

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

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Response to reviewer # 2

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Reviewer: I agree with reviewer #1's comments, especially the use of the terms fingerprint and footprint. I actually find the transformation of a fingerprint into a footprint a little silly. Perhaps the authors could come up with better words. I prefer using “forcing function”, “response function” etc., though I know it is not usually defined to be completely equivalent.

Response: I think the meaning I give to these words are clearly explained in the text, but I will include some more discussion in the revision. 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 my usage is simpler since I don't employ principal component analysis or other noise reducing techniques prior to extracting the fingerprint. My usage of the word footprint is not conventional. I will explain below why I have used it, but first discuss the reviewer' suggestions and other alternatives.

What we are discussing is to find an appropriate word that names the various compo-

nents of the “explained signal” (or “response variable” or “predictand”) in a linear regression. “Forcing function” is very misleading, for two reasons. One is that it will give the impression that the footprints represent the forcing, which it does not. When the fingerprint arises from a forcing the corresponding footprint represents the *the response* to that forcing. But some footprints are not necessarily the response to a forcing, which is the case if it represents an internal mode. “Response function” (or rather “response variable”) is better than “forcing function,” but I think that “response function” is a misnomer in the statistics literature, because “response” is associated with cause-effect linkage. This is as bad as assuming that correlation implies causation.

This paper is not written for statisticians, and I have in mind that the main results should be accessible even for non-scientists. I therefore try to avoid too much of the statistics jargon. Lay-people understand that a fingerprint is a weak signal that contains a lot of information, and is therefore suitable for detection. A footprint is influenced by the weight of the person that makes it, and as an allegory it is used to indicate *an effect, or an imprint*. This is exactly the way I use this word in this paper. I am therefore not willing to drop the usage of these words, but I can add some more discussion of their meaning.

Reviewer: What I would like to see added is a discussion of the physical origin of the time scales involved in the temperature response. Especially, why should we expect these time scales to be the same for the different components? ... This perhaps is even more so with the AMO and Nino heat exchange with the ocean.

Response: In principle it would be possible to introduce different response times (for SRM) or scaling exponents (for LRM) for different forcings. But this would create more complex models, and if these exponents are treated as regression coefficients, more unknown parameters and increased chance of overfitting. Going to this kind of complexity would make the kind of study I have made here pointless, and full GCM-type modelling would be better. Here there already exist a vast literature.

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When it comes to “the AMO and Nino heat exchange with the ocean,” I don’t see the relevance. Here the indices themselves have been used as fingerprints (predictors), and hence there is no response model, and hence no response times, involved.

Reviewer: Regarding the many internal variations (or modes of oscillation, if you want), it should be discussed why AMO and Nino are the ones chosen. Nino I can understand, as it is the biggest reorganization of heat. It seems that the AMO is “convenient” since it is the only one of the five forcing component, which seems to be correlated with the warm forties/cold sixties seen in the global temperature.

Response: I have discussed why I have chosen those two modes, and it is true that the AMO is chosen because it carries an obvious long-time scale signature of the instrumental record. This is a dubious thing only if one interprets attribution as causation. I have been very clear on emphasizing that this analysis does not imply that AMO is the cause of the large scale variability in GMST, only that using this signal obtained by probing the Atlantic SST serves as a good predictor for these features of the GMST. I could have done the same with the PDO, and found that it is not that good a predictor, because the phase-match with the GMST is not so good. That would have been an interesting result too, but then I could go on and include all known modes in the climates system, which wouldn’t make much sense.

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