We thank Reviewer 1 for their thoughtful and insightful comments. The review provided thoughtful guidance for revising the paper, and we gratefully acknowledge the reviewers' time and feedback. The following response to review addresses each of the reviewers' comments and/or questions.

Our responses are given below with reviewer comments in italics; author response in regular font, and revised text from the paper is provided in blue.

68. Which subset? What were the criteria for selection? Say something briefly also in the main text.

While the entire Abakus measurements ranged from 1.1 – 12µm we only use 1.1 – 5.1µm due to limited number of particles in larger bin sizes. We add a new Figure 1e, highlighting size distribution variability over the over the Holocene, and the following sentence, "We analyze particles ranging from 1.1 – 5.1 µm and limit our temporal analysis from 11300 years BP to 250 years BP."

Text S1, p2. How are all the bins defined? You report "additional" bins by numbers … are they bin centers or lower/upper edges? How are those bins spaced?

We currently state in the text that bins "ranged continuously in 0.1µm increments from endpoints (lower) 1.0 – 2.5 µm, followed by bins 2.7, 2.9, 3.2, 3.6, 4.0, and 4.5 µm with an upper limit of 5.1 µm. We add additional sentence to state that "Bin lower limit represents the upper extent of the of the previous bin size."

Text S1, p2. "The CFA system has an effective resolution of 3 mm with a dispersion signal of 1 cm". What are the implications?

We add, "The implications of the CFA resolution and dispersion are negligible to the timeframe that we resample our average data to 50-year intervals. Current accumulation rates at the South Pole are ~8cm/year. While the CFA system can resolve particle concentrations to 3 mm intervals well below the accumulation rate, the coregistration of particles in the melter is a function of melt speed, ice density, and signal symmetry (Breton et al., 2012). Because we resample our data to 50 years intervals (mean depth interval of ~3.5 m), the dispersion of particles at 1 cm is negligible."

72. "we do not use metrics …" I suppose you refer only/specifically to the calculations of CPP, since your section 3.1 is called "Holocene dust flux". Please clarify.

We rephrase the paragraph to say, "We measure microparticle concentration and size distributions using subset of data collected from a continuous flow analysis (CFA) Klotz Abakus laser dust sensor at Dartmouth College (Text S1; Breton et al., 2012; Winski et al., 2021; Osterberg et al., 2006). We analyze particles ranging from 1.1 – 5.1 µm and limit our temporal analysis from 11300 years BP to 250 years BP. To facilitate a comparison with other ice core records, we use a density of 2.6 g cm-3 (following Koffman et al., 2014) and a spherical shape to estimate flux, rather than the measured prolate particle shapes (Chesler et al., 2023). While we recognize that South Pole particle shape metrics (i.e., mass and flux) are unconstrained for the Holocene (i.e., Chesler et al., 2023) because of limited available data, we use South Pole flux as a comparison tool to assess similarities between other available microparticle Antarctic Holocene. We restrict particle metrics to number concentration and CPP because the particle shape assumption (i.e., particle flux and mass concentration), can artificially increase particle metric concentrations by 25 – 44%. We use particle number concentration measured between 1.1 – 5.1 µm and CPP (defined as number of particles mL-1 [3.2 – <5.1] /[1.1–5.1] µm diameter x 100) following other East Antarctic studies (i.e., Delmonte et al., 2020). We use a spherical particle shape assumption to facilitate comparison to other Antarctica ice core particle records that include a volume assumption (i.e., flux). While this produces higher-than-realistic particle flux values, it mitigates discrepancies from comparing dissimilar metrics, whereas in the past particle shape has been assumed to be spherical (Chesler et al., 2023; Simonsen et al., 2018; Potenza et al., 2016). Studies concerned with the absolute magnitude of dust flux at the South Pole should use prolate particle shapes to calculate flux (Chesler et al., 2023; data at USAP-DC, DOI: 10.15784/601553)."

74. You should probably specify "we use particle number concentration"

Changed sentence to, "We use particle number concentration measured between 1.1 – 5.1 µm and CPP (defined as number of particles mL^{-1} [3.2 – 5.1] /[1.1–5.1] µm diameter x 100) …"

75. Remove "<" before "5.1"

The "<" has been removed.

Text S1, p2. "We use a spherical particle shape assumption to facilitate comparison to other Antarctica ice core particle records that include a volume assumption (i.e., flux)". You could compare your "best" fluxes, i.e. assuming spheroids, with Coulter Counter based fluxes (and for calculating CPP). Those measurements are deemed accurate with respect to the actual volume of the particles, without the need of any assumption on their shape. Using spherical equivalent diameters to identify their sizes does not conflict with this notion. In fact, I think you should add in the main text a description of how you calculate dust mass flux, and move Figure S1 to the main text. The shape is not the only possible source of uncertainty, as there might be an unconstrained bias, in terms of a systematic underestimation of dust fluxes, due to the limited size range of the laser counter; the comparisons with coulter counter measurements in Chesler et al. (2023) over the same size range do not allow a full evaluation this aspect. Also, you could compare different assumptions on particles shape (spheres and spheroids) to calculate mass-based FPP/CPP for the South Pole record and allow an easier comparison to previous published work using the same metric. At least this should be added as part of the supplement.

We move Figure S1 into the main text of the paper, becoming the new Figure 2 and add a new Figure 1e to show particle size distribution from the Holocene. Due to sample volume limitations, we were unable to take Coulter Counter measurements during the Holocene, which is why Chesler et al., 2023 is limited temporally to the last glacial period (54 – 16 ka). Furthermore, publicly available Holocene FPP/CPP is limited to Talos Dome of which the size information is not comparable to the South Pole (Albani et al., 2012). At Talos Dome, the fine particle fraction ranges from 0.6 – 5.0 µm and the course particle fraction ranges from 5.0 – 10 µm. Furthermore, we limit our dust concentration to 1.1 – 5.1µm, because coarser particles (5.1 – 12µm) make up on average 4% of all dust concentrations (median dust concentration; 1Q = 1.67%; 3Q = 9.26%). Since particles <5.1µm make up over 90% of the data and the South Pole spherical particle flux is similar to other East Antarctic ice core records we limit the size range to similar values to facilitate comparison.

We add, "We use a spherical particle shape assumption to facilitate comparison to other Antarctica ice core particle records that include a volume assumption (i.e., flux). While this produces higher-than-realistic particle flux values, it mitigates discrepancies from comparing dissimilar metrics, whereas in the past particle shape has been assumed to be spherical (Chesler et al., 2023; Simonsen et al., 2018; Potenza et al., 2016). Studies concerned with the absolute magnitude of dust flux at the South Pole should use prolate particle shapes to calculate flux (Chesler et al., 2023; data at USAP-DC, DOI: 10.15784/601553)."

78-80. Please provide a little more information on how you set up HYSPLIT runs, e.g. the starting vertical level of back trajectories, etc.

We add, "We run the model at an altitude of 1000 m following Schwanck et al. (2017)." After the first sentence of the paragraph.

83. "pre-industrial (1850 – 2014 AD)": this not pre-industrial. The indicated period suggests that you used the output from historical CMIP6 experiments, rather than the pre-industrial equilibrium control experiments with 1850 CE boundary conditions. Please clarify, also by adding the experiments IDs, and add references for both periods referring to the CIMP6 and PMIP4 experimental setup (or synthesis of the main results) publications, e.g. for the mid-Holocene: Otto-Bliesner et al., 2017, https://doi.org/10.5194/gmd-10-3979-2017 (or Brierley et al., 2020, https://doi.org/10.5194/cp-16-1847-2020). In fact, you should also justify why you chose the historical rather than the (more logic option) piControl experiments.

We rerun our model agreement analysis using the piControl model runs and add both citations to the figure caption. Figure 3 is now Figure 4. The figure caption now states, "Figure 4a – c: CMIP6-PMIP4 models agreement displaying difference between mid-Holocene and piControl precipitation (4a), wind speed(4b), and temperature (4c; Otto-Bliesner et al., 2017; Brierley et al., 2020). The color bar indicates the number of models that infer a positive or no/negative change in each variable between 6000 years BP and during the Pre-Industrial. Red regions indicate a stronger model consensus towards an increase and blue indicates a consensus towards a decrease in the respective variable. Values in the middle represent a lack of consensus. The black dotted line represents the average position of peak surface wind speed for both time periods.". We replace instances "historical" with pre-Industrial or piControl.

84. Do you mean "We replace all positive values, …" with ones?

To clarify, we amend the sentence to state, "We replace all positive values with a value of 1, which signifies an increase with time, and replace all negative values with a 0 and sum all model runs."

Table 1. I believe it's NCAR - CESM2

We replace the NCAR – CESM3 value with CESM2.

95-98. I would still prefer to read "number concentrations" for the sake of immediate clarity to the readers

We add the '#' symbol to the first sentence and add number concentration for immediate clarity. The sentences now read, "Total dust number concentrations (i.e., 1.1 – 5.1 µm # particles mL^{-1}) make up on average ~85 – 96% of all particles measured (median ± 1σ; Figure 1). The total dust number concentration and CPP abundance have opposing trends throughout the Holocene…"

97. "the timing of relative change within each metric is relatively similar": I do not understand this sentence, please clarify.

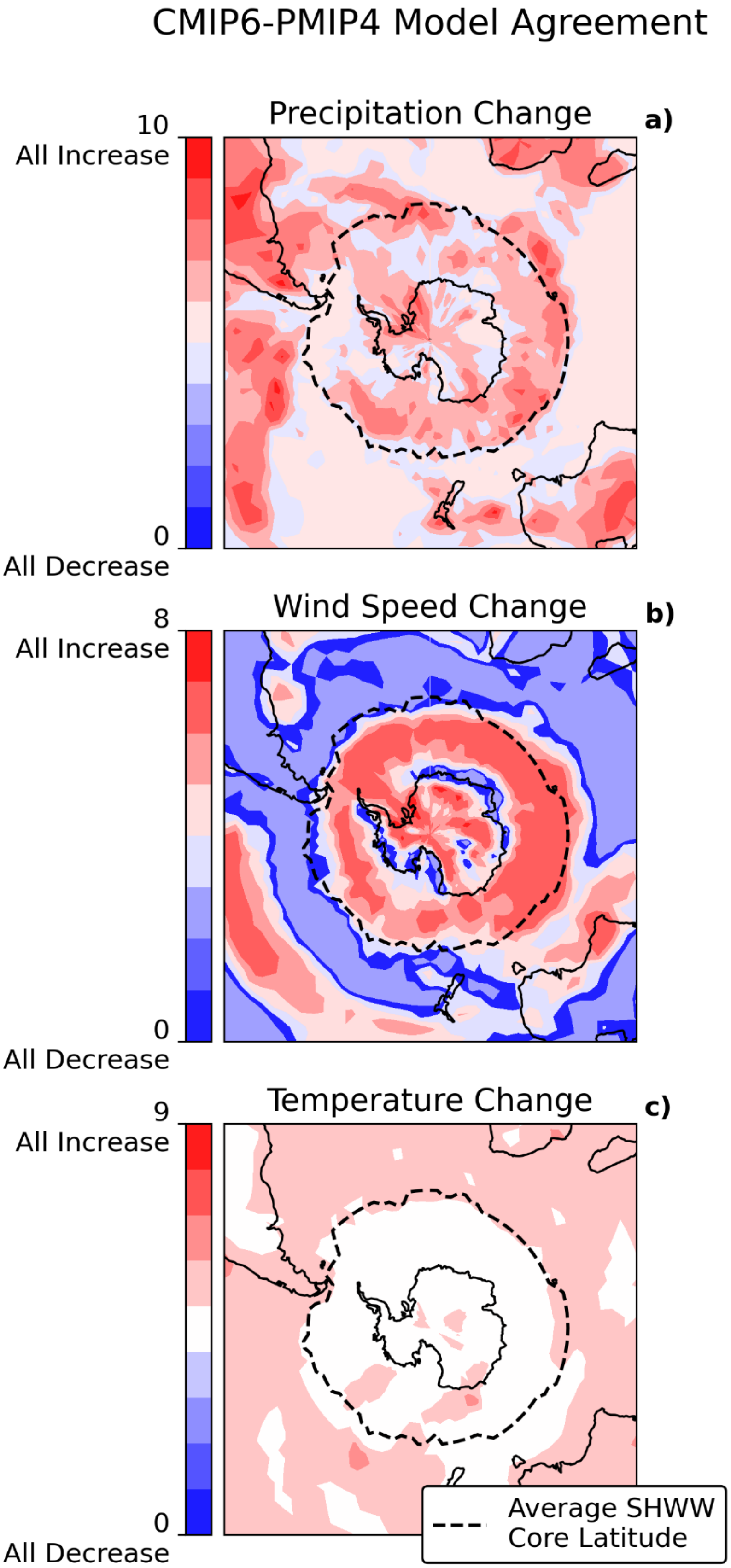
We clarify the sentence so that it now reads, "The total dust number concentration and CPP abundance have opposing trends, yet the timing of change in both trends begins about ~7000 years BP. This inverse relationship is most apparent during the mid-Holocene (~7000 – 3000 years BP)."

97-98. What I see is a generalized inverse relationship between number concentrations and CPP along the entire record, which breaks between ~2,000 and ~4,500 Years BP, when the two records run almost parallel to each other. The phrasing of the description here should be more accurate. In addition, this feature should be discussed when positing a significant relationship between d18O and dust in the following section, i.e. at lines 112-114. Perhaps, you could use a running window approach for calculating correlations.

We ran a running Pearson correlation window (1000 – 2000 years) and find strong correlations ($r > 0.4$) exist between dust concentration and CPP but only before 9000 years BP and between ~4500 – 3000 years BP. There was no substantial relationship between South Pole $\delta^{18}O$ and dust concentration ($r > 0.4$ or $r < 0.4$) throughout our record.

Figure 3. "No increase" should read "All decrease", and a symmetrically diverging red-white-blue palette might be more effective at depicting the actual situation.

Figure 4 (originally Figure 3) now has "All Decrease" instead of "No Increase" and we add a diverging color scheme so that the figure is more effective at depicting the model agreement (see below).


CMIP6-PMIP4 Model Agreement
Precipitation Change
a)
10
All Increase
0
All Decrease
Wind Speed Change
b)
8
All Increase
0
All Decrease
Temperature Change
c)
9
All Increase
0
All Decrease
Average SHWW
Core Latitude

156-160. Those two sentences are unclear. Please rephrase.

We clarify the two sentences to say, "While we recognize that some air masses and dust particles can be sourced from the East Antarctic Plateau, this area would not be the primary source of reduced dust emission during the mid-Holocene since southern South America and Australia are the primary sources of dust during the Holocene and modern period (Wegner et al., 2012; Vecchio et al., 2024; Delmonte et al., 2020). Rather we suggest that the decrease in dust concentration was driven by reduced SHWW activity in the wind in the mid-latitudinal regions (Figure 4)."

178-179. Not surprisingly you see a spatially consistent warming in all model simulation: you are comparing, apparently, mid-Holocene simulations with the average of historical simulations, which include the response to increased greenhouse gases emissions up to the present-day. Data. You should acknowledge the HYSPLIT website, World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, the Earth System Grid Federation, as well as indicate the specific ESGF node and access date of your downloads for CMIP6/PMIP4 model output data.

We changed our analysis so that we are using the piControl simulation, thereby removing the anthropogenic greenhouse gas forcing from our comparison and targeted the middle to late Holocene climate variability. We update our acknowledgements by adding in the following statements, which now read, "The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model and/or READY website (https://www.ready.noaa.gov) used in this publication. We acknowledge the World Climate Research Programme, which, through its Working Group on Coupled Modelling, coordinated and promoted CMIP6. We thank the climate modelling groups for producing and making available their model output, the Earth System Grid Federation (ESGF) for archiving the data and providing access, and the multiple funding agencies who support CMIP6 and ESGF. CMIP6 and PMIP4 model data was retrieved from the World Data Center for Climate (hosted by DKRZ) and Lawrence Livermore."

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