

# **DEVELOPING AND NON DEVELOPING TROPICAL CYCLONES REVEALED BY HIGH DENSITY CLOUD MOTION WINDS**

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## **Abstract**

It has been indicated by many authors that tropical cyclones with easterly in high troposphere have less probability of development, while tropical cyclones with multidirectional out flow in high troposphere have more probability of development.

National Satellite Meteorological Center of China developed an algorithm of cloud motion wind calculation. This algorithm has an advantage of calculation amount saving. With this algorithm, cloud motion winds with grid length 1.25 degree lat/lon have been calculated since Oct. 1996 by using GMS-5 data in the North West Pacific region. The development perspective of tropical cyclones in the North West Pacific was examined.

It was found that tropical cyclones were usually initiated by westerly jets in high troposphere. Those westerly jets may be supplied by middle latitude troughs that deeply invade into tropics. In mid-summer season those westerly jets may be supplied by westerly to the equatorial side of TUTT.

It is concluded that cloud motion winds with high density are useful at diagnosing tropical cyclone development perspective in operation.

## **1. Introduction**

Tropical cyclone development forecasts are one of the major tasks for tropical forecaster in area with tropical cyclone activities. They are also one of the most challenged tasks for research scientists. Comprehensive research activities have been made in this field. The CISK theory (Charney and Eliassen, 1964) indicated that cyclonic inflow in lower tropospheric boundary layer is essential for development of tropical cyclones. With composition analysis, W. Gray (1968) indicated that developing and non-developing tropical cyclones are associated with different upper tropospheric circulation patterns. While non-developing tropical cyclones have unique direction upper tropospheric flow which causes vertical shear above the cloud clusters relatively stronger, the developing tropical cyclones normally have multidirectional out flow which is favorable not only to weaker vertical shear above the cyclones, but also to the effective cyclonic angular momentum inflow (G.Holland,1983). With aircraft reports and cloud motion winds, Sadler (1976) indicated that developing tropical cyclones should have multidirectional out flow near tropopause above them.

The formal research works all agree that there must be multidirectional out flow for tropical cyclones to get development, but two questions are still remained. Those are:

1. Is the high level multidirectional out flow generated by the low level inflow as indicated by the CISK theory,

or is it supplied by the environmental circulation?

2. Is real time data dense enough for tropical weather forecasters to judge the upper troposphere circulation patterns which are essential to the diagnosis of development perspective of tropical cyclones?

Up to recently in low latitude of North West Pacific, data for answering the above questions are still not sufficient. In this region, there are very few radiosonde stations. Aircraft reports and satellite winds in very low latitudes of this region are not dense either.

National Satellite Meteorological Center (NSMC) of China recently developed an algorithm of Cloud Motion Winds (CMWs). This algorithm has an advantage of calculation amount saving. With this algorithm, high density cloud motion winds with grid length 1.25 degree lat/lon have been calculated since Oct. 1996, by using GMS-5 data in the North West Pacific. With this set of data, the development perspective of tropical cyclones in the North West Pacific were examined. This paper describes our analysis results. Section 2 of this paper presents the abnormal tropical cyclone activities in the summer of 1998. Section 3 shows upper tropospheric environmental circulation associated with developing and non-developing tropical cyclones. Section 4 supplies observational events which shows that the multidirectional out flow is supplied by the environmental circulation. Section 5 is discussion and conclusion.

## 2. Exceptional Low Tropical Cyclone Activities in North West Pacific in Summer of 1998

In summer of 1998, tropical cyclone activities in North West Pacific were extremely low. Up to the end of August, the number of named tropical cyclone was only 3. While it is 6 for normal years. What is the reason which caused such low activity of tropical cyclones in this region in the summer of 1998? SST and circulation anomalies were examined. Fig. 1 is SST distributions and their anomalies to multiyear means in July 1998. Data are from NOAA. Fig. 1 a shows clearly that in North West Pacific region to the south of 28 N and West of 180 E in July 1998, the SSTs were above 26°C, which was higher than the critical SST required for tropical cyclone formation. Fig. 1 b shows that in North West Pacific in July 1998, the SST anomalies were mostly positive. In June and August 1998, the situations were the same. The SST and its anomaly were unable to explain the reason why tropical cyclone activities in North West Pacific in summer of 1998 approached the minimum.

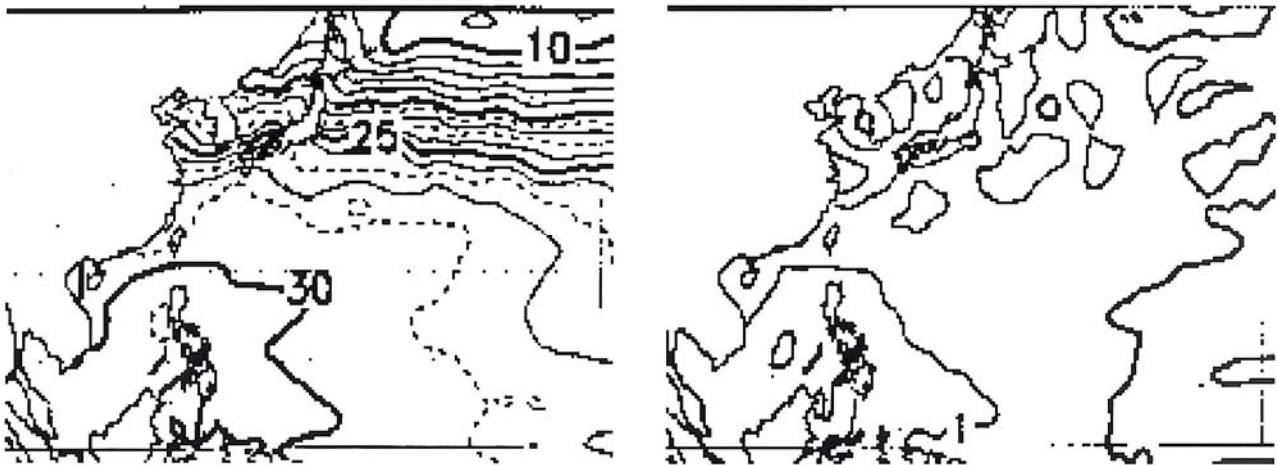


Fig. 1 SST distributions and their anomaly to multiyear means in July 1998.

- a) SST distribution
- b) SST anomaly

Fig. 2 is high level (higher troposphere or lower stratosphere) monthly mean cloud motion winds in July 1998. Data was from NSMC. Fig. 2 shows that in the lower latitudes of the North West Pacific to the South of 28N and

West of 160E in July 1998, easterly was prevail at high level. In the region around the Philippines where monthly mean SSTs were above 30°C, the monthly mean easterly exceeded 20 m/s. For June and August 1998, the same tendencies were found. The circulation anomaly may explain the lowest frequencies of tropical cyclone activities in North West Pacific in the summer of 1998.

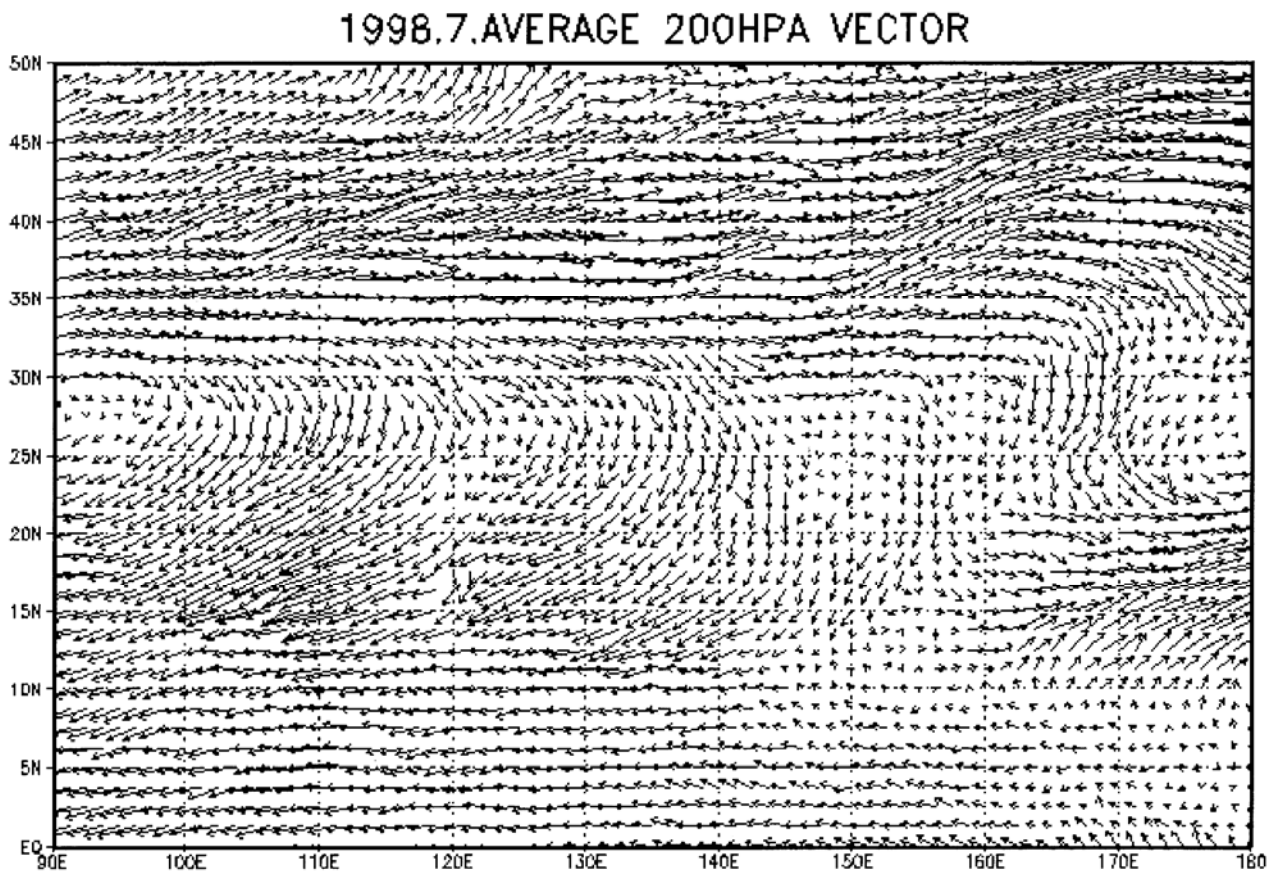


Fig. 2 Monthly mean high level cloud motion winds in North West Pacific in July 1998.

### 3. Upper Tropospheric Environmental Circulation Associated with Developing and Non-developing Tropical Cyclones

Fig. 3 c is high level cloud motion winds developed by NSMC, China on 00z 25 Aug.1998. At that time tropical storm Rex was named. The center of Fig. 3 c is just at the center of Rex. Rex got further development during the next day. Fig. 3 c clearly shows that multidirectional out flow were above Rex, and that there was a westerly trough to the North side of Rex.

Fig. 4 is high level cloud motion winds on 00z 10 Aug. 1998. At that time, tropical storm Winne was named. Winne also got further development during the next day. Fig. 4 shows also that there were multidirectional out flow above Winne. The difference between Fig. 4 and Fig. 3 is that for Fig. 4, the westerly to the North side of the tropical cyclone was supplied by the westerly at the south side of TUTT rather than by a middle latitude trough. In fig.4, TUTT was along 28 N, 13 degree Northward of Winne.



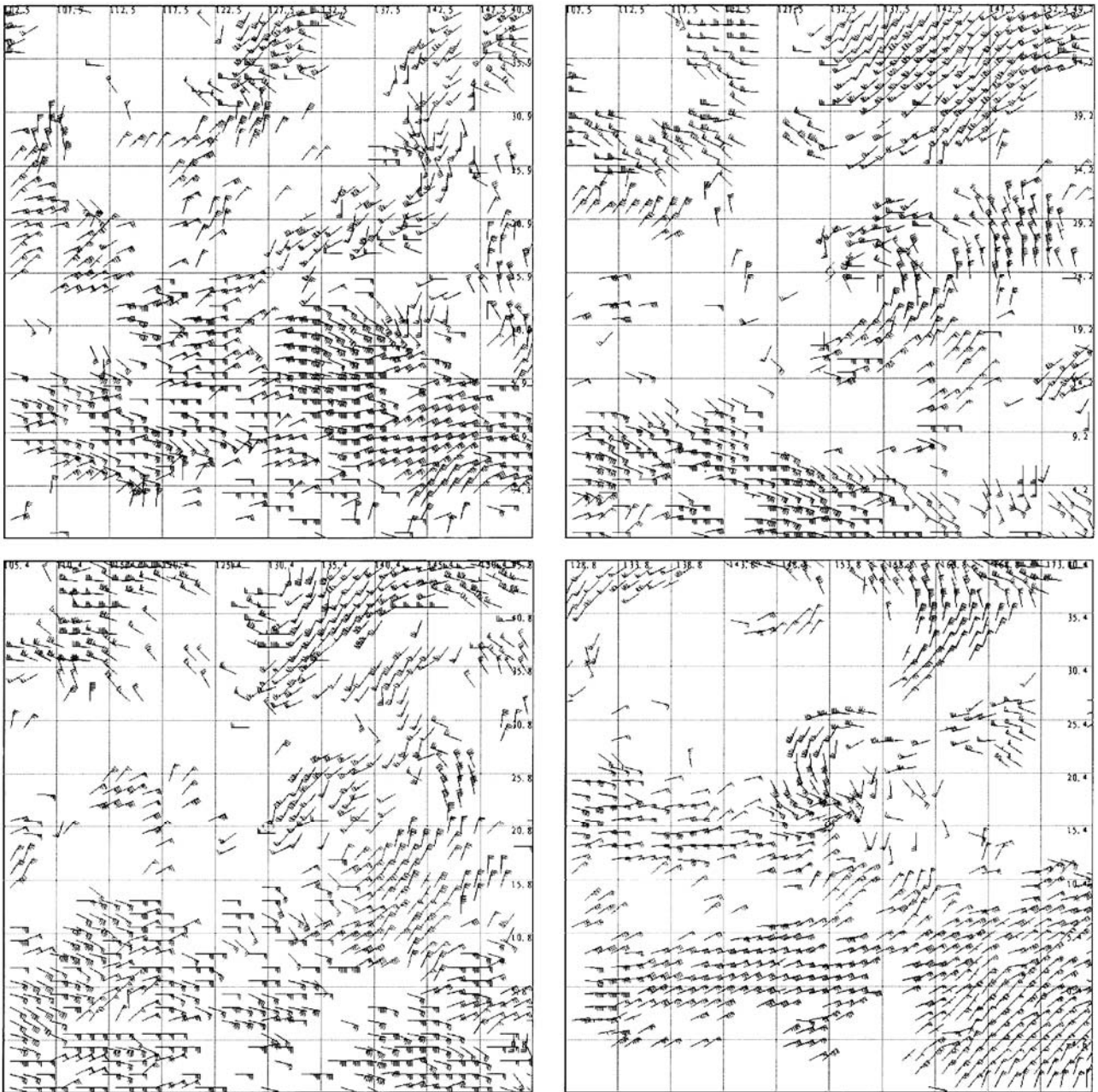


Fig.3 CMWs at high level around Rex.

- a. 48 hours before it reached tropical storm intensity (up left)
- b. 24 hours before it reached tropical storm intensity (up right)
- c. When it reached tropical storm intensity (down left)

Fig. 4 CMWs at high level around Winne when it reached tropical storm intensity (down right)

Fig. 3 and Fig. 4 are typical upper tropospheric environmental circulation of developing tropical cyclones for the summers of 1997 and 1998. Fig. 4 represents the situation when there is TUTT. In summer season, TUTT is prevail in North West Pacific. Fig. 3 represents the situation when there is no TUTT to the North side of the tropical cyclone. This type of environmental circulation may appear at any seasons. Fig. 5 is composition of high level wind fields of 6 tropical storms from March to June 1997 at the time of their formation. Fig. 5 summarized the above mentioned multidirectional out flow circulation above developing tropical cyclones. Fig. 5 clearly shows that a westerly trough is to the North West side of developing tropical cyclones.

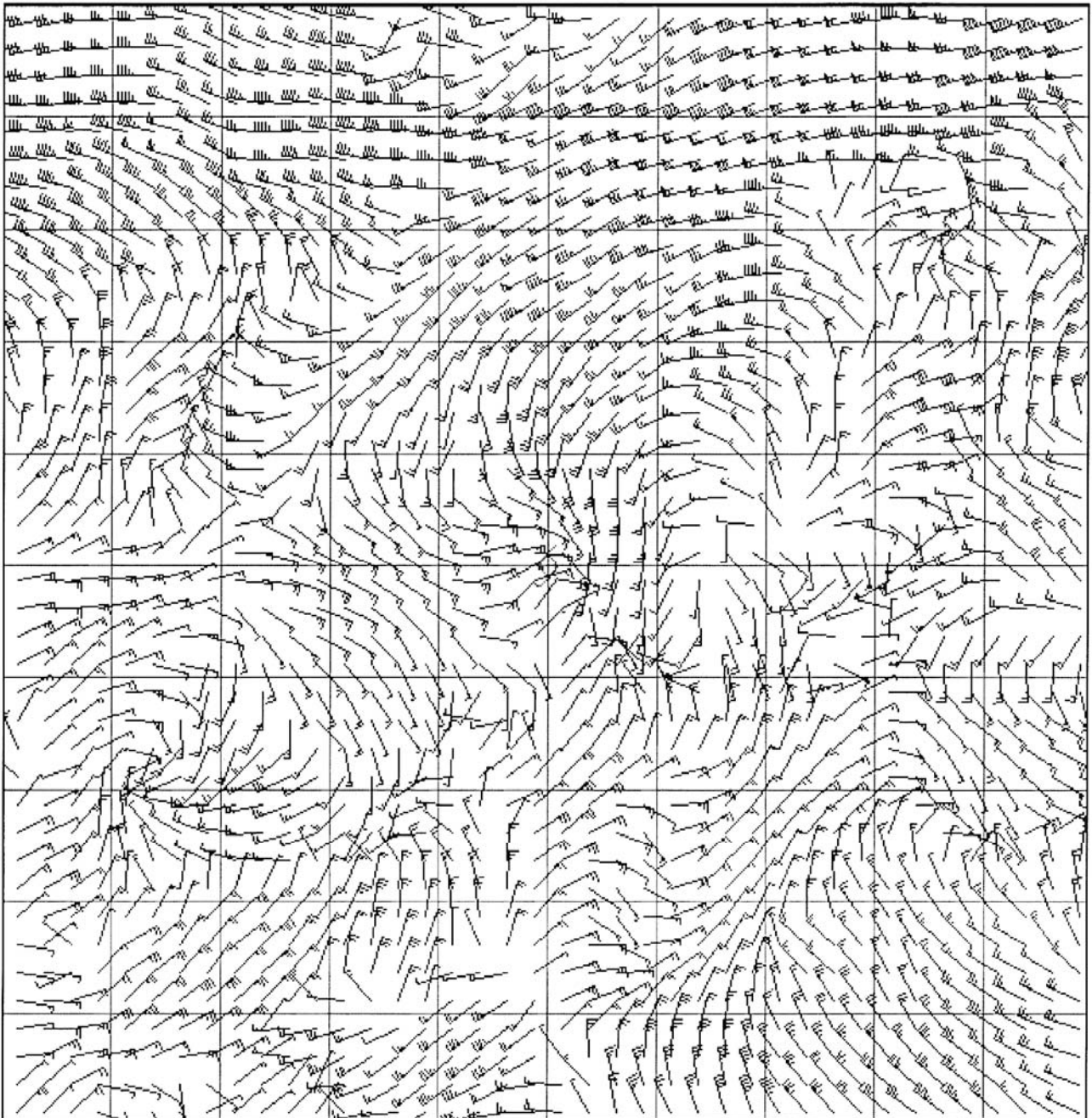


Fig. 5 Composition of high level wind fields of 6 tropical cyclones from March to June 1997 at the time when they reached tropical storm intensity.

Fig. 6 is taken from 00z 18 Aug. 1998, the center of Fig. 6 is at 15.7 N, 132.3 E where a tropical depression was located. This depression did not get development during the next day. Fig. 6 shows that above the non-developing tropical depressions, the upper level winds were in the unique direction. Multidirectional out flow did not exist. Fig. 7 is taken from 06z 29 May 1998, the center of Fig. 7 is at 25.3 N 128.5 E where tropical storm Levi was dissipating. Fig. 7 shows coincidence Westerly above the dissipating tropical storm. The westerly was apparently supplied by a westerly trough.



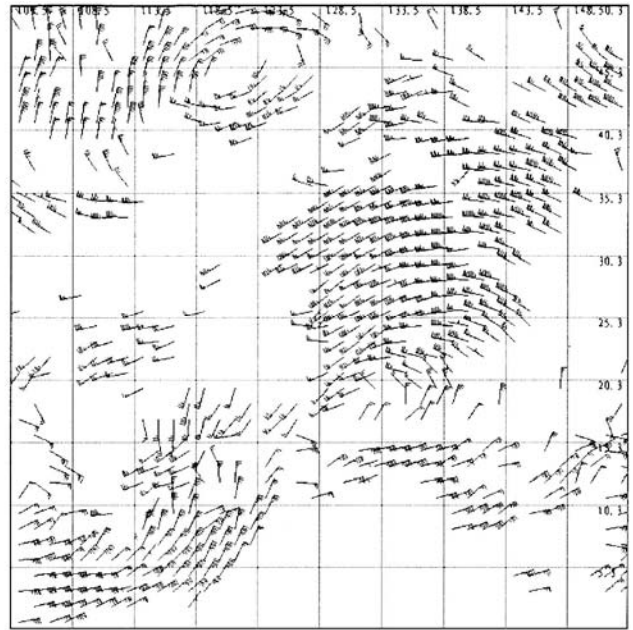
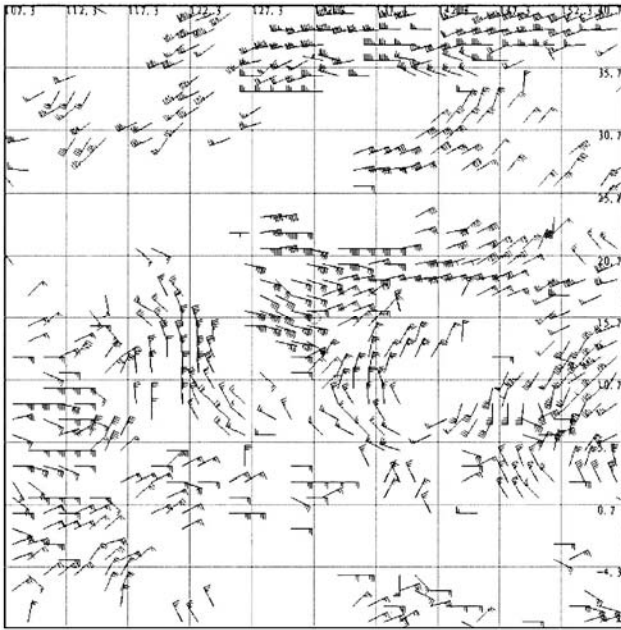


Fig.6 CMWs at high level around a non-developing tropical cyclone. (left)

Fig.7 CMWs at high level around a dissipating tropical storm Levi. (right)

Fig. 6 and Fig. 7 shows that there are coincidence upper tropospheric environment circulation for non-developing or dissipating systems. The non-developing tropical depressions are usually under the upper level easterly, the dissipating tropical storms or typhoons are usually under the upper level westerly. After examining all tropical cyclone events since Oct. 1996, we chose the above mentioned situations as representative cases.

#### 4. Moving Westerly Troughs Associated with Tropical Storm Formation.

In order to exam what supplies the westerly to the North side of developing tropical cyclones, individual cases were examined since Oct. 1996. It was shown that for mid-summer season, it was difficult to judge whether the westerly to the North side of the system was supplied by the tropical cyclone itself or by the environment circulation. But, it was apparent that the when TUTT was not exist, the westerly to the North side of developing systems were supplied by the environmental circulation. Fig. 3 is an example. Fig. 3 a, b and c are CMWs around tropical cyclone 48, 24 and 0 hours before the cyclone reached tropical storm intensity. From Fig. 3 a, b and c the approach of a westerly trough was apparent. Other examples during the two years of 1997 and 1998 showed the similar situations. When a westerly trough approaches a tropical cyclones at a distance around 12-15 latitude North West side of the tropical cyclone, it supplies westerly which forms a component of the multidirectional out flow necessary for the development of the cyclone. In North West Pacific in 1997 and 1998, the high density CMWs revealed that most tropical storm were initiated by environmental multidirectional out flow supplied by westerly trough deeply invade the tropics.

#### 5. Conclusions

1. There were multidirectional high level out flow above developing tropical cyclones.
2. In North West Pacific, the upper tropospheric westerly to the North side of the cloud cluster was often supplied by the middle latitude westerly troughs which deeply invade the tropics.
3. In mid-summer season in North West Pacific, the upper tropospheric westerly to the North side of the cloud cluster may be supplied by the westerly to the south side of TUTT.
4. The non-developing tropical cyclones are usually associated with coincidence easterly at upper troposphere.

5. The dissipating tropical storms or typhoons are usually associated with coincidence westerly at upper troposphere.

6. High density cloud motion winds are good tool in daily weather forecast in diagnosing development potential for tropical cyclones.

### **Acknowledgment**

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