Chapter 2
Climate Security—The Physical Basis

Abstract This chapter provides an introduction to the physical science of climate change, current and projected levels of anthropogenic GHG emissions and a brief account of the political challenges associated with a coordinated and binding international policy response to limit global warming. This wider examination of climate change is also undertaken within a security and military context. Perforce, 'climate security' is defined upfront and the key physical (environmental) risks of climate change are mapped to potential security and military impacts. The chapter also examines military GHG emissions (estate and operations) for the Australian, US and UK militaries. It concludes that the military sector is a significant contributor to global emissions.

Keywords Climate science · Climate risk · Climate security · Military emissions · Military GHG emissions · Climate security definition

2.1 Defining Climate Security

Before reviewing the science of climate change it is important to have a working understanding of what is meant by the term 'climate security'. Reflecting earlier debates within the field of security studies, definitions of 'climate security' (like the term 'security' itself) remain imprecise, fluid and contested (Wolfers 1952; Buzan 1991; Dalby 1992; Youngs 2015). In the US, climate security has been defined as a 'threat multiplier' with a tendency to focus on national security implications; in contrast the UN has framed it as a 'threat minimiser' with a focus on its implications for human security. Others again have identified it as a 'nexus' issue that affects the 'broader determinants of stability' that encompass the economy, patterns of resource production and consumption as well as the direct physical impacts of global warming (Youngs 2015).

A common thread amongst the various definitions is the acceptance that climate change presents as a major security threat operating with varying effects across multiple time-frames, scales, locations and domains. Adopting this wide approach,

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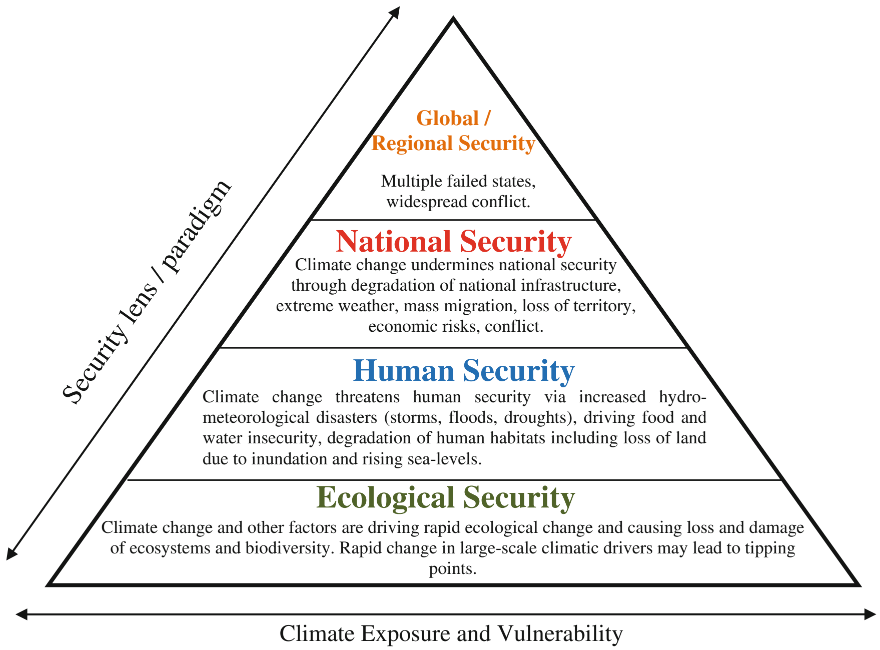


Fig. 2.1 Climate security framework. Security of ecosystems and biodiversity forms the basis of all other forms of security. Since climate change undermines the base, it degrades the pyramid. *Source* The author

'climate security' can be said first and foremost to concern the return to, and maintenance of, atmospheric GHG concentrations within the range of 280–350 ppm[1] for the purpose of stabilising global average surface temperatures below 1.5 °C in order to preserve and sustain planetary ecological systems. For the purpose of this book, 'climate security' can be defined more narrowly as: *the absence of threats to individuals, states, and the international system that arise from anthropogenic warming*.[2] Throughout this book, climate security is generally viewed through the prism of national security; that is to say, the nation-state is the referent object to be secured against an adversely changing climate. This is not intended to downplay or disregard other legitimate forms of security, but should rather be viewed simply as an effort to have a workable research boundary. The armed forces, as critical enablers of national security (but not the only enablers), are central actors in this discourse.

[1]Using CO_2 (carbon dioxide) as the GHG indicator.

[2]While much discussion exists on what target is appropriate, this definition uses the 1.5 °C target that was previously adopted by the Association of Small Island States (AOSIS) as well as many NGOs and scientists (Tschakert 2015).

Figure 2.1 is a simplified representation of the linkages of climate security across the security domains described above. This simplified representation shows that each security 'level' (or 'lens') is reliant upon, or sustained by, the ones below it; and that climate change has the potential to undermine the most fundamental basis (i.e., planetary ecological systems) from which all other forms of security (human, national and global) are made possible. The horizontal axis indicates 'climate exposure' and 'climate vulnerability', indicating that ecosystems (including biodiversity) are the most exposed and vulnerable to climate change.

2.2 Overview of Climate Science

This section overviews the fundamental science of climate change. While this will be familiar territory to many involved in disciplines and sectors addressing climate change, it is an often overlooked area and one that is arguably given less attention than it deserves by security sector professionals more generally (Sturrock/Ferguson 2015). For brevity, this literature survey does not attempt to build on the science of climate change per se, but rather aims to provide wider context on the scale of the challenges at hand and an update on the most recent data (as at the end of 2016).

The foundation science of climate change was laid down in the nineteenth century by naturalists, philosophers and part-timers investigating the 'riddle of the ice age' (Weart 2008: 5). Key discoveries during this period included the basic mechanism of global warming (1827, Joseph Fourier); the discovery of the main greenhouse gases (1859, John Tyndall); the quantification of those gases to global warming (1896, Svante Arrhenius); and the postulation in 1907 that industrial pollution was the main cause. Swedish scientist Svante Arrhenius is particularly noteworthy. Building on the experiments and observations of other scientists, he stated (in 1896): 'If the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression' (Arrhenius 1896: 267). He surmised that a 50% increase of 'carbonic acid' (carbon dioxide, CO_2) would lead to temperature increases of more than 3 °C (Arrhenius 1896: 266).

Figure 2.2 shows the Earth's energy balance. Of the 341 watts per square meter (W m^{-2}) of solar radiation reaching the Earth's atmosphere, roughly 30% (102 W m^{-2}) is reflected back into space, while 70% (239 W m^{-2}) is either reflected or absorbed and then re-radiated as long-wave (infrared radiation) at the Earth's surface (Trenberth et al. 2009).[3] In the lower reaches of the Earth's atmosphere, GHGs

[3]The figures in the text differ slightly from those given in the diagram. The diagram is from NASA Earth Observatory while the figures in the text are from the citation. For an explanation, see NASA at: http://earthobservatory.nasa.gov/Features/EnergyBalance/page4.php (2 November 2016).

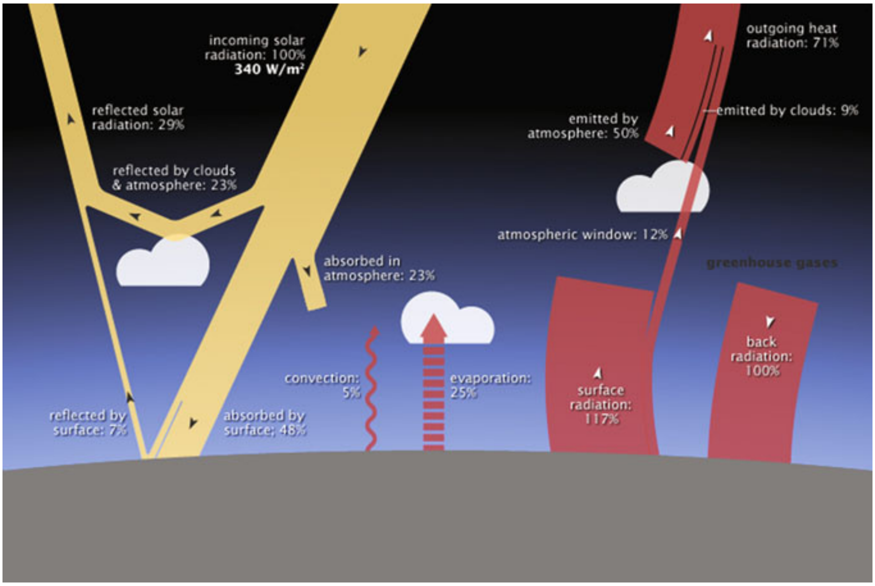


Fig. 2.2 Earth energy balance. *Source* NASA Earth Observatory (2016). Reprinted with permission.

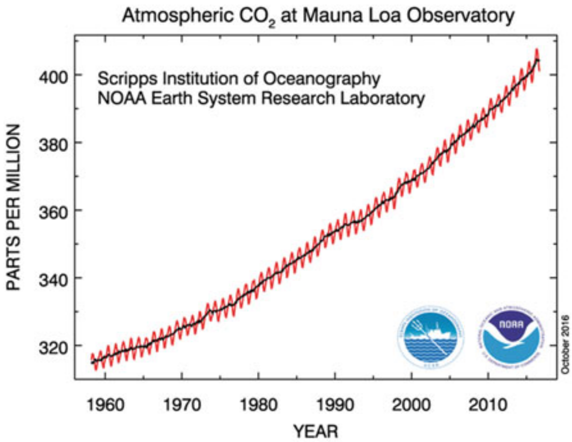
absorb a small fraction of the re-radiated long-wave radiation (about 5%), scattering heat energy back to Earth ('back radiation') and warming the lower atmosphere. This is called the 'greenhouse effect' and, without it, global average temperatures would be about 30 °C colder than current conditions (Cotton/Peilke 2007: 121).

As John Tyndall discovered in 1859, the two most abundant gases in the atmosphere (nitrogen and oxygen) exert almost no greenhouse effect (LeTreut et al. 2007). Rather, the two main GHGs are water vapour and CO_2. Although water vapour is a critically important GHG, humans only have a very small direct influence on the actual amount in the atmosphere. CO_2, by contrast, is primarily emitted into the atmosphere through human industrial action via combustion of fossil fuels. Invariably, climate scientists pinpoint CO_2 as the most important GHG due to a combination of increasing anthropogenic emissions combined with its high 'radiative forcing', high atmospheric concentrations, long residence time (centuries) and global dispersion pattern (Blasing 2012). Methane (CH_4), nitrous oxide (N_2O) and a range of other minor gases including ozone gases, hydroflourocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) also contribute as GHGs.

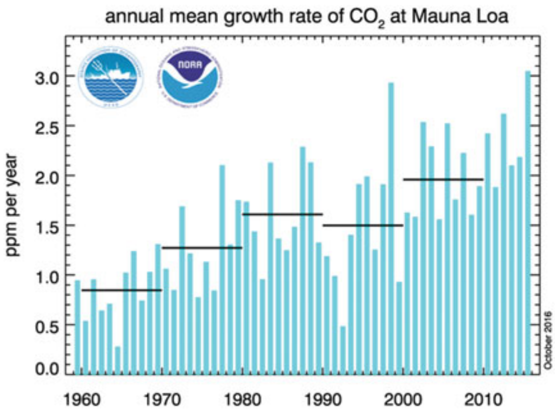
Any change to the Earth's energy balance (a 'pertubation') requires what is known as a 'climate forcing'. A climate forcing can occur in one of three ways: (1) changing the amount of incoming solar radiation (e.g., orbital changes), (2) changing the amount of solar radiation that is reflected (e.g., albedo, aerosols), or (3) altering the long-wave radiation from Earth back towards space (e.g., by changing the level of GHG concentrations) (LeTreut et al. 2007: 96). In 1957 attention was drawn to the last of these when a research programme funded by the US Navy's Office of Naval Research at the Scripps Institution of Oceanography (notably led by Roger Revelle) published results indicating that sequestration of CO_2 by the world's oceans was not as rapid as originally thought. Further analysis by Charles Keeling and others showed an accumulation of atmospheric CO_2 and again led to the postulation that increasing anthropogenic emissions might produce a positive climate forcing (i.e., warming) by the end of the twentieth century (Weart 2008).

Like Svante Arrhenius and the nineteenth century scientists before them, those working in the field of 'climate science' in the 1950s did not consider this to be a problem. Indeed, it was viewed by some as a practical way to actually warm the planet, particularly across northern Europe! However, the scale of industrialisation

Fig. 2.3 Atmospheric CO_2 concentrations and growth rate, 1960–2016. *Source* NOAA ESRL (2016). Reprinted with permission.



(a) Atmospheric CO_2 concentration, 1960–2016.



(b) Annual mean growth rate of atmospheric CO_2 1960–2016 through the rapid uptake of coal, oil and gas, combined with rapid population increases—particularly following World War II—witnessed an unforeseen growth in GHGs emissions and concomitant atmospheric concentration levels. Thus, for the first time in 800,000 years, atmospheric CO_2 now exceeds 400 ppm (higher when factoring in 'masking agents' such as aerosols) and has been accumulating in the atmosphere at increasing rates (see Fig. 2.3). Moreover, since industrialisation, humans have emitted more than 550 billion tonnes (GtC) of carbon into the atmosphere (with 40% remaining in the atmosphere and about 30% each in oceanic and terrestrial sinks) (IPCC 2015: 4). Scientists now understand atmospheric GHGs to be the dominant contributor to the Earth's energy imbalance, with the Goddard Institute for Space Studies (GISS) recording a globally averaged energy imbalance of 1.73 W m^{-2} (Hansen et al. 2011) and IPCC AR5 placing total anthropogenic radiative forcing over 1750–2011 at 2.3 W m^{-2} (IPCC 2015: 44). Despite the cooling effect of aerosols and other agents, the overall positive net forcing has resulted in a globally averaged surface temperature increase approaching 1 °C since 1850, with further warming 'locked-in' as a consequence of the climate's inertia (Hansen et al. 2011).

2.3 Climate Change and Implications for Security and Military Forces

Having overviewed the science of climate change, this section maps the observed changes in the climate system to possible impacts on security and on military forces. The observed changes are drawn from IPCC AR5 (IPCC 2015: 39–54), while accompanying security and military impacts have been synthesised from a variety of subject literature (CNA 2007; NIC 2008; UNSG 2009; Carmen et al. 2010; Thomas 2012; CNA 2014; Barrie et al. 2015):

- *Atmospheric warming and altered rainfall patterns.* Globally averaged combined land and ocean surface temperatures show a warming of 0.85 °C over the period 1880–2012, with global scale changes in precipitation patterns, intensification of heavy precipitation, desertification and reductions in renewable surface and groundwater. Warming is not evenly distributed across the globe, impacting some countries more and others less.
  - *Security Impacts*: Increased risk of heat-related mortality (heat waves, dehydration, heat stroke, heat exhaustion); changes in distribution of water-borne illnesses and disease vectors; risks to food security as a result of negative impact on crop production (particularly wheat, maize, rice and soy), crop access, use and price stability; risks to water security through altered flows, run-off and availability; threats to the capacity of governments to meet

the basic needs of their people and risks to development from the combined and associated impacts listed above (and below).
- *Military Impacts*: Potential for increased tension over changes to resource availability, access and use may flare into low-level and wide-scale conflict involving national, regional and international military intervention. Increased warming may also impact military training regimes (changes to soldier/sailor/airmen productivity due to heat, duration of exercises, seasonality), military training grounds (e.g., increased risk of wild-fire, changes in suitability of training grounds from longer fire-seasons or permafrost thaw), and military logistics (e.g., long-term storage of supplies requiring stable temperature ranges).

• *Extreme Weather*: Extreme weather events have become more common since the mid-twentieth century. Examples include heatwaves, heavy precipitation, coastal flooding, storm surge, flooding, landslides, wildfires, droughts and more intense cyclones/hurricanes/typhoons in certain regions.

  - *Security Impacts*: Increased extreme weather combined with population growth has the potential to cause increased destruction of infrastructure and agriculture, loss of life, displacement and loss of economic output that may place increased strain on fragile states and capacity of developed nations to respond. Also, risks to development from associated impacts listed above.
  - *Military Impacts*: Potential increase in domestic and offshore Humanitarian Aid and Disaster Relief (HADR) missions could influence military force structure, capability acquisitions, training regimes and strategic scenario planning. Extreme weather may also impact military bases and hardware through direct physical destruction and degradation.

• *Ocean warming and acidification.* IPCC AR5 has 'high confidence' that ocean warming dominates the increase in energy stored in the climate system (accounting for more than 90% of energy accumulated between 1971 and 2010). There is 'virtual certainty' that the upper ocean (0–700 m) has warmed since 1971 and 'high confidence' that the ocean has absorbed 155 GtC since 1750, resulting in pH decrease of 0.1 and a 26% increase in ocean acidity.

  - *Security Impacts*: Potential changes in the geographic range, regional abundance, seasonal activities and migration patterns of marine species could result in new/increased tensions over marine resources.
  - *Military Impacts*: Potential impacts on naval crews and coastguards from increased requirement to protect commercial fishing fleets and EEZs. Changes to ocean thermal stratification, warming and acidity could all impact naval surface and sub-surface operations and capability as well as ship maintenance and marine infrastructure.

- *Sea level rise*. IPCC AR5 has 'high confidence' that the rate of sea-level rise since the mid-nineteenth century has been larger than the mean rate during the previous two millennia. There is 'high confidence' that glacial mass loss and thermal expansion account for 75% of sea level rise. Over the period 1901–2010 global mean sea-level rose by 0.19 m and the *rate* of sea level rise is increasing (it is 'very likely' that the mean global sea level rise between 1971–2010 was 2.0 mm/year and between 1993–2010 was 3.2 mm/year). Sea level rise is not evenly distributed, impacting some countries more, others less.
  - *Security Impacts*: Destruction and loss of coastal crops due to inundation, intrusion and salinisation; damage to infrastructure along coastal communities, cities; gradual loss of sovereign territory (particularly low-lying islands) and displacement/migration.
  - *Military Impacts*: Physical loss and damage to low-lying military infrastructure, bases, training grounds, ports, airstrips, barracks. Other considerations include the potential loss and damage of critical civilian infrastructure that supports military mobilisation and basing (e.g., emergency services, utilities) (e.g., power, water, sewer, gas).
- *Cryosphere*. Melting ice and permafrost across the Arctic, Greenland and Antarctica are driving sea-level rise, increased coastal erosion, impacts on biodiversity, changes in thermokarst lakes, altered river runoff, impacts on coastal communities and cities; opening of new trade routes and resource fields. The Arctic is particularly vulnerable, with summer sea-ice decreasing at a rate of between 0.73 and 1.07 million km^2 per decade ('very likely').
  - *Security Impacts*: Changes to the hydrological system have potential to create competition (or cooperation) between countries over access to water. Threats to water security are especially relevant in glacial-fed rivers of Himalaya ranges (Indus, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze and Yellow) that support more than one-quarter of the world's population through long-term change effecting river runoff and flows which impact irrigation, agriculture and drinking water. Rapid change in the Arctic has potential for new trade routes, tourism and resource exploitation (fishing grounds, oil and gas) that may generate competition and tensions.
  - *Military Impacts*: Rapid change in the Arctic may drive requirement for increased military presence conducting asset protection, assistance in clean-up operations and emergency response. Arctic presence may also see countries develop new military capabilities, installations/bases opening up or being revamped, and increased military exercises being conducted across the Arctic. Changes in river-flows across the key Asian river basins may see increased military focus on asset protection (e.g., dams, river alterations, hydro-electricity plants, irrigation schemes) and possible deployment for water-related conflict resolution.

2.4 Global and Military GHG Emissions

This section briefly reviews global GHG emissions, the primary cause of anthropogenic climate change and, by implication, a contributor to the security and military impacts just mentioned. It opens with an overview of the current global GHG emissions picture, identifying the major emitting nations, sources of GHGs and possible future emissions scenarios. In keeping with the focus for this book, attention then turns to an examination of military GHG contributions. While much information exists on national GHG tallies, including the various sectoral contributions (e.g., aviation, agriculture, transport and so on), there is less clarity, understanding and knowledge of the size and scale of global military GHG contributions (Michaelowa/Kock 2001). Some of the challenges in obtaining clear information on military GHG data include: (1) a lack of a clear guiding international or national regulatory or legal requirement for nations to account for and report military emissions; (2) difficulties in data collection relating to offshore/non-domestic consumption and usage of fossil fuels by military forces involved in permanent off-shore basing arrangements, exercises, routine patrols and operations, or war; (3) an unwillingness by nations to report military emissions for operational or security-related reasons; and (4) challenges in developing an appropriate set of emissions boundaries that attribute responsibility in an equitable manner (e.g., if nation A contributes military forces to nation B who are both operating within the boundaries of nation C, then which nation should emissions be attributed to? Alternatively, if multiple nations contribute military assets to supply-line protection or anti-piracy operations for the greater regional or global good, and are operating in international waters, then which nations should emissions be attributed to?). The section examines GHG emissions for the Australian, US and UK militaries and uses a general approach to estimating global emissions for the military sector.

2.4.1 Current Global GHG Emissions and Projections

Since industrialisation (1750), the primary source of anthropogenic GHG emissions has been the extraction and combustion of fossil fuels and land-use change (e.g., deforestation). Total cumulative anthropogenic GHG emissions since industrialisation is 470–640 GtC (IPCC 2015: 4).[4] On an annual basis, fossil fuel and land use change emissions in 2016 are estimated at 36.4 $GtCO_2$ or around 9.9 GtC (LeQuéré et al. 2016: 630).[5] This is 63% above 1990 levels (ibid). Key sources of emissions

[4]The most recent report by the Carbon Dioxide Information Analysis Center (CDIAC) places total cumulative emissions 1870–2016 at 565 ± 55 GtC (LeQuéré et al. 2016: 632).

[5]1 Pg = 1 Petagram = 1 × 10^{15} g = 1 billion metric tonnes = 1 Gigatonne (Gt).
1 kg carbon (C) = 3.67 kg carbon dioxide (CO_2).
1 PgC = 3.67 billion tonnes CO_2 = 3.67 $GtCO_2$.

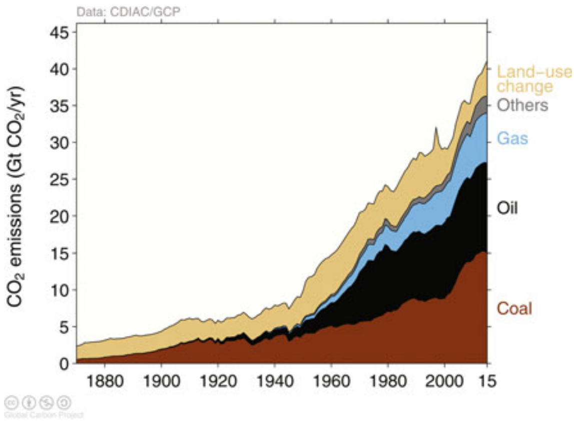


Fig. 2.4 Total global GHG emissions by source. *Source* LeQuéré et al. (2016). Reprinted with permission under CDIAC guidelines.

are at Fig. 2.4 and major emitting countries are at Fig. 2.5. To have a 66% change of keeping global warming below 2 °C to avoid dangerous climate change, then remaining quota is 856 Gt CO_2, or about 240 GtC (LeQuéré et al. 2015). Assuming current emission rates of about 10 GtC per year, then this quota will be consumed around 2040.

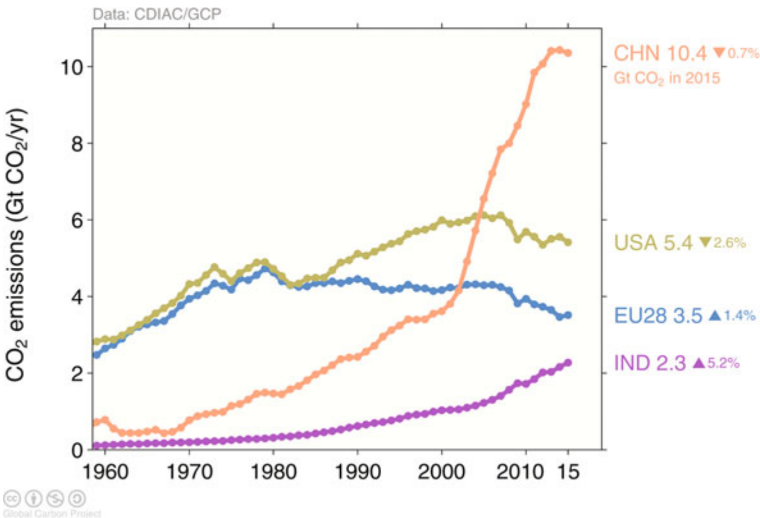


Fig. 2.5 Major fossil fuel emitters, 1960–2015. *Source* LeQuéré et al. (2016). Reprinted with permission under CDIAC guidelines.

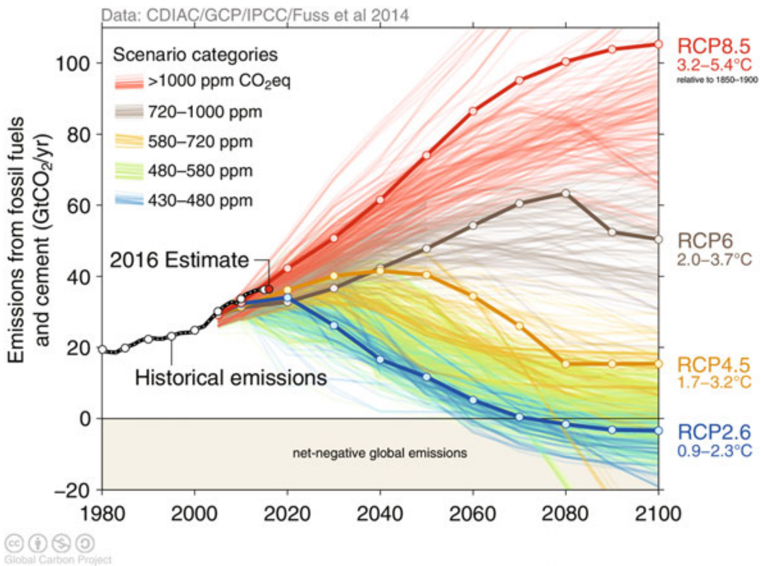


Fig. 2.6 Representative concentration pathways, 2014–2100. *Source* LeQuéré et al. (2016). Reprinted with permission under CDIAC guidelines.

Emissions scenarios, referred to as Representative Concentration Pathways (RCPs), were developed for IPCC AR5 and to provide policy-makers with plausible descriptions of how future climate scenarios may unfold. The RCP names are given after a possible range of radiative forcing values in the year 2100 (i.e., 2.6, 4.5, 6.0 and 8.5 W m^{-2}, respectively). Figure 2.6 shows the various emissions scenarios with the expected temperature increase at 2100, should a given RCP scenario unfold. These indicate that to have a 'likely chance' of keeping temperatures of below 2 °C, current emissions need to peak about 2020 and sustain a steady reduction until net negative emissions are achieved by around 2070 (RCP 2.6). Based on recent historical emissions, however, such a scenario appears unlikely, with studies indicating that anthropogenic emissions have tracked at the top end of all emissions scenarios developed since 1985 (ESSP 2012). On this basis, scientists estimate that, under RCP8.5, globally averaged surface temperatures are now more likely to be in the range 4.78–7.36 °C by 2100 (Friedrich et al. 2016).

2.4.2 *Military GHG Emissions*

Military GHG emissions continue to be a source of interest on the basis of their oft-stated sizeable contribution to global emissions and the lack of clear and transparent data (Savage 2015; Flounders 2014; Neslen 2015). This section shows

Table 2.1 Australian DoD GHG emissions 2001–2012[6]

AS DoD GHG emissions (Mt CO_2e)							
Year	**AS DoD estate**[a]	**AS DoD operations**[b] **(2)**	**AS DoD total**[c] **(b + c)**	**AS Gov't**	**% (d/e)**	**Total AS emissions**	**% (d/g)**
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**
2001	0.76	1.34	2.10	3.18	66.18	491.44	0.43
2002	0.73	1.13	1.86	2.93	63.50	494.74	0.38
2003	0.73	1.09	1.82	2.86	63.43	495.15	0.37
2004	0.76	0.99	1.76	2.61	67.26	511.71	0.34
2005	0.76	1.01	1.77	2.61	67.73	518.85	0.34
2006	0.81	0.96	1.77	2.59	68.42	522.52	0.34
2007	0.82	0.93	1.75	2.70	64.80	529.84	0.33
2008	0.78	0.90	1.67	2.83	59.11	533.69	0.31
2009	0.76	0.72	1.48	2.66	55.70	537.89	0.28
2010	0.75	0.87	1.62	2.82	57.51	533.92	0.30
2011	0.74	0.96	1.71	2.89	59.09	534.09	0.32
2012	0.74	0.93	1.68	2.84	59.01	537.38	0.31

GHG emissions for the Australian Department of Defence (AS DoD), United States Department of Defense (US DoD) and UK Ministry of Defence. Efforts are made to show emissions resulting from respective Defence infrastructure, facilities and buildings (the 'Estate'), as well as those resulting from military operations ('Defence Operations' are emissions generated from the domestic use of military equipment including planes, ships, tanks and so on). Notable exclusions in these tallies are off-shore military exercises and operations, land use, land use change and forestry (LULUCF) and whole-of-life-cycle emissions resulting from military-industrial research, development and manufacturing (generally covered under other sectoral reporting requirements). This section concludes by estimating total global military GHG emissions which are further compared against individual country contributions.

[6]Million Metric Tonnes CO_2 equivalent (Mt CO_2e) (Emissions data from the individual EEGO reports differ slightly from those in the most recent Excel database provided by the AS Government (refer to 'Energy Use in the Australian Government Operations: Annex C'). This table has used data from the most recent agency reporting, and includes updates from each Agency expressing previous 'under-reporting' (refer to 'Department of Defence, Agency Comments' within cited source). Final EEGO report was published in 2013 (covering 2012), following election of the Abbott government.). *Sources* Commonwealth of Australia (2013b, c, 2016)

[a]Covers all buildings and facilities within established Defence bases (does not include office building and stores outside base perimeters)

[b]Covers emissions from domestic Defence operations for aircraft, tanks, ships and combat vehicles. Excludes offshore emissions used on operations, exercises or war

[c]Figures exclude Australian War Memorial and the Department of Veterans' Affairs

AS DoD GHG Emissions. Table 2.1 shows AS DoD GHG emissions between 2001–2012. Table 2.1, Column D shows that GHG emissions in this period varied from a minimum of 1.48 Million tonnes of CO_2 equivalent (Mt CO_2e) in 2009 to a maximum of 2.10 Mt CO_2e in 2001. To place this in context, this is roughly equivalent to the total national emissions of many small developing nations, such as Haiti (2.3 Mt CO_2), Gabon (1.9 Mt CO_2), Guinea (1.9 Mt CO_2) or Madagascar (1.9 Mt CO_2), or the combined total national emissions of several smaller countries, e.g., Timor-Leste (0.2 Mt CO_2), Solomon Islands (0.2 Mt CO_2), Tonga (0.1 Mt CO_2), Greenland (0.6 Mt CO_2), and Fiji (0.8 Mt CO_2). Globally, if the AS DoD were a country, it would be ranked roughly between 143rd and 157th largest in the world (CDIAC 2015; UNFCCC 2015). Table 2.1, Column F shows that the AS DoD contributes between 55 and 68% of all Australian government emissions. As a percentage of the overall Australian GHG emissions (i.e., for the entire economy), this represents less than one-half of 1% (i.e., ranging from 0.28% in 2009 to 0.43% in 2001).

US DoD GHG Emissions. Table 2.2 shows US DoD estate and operational emissions over the period 2008–2015. All US DoD emissions figures are obtained from the US Strategic Sustainability Performance Plans (SSPP), which have been published by US DoD since 2010, and US Department of Energy Comprehensive Annual Energy and Data Sustainability Performance publications. Table 2.2 shows that US DoD emissions (including US DoD international bunkers and Scope 3 emissions) vary from 75.62 CO_2e in 2014 to 93 Mt CO_2e in 2010. This represents roughly three-quarters of all US government emissions and about 1.2% of all US domestic emissions.[7] To place this in context, it is almost one-sixth of the entire Australian economy (based on 84 Mt CO_2e for US DoD and 500 Mt CO_2e for Australia). If the US DoD were a single country, it would rank around the 40th largest emitter in the world, larger than some 176 other countries (CDIAC 2015; UNFCCC 2015).[8]

UK DoD GHG Emissions. Table 2.3 shows UK Ministry of Defence (MoD) estate and operational emissions over the period 2010–2014. Although some

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[6] Million Metric Tonnes CO_2 equivalent (Mt CO_2e) (Emissions data from the individual EEGO reports differ slightly from those in the most recent Excel database provided by the AS Government (refer to 'Energy Use in the Australian Government Operations: Annex C'). This table has used data from the most recent agency reporting, and includes updates from each Agency expressing previous 'under-reporting' (refer to 'Department of Defence, Agency Comments' within cited source). Final EEGO report was published in 2013 (covering 2012), following election of the Abbott government.). *Sources* Commonwealth of Australia (2013b, c, 2016)

[a]Covers all buildings and facilities within established Defence bases (does not include office building and stores outside base perimeters)

[b]Covers emissions from domestic Defence operations for aircraft, tanks, ships and combat vehicles. Excludes offshore emissions used on operations, exercises or war

[c]Figures exclude Australian War Memorial and the Department of Veterans' Affairs

[7]Noting that this does not include any emissions associated with defence industrial manufacturing and production.

[8]Based on 2014 emissions.

Table 2.2 US DoD emissions, 2008–2013

US DoD GHG emissions (Mt CO_2e)								
Year	**US DoD estate**[a]	**US DoD operations**[b]	**US DoD intern'l bunkers**[c]	**US DoD total (b + c + d)**	**US Gov't**[d]	**% (e/f)**	**Total US emissions**[e]	**% (e/h)**
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
2008	34.49	50.44	8.20	93.13	121.20	76.84	7216.00	1.29
2009	N/A	N/A	7.40	N/A	N/A	N/A	N/A	N/A
2010	34.37	49.59	8.20	92.16	117.76	78.26	6985.00	1.32
2011	33.76	48.83	7.00	89.59	114.71	78.10	6865.00	1.31
2012	31.99	44.99	7.00	83.99	114.71	73.22	6643.00	1.26
2013	31.23	39.57	6.00	76.80	106.66	72.00	6800.00	1.13
2014	31.00	38.12	6.50	75.62	97.21	77.79	6870.00	1.10
2015	30.82	38.91	6.25[f]	75.98	97.89	77.62	N/A	N/A

Million Metric Tonnes CO_2 equivalent (Mt CO_2e). *Sources* US DoD (2012b, 2016a), US DoE (2016), US EPA (2016)

[a]Covers installations, facilities, buildings etc. Does not include US Army Corps of Engineers and other military related agencies. Includes Scope 1, 2, and 3 emissions. Data available at: http://ctsedwweb.ee.doe.gov/Annual/Report/ComprehensiveGreenhouseGasGHGInventoriesByAgencyAndFiscalYear.aspx (12 November 2016)

[b]Covers domestic military emissions of tactical ships, planes, vehicles (includes Scope 1, 2 and 3 emissions). Data available at: http://ctsedwweb.ee.doe.gov/Annual/Report/ComprehensiveGreenhouseGasGHGInventoriesByAgencyAndFiscalYear.aspx (12 November 2016)

[c]For US military emissions related to International Bunkers, see Table A-168. Page A-235, data available at: https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-annex-3-additional-source-or-sink-categories-part-a.pdf (12 November 2016)

[d]For US Government agency emissions, see Department of Energy website, data available at: http://ctsedwweb.ee.doe.gov/Annual/Report/ComprehensiveGreenhouseGasGHGInventoriesByAgencyAndFiscalYear.aspx (12 November 2016)

[e]For US emissions see US EPA Inventory of US Greenhouse Gas Emissions and Sinks 1990–2014, specifically see Figure ES-1: US Greenhouse Gas Emissions by Gas, page ES-4, data available at: https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf (12 November 2016)

[f]This is an estimate based on the mean of the previous two years' data—i.e., (6.0 + 6.5/2)

data was unavailable, it is worth highlighting that, as a percentage of the overall national economy, the UK MoD contributes between 0.74–0.85% of all UK emissions. This is approximately mid-point between the Australian and US militaries.[9]

Estimating Global Military GHG Emissions. Based on total global GHG emissions of 52,763.43 Mt CO_2e (World Bank 2016), and assuming that any given

[9]Major exclusions from all data sets are emissions produced by offshore (global) operations (including from offshore military installations and tactical platforms operating internationally), emissions from land use, land use change and forestry (LULUCF) on military training grounds and bases, and emissions produced by the civilian military-industrial manufacturing sector during its manufacturing processes.

Table 2.3 UK MoD GHG emissions, 2010–2015

UK MoD GHG emissions (Mt CO_2e)								
Year	**UK MoD estate**[a]	**UK MoD operations**[b]	**N/A**	**UK MoD total (b + c + d)**	**UK Gov't**	**% (e/f)**	**Total UK emissions**[c]	**% (e/h)**
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
2010	1.43	3.33	N/A	4.77	N/A	N/A	602.10	0.79
2011	1.44	3.25	N/A	4.70	N/A	N/A	553.40	0.85
2012	1.29	3.12	N/A	4.41	N/A	N/A	570.50	0.77
2013	1.24	2.86	N/A	4.11	N/A	N/A	557.30	0.74
2014	1.22	3.06	N/A	4.28	N/A	N/A	514.40	0.83
2015	1.17	1.83	N/A	3.00	N/A	N/A	N/A	N/A

Sources UK MoD (2013, 2015), UK DECC (2016)

[a]UK MoD, Sustainable MOD Annual Report 2014/15, Table 3, Greenhouse Gas GGC target performance (p. 3), at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/447951/20150723-Sustainable_MOD_Annual_Report-internet-ver.pdf (12 November 2016)

[b]Figures for MoD Operations can be deduced by subtracting estate emissions with gross emissions data at Annex A (refer to above citation). Earlier UK MoD reports also provide a breakdown of gross MoD GHG emissions data and can be used to check accuracy. For example, see 'graphical table' at Annex D to MoD Annual Sustainability Report and Accounts 2011–2012, at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/35010/20121205_mod_annualreport_Annex_D.pdf (12 November 2016)

[c]For UK emissions see Department of Energy and Climate Change 2014 UK greenhouse gas emissions: final figures—data tables, Table 1, row 12, at: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2014 (11 November 2016)

military represents between 0.3–1.1% of all national emissions, total global military emissions may be estimated at between 158.29 and 580.39 Mt CO_2e for estate and domestic military operations. The higher-end estimate would place the global military sector between the 10th and 15th largest global emitter (depending on what year it is compared). A mid-way point has the military sector at nearly 370 Mt CO_2e per year—still within the top 20 emitting nations. Clearly, these are very broad estimates and further analysis, including a full set of assumptions, would be required before higher levels of confidence could be achieved. Major omissions from these estimates include offshore operations and wars, LULUCF, and the emissions from the military industrial-manufacturing base (although these are accounted for separately in national inventories according to UNFCCC rules). Despite this, as a rough-order-magnitude estimate, the results suggest what has long been suspected: that the military sector is a significant, but not overwhelming, contributor to overall global GHG emissions. As major global emitters, however, military forces are known contributors to the very security challenges that they themselves may ultimately be called upon to resolve.

2.5 International Political Response to Climate Change

Having now reviewed the fundamental science of climate change as well as the emissions and security aspects, this section provides a brief summary of the main political attempts to address climate change. Scientific and political recognition of the need to reduce GHG emissions (and limit global warming) first arose in the 1970s. This early momentum culminated in the establishment of the IPCC (1988) and UNFCCC (1992). These institutions are regarded as the main forums for collective international action to reduce emissions and address the global consequences of climate change. The UNFCCC, in particular, was mandated to establish internationally binding quantitative emissions reductions via international agreements ('protocols').[10] Parties to the UNFCCC are classified as either 'Annex I Parties' that mainly include developed countries and those defined as 'economies in transition' (EIT), as 'Annex II Parties' consisting of developed countries from Annex I (but not EITs), or as 'Non-Annex I' countries mostly made up of developing countries. The main forum of the UNFCCC is an annual meeting between country representatives known as the Conference of the Parties (COP) that has been held every year since 1995.[11]

Until the Paris Agreement in 2015/16, the most prominent outcome from UNFCCC was the Kyoto Protocol that sought a binding 'top-down' international agreement to reduce GHG emissions according to underlying national differences in emissions, wealth, capacity and historical responsibility (enshrined in the principal of 'common but differentiated responsibilities' (UNFCCC 1997: Article 10).[12] Though the IPCC has previously trumpeted the Kyoto Protocol (Barker et al. 2007: 89), criticism was widespread and variously decried as a 'narrow, thin, and in most of the world, [an] ultimately symbolic' measure (Keohane/Victor 2011: 10). In response to the failure of the Kyoto Protocol, the UNFCCC adopted a more flexible approach in the lead-up to the 2015 COP 21 (Paris), particularly with respect to the

[10]The UNFCCC came into force in March 1994 and, as of 2014, had 196 signatories. The IPCC remains the primary international authority responsible for synthesising global climate change science from peer reviewed published scientific and technical literature. Its mission is to publish the latest scientific updates, identify uncertainties in climate science that require further research and to prepare response policies. Since 1990, the IPCC has reported via a series of Assessment Reports (1990, 1995, 2001, 2007 and 2013) that represent the latest global scientific research on climate change. Each Assessment Report has noted with increasing conviction that climate change is occurring, that humans are responsible and that its consequences will be serious and far-reaching.

[11]A Meeting of the Parties (MOP) has also been held annually in conjunction with COPs. The MOP is a meeting of those countries who have emissions responsibilities under the Kyoto Protocol.

[12]In total, there are 191 parties that are signatories to the Kyoto Protocol (from which some nations have since withdrawn), which was adopted in 1997 and came progressively into force from February 2005. Of the countries that ratified the Kyoto Protocol, 37 undertook legally binding emissions reductions of at least 5% below 1990 levels for the first commitment period (2005–2012), with the second commitment period (2013–2020) increasing commitments to at least 18% below 1990 levels (UNFCCC 2012).

concept of Intended Nationally Determined Contributions (INDCs). Under this process, countries openly declared their contributions prior to the conference (a ‘bottom-up’ process).

Irrespective of the *type* of mechanism in a post-Kyoto world, any future success of a global agreement must overcome perceptions of unfairness (real or imagined) as well the ability to account for the rapidly evolving structural changes in the international system that has made UN-styled consensus-based agreement far more difficult to achieve (Leal-Arcas 2011). Some scholars have framed the issue as an ethical dilemma (Baer et al. 2010; Gardiner 2010b; Jamieson 2010; Caney 2010) which has been used to promote the idea that developing nations should bear responsibility since ‘given the historical responsibility for cumulative emissions of GHG in the developed world [and resultant high levels of prosperity], inaction implies a neglect of overall responsibility and ethical considerations’ (Rajendra K. Pachauri quoted in Gardiner 2010a: 7). Others, however, look to future projections and consider the relative decline of developed nations against developing ones and a requirement for structural change in how to address the costs of adaptation and mitigation. Rafael Leal-Arcas has argued that approximately 50 non-Annex I countries now have higher per capita incomes than the poorest of the Annex I countries with Kyoto commitments; 40 non-Annex I countries rank higher on the Human Development Index in 2007 than the lowest ranked Annex I country; and that developing economies are out-performing many industrialised countries who have remained in economic stagnation or recession since the 2007 Financial Crisis (Leal-Arcas 2011). These points are reinforced by the IEA forecast that in the next 25 years the non-Annex I countries will account for 75% of all global emissions (IEA 2011). Fundamentally, shifts occurring in international relations between the major powers have made consensus-based agreement more difficult to achieve:

> In the UN machinery, consensus among the parties is required … The turn today towards a multipolar world indicates that approaches based on consensus are unlikely to produce results. No country, or group of countries, today is in a position to forge a global deal … of environmental goals (Leal-Arcas 2011: 14).

Leal-Arcas then goes to the crux of the issue by pinpointing the enduring nature of state self-interest:

> When negotiating trade agreements, parties have an interest to negotiate as they believe they will benefit from the agreement. By contrast, in climate change negotiations, most parties see mitigation as a burden to their economies, i.e., *they negotiate to ensure that they do not have to do more than other parties in the negotiation* (Leal-Arcas 2011: 43; emphasis added)

Australian political-economist Ross Garnaut has previously likened this situation to a ‘prisoner’s dilemma’, whereby the international community remains split into contending blocs, refusing to cooperate even though (in the medium to long-term) it remains in everyone’s best interest to do so (Garnaut 2008). These insights reinforce what Harriet Bulkeley and Peter Newell have described as the ‘intractable problem’ that climate change presents for global governance (Bulkeley/Newell

2010). These authors note that climate change is a problem of unique complexity, where multiple scales of political decision-making, the fragmented nature and blurred roles of states and non-state actors, and the deeply embedded nature of emissions production and consumption make many aspects of climate change an issue beyond the capacity of traditional governance processes. It is a theme highlighted by other scholars (Knieling/Filho 2013), and in a related manner has been identified as a 'governance trap' in which climate change is simply 'too big a problem' resulting in a situation where 'the governing and the governed seek action from the other but where none is forthcoming' (Newell et al. 2015: 536). Moreover, climate governance continues to remain in a 'state of flux' (Bulkeley/Newell 2010: 108 and 110), with recent assessments noting that a 'resurgence of climate scepticism, and pessimism about the possibility of collective action' has produced a 'crisis of climate politics' (Newell et al. 2015: 536). While COP 21 gave the appearance of assuaging some of these concerns, Garnaut's assessment that climate change remains 'harder than any other issue of high importance that has come before our polity in living memory' remains a potent descriptor (Garnaut 2008: xvii). Underscoring this point was the election of Donald Trump who, on a platform of climate-denial, presents the very real prospect of the US walking away from the Paris agreement and advances in emissions reductions made during the Obama Administration.

The fundamental point to be made for this book is that since the realisation of the problem some forty years ago, the collective global political order has systematically failed in its efforts to reduce emissions and thereby limit global warming and its attendant consequences. The failure of *normal* politics has led some to press the political establishment to adopt a war-footing response: widening the scope and raising the profile and urgency of the issue such that emergency measures may become justified (UNGA 2008; Spratt 2012).

2.6 Chapter Conclusion

Anthropogenic emissions of greenhouse gases since 1750 have been the dominant contributing factor of present-day global warming. Global warming is already wreaking change to the earth's climate systems through increased global surface temperatures, sea-ice and glacial loss, sea level rise, ocean acidification, increased precipitation, extreme weather and a range of other environmental impacts. These changes are projected to take place at increasing rates and intensity across the twenty-first century as global emissions increase. Currently, emissions are tracking on a BAU for a worse-case scenario such that it is highly likely that global average temperatures will exceed 4 °C by 2100 on pre-industrial levels, if not more. International policy response to reduce emissions has been stymied by self-interest. Developing nations, seeking to lift their people out of poverty, have sought access to cheap forms of electricity, predominately supplied through large-scale uptake of fossil fuels. Developed nations, who are responsible for the majority of historical emissions, have had a mixed record in shifting their economies away from fossil fuels. All told, despite the knowledge that rising emissions will cause continued global warming, global political leaders have been unable to stem increasing fossil fuel consumption. Attempts at top-down global agreements via the UNFCCC have so far failed to bring about meaningful reductions in emissions.

What relevance does this conclusion have for this book? First, it identifies climate change as a major—if not *the*—strategic challenge for the twenty-first century. By *strategic* it is meant that there have been no previous challenges on the pervasiveness, penetration or scale presented by climate change. Or, as Shannon O'Lear and Simon Dalby have stated, that climate change and its implications have 'had no obvious analogy in human affairs' (O'Lear/Dalby 2016: 3). Statements from the global scientific community that planetary temperatures may exceed 4 °C by the end of this century are *unprecedented* in civilisational history. This point serves to emphasise not just the scale of the problem but also the relative urgency if humankind is to reverse the trajectory of current emissions pathways. These are important concepts for this book, as it seeks to examine how the US and Australian militaries have approached climate change and to understand whether the two militaries have placed greater or less emphasis on both the scale and urgency of the threat than their political masters.

The second point is that climate change will present (if it is not already doing so) wide-ranging security challenges. In this respect, military forces are not exceptional to debates surrounding climate change. There is sufficient evidence to suggest militaries have a requirement to understand not just current climate impacts but also how future climate change will remake existing socio-political orders. In essence, militaries exist primarily as institutions designed to anticipate and respond to strategic risks that threaten the sovereign interest of their nation-states and the security of peoples living within their jurisdictions. In this respect, greater understanding of how militaries are responding to climate change is an important aspect in gauging whether the militaries are doing too much, just enough, or too little in warning the public and influencing political elite on the importance of the strategic risks of climate change.

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