# Height Assignment of GMS High-Level Cloud Motion Wind

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## ABSTRACT

The two types of attempt were made to improve accuracy of high-level GMS Cloud Motion Winds (CMWs). One was the replacement of a height assignment table in April 1990. The new table has height assignment for individual months and individual zones with ten degree interval in latitude. The old table was prepared for four seasons and three zones. The new table brought a fairly significant improvement of accuracy of the CMWs, in particular, in the zone around 20°S. Further-more, in April 1991 modification of the manual quality control procedure for the area around the Jet Steam was successfully introduced to reduce the speed bias of the CMWs in mid-latitude between 20°N and 50°N.

## 1. Introduction

Some observations indicate that the GMS high-level Cloud Motion Wind (CMW) is not satisfactorily accurate. The comparison of the GMS high-level CMW with rawin wind has revealed minus bias of GMS high-level CMW, in particular for high-speed winds.

Two attempts were made at Meteorological Satellite Center (MSC) for reducing the the minus bias: revision of the height assignment table for high-level CMW and modification of quality control process in manual selection of heights. In this paper, the studies for reducing the minus bias and the recent verification of the quality of CMWs are presented.

## 2. Revision of Height Assignment Table

It is quite difficult to determine cloud top height correctly with a single channel IR data. In the Meteorological Satellite Center, the Japan Meteorological Agency, cloud top heights have been determined based on the height assignment table statistically prepared.

A new table of representative heights was introduced on 1 April 1990 so as to well respond to the seasonal variation of level-of-best-fit. The old table contained the representative heights for individual seasons and three latitudes zones (Hamada, 1982). On the

Table 1. Revised table of representative heights.

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

other hand, in the new table (Table 1), the representative heights are assigned for individual month and every 10°-latitude zone (Doi et al., 1990).

The vector difference between CMWs and rawin winds was calculated to estimate the performance of the old and new tables for the data in 1990. Table 2 shows the mean and the root mean squares (RMS) of error of the vector winds. The better performance of the new table is well demonstrated in all zones, especially in the zone centered at 20°S.

Table 2. Mean and RMS error of vector difference between CMWs and rawin winds.

| Zone | Old Table Mean | Old Table RMS(m/s) | New Table Mean | New Table RMS(m/s) | No. of Data |
|---|---|---|---|---|---|
| 40°N | 9.4 | 11.6 | 8.4 | 10.2 | 2287 |
| 30°N | 8.2 | 10.0 | 7.6 | 9.1 | 2634 |
| 20°N | 7.9 | 9.9 | 7.3 | 8.9 | 1152 |
| 10°N | 6.1 | 7.8 | 5.6 | 6.8 | 1780 |
| EQ | 6.7 | 8.3 | 5.9 | 7.0 | 203 |
| 10°S | 5.5 | 6.5 | 5.4 | 6.2 | 241 |
| 20°S | 15.4 | 18.3 | 10.3 | 12.7 | 315 |
| 30°S | 10.0 | 12.5 | 9.1 | 11.4 | 658 |
| 40°S | 9.6 | 11.9 | 8.8 | 10.7 | 269 |

## 3. Modification of Representative Heights in Quality Control

Increase of speed bias of high-level CMWs from rawin winds with latitude has been already revealed. In this regard, some studies were carried out at the Meteorological Satellite Center for mid-latitudes in the northern hemisphere (Naito et al., 1991). In the following sections their work is briefly reviewed and modification of operational quality control procedure of the CMWs to improve accuracy of high-level CMWs in mid-latitudes of the northern hemisphere is presented.

### 3.1. Speed Difference between CMWs and Rawin Winds

Comparison of CMWs with rawin winds was made for the data in May 1990. The study was conducted for three cases in the Far-East region where many rawin winds were available. CMWs for the study were derived by a manual method using loop movie images on a TV-display. Rawin winds were chosen at the level of the mandatory surface where the wind direction was best-fit to that of CMWs. The scatter plot of speed of CMWs and rawin winds is given in Fig. 1. CMWs in speed are fairly coincident with rawin winds in the wide range from low-speed to high-speed.

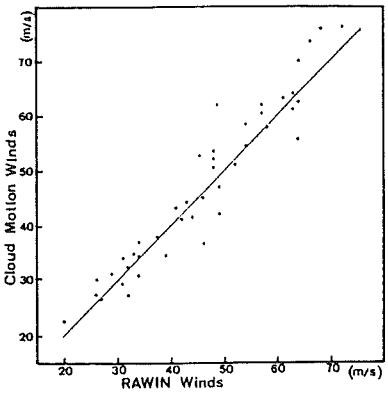


Fig.1 Comparison between CMW and rawin wind speed for the three cases in May 1990.

### 3.2. Vertical Profile of CMWs near the Jet Stream

The high-level CMW around the Jet Stream has been revealed to have a fairly big bias from experience of quality control operators. Over Japan, the Jet Stream is generally very swift and such a big bias in this region is a serious issue to be solved for the adequate extraction of the CMWs from GMS data.

The analisis of wind speed at 200 hPa level and tropopause height on 21 January 1989 is shown in Fig. 2. Along a section from the Korean Peninsula to the Nansei Islands, vertical distributions of rawin winds, CMWs and thick cloud tops are shown in Fig. 3. The height of CMW is assigned to the level where the CMW speed is the same as the rawin wind speed. The CMWs are obtained by the method used in the study described in the subsection 3.1.

In this case cloud top temperature gradually incenses from north to south. Cloud top is seen under the isothermal layer corresponding to a frontal boundary between the polar and subtropical air masses. A core of the Jet Stream is located above the isothermal layer where a strong wind speed shear exists. Therefore, small error of height assignment of CMWs around the isothermal layer causes large speed difference between CMWs and rawin winds.

To investigate zonal distributions of the accuracy of the CMWs in vicinities of the Jet Stream, CMWs were compared with rawin winds observed within 100 km

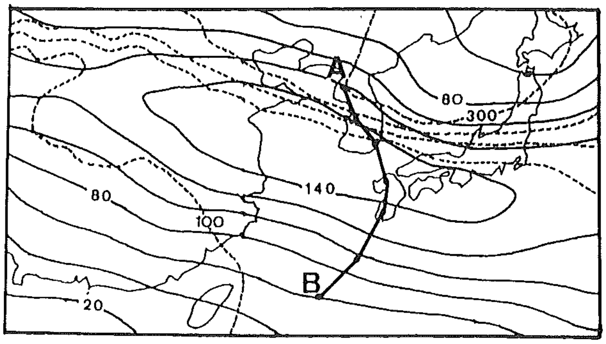


Fig. 2. Objective analysis at 12UTC on 21 January 1989. Dashed and solid lines show height of tropopause (every 50 mb) and wind speed (every 20 knots) at 200 mb, respectively.

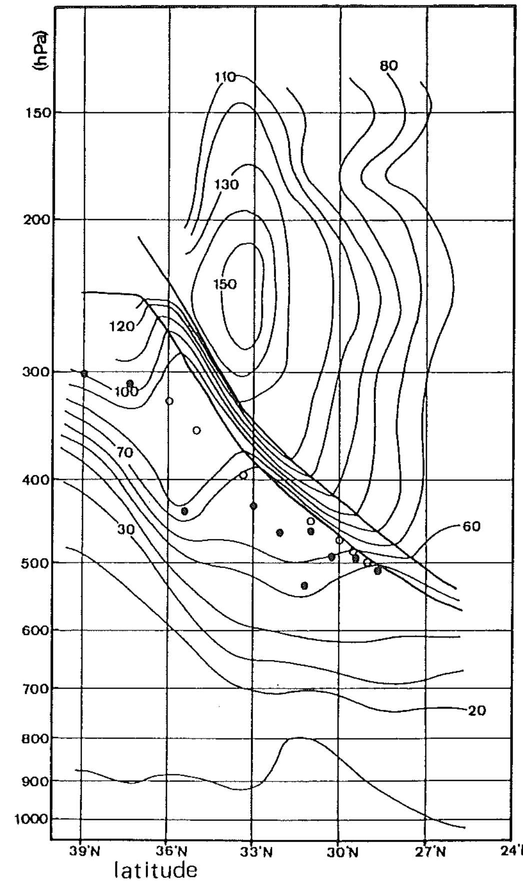


Fig. 3. Cross section along A-B of wind speed (in knots, thin solid line). Bold solid lines show the boundary of the polar front. Open and solid circles show thick cloud top and CMW, respectively.

distance from the position of CMW. The erroneous CMWs which had vector differences from rawin winds greater than 15 m/s in their absolute values were chosen from the data in 1988 and 1989. Frequency distributions of the erroneous CMWs in individual 100 km zones in south and north of the Jet Stream are shown in Fig. 4. The erroneous CMWs are distributed around the Jet Stream and in the south of the zonal discontinuation of tropopause.

3.3. Difference between CMWs and Rawin Winds for High-speed Winds

CMWs over 20 m/s in speed from 1987 to 1989 were compared with rawin winds in the same manner as the International Type 2 Comparison for the mid-latitude (25°N - 50°N) area. Over this area, the directions of rawin winds are mainly ranged from 220°T to 320°T.

The mean speed difference between CMWs and rawin winds is illustrated in Fig. 5 (a). The discrepancy of speed increases with wind speeds. The mean of direction difference between CMW and rawin wind is shown against rawin direction in Fig. 5 (b). Fig 5 (b) means that CMW directions tend toward west against rawin-wind.

Erroneous CMWs were individually checked using loop movie images on a TV-display and miss-tracking were occasionally found in the circus streaks across a ridge (Fig. 6). Such a miss-tracking can be considered to be one of causes of erroneous estimation of speed and direction of CMWs. Those poor CMWs data are expected to be easily rejected in a

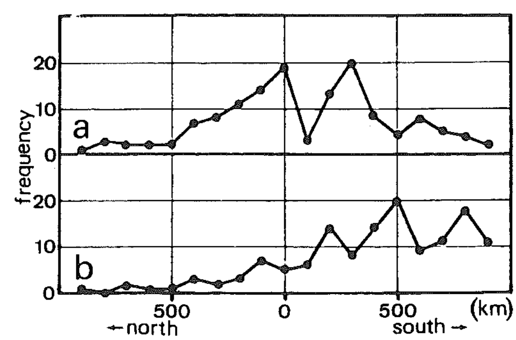


Fig. 4. (a). The frequencies of erroneous CMWs in every 100 km from jet stream core. Most erroneous CMWs distribute within 500 km distance from jet stream core.
(b). Same as (a), but for from the northern edge of the zonal discontinuation of tropopause.

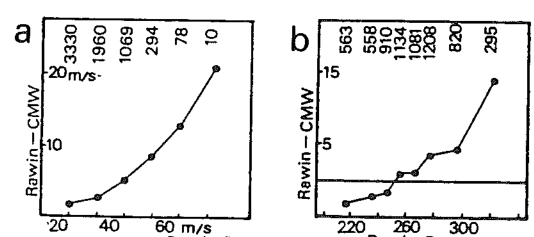


Fig. 5. (a). The mean speed bias (rawin - CMW) vs rawin speed.
(b). Same as (a), but for direction.

manual quality control procedure.

### 3.4 Modification of Quality Control Process

The results of the studies mentioned above can be summarized as follows:

(1) To obtain accurate CMWs, adequately tracked and correct assignment of height are required necessary.

(2) Around the Jet Stream the quality of CMWs is limited due to significant large wind shear.

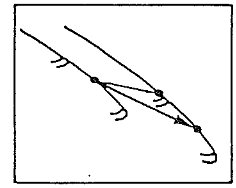

Fig. 6. Schematic drawing of miss-tracking (short arrow).

(3) Tracking of clouds in Ci streaks across a ridge will not always be made adequately in the present automatic tracking.

Based on those outcomes, as from April 1991 the modification mentioned below was introduced in the quality control procedure.

(1) The height assignment of the high-level CMWs can be manually adjusted in considering of rawin winds and winds of numerical weather forecast products. In particular, in vicinities of the Jet Stream careful quality controls are encouraged.

(2) Operators are invited to put extensive efforts in the quality control of the CMWs based on tracking of clouds in Ci streaks across a ridge.

## 4. Performance of the Revision of Table for Height Assignment and Modification of Quality Control Process

For evaluation of the two types of modification, the introduction of the new height assignment table as from April 1990 and the intensive quality control as from April 1991, the monthly mean difference of the winds data between CMWs and rawin winds were calculated in the same way as the International Comparison of Satellite Winds. Vector difference and speed bias from January in 1988 through July in 1991 are shown in Fig. 7 and Fig. 8. An improvement is seen after the introduction of the new height assignment table in April 1990, and the bias of CMWs to rawin winds has been less than 3 m/s since the April. A further improvement by the modification of representative height in manual quality control process is also recognized in the extraction of the CMWs after April 1991.

The speed bias over 20°N - 50°N area is illustrated in Fig. 9 and Fig. 10. A speed bias was reduced by 2 m/s after April 1990 when the new height assignment table was introduced. The current speed bias is less than 2 m/s.

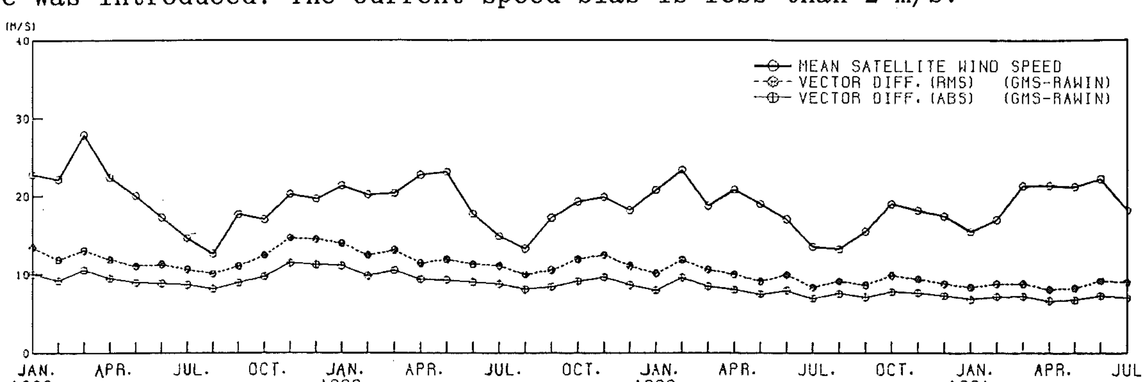


Fig. 7. Monthly means of vector difference between CMW and rawin wind.

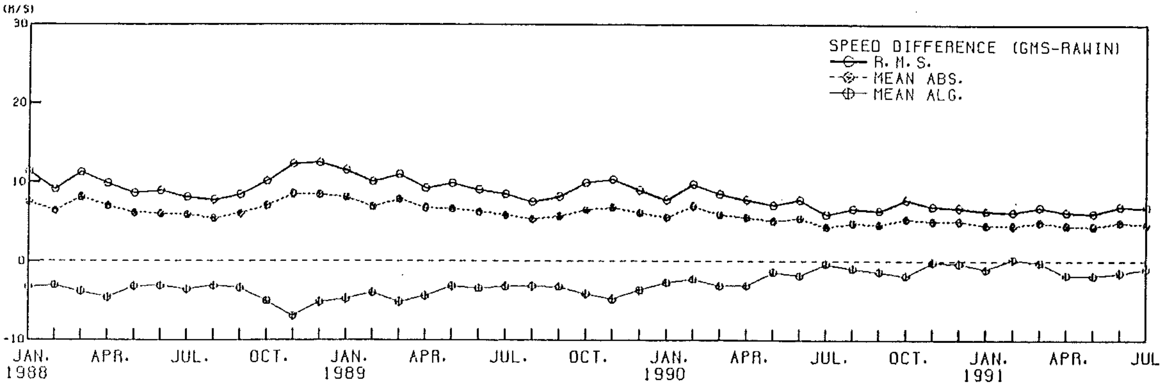


Fig. 8. Same as Fig. 7, but for speed bias.

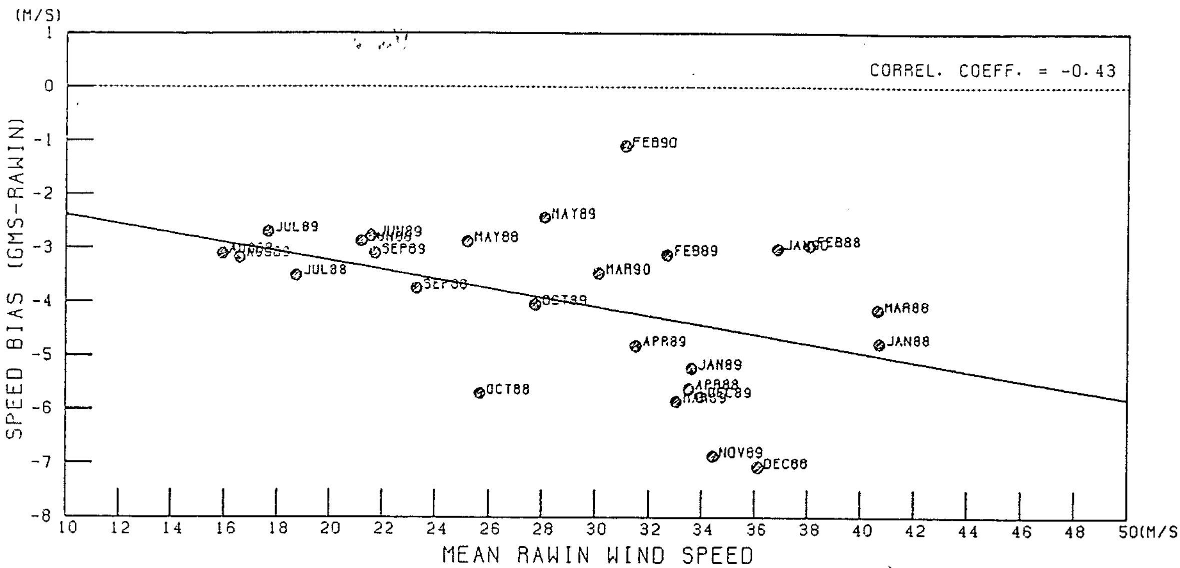


Fig. 9. Monthly means of speed bias between CMW and rawin wind over 20°N - 50N° area from January 1988 to March 1990.

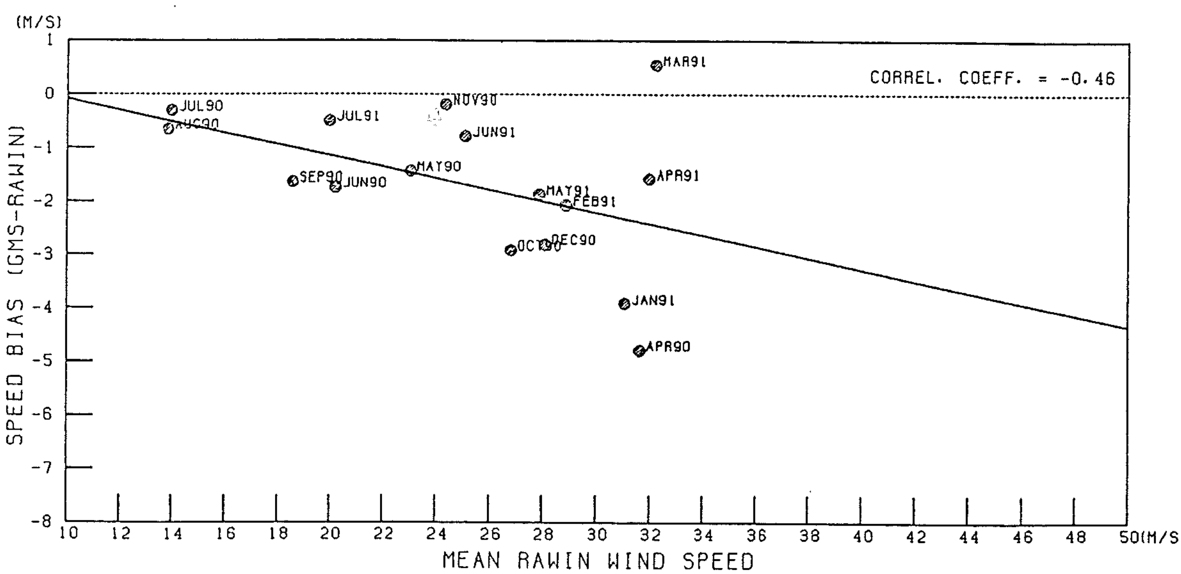


Fig. 10. Same as Fig. 9, but for from April 1990 to July 1991.

## 5. Concluding Remarks

To improve accuracy of CMW in an upper layer, a new level-of-best-fit table was introduced. Furthermore, in vicinity of the Jet Stream a speed bias can be reduced by employing a new height assignment procedure by quality control operators. Those have provided significant improvements of accuracy of the CMWs.

For further improvement of CMWs accuracy, the Meteorological Satellite Center, the Japan Meteorological Agency will continue intensive efforts particularly in the following:

(1) The GMS-5, a successor to the GMS-4 will be equipped with a two-channel IR sensor and a water vapor channel detector. Those new functions are expected to enable us to have more accurate estimation of cloud top heights.

(2) Software of the quality control which refers to outcome of the numerical weather prediction models on a real time basis is expected to be developed in near future.

## References

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