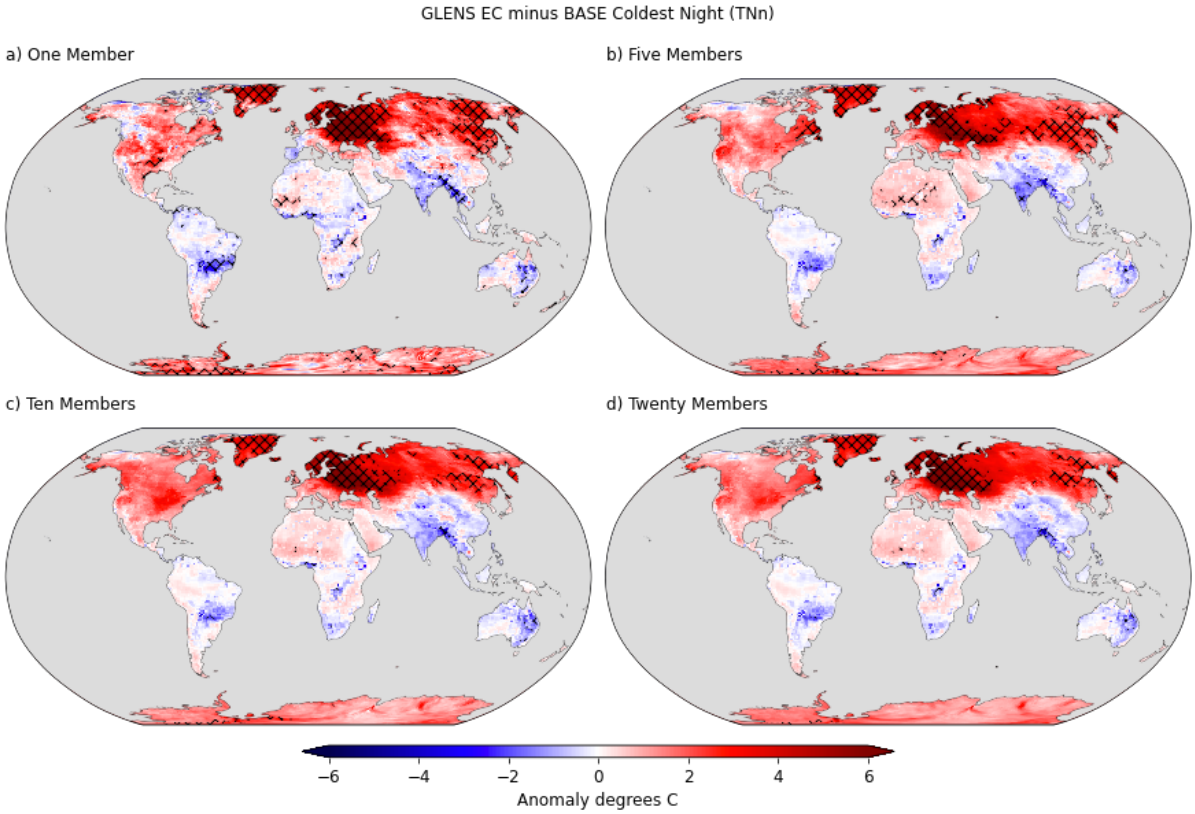
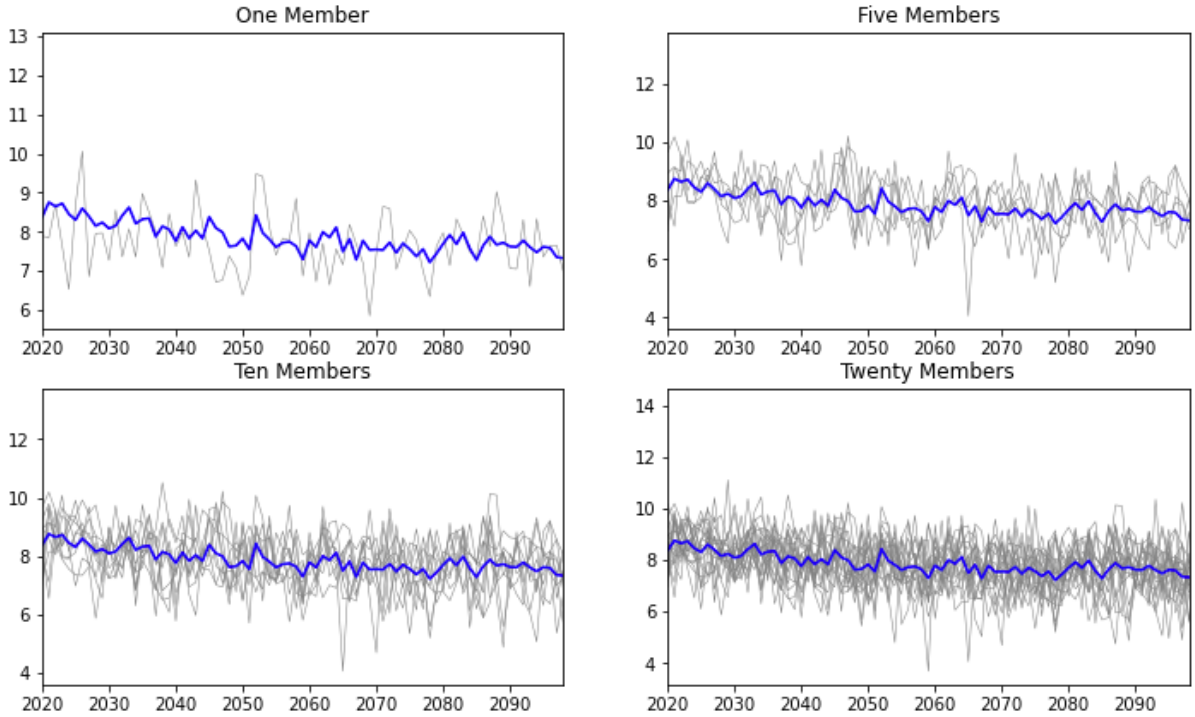
Tye et al. analyse climate model projections under a high-emissions scenario (RCP8.5) and a scenario in which the warming and some aspects of it (gradients) are counterbalanced by stratospheric aerosol injection (GLENS). A novelty of their approach is that they have a single-model large ensemble (20 members). The analysis focuses on extreme climate indices in an early and a late 21-year period.

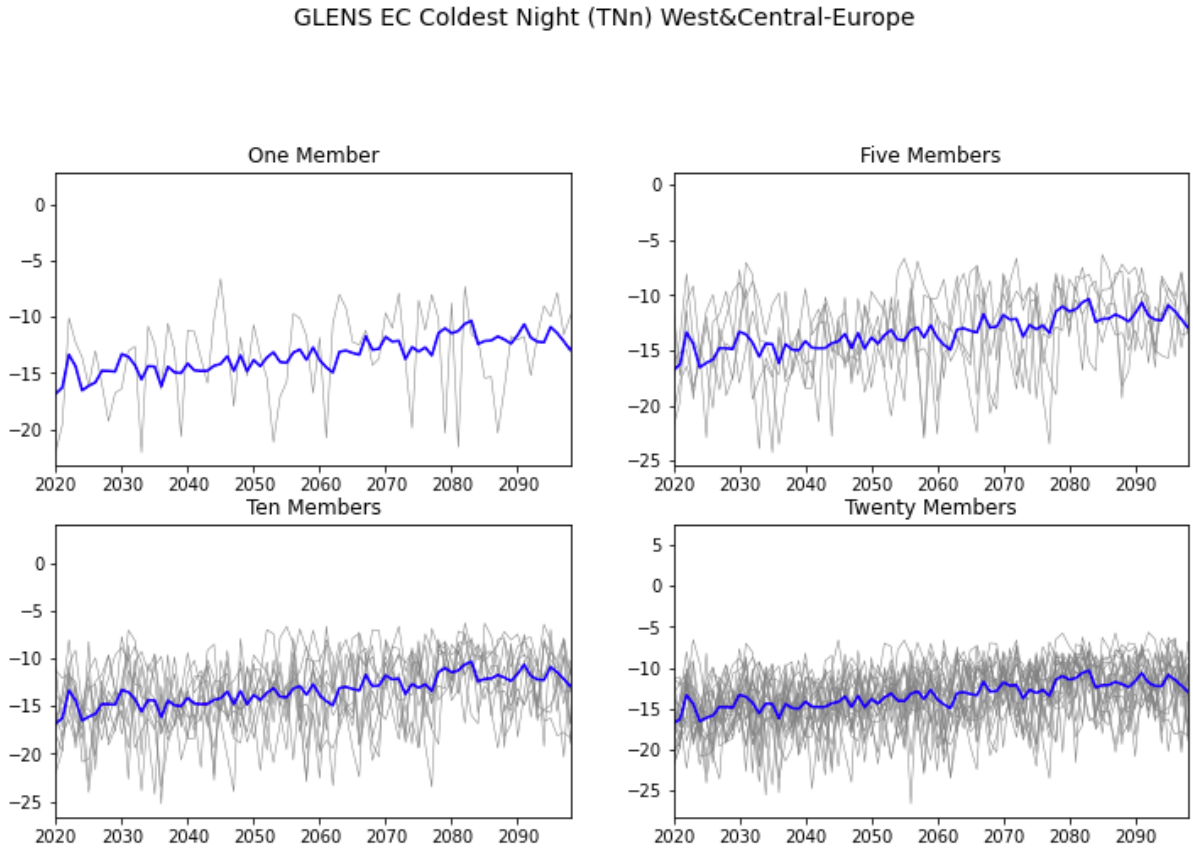
The study is written in excellent English language and Figures are in very good shape.

The paper does not include much novelty or surprising results. Temperature and precipitation indices approximately behave as expected and as documented in earlier studies. The authors do not exploit much the fact that they dispose of a large ensemble. Basically only the average effects are investigated, not the possible variation between individual weather trajectories. An aspect that is not treated in many other studies is the investigation of vegetation. However, for unclear reason, the authors do not disentangle the role of CO2 (RCP8.5) and of SAI (GLENS minus RCP8.5). This is in contrast to the analysis of temperature and precipitation and would seem to me very useful for vegetation, too.

We chose to present only the mean of the model ensemble in the main body of the paper as the principal difference between this and the individual members is the statistical significance of results. Please see below for a sensitivity test carried out on the Coldest night index (TNn) showing global anomalies and two regional time series. The climatological and ensemble spread are also well represented in the box plots and time series plots that were already included in the supplemental material.


GLENS EC minus BASE Coldest Night (TNn)
a) One Member
b) Five Members
c) Ten Members
d) Twenty Members
−6
−4
−2
0
2
4
6
Anomaly degrees C


GLENS EC Coldest Night (TNn) SAS
One Member
Five Members
Ten Members
Twenty Members
2020
2030
2040
2050
2060
2070
2080
2090



However, since the study is thoroughly conducted, has a synopsis of the various effect, and also shows quantitative effects (particularly usefully readable in Fig. 5 and 9), it might still be useful to publish the paper. Certainly, it would be beneficial if the authors could demonstrate from observations for the BASE period that the model compares well to observations; so far it is a pure simulation study.

Thank you for your very useful suggestions. Our responses are interspersed with your comments and suggestions below.

In conclusion, I propose that the authors consider

- showing some evaluation of the BASE period with observational data in terms of extreme indices

Your observation that this is a pure simulation study is correct. As the BASE period of our simulations cover the period 2010-2030, it is not possible to evaluate this data against observational data! However, Marsh et al. (2013) https://doi.org/10.1175/JCLI-D-12-00558.1 presented a thorough assessment of CESM1(WACCM) and its ability to simulate the current climate. They found that inclusion of the upper atmosphere improved the representation of sudden stratospheric warmings, with comparison to the “low top” atmospheric model CCSM4, which led to improved representation of northern hemisphere winter precipitation and temperature. In many respects, however, the surface climate responses for both the whole atmosphere model (WACCM) and the version that does not resolve the stratosphere are very similar. The climate has been evaluated in these papers:

Furthermore, Sillmann et al. (2013) https://doi.org/10.1002/jgrd.50203 examined the representation of the same extreme indices as we assessed here for a number of models included in the CMIP5 archive, including those simulated by CESM1 and CCSM4. These two models were among the best performing, with the smallest RMSE values compared to the four sets of observation and reanalysis data. As a result, we consider that the models have been sufficiently evaluated by others to be able to draw meaningful conclusions from the later years of the simulations.

- adding the RCP8.5 to the vegetation response analysis,

These have been added as discussed below.

- as well as a number of specific comments below.

l69 could specifically note the difference in energetic influences of greenhouse gases and aerosols (e.g. Salzmann, Sci. Advances 2016)

Reference added.

l175/176 The values that are not discussed can be omitted from the Table.

OK, values removed and caption edited.

l181 is that IPCC AR6? Should be clarified

Sentence amended to make this clear.

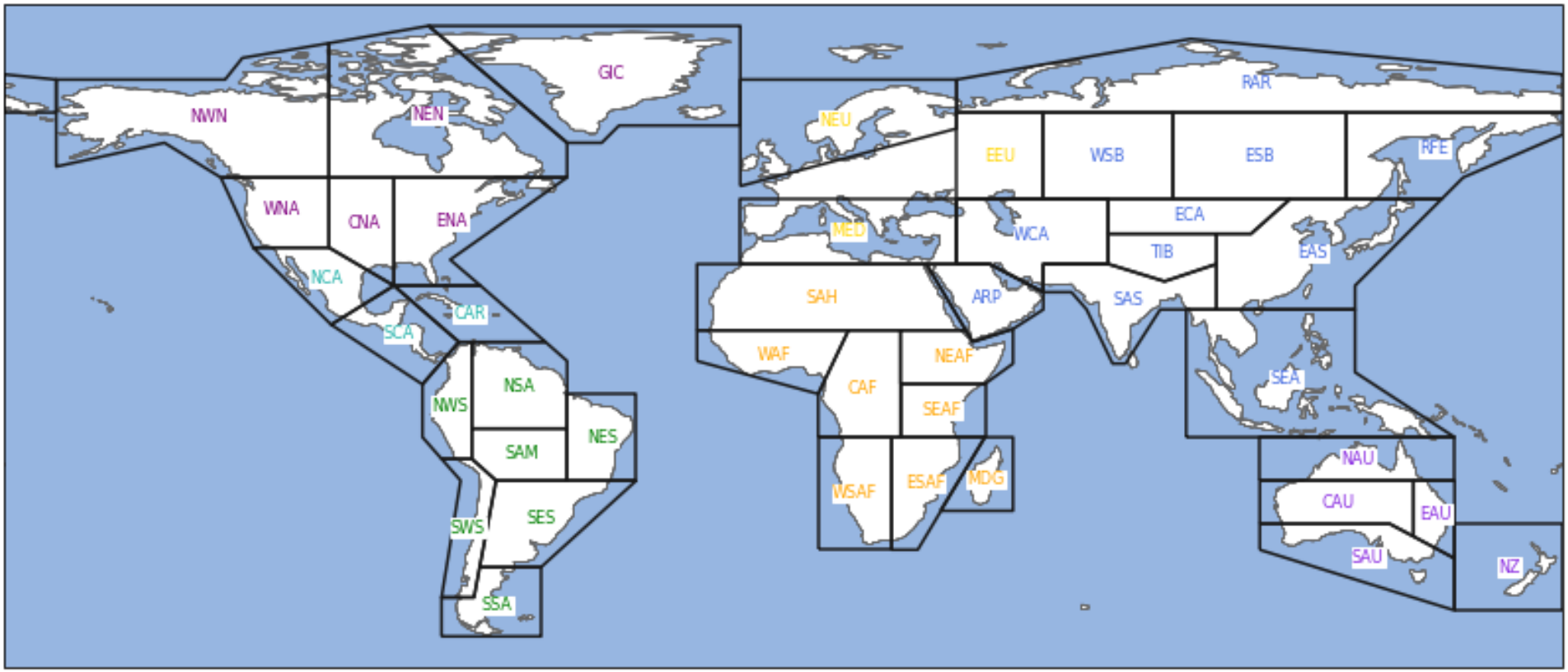
l230 the label “Feedback” is inconsistent.

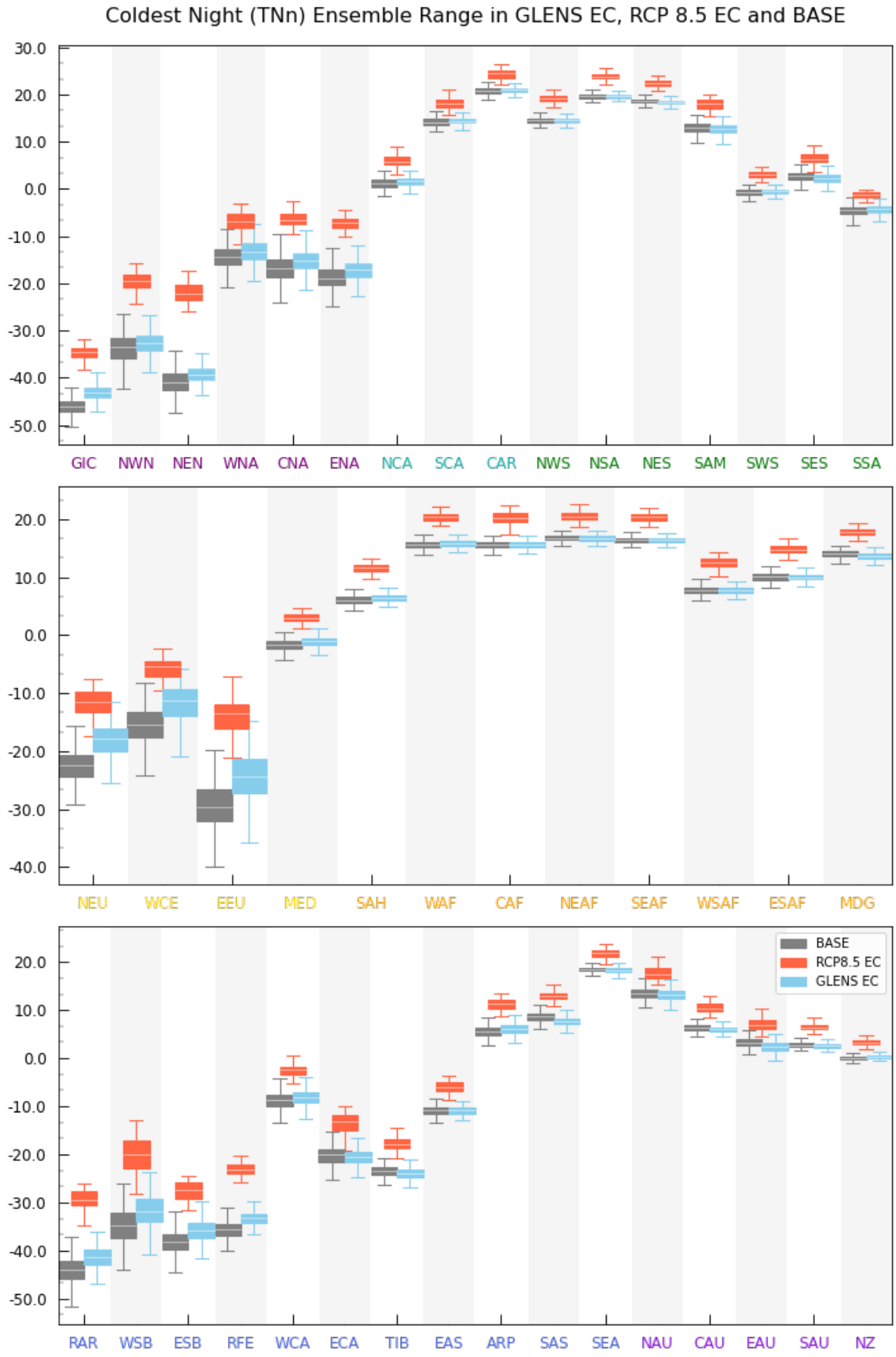
Figure 3 legend has been corrected.

l230 It is necessary that some logic is brought to the order of the regions, e.g. clarifying by colour the continents and perhaps a north-south gradient. There is very little discussion of these results in the text.

The regions are ordered in three tranches of north-south gradients along three approximate longitudes covering the Americas, Zero Degrees, and Asias. Some additional text has been added to discuss the figure, and to highlight the use of all 20 ensemble members in producing the figure. The figure now also colour codes the regional labels, similar to that found in Sillmann et al. (2013) and according to Iturbide et al. (2020); Figure 1 has also been updated to include the colour coded regions.

AR6 Land Regions (Iturbide et al., 2020)




Coldest Night (TNn) Ensemble Range in GLENS EC, RCP 8.5 EC and BASE
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
GIC NWN NEN WNA CNA ENA NCA SCA CAR NWS NSA NES SAM SWS SES SSA
NEU WCE EEU MED SAH WAF CAF NEAF SEAF WSAF ESAF MDG
RAR WSB ESB RFE WCA ECA TIB EAS ARP SAS SEA NAU CAU EAU SAU NZ
BASE
RCP8.5 EC
GLENS EC

l236 There is circular reasoning in the sentence. What is the true cause for the impacts?

The sentence was just repetitive. We have removed the second part of the sentence.

l241 “consistent” in magnitude or pattern? or just in sign?

Sentence has been amended to read “spatially consistent”

l243 Here as well: what is the real unit? days per year? or days per 21-year-period (see below)

Added “per year”

l245 Magnitude and in some extended regions, sign

Sentence amended.

l261 check units?

This is correct - GLENS EC projects a significant increase in temperatures over the southeastern part of South Africa, reflected in an increase in the number of Summer Days (SU) - Figure 4d, left.

l263 Where does this discussion of aerosol come from? Do the authors mean, aerosol sedimenting from the stratosphere after injection? Much more discussion on such an effect would be needed.

Sentence edited to read:

Prior research has indicated that medium altitude clouds, that can have impacts on localized temperature differences, are more sensitive to the presence of sulfate aerosols than to climate related warming (Visioni et al., 2020). However these cloud effects were not explicitly examined in this research.

l268 Fig. 4. The label says “Frequency”, Table 1 says “days” as unit. What is true? Is it days per 21-year-period? Or days per year?

The caption has been edited to read Frequency (days per year). Table 1 has also been edited to read “days per year”

l289 Is this a result at all? I thought to understand that should be true by construction of GLENS?

That is correct, as we go on to state in the following sentence.

l291 But is this not the entire meaning of a large ensemble, to be independent of the specific initial conditions for each run?

We agree that the point of the ensemble is to be independent of the specific initial conditions. However, our point is that other simulations may inject SO2 at other locations

(e.g. Kravitz et al., 2019 compared injections only at the equator), or use different model configurations and so will potentially produce other regional responses to SAI.

l296 Explain shading around curves

The shading relates to the individual model ensembles. The caption has now been adjusted to include

Regional time series comprise ensemble mean TNx for GLENS EC minus BASE in thick blue and individual members in light gray; ensemble mean TNx for RCP 8.5 EC in thick red and individual members in light pink; ensemble and climatological mean for BASE in thick dashed black.

And the same change has been made to Figure 9

l303 Eleven years are not exactly half of 21 years.

"Approximately" added to the sentence.

l313 It would be useful to show this induced east-west SST gradient and discuss its reasons here, since this is fundamental for the subsequent discussion.

Thank you for the suggestion. However, we believe that including another figure will only add to an already lengthy article rather than adding substantively to the reader's understanding. The cited publication is available as open access for the interested reader.

l346 Is this also quantitatively the case, i.e. 7 % per K?

Not necessarily. As the reviewer alludes to, the response of precipitation is not necessarily a direct comparison to Clausius-Clapeyron and may vary between 1%-15% per degree K depending on the quantile of precipitation under consideration. We have adjusted the sentence.

l364 Check units

Units changed to "Number of days". Units also checked for Figure 8.

l399 Is this just a qualitative statement (then referring to Clausius-Clapeyron seems useless) or does it hold quantitatively?

Sentence has been changed, this was just a qualitative relationship.

l420 Why is the reference (RCP8.5) not shown here? (and not in Fig. 11 either?)

Good point - we have modified Figures 10 and 11 to show the differences between RCP8.5 EC and BASE to be consistent with the other figures. We have also added the differences between GLENS EC and RCP8.5 EC as a third column in these figures, to disentangle the role of CO2 and SAI (as the reviewer suggested above). These modified figures are further discussed in the revised text.

l505 The authors could check in a straightforward manner whether the contraction is also found in their model.

While the controller for the GLENS simulations is designed to minimize changes in the ITCZ, recent evaluations have concluded that there is a very slight southward shift even when interhemispheric temperature gradients are maintained (Lee et al., 2020; Alamou et al., 2020; Cheng et al., 2019). This is also accompanied by a weakening (in the order of 10%) of the Hadley Cell intensity (Cheng et al., 2022). We have amended this paragraph to reflect the recent literature.

Alamou, A. E., Obada, E., Biao, E. I., Zandagba, E. B. J., Da-Allada, C. Y., Bonou, F. K., Baloïtcha, E., Tilmes, S., & Irvine, P. J. (2022). Impact of Stratospheric Aerosol Geoengineering on Meteorological Droughts in West Africa. *Atmosphere*, *13*(2), 234. https://doi.org/10.3390/atmos13020234

Cheng, W., MacMartin, D. G., Dagon, K., Kravitz, B., Tilmes, S., Richter, J. H., Mills, M. J., & Simpson, I. R. (2019). Soil Moisture and Other Hydrological Changes in a Stratospheric Aerosol Geoengineering Large Ensemble. *Journal of Geophysical Research: Atmospheres*, *124*(23), 12773–12793. https://doi.org/10.1029/2018JD030237

Cheng, W., MacMartin, D. G., Kravitz, B., Visioni, D., Bednarz, E. M., Xu, Y., Luo, Y., Huang, L., Hu, Y., Staten, P. W., Hitchcock, P., Moore, J. C., Guo, A., & Deng, X. (2022). Changes in Hadley circulation and intertropical convergence zone under strategic stratospheric aerosol geoengineering. *Npj Climate and Atmospheric Science*, *5*(1), 32. https://doi.org/10.1038/s41612-022-00254-6

Lee, W., MacMartin, D., Visioni, D., & Kravitz, B. (2020). Expanding the design space of stratospheric aerosol geoengineering to include precipitation-based objectives and explore trade-offs. *Earth System Dynamics*, *11*(4), 1051–1072. https://doi.org/10.5194/esd-11-1051-2020