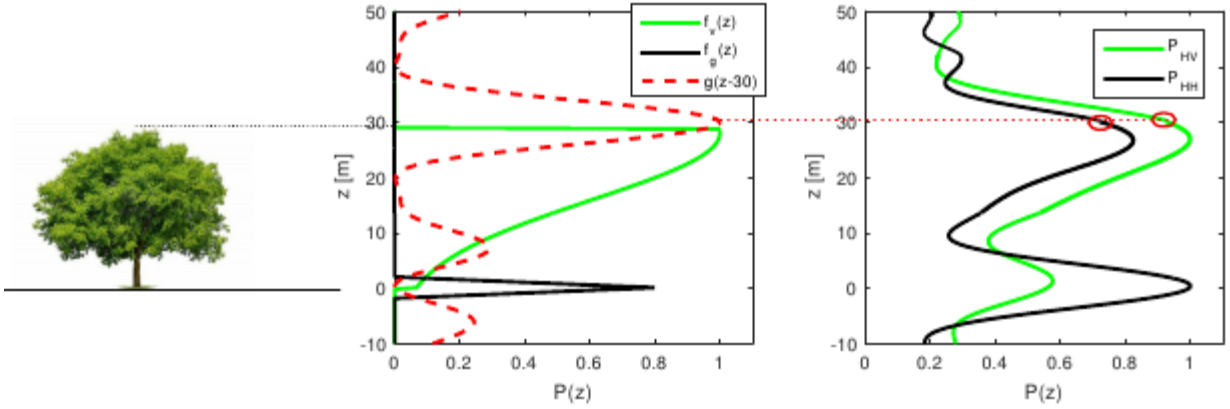


HV-polarization reduces ground contribution

$P_{HV_{30m}}$ better AGB indicator

$P_{HV_{30m}}$ interpretation

$$P_{30m} \propto \int f(z)g(30-z)dz$$

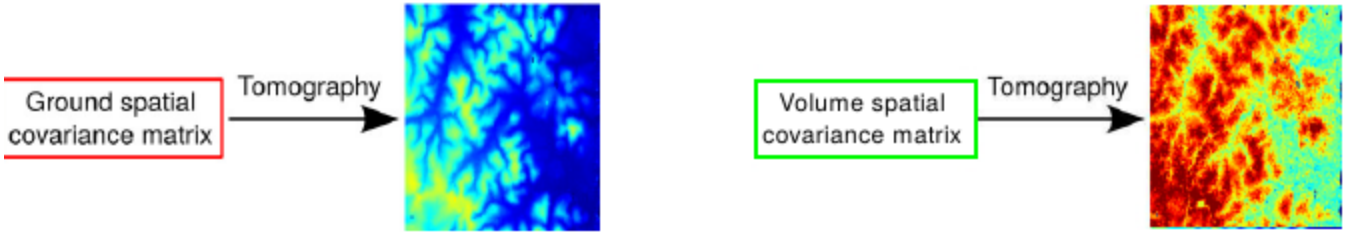


- Advantages:
  - HV polarization → low ground-to-volume ratio
  - 30−meters layer → get canopy information (for high enough trees)
- **Biomass estimation improvement:**
  - **Space-pol separation of ground and volume responses(SKP2-decomposition)**
  - **Adaptive height selection**

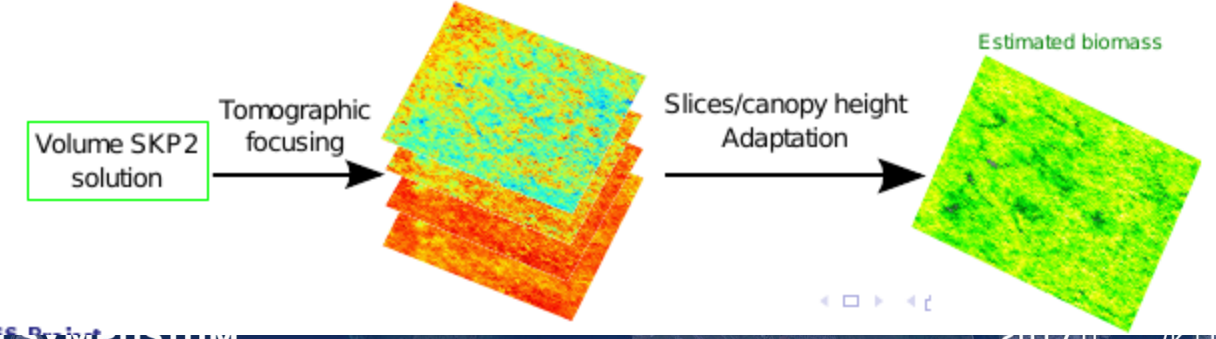
Biomass estimation procedure

Ground/Volume separation:

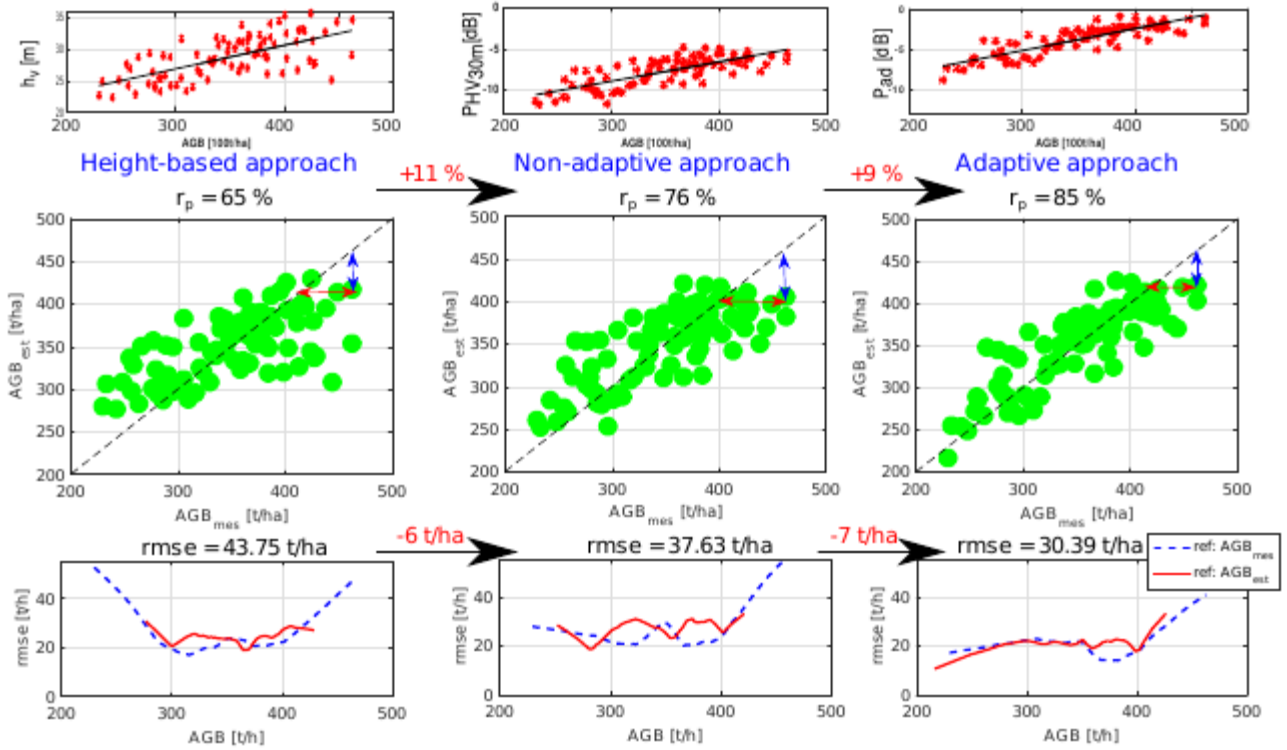
Ground/tree top heights estimation:



Biomass estimation:



Biomass estimators performance



- 2 visitors at the IETR working on polTomSAR and PolinSAR

-SUN Jili, IECAS, Beijing, China

- SUN Sheng, GuangDong University of Technology, China

- 1-week ESA training course in 2017, Frascati, Italy

- joint publications

Tebaldini, F. Rocca, M. Mariotti d'Alessandro, and L Ferro-Famil. Phase Calibration of Airborne Tomographic SAR Data via Phase Center Double Localization. IEEE Transactions on Geoscience and Remote Sensing, 54(3):1775–1792, March 2016.

Laurent Ferro-Famil, Yue Huang, and Eric Pottier. Principles and Applications of Polarimetric SAR Tomography for the Characterization of Complex Environments. International Association of Geodesy Symposia. F. Sanso Ed.., Springer-Verlag, 142(1-13):243–255, 2016.

W. Wu, X. Li, H. Guo, L. Ferro-Famil, and L. Zhang. Noncircularity Parameters and Their Potential Applications in UHR MMW SAR Data Sets. IEEE Geoscience and Remote Sensing Letters, 13:1547–1551, 2016.