Analysis of the Tropical Tropopause Layer using the global nonhydrostatic atmospheric model (2)

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The tropical tropopause layer (TTL) is the main entrance where the tropospheric air passes through before entering the stratosphere. Water vapor mixing ratio which affects the stratospheric ozone is determined by both dynamics and transport in the TTL. In this study, we attempt to understand the effective processes with small to planetary scales controlling the TTL dynamics and dehydration using the global nonhydrostatic atmospheric model, NICAM. The NICAM is operated on the Earth Simulator, and has cloud-scale horizontal resolutions. Three hourly time-series data (horizontal resolution, dh=7 km) and an instantaneous output data (dh=3.5 km) of an aqua-planet experiment are analyzed. Following results are obtained.

(i) The TTL definitions are reconsidered by using the temperature profiles, cloud data, and vertical wind data. For the 3.5-km instantaneous data, convective clouds are found to overshoot the TTL bottom defined by the lapse rate minimum in 22.2% of the 5N-5S region, and to overshoot the cold point tropopause in 0.2% of the same region.

(ii) Convective clouds are organized to become convectively coupled Kelvin waves with a zonal scale of 12,000km. Also, there is a single, large-scale convective system (hereafter CS) with a scale of 700 km. The former systems generate large-amplitude Kelvin waves in the TTL, which make the dominant contribution to the temperature perturbations in this region. A part of the latter system penetrates the cold point and produce coldest tropopause with a scale of 200km.

(iii) For the 7-km time-series data, the downward motion associated with the Kelvin waves mainly control the variation of the water vapor mixing ratio in the TTL. For both 3.5-km and 7-km data, it is found that Kelvin waves make a dominant contribution to producing low saturation-mixing-ratio regions in the TTL. Also, large-amplitude gravity waves with a scale of 600 km are found to be superimposed in the cold phase of Kelvin waves, producing one of the coldest regions around the tropopause.It is suggested that the combination of Kelvin waves and gravity waves are one of the most effective dehydration processes in the TTL.