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Is the Arctic an Economic Time Bomb?
Integrated Assessment Models Can Help Answer This Question

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Summary

In recent years the Arctic has been warming nearly twice as fast as the global average. Such change leads to various economic opportunities in the Arctic, but also negative impacts on the climate, ecosystems and communities in the region itself and also worldwide. It is therefore essential to accurately quantify the global costs associated with Arctic change. To do this properly we need to bring together up-to-date, transdisciplinary knowledge on both the climate and economic systems. We assess if and how leading Integrated Assessment Models, including PAGE09, can be used to compute the economic valuation of potential long-term global impacts of the changing Arctic.

Extended Abstract

The Arctic has been changing at unprecedented rates over the past two decades, with the average rate of warming in the region roughly twice as high as the global average (IPCC, 2014). According to WG1 of the 5th Assessment Report by IPCC (2013), there is growing evidence that the Arctic is is an integral part of the Earth system. This means that the climatic processes that occur in the region could have far-reaching consequences across the globe.

Arctic warming is manifested primarily by retreating sea ice, receding glaciers and thawing permafrost (Wadhams 2012; Maslowski et al, 2012). This creates multiple economic opportunities in the region: oil and gas extraction, mining, commercial shipping, fisheries, tourism and agriculture (Gautier, 2009; Smith & Stephenson, 2013). All these drivers are likely to lead to substantial investments into new infrastructure in the Arctic, with potential to generate multi-billion dollar annual revenues over the coming years and decades (Emmerson & Lahn, 2012). There are however multiple vested interests in the Arctic, and these are only expected to grow while more opportunities open up as a result of Arctic warming (Ebinger & Zambetakis, 2009).

Amid the short-term economic potential of a warmer Arctic (Masters, 2013), there is also concern about the negative global impacts related to the rapid Arctic warming (IPCC, 2014). This applies not only to the obvious direct impacts on the climate, ecosystems, and local communities itself, but also to the likely repercussions of the destabilising Arctic across the globe.

For example, the strength of Arctic polar amplification may be affecting climate patterns in the entire Northern hemisphere, which is manifested by a growing number of extreme weather events (Francis & Vavrus, 2012; Petoukhov et al, 2013; Walsh, 2014). These weather extremities include heat waves, floods and severe winters, posing threats to the highly-populated regions such as Western Europe, North-East US, China and India. The growing number of these events has been linked to a greater jet stream variability, which in turn in being attributed to the rapid warming in the Arctic (Coumou et al, 2014; Hall et al, 2014; Mori et al, 2014).

Some of the more pessimistic scenarios for the Arctic warming suggest that the summer sea ice could disappear within the next couple of decades (Overland & Wang, 2013), and considerable

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amounts of greenhouse gases, most notably CO2 and methane, could be released from thawing permafrost on land and beneath the sea bed (Shakhova et al, 2010; Shakhova et al, 2014). All these processes can accelerate regional and global warming.

Research in ecological economics demonstrates that climate change carries significant economic impacts worldwide (IPCC, 2014; Stern, 2007; Dietz and Stern, 2014; Nordhaus, 2013; Hope, 2013). However, these studies do not specifically analyse how the changing Arctic may generate additional costs incurred because of accelerated climate change and various feedbacks loops. Thus, a key outstanding question is whether the changing Arctic will result in significant economic impacts worldwide, and how best to quantitatively asses different scenarios of change.

According to the recent study by Whiteman et al (2013), one of the most extreme scenarios occurs when warming Arctic waters lead to abrupt atmospheric release of methane from potent gas hydrates which are stored under the Arctic subsea permafrost (Shakhova et al, 2010). This scenario could cost the global economy an estimated 60 trillion dollars (net present value). While some natural scientists suggest such sudden releases of vast quantities of methane are 'implausible' (e.g., Archer, 2014), others argue that underwater methane release in the East Siberian Sea is a valid threat (Shakhova et al, 2014).

Arctic climate feedbacks that carry economic costs are not restricted to this one example. Methane releases from land-based permafrost is another potential threat (Shaver et al, 2014), and preliminary estimates suggest that the economic impacts could be significant (Hope and Schaefer, under review). In addition, further economic impacts from a number of Arctic-related processes such as accelerated sea ice retreat, Greenland ice sheet melt and the resulting rising of global sea level, increased incidents of extreme weather events in the Northern hemisphere and ocean acidification have not yet been incorporated into economic models of the climate change.

Given the global and systemic nature of Arctic climate feedbacks, the additional economic costs of Arctic-related climate change may counter-balance and possibly outweigh the economic opportunities arising from a warming Arctic region (e.g., from shipping, increased access for the extractive industry).

Integrated Assessment Models can help clarify this issue. IAMs provide a comprehensive tool capable of addressing the very complex issue of the impacts of the climate change through combining simplified representations of the climate, economy and policy options (Weyant & Hill, 2000; Parson & Fisher-Vanden, 1997). This approach requires a number of assumptions and trade-offs, but nevertheless has proved to be effective in communicating the key economic figures to policymakers (van Vuuren et al, 2011). In this paper, we review three leading Integrated Assessment Models (PAGE09, DICE 2013R and FUND 3.9) and critically assess the strengths and limitations of these tools for decision-making in the context of a changing Arctic.

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