

# The threat of nuclear winter

Dr Stuart Parkinson



*These slides will be made available at: <https://www.sgr.org.uk/>*

Presentation given at a webinar 'What would a nuclear war be like?', organised by CND, on 10<sup>th</sup> March, 2022

## Nuclear war can cause extreme climatic change

- World rightly concerned about global climate change due to **carbon emissions**
- Few people aware of threat from global climate change due to **nuclear war**
- Recent academic research shows impacts to be high, even from 'regional' nuclear war
- Key differences:
  - Direction – nuclear war would cause global **cooling**
  - Speed – nuclear war would cause **much more rapid** changes
  - Magnitude – nuclear war can cause **larger** changes



- *Image credit: AlexAntropov86 via Pixabay*

## Nuclear winter: the key steps



*Image credit: Alicja via Pixabay*

## Key recent academic studies

- **The potential impact of nuclear conflict on ocean acidification (2020)**  
N Lovenduski, C Harrison, H Olivarez, C Bardeen, O Toon, J Coupe et al  
*Geophysical Research Letters*, 47:3; DOI:10.1029/2019GL086246
- **A regional nuclear conflict would compromise global food security (2020)**  
J Jägermeyr, A Robock, J Elliott, C Müller, L Xia, N Khabarov et al  
*Proceedings of the National Academy of Sciences of the USA*, 117:13; DOI:10.1073/pnas.1919049117
- **Rapidly expanding nuclear arsenals in Pakistan and India portend regional and global catastrophe (2019)**  
O Toon, C Bardeen, A Robock, L Xia, H Kristensen, M McKinzie et al  
*Science Advances*, 5:10; DOI:10.1126/sciadv.aay5478
- **Multidecadal global cooling and unprecedented ozone loss following a regional nuclear conflict (2014)**  
M Mills, O Toon, J Lee-Taylor, A Robock  
*Earth's Future*, 2, 161–176; DOI:10.1002/2013EF000205
- **Nuclear winter revisited with a modern climate model and current nuclear arsenals: still catastrophic consequences (2007)**  
A Robock, L Oman, G Stenchikov  
*Journal of Geophysical Research: Atmospheres*, 112:D13; DOI:10.1029/2006JD008235
- **Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism (2007)**  
O Toon, R Turco, A Robock, C Bardeen, L Oman, G Stenchikov  
*Atmospheric Chemistry and Physics*, 7, 1973–2002, DOI:10.5194/acp-7-1973-2007

- Several others since mid-2000s including:
  - Nuclear weapons in a changing climate: probability, increasing risks, and perception (2017)  
A Liska, T White, E Holley, R Oglesby  
*Environment: Science and Policy for Sustainable Development*, 59:4, 22-33; DOI:10.1080/00139157.2017.1325300
  - Decadal reduction of Chinese agriculture after a regional nuclear war (2015)  
L Xia, A Robock, M Mills, A Stenke, I Helfand  
*Earth's Future*, 3, 37-48, doi:10.1002/2014EF000283.
  - Impacts of a nuclear war in South Asia on soybean and maize production in the Midwest United States (2013)  
M Özdoğan, A Robock, C Kucharik  
*Climatic Change*, 116, 373-387, doi:10.1007/s10584-012-0518-1
  - Impacts of a nuclear war in South Asia on rice production in mainland China (2013)  
L Xia, A Robock  
*Climatic Change*, 116, 357-372, doi: 10.1007/s10584-012-0475-8
  - Climate and chemistry effects of a regional scale nuclear conflict (2013)

A Stenke et al

*Atmospheric Chemistry and Physics*, 13, 9713-9729, DOI:10.5194/acp-13-9713-2013

- Climatic consequences of regional nuclear conflicts (2007b)

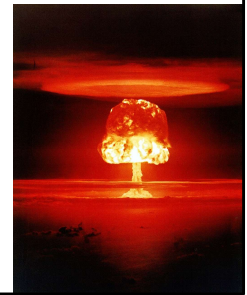
A Robock, L Oman, G Stenchikov, O Toon, C Bardeen, R Turco

*Atmospheric Chemistry and Physics*, 7, 2003–2012; DOI:10.5194/acp-7-2003-2007

- Also at least nine peer-reviewed papers during 1980s and early 1990s

## 3 nuclear war scenarios studied

- **‘Regional’** – examples:
  - India-Pakistan conflict – about 100 Hiroshima-sized warheads
  - 1 UK Trident submarine (used to repel invasion) – about 40 larger warheads
  - Less than **1%** of global number of warheads
- **‘Global-low’**
  - All current ‘active’ US-Russian missiles
- **‘Global-high’**
  - All active weapons in mid-2000s or in the future?



- Scenarios defined in two papers from 2007 by Robock et al
- UK scenario – SGR (2015). <https://www.sgr.org.uk/publications/uk-nuclear-weapons-catastrophe-making>
- Global total number of nuclear weapons approx. 12,700 in 2022 – FAS (2022). <https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/>
- *Image credit: Gerd Altmann*

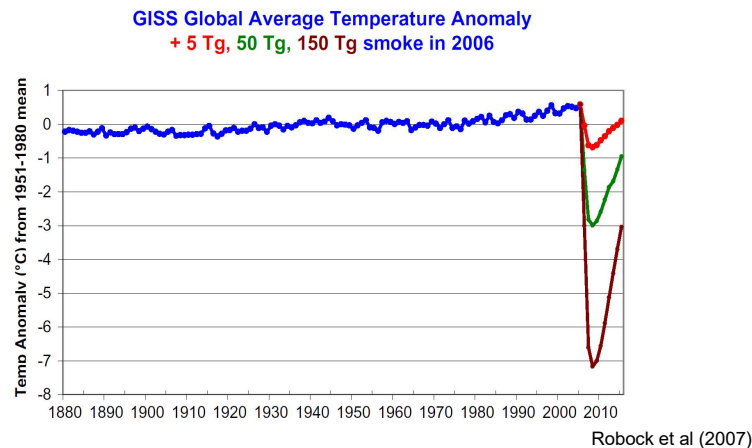
## Key impacts of regional nuclear war scenario

- Large areas of 'severe fire zone', injecting 5m tonnes of soot into stratosphere
- Sudden major drop in surface temperatures lasting over 7y
- Coldest global temperature for at least 1,000 years
- Severe frosts/ drought lead to much shorter growing season/ reduction in crop yields for years
- Major loss of ozone layer
- Major impact on global ecosystems
- **Global famine affecting about 2,000,000,000 people**
- (In addition to 10-21 million direct deaths from explosions)



- Key findings from Toon et al (2007); Robock et al (2007b) – other studies give comparable results
- Global famine affecting 2 billion – IPPNW (2013).  
<https://www.ippnw.org/programs/nuclear-weapons-abolition/nuclear-famine-climate-effects-of-regional-nuclear-war>
- *Image credit: Alicja via Pixabay*

# Nuclear war: global temperature scenarios



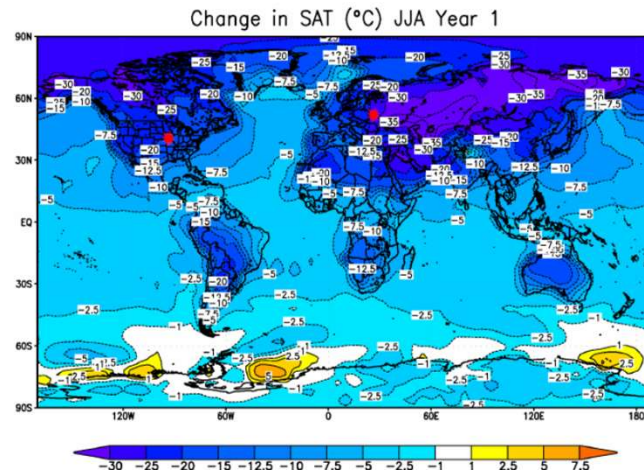
- Scenario 1 (Red) – ‘regional’ nuclear war, e.g. India-Pakistan, UK arsenal
- Scenario 2 (Green) – ‘global-low’ nuclear war, e.g. all current ‘active’ US-Russian weapons
- Scenario 3 (Brown) – ‘global-high’ nuclear war, e.g. mid-2000s weapons level

- 3 nuclear war scenarios and the resultant ‘global cooling’
  1. 5 million tonnes (Mt) of black carbon (soot) injected into stratosphere
  2. 50 Mt of black carbon
  3. 150 Mt of black carbon
- From research led by Prof Alan Robock, Rutgers University, USA, published in 2007
- Blue line is measured global temperature change 1880-2006 (relative to 1951-1980 average level)
- For UK nuclear scenarios, see: SGR (2015).  
<https://www.sgr.org.uk/publications/uk-nuclear-weapons-catastrophe-making>



# Nuclear winter scenarios

- 'Global-high' USA-Russia war scenario



- Graph: Surface air temperature changes (degrees Celsius) for the '150 Tg case' – i.e. a major nuclear war between USA and Russia using arsenals available in mid-2000s leading to emissions of 150 million tonnes of black carbon into the upper atmosphere, mainly in the form of smoke – averaged for June, July, and August of the year of smoke injection and the next year. Effects are largest over land, but there is substantial cooling over oceans, too. The warming over Antarctica in Year 0 is for a small area, is part of normal winter interannual variability, and is not significant. Also shown as red bursts are two example locations for nuclear weapon explosions.
- 'Global-low' war scenario – reductions in temperature are about half the magnitude, but follow a similar geographical distribution

## We need to spread the word...

- Nuclear weapons labs trying to muddy the waters
  - but their counter-research is flawed
- Science/ defence journalists rarely report on the issue
- Governments/ militaries avoid talking about the issue
- So it's not well known among public/ parliamentarians
- **But the threat is all too real!**

- For scientific debate on nuclear winter scenarios, see: Nature (2020).  
<https://www.nature.com/articles/d41586-020-00794-y>