Nonlinear Processes
in Geophysics
Discussions

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Interactive
comment

Interactive comment on "Trend analysis by a piecewise linear regression model applied to surface air temperatures in Southeastern Spain (1973–2014)" *by* P. Campra and M. Morales

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Dear Sr, Thanks for carefully reading our paper and for your interesting suggestions on key issues. I answer to your suggestions in between lines.

A) (1) comments from referee 2 and author's responses

1- "In my opinion the paper is too center in the statistical analysis and more explanation about the possible reasons or justifications of these breakpoints in the periods observed are necessary in a climatic sense..."

Our intention here was just to describe the changes in surface temperature series in the area for a limited period of study. So this study is limited to two goals: -First, by fit-

ting a simple linear regression model, estimate statistically significant trends -Second, an complementary to simple linear fit, by fitting a piecewise regression model, detect and characterize internal and significant breakpoints inside the time series. So, this is just a "detection" study, not an "attribution" study. Here, we just deal with the detection of changes, not with attribution to physical explanations. As stated by the IPCC Good Practice Guidance Paper (Hegerl et al., 2010): Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example <10%. We have presented here such a detection study, using $p<0.05$ as significance level. However, our study does not deal at all with attribution, is defined at the same Guidance as "the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence. The process of attribution requires the detection of a change in the observed variable or closely associated variables". As you have stated, the most interesting consequence of detecting breakpoints in temperature time series is the search of new forcings of climatic nature that might have driven those changes in linear trends. However, that goal is further away than our intention in this short communication paper. The issue of understanding the sensitivity of the climate system to both natural and anthropogenic changes still remains even in long term temperature changes. This task is much more difficult when trying to explain causality of short or mid-term breakpoints in a local time series, were non-linear climate response might be linked to smooth changes in local forcings. Nevertheless, in the manuscript we have suggested some future lines of research in the field of attribution studies aimed to estimate the impact of dramatic land use changes around two of the stations, MA and AL series. For this, numerical simulations with mesoscale climatic models are the best way to study such attribution to physical forcings, a methodology that is totally out of the scope of this paper. In the case of AL (Almeria), we have indeed carried out these climatic simulations with WRF model and obtained solid evidences

of land use changes influence on long term trends (Campra et al, 2008, Campra and Millstein, 2013).

2-"The reasons of the breakpoints should be look for in the possible changes of atmospheric circulation""

As stated above, this kind of attribution link is not possible simply by regression studies as ours. As Tome and Miranda (2004) state, turning points obtained by piecewise regression are only related to a given series of data used for the fit. This way, for instance, it must be beared in mind that breakpoints obtained for global temperature series might not have special meaning for other local or regional climate series.

3-"" more discussion in this sense is necessary in order to justify the use of this method instead of a simple regression trend."

As we state in the introduction section, our initial justification for the use of non-linear fitting regression instead of conventional simple linear regression was the possibility to detect inner changes in long term climatic trends and their structural changes. We have chosen piecewise regression in an attempt to obtain a better fit as well as to improve the predictive performance of the model. Our starting point was the few previous works were piecewise regression was applied to temperature series (Karl et al, 2000; Tome & Miranda, 2004). In none of these attribution analysis are presented, due to the issues explained above. Furthermore, at the discussion and conclusion we have shown that the empirical results with the analyzed data suggest that the choice was appropriate, in our opinion. This model allowed us to better describe the inner structure of change and determine breakpoints in long term trends in surface air temperatures at the main SE Spain records. In conclusion, we present here a non-linear fit COMPLEMENTARY to, but not instead of a simple linear fit. We have explained this idea with a new paragraph on p34, L9.

4-" Could be the breakpoint observed in 1996 with climate shift?"

We guess that you mean if we have detected breakpoints around the global climate cooling caused by the Pinatubo eruption in 1991. Though this disturbance can be clearly seen by causal inspection of time series (Fig 1), it was a short-term cooling and global temperatures recovered their mean values in 1-2 years. The breakpoints are detected by checking if there exist a significant difference between the slopes from both segments with the restriction of each segment includes a time period of, at least, 5 years. So, the non-detection of the previously mentioned point can be due to the restriction or to the lack of significance in the change of the slopes. Due to this restriction given to the piecewise algorithm, it does not yield a breakpoint exactly at 1991-92, but in general breakpoints are located around the early 90s for every series. To avoid confusion about this point, we have now deleted the mention to Pinatubo eruption in the reviewed text, taking into account that we have not studied the attribution of our breakpoints.

5- "the authors could say why the method work different in Tmean that in Tmax or Tmin"

It is logical that there is less difference in the goodness of fit for Tmean, as the time series is obtained by averaging Tmin and Tmax, obtaining a smoothed time series.

We have included this idea in the text (P7, L10)

âĂČ b) Changes in the manuscript

In order to make clearer these issues, and improve the manuscript with the suggestions of Referee 2, we present a more conservative manuscript, by deleting or modifying the text were the main doubts or confusion have been pointed out by referees 1 and 2 , basically dealing with attribution of changes or the global pause issue. We have made these changes in the manuscript:

P4 L15. Deleted the reference to global pause ("However, recent warming trends throughout the planet. . .)

P4 L30 . End of introduction section. Deleted last lines (p4, l30-37) and inserted new

lines to make clear that we present a "detection", not an "attribution study" (p5, L1 y ss, "Here we present. . ."

P7, L10. Inserted explanation of differences between Tmean vs Tmin and Tmax at table 2.

P7, L17. Mention to Pinatubo eruption deleted.

P9, L10. Last line deleted from, "Our regression analyses. . ."

P9, L24. Deleted from "no matter the uncertantiy of breakpoints. . ."

P9, L29. Deleted from " Furthermore, recent breakpoints observed in MA and GR..",

P9, L37. Deleted from "To obtain statistical evidence. . ."

P10, L3. Inserted final suggestion on attribution studies: "Future attribution studies. . .

P10, L6. Inserted ", neither that long term warming trends in the area of study have come to an end."

P10, L9. Deleted final comment "Complementary to this search of statistical relationships. . ."

P34, L9. Inserted a final conclusion justifying the use of piecewise fit, "complementary" to simple linear approach: "We believe that our analysis of piecewise regression fit. . ."

Finally, references included at the deleted text have been deleted, and a new reference has been added:

Hegerl, G.C., O. Hoegh-Guldberg, G. Casassa, M.P. Hoerling, R.S. Kovats, C. Parmesan, D.W. Pierce, P.A. Stott, 2010: Good Practice Guidance Paper on Detection and Attribution Related to Anthropogenic Climate Change. In: Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution of Anthropogenic Climate Change [Stocker, T.F., C.B. Field, D. Qin, V. Barros, G.-K. Plattner, M. Tignor, P.M. Midgley, and K.L. Ebi (eds.)]. IPCC Working Group I Technical

Support Unit, University of Bern, Bern, Switzerland.

We enclose here the reviewed manuscript with tracked changes.

Regards,

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Please also note the supplement to this comment:
http://www.nonlin-processes-geophys-discuss.net/npg-2016-29/npg-2016-29-AC2-supplement.pdf

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