Upgrade of JMA El Niño Forecast Model (JMA-CGCM02)

Yoshiteru Kitamura and Goro Yamanaka
ykitamur@met.kishou.go.jp
Japan Meteorological Agency, Tokyo, JAPAN

1. Introduction

The Japan Meteorological Agency (JMA) has operated a Coupled ocean-atmosphere General Circulation Model (JMA-CGCM01) for the prediction of ENSO since 1999. In July 2003, JMA put into operation a new coupled model (JMA-CGCM02). This model revised the physical process in the Atmosphere General Circulation Model (AGCM) and introduced a new Ocean Data Assimilation System (ODAS). The ENSO forecast of JMA-CGCM02 show better performance. The improvement is more evident within shorter lead time until 7 to 8 months. This article describes the changes of specification of the new model and the forecast skill.

2. Outline of JMA-CGCM02

Major specifications and their change from the former model are summarized in Table 1.

JMA-CGCM02 includes the following main three changes:

(1) The atmospheric part is a lower resolution version (T42L40) of the current three-month prediction model in operation since March 2001. Compared with the former AGCM, the top level height is increased and the vertical resolution is enhanced. The cumulus convection and radiation schemes are revised. Cloud water content becomes a prognostic variable.

(2) The oceanic part is a Bryan-Cox type ocean general circulation model (OGCM) and is identical to the former OGCM only except slight change in the vertical mixing parameterization. In a new ODAS, a three dimensional variational analysis scheme based on Derber and Rosati (1989) is introduced. The nudging scheme is replaced by an incremental analysis update scheme (Bloom et al., 1996). Salinity and sea surface height data are newly assimilated in addition to temperature.

(3) The flux adjustment amounts of momentum and heat flux are newly derived with the observed SST variations.

The coupling takes place every 24 hours, that is, the ocean model gives the sea surface temperature to the atmospheric model, and the atmospheric model provides the daily mean heat and momentum flux to the ocean model. The fresh water flux is not given in the forecast integration.

Table 1: Major specifications of JMA-CGCM02 and their change from the former model

Atmospheric General Circulation Model

	Former model (T42L21 GSM8911)	New Model (T42L40 GSM0103)
Vertical resolution	21 levels (model top: 10hPa)	40 levels (model top: 0.4hPa)
Cumulus convection parameterization	Kuo scheme	Prognostic Arakawa-Schubert scheme
Cloud water content	Diagnostic	Prognostic variable
Radiation process	Solar, Infrared	Solar, Infrared, direct aerosol effect

Ocean Data Assimilation System
(OGCM : 2.5° (lon.) x 0.5 - 2° (lat.), L20)

	Former model	New Model
Analysis scheme	Two-dimensional optimum interpolation method	Three-dimensional variational method
Assimilation scheme	Nudging	Incremental Analysis Update
Assimilated data	Temperature	Temperature, Salinity, Sea surface height
Analysis interval	5-day	1-day

3. Predictions of SST variability by JMA-CGCM02

Prediction skill for the tropical Pacific SST anomalies is estimated through evaluation of 1-year hindcast experiments (a set of 117 runs) initiated monthly from January 1988 to September 2002.

Figure 1 shows anomaly correlation coefficient (ACC) and root mean square error (RMSE) for the Nino-3.4 (5S-5N, 170W-120W) SST anomalies. As of ACC, the model prediction skill is higher than the persistence prediction skill at 3-month or longer lead time. The ACC of the model is about 0.7 at 6-month lead time. As of RMSE, the skill of the model exceeds that of the persistence prediction after 5-month lead time, and is better than that of the climatology prediction until 9-month lead time. However, comparison of the skill for summer and winter (not shown) indicates that, even with this model, the skill levels for the summer predictions are still lower than those for the winter predictions, suggesting the "spring prediction barrier".

Figure 2 shows the spatial distributions of two-season-lead predicted versus observed SST anomaly temporal correlations for JMA-CGCM02 and for the persistence forecasts. The skill of the model is higher than the persistence prediction over most of the tropical Pacific at 6-month lead time. The highest skill is found especially in the eastern equatorial Pacific around 150W, where SST variability associated with ENSO is large. In the western tropical Pacific and the Indian Ocean, some promising skill can be found, though the values of the ACC are relatively small.

References

Bloom, S. C., L. L. Tacks, A. M. daSilva, and D. Ledvina, 1996: Data assimilation using incremental analysis updates. *Mon. Wea. Rev.*, 124, 1256-1271.

Derber, J. C. and A. Rosati, 1989: A global oceanic data assimilation technique. *J. Phys. Oceanogr.*, 19, 1333-1347.

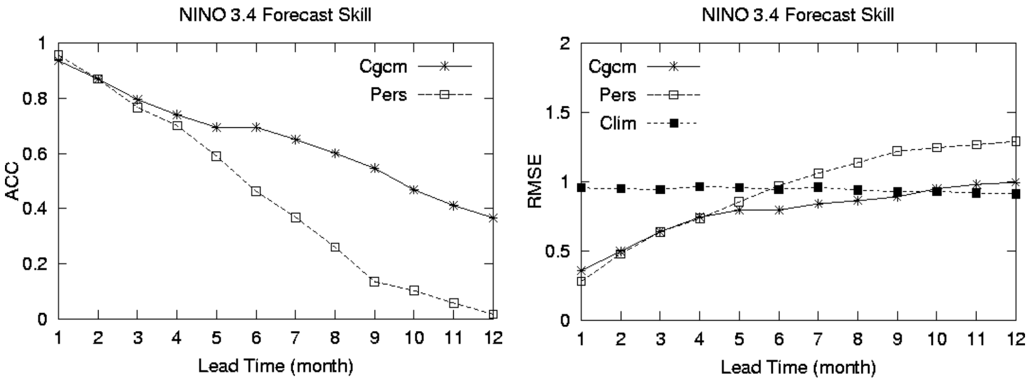

Figure 1: Anomaly correlation coefficient (ACC) (left) and root mean square error (RMSE) (right) for the Nino-3.4 SST anomalies between prediction and observations for the period of February 1988-August 2003. The ACC and RMSE for the persistence forecasts (Pers) and RMSE for the climatology forecasts (Clim) are also shown for reference.

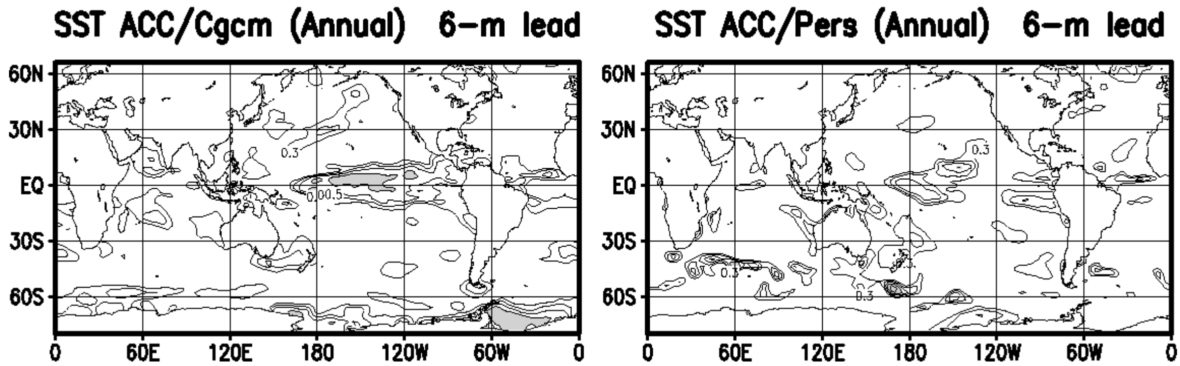

Figure 2: Temporal SST anomaly correlation coefficients with 6-month lead time for JMA-CGCM02 (left) and the persistence forecast (right). Contours are drawn only for areas where the anomaly correlation coefficients are greater than 0.3 and contour interval is 0.1. Shaded areas denote where the anomaly correlation coefficients are greater than 0.6.