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The Fine Tuning of the Earth and Its Climate

By Dan Reynolds, PhD

The Bible teaches that the Earth and its climate were designed by God for our benefit. There are several remarkable things about our planet that make it habitable for human beings including the Earth's mass, distance from sun, axial tilt, atmosphere, magnetic field, rotational speed, orbital shape, and the presence of a large moon. Our solar system possesses a unique and special star and has a gas giant like Jupiter with a larger orbit. Even the location of our solar system in the Milky Way galaxy is special. Many of the aforementioned properties of the Earth and solar system make Earth's climate suitable for us. The habitability of the Earth requires that liquid water be present because all biochemistry requires water. Water has many unique properties that make life possible and help stabilize Earth's climate. There are good biblical and scientific reasons to believe that Earth's climate is stable and that carbon dioxide emissions will not be our undoing. Recent research suggests our understanding of the climate may need revision.

As Christians, we believe the Bible, the Word of God, is inerrant and infallible. We know God created the Earth (Gen. 1:1) to be inhabited by us (Isa. 45:18). Consider the implications. An omnipotent, omniscient, benevolent, purposeful, and omnipresent being that knows every detail of the past, present, and future of the universe and every subatomic particle in it, intentionally invented a planet for beings made in His image designed to fulfill His purposes. Could God's design of the Earth somehow have been inadequate to handle what humans would eventually do technologically? In Genesis 8:22, God, after the Flood, made a promise to Noah that "while the earth remains, seedtime and harvest, cold and heat, summer and winter, day and night, shall not cease." In other words, God promised Noah (and us) that Earth's climate cycles, seasons, and temperature excursions would remain more or less constant until there was a new heaven and a new Earth (Rev. 21). God foresaw and preordained that human activity would not destroy the climate balance that we currently enjoy.

As scientists, we can investigate the nature of God's design that permits and sustains the habitability of our planet.¹ There are many factors that, when taken together, show the fingerprints of our Creator. Central to the Earth's habitability is the presence of liquid water. Liquid water can only exist under specific ranges of temperature and pressure. Outside of those temperature and pressure ranges, water may only exist as a gas or a solid. The Earth's distance from the sun is a critical factor. The distance from the sun determines how

much of the sun's energy reaches us. The correct atmospheric pressure is another critical factor. Atmospheric pressure depends on the thickness and composition of the atmosphere and the gravity of the planet. The gravity of the planet depends upon its mass. So, in order to have liquid water, the Earth must be the right distance from the sun, have the right atmospheric composition and thickness, and have the right mass.

A major factor that contributes to the stability of our climate is water itself. Water covers about 71% of the Earth's surface and has a relatively high heat capacity. The heat capacity of a substance is a measure of how much heat energy is required to raise the temperature of one gram by 1°C. The higher the heat capacity, the slower the temperature will rise or fall during absorption or release of heat energy, respectively. Hence water helps moderate rapid temperature swings globally.

Water also has many properties that make biochemistry possible.² Water is a "universal solvent" that can dissolve ions, gases such as oxygen and carbon dioxide, proteins, nucleic acids, and carbohydrates. Water's polar nature is essential for formation of the double helical structure of DNA and RNA. Water can exert a "hydrophobic force" that facilitates the formation of the lipid bilayers of cell membranes and the folding of proteins. Water is one of the few substances whose solid form (ice) is less dense than the liquid. This property makes ice float on water. In the winter, ice covers lakes and ponds, thereby protecting them from freezing completely; freezing from the bottom up would destroy most aquatic life.

The Earth's rotation axis is tilted 23.4° relative to the ecliptic, the plane within which the planets orbit the sun. This tilt is the cause of our seasons in the mid latitudes. The seasons bring varying temperatures and pressure to many parts of the globe annually. Varying pressure results in winds that carry the energy absorbed from the sun to other places on the Earth. In other words, the Earth's axial tilt results in winds that distribute the sun's heat around the world, mitigating large temperature extremes.

The composition of the Earth's atmosphere is also fine-tuned for life and the climate. The Earth's atmosphere consists of 78% nitrogen, 21% oxygen, and 1% argon and other gases including 0.04% carbon dioxide. Our atmosphere is transparent to visible light. Visible light is the part of the electromagnetic spectrum the sun produces most and what plants need most for photosynthesis. Carbon dioxide and other greenhouse gases are needed to retain some of the sun's heat in order to keep the Earth warm. Carbon dioxide is also what plants use during photosynthesis to form glucose and oxygen; it is airborne fertilizer. The mass of the atmosphere determines the atmospheric pressure at the surface. The pressure is just right for liquid water. The transparency of the atmosphere also permits us to observe the heavens that declare God's glory (Psa. 19:1). Oxygen provides biochemistry a way to make large amounts of the molecule ATP, the energy currency of the cell. Large amounts of ATP are required to power larger animals like humans. Oxygen is also the source of the ozone in the stratosphere, which protects us from much of the sun's UV rays that can cause cancer. Nitrogen is relatively inert except in nitrogen-fixing bacteria in the soil, which use nitrogen to make the amino acids essential for building proteins.

The Earth's magnetic field protects the atmosphere from erosion by the solar wind. Scientists believe the Earth's magnetic field is created by the circulation of charged particles in the Earth's liquid outer core. The solar wind is a stream of charged particles emitted by the sun. Instead of these particles eroding our atmosphere, they are deflected by the Earth's magnetic field towards the poles where they enter the atmosphere and become visible as the auroras. The Earth's magnetic field depends upon the inner structure of the Earth. Notably, neither Venus nor Mars have a significant magnetic field.

The Earth's rotational speed also helps distribute the sun's heat energy. If the Earth rotated much more slowly, greater temperature differences between the day and night sides would develop. If the rotation were much faster, wind speeds would become extreme.

The shape of Earth's orbit around the sun, while technically elliptical, is almost circular. The distance varies by about 3.3% during the year. This means the heat energy the Earth receives from the sun remains essentially constant year-round. The orbits of the other planets are also almost circular.

Our moon provides benefits. The moon helps stabilize the Earth's axial tilt and cycle of seasons. And the moon causes the tides which keep shoreline ecosystems healthy. Incidentally, our moon provides the only total solar eclipses in the solar system. Total solar eclipses have allowed us to study the sun's atmosphere and confirm predictions made by general relativity.

The planet Jupiter, with a gravity 2.3 times greater than that of Earth, helps protect the inner solar system from potentially destructive comets and asteroids by deflecting or absorbing them.

The sun is also fine-tuned. The sun is solitary, but most stars are binary. A binary star system would be less likely to provide a stable climate. The sun is also a relatively quiet star in that it does not vary much in brightness or have many strong solar flares. It emits its peak power in the visible part of the electromagnetic spectrum, which is beneficial for plants.

Our solar system is located in Orion Spur which branches off of the Sagittarius Arm of the Milky Way. The Orion Spur is located between the larger Perseus and Scutum-Centaurus Arms. Our closest stellar neighbor, Alpha Centauri, is about 4.3 light years away. Our place in the galaxy is relatively less crowded, making it less likely that we would suffer the impact of a nearby supernova. We also have a good place to make observations of the realm beyond our galaxy.

All of the aforementioned features of the Earth and our solar system, taken together, seem improbable, result in our world being habitable, and suggest intelligent design as an explanation. The climate is a key part of that design.

There is much speculation about what controls our climate. In previous articles,^{3,4} we have discussed reasons to doubt the Milankovitch (astronomical) theory of climate change. That theory basically holds that the slight differences of the amounts of incident solar radiation caused by the Earth's varying orbital behavior over deep time initiates positive feedback loops of physical processes that plunge the Earth into and out of ice ages. The

exact nature of the alleged positive feedback loops is not well understood but is assumed to exist because of the alleged correlation. Hence the climate is seen as very susceptible to slight variations that could potentially result in climate extremes. The evidence cited for the Milankovitch theory has been the apparent correlation between Earth's past temperatures as measured by oxygen isotope ratios and the assumed orbital behavior of the Earth over deep time. This correlation was dependent upon the dating of deep-sea sediments using radiometric dating of a reversal of Earth's magnetic field that allegedly occurred 700 ka. That "pacemaker" dating has recently been revised to 780 ka.⁵ The problem for the Milankovitch theory is that now the historical temperature variations and the Earth's alleged planetary behavior over deep time no longer correlate. This result not only casts into question the astronomical theory but also undercuts deep time (the dating of ice cores and deep sea sediments) and the idea that the Earth's climate is prone to mysterious runaway positive feedback behavior.

Recent research suggests that carbon dioxide levels actually *follow* changes in Earth's temperature, not vice versa.^{6,7} This applies to all time scales over the last (alleged) one million years. Hence it appears that temperature causes the carbon dioxide levels, not the other way around. This is explained by how the solubility of carbon dioxide in water depends upon temperature. When the temperature rises, the solubility of carbon dioxide in the oceans decreases resulting in greater amounts in the atmosphere. On the other hand, when the temperature decreases, the solubility of carbon dioxide in the oceans increases, resulting in smaller amounts in the atmosphere. On a decadal timescale, the temperature and carbon dioxide levels are depicted graphically in Figure 1.⁶ As can be seen, the changes in the surface temperatures on land or sea precede changes in the carbon dioxide levels.

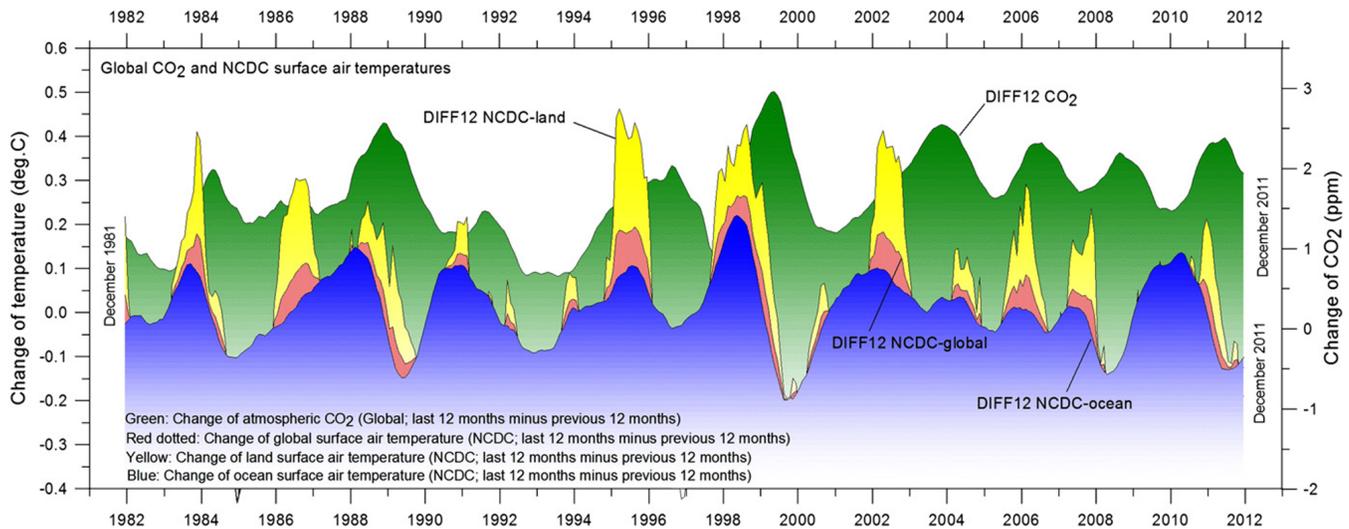


Figure 1: Carbon dioxide and temperature levels from 1982-2012.

Researchers have shown that the impact of increasing the carbon dioxide level on temperature decreases logarithmically as the concentration of carbon dioxide increases⁸ (see Figure 2).⁹

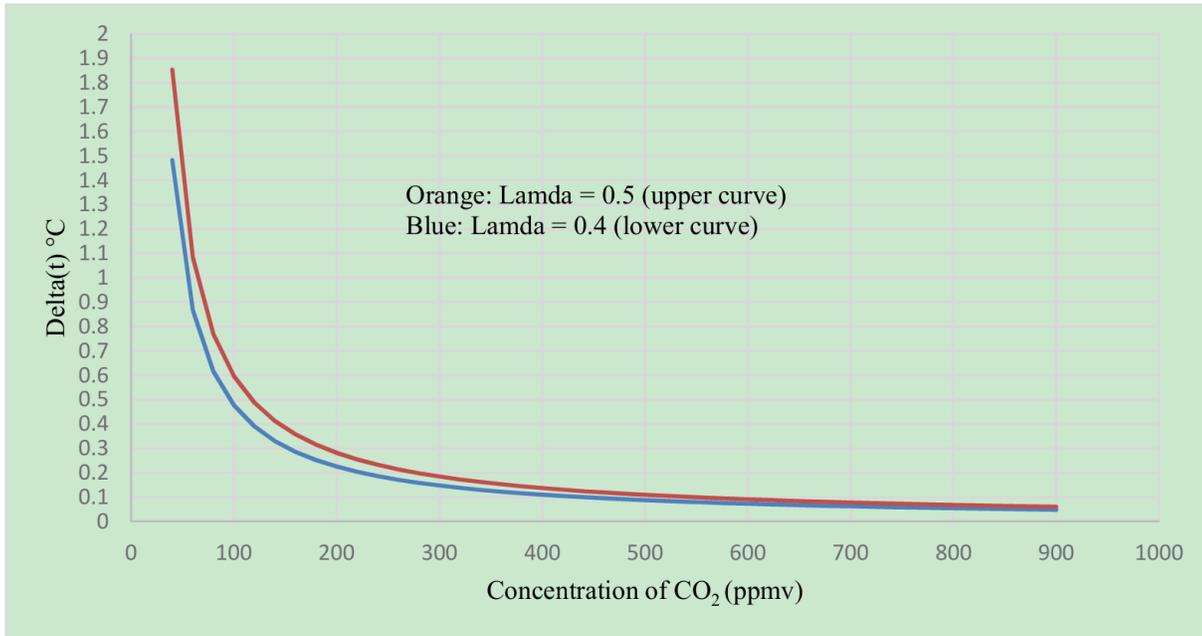


Figure 2: Change in temperature as a function of carbon dioxide concentration

The current atmospheric carbon dioxide level is 427 ppm.¹⁰ As shown in Figure 2, increasing the carbon dioxide level to 800 ppm should only result in about a 0.5°C temperature increase. As can be seen, there is an ever-diminishing impact of increasing the carbon dioxide concentration on temperature. This means the atmosphere is already almost “saturated” with carbon dioxide insofar as its impact on temperature is concerned.

A theoretical study on the impact of various greenhouse gases on Earth’s temperature based on spectral data from the HITRAN database was conducted.¹¹ Calculations suggest the Earth’s temperature without an atmosphere would be 255 K (−18°C). The present measured average temperature of the Earth is 288 K (15°C). The increased temperature (33 K) is due to heat retained by the atmosphere. Calculations showed that of the 33 K increase, 29.4 K (89.1%) was due to water vapor, 3.3 K (10%) was due to carbon dioxide, and the remaining 0.3 K (<1%) was due to other gases. The calculated impact of doubling the carbon dioxide concentration from 400 to 800 ppm was a 0.5°C increase, including water vapor feedback¹² (see Figure 3).¹¹

CO ₂ ppm doubling	50-100	100-200	200-400	400-800	800-1600
Climate sensitivity K	0.34	0.38	0.41	0.45	0.54
Sensitivity x feedback K	0.38	0.42	0.46	0.50	0.61

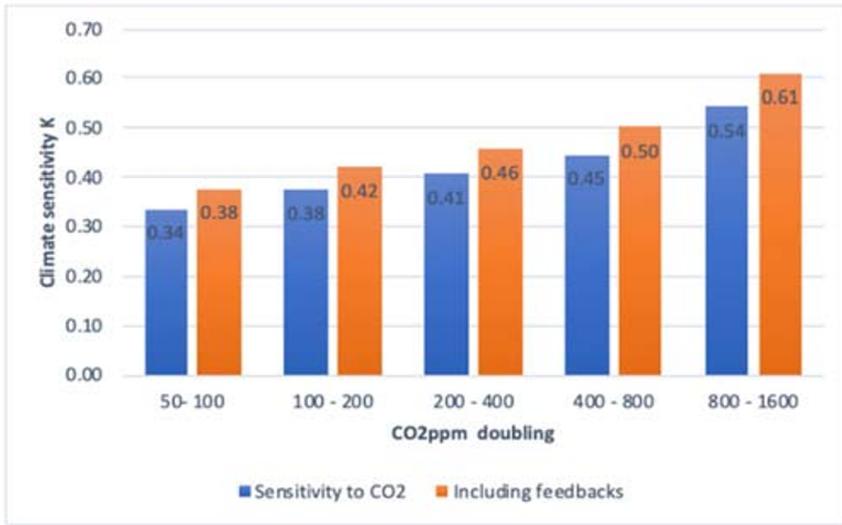


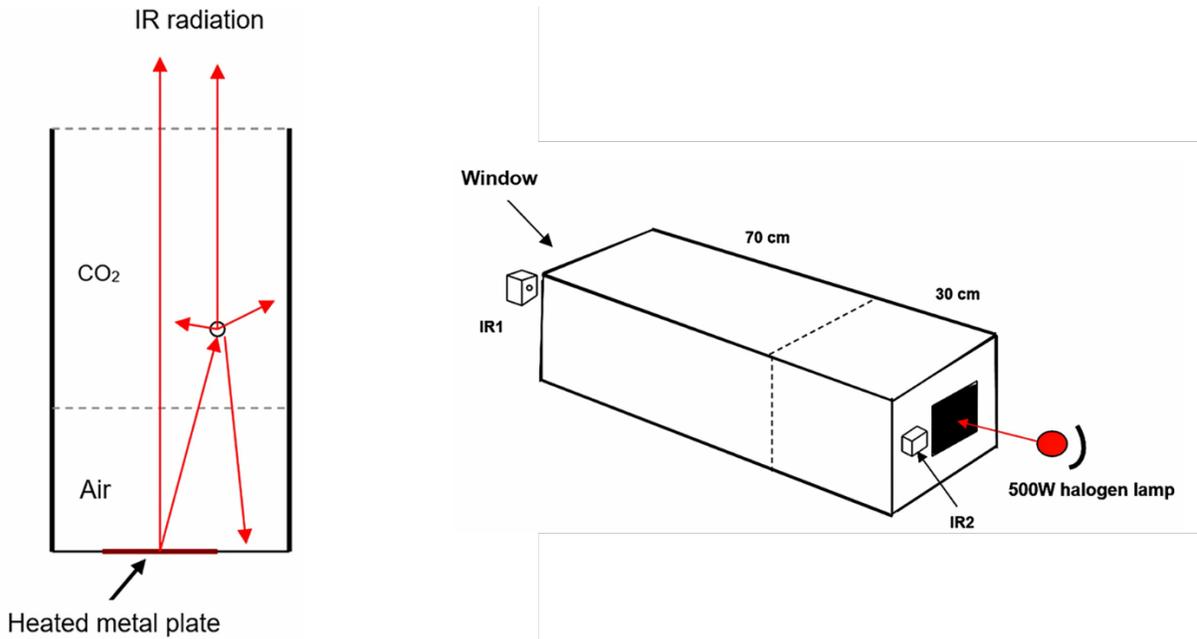
Figure 3: Climate sensitivity to carbon dioxide doublings

This is much lower than the predictions from the International Panel of Climate Change (IPCC) of 2 to 4°C.¹³ Note that the impact of doubling the carbon dioxide concentration on temperature does increase slightly as the total carbon dioxide concentration increases. According to the calculations, quadrupling the carbon dioxide content from 400 to 1600 ppm would only result in a 1.11°C temperature increase. The total impact of anthropogenic carbon dioxide on global temperature since before the industrial revolution until now (280 to 420 ppm carbon dioxide) was calculated to be 0.24 K. The authors noted that the many frequencies of infrared (IR) radiation absorbed by carbon dioxide are also absorbed by water vapor. There is on average an order of magnitude more water vapor in the atmosphere than carbon dioxide. Water vapor is a much more important greenhouse gas than is carbon dioxide.

The authors also made another interesting observation about an important negative feedback loop. As the temperature of the Earth increases, the wavelengths of the emitted radiation from the Earth decrease in accordance with Wien's Law.¹⁴ This results in less absorption of the emitted radiation by greenhouse gases and hence a reduction of the greenhouse effect.

In an experimental study, researchers wanted to see if backscatter of IR radiation by carbon dioxide could account for significant greenhouse warming of the Earth's atmosphere.¹⁵ The Earth is warmed by radiation from the sun and then cools by emitting IR radiation. Greenhouse gases are able to absorb some of the emitted IR radiation. The absorbed radiation is then released in all directions, some into space, and some back towards the Earth. Hence greenhouse gases may slow the radiative cooling of the Earth, which could result in a net warming effect. The researchers designed experiments to determine if a significant increase in

atmospheric carbon dioxide would result in a significant rise in temperature. Their experimental setup is shown in Figure 4.



Simulation of the greenhouse effect for use in a laboratory experiment.

Figure 4: Experiment to test the effect of backscattered IR radiation by carbon dioxide on temperature

As can be seen in Figure 4, the experimental setup consisted of two adjacent foil-lined chambers with a heat source (500W halogen lamp) and two IR detectors (IR1 and IR2). Air was always the gas in the 30 cm (IR source chamber) chamber. The 70 cm (experimental) chamber was filled with air, then pure carbon dioxide, then argon. The heat source was activated, and then various temperature and IR radiation measurements were made. In theory, the IR radiation generated by the heat source would shine through the air of the source chamber and then through the gas in the experimental chamber. If any of the IR radiation was backscattered by the gas in experimental chamber, IR1 would detect an IR radiation drop and IR2 would detect a radiation increase. Any radiation increase could then be used to calculate an expected temperature increase, which could then be compared with the actual temperature measurements. The results were that when the experimental chamber was filled with pure carbon dioxide instead of air or argon, there was a drop in the radiation detected at IR1 and an increase in radiation at IR2, but only about 0.15°C temperature increase in the source chamber. The measured intensity of the IR radiation at IR1 was the same as was calculated based on the spectral data available in the HITRAN archive. IR2 detected 80% of the IR drop measured by IR1. Calculations using equations employed by the IPCC said the temperature increase should have been 2.4 to 4.0°C. The results suggest that while increased backscattering of IR radiation did indeed occur because of carbon dioxide, the resulting temperature increase was an order of magnitude less than predicted by the IPCC. Other recent research has revealed that the choice of temperature data sets spanning from 1850 to present and satellite data sets will determine if one concludes rising temperatures are caused by natural or

anthropogenic forcing.¹⁶ In IPCC's Sixth Assessment Report (AR6), the data suggest that natural phenomena have little to do with observed increasing temperature trends since 1850. On the other hand, there are equally valid temperature and satellite datasets that show solar activity correlates very well with temperature changes with human activity playing only a minor role.¹⁶

In another study, the selection of temperature proxies greatly affected the observed temperature trends over the last two millennia.¹⁷ Tree ring proxies, favored by the IPCC, tended to give "hockey stick" graphs with a relatively flat temperature trend line until recent times suggesting all was well until human industrialization. Use of other proxy data, however, showed greater variance in temperatures over the past 2000 years suggesting the influence of natural forces on the climate. In AR6, a new "hockey stick" has been introduced.¹⁸ Once again, the selection of proxies determined the shape of the graph. In addition, as in the case of temperature histories, there are various proxies for solar behavior, providing different histories of solar activity. Many scientists questioned the proxies selected by the IPCC, which showed a decline in solar activity as the temperature increased, leaving carbon dioxide emissions as the likely culprit. However, good correlations between several alternative solar activity histories and rural temperatures from 1850 until present were demonstrated in the study, calling into question the importance of anthropogenic climate change.¹⁸

In summary, it is clear from scripture that God created and designed the Earth to be inhabited and managed by us. There are numerous properties of the Earth, our solar system, water, and our location in the Milky Way that, taken together, suggest design. Our climate is one of the results of this fine tuning. The "pacemaker" date no longer supports the Milankovitch theory, calling into question the theory's validity. Careful research has shown that temperature changes precede carbon dioxide levels over the last (alleged) million years. The effect of increasing the carbon dioxide levels upon greenhouse warming decreases logarithmically. A theoretical study using absorption spectra of the atmosphere's gases showed the impact of doubling the carbon dioxide concentration from 400 to 800 ppm would be a 0.5°C increase, including water vapor feedback. This is much lower than the IPCC's estimate of 2 to 4°C. Another careful experiment showed that carbon dioxide does backscatter IR radiation but that the resulting temperature increase was an order of magnitude less than predicted by equations used by the IPCC. Choice of temperature and solar activity datasets can paint very different climate histories consistent with anthropogenic forcing, natural variability, or a mixture of both. We still have much to learn about the climate and what role we play in it. God has promised the Earth's climate will remain stable until the end of the age. Let's be good stewards of the Earth without fear of using it for human flourishing.

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