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A Comparison of the Estimated Internal Variability of Near-surface Air Temperature Using Three Methods

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The combined effects of externally forced change and natural climate variability determine the climate anomalies. Internal variability has a great impact on climate change at various spatial-temporal scales. Characterizing and quantifying internal variability is of fundamental importance not only for purposes of detection and attribution, but also for reliability of climate projections. Therefore, the estimated internal variability of near-surface air temperature is compared using three widely adopted methods (pre-industrial control (piControl) simulations, polynomial fit method and analysis of variance method), based on 37 models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) and 40 large-ensemble simulations from the Community Earth System Model (CESM). The associated influences on the time of emergence (TOE) of near-surface air temperature in future climate projections are also quantified. The results show that for the multimodels from CMIP5, the estimated internal variability is comparable based on the piControl simulations and the polynomial fit method, while that estimated by the analysis of variance method is exaggerated in terms of the magnitude due to its inclusion of model uncertainty. Polar amplification is evident in the spatial distribution of estimated internal variability of surface temperature, with considerably larger magnitudes in the mid- to high-latitudes than the low-latitudes. The internal variability of surface temperature does not vary significantly with time or emission scenarios, except for that in the tropics estimated by the analysis of variance method. Moreover, the estimated internal variability shows high consistency among the three methods based on large-ensemble simulations from CESM. The different estimated internal variability further affects the TOE in future climate projections, mainly in the North Atlantic Labrador Sea and the Weddell and Ross Seas in the Southern Ocean where ocean deep overturning circulations occur. Specifically, the internal variability is estimated to be less than 15% of the forced signals over China based on all the three methods in the CESM large-ensemble simulations. This result is comparable to those estimated by the piControl simulations and polynomial fit method based on the CMIP5 multimodels, but tends to be overestimated by the analysis of variance method.