No One's Home: the Fate of Carbon on Lifeless Earths. R. Felton[1], S. Domagal-Goldman[2], S. Desch[3], M. Neveu[4], [1]Catholic University of America (ryan.c.felton@nasa.gov), [2]NASA Goddard (shawn.goldman@nasa.gov), [3]Arizona State University (steve.desch@asu.edu), [4]Arizona State University (mneveu@asu.edu).

Introduction: Although several thousands of exoplanets are now known, including many terrestrial planets, their possible geology and climates remain poorly understood and understudied. Yet, understanding how elements such as carbon are cycled between a planet's interior, surface, and atmosphere is crucial to predict how lifeless planets operate and, by contrast, be able to detect deviations from abiotic backgrounds due to biology, the holy grail of exoplanet science. As a first, feasible step towards the difficult, long-term goal of understanding how key reactive elements (H, C, N, O, S) are cycled in the atmospheres, surfaces, and interiors of terrestrial exoplanets through time, we propose to carry out a self-consistent theoretical study of the fate of carbon in the atmospheres and at the surfaces of Earth-like, lifeless exoplanets.

We have recently obtained funding that will allow us to pursue this project. Over the next three years we will:

1. Model the near-surface geochemistry and geophysics of the carbon cycle to determine net carbon gas fluxes as a function of terrestrial planet size and redox conditions;

2. Model the atmospheric fate of carbon species as a function of stellar input;

3. Perform simulations that self-consistently combine geological and atmospheric processes;

4. Convert resulting atmospheric compositions to spectra to be archived as a public database for use by observers.

We will track the abiotic fate of carbon and its atmospheric expression on Earth-like planets as a function of three key parameters: planet size, surface and atmospheric redox conditions, and stellar irradiation. To do so, we will further develop and use state-of-the-art planetary geological ("Geo") and atmospheric ("Atmos") models.

We have previously developed a code that couples geophysical evolution and water-rock geochemistry [1]. Using this code, we will calculate the speciation of carbon species versus depth in subaerial oceans, their possible incorporation into the crust by water-rock interaction at the seafloor or by subduction of sediments, and outgassing as a function of temperature, pressure, and fluid/rock composition. We will expand this code with benchmarked parameterizations of land and seafloor weathering and outgassing rates. This modeling will result in detailed boundary conditions to be implemented into an existing atmospheric photochemical-climate model [2].

The atmospheric model will be used to predict species mixing ratios from net surface fluxes, given planetary and stellar parameters. The models will be benchmarked against what is known of the surfaces and atmospheres of the Earth (present and prior to atmospheric oxygenation) and Titan.

Atmospheric model outputs will be fed back into the geological model in combined simulations of carbon cycling. We will investigate in detail the mutual feedbacks between geological and atmospheric processes, so far understudied for terrestrial exoplanets.

The resulting atmospheric compositions will be converted to predicted exoplanet spectra using the Spectral Mapping Atmospheric Radiative Transfer model [3]. This grid of spectra will be made freely available to the exoplanet community.

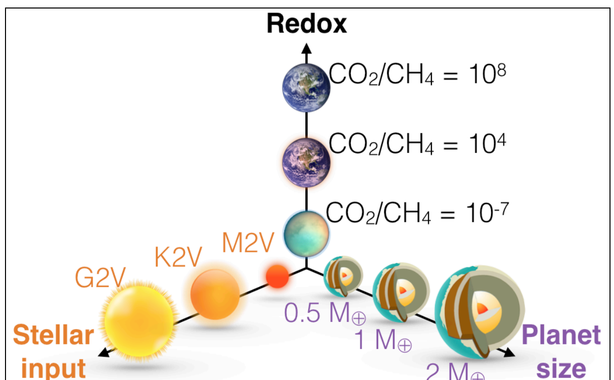
Since we are at the beginning point of our project, we want to use AbSciCon 2017 as an opportunity to share our idea with the community and receive feedback.

References:

[1] Neveu et al. (2015) *GRL, 42,* 10197-10206.

[2] Domagal-Goldman et al. (2014) *ApJ, 792.2,* 90.

[3] Meadows and Crisp (1996) *JGR, 101.E2,* 4595-4622



Example of the simulations we will perform by varying stellar input, planet size and redox state to study how these parameters affect the carbon cycle.