EQUATORIAL ALPINE REGIONS AS A SCIENTIFIC ANALOG FOR PAST/PRESENT LIFE ON MARS. D. Viola[1] and C. P. McKay[1], [1]NASA Ames Research Center, Moffett Field, CA.

Introduction: Most regions of modern Mars are predominantly cold (below freezing) year-round. However, few terrestrial Mars analogs meet this criteria. Even in Antarctica, most of the extremophiles found are dormant during the coldest months, reactivating only in summer, when higher temperatures permit the melting of ice [1, 2]. To mitigate this, we propose the study of potential Mars analog environments near the equator to minimize this seasonal temperature fluctuation and at high elevations where temperatures remain below freezing throughout the day. The goal is to identify areas where ground temperatures never/rarely exceed the freezing point of water.

Many equatorial alpine regions host glaciers near their summits [e.g. 3], but significant glacier retreat has been observed in recent decades [4]. Both consistently-cold and actively-retreating glacier regions are of interest for astrobiology. Identifying the microbial biodiversity/activity in these types of habitats will help us understand life under perpetually-cold conditions (analogous to modern Mars) as well as how these parameters change relative to the time since they have emerged from glacier cover (analogous to past Martian climate fluctuations). Here, we present the results of orbital remote sensing efforts (using Landsat 7-8) to characterize two potential Mars analog sites by assessing (1) modern glacier bounds, (2) temporal variations and glacier retreat, and (3) ground temperatures.

Study Areas: Our first target study area is Pico de Orizaba (19°N, 97.3°W), the highest peak in Mexico at 5,636 m. Pico de Orizaba has a small summit ice cap glacier (area~0.6 km^2), which is the largest permanent ice mass near 20°N but which has been retreating over the last several decades [5].

We have also identified a potential South American site: Illimani in Bolivia (16.6°S, 67.8°W). This summit, on the western edge of the Cordillera Oriental (bordering the Antiplano) has an elevation of 6,440 m and is more extensively glacierized than Pico de Orizaba, although recent retreat has been documented [6].

Methods: Orbital multispectral datasets, primarily from the Enhanced Thematic Mapper Plus (ETM+) on Landsat 7 and the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) on Landsat 8, were obtained from the U. S. Geological Survey. We identified images with minimal cloud cover over the summit areas at each study site (and, for mapping glacier extents, minimal snow cover). Glacier extent mapping was performed using semi-automated methods [7-9] using the ratio of the panchromatic and short-wave infrared bands to identify regions with ice/snow, paired with manual vector editing as needed. Surface temperatures are estimated from Landsat's thermal infrared bands, using simple atmospheric corrections [10, 11] and automated surface classifications using the glacier mapping and the normalized difference vegetation index (NDVI) to assign ground properties [12-14]. To assess temporal changes in both glacier extent and ground temperature, these procedures were repeated on as many images as possible since the start of the Landsat 7 mission in 1999.

Discussion: At Pico de Orizaba, we have observed approximately 100 m of horizontal glacier retreat at the northeastern face over the past twenty years (total area loss of ~1/3 since 2000) [15]. In addition, soil temperatures southwest of the glacier were found to be consistently below the freezing point of water (-5 to -15°C) in all images [15]. Therefore, future fieldwork should target this area to assess the microbial biodiversity/activity to better understand any ongoing processes in this consistently-cold environment.

Glacier mapping and surface temperature estimation are ongoing at Illimani. Retreat has been observed in several glacier tongues over the last 20 years, and ground temperatures appear to be lower to the west of the summit, on the drier side of the Cordillera Oriental – also promising for the Mars analog potential of this location. However, additional work must be done to compile data from all available time points to identify any seasonal fluctuations.

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