AN EXPERIMENT WITH THE CONSENSUS FORECAST OF TYPHOON TRACK[1]

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ABSTRACT

Obvious results have been achieved in the forecast of typhoon track that is improved with a consensus procedure. Forecast experiments were conducted with the analogue model (TSF) and the Markov type model (MTSF) that are widely used and the results show that there has been significant increase in the capability of forecasting with the improvement by the consensus procedure.

Key words: typhoon, consensus forecast, *El Nino*, typhoon track

I. INTRODUCTION

As typhoon is one of the major catastrophe weather that affects China, it is essential to have good forecasting of its track. There are three methods in the aspect. There are the statistic approach, or the statistic forecasting followed by the dynamic approach, or the numerical model forecasting. Because of the relative advantages and disadvantages with either of them, a third method has come into being — a statistic/dynamic approach by combining the previous two methods. Applications have shown that it is potentially useful with considerable prospect of development. The consensus forecast is one that falls within the category. Little work has been reported in the respect at home while satisfactory results are with the forecast research by their colleagues overseas concerning the application of the consensus forecast in the track of tropical cyclones in the Atlantic Ocean. In view of its effectiveness, the method is used here to address the issue of forecasting the typhoon that affects China by a number of tests.

II. THE CONSENSUS SCHEME AND SELECTION OF FORECAST MODEL

The consensus forecast method was first proposed by Staël Von Holstein (1971) and documented in detail in Ye, Zeng and Guo (1991). In summary, there are four categories as follows:

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(1) Ensemble Average Forecast,

(2) Lagged-Average Forecast,

(3) Monte-Carlo Forecast, and

(4) Tempered Forecast.

Currently, quite a number of models involve themselves with the forecasting of the track of typhoons. The Markov analogue forecast model (MTSF), being used at the Central Meteorological Observatory, China, is selected for this work in conjunction with its prototype — the TSF for comparing tests. Our forecast scheme is presented as follows:

(1) Analogue Forecast Model (TSF), details referred to Chen and Ding (1979),

(2) Markov Analogue Forecast Model (MTSF), details referred to Wang and Neumann (1984), and

(3) Consensus Forecast Scheme, for which the Lagged-Average Forecast is employed for improvement of the forecasts. The scheme includes the Lagged-Average Analogue Forecast Model (LTSF) and the Markov Analogue Forecast Model (LMTSF), and the model is expressed by

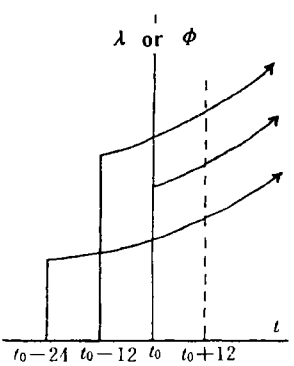


Fig.1. Schematic of lagged-Average Forecast.

$$\begin{cases} \Delta\overline{\lambda}_i = \dfrac{1}{M}\sum_{j=1}^{M}\Delta\lambda_{ij} \\ \Delta\overline{\phi}_i = \dfrac{1}{M}\sum_{j=1}^{M}\Delta\phi_{ij} \end{cases} \tag{1}$$

where i=12, 24, 36, 48, 60, 72 h for varying periods of forecast, $\Delta\overline{\lambda}_{ij}$, $\Delta\phi_{ij}$ are forecast results in the latitude and longitude at the forecast time i using different initial time j, and M is the number of initial time selected, taken as M=3 here (See Fig.1).

To investigate whether the *El Nino* year has any effects on the track of typhoon movement, the results concerning the *EL Nino* and anti-*El Nino* years are analyzed as follows.

The data used in the experiment are those observed for 1949 – 1987 and the forecast error are computed using the formula (Wang et al., 1984) of

$$FE = \left\{\left[(x_0 - x_f)\cos(y_0 + y_f)/2\right]^2 + (y_0 - y_f)^2\right\}^{1/2}$$

where (y_f, x_f) and (y_0, x_0) are the latitudes and longitudes of the typhoon forecast and observed.

The evaluation uses the following standard.

Table 1. Evaluation grades in the study.

X value	Ability of improvement of the scheme
$X \leq 65\%$	Lack of ability
$65\% < X < 75\%$	Having some ability
$X > 75\%$	Having strong ability

Here, the forecast improvements rate X = number of improved forecasts / total number of forecasts.

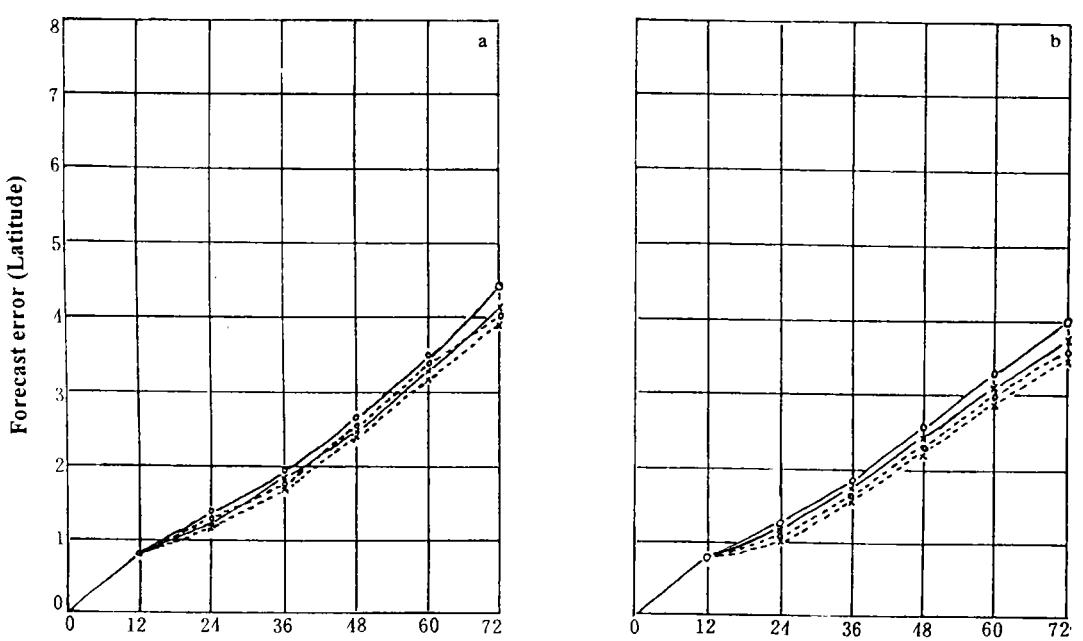
1. *Improvement on TSF error with MTSF, LMTSF, LTSF*

It is seen in Table 2 that the improvement rate is above 65% in all the forecast schemes for the *El Nino* and anti-*El Nino* years. The improvement is more significant for the *El Nino* year, being 79.7% with the LMTSF, suggesting effects on the track of typhoon in such years.

Table 2. Improvement on TSF with MTSF, LMTSF and LTSF.

	Year	Total number of Forecasts(TSF)	Number of improved forecasts with the schemes		
			MTSF	LMTSF	LTSF
El Nino years	1969 1972 1976 1983 1987	468	304 (65.0%)	312 (66.7%)	306 (65.4%)
Anti-*El Nino* years	1970 1985	222	156 (70%)	177 (79.7%)	159 (71.6%)

2. *Improvement on TSF error with MTSF, LMTSF, LTSF*



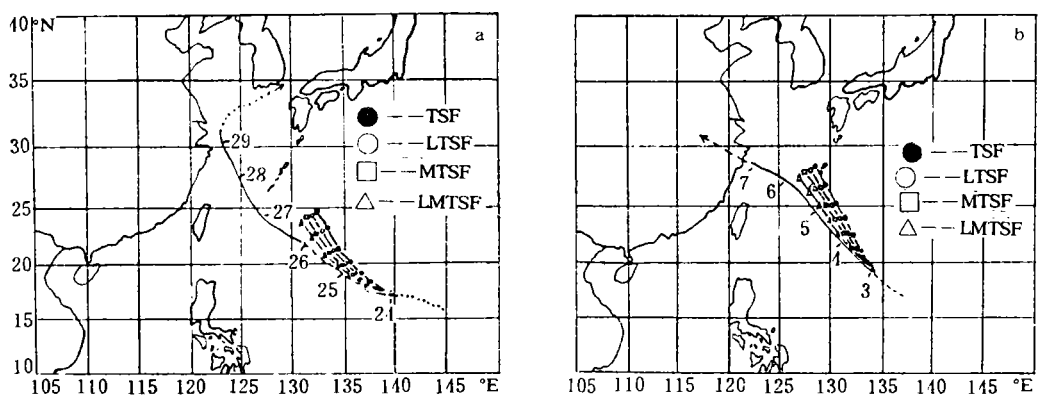
(a) *El Nino* years (b) Anti-*El Nino* years

Fig.2. Mean error of forecast in the four schemes.

It is understood in Fig.2 that there is error in some extent for all of the schemes, the improvement is especially good with LMTSF at various periods of forecasting. In comparison, the anti-*El Nino* years have greater improvements.

III. ILLUSTRATIVE ACCOUNTS OF FORECAST

To compare the forecasting capabilities of each of the schemes, the forecasting procedures are separately given for Typhoon Gerald (1987) in the *El Nino* year and Typhoon Mamie (1985) in the anti-*El Nino* year and compared with relevant observed tracks (Fig.3). Due to the limitation of text, only the results for an initial position of forecast are presented in the figure. Similar results are with other initial positions. Comparing the forecast results of Fig.3 and Fig.4, it is easy to see improved capabilities of the three schemes, e.g. MTSF, over the original ones, the effect being especially marked with the LMTSF scheme, which shows a track of the storm much closer to reality. It suggests that the consensus forecast is successful in improving the TSF.



(a) Initial position of forecast for the *El Nino* years (17.4°N, 139.5°E)

(b) Initial position of forecast for the anti-*El Nino* years (19.3°N,134.2°E)

Fig.3. Observed and forecast tracks of two typhoons

IV. CONCLUDING REMARKS

a. The Analogue Model (TSF) is one that the tracks of the typhoon are matched for similarity in the historical record. It is obvious that the longer the historical record, the more the number of similar cases and the more accurate the forecast will be. The TSF is not appropriate for the forecasting of abnormal typhoons with small probabilities. They have been removed from the experiment.

b. With a number of experiments done, it is found that some improvements have been made on the TSF by the Markov Analogue Forecast Model and the effect is more obvious with the LMTSF, indicating that the consensus forecast is indeed an effective way.

c. It is found in the experiment that the forecast is relatively poor for all of the schemes in the *El Nino* years. Is it that the *El Nino* years have effects on the track of typhoons? No conclusions have been drawn yet in this aspect, as the length of data used is limited. Further study and verification are necessary in the future.

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