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# Evaluation of Upper Winds as a Translation Vector for the Short-Term Forecast of Precipitation Echoes

By

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**Abstract**

Observation of precipitation echoes with conventional weather radar of 3.2 cm wavelength was carried out from September 7 to October 6, 1981 at the center of the Kanto Plain in Japan. For studies on the short-term forecast of precipitation echoes, the evaluation of upper winds as a translation vector was made by simple translation with recorded echo data for 1 or 2 hours. The winds used for the translation were those at 800, 700, 600, 500 and 400 mb and the mean wind from 850 to 400 mb, provided from rawin data at Tateno.

The result of the forecasts was evaluated by Critical Success Index (CSI). Overall, the mean wind gave the largest CSI score for translation. Next to this, the CSI score for translation from the wind at 700 mb was larger than that from the other upper winds. The analysis demonstrated, therefore, as a whole that the mean wind would be practical for use as a translation vector for the short-term forecast of precipitation echoes.

In addition to CSI analysis, meteorological analysis was made for two cases. The possibility of the application of Doppler radar to the present method of short-term forecast of precipitation echoes is also discussed.

## 1. Introduction

Aioi in 1971 and Nagasaki in 1982 are two examples of heavy rainfall which is not infrequent in Japan, causing serious loss of life, crops and property. Weather radar has been playing an important role in the watching of such heavy rainfall. Recently, several studies of short-term weather forecasts with radar records have been carried out. The information of short-term forecasts will be valuable for disaster prevention in large cities and public facilities like dams and airports. To protect these important locations,

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a medium radar range of about 100 km might be practical, considering the scale and lifetime of most cases of heavy rainfall.

Up to date, several methods of forecasting from radar echo patterns with the use of digital echo data have been developed. Austin and Bellon (1974) proposed a technique to translate digital radar echoes by Crosscorrelation Method (CCM). Bellon and Austin (1978) made an evaluation of real-time operation of a short-term precipitation forecasting procedure (known as SHARP) with actually observed data. Elvander (1976) evaluated three different methods of short-term precipitation forecasting by using the same data. In Japan, Tatehira and Makino (1974) made an evaluation of the forecast of digital echo patterns with an echo composite map from several adjacent radars. They extrapolated the echoes from the wind at 700 mb including an adjustment by echo development. Tatehira *et al.* (1976) examined the forecasting technique of translation from 700 mb wind, considering the development and dissipation derived from two photographs at an interval of 1 hour. These studies have shown that a short-term forecasting procedure using CCM or translation method from a certain wind could be practicable.

Any method of short-term forecasting first needs to determine a translation vector. For CCM, both current map and past map stored from the previous hour are necessary ; therefore, a certain store time is required to determine the displacement vector. In the case of a 1 or 2 hour short-term forecast, the displacement vector should be determined as quickly as possible. Not only is this a difficult requirement, but also a proper displacement vector may not be determined when locally irregular movements of widely spread precipitation echoes are prevailing. Therefore, in this paper we use a certain wind vector instead of a displacement vector for translation. For this purpose, Doppler radar is considered to be useful and convenient to determine the translation vector quickly and simply by measuring upper winds at real time when the precipitation echo holds its activity for 2 or 3 hours.

The technique of measuring the wind by a single Doppler radar has been described by Lhermitte and Atlas (1961), Browning and Wexler (1968) and others. The present authors tried real-time measurement of horizontal winds using fan-beam Doppler radar (Uyeda and Yagi, 1980 a, 1980 b).

In the present investigation, the radar observations were made in the rainy periods in September and October in 1981 and 1982, using conventional radar to measure the intensity of reflectivity. For a translation vector, the authors used upper winds from rawin data, regarding them as upper winds measured by a single Doppler radar. Aoyagi (1982) has observed that upper winds measured by a single Dopper radar coincided with rawin winds. In this paper, the evaluation of upper winds as a translation vector is described as the result of analysis for the 1981 observation data, and the possibility of the application of Dopper radar to the short-term forecast of precipitation is discussed.

## 2. Methods of observation and analysis

### 2.1 Radar data acquisition and digitization

Observation of radar echo for the study of short-term forecast of digitized echo pattern was carried out in a rainy period from September 7 to October 6, 1981 in the center of the Kanto Plain. The observation range was 100 km in radius, as shown by the circle in Fig. 1. Mountainous regions over 600 m above sea level are hatched. A mobile weather radar set was set up on the bank of the River Tone. The height of the bank was about 20 m above the neighbouring ground. The wavelength of the radar was 3.2 cm ; other specifications of the radar are listed in Table 1.

The program of radar observation was scheduled from 0200 to 0600 JST, from 0800 to 1200 JST, from 1400 to 1800 JST and from 2000 to 2400 JST. These observation series were chosen to utlize the rawin data of 0300, 0900, 1500 and 2100 JST which would provide a translation vector for radar echo patterns. After first precipitation echo was identified, photographs of isoecho (ISO) contours on a plan position indicator (PPI) were taken by 35 mm cinecamera every 10 minutes. The range of the PPI scope was 100 km in radius, and the elevation was set at an angle of 3°. In addition to this PPI recording, ISO contours of a range elevation indicator (REI) were photographed at intervals of 30 minutes.

After the observation period was completed, off-line analysis was made of the obtained data. The intensity of PPI echoses on the screen of a cinefilm analyzer was digitized in a 2 km × 2 km mesh by hand. The digitized levels were ISO 1, 2, 3, 4, 5 and 6 of the isoecho device of the radar set used. Ground echoes were eliminated from the digitization by the comparison of PPI echoes to the ground echoes taken on days without precipitation.

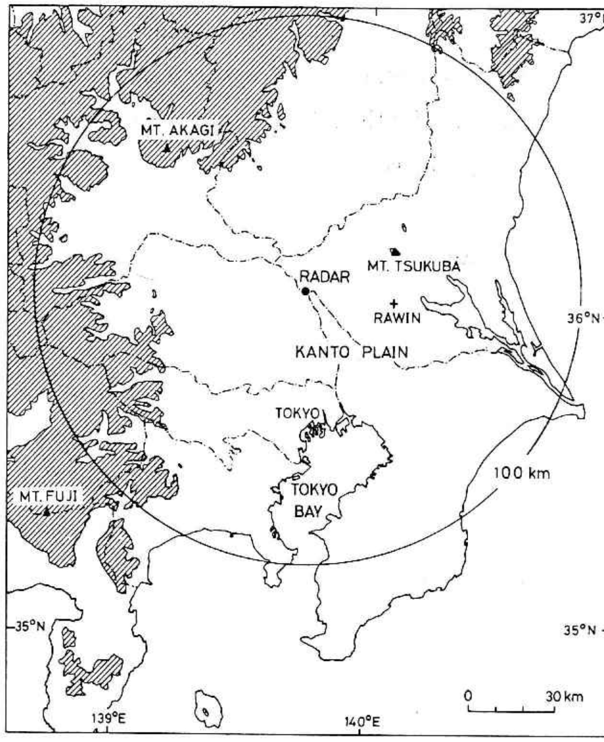



**Fig. 1** Schematic map showing the location of a mobile weather radar set in Goka Village (●) and the location of the rawin observation (Aerological Observatory, Japan Meteorological Agency) at Tateno (+). The circle 100 km in radius shows the radar observation range. Mountainous regions over 600 m above sea level are hatched.

**Table 1** Specifications of the mobile weather radar set.

| TERM | PERFORMANCE |
|---|---|
| FREQUENCY | 9375 MHz |
| PEAK POWER OUTPUT | 40 kw |
| PULSE WIDTH | $1\mu s$ |
| PULSE REPETITION RATE | 260 pps |
| REFLECTOR | 1.2 m$\phi$PARABOLA |
| BEAM WIDTH | $2^{\circ}$ |
| INDICATOR | PPI, REI, A/R |
| ISO ECHO | $<100$ km |

## 2.2 Echo translation by wind vector

These digitized echo patterns were simply translated by computer using the upper winds observed by the Aerological Observatory at Tateno. The evolution of precipitation echoes was not considered in the translation for one or two hours. The observatory is located 32 km from the radar site at 100°, as shown in Fig. 1. The upper winds used for the translation were the winds at 800, 700, 600, 500 and 400 mb and a mean wind (Vm). The mean wind Vm is defined as the vector mean of winds at ten points from 850 to 400 mb at intervals of 50 mb. Initial echo patterns applied in the translation using these winds were the records observed on the hour or 30 minutes after the hour. The translation lengths were 10, 20, 30 and 60 minutes and, if possible, the lengths were extended up to 90, 120 and 180 minutes. The REI echoes in these translation spans were examined to check the vertical structure of precipitation.

For verification of forecasts from radar echoes, a well known parameter was chosen. That parameter is the Critical Success Index (CSI) (Donaldson *et al.*, 1975), defined as

$$\mathrm{CSI}=100\frac{X}{X+Y+Z}$$

where X, Y and Z have meanings explained in Table 2. Fig. 2 will aid better interpretation of the table. The CSI score was calculated for each translation from upper winds. The level of intensity of the echoes translated were over ISO 1 (corresponding to 1 mm/h) and over ISO 2 (corresponding to 2 mm/h), since the area of intensity over ISO 3 was very small.

**Table 2** Definition of parameters used in the calculation of CSI, adapted from Donaldson *et al.* (1975). X, hits; Y, missed; Z, false alarms, as schematically illustrated in Fig. 2.

| OBSERVED | FORECASTED | |
|---|---|---|
| | VALUE EQUAL TO OR LARGER THAN THRESHOLD | VALUE LESS THAN THRESHOLD |
| VALUE EQUAL TO OR LARGER THAN THRESHOLD | X | Y |
| VALUE LESS THAN THRESHOLD | | Z |

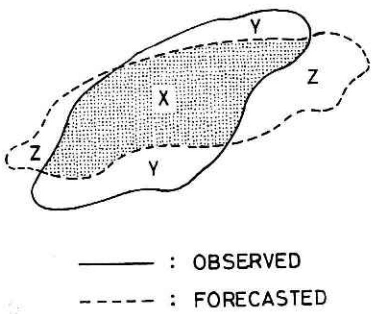



**Fig. 2** Conceptional illustration of overlapping of two echoes. The area inside the solid line shows the observed echo and the area of broken line shows the forecasted echo. Part X is the "overlapped" area, parts Y are "observed but not forecasted", and the parts Z are "forecasted but not observed".

### 2.3 Echo translation by displacement vector

A displacement vector between a present PPI echo and the one 30 minutes previous was also calculated for the translation of a present echo into the future. The common method of obtaining the displacement vector was described by Austin and Bellon (1974). In the present paper, many CSI scores between two PPI echo patterns were first calculated by computer by translating the past echo in many directions and distances around the present echo. Then, for future translation, one single displacement vector was determined so as to give the largest CSI score. The interval between the two echoes was 30 minutes. This method derives the same result as the Crosscorrelation Method for the echo area of ISO 1.

Using the displacement vector, short-term forecasts of precipitation echoes were made in the same manner as short-term forecasts using the wind vector, for comparison.

### 2.4 Meteorological analysis

Meteorological analysis was made for typical cases observed from September 7 to October 6, 1981.

In order to examine the relation between the types of precipitation and the validity of translation vectors of echo patterns, surface weather analysis using Automated Meteorological Data Acquisition System (AMeDAS) data was made for every case in the observation period. Also, time cross-sections were made for typical cases.

## 3. Results

### 3.1 Averaged CSI scores

The movements of precipitation echoes were observed in the period from September 7 to October 6, 1981 in the Kanto Plain. The observation data were classified into eight cases, as listed in Table 3, in terms of rawin observation time of 0300, 0900, 1500 and 2100 JST. In Cases 1, 2 and 3, observed rains were associated with a cyclone. Especially in Case 2, heavy rainfall was observed in a small area according to the AMeDAS data analysis. In Case 4, the echo observed by the radar was of convective type and its intensity was high, but no heavy rains were observed at the ground. In Cases 5, 6, 7 and 8, observed rains were associated with Typnoon No. 8122 (Elsie) approaching the radar observation range. Especially in Case 8, the duration of the precipitation echo was long enough for translation of over 2 hours.

On each case, the echo areas over the level of ISO 1 on the hour and 30 minutes after the hour were translated for forecast length as long as possible by upper winds at 800, 700, 600, 500 and 400 mb and the mean wind, Vm (850 to 400 mb), at Tateno. The averaged CSI scores of the translations are shown in Table 4. Two echo patterns of Case 2 were translated up to 90 minutes and three echo patterns of Case 8 were translated up to 120 minutes. Case 3 and Case 4 were eliminated from the averaging in the table because the precipitation .echoes could not be translated more than 60 ·minutes.

**Table 3** List of casens of radar observation data. The observation time of rawin data used for the translation is shown in the RAWIN TIME column. The disturbance associated with the precipitation echoes observed is shown in the REMARKS column.

| CASE NO. | RADAR OBSERVATION TIME | RAWIN TIME | REMARKS |
|---|---|---|---|
| 1 | 2000-2400 JST, SEP.25, 1981 | 2100 JST | CYCLONE |
| 2 | 0000-0600 JST, SEP.26, 1981 | 0300 JST | CYCLONE |
| 3 | 1640-1800 JST, SEP.26, 1981 | 1500 JST | CYCLONE |
| 4 | 1400-1630 JST, SEP.28, 1981 | 1500 JST | FRONT |
| 5 | 0805-1200 JST, OCT. 1, 1981 | 0900 JST | TYPHOON |
| 6 | 1200-1800 JST, OCT. 1, 1981 | 1500 JST | TYPHOON |
| 7 | 2000-2400 JST, OCT. 1, 1981 | 2100 JST | TYPHOON |
| 8 | 0000-0600 JST, OCT. 2, 1981 | 0300 JST | TYPHOON |

**Table 4** Averaged CSI score for translation from winds at 800, 700, 600, 500, and 400 mb and the mean wind Vm.

| | 30 min. | 60 min. | 90 min. | 120 min. |
|---|---|---|---|---|
| 800 mb | 22.7 | 8.0 | 2.6 | 0.3 |
| 700 mb | 23.3 | 11.7 | 8.3 | 5.1 |
| 600 mb | 21.6 | 8.0 | 3.2 | 0.9 |
| 500 mb | 19.8 | 5.4 | 1.3 | 0.1 |
| 400 mb | 19.9 | 4.6 | 2.1 | 0.2 |
| Vm | 27.3 | 15.5 | 11.2 | 10.9 |

Eventually, the number of translations were 14, 14, 6 and 3 for translation length up to 30, 60, 90 and 120 minutes, respectively.

In Case 2 and Case 8, the echo duration was longer and precipitation amount was greater than in the other cases. The results of translation on the two cases are precisely described in the following sections and, in addition, the results of meteorological analysis for these cases are given.

### 3.2 Detailed description of Case 2

Early on September 26, 1981, Kanagawa Prefecture and Chiba Prefecture, the southern part of the Kanto Plain, had heavy rainfall of about 60 to 70 mm in 6 hours. The radar echo corresponding to this rain was obtained, and designated as Case 2 in Table 3. An example of the PPI echo and the REI echo at 0030 JST is shown in Photo. 1. The height of the echo top was 8 km, the strongest echo was ISO 5 in the intensity level which corresponded to 16 mm/h, and the echo moved toward the east-northeast. The echo features in the photograph show that the echo was widely spread and was of convective form.

The changes in CSI score for forecast length up to 90 minutes starting at 0030 and 0010 JST are shown in Fig. 3 (a) and (b). The echo pattern translated was of the level over the intensity of ISO 1. In addition to the changes in CSI score *versus* each upper wind and the mean wind, the change in CSI score in the case of a displacement vector is

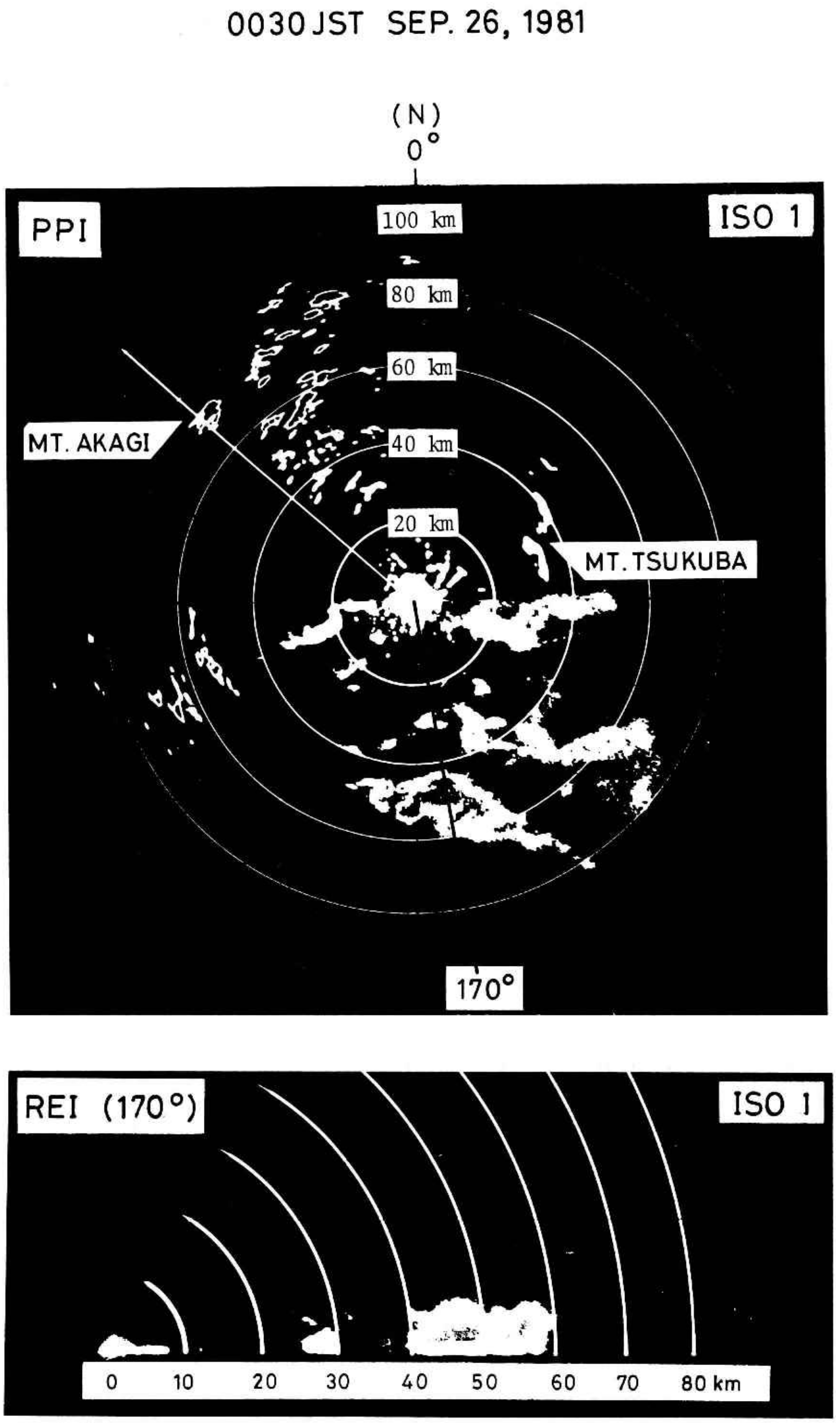



**Photo. 1** An example of the PPI echo and REI echo at 0030 JST, September 26, 1981. The REI is the vertical cross-section in the direction of 170° on the PPI scope.

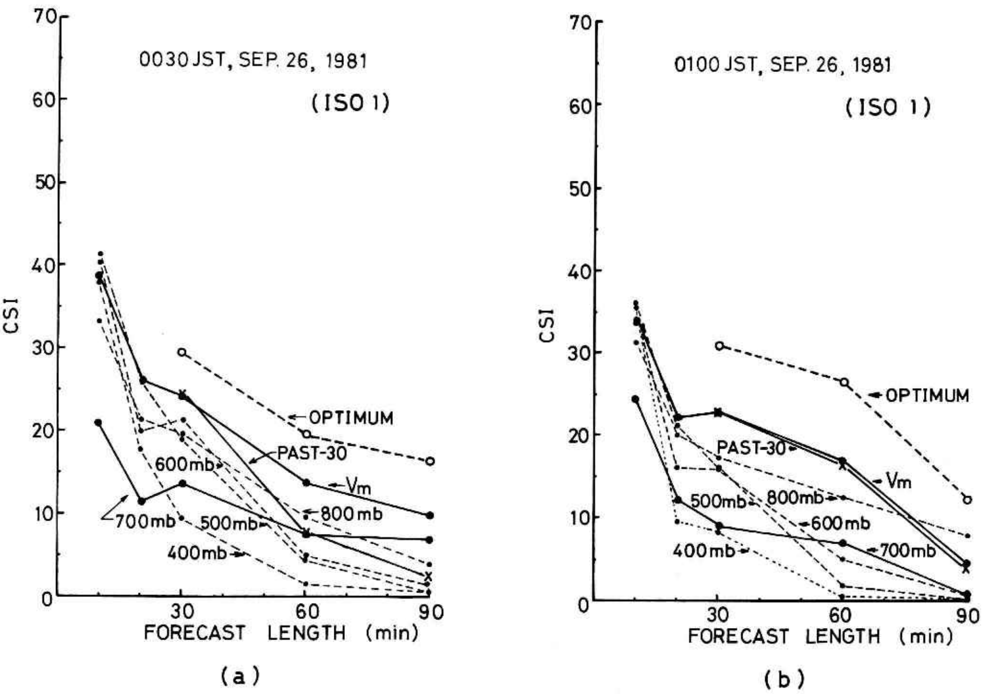



**Fig. 3** Change in CSI scores for forecast lengths up to 90 minutes : (a) starting at 0030 JST, and (b) starting at 0100 JST. The threshold of echo intensity is ISO 1 for the calculation of CSI score. The translation vectors are the wind velocities at 800, 700, 600, 500 and 400 mb and the velocity of the mean wind, Vm (from 850 to 400 mb). The CSI score for translation from a displacement vector calculated between past and present PPI echoes is shown by PAST-30. The possible maximum CSI score by the simple translation method is shown by OPTIMUM.

shown as PAST-30 in both figures. The displacement vector was determined from two PPI echoes: present and 30 minutes previous. Furthermore, the change in possible maximum score by the simple translation method was shown as OPTIMUM for comparison.

As is well known, any CSI score decreases with the forecast length as a whole. Among them, translation from mean wind Vm shows the largest CSI score, being close to the OPTIMUM. Translation from PAST-30 also presents a relatively good score. On the other hand, translation from the wind at 700 mb shows a small CSI score, not as generally expected. Fig. 4 shows the result of forecasts of the echoes over the intensity of ISO 2 starting at 0030 and 0100 JST. The total tendency is almost the same as mentioned above and illustrated in Fig. 3.

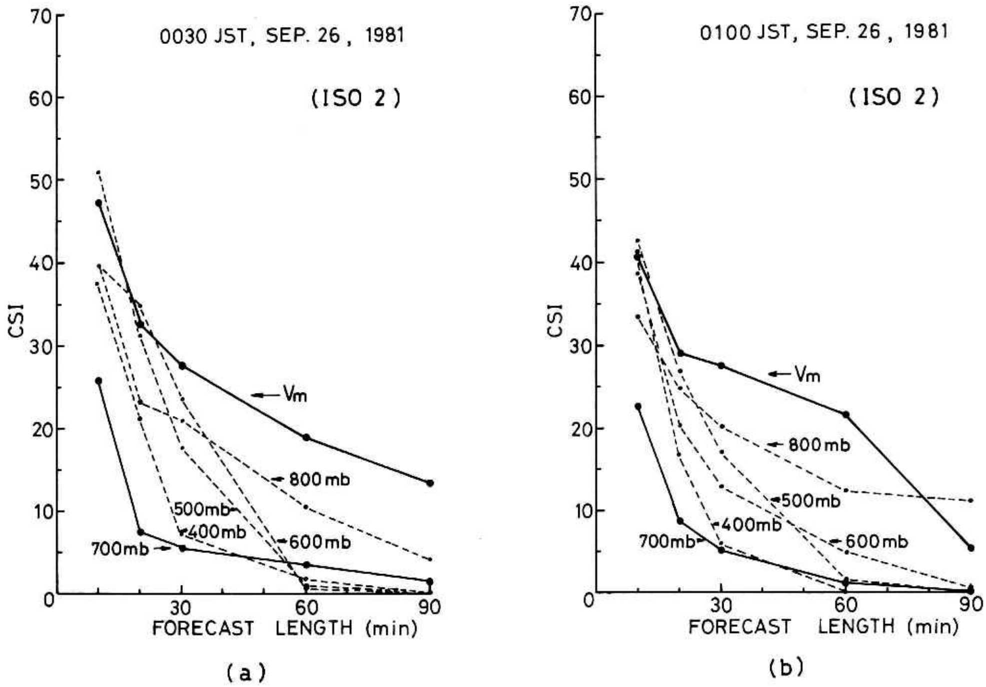



**Fig. 4** Same as Fig. 3, but the threshold of echo intensity is ISO 2.

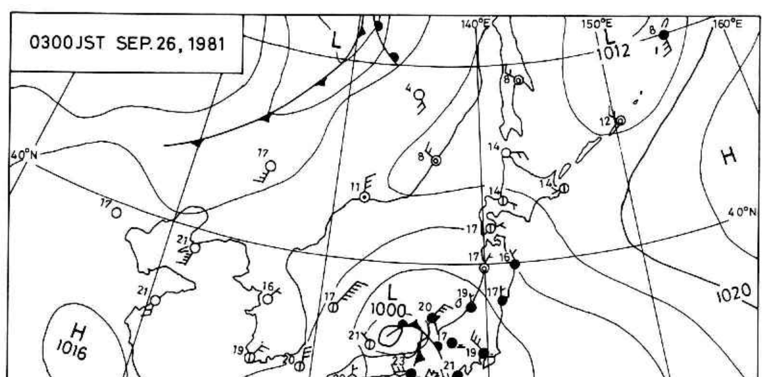



**Fig. 5** Surface weather chart at 0300 JST, September 26, 1981 (○: clear, ⦶: fine, ◎: cloudy, ●: rain, ●≟: shower, ⊙: fog).

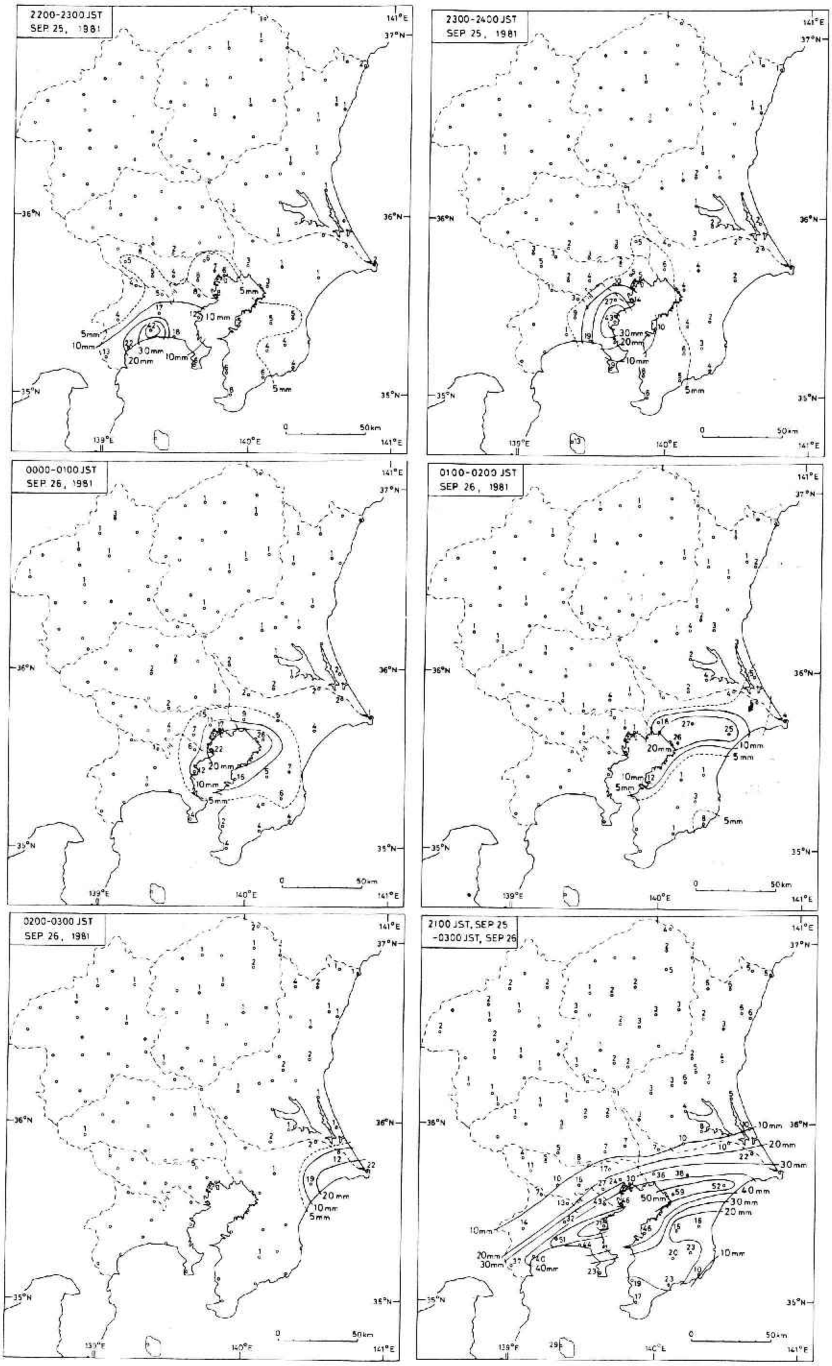



**Fig. 6** Hourly amounts of precipitation from 2100 JST, September 25 to 0300 JST, September 26, 1981 and 6 hour amount of precipitation from 2100 JST, September 25 to 0300 JST, September 26, 1981

Next to the CSI analysis, the surface weather data and rawin data were analyzed as follows. Fig. 5 shows the synoptic chart of 0300 JST, September 26. The warm front of a cyclone is located south of the Kanto area. Fig. 6 shows the hourly amounts and 6-hour amount of precipitation from 2100 JST, September 25 to 0300 JST, September 26 from AMeDAS data. The figure shows that heavy rainfall is distributed in the southern part of the radar observation range ; the heavy rainfall area moved from west to east. According to echo tracing, the movement of the precipitation area coincided with the movement of the radar echo. Fig. 7 shows the time cross-section of wind at Tateno from 2100 JST, September 24 to 2100 JST, September 26. The wind at 700 mb at 0300 JST, September 26 is seen to be different from the adjacent wind. Fig. 8 shows the cange in the surface wind fields. A small cyclonic convergence zone moved to the east, corresponding to the movement of the precipitation area in Fig. 6. Fig. 9 shows the change in temperature distributions. It can be seen that the 20°C isotherm in the southern part migrated locally eastward, corresponding to the movement of the rainfall area, although the temperature situation scarcely changed as a whole.

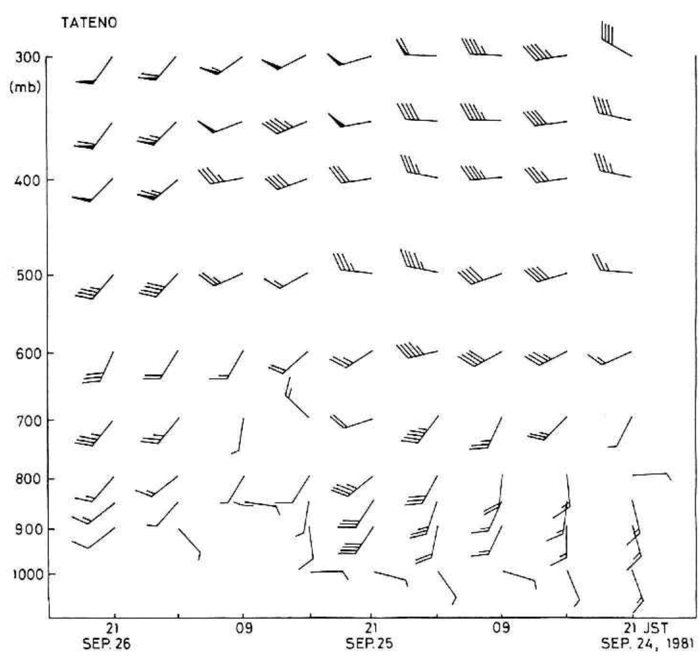



**Fig. 7** Time cross-section of winds at Tateno from 2100 JST, September 24 to 2100 JST, September 26, 1981.

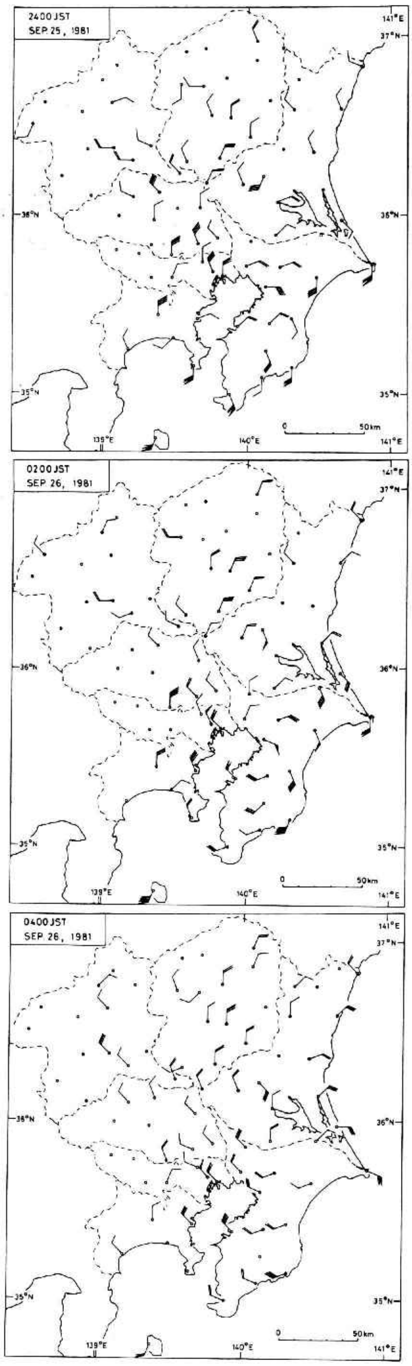



**Fig. 8** Change in surface wind fields from 2400 JST, September 25 to 0400 JST, September 26, 1981.

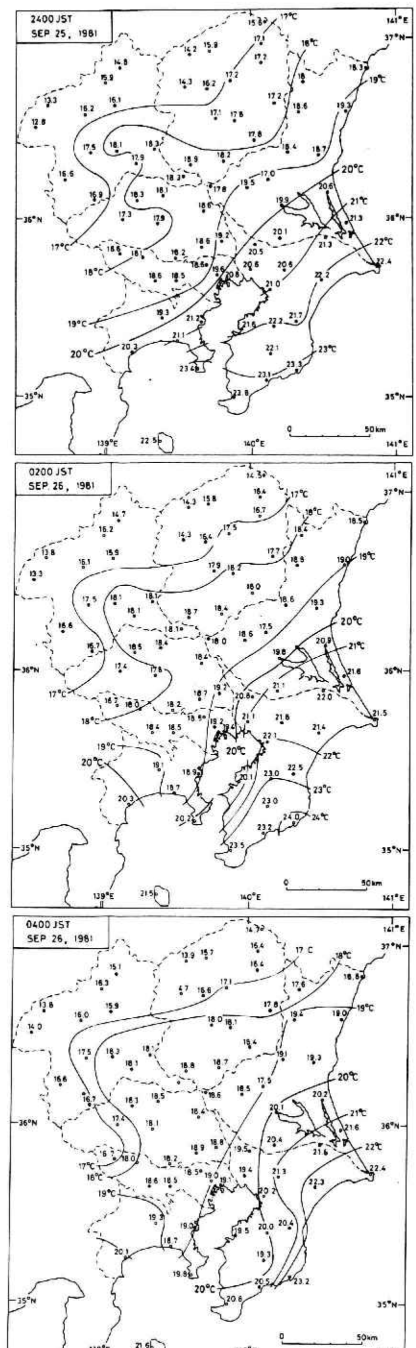



**Fig. 9** Change in surface temperature fields from 2400 JST, September 25 to 0400 JST, September 26, 1981.

### 3.3 Detailed description of Case 8

Typhoon No. 8122 (Elsie) was about 200 km south of the radar observation site at about 0300 JST, October 2, and her outer rain band was catched by the radar as Case 8. The amount of precipitation during the radar observation times from 0000 to 0600 JST was 10 to 20 mm in the radar observation range. Photo. 2 shows an example of PPI echo and REI echo at 0200 JST, October 2. The echo feature in the photograph shows that the echo was stratiform. The direction of echo mevement was north-northeast.

The changes in CSI score for forecast length up to 120 minutes starting at 0200 JST are shown in Fig. 10. The echo pattern translated was of the level over the intensity of ISO 1. The legend for Fig. 10 is the same as for Fig. 3. Any CSI score decreases with the forecast length as a whole in the same manner as seen in Fig. 3. Translation from mean wind Vm shows the largest CSI score, being close to the OPTIMUM. Translation from PAST-30 also presents a relatively good score. Translation from the wind at 700 mb shows a larger CSI score than from the winds at the other heights in this case. Fig. 11 shows the forecasts from echoes over the intensity of ISO 2 starting at 0200 JST. The total tendency of the forecasts for ISO 2 echoes is similar to that for ISO 1 in Fig. 10.

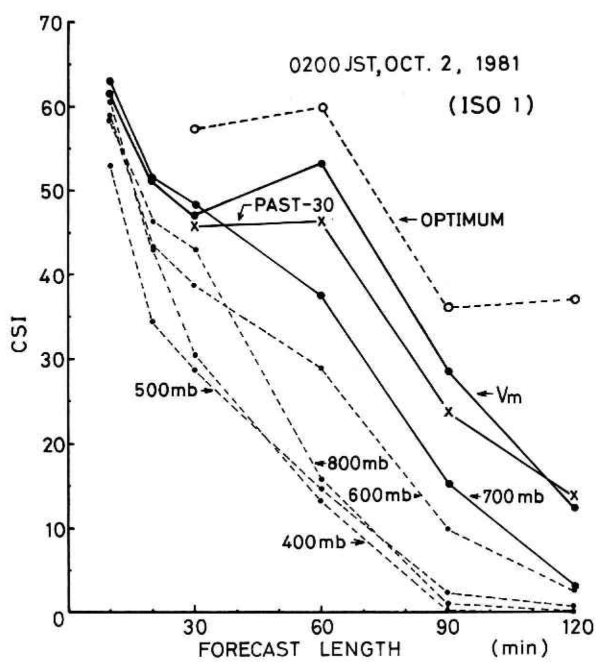
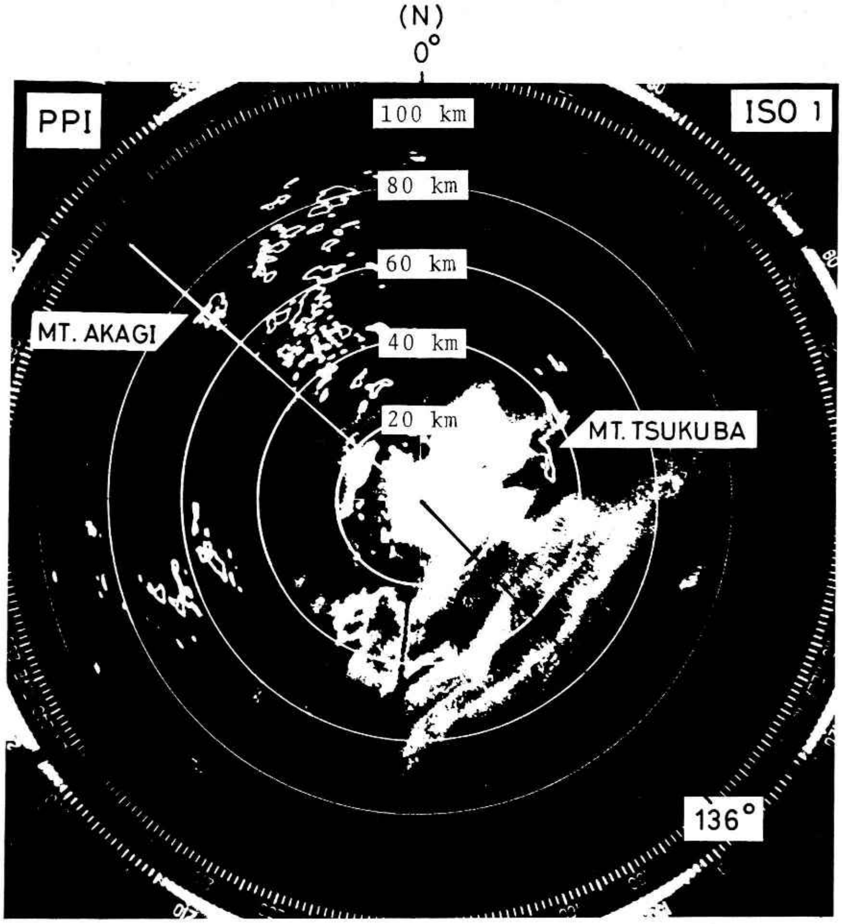



**Fig. 10** Change in CSI score for forecast length up to 120 minutes starting at 0200 JST, October 2, 1981. The threshold of echo intensity is ISO 1 for the calculation of CSI score. The legend is the same as for Fig. 3.

0200JST OCT. 2, 1981



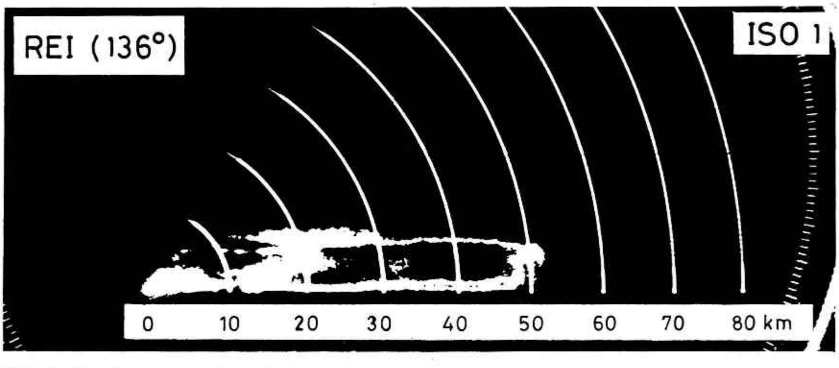




**Photo. 2** An example of the PPI echo and REI echo at 0200 JST, October 2, 1981. The REI is the vertical cross-section in the direction of 136° on the PPI scope.

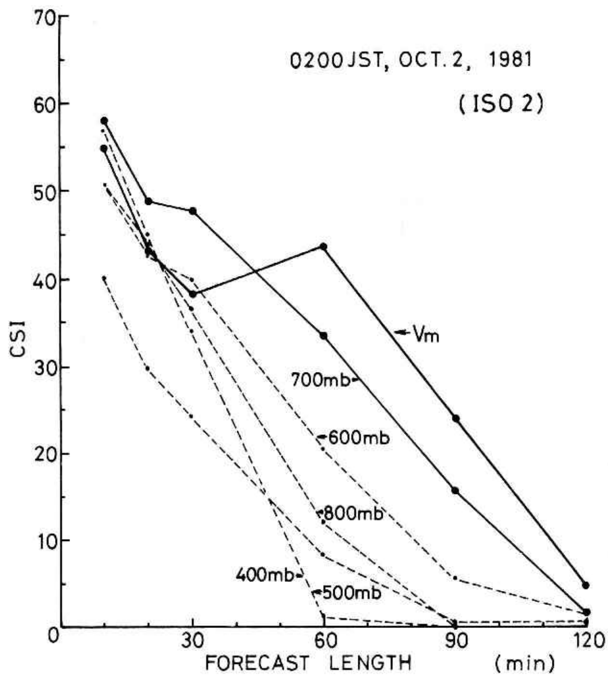



**Fig. 11** Same as Fig. 10, but the threshold of echo intensity is ISO 2.

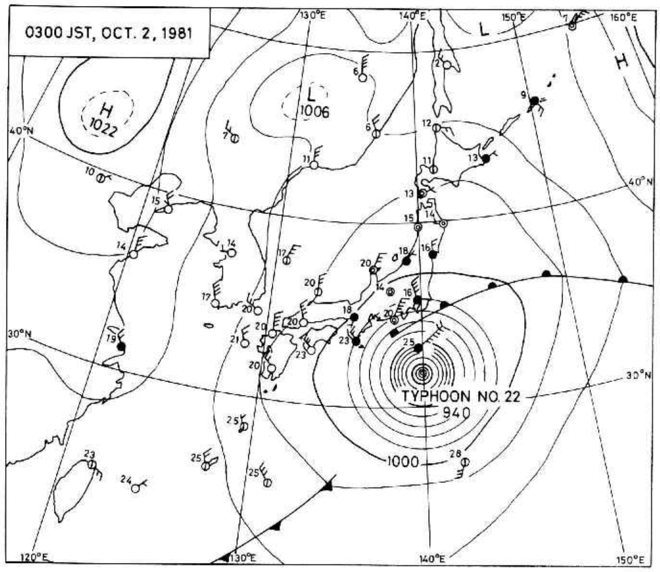



**Fig. 12** Surface weather chart at 0300 JST, October 2, 1981 (○ : clear, ⦶ : fine, ◎ : cloudy, ● : rain, ●⩧ : shower).

Next to CSI analysis, the surface weather data and rawin data were analyzed as follows. Fig. 12 shows the synoptic chart for 0300 JST, October 2. The typhoon's area of influence had extended to the Kanto Plain. Fig. 13 shows the hourly amounts of

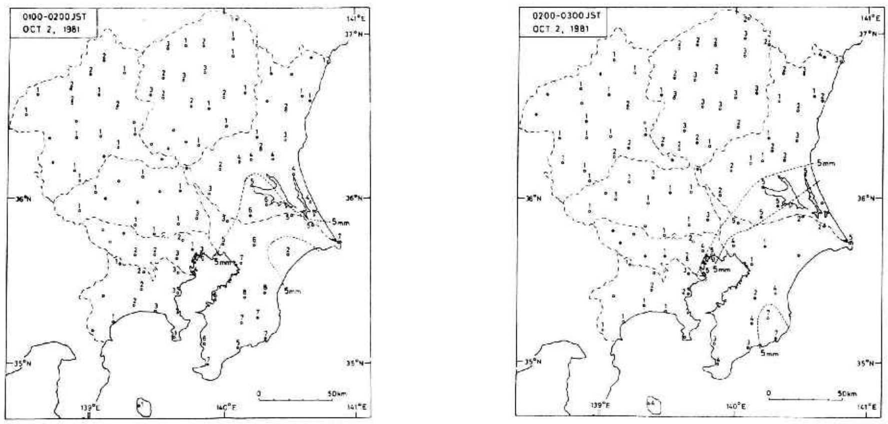



**Fig. 13** Hourly amounts of precipitation at 0200 and 0300 JST, October 2, 1981.

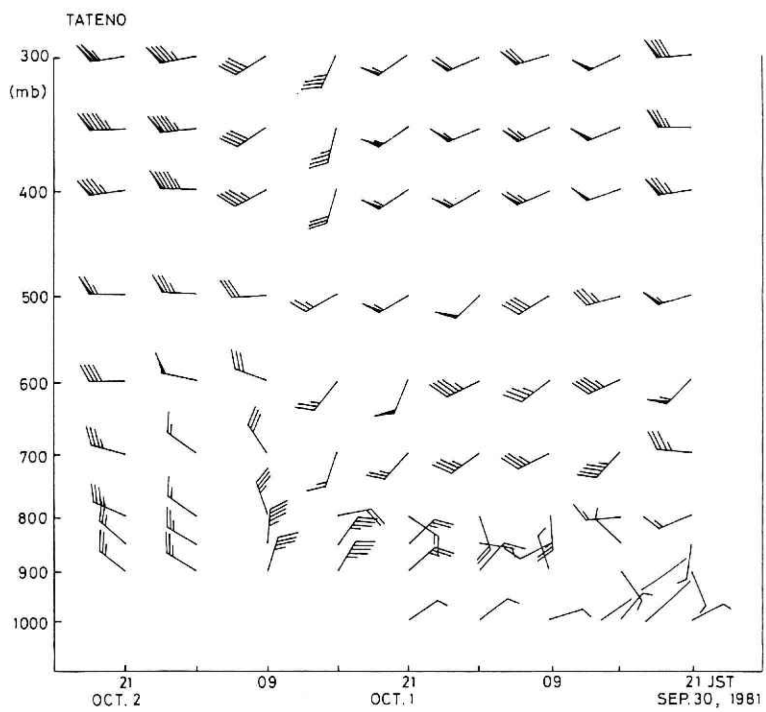
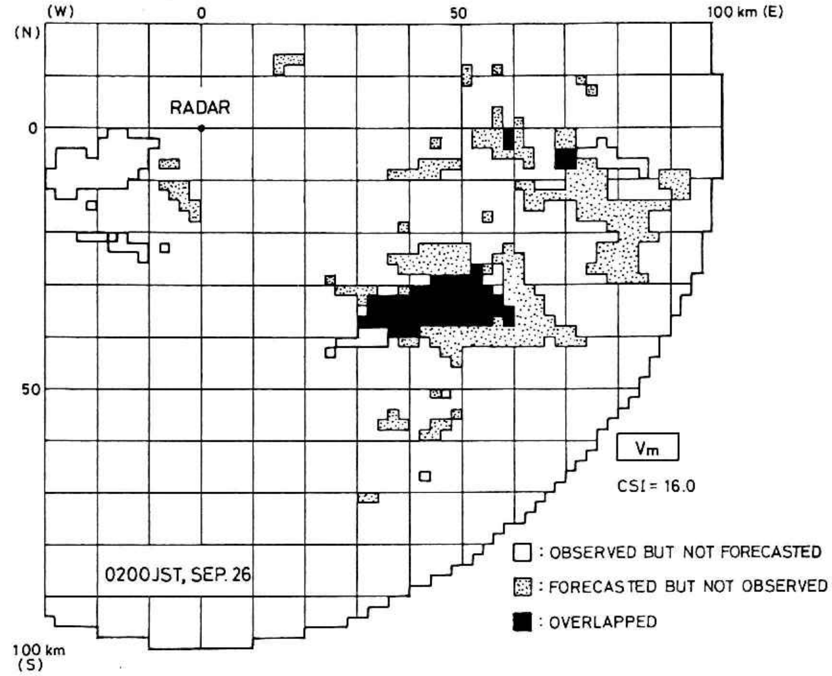



**Fig. 14** Time cross-section of wind at Tateno from 2100 JST, September 30 to 2100 JST, October 2, 1981.

precipitation at 0200 and 0300 JST, October 2. The amount of precipitation was not so great, since the typhoon did not land in the Kanto Plain and left rapidly after a change of course to the northeast. Fig. 14 shows the time cross-section of wind at Tateno from 2100 JST, September 30 to 2100 JST, October 2. The wind direction at low level below 800 mb at 0300 JST, October 2 was NNE, associated with the typhoon.

(a)




(b)

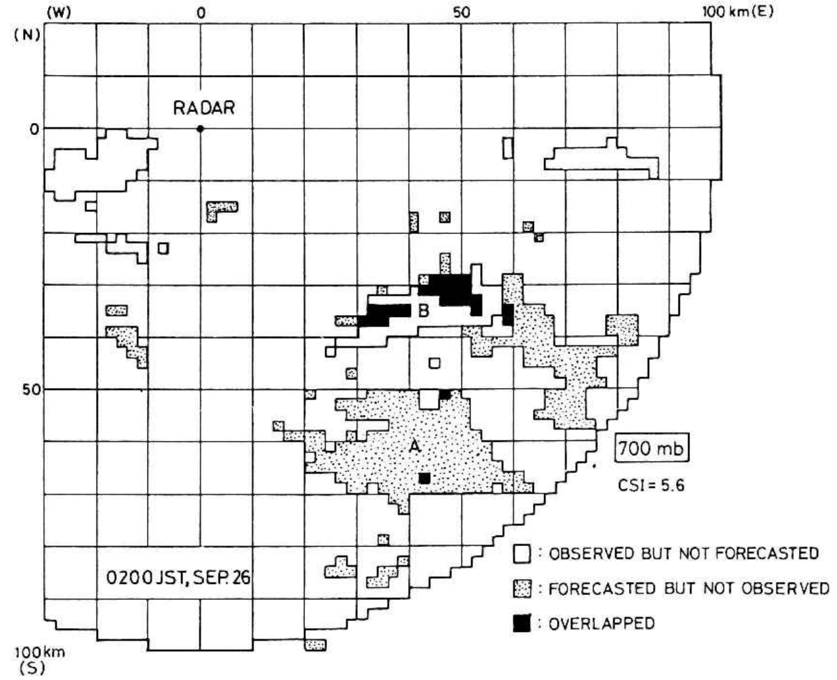



**Fig. 15** Illustration of two examples of the fit between forecast echoes and present echoes. (a) : the echo observed at 0200 JST and the echo translated from the echo observed at 0100 JST for 60 minutes by the mean wind Vm. (b) : the echo observed at 0200 JST and the echo translated from the echo observed at 0100 JST for 60 minutes by the wind of 700 mb. The overlapped parts are blacked, corresponding to X in Fig. 2.

## 4. Discussion

### 4.1 Meaning of CSI score

In order to investigate the proper translation vector for short- term forecasts of precipitation echoes, the meaning of CSI scores in the present analysis must be considered beforehand. Fig. 15 illustrates two examples of how forecast echoes and present echoes fit. The S.E. sector of the radar observation range was chosen for illustration. The overlapped echo areas are blacked, corresponding to area X in Fig. 2. The upper figure (a) shows the fit between the echo observed at 0200 JST and the echo translated from the echo observed at 0100 JST for 60 minutes from mean wind Vm ; the lower figure (b) shows the fit between the echo observed at 0200 JST and the echo translated from the echo observed at 0100 JST for 60 minutes from the wind at 700 mb. The CSI score in the case of translation from Vm is 16.0 and the main part of the echo coincides well, according to analysis by echo tracing. On the other hand, the CSI score

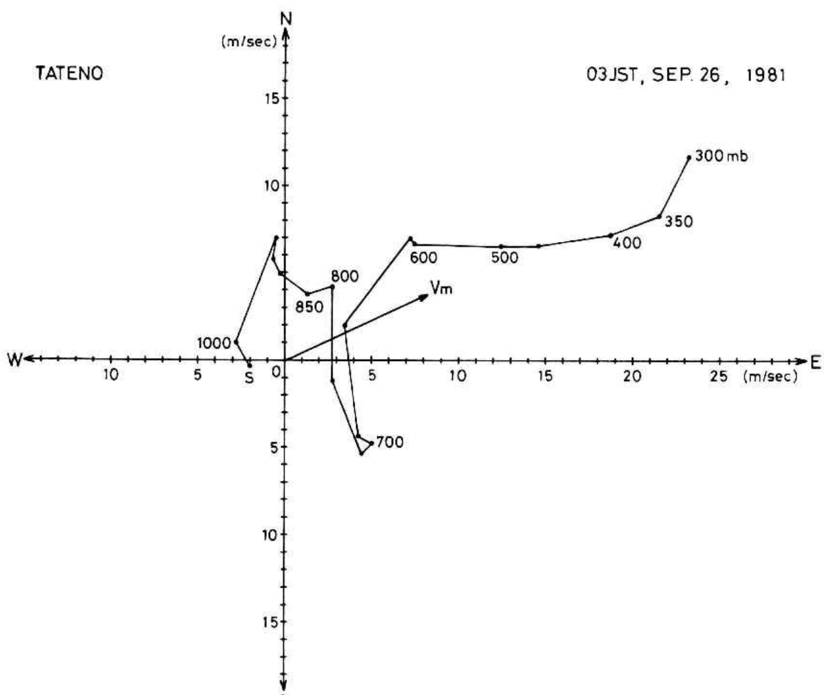



**Fig. 16** Wind hodograph at 0300 JST, September 26, 1981 at Tateno. The mean wind is shown by arrow designated Vm.

in the case of translation from the 700 mb wind is 5.6. The blacked echo area is overlapped by different echoes: echo A of Fig. 15 (a) should overlap to echo B, as was analyzed from the successive tracing of PPI echoes recorded at intervals of ten minutes. Thus, the comparison of CSI scores gives an interpretation of how well translations fit.

In general, a small mesh gives a small CSI score, as suggested by Tatehira *et al.* (1976). The authours adopted a small mesh of 2 km × 2 km for convenience to evaluate upper winds as a proper translation vector. For the puspose of present paper, it is not important whether the absolute value of CSI scores is large or small. The important thing is to compare the relative value of CSI scores for the selection of a proper translation vector. In operational forecasts, several kinds of mesh size are used according to the operational purpose.

### 4.2 Proper wind as translation vector

The translation vectors evaluated in the analysis were the winds at heights of 800, 700, 600, 500 and 400 mb and the mean wind from 850 to 400 mb at Tateno. The selection of these winds was reasonable since most precipitation echoes were vertically distributed from the ground to a height of 400 mb according to REI observation records.

A proper translation vector can be derived from comparison of the averaged CSI scores in Table 4. The wind at 700 mb was the best as a translation vector among the upper winds, which has already been well discussed (e.g. Tatehira *et al.* (1976)). However, the CSI score for translation from the mean wind was larger than from the wind at 700 mb as a whole. Hence, it can be said as the result of the present analysis that the mean wind is of practical use as the translation vector on average for short-term forecasts of precipitation echoes. In particular, the mean wind gives a better CSI score when a wind at specific height is greatly different from the winds at other heights, as briefly discussed below.

In Case 2, the CSI score for translation from the wind at 700 mb was unexpectedly smaller than from other upper winds. The reason for this dissimilarity can be explained as follows. Fig. 16 shows the wind hodogragh at 0300 JST, September 26 at Tateno. The mean wind is shown by the arrow designated Vm in the figure. The wind direction at 700 mb is NW, being remarkably different from the other upper winds and the mean wind Vm. This noticeable aspect is also seen in the time cross-section of winds (Fig. 7). The deviation in the wind direction at 700 mb from the direction of the mean wind would produce the small CSI score.

The above discussion indicates that a translation vector for the short-term forecast should be chosen carefully since a wind at a certain height does not necessarily represent the driving force of echo movements.

### 4.3 Usage of Doppler radar for short-term forecasts

In the present paper, the wind information from rawin data at limited times was made use of for *ex post facto* analysis, but for operational short-term forecasts, real-time wind information is necessary for translating echoes. Doppler radar is considered to be useful and profitable for measuring the upper winds on a real-time basis.

Techniques of measuring wind by a single Doppler radar have been reported by Lhermitte and Atlas (1961), Browing and Wexler (1968) and others. The present authors tried the real-time measurement of horizontal winds using fan-beam Doppler radar (Uyeda and Yagi, 1980a, 1980b). The technique required in the present translation method is the so-called Velocity-Azimuth Display (VAD). The VAD technique employs an azimuthally scanning beam at an intermediate elevation angle, providing a profile of horizontal winds above a Doppler radar set when the radar is surrounded by scatterers with uniform motion (Battan, 1973).

An operational experiment with short-term forecasts using Doppler radar should be undertaken.

## 5. Conclusion

Observation of precipitation echo mevemonts was planned for the evaluation of upper winds as a translation vector, which is necessary for short-term forecasts. The observation in 1981 was carried out with conventional radar from September 7 to October 6, in the Kanto Plain. Digital echo patterns were simply translated by computer using the upper wind data provided by the Aerological Observatory at Tateno. The rawin winds were regarded as upper winds measured by a single Doppler radar.

The results of translation were evaluated by Critical Success Index (CSI). The CSI score for translation from the mean wind was the largest in the present data. Next to this, the wind at 700 mb gave better CSI scores for translation than the other upper winds. However, the CSI score for translation from the wind at 700 mb was unexpectedly small in a certain example. The reason for this was that the wind at 700 mb was noticeably different from other upper winds : this wind was not likely to represent the driving force of echo movements. Therefore, the upper wind as a translation vector for short-term forecasts should be chosen carefully. The general conclusion of the present analysis is that the mean wind is of practical use as the the translation vector.

The application of Doppler radar to the real-time measurement of the upper wind was discussed for possible operational short-term forecasts.

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## 降水エコーの短時間予測のための上層風の補外ベクトルとしての評価研究

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降水エコーの短時間予測の研究の一環として，降水エコーの観測を，波長 3.2 cm の通常気象レーダーを用いて，関東平野の中心部で 1981 年 9 月 7 日から 10 月 6 日まで行った．降水エコーの短時間予測の補外ベクトルとしての上層風の評価を行うために，レーダーエコーの記録を 1，2 時間先まで単純補外した。補外に用いた上層風は，館野に位置する高層気象台で観測されているレーウィンのデータによる 800, 700, 600, 500 及び 400 mb の風と 850 mb から 400 mb までの平均風である．

予測結果は CSI の値によって評価した．全体として，平均風による補外が CSI の最大値を示した．これに次いで，700 mb の風による補外が他の高度の風による補外よりも大きな CSI の値を示した．この解析から，全体的には，平均風を降水エコーの短時間予測のための補外ベクトルとして用いるのが実用的であると結論された．

CSI の解析に加え，二つの例について気象解析を行なった．また，降水エコーの短時間予測にドップラーレーダーを適用する可能性な手法について討論した．