Title:

**Biomass Detection via Simulation of Elemental Planetary Cycles**

Goal:

We want to model the probable presence of biomass on a planet based on the chemical cycles of Nitrogen, Phosphorous, Sulfur, and Carbon Dioxide. We will model this using systems dynamics approach, with the possibility of extending the simulation into an agent-based model.

Hypothesis:

Can the cycling of certain key elements (Nitrogen, Oxygen, Phosphorous, Sulphur, and Carbon Dioxide) indicate whether a planetary body has a likelihood of containing biomass?

Background:

Astrobiology studies life outside of and on Earth, in extreme environments, and aims to define methods and metrics to detect life on exoplanets. Previous elemental models of Earth include the impact of life on the cycle of specific elements such as N, P, S, O and CO2. Although on Earth this influence of biomass is evident and well studies, in the Universe we want to assess whether these influences can be identified, removed, and the applied to exoplanets in order to detect the presence of biomass there. This is one of question astrobiology has been researching. One major issue with the current models is the absence of data, and current data from studying Earth acts as a proxy.

The absence of data is due to the inexistence of instruments that can very finely detect the chemical composition of planetary atmospheres, although current instruments such as TESS and upcoming James Webb telescope might fine-tune the levels of detection from distant exoplanetary bodies. Thus scientists mostly use simulation models to test theories and hypotheses, but until these models can be tested on the data collected from planets, validation of findings can be problematic, and thus the accuracy might be difficult to pinpoint.

Method:

The model we will be developing in Julia will be a system dynamics simulation model that will break a planet into parts of the planet that interact with one another. The ‘pools’ will include atmosphere, crust, mantle, and ocean. There are two ‘pools’ that are not tracked but are still influential, the core and space. The processes by which elements move between the pools will include: volcanic activity (oceanic and continental), erosion, lightning, tectonic plate activity, meteors, sedimentation, and gas-fluid exchange (ocean to atmosphere). Additionally, this model will look at planets not over a small period of time, but over thousands of years, due to many of the processes having less frequent occurrences and the geological age.

As the model has two main structures - the pools and the processes -, the model can also be implemented as a agent based model as an extension of the dynamic system.

Diagram

Description automatically generated

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