The Importance of Ozone and UV Capability in Detecting Biosignatures on Planets With Intermediate Oxygenation States

E. W. SCHWIETERMAN[1,2,3,4], S. L. OLSON[1,3], C. T. REINHARD[3,5], T. W. LYONS[1,3]

[1]Department of Earth Sciences, University of California, Riverside, CA, USA (eschwiet@ucr.edu)
[2]NASA Postdoctoral Program, Universities Space Research Association, Columbia, Maryland, USA
[3]NASA Astrobiology Institute, Alternative Earths Team, Riverside, CA, USA
[4]Blue Marble Space Institute of Science, Seattle, WA, USA
[5]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA

The strongest remotely detectable signature of life on our planet today is the photosynthetically produced oxygen (O_2) in our atmosphere. However, recent studies of Earth's geochemical proxy record suggest that for all but the last ~500 million years, atmospheric O_2 would have been undetectable to a remote observer—and thus a potential false negative for life [1]. During an extended period in Earth's middle history (2.0 – 0.7 billion years ago, Ga), O_2 was likely present but in low concentrations, with pO_2 estimates of ~ 0.1 – 1% of present day levels [2, 3]. Although O_2 has a weak spectral impact in reflected light at these low abundances, O_3 in photochemical equilibrium with that O_2 would produce notable spectral features in the UV Hartley-Huggins band (~0.25 μm), with a weaker impact in the mid-IR band near 9.7 μm. Thus, taking Earth history as an informative example, there likely exists a category of exoplanets for which conventional biosignatures can only be identified in the UV. Here we emphasize the importance of UV capabilities in the design of future space-based direct imaging telescopes to detect O_3 on planets with intermediate oxygenation states. We use a coronagraph instrument model to show that the Hartley-Huggins O_3 UV band is detectable in reflected light for a low-oxygen exoplanet (pO_2=0.5% PAL) orbiting a Sun-like star. This example highlights the broad implications of studying Earth history as a window into understanding potential exoplanet biosignatures [4].

[1] Reinhard et al. 2017, *Astrobiology*, 17, 287–297
[2] Planavsky et al. 2014, *Science*, 346, 635–638
[3] Lyons, et al., N. J. 2014, *Nature*, 506, 307–15
[4] Schwieterman, E., et al. 2018. arXiv preprint 1801.02744