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# DEFORMATION OF LARGE CLOUD DISTURBANCE OVER THE WESTERN TROPICAL PACIFIC

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## 1. INTRODUCTION

A case study on the meridional separation of zonally elongated large cloud disturbance over the western tropical Pacific during TOGA-COARE is presented. The notice is taken particularly on the stratiform clouds with the fine structures. Upper tropospheric stratiform clouds were considered to play an important role in such as radiation budget or determination of tropical wave mode.

## 2. DATA

Mainly used in this study was the data of infrared (IR) equivalent blackbody temperature ($T_{BB}$) of GMS-4 during TOGA-COARE (November 1992 – February 1993). We also used ECMWF twice-daily global analysis data to investigate the dynamical field related with separation of the cloud band.

## 3. RESULTS

There were four distinct cases of separation, listed in Table 1. All cases were observed on January 1993. Separated cloud bands had zonal extent up to a few thousand kilometers. Three of four cloud band was separated into two parts and the other one into three.

Figure 1 shows the example of the separation. Cloud clusters continued developing and merged into zonally extended large cloud band with the zonal extent up to a few thousand kilometers. This cloud band continued extending meridionally. While active convective area remained along about 2°N, clouds which were between the northern and southern edges and the convective area of cloud band were broken up. Consequently, the large cloud band was, in this case, separated into zonally elongated three parts (8°N, 2°N and 2°S). During the separation, it was observed that active convective cloud cluster developed (142°E, 5°N) and propagated westward. The zonal scale of this cloud cluster and the phase speed of propagation imply the relationship with equatorially trapped waves, but needs further investigation.

There was strong upper-tropospheric divergence well corresponding to zonally elongated cloud band (not shown). This divergence still remained after the zonal cloud band weakened. The northern and south-

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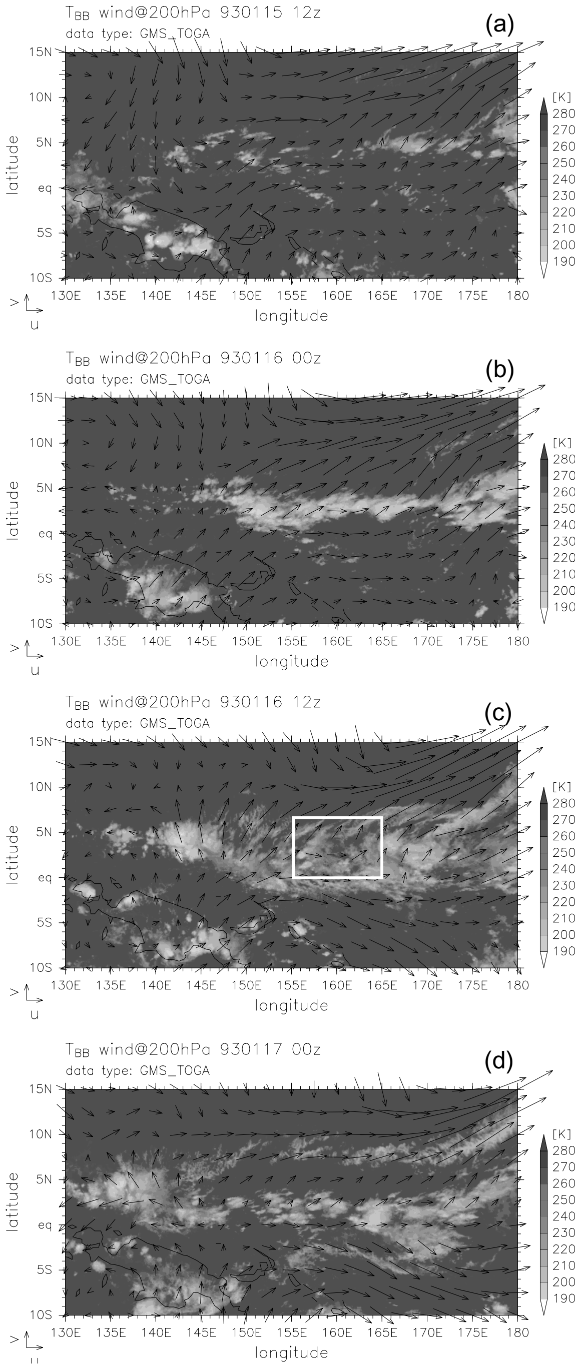


Fig. 1: Time series of GMS IR–$T_{BB}$ and horizontal wind field (arrows) on 200 hPa from 12 UTC 15 January to 00 UTC 17 January 1993 every 6 hour. Unit vector length of 10 m $s^{-1}$ are shown on the lower left corner.

| detected date | longitudinal section | zonal axis | # | maximum time (LT) | | start time (LT) | moving speed (m $s^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | | | | $PHC_{210}$ | $PHC_{250}$ | | to north | to south |
| 93/01/06-07 | 160°E–175° | 5°N | 2 | 0707 | – | 0717 | 7.4 | 8.0 |
| 13-14 | 150°E–180° | 5°N | 2 | 1407 | 1410 | 1420 | 9.5 | 7.5 |
| 16-17 | 145°E–180°E | 3°N | 3 | 1613 | 1621 | 1623 | 8.7 | 5.0 |
| 20-21 | 152°E–165°E | 5°N | 2 | 2111 | 2118 | 2120 | 8.6 | 8.6 |

Table 1: Characteristics of four separation cases during TOGA-COARE. Statistics include detected date, longitudinal section, latitude of zonal axis of the separation, the number of separated parts, maximum time (LT in ddhh) of $PHC_{210}$ and $PHC_{250}$ (percent high cloudiness of the clouds whose $T_{BB} < 210$ K), start time of the separation and north-to-south-moving speed of the northern and southern parts of the separated cloud band.

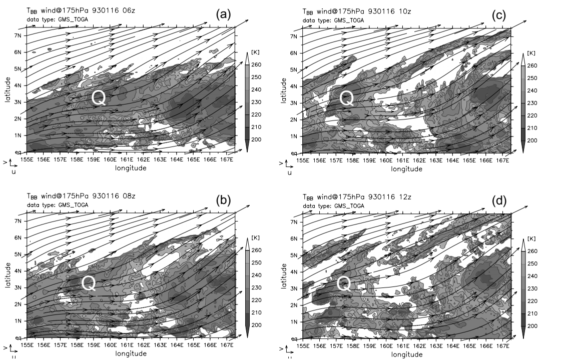


Fig. 2: Two-hourly time series of $T_{BB}$ and horizontal wind averaged between 150 and 200 hPa. The drawing area is shown by solid rectangle in Fig. 1. Unit vector length are 5 m $s^{-1}$.

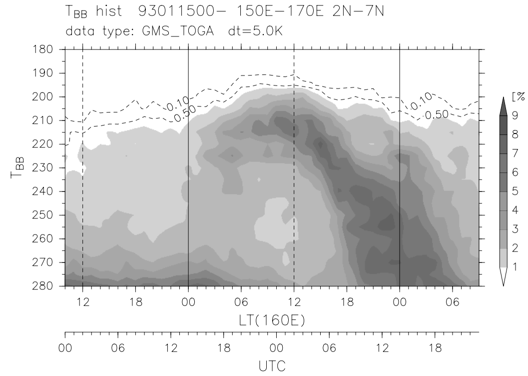


Fig. 3: Time-temperature (height) diagram of the percent coverage of the $T_{BB}$ for the the separated cloud band. Analyzed area is shown in the title of each figure. Abscissa shows UTC and corresponding local time.

ern parts of the separated cloud band continued moving north-to-south, advected by this divergent wind. The mean north-to-south meridional moving speed, listed in Table 1, may not show any regularity about the north-to-south moving speed among four cases, indeed between the moving speed of the northern and southern parts in each case.

Figure 2 shows that the difference of the disappearance process of upper-tropospheric stratiform clouds between northern and southern parts and the middle part. In northern and southern parts, separated cloud band had fine line structures. The orientation were well coincident with horizontal wind direction in the upper troposphere. Line clouds originated from convective cluster such as labelled Q, advected leeward and were cut off from middle part. Consequently, the clear-sky regions were emerged and the cloud band was separated. Stratiform clouds over the convective area weakened with time. On the other hand, line clouds were rather remained for a long time, and it was partly observed that $T_{BB}$ decreased with time. This implies the redevelopment of the stratiform clouds. This is interesting feature, but the right cause is still unknown.

The plausible cause of zonally simultaneous development and separation of the cloud band is sun-synchronous diurnal convective activity, where the very deep cloud amount reached maximum around early morning and the shallower clouds delays. Figure 3 clearly synchronized with the diurnal convective activity as shown in many studies (e.g., Chen and Houze 1997). In the all cases, $PHC_{210}$ peaked from the morning to early afternoon and start time of the separation was in the evening (Table 1). At the start time of separation, high clouds almost disappeared.

## 4. CONCLUSION

Northern and southern parts of separated cloud band obviously originated from the middle part of that and had fine line structure whose orientation well coincided with the horizontal wind direction in the upper troposphere. This implies that northern and southern parts were the upper-tropospheric stratiform clouds extended from convective clouds. The clear-sky regions, which emerged between separated zonal parts, were formed by the earlier dissipation of stratiform clouds of the middle part than those of the northern and southern parts.

The development and the separation of the cloud band had the zonal simultaneity in more than thousand kilometers. Indeed, the time of the development and the separation fairly fixed in local time. It shows that the separation is considerably related with sun-synchronous diurnal convective activity.

## REFERENCES


Chen, S. S., and R. A. Houze Jr., 1997: Diurnal variation and life-cycle of deep convective systems over the tropical Pacific warm pool. *Quart. J. Roy. Meteor. Soc.,* **123,** 357-388.