11th Wernher von Braun Memorial Symposium
October 23 – 25, 2018

Thermal moonquake identification and localization from Apollo 17's Lunar Seismic Profiling Experiment

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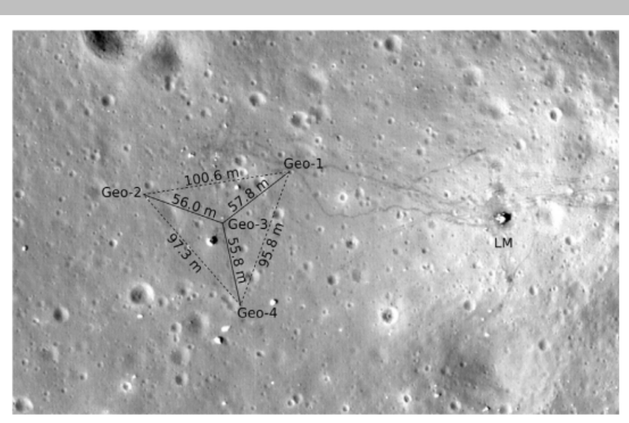
Purpose

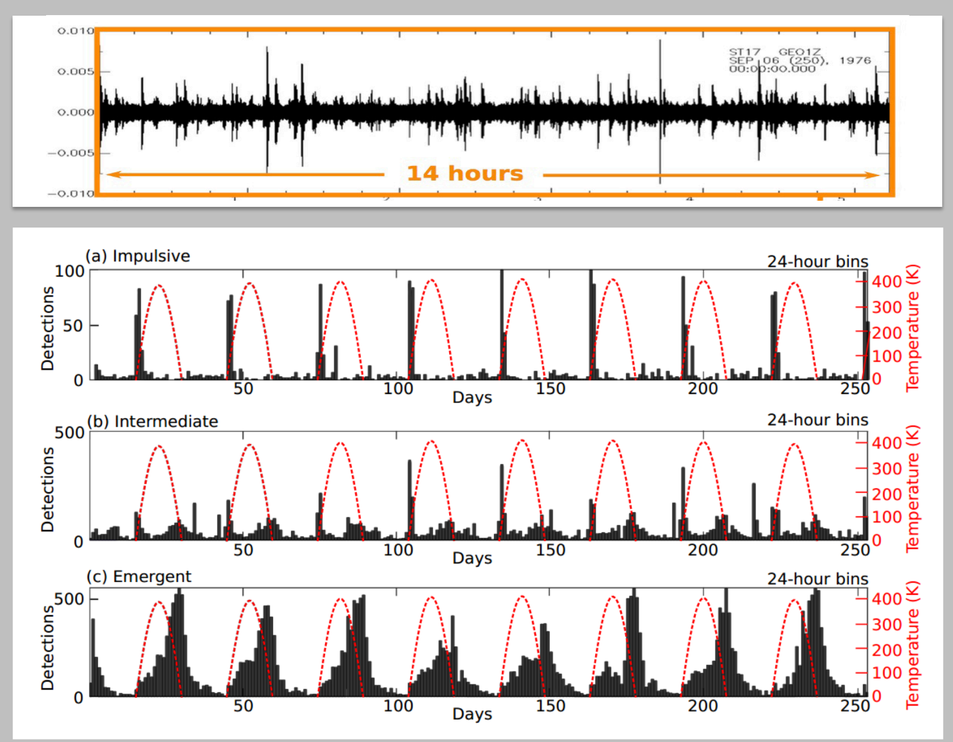
By correlating the physical location of thermal moonquakes with lunar terrain features such as boulders, we will gain a better understanding of lunar surface processes on the Moon.

Data

- Apollo 17 Lunar Seismic Profiling Experiment (LSPE) continuous data contains numerous events associated with temperature fluctuations
- A computer event recognition program (HMM) identified thousands of detections from August 1976 to April 1977.
- Three event types were classified determined by the waveform arrival; impulsive, intermediate, and emergent.

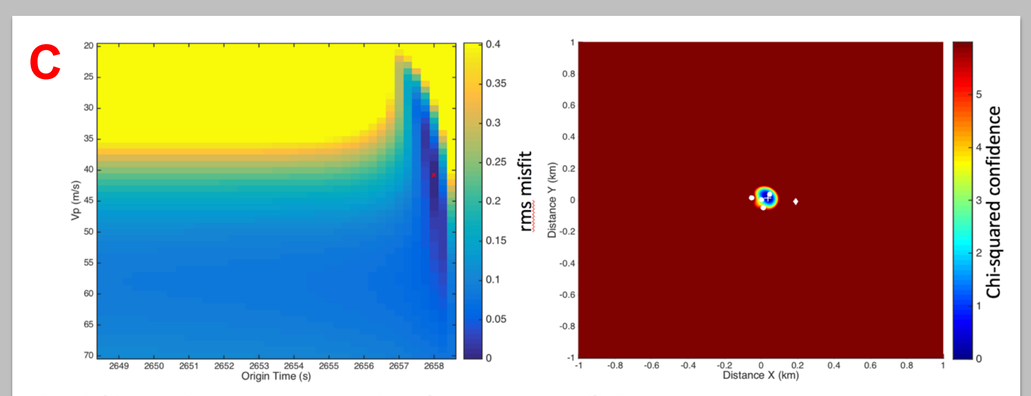


Left: Apollo 17 LSPE geophone locations and the location of the lunar module. (Heffels et al., 2017) Top right: Continuous LSPE data showing numerous thermal moonquakes. Bottom right: Analysis from HMM shows the three types of events broken down in 24-hour time bins for 8 months of data. The red curve is model temperature based on the solar flux.

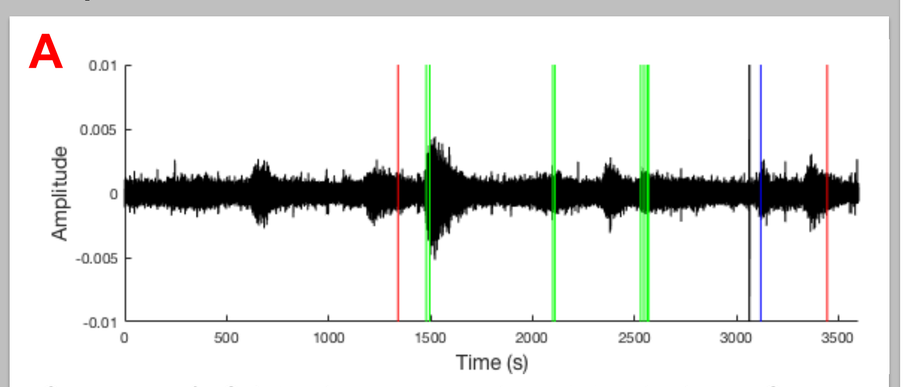


Results

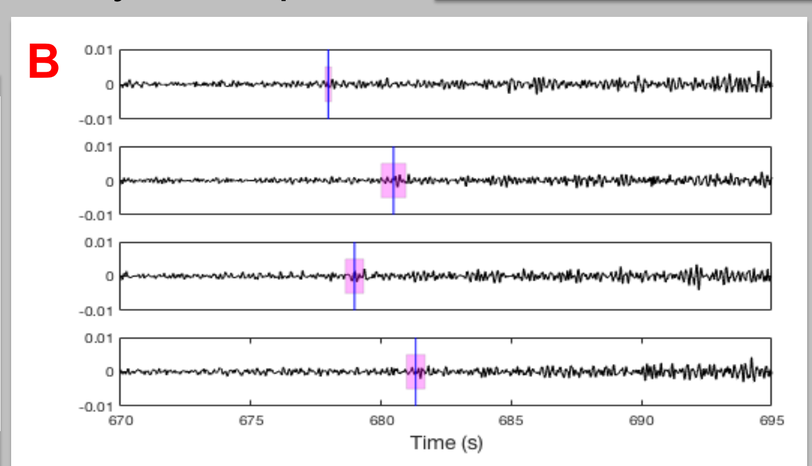
A. HMM produced false and missed detections but provide an first approximation of events within the LSPE data.
B. Seismic waves arrive at each geophone at different times with different arrival time uncertainties.
C. With four arrivals, we can locate the event and origin time assuming surface event with free velocity.
D. Using images of the Moon, we can correlate locations of event to physical surface to determine if they overlap with particular terrain features.



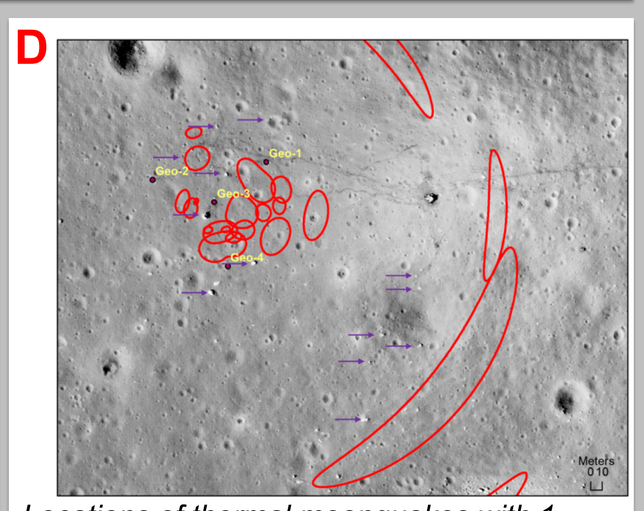
Best fit location and velocity of a sample LSPE event, on a 1-km grid centered on LSPE array.



One hour of LSPE data overlaid with HMM detections. Green lines indicate emergent events, red lines indicate intermediate events, and blue lines indicate impulsive events.



Event arrival indicated by blue line and arrival time uncertainty highlighted in purple for geophones 1-4.



Locations of thermal moonquakes with 1 second misfit contours overlaid on high resolution LROC image with rocks indicated by purple arrows.

Future Work

Use a location algorithm that includes a velocity model for an entire lunation (lunar sunrise to sunrise) to locate thousands of events to compare location versus event types, origin time, etc.

Acknowledgements

Dr. Max Bonamente (UAH Advisor)

References

Heffels, A., Knapmeyer, M., Oberst, J., Haase, I., 2017. Re-evaluation of Apollo 17 Lunar Seismic Profiling Experiment data. Planet. Space Sci. 135, 43–54. https://doi.org/10.1016/j.pss.2016.11.007