A new model of the Earth system nitrogen cycle: how plates and life affect the atmosphere

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Introduction: Nitrogen is the main component of Earth's atmosphere. Nitrogen plays a key role in the evolution of the biosphere and surface of Earth [1]. There are contrasting views, however, on how N has evolved on the surface of the Earth over time. Some modeling efforts [e.g., 2] indicate a steady-state level of N in the atmosphere over geologic time, while geochemical [e.g., 3], other proxies [e.g., 4], and more recent models [5] indicate the mass of N in the atmosphere can change dramatically over Earth history. This conundrum, and potential solutions to it, present distinct interpretations of the history of Earth, and teleconnections between the surface and interior of the planet have applications to other terrestrial bodies as well.
To help investigate this conundrum, we have constructed an Earth-system N cycle box model. To our knowledge, this is the most capable model for addressing evolution of the N reservoirs of Earth through time. The model combines biologic and geologic processes, driven by a mantle cooling history, to more fully describe the N cycle through geologic history. In addition to a full biologic N cycle (fixing, nitrification, denitrification), we also dynamically solve for PO4 through time and we have a prescribed O2 history.

Initial model results indicate that the atmosphere of Earth could have experienced major changes in mass over geologic time. High initial atmospheric mass, suggested as a solution to the Faint Young Sun Paradox [1], is drawn down over time, supports work that indicates the mantle has significantly more N than the atmosphere does today [6]. Importantly, the amount of N in the atmosphere today is directly dependent on the total N mass in the silicate Earth. Thus, given some assumptions, the atmosphere itself may be a proxy for total planetary N.

References: Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:
[1] Goldblatt et al. (2009) *Nat. Geosci., 2,* 891-896. [2] Berner, R. (2006) *Geology., 34,* 413-415. [3] Barry, P.H. and Hilton (2016) *Geochem. Persp. Letters, 2,* 148-159. [4] Som, S.M. et al. (2016) *Nat. Geosci., 9,* 448-451. [5] Stueken et al. (2016) *Astrobiology, 16,* in press. [6] Johnson et al. (2015) *Earth Science Reviews, 148,*150-173.