A mechanism to explain the variations of tropopause and tropopause inversion layer in the Arctic region during a sudden stratospheric warming in 2009

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The mechanism to explain the variations of tropopause and tropopause inversion layer (TIL) in the Arctic region during a sudden stratospheric warming (SSW) in 2009 was studied with MERRA reanalysis data and GPS/COSMIC temperature data. During the prominent SSW in 2009, the cyclonic system changed to the anticyclonic system due to the planetary wave with wavenumber 2 (wave2). The GPS/COSMIC temperature data showed that, during the SSW in 2009, the tropopause height in the Arctic decreased accompanied with the tropopause temperature increase and the TIL enhancement. The variations of the tropopause and TIL were larger in higher latitudes. A static stability analysis showed that the variations of the tropopause and TIL were associated with the variations of the residual circulation and the static stability due to the SSW. Larger static stability appeared in the upper stratosphere and moved downward to the narrow region just above the tropopause. The descent of strong downward flow was faster in higher latitudes. The static stability tendency analysis showed that the strong downward residual flow induced the static stability change in the stratosphere and around the tropopause. The strong downwelling in the stratosphere was mainly induced by wave2, which led to the tropopause height and temperature changes due to the adiabatic heating. Around the tropopause, a pair of downwelling above the tropopause and upwelling below the tropopause due to wave2 contributed to the enhancement of static stability in the TIL immediately after the SSW.

Keywords: tropopause, TIL, SSW, planetary wave, static stability, residual vertical velocity

