DECORRELATION ANALYSIS OF L-BAND INTERFEROMETRY OVER THE PITON DE LA FOURNAISE VOLCANO (FRANCE) USING AIRBORNE LIDAR DATA AND *IN SITU* MEASUREMENTS

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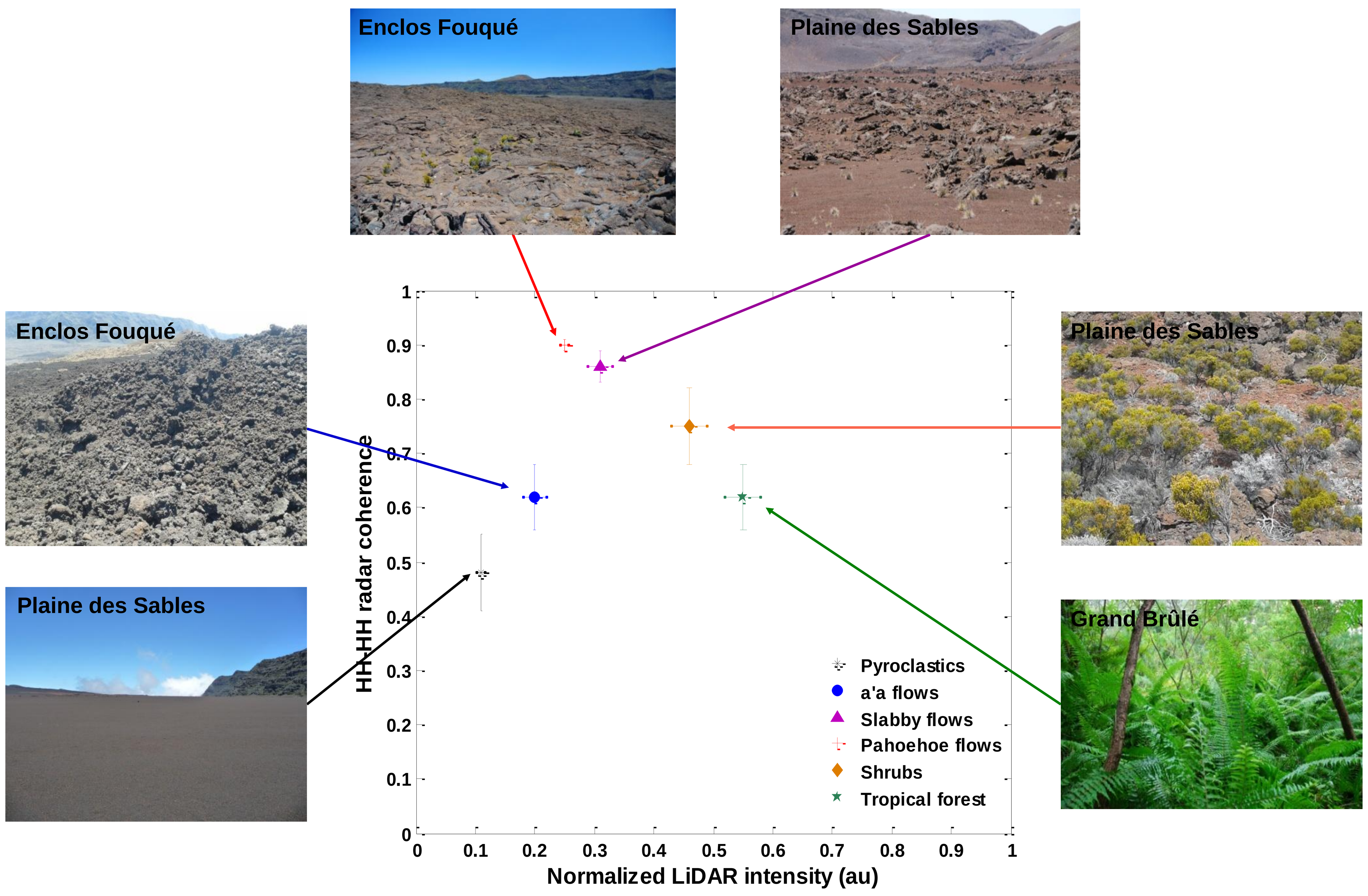
Introduction:

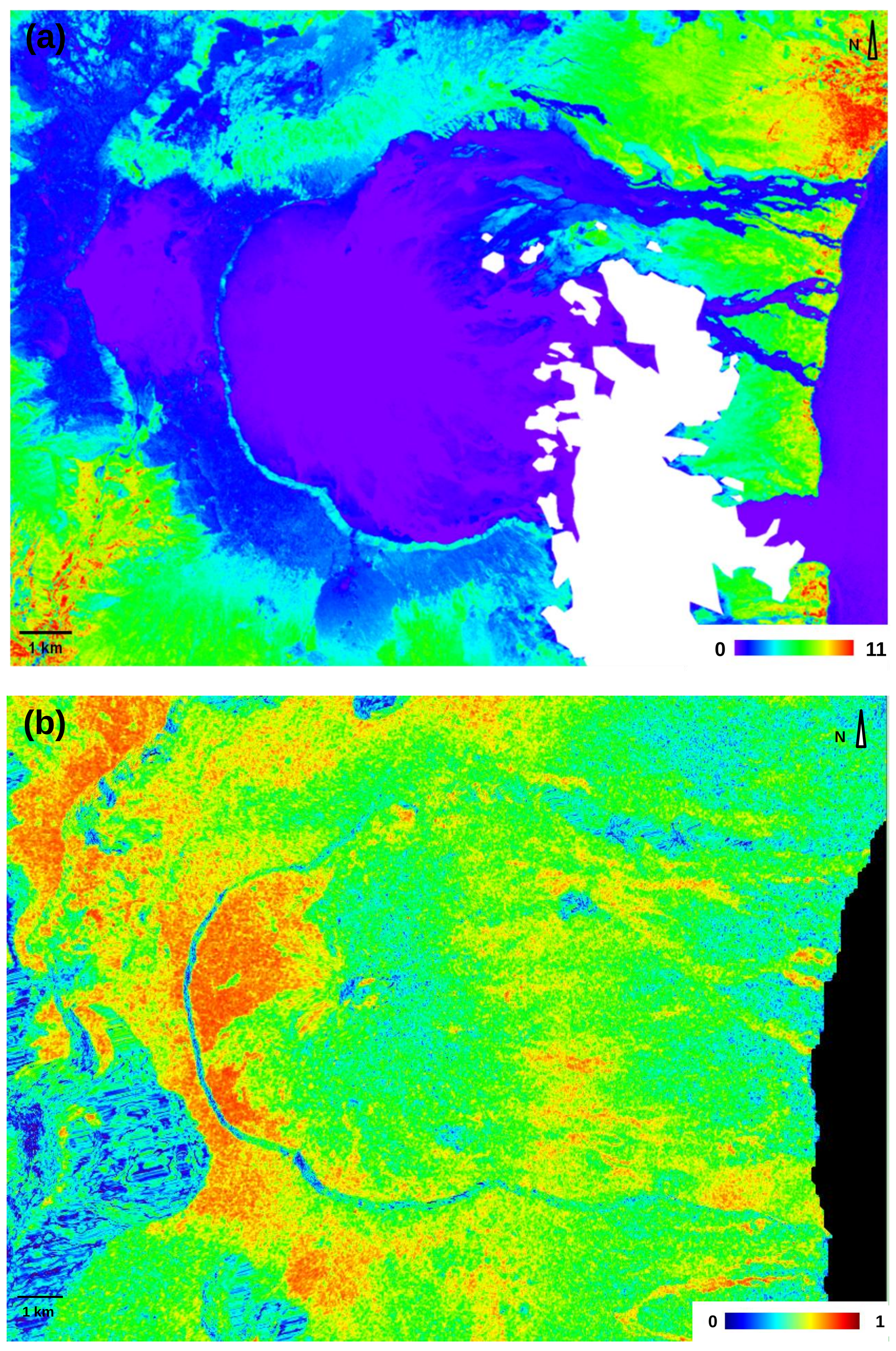
- ALOS-PALSAR coherence images are combined with airborne LiDAR data to investigate the main causes of errors that affect repeat-pass InSAR measurements.
- Both have been acquired over the Piton de la Fournaise (Reunion Island, France), one of the world's most active volcano.
- Our study is focused on several sites characterized by different levels of vegetation density (LAI) and on bare volcanic surfaces displaying contrasting geophysical properties: pahoehoe and a'a lava flows, slabby pahoehoe lava flows, and pyroclastic deposits (lapillis).
- A field experiment has been carried out in 2011 in the central and western parts of the volcano to better understand InSAR and LiDAR data.

InSAR-LiDAR synergy

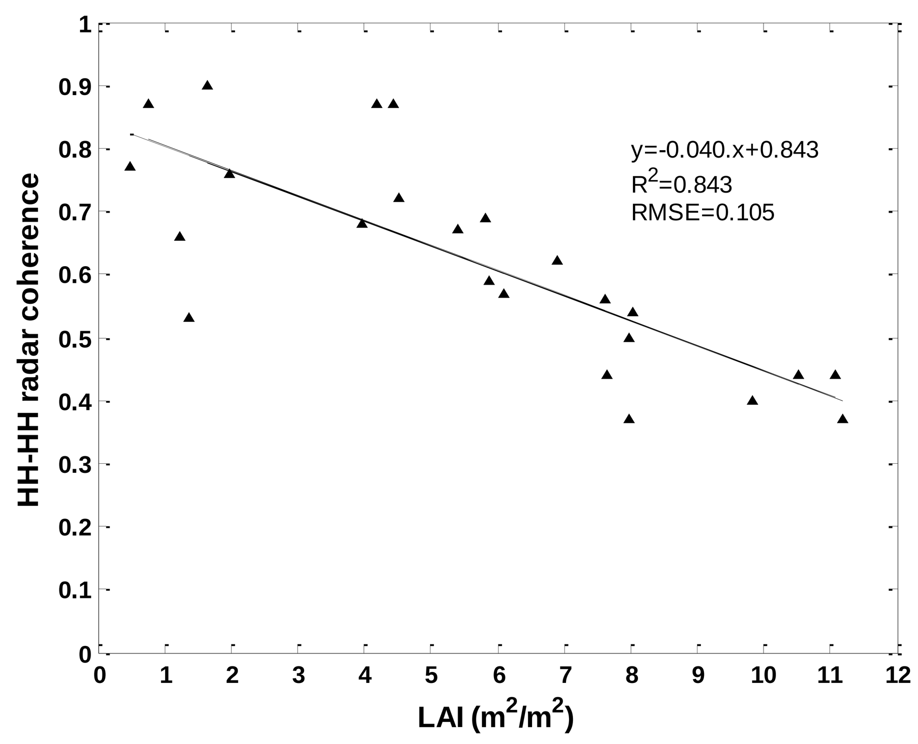


Correlation between HH-HH radar coherence (06 Sept – 22 Oct 2008) and normalized LiDAR intensity (Oct 2008) over various surfaces.

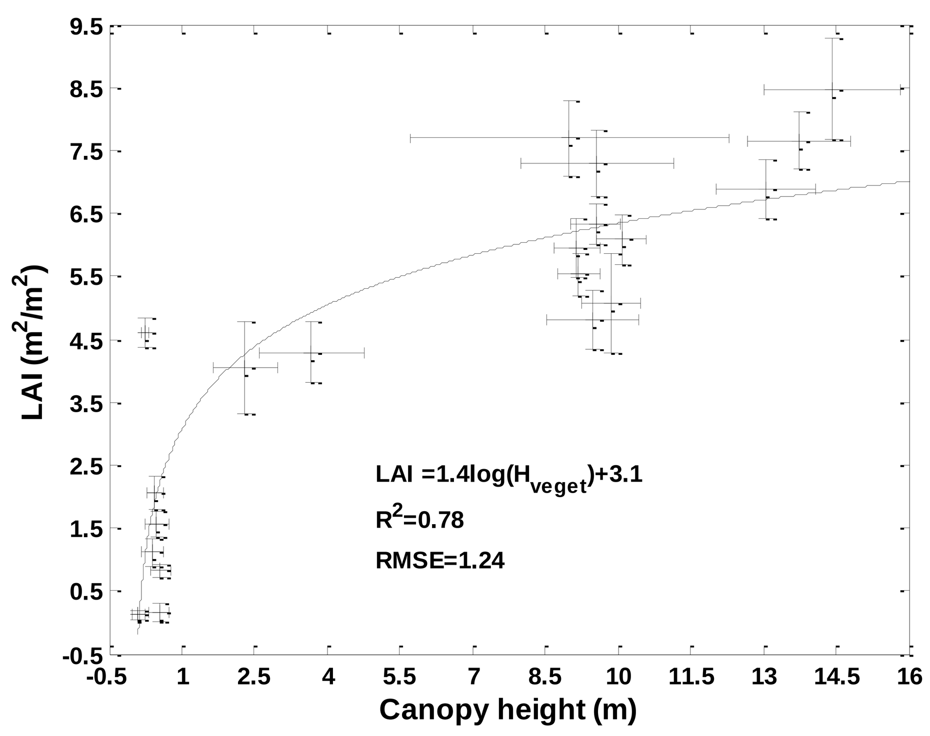
Vegetation density



(a) Leaf Area Index (LAI, [m².m⁻²]) map calculated from a SPOT-5 image (May 2011, http://kalideos.cnes.fr/). (b) HH-HH coherence map calculated between two PALSAR images (28 Jul. – 22 Sept. 2010).

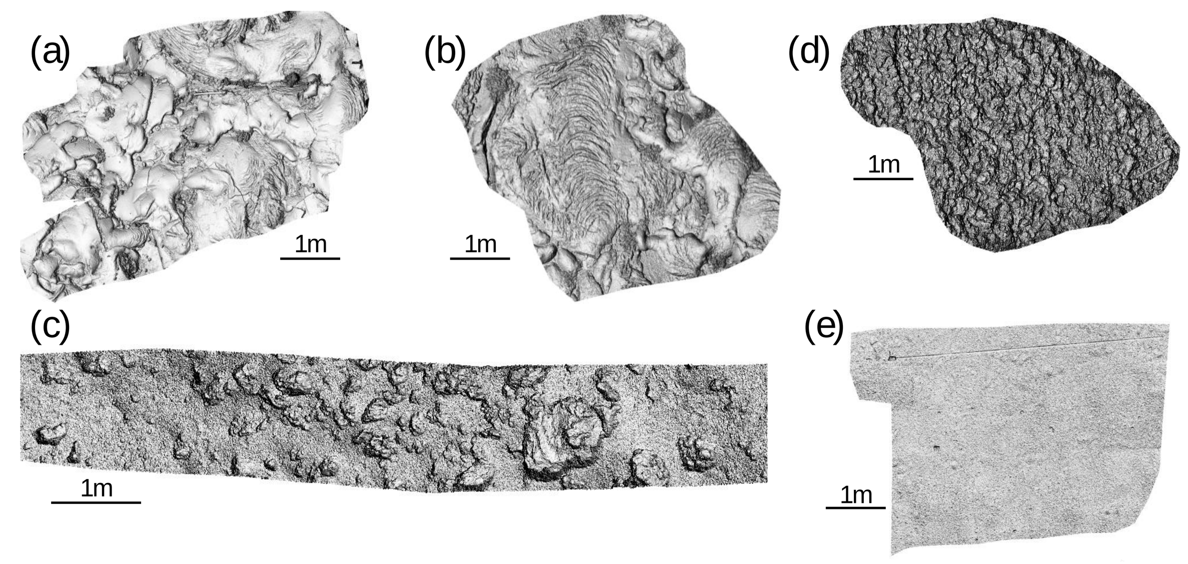


Correlation between HH-HH radar coherence and LAI.



Correlation between LAI and canopy height.

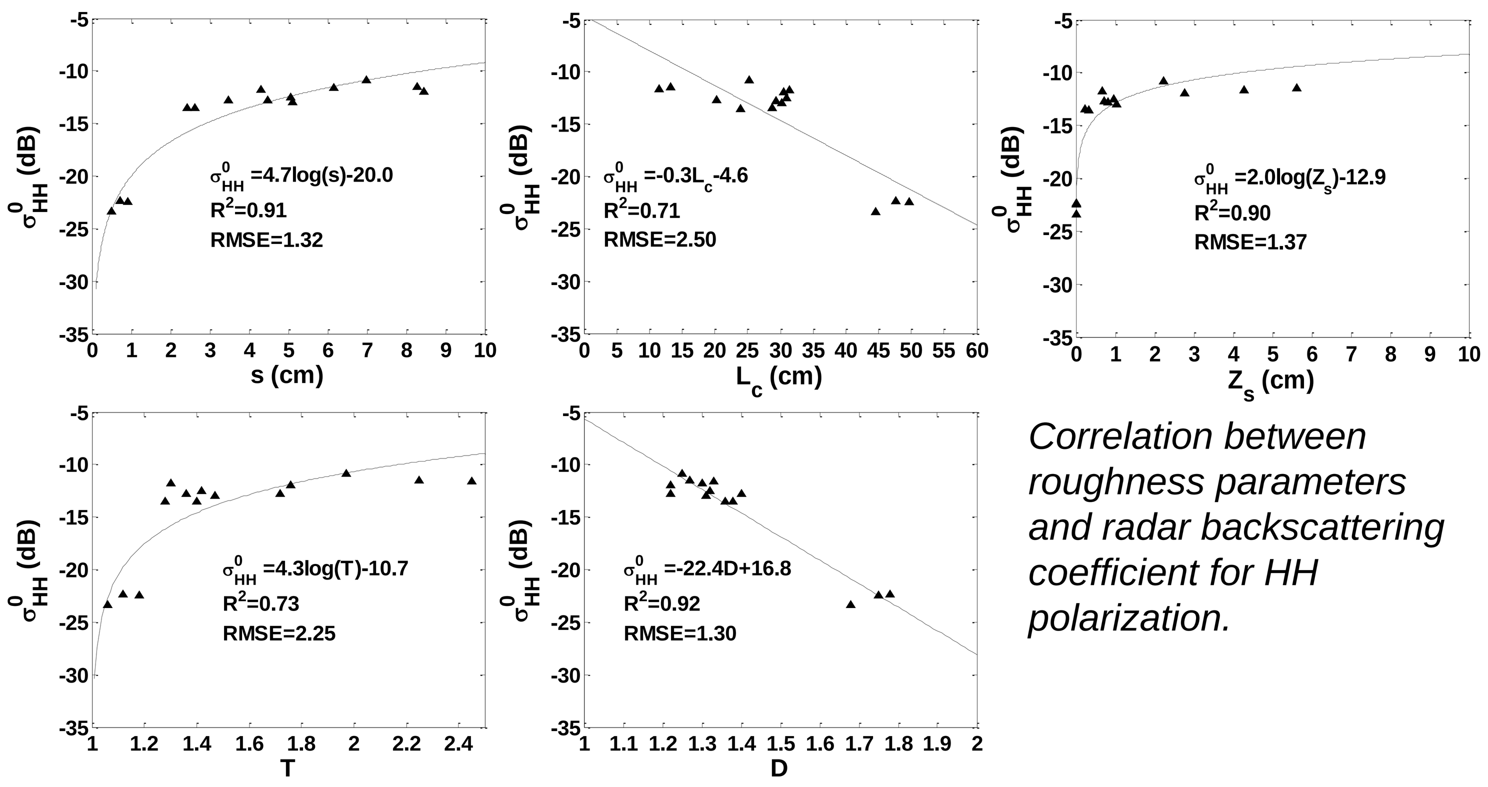
Surface roughness



Digital terrain models for five volcanic terrains generated using a multi-view stereo software: (a) bumpy pahoehoe lava flow, (b) ropy pahoehoe lava flow, (c) slabby pahoehoe lava flow, (d) a'a lava flow, and (e) lapillis.

Surface	Standard deviation of height s (cm)	Correlation length L_c (cm)	$Z_s = s^2/L_c$ (cm)	Tortuosity index T	Fractal dimension D
Lapillis	1.10 ± 0.00	60.87 ± 0.00	0.02 ± 0.00	1.12 ± 0.00	1.78 ± 0.00
Slabby pahoehoe lava flow	3.32 ± 0.83	27.56 ± 10.08	0.56 ± 0.47	1.49 ± 0.30	1.35 ± 0.06
Pahoehoe lava flow	4.74 ± 0.89	36.30 ± 7.71	0.69 ± 0.17	1.37 ± 0.05	1.28 ± 0.08
A'a lava flow	8.48 ± 0.00	42.01 ± 0.00	2.05 ± 0.00	1.74 ± 0.00	1.24 ± 0.00

Surface roughness parameters for different volcanic terrains.



Correlation between roughness parameters and radar backscattering coefficient for HH polarization.

Penetration depth

Loss tangent for lossy dielectric media:

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \qquad \begin{cases} \varepsilon' = \text{real part of the permittivity} \\ \varepsilon'' = \text{imaginary part of the permittivity} \end{cases}$$

Penetration depth in the case of slightly dispersive media:

$$\delta_p \approx \frac{\lambda}{2\pi}\frac{\sqrt{\varepsilon'}}{\varepsilon''}$$

Surface type	ε'	ε''	tan δ	δ_p (cm)
Lapillis	5.18	5.85×10^{-2}	1.13×10^{-2}	146.1
Pahoehoe lava flow	4.81	1.29×10^{-1}	2.69×10^{-2}	63.9
A'a lava flow	4.75	1.03×10^{-1}	2.16×10^{-2}	79.5

Electromagnetic properties of several volcanic surfaces measured at 1.27 GHz (L-band).

Conclusion

Over bare surfaces, it is possible to discriminate between **surface** and **volume scattering**: we observed high coherence loss over rough a'a lava flows (Enclos Fouqué) and pyroclastic deposits (Plaine des Sables) due to surface and in-depth interactions of radar waves with the medium, respectively.
When vegetation covers the ground, the radar coherence is related to plant density: the higher the LAI, the lower the coherence. The accuracy of InSAR measurements strongly decreases for LAI higher than 7.