Web links to the author's journal account have been redacted from the decision letters as indicated to maintain confidentiality.

4th Nov 20

Dear Dr Van der Wiel,

Your manuscript titled "Contribution of climatic changes in mean and variability to temperature and precipitation extremes" has now been seen by our reviewers, whose comments appear below. In light of their advice I am delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment under the open access CC BY license (Creative Commons Attribution v4.0 International License).

We therefore invite you to revise your paper to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

EDITORIAL REQUESTS:

Please review our specific editorial comments and requests regarding your manuscript in the attached "Editorial Requests Table". Please outline your response to each request in the right hand column. Please upload the completed table with your manuscript files.

If you have any questions or concerns about any of our requests, please do not hesitate to contact me.

SUBMISSION INFORMATION:

In order to accept your paper, we require the files listed at the end of the Editorial Requests Table; the list of required files is also available at https://www.nature.com/documents/commsj-file-checklist.pdf .

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We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Heike Langenberg, PhD

Chief Editor
Communications Earth and Environment

On Twitter: @CommsEarth

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

Review of “Contribution of climatic changes in mean and variability to temperature and precipitation extremes” by K. van der Wiel and R. Bintanja

This paper aims at separating the influence of mean and variability changes in future changes of extreme temperature and precipitation across the globe. They use data from a large ensemble (LE) of simulations performed using a single model although they also assess results with other LEs. To quantify the contribution from mean/variability they use the so-called Probability Ratio that has been widely used in detection/attribution studies. The paper is well written and rigorous. The results are also clearly presented and easy to understand.
Having said that, I have two main criticisms about the paper. The first one is that the literature review is not as comprehensive as it should be and is missing a number of papers that have address the topic, particularly regarding temperature extremes. As a consequence, the contribution of the paper is much less original than claimed here. For example, a similar methodology to the one presented here to separate changes into a mean shift and variability has been applied by Lau and

Nath (2012, 2014) and Argüeso et al. (2016). Other papers that should be included are Donat et al. (2017), Wehner et al (2018) and Di Luca et al (2020). Di Luca et al (2020) discusses in detail how the separation in mean/variability depends on some issues that are here overlooked in this paper including the use of the annual mean instead of the seasonal mean and the influence of changes in the diurnal temperature range.
The second main comment is about the paper being based on monthly data (i.e., addressing monthly extremes). This is not made clear in the abstract nor in the introduction of the paper and comes as a surprise when reading the results. For example, the paper often refers to "heatwaves" and "extreme events" which are not likely to be identified using monthly data. One problem I see when using monthly data is that most of the theory we have about extremes (e.g., about how precipitation extremes will change in the future and why they might differ from the average precipitation) are associated with short-live events, definitely shorter than the monthly scale. As a consequence, the interest of separating mean and variability is much more limited when looking at monthly data compared with daily or subdaily data. This is not to say that there is no scope for studies focusing on monthly extremes, but they are definitely less interesting.

References:
Argüeso, D., Di Luca, A., Perkins-Kirkpatrick, S.E., Evans, J.P. (2016). Seasonal mean temperature changes control future heat waves. Geophys. Res. Lett. 43 (14), 7653–7660.
Di Luca, A., de Elía, R., Bador, M., & Argüeso, D. (2020). Contribution of mean climate to hot temperature extremes for present and future climates. Weather and Climate Extremes, 28, 100255.
Donat, M. G., Pitman, A. J., & Seneviratne, S. I. (2017). Regional warming of hot extremes accelerated by surface energy fluxes: Accelerated warming of hot extremes. Geophysical Research Letters, 44, 7011–7019.
Lau, N.-C., and M. J. Nath (2012), A model study of heat waves over North America: Meteorological aspects and projections for the twenty-first century, J. Clim., 25(14), 4761–4784.
Lau, N.-C., and M. J. Nath (2014), Model simulation and projection of European heat waves in present-day and future climates, J. Clim., 27(10), 3713–3730.
Wehner, M., Stone, D., Mitchell, D., Shiogama, H., Fischer, E., Graff, L.S., Kharin, V.V., Lierhammer, L., Sanderson, B., Krishnan, H., 2018. Changes in extremely hot days under stabilized 1.5 and 2.0 C global warming scenarios as simulated by the HAPPI multi-model ensemble. Earth Syst. Dynam. 9 (1), 299–311.

Reviewer #2 (Remarks to the Author):

The study is novel and interesting to read.
It has a well thought out methodology, in which I believed will be of considerable interest to a large audience in climate science and impact community.
The result has shown contributing mechanisms to climate extreme at different IPCC SREX regions of the world.
The method of analysis is robust with such a large ensemble of CMIP5 climate model data, this would however reduce uncertainty in the result presented.

Review on "Contribution of climatic change in mean and variability to temperature and precipitation extremes.

The study is interesting and novel with well thought out methodology, the result has shown contributing mechanisms to climate extreme at different IPCC SREX regions of the world.

Here below are some minor revisions to the manuscript:

Abstract

Page 1, line 10 and 11: Recast these statements for more clarity. I think " The Probability Ratio is applied to output of large ensemble of climate models to quantify the contribution of mean climate and climate variability.

Page1 line 11,12: consequently, the next sentence can read " The results shows that the increasing occurrence of high temperature is governed mainly by mean climate while in contrast, heavy precipitation depend considerably on climate variability"

Introduction

Page 1 line 23-24: Recast! Climate variability is not always on the higher extreme, it could also result in reduction than normal

Figure 1: The conceptual framework in figure 1 is better to be presented under the method section of the manuscript.

Result

Page 3 Line 70: events in a 2^{o}C warmer "climate". Remove world

Page 4 Line 81: Will precipitation increase 85% of the Earth's surface or Will they increase in over 85% of the Earth surface. Re-construct for clarity

Page 7 Line 124: Close the bracket after convection

Page 7 Line 126: You don't always have to refer the reader to see the Methods. It is assumed/expected readers have understood the methods before reading through the results

Page 7 Line 133: To what extent does this similarity exist in all the models? Usually, there is always the possibility of few models saying contrary in most researches.

Figure 4: Which of the lines from the plot represent each model. They are only representative of the Pr total, PR mean and the PR variability. However, I believe 6 models are also consisted here to reflect the PR mean, PR total and PR variability

Contribution of climatic changes in mean and variability to monthly temperature and precipitation extremes

Karin van der Wiel, Richard Bintanja

= Response to the reviewers =

Reviewer #1:

This paper aims at separating the influence of mean and variability changes in future changes of extreme temperature and precipitation across the globe. They use data from a large ensemble (LE) of simulations performed using a single model although they also assess results with other LEs. To quantify the contribution from mean/variability they use the so-called Probability Ratio that has been widely used in detection/attribution studies. The paper is well written and rigorous. The results are also clearly presented and easy to understand.

We'd like to thank the reviewer for their time and their positive comments. We agree with the comments made and have modified the manuscript in response.

Having said that, I have two main criticisms about the paper. The first one is that the literature review is not as comprehensive as it should be and is missing a number of papers that have address the topic, particularly regarding temperature extremes. As a consequence, the contribution of the paper is much less original than claimed here. For example, a similar methodology to the one presented here to separate changes into a mean shift and variability has been applied by Lau and Nath (2012, 2014) and Argüeso et al. (2016). Other papers that should be included are Donat et al. (2017), Wehner et al (2018) and Di Luca et al (2020). Di Luca et al (2020) discusses in detail how the separation in mean/variability depends on some issues that are here overlooked in this paper including the use of the annual mean instead of the seasonal mean and the influence of changes in the diurnal temperature range.

Thank you for these suggestions, we have added the papers by Lau and Nath, Argüeso et al, Donat et al, and Di Luca et al. Indeed changes in seasonal temperatures or the diurnal temperature range will influence the occurrence of high-temperature extremes, in our split we have grouped those under variability changes. .

The second main comment is about the paper being based on monthly data (i.e., addressing monthly extremes). This is not made clear in the abstract nor in the introduction of the paper and comes as a surprise when reading the results. For example, the paper often refers to "heatwaves" and "extreme events" which are not likely to be identified using monthly data. One problem I see when using monthly data is that most of the theory we have about extremes (e.g., about how precipitation extremes will change in the future and why they might differ from the average precipitation) are associated with short-live events, definitely shorter than the monthly scale. As a consequence, the interest of separating mean and variability is much more limited when looking at monthly data compared with daily or subdaily data. This is not to say that there is no scope for studies focusing on monthly extremes, but they are definitely less interesting.

To avoid confusion, we have added the word 'monthly' to the title, abstract (two times) and earlier in the introduction. A similar split for daily extremes is indeed also of interest, day-to-day variability is also influenced by climate change, and may be governed by different climate mechanisms than that of monthly variability. We have taken this suggestion on board for future studies.

Reviewer #2:

The study is novel and interesting to read. It has a well thought out methodology, in which I believed will be of considerable interest to a large audience in climate science and impact community. The result has shown contributing mechanisms to climate extreme at different IPCC SREX regions of the world. The method of analysis is robust with such a large ensemble of CMIP5 climate model data, this would however reduce uncertainty in the result presented.

We'd like to thank the reviewer for their time and their positive feedback. Below we note the revisions done in response to the suggestions of the reviewer.

Minor revisions:

Abstract
Page 1, line 10 and 11: Recast these statements for more clarity. I think " The Probability Ratio is applied to output of large ensemble of climate models to quantify the contribution of mean climate and climate variability.

Thank you for this suggestion. We have reworded the abstract to improve clarity. The journal guidelines state the abstract cannot exceed 150 words, so we have had to shorten the text as suggested by the reviewer a little. The editor also provided guidance here.

Page1 line 11,12: consequently, the next sentence can read " The results shows that the increasing occurrence of high temperature is governed mainly by mean climate while in contrast, heavy precipitation depend considerably on climate variability"

See previous comment.

Introduction
Page 1 line 23-24: Recast! Climate variability is not always on the higher extreme, it could also result in reduction than normal

More severe weather than normal could indeed also indicate the negative, we have added an example of severe cold or drought to highlight this.

Figure 1: The conceptual framework in figure 1 is better to be presented under the method section of the manuscript.

We have asked the editorial team whether this was an option. They do not normally have figures in the method section. We therefore have kept the figure in its current location.

Results

Page 3 Line 70: events in a 2oC warmer "climate". Remove world

Modified as suggested.

Page 4 Line 81: Will precipitation increase 85% of the Earth's surface or Will they increase in over 85% of the Earth surface. Re-construct for clarity

Precipitation extremes will become more likely for 85% of the Earth's surface area. We have clarified.

Page 7 Line 124: Close the bracket after convection

Modified as suggested.

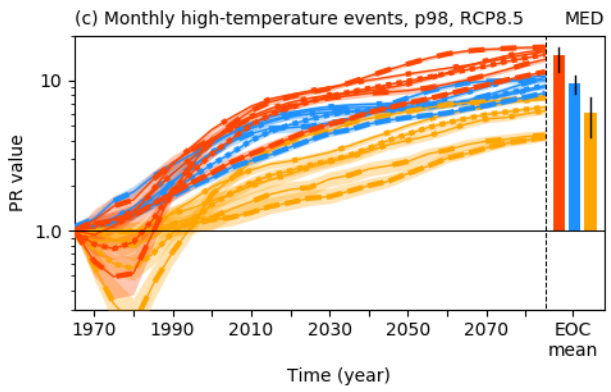
Page 7 Line 126: You don't always have to refer the reader to see the Methods. It is assumed/ expected readers have understood the methods before reading through the results

Because this is the first time we use the MMLEA data, we prefer to keep this reference. The copy editors may remove it if this is against journal standards.

Page 7 Line 133: To what extent does this similarity exist in all the models? Usually, there is always the possibility of few models saying contrary in most researches.

Following the suggestion of the editor the supplementary figure has been moved to the main text. In the new figure 8 it can be seen that all models agree on the temperature split, which is dominated by changes in mean climate. For precipitation extremes the differences are larger as noted in the text and further highlighted in figure 9d for the Mediterranean region.
In figure 7 we have highlighted by means of thicker uncertainty lines if there is intermodel disagreement in the direction of change (PR above or below 1).

Figure 4: Which of the lines from the plot represent each model. They are only representative of the PR total, PR mean and the PR variability. However, I believe 6 models are also consisted here to reflect the PR mean, PR total and PR variability



Each of the panels contains 18 lines: 6 models x 3 PR values. We have tried to have unique lines for each model, but haven't found a way to do that while conveying our intended message as well (see figure to the side).

We therefore opted to keep the figure as it was, with only the EC-Earth model identifiable. The reason for this is that the other single-model figures are based on the EC-Earth model, and can therefore be put in context.

The aim of this figure is to show that our findings are robust, each of these independent models shows the same contribution of mean/variability changes to the total change in extreme event occurrence. For this we do not need the identify the individual models.

Editor:

The editorial comments were provided in a separate Word document. If substantial changes to the manuscript were made we have copied the question and response here.

The title should be a single declarative sentence of no more than ~15 words that gives a sense of your main finding. We would suggest you include "monthly" before "temperature and precipitation extremes", in line with reviewer 1's request to make the timescales clearer early on.

Modified as suggested.

The abstract advertises your paper and ideally appeals to a broad audience. Please make it as accessible as possible, and avoid or explain specialist terms. We recommend the following:
Format/style:

- Length: no more than 150 words.
- Accessible to non-specialists; no acronyms (please spell out probability ratio everywhere in the abstract, you can introduce the acronym at first use in the main text); no parentheses (please just make the parenthesis a sub-clause).
- Use language that accurately represent levels of uncertainty.

Content:

- Start with "Here we' to mark the description of the new work
- Briefly explain "probability ratio" methods where it is first mentioned.
- State findings, conclusions, implications concisely and explicitly (if you can, please state what we learn about the robustness of projections in the final sentence, rather than just saying that we learn something).

We have modified the abstract following these suggestions, it is difficult to fit it all within 150 words.

Please consider moving all your Supplementary Figures to the main text; we can allow up to 10 Figures in the main text.

We have moved all figures except the one defining the SREX regions (this is well known) to the main text. No supplementary material is left.

Please provide us with more information on the creation of the maps in your Figures (2, 3, Supp Info). Were these images and every element of these images created by you and/or your co-Authors? Please provide us with more information on the software and any third-party data used in the creation of these maps.

No permissions are needed. All figures (incl maps) were created using Python and only show data that were calculated especially for this manuscript. In the acknowledgements we thank Peter Pfleiderer who provided us with a script (which we modified) to create the SREX figure. His script is openly available online.