MAPPING THE EXTENT AND TIMING OF WATER TRACKS WITH HIGH TEMPORAL RESOLUTION SATELLITE IMAGERY IN THE MCMURDO DRY VALLEYS, ANTARCTICA: CAN SUBSURFACE MELT CONDITIONS BE DEDUCED FROM ORBITAL IMAGERY FOR RSL-ANALOGS? L. Kuentz[1], J. Levy[1], M. Salvatore[2] [1]Colgate University Department of Geology, Hamilton, NY 13346, [2]Northern Arizona University Department of Astronomy and Planetary Science. lkuentz@colgate.edu

Introduction: The cold desert ecosystem of the McMurdo Dry Valleys features a variety of seasonal meltwater features [1], including water tracks [2] that may be analogs for shallow groundwater or brine flow features on Mars [3,4]. Water tracks are stretches of soil that exhibit high moisture content during the summer months as meltwater and solutes flow downslope through ice table channels. In satellite imagery they stand out from the surrounding soil as dark patches that develop into linear tracks and branching networks.

Water tracks contribute to microclimate feedback systems because their low albedo and high thermal diffusivity relative to the surrounding soil enhances thawing along these paths [5]. This process also leads to increased evaporation of water in these channels, which leaves behind salt-enriched soils. Additionally, increased clay content in the water tracks [6] suggests that chemical weathering may be more active along these paths than outside of them. Water tracks range in solute concentration from fresh snowmelt to hypersaline [2], bringing some water track habitats near the limits of life for reproduction of terrestrial organisms [7], consistent with high preserved organic matter content in water tracks and relatively low primary productivity and respiration [8].

All these processes: thaw, solute transport, weathering, and metabolism rely on the presence of meltwater and solutes in water tracks. However, the duration and extent of water track thaw remain incompletely constrained [9]. Examining the hydropattern of these cold desert features will inform when and where biogeochemically active groundwater flows, what its sources are, and under what environmental conditions it is available—a problem analogous to determining the seasonal behavior of RSL on Mars [12]. In particular, our goal was to determine whether water track thaw initiates due to snow melt (when ground surface temperatures reach 0˚C) or

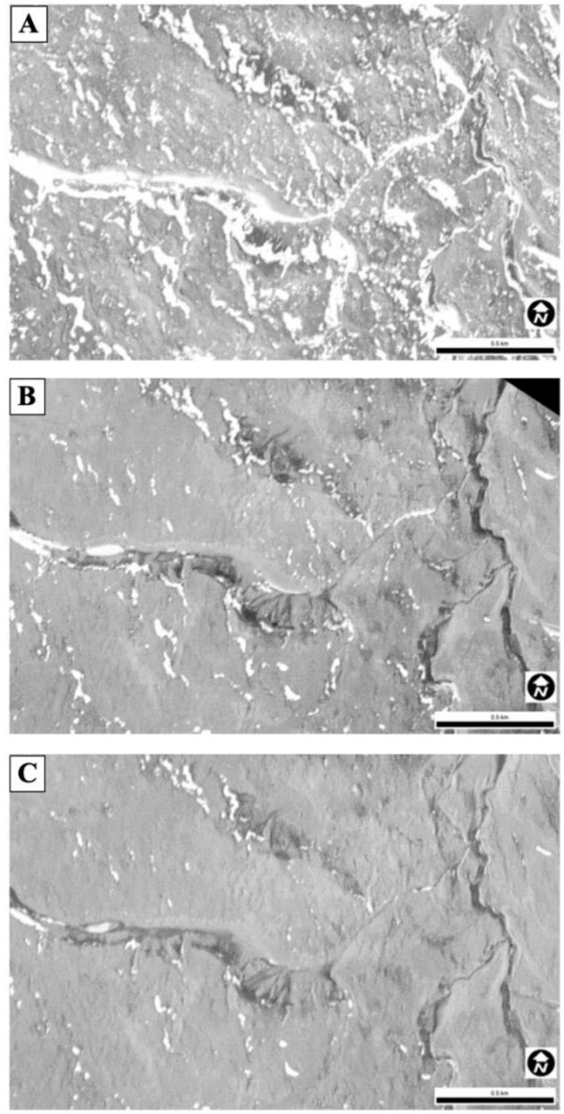


Figure 1: Image sequence at the Coral Ridge water track site shows increasing extent of water track coverage from A. 11/13/2018 to B. 12/06/2018 to C. 12/17/2018. Image contrast has been adjusted uniformly for clarity.

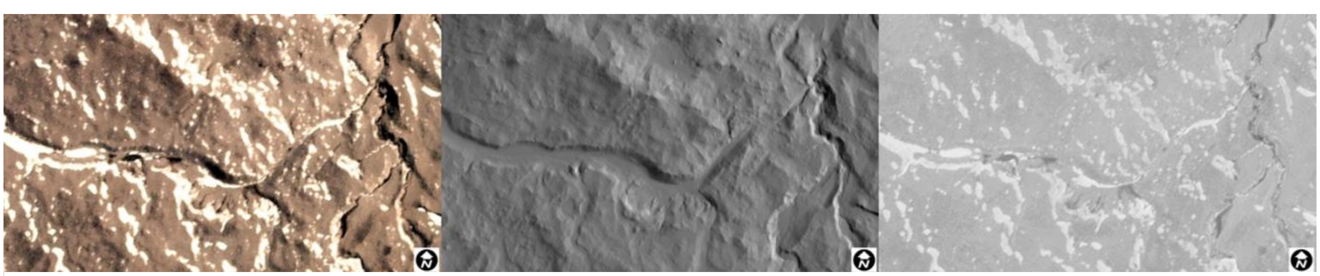
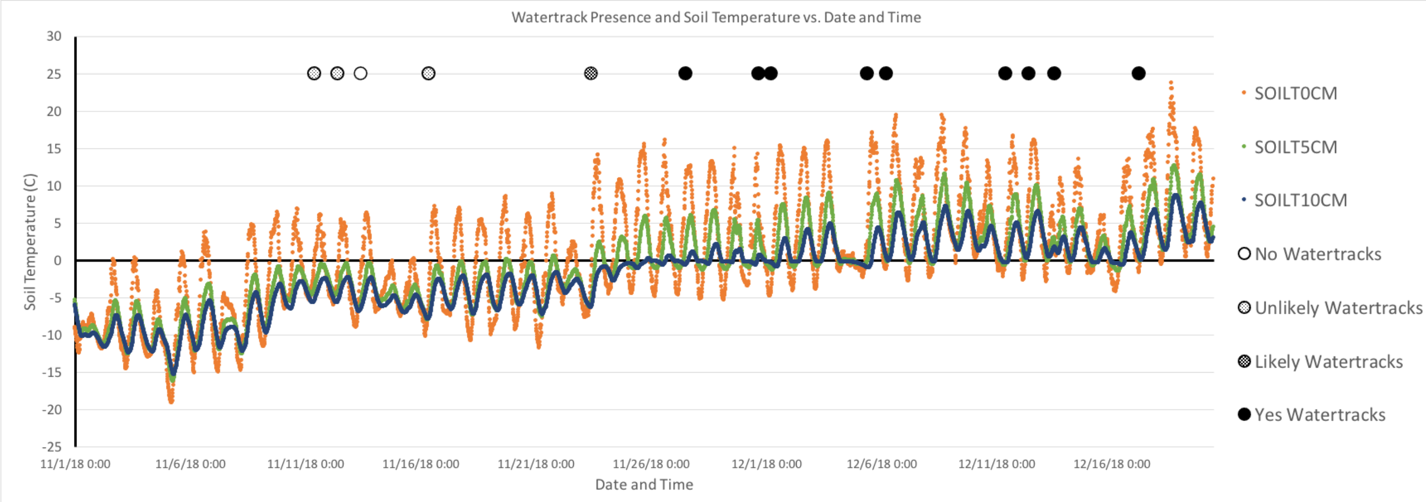


Figure 2: Image processing example. A. shows the original 3-band raster from Planet Labs. B. shows the LIDAR 3 meter DEM. C. shows the final terrain-corrected image with topographical shading removed from a summed reflectance raster calculated from A.



whether subsurface melt or solute-driven freezing point depression determine the timing of thaw.

Image Analysis: We used Planet PlanetScope 8-bit visual image data (RGB and RGBIR) at ~3 m/pixel to identify water track features on daily to sub-weekly timescales in November and December 2018 in a test plot at Coral Ridge, Taylor Valley, Antarctica. Because wetted soil and shadows are both dark in RGB imagery [9], images were corrected for topographic shadowing by generating a time-of-collection hillshade for each scene and subtracting out a linear model for PlanetScope scene summed DNs based on the underlying lidar hillshade [10]. This produces a terrain-corrected image for which brightness changes are entirely due to surface reflectance properties rather than illumination and relief. Although Taylor Valley features significant lithologic variability, the Coral Ridge study site is dominated by only one soil type, Ross Sea Drift,, and so brightness variability attributed to terrain composition is presumed negligible.

Results and Discussion: We find that water tracks at the Coral Ridge site initiate not at the onset of surface temperatures exceeding 0˚C, but rather when temperatures at 10 cm depth reach 0˚C. This suggests thaw of ground ice and wicking of moisture to the surface to initiate water track-related albedo change.

The findings shown here indicate that water track formation is not driven primarily by surface melt fed by nearby snow deposits at this site, but rather by the thaw of underlying ground ice. This site has low measured soil salinity [5], suggesting that freezing point depression and early (sub-0˚) thawing is not occurring.

Knowing the extent, duration, and processes that drive water track formation will determine seasonal habitability for Antarctic organisms and constrain regions of increased chemical weathering across the cold desert. Antarctic Dry Valley water tracks are also particularly interesting for their resemblance to recurring slope lineae (RSL), the seasonal timing for which still remains mysterious [11,12].

Next Steps: The application of these methods to other water track sites in the Dry Valleys is currently underway. A broader spatial scale throughout the valleys will demonstrate how microclimatic effects and soil salinity may influence the timing and extent of water track formation. Furthermore, quantitative analysis of the water tracks' extents using calibrated change in pixel brightness values is still in progress.

Acknowledgements:

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References: [1] Gooseff, M. N., et al. (2016). *Geomorphology*. doi:10.1016/j.geomorph.2016.04.024. [2] Levy, J. S. et al. (2011) *GSA Bul.*, 123, 2295–2311. [3] McEwen, A. S. et al. (2011) *Science* 333, 740–743. [4] Levy, J. (2012) *Icarus*, 219, 1–4. [5] Levy, J. S. & Schmidt, L. (2016) *Ant. Sci.*, 28, 361–370. [6] Levy, J. S. et al. (2013) *Ant. Sci.*, 26, 153–162. [7] Rummel, J. D. et al. (2014) *Astrobio.*, 14, 887–968. [8] Ball, B. A. & Levy, J. S. (2015) *JGR-Biogeo.*, 120, 270–279. [9] Langford, Z. L., et al. (2012) *Ant. Sci.*, 27(2), 197–209. [10] Fountain, A. G. *et al.* (2016) *Earth Sys. Sci. Data*, 66(10), 435-443. [11] Schorghofer, N., et al. (2019) *JGR*-Planets, 124, 2852–2862. [12] Stillman, D. E., et al. (2014) *Icarus*, 233, 328–341.

Figure 1: Plot comparing images with confirmed water track presence with soil temperatures at depths of 0 cm, 5cm, and 10 cm.