important goal and is essential for assessing the potential for life to have existed on the planet over its recent history.

The thin atmosphere and low temperatures that are thought to have persisted on Mars throughout the Amazonian (Carr, 1996) mean that water-related landforms (regardless of whether in the solid or liquid phase) can be important indicators of the presence of specific environmental conditions. For example, the presence of fluvial landforms, however limited in distribution and scale, can indicate the presence of climatic conditions conducive to surface melting (i.e. surface temperatures above 273 K, assuming the absence of salts, which can enable melting point depression). The presence of deposits indicative of glaciers, without evidence for basal or surface melting, signals the presence of climatic conditions permitting sufficient accumulation of snow and ice to cause cold-based ice flow (i.e. glaciers that are frozen to their bed and flow through internal deformation rather than basal sliding). The combination of glacial landforms and meltwater might signal conditions favoring wet-based glaciation. Finally, superposition and overprinting of landforms produced by cold-based ice with those of a fluvial origin point to initial glacial conditions *followed* by melting conditions (e.g., Milliken et al., 2003; Head et al., 2008).

In summary, many landforms are produced within a narrow range of conditions and thus can be extremely sensitive indicators of local climate. The linkage of climatically sensitive surface processes and resultant landforms, e.g., climatic geomorphology, is highly dependent on both the spatial scales of the landscapes being studied and the temporal scales over which the landforms are generated. For climatic geomorphology, the assumptions are either that (1) the landforms observed are in equilibrium with prevailing climate conditions (see also Chorley et al. (1985) for more discussion); or (2) for large-scale landforms and landscapes that have evolved over long periods of time and experienced multiple climatic transitions, the distinctive elements inherited from past conditions are still preserved and recognizable in the morphologic record. As an example of the latter, we highlight the combined imprints of both ancient fluvial incision and modern glaciation that are still preserved within the Antarctic Dry Valleys (Sugden et al., 1995; Jamieson et al., 2008). Likewise, on Mars the fretted valleys and associated alcoves along the northern dichotomy boundary of Mars show evidence for initial alteration by liquid water during the Early Hesperian (Irwin et al., 2004) followed by subsequent Amazonian glaciation (e.g., Head et al., 2006b).

Here we report on geomorphological investigations of Asimov Crater located in Noachis Terra at 46°S, 5°E (Figs. 1–3), a site chosen because of its unique mid-latitude setting and its distinctive topographic configuration that displays an unusually wide range of insolation conditions. Within the site we have identified a multitude of distinctive ice-and-water-related landforms of various scales, including lobate debris tongues and gullies. Through the morphological analyses of these features, and investigations of their relative age and stratigraphy, we reconstruct and interpret changes in local climatic conditions during the Late Amazonian. We then place this analysis within the context of larger-scale morphological investigations conducted elsewhere on Mars (e.g., Mustard et al., 2001; Milliken et al., 2003; Head et al., 2006a,b; Morgan et al., 2009).

2. Data sets and analysis

The identification of landforms made use of all available image data sets. The study area was initially chosen because of its unusual setting and the extensive available imagery, including full coverage of Context Imager (CTX) images (8 m/pixel) and High Resolution Stereo Camera (HRSC) images (18 m/pixel), in addition to 16 HiRISE images (0.3 m/pixel) and 73 Mars Orbital Camera (MOC) narrow angle images (1.5–12 m/pixel). The investigation was conducted using a Geographical Information System (GIS) database comprised of the visible image data sets co-registered and overlain on digital terrain models (DTMs). The topographic data was derived from both 128 pixel/degree gridded Mars Orbiter Laser Altimeter (MOLA) data and Mars Express HRSC stereo data (200 m/pixel) derived from HRSC orbit 1932_0000. ESRI's ArcMap (9.2) provided the GIS platform, which in addition to data set management was also used to produce slope maps and topographic

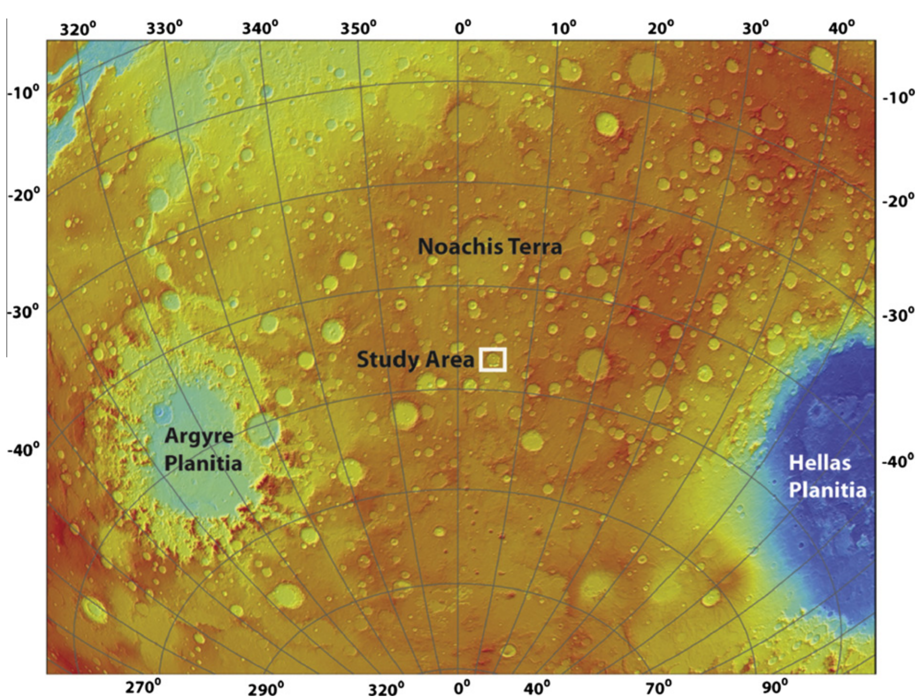

Fig. 1. Regional setting of the Asimov Crater study area on Mars. MOLA shaded relief overlain on MOLA gridded data. Red is high, blue is low. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)