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Revisiting the stratospheric ozone response to global warming

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In response to global warming, ozone is predicted to increase aloft due to stratospheric cooling but decrease in the tropical lower stratosphere. The ozone reductions have been primarily attributed to a strengthening Brewer-Dobson circulation, which upwells ozone-poor air. Yet, we find that strengthening upwelling only explains part of the reduction. The reduction is also driven by tropospheric expansion under global warming, which erodes the ozone layer from below, the low ozone anomalies from which are advected upwards. Strengthening upwelling and tropospheric expansion are correlated under global warming, making it challenging to disentangle their relative contributions. Therefore, chemistry-climate model output is used to validate an idealized model of ozone photochemistry and transport with a tropopause lower boundary condition. In our idealized decomposition, strengthening upwelling and tropospheric expansion both contribute at leading order to reducing tropical ozone. Tropospheric expansion leads to an upward shift in the tropospheric destruction of ozone—not to an upward shift in ozone itself—implying that tropopause-following coordinates do not generally remove the effects of tropospheric expansion on ozone.