## Detailed replies to both anonymous referees comments on

Krätschmer, S., van der Does, M., Lamy, F., Lohmann, G., Völker, C., and Werner, M.: *Simulating glacial dust changes in the Southern Hemisphere using ECHAM6.3-HAM2.3*, Clim. Past Discuss. [preprint], https://doi.org/10.5194/cp-2021-73, in review, 2021.

## Referee 1:

| Comment by referee 1 | Reply by authors | Changes in the manuscript |
|---|---|---|
| 30-33: More precisely, dust scatters and absorbs both SW and LW radiation, although scattering prevails in SW (still, the single scattering albedo of dust is not equal to 1, e.g. Balkanski et al., 2007) and absorption in the LW (although scattering may be important too, e.g. Dufresne et al., 2002). | We will rephrase the sentence as follows:<br><br>"During transport, the dust particles directly influence Earth's radiation budget by scattering and absorbing short- and longwave radiation depending on particle size and mineralogical composition (Dufresne et al., 2002; Balkanski et al., 2007), which in turn affects the atmospheric stability by altering the vertical temperature profile and relative humidity (Boucher, 2015)." | We rephrased the sentence accordingly in the lines 30–33. |
| 63-65: "We compare present-day simulation results to model results …". Please rephrase. | We will rephrase the sentence as follows:<br><br>"We compare our present-day simulations to results obtained in the scope of the global dust model intercomparison in AeroCom phase I in order to […]" | We rephrased the sentence accordingly in the lines 82-84. |
| 165-169: It's not very clear to me what these regional correction factors are exactly, and how they are applied to the present study, to maximize the match with which observations and how, or what are they values. Please clarify the procedure in more detail. | The regional correction factors are a natural consequence of the parameterization of a sub-grid process on a mm scale in a model running with a typical resolution of 100 km and is essentially a mean to compensate for the lack of required information for an exact calculation of the considered process. A precise explanation can be found in Tegen et al. (2019):<br><br>"In previous versions, a global correction factor of 0.86 was applied on the threshold friction velocity to account for the inhomogeneity of the factors influencing dust emissions (e.g., surface wind) across the rather coarse model grid boxes. In ECHAM6.3 the surface orography is not taken into account for the aerodynamic surface roughness, in contrast to earlier versions. The subsequent changes in surface wind distributions over dust source areas require additional regional correction factors. For each relevant region that contains dust sources the correction factors are chosen such that the emissions agree with the values by Huneeus et al. (2011). These regional correction factors can be modified via the model namelist."<br><br>We will include some of the information above on the correction factors as well as the according reference in our revised manuscript. | We included the according information as well as a reference to Tegen et al. (2019) in the lines 185-188. |
| 176: "Since our simulation periods are comparably short"… compared to what? I do not understand this passage. I gather you use an atmosphere only model coupled to land surface scheme and consider prescribed SST for the ocean surface. Okay, so how does this sentence fit into that? Please rephrase. | This sentence has been used to emphasize that the temporal change in the interaction (more precisely, the heat exchange) between ocean and atmosphere can be neglected due to the much higher inertia of the ocean surface, i.e. $\tau_{Oc} \gg \tau_{At}$. Since taking into account the spatio-temporal development of SIC and SST would imply coupling a complete ocean/sea-ice model to our current setup, this approximation saves a | We rephrased the sentence accordingly in the lines 198-199. |

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<td>significant amount of computational resources. Instead, a constant external forcing file of SSTs representative for the considered time period is prescribed.</td>
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<td>213-214: This statement is essentially based on a set of global metrics compared to Huneeus et al. (2011). It is true that the dust scheme is described in more detail Stanelle et al. 2014, and there validated against a wide set of observations of other features of interest for the representation of the dust cycle; however I would expect to see some comparison here too, with the current version of the ECHAM model setup, also because it appears that some tuning was done, and I found no reference to another paper describing it. The spatial patterns of dust emissions indeed appear to show some difference with Stanelle et al. 2014, also concerning the Southern Hemisphere. Please add some more information in this respect or an appropriate reference if that exists already.</td>
<td>Since it turned out that the model version already came with a set of tuning factors matching the results found in Huneeus et al. (2011) for present-day conditions, we did no further tuning. The tuning factors were only changed in the scope of the provenance studies. Stanelle et al. (2014) only shows the emission flux for present-day (PD) and the anomaly PD-historic, while we show the emission flux for pre-industrial (historic) conditions and the LGM, which makes a direct comparison rather difficult. However, comparing the PD plot of Stanelle et al. (2014) to our PI plot, we can still recognize the typical dust source areas and emission patterns, in particular in the Southern Hemisphere.<br><br>Concerning changes in absolute values for dust emission etc., it needs to be emphasized that Stanelle et al. (2014) used the model version ECHAM6.1.0-HAM2.1-MOZ0.8 for their simulations, while we used ECHAM6.3.02-HAM2.3-MOZ1.0 for our study. Besides the changes in the mineral dust emission scheme already addressed above, further changes in the model include in particular modified aerosol-cloud interactions (Tegen et al., 2019). Due to the full coupling of HAM2.3 to ECHAM6.3, all those changes have eventually an effect on regional, and thus global, dust emissions. Since the aim of our study is completely different from Stanelle et al. (2014), a thorough comparison between results obtained with the outdated model setup from 2014 and our new setup is beyond the scope of our study.</td>
<td>According to our response, we made no further changes in our manuscript.</td>
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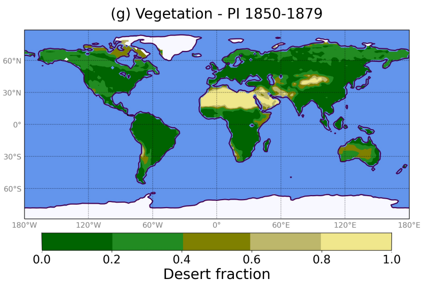
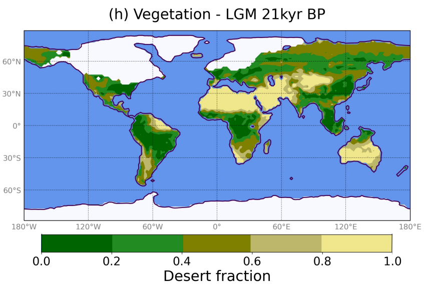
<td>261: Among the model factors affecting dust emissions surely there is also the vegetation cover, here simulated thanks to a dynamic vegetation model. I would suggest adding a panel showing a map of the vegetation fraction, or anyway a vegetation-related variable that closely resembles the way vegetation affects dust emissions in the model.</td>
<td>Thank you for your suggestion, the dust emissions are indeed affected by the dynamic vegetation model. Please find in the following two maps showing the simulated deserted fraction of each grid box for PI and LGM as an addition to Figure 2.<br><br>




</td>
<td>We included both subplots in Fig. 2.</td>
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| 283: The observational data used for figure 3 do not appear to correspond to the original DIRTMAP dataset (i.e. Figure 8 in Kohfeld and Harrison, 2001). Please make sure that you add a reference corresponding to the actual version of the dataset you used, and specify whether additional data were included. | Thank you for the hint! The correct reference is:<br><br>K.E. Kohfeld, R.M. Graham, A.M. de Boer, L.C. Sime, E.W. Wolff, C. Le Quéré, L. Bopp: Southern Hemisphere westerly wind changes during the Last Glacial Maximum: paleo-data synthesis, Quaternary Science Reviews, Volume 68, 2013.<br><br>No additional data were included. We will correct the reference in our revised manuscript. | We corrected the according reference in line 313. |
| 283-315: Several data points in the Southern Ocean appear to be south of the Polar front, which should raise a flag about non-aeolian contributions to the terrigenous fraction of the sediment, and therefore the opportunity to use these data for a robust estimation of dust mass accumulation rates (e.g. Kohfeld and Harrison, 2001). | Although data from "[…] marine sites that have been flagged because they are located within zones of thick nepheloid layers and ice-rafted detritus, which can contaminate aeolian signals […]" had already been excluded from the dataset we use for comparison (Kohfeld et al., 2013), we agree that the reconstructed detrital flux estimates based on changes in $^{232}$Th might still contain non-aeolian contributions from glacier erosion and riverine input, which are not considered in our model. Additionally, it should be taken into account that we compare (simulated) aeolian dust deposition fluxes onto the ocean surface to marine sediment data, i.e. also any horizontal dust transport processes in the ocean during sedimentation are not considered. We will point this uncertainty out in the discussion section in our revised manuscript. | We added the according aspects in the lines 336-348. |
| 352-356: There is a substantial difference in the experimental design of Albani et al. (2012 and 2014) and this work; here it appears that the amount and proportions of dust from different sources result only from the model itself (and indirectly the regional tuning on dust emissions made on present day conditions, apparently), whereas the cited work explicitly used regional tuning also for the LGM, in a data-assimilation fashion, in order to obtain a match on dust amounts, LGM/interglacial ratio, as well as source mix based on geochemical fingerprinting on Antarctic ice core samples (e.g. Delmonte et al., 2010). In other words, one could say that the CAM3 results that you mention indicate a dominance of South American dust because ice core data suggest just that, of course under the assumption that simulated transport and deposition can be considered reasonable. | We agree! Albani et al. (2012) found the dominance of South American dust only because they tuned the dust emissions in their simulations "for each macro-area […] a posteriori by applying a factor yielding the best fit between the simulated and observed LGM and current deposition rates […]" and is thus not suitable to be used as a reference indicating contradicting model results compared to our simulations. We will adjust our argumentation accordingly in our revised manuscript. | We adjusted our argumentation accordingly in the lines 399-403. |
| 352-368: Based on my previous comment, I would recommend that a more thorough discussion is carried out considering also the available data on dust provenance. It is indeed very important that you explain your results based on the modeled processes, as you did, but I believe that they should also be put more in perspective by comparing them to observational evidence, also for this particular aspect (which by the way | We will point out more clearly in our revised manuscript that our model results are not intended to question the geochemical data regarding the provenance of dust found in Antarctic ice cores.<br><br>Additionally, we will include in the discussion section that the reconstructed dust fluxes used in our study for comparison with our simulation results (DIRTMAP, Kohfeld et al. (2013)), which are based on the assumption of relatively constant proportions of $^{232}$Th in continental | We pointed out to the data-model discrepancy in the lines 336-348 and 399-403. |

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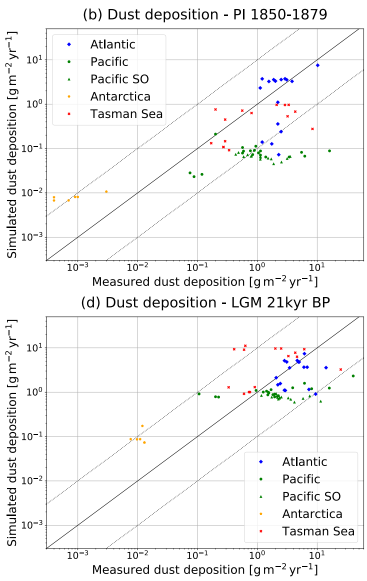
| you mention later on while discussing the matter of size, and you also acknowledge in the conclusions). | lithogenic materials, might be overestimated by 30–40 % in regions receiving fine-grained dust from Patagonia and Australia (McGee et al., 2015). The study of Trudgill et al. (2020) supports our finding of Australia being the predominant dust source during the LGM for dust deposited in the SW Pacific, however, they also suggest based on their grain-size analysis of sediment cores from the Tasman Sea that these might contain non-aeolian contributions, more precisely fluvial sediments from New Zealand, which are not considered by our model and might partly explain the discrepancy between our model results and the observational data. | |
| 412-414: Is there a variability on size distributions at the stage of dust emissions in your model formulation? I don't think so, so I'm a bit confused, why would you expect that? | Ice core data from Greenland (Steffensen, 1997) and Antarctica (e.g. Delmonte et al., 2004) indicate the dust deposition of varying particle size distributions during glacials compared to interglacials. Since we also find a change in dust particle size during the LGM compared to PI (in particular over Antarctica), this formulation has been chosen to point out to the reader that although one might expect that the model exhibits this change in particle size for physical reasons and thus might yield a possible explanation for the according observational data, it is caused for a different reason. Considering the confusion this formulation has apparently caused, we will rephrase this sentence accordingly. | We rephrased this sentence accordingly in the lines 478-482. |
| 472-474: Where does this come from? This aspect is not shown or discussed anywhere in the text. | We agree! It was not mentioned at an earlier point in the text. However, this were the findings of Stanelle et al. (2014) using an older version of the model, so it can be considered very likely that the same findings can be attributed to the same causes. We will include the according reference in our revised manuscript. | We removed the according sentence because it is irrelevant in the scope of our study. |
| 478-479: I would suggest adding two lines bracketing the +/- 1 order of magnitude in the scatterplots of Figure 3, for a clearer reading. | Thank you for this suggestion, please find below the accordingly adjusted scatterplots.   | We updated the according subplots in Fig. 3. |

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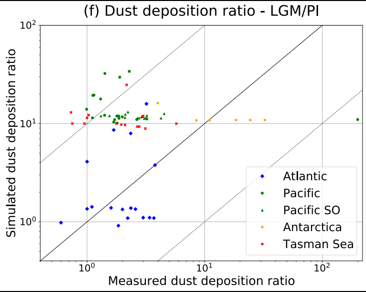
| |  | |
| 500-504: I would recommend that these considerations on the chosen boundary conditions are also reported in the methods and/or results sections, as appropriate. | We agree! We will include the considerations about the potential influence of the prescribed sea surface temperatures on our simulation results already in the discussion in section 3.2. | We included these considerations in the lines 264-266. |
| 466-504: I would suggest enriching a bit the conclusion section with references to the literature, where appropriate. | Since we do not bring up new aspects to the discussion in our final paragraph *4. Conclusions*, in particular after moving the considerations about the potential influence of the prescribed sea surface temperatures on our simulation results already up to discussion section 3.2, we tend to not give any references in the conclusion section at all because those relevant for our paper are already mentioned in the discussion section. | Since we enriched the discussion section of our manuscript by several aspects including the according references in the scope of the revision process, we did not give any references in the conclusion section. |

## Referee's references:


Balkanski, Y., Schulz, M., Claquin, T., & Guibert, S. (2007). Reevaluation of mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data. Atmospheric Chemistry and Physics, 7, 81–95. https://doi.org/10.5194/acpâ7â81â2007

Dufresne, J. L., Gautier, C., Ricchiazzi, P., & Fouquart, Y. (2002). Longwave scattering effects of mineral aerosols. Journal of the Atmospheric Sciences, 59, 1959–1966. https://doi.org/10.1175/1520â0469(2002)059<1959:LSEOMA>2.0.CO;2

Delmonte, B., Andersson, P., Schöberg, H., Hansson, M., Petit, J. R., Delmas, R., Gaiero, D. M., Maggi, V., and Frezzotti, M.: Geographic provenance of aeolian dust in East Antarctica during Pleistocene glaciations: preliminary results from Talos Dome and comparison with East Antarctic and new Andean ice core data, Quat. Sci. Rev., 29, 256–264, doi:10.1016/j.quascirev.2009.05.010, 2010


## Author's references:


Albani, S., Mahowald, N. M., Delmonte, B., Maggi, V., and Winckler, G.: Comparing modeled and observed changes in mineral dust transport and deposition to Antarctica between the Last Glacial Maximum and current climates, Clim. Dyn., 38, 1731–1755, https://doi.org/10.1007/s00382-011-1139-5, 2012.

Balkanski, Y., Schulz, M., Claquin, T., and Guibert, S.: Reevaluation of Mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data, Atmospheric Chem. Phys., 7, 81–95, https://doi.org/10.5194/acp-7-81-2007, 2007.

Boucher, O.: Atmospheric Aerosols: Properties and Climate Impacts, Springer Netherlands, https://doi.org/10.1007/978-94-017-9649-1, 2015.

Delmonte, B., Petit, J.-R., Andersen, K., Basile-Doelsch, I., Maggi, V., and Lipenkov, V.: Dust size evidence for opposite regional atmospheric circulation changes over East Antarctica during the last climatic transition, Clim. Dyn., 23, 427–438, https://doi.org/10.1007/s00382-004-0450-9, 2004.

Dufresne, J.-L., Gautier, C., Ricchiazzi, P., and Fouquart, Y.: Longwave Scattering Effects of Mineral Aerosols, J. Atmospheric Sci., 59, 1959–1966, https://doi.org/10.1175/1520-0469(2002)059<1959:LSEOMA>2.0.CO;2, 2002.

Kohfeld, K. E., Graham, R. M., de Boer, A. M., Sime, L. C., Wolff, E. W., Le Quéré, C., and Bopp, L.: Southern Hemisphere westerly wind changes during the Last Glacial Maximum: paleo-data synthesis, Quat. Sci. Rev., 68, 76–95, https://doi.org/10.1016/j.quascirev.2013.01.017, 2013.

McGee, D., Winckler, G., Borunda, A., Serno, S., Anderson, R., Recasens, C., Bory, A., Gaiero, D., Jaccard, S., Kaplan, M., McManus, J., Revel, M., and Sun, Y.: Tracking eolian dust with helium and thorium: Impacts of grain size and provenance, Geochim. Cosmochim. Acta, 175, https://doi.org/10.1016/j.gca.2015.11.023, 2015.

Steffensen, J. P.: The size distribution of microparticles from selected segments of the Greenland Ice Core Project ice core representing different climatic periods, J. Geophys. Res. Oceans, 102, 26755–26763, https://doi.org/10.1029/97JC01490, 1997.

## Referee 2:

| Comment by referee 2 | Reply by authors | Changes in the manuscript |
|---|---|---|
| **Primary comments** | | |
| The paper would benefit from more time in the introduction and conclusion spent reviewing what is known and the disagreements regarding dust provenance to Antarctic and the Southern Ocean. I was pleased when the authors brought up many of the studies when discussing their results, but I felt the bigger picture was somewhat overlooked. Specifically, there are conflicting studies regarding whether South America or Australia is the primary source of dust (and for that matter how much is contributed by Antarctic sources), and the relative role of dust source strength and transport efficiency. I think the authors have room here to set up and then answer some questions about how these discrepancies can be resolved by considering the time-varying relative strength of sources, the transport efficiency, and the spatial distribution of their influence. I think much of this information is already contained in the paper, but an explicit consideration of the debate would be valuable. One additional source to consider is Markle, et al. (2018). | Since the provenance studies for dust in the Southern Hemisphere are an important part of our study, we agree and will include a brief overview on the conflicting studies regarding whether South America or Australia is the primary source of dust already into our introduction section. As written in our reply to Eric Wolff's comment on our manuscript [1], we will not be able to give an ultimate answer on the question whether changes in source strength or transport efficiency eventually led to the observed increase in mineral dust aerosol concentration during the LGM found in marine sediments and Antarctic ice cores. Considering the fact that more than 90% of the dust deposition in the Southern Ocean region occurs due to precipitation in our model, we agree with Markle et al. (2018) that "precipitation in the mid-latitudes is the principal barrier to aerosol reaching the poles". However, we disagree that changes in the hydrologic cycle are the primary driver since we also find substantial and required changes in source strength by a factor of 16 for both Patagonia and Australia, which we can trace back well to changes in vegetation, wind speed, soil moisture and extension of the source areas. Moreover, the authors find the best agreement between their modeling results and data "at multi-centennial and longer timescales", while our study captures only a 30-year period under LGM conditions and thus considers in particular processes on much shorter timescales. We will include those aspects in our revised manuscript. | We included a brief overview on the conflicting dust provenance studies in the introduction section in the lines 66-79.<br><br>We combined our results with the ongoing debate on the relative role of source strength and transport efficiency in the lines 431-450. |
| What about New Zealand? I was surprised that the LGM simulations don't seem to include an expanded dust source from the exposed continental shelf around New Zealand, nor any discussion of it as a dust source during that period. Neff, et al. (2015) and Koffman, et al. (2021) would be relevant to this discussion. | We are aware of the ongoing discussions on New Zealand as a potential dust source especially for the South Pacific during the last LGM (e.g. Lamy et al., 2014). Our model yields annual dust emissions of less than 1 Gg $yr^{-1}$ from New Zealand during the LGM, which is effectively negligible compared to the simulated emissions of 748 Tg $yr^{-1}$ (Australia) and 36 Tg $yr^{-1}$ (Patagonia). The low emissions in our model also explain why New Zealand appears to not represent a dust source at all during the LGM in Fig. 1b (*paper*).<br><br>One reason to consider is that New Zealand's geographical expanse is rather small and thus only marginally captured by our model running in the spatial resolution of T63, which corresponds to a grid box size of approximately 180 km (Sidorenko et al., 2015). Consequently, New Zealand's source strength and the according contribution to the dust deposition in the Pacific sector of the Southern Ocean during the LGM (Koffman et al., 2021) might be underestimated in our model. The study of Neff and Bertler (2015) uses a trajectory modeling approach for the years 1979 to 2013 based on reanalysis datasets for the according pressure | We added the according information in the lines 367-372. |

[1] https://cp.copernicus.org/preprints/cp-2021-73/cp-2021-73-AC1-supplement.pdf

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| | fields. Additionally, the authors mention in their study that they investigate solely the trajectories without taking into account emission and deposition processes, which does not enable us to compare our simulation results for the LGM to the results of their study.<br><br>However, we agree that our findings concerning New Zealand's role as a dust source during the LGM should be included in our study and we will do so in our revised manuscript. | |
| The authors cover many of the modeling studies of dust transport to the Antarctic in their discussion of provenance, but there are also studies that take an isotopic approach that should be discussed as well. Wengler et al. (2019), McGee et al. (2016). | The study of Wengler et al. (2019) provides lithogenic flux data only for the Holocene, stating that surface sediments near New Zealand "most likely indicate a combination of Australian dust and riverine input from New Zealand". Since our model only considers aeolian dust fluxes, we cannot compare our simulation results for PI and LGM.<br><br>However, we will include in our revised manuscript that the reconstructed dust fluxes used in our study for comparison with our simulation results (DIRTMAP, Kohfeld et al. (2013)), which are based on the assumption of relatively constant proportions of $^{232}$Th in continental lithogenic materials, might be overestimated by 30–40 % in regions receiving fine-grained dust from Patagonia and Australia (McGee et al., 2015). | We considered studies on dust provenance based on an isotopic approach in the lines 66-79, 336-348 and 399-403. |
| **Minor comments** | | |
| How is land tiling / vegetation coverage determined for the newly exposed continental shelf? Essentially, is the newly exposed land always a dust source, or can it become vegetated? | As mentioned in our manuscript, we perform a restart for our LGM experiments using restart files, which represent a dynamic equilibrium of our model for the according topographic, vegetation and climate conditions obtained after several hundred years of simulation (line 172).<br><br>Generally, the land fraction of *each* grid cell can become vegetated according to the rules and equations for dynamic vegetation implemented in the land surface and vegetation model JSBACH, which are described in detail in Reick et al. (2013), paragraph 3 "*Natural Land Cover Change*". In short, the process of increasing / decreasing vegetation for each grid cell depends on several factors like meteorological conditions (temperature, precipitation, humidity, …), competition among the different plant functional types (PFT), the respective time constants for growth and lifetime for each PFT etc.. One of the leading principals is the so-called *universal presence*, i.e. seeds of each PFT are always on the land fraction in each grid cell available and the factors mentioned before determine the respective proportion of each PFT per grid cell. The land fraction of each grid cell can be further divided into a vegetated and a non-vegetated (desert) fraction. The latter has been used by (Stanelle et al., 2014) to determine the area for dust emissions in each grid cell, which are additionally influenced by several meteorological factors like wind speed, soil moisture etc.. The following maps show the desert fraction for each grid cell for PI and LGM. | Since the reference to the dynamic vegetation model JSBACH is given in line 127 and a detailed description of the model would be beyond the scope of our study, we did not include further background information.<br><br>However, we included the according subplots on vegetation in Fig. 2, showing the desert fraction for each grid cell. |

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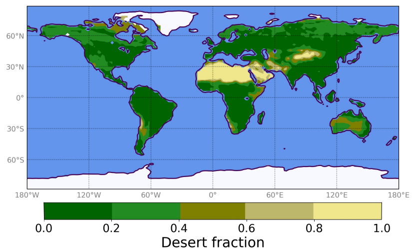
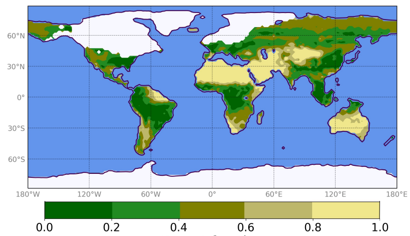
<td>(g) Vegetation - PI 1850-1879<br><br><br>(h) Vegetation - LGM 21kyr BP<br><br></td>
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<td>Since additional land area during the LGM is credited as one of the causes of increased dust emission, I would like some information, similar to the reported wind and precip changes, that tells me how much additional land there is in each region (and possibly some discussion of how much of the dust is being created from this new land).</td>
<td>Please find the according information in the following table.<br>
<table>
<tr><th></th><th>Additional land area LGM [Mio. km$^2$]</th><th>Dust Emission [Tg yr$^{-1}$] PI 1850-1879</th><th>Dust Emission [Tg yr$^{-1}$] LGM 21kyr BP</th><th>Dust Emission [Tg yr$^{-1}$] on additional land areas</th></tr>
<tr><td>Globally</td><td>19.5</td><td>923</td><td>5159</td><td>230</td></tr>
<tr><td>Australia</td><td>1.8</td><td>47</td><td>748</td><td>92</td></tr>
<tr><td>Southern Africa</td><td>0.04</td><td>12</td><td>63</td><td>5</td></tr>
<tr><td>Patagonia</td><td>0.8</td><td>2.3</td><td>36</td><td>29</td></tr>
</table>
<br>Globally as well as in Australia and Southern Africa, the additional land areas as a consequence of the lower sea level during the LGM contribute only a small proportion to the additionally emitted dust. Consequently, the main reasons for the increase are changes in vegetation (see maps above) and meteorological factors, for instance precipitation patterns and wind speed. In Patagonia, however, the additional land area, mainly consisting of drylands (see vegetation maps), contributes substantially to the absolute dust emissions, which can also be seen in Fig. 1b (paper).</td>
<td>We included the according table as Table 4 in our manuscript and discussed certain aspects in the lines 284-287.</td>
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<td>In Figure 3, why are the simulated dust deposition values so stratified? The observations appear continuous across a couple orders of magnitude, while the simulated deposition values appear to form horizontal lines.</td>
<td>The stratification of the simulated dust deposition values indicate that the model is not able to capture the observed variation for both PI and LGM, in particular in the Pacific / Pacific SO region. Since the measurement locations are rather close to each other, the discrepancy might be caused by a shortcoming in the representation of the deposition process on a small scale in our model. However, it should be taken into account that we compare aeolian dust deposition fluxes onto the ocean surface to marine sediment data, i.e. aside from potential shortcomings in our model, horizontal dust transport processes in the ocean during sedimentation as well as dust flux contributions due to glacier erosion and fluvial inputs are not considered and might play a crucial role (e.g. Trudgill et al. (2020))</td>
<td>We discussed the data-model discrepancy in the lines 336-348.</td>
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<td>Continuous colorbars on log plots are difficult to accurately interpret. The maps in Figures 3 and 1 would be much easier to read if the colorbars had</td>
<td>Thank you for this suggestion, please find the accordingly adjusted plots (Fig. 3a, c, e) below.</td>
<td>We updated the according subplots in Fig. 3.</td>
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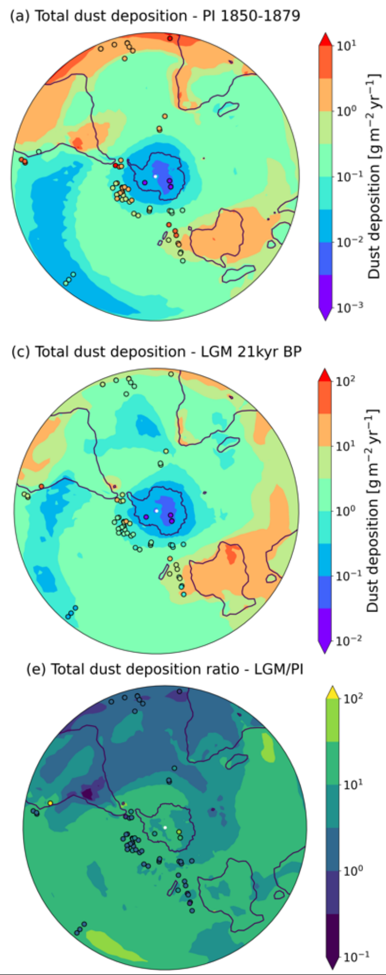
<td>discreet steps (while keeping the log scale). In Figure 1 it didn't bother me to much because I was more interested in the qualitative pattern than the quantitative values, but Fig. 3e I wanted o know where the one contour was, which is quite difficult to tell. I would suggest colorbars similar to those in Figs 2 and 5.</td>
<td>
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## Referee's references:

Markle, et al. (2018) Concomittant variability in high-latitude aerosols, water isotopes, and the hydrologic cycle, Nature Geoscience.

Neff, et al. (2015) Trajectory modeling of modern dust transport to the Southern Ocean and Antarctica, JGR: Atmospheres.

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