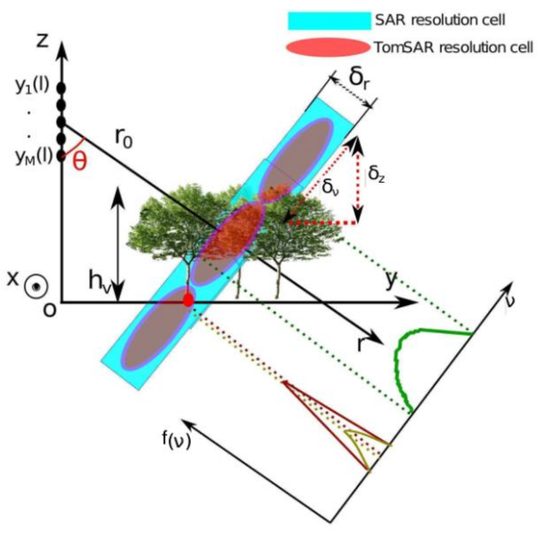
A NEW POLTOMSAR DECOMPOSITION APPLIED TO VEGETATED AREAS IN 3D IMAGERY

Ray ABDO, Laurent FERRO-FAMIL,
ray.abdo@univ-rennes1.fr, University of Rennes 1

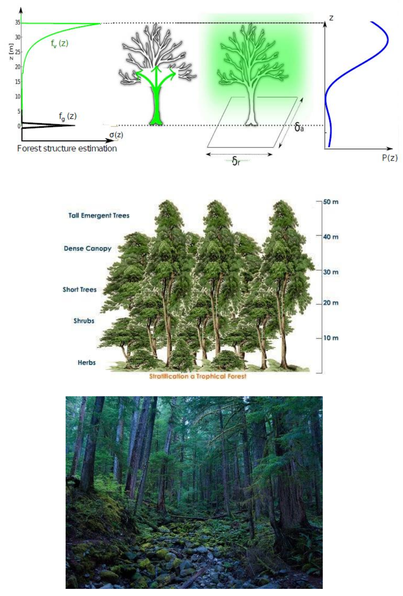
Objectives

- Analyze coherent and incoherent double-bounce scattering mechanisms
- Separate double-bounce contributions from ground response
- Characterizing underlying ground (roughness, humidity).

SAR (Synthetic Aperture Radar) Tomography

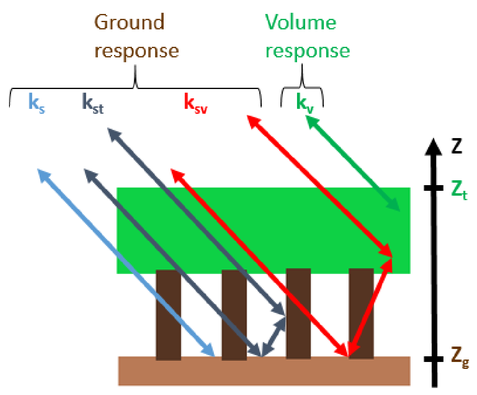


PolTomSAR acquisition Geometry



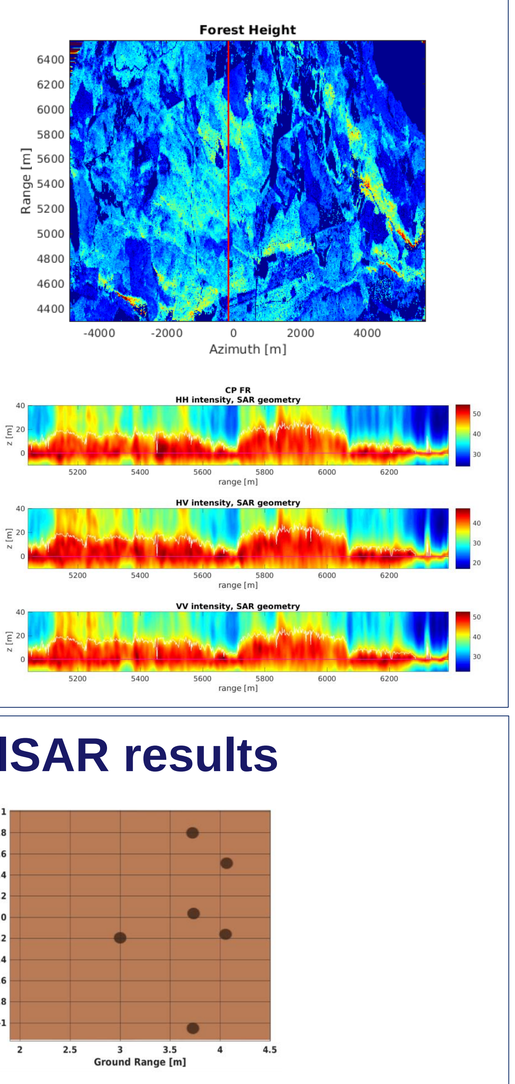
Parameters characterization

Random Volume over Ground (RVoG) Modeling

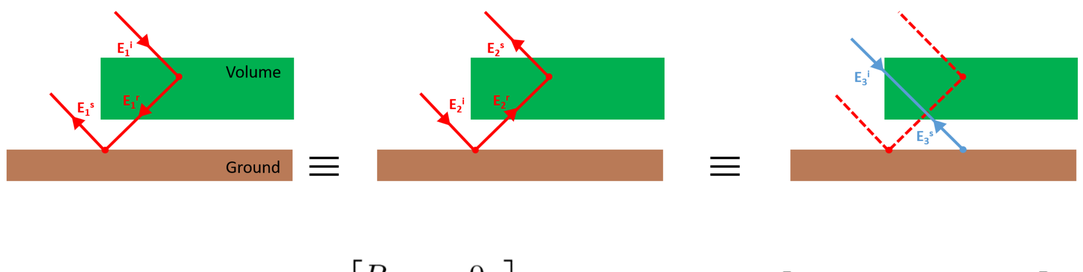


- Single bounce on ground
- Double bounce ground/trunk
- Single bounce on volume (diffusion)
- Double bounce ground/volume (diffusion)

BioSAR II L Band



Double-bounce scattering 2-D imaging



$$E_t^s = \mathbf{S}_{db} E_t^i \quad \mathbf{R} = \begin{bmatrix} R_{hh} & 0 \\ 0 & R_{vv} \end{bmatrix} \quad \mathbf{S}_i = \begin{bmatrix} S_{i_{hh}} & S_{i_{hv}} \\ S_{i_{vh}} & S_{i_{vv}} \end{bmatrix}$$

$$\mathbf{S}_d = \mathbf{R}\mathbf{S}_1 = \begin{bmatrix} R_{hh}S_{1_{hh}} & R_{hh}S_{1_{hv}} \\ R_{vv}S_{1_{vh}} & R_{vv}S_{1_{vv}} \end{bmatrix} \quad \mathbf{S}_u = \mathbf{S}_2\mathbf{R} = \begin{bmatrix} S_{2_{hh}}R_{hh} & S_{2_{hv}}R_{vv} \\ S_{2_{vh}}R_{hh} & S_{2_{vv}}R_{vv} \end{bmatrix}$$

BSA convention

$$S_{1_{hh}} = S_{2_{hh}}; S_{1_{vv}} = S_{2_{vv}};$$
$$S_{1_{hv}} = S_{2_{vh}}; S_{1_{vh}} = S_{2_{hv}}$$

FSA convention

$$S_{1_{hh}} = S_{2_{hh}}; S_{1_{vv}} = S_{2_{vv}};$$
$$S_{1_{hv}} = -S_{2_{vh}}; S_{1_{vh}} = -S_{2_{hv}}$$

$$\mathbf{S}_{db} = \mathbf{S}_d + \mathbf{S}_u \longrightarrow \mathbf{S}_{db} = \begin{bmatrix} 2R_{hh}S_{hh} & R_{hh}S_{hv} - R_{vv}S_{hv} \\ R_{vv}S_{hv} - R_{hh}S_{hv} & 2R_{vv}S_{vv} \end{bmatrix}$$

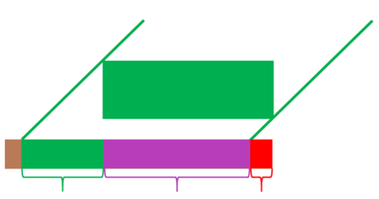
Assumption: The scene contains vegetation i.e. not homogeneous and speckle noise is present

Outcome: R and **S** are Gaussian, centered, independent scattering mechanisms ⟶ Intercorrelations null

Covariance matrix as a function of $4I_{R_{hh}}\ I_{S_{hh}}$ **and** $\alpha_{i_{pq}} = \sqrt{\frac{I_{i_{pq}}}{I_{i_{hh}}}}$

$$\mathbf{C}_{db} = 4I_{R_{hh}}I_{S_{hh}} \begin{bmatrix} 1 & \frac{1}{2}\alpha_{S_{hv}}\rho_{S_{hhhv}}(1-\alpha_{R_{vv}}\rho_{R_{hhvv}}) & \alpha_{R_{vv}}\rho_{R_{hhvv}}\alpha_{S_{vv}}\rho_{S_{hhvv}} \\ & \frac{1}{4}\alpha_{S_{hv}}^2(1+\alpha_{R_{vv}}^2+2Re(\alpha_{R_{vv}}\rho_{R_{hhvv}})) & \frac{1}{2}\alpha_{S_{hv}}\alpha_{S_{vv}}\rho_{S_{hvvv}}\alpha_{R_{vv}}(\rho_{R_{hhvv}}-\alpha_{R_{vv}}) \\ & & \alpha_{R_{vv}}^2\alpha_{S_{vv}}^2 \end{bmatrix}$$

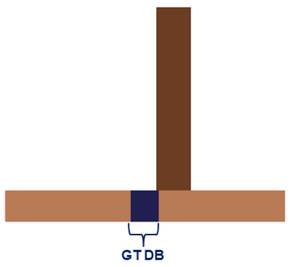
Ground/Volume scattering $\gamma \approx 0$



$$\mathbf{C}_{gv} = 4\mathrm{I}_{R_{hh}}\ \mathrm{I}_{S_{hh}}\mathbf{P}_{gv}\begin{bmatrix} 1 & 0 & \gamma \approx 0 \\ & 1 & 0 \\ & & 1 \end{bmatrix}\mathbf{P}_{gv}$$

- Incoherent double-bounce
- Focused on the ground below the volume
- Occurs over the majority of the scene

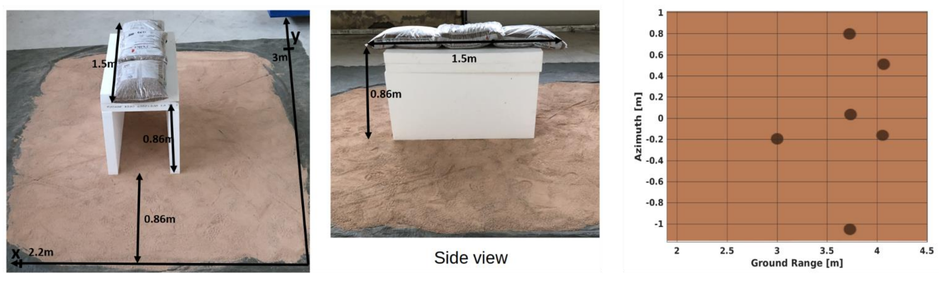
Ground/Trunk scattering $\gamma \approx 1$

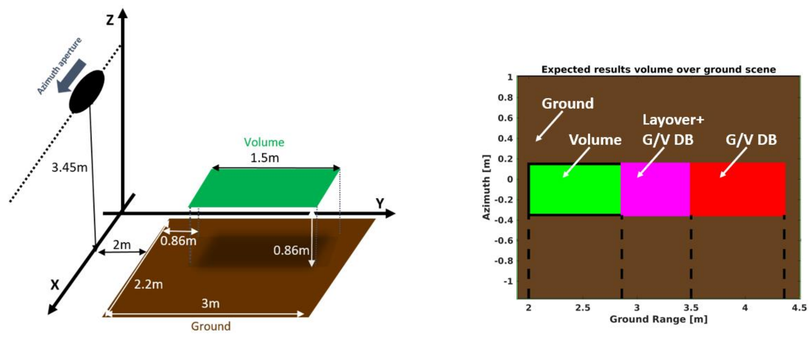


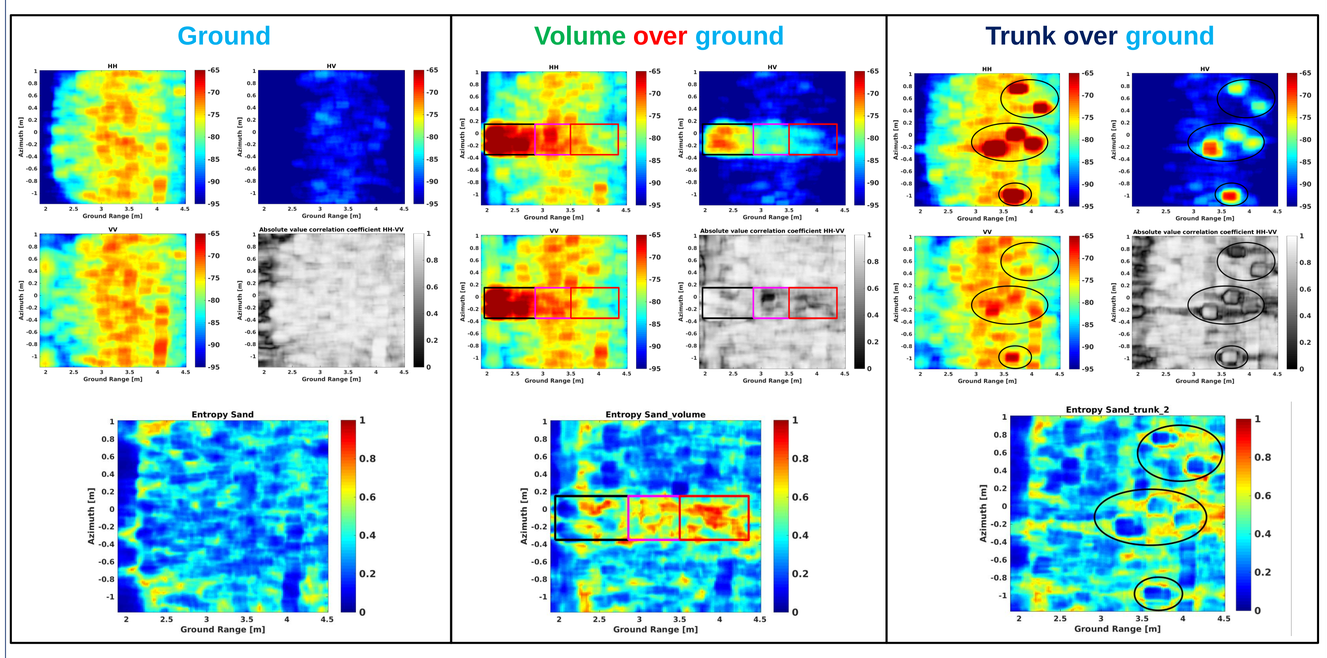
$$\mathbf{C}_{gt} = 4\mathrm{I}_{R_{hh}}\ \mathrm{I}_{S_{hh}}\mathbf{P}_{gt}\begin{bmatrix} 1 & 0 & 1 \\ & 1 & 0 \\ & & 1 \end{bmatrix}\mathbf{P}_{gt}$$

- Coherent double-bounce
- Focused on the ground at the bottom of the trunk
- Occurs over a very small part of the scene

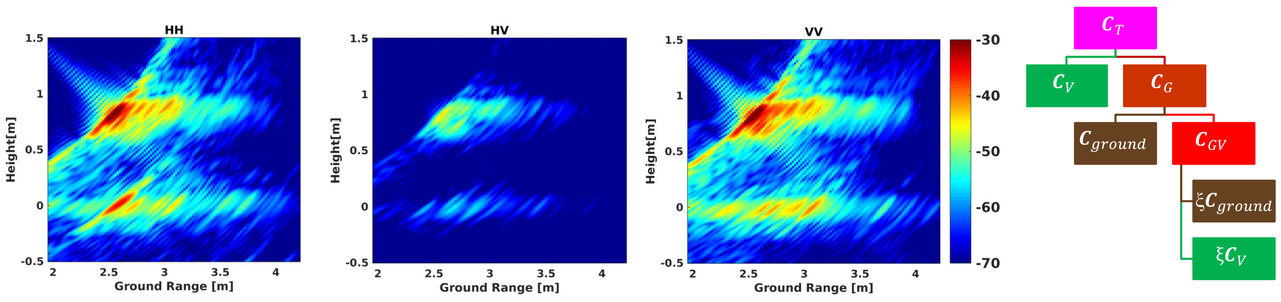
Geometry acquisition & PolSAR results







PolTomSAR results and proposed solution



HH: Ground/volume double-bounce + Single-bounce on ground

HV: Ground/volume double-bounce

VV: Single-bounce on ground

Conclusion:

Double-bounce GT is coherent meaning that its contributions can be avoided.
Double-bounce GV is incoherent and cannot be avoided.
Pure ground contributions are retrieved by subtracting a portion of volume contributions.

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