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Emergence of Low-Frequency Temperature Variability in Instrumental Data and Model Simulations

Raphael Hébert and Thomas Laepple
Alfred-Wegener-Institut Helmholtz-Zentrum für Polar-und Meeresforschung Stiftung des öffentlichen Rechts, Potsdam, Germany (raphael.hebert@awi.de)

The amplitude and spatial distribution of low-frequency natural variability is determinant for regional climate projections, but it is still poorly understood.

In a previous study, pollen-based temperature reconstructions were used to quantify spatial patterns of millennial temperature variability. This showed an inverse relationship across timescales with sub-decadal variability from instrumental data in extra-tropical regions over land (Hébert et al., 2022, under review). We concluded that due to varying marine influence, regions characterized by stable oceanic climate at sub-decadal timescales experience stronger long-term variability while continental regions with higher sub-decadal variability show weaker long-term variability. Indications of this relationship could also be inferred from instrumental data alone as regions of low sub-decadal variability were more likely to exhibit a steeper increase of variability over multi-decadal timescales and vice versa.

In the current work, the relationship found in the instrumental data was further investigated using different instrumental products. In addition, a large multi-model ensemble of CMIP6 models, as well as single-model ensembles, were considered for analysis and it was found that they do not systematically reproduce the relationship found in the instrumental data. This indicates a fundamental deficiency in the model simulations with regard to the mechanism driving the emergence of low-frequency climate variability. This characteristic being related to multi-decadal variability thus has important significance for multi-decadal regional climate projections and might be used as an emergent constraint in model evaluation and inter-comparison.