

Point-by-point reply

Line 331: “neglecting shallow waters can account for 5-10%” of what. Of total OHC? Of only the 0 - 300 m OHC? Clarification needed here. In the following lines (332, 333), the authors specify 0 - 2000 m underestimated by 10% due to latitudinal constraints. We need similar specificity with respect shallow bathymetric limits. Good section, just needs a bit of clarification.

Yes, thank you for rising this, and 0-2000m depth OHC trends have been added to the shallow water part as well.

Line 342: replace “All-time” with ‘All time’?

Thank you, done.

Line 351: CAR2009 in the legend but CARS2009 in the figure (and in the URL). An error in the legend?

Thank you, an error in the figure caption, done.

Line 551, Figure 3: Important figure but still hard to read. Does not scale / zoom. Authors can fix this during proofreading.

Yes, we have already prepared a high-quality version of this figure (we have this for all figures), and can provide this during the proof read process?

Line 562 and following: Section 3 Land uses 1.5 line spacing, different to other sections. Authors can correct these differences after typesetting and during proofreading.

Yes, thank you, and I assume this will be solved during the processing? It is fixed now for this resubmission.

Line 564: Something like this opening sentence should also have preceded the atmospheric section (Section 2). If true of land, certainly true of atmosphere.

Thank you, and we agree. We have modified the first sentence by: ‘While the amount of heat accumulated in the atmosphere is small compared to the ocean, warming of the Earth's near-surface air and atmosphere aloft is a very prominent effect of climate change, which directly affects society.’ and the last sentence of the second paragraph by ‘In contrast, long-term heat accumulation in the atmosphere is limited by its small heat capacity as the gaseous component of the Earth system (von Schuckmann et al., 2016).’

Line 565: land-based rather than land based?

Yes, thank you, done.

Line 584: “small, but persistent” remove the comma?

Yes, thank you, done.

Line 621: proofreaders will question capitalization of LANE 1923 citation but it at least seems consistent with reference list. Artifact carried forward from bibliographic software?

Yes, thank you, done.

Lines 653 - 658: These sentences seem redundant with previous section? If authors add a section on borehole climatology, which I agree adds substantial value, then they do not need to re-introduce the topic here?

We checked the lines and we think there is no repetition. We describe the borehole climatology in the first part of the section, and then we focus on the previous estimates of continental heat content, from boreholes and meteorological observations. So we think there is no need to change the text

Line 805: comparably rather than comparable?

Yes, thank you, done.

Line 834: Figure 7 copied from elsewhere? We need a complete high-resolution (scalable) version here. Make the upgrade during proofreading?

Yes, we have a high-resolution version available, even .ai (done by a graphic designer).

Line 847: Something awkward here? Remove the comma?

Yes, thank you, and the sentence is modified to 'Over the last quarter of a decade this Earth heat inventory reports - in agreement with previous publications - an increased rate of Earth heat uptake reaching up to 0.9 W/m^2 (Fig. 7).'

Line 919 and Figure 9: If authors present atmospheric CO₂ reductions as a rate, they need a time unit. The text narrative seems clear. Perhaps the term 'rate' causes the confusion? -57 ppm represents a cumulative CO₂ accumulation/removal, not a rate. One can check this number and the underlying assumptions. The authors, working from energy imbalance, estimate 57 ppm reduction (410 ppm back to 353 ppm) needed to achieve 0.87 W/m^2 increase in outgoing energy. E.g. so that outgoing increases to match incoming. Eyeball from Moana Loa CO₂ curve, planet last had global average of 355 ppm CO₂ in 1990. From Global Carbon Budget, atmospheric growth of CO₂ from 1990 through 2018 sums to 117 GtC, or 55 ppm. Given uncertainties all around (including in my eyeball estimates), restoration (removal) requirements calculated from energy imbalance, -57 ppm, match very closely what carbon budget shows as incremental CO₂ inputs, 55 ppm, over roughly the past 30 years. Two very different global budget approaches, one from radiative (energy/heat) viewpoint and second from carbon emissions estimates, arrive at the same answer? To first order, acknowledging various necessary assumptions and uncertainties, we quantify with confidence human impact on climate? Small effort on my part to make this comparison, in part because at this point I hold good knowledge of both products. Worth including something like this as a non-radiative non-energy confirmation?

Thank you for this comment. We have discussed your proposition with some co-authors, and we thus propose at this stage only minor changes, ie: we have removed the wording 'rates' from the caption which we agree was rather confusing, and we have added the sentence: 'Atmospheric CO₂ was last 350 ppm in the year 1988, and global Earth's surface temperature was then $+0.5^\circ\text{C}$ relative to the pre-industrial period (relative to the 1880-1920 mean) (Hansen et al., 2017; Friedlingstein et al., 2019).'

Line 972: For cryosphere, we don't need to measure gravity itself but rather use gravimetric measurements to constrain ice mass change and water redistribution?

Thank you and we have changed to gravimetric measurements.

Line 1008: at the forward or leading edge, not at the (peripheral) edge?

Thank you, yes, and applied.

Please take great care to reference primary peer-reviewed source literature when possible. I react mostly to WMO 2020, their 2019 annual statement on climate. I understand benefits:

annual, recent, carries WMO imprimatur, etc. But those WMO reports remain highly derivative, second-hand at best. They compile entirely from outside sources, mostly from NOAA. Internal staff compile and write them, with only weak internal review, from almost exclusively a meteorological viewpoint. Unlike IPCC reports, WMO annual reports get virtually no community review. If you need an annual product, consider the AMS annual statement on climate which incorporates a broader range of inputs and gets strong review.

(<https://www.ametsoc.org/index.cfm/ams/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/>) Often WMO hurries their annual report, even issuing provisional versions before they have a full year of data, to promote themselves within UN system. AMS follows a stricter and more regular assembly and review schedule.

Not a big issue and you have referenced the WMO report correctly; AMS report would add more credibility to your product. I think it has all or most of the same information. My caution but your choice.

Thanks a lot, and I have added to each WMO reference another one, such as BAMS, or Richter-Menge, J., M.L. Druckenmiller, and M. Jeffries, Eds., 2019: Arctic Report Card, 2019. <https://www.arctic.noaa.gov/Report-Card>.

And for the CO₂ concentrations I have started with the last ESSD value, yes, you are completely right...