6.3 Ocean Data Assimilation System

JMA has been operating an ocean data assimilation system (ODAS) since 1995 for the monitoring of El Niño and the Southern Oscillation (ENSO). The ODAS consists of an ocean general circulation model (OGCM) and an objective analysis scheme. The details of the ODAS are described in Kimoto et al. (1997). In July 2003, the analysis scheme of the ODAS was revised. The system is introduced briefly below.

6.3.1 Ocean General Circulation Model

The OGCM follows Bryan (1969) for its dynamical framework. The horizontal resolution is 2.0° latitude and 2.5° longitude except for the 20°S-20°N band, where the latitudinal grid spacing decreases to the minimum of 0.5° between 10°S and 10°N (see Fig. 6.3.1).

The model has 20 vertical levels, 15 of which are placed above 400 meters (see Fig. 6.3.2). The model has realistic bottom topography, but the maximum depth of the bottom is set to 4000 meters. The computational domain is global, excluding the Arctic Ocean.

Included in the physical schemes of the model are nonlinear horizontal diffusion (Rosati and Miyakoda, 1988) and vertical mixing of the level 2.5 turbulence closure scheme (Mellor and Yamada, 1974). Currently, the sea ice is only crudely taken care of by setting a minimum value of sea water temperature (−1.5°C) at sea-ice grid points.

The wind stress, heat and fresh water fluxes to drive OGCM are calculated from JMA global atmospheric analysis (see 3.5) using the bulk formulae proposed by Bunker (1976).

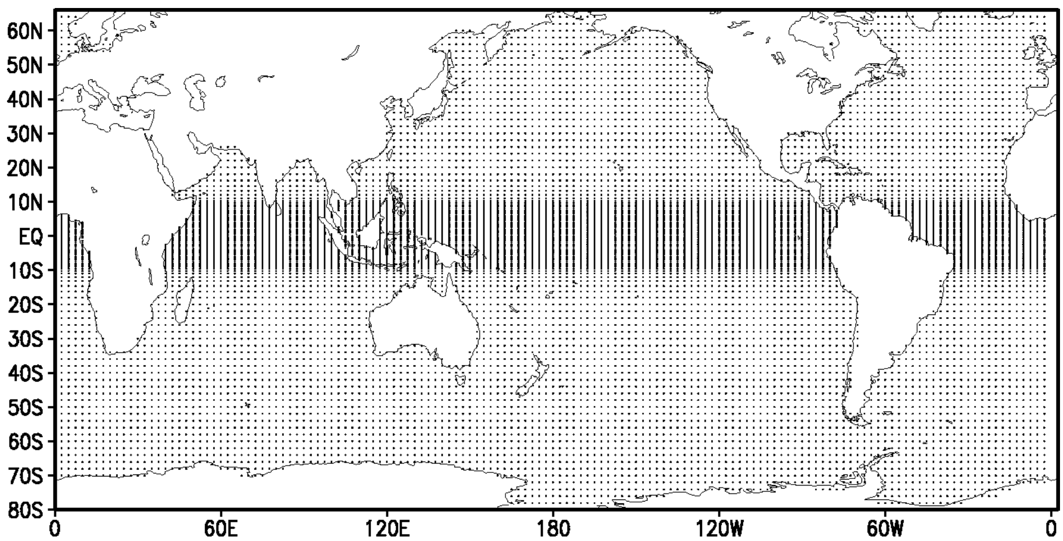

Fig. 6.3.1 The OGCM horizontal grids

6.3.2 Observations and data assimilation

JMA introduced a three-dimensional variational (3DVAR) analysis scheme based on Derber and Rosati (1989) in July 2003. In this scheme, not only temperature observations but also salinity observations and satellite altimeter data are assimilated, and the model integration incorporates the heat and fresh water fluxes. In situ observations reported from ships, moored and drifting buoys are obtained through the GTS and domestic communication systems. The SST analysis is made independently of the ODAS using buoy and ship observations (see 6.2) and is utilized to estimate temperatures of ocean upper layers. The data quality control and variational technique are described in Ishii et al. (2003).

Subsurface temperature and salinity fields are analyzed every day at levels above the 1000 meters depth with 3DVAR technique. Then the analyzed temperature and salinity data are assimilated to the model with incremental analysis update (IAU) scheme (Bloom et al., 1996). The OGCM is integrated with a delay of 35 days from the real time to allow the delayed observation data to be fed into the assimilation system. In addition, for the real time monitoring and ocean initials of the El Niño forecast model (see 6.4), the assimilation model is run every 5 days for the last 30 days with the in-situ observation data available over the integration period.

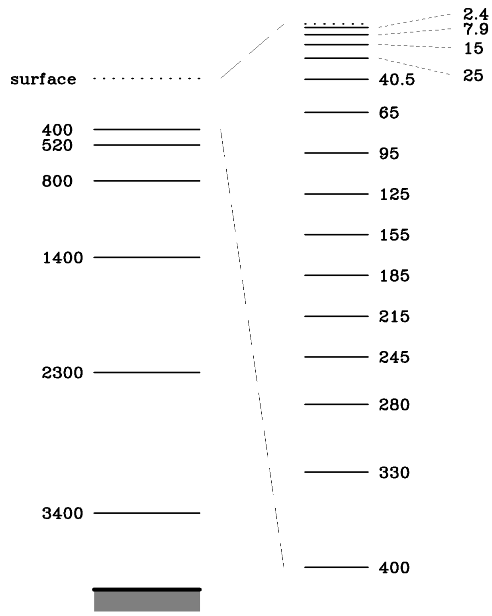

Fig. 6.3.2 The OGCM vertical levels which indicate depths in meter.

6.3.3 Products

The output from ODAS is used in various forms for the monitoring of ENSO at JMA, and some products for the equatorial Pacific region are distributed in a couple of publications, namely, "Monthly Report on Climate System" and "Monthly El Niño Monitoring Report". Fig. 6.3.3 is one of such charts of the ODAS, which shows the depth-longitude sections of temperature and its anomalies. The charts in the reports are also made available through JMA's Distributed Data Base (http://ddb.kishou.go.jp) and the Web page of Tokyo Climate Center (http://okdk.kishou.go.jp/index.html).

6.3.4 Future plan

JMA is now in process of introducing a new ocean data assimilation system which has been developed at Meteorological Research Institute (MRI)/JMA. The system is also composed of an OGCM and a variational analysis scheme. The OGCM is MRI community ocean model (MRI.COM) described in Ishikawa et al. (2005) and has a higher resolution of 1° latitude and 1° longitude and 50 vertical levels. The analysis scheme is a multivariate 3DVAR analysis with vertical coupled temperature-salinity empirical orthogonal function modal decomposition of background error covariance matrix (Usui et al., 2006).

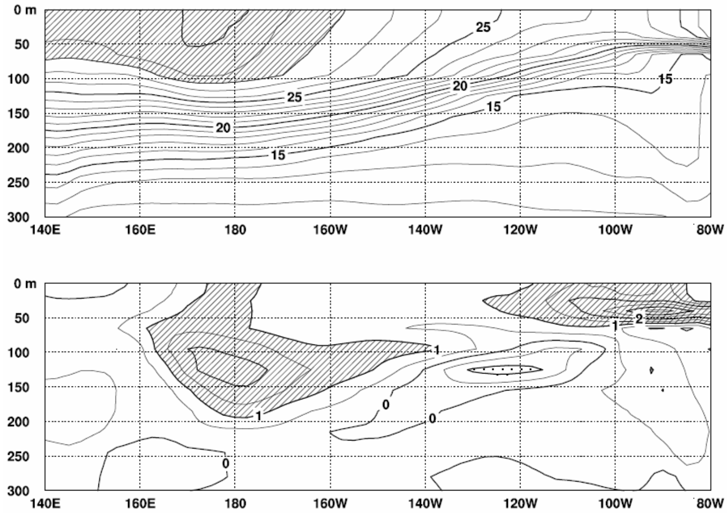

Fig. 6.3.3 Depth-longitude cross sections of monthly mean temperature and temperature anomalies along the equator in the Pacific Ocean for October 2006 by the ODAS. Base period for normal is 1987-2005. Dark shading indicates values higher than 28°C in the upper panel. Dark and light shadings indicate values higher than 1°C and lower than −1°C, respectively in the lower panel.

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.

Bryan, K., 1969: A numerical method for the study of the circulation of the world ocean. *J. Comput. Phys*., **4**, 347–376.

Bunker, A.F., 1976: Computations of surface energy flux and annual air-sea interaction cycles of the North Atlantic Ocean. *Mon. Wea. Rev.*, **104,** 1122–1140.

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

Ishii, M., M. Kimoto, and M. Kachi, 2003: Historical Surface Temperature Analysis with Error Estimates. *Mon. Wea. Rev.,* **131**, 51–73.

Ishikawa, I., H. Tsujino, M. Hirahara, H. Nakano, T. Yasuda, and H. Ishizaki, 2005: Meteorological Research Institute Community Ocean Model (MRI.COM) manual. *Technical Reports of the Meteorological Research Institute,* **47**, 189pp.

Kimoto, M., I. Yoshikawa, and M. Ishii, 1997: An ocean data assimilation system for climate monitoring. *J. Meteor. Soc. Japan,* **75**, 1–16.

Mellor, G.L. and T. Yamada, 1974: A hierarchy of turbulence closure models for planetary boundary layers. *J. Atmos. Sci.,* **31**, 1791–1806.

Rosati, R.K. and K. Miyakoda, 1988: A general circulation model for upper ocean simulation. *J. Phys. Oceanogr.*, **18**, 1601–1626.

Usui N., S. Ishizaki, Y. Fujii, H. Tsujino, T. Yasuda, and M. Kamachi, 2006: Meteorological Research Institute multivariate ocean variational estimation (MOVE) system: Some early results. *Advances in Space Res.,* **37**, 806–822.