The Climatology of Brewer-Dobson Circulation and the Contribution of Gravity Waves

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The climatology of residual mean circulation, which is a main component of Brewer-Dobson circulation, and the potential contribution of gravity waves (GWs) are examined for the annual mean state and for each season based on the transformed-Eulerian mean zonal momentum equation using modern four reanalysis data, which allows us to examine the whole stratosphere. First, the potential contribution of Rossby waves (RWs) to residual mean circulation is estimated from Eliassen-Palm flux divergence. The rest of residual-mean circulation, from which the potential RW contribution and zonal mean zonal wind tendency are subtracted, is regarded as the potential GW contribution. These potential wave contributions are exact contributions for the annual mean state and give good approximates for solstitial seasons. The GWs contribute to drive not only the summer hemispheric part of the winter deep branch and low-latitude part of shallow branches, as indicated by previous studies, but also cause a higher-latitude extension of the deep circulation in all seasons except for summer. This GW contribution is essential to determine the location of the turn-around latitude. The autumn circulation is stronger and wider than that of spring in the equinoctial seasons, regardless of almost symmetric RW and GW contributions around the equator. This asymmetry is attributable to the existence of the spring-to-autumn pole circulation corresponding to the angular momentum transport associated with seasonal variation due to the radiative process. The potential GW contribution is larger in September-to-November than in March-to-May in both hemispheres. The upward mass flux is maximized in the boreal winter in the lower stratosphere, while it exhibits semi-annual variation in the upper stratosphere. The GW contribution to the annual mean upward mass flux is in a range of 10–30 %, depending on the reanalysis data. The boreal winter maximum in the lower stratosphere is attributable to stronger RW activity in both hemispheres than in the austral winter. This study is positioned as a part of the WCRP/SPARC S-RIP project.

Key words: Brewer-Dobson circulation, gravity waves, Rossby waves, climatology, seasonal variation

References

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