Spatial Magnitude Frequency Distributions for Preliminary Lunar Probabilistic Seismic Hazard Assessments

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The establishment of permanent crewed installations on the Moon has become a priority by space agencies around the globe, and with those plans it is becoming increasingly important to accurately characterize the hazards faced by longer-lived installations. Probabilistic seismic hazard analysis (PSHA) is a key tool that is used to inform the development and application of seismic design criteria for structures constructed on Earth. We now look to leverage PSHA to inform design criteria for future lunar installations.

A key component required for a PSHA is the characterization of a magnitude-frequency distribution (MFD) for seismic events that create the ground motion hazard. For the Moon, this can be derived from the seismometer data collected at the Apollo astronaut-deployed seismic stations. These instruments were active from 1969 to 1977, but their use for a PSHA is limited by the distribution the instrument locations on the lunar surface as well as sensor performances. Nonetheless, the Apollo seismic data provides essential information about lunar seismicity, including t28 shallow moonquakes recorded during the Apollo operational period. Combining the seismometer data with Lunar Reconnaissance Orbiter mapping efforts of surface fault expression, we can extrapolate the MFD across the entire lunar surface.

For our investigation, we analyzed the spatial correlations between a subclass of lunar faults, the lobate scarps and detected shallow moonquakes, both to examine the significance of lobate scarp clustering on magnitude distributions, and to attempt to contextualize the absence of detected shallow moonquakes on the far side of the moon. In this study, we provide insights into development of MFD to support a preliminary probabilistic seismic hazard assessment of relevance to lunar base design considerations and identify what knowledge gaps exist to be addressed by future missions and new observations.