TOPOGRAPHICALLY INDUCED THERMAL EFFECTS ON LUNAR HYDROGEN DISTRIBUTIONS: CORRELATED OBSERVATIONS FROM THE LRO LEND AND LOLA INSTRUMENTS. T.P. McClanahan[1], I.G. Mitrofanov[2], W.V. Boynton[3], G. Chin[1], G. Droege[3], L.G. Evans[1,6], J. Garvin[1], K. Harshman[3], M.L. Litvak[2], A. Malakhov[2], G.M. Milikh[4], M. Namkung[1], G. Nandikotkur[5], G. Neumann[1], D. Smith[1,7], R. Sagdeev[6], A. G. Sanin[2], R.D. Starr[1,4], J.I. Trombka[1,5], M.T. Zuber[1,7], [1]Space Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD, USA., [2]Inst. for Space Research, Moscow, Russia, [3]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, [4]Catholic Univ., Washington , DC, USA. [5]Space Physics Dept., Univ. of Maryland, College Park, MD, [6]Computer Sciences Corp., Glenn Dale, MD, USA, [7]Dept. of Earth, Atmos., and Planet. Sci., MIT, Cambridge, MA, USA.

Introduction: The question of whether water exists on the Moon's surface has long been an enigma to Lunar researchers [1]. Largely, this was due to the thermally extreme lunar surface environment that would seem to preclude any long term maintenance, manufacture, transport or accumulation of hydrogen (H) volatiles over most of the lunar surface [2]. As a result, for many years the cold permanent shadow regions (PSR) in the bottoms of craters near the lunar poles appeared to provide the basic conditions at least for maintenance of lunar hydrogen. Importantly, recent discoveries indicate that there is some hydrogen at the poles [3]. However, the picture of the lunar hydrogen budget may be more complex than the PSR hypothesis has suggested. This evidence comes from observations by the Lunar Exploration Neutron Detector (LEND) onboard the Lunar Reconnaissance Orbiter (LRO) that indicate 1) some H concentrations lie outside PSR and 2) though a few of the larger PSR's have high hydrogen, PSR does not appear to be an independent factor influencing the large-scale suppression of polar epithermals observed by LEND and the Lunar Prospector Neutron Spectrometer [4, 5, 6].

In this research we investigate the possibility that the thermal contrast between pole-facing and equator facing-slopes is a factor influencing the surface distributions of lunar H. We perform this bulk correlated observation and study by developing a thermal proxy from slope data of the Lunar Orbiting Laser Altimiter (LOLA) digital elevation model (DEM) which is registered with the collimated LEND epithermal map [7]. From the LOLA transforms we impose a thermal functional decomposition and systematic statistical analysis of the LEND epithermal map. Our hypothesis testing suggests in most high latitude bands studied > ±45°: **Epithermal rates in pole-facing slopes are significantly lower than epithermal rates in equivalent equator-facing slopes.** As a control study, we find that there is no statistically significant difference between equivalent east and west facing slopes. This finding suggests topographic modulation of insolation is a factor influencing the lunar H budget. Importantly, this result is consistent with observations in terrestrial, Martian research.

Methods: Several important factors influence the design of the methods used in this series of experiments. 1) Due to LRO's polar coverage, LEND map uncertainties increase as a function of lower latitudes increasing correlation uncertainties with small-scale topographic features. 2) LEND maps are long duration accumulations ~2yrs, and diurnal, and seasonal thermal variations are convolved into the maps.

For factor 1) two approaches are used, 1a) use LOLA slope transforms to decompose and classify sets of LEND pixels and to perform class statistical comparisons. This technique takes advantage of the larger areas available in the low latitudes, thus minimizing the issue of uncertainties. 1b) Perform hypothesis testing of LEND epithermal classes as a function of discrete 5° latitude bands. For polar regions we implement 18 independent statistical t-tests (test of class mean differences), 18 F-tests (tests for class variance differences). For factor 2) We define a first-order assumption that the dominant solar irradiance direction *and the expected maximum local annual thermal conditions* for all LOLA DEM pixels occurs at local noon at polar summer solstice. This assumption fixes the solar direction along a given pixel's longitude and defines the requirement for deriving each pixel's slope orientation Φ. This defines a map with a slope orientation continuum with the following coding: [Φ = 0 is pole-facing, Φ =90= East, West-facing and Φ = equator-facing slopes]. Thus, we derive three parameters for each DEM pixel [latitude, slope°, slope angular orientation with respect to the pole-direction Φ].

From these meta-data we perform slope based classifications of LEND epithermal pixels. For experiment 1, we classify pole-facing (**PF**) and equator-facing pixels (**EF**) using the following conditions, 9-latitude bands, High-slope > 5° (to provide local thermal contrast), [**PF** = Φ < 15°, **EF** = Φ > 165°]. Contiguous pixels are region-grown into 'spots' to reduce high pixel spatial correlations and the ground clutter of numerous small spot areas << LEND's FOV = 10km FWHM = ~78 km^2. We only classify spot sizes > 10 km^2 [4]. The average epithermal rate over valid spots is obtained and entered as class sample, Figure 1.

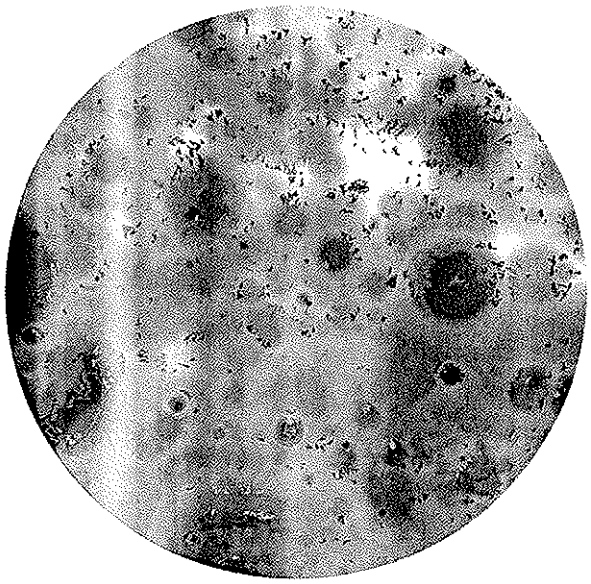


Figure 1: South Pole centered DEM -80:-90, of **PF** *blue* and EF *red* classified spots used in experiment 1. LEND epi's are averaged over spots. Spots $\subseteq$ **Class**

Experiment 1 Results:

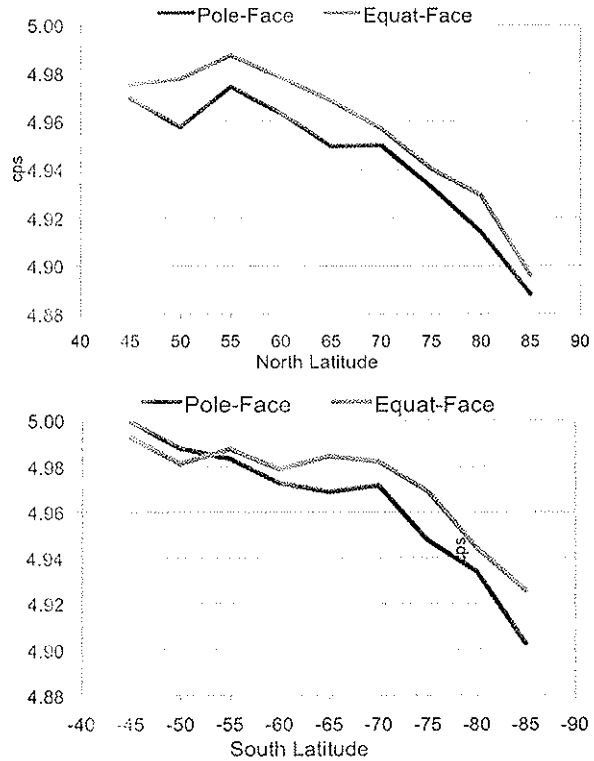
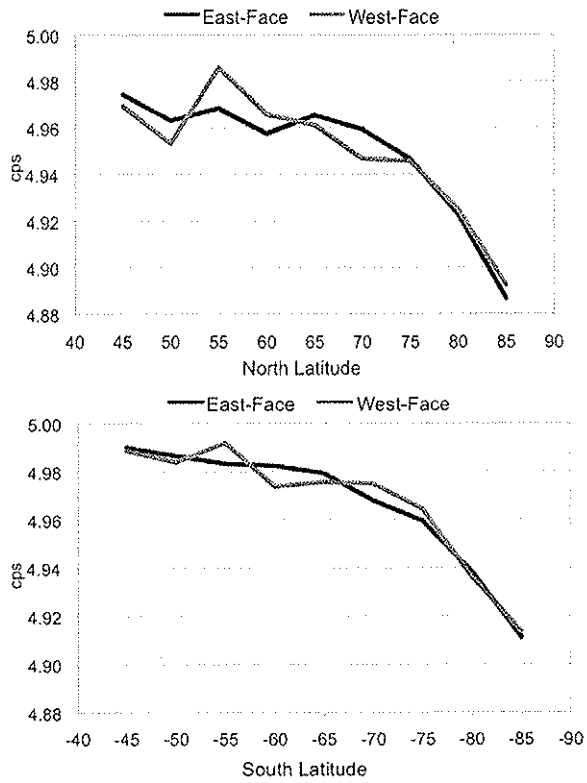


Figure 2a North, 2b South: 5° lat. band, pole-facing **PF** *blue* vs equator-facing **EF** *red* mean epi class rates.

Experiment 1: we evaluate our hypothesis that pole-facing slopes have lower epithermal rates than equator-facing slopes. For 16 of 18 North and South polar latitude bands pole-facing epi-rates were less than equator facing rates. Hypothesis testing using t-tests of the **PF**, **EF** class means in each band (which include latitude uncertainties) indicated 10 of the 16 were significant, p-values $< \alpha$=0.05. From this result we conclude **PF** slopes have lower epithermal rates than **EF** classes in regions > ±60° latitude.

Experiment 2 Results:



Figures 3a North, 3b South: North and South latitude > ±45°, study of **East** vs **West** facing slopes.

Experiment 2: is a control experiment and assumes similar irradiance and thermal conditions for East and West slopes. The hypothesis is that there should be no epi-rate differences in lat bands. Combined North and South evaluations observed in 10 of 18 cases of east vs. west-facing slopes, East-facing slopes had higher epithermal rates. Two low latit. values had significant p-values < 0.05, but 1 for **East**, 1 for **West**. We find no significant differences for **East** vs **West** epi-rates.

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