NEWS & VIEWS

doi:10.1038/nature12406

EARTH SCIENCE

A holistic approach to climate targets

An assessment of allowable carbon emissions that factors in multiple climate targets finds smaller permissible emission budgets than those inferred from studies that focus on temperature change alone.

JOERI ROGELJ

Ensuring sustainable human development for future generations will involve putting limits on the pressures that global society exerts on our planet[1]. Global warming is only one of those pressures; ocean acidification, chemical pollution and the rate of biodiversity loss are examples of others. These impacts do not occur in isolation. Many are intertwined and thus call for an integrated approach that explicitly accounts for possible interactions. A study by Steinacher *et al.*[2] published on *Nature*'s website today shows the importance of such an integrated-systems perspective, and provides valuable insight into what could form part of a "safe operating space for humanity"[1]. The authors quantify the ways in which simultaneously achieving multiple sustainability objectives influences the amount of carbon emissions we are allowed to emit. Their most striking finding is that when multiple limits are not allowed to be exceeded, permissible carbon emissions are generally lower than for the most restrictive single limit — a direct result of this holistic approach.

Steinacher and colleagues' study focuses mainly on the climate system, but is not restricted to warming alone. Consistent with how the climate system is being defined in the international policy arena[3], the authors include aspects and interactions of the atmosphere, hydrosphere and biosphere in their analysis. By doing so, they go the crucial extra mile beyond previous studies that focused on temperature[4,5] or other effects in isolation. They impose limits on six target variables of the climate system that are related to one or more of the above-mentioned 'spheres': global-mean warming; sea-level rise from thermal expansion; ocean-acidification indicators both in the Southern Ocean and in locations that are common coral-reef habitats; changes in the net primary production of the terrestrial biosphere; and the loss of carbon from cropland soils.

How do Steinacher *et al.* explain their finding that allowable carbon emissions under multiple climate objectives turn out to be lower than for the most restrictive single limit? They explored this question using a global climate model of intermediate complexity in a probabilistic set-up. Such an approach provided them with a fully interactive representation of the geophysical processes of interest at manageable computational cost. They observed many cases in which meeting one objective in isolation simultaneously leaves open the possibility that other objectives are pushed beyond their allowed values. Combining emission constraints for all objectives then results in an overall smaller allowable carbon budget.

As is the case for most modelling studies, the true value of Steinacher and colleagues' work lies in its insights, not in its numbers[6]. The study is instructive because the authors point out its limitations, and caution against reading too much into its results. The target variables that they assessed are illustrative and will need further elaboration. For instance, their choice of objectives was limited to processes actually represented in their model. Therefore, targets on regional sea-level rise, for example, or interactions between human health and air pollution, could not be evaluated. Stakeholders might also need to evaluate trade-offs and set priorities with regard to the stringency of the respective limits. Furthermore, because the authors could not account for uncertainties in the model's structure, the assessment remains dependent on the model used[7]. Finally, the analysis uses a set of emissions scenarios from the literature that were not explicitly developed to span the entire range of possible future outcomes, and can therefore be at best informative.

> ***"The results clearly demonstrate the importance of holistic and integrated assessments of sustainable human development."***

The study's results clearly demonstrate the importance of holistic and integrated assessments of sustainable human development. The conventional focus on temperature change alone should move towards a more comprehensive accounting of multiple objectives and their interactions, from the global to the local scale. It calls not only for fuller integration of geophysical processes and biogeochemical cycles, but also for approaches that explore integrated policy answers to those challenges.

The relevance of such assessments for policy-making cannot be overemphasized. Nowadays, policy-makers need to carry out the often difficult task of linking global objectives to a variety of local effects. Approaches that follow Steinacher and colleagues' study could allow them to define explicit sustainability limits for a range of effects that directly influence the well-being of the populations involved. This will result in a better understanding of trade-offs and synergies between objectives, allowing them to be prioritized more effectively. To be sure, no modelling framework can by itself objectively make such prioritization. This will remain subject to value-and-risk judgements, on which people rarely agree. Even integrated modelling will not avoid that, but it will provide a more formal way to explore the consequences of certain choices.

In conclusion, Steinacher and colleagues' work adds further weight to the large body of scientific evidence that shows the increasing risk of climate-impact thresholds being exceeded if global action is delayed further[8–10]. On the positive side, when looking for robust and integrated solutions to these challenges, it is often the case that significant synergies are found if multiple objectives are pursued simultaneously[11]. Steinacher *et al.* have added an important piece to the puzzle of attempting to manage the transition to a sustainable future for our society, a puzzle that in itself will undoubtedly be subject to great societal debate. ■

Joeri Rogelj *is at the Institute for Atmospheric and Climate Science, ETH Zurich, CH-8092 Zurich, Switzerland, and at the International Institute for Applied Systems Analysis, Laxenburg, Austria.*
e-mail: joeri.rogelj@env.ethz.ch

1. Rockström, J. *et al. Nature* **461,** 472–475 (2009).
2. Steinacher, M., Joos, F. & Stocker, T. F. *Nature* http://dx.doi.org/10.1038/nature12269 (2013).
3. *United Nations Framework Convention on Climate Change* (UNFCCC, 1992).
4. Meinshausen, M. *et al. Nature* **458,** 1158–1162 (2009).
5. Allen, M. R. *et al. Nature* **458,** 1163–1166 (2009).
6. Hamming, R. W. *Numerical Methods for Scientists and Engineers* (McGraw-Hill, 1962).
7. Smith, L. A. & Stern, N. *Phil. Trans. R. Soc. A* **369,** 4818–4841 (2011).
8. *The Emissions Gap Report 2012* (UNEP, 2012).
9. Rogelj, J., McCollum, D. L., Reisinger, A., Meinshausen, M. & Riahi, K. *Nature* **493,** 79–83 (2013).
10. van Vliet, J. *et al. Clim. Change* **113,** 551–561 (2012).
11. McCollum, D. L. *et al. Clim. Change* **119,** 479–494 (2013).