

# Keeping the young Earth cozy

Fluctuating nitrogen levels may help to keep the Earth habitable across aeons.

[Quirin Schiermeier](#)



Changes in atmospheric pressure may help to keep the Earth habitable. NASA

Nitrogen now stored in the planetary crust and mantle may have prevented the early Earth from freezing, scientists suggest. The study lends weight to the idea that on geological timescales atmospheric pressure helps to regulate climate and habitability of Earth-like planets.

When the Earth was born around 4.5 billion years ago, the Sun was a great deal weaker than today. Two billion years on, the budding planet still received only some 80% of today's solar heat.

This has been sufficient to support the evolution of life; but if the young Earth's overall heat balance was roughly similar to what it is now, heat loss would have put much of the planet into deep freeze. Why this didn't happen is a long-standing mystery known as the 'faint young Sun paradox'.

None of the previously proposed solutions, including high ammonia and carbon dioxide abundance, are sufficient to resolve the paradox. Now Colin Goldblatt, a postdoctoral fellow at NASA's Ames Research Center in Moffett Field, California, and colleagues, suggest that nitrogen may have been responsible.

The team examined the isotopes of nitrogen in sediment and rock. Nitrogen that was formerly in the atmosphere has a different isotopic signature than nitrogen that has always been buried. They found that since the Archaean era, 2.5–3.8 billion years ago, substantial amounts of nitrogen of atmospheric origin have been biologically sequestered in sediments and rocks. Using their data, they estimate that the Earth's crust and mantle store almost twice as much nitrogen as is now in the air. The extra pressure of all that extra gas may have kept the early

Earth warm enough to escape extreme glaciation, the team report in *Nature Geoscience*<sup>1</sup>.

"Our inspiration was Venus," says Goldblatt. Earth's sunward neighbour planet, which has an extreme greenhouse climate, has much more nitrogen in its atmosphere than Earth.

## Contents under pressure

Nitrogen, which makes up around 75% of the air we breathe, is not a greenhouse gas itself. But larger amounts of nitrogen in the air also gives rise to higher atmospheric pressure. This increases the amount of heat that the lower atmosphere absorbs after the Sun's rays are reflected from the Earth's surface. This mechanism, known as 'pressure broadening', amplifies the natural greenhouse effects of carbon dioxide, water vapour and other gases.

"This is a terrific thought experiment tied to rigorous analysis of the nitrogen cycle," says Timothy Lyons, a biogeochemist at the University of California in Riverside, who was not involved in the study.



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"The basic idea — that nitrogen is fixed biologically and buried with organic matter and, through subduction, transferred to the mantle — is clever and clean. The question then becomes one of constraining when and why this sink turned on, and how the world responded."

The team used a special climate model to calculate the effect of increased nitrogen in the young Earth's atmosphere. Under present-day greenhouse gas concentrations, doubling the amount of nitrogen in the atmosphere would increase surface temperatures by 4.4 degrees Celsius. Around 2.5 billion years ago, when there was 25 times more carbon dioxide in the atmosphere than there is now, twice as much nitrogen in the atmosphere would have caused a warming of 12–15 degrees Celsius — enough to account for the faint young Sun paradox, the scientists

found.

The study sheds light on the "fascinating problem" of why Earth has been continuously habitable throughout its lifetime, says Euan Nisbet, a geologist at Royal Holloway, University of London. "There is no final evidence, but increased nitrogen is a very plausible explanation of that rather odd fact," he says.

## Natural thermostat?

A group of researchers at the California Institute of Technology in Pasadena have recently suggested that a gradual drop in atmospheric pressure, which weakens the greenhouse effect, may help to cool the atmosphere as the Sun gets hotter with age<sup>2</sup>. The two groups, however, worked independently. "We discussed it with Joe [Kirschvink, a co-author of that paper] and had a tacit agreement that we would stick to the past and they would stick to the future," says Goldblatt.

Together, the studies suggest that atmospheric pressure is a subtle planetary tuning mechanism capable of keeping worlds such as ours first warm and then cool enough to support life for billions of years.

Being the result of oxygen-producing photosynthesis, Earth's atmosphere is, ultimately, a biological construction. The studies' "unspoken implication", says Nisbet, is that the so-called Gaia hypothesis, which holds that living things have a regulatory effect on the complex Earth system that in turn promotes life overall, has got it right.

### • References

1. Goldblatt, C. et al. Nat. Geosci. advance online publication [doi:10.1038/ngeo692](https://doi.org/10.1038/ngeo692) (2009).
2. Li, K-F., Pahlevan, K., Kirschvink, J.L. & Yung, Y.L. Proc. Natl Acad. Sci. USA 106, 9576-9579 [doi:10.1073/pnas.0809436106](https://doi.org/10.1073/pnas.0809436106) (2009).