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Key Points:

- The notion of a global threshold of dangerous climate change is now an obstacle
- We propose an alternative framework to manage the spectrum of climate risks
- We present a solution space defined by the limits of mitigation and adaptation

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The difficult, the dangerous, and the catastrophic: Managing the spectrum of climate risks

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Abstract The notion of a threshold of dangerous climate change has been central to national and international efforts to address climate risks. However, the focus on a single target has now become an obstacle because it reinforces three key problems: it frames climate change as a distant abstract threat, it impedes integration of mitigation and adaptation, and it fails to recognize the diversity of values and risk perceptions of people around the globe. We present an alternative framework that considers both biophysical science and social values in characterizing the broad spectrum of climate risks. The framework also presents the options for managing these risks within four quadrants defined by the inherent limits to mitigation and adaptation. This quadrant-based approach to managing the spectrum of climate risks restructures the climate change problem from avoiding a distant catastrophe to minimizing collective suffering.

1. Introduction

For the last two decades, climate advocates and policy makers have pursued a global solution to avoid "dangerous" change, a goal originally set in the United Nations Framework Convention on Climate Change in 1992. Many have adopted a 2°C rise in global average surface temperature above preindustrial levels as the threshold beyond which dangerous change will occur [*Randalls*, 2010]. Others have focused on thresholds in greenhouse gas concentrations such as 350 ppm of carbon dioxide [e.g., *Hansen et al*., 2008]. Although some have questioned the feasibility or appropriateness of such targets [*Shaw*, 2009; *Dessai et al*., 2004; *Risbey*, 2006], the notion of a dangerous threshold has been valuable in the popular discourse for highlighting the scale of the challenge and helping to focus climate negotiations. But the single global threshold has now become an obstacle to progress because it reinforces three key problems confronting society in addressing climate change: it frames climate change as a distant abstract threat; it impedes integration of mitigation and adaptation; and it fails to recognize the diversity of values and risk perceptions of people around the globe. Here we outline these problems and propose an alternative framework to facilitate collective management of the wide spectrum of climate risks.

2. Dangers of a Single Dangerous Threshold

First, a single global threshold isolates climate change as a distant and abstract threat, which inhibits many from understanding it and seeing it as a priority [*Nisbet and Myers*, 2007]. Climate affects almost every aspect of society, including the food that people eat, the water that communities drink, and the economies that societies build. Each of these is at risk to a continuum of adverse impacts as a result of climate variability and climate change. Individuals are often more concerned with the immediate risks, such as those associated with the intensity and frequency of heat waves, droughts, and hurricanes, because these threaten aspects of ordinary life. Yet a single global threshold, such as 2°C, focuses attention on the more distant risks associated with crossing that threshold, for example, the loss of ice sheets and mass extinction of species, impacts that can only be imagined because they are outside our daily experience. This focus is amplified by a popular narrative that the threshold is a "red line" separating difficult impacts from the truly catastrophic [*McKibben*, 2012]. Thus, the notion of one global threshold has shaped the climate problem as an abstract struggle to "save the planet," apart from the risks confronting society today.

Second, the single dangerous threshold has impeded integration of efforts to reduce the atmospheric concentration of greenhouse gasses (mitigation) with efforts to adjust to the changing climate (adaptation),

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because it has focused the climate discourse narrowly on policies and technical solutions for reducing emissions of greenhouse gasses. Although climate advocates and policy makers increasingly recognize that mitigation and adaptation are both needed to manage the spectrum of climate risks [*Klein et al*., 2007], in practice, mitigation and adaptation are promoted by different communities, and each mostly fails to consider the full risk spectrum. This disconnect is illustrated when mitigation advocates use weather-related disasters, such as Superstorm Sandy, to motivate emissions cuts, even though the risks of similar disasters in the near future cannot be lessened through emissions reductions because of inertia in our biophysical and social systems [*Metz et al*., 2007; *Tebaldi and Friedlingstein*, 2013]. In the near term, reducing the risks of the next Sandy will depend on changing development patterns.

Finally, *the focus on* a *single dangerous threshold fails to acknowledge that diverse stakeholders perceive climate risks and evaluate potential solutions differently*. Scientists commonly define risk as the product of the severity of impact and the probability of occurrence, and use data and models to forecast how the climate will change, estimate the likelihood of any given change, and predict the consequences. Yet, independent of what risk models show, the broader public perceives the probability and severity of a given impact through the filter of their personal values and social context [*Kahan*, 2010; *Kahan et al*., 2011; *Weber and Stern*, 2011]. Consider two stakeholders presented with a scientific assessment of the risk of mass species extinctions by end of the century. One stakeholder may value species threatened with extinction more than another stakeholder, and thus judge their loss as more severe. Stakeholders also perceive the likelihood of future events differently, especially when scientific estimates of the probability have large uncertainties [*Lorenzoni et al*., 2005; *Fischhoff*, 2007].

The 2°C target itself is a value judgment agreed to by international negotiators at the United Nations Climate Change Conference in Copenhagen in 2009 as the temperature above which the aggregate risks to global society become unacceptable [*Mann*, 2009; *Randalls*, 2010]. However, members of global society have diverse values and thus diverse perspectives on what constitutes "dangerous" change [*Dessai et al*., 2004; *Risbey*, 2006]. The substantial uncertainty about what will happen if temperatures rise by 2°C [*Keller et al*., 2008] combined with the diversity of stakeholder priorities has contributed to the "climate change collective action problem," in which countries would be better off collectively reducing emissions but perceived self-interest compels them to continue emitting at high levels [*Ostrom*, 2000]. Acknowledging the diversity of stakeholder values and risk perceptions may open greater opportunities for collective action in emissions reductions [*Vasconcelos et al*., 2013] and also highlights the need for a more comprehensive approach to managing the spectrum of climate risks.

3. An Alternative Framework for Managing Climate Risks

Here we propose an alternative framework that captures the spectrum of climate risks, incorporates science and values, and shifts the focus from a top-down declaration of danger to a bottom-up characterization of the risks that a diversity of stakeholders perceive as dangerous. In Figure 1, we present a climate risk space defined by the severity of potential impacts and the time scale over which impacts may be realized with rising temperatures. The single dangerous threshold focuses on the upper right portion of this space. Yet the differing values and risk perceptions of global society require consideration of the full space. To illustrate how one might populate this space based on multiple stakeholder values and perceptions, we plot a few potential impacts, enclosed by boxes colored to represent two hypothetical stakeholders (red and blue). The vertical position indicates the stakeholder's value of impact severity and the box-line thickness indicates stakeholder perception of impact likelihood. For example, consider two stakeholders presented with the Intergovernmental Panel on Climate Change results characterizing the extent and probability of loss of Arctic sea ice [*Parry et al*., 2007]. Although both may accept a high likelihood of losing Arctic sea ice in the near future, they may value the loss differently: catastrophic for one, acceptable for the other. In contrast, although both stakeholders may value the potential loss of the Greenland ice sheet as equally severe, they may differ in how they respond to scientific estimates of probability; one may believe that the likelihood of it occurring in a relevant time frame is lower and thus perceives it as a lower risk.

This framework also provides a conceptual space to evaluate possible climate management options (Figure 2). As John Holdren, U.S. President Obama's Science Advisor, has argued, society has three options

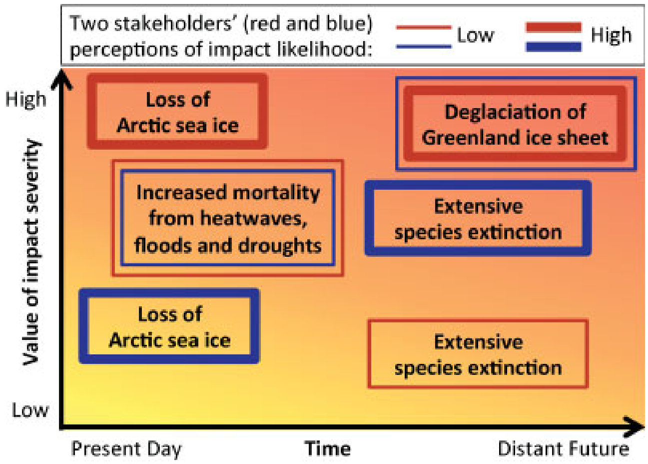

Figure 1. Climate risk space. Conceptual map of climate risk perceptions held by multiple stakeholders. Risks vary across a spectrum of severity and time scale over which impacts may be realized with increasing global temperature. Two hypothetical stakeholders (red and blue) may value impacts differently (vertical position) and perceive impact likelihood differently (box-line thickness). Four possible combinations are illustrated.

for managing climate risks: mitigate, adapt, or suffer [*Holdren*, 2008]. To the extent that impacts are not avoided through mitigation and adaptation, society will simply suffer them. However, no matter how much emissions are reduced and preparations are made for a changing climate, there are limits to how much suffering can be avoided. These limits depend on biophysical thresholds and social values [*Adger et al*., 2012]. For example, warming above a certain threshold may lead to the irreversible loss of species or loss of Arctic sea ice [*Metz et al*., 2007]. These losses would be beyond the limits of adaptation [*Dow et al*., 2013], to the extent that we value these attributes of our current world [*Adger et al*., 2012]. There are also fundamental limits to mitigation. Because of the warming already committed to by past and present emissions, and the inertia of our biophysical and social systems, mitigation policies implemented today will not have a significant influence on the climate for decades [*Wetherald et al*., 2001; *Friedlingstein and Solomon*, 2005; *Metz et al*., 2007; *Tebaldi and Friedlingstein*, 2013].

The limits of mitigation and adaption define four quadrants that represent the potential solution space for addressing climate risks (Figure 2). The upper right quadrant represents potential adverse impacts that are too severe to be adapted to, but are far enough in the future to be potentially avoided by mitigation. In contrast, the lower left quadrant consists of less-severe, near-term impacts that can only be addressed by adaptation. The quadrant in the lower right encompasses impacts that could be managed by either mitigation or adaptation. And finally, the quadrant in the upper left includes the potential impacts that are both too immediate and too severe to be dealt with through either adaptation or mitigation; the only possible outcome is suffering. The actual size of the suffering quadrant will depend on society's ability to achieve the full potential for mitigation and adaptation within these inherent limits.

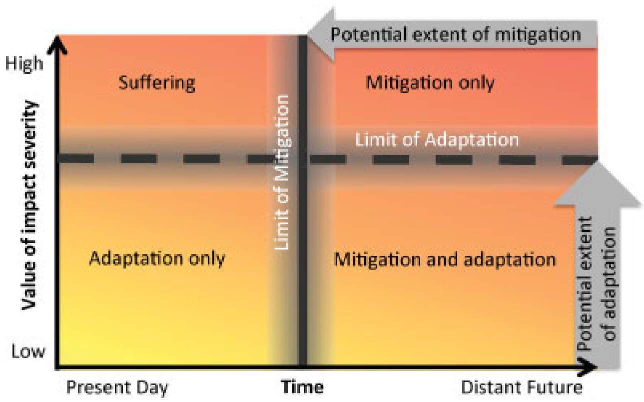

Figure 2. Risk management quadrants. Conceptual map of options for managing climate risks. Four distinct quadrants are defined by inherent limits to mitigation (vertical, solid line) and adaptation (horizontal, dashed line). Grey bands represent uncertainty. The size of the suffering quadrant will depend on the extent (arrows) to which the full potential of mitigation and adaptation are realized by climate policies.

Figure 2 provides a conceptual framework for an integrated approach to managing the full climate risk space, which overcomes the three problems with the single global threshold. First, this framework integrates the full spectrum of potential climate risks. Second, by identifying both the limits and the opportunities of adaptation and mitigation, it facilitates an integrated approach to solutions. Third, it provides a structure for considering a diversity of values and risk perceptions rather than imposing a fixed set of priorities as defined by a global threshold.

We depict the climate risk management space in Figure 2 in the simplest possible terms to focus on a broad reconceptualization of the climate challenge. Applying this framework across multiple spatial and temporal scales will introduce some complexities. For example, where the limits of mitigation and adaptation polt will depend on the context. The limit to mitigation line is plotted relative to any present moment and will shift with time, moving further to the right until aggressive mitigation measures are adopted. It could also move to the left for consideration of rapid reductions in emissions of gasses with short atmospheric residence times [*Smith and Mizrahi*, 2013]; however, over the long-run, the limits of mitigation will be largely defined by reductions in CO_2 emissions [*Tebaldi and Friedlingstein*, 2013; *Shindell et al*., 2012]. Similarly, the limits of adaptation may be defined differently by different communities [*Adger et al*., 2009]. In some applications the limit of adaptation may not plot as a horizontal line. Instead, it could slope down to the right to account for both the present-day unrealized potential to reduce suffering from the impacts of current climate variability [*Hulme et al*., 1999; *Adger et al*., 2005] and future loss of resilience as impacts accumulate [*Scheffer et al*., 2001]. The risk management quadrants framework could also be elaborated to encompass risks introduced by solar radiation management and other geo-engineering schemes, which create the potential for rapid changes in the climate system and a suite of unintended consequences [*Ricke et al*., 2010].

4. Conclusion

We argue that the notion of a single, global threshold of dangerous climate change, has outlived its usefulness as a focus for the climate discourse. In its place, we propose a new climate risk management framework that incorporates the inherent limits to mitigation and adaptation, and links scientific risk assessment with social values and risk perceptions. This risk management quadrants framework overcomes the problems with the dangerous threshold by restructuring the climate challenge around minimizing collective suffering, rather than averting a distant catastrophe.

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