EVOLUTION OF THE WATER CONTENT OF PROXIMA CENTAURI b. R. Luger[1,2], R. Barnes[1,2], R. Deitrick1,2, R. Luger[1,2], P. E. Driscoll[2,3], T. R. Quinn[1,2], D. P. Fleming[1,2], B. Guyer[1,2], D. V. McDonald[1,2], V. S. Meadows[1,2], G. Arney[1,2], D. Crisp[2,4], S. D. Domagal-Goldman[2,5], A. Lincowski[1,2], J. Lustig-Yaeger[1,2], E. Schwieterman[1,2] [1]Univ. of Washington, Department of Astronomy; rodluger@uw.edu, [2]NASA Astrobiology Institute - Virtual Planetary Laboratory Lead Team, USA, [3]Department of Terrestrial Magnetism, Carnegie Institution for Science, Washington DC, [4]Jet Propulsion Laboratory, Cal. Tech., Pasadena, CA, [5]Planetary Environments Laboratory, NASA Goddard, Greenbelt, MD

Introduction: The recently discovered planet Proxima Centauri b, the closest known exoplanet, is a small and potentially terrestrial world residing in the habitable zone of its host star [1]. Whether or not it is habitable, however, depends on many factors, since a host of planetary, stellar, and even galactic processes can fundamentally affect the planet's ability to support life [2]. Here we focus on how the coupled evolution of the star, the planetary atmosphere, and the planetary surface may have contributed to the loss of vast amounts of water from Proxima Centauri b, potentially rendering the planet uninhabitable.

Low mass M dwarfs such as Proxima Centauri experience a prolonged and extremely active pre-main sequence phase, during which the bolometric luminosity is a factor of several higher and the X-ray/extreme ultraviolet (XUV) flux is orders of magnitude higher than the respective values during the main sequence [3]. Exposed to such high levels of radiation, a water-rich Proxima Centauri b would have spent its first ~200 Myr in a runaway greenhouse, losing photolytically-produced hydrogen to space in a vigorous XUV-driven hydrodynamic wind and thus depleting its surface water reservoir.

Methods: We present our ongoing efforts to model the history of water loss from Proxima Centauri b. We couple a stellar evolution model [4] to a 1D hydrodynamic escape model [5] and a simple O+H photochemistry scheme to model the escape of hydrogen from the planet and the evolution of its surface and atmospheric water content. We simultaneously model the absorption of photolytically-produced oxygen by a surface magma ocean, whose evolution we model similarly to [6], to obtain predictions for the present-day atmospheric oxygen abundance on Proxima Centauri b.

Results: Preliminary results suggest that Proxima Centauri b may have lost several Earth ocean equivalents of water and built up massive amounts of O_2 in its atmosphere over its ~5 Gyr lifetime. The Figure shows the water loss as a function of time for a simple energy-limited escape model and no photochemistry. Nearly 10 terrestrial oceans (TO) are lost in these simulations. We are currently developing a fully coupled model to address the detailed effects of photochemistry

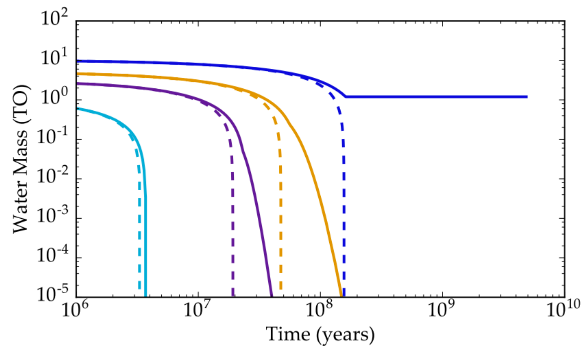

***Figure:** Evolution of the water content of Proxima Centauri b in terrestrial oceans (TO) as a function of time for initial inventories of 1 (light blue), 3 (purple), 5 (gold), and 10 (blue) TO. Solid lines correspond to model runs with inefficient O_2 surface sinks, while dashed lines correspond to runs in which O_2 is absorbed by a surface magma ocean at the rate it is produced.*

and interactions with a magma ocean at the surface; the inclusion of these effects will likely change the values reported here. Nevertheless, such extreme water loss may have permanently compromised the planet's ability to host life, while the abiotic oxygen could be abundant enough to be mistaken for a biosignature in future spectroscopic observations of the planet. A complete picture of the evolution of water on Proxima Centauri b is critical to understanding the planet's present-day habitability.

References: [1] Anglada-Escudé, G. et al. (2016) *Nature*, 536, 437. [2] Barnes, R. et al. (2016) *arXiv: 1608.06919*. [3] Luger, R., and Barnes, R. (2015) *Astrobiology*, 15, 57-88. [4] Baraffe et al. (1998) *A&A*, 337, 403. [5] Kuramoto, K. et al. (2013) *EPSL*, 375, 312. [6] Schaefer, L. et al. (2016) *ApJ*, 829, 63.