The precipitation characteristics of Typhoon Nari(2001)

Tai-Chi Chen Wang, Wei-Yu Chang, Kao-Shen Chung

National Central University

Jen-Hsin Teng

Central Weather Bureau

Abstract

On 16 Sep. 2001, Typhoon Nari (2001) landed on Taiwan. The warmer ocean temperature and unique track sustained the convection and circulation of this typhoon. The slow motion of Nari and the orographic effects brought record-breaking rainfall and caused flood in Taipei basin, taking 92 lives. The disdrometer, rain gauge network and dual-Doppler radar data were collected during Nari's landfall. The drop size distributions collected by the disdrometer reveal the unique microphysical structures of different stages of Nari. The terrain following dual Doppler synthesis wind field showed the structure change of circulation and topographic influence. It explained the location and duration of the heavy rain.

1. Introduction

The radar data sets collected from WSR88D at Wufensan and CAA at CKS airport were edited and synthesized through the RASTA, a terrain following Doppler wind synthesis program. The three dimensional wind fields of different stages of Nari's landfall were retrieved. Used the reflectivity field and wind field the structure changes of Nari were studied.

Based on the Drop size distribution, the relations of Z-R are derived through the Gamma distribution fit of DSD. The radar reflectivity field was compared to the reflectivity calculated from the observed DSD. Then the radar rainfall estimate was evaluated through the DSD derived Z-R relations. The area rainfall from rain gauge network was used as verification of radar estimate.

2. Wind Characteristics

The dual Doppler synthesis wind fields at three time periods, 1600,1630 UTC at Sep 16 and 1000 UTC at Sep 17 were derived. The vortex center of Nari still could be clearly identified two hours after landfall. We found the wind was still quite circular, however the 20m/sec isotach banded along the terrain, indicating the blocking of terrain forced the strong wind blew around the terrain and converged with the weaker wind at outer skirt at lower level and formed a rainband. This rainband moved slowly toward northwest and brought heavy rain to Taipei. Although the maximum wind radius expanded to 40km in the NW-SE direction, and 20 km in the NE-SW direction, the relative pressure deficit still could be maintained. Fig. 1 showed the wind field at 1600 UTC.

18 hours latter, at 1000 UTC Sep 17 the circular motion of Nari was no longer obvious, at 4.5 km height, we still can observed the southwest wind got around the terrain and cyclonically turned toward west. A rainband across Taipei again associated with the stronger wind. The unique track and structure change of Nari together with the terrain blocking may explain where the rainband was going to form.

3. The Drop Size Distribution and rainfall estimate

A quality control sequence was applied to the raw disdrometer data; the vertical velocity of the drops with unreasonable fall velocity and oblateness was changed to the empirical fall speed formula. Through these steps, the peculiar spike in the DSD was diminished. The accumulated rainfall was also agreed with the tipping bucket rain gauge at the same location after the vertical velocity correction. Through the calculation of different moments of DSD, the **No**, **m**, **Λ** of Gamma distribution $N(D)=N_0D^m\exp(-\Lambda D)$ were calculated. The total drops number **Nt** and median volume diameter **D0** were also calculated in every six-minute intervals of 12 hours analysis time period. The relations between rainfall rate and these parameters were studied.

In Nari case we have analyzed 12hrs data of disdrometer, the detail of the results of the heaviest rain period were shown. Between 0200-0300 Sep. 17th, the rainfall accumulation was 44mm; the largest rainfall rate for every six minutes interval was 96mm/hr. The smaller **A** in $Z=AR^b$ was associated with the heavier rainfall rate. In the statistics of these parameters in 12 hours, the coefficient **m** and **A** have the same tendency. The **Nt** had very good correlation with the rainfall rate. The major reason for this result is in the typhoon Nari situation the large increase of the total drops number was responsible for the decrease of **A** and greater rainfall rate.

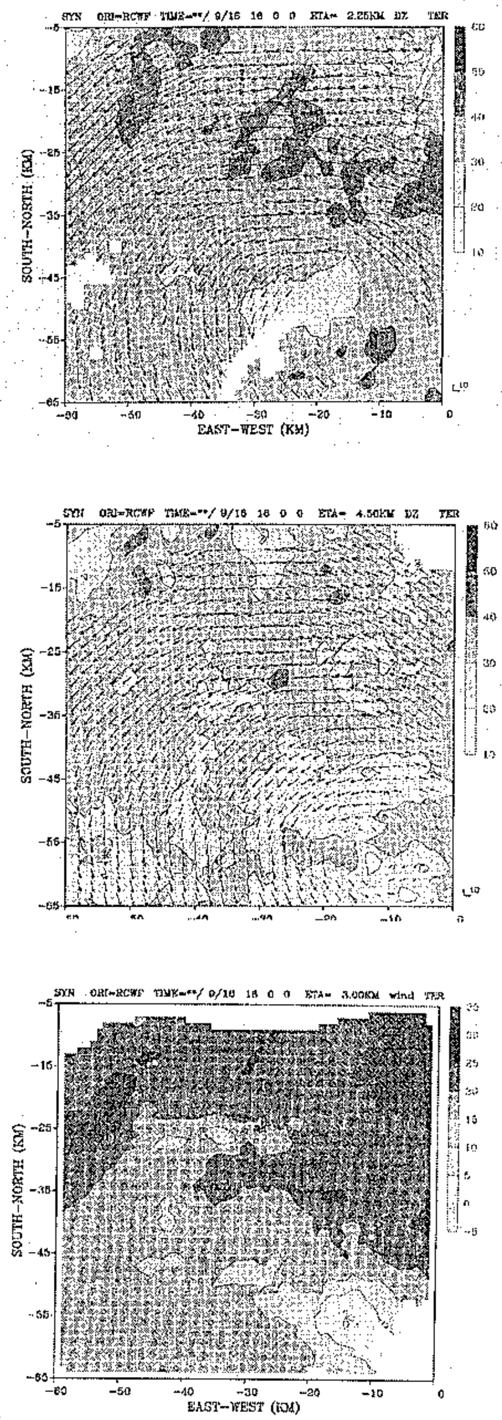
We also apply the disdrometer derived **Z-R** relations to the radar reflectivity. Before this calculation, the correlation between the disdrometer derived reflectivity and the radar observed reflectivity is checked. During the heavy rain period, radar reflectivity is about three dBZ less than the disdrometer. The smoothing in horizontal area and the difference of reflectivity between 1.75km and surface may both cause the underestimate. During the weak rainfall period there are very small difference between disdrometer and radar. The area rainfall accumulation was quite satisfactory by using the disdrometer derived **Z-R** relation and corrected radar reflectivity.

4. Conclusions

The weaken but persistent circulation of Nari maintained the low after landfall , the terrain blocking influenced the location of rainband, which was responsible for the heavy rain in the basin area. Further study of retrieved thermodynamic field will help to understand the mechanism of the long living convection. The disdrometer derived DSD indicated the upper limit of the drop size was about 5mm, the number of drops increased very fast and dumped heavy rainfall in very short time. The DSD Gamma distribution provided more realistic Z-R relation and more correct rainfall.

5. Acknowledgement

Thank Central Weather Bureau for providing radar data. and National Science Council for the funding.



(a) Fig 1m height above terrain,, reflectivity at 10 dBZ interval.

(b) Same as (a) except at 4.50 km height

(c) The isotach at 3.0km height above terrain.

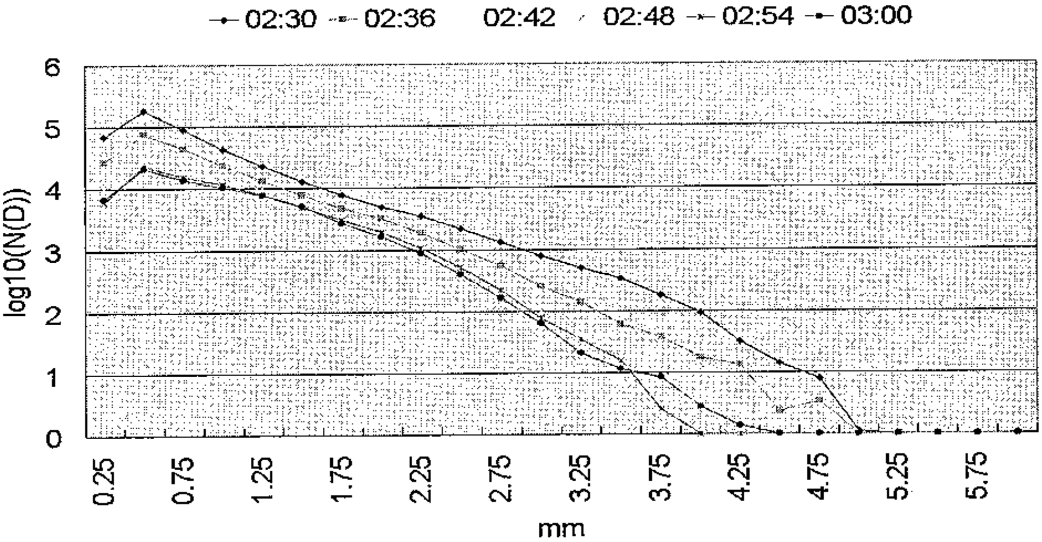


Fig.2 The drop size distributions at 0230,0236,0242,0248,0254 and 0300

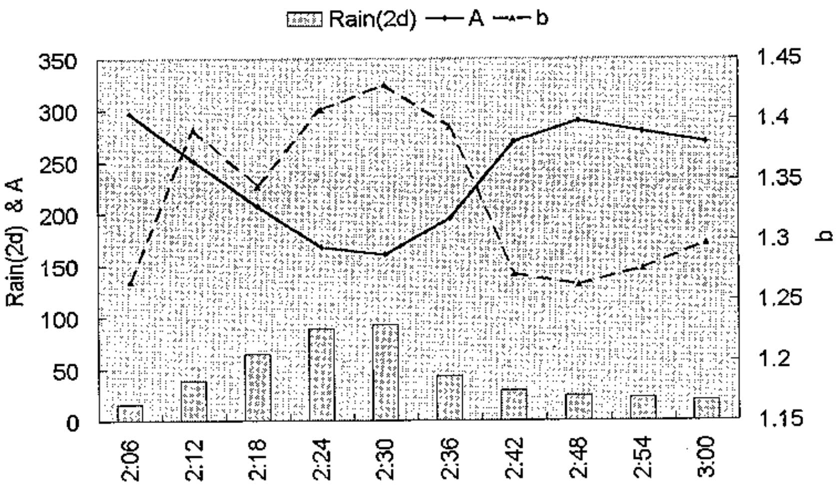


Fig3 The A and b values of Z-R relation at six different times

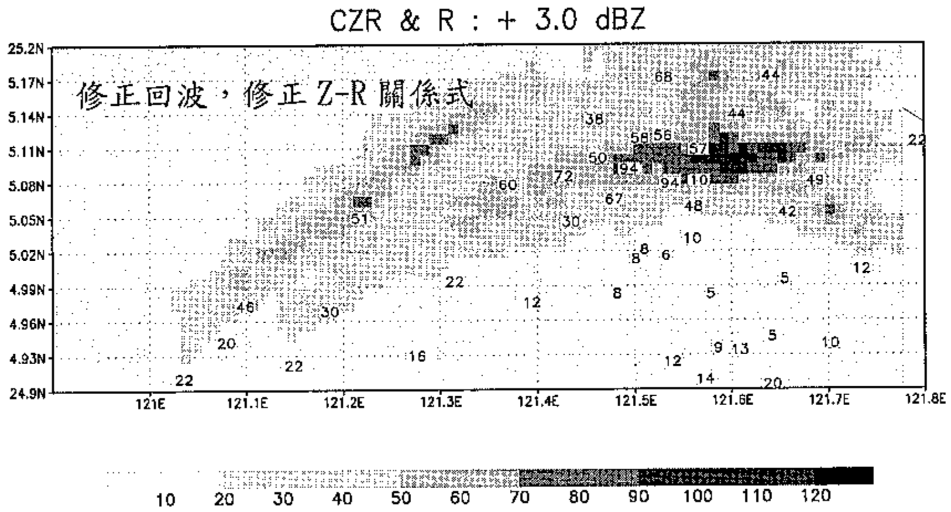


Fig.4 The rainfall estimate using the disdrometer DSD derived Z-R relation.