CORRESPONDENCE:

Solar radiation management could be a game changer

To the Editor — Barrett *et al.*[1] argue that, given the challenges with solar radiation management (SRM) geoengineering, "when the use of geoengineering is politically feasible, the intervention may not be effective; and … when the use of geoengineering might be effective, its deployment may not be politically feasible". We believe the first part of this conclusion depends on a relatively narrow definition of efficacy that may not reflect the real concerns that would motivate a potential deployment of SRM, whereas the second part of the conclusion lacks evidence and therefore is speculative at this stage.

Although the evidence from model studies about the impacts of SRM geoengineering is, at present, limited, the initial evidence broadly indicates that SRM deployed to cool the climate could potentially reduce many of the physical impacts of climate change as well as the risk of crossing tipping points[2–4], as Barrett *et al.* acknowledge. This is because many climate impact drivers depend directly on temperature, such as high-temperature extremes, the thermal expansion of water, the melting of snow and ice and the intensity of precipitation[2–5].

Barrett *et al.* argue that the potential benefits of SRM could not be secured due to political controversy around regionally differentiated effects and fears of becoming 'addicted' to SRM. While there are undoubtedly regional differences in the climate response to SRM, the general reversal of temperature increases would be felt worldwide, as would some benefits such as a reduction in sea-level rise[2,4,6]. To argue that SRM deployment is politically infeasible due to its differentiated regional effects, which will be challenging to predict in detail, it would have to be demonstrated that regional considerations would trump the benefits of an overall reduction of physical climate impacts in shaping states' preferences. The claim that the fear of becoming addicted to SRM would make SRM politically unfeasible would similarly need to be substantiated by theoretical considerations and evidence from analogous cases.

Barrett *et al.* claim that as a response to crossing a tipping point, SRM would be politically feasible, but ineffective. However, they fail to acknowledge that while SRM may not reverse the changes following the passing of a tipping point, in many cases it could reduce the rate of change and hence reduce some of the harm that the passing of a tipping point would cause[7].

SRM is no panacea; it would introduce new risks and would shift the overall burden of risks, which might pose substantial political problems, as Barrett *et al.* indicate. It is also clear that to minimize the risks posed by climate change, mitigation will need to be pursued vigorously. Although much is uncertain about the potential impacts of SRM, should we not at least seriously consider how the world would react if SRM eventually proved to be a highly effective means of reducing the physical risks of climate change? In this case, SRM geoengineering would indeed be a game changer. ❐

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Peter J. Irvine*, Stefan Schäfer and Mark G. Lawrence
Institute for Advanced Sustainability Studies, Sustainable Interactions with the Atmosphere, Berliner Strasse 130, Potsdam 14467, Germany.
*e-mail: peter.irvine@iass-potsdam.de

CORRESPONDENCE:

Enhancing the impact of climate science

To the Editor — Rose[1] argues that embracing an 'evidence-informed' rather than 'evidence-based' attitude to policymaking should result in more effective action on climate change. As scientists who advise policymakers and environmental managers, we suggest instead that (1) scientists need to work harder to communicate results in a concise and accessible way and (2) more attention needs to be given to turning policy into practice.

Science can't — and shouldn't — prescribe policy, but it can ground it in reality, and the aspiration to be evidence-based is important. To do this, a clear distinction needs to be drawn between the presentation of evidence and advocacy of policy responses, otherwise the science may be undermined by a perception that it is politically biased[2]. We think Rose is unduly pessimistic about how influential climate science has been in setting many international and regional policy agendas, including those of the United Nations, the European Union and many national governments. The problems of turning policy into action are, however, often underestimated. Indeed, a significant challenge to further policymaking is that climate change mitigation is perceived by some to be impractical or too expensive.

The primary duty of scientists to policymakers is to present their work clearly and effectively. As the volume of publications on climate change has increased, this has become increasingly challenging. The latest Intergovernmental Panel on Climate Change reports are as close to comprehensive as it is possible to be and are fantastic resources, but will be read only rarely and selectively by policymakers. Even the summaries for policymakers are more appropriate to specialists within government departments than decision-makers. There is a need to concisely summarize the most important points and present them clearly. Distilling the message down to the key points for the intended audience is an essential element of review and synthesis, and the challenge is to do this in such a way that there is traceability from headlines to the underlying science. We have used the concept of a report card, where simple evidence statements can be tracked back through more detailed reviews to the original literature[3], and commend this as one effective option.

Developing good policy is not the same as solving a problem: it has to lead to effective action. In the UK there has been a high-level policy direction to adapt to and mitigate climate change for many years and this was hard-wired into law in the 2009 Climate Change Act. Nevertheless, a recent report[4] concluded that while there was progress, the "underlying pace of emissions reduction was insufficient to meet future carbon budgets". Adaptation and mitigation are intrinsically different from climate science and impacts studies, requiring input from many sciences and leadership by practical people: engineers, farmers, planners and many others. The challenge to scientists is to inform and challenge them as much as policymakers. ❐

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M. D. Morecroft*, H. Q. P. Crick, S. J. Duffield, N. A. Macgregor and S. Taylor
Natural England, Mail Hub Block B, Whittington Road, Worcester WR5 2LQ, UK.
*e-mail: Mike.Morecroft@naturalengland.org.uk

CORRESPONDENCE:

Statistics of flood risk

To the Editor — Jongman *et al.*[1] used numerically derived river discharges from climate simulations to estimate river flood risk for Europe for previous and future time periods. Based on mathematical statistics[2–7], I argue here that the statistical modelling and assumptions underlying the study are inadequate and that the resulting risk estimations are poorly supported.

Jongman and colleagues' model[1] has several steps (Fig. 1). The model combines river discharges and estimated annual maxima, regional risk of river basins, dependence between discharges and the linking of the sub-models to estimate the entire risk. If one of these steps is not validated, then the entire estimation becomes questionable. Sufficient statistical modelling should include parameter estimation, statistical model selection and test of hypothesis and/or significance of the model[2–5].

The annual discharge maxima at gauging stations of European rivers have been modelled using the Gumbel distribution (Fig. 1, step 6). This is an extreme value distribution, which is reasonable. However, the significance of the applied model has not been validated, for example, by a goodness-of-fit test[5], and alternatives such as the generalized extreme value distribution[6] are not considered.

Jongman *et al.*[1] modelled the dependence between the monthly local discharge maxima by the flipped[1] Clayton copula[4] called the Survival–Clayton copula (Fig. 1, step 4). If a bivariate random distribution is modelled by a copula, then the marginal distribution has to be the same for each random realization. But the gauging process is a seasonal phenomenon with an individual maxima distribution for every season. This seasonality has to be removed before all observations can be used for estimating a single copula for all months, which Jongman *et al.* did not do. Furthermore, the significance of the applied copula has not been tested[7].

The Survival–Clayton copula includes an asymptotic upper-tail dependence that is in contrast to records of river floods in the United Kingdom[8,9]. The tail behaviour of the Survival–Clayton copula also results in an increasing dependency between the maxima for increasing return periods (Supplementary Figs 1 and 2). This is why the copula of the monthly peaks must not be applied for the annual peaks, as done by Jongman and colleagues[1]: they fitted the return periods of the loss estimation for the 'annual maxima' and computed the copulas for the 'monthly peak'. Such a procedure would only be correct

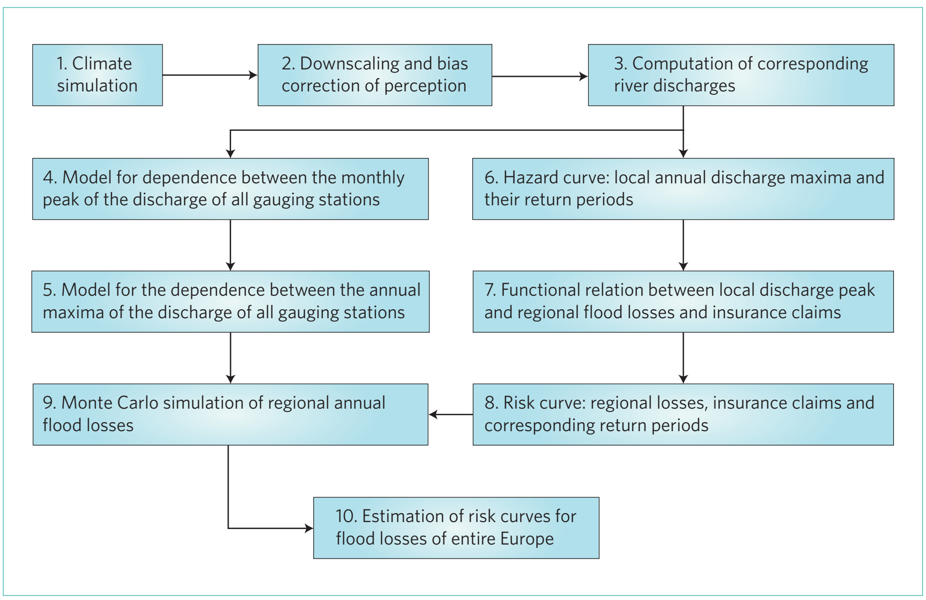

Figure 1 | Scheme of the model elements of the flood risk estimation by Jongman and colleagues[1].