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#### Rigorous climate simulations prove that hydrophilic black carbon results in a rainout effect that quickly reverses nuclear cooling

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\*BC = Black Carbon

The no-rubble simulation produces a significantly more intense fire, with more fire spread, and consequently a significantly stronger plume with larger amounts of BC reaching into the upper atmosphere than the simulation with rubble, illustrated in Figure 5. While the no-rubble simulation **represents the worst-case scenario** involving vigorous fire activity, **only a relatively small amount of carbon makes its way into the stratosphere** during the course of the simulation. But while small compared to the surface BC mass, stratospheric BC amounts from the current simulations are significantly higher than what would be expected from burning vegetation such as trees (Heilman et al., 2014), e.g., the higher energy density of the building fuels and the initial fluence from the weapon produce an intense response within HIGRAD with initial updrafts of order 100 m/s in the lower troposphere. Or, in comparison to a mass fire, wildfires will burn only a small amount of fuel in the corresponding time period (roughly 10 minutes) that **a nuclear weapon** fluence can effectively ignite a large area of fuel producing an impressive atmospheric response. Figure 6 shows vertical profiles of BC multiplied by 100 (number of cities involved in the exchange) from the two simulations. The total amount of BC produced is in line with previous estimates (about 3.69 Tg from no-rubble simulation); however, the majority of BC resides **below the stratosphere** (3.46 Tg below 12 km) and can be **readily impacted by scavenging from precipitation** either via pyro-cumulonimbus produced by the fire itself (not modeled) or other synoptic weather systems. While the impact on climate of these more realistic profiles will be explored in the next section, it should be mentioned that **these estimates are** still **at the high end**, considering the inherent simplifications in the combustion model that lead to **overestimating BC production**. 3.3 Climate Results Long-term climatic effects critically depend on the initial injection height of the soot, with larger quantities reaching the upper troposphere/lower stratosphere inducing a greater cooling impact because of longer residence times (Robock et al., 2007a). Absorption of solar radiation by the BC aerosol and its subsequent radiative cooling tends to heat the surrounding air, driving an initial upward diffusion of the soot plumes, an effect that depends on the initial aerosol concentrations. Mixing and **sedimentation** tend to **reduce this process**, and low altitude emissions are also significantly impacted by precipitation if aging of the BC aerosol occurs on sufficiently rapid timescales. But once at stratospheric altitudes, aerosol dilution via coagulation is hindered by low particulate concentrations (e.g., Robock et al., 2007a) and lofting to much higher altitudes is inhibited by gravitational settling in the low-density air (Stenke et al., 2013), resulting in more stable BC concentrations over long times. Of the initial BC mass released in the atmosphere, most of which is emitted below 9 km, **70% rains out within the first month** and 78%, or about 2.9 Tg, is removed within the first two months (Figure 7, solid line), with the remainder (about 0.8 Tg, dashed line) being transported above about 12 km (200 hPa) within the first week. This outcome differs from the findings of, e.g., Stenke et al. (2013, their high BC-load cases) and Mills et al. (2014), who found that most of the BC mass (between 60 and 70%) is lifted in the stratosphere within the first couple of weeks. This can also be seen in Figure 8 (red lines) and in Figure 9, which include results from our calculation with the initial BC distribution from Mills et al. (2014). In that case, only 30% of the initial BC mass rains out in the troposphere during the first two weeks after the exchange, with the remainder rising to the stratosphere. In the study of Mills et al. (2008) this percentage is somewhat smaller, about 20%, and smaller still in the experiments of Robock et al. (2007a) in which the soot is initially emitted in the upper troposphere or higher. In Figure 7, the e-folding timescale for the removal of tropospheric soot, here interpreted as the time required for an initial drop of a factor e, is about one week. This result compares favorably with the “LT” experiment of Robock et al. (2007a), considering 5 Tg of BC released in the lower troposphere, in which 50% of the aerosols are removed within two weeks. By contrast, the initial e-folding timescale for the removal of stratospheric soot in Figure 8 is about 4.2 years (blue solid line), compared to about 8.4 years for the calculation using Mills et al. (2014) initial BC emission (red solid line). The removal timescale from our forced ensemble simulations is close to those obtained by Mills et al. (2008) in their 1 Tg experiment, by Robock et al. (2007a) in their experiment “UT 1 Tg”, and © 2018 American Geophysical Union. All rights reserved. by Stenke et al. (2013) in their experiment “Exp1”, in all of which 1 Tg of soot was emitted in the atmosphere in the aftermath of the exchange. Notably, the e-folding timescale for the decline of the BC mass in Figure 8 (blue solid line) is also close to the value of about 4 years quoted by Pausata et al. (2016) for their long-term “intermediate” scenario. In that scenario, which is also based on 5 Tg of soot initially distributed as in Mills et al. (2014), the factor-of2 shorter residence time of the aerosols is caused by particle growth via coagulation of BC with organic carbon. Figure 9 shows the BC mass-mixing ratio, horizontally averaged over the globe, as a function of atmospheric pressure (height) and time. The BC distributions used in our simulations imply that the upward transport of particles is substantially less efficient compared to the case in which 5 Tg of BC is directly injected into the upper troposphere. The semiannual cycle of lofting and sinking of the aerosols is associated with atmospheric heating and cooling during the solstice in each hemisphere (Robock et al., 2007a). During the first year, the oscillation amplitude in our forced ensemble simulations is particularly large during the summer solstice, compared to that during the winter solstice (see bottom panel of Figure 9), because of the higher soot concentrations in the Northern Hemisphere, as can be seen in Figure 11 (see also left panel of Figure 12). Comparing the top and bottom panels of Figure 9, the BC reaches the highest altitudes during the first year in both cases, but the concentrations at 0.1 hPa in the top panel can be 200 times as large. Qualitatively, the difference can be understood in terms of the air temperature increase caused by BC radiation emission, which is several tens of kelvin degrees in the simulations of Robock et al. (2007a, see their Figure 4), Mills et al. (2008, see their Figure 5), Stenke et al. (2013, see high-load cases in their Figure 4), Mills et al. (2014, see their Figure 7), and Pausata et al. (2016, see one-day emission cases in their Figure 1), due to high BC concentrations, but it amounts to only about 10 K in our forced ensemble simulations, as illustrated in Figure 10. Results similar to those presented in Figure 10 were obtained from the experiment “Exp1” performed by Stenke et al. (2013, see their Figure 4). **In that scenario as well, somewhat less that 1 Tg of BC remained in the atmosphere after the initial rainout**. As mentioned before, the BC aerosol that remains in the atmosphere, lifted to stratospheric heights by the rising soot plumes, undergoes sedimentation over a timescale of several years (Figures 8 and 9). This mass represents the effective amount of BC that can force climatic changes over multi-year timescales. In the forced ensemble simulations, it is about 0.8 Tg after the initial rainout, whereas it is about 3.4 Tg in the simulation with an initial soot distribution as in Mills et al. (2014). Our more realistic source simulation involves the worstcase assumption of no-rubble (along with other assumptions) and hence serves as an upper bound for the impact on climate. As mentioned above and further discussed below, our scenario induces perturbations on the climate system similar to those found in previous studies in which the climatic response was driven by roughly 1 Tg of soot rising to stratospheric heights following the exchange. Figure 11 illustrates the vertically integrated mass-mixing ratio of BC over the globe, at various times after the exchange for the simulation using the initial BC distribution of Mills et al. (2014, upper panels) and as an average from the forced ensemble members (lower panels). All simulations predict enhanced concentrations at high latitudes during the first year after the exchange. In the cases shown in the top panels, however, these high concentrations persist for several years (see also Figure 1 of Mills et al., 2014), whereas the forced ensemble simulations indicate that the BC concentration starts to decline after the first year. In fact, in the simulation represented in the top panels, mass-mixing ratios larger than about 1 kg of BC © 2018 American Geophysical Union. All rights reserved. per Tg of air persist for well over 10 years after the exchange, whereas they only last for 3 years in our forced simulations (compare top and middle panels of Figure 9). After the first year, values drop below 3 kg BC/Tg air, whereas it takes about 8 years to reach these values in the simulation in the top panels (see also Robock et al., 2007a). Over crop-producing, midlatitude regions in the Northern Hemisphere, the BC loading is reduced from more than 0.8 kg BC/Tg air in the simulation in the top panels to 0.2-0.4 kg BC/Tg air in our forced simulations (see middle and right panels). The more rapid clearing of the atmosphere in the forced ensemble is also signaled by the soot optical depth in the visible radiation spectrum, which drops below values of 0.03 toward the second half of the first year at mid latitudes in the Northern Hemisphere, and everywhere on the globe after about 2.5 years (without never attaining this value in the Southern Hemisphere). In contrast, the soot optical depth in the calculation shown in the top panels of Figure 11 becomes smaller than 0.03 everywhere only after about 10 years. The two cases show a similar tendency, in that the BC optical depth is typically lower between latitudes 30º S-30º N than it is at other latitudes. This behavior is associated to the persistence of stratospheric soot toward high-latitudes and the Arctic/Antarctic regions, as illustrated by the zonally-averaged, column-integrated mass-mixing ratio of the BC in Figure 12 for both the forced ensemble simulations (left panel) and the simulation with an initial 5 Tg BC emission in the upper troposphere (right panel). The spread in the globally averaged (near) surface temperature of the atmosphere, from the control (left panel) and forced (right panel) ensembles, is displayed in Figure 13. For each month, the plots show the largest variations (i.e., maximum and minimum values), within each ensemble of values obtained for that month, relative to the mean value of that month. The plot also shows yearly-averaged data (thinner lines). The spread is comparable in the control and forced ensembles, with average values calculated over the 33-years run length of 0.4-0.5 K. This spread is also similar to the internal variability of the globally averaged surface temperature quoted for the NCAR Large Ensemble Community Project (Kay et al., 2015). These results imply that surface air temperature differences, between forced and control simulations, which lie within the spread may not be distinguished from effects due to internal variability of the two simulation ensembles. Figure 14 shows the difference in the globally averaged surface temperature of the atmosphere (top panel), net solar radiation flux at surface (middle panel), and precipitation rate (bottom panel), computed as the (forced minus control) difference in ensemble mean values. The sum of standard deviations from each ensemble is shaded. Differences are qualitatively significant over the first few years, when the anomalies lie near or outside the total standard deviation. Inside the shaded region, differences may not be distinguished from those arising from the internal variability of one or both ensembles. The surface solar flux (middle panel) is the quantity that appears most affected by the BC emission, with qualitatively significant differences persisting for about 5 years. The precipitation rate (bottom panel) is instead affected only at the very beginning of the simulations. The red lines in all panels show the results from the simulation applying the initial BC distribution of Mills et al. (2014), where the period of significant impact is much longer owing to the higher altitude of the initial soot distribution that results in longer residence times of the BC aerosol in the atmosphere. When yearly averages of the same quantities are performed over the IndiaPakistan region, the differences in ensemble mean values lie within the total standard deviations of the two ensembles. The results in Figure 14 can also be compared to the outcomes of other previous studies. In their experiment “UT 1 Tg”, Robock et al. (2007a) found that, when only 1 Tg of soot © 2018 American Geophysical Union. All rights reserved. remains in the atmosphere after the initial rainout, temperature and precipitation anomalies are about 20% of those obtained from their standard 5 Tg BC emission case. Therefore, the largest differences they observed, during the first few years after the exchange, were about - 0.3 K and -0.06 mm/day, respectively, comparable to the anomalies in the top and bottom panels of Figure 14. Their standard 5 Tg emission case resulted in a solar radiation flux anomaly at surface of -12 W/m2 after the second year (see their Figure 3), between 5 and 6 time as large as the corresponding anomalies from our ensembles shown in the middle panel. In their experiment “Exp1”, Stenke et al. (2013) reported global mean surface temperature anomalies not exceeding about 0.3 K in magnitude and precipitation anomalies hovering around -0.07 mm/day during the first few years, again consistent with the results of Figure 14. In a recent study, Pausata et al. (2016) considered the effects of an admixture of BC and organic carbon aerosols, both of which would be emitted in the atmosphere in the aftermath of a nuclear exchange. In particular, they concentrated on the effects of coagulation of these aerosol species and examined their climatic impacts. The initial BC distribution was as in Mills et al. (2014), although the soot burden was released in the atmosphere over time periods of various lengths. Most relevant to our and other previous work are their one-day emission scenarios. They found that, during the first year, the largest values of the atmospheric surface temperature anomalies ranged between about -0.5 and -1.3 K, those of the sea surface temperature anomalies ranged between -0.2 and -0.55 K, and those of the precipitation anomalies varied between -0.15 and -0.2 mm/day. All these ranges are compatible with our results shown in Figure 14 as red lines and with those of Mills et al. (2014, see their Figures 3 and 6). As already mentioned in Section 2.3, the net solar flux anomalies at surface are also consistent. This overall agreement suggests that the **inclusion of organic carbon aerosols, and** ensuing **coagulation** with BC, **should not dramatically alter the climatic effects** resulting from our forced ensemble simulations. Moreover, aerosol growth would likely **shorten the residence time of the BC particulate in the atmosphere** (Pausata et al., 2016), possibly **reducing the duration of these effects.**

#### PND is just based on robock and toons ev and barely has a warrant – just asserts that civilization is destroyed without any explanation

PND 16. internally citing Zbigniew Brzezinski, Council of Foreign Relations and former national security adviser to President Carter, Toon and Robock’s 2012 study on nuclear winter in the Bulletin of Atomic Scientists, Gareth Evans’ International Commission on Nuclear Non-proliferation and Disarmament Report, Congressional EMP studies, studies on nuclear winter by Seth Baum of the Global Catastrophic Risk Institute and Martin Hellman of Stanford University, and U.S. and Russian former Defense Secretaries and former heads of nuclear missile forces, brief submitted to the United Nations General Assembly, Open-Ended Working Group on nuclear risks. A/AC.286/NGO/13. 05-03-2016. http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/OEWG/2016/Documents/NGO13.pdf

Consequences human survival 12. Even if the 'other' side does NOT launch in response the smoke from 'their' burning cities (incinerated by 'us') will still make 'our' country (and the rest of the world) **uninhabitable**, potentially inducing global famine lasting up to **decades**. Toon and Robock note in ‘Self Assured Destruction’, in the Bulletin of Atomic Scientists 68/5, 2012, that: 13. “A nuclear war between Russia and the United States, even after the arsenal reductions planned under New START, could produce a nuclear winter. Hence, an attack by either side could be suicidal, resulting in **self assured destruction**. Even a 'small' nuclear war between **India** and **Pakistan**, with each country detonating 50 Hiroshima-size atom bombs--only about 0.03 percent of the global nuclear arsenal's explosive power--as air bursts in urban areas, could produce so much smoke that temperatures would fall below those of the Little Ice Age of the fourteenth to nineteenth centuries, shortening the growing season around the world and threatening the global food supply. Furthermore, there would be massive ozone depletion, allowing more **ultraviolet** radiation to reach Earth's surface. **Recent studies** predict that agricultural production in parts of the **U**nited **S**tates and **China** would decline by about 20 percent for four years, and by 10 percent for a decade.” 14. A conflagration involving USA/NATO forces and those of Russian federation would most likely cause the deaths of most/nearly all/**all humans** (and severely impact/extinguish **other species**) as well as destroying the delicate interwoven techno-structure on which latter-day 'civilization' has come to depend. Temperatures would drop to below those of the last ice-age for up to 30 years as a result of the lofting of up to 180 million tonnes of very black soot into the stratosphere where it would remain for decades. 15. Though human ingenuity and resilience shouldn't be underestimated, human survival itself is arguably problematic, to put it mildly, under a 2000+ warhead USA/Russian federation scenario. 16. The Joint Statement on Catastrophic Humanitarian Consequences signed October 2013 by 146 governments mentioned 'Human Survival' no less than 5 times. The most recent (December 2014) one gives it a highly prominent place. **Gareth Evans**’ ICNND (International Commission on Nuclear Non-proliferation and Disarmament) Report made it clear that it saw the threat posed by nuclear weapons use as one that at least threatens what we now call 'civilization' and that potentially **threatens human survival with an immediacy that even climate change does not**, though we can see the results of climate change here and now and of course the immediate post-nuclear results for Hiroshima and Nagasaki as well.

#### They have bad models that assumes the smoke ends up the atmosphere, it doesn’t – rainout

**Seitz 6** – Visiting Scholar at Harvard’s Center of International Affairs (Russell, “The ‘Nuclear Winter’ Meltdown”  http://adamant.typepad.com/seitz/2006/12/preherein\_honor.html)

Dark smoke clouds in the lower atmosphere don’t last long enough to spread across the globe. Cloud droplets and rainfall remove them. Rapidly washing them out of the sky in a matter of days to weeks- not long enough to sustain a global pall. Real world weather brings down particles much as soot is scrubbed out of power plant smoke by the water sprays in smoke stack scrubbers. **Robock acknowledges this- not** even **a single degree of cooling results when soot is released at lower elevations in his models**. The workaround is to inject the imaginary aerosol at truly Himalayan elevations - pressure altitudes of 300 millibar and higher , where the computer model's vertical transport function modules pass it off to their even higher neighbors in the stratosphere , where it does not rain and particles linger. The new studies like the old suffer from the disconnect between a desire to paint the sky black and the vicissitudes of natural history. As with many exercise in worst case models both at invoke rare phenomena as commonplace, claiming it prudent to assume the worst. But the real world is subject to Murphy's lesser known second law- if everything must go wrong, don't bet on it. In 2006 as in 1983 firestorms and forest fires that send smoke into the stratosphere rise to alien prominence in the modelers re-imagined world , but in the real one remains a very different place, where though every month sees forest fires burning areas the size of cities - 2,500 hectares or larger , stratospheric smoke injections arise but once in a blue moon. So how come these neo-nuclear winter models feature so much smoke so far aloft for so long? The answer is simple- the modelers intervened. Turning off vertical transport algorithms may make Al Gore happy- he has bet on reviving the credibility Sagan's ersatz apocalypse , but there is no denying that in some of these scenarios human desire, not physical forces accounts for the vertical hoisting of millions of tons of mass ten vertical kilometers into the sky.to the level at which the models take over , with results at once predictable --and arbitrary. This is not physics, it is computer gamesmanship carried over to a new generation of X-Box. I must now return to getting and vetting the new papers and their references- this has been a prelimnary examination of what the public has been told, and more detailed critiques of the science will doubtless be direected to the journals were the new work appeared . This time round , the details are scarcely worth arguing, because the global frost made famous by the original 'TTAPS' model has disappeared . From the truly frigid 7,000 degree-day "baseine case" advertised as hard science in 1983 to a tepid results of today, "Nuclear Winter has well and truly melted down. The 1986 review of TTAPS reception follows. *The Melting of 'Nuclear Winter'*

#### Newest research proves even worst-case nuclear winter is survivable – assumes secondary effects, fallout, arsenal sizes,

**Rodriguez 20** [Luisa Rodriguez is research fellow at the Forethought Foundation for Global Priorities Research. Previously, she researched nuclear war at Rethink Priorities and as a visiting researcher at the Future of Humanity Institute, "What is the likelihood that civilizational collapse would directly lead to human extinction (within decades)? - EA Forum", 24th Dec 2020, <https://forum.effectivealtruism.org/posts/GsjmufaebreiaivF7/what-is-the-likelihood-that-civilizational-collapse-would#Concrete_example__A_large_nuclear_war_that_causes_a_nuclear_winter//imp>]

Case 2: 90% population loss, infrastructure damage, and extreme climate change (e.g. nuclear war that caused nuclear winter) In a scenario in which a catastrophe causes the deaths of 90% of the population (800 million survivors), major infrastructure damage, and climate change — for example, a severe, global nuclear war that caused a nuclear winter — I believe the question of whether humans would be able to meet their basic needs becomes more difficult.[14] The questions I consider for this scenario are: What is the likelihood that survivors are able to continue to survive using traditional forms of agriculture, given a catastrophe that causes severe infrastructure damage and climate change? What is the likelihood that radiation causes extinction? What is the likelihood that humanity would survive in the event of conflict immediately following the catastrophe? What is the likelihood that survivors are able to continue to survive using traditional forms of agriculture? Time spent on this section: 2–3 hours Types of sources: Academic literature, non-academic reports, and expert interviews Expert judgment: Several experts, including ALLFED director David Denkenberger, have affirmed this conclusion — they do not expect humanity to dip below the minimum viable population even in relatively extreme sun-blocking scenarios. Literature review: The nature of all of the catastrophes we know of that would cause extreme global cooling (e.g. nuclear winter, asteroid impacts) **would have unevenly distributed impacts** — causing extreme global cooling in some parts of the world, but more moderate cooling in others. For example, in the case of a nuclear war between the US and Russia, nuclear winter models suggest that the most **severe climate effects would be limited** to the Northern Hemisphere, where temperatures would fall by 10–30 degrees C. But in the Southern Hemisphere, and especially at the equator, those effects would be much less severe: between 5–10 degrees Celsius. With heterogeneous impacts like this, it’s likely that agriculture would still be possible in some regions — especially in New Zealand and Australia, and possibly in South America and Central Africa.[15] To be clear, I’m describing a very grim scenario, in which basically everyone in the Northern Hemisphere — and in many parts of the Southern Hemisphere — would be unable to grow food using standard agricultural techniques. Given this, I expect there would be mass starvation and violent competition and conflict until a new equilibrium was reached, one where the remaining survivors didn’t exceed the Earth’s carrying capacity. While I expect this would be a truly terrible period of widespread suffering, I believe this equilibrium would be reached long before the population got anywhere near the minimum viable population. My best guess is the population would fall to hundreds of thousands to tens of millions, but not much lower. While I haven’t looked into this much, I feel fairly convinced that hundreds of thousands or **millions** of people **could survive** using traditional approaches to agriculture in parts of the world with more moderate climate effects (and basic mitigation strategies, like switching to crop types that are more resilient to temperature and precipitation fluctuations). And as with Case 1, at least some of the survivors in a Case 2 scenario would probably be able to survive the immediate aftermath of a catastrophe that caused civilizational collapse by exploiting food and other supplies in stores and larger stockpiles. This would give survivors some buffer time to learn additional skills required to survive once those supplies run out (e.g. fishing) or develop the techniques necessary to produce food using methods that don’t rely on climate factors like warm temperatures and regular precipitation. BOTEC: The longer the buffer time, the more likely humanity would be to subsequently survive. But there are a number of different considerations (relative to Case 1) that affect the calculus of just how long such a grace period would be in the context of a catastrophic event like a nuclear war that killed 90% of people and caused a nuclear winter. So I’ve done a similar exercise to the one above where I try to account for some of those differences. Note: As above, the following BOTEC relies on particularly poor sources, makes a bunch of dubious assumptions (discussed more below), and I’m not confident I’ve thought of all of the most important supplies. It should be considered very rough. TABLE5 See table note here.[16] Bottom line: I think it’s extremely likely that these supplies would last somewhere between around a year and a decade or more. I expect it would be closer to the lower end, given that competition and violence could lead to the depletion of supplies more quickly than if the population were reduced to a smaller number by the catastrophe directly. All this in mind, I think it is very likely that the survivors would be able to learn enough during the grace period to be able to feed and shelter themselves ~indefinitely. What is the likelihood that radiation causes extinction? Time spent on this section: 2–3 hours Types of sources: Academic papers, Wikipedia, and interviews with experts Literature review: In the aftermath of a nuclear war, radioactive fallout from the nuclear detonations would have long-lasting health impacts. In **the most extreme** nuclear war **scenario**s considered by academics (a nuclear war between the US and Russia and their allies, using 10,000 megatons (MT) of nuclear bombs), approximately 30% of the geographic area in the Northern Hemisphere would have enough fallout to be lethal to any adult in the area (Ehrlich et al., 1983). The current US and Russian nuclear arsenals don’t currently have that kind of megatonnage (they currently have closer to 2,500 MT). If we naively assume that radiation scales linearly, we might expect a modern day US-Russia nuclear war to contaminate up to 7.5% of the land area of the Northern Hemisphere. This may not sound like much, but consider that 95% of the world’s population lives on just 10% of its land area — meaning that 7.5% of land area could be home to millions or even billions of people. What’s more, tens to hundreds of millions more might be exposed to enough radiation to be more susceptible to cancer for the rest of their lives. On top of this, there are currently around 440 civilian nuclear power reactors scattered around the world, and likely tens or hundreds more military reactors. These have fail-safes and automatic shut down measures that are designed to ensure that all of the nuclear material in these reactors would be safely contained in the event of a global catastrophe that meant people stopped attending to them. Concretely, these fail safes make sure that water continues to be circulated around the nuclear fuel to ensure it doesn’t get so hot it causes a meltdown — i.e., an event where the nuclear core partially or completely melts, which might allow the nuclear fuel to breach its multiple layers of containment and leak out into the environment. If fuel did reach the environment, the radioactive fallout could spread across continents, creating exposure levels ranging from immediately fatal (in areas ranging from tens to thousands of square kilometers) to non-lethal but causing potential higher rates of cancer and infertility. But some of these fail-safes could plausibly fail during a catastrophe that caused infrastructure damage (or afterward, if any components of the fail system degraded). For example, some nuclear reactors rely on backup generators to power the pumps that keep water circulating in the core of the reactor. If those backup generators eventually all broke down, the reactor might melt down. I currently don’t have a good sense of how likely these failures would be. Newer nuclear reactors rely on more robust safety systems, with parts that wouldn’t break down as easily. And all nuclear reactor safety systems are designed to account for infrastructure damage caused by earthquakes and other physical shocks. But in a large-scale nuclear war, it seems very plausible that at least some nuclear reactors would melt down. My best guess is that this wouldn’t happen at a large scale, but even if it did, some areas would likely be far enough away from reactors to be spared the radioactive contamination. For example, Australia has just one nuclear reactor. Even if that reactor were to melt down, much of Australia would likely remain uncontaminated (Australia is just under 3 million square miles, and the Chernobyl meltdown is estimated to have contaminated under 60,000 square miles; and only a much smaller fraction of that area was sufficiently contaminated as to be lethal to humans). Bottom line: While radioactive fallout from nuclear detonations and power plant meltdowns would increase the death toll in the years following the collapse, I expect it **wouldn’t be** widespread enough to be immediately **fatal to everyone**, nor would it cause fertility rates or life expectancy to decrease enough to threaten extinction. And at the very least, **some** areas **are sufficiently far away as to be** relatively **safe** from radioactive fallout. What is the likelihood that humanity would survive in the event of conflict immediately following the catastrophe? Time spent on this section: 1–2 hours Types of sources: Academic literature, expert interviews, and speculation Historical base rate: In Case 2, it seems slightly more plausible to me that violence would lead to human extinction than in Case 1, but still fairly unlikely. I don’t think human extinction could be caused by a conflict fought with conventional weapons; **there would** just **be** **too many survivors (~800 million)** to be killed in conventional warfare (compare this to WWI and WWII, during which ~20 million and ~75 million people were killed, respectively). Weapons of mass destruction: My best guess is that the only way violence in the wake of a Case 2 civilizational collapse could directly lead to human extinction is if one group of **survivors** had access to and deployed weapons of mass destruction. This seems unlikely to me, first because it seems hard to imagine a group of survivors incapable of recovering critical infrastructure — and barely capable of meeting even their basic needs — would be able to successfully deploy weapons of mass destruction (though I’m not very confident about this). Second, it’s hard to imagine a scenario where the use of weapons of mass destruction kills millions of survivors, spread all over the world, without modern technologies like transportation. For example, with potentially many survivor groups, it seems hard to imagine how nuclear detonations would kill ~everyone despite the fact that the groups would likely be spread out all over the world, potentially in small bands that can’t each be individually targeted. Similarly, it’s hard to imagine how a pathogen could spread ~everywhere when survivors would likely have greatly reduced mobility (the latter isn’t obviously impossible, but it at least seems exceedingly difficult to me). There’s one counterargument I find somewhat persuasive, which is that it seems possible that all of the survivors might be confined to a relatively small area (for example, if only a small fraction of the Earth’s land area is habitable), making them more vulnerable to a single, large attack. If this were the case, it’s easier for me to imagine that the use of weapons of mass destruction could kill all of the remaining survivors. This would presumably mean the aggressors would be killing themselves, which makes it seem even less likely to me. But we’ve seen humans come dangerously close to threatening their own survival before, often because human aggressors aren’t always good at predicting how cascading effects could threaten their survival as well. A random example to make this concrete: If all of the survivors of a nuclear war were confined to Australia, which might be less impacted by a nuclear winter, one group might choose to use nuclear weapons against another group, not realizing that the radioactive fallout or further climate change could make Australia uninhabitable, even for them. Bottom line: I expect the survivors in Case 2 would not deploy weapons of mass destruction against their competitors, as it would likely pose a pretty big risk to the aggressor as well as the target. But I’m uncertain about this — humans have come close to making similarly self-destructive choices before. Thankfully, even if one group did use weapons of mass destruction against their competitors, I still think it’s very unlikely that their use would cause human extinction. This is because except in a few very specific and very strange scenarios, I expect the survivors would be too geographically distributed and disconnected to be wiped out by a single act of aggression. I therefore expect the result would be a much higher death toll, but not extinction. Concrete example: A large nuclear war that causes a nuclear winter So what, concretely, do I think would happen in the event of a catastrophe like a nuclear war that led to the death of 90% of the population, and caused severe infrastructure damage and significant global cooling? I expect that, in addition to the billions of people killed in the initial catastrophe, hundreds of millions or more would likely die in the famines and violent competition that followed. But my best guess is that hundreds of thousands to hundreds of millions of the survivors of the initial catastrophe would survive this violent period. I think it’s extremely likely these survivors would be able to support themselves using leftover food stocks and supplies, before eventually working out how to feed themselves through traditional agriculture and fishing and/or modified agriculture (using methods that don’t rely on climate factors like warm temperatures and regular precipitation). **All of the catastrophes** we know of **that would lead to extreme cooling** would only do so **for** 1–**10 years, and agriculture would become possible again once the climate began to return to normal**. At that point, it seems even more likely that the surviving humans would be able to meet their own basic needs by returning to traditional forms of agriculture. My key uncertainties are around whether I’m putting too much weight on the idea that humans would figure out how to subsist without traditional agriculture just because it’s technically possible, and whether conflict could lead to extinction through channels I haven’t foreseen. Another toy calculation suggests that these **uncertainties** probably **aren’t troubling enough to change my bottom line**. Note: I again assume each group’s fate is independent of the fates of other groups. I actually think this is a pretty reasonable assumption in this case. I expect that the **survivors** of a catastrophe like a severe nuclear war **would end up somewhat spread out** (at least across the Southern Hemisphere), as doing so would create less competition for resources within a smaller area (I discuss this more later). The farther apart the surviving groups are, the less likely they are to be affected by the same shocks (natural disasters, disease outbreaks, conflict). Additionally, in the event of a catastrophe like a nuclear war, transportation, communication, and other technologies that facilitate contact between geographically distributed groups would be enormously limited. This would further limit the extent to which each group’s fate ended up relating to another’s. There would be other sources of variation between groups that made their fates less correlated: Some groups might be made up mostly of farmers, while others will be made up of lawyers, some groups will tend toward cooperation, while others toward conflict, plus pure randomness (e.g. some groups might have a high proportion of survivors with genetic immunity to a particular disease). But there are also factors that point in the other direction — factors that suggest the surviving groups would be at least somewhat correlated. For example, nuclear winter climate conditions, while nonuniform, would nonetheless impact all surviving groups. Similarly, more severe natural disasters might affect large regions, meaning that at least all of the survivor groups at the regional level might end up experiencing very similar challenges to survival simultaneously. Likewise, there might be things about "human nature" that would be shared amongst all survivors. For example, it’s possible that all of the survivors, having witnessed the initial catastrophe, would have similar psychological experiences — like shock, stress, and social distrust, among others — that would make it more difficult to survive and cooperate. As above, the higher the true correlation between survivor groups, the more my toy calculations will cause me to underestimate the probability that all of the survivor groups would be wiped out. TABLE6 With 800 million survivors, the degree of pessimism you have to have about their ability to survive to end up believing that no groups would survive indefinitely is actually kind of extreme. The exact beliefs you’d have to have would depend on whether survivors were concentrated into a few big groups, or distributed in many smaller ones. Specifically: Even if you thought any given group of 100, 1,000, or 10,000 survivors had a 99% chance of being wiped out, it would still be virtually guaranteed that at least one group would survive. If you thought there was a 99% chance that any one of 800 groups of 100,000 people would be wiped out, there would still only be a 1 in 3,000 chance of extinction. The probability of extinction is higher (45%) if you believe that larger groups of 10 million would also have a 99% chance of being wiped out. But, again, to hold that view, you’d have to think that out of a group of 10 million people (again, bigger than the largest US city), not even a few hundred of those people would overcome the obstacles of the post-collapse environment (how to fish, how to farm despite global cooling, avoiding being killed by a hurricane or drought). I do not find this view very plausible. Similarly, the probability of extinction is very high indeed if you think that any given group of 100 million survivors has a 99% chance of being wiped out. Again, to believe extinction risk was that high, you’d have to think that there would be a 99% chance that none of the 100 million people would work out how to survive (for reference, only 14 countries have a population of 100 million or higher). Given all of this, my subjective judgment is that **it’s very unlikely that this scenario would more or less directly lead to human extinction.**

#### War now spurs disarm – otherwise, nuclear war is inevitable

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Although nuclear war is the oldest of these technogenic threats to civilization and human survival, and although important steps to restraint, particularly at the end of the Cold War, have been achieved, the nuclear world is increasingly changing in major ways, and in almost entirely dangerous directions. The third “bombs away” phase of the great debate on the nuclear-political question is more consequentially divided than in the first two phases. Even more ominously, most of the momentum lies with the forces that are pulling states toward nuclear-use, and with the radical actors bent on inflicting catastrophic damage on the leading states in the international system, particularly the United States. In contrast, the arms control project, although intellectually vibrant, is largely in retreat on the world political stage. The arms control settlement of the Cold War is unraveling, and the world public is more divided and distracted than ever. With the recent election of President Donald Trump, the United States, which has played such a dominant role in nuclear politics since its scientists invented these fiendish engines, now has an impulsive and uninformed leader, boding ill for nuclear restraint and effective crisis management. Given current trends, it is prudent to assume that sooner or later, and probably sooner, nuclear weapons will again be the used in war. But this bad news may contain a “silver lining” of good news. Unlike a general nuclear war that might have occurred during the Cold War, such a nuclear event now would probably not mark the end of civilization (or of humanity), due to the great reductions in nuclear forces achieved at the end of the Cold War. Furthermore, politics on “the day after” could have immense potential for positive change. The survivors would not be likely to envy the dead, but would surely have a greatly renewed resolution for “never again.” Such an event, completely unpredictable in its particulars, would unambiguously put the nuclear-political question back at the top of the world political agenda. It would unmistakeably remind leading states of their vulnerability It might also trigger more robust efforts to achieve the global regulation of nuclear capability. Like the bombings of Hiroshima and Nagasaki that did so much to catalyze the elevated concern for nuclear security in the early Cold War, and like the experience “at the brink” in the Cuban Missile Crisis of 1962, the now bubbling nuclear caldron holds the possibility of inaugurating a major period of institutional innovation and adjustment toward a fully “bombs away” future.

#### That’s good – war later is worse

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2. “Civilizational collapse risks” As most human societies are fairly complex, a true civilizational collapse would require a drastic reduction in human population, and the break-down of connections between surviving populations. Survivors would have to rebuild civilization from scratch, likely losing much technological abilities and knowledge in the process. Hanson (2008) estimated that the minimal human population able to survive is around 100 people. Like X risks, there is little agreement on what is required for civilizational collapse. Clearly, different types and levels of the civilizational collapse are possible (Diamond, 2005) (Meadows, Randers, & Meadows, 2004). For instance, one definition of the collapse of civilization involves, collapse of long distance trade, widespread conflict, and loss of government (Coates, 2009). How such collapses relate to existential risk needs more research. 3. “Human extinction risks” are risks that all humans die, and no future generations (in the extended sense mentioned above) will ever exist. 4. “All life on Earth ends risks” involve the extinction of all life on earth. As this includes H. sapiens, such risks are at the very least on a par with human extinction, but are likely worse as the loss of biodiversity is higher, and (without life arising a second time) no other civilizations, human or otherwise, would be possible on Earth. 5. “Astronomical scale risks” include the demise of all civilizations in the affectable universe. This of course includes human extinction, and all life on Earth, and so again are at the very least on a par, and very likely much worse outcomes, than those two. 6. “S-risks” include collective infinite suffering (Daniel, 2017). These differ from extinction risks insofar as extinction leads to a lack of existence, whereas this concerns ongoing existence in undesirable circumstances. These also vary in scale and intensity, but are generally out of scope of this work. Even with a focus squarely on X Risk, global catastrophic risks and civilizational collapse are critically important. This is because there is at least some likelihood that global catastrophic risks increase the probability of human extinction risks—and the more extreme end of civilizational collapses surely would. Before shifting to a discussion of probability appropriate to X risk, we’ll discuss some reasons to link these kinds of risk. First, global risks may have a fat tail—that is a low probability of high consequences—and the existence of such fat tails strongly depend on the intrinsic uncertainty of global systems (Ćirković, 2012) (Baum, 2015), (Wiener, 2016) (Sandberg & Landry, 2015). This is especially true for risks associated with future world wars, which may include not only nuclear weapons, but weapons incorporating synthetic biology and nanotechnology, different AI technologies, as well as Doomsday blackmail weapons (Kahn, 1959). Another case are the risks associated with climate change, where runaway global warming is a likely fat tail (Obata & Shibata, 2012a), (Goldblatt & Watson, 2012). Second, global catastrophes could be part of double catastrophe (Baum, Maher, & Haqq-Misra, 2013) or start a chain of catastrophes (Tonn & and MacGregor, 2009), and in this issue (Karieva, 2018). Even if a single catastrophic risk is insufficient to wipe us out, an unhappy coincidence of such events could be sufficient, or under the wrong conditions could trigger a collapse leading to human extinction. Further, global catastrophe could weaken our ability to prepare for other risks. Luke Oman has estimated the risks of human extinction because of nuclear winter: “The probability I would estimate for the global human population of zero resulting from the 150 Tg of black carbon scenario in our 2007 paper would be in the range of 1 in 10,000 to 1 in 100,000” (Robock, Oman, & Stenchikov, 2007), (Shulman, 2012). Tonn also analyzed chains of events, which could result in human extinction and any global catastrophe may be a start of such chain (Tonn and MacGregor, 2009). Because this, we suggest that any global catastrophe should be regarded as a possible cause of human extinction risks with no less than 0.01 probability. Similarly, scenarios involving civilization collapses also plausibly increase the risk of human extinction. If civilization collapses, recovery may be slowed or stopped for a multitude of reasons. For instance, easily accessible mineral and fossil fuel resources might be no longer available, the future climate may be extreme or unstable, we may not regain sufficient social trust after the catastrophe’s horrors, the catastrophe may affect our genetics, a new endemic disease could prevent high population density, and so on. And of course, the smaller populations associated with civilization collapse are more vulnerable to being wiped out by natural events. We estimate that civilization collapse has a 0.1 probability of becoming an existential catastrophe. In section 4, this discussion will form the basis of our analysis of an X risk’s “severity”, which is the main target of our scale. Before getting there, however, we should first discuss the difficulties of measuring X risks, and related worries regarding probabilities. 3. Difficulties of using probability estimates as the communication tool Plain probability estimates are often used as an instrument to communicate X risks. An example is a claim like “Nuclear war could cause human extinction with probability P”. However, in our view, probability measures are inadequate, both for measuring X risks, and for communicating those risks. This is because of conceptual difficulties (3.1), difficulty in providing meaningful measurements (3.2), the possibility of interaction effects (3.3) and the measurement’s inadequacy for prioritization (3.4) purposes. After presenting these worries, we argue that the magnitude of probabilities is a better option, which we use in our tool (3.5). 3.1 Difficulties in defining X risk probabilities Frequentism applies to X risks only with difficulty. One-off events don’t have a frequency, and multiple events are required for frequentist probabilities to apply. Further, on a frequentist reading, claims concerning X risks cannot be falsified. Again, this is because in order to infer from occurrences to probability, multiple instances are required. Although these conceptual and epistemic difficulties may be analyzed and partly overcome in technical scientific and philosophical literature, they would overcomplicate a communication tool. Also, discussion of X risks sometimes involves weird probabilistic effects. Consider, for example, what (Ćirković, Sandberg, & Bostrom, 2010) call the ‘anthropic shadow’. Because human extinction events entail a lack of humans to observe the event after the fact, we will systematically underestimate the occurrence of such events in an extreme case of survivorship bias (the Doomsday Argument (Tegmark & Bostrom, 2005) is similar). All of this makes the probabilities attached to X risks extremely difficult to interpret, bad news for an intended communication tool, and stimulates obscure anthropic reasoning. In addition, the subtle features involved in applying frequentism to one-off events, would otherwise tamper with our decision making process. 3.2 Data & X Risk There are little hard data concerning global risks from which probabilities could be extracted. The risk of an asteroid impact is fairly well understood, both due to the historical record, and because scientists can observe particular asteroids and calculate their trajectories. Studies of nuclear winter (Denkenberger & Pearce, 2016), volcanic eruptions, and climate change also provide some risk probability estimates, but are less rigorously supported. In all other cases, especially technological risks, there are many (often contradicting) expert opinions, but little hard data. Those probability calculations which have been carried out are based on speculative assumptions, which carry their own uncertainty. In the best case, generally, only the order of magnitude of the catastrophe’s probability can be estimated. Uncertainty in GCRs is so high, that predictions with high precision are likely to be meaningless. For example, surveys could produce such meaningless over-precision. A survey on human extinction probability gave an estimate of 19 percent in the 21st century (Sandberg & Bostrom, 2008). Such measurements are problematic for communication, because probability estimates of global risks often do not include corresponding confidence intervals (Garrick, 2008). For some catastrophic risks, uncertainty is much larger than for others, because of objective difficulties in their measurement, as well as subjective disagreements between various approaches (especially in the case of climate change, resource depletion, population growth and other politicized areas). As we’ll discuss below, one response is to present probabilities as magnitudes. 3.3 Probability density, timing and risks’ interactions Two more issues with using discrete frequentist probabilities for communicating X risks are related to probability density and the interactions between risks. For the purpose of responding to the challenges of X risk, the total probability of an event is less useful than the probability density: we want to know not only the probability but the time in which it is measured. This is crucial if policy makers are to prioritize avoidance efforts. Also, probability estimates of the risks are typically treated separate: interdependence is thus ignored. The total probability of human extinction caused by risk A could strongly depend on the extinction probability caused by risks B and C and also of their timing. (See also double catastrophes discussed by Baum, Maher, & HaqqMisra, 2013 and the integrated risk assessment project (Baum, 2017). Further, probability distributions of different risks can have different forms. Some risks are linear, others are barrier-like, other logistical. Thus, not all risks can be presented by a single numerical estimate. Exponentially growing risks may be the best way to describe new technologies, such as AI and synthetic biology. Such risks cannot be presented by a single annual probability. Finally, the probability estimation of a risk depends on whether human extinction is ultimately inevitable. We assume that if humanity becomes an interstellar civilization existing for millions of years, it will escape any near-term extinction risks; the heat death of the universe may be ultimate end, but some think even that is escapable (Dvorsky, 2015). If near-term extinction is inevitable, it is possible to estimate which risks are more probable to cause human extinction (like actuaries do in estimating different causes of death, based in part on the assumption that human death is inevitable). If near-term human extinction is not inevitable, then there is a probability of survival, which is (1- P(all risks)). Such conditioning requires a general model of the future. If extinction is inevitable, the probability of a given risk is just a probability of one way to extinction compared to other ways. 3.4 Preventability, prioritizing and relation to the smaller risks Using bare probability as a communication tool also ignores many important aspects of risks which are substantial for decision makers. First, a probability estimate does not provide sufficient guidance on how to prioritize prevention efforts. A probability estimate does not say anything about the risk’s relation to other risks, e.g. its urgency. Also, if a risk will take place at a remote time in the future (like the Sun becoming a red giant), there is no reason to spend money on its prevention. Second, a probability estimate does not provide much information about the relation of human extinction risks, and corresponding smaller global catastrophic risks. For example, a nuclear war probability estimate does not disambiguate between chances that it will be a human extinction event, a global catastrophic event, or a regional catastrophe. Third, probability measures do not take preventability into account. Hopefully, measures will be taken to try and reduce X risks, and the risks themselves have individual preventability. Generally speaking, it ought to be made clear when probabilities are conditional on whether prevention is attempted or not, and also on the probability of its success. Probability density, and its relation with cumulative probability could also be tricky, especially as the probability density of most risks is changing in time. 3.5 Use of probability orders of magnitude as a communication tool We recommend using magnitudes of probabilities in communicating about X risk. One way of overcoming many of the difficulties of using probabilities as communication tool described above is to estimate probabilities with fidelity of one or even two orders of magnitude, and do it over large fixed interval of time, that is the next 100 years (as it the furthest time where meaningful prognoses exist). This order of magnitude estimation will smooth many of the uncertainties described above. Further, prevention actions are typically insensitive in to the exact value of probability. For example, if a given asteroid impact probability is 5% or 25%, needed prevention action will be nearly the same. For X risks, we suggest using probability intervals of 2 orders of magnitude. Using such intervals will often provide meaningful differences in probability estimates for individual risks. (However, expert estimates sometimes range from “inevitable” to “impossible”, as in AI risks). Large intervals will also accommodate the possibility of one risk overshadowing another, and other uncertainties which arise from the difficulties of defining and measuring X-risks. This solution is itself inspired by The Torino scale of asteroid danger, which we discuss in more detail below. The Torino scale has five probability intervals, each with a two order of magnitude difference from the next. Further, such intervals can be used to present uncertainty in probability estimation. This uncertainty is often very large for even approximately well-defined asteroid risks. For example, Garrick (Garrick, 2008) estimated that asteroid impacts on the contiguous US with at least 10 000 victims to have expected frequency between once 1: 1900 and 1: 520 000 years with 90 percent confidence. In other words, it used more than 2 orders of magnitude uncertainty. Of course, there is a lot more to be said about the relationship between X risks and probability—however here we restrict ourselves to those issues most crucial for our purpose, that is, designing a communication tool for X risks. 4. Constructing the scale of human extinction risks 4.1. Existing scales for different catastrophic risks In section 2 we established the connection between global catastrophic risks, civilizational collapse risks, human extinction and X risks; we explored the difficulty of the use of probabilities as a communication tool for X risks in section 3; now we can construct the scale to communicate the level of risk of all global catastrophic and X risks. Our scale is inspired by the Torino scale of asteroid danger which was suggested by professor Richard Binzel (Binzel, 1997). As it only measures the energy of impact, it is not restricted to asteroids but applies to many celestial bodies (comets, for instance). It was first created to communicate the level of risk to the public, because professionals and decision makers have access to all underlying data for the hazardous object. The Torino scale combines a 5 level color code and 11 level numbered codes. One of the Torino scale’s features is that it connects the size and the probability using diagonal lines, i.e., an event with a bigger size and smaller probability warrants the same level of attention as smaller but more probable events. However, this approach has some difficulties, as was described by (Cox, 2008). There are several other scales of specific global risks based on similar principles: 1. Volcanic explosivity index, VEI, 0-8, (USGS, 2017) 2. DEFCON (DEFense readiness CONdition, used by the US military to describe five levels of readiness), from 5 to 1. 3. “Rio scale” of the Search for Extra-Terrestrial Intelligence (SETI) – complex scale with three subscales (Almar, 2011). 4. Palermo scale of asteroid risks compares the likelihood of the detected potential impactor with the average risk posed by objects of the same size measured both by energy and frequency (NASA, 2017). 5. San-Marino scale of risks of Messaging to Extra-Terrestrial Intelligence (METI) (Almar, 2007). The only more general scale for several global risks is the Doomsday Clock by the Bulletin of the Atomic Scientists, which shows global risks as minutes before midnight. It is oriented towards risks of a nuclear war and climate change and communicates only emotional impact (The Bulletin of the Atomic Scientists, 2017). 4.2. The goals of the scale How good a scale is depends in part on what it is intended to do: who will use it and how will they use it. There are three main groups of people the scale addresses: Public. Simplicity matters: a simple scale is required, similar to the hurricane Saffir-Simpson scale (Schott et al., 2012). This hurricane ACCEPTED MANUSCRIPT 13 measuring scale has 5 levels which present rather obscure wind readings as corresponding to the expected damage to houses and thus can help the public make decisions about preparedness and evacuation. In the case of X risks, personal preparedness is not very important, but the public make decisions about which prevention projects to directly support (via donations or crowdfunding) or voting for policymakers who support said projects. Simplicity is necessary to communicate the relative importance of different dangers to a wide variety of nonexperts. Policymakers. We intend our scale to help initiate communication of the relative importance of the risks to policymakers. This is particularly important as it appears that policymakers tend to overestimate smaller risks (like asteroid impact risks) and underestimate larger risks (like AI risks) (Bostrom, 2013). Our scale helps to make such comparison possible as it does not depend on the exact nature of the risks. The scale could be applicable to several groups of risks thus allowing comparisons between them, as well as providing a perspective across the whole situation. Expert community. Even a scale of the simplicity we suggest may benefit the expert community. It can act as a basis for comparing different risks by different experts. Given the interdisciplinarity inherent in studying X risk, this common ground is crucial. The scale could facilitate discussion about catastrophes’ probabilities, preventability, prevention costs, interactions, and error margins, as experts from different fields present arguments about the importance of the risks on which they work. Thus it will help to build a common framework for the risk discussions. 4.3. Color codes and classification of the needed actions Tonn and Steifel suggested a six-level classification of actions to prevent X risks (Tonn & Steifel, 2017). They start from “do nothing” and end with “extreme war footing, economy organized around reducing human extinction risk”. We suggest a scale which is coordinated with Tonn and Steifel’s classification of actions (Table 1), that is our colors correspond to the needed level of action. Also, our colors correspond to typical nonquantifiable ways of the risks description: theoretical, small, medium, serious, high and immediate. We also add iconic examples, which are risks where the probability distribution is known with a higher level of certainty, and thus could be used to communicate the risk’s importance by comparison. Such ACCEPTED MANUSCRIPT 14 examples may aid in learning the scale, or be used instead of the scale. For instance, someone could say: “this risk is the same level as asteroid risk”. The iconic risks are marked bold in the scale. Iconic examples are also illustrated with the best-known example of that type of event. For example, the best known supervolcanic eruption was the Toba eruption 74,000 years ago (Robock et al., 2009). The Chicxulub impact 66 million years ago is infamous for being connected with the latest major extinction, associated with the non-avian Dinosaur extinction. The scale presents the total risk of one type of event, without breaking categories down into subrisks. For example, it estimates the total risks of all known and unknown asteroids, but not the risk of any particular asteroid, which is a departure from the Torino scale. Although the scale is presented using probability intervals, it could be used instead of probabilities if they are completely unknown, but other factors, such as those affecting scope and severity, are known. For example, we might want to communicate that AI catastrophe is a very significant risk, but its exact probability estimation is complicated by large uncertainties. Thus we could agree to represent the risk as red despite difficulties of its numerical estimation. Note that the probability interval (when it is known) for “red” is shorter and is only 1 order of magnitude, as it is needed to represent most serious risks and here we need better resolution ability. As it is a communication scale, the scientists using it could come to agreement that a particular risk should be estimated higher or lower in this scale. We don’t want to place too many restrictions on how different aspects of a risk’s severity (like preventability or connection with other risks) should affect risks coding, as it should be established in the practical use of the scale. However, we will note two rules: 1. The purple color is reserved to present extreme urgency of the risk 2. The scale is extrapolated from the smaller than extinction risks and larger than extinction risks in Table 2. (This is based on idea that smaller risks have considerable but unknown probability to become human extinction risks, and also on the fact that policy makers may implement similar measures for smaller and larger risks). 4.4. Extrapolated version of scale which accounts for the risk size In Table 2 we extend the scale to include smaller risks like civilization collapse and global catastrophic risks as well as on “larger” ACCEPTED MANUSCRIPT 15 risks like life extinction and universe destruction, in accordance with our discussion in section 2. This is necessary because: 1) Smaller risks could become larger extinction risks by starting chains of catastrophic events. 2) The public and policymakers will react similarly to human extinction level catastrophe and to a global catastrophe where there will be some survival: both present similar dangers to personal survival, and in both similar prevention actions are needed. [[TABLE 2 OMITTED]] 4.5. Accessing risks with shorter timeframes than 100 years In Table 2 above we assessed the risks for the next 100 years. However, without prevention efforts, some risks could approach a probability of 1 in less time: climate change, for instance. We suggest that the urgency of intervening in such cases may be expressed by increasing their color coding. Moreover, the critical issue is less the timing of risks, but the timing of the prevention measures. Again, although extreme global warming would likely only occur at the end of the 21st century, it is also true that cutting emissions now would ameliorate the situation. We suggest, then, three ranks which incorporate these shorter time-frame risks. Note that the timings relate to implementation of interventions not the timings of the catastrophes. 1) Now. This is when a catastrophe has started, or may start in any moment: The Cuban Missile Crisis is an historical example. We reserve purple to represent it. 2) “Near mode”. Near mode is roughly the next 5 years. Typically current political problems (as in current relations with North Korea) are understood in near mode. Such problems are appropriately explored in terms of planning and trend expectations. Hanson showed that people are very realistic in “Near mode”, but become speculative and less moral in “Far mode” thinking (Hanson, 2010). Near mode may require one color code increase. 3) “Next 2-3 decades”. Many futurists predict a Technological Singularity between 2030-2050: that is around 10-30 years from now (Vinge, 1993), (Kurzweil, 2006). As this mode coincides with an adult’s working life, it may also be called “in personal life time”. In this mode people may expect to personally suffer from a catastrophe, or be personally responsible for incorrect predictions. MIRI recently increased its estimation of the probability that AGI will appear around 2035 (MIRI, 2017), pushing AGI into “next 2-3 decades” mode. There is a consideration against increasing the color code too much for near-term risks, as that may lead to myopia regarding longterm risks of human extinction. There will always be smaller but more urgent risks, and although these ought to be dealt with, some resources ought to be put towards understanding and mitigating the longer term. ACCEPTED MANUSCRIPT 19 Having said this, in high impact emergency situations, short term overwhelming efforts may help to prevent impending global catastrophe. Examples include the Cuban missile crisis and fighting the recent Ebola pandemic in Western Africa. Such short-term efforts do not necessarily constrain our long-term efforts towards preventing other risks. Thus, short term global catastrophic and larger risks may get a purple rating. 4.6. Detailed explanation of risk assessment principles in the color coded scale In Table 3, we estimate the main global risks, according to the scale suggested in section 4.4. Table 3. Detailed explanation of the X risks scale Color code Examples of risks White Sun becomes red giant. Although this risk is practically guaranteed, it is very remote indeed. Natural false vacuum decay. Bostrom and Tegmark estimated such events as happening in less than one in 1 billion years, (that is 10-7 in a century) (Tegmark & Bostrom, 2005). Moreover, nothing can be done to prevent it. Green Gamma-ray bursts. Earth threatening gamma-ray bursts are extremely rare, and in most cases they will result only in a crop failure due to UV increases. However, a close gamma-ray burst may produce a deadly muon shower which may kill everything up to 3 km in depth (A. Dar, Laor, & N.J, 1997). However, such events could happen less than once in a billion years (10-7 in a century) (Cirković & Vukotića, 2016). Such an event will probably kill all multicellular life on Earth. Dar estimates risks of major extinction events from gamma ray bursts as 1 in 100 mln years (A. Dar, 2001). Asteroid impacts. No dangerous asteroids have been thus far identified, and the background level of global catastrophic impacts is around 1 in a million years (10- 4 in a century). Extinction-level impact probability is 10-6 per century. There are several prevention options involving deflecting comets/asteroids. Also, food security could be purchased cheaply (Denkenberger, 2015). However, some uncertainty exists. Some periods involve intense comet bombardment, and if we are in such a time investment in telescopes should be larger (Rampino & Caldeira, 2015). High energy accelerator experiments creating false vacuum decay/black hole/strangelet. Vacuum decay seems to have extremely low probability, far below 10-8 currently. One obvious reason for expecting such events to have very low probability is that similar events happen quite often, and haven’t destroyed everything as yet (Kent, 2004). However, we give this event a higher estimation for two reasons. First, as accelerators become more capable such events might become more likely. Second, the risks are at an astronomical scale: it could affect other civilizations in the universe. Other types of accelerator catastrophes, like mini-black hole or strangelet creation, would only kill Earth life. However, these are more likely, with one estimate being <2E-8 risk from a single facility (the Relativistic Heavy Ion Collider) (Arnon Dar, De Rújula, & Heinz, 1999), which should be coded white. There many unknowns about dangerous experiments (Sandberg & Landry, 2015). Overall, these risks should be monitored, so green is advisable. Yellow Supervolcanic eruption. Given historical patterns, the likelihood of living in a century containing a super volcanic eruption is approximately 10-3 (Denkenberger, 2014). However, the chance of human extinction resulting is ACCEPTED MANUSCRIPT 21 significantly lower than this. If such an eruption produces global crop failure, it could end current civilization. Conventional wisdom is that there is nothing that could be done to prevent a super volcano from erupting, but some possible preventive measures have been suggested (Denkenberger, this issue). We estimate supervolcanic risks to be higher than asteroid impacts because of the historical record, as they likely nearly finished us off 74 000 ago (Robock et al., 2009). Natural pandemic. A natural pandemic is fairly likely to kill 1% (to an order of magnitude) of the global population during this century, as the Spanish flu did. However, such a pandemic is very unlikely to cause total extinction because lethality is under 100% and some populations are isolated. Between all natural pandemics, emerging pandemic flus have a shorter timespan and need much more attention. Bird flu has a mortality above 0.5 (WHO, 2017) and could produce widespread chaos and possible civilizational collapse if human-to-human transmission starts. Therefore, we estimate 10% probability this century of 10% mortality. Global warming triggering global catastrophe. According to the IPCC anthropogenic global warming may affect billions of people by the end of the 21st century (Parry, 2007), causing heat waves, crop failures and mass migration. Those events, and downstream consequences such as conflicts, could conceivably kill 1 billion people. However, this would only occur for tail risk scenarios which have order of magnitude 1% probability. Having said this, several experts think that methane release from permafrost and similar positive feedback loops may result in runaway global warming with much larger consequences (Obata & Shibata, 2012). Orange Full-scale nuclear war. There is roughly 0.02-7% chance per year of accidental full-scale nuclear war between the US and Russia (Barrett, Baum, & Hostetler, 2013). With fairly high probabilities of nuclear winter and civilization collapse given nuclear war, this is order of magnitude 10% this century. We should also take into consideration that despite reductions in nuclear weapons, a new nuclear arms race is possible in the 21st century. Such a race may include more devastating weapons or cheaper manufacturing methods. Nuclear war could include the creation of large cobalt bombs as doomsday weapons or attacks on nuclear power plants. It could also start a chain of events which result in civilization collapse. Nanotechnology risks. Although molecular manufacturing can be achieved without self-replicating machines (Drexler & Phoenix, 2004), technological fascination with biological systems makes it likely that self-replicating machines will be created. Moreover, catastrophic uses of nanotechnology needn’t be due to accident, but also due to the actions of purposeful malignant agents. Therefore, we estimate the chance of runaway self-replicating machines causing “gray goo” and thus human extinction to be one per cent in this century. There could also be extinction risks from weapons produced by safe exponential molecular manufacturing. See also (Turchin, 2016). Artificial pandemic and other risks from synthetic biology. An artificial multipandemic is a situation in which multiple (even hundreds) of individual viruses created through synthetic biology are released simultaneously either by a terrorist state or as a result of the independent activity of biohackers (Turchin, Green, & Dekenbergern, 2017). Because the capacity to create such a multipandemic could arrive as early as within the next ten to thirty years (as all the needed technologies already exist), it could overshadow future risks, like nanotech and AI, so we give it a higher estimate. There are also other possible risks, connected with synthetic biology, which are widely recognized as serious (Bostrom, 2002). Agricultural catastrophe. There is about a one per cent risk per year of a ten per cent global agricultural shortfall occurring due to a large volcanic eruption, a medium asteroid or comet impact, regional nuclear war, abrupt climate change, or extreme weather causing multiple breadbasket failures (Denkenberger 2016). This could lead to 10% mortality. Red AI risks. The risks connected with the possible creation of non-aligned Strong AI are discussed by (Bostrom, 2014), (Yudkowsky, 2008), (Yampolskiy & Fox, 2013) and others. It is widely recognized as the most serious X risk. AI could start an “intelligence explosion wave” through the Universe, which could prevent appearance of the other civilizations before they create their own AI. Purple Something like the Caribbean crisis in the past, but larger size. Currently, there are no known purple risks. If we could be sure that Strong AI will appear in the next 100 years and would probably be negative, it would constitute a purple risk. Another example would be the creation of a Doomsday weapon that could kill our species with global radiation poisoning (much greater ionizing radiation release than all of the current nuclear weapons) (Kahn, 1959). A further example would be a large incoming asteroid being located, or an extinction level pandemic has begun. These situations require quick and urgent effort on all levels.

#### Extinction is inevitable from future technology — nanotech, biotech, particle accelerators, and black swans

Bruce **Sterling**, 6-1-20**18**, "When Nick Bostrom says “Bang”," WIRED, https://www.wired.com/beyond-the-beyond/2018/06/nick-bostrom-says-bang/

4.1 Deliberate misuse of nanotechnology

In a mature form, molecular nanotechnology will enable the construction of bacterium-scale self-replicating mechanical robots that can feed on dirt or other organic matter [22-25]. Such replicators could eat up the biosphere or destroy it by other means such as by poisoning it, burning it, or blocking out sunlight. A person of malicious intent in possession of this technology might cause the extinction of intelligent life on Earth by releasing such nanobots into the environment.[9]

The technology to produce a destructive nanobot seems considerably easier to develop than the technology to create an effective defense against such an attack (a global nanotech immune system, an “active shield” [23]). It is therefore likely that there will be a period of vulnerability during which this technology must be prevented from coming into the wrong hands. Yet the technology could prove hard to regulate, since it doesn’t require rare radioactive isotopes or large, easily identifiable manufacturing plants, as does production of nuclear weapons [23].

Even if effective defenses against a limited nanotech attack are developed before dangerous replicators are designed and acquired by suicidal regimes or terrorists, there will still be the danger of an arms race between states possessing nanotechnology. It has been argued [26] that molecular manufacturing would lead to both arms race instability and crisis instability, to a higher degree than was the case with nuclear weapons. Arms race instability means that there would be dominant incentives for each competitor to escalate its armaments, leading to a runaway arms race. Crisis instability means that there would be dominant incentives for striking first. Two roughly balanced rivals acquiring nanotechnology would, on this view, begin a massive buildup of armaments and weapons development programs that would continue until a crisis occurs and war breaks out, potentially causing global terminal destruction of a nuclear war, it could lead to the collapse of civilization. A human race living under stone-age conditions may or may not be more resilient to extinction than other animal species.

4.3 We’re living in a simulation and it gets shut down

A case can be made that the hypothesis that we are living in a computer simulation should be given a significant probability [27]. The basic idea behind this so-called “Simulation argument” is that vast amounts of computing power may become available in the future (see e.g. [28,29]), and that it could be used, among other things, to run large numbers of fine-grained simulations of past human civilizations. Under some not-too-implausible assumptions, the result can be that almost all minds like ours are simulated minds, and that we should therefore assign a significant probability to being such computer-emulated minds rather than the (subjectively indistinguishable) minds of originally evolved creatures. And if we are, we suffer the risk that the simulation may be shut down at any time. A decision to terminate our simulation may be prompted by our actions or by exogenous factors.

While to some it may seem frivolous to list such a radical or “philosophical” hypothesis next the concrete threat of nuclear holocaust, we must seek to base these evaluations on reasons rather than untutored intuition. Until a refutation appears of the argument presented in [27], it would intellectually dishonest to neglect to mention simulation-shutdown as a potential extinction mode.

4.4 Badly programmed superintelligence

When we create the first superintelligent entity [28-34], we might make a mistake and give it goals that lead it to annihilate humankind, assuming its enormous intellectual advantage gives it the power to do so. For example, we could mistakenly elevate a subgoal to the status of a supergoal. We tell it to solve a mathematical problem, and it complies by turning all the matter in the solar system into a giant calculating device, in the process killing the person who asked the question. (For further analysis of this, see [35].)

4.5 Genetically engineered biological agent

With the fabulous advances in genetic technology currently taking place, it may become possible for a tyrant, terrorist, or ~~lunatic~~ to create a doomsday virus, an organism that combines long latency with high virulence and mortality [36].

Dangerous viruses can even be spawned unintentionally, as Australian researchers recently demonstrated when they created a modified mousepox virus with 100% mortality while trying to design a contraceptive virus for mice for use in pest control [37]. While this particular virus doesn’t affect humans, it is suspected that an analogous alteration would increase the mortality of the human smallpox virus. What underscores the future hazard here is that the research was quickly published in the open scientific literature [38]. It is hard to see how information generated in open biotech research programs could be contained no matter how grave the potential danger that it poses; and the same holds for research in nanotechnology.

Genetic medicine will also lead to better cures and vaccines, but there is no guarantee that defense will always keep pace with offense. (Even the accidentally created mousepox virus had a 50% mortality rate on vaccinated mice.) Eventually, worry about biological weapons may be put to rest through the development of nanomedicine, but while nanotechnology has enormous long-term potential for medicine [39] it carries its own hazards.

4.6 Accidental misuse of nanotechnology (“gray goo”)

The possibility of accidents can never be completely ruled out. However, there are many ways of making sure, through responsible engineering practices, that species-destroying accidents do not occur. One could avoid using self-replication; one could make nanobots dependent on some rare feedstock chemical that doesn’t exist in the wild; one could confine them to sealed environments; one could design them in such a way that any mutation was overwhelmingly likely to cause a nanobot to completely cease to function [40]. Accidental misuse is therefore a smaller concern than malicious misuse [23,25,41].

However, the distinction between the accidental and the deliberate can become blurred. While “in principle” it seems possible to make terminal nanotechnological accidents extremely improbable, the actual circumstances may not permit this ideal level of security to be realized. Compare nanotechnology with nuclear technology. From an engineering perspective, it is of course perfectly possible to use nuclear technology only for peaceful purposes such as nuclear reactors, which have a zero chance of destroying the whole planet. Yet in practice it may be very hard to avoid nuclear technology also being used to build nuclear weapons, leading to an arms race. With large nuclear arsenals on hair-trigger alert, there is inevitably a significant risk of accidental war. The same can happen with nanotechnology: it may be pressed into serving military objectives in a way that carries unavoidable risks of serious accidents.

In some situations it can even be strategically advantageous to deliberately make one’s technology or control systems risky, for example in order to make a “threat that leaves something to chance” [42].

4.7 Something unforeseen

We need a catch-all category. It would be foolish to be confident that we have already imagined and anticipated all significant risks. Future technological or scientific developments may very well reveal novel ways of destroying the world.

Some foreseen hazards (hence not members of the current category) which have been excluded from the list of bangs on grounds that they seem too unlikely to cause a global terminal disaster are: solar flares, supernovae, black hole explosions or mergers, gamma-ray bursts, galactic center outbursts, supervolcanos, loss of biodiversity, buildup of air pollution, gradual loss of human fertility, and various religious doomsday scenarios. The hypothesis that we will one day become “illuminated” and commit collective suicide or stop reproducing, as supporters of VHEMT (The Voluntary Human Extinction Movement) hope [43], appears unlikely. If it really were better not to exist (as Silenus told king Midas in the Greek myth, and as Arthur Schopenhauer argued [44] although for reasons specific to his philosophical system he didn’t advocate suicide), then we should not count this scenario as an existential disaster. The assumption that it is not worse to be alive should be regarded as an implicit assumption in the definition of Bangs. Erroneous collective suicide is an existential risk albeit one whose probability seems extremely slight. (For more on the ethics of human extinction, see chapter 4 of [9].)

4.8 Physics disasters

The Manhattan Project bomb-builders’ concern about an A-bomb-derived atmospheric conflagration has contemporary analogues.

There have been speculations that future high-energy particle accelerator experiments may cause a breakdown of a metastable vacuum state that our part of the cosmos might be in, converting it into a “true” vacuum of lower energy density [45]. This would result in an expanding bubble of total destruction that would sweep through the galaxy and beyond at the speed of light, tearing all matter apart as it proceeds.

Another conceivability is that accelerator experiments might produce negatively charged stable “strangelets” (a hypothetical form of nuclear matter) or create a mini black hole that would sink to the center of the Earth and start accreting the rest of the planet [46].

These outcomes seem to be impossible given our best current physical theories. But the reason we do the experiments is precisely that we don’t really know what will happen. A more reassuring argument is that the energy densities attained in present day accelerators are far lower than those that occur naturally in collisions between cosmic rays [46,47]. It’s possible, however, that factors other than energy density are relevant for these hypothetical processes, and that those factors will be brought together in novel ways in future experiments.

The main reason for concern in the “physics disasters” category is the meta-level observation that discoveries of all sorts of weird physical phenomena are made all the time, so even if right now all the particular physics disasters we have conceived of were absurdly improbable or impossible, there could be other more realistic failure-modes waiting to be uncovered. The ones listed here are merely illustrations of the general case.

#### Global wars drive calls for world government

**Chase-Dunn 12** [Christopher Chase-Dunn, Distinguished Professor of Sociology and Director of the [Institute for Research on World-Systems](http://www.irows.ucr.edu/)at the University of California-Riverside, Hiroko Inoue, Research Assistant at the Institute of Research on World-Systems, “Accelerating democratic global state formation”, <https://journals.sagepub.com/doi/full/10.1177/0010836712443168>, June 6, 2012, imp, \*\*we do not endorse this cards pathetic non-utilitarianism]

All the previous advances in global governance have taken place after a hegemon has declined and there has been a world war among rivals. H. G. Wells saw the importance of catastrophes in the emergence of a new civilization (Wagar, 1961). The idea here is that **major** organizational **changes** tend to **emerge after huge catastrophes** when the existing institutions are in disarray and need to be rebuilt and when people are sufficiently disgusted with the old failed institutions that have led to disaster.15 Of course, political actors who seek to promote the emergence of an effective and democratic global state must also do all that they can to try to prevent another war among the great powers because humanistic morality must trump whatever advantages might result from such a catastrophe. This said, many believe that it is rather likely that major calamities will occur in the coming decades regardless of the efforts of far-sighted world citizens and social movements. And it would make both tactical and strategic sense to have plans for how to move forward if indeed a perfect storm of calamities were to come about.

#### disarm movements are latent now

**Ragheb 18** [Magdi Ragheb, Prof. @ Department of Nuclear, Plasma, and Radiological Engineering, University of Illinois at Urbana-Champaign. 08-08-18. “Safeguards, Non -Proliferation, and Peaceful Nuclear Energy.” <http://mragheb.com/NPRE%20402%20ME%20405%20Nuclear%20Power%20Engineering/Safeguards%20Non%20Proliferation%20and%20Peaceful%20Nuclear%20Energy.pdf> //reem

The “axiom of proliferation” states that as long as some states cling to the possession of nuclear weapons, others will also seek to acquire them. According to “catastrophe theory,” **serious nuclear disarmament** is apparently **waiting** for some **event** that would **stir action** toward the **eventual goal of humanity to eliminate nuclear weapons**. An analogy is advanced of a village fully aware about the need to build gates along railroad tracks that pass through it, remaining **inactive** then **spring into action** until the time that one of its residents is **hit by a passing train**.

#### States are motivated by fear – elevating the nuclear threat via use would cause global buy-in for a world state

**Sargent 19** [Brianna Sargent, “THE HOBBESIAN STATE OF NATURE AMONG NATIONS”, Undergraduate Thesis @ Ashland University Honors College, <https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=auhonors1556751283322051&disposition=inline>, April 2019, imp]

Were the threat great enough, the nations would either form an international government with an assembly to represent each nation or allow one man or one government to rule over them all. This threat would have to be a threat to the very existence of each nation. This principle of **existential fear controls all nations** and why they have not exited the state of nature to be under one sovereign. As of now, there is no threat that scares nations enough to give up their own sovereignty, but if a threat of this magnitude were to be felt, then a world government would be absolutely necessary to the survival of the nations and the world.

#### Nuclear war weakens or destroys the states most likely to resist transition

**Martin 82** (Brian, Professor of Social Sciences at the University of Wollongong. “How the Peace¶ Movement Should be Preparing for Nuclear War,” Bulletin of Peace Proposals, Vol. 13, No. 2, 1982, pp. 149-159)

As well as encouraging moves towards repressive rule, the political and social upheaval resulting from nuclear war could also provide major opportunities for rapid social change in progressive directions. Several factors would operate here.¶ (a) There would be worldwide anguish and outrage at any significant use of nuclear weapons against populations. This emotion could easily turn against established institutions.¶ (b) A nuclear war involving the US, Soviet Union and Europe would weaken or destroy the bases for imperialism and neocolonialism in poor countries, and stimulate widespread revolutionary action that could not be contained by local elites left without rich country support.¶ (c) In areas directly affected by nuclear attack, the destruction of established institutions would allow the creation of new structures.¶ Historically, periods of economic or military crisis often have preceded revolutionary change, though not always with desirable results. Crises provide opportunities for groups which are organised and able to take advantage of them.

#### Instability drives calls for world government – thousands of years of empirics prove

**Houghton 65** [Neal D. Houghton, University of Arizona, “THE CASE FOR WORLD GOVERNMENT AS AN OUTGROWTH OF THE UNITED NATIONS”, *THE WESTERN POLITICAL QUARTERLY,* Vol. 18, No. 3, link, <https://www.jstor.org/stable/446065>, September 1965, imp]

Man's demands for "world order" and "world government" have come most notably in periods of great regional disorder. Some identifiable periods of great disorder, with consequent demands for and efforts toward "world order," include: (1) the long disorderly period following the fall of the Roman Empire; (2) the Thirty Years' War of the seventeenth century and its long chaotic aftermath; (3) the basic social and political disturbances of the French Revolution and the Napoleonic era (when the frighteningly menacing ism in Europe was constitutionalism), which brought forth our first modem league of nations (the so-called "Concert of Europe") by way of the Quadruple-Quintuple Alliance; (4) the traumatic collapse of the prospectively western white man's capitalistic world - as it had looked in the 1890's to those for whom it had been arranged; (5) the inter-World War decades with our frantic and futile efforts to re-create the essence of that unrealistic world concept, for Asia and Europe, and to protect it from further disturbance by Germany, Japan, and Russia; and (6) the uniquely global and unprecedentedly complicated current and prospectively permanent great convulsive transition period - whose irrepressibly impelling forces have their roots running far back into the history of all continents. The intensity of man's crying-out for "world order" and "world government" may seem to be roughly in direct proportion to the extent and degree of the activating disorder.

#### International anarchy guarantees war makes threat response impossible

**Craig 8** [Campbell Craig, “The Resurgent Idea of World Government”, Ethics & International Affairs, <https://ciaotest.cc.columbia.edu/journals/cceia/v22i2/f_0007579_6441.pdf>, June 2008, imp]

Certainly, one of the most evident failures of the nation-state system in recent years has been its inability to deal successfully with problems that endanger much or most of the world’s population. As the world has become more globalized—economically integrated and culturally interconnected—individual countries have become increasingly averse to dealing with international problems that are not caused by any single state and cannot be fixed even by the focused efforts of individual governments. Political scientists refer to this quandary as the ‘‘collective action problem,’’ by which they mean the dilemma that emerges when several actors have an interest in eradicating a problem that harms all of them, but when each would prefer that someone else do the dirty work of solving it. If everyone benefits more or less equally from the problem’s solution, but only the actor that addresses it pays the costs, then all are likely to want to ‘‘free ride’’ on the other’s efforts. The result is that no one tackles the problem, and everyone suffers.

Several such collective action problems dominate much of international politics today, and scholars of course debate their importance and relevance to world government. Nevertheless, a few obvious ones stand out, notably the imminent danger of climate change, the difficulty of addressing terrorism, and the complex task of humanitarian intervention. All of these are commonly (though not universally) regarded as serious problems in need of urgent solutions, and in each case powerful states have repeatedly demonstrated that they would prefer that somebody else solve them.

The solution to the collective action problem has long been known: it requires the establishment of some kind of authoritative regime that can organize common solutions to common problems and spread out the costs fairly. This is why many scholars and activists concerned with acute global problems support some form of world government. These advocates are not so naive as to believe that such a system would put an effortless end to global warming, terrorism, or human rights atrocities, just as even the most effective national governments have not eradicated pollution or crime. The central argument in favor of a world-government approach to the problems of globalization is not that it would easily solve these problems, but that it is the only entity that can solve them

A less newsworthy issue, but one more central to many advocates of world government, is the persistent possibility of a third world war in which the use of megaton thermonuclear weaponry could destroy most of the human race. During the Cold War, nuclear conflict was averted by the specter of mutual assured destruction (MAD)—the recognition by the United States and the Soviet Union that a war between them would destroy them both. To be sure, this grim form of deterrence could well obtain in future international orders, but it is unwise to regard the Cold War as a promising model for future international politics. It is not at all certain that international politics is destined to return to a stable bipolar order, such as prevailed during the second half of the Cold War, but even if this does happen, there is no guarantee that nuclear deterrence would work as well as it did during the second half of the twentieth century. It is well to remember that the two sides came close to nuclear blows during the Cuban crisis, and this was over a relatively small issue that did not bear upon the basic security of either state. As Martin Amis has written, the problem with nuclear deterrence is that ‘‘it can’t last out the necessary timespan, which is roughly between now and the death of the sun.’’4 As long as interstate politics continue, we cannot rule out that in some future conflict a warning system will fail, a leader will panic, governments will refuse to back down, a third party will provoke a response— indeed, there are any number of scenarios under which deterrence could fail and thermonuclear war could occur

#### Only a world state solves extinction – outweighs on probability and magnitude

**Czarnecki 20** [Tony Czarnecki, Economist, founder of the Sustensis Think Tank, “Existential threats require a planet-wide approach managed by the World Government”, <https://sustensis.medium.com/existential-threats-require-a-planet-wide-approach-managed-by-the-world-government-cd496f746102>, October 29, 2020, imp]

We have heard a lot about an existential threat of Climate Change. But this is only one of about a dozen of such existential risks. Among them, the **most severe** is the threat of Artificial Intelligence and especially, its mature form — Superintelligence. **This is an existential threat of an entirely different magnitude**, which can either make our species extinct by a direct malevolent action, or by taking over the control over the future of Humanity. This risk is also different from Climate Change because it may come much earlier, within the next few decades. Secondly, we cannot stop (uninvent AI) — the proverbial genie is already out of the bottle. Incidentally, both Superintelligence (immature) and Climate Change have a tipping point at about 2030.

There is at least 20% chance that one of the man-made existential risks will materialize by the end of this century, making our species extinct. However, some experts, like prof. Martin Rees, or the late Stephen Hawking, assess such a risk as at least 50%. If we are to survive, we need to apply a planet-wide risk mitigation strategy managed by a powerful planetary organization. **We would need the World Government**, which if it is to be effective, would have to be created by the end of this decade.

#### Military leaders check the impact

**Ladish 20** [Jeffery Ladish, Biologist, Existential Risk Consultant @ Gordian Research, an existential risk consulting firm, “Nuclear war is unlikely to cause human extinction”, https://jeffreyladish.com/Nuclear\_war\_is\_unlikely\_to\_cause\_human\_extinction/, November 7th, 2020, imp]

C: Nuclear war planners are aware of nuclear winter risks and can incorporate these risks into their targeting plans

A very simple way to reduce risks from nuclear winter is to refrain from targeting cities with nuclear weapons. The proposed mechanism behind nuclear winter results from cities burning, not ground bursts on military targets. I’ve spoken with some of the officials in the US defense establishment responsible for nuclear war planning, and they’re well aware of the potential risks from nuclear winter. Of course, being aware of the risks does not guarantee they will have reasoned about the risks well, or have engaged in good risk management practices. However, the fact that this risk is well publicized makes it more likely that nuclear war planners will take steps to minimize blowback risk from climate effects.

It’s hard to know to what extent this has been done. Nuclear war plans are classified, and [as far as we know](https://www.lesswrong.com/posts/rn2duwRP2pqvLqGCE/does-the-us-nuclear-policy-still-target-cities) current US nuclear war plans do target cities under some circumstances but not under others. However, the defense establishment has access to classified information and models that we civilians do not have, in addition to all the public material. I’m confident that nuclear war planners have thought deeply about the risks of climate change from nuclear war, even though I don’t know their conclusions or bureaucratic constraints. All else being equal, the knowledge of these risks makes military planners less likely to accidentally cause human extinction.

#### Key to space colonization

**Crawford 17** [Ian A. Crawford, British professor of planetary science and astrobiology at Birkbeck, “Space, World Government, and a 'Vast Future' for Humanity”, <https://www.researchgate.net/publication/318949832_Space_World_Government_and_a_'Vast_Future'_for_Humanity>, August 2017, imp]

3.1 Benefits of world government for space expansion

Geopolitical stability. Building a space-faring civilisation will require governmental and corporate entities to sustain major projects for many decades, and perhaps centuries. The organisation of today’s world is not conducive to such long-term planning, as governments are constantly distracted by a host of domestic and foreign policy issues. If outer space is to occupy governments to the same extent that they are occupied by (say) foreign affairs, then these other distractions must somehow be made less urgent. Moreover, private entities will have little incentive to invest in long-term space projects unless they can be sure that the political and financial environment is sufficiently stable that their investment will pay off decades in the future. As one of the main objectives, and perhaps the main objective, of a world government would be to ensure geopolitical stability, it follows that space development, along with other long-term projects on Earth itself, would be a beneficiary. As noted above (and to address some of the concerns raised by Deudney [6]), once space colonisation gets going in earnest it will be desirable to expand a world government into an interplanetary government in order to prevent conflict between space colonies and between the colonies and the Earth. I have suggested elsewhere [25] that the nature of federalism is such that a federal world government would be uniquely well-suited to being extended in this way.

Legal oversight of space activities. In additional to providing a stable geopolitical environment within which space development can occur, it will be desirable to provide legal clarity on space activities. For example, if commercial entities are to be involved in extracting space resources they will need to be confident that they have legal title to the fruits of their investment, because otherwise such investment may not occur [26]. Moreover, there will be some activities in space that will need to be restricted because they would pose a potential hazard (changing the orbits of asteroids might be an example), or because they would negatively affect locations or phenomena of scientific importance. To the extent that such activities are regulated today they are governed by a handful of international treaties negotiated under UN auspices, most notably the Outer Space Treaty (OST) of 1967 [27]. However, the OST is woefully inadequate to manage the large-scale space activities envisaged here, not least because many activities that are likely to be important in the future (e.g. the commercial exploitation of space resources, or space tourism) were not envisaged when it was drawn up. Space is a transnational domain, and the current approach of trying to govern space activities by coordinating different national jurisdictions with reference to an out-of-date treaty is unlikely to work well in the longer term. On the other hand, one of the motivations for establishing a world government is to better manage the global commons, and a world (later interplanetary) government would thus appear to be the most logical and legitimate means of managing extraterrestrial activities on behalf of humanity as a whole.

Provision of resources for space development. In addition to long-term economic and political stability, building a space-faring civilisation will require substantial material and intellectual resources. In the early stages, before extraterrestrial resources can themselves make a significant contribution, these resources will have to come from some combination of economic growth and a diversion of resources from other sectors of the world economy. The stability provided by a world government would be expected to help with global economic growth, rendering a world space programme more affordable. More importantly, however, by eliminating the need for national military expenditures, a world government would liberate the approximately 8% of global government expenditures (or ~2.2% of the Gross World Product [28]) that is currently consumed by this largely unnecessary, dangerous, and unproductive sector of the world economy. Presumably, much of this ‘peace dividend’ would (and should) be devoted to global economic development. However, given the extent to which the ‘military-industrial complex’ is embedded in many developed economies, even a world government may find it desirable to divert some of the liberated arms budgets into space development just to maintain employment and innovation in these key industries. I will return to this ‘swords into spaceships’ [29] idea below, where I argue that it might also help a world government overcome resistance to disarmament by industrial vested interests.

### 1NC---AT: Asteroids

#### No chance of apocalyptic NEOs. Consensus of studies.

Mark Boslough, Earth and Planetary Sciences @ University of New Mexico, PhD in applied physics from CalTech '19, Uncertainty and Risk at the Catastrophe Threshold, in Planetary Defense Global Collaboration for Defending Earth from Asteroids and Comets

There has been confusion over language used to describe risk reduction attributed to surveys. It is often said that risk is “retired” when an asteroid is discovered and is found to be in a benign orbit. However, risk is (by definition) a human assessment that includes uncertainty. Assessed risk is a redundant term, but the adjective reinforces this notion. When uncertainty is reduced through more observation or understanding, the assessed risk can change. The act of discovering an asteroid that is not on a collision course reduces the assessed risk. For a population of NEOs in unknown orbits, the risk is aleatory, because the trajectories can be thought of as random within some range. After they are discovered (and determined to be no threat), they can be “retired” or removed from the random population for purposes of risk assessment. The assessed risk is reduced, but the intrinsic (previously unknown) probability of impact is unchanged. An asteroid is either on a collision course or it isn’t, regardless of whether or not it has a name and entry in the Minor Planet Center database. A rational policy and course of action can only be based on our current risk assessment, which incorporates all we know. If our knowledge changes because something is discovered to be on a collision course, we can reduce its contribution to the risk by deflecting it.

NEO surveys have greatly succeeded in contributing to risk reduction because our assessment of impact probability has decreased. The 90% goal has been exceeded, and discovery of smaller objects continues to accelerate. The assessed risk of a global impact apocalypse has been virtually eliminated in our time. The likelihood of a continental-scale catastrophe has been greatly diminished, and the overall risk (measured in average fatalities per year) has been cut by an order of magnitude to a round-number estimate of about 100. More recent assessments (Boslough et al. 2015b; Mathias et al. 2017; Reinhardt et al. 2016; Rumpf et al. 2017; Stokes et al. 2017) make use of large-scale computer simulations and include the Earth’s population distribution with better estimates of asteroid populations and physical effects over a wide range of energies and asteroid physical properties. They remain in broad agreement with one another.

**1 in 100 million chance of extinction level NEOs.**

David A. **Koplow**, Professor of Law, Georgetown University Law Center, **’19**, "Exoatmospheric Plowshares: Using a Nuclear Explosive Device for Planetary Defense against an Incoming Asteroid," UCLA Journal of International Law and Foreign Affairs 23, no. 1 76-158

The first graphic indicates, for example, that events roughly comparable to the Chelyabinsk asteroid might occur once every 50 years, while the bigger Tunguska-like strike might be a once-in-250- or 500-year phenomenon. A regional event, which could endanger tens ofthousands of square miles, would be expected every 5,000 years. At the high end of the spectrum, an **extinction class occurrence, such as Chicxulub, would be anticipated on average, every 100 million years**.40

**We know where asteroids are. None could hit earth.**

Al **Globus 14**, worked on the asteroid mining, space settlement, Hubble, ISS, X37, Earth observation, TDRSS, cubesats, lunar teleoperation, spaceflight affects on bone, computational fluid dynamics visualization, molecular nanotechnology and space solar power, board member of the National Space Society, June 6, “Understanding the Asteroid Threat,” Rooster GNN, http://en.roostergnn.com/2014/06/06/understanding-the-asteroid-threat/128689/

What is the current probability of an asteroid striking Earth? Depends on the size. Little ones hit every day. A city killer once or twice a century. Extinction event about **every 100 million years** (it’s been 66 million years). These, of course, are averages. We could get an extinction event tomorrow — or not for 200 million years. Fortunately, **we know where almost all of the big asteroids** (extinction event) that could hit Earth are and **none of them will hit us for at least 100 years**. We don’t know where 90% of the somewhat smaller asteroids are — ones that could devastate a region (say, the Eastern seaboard). We only know the location of 1% of the city killers. Even better, if we detect an incoming asteroid in time **we could deflect it.** Thus, if we were to mount a vigorous detection campaign we could make the probability essentially zero. This would cost around 1% of our civil space program budget.

**Prefer empirics.**

**Bennett 10** [James, Eminent Scholar and William P. Snavely Professor of Political Economy and Public Policy at George Mason University, and Director of The John M. Olin Institute for Employment Practice and Policy, “The Chicken Littles of Big Science; or, Here Come the Killer Asteroids!” THE DOOMSDAY LOBBY 2010, 139-185, DOI: 10.1007/978-1-4419-6685-8\_6]

**The smallest falling bodies**, those with diameters under a few meters, **are of “no practical concern**,” says Chapman, and in fact they are to be desired, at least by those who keep their eyes on the skies watching for brilliant fireballs whose burning up in the atmosphere provides a show far more spectacular than the most lavish Fourth of July fireworks. **Even bodies with diameters of 10–30 meters**, **of which** Chapman estimates **six may fall to earth in a century, cause little more than broken windows.** **They explode too high in the atmosphere** to cause serious harm. **The** next largest potential strikers of Earth are those in the **Tunguska range** of 30 meters–100 meters. The shock waves from the atmospheric explosion **would “topple trees**, wooden structures and ignit[e] fires within 10 kilometers,” writes Chapman. Human deaths could result if the explosion took place over a populated area. Though Chapman estimates the likelihood of a Tunguska occurring in any given century at four in ten, it is worth noting that **there is no evidence that such an explosion has killed a single human being in all of recorded history**. Either we’re overdue or that 40 percent is high. Moreover, **given that the location of such an explosion is utterly unpredictable, it would be far more likely to happen over an ocean or a desert** than over, say, Tokyo or Manhattan. **The after effects would be minimal,** **and** Chapman says that **“nothing practical can be done about this modest hazard** other than to clean up after the event.” In fact, “**It makes no sense to plan ahead for such a modest disaster**… other than educating the public about the possibility.” **The cost of a telescopic survey capable of picking up bodies of such diminutive size would be prohibitive**. It would be the ultimate Astronomers Full Employment Act. **A body of 100 meters–300 meters** in diameter **would either explode at low altitude or upon impact with the ground;** it would be “regionally devastating,” **but Chapman pegs the chances of such a catastrophe at 1 percent per century.** **A small nation could be destroyed by the impact of** **a body of 300 meters—1 km** in diameter, or a “flying mountain” of sorts, which would explode with energy yield ten times more than “the largest thermonuclear bomb ever tested.” If striking land, it would carve out a crater deeper than the Grand Canyon. If it hit a populated area, the death toll could be in the hundreds of thousands. The likelihood of such a collision Chapman estimates at 0.2 percent per century. An asteroid or comet of 1–3 kilometers in diameter would cause “major regional destruction,” possibly verging on “civilization-destruction level.” Chapman puts the chances of this at 0.02 percent per century. The impact of a body more than 3 kilometers in diameter might plunge the Earth into a new Dark Age, killing most of its inhabitants, though the chances of this are “extremely remote” — less than one in 50,000 per century. Finally, **mass extinction would likely occur should a body greater than 10 kilometers** pay us a visit, **though the chances of this are less than one in a million every century, or so infinitesimal that even the most worry-wracked hypochondriac will not lose sleep over the possibility**. In fact, **for any impact with a Chapman-calculated likelihood of less than one in a thousand per century, he concedes that there is “little justification for mounting asteroid-specific mitigation measures.” The chance of a civilization-ender is so remote that he counsels no “advance preparations**” — or almost none. For Chapman recommends further study of NEOs, as well as investigation into methods of their diversion. 82 This is exactly what the NEO lobby wants.

#### Just because there is a random chance of asteroids doesn’t mean that the risk is high – that’s also a reason why the aff cant solve – there’s always a risk of random asteroids popping up that we can’t detect

**European union solves.**

**Pelton 13**—Joseph Pelton, Executive Board International Association for the Advancement of Space Safety, Director Emeritus of the Space and Advanced Communications Research Institute at George Washington University, PhD from Georgetown University (“Space Debris and Other Threats from Outer Space,” Springer, 2013, DOI 10.1007/978-1-4614-6714-4, Chapter 8, p 57-63)

Although the man in the street does not think about the threat from asteroids and comets, space scientists at NASA, ESA, and JAXA certainly do. The WISE space telescope launched by NASA in mid-December 2009 has been carefully mapping as many NEOs as possible during its time in orbit as well as far flung galaxies as well. In the time between its launch and its shut down on February 17,2011, the Wide-field Infrared Space Explorer had collected millions of images and com- pleted one and a half inventories of Earth’s overhead sky by a systematic scanning process. The WISE satellite infrared sensors during its mission captured some 1.8 million images. These have allowed scientists to detect nineteen previously unseen comets. It also allowed the detection of over 33,500 asteroids and 120 previously unknown near-Earth objects (NEOs) that could become potential hazards to Earth at a future date. The infrared sensors that detect radiation outside the visible light range was able to detect low heat dwarf “brown stars” and detect objects that might be invisible due to dense dust cloud layers and other obscuring elements. The quarter-of-a-billion-dollar project was certainly successful in living beyond its projected 10-month mission lifetime. Ultimately it was the exhaustion of the coolant for the infrared sensors that was the lifetime limiting factor. By cleverly shifting from a four IR sensor operation to only two the lifetime was extended further than expected. After the coolant was entirely expended, a further program called NEO-WISE was undertaken for three months up until its February 2011 end date. During this NEO-wise phase, the spacecraft was entirely devoted to searching for NEOs. But this task still remains to be completed. Currently this comet- and asteroid-detecting spacecraft is now in hibernation with its coolant expended. In order to complete this crucial inventory of potentially dangerous asteroids and comets that might eventually hit Earth, additional space telescopes are needed. This would likely mean satellites with the ability to alter their range of view, more IR sensors and sufficient coolants to extend the space- craft’s lifetime. The question that many would ask is: “Is it really necessary to spend this much money on the very long shot that we might find a killer asteroid?” It turn out there is a fairly good answer to that question. Asteroid 2011 AG5 was discovered in January 2011 by the WISE imaging process. After initial analysis it was determined that there was a very credible chance that Asteroid 2011 AG5 could indeed collide with Earth in 2040. After further analysis it was decided that this was a long shot indeed unless something very strange happens in terms of the asteroid’s interaction with the Sun’s gravity, known as a “keyhole” event. This “keyhole” gravitation event that would make the asteroid do a “loop-de-loop” in a way that could put this asteroid in a resonance orbit with Earth. If this should happen it could result in about a 15 % chance of a horrific collision in 2040. The problem at this time is that this PHA (potentially hazardous asteroid) is on the other side of the Sun, and thus no precise measurements can be taken until late in 2013 or 2014. Figure 8.2 indicates the possible “keyhole” event and how this could actually spell trouble down the road. Asteroid Diversion If it turns out the 2011 AG5 goes through the gravitational keyhole in just the wrong way, and it is set to hit Earth like multiple atomic bombs, what could we do about it? Well, the European Union has launched an admirable new multi-national research project involving efforts to develop better ways to divert the course of “killer asteroids”. The three prime areas of research are exploring the use of gravitational attraction for course diversion, “bombing” the asteroid out of existence, or hitting it with a missile. This program is called NEOShield. The problem is that the fouryear program is funded at a very inadequately low level of 4 million Euros. We spend billions on national defense and medical research against pandemics. The funding for NEOShield is a mere pittance. We need to be spending at least 10 times more to produce any real hope of viable results. There are dozens of meteor showers that occur each year as Earth orbits the Sun, since there are literally millions of small meteors in solar orbit. Larger meteoroids are called bolides and even larger ones still are called asteroids. It is the larger scale near-Earth asteroids (NEAs) and particularly the PHAs that come within 5 million miles (8 million km) that are the ones that are of the largest concern. Typical orbits for these asteroids and how they could intersect Earth orbit are shown in Fig. 8.3. Since it has been 65 million years since the K-T mass extinction event there is some reassurance that another such horrendous event is a very remote possibility. Nevertheless it is estimated that some 10 % of the really big PHA’s have still be discovered, and 80% of the PHSs in the 100–1,000 m range have not been identified. These projections are based on the NEO-WISE program activity and calculations undertaken based on the NEO-WISE program activity and calculations undertaken based on its observation of just one sector of the sky. Space scientists have take the potential threat seriously enough to adopt a hazard scale as provided in Fig. 8.4 [32].

### 1NC---AT: Ozone

#### Ozone Layer is increasing – flips U/Q.

Horton 21 Helena Horton 9-15-2021 "‘Larger than usual’: this year’s ozone layer hole bigger than Antarctica" <https://www.theguardian.com/environment/2021/sep/16/larger-than-usual-ozone-layer-hole-bigger-than-antarctica> (Environmental Journalist for the Guardian)//Elmer

The hole in the ozone layer that develops annually is “rather larger than usual” and is currently bigger than Antartica, say the scientists responsible for monitoring it. Researchers from the Copernicus Atmosphere Monitoring Service say that this year’s hole is growing quickly and is larger than 75% of ozone holes at this stage in the season since 1979. Ozone exists about seven to 25 miles (11-40km) above the Earth’s surface, in the stratosphere, and acts like a sunscreen for the planet, shielding it from ultraviolet radiation. Every year, a hole forms during the late winter of thesouthern hemisphere as the sun causes ozone-depleting reactions, which involve chemically active forms of chlorine and bromine derived from human-made compounds. In a statement Copernicus said that this year’s hole “has evolved into a rather larger than usual one”. Vincent-Henri Peuch, the service’s director, told the Guardian: “We cannot really say at this stage how the ozone hole will evolve. However, the hole of this year is remarkably similar to the one of 2020, which was among the deepest and the longest-lasting – it closed around Christmas – in our records since 1979.

#### Two Thumpers to Ozone:

#### 1] Space Tourism

Marais 21 Eloise Marais 7-19-2021 "Space tourism: rockets emit 100 times more CO₂ per passenger than flights – imagine a whole industry" <https://theconversation.com/space-tourism-rockets-emit-100-times-more-co-per-passenger-than-flights-imagine-a-whole-industry-164601> (Associate Professor in Physical Geography, UCL)//Elmer

The commercial race to get tourists to space is heating up between Virgin Group founder Sir Richard Branson and former Amazon CEO Jeff Bezos. On Sunday 11 July, Branson ascended 80 km to reach the edge of space in his piloted Virgin Galactic VSS Unity spaceplane. Bezos’ autonomous Blue Origin rocket is due to launch on July 20, coinciding with the anniversary of the Apollo 11 Moon landing. Though Bezos loses to Branson in time, he is set to reach higher altitudes (about 120 km). The launch will demonstrate his offering to very wealthy tourists: the opportunity to truly reach outer space. Both tour packages will provide passengers with a brief ten-minute frolic in zero gravity and glimpses of Earth from space. Not to be outdone, Elon Musk’s SpaceX will provide four to five days of orbital travel with its Crew Dragon capsule later in 2021. What are the environmental consequences of a space tourism industry likely to be? Bezos boasts his Blue Origin rockets are greener than Branson’s VSS Unity. The Blue Engine 3 (BE-3) will launch Bezos, his brother and two guests into space using liquid hydrogen and liquid oxygen propellants. VSS Unity used a hybrid propellant comprised of a solid carbon-based fuel, hydroxyl-terminated polybutadiene (HTPB), and a liquid oxidant, nitrous oxide (laughing gas). The SpaceX Falcon series of reusable rockets will propel the Crew Dragon into orbit using liquid kerosene and liquid oxygen. Burning these propellants provides the energy needed to launch rockets into space while also generating greenhouse gases and air pollutants. Large quantities of water vapour are produced by burning the BE-3 propellant, while combustion of both the VSS Unity and Falcon fuels produces CO₂, soot and some water vapour. The nitrogen-based oxidant used by VSS Unity also generates nitrogen oxides, compounds that contribute to air pollution closer to Earth. Roughly two-thirds of the propellant exhaust is released into the stratosphere (12 km-50 km) and mesosphere (50 km-85 km), where it can persist for at least two to three years. The very high temperatures during launch and re-entry (when the protective heat shields of the returning crafts burn up) also convert stable nitrogen in the air into reactive nitrogen oxides. These gases and particles have many negative effects on the atmosphere. In the stratosphere, nitrogen oxides and chemicals formed from the breakdown of water vapour convert ozone into oxygen, depleting the ozone layer which guards life on Earth against harmful UV radiation. Water vapour also produces stratospheric clouds that provide a surface for this reaction to occur at a faster pace than it otherwise would. Space tourism and climate change Exhaust emissions of CO₂ and soot trap heat in the atmosphere, contributing to global warming. Cooling of the atmosphere can also occur, as clouds formed from the emitted water vapour reflect incoming sunlight back to space. A depleted ozone layer would also absorb less incoming sunlight, and so heat the stratosphere less. Figuring out the overall effect of rocket launches on the atmosphere will require detailed modelling, in order to account for these complex processes and the persistence of these pollutants in the upper atmosphere. Equally important is a clear understanding of how the space tourism industry will develop. Virgin Galactic anticipates it will offer 400 spaceflights each year to the privileged few who can afford them. Blue Origin and SpaceX have yet to announce their plans. But globally, rocket launches wouldn’t need to increase by much from the current 100 or so performed each year to induce harmful effects that are competitive with other sources, like ozone-depleting chlorofluorocarbons (CFCs), and CO₂ from aircraft. During launch, rockets can emit between four and ten times more nitrogen oxides than Drax, the largest thermal power plant in the UK, over the same period. CO₂ emissions for the four or so tourists on a space flight will be between 50 and 100 times more than the one to three tonnes per passenger on a long-haul flight. In order for international regulators to keep up with this nascent industry and control its pollution properly, scientists need a better understanding of the effect these billionaire astronauts will have on our planet’s atmosphere.

#### 2] Dichloromethane

Perkins 17 Sid Perkins 6-27-2017 "New threat to ozone layer found" <https://www.science.org/content/article/new-threat-ozone-layer-found> (Sid is a freelance science journalist based in Crossville, Tennessee. He specializes in earth sciences and paleontology but often tackles topics such as astronomy, planetary sciences, materials sciences, and engineering. Sid has a bachelor’s degree in natural science from Christian Brothers College in Memphis, Tennessee; bachelor’s and master’s degrees in aeronautical engineering from the Air Force Institute of Technology in Ohio; and a master’s degree in journalism from the University of Missouri in Columbia)//Elmer

The ozone layer—a high-altitude expanse of oxygen molecules that protects us from the sun's ultraviolet rays—has been on the mend for the past decade or so. But a newly discovered threat could delay its recovery. Industrial emissions of a chemical commonly used in solvents, paint removers, and the production of pharmaceuticals have doubled in the past few years, researchers have found, which could slow the healing of the ozone layer over Antarctica anywhere between 5 and 30 years—or even longer if levels continue to rise. The findings are "frightening" and "a big deal," says Robyn Schofield, an environmental scientist at the University of Melbourne in Australia who was not involved with the work. The chemical in question is called dichloromethane (CH2Cl2). Natural sources of this substance are small, says Ryan Hossaini, an atmospheric chemist at Lancaster University in the United Kingdom. Thus, he notes, the increase in emissions seen in recent years likely stems from human sources. Between 2000 and 2012, low-altitude concentrations of CH2Cl2 vapor rose, on average, about 8% per year, he adds. Globally, concentrations of CH2Cl2 approximately doubled between 2004 and 2014. Current CH2Cl2 emissions are about 1 million metric tons per year, Hossaini and his team estimate. Like chlorofluorocarbons (CFCs) and several other ozone-destroying chemicals you may have heard of, CH2Cl2 breaks apart when struck by sunlight. The chlorine atoms that are released then dismantle any ozone molecules they interact with. In 1987, an international agreement known as the Montreal Protocol led to a ban on the production and use of CFCs and many related compounds in industrial nations, but it ignored CH2Cl2 because researchers thought it didn't stay intact in the atmosphere long enough to rise into the stratosphere. Recent evidence now suggests, however, that the molecules can reach the lower edge of the stratosphere, which includes the ozone layer, despite its height 8 kilometers above the poles. To gauge the current and future threat to high-altitude ozone from CH2Cl2, Hossaini and his colleagues used computer simulations. In 2016, their analyses suggest, about 3% of the summer ozone loss in the Antarctic could be traced to CH2Cl2. That seems small, but in 2010 the substance was responsible for only 1.5% of the region's summer ozone loss, Hossaini says. If CH2Cl2 emissions continue to rise at the rate seen in the last decade, recovery of the ozone hole would be delayed about 30 years, the researchers estimate in Nature Communications. But if emissions of CH2Cl2 are held to current levels, healing of the ozone hole would be delayed only 5 years or so, the team finds. Simulations that don't include the effect of CH2Cl2 suggest that high-altitude ozone in the Antarctic will return to pre-1980 levels, the concentration measured before CFCs and other ozone-destroying chemicals were recognized as a problem, in 2065. The team's analyses "are quite important," says Björn-Martin Sinnhuber, an atmospheric scientist at Karlsruhe Institute of Technology in Germany. "It's clear that concentrations [of CH2Cl2] have increased quite a lot," he notes. But one critical question, he contends, is what will happen to emissions over the long term: "They've been quite variable in recent years, and it's difficult to say how they might evolve." Although the rapid rise in CH2Cl2 emissions may one day level off, it's also possible that emissions of this multipurpose chemical may accelerate even further. Hossaini and his team also assessed what would happen to high-altitude ozone if CH2Cl2 emissions rose at twice the rate seen in the past decade. The answer? Not good. Antarctic ozone wouldn't recover to pre-1980 levels until well after the year 2100, the analyses suggest. All this means that scientists now reviewing the Montreal Protocol should consider expanding the agreement to also regulate substances like CH2Cl2 that have atmospheric lifetimes of less than 6 months, Schofield says. Possibly as important, however, the team's results might also help other researchers identify which sources of CH2Cl2 are contributing most to the recent rise in emissions. That sort of information, Hossaini admits, is sadly lacking as of now.

#### No Ozone Impact.

Ridley 14 (Matthew White Ridley, BA and PhD in Zoology from Oxford. “THE OZONE HOLE WAS EXAGGERATED AS A PROBLEM,” *Rational Optimist*, 9/25/14, <http://www.rationaloptimist.com/blog/the-ozone-hole-was-exaggerated-as-a-problem.aspx>) dwc 19

Serial hyperbole does the environmental movement no favours My recent Times column argued that the alleged healing of the ozone layer is exaggerated, but so was the impact of the ozone hole over Antarctica: The ozone layer is healing. Or so said the news last week. Thanks to a treaty signed in Montreal in 1989 to get rid of refrigerant chemicals called chlorofluorocarbons (CFCs), the planet’s stratospheric sunscreen has at last begun thickening again. Planetary disaster has been averted by politics. For reasons I will explain, this news deserves to be taken with a large pinch of salt. You do not have to dig far to find evidence that the ozone hole was never nearly as dangerous as some people said, that it is not necessarily healing yet and that it might not have been caused mainly by CFCs anyway. The timing of the announcement was plainly political: it came on the 25th anniversary of the treaty, and just before a big United Nations climate conference in New York, the aim of which is to push for a climate treaty modelled on the ozone one. Here’s what was actually announced last week, in the words of a Nasa scientist, Paul Newman: “From 2000 to 2013, ozone levels climbed 4 per cent in the key mid-northern latitudes.” That’s a pretty small change and it is in the wrong place. The ozone thinning that worried everybody in the 1980s was over Antarctica. Over northern latitudes, ozone concentration has been falling by about 4 per cent each March before recovering. Over Antarctica, since 1980, the ozone concentration has fallen by 40 or 50 per cent each September before the sun rebuilds it. So what’s happening to the Antarctic ozone hole? Thanks to a diligent blogger named Anthony Watts, I came across a press release also from Nasa about nine months ago, which said: “ Two new studies show that signs of recovery are not yet present, and that temperature and winds are still driving any annual changes in ozone hole size.” As recently as 2006, Nasa announced, quoting Paul Newman again, that the Antarctic ozone hole that year was “the largest ever recorded”. The following year a paper in Nature magazine from Markus Rex, a German scientist, presented new evidence that suggested CFCs may be responsible for less than 40 per cent of ozone destruction anyway. Besides, nobody knows for sure how big the ozone hole was each spring before CFCs were invented. All we know is that it varies from year to year. How much damage did the ozone hole ever threaten to do anyway? It is fascinating to go back and read what the usual hyperventilating eco-exaggerators said about ozone thinning in the 1980s. As a result of the extra ultraviolet light coming through the Antarctic ozone hole, southernmost parts of Patagonia and New Zealand see about 12 per cent more UV light than expected. This means that the weak September sunshine, though it feels much the same, has the power to cause sunburn more like that of latitudes a few hundred miles north. Hardly Armageddon. The New York Times reported “an increase in Twilight Zone-type reports of sheep and rabbits with cataracts” in southern Chile. Not to be outdone, Al Gore wrote that “hunters now report finding blind rabbits; fisherman catch blind salmon”. Zoologists briefly blamed the near extinction of many amphibian species on thin ozone. Melanoma in people was also said to be on the rise as a result. This was nonsense. Frogs were dying out because of a fungal disease spread from Africa — nothing to do with ozone. Rabbits and fish blinded by a little extra sunlight proved to be as mythical as unicorns. An eye disease in Chilean sheep was happening outside the ozone-depleted zone and was caused by an infection called pinkeye — nothing to do with UV light. And melanoma incidence in people actually levelled out during the period when the ozone got thinner.

### 1NC---AT: Radiation

#### No impact---collisions have already happened, radioactive material will stay in space, and it’s higher than most objects in orbit.

Rebecca Harrington 16. Senior News Editor who works across INSIDER and Business Insider, 3/10/16, “Dozens of dead nuclear reactors are floating in space, and they'll eventually hit the earth,” https://www.businessinsider.com/nuclear-powered-satellites-space-2016-3

Radioactive materials, like uranium-235, can power a tiny satellite for years. They're more reliable than batteries and provide more energy than solar panels. But back then, space-faring nations weren't as concerned with radioactive waste. Nuclear disasters like Three Mile Island and Chernobyl hadn't happened yet, and now we're much more worried about radiation exposure. That's why the last nuclear-powered satellite, launched by the Soviet Union, blasted into orbit in 1988. More than 30 different nuclear-reactor-powered satellites still orbit the earth. The US launched only one while the USSR launched all the rest. Those nuclear reactors are similar to the ones in nuclear power plants on the ground. Uranium-235 undergoes fission, where its nucleus splits, giving off energy. This energy can be converted into electricity to power satellite instruments, or your house. America's uranium-fueled SNAP-10A entered into an orbit of 575 miles above the earth in 1965. It operated for 43 days before it stopped responding. It's now in a slow trajectory to hit the ground in about 3,000 years. By then, hopefully, its radioactive cargo will be mostly harmless. But if any of these nuclear-reactor-powered satellites collide with another object in space, or suddenly crash to the ground, they could release radioactivity. The Soviet Union had a few such mishaps since it launched all those nuclear satellites. In 1978, its spy satellite, Kosmos 954, crashed into the Northwest Territories, scattering radioactivity across almost 48,000 square miles. The USSR had to pay Canada $10 million for the damage. And in 1995, NASA scientists found a cloud of liquid, radioactive sodium and potassium coolant in orbit. The space agency eventually figured out that it came from the Soviet satellite Kosmos 1900. Something else in space crashed into it, causing the nuclear reactor to leak. The cloud of radioactive fluids is still floating up there, and space agencies continue to monitor it. The good news is that all of these dead nuclear-reactor-powered satellites are in orbits higher than 430 miles. There's barely any air molecules at that height to slow down the satellites, so it should take them hundreds or thousands of years to wind their way back to the earth — at which point much of their radioactive contents will have significantly decayed.

No UQ about nuclear powered space