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## Planetary wave-tide nonlinear interactions increase the variety of MLT waves in summer 2019

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Mesospheric winds collected by multiple meteor radars at mid-latitudes in the northern hemispheric are combined to investigate wave activities in June—October 2019. Dual-station approaches are developed and implemented to diagnose zonal wavenumber  $m$  of spectral peaks. In September—October, diagnosed are quasi-10 and 6-day planetary waves (Q10DW and Q6DW,  $m=1$ ), solar semi-diurnal tides with  $m=1, 2, 3$  (SW1, SW2, and SW3), lunar semi-diurnal tide, and the upper and lower sidebands (USB and LSB,  $m=1$  and 3) of Q10DW-SW2 nonlinear interactions. During June—September, diagnosed are Rossby-gravity modes ( $m=3$  and 4 at periods  $T=2.1$  d and 1.7 d), and their USBs and LSBs generated from interactions with diurnal, semi-diurnal, ter-diurnal, and quatra-diurnal migrating tides. These results demonstrate that the planetary wave-tide nonlinear interactions significantly increase the variety of waves in the mesosphere and lower thermosphere region (MLT).