A GEOPHYSICAL INVESTIGATION OF THE COMPENSATION STATE OF HELLAS PLANITIA N. L. Wagner[1], R. S. Park[2], and P. B. James[1]. [1]Baylor University, Department of Geosciences, One Bear Place #97354, Waco, TX 76798, USA (nick_wagner2@baylor.edu), [2]Jet Propulsion Laboratory, California Institute of Technology.

Introduction: Hellas Planitia is the largest confirmed impact crater on Mars and one of the largest in the solar system. It exhibits a relief of over 9 km, a diameter of over 2,300 km, and has a fairly subdued free-air gravity anomaly [1]. It's thought that it has this gravity anomaly because the basin is nearly isostatic [1-3]. However, there are more nuanced gravity signatures within the crater that beg a closer inspection. Specifically, it has a moat of higher negative free-air gravity surrounding a mound of low positive free-air gravity that is rather anomalous, especially compared to other craters of similar size (Utopia on Mars, South-Pole-Aiken Basin on the Moon, e.g. [1,4]). Hellas also lacks a significant amount of crater infilling, either from volcanic or sedimentary material comparatively to impact basins such as Isidis or Utopia [1]. In this study we created a suite of variable compensation models that match the observed gravity and topography and minimize the misfit of the observed admittance and correlation spectra with our synthetic models. Our end goal is to be able to explain the odd gravity anomaly that Hellas has through exploring various compensation states.

Procedure: In our admittance and correlation modeling, we're using the spatio-spectral localization technique frequently used in gravity topography analysis [5]. We used the latest gravity field, made up of radio tracking measurements from Mars Odyssey, MRO, and MGS, up to degree and order 120, and topography data from MOLA up to degree and order 2600 [6,7]. At higher spherical harmonic degrees, there's a significant amount of noise in the gravity data. When determining the gravity field this is often alleviated by applying a Kaula rule constraint where the error starts to surpass the strength of the signal itself. In our study, we model this error as spectrally white noise and add it to synthetic admittance and correlation spectra when matching the observed data [8]. Equation 1 shows how characteristics of an orbiting satellite are related to the expected noise as a function of spherical harmonic degree. Here, l_s is the degree strength of the field, r_0 is the radius that the satellite is orbiting at, a is the reference radius of the gravity field, and β is a power law term, most often assumed to be -2 to represent a Kaula constraint [8].

$$n_l = \left[1 + \left(\frac{l_s}{l}\right)^{\beta} \left(\frac{r_0}{a}\right)^{l-l_s}\right]^{-\frac{1}{2}} \tag{1}$$

$$\gamma^{obs} = n_l \gamma^{true}, Z^{obs} = n_l Z^{true} \tag{2}$$

Equation 2 shows hows this noise model is applied to admittance and correlation spectra. In essence it suppresses the signal at higher degrees in order to match the noise seen there. In our work we applied this to our synthetic models in order to match the observed data, as our synthetic models represent γ^{true} and Z^{true}. For this study we have implemented a particle swarm optimization technique to find the best fit parameters. In our objective function we used a variation of the misfit function used in [9].

Results: We calculated the synthetic admittance and correlation spectra assuming any lithospheric loading comes from either the crust-mantle interface (subsurface loading) or any material sitting upon the lithosphere (surface loading). The formulas for calculating the spectra for the combined scenario can be found in reference [10]. After calculating the theoretical spectra and defining localization window around Hellas for the observed spectra, we then used the misfit function that represents the difference between the observed and theoretical spectra curves to solve for the optimal loading parameters. For the localization window, we drew out a mask that incorporates the basin floor, crater walls, and some of the surrounding highlands in order to encompass a significant amount of topography change. However, we masked out volcanic areas such as Peneus Patera, Amphitrites Patera, Malea Patera, Pityusa Patera, Hadriaca Patera, and Tyrrhena Patera, as the loading style in these volcanic regions will be inherently different than those directly influencing Hellas. We ran two model searches: one with three free parameters keeping α equal to 0 and one with four free parameters. We ran the model search 25 times and created histograms to evaluate the spread of the results.

Discussion and Future Work: The three parameter search provided a tighter spread on parameter values after 25 iterations. However, overall the four parameter search provided a lower average RMS, although not by much. The results are similar with previous studies, as both of them predict a relatively low T_e of 7 to 8 km, but differ from there [1,11]. Both searches resulted in lower than expected load densities of around 2300 kg/m^3 for the three parameter search and around 2700 kg/m^3 for the four parameter search. However, this could be due to a combination of two effects: the extremely low values of f show that surface loading dominates flexure in the Hellas basin, and thus this material is either sedimentary or volcanic in nature and would be less dense that intruded subsurface material. Also the gravity is sensitive to the bulk density of the rocks at the surface and its been estimated that the bulk density of the Martian crust is much

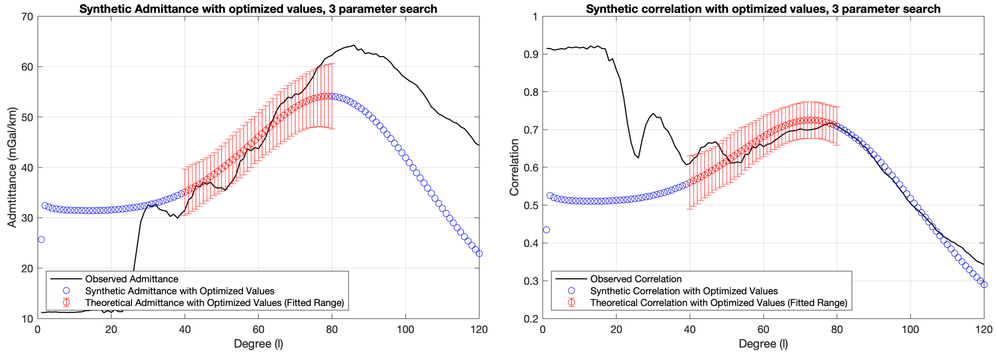

Figure 1: Synthetic admittance and correlation spectra plotted with lowest RMS values from 25 iterations of particle swarm. Optimized values are: T_e of 8.9 km, ρ_l of 2381 kg/m^3, and a f of 1.7e^{-4}

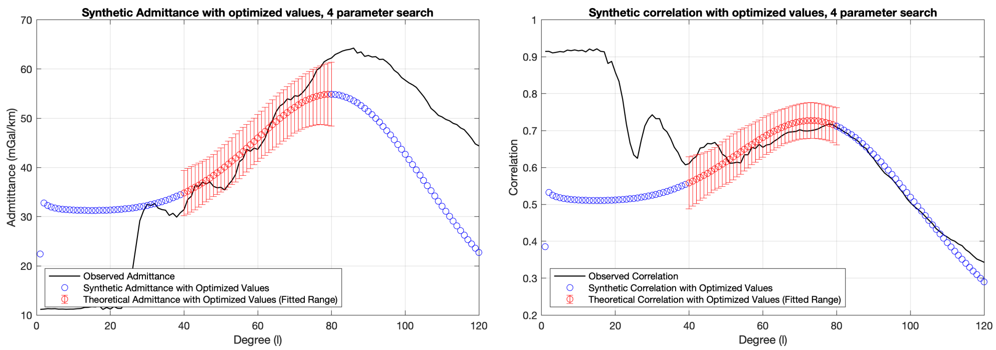

Figure 2: Synthetic admittance and correlation spectra plotted with lowest RMS values from 25 iterations of particle swarm. Optimized values are: T_e of 7.1 km, ρ_l of 2769 kg/m^3, f of 7.53e^{-5}, and α of 0.48.

lower than previously thought, potentially resulting in this lower value of density [12]. With positive α values averaging around 0.4 it seems that with whatever small amount of subsurface loading is present is relatively correlated with the surface loads. When the parameter α is forced to be zero, implying uncorrelated loads, the model results do not change substantially. This is due to very small load fractions associated with this basin (i.e., f<<0). Thus, we think, for now, it's safe to assume the lower densities of the three parameter model search are more accurate and representative of the bulk composition of the geology present. The lower value of density indicates it's more likely to be fluvially and pyroclastically sourced, which is in line with the morphologic history and surface composition of the basin [13]. We're currently incorporating two methods to augment our study: the first is using forward models of the expected gravity due to flexure using a variable elastic thickness [14]. Secondly, we will be implementing a MCMC parameter search to provide us with a distribution of values instead of a single answer.

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