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Earth System Dynamics Discussions

Interactive comment on "Incremental improvements of 2030 targets insufficient to achieve the Paris Agreement goals" *by* Andreas Geiges et al.

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Geiges et al.: "Incremental improvements of 2030 targets insufficient to achieve the Paris Agreement goals" https://doi.org/10.5194/esd-2019-54 Compiled author responses to reviewer 2 comments

REVIEWER #2

General Comment

Reviewer Comment (RC2.00): In this paper, the authors first estimate emissions related to Nationally Determined Contributions scenarios, and then calculate correspond-

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Discussion paper

ing climate impacts. The paper is well written albeit brief in the analysis. The study design is particularly interesting and novel and the methods used are comprehensive. Presentation of the climate impacts and results in general, could be improved. The results section is shorter than the methods. Discussion could be made more interesting. Overall, this will be a very good paper, but I think there are some changes that are within the authors reach to greatly improve the work. Criticisms below.

Author Response (AR2.00): We would like to thank the reviewer very much for these thorough and constructive comments. We believe that by addressing them, we were able to improve the submission a lot. We have revised all figures, and expanded the results and discussion section, following the referee's suggestion. We provide more detailed responses to the individual comments below.

Major Comments

RC2.01: The authors appear to have made no efforts to make neither the results nor code available. I urge the authors to make at least the additional data used to make the figures available. Additionally, data on the NDC emissions scenarios and corresponding term-perature outcomes from MAGICC would also be useful to the community (e.g. Fig1).

AR2.01: Thank you for raising this important issue! We have made the results and the necessary plotting routines available in an online repository. A data and code availability section has been added to the manuscript, reading: "All data and code underlying the results presented in the figures of the study can be found here: https://gitlab.com/ageiges/ndc_ambition_esd_paper_material"

RC2.02: One weakness, given the substantial work already done, is why not more climate impacts considered. The authors have gone to great efforts in the first half of the work relating to NDCs, then only present three first order climate impacts. In the paper the authors estimate sea level rise impacts, extreme temperatures and economic damages – from different models/approaches. Considering precipitation, both high and low indicators, would have surely been straightforward to add to the statistics on extreme temperatures, for example.

AR2.02: We thank the referee for these suggestions. However, we would like to point out that the scope of our analysis focussing on the different updated NDC pathways. The three selected impacts have been chosen to illustrate the consequences of those pathways for different systems: extreme events, long-term changes and human systems. We agree that this could be motivated better in our paper and added the following paragraphs to section 2.4 of the manuscript (starting from from line 125): “Global mean temperature is an established metric that allows to approximate a range of different climate impacts. However, regional or sectoral changes can be much more pronounced than those in global mean temperature. As established in the IPCC SR1.5, a wide range of vulnerable systems are sensitive to temperature differences of 0.5°C or less, including terrestrial and marine ecosystems such as coral reefs, cryosphere changes and extreme weather indices \citep{Schleussner2016b}. Providing a comprehensive analysis of the differences in climate impacts would go beyond the scope of this analysis that focuses on the implications of different 2030 NDC update scenarios. However, to illustrate the relevance of these differences for a range of different climate impacts, we have chosen three exemplary impact indicators: an extreme event indicator (extreme hot days), a time-lagged response (long-term sea level rise), and economic damages.”

With regard to the specific suggestion on adding precipitation, we note that precipitation changes are less robust than other variables, at least on the global scale. Extreme precipitation is scaling more or less linear with GMT increase, but the drought signal is very regionally dependent and linked to circulation changes (compare e.g. Schleussner et al. 2016). Therefore, we are of the view that a precipitation analysis would require substantial additional effort, including a more detailed analysis on the regional level which we consider out of scope of the paper. We, however, very much agree that it is exactly that differentiation in terms of differential impacts per warming level that is required to inform the policy discourse around NDC updating and hope to address this important question in future research.

RC2.03: Figure 4 is nicely designed, essentially useless. Even if one could accurately read such small graphs, knowing the change in probability density function conveys very little information. You have made great efforts to make the first half of the paper policy-relevant – linking to NDCs etc – and then the way the Temperature and SLR impacts are presented and discussed is without value. At least CDFs could be used to show% of land impacted, or population impacted. In any case the figures are so small they cannot be used – the only point is to demonstrate that you have the information but have no intention for other people to use it.

AR2.03: We thank the reviewer for the comment on this figure and for the suggested improvements. We revised the figure (now Figure 3) to show CDFs (as suggested by the reviewer), increased the size of the global panel (lower left corner), and added some interpretation guidance. For instance, we better capture the land area affected by an increase in TXx by at least 2°C with dashed lines going from the 2°C change (vertical dashed gray line) towards the left y-axis. In the global panel, these land area fractions are labelled next to the y-axis, in all other regional panels, only the corresponding lines are shown. These additions should help the reader to understand how the CDF graphs have to be interpreted and hopefully contribute to the usefulness of the figure.

We agree that the regional panels are relatively small. It is however technically difficult to increase their size. For many stakeholders, impact projections only become relevant on a regional level (not globally). Therefore, we want to keep the regional panels in the figure. While the global panel is large enough to be read and interpreted in detail, the regional panels can be compared with the global panel to get an idea about regional differences in heat extreme projections.

Figure 1 (manuscript Figure 3): Changes in hot extremes (TXx) in the period 2081-2100 relative to 1986-2006 for the NDC scenario (red), the BE33 scenario (yellow) and the

1.5°C scenario (cyan). Changes are presented as land area fraction (y-axis) affected by changes in TXx (x-axis) for 26 world regions and globally. Cumulative distributions are based on an area weighted aggregation of all TXx change values projected at grid-cells within a region and across climate models. A vertical dashed gray line indicates TXx changes of 2°C. The asterixis and the horizontal lines going from the 2°C line to the left y-axis show the land fraction that is affected by an increase in TXx of at least 2°C.

RC2.04: Perhaps an illustrative diagram in section 2.1 would help describe the methods. I'm not convinced by using Txx – hottest day of the year, because I am unconvinced that theGCMs are able to consistently, especially across regions, reproduce the single hottest day each year. Why pick such a difficult target, when perhaps the 5th hottest day each year, or a p99 over the 21-year period would probably equally be sufficient to estimate the changing temperature distribution and is likely much better reproduced by the models?If you insist on this indicator, can you provide some validation that at least the GCMsused accurately reproduce Txx for the historical period with error less than 0.6 degC –because that's the difference between your BE33 and 1.5C scenarios.

AR2.04: We chose TXx as an absolute measure of heat extremes as it is a metric with a very simple definition that is very common in the climate impact literature. Furthermore, GCMs have been shown to reproduce TXx changes well (compare e.g. Sillmann et al. 2013, Seneviratne et al. 2016, Schleussner et al. 2017 and the IPCC AR5 WG1 and SR1.5).

For instance, the section about hot extremes in the IPCC 1.5C Special Report also chose to present changes in TXx in the same regions we are using here (please see Figure 2). Our revised figure (now Figure 3) clearly shows how differences of 0.5°C (between 1.5°C and 2°C) can be distinguished on the regional level. In other work, we have shown how GMT differences down to 0.2°C can be meaningfully differentiated in this indicator (Pfleiderer et al. 2018). As a validation against observations, we also include Figure 3 below, comparing a 0.5°C difference in observations and CMIP5 model output, clearly showing significant differences.

Please note as well that the CDF's (previously PDF's) shown in the new Figure 3 are a highly aggregated result of all used CMIP5 models and averaged over 20 years. We are quite confident that a twenty year average of yearly temperature extremes is a robust metric and that the signal of climate change as illustrated in Figure 4 can be clearly distinguished from internal variability.

Figure 2: the IPCC 1.5C Special Report also chose to present changes in TXx

Figure3: Comparison of a 0.5°C difference in observations and CMIP5 model output

RC2.05: Figure 3 – why is 1.5 in red, and NDC in Blue? This doesn't make sense and is opposite to Fig 4 and Fig 2 colour schemes. Are there no uncertainty ranges associated with the economic impacts assessment from the Burke methodology?

AR2.05: We thank the reviewer for pointing out this oversight in Figure 3 (now Figure 4). The color scheme has been updated and is now consistent with the other figures.

Burke et al. (2018) report four sources of uncertainty that arise in their analysis, namely from SSPs, discount rates, regression (bootstrapping) and the climate models. Our analysis uses SSP 2 and does not test for different discount rates, therefore leaving two sources of uncertainty.

Our new Figure 4 now shows boxplots that capture uncertainty from the GCMs (using median bootstrap estimates for each GCM). We thank the reviewer for this very valuable suggestion that contributes to a more robust representation of the economic impacts:

Figure 4 (manuscript Figure 3): Economic damages under different scenarios of GMT increase. The boxplots contain estimates for different GCMs, and show the percentage difference between GDP per capita under selected temperature pathways (no change in current NDCs, BE33 scenario resembling a 33\% change in NDCs of big emitters and a 1.5°C pathway) and GDP per capita under a no climate change scenario. The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends from the hinge to the highest value that is within 1.5 × the interquartile range of the hinge. Estimates are given for mid-century (2046-2065) and end-of-century (2081-2100). Countries are grouped by either geographical regions (South Asia and Latin America) or political groupings following the UN classifications (Small Island Development States, SIDS and Least Developed Countries, LDCs).

RC2.06: It's not clear what is the point of the including these climate impacts. The results are presented in a mechanical fashion. Why they are included, and justification for the specific impacts, is not provided. In the discussion there are only 4 lines about them. Try to explain the "so what" for the reader. What does 1m sea level rise mean? Does 1-3degC really make a difference for the hottest day of the year. It doesn't sound like much to regular people, but if you're an expert, we know it has impacts on animals, vulnerable people, chance of crop failure, labour productivity, power plant efficiencies, peak electricity demands, rail tracks and roads – and on and on and on. So try and bring this perspective to the reader, on why 1-3 degC change for the hottest day of the year is significant. The same applies to sea level rise that is in the order of centimeters... doesn't sound like much, but if you live in the Netherlands, or Bangladesh, or Miami – it's terrible news!

AR2.06: We thank the referee for this suggestion. We have substantially expanded the section motivating our impact selection (see AR2.02) as well as the discussion of the implications of these impact differences.

We added the following text to the discussion section from line: "The IPCC Special Report on 1.5°C has identified a range of key reasons for concern as high above 1.5°C including by extreme weather events, for unique and threatened systems as well as globally unequal impacts (Hoegh-Guldberg et al 2018). Our results confirm these findings and add additional information also in comparison with trajectories implied by current NDCs. Differences in median sea level rise between a 1.5°C and NDC scenario in 2100 amount to about 20cm, as much as the world has experienced over the observational period, which has already contributed significantly to the occurrence of coastal flooding (IPCC 2019). Beyond 2100, the difference could amount to almost one meter or more until 2300 (compare Table 2). For extreme heat, we find a doubling in impacts between 1.5°C and NDC pathways (compare Figure 4), with profound regional differences. For Central Europe, for example, we project that about 40% of the land-area would experience a TXx increase under current NDC pathways of about 4°C. For tropical regions, exceeding a new climate regime in terms of extreme temperatures will be reached already for 2°C warming. Exceeding 1.5°C will also substantially increase the risks of exceeding tipping points of the earth system going forward (Schellnhuber and Rahmstorf 2016)."

RC2.07: Supplementary information is quite concise and no results provided in data form.

AR2.07: We agree, but do not see the need to substantially extend the currently provided Supplement. All data shown in the figures is now also available on the new gitlab repository, included in the data and code availability section: https://gitlab.com/ageiges/ndc_ambition_esd_paper_material

Minor Comments

RC2.08: Line 79: Spell out AR5

AR2.08: Line 79 has been changed accordingly.

RC2.09: Line 198-199 – you say 4degC here – but you should clarify that this is for the hottest day only, not mean temperature rise, as it could easily be misunderstood.

AR2.09: We have changed the corresponding paragraph in the manuscript to read: "Under the NDC scenario, changes in TXx would be most pronounced. The global median increase of TXx under this scenario is projected to be 2.7°C above the 1986-

2005 level. The increase in the high-end tail is most pronounced under this scenario with 10\% of the land area experiencing increases in TXx of over 4°C above the 1986-2005 levels."

RC2.10: Line 231: You say results in line with other studies, yet you only provide one citation? Consider works that could back up this statement e.g. by Piontek et al (2014, PNAS), Scheussner et al (2016, ESD), Byers et al (2018, ERL), Mora et al (2018, Nat CC)

AR2.10: We thank the referee for pointing that out and have expanded the reference list.

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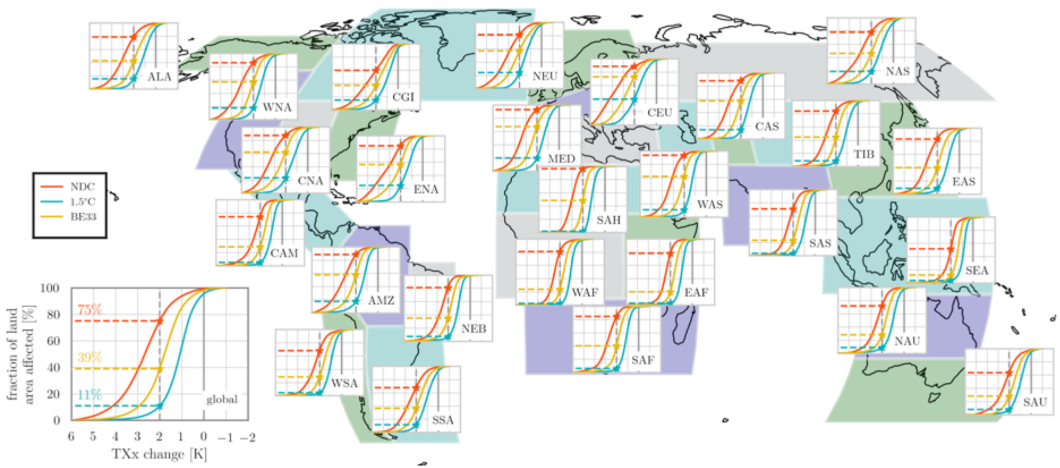

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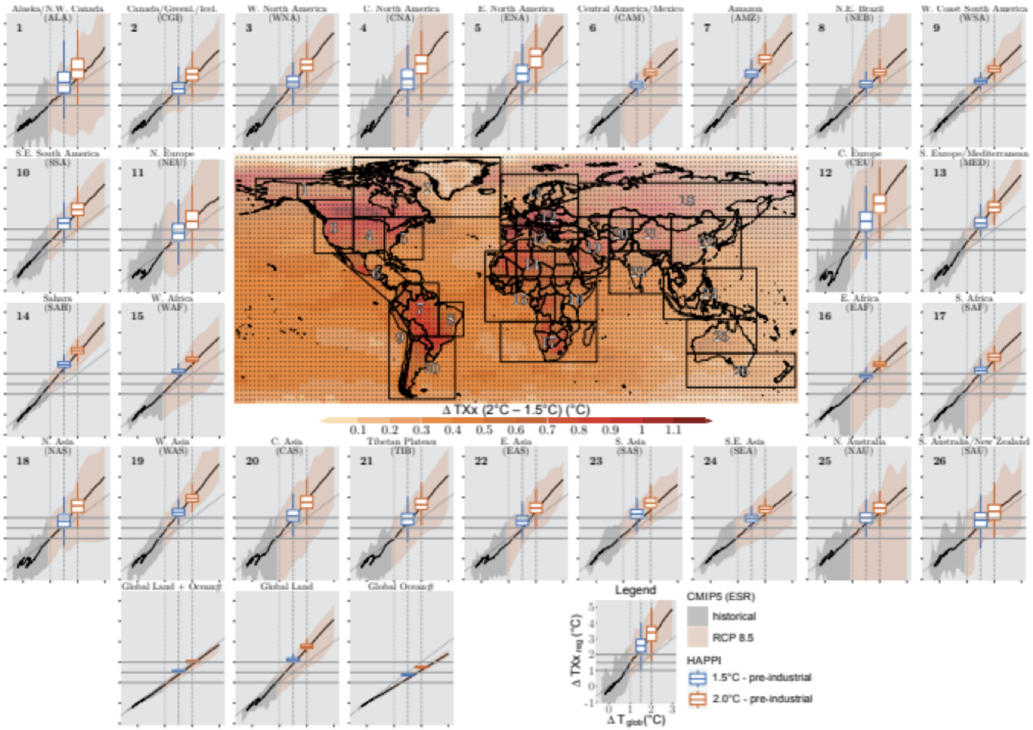

Figure 3.5 | Projected changes in annual maximum daytime temperature (TXx) as a function of global warming for IPCC Special Report on Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) regions (see Figure 3.2), based on an empirical scaling relationship applied to Coupled Model Intercomparison Project Phase 5 (CMIP5) data (adapted from Seneviratne et al., 2016 and Wartenburger et al., 2017) together with projected changes from the Half a degree additional warming, prognosis and projected impacts (HAPPI) multimodel experiment (Mitchell et al., 2017; based on analyses in Seneviratne et al., 2018c) (bar plots on regional analyses and central plot, respectively). For analyses for other regions from Figure 3.2 (with asterisks), see Supplementary Material 3.SM.2. (The stippling indicates significance of the differences in changes between 1.5°C and 2°C of global warming based on all model simulations, using a two-sided paired Wilcoxon test (P = 0.01, after controlling the false discovery rate according to Benjamini and Hochberg, 1995). See Supplementary Material 3.SM.2 for details.

Fig. 2. Figure 2: the IPCC 1.5C Special Report also chose to present changes in TXx

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Discussion paper

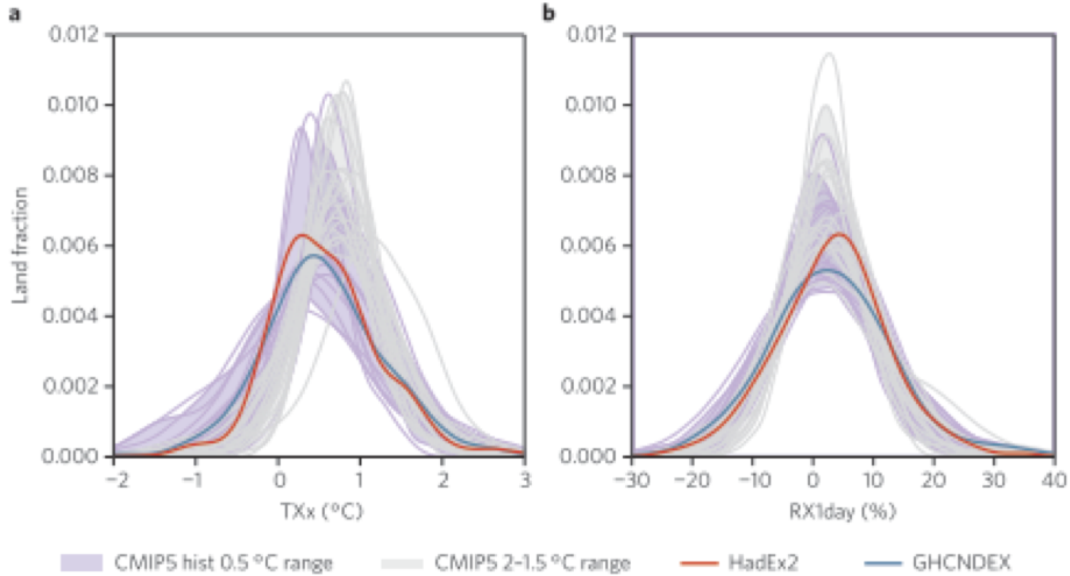
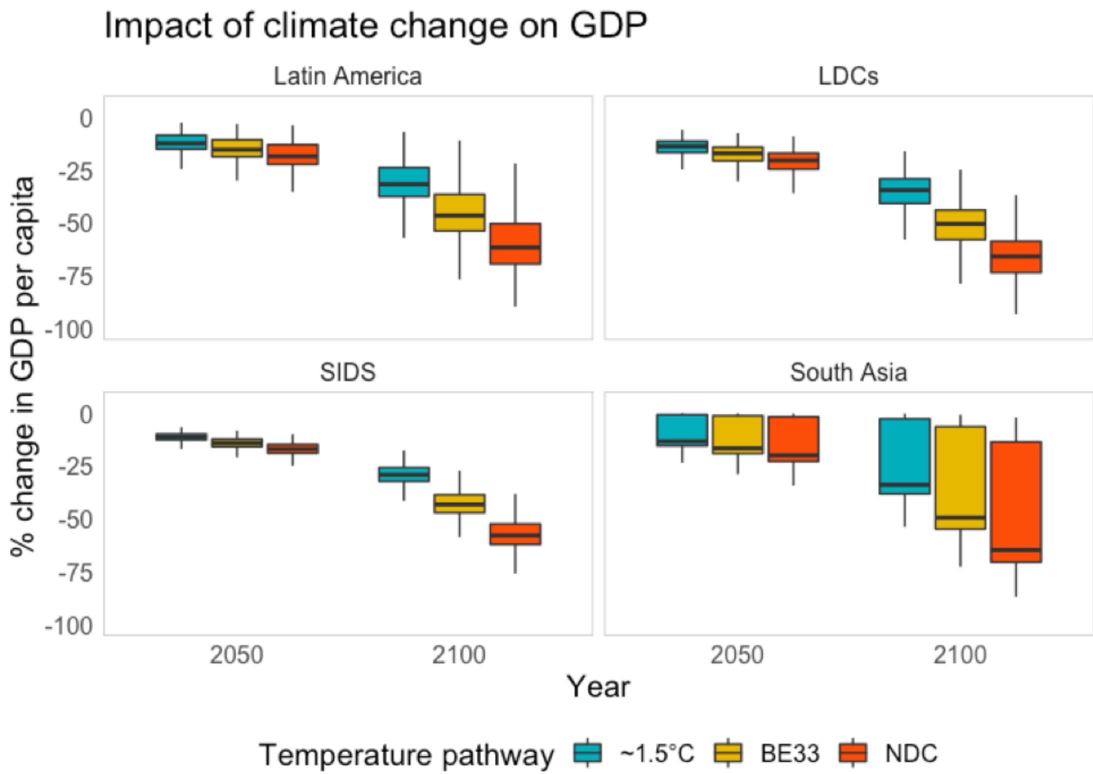


Figure 2 | Historical 0.5 °C warming is representative for 1.5 °C versus 2 °C differences. Changes in hot extremes (**a**) and extreme precipitation (**b**) due to 0.5 °C warming over the historical period (purple) and between 1.5 °C and 2 °C (grey) as simulated in an ensemble of CMIP5 models. Model-specific time slices are derived to match historical 0.5 °C warming up to the 1991–2010 reference period and future warming levels of 1.5 °C and 2 °C above pre-industrial conditions (see Supplementary Information). The filled envelope depicts the 5–95% ensemble range and thin lines represent individual models. The observed differences are given for comparison in blue and red as in Fig. 1.

Fig. 3. Figure3: Comparison of a 0.5°C difference in observations and CMIP5 model output



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