considered if no portion of the rim had been breached or eroded to the level of the adjacent unit. Ice-related flow features found within craters with rims that are breached at any point were segregated into a separate category and assessed for potential infilling of ice/debris from a regional ice field. A conformal projection was necessary to preserve angles at all latitudes, so all mapping of flow orientation was conducted in a Mercator map projection. Previous studies have determined the necessary requirements for mapping ice-related flow on Mars, so we utilized the criteria listed by Head et al. (2010). Among the 14 criteria that they defined, several provide information not simply about the presence of ice, but the orientation of flow. These include: (1) parallel arcuate ridges trending away from the host crater wall (Fig. 1c); (2) constriction of flow between obstacles; (3) broadening of arcuate ridges on unobstructed plains; (4) folding and deformation of broad lobes into smaller lobes; and (5) integration of multiple smaller lobes into larger lobes (Fig. 2a). Rare instances where flow was apparent but the direction of flow was ambiguous were not included in the orientation measurements. A line indicating the direction of flow was mapped for each individual lobe that we observed. Hence, a suite of smaller individual flows would be statistically amplified in our study, relative to a broader lobe of material. Each line indicative of flow was traced back towards the host crater wall, where the orientation measurement was made. Thus, depending on the original source of the ice, we are either measuring (1) where ice accumulated on the wall and the direction of localized flow, or (2) the direction from which ice overtopped the crater from the surrounding plains, with the steep crater rim providing a source for rock-fall and debris-cover not available on the adjacent plains. Considering that present topography on ice-related flow features is not necessarily indicative of topography at the time of maximum ice-volume (Dickson et al., 2008, 2010), only surface morphology was used to evaluate flow direction.

3. Results

Our survey provides the most complete map of the distribution of ice-related landforms yet constructed for the mid-latitudes of Mars. Fig. 3a shows the mid-latitude distribution of all CTX orbits

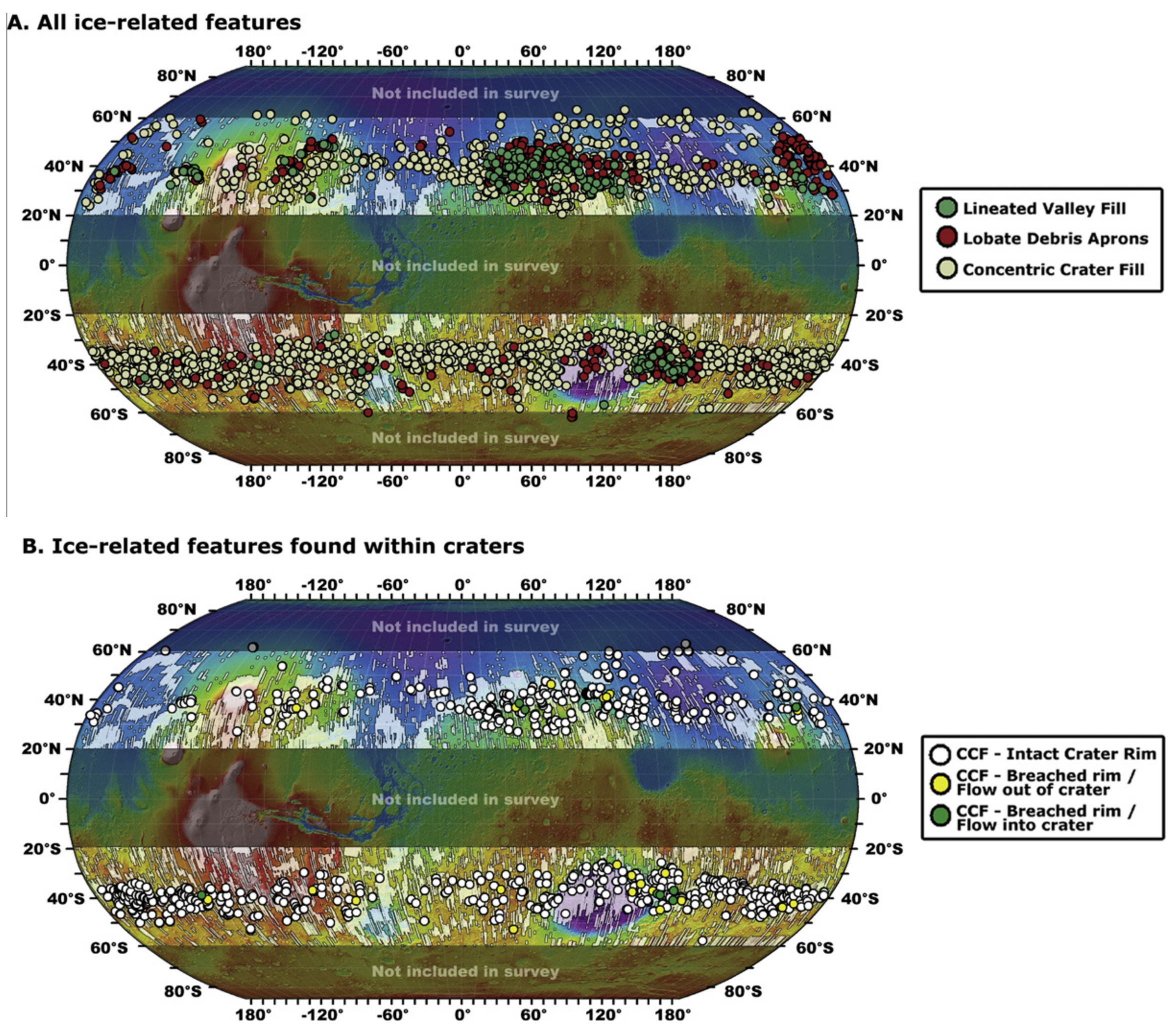

Fig. 3. (A) The distribution of ice-related flow features (LDA, LVF, CCF) in the mid-latitudes of Mars (20–60° in each hemisphere). Each dot represents the center coordinates of a CTX frame that contains any features known to be the product of ice-related flow. A footprint map of all CTX images included in the survey (through mission phase B09) is rendered in white to show where targeting heterogeneities could potentially influence data accumulation and interpretations. Ice-related flow is abundant in each hemisphere poleward of 30°, particularly where steep topography occurs. Map projection is Robinson. (B) The distribution of flow features confined to the interior of impact craters with fully intact rims in the mid-latitudes of Mars. Each dot represents a mapped feature from our survey. The distribution of flow features within impact craters is identical to that of ice-related flow features as a whole in the mid-latitudes, suggesting that there is nothing intrinsic to the impact process itself that enhances or inhibits glaciation on Mars. Craters that show evidence for flow out of (yellow) or into (green) are displayed here but were not used for orientation calculations, as they did not contain intact rims. Map projection is Robinson; measurements were made in Mercator projection. Background map is MOLA color topography over a global MOLA hillshade map. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)