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Blue limits of the Blue Planet: an exploratory analysis of safe operating spaces for human water use under deep uncertainty

Jos Timmermans (1), Jan Kwakkel (1), Nick van de Giesen (2), and Wil Thissen (1)

(1) Delft University of Technology, Faculty of Technology, Policy and Management, Multi Actor Systems Department, Delft, Netherlands (j.s.timmermans@tudelft.nl), (2) Delft University of Technology, Faculty of Civil Engineering and Geosciences, Water Management Department, Delft, Netherlands (n.c.vandegiesen@tudelft.nl)

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In the Nature article 'A safe operating space for humanity', Rockström et al. (2009) introduce the concept of a safe operating space for humanity. A safe operating space is the space for human activities that will not push the planet out of the 'Holocene state'. Rockström et al. have identified nine earth-system processes and associated thresholds which, if crossed, are expected to generate unacceptable environmental change. For climate change, rate of biodiversity loss, and the nitrogen cycle the safe global limits are substantiated theoretically and methodologically. The threshold for the global fresh water cycle is a tentative 'best guess' (Rockström et al. 2009). The article is, thus, an open invitation for further research to improve on this tentative best guess. This paper describes a research program that accepts this invitation and solicits methodological feedback, practical support and fruitful cooperation.

Our scientific approach is informed by four methodological points of critique on the method advanced by Rockström et al. notably, the ambiguous treatment of reductionism, the neglect of dynamic interactions between the subsystems, the importance of local conditions and scale, and structural uncertainties in the relation between the sub-systems. There is uncertainty about the fundamental relations between subsystems, there is uncertainty about future developments external to the modelled systems, and there is uncertainty about the valuation of the model outcomes both now and in the future. These uncertainties are referred to as 'deep' uncertainty.

In this paper, we propose an innovative, non-predictive re-use of the available predictive models, while focusing on the impacts of deep uncertainty and propose Exploratory Modelling and Analysis (Bankes, 1993) as an appropriate methodology. Exploratory Modelling and Analysis (EMA) uses computational experiments to analyze complex and uncertain systems and assumes the existence of and uses multiple models that are consistent with the available information, data, and knowledge. EMA explores these models across the range of plausible parameter values and offers methodological support for drawing valid inferences. We propose to apply EMA to existing global and regional dynamic water cycle models and derive conclusions on the resulting safe operating spaces from this exploration. For this interdisciplinary research we have arranged a team incorporating hydrologists and specialist in operations research, policy analysis and modelling and simulation. Furthermore this group is embedded in an international group of renowned specialist in similar fields.

The Nature article 'A safe operating space for humanity' (Rockström et al. 2009), has received worldwide attention. The proposed research contributes directly to its practical implementation and develops a methodological approach based on integrated dynamic models combined with innovative methods to deal with deep uncertainty that allow for the direct demarcation of safe operating spaces. This method can be transferred to the other sub-systems and thus carries the potential to seriously influence the methodological merits of the safe operating space concept. Societal impact of this research can be expected in the field of long term policy development for which EMA was originally developed, especially through the design of adaptive policies.

References

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