The sentinel lighthouse warns mariners of rocky shores. *Climate Sentinel News* provides similar warnings to Australians and people everywhere threatened by the growing Climate Emergency.

Note: if you want to follow links, the electronic version of this document can be downloaded from https://voteclimateone.org.au/wp-content/uploads/2023/07/act_now.pdf

Australian MPs: Act now! Later may be too late!

William P. Hall on 4 July, 2023, Climate Sentinel News
Editor, Climate Sentinel News
VoteClimateOne.org

February 8, 1983 – Dust storm engulfs Melbourne, Vic., in the run-up to the Ash Wednesday bushfires 8 days later. On the 8th, on my way with friends to a meeting in the Melbourne CBD, when I saw this brown cloud engulfing Melbourne and visibility drop to a few metres as everything went dark, I thought that this was the end of the world. However, Ash Wednesday was only a preview of much worse to come. Black Summer 2019-2020 towards the end of the worst El Niño to date, that marked the end of the first act of the growing climate crisis. Even worse is likely to come with the next El Niño, which the Bureau of Meteorology thinks is beginning to ramp up now. / Note: the image may not be from Melbourne as it has been used in several different contexts. However, there are several other views of the day (mostly in B&W. See Melbourne Dust Storm 1983. It really did look as if the Apocalypse was rolling over the City.

Version: email/print

Australian MPs: Act now! Later may be too late!

Human activities are triggering self-reinforcing existential climate risks that are becoming more likely with time

Over the last 200 years we have burned prodigious amounts of carbon-based fossil fuels (coal, oil, methane) to produce waste gases (mostly CO_2) and useful energy to drive the Industrial Revolution, our affluence, our toys, our technologies, our wars, and everything that has followed. *The fossil carbon humans have extracted from the Earth and burned in an instant of geological time took our planet millions of years to accumulate and store in the geosphere* (i.e., rocks & soil). These waste gases are changing Earth's atmosphere (the air we breathe, etc…).

The physical properties of CO_2 molecules and other atmospheric emissions have trapped enough additional solar heat to significantly raise average temperatures around the world. The added heat is already causing unprecedented climatic disasters. These existential climate risks will only become more frequent and catastrophic as temperatures continue to rise. (See CO2: Past, Present, & Future – one of many dozens of articles covering the same facts, and Climate apocalypse).

However, natural regulatory processes in the climate system have kept the environment reasonably stable for more than 800,000 years up until the 20th Century – enough time for humans to evolve and develop the social systems, agriculture, technology, and cultural riches we benefit from today.

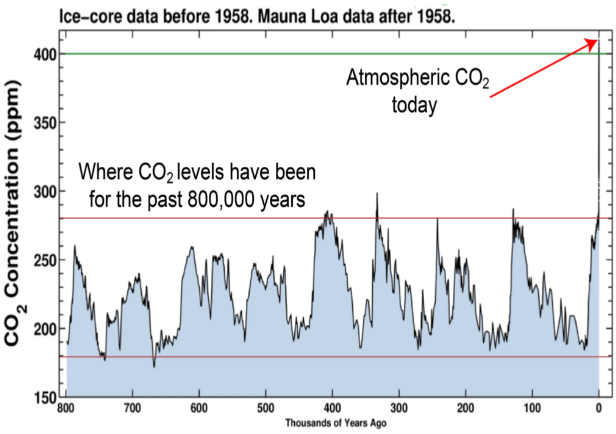


Fig. 1. Image modified from the Scripps Institution of Oceanography

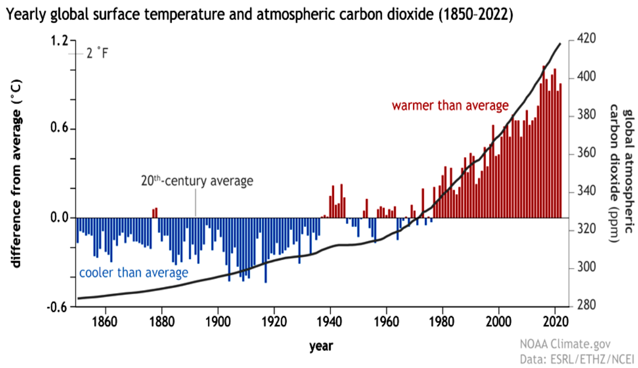


Fig. 2. Yearly temperature compared to the twentieth-century average (red bars mean warmer than average, blue bars mean colder than average) from 1850–2022 and atmospheric carbon dioxide amounts (gray line): 1850-1958 from IAC, 1959-2019 from NOAA ESRL. Original graph by Dr. Howard Diamond (NOAA ARL), and adapted by NOAA Climate.gov.

As shown in the graphs above, the shock to the composition of the atmosphere caused by these human generated changes is increasingly disrupting natural climate regulation. If we do not quickly stop and repair the damage we have done to the atmosphere, then over the next few decades increasingly extreme, frequent and extensive climate changes and catastrophes will be causing more death and destruction than our societies have the capacity to repair. In turn, *this climate collapse will lead to agricultural, economic and social collapse followed by mass die-offs and probable human extinction within a century or two*.

Business as usual cannot cope with a global systems breakdown. Nor can uncoordinated individual actions. However, at least for a few more years before systems breakdown has progressed too far, we should still be able to assemble the technology and knowledge to avoid this doom. Beginning with primitive Victorian era steam-punk technologies backed by a very limited scientific understanding of climate and geophysics, humans took over 150 years to burn enough fossil fuel to accidentally cause the present crisis. Today we have now developed a deep and detailed scientific understanding of how the world works and vastly more powerful technologies. With will, leadership, and cooperation at international, national, state, and local areas we should be able to locate, diagnose and repair aspects of the climate system we have broken to re-stabilize it in a state we can live with.

However, to do this we will have to revolutionise many of our governments. We need to change them from their usual businesses of representing and working for the special interests of their donors, patrons and puppet masters (many of them associated with fossil fuel industries), to a new business of truly representing the needs of the citizens they supposedly represent — especially in the face of the growing climate crisis.

If you are an MP, you need to join this revolution!

The factual scientific evidence of the consequence we face if we fail to stop and reverse global warming is overwhelming. However, I recognize that a life in politics where almost everything can be ‘negotiated’ does not prepare most politicians to understand the difference between responding to non-negotiable facts of physical reality and the business-as-usual of getting elected/re-elected and trading influence.

In the remainder of this work I present some of the overwhelming evidence of the dangers we face from an increasingly destabilised climate system driven by unrestrained global warming, and why our governments must change and act if we are to have any hope of surviving the existential global crisis this is causing. *Because this evidence is based on scientific laws developed over some 400 years of testing and practical use, it is totally independent of whatever people might want to ‘believe’ about how the world works*. The world works as it does, and it is up to us to try to understand *that*.

Laws of physics, geology, chemistry and biology

The scientific laws of physics and chemistry describe how we think the universe we live in works. Because atoms and molecules work the way they do, burning carbon releases ‘greenhouse’ (i.e., heat trapping) gases into the atmosphere. Because the increased concentration of these gases in the atmosphere traps reduces the amount of solar energy leaving our planet, the world is growing warmer.

The US National Oceanic and Atmospheric Administration‘s (NOAA) Mauna Loa observatory’s records show the longest available continuous series of meticulous(!) measurements of important greenhouse gases. Variation in the two most important gases are shown below. The amount of these gases in the atmosphere increased every year since the recording began (except for methane which showed slight decreases in three out of 5 years beginning in 2000). More importantly, the rate of CO_2 increase has also increased in 5 of the 6 decades in the record (i.e., it’s getting worse even faster now than it was earlier!). These kinds of graphs are based on many discrete observations taken every day for many years at particular locations (in this case Mauna Loa, Hawaii) that are replicated by similar observations from other stable locations around the world (e.g., Cape Grim, Tasmania – see also CSIRO Atmospheric Composition and Chemistry).

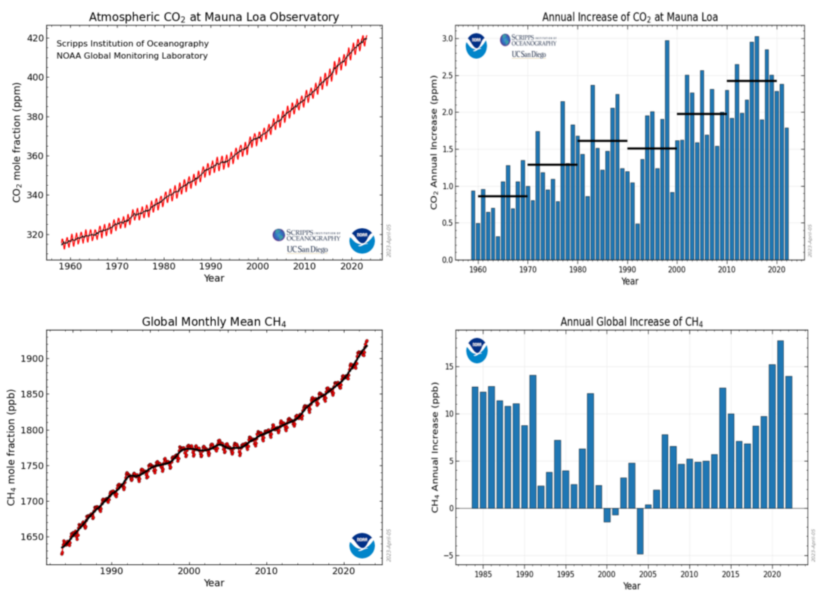


Fig. 3. NOAA Carbon Cycle Greenhouse Gases / Trends in CO_2 (carbon dioxide) / Trends in CH_4 (methane). The average amounts of gas are plotted (red dots) on a monthly basis. The average increase in the amounts of gas are plotted yearly. Source gml.noaa.gov

Greenhouse gases in the atmosphere act as a thermal blanket causing the Earth’s temperature to rise by reducing the amount of solar heat lost to space — same heat in, less heat out: inevitably everything covered by the blanket gets warmer. Just how much warmer is measured by the 'temperature anomaly'.

It should be no surprise that dumping millions of years worth of carbon accumulation into the atmosphere as greenhouse gases at an accelerating rate over 200 years or so has significantly affected global temperatures.

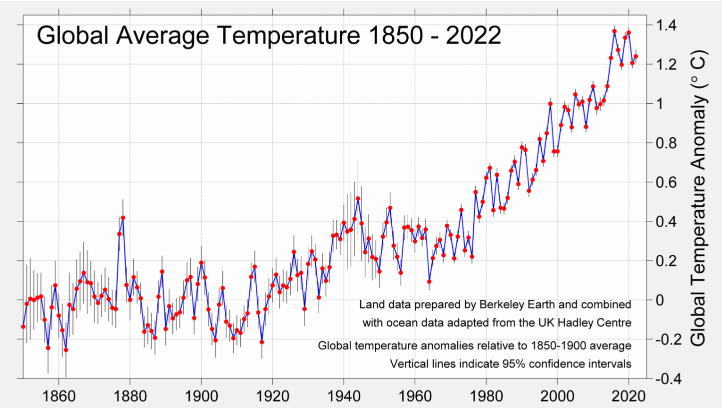


Fig. 4. Berkeley Earth's **Global Temperature Report for 2022** – Posted on January 12, 2023 by Robert Rohde.

The global mean temperature in 2022 is estimated to have been 1.24 °C (2.24 °F) above the average temperature from 1850-1900, a period often used as a pre-industrial baseline for global temperature targets. This is ~0.03 °C (~0.05 °F) warmer than in 2021. As a result, 2021 is nominally the fifth warmest year to have been directly observed, although the years 2015, 2017, 2018, 2021, and 2022 all cluster closely together relative to their uncertainty estimates. In particular 2022 and 2015 are essentially tied, and 2022 could just as easily be regarded as the 6th warmest year. This global mean temperature in 2022 is equivalent to 0.91 °C (1.64 °F) above the 1951-1980 average, which is often used as a reference period for comparing global climate analyses. ***The last eight years stand out as the eight warmest years to have been directly observed.*** (Note: Berkeley Earth's methodologies and their differences from other groups providing similar global temperature records are described here.)

Around ninety percent of the excess heat Earth absorbs is held in the oceans. Water in its three forms (gas, liquid and ice) is the main transporter for distributing that energy around the planet.

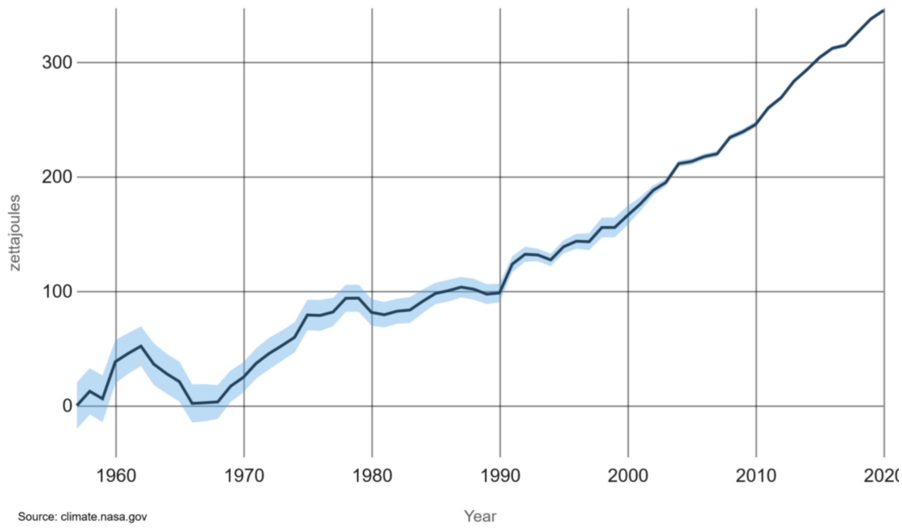


Fig. 5. Ocean heat content changes since 1955 (NOAA)

Sources for ocean temperature observations made by various ocean measurement devices, include conductivity-temperature- depth instruments (CTDs), Argo profiling floats, and eXpendable Bathy- Thermographs (XBTs). Credit: NOAA/NCEI World Ocean Database. A more detailed graph including additional measurements from instrumented mooring arrays, and ice-tethered profilers (ITPs) covers the period 1992 – 2022. Credit NASA ECCO.

Covering more than 70% of Earth's surface, our global ocean has a very high heat capacity. *It has absorbed 90% of the warming that has occurred in recent decades due to increasing greenhouse gases, and the top few metres of the ocean store as much heat as Earth's entire atmosphere.* Note: If you want to grasp how many and what kinds of precision measurements cross-checked across a variety of measurement platforms go into constructing these graphs, refer to ECCO's presentation: ECCO: Integrating Ocean and Water.

Water (= H_2O) is a major component in the climate system and the main carrier of energy driving weather and climate change.

Each of water's three physical states: water vapour (=gas), liquid water, and frozen water (=ice), together with transitions between the three states, all play important roles in the absorption, storage, transport, and release of heat around the planet. In its own right water vapour is also the most important and variable greenhouse gas.

Of all the natural materials forming the outer layers of the Earth, liquid water has one of the highest heat capacities of any known chemical compound. A lot of energy needs to be absorbed or released to warm or cool a quantity of water by even one degree — **the amount of heat needed to raise the temperature of 1 gm water by 1 °C at standard pressure and temperature has its own name, the calorie**. (An old unit of measure, but the easiest to follow here.) This same amount of heat is released when the 1 gm cools by 1°. To raise the temperature of 1.3 sextillion litres just by 1° of the world's oceans takes the absorption of a humongous amount of heat!

Water (Hydrosphere) and Air (Atmosphere)

Water in the world Ocean

At temperatures above 4 °C, water expands as it warms. In other words, a parcel of water composed of a given number of molecules occupying space expands in volume as it warms from 4 °C to boiling. It also expands as it cools from 4 °C and expands more as it freezes. Thus, as the ocean warms, sea levels rise. Water running off the land from melting glaciers and ice sheets causes sea levels to rise further and faster. Also, ice floats on top of warmer water, insulating it from rapid cooling in frigid polar nights. When liquid water freezes to form solid ice it releases ~80 calories/gm while 80 calories of energy needs to be extracted from the surrounding environment to melt 1 gm of ice to liquid water.

Warmer waters lying over cooler waters of the same salt content tend not to mix. However, as warm salt water evaporates, salt is left behind, making the remaining surface water denser, until it becomes heavier than cooler water below, allowing the warm salty water to sink and mix with the cooler water. This helps to suck in ocean currents to replace parcels of the cooling saltier water as they sink into the depths.

Thus, ocean currents are important engines for transporting heat around the globe.

Water in the atmosphere

Boiling or evaporating 1 gm of liquid water to gas (i.e., invisible steam) at one atmosphere of pressure takes approximately 540 calories of energy (= ‘heat of vaporisation/evaporation‘)! Similarly, when H_2O gas condenses to form visible steam (i.e., a mist of liquid water) the same energy of vaporisation is released as heat.

The gas laws discovered in the 1800s through practical experience with the thermodynamics of steam and internal combustion engines govern the relationships between temperature, volume, and pressure of gases. As heat energy warms a parcel of gas at a standard pressure, the absorbed energy causes the gas molecules comprising the parcel to move faster – resulting in increased volume (lowering the density of the parcel compared to surrounding parcels that have not changed in temperature). Or, vice versa, increasing pressure will cause the gas parcel to heat up. Similarly, cooling gas will shrink in volume (i.e., become more dense) as its temperature decreases, or warming gas will increase its volume becoming less dense as it is heated. This is why parcels of warm air tend to rise in generally cooler air and vice versa.

Finally, another set of laws describes the solubility of water vapour in Earth’s atmosphere, and the solubility of the various gases forming the atmosphere in water. A parcel carrying the maximum concentration of a dissolved material is said to be ‘saturated’. Normally any excess over the point of saturation is precipitated out of the solution. Where precipitation of water vapour in the atmosphere is concerned, the precipitated water is called dew (if it collects on a surface), mist (if the droplets are small enough to remain floating in the atmosphere), rain (if droplets are large enough to fall to the ground) or snow (if it is cold enough for the precipitation of solid water). Hail is precipitated as liquid droplets that coalesce and freeze on the way to the ground. Basically, the capacity for the atmosphere to carry water as dissolved water vapour and the rate at which the vapour evaporates from the liquid increases substantially with temperature.

Note that the process of evaporation absorbs a lot of energy (i.e., the vapour stores the energy that drove the evaporation as latent heat) which is released as sensible heat when the dissolved vapour condenses and precipitates. Warm air can hold a lot of water vapour while cold air can only hold a little vapour. Thus a warm air mass is often able to suck moisture out of vegetation and soils, but as that mass rises in elevation and cools a temperature may be reached where the air is saturated (this is called the ‘dew point‘) and possibly massive amounts of water are precipitated as rain or snow together with the release of huge amounts of latent heat as sensible heat causing the air mass to rise still higher (e.g., into towering anvil topped cumulonimbus clouds) forcing still more water and heat out of the air. Also, the rising air is liable to suck in high speed winds and possibly even form small and large hail, cyclones, and tornadoes. The higher the temperature of the air mass is when the dew point is reached, the more precipitation, heat and wind is generated.

As global warming increases baseline and average temperatures around the world, the amount of energy contained in parcels of water vapour increases, and thus increases the total amount of energy available to drive extreme weather events.

Water on the land and in the biosphere

Liquid water is a powerful solvent for all kinds of minerals and flows downhill wherever it can. Flowing water is relatively dense, and therefore an important agent for the transport of solid materials ranging from particles of sand to potentially huge boulders and even buildings. Consequently, standing and flowing waters are the major agents of dissolution, erosion and storm damage: especially when combined with storm-force winds.

All living things on Earth are partially comprised of water, with humans being about 60% water and even trees 50% water. The water in and around living things acts, **a)** as a solvent and as a medium of transport for the dissolved gases required for photosynthesis (where this exists) and respiration; **b)** as a medium of transport of the ions, molecular nutrients and waste products of cellular metabolism and growth; **c)** as a structural element in the three-dimensional folding of proteins and other macromolecules; and **d)** as a structural element in the maintenance of hydraulic rigidity of the shapes of cells and vesicles, and even whole organisms.

Every type of living thing requires the availability of a minimum amount of water of a minimum quality to survive. Conversely, too much water and/or water of the wrong quality (i.e., it may be transporting harmful substances as particles or in solution) or wrong temperature (i.e., the shapes and activities of proteins involved in metabolism unavoidably change with changing temperature) may also kill.

Atmospheric gases in the water

Atmospheric gases (e.g., nitrogen, oxygen, carbon dioxide) are more soluble in cold water than warm water. In other words, cold water can carry a lot more dissolved O_2 and CO_2 than warm water can.

CO_2 is relatively soluble in water because it readily forms carbonic acid. This is important for global warming because the oceans currently absorb about 30% of all global CO_2 emissions, thus slowing the rise of global temperatures due to the greenhouse effect. However, even this is bad news for life on Planet Earth for three reasons: First, as the gas is increasingly absorbed into the water some of it turns into carbonic acid. This makes the water more acidic, dissolving calcium from shells and bones – contributing to the die off of plankton, corals, shellfish and bony fish. Secondly, given that CO_2 is the waste product of respiration rising CO_2 slows and backs up the respiration of all marine and aquatic organisms. Three, as water temperature rises CO_2 is substantially less soluble. This can be catastrophic for global warming because it acts like a time bomb. Rising temperatures drive significant amounts of CO_2 out of solution, back into the atmosphere, where it acts as a positive feedback driving global temperatures still higher in apotentially vicious cycle

O_2's solubility in water is limited, but dissolved O_2 is critical to life for all complex organisms that respire water. This includes all aquatic or oceanic organisms: many bacteria, most protozoa, single-celled and multicellular algae (net O_2 producers by day, overnight they must extract O_2 at night for respiration) up to whole forests of giant kelp, giant squids, and whale-sharks. In the pre-industrial world O_2 levels in most waters were close to saturation. Any degree of warming reduces the amount of O_2 the water can carry. Species will begin dying when the O_2 levels fall below levels the different species have evolved to tolerate. For example, along the Southern California coast where I grew up, whole forests of giant kelp die off when the ocean temperature rises to around 23 °C. So do the myriad of other species living in those forests that may still be able to respire, because at some to many points in their lifecycles they required something the kelp provided. Other kelp forests around the world, and in Australia are also dying off, e.g., the once rich kelp forests of Tasmania – possibly even more comprehensively than they have in California (e.g., northern Tasmania).

And then there are the horrific die-off events in the rivers and lakes of Australia's Murray-Darling region, where the combination of blistering heat combined with off-the-charts CO_2 levels is absolutely lethal to whole ecosystems. This year's event even killed carp that can breathe air!

How will our Atmosphere, Hydro-/Cryo-sphere, Geosphere and Biosphere respond to global warming on the real Planet Earth

Meteorology, climate science, and earth systems science extend the basic laws of physics, chemistry and a little bit of biology into the real world. However, even the brief review of some of the basic laws of physics and chemistry above for water, oxygen, and CO_2 gives some hint of just how complex weather and climate change really are. Earth's Climate System that generates weather and climate change in the world we live in is a complex dynamical system composed of probably hundreds of variables often interacting with one another in non-linear and often poorly understood or even unrecognised ways.

Even though the Earth System is absolutely and fundamentally governed by the physical laws of nature, trying to predict future weather and climate conditions is fraught with difficulties of two kinds. First, complex systems of many variables, where some of the variables have non-linear positive feedback relations with one another, often behave chaotically under some or even many conditions. (See also climate change feedback.) Second, is that some of the variables are probably still unknown to science or not well understood. Even the largest supercomputers in the world capable of performing more than 100 quadrillion calculations per second and working with millions of daily observations from around the world can only make usefully accurate weather predictions out to around 8 days before wandering off into random noise.

For these reasons, predicting the future trends of global warming with a high degree of accuracy and certainty is frankly impossible. However, what is almost certain is that if we do not stop and reverse the process of global warming there will be major disruptions to all of these systems ways that will make much of the Earth uninhabitable for complex life.

How trustworthy are the science and the warnings?

The UN's Intergovernmental Panel on Climate Change (IPCC) deals with the uncertainties by running large numbers of similar earth/climate system models (ensembles) with slightly varying inputs on supercomputers to forecast possible future trends and their likelihoods. These outputs are analysed statistically to determine frequent trends and the range of uncertainties around these trends. Thus, many believe that the models give us a relatively good idea of how changes in specific environmental variables are likely to change the climate.

Unfortunately, with regard to managing climate risks, the reality is that this approach is *too conservative* because:

- It filters out some or all of the instances of chaotic extreme deviations from the likely results because these are usually considered to be consequences of "system breakdown" in what is assumed to be a *bad model* — even though system breaking 'exponential blow-ups' are to be expected in complex dynamical systems. In other words, the *bad* result where the model 'breaks down' may well be a realistically valid prediction of the model.
- Most scientists agree that the RATE of climate change is increasing with time. However, the delays in knowledge flow between observation of reality and assessment and presentation of results mean that there is a lag built into the IPCC's reports. That is, the delays inherent in analysing and writing up the results, delays in conducting peer reviews and publishing the original research, conceiving and constructing and running the mathematical models based on those results to forecast the future, analysing and writing up the results of the modelling, delays in publishing these results; and then comes the time cost to incorporate

the published results in an IPCC Report. This IPCC process alone takes a minimum of 2-3 additional years of three drafts, two peer reviews, and a final sign-off by the political appointees of the 170 *countries* comprising the UN's World Meteorological Organization. Thus, the years old input data providing a baseline for the models' predictions necessarily underrepresent, or do not include the array of record temperature, greenhouse gas, and weather readings associated with the increasingly extreme weather events of the last few years.

- Finally most IPCC scientists are associated with academic and research institutions funded by governments, where academic progress and promotions depend on not being too novel or controversial. This leads to scientific self-censorship (i.e., 'scientific reticence') — downplaying alarming findings, reinforced by the need that IPCC Reports require political approvals by government appointees to be published.

The following graphic is the IPCC's own depiction of their authoring and review process.

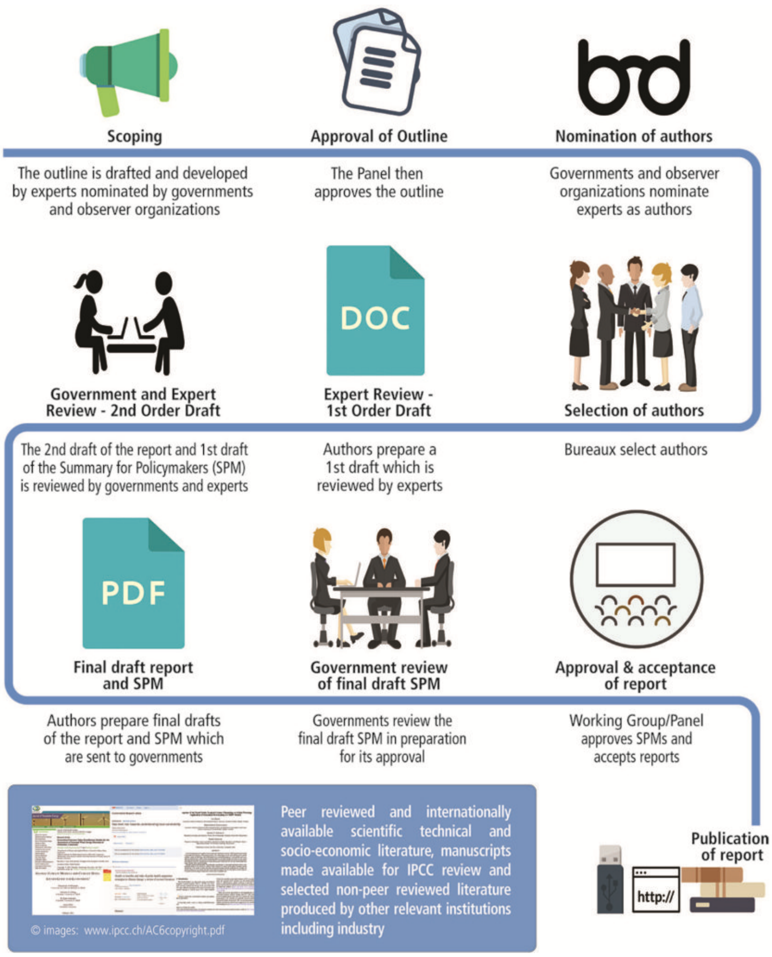


Fig. 7. The graphic and a comprehensive description of IPCC's writing and review processes are given in their document, Preparing Reports. In turn, even more detail on how each kind of document is prepared, reviewed and signed off is provided in the IPCC [Documentation] Procedures, according to the the **Principles Governing IPCC Work** that lay down the role, organisation and procedures of the IPCC. *These guiding Principles establish comprehensiveness, objectivity, openness and transparency for all IPCC Work*.

Note, this and other issues with the IPCC's predictions are examined in detail in my presentation: Some fundamental issues relating to the science underlying climate policy: The IPCC and COP26 couldn't help but get it wrong.

Thus, when the formal IPCC reports publish their predictions for the future consequences: it follows that this is a gold-standard, scientifically correct but somewhat rose-tinted statement of the best possible outcomes we can hope for from the present state of the escalating climate emergency. *The actual future is most likely to be worse, or even more worse.*

Given all of these factors, it is virtually impossible that the IPCC reports are in any way overstating the magnitude and dangers of the climate crisis. Those who claim the IPCC reports are alarmist are seriously misinformed or else aim to be deliberately misleading.

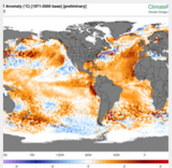
How do we know all of this?

There is a vast array of direct observational evidence from the real world (e.g., the graphs of increasing greenhouse gas concentrations and rising global temperatures presented above) showing that our global climate is already deteriorating at historically and even geologically unprecedented rates. A few recent observations sample this kind of evidence.

Some of what our Mother Earth is telling us

Following are some of my Climate Sentinel News takes from the stream of climate news crossing my desk on a daily basis. [Click the thumbnail to open the article.]

A warming ocean will take its revenge on us

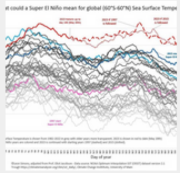


William P. Hall

2023-05-22 18:26:23

Around 90% of the extra heat trapped by the greenhouse layer warms our Ocean to slow rising temperatures. We'll pay the price. The climate scientist, Bill McKibben reminded me of this fact in his regular newsletter, The Crucial Years, in his 18 May post, Maybe we should have called this planet 'Ocean'. His post on ...

More on our warming World Ocean's revenge...



William P. Hall

2023-06-01 23:10:04

Following on from my May 22 post, the Australian Bureau of Meteorology is raising warning flags that the impending El Niño will be the worst yet. There is actually a lot more on the front burner than El Niño. There are signs we may have just crossed a catastrophic ocean tipping point over the last ...

Bad news for whales and oceanic carbon capture

William P. Hall

2023-05-06 14:58:31

Warming oceans are bad news for twilight zone organisms carrying captured carbon into the abyss when they die (and whales eat). An observation How warming works in the twilight zone The science behind the observations Why is all this important to know? Ocean fertilization to stimulate algal growth over the surface of the abyssal ocean ...

Puppet politics: Majority governments work for themselves

William P. Hall

2023-05-11 16:09:39

Labor puppets will work to benefit fossil fuel industries' continued hyper-profitable exploitation come hothouse hell or high water flooding! How do we know this? In the feature article here, Fake Reform: Jim Chalmers' itsy-bitsy tax "hit" is a gift for foreign fossil fuel giants, Michael West Media compares the Australian experience with fossil fuel exploitation ...

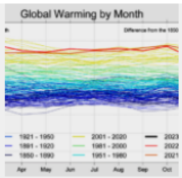
Updating IPCC AR6: still bound for catastrophe

William P. Hall

2023-05-08 13:32:47

International group of climatologists launch a set of annually updated climate indicators to track human induced global warming through time. This decade is absolutely critical for climate action if we are to avoid climate catastrophe. However, up to now we have lacked a standardized set of measures of the level of human-induced warming for tracking ...

Ominous climate crisis trends for 2023 onward



Climate News Links

2023-05-04 14:08:20

Berkeley Earth shows March 2023 was abruptly warmer than February and tied for the 2nd warmest March globally since records began in 1850. Berkeley Earth's global temperature readings are ominous news where the climate crisis is concerned. Berkeley Earth is an independent climatology research organization established in 2010 to systematically address five major concerns that ...

Identifying, analysing, and managing climate risks

Most climate scientists have backgrounds in mathematics, physics or geology where they are used to working with well behaved regular systems — not complex dynamical systems with potentially chaotic and unknown variables where the models are inherently fallible in their predictions of the future. Although the mathematical theory of chaos emerged from early attempts to model climate, few have any formal grounding in complex systems or chaos theory. Consequently, they tend to believe their models can predict the future with some degree of statistical accuracy, rather than accepting that models are good for explaining what *can* happen but not what *will or won't* happen.

Scientists (including a few climate scientists) who continue to deny that current climate change is mainly due to human activity are often used to dealing with changes over long periods of time, where natural and well understood processes are more or less adequate to explain how climate has changed in the past. Many of today's deniers formed their opinions years ago (e.g. 1980s) when even climate specialists actively debated the extent and causes of climate change. In people prone to denial, 'confirmation bias' then begins to reinforce conclusions, where data fitting their belief is eagerly accepted, but seemingly contradictory data is critically scrutinised and rejected.

Over time, with the overwhelming additional data supporting unnaturally accelerated climate temperatures on land, air and sea, almost all genuine climate scientists have come to conclude that human activities are in fact changing the climate. The holdouts are usually in those other disciplines that have a default assumption that natural processes always explain changes in climate. And then, there are those who have totally unscientific reasons for denying that humans cause climate change.

Following on my career as an evolutionary biologist (PhD Harvard 1973) with strong backgrounds in geology, physics, systems sciences (systems ecology, genetic systems, cybernetics), I was employed for 17 years as a knowledge management systems analyst and designer with what became Tenix and then Tenix Defence through the life-cycle of "Australia's most successful naval surface combatant project – by far" – the ANZAC ship project. I worked very closely with the company's engineering systems analysts and risk managers (often the same people did both). The ANZAC Project was so successful because the prime contract was performance-based rather than specifications based. We were contracted to deliver for a fixed price certain capabilities and reliabilities in service rather than meticulously detailed products. (My Intellectual Biography tries to make sense of this genuinely weird juxtaposition of disparate disciplines.)

Large defence systems – especially like warships and aircraft with their multitudes of subsystems, assemblies and piece parts, are complex dynamical systems that are inherently but unpredictably fallible due to unanticipated dynamics, human errors, or unpredictable failures of critical parts. It was the job of contract analysts, systems engineers, design engineers and knowledge managers (me), to work out a ship design and construction process that could be trusted to meet the customers' requirements within the negotiated fixed price.

Failure Modes Effects and Criticality Analysis (FMECA)

The critical analytical tool in Tenix's success, apparently unknown to climate science, is application of the Military Standard, Failure Modes Effects and Criticality Analysis (FMECA) within a risk analytical and management framework. Briefly, this involves (1) tabulating all conceivable failures and the potential consequence of the particular failure mode (i.e., its criticality) for every component of the system that might have a detrimental effect on the system's safety or functionality, (2) preparing at least a matrix for every failure mode showing the approximate likelihood of failure, and (optionally) the likely consequences/costs to the system should the failure occur, and the costs to repair or mitigate the mode.

Applying FMECA to global warming

Should we ignore a risk because its consequences are so severe we fear accepting that it is real?

The following graphic plots an analytical matrix for the risk of human extinction from a failure to stop global warming at a safe global temperature for human survival. A serious analysis of this risk (that is unthinkable to many) demands examining the physical realities associated with each dimension of the matrix and looking for solutions to reduce consequences and likelihood of the risk happening, and to provide the maximum time possible to manage it; or alternatively, to entirely avoid the activities causing the risk. Unfortunately, given that the risk from global warming is associated with the project to power industrial, technological, and population growth by burning fossil fuels that began 150 years ago. Thus we have no choices but to live or die with the consequences arising from this project.

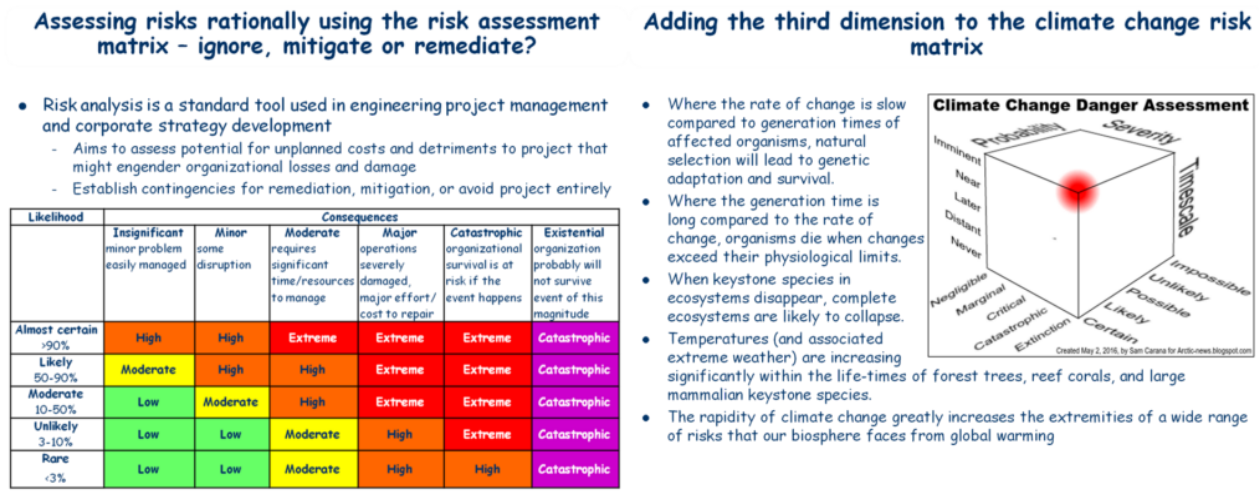


Fig. 8. Slides 10 and 76 from Hall (2016). The angst of global warming – our species' existential risk.

Our planning to manage the risk must consider the third dimension — TIME. How much time do we have to manage the risk if we are to avoid its consequences? The possible consequences of the risk are **existential** – i.e., extinction of human society as we know it or even the entire species. The probability is **likely to be certain** if we do not stop and reverse global warming. The timescale is **imminent**, i.e., within the expected lifespan of today's children.

Should we heed the science and the warnings?

The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations to research and provide the "best" scientific advice available to governments of the world regarding the science, trends, and likely progress of climate change. The Panel's staff is selected and overseen by all the member states of the World Meteorological Organization. The peer review is exhaustive and intensive – probably more so than for any other scientific endeavour ever.

For reasons I have detailed it would be virtually impossible for any formal publication of the IPCC to overstate the dangers represented by climate change. Where the IPCC says that even the current trends will be catastrophic if realised, I would say that they are ‘existential’: A word the IPCC rarely uses and never defines.

Most dictionaries (e.g., see OneLook Dictionary Search) only define the word in terms of ‘existentialism’ – a branch of philosophy. In discussion of the climate crisis, in the framework of global catastrophic risk, “an existential danger threatens the very existence of something” (ref. Macmillan Dictionary).

The Wikipedia article on Global Catastrophic Risk defines “existential” in these terms:

> Existential risks are defined as “risks that threaten the destruction of humanity’s long-term potential.” The instantiation of an existential risk (an *existential catastrophe*) would either cause outright human extinction or irreversibly lock in a drastically inferior state of affairs. Existential risks are a subclass of global catastrophic risks, where the damage is not only *global* but also *terminal* and *permanent,* preventing recovery and thereby affecting both current and all future generations.

Note: This discussion of definitions may seem to be highly pedantic. It isn’t. It is deadly serious. Humanity faces a serious risk of triggering a global mass extinction event akin to the End Permian event that was “Earth’s most severe known extinction event,[11][12] with the extinction of 57% of biological families, 83% of genera, 81% of marine species[13][14][15] and 70% of terrestrial vertebrate species.[16] It is the largest known mass extinction of insects.[17]”

If you are declaring a state of emergency, it does not help to describe the emergency in soothing terms.

The crisis described here raises three important questions

Prodigious amounts of carbon-based fossil fuels (coal, oil, methane) have been burned to produce waste gases (mostly CO_2) and useful energy to drive the Industrial Revolution, our affluence, our toys, our technologies, our wars, and everything that has followed. The carbon we took out of the Earth and burned in an instant of geological time took our planet millions of years to accumulate and store in the geosphere (i.e., rocks & soil). In the same instant, the waste gases released from the burning are fundamentally changing Earth’s atmosphere (the air we breathe, etc…). Because of physical properties of CO_2 molecules and other atmospheric emissions, the greenhouse layer formed by these emissions has trapped enough additional solar heat in the atmosphere to significantly raise average temperatures around the world, which, in turn, is already causing unprecedented climatic disasters.

What can Australians do to help reverse or mitigate this trend?

> There are many things that Australians can do to help reverse or mitigate climate change. Some of the most important things include:
>
> - **Reduce your carbon footprint.** This means making changes to your lifestyle that use less energy and produce less pollution. Some easy ways to reduce your carbon footprint include driving less, using public transportation or biking, eating less meat, and conserving water and energy at home.

- **Support renewable energy.** Renewable energy sources like solar and wind power don't produce greenhouse gases, so they're a great way to reduce your impact on the environment. You can support renewable energy by switching to a green energy provider, installing solar panels on your home, or investing in renewable energy projects.
- **Get involved in climate activism.** One of the most important things you can do to help fight climate change is to get involved in activism. There are many different ways to get involved, such as contacting your elected representatives, attending protests, and volunteering for climate change organisations.
- **Educate yourself and others about climate change.** The more people who understand the science of climate change and the risks it poses, the more likely we are to take action to address it. You can help educate yourself and others by reading books and articles about climate change, watching documentaries, and talking to your friends and family about the issue.

Climate change is a serious threat, but it's not too late to take action. By making changes in your own life and getting involved in activism, you can help make a difference.

What help can the Australian Federal and State Governments do to help solve the climate emergency?

The Australian Federal and State Governments can do a lot to help solve the climate emergency. Here are some of the things they can do:

- **Set ambitious emissions reduction targets.** The Australian Government has set a target of net zero emissions by 2050, but this is not ambitious enough. The Government should set a target of net zero emissions by 2030.
- **Invest in renewable energy.** The Australian Government should invest heavily in renewable energy sources like solar and wind power. This will help to reduce our reliance on fossil fuels and lower our emissions. [This also means a significant investment in a new electrical grid that handles a more dynamic network that includes significant energy storage options.]
- **Support energy efficiency measures.** The Australian Government should support energy efficiency measures like insulation and energy-efficient appliances. This will help us to use less energy and reduce our emissions.
- **Phase out fossil fuel subsidies.** The Australian Government should phase out subsidies for fossil fuels. These subsidies encourage the use of fossil fuels, which are a major source of emissions. [The phasing could also be designed to benefit early adopters of the transition of industrial processes to renewable energy.]
- **Create a carbon price.** The Australian Government should create a carbon price [mechanism]. This would put a price on emissions, which would encourage businesses and individuals to reduce their emissions. [By leading the world on this topic, Australia could play a major role in influencing other countries to follow suit.]
- **Support climate adaptation measures.** The Australian Government should support climate adaptation measures like building seawalls and improving water infrastructure. This will help us to cope with the impacts of climate change, such as more extreme weather events. [Community support for these

mitigation measures will be contingent on a much greater effort in the above prevention measures].

The Australian Federal and State Governments have a responsibility to act on climate change. By taking these steps, they can help to create a cleaner, healthier future for Australia.

What can Australians do to ensure that their governments do these things?

Australians can do a lot to ensure that their governments do the things that are needed to address climate change. Here are some of the things they can do:

- **Vote for parties and candidates that have strong climate policies.** When it's time to vote, make sure to vote for parties and candidates that have strong commitments to addressing climate change. [i.e., Vote Climate One!]
- **Contact your elected representatives.** Let your elected representatives know that you care about climate change and that you expect them to take action. [i.e., Send copies of this post to as many politicians as you can find addresses for.]
- **Get involved in climate activism.** There are many different ways to get involved in climate activism, such as attending protests, contacting your elected representatives, and volunteering for climate change organisations. [Join your local organisations and party branches where there are possibilities for face-to-face contacts.]
- **Support climate change organisations.** There are many organisations working to address climate change. You can support their work by donating money, volunteering your time, or spreading the word about their work. [Amen!]
- **Educate yourself and others about climate change.** The more people who understand the science of climate change and the risks it poses, the more likely we are to take action to address it. You can help educate yourself and others by reading books and articles about climate change, watching documentaries, and talking to your friends and family about the issue. [e.g., read articles on Vote Climate One's Climate Sentinel News.]

Climate change is a serious threat, but it's not too late to take action. By making changes in your own life, getting involved in activism, and supporting climate change organisations, you can help make a difference.

Note: the answers shown above in the dot points were supplied by Google's Artificial Intelligence, Bard AI with a few modifications by me to the detailed explanations. Bard assembles its responses to questions from Google's vast electronic collection of human knowledge. As such, we can accept these answers as representing human common knowledge.