Article ID: 1006-8775(2005) 02-0220-02

THE DIAGNOSTIC ANALYSIS OF THE RAPID CHANGE IN TROPICAL CYCLONES INTENSITY BEFORE LANDFALL IN SOUTH CHINA

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1 INTRODUCTION

Sudden changes in the intensity of the tropical cyclone (TC) are a difficult issue to be tackled. Few of the previous works dealt with the characteristics of large-scale circulation background of TCs that experience sudden intensity changes prior to landfall. Studies that do address the issue are only case-based, which do not isolate large-scale circulation background common to all cases, whether it be favorable or not. By diagnostically studying large-scale characteristics of two categories of TCs, one intensifying and the other weakening, suddenly, before making landfall on the area of South China, the current work attempts to support the prediction of TC intensity.

2 DATA AND METHODS OF ANALYSIS

With the TC data from 1992 to 2002, the intensity is compared at 24 h before landfall and right at landfall to select six TCs intensifying rapidly (to be simplified as “I-sample”) and another six TCs weakening rapidly (to be simplified as “W-sample”) just prior to landfall on the area of South China west of 118°E. The period of interest is divided into nine levels from 48 h before landfall to the time of landfall, 6 h in between. The ambient data selected to use in the study is the NCEP reanalysis data at intervals of 6 h, which has a horizontal resolution of 2.5°×2.5° and 12 vertical layers. Used to show the potential capabilities of TC development, the difference between maximum potential intensity and observed intensity, denoted as POT, is also determined in the work.

$\mathrm{POT}(i)=\mathrm{MPI}(i)-V_{max}(i)$ (i = 1 – 9，i = 1 is the time 48 h before landfall and i = 9 is the time at landfall)

$$\mathrm{MPI}(i)= A+B \exp[-C(SST_0-SST(i))]$$

in which A = 66.5 kt, B = 108.5 kt, C = 0.1813/°C, SST_0=30.0°C and the unit of MPI so derived is kt, which is converted to m/s, V_{max} is the observed maximum wind speed of TC (m/s), and SST is the sea surface temperature, which is the weekly mean SST data from NCEP with a horizontal resolution of 1°×1°.

3 DIAGNOSTIC ANALYSIS OF THE FIELD OF PHYSICAL QUANTITY

3.1 *Divergence field*

Received date: 2004-12-07; **revised date:** 2005-11-07
Foundation item: Natural Science Foundation of China (40275018；49975014；40333025)
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The “I sample” has obvious convergence at lower levels and intense divergence at upper levels, which is favorable for ascending motion to keep convection in vigorous growth, which in turn favors the strengthening and development of TCs. In contrast, the “W sample” has weaker low-level convergence than the “I sample” and its upper-level divergence are weaker 24 h before landfall, which is unfavorable for TC development.

3.2 *Transportation of water vapor*

In the I-sample, there is abundant transportation of water vapor, which is favorable for the maintenance of the warm-core structure of TC and provides sufficient amount of energy for the its development. The water vapor transportation is much weaker in the W-sample than in the I-sample.

3.3 *Vertical wind shear in the ambient field*

For the whole air column of the troposphere (at both 200 hPa and 850 hPa), there is not much difference in vertical shear between the two samples. As for the vertical shear at the tropospheric upper levels (200 hPa and 500 hPa) and lower levels (500 hPa and 850 hPa), the difference is also moderate. It shows that the vertical shear in the ambient field does not have significant impacts on the sudden intensity change of the two categories of TC in the South China Sea, possibly due to the lack of interactions between the selected samples and upper-level troughs. In addition, the impacts of vertical shear are associated with the TC intensity itself and its internal structure, which need to be studied further with numerical experiments.

4 RESULTS AND DISCUSSIONS

a. The TC intensifying just before landfall is usually to the southwest or south of the subtropical high and the 850-hPa southwesterly with cyclonic shear causes significant growth of TC at landfall as the subtropical high intensifies. In contrast, the TC weakening just before landfall is usually to the northwest of the subtropical high, with weak inflow at the lower levels of the TC.

b. Low-level convergence is well-defined and upper-level divergence is strong in the I-sample. The mutual allocation of upper and lower levels helps increase the TC intensity. Locating to the northwest of the subtropical high, the W-sample is characteristic of weak low-latitude southwesterly, low-level convergence and poorly-defined upper-level divergence. Such unfavorable allocation between upper and lower levels is restraining the TC from developing.

c. Associating with low-level ambient flow field, sufficient water vapor is entrained into the interior of the TC with the southwesterly flow to power the TC. The I-sample is thus intensified rapidly. In the W-sample, however, water vapor in 1/2 of the sample is transported mainly by the southeasterly airflow and that in another 1/2 by the southwesterly airflow. The flux of water vapor is smaller compared with the I-sample.

d. Generally speaking, vertical shear in the ambient field does not have significant impacts on the sudden intensity change in the two categories of TC.

Some preliminary conclusions have been drawn based on comparisons and analysis of the two categories of TC rapidly changing intensity just before landfall. One must keep in mind that there are always exceptions besides common features, for individual TCs have their unique interior structure and external environment and intensify or weaken rapidly for varying causes. This work presents only common features. With the help of numerical experiments, more study is needed to probe into the specific mechanism responsible for the sudden change of TCs.