Figure 1: Series of plots exploring various 1-D temperature profiles of the Enceladus internal structure and it's effect on 2-way attenuation. Variables investigated are ice shell depth, regolith thickness, and regolith conductivity. Each row contains the 1-dimensional temperature profiles (left, in purple/blue) and two multi-line plots that show the increase in 2-way attenuation with depth/temperature as a gradient hue change along each profile. The leftmost column represents the “high loss” attenuation model, and the middlemost column represents the “low loss” attenuation model.

Figure 1 demonstrates the difference in the “high” and “low” loss attenuation models on multiple 1-dimensional scenarios of the Enceladus internal structure. The leftmost column includes the various 1-dimensional temperature profiles, and the two right columns explore the change in attenuation across the different scenarios, using a slow shift in hue to denote an increase in attenuation with depth. This hue change maps to a continuous color bar, with the lightest color denoting attenuation less than 1 decibel (dB) and the darkest color denoting attenuation above 100 dB. The top-left corner multi-line plot shows how temperature changes with depth in various ice-shell depths. Each of the three profiles simulates 250 meters of regolith, regolith thermal conductivity of 0.025 watts per meter-kelvin (W/mK), and three ice shell depth scenarios of 5 kilometers, 21 kilometers, and 35 kilometers, respectively. The next set of profiles simulates constant ice shell depth (21 km) and regolith conductivity but varies the regolith thickness with 0, 100, 400, and 700 meters, respectively. The last set of profiles maintains constant ice shell depth (21 km) and regolith thickness (250 m) but varies regolith thermal conductivity using 0.1, .025, and 0.001 W/mK.

When varying ice shell depth, attenuation reaches 100 dB at similar penetration percentages relative to that scenario’s ice shell depth. The 5 km, 21 km, and 35 km temperature profiles reach 100 dB of 2-way attenuation at 90.5,% 94.4%, and 95.4%, respective to each profile’s total depths in the low loss case. The simulated penetration percentages relative to total depth in the high loss case are 16.4%, 32.7%, and 48.1%, respectively, with their differences attributable to the difference in ice shell depth.

The second row indicates that attenuation dramatically increases with regolith thickness. The low-loss scenario with 0 regolith in the second row doesn’t reach 100 dB, but only 53.4 dB, when it reaches the ice-ocean interface. At 21 kilometers, the 0 regolith case reaches 53.4 dB. For low loss, 100 meters regolith penetrates 99% of the 21 km, 400 meters penetrates 88% of the ice shell, and 700 meters penetrates 74%. For the high loss, 0 regolith does not penetrate the entire ice shell. The 0 regolith case penetrates 87.9% of the ice shell, the 100-meter case penetrates 64%, the 400-meter case penetrates 16.4%, and the 700-meter regolith high loss case penetrates only 8% of the ice shell.

When varying regolith conductivity, the most conductive case (0.1 W/mK) in the low loss scenario also penetrates the entire ice shell, reaching 95 dB at the ice-ocean interface. In both high and low loss cases, the 0.025 W/mK scenarios penetrate ~80% of the ice shell. In the least conductive case(0.001 W/mK), less than 10% of the ice shell is penetrated in both the high and low-loss cases. Both instances of 0.001 W/mK conductivity penetrate less than 2500 meters into the ice shell.