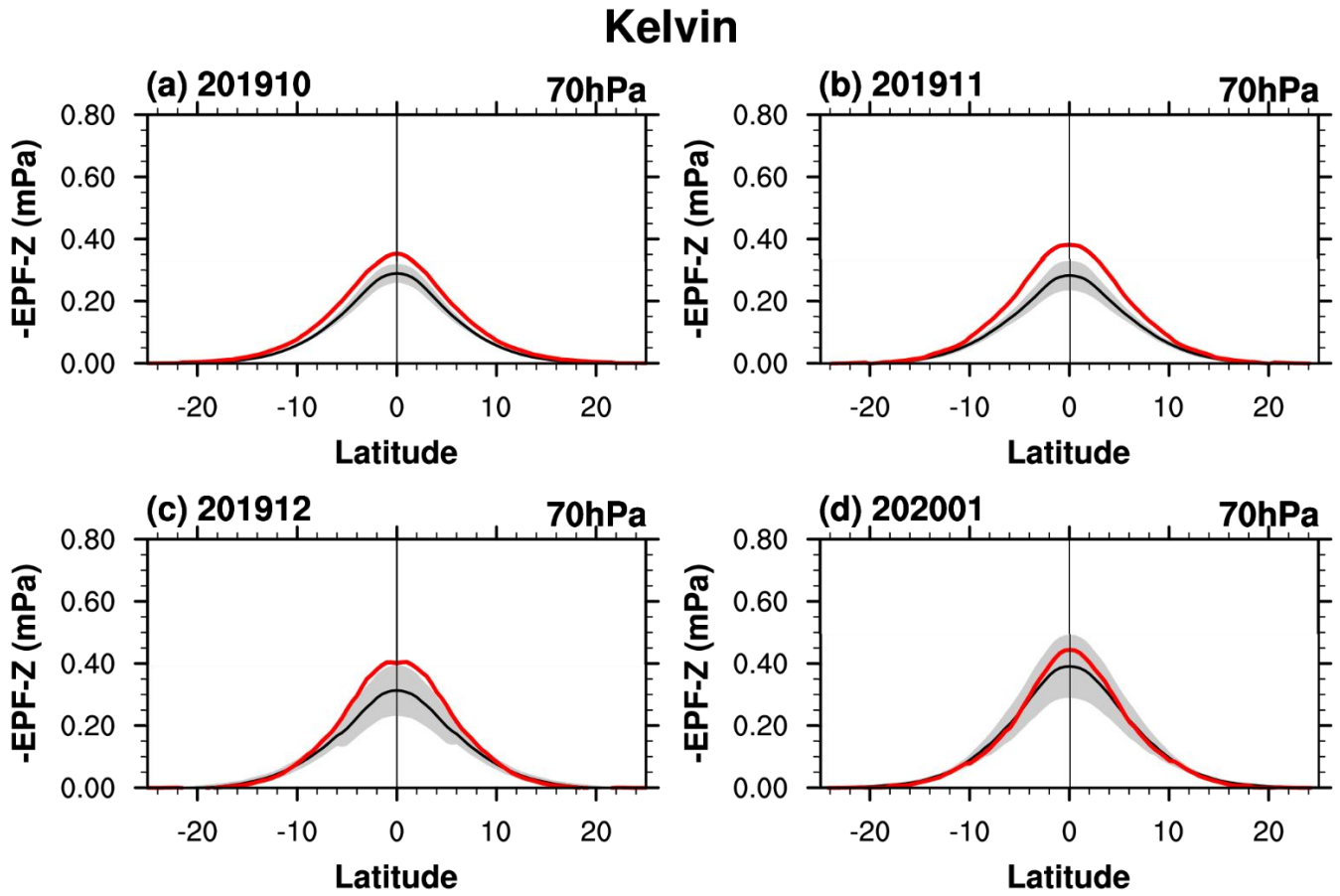

Figure S1. The vertical EP flux for the Kelvin waves at 70 hPa multiplied by -1 during the disruption (red) and the monthly climatology (black) along with ±1 standard deviation (gray shading) in (a) October 2019, (b) November 2019, (c) December 2019, and (d) January 2020.

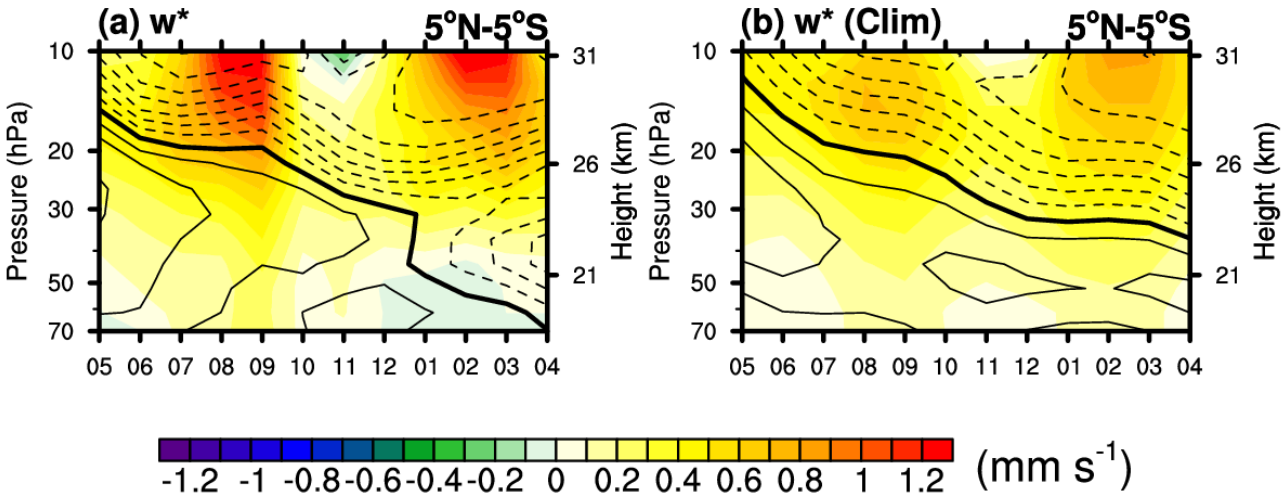

Figure S2. Time-height cross section of the vertical upwelling ($\overline{w}^*$) averaged over 5°N–5°S (a) from May 2019 to April 2020 and (b) their climatology from May to April, overlaid with the zonal-mean zonal wind (black contour lines). Positive (negative) zonal winds are plotted with solid (dashed) lines with a contour interval of 5 m s^{-1}, and thick contour lines denote a zero zonal wind speed.

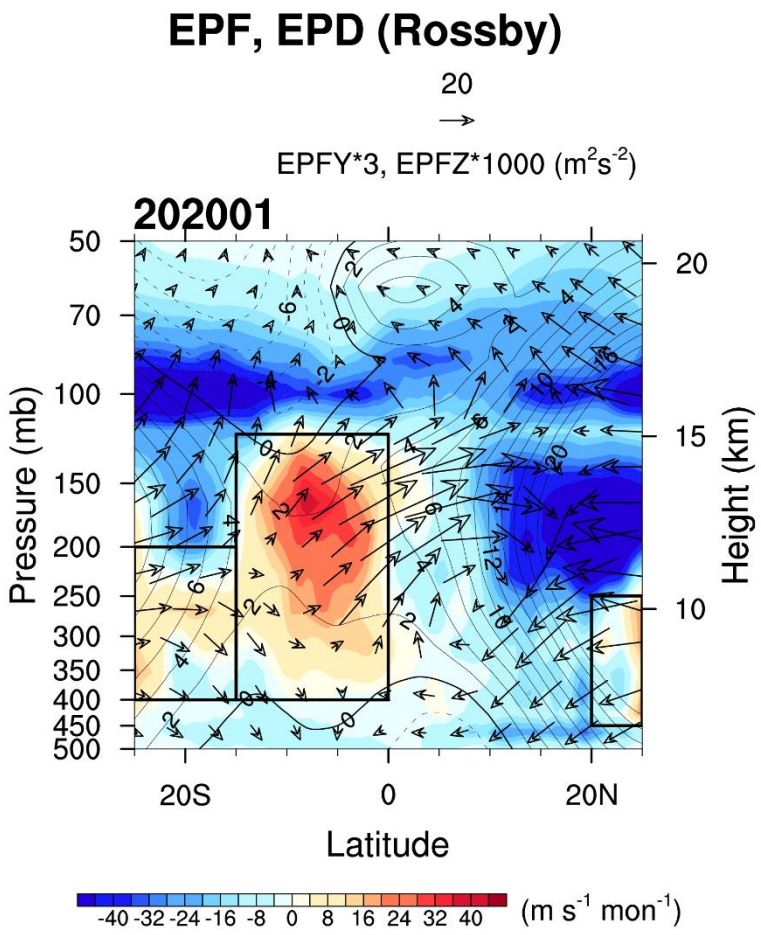

Figure S3. Latitude–height cross sections of the EP flux (vectors) divided by air density and EP flux divergence (shading) for the Rossby waves and in January 2020. Note that below 100 hPa, the L_w waves ($\omega \leq 0.4$ cpd and $-20 \leq k < 0$) are assumed to be the Rossby waves. Black boxes denote the three-potential source regions.

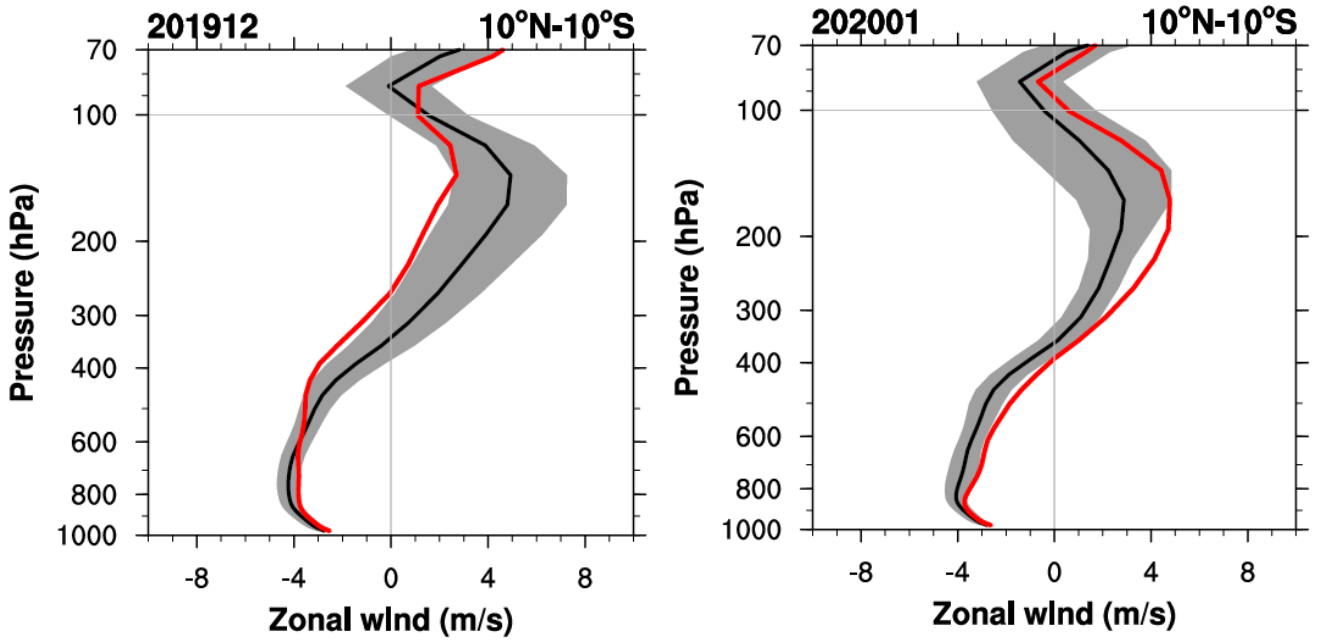

Figure S4. Vertical profile of the zonal-mean zonal wind averaged over 10°N–10°S in (left) December 2019 and (right) January 2020. Red lines represent 2019–20 QBO disruption and black lines represent the climatology (defined in Sect. 2.1) with ±1 standard deviation (gray shading).