Momentum flux of convective gravity waves derived from an offline gravity wave parameterization: Impact to the QBO

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Characteristics of small-scale convective gravity waves (CGWs) (λ_h <100 km) and their contribution to the quasi-biennial oscillation (QBO) is investigated using an offline calculation of a source-dependent and physically-based CGW parameterization by Kang et al. (2017) with 1-hourly NCEP Climate Forecast System Reanalysis (CFSR) forecast data with a horizontal resolution of 1˚ x1˚ from 1979 to 2010. The CGW momentum flux (CGWMF) and CGW drag (CGWD) are calculated from the cloud top (source level) to the upper stratosphere using the Lindzen-type wave propagation scheme, and the magnitude of the CGWMF is constrained by GW observation by super-pressure balloon in the tropical region. The hotspots of CGWMF are in the northern Atlantic Ocean and Norwegian coast in January and Asian summer monsoon region in July, while there are common peaks in the tropical region in the mid to upper stratosphere. The sign of CGWD is various with latitude, longitude, and time, and the maximum positive drag of 0.1 (1.5) m s^{-1} day^{-1} and the negative drag of -0.9 (-0.7) m s^{-1} day^{-1} occur in January (July). For driving QBO, the momentum forcing by CGWs at 30 hPa is 3.5-6 m s^{-1} month^{-1}, which is comparable to that by Kelvin waves in the easterly-to-westerly transition phase, while it (3-6 m s^{-1} month^{-1}) is greater than any other equatorial waves in the westerly-to-easterly transition phase. The composite analyses of easterly (EQBO) and westerly QBO (WQBO) cases reveal that the CGWMF is concentrated near the 10˚N and the negative (positive) CGWD is extended to ±20˚ (±10˚). There are the strongest (weakest) negative CGWD in March-April-May (September-October-November) during EQBO and the strongest (weakest) positive CGWD in June-July-August (March-April-May) during WQBO. CGWMF and CGWD are generally stronger during El Niño than La Niña.