**Introduction:** Electromagnetic (EM) sounding is a group of geophysical methods used to characterize the interiors of planetary bodies from the near-surface (~ 1 m) to the deep interior (> 1000 km). Previous EM soundings of the Moon performed during the Apollo Era utilized a transfer function method requiring both orbiting and surface magnetometers. In the magnetotelluric (MT) method, the orthogonal components of the horizontal electric and magnetic fields on the surface are used to discern the subsurface conductivity structure. Sensor suites commonly used in space physics (electrometers and magnetometers) can make measurements for EM sounding on the surface of the Moon. The Moon encounters a wide variety of plasma regimes and EM source signals over a broad range of frequencies. Here, our goal is to consolidate previous observations to develop a catalog of EM disturbances at the Moon that will be useful for surface MT measurements. This work is an important step toward understanding the depth and resolution that could be obtained from these measurements on future missions.

**Source Signals:** On the terrestrial planets, electromagnetic discharges (lightning) or magnetic field variations due to interactions with the solar wind can provide MT source signals. On airless bodies such as the Moon, solar wind turbulence and other plasma waves can create source signals.

Below is a table listing expected target layers, depths, and EM frequency ranges necessary for MT sounding of the Moon.

<table>
<thead>
<tr>
<th>Target</th>
<th>Depth</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crust</td>
<td>0 – 60 km</td>
<td>&gt; 1 Hz</td>
</tr>
<tr>
<td>Mantle</td>
<td>60 – 1500 km</td>
<td>10⁻³ – 1 Hz</td>
</tr>
<tr>
<td>Core</td>
<td>&gt; 1500 km</td>
<td>&lt; 10⁻³ Hz</td>
</tr>
</tbody>
</table>

The Moon spends ¾ of its orbit in the solar wind. Observations show that solar wind turbulence can provide a robust source of electromagnetic fluctuations spanning frequencies from < 10⁻⁴ Hz to > 10² Hz [1-4]. Figure 1 shows the power spectral density of magnetic fluctuations as a function of frequency in the solar wind.
Analysis Method: In MT, assuming a simple planar geometry, the apparent resistivity as a function of frequency, $\rho_\alpha$, is determined from the measured electric field, $E$, and magnetic field, $B$:

$$\rho_\alpha = \frac{1}{5f} \frac{E^2 (\text{mV/m})}{B^2 (\text{nT})} \text{ohm-m} \quad (1)$$

with each wave penetrating the subsurface according to its skin depth, $\delta$, given by

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} \sim 500 \sqrt{\frac{\rho}{f}} \text{ m} \quad (2)$$

Using (1) and (2), standard inversion procedures convert apparent resistivity, $\rho_\alpha$, to true resistivity as a function of depth, $\rho(z)$.

This result can be generalized to spherical geometries at longer wavelengths using a response function, $c(\omega)$, as outlined by [8]:

$$c(\omega) = \frac{E(r_m, \omega)}{i \omega B(r_m, \omega)} \rightarrow \rho_\alpha = \omega \mu |c(\omega)|^2$$

Again, the apparent resistivity, $\rho_\alpha$, can be inverted to find conductivity versus depth.