

## Seasonal variations of thermospheric nonmigrating tides observed by CHAMP and GRACE

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In this paper, we present a new method of extracting nonmigrating tides from thermospheric density using CHAMP and GRACE data. The seasonal variations of the global structures of nonmigrating tides of the thermospheric densities near the altitudes of CHAMP and GRACE are obtained using multi-year observations of these two satellites. The results show that the strongest nonmigrating diurnal tides are eastward with zonal wavenumber 3 (DE3), westward with zonal wavenumber 2 (DW2), eastward with zonal wavenumber 2 (DE2) and eastward with zonal wavenumber 1 (DE1). The primary nonmigrating semidiurnal tides are eastward with zonal wavenumber 2 (SE2), westward with zonal wavenumber 3 (SW3), westward with zonal wavenumber 1 (SW1) and eastward with zonal wavenumber 1 (SE1). The seasonal variations for each tidal mode are investigated in this work. We also study the wave-4 structure of the neutral density in the upper thermosphere in detail, which is mainly by the eastward semidiurnal tide with zonal wavenumber 2 (SE2) and the eastward diurnal tide with zonal wavenumber 3 (DE3). SE2 is the main cause of the wave-4 structure at middle latitudes and is asymmetry in phases in the two hemispheres. On the other hand, DE3 is the major driver of the wave-4 structure in the tropical region. The superposition of these two tides results in strong hemispheric asymmetries in the 4-peak structure as well as asymmetries between midday and midnight.