Scientific and Spiritual Dimensions of Climate Change

Unit 4
The Causes of Global Warming

The pursuit of science is a spiritual matter because science strives to discover the laws of nature which God created.

> *God saw everything that he had made, and indeed, it was very good.*[1]
>
> The Bible

> *No defect canst thou see in the creation of the God of Mercy: Repeat the gaze: seest thou a single flaw.* [2]
>
> The Qur'an

> *How great, O my God, is this Thy most excellent handiwork, and how consummate Thy creation, which hath caused every understanding heart and mind to marvel!"*[3]
>
> Bahá'u'lláh

Section 1: Scientific Observations of Global Warming and Changes in Climate

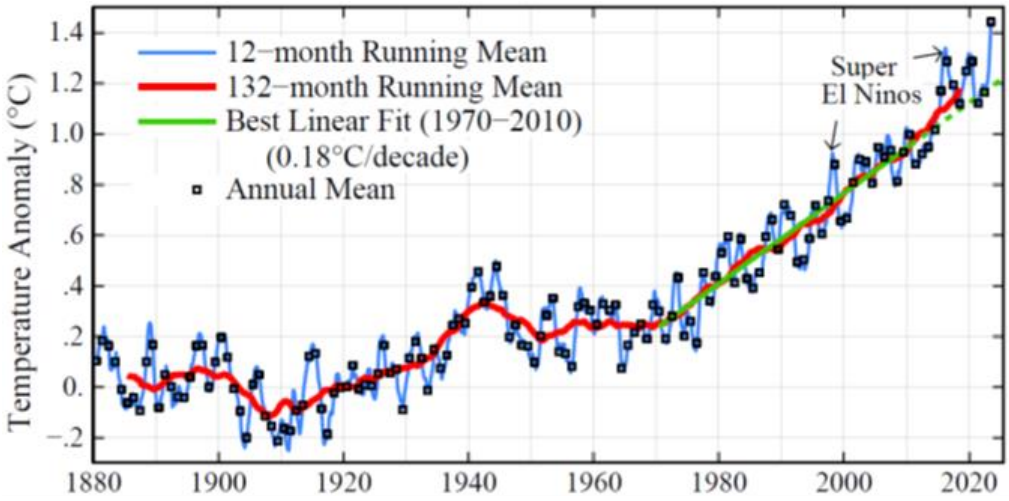
Over the past few decades, the science of global warming has made much progress. Now, there is certainty that the planet has been warming and that humans are responsible for it.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."[4] "It is unequivocal that human influence has warmed the atmosphere, ocean and land."[5]

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

The graph below shows that 2023 was the warmest year on record by far:

Image 1:[6] **Global temperature relative to 1880-1920 based on the GISS analysis**



“2023 was 1.48°C warmer than the 1850-1900 pre-industrial level.
“2023 marks the first time on record that every day within a year has exceeded 1°C above the 1850-1900 pre-industrial level. Close to 50% of days were more than 1.5°C warmer than the 1850-1900 level, and two days in November were, for the first time, more than 2°C warmer.”[7]

Section 2: Why Is the Earth Warming?

> *We, assuredly, have decreed a cause for all things and vouchsafed everything with an effect. All of this is by virtue of the effulgence of My Name, the Efficacious (the 'Producer of Effects') upon existing things. Verily, thy Lord is the One Who exerciseth command over all that He willeth.* [8]
>
> Bahá’u’lláh

Both the Baha’i Writings and science tell us that all life is dependent on the energy of the sun. ‘Abdu’l-Baha wrote:

> *The sun is the source of life and light, and is the cause of the growth and development of all things within the solar system. Were the bounty of the sun to cease, no living thing could continue to exist therein: All things would grow dark and be reduced to naught. It is therefore clear and evident that the sun is the centre of all light and the source of the life of all things in the solar system.*[9]

From science we learn that the sun is the source of all physical energy and therefore of all life on our Earth. It provides the warm temperature necessary for the existence of life.

Photosynthesis

Plants absorb carbon dioxide and emit oxygen *with the help of sunlight*. This process is called photosynthesis. During photosynthesis, plants transform atmospheric carbon into organic compounds, especially glucose (sugars). That glucose is used in various forms by every creature on the planet for energy and growth. Photosynthesis **i**s the foundation for all plant life and therefore supports all animal life as well.

The energy of the sun also drives climate patterns and the weather, as differences in air and water temperatures create wind and ocean currents.

The Carbon Cycle

For the understanding of global warming, it helps to have some insight into the carbon cycle: “The biosphere is maintained by a complex set of delicately balanced systems which are still poorly understood. The atmospheric conditions that permit life to exist were themselves created in part by the action of living things. The early plants removed carbon dioxide from the atmosphere and added oxygen, making animal life possible. Dead plants, both the remains of marine plankton and terrestrial vegetation, were buried and fossilized as coal, oil and gas, and their carbonate skeletons became layers of limestone, locking a significant part of the Earth's carbon away in geological formations. Carbon cycles through the biosphere, as plants take up carbon dioxide to make organic matter, while animals and decomposers return the carbon dioxide to the oceans and atmosphere.” [10]

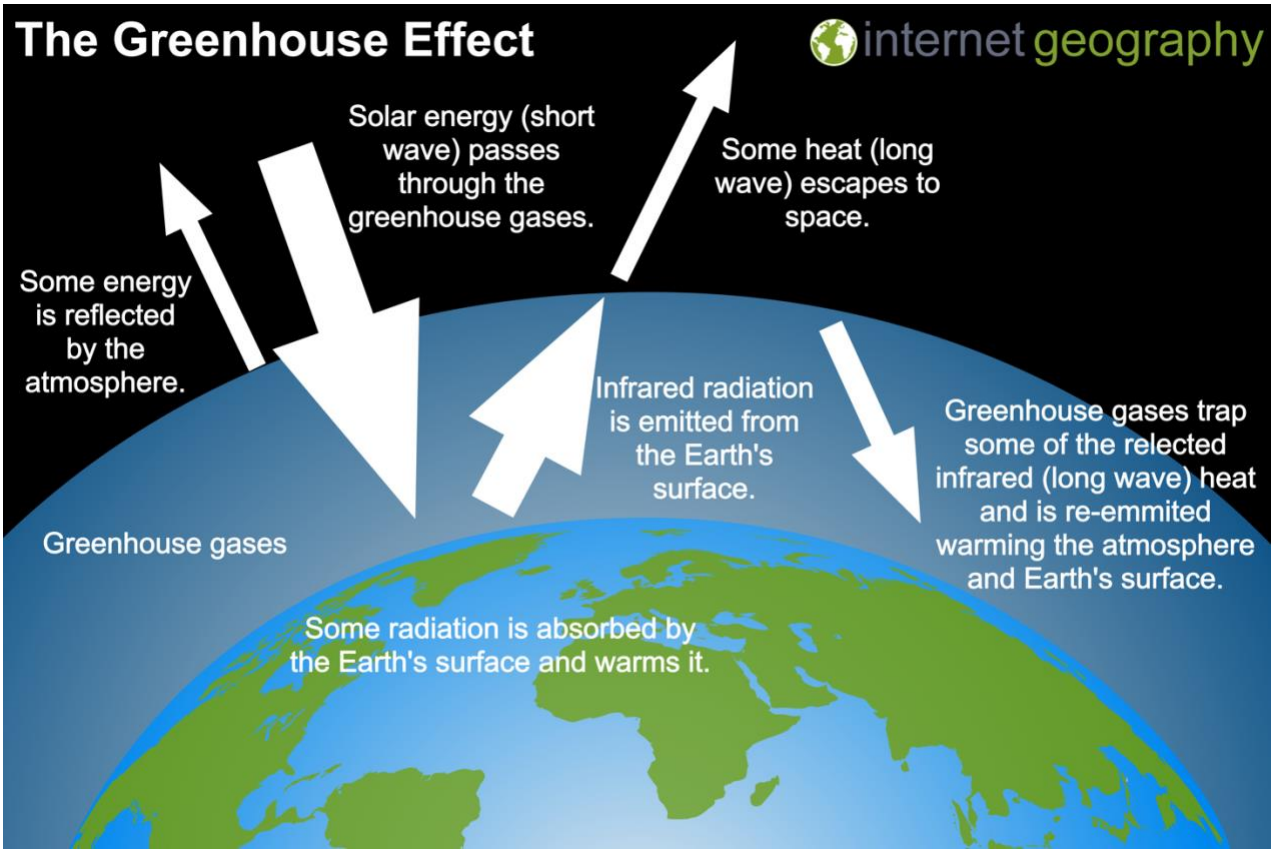
Fossil fuels such as gas, coal and oil are an accumulation of the sun's energy. They were created from broken down dead plants and animals many millions of years ago under great pressure over a very long period of time. One could consider them as stored solar energy from ancient times. Today's rapid burning of these fossil fuels brings nature out of balance.

The Greenhouse Effect

Atmospheric gases such as carbon dioxide (CO_2), methane and nitrous oxide are called greenhouse gases because they act similar to the glass in a greenhouse by trapping heat. Or more specifically worded: "the greenhouse gases are transparent to most incoming (short wave) radiation from the sun, which passes through the atmosphere and hits the Earth. The Earth is warmed by this radiation, and in response radiates infrared (long wave) energy back into space. That is where greenhouse gases come into play. These atmospheric gases absorb some of the outgoing infrared radiation, trapping the heat energy in the atmosphere and thereby warming the Earth." [11]

The greenhouse effect has kept the Earth's average surface temperature stabilized at around 13.5°C (56.3°F) in radiative balance for the last 10,000 years or so, up until the industrial revolution. Without it our Earth would be 28 - 32°C colder! Life on Earth is only possible because of this greenhouse effect.

Image 2:[12]



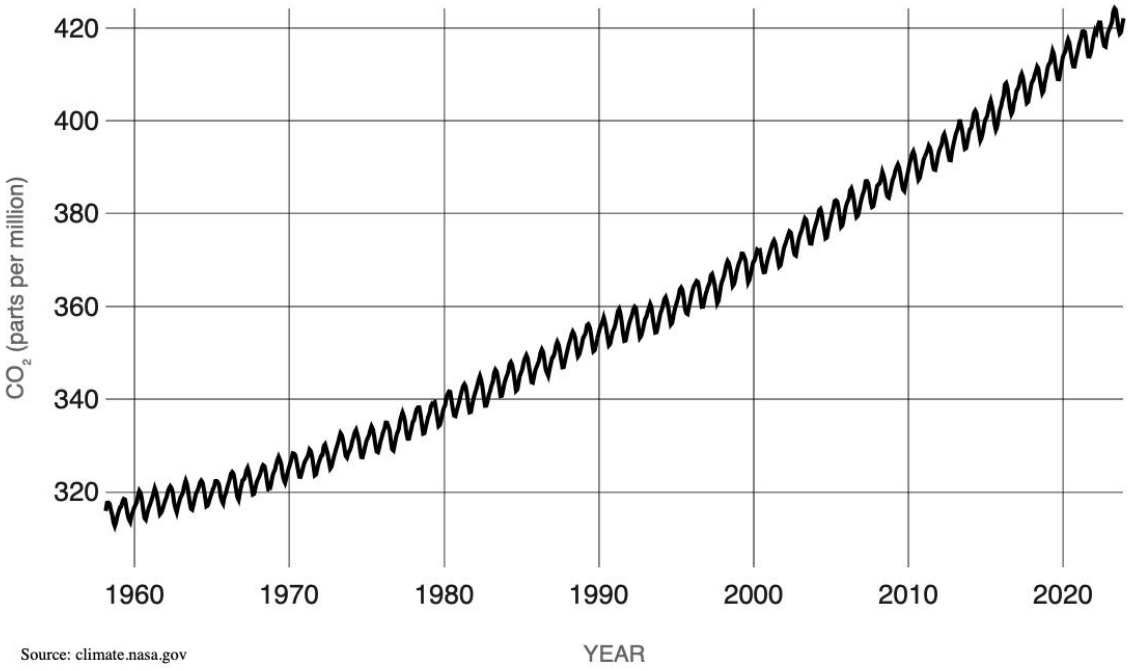
Since the industrial revolution, greenhouse gases have sharply increased upsetting the previously long-lasting balance. Scientists confirm that this increase of greenhouse gases is for the most part anthropogenic (man-made). The increase comes mainly from emissions from power plants, cars, airplanes, from deforestation and industrial activities. We are "returning carbon to the atmosphere and oceans that has long been out of circulation."[13]

The more greenhouse gases there are in the atmosphere the warmer our planet becomes.

A little bit of climate science history

The Greenhouse Effect has been an accepted scientific fact since the 19th century. Already in 1863, John Tyndall explained the greenhouse effect in a public lecture. In 1896 Svante Arrhenius, a Swedish scientist, claimed that the burning of fossil fuels may eventually result in the warming of the atmosphere. While at that time the greenhouse effect was already an established scientific fact, the potential warming of the Earth by the burning of fossil fuels was a theory that was thought to only be of concern far in the future. Then in 1958, Prof. Charles Keeling began to measure carbon dioxide concentrations in the atmosphere. A graph of his findings shows a dramatic and clear multidecadal trend of increasing CO_2 concentration (see image 3). Note, however, that each year there is a temporary sharp decline and sharp rise in the curve. *Why do you think does the curve go down and up every year?* (The answer is given below the image).

Image 3:[14]



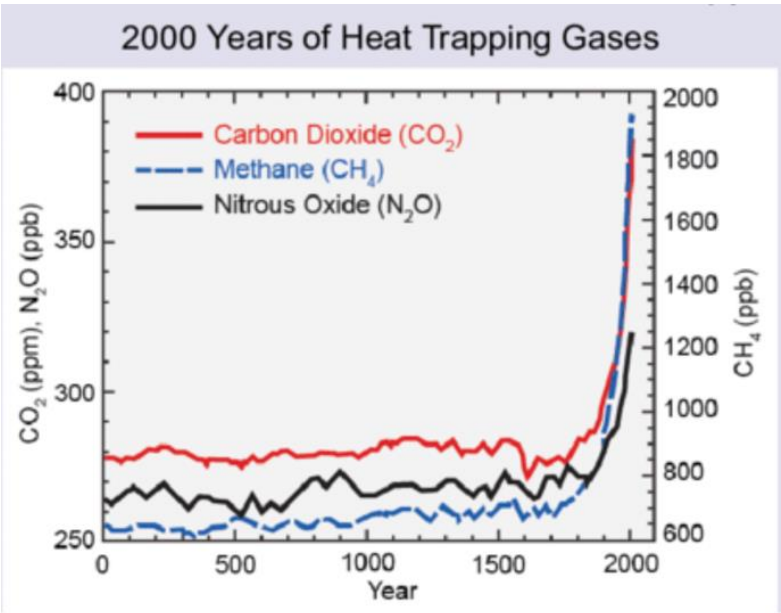
Answer: Whenever it is spring and summer in the Northern Hemisphere (which has much more land mass than the Southern Hemisphere), CO_2 concentrations in the atmosphere fall, because its vegetation is sequestering (taking in) CO_2.

Greenhouse Gases

Many more studies have been done since then. Besides carbon dioxide (CO_2), the main greenhouse gases are methane (CH_4) and nitrous oxide (N_2O). (Water vapor, a naturally occurring greenhouse gas, will be discussed in Unit 8.)

Scientists collected data on the atmospheric concentrations of **carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)** during the past 1000 years. As you can see on the curves below, for a long time their levels were pretty constant with only minor variations, but then they started to increase dramatically in the 19th century.

Image 4:[15]



Carbon Dioxide (CO_2) is emitted primarily by burning fossil fuels and by the clearing of forests. CO_2 remains in our atmosphere for many decades and some of it for many thousands of years.

Methane (CH_4) is emitted from landfills, coalmines, oil and gas operations, beef production and rice paddies. Methane is a very powerful greenhouse gas. It stays in the atmosphere for about 12 years. In the short term, methane is 86 times more powerful in trapping heat than CO_2.

Nitrous oxide (N_2O) is emitted by nitrogen-based fertilizers and industrial activities. It stays in the atmosphere on average for 114 years.

We should also be aware of another category of greenhouse gases, the **Fluorocarbons or F-gases**. Chemical engineers have designed these gases specifically to trap heat. That's why they are very powerful greenhouse gases. These chemicals are used mainly "in refrigeration and air conditioning, but also as solvents, as blowing agents in foams, as aerosols or propellants, and in fire extinguishers. The Intergovernmental Panel on Climate Change calculated that the cumulative buildup of these gases in the atmosphere was responsible for at least 17% of global warming due to human activities in 2005. The most commonly used F-gases are the hydrofluorocarbons (HFCs). HFCs were developed by the chemical industry in response to the discovery of damage to the

Earth's ozone layer due to chlorofluorocarbons (CFC) use. But this development ignored the known global warming effect of the newer chemicals. For some applications, there are environmentally safe and efficient alternatives to F-gases available.[16] For refrigerants scientists have not found an ideal alternative yet, despite much effort. A major study showed that out of 184.000 chemicals, the "27 that made the final cut, the best were still flammable to some degree."[17] As many F-gases stay in the atmosphere for a very long time it is extremely important that we discontinue their use and production. Under the Kigali Amendment, the United States and Europe made a commitment to significantly cut back their use of HFCs.

Section 3: Where Does the Warming Go?

"The vast amount of overall human-caused warming, 91% goes into heating the oceans. Water has a tremendous capacity to store heat. The atmosphere stores only approximately 1% of man-made warming because it has a relatively poor heat storage capacity."[18] Land also cannot store heat as well as the oceans do. Warming oceans have a tremendous impact on the climate as well as on ocean life.

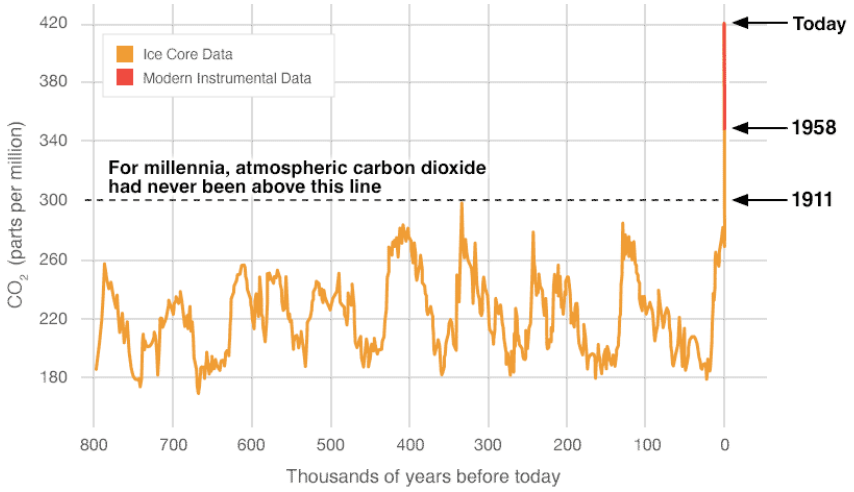
Section 3: A Look into the Past

> *"Science is the discoverer of the past. From its premises of past and present we deduce conclusions as to the future".* [19]
>
> 'Abdu'l-Bahá

Looking back into the more distant past, we know that there have been natural cycles of warming and cooling. The Earth went through many ice ages and interglacial periods. Scientists drilled three kilometers deep into the Antarctic ice and measured gas concentrations in pockets of air that have been trapped in the ice for thousands of years. From the analysis of the ice cores, they could estimate the temperatures and CO_2 concentrations in the past hundreds of thousands of years.

On image 5 below we see the atmospheric CO_2 concentrations over the past 800'000 years up to the present. Currently, CO_2 concentrations are at about 420ppm.

Image 5:[20]



“The atmospheric concentrations of CO_2 consistently fluctuated between 200 parts per million (ppm) during the ice ages and 280 ppm during the warm intervals. This shift from ice age to warm period occurred many times and always within this CO_2 range. When the Industrial Revolution began, the atmospheric CO_2 level was roughly 280 ppm.”[21]

On the graph we can see that CO_2 never went above 300ppm. On February 3, 2023, the CO concentrations measured at Mauna Loa, Hawaii, were 420ppm.[22]

This high CO_2 concentration “is not only far above any level over the last 740,000 years, it may be nearing a level not seen for 55 million years. At that time the Earth was a tropical planet. There was no polar ice; sea level was 80 meters (260 feet) higher than it is today.” [23] Let's put the number of 740,000 years into proper perspective. What we consider human civilization doesn't extend farther back than 10,000 years. At that time, a relatively warm and stable climate emerged which allowed agriculture.

Atmospheric CO_2 concentrations have never been as high as they are now in the entire history of human civilization. In fact, the atmospheric CO2 concentration is the highest in 2 million years![24]

Despite global consensus in the Paris Climate Agreement that carbon emissions must be quickly and significantly reduced, they are still increasing at an alarming rate.

Section 4: The Present and the Future

The situation today is very different from the past’s natural cycles. In a very short period of time, human beings have used huge quantities of stored solar energy (fossil fuels) thereby releasing unprecedented amounts of greenhouse gases into the atmosphere. That’s why greenhouse gas concentrations have been rising so rapidly.

The global warming we have already experienced and the many changes in climate all over the world can only be explained by these tremendous increases in greenhouse gases. They cannot be explained by any natural cycle or changes in solar activity.

Today, human activities have a stronger impact on climate than natural occurrences:

The underlying long-term trend for the Earth – driven largely by changes in our orbit – has been a very slow cooling. However, now human activity has overwhelmed all of these trends.[25] There is so much CO_2 in the atmosphere that its huge radiative forcing overwhelms the changes associated with orbital forcing. No ice age could start at this point!

If greenhouse gases were held constant at today's level, it is estimated that it would take several decades for their full impact to be felt. The Earth would continue to warm until the climate is in balance with the current greenhouse gases. Unfortunately, CO_2 levels are not constant but are continuing to rise, which will change the climate and the living conditions on Earth in a very dangerous way.

REFERENCES

[1] Genesis 1,31
[2] The Qur'an (Rodwell tr), Sura 67 - The Kingdom)
[3] Bahá'u'lláh, *Prayers and Meditations*, p. 48
[4] Working Group 1 of the Intergovernmental Panel on Climate Change, Report on the Physical Science, Sept. 30, 2013, ex. summary p. 3 and 4
[5] IPCC Climate Change, the Physical Science 22021 https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf
[6] *Global Warming Acceleration: Causes and Consequences* 12 January 2024 James Hansen, Makiko Sato, Reto Ruedy https://www.columbia.edu/~jeh1/mailings/2024/AnnualT2023.2024.01.12.pdf
[7] Copernicus: 2023 is the hottest year on record, with global temperatures close to the 1.5°C limit https://climate.copernicus.eu/copernicus-2023-hottest-year-record
[8] Bahá'u'lláh, *Lawh-i-Tibb* (Tablet to a Physician), Provisional Translation
[9] 'Abdu'l-Baha, *Some Answered Questions* www.bahai.org/r/481173913
[10] CLIMATE CHANGE: SCIENTIFIC AND FAITH PERSPECTIVES, Arthur Lyon Dahl, http://iefworld.org/ddahl06b.htm
[11] Jeffrey D. Sachs, *Common Wealth – Economics for a Crowded Planet,* p. 84
[12] Internet Geography https://www.internetgeography.net/topics/what-is-the-greenhouse-effect/
[13] Arthur Lyon Dahl, *CLIMATE CHANGE: SCIENTIFIC AND FAITH PERSPECTIVES,* http://iefworld.org/ddahl06b.htm
[14] NASA, https://climate.nasa.gov/vital-signs/carbon-dioxide/?_hsenc=p2ANqtz-8HpRVv9oVuSCF0VZQsQUZzqFhGtkLyw06Pme5RT0S-5vbMKKeT7887JYALC3WjAsIKVkac
[15] https://www.researchgate.net/figure/Observed-increase-in-the-atmospheric-abundance-of-carbon-dioxide-CO-2-nitrous-oxide_fig4_253691416
[16] Janos Mate, Kert Davies, and David Kanter, "The Risk of Other Greenhouse Gases", published in *State of the World 2009* by the Worldwatch Institute
[17] Inside Climate News, Climate-Friendlier Air Conditioning Chemicals Hard to Find, Study Shows, BY ZAHRA HIRJI, 23 Feb. 2017, https://insideclimatenews.org/news/22022017/climate-change-refrigerants-montreal-protocol-hfc-global-warming-donald-trump
[18] *Climate Change – What Everyone Needs to Know*, Joseph Romm, p. 6
[19] Abdu'l-Bahá, *The Promulgation of Universal Peace*, p. 28
[20] NASA, Vital Signs, Carbon Dioxide https://climate.nasa.gov/vital-signs/carbon-dioxide/?_hsenc=p2ANqtz-8HpRVv9oVuSCF0VZQsQUZzqFhGtkLyw06Pme5RT0S-5vbMKKeT7887JYALC3WjAsIKVkac
[21] up-dated from Plan B 2.0 by Lester R. Brown p.59 2. EPICA Community Members, op. cit. note 1; current carbon dioxide level from C. D. Keeling and T. P. Whorf, "Atmospheric CO 2 Records from Sites in the SIO Air Sampling Network," *in Trends: A Compendium of Data on Global Change* (Oak Ridge, TN: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, May 2005); Brown, op. cit. note 1; Quirin Schiermeier, "A Rising Tide," *Nature*, vol. 428 (11 March 2004), pp. 114–15.
[22] NOAA https://gml.noaa.gov/ccgg/trends/monthly.html
[23] Plan B 2.0 by Lester R. Brown p.59 2. EPICA Community Members, op. cit. note 1; current carbon dioxide level from C. D. Keeling and T. P. Whorf, "Atmospheric CO 2 Records from Sites in the SIO Air Sampling Network," *in Trends: A Compendium of Data on Global Change* (Oak Ridge, TN: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, May 2005); Brown, op. cit. note 1; Quirin Schiermeier, "A Rising Tide," *Nature*, vol. 428 (11 March 2004), pp. 114–15., http://www.earth-policy.org/books/pb2/pb2ch4_intro
[24] IPCC, AR6 WG I Report, August 2021
[25] *Climate Change – What Everyone Needs to Know*, Joseph Romm p. 7/8