Brief Description for Error Estimates of Satellite Winds Derived by CWES System

Abstract

Error sources of satellite winds derived from picture pair are as follows;

(1) Tracking target clouds which do not move with air motion (wind).

(2) Error caused by wind derivation system (misalignment, mismatching etc.).

(3) Error caused by assigning improper heights.

Errors of satellite winds stated as above are discussed in this article on the basis of recent investigation on the resultant winds derived from GMS images.

1. Error in the case that improper target clouds are tracked.

Hubert et al. (1971) have pointed out that non-advective clouds which do not move with environmental winds are improper target for tracking. An analyst needs to track "passive tracer" based on his experience. The error has decreased rapidly with accumulated experience.

2. Error caused by wind derivation system.

2.1. Misalignment of images

Precise registration of two or more images is required to measure cloud motion vectors accurately. Accurate determination or prediction of satellite orbit and attitude, especially attitude, is the most important factor to get accurate cloud displacement in CWES system. Maeda et al. (1979) show that a pair of images, from which operational MM-1 winds are derived, has relative misalignment as large as 2 visisble lines at the sub-satellite point (SSP). The misalignment among the images with 30-minute intervals causes the satellite with error of 1.4 m/s at SSP.

Algebraic means of the differences of v-component between satellite winds and rawin winds in lower level, reported in Type 2 Reports for International Comparison of Satellite Winds by our center, are caused mostly by the relative misregistration. The algebraic means of v-component differences given in the Type 2 Reports are as follows;

−1.9 m/s	May/June 1979
−1.3 m/s	Jan/Feb 1979
−1.8 m/s	July 1978

(Satellite wind minus rawin wind).

Recent experimental cloud selection with horizontally high density shows the resultant vectors have the bias in v-components of satellite winds.

Maeda et al. (1979) verified that it is possible to remove the relative misalignment by correcting some parameters used

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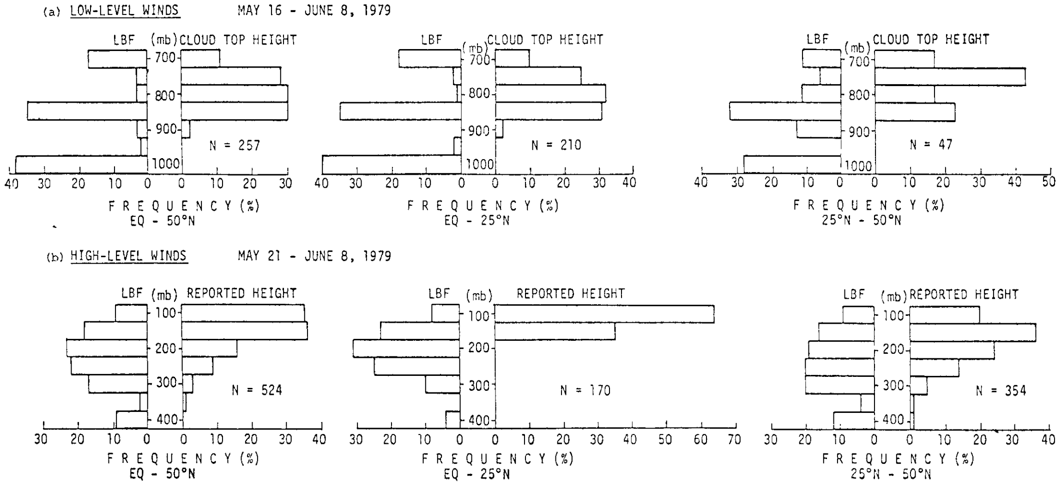


Fig. 1 Height distribution of LBF and reported height. Horizontal distance between satellite wind and radiosonde wind for estimating LBF is restricted within 220 km.

(a) For low-level satellite winds with cloud top heights from surface to 700 mb. Many radiosonde winds being available only at standard pressure levels, 1000, 850 and 700 mb, frequencies at other levels are than those levels. Cloud top heights derived from infrared images are reported as wind levels.

(b) For high-level satellite winds with reported heights from 100 to 400 mb. Many radiosonde winds not being available at the level of 350 mb, frequency at the level is less than at the other levels. The height of tropopause levels are reported as wind levels.

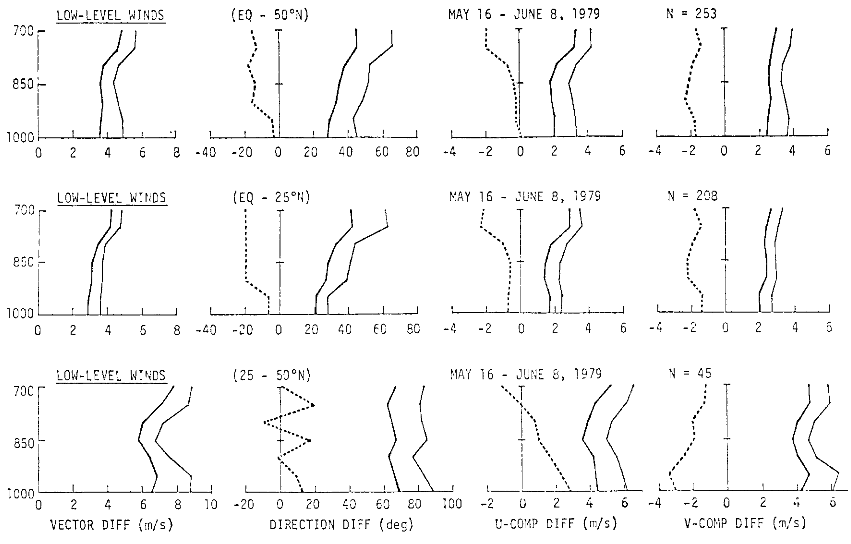


Fig. 2 Differences between low-level satellite winds and radiosonde winds at seven levels during the period from May 16 to June 8, 1979. Target cloud heights are between surface to 700 mb. Horizontal distance between both winds are restricted within 220 km. Most of the satellite winds are derived man-machine interactively by MM-1 procedure of CWES. A few of them are derived by Film-loop procedure. Thick lines are absolute means of differences, thin lines RMSs and broken lines algebraic means.

for image registration referring to earth edge of IR image. Now the Meteorological Satellite Center of Japan is planning to correct the misregistration automatically in routine operation.

2.2. Error caused by pattern matching.

The error caused by pattern matching is not serious problem when good cloud targets are selected. There is a truncation error caused by discrete sampling of

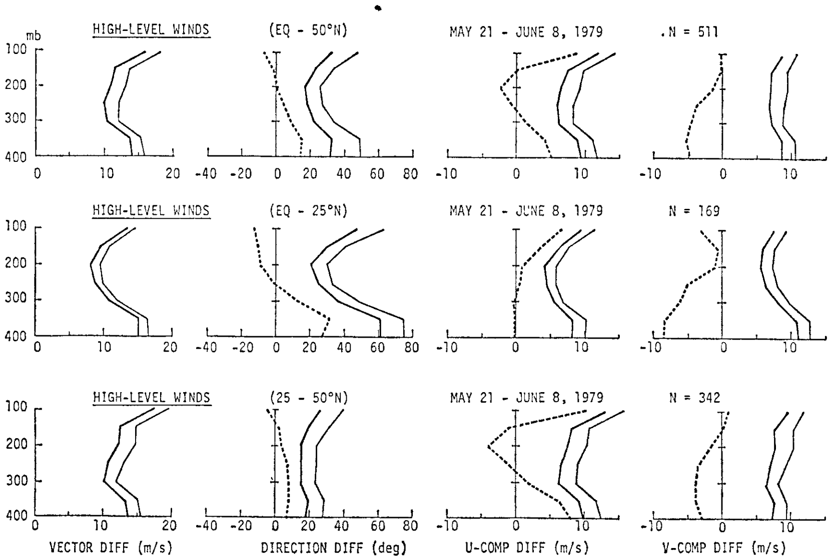


Fig. 3 Same as Fig. 2, but for high-level satellite winds derived by tracking cirrus clouds in film-loop procedure of CWES during the period from May 21 to June 8, 1979.

Table 1 Vector differences between satellite winds and radiosonde winds, and representative altitudes.

Target Cloud	Area	Samples	Representative Altitude***	Vector Difference****	
				At Level with Min. Diff. (The Level)	At LBF
Cu	EQ*	93	850-950 mb	2.7 m/s (1000) mb	1.8 m/s
	MID**	19	850	5.9 (850)	4.3
Ci	EQ*	69	200	7.3 (200)	4.4
	MID**	131	300	9.4 (300)	4.6

* EQ: Equatorial Area (0-25°N)

** MID: Middle Latitude (25-50°N)

*** Representative Altitude: Estimated from Fig. 1—Fig. 3 and from the results given by Hubert et al. (1971), Hasler et al. (1977), etc.

****Vector Difference: Differences from pairs of winds with horizontal distances less than 139 km.

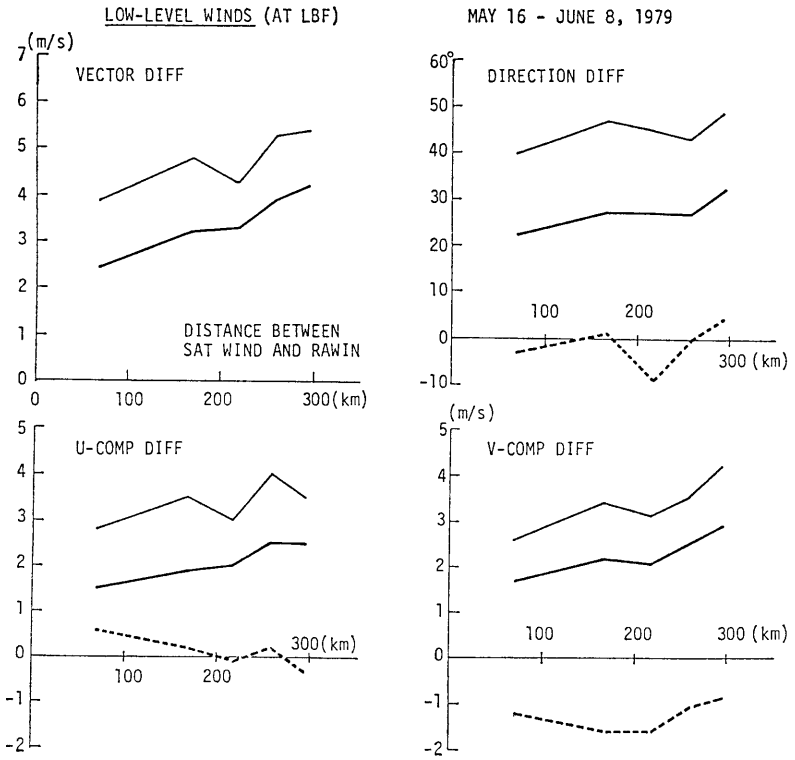
image. However, the error is corrected by interpolation of matching position, as shown by Hamada et al. (1978).

3. Error caused by assigning improper heights.

This error has great impact on derived winds, as known well. The distribution of the Level of Best Fit (LBF) and reported heights of satellite winds is shown in Fig. 1. For both high-level winds and low-level winds reported heights are higher than LBF. For low-level winds cloud top heights derived for infrared images are reported as wind levels. For high-level winds the height of climatological tropopause levels are reported as wind levels.

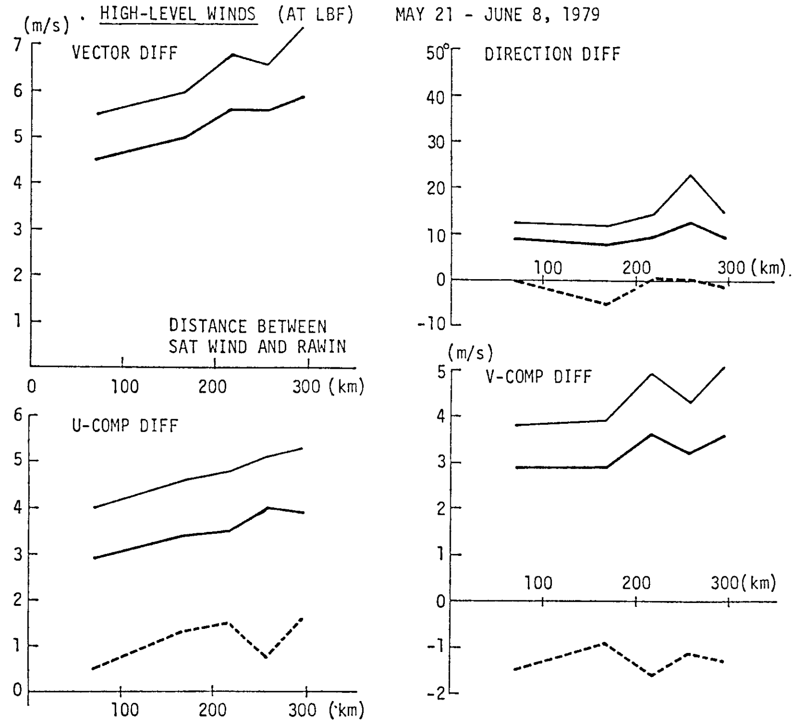
Further investigation shows the differences between satellite winds and radiosonde winds at seven levels (Fig. 2 and Fig. 3). The statistics are given in equatorial area and in middle latitude area. The altitudes representing actual winds are estimated in Table 1.

In current operation, it is impossible to assign different heights in different latitude in CWES system. The reported heights should be read by proper heights shown in the Table 1, or by those based on further investigation.



Distance (km)	Number of Samples
0 - 139	116
139 - 196	122
196 - 240	121
240 - 277	103
277 - 310	99
Total	561

Fig. 4 Difference at LBF between low-level satellite winds and radiosonde winds as function of horizontal distance during the period from May 16 to June 8, 1979. Numbers of samples are shown beside of the figure.



Distance (km)	Number of Samples
0 - 139	184
139 - 196	195
196 - 240	212
240 - 277	170
277 - 310	182
Total	943

Fig. 5 Same as Fig. 4, but for high-level satellite winds during the period from May 21 to June 8, 1979. Numbers of samples are shown beside of the figure.

4. Estimation of total error.

Vector differences as function of the horizontal distance between satellite wind and radiosonde wind are shown in Fig. 4 and Fig. 5. The algebraic means of v-component difference do not fluctuate with distance and are representing the bias error caused by the misalignment stated in the Section 2.1.

The magnitude of vector difference between satellite wind and rawin vector decreases as the vectors become closer each other. And it is concluded that the total error of the satellite winds is less than 3 m/s for low-level winds and less than 4.5 m/s for high-level winds. The error includes the bias error caused by the misalignment.

References

Hubert, L.F. and L.F. Whitney (1971); Wind Estimation from Geostationary Satellite Pictures. Mon. Weath. Rev., **99**, 665-672.

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