

CLIMATE EXTREMES: RECENT TRENDS WITH IMPLICATIONS FOR NATIONAL SECURITY*

*By Michael B. McElroy and D. James Baker***

Introduction—Setting the Stage for the Symposium	727
I. Observations and the Physics of Greenhouse gases	729
II. A New Normal: Impacts and Challenges	731
III. Implications of Changing Extremes	734
IV. The National Security Context	737
Conclusion	742

INTRODUCTION—SETTING THE STAGE FOR THE SYMPOSIUM

This paper was presented at the Symposium on “Rising Temps and Emerging Threats: The Intersection of Climate Change and National Security in the 21st Century” that was held at the Vermont School of Law on October 25, 2013, sponsored by the Vermont Journal of Environmental Law. The paper was designed to set the stage for the symposium discussion by summarizing current knowledge of weather and climate extremes in the recent past, showing what might be expected in the near-term future (next decade) for both urban and rural regions, and laying out the national security implications for the most affected regions. Following the presentations of the climate and security threats, the Symposium participants dwelt on how the military would respond by adapting to climate change, how society would respond with a special emphasis on forced climate-based migration, and how food security becomes part of national security. There was a lively discussion of these issues throughout

* Summary of a presentation by D. James Baker at the Fall 2013 Symposium of the Vermont Journal of Environmental Law on “Rising Temps and Emerging Threats: The Intersection of Climate Change and National Security in the 21st Century”

** Michael B. McElroy is the Gilbert Butler Professor of Environmental Studies at Harvard University and D. James Baker is the Director of Forest and Land-Use Measurement at the Clinton Foundation and a former Administrator of the U.S. National Oceanic and Atmospheric Administration. The authors would like to thank Ric Cicone, Marc Levy, and the reviewers listed in the online version of the report.

the day. The other speakers and audience participants raised a number of points that will help inform future research in both science and policy.

The Symposium presentation and this paper is a summary based on a longer report by McElroy and Baker (2012) that examines the science behind near-term climate extremes and analyzes implications for national security.¹ This summary, in order to be most relevant to the Symposium discussion, focuses more on the policy implications and national security issues rather than on the basic science context. The reader is referred to the original report for detailed information on observations, analyses, and more national and regional examples.

The authors of the report recognized that fundamental to all of this discussion is an understanding of the climate and weather changes that we have seen in the past, and therefore start by analyzing recent climate and weather extremes. The authors then showed how these changes might be extrapolated into the future and what the societal implications might be in various regions around the world. The authors also examined whether the increasing number of extreme events and manifestations of change are rooted in human-induced climate change or whether they can be explained as a consequence of decadal manifestations of natural weather variability. They concluded by analyzing the national security implications for such change.²

To make decisions, policy makers need near-term information, asking what can happen in the next decade. Up to now, assessments of climate impact relied on projections of climate change tuned to identify impacts over roughly a one-century time frame. That long time frame is driven by the nature of the questions that dominated the initial literature (e.g., what impacts can be expected from a doubling of pre-industrial carbon dioxide). It is also driven by the fact that global climate models are generally able to resolve expected impacts only over large scales and the long term.³ Examining the impacts of near-term climate change poses challenges and requires a different assessment of climate science. The models as yet do not provide robust regional forecasts. One must piece together from first principles the physical dynamics that are likely to generate significant impacts, evaluate the signals available in the observational record, and assess plausible societal responses to such changes.⁴

1. MICHAEL MCELROY AND D. JAMES BAKER, CLIMATE EXTREMES: RECENT TRENDS WITH IMPLICATIONS FOR NATIONAL SECURITY, HARVARD UNIV. CENTER FOR THE ENV'T. (October 2012), <http://environment.harvard.edu/climate-extremes>.

2. *Id.* at 1.

3. *Id.*

4. *Id.* at 2.

The focus here is on information about extreme events in the next decade that can provide useful guidance to national security planning. Will extreme weather patterns worsen or continue to persist? Will we witness new manifestations of extreme weather? How will these changing patterns affect U.S. national security interests? To answer these questions, the authors undertook a careful examination of the physical drivers that influence weather and that underlie changes in the climate system. They reviewed current literature, examined the record of recent observations and model results, and consulted with scientists familiar with the dynamics of weather, climate, and society. The authors thus combined the best insights of natural and social scientists to examine the extent and pace of near-term climate changes and the consequences of the resulting stresses placed on people and nature.⁵

I. OBSERVATIONS AND THE PHYSICS OF GREENHOUSE GASES

The authors also commissioned an empirical analysis of open-source temperature and precipitation data by Dr. Tom Parris. Dr. Parris provided important insight with respect to recent decadal trends in extreme temperature and precipitation events and their impact on fresh water resources by examining a one-hundred-year terrestrial record of temperature, a sixty-year record of precipitation, and a global hydrological model.⁶

The analysis of observational data shows that the climate of the past decade has indeed been unusual. The annual global average surface temperature for each year from 2002 through 2011 ranked among the top thirteen in the 132-year instrumental record, which began in 1880. That decade was also marked by a number of high-impact, weather-related disasters that include dramatic heat waves, droughts, floods, and storms. Naturally induced climate changes are revealed by active El Niños, large scale changes in the Atlantic Ocean, and other regional oscillations, which can have an effect on extremes. These phenomena are occurring at the same time that greenhouse gases are driving climate change..

The documented empirical record thus includes both natural and human influences. It provides evidence clarifying that the intensity of recent unusual events exceeds normal expectations and that their extent is worldwide, affecting people where they live, draw upon fresh water resources, and grow food. While climate extremes are an on-going fact of

5. *Id.* at 1–2.

6. *Id.* at 3.

nature, the study found clear evidence that the recent prevalence of events and conditions exceeded expectations based on the past century of weather.⁷

The report reviews the observational record for surface temperatures, precipitation events, floods, and droughts particularly focuses on trends in the prevalence of extremes. It then reviews trends in the observed impact of climate changes on arctic ice, permafrost, glaciers, ice caps, ice sheets, and sea level. This gives us a basis for understanding the scale and scope of extreme events and manifestations of changes in important physical components of the Earth system that can affect weather patterns. In particular, global average land surface temperature has increased by about 0.9° C since the 1950s. During the same period, the prevalence of extreme warm anomalies increased while the prevalence of extreme cool anomalies decreased.⁸

The observations indicate that there is no obvious long-term trend in global annual precipitation over land. However, there is strong evidence that precipitation has occurred in more extreme events for most of the northern hemisphere. Higher temperatures combined with more extreme precipitation, increased the prevalence of severe freshwater deficits since about 1980. They produced a much smaller increase in freshwater surpluses since about 1990. In the Arctic, most of the permafrost observatories in the Northern Hemisphere show significant warming of permafrost during the 1980s. The minimum September arctic ice extent for each of the past five years from 2007-2011 was lower during any other year in the period of record and declines at an average rate of about 12% per decade.⁹

All of this information is growing evidence of human-induced climate change. The multiple lines of observational information lead to the conclusion that atmospheric concentrations of greenhouse gases are increasing and that most of this increase can be attributed to the combustion of fossil fuels. The primary reasons are: 1) the north-south difference in concentrations is increasing in a manner that is consistent with CO₂ emissions from fossil fuel combustion, predominantly in the Northern Hemisphere, and 2) measurements of isotopic tracers indicate fossil fuel combustion.¹⁰

Other key evidence from routine monitoring by the National Oceanic and Atmospheric Administration (“NOAA”) and other international services include the facts that: 1) global average surface temperature, sea

7. *Id.* at 43.

8. *Id.*

9. *Id.*

10. *Id.* at 44.

level, global upper ocean heat content, and specific humidity are all rising; 2) northern hemisphere snow cover and Arctic ice are decreasing; 3) the lower stratosphere is cooling while the upper troposphere is warming; 4) and the Arctic is warming faster than mid-latitudes and the tropics. All of these observations are consistent with the physics of greenhouse gas warming. The observations and the underlying physics support the view that increased atmospheric concentrations of greenhouse gases are largely responsible for observed increases in global average surface temperature, increases of temperatures in the upper troposphere, and decreases of temperatures in the stratosphere. The latter two conditions taken together may be considered as critical fingerprints of greenhouse gas-driven climate change. We are led to the conclusion that for the future, we must consider the forced trends from rising concentrations of greenhouse gases as well as the natural variability of climate.¹¹

The conventional approach to looking at the impacts of climate change assumes they will unfold only slowly and in the distant future, following pathways to which society can easily adapt. It seems clear that this approach is inadequate. Now, we can see that human-driven changes in Earth's energy balance are producing a warmer and wetter atmosphere. This trend superimposes on and, in some cases, magnifies natural variability. Small positive changes in the global mean annual temperature are causing an increased prevalence of local extreme weather conditions. Greenhouse gas warming has given us a new climate—a new normal, if you will—where climate disruptions are more likely.¹²

II. A NEW NORMAL: IMPACTS AND CHALLENGES

The new normal for climate leads to a more vulnerable world in general. We are facing a future where the risk of major societal disruption from weather and climate extremes such as droughts, floods, heat waves, wildfires, and destructive storms is expected to increase. These stresses will affect water and food availability, energy decisions, the design of critical infrastructure, and the use of the commons. They will have large costs in terms of both economic and human security. This new normal has the following characteristics:¹³

A more vulnerable world: More prevalent extreme weather can be expected to have a comparatively disproportionate social and economic

11. *Id.*
12. *Id.* at 4.
13. *Id.* at 8.

impact on human societies today. That is because society has changed. Increased population; growing industrial infrastructure; urban growth and burgeoning mega cities; increased habitation of coastal regions; and growing dependency on water resources to satisfy agricultural, industrial, energy, and domestic needs are all characteristics of a human society with increasing demand on nature's services. Without deliberate adaptation, the human toll of extreme events will continue to mount and the escalation of extreme events as the climate warms will only make matters worse.¹⁴

Impacts on water security: Severe weather conditions directly impact the hydrological cycle and the availability of fresh water resources. Global freshwater withdrawals have increased approximately eight-fold in the last century. Water exploitation, making it unavailable for subsequent downstream use, increased about five-fold in the last century. These trends are projected to continue well into the 21st century. With an expected increase in the numbers of floods and droughts, many countries important to the U.S. could face environmental stress that may lead to responses and adaptations that, in turn, may present opportunities or challenges to U.S. national security interests. Large scale migrations, political realignments, increased competition over resources, changes in economic policy, price shocks, and possible conflict over increasingly scarce water resources and trans-boundary waters, even failure of marginal states, are all plausible.¹⁵

Challenges to food security: Food production, already in increased demand, will suffer from more heat extremes and increased variability of rainfall, leading to instability in the food markets. Over the past four years, major spikes in global food prices have arisen from a perfect storm of widespread drought in multiple major agricultural regions, diversions of commodity grain for biofuel production, and increasing demand from rapidly growing economies such as India and China.¹⁶

Implications for energy security: Emissions from energy-based fossil fuel combustion are the largest human contribution to greenhouse gas concentrations. The energy production infrastructure, requiring copious amounts of water, is often located in regions susceptible to drought, flood, and damaging storms that are expected to become more prevalent in the coming decade. The infrastructure is, therefore, vulnerable to disruption due to extreme weather. Nuclear power generation is also sensitive to heat

14. *Id.*

15. *Id.*

16. *Id.*

waves. During the 2012 heat wave, reactors were shut down because incoming cooling water was too warm. Large-scale geoengineering efforts to increase the concentration of cooling aerosols in the atmosphere and hence counter the impact of fossil fuel emissions are being developed, but little is known about the impacts of these efforts. There is also a notable absence of workable mechanisms for diplomatic coordination for such geoengineering projects.¹⁷

Threat to critical societal infrastructure: The probability of a major storm crippling cities will increase because there will be more coastal megacities due to population growth and increasing urbanization. Storms will become more destructive and there will be more flooding as storm surges increase from higher sea-levels. Critical infrastructure, including dams, roads, bridges, ports, rail systems, and airports is engineered and constructed to specifications based on the extremes observed under the climate of the past century. Significant infrastructure is concentrated in coastal zone areas that are particularly vulnerable to extreme weather and rising sea level. In areas of permafrost, where ground stability is threatened by warming, infrastructure such as pipelines is highly vulnerable. The vulnerability is especially clear in our defense and maritime shipping apparatus reliant upon coastal ports. More frequent and prevalent climate extremes in the coming decade imply that we will likely see more frequent infrastructure failure and growing demand for financial resources to harden existing infrastructure.¹⁸

Impact upon the Arctic, the global commons, and natural ecosystems: The global impact of climate change, as well as the impact on the Arctic region, coastal zones, and critical ecological resources such as Amazonia, will increase competition and hopefully cooperation among nations to accommodate change. A good example is the Arctic Basin. As it loses its summertime ice cover faster than expected, new trade routes and expanded opportunities for oil and other mineral exploration are appearing.¹⁹

17. *Id.* at 9.

18. *Id.* at 9–10

19. *Id.* at 10.

III. IMPLICATIONS OF CHANGING EXTREMES

Global Impacts

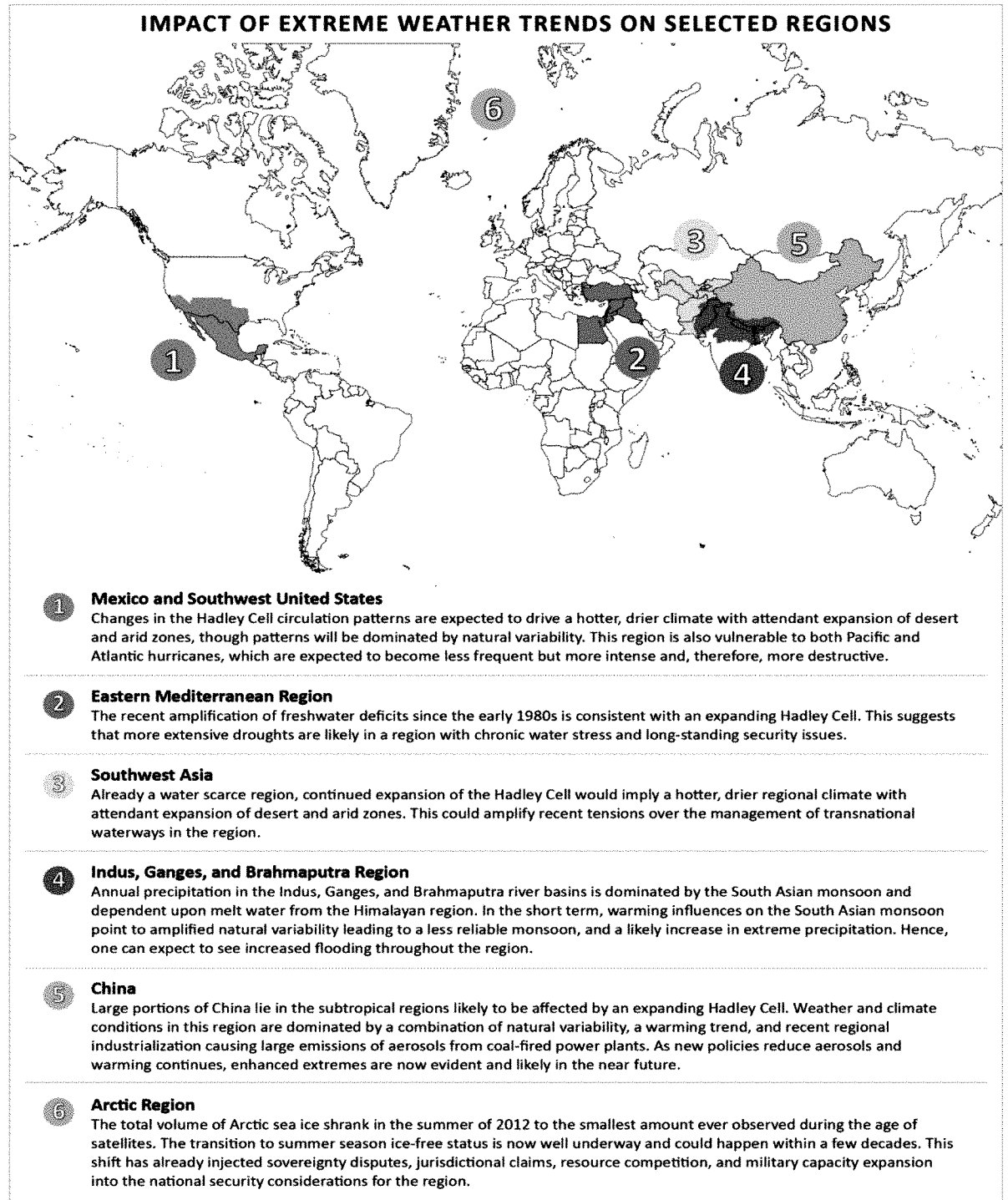
The important security implication of global warming in the near term is that the extremes are likely to become more prevalent and more frequent. What was once a 1 in 100 year anomaly is likely to become a 1 in 10 or 1 in 30 year anomaly or even more frequent in the near future. Our infrastructure and agriculture are not designed to accommodate the increasing frequency and prevalence of such extremes. Human security and the interests of most nations are at stake as a result of such increasing climate stress. The potential for profound impacts upon water, food and energy security, critical infrastructure, and ecosystem resources will influence the individual and collective responses of nations coping with climate change. U.S. national security interests have always been influenced by extreme weather patterns. Now the global risks are larger and more apparent.²⁰

Regional Effects of Near-Term Climate Stress

Large-scale features of the climate system such as the ocean sea surface temperatures, the atmosphere's water vapor holding capacity, and atmospheric circulation patterns drive regional trends. One can expect increased warming worldwide, resulting in amplification in the Arctic, a warmer ocean, increasing storm intensity in the tropical regions generally drier subtropical regions, likely wetter conditions in temperate and boreal regions with more intense and less frequent precipitation events, and an increasing likelihood of wildfires. Regional prediction remains challenging and will require focused efforts to maintain and enhance Earth observations, especially of the oceans. However, all the evidence points toward intensifying climate extremes. The effects will be worldwide. The illustration below highlights some of the changes we expect to see in selected regions that are highly relevant to US national security interests. Note that the Hadley Cell referred to in the illustration is an atmospheric circulation pattern characterized by rising warm air at the equator and sinking cooler air further north.²¹

20. *Id.* at 5.

21. *Id.*



The McElroy and Baker report was published at the end of 2012 when the U.S. had just seen the grip of widespread and severe drought. That drought strongly affected both energy availability and agricultural productivity. For example, nuclear power production in the U.S. in 2012 was measured at the lowest seasonal levels in nine years as drought and heat slowed reactor output. Of course, the United States has faced severe climate stress before. The impact of the dust bowl in the early 1930s is imprinted in the memory of our nation's history. The affected areas of the dust bowl period were widespread in the United States and Northern Europe. The intensity and scope of the 2012 drought combined with record high temperatures reawakened memories of the dust bowl era. Today, we again are facing a similar problem in California with the drought of 2013 continuing into 2014. We find widespread drought in many important parts of the world at the same time. Water resources, while already much in demand and inefficiently used in certain critical regions, are thus further stressed due to this extreme weather. The impact of this unfolding event on people, and how it may echo through the world markets, has yet to play itself out. However, it certainly bears watching, as the breadth of impacts is much larger geographically and society is much more vulnerable today than it was in the 1930s.²²

With weather and climate extremes, as with any threat our nation faces, there is a fundamental imperative to observe, monitor, and study related factors to provide insight and objective analysis to our nation's policy makers about the implications to U.S. national security interests. Changes of the magnitude we are witnessing have implications for food, water, and energy security. We design our society, including its infrastructure and its defense apparatus, around expectations, including climate and the expectations of weather patterns and events. Climate is and has always been a natural constraint on national power and prosperity. Up to now, it has not been perceived as a threat, only a surrounding condition that must be accommodated in both tactical and strategic planning. However, we can no longer assume that climate is fixed and unchanging. The scope of recently observed extreme events and the prospect of future changes that could drive more extreme weather warrant close attention. We can no longer assume that the extremes of tomorrow will resemble the extremes of yesterday—as mentioned above, we are facing a new normal.²³

22. *Id.* at 7.

23. *Id.*

IV. THE NATIONAL SECURITY CONTEXT

The national security context is changing as a result of the environmental changes we expect to see in the coming decades. The prospect of serious socioeconomic disruptions in response to weather and climate related extreme events is more imminent than previously thought— affecting society in significant ways today and through the coming decade. It is cause for significant concern in the later part of this century. The impact on individuals and nations will be profound.²⁴

Much of what we assume about the future based upon our experience with the past may be in doubt. Human population is projected to grow to 9.2 billion in 2050, an increase of more than 30% from the present. The increase over the seventy years from 1980-2050 will exceed the increase experienced during the 150,000 years prior to 1980. Economic activity per person has also grown substantially. The production and consumption of goods and services per capita grew by more than 70% between 1975 and 2010. While improvements in technology have enabled us to make more efficient use of resources, aggregate resource use has generally outstripped these efficiency gains due to larger, more affluent, populations. In addition, environmental pressures such as climate change will further stress the resource base required to sustain human development.²⁵

As a result, we must now seriously consider futures constrained by Earth's continuing capacity to provide the resources to support human society in context of social and environmental stressors. When and where we bump up against these constraints we will need to adapt. In some cases, these adaptations may be long anticipated, well planned, and orderly. In other situations, they may be forced by surprises, chaotic in implementation, and pose significant national security challenges. In some cases, self-organizing processes such as markets will carry out adaptations smoothly. In other cases, adaptations will require interventions. Whenever the stakes are high, decision makers who already have robust assessments will hold a significant advantage.²⁶

The full report includes an analysis of the scientific basis for expecting an increase in the frequency of extreme weather and an increase in the total area affected by extreme weather over the next decade. The conclusions will be controversial to some. But the evidence is inescapable that more frequent weather extremes are having impacts that concern our security interests today. The report warns that we can expect this to

24. *Id.* at 10.

25. *Id.*

26. *Id.*

continue. The risk is sufficient to warrant attention. It is evident that human security and the interests of most nations are at stake. The impacts of climate changes affect society in significant ways today and will continue to do so through the coming decades. They pose complex questions regarding the human dimension—the response of people, individually and collectively, as their environment changes.²⁷

Recent years have witnessed a marked increase in concern that climate stress will pose significant challenges for U.S. national security. Such concern has been reflected in scientific scholarship, publications of policy think tanks, and high-level government publications such as the Quadrennial Defense Review. Behind this recent thinking about climate-security linkages is a combination of new understanding of the vulnerability of societies to climatic stress (underscored by a series of recent case examples that bring these vulnerabilities into sharp relief) and a mounting empirical record that demonstrates that weather extremes are becoming more common. These linkages can be broadly categorized as: 1) multipliers of political instability threats; 2) interaction of climate stress and globalization; 3) disruption of international politics through changes in territory and diplomacy; and 4) drivers of humanitarian crises.²⁸

Multipliers of political instability threats

Political instability, in the form of coups, civil war, and other forms of internal political violence constitutes a major U.S. national security threat for which strong possible connections to climate stress have been identified. In the aftermath of the Cold War and the rise of major security problems linked to political instability, major resources were devoted to, and advances were made in, understanding the causes of political instability.²⁹

Several key drivers of instability have clear links to climate stress. For example, a prolonged drought in a poor, agriculturally dependent society will generate consequences:

- Depression of livelihoods among rural societies, as herding and farming yields decline
- Depression of government revenue, as agricultural exports decline
- Increased movement of populations in search of suitable pasture and cropland

27. *Id.* at 11.

28. *Id.*

29. *Id.*

- Decreased perceptions of government legitimacy, if responses to the crisis are judged inadequate.

Each of these consequences has been shown to elevate the risk of political instability. The same dynamics contribute to the risk of humanitarian emergencies. The genocide in Darfur was preceded by a multi-decade drought that generated such consequences. The recent collapse of the Mali state also was preceded by a severe drought linked to these consequences.³⁰

In any single case it is not possible to attribute causal responsibility for political instability to climate stress, but statistical tests can help identify the overall pattern. Published tests clearly demonstrate that deviations from normal climatic conditions are associated with a significant increase in the risk of political violence (see the illustration above). Although the strength of this proposition continues to be debated by scholars, there is no doubt that the evidence supports heightened attention to the linkages.³¹

Interaction of climate stress and globalization

Political instability can also be exacerbated by climate stress that operates through less direct means. Globalization creates patterns of vulnerability that can be accentuated by climate shocks. The food price spikes of 2010, generated by severe drought in key global wheat producing regions in Eurasia, led to a sharp increase in dissatisfaction with political leadership in several Arab countries. The combination of an acute shortage of affordable food, deep-rooted concerns about legitimacy, and absence of mechanisms for peaceful political contestation are some of the factors behind the emergence of the Arab Spring in 2011.³²

Another example of indirect transmission is in the area of policy responses. In 2008 and 2010, the worldwide diversion of crop production to biofuel contributed to sharp increases in global food prices. The biofuel surge is largely a result of climate policies mandating increased production. Similarly, concerns about water scarcity, in part elevated by worries over climate change, but also prompted by economically driven increases in consumption, have led some countries to increase construction of reservoirs on trans-boundary rivers, or even in some cases to contemplate diversion that harms downstream interests. Such policy responses elevated cross-

30. *Id.*

31. *Id.* at 13.

32. *Id.*

border tension in regions such as the Lancang-Mekong, Ganges-Brahmaputra, and Ili River (Kazakhstan-China) basins.³³

A third and key category of policy response that has raised alarms is the sharp increase in foreign land acquisitions by some countries. Several countries that are worried about their long-term ability to meet food security needs (driven again in part by climate change projections) have responded by executing long-term leases and purchases of agricultural land in poor countries. Because poor agrarian countries are often politically fragile, the injection of contentious land politics may be destabilizing. Indeed, the government of Madagascar fell in 2009 precisely because of a controversy over the government's handling of a major land deal with South Korea.³⁴

The vulnerabilities associated with globalization have the potential to transmit the impacts of weather and climate extremes to the U.S. homeland. The Thailand floods of 2011, triggered by a combination of unusually heavy rains and land use changes in the region, shut down production of key components for computer hard drives. This led to a global hard drive shortage that lasted for months. The heavy concentration of critical elements of the global supply chain in this vulnerable region could easily be repeated elsewhere. Another possible threat to the U.S. homeland lies in the shifting patterns of infectious disease that could be triggered by climate change. Dengue fever, for example, has shown signs of moving into the southern U.S. as habitat conditions for the *Aedes aegypti* mosquito shift. Similarly, *Vibrio* bacteria, a precursor to gastrointestinal diseases such as cholera, are now living in the Baltic Sea—a migration enabled by warmer waters.³⁵

Disruption of international politics through changes in territory and diplomacy

Finally, climate change has the potential to disrupt international politics in a way that creates national security problems for the U.S. Reductions in Arctic sea ice have already triggered fears of a scramble for control of shipping lanes and mineral deposits in the region. Competing territorial claims in the region had not been associated with international tension in the past, because there were no viable prospects for acting on such claims. As the Arctic has been free of ice in late summer to a greater extent and for longer periods than ever before, prospects for mineral

33. *Id.*

34. *Id.*

35. *Id.*

exploitation, fisheries exploitation, and shipping are now much more real. The prospects for challenging conflicts over control are potent. A similar dynamic has emerged in the northern border between India and Pakistan. Unresolved territorial disputes are being exacerbated by fears that climate change is affecting transboundary water resources of the Himalayan glaciers and thus upsetting the fragile political equilibrium.³⁶

Weather and climate extremes may create degraded conditions that terrorist and criminal organizations could exploit to their advantage. The water crisis in Yemen, for example, though largely driven by growth in consumption in an arid region, has been augmented by rainfall shortages. This crisis has been linked to the weakness of the regime, which in turn has heightened concerns of a growing Al Qaeda presence. Similarly, in northern Mali there are fears that the loss of state control has created a potential haven for Al Qaeda and its sympathizers. The drought in Mali cannot be blamed as the primary force behind this development, but it clearly played a role in the history of contested control in the region. The collapse of the Somali state was exacerbated by long-term drought in the region, and has generated long-lasting security threats. These examples demonstrate that weather and climate extremes can influence hostile interests in new regions of the world.³⁷

Drivers of humanitarian crises

Humanitarian crises with clear direct links to climatic stresses—disasters associated with droughts, floods, severe storms, temperature extremes, wildfires, and landslides—are growing rapidly. In addition, complex humanitarian emergencies arise through the interaction of multiple stresses, such as political violence, refugee flows, malnutrition, and epidemics. Often such crises emerge in places that constitute threats to U.S. national security because of the need to employ U.S. military resources as part of an organized response or because of destabilizing effects in critical regions.³⁸

During the 20th century, patterns of interdependence and vulnerability evolved in a way that led to a dramatic increase in the role of socioeconomic forces in shaping U.S. national security. These processes accelerated in the aftermath of the Cold War. Now the 21st century is shaping up to be a period in which weather and climate extremes are generating similar levels of security threats. Therefore, understanding the

36. *Id.* at 14.

37. *Id.*

38. *Id.*

nature of these climatic stresses, as they are likely to unfold in the near term, is of crucial national security importance.³⁹

CONCLUSION

In short, the observational record shows that the world has been beset with a decade of unusual weather conditions. Droughts, stronger storms, heat waves, floods, wildfires, and anomalous seasonal weather have been outside historical expectations. The facts are that all of this is consistent with a greenhouse-gas-warmed climate that is wetter in some areas and drier in others. This warming is driven by radiative energy imbalance of the Earth resulting from increasing atmospheric concentrations of greenhouse gases. Greenhouse warming is expected to continue in the coming decades and may in fact accelerate through the removal of cooling aerosols. Attendant oceanic and atmospheric conditions will likely lead to persistent and amplified extreme weather events and climatic conditions in the coming decade, though natural variability will modulate (both worsening and ameliorating) these conditions.⁴⁰

All of the above underscores the fact that climate change is a potential threat to U.S. national security. As an example of this, both the 2010 Quadrennial Defense Review and the 2010 National Security Strategy identify climate change as likely to trigger outcomes that will threaten U.S. security. The analysis finds that, absent unknown or unpredictable forces, the increase in extreme events observed in the past decade or two is likely to continue in the next one to two decades. This increase will impact water, energy, food security, and critical infrastructure as was discussed at the Symposium. It brings into focus the need to consider the accelerating nature of climate stress, in concert with the more traditional political, economic, and social indicators.⁴¹

As the presentations and discussion at the Symposium showed, the necessary adaptation to the stress of climate change will cut across many sectors and will require new policy commitments and new funding. Improved scientific understanding will be required to provide better forecasts and both civil and military sectors will have to recalibrate their response and plans for infrastructure. We are facing a new normal, one whose full impacts are not yet understood. It might be useful to consider revisiting all of these issues in another Vermont Journal of Environmental

39. *Id.*

40. *Id.* at 1.

41. *Id.*

Law Symposium, a few years from now, to assess how well society is adapting and what changes in strategy might be needed.