GIS-BASED DATA PIPELINE FOR THE EXTRACTION OF RADAR EMISSIVITY AND DIELECTRIC CONSTANT VALUES FOR PHYSIOGRAPHIC SURFACE UNITS ON VENUS. A. J. Stein[1] and M. S. Gilmore[1], [1]Planetary Science Group, Wesleyan University, Middletown CT (ajstein@wesleyan.edu), wesleyan.edu/planetary.

Introduction: The surface composition of Venus is important to understanding its geologic history. Impact ejecta may obscure the signature of the underlying bedrock as detected from orbit, aerial vehicle, or lander. A goal of our work is to study the effect of impact ejecta on the radar emissivity and derived dielectric constant of underlying materials. Specifically, we wish to consider visible and modeled crater ejecta on top of both plains and tesserae, from craters originating on both plains and tesserae [1]. To accomplish this, we developed a data pipeline to correct Magellan global radar emissivity for radar incidence angle and convert to dielectric constant, following on [2,3].

Methods: We used ArcGIS 10.3, RStudio, and Python for mapping and data manipulation, and GIS-ready basemaps available from the USGS PIGWAD [4].

Mapping of Crater Parabolas. When a bolide hits Venus, upper-level winds blow a portion of its lofted ejecta steadily westward, which settles out as a parabola with the resulting crater at its focus [5]. We consider three types of crater parabolas on Venus using left-looking Magellan data. The first type is visible crater parabolas, typically radar-dark, as mapped by [5]. The second type assumes that all craters >11 km would have produced a crater parabola that has since been removed; the size and position of these parabolas were modeled using the empirical formula of [6] from craters in the Venus crater database [7]. The third type is crater parabolas modeled from [6] derived from a list of tessera craters [8]. We used the *Table-to-Ellipse* tool in ArcMap to generate ellipses across the planet derived from these parameters, convert the ellipses to polygons, and cut each precisely in half with the *Dice* tool. The calculated parameters for these ellipses/parabolas have two terms of latitudinal dependence (Eq. 1), one to ensure the parabolas are properly positioned relative to their impact crater, and one to project them appropriately on the USGS base map [4].

$$l_n = \frac{0.85 l_o}{\cos(\theta)} \left(\frac{180°}{\pi R_p \cos(\theta)} \right)$$

Equation 1: The position and length of the new parabola length l_n is dependent on the original length l_o and latitude, θ, where R_p is Venus' radius (6051.8 km).

Correction of Magellan Emissivity. The emissivity base map (GEDR) must be corrected for incidence angle, (Eq. 2) [2]. Using Python, we queried the allowable parameter space of emissivity for rocks (0.7 to 0.99), incidence angles (25 to 45 degrees), and dielectric values (1.10 to 10.00) [2, 9]. We ignored extreme values of low emissivity typical of venusian mountaintops [3].

$$E_h = \frac{\sin 2\phi \sin 2\theta}{\sin^2(\theta + \phi)}$$

$$E_v = \frac{\sin 2\phi \sin 2\theta}{\sin^2(\theta + \phi)\cos^2(\phi - \theta)}$$

$$\theta = \sin^{-1}\left(\frac{\sin\phi}{\sqrt{\varepsilon}}\right)$$

Equation 2: Relationship between emissivity, E, incidence angle, ϕ, and dielectric constant, ε, for horizontally- and vertically-polarized radar signals. E_h approximates smooth surfaces, while the average of E_h and E_v approximate rough surfaces [reproduced from ref. 2].

For our parameter space, we found emissivity derived using the rough criterion (applied to tesserae) varied little with dielectric constant. Emissivity derived using the smooth criterion (applied to plains) had more variation. Thus for the plains we chose ε = 4.00 as an average dielectric value for basalts [3, 9] to correct the emissivity. Calculated average emissivity values for each latitude were subtracted from a planetary average emissivity of 0.845, made into a latitudinal correction table for each pixel, and checked against the look-up table of [2]. The average emissivity correction is less than 1% (Figure 1 and 2). Our code, written in R, was used to correct the tessera regions inside ArcGIS, but because of data processing limitations the plains regions were calculated inside RStudio.

Each corrected emissivity pixel was assigned latitude and longitude coordinates in ArcGIS and piped into RStudio to numerically calculate their dielectric constants.

Extracting Dielectric Constants. By working backwards through Eq. 2, the dielectric constant (ε) can be solved numerically. For a given emissivity value and incidence angle (converted from latitude), the dielectric value was allowed to vary from 1.10 to 10.00 until it matched within three significant digits to the emissivity value. If the pixel being converted fell on a plains region, the calculation used the horizontally-polarized emissivity equation in Eq. 2. If it fell on a tessera region, the calculation used the average of the horizontally- and vertically-polarized equations to calculate the dielectric constant [3]. By extracting the dielectric constant for each pixel with a coordinate pair, it is possible to map the dielectric values (Figure 3).

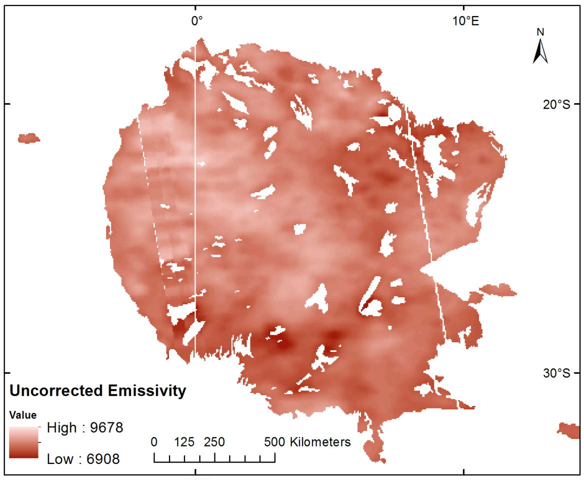

Figure 1: Uncorrected emissivity of the Alpha Regio tessera.

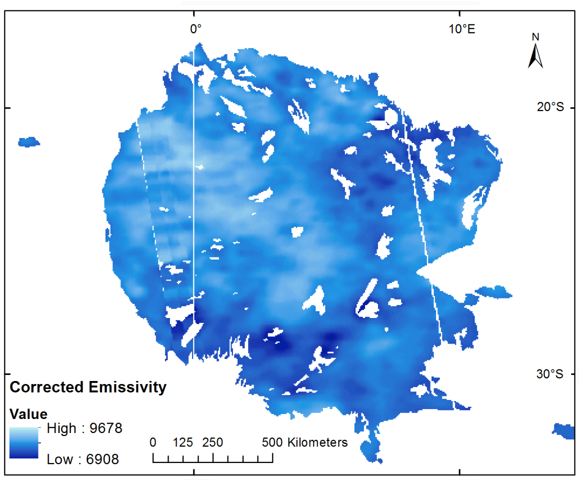

Figure 2: Latitudinally-corrected emissivity of Alpha Regio, using the rough criterion of Eq. 2.

With the dielectric values appended to each pixel and the computational heavy lifting out of the way, the data were piped back into ArcGIS, where they can generate maps of dielectric constant (Figure 3).

Interpretation: As seen in Figures 1 and 2, there is not a considerable change in the emissivity values because of the latitudinal correction using the rough criterion. Even over a wide range of latitudes, these differences do not change the emissivity of these regions significantly.

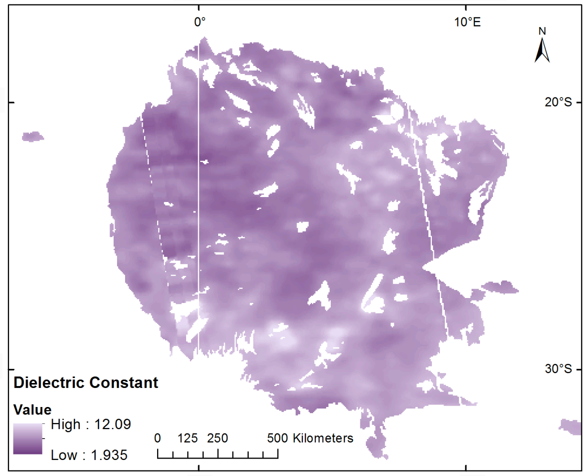

Figure 3: Calculated dielectric values of Alpha Regio from the corrected emissivity.

When comparing the corrected emissivity and the dielectric values (Figures 2 and 3), the calculated dielectric values are inversely proportional to the emissivity values. Dielectric values climb to higher values at elevations greater than 6054 km, suggesting a shift of dielectric above the "snow line" [10]. There is no correlation between dielectric value and elevation (not shown) below 6054 km, with a general relation of $r = 0.07591$, and $r = 0.10444$ for the highest 20% of the regions.

While previous studies have identified emissivity in concurrence with the fresh impact regions [e.g., 3], this study seeks to extend this idea by quantitatively comparing regions from modeled plains and tessera impacts [1]. Comparing the modeled and the present parabolas may also allow us to better understand how the erosion process affects the dielectric values of these rocks.

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