

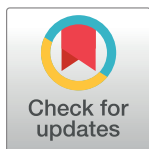
OPINION

# Managing values in climate science

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Climate science has been deeply affected by social and political values in the last fifty years [1]. If we focus on climate denial and obfuscation, we might see the influence of values as wholly negative and aim instead for objective, value-free climate science. But, perhaps surprisingly, this is at odds with the view of many philosophers who study the influence of values on science. Science cannot and should not be free from values, they argue. Rather, we should be transparent about our values, study their influence, and ensure that the right values play the right roles. But philosophers alone cannot determine what the right values are or what their appropriate use is. Close collaboration between climate scientists and philosophers is required for values in climate science to be accurately studied and appropriately managed.

## How do values enter science?

Values enter science through choices that are not determined by evidence or the pure pursuit of knowledge [2]. Choices of research prioritization are perhaps most directly value-driven, reflecting evaluations of societal importance by scientists or funders. Values also play a role within the research process, in the choice of methods [3], thresholds for reporting results [4], priorities in model development [5, 6], and the communication of uncertainty [7]. Sometimes values are active parts of the choice, while other choices have value implications which philosophers have urged scientists to be aware of.

As an example of the former, Winsberg et al. [3] argue that the debate in extreme weather event attribution, between scientists who favor fraction-of-attributable-risk methods and those favoring storylines, turns on how they weigh the risks of over-attribution vs. under-attribution. This is not a purely scientific question; it turns on considerations such as capturing the news cycle, motivating political action, and avoiding reputational harm to climate science.

Undorf et al. [6] consider a choice in equilibrium climate sensitivity (ECS) modelling to prioritize dust aerosols vs. black carbon aerosols in model development. This choice informs the model's strengths—the former is more important for Caribbean climate and the latter for the Indian summer monsoon. Resource-constrained teams cannot do everything and such choices impact the model ECS. This kind of trade-off is common, and while likely not made on ethical grounds, it does impact users and other stakeholders in those regions.

## Transparency through sensitivity analysis

The role of values should be minimized. One might hope that scientists can illuminate their impact and hand responsibility for them on to others. Sensitivity analysis is an important tool for this (as are its generalizations, such as perturbed-physics ensembles and multi-model ensembles). The simplest case is a choice involving the value of a continuous parameter which can be varied systematically. Sensitivity analysis performs best as a value-management strategy when a crucial values question is located in a single parameter, such as the discount rate.

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Complex choices are less amenable to this treatment, such as the choice of an attribution method which turns on a hard-to-introspect attitude to risk. Other issues aren't readily modeled, such as the classification of ambiguous data. (These choices can be studied, though the results are qualitative and partial [2, 3].) Priorities in model development are difficult to evaluate, as large climate models are costly to rebuild and rerun with different structural-dynamical features. Gathering existing models allows for some robustness analysis, but these "ensembles of opportunity" are limited in their ability to test unmodeled alternatives [8]. This may be a reason to design future models with alternative characteristics [9].

## Value management

So, the influence of values on results can only partially be illuminated. Philosophers thus argue that value transparency must be paired with value management [10]. Some insist that scientists have moral duties and encourage them to employ the right values [2]. Others highlight science's social role and aims, and argue that the values employed in scientific practice ought to support these [11]. For example, Cash et al. [12] suggest that information must be credible, legitimate, and salient to be usable. Legitimacy and salience, which directly relate to user interests and values, may require science that is value-influenced [13].

How might one ensure that the right values are used in the right ways? In addition to transparency and alignment with social priorities, Elliott [10] argues that value influences should be scrutinized through engagement with stakeholders. This is often realized via proposals for consultative forums with stakeholder representatives [14].

This proposal provides a mechanism for supplying values and defines the right values as those so provided. But while stakeholder engagement may be plausible in climate services, where there are well-defined uses and users [15], it is much less so in general research which produces multipurpose models and information. Suppose a Swedish team is modelling ECS and faces the aerosol-prioritization choice. Should *Swedish* social and ethical values determine whether to prioritize the Caribbean or Indian subcontinent? This choice may be irrelevant to the team's natural stakeholders. If they consult Caribbean and Indian stakeholders, how can they avoid prioritizing a few select voices?

## Conclusion

Understanding the role values play in climate science is crucial. Process-mapping efforts [6] can provide this understanding, but tracking choices in a modeling process requires scientific expertise, while evaluating their value-influences and implications requires philosophical expertise. Developing proposals for managing these values requires an assessment of what is practical, which in turn will depend on the complexity of the study and the extent of its value entanglement. So, interdisciplinary collaboration is crucial for successful value management. To start, the literature on values in climate science should move out of philosophy journals and into scientific fora such as this.

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