Stratospheric Change and its Role for Climate Prediction
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The role of methane in projections of stratospheric water vapor trends

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Stratospheric water vapor (SWV) is an important component of the Earth's atmosphere as it affects both radiative transfer and the chemistry of the atmosphere. Key processes controlling SWV concentrations are dehydration of air masses transiting the cold-point tropopause, water vapor and methane transport via the Brewer-Dobson circulation and methane oxidation. Here, we use a range of simulations with the chemistry-climate model SOCOLv.3 to first isolate methane's contribution to SWV from climate effects, and then show projections of SWV following the four canonical Representative Concentration Pathways (RCPs) in the 21st century, and methane's contribution to these projections. Methane reduces by one-third of its year 2000 value by 2100 under RCP 2.6, while concentrations more than double under RCP 8.5 over the same period. We show that SWV trends are driven predominantly by warming of the cold-point tropopause and strengthening of the Brewer-Dobson circulation rather than by increasing methane oxidation. The largest contribution methane makes to SWV in 2100 is ~50% following RCP 8.5 in the extra-tropical upper stratosphere. Water vapor itself increases everywhere throughout the stratosphere following RCPs 4.5, 6.0 and 8.5, with the largest increase of ~60 % occurring in RCP 8.5 in the extra-tropical upper stratosphere. In RCP 2.6 SWV decreases by up to 5% in the upper stratosphere between 2000 and 2100, but increases by up to 10% in the tropical lower stratosphere. Given that it is water vapor in the lower stratosphere that exerts the largest influence on radiative forcing, SWV's influence on surface climate is expected to increase through the 21st century following all of the RCPs.