ANCIENT EOLIAN LANDFORMS AND FEATURES FROM A TERRESTRIAL MID-LATITUDE PERIGLACIAL ENVIRONMENT. M. Demitroff1, M. Cicali2, J. Smith3, and A.N. Demitroff2, 1University of Delaware, Department of Geography, 216 Pearson Hall, Newark, DE 19716 (mdemitrof@udel.edu), 2Richard Stockton College of New Jersey, School of Natural Sciences and Mathematics, Environmental Science Program, 101 Vera King Farris Drive, Galloway, NJ 08205, 3URS - FAA William J. Hughes Technical Center, ANG-E332, Atlantic City, NJ 08405, 4Nature Conservancy, Delaware Bayshore Office, 2350 Route 47, Delmont, NJ 08314.

Introduction: The “Pine Barrens” region of southern New Jersey has recently been the focus of intensive examination of evidence for deep seasonal frost and permafrost [1,2,3]. Surprisingly little is known of the Mid-Atlantic States’ cold, nonglacial (periglacial) history, a dynamic dry, windy, and poorly vegetated environment subject to abrupt changes. Conditions in southern New Jersey during the Late Glacial Maximum have few modern terrestrial analogs. Cryostratigraphic studies of the region’s Coastal Plain has revealed Pleistocene periglacial relicts that could provide serviceable analogs for Mars eolian research.

Remote Sensing: Laser altimetry provided survey through the region’s dense vegetation to reveal the underlying terrain. Down-looking airborne light detection and ranging (LiDAR) point cloud data were used to reveal bare-earth ground terrain. This was performed using high resolution LiDAR (1 meter) geodetically corrected data captured in early April 2010. The LiDAR data enabled the separation and extraction of surface vegetation from the measured bare-earth ground surface. The geodetically controlled bare-earth point cloud matrices and surfaces were modeled and analyzed using Quick Terrain Modeler (QtModeler) version 7.1.5. Through this analyses, it was evident strong density-driven katabatic winds from the Laurentide Ice Sheet and enhanced westerlies sculpted Pine Barrens ground through sand deposition and deflation. Subtle en-echelon parabolic dunes and sand sheets were formed, remnants of a sand-starved eolian system. South Jersey sediments were often frozen when winds were strongest [4]. Eolian landforms interacted with the local paleohydrology. In some places dunes occluded, dammed (Figure 1), or avulsed drainage ways, in others fluvial channels cut across and reshaped ancient eolian bed forms. Numerous playa-like deflation hollows have been recorded [5].

Fieldwork: A suite of macrostructures observed in the field, abundantly expressed in local sand and gravel operations, also provided evidence of past permafrost and rigorous periglacial conditions. Ventifacts were abundant, often present in lag pavements. Cracks of primary infill ranged from small desiccation fissures in fragipan to somewhat enigmatic ground or soil wedges produced under deep-seasonal frost (cryodesiccation) to large (+2.5 m depth) thermal-contraction sand-wedge casts [1,4,6]. Along with features associated with a cooling climate (e.g., permafrost aggradation) were features of climate amelioration (e.g., permafrost degradation). Subsidence structures attributable to melt of ground ice, such as modified sand wedges and sediment-filled pots (bulb-like wedge intersections), were also commonplace. Fragipan, a densified soil horizon, was coincident with the prior permafrost table [2]. Cryogenic weathering of silicates, a process best developed in the active layer of permafrost regions, was represented in local paleosols [7,8].

Conclusion: Examination of Pine Barrens periglacial phenomena will add to the range of Earth analogs for Mars dune studies, especially concerning mid-latitude climate change dynamics. The frozen ground of Mars and New Jersey both experienced: 1) diurnal cycles of high-amplitude temperature change across the freezing point; and 2) polycyclic warming and cooling episodes possibly related to Milankovitch cycles. By comparison, Antarctica or Baffin Island may share a very cold Mars-like environment, but these high-latitude Earth analogs have been relatively quiescent from a geomorphological perspective. South Jersey’s periglacial features provided good representation of the effects of the polycyclic nature of global climate change, in a location far more accessible than high-latitude locations like Greenland or Antarctica. Similarities between the mid-latitude regions of Earth and Mars during cold climatic intervals will help us better understand the past geologic temperature record of both realms, and help predict future changes as a consequence.

Figure 1: LiDAR image of a completely dune blocked paleochannel at Indian Branch (1–3 m infill), an event that has been luminescence dated to $28.16 \pm 2.80$ ka BP. A layer from 1931 aerial photomosaics [9] has been added to show fossil patterned ground polygons behind the dam. Damming coincided with MIS 3 climate amelioration and regional development of thermokarst terrain. Location 39 33 20.22, -74 48 47.26.

Figure 2: Typical Late-Pleistocene and Holocene terrace stratigraphy of the Pine Barrens, southern New Jersey. The smaller wind-faceted pebbles are commonly found beneath Holocene colluvium and above Late Tertiary-age sand and gravel. The sketch shows Late Pleistocene periglacial features, including $\geq$MIS-4 and MIS-2 frost cracks, a MIS-3 thermokarst thaw bulb with inclusions, fragipan fissures capped by cover sand, and Holocene (Pleistocene-transitional?) colluvium. Modified from [10].