UV SURFACE ENVIRONMENTS OF M STAR PLANETS: SURFACE HABITABILITY & TEMPORAL BIOSIGNATURES. J. T. O'Malley-James[1] and L. Kaltenegger[1], [1]Carl Sagan Institute, Cornell University, Ithaca, NY 14853, USA.

Introduction: The nearest known habitable planets orbit red dwarf (M) stars in the solar neighborhood, such as Proxima Centauri[1], TRAPPIST-1[2] and LHS-1140[3]. More nearby habitable worlds around similar stars will be uncovered in the near future. Therefore, the first cohort of habitable worlds we are likely to characterize will be orbiting nearby M stars. However, M stars present a challenge for habitability in the form of strong, frequent flares. These flares can cause surface ultraviolet (UV) radiation fluxes on habitable zone (HZ) planets to increase by up to two orders of magnitude[4], which would be harmful for any surface life. Even more intense UV surface regimes would exist on planets without protective ozone layers, or planets with thin atmospheres.

Biosignatures exhibited by life on Earth may not be present on these highly UV-irradiated worlds. Any surface life would need to employ UV defense strategies, while atmospheric biosignature gases could be reduced or erased. Therefore, we need to begin assessing the UV environments of these planets to determine the types of life that could both survive and produce observable biosignatures. These biosignatures could be very different from the traditional suite of signatures associated with Earth's biosphere.

Here we begin this process by presenting models of the UV surface environments of the TRAPPIST-1[5] and Proxima Centauri[6] systems, for both oxygen-containing and anoxic atmospheres over a range of possible atmospheric densities. We compare these environments to the known tolerances of terrestrial life and determine the forms of life best suited to forming stable biospheres on these worlds.

Methods: The high-energy X-Ray and EUV fluxes from stars like these can erode planetary atmospheres. Therefore, our model atmospheres range from dense 1 bar atmospheres to low-density 0.1 bar atmospheres. To simulate UV surface radiation environments we use a coupled 1D radiative-convective atmosphere code developed for rocky exoplanets (EXO-Prime)[7] with stellar input spectra based on observations or models of the active M star hosts.

Results: If a dense Earth-like atmosphere with a protective ozone layer could be maintained on these planets, UV surface environments would be similar to the present-day Earth, even for highly active stars. However, eroded or anoxic atmospheres allow high shortwave UV fluxes to reach planetary surfaces, making surface environments hostile even to highly UV-tolerant terrestrial extremophiles (*Fig. 1*). If future observations detect ozone in the atmospheres of any of the HZ planets around active stars, these would be interesting targets for the search for surface life. However, some UV defense strategies, such as biofluorescence could produce an observable temporal biosignature for more highly UV-irradiated planets during flares[8][9].

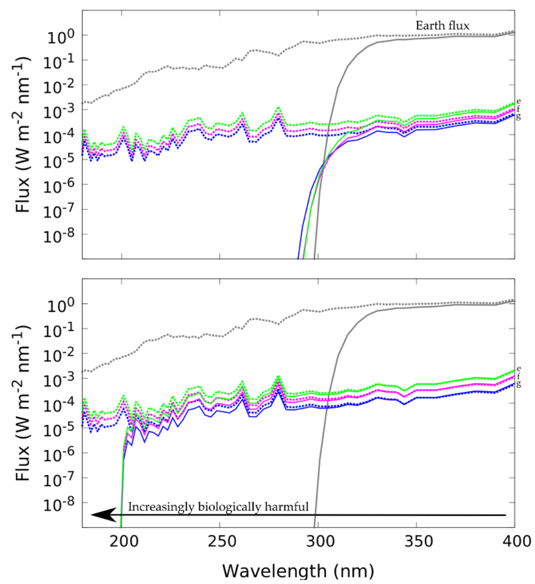

***Figure 1**. Model UV top-of-atmosphere (dashed) and surface fluxes (solid) for the TRAPPIST-1 system (planets e, f, g)[5]. (Top) Earth-like atmosphere. (Bottom) Anoxic atmosphere. Earth fluxes are shown for comparison in gray. Surface UV fluxes increase to extremely biologically damaging levels for anoxic and low-density atmospheres, making planets uninhabitable for exposed surface life.*

References:

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