National Aeronautics and Space Administration

Investigating Lunar Caves with Diviner Thermal Infrared Data and Numerical Models

Principal Investigator: Catherine Elder (322); Co-Investigators: Paul Hayne (University of Colorado, Boulder), Andrew Wilcoski (University of Colorado, Boulder)

Program: FY22 SURP
Strategic Focus Area: Lunar science

Objective: Determine the plausibility of finding volatiles in lunar pits and caves.

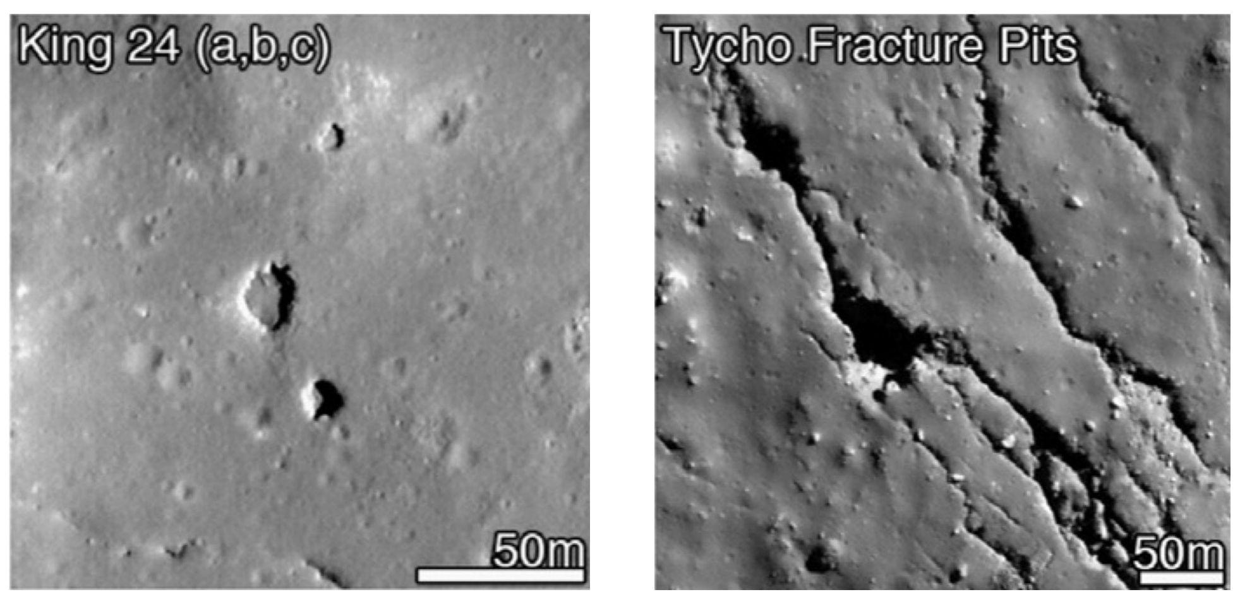

Figure 1 Examples of lunar pits. Figure credit [1].

Background:

- Lunar volatiles are high priority targets for both their science and resource value
- Locations that store volatiles in high abundances would make the best mission targets
- Pits are plentiful on the Moon [1], and previous work suggested that high latitude pits could cold trap volatiles and protect them from destruction [e.g. 2] but that had not been modeled

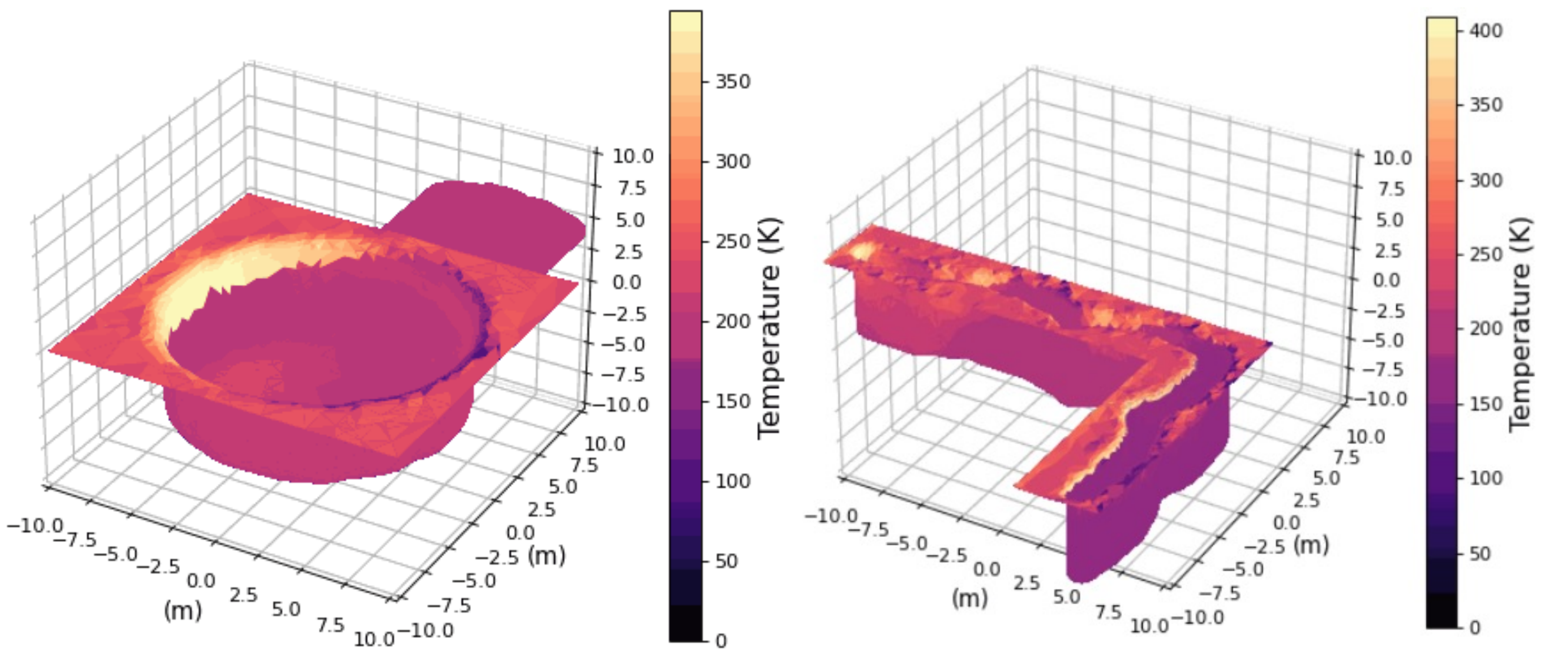

Figure 2 Local noon surface temperatures for pit-cave system (left) and a fracture system (right) both at 80° S latitude. Only facets on the equator-facing rim see direct insolation. The remaining interior facets are in shadow where IR multiple-scattering dominates.

Results:

- Multiple-scattered IR radiation is the most important energy source within high latitude pits (Fig. 2)
- Pits with more enclosed geometries have more stable temperatures (Fig. 3)
- Doubly shadowed pits and caves are much colder than pit-cave systems outside existing PSRs (Fig. 4)
- Water ice is most stable at very high latitudes (>88°) (Fig. 5)

Significance/Benefits to JPL and NASA:

- **We determined that missions aiming to sample lunar volatiles should target craters rather than pits or caves, because craters are better cold traps.**
- We strengthened the relationship between CU Boulder and JPL and engaged experts in lunar polar volatiles at CU Boulder

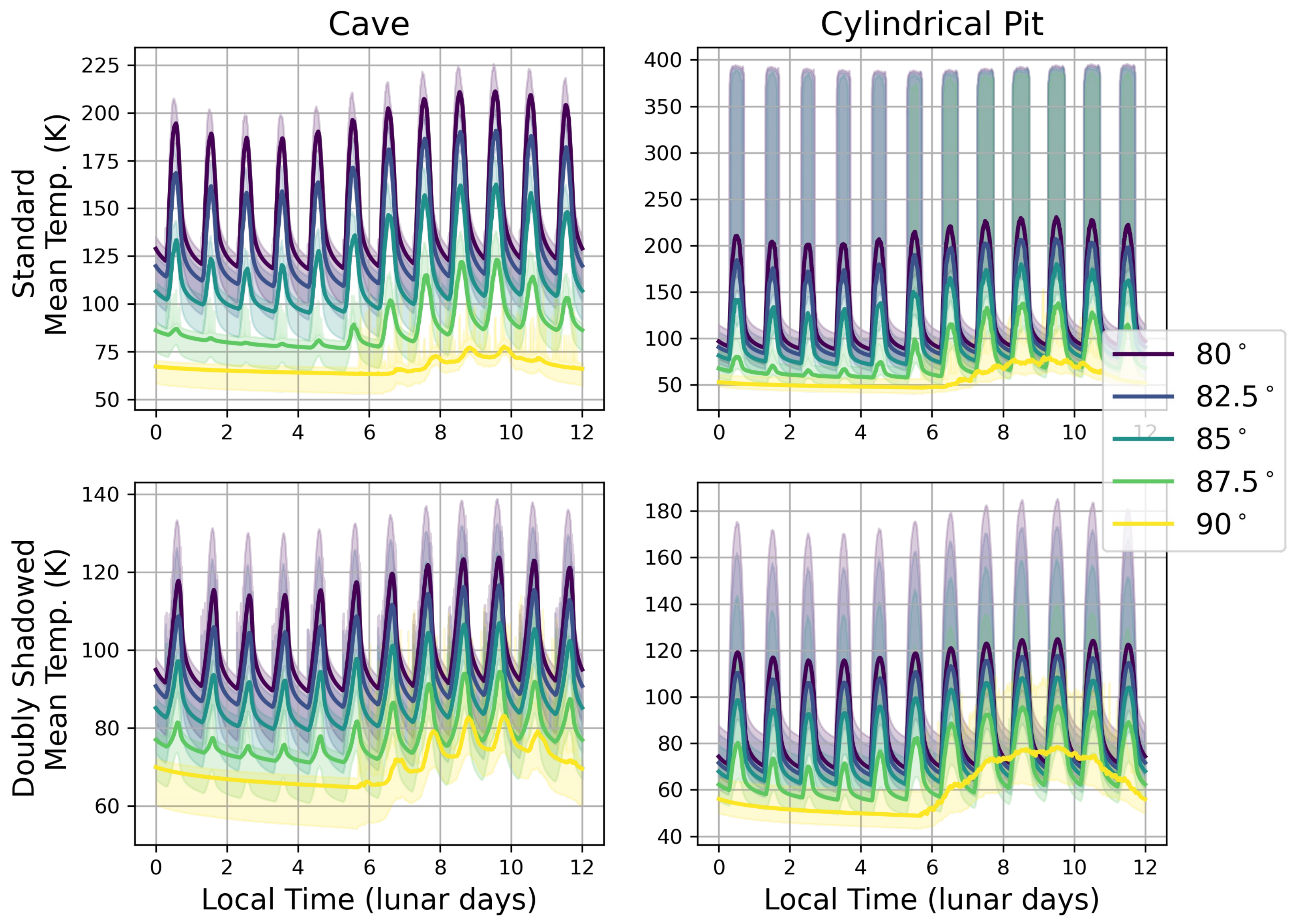

Figure 4 Mean temperatures over a lunar year at latitudes from 80° S to 90° S within a cylindrical pit (right column) and its attached cave (left column) for both a standard pit-cave system (top row) and a doubly shadowed pit-cave system (bottom row). Note the y-axis scale varies between subfigures.

Approach

- Created and validated a 3D thermophysical model
- Applied the model to a range of pit geometries
- Explored variation in temperature with geometry and latitude
- Created a 3D volatile transport model
- Used coupled thermal and volatile model to assess ice stability within lunar pits

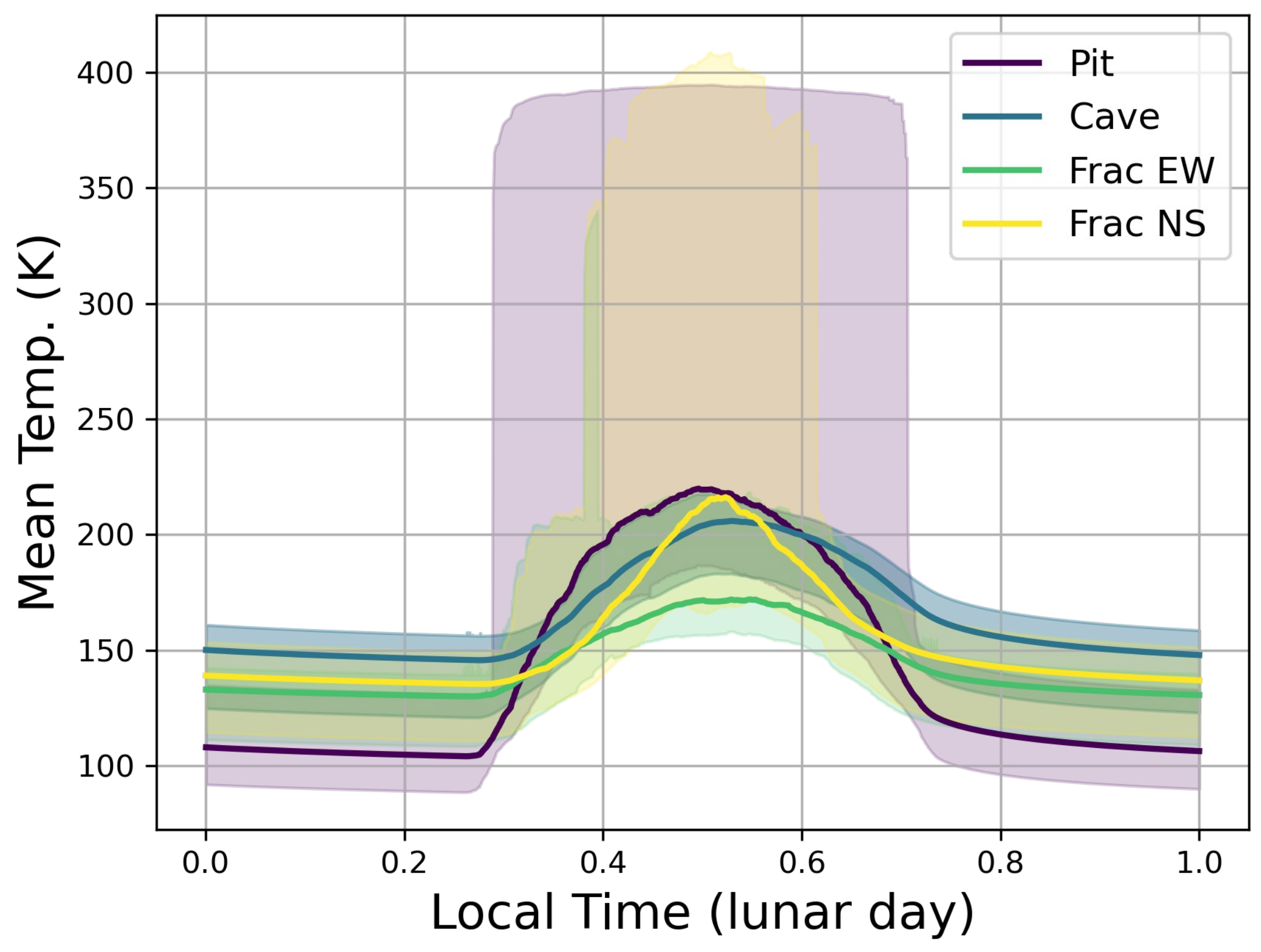

Figure 3 Mean temperature vs time for a cylindrical pit (purple), an attached cave (blue), an east-west fracture (green), and a north-south fracture (yellow) at 80° S latitude. Shaded regions show min and max temperatures.

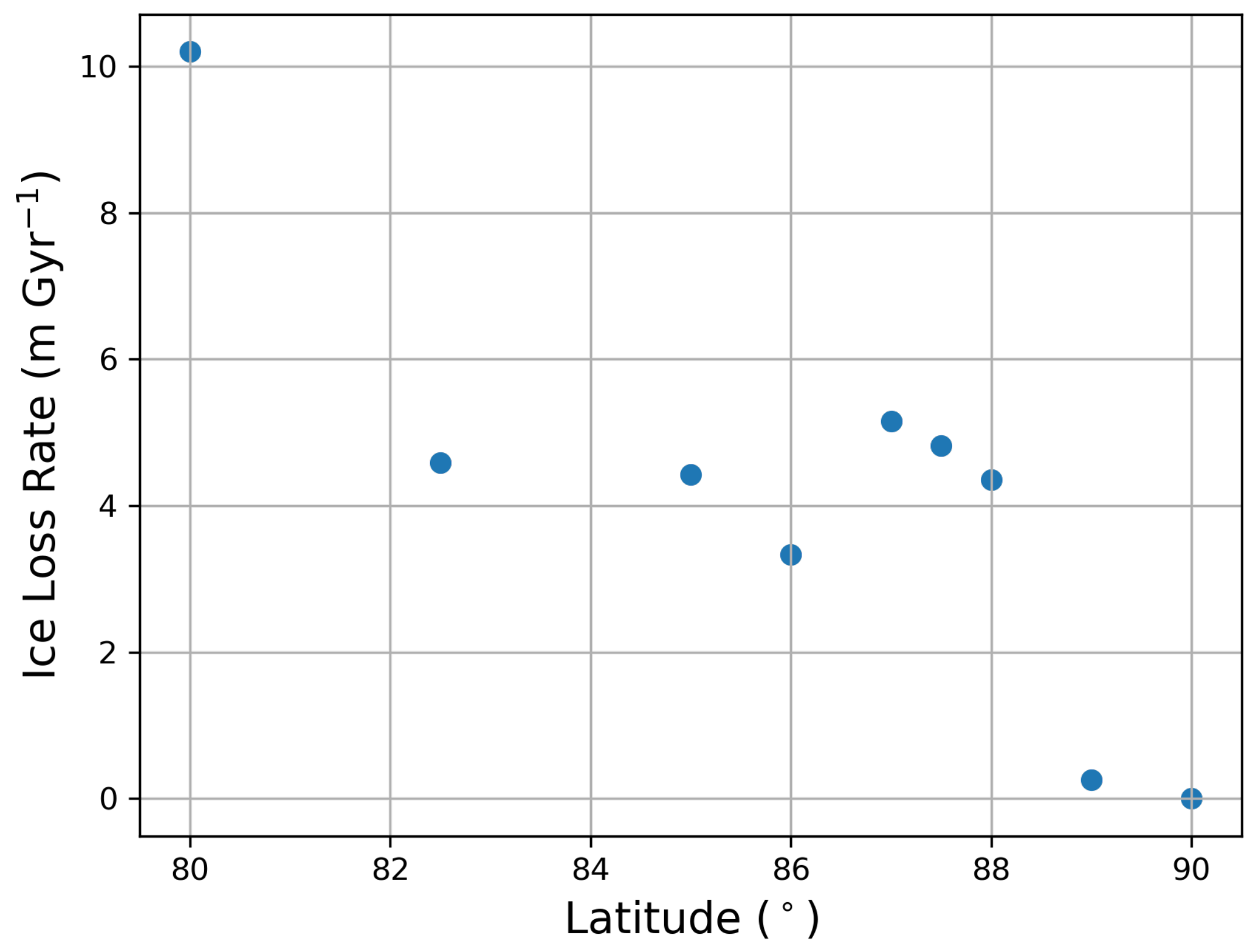

Figure 5 Ice loss rate vs latitude for a doubly shadowed pit-cave. Net ice loss rate across all ice-bearing facets within the pit-cave system. Scatter is due to the spatial resolution of the surface geometry.

References

[1] Robert Wagner, and Mark Robinson (2014) *Icarus* 237: 52-60.
[2] Lee, P. (2018) *Lunar and Planet. Sci. Conf., #2083.*

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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PI/Task Mgr. Contact Information:
Email: Catherine.Elder@jpl.nasa.gov