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Climate of the Past Discussions

Interactive comment on "Multi-periodic climate dynamics: spectral analysis of long-term instrumental and proxy temperature records" *by* H.-J. Lüdecke et al.

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There have been a series of interesting and controversial comments and reply ion this manuscript. Both reviewers see interesting aspects in the manuscript but both also highlight major concerns on the main conclusion of the paper, namely that the effect of greenhouse gases is not necessary to explain the evolution of the observed European temperatures and that the analysis indicated that the detected periodicities originated in intrinsic dynamics. I concur with the views of the reviewers that a major revision is needed before these conclusions can be justified, but I encourage the authors to submit a revised version addressing the criticism raised in the open review phase.

Both reviewers and some commentators expressed their concern that the statistical analysis may be qualified as a fit to the observed time series. The estimation of the periodicities is based on the whole instrumental record available and therefore they are influenced by all possible factors affecting variability, internal and external. The fact that the inverse Fourier transform can well describe the observed record doe not lead per se to the conclusion that greenhouse gases are not required to explain the temperature evolution. I see some misunderstandings in this chain of reasoning. First, greenhouse gases are not the only external climate driver. There exists many others, both anthropogenic factors , such as tropospheric aerosols and land-use, and natural factors such as solar variations and volcanic eruptions. The authors seem to base their conclusion on the assumption that anthropogenic greenhouse gases must display a secular (i.e. non oscillatory) influence. Whereas this is true, the authors have not shown that the combination of all external forcings in the period analysed cannot lead to an apparent quasi-period influence. A second concern, this time from my side solely, is that it is difficult for the sole statistical analysis of temperature series to lead by itself to the conclusion that variability is due to internal dynamics. For instance, if Earth temperatures would just linearly respond to variations in solar activity, and solar activity would be governed by periodic, chaotic, long-term persistence or any other type of behaviour, we would observed this type of behaviour in the temperature record as well, but its variability would be totally externally driven and not internally generated. This simple example illustrates that the attribution of temperature variations should include an analysis of the external climate forcing. Though found interesting by both reviewers, this caveat relates to a large part of section 7.

A minor, but not totally unimportant point, related to the discussion is the reference to Esper et al. (2012), a paper of which I happen to be co-cauthor and thus I feel impel to comment on. The quote from this paper is a misrepresentation of its actual contents. Esper el. al (2012) focused on millennial reconstructions of summer Scandinavian temperatures and not of the 'world temperature'. The millennial temperature drop is caused by a well understood orbital forcing that in summer time exhibits a negative

trend at high latitudes. It, however, shows a positive trend in the tropics over the last 2000 years.

Fortunately, I see at least two ways in which the authors can prove their main point, and I would welcome if a revised version could incorporate both avenues. A positive outcome from both would certainly strengthen the authors' conclusion. One way is to limit the spectral analysis to the period in which anthropogenic forcings can be assumed to have been smaller, say until 1950, and try to predict the subsequent temperature evolution in which anthropogenic greenhouse forcing has grown stronger. If the main conclusion is correct, the good fit between observed record and reconstructed record should remain basically unaffected. The authors include in the Figure 5 a prediction of the future temperature evolution. It is now customary in climate science that a predictive statistical model be validated by withholding part of the data and testing its predictive skill with independent data. Uncertainty bounds in the prediction should also be included, thus addressing the point raised by one commentator about the uncertainty in the determination of the spectral frequencies and amplitudes. All in all it would address the reviewers and commentators' general concern that the good agreement between the observed and the reconstructed record merely may just represent a statistical fit to the data.

Another possible way for the authors is to analyse series of European temperature simulated by a climate model. Both CMIP3 and CMIP5 projects make data from many model simulations over the historical period 1850-2000 driven by the best estimations of external forcings, natural and anthropogenic, available to all researchers. These simulated series undoubtedly contain the influence of greenhouse gases among other external drivers. If the authors' conclusion turns out to be correct, the spectral analysis of these series should indicate that it is not possible to describe them by just a few periodicities. A fit of comparable skill, on the other hand would indicate that this type of analysis is not able to discriminate between internal, anthropogenic and other external natural forcings.

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