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Introduction: The Subsurface Water Ice Mapping (SWIM) project supports an effort by NASA's Mars Exploration Program to inform *in situ* resource availability [1–2]. We are performing global reconnaissance mapping and focused multi-dataset mapping to characterize the distribution of water ice from 60ºS to 60ºN (Fig. 1). In 2019, we produced ice consistency maps for the northern hemisphere (0–60ºN and 0–225ºE, 290–360ºE). In 2020, we are extending our mapping into the southern hemisphere (0–60ºS) and 225–290ºE in the northern hemisphere at elevations < +1 km. Our maps are being made available on the SWIM Project website (https://swim.psi.edu), and we intend to complete our global mapping by the summer of 2020. Follow us on Twitter @RedPlanetSWIM for project news and product release information.

The SWIM Datasets: To search for and assess the presence of shallow ice across our study regions, we are integrating multiple datasets to provide a holistic view of the upper 10s of m of the Martian subsurface. The individual datasets we consider include neutron-detected hydrogen maps (MONS), thermal behavior (TES, THEMIS, and MCS), multiscale geomorphology (HiRISE, CTX, HRSC and MOLA), and radar surface and subsurface echoes (SHARAD) [3–10]. Along with these datasets, we are incorporating locations of ice-exposing impacts [11] and icy scarps [12] as 'ground-truth' locations to tie our methods into direct observations of intact Martian subsurface ice. It is important to note that this study does not intend to identify all existing ice, because currently available data impose limits on lateral and vertical resolutions as well as the sensing depth (Fig. 2). We are also developing new techniques to improve the detection of water ice within 5 m of the surface [13,14].

The SWIM Equation and Ice Probabilities: For the 2019 work, we used the SWIM equation [1,2] to provide a quantitative assessment of how consistent (or inconsistent) the various remote sensing datasets are with the presence of water ice. Mapping results for each dataset are assigned consistency values ranging between +1 and -1, where +1 means that the data are consistent with the presence of ice, 0 means that the data give no indications of the presence or absence of ice, and -1 means that the data are inconsistent with the presence of ice.

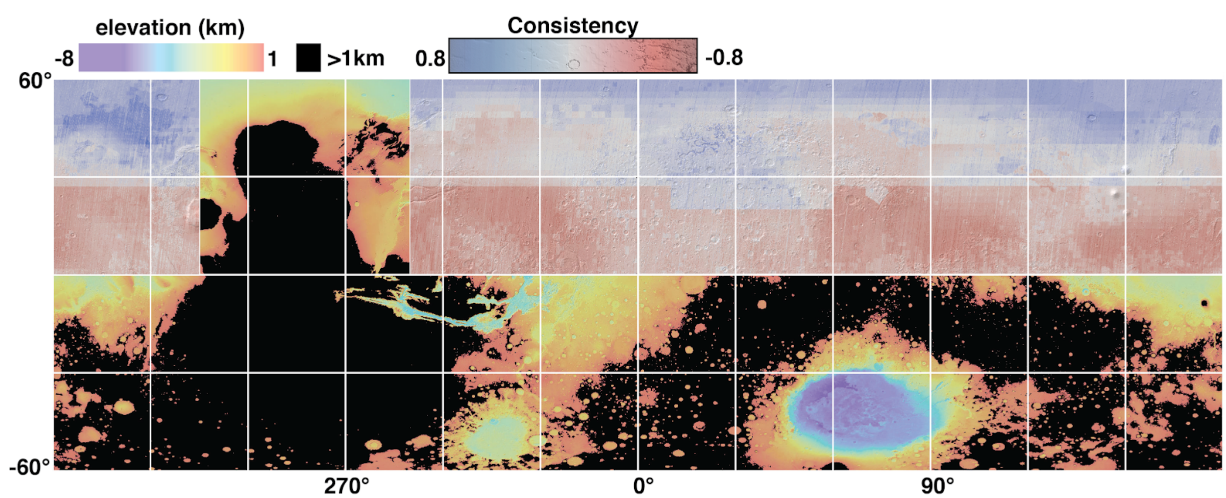

Figure 1: Caption Composite map incorporating resulting from 2019 SWIM and highlighting the new regions covered in 2020 SWIM. The northern hemisphere minus Tharsis shows where the data are consistent (blue) and inconsistent (red) with the presence of subsurface water ice. Our analysis for 2020 SWIM focuses on areas below 1 km in elevation (rainbow color scale) as those elevations are considered valid for human landing site targets.

The SWIM equation combines these results to yield a composite ice consistency map for all available data (Fig. 1). Presently, the combination is carried out by a simple averaging process, and is thus not a formal representation of ice probability.

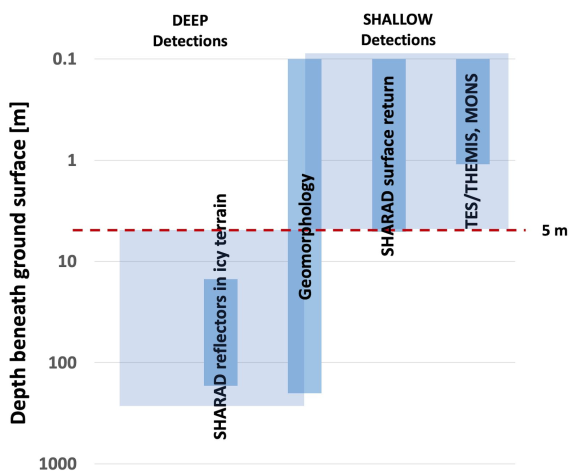

Figure 2: Depth resolutions of the data sets currently in use. In broad terms, the available datasets examine four zones: 1) the surface itself: image and elevation data; 2) the upper ~1 m: thermal and neutron spectrometers; 3) the upper ~5 m: radar surface reflections, and 4) ~20–>100 m: radar reflections from sub-surface interfaces.

We are currently revisiting the formulation of the SWIM equation through Bayesian statistics [15]. We seek to modify the SWIM equation such that, for any location on Mars, it can assign an ice content percentage with a corresponding uncertainty value. To accomplish this goal, we will relate data from each remote-sensing method to probability density functions that represent percentage ice content. The conjunction of all the probability density functions yields one final cumulative probability density function representing our combined knowledge of ice content from every dataset.

Project Infrastructure: Since the SWIM team has investigators located throughout North America, we developed a project infrastructure to facilitate information sharing, ease of access, and consistency of data analysis for the duration of the project [16]. We created a shared file system ("Swimming Pool") with built-in fail safes and routine backups in the event of catastrophic systems failure of either the equipment or the investigator. The Pool centralizes the individual datasets and analyses, which allow users to work on multiple study areas in different locations. The Pool houses the various Seisware projects used for radar data analysis, TES and THEMIS analysis data, geomorphological data and regions of interest, resources and references for investigators, and preliminary results used to generate the overall consistency maps. An additional aspect of the project infrastructure is the web application MARSTHERM (https://marstherm.psi.edu) [17], which will be undergoing major updates to the underlying thermal modeling code during the SWIM project [12].

Public Access and Outreach: To disseminate information and products to other researchers and the public, we created the SWIM website (https://swim.psi.edu) and established a social media presence (@RedPlanetSWIM). Our deliverables include presentations and publications, individual dataset results and consistency maps, and composite consistency maps created using the SWIM equation.

Other presentations: Preliminary results for the 2020 phase of SWIM are available in various presentations at this LPSC: Putzig at al. (summary), Baker et al. (geomorphology), Sizemore et al. (thermal and neutron analysis), Morgan et al. (surface reflectivity), Petersen et al. (radar subsurface mapping), and Bain et al. (site analyses).

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