Martian Icy Outliers and Climate History

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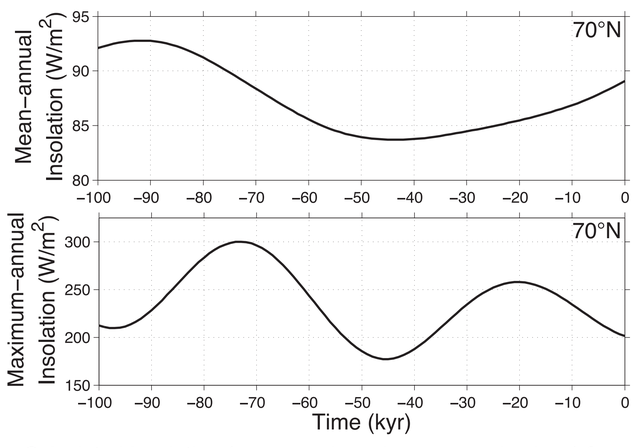
Introduction

The climate of Mars is in a constant state of flux due to its chaotic obliquity [1]. Variation in its orbital parameters significantly alters the distribution of sunlight at the surface. This mechanism is especially effective at stabilizing/destabilizing volatiles at and below the surface, due to the near-exponential behavior of vapor pressure with respect to temperature [2].

Louth Crater is a ~36 km diameter crater in the northern plains of Mars and hosts a large ~12 km diameter, quasi-circular water ice mound, which lies off-center on the crater floor [3]. This ice mound, although a common feature in northern plains' polar craters, represents the most- equatorward (70°N) example (i.e., on average, it is the warmest perennial surface ice on the planet). Its position makes it potentially sensitive to ongoing climate change, which may be visible through repeated high-resolution imagery over multiple years. We seek evidence of change at the ice mound boundary in response to changing climate of Mars.

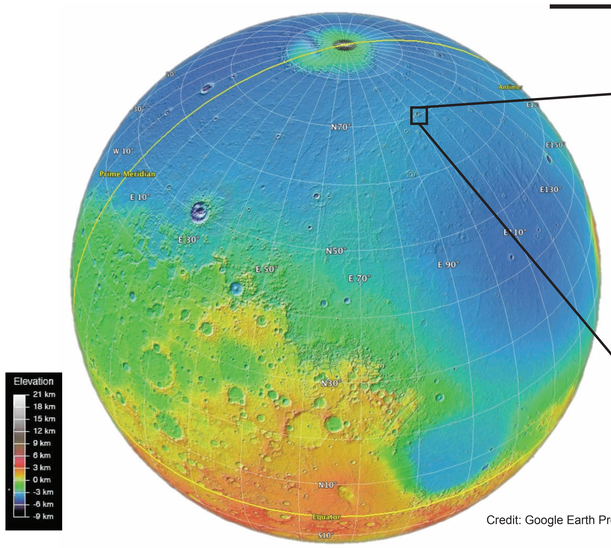
Theoretical Expectations

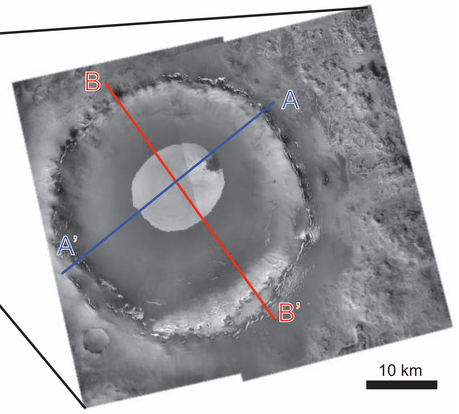
Using orbital solutions from [1] we calculate changes in insolation at 70°N for the past 100 kyr. Mean-annual insolation undergoes smaller variations (<10%) and is currently increasing at present. Maximum-annual insolation experienced more variation (>30%) and is decreasing at present. Interestingly these insolation proxies point to opposite expectations of how Louth Crater ice may be changing. We argue that maximum-annual insolation is a more useful proxy for ice extent (due to the strong temperature dependence of sublimation), but because of poorly known feedbacks (e.g., ice albedo changes and global atmospheric water levels [4]) this assumption remains uncertain. In spite of these reservations, our current expectation is that ice is becoming more stable as peak insolation decreases.

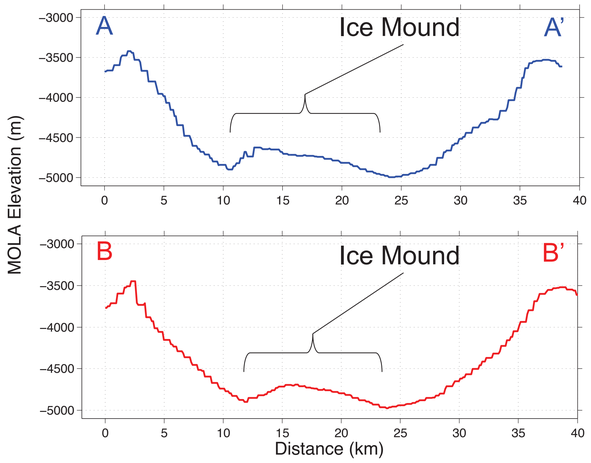


Calculated insolation (mean- and maximum-annual values) for the past 100 kyr at Louth Crater. Substantial changes in insolation could affect the stability and extent of the ice mound.

Louth Crater Context

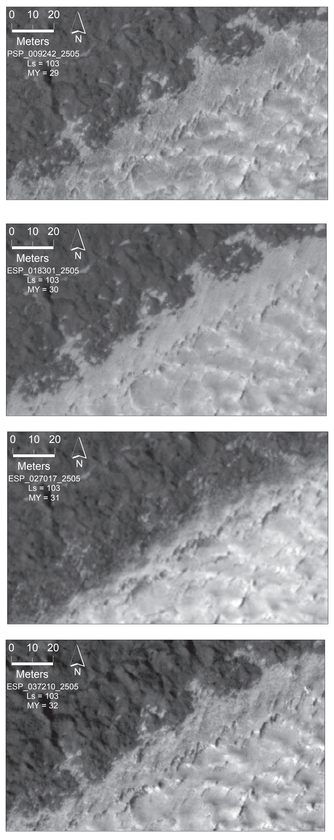




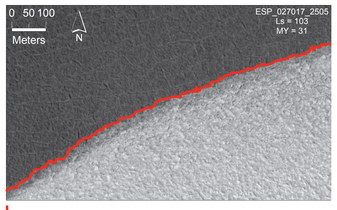


Interannual Changes In Extent

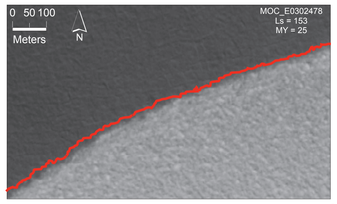
HiRISE



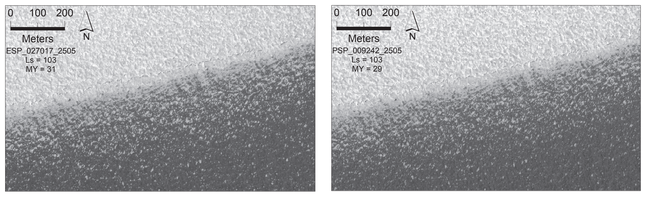
HiRISE

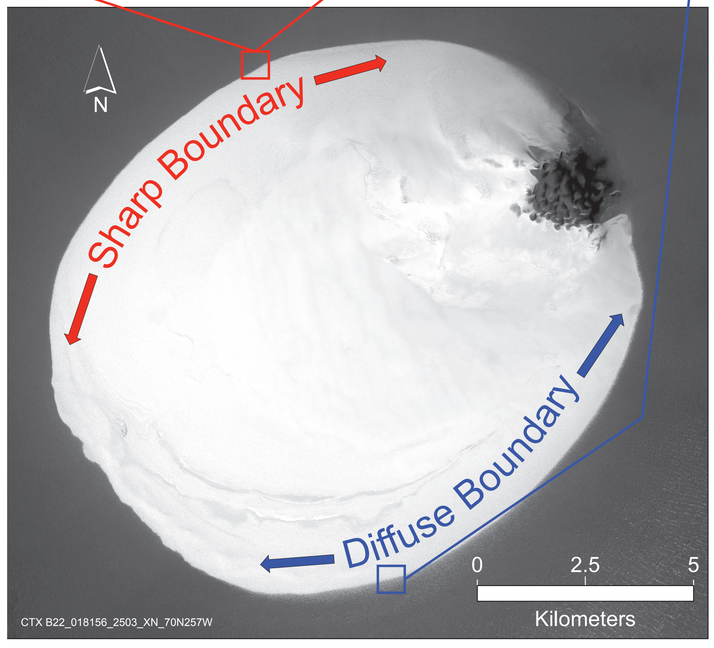


MOC



HiRISE





Summary

- Interannual variation is observed only in a small region of the north boundary
- No clear trend is obtained from analysis of the images, two explanations exist:
  - The ice mound is near equilibrium and the observed changes are likely year-to-year variation in seasonal frost coverage
  - Permanent changes are small such that they cannot be perceived in our limited temporal coverage
- Future modeling will help evaluate these possibilities

References: [1] Laskar, J. et al. (2004) *Icarus*, 170, 343 [2] Mellon, M. T. and Jakosky, B. M. (1995) *JGR*, 100, E6, 11781-11799. [3] Brown, A. et al. (2008) *Icarus*, 196(2), 433–445 [4] Smith, M. D. (2004) *Icarus*, *167*, 148-165.

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