Putin and the Bomb: Why New Zealand national risk assessments should include planning for the potential impacts of nuclear winter

13 March 2022

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In this blog we briefly review the literature on the probability of nuclear war and what various models estimate to be the potential global climate impacts (eg, of nuclear winter). Although New Zealand is relatively well placed as a major food producer – a range of mitigation strategies could increase the probability of sustaining food security during a recovery period. To get the ball rolling the Government needs to perform a national risk assessment on this topic and commission work on identifying the most cost-effective preparations

Putin's Ukraine invasion and nuclear weapons

Does Russian President Vladimir Putin intend to use nuclear weapons, under what circumstances, and what would be the impact of such aggression?

This question is important because days after Russia's invasion of Ukraine began in February 2022, Putin ordered Russia's nuclear forces to high alert. It is also important because of the potentially dire consequences following a nuclear war, given that Russia possesses approximately 4500 nuclear warheads, not counting 'retired' weapons.

Below, we address the probability of nuclear war, the modelling work around its potential consequences, and some mitigation strategies that could minimise the impact of nuclear war on New Zealand.

How likely is nuclear war?

Since 1945 when nuclear weapons were used to end The Second World War, none have been used in combat. Unlike many natural phenomena there is no frequency distribution to base probability estimates upon. However, subjective estimates have been published.

In 2008 Hellman estimated the probability of full-scale nuclear war between the US and Russia in any given year at 0.02–0.5% (Hellman, 2008), however this calculation included a 6% annual probability of an 'initiating event' that could lead (with 33% probability) to a 'Cuban missile crisis type' event. If we follow Hellman's assessment and consider Putin's move to nuclear high alert in the context of the Ukraine invasion to be an 'initiating event', then the annualised probability of 'a nuclear weapon being detonated' rises to 3.3–16.5% and that of nuclear war to 0.3–8.3% (or higher if Putin's Ukraine posture is considered an actual Cuban crisis-type event).

In 2013, Barrett et al estimated the annualised probability of *inadvertent* US-Russia nuclear war at 2% (90% CI, 0.02–7%) or 1% (0.001–5%) if it is assumed launch could not occur during 'calm' geopolitical periods (Barrett, Baum, & Hostetler, 2013). Half of the total risk was contained in periods of US-Russia tensions (perhaps the Ukraine war for example), but importantly this means the other half of the risk lies in peacetime. This is due to risks such as systems faults, miscalculations, malice, and third-party interference.

Several, other assessments put the probability in a similar range. However, these assessments usually focus on one possible scenario (eg, US-Russia war, inadvertent war, regional war between Pakistan and India, etc) and so the true probability of *any* kind of nuclear war between *any* nuclear armed nations will necessarily be higher. Baum et al have elaborated a full model (see p.21) for the factors which must be included to deduce the total probability of nuclear war (S Baum, de Neufville, & Barrett, 2018). However, multiple war games have concluded that Putin would probably use a nuclear weapon if he felt his regime was threatened (Civvis, 2022).

The crowd forecasting organisation Good Judgment has reported the estimated number of nuclear weapons detonated conditional on a nuclear weapon being used. Results were: 84% probability of 1–9 weapons detonating, 13% to 10–99, 2% to 100–999, and 1% to 1000 or more (Beard, Rowe, & Fox, 2020).

So, the risk of nuclear war is generally considered to be low in any given year, but certainly not trivial, and it may be elevated to the concerning level of several percent per annum in times of crisis. This makes the annual risk of nuclear war in times of US-Russia tensions possibly greater than the risk of a Covid-19-like pandemic, which has an estimated return time of 59 years (Marani, Katul, Pan, & Parolari, 2021).

Models suggest nuclear war would have significant climate impacts

Nuclear war would have impacts that reach far beyond the mass deaths and destruction from blast, thermal and radiation impacts from the bombs themselves at explosion sites. Baum and Barrett systematically collated these impacts in a model of nuclear war (S Baum & Barrett, 2018). The impacts include: 'fire, blocked sunlight, damage to infrastructure, water supply disruption, agriculture disruption, food insecurity, healthcare disruption, infectious disease, transportation disruption, transportation systems disruption, energy supply disruption, satellite disruption, telecommunications disruption, shifted norms, and general malfunction of society'.

Since the 1980s it has been supposed that the greatest of these wider impacts would result from climate disruption. Nuclear firestorms would burn combustible material in cities and loft black carbon (soot) far into the stratosphere, where it would spread globally, and could persist for years imposing a global 'nuclear winter'.

A regional nuclear war (such as between India and Pakistan where up to 100 bombs are used) might loft up to 5 teragrams (Tg) of soot, whereas a full-scale global war (eg, between the US and Russia where hundreds to thousands of weapons are exploded) might push as much as 150 Tg of soot into the stratosphere.

Modelling the effects of this in the 1980s relied on computing capacity that did not allow models to 'look' beyond the very short term or perform numerous model runs. However, in 2007 Robock et al modelled nuclear climate impacts with a, then, modern climate model, NASA's ModelE. They found that 5 Tg, 50 Tg and 150 Tg scenarios would have significant climate impacts with severe reductions in surface temperature, precipitation and solar radiation (Robock, Oman, & Stenchikov, 2007; A. Robock et al., 2007). The climate changes were predicted to be large and long-lasting. At the lower end of the spectrum the impact might be similar to the impact from the worst volcanic climate impacts in recorded history, for example the civilisation altering impact of the Late Antiquity Little Ice Age (536–556CE) and at the upper end (150 Tg) could impose a 'nuclear winter' which might see summer time temperatures in the northern hemisphere 20–30 degrees C below normal, with an 8–9 degree C drop in mean global temperature spanning a decade. The 150 Tg case is very much a worst case scenario given that it assumes the use of almost the entire global nuclear arsenals, which is probably unrealistic given that many reserve warheads would need to be mobilised and deployed.

More recent modelling of both the regional nuclear war scenario (Reisner et al., 2018; Wagman, Lundquist, Tang, Glascoe, & Bader, 2020), and the global scenario (Coupe, Bardeen, Robock, & Toon, 2020), using more sophisticated climate models such as the WACCM, generally concur with these earlier estimates. Nevertheless, the regional war case might produce lesser impacts than previously thought, yet still have an impact on global agriculture and food trade 'unmatched in modern history' (Jagermeyr et al., 2020). Even so, the potential impacts are still highly uncertain and depend on the behaviour of the relevant fires and the material that is available to be burned, which in turn depends on where the weapons are targeted.

What is generally agreed is that the worst-case scenarios would devastate ordinary global agriculture. Results of global modelling of 150 Tg scenarios, currently available as a preprint (Xia et al., 2021), suggest yield losses for major food crops (maize, rice, soybean and spring wheat) and marine fish, averaged over the first five years, might hit 79% loss globally and approach 100% loss in the northern hemisphere, (see also Jagermeyr et al 2020 for related peer-reviewed estimates pertaining to regional war). The impact on global food trade would be disastrous and billions of people would be at risk of starvation.

Additionally, ozone could be catastrophically depleted by stratosphere heating and the UV index at the Earth's surface could rise to 35–45, or more, in places for several years (yes, this is the index reported by weather forecasters where 11+ is considered 'severe'). The impact of this on global agriculture is unknown (Bardeen et al., 2021), but could be important.

Despite these catastrophic impacts, these models suggest that some places might be comparatively unscathed. This is because regions between the equator and 30 degrees south are not likely to be as impacted by climate changes. Although the equatorial monsoons may be greatly diminished, the growing seasons in some regions of Africa and South America may persist (Coupe et al., 2020). Additionally, remote southern hemisphere islands like New Zealand and Australia appear in the models to suffer less severe temperature drops (Coupe et al., 2020; A Robock et al., 2007), and some regions such as the Caribbean might even see increased fish catch (Scherrer et al., 2020).

What could be done to mitigate nuclear winter in New Zealand?

As with pandemics, prevention of nuclear war would be vastly better than being forced to respond. Immense diplomatic efforts are needed to resolve the situation in Ukraine. However, just as the world ought to be planning to mitigate the impacts of the next pandemic, we ought to address the potential impacts of nuclear war. In particular, policy should address food insecurity. This can be done by striking the right mix between the following three strategies (S. Baum, Denkenberger, Pearce, Robock, & Winkler, 2015):

- Food stockpiles (which while expensive can allow for transition to a new normal in the event)
- Agricultural adaptation including winter hardy crops
- Development of alternative resilient food systems which do not depend on normal levels of sunlight

New Zealand specifically is a vast food overproducer due to its export economy. In a context where global food trade is severely disrupted, New Zealand could retain for domestic use food that is normally exported. Indeed, current volumes of dairy exports alone would be able to supply more than all the dietary energy needs of the whole New Zealand population (calculations by the authors – available on request). However, normal agricultural yields are likely to be diminished after a nuclear war. The calculations by Xia et al suggest that New Zealand might suffer reduced production of major crops of approximately 60% in worst scenarios (Xia et al., 2021). Applied to grass yield, along with the absence of palm kernel extract imports, this would severely impact dairy production. We note that Xia et al’s estimates are extrapolated from crude global macro-indicators and more detailed regional studies should be performed.

Production and distribution might additionally be hampered by lack of fossil fuel and fertiliser imports, and other impacts on machinery and access to parts. In cases where exports are retained for local consumption, there would need to be a plan in place to redistribute the food locally.

But with appropriate foresight, much agricultural production could continue with domestic production of biodiesel for farm machinery (or greater use of electric vehicles on farms), and increased local production capacity of fertiliser. The expansion of household and community gardens could be promoted by both central and local governments. These could focus on such highly efficient crops such as potatoes, but also crops that tolerate lower sunlight levels eg, winter vegetables. Also, the stock of marine food could be managed pre-war to maximise reserves and therefore yield if fishing is ramped up in the near-term aftermath of a nuclear war (Scherrer 2020).

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New Zealand could also invest in research and development of alternative foods such as ocean greens (eg, farming seaweed), single-celled protein (García Martínez et al., 2021), synthetic fat (García Martínez, Alvarado, & Denkenberger, 2022), as well as the role of cheap polymer film greenhouses which could be rapidly scaled up in the months after nuclear war (Alvarado et al 2020) – especially if planning for more severe nuclear winter impacts was thought to be worthwhile.

Additional research on nuclear winter is needed

Some government-funded work on the impact of nuclear war was done in the 1980s by the NZ Planning Council (Preddey, Wilkins, Wilson, Kjellstrom, & Williamson, 1982). But, as far as we are aware little has been done since then. It is currently unclear whether nuclear winter is contemplated in the country’s National Risk Register, given that the contents of this document is classified. We discovered in February 2020 that New Zealand was very unprepared for a Covid-19-type pandemic. We don’t want to discover that we are just as unprepared for a nuclear winter if it happens.

We have previously argued for transparency around the national risk assessment process, wider consultation and a publicly accessible national risk register, along with the appointment of a Parliamentary Commissioner for Extreme Risks to oversee analysis and planning across a portfolio of risks (Boyd & Wilson, 2021).

These issues around nuclear winter should also be raised at the United Nations (UN), as we have argued before (Boyd & Wilson, 2020), and as would be consistent with the recent UN framework for ‘risk informed sustainable development’ (UNDRR, 2021).

The Royal Society of New Zealand and/or the Department of the Prime Minister and Cabinet (DPMC), should consider doing an updated report on the impacts and responses to nuclear war and nuclear winter, including what the government and citizens might consider doing in anticipation. Engagement with iwi and key New Zealand agricultural and fisheries organisations would be important to shift the perspective on New Zealand's food supply towards one of long-term resilience 'no matter what', beyond anticipated greenhouse gas climate change, by thinking about severe cooling episodes too. These 'winters' could be produced not just by nuclear war, but by major volcanic events as well. The eruption of Mt Tambora in 1815 produced 53-58 Tg of SO_2 and produced global winter-like effects (it was the 'year without a summer'). The eruption in January 2022 of Hunga Tonga-Hunga Ha'apai puts this in perspective as it produced only 0.4 Tg.

In summary, the available literature suggests that the risk of nuclear war is far from trivial and is likely to be increased at times of international crisis. Various models have estimated that the potential global climate impacts (eg, of nuclear winter) could be severe – though less so for islands in the southern hemisphere such as New Zealand. Although New Zealand is relatively well placed as a major food producer – a range of mitigation strategies could increase the probability of sustaining food security during a recovery period. To get the ball rolling the Government needs to perform a national risk assessment on this topic and commission work on identifying the most cost-effective preparations.

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Syndicated from the Adapt Research Blog

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Public Health Expert Briefing (ISSN 2816-1203)
