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The Emergence of Low-Frequency Variability: Comparison of Historical Data and Simulations

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Regional climate change projections over the course of the 21st century require the accurate simulation of both anthropogenic and natural variability. The spatial patterns of natural variability are relatively well constrained on sub-decadal timescales based on instrumental data evidence, and climate models can simulate them. For longer (supra-decadal) timescales, however, the spatial patterns of natural (temperature) variability are poorly constrained because of the shortness of the instrumental record and the overlap with anthropogenic influences. Insights gained from paleoclimate data over land in mid-latitudes suggest that oceanic influence was the main driver of increased low-frequency natural variability, in contrast to its stabilizing role on sub-decadal timescales. Here, by studying the spatial imprint of multi-decadal climate variability, we show that the instrumental data is consistent with this hypothesis. While the pattern is also observed in climate models, it is much weaker and seems to rely solely on forced variability. Therefore, while climate models can simulate anthropogenic warming, our evidence indicates, particularly over the northern land mid-latitudes, that they are not simulating supra-decadal natural variability (forced and internal) consistent with instrumental observations in terms of the spatial pattern and its amplitude.