Morphology of E1 and E2 Kelvin waves from ECMWF reanalysis

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Kelvin waves are planetary waves traveling eastwards and confined in the equatorial latitudes. The waves play an important role in middle atmosphere dynamics because they transfer energy and momentum from lower to higher altitudes, which contributes to the quasi-biennial oscillation (QBO) and further influences the global climate. Kelvin waves have been studied for many decades, and the most of studies were focused on the waves of wavenumber 1 (E1). On the other hand, the wavenumber-2 Kelvin waves (E2) are also an important part of Kelvin wave activities although their amplitude less than the E1. In this study, we analyzed the long-term European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis data and reported the morphology of E1 and E2 Kelvin waves in the stratospheric altitudes individually. The temperature from ECMWF reanalysis was used to extract the wave properties. Temperatures between latitudes of 10S and 10N were firstly gridded into the structure of day-altitude-longitude, and then subtract background (longitudinal means) to get equatorial temperature fluctuations. For each altitude, the two-dimensional fast Fourier transform was applied to each 96-day data segment and stepped forward in time by 1 day. The output spectra were then analyzed to get primary wave periods and amplitude variations. From spectra, the E1 amplitude is 1.5 to 2.0 times larger than the E2 in average. The E1 primary periods are 12 to 25 days and are restricted under the 20-km altitude. The periods of 8 to 14 days are the secondary group. They can propagate upward to the 40-km altitude. Regarding the E2, the primary periods are 7 to 12 days and are also restricted under the 20-km altitude. Its secondary group is the periods of 5 to 8 days, which also can propagate upward to the 40-km altitude. Furthermore, the altitude-time-amplitude variation show that the E2 waves are influenced strictly by the QBO westerly. Finally, the cross correlation between E1 and E2 show that the E1 and E2 have high correlation at altitudes close to the tropopause, which implies they are excited simultaneously.

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