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Earth System Dynamics
Discussions

# *Interactive comment on* "Economic impacts of a glacial period: a thought experiment. Assessing the disconnect between econometrics and climate sciences" *by* Marie-Noëlle Woillez et al.

**Anonymous Referee #2**

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This is an interesting article. While I see the point (raised by an earlier reviewer and editor) that it does not generate much knowledge on the real (warming) world, I believe it neatly summarises and illustrates issues with climate damage function, with an original twist of argumentation. The current article could stimulate discussion on the merits, limitations, and validation of damage functions, which would be a valuable contribution to the scientific discourse around climate change.

I therefore think that the article should be published. However, there are some issues which require clarification, as listed below.

Major Comments

Inconsistency: "known" cooling vs "unknown" warming scenario

An important line of argumentation seems to me that while we don't know what a warming world looks like, we can form an idea about a cooling of similar magnitude by looking at the ice age data. However, in fact, the paper does not assume a full transition to an ice age (which would involve long-term equilibration of ice sheets etc) but a quick cooling, i.e. a scenario for which we have no data. The uncertainty may involve the question of snow accumulation, raised by an earlier interactive comment, and effects

depending on it (e.g. circulation changes due to the albedo effect of the snow), but also changes in ocean circulations (how does the AMOC react to the cooling?). The fast cooling scenario may thus differ form an ice age in more respects than the presence or absence of ice caps.

So, is the damage in a fast cooling scenario just as speculative and difficult to assess than in a warming scenario?

There are in fact two types of uncertainty here, 1. what would the state of the climate system be like under fast cooling, 2., what would be the impacts for society?

In my view, there are two ways to deal with the first issue.

- Simply *define* that your cooling scenario is "an ice age except that ice sheets are not there yet". You would have to explicitly acknowledge that this may not be the actual response of the Earth system to a cooling stimulus (such as rapid greenhouse gas depletion), but you could still analyse the potential (societal) impact of such a hypothetical climate.
- Or perform a model simulation (/team up with a modelling group) of a 4degree cooling in 100 years, either by dropping GHG concentrations or a reduction in solar irradiation.

I strongly encourage you to consider the second option.

Once you clarified your climate scenario, you can argue, as you do now, that the impact of society would be severe (with higher certainty than the severity of an equivalent warming?).



Asymmetry warming - cooling

The ice-age scenario obviously contains very severe impacts for human activities, many of which cannot be captured by looking at recent data, as the ice-age Earth might be a qualitatively different place from our current world.

However, this does not *automatically imply* that a warming of equal magnitude would have similarly huge impacts.

This does not invalidate your main argument, that (statistical) damage functions *may* well overlook major impacts of climate change which current data cannot capture, but I would like this asymmetry to be acknowledged explicitly. Even better, if possible, would be to include a brief discussion on whether it is plausible/impossible to know/implausible that warming has similarly strong impacts as cooling. For example, how does the area (or number of inhabitants, or value of infrastructure) threatened by sea level rise under 4 degree warming compare to the area (or number of people/amount of wealth) threatened by snow under 4 degree cooling? Obviously, uncertainties are huge, but maybe something meaningful can still be said about the issue?

Enumerative vs. data-driven damage function

You use two damage functions of the statistical kind and none of the enumerative kind. Is this a conscious choice, and could you please motivate it? For example, did you make this choice because statistical damage functions inherently include the (statistical) effect of both cooling and warming, whereas the enumerative ones primarily look at warming (e.g. they may include a term for heat stress on maize plants, but not for frost stress...)?

In particular, it seems to me that your argumentation shows that capturing climate damage exhaustively with a statistical approach is impossible, whereas an enumerative

approach could work in principle (but maybe not in practice). Please clarify.

Minor Comments

- Line 253: “these regions would be about as suitable for humans as present-day Arctic is”... Instead of this picturesque metaphor, I suggest to specify the conditions (how cold and dry? unsuitable for any form of present-day agriculture, forestry, even Sami-style animal husbandry?).
- Line 266ff: “Most places would become unsuitable for agriculture and water resources would largely decrease. Drier regions include ...India and Indonesia”. Would drying be a severe concern in regions that are currently wet (like Indonesia and parts of India)? And even if rainfall decreases, could it not be that the reduction of evaporation due to cooling compensates the effect, leading to no severe increase in drought? Note that several regions, including the Mediterranean, and parts of South Africa, are threatened by drought under global warming (for example because of poleward expansion of the ITCZ system and hence the subtropical deserts). Of course, drought needn’t be linear in global mean temperature, but possibly these regions would get less drought-prone under global cooling.
- This reference could be interesting for the general discussion on damage functions: JCV Pezzey, “Why the social cost of carbon will always be disputed”, https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.558,

Technical Comments (typos etc)

- line 265: o fthe -> of the
- line 294: does not captures -> capture



- fig. 1: Islande -> Iceland