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On the role of scenarios in designing robust strategies: a comparison of MORDM, multi-scenario MORDM and Robust Optimization

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Abstract: The management of complex environmental problems typically involves deep uncertainties as well as competing priorities. Several methods have been presented in the literature to help decision-makers cope with these characteristics; these include many-objective robust decision making (MORDM) (Kasprzyk et al., 2013), and different techniques based on robust optimization (RO, reviewed in e.g. Beyer & Sendhoff, 2007). MORDM identifies a set of optimal management solutions under a given combination of uncertain conditions (i.e. a single scenario), then tests these solutions for their robustness across a broader set of scenarios. Conversely, RO directly evaluates robustness across multiple scenarios to define optimal solutions. Recently, Watson & Kasprzyk (2017) presented multi-scenario MORDM as a possible middle ground between the reference scenario approach of MORDM, and the multi-scenario perspective of RO. To better understand how the relative effectiveness of these methods may depend on the structure of the problem and its management options, we compare MORDM, multi-scenario MORDM, and RO with the classic lake problem (Carpenter, Ludwig, & Brock, 1999). The problem is simulated with open-loop management (Ward et al., 2015), and with two variants of a direct policy search (DPS) approach (Quinn, Reed, & Keller, 2017) which apply closed-loop management at different time scales. The analysis indicates that MORDM performs reasonably well with the DPS variants, but is less effective with open-loop management. RO is effective across management variants, but is more computationally expensive. Improved sampling techniques could mitigate this issue by reducing the size of the scenario ensemble used for optimization.

Keywords: deep uncertainty, many-objective robust decision making, many objective robust optimization