The operational 3D-Var assimilation system of JMA for the Global Spectrum Model and the Typhoon Model

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1. Introduction

The JMA 3D-Var operational assimilation system (Takeuchi, 2002) has been used for the global assimilation cycle four times a day (00,06,12,18UTC), the global early analysis for the global spectral model (GSM) forecast (00,12UTC), and the typhoon analysis for the typhoon model (TYM) forecast (06,18UTC) since 25 September 2001. The scheme has the following benefits over the former optimal interpolation (3D-OI) scheme 1) applying more general balance conditions among analysis variables (i.e. wind, temperature, surface pressure, and specific humidity) such as the geostrophic balance and surface frictions, 2) analyzing all observational data simultaneously, 3) capability of satellite data assimilation in a straight-forward manner. Typhoon bogus data are embedded in first guess fields of surface pressure, temperature, and wind.

The 3D-Var uses 6-hour forecast from GSM(T213L40) as a first guess (background). All data within 3 hours from analysis time are regarded as observational data taken at the analysis time. An incremental method is adopted in the 3D-Var to save computer resources. The method calculates an analysis increment at a lower resolution (T106L40) and then adds the increment to the high-resolution first guess. The background error was calculated based on one year statistics by using the NMC method.

2. Improvements in analysis

In numerical weather prediction, an initialization procedure is applied to eliminate noises caused by dynamically unbalanced analysis fields. The analysis field by the 3D-Var is well dynamically balanced, therefore, the analysis is not much modified by the initialization. Fig.1 shows the differences between initial fields and analysis fields of vertical p-velocity at 850hPa at 12UTC 17 September 2001. The shaded area denotes modifications by the initialization is more than 2hPa/hour. Though the 3D-OI analysis is modified everywhere, the 3D-Var analysis is not modified except for high terrain areas and around typhoons near Taiwan island and the south sea of Japan.

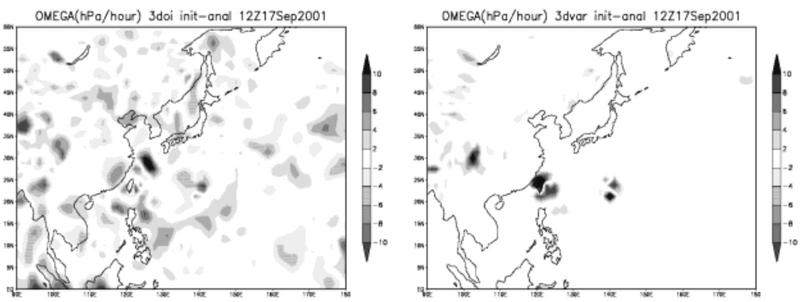

Fig.1 Differences between initial and analysis fields of vertical p-velocity (hPa/hour) at 850hPa at 12UTC 17 September 2001. Left panel for 3D-OI and right for 3D-Var.

3. Improvements in forecast

In this section, it is shown how much the 3D-Var improves short range forecasts. Examples shown are the results from forecast experiments by GSM and TYM for July 2000, March 2001 and July 2001. All experiments use the same observations and the same model. Therefore, we can find impacts of the change in the analysis scheme from 3D-OI to 3D-Var.

3.1 Performance of GSM forecast

Fig.2 shows the RMSE score of the experiment for March 2001. We carried out cycle analysis during 1 to 31 March and 216hour forecasts are performed from the initial time at 12UTC from 8 to 22 March. In Fig.2 improvements in sea level pressure, 500hPa geopotential height, 850hPa wind are remarkable even in the Northern hemisphere. The advantage of 3D-Var is more significant in the Southern hemisphere. For experiments for July 2000, the score of the Northern Hemisphere sea level pressure and 500hPa geopotential height is similar to those for the 3D-OI and the score of 850hPa wind is improved. In the Southern hemisphere, all verification scores are also improved.

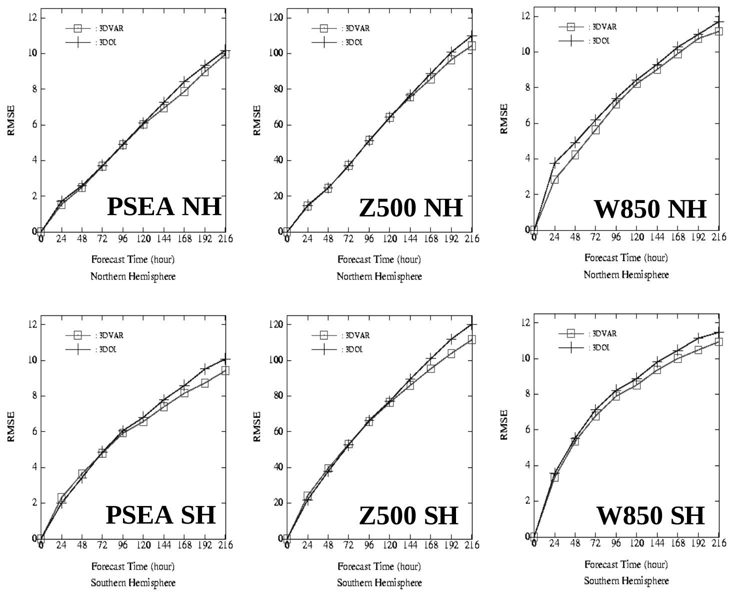

Fig.2 RMSE of forecast score in March 2001. Upper panel are for the Northern hemisphere and lower for the Southern hemisphere. Square marks denote 3D-Var and cross marks denote 3D-OI.

3.2 Impacts on typhoon forecasts

This section describes a few examples on the improvements of forecast of typhoon center position. Fig.3 is the comparison of typhoon (T0104) forecasts by GSM, the initial fields of which are given by the 3D-Var and the 3D-OI, with best tracks given as a truth. The initial time is 12UTC 9 July 2000, forecast time is 90hour. The character B shown in Fig.3 denotes best track, V denotes the 3D-Var, and O denotes the 3D-OI. The forecasted track by the 3D-OI crosses mid-Korean peninsula and that by the 3D-Var goes through northern part of Korean peninsula which is close to the best track.

Fig.4 shows the result for T0108 by TYM from the initial time at 00UTC 27 July 2001. Though the 3D-OI forecast turn right toward the Okinawa islands, the 3D-Var forecast goes straight to Taiwan island similar to the best track. Though the number of the case studies is insufficient to carry out statistical verification, the forecasts of typhoon tracks are improved in most cases.

4. Summary

The 3D-Var assimilation scheme for GSM and TYM was developed and implemented as the operational analysis system on 25 September 2001. Some experiments prior to the implementation show improvements in short- to medium-range forecasts and typhoon forecasts. The improvements are achieved without adding any new observation data and without change in forecast models.

We hope the improvement in forecast models and utilization of satellite and airplane data will contribute to more accurate initial fields for GSM and TYM. In a few years a 4D-Var scheme for those models will be implemented in operation and satellite data, the observation time of which is not regular, is treated more accurately and the forecast score will be improved significantly.

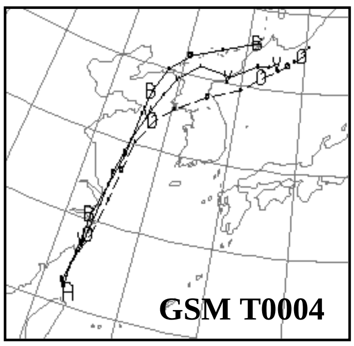

Fig.3 Typhoon forecast by GSM. The initial time is 12UTC 09 July 2000. B denotes best track, O for 3D-OI, and V for 3D-Var. Each character is positions of 24, 48, and 72 hours forecast

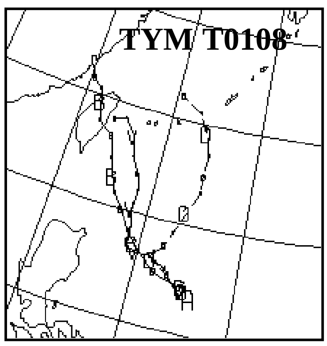

Fig.4 Same as Fig.3 except for the forecast by TYM. The initial time is 00UTC 27 July 2001.

References

Takeuchi, Y., 2002: Global analysis. *Outline of the operational numerical weather prediction at the Japan meteorological agency.* JMA, 16-20.