Vol. 48, No. 4 October 2019

PHYSICS & SOCIETY

A Publication of The Forum on Physics and Society A Forum of The American Physical Society

From the Editor

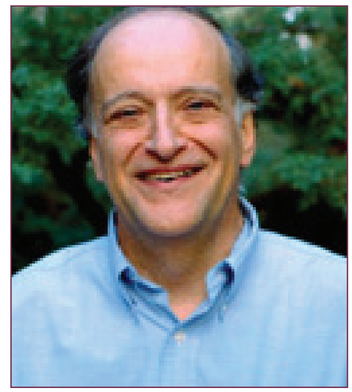
One the news in this issue is that an APS Innovation Fund project, entitled "Informing and Activating the U.S. Physics Community in Nuclear Threat Reduction" has been approved. One of the leaders is Stewart Prager, one of our own sponsored speakers at the last March meeting. Congratulations: this is very important work. I hope to be able to publish an article on this topic in a forthcoming issue.

We are continuing our effort to expand our media presence. Please contact our Media Editor, Tabitha Colter, at *tabithacolter@gmail.com* for suggestions and comments.

We have four articles in this issue, more than usual, including one by our last Szilard prize winner, Zia Mian, and two by recently Forum session invited speakers, Bruce Wielicki (March meeting) , and Doug O'Reagan (April). As I said in the previous issue, I intent to continue soliciting articles from our prize winners and invited speakers.

However, contributions from our general readership and their friends are needed also and always welcome. Articles and suggestions for articles should be sent to me. Book reviews should go to the reviews editor directly (ahobson@uark.edu). Since content is **not peer reviewed and opinions given there are the author's only, not necessarily mine, nor the Forum's or, *a fortiori*, not the APS's either,** we are able to be very open as to what is appropriate. If you do not like a published article, write a response in the form of a letter to the Editor or, even better, as a responding article.

Oriol



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IN THIS ISSUE

FORUM NEWS

APS Innovation Fund

The APS Innovation fund has approved a proposal entitled "**Informing and Activating the U.S. Physics Community in Nuclear Threat Reduction.**" The leaders are Stewart Prager, Alex Glaser, Zia Mian, Frank von Hippel (Princeton University), and Steven Fetter (University of Maryland). We hope it will engage the FPS membership.

Today, the global threat from nuclear weapons remains grave and is worsening. In addition to concerns about existing nuclear arsenals, international tensions continue to rise over the threat of nuclear weapons proliferation. This project will educate and reengage the powerful voice of the physics community and the APS membership on this pressing and globally important issue. A team of experts will visit physics institutions, present overviews, conduct discussions, and build a coalition of volunteers to advocate for nuclear threat reduction measures.

Congratulations to the leaders!

ARTICLES

Scientists and the Struggle Against Nuclear Weapons Today: What would Szilard Do?

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Zia Mian received the American Physical Society's 2019 Leo Szilard Lectureship Award. This essay is adapted from a 2019 Leo Szilard Award talk at the American Physical Society meeting in Boston on 8 March 2019. A video of the talk is at youtu.be/x96oEoBQil4.

INTRODUCTION

Long standing arms control and nonproliferation arrangements intended to forestall, halt, reverse and eventually eliminate nuclear weapons programs are unraveling and prospects for near-term progress on this critical issue appear bleak. Alongside renewed and intensified strategic rivalry among the major nuclear-armed states, there are ambitious programs for modernization and further development of nuclear arsenals and production complexes, and for some states the conditions for nuclear weapons use seem to be broadening rather than shrinking. The one hopeful recent development, the 2017 United Nations Treaty on the Prohibition of Nuclear Weapons, has elicited opposition rather than support from nuclear-armed states. This turn away from restraint towards a retrenchment of nuclear weapons and warfighting postures exposes some of the inherent contradictions in arms control as a way to end the threat of nuclear war and raises questions about what scientists can do today as part of a renewed struggle against the bomb.

In these remarks, I will review the crisis of arms control and nonproliferation by sketching out what I see as some of the important elements of the present conjuncture, and suggest why it has deeper roots and greater dangers than one might think. I will then focus on lessons that might usefully be learned from organizing initiatives involving Leo Szilard (1898 – 1964), the discoverer of the nuclear chain reaction and a key member of the first generation of physicists to take up the challenge of reducing the danger from nuclear weapons and working for their elimination. In particular, I will highlight some of the ways in which Szilard was a pioneer in efforts by physicists as citizen-scientists to transcend nationalism and to bring science and democracy to bear on the challenge of reducing and eliminating the risks from nuclear weapons. The title of the talk and this essay are inspired by William Lanouette's biography of Szilard, *Genius in the Shadows*, which concludes that "Szilard's legacy is best captured in his mode of thinking.. [and] feisty spirit ... and to ask "What would Leo think?"[1]

THE CRISIS OF ARMS CONTROL AND NONPROLIFERATION

The most recent expression of the crisis of arms control and nonproliferation is the Intermediate Nuclear Forces Treaty, with the United States and Russia withdrawing from the treaty in 2019.[2] This treaty, signed in December 1987, had been in force for 30 years. It is important to note, however, that this is not the first long-standing arms control treaty that has been undone and may not be the last.

There seems to be a 30-year rule that applies to this great unraveling of arms control. In December 2001 the Bush Administration withdrew the United States from the Anti-Ballistic Missile Treaty.[3] This treaty also was about 30 years old at that time, having been signed in May 1972. The remaining part of the bilateral Cold War era nuclear arms control regime is the series of Strategic Arms Reduction Treaties which began with START I, signed in July 1991. These treaties no longer just capped the number of nuclear weapons for the United States and Russia as had been done under the earlier agreements known as the Strategic Arms Limitation Talks that led to SALT I (signed in 1972) and SALT II (signed in 1979), but began the process of reducing deployed arsenals.[4] New START, the most recent of these treaties, was signed in April 2010, and is set to expire on February 5, 2021.[5] There is great concern that New START will not be renewed because of opposition from the Trump Administration.[6] In the absence of New START, there would be no mutually agreed limit on nuclear arsenals for the United States and Russia for the first time since 1972.

What makes the present crisis more significant still is that for most of the past half century nuclear arms control had been taken for granted. Arms control since at least the early 1970s was supposed to be a ratchet that once put in place would stay in place and prevent the return to the kinds of arms racing and nuclear crises that we had seen earlier. By the late 1960s the U.S. nuclear arsenal peaked at over 30,000 weapons, out of an estimated 40,000 nuclear weapons worldwide – after peaking at an estimated 70,300 weapons in 1986, dramatic reductions in the global nuclear weapons inventory only began in the late 1980s with the INF Treaty.[7]

The second thing worth paying attention to in the present conjuncture is that in the last 25 years a whole series of expected multilateral arms control measures have failed to be realized. These efforts were all part of what was imagined and promised as a step-by-step process to restrain the spread of nuclear weapons and to begin to reverse and roll them back with a view to their elimination.

The first missed step has been the Comprehensive Nuclear Weapons Test Ban Treaty. It is now over 20 years since the treaty was opened for signature. Now signed by 184 countries and ratified by 168 of them, the treaty has still not entered into force. Even though President Clinton signed the treaty in 1996, the United States Senate in 1999 voted by 51-48 along party lines to not ratify it.[8] Among the other nuclear armed states, China and Israel also have not ratified the treaty, while India, Pakistan, and North Korea have not signed it.[9] Entry into force is uncertain.

A second agreement that has failed to materialize is the fissile material cutoff treaty. In 1993 the United Nations, without a dissenting vote, gave a mandate for negotiations at its Conference on Disarmament for a "non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile materials for nuclear weapons or other nuclear explosive devices."[10] Talks have still not started.

A third multilateral arms control treaty that could have been agreed was on no first use of nuclear weapons. In 1994, China offered the other permanent members of the United Nations Security Council (the United States, Russia, Britain, and France), a draft text of a multilateral treaty of no first use of nuclear weapons.[11] There have been no negotiations.

Another missed step is associated with the 1996 International Court of Justice advisory opinion on the legality of the threat or use of nuclear weapons.[12] This opinion by the highest court in the United Nations system followed a request made by the United Nations General Assembly for a finding on the question: "Is the threat or use of nuclear weapons in any circumstance permitted under international law?"[13] The Court found that "the threat or use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict, and in particular the principles and rules of humanitarian law."[14] This has obvious implications for the nuclear plans and postures of the nine nuclear-armed states. These states have made no public effort to explain, reassess or revise nuclear war plans and postures in light of the Court's finding.

Alongside arms control unraveling, and arms control steps that could have been taken but were not taken, nuclear dangers are getting worse in other ways. Most important, all nine nuclear weapon states have plans for undertaking expansion, development or modernization of their nuclear arsenals.[15] In some cases, for instance the United States, these plans are going to put in place nuclear weapon systems that will be in operation 60–80 years from now.[16]

Also, the conditions under which some states imagine using nuclear weapons are broadening rather than becoming more restrictive. The 2018 United States Nuclear Posture Review envisages using nuclear weapons to respond to "significant non-nuclear strategic attacks" against "U.S., allied or partner civilian population or infrastructure, and attacks on U.S. or allied nuclear forces, their command and control, or warning and attack assessment capabilities" and cites "chemical, biological, cyber, and large-scale conventional aggression" as specific concerns.[17]

Along with the resumption of a nuclear weapons competition and arms racing between the United States and Russia, the arms race in South Asia has also become a growing concern and is something that could have been prevented. There has been no significant effort by the international community to try and prevent India and Pakistan developing their nuclear weapons since their nuclear tests of 1998. The two countries now have an estimated 130 to 150 nuclear weapons each, and short-range and long-range ballistic missiles, cruise missiles and aircraft to deliver these weapons.[18] They also are putting nuclear weapons at sea and Pakistan is developing battlefield nuclear weapons.

As we saw again in early 2019, India and Pakistan are in a recurring often violent crisis cycle. This time, following a suicide bombing of security forces in Indian-held Kashmir, Indian jets flew into Pakistan to target militants blamed for the attack, leading Pakistan to send jets into India and shoot down an Indian fighter aircraft.[19] This may set a new minimum level of violence that political leaders and generals there think they can safely undertake. The August 2019 decision by India to end the special constitutional status of relative autonomy formally accorded Indian-held Kashmir since 1949 has triggered a new crisis, with large scale repression by Indian forces of the Kashmiri population and threats by Pakistan's Prime Minister Imran Khan that "The time has arrived to teach you [India] a lesson," and that Pakistan would "fight until the end."[20]

Where nonproliferation progress existed, it has started to come undone. The Trump Administration's withdrawal from the July 2015 nuclear deal with Iran reached by President Obama, and imposition of significant new sanctions on Iran – in defiance of a unanimous vote of the United Nations Security Council supporting the deal – triggered Iranian steps away from the caps and restraints it had accepted under the deal.[21] This decision also undercuts prospects of international trust in future nuclear agreements involving the United States

Shifts in United States priorities have undercut other nuclear agreements it sought and helped create. Since the early 1990s the United States has been talking to North Korea about denuclearization and at various times failed to uphold deals that were made or take possible opportunities.[22] In this time, North Korea has gone from a latent nuclear weapons capability to have tested nuclear weapons and various missile types.[23] The current diplomatic process with North Korea seems very uncertain.

In the last part of this sketch of the arms control and nonproliferation crisis, I want to highlight an underlying structural crisis. This structural crisis is a bit like the crisis in the Cold War over the legitimacy of the international order. The United States and the Soviet Union were contesting not just each other's nuclear weapons but who gets to decide what happens in the world. We are at a similar stage now.

A case can be made that there is now a contest over the legitimacy of the international nuclear order. One place that this is being played out is the Nuclear Non-Proliferation Treaty (NPT) Next year, 2020, will mark 50 years since the entry into force of the NPT, with the 10th in the series of the treaty's once every five years Review Conferences. What we have seen in the last few Review Conferences is that the NPT process has gone into profound oscillations between the appearance of progress and the failure to make any kind of progress. This process has reached the point where there are signs not just of cracks but of potential failure of the NPT as an architecture for managing the nuclear part of the international order.

In 1995, there was the coercive extension and indefinite extension of the NPT.[24] By coercive, I mean the United States and the other weapon states that were in the NPT forced an unconditional indefinite extension. Non-weapon states at that time were not happy with the lack of progress towards nuclear disarmament that had been promised in the treaty but could do little. The balance of power in the world system I think has shifted significantly in their favor since then.

At the NPT Review Conference in 2000, in the Final Declaration there was agreement on 13 "practical steps" aiming to make progress on the disarmament obligations of the treaty.[25] As I suggested earlier, none of these steps have been taken and some steps have involved back-tracking, such as the steps to keep the Anti-Ballistic Missile Treaty in force, bring the nuclear test ban treaty into force, and agree a Fissile Material Cutoff Treaty. In 2005, the NPT Review Conference failed to agree on almost anything at all – in large part because the Bush Administration walked back the commitment to the 13 steps and more broadly "rejected the 2000 Final Declaration and all references to it".[26] In 2010, with the Obama Administration in office, the NPT Review Conference saw agreement on a 64-point action plan, which included some of the earlier 13 steps and a promise of a conference to establish a middle east zone free of nuclear weapons and other weapons of mass destruction.[27] No significant progress on the action plan has been made and the promised conference has not taken place. In 2015, the NPT Review Conference failed even to agree on a final document when the United States, Britain and Canada rejected it.[28]

The prospects for 2020 look very bleak. The United States, under the Trump Administration, has said that rather than taking steps on nuclear disarmament it wants to talk about what it would take to create the conditions for further steps on nuclear disarmament.[29] Implicit here is the possibility that the United States and other nuclear weapon states may decide that the conditions for progress on disarmament, as they see them, may never be allowed to come to pass.

At the same time, the structural dynamics and legitimacy crisis of the nuclear order has seen a shift in global power towards a greater exercise of agency by non-weapon states. This is evident in the process that in 2017 led 122 countries at the United Nations to agree on the Treaty on the Prohibition of Nuclear Weapons.[30] This is a historic step. This is the first multilateral nuclear weapons treaty that came from non-weapon states. It was led by countries from the global south and civil society. This is where people hoped back in 1946 we were going to get to with the United States and the Soviet plans to eliminate nuclear weapons before we had the horrors of the arms race.

The fact that 122 countries felt compelled and able to go through this treaty-making process despite the opposition of the nuclear-weapon states shows that these non-weapon states were willing to take a risk that they have never felt willing to take before. Also, the non-weapon states were able to organize themselves in a way that they had not been able to organize themselves before. Through hard-fought NPT Review Conferences and other multilateral disarmament for a, non-weapon states have seen weapon states make commitments and then watched these promised steps remain unfulfilled. The ban treaty also reflects a positive recommitment by non-weapon states to the NPT and to a world without nuclear weapons despite the failure of the weapon states to meet NPT commitments to nuclear disarmament and despite the emergence of nuclear weapon states outside the NPT. Rather than contemplate withdrawal from the NPT or seek a new bargain with the weapon states, the non-weapon states of the ban treaty have accepted freely an obligation to not acquire nuclear weapons. As of the end of August 2019, the treaty had been signed by 70 countries and ratified by 26 countries.[31]

The ban treaty opens the door for nuclear-weapon states, should they become so enlightened, to join the treaty. A weapon state can do so either by giving up its nuclear weapons and joining the treaty and proving after the fact that it has already eliminated its weapons, or a state can join the treaty and agree with the other treaty members to a verifiable, irreversible, time-bound plan for the elimination of its nuclear weapons. Even without such action by weapon states, the new treaty breaks fundamentally new ground on nuclear weapons in important ways. The treaty does not just say that a state cannot develop, test, produce or manufacture nuclear weapons. It says a state is not allowed to use or threaten to use nuclear weapons. It is a direct and unambiguous challenge to the doctrine of nuclear deterrence: a state cannot base its military and national security policy on the threat to use nuclear weapons. How the countries of the ban treaty and the nuclear-weapon states are going to resolve this fundamental challenge to nuclear doctrines is something that is going to be a critical part of a new and more contentious global nuclear politics for many years.[32]

A NARROW MARGIN OF HOPE

Despite the efforts of a previous generation of activists, scientists, and policy makers, the bomb and the system that makes it possible seem to be winning a new lease of life. The hopefulness at the end of the Cold War 30 years ago that nuclear weapons soon might be abolished has passed, and more recent prospects of progress on disarmament raised by President Obama in his speeches in Prague and in Hiroshima have dimmed.[33] Faced with this reality, what are physicists today to do, and what would Szilard do? Szilard's interventions have been described as "disruptive and creative" and in what follows I will look at four of Szilard's efforts that may be relevant today.[34]

I want first, however, to focus on Szilard's idea that faced with the world as it was he had to do something, whatever he could, without any guarantee of success. This is evident in Szilard's retrospective judgement that in the struggle against nuclear weapons "It is not necessary to succeed in order to persevere. As long as there is a margin of hope, however narrow, we have no choice but to base all our actions on that margin."[35] For Szilard, this determination to act and to persevere came from his sense of responsibility. This sense is on display in his famous short story written in 1947 "My Trial As a War Criminal" in which Szilard is charged with war crimes for his role in the Manhattan Project and the use of the bomb.[36] This impulse was recognized by Soviet physicist and dissident Andrei Sakharov, winner of the 1975 Nobel Peace Prize and the 1983 American Physical Society's Leo Szilard Award, when he spoke of Szilard's "innate, acute feeling of personal responsibility for the fate of mankind on our planet."[37]

I want to begin with one of Szilard's interventions before nuclear weapons. In the early 1930s, Japan was establishing a colonial empire in China. This included in January 1932 a Japanese attack on Shanghai that included aerial bombing.[38] The League of Nations, the forerunner to the United Nations, sought to intervene but the Japanese government resisted. Szilard took exception to this and together with several other young scientists prepared a draft statement that proposed a scientific boycott of Japan. Szilard explained in a letter that "a mere protest by scientists would not be of any great value, but a pledge on the part of leading scientists to initiate and maintain a scientific boycott of Japan might help raise the issue, both in the Japanese scientific community and in the international community that this is an injustice, that what Japan is doing in China is an obvious injustice, and we need

Physics and Society is the non-peer-reviewed quarterly newsletter of the Forum on Physics and Society, a division of the American Physical Society. It presents letters, commentary, book reviews and articles on the relations of physics and the physics community to government and society. It also carries news of the Forum and provides a medium for Forum members to exchange ideas. ***Opinions expressed are those of the authors alone and do not necessarily reflect the views of the APS or of the Forum. Articles are not peer reviewed.*** Contributed articles (up to 2500 words), letters (500 words), commentary (1000 words), reviews (1000 words) and brief news articles are welcome. Send them to the relevant editor by e-mail (preferred) or regular mail.

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to have it stopped."[39] In the letter, Szilard argued the boycott was a way to "keep up faith in the cause of justice" and he hoped "scientists in Japan will understand that there is no feeling against them" and see the boycott as encouragement to "undertake the difficult and ungrateful task of exerting their influence in favour of Japan's giving up any attempt at taking the law into its own hands."

Szilard's argument was that even if it does not have great effect in the short term, an organized collective intervention by physicists in the issues that play out in the world could serve to keep "faith in the cause of justice", even if these issues have nothing to do with science. Szilard's sense of responsibility meant throwing whatever political voice and weight he and other scientists had into the process of finding just solutions to the world's problems.

What are the injustices today where the scientific community could call for scientists to show that they have "faith in the cause of justice"? What is so obviously unjust that we should speak up and act? There are many issues. For physicists and scientists in many countries, Israel's occupation of Palestine is sufficient grounds for a boycott. Cosmologist Stephen Hawking, among others, participated in boycotting scientific activities in Israel because of the occupation.[40] But that is not the only injustice in the world. One question for us is to determine if today we even have the commitments and adequate mechanisms as a community to have the conversation about what we as physicists can and should be doing to keep "faith in the cause of justice" rather than focusing only on things that affect us directly.

The second lesson from Szilard that I want to highlight is about scientists taking responsibility for their work. After the first ideas about the nuclear chain reaction and fission started to emerge, Szilard tried to organize a "conspiracy of those scientists who work in this field" to prevent this new knowledge becoming public.[41] Szilard started lobbying the physicists working on these issues that he knew to not publish their work. Szilard, for instance, wrote a letter to Lord Rutherford in 1936 noting that he was worried about "nuclear chain reactions" and the possible "misuse of chain reactions ... if they could be brought about and become widely known in the next few years", explaining that "feeling that I must not publish anything which might spread information of this kind – however limited – indiscriminately, has so far prevented me from publishing anything on this subject."[42]

By February 1939, Szilard was writing more bluntly to Frédéric Joliot that the idea of "a sort of chain reaction … [that] .. might then lead to the construction of bombs which would be extremely dangerous" was being discussed by physicists among themselves and least so far "every individual exercised sufficient discretion to prevent leakage of these ideas into the newspapers", and proposing that "we should take action to prevent anything along this line from being published in scientific periodicals."[43] The effort eventually failed.

The idea of scientists taking responsibility by refusing to work on nuclear weapons has persisted, however. The Göttingen Manifesto of 1957 issued by a group of leading German scientists was a public declaration that none of them were prepared to participate in the creating, testing, or deployment of any type of nuclear weapon.[44] At the time, there was a debate about arming the German military with nuclear weapons. The scientists also declared that "we cannot remain silent on all political questions" and when it came to nuclear weapons they felt "responsible to inform the public about facts that every expert may know about, but the public not enough."[45]

This question has been raised more indirectly within the American Physical Society. In 1986 APS President Sidney Drell was reported to have "raised an interesting, delicate, surely controversial question: Should physicists - and other scientists - try to develop guidelines and appropriate procedures for encouraging self-restraint on the kind of applied research work they conduct when there are potentially harmful consequences of that work (to the environment, to individuals, to mankind)?"[46] The options for discussions included "Can one imagine a version of a "Hippocratic Oath" for research scientists?" The timing of this question was informed no doubt by the debate over President Reagan's Strategic Defense Initiative (SDI) program, commonly known as 'Star Wars', and the Cornell Pledge to not seek or accept funding to work on this program that already had been signed by over 5000 scientists and engineers.[47]

In 1995 on the 50th anniversary of the bombing of Hiroshima and Nagasaki, Nobel Laureate Hans Bethe, who had led the Theoretical Division at Los Alamos during the Manhattan Project, made a public statement in which he said, "I call on all scientists in all countries to cease and desist from work creating, developing, improving, and manufacturing nuclear weapons and other weapons of mass destruction."[48] This is an important call to individual scientists to not do nuclear weapons work, but as in earlier initiatives leaves hanging the larger question: as a community, what does our work make possible that is separate from our work as individuals? One question I would pose to us as a community is what can we do given that today we have a nuclear arms race taking off and nuclear weapons complexes are going out actively recruiting the next generation of young scientists? More simply, what can we do or should we do to prevent the next generation of nuclear weapons and the next generation of nuclear weapon scientists?

A third lesson from Szilard that I want to bring out concerns efforts to impact policy and decision making. Szilard was a great believer in educating and pressuring decision-makers. He wrote and sent an endless stream of letters to important people, including heads of state. He also produced lots of petitions, gathering other people to sign onto his view of looking at things or agreeing together with people to present options and possibilities, and to register public dissent.

Szilard famously was part of the group of Manhattan Project scientists led by James Franck in Chicago that produced the Franck report in 1945 about the future challenges of nuclear weapons.[49] In one section of their report, they raised the question of the possible use of nuclear weapons by the United States against Japan. This is one of the first discussions on the subject. The scientists said that the "the question of the use of the very first available atomic bombs in the Japanese war should be weighed very carefully, not only by military authority, but by the highest political leadership of this country". They argued on humanitarian grounds and prudential grounds against "the first introduction by our own country of such an indiscriminate method of wholesale destruction of civilian life." The United States should desist from dropping the bomb on Japan and they proposed instead that "a demonstration of the new weapon may best be made before the eyes of representatives of all United Nations, on the desert or a barren island." The idea was that Japanese leaders would see what a terrible thing this was and hopefully that might convince them to surrender. The scientists argued that if after such a demonstration and if the ultimatum to surrender failed, the weapon could be used against Japan only "if a sanction of the United Nations (and of the public opinion at home) could be obtained." In other words, it should not be the sole decision of the President and political and military leaders of the United States to decide to drop the atomic bomb. The use of nuclear weapons was something with such grave consequences for humanity that it had to be a decision taken by the world as a whole and by American people because they would carry the moral responsibility of this deed forever.

What would Szilard do now given that the first use of nuclear weapons is a core part of the policy of the United States and of some of the other nuclear-weapon states? One step might be to launch and lead a process within the physics community and the larger scientific community to challenge the possibility of first use of nuclear weapons and seek to end it by engaging with existing decision making processes, which in this case would be for instance the United States Congress. Szilard might well suggest a search for ways to participate in a more organized and collective way with Congress. In 1952, Szilard proposed a lobby for peace, given that industrialists have lobbies and unions have lobbies. There should be a peace lobby in Washington D.C. and a political action committee, whose job it would be to raise money and influence presidential elections. This came to pass in 1962, when Szilard helped found the Council for a Livable World, which still does this work in Washington D.C.[50] Szilard explained this decision to go from organizing scientists to intervening in election campaigns by saying that "I was led to conclude that the sweet voice of reason alone could not do the job, that campaign contributions could not do the job, but the combination of the sweet voice of reason and substantial campaign contributions might very well do the job."[51]

A fourth and last lesson that may be relevant today is that Szilard put great faith in the possibility that if you educate fellow citizens, they will rise to the challenge. In May 1946, Szilard proposed to Einstein that they found an Emergency Committee of the Atomic Scientists.[52] A small group of like-minded scientists was assembled.[53] The office came to be 90 Nassau Street, in Princeton, down the street from Princeton University's Program on Science and Global Security where I work.

Einstein signed and sent to physicists all over the world a fundraising letter, drafted by Szilard in part, asking for a million dollars for the Emergency Committee of the Atomic Scientists.[54] The letter explained the impulse, the ends and the means of this early scientist-led nuclear disarmament effort: "We scientists recognize our inescapable responsibility to carry to our fellow citizens an understanding of the simple facts of atomic energy and its implications for society. In this lies our only security and our only hope. We believe that an informed citizenry will act for life and not for death."[55] Einstein's letter was clear about where he and the other scientists saw Szilard's "margin for hope." Faced with the nuclear danger, the letter declared "there is no possibility of control except through the aroused understanding and insistence of the peoples of the world." The effort attracted a compelling public response.[56]

What would Szilard do, given where we are today? Likely, the advice would be to organize ourselves to act as a community that shows "faith in the cause of justice" in all its aspects in an unjust and violent world, play no part in enabling the renewed threat from nuclear weapons and in training the next generation of nuclear weaponeers, make our voices heard in democratic processes in every way, and reach out to people as fellow citizens and educate them about what it means to live in nuclear-armed world. With a narrow margin of hope, we can play our fullest part in finding ways to shape, choose, and implement policies to end the dangers that nuclear weapons pose to humankind.

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The Economic Value of a More Accurate Climate Observing System

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Climate change drives a wide range of current and future societal impacts that cross the spectrum of economic activities. Unfortunately, large uncertainty remains in key climate science questions that in turn drive uncertainty in cost/benefit analyses of societal mitigation and adaptation strategies. One of the largest of these factors is the uncertainty in climate sensitivity which remains a factor of 4 at 90% confidence level (IPCC, 2013). Climate sensitivity can be thought of as the volume dial on the climate system: it determines the amount of long term warming that will occur for a given level of radiative forcing from greenhouse gas increase. The amount of warming in turn drives a host of global and regional climate system changes including sea level rise, temperature and precipitation extremes, water resources, and ecosystems. Those climate system changes then drive economic impacts. While economic impacts of climate change including costs of mitigation and adaptation strategies have been studied extensively (e.g. IPCC Working Group II and III reports), little attention has been placed on the economic value of improved climate science. For science, business as usual means doing the best science for the usual societal investment in scientific research. In the U.S., federal government investment in climate science is ~ $2 Billion dollars/year, and has remained constant for the last 25 years when adjusted for inflation (see USGCRP annual reports). Yet the proper economic question to ask is "How much should society invest in climate research?" Such a question falls under the umbrella of research called "Value of Information" or VOI. We will summarize in this article the need for an improved climate observing system, as well as recently documented estimates of such an observing system's economic value and return on investment.

There are many observations that are used by climate scientists to determine climate change over decades and even centuries. Unfortunately, very few of them were designed with climate change observations in mind. A good example is our weather observing system: with typical temperature absolute accuracy of 0.3K, compared to the desired 0.03K for decadal climate change (NRC, 2015). For many if not most observations, climate change observations would typically require a factor of 5 to 10 more accuracy than weather or process observations including high accuracy traceability to international standards (e.g. SI standards maintained by the international metrology laboratories). A second challenge is that there are roughly 50 essential variables in the climate system (WMO GCOS, 2016) compared to 5 for weather prediction. This large difference is driven by the many complex systems that interact in determining the Earth's climate system and its impact on society. These include measures of the global atmosphere, ocean, cryosphere, biosphere (land and ocean), land use, land hydrology, chemistry, solar variability and geology including volcanism. Third, weather can be thought of as one small part of the climate system at a subset of climate time scales: those out to a few days as opposed to those including seasonal, annual, decadal, and even century time scales. As a result, climate system observations must deal with much greater complexity, at much higher accuracy, over much longer time scales than weather. The observations must maintain their accuracy and traceability to international standards over decades: times longer than the life of in-situ or even satellite based instrumentation, indeed longer than the length of a scientist's or engineer's career.

The challenge of such an observing system far exceeds typical scientific observing systems including those of weather, large particle physics experiments, or astronomy which are some of the largest current scientific endeavors. It is perhaps not surprising that we currently lack such a rigorous detailed and designed climate observing system. Instead we have a collage of weather, resources, and research observing systems that are cobbled together in a heroic effort to study climate change. In some cases like surface air temperature there are 7 different weather observing systems (surface sites, weather balloons, ocean buoys, ocean ships, aircraft, infrared satellite sounders, and microwave satellite sounders) allowing sufficient independence to verify, improve, and eliminate most artifacts that might confound climate change. But for most of the 50 essential climate variables there are at most 1 or 2 or none, leading to major challenges in detecting calibration drifts, changes in instrument design or sampling, or accurately crossing gaps in observations that may last several years.

There are many national and international documents that discuss the shortcomings in our current climate observations (Dowell et al. 2013; WMO GCOS, 2016; Weatherhead et al. 2017, NASEM, 2018, NRC 2015, Trenberth et al., 2013). But the bottom line remains that we lack a rigorous designed and maintained climate observing system. In the most recent U.S. National Academy Earth Science Decadal Survey (NASEM, 2018), an examination of over 30 quantified and prioritized climate science objectives shows that critical observations are missing for 80% of the "Most Important" climate science objectives, 71% of "Very Important" objectives, and 47% of "Important" objectives. Critical observations are missing for roughly 2/3 of all climate science objectives. See Chapter 9 and Appendix B and C of the report for details (NASEM, 2018).

How would one design a rigorous international climate observing system? Discussion of this topic can be found in recent Academy of Science reports: the "Continuity Report" (NRC, 2015), and the Earth Science Decadal Survey (NASEM, 2018). An overview of the topic is also discussed in a recent journal article in AGU Earth's Future (Weatherhead et al. 2017). We give a summary of key points in the list below.

- Use of quantified climate science objectives based on major national and international reviews and reports such as the IPCC and USGCRP reports. Examples would be to narrow the uncertainty in long term climate sensitivity or aerosol radiative forcing by a factor of 2. Or to reach a specific level of accuracy in the rate of global and regional sea level rise. See a wide range of examples in the 2018 Decadal Survey (chapter 9 and Appendix B of NASEM, 2018).
- Rigorous quantitative requirements for instrument accuracy, sampling accuracy, and remote sensing retrieval accuracy sufficient to eliminate large delays in quantifying climate change trends. Observing system lack of accuracy increases trend uncertainty beyond the minimum caused by climate system internal natural variability. This increase typically extends the time to detect climate change trends by decades. (NAS, 2015, Leroy et al. 2008, Wielicki et al. 2013, Trenberth et al 2013).
- Improved use of Observation System Simulation Experiments (OSSEs) to quantify the utility of a given observation to reduce scientific uncertainty in past and future climate change (NRC 2012, NASEM 2018, Weatherhead et al. 2017).
- Traceability of instrument observations to international (SI) standards to enable removal of calibration drifts and the ability to rigorously deal with data gaps. This is especially critical for space based observations which provide many of the global climate change data sets. (NRC 2007, NASEM, 2018)
- Provision of a much more complete set of climate system observations based on quantified climate science objectives, which currently suggest that critical observations are missing for 2/3 of all climate science objectives in the recent 2018 Decadal Survey report. GCOS implementation plans provide definition of the 50 essential climate variables (WMO GCOS, 2016).
- Follow existing GCOS observing principles (WMO GCOS, 2016)
- Provide independent observations of all essential climate variables (instruments, techniques, systems) to allow verification of climate system surprises after they occur.
- Provide independent analysis (methods, research groups) of all essential climate variables. Almost all computer code has errors, but independent development of analysis systems will have different errors, thereby allowing comparisons to discover and correct issues.

The above list indicates that major improvements are needed in climate system observations: both long term climate change and climate process observations. Some of the advances would simply require more rigorous processes than currently employed (independent analysis) while others would require improved global sampling, or design of instrumentation with more accurate traceability to international standards. In many cases more complete observations would require application of new technologies such as space based advanced lidar (wind profiles, aerosols, clouds, ocean phytoplankton), radar (rain, snowfall, convective vertical velocities) and radio occultation temperature profiles. New technologies for in-situ observations would also be key: such as adding chemistry measurements to deep ocean floats, and increasing the depths the floats reach.

How much would such an observing system cost? Adding independent observations, independent analysis, higher accuracy, and more complete observations might triple the cost of current global investments in climate research (observations, analysis, modeling, data storage/archive/distribution). Building a global climate observing system will also require increased investment in the data analysis, climate modeling, and data stewardship needed to benefit from such a system. The total of global climate research investments are currently estimated at $4 billion/yr, so that an additional $8 billion/yr might be required. The investment would be required for many decades (at least 30 years) because of the intrinsic long term nature of climate change itself. Once built, however, efficiencies of reproduction and scale might decrease costs over time for the basic instrumentation which is one of the largest costs.

Given that $8 billion/yr is a significant global investment, how could we estimate what the return on that investment might be? Four recent research papers (Cooke et al. 2014, 2016, 2019; Hope 2015) have estimated that economic value and concluded that through 2100 it ranges from $5 to $20 Trillion U.S. dollars. The cost of tripling the global investment in climate research (including development of the more rigorous climate observing system above) was estimated to provide a return on investment of roughly $50 per dollar invested (Cooke et al. 2014). All economic values are given in net present value using a discount rate of 3% (The nominal value from the U.S. Social Cost of Carbon Memo, 2010, hereafter SCCM2010).

As scientists, how do we understand such large economic value and return on investment estimates? We first need to consider some basic economic concepts. We begin by scaling the magnitude of global gross domestic product or "global economy" as roughly $85 Trillion U.S. dollars. Second, "business as usual" carbon dioxide emissions are predicted to cause climate damages in 2050 to 2100 that range from 0.5% to 5% of GDP annually (SCCM2010). Such damages would range from 400 billion to $4 Trillion per year. The large range is to first order because the uncertainty in climate sensitivity remains a factor of 4 at 90% confidence level (IPCC, 2013, SCCM2010). Climate sensitivity measures the amount of global temperature change per unit change in atmospheric carbon dioxide. A range of economic impact studies conclude that impacts rise roughly as the square of the amount of global temperature change (SCCM2010). The economic value of narrowing the uncertainty in critical issues like climate sensitivity as a result are very large (Cooke et al. 2014, 2016, 2019; Hope 2015).

Relating the economic value of benefits that return in the future to alternative investments that could be made requires the use of a concept called Discount Rate. All future benefits are discounted X% per year to account for the fact that most people would prefer to have money now vs the future, and to allow comparison of how the same funds could be invested in alternative investments, including those with short term goals. The nominal discount rate used for long term climate change is 3% (SCCM2010) but arguments have been made for both lower values at 1.5% (Stern, 2008), or higher values at 5%. Using the nominal 3% discount rate, an investment that pays back in 10 years is discounted by 1.03^10 or a factor of 1.3, 25 years by a factor of 2.1, 50 years by a factor of 4.4, and 100 years by a factor of 21. This makes it obvious that discount rate is very important to such calculations, and that paybacks 100 years in the future are negligible. For climate change returns on investment, discount rate is then used to derive the Net Present value by discounting any return by the number of years into the future that it will be realized. There is another way to think about discount rate and why 3% might be a reasonable value for global issues such as climate change. The growth rate of global GDP averages about 3% and has so for a long period of time. Therefore discounting at 3% per year also provides a reference to returns that are above those expected for global average GDP increase.

Now that we have a few basic concepts in mind, Figure 1 provides a schematic for the economic value of information (VOI) estimates in the Cooke et al. papers (2014, 2016, 2019). This figure shows the methodology for converting improved climate science knowledge into economic value. The blue boxes at left gives the baseline condition with Business as Usual greenhouse gas emissions (e.g. SCCM2010), which through climate sensitivity lead to the baseline amount of climate change, which in turn leads to the baseline amount of economic impacts. This is the state with no or modest societal action on climate change. Meanwhile society (and scientists) are looking through 3 fuzzy lenses at climate change: the first fuzzy lens is that of natural variability of the climate system such as swings between warm and cold phases of the ENSO cycle or the Arctic Oscillation or the Pacific Decadal Oscillation. All these are examples of internal variability of the climate system itself and represent noise that we must detect human climate signals against. Even a perfect observing system cannot eliminate this fuzzy lens. The second fuzzy lens is the fact that our climate observations are themselves inaccurate whether through calibration, sampling, or through weak relationships to the climate variable desired (e.g. indirect

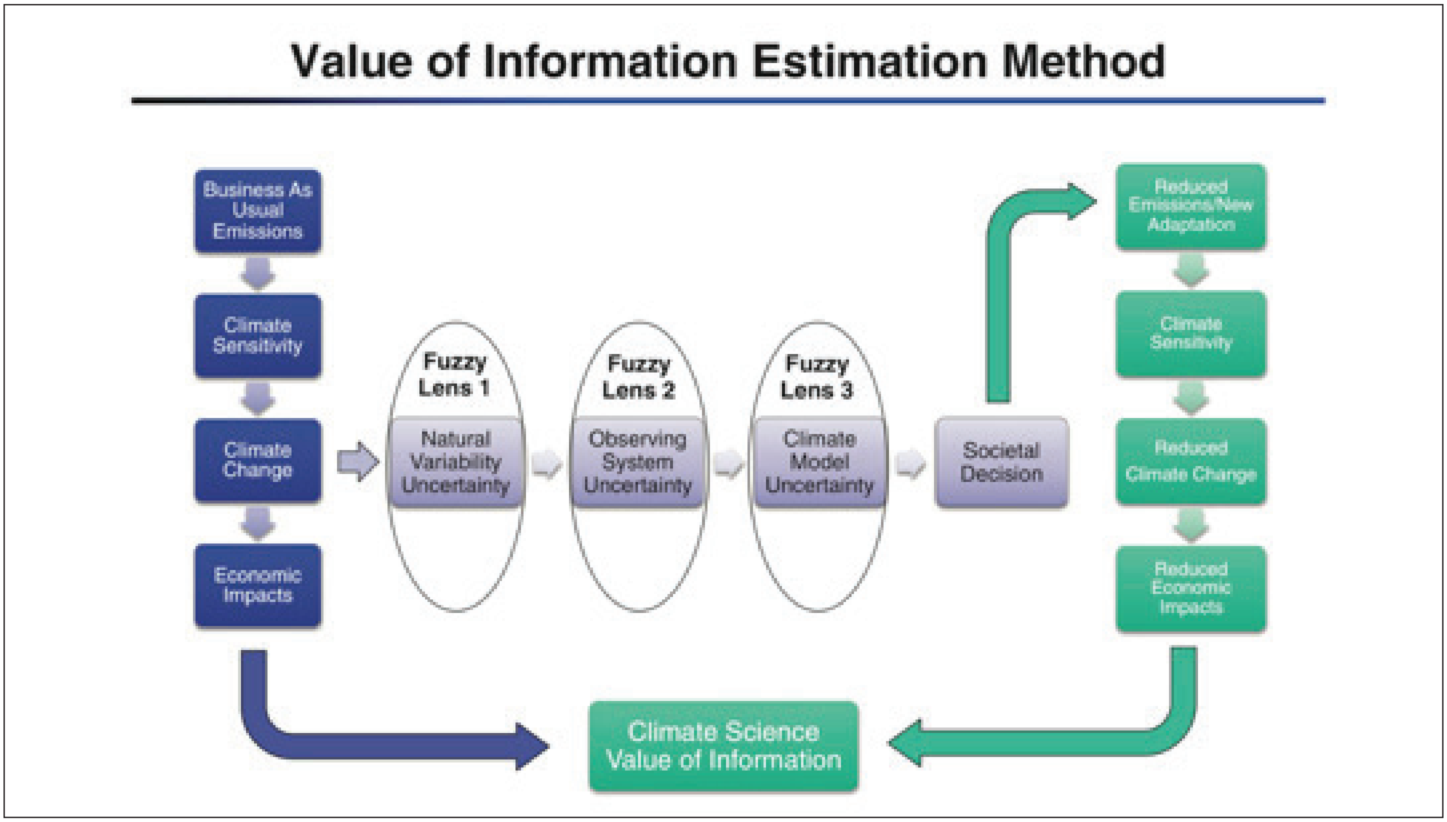

Figure 1. Schematic for estimating the economic value of improved climate change information (from Weatherhead et al. 2017).

proxy observations). When added to the fuzzy lens of natural variability, these observing system uncertainties can delay the time to detect climate trends by 5 to 50 years (Leroy et al. 2008, NRC, 2015, Wielicki et al. 2013). This large information time delay is the factor in societal decisions that improved accuracy in our climate observations can directly impact. The third fuzzy lens is that of climate model uncertainty. Climate models are used to predict the change that will occur under a range of proposed emissions scenarios (e.g. weak, moderate, or strong greenhouse gas emissions policies). But those models are imperfect and currently show a range of a factor of 4 uncertainty in climate sensitivity (IPCC, 2013). Improving the models requires both improved climate process observations for driving model uncertainties (e.g. aerosol forcings, cloud feedbacks, glacier melt) as well as improved long term decadal observations of climate change to verify model performance and uncertainties. As a result, this fuzzy lens can also be improved through a more rigorous climate observing system.

The key concept used in Figure 1 is that better observations, analysis, and modeling can shorten the time to reduce critical climate science uncertainties like climate sensitivity that are holding back improved societal decisions on balancing emissions reduction vs later climate change adaptation. The shortened time to reach a given level of confidence can be related to the amount of improvement in accuracy and quality of the observations of climate change for key elements such as cloud feedback (NRC, 2015; NASEM 2018; Wielicki et al. 2013). This shortened time to narrow uncertainty can in turn be used to relate changes in society decision points to change in emissions strategies. Once emission strategies are changed, then economic estimates of reduced economic impacts and costs of emissions reductions can be used to determine the Net Present Value of improved observations (Cooke et al. 2014, 2016, 2019).

While such studies cannot predict when society will make such decisions, they can compare the sensitivity of change in economic value if society requires more or less confidence in scientific predictions (e.g. 80% vs 90% vs 95%), requires lower or higher climate change signals to occur, changes which emissions reduction strategy is used (moderate or strong), which discount rate is used (2.5%, 3%, 5%), or even how soon such improved climate observations become available (5, 10, or 20 years). Sensitivity to how society makes the decision (moderate or high confidence, amount of signal, emissions reduction strategies) only varies the economic value by about 30% (Cooke et al. 2014). Discount rate variations can vary the economic value from $3 Trillion to $18 Trillion (Cooke et al. 2014). Changing when the more rigorous climate observations become available suggest that every year of delay costs society ~ $500 billion in lost investment opportunity, a figure 50 times the estimated cost of such observation improvements.

What are additional caveats on such an economic analysis in addition to those mentioned? There are uncertainties in the cost of climate change impacts from factors that were not included in the SCCM2010 analysis and would therefore increase the economic value: ocean acidification, international conflicts over resources and refugees, species loss, unexpected climate change accelerations such as arctic or sea bottom methane release, larger than IPCC estimated range of sea level rise. Uncertainties that could reduce the economic value would include unexpected rapid shift to greenhouse gas emissions well beyond the current Paris agreement (factor of 2 to 4 faster) or unexpected early technological breakthroughs in cost reduction of renewable energy and battery technologies (e.g. a sudden factor of 4 reduction in 2020). Such technology breakthroughs would be in excess of the existing rapid reductions underway in solar, wind, and battery technologies with learning rates of 15 to 25% cost reduction for every doubling of cumulative production.

How do such economic value estimates compare to weather prediction economic value? An estimate for the U.S. alone was given as $33 billion/year and ROI of 6:1 (Lazo, 2011). The global climate change observing system value discussed above provides an ROI that is roughly 10 times as large as the U.S. current weather prediction ROI.

In summary, we lack a designed, rigorous and complete global climate observing system. The cost of providing such a system might be an additional $8 Billion U.S. dollars per year in global climate research investment (tripling current levels). A new improved climate observing system could reduce uncertainties 15 to 30 years sooner than current observations. The total value to the world of such a system is estimated at between $5 and $20 Trillion dollars. Return on investment is estimated as 25 to 100:1. The return on investment is expected to exceed that for weather observations. Inflation adjusted U.S. investments in climate research have stagnated over the last 25 years, despite the large remaining uncertainties and their large potential economic impacts. Even very large uncertainty of a factor of 5 in economic value would not change the conclusion: ROI would in that case range from 10:1 to 250:1. The cost of delaying such a system is estimated at roughly $500 Billion/yr. A new global international climate observing system would be one of the most cost effective investments that society could make.

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Seizing German Science after the Second World War

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Following the Second World War, the Allied Powers attempted the largest-scale technology transfer in history, aiming to take "intellectual reparations" from occupied Germany. The most famous case is America's willingness to take in Werner von Braun and other German rocket scientists and physicians. Some of these physicians had been war criminals, experimenting on prisoners; the rocket scientists at minimum were willing to work in facilities staffed by enslaved laborers. In the rush to retain a monopoly on atomic weapons and gain every possible edge in a possible World War III against the Soviet Union, American policymakers pushed aside any moral qualms and hired anyone who might benefit others.

Less well known is that this story is just one facet of a much larger, international race for German science and technology of all kinds. In the wake of the war, the United States, France, United Kingdom, Soviet Union, and to some extent other nations sought out not just rockets and jet engines, but also toy manufacturing, watch design, precision optics, forestry, chemicals, audio equipment, automobile engines, and many, many more areas. It was not even limited to just industrial applications. These nations sought out academic scientists throughout Germany, first to interrogate them about any developments that took place during the war, then to decide whether it was worth the trouble to deny scientific manpower to other nations.

This hunt for intellectual reparations, which happened in different forms in each of the Allied nations as they both cooperated and competed, is the basis for *Taking Nazi Technology: Allied Exploitation of German Science after the Second World War,* recently published by the Johns Hopkins University Press. These efforts were massive. The American program screened about 3 billion pages of materials from German factories and research institutes, selecting tens of millions of pages to be processed into reports and sold to US (and international) purchasers. British authorities sent hundreds of investigators to Germany, France aggressively controlled German institutes in its occupation zone, and the Soviet Union famously mass-kidnapped hundreds of German technical personnel in one swoop.

While these programs were far-reaching and ambitious, however, they often ignored an idea J. Robert Oppenheimer summed up in an interview in 1948: "The best way to send information is to wrap it up in a person." Historian David Kaiser describes in *Drawing Theories Apart: The Dispersion of Feynman Diagrams in Postwar Physics* how in the Cold War era, physicists found it nearly impossible to figure out how to use Feynman diagrams unless they learned in-person from those who had themselves learned in-person. Articles were almost never enough.

Similarly, though the Allies had full control over occupied Germany, over and over again they found that reports and writings weren't enough. Science consists not just of data and numbers, but also intangible skills, experience, and relationships. Taking German technology successfully meant working closely with Germans over a sustained period. Meanwhile, this sustained contact led to business relationships benefitting both sides. America benefitted in areas it hired German scientists, but West Germany, too, rebounded into once again being an economic and scientific power within a decade of this great technology heist.

Another big lesson from the hunt for German science for today, then, might be that we should be less concerned about leaked USB data drives, and more concerned with building scientific and business relationships across national borders. This means exchanging scientific personnel from undergraduate students through top scholars, and thereby exchanging our technical know-how. Even in the era of McCarthyism, such scientific knowledge exchanges were important diplomatic tools, as Audra Wolfe's *Freedom's Laboratory: The Cold War Struggle for the Soul of Science* convincingly shows. Recent threats to slash education and scientific visas, and generally limit the movement of people across America's borders, in contrast, take all the wrong lessons from our history.

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Climate Change: On Media Perceptions and Misperceptions

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This essay claims that the media vastly overstates the risks of climate change. It has a mandate to report an unbiased view of issues, not just present a single view of an extraordinarily complicated scientific controversy, and pretend the other side does not exist, or is corrupt. They assert a single cause for the supposed crisis, excess CO_2 in the atmosphere caused by burning fossil fuel, something on which billions of people depend. They advance a single solution, stop using fossil fuel. But even if we do this, how sure can we be that the environmental effects will be beneficial? The earth's climate is extremely complicated and poorly understood, and is affected by many things besides CO_2. In fact, there is plenty of easily accessible contrary evidence. Furthermore, one does not have to be Sherlock Holmes to find it, all it takes is an Internet search. Dr. Watson is perfectly capable of performing it.

To see the mainstream media's obsession, *The Washington Post*, *New York Times*, ABC News and CBS News, all major media outlets have parts of their web site dedicated to environment and climate. Here are their web sites:

abcnews.go.com/alerts/climate-change

nytimes.com/section/climate

washingtonpost.com/climate-environment/?utm_term=.f78f7f783bb6

cbsnews.com/climate-change/

On Mar 31, 2019, I scanned about the top 40 on each web site (the entries change constantly), well over hundred entries. On the first 3, there was no entry expressing even the slightest doubt about the coming catastrophe. It was a gigantic parade of Chicken Littles. CBS did have a single entry, which expressed doubt; it concerned a glacier in Greenland that everyone thought was receding, but turns out to be growing; cbsnews.com/news/glacier-growing-melting-jakobshavn-glacier-in-greenland-is-growing-again-a-new-nasa-study-finds/

Actually most glaciers have been receding for ~200 years, for most of that time, excess CO_2 played **NO** role, i.e. there was no excess CO_2.

I give special attention to NBC News. In addition to their web site expressing absolutely no doubt, Meet The Press on December 30 2018, had a special edition on climate change. As Chuck Todd, the host, said:

"We're not going to debate climate change, the existence of it. The Earth is getting hotter. And human activity is a major cause, period. We're not going to give time to climate deniers. The science is settled, even if political opinion is not."

In fact, the science is **not** settled; it is a legitimate and very complicated scientific controversy. CO_2 is one of many, many factors affecting climate.

This essay will point out just a tiny part of the voluminous data, which does not support the theory that climate change is a fast approaching CO_2 caused disaster. Some of the data presented here does indicate climate change; most does not. Even for supporting data, it is not easy to tell if the evidence for climate change is real, or is just a statistical fluctuation. For the most part I let the data speak for itself with minimal explanation or interpretation.

To start, let us look at the most fundamental quantity, the temperature data. Figure 1 shows a NOAA plot.

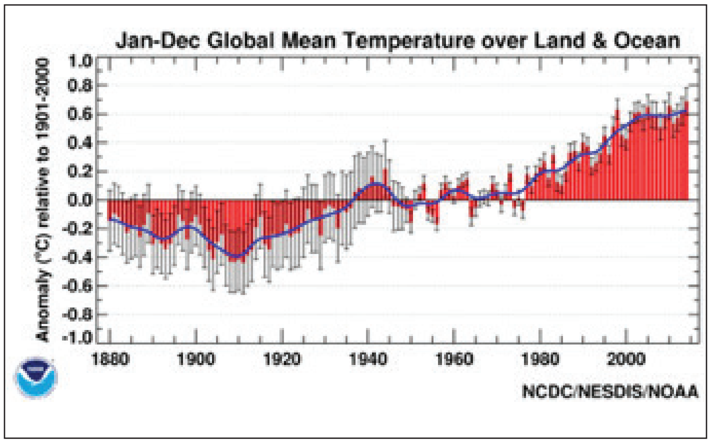


Fig 1: NOAA temperature data 1880-2019

Figure [1] does show significant warming of about 0.6° C from about 1970 to 2000, but on the other hand, the warming plateaued for ~ 20 years after that, even though CO_2 continued to be added to the atmosphere. It seems as though the longer the temperature stays roughly constant, the more hysterical become the claims that there is an existential threat. Now many politicians and media personalities are advancing the Green New Deal. Its presumed window is 12 (or maybe 10) years before the world is destroyed. The only hope is to end all fossil fuel by then, impoverishing billions. In the July 31 Democratic presidential debate, several candidates enthusiastically espoused this. However, the graph also shows an increase of about 0.5° from 1910 to 1940. Assuming the same atmospheric processes were at work during both 30-year time periods, this would argue that added CO_2 was responsible for at most a small portion of the temperature rise of the more recent temperature increase. The media ignores this undeniable fact.

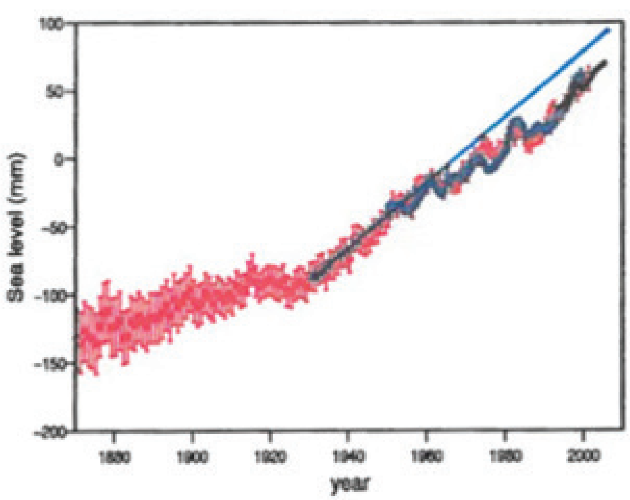
None other than the head of the UN declared we must keep the temperature rise from preindustrial conditions less than 1.5° C [1] (just under the temperature difference between New York City and Boston).In other words, billions of people should drastically reduce their life style because some theory predicts calamity with a 1.5° rise. However, as Fig 1 shows, there has already been a 1° rise. But now every measure of human wellbeing, longevity, health, wealth, education, environment, …. is much improved from 1910 when it was 1° cooler. I would think that if a 1.5° rise would produce calamity, the 1° rise we have experienced already would show sure indications of it. The media ignores this obvious fact.

Another thing the mainstream media emphasizes is that sea levels are rising rapidly because of added CO_2 in the atmosphere, perhaps 10 feet by 2100 [2].

Chris Mooney of the *Washington Post* [3] puts even this to shame, he suggests as much as a 30-foot rise in the next century!

To get some perspective, note that when the glaciers melted after the last ice age, the oceans rose about 1 meter per century for about 10,000 years (~100 meter total rise). However, Ref [2] speaks of ~ 3 meters per century, 3 times the rate of rise as when the glaciers were melting, and Ref [3] speaks of ten times that rise; all because of a small increase of a trace gas in our atmosphere. Not only is a catastrophic rise potentially inevitable according to the *Washington Post*, but like King Canute, we have the power to command it to stop, because the cause is clear and unambiguous, additional CO_2 in the atmosphere [4]. All we have to do is stop using fossil fuels; what could be easier?

In any case, let us look at a graph of sea level rise. Fig [2] is an often-quoted one from IPCC.



ipcc.ch/publications_and_data/ar4/wg1/en/figure-5-13.html

Figure 2: A plot of sea level rise from 1880 to about 2010. Notice that before about 1920, the ocean hardly rose. Then it started to rise rather rapidly to about 20-25 cm per century. Also on the figure is a straight line drawn by the author through the curve from 1925 to 1960. Notice, that after 1960, just when the effect of excess CO_2 would begin to be felt, the ocean rise began to ***decrease****.*

Perhaps by 2100, the ice caps will all melt, as many speculate now, on the basis of various theoretical models. However at least up to now, there is no sign of such an impending calamity in the actual data. But the mainstream media seems oblivious to current data, it focuses only on what might or might not be 30, 80 or even 180 years from now years from now.

In any case, how valid are the theoretical models? James Hansen in 1988 predicted much greater warming today than is actually measured. Anthony Watts plotted Hansen's 1988 calculated predictions of temperature rise as a function of year for various assumptions of CO_2 input into the atmosphere [5]. His calculations are shown in Fig. 3a, and beneath it, explaining it, is the caption by Anthony Watts. He also plotted the actual temperature rise. Considering the actual rate of CO_2 increase in the atmosphere, the actual temperature increase (the black curve) should have been well above his maximum estimate (the blue curve).

John Christy, one of the heads of the space based earth measurements laboratory at the University of Alabama Huntsville presented testimony to congress [6] pointing out that the theoretical models have greatly overestimated the actual heating. Below as Fig. 3b, is one of the graphs he presented, along with his caption. Note that the computer models are not making random errors, if they were there would be many that under predicted the temperature rise. Since all, except the Russian model, greatly over predict the temperature rise, it is difficult to escape the conclusion that biases are built into the models. The media has little if anything to say on how disastrously wrong these earlier theories were in predicting today's reality.

Now let us focus on hurricanes. The 2018 hurricane season had hurricanes doing significant damage to Houston and the Florida Pan Handle. Many commentators, including Eugene Robinson in the *Washington Post* [7] blamed it on CO_2 induced climate change. However there always were, and

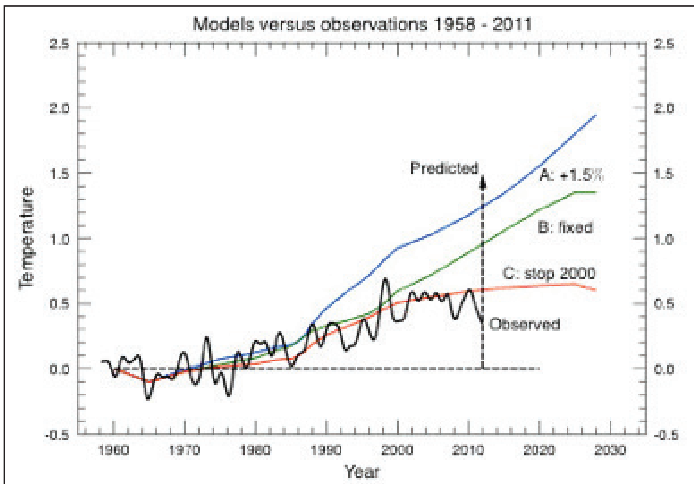


Figure 3a. Temperature forecast Hansen's group from the year 1988. The various scenarios are 1.5% CO_2 increase (blue), constant increase in CO_2 emissions (green) and stagnant CO_2 emissions (red). In reality, the increase in CO_2 emissions by as much as 2.5%, which would correspond to the scenario above the blue curve. The black curve is the ultimate real-measured temperature (rolling 5-year average). Hansen's model overestimates the temperature by 1.9 ° C, which is a whopping 150% wrong.

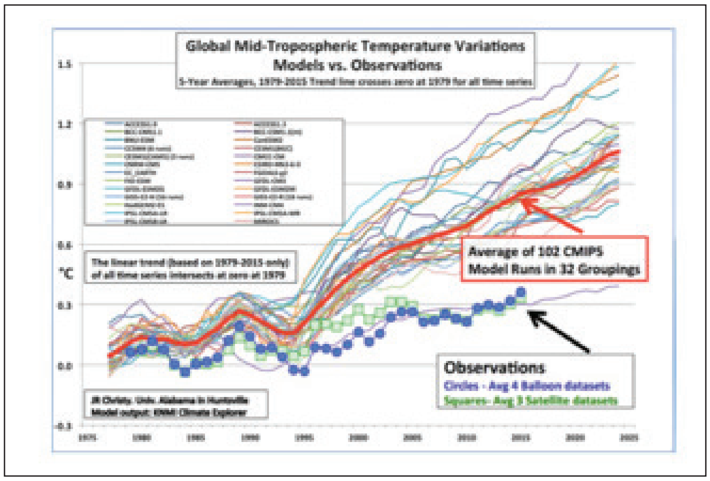


Figure 3b: Global average mid-troposheric temperature variations (5-year averages) for 32 models (lines) representing 102 individual simulations. Circle (balloons) and squares (satellites) depict the observations. The Russian model (INM-CM4) was the only model close to the observations.

always will be extreme weather events; that is the way the earth does its business. Figure [4] is a plot of hurricanes by decade from the National Hurricane Center, a part of NOAA and the National Weather Service.

It is difficult to conclude from Fig 4, that hurricanes now are the result of excess CO_2 in the atmosphere, yet that is exactly what the media does; it ignores the NOAA data.

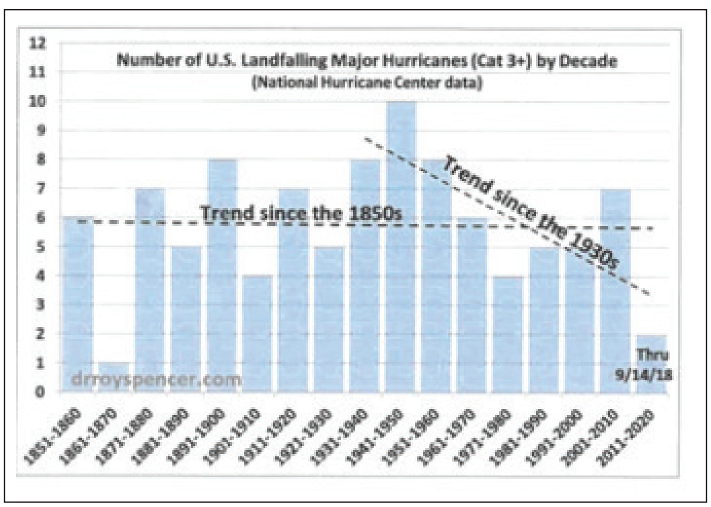


Figure 4: A graph of number of hurricanes Cat 3 and above making landfall in the USA as compiled by the National Hurricane Center. Clearly the worst decade is not the present one, but the 1950's; and then the 1940's and 1960's. After this, there seems to be a decrease in the number of hurricanes making landfall.

Some claim hurricanes are getting more intense and destructive. But, as more people move to coastal regions, the hurricane damage will inevitably increase. However intense storms go way back. The most damaging storm to the United States was not one of the recent ones, but the terrible hurricane that hit Galveston, TX in 1900, 60 years before excess CO_2 began to have any impact on the atmosphere. In that hurricane, thousands died, and the city was totally destroyed. Figure 5 is a photo of Galveston right after the hurricane hit.

What about tornadoes? USA Today reported [8] that they have gotten worse with all the extra atmospheric CO_2. While there has been a slight increase in the number of tornadoes, there has been a slight decrease in the number of extremely violent tornadoes, category, F3 and above. Figure 6 is a plot, year by year of violent tornadoes taken from NOAA data. Again, the media ignores this.

Figure 5: A photo of Galveston after the 1900 hurricane, from history.com.

Now look at droughts. Every time California has one of its severe droughts, we hear the TV newsmen and even the *New York Times* [9] say that this is all caused by excess CO_2. However, Figure 7 shows the Palmer drought index from 1890 to the present.

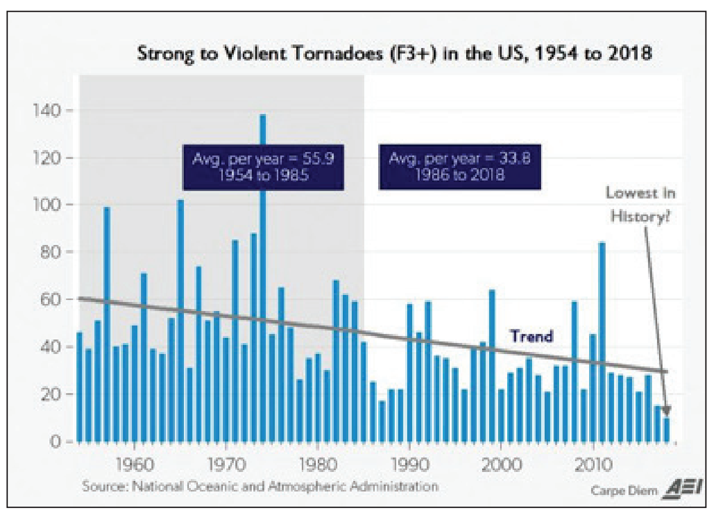


Figure 6: A plot of the number of strong to violent tornados (F3 and above) year by year from 1954 to 2014. Clearly there is no correlation with an increase of CO_2 in the atmosphere; in fact if anything the number of these storms seem to be slightly decreasing with increasing atmospheric CO_2.

Clearly no recent drought even comes close to the to the drought of the dust bowl in the mid 1930's. There is certainly no increase in either the frequency or intensity corresponding with the increase of atmospheric CO_2. In fact, Fig. 7 shows that over the past 20 years, the tendency for either flooding of drought has greatly decreased, just as it did in the 20 years between 1910 and 1930, i.e right before the dust bowl. Perhaps this current pause is a harbinger of a new season of floods or droughts as it was in 1930.

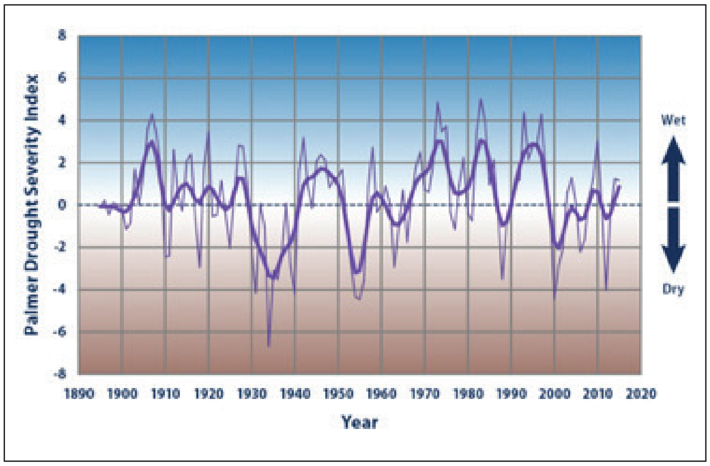


Figure 7: This chart shows annual values of the Palmer Drought Severity Index, averaged over the entire area of the contiguous 48 states. Positive values represent wetter-than-average conditions, while negative values represent drier-than-average conditions. A value between -2 and -3 indicates moderate drought, -3 to -4 is severe drought, and -4 or below indicates extreme drought. The thicker line is a nine year weighted average. Data source: NOAA, 2016 [5] *Web update: August 2016*

Regarding agriculture, here is Marcia McNutt, the editor of *Science* [10]:

"But now with climate change, we face a slowly escalating but long-enduring global threat to food supplies, health, ecosystem services, and the general viability of the planet to support a population of more than 7 billion people.

The time for debate has ended. Action is urgently needed. (we must) set more aggressive targets, developed nations need to reduce their per-capita fossil fuel emissions even further..."

Naturally it is intimidating to contradict Dr. McNutt, but information contradicting her abounds on the Internet. Simply type in 'graph of agricultural productivity' on your search engine, and many graphs will pop up, all saying the same thing, namely that agricultural productivity is uniformly increasing throughout the world. Figure [8] shows a typical example:

If there is to be any threat to agriculture, there is no sign of it at this point. It is very likely that one reason for this increase in agricultural productivity is the increasing CO_2 in the atmosphere. Carbon dioxide is an important nutrient for plants [11]. The media ignores all of this.

The Polar Regions are particularly timely, as the week this is being written, April 1-5, 2019, Al Roker, for the Today Show was in Alaska discussing climate change. The entire

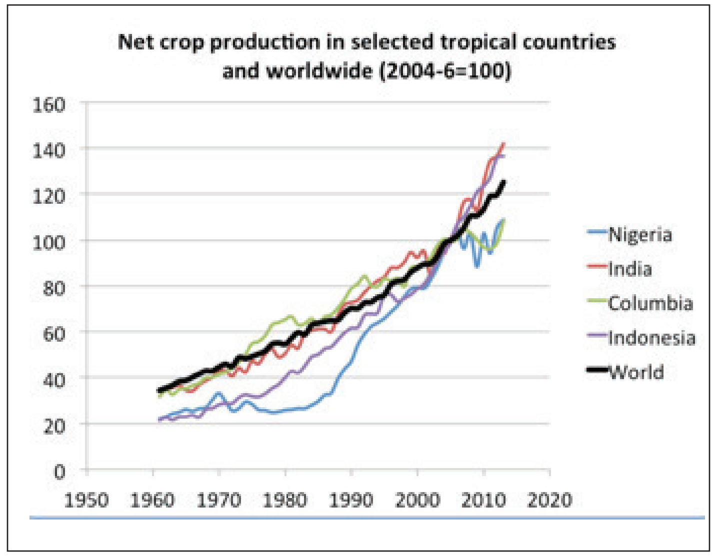


Figure 8: A plot of net crop production in selected tropical countries and the world as a whole. Notice that there is a steadily increasing production, with no sign of any 'slowly escalating but long-enduring global threat to food supplies'.

emphasis of the series was on how climate change is occurring there right now and is having a major effect adverse on life there. Figure 9 is a picture of Mr. Roker there, discussing a scientific measuring tool with one of the scientists there.

Of course, the assumption underlying the series, without the slightest doubt, is that climate change is real, serious, is caused by excess atmospheric CO_2. It is an imminent threat to civilization. It mentioned that recently Alaska has warmed up considerably, meaning (they claim) that the polar regions are where climate change is really beginning; it is occurring there right now, and will soon move to the mid latitude and tropical regions.

Figure 10 is a graph, year by year of average temperature over all Alaska, taken from the measurements of NOAA, Alaska division:

Figure 9: Al Roker (right) in Alaska, on the shore of the Arctic Ocean, interviewing one of the scientists there doing measurements of the Alaskan environment.

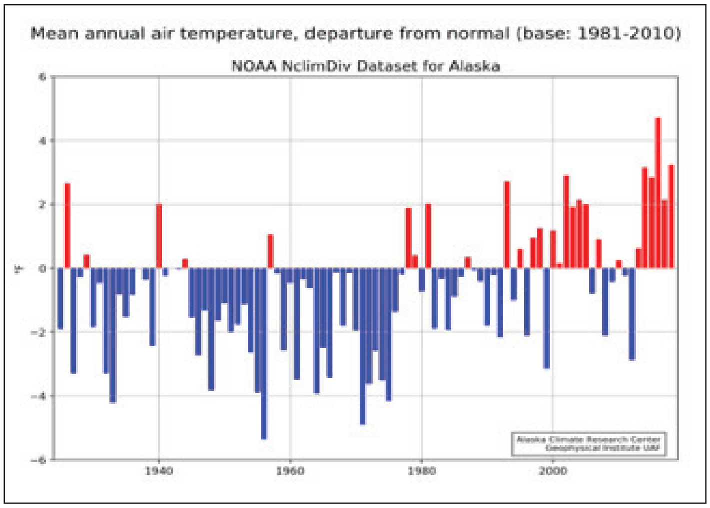


Figure 10: The temperature in Alaska from 1920 to the present taken from NOAA measurements.

Notice that, as the Today Show asserts, there has indeed been a significant warm up over the past 5 years. Perhaps this is a harbinger of climate change, or perhaps just a normal fluctuation. The graph shows a statistically much more significant cooling trend from 1960 to 1980. The Today Show ignored this.

To obtain further insight it is helpful to look into what is happening in the entire northern polar region, not just Alaska. The other parts of the region are the Arctic Ocean and Siberia. The information for these regions is also available [12].The Arctic Ocean is warming some, but Siberia is cooling very significantly. Figure 11 shows a picture of the Siberian City of Yakuskt in January, 2018. The temperature at the time the photo was taken was a relatively normal value, i.e. about -60^o degrees!

Figure 11: Yakutusk, Siberia in January, 2018, when the temperature was less than 60 degrees below zero.

So let's summarize the situation; Alaska and the northern ocean is getting warmer, and Siberia is getting considerably colder. Figure 12 shows polar orbiting satellite measurements over both the northern and southern Polar Regions.

As Figure 12 shows, there has been a slightly increasing temperature in the Northern polar region for about the last 25 years, after about a 15-year period of a slightly decreasing temperature. In any case, the warming is much more gradual than the Today Show indicated. Also, it is worth noting that in the southern Polar Regions, the temperature has been about constant; possibly one could even see a very slight temperature decrease there. Again, the media ignores this undeniable, easily obtainable data.

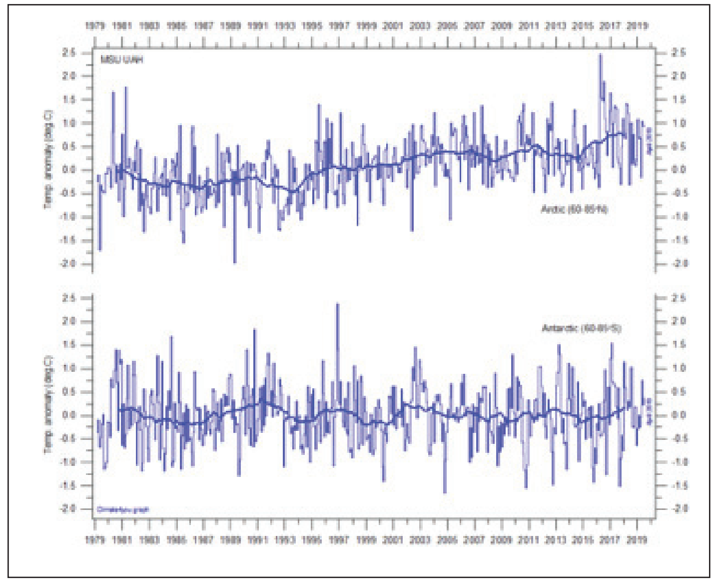


Figure 12: Global monthly average lower troposphere temperature since 1979 for the North Pole and South Pole regions, based on satellite observations (University of Alabama at Huntsville, USA). This graph uses data obtained by the National Oceanographic and Atmospheric Administration (NOAA) TIROS-N satellite, interpreted by Dr. Roy Spencer and Dr. John Christy, both at Global Hydrology and Climate Center, University of Alabama at Huntsville, USA. Thick lines are the simple running 37 month average, nearly corresponding to a running 3 yr average.

So let's see where we are. The temperature measurements do show a slight warming, and this *may* have been caused in part by excess CO_2 in the atmosphere. It is no simple matter to separate the CO_2 cause from other natural causes for the warming. The other figures of merit presented here, which the media focuses on, fail to show *any* evidence of destructive climate change.

The author hopes this essay will play some small role to inspire the media to consider the climate change dilemma more responsibly. They should look at actual data, compare yesterday's predictions to today's reality, and to view climate change alarmists with at least as much suspicion as they view the skeptics. They should recognize and focus on the enormous reduction in life style they are insisting on, for billions of people; a life style change that should not be undertaken without very, very, very convincing evidence of the necessity for doing so. In this author's opinion, the present climate evidence, and the present theoretical understanding of it, does not nearly argue for undertaking such a change.

Acknowledgement: This work was not sponsored by any organization, public or private

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The End of Ice: Bearing Witness and Finding Meaning in the Path of Climate Disruption

Dahr Jamail (New Press, New York, 2019) 257 pp. $25.99. ISBN 978-1-62097-234-2.

A reporter for *Truthout* and author of several books based on his reporting, Dahr Jamail writes in his introduction that he first saw "anthropogenic climate disruption" from glacial reduction in successive years of mountain climbing in Alaska. Following his reporting on climate and environment in 2010 (beginning with the BP oil spill), he sought to share what he found in other climate-sensitive areas of the world and came "to realize that only by sharing an intimacy with these places can we begin to know, perhaps love, and certainly care for them."

In 2016 and 2017 he visited several places in Alaska, Mount Rainier, Glacier National Park, three coral reefs (Palau, Guam, Australia), Florida, US temperate forests, and Brazil's rain forest. Everywhere, he interviewed local experts who pointed out consequences of a warming climate. In his own mountain climbing, he could see the differences for himself by comparison with his previous experiences.

In Alaska and the Pacific Northwest Jamail found reduced snow cover and vanishing glaciers which in turn endanger the 69% of the world's fresh water they contain. For Alaskan native tribes such changes mean a change in their traditions and the way they live their lives. But there are consequences for the rest of the world as well. Jamail reports on Ira Leifer's research that tracks Arctic warming from currents in seas adjoining the Arctic Ocean, some of which contain methane bubbling up from the ocean floor. These releases are believed to carry a potential fifty gigatons of methane, which would have the equivalent effect of a thousand gigatons of carbon dioxide--two thirds of the 1475 gigatons of carbon dioxide released by humans since 1850. Leifer feels that release of this methane into the atmosphere is inevitable and that "there is no reason the global climate couldn't push past tipping points that mean only 1 billion people can live on the planet."

Jamail's visits to coral reefs, which "cover less than 2 percent of Earth's ocean floor yet are home to one quarter of all marine species," and to western temperate forests offer no compensating encouragement. He laments that oceans are treated as dumps, because people can't see below the water. He feels that if they could see what happens to reefs the same as they can see what happens to a forest, they would show greater concern. Not that he finds much concern about "drought, clear-cutting, deforestation, wildfires, beetle infestation" endangering forests, with the world's dead trees contributing 20% of global carbon dioxide emissions. In several chapters Jamail expresses his emotional reaction to what he is learning.

Jamail also received some emotional reaction when he visited Thomas Lovejoy in the Amazon rain forest. This forest contains 20% of the world's rivers, untold numbers of yet-to-be-discovered species, and the bases of many pharmaceuticals. Having worked there since 1965, Lovejoy predicts that the 2°C global temperature increase above pre-industrial levels sought by the Paris Accord (we are at 1.2°C now) will raise sea levels 4 to 6 meters and destroy much of the coral.

The additional temperature increases resulting from Arctic methane release to the atmosphere is one of the book's most dire consequences of climate change. Another is the sea level rise cited by Lovejoy during Jamail's visit to Florida, where climate change threatens sea level rises up to a foot by 2030, three feet by 2050, and eight feet by 2100. There Jamail found Ben Kirtman of the University of Miami acknowledging the need for *adaptation* in addition to *mitigation* against rising sea level. In Miami this means keeping freshwater systems free of contamination by sea water. Already high ocean tide in Florida covers fresh water drain pipes and causes sewage to back up. This is decreasing real estate values and increasing insurance rates. Yet construction continues with, for example, 230 new condos in 2018. Bruce Mowry, city engineer of Miami Beach, is dealing with "sunny-day flooding" with some 60 pump stations, raising city streets 30 inches, and requiring single family homes to be at base flood elevation. South Miami Mayor Philip Stoddard (who is also a biology professor at Florida International University) grieves that climate change-denying Governor Rick Scott vetoed sewers for the two thirds of South Miami still on septic tanks which are backing raw sewage into bathtubs. At the bottom of the political hierarchy, he feels alone in what he knows and is regarded as a Cassandra speaking amid the culture of denial which surrounds him.

Harold Wanless, Geology Chair at the University of Miami, criticizes the Intergovernmental Panel on Climate Change for underestimating the effects of climate change because they use only peer-reviewed materials published more than three years previously and need to come to a consensus based on them. With only 44% of Miami-Dade County higher than six feet above sea level, Wanless realizes that not all of south Florida can be protected against expected sea-level rise. In addition to affecting Florida, projected sea level rise will be disastrous for Vietnam, Bangladesh (where India maintains a barrier against future refugees), Lower Manhattan, and many islands.

Although many of the changes that Jamail describes are now part of our daily news, it is even more sobering to encounter them all together in one book, and described by the experts who have been keeping track of them. The situation he describes is a source of frustration for Jamail. He cites articles recalling that in 1965 President Lyndon Johnson was warned of the risks of increased carbon dioxide emissions, and that a 2°C temperature increase above pre-industrial levels would reduce the Amazon rainforest by 40%. He sees the Paris Accord as "just the latest instance of governments failing to respond to the fact that we are dealing with the single largest existential crisis humanity has ever faced."

It should then come as no surprise that at the end of his book Jamail returns to his beloved Denali to compose a very personal conclusion from what he has learned and shared with his readers. He recalls how the ill effects of cockiness in his first attempt to ascend Aconcagua, the highest mountain in the Western Hemisphere, taught him the importance of respect for nature, the lack of which he feels "is leading us to our own destruction." "By desecrating the biosphere . . . we are setting ourselves up for what I believe will ultimately be our own extinction," he writes. "This is the direct result of our inability to understand our part in the natural world. We live in a world where we are acidifying the oceans, where there will be few places cold enough to support year-round ice, where all the current coastlines will be underwater, and where droughts, wildfires, floods, storms, and extreme weather are already becoming the new normal. ...There is no removing the heat we have introduced into the oceans, nor the 40 billion tons of carbon dioxide we pump into the atmosphere every single year. There may be no changing what is happening, and far worse things are coming."

Writing this reflects Jamail's feelings for a planet that he feels is dying. He quotes Stephen Jenkinson that the appropriate response is grief rather than its "great enemy" hope. Grief, to him, is "a way to honor what we are losing. ...Writing this book is my attempt to bear witness to what we have done to the Earth. I want to make my own amends to the Earth in the precious time we have left. . . .," he writes. "Each of us must now find our own honest, natural response to the conditions we have brought upon ourselves." He lauds those who have devoted their lives to protecting the part of Earth closest to their hearts, with a sense of *obligation* rather than a sense of *right*. Jamail finds his "deepest conviction and connection to the Earth by communing with the mountains."

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Surviving Global Warming: Why Eliminating Greenhouse Gases Isn't Enough

Roger A. Sedjo, Prometheus Books, ISBN 9781633885288, hardcover $24, 245 pages.

Climate change and global warming remain controversial topics in fewer and fewer circles, but President Trump's policies are minimizing action to combat it which is one of the reasons this book is topical. The current amount of CO_2 in the atmosphere of 410 ppm is the highest in over 800,000 years and is largely driven by increased burning fossil fuels since the beginning of the industrial age. The recent meeting of the working group of the UN International Panel on Climate Change (IPCC) concluded that the nations of the world are not meeting their goals to address reductions in greenhouse gas (GHG) emissions. The author, a contributing member of the IPCC, has the credentials to evaluate how to address the impacts of global warming. However, the book gives the impression that his idea of adaptation to climate change in addition to mitigation of GHG emissions is a new one, when in fact adaptation is in the Paris Agreement. Nevertheless, the focus on the adaptation part of that agreement is welcome as it has had much less publicity than mitigation. The book's discussion of the many issues that face the nations of the world in response to a changing climate demonstrate the importance of the Paris Agreement.

Well before humankind had a chance to have a major impact on the climate by emitting large amounts of GHGs (especially CO_2) into the atmosphere, Earth had major warm and cold periods. The large long term (tens of thousands of years) cycles of ice ages and warmer periods are driven largely by changes of Earth's orbit and orientation to the sun. Shorter, far less extreme periods of cooling or warming are believed to have been driven largely by changes in solar radiance. These natural (non-human caused) impacts cannot be ignored and the author concludes that reducing GHG emissions are a necessary but not sufficient action to prevent major global warming. He notes the IPCC has stated that human caused global warming accounts for something over half of the recent temperature rise and expresses doubts that the pledges to reduce GHG emissions will be met.

Following a description of the history and current drivers of global warming the book turns to actions to address this problem with what the author calls Plan A and Plan B. Plan A focuses on mitigation of CO_2 emission (which he calls the Gore plan) using a variety of methods, but largely through switching to renewable sources of energy. Making mitigation more difficult is that China (the #1 emitter) and India, in particular, have been focusing on increasing their economic development so their GHG emissions have been growing rapidly. In contrast the U.S. and EU have actually been able to reduce their emissions in recent years. One of the first mitigation steps to take is replacing the use of coal by natural gas, which emits half as much CO_2 per joule of produced energy. GHG-emissions-free sources of energy, which have grown recently, come with their own issues such as the intermittency of wind and solar, and long-term waste and safety concern issues with nuclear. He notes that Germany has increased both solar and wind power while eliminating nuclear power, but has actually increased its emissions. This is because the needed backup power required when the intermittent sources are not producing is now coal, a major GHG emitter.

Even if the world meets its Paris Agreement mitigation targets, the author does not believe it will be sufficient to keep the temperature rise to the Paris target of 2 deg C by 2100. His Plan B adds adaptation to mitigation, which essentially amounts to the Paris Agreement. Actions will be needed to address impacts such as sea level rise, loss of habitat, increases of extreme weather and concern about food production. Sedjo describes examples of specific impacts in several U.S. locations and actions that to minimize impacts of global warming, including construction of sea walls such as have been used in the Netherlands for 50 years. Agricultural impacts may require planting different crops and changing tree types in forests. He notes that protective actions may be necessary, but could also be viewed as welcome insurance even if the temperature is held to moderate levels.

New technology will need to be part of the adaptation solution. Options such as carbon capture and sequestration, and geo-engineering, will require considerable research and development. Carbon capture and sequestration would capture CO_2 before it reached the atmosphere and store it underground, while geoengineering could include changes to the reflectivity of Earth or introducing aerosols into the atmosphere the amount of solar radiation reaching the surface. But geo-engineering brings concerns about unintended consequences. One social barrier to some actions will be the reticence of people to adapt. For example, economic concerns such as the loss of house value, or the loss of the house itself, when families must move away from a shoreline. Solutions to such issues will involve politics. It's a difficult problem, especially since it is global. The Montreal Protocol that addressed the emission of chloro-fluoro-carbons which were depleting atmospheric ozone has been successful, but addressing global warming is and will continue to be more complex. A carbon tax is currently being used in some countries as a stimulus to get people to reduce carbon emissions but is a hard sell in many parts of the world.

The topic of addressing global warming is certainly relevant, but I would have preferred that the book explained issues such as the Paris Agreement plan, rather than suggesting that the author was proposing something new. Additional editing would have been beneficial as there was some repetition, but the book is nevertheless a relevant discussion of a global problem.