The daily 3D Ozone produced by the Chemical Transport Model for JRA-25.

Takashi MAKI[1], Ayataka EBITA[2], Takahisa ISHIMIZU[3], Kazuhiko NAGATA[4], Masaaki IKEGAMI[1] and Toru SASAKI[5]

[1]Atmospheric Environment Division, Global Environment and Marine Department, Japan Meteorological Agency, Japan

[2] Administration Division, Global Environment and Marine Department, Japan Meteorological Agency, Japan

[3] Climate Prediction Division, Global Environment and Marine Department, Japan Meteorological Agency, Japan

[4] Forecast Division, Forecast Department, Japan Meteorological Agency, Japan

[5] Director of the Utsunomiya Local Meteorological Observatory, Japan Meteorological Agency, Japan

Correspondence: maki@met.kishou.go.jp

INTRODUCTION

An ozone 3D distribution influences atmospheric energy balance through radiation. However, Japan Meteorological Agency (JMA) had only monthly 2D climatology of ozone as of 2002. Analyzed 3D ozone fields were keenly required for JRA-25. We have run our Chemical Transport Model (CTM) nudging with satellite observational data and analyzed meteorological field from 1979 to 2004. The simulated ozone field could almost reproduce realistic ozone distribution. The simulated total ozone tends to lower in the tropical region and the period when there are not enough satellite data.

METHOD and DATA

We have calculated ozone distribution from 1979 to 2004. Also we continue this calculation from 2005 to present in order to provide 3D ozone distribution for JMA Climate Data Analysis System (JCDAS).

We make use of chemical transport model (CTM) developed in Meteorological Research Institute. One of the most important features of CTM is that a chemical module is directly coupled with the MRI-JMA98 General Circulation Model (Shibata et al., 1999, figure 1) and can make use of several GCM parameters without temporal or spatial interpolation. The horizontal resolution is T42 (280km) and vertical resolution is 45 layers (from surface to 0.01hPa).

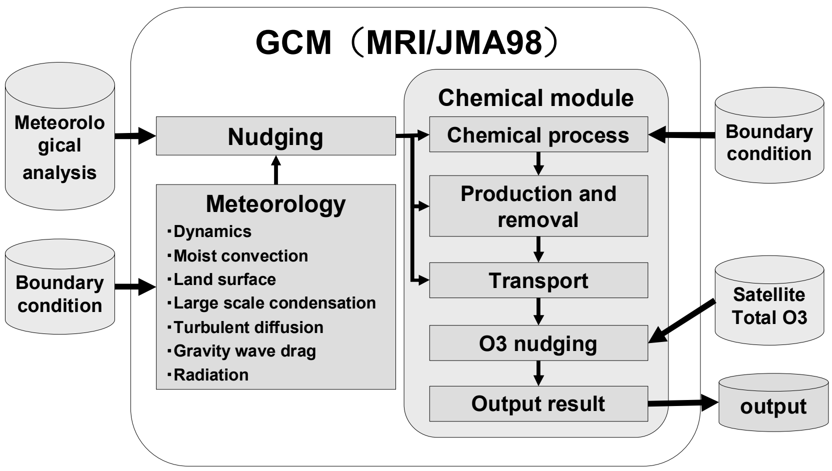

Figure 1 Structure of Chemical Transport Model (CTM)

The chemical module was developed in the Meteorological Research Institute (Shibata et al., 2005). The resolution of the CTM (and GCM) is T42L45. The chemical module is composed of chemical processes and a transport process. The chemical process is based on the family method and contains major stratospheric species, i.e., 34 long-lived species including 7 families and 15 short-lived species with 79 gas phase reactions and 34 photo-dissociations.

The GCM has a built-in, four-dimensional data assimilation system with a nudging scheme incorporating an assimilated meteorological field (ERA-15, ECMWF operational analysis and JMA operational analysis). Also the CTM has a nudging system which could assimilate total ozone obtained once a day by several satellites. The weight of the model guess and satellite data are determined by the root mean square error against the surface observational data. Used data are shown in table 1.

Table 1 Adopted data in producing daily O3

Data type	Data name	Remarks
Meteorological Field	ERA-15	1979.1 – 1992.12
	ECMWF (operational)	1993.1 – 2002.8
	JMA (operational)	2002.8 – 2004.12
	CIRA-86	
Satellite Observation	TOMS	First priority
	SBUV (bias corrected)	Second priority
	TOVS (bias corrected)	Third priority
Ozone profile data	AMIP climatology	
	Analyzed climatology	Vertical profile from SAGE II

We could use satellite data almost every day. But, the satellite data coverage ratio reduced from 1993 to 1996 (Figure 2). During this period, we could only use SUBV or TOVS data.

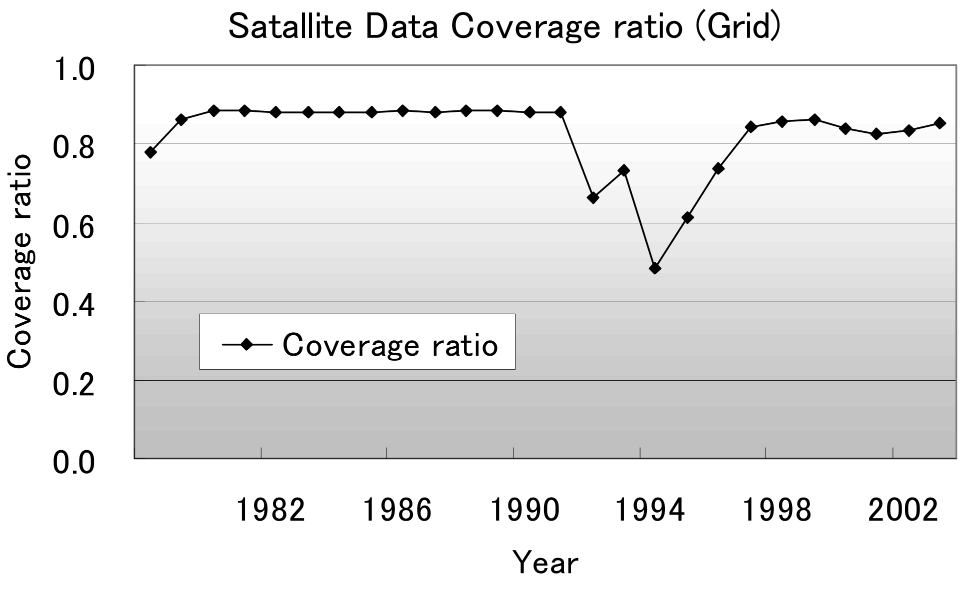

Figure 2 Satellite Observational data coverage ratio according to the number of model grids.

At first step, we add only prepared Cl boundary condition to CTM. We call this as calculation A. The simulated ozone field show smaller and lower ozone peak concentration and higher ozone concentration in the troposphere comparing with the climatology and observation. According to these results, we add Br boundary condition, tropospheric ozone destruction and vertical profile nudging scheme to calculation A. We call this as calculation B. This calculation resolves almost all problems of calculation A. But we found another problem that total column ozone tends to reduce in this revision. Therefore, we enhanced satellite nudging ratio and we define this version as calculation B2.

RESULTS

The simulated total column ozone amount shows good agreement with satellite observation (Figure 3). We can obtain ozone distribution even in lack of observational area.

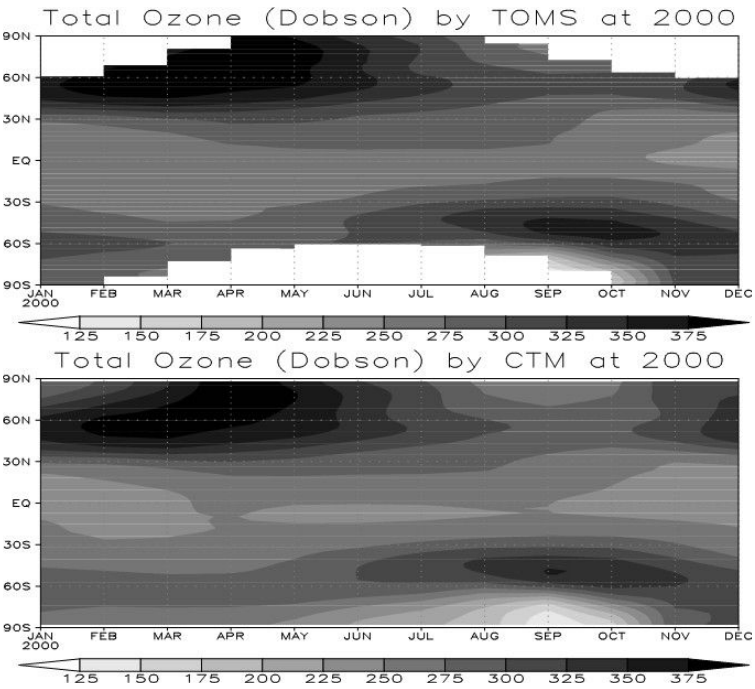

Figure 3 Comparison with satellite observation

But, we could find some problems in vertical profile of ozone concentration shown in figure 4.

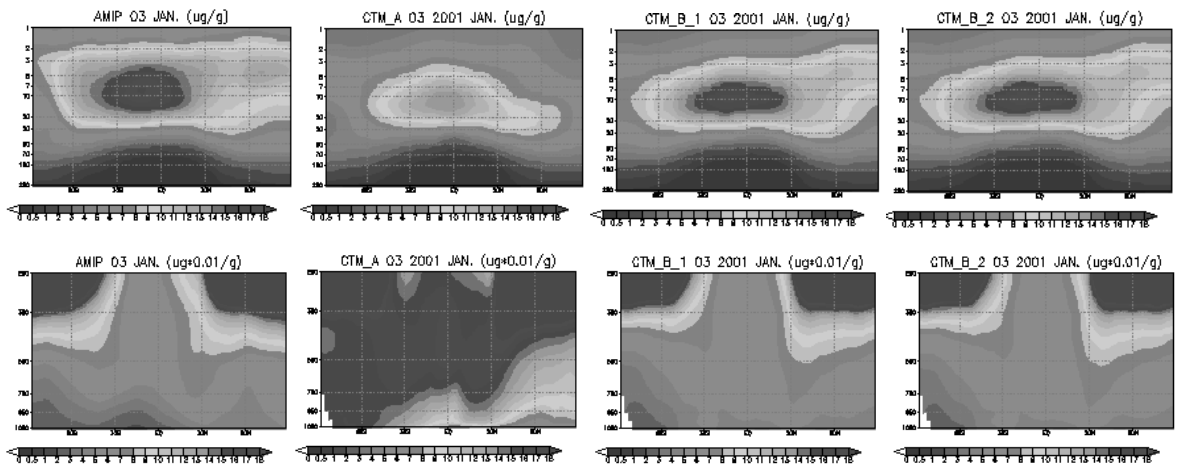

Figure 4 Vertical profiles of ozone concentrations. First row shows stratospheric concentrations and second row shows tropospheric one. Left column shows AMIP climatology, second left column shows calculation A, second right column shows calculation B and right column shows calculation B2.

We can easily know that the calculation A shows some problems. First, the ozone peak concentration is too low comparing with AMIP climatology. Second, the ozone concentration at stratosphere is too low. Third, Tropospheric ozone concentration is too high. We can see that the calculation B almost solves these problems. But the total column ozone amount tends to reduce. Therefore, we enhance satellite nudging ratio and call this as calculate B2. Considering these points and suitability for our global model radiation scheme, ozone field of calculation B2 is adopted in JRA-25. We also provide monthly 3D ozone climatology using this method to JMA operational global forecast model.

Figure 5 shows time serious of total column ozone comparing against satellite data in each latitudinal zone. The biases of simulated total O3 are remarkably reduced in 1993 – 1997. The data availability rate is relatively low exactly in this period comparing to the other period (Figure 2). The low total O3 bias in the tropics may come from the ozone reduction scheme in the lower troposphere. This scheme was adopted to avoid high ozone tendency of CTM in the lower troposphere. We consider that we can reduce such bias by using less biased CTM. We could find that the simulated total column ozone amount tend reduce especially in the tropics during calculated period. This may come from Cl and Br boundary condition which we have introduced.

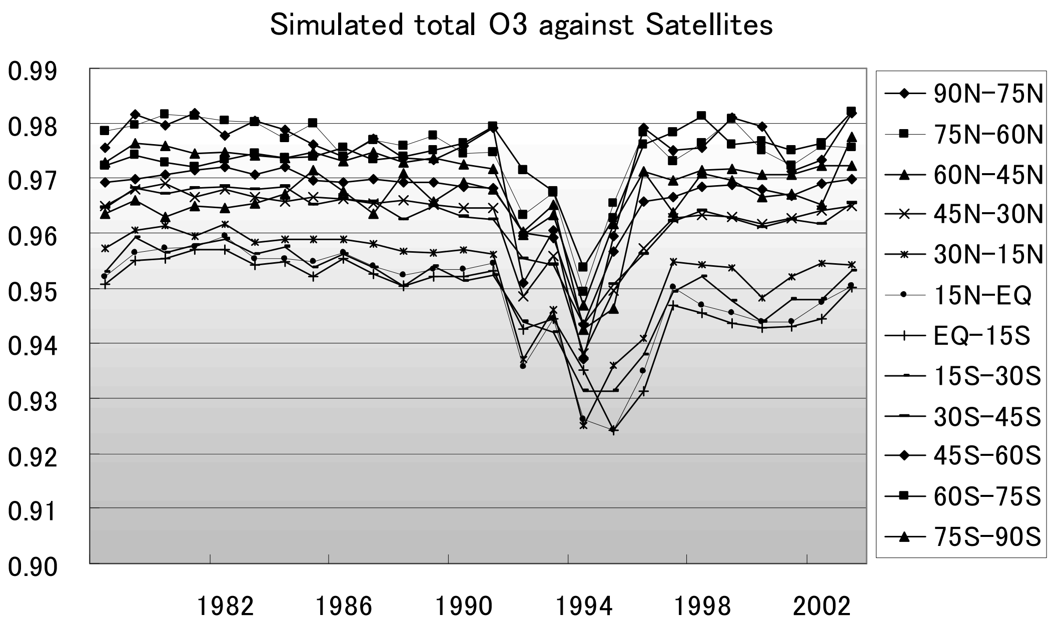

Figure 5 Total column ozone bias against satellite observational data

SUMMARY

We have produced a daily 3D ozone field from 1979 to 2004 with CTM, satellite data and meteorological analysis. We made use of TOMS, SBUV and TOVS satellite observational data. The calculated ozone field could reproduce rational ozone distribution even in lack of observational data area. The calculated total column ozone tends to smaller than satellite observational data. This tendency consists of data coverage ratio. Comparing with AMIP climatology, the ozone field tends to show a larger ozone peak and lower concentration at upper stratosphere. The ozone peak position tends to little lower comparing against ozone sonde observation. The precision of ozone data tend to reduce from 1993 to 1996 (satellite missing period).

We have some plans to modify our ozone field to prepare next re-analysis. First, we have a plan to use revised CTM developed in MRI. We consider this can improve vertical profile of ozone field. Second, we have a plan to correct other satellite observational data (especially from 1993 to 1996). We think this can avoid the ozone reduction at this period. Finally, we have a plan to modify ozone assimilation scheme. We consider this will improve ozone distribution at all area.

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