GEOPHYSICAL CONSTRAINTS ON EUROPA'S ICE SHELL AND ROCKY CORE FROM A FLYBY MISSION. P. B. James[1], [1]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA (pjames@alum.mit.edu).

Introduction: A future Europa flyby mission [1] will provide an opportunity study the internal structure of Europa, specifically the depth of its liquid water ocean, the thickness of its ice shell, and the rheological properties of the ice shell. This work describes the techniques and scientific benefits of short wavelength gravity recovery.

Methodology: While a spherical harmonic decomposition of a moon's gravity field is convenient for spatial and spectral analysis of internal structure, spherical harmonic coefficients calculated amidst non-global spacecraft coverage generally have large uncertainties, as would be the case for a series of flyby maneuvers at Europa. An alternative approach is to utilize line-of-sight Doppler residuals [2,3]. The resulting data represent gravitational accelerations along individual orbital tracks, which can be compared to gravity from topography along the same track. The Fourier transforms of gravity and gravity from topography can then be compared in the spectral domain to produce admittance and correlation spectra for each track.

An approximate power spectrum of gravity provides insights into the nature of topography, but the gravity signal is considerably more useful if topography is known at a comparable resolution. Digital terrain models can be produced via photogrammetry, limb measurements, and radio occultations, but laser altimetry provides the most reliable means of measuring topography for geophysical analyses.

Science Opportunities: Density contrasts are expected to be small in Europa's icy shell, and all but the smallest and/or most recently generated density anomalies will have relaxed to a state of Airy or Pratt isostasy as a result of the ice shell's low viscosity. This implies two things about the icy shell: gravity anomalies from the shell will be very low, and they will be highly correlated with topography. In contrast, the seafloor will exhibit a density contrast in excess of 1500 kg m^{-3}, and the associated gravity signal will likely dominate Europa's gravity field at the lowest spherical harmonic degrees.

Europa's ocean decouples seafloor topography from surface topography, and this has an important observational implication: seafloor topography will produce a gravity signal that is nearly uncorrelated with topography on average. The seafloor therefore produces no bias on the observed admittance function. This assumption may break down if seamounts produce significant hydrothermal activity or if ocean circulation patterns are influenced by seafloor topography [4]. Since ice shell gravity is expected to correlate somewhat with topography, the admittance function at long wavelengths indicates depth of compensation (i.e. the thickness of the ice shell). At the shortest wavelengths, the admittance function is primarily dependent on the density of surface topography, and the admittance at intermediate wavelengths is sensitive to the mechanical and rheological properties of the icy shell. Short-wavelength gravity studies will complement topographic analyses of crater relaxation [e.g., 5].

Even though the mass anomalies associated with the rocky seafloor are much larger than those of surface topography, the short-wavelength gravity anomalies associated with seafloor topography are attenuated above the planet's surface. Upward continuation of a gravity anomaly dampens signals with wavelengths approximately greater than or equal to the height of upward continuation. Therefore, the length scale at which gravity/topography correlation increases will provide insight into the depth of Europa's seafloor (see Fig. 1).

Conclusions: Line-of-sight residuals offer a way to study Europa's ice shell structure and sea floor, even when coverage is not fully global. The effectiveness of this analysis will depend on the periapsis altitude (with a maximum resolution comparable to altitude) and the accuracy of topography data.

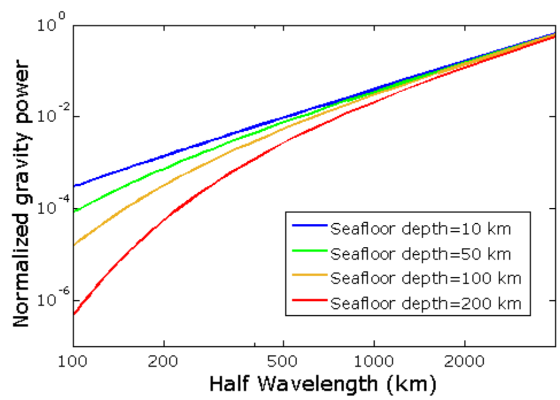

Figure 1. Normalized gravity power from Europa's seafloor for a variety of seafloor depths.

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