

# ***Interactive comment on “Attribution in the presence of a long-memory climate response” by K. Rypdal***

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# Response to reviewer # 1

K. Rypdal

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Thanks for a constructive review. My response to the reviewer's comments and how they will be adopted in the revised manuscript can be found below.

1. *Reviewer*: Please define AD.

*Response*: This will be done. Actually, there are different conventions, and the usage of AD (Anno Domini) should be done by placing it before the year (e.g., AD 1880), not after as I have done. A more neutral convention is to use CE (Common Era), which is placed after the year (e.g., 1880 CE). In the revision I will adopt the latter.

2. *Reviewer*: Please define in detail the meanings of fingerprint and footprint.

*Response*: I think the meaning I give to these words are clearly explained in the text, but I will include some more discussion. In particular because the word "climate footprint" is used in the literature in the meaning of the contribution of specific human activities to the increase in greenhouse gas concentrations. The meaning I give to the fingerprint concept is essentially the same as presented in Chapter 10 on "Detection and Attribution" in the IPPC AR5, WG1, although

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my usage is simpler since I don't employ principal component analysis or other noise reducing techniques prior to extracting the fingerprint. The usage of the word footprint is not conventional. Reviewer #2 finds it "a little silly," and suggest to replace it by "forcing function" or "response function." In my response to Reviewer #2, I explain why I don't find any of these terminologies adequate. I will also explain in more detail why I use this terminology in the revised manuscript.

3. *Reviewer:* Page 1311, line 15-17: I don't understand this sentence. Attribution does not necessarily only refer to anthropogenic changes, so also internal modes can cause global temperature changes which are attributable.

*Response:* I don't see the problem here. What the reviewer writes is essentially the same as what I write, except that the word "anthropogenic" has no place here. Anthropogenic causes are treated on the same footing as natural ones. My point is that statistical inference like multiple, linear regression does not establish a causal link, but rather establishes a statistical model where the observation is expressed as a linear combination of predictor functions (here called fingerprints). These predictor functions may be components of the forcing, and for those cases the attribution is causal. But predictor functions can also be characteristic signatures (fingerprints) of internal modes, which may be established from theory or observation of another climate variable than the one we are modelling. In the latter case we postulate a link (correlation) between the predictor and the modelled variable (predictand), but this link does not have to be causal in the sense that the predictor causes the response. They can for instance have a common cause. This is also discussed on page 1320, lines 24-27.

4. *Reviewer:* Page 1316: Fig. 6a is referenced before Figs. 3-5.

*Response:* Yes, I know that this is not formally right. But I just wanted to point out that this also is done in Fig. 6a and c, which deals with a different data set. I cannot move this figure, so the alternative is not to mentioned Fig. 6 here.

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5. *Reviewer*: Page 1320: Empirical mode decomposition should be explained and referenced.

*Response*: The empirical mode decomposition is just one of many decomposition methods that give very similar results, so I rather rephrase the paragraph than digress on this particular method.

6. *Reviewer*: The LM model diverges for large times. I think it would be good if the reasons for this would be discussed. Is this due to missing nonlinear effects/feedbacks in the model? Or is this the imprint of the non-stationarity of a long-memory climate?

*Response*: The LM response diverges for large times only if the forcing is permanently changed, i.e. if the time-average over a wide time-window is changed. The model is intended to be a simple one-parameter representation of the temperature response valid only within a certain range of scales. One way to think about it is that it describes a linear system involving a hierarchy of exponential responses. It can be shown that such a system is distinguishable from a system with power-law response up to the largest exponential response time. Hence, the power-law kernel should be cut off at certain scale. In Rypdal and Rypdal, *J. Climate* (2014) we investigated this question, and showed that this cut-off scale should be larger than several centuries in order for the model to predict the Moberg record with acceptable accuracy. I see no reason to repeat that discussion in this paper, but in the revision I have expanded the discussion of the long-term effect of an initial radiative imbalance.

7. *Reviewer*: Figure axes: I would prefer if the figure axis would be labeled with absolute years instead of relative.

*Response*: I will fix that.

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