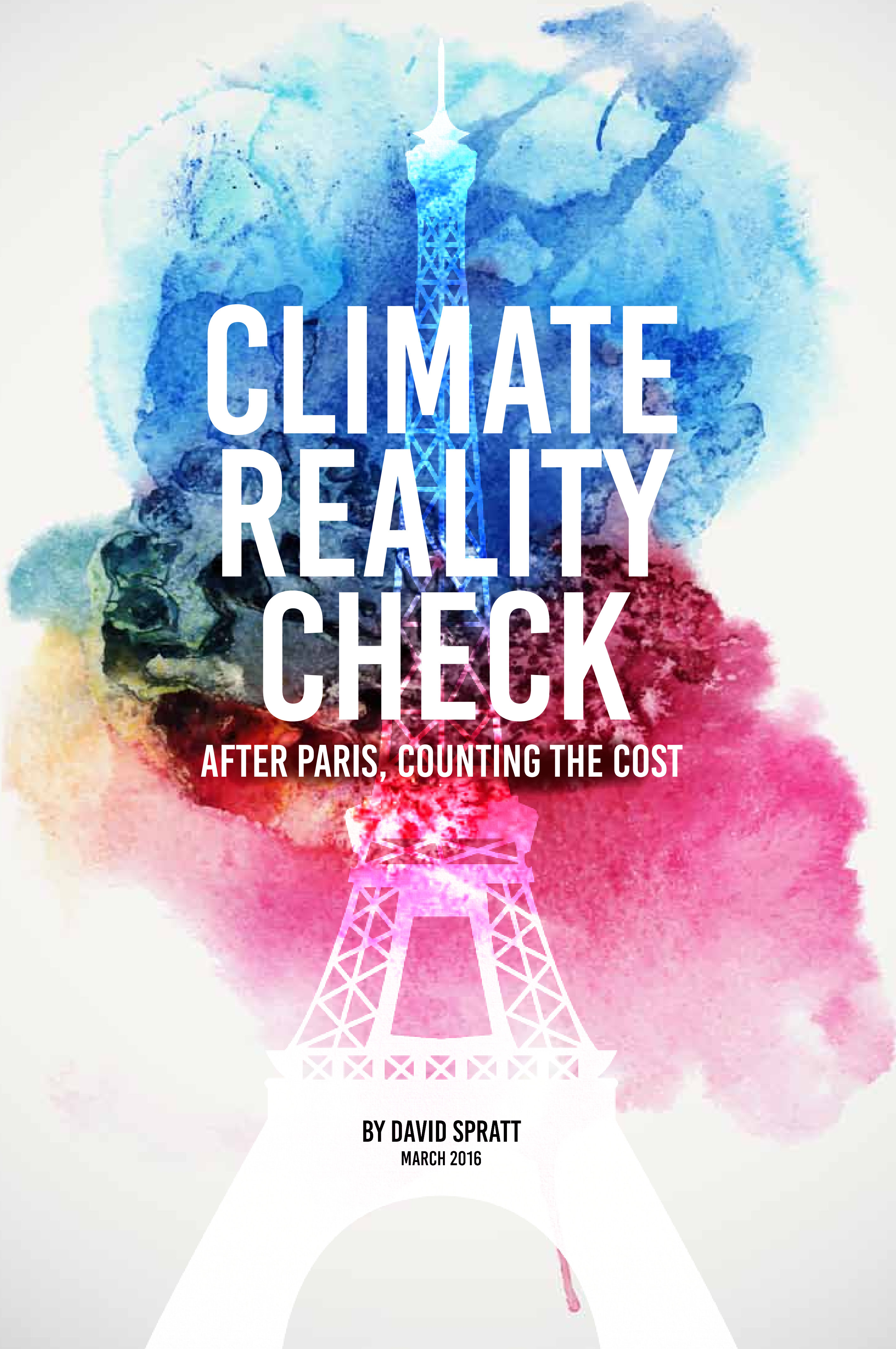

CLIMATE REALITY CHECK

AFTER PARIS, COUNTING THE COST

BY DAVID SPRATT

MARCH 2016

“OUR CLIMATE IS NOT SAFE NOW, SO WHAT DOES DANGEROUS CLIMATE CHANGE MEAN?”

Prof. David Karoly, THE AGE, 4 December 2015

BREAKTHROUGH

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AFTER PARIS, COUNTING THE COST

The December 2015 Paris climate conference was another — and perhaps final — chapter in decades of climate policy-making failure. It set the world on course for more than 3°C of warming and all but precludes a less-than-2°C future without radical climate interventions. Commentators say “deadly flaws” in the Paris deal mean it gives the impression that global warming is now being properly addressed, when in fact the measures fall woefully short of what is needed to avoid runaway climate change.

Prof. Kevin Anderson of the UK Tyndall Centre for Climate Change is fond of quoting the twentieth century Nobel laureate quantum physicist Richard P. Feynman: “For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled.”

We fool ourselves if we are not deeply alarmed by the recent news about the state of global warming. According to new data released by the US National Oceanic and Atmospheric Administration, measurements taken at the Mauna Loa Observatory in Hawaii show that carbon dioxide (CO2) concentrations jumped by 3.05 parts per million (ppm) during 2015, the largest year-to-year increase in 56 years of research. 2015 was the fourth consecutive year that CO2 grew more than 2 ppm.

And scientists say they are shocked and stunned by the “unprecedented” NASA temperature figures for February 2016, which are 1.65°C higher than the beginning of the twentieth century and around 1.9°C warmer than the pre-industrial level. Prof. Michael Mann says “we have no carbon budget left for the 1.5°C target and the opportunity for holding to 2°C is rapidly fading unless the world starts cutting emissions hard right now”. The current El Niño conditions have contributed to the record figures, but compared to previous big El Niños, we are experiencing blowout temperatures.

Stefan Rahmstorf of Germany’s Potsdam Institute of Climate Impact Research says we are now “in a kind of climate emergency”.

Like the dramatic and unexpected “big melt” in the Arctic in 2007, we are now in another moment of terrifying climate reality, for Nature cannot be fooled. The recent data suggests it has taken just three months for the Paris climate accord — with its escalating emissions to 2030 — to become a relic, completely disconnected to the task the world now faces.

So what is the reality after Paris?

1. CARBON EMISSIONS & TEMPERATURE

Human-caused carbon dioxide (CO2) emissions increase the global average temperature, such that the elevated temperatures remain roughly constant for many centuries.[1] One landmark research paper says that "any future anthropogenic emissions will commit the climate system to warming that is essentially irreversible on centennial timescales".[2]

In other words, we cannot, on human time scales and in the normal course of events, undo the elevated temperatures and damage done by CO2 emissions. The only exceptions to this understanding would be the deployment of incoming solar radiation management or very large-scale CO2 removal (negative-emission) technologies, which at present are at little more than a conceptual stage of development and not currently deployable at scale (see section II).[3]

2. "UNAVOIDABLE" WARMING

The UK Met Office says 2016 is likely to be hotter than 2015, which was the hottest year on the instrumental record by a significant margin.[4]

Accounting for inter-annual variability, global warming has now reached ~1˚C above the 1880-1920 level.[5] And warming is now ~1.2˚C above the 1750 pre-industrial level.[6]

If we were to cease burning fossil fuels today, the loss of aerosol cooling (see next section) would quickly add ~0.5˚C or more to temperatures, taking warming over the pre-industrial level to ~1.7˚C.[7] The more fossil fuels we burn, the higher this level of "unavoidable" warming will become in the absence of yet unproven, large-scale, negative-emission and/or solar radiation technologies.

Each decade, human activity is adding ~20 parts per million of CO2 to the atmosphere,[8] enough to cause an extra ~0.2˚C of warming. So if the emissions trajectory over the next 15 years follows the Paris path — in which annual emissions would be ~10% higher in 2030 than they are today[9] — then by 2030 "unavoidable" warming will have risen by ~0.3˚C to ~2˚C.

Analyst Bill Hare of Climate Analytics says: "It is clear that if the Paris meeting locks in present climate commitments for 2030, holding warming below 2˚C could essentially become infeasible." [10] In this sense, Paris has locked out a less-than-2˚C outcome, unless immediate and radical emission reductions occur across the high-polluting, developed economies.[11]

Alarming figures for February 2016 show that month to be 1.65˚C higher than the beginning of the twentieth century and around 1.9˚C warmer than the pre-industrial level.

3. FAUSTIAN BARGAIN

A by-product of burning fossil fuels is a group of substances known as aerosols (including black-carbon soot, organic carbon, sulfates, and nitrates) which have a short-term (~1 week) cooling impact generally estimated to be in the range of ~0.5–0.8˚C. For now, these aerosols are ameliorating the warming impact of increasing levels of greenhouse gases, including carbon dioxide, methane and nitrous oxide.

However, reducing the use of fossil fuels will also reduce the production of aerosols, and the loss of their cooling effect will increase the global temperature. But not stopping fossil fuel use will eventually cause global warming sufficient to threaten human civilisation.

Former NASA climate science chief James Hansen keenly observed this dilemma to be our Faustian bargain, in which the "devil's payment" will be extracted from humanity via increased global warming: "As long-lived CO2 accumulates, continued balancing requires a greater and greater aerosol load. Such a solution… would be a Faustian bargain. Detrimental effects of aerosols, including acid rain and health impacts, will eventually limit the permissible atmospheric aerosol amount and thus expose latent greenhouse warming." [12]

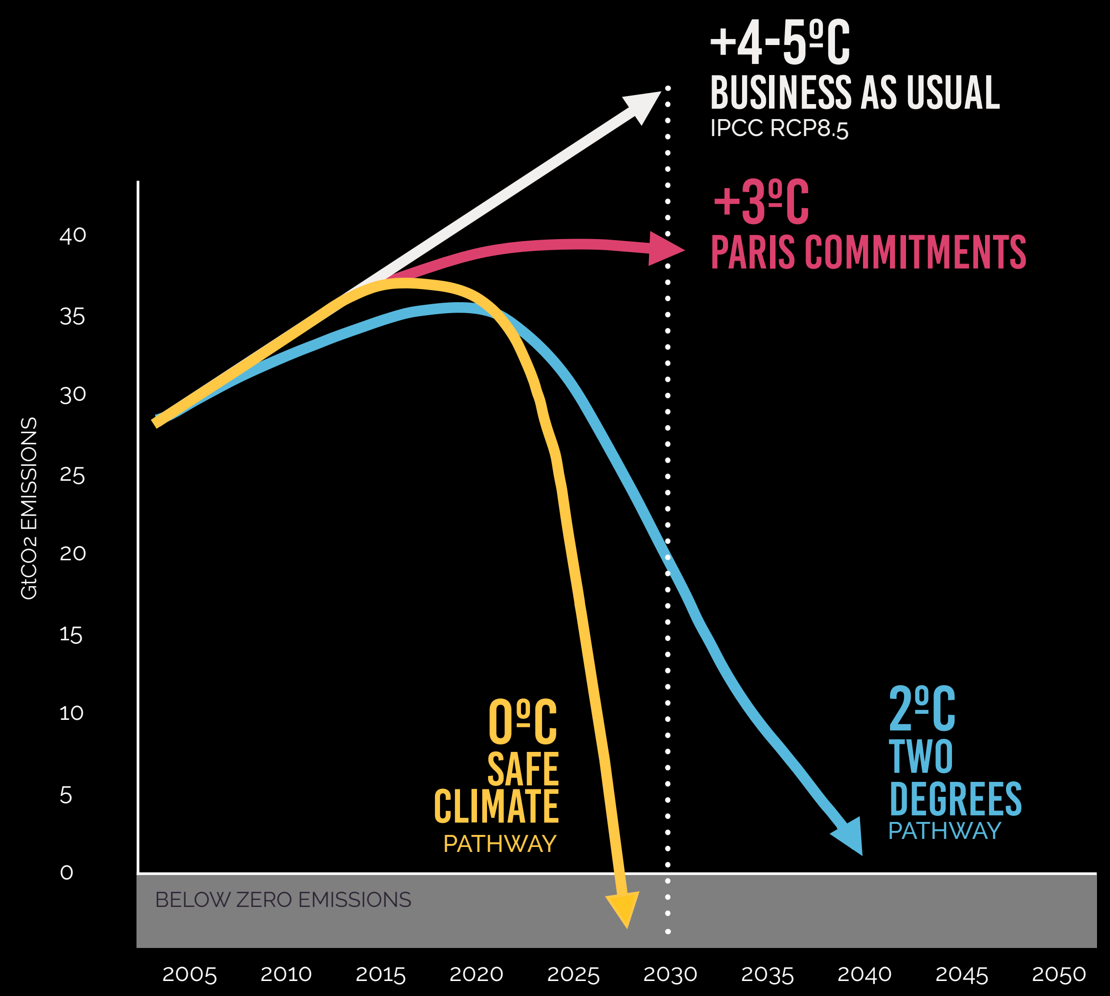
4. PARIS COMMITMENTS

Although the Paris deal gives the impression that global warming is now being properly addressed, in fact the measures fall woefully short of what is needed to avoid runaway climate change.[13] Amongst its "deadly flaws" is the lack of any requirement that the parties must upgrade their existing pledges before 2030.

Climate Interactive analysis[14] reveals that the Paris voluntary commitments, with no further progress in the post-pledge period, would result in expected warming by 2100 of 3.5˚C (uncertainty range 2.0–4.6˚C). That figure assumes no un-modelled carbon cycle feedbacks, and is likely too conservative.

Claims that the Paris commitments represent a 2.7˚C path are a misconception, based on an unjustified assumption that countries will commit in the future to keep reducing emissions after 2030 at the rate they did before 2030.[15]

PARIS COMMITMENTS COMPARED TO 2°C PATHWAY



SOURCES[7]: WBGU special report 2009, Boyd, Stern & Ward (May 2015), IPCC 2014, Climate Action Tracker, Philip Sutton

5. FEASIBILITY OF 1.5ºC GOAL

The Paris agreement's stated aims are to keep warming "well below 2˚C above pre-industrial levels" and to "pursue efforts to limit the temperature increase to 1.5˚C".

A goal far below 1.5˚C is highly desirable, because climate change is already dangerous.

"Unavoidable warming" today is now 1.7˚C[16] and will be ~2˚C by 2030 if emissions proceed along the Paris pathway. So there is no carbon budget left for 1.5˚C: "And what about 1.5˚C stabilisation? We're already overdrawn", says Prof. Michael E Mann, one of the world's foremost climate scientists.[17]

There are no model scenarios where global temperatures remain below 1.5˚C throughout this century, and scenarios that overshoot 1.5˚C and return to 1.5˚C by 2100 with large-scale negative-emission technologies "impose a range of stretching requirements".[18]

That is, staying below 1.5˚C of warming for the whole of this century would be possible only with the use of sulfate-based incoming solar management geo-engineering which is not a proven or safe technology, and which the large climate action NGOs appear to oppose without exception. Likewise, returning to 1.5˚C by 2100 requires an application of large-scale negative emission technologies which are not presently deployable in an environmentally safe way and at manageable cost, and which significant elements of the climate justice movement strongly oppose.

6. RELIANCE ON NEGATIVE EMISSIONS TECHNOLOGIES

Rather than requiring large and immediate emission reductions in the short-to-medium term, the Paris agreement instead assumes that the world will successfully suck the carbon pollution back from the atmosphere in the longer term, plumping for biomass energy with carbon capture and storage (BECCS) as the most promising "negative-emissions technology".

BECCS is an unproven technology at scale and "negative-emission technologies... are currently at little more than a conceptual stage of development", yet the framing of the 2˚C goal and, even more the 1.5˚C one, is premised on the massive uptake of BECCS some time in the latter half of the century.[19]

Potsdam Institute head Prof. John Schellnhuber warns against "the illusion you can just extract huge mounts of carbon from the air in order to restore the atmosphere".[20]

The land-use intensity of BECCS is quite high, with values ranging from ~1-1.7 hectares per ton of carbon per year.[21] In other words, if ALL the world's land currently devoted to cropping (~3 billion hectares) was devoted to BECCS, the drawdown would be ~3 billion tons of carbon per year — still only about 30% of the world's current annual emissions. Whether the storage of the compressed carbon dioxide in expired oil and gas fields and other underground geological sites would be secure and stable over the long term is another question for which there is yet no satisfactory answer.

7. CARBON BUDGETS

Any temperature target only has practical meaning if the size of the risk of exceeding it is known, and the scale of the impacts of exceeding the target are also known.

A low-impact risk target for atmospheric greenhouse gases is very much less than the current level: the IPCC reported that "to provide a 93% mid-value probability of not exceeding 2˚C, the concentration (of atmospheric greenhouse gases) would need to be stabilised at or below 350 parts per million carbon dioxide equivalent (ppm CO2e)" compared to the current level of ~485 ppm CO2e.[22]

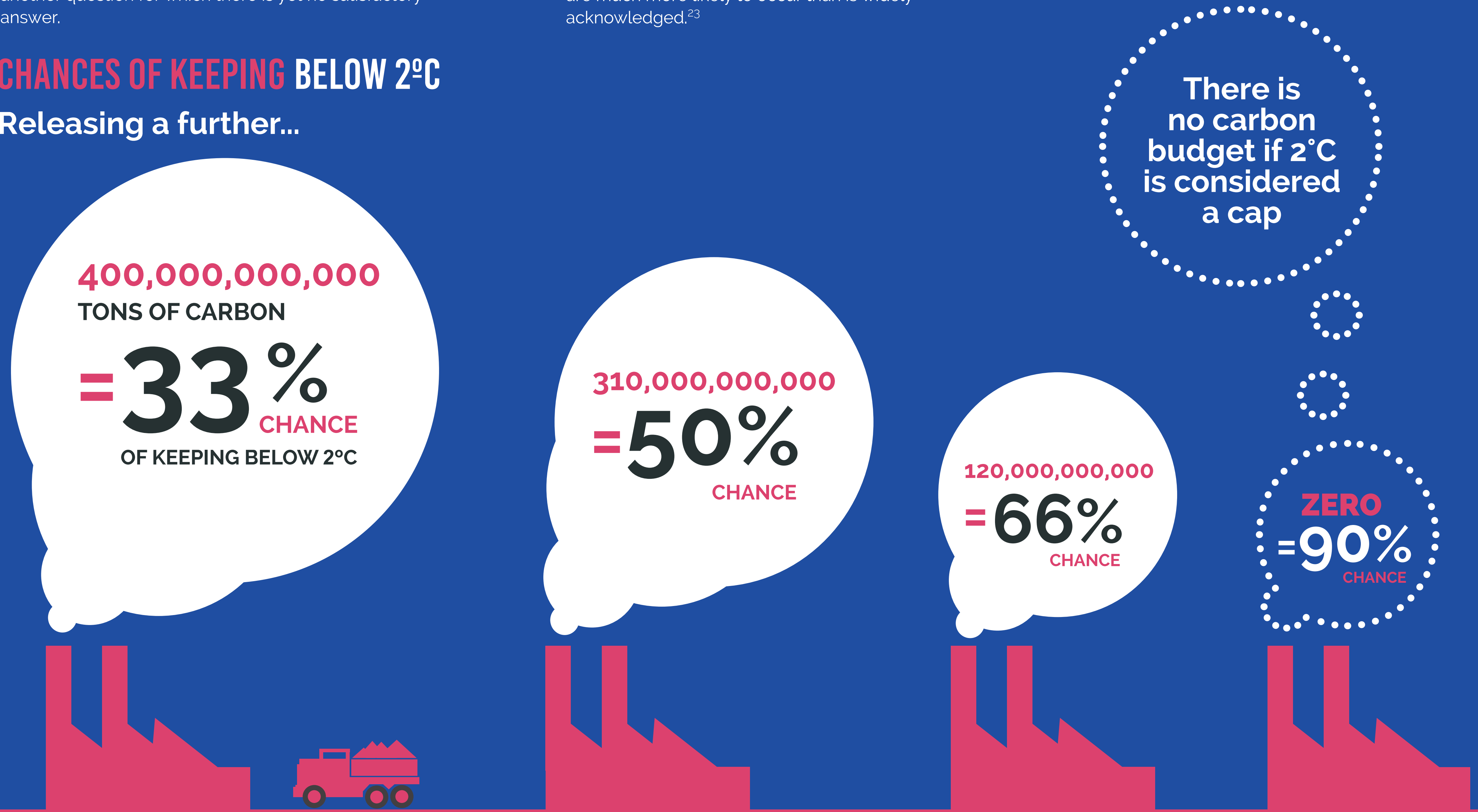
Catastrophic and irreversible consequences caused by 2˚C of warming demand a strong risk-management approach, yet we find policymakers focused on "middle of the road" outcomes and carbon budgets, and turning a collective blind eye to "high-end" possibilities that are much more likely to occur than is widely acknowledged.[23]

Whilst policy-makers and advocates often talk about a carbon budget of allowable fossil fuel use that would keep warming to 2˚C, the evidence shows we have no such budget for a sensible risk-management, low-risk probability of exceeding the target.[24] There is no carbon budget if 2˚C is considered a cap (upper boundary) as per the Copenhagen Accord, rather than a target (which can be significantly exceeded). And there is no carbon budget for fossil fuel emissions after accounting for likely future food and deforestation emissions.

Anderson and Bows have shown that even with a too-high goal of holding temperatures to 2˚C (with only a 66% probability of success), for developed economies to play an equitable role they would have to cut their emissions by 40% reduction by 2018, 70% reduction by 2024, and 90% by 2030 from 1990 levels.[25]

CHANCES OF KEEPING BELOW 2ºC

Releasing a further...



2˚C is the boundary between dangerous & very dangerous climate change - how much can we chance?

8. CARBON CYCLE FEEDBACKS

There is an unacceptable risk that before 2˚C of warming, significant "long-term" feedbacks will be triggered, in which warming produces conditions that generate more warming, so that carbon sinks (stores) such as the oceans and forests become less efficient in storing carbon, and polar warming triggers the release of very significant permafrost and/or frozen methane clathrate carbon stores.

It is conventionally considered that these feedbacks operate on millennial timescales, but the rate at which human activity is changing the Earth's energy balance is without precedent[26], and the rate of change in energy forcing is now so great that these "long-term" feed-backs have already occurred within short time frames.

A recent study makes use of projections from the most recent IPCC report to estimate that up to 205 billion tons equivalent of carbon dioxide could be released due to melting permafrost and cause up to 0.5˚C extra warming.[27] Some carbon stores have already reached a tipping point, and are now becoming carbon emitters rather than carbon sinks, including Arctic tundra carbon stores.[28]

One research paper concluded that: "the permafrost carbon feedback will change the Arctic from a carbon sink to a source after the mid-2020s and is strong enough to cancel 42–88% of the total global land sink."[29]

In February 2013, scientists using radiometric dating techniques on Russian cave formations to measure melting rates warned that a 1.5°C global rise in temperature compared to pre-industrial was enough to start a general permafrost melt.[30]

In the first half of 2015, new lines of evidence were published suggesting that more elements of the system may be heading towards tipping points or experiencing qualitative change, including: the slowing of the major sea current known as the Atlantic conveyor likely as a result of climate change; accelerating ice mass loss from Antarctic ice shelves and the vulnerability of East Antarctica glaciers; declining carbon efficiency of the Amazon forests and other sinks; rapid thinning of Arctic sea-ice; and the vulnerability of Arctic permafrost, exemplified by the proliferation of Siberian methane craters.[31]

9. "IRREVERSIBLE" CRYOSPHERE THRESHOLDS

In late 2015, a chilling report on "Thresholds and closing windows: Risks of irreversible cryosphere climate change"[32] warned that the Paris commitments will not prevent our "crossing into the zone of irreversible thresholds" in our polar and mountain glacier regions, and that crossing these boundaries may result in processes that cannot be halted unless temperatures return to levels **below** pre-industrial.

To put it most bluntly, only a new "Little Ice Age" may re-establish some of today's mountain glaciers and their reliable water resources for millions of people; or halt melting polar ice sheets that, once started, irrevocably would set the world on course to an ultimate sea-level rise of between 4–10 metres or more.

These thresholds are drawing closer… some of these changes may close during the 2020–2030 commitment period. And some of these cryosphere thresholds, including potential fisheries and ecosystem loss from polar ocean acidification, cannot be reversed at all.

Cryosphere climate change, driven by the physical laws of water's response to the freezing point, is different. Slow to manifest itself, once triggered it inevitably forces the Earth's climate system into a new state, one that most scientists believe has not existed for 35–50 million years.

10. ONE-DEGREE IMPACTS

The Arctic is warming roughly two-to-three times as fast as the global average.[33] Even before we reached 1˚C of global warming, Arctic tipping points had been crossed for sea-ice-free summer conditions, with severe consequences for the future stability of permafrost and frozen methane stores, for sea-level rises, as well as for accelerated global warming as ice sheets retreat and the Earth's albedo (reflectivity) decreases.[34]

Evidence suggests tipping-points for events, which may be irreversible on century time scales, are being passed. One of the most significant research findings in 2014 was that the "tipping point" has already been crossed for the Amundsen Sea sector of West Antarctica at under 1˚C of warming. Scientists found that the retreat of ice was "unstoppable", with major consequences: "it will mean that sea levels will rise 1 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."[35] (Note: "millions" would seem a significant understatement.)

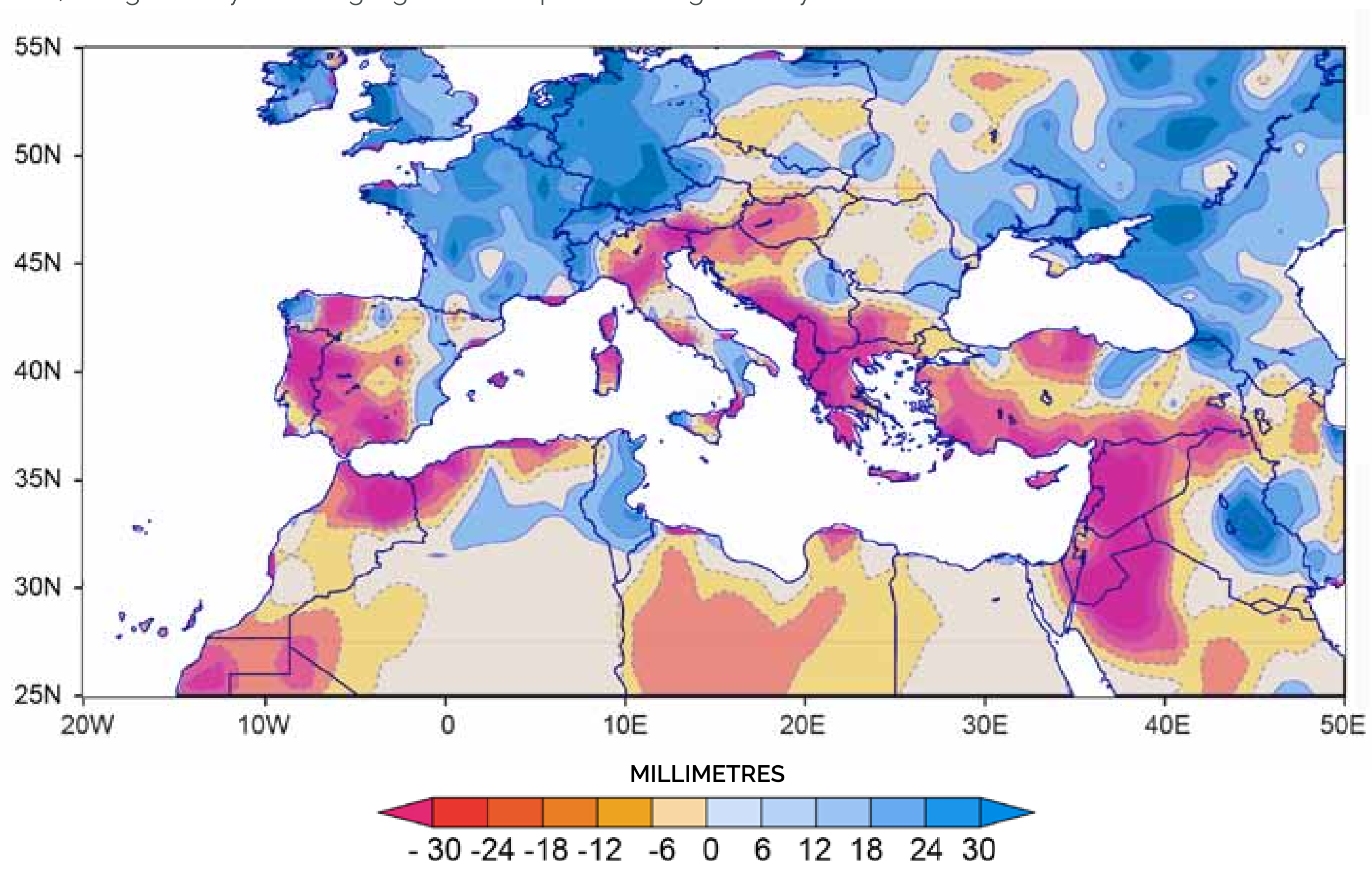
Whilst a 1-metre sea level rise may sound manageable, it would drown some nations, and flood some of the world's richest agricultural lands on river deltas or render them unusable due to salination, and likely create climate-change failed states. In Bangladesh, a 1-metre sea level rise would inundate 15-17% of the land and threaten more than a million hectares of agricultural land. The Mekong River Commission warns that a 1-metre sea level would wipe out nearly 40% of the Mekong Delta.[36] A 1-metre rise would flood one-fourth of the Nile Delta, forcing more than 10% of Egypt's population from their homes. Nearly half of Egypt's crops, including wheat, bananas and rice, are grown in the delta.[37]

Current climate trends, if not arrested rapidly, will likely lead to a substantial reduction in global population, with attendant mass social conflict and migration, early signs of which are already evident in the Middle East and North Africa.

The Syrian conflict was preceded by the worst long-term drought and crop failures since civilisation began in the region, resulting in 800,000 people losing their livelihoods by 2009, and 2–3 million being driven into extreme poverty.[38] The eastern Mediterranean has experienced significant deceases in winter rainfall over the past four decades, as illustrated below.[39] Australia, as the driest continent on Earth, is more exposed than most to new climate extremes.

Cold season (Nov-Apr) rainfall anomaly 1971-2010 compared to 1902-1970

reds, oranges and yellows highlight lands experienced significantly drier winters



11. DAMAGE BEFORE 2°C OF WARMING

The damage that will eventually be caused by just 1°C of warming is beyond adaptation for many nations and peoples, yet much higher temperature limits have been the goal of policy-makers.

Former NASA climate science chief Prof. James Hansen says it is "well understood by the scientific community" that goals to limit human-made warming to 2°C are "prescriptions for disaster", because "we know that the prior interglacial period about 120,000 years ago was less than 2°C warmer than pre-industrial conditions and sea level was a least five to nine metres higher, so it's crazy to think that 2°C is a safe limit".[40]

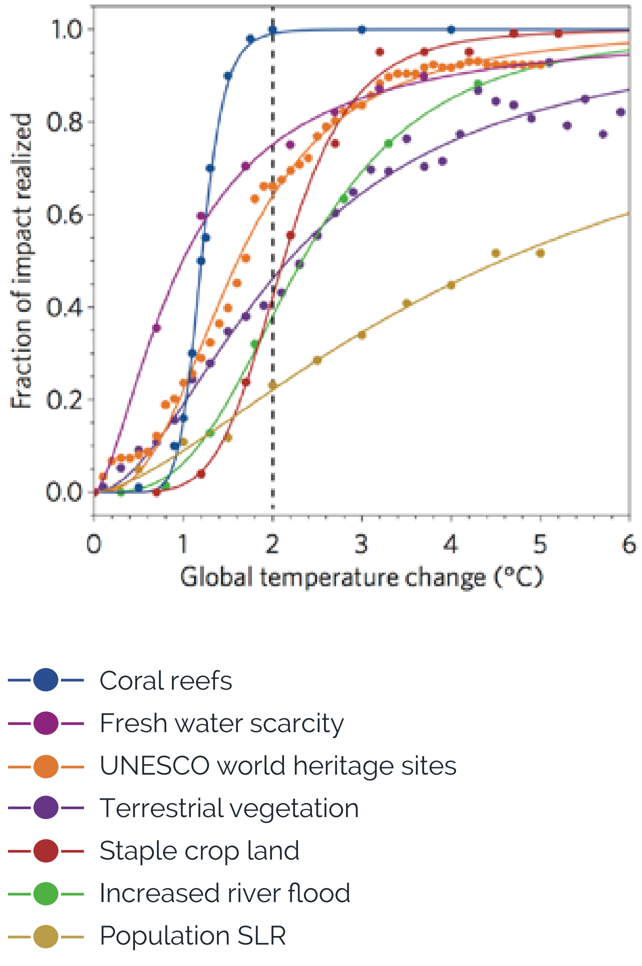
The 2009 Copenhagen climate conference of governments agreed that there should be a scientific review of the 2°C cap. It was completed in 2015 for the secretariat of the UN Framework Convention on Climate Change and concluded that that 2°C is not a safe temperature cap and that a 1.5°C cap, while causing less damage than the 2°C cap, is also not safe.[41]

Warming of 1.5°C would set sea level rises in train sufficient to challenge significant components of human civilisation, and reduce the world's coral ecosystems to remnant structures.[42]

New research just published looks at the damage to system elements including water security, staple crops land, coral reefs, vegetation and UNESCO world heritage sites as the temperature increases. And the findings are very sobering: almost all the damage from climate change to vulnerable categories like coral reefs, freshwater availability and plant life could happen before 2°C, as the chart from this research result dramatically shows.[43]

And as noted above, there is an unacceptable risk that before 2°C of warming, significant "long-term" feedbacks will be triggered, in which warming produces conditions that generate more warming, so that carbon sinks such as the oceans and forests become less efficient in storing carbon, and polar warming triggers the release of significant permafrost and clathrate carbon stores. Such an outcome could render ineffective human efforts to control the level of future warming to manageable proportions.

Maximum potential climate change impacts for various sectors as determined by the sigmoidal fit



12. HOLOCENE CONDITIONS

Human civilisation has flourished over the last 11,000 years under relatively stable climate conditions and sea levels in a period known as the Holocene, which provided a "safe operating space" for global societal development.[44] However, we have already left the Holocene temperature range. Reestablishing Holocene conditions of less than 325 ppm CO2e is safe for humanity, especially given that so much of human civilisation comprises coastal settlement and delta/flood plain agriculture. If a significant proportion of coastal settlement is overwhelmed by rising sea levels and is forced to retreat, the question of what is safe for humanity becomes a different question.

Even a small global warming above the level of the Holocene begins to generate a disproportionate warming on the Antarctic and Greenland ice sheets,[45] yet a moderate sea level rise of 1–2 metres in less than a century would produce a change in coastlines that is unprecedented for human civilisation.

Current atmospheric greenhouse gas levels (~400ppm CO2 and ~485 CO2e) are likely the highest in the last 15 million years, and never previously experienced by humans. The current conditions, if maintained over centuries/millennia (that is, until the system reaches equilibrium), would likely produce temperatures +3– 6°C and sea levels 25–40 metres higher, based on evidence of past climates.[46] There is a widespread view amongst scientists that "a 4°C future is incompatible with an organised global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems and has a high probability of not being stable".[47]

Given the current state of the atmosphere, getting back to Holocene-like greenhouse gas conditions would require an effort on century time scales, rather than a decadal one. It requires a rapid end to human-caused emissions, and the deployment at massive scale of efficacious biological and other carbon dioxide drawdown measures to reduce the level of atmospheric greenhouse gases.

13. CLIMATE INTERVENTIONS

Solar radiation (or albedo) management (SRM), and carbon dioxide removal and sequestration may be termed climate interventions (engineering): "purposeful actions intended to produce a targeted change in some aspects of the climate".[48] They could only make a practical contribution if they complement dramatic emissions reduction efforts, and their net benefit depends upon their technical effectiveness, cost, risk and governance.

SRM techniques are designed to produce immediate surface cooling by employing aerosol-cooling sulfates or similar into the lower stratosphere, or boosting the earth's reflectivity in some other way. The cooling effect is almost immediate (within months) and substantial (degrees of °C), the cost is relatively low and it can be done at the scale required.[49]

SRM techniques have not demonstrated clear net benefits because of as yet not-fully-understood but damaging side effects,[50] they may not be able to simultaneously restore all features of the climate (e.g., temperature and rain/snow) and there are very large unresolved ethical, political and governance issues. SRM does not address the issue of dangerous levels of ocean acidification and could reduce the incentive to curb anthropogenic CO2 emissions and could lead to a climate with different characteristics than the current climate if accompanied by continued high emissions.

Some carbon drawdown techniques such as reforestation and afforestation are proven and safe, but limited in scale. Covering 3% of the world's surface with forests would be equivalent to negating just 10% of the world's current greenhouse gas emissions (a billion tonnes of carbon annually). Other techniques include biochar, land management, accelerated weathering, bioenergy with carbon capture and sequestration (BECCS), direct capture and sequestration, ocean fertilization, and seaweed and algal farming. Many of these are unproven, high cost at present, slow to implement, not currently deployable at massive scale, and have implications for land use and the maintenance of food production and traditional land ownership, farming and biodiversity protection because of the large spatial areas required (See section 6, above).

The impact of carbon drawdown is slow and "will not have an appreciable effect on global climate for decades", and hence does not provide an opportunity for rapid reductions of global temperature.[51] The use of carbon capture and storage technology to store liquid carbon dioxide either from power and industrial plants or direct capture from the atmosphere in disused oil and gas fields and other geological formations is being deployed and has substantial business sector and policymakers' support in establishing a liquid carbon dioxide market perhaps larger than the existing oil industry. There is concern about the ethics and efficacy of such an approach, and the safety and stability of such storage, especially in geological formations other than disused oil and gas fields and in deep ocean sediments.

It must be emphasized that none of these technologies are currently viable in terms of technical effectiveness, cost, risk and governance.

14. DISCUSSION

Living with 2˚C or more of warming over the medium-to-long term will, in James Hansen's words, condemn "our biggest, most prosperous and populated cities to an underwater existence".[52] Climate change is already dangerous, especially for the world's most vulnerable people and species. Yet, there is no pathway to keeping warming below 1.5˚C without unproven solar radiation management. In light of the Paris commitments over the next 15 years, it is also very difficult to construct pathways that do not exceed 2˚C thresholds and more significant tipping points being crossed, without large-scale climate interventions.

Humanity faces an existential crisis and, like a nation at the beginning of a great battle, we don't know how this will end, and whether we will succeed or not. But there is chance, so we must find the path that gives us the best chance. As a species we have been down this road before, not least at the time of the end of the last ice age, when temperature warmed by 3–4˚C to a little below the current level over a millennium, with huge ice sheets retreating and sea levels rising more than a hundred metres over several millennia. But in these past climate crises, humans were not the cause of the change, nor was the rate of change so fast.

HOW DO WE RESOLVE THESE CHALLENGES?

• **The immediate goal of any climate strategy must be to avoid passing further significant tipping points, including those related to the carbon cycle, ice sheets and sea levels.** We must seek actions that form the least-worse path for future emissions, greenhouse gas levels and temperatures.

• **No matter what we do, there will be very severe and unavoidable consequences, especially for the world's regions, peoples and ecosystems most vulnerable to a hotter climate.** That requires a keen focus on preparing for and adapting to the changes that are now inevitable, as well as a whole-of-society effort to achieve negative emissions and reduce warming in a manner that causes the least damage.

• **The best path is one of emergency-scale action to get to zero emissions in Australia as fast as possible and by 2030.** Like a rescue plan after a natural disaster, the more resources we devote to the problem, the more likely we are to succeed, and the sooner the better. This requires a whole-of-government effort based on conscious recognition that climate warming now represents a near-term threat to human civilisation. It requires a strong regulatory approach, because simply pushing and prodding the market within a neo-liberal framework cannot get the job done. A rescue plan must lay out the many steps to solving the problem: a plan to drive rapid emissions reductions; a plan for a just transition away from fossil fuels; a plan for the labour, skills and investment to do it; a plan for sustainable modes of work and leisure, and so on. The transition will be economically and socially disruptive because old, carbon-intensive industries must die, and current lifestyles in the high-income economies are not sustainable.

• **Innovation has astounded us: 40 years ago when solar PV cells were ~$A100 a watt, who would have imagined that in 2015 they would be around 30 cents?** And carbon fibre, low-cost battery storage, digitization and new materials. We have many of the technologies we need, and the obstacles are largely social and political, with a lack of commitment and poor regulatory systems slowing change for technologies that are already mature or rapidly sliding down the cost curve. Where technological challenges remain, we need a huge innovation and deployment effort on many fronts, including a search for efficacious climate interventions.

• **It is clear that a zero emissions strategy can't deliver, by itself, the degree of protection that would be desirable and that might be possible.** We need to set aside the reflex taboo that some people have begun to build up around CO_2 drawdown or solar radiation management and openly and rigorously assess if these interventions are able to contribute in strategically important ways to a least worst, or most beneficial, climate outcome for all people and species, especially the most vulnerable.

• **Some people say climate interventions are all about big business making money, but so too is much economic activity and much of the new "green" economy.** It is suggested that climate interventions are just an excuse for continuing high fossil fuel use, but it is clear they could only be effective over the longer term if allied to a zero-emissions plan. Others say climate interventions are not ethical. From my perspective, not finding the path of least damage is not ethical. The US National Academy of Sciences has asked what do we do if the impacts of climate change become intolerable, such as massive crop failures throughout the tropics? What are the ethics of saying "no climate intervention, no matter what" in those circumstances? To not accept that a large-scale research-and-development effort is necessary to see if climate interventions can help us along the least-worse path seems presumptuous.

• **Radical emissions reductions can be driven more quickly by energy-efficiency-driven demand reduction than by replacing the energy supply system[53], though of course both are essential.** It's popular to say that the era of fossil fuels is coming to an end[54] as forces of creative destruction haunt the industry, but it is not coming soon enough: the Paris path see emissions increasing to 2030 and new coal power stations are still being built. Together with technological innovation in the energy sector, our efforts are helping to destroy the fossil fuel industry business model and withdraw its social licence, but a popular mobilization must be part of getting to zero much quicker.

IDEAS LEADERSHIP

The reasons for not doing what is obviously in our collective best interest have been widely canvassed, but one striking element is the lack of public ideas leadership. How many figures of public standing in Australia are prepared to consistently canvas the main issues discussed here, even if we disagree about some of the details? You could count them on the fingers of one hand. In fact, how many are prepared to talk about these issues in the public arena at all? Timidness and a relentless bright-siding infuse the public conversation, as if people cannot bear to hear the truth.

But what if public is more prepared for the conversation than are our public ideas leaders?

Recent work by Melanie Randle and Richard Eckersley investigated the perceived probability of threats to humanity and different responses to them (nihilism, fundamentalism and activism) in the US, UK, Canada and Australia:

> *Overall, a majority (54%) rated the risk of our way of life ending within the next 100 years at 50% or greater, and a quarter (24%) rated the risk of humans being wiped out at 50% or greater. The responses were relatively uniform across countries, age groups, gender and education level, although statistically significant differences exist. Almost 80% agreed "we need to transform our worldview and way of life if we are to create a better future for the world" (activism). About a half agreed that "the world's future looks grim so we have to focus on looking after ourselves and those we love" (nihilism), and over a third that "we are facing a final conflict between good and evil in the world" (fundamentalism). The findings offer insight into the willingness of humanity to respond to the challenges identified by scientists and warrant increased consideration in scientific and political debate.*[56]

So here is the great irony: people have got a fair, intuitive sense of what might be coming, but our ideas leaders can't talk about it.

Now is the time to press those who aspire to leadership on climate issues and action to ask the questions that prompted the writing of this discussion paper. If the propositions are contentious, let's debate them rather than keeping them hidden under a cone of silence. Repressing troubling thoughts does not resolve them, but means only they will come back to haunt us in an increasingly intense manner.

NOTES

1 Matthews and Solomon (2013) "Irreversible Does Not Mean Unavoidable", Science 340:438-39

2 Matthews and Caldeira (2008) "Stabilizing climate requires near-zero emissions", Geophysical Research Letters 35:L04705

3 Anderson (2015) "Duality in climate science", Nature Geoscience, 8: 898–900

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