Earth as an Exoplanet: Spectral Monitoring of an Inhabited Planet. D. A. Caldwell[1] and F. Marchis[1], N. M. Batalha[2], N. A. Cabrol[1], J. C. Smith[1], [1]SETI Institute (189 Bernardo Ave, Suite 200, Mountain View, CA 94043, contact email: dcaldwell@seti.org), [2]NASA Ames Research Center, Moffett Field, CA 94035.

Introduction: In the past two decades, the study of exoplanets has grown from a niche science to being a major part of the goals of NASA's future flagship missions. Led by ground- and space-based projects, we now know that planets are common in our galaxy as are planets the size of Earth in the habitable zone around their star [1, 2]. Scientists have detected atmospheres around some of these exoplanets and through spectroscopy, are working to identify the constituents of these atmospheres [3, 4]. One of the key goals of future missions, including JWST, WFIRST, and LUVOIR is to detect and characterize the atmospheres of terrestrial size habitable zone planets. The ultimate purpose of these studies is to detect indications of life, or "biomarkers" in these atmospheres.

In order to understand and interpret the data that will come from these measurements, we have to have detailed models that allow for the retrieval of atmospheric constituents and properties from the spectra [5, 6]. Since there is only one known inhabited planet (Earth), these models rely on Earth observations as a ground-truth. While there are detailed high-spatial resolution data of the Earth from weather and climate-monitoring satellites, there are limited observations of the spectrum of the Earth seen as an exoplanet. To date these observations have been done using Earth-shine on the Moon [7], or during lunar eclipse [8]. More recent work has relied on serendipitous measurements that collected spectra of the whole-Earth from the EPOXI [9] and LCROSS [10] satellites. While these observations have provided valueable ground-truth spectra for models, they cover only a limited time and set of conditions and do not span the full range of variability of the Earth's atmosphere.

We propose a spectrometer for the Deep Space Gateway to monitor Earth as an exoplanet. We will take whole-Earth spectra measure the variability with illumination phase, rotation (land vs ocean), cloud cover, and season. Results will inform instrumentation, models, and analyses for future NASA missions to search for biomarkers on distant exoplanets.

The mission concept is to mount a small satellite at the Deep Space Gateway with one or more spectrometers viewing the whole Earth disk several times per day over 1 or more years. The instruments would include visible, near-infrared (NIR), and mid-infrared (MIR) spectrometers. The spectrometers will be based on small instruments developed for flight missions such as LCROSS [11], or under development for Earth observing missions [12]. Spatially resolved spectra are not needed, or even really desired, so the optical requirements are minimal. Based on these designs, the instrument to have a mass of ~30 kg and power requirements of a few 10's of watts. Detailed instrument requirements based on the science goals are under development.

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