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The vertical profile of tropical temperature trends: Persistent model biases in the context of forced and internal variability

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Tropospheric and stratospheric tropical temperature trends in recent decades have been notoriously hard to simulate using climate models, notably in the upper troposphere. Aside from the warming signal itself, this has broader implications, e.g. atmospheric circulation trends depend on latitudinal temperature gradients. In this study, tropical temperature trends in the CMIP6 models are examined, from 1979 to 2014, and contrasted with trends from the RICH/RAOBCORE radiosondes, and the ERA5/5.1 reanalysis. Confirming previous studies, we find considerable warming biases in the CMIP6 modeled trends, and show that these biases are linked to biases in surface temperature (the models warm too much). We also uncover previously undocumented biases in the lower-middle stratosphere: the CMIP6 models appear unable to capture the time evolution of stratospheric cooling, which is non-monotonic owing to the Montreal Protocol. This troposphere-warming, stratospheric-cooling fingerprint of climate change is therefore not well captured in CMIP6 models. Finally, we quantify the relative roles of individual climate forcings in tropspheric and stratospheric temperatures, including that of internal variability.