Introduction: On the Moon, the diurnal variations of the surface temperature are controlled—at least partially—by the thermal inertia of the upper ~30 cm of the regolith, which is in turn linked to the regolith physical properties (i.e., composition, grain sizes, roundness, porosity, sorting, etc.) [1]. Deriving these properties provides fundamental constraints on the current and past geological processes that shaped the lunar surface and other airless bodies throughout the solar system.

The analysis of surface temperature cooling trends acquired during the lunar night by Diviner has demonstrated that the regolith thermophysical properties (e.g., density and conductivity) are not constant with depth, and decrease towards the surface. This observation has led to the definition of the $H$ parameter in order to describe the vertical variations of the thermal properties of the regolith [2].

$H$, derived from diurnal temperature cycles of warming and cooling, reflects the thermophysical properties of the regolith and their changes over the scale of a diurnal skin depth $\delta$ (a few cm to 10’s of cm on the Moon), with:

$$
\delta = \sqrt{\frac{kP}{P C \pi}}
$$

(1)

with $k$ the thermal conductivity (J m$^{-1}$ K$^{-1}$ s$^{-1}$), $P$ the duration of the thermal pulse (s), $\rho$ the density (kg m$^{-3}$), and $C$ the specific heat (J kg K$^{-1}$). Much shorter thermal pulses, such as those associated with lunar eclipses or topography-induced transient shadows, have the potential to allow a derivation of the $H$ parameter over much finer vertical scales (i.e., a few cm) [3].

This work aims to identify promising locales experiencing topography-induced transient shadows, and evaluate their potential for subsurface regolith characterization as a function of depth. We focus on the polar regions, where these transient shadows are most prevalent, and where subsurface variations in thermophysical properties may be associated with ground ice.

Methods: Subsurface regolith characterization using transient topography-induced shadows will require four distinct phases: 1) identification of shadowed locations; 2) quantification of the cooling during the shadowing phase; 3) determination of the energy budget (e.g., solar illumination ephemeris and radiative environment); 4) fit of the observations with numerical model results predicting lunar surface temperatures and using variable regolith properties.

Identification of Sites: We have generated surface temperature maps at a resolution of 128 pixels per degree (~240 m) every 0.5 hours using Diviner Channel 1 (broadband visible wavelength channel) [4]. Sites where signal is consistent with solar illumination are scrutinized for daytime decrease of solar illumination consistent with nighttime conditions, followed by a new episode of illumination are flagged as “shadowed”. Sites characterized by local slopes > 10$^\circ$ are eliminated.

Cooling Determination: Following the same procedure, we have generated surface temperature maps using Channels 7 and 8 (Fig. 1). The temperature of locations flagged as “shadowed” is extracted, as well...
as an average temperature of the nearest “no shadow” terrains for comparison. This step yields a collection of temperature measurements during shadowing and without shadow for adjacent terrains.

**Boundary Conditions**: A quantitative analysis of the surface temperature cooling during shadowing requires the knowledge of the timing of the beginning of the events, as well as the insolation and radiative environment history prior to the shadowing phase. This information is typically not available from Diviner data alone but can be generated using a numerical model of heat transfer for planetary surfaces including ray tracing capability and coupling of adjacent surfaces. This model is used to predict the direct solar input, reflected solar insolation off adjacent surfaces, and radiative environment emanating from the coupling with the local topography) [5]. This information describing the energy balance at any point of the surface is a necessary input for numerical modeling of the surface/subsurface temperature.

**Data/Model Fit**: A numerical model describing the environmental energy budget (see previous section) and heat transfer mechanisms will be used to derive the best fit regolith properties and trends with depth to best reproduce the observed cooling trends. Locations experiencing short duration shadows will be most sensitive to near surface properties, whereas locations experiencing longer duration shadows will display more sensitivity to deeper regolith properties.

**Results**: We have identified 33,000+ locations experiencing transient shadowing induced by topography and meeting our local slope criteria. Fig. 2 displays the observed surface temperature during shadowing, and on nearby terrains where no shadows are observed. This plot typically shows a 0-100 K cooling during the shadowing (69.9 K on average). Fig. 2 blends all the available observations, but manual inspection of a few sites confirms that the amplitude of the cooling seems proportional to the duration of the shadow.

In this abstract, we demonstrate that transient shadows by topography yield a clear and exploitable temperature signal (e.g., 10’s of K of cooling) that will then be used constrain subsurface regolith properties with depth. The presentation associated with this abstract will present the latest advancement of this project.