CURRENT STATUS OF GMS WIND AND OPERATIONAL LOW-LEVEL WIND DERIVATION IN A TYPHOON VICINITY FROM SHORT-TIME INTERVAL IMAGES

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ABSTRACT

The modifications of the height assignment method for high-level cloud motion winds (CMWs) and the improvement of manual quality control software were implemented in stages from 1990 to 1993 at the Meteorological Satellite Center (MSC). The quality of CMWs has been routinely monitored using monthly mean differences between CMWs and radiosonde winds. It is clarified from the monitoring results that the modifications contribute greatly to the improvements of the high-level CMWs.

The CMWs derivation from 15-minute interval images in a typhoon vicinity was put into operation at the MSC in May 1988. The operation has been carried out when a typhoon exists in GMS coverage. These CMWs are intensively used for gale-force area determination in JMA Forecasting Division. Furthermore, these data are expected to be used for numerical and objective analysis of typhoon area.

1. Introduction

The Meteorological Satellite Center (MSC) has made efforts concentrated on the improvement of GMS high-level cloud motion winds (CMWs). Three changes to height assignment method for high-level CMWs and the improvement of manual quality control software were implemented in operation after the introduction of automatic wind extraction in 1987. Two changes to the method and the improvements in qualities of high-level CMWs until 1991 were reported at first International Wind Workshop by Uchida (1991). Additional changes introduced in operation after 1992 and the improvements in qualities of high-level CMWs are presented in this paper (section 2).

Section 3 describes the operational derivation of low-level CMWs in a typhoon vicinity at the MSC. The CMWs are extracted from half-disk images (northern hemisphere) at an interval of 15-minute around 04 UTC in automatic procedure without manual quality control. Fifteen-minute interval images are used to obtaining the winds with higher horizontal density and closer distances to a typhoon center compared with the CMWs that are extracted every 6-hour from full-disk images at an interval of 30-minute.

2. Current status of GMS wind

2.1 Low-level CMWs

Low-level CMWs extraction scheme has not been changed since the introduction of automatic wind extraction in 1982. The monthly mean differences between low-level CMWs and radiosonde winds were calculated in the same way as the International Comparison of Satellite Winds (Type 2 comparison). Vector and speed differences from January 1992 to October 1993 are shown in Fig. 1. RMS vector differences and the absolute values of the speed differences are respectively smaller than 5.0 m/s and 0.5 m/s.

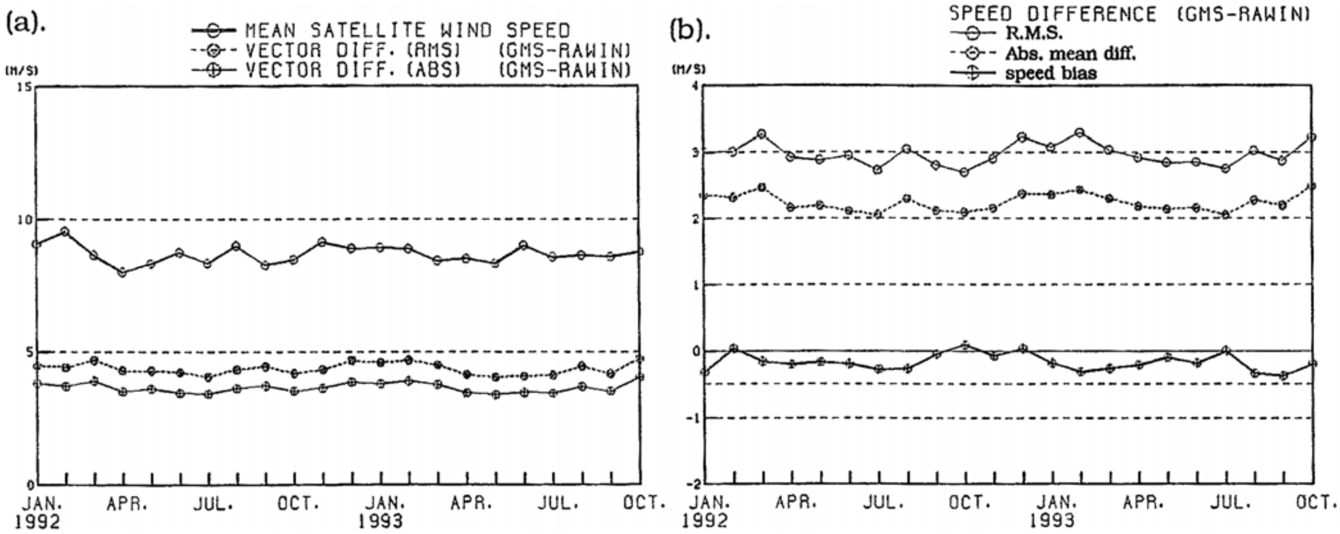


Fig. 1. Monthly means of differences between low-level CMW and radiosonde wind (a); vector differences, (b); speed differences.

2.2 High-level CMWs

To improve the quality of high-level CMWs, the changes to height assignment method introduced in operation from the employment of automatic wind extraction scheme in 1987 until 1992 were as follows;

(a). The revision of height assignment table as from April 1990.
(b). The introduction of intensive manual quality control technique for the area around the Jet Stream as from April 1991 including reassignment of wind height assigned automatically.

For further improvement in quality, two changes were also introduced in operation.

(c). The employment of improved manual quality control software as from April 1992.
(d). The second revision of height assignment table as from April 1993.

2.2.1 The employment of improved manual quality control software

The manual quality control of CMWs is performed using graphic display and TV-screen of Image Processing Console. In this procedure, height reassignment is also performed.

The software for the manual quality control was changed in April 1992. Until the employment of new software, height reassignment was mainly performed over the northern hemisphere due to the time limit to send to the Forecast Department of Japan Meteorological Agency (JMA). To perform the height reassignment over the southern hemisphere, the manual quality control software was improved. Quality control can be performed rapidly using the new software.

2.2.2 The second revision of height assignment table

It is difficult to determine cloud top height correctly with a single channel IR data. In the MSC, cloud top height has been determined based on height assignment table statistically prepared. The old table used from April 1990 to March 1993 was determined from the statistical comparison between CMWs and radiosonde winds in 1988. In the table, the representative heights were assigned for individual month and every 10°-latitude zone. To improve the height assignment, the table was revised using the CMW data from April 1991 to January 1993 whose quality was better than that of the CMW data in 1988. Table 1 shows the representative heights introduced in April 1993. In this table, the representative heights are assigned for individual month and every 5°-latitude zone.

Table 1. Revised table of representative heights (1993).

Zone (latitude)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov	Dec.
50N - 45N	400	400	400	400	300	300	300	300	300	300	400	400
45N - 40N	400	400	400	400	300	300	300	300	300	300	400	400
40N - 35N	400	400	300	300	300	300	250	250	300	300	300	400
35N - 30N	400	400	300	300	300	250	250	250	250	300	300	400
30N - 25N	400	400	300	300	300	250	200	200	250	300	300	400
25N - 20N	400	400	300	300	300	200	200	200	200	200	200	400
20N - 15N	200	200	200	200	200	200	200	200	200	200	200	200
15N - 10N	200	200	200	200	200	200	200	200	200	200	200	200
10N - 5N	200	200	200	200	200	200	200	200	200	200	200	200
5N - EQ.	200	200	200	200	200	200	200	200	200	200	200	200
EQ. - 5S	200	200	200	200	200	200	200	200	200	200	200	200
5S - 10S	200	200	200	200	200	200	200	200	200	200	200	200
10S - 15S	200	200	200	200	200	200	200	200	200	200	200	200
15S - 20S	200	200	200	300	300	300	400	400	400	300	200	200
20S - 25S	300	300	300	300	300	300	400	400	400	300	300	300
25S - 30S	300	300	300	300	300	400	400	400	400	400	300	300
30S - 35S	300	300	300	300	400	400	400	400	400	400	400	300
35S - 40S	300	300	300	300	400	400	400	400	400	400	400	400
40S - 45S	300	300	300	300	400	400	400	400	400	400	400	400
45S - 50S	300	300	300	300	400	400	400	400	400	400	400	400

2.2.3 Comparison between high-level CMWs and radiosonde winds

To evaluate the modifications of the height assignment method and the employment of improved manual quality control software as described in subsection 2.2, the monthly mean differences between high-level CMWs and radiosonde winds were also calculated in the same way as the Type 2 comparison. Vector and speed differences over three latitudinal areas, that are 50°N - EQ., EQ. - 50°S and 50°N - 50°S areas, from January 1990 to October 1993 are shown in Figs. 2 and 3.

In 50°N - 50°S area, the major improvements of vector and speed differences are after the revision of height assignment table in April 1990. Annual means of RMS vector difference before and after April 1990 are 11.3 m/s and 9.2 m/s respectively. Those of speed difference are -3.5 m/s and -1.0 m/s respectively. Smaller improvements are seen by the method changes and the employment of improved manual quality control software in April 1991, 1992 and 1993.

In 50°N - EQ. area, the improvements of vector and speed differences show similar trends as those in 50°N - 50°S area.

On the other hand, in EQ. - 50°S area, the improvements after the employment of improved manual quality control software in 1992 are remarkable. Yearly RMS vector differences in June from 1990 to 1993 in Fig. 2-(c) are 14.7 m/s, 13.1 m/s, 10.5 m/s and 9.4 m/s respectively. Those of speed difference in Fig. 3-(c) are -8.3 m/s, -5.7 m/s, -2.1 m/s and -1.9 m/s respectively. Both of them are improved though mean CMWs speed increases from 22.1 m/s in 1990 to 27.4 m/s in 1993 through 25.4 m/s in 1991 and 26.6 m/s in 1992. Annual means of RMS vector difference before and after April 1992 are 9.6 m/s and 9.1 m/s respectively. Those of speed difference are -2.0 m/s and -1.9 m/s respectively.

In all the area, the small improvements of vector and speed differences caused by the second revision of height assignment table in April 1993 are seen though the period of seven months from

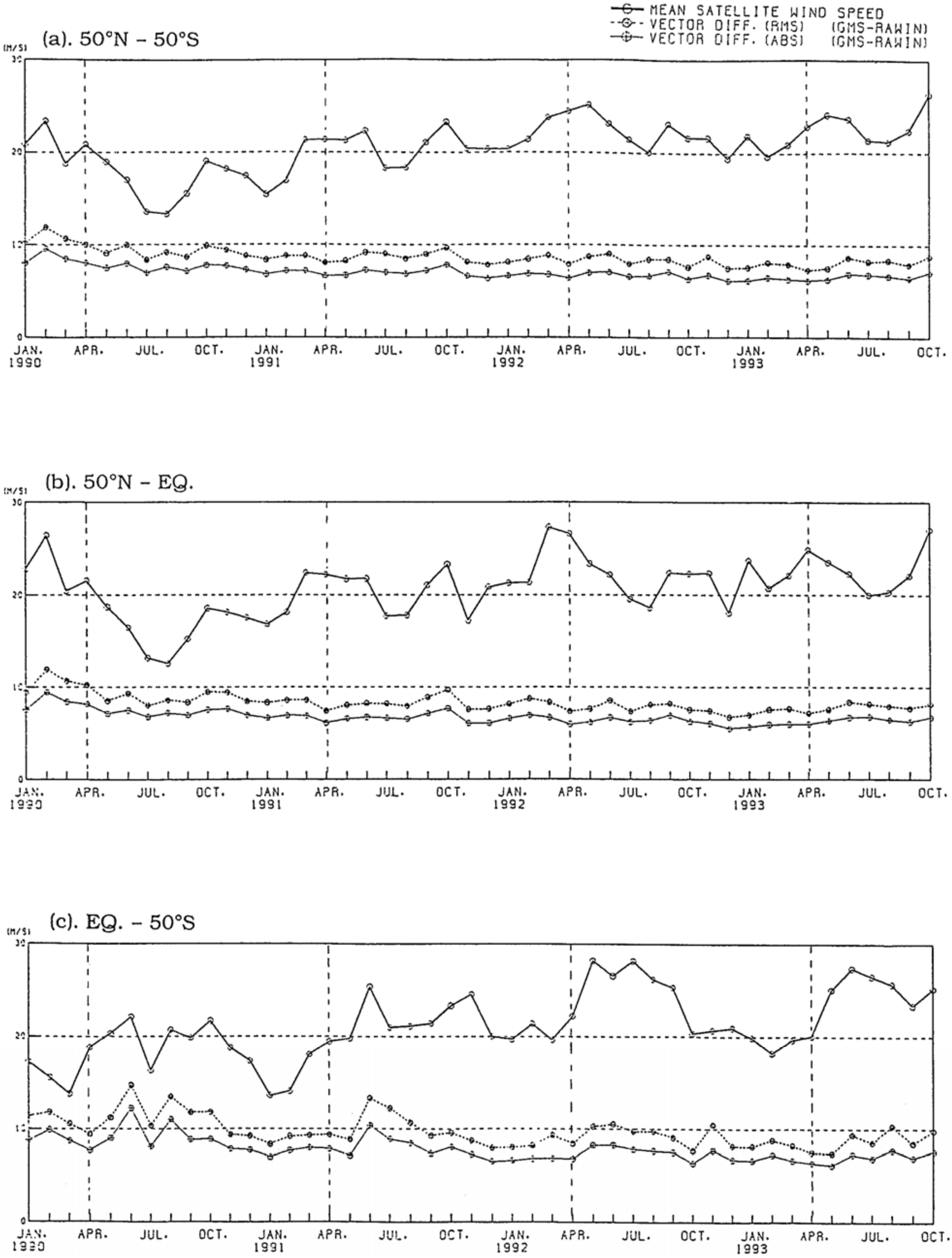
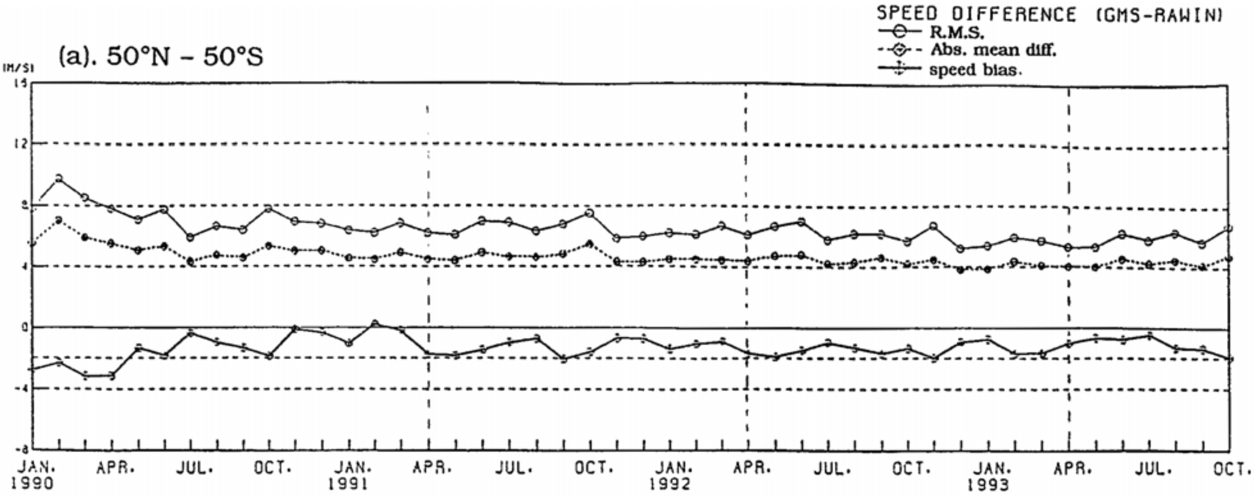
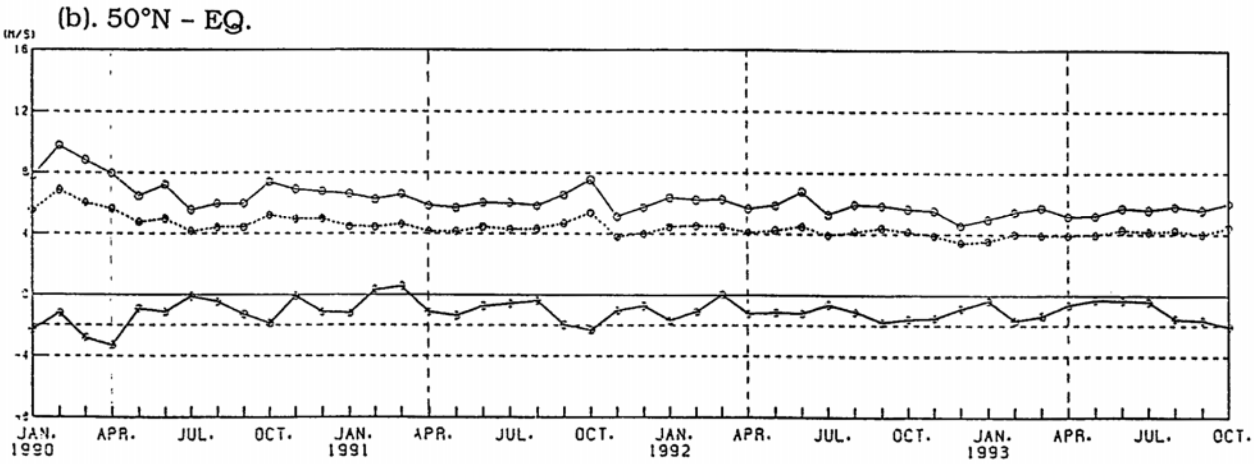


Fig. 2. Monthly means of vector differences between high-level CMW and radiosonde wind (a); over 50°N - 50°S area, (b); over 50°N - EQ. area, (c); over EQ. - 50°S area.





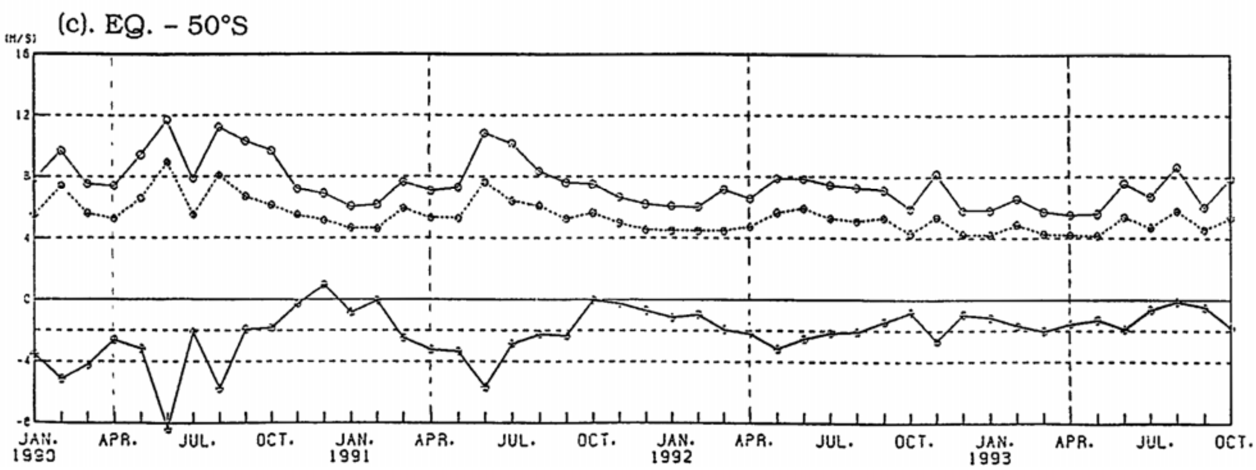


Fig. 3. Same as Fig. 1, but for speed differences.

April to October in 1993 is not long enough to evaluate the efficiency of the new table. The average values of RMS vector differences after April 1993 in 50°N - 50°S, 50°N - EQ. and EQ.-50°S areas are 8.1 m/s, 7.9 m/s and 8.8 m/s respectively. Those of speed differences are -1.0 m/s, -1.0 m/s and -1.1 m/s respectively.

These results indicate that the quality of high-level CMWs was improved in stages corresponding to the changes to height assignment method and the employment of improved manual quality control software from April 1990. The vector and speed differences decreased despite the increasing mean CMWs speed.

The results are summarized that;

(1). The quality of high-level CMWs was improved in stages corresponding to the changes to the height assignment method and the employment of improved manual quality control software from April 1990 despite the increasing mean CMWs speed.

(2). The biggest improvement was achieved in EQ. - 50°S area after the employment of new software in April 1992.

(3). The difference in quality between high-level CMWs in 50°N - EQ. and EQ. - 50°S areas becomes small after the second revision of the height assignment table in April 1993.

3. Operational derivation of low-level CMWs in a typhoon vicinity

3.1 Method and features

The CMWs provide useful information on the ocean surface in typhoon vicinity where conventionally acquired data are sparse. However, to estimate ocean surface wind field from the low-level CMWs in typhoon vicinity, it is necessary to increase the number of low-level CMWs derived and to establish estimation method of ocean surface winds in typhoon vicinity.

Two studies were done at the MSC in 1987. Uchida et al. (1991) showed that short-time interval (7.5-, 15-minute) images make it possible to extract larger number of low-level CMWs in typhoon vicinity, and to extract CMWs closer to typhoon center than routine time interval (30-minute) images. Ohshima et al. (1991) showed that the relationships between the ship-observed wind and the low-level CMW in typhoon vicinity are available for the conversion of CMW to ocean surface wind in typhoon vicinity.

On the basis of these studies, the derivation of low-level CMWs in a typhoon vicinity (hereafter referred to as $CMWs_{15}$) using visible images at an interval of 15-minute around 04 UTC was put into operation in May 1988. This operation has been carried out when a typhoon exists in GMS coverage.

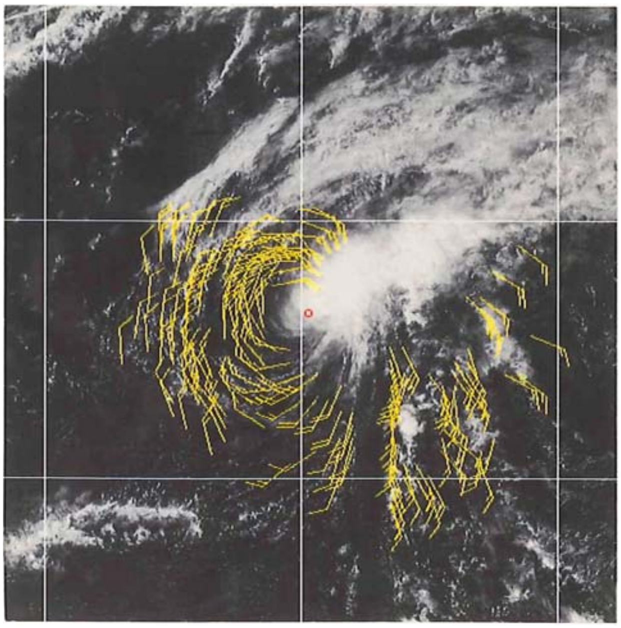
The low-level CMW_{15} is derived automatically without manual quality control in the area of 20° x 20° in longitude and latitude whose center is chosen to be the typhoon center at 00 UTC. To reject bad winds and to eliminate the winds extracted in the area where is no influence of typhoon, automatic quality control procedure introduced in 1992. In this procedure, the weak wind whose speed is less than 5 m/s and the wind whose direction is anticyclonic in regard to typhoon center are excluded.

Fig. 4 shows: (a) the low-level $CMWs_{15}$ at 04 UTC, (b) the low-level CMWs extracted from 30-minute interval images (hereafter referred to as $CMWs_{30}$) at 06 UTC in the same area as the CMW_{15} and (c) radial distributions of $CMWs_{15}$ speed relative to the motion of typhoon center. The number of the $CMWs_{15}$ is larger than that of the $CMWs_{30}$ and the $CMWs_{15}$ are calculated closer location to the typhoon center than the $CMWs_{30}$. The distributions of the $CMWs_{15}$ speed delineate the wind profile that the wind speed increases as the distance from a typhoon center decreases.

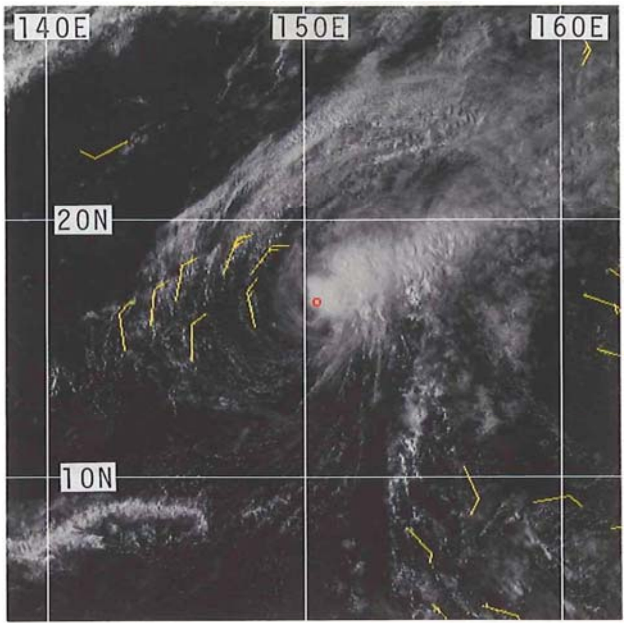
3.2 Comparison between the low-level $CMWs_{15}$ in typhoon vicinity and radiosonde winds

The low-level CMW_{15} extracted at 04 UTC was compared with radiosonde winds observed at 06 UTC that locate within 75 km from the CMW_{15}. The annual mean differences between the CMW_{15} and radiosonde winds since January 1991 until October 1993 are tabulated in Table 2. RMS vector difference decreases significantly in 1992 by the introduction of automatic quality control. Those in 1992 and 1993 are 4.2 m/s and 4.4 m/s respectively. Considering the difference of observation time between the $CMWs_{15}$ and radiosonde winds to be compared, the $CMWs_{15}$ are extracted with a good quality.

(a).



(b).



(c).

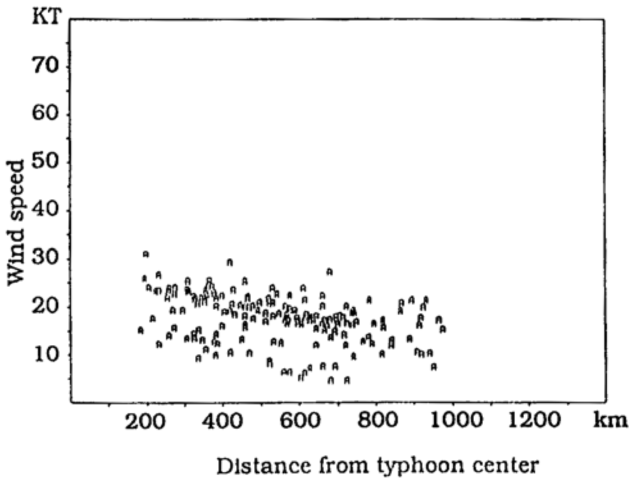


Fig. 4. Illustration of the CMWs in typhoon vicinity on March 16 1993.

(a); the $CMWs_{15}$ in typhoon vicinity and visible image at 04 UTC, (b); the $CMWs_{30}$ in the same area, but for 06 UTC and (c); radial distributions of the $CMWS_{15}$ speed. The $CMWs_{15}$ speed is relative to the motion of the typhoon center.

Year	1991	1992	1993
Number of obs.	135	121	80
Sample No.	296	225	89
Mean speed	11.00	11.00	12.20
RMS Vector diff.	6.00	4.20	4.40

Table 2.
The annual mean differences of the winds data between $CMWs_{15}$ and radiosonde winds, (within 75 km)

4. Remarks

(1). To Improve the accuracy of high-level CMWs, height assignment method and improved manual quality control software were modified. Those have provided significant improvements of the accuracy.

The GMS-5, a successor to the GMS-4, will be equipped with a split-window channel and water vapor channel sensor. These new sensor data are expected to contribute to improvement of height assignment.

(2). The low-level $CMWs_{15}$ in a typhoon vicinity are coded into WMO formats (FM 94-IX BUFR) and transmitted to the Forecast Department of Japan Meteorological Agency (JMA).

These data are intensively used at the Forecasting Division to determine the radius of gale-force wind area.

Furthermore, the low-level $CMWs_{15}$ are expected to be used for numerical and objective analysis of typhoon. Ingestion of the $CMWs_{15}$ to the numerical and objective analysis model has been investigated at the Numerical Prediction Division, JMA.

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