

4D-VAR Ocean State Estimation

November 1, 2010

Revision Date: October 22, 2015

■ Name of data set and the abbreviated name

Name: Estimated state of ocean for climate research

Abbreviation: ESTOC

■ Data Overview

Our 4D-VAR data synthesis system is developed as a part of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC)-Kyoto University collaborative program (known as "the K7 consortium"). The Ocean General Circulation Model is version 3 of the GFDL Modular Ocean Model (MOM3), which is equipped with several sophisticated schemes; e.g., Noh scheme for mixed layer physics, the Gent and McWilliams (GM) scheme for isopycnal mixing, and quicker advection scheme. The horizontal resolution is 1° in both latitude and longitude, with 46 vertical levels spaced from 10 m near the sea surface to 400 m at the bottom. This model is better able to reproduce ocean circulation processes and is expected to form a platform suitable for the use of the 4D-VAR adjoint model.

4D-VAR adjoint data assimilation approach is applied. The adjoint codes of the OGCM were obtained using the Tangent linear and Adjoint Model Compiler (TAMC) and the Transformation of Algorithms in Fortran (TAF). In the 4D-VAR approach, optimized 4-dimensional datasets are sought by minimizing a cost function.

Physical parameters:

The assimilated elements in this study are temperature and salinity from ENSEMBLES (EN3) dataset which was quality controlled using a comprehensive set of objective checks developed at the Hadley Centre of the UK Meteorological Office. This dataset is largely composed of observations from the World Ocean Database 2005 and supplemented by data from the GTSP (Global Temperature and Salinity Profile Program) and Argo autonomous profiling floats. In addition of EN3 dataset, recent independent MIRAI RV profiles are simultaneously synthesized. Sea-surface dynamic-height anomaly data derived from high-precision multi-satellite altimetry products distributed by Aviso is also incorporated. All observational data were averaged onto 1° by 1° bins and then compiled as series of 10-day means for the surface data and monthly means for the subsurface data. The control variables are surface fluxes (for net-heat, fresh water, and momentum) and oceanic initial conditions. The assimilation window is 53 years during 1957-2009.

Biogeochemical parameters:

The synthesis of available observations and a pelagic ecosystem model based on nitrogen cycle produces a dynamically self-consistent dataset. Optimized 4-dimensional datasets are sought by minimizing a cost function on the basis of Green's function approach. The assimilated elements are the climatological monthly mean nitrate from WOA05, monthly mean ocean color data from SeaWiFS, and annual mean chlorophyll-a from WOA98 as detritus.

■ Dataset release date

October 7, 2014

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■ References to be cited

Please cite as follows:

Masuda, S., T. Awaji, N. Sugiura, J. P. Matthews, T. Toyoda, Y. Kawai, T. Doi, S. Kouketsu, H. Igarashi, K. Katsumata, H. Uchida, T. Kawano, M. Fukasawa (2010), Simulated Rapid Warming of Abyssal North Pacific Waters, *Science*, 329, 319-322, DOI, 10.1126/science.1188703.

Kouketsu, S., T. Doi, T. Kawano, S. Masuda, N. Sugiura, T. Toyoda, H. Igarashi, Y. Kawai, K. Katsumata, H. Uchida, M. Fukasawa, and T. Awaji (2011), Deep ocean heat content changes estimated from observation and reanalysis product and their influence on sea level change, *J. Geophys. Res.*, 116, C03012, doi: 10.1029/2010JC006464.

Masuda, S., T. Doi, N. Sugiura, S. Osafune, and Yoichi Ishikawa (2013), Data Synthesis for Biogeochemical Variables by Using a 4 Dimensional Variational Approach, Earth Simulator annual report 2012.

■ Available Products

Variables, abbreviations	Potential temperature [$^{\circ}\text{C}$], Salinity [PSU], Horizontal velocity u [m/s] v [m/s], Surface heat flux [$\text{cal}/\text{m}^2/\text{s}$], Surface freshwater flux [m/s], Wind stress τ_x [N/m^2] τ_y [N/m^2], Nitrate [$\mu\text{mol}/\text{L}$], Phytoplankton [$\mu\text{mol}/\text{L}$], Detritus [$\mu\text{mol}/\text{L}$], Zooplankton [$\mu\text{mol}/\text{L}$], Dissolved inorganic carbon [$\mu\text{mol}/\text{kg}$],	tmp sal vel shf sff tau no3 pht det zoo dic
Region	Quasi-global (75°S - 80°N)	
Resolution	Horizontal $1^{\circ}\times 1^{\circ}$, Vertical 46 levels	
Period	1957-2009 (Ver. 01a)	
File format	Monthly data in netcdf format: “k7oda_[XXX]_[YYYY][MM]00_[VVV].nc” where “[XXX]” is model variable, “[YYYY]” year, “[MM]” month, and “[VVV]” version, respectively.	

■ Reference URL

- K7 Database
<http://www.jamstec.go.jp/frcgc/k7-dbase2/eng/index.html>
- K7 Ocean State Estimate based on 4D-VAR Ocean Data Assimilation
http://www.jamstec.go.jp/frcgc/k7-dbase2/eng/datadoc/k7ra_ocean.html
- Data and Sample Research System for Whole Cruise Information in JAMSTEC
<http://www.godac.jamstec.go.jp/darwin/e>
- Japan Argo Delayed-mode Data base
http://www.jamstec.go.jp/ARGO/argo_web/argo/?lang=en