DETECTABILITY OF ARTIFICIAL LIGHT ON THE NIGHTSIDE OF EXOPLANETS. M. W. Webber[1] and K. Cahoy[2], [1]Department of Earth, Atmospheric, and Planetary Sciences. Massachusetts Institute of Technology. 77 Massachusetts Ave. Cambridge MA 02139 mwwebber@mit.edu, [2]Department of Aeronautics and Astronautics. Massachusetts Institute of Technology.

Abstract: We explore the detectability of artificial light over the naturally reflected stellar light in an exoplanetary system. We create a simple, tunable model to explore the spectral dependence of detecting exoplanet urban light. We define a detectability parameter, D, as the ratio of artificial flux to natural flux multiplied by instrument transmission range and integrated versus wavelength. Results show plots of log(D) vs. parameters including semi-major axis, phase angle, stellar blackbody temperature, and artificial light Gaussian parameters. Plots are shown for a range of possible civilization and planet types. Equations for natural flux, F_{nat}, and artificial flux, F_{art}, are presented. They depend on the phase function for the day and night side, φ_d and φ_n, which are offset 180° in phase angle, α. The natural flux depends on the stellar spectrum, the planet albedo spectrum, and physical system parameters. The artificial flux depends on U, the illumination spectrum, which includes the energy consumption characteristics of a society and can be scaled by a temporal factor G to represent urban growth/size vs time. Figure 1 shows the observed Albedo spectrum by Turnbull et al. that we use for Earth-like cases [1]. The measure relative spectrum is weighted for our study so that the average albedo matches the accepted global bond albedo of ~0.3. Using inputs for present-day Earth we see a contrast of ~5 x 10^{-5} which agrees well with the current dayside-nightside contrast of Earth at ~6 x 10^{-5} [2].

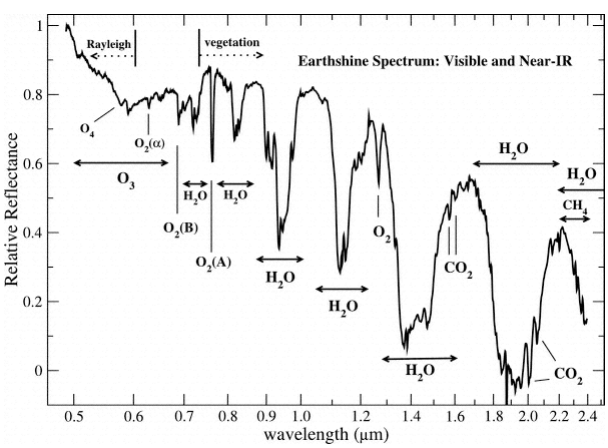

Figure 1: The relative albedo spectrum of Earth measured by Turnbull et al. (2006) [1] obtained by the Earthshine method that measures light reflected off the Earth, then off the darkside of the moon back to Earth again. This gives a disk- integrated average spectrum.

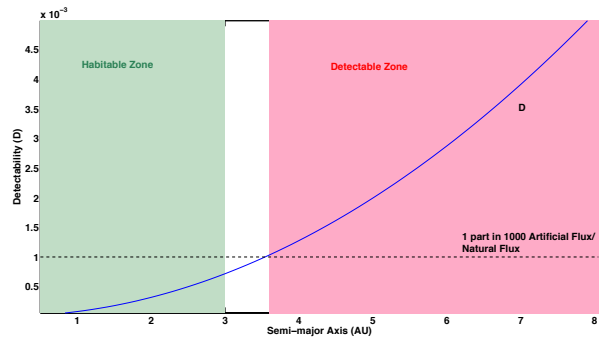

Figure 2: The detectability of a civilization on a Mars-sized planet with 50x more cities than modern Earth vs. semi-major axis compared to the Solar System habitable zone For reference, Jupiter is at ~5 AU, Saturn is at ~ 10 AU, and Pluto at ~ 40 AU. We define the detectability threshold at 1 part in 1000. (5x the proposed photometric precision of *Transiting Exoplanet Survey Satellite* (*TESS*) [3]

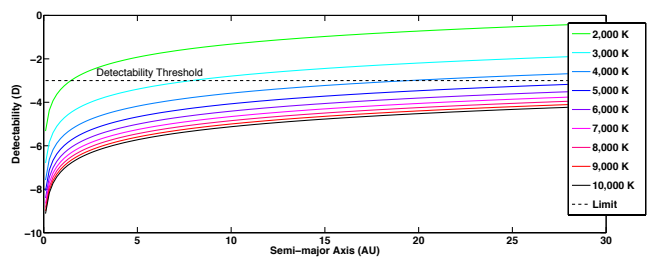

Figure 3: The logarithm of detectability of an Earth-like planet vs. the stellar blackbody temperature and semi-major axis. Cooler stars show a better detectability for Earth-like planets and Earth-like light sources, but cooler stars will have a decreased habitable zone vs. semi-major axis. This plot is without decreasing the stellar radius from that of the sun, which could increase detectability another factor of 2.

References:

[1] Turnbull, Margaret C., et al. (2006) *ApJ,644.1 551.*
[2] Loeb A. Turner E. L. (2012) *Astrobiology 12,* 290-294.
[3] KVanderspek, R. K. et al. (2010) *Bulletin of the American Astronomical Soc*. Vol. 42. 2010.