On the Dissipation Process of the Upper-Tropospheric Cirriform Clouds in the Tropics

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1. Introduction

In the tropics, it is frequently observed that the upper tropospheric cirriform clouds (UTCCs) last more than a day after detached from convective clouds (Hamada, *et al.*, JMSJ, submitted).

Previous studies using numerical models on the UTCCs showed:

・The height and optical thickness of UTCC are lower and thinner with time, respectively (e.g., Boehm *et al.* 1999, JGR)

→ T_{BB} should increase with time

・Long lifetime of UTCC requires not only in-cloud dynamical and radiative process, but also large-scale updraft (e.g., Jensen *et al.* 1996, JGR) but only those results cannot explain the T_{BB} decrease with the small horizontal scale.

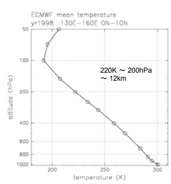
Objective

We made data analyses focused on the following points:

・The time variation of T_{BB} of general dissipating UTCC
・Characteristics of T_{BB} decrease
・The time variation of vertical structures of dissipating UTCC

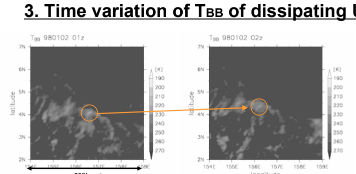
Data

・GMS-5 IR-T_{BB} 0.05° (Kochi-Univ.)
・ECMWF global analysis 2.5°
・Communications Research Laboratory airbone cloud radar (SPIDER) 82.5m vertical, minutely
・period: Jan, Apr, Jul and Oct 1998 (Sec 3,4)
11/09-12/09 2001 (Sec 5)
・area: 130E-160E, 0-10N (Sec 3,4)
around (138E, 2N) (Sec 5)
(Western equatorial Pacific)

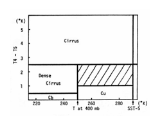


Vertical profile of the mean temperature during 1998 from ECMWF objective analysis. The circles indicate the levels of ECMWF data.

3. Time variation of T_{BB} of dissipating UTCC



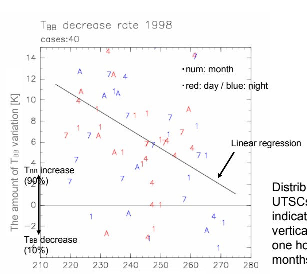
Images of GMS IR-T_{BB} at 01 UTC (left) and 02 UTC(right) on 2 January 1998. Orange circles indicate the 'general' UTSC defined in this study.



Schematic diagram for cloud type classification used in this study (after Inoue, 1987).

Procedure for detecting UTCC:

1. Determine time and location randomly
2. Identify the cloud patch around that point as UTCC which satisfy following requirements
   ・It should be classified as cirrus with Inoue(1987)'s technique
   ・It can be tracked by pattern matching with GMS IR images for several hours
3. Continuing 1., 2. until 10 cases are detected on each 4 months



Distribution of the T_{BB} variations of 'general' UTSCs during 4 months in 1998. The abscissa indicates T_{BB} of UTSCs at given time and the vertical axis indicates the amount of T_{BB} variation one hour after. Labels represent hexadecimal months in 1998 ('A' means October).

・T_{BB} generally increases with time, while in about 10 % cases T_{BB} decreases with time
・There is no seasonality and no difference between day and night
・The amount of T_{BB} increase is larger in UTSC patches which have lower T_{BB} before decrease

4. T_{BB} decrease in the detached UTCC

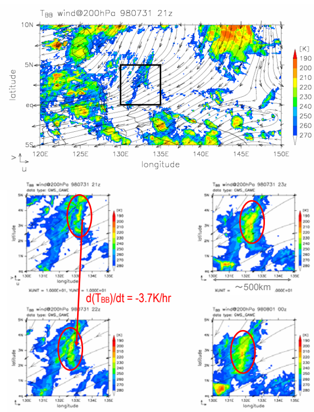
In some of long-lived UTCC, it is sometimes observed that the equivalent blackbody temperature (T_{BB}) of such a UTCC partly decreases with time.

Definition of T_{BB} decrease of UTCC in this study:

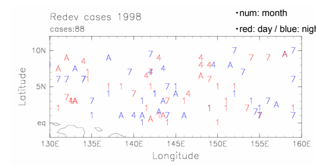
・Cloud patch should be classified as cirrus with Inoue(1987)'s technique
・The T_{BB} of cloud patch before decrease should be less than 230 K

→ 31,12, 26 and 19 (total 88) cases are identified on Jan, Apr, Jul and Oct, respectively

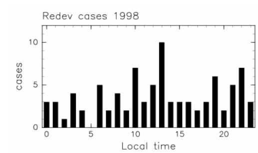
・The difference of the number of case in each month is considered as the difference of the large scale convective activity in each month



GMS IR-T_{BB} (color tone) and horizontal wind field (vectors and streamlines) at 200 hPa. Upper: large scale cloud pattern at 21 UTC on 31 July. Lower: the area indicated by solid rectangle in the upper figure from 21 to 24 UTC on 31 July 1998 every hour.



Locations of cases where T_{BB} decrease with time during 4 months in 1998. Labels represent hexadecimal months in 1998.



Histgram of cases where T_{BB} decrease with time. The abscissa indecates local time of the day.

・The maximum amount of T_{BB} decrease is about 10K/hr (~240K/day) in 88 cases
・The duration of T_{BB} decrease is a few hours in the maximum
・T_{BB} decrease occurs rather partly, than equally in the all UTSC originated from the same convective region

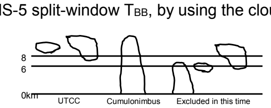
→ The horizontal scale of T_{BB} decrease is 10~100km

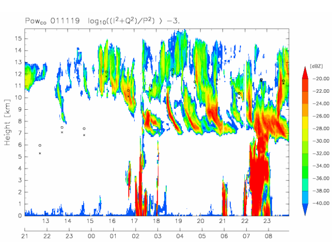
・T_{BB} decrease occurs almost equally in the analyzed area, having no seasonality
・Not fixed in the local time

→ Radiative instabilization between the top and bottom of stratiform clouds during nighttime (Ackerman 1988, JAS) is not important to T_{BB} decrease

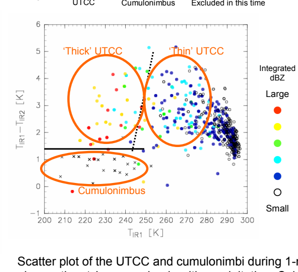
5. Cloud classification table by using millimeter-wave cloud radar

Millimeter-wave cloud radar can observe fine vertical structures of thick UTCC which cannot be observed micrometer-wave radar or lidar. In this study, we are attempting to make the cloud classification table with the GMS-5 split-window T_{BB}, by using the cloud radar as the ground truth.





Time-height cross section of the radar echo observed by SPIDER from 12 to 24 UTC on 19 November 2001.



Scatter plot of the UTCC and cumulonimbi during 1-month observation. 'x' means clouds with precipitation. Color shows the vertically integrated reflectivity (unit arbitrary). The abscissa indicates 11um T_{BB} and the vertical axis indicates the difference of T_{BB} between 11um and 12um.

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