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

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Stratospheric final warmings (SFWs) in the Southern Hemisphere are examined in terms of their interannual variability using reanalysis data from 1979 to 2013. First, it is shown from a two-dimensional (2D) transformed Eulerian mean (TEM) analysis that a time-integrated vertical component of Eliassen-Palm flux during the spring is significantly related with SFW date. To clarify the role of residual mean flow in the interannual variability of SFW date, SFWs are categorized into early and late SFW groups according to the SFW date and their differences are examined. Significant difference in potential temperature tendency is observed in the middle and lower stratosphere in early October. Their structure in the meridional cross section agrees well with that of vertical potential temperature advection by the residual mean flow. Difference in heating rate by shortwave radiation is minor, though it is significant. These results suggest that the adiabatic heating associated with the residual mean flow largely affects the polar stratospheric temperature during austral spring and the SFW date. The analysis is then extended to three dimensions to investigate the longitudinal structure by using a three-dimensional (3D) TEM theory. The significant difference in potential temperature tendency is observed mainly around the Weddell Sea at 10 hPa, and around the Ross Sea and in the vicinity of the South Pole at 50 hPa. This difference is suggested to be mainly contributed by potential temperature advection by residual mean flow, which is similar result obtained in the 2D TEM analysis. Interestingly, the potential temperature advection by residual mean flow mainly comes from the vertical component at 10 hPa, and from the horizontal one at 50 hPa. Next, climatological 3D structure of a vertical component of the residual mean flow in association with SFW is examined in terms of the effect on the troposphere. The results suggest that a downward residual mean flow from the stratosphere penetrates into underlying troposphere over East Antarctica and partly influences tropospheric temperature there.

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