4D-VAR Ocean State Estimation

October 13, 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, two tidally-induced vertical mixing using the tidal energy distribution [4,5] are used for interior mixing below the surface mixed layer, and geothermal effect [6] is taken into account. Major physical parameter values are determined through a variational optimization procedure [7]. The horizontal resolution is 1^{o} 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 GTSPP (Global Temperature and Salinity Profile Program) and Argo autonomous profiling floats [16]. The SST data is from Reynolds and OISST, and SSHA data is derived from high-precision multi-satellite altimetry products distributed by Copernicus Marine Service. The GMSL data is monthly data until 2013, which is reconstructed based on Church and White (2011) and published by Ocean and Atmosphere unit in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (http://www.cmar.csiro.au/sealevel/sl_data_cmar.html). All observational data except for GMSL were averaged onto 1^{o} by 1^{o} bins and then compiled as series of 10-day means for the SST and SSHA data and monthly means for the subsurface and GMSL data. The control variables are surface fluxes (for net-heat, fresh water, and momentum), oceanic initial conditions, and five parameters in the tidally-induced mixing schemes. The assimilation window is 60 years during 1957-2016. The energy dissipation rate observation data are experimentally assimilated,

but no significant cost reduction has been confirmed.

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■ Dataset release date

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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. Kouketsu, T. Doi, N. Sugiura, S. Masuda (2022) A global ocean state estimation using tidally induced vertical-mixing schemes, Ocean Modelling, 179, 2022, 202111, doi:10.1016/j.ocemod.2022.102111

■ 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

Variables, abbreviations	Potential temperature [^{o}C],	tmp
	Salinity [PSU],	sal
	Horizontal velocity u[m/s] v[m/s] w[m/s],	vel
	Surface heat flux [cal/m^2/s],	shf
	Surface freshwater flux [m/s],	sff
	Wind stress τx[N/m^2] τy[N/m^2],	tau
	Vertical diffusivity for Pot. Temp. [m^2/s]	cbt1
	Vertical diffusivity for Sal. [m^2/s]	cbt2
Region	Quasi-global (75^{o}S-80^{o}N)	
Resolution	Horizontal 1^{o}x1^{o}, Vertical 46 levels	

Period	1957-2016 (Ver. 05a)
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 (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