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Earth System Dynamics
Discussions

Interactive comment on "The impact of uncertainty on optimal emission policies" *by* Nicola Botta et al.

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Thank you for the detailed review and suggestions. In the following, we provide point-to-point answers to the general comments 0 to 4 and to the specific comments 0 to 2.

Generic comments 0 and 1:

We have failed to make the point clear in the introduction: one would of course like to tackle the problem of computing optimal emission policies for individual countries as a (mixed sequential and simultaneous) sequential coordination game with a finite number of decision makers over a finite (but not necessarily known) number of decision steps and under different sources of uncertainty.

To the best of our knowledge, no theory (let apart a computational theory) is available for such problems today. A very common approach is that of slicing the problem into two main questions:

a) *When* and by *how much* global GHG emissions should be reduced to avoid unmanageable future states?

b) *How* to make sure that (fair, optimal, etc.) emission reduction quotas consistent with given optimal global reduction are actually implemented by individual countries or regions?

Answers to a) can be sought, among others, by extending standard control-theory approaches (one decision maker) to sequential decision problems with uncertain (non-deterministic, stochastic, fuzzy) outcomes.

Answers to b) can be sought, among others, by extending standard game-theory approaches (multiple decision makers) to decision games under mechanisms for incentivating the emergence of trust, coalitions and binding agreements.

From this perspective, "solving the GHG emission problem" requires an iterative solution of a) and b). Again, to the best of our knowledge, no attempts have been done so far at coupling a) and b) and solving the full problem. In our contribution, we focus the attention on a).

In revising our manuscript, we will expand the introduction and make the context of our contribution more clear.

Generic comment 2:

Using a verified computational method for computing optimal policies is crucial because optimality (e.g., of supposedly optimal policies) cannot, in general, be tested. This is one of the most prominent examples where "proving" is easier than "testing". From an applicational perspective, computing verified policies allows us to study the impact of different assumptions (e.g. about uncertainties) in a rigorous fashion. In revising our

manuscript, we will discuss this point in more detail in section 3.

Generic comment 3:

In revising our manuscript, we will make the context of our contribution more clear and compare our results to, among others, those presented in the works of works of M. Webster.

Generic comment 4:

We are going to summarize the results of Botta et al. (2017a,b) in an appendix of our revised manuscript.

Specific comment 0:

The theory presented in Botta et al. (2017a,b) is based on the notion of *monadic* dynamical systems originally introduced by Ionescu in his PhD thesis. This allows us to treat deterministic, non-deterministic, stochastic, fuzzy, etc. problems with a seamless approach: the differences are captured by a single problem parameter and all computations (e.g. of optimal policies, possible trajectories, rewards, etc.) are generic with respect to this parameter. In revising our manuscript, we will make this point more clear.

Specific comment 1:

A sequential decision problem cannot be described as a sequence of payoffs: one has to give a function that returns one payoff for every suitable combination of current state, selected control and next possible state. We will summarize the results of Botta et al. (2017a,b) in an appendix of our revised manuscript and make this point more clear.

Specific comment 2:

This is a very important criticism that we have tried to anticipate with a "On a legitimate criticism to our contribution" comment posted on Oct. 13 on the ESD discussion site. Is there something specific that you find unconvincing in our comment? If the comment

helps dissipating some of your concerns about the robustness of the results presented in section 5, we would be pleased to add a revised version of the comment to section 5 of our revised manuscript.

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