

Interactive comment on “Diverging responses of high-latitude CO₂ and CH₄ emissions in idealized climate change scenarios” by Philipp de Vrese et al.

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As a whole, the paper is well written. The topic is timely in light of the ongoing attempts to understand and quantify the multi-centennial climate response to the continuing anthropogenic greenhouse gas emissions and their decline in future.

Thus, I vote for publishing this manuscript subject to addressing the following comments.

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Major comments

The major comment to the paper is due to the lack of studying the regional pattern of the hysteresis-like phenomenon in the manuscript. Eliseev et al. (2014) found that the hysteretic response of permafrost extent is due to strong difference in thermophysical properties between the mineral soil and peat. I expect that this issue could be applicable to this manuscript as well.

In addition, there is a subtlety in term 'hysteresis'. In physics, this term is reserved for the response of a multi-stable system to change of an *externally imposed* governing parameter. This is different from the phenomenon studied in the present paper. Here, the hysteresis-like response is due to transient properties of the system under investigation — basically, because of difference in response time scales between different compartments (e.g., due to different thermal inertia between peat and mineral soil in (Eliseev et al., 2014)). This is highlighted by the fact that both variables forming the hysteresis curve (e.g., in Figs. 3-6 of the manuscript) are *internal* variables of the system. As a result, term 'transient hysteresis' was introduced by Eliseev et al. (2014). I suggest to discuss this issue in the paper under review as well.

Minor comments

- ll. 74 and 789: The correct year for Eliseev et al.'s paper is 2014.
- l. 110: '...very different properties ...' Very different for thermophysical or for hydrological processes?
- l. 137: z in Eq. (1) lacks units. Otherwise, this equation is ambiguous.
- l. 163: '...the number of days per year in which surface temperatures crossed

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- ...'. I guess, it should be 'the day of the year when surface temperature crossed ...'.
- l. 201: it should be 'anaerobic or aerobic'.
 - l. 201: it should be 'its shape'.
 - l. 265: the better spelling would be 'soil chemical composition'.
 - l. 270: the better spelling would be 'soil pore space'.
 - l. 343: '2' and '4' in chemical formulae should be subscripts.
 - l. 537: I guess, one of two numbers is wrong, because 9 MtC yr^{-1} is $12 \text{ TgCH}_4 \text{ yr}^{-1}$.
 - Fig. 2: This figure is difficult to read. I suggest to place ensemble means in the left column and draw the maps in the middle and right columns as *differences* from these ensemble means. In addition, phrases like 'Ensemble–minimum thaw depth (annual maximum) ...' in caption to this figure is quite difficult to understand for a general reader. I suggest to put the wording in form 'Ensemble minimum for annual maximum thaw depth ...' and so on.

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