Objective Consensus Typhoon Track Forecasting Using Multimodel Superensemble

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1 Introduction

▪Tropical cyclone track forecast has been significantly improved for last 20 years due to using and developing the numerical models and consensus. The consensus of deterministic numerical models shows better performance than any of the component models because of offsetting random errors (Elsberry, 2014).

▪Consensus, a combination of the forecasts from a collection of models (Cangialosi and Franklin, 2013) has improved overall track forecasting performance since being implemented in major operational centers (WMO, 2007).

▪**Multimodel superensemble, the objective and weighted consensus method can outperform the simple mean consensus, Goerss (2000) method of the same set of models (Buton, 2006).** Superensemble developed by Krishnamurti *et al*. (1999) was first applied to tropical cyclone real-time forecast by Williford *et al.* (2003)**.** FSSE (Florida State University Superensemble) constructed by this method showed the highest skill and was only guidance that consistently beat the official forecast for hurricane forecast in NHC (National Hurricane Center) verification report (Cangialosi and Franklin, 2013).

▪**Thus, this study constructs objective consensus using multimodel superensemble and evaluates this consensus to provide typhoon track forecasting guidance.**

2 Data and Methods

▪**Dataset :** KMA typhoon analysis track data, model forecast used in KMA during 2011~2013 (77 typhoons)

−Deterministic : CMSC (CMC global), DBAR (KMA barotropic), ECMWF (global), ECMWF_TIGG (ECMWF from TIGGE), GDAPS (KMA global), GFS (NCEP global), GFS_TIGGE (GFS from TIGGE), GRAPES_TCM (CMA STI typhoon), JGSM (JMA global), KWRF (KMA WRF), NOGAPS (U.S. navy global), RDAPS (KMA regional), TWRF (KMA typhoon WRF)

−Ensemble System : CMA_EPS (CMA ensemble from TIGGE), CMSC_EPS (CMC ensemble from TIGGE), ECMWF_EPS (ECMWF ensemble from TIGGE), EGRR_EPS (UKMO ensemble from TIGGE), GFS_EPS (NCEP ensemble from TIGGE), KEPS (KMA ensemble), TEPS (JMA ensemble)

▪**Verification : harversine formula for track error (Sinnott, 1984)**

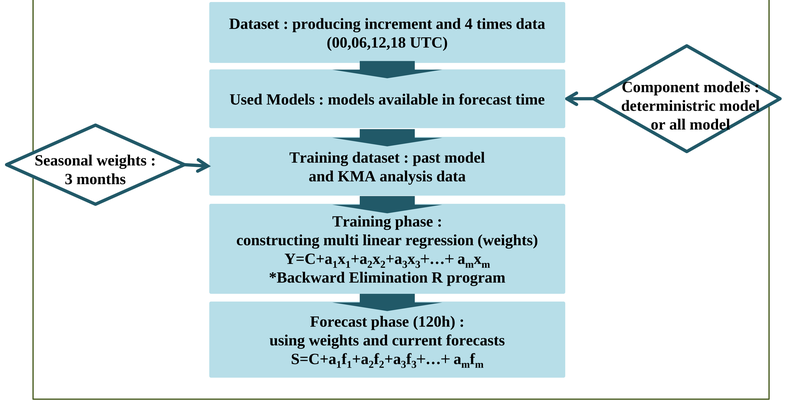
−2012 forecast : 2011 and latest typhoon data for training set

−2013 forecast : 2011~2012 and latest typhoon data for training set

▪**3 optimized experiments for superensemble**

Used models	① **MO_DE**	*Deterministic models*
	② **MO_ALL**	*Adding ensemble prediction system models*
Month	③ **MON_3**	*Calculating weights seasonally (3months)*

▪**Multimodel superensemble prediction flow chart in this study**



3 Results

▪**The comparison of 3 optimized experiments for superensemble**

–**MO_ALL** shows the smallest track error in all forecast period and lower error distribution than any other experiments (Fig. 1).

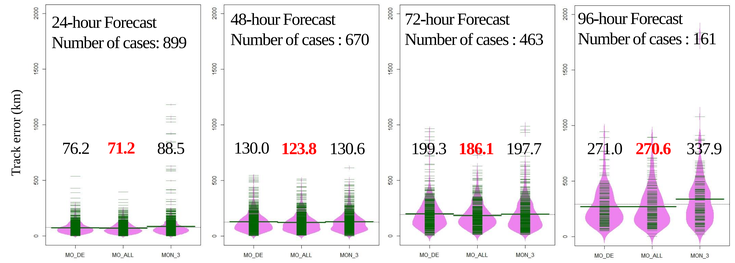


Fig. 1. Beanplot of track error for the superensemble forecasts of three optimization experiments in 2012~2013 (thick green lines are average errors, thin green lines are errors, the pink area of bean means a density trace of a normal distribution.).

▪**Evaluating MO_ALL superensemble**

–Superensemble outperforms GFS, ECMWF_TIGG, KMA and simple mean consensus for 24~120 h in 2012~2013 (Fig. 2).

–The mean track error of superensemble is smaller than simple mean consensus by 9.8~69.7 km for 24~120 h in the 2012~2013 (Table 1).

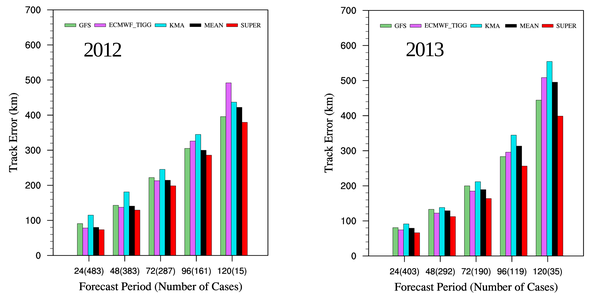


Fig. 2. The comparison of mean track error of GFS, ECMWF_TIGG, KMA forecast (KMA), simple mean consensus (MEAN), superensemble (SUPER) for 2012~2013.

Table1. The comparison of mean track error of superensemble, simple mean consensus , KMA forecast, ECMWF_TIGG and GFS for 2012~2013.

Model	Forecast Period (Number of Cases)				
	24(886)	48(675)	72(477)	96(280)	120(50)
Superensemble	**69.9**	**120.8**	**181.2**	**271.1**	**389.2**
Simple mean	79.7	134.9	201.8	306.6	458.8
KMA forecast	103.2	159.6	228.5	344.7	495.8
ECMWF_TIGG	76.3	129.8	199.0	310.9	500.2
GFS	85.8	138.0	210.9	294.3	420.0

❖References

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▪**Case analysis of 3 typhoons landfalling on the Republic of Korea in the 2012**

−1207 typhoon KHANUN : The track errors of superensemble tends to be larger than simple mean consensus. This case is that superensemble shows high rank track error (Fig. 3).

−1214 typhoon TEMBIN and 1216 typhoon SANBA : Superensemble performs well compared with simple mean consensus, GFS, ECMWF_TIGG. Performance of GFS is better than ECMWF_TIGG for TEMBIN, but performance of ECMWF_TIGG is better than GFS for SANBA. **Notice that superensemble shows similar performance of the best model of each case (Fig. 3).**

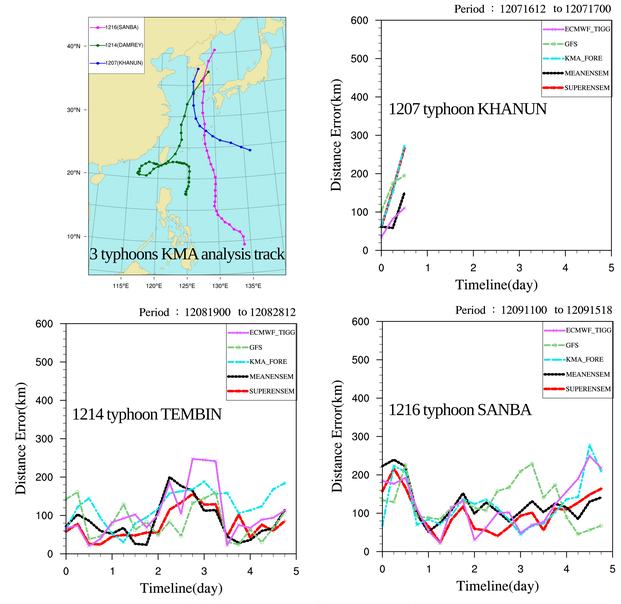

Fig. 3. The time series of 48h track error for 3 typhoons

4 Conclusions

▪Superensemble shows the better performance when component models consist of deterministic and ensemble prediction models and weights are calculated from total past typhoon data in whole year. Also, this consensus performs better than simple mean consensus and deterministic models (ECMWF_TIGG and GFS).

▪**This results shows the good possibility that objective consensus using superensemble will be used in typhoon forecast guidance.**

❖Future Work

•Perform and verify real time forecasts simulation for operational use.

•Examine characteristics of superensemble performance compared with simple mean and deterministic models using spread of model forecasts and environment parameter for operational use (guidance on guidance) and improving forecast performance.

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