On analysis of typhoon activities from a thermodynamic viewpoint

Shinya Shimokawa * and Hisashi Ozawa **

* National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan
** Hiroshima University, Higashi-Hiroshima, Japan

1. Introduction

Typhoons form in the region where sea surface temperature is high, usually at about 27 degrees Celsius. A typhoon moves from the formation region. The forecast of the track is difficult even when using high-resolution numerical models. It, however, will be certain that a typhoon decays gradually when it moves over a region with low temperature and the energy supplied from the region is small. Thus, the ratio of the number of tropical cyclones which land on Japan with typhoon intensity to that of all tropical cyclones which approach Japan will be high when sea surface temperature around Japan is high.

Strictly speaking, the formation and track of typhoons are related to not only sea surface temperature but also vertical structure of the atmosphere and sea level pressure because when considering typhoon as a heat engine, the high-temperature reservoir is at the sea surface and the low-temperature reservoir is at the tropopause. Thus, it is desirable to use an index reflecting these factors when considering the formation and track of typhoons. Maximum potential intensity (MPI: Emanual, 1987) is known as one of such indices.

It is considered from a dynamic viewpoint that typhoons are carried by a synoptic-scale wind system which includes typhoons themselves. Especially for typhoons which land on Japan, the position of North Pacific high-pressure for 500-700 hPa is considered to be important. Our thermodynamic viewpoint does not contradict the above view, but gives a different viewpoint, e.g. an important suggestion for typhoon activities in the cases with difficulties in the forecast of exact dynamic fields such as simulations for global warming.

On the basis of the above idea, we investigate the relationship between MPI (calculated from NCEP reanalysis 2 and NOAA OISST V2) and typhoon tracks (RSMC Tokyo best track data) during 1982-2005.

2. Method of Analysis and Data

Let us consider the following index:

Index = (MPI at the location of a typhoon)

/ (longitudally averaged MPI over the latitude including the typhoon)

The index is averaged over the path of the typhoon. The index larger than 1.0 means that the typhoon moves across regions with relatively large MPI. The index smaller than 1.0 means that the typhoon moves across regions with relatively small MPI.

In this study, minimum potential pressure is used as MPI. Therefore, the index should be smaller than 1.0 when the typhoon moves across regions with relatively large MPI. The index should be larger than 1.0 when the typhoon moves across regions with relatively small MPI. The index should be nearly 1.0 when the path of the typhoon is irrelevant to MPI.

Information about data used in this study is as follows:

Data for calculation of MPI: NCEP 2 and NOAA OISST V2 (monthly mean)
Data for typhoon path: RSMC Tokyo best track data
Period: 1982-2005
Region: 125E-185E (123.75E-186.25E), 2.5N-30N (1.25N-31.25N)
Interpolation: time and longitude

3. Results

Results for the calculated index are summarized as follows;

Averages: 0.9958 (averaged over all typhoons), 0.9669 (averaged over all data points). The number of typhoons is 633, and the number of data points for typhoon paths is 23991. In all typhoons moving across the region (554 typhoons), the number of typhoons with the indices smaller than 1.0 is 462 (83%). In all data points within the region (13064 data points), the number of data points with the indices smaller than 1.0 is 8802 (67%).

Latitudal change: In all latitudes (12 ranges from 2.5N to 30N with an interval of 2.5 deg.), the number of ranges with the indices smaller than 1.0 is 10 (83%). The ranges with the indices larger than 1.0 are 22.5N and 25.0N. The ranges with the indices of nearly 1.0 are 5.0N and 7.5N.

Annual change: In all years (24 years), the number of years with the indices smaller than 1.0 is 21 (88%). The years when a ratio of the number of typhoons with the indices smaller than 1.0 to the total number of typhoons is relatively low are 1984, 1985, 1996, 1997, 2000. There exist large annual variations. In 1982, 1983, 1989, 1998, 1999, and 2003, all typhoons have the indices smaller than 1.0 (the ratios are 1.0). In contrast, the ratios are 209/449 (46%) in 1984, 192/472 (40%) in 1985, 174/621 (28%) in 1996, 305/828 (37%) in 1997, and 84/451 (17%) in 2000.

Monthly change: In all months with data (213 months), the number of months with the indices smaller than 1.0 is 160 (75%). The month with the index larger than 1.0 is only February. The months with the indices of nearly 1.0 are September and October. The months with the indices not very smaller than 1.0 are February, March, September, and October. Note that the denominator in the ratio (the number of typhoons) is relatively small in February.

More detailed discussions will be presented in future publications.

References:

K. Emanuel 1987, Nature, 326, 483-485