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Supplement of

Changes in the tropical upper-tropospheric zonal momentum balance due to global warming

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Supplement

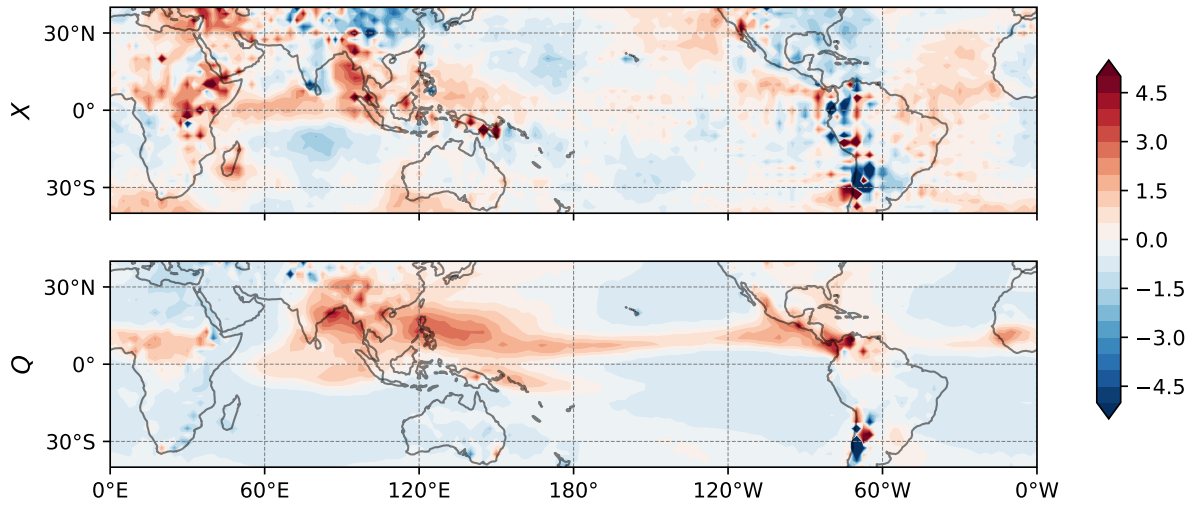

Figure S1. JJAS and 150-300 mbar averaged (top) Momentum budget residual (unit $ms^{-1}day^{-1}$) and (bottom) diabatic heating rate (unit K day^{-1}) estimated as a residual from the thermodynamic energy equation (Holton and Hakim, 2012). X is calculated using the advective form of the momentum eqution (for e.g., Lin et al., 2008)

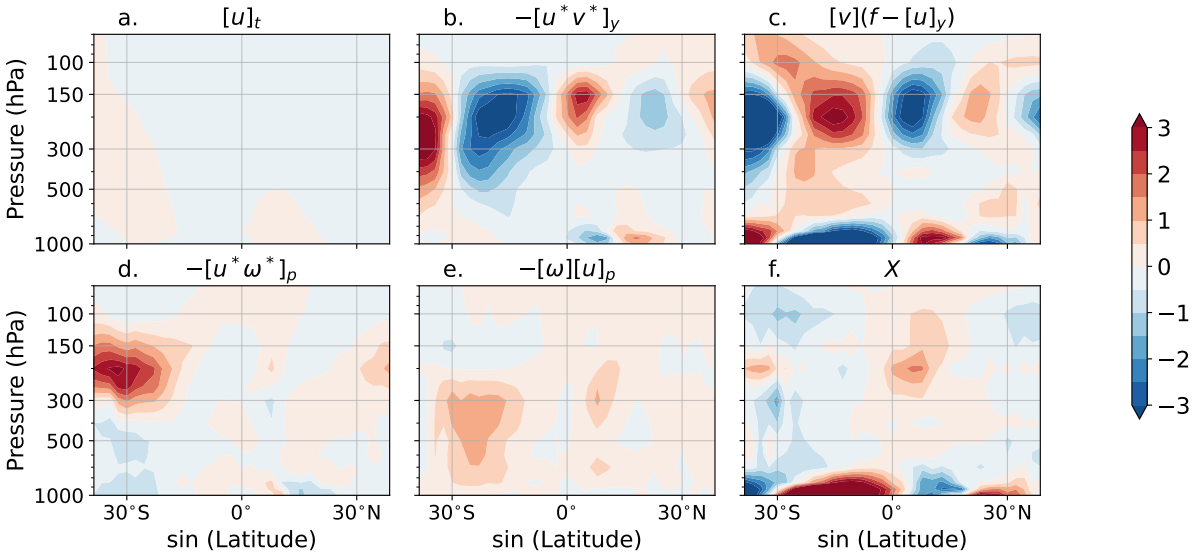

Figure S2. Climatological latitude-pressure profile of all terms in the zonal mean zonal momentum budget averaged over JJA.

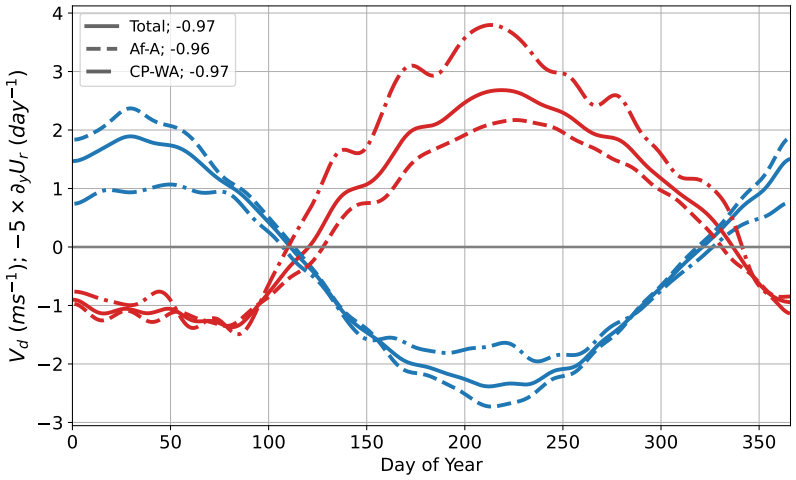

Figure S3. Climatological Day of Year variation of v_d (blue) and $-5 \times \partial_y u_r$ (red) zonally averaged over all longitudes (solid), A-Af (dashed), CP-WA (dash-dotted) and Africa (dotted). As Figures 1 and 3, all quantities are averaged over 150-300 hPa, about $\pm 5°$. $-\partial_y u_r$ has been multiplied by 5 to ensure a vertical scale similar to v_d. A 20-day low-pass filter has been applied prior to presentation.

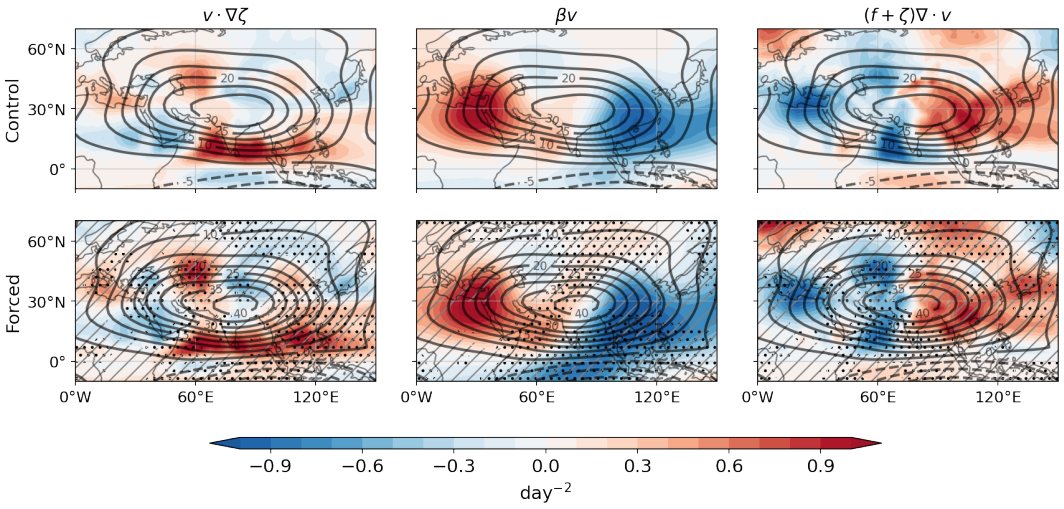

Figure S4. All terms in the upper atmospheric steady-state vorticity budget (Sardeshmukh and Held, 1984). The top panels are for the control run while the bottom panels are for forced.

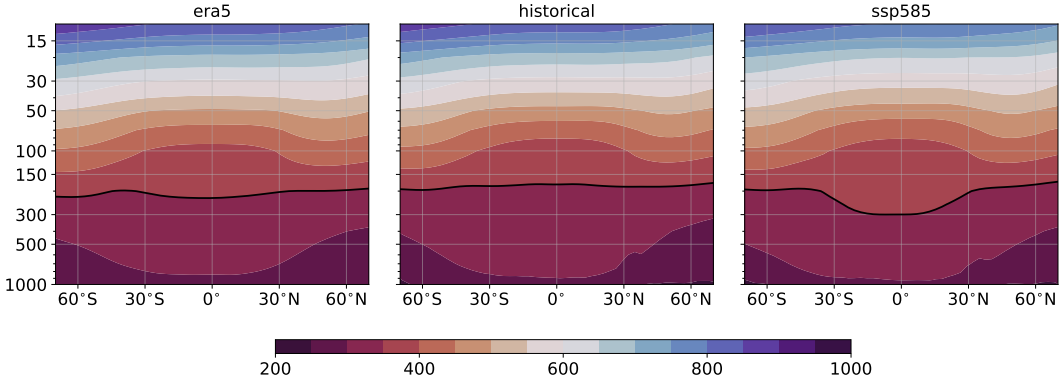

Figure S5. Latitude-height section of zonal mean potential temperature for (left) historical and (right) ssp585.

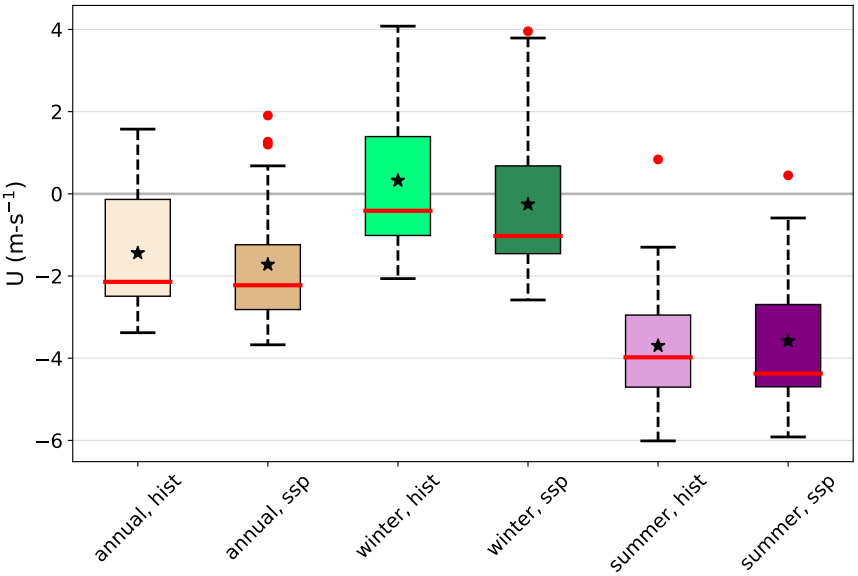

Figure S6. Temporally and zonally averaged zonal wind spread for the CMIP6 fully coupled simulations for averaged over $\pm 5^{\circ}$ of the equator and 150-300 mbar. The data represented are annual, winter, and summer season means for the control and forced multi-model ensembles. Points marked with black stars indicate the mean, while the horizontal red lines indicate the median. The lower value indicated by the box plot is the first quartile (Q_1), while the upper value is the third quartile (Q_3). For each box plot, the reach of the whiskers is 1.5xIQR beyond Q_1 and Q_3, where IQR = Q_3 - Q_1. The red dots are outliers.

References

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Sardeshmukh, P. D. and Held, I. M.: The vorticity balance in the tropical upper troposphere of a general circulation model, Journal of Atmospheric Sciences, 41, 768–778, https://doi.org/10.1175/1520-0469(1984)041<3C0768:TVBITT>2.0.CO;2, 1984.