DIELECTRIC PROPERTIES OF VENUS: RESULTS FROM EMISSIVITY MODELING AND TERRESTRIAL FIELD MEASUREMENTS; Bruce A. Campbell, Center for Earth & Planetary Studies, National Air & Space Museum, Smithsonian Institution.

The two primary surface properties which control microwave scattering and emission are roughness and dielectric constant. Magellan synthetic aperture radar (SAR) measurements for Venus are strongly influenced by wavelength-scale roughness, while observations of the 12.6-cm brightness temperature are more dependent upon dielectric constant. Neither dataset, however, can be used in isolation to derive these physical quantities, since roughness changes affect the emissivity and reflectivity variations will be mirrored in the SAR return. This project examines the mean behavior of backscatter and emissivity data over the entire planet, and uses the observed relationships to derive a model which estimates the dielectric constant and a "surface roughness fraction". Use of this model may permit rapid separation of areas with actual dielectric variability from those whose emissivity variations are caused by roughness changes. The second portion of the work uses a field dielectric probe to determine the complex permittivity of terrestrial basalts, which are often characterized by vesicular upper layers. This field study was necessary to fill in a gap between lab measurements of powders and dense rock samples.

DATA. Magellan collected interleaved emissivity (E) and SAR measurements, and the ARCDR dataset contains values of E and "unfocused" (footprint-averaged) backscatter for each surface footprint of the high-gain antenna [1]. There are ~6 million footprints across the planet through Orbit 3900, with the incident/emitted angle varying as a function of latitude through Cycle 1 and held fixed through much of Cycle 2. The emissivity data were binned as a function of radar backscatter brightness (σ_o) within different incidence angle ranges to analyze the relative influence of roughness and dielectric changes on each parameter. Figure 1 shows the average H and V-polarized emissivity vs. σ_o for angles >30° and elevations below 6053.0 km. The H-polarized data represent a global average, while the V data are from 10 orbits for which the spacecraft was rotated about its axis. In this plot, E_h increases linearly with $\log(\sigma_o)$ over a wide range of radar brightness, while E_v falls. These behaviors are attributed to the effects of roughness on both emissivity and radar backscatter. The rise in E_h and the decline in E_v with greater roughness (higher σ_o) are consistent with theoretical models for scattering and emission, which predict that, for angles >30° and dielectric constants below ~15, the rough-surface emissivity is approximately the average of the H and V plane-surface values [2].

Based on the observed behavior of E and σ_o, a model was developed which treats each region within an antenna footprint as a checkerboard mixture of smooth and rough terrain. The surface is assumed to have a single dielectric constant within the footprint. With this "end-member" approach to the surface, we can use the SAR and emissivity data to derive values for the dielectric constant and "roughness fraction". This model, although dependent upon several assumptions, provides a first-order method for identifying areas which are truly anomalous in their roughness/dielectric properties.

MODEL RESULTS. The model was tested on areas for which Magellan incidence angles are >30° (54 N - 34 S). One obvious result is the lack of strong dielectric contrasts between the smooth plains and rough tessera, suggesting that the latter are simply deformed areas with essentially the same material composition as the plains. Most of the differences in plains emissivity fall along the best-fit E vs. σ_o line in Figure 1, indicating that these variations are also due to roughness. The planetary average dielectric constant is ~4.15, which lies between the values found in lab studies for rock powders (~2) and dense basalt (5-8) [3,4]. In regions below 6053 km radius, there are many localized instances of higher and lower dielectric constants. High dielectric values (6-8) are found in some crater floors and in most of the extended crater "haloes", consistent with earlier analyses of these features [5, 6]. These high values may be caused by loading of impact melt material with conductive mineral phases [7]. If such loading is the cause of the high dielectric constant, then the crater haloes must be young enough to avoid weathering of these minerals by the atmosphere. Low dielectric values (2-3) are found in a few crater-related mantling deposits (most noteably east of Gula Mons) and in patches in the plains which may be more vesicular basalts or occasional accumulations of fine soil. The model dielectric results are in general agreement with those from the Magellan altimeter data, but appear to be more reliable in rough areas, where the Hagfors model breaks down.

FIELD DIELECTRIC DATA. Laboratory measurements of rock dielectric constants exist for powdered samples and for polished sections of dense basalt, but there is little information on the *in situ* density or dielectric constant of typical pristine terrestrial lava flows. To fill in this gap, a portable 6-cm dielectric probe was used on 14 Hawaiian volcanic surfaces (lava, ash, and weathered soil). Preliminary analysis shows that: (1) many Hawaiian basalts are characterized by a vesicular upper layer 5-20 cm thick which significantly lowers the effective density in the region "seen" by the radar, and (2) the lava flows have dielectric constants of 2.0-3.3, intermediate between lab values for powders and dense rock. The nature of the surface glass coating and the presence of patches of oxidized material had little effect on the bulk dielectric properties. The average estimated dielectric constant of 4.15 for Venus suggests that this surface is typically less vesicular than that of Hawaiian volcanoes (consistent with the higher atmospheric pressure), and that the global soil density must be rather low.

REFERENCES. [1] Pettengill, G.H., et al., JGR 97, 13091-13102, 1992. [2] Ulaby, F.T., et al., Microwave Remote Sensing, Addison-Wesley, 1987. [3] Campbell, M.J., and J. Ulrichs, JGR 74, 5867-5881, 1969. [4] Ulaby, F.T., et al., Univ. Michigan Rad. Lab Rep. 23817-1-T, 1988. [5] Plaut, J.J., and R.E. Arvidson, JGR 97, 16279-16292, 1992. [6] Campbell, D.B., et al., JGR 97, 16249-16278, 1992. [7] Pettengill, G.H., et al., JGR 93, 14881-14892, 1988.

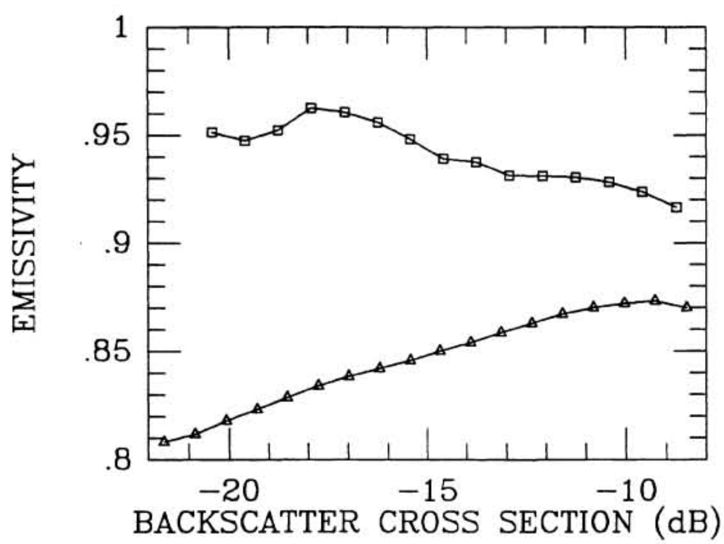

Figure 1. Average emissivity calculated for narrow bins of specific radar backscatter cross section (σ_0) from Magellan data for Venus. Upper line is V-polarized emissivity from 10 orbits; lower curve is H-polarized emissivity across entire planet from 54 N to 34 S (incident/emitted angle >30°). Areas above 6053.0 km radius excluded from averaging to avoid contamination by the very-high dielectric mountaintops. Note the linear rise in E_h between -22 and -9 dB, and the drop in E_v over the same range.