A TEST FOR THE HABITABLE ZONE CONCEPT. J. Checlair[1] and D. S. Abbot[1], [1]University of Chicago, Department of the Geophysical Sciences, 5734 S, Ellis Ave., Chicago, IL 60637 (email: jadecheclair@uchicago.edu)

Abstract: Traditional habitable zone theory assumes that the silicate-weathering feedback regulates the atmospheric CO2 of planets within the habitable zone to maintain surface temperatures that allow for liquid water. There is some non-definitive evidence that this feedback has worked in Earth history, but it is untested in an exoplanet context. A critical prediction of the silicate-weathering feedback is that, on average, within the habitable zone planets that receive a higher stellar flux should have a lower CO2 in order to maintain liquid water at their surface (Figure 1). We can test this prediction directly by using a statistical approach involving low-precision CO2 measurements on many planets with future observing facilities such as JWST, LUVOIR, or HabEx. The purpose of this work is to carefully outline the requirements for such a test. First, we use a radiative-transfer model to compute the amount of CO2 necessary to maintain surface liquid water on planets for different values of insolation and planetary parameters. We run a large ensemble of Earth-like planets with different masses, atmospheric masses, inert atmospheric composition, cloud composition and level, and other greenhouse gases. Second, we post-process this data to determine the precision with which future observing facilities such as JWST, LUVOIR, and HabEx could measure the CO2. We then combine the variation due to planetary parameters and observational error to determine the number of planet measurements that would need to effectively marginalize over uncertainties and resolve the predicted trend in CO2 vs. stellar flux. The results of this work may influence the usage of JWST and will enhance mission planning LUVOIR and HabEx.

References: [1] Bean J. L. et al. (2017) *ApJ Letters, 841, 2.*

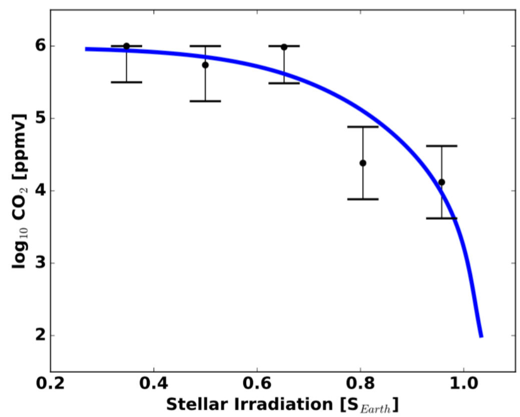

Figure 1. A decrease in atmospheric CO_2 as stellar irradiation increases is expected within the habitable zone, assuming a functioning silicate-weathering feedback. This could provide a viable test for the concept of the habitable zone. The blue curve shows the predicted CO_2 needed to maintain a surface temperature of 290 K. The black points are binned data for hypothetical planets that assume the theoretical irradiation-CO_2 curve but are scrambled away from it based on the plotted 1-error bars, assuming four planets per bin. Points and error bars have a physical limit on CO_2 values of 10^6 ppmv or less. Using the error estimations shown here the trend predicted by the theory could be inferred from the data. Taken from [1].