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Warming holes: Can climate models represent the variability and sources of regional temperature trends in the Continental United States?

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Climate changes in the 20th Century, even when averaged over many decades, reveal significant regional structures. Prominent among these are regions of reduced warming or of cooling over the United States Midwest. These regions have been called "warming holes." The region of the U.S. warming hole includes some of the most productive agricultural lands in the world. If the hole should "fill", this likely will reduce the yields of food and bioenergy crops. Through analyzing model output, investigators have attributed the U.S. warming hole to regional changes in atmospheric circulation and hydrometeorology and to changes in cloud cover and precipitation driven by observed decadal variability in ocean temperatures Coupled atmosphere-ocean models from the IPCC 4th Assessment did not generally reproduce the observed warming holes when driven by estimated climate forcings for the 20th Century, showing either that the regional trends result from internal variability of the atmosphere-ocean system or that these models did not capture the relevant processes. If regional cooling trends are, indeed, a consequence of internal variability in the climate system, it is reasonable to expect these regions will "catch up" with the rest of the warming globe when the responsible internal dynamics swing the other way. Conversely, if the warming hole is a response to anthropogenic greenhouse warming, it could be expected to continue. The U.S. warming hole is precisely the sort of climate variability that must be represented - and predicted, if this is possible - accurately, if climate models are to provide actionable projections to guide adaptation and mitigation. Here we present analyses of 20th century model runs from the CMIP5 archive, in order to: 1. Assess whether the earlier result that global models do not reproduce the warming hole as a response to anthropogenic forcing, remains valid for CMIP5 models. 2. Assess whether warming holes, defined as regions of reduced warming over multiple decades, are captured in the internal variability of CMIP5 models, and, if so, whether they occur in preferred locations, such as the U.S. Midwest. 3. Assess whether CMIP5 models capture the observed local relationships between regional U.S. temperatures and clouds and precipitation and the global teleconnections to sea-surface temperatures.