

GEOENGINEERING AND THE DISTANT FUTURE OF EARTH'S CLIMATE. J. Haqq-Misra¹, ¹Blue Marble Space Institute of Science (1200 Westlake Ave N Suite 1006, Seattle WA 98109; jacob@bmsis.org).

The climate of Earth is susceptible to catastrophes that could threaten the longevity of human civilization. The distant future of Earth's biosphere will be shaped by the balance between factors such as orbital variations in solar insolation, cycles in glacial coverage, and the carbonate-silicate cycle. The resonating effects of anthropogenic contributions to climate change may extend the length of the present interglacial and could even damp out the 100,000 year glacial cycle, leading Earth on a path toward an ice-free state that only weakly responds to orbital forcing [1]. Even longer geologic timescales will force the climate to adapt to a steadily brightening sun by drawing down atmospheric carbon dioxide until habitable conditions no longer remain [2].

Geoengineering to reduce incoming solar radiation has been suggested as a way to mediate the warming effects of contemporary climate change, and geoengineering may also serve as humanity's last hope to withstand the sun's transition into a red giant [3]. Geoengineering technology may therefore be useful to keep on hand in case of a "climate emergency". However, a pre-emptive geoengineering program that lasts thousands of years could also be used to enlarge the size of the polar ice caps and create a permanently cooler global climate. Such a large ice cap state would be more resilient to climate threats and could allow human civilization to survive further into the future than otherwise possible. Intentionally extending Earth's glacial coverage will require uninterrupted commitment to this program for millennia but would ultimately reach a cooler equilibrium state where geoengineering is no longer needed. Whether or not this program is ever attempted, this application of geoengineering to short-term and long-range climate emergencies illustrates the need to identify preferable climate states that could ensure the long-term success of civilization.

[1] Haqq-Misra (2014) *Journal of Advances in Modeling Earth Systems*, 6, 950–955. [2] Caldeira K. and Kasting J. (1992) *Nature*, 360, 721–723. [3] Goldblatt C. and Watson A. J. (2012) *Physical Transactions of the Royal Society A*, 370, 4197–4216.