We thank both the reviewers for the careful reading of our manuscript and their constructive comments that helped further improving the presentation of the manuscript.

Here-below our point-by-point replies to the reviewers' comments.

Reply to reviewer #1

Comment: Why was new data added to Figure 10? There is substantially more data, which appears to have come from the addition of the Bigg datasets. Why was this added and why was it not included in the previous version? There is no explanation in the response.

Response: Following the other reviewer comment, we have added datasets even if they did not fall inside the simulated period. These data (Bigg 1973 and 1990, Yin et al., 2012) have been compared with the climatological monthly mean simulations as explicitly stated in the caption of Figure 10.

Reply to reviewer #2

Reviewer's statement: The updated figures and restructuring of the discussion greatly enhance the manuscript and increase clarity for the reader. The manuscript now also includes a more detailed and nuanced discussion of potential model biases, which is appreciated and helps put the current study in context and provides suggestions for future modeling and observational studies. I have only one broader comment and some suggested minor (mainly grammatical errors and typos) edits.

Response: We thank the reviewer for the very positive comment and the careful reading of the manuscript.

The broader comment of the reviewer is addressed as follows:

Comment: I still don't fully understand why 600 hPa was chosen as an example pressure level for Fig. 5. Although it is true that most INP measurements are made at a different temperature inside the instrument than the ambient temperature ([INP]T vs [INP]ambient), the aerosol being measured is still more representative of the boundary layer than the free troposphere, just at a different temperature than ambient ([INP]T). I agree that -20 °C is a reasonable temperature to choose to be representative of MPC glaciation, but at high latitudes -20 °C is reached within or very near to the boundary layer and the MPCs are typically not located in the free troposphere. Perhaps clarify that the pressure level chosen is representative of MPCs at low latitudes only, and not broadly representative of MPCs across all latitudes (lines 496-504). Much of the rest of the paper, and all the measurements being compared to in other figures are in the boundary layer, so it seems an odd choice to focus on the spatial distribution at a relatively high altitude, unless there is another reason I have missed.

Response: We have modified part of this discussion that now reads: "The chosen pressure level is representative of the low free troposphere and average temperatures broadly consistent with those of the INP measurements. These conditions of temperature and pressure are representative of low latitude MPC's glaciation, where most of the INP is simulated to occur (Fig. 5)."

Comment: The discussion of Fig. 5 is thorough, and the addition of the circled areas is helpful to follow the analyses. However, the mentions of "continental outflow" and "downwind of source areas", etc would make more sense for a lower altitude than 600 hPa, either near the surface, or at least within the boundary layer. Extensive long-range transport and mixing is expected for aerosols above the boundary layer, as well as a longer time since emission. There is no problem with discussing the results at this pressure/altitude, but trying to connect the results at 600 hPa to surface emissions perhaps needs to be more nuanced. This is particularly true since the high and low latitudes are discussed

together, but the fixed altitude used does not account for the changes in boundary layer height (temperature) or vertical mixing that occur between the equatorial regions and poles.

Response: Indeed, advection and vertical mixing are important for heights above the boundary layer and these are taken into account in the model. We mentioned already this when discussing Fig. 5a (INP from dust): 'dust sources and long-range atmospheric transport pattern'
For clarity, we have rephrased the sentence mentioning 'continental outflow' as follows:
" INP_D[600hPa, -20°C] shows also significant levels over the North Pacific, where dust is carried by continental outflows within the boundary layer or/and the free troposphere."

We have also added the following sentence that connects the discussion of Figure 5 (fixed pressure and temperature) with Figure 6 (averaged zonal mean profiles of INP number concentrations calculated at modelled temperature).
"Note that the spatial distribution of INP at a fixed pressure level and temperature shown in Fig. 5 and discussed above needs to be complemented by the vertical distribution of INP, which represents the combined effect of sources, long-range transport, vertical mixing and boundary layer height changes, that differ between low and high latitudes. In this context, figure 6 depicts…"

All minor suggested corrections have been considered in the revised version of the manuscript as can be seen in the track changes version. Figure captions have been rephrased for clarity. Fig 3 has not been redrawn as the original file is of excellent quality compared to the pdf version. The suggested corrections to the supplementary figures and the Table were implemented.

Regarding the comment on supplementary figure S1:
Check the legend on this figure, for example, the "ISAC_CNR_2012_Antarctica" and "Yin_China_2012" data have the same symbol, and the Antarctic data doesn't appear to be plotted.
Are all the points marked as "Bigg_1969-1989" from Bigg's papers, or are some from Welti et al. (2020) previously unpublished data (eg Tan1502, SHIPPO, etc)? I thought Bigg's measurements largely ended ~140°E south of Australia. Also a note that Bigg's Southern Ocean measurements are much higher (2-3 orders of magnitude) than all modern measurements (see e.g. McCluskey et al., 2018; Moore et al., 2024; Tatzelt et al., 2022) and may not provide the best comparison dataset for simulations in 2009-2016. The reference to "Figure 4" was probably meant to be for Figure 10, and perhaps also Fig. S6 and S7.

Response: The figure has been redrawn to avoid data with the same symbol. The caption has been also corrected. Note that the data points labelled "Bigg_1969-1989" are from Bigg's studies, accessible via the BACCHUS database at https://www.bacchus-env.eu/. While these measurements by Bigg are significantly higher—by two to three orders of magnitude— than contemporary data from sources such as McCluskey et al. (2018), Moore et al. (2024), and Tatzelt et al. (2022), they are nevertheless valuable for their extensive coverage of the Southern Hemisphere, particularly over the Southern Ocean. As can be seen in Figure 4 of the Bigg 1973 paper https://doi.org/10.1175/1520-0469(1973)030<1153:INCIRA>2.0.CO;2 there are data covering the area south of Australia from 60°E to 140°W. To our knowledge there are no modern measurements covering this large part of the hemisphere.