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Addressing uncertainty, multiple objectives, and adaptation in DICE: Can dynamic planning shed new light on the decision-making process?

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Integrated assessment models are often criticized because of: i) the simplified treatment of the severe uncertainties involved, ii) the strong dependency on the difficult quantification of future climate damages and iii) their implicit description of adaptation strategies.

We propose a novel approach to tackle these three issues by coupling a closed loop control strategy and an updated AD-DICE (ADaptation - Dynamic Integrated Climate-Economy) model. First, we model explicitly uncertain parametrization and stochastic processes for climate sensitivity, atmospheric temperature, population, productivity, and carbon intensity. We then ensure an adaptive response to the uncertainties by implementing a closed-loop control system where we condition the decision variables on state observation. This leads to an improvement with respect to the traditional static optimization approach. Second, we propose a multi-objective formulation of the optimization problem traditionally solved by DICE in order to separate temperature targets from economic objectives. This allows us to be less dependent on the climate damages quantification while studying the tradeoffs to find compromise solutions. Third, we include an explicit description of adaptation strategies introducing stock and flow adaptation investments as additional decision variables. Thanks to this last modification, we can also thoroughly analyze the tradeoffs between mitigation and adaptation.

Results show that the proposed method outperforms traditional static optimization both in single-objective and multi-objectives contexts. Moreover, we confirm the absolute need for fast and strong mitigation since we observe that the tradeoff between temperature and economic objectives is strongly reduced under uncertainty and when considering adaptation. On the other hand, different adaptation strategies correspond to a different balance of present value damages and economic objectives. By making explicit this tradeoff between two socio-economic objectives, results reveal the political nature of the choice over climate adaptation strategies.