Radar Backscatter Models of Possible Pyroclastic Deposits on Venus

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Background and motivation

- Bright, relatively young, diffuse deposits on the summits of volcanoes and coronae; commonly interpreted as pyroclastic density current (PDC) deposits ***(Figure 1a)*** [1-5]
- _Radar properties:_
  1. high backscatter coefficient (σ_{hh} ~ -9 to -14 dB)
  2. moderate emissivity values (e_h~ 0.81 to 0.87)
  3. moderate degree of linear polarization (DLP), high circular polarization ratio (CPR).
- Present near (and in some cases, appear to be mantling) low emissivity regions [6] *(green areas in **Figure 1b**)*.

What types of shallow-subsurface structure and dielectric properties could result in the observed radar properties (high σ_{hh} and moderate e_h)?

Data and methods

- σ_{hh} and e_h measured for proposed PDC deposits in central / eastern Eistla Regio and Dione Regio from Magellan data.
- Different one- and two-layer synthetic pyroclastic models considered ***(Figure 2, top panel)***.
- _Model parameters:_
  1. complex dielectric permittivity of layers ($\varepsilon_1, \varepsilon_2$)
  2. upper layer thickness d_1
  3. interface roughness (characterized by electromagnetic surface roughness ks_1, ks_2)
- Scattering from surface and subsurface interfaces modeled using I^{2}EM [7]. Model results compared to data to place constraints on proposed PDC deposit properties.

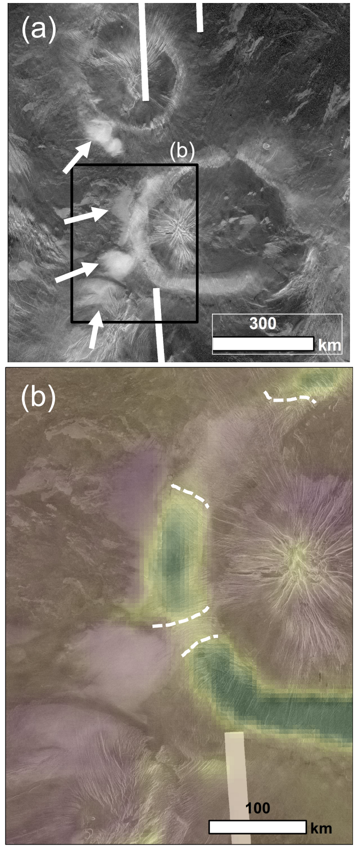

Figure 1. (a) Magellan SAR backscatter image of Pavlova & Didilia Corona. White arrows point to proposed PDC deposits. (b) Magellan emissivity overlaid on Magellan SAR backscatter. Dashed white lines show areas where low emissivity signature appears muted by overlying diffuse deposits.

Results and discussion

Case 1: Low density deposit with high surface roughness

Even for units with high surface roughness (ks_1 ~ 2), relatively high permittivity ε_1' ~ 7 is required to reproduce the observed σ_{hh} and e_h.

Case 2: Lossy deposit with moderate - high surface roughness

While high ε_1'' (conducting material) combined with intermediate roughness could explain high σ_{hh}, this scenario results in notably lower e_h than measured.

Case 3: Lossy deposit under a thin mantle of low-density material

Low-density mantling layer of few centimeters thickness overlying ferroelectric (or conducting) medium could also fit the observed σ_{hh} and e_h.

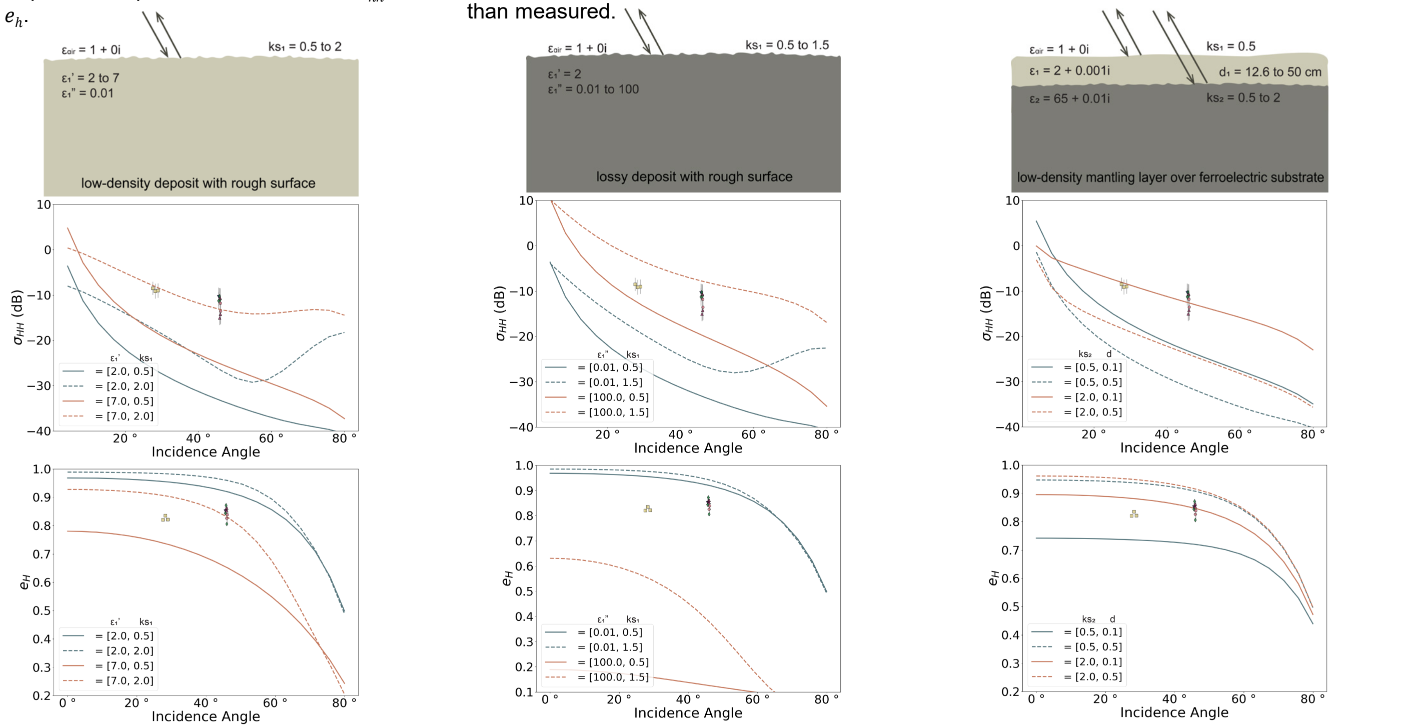

Figure 2. Top: Schematic representation of different subsurface models considered. Middle: Rough surface backscatter in HH (σ_{hh}) as a function of incidence angle. Bottom: Rough surface emissivity (e_h) as a function of emission angle. Markers and error bars correspond to σ_{hh} and e_h measured from Magellan data.

Inferences and next steps

- We infer that the proposed PDC deposits could be
  - Units with **rough surface and relatively higher ε' ~ 7** (similar to lunar rocks [8]). Higher ε' could be due to higher density caused by welding during emplacement or due to presence of higher ε' minerals. (For comparison, most Venusian plains are inferred to have ε' ~ 4 to 5)
  - **Thin low-density unit on top of** substrate rich in **loaded dielectric or ferroelectric minerals** ***(Figure 2, case 3)***
- Dione Regio units exhibit lower e_h (at smaller incidence); could be due to difference in surface + volume scattering contribution.
- _Next steps:_ Investigating volume scattering contribution from clasts and voids in a low loss unit.

References

[1] McGill, G. E. (2000). *USGS Sci. Inv. Map 2637*.[2] Campbell, B. A. and Clark, D. A. (2006), *USGS Sci. Inv. Map 2897*. Keddie S. T. and Head, J. W. (1995) *JGR, 100*, 11729-11753. [4] Campbell B. A. et al. (2017) *JGR, 122*, 1580–1596. [5] Ganesh et al. (2021). *JGR, 126*, e2021JE006943. [6] Pettengill et al. (1988), *JGR, 93*, 14881-14892. [7] Fung A.K. et al. (2002), *J. Electromagn. Waves Appl.*, 16, 689-702. [8] Carrier et al. (1991), 475-594.