

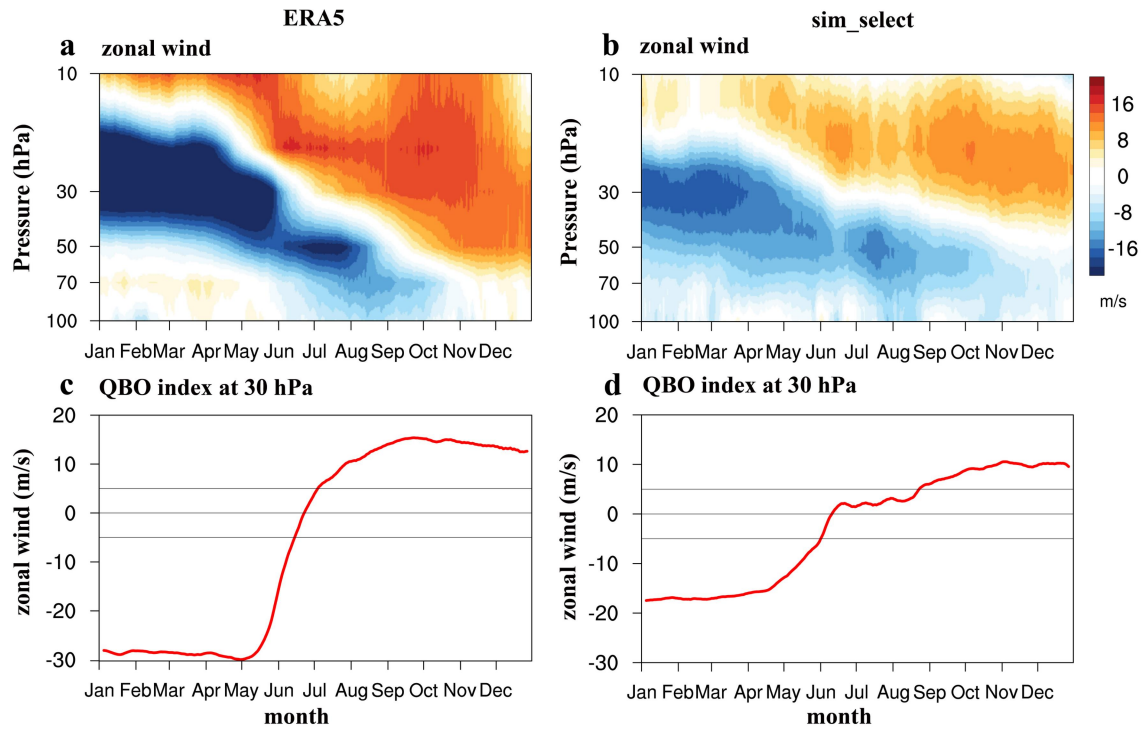


Figure S1. Zonal wind over 2°S–2°N at 10–100 hPa in (a) ERA5 in 2022, (b) sim_select. The QBO index at 30 hPa in (c) ERA5 in 2022, (d) sim_select.

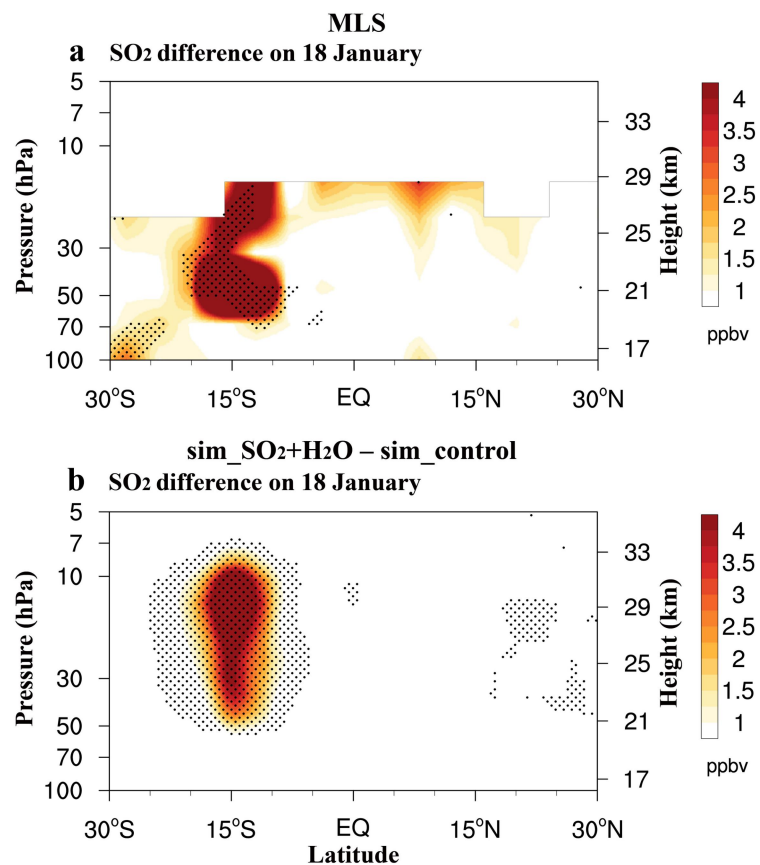


Figure S2. SO₂ difference on 18 January based on (a) MLS data, (b) WACCM6 data. In (a), the differences are obtained by minusing climatology between 2007–2021. In (b), the differences are obtained by sim_SO₂+H₂O minusing sim_control. Hatching indicates statistically significant areas at the 95% confidence level. Here, the statistical significance is estimated by Student's t-statistic, which tests whether two sample populations have significantly different means (the same as follows).

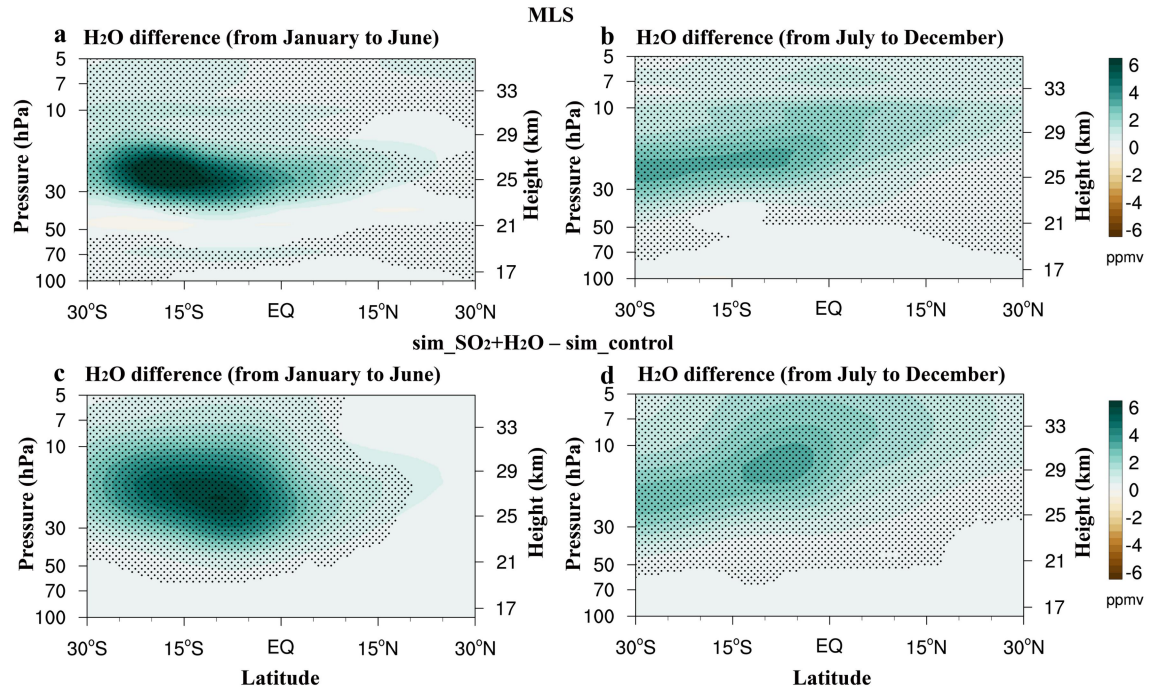


Figure S3. Zonal mean H₂O differences for the (a) first and (b) second half-year based on MLS data. (c-d) same as (a-b), but for WACCM6 data. In (a-b), the differences are obtained by minusing climatology between 2007–2021. In (c-d), the differences are obtained by sim_SO₂+H₂O minusing sim_control. Hatching indicates statistically significant areas at the 95% confidence level.

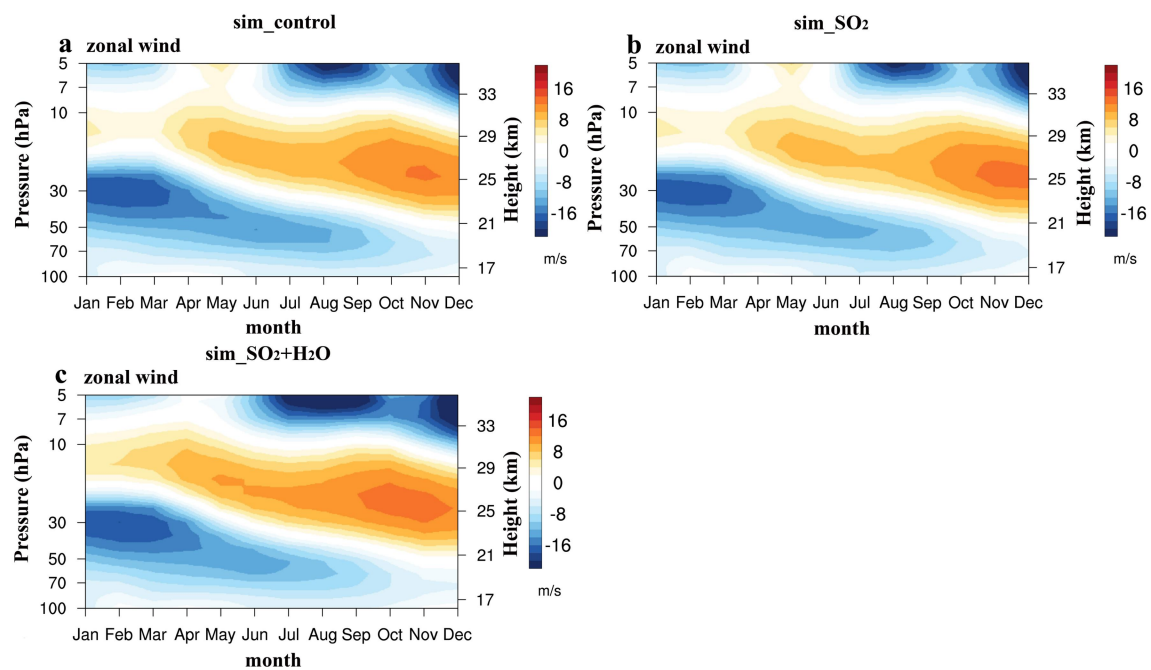


Figure S4. Temporal distribution of zonal mean zonal wind in (a) sim_control, (b) sim_SO₂, (c) sim_SO₂+H₂O over 2°S–2°N at 5–100 hPa.

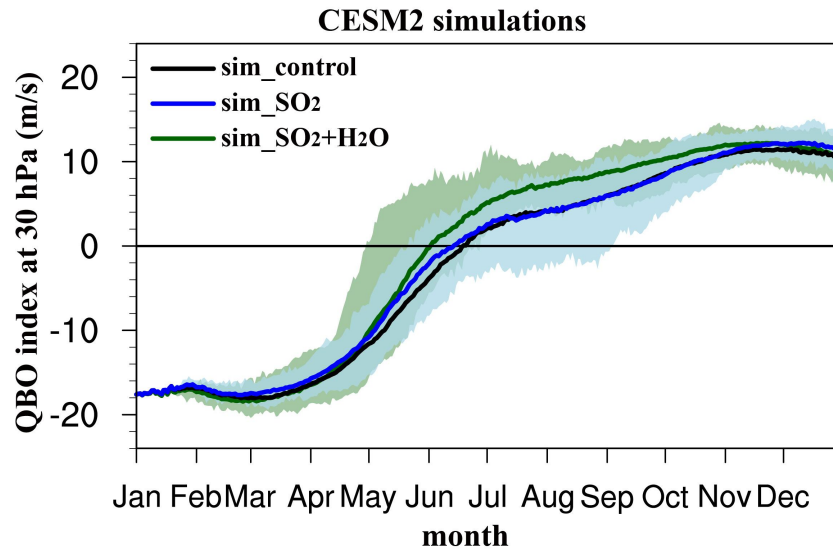


Figure S5. The QBO index at 30 hPa in CESM2 simulations. The shaded areas represent the maximum and minimum values, respectively. The black, blue, and green lines represent the results of **sim_control**, **sim_SO2**, and **sim_SO2+H2O**, respectively.

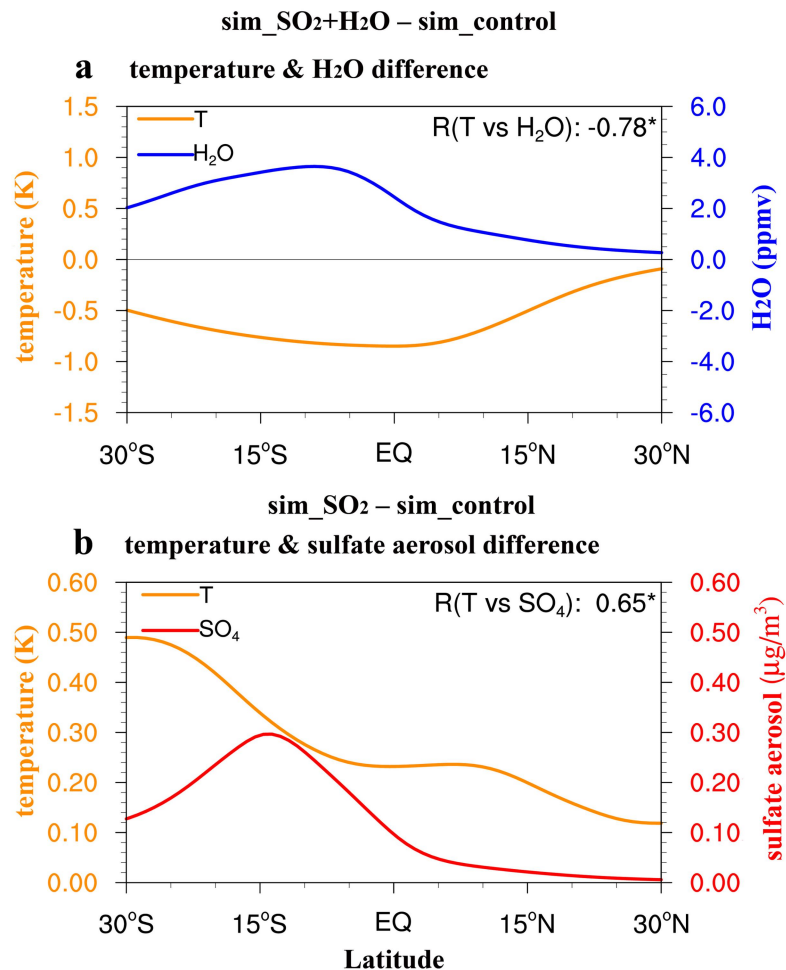


Figure S6. Zonal mean H₂O and sulfate aerosol concentration differences and stratospheric temperature differences in the tropical stratosphere (10–30 hPa). (a) Zonal mean temperature and H₂O anomalies between sim_SO₂+H₂O and sim_control (sim_SO₂+H₂O – sim_control); (b) zonal mean temperature and sulfate aerosol anomalies between sim_SO₂ and sim_control (sim_SO₂ – sim_control). The blue, red, and orange solid lines represent H₂O, sulfate aerosol, and temperature differences, respectively. The correlation coefficient (R) is shown in the top-right corner. Asterisks indicate that the correlation coefficient is significant at the 95% confidence level.

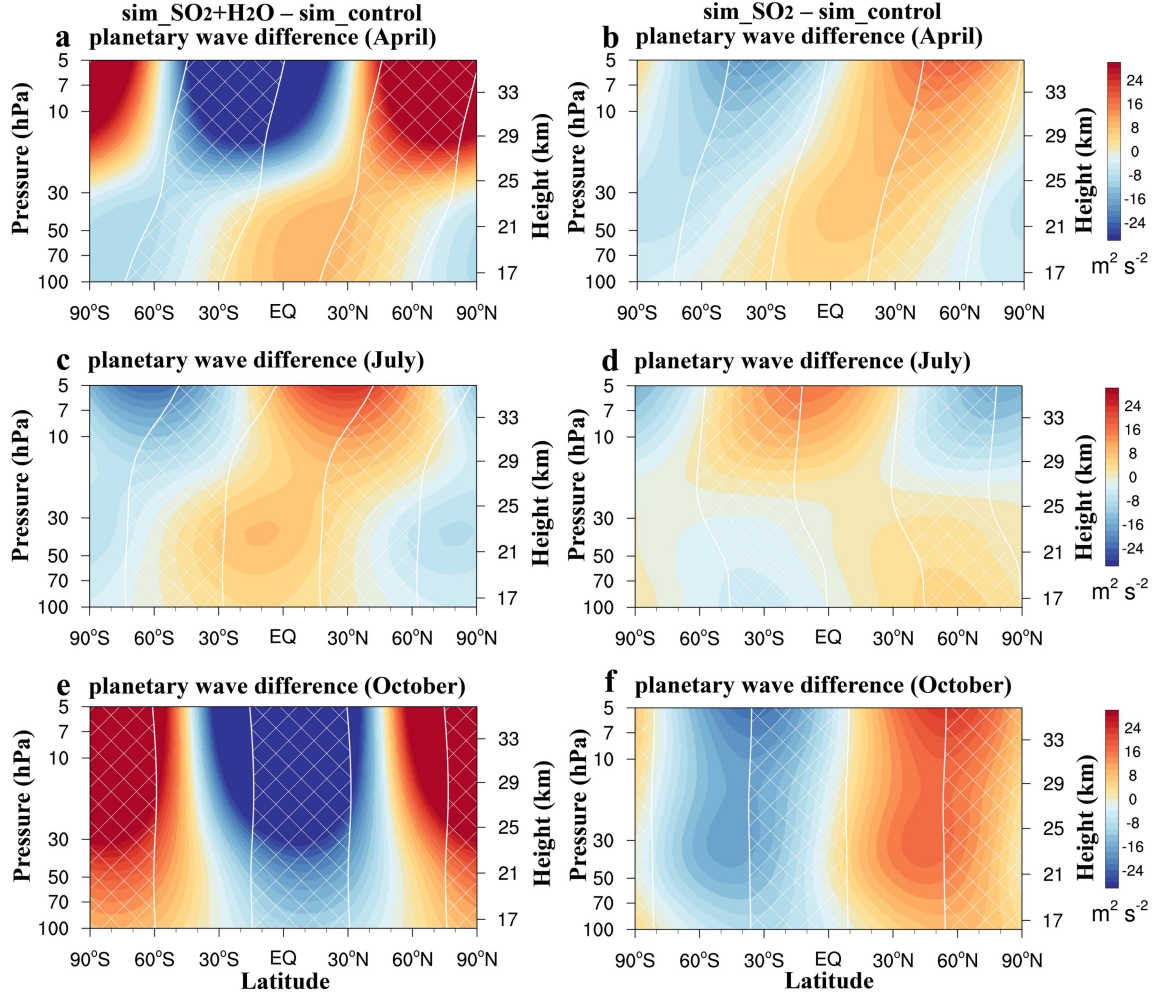


Figure S7. Zonal mean planetary wave 1 and 2 differences in the stratosphere. (a, c, e) Zonal mean planetary wave 1 and 2 differences between sim_SO₂+H₂O and sim_control (sim_SO₂+H₂O - sim_control), with results for (a) April, (d) July, and (g) October, respectively, from top to bottom; (b, d, f) the same as (a, c, e), but showing the results between sim_SO₂ and sim_control (sim_SO₂ - sim_control). The shading indicates the planetary wave 1 differences. The white gridded area indicates planetary wave 2 positive differences.