Maximum Wind Gust Estimation in Tropical Cyclones Using Cloud Resolving Model

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1. Introduction

The maximum wind gust is the important parameter to estimate the natural disaster and its corresponding economical damage due to the strong wind in tropical cyclones. It is difficult to calculate the maximum wind gust directly, because the wind speed in a numerical model is a grid averaged value. In this study, we estimated the maximum wind gust from the wind speed which the Cloud Resolving Storm Simulator (CReSS: Tsuboki and Sakakibara, 2002) simulated by using the gust factor.

2. Method

The gust factor is defined as the ratio between the observed maximum wind gust and the simulated maximum surface wind in this study. The optimal gust ratio was derived by calculating the regression coefficient between the observed wind gust and the simulated maximum wind at the nearest grid point. To evaluate the horizontal resolution dependency, the horizontal resolution was changing from 1km to 5km.

We performed numerical simulations of several typhoons which made landfall and had sever damages in Japan. The using model was CReSS. The RSM and the MGDSST provided by JMA were used as initial and boundary conditions.

3. Results

We performed numerical simulations of typhoon Dianmu and Songda in 2004. The trajectory of both typhoons was well simulated for all resolutions. Table 1 shows the summary of all simulations. The minimum central pressure and the maximum surface wind were also well simulated. The result, dx=4km and 5km, was less accuracy than that of finer resolutions. The maximum surface wind of 1km result was overestimate. The gust ratio derived from the observation and the CReSS was about 1.63 to 1.76. It decreased as horizontal resolution became small, because the maximum surface wind was greater than that of lower resolution. RMSE between the observed wind gust and the estimated wind gust from the CReSS using the gust ratio was 6.91 to 8.02 m/s.

Table 1. The gust ratio for each horizontal resolution. The mean of the minimum central pressure and the maximum surface wind of all simulated typhoons are shown as SLP and Wind. The gust ratio (GR) was calculated from N observation points. RMSE is the root mean square error of the wind gust between the observation and the CReSS. The result of best track was also shown in "best" row.

dx	SLP (hPa)	Wind (m/s)	N	GR	RMSE (m/s)
best	940.0	43.7			
5km	947.0	41.1	118	1.76	7.71
4km	945.0	41.2	113	1.74	8.02
3km	941.5	42.9	117	1.74	7.22
2km	942.7	43.4	113	1.72	6.91
1km	942.7	52.0	111	1.63	6.98

Though RMSE of dx = 4km and 5km was less accuracy than others, the estimation of the gust ratio was acceptable for all resolutions.

4. Summary and discussion

We estimated the maximum wind gust in tropical cyclones using the CReSS. The gust ratio was the good parameter. It depended on horizontal resolution. The accuracy of the simulation and the maximum gust estimation increased as horizontal resolution became finer. It is suitable that the horizontal resolution is less than 3km. In this study, the gust ratio is treated as a constant. However, the gust ratio depends on the roughness length. For more accurate the wind gust estimation, it is necessary to take the roughness length and the spatial distribution, such as the standard deviation of the horizontal wind, into account.

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References

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