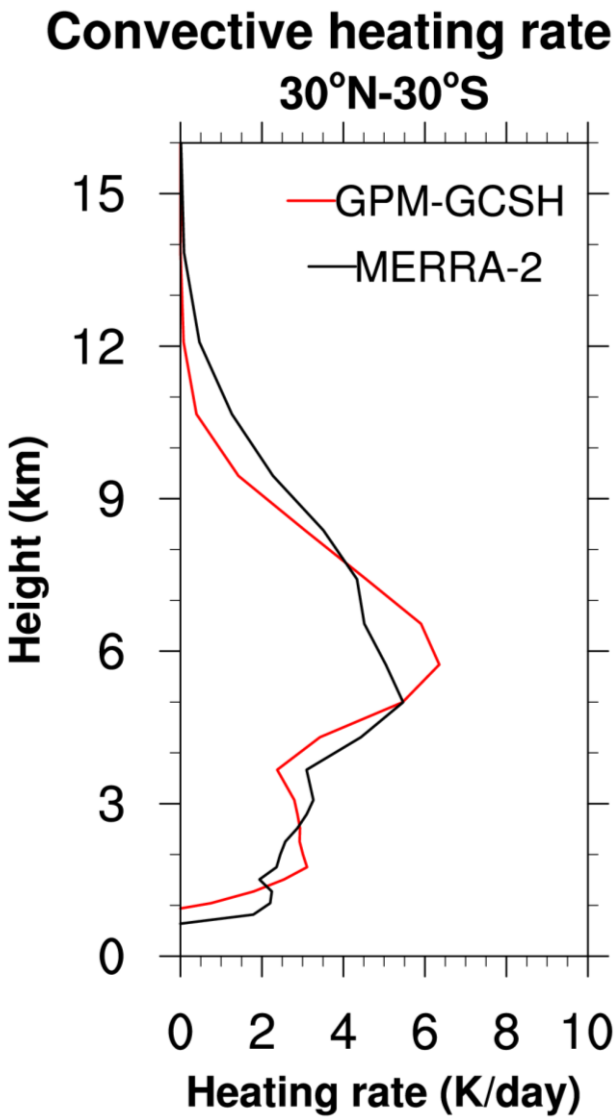

Figure S1. The vertical profiles of the convective heating rate given by the MERRA-2 data after applying criteria described in Sect. 2.4 (black) and those of the gridded convective stratiform heating (GCSH) estimated from Global Precipitation Measurement (GPM) observations (red) averaged over 30°N-30°S in February 2016. The comparison was made only when the GPM data exists and the MERRA-2 heating rate is nonzero. Note that the MERRA-2 heating rate is multiplied by a scale factor of 1.5 to focus on the shape of the profile. While the latitudinal and longitudinal distribution of the convective heating rate is important for the distribution of the parameterized CGW momentum flux, the overall magnitude of the heating rate can be adjusted by a conversion factor (c_f; Kang et al. 2017), a tuning factor that determines the magnitude of the CGW momentum flux.

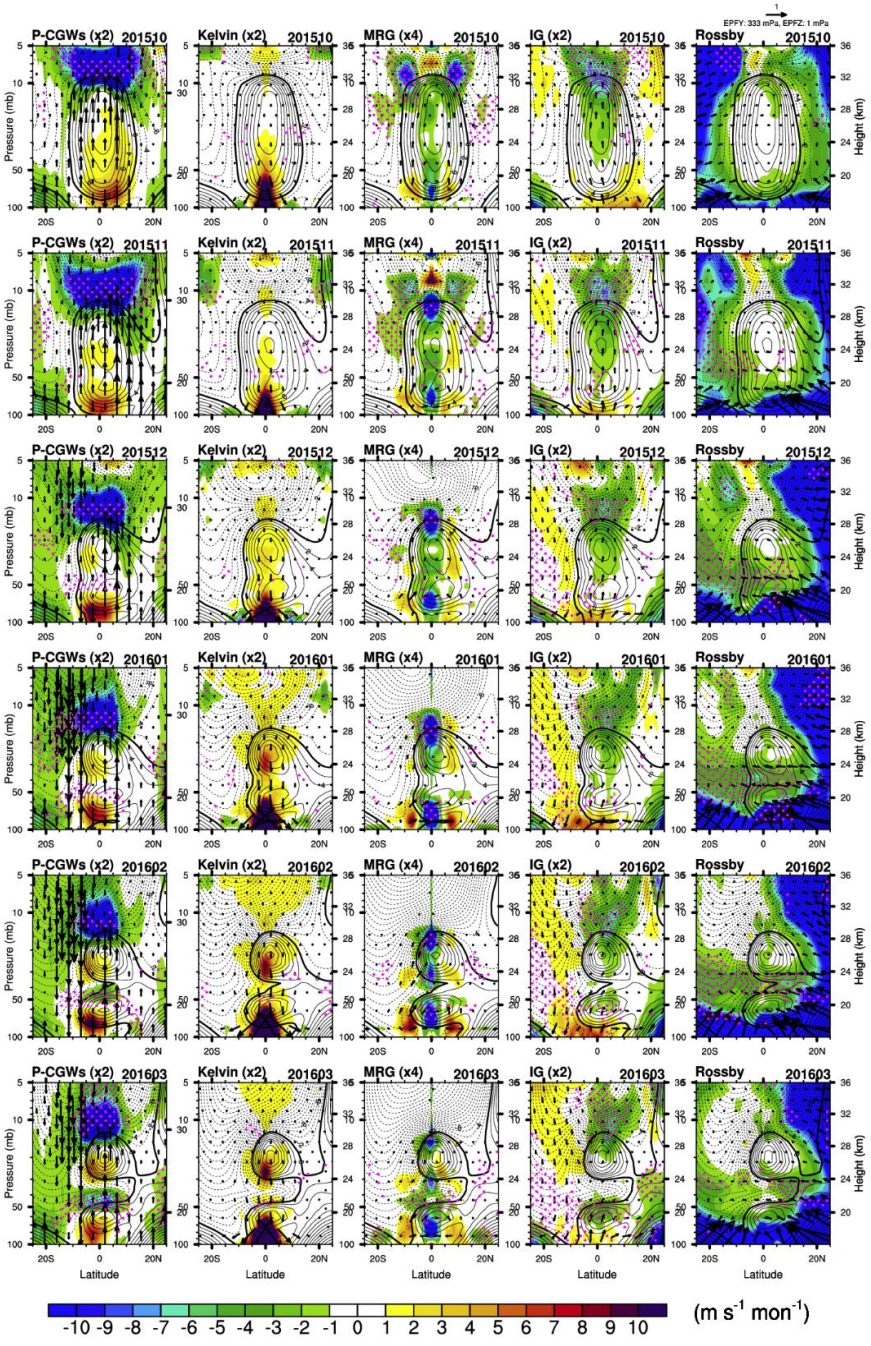

Figure S2. Latitude-height cross sections of the EP flux vectors and EP flux divergence (EPD) by parameterized CGWs (P-CGWs, multiplied by 2) and resolved equatorial waves, including Kelvin (multiplied by 2), MRG (multiplied by 4), inertia-gravity (IG, multiplied by 2), and Rossby waves from October 2015 to March 2016, superimposed with the zonal-mean zonal wind (contour lines). Positive (negative) zonal winds are plotted with solid (dashed) lines with a contour interval of 2 m s^{-1}, and thick contour lines denote a zero-zonal wind speed. The magenta-colored stippled pattern denotes a region where the EPD is smaller than the 1-standard deviation of WQBO climatology.

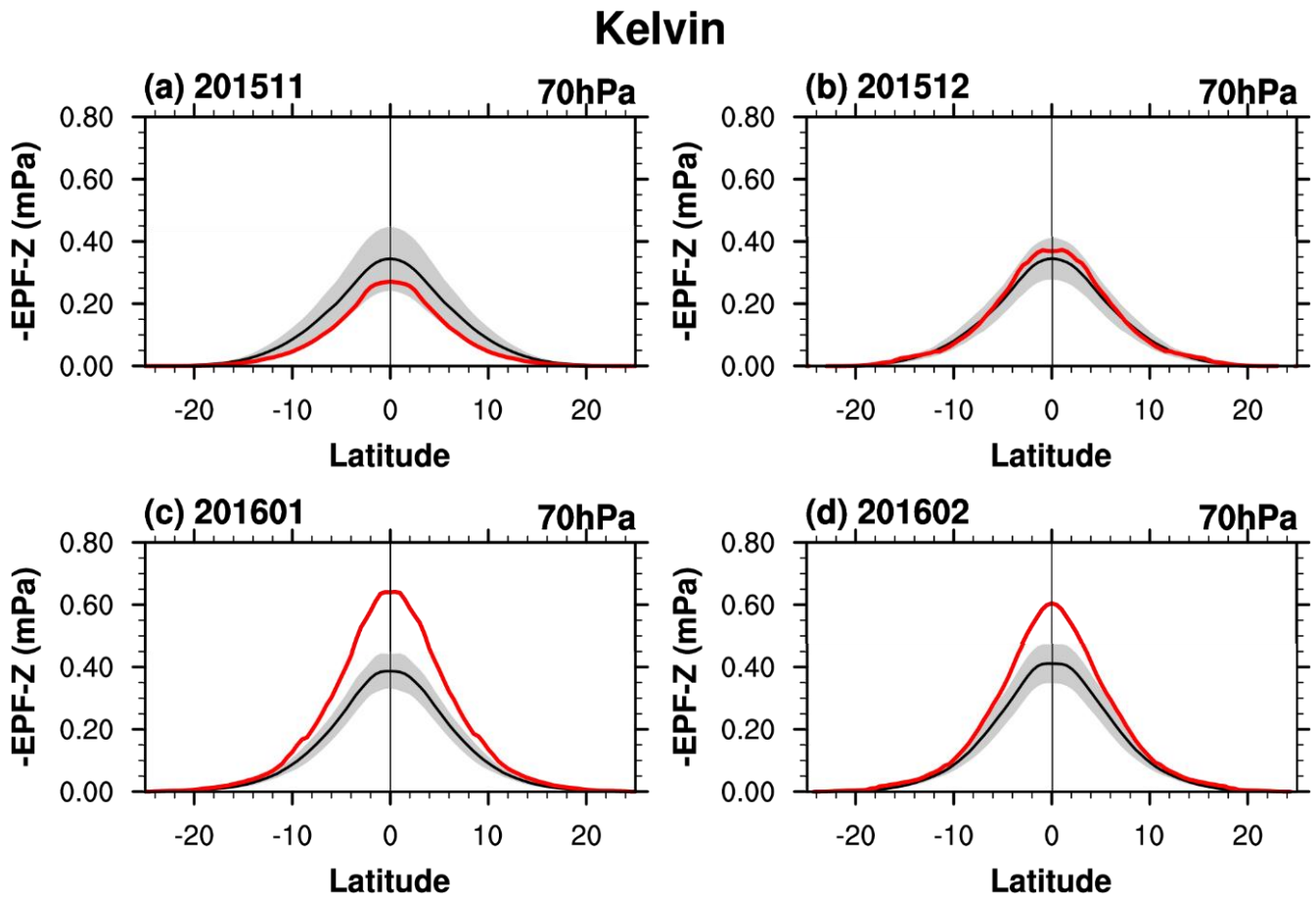

Figure S3. The magnitude of the vertical EP flux for the Kelvin waves at 70 hPa during the disruption (red): (a) November 2015, (b) December 2015, (c) January 2016, and (d) February 2016, and their monthly climatology for WQBO (black) along with ±1 standard deviation (gray shading).

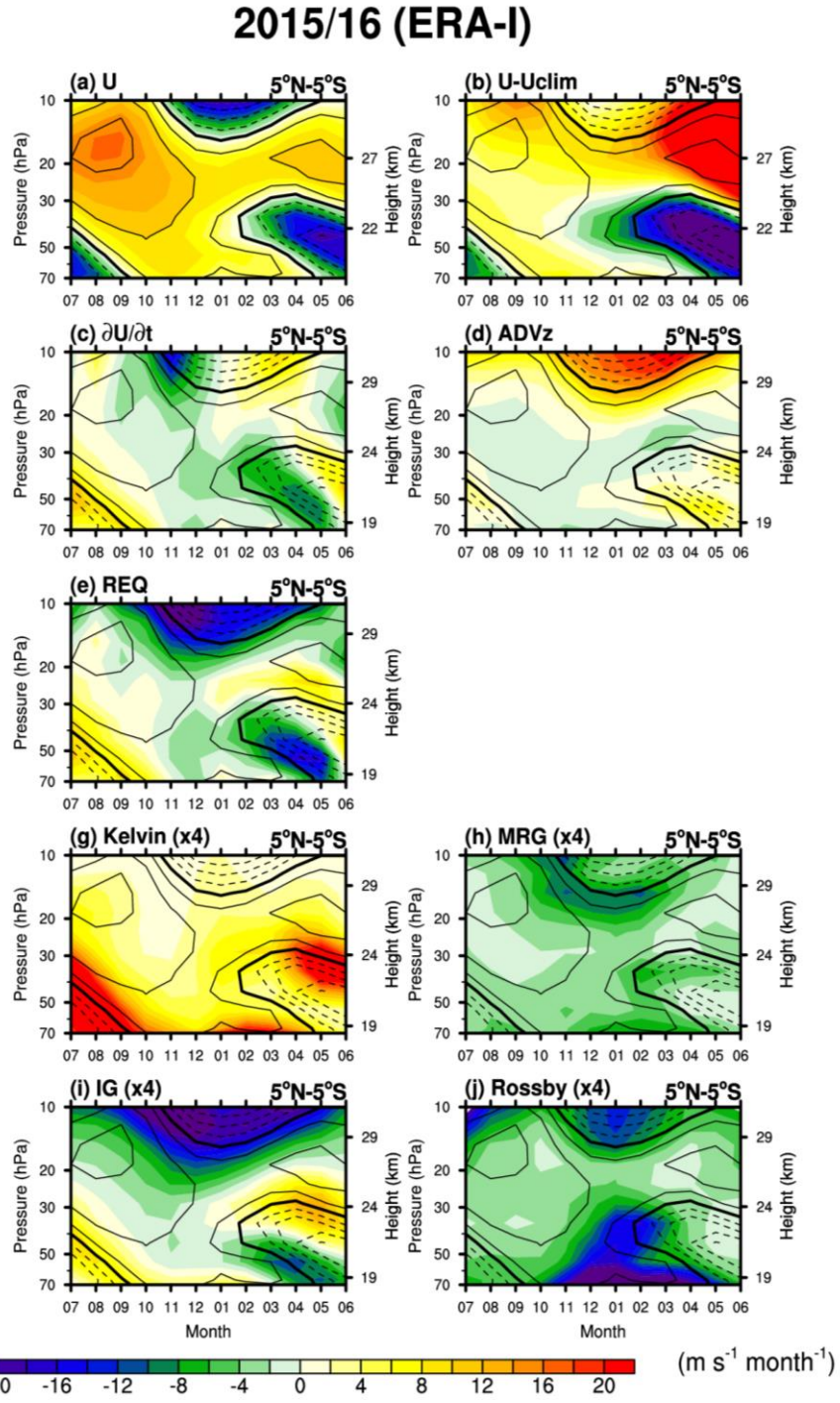

Figure S4. The same as in Fig. 3 but for the QBO disruption period exclusively using the ERA-Interim data except for parameterized CGWD.

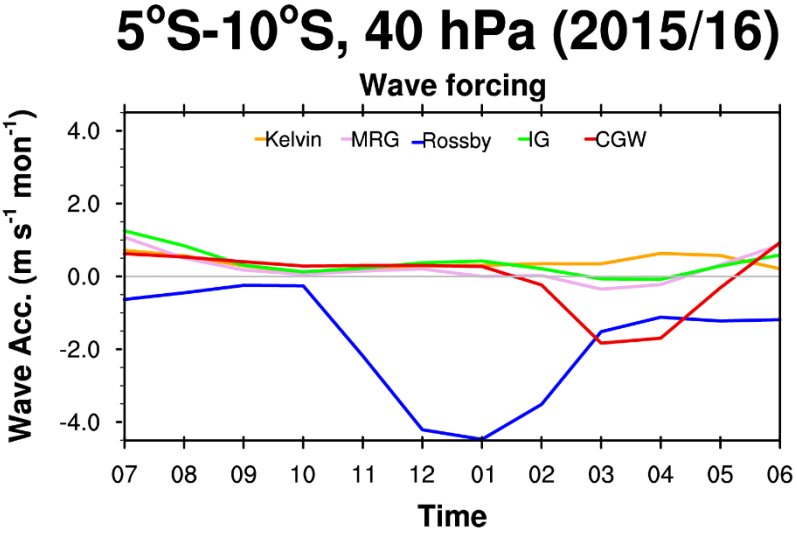

Figure S5. Time series of the wave forcing by the Kelvin waves (orange), MRG waves (pink), Rossby waves (blue), IG waves (light green), and CGWs (red) averaged over 5°S–10°S at 40 hPa from July 2015 to June 2016.

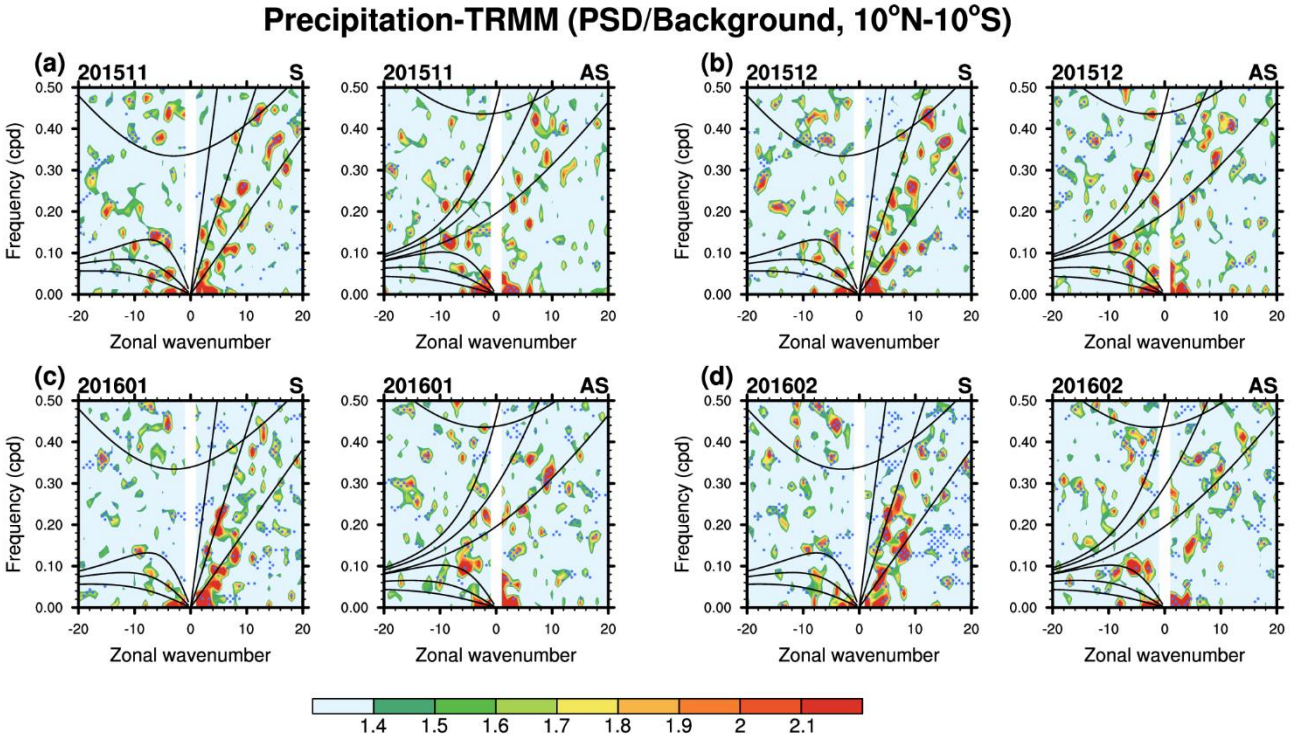

Figure S6. The same as in Fig. 10 but using TRMM 3B42 precipitation data. Note that TRMM data are available form 1998, so the WQBO climatology includes only five winters: 2013-2014, 2010-2011, 2008-2009, 2006-2007, 1999-2000. The ratio of 1.4 corresponds to a statistically significant spectrum at 99% level for TRMM (dof=82) because the horizontal resolution is 0.25°.