THE CASE FOR A GEOLOGICALLY NEUTRAL SITE AT TEMPERATE LATITUDE. T. A. Livengood[1,2], C. M. Anderson[2], M. K. Barker[2], D. Bower[1,2], G. Chin[2], and T. Hewagama[2], [1] Department of Astronomy, University of Maryland, College Park, MD 20742 (tlivengo@umd.edu), [2]NASA Goddard Space Flight Center, Solar System Exploration Division, Greenbelt, MD 20771.

Introduction: Two processes are known to affect the lunar surface globally: space weathering (including impact gardening, radiation exposure, plasma sputtering, and possible other phenomena) and modest but measurable hydration. These processes are poorly understood, yet they affect every exposed surface on the Moon [1,2,3]. We argue that the key to understanding these phenomena is ground-level exploration of at least one landing site, but preferably several, selected for being geologically and geographically ordinary.

Space Weathering: The alteration of surface spectra by age of exposure to space is an observed fact, leading to the Optical Maturity (OMAT) index correlated with surface age [1]. What is not clear is the mechanism by which the surface is aged, and the quantitative relationship between OMAT value and actual age of exposure. Buried surfaces excavated by rocket exhaust or by small impacts, small enough not to melt or fundamentally alter ejecta, create brightened surfaces, even though the revealed surface once had been exposed to space itself in the past. What is the mechanism by which the surface is modified through exposure? How is that modification reset through excavation?

Widespread Hydration: One of the most important scientific discoveries of lunar science has been the ubiquity of water [2,3,4,5]. The presence of water in the polar cap regions has been known since Lunar Prospector measurements in 1998. The Lunar Reconnaissance Orbiter (LRO) mission confirmed widespread polar hydration, with unexpected complexity in its distribution but with direct confirmation of its existence by the Lunar CRater Observation and Sensing Satellite (LCROSS) impact excavation. Remote sensing by other spacecraft detected extensive low levels of hydration at all latitudes, favoring the terminators. The observed pattern suggests a diurnal cycle, although alternative interpretations have been offered [e.g., 6]. Later measurements have confirmed the existence of diurnal variability with substantial uncertainty in the quantity of H_2O/OH, its supply mechanism, loss rate, and total equilibrium abundance [7]. These processes of variability appear to operate on all lunar terrains and as a global feature. Understanding this feature can be pursued most effectively by selecting a site that lacks confounding influences.

Landing Site Selection: The next six landing sites that have already been announced are targeted to regions that are distinct, but not representative of most of the lunar surface. The four landing sites so far offered for the Payloads and Research Investigations on the Surface of the Moon (PRISM) program include a lunar swirl (magnetic anomaly), a silicic volcanic province, and two sites at high or extremely high southern latitude in regions already known to feature relatively high abundance of permanently stored surface/subsurface water as well as distinctive geology in an impact melt region. The VIPER project (Volatiles Investigating Polar Exploration Rover) will return to the extreme southern polar region.

Recommendation: We recommend delivering a payload to a mid-latitude (temperate) site, as it represents a median condition for much of the lunar surface as well as facilitating engineering issues on the lunar surface by avoiding extremes. Mid-latitudes provide access to shadows due to topography and surface rocks that can be used to investigate proposed local transport and sequestration as shadows precess through the day. A suitable instrument package would support at least the ability to conduct measurements analogous to orbital measurements at multiple orders of magnitude finer scale, including measuring the spectroscopic signature of mineral hydration and its change with time. A potential mechanism for diurnal variability of hydration is desorption from the surface to form a tenuous water atmosphere with horizontal transport or vertical loss balanced by exogenous delivery. A high dynamic-range capability to investigate gaseous water or other gases, collisionless or collisional, is essential. Microscopic inspection of unaltered surface outside the lander's blast zone would provide access to representative samples of lunar surface that can be investigated for variability and for properties not resolvable from space.

References:

[1] Nettles *et al*. (2011) *JGR-Planets* **116***,* E00G17
[2] Honniball *et al.* (2020) *JGR-Planets* **125**, JE006484
[3] Livengood *et al.* (2015) *Icarus* **255**, 100–115
[4] Li *et al.* (2018) *PNAS* **115**, 8907–8912.
[5] Livengood *et al.* (2018) *P&SS* **162**, 89–104
[6] Benna *et al.* (2019) *NatGeoSci* **12**, 333-338
[7] Zhu *et al.* (2019) *PNAS* **116**, 11165-11170.