The study of the influence of the tropical cyclones initialization on the forecast of trajectories using the ETA model

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The tropical cyclones (TC) are one of the most dangerous weather phenomena in the Russian Far East. For this reason the study, numerical modelling and forecasting of TCs are extremely important for Russia. The quality of forecast of the motion and evolution of TCs considerably reduces the damage from TC consequences. The result of experimental forecasts performed with the ETA-model (Mesinger F., 1996) has been considered in this article. The model is adapted for the northwest region of the Pacific Ocean. With this model experimental forecasts have been done for the situations with the most remarkable typhoons of last seasons. The input data for the ETA-model were the objective analysis at 00 h UTC of the Russian Hydrometeorological Centre (RHMC), and for updating lateral boundary conditions the fields from the spectral model of RHMC with 6-h resolution were used (Pokhil A.E., Naumov A.D., 2003).

For a better forecast of the TC motion accurate definition of the TC initial location is very important. The accuracy of the definition of the TC centre is estimated in (Naumov A.D. and Nikolaeva A.V., 2003) for the current variant of the model. The errors in 46 sample cases constituted 134 km in the average. This error was significantly reduced using the vortex initialization procedure. An artificial axially symmetric vortex given by equations (1) or (2) is superimposed on the wind field (obtained from the objective analysis) at the initial moment. We considered the profiles (1, 2) of the wind velocity tangential component:

$$V(r)=Vm\frac{r}{Rm}\exp\left[\frac{1}{b}\left(1-\left(\frac{r}{Rm}\right)^{b}\right)\right] \quad , \qquad (1)$$

$$V(r)=Vm\frac{r}{Rm}\frac{3}{\left[2+\left(\frac{r}{Rm}\right)^{3}\right]} \quad , \qquad (2)$$

where r - distance from the vortex centre; V_m - maximum of the tangential component of the wind velocity; R_m - distance at which V_m is reached; b - a parameter determining the degree of the decrease of the wind velocity tangential component in the radial direction.

The maximum velocity is got from synoptic telegrams. Its radius is assumed to be equal to 3 grid steps. The following conditions are used:

1) The artificial vortex centre is located in the point of the TC centre defined from the satellite data. Thus the error of the TC centre initial location is comparable with the grid step.
2) The area of the artificial vortex in the current version of the model is equal to 30 grid steps, i.e. is about 1000 km.
3) On the boundaries of the artificial vortex the wind velocity values equal the objective analysis wind velocity values.

The initial field of the geopotential is obtained through the solution of the balance equation. This procedure is performed for the 5 lower levels: 1000, 850, 700, 500 and 400 hPa. This initialization provides good accuracy when determining the TC centre location. When specifying initial fields in the neighbourhood of the TC, it is performed in a separate block during the preparation of input data for the ETA-model.

The influence of the initialized vortex structure on the forecast of the real TC motion has been studied. (Pokhil A.E. and Polyakova I.V., 1994) shows that the way of specifying the wind velocity initial field in a model vortex plays a significant role in the motion of this vortex in the surrounding stream. It was necessary to study which kind of the initialized vortex reflects the structure of real TCs best.

To estimate the influence of the initialization way on the behaviour of a real TC a numerical experiment has been performed with the TC Halong, which was passing in the northwest of the Pacific from 7 to 16 July 2002. It reached a hurricane stage with pressure at the centre 945 hPa and the maximum velocity of wind about 90 knots. The change of the TC behaviour has been studied for several algorithms of the initial vortex restoration simulating the TC in the objective analysis fields according to formula (1) at b=1.0; 1.5; 2.0. Initial fields with initialization at b=1.0 and the forecast for 24 and 48 h reflect the real situation well. We have obtained that for the considered synoptic situations the change in trajectories with the change of the initialization way is less than 10-15 %. However more detailed study in this direction is necessary.

References

1. Mesinger F., 1996**:** Improvements in quantitative precipitation forecasts with the ETA regional model at the National Centers for Environmental Prediction. Bull. Amer. Met. Soc., 77, No 11.
2. Pokhil A.E., Naumov A.D., 2003: Using the ETA-model for calculating the evolution and motion of pairs of tropical cyclones in the Pacific. Meteorology and Hydrology, No. 6.
3. Pokhil A.E., Naumov A.D., 2003**:** Analysis of the evolution and motion of tropical cyclones on the basis of calculations using the ETA model and satellite data . -CAS/JSC Working Group on numerical experimentation. Research activities in atmospheric and oceanic modelling. Report N 33, April, WMO/TD-N 1161.
4. Naumov A.D., Nikolaeva A.V., 2003: Using a regional ETA model for forecasting tropical cyclone tracks from data of the Hydrometeorological Scientific Research Center of Russia. Meteorology and Hydrology., 2003, No. 10.
5. Pokhil A.E., Polyakova I.V., 1994: The influence of interactive vorticities on their movement. Meteorology and Hydrology., 1994, No. 7.