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PERSPECTIVE ON A TIMELY POLICY ISSUE

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Wargaming Climate Change

A Structure for Incorporating Physical and Social Effects into Strategic Military Planning

Defense strategists and planners increasingly contend with the need to plan for a changing climate, understanding the direct and indirect demands that this places on militaries, and how the changing climate will affect their ability to conduct operations. This necessitates understanding how to integrate information about climate change and its impacts—amply available from the United Nations' Intergovernmental Panel on Climate Change (IPCC) and elsewhere as described later in this paper—into processes and outputs.[1]

However, the defense community—not uniquely, but perhaps acutely—faces barriers to doing so. Despite increasingly urgent reports about warming global temperatures and an array of documented and potential adverse effects as documented by the IPCC and the U.S. National Climate Assessment (among the rich body of literature fed by scientific and traditional knowledge),[2] climate change has been perceived by many as a slow-burning issue and thus can be difficult to prioritize alongside threats and hazards that are viewed as more immediate, such as an adversary's growing offensive capabilities or the vulnerabilities of communications infra-

structure. The uncertainty associated with climate change projections—and the fact that this issue has been politicized at times—has also made it difficult for strategists and planners to explore and assess links between this longer-range phenomenon and the immediate concerns that have historically been given greater priority. Navigating a vast array of climate change–related datasets, derivative products, and literature makes it challenging for stakeholders to parse which data or sources to use.

Wargames offer one familiar avenue for working through complex issues and contending with such barriers as those illuminated previously, even in dealing with imperfect or varied information. Although the shorter-term focus of the wargames is at odds with the longer time horizon for understanding climate change implications, strategic foresight work in the past five years has used games to analyze issues perceived as longer term, and thus there are proofs of concept for this kind of application.[3] Whereas climate change is beginning to be acknowledged in some U.S. Department of Defense (DoD) wargames, it is less frequently incorporated in concrete, data-driven ways.[4]

This paper presents a structure as a starting point for incorporating climate change information into wargaming in different ways to engage the gaming and climate communities, as well as the policymakers who use insights from these games. These insights are based on our experiences developing and facilitating a series of Wargaming Incentive Fund–supported games and thus do not provide the depth of findings or any recommendations that a research effort focused solely on understanding climate data needs for wargames would be able to provide.

Why Is Gaming Well Suited for Examining Climate Change?

Globally, many militaries do not appear to be actively planning for climate change (or at all), but there are increasing calls to review policies and plans that previously left military greenhouse gas emissions out of the equation.[5] For example, the leadership in DoD has issued strategies and guidance that necessitate greater focus on climate change in future planning.[6]

Gaming can both assist the defense community in understanding (1) the various facets of climate change and (2) the data and information used to characterize it, and help play out possible implications. Games are a versatile tool for exploring the implications of different sources of uncertainty and what-ifs in addition to exploring solutions for adapting to and mitigating consequences through changes across the Doctrine, Organization, Training, Materiel, Logistics, Personnel, Facilities, and Policy (DOTMLPF-P) spectrum. Games can also allow players to weigh the potential consequences of immediate issues versus long-term ones and consider the combined effects of such factors as climate change, geopolitics, economics, and demographics. DoD has taken initial steps to wargame climate change; for example, through the Elliptic Thunder wargame, which took place in March 2021 and focused primarily on issues associated with extreme weather events that could be driven by a changing climate in East Africa.[7]

Wargames can illuminate new questions that need addressing and novel approaches and can complement other existing analysis and planning efforts. Some priorities for using wargaming to study the implications of climate change for the defense community can include

the following applications beyond studying the immediate effects of weather-driven disasters:

- continuing efforts to develop climate literacy, including understanding the inherent uncertainties that climate change introduces
- enabling strategic foresight exercises that identify emerging operational areas (e.g., at the poles) and mission types (e.g., support to climate change mitigation measures)
- exploring how changing weather phenomena could necessitate new tactics, techniques, and procedures alongside accompanying DOTMLPF-P adjustments to facilitate new ways of operating
- developing concepts for what net-zero warfare might entail and how to operationalize broad-scale energy transition
- complementing the analysis of installation risk to climate change by gauging broader mission impacts of climate-related hazards
- using games as opportunities to learn from and communicate with partners (interagency and international).

Figure 1 summarizes some applications of wargames as an illustration of the purposes for which they can be used to explore a complex issue, such as climate change. Here, we discuss these applications in a climate change and defense context, noting that games can also be useful analytic tools in other contexts, though not all.[8]

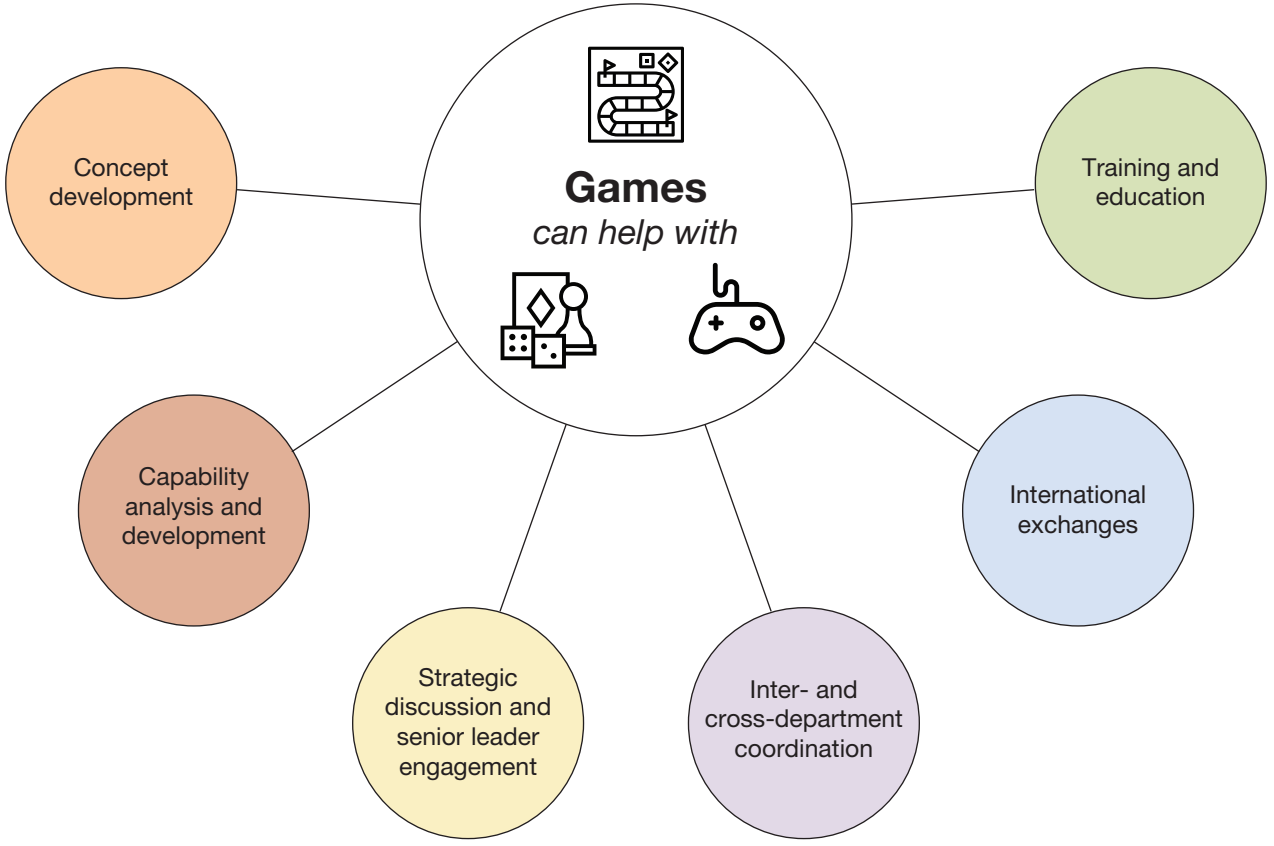
Concept development games can explore how and why militaries might have to adapt missions, areas of responsibility, and ways of operating. Examples of concept development games include those that study approaches for (1) establishing new operating patterns to avoid and respond to accidents given shifting maritime commerce patterns and widely expanded offshore wind facilities, (2) operating at greater capacities near the poles or areas surrounding the equator where violence could intensify with more heat, (3) ensuring personnel readiness for extreme heat, and (4) reshaping ports and other coastal infrastructure to manage the effects of sea level rise.

Games can also be used as early stress tests for the adaptation and development of new capabilities and tactics that would be employed under different or even totally novel conditions generated by or through a changing climate. This includes the examination of expanded humanitarian assistance and disaster response logistics and mechanisms for employing renewable energy sources. Similarly, training and other forms of education can be facilitated through games, illustrating new concepts, capabilities, and tactics that personnel may encounter, such as operating at night instead of during the day to take advantage of relatively cooler temperatures and responding to extreme weather driven energy interruptions. To date, many of DoD's games involving climate change have been related to education and knowledge-sharing.[9]

The other three gaming applications highlighted in Figure 1 primarily have to do with communication. Games can be used to explain findings about climate change impacts to senior decisionmakers through an executive summary or outbriefing following the completion of a wargame, highlighting areas of the world where climate change may amplify social unrest and resource scarcity. Government departments, agencies, offices, and their respective stakeholders can experience impacts from climate change differently, leading to varied solution sets. Gaming offers an opportunity to see where coordination

FIGURE 1

Example Gaming Applications Relevant to Climate Change Planning



NOTE: Derived from Tingstad, Wong, and Savitz, *How Can the Coast Guard Use Gaming?*

for climate change adaptation and perhaps even mitigation might be mutually beneficial. For example, coordination is required to integrate renewable energy sources into mobility options. Finally, climate change presents an opportunity to engage with and learn from international partners, which is especially important because of the global nature of the problem set. A good example of this is the cooperation with Canadian and Nordic partners that has raised awareness about changes in the Arctic.

Regardless of game purpose, the ability to explore the uncertainties that arise from climate change through a wargame is valuable for the defense community. The inherent nature of (1) gameplay that emphasizes interaction with both information and humans and (2) the familiarity of wargames within the community create favorable conditions for looking at climate change–induced uncertainty through multiples lenses and in varied decisionmaking contexts.

Games complement other forms of analysis that can support the defense community in climate change planning. Although games are helpful in understanding the implications of various dimensions of climate change, they are less fit for doing impact assessments or specifying engineering requirements for adaptation measures, as examples. For these latter examples and others, access to climate data and modeling and simulation is needed.

We discuss some of these more quantitatively based approaches in the next section because these can also provide useful inputs to games. We wouldn't use games to assess the quantitative degree of climate change—which is far more suited to computer models—but these models can provide useful inputs to game assumptions. Furthermore, surveys and interviews might also be more appropriate than games when seeking to understand climate change understanding and impacts at the individual level. We would not necessarily use games to determine individual mental health impacts associated with disasters.

TABLE 1
Broad Types of Climate Information

Record Type	Selected Data Sources	Example Data Access Points
Quantitative, computer projections	• Global climate models • Regional and local downscaled data • Impact models driven by global climate model data	• U.S. National Oceanographic and Atmospheric Administration (NOAA) • Localized Constructed Analogs statistical downscaling • Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) archive
Instrumental	• Civilian weather stations • Military weather stations • Flux towers	• Weather.gov • 14th Weather Squadron • FLUXNET
Paleoclimatological	• Tree rings • Lake sediments • Ice cores	• NOAA • Academic literature
Socioeconomic, historical	• Energy demand scenarios • Documents	• International Institute for Applied Systems Analysis, International Energy Agency archives

NOTE: FLUXNET is a "network of networks" for earth system scientists.

What Types of Climate Information Might Wargamers Use?

Climate is, in essence, long-term weather patterns and trends. *Climate science* can be thought of as an effort to understand the mechanisms governing these patterns and trends, how the trends may change in the future, and the resulting effects of such change. The field of climate science benefits from contributions from many other disciplines, including physical and ecological sciences, social science, economics, and computer science.

Generally speaking, insights about climate can be gleaned through four types of information, summarized in Table 1. Quantitative projections provide concrete inferences about how climate could change over the coming decades under various assumptions and what effects this will have in specific contexts (e.g., sea level rise, storm intensity). Instrumental records document historical and contemporary real-world weather. Paleoclimate records are derived from the physical environment (e.g., tree rings, ice cores) to extend inferences about climate back in time prior to the beginning of the instrumental record. Socioeconomic and historical data can also extend instrumental records back in time and inform how various policy interventions might affect the degree of future climate change[10].

For many, future projections of climate change are what immediately come to mind for climate data because these are frequently discussed in the media. These projections are usually informed by quantitative climate projections derived from physics-based computer models that are known as General Circulation Models (GCMs). There are several generations of GCMs, the majority of which have been the subject of widespread academic collaboration, quality assurance, and constructive debate. The international scientific community maintains databanks to manage models and share data so that derivative research (e.g., looking at effects) can use common data sources to ensure the consistency of inputs to allow for comparison.[11]

Climate models developed by different modeling groups contain various representations of the relationships within and between the atmosphere and oceans and therefore produce different estimates of future climate. In addition to this uncertainty in the structure of the climate system, climate models represent uncertainty in future socioeconomic trends and levels of emissions using agreed sets of scenarios that depict plausible ways that the future could unfold. These scenarios are combinations of the Representative Concentration Pathways (RCPs),[12] which denote changes in radiative forcing related to greenhouse gas and aerosol concentration (or how intensely climate change develops over time in the future); and Shared Socioeconomic Pathways (SSPs),[13] which correspond to levels of challenges to climate change mitigation (e.g., the intensity of fossil fuel use) and adaptation (e.g., how wealthy future populations are). The original set of RCPs were four alternative radiative forcings in watts per meters squared (2.6, 4.5, 6, and 8.5; the amount of warming generally grew as the radiative forcing increased), and the SSPs were five sets of assumptions (1 = sustainability, 2 = middle of the road, 3 = regional rivalry—a rocky road, 4 = inequality—a road divided, 5 = fossil-fueled development).[14]

The more recent projections of future global temperature changes use scenarios that combine assumptions for the physical environment, as represented in an RCP, with those for social and economic factors, as represented in an SSP. There is not a single one-to-one mapping of RCPs and SSPs, but there are some combinations that models suggest

are infeasible. The purpose of having both RCPs and SSPs is two-fold: (1) to ensure that both physical and human-constrained systems are represented in future projects and (2) to allow exploration of uncertainty in how the physical system responds to changes in the behavior of human society. For the interested reader, there are many publications that further detail the RCPs and SSPs and how they are used.[15]

In practice, DoD wargamers will not need to become deeply versed in RCPs and SSPs. Rather, they should have awareness that RCPs and SSPs are used to guide assumptions that help determine the outcomes in climate projections. Game assumptions should be consistent with the assumptions behind any projected climate information. For example, a game run under the assumption that a military in 2050 is operating primarily using vehicles running on carbon-based fuels would raise plausibility questions in a scenario whose climate trajectory is guided by SSP 1 (sustainability) assumptions which, among other things, emphasize lower energy intensity.

Climate model projections can be validated using observational data from either instrumental or paleoclimatological records. These records are key means for understanding the range of climate fluctuations in the past. Instrumental data come from weather stations, while paleoclimatological records are derived from long-lasting physical mechanisms, such as tree rings, lake sediments, and ice cores. Although neither information source stipulates anything about the future, these sources are useful for understanding the range within which Earth's climate system has operated in the past and for understanding the connections between climate phenomena.[16]

Finally, there are historical, cultural, socioeconomic, and other data and information that climate scientists and other experts use to extend, refine, and corroborate other sources. Examples of famous historical records include ancient Nile River flood data and European grape harvest date logs.[17] Looking to the future, social scientists and economists have developed scenarios of future energy mixes to understand their corresponding impacts on climate and society.[18]

How Can Climate-Related Information Shape Wargame Play?

Climate data and information of the types introduced in this paper can be shaped to inform most aspects of wargames, depending on game purpose (including those outlined previously), focus, and player knowledge. Table 2 summarizes four major aspects of many wargames that can be informed by different types of climate information and thus can serve as a starting point of reference for wargamers looking to incorporate climate change information or data, such as those referenced in Table 1.

The bottom line is that there are at least five aspects of games that are conducive to incorporating climate and weather hazards. Starting assumptions lay out the rules of the road, noting trends, events, and perceptions that affect the course of the game but are not particularly notable in the road to war, which we discuss next. One particularly important assumption for climate-related wargaming is the trajectory of climate change and expectations about the further future. The international scientific consensus through climate modeling is that the warming effect will be roughly similar through the 2030s and even into the

TABLE 2

Aspects of Games That Climate Information Can Inform

Game Aspect	Climate or Weather Information Examples
Future state narrative, assumptions	• Average annual temperature and expectations about temperature trajectory in future decades • Global progress on energy transition (fossil fuels to renewables) commitments • Changes in flooding zones based on existing sea level rise by the time of game start
Road to war, starting conditions	• Expansion of access to the Arctic region via melting of multi-year sea ice • Extent of agricultural area loss because of desertification and other climate-related hazards • Military and other installations that are unavailable at the start of game play because of severe storms
Crises, scene-setting for moves	• Weather report (e.g., change in expected seasonal wind direction, onset timing of stormy season) • Extended dangerous heat wave • Sudden flood along coast resulting from unseasonal storm surge or inland flooding from heat-induced glacial lake outburst
Game moves	• Consideration of climate and weather as an opponent during calculus • Unpredictability in weather conditions (e.g., dice roll determines category of hurricane bearing down)[a]
Adjudication	• Heat thresholds that challenge human physiology, electronics, and logistics (e.g., runway length) • Water and wind impacts to fixed and mobile infrastructure, making facilities and capabilities temporarily or permanently unavailable • Uncertainty in sufficiency of adaptation measures (e.g., lighter-weight body armor, raising structures)

[a] As an aside, climate information and data come with their own inherent uncertainties, which, viewed from a positive aspect, can also help simulate climate change–induced uncertainty in games. For example, computer simulations used to project climate change bear uncertainty in both the assumptions used to run the models as well as the design of the model itself (that is, how the model simulates the physics of climate).

2040s *regardless* of what actions are taken in the near term. However, ideas about the level of warming diverge considerably after 2040. Wargames taking place in futures within the 2020s and 2030s may not have many reasons to debate about the degree of warming within the game's time frame, but players might have very different outlooks about the further future, which will certainly affect mindsets and decisions depending on how quickly global dependence on fossil fuels has waned during the 2020s and onward. For example, a major series of heat waves in the wargame present of 2035 might be contextualized very differently if players believe that the amount of climate change will level off by 2050 versus players believing that climate change will continue unabated into the future.

Climate data and information can also inform the road to war or game starting conditions. Summary findings from the scientific community can inform, for instance, African continent biome vulnerability that, in turn, could have grave effects on food security and livelihoods.[19] This is also a game aspect that quantitative data analyses—already published or from primary datasets—can be helpful. A wargame designer may wish, for example, to provide players with a sense of where emerging maritime routes could exist because of changes in sea ice conditions or areas

of Southeast Asia that have been inundated by seawater,[20] rendering humanitarian disasters and vast areas of infrastructure unavailable.

Using climate and weather hazards as game crisis injects or scene-setters, such as a weather report, could be the most accessible means of including climate change in a wargame. Scene-setters at the beginning of a move and crisis injects may include climate or weather hazards as components or as issues unto themselves. Examples of climate-related events that can be inserted into a game in various ways include storms (e.g., high winds, floods); heat waves; cold snaps; changes in the timing, duration, or intensity of seasonal precipitation and winds; faster-than-expected ice or snow melt; and droughts, amongst others.[21]

Climate information and data can also be informative for shaping play during the moves themselves. Given the assumptions and scene-setting conditions, players can be encouraged to think of climate and weather as opponents—in addition to human adversaries, how is the climate likely to challenge a force and what can be done to mitigate it? Depending on the focus of the game, players might be assessed on climate in addition to other traditional strategic and military objectives.

The inherent unpredictability that has been introduced by climate change can also influence play during a move. Weather patterns are no longer as predictable as in the past, so players might not have "perfect" information on weather at the beginning of the move, and dice rolls determine those conditions during the move itself. In this way, players may experience flash floods despite overarching drought conditions, for example.

Perhaps less intuitive is how climate data and information can inform adjudication decisions. Climate and weather hazards will limit what players aspire to do in a given move or result in surprising consequences of their decisions. In one example, an adjudicator might invoke the limits of human and machine activity in extreme heat to adjust how far and fast players move. In another example, a dice roll may determine that because of growing uncertainty in seasonal prevailing wind patterns, players' decisions to fly aircraft out of a certain facility may be thwarted by rising dust storms.

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Introducing More Climate Data to Wargaming Will Necessitate Additional Effort

A remaining open question is what specific type(s) of climate data and information are most useful for DoD-related wargames. The specific answer to this question will vary by application and community, but we note here that there is an important analytic limitation to the research community's understanding and documentation of the connection between climate change and its implications for human and hard security and thus military operations and needs.

Both qualitative and quantitative data and information can support any of the five game aspects outlined previously. For example, general assessments from the IPCC and the U.S. National Climate Assessment can provide solid assumptions for the future state narrative and road to war. Global and regional trends that use forward-leaning climate projections can also contribute to the future state narrative, including the outlook during that future looking further ahead (e.g., if the wargame takes place in 2040, what expectations for climate might be in 2060). Downscaled climate projections more specific to a subregion or locality can help with weather reports and move adjudication, which requires more-specific information on local temperatures, extreme precipitation, and other factors. Instrumental climate data and paleoclimate data can help demonstrate how norms are changing in the road to war and provide a baseline for "normal" versus "extreme" weather conditions in a weather report or during the course of a move. Historical climate information (e.g., from archives) can help simulate what the effects of extreme weather might be, such as the number of deaths associated with heat waves of what degree and length in the past.

Generic global projections of temperature are not that useful for providing data-driven climate assumptions for a game in which future military physical training solutions are being considered.

In many cases, existing academic and (inter)governmental publications can provide sufficient insights; that is, wargamers should typically not need to analyze projected, instrumental, historical, or paleoclimatological datasets themselves. This is because there is already a vast amount of published information; there are hundreds of thousands of peer-reviewed documents about or related to climate change, and that number has been growing for decades.[22] The primary issue is sorting through the research and interpreting what it means in the context of a specific game.

Although the types of data discussed here are generally obtainable because they are publicly available and well documented,[23] the choices of what dataset to use, how to process the data, and how to analyze the data so that they apply to the problem at hand are nontrivial. This is because

of the amount of training, computing power, and focused time and effort that are needed to tailor existing available climate data for an analytic purpose. For example, generic global projections of temperature are not that useful for providing data-driven climate assumptions for a game in which future military physical training solutions are being considered. In a different example, U.S. military installations in Alaska looking at paleo-fire records for a reasonable worst-case scenario in a game in which players can invest in wildfire countermeasures would not use lake charcoal and tree-fire-scarring records from Wyoming to assess the potential risks of not making the investment in question.

DoD and the armed services have taken steps to scope vetted datasets from the climate science community and make these available to planners across the enterprise. For example, the U.S. Air Force's 14th Weather Squadron "collects, protects and exploits authoritative climate data to optimize military and intelligence operations and planning in order to maximize the combat effectiveness of Department of Defense personnel and weapons systems."[24] The Naval Meteorology and Oceanography Command and its predecessors have also had an important role in enhancing DoD's understanding of weather and climate. Another important development is the DoD Climate Assessment Tool,[25] which is useful for exploring climate hazards for U.S.-based installations.

Although this is not likely for most game applications, tailored or even novel analysis could be needed when two conditions are met: (1) gameplay requires very specific types of data (e.g., particular thresholds or probabilities) and (2) existing, available data or published work are not scoped (geographically, temporally, thematically) appropriately, they are outdated, or wargamers simply cannot access the information. In these instances, publicly available data may be available to support new or adapted analyses to suit wargaming needs, including from some of the sources given as examples in Table 1.

We do not foresee instances in which wargamers would wish to generate their own primary datasets; for example, by developing new global climate models or by conducting field work to generate tree-ring datasets. Furthermore, the skills needed to create these primary datasets require years of development and large collaborations. Once again, publicly available data should already exist to support the few novel analyses that wargamers may wish to tailor to a specific game instance. As a stakeholder, the DoD wargaming community might, however, contribute data (e.g., from weather stations or satellites) or insight to inform future developments in climate data analysis and products. NOAA's Climate Adaptation Partnerships Program,[26] for example, helps facilitate connections between climate practitioners and data users to help better tailor climate products.

Conclusion

We have noted that uncertainty itself is the primary challenge that climate change posits for military strategists and planners, among other decisionmakers and practitioners. It is also true that the effects of climate change do and will continue to present new and ongoing challenges to existing military infrastructure and logistics while reshaping military mission spaces. Furthermore, the analytic community is still working to document data-informed connections between climate change and risks to peace and security.

Wargames have significant potential for exploring, analyzing, and communicating climate data and information using a familiar format for the defense community. For this reason, we foresee more wargames that focus on climate and weather hazards and leverage the large and ever-growing body of work on this topic (that is increasingly coming into focus as an important consideration for militaries).

Alongside the ample amount of climate change–related data and information, there are also considerable opportunities for using such data in wargames, particularly in game assumptions, starting conditions, and the road-to-war narrative; as crisis injects and scene-setting information; and for the purposes of adjudication. The next challenge for wargamers is to further develop knowledge about where to go for these data and information, and how to accurately portray climate change–related analyses and findings in games. Importantly, wargamers should be aware that data and insights found in peer-reviewed articles and through credible government, intergovernmental, or academic institutions are good sources to use. It is always valuable to go to more than one source to better understand the full implications of climate change–induced uncertainty on the effects in which wargamers might be interested.

Any substantial narrowing of the range of climate and weather hazard–related data and information seen as acceptable for wargaming use could be detrimental to military strategists and planners. Wargamers should be able to select the best contextualized data and information for their respective problem sets, given that the international practitioner and academic communities have already established systems over decades to develop, vet, and share this information. Creating policies to curtail use of credible data and information could even hamper the quality of future games. Rather, the wargaming community might consider bringing in more climate change expertise to advise on which data, information, and additional analyses might be beneficial for a particular gaming problem. Additionally, wargamers could have a lot insight to offer back to the climate research community in terms of what data and insights are most useful. One area for fruitful collaboration, for example, might be in the further development of models for potential higher-order impacts of climate change on economic, social, and political systems.

Tackling the effects of climate change is a looming issue for the defense community. Wargaming can help with strategizing and planning for this slow-burning yet increasingly urgent and encompassing issue. Accessing climate change–related data and information and using them to design and play games can help the defense community better characterize and understand changes that may be necessary to take on an uncertain future environment. To effectively do so, however, the DoD wargaming community likely will need to explore options for increasing climate literacy, developing internal capabilities (e.g., climate officer track), and developing more-regular working relationships with those that routinely create, tailor, and analyze climate data and information (e.g., universities and other government offices that specialize in relevant areas).

Notes

1 IPCC, homepage; see also various IPCC reports, including Lee and Romero, *Climate Change 2023: Synthesis Report*, pp. 35–115.

2 Fourth National Climate Assessment, homepage.

3 Parkes and McQuay, "The Use of Games in Strategic Foresight: A Warning from the Future"; Davenport et al., *USCG Project Evergreen V: Compilation of Activities and Summary of Results*.

[4] Burke and Cameron, "Wargaming Climate Change: Who Plays for the Red Team?"

[5] Mcfarlane and Volcovici, "Insight: World's War on Greenhouse Gas Emissions Has a Military Blind Spot."

[6] See, for example, Ali and Stewart, "Pentagon to Include Climate Risk in War Gaming, Defense Secretary Says"; Department of Defense Directive 4715.21, *Climate Change Adaptation and Resilience*; Office of the Under Secretary of Defense for Acquisition and Sustainment, *Department of Defense Climate Adaptation Plan*.

[7] David Vergun, "DOD Exercise Highlights Need to Address Climate Change, Its Impacts."

[8] See, for example, Wong et al., *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action*, and the references therein; games are but one of a suite of analytic tools and are most suited to contexts in which engaging humans in decisionmaking and some form of adjudication is appropriate. Other analytic methods that can be used with or instead of games might include—depending on the context—interviews and focus groups, less structured workshops or discussions, literature review and case studies, quantitative data analysis, and modeling and simulation.

[9] Burke and Cameron, "Wargaming Climate Change: Who Plays for the Red Team?"

[10] Work looking at socioeconomic drivers and outcomes is growing, but it represents a more modest body of work when compared with physical science research on climate change, highlighting a general issue that there are differences in knowledge depth across climate change–related topics.

[11] Meehl et al., "The Coupled Model Intercomparison Project (CMIP)."

[12] Van Vuuren et al., "The Representative Concentration Pathways: An Overview."

[13] O'Neill et al., "A New Scenario Framework for Climate Change Research: The Concept of Shared Socioeconomic Pathways."

[14] Lee and Romero, *Climate Change 2023: Synthesis Report*.

[15] O'Neill et al., "Achievements and Needs for the Climate Change Scenario Framework"; Coelho et al., "How the New Climate Scenarios Will Affect Air Quality Trends: An Exploratory Research"; Lee and Romero, *Climate Change 2023: Synthesis Report*; Oh et al., "Sources and Uncertainties of Future Global Drought Risk with ISIMIP2b Climate Scenarios and Socioeconomic Indicators."

[16] These data sources have also been used to benchmark expectations for policymaking (for example, to determine water rights); Hartman et al., *Recommendations for an Effective Water Rights Response to Climate Change*.

[17] Bell, "The Oldest Records of the Nile Floods"; Labbé et al., "The Longest Homogeneous Series of Grape Harvest Dates, Beaune 1354–2018, and Its Significance for the Understanding of Past and Present Climate"; Kornei, "600 Years of Grape Harvests Document 20th Century Climate Change."

[18] Kober et al., "Global Energy Perspectives to 2060–WEC's World Energy Scenarios 2019."

[19] Niang et al., "Africa," p. 1215.

[20] See, for example, Smith and Stephenson, "New Trans-Arctic Shipping Routes Navigable by Midcentury"; and Hauer et al., "Sea-Level Rise and Human Migration."

[21] Illingworth, "Developing Science Tabletop Games: Catan and Global Warming."

[22] Fu and Waltman, "A Large-Scale Bibliometric Analysis of Global Climate Change Research Between 2001 and 2018."

[23] National Centers for Environmental Information, "Paleoclimate"; National Centers for Environmental Information, "Global Historical Climatology Network Daily"; World Climate Research Programme, "WCRP Coupled Model Intercomparison Project (Phase 6)."

[24] 557th Weather Wing, "14th Weather Squadron."

[25] DoD, "DoD Climate Assessment Tool."

[26] National Oceanographic and Atmospheric Administration, "Climate Adaptation Partnerships Program."

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About This Paper

This paper summarizes insights about approaches for understanding the implications of climate change in a national security context through the use of analytic gaming. These reflections are based on experience that has been developed while gaming climate change, specifically for the U.S. Department of Defense. There are multiple sources of climate information and data that are available to the defense gaming community, but using these sources effectively requires knowledge of how to obtain them and their respective benefits and limitations. Wargames focusing on or including climate change can serve purposes from concept development to education to engagement. Climate information and data can be used to shape assumptions, model starting conditions, create crisis narratives, move scene-setters, and make final adjudications.

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