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Uncertainty as the Reason for Action: Last Opportunity and Future Climate Disaster

Abstract: In cases in which there is the possibility of massive human losses, the threshold likelihood of their occurrence, and the non-excessive costs of their prevention, we ought to act now. This is all the more definitely the case because it may well be that this is the time-of-last-opportunity to head off one or more potential disasters, all of which may still be preventable by sufficiently rapid reductions in carbon emissions from the combustion of fossil fuel. It is unfair that the present generation should incur as heavy a burden as it does of seizing the last opportunity for prevention of disasters like large sea-level rises, but the unfairness is not sufficient to make the burden unreasonable to bear, especially since it is not in fact as heavy as often believed.

Keywords: Irreversibility, precautionary principle, sea-level rise

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'Far from being an aberration, 'catastrophe' forms
an integral part of human history.'[1]

'Uncertainty is *not* our friend when it comes to the prospects
for dangerous climate change.'[2]

'Most everything we know tells us climate change is bad.
Most everything we don't know tells us it's probably much worse.'[3]

Ordinarily we tend to take uncertainty as a reason not to act. Often this is perfectly reasonable, at least when the uncertainty is genuine.[4] Uncertainty can sometimes provide a solid basis for inaction when inaction reduces the danger of taking the wrong action (at worst: the danger of doing something counter-productive - an action that makes a situation worse), when inaction reduces the danger of acting where no action is needed (and thereby making pointless

1 Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven, Ct.: Yale University Press, 2014), p. xxxii. I am grateful to Simon Caney for the reference to Parker.

2 Michael Mann, 'The 'Fat Tail' of Climate Change Risk', *Huff Post Green*, 11 September 2015. <http://www.huffingtonpost.com/michael-e-mann/the-fat-tail-of-climate-change-risk_b_8116264.html>.

3 Gernot Wagner and Martin L. Weitzman, *Climate Shock: The Economic Consequences of a Hotter Planet* (Oxford and Princeton: Princeton University Press, 2015), p. xi. For an accessible explanation of probability densities with 'fat tails', see pp. 48-58.

4 In the case of climate change much of the politically salient uncertainty in the United States has been what Steve Vanderheiden aptly called 'manufactured uncertainty' - see Steve Vanderheiden, *Atmospheric Justice: A Political Theory of Climate Change* (New York: Oxford University Press, 2008), pp. 38-43. The method of manufacture was documented by Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York and Berlin: Bloomsbury Press, 2010), especially pp. 169-215.

sacrifices, expending wasted effort, or incurring needless costs), and when inaction reduces the risk of doing more than one's fair share, *if* it is justified and important to do no more. But two features connected with time combine to generate circumstances in which uncertainty becomes part of a compelling reason for action, not inaction. One is the irretrievability of opportunities lost through the passage of time – the irreversibility of history – especially as embodied in the inexorable fundamental dynamics of earth's climate that are slow to change and slow to change back once they have changed. The other is the closely connected profoundly asymmetrical relationship between those who live now and whoever will live in future. Or so I will try to show. And then the questions arise whether the action that I maintain is required in these circumstances would be unfairly or otherwise unreasonably demanding. So, first we examine some issues about precaution and then some consequent issues about fairness.

I would like to build upon two of my earlier analyses that highlighted facets of the one-way path between present and future. I will begin by developing a previously unseen connection between the two of them. It is essential that one refrain from 'treating all shadows as equal, all futures as equally foreclosed'[5] – one must avoid any paranoid inclinations and be highly selective in the worries one takes seriously. First, in 'Deadly Delays, Saving Opportunities' I nevertheless contend that in at least one specific set of circumstances one ought to act urgently and vigorously in spite of uncertainty.[6] Emphasizing that the fact that a probability is unknown does not to any extent imply that the probability is small, I specified cases in which one ought to 'ignore entirely questions of probability beyond a certain minimal level of likelihood' by noticing three features that jointly constitute a sufficient set for prompt and robust action to be required: '(1) *massive loss*: the magnitude of the possible losses is massive; (2) *threshold likelihood*: the likelihood of the losses is significant, even if no precise probability can be specified, because (a) the mechanism by which the losses would occur is well understood, and (b) the conditions for the functioning of the mechanism are accumulating; and (3) *non-excessive costs*: the costs of prevention are not excessive …'[7] Obviously threshold likelihood is

5 Paul Saint-Amour, 'The Stone: Waiting for the Bomb to Drop', *New York Times*, 3 August 2015.

6 Henry Shue, 'Deadly Delays, Saving Opportunities: Creating a more dangerous world?' *Climate Justice: Vulnerability and Protection* (Oxford: Oxford University Press, 2014), pp. 263-286. All quotations following immediately in the text are from pp. 265-266.

7 In her far more thorough analysis, *A Climate of Risk: Precautionary principles, catastrophes, and climate change* (under review) Lauren Hartzell Nichols maintains that it is a mistake to embed the consideration of cost in the principle itself and recommends reserving it until an implementation stage. This is a difficult issue about the relation of principle and implementation. However, her Catastrophic Precautionary Principle, which is an important contribution, is intended as a prima facie moral principle, while I am attempting to formulate a sufficient condition for action to be required and consequently cannot postpone issues of relative costs.

intended to take over the role that would be played by a calculable probability, if one were available, for the cases of potential massive human loss with non-excessive costs of prevention. Threshold likelihood, which is the 'anti-paranoia requirement' in the sufficient set, combines (a) a requirement of theory – a well-understood mechanism – with (b) a requirement of supporting empirical observations – conditions needed for the mechanism to function are seen to be coming together. The fundamental argument in support of these three conditions being jointly sufficient for action to be required is 'that because the magnitude of particular losses is so serious, the only acceptable probability is as close as possible to zero, provided this reduction in likelihood can be achieved at a cost that is not inordinate'.[8] Because it is uncertain whether massive losses will occur, it is entirely possible that unknown to us it is likely – I repeat: that the probability is unknown does not in any way support an assumption that it is small. But its being likely is unacceptable because such massive losses are so terrible, so we ought to act in order to make the potential catastrophe as unlikely as we can until the marginal costs of trying to block it become inordinate, or we meanwhile find compelling evidence that its probability is indeed low. If, through, for instance, extravagant greenhouse gas emissions, we have been opening doors to intolerable dangers, we ought to re-close as many of those doors as we can as fast as we can.

Clearly, then, this set of three jointly sufficient conditions constitutes one very particular narrowly-focused version of a precautionary principle. Precautionary principles come in many importantly and controversially different formulations. One distinctive feature of this one is its incorporation of empirical information by way of the condition of threshold likelihood. In her discussion of a different precautionary principle, which requires one 'adequately to protect' people from harm, Catriona McKinnon notes the danger that 'what is adequate loses its anchor, and we must rely on guesswork', especially in cases in which 'we remain strongly uncertain of the probability of these catastrophes within the range of anything more than zero,

8 This draws on a suggestion about how to deal with prospects that are 'infinitely awful', or 'virtually infinitely awful', made long ago by Robert Goodin, 'Nuclear Disarmament as a Moral Certainty', *Ethics* 95 (1985), 641-658, p. 648. More needs to be said about how to decide when costs are 'inordinate'. Although this is not the place to explore them, this proposal also has similarities with, and dissimilarities from, two other interesting suggestions that also, like Goodin's, emerged from thinking about the catastrophic effects of the use of nuclear weapons, including 'nuclear winter', which is a transient form of climate change. One is Gregory Kavka's 'Disaster Avoidance Principle (DAP)' - see Gregory S. Kavka, 'Deterrence, Utility, and Rational Choice', *Theory and Decision*,12 (1980), 50; rpt. in Gregory S. Kavka, *Moral Paradoxes of Nuclear Deterrence* (Cambridge: Cambridge University Press, 1987), p. 67. The other is Jeff McMahan's Worst Disaster Avoidance Principle - see Jefferson McMahan, 'Nuclear Deterrence and Future Generations', in Avner Cohen and Steven Lee (eds.), *Nuclear Weapons and the Future of Humanity: The Fundamental Questions* (Totowa, N.J.: Rowman and Allanheld, 1986), 319-339, p. 321. Valuable comparative discussion of Goodin, Kavka, and McMahan is in John Finnis, Joseph Boyle, and Germain Grisez, *Nuclear Deterrence, Morality and Realism* (Oxford: Clarendon Press, 1987), pp. 189-194 and pp. 219-233.

and anything less than 100' [i.e., certainty].[9] What I hope to have shown is that even where specific probabilities cannot be assigned, scientists can develop theoretical understanding of mechanisms and make empirical observations about the conditions for the mechanisms to activate that will provide a firm anchor in one kind of situation requiring decisive precautionary action.[10]

Second, in 'Distant Strangers and the Illusion of Separation: Climate, Development, and Disaster' I emphasize that 'the fact that whether profoundly important events – sometimes disastrous events – will occur centuries into the future will be determined by the choices made by the present set of generations' is 'a fundamental kind of structural feature of the asymmetrical relationship between present generations and generations in the far future.'[11] We choose some of the basic structures of the world in which generations who succeed us must at least begin to live their lives. Whether over the course of their lives they can modify aspects of this fundamental architecture is at best an open question – many structural changes, like changes in global energy regime, take more than a single generation to bring about, when they are possible at all. This means that the time-of-last-opportunity to prevent many disasters occurs much earlier than the actual beginning of the disaster – sometimes decades, sometimes centuries, earlier.[12] The clouds must gather before the storm can break. And for some kinds of clouds, once they have gathered, the storm will come, however long it takes for it to develop. Scientists call this 'commitment', technologists call it 'lock-in', and others call it a 'tipping point'. I illustrate the conception of times-of-last-opportunity with the now well-supported finding of the irreversibility of the melting and collapse of the West Antarctic Ice Sheets, which became irreversible before most people realized what was happening. The general argument in 'Deadly Delays' for treating the set of conditions proposed as sufficient had been that continuing to burn fossil fuels is clearly feeding various degrees and varieties of danger by fulfilling a crucial condition for the functioning of various well-understood climate mechanisms; and I had noted 'four aspects of danger' [269] but, in an attempt to skirt widely around alarmism, had set aside the fourth. This fourth, however, was catastrophic danger, which I happened to illustrate by, among other things, the

9 Catriona McKinnon, 'Runaway Climate Change: A justice-based case for precautions', *Journal of Social Philosophy* 40 (2009), 187-203, p. 190 and pp. 197-198. Unlike McKinnon's valuable formulation, my precautionary principle is not based on a specific principle of justice.

10 See, for example, N.R. Golledge, D.E. Kowalewski, T.R. Naish, et al., 'The Multi-Millenial Antarctic Commitment to Future Sea-level Rise', *Nature* 526 (2015), 421-425.

11 Henry Shue, 'Distant Strangers and the Illusion of Separation: Climate, Development, and Disaster', in Thom Brooks (ed.), *The Oxford Handbook of Global Justice* (Oxford: Oxford University Press, forthcoming).

12 One way to understand this is the following: before the catastrophe itself becomes imminent, the last chance to prevent it becomes imminent. The latter is in its own way also an imminent danger/opportunity. I was helped to see the significance of this by the manuscript of Hartzell Nichols' *Climate of Risk*.

potential collapse of the West Antarctic Ice Sheet [WAIS]. At that earlier time I quoted the somewhat consoling judgement of the 2007 IPCC Science Report that the WAIS collapse was 'not considered likely to occur in the 21st century'.[13] The new research reported in 2014 (after the cut-off date for even the 2013 IPCC Science Report) still suggests that most of the collapse will not occur in the 21st century, but in finding that the collapse is now irretrievably underway, the 2014 research shows that the collapse will in fact occur, most likely stretched over the next 200/300 years.[14]

The previously unseen connection that now seems clear is that an exceptionally powerful reason to accept that the conditions specified in 'Deadly Delays' are indeed sufficient is that if one does not act when those conditions are satisfied, one may fail to act while the time-of-last-opportunity for preventing one or more additional true catastrophes passes unobserved – precisely, we know since 2014, as humanity already tragically has done in the case of the melting of WAIS! To the extent that humans fail to change our behaviour in time, we create not simply 'dangers' but *fait accompli*, rolling catastrophes to which future generations can try to adapt or from which they can attempt to flee (by, for example, trying to migrate from the regions inundated by the sea-level rises and threatened by the new levels of storm surges from the water released by the melting ice), but which they cannot stop. It is difficult to imagine a better reason for action than avoidance of our imposition of society-disrupting levels of catastrophe on hundreds of millions of temporally distant strangers through continuing business-as-usual.[15] This is the promised connection between the two earlier analyses.

What Did We Know and When Did We Know It?

We ought not to become diverted into any 'blame games' regarding who, if anyone, was at fault for our failure to act against fossil fuel burning soon

13 Gerald A. Meehl, Thomas F. Stocker, William D. Collins, et al., 'Global Climate Projections', in Susan Solomon, Dahe Qin, Martin Manning, et al. (eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007), p. 818.

14 See Thomas Sumner, 'No Stopping the Collapse of West Antarctic Ice Sheet', *Science* 344 (2014), p. 683, <DOI:10.1126/science.344.6185.683>; Ian Joughin, Benjamin E. Smith, and Brooke Medley, 'Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica', *Science* 344 (2014), 735-738, <DOI:10.1126/science.1249055>; and E. Rignot, J. Mouginot, M. Morlighem, H. Seroussi, and B. Scheuchl, 'Widespread, Rapid Grounding Line Retreat of Pine Island, Thwaites, Smith, and Kohler Glaciers, West Antarctica, From 1992 to 2011', *Geophys. Res. Lett.* 41 (2014), 3502–3509, <DOI:10.1002/2014GL060140>. Also see Chris Mooney, 'Scientists Are Still Trying to Figure Out How Fast We Could Lose West Antarctica', *Washington Post* (20 August 2015); and - for conflict between what is suggested about the future in this case by climate models and by paleoclimate history - see Paul A. Mayewski, T. Bracegirdle, I. Goodwin, et al., 'Potential for Southern Hemisphere Climate Surprises', *Journal of Quaternary Science* 30 (2015), 391-395, <DOI:10.1002/jqs2794>.

15 Specifically which people whose continuation of business-as-usual is responsible for the imposition of catastrophe is of course a long story. My most recent attempts to tell parts of it are: 'Transboundary Damage in Climate Change: Criteria for Allocating Responsibility', in André Nollkaemper & Dov Jacobs (eds.), *Distribution of Responsibilities in International Law* (Cambridge: Cambridge University Press, 2015), 321-340 - also available on-line on SSRN; and 'Historical Responsibility, Harm Prohibition, and Preservation Requirement: Core Practical Convergence on Climate Change', *Moral Philosophy and Politics* 2 (2015), 7-31. <DOI:10.1515/mop-2013-0009>; published on-line: 30/9/2014.

enough to avert the irreversible collapse of WAIS. However, some consideration of the epistemological situation has other value. One of the tricks currently being employed by politicians who have been irresponsible for years about the threats to security posed by climate change is to feign shock at the sudden, surprise discovery that the human use of fossil fuel is driving climate change. On the one hand, of course, no such sudden or surprise finding has occurred. The basic dynamics of climate change have been understood for well over a century,[16] and scientists have been struggling for decades to make the dangers politically salient to politicians who usually see only dangers with supposed military solutions. In his valuable brief history of the political emergence of the issue of climate change, Dale Jamieson mentions, for example, a report in 1965 - the year the U.S. sent Marines to seize control of the Dominican Republic - to President Lyndon B. Johnson by the President's Science Advisory Committee, Panel on Environmental Pollution, with an appendix on 'Atmospheric Carbon Dioxide'; and elements of the UN, which is hardly famous for rapid reactions, established in 1988 the IPCC, which brought out a substantial report in 1990.[17] Any ignorance about climate change after about 1990 on the part of societal leaders, whose principal role after all is to know about the primary threats to their societies and to respond effectively, is culpable, if not wilful.

On the other hand, one of the two 2014 articles providing evidence of irreversible collapse of WAIS observes in passing that 'the ice stream was already out of balance before 1996, which may have been the result of thinning that

16 See Gale E. Christianson, *Greenhouse: The 200-Year Story of Global Warming* (London: Penguin Books, 1999). This study in intellectual history is especially persuasive because it was written at a time when the author clearly was not yet fully convinced about anthropogenic climate change. Irish physicist John Tyndall revealed in his Bakerian Lecture to the Royal Society in London on 7 February 1861 that carbon dioxide absorbed surprising amounts of radiation, much more than a number of other gases - see Peter Moore, 'The Great Victorian Weather Wars', *New York Times*, 7 August 2015. For the classic scientific papers, see David Archer and Raymond Pierrehumbert (eds.), *The Warming Papers: The Scientific Foundation for the Climate Change Forecast* (Oxford: Wiley-Blackwell, 2011).

17 See Dale Jamieson, *Reason in a Dark Time: Why the Struggle Against Climate Change Failed – and What It Means for Our Future* (New York: Oxford University Press, 2014), p. 20; Bert Bolin, *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007), pp. 43-52; and John T. Houghton, Geoff J. Jenkins, and Jim J. Ephraums (eds.), *Climate Change: The IPCC Scientific Assessment, Report Prepared for IPCC by Working Group I* (Cambridge: Cambridge University Press, 1990) - the science volume of the three-volume 'First Assessment Report'. The first page of the IPCC's 'Policymakers' Summary' of the science report said: 'We calculate with confidence that: some gases are potentially more effective than others at changing climate, and their relative effectiveness can be estimated. Carbon dioxide has been responsible for over half the enhanced greenhouse effect in the past, and is likely to remain so in the future.... The longer emissions continue to increase at present day rates, the greater reductions would have to be for concentrations to stabilise at a given level. The long-lived gases would require immediate reductions in emissions from human activities of over 60% to stabilize their concentrations at today's levels....', p. xi. To be confident that the climate would not change emissions of carbon dioxide would need to be reduced by more than 60% - what else exactly did prudent politicians taking due care of their constituents' interests need to know in 1990? The 'Policymakers' Summary', which was also published separately as a small booklet by the World Meteorological Organization and the United Nations Environment Programme (the sponsors of the IPCC), contained as an Annex four emissions scenarios calculated by the USA and the Netherlands from the First Report of IPCC Working Group III. These were promptly followed up by John T. Houghton, Bruce A. Callander and Shelagh K. Varney (eds.), *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment, Report Prepared for IPCC by Working Group I* (Cambridge: Cambridge University Press, 1992). The three-volume Second Assessment Report appeared in 1995.

caused the ice to unground several decades or more ago from a ridge seaward of the present grounding line'.[18] Several decades earlier would be no later than around the time of World War II when average global temperature had, we now also know, indeed already been rising for several decades and could have started the thinning of the ice in question. And in 1978 glaciologist J.H. Mercer had suggested: 'If the CO_2 greenhouse effect is magnified in high latitudes, as now seems likely, deglaciation of West Antarctica would probably be the first disastrous result of continued fossil fuel consumption'.[19]

People other than specialists on the cryosphere can, I suppose, be excused for not firmly grasping decades ago that a global disaster for coastal residents was then already in the works.[20] So one is tempted to conclude that the collapse of WAIS is one catastrophe that crept up on the public and the politicians, even if not on all the scientists, before they could have been expected to be fully aware and that it would be unreasonable to try to hold anyone responsible for failing to guard against it.[21] However, my fundamental thesis here, defended throughout the article, is that one is sometimes responsible for acting cautiously and with care well before one is 'fully aware' that a potential danger will definitely be actualized. So I think we can hold politicians of earlier decades responsible because and to the extent that they failed to take a sufficiently precautionary approach. In any case, in 2015 the situation has been entirely transformed by additional decades of accumulated climate science, surveyed now in five periodic IPCC syntheses, each containing a brief and extremely conservative 'Summary for Policymakers', and a continuing flood of scientific articles by hundreds of humanity's brightest minds, publicly and critically assessing and refining each hypothesis regarding climate.

My central thesis in 'Deadly Delays' in 2010 was, as we have just seen above, that we ought to take urgent action when there is '*threshold likelihood*: the likelihood of the losses is significant, even if no precise probability can be specified, because (a) the mechanism by which the losses would occur is well understood, and (b) the conditions for the functioning of the mechanism

18 Joughin, Smith, and Medley, 'Marine Ice Sheet Collapse', p. 737. The grounding line is the last point at which an ice sheet rests on ground - the point at which the ice becomes instead an ice shelf floating on the ocean.

19 John H. Mercer, 'West Antarctic Ice Sheet and CO_2 Greenhouse Effect: a threat of disaster', *Nature* 271 (26 January 1978), 321-325, p. 325.

20 For accessible general background, see David Archer and Stefan Rahmstorf, *The Climate Crisis: An Introductory Guide to Climate Change* (Cambridge: Cambridge University Press, 2010), 'Snow and Ice', 68-85. They concluded (already in 2010): 'The ice sheets in Greenland and Antarctica hold enough water to flood the continents by 70 meters, a change that would be visible on a grade-school globe of the earth. The ice sheets appear to be responding to warming so far much more quickly than had been predicted, and in ways which hadn't been thought of', pp. 84-85.

21 I was *very* tempted indeed until Simon Caney pointed out that I was failing to apply to the past the same standard I recommend applying to the present. See his argument in 'Climate Change and the Duties of the Advantaged', *Critical Review of International Social and Political Philosophy* 13 (2010), 203-228, pp. 208-209.

are accumulating'.[22] We face no shortage of potential disasters from climate change if emissions of carbon dioxide from burning fossil fuels exceed any reasonable cumulative carbon budget, as they will soon do unless they are very sharply cut.[23] Several of them involve the melting of ice that will add many cubic miles of water to the oceans: melting of the East Antarctic Ice Sheet (far larger than WAIS - enough water to raise sea-level by 50 meters[24]); melting of the Greenland Ice Sheet (also larger than WAIS – enough water to raise sea-level by 7 meters); further melting of Arctic ice that could dilute the salinity of, and thereby disrupt, the Atlantic Meridional Overturning Circulation [AMOC] that warms Western Europe (as happened in the Younger Dryas just before the beginning of the quiet 10,000 years of the Holocene in which human agriculture has flourished)[25]; and thawing of the Siberian permafrost that would release a surge of methane. Scientists understand the general mechanisms ([a] in 'Deadly Delays') by which each of these processes can occur and, in the past, have occurred – in some instances, like the disruption of the AMOC by Arctic melting, a number of documented times in the past. The difficulty may seem to be that they may not fully grasp the state of all the conditions ([b] in 'Deadly Delays') – and in some cases, alternative sets of possible conditions – that need to come together to launch the process in question. Ice can melt, for example, either because the air temperature above the ice sheets and ice shelves is warmer or because the ocean water beneath the ice shelves, and in some cases bathing the seaward edge of the ice sheet at the grounding line, is warmer.[26] Air temperature and water temperature need not move in lock-step, especially when winds that drive ocean currents change direction or speed.

22 The other two conditions making up the sufficient set were *massive loss*, which is what makes the possible outcome a disaster, and *non-excessive costs*, which is essential to making efforts at prevention reasonable to bear (Shue (2014), p. 265).

23 For a clear and accessible explanation of what is meant by the cumulative carbon budget and its relevance to policy, see David J. Frame, Adrian H. Macey and Myles R. Allen, 'Cumulative emissions and climate policy', *Nature Geoscience* 7 (published online: 21 September 2014), 1-2, <doi:10.1038/ngeo2254>. For the original formulation, see Myles Allen, David Frame, Katja Frieler, *et al.*, 'The Exit Strategy', Nature Reports Climate Change 3 (published online: 30 April 2009), 56-58, <doi:10.1038/climate.2009.38>. For disturbing recent calculations indicating that 'the total quota [budget] will likely be exhausted in a further 30 years at the 2014 emissions rates', see P. Friedlingstein, R.M. Andrew, J. Rogelj, et al., 'Persistent growth of CO2 emissions and implications for reaching climate targets', *Nature Geoscience* 7 (2014), 709-715, DOI:10.1038/NGEO2248. Wagner and Weitzman (2015) conclude: 'With the immense longevity of atmospheric carbon dioxide, "wait and see" would amount to wilful blindness' (p. 79).

24 See National Snow & Ice Data Center, *State of the Cryosphere: Ice Sheets*. <https://nsidc.org/cryosphere/sotc/ice_sheets.html>.

25 See Paul Gierz, Gerrit Lohmann, and Wei Wei, 'Response of Atlantic overturning to future warming in a coupled atmosphere-ocean-ice sheet model', *Geophysical Research Letters* (31 August 1015) - open access: <http://onlinelibrary.wiley.com/doi/10.1002/2015GL065276/full>; and J.W. Partin, T.M. Quinn, C.-C. Shen, et al., 'Gradual onset and recovery of the Younger Dryas abrupt climate event in the tropics', *Nature Communications* 6 (2015) - <doi:10.1038/ncomms9061>. For an account for non-scientists of the significance of these first two articles, see Joby Warrick, 'New studies deepen concerns about a climate-change "wild card"', *Washington Post* (7 September 2015). Also see Stefan Rahmstorf, Jason E. Box, George Feulner, et al., 'Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation', *Nature Climate Change* 5 (2015), 475-480. <doi:10.1038/NCLIMATE2554>.

26 Ice shelf Larsen C, for example, is suffering both 'basal melting' (from warming water) and 'surface melting' (from warming air) - see P.R. Holland, A. Brisbourne, H.F.J.Corr, *et al.*, 'Oceanic and atmospheric forcing of Larsen C Ice-Shelf thinning', *The Cryosphere* 9 (2015), 1005-1024, <doi:10.5194/tc-9-1005-2015>.

So it is clear that all these events have happened in the distant past (although mostly before humans were around to be threatened by them so not as 'disasters' in the anthropocentric sense) and will happen again if we continue much longer to force the climate to change by modifying the composition of the planet's atmosphere with our emissions. But the scientists do not know enough about the possible combinations of conditions that can launch each process to be able to say when it might occur or what the probability of its occurrence is, even if a specific level of greenhouse gas emissions is assumed. The re-occurrence of each of these disasters is entirely possible - having occurred at earlier points in earth's history – but uncertain for the near future.

What to do? How should we think about what to do? How does one prevent a causally sufficient set of conditions for a particular disaster from gathering if one does not know all the conditions in the set – or likely, all the conditions in all the alternative sets, since processes can be launched in alternative ways? How can we reflect on our own responsibility, if any, if we do not adequately understand the climatic processes in which we are involved? Perhaps what we do does not matter. Fortunately, an extremely elementary point of logic is actually of some help here.

On the one hand, one way to prevent a process from occurring is, as the preceding has been presupposing, to figure out all the members of the causally sufficient set, or sets, for its occurrence, and then see to it that not all of the conditions ever come together. If I know that if you are in a bad mood, your girl-friend is present, and I say that you appear to be becoming fat, you will punch me, then I know that a bad mood plus a girl-friend within hearing range plus a comment about excessive weight is a sufficient set for a punch. And it is easy to figure out how not to get punched. Either I must wait to comment until you are in a good mood, I must wait until your girl-friend leaves, or I must not say that you seem to be becoming fat – I merely must arrange that not all three conditions come together. But we have just noted that we do not know enough about the conditions leading to the various processes that produce specific climate disasters to be very confident about whether a sufficient set of conditions, which in this case will be considerably more complicated, are about to come together.

On the other hand, sometimes there is a short-cut to avoiding the accumulation of a sufficient set of conditions because at least one condition that is in the sufficient set is also necessary, which means that however many sufficient sets there are, this one condition must be in all of them. Then I can prevent any sufficient set from coming together simply by blocking the

necessary condition. Nothing else needs to be done, and I do not need to know anything except that this is a necessary condition for the occurrence of the process that I wish not to occur. Suppose I find out that you are a very placid fellow and almost never punch anyone – indeed I find out (never mind how) that you never punch anyone unless he implies that you are getting fat. Now if I want to be sure not to get punched, I do not have to try to figure out how good a mood you are in or whether your girl-friend is within earshot. All I have to do is not comment on your apparent weight. I block the necessary condition and thereby prevent the occurrence of the process for which it is necessary: no necessary condition, no process.

Obviously it is extremely difficult to establish that any condition is causally necessary for the occurrence of some natural process.[27] If, however, our primary concern is a practical interest in preventing the process for which, as far as we can tell, the condition is necessary, the best strategy is to block the evidently necessary condition. If the condition turns out not to be strictly necessary, this strategy will of course not work, and we will have to re-assess. But on the basis of what we know, it may be a very promising strategy – possibly, the best.

Suppose that there are a number of processes that we would like to prevent and that every one of them seems on the available evidence to have the same necessary condition: we know of no case of the tentative beginnings of one of the undesirable processes that was not preceded by this one condition. Then the strategy of blocking that condition looks much more promising still: even if the condition turns out surprisingly not to be necessary to one or more of the undesirable processes, it may be necessary to several others. And on the basis of everything we know it looks necessary to them all. If it is important to prevent as many of these processes as possible, going after the evidently necessary condition for them looks very promising indeed.

Now obviously I am talking in highly abstract terms about the possible disasters like the melting of the Greenland ice sheet and the thawing of the Siberian permafrost, and the necessary condition is the increase in atmospheric carbon dioxide over the last century and a half. For 10,000 years the atmospheric carbon dioxide remained within a narrow band of variation, and the WAIS did not melt, the East Antarctic Ice Sheet did not melt, AMOC was not disrupted, the permafrost did not thaw, etc. In recent decades atmospheric carbon dioxide has been shooting up ever higher, and there is straightforward empirical evidence that these various disastrous processes are making tentative, but possibly still reversible, starts. Is this a 'mere

27 Logical necessity is of course another matter but is no help to us here.

correlation'? Absolutely not: climate science contains explanations of the mechanisms by which increased cumulative atmospheric concentrations of carbon dioxide lead to processes like the melting of polar ice. In other words, besides (1) observable correlations, there are (2) strong theoretical explanations. Further, (3) increasingly well validated modelling also supports the same correlations, as do (4) multiple findings from the depths of geological history. Evidence, theory, modelling, and earth history are all four converging on the importance of cumulative carbon emissions.[28] In short, according to multiple methodologies, the best strategy for avoiding the disasters appears to be to eliminate the carbon emissions. The carbon emissions seem to be a necessary condition for multiple disasters.

Too Much to Ask of Us?

So, 'somebody ought to do something' (soon) about carbon emissions,[29] which brings us to issues about the assignment of responsibility, like: who? Which agents should do something?, and how much should they each do? Why us?[30] The general implication so far is that if it may turn out that this is the time-of-last-opportunity for preventing one or more disasters, making this now-or-never for the rescue from otherwise evolving desperate straits of many millions of those who live after us, then some in the current generation can reasonably be expected to do more – perhaps a great deal more – than members of the 'average generation' that confronted no such last chance to block a commitment to such ferociously dangerous change.[31] But the arguments must not move too quickly. Objections are available.

A first common kind of objection likely to be made against the claim that we have a responsibility to do what must be done to keep from finally locking-in a catastrophe for those who inherit the world we bequeath rests on fairness, that is, unfairness to us if we must do more than others. In the case of ordinary

28 See 'Summary for Policymakers', in Thomas Stocker, Dahe Qin, Gian-Kasper Plattner, *et al.*, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2013), 4; and Matthew Collins, Reto Knutti, Julie Arblaster, et al., 'Long-term Climate Change: Projections, Commitments and Irreversibility', also in the same source, 1029-1136, <http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf> (accessed 22 August 2015).

29 The analysis in this paper takes for granted that, as Pope Francis has recently put it, 'intergenerational solidarity is not optional, but rather a basic question of justice, since the world we have received also belongs to those who will follow us' - see *Laudato Si': Encyclical Letter of the Holy Father Francis on Care for Our Common Home*, para. 159, p.118. <http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html>.

30 The arguments in the text support the conclusion that the 'us' includes members of current generations. On which members of current generations, see arguments cited in note above. And for arguments for a longer list, see Simon Caney, 'Two Kinds of Climate Justice: Avoiding Harm and Sharing Burdens', *Journal of Political Philosophy* 22 (2014), 125-149, pp. 141-144.

31 I have given some other arguments for this conclusion in 'Distant Strangers and the Illusion of Separation' in Brooks (forthcoming).

issues about the sharing of burdens among generations, both forward-looking and backward-looking questions of fairness can be raised. The forward-looking question, crudely put, is: is the share of the total burden that is said to fall on current generations excessive, given that some of the burden could be carried forward to one or more succeeding generations, thereby reducing the burden on current folks? Strikingly, this concern cannot get any foothold at all here, however, if we do indeed confront the advent of a time-of-last-opportunity. It is not possible to defer such burdens until a later date: it is now or never, and if we do not do the job, it will never be done because it will have become too late for anyone to do it. This is part of what is special about a time-of-last-opportunity – inaction at such a time leads to irretrievable loss. All that remains of an appeal to forward-looking unfairness must rest on uncertainty about whether this is in fact a time-of-last-opportunity, the issue to which we will return in conclusion.

The usual backward-looking question of fairness, by contrast, can easily be raised – and answered. Has the time-of-last-opportunity arrived now only because one or more earlier generations failed to carry out their responsibilities? If so, is it fair for us to have to pick up the slack? We need to be slightly more specific, although since we have no standard way of dividing up generations, particular divisions are arbitrary. My impression is that as people ordinarily picture it, significant portions of three generations live simultaneously: children, parents, and grandparents. Let's say that the three generations typically consist of ages 0 - 21 [youth], 21- 65 [parents], and 65 - [grandparents] – obviously this is rough-and-ready. The average person who is 65 or older now was at the height of her powers in 1990 when the IPCC issued its first three-volume assessment of climate change recommending reductions in carbon emissions of more than 60%[32] and in 1992 when the *Framework Convention on Climate Change* was adopted in Rio and then ratified by the U.S Senate. Where were they?

Or rather we? This is my generation, and I think it would be easy to make the case that those of us Americans now in the grandparents generation who were indeed fully active for much of the period 1992 - 2014 and allowed the United States to waste those two decades by pretending that climate change was not happening, utterly failed to carry out our minimum responsibilities regarding climate change, with few exceptions. We lived in a manner that sent carbon emissions soaring and added a huge increment to cumulative carbon

32 See fn. above.

emissions, without taking any serious measures to try to restrain ourselves or to wake our sleeping political 'leaders'. Consequently, I would think that today's parents and youths who have inherited this crisis would be entirely correct to think that we 'grandparents' shirked our duties to do our generational share and that it is unfair to them that, thanks to our inaction, they now face challenges as large as we are leaving them, especially if exceptional efforts by them are all that stand between the generations to come and various catastrophes.

The issue now, however, is what, if anything, are the implications of this past failure for current responsibilities – the responsibilities of 'parents'. And I want to suggest that there are no implications. Before I explain why, a final remark about us delinquent 'grandparents'. Certainly we, and especially those who have held positions of power and trust, like seats in the U.S. Senate, owe today's parents and youths a heartfelt apology for our fecklessness, heedlessness, and general failure to do our jobs, much less to exercise anything remotely resembling due diligence and due care, not to mention leadership. If they choose to spit on our graves when they feel the effects of climate change in coming decades, we hardly have grounds for complaint. It would be a digression here, but I think one could make a strong case that we 'grandparents' ought to devote significant portions of any assets we have accumulated to underwriting the efforts to avoid catastrophe, instead of to our own consumption, in compensation for our failure to carry our share of the load until now. But here I want to look forward.

The current generation (that is, the 'parents') have, I would say, certainly been saddled with unfairly heavy burdens. They must carry more than their intergenerational share because we 'grandparents' carried less than ours. But they should do it nevertheless. Why? Because, as Anja Karnein has lucidly demonstrated, the unfairness of the burden that now needs to be carried is irrelevant to whether it is reasonable for it to be carried, fundamentally because two different pairs of relationships are involved.[33] Focus on the parents as the relevant agents. The parents have a legitimate and serious complaint against the grandparents: the parents have been treated unfairly by the grandparents by being saddled with a much greater burden than they ought to have to bear, namely, successfully to seize the last opportunity to prevent a catastrophe for future generations, as a result of the grandparents' failure to shoulder any reasonable share of the total burden involved in preventing

33 Anja Karnein, 'Putting Fairness in its Place: Why There is a Duty to Take Up the Slack', *Journal of Philosophy* 111 (2014), 593-607. This article presents a thorough and persuasive general argument to which I can only allude here. For her analysis of issues specifically about climate change, closely related to those here, see Anja Karnein, 'Climate Change and Justice Between Non-overlapping Future Generations', this issue.

this climate disaster. If the parents can still obtain some compensation from the grandparents while they are still alive – perhaps a special surcharge on their income tax with the proceeds to be used for preventing the catastrophe, or a deduction from their Social Security payments – they are fully entitled out of fairness to do so.

But, as Karnein convincingly shows, what the parents owe people to come (including their own children, who are already here) is a separate matter. The relationship between the parents and the grandparents is one relationship. The relationship between the parents and the children and others yet to arrive is another relationship. It is misguided for the parents to think, in effect, that because they were badly treated by the grandparents, they are entitled to treat the children badly – in effect, to pass the bad treatment on down the line, like a fraternity member who hazes the new boys because he was hazed. That would be as if I owe you $10, but yesterday someone cheated me out of $5, so I decide I will only re-pay you $5 on the grounds that otherwise I will not come out even. It is true that otherwise I will not come out even, but that is a complaint I should take to the person who cheated me yesterday, not to you today. As Karnein emphasizes, in any relationship there is some limit on how much one party can be expected to do for another party, but her main point is that this limit is unaffected by the fact that some third party's failure to do her fair share increases the amount that needs to be done. If the total amount that now needs to be done, including the increment added by someone else's shirking, still falls within the maximum I can be expected to do, I ought to do it, thereby taking up the slack created by the unfairness to me.[34] The limit is what it is reasonable for me to bear, not what it would have been fair for me to bear if others, who did not do their part, had done it.

If two children are drowning, and you and I could each save one, but you walk away, then I ought to save both as long as saving both is safely within my capacity. I may not 'even the score' between me and the universe by allowing the second child to drown to make up for how unfairly you have treated me by leaving me to do everything. This would be to treat oneself as the centre of the universe and entitled somehow always to 'come out even' overall whatever else happens and whoever suffers for it. Should I feel that it was bad luck that I had to do double work? Perhaps, but there is no need to take such a why-poor-me? attitude. One might also reasonably feel that it was a privilege to have an

34 Simon Caney has supported the same conclusion specifically with reference to climate change: 'The virtuous are being ill-treated but … the right reaction for them is to take this up with non-compliers (against whom they have just cause for complaint) and not to react by disregarding the legitimate interests of those who would otherwise suffer the dire effects of climate change' - see Simon Caney, 'Cosmopolitan Justice, Responsibility, and Global Climate Change', *Leiden Journal of International Law* 18 (2005), 747-775, p. 772, <doi:10.1017/S0922156505002992>. Also see his 'Two Kinds of Climate Justice: Avoiding Harm and Sharing Burdens', *Journal of Political Philosophy* 22 (2014), 125-149, pp. 125-127, <doi:10.1111/jopp.12030>.

opportunity to be of twice as much service and rescue two young lives rather than only one. Was there really something else more important that I could have been doing than preserving two young lives?

A second objection, fully allowed for by Karnein's analysis, to my suggestion that the generation alive at a time-of-last-opportunity, ought to go, if necessary, to great lengths to prevent any disaster to which the climate is about to become committed is that, leaving aside (comparative) fairness, the burden is simply (absolutely) unreasonably great – 'excessive' in the language of the third member of the sufficient set in 'Deadly Delays'. I assume that whatever the stakes are for others – any number of others – each of us has at least a few indefeasible entitlements, or basic rights.[35] This means, then, that there must be some limit on what can legitimately be demanded of anyone, although saints and heroes may nevertheless admirably choose to define their identity in ways that embrace taking on much more than required. Specifying, in the abstract, general limits on the total extent of reasonably demandable sacrifice is a daunting, if indeed even satisfiable, philosophical challenge. It is, however, a theoretical challenge that we need not take up here because of empirical features of our case.

Obviously the burdens inherent in current generations' acting to prevent climate catastrophe for future generations will be significant,[36] but are they unreasonable, analogously to your being asked to save so many drowning children that you yourself are at high risk of drowning because the total task is beyond your capacity and fatigue seriously threatens your life? No - the task at hand, rapidly reducing carbon emissions, is manifestly nowhere near so unreasonable.[37] For instance, in the executive summary of the latest item in the series it calls Citi GPS: Global Perspectives and Solutions, 'our premier thought-leadership product,' Citigroup analysts observe: 'while fossil reserves aren't running out, our ability to burn them without limit may be, due to the fact that atmospheric concentrations of CO_2 and equivalents are rapidly

35 Some arguments are in Henry Shue, *Basic Rights: Subsistence, Affluence, and U.S. Foreign Policy*, 2nd ed. (Princeton, N.J.: Princeton University Press, 1996), pp. 13-64.

36 They are certainly not unique, however - or historically impressive. How about the generations who lived during the Great Depression? One of the World Wars? The Hundred Years' War? The Black Plague? Many a medieval monk must have sacrificed both his eye-sight and his lower back by hunching over manuscripts in bad light in the effort to preserve truth (and, with painted illuminations, create beauty) for succeeding generations. Geoffrey Parker's *Global Crisis* quotes a provincial report to the emperor of China during the 17th century's 'Little Ice Age': 'in the ninth year [of the reign: 1636] severe famine affected Nanyang [Henan province] during which mothers killed and cooked their daughters [for food]. That year there was also famine in Jiangxi province. In the tenth year [1637], there was a severe famine in Zhejiang province during which fathers and children, siblings and husbands resorted to cannibalism' (p. 125) That's a demanding situation.

37 Segments of society, for example, coal-miners, will face difficult transitions out of an industry that must fail because its owners refused to invest enough of their profits in carbon capture and storage to save their industry, but it is the duty of the rest of us to see that the miners and their families do not suffer any more than is absolutely unavoidable. The necessary social programs need to be put in place immediately as coal firms rapidly go bankrupt.

approaching [the limits of] the so-called 'carbon budget'.' Having embraced the scientific concept of the cumulative carbon budget, the bank's analysts continue: 'In this report, we examine the likely costs of inaction in terms of the potential liabilities from climate change to see whether we can afford not to act. We also examine whether the world *can* afford to act, by comparing the incremental costs of following a low carbon path to global GDP. Overall, we find that the incremental costs of action are limited (and indeed ultimately lead to savings), offer reasonable returns on investment, and should not have too detrimental an effect on global growth' [emphasis in original]. And they conclude: 'The incremental costs of following a low carbon path are in context limited and seem affordable, the 'return' on that investment is acceptable and moreover the likely avoided liabilities are enormous. Given that all things being equal cleaner air has to be preferable to pollution, a very strong 'Why would you not?' argument begins to develop.'[38]

I quote this bankers' report neither to endorse its methodology nor to endorse its precise conclusions about what counts as a 'low carbon path', but simply in order to present one of increasingly many readily available indications that mainstream institutions, like a global super-bank with no particular commitment to either the environment or future generations, are accepting the climate scientists' analysis centred on the cumulative carbon budget and beginning to conclude that robust movement away from the current fossil fuel regime is not only not an excessive sacrifice but the profitable way to go! For the conclusions of a study from a group less exclusively focused on profits than Citigroup and more committed to sustainable development by poorer nations, see the latest report from the Global Commission on the Economy and Climate – the 'Calderón Commission'.[39] Or, the Mary Robinson Foundation – Climate Justice has issued a briefer report showing an empirically plausible pathway to zero carbon emissions by 2050 accompanied by decreasing poverty in the poorer countries, and various others are working on more detailed versions of such pathways yoking emissions reduction together with poverty

38 Citigroup, *Energy Darwinism II: Why a Low Carbon Future Doesn't Have to Cost the Earth*, Citi GPS: Global Perspectives and Solutions 38 (14 August 2015), p. 3, <https://www.citivelocity.com/citigps/ReportSeries.action>, (accessed 20 August 2015). The report has especially bad news for the coal industry as long as it continues to refuse to invest in carbon capture and storage - see pp. 87-91.

39 Global Commission on the Economy and Climate, *Seizing the Global Opportunity: Partnerships for Better Growth and A Better Climate*, The 2015 New Climate Economy Report (Washington: World Resources Institute and London: Overseas Development Institute, 2015), <http://2015.newclimateeconomy.report/wp-content/uploads/2014/08/NCE-2015_Seizing-the-Global-Opportunity_web.pdf>.

reduction.[40] We have no good reason to think the burdens in this specific case are excessive even if they would have been fairer and easier if other generations had acted sooner.

Conclusion: The Tilt of Uncertainty

Given the possibility of massive human losses, the threshold likelihood of their occurrence, and the non-excessive costs of their prevention, we definitely ought, I believe, to act now. This is all the more the case because it may well be that this is the time-of-last-opportunity to head off one or more potential disasters, all of which may still be preventable by sufficiently rapid reductions in carbon emissions from the combustion of fossil fuel to keep the cumulative total of atmospheric carbon dioxide within the budget for some endurable degree of climate change. Of course, we are uncertain – it is also possible that this is in fact not yet a time-of-last-opportunity for the prevention of any further catastrophe beyond the melting of the WAIS. But this uncertainty, when one examines it concretely, cuts both ways.[41] Either this is the time-of-last-opportunity for one or more disasters, or it is not.

Suppose it is not, but we choose to act in worthwhile ways like rapidly reducing carbon emissions. Then we will exert ourselves and incur expenses beyond our obligations to people of the future. We will not save future generations from catastrophe but only improve their lives to a degree that we have no duty to bring about. We will have morally 'over-achieved'. But if the tasks we undertake are clearly not excessively burdensome for us – some bankers, as we have just seen, believe they can even be profitable and healthy – at worst we will have left a legacy for future generations that exceeds our responsibilities.[42] If that is a 'mistake', it seems like a good kind of mistake to make.

Or suppose it is. If in fact we are in a time-of-last-opportunity for one or more climate disasters, and we choose not to act, we will have allowed an avoidable disaster to engulf those who come after us. We will have done nothing while an irretrievable opportunity disappears. A disaster that we could have locked out

40 See Mary Robinson Foundation - Climate Justice, *Zero Carbon Zero Poverty The Climate Justice Way: achieving an equitable phase-out of carbon emissions by 2050 while protecting human rights*, Report 1 2015 V1 Feb (Dublin); report of an analysis conducted by Sivan Kartha and Paul Baer, <http://www.mrfcj.org/pdf/2015-02-05-Zero-Carbon-Zero-Poverty-the-Climate-Justice-Way.pdf>. Also see Sustainable Development Solutions Network and Institute for Sustainable Development and International Relations, *Pathways to Deep Decarbonization*: 2014 Report, Deep Decarbonization Pathways Project <http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit_updated.pdf>. We need not, therefore, choose between 'the current poor' and 'the poor of the distant future', however interesting philosophers find debates about such extreme dilemmas.

41 I am grateful to Anja Karnein for this point.

42 Provided of course that the actions we choose to take are not misguided or counter-productive. But we have overwhelming evidence that carbon emissions need to be phased out before the cumulative carbon budget for an endurable temperature is exceeded, so there is no danger that exiting fossil fuels is a mistake - see the sources in note 20 above.

will have become locked-in to the climate system. If we miss the last opportunity, it is lost – forever.

An uncertainty between whether to risk putting in more worthwhile effort than we might have been required to – to over-achieve – or to risk leaving the door open to a catastrophe that will reverberate through generations helpless to stop it – to fail to rescue untold millions from terrible fates – is indeed a reason for action. Few 'gambles' are so bearable on the down-side and so promising on the up-side, which is an opportunity – perhaps the last – to make an event that is intolerably bad far less likely, if not even impossible. And gamble we must – after all, the situation is uncertain.[43]

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43 For valuable comments on earlier drafts I am grateful to Simon Caney, Anja Karnein, and Miriam Ronzoni.