ASSESSING HABITABILITY ON MARS USING ORBITER DATA AND A HABITABILITY INDEX.

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Introduction: One of the challenges facing astrobiological investigations of Mars is determining which locations on the planet possess the highest probability of past or present habitability. Often studies utilize specific data sets to investigate individual aspects of habitability in select martian environments [e.g. 1-10]. These types of studies have been, and continue to be, invaluable. However, habitability is the product of a combination of factors within a common environment - not just one [11, 12]. Further, our experiences on Earth in places like the Antarctic or Atacama Desert tell us that some environments are more habitable than others due to a range of factors. As our understanding of both life and Mars evolves, our investigation approach to habitability should also evolve to one that can take into account more of the library of data now available to us.

Habitability Indices (HI) are equations which incorporate multiple datasets to produce a habitability probability or "score" for an environment. These equations have been applied to exoplanets, as well as martian landed mission sites [13-15]. Stoker et al., (2010) [14] developed an HI (HI_{surf}) to make habitability assessments of completed or in progress surface mission sites by expanding on an index (HI_{MEPAG}) suggested by the Mars Exploration Payload Analysis Group (MEPAG) [13]. In this work we have begun to develop a HI (HI_{Orbit}) which allows orbiter data incorporation so site assessments can be made in advance of, or without the requirement of, a prior surface mission.

Methods: For the index being developed here, a series of contributing factors, F_x (where F is the value of contributing factor x, *e.g.* "F_{water}") are assigned values according to a prescribed reference table. Factor values range from 0 to 1, with 0 meaning the factor is not present and 1 meaning it is absolutely present. Our current preliminary HI considers 9 contributing factors including: water evidence, nutrients, energy, and biomineralization, as well as environments inventoried by Dohm et. al., 2011.

Because not all contributing factors hold the same importance to potential habitability on Mars, they are grouped into weighted categories (i.e. C_3, C_2, C_1). These categories are labeled as "Major (C_3)," "Important (C_2)," and "Influencing (C_1)," in order of decreasing weights. Factors in each category (C_i) are averaged and then weighted with a multiplier (i) to create a category value:

$$\boldsymbol{C_i = \{\overline{F_{(x1)}F_{(x2)}F_{(x3)}\ldots}\} \times i,}$$

With calculated weighted category values, HI_{orbit} is calculated as an average by summing the categories and dividing by the sum of the weights:

$$\boldsymbol{HI_{Orbit} = \frac{\Sigma_{Ci}}{\Sigma_i}.}$$

Dividing by Σ_i brings the values into a range of 0 to 1 while still retaining weight on individual categories.

Preliminary Results and Ongoing Work: A comparison of scores from HI_{Orbit}, HI_{surf}, and HI_{MEPAG} show that HI_{Orbit} produces similar relative results as the other indices (Table 1). The current version of HI_{Orbit} produces a narrower overall score span, however, HI_{Orbit} has the advantage of using orbital data, thus previously landed missions are not required for habitability indexing.

In future work, HI_{Orbit} will be refined to increase the score span and include additional contributing factors. The index will eventually be applied to a variety of unvisited sites on Mars to assess habitability. These types of indices may be useful tools in helping to direct future martian surface missions.

Table 1. Preliminary results from HI_{orbit} compared to other HI's.

Mission	HI_{orbit}	HI_{surf}	HI_{MEPAG}
MSL	0.64	NA	NA
Phoenix	0.58	0.43	0.53
Opportunity	0.57	0.23	0.46
Spirit	0.57	0.22	0.36
Viking 2	0.50	0.07	0.10
Viking 1	0.50	0.01	0.02
Pathfinder	0.47	0.05	0.10

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