Development of Taiwan Central Weather Bureau Global Ensemble Prediction System for Typhoon-track

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1. The ensemble prediction system

The current Taiwan Central Weather Bureau operational Global Forecast System (CWBGFS) is spectral Eulerian model in resolution T511L60 with horizontal wave number 511 triangular truncation and vertical 60 layers in sigma-pressure hybrid coordinate. The horizontal resolution is about 25 km and the model top layer is at 0.1 hPa. The physical parameterizations include Noah land surface 4-layer model (Ek *et al*., 2003), vertical turbulence (Hong and Pan, 1996), cumulus convection with simplified Arakawa-Schubert scheme (Pan and Wu, 1995; Han and Pan, 2011), shallow convection (Han and Pan, 2011), grid scale precipitation (Zhao and Carr, 1997), gravity wave drag (Palmer *et al*., 1986) , nonorographic gravity wave drag (Scinocca, 2003), and radiation process (Fu and Liou, 1992; 1993). The data simulation system adopts NCEP hybrid EnKF with 36 members.

This global forecast model can provide 5-7 days typhoon track forecast when the typhoon appears on the western Pacific oceans. Based on this deterministic forecast system, Global Ensemble prediction system for Typhoon-track, also called GET, was developed with tiny initial perturbations for getting the possibility of typhoon movement.

Table 1. CWB GET Structure

CWB Global EPS for Typhoon-track (GET)			
resolution	deterministic model		T511L60
	ensemble		T511L60
initial perturbation, singular vector	global		T42L60
	nested typhoon domain	east Asia	20^0N-60^0N, 100^0E-180^0E
		typhoon	$15^0 \times 10^0$
optimization time	48 hrs		
ensemble size	20		
forecast length	5-day		

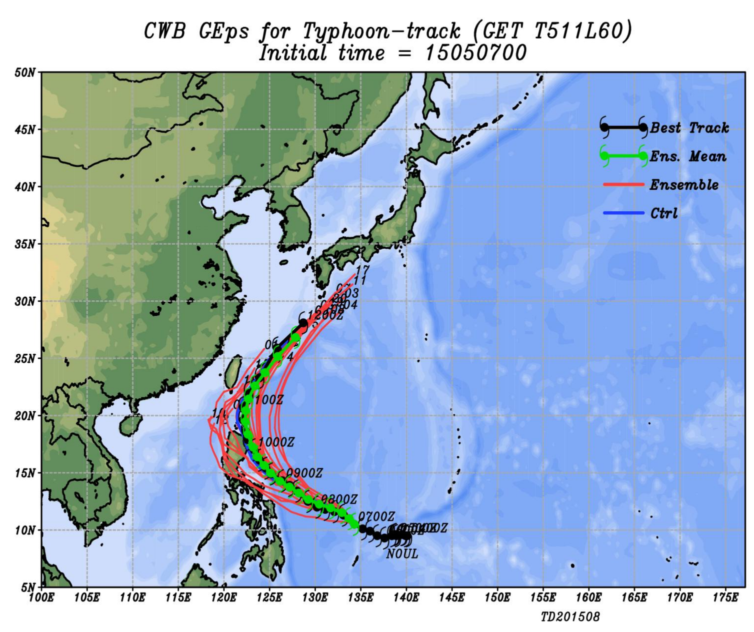

Figure 1. The track forecast by GET on 00 UTC 7 May 2015.

The initial perturbations are decided by singular vectors (Buizza *et al*., 1993) calculating around typhoon center and East Asia total energy domain. The GET system setup is shown in Table 1. Besides using the initial singular vectors, the GET is also going to implement the Stochastically Perturbed Parameterization Tendency (SPPT) for showing the model uncertainty in 2016. The current SPPT of GET follows ECMWF method with horizontal 500 km perturbation scale (Palmer *et al*., 2009).

2. Case

The Typhoon Noul, from 18 UTC 3 May to 06 UTC 12 May 2015, was one of the best typhoon track forecast cases that GET predicted. The Figure 1 shows the best track prediction on 00 UTC 7 May. In Figure 1, the blue line is from deterministic forecast; the red lines are ensemble members; green line is ensemble mean; black line is the best track. The spread of ensemble is large in contrast to other time moment. At the same time, the whole Noul life time track errors are calculated and shown in Figure 2. The blue line depicts the track error of deterministic run and the purple line is the ensemble mean forecast error. The dash green dash line is the standard deviation of ensemble members and ensemble mean. The stem lines record

3. Performance

the number of cases in specific forecast time. The blue and purple lines show that the 72 hrs track error is about 250 km and the 120 hrs track error is about 360-380 km. The standard line is close to ensemble mean error line somehow displays the spread of ensemble is enough. The error of ensemble mean, the purple line, is slightly smaller than deterministic forecast.

In Noul's case, the performance of GET is acceptable but it is still a preliminary result. The CWBGFS still need to do some fine tune for typhoon deterministic forecast for reducing the track error. Once the value of track error is smaller, the spread is too large and GET needs to reduce the ensemble spread.

The SPPT is tested in Noul's case, but there is no significant difference in track performance. The track tends to move northward than without SPPT. However, when we check the standard deviation of east-west wind component, the SPPT enhances more differences around high level jets in two hemispheres (Figure 3). The Figure 3 is 120 hrs forecast of the zonal mean U component wind standard deviation difference between SPPT and without SPPT. The major difference happens around the high level jet areas especially southern hemisphere. That points that the SPPT can enlarge the spread of ensemble

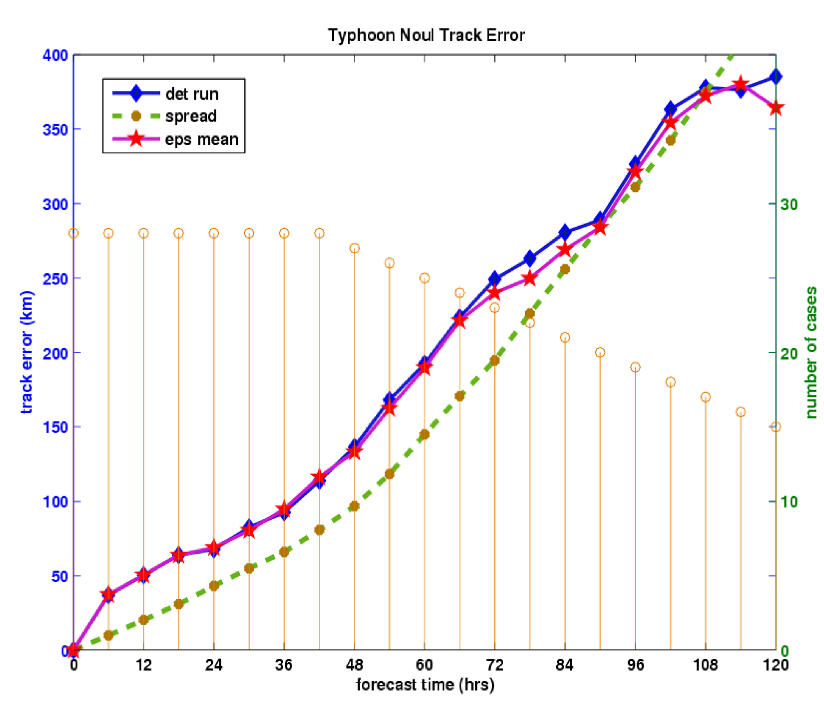

Figure 2. The track error of typhoon Noul from 18 UTC 3 May to 18 UTC 11 May 2015.

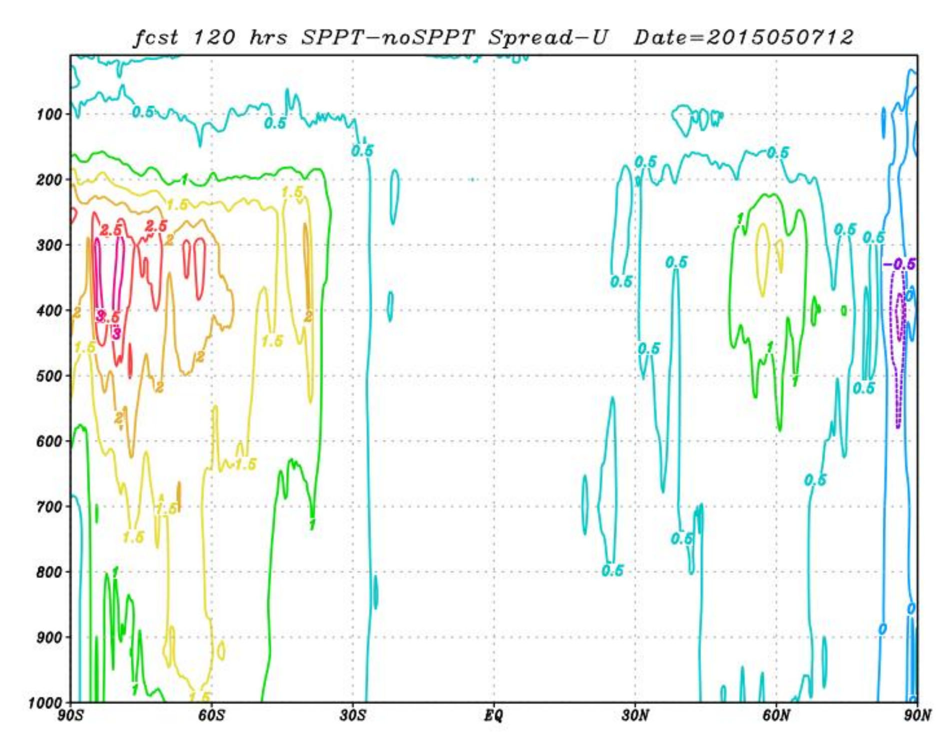

Figure 3. The zonal mean U component wind standard deviation difference between the SPPT and without SPPT at 120 hrs forecast initiated on 12 UTC 7 May 2015.

prediction but is does not directly affect the typhoon track. The typhoon track is affected by many factors and we cannot hope the SPPT could have dramatically spread result without carefully tests.

4. Summary

The singular vector perturbations in typhoon Noul case can get pretty good track spread. The spread somehow can be used for future probability forecast. In Noul's case, the perturbations initially are accumulated around 300 hPa, and then propagate downward over the time (not shown). This is different from midlatitude singular vectors which are from bottom layer and propagate upward. This will be diagnosed by potential vorticity which can trace back the perturbation from where.

The SPPT with singular vector can increase the spread in entire sphere. This method is mainly used for replacing the inflation in EnKF data assimilation cycle. So far, it does not have significant impact on typhoon track forecast. On the other hand, we are testing Stochastically boundary layer Humidity (SHUM), and the typhoon track tend to move northward. In current situation, the SHUM will affect the typhoon's movement speed more than the track spread.

5. Reference

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