JMA's Five-day Tropical Cyclone Track Forecast

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Abstract

Since 22 April 2009, the Japan Meteorological Agency (JMA) has issued five-day tropical cyclone (TC) track forecasts. This paper introduces these forecasts, including the method used, interpretation of the results obtained, forecast cases and future challenges. One of the forecast's unique aspects is its determination of the radius of a 70% probability circle (PC) using the level of forecast uncertainty based on the ensemble spread of JMA's Typhoon Ensemble Prediction System (TEPS).

1. Introduction

Since 22 April 2009, the Japan Meteorological Agency (JMA) has issued five-day tropical cyclone (TC) track forecasts to encourage early public attention to and preparation for TCs. The purpose of this paper is to introduce these forecasts. First, an overview is given in Section 2, and then the forecast method, interpretation of the results obtained and some sample forecast cases are described in Sections 3, 4 and 5, respectively. s To conclude, future challenges are outlined in Section 6.

2. Overview of five-day TC track forecasts

Figure 1 shows a schematic representation of JMA's TC forecast issuance. First, the Agency issues three-day TC track and intensity forecasts about 50 minutes after the usual observation times (0050, 0650, 1250 and 1850 UTC). A five-day TC track forecast is then made for any TCs expected to maintain tropical storm (TS) intensity or higher over the next three days. This is issued about 40 minutes after the three-day forecast (0130, 0730, 1330 and 1930 UTC). If two or more named TCs exist at the same time, three-day and five-day forecasts for the second and subsequent TCs are issued about 70 minutes after the observation time (0110, 0710, 1310 and 1910 UTC) and about 40 minutes after the issuance of three-day forecasts (0150, 0750, 1350 and 1950 UTC), respectively. The five-day track forecast includes the center positions and radii of 70% probability circles (PCs) for the fourth and fifth days. The PC is a circular range into which a TC is expected to move with a probability of 70% at each valid time. TC intensity (central pressure, maximum sustained wind, peak gusts and storm warning area) is not predicted in five-day forecasts.

3. Method for five-day TC track forecasts

JMA makes five-day TC track forecasts mainly using outputs from the JMA typhoon ensemble prediction system (TEPS), which is run four times a day when there is a TC with TS intensity or higher (or one expected to reach such a level in the next 24 hours) in the area. The main specifications of TEPS are shown in Table 1. The system is explained in further detail by Yamaguchi and Komori (2009).

Figure 2 (a) shows a schematic representation of the forecast method. PCs for the fourth and fifth days are determined based on the distribution of TEPS ensemble members. The center of a PC is determined mainly using the mean position of these members. If they are divided clearly into two courses, the center does not represent the highest likelihood of the TC's position (see Figure 2 (b)). The size of a PC is determined mainly using the spread of TEPS ensemble members. Forecasters use products from TEPS as shown in Figure 3 as a measure of forecast uncertainty in order to determine the radius of a PC. Such circles show the latest status of forecast uncertainty, and are categorized into one of three groups (A, B and C) known as confidence levels. Once a forecaster determines the level of a forecast, the radius is automatically fixed through the conversion table from the confidence level to a PC radius prepared based on verification results from recent years (see Figure 4). Details of the categorization are given by Yamaguchi and Komori (2009).

4. Interpretation of five-day TC track forecasts

In five-day TC track forecasts, possible tracks are indicated using a distribution of PCs. Figure 5 illustrates some examples of possible tracks shown by such circles. Figure 5 (a) shows that a TC has a high chance of approaching the northern or eastern part of Japan within the next five days, while Figure 5 (b) indicates various possibilities, including a westward track to the Okinawa region and a northward track to mainland Japan.

5. Forecast cases

JMA conducted experimental operation of five-day TC track forecasts in autumn 2008. This section outlines the forecast results for two typhoons – Sinlaku (0813) and Jangmi (0815) – that formed in September and took similar courses. Section 5.1 explains their tracks, and Section 5.2 presents the forecast results.

5.1 Tracks of Sinlaku (0813) and Jangmi (0815)

The best tracks of Sinlaku and Jangmi are shown in Figure 6. Sinlaku formed east of the Philippines at 18 UTC on 8 September. Moving northwestward, it approached the Okinawa Islands then Taiwan Island. After recurving north of Taiwan Island on 15 September, it moved east-northeastward over the East China Sea and transformed into an extratropical cyclone east of Japan. Jangmi formed east of the Philippines at 12 UTC on 24 September. Moving northwestward, it hit Taiwan Island. After recurving north of Taiwan Island on 29 September, it transformed into an extratropical cyclone south of Kyushu at 00 UTC on 1 October.

5.2 Forecast results

Figure 7 (a) shows three forecasts made for Sinlaku in one day from 18 UTC on 11 September. In the first forecast (the upper figure), the PC for the fifth day (the five-day PC) indicated that Sinlaku had a high chance of moving westward through Taiwan before hitting China. In the last one (the lower figure), the five-day PC generally covered the East China Sea, suggesting that it had a high chance of moving northeastward over the sea after recurving north of Taiwan. In this series of forecasts, the forecast tracks shown by the PC centers changed from northwestward to northeastward, while the sizes of the PCs themselves remained the same.

Figure 7 (b) shows forecasts made for Jangmi in one day from 06 UTC on 26 September. In the forecast track view showing only PC centers, the second forecast (the middle figure) seems quite different from the last one (the lower figure). On the other hand, the size of the five-day PC exhibited a large change. The one in the second forecast (the middle figure) was very large, indicating significant forecast uncertainty including the possibility of a northwestward track to China and an eastward track to Japan. In the final one (the lower figure), it shrunk to cover only the sea south of Japan, indicating a much higher chance of moving eastward to Japan and a lower likelihood of moving northwestward to China.

As shown in Jangmi's case, PC sizes for subsequent fourth and fifth days change depending on forecast uncertainty. It should be noted that possible TC tracks must be viewed not only in terms of PC centers but also in consideration of PC sizes.

6. Future challenges

With the extension of the forecast term from three to five days, one particular challenge needs to be addressed in the display of track forecasts. Figure 8 (a) shows the forecast for Nepartak (0919) at 06 UTC on 10 October 2009; the very large five-day PC indicated the possibility of its approaching mainland Japan. Figure 8 (b) shows the TEPS result used for this forecast; it indicates a very large spread from the northeastward and southwestward tracks and no chance of movement northwestward to the Japanese mainland – a scenario that could not be expressed using PCs. JMA will consider alternative methods such as an elliptical form instead of a circular form based on verification results over the next few years.

References

Yamaguchi and Komori (2009): Outline of the Typhoon Ensemble Prediction System at the Japan Meteorological Agency, RSMC Tokyo - Typhoon Center Technical Review No. 11, 14-24.

http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/techrev/text11-2.pdf

Table 1　Specifications of JMA's Typhoon Ensemble Prediction System (TEPS)

Horizontal resolution	0.5625 deg. (60 km)
Vertical resolution	60 unevenly spaced hybrid levels from the surface to 0.1 hPa
Forecast range	132 hours
Initial time	00, 06, 12, 18 UTC
Ensemble size	11 members (10 perturbed forecasts and 1 control forecast)
Perturbation generator	Singular Vector (SV) method

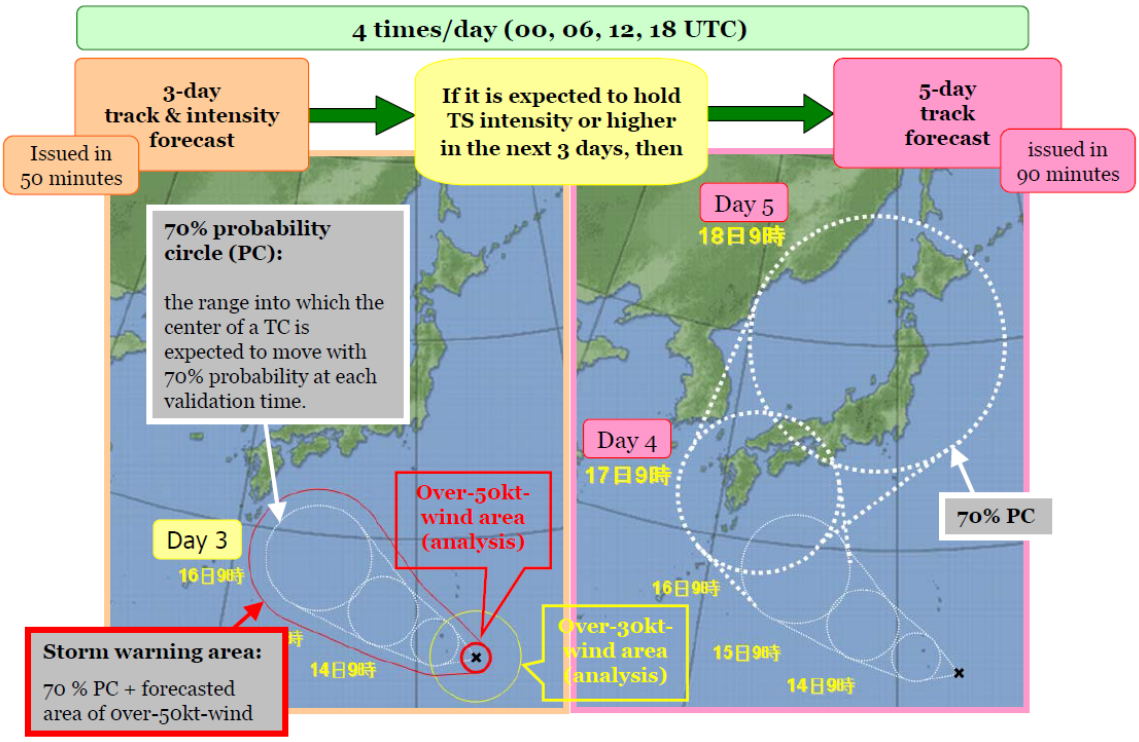


Figure 1　Issuance of JMA's TC forecast

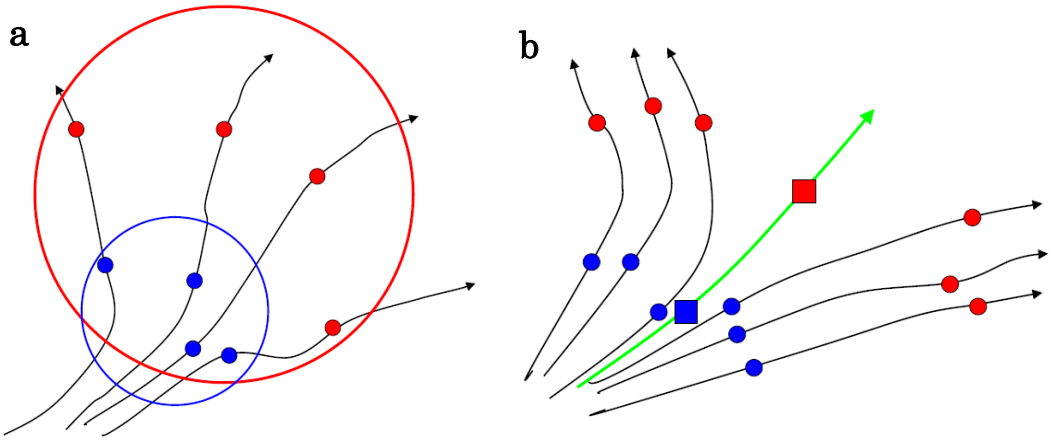


Figure 2　Five-day TC track forecast method.　The circles show the 70% probability area, while the arrowed lines with circles and squares indicate member tracks and the ensemble mean track of TEPS, respectively.

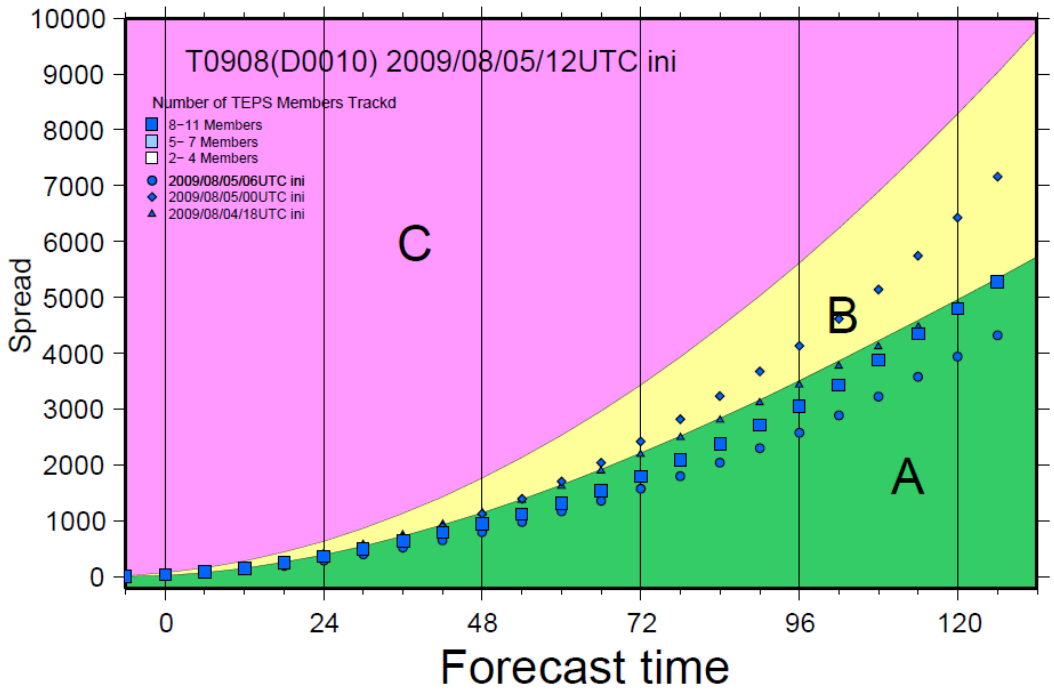
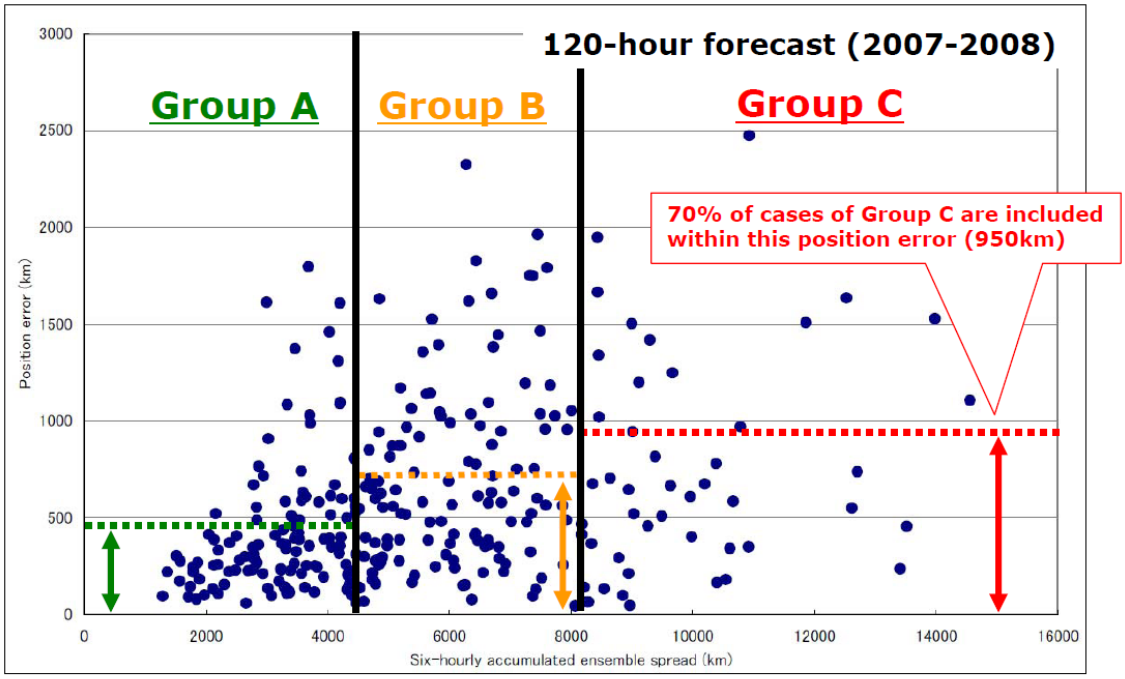


Figure 3　TEPS product on forecast uncertainty.　The horizontal and vertical axes show the forecast time and the six-hourly accumulated TEPS ensemble spread, respectively.



A	B	C
480km	700km	950km

Figure 4　Verification results for each group (confidence level) from 2007 to 2008 (upper figure) and the conversion table from confidence level to PC radius as of 2009 (lower figure)

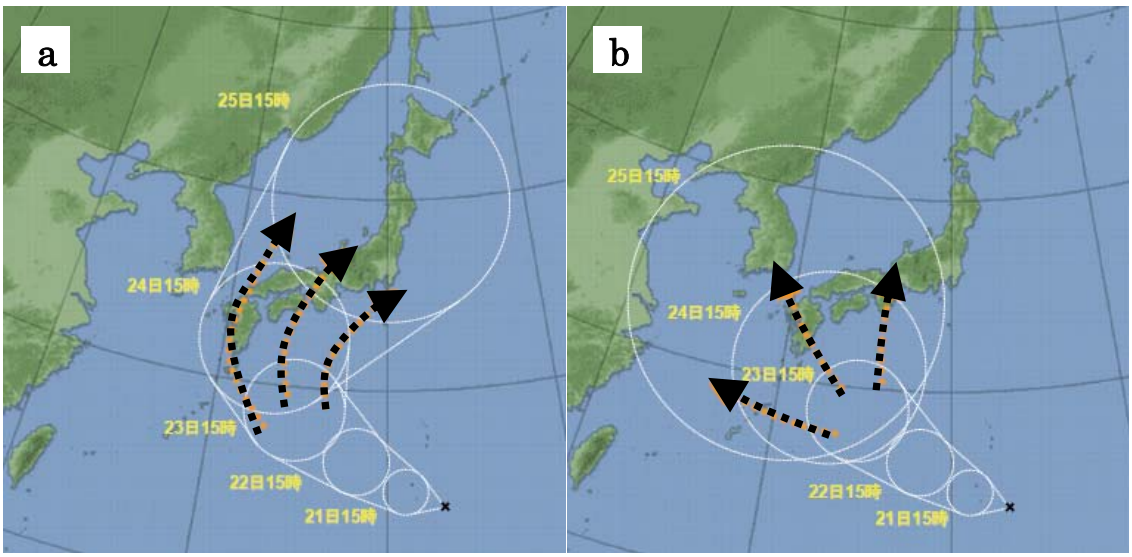


Figure 5　Examples of five-day track forecasts
The dotted arrow lines indicate possible TC tracks.

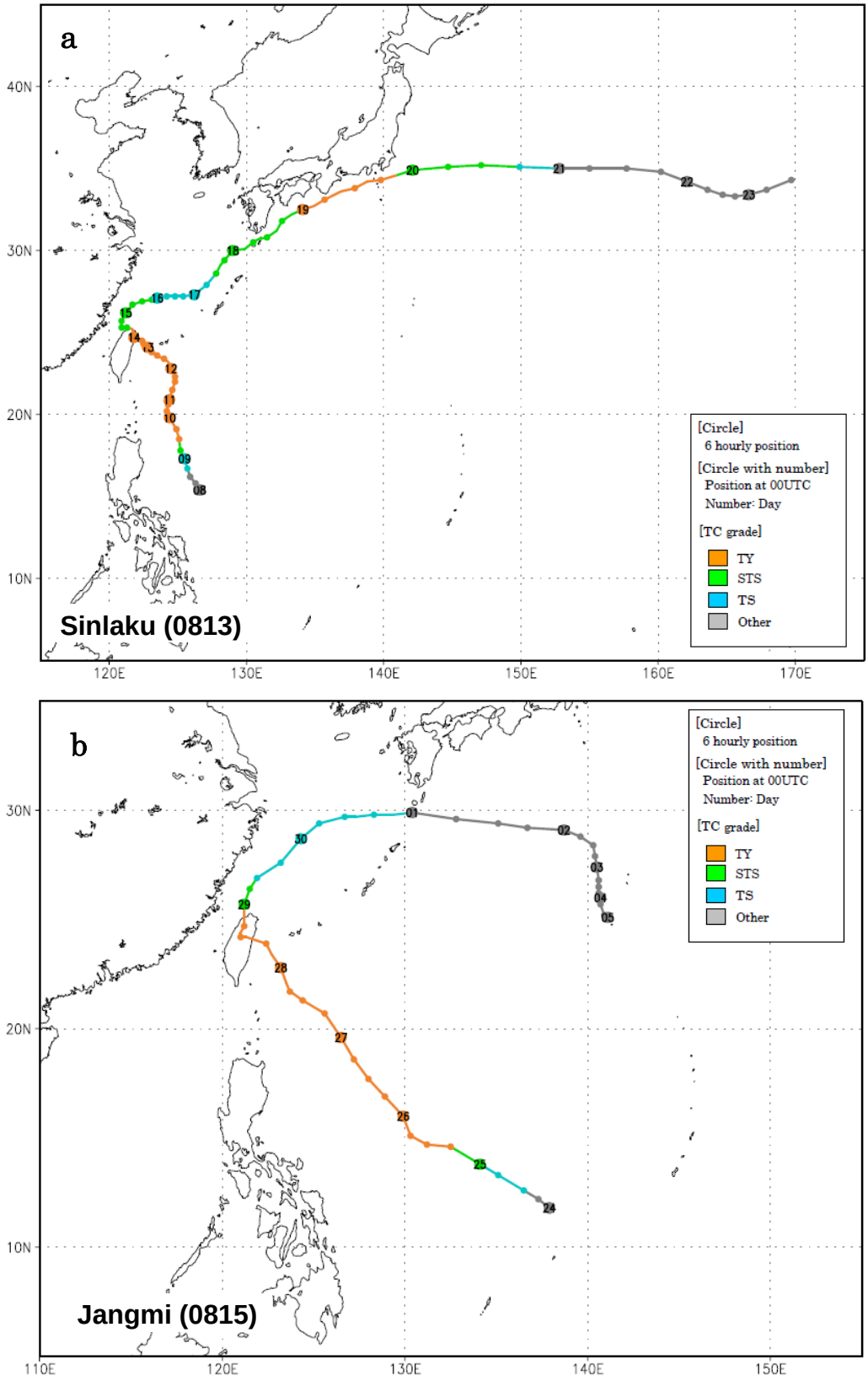


Figure 6　Tracks of a) Sinlaku (0813) and b) Jangmi (0815)

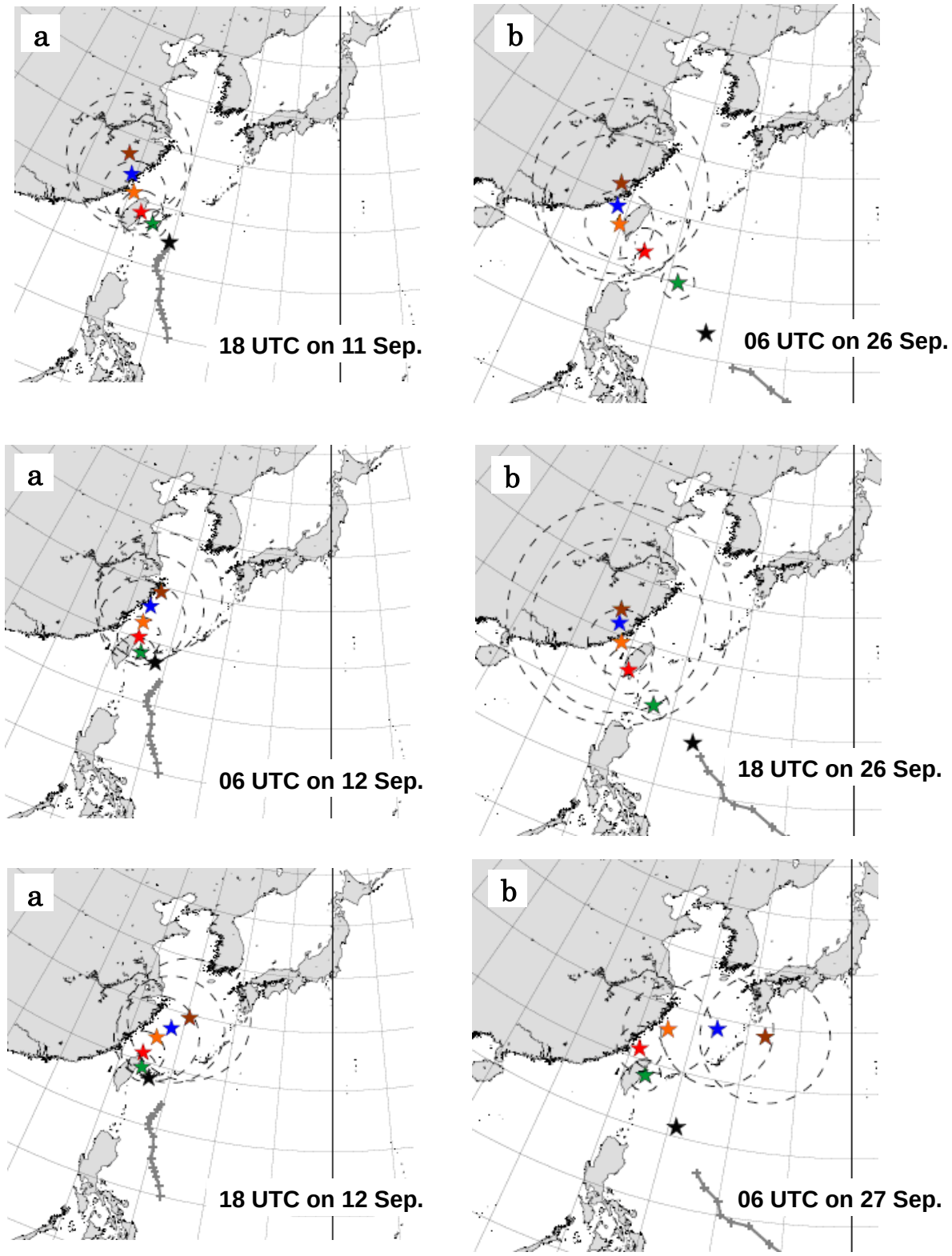


Figure 7　Forecast results for a) Sinlaku (0813) and b) Jangmi (0815)
The stars show PC centers for the next one-to-five days.

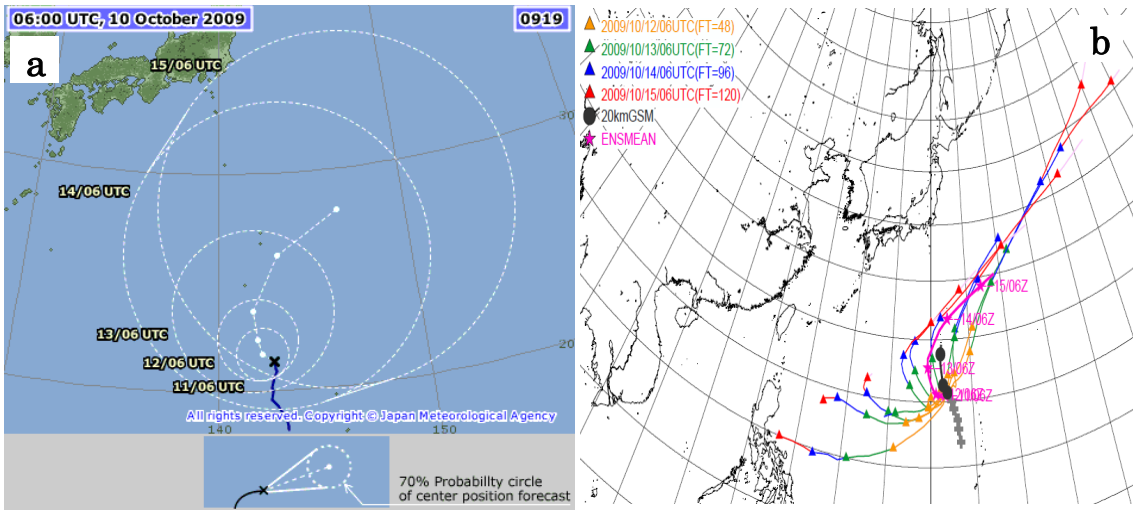


Figure 8　Five-day track forecast for Nepartak (0919)

Results of a) operational forecast at 06 UTC on 10 October 2009,

and b) TEPS at the initial time of 00 UTC on 10 October 2009