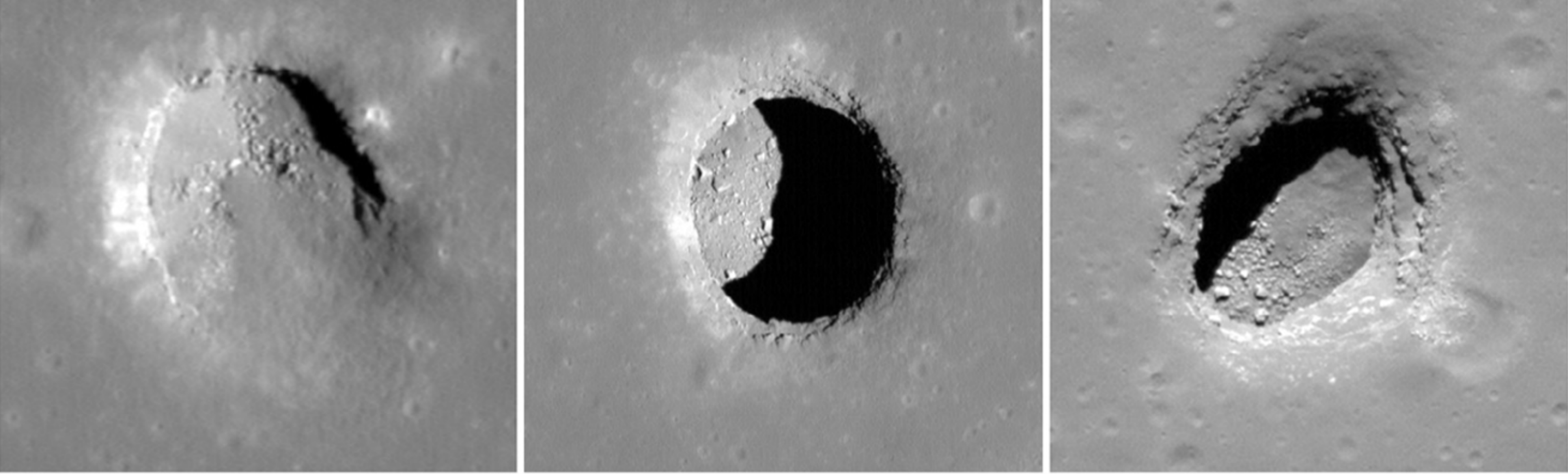

Virtual Research Presentation Conference

Investigating Lunar Caves with Diviner Thermal Infrared Data and Numerical Models

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Program: SURP

Assigned Presentation #RPC-216

Jet Propulsion Laboratory
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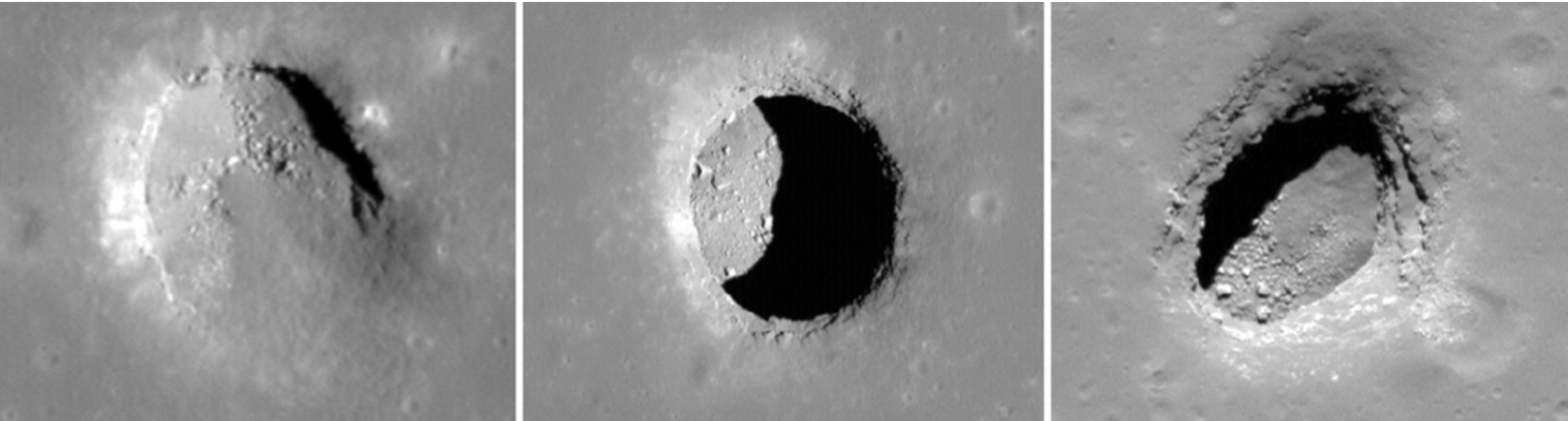
Introduction

- Over 200 steep-walled pits have been found on the Moon
- They may connect to subsurface void space that could provide shelter to astronauts
- Understanding the temperature conditions in the pits is an important prerequisite for both robotic and human exploration



Problem Description

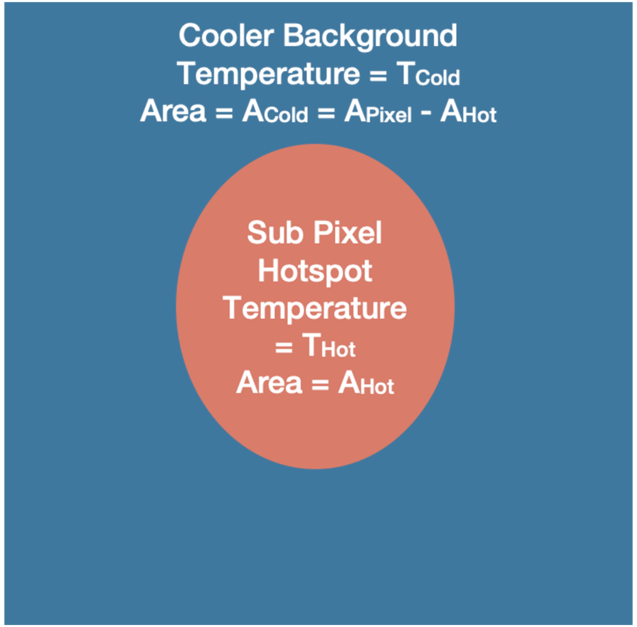
- Lunar pits are a high priority target for both science and human exploration missions
  - They serve as a natural drill core through the lunar subsurface. Moon Diver is a mission concept that would study the volcanic history of the Moon by observing the morphology and composition of lava flow layers exposed in the pit wall
  - Lava tubes would provide astronauts a benign thermal environment and protection from radiation and micrometeorites
- The Lunar Reconnaissance Orbiter (LRO) Diviner Lunar Radiometer Experiment (Diviner) observes the Moon in the infrared, but observations of lunar pits have not previously been analyzed
- Understanding how the thermal environment varies with pit geometry and latitude could guide the design and objectives of future mission concepts

Methodology

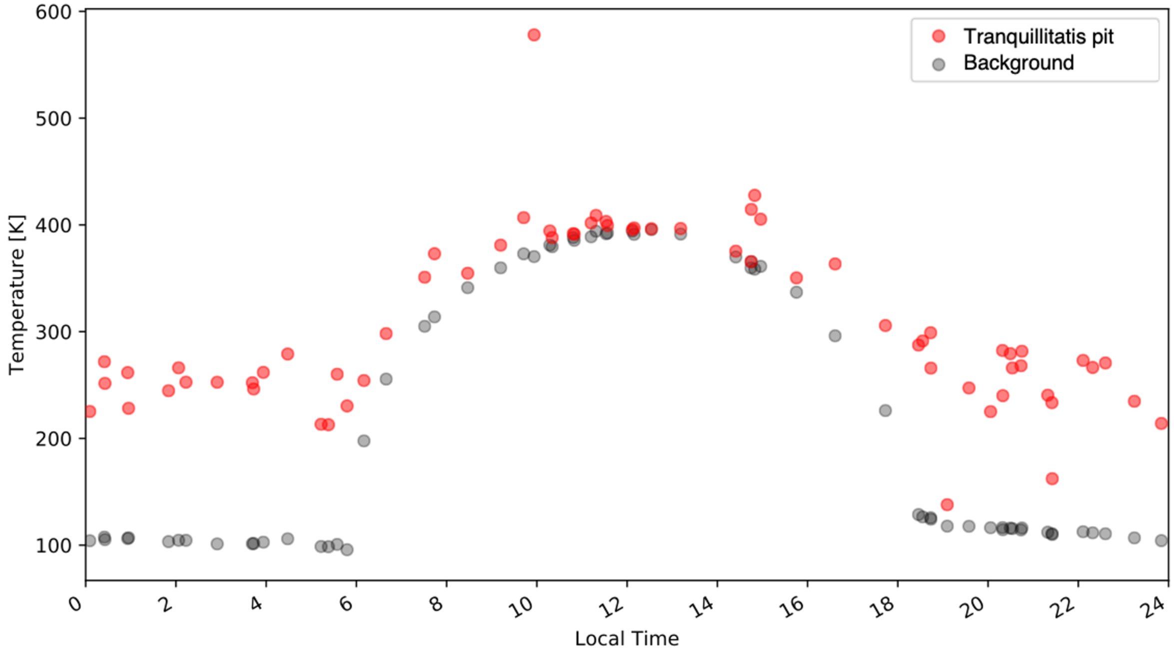
- Multispectral infrared observations provide constraints on subpixel anisothermality
- Fit the nighttime observations with a two component model: T_{pit} and $T_{background}$
- Assume $T_{background}$ = material surrounding pit

$$B(T_{Pixel}) = \frac{A_{Hot}}{A_{Pixel}} B(T_{Hot}) + \left(1 - \frac{A_{Hot}}{A_{Pixel}}\right) B(T_{Cold})$$

B(T) = Planck function



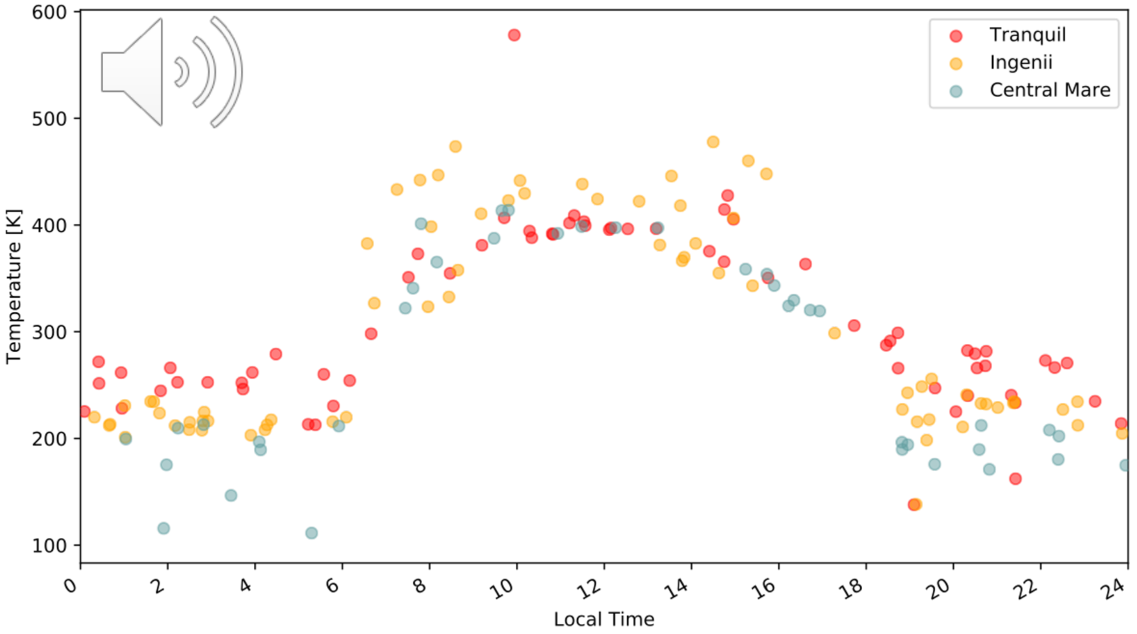
Results



- Three of the largest lunar pits are warmer than their surroundings

Results

- Central Mare Fecunditatis pit is cooler at night than the other two pits
- Partial collapse of its walls means it does not trap heat as efficiently



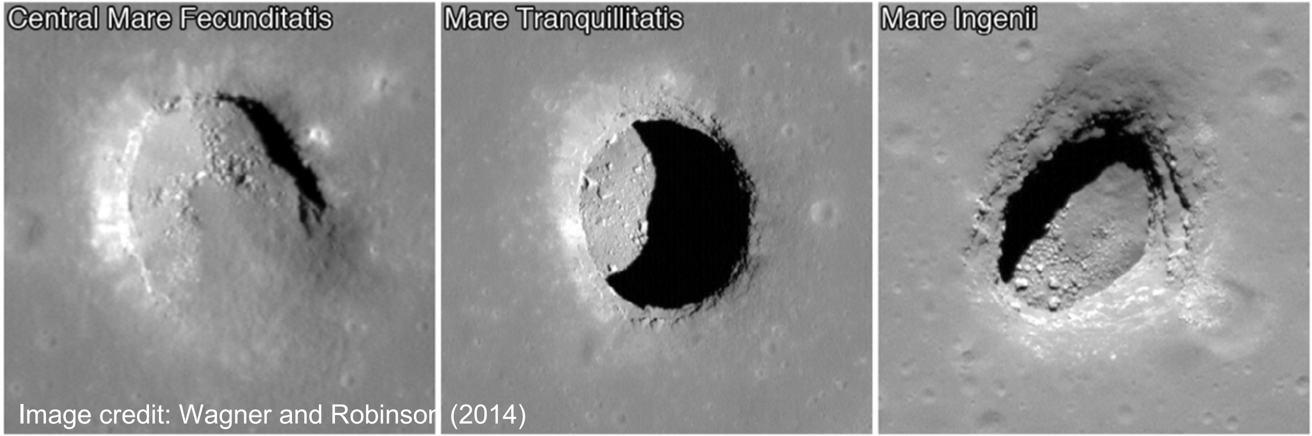
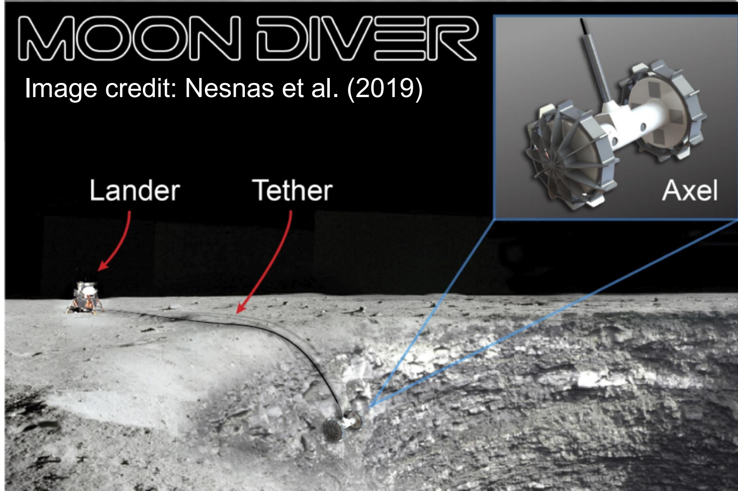


Image credit: Wagner and Robinson (2014)

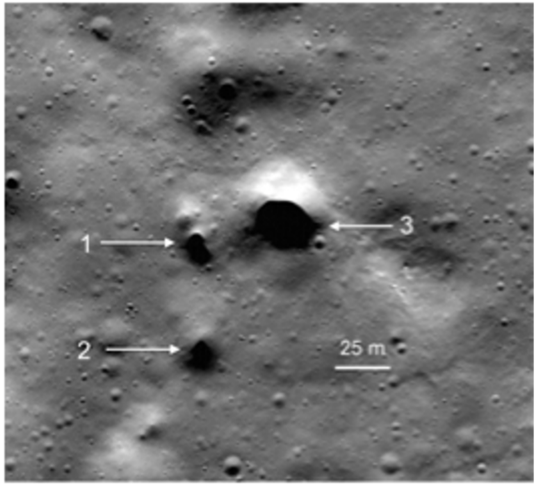
Significance

- Lunar pits are a potential target for both future science and human exploration missions.
- Understanding the thermal conditions in these pits is an important step to guide mission design.
- We have shown that pits with partial wall collapse do not retain as much heat as cylindrical pits and may therefore provide a more benign thermal environment for exploration



Next steps

- Lee (2018) identified potential pits at 72°N and claimed they could host trapped water ice, but their ability to trap water has not been modeled
- We will model volatile stability in pits at a range of latitudes
- The floor and all but the equator facing wall may be in permanent shadow for pits near the pole
- Water ice is unstable at T>110 K, but the residence time of a water molecule physically adsorbed to surfaces within a cave could be significant.
- The depth to diameter of the pit and the presence or absence of an overhang and/or possible cavern will all affect the ability of a water molecule to escape again after entering the pit.
- If we find that volatiles may become trapped in lunar pits and caves, this would further heighten their science value and exploration potential.



Possible pits in Philolaus Crater at 72.1°N, 32.5°W. Figure credit Lee (2018)

References

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[2] Nesnas, I. A., Kerber, L., Parness, A., Kornfeld, R., Sellar, G., McGarey, P., ... & Heverly, M., "Moon Diver: A Discovery Mission Concept for Understanding the History of Secondary Crusts through the Exploration of a Lunar Mare Pit.” In *2019 IEEE Aerospace Conference* (pp. 1-23). IEEE.

[3] Lee, P. “Possible Lava Tube Skylights Near the North Pole of the Moon," *Lunar and Planetary Science Conference* **49** (2018), 2982.