A three-dimensional analysis on the role of atmospheric waves in the interannual variability of stratospheric final warming in the Southern Hemisphere

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Stratospheric final warmings (SFW) in the Southern Hemisphere are examined in terms of their interannual variability using reanalysis data from 1979 to 2013. It was first shown in zonal mean field that the vertical component of EP flux during austral spring is significantly related with SFW date. In order to clarify the role of wave-induced residual mean flow in the interannual variability of SFW date, we categorized SFWs into early and late SFW groups according to the SFW date and examined differences between them. There is a rapid increase of polar temperature difference in early October, although the difference is insignificant until September. In order to examine what causes the sudden increase of temperature difference, we calculated differences in potential temperature tendency, potential temperature advection by meridional and vertical component of residual mean flow, and diabatic heating by long and short wave radiation. Significant positive differences in potential temperature tendency in the middle stratosphere correspond well to those in vertical potential temperature advection by residual mean flow. Differences in diabatic heating by short wave radiation are minor. This result suggests the importance of adiabatic heating associated with wave-induced residual mean flow in determining polar stratospheric temperature during austral spring, and hence SFW date. This analysis is then extended to three dimensions to investigate the longitudinally dependent structures. The formulae of three-dimensional (3D) residual mean flows applicable both to Rossby waves and to gravity waves are used. Although basic characteristics are similar to the results in zonal mean field, significant positive differences in potential temperature tendency and vertical potential temperature advection by residual mean flow are significant in the south of Atlantic Ocean. Furthermore, longitudinally asymmetric structures of tropospheric responses to SFW are examined. The downward 3D residual mean flow in the stratosphere may penetrate into the underlying troposphere and influence the tropospheric temperature in the East Antarctica.

Key words: stratospheric final warming, three-dimensional residual mean flow, stratosphere-troposphere coupling