BREAKTHROUGH
National Centre For Climate Restoration

SUPPLEMENTARY SUBMISSION

TO THE VICTORIAN CLIMATE CHANGE TARGETS 2021-2030 EXPERT PANEL

30 APRIL 2018

BREAKTHROUGH - NATIONAL CENTRE FOR CLIMATE RESTORATION

Supplementary submission

To the Victorian climate change targets 2021-2030 expert panel

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The Victorian Government's emission targets process is framed by the *Paris Agreement* of a 1.5–2°C goal, whilst current commitments under the *Agreement* are a path of 3.4°C warming to 2100[1], without taking carbon-cycle feedbacks into account. This supplementary information includes evidence that:

1. 1.5°C of climate warming is not safe;
2. There is no carbon budget remaining for 1.5°C, so "What goes up must come down";
3. "Overshoot" in emission reduction scenarios should be minimised in extent and duration to avoid tipping points that may be irreversible on human time-frames;
4. Caution must be taken in using emission-reduction scenarios from climate models because models are generally too conservative and omit important drivers of future warming;
5. Consideration that Victoria could adapt to 4°C of warming is inappropriate because 4°C is likely beyond reasonable adaptation;
6. Climate change is now an existential threat to human civilisation and emission-reduction strategies must be based on this understanding.

1. 1.5°C of climate warming is not safe

The Paris Agreement has a policy goal of 1.5–2°C, but even 1.5°C is far from safe and is not a satisfactory target.

- In 2015, researchers looked at the damage to system elements — including water security, staple crops, land, coral reefs, vegetation and UNESCO World Heritage sites — as the temperature increases.[2] They found all the damage from climate change to vulnerable categories like coral reefs, freshwater availability and plant life could happen before 2°C warming is reached, and much of it before 1.5°C warming.
- In 2013, Australian scientists contributed to an important research paper which found that preserving more than 10% of coral reefs worldwide would require limiting warming to below 1.5°C.[3] Recent research found that the surge in ocean warming around the Great Barrier Reef in 2016-17, which led to the loss of half of the 2015 reef area, has a 31% probability of occuring in any year at just the current level of warming.[4] In other words, severe bleaching and coral loss is likely on average every 3–4 years at the present level of warming (1–1.1°C), whereas corals take 10–15 years to recover from such events.

[1] http://climateactiontracker.org/publications/briefing/288/Improvement-in-warming-outlook-as-India-and-China-move-ahead-but-Paris-Agreement-gap-still-looms-large.html
[2] http://www.nature.com/ngeo/journal/v9/n1/full/ngeo2607.html
[3] http://www.nature.com/nclimate/journal/v3/n2/full/nclimate1674.html
[4] https://www.nature.com/articles/nclimate3296

- There is evidence that a 1.5ºC global rise in temperature is likely to cause widespread thawing of continuous permafrost as far north as 60°N.[5] At 1.5°C, the loss of permafrost area is estimated to be four million square kilometres.[6]
- At 1.5°C, it is very likely that conclusions first aired in 2014 — that sections of the West Antarctic Ice Sheet (WAIS) have already passed their tipping points for a multi-metre sea-level rise — will have been confirmed. Four years ago scientists found that "the retreat of ice in the Amundsen Sea sector of WAIS was unstoppable, with major consequences – it will mean that sea levels will rise one metre worldwide… Its disappearance will likely trigger the collapse of the rest of the West Antarctic ice sheet, which comes with a sea-level rise of between 3–5 metres. Such an event will displace millions of people worldwide."[7]
- By 1.5°C, a sea-level rise of many metres, and perhaps tens of metres will have been locked into the system. In past climates, carbon dioxide (CO_2) levels of around 400 parts per million (ppm) have been associated with sea levels around 25 metres above the present.[8] Prof. Kenneth G. Miller notes that "the natural state of the Earth with present CO_2 levels is one with sea levels about 20 meters higher than at present".[9] The expected sea-level rise this century is generally in the range of one to two metres, but higher increases cannot be ruled out. The US military, for example, uses one- and two-metre sea-level-rise scenarios. The US NOAA provides an "extreme" scenario of 2.5 metres sea level rise by 2100.[10]
- On carbon cycle feedbacks, it is worth noting recent work which shows that some tropical forests — in the Congo, the Amazon, and in Southeast Asia — have already shifted to a net carbon source,[11] and recent work on a soil carbon feedback in a 26-year soil-warming experiment in a mid-latitude hardwood forest, in which warming resulted in a complex pattern of net carbon loss from the soil, supporting projections of a long-term, positive carbon feedback from similar ecosystems as the world warms.[12]

At the current warming of just over 1°C compared to the late nineteenth century, Earth is now approximately 0.5°C warmer that the maximum of the Holocene (the period of relatively stable temperatures over the last nine thousands years and the period of human civilisation), and as warm as it was during the prior Eemian interglacial period, when sea level reached 6-9 meters higher than today.[13] It would be precautionary to establish a warming goal of less than 0.5°C, with the aim of cooling Earth back to this safe zone at the greatest possible speed.

2. There is no carbon budget remaining for 1.5°C, so "What goes up must come down"

There is no carbon budget for 1.5°C,[14] which means that to achieve this outcome, from now on every tonne of emissions must be matched by a tonne of drawdown of atmospheric carbon.

[5] http://science.sciencemag.org/content/340/6129/183
[6] https://www.nature.com/articles/nclimate3262
[7] https://www.sciencedirect.com/science/article/pii/S0012821X14007961
[8] http://www.eurekalert.org/pub_releases/2013-01/nocs-nsd010213.php
[9] http://www.sciencedaily.com/releases/2012/03/120319134202.htm
[10] https://pubs.giss.nasa.gov/abs/sw01000b.html
[11] https://grist.org/article/the-last-ditch-effort-to-save-the-worlds-forests-from-climate-change/
[12] http://science.sciencemag.org/content/358/6359/101
[13] https://www.earth-syst-dynam.net/8/577/2017/esd-8-577-2017.pdf
[14] https://www.theguardian.com/environment/climate-consensus-97-per-cent/2015/dec/30/why-we-need-the-next-to-impossible-15c-temperature-target

The issues are canvassed at “Unravelling the myth of a ‘carbon budget’ for 1.5°C.”[15] Rogelj et al. noted in 2017: “ If the 1.5°C limit should not be breached in any given year, the budget since 1870 is roughly halved and **already overspent today**”[16] (emphasis added).

In fact, today’s CO_2 level if maintained would produce a lot more warming that 1.5°C. In the early- to mid-Pliocene 3–4.5 millions year ago, CO_2 levels were similar today at 365–415 ppm but temperatures were 3–4°C warmer than pre-industrial values and sea levels were 25 metres higher.[17]

Warming is being masked by anthropogenic aerosol emissions, a good proportion of which are coming from fossil fuel extraction and use. This temporary cooling is estimated at 0.7°C[18], so global warming is likely to accelerate in the next few decades if the cooling influence of human-generated aerosols declines as predicted.[19] When this is taken into account, the implied warming for the current level of greenhouse gases is more than 2°C.[20]

Hence the Paris path of delayed emissions reductions, balanced by a probably unfeasible amount of drawdown in the second half of the century proposed by use of a technology that is unproven at scale — BECCS — is a dangerous path. There is growing alarm amongst scientists about the BECCS political fix, for example Smith et al. 2016, van Vuuren et al. 2017 and Honegger & Reiner 2017.[21] It is worth noting the comments by Oliver Geden, head of the EU Research Division at the German Institute for International and Security Affairs in Berlin:

> Climate scientists and economists who counsel policy-makers **are being pressured to extend their models and options for delivering mitigation later**. This has introduced dubious concepts, such as repaying ‘carbon debt’ through ‘negative emissions’ to offset delayed mitigation — in theory… Climate researchers who advise policy-makers feel that they have two options: be pragmatic or be ignored… Many advisers are choosing pragmatism… Each year, mitigation scenarios that explore policy options for transforming the global economy are more optimistic — and less plausible (emphasis added).[22]

A more rapid rate of emission reduction than generally associated with the Paris path can reduce the reliance on drawdown, and especially BECCS.

A paper just out, “Alternative pathways to the 1.5°C target reduce the need for negative emission technologies”, is worthy of a close look, and some of its propositions could be adopted by the Victorian Government.[23]

Since all emissions from now on must be matched by at least an equivalent amount of drawdown:

- **A Victorian carbon budget and emissions target should be complemented by a Victorian <u>carbon drawdown budget</u> and target.**

The adoption of a carbon drawdown budget would help to normalise as necessary what is still, too often, constructed as a distant and theoretical task.

A recent paper by Kate Dooley at UniMelb, “Land-based negative emissions: risks for climate mitigation and impacts on sustainable development”, found the most cost-effective large-scale drawdown action is the restoration of carbon-dense and biologically rich natural forests.[24] There are also opportunities

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15 http://www.climatecodered.org/2016/09/unravelling-myth-of-carbon-budget-for.html
16 http://onlinelibrary.wiley.com/doi/10.1002/2017GL075612/abstract
17 https://www.nature.com/articles/ngeo724
18 https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2017GL076079
19 https://theconversation.com/masking-and-unmasking-of-global-warming-by-aerosols-19990
20 http://www.pnas.org/content/105/38/14245.short
21 https://www.nature.com/articles/nclimate2870; https://www.nature.com/articles/s41560-017-0055-2; https://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1413322
22 https://www.nature.com/news/policy-climate-advisers-must-maintain-integrity-1.17468
23 https://www.nature.com/articles/s41558-018-0119-8
24 https://link.springer.com/article/10.1007/s10784-017-9382-9

for increasing soil organic carbon (SOC), where more research work needs to be done, but one estimate from the European Academies' Science Advisory Council is that increasing SOC could have the potential to absorb 2-3 GtC/year.[25]

3. "Overshoot" in emission reduction scenarios should be minimised in extent and duration to avoid tipping points that may be irreversible on human time frames

All 1.5°C scenarios involved "overshooting" the target before cooling back to 1.5°C by 2100. This overshoot should be minimised by adopting more stringent emission scenarios as the basis for policymaking.

Global warming will pass the 1.5°C threshold in about a decade from now.[26]

All 1.5°C emission scenarios include a period of "overshoot" towards 2°C, before returning to the 1.5°C threshold by 2100.

On the present high emissions path, warming will hit the 2°C by the mid-2040s, and large reductions in CO_2 emissions will not by themselves significantly delay this timing, due to the "Faustian bargain" we have struck with our reliance on aerosols — a by-product of fossil fuel use — that by their significant but very short-term cooling impact are masking considerable warming.[27] Going to zero emissions with CO_2 at ~420 ppm would result in a warming of around 2°C at equilibrium, if the level of short-lived gases was constant.[28]

Thus the 1.5°C overshoot will last several decades and up to half a century in the Paris scheme of things.

There are specific dangers in overshooting, which increase both with the duration and the magnitude of the overshoot.

In a period of rapid warming, most major tipping points once crossed are irreversible in human time frames, principally due to the longevity of atmospheric CO_2 (a thousand years).[29] At the COP23 in Bonn, Pam Pearson, Director of the International Cryosphere Climate Initiative, warned that the cryosphere is becoming "an irreversible driver of climate change". She said that most cryosphere thresholds are determined by peak temperature, and the length of time spent at that peak, warning that **"later, decreasing temperatures after the peak are largely irrelevant, especially with higher temperatures and longer duration peaks".** She added: "What keeps cryosphere scientists up at night are irreversible thresholds, particularly West Antarctica and Greenland. The consensus figure for the irreversible melting of Greenland is at 1.6°C."

Thus "overshoot scenarios", which are now becoming the norm in policy-making circles hold much greater risks.[30] Specifically, overshoot to 2°C for up to half a century may trigger events and activate tipping points that cannot be reversed even with significant cooling.

Hence a more rapid rate of emission reduction than generally associated with the Paris path can reduce in extent and duration the overshooting of the 1.5°C threshold.

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25 http://www.academie-sciences.fr/en/Reseaux-internationaux-dacademies/negative-emission-technologies-what-role-in-meeting-paris-agreement-targets-report-by-the-easac.html

26 http://www.climatecodered.org/2018/04/15c-of-warming-is-closer-than-we.html

27 http://www.climatecodered.org/2018/02/quantifying-our-faustian-bargain-with.html

28 https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2017GL076079

29 http://www.pnas.org/content/early/2009/01/28/0812721106.short

30 https://www.youtube.com/watch?v=S7z61UZoppM&feature=youtu.be

4. Caution must be taken in using emission-reduction scenarios from climate models because models are generally too conservative and omit important drivers of future warming

Because climate models are too conservative and do not include the full range of carbon cycle feedbacks, future warming is underestimated and emissions budgets overestimated. This is a compelling reason for adopting the most stringent emission-reduction scenarios.

It is likely that modelling of future emission scenarios in general understates future warming and overstates the available carbon budgets. Two research papers released towards the end of 2017 suggest that warming is likely to be greater than the projections of the IPCC, on which climate policy-making and carbon budgets are generally based. This is because equilibrium climate sensitivity (ECS), an estimate of how much the planet will warm for a doubling in the level of greenhouse gases, is higher than the median of the IPCC's modelling analysis.

Brown and Caldeira compared the performance of a wide range of climate models (raw model projections) with recent observations (especially on the balance of incoming and outgoing top-of-the-atmosphere radiation that ultimately determines the Earth's temperature), in order to assess which models perform best.[31] The models that best capture current conditions (the "observationally-informed" models) produce 15% more warming by 2100 than the IPCC suggests, hence r**educing the "carbon budget" by around 15% for the 2°C target**. They find the warming associated by the IPCC with RCP 4.5 would in fact "follow the trajectory previously associated with RCP 6.0", indicating that the available carbon budgets have been overstated. They find that the observationally-informed ECS prediction has a mean value of 3.7°C, compared to 3.1°C used in raw models, and in the carbon budget analyses widely used by the IPCC, the UN and at climate policy conferences.

These findings are consistent with Fasullo and Trenberth who found that the climate models that most accurately capture observed relative humidity in the tropics and subtropics and associated clouds were among those with a higher sensitivity of around 4°C[32], and with Zhai et al. who found that seven models that are consistent with the observed seasonal variation of low-altitude marine clouds yield an ensemble-mean ECS of 3.9°C.[33]

Xu and Ramanathan looked at what are called the "fat tail" risks. These are the lower-probability, high-impact consequences of future emission scenarios; that is, events with a 5% probability at the top end of the range of possible outcomes. They say these "top end" risks are more likely to occur than we think. When these are taken into account, the researchers find that the ECS is more than 40% higher than the IPCC mid-figure, at 4.5-4.7°C. And this is without taking into account carbon cycle feedbacks (such as melting permafrost and the declining efficiency of forests carbon sinks), and increase methane emissions from wetlands, which together could add another 1°C to warming by 2100.[34]

As well, Friedrich et al. show that climate models may be underestimating climate sensitivity because it is not uniform across different circumstances, but in fact higher in warmer, inter-glacial periods (such as the present) and lower in colder, glacial periods.[35] Based on a study of glacial cycles and temperatures over the last 800,000 years, the authors conclude that in warmer periods climate sensitivity averages around 4.88°C.

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[31] https://www.nature.com/articles/nature24672?sf175952939=1
[32] http://science.sciencemag.org/content/338/6108/792
[33] http://onlinelibrary.wiley.com/doi/10.1002/2015GL065911/full
[34] http://www.pnas.org/content/early/2017/09/14/1618481114.short
[35] http://advances.sciencemag.org/content/2/11/e1501923.short

In 2015, researchers reported that global climate models ignore long-term feedbacks, and estimates of climate sensitivity “ignore certain processes even within the time frames they consider”.[36] This is illustrated in Figure 1, where grey bars within the red ellipse signify processes that are ignored.

A 2016 study concluded that a soil carbon-cycle feedback “has not been incorporated into computer models used to project future climate change, raising the possibility that such models are underestimating the amount of warming that is likely to occur”.[37] Another study found that the land sink for CO_2 appears much smaller than is currently factored into climate models, suggesting that emissions cuts may need to be even more ambitious than currently estimated.[38]

In the 2017 *Fourth National Climate Assessment,* US government agencies found that “Positive feedbacks (self-reinforcing cycles) within the climate system have the potential to accelerate human-induced climate change and even shift the Earth’s climate system, in part or in whole, into new states that are very different from those experienced in the recent past”, and whilst some feedbacks and potential state shifts can be modelled and quantified, “others can be modeled or identified but not quantified and some are probably still unknown.” Hence:

> While climate models incorporate important climate processes that can be well quantified, they do not include all of the processes that can contribute to feedbacks, compound extreme events, and abrupt and/or irreversible changes. For this reason, future changes outside the range projected by climate models cannot be ruled out. Moreover, the systematic tendency of climate models to underestimate temperature change during warm paleoclimates suggests that climate models are more likely to underestimate than to overestimate the amount of long-term future change.[39]

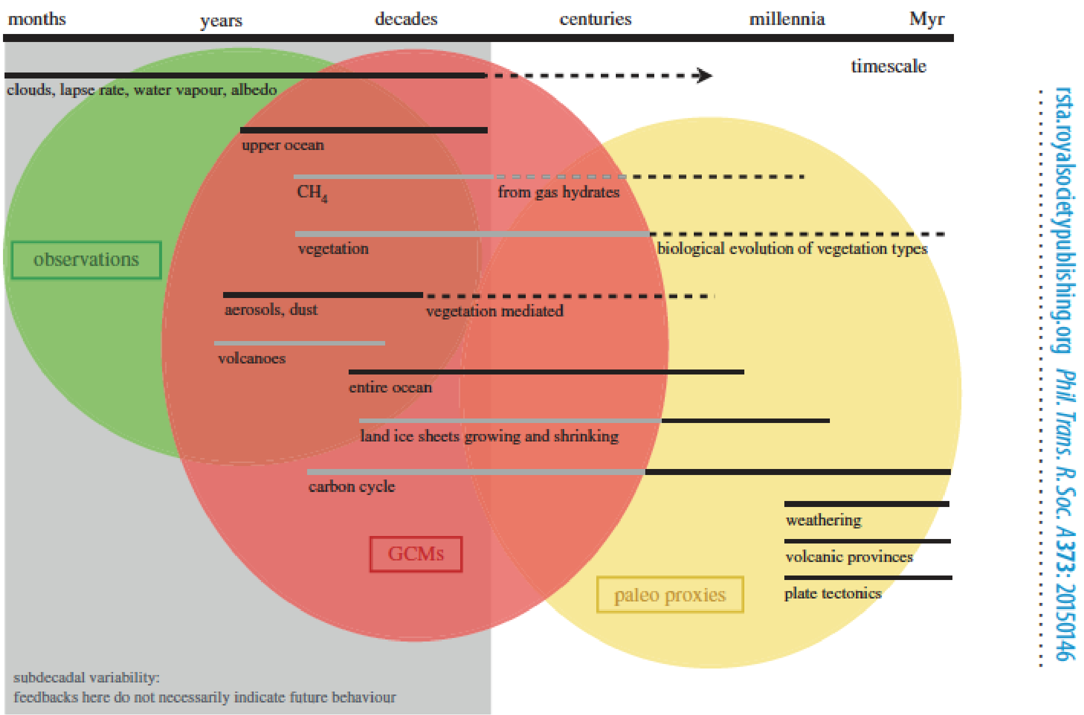

Figure 1 (from Friedrich et al.)

Timescales of climate relevant processes. Light grey bars indicate processes that act on timescales that a GCM can resolve, but are usually assumed to be (partly) inactive or non-existent. Dashed lines indicate timescales where specific feedbacks are weaker or only operate under certain circumstances. The arrow for clouds, lapse rate, water vapour and albedo indicates that those feedbacks operate on short timescales, but, because the surface warming takes centuries or more to equilibrate, these feedbacks continue to change and affect the overall response of the systems up to millennia.

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[36] http://rsta.royalsocietypublishing.org/content/373/2054/20150146
[37] https://www.nature.com/articles/nature20150
[38] https://www.nature.com/articles/nclimate3332?WT.feed_name=subjects_chemistry
[39] https://science2017.globalchange.gov/chapter/15/

5. Consideration that Victoria could adapt to 4°C of warming is inappropriate because 4°C is likely beyond reasonable adaptation

4°C is likely incompatible with the maintenance of human civilisation, involving extreme heat for most lands and peoples, and sea level rise in the tens of metres.

Just 3°C of warming may constitute an existential risk. A 2007 study by two US national security think tanks concluded that 3°C of warming and a 0.5 metre sea-level rise would likely lead to "outright chaos" and "nuclear war is possible", emphasising how "massive nonlinear events in the global environment give rise to massive nonlinear societal events".[40] The Global Challenges Foundation explains what could happen:

> If climate change was to reach 3°C, most of Bangladesh and Florida would drown, while major coastal cities — Shanghai, Lagos, Mumbai — would be swamped, likely creating large flows of climate refugees. Most regions in the world would see a significant drop in food production and increasing numbers of extreme weather events, whether heat waves, floods or storms. This likely scenario for a 3°C rise does not take into account the considerable risk that self-reinforcing feedback loops set in when a certain threshold is reached, leading to an ever increasing rise in temperature. Potential thresholds include the melting of the arctic permafrost releasing methane into the atmosphere, forest dieback releasing the carbon currently stored in the Amazon and boreal forests, or the melting of polar ice caps that would no longer reflect away light and heat from the sun.[41]

Warming of 4°C or more could reduce the global human population by 80% or 90%,[42] and the World Bank reports "there is no certainty that adaptation to a 4°C world is possible".[43] Prof. Kevin Anderson says a 4°C future "is incompatible with an organized global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems, and has a high probability of not being stable".[44] It is a commonly-held sentiment amongst climate scientists. A recent study by the European Commission's Joint Research Centre found that if global temperatures rise 4°C, then extreme heatwaves with "apparent temperatures" peaking at over 55°C will begin to regularly affect many densely populated parts of the world, forcing much activity in the modern industrial world to stop. ("Apparent temperatures" refers to the Heat Index, which quantifies the combined effect of heat and humidity to provide people with a means of avoiding dangerous conditions.[45])

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[40] Campbell, K, Gulledge, J, McNeill, JR, Podesta, J, Ogden, P, Fuerth, L, Woolsley, J, Lennon, A, Smith, J, Weitz, R & Mix, D 2007, *The Age of Consequences: The foreign policy and national security implications of global climate change*, Centre for Strategic and International Studies & Centre for New American Security, Washington.

[41] Global Challenges Foundation 2017, 'Global Catastrophic Risks 2017', Global Challenges Foundation, Stockholm.

[42] Anderson, K 2011, 'Going beyond dangerous climate change: Exploring the void between rhetoric and reality in reducing carbon emissions', LSE presentation, 11 July 2011, <http://www.slideshare.net/DFID/professor-kevin-anderson-climate-change-going-beyond-dangerous>; Fyall, J 2009, 'Warming will 'wipe out billions', *The Scotsman*, 29 November 2009, <http://www.webcitation.org/5ul6K9Jmt?url=http://news.scotsman.com/latestnews/Warming-will-39wipe-out-billions39.5867379.jp>.

[43] World Bank 2012, *Turn Down the Heat: Why a 4°C warmer world must be avoided*, World Bank, New York.

[44] Roberts, D 2011 "The brutal logic of climate change", Grist, 6 December 2011, <https://grist.org/climate-change/2011-12-05-the-brutal-logic-of-climate-change/>

[45] Ayre, J 2017, 'Extreme heatwaves with 'apparent temperatures' as high as 55° celsius to regularly affect much of world', Extreme heatwaves with 'apparent temperatures' as high as 55° celsius to regularly affect much of world, 11 August 2017, <https://cleantechnica.com/2017/08/11/extreme-heatwaves-apparent-temperatures-high-55-celsius-regularly-affect-much-world-4-celsius-warming-pre-industrial-levels/>.

6. Climate change is now an existential threat to human civilisation and emission reduction strategies must be based on this understanding

It is imperative that the Victorian Government take a sensible, existential risk-management approach to climate policymaking.

Climate change is an existential risk to human civilisation: that is, an adverse outcome that would either annihilate intelligent life or permanently and drastically curtail its potential.[46]

Temperature rises that are now in prospect, after the *Paris Agreement*, are in the range of 3–5°C. At present, the Paris Agreement voluntary emission reduction commitments, if implemented, would result in planetary warming of 3.4°C by 2100, without taking into account "long-term" carbon-cycle feedbacks. With a higher climate sensitivity figure of 4.5°C, for example, which would account for such feedbacks, the Paris path would result in around 5°C of warming, according to a MIT study. A study by Schroder Investment Management published in June 2017 found — after taking into account indicators across a wide range of the political, financial, energy and regulatory sectors — the average temperature increase implied for the Paris Agreement across all sectors was 4.1°C.

As noted in 5. above, warming in the range of 3–4°C is likely to be an existential risk.

In 2017, one of the first research papers to focus explicitly on existential climate risks proposed that "mitigation goals be set in terms of climate risk category instead of a temperature threshold", and described 3°C as a level of "catastrophic" warming. The authors focussed on the impacts on the world's poorest three billion people, on health and heat stress, and the impacts of climate extremes on such people with limited adaptation resources. The found that a 2°C warming "would double the land area subject to deadly heat and expose 48% of the population (to deadly heat). A 4°C warming by 2100 would subject 47% of the land area and almost 74% of the world population to deadly heat, which could pose existential risks to humans and mammals alike unless massive adaptation measures are implemented".[47]

Existential risks require a particular approach to risk management. They are not amenable to the reactive (learn from failure) approach of conventional risk management, and we cannot necessarily rely on the institutions, moral norms, or social attitudes developed from our experience with managing other sorts of risks. Because the consequences are so severe — perhaps the end of human global civilisation as we know it — "even for an honest, truth-seeking, and well-intentioned investigator it is difficult to think and act rationally in regard to… existential risks".[48]

Existential risk management requires brutally honest articulation of the risks, opportunities and the response time frame; new existential risk management techniques outside conventional politics, and global leadership and integrated policy. Since it is not possible to recover from existential risks, "we cannot allow even one existential disaster to happen; there would be no opportunity to learn from experience",[49] but at the moment we are facing an existential disaster seemingly without being able to articulate that fact.

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[46] Dunlop and Spratt 2017, op cit.

[47] Xu, Y & Ramanathan, V 2017, "Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes" *Proc. Nat. Acad. Sci.,* vol. 114, pp. 10315-10323.

[48] Bostrom, N & Cirkovic, MM 2008, *Global Catastrophic Risks*, Oxford University Press, Oxford.

[49] op. cit.