

## 4D-VAR Ocean State Estimation

March 31, 2022

### ■ Name of data set and the abbreviated name

**Name:** Estimated state of ocean for climate research

**Abbreviation:** ESTOC

### ■ Data Overview

This version of dataset is an updated version of dataset shown by Osafune et al. (2015) (see them for more details). Our four-dimensional variational (4D-VAR) data synthesis system, which consists of an ocean circulation model, its adjoint and an optimization system, is based on a system 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 (OGCM) is version 3 of the GFDL Modular Ocean Model (MOM3) [1], which is equipped with several sophisticated schemes; e.g., Noh scheme for mixed layer physics [2], the Gent and McWilliams (GM) scheme for isopycnal mixing [3], and quicker advection scheme. In this version, we have implemented two tidally-induced vertical mixing using the tidal energy distribution [4,5], and geothermal effect [6]. Major physical parameter values are determined through a variational optimization procedure [7]. The horizontal resolution is  $1^\circ$  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.

Physical parameters:

4D-VAR adjoint data assimilation approach is applied [8,9]. The adjoint codes of the OGCM were obtained using the Tangent linear and Adjoint Model Compiler (TAMC) [10] and the Transformation of Algorithms in Fortran (TAF) [11]. In the 4D-VAR approach, optimized 4-dimensional datasets are sought by minimizing a cost function [12,13].

The assimilated elements in this dataset are subsurface temperature and salinity, Sea-surface Temperature (SST). The subsurface data is from EN4 dataset which was quality controlled using a comprehensive set of objective checks developed at the Hadley Centre of the UK Meteorological Office [14]. This dataset is largely composed of observations from the World Ocean Database 2009 [15] and supplemented by data from the GTSP (Global Temperature and Salinity Profile Program) and Argo autonomous profiling floats [16]. The SST data is from Reynolds and OISST. All observational data were averaged onto  $1^\circ$  by  $1^\circ$  bins and then compiled as series of 10-day means for the SST and monthly means for the subsurface data. The control variables are surface fluxes (for net-heat, fresh water, and momentum), oceanic initial conditions, and six parameters in the tidally-induced mixing schemes. The assimilation window is 58 years during 1957-2014. The energy dissipation rate observation data are experimentally assimilated, but no significant cost reduction has been confirmed.

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 [4]. 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.

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#### ■ Dataset release date

March 31, 2022

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#### ■ Data Citation

Please cite the following data and papers. “YYYY-MM-DD” is date of access.

Satoshi Osafune, Toshimasa Doi, Shuhei Masuda, Nozomi Sugiura, Tadashi Hemmi (2014)  
Estimated state of ocean for climate research (ESTOC). JAMSTEC. doi:10.17596/0000106  
(accessed YYYY-MM-DD)

Osafune, S., S. Masuda, N. Sugiura, T. Doi (2015) Evaluation of the applicability of the Estimated State of the Global Ocean for Climate Research (ESTOC) data set, *Geophys. Res. Lett.*, 42, 12, 4903–4911.

#### ■ Reference papers

Osafune, S., S. Masuda, N. Sugiura, T. Doi (2015) Evaluation of the applicability of the Estimated State of the Global Ocean for Climate Research (ESTOC) data set, *Geophys. Res. Lett.*, 42, 12, 4903–4911.

Doi, T., S. Osafune, N. Sugiura, S. Kouketsu, A. Murata, S. Masuda, and T. Toyoda (2015) Multi-decadal change in the dissolved inorganic carbon in a long-term ocean state estimation, *Journal of Advances in Modeling Earth Systems*, 7, 4, 1885–1990.

#### ■ Available Products

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Variables, abbreviations	Potential temperature [°C],	tmp
	Salinity [PSU],	sal
	Horizontal velocity u[m/s] v[m/s],	vel
	Surface heat flux [cal/m <sup>2</sup> /s],	shf
	Surface freshwater flux [m/s],	sff
	Wind stress τ <sub>x</sub> [N/m <sup>2</sup> ] τ <sub>y</sub> [N/m <sup>2</sup> ],	tau
	Vertical diffusivity for Pot. Temp. [m <sup>2</sup> /s],	kzt
	Vertical diffusivity for Sal. [m <sup>2</sup> /s],	kzs
	Nitrate [μmol/L],	no3

	Phytoplankton [ $\mu\text{mol/L}$ ], Zooplankton [ $\mu\text{mol/L}$ ], Detritus [ $\mu\text{mol/L}$ ], Dissolved inorganic carbon [ $\mu\text{mol/kg}$ ], Dissolved Oxygen [ $\mu\text{mol/L}$ ],	pht zoo det dic oxy
Region	Quasi-global (75°S-80°N)	
Resolution	Horizontal 1°x1°, Vertical 46 levels	
Period	1957-2014 (Ver. 04a)	
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](http://www.jamstec.go.jp/frcgc/k7-dbase2/eng/datadoc/k7ra_ocean.html)
- Data and Sample Research System for Whole Cruise Information in JAMSTEC (DARWIN)  
<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](http://www.jamstec.go.jp/ARGO/argo_web/argo/?lang=en)

#### ■ Update History

2022-03-31 Biogeochemical parameters of Ver.04a were supplemented  
2020-04-20 Ver.04a has been published.