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The Stationarity of Dynamically-Driven European Temperature Variability in N x CO_2 Multi-Century Simulation Ensembles

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Changes in European near-surface air temperature variability are projected in response to anthropogenic climate change, due to changes in atmospheric circulation patterns and thermal advection (‘dynamics’) and changes in local radiative and land surface processes (‘thermodynamics’). Statistical techniques have been developed to quantify the relative importance of dynamics on regional temperature variability by empirically determining the relationship between sea level pressure (SLP) and temperature. These techniques can be used to explore whether dynamically-driven temperature variability changes result from changes in SLP or solely from changes in the SLP - temperature relationship due to differential midlatitude-pole and land-sea warming rates. Removing the effect of dynamics on temperature also reveals regions where changes in land surface feedbacks associated with snow cover or soil moisture may contribute to variability change in future climate.

In this study, two such techniques, machine learning dynamical adjustment (Sippel et al., submitted) and circulation analogue dynamical adjustment (e.g. Deser et al. 2016, Lehner et al. 2017), are applied on monthly timescales to sets of four 20-member ensembles constructed from multi-century control runs subject to preindustrial, 2, 4, and 8 x CO_2 forcing levels. The use of large ensembles in this study is a necessity to robustly determine an estimate of internal variability, a baseline from which one can ascertain forced change. The frequency and spatial extent of atmospheric circulation patterns are compared within and between ensemble sets. Dynamical temperature variability is computed in each ensemble by training on/selecting analogues from 1) the preindustrial ensemble and 2) the respective N x CO_2 ensemble (i.e. dynamically adjust 2 x CO_2 ensemble with 2 x CO_2 training/analogues etc.) to assess the stationarity of the SLP - temperature relationship. Preliminary results suggest that changes in the frequency of winter circulation patterns emerge and contribute to European temperature variability change at 8 x CO_2. In contrast, variability change at lower levels of CO_2 forcing is primarily due to advection of warmer temperature anomalies by circulation patterns that fall within the range of preindustrial variability. Seasonal differences in dynamic vs. thermodynamic drivers of temperature variability change are also investigated.