**Saini et al. “The Influence of Glacial Northern Hemisphere Ice Sheets on Atmospheric Circulation”**

**General comments:**

The authors describe the impacts of the Northern Hemisphere (NH) ice sheets at 49,000 years ago on the global atmospheric circulation. They shifted the NH westerlies southward, enhancing Eurasian summer rainfall but reducing it in winter. Their influence also extended to the tropics and the Southern Hemisphere (SH), displacing the Intertropical Convergence Zone (ITCZ) southward and intensifying Australian rainfall. The Laurentide and Antarctic ice sheets further modified the SH circulation, pushing the SH Hadley cell and westerlies equatorward. These results highlight the complex, far-reaching impacts of ice sheets on global climate patterns.

The manuscript is well-written, with clear articulation of the main findings and their broader implications. However, the study's conclusions are highly model-dependent, and further validation is needed to assess whether the simulated responses accurately reflect the glacial climate conditions of 49,000 years ago. Geographically extensive observational data for this specific period would be ideal for evaluation. If such data are unavailable, conducting a Last Glacial Maximum (LGM) experiment using the Australian Earth System Model (ACCESS-ESM1.5) could help assess the impacts of continental ice sheets on glacial climate. Given the computational cost and time constraints, referencing prior studies that used the same model for LGM simulations—along with their data-model comparisons—may suffice as an alternative.

Additionally, the authors could consider compiling a global footprint table for the 49,000-year (or MIS3) climate responses, similar to the Dansgaard-Oeschger (DO) event table in Izumi et al. (2023, QSR). While such a table would not provide quantitative metrics, it would facilitate a qualitative assessment of spatial patterns and enhance model evaluation.

If the authors maintain that this study exclusively examines the model’s responses, I recommend publication pending the resolution of minor revisions outlined in the specific comments below.

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**Specific comments:**

- The rationale for focusing on continental ice sheets at 49 ka rather than the Last Glacial Maximum (LGM) remains unclear. Given the greater availability of paleoclimate records for the LGM, as well as the more extensive ice sheet coverage and its pronounced influence on atmospheric circulation, the choice of 49 ka warrants further justification. The authors should explicitly address why the LGM was deemed unsuitable for this study or why the 49 ka timeframe provides critical insights that the LGM cannot.

- Do the ice sheets of the Last Glacial Maximum (LGM) and Marine Isotope Stage 3 (MIS3 or 49 ka) produce similar large-scale atmospheric and oceanic circulation responses—such as shifts in the Hadley Cell, Intertropical Convergence Zone (ITCZ), and the Atlantic Meridional Overturning Circulation (AMOC) —even if their magnitudes differ? For

instance, do they induce the same direction of change (e.g., positive or negative anomalies) despite amplitude variations?

- L43-45: Is it possible to take into account millennial-scale fluctuations in this study design? Do the author's results indicate stadial or interstadial climates? Isn't the concentration of research in the northern hemisphere due to the distribution of data for comparison?

- What were the thicknesses of the continental ice sheets—particularly the Laurentide and Antarctic ice sheets—at 49 ka (thousand years ago)?

- L97-98: "The final experiment… 49ka-full…was run for 292 years." Is it true? It does not match the contents of Table 2, if I understand correctly.

- L100: The authors should start a new paragraph here.

- L116: The study suggests that higher sea surface temperatures (SSTs) in the Labrador region are associated with a stronger AMOC in the 49ka-full experiment. Is this AMOC response mechanistically plausible?

- Precision in AMOC Comparisons (L245–246): "AMOC strength at the onset of interstadials versus the pre-industrial (PI) control", or "AMOC strength during stadial versus interstadial periods?"

- In section 3.3, I don't quite understand the relationship between the strength of the Hadley cell and the migration of the ITCZ through the texts and figures. Does the strength of the Hadley cells affect their width?