Global climate change – facts and implications for environment and society

Introduction

“Multiple studies published in peer-reviewed scientific journals1 show that 97 per cent or more of actively publishing climate scientists agree that climate-warming trends over the past century are extremely likely due to human activities (NASA, 2022). However, there is still reluctance by many in decision-making capacities governing world populations that indicate a more retarded acknowledgement of this change. This is creating a less-than-optimal situation in addressing the climatic disturbances the world is now experiencing “at a rate that is unprecedented in at least the last 2000 years” (IPCC, 2021).

It is also apparent that many of the world’s population are becoming, in many ways, painfully aware of how these disturbances are becoming destructive and life-threatening (IPCC, 2022). Notwithstanding the naysayers and conspiracy theorists, who mistakenly voice otherwise and have a poorer understanding of what is really occurring, this knowledge is becoming more available through multi-dimensional methodologies to gain greater public involvement (Khatibi, et al., 2021)

This discussion reflects on the facts researched and, for the greater part, resolved global climate change and the implications for both environment and society. These data and observations should be part of the consistent and persistent message that should be presented clearly to all populations and urge Governments to show stronger leadership with this issue.

Global Climate Change - The Facts

Climate change is occurring rapidly and is exhibited by several indices. The most obvious and telling are the issues that NASA refers to as “Vitals Signs of the Planet”. These are the changes to the following:

1. Atmospheric Carbon Dioxide
2. Global Temperatures (Land and Ocean)
3. Arctic Sea Ice
4. Land Ice in Antarctica
5. Land Ice in Greenland
6. Sea level
7. Ocean Heat

The trends observed in each of these elements are graphically represented as follows:

1. Atmospheric Carbon Dioxide

Carbon Dioxide (CO2) is a heat-trapping gas released through human activities such as deforestation and fossil fuel use. The graph below shows CO2 levels measured at the Mauna Loa Observatory and indicates the latest measurement as 418 ppm as of February 2022 (NASA, 2022)

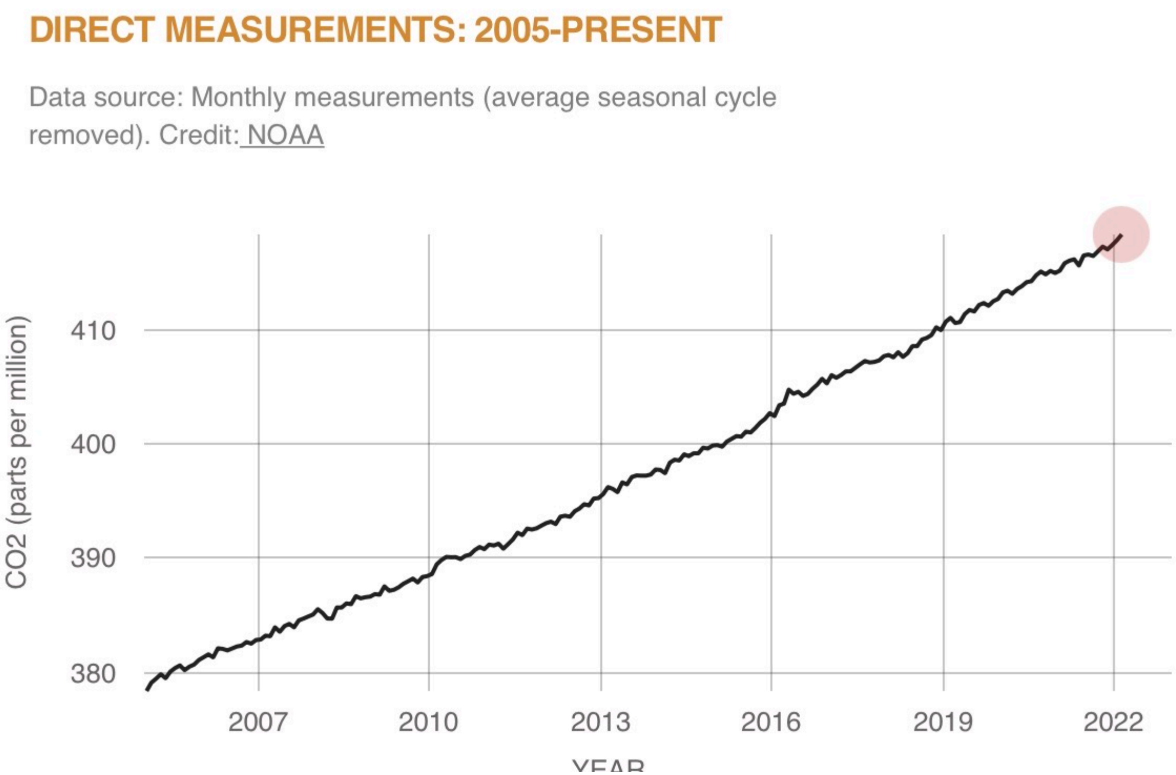


Figure 1. NASA Carbon Dioxide, 2022, Latest Measurement: February 2022, viewed 7 April 2021, https://climate.nasa.gov/vital-signs/carbon-dioxide/

2. Global Temperatures

This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures. Nineteen of the hottest years have occurred since 2000, except 1998, which a very strong El Niño helped. 2020 tied with 2016 as the hottest year on record since record-keeping began in 1880 (source: NASA/GISS) (NASA, 2022).

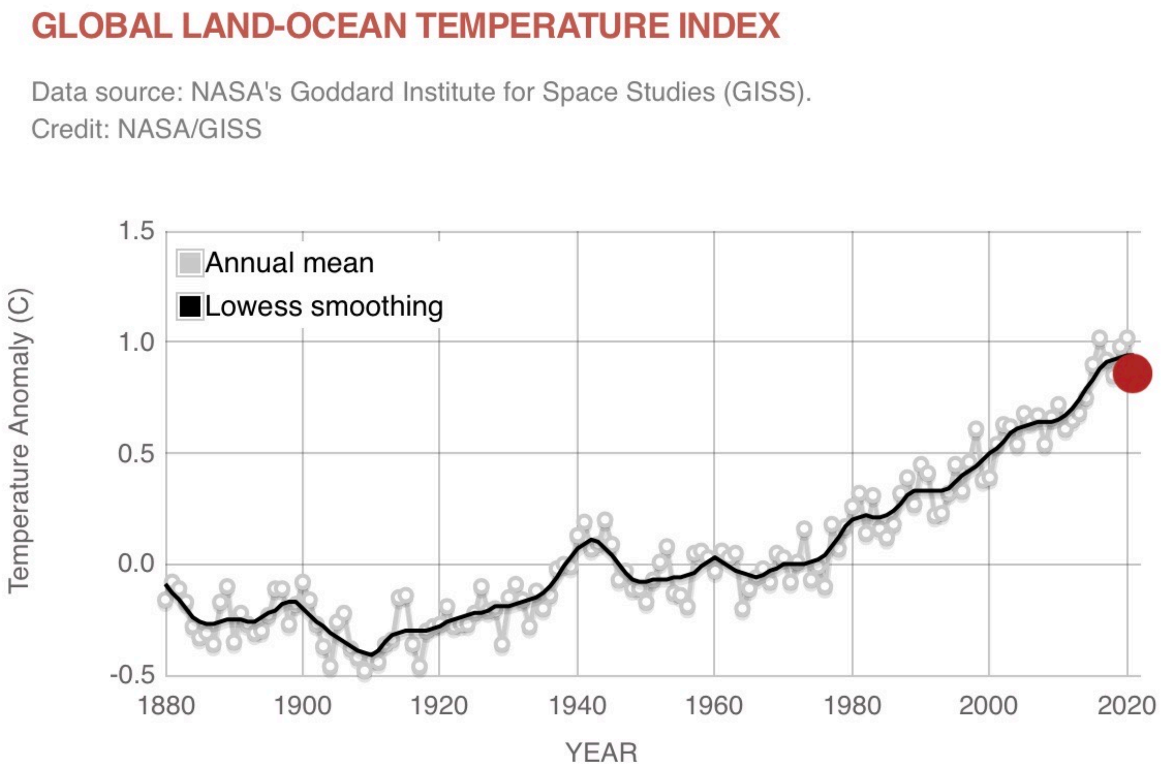


Figure 2. NASA Goddard Institute for Space Studies, 2022, Global Land-Ocean Temperature Index, Latest Annual Average Anomaly: 2021, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/global-temperature/

3. Arctic Sea Ice

Arctic sea ice reaches its minimum each September. The graph below shows the rate of decline as 13 per cent per decade relative to the 1981 to 2010 average (NASA, 2022)

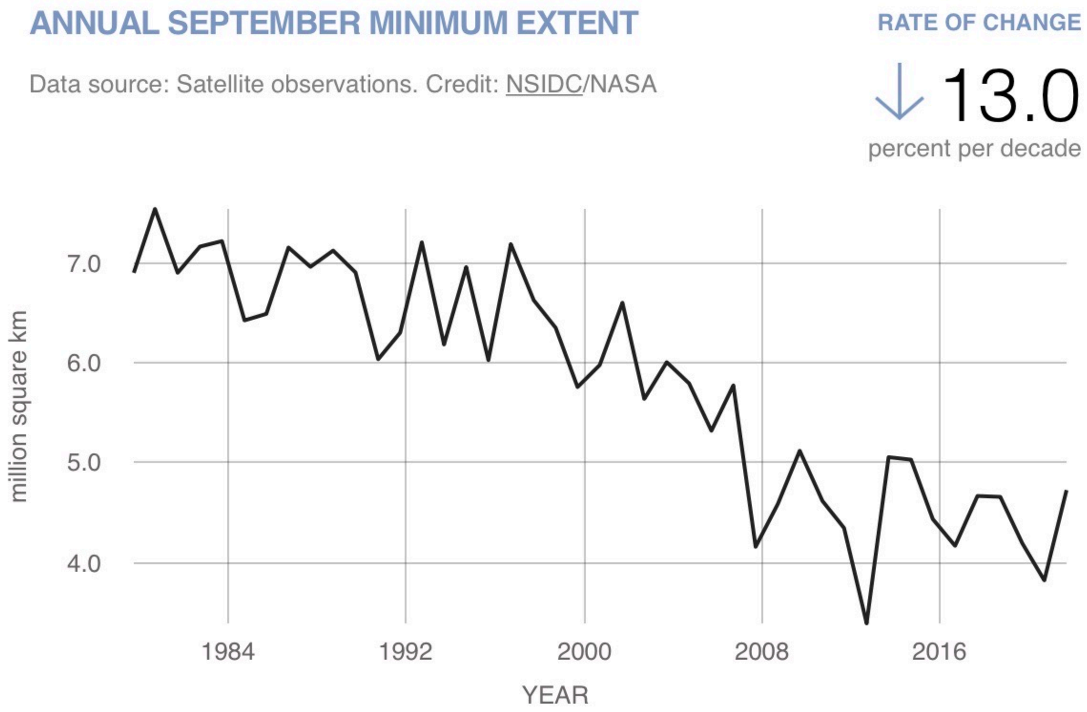


Figure 3. NSIDC/NASA Satellite observations, 2021, Arctic Sea Ice Minimum: Average September Extent, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/arctic-sea-ice/

4. Land Ice in Antarctica

Land ice sheets in Antarctica have been losing mass since 2002 (NASA, 2022).

The graph below indicates a rate of change in mass variation in Antarctica at 152 billion metric tonnes per year since 2002

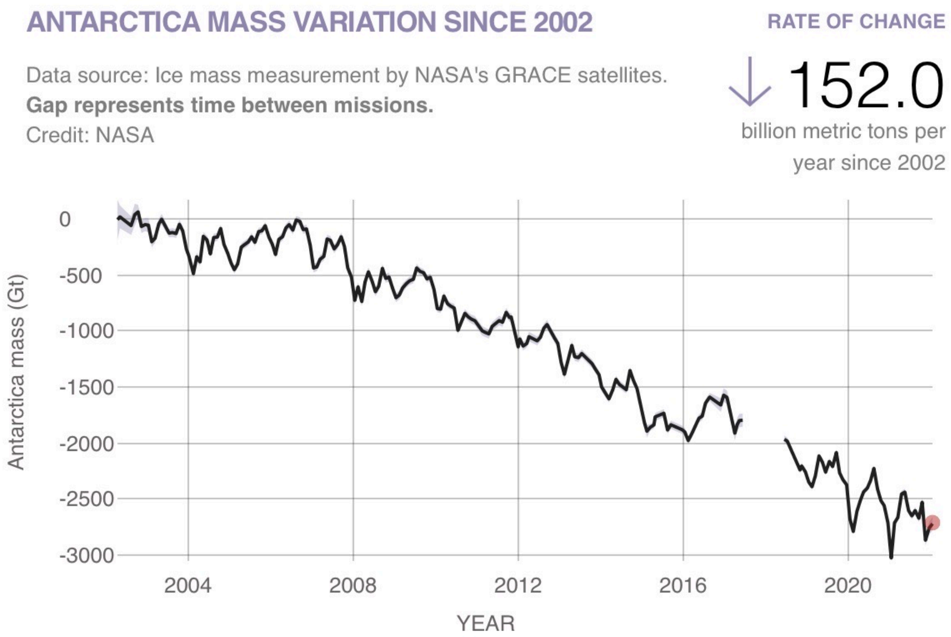


Figure 4. NASA/GRACE (Gravity Recovery and Climate Experiment), January 15 2022, Antarctica Mass Variation Since 2002, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/ice-sheets/

Data from NASA's GRACE and GRACE Follow-On satellites show that the land ice sheets in both Antarctica (upper chart) and Greenland (Figure 5) have been losing mass since 2002. The GRACE mission concluded science operations in June 2017 (NASA, 2022)

5. Land Ice in Greenland

Land ice sheets in Greenland have been losing mass since 2002 (NASA, 2022). The graph below indicates a rate of change in mass variation in Greenland at 275 billion metric tonnes per year since 2002

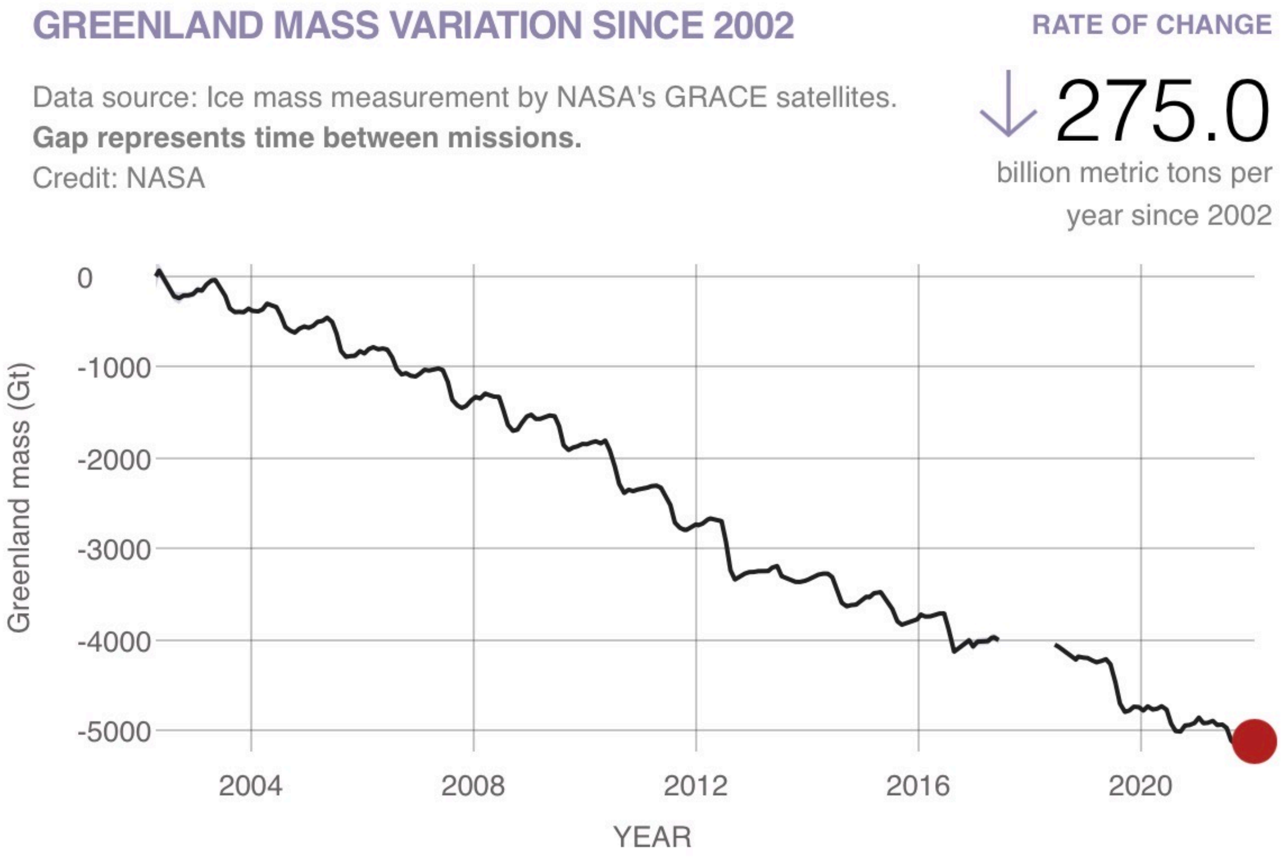


Figure 5. NASA/GRACE (Gravity Recovery and Climate Experiment), 2022, Greenland Mass Variation Since 2002, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/ice-sheets/

6. Sea Level Rise

Sea level rise is caused by thermal expansion by water warming and the increased melting of land ice sheets and glaciers (NOAA, 2021). The following graph indicates the changing sea height variation from 1993 to November 2021.

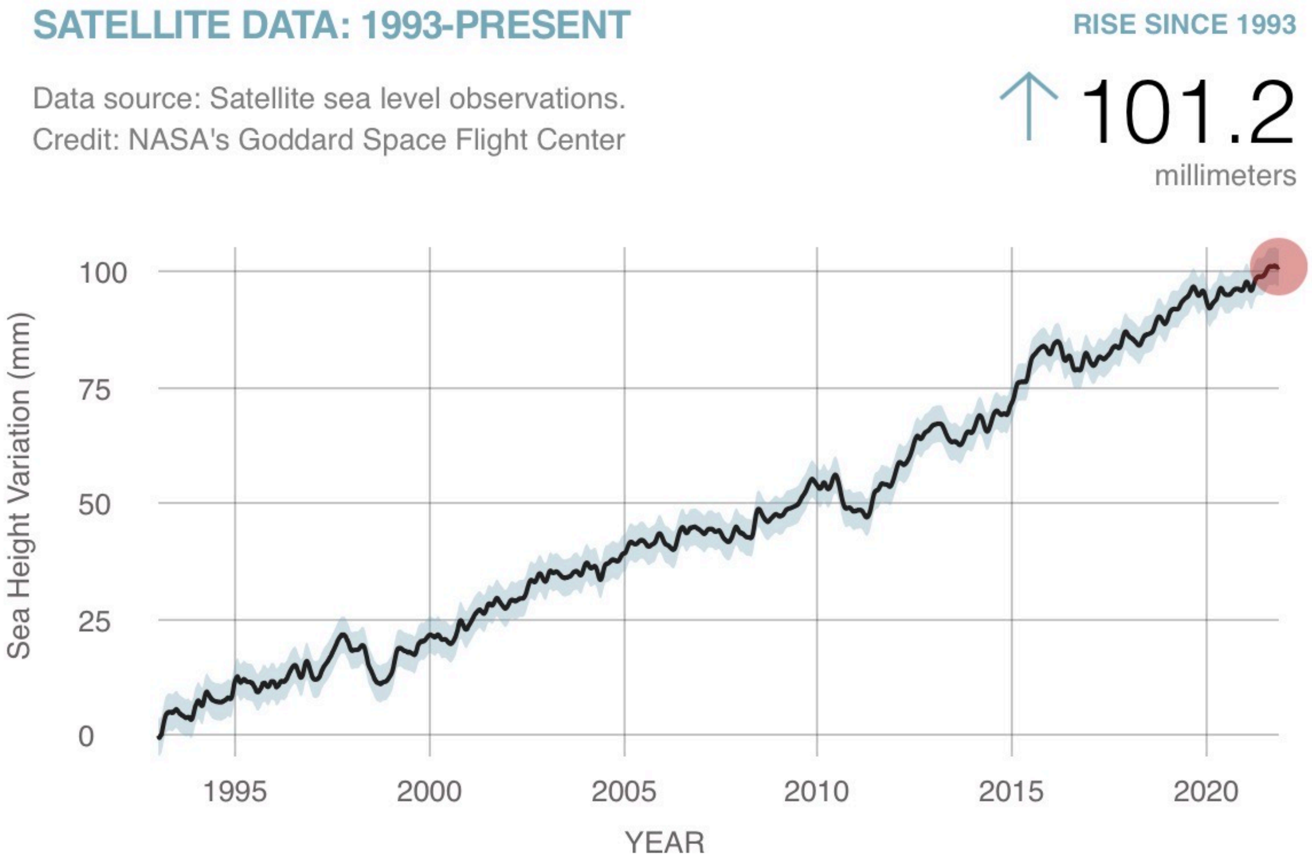


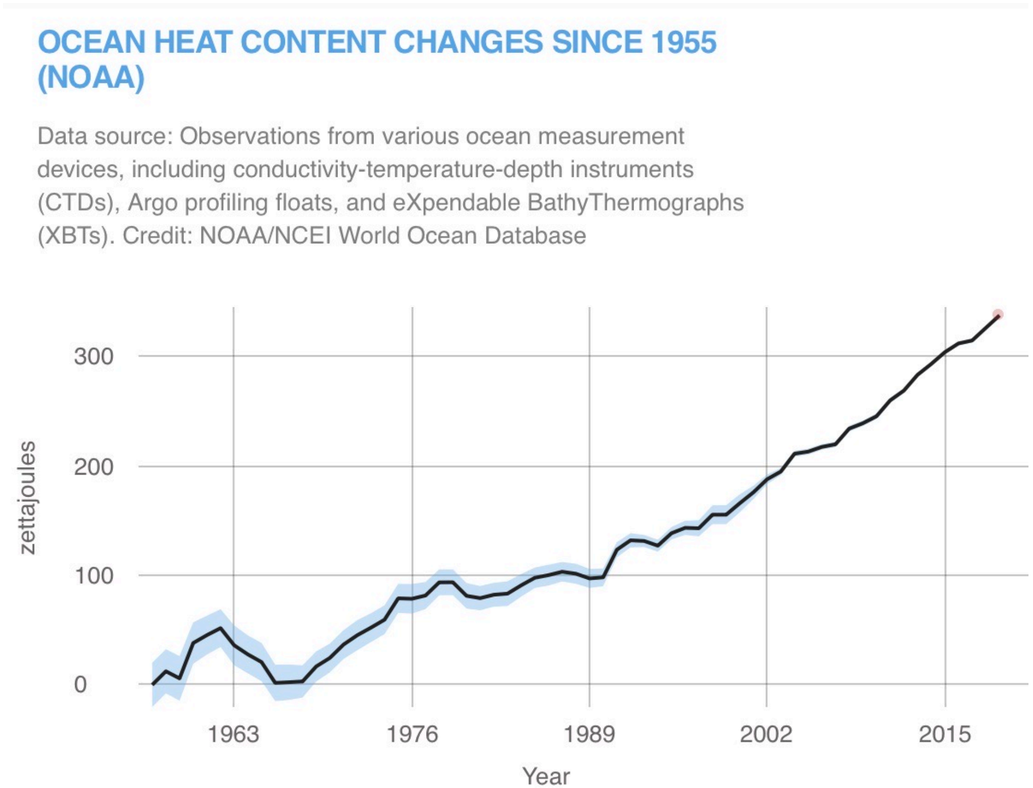
Figure 6. NASA Goddard Space Flight Center, 2022, Sea Level, Latest Measurement: November 2021, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/sea-level/

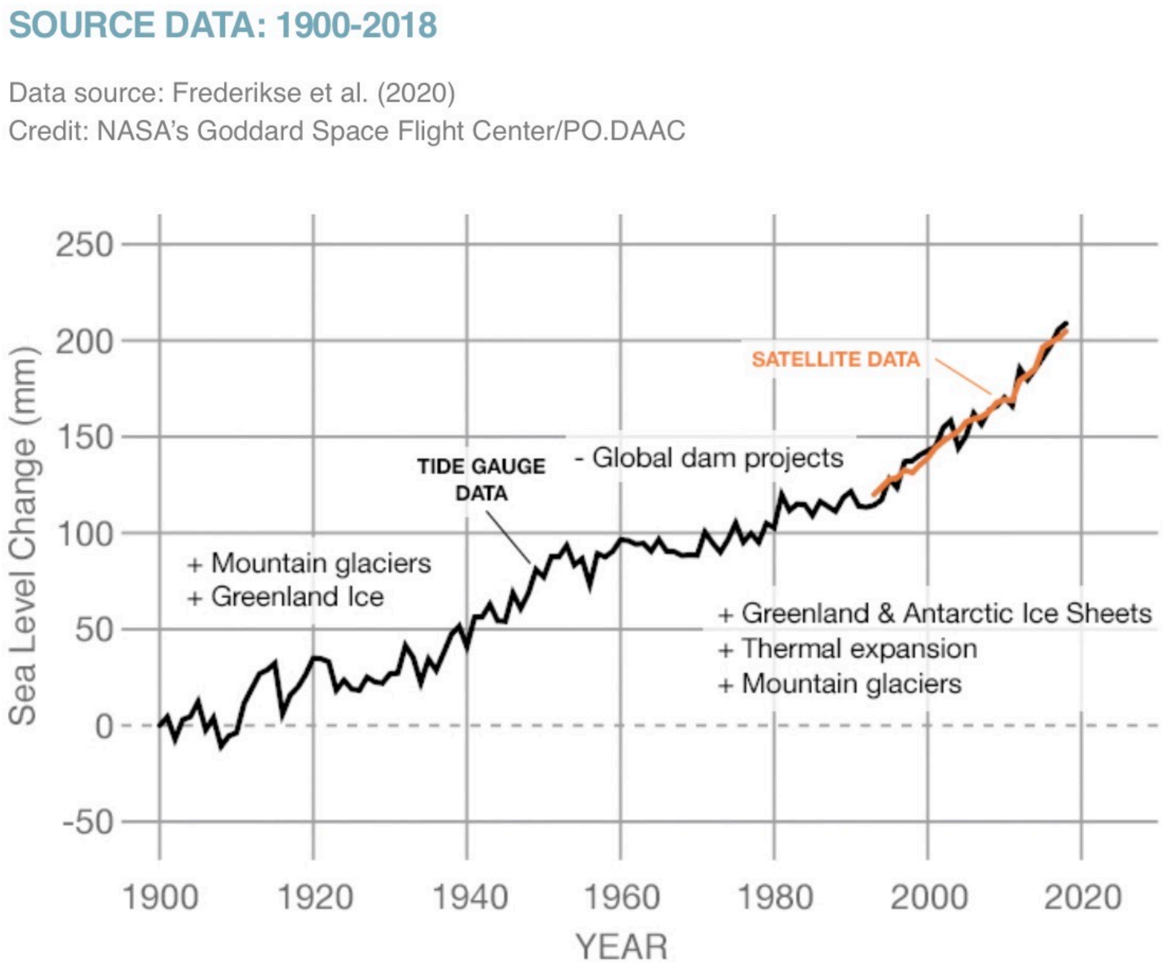
Figure 7. NASA Goddard Space Flight Center, 2022, Sea Level Change, Latest Measurement: November 2021, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/sea-level/

The above data also indicates causes of increased levels through the shrinking of mountain glaciers, Greenland ice sheets, Global Dam projects, and thermal expansion created by warming water.

7. Ocean Heat Content

The thermal expansion of the oceans is due to increased heat absorbed due to global warming. The ocean experiences ninety per cent of global warming. The heat energy stored lies in the surface layers put to a depth of 700 metres. The year 2021 experienced the greatest





absorption of heat and, consequently, the highest global sea level (NASA, 2022). The following two graphs indicate the data of these extreme and accelerating changes.

Figure 8. NOAA, 2019, Data points indicate cumulative averaging of heat values since 1955, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/ocean-heat/

The below chart indicates ocean heat absorbed between 1992 and 2017, combining data received from the instruments as listed in the chart. This once more indicates the accelerating changes occurring in all of the previous vital signs of the planet.

Figure 9. NOAA, 2019, Data points indicate monthly changes in heat content from 1992 to November 2017, viewed 7 April 2022, https://climate.nasa.gov/vital-signs/ocean-heat/

Implications for the Environment and Society

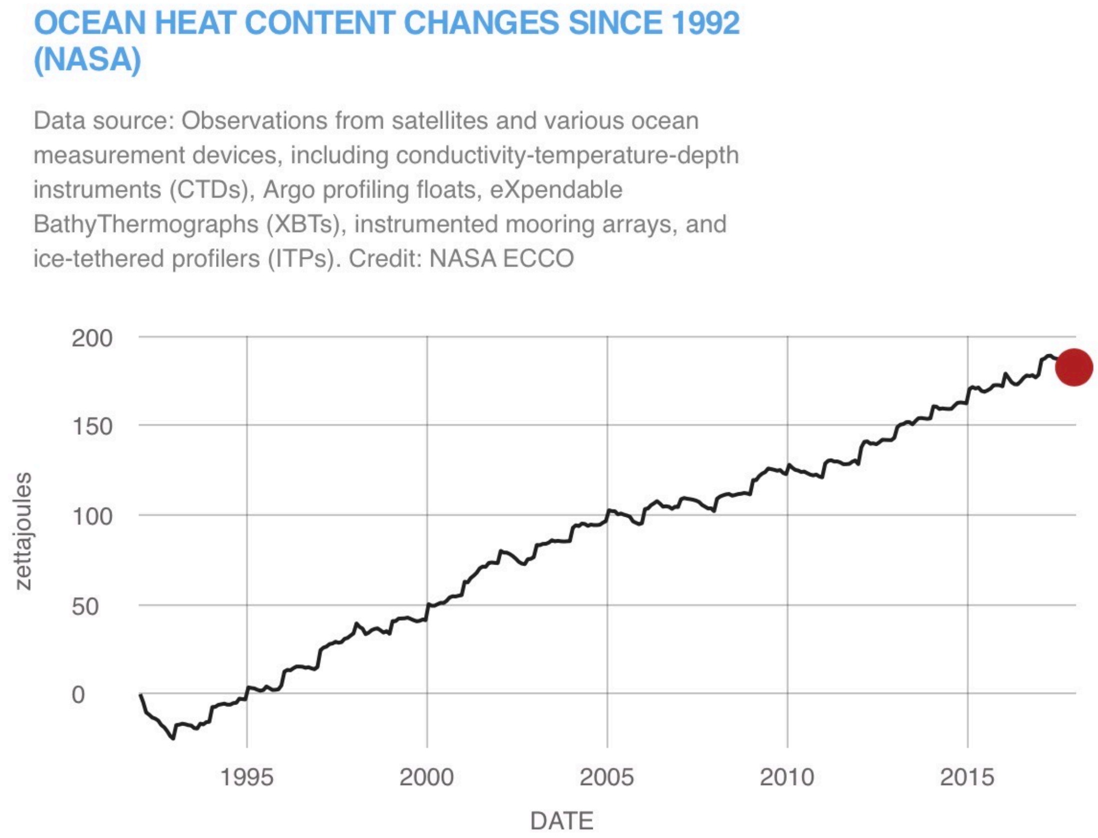
All of the above-listed "Vital Signs" indicate rapidly accelerating changes to both the Terrestrial and Aquatic Biospheres. Each, in turn is affected by one principal element of excessive heat. In the terrestrial biosphere (lithosphere) as Tian et al. (2016) describe:

> Anthropogenic activities such as land-use change, agriculture and waste management have altered terrestrial biogenic greenhouse gas fluxes, and the resulting increases in methane and nitrous oxide emissions in particular, can contribute to climate change

In the aquatic biosphere (hydrosphere) the main influences of change are those abiotic elements resulting from anthropogenic activity. These include light, temperature, precipitation and contamination. With this environment representing more than 70% of the earth's surface and absorbing more than 30% of the carbon dioxide produced by anthropogenic activity, it correspondingly represents many key concerns for the future of humanity if remaining unchecked (IPCC, 2022).

The Terrestrial Biosphere (Lithosphere)

Carbon Dioxide is the most consistent and voluminous greenhouse gas emitted through human activities. The main activities that produce this gas are using fossil fuels for energy and transportation, other industrial and commercial chemical processes and less than optimal land use, such as deforestation and land-use changes (EPA, 2022). Of this increase in CO_2 production, we are faced with the "existential threats posed by the increase in extreme weather events and changing climate patterns" (Nguyen et al.,2021).



Some of the major changes to natural climate regimes are increasing temperatures up to and beyond species' threshold tolerances, altered precipitation, effects on vegetation, habitat destruction and fragmentation, invasive species and the emergence of wildlife diseases. These changes all contribute to the imbalance of all-natural cycles; Carbon, Nitrogen, Phosphorous and Hydrologic.

The exacerbation of these changes is caused by the world's increasing population and its need to provide sufficient food and fresh water, vital needs for humanity's survival. Climate change alters the structure, resource availability and environmental favourability of habitats rendering them unsuitable for native fauna and flora, predisposing them to extinction (Surasinghe, 2011). With increasing temperatures and without areas of deliberate deforestation to increase agricultural production, wildfire damage is also reducing forest and vegetative cover, creating a toll on habitats, reduction in animal species and natural sinks for carbon dioxide. Alongside this damage is the lowered ability of vegetative habitats to resist excessive water flow, which assists in the undue flooding of susceptible areas. Prime examples of the results of both of these extremes have been clearly evidenced in Australia's recent extreme weather outcomes (Climate Council, 2022)

According to Almond et al. (2020) in their text *Living Planet Report 2020-Bending the curve of biodiversity loss*:

> • The alteration of the world's natural systems threatens to undo the extraordinary gains in human health and well-being of the past century.
>
> • Urgent action is needed to address the loss of the biodiversity that feeds the world.
>
> • There is a fundamental mismatch between artificial 'economic grammar' and 'nature's syntax' which determines how the real world operates.
>
> • It is becoming ever clearer that biodiversity is a non-negotiable and strategic investment to preserve our health, wealth and security.

Human health, as well as other issues, is also directly threatened by the increasing intensity, duration and frequency of heatwaves (Perkins-Kilpatrick & Lewis, 2020) and the creeping spread of species carrying airborne diseases such as the dengue virus transmitted by the *Aedes aegypti* mosquito (Brady & Hay, 2020)

This, of course, includes changes to our aquatic environment

The Aquatic Biosphere (Hydrosphere)

Damage to this biosphere would have a dramatic effect on the economic prosperity of humanity. According to UNESCO (2021) :

> An estimated three out of four jobs that make up the global workforce are either heavily or moderately dependent on water. This means that water shortages and problems of access to water and sanitation could limit economic growth and job creation in the coming decades…also notes that half of the world's workers - 1.5 billion- are employed in eight water and natural resource-dependent industries.

As a driver of economic growth, concern should be given to increasing temperatures' effect on these natural resources.

Poff et al. (2002) aver that: "Increases in water temperatures as a result of climate change will alter fundamental ecological processes and the geographic distribution of aquatic species". This also includes the need for humanity for adequate and potable water to drink (WHO, 2011). Water quality is considerably affected by what goes into it, such as nutrient runoff from agricultural production (Hamman et al., 2018) and other forms of pollution, such as plastic waste, which deteriorates sufficiently to produce particles of microplastics that eventually find their way into our food chain (Hollman et al., 2013)

According to Virto (2018): "Concerning pollution in the oceans, 80% comes from land-based sources" and"Excess nutrients lead to eutrophication which can lead, in turn to hypoxic dead zones, the latter having increased ten times between 1969 and 2010."

Increased eutrophication is also being experienced by many freshwaters and coastal wetlands (Chislock et al., 2013). In freshwater, for example, the freshwater Mollusca populations, "livers of the rivers" (ABC, 2022) are being decimated as shallow freshwater temperatures are exceeding the temperature threshold of these species for their existence.

Increased absorption of CO_2 causes "Ocean acidification which is already impacting many ocean species, especially organisms like oysters and corals that make hard shells and skeletons by combining calcium and carbonate from seawater" (NOAA, 2020).

Further to the alarming threats to economies, habitats, and species survival rates, pollution such as microplastics becoming part of our food source, ocean acidification, and rising sea levels also offer dire consequences to humanity. McMichael et al.,(2020) citing the IPCC (2019) aver that "Around 680 million people live in low-lying coastal zones – that is expected to increase to a billion by 2050."

Clearly, livelihoods and living space are being threatened with accelerating concern.

Conclusions

Data has been obtained from reputable sources such as the National Aeronautics and Space Administration (NASA), the National Climatic Data Center (NCDC), the National Oceanic and Atmospheric Administration (NOAA) and the Australian Government's Bureau of Meteorology (BOM). This is supported by considerable peer-reviewed research on the changes to both global and local climatic changes.

It is with little doubt that temperature, through the capture of excess heat due to increasing GHG emissions, is increasing at an accelerated rate. This is creating climatic disturbances that are increasing in frequency and intensity.

With regard to the terrestrial biosphere and as part of the United Nations Sustainable Development Goal (SDG), (2015), 15:

> 60% of the world's ecosystem services have been degraded over the past 50 years and we continue devaluing our natural resources at an alarming rate. Estimates indicate that 2-5 trillion USD of ecosystem services are lost each year from deforestation alone. While many of the effects are felt locally first, the long-term consequences are global and the scale is highly relevant to business, presenting risks and opportunities.
>
> https://sdgcompass.org/sdgs/sdg-15/

With regard to the aquatic biosphere and as part of SDG 14:

> Careful management of this essential global resource is a key feature of a sustainable future. However, at the current time, there is a continuous deterioration of coastal waters owing to pollution, and ocean acidification is having an adversarial effect on the functioning of ecosystems and biodiversity. This is also negatively impacting small-scale fisheries.

https://www.un.org/sustainabledevelopment/oceans/

This is proving increasingly problematic for decisions to be made in adapting to protocols for managing changes — especially in regard to the resources required to provide appropriate assistance for the health and well-being of the world's population.

Davis & Hanna (2020) observe that with the stochastic element of climate system behaviour, variations in data gained make it difficult to accurately predict the frequency and intensities of extreme conditions earlier referred to (p.13).

Regarding the Australian continent, according to Zillman (2015), cited in Davis & Hanna (2020):

> The climate change 'debate' in Australia has become embroiled in economic and ideological issues rather than ones based on scientific evidence. Even though the Australian Government in 2015 outlined a proposal to invest $6 billion to develop Northern Australia, for example (Office of the Prime Minister and Cabinet 2015), there was no reference for the need for climate risk analysis.

This suggests a need for a better understanding of the role of the driving forces of climate change such that we can defend our populations from the disastrous effects of extreme climatic conditions.

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