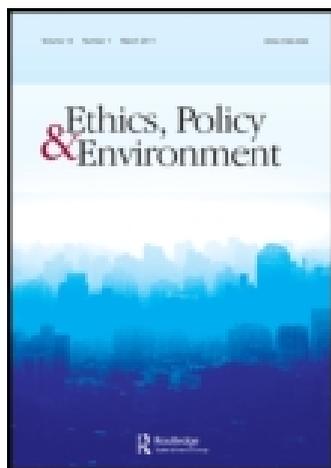


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OPEN PEER COMMENTARY

Solar Geoengineering: Reassessing Costs, Benefits, and Compensation

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In their article ‘Ethical and technical challenges in compensating for harm due to solar radiation management geoengineering,’ Svoboda and Irvine argue that setting up a just system of compensation for solar radiation management (SRM) geoengineering ‘faces severe difficulties’ that might be insurmountable. At the same time, they contend, ‘instituting a *just* SRM compensation system might be a necessary condition for SRM to be ethically permissible’ (italics original). I agree that building a just system of SRM compensation would entail overcoming serious technical and ethical challenges. However, I believe that these problems are more tractable than Svoboda and Irvine appreciate, and that a proper concern for ethics demands that critics of geoengineering take the possible benefits of SRM much more seriously. In this brief commentary, I will consider the true severity of several of the obstacles identified by Svoboda and Irvine, and make the case that a comprehensive ethical perspective on SRM requires a more complete exploration of the potential costs *and* benefits of solar geoengineering.

Svoboda and Irvine start from the premise that, ‘If deployed, SRM geoengineering likely would result in harm to some persons and benefit to others, thus creating both “winners” and “losers”’; unequal distributional consequences across countries and regions, they argue, would necessitate some form of SRM compensation system. The meme of regional ‘winners and losers’ is common in the literature on geoengineering, but new evidence from innovative modeling work suggests that realistic SRM deployment scenarios might produce few if any losers while benefiting virtually all regions of the world. Moreno-Cruz, Ricke, and Keith (2012) developed a basic model demonstrating that SRM can successfully compensate for more than half the world’s climate change-related temperature and precipitation damages while leaving no region worse off. Kravitz et al. (2014) build on this work to show that, if both temperature and precipitation changes are valued, all regions of the world are better off (closer to preindustrial conditions) with some SRM than with no SRM. According to these and other research efforts, the unequal impacts of SRM may be much less severe than typically assumed, reducing the potential for conflict and lessening demands on any compensation system.

The need to provide compensation to possible victims of SRM deployment may be less acute than previously thought; nevertheless a workable compensation system is likely to

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be essential to any decision to implement solar geoengineering. Svoboda and Irvine are correct in pointing out the serious technical difficulties that would hamper efforts to attribute specific damages to particular SRM interventions. Yet the potential solution they identify, Fraction Attributable Risk (FAR), holds more promise for overcoming the attribution problem than they acknowledge. They point to one study that successfully used FAR to attribute the 2003 European summer heat wave to climate change, yet many other similar analyses have since been published demonstrating attribution for events including flooding in the UK in 2000 (Pall et al., 2011), the Russian heat wave of 2011 (Dole et al., 2011), and drought in East Africa in 2011 (Funk, 2012). Moreover, methodological improvements to FAR are being matched by innovations in legal reasoning and increased reliance on statistical evidence in courts around the world, which together facilitate greater use of probabilistic techniques such as FAR to resolve damage claims (Lord, Goldberg, Rajamani, & Brunnee, 2012). Without question, the attribution issue poses a serious obstacle to awarding compensation for SRM damages; however, continuing advances in climate modeling and legal thinking render this problem more tractable than it otherwise appears.

Svoboda and Irvine devote the bulk of their attention to some of the more vexing ethical challenges that would confront a SRM compensation system. They focus in particular on issues of who should pay, who should be paid, and how much should be paid, rightly highlighting the fact that there are no self-evident answers to these questions. Yet their essential line of criticism is that these issues represent instances of 'ethical uncertainty,' implying that for compensation to be regarded as just, ethical certainty is required. It is difficult to imagine any matter of public policy meeting such a standard. But plenty of real-world policy mechanisms, including for compensation, are considered morally acceptable by a diverse range of thoughtful observers. Indeed, the field of international relations offers many examples of compensation systems that, while undoubtedly imbued with ethical uncertainty, nonetheless are widely viewed as equitable, efficient, and just.

The international oil spill regime, for instance, rests on a compensation system in which ship owners and oil companies jointly compensate a wide array of spill victims based on mutual recognition of national damage awards. To date, the regime has distributed more than \$700 million in payments for damages (International Oil Pollution Compensation Funds, 2011). Not only have the number and volume of oil spills fallen dramatically since the system became operational, there is general agreement that its arrangements strike a fair balance between the interests of victims and those responsible for spills (de la Rue and Anderson, 2009; Faure and Hui, 2005; Tan, 2006). Ethical ambiguity and disputes, of course, continue to apply to most if not all aspects of the oil spill regime; the USA, for example, refuses to ratify key conventions because it believes regime liability limits are too low given the scale of possible damages. Nevertheless, the oil spill regime is one of many examples of an international compensation system that, despite the persistence of ethical uncertainty, is widely viewed as legitimate and effective.

By definition, a discussion about compensation, for SRM or any other activity, is concerned with costs. However, focusing exclusively on costs threatens to obscure the real benefits that such activities might provide. It is important to keep in mind that, historically, societies have adopted systems of compensation for hazardous activities precisely because the benefits are believed to outweigh the costs (International Law Commission, 1995). Indeed, the recent modeling work described above has begun to make such assessments on global and regional scales and, as noted, initial findings suggest that the benefits of SRM

may outweigh its costs both globally *and* for individual regions. To repeat, this evidence indicates that, with moderate levels of SRM, every region on the planet would likely experience conditions closer to what prevailed in the preindustrial era than what they will face in a world of unmitigated climate change. Because the global South is less capable of adapting to climate change than the global North, SRM is likely to benefit developing countries disproportionately by reducing the magnitude of climate damages they would otherwise suffer. From an ethical point of view, this is very important, as SRM has the potential to help the world's most vulnerable, least well-off populations most of all, while also benefiting wealthier countries.

Ethics certainly requires that issues of loss and compensation be recognized and addressed, even if the associated challenges are less daunting than they first appear. But ethics also requires promoting the interests of all, in particular those who are least powerful. When discussing the possible costs and benefits of solar geoengineering, it is incumbent on ethicists to take account of both sides of the ledger, and to acknowledge the possibility (probability?) that the benefits of SRM may outweigh its costs by a significant margin, for the rich but especially for the poor.

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