The IPCC: Forty Years of Great Science in Understanding Climate Change

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EDRC

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Cover Photo: IPCC adoption of the Summary for Policymakers of the Special Report on Global Warming of 1.5°C., at the 48th Session of the IPCC and the First Joint Session of Working Groups I, II and III. Incheon, Republic of Korea, 1-5 October 2018 - Photo by IISD/ENB | Sean Wu, International Institute for Sustainable Development, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons

Abstract

This paper, authored by retired US Army Brigadier General and environmental engineer Dr. Wendell Chris King, argues that climate change represents the primary threat to global peace and security in the modern era. Bridging a 36-year military career with extensive academic expertise, King synthesizes personal insights with nearly 40 years of scientific data generated by the United Nations Intergovernmental Panel on Climate Change (IPCC).

The text examines the history of environmental security and details the evolution of the IPCC's rigorous, risk-based peer-review methodology. By tracking data across six successive Assessment Reports (AR1 through AR6), King demonstrates how scientific confidence has steadily strengthened. Findings that were once conservatively uncertain have matured into the unequivocal conclusion that human activity is the primary driver of global warming. This predictive accuracy is underscored by the fact that the IPCC's 1990 projection of a 1.0°C temperature increase by 2025 closely matches the actual recorded warming of 1.09°C.

The paper systematically analyses critical climate parameters—such as warming, sea level rise, vanishing snow cover, and extreme weather—and maps them against their direct impacts on human stability. King frames climate change as a critical "threat multiplier" that worsens existing geopolitical vulnerabilities. When environmental shifts deny populations basic human needs, they trigger secondary security crises, including famines, resource scarcity, epidemic diseases, mass migrations, and regional conflicts. This dynamic is prominently illustrated by the melting glaciers of the Tibetan Plateau, a vital water source shared by heavily armed, competing nations. Ultimately, King issues an urgent warning against political climate denial, calling for immediate, cooperative global action to implement vital mitigation and adaptation strategies before unpreventable damage overwhelms global security.

The IPCC: Forty Years of Great Science in Understanding Climate Change

Dr. Wendell Chris King, Brigadier General, US Army retired

INTRODUCTION

What you have in front of you is an essay (or OP-ED) that will argue that the biggest threat to security and peace in the world today and in the future is **Climate Change**. It is both a science paper and an essay of personal beliefs formed through my study of the scientific evidence about climate change generated primarily by the United Nations Intergovernmental Panel on Climate Change (IPCC) and supported by many other sources as well.

> *"The biggest threat to security and peace in the world today and in the future is Climate Change."*

The essay evolved from a decision I made to prepare a new seminar to offer to whomever will listen updating my views on climate change and the threats it poses to human security in an already very dangerous world. I am drawn to this effort by what I see as my split personality. I was a career military officer serving 36 years in an Army uniform. That was followed by 10 years as the Academic Dean at the US Army Command and General Staff College, the Army's graduate school for career officers. We can call that part, my Mr. Hyde. My Dr. Jekyll personality comes from multiple advanced degrees in Environmental Engineering and teaching the discipline at the United States Military Academy and several other universities. My scholarly pursuits led me into a research area where the two personalities came back together, strategic environmental security; you will learn what that is shortly, but for now understand that Climate Change (CC) is a scientific subset of environmental security.

The work on the seminar carried me well beyond the point where the story could be told in one or two evening presentations. Also, many people who have attended my lectures before have asked about references and notes that would allow them to conduct their own studies and develop their own views (the hope of every teacher). So, asking your patience, what follows is my humble review and analysis of the more than 35 years of research into climate change produced by a world-wide team of scientists who dedicated themselves to making our world better through applying their expertise to the study of climate change.

THE SCIENTIC HISTORY OF UNDERSTANDING CLIMATE CHANGE

Shortly after, in geological time, the idea that the earth was round was adjusting thinking about our planet, but long before there was the science of meteorology, the great minds of the time past millennia were thinking deeply about why the earth's climate was warm, and overall, how it really functions. In 1824 Joseph Fourier, most noted for his mathematical works, first proposed that the earth's atmosphere worked much like a greenhouse in capturing heat in the atmospheric gases, thus making the planet livable. By 1896 Svante Arrhenius had confirmed Fourier's theory when he developed his equation defining the relationship between atmospheric carbon dioxide levels and temperature; Work that earned him the 1903 Nobel Prize in chemistry. In 1958, Charles David Keeling established a carbon dioxide (CO_2) monitoring station on the top of Mauna Loa volcano in Hawaii which became the primary source of data for tracking the relationship between world CO_2 concentrations and atmospheric temperatures, which as the Arrhenius Equation predicts, CO_2 concentrations are directly proportional to temperatures in the earth's lower atmosphere. The first atmospheric computer model of weather and climate was not developed until 1967.

Two points come to mind from this brief history, 1) We really have not understood much about the chemistry and physics of our climate for very long, 2) It remains quite amazing how really smart people could just think deeply about complex problems, without the aid of the modern scientific tools, and through keen observation unlock the mysteries of our world. Where we stood in the 1980s can be summarized in Figure 1.

The Science and Mathematics of Climate Change

- Climate is the average weather in a place over time; i.e. the temperature, winds, moisture, and pressure averaged by day, season, and annual cycles. Climate is a function of the atmospheric concentrations of gases and particles that determine the thermal energy balance on earth. The gases that adsorb thermal energy emitted from the surface are called greenhouse gases (GHGs). In order of their climate impact they are: carbon dioxide, methane, nitrous oxide, CFCs, and water vapor.
- Climate change (CC) occurs when the current atmospheric variables are outside long-term historical results.
- There are natural variations that occur over long periods that cause CC plus human activities that also produce CC. Mathematically, it looks like:

$$\Delta H \text{ Energy} = GHG_{initial} + GHG_{added} - GHG_{Losses}$$

ΔH is the change in total heat energy in the atmosphere.

Figure 1

THE HISTORY OF CLIMATE CHANGE AS A SECURITY THREAT

Based just on this brief review of the historical development of climate science, it is unsurprising that the study of climate change as a security threat is also a relatively recent scholarly interest. It is nested in an area of study that was titled Environmental Security by its founders. These included distinguished scholars such as Norman Myers at Oxford, Marc Levy at Princeton, and Thomas Homer-Dixon at the University of Toronto. A great summation of these early works came in an article published in 1986 by Norman Myers in the **Environmentalist** when he summarized the concept in stating,

"*Hence national security is not just about fighting forces and weaponry. It relates to watersheds, croplands, forests, genetic resources, climate and other factors that rarely figure in the minds of military experts and political leaders, but increasingly deserve, in their collectivity to rank alongside military approaches as crucial to a nation's security*[1]."

In examining the application of environmental security theory within US defense strategic studies I defined environmental security as,

"Environmental degradation and resource scarcity are of such a magnitude that they can become, if they are not already, an issue of national security for the United States.[2]

By the 1990s the US Department of Defense had developed a position of Deputy Undersecretary of Defense for Environmental Security. A number of institutions and researchers were evaluating environmental issues such as water as a scarce resource, loss of arable lands, desertification, and other changes in the environment for their ability to threaten stability and security. In 2007, eleven 3 and four 4-star US General Officers from all services joined together to produce a seminal analysis of **National Security and the Threat of Climate Change**[3]**.** Led by former Chief of Staff of the Army Gordon Sullivan, this report concluded that climate change is a severe threat to US National Security and **must be** considered in our National Security Strategy. (as you will see later, this report was issued at the time that the 4th Assessment Report was published by the IPCC.

Putting it bluntly, since that time it has been a swift downhill slide for environmental security within the strategic thinking of the US military. After appearing in several issues of the National Defense Strategy in the 1990s and 2000s, the current version of this primary official defense guidance document from the President makes no mention of climate change or any other environmental security threat as a security risk to the United States. We reached a free fall state as President Trump continues to proclaim climate change is a hoax promulgated by his political enemies. Executive orders have been used to destroy much of 30 years of progress in developing renewable energy sources and reducing air pollution. As I am writing today, it was announced that EPA was rescinding the notice of endangerment it issued in 2009 which was the basis for regulation of CO_2 emissions. This action was taken even though this rule had been reviewed and approved by the US Supreme Court at the time it was published.

INTRODUCTION TO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

Created in 1988 jointly by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), "the objective of the Intergovernmental Panel on Climate Change (IPCC) is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations."[4] This body rapidly grew to including 195 member nations participating in efforts to advance the body of knowledge of how the earth's climate functions and if there is actually climate change being caused by human activity today. The first scientific report issued by the IPCC came in 1990[5]. By 2023 the IPCC had issued its 6th Assessment Report (AR6)[6]. In addition to its 6 major reports the IPCC has issued a number of special reports to provide emphasis to major findings and critical concerns discovered in their research. An example of the value of these special reports is seen in the 2018 report, "Understanding Global Warming of 1.5°C", which described the criticality of limiting global temperature rise to 1.5°C.[7]

The IPCC as a body does not conduct primary climate research. It functions by collecting research findings from scientists throughout the world which are then evaluated through a rigorous peer review process. The IPCC does guide the focus of research efforts in identifying gaps in knowledge needed to better understand climate change. The IPCC process has evolved and grown in capability throughout its history. It applies a risk-based approach to evaluating data and developing recommendations. An explanation of the process as it now exists with the 6 assessment reports follows shortly. All findings are reported with calculated confidence measures derived from the strength of the available evidence. Considering that more than 2,000 of the world's experts participate in the IPCC process, their reports are some of the best reviewed science ever seen.

> *"Over 2,000 respected scientists from almost every country in the world have worked cooperatively together for 38 plus years… It is dangerously sad and a major failing for all humanity that their great good work has not been applied by governments with the same spirit of cooperation."*

The primary purpose of this paper is to examine the growth of climate change knowledge over the IPCC's six major scientific reports. My bottom line up front is—Because of the superb efforts of the IPCC, we now know much more about how our climate and weather functions than we did in 1988. We are now able to make sound conclusions defining the impacts of climate change and recommendations for actions to mitigate and adapt for the protection of the whole world. This will be clear when you see the high degree of confidence the 6th Assessment Report attributes to its findings and

conclusions. The last idea I hope the reader will take away from this introduction to the IPCC is a recognition that the IPCC process itself is a major good news story at a world scale. Over 2,000 respected scientists from almost every country in the world have worked cooperatively together for 38 plus years. They have been able to reach strong consensus on critical issues unbounded by political or governmental constraints to this cooperation. It is dangerously sad and a major failing for all humanity that their great good work has not been applied by governments with the same spirit of cooperation.

THE IPCC METHODOLOGY

Every scientific discipline employs journals, scientific meetings, and technical publications to announce and share findings that advance the body of knowledge in their discipline. The Peer Review Process for scientific acceptance of any new finding could be viewed as a large group of highly educated pessimists who are dedicated to proving the author(s) results are wrong. Only the best science passes the gauntlet of peer review. Climate denying organizations primarily funded by oil and coal companies continue to claim that IPCC scientists are in cahoots to rig the data, and human caused climate change is a hoax. Scientists just don't work that way and certainly that 2,000 scientists from 195 countries could never be convinced to agree on anything without the evidence being so powerful it is unequivocal. The confidence measures reported herein have improved greatly over the lifespan of the IPCC. The data herein will demonstrate that is a fact. A major conclusion of this essay is that the IPCC is the primary reason we have a much deeper understanding of climate change than when the IPCC began in 1988. The good science produced by the IPCC over its 38 years of inquiry now allows us to make critical decisions on what we MUST do to address the dire threats we face from climate change.

Critical to understanding the power of the IPCC is understanding how the confidence levels are developed. Figures 2 and 3 depict the basic process used to peer review each study that the IPCC evaluates, and each finding/ recommendation that goes into the reports.

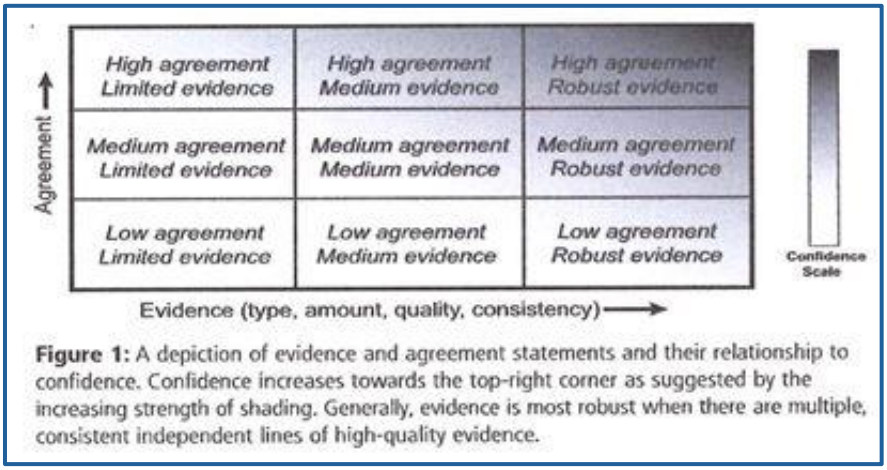


Figure 1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

Figure 2 – Source: IPCC, Guidance Note for Authors of AR5, July 2010

Table 1. Likelihood Scale	
Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

* Additional terms that were used in limited circumstances in the AR4 (*extremely likely* – 95-100% probability, *more likely than not* – >50-100% probability, and *extremely unlikely* – 0-5% probability) may also be used in the AR5 when appropriate.

Figure 3 – Source: IPCC, Guidance Note for Authors of AR5, July 2010

Applying these two figures begins with compilation of all reports that address a specific finding (rate of sea level rise as an example). As indicated in Figure 2, the more evidence that addresses a topic and the higher the agreement among those sources yields a high confidence/ probability that the finding can be trusted. A lack of supporting data, but strong agreement from limited research creates less confidence. It is important to understand that this approach is critical to appreciate the value of the IPCC process over time. It is the confirmation that comes from additional follow-on work that develops the confidence needed to become a finding for an IPCC report. This paper follows the history of the six ARs to evaluate the power of the methodology. Findings were presented in the early reports, but with lower confidence because of a lack of supporting research. One example from the 6 reports helps make this clearer. In the second report (AR2), one finding stated, 'human impact in climate change is discernible', that was 1995. By the time of the sixth report, 2023, the follow-on research has confirmed that, **unequivocally**, human activity is causing climate change and drives most of global warming. Nearly all rational scientists believed this was true in 1995, but the IPCC required further supporting scientific evidence to earn an unequivocal confidence rating. This demonstrates the power of the methodology to produce critical findings that are reliable. **Unequivocal applies only to findings that are 100% certain.**

The methodology of the IPCC continued to evolve over the period of the six primary reports. Early in development process the format of the assessment reports became one of three separate sub-reports, each managed by a separate working group. The documents were organized as:

Working Group I – The Physical Science Basis

Working Group II – Approaches to Climate Change Mitigation

Working Group III -Observed Impacts, Vulnerability, and Adaptation

The reporting process begins with the issuance of the Physical Science Basis. The findings of the science report become the starting point for Groups II and III to conduct their work. These two reports come sometime later in the final reporting process. A critically helpful part of the IPCC methodology is that each working group produces a separate document titled "Summary for Policymakers" (SPM). This is very important to the utility of each report. Consider, a typical Working Group I report is thousands of pages. Working Groups II and III are not that size, but still hundreds of pages. The sheer volume of the report would overwhelm most senior decision makers. Further, these reports are drafted by scientists to share research among experts. Lay readers would struggle to gain the full importance of these highly technical full reports without the summary document. The SPMs boil the complex details of the science into useable findings and recommendations typically in 30 to 50 pages including graphics designed for non-science policy leaders.

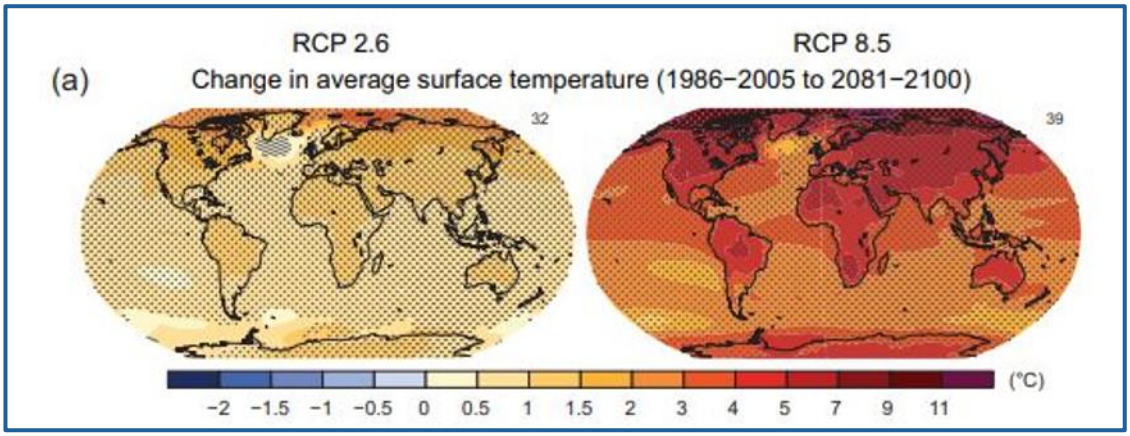
It is critically important to recognize as we start discussing the IPCC research results that the **unknown** (independent) **variable** in predicting our climate future is knowing the mass of greenhouse gases (GHGs) that will be discharged in the future. You can understand the enormity of the problem we face just from looking at the units of this variable. GHGs emissions are measured in millions of tons per year being added to the existing concentrations retained by the atmosphere. How many billion tons more will be dumped into the atmosphere is a decision that humans will make based on set complex social, economic, and ecological factors! It will be the political will which will finally determine our future. Since the 1850s humans have continued to dramatically increase the annual discharge of GHGs into the atmosphere. These gases (see Table 1) led by carbon dioxide generated in energy production have long life spans in the atmosphere. There are natural sinks which through physical and chemical processes take GHGs out of the atmosphere, but not at rates close to what we add annually. (see Figure 1).

CHEMICAL	LIFESPAN yr	GW 100 yr	MASS /YR tgrams	CC% IMPACT
CO_2	50-200	1	26000	61
CH_4	10	21	300	15
N_2O	150	290	6	4
CFC	130	na	.8	11
HCFC	na	1500	.2	.5
Others	varies	varies	varies	8.5

Table 1- Primary Greenhouse Gases- Physical Data - Source- AR1- IPCC, 1990

Current estimates show just over 50% of GHG emissions are being removed. This leads to the major conundrum in climate science, how to estimate future climate changes when we do not know how much GHG will be discharged in the future? The approach developed by the IPCC team is to analyze the futures for a grouping of emission levels. Typically, 5 levels are used that bracket the discharge rate at the time of the report. The median of the 5 levels is business as usual for the specific AR publication date. The highest two levels apply historic rates of increase for GHG emissions to estimate worst case scenarios. The lowest level is a calculated reduction in the discharges to reach an acceptable equilibrium temperature level in the future. For example, the number of gigatons of carbon equivalent ($GtCO_2$ eq) of GHGs that would allow the temperature to stabilize at 1.5 °C by 2050. This allows the IPCC reports to analyze the mitigations and adaptations across the range of futures. Figure 4 demonstrates the strength of this approach in analyzing climate change futures. It shows the impacts on temperature for GHG emissions at best and worst case scenarios.

In summary of the IPCC process, it is completely appropriate to conclude that without the IPCC we would not have advanced climate science to where it is today. The magnitude of the threats hypothesized at the start of the IPCC brought the necessary resources to the research studies needed. The remainder of this report highlights what we have learned from the IPCC about our climate and its rapid changes in recent history, and what we can expect for our future, if we have one.



Source – IPCC WGI AR5, SPM, 2013 Note: RCP = giga tons CO_2 equivalents

Figure 4 -Predicted Temperatures for Best and Worst Case GHG Emissions

MAJOR FINDINGS AND CONCLUSIONS FROM 40 YEARS OF IPCC RESEARCH

The story of climate change over the past 40 years has three interrelated goals: 1) what have been the actual measured changes in climate and can we develop models that effectively predict future changes, 2) how do those changes impact human security now and finally, 3) with, as will be shown, the IPCC assessment process proving to be predictive across a range of GHG emissions, what are the possible futures that will sustain human security through implementation of recommended mitigation and adaptation strategies? **Our future will be determined by the way the world manages the emission and buildup of GHGs going forward**. As shown in Table 1, the IPCC efforts have identified that past emissions will persist in the atmosphere for long periods producing unpreventable damage. These are the sunk costs of climate change today. Now we must find ways to limit future emissions or suffer a disaster of our own making through overwhelming the natural climate system with billions of tons more GHGs every year. The most impactful of these gases are carbon dioxide and methane. Though not as toxic or persistent as others, the IPCC work has shown *unequivocally* that the mass of these two gases discharged annually is the driving force of all climate change. Both these gases have natural sources, but the sources for the vast volume of annual discharges for both are anthropogenic.

The best way to appreciate the power of the IPCC process is to follow the major findings as they developed over time. Table 2 is a summary of all 6 of the assessment reports published by the IPCC. There are many metrics of how our climate is changing. In Table 2, this review will follow only those climate parameters which have been identified as having major and lasting impact on human and environmental security. Those are the first 7 parameters in the left-hand column of Table 2, beginning with WARMING. The last two parameters in Column 1, Table 2, are metrics for specific questions fundamental to the purpose of the IPCC. The parameter **Natural Sinks for**

GHGs follows how the IPCC advanced our scientific understanding of the natural system's ability to remove GHGs from the atmosphere as GHG concentrations continued to increase. As the IPCC began its work, the general concepts of the sinks that impacted GHG concentration in the atmosphere were generally understood but not quantifiable. There was certainly no understanding how their effects would change as the land and oceans warmed, and the GHGs concentrations increased. We understood elements of the carbon dioxide cycle in our ecosystem, but the fate of carbon dioxide at much higher atmospheric concentrations and higher temperatures was unknown. For methane, one gigantic question still exists. The major anthropogenic source of methane is currently food production. We also must recognize that huge quantities of methane are sequestered in frozen soils in the Arctic, which are melting at the high rates with the warming in the polar regions[8]. (See Figure 4) The IPCC data shows that the poles are warming at the fastest rates on earth, already exceeding several degrees centigrade above their historic levels dating back hundreds of thousands of years[9].

"The IPCC data shows that the poles are warming at the fastest rates on earth, already exceeding several degrees centigrade above their historic levels dating back hundreds of thousands of years."

The last climate change impact in Column 1 of Table 2 follows the growth of our understanding the most contentious issue of the climate change debate- **what part of climate change today is caused by natural processes and what part is a result of human activities**? The IPCC began with a scientific certainty that the climate has always changed over time, but historically change occurred over long periods of time, thousands of years for large shifts. The work of the IPCC has yielded an *unequivocal* solution to this question- Nearly all of warming measured over the last 150 years has been caused by human activity. This is seen clearly when you examine the last row of Table 2. Over the history of the IPCC, carbon dioxide has grown from 353 ppm to 430 ppm in 2025. In that time the earth has warmed by 1.09 °C with 1.07 °C unquestionably attributable to human activity. All credible research confirms the natural processes have NOT caused this rate or magnitude of change.

Table 2 - SUMMARY OF IPCC ASSESSMENT REPORTS

CLIMATE CHANGE IMPACT	**AR1** 1990	**AR2** 1995	**AR3** 2001	**AR4** 2005	**AR5** 2013	**AR6** 2021
Warming (°C)	0.3/ 10yr (N) 1. by 2025	.3 to.6 (N)	0.6 (VL)	0.72 (U)	0.85 (U)	1.09 (U) actual
Sea Level Rise (CM)	6/10yr 15-25 by 2025 (N)	50 by 2100 (N)	1-2 mm/yr (VL)	3.1 mm/yr (U)	.19M by 2010 (VL)	3.7mm/yr .2M Human caused
Precipitation (%)	NA	NA	5-10 % increase (VL)	Increasing (N)	More in North H (VL)	Increase from 1950 (VC)
Snow and Ice Cover % losses	NA	33-50% loss by 2100	40% lost in last 10 yrs (VL)	(U)	3.5%/yr (VL)	Losses increasing Arctic clear 2050
Extreme Weather	NA	Increasing (N)	Increasing (N)	Increasing (VL)	Increasing (VC)	(VC)
Droughts and drying Frequency and intensity	NA	Increasing (N)	Increasing (VL)	Both increasing (VL)	VC	VC
Flooding Frequency and intensity	NA	Increasing (N)	More intensity (VL)	Both increasing (VL)	(VL)	VC
Natural Sinks for GHGs	unknown	Weak understanding	NA	NA	Not quantified	Drop from 68% to 38% removals.
Anthropogenic Caused Change CO_2=ppm	Uncertain CO_2= 353	Measurable (N) CO_2= 360	Causing CC (VC) CO_2= 368	Majority human CO_2= 379	Human caused (U) CO_2=391	1.07 of 1.09 °C caused by human activity CO_2=430

Confidence Ratings --– (U) = Unequivocal (VC) = Virtually Certain (VL) = Very Likely (N) = Likely as not (UN) = Unlikely (NA) Not covered

Examining each row in Table 2 offers us a good picture of what the IPCC has added to our understanding of the earth's climate processes. Warming has continued throughout the study period. This is not a surprising finding in that Arrhenius received the Nobel Prize for quantifying the relationship between carbon dioxide concentration and temperature in 1903. Sea level rise has two components, 1) warming water expands the volume of a mass of water, and 2) ice and snow melting off the land masses because of warming adds to volume in the oceans. The rates that these occur had not been well studied before the IPCC. The initial IPCC reports were therefore conservatively uncertain in the beginning. The AR6 report found with *high confidence* that the rate of sea level rise was higher than initially predicted by the IPCC and that most of this rise was human caused. This was the largest deviation I found across the 6 reports and in this case the situation was worse than initially reported by the IPCC.

The changes in precipitation frequency and magnitude are much more complex to describe because they are heavily geographically dependent. Simple thermodynamics confirms that when more heat energy goes into the atmosphere there will be an increase in evaporation. As the IPCC process progressed, more and more clarity was added to our understanding. By AR6 the IPCC was able with *virtual certainty* predict climate change would increase the amount and intensity of precipitation for many areas of the world. Data now confirms that the temporal distribution of rainfall is being altered by warming. This then enhanced our ability to predict droughts and flooding would become likely because of climate change.

CONCLUSIONS

In summary of the science of the IPCC, the only evidence-based conclusion that any reasonable person can reach is the, **the IPCC process has been a tremendous success.** It has answered the most critical questions needed to identify the causes of climate change, particularly focused on the last 180 years. It has provided the tools needed to assess climate change futures based on different scenarios of GHGs emissions. The best way I can think of to demonstrate this point is to go back to Table 2. Let's focus on the first data point for AR1 and then the last data under AR6. We recall there was significant uncertainty as this process started. In AR1 the IPCC concluded that global warming would reach 1 °C by 2025, an estimate 35 years ahead. It rated confidence in this conclusion as *likely as not*. Now move to the last data entry under AR6. The actual warming in 2025 was 1.09 °C. So how well did the IPCC meet its mission? *Unequivocally*, the IPCC now provides the science needed to address climate change as a threat to human security. It has provided a process to apply this science to the range of possible outcomes based on a reasonable range of future GHG emissions. This process gives a science-based approach to measure impacts, examine

alternative solutions to mitigate and adapt to climate change. Unfortunately, the IPCC also identified the unavoidable consequences we must live with from the GHGs already added to the atmosphere and which will persist for years to hundreds of years in the future.

Today, I am certain the single most important aspect of the climate change debate is creating the will to act on a global scale to save ourselves from the worst consequences of climate change. Well financed corporations campaign to deny, delay, and discredit any efforts to boldly step forward with action to save ourselves. In my judgment, the worst example of this has been the current United States government which now, in the face of overwhelming science, continues to deny climate change is real. It boldly runs away from the fight by reversing all US regulatory efforts to reduce GHG emissions implemented for at least the last 20 years.

In my introduction I included a brief explanation of my personal focus on environmental security and its relationship with climate change. Now that we see through our examination of the good work of the IPCC data confirming the major climate changes that are occurring, I want to close by focusing on how climate change adversely affects human security. (I know I should also include how climate change helps human security: it doesn't, at all.) Moving on, it has been my research hypothesis that any environmental changes that deny people their basic human needs create insecurity which leads to many bad results--including death, mass migrations, epidemic disease, famines, conflicts over scarce resources, and even war. Table 3 presents one way of looking at the cause/effect relationship between climate change and human security. A good way to think about Table 3 is to consider what you have observed in our world today. The science of the IPCC has shown that many of the disasters occurring around the world recently find roots in climate change. Like most things in earth science climate change never acts alone, but it is its interactions with the other laws of nature all intertwined with human activity which define the final impacts of climate change. Stated another way, climate change may not always directly cause harm, but can become the straw that broke the camel's back in this dangerous, overcrowded world we live in. Military strategists refer to issues like this as "Threat Multipliers."

"Climate change may not always directly cause harm, but can become the straw that broke the camel's back in this dangerous, overcrowded world we live in. Military strategists refer to issues like this as 'Threat Multipliers.'"

Table 3 - Key Impacts and Security Implications of Climate Change

Climate Driver	Key Impacts	Security and Defense Threats
Warming 1.09 °C in 2025 Higher at the poles	Increased water demand, excess drying, loss of arable land, food production reduced overall	Famines, water losses, disease from dirty water, migrations, conflict over food and water. Humanitarian disaster responses
Sea Level Rise 0,2 Meters by 2021 from human activity	Loss of land, islands lost, massive infrastructure damage, damage to fresh water	Small island nations lost, never seen numbers of mass migration of coastal populations with no return, increased disease in lowlands.
Precipitation (%) More in the higher latitudes and near equator. Drier in mid-latitudes where most people live.	Stresses water resources for all human uses. Sanitation and disease threats from poor water quality	Threats to basic needs for food and water for large populations, particularly in developing nations. Competition for scarce resources and mass migrations stress weaker nations.
Snow and Ice Cover 40% lost in last 10 yrs (VL) Arctic clear by 2050 3.5%/year	Major source of water for more than half the world. Floods in Spring droughts in the summer across the world	Threats to ½ world's population in the Tibetan Plateau region, critical for conflicts in the Mideast with Tigris and Euphrates Rivers, western US.
Extreme Weather; Predicted to increase in mid-latitudes and wet tropics	Loss of life, property damage	Military support to humanitarian operations increases greatly, disease follows disasters, massive logistics demands
Droughts and drying Frequency and intensity will increase with warming	Food security and water resources stressed	Disease, mass migrations, regional conflicts
Flooding Frequency and intensity will increase with more energy in the system	Loss of life, permanent displacement of large populations	Disease, mass migrations, regional conflicts

China is now the largest emitter of GHGs in the world and continues to annually increase its emissions. India also is challenged to respond to its growing energy demand which is driven by the world's largest population. I often use the Tibetan Plateau as an environmental security worst case example. Climate change is drastically impacting water resources for this region as ice and snow melt continues to accelerate losses driven by global warming. Nearly half the world lives in this region. Three of the countries possess nuclear weapons and 6 of the 15 largest militaries in the world are in the region- wonder why? They all depend on the 7 major rivers of the Tibetan Plateau for survival. This same analysis can be seen in many other areas around the world. Climate Change and environmental security are both real; they present National Security threats to all nations. The IPCC's work has also shown that the nations least able to defend themselves are often the most at risk. Dealing with CC is a world war and a long war because of the persistence of GHGs in the atmosphere. It is a war where we all win or we all lose.

"Dealing with CC is a world war and a long war because of the persistence of GHGs in the atmosphere. It is a war where we all win or we all lose."

From a global security standpoint, this author concluded that a world scale nuclear war may be a better alternative future for the world than the path we continue to follow in our unabated discharge of GHGs. I admit this is not a well-researched judgement; I leave it for your final consideration.

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Note: All IPCC Assessment Reports are available on the IPCC Website: https://www.ipcc.ch/reports/

About the Author

Brigadier General Wendell Christopher King (Ret.) (1949) Dr. King holds a BS in Chemical Engineering and a Masters and Ph.D. in Environmental Engineering. He is a licensed professional engineer and Life Diplomat of the American Academy of Environmental Engineers. He received an honorary Doctorate from Kansas State University for his lifetime of service to higher education.

After numerous environmental engineering assignments with the U.S. Army domestically and in Europe, he was deployed in 1991 as the Officer in Charge of the Southwest Asia Health Risk Assessment Team to determine health risks to US troops exposed to the smoke from the Kuwait oil fires and to support the war restoration of Kuwait. For this work he received the American Academy of Environmental Engineering Honor Award.

In 1994, Dr King was assigned to the Army Chief of Staff's crisis action team for the Rwanda relief mission as the medical operations planner and assigned to the deploying headquarters for Operation Support Hope assisting in the humanitarian and relief work for the refugees in Rwanda and its neighbouring countries. In 1998, then Colonel King was appointed Professor and Head of the Department of Geography and Environmental Engineering at the United States Military Academy, West Point NY. In 2005 he helped develop the new Afghanistan Military Army. As a specialist in hazardous waste management, he advises NATO on the clean-up of military hazardous wastes and the restoration of closed military facilities in East Europe. Dr King has authored numerous articles, reports and two books, the most recent being "Understanding International Security: A Strategic Military Perspective".

Dr King retired in 2006 after 32 years of active service at the rank of Brigadier General, having received the Distinguished Service Medal as his highest military award.

From 2006 to 2016 Dr King served as Dean and Chief Academic Officer for the Unites States Army's Command and General Staff College. The College has a 125-year tradition of educating military officers on national security and the art of war. Dr King directed a college faculty of over 400 people organised into five separate schools, all with the mission of developing army leaders for service to the nation. Officers from more than 125 nations have attended CGSC.

Other publications by the author of more than 50:

"Strategic Defense Impacts of Climate Change: An Interagency Challenge"
In InterAgency Journal, Vol. 9 No. 4 – 2018, pp 14-25
https://thesimonscenter.org/wp-content/uploads/2018/11/IAJ-9-4-2018-pg14-25.pdf

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The **Global Military Advisory Council (GMACCC**) - launched in 2009 by the Institute for Environmental Security (IES) – is a network of serving and retired military officers, other climate and security experts, and associated institutions, committed to highlighting the potential security implications of a changing climate.

The Council consists of 40 **Individual Members** from 20 countries in Asia, Europe, North America, Oceania and South America and 9 **Partner Organisations**:

- **American Security Project (ASP)**
- **Bangladesh Institute for Peace and Security Studies (BIPSS)**
- **Climate Security Association of Canada (CSAC) / Association canadienne sur la sécurité climatique (ACSC)**
- **Environment & Development Resource Centre (EDRC)**
- **European Climate Foundation (ECF)**
- **Institute for Environmental Security (IES)**
- **Institute for Planetary Security (IPS)**
- **Institute for Governance & Sustainable Development (IGSD)**
- **The Hague Roundtable on Climate & Security**

Website: **https://www.gmaccc.org/**

The **Environment & Development Resource Centre (EDRC)** – founded in 1988 - serves as a catalyst for new initiatives to redress shortcomings in the international environment, development and peace policymaking processes. The Centre acts as an independent 'honest broker,' commissioning and carrying out innovative studies and promoting cooperation between environment, development, and peace movements, between researchers and activists, and between civil society and policymakers.

EDRC coordinates the following projects and networks:

- **Brussels Dialogue on Climate Diplomacy (BDCD)**
- **Climate and Security Action Network (CASAN)**
- **Global Military Advisory Council on Climate Change (GMACCC)**
- **North-Atlantic Civil-Society Working-Group on Environment and Security (NCWES)**
- **Project on Climate and Security Action through Civil-Military Cooperation in Climate-Related Emergencies (Project CASA)**

Website: **https://www.edrc.net/**

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"US Army Brigadier General (Retired) Dr. Chris King offers a combined practitioner and scholarly perspective on climate change and environmental security. His insights are particularly salient at a time when grounded, experiential understanding must inform meaningful and effective action."

- Dr. Lloyd Chubbs, Retired Environmental Engineer, Canadian Armed Forces

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"As a military professional trained to counter uncertainties with facts and contingency planning, Brigadier General King highlights the indisputable scientific conclusions of IPCC to urge climate change action to prevent human conflict. His stark warning that a nuclear winter may well be preferable to the path we are following is a thought that is much too sobering, especially for those of us who are dependent on the Tibetan Plateau. Dr. King is preparing us for a future many of us will not live to see, but one we can avert by changing how we live today."

- Lieutenant General Tariq Waseem Ghazi (Ret.), Former Defence Secretary of Pakistan (2005-2007)

"Brigadier General Dr. Chris King provides a sweeping analysis of the rigor and import of IPCC findings over the last four decades. As he expertly shows, the cooperative scientific work led by the IPCC has produced unprecedented, actionable data on the impacts of climate change and viable paths to address them. Cautioning that our response will determine our collective future, he underscores the clear imperative stemming from the IPCC findings. Written for scientific and policy communities alike, the piece is a must read for students and practitioners in the fields of climate and environmental security."

- Dr. Ashley Moran, Co-Director, Center for Law and Democracy, University of Texas at Austin

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"BG Dr King's central thesis is that the unequivocal scientific data made available by the IPCC, identifies Climate Change as the defining threat to human security in our time. He courageously warns that to ignore or to be dismissive of this threat, is to contribute to the demise of global security. He valiantly advocates that our collective efforts should be devoted to countering the vulnerabilities to Climate Change".

-Major General Joseph G. Singh, (Ret.), Former Chief of Staff of the Guyana Defence Force (1990-2000)

"US Army Brigadier General (Ret) Dr. Chris King presents a powerful reflection on the role of climate change in national security, tracing the role of the IPCC process through all six assessments. He's a man to listen to."

- **Durwood Zaelke, President, Institute for Governance and Sustainable Development**

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