Exhibit A

Declaration of Dr. James E. Hansen in Support of Our Children's Trust et al.'s Submission to the UN Committee on the Rights of the Child Regarding State Obligations, Children's Rights and Climate Change

I, DR. JAMES E. HANSEN, hereby declare as follows:

1. I make and offer this declaration as an expert in the field of climate science.

2. I am a U.S. citizen, an Adjunct Professor at Columbia University's Earth Institute, and Director of the Climate Science, Awareness and Solutions program at the Earth Institute, Columbia University. I am also the immediate past Director of the NASA Goddard Institute for Space Studies and a member of the United States National Academy of Sciences.

I have testified before the United States Senate and House of Representatives on many occasions, and in court on several occasions, in support of efforts to reduce reliance on carbon-intense energy from fossil fuels and rapidly transition to carbon-free energy.

3. My training is in physics and astronomy, with early research on the clouds of Venus. Since the late 1970s, I have focused my research on Earth's climate, especially human-made climate change. Most recently, I have dedicated significant effort towards outlining the actions that must be undertaken by communities, governments around the world, the international community, and others, in order to preserve a viable climate system for young people, future generations, and other life on Earth. For the Committee's more complete reference, I have attached my full CV as Exhibit 1 to this declaration.

4. In my opinion, the necessity of a clear scientifically-supported standard for governments to follow in order to halt climate change and protect the fundamental human rights of current and future generations of children is made necessary by the at-best schizophrenic, if not suicidal, nature of global climate and energy policy.

5. On the one hand, many governments around the world have recognized a fundamental duty to protect the public resources of their own nations; to safeguard lives, liberty, and property;

to ensure equal protection under the law for both present and future generations; and, pursuant to the United Nations Framework Convention on Climate Change (UNFCCC), to "protect the climate system for present and future generations."

6. On the other hand, these same governments continue to permit and otherwise support industry's efforts to exploit fully our reserves of gas, coal, and oil, even in the face of increasingly overwhelming evidence that our continued fossil fuel dependency is driving the atmospheric concentration of carbon dioxide (CO_2) far beyond that in human experience, and constitutes one of the greatest threats to human civilization and nature alike.

7. These antinomies cannot be explained away as the product of ignorance. Governments have known for decades that the continued burning of coal, oil and natural gas, compounded by global deforestation and other land use change, causes global warming and risks dangerous and uncontrollable destabilization of the planet's climate system, on which young people and future generations depend.

8. Moreover, governments across the globe have, during this last half decade, promoted the exploitation and consumption of fossil fuels in myriad ways. They include: permitting of fossil fuel development projects; financing of extra-territorial fossil fuel development projects through the Export Import Bank and World Bank; issuance of leases and permits for oil, gas and coal extraction and development within their own borders; and subsidies through tax credits, deductions, preferences, percentage depletion, expensing, favorable loans and guarantees, accelerated amortization, below fair-market-value lease and royalty requirements, and other favorable tax treatment for fossil fuel development. This listing is partial.

9. It is now clear, as the relevant scientific community has established for some time, that continued high CO_2 emissions from fossil fuel burning will further disrupt Earth's climate system, and that, in turn, will impose profound and mounting risks of ecological, economic and social collapse. In my view, the actions and inactions of the world's governments that cause or contribute to those emissions violate the fundamental human rights of children and future generations. Those violated rights include the rights to life, survival and development guaranteed by Article Six of the Convention on the Rights of the Child, as well as the rights to the attainment of the highest standard of health and an adequate standard of living guaranteed by Articles 24 and 27. These and other fundamental rights of children will be honored only in their breach should nations and the international community fail to preserve and restore a habitable climate system.[1]

10. Here, then, I will address the fundamental context in which those fundamental rights violations arise. That context includes Earth's present and growing energy imbalance and the still real, but highly time-limited, opportunity to rapidly phase-down CO_2 emissions, restore energy balance, and stabilize the climate system.

11. More detailed treatment of these points, with supporting explanatory material and data, can be found in two recent papers of which I am the lead author.

12. The first, Assessing ''Dangerous Climate Change'': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature, was published in late 2013, in conjunction with 17 colleagues.[2] In that study we established that continued fossil fuel burning

[1] These and other fundamental rights – all of which are at least implicit in other Articles in the Convention –- include the right to liberty, the right to property, the right to equal protection under the law, the right to government protection of public trust resources

[2] I hereby incorporate into this declaration the analyses and conclusions of: James Hansen et al., (2013) *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, PLOS ONE 8, e81648, available at

up to even 2°C above the preindustrial level[3] likely would cause large climate change with disastrous and irreversible consequences. Accordingly, actions to rapidly phase out CO_2 emissions and draw down excess atmospheric carbon are urgently needed to reduce the atmospheric CO_2 concentration to no more than 350 ppm, allowing temperature to decline this century to a level less than 1°C above preindustrial temperatures.

13. The second, Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations that 2°C Global Warming Could be Dangerous, was published in March 2016.[4] In it we conclude that, if CO_2 emissions are allowed such that energy is continuously pumped at a high rate into the ocean, then multi-meter sea level rise will become practically unavoidable, with consequences that may threaten the very fabric of civilization.

I. PRESENT AND LOOMING CLIMATE CRISES, AND A PATH TO STABILITY

14. As indicated above, our late-2013 study provides a detailed treatment of our present predicament and the route that must be taken to sufficiently reduce atmospheric CO_2 to preserve a habitable climate system.[5] Our most recent work – establishing that nonlinear melting of Earth's major ice sheets is likely within a century, among other things, if fossil fuel emissions continue

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http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081648 [hereinafter *Dangerous Climate Change*].

[3] In just this past year global temperature passed the 1°C level above preindustrial temperature. However, this current high temperature is partly a temporary effect of a strong El Nino, a natural oscillation of tropical Pacific Ocean temperature. Global temperature will decline to a level below 1°C on a long-term basis if CO_2 is reduced to 350 ppm.

[4] I hereby incorporate by reference into this declaration the analyses and conclusions of: James Hansen et al., (2016), *Ice Melt, Sea Level Rise and Superstorms: Evidence From Paleoclimate Data, Climate Modeling, and Modern Observations That 2 ◦C Global Warming Could Be Dangerous*, Atmos. Chem. Phys., 16, 3761–3812, doi:10.5194/acp-16-3761-2016, available at http://www.atmos-chem-phys.net/16/3761/2016/ [hereinafter *Ice Melt*].

[5] *See Dangerous Climate Change*.

unabated – adds an additional element of immediacy to what, for too long, has been treated in practical terms as, at best, a distant but growing complication.[6]

15. I outline and summarize these matters here, before proceeding to a further explanation of them.

16. **First**: Human burning of fossil fuels has disrupted Earth's energy balance. In response, the planet is heating up – with no end in sight, unless we alter our present path. Atmospheric CO_2 concentration, for example, is now at its highest level in 3 million years, and global surface temperatures now have reached the prior maximum of the Holocene era, the period of relatively moderate climate that, over the last 10,000 years, enabled civilization to develop.

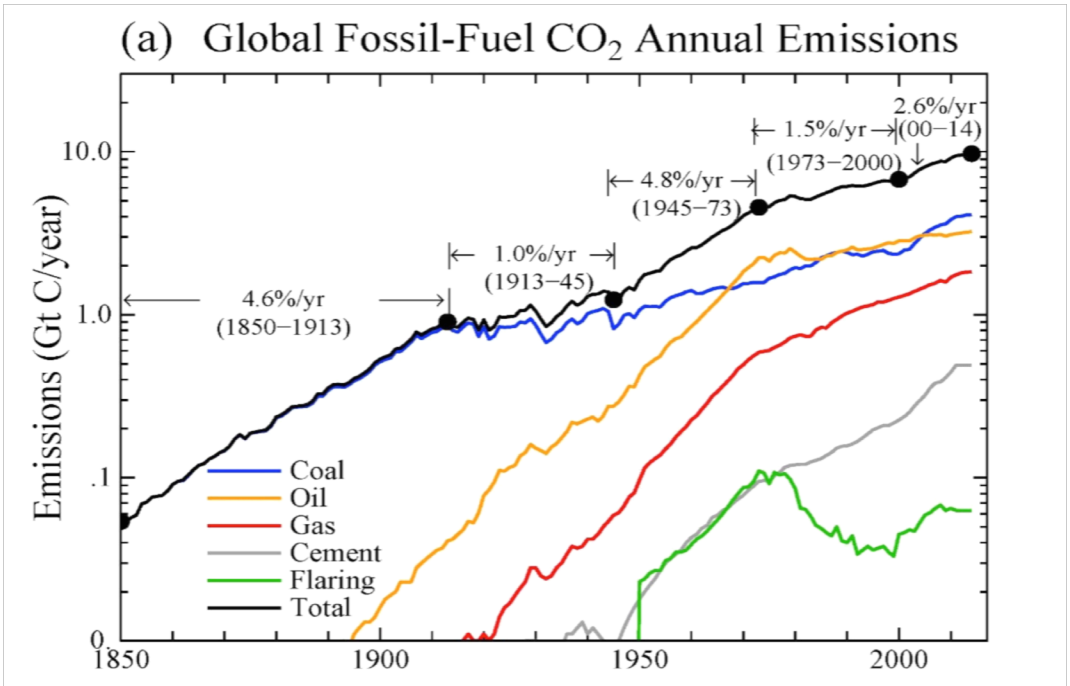
17. **Second**: We are observing impacts of the relatively small amount of warming that has already occurred, and these constitute harbingers of far more dangerous change to come. We can discuss the observable consequences, and their implications, but the key point is that, if unabated, continued carbon emissions will initiate dynamic climate change and effects that spin out of human control, as the planet's energy imbalance triggers amplifying feedbacks and the climate and biological systems pass critical tipping points. Sea-level rise provides a key metric here.

18. **Third**: There is still time and opportunity to preserve a habitable climate system—if we pursue a rational course. I will outline the glide path that we think remains feasible, though further delay in taking effective action will consign that effort to failure. Objectively, then, the situation is urgent and what governments and other decision-makers around the world do today, or fail to do tomorrow, so as to reduce carbon pollution matters immensely.

II. OUR PLANET IS NOW OUT OF ENERGY BALANCE

[6] *See Ice Melt*.

19. In Chart 1, we show global fossil fuel CO_2 emissions on an annual basis from the burning of coal, oil, and natural gas, and from cement production and flaring, along with the total emissions from these major sources. Although it is more than twenty-three years since 170 nations agreed to limit fossil fuel emissions in order to avoid dangerous human-made climate change, the stark reality – as illustrated here – is that global emissions have accelerated. Specifically, the growth rate of fossil fuel emissions increased from 1.5%/year during 1973–2000 to 2.6%/year in 2000–2014 (Chart 1(a)), due in the main to increased utilization of coal, oil, gas and cement (Chart 1(b)).



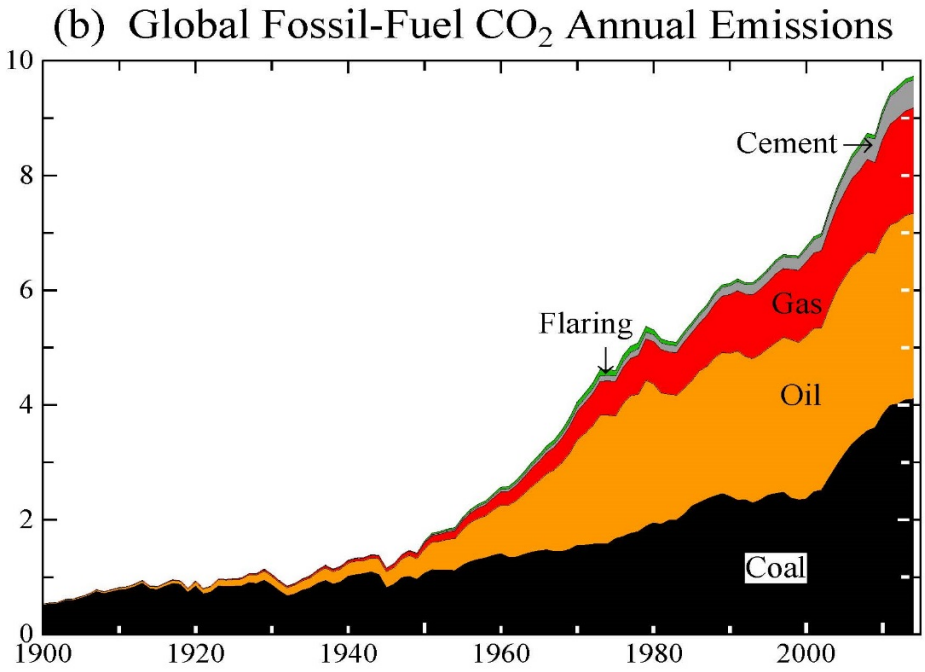


Chart 1: **CO_2 Annual Emissions From Fossil Fuel Use And Cement Manufacture**
Source: *Dangerous Climate Change*, at Fig. 1, updated through 2014 from http://www.columbia.edu/~mhs119/CO2Emissions/.

20. Our increased emissions are reflected, at least in part, in the rising concentration of atmospheric CO_2, as is illustrated in Chart 2[7] that is based on readings taken at the Mauna Loa, Hawaii, observatory. The CO_2, atmospheric level now exceeds 400 ppm, over 40 percent more than the preindustrial level.

[7] *From* http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_growth

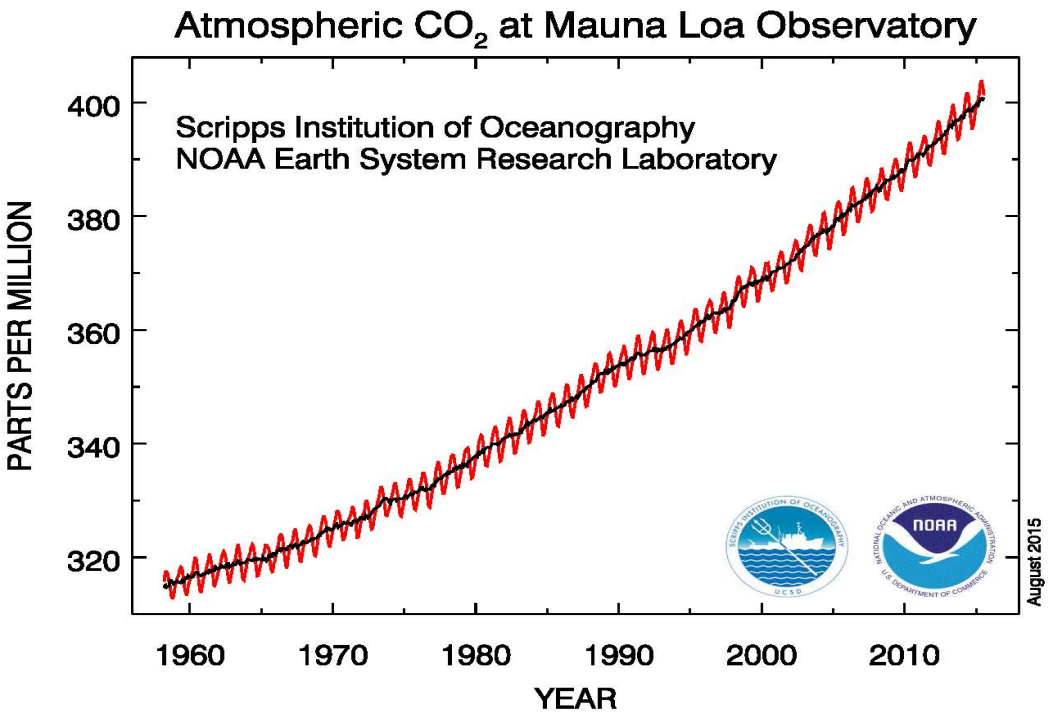


Chart 2: From Noaa's Earth System Research Laboratory
at http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_full.

21. Moreover, the *increase* in the atmospheric CO_2 concentration is itself speeding up, as is illustrated in Chart 3.[8] The annual mean rate of CO_2 growth more than doubled from 0.85ppm in the 1960-70 period to 2.0ppm in 2000-2010.

[8] *Id.*

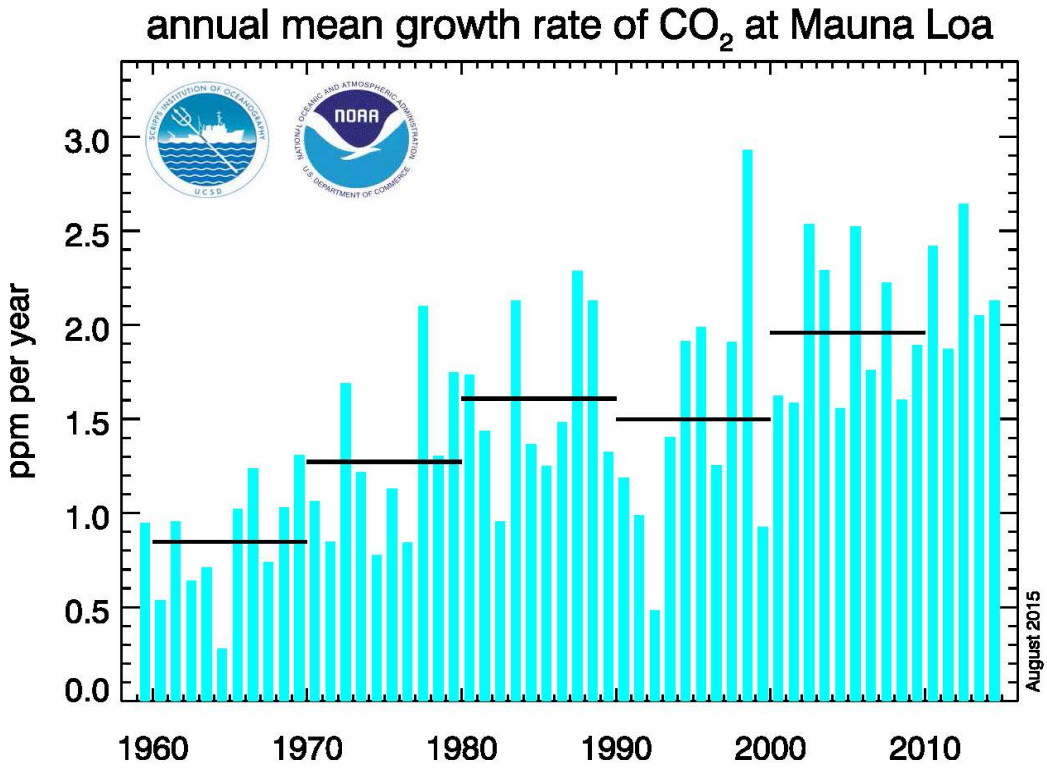


Chart 3: From Noaa's Earth System Research Laboratory
at http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_growth.

22. This increased concentration of CO_2 and other GHGs in the atmosphere operates to reduce Earth's heat radiation to space, thus causing an energy imbalance – less energy going out than coming in. This imbalance causes Earth to heat-up until it again radiates as much energy to space as it absorbs from the sun.

23. In point of fact, warming of Earth caused by the increasingly thick CO_2 "blanket" persisted even during the recent five-year solar minimum from 2005-2010. Had changes in insolation been the dominant forcing, the planet would have had a negative energy balance in that period, when solar irradiance was at its lowest level in the period of accurate data, i.e., since the 1970s. Instead, even though much of the greenhouse gas forcing had been expended in causing observed 1°C global warming to date, the residual positive forcing from CO_2 emissions

overwhelmed the negative solar. This illustrates, unequivocally, that it is human activity, and not the sun, that is the dominant driver of recent climate change.

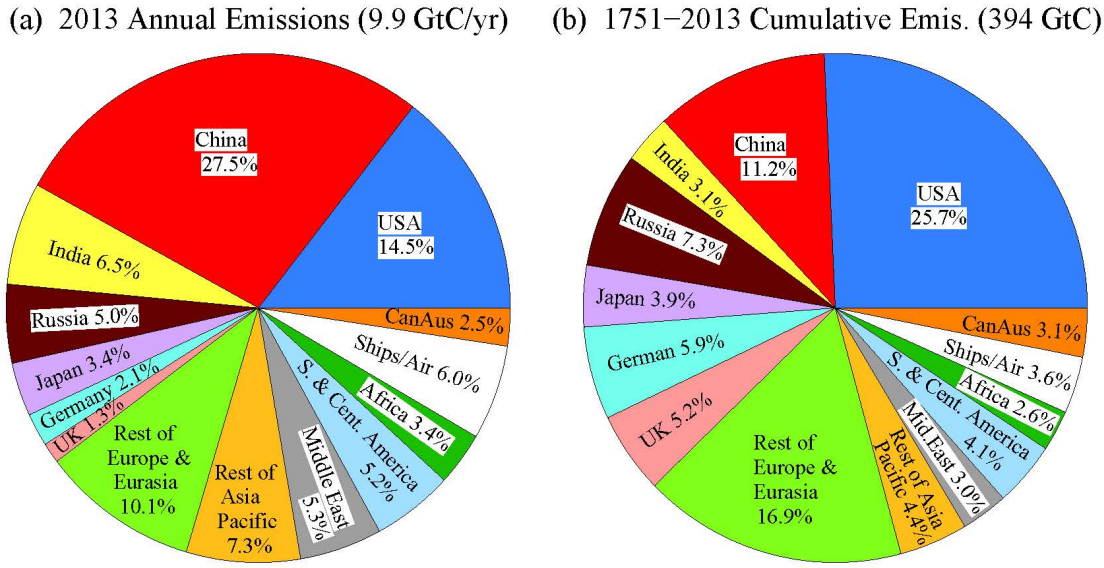


Chart 4: Fossil Fuel CO_2 Emissions
Source: *Dangerous Climate Change*, at Fig. 11.
updated through 2013 at http://www.columbia.edu/~mhs119/CO2Emissions/Emis_moreFigs/.

24. In light of the long residence time of CO_2 following its injection into the atmosphere, it is a sovereign state's sum total of its emissions that is the more proper measure of its responsibility for already-realized and latent climate change. *See* Chart 4(b) (right side). Here, I believe that a further word about the atmospheric residence time of CO_2 is in order, and we can do that with the aid of Chart 5 (left side).

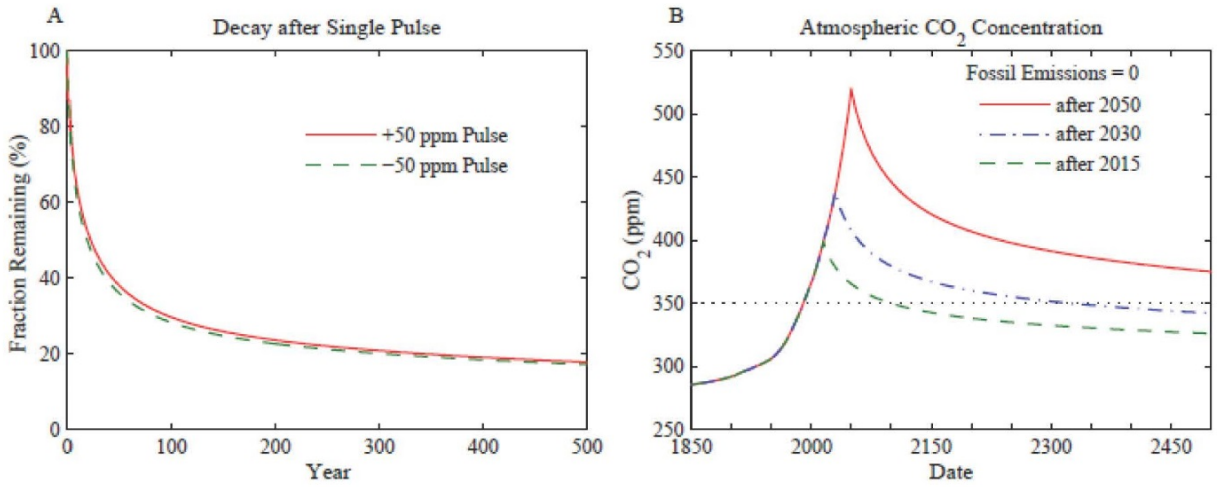


Chart 5: Decay Of Atmospheric Co_2 Perturbations
Source: *Dangerous Climate Change*, at Fig. 4. (A) Instantaneous injection or extraction of CO_2 with initial conditions at equilibrium. (B) Fossil fuel emissions terminate at the end of 2015, 2030, or 2050 and land use emissions terminate after 2015 in all three cases, i.e., thereafter there is no net deforestation.

25. A pulse of CO_2 injected into the air decays by half in about 25 years, as CO_2 is taken up by the ocean, biosphere and soil, but nearly one-fifth remains in the atmosphere after 500 years. Indeed, that estimate is likely optimistic, in light of the well-known nonlinearity in ocean chemistry and saturation of carbon sinks, implying that the airborne fraction probably will remain larger for a century and more. It requires hundreds of millennia for the chemical weathering of rocks to eventually deposit all of this initial CO_2 pulse on the ocean floor as carbonate sediments.

26. The critical point here is that carbon from fossil fuel burning remains in the climate system, with much of it in the atmosphere, and thus continues to affect the climate system for many millennia.

27. It is in part for this reason – the atmospheric persistence of CO_2 – that the contribution to the problem by developed nations, in particular the United States, is so large. Moreover, we can observe that, the contributions of these major historical emitters to the global climate crisis are not

only disproportionately large in absolute amount (Chart 4(b)), they dwarf the contributions of the most populous developing nations on a per capita basis. Chart 6. Nonetheless, all nations must transition away from fossil fuels if we are to preserve a habitable climate system and protect the rights of children.

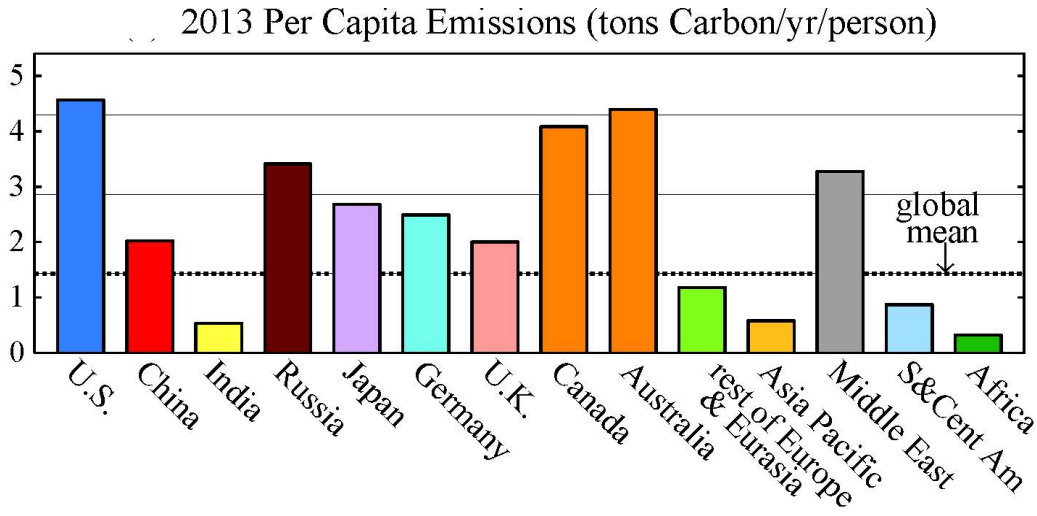
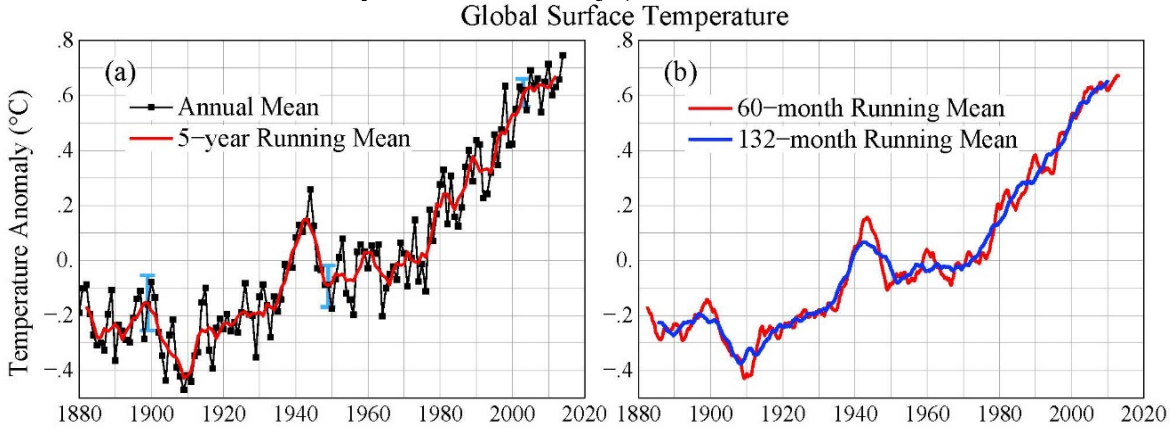


Chart 6: **Cumulative Per Capita Carbon Dioxide Emissions**
Source: www.columbia.edu/~mhs119/YoungPeople/.

28. Turning, now to Chart 7, we see the upward march of recent global surface temperature.

Chart 7: **Global Surface Temperature Anomaly (60-Month And**



132-Month Running Means) With A Base Period Of 1951-1980
Source: *Dangerous Climate Change*, at Fig. 3, updated at
http://www.columbia.edu/~mhs119/Temperature/.

29. Earth has now warmed about 1°C above the pre-industrial level. That is now close to, and probably slightly above, the prior maximum of the Holocene era – the period of relatively stable climate over the last 10,000 years that has enabled human civilization to develop.

30. The warming increases Earth's radiation to space, thus reducing Earth's energy imbalance. However, because of the ocean's great thermal inertia, it requires centuries for the climate system to reach a new equilibrium consistent with a changed atmospheric composition. The planet's energy imbalance confirms that substantial additional warming is "in the pipeline". That energy imbalance is now measured by an international fleet of more than 3,000 submersible floats that plumb the depths of the world's ocean measuring the increasing heat content.

31. Earth's energy imbalance now averages about 0.6 Watts/m^2 [Jim: still 0.6 Watts?] averaged over the entire planet, but I am uncertain whether this conveys the scale of what is going on. I can note that the total energy surplus is 300 trillion joules per second, but that large number may still be insufficiently evocative. Accordingly, it may be more useful to observe, and with equal validity, that Earth's energy imbalance is equivalent to exploding more than 400,000 Hiroshima atomic bombs per day, 365 days per year. That is how much extra energy Earth is now gaining each day because of our use of the atmosphere as a waste dump for our carbon pollution.

32. We can turn now to Chart 8.

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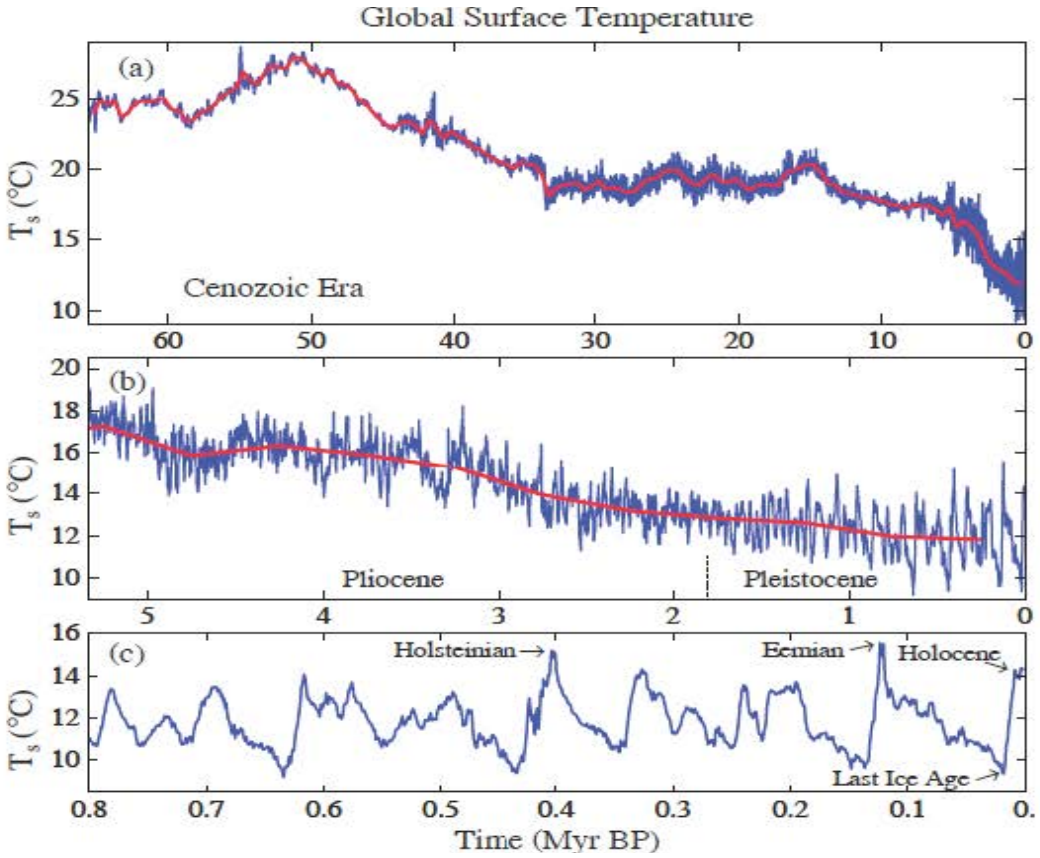

Chart 8: **Surface Temperature Estimate for the Past 65.5 Myr, Including An Expanded Time Scale for (B) The Pliocene and Pleistocene and (C) The Past 800 000 Years**
Source: J. Hansen, et al, (2013) *Climate Sensitivity, Sea level and Atmospheric Carbon Dioxide*, Phil Trans R Soc A, Fig. 4.

33. Here, we summarize the average global surface temperature record of the last 65 million years. This record is based on high-resolution ice core data covering the most recent several hundred thousand years, and ocean cores on time scales of millions of years. It provides us with insight as to global temperature sensitivity to external forcings such as added CO_2, and sea level sensitivity to global temperature. It also provides quantitative information about so-called "slow" feedback processes – such as melting ice sheets and lessened surface reflectivity attributable to darker surfaces resulting from melting ice sheets and reduced area of ice.

34. Several relevant conclusions can be drawn. First, the mechanisms that account for the relatively rapid oscillations between cold and warm climates were the same as those operating today. Those past climate oscillations were initiated not by fossil fuel burning, but by slow insolation changes attributable to perturbations of Earth's orbit and spin axis tilt. However, the mechanisms that caused these historical climate changes to be so large were two powerful amplifying feedbacks: the planet's surface albedo (its reflectivity, literally its whiteness) and atmospheric CO_2.

35. Second, the longer paleoclimate record shows that warming coincident with atmospheric CO_2 concentrations as low as 450 ppm may have been enough to melt most of Antarctica. Global fossil fuel emissions have already driven the atmospheric CO_2 concentration above 400 ppm – up from approximately 280 ppm in the preindustrial era.

36. I conclude that the present level of CO_2 and its warming, both realized and latent, is already in the dangerous zone. Indeed, we are now in a period of overshoot, with early consequences that are already highly threatening and that will rise to unbearable unless action is taken without delay to restore energy balance at a lower atmospheric CO_2 amount. We can turn now to a brief review of the increasingly unacceptable, but still avoidable, consequences.

III. UNABATED EMISSIONS MAY DEVASTATE OUR COASTS, CIVILIZATION AND NATURE AS WE KNOW IT

37. I will start with the ocean, in light of our most recent research.

38. While I have postulated previously that major ice sheet disintegration and resulting sea level rise is likely to be nonlinear in the event of continued high fossil fuel impacts, my concern had been based largely on heuristic grounds. Now, utilizing multiple lines of evidence – including satellite gravity measurement, surface mass balances, and satellite radar altimetry – it

has become clear, regrettably, that ice mass losses from Greenland, West Antarctica and parts of East Antarctica are growing nonlinearly, with doubling times so far this century of approximately 10 years.

39. My colleagues and I expect the growth rate for ice mass loss in Greenland to slow, based on the most recent few years of data, but because of amplifying feedbacks described in our paper we also think it likely that Antarctic ice mass loss will continue to climb exponentially – again, if fossil fuel emissions are not rapidly abated. This prospect alone cries out for urgent national and international action to constrain carbon pollution, considering that complete disintegration of the Totten glacier in East Antarctica could raise sea levels by approximately 6-7m; that ice fronted by the Cook glacier in East Antarctica could add 3-4m of sea rise; and that West Antarctic ice fronted by Amundsen Sea glaciers have the potential to raise sea level an additional 3-4m.[9]

40. The rising seas will combine, in places, including especially in the North Atlantic region, with growing storminess to further threaten low-lying and other coastal regions. The phenomenon is a function not only of a warming atmosphere that renders additional water and energy available to any developing weather event, but also because melting ice sheets increase sea level pressure at middle (relative to polar) latitudes and thereby strengthen temperature gradients, supercharging storms with baroclinic sources. This growing climate chaos will increasingly lash regions within the storms' reach. Persons within these regions who lack discretionary resources to flee and rebuild, or else to relocate, predictably will be among those most severely harmed.

41. Persons situated in low-lying regions therefore will predictably be disproportionately impacted by unarrested global warming. So too will young people and future generations be

[9] *Ice Melt*, at 3795.

severely harmed. Our children and their progeny will be the ones to experience the full impact of slow feedbacks that, only now, are coming into play, including ice sheet disintegration, as well as changes in the global vegetation distribution, melting of permafrost, and possible release of methane from hydrates on continental shelves. Indeed, sovereign governments around the world are on the verge of collectively imposing an overwhelming burden – intergenerational injustice in the extreme – upon young people and future generations who stand to inherit a climate system that is not at all conducive to their well-being or survival, as guaranteed under the Convention, through no fault of their own.

42. In the light of this and related information, we have concluded that "if GHG emissions continue to grow...[a] multi-meter sea level rise would become practically unavoidable, probably within 50–150 years."[10] Much of the U.S. eastern seaboard, as well as low-lying areas of Europe, the Indian sub-continent, and the Far East, would then be submerged. *See* Chart 9.[11]

[10] *Ice Melt*, at 3799. As we've noted, "Sea level reached +6–9 m in the Eemian, a time that we have concluded was probably no more than a few tenths of a degree warmer than today." *Ice Melt*, at 3800.

[11] *See also* Climate Central's "Surging Seas" project at http://sealevel.climatecentral.org/.

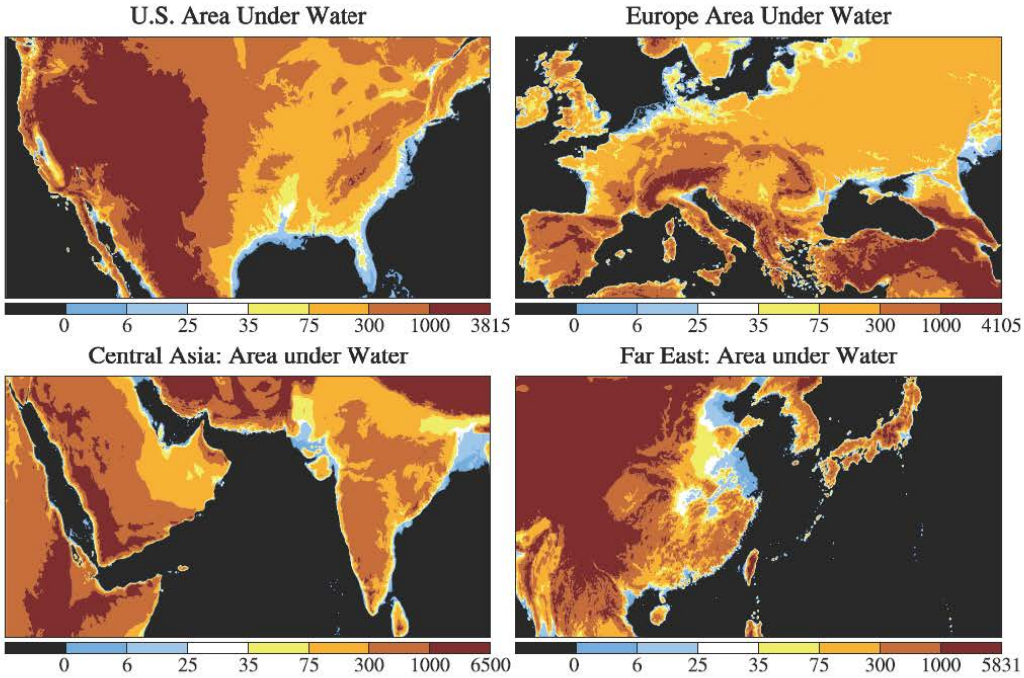

Chart 9: **Areas (Light And Dark Blue) That Nominally Would Be Under Water For 6 And 25 M Sea Level Rise**
Source: Climate Science, Awareness, and Solutions, Earth Institute, Columbia University (2015).

43. That order of sea level rise would result in the loss of hundreds of historical coastal cities worldwide, with incalculable economic consequences. It would also create hundreds of millions of global warming refugees from highly populated low-lying areas, and thus likely cause or exacerbate major international conflicts.[12]

44. To avoid such a calamity, sea level rise must be recognized as a key limit on any conceivably allowable human-made climate forcing and atmospheric CO_2 concentration, with

[12] In addition, strong temperature gradients caused by ice melt freshening is likely to increase baroclinicity and provide energy for more severe weather events, including in the North Atlantic. This set of circumstances will drive the powerful superstorms of our future. Some of these impacts are beginning to occur sooner in the real world than in our climate model. *See Ice Melt*, at 3773.

fossil fuel emissions and land use changes constrained accordingly.[13] As discussed, ice sheet melting has now commenced even though global warming to date measures "only" 1°C above the pre-industrial period. This is consistent with the relevant paleoclimate evidence showing a multi-meter rise in sea level in the late Eemian period, approximately 125K years ago, when temperature was at most ~2°C warmer than pre-industrial climate (at most ~1°C warmer than today). This, in itself, and quite apart from the additional harm to terrestrial systems that must also be considered, implies that national and international goals and targets that aim to limit global warming to no more than 2°C run an unacceptably high risk of global catastrophe.

45. An important effect for the coming period of large scale ice sheet melting, in our view, is that the discharge of ice and cold fresh water will expand sea ice cover and result in ocean surface, regional and global cooling effects.[14] For varying periods, these effects would mask some of the global warming that would otherwise result from projected high CO_2 levels. The temporary surface cooling, however, would coincide with a further increase in the planet's energy imbalance, with added energy pumped into the ocean, and there be available, at Antarctica and Greenland, to further melt the subsurface shelves that, at present, restrain several of the planet's major ice sheets at their grounding lines.[15]

46. Upon cessation of ice sheet disintegration and freshwater discharge, global temperature will recover – with the time period for such recovery depending on the amount of ice melt (and

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[13] This is so, as we wrote in *Ice Melt*, since the "[s]ocial disruption and economic consequences of [multi-meter] sea level rise, and the attendant increases in storms and climate extremes, could be devastating. It is not difficult to imagine that conflicts arising from forced migrations and economic collapse might make the planet ungovernable, threatening the fabric of civilization." *Ice Melt*, *at* 3799.

[14] *Ice Melt,* at 3761-3780

[15] *Ice Melt*, at 3776-3777.

sea level rise), and with geographical, geophysical and oceanic circulation factors detailed in our recent study.[16]

47. With respect to other important natural and human systems, to which I will now turn, the impacts of global warming – including the renewed warming – will depend in part on the magnitude of Earth's energy imbalance, and that, in turn, will be controlled by the level of excess atmospheric CO_2. As I have noted already, global warming to date measures "only" 1°C above the pre-industrial period, and yet, that level of warming has already begun to have a widespread effect on natural and human systems, including the safety and well-being of children.

48. For example, mountain glaciers, the source of fresh water to major world rivers during dry seasons, are receding rapidly all around the world. Glaciers in North America's iconic Glacier National Park, for example, appear to be in full retreat: In 1850, according to the U.S. National Park Service, the park had 150 glaciers measuring larger than twenty-five acres. Today, it has just twenty-five. Significant glacial retreat has also been observed throughout the Rockies and in many other regions including the Cascades, the Alps, the Pyrenees, the Himalayas, the Andes, Greenland, Iceland, and Siberia.

49. As well, tropospheric water vapor and heavy precipitation events have increased, as we would expect. A warmer atmosphere holds more moisture, thus enabling precipitation to be heavier and cause more extreme flooding. Higher temperatures, on the other hand, increase evaporation and can intensify droughts when they occur, as can the expansion of the subtropics that occurs as a consequence of global warming.

[16] *Ice Melt*, at 3766.

50. Coral reef ecosystems, harboring more than 1,000,000 species as the "rainforests" of the ocean, are impacted by a combination of ocean warming, acidification from rising atmospheric CO_2, and other human-caused stresses, resulting in a 0.5-2% per year decline in geographic extent.

51. With respect to rising temperatures, global warming of recent decades has been sufficient to shift the bell curve distribution of temperature anomalies (in units of standard deviation) above the climatological base period of 1951-1980 for the aggregate areas of the northern hemisphere as well as that of the southern hemisphere. This is true for most large sub-hemisphere geographical regions as well.

52. For instance, the summer bell curves for the United States and North and Central Europe are shifted more than one standard deviation (1σ).[17] That shift is enough to increase the frequency of summers warmer than $+2\sigma$ from less than 1 percent to greater than 10 percent. Even larger temperature distribution shifts are observed for the period 2005-2015 in China, India, the Mediterranean, the Middle East, the Sahara and Sahel, South-east Asia, and the African rainforest. Within the continental United States, large summer warming has been experienced in much of the western region and, to a somewhat lesser but still significant extent, along the eastern seaboard. The large warming and dry conditions over the period exacerbated wildfire in the western United States, and I anticipate worse to come with continued global warming.

53. Subtropical climate belts have expanded, contributing to more intense droughts, summer heat waves, and devastating wildfires. Further, summer mega-heat-waves, such as those in Europe in 2003, the Moscow area in 2010, Texas and Oklahoma in 2011, Greenland in 2012, Australia in 2013, Australia and California in 2014, and India, France and Spain in 2015, have

[17] The shift in the winter is only about half of a standard deviation.

become more widespread.[18] 2016 is set to break all previous temperature records. The probability of such extreme heat events has increased by several times because of global warming, and the probability will increase even further if fossil fuel emissions continue to be permitted, so that global warming becomes locked in or rendered increasingly severe.

54. Wildfire frequency and magnitude will climb in ensuing decades if CO_2 emissions are not rapidly phased out, but I observe here, on the basis of research that colleagues and I have recently completed, that such infernos may not prove to be the most severe foreseeable climate-driven calamity confronting civilization in coming decades.

55. I have already mentioned the unparalleled calamity that the loss of scores of coastal cities to rapid sea level rise presents to human civilization. But I should mention that many other impacts also will abound.

56. For example, acidification stemming from ocean uptake of a portion of increased atmospheric CO_2 will increasingly disrupt coral reef ecosystem health, with potentially devastating impacts to certain nations and communities. Inland, fresh water security will be compromised, due to the effects of receding mountain glaciers and snowpack on seasonal freshwater availability of major rivers.

57. Other practical consequences include lost work capacity. Agricultural and construction workers in tropical developing countries may be most exposed to increasing heat stress and stroke, but workers in places such as Southeast and Southwest United States and Eastern China will also be affected by increasing temperature and, in places, increased absolute humidity.[19]

58. World health experts have concluded with "very high confidence" that climate change already contributes to the global burden of disease and premature death with expansion of

[18] In general, however, local observations of climate (heat) extremes are illustrative of what will occur with the increasing atmospheric CO_2 concentration, but I will caution that other, more stochastic, variables usually will be in play as well.

[19] Generally, as global warming increases, climatologically wet regions, such as the American Southeast, tend to get wetter, and dry regions, such as the American Southwest, tend to get hotter and drier.

infectious disease vectors. Increasing concentrations of CO_2 and associated increased global temperatures will deepen human health impacts from climate change, with children being especially vulnerable. Climate threats to health move through various pathways, including by placing additional stress on the availability of food, clean air, and clean water. Accordingly, unabated climate change will increase malnutrition and consequent disorders, including those related to child growth and development. It will increase death and illness associated with COPD, asthma, and other respiratory distress triggered by worsened allergies. Unabated emissions will also produce other injuries from heat waves; floods, storms, fires and droughts, and it will increase cardio-respiratory morbidity and mortality associated with increased ground-level ozone.

59. With regard to other species, we see that climate zones are already shifting at rates that exceed natural rates of change; this trend will continue as long as the planet is out of energy balance. As the shift of climate zones becomes comparable to the range of some species, the less mobile species will be driven to extinction. According to the UN Panel on Climate Change, with global warming of 1.6°C or more relative to pre-industrial levels, 9-31 percent of species are anticipated to be driven to extinction, while with global warming of 2.9°C, an estimated 21-52 percent of species will be driven to extinction. These temperature/extinction thresholds will not be avoided absent concerted, rational action on carbon emissions.

60. At present, we remain on track to burn a significant fraction of readily available fossil fuels, including coal, oil, natural gas, and tar sands, and so to raise average surface temperature, over time, to far above pre-industrial levels.

61. High global surface temperatures have been recorded previously, in the age of mammals, with some successful adaptation through evolution of higher surface-area-to-mass ratio body types – for example transient dwarfing of mammals and even soil fauna. However, human-made warming is occurring rapidly and will be fully realized in only centuries, as opposed to millennia, thus providing little opportunity for evolutionary dwarfism to alleviate impacts of global

warming. Along with several colleagues, I have been forced to conclude that the large climate change that would result from burning all or most fossil fuels threatens the survival of humanity.

62. All of which brings me to my third point.

IV. RESTORATION OF OUR CLIMATE SYSTEM, AND SO PROTECTION OF OUR FUTURE, IS STILL POSSIBLE, BUT WE MUST ACT WITH REASON, COURAGE, AND NO FURTHER DELAY

63. As I indicated above, the energy imbalance of Earth is about 0.6 W/m^2. In light of that imbalance, colleagues and I have calculated the level to which atmospheric CO_2 must be drawn down in order to increase Earth's heat radiation to space by the same amount and thus restore energy balance – the fundamental requirement to stabilize climate and avoid further dangerous warming.

64. The measured energy imbalance indicates that atmospheric CO_2 must be reduced to a level below 350 ppm and the long-term average global temperature increase above preindustrial levels must be limited to below 1^oC, assuming that the net of other human-made climate forcings remains at today's level. Specification now of a CO_2 target more precise than <350 ppm is difficult due to uncertain future changes of radiative forcing from other gases, aerosols and surface albedo, but greater precision should be feasible during the time that it takes to turn around CO_2 growth and approach the initial 350 ppm target. I give my best expert opinion based upon my decades of study and research that these are the maximum safe levels of CO_2 and temperature increases that would allow for the nations of the world to preserve most of the rights of children as identified in the CRC. These limits may indeed be lower, but they are certainly not higher.

65. Let us return, for a moment, to Chart 5, so as to consider again the question of delay. On the left side of the chart, the long-residence time for atmospheric CO_2 is illustrated. It is reflected

in the length of time it would take to return CO_2 to lower concentrations even if, as indicated on the right side of the chart, fossil fuel emissions were to cease entirely.

66. Of course, an abrupt cessation of all CO_2 emissions, whether this year or in 2030, is unrealistic. Industry, other business, and consumers all need time to retool and reinvest in emission-free options to fossil fuels.

67. Accordingly, we have evaluated emissions reduction scenarios to devise the path that is both technically and economically feasible, while being sufficiently rigorous to constrain the period of "carbon overshoot" and avoid calamitous consequences (greatly accelerated warming, ecosystem collapse, and widespread species extermination). *See* Chart 10.

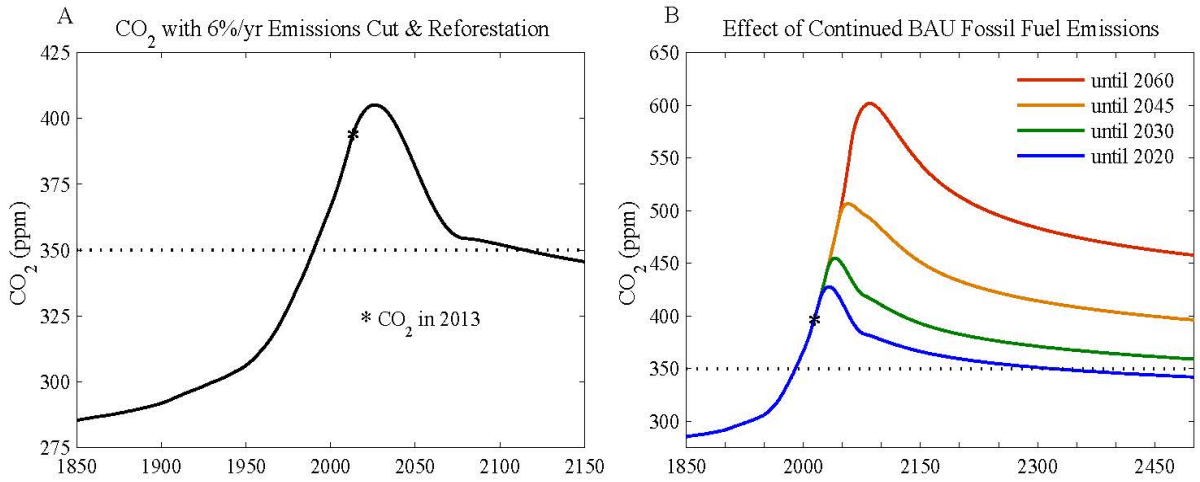

Chart 10: **Atmospheric CO_2 If Fossil Fuel Emissions Are Reduced.**
(A) 6% Annual Cut Begins In 2013 and 100 GRC Reforestation Drawdown Occurs In 2031-2080,
(B) Effect Of Delaying Onset Of Emission Reductions.
Source: *Dangerous Climate Change* at Fig. 5.

68. Our analysis prescribes a glide path towards achieving energy balance by the end of the century. It is characterized by large, long-term global emissions reductions (of approximately 7

percent annually if commenced this year, 8 percent if commenced in 2017, and 8.5 percent if commenced in 2018),[20] coupled with programs to limit and reverse land use emissions via reforestation and improved agricultural and forestry practices (drawing down approximately 100 GtC globally by the year 2100).

69. These actions could achieve the goal of restoring the atmosphere to approximately 350 ppm within this century if the plan were commenced without delay, and then adhered to. As I have indicated, such action is minimally needed to restore Earth's energy balance, preserve the planet's climate system, and avert irretrievable damage to human and natural systems – including agriculture, ocean fisheries, and fresh water supply – on which human civilization depends. However, consistent with the abrupt phase out scenarios discussed in the prior paragraph, if rapid annual emissions reductions are delayed until 2030, then the global temperature will remain more than 1°C higher than preindustrial levels for about 400 years. Were the emissions cessation only to commence after 40 years, then the atmosphere would not return to 350 ppm CO_2 for nearly 1000 years. Overshooting the safe level of atmospheric CO_2 and the safe range of global ambient temperature for anything approaching these periods will consign succeeding generations to a vastly different, less hospitable planet.

70. Considered another way, the required rate of emissions reduction would have been about 3.5% per year if reductions had started in 2005 and continued annually thereafter, while the required rate of reduction, if commenced in 2020, will be approximately 15% per year.

[20] This path assumes that global emissions are held fixed from 2014 (the last year of available historical data) until and including the year before the cuts begin. If we instead assume 2 percent per year emissions increases over the same time periods (for consistency with the scenario in *Dangerous Climate Change*), then the required minimum annual reductions will be marginally higher, at 7.5, 8.2, and 9 percent.

Accordingly, the dominant factor is the date at which fossil fuel emission phase out begins, again presuming the rate of annual emissions reductions thereafter are sustained.

V. TO PRESERVE A STABLE CLIMATE SYSTEM, AVERAGE GLOBAL TEMPERATURE INCREASE MUST BE LIMITED TO LESS THAN 1°C

71. In a 2008 study, *Target Atmospheric CO_2: Where Should Humanity Aim?* nine co-authors and I observed that "[p]aleoclimate evidence and ongoing global changes imply that today's CO_2, about 385 ppm, is already too high to maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted."[21] We suggested "an initial objective of reducing atmospheric CO_2 to 350 ppm" through a practical strategy, including "a rising global price on CO_2 emissions" and a phase-out of most coal utilization.[22]

72. Regrettably, in the intervening 8 precious years since *Target Atmospheric CO_2* was published, governments have dithered – except, in the main, to engage in rancorous debate producing lax and highly-perforated carbon caps, among other small steps – while the concentration of atmospheric CO_2 has shot to, and is now going beyond, 400 ppm.[23]

73. The Intergovernmental Panel on Climate Change (IPCC), the international body of scientists that has done so much to bring together climate-relevant information on a six-year basis,[24] has neither established nor endorsed a target of 2 °C warming over the preindustrial period as a limit below which the climate system will be stable. It is true that the Parties to the

[21] Hansen J, Sato M, Kharecha P, Beerling D, Berner R, et al., (2008), *Target Atmospheric CO_2: Where Should Humanity Aim?* The Open AtmosphericScience Journal 2: 217–231, available at http://benthamopen.com/ABSTRACT/TOASCJ-2-217.

[22] I have published scores of other papers that explore the essential features of Earth's climate system and detail the need to phase out fossil fuel emissions rapidly so as to preserve those essential features that enabled human civilization to develop. *See* Exhibit 1 (my CV).

[23] The trends may be usefully explored at the public site of the Earth System Research Laboratory, available at http://www.esrl.noaa.gov/gmd/ccgg/trends/.

[24] The IPCC lays out its multi-year process leading to the publication of each assessment here: http://www.climatechange2013.org/ipcc-process/.

UNFCCC have acknowledged that the rise in global surface temperature must kept to less than 2°C. The important question, of course, is "how much less?" That question is the subject of endless debate within the UNFCCC,[25] where delegates jockey over proposed national carbon reduction commitments aimed, alternately, to protect people or major carbon polluters.

74. More importantly, the question also is not answered by the IPCC. In places, the IPCC has been clear about this point, noting, for example, that: "each major IPCC assessment has examined the impacts of [a] multiplicity of temperature changes but has left [it to the] political processes to make decisions on which thresholds may be appropriate."[26]

75. Moreover, the most recent IPCC synthesis of climate science strongly confirms that additional warming of 1°C above the preindustrial average jeopardizes unique and threatened systems, including ecosystems and cultures, with certain natural systems and species of limited adaptive capacity considered at "very high risk."[27] The IPCC warns, as well, of risks of extreme

[25] That said, at long last a consensus may be emerging, "although it remained for the parties to articulate." According to a Coordinating Lead Author of the IPCC's Fifth Assessment Report, at a recent "structured expert dialogue" between parties to the UNFCCC and selected IPCC authors, the 2°C "danger level" seemed "utterly inadequate given the already observed impacts on ecosystems, food, livelihoods, and sustainable development, and the progressively higher risks and lower adaptation potential with rising temperatures, combined with disproportionate vulnerability." Petra Tschakert, *1.5 °C or 2 °C: a conduit's view from the science-policy interface at COP20 in Lima, Peru*, Climate Change Responses 2:3, 8 (2015), available at http://www.climatechangeresponses.com/content/2/1/3.

[26] IPCC, 2014: Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report at 125, available at http://report.mitigation2014.org/report/ipcc_wg3_ar5_chapter1.pdf.

[27] IPCC 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press) at 13-14. Available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf.

events – including heat waves, extreme precipitation, and coastal flooding, and "irreversible regime shifts" with additional warming.[28] *See* Chart 11.

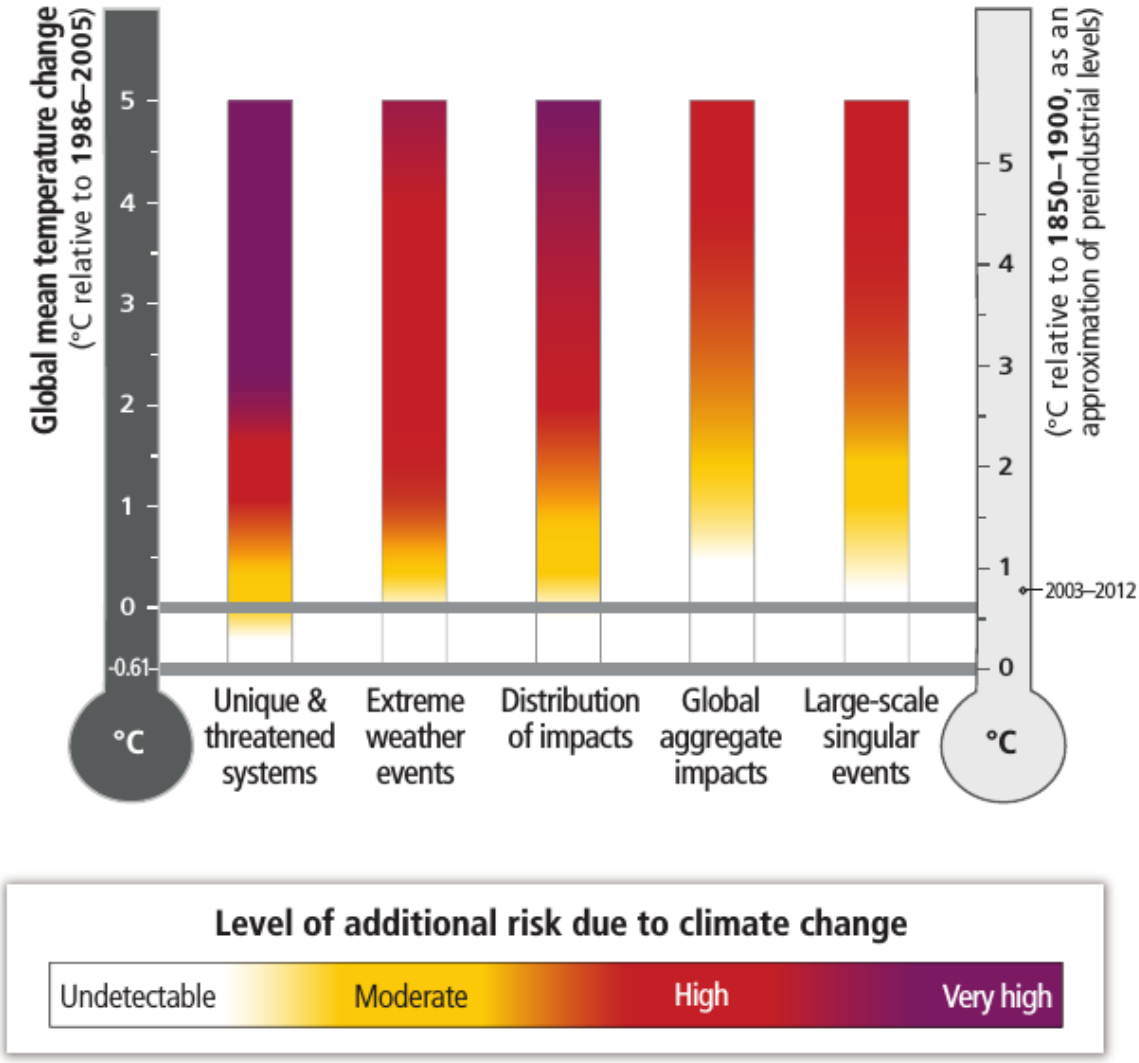

Chart 11 Burning Embers. Illustration of climate risks associated with the IPCC's principally identified reasons for concern. 5th Assessment Report Summary for Policymakers at 13, available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf.

[28] *Id*. The IPCC also warns that risks are and will be "unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development." *Id*. The IPCC also sees "moderate risk" of global aggregate impacts to our planet's biodiversity and the overall economy with additional warming of 1-2°C, with "extensive biodiversity loss with associated loss of ecosystem goods and services" and accelerated economic damages for additional warming around 3 °C or above. *Id*.

76. Accordingly, while the IPCC has not expressly stated what level of warming is too dangerous, and it likely never will, the answer is plain enough – even based simply on IPCC syntheses – that 2°C warming will be very dangerous.[29] In light of our recent work, I think it is clear that such warming, if maintained (or exceeded) even for decades, will produce calamitous effects to human and natural systems alike.

VI. THE "COMMITMENTS" MADE AT COP-21

77. The largely precatory agreement secured in December 2015 at the Conference of the Parties to the UNFCCC (COP-21) neither resolves nor ameliorates the unfolding crisis of dangerous, human-caused disruption of the climate system.

78. By the time COP-21 commenced on November 30, 2015, most nations – including all of the so-called "G20 nations"[30] responsible for nearly 80% of global emissions – had presented their "intended nationally determined contributions" ("pledges") to the UNFCCC.

79. Independent analysis of the major nations' pledges heading into COP-21 established that, when taken together, there remained a large gap between the aggregate emissions that would be allowed (even assuming that pledges constituted binding commitments) and the level of action, in terms of actual emissions reductions, required to hold global warming below 2˚C.[31]

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[29] For example, Professor Mann of Pennsylvania State University, argued in 2009 that, given the risks to threatened systems, risks associated with extreme weather, and the "distribution of impacts [that may] weigh heavily toward being adverse across diverse regions at ~1 °C additional global mean warming (defined relative to a 1990 baseline), it would seem difficult for the risk averse among us to accept anything much above that as the standard" for dangerous anthropogenic interference with the climate system. Michael E. Mann, (2009), *Defining dangerous anthropogenic interference*, Proceedings of the National Academic of Sciences, 4065, available at http://www.pnas.org/content/106/11/4065.full.pdf.

[30] The G20 is comprised of Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom, and the United States.

[31] *See*, for example, Climate Action Tracker, *Update: G20 – all INDCs in, but large Gap remains*, Nov. 13, 2015, available at http://climateactiontracker.org/assets/publications/briefing_papers/G20_gap.pdf.

80. It was therefore unsurprising that in its decision to adopt the Paris Agreement, the Conference of the Parties emphasized the Parties' "serious concern" with "the significant gap between the aggregate effect of Parties' mitigation pledges" and what is required to preserve the planet.[32]

81. In that regard, in adopting the Paris Agreement, the Parties properly took "note of the synthesis report on the aggregate effect of intended nationally determined contributions."[33] That synthesis report, in turn, states, among other things, that even if the nations' announced targets were to be "exactly met" then "global emissions are *likely to increase until 2030*."[34]

82. Based on my experience and applying my scientific judgment, and consistent with the judgment of numerous other climate scientists, it is clear that allowing global CO_2 emissions to *increase* for another 15 years would likely consign future generations to a far different, largely unrecognizable, planet, one marked in vast reaches by unbearable summer heat, ecological collapse, species extinction, widespread famine, coastal cities lost to rising seas, mass human migration, and riven national and international conflict. That list is but a start of what probably will occur. Such an unappealing, but increasingly likely, scenario is outlined above. In that light, then, the Parties to the Paris Agreement were understated in noting "*with concern* that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2˚C scenarios."[35]

83. Also as discussed above, based on multiple lines of inquiry, including analysis of the paleoclimate record, my colleagues and I have concluded that dangerous disruption of current

[32] *See* UNFCCC, Adoption of the Paris Agreement, FCCC/CP/2015/10/Add.1, at 2, Dec. 12, 2015, available at http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf.
[33] *Id*. at 4.
[34] UNFCCC, *Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions*, FCCC/CP/2015/7, at 41, par. 193, Oct. 30, 2015 (emphasis added), available at http://unfccc.int/resource/docs/2015/cop21/eng/07.pdf.
[35] Adoption of the Paris Agreement at 3, par. 17.

climate system to which humanity is adapted likely will commence shy of the politically-driven 2˚C warming target.[36]

84. Moreover, the Parties to the Paris Agreement did not agree to any binding commitments, and instead, only announced intentions and precatory exhortations to do more. These intentions and exhortations do not amount to binding, enforceable, emissions reduction commitments. As a result, the Paris Agreement – even if it encourages additional nationally-determined emissions reduction pledges – cannot provide genuine assurance that even the inadequate 2˚C target will be attained and not blown.

85. Accordingly, the substantive utility of the Paris Agreement must reside in the unanimous acknowledgment by the Parties, including the major emitters, that their emissions reduction programs and pledges to date fall short of what is minimally required to preserve the fundamental features of a viable planet. Indeed, even assuming that the pledges made by governments of the world are converted to binding programs, the total efforts will fall short of a fair contribution even to halting global warming at 2°C, a target that is itself so lacking in ambition that, even if secured, would be unlikely in the long run to stave off catastrophic change.[37]

VII. THE FUNDAMENTAL HUMAN RIGHTS OF CHILDREN AND FUTURE GENERATIONS TO A HABITABLE PLANET

[36] *See*, for example, *Ice Melt*, at 3801, where we conclude that "2°C global warming is dangerous" and that there is a "real danger" that "we will hand young people and future generations a climate system that is practically out of their control."

[37] *See supra,* Section VI. Further , based on my review of the paleoclimate record, among other factors, I am forced to conclude that, if sea level rise adds to migration pressures from regional climate change, the world could become nearly ungovernable even with global warming of "only" 2°C. On that point s*ee*, for example, our recent comprehensive assessment concluding that "[f]ossil fuel emissions of 1000 GtC, sometimes associated with a 2°C global warming target, would be expected to cause large climate change with disastrous consequences." *Dangerous Climate Change*, at 13.

86. With all of the above having now been said, and serving as background, I can return, finally, and briefly, to consider the nature of the violations of the fundamental human rights of children and future generations that are properly attributable to the continued permitting, leasing, and other support for fossil fuel exploitation and expansion projects, as well as deforestation, by governments around the world, particularly in the absence of any countervailing, coherent, effective international programs to rapidly reduce atmospheric CO_2 to a safe level which, as discussed above, requires at least 8.5 percent annual emissions reductions, commenced in 2018, coupled with massive global reforestation to return atmospheric CO_2 to below 350 ppm and limit long-term global heating to no more than 1°C.[38]

87. In this failure of governments to cease actions engendering additional emissions and to take immediate and concrete steps to reduce emissions, governments around the world, through their actions and inactions, are ensuring a further increase in the atmospheric concentration of CO_2, and thus a further increase of Earth's energy imbalance – *thereby driving our planet towards and potentially beyond irretrievable climate system tipping points*.

88. This is so because, by exacerbating or locking-in Earth's energy imbalance, such government action and inaction jeopardizes the signal features of the relatively benign and favorable climate system that, over the last 10,000 years, enabled civilization to develop and nature to thrive, as I have discussed. These features included relatively stable coastlines, moderate weather, fertile soils, and dependable hydrological systems – the natural capital on which the lives of young people depend no less than did the lives of their parents and *their* forebears.

[38] *See supra*, ¶68.

89. The resulting diminution of young people's life prospects and ability to exercise their human rights – their compromised ability to earn a living, to meet their basic human needs, to safely raise families, to practice their religious and spiritual beliefs, and otherwise to lead dignified lives – is a predictable if not intended result. In addition, where such government action exacerbates or locks-in Earth's energy imbalance, that, in turn, predictably will lead to the climate change-driven inundation, burning, or other destruction of property in which young people and their families hold interests.

90. Government action that allows the continued increase of atmospheric CO_2 levels, and the consequential long-term impacts on Earth's climate system and the thermal inertia of the ocean, will disproportionately impose harsh burdens on youth and future generations. If fossil fuel emissions are not systematically and rapidly abated, as I have discussed above – including in the materials that I have incorporated by reference – then youth and future generations will confront what reasonably only can be described as, at best, an inhospitable future. That future may be marked by rising seas, coastal city functionality loss, mass migrations, resource wars, food shortages, heat waves, mega-storms, soil depletion and desiccation, freshwater shortage, public health system collapse, and the extinction of increasing numbers of species. That is to mention only the start of it. At this late stage it is important not to sugarcoat the fundamental assault on their basic human rights as articulated in the Convention. While prior and current generations of adults in the developing world have been enriched by the exploitation of fossil fuels, all the world's children and their progeny are now at extreme risk. To be more specific, the continued permitting and promotion of the fossil fuel enterprise by governments now impairs and increasingly will compromise the fundamental natural resources on which youth and future generations will depend. Again, these are the fundamental resources on which the prior and

present generations have relied, and on which youth now and in the future must rely. They include the air, freshwater, the oceans and stable shores, the soil and its agronomic capacity, the forests and its wildlife, biodiversity on earth, and the planet's climate system in a form conducive to civilization, humanity and nature as we know it.

91. Furthermore, it is clear to me that young people's right to governments that retain any significant capacity to address the climate crisis adequately is violated by prior and present actions of governments around the world that exacerbate or lock-in our planet's energy imbalance. In time and, as I have argued, likely within the century, such action will irretrievably damage our planet's favorable climate system. Once begun, for example, collapsing and disintegrating ice sheets will not readily be reformulated – certainly not within a timeframe relevant to present and foreseeable generations. The loss of species too is irretrievable. Many are adapted to specific climate zones, so those species adapted to polar and alpine regions will have no place to run. Present and pending actions by governments now must be viewed in the context of a climate crisis that governments to date have done so much to bring about. Action is required to preserve and restore the climate system such as we have known it in order for the planet as we have known it to be able to continue adequately to support the lives and prospects of young people and future generations. But that cannot be done effectively by future governments if governments currently in power continue to turn a blind eye to a scientifically-defensible standard for CO_2 levels and global warming, and continue to exacerbate the planet's energy imbalance and press our planet towards irretrievable tipping points from which there can be no practical opportunity to return.

92. The rapid growth of coal emissions is both a threat to global climate and a source of hope. If coal can be replaced with carbon-free energy, a huge reduction of global emissions becomes

possible. In view of the responsibility of the major-emitting developed nations for the excess CO_2 in the atmosphere today, it is incumbent upon them not only to rapidly phase out their own fossil fuel emissions, but also to vigorously assist China, India and other rapidly developing nations to replace coal with carbon-free sources of electricity generation.

93. More generally, governments and governing bodies (state, national, and international) need to marshal every available tool, talent, and resource to address and resolve the present crisis with honesty and without further delay.

94. Young people have multiple rights that are guaranteed by national Constitutions, the public trust doctrine, and international agreements– rights that should not be denied without due process. It is the duty of sovereign governments, including every branch of government and every government official, to protect those rights. Specifically, it is a duty of sovereign governments to lead and propose and pursue policies and standards that achieve the required ends, as opposed to ineffectual actions that are demonstrably far short of what is needed.

95. The essential first step, in my view and that of other experts, including economists,[39] is an accord establishing a growing price on CO_2 emissions, which would lead over time to their phase-out. Agreement upon such a domestic fee by major emitters, with a border duty on products from nations that do not have an equivalent domestic carbon fee, would be expected to lead to widespread global movement toward carbon-free energies.

[39] These include three co-authors of our 2013 PLOS One study. *Dangerous Climate Change*. The United States federal government also has understood the central importance of a rising carbon price, and for at least 25 years. *See*, e.g., Congressional Office of Technology Assessment, (1991), *Changing by Degrees: Steps To Reduce Greenhouse Gases*, at 15 ("a particularly effective way of targeting the heaviest economic sanctions against the worst emitters of CO_2.") (http://govinfo.library.unt.edu/ota/Ota_2/DATA/1991/9111.PDF (last visited Aug. 16, 2016). As colleagues and I noted in 2013, *Dangerous Climate Change*, at 19, "[a] rising carbon fee is the *sine qua non* for fossil fuel phase out."

96. I could go on, but I will end here with a summary statement in the light of the foregoing material that I have outlined and referenced, and with the offer to further explain my views and reasoning if requested.

97. Simply put: The persistent permitting and underwriting of fossil fuel projects by governments of the world serves now to further disrupt the favorable climate system that to date enabled human civilization to develop. In order to preserve a viable climate system, our use of fossil fuels must be phased out as rapidly as is feasible. Only governments can ensure this will be done. Instead, sovereign governments initiate, subsidize and permit fossil fuel infrastructure that would close the remaining narrow window of opportunity to stabilize climate and ensure a hospitable climate and planet for young people and future generations. These projects only allow sovereign governments to shirk their duty of care to their people. Governments' permitting of additional, new, or renewed fossil fuel projects is entirely antithetical to their fundamental responsibility to our children and their posterity. Their fundamental rights now hang in the balance.

98. A rapid transition off fossil fuels would have numerous near-term and long-term social benefits, including improved human health and outstanding potential for job creation. There are, accordingly, reasons beyond the mere avoidance of catastrophe for governments to institute the necessary changes, such as my colleagues and I have repeatedly urged.[40] But, based on recent history, mere exhortation to voluntary action, whether directed to governments, as discussed above, or to fossil fuel corporations, is unlikely to be effective in time to secure the fundamental interests of young people and future generations.

99. What can be stated with reasonable scientific certainty is that a rapid phase out of fossil fuel emissions by governments around the world, accompanied by widespread improvements in land use aimed to naturally draw down a portion of the excess atmospheric carbon into the terrestrial system, is fully within our technological reach. In *Dangerous Climate Change*, my

[40] *See*, for example, *Dangerous Climate Change*.

colleagues and I laid out scientifically defensible global temperature and atmospheric CO_2 concentration targets and suggested a glide path to achieve these targets.

100. It is urgent that governments act to reduce emissions on a trajectory tiered to returning atmospheric CO_2 to below 350 ppm and limiting the long-term average global temperature increase above preindustrial levels to below 1^oC. Failure to do so serves only to ruin young people's future and violate their fundamental and inalienable rights.

101. Immediate, effective action to restore Earth's energy balance in time to avert wider disintegration of the major ice sheets would achieve multiple benefits, virtually at the same time. These benefits include slowing and eventually stopping sea level rise, averting further acidification of the oceans and consequential disruption of the marine food chain, slowing and in time stemming the loss of terrestrial species, preserving a viable agricultural system, stemming the growth in wildfires, securing essential water resources – the list goes on.[41]

102. What must be recognized is that atmospheric CO_2 functions now as the control knob for the planet's climate system. Within the remaining period prior to the full manifestation of slow feedbacks and the crossing of climate tipping points of no return, it remains within the power of the governments around the world to help dial it back so as to secure a viable future for our children and their progeny. At this late stage all sovereign governments must do their part to turn this thing around.

[41] Such action also should avert the feared shutdown of the Atlantic Meridional Overturning Circulation. *See* James Hansen and Makiko Sato, (2015), *Predictions Implicit in "Ice Melt" Paper and Global Implications*, Sept. 21, 2015 http://csas.ei.columbia.edu/2015/09/21/predictions-implicit-in-ice-melt-paper-and-global-implications/ (last visited Aug. 16, 2016).

I declare under the penalty of perjury under the laws of the State of Oregon that the foregoing is true and correct.

Signed this 19th day of August, 2016.

Dr. James E. Hansen

Exhibit 1

James E. Hansen

Columbia University Earth Institute, Climate Science, Awareness and Solutions
Interchurch Building, 475 Riverside Drive, Room 239T, New York, NY 10115 jimehansen@gmail.com

1-paragraph bio/introduction:
Dr. James Hansen, formerly Director of the NASA Goddard Institute for Space Studies, is an Adjunct Professor at Columbia University's Earth Institute, where he directs a program in Climate Science, Awareness and Solutions. Dr. Hansen is best known for his testimony on climate change in the 1980s that helped raise awareness of global warming. He is a member of the U.S. National Academy of Sciences and has received numerous awards including the Sophie and Blue Planet Prizes. Dr. Hansen is recognized for speaking truth to power and for outlining actions needed to protect the future of young people and all species on the planet.

1-long-paragraph bio:
Dr. James Hansen, formerly Director of the NASA Goddard Institute for Space Studies, is an Adjunct Professor at Columbia University's Earth Institute, where he directs a program in Climate Science, Awareness and Solutions. He was trained in physics and astronomy in the space science program of Dr. James Van Allen at the University of Iowa. His early research on the clouds of Venus helped identify their composition as sulfuric acid. Since the late 1970s, he has focused his research on Earth's climate, especially human-made climate change. Dr. Hansen is best known for his testimony on climate change to congressional committees in the 1980s that helped raise broad awareness of the global warming issue. He was elected to the National Academy of Sciences in 1995 and was designated by Time Magazine in 2006 as one of the 100 most influential people on Earth. He has received numerous awards including the Carl-Gustaf Rossby and Roger Revelle Research Medals, the Sophie Prize and the Blue Planet Prize. Dr. Hansen is recognized for speaking truth to power, for identifying ineffectual policies as greenwash, and for outlining actions that the public must take to protect the future of young people and other life on our planet.

3-paragraph bio:
Dr. James Hansen, formerly Director of the NASA Goddard Institute for Space Studies, is an Adjunct Professor at Columbia University's Earth Institute, where he directs a program in Climate Science, Awareness and Solutions. He was trained in physics and astronomy in the space science program of Dr. James Van Allen at the University of Iowa, receiving a bachelor's degree with highest distinction in physics and mathematics, master's degree in astronomy, and Ph. D. in physics in 1967. Dr. Hansen was a visiting student, at the Institute of Astrophysics, University of Kyoto and Dept. of Astronomy, Tokyo University, Japan from 1965-1966. He received his Ph.D. in physics from the University of Iowa in 1967. Except for 1969, when he was an NSF post-doctoral scientist at Leiden Observatory under Prof. H.C. van de Hulst, he has spent his post-doctoral career at NASA GISS.

In his early research Dr. Hansen used telescopic observations of Venus to extract detailed information on the physical properties of the cloud and haze particles that veil Venus. Since the mid-1970s, Dr. Hansen has focused on studies and computer simulations of the Earth's climate, for the purpose of understanding the human impact on global climate. He is best known for his testimony on climate change to Congress in the 1980s that helped raise broad awareness of the global warming issue. In recent years Dr. Hansen has drawn attention to the danger of passing climate tipping points, producing irreversible climate impacts that would yield a different planet from the one on which civilization developed. Dr. Hansen disputes the contention, of fossil fuel interests and governments that support them, that it is an almost god-given fact that all fossil fuels must be burned with their combustion products discharged into the atmosphere. Instead Dr. Hansen has outlined steps that are needed to stabilize climate, with a cleaner atmosphere and ocean, and he emphasizes the need for the public to influence government and industry policies.

Dr. Hansen was elected to the National Academy of Sciences in 1995 and, in 2001, received the Heinz Award for environment and the American Geophysical Union's Roger Revelle Medal. Dr. Hansen received the World Wildlife Federation's Conservation Medal from the Duke of Edinburgh in 2006 and was designated by Time Magazine as one of the world's 100 most influential people in 2006. In 2007 Dr. Hansen won the Dan David Prize in the field of Quest for Energy, the Leo Szilard Award of the American Physical Society for Use of Physics for the Benefit of Society, and the American Association for the Advancement of Science Award for Scientific Freedom and Responsibility. In 2008, he won the Common Wealth Award for Distinguished Service in Science and was also awarded both the Ohio State University's Bownocker Medal and the Desert Research Institute's Nevada Medal. In 2009, Dr. Hansen received the American Meteorological Society's Carl-Gustaf Rossby Research Medal. In 2010 he received the Sophie Prize and the Blue Planet Prize.

Additional Information:

Http://www.columbia.edu/~jeh1/
http://www.columbia.edu/~mhs119/
Photos: http://ww.mediafire.com/?8ecel33ccmg81

Education:

BA with highest distinction (Physics and Mathematics), University of Iowa, 1963
MS (Astronomy), University of Iowa, 1965
Visiting student, Inst. of Astrophysics, University of Kyoto & Dept. of Astronomy, Tokyo University, Japan, 1965-1966
Ph.D. (Physics), University of Iowa, 1967

Research Interests:

Analysis of the causes and consequences of global climate change using the Earth's paleoclimate history, ongoing global observations, and interpretive tools including climate models. Connecting the dots all the way from climate observations to the policies that are needed to stabilize climate and preserve our planet for young people and other species.

Professional Employment:

1967-1969	NAS-NRC Resident Research Associate: Goddard Institute for Space Studies (GISS), NY
1969	NSF Postdoctoral Fellow: Leiden Observatory, Netherlands
1969-1972	Research Associate: Columbia University, NY
1972-1981	Staff Member/Space Scientist: Goddard Institute for Space Studies (GISS), Manager of GISS Planetary and Climate Programs
1978-1985	Adjunct Associate Professor: Department of Geological Sciences, Columbia University
1981-2013	Director: NASA Goddard Institute for Space Studies
1985-present	Adjunct Professor: Earth and Environmental Sciences, Columbia University
2013-present	Director: Program on Climate Science, Awareness and Solutions, Columbia University

Project Experience:

1971-1974	Co-Principal Investigator AEROPOL Project (airborne terrestrial infrared polarimeter)
1972-1985	Co-Investigator, Voyager Photopolarimeter Experiment
1974-1994	Principal Investigator (1974-8) and subsequently Co-Investigator, Pioneer Venus Orbiter Cloud-Photopolarimeter Experiment
1977-2000	Principal Investigator, Galileo (Jupiter Orbiter) Photopolarimeter Radiometer Experiment

Teaching Experience:

Atmospheric Radiation (graduate level): New York Univ., Dept. of Meteorology & Oceanography
Intro. to Planetary Atmospheres & Climate Change: Columbia Univ., Dept. of Geological Sciences

Awards:

1977	Goddard Special Achievement Award (Pioneer Venus)
1978	NASA Group Achievement Award (Voyager, Photopolarimeter)
1984	NASA Exceptional Service Medal (Radiative Transfer)
1989	National Wildlife Federation Conservation Achievement Award
1990	NASA Presidential Rank Award of Meritorious Executive
1991	University of Iowa Alumni Achievement Award
1992	American Geophysical Union Fellow
1993	NASA Group Achievement Award (Galileo, Polarimeter/Radiometer)
1996	Elected to National Academy of Sciences
1996	GSFC William Nordberg Achievement Medal
1996	Editors' Citation for Excellence in Refereeing for Geophysical Research Letters
1997	NASA Presidential Rank Award of Meritorious Executive
2000	University of Iowa Alumni Fellow
2000	GISS Best Scientific Publication (peer vote): "Global warming – alternative scenario"
2001	John Heinz Environment Award
2001	Roger Revelle Medal, American Geophysical Union
2004	GISS Best Scientific Publication (peer vote): 'Soot Climate Forcing'

2005	GISS Best Scientific Publication (peer vote): 'Earth's Energy Imbalance'
2006	Duke of Edinburgh Conservation Medal, World Wildlife Fund (WWF)
2006	GISS Best Scientific Publication (peer vote): 'Global Temperature Change'
2006	*Time Magazine* designation as one of World's 100 Most Influential People.
2007	Laureate, Dan David Prize for Outstanding Achievements & Impacts in Quest for Energy
2007	Leo Szilard Award, American Physical Society for Outstanding Promotion & Use of Physics for the Benefit of Society
2007	Haagen-Smit Clean Air Award
2008	American Association for the Advancement of Science Award for Scientific Freedom and Responsibility
2008	Nevada Medal, Desert Research Institute
2008	Common Wealth Award for Distinguished Service in Science
2008	Bownocker Medal, Ohio State University
2008	Rachel Carson Award for Integrity in Science, Center for Science in the Public Interest
2009	Carl-Gustaf Rossby Research Medal, American Meteorological Society
2009	Peter Berle Environmental Integrity Award
2010	Sophie Prize for Environmental and Sustainable Development
2010	Blue Planet Prize, Asahi Glass Foundation
2011	American Association of Physics Teachers Klopsteg Memorial Award for communicating physics to the general public
2011	Edinburgh Medal from City of Edinburgh, Edinburgh Science Festival
2012	Steve Schneider Climate Science Communications Award
2012	*Foreign Policy* designation as one of its Top 100 Global Thinkers
2013	Ridenhour Courage Prize
2013	NASA Distinguished Service Medal
2014	Center for International Environmental Law's Frederick R. Anderson Award for Outstanding Contributions to Addressing Climate Change
2014	Walker Prize, Museum of Science, Boston

Publications:

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