Cirrus cloud variations near the tropical tropopause layer (TTL) inferred from the lidar measurement

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It has been recognized that cirrus clouds near the tropical tropopause where the air mass enters the stratosphere from the troposphere might be crucial to define the stratospheric water content through the dehydration process. The cirrus clouds around the tropical tropopause could also affect the heat balance with an increase of 1 K/day locally. It is important for the earth's radiation budget and the climate variability to investigate the global distribution of the cirrus clouds and their space-time variations. However, an observation of the cirrus clouds is very difficult since they are optically thin and appear at high altitude near the tropopause level. In this study using lidar observations performed onboard the research vessel "Mirai" and intensive radiosonde observations with every three hours we investigate the cirrus variations around the tropical tropopause layer (TTL) and clarify a relation between the ambient temperature and the occurrence of the cirrus clouds. The observation period is mostly for the northern winter season around December and for two years, 2001 and 2002.

We first investigated the temperature structure for the two years in relation to the cirrus clouds. In 2002 the temperature field shows a clear contrast between the former half of the observation period being warm and the latter half being cold, while in 2001 it is almost cold for the whole period. Then the cirrus cloud occurrence was investigated for the two years corresponding to the temperature structure. In 2002 the cirrus clouds appear at 10- 16 km height range in response to convective activity in the former half period, while they appear around 18 km where it is very cold in the latter half period. The observation evidence in the latter half is similar to that reported in a previous work by Winker and Trepte (1998). Based on observations for the polarization ratio and the backscatter coefficient, it is suggested that the particles are non-spherical and rather large, resulting that the cirrus clouds at 15- 18 km height range consist of cloud particles with ice nuclei.

Next we investigated the cirrus cloud occurrence and the ambient temperature at each altitude in the upper troposphere and around the tropopause (15- 18 km height range). In 2001 the cirrus clouds appear in the specific temperature range around the TTL. The appearance in the 15- 18 km height range tends to be high when the temperature is high, and it is about 10%. On the other hand in 2002 the appearance is rather variable with height and temperature, but it tends to be high where it is cold at high altitude. Overall appearance in the 15- 18 km height range is about 40% with higher occurrence in the colder temperature, which contradicts with the case in 2001.

As further investigation we saw the cirrus cloud and the ambient temperature for three selected periods and height ranges. During the first half when the tropopause is relatively warm the cirrus clouds appear at 15- 16.5 km where the background temperature is cold, which is similar to the result in 2001. During the latter half when the tropopause is relatively cold at 17- 18 km height range the cirrus clouds appear in the cold region. In addition we saw the cirrus clouds at 15- 16 km height range, which has no clear relation to the temperature. This study clearly demonstrated the different appearance of the cirrus clouds and their dependences on the temperature conditions in 2001 and 2002.

REFERENCE

[1] Winker, D. M., and C. R. Trepte (1998) Laminar cirrus observed near the tropical tropopause by LITE, *Geophys. Res. Lett.*, *25*, 3351-3354.