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Tropical cooling in the case of stratospheric sudden warming in January 2009: focus on the tropical tropopause layer

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Temperature changes in the tropics, especially in the tropical tropopause layer, are investigated at the time of a major stratospheric sudden warming (SSW) event that started on about 16 January 2009. During the SSW, the temperature in the tropical upper stratosphere declined and the cold anomaly propagated downward, while the tropics between 150 and 100 hPa started to cool from 18 January, prior to a temperature drop at 70 hPa. We performed thermodynamical and dynamical analyses with ERA-Interim data. During the SSW event, the tropical stratosphere was cooled by upwelling, and the upwelling was induced by wave forcing in the northern extratropical stratosphere. The stratospheric pumping mechanism well explains the cooling in the tropical stratosphere above 70 hPa. However, the stratospheric wave forcing generated only weak upwelling in the tropics below 100 hPa. During the cooling period at around 18 January, tropical ascent was the main contributor to cooling of the tropics between 150 and 100 hPa. Subsequently, vertical convergence of the vertical heat flux, which is closely tied to the convection structure, resulted in a gradual decrease in temperature within the tropical uppermost troposphere. Waves that had same source region with the upward-propagating waves that caused the SSW event, propagated from Alaska to the tropics of eastern South America and eastern Africa at around 100 hPa, and dissipated in these areas; the associated wave forcing drove the tropical ascent between 150 and 100 hPa.