PROJECT SUMMARY

Collaborative Research: Identifying model biases in poleward heat transport: atmosphere-ocean partitioning, trends over the historical period and sub-seasonal variability

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Overview: The poleward movement of energy by atmospheric and oceanic circulations (meridional heat transport – MHT) plays a fundamental role in many characteristics of Earth's climate including climatological patterns of temperature and precipitation, their variability, and their changes in the future. Future changes in MHT rely on model projections of how the atmosphere and ocean will respond to global warming and have downstream impacts on climate change and variability. The proposed work will analyze the ways in which models are systematically biased relative to observations in their MHT. Specifically, we will analyze model biases in the partitioning of MHT between the atmosphere and ocean, MHT trends over the historical period, and the role of sub-seasonal variability in driving extreme heating events. The overarching theme of the research is to develop a process level understanding of misrepresented model physics at the global scale through a model-observational comparison across multiple observational timescales: climatological, trends, and natural variability. The broader goal is to understand the robustness of future changes in MHT—and their climate impacts -- considering the model biases at observable timescales. We emphasize that the PI and Co-I are uniquely positioned to analyze model biases in MHT partitioning and trends due to recent advances on the closure of energy budgets across observational timescales.

Intellectual Merit: Energetic analysis is ubiquitous in the climate research community and the proposed work will develop methods and resources for the model-observation comparison of global scale energy flows. These novel metrics for observational-model comparison will provide insight into potential model biases in the underlying physical processes. Complementary idealized model experiments will further probe the hypothesized sources of model biases, providing mechanistically grounded insights for potential improvements (or bias corrections) to future model generations. Additionally, the proposed work will analyze the role of observed MHT variability in historical surface heating events (e.g. terrestrial heat waves and sea ice loss) which have large societal impacts.

Broader Impacts: The proposed work will provide a process level improvement of biases in comprehensive climate models, thereby advancing our fundamental understanding of a natural system of significant scientific and societal importance. This project will support the training of a graduate student and will additionally contribute to undergraduate education through research and teaching. The research component will lead to more robust predictions of future changes in societally relevant climate fields including heat wave intensity. The public release of accurate codes for diagnosing energy transport from standard model outputs and from high-frequency reanalysis products will facilitate research by scientists from other disciplines. Public outreach by the PI and Co-I on project related science concepts will engender enthusiasm amongst younger generations and raise awareness of climate research among the general public.