# Changing pressure, changing climate: theory and constraints

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Change in the pressure of Earth's atmosphere is a frontier in understanding and documenting the planet's climate evolution. Atmospheric pressure today is dominated by nitrogen; recent nitrogen budgets indicate substantive reservoirs in the continental crust and mantle, which can be shown to originate from the atmosphere by nitrogen fixation, inclusion or organic carbon or ammonium in rocks, and subduction for the mantle [1]. Whilst the existence of these reservoirs is clear, when the transfers took place is not. However, there are only a few viable options, which we can help constrain with models of nitrogen cycle evolution.

The climatic effect of changing the pressure of a radiatively inert species (like nitrogen) varies with pressure. At lower pressures, similar to Earth's present atmosphere, pressure broadening of absorption lines of the radiatively active species dominates [1]. Our new results for the forcing from a wide variety of potential greenhouse gases include dependence on background pressure, which is of first order importance. At higher pressures, increased Rayleigh (molecular) scattering dominates. For hot climates at risk of a runaway greenhouse, this helps stabilize climate by increasing planetary albedo [2]. Did this help early Venus stay temperate? Answering this requires understanding how atmospheric nitrogen evolves through time, with the record from Earth being our best proxy.

Empirical constraints on Archean pressure have recently been proposed. Som *et al* [3] proposed a constraint based on fossilised raindrop imprints. However, our analysis of this suggests that a critical assumption–that imprints from a theoretical maximum raindrop size would be preserved–fails. Application to the modern atmosphere with contemporary imprints likewise failed. Marty *et al* [4] proposed a noble gas systematics constraint, which is quite enigmatic. We suggest that this needs to be understood in the context of a model for the evolution of the K-Ar-N system, assimilating all the noble gas data.

[1] Goldblatt *et al* (2009) *Nature Geoscience*, **2**, 891-896 [2] Goldblatt *et al* (2013) *Nature Geoscience*, **6**, 661-667[3] Som *et al Nature*, **484**, 359-362[4] Marty *et al* (2013) *Science*, **342**, 101-104