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THE DIAGNOSTIC ANALYSIS OF THE TRACK AND PRECIPITATION OF TYPHOON "RANANIM" AFTER LANDFALL

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1 INTRODUCTION

Over the past few years, landfall and track, intensity, sustaining mechanisms of tropical cyclones (hereafter TCs) and associated weather changes have become heated topics of research. From the viewpoints of energy transformation, moisture transfer, mid-latitude baroclinic frontal zones and ambient wind fields, Chen et al.[1] Le et al.[2] and Zeng et al.[3] studied the sustaining mechanism of TCs that have made landfall. Li et al.[4] also pointed out that the intensification of TCs during transition was associated with the disturbance and downward transportation of high-level potential vortexes, low-level frontal zones and low-pressure circulation around TCs, after explaining the difference in TCs transition following the theory of wet potential vortexes. With large-scale diagnostic study of two types of TCs that unexpectedly weaken or enhance just before landfall in southern China, Hu et al.[5] noted that enhancing TCs were usually to the southwest or south of the subtropical high with low levels featured by well-defined southwesterly inflow inside TCs and sufficient supply of water vapor. Liang et al.[6] not only analyzed the changes in convective cloud bands, precipitation, track and temperature and humidity structure in the course of TC Vongfang landfall, but the effect of cold air and Southwest Monsoon on its intensity in particular. As also shown in numerical experiments conducted both at home and abroad and relevant studies[1, 7], saturated humidity and large-sized bodies of water are favorable for the maintenance and enhancement of landfall TCs circulation. All of the above research achievements not only help broaden the understanding of the patterns by which TCs behave but are positive in improving the forecast of the track, winds and rains after landfall. It is, however, not much addressed in the field of evolution of landfall TCs when they are with special underlying surface and circulation background. TC Rananim (0414) was the most serious typhoon that ever affected Zhejiang province after landfall in the 48 years from 1956 to 2004, which was also the storm that caused heavy rains in the most widespread area in Jiangxi province in the past 20 years. There are two points about Rananim that stand out from the other storms. The first was the sudden westward turning of its track and the second the significant enhancement of precipitation after moving above the Boyang Lake. What kind of mechanism caused such remarkable change in the storm? With 6-hourly 1°×1° NECP global reanalysis data, real-time upper-level observations and TCs location reports by the Central Observatory, the above two points and possible causes are studied in terms large-scale circulation background, underlying surface, cold air and diagnosis of physical quantity fields. New understanding has been made about the behavioral pattern of landfall TCs and related results will offer effective help in operational forecast.

2 TRACK AND PRECIPITATION OF RANANIM AFTER LANDFALL

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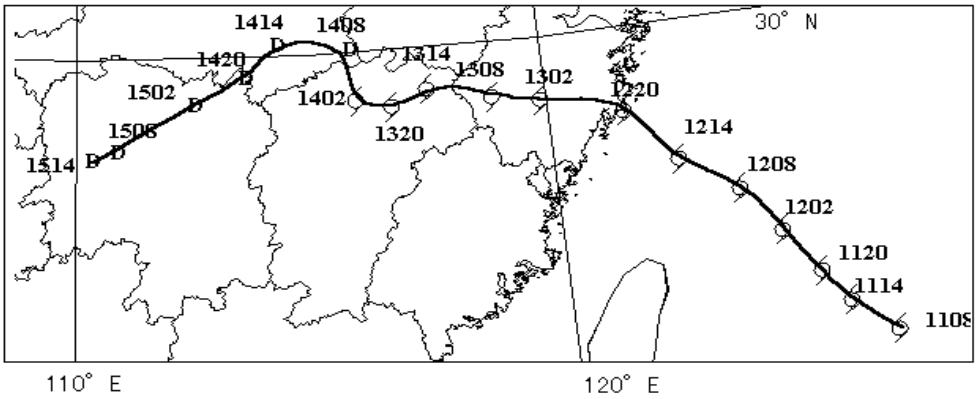

Fig.1 The track of Rananim from 08:00 Aug.11 to 14:00 Aug.15.

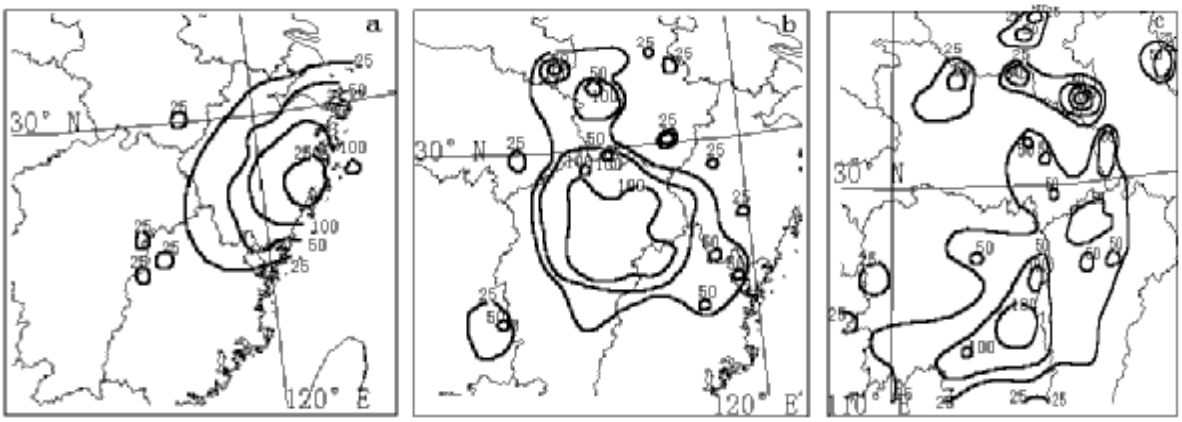

Fig.2 Distribution of daily rainfall above 25 mm from 08:00 Aug.12 to 08:00 Aug.15. Unit: mm. (a) 08:00 Aug.12 – 08:00 Aug.13; (b) 08:00 Aug.13 – 08:00 Aug.14; (c) 08:00 Aug.14 – 08:00 Aug.15.

At 20:00 (L.T.) Aug. 12, 2004, Rananim made landfall on Shitang, Wenling, Zhejiang with the central pressure at 950 hPa and maximum wind speed at 45 m/s near the eye. After landfall, the storm moved towards the west and went through central Zhejiang. It weakened to a tropical storm at 08:00 Aug. 13 and moved to southeast of Hubei after 08:00 Aug.14 before turning to northeast of Hunan and disappeared in the central part of the province at 14:00 Aug.15 (Fig.1). Rananim maintained for as long as 66 h from its landfall to the disappearance of low-pressure circulation.

Although Ranannim showed a generally decreasing rain rate after landfall, precipitation intensified greatly after it moved into the Boyang Lake. For daily precipitation from 08:00 Aug. 12 to 08:00 Aug.15, see Fig.2a – Fig.2c.

3 ANALYSIS

It's been very difficult to forecast the track of TCs after landfall. Deflection or zigzagging of its track affects the distribution of winds and rains associated with their landfall. As shown above, after landfall, Rananim turned westward, followed by north-south swings afterwards. Let's first look at the allocation and dynamic variation of the subtropical high and westerly troughs and ridges at 500 hPa. It is known from Fig.3a that the axis of the high for the contour of 588 dgpm at 20:00 Aug.12 became nearly east-west oriented with the width decreasing towards the west. It is seen from the 500-hPa mean field for 08:00 Aug.13 – 08:00 Aug.15 (Fig.3b), there was little change in the outer form of the strip-shaped of the subtropical high, only a mildly weakened western part. The easterly south of the subtropical high steered Rananim to go westward after landfall. Within 300 – 500 km north and south of the eye 12 h before the landfall, the easterly increased and the difference between the absolute values of the maximum easterly component north of the storm and maximum westerly component south of it increased sharply. It is known from Fig.4 that they are well

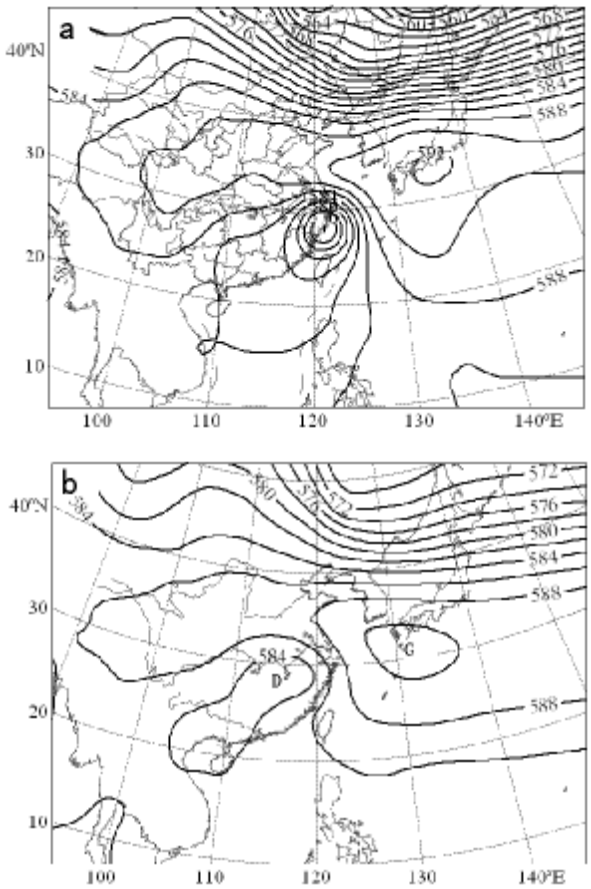

Fig.3 The 500-hPa geopotential height field for 20:00 Aug.12 (a) and that averaged for the time from 08:00 Aug.13 to 08:00 Aug.15 (b).

associated with TC acceleration and westward turning. For analyses of other aspects, refer to the Chinese edition of the journal.

4 CONCLUSIONS

It is known from the above analyses that the variation of track and precipitation after the landfall of Rananim was subject to factors like the subtropical high, underlying surface and cold air.

(1) Before the landfall of Rananim, continental and west Pacific subtropical highs merged and extend westward. Affected by the eastward movement of the westerly trough, the ridge of the subtropical high moved southward and became strip-shaped, reflecting a much inland large-scale background of the circulation. A main cause for the storm to turn westward is that the easterly increased at 500 hPa and the difference between the absolute values of the maximum easterly component north of the storm and maximum westerly component south of it increased sharply 12 h before landfall.

(2) After the landfall, the cold air was mainly responsible for the southwest turn of the track over land, which was displayed by increased northerly west of the storm at 850 hPa and a change from positive to negative in the difference of absolute value between the maximum southerly component to the east and the maximum northerly to the west. Its impact on precipitation varied with the stage of the TC low system. In the early stage, the invading cold air in the west of the storm provided the low with baroclinic energy that favored the maintenance of the low and heavy rain; in the late stage, however, the invading cold air had spread across the low, which was rapidly filled to weaken the rain significantly.

(3) When the storm was over the Boyang Lake, the slowdown of moving speed and intensified precipitation were caused by the blockage of mountain ranges on its path ahead and the exchange of sensible and latent heat and water vapor over the surface of the lake. It is shown in diagnostic study that physical quantities of ascending motion, low-level convergence and divergence of moisture fluxes tend to weaken after landfall but show signs that enhanced rainfall when Rananim moved to the lake. It is suggested that the variation of Rananim track and precipitation be closely

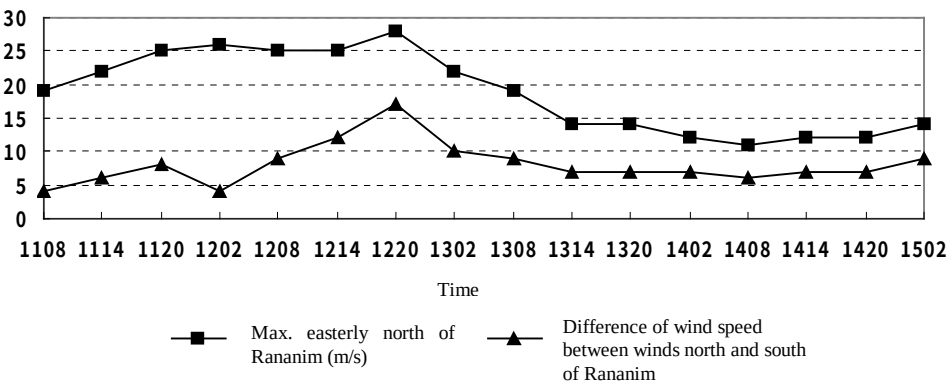

Fig.4 Maximum easterly wind north of Rananim and the difference of wind speed between maximum easterly and westerly on its north and south sides, at 500 hPa, from 08:00 Aug.11 to 02:00 Aug.15. Unit: m/s.

related with such large body of water as the Boyang Lake.

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