PLANETARY HABITABLITY FROM THE PRE- TO POST-MAIN-SEQUENCE R. M. Ramirez[1,2] and L. Kaltenegger[1], [1]Institute for Pale Blue Dots/Astronomy/Cornell [2]Center for Radiophysics and Space Research (rramirez@astro.cornell.edu).

Introduction: The ability to measure habitability on an extrasolar planet is closely linked with the detectability of biosignatures in its atmosphere. That determines the limits of the liquid water habitable zone (HZ), the circular region around a star in which liquid water could be stable on a planetary surface for an Earth-like planet [1]. The HZ is a tool that guides future missions and surveys to find potentially habitable planets around other stars. To date, the vast majority of habitability studies have focused on the main-sequence stage of stellar evolution, implicitly extrapolating habitability conditions valid for the present day to other stars at various stages of stellar evolution [1-3]. However, several investigators have argued that 1) the temporal dependence of the HZ shoud be accounted for, and 2) potentially habitable worlds face distinct challenges during the post- and pre-main-sequence stages of a star's lifetime [4-6]. Thus, an updated HZ boundary "roadmap" for next-generation missions will require an improved understanding of how stellar evolution influences planetary habitability.

Methods: We use a new version [5] of the 1-D radiative convective climate model of [1], which has been recently updated to model stars of stellar effective temperatures ranging from 2400 K – 10,000 K (~M8 to A5 spectral class) [5] with Bt-Settl stellar models to derive these new limits through a star's lifetime [2].

Results and Discussion: One issue HZ planets face during the pre-main-sequnce is potential devolatilization in the initial superluminous stage of their host stars (Fig. 1)[5-6]. In contrast, although the post-main-sequence is characterized by low radiation levels [7], high stellar winds can lead to massive atmospheric erosion of HZ planet atmospheres [8]. Although HZ planets face certain challenges during the pre- and post-main-sequences, these are not unsurmountable. A recent study suggests that "gatekeeper planetesimals" allow M-dwarf HZ planets to acquire up to a couple of hundred Earth oceans of water [9]. Moreover, HZ planets can potentially be resupplied later. In comparison, post-main-sequence HZ planets benefit from low EUV cosmic environments. Also, it is possible that life that is submerged underneath an ice layer can reemerge once surface temperatures become high enough for the ice to melt, potentially triggering further evolution [5]. Tidal-locking and flares are among other problems that some HZ planets face during all stages of stellar evolution [1, 10-11]. However, we discuss potential solutions to all of these problems. The likelihood of habitable conditions for icy rocky moons and planets that undergo defreezing due to excessive heating during their lifetime will also be discussed.

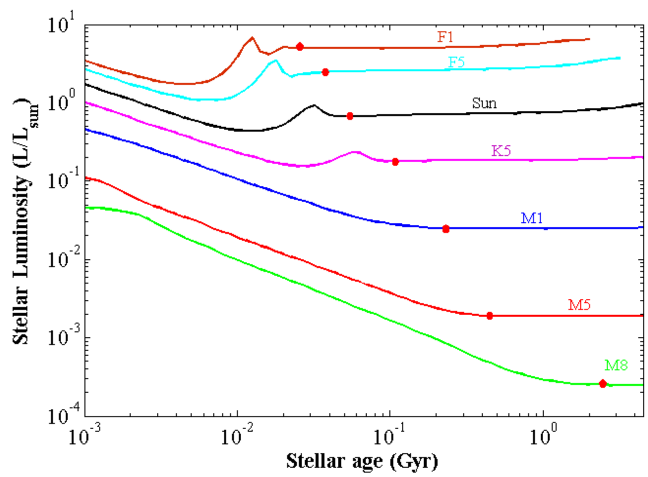

Figure 1: Evolution of stellar luminosity for our grid of F-M stars (F1, F5, Sun, K5, M1, M5, and M8). When the star reaches the MS (red point) its luminosity curve flattens (from [5])

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