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Data Article

# Historical CTD dataset and associated processed dissipation rate using an improved Thorpe method in the Indonesian seas

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ABSTRACT

In this article, we present the datasets which are used to estimate the turbulent kinetic energy dissipation rates and vertical diffusivity in the Indonesian seas. An archived CTD (conductivity, temperature, depth) datasets collected between 1990 and 2016 with 1 m vertical resolution is presented and analyzed using an improved Thorpe method. The direct estimates dataset of the dissipation rate from two research expeditions, i.e., INDOMIX Program in 2010 and TOMTOM Program in 2015 were also presented, available to be compared with the indirect estimates from CTD profiles. We also present the dissipation rate output of three recent regional internal tide models in the Indonesian seas for comparison with microstructure measurements and improved Thorpe estimates. The datasets refer to "Spatial structure of turbulent

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mixing inferred from historical CTD datasets in the Indonesian seas" [1].



## Specifications table

| | |
|---|---|
| Subject | Earth and Planetary Sciences: Oceanography |
| Specific subject area | Physical Oceanography |
| Type of data | Table |
| How data were acquired | (1) CTD (conductivity, temperature depth) dataset: Seawater properties (temperature, depth, salinity) were measured using Seabird Electronics instruments.<br>(2) Microstructure measurements: Dissipation rate estimates were inferred from measured shear using vertical microstructure profiler (VMP) by Rockland Scientific Ltd.<br>(3) Thorpe scale analysis output: the output of the analysis was obtained after applying overturn selection criterion and equations of turbulent mixing.<br>(4) Nagai 2015 Model: the vertical profile of dissipation rate were deduced from 3D hydrostatic MITGCM with 1/100° horizontal resolution and resampled at 0.5° spatial resolution.<br>(5) Nagai 2017 Model: the vertical profile of dissipation at 3 stations in the Halmahera Sea from 3D non-hydrostatic MITGCM model.<br>(6) Nugroho 2018 Model: the vertical profile of dissipation rate at 5 stations from 3D hydrostatic model NEMO 2.3 for the Indonesian seas region (INDESO Project) with 1/12° horizontal resolution. |
| Data format | Raw<br>Analyzed |
| Parameters for data collection | The CTD datasets contains information of station positions (longitude, latitude), temperature and salinity at specified depths. The dissipation rates dataset from both microstructure measurements and model contains information of station positions and dissipation rates ($m^2s^{-3}$) values at certain depths. The Thorpe scale analysis output contains various information related to mixing properties (Thorpe vertical displacements, overturn selection criterion, buoyancy frequency, dissipation rate and vertical diffusivity). |
| Description of data collection | The CTD datasets were acquired from various research expeditions directed by Research Center for Oceanography- Indonesian Institute of Sciences (RCO-LIPI), Indonesian Ministry of Marine Affairs and Agency for the Assessment and Application of Technology (BPPT) under the supervision of Indonesian Minister of Research and Technology. Some of the CTD dataset outside Indonesian territorial waters are available and are freely downloadable from the World Ocean Database (WOD). The microstructure measurements were acquired during INDOMIX 2010 expedition a joint Research between Indonesia and French; and during TOMTOM 2015 expedition, a joint research between French and Australia. |
| Data source location | Institution: Research Center for Oceanography-Indonesian Institute of Sciences (RCO-LIPI) and LOCEAN-Sorbonne University<br>City/Town/Region: Jakarta and Paris<br>Country: Indonesia and France<br>Latitude and longitude for collected data: [100°–138° E, 13° N-13° S] |

(*continued on next page*)

| | |
|---|---|
| Data accessibility | Repository name: Mendeley Data<br>Data identification number: 01<br>Direct URL to data:<br><br>(1) Historical CTD Dataset<br>https://data.mendeley.com/datasets/4ysksfvtyw/draft?a=1c781591-21cb-4e1d-a3df-2dcef6b3c79d<br>(2) Selected World Ocean Dataset (WOD) CTD profiles<br>https://data.mendeley.com/datasets/tgfsb766vr/draft?a=542e9320-a3a8-48de-9aba-625b62f427e9<br>(3) Thorpe Scale Output<br>https://data.mendeley.com/datasets/nndbfdc96j/draft?a=173c6a14-2321-4adb-bc16-5abece4726cb<br>(4) Microstructure INDOMIX 2010<br>https://data.mendeley.com/datasets/pnpty39v4t/draft?a=79c878c1-8a46-475f-8cb4-aa82d3872976<br>(5) Microstructure TOMTOM 2015<br>https://data.mendeley.com/datasets/ybch479j8h/draft?a=488d639c-1860-4227-917d-eabf4ac576b1<br>(6) Nagai 2015 Model<br>https://data.mendeley.com/datasets/b2djdt3bmy/draft?a=a90e0ec3-e3f2-43db-a459-d0746ffa39a2<br>(7) Nagai 2017 Model<br>https://data.mendeley.com/datasets/9f9krnjxrr/draft?a=d7d19916-9c7f-4f7a-8c79-eff346813841<br>(8) Nugroho 2018 Model<br>https://data.mendeley.com/datasets/kcm8bdjpgy/draft?a=c8b1b296-c9ca-40f4-b98b-7ed176e455ca<br>(9) Gridded 0.5° dissipation rate and diffusivity https://data.mendeley.com/datasets/s5xd2hry83/draft?a=5d5f18cb-b7d5-4e64-8956-14773e8c209d<br>(10) Thorpe Analysis scripts<br>https://data.mendeley.com/datasets/b64669fjg7/draft?a=1bf72908-4ccd-4bd1-bd64-8f7a710f96e5 |
| Related research article | Purwandana, A., Cuypers, Y., Bouruet-Aubertot, P., Nagai, T., Hibiya, T., Atmadipoera, A.<br>Spatial structure of turbulent mixing inferred from historical CTD datasets in the Indonesian seas<br>Progress in Oceanography<br>DOI: https://doi.org/10.1016/j.pocean.2020.102312 |

## Value of the data

- The historical CTD datasets presented here were collected between 1990 and 2016, and most of them have never been published on the World Ocean Datasets (WOD) platform. The Thorpe estimates are presented based on a recent improved method. The turbulent kinetic energy dissipation rate from vertical microstructure profiler (VMP) observations presented here are the latest in situ observation on mixing estimates in the Indonesian seas (INDOMIX Program in 2010 and TOMTOM expedition in 2015). The model output of the dissipation rates presented here are the latest high-resolution regional model including tidal forcing in the Indonesian seas.
- The datasets on turbulent mixing in the Indonesian seas presented here are useful for oceanographers who want to analyze the seawater and mixing properties in the Indonesian seas as well as a proper input for any oceanography modeling related to oceanic mixing.
- The observed and modeled dissipation rates dataset presented here provide a baseline datasets to validate the representation of mixing in circulation models.

## 1. Data

(1.1) Historical CTD datasets
Seawater properties were collected using standardized instruments, CTD (conductivity, temperature, depth) probe. We consider only the CTD cast with vertical resolution higher than or equal to 1 m. The dataset consists of 822 geographically distributed single casts CTD profiles and hourly CTD cast in some sub-regions in the Indonesian seas (Sulawesi Sea/SLA, Makassar Strait/MAK, Flores Sea/FLO, Banda Sea/BAN, Maluku Sea/MAL, Lesser Sunda/LES). Please see Fig. 2 in [1] for the region map.

(1.2) Selected World Ocean Dataset (WOD)
The dataset consists of 1405 CTD casts sampled with CTD probe that can be downloaded from World Ocean Database (WOD) (https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html). We only consider the CTD casts with vertical resolutions greater or equal to 1 m.

(1.3) Thorpe scale output
The datasets contain the outputs from Thorpe scale analysis.

(1.4) Microstructure INDOMIX 2010
There are five stations of dissipation rate inferred from microstructure measurements sampled in the Halmahera Sea, Banda Sea and Ombai Strait (see Fig. 4 in [1]).

(1.5) Microstructure TOMTOM 2015
The dissipation rate profiles from three stations in the Timor Passage obtained using microstructure measurements are available for comparison (see Fig. 4 in [1]).

(1.6) A half degree grid of Thorpe estimates
The datasets contain a half-degree grids of dissipation rates and vertical diffusivities at several depth ranges: 50–300 m, 300–500 m, 500–800 m, 800–2000 m (Figs. 1 and 2).

(1.7) Nagai 2017 Model
The dissipation datasets from the 3D non-hydrostatic MITGCM with 1/600° horizontal resolution. Since the datasets only cover the Halmahera Sea region, there are only three vertical profiles corresponding to a spring-neap average in this region, which correspond to the microstructure measurements of the INDOMIX 2010 stations (see Fig. 4 in [1]).

(1.8) Nugroho 2018 model
The datasets contain dissipation rates inferred from 3D hydrostatic model NEMO 2.3 for the Indonesian seas region (INDESO Project) with 1/12° horizontal resolution. There are five vertical profiles of the dissipation rates presented in this dataset, which are located at the same location as the microstructure measurements of the INDOMIX 2010 (see Fig. 4 in [1]).

(1.9) Nagai 2015 model
The dissipation rate datasets were the output of 3D hydrostatic MITGCM with 1/100° that has been re-gridded at 0.5° horizontal resolution. The datasets covered entire Indonesian seas (see Fig. 3 for the horizontal grid and Fig. 4 in [1] for the vertical profiles at INDOMIX stations).

(1.10) Thorpe analysis scripts
The datasets contain some scripts to infer dissipation rates and diffusivities from CTD casts.

## 2. Experimental design, materials, and methods

(2.1) Historical CTD datasets and Selected World Ocean Dataset (WOD)
Seawater properties were collected using standardized instruments, CTD (conductivity, temperature, depth) probe. We consider only the CTD casts with vertical resolution higher than or equal to 1 m which allows us to detect a significant fraction of overturns related to turbulent events.

(2.2) Microstructure datasets (INDOMIX 2010 and TOMTOM 2015)

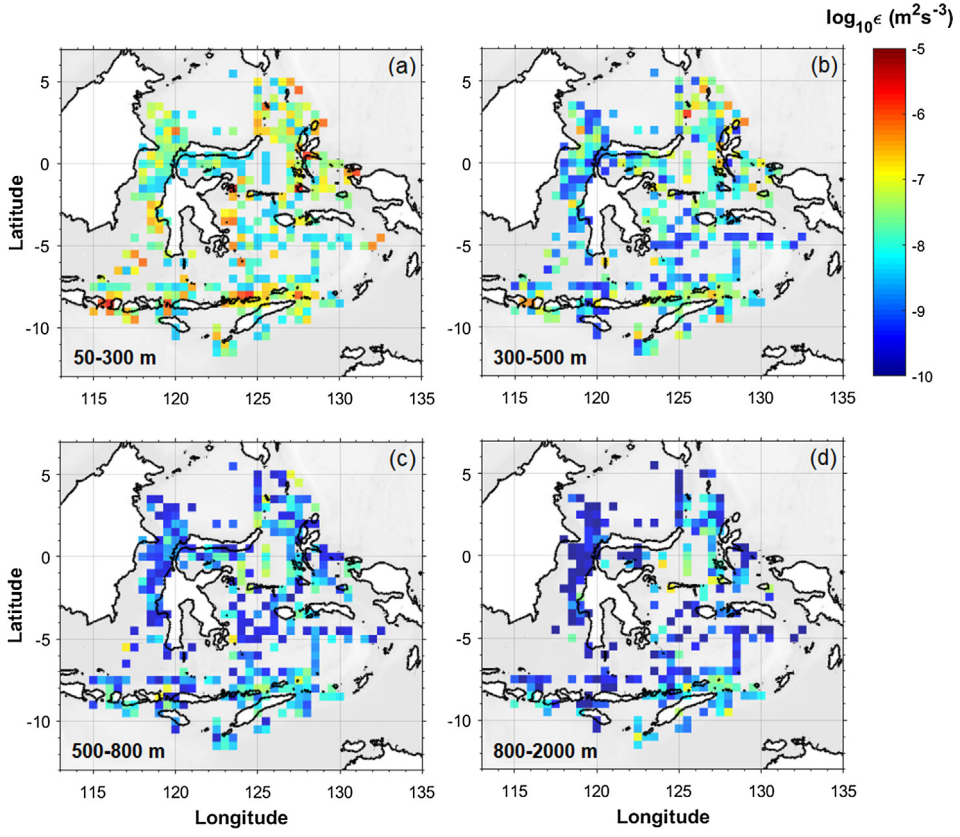


**Fig. 1.** A half degree grid mean of turbulent kinetic energy dissipation rates ($\varepsilon$, in $\log_{10}$ $m^2s^{-3}$) inferred from geographically distributed historical CTD datasets using improved Thorpe method proposed by Purwandana et al. [1] at (a) 50–300 m, (b) 300–500 m, (c) 500–800 m, (d) 800–2000 m.

There are five stations of dissipation rate inferred from microstructure measurements available to analyze, sampled in the Halmahera Sea, Banda Sea, Ombai Strait and Timor passage. The detail of processes to infer the dissipation rate from measured shear for the VMP of the INDOMIX 2010 was presented by Bouruet-Aubertot et al. [2].

(2.3) Nagai 2015 model

The modeled dissipation rates were inferred using 3D hydrostatic MITGCM with 1/100° horizontal resolution and 100 vertical levels with a spacing ranging from 5 m at the ocean surface to 1200 m at the maximum depth of 10,028 m. This high-resolution model covers the full Indonesian seas region but is forced by the dominant barotropic $M_2$ tides only and considers no initial horizontal gradient and velocity. The dissipation rate in this model is averaged over one tidal period once a quasi-steady state is achieved, that is after around 20 $M_2$ tidal periods. The detail of processes to infer the dissipation rate from the model was presented by Nagai and Hibiya [3].

(2.4) Nagai 2017 model

The dissipation rates were inferred from 3D non-hydrostatic MITGCM with 1/600° horizontal resolution. The model is forced by $M_2$, $S_2$, $N_2$, $K_2$ and ITF, this model is limited to the Halmahera Sea. The detail of processes to infer the dissipation rate from the model was presented by Nagai et al. [4].

(2.5) Nugroho 2018 model

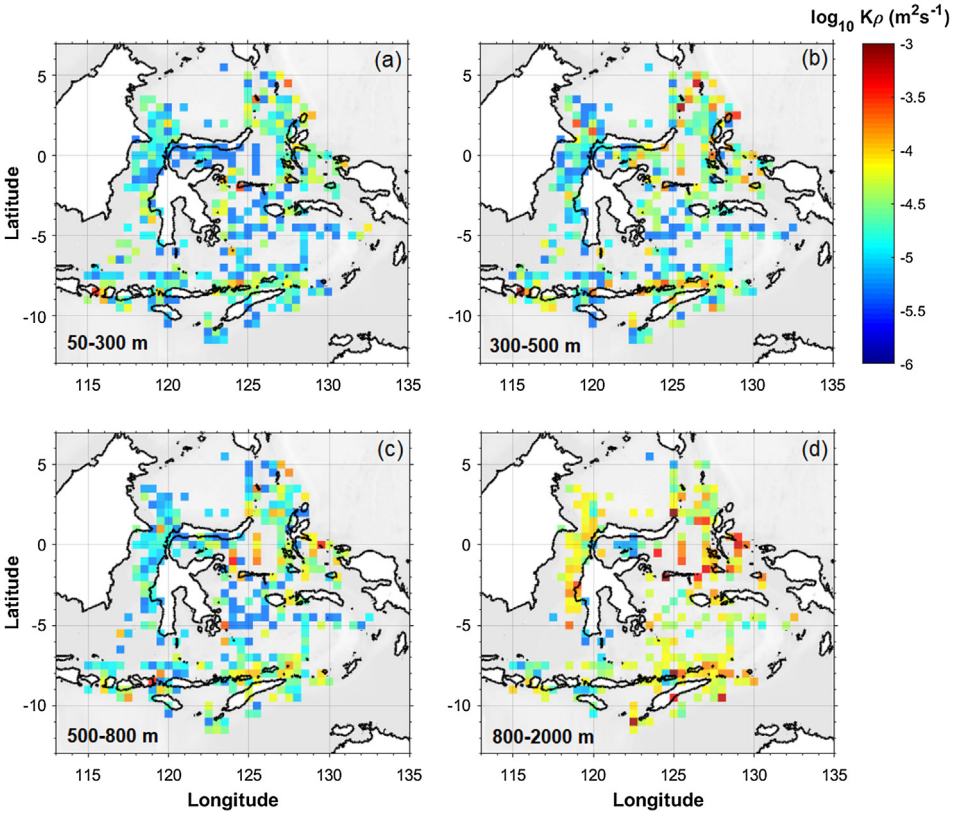


**Fig. 2.** A half degree grid mean of vertical diffusivity rates ($K_\rho$, in $\log_{10}$ $m^2s^{-1}$) inferred from geographically distributed historical CTD datasets using improved Thorpe method proposed by Purwandana et al. [1] at (a) 50–300 m, (b) 300–500 m, (c) 500–800 m, (d) 800–2000 m.

The dissipation rates inferred from 3D hydrostatic model NEMO 2.3 for the Indonesian seas region (INDESO Project) with 1/12° horizontal resolution. The model included atmospheric and geopotential tidal forcing $M_2$, $S_2$, $N_2$, $K_2$, $K_1$, $O_1$, $P_1$ and $Q_1$; started from January 3rd 2007 until December 31st 2011. The detail of processes to infer the dissipation rate from the model was presented by Nugroho et al. [5].

## Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgments

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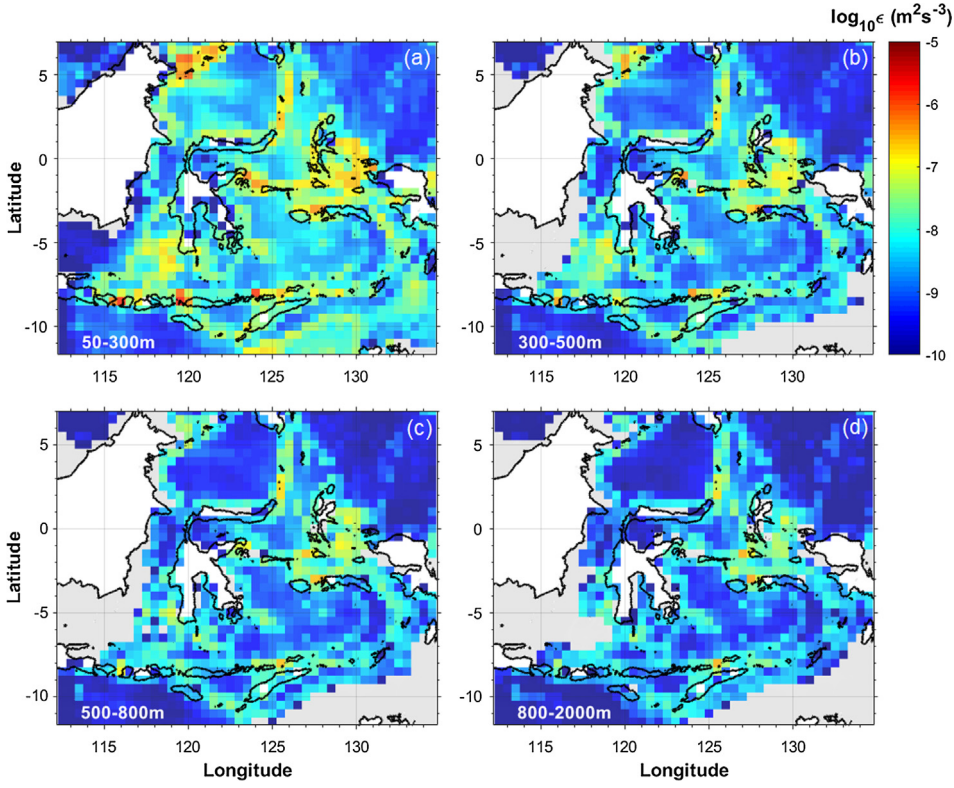


**Fig. 3.** A half degree grid mean of turbulent kinetic energy dissipation rates ($\varepsilon$, in $\log_{10}$ $m^2s^{-3}$) inferred from MITGCM by Nagai and Hibiya [3] at (a) 50–300 m, (b) 300–500 m, (c) 500–800 m, (d) 800–2000 m.

RCO-LIPI for helping us to prepare the Indonesian CTD datasets and Dr. Dwiyoga Nugroho from BRPL for preparing NEMO 2.3 INDESO output. We thank B. Sloyan and RV Solander crew for helping us to conduct the VMP measurements in the Timor passage as part of the IMOS Long-term monitoring of the Indonesian Throughflow and TOMTOM project. The publication of this research is supported by the funding scheme under the Deputy of Earth Sciences of the Indonesian Institute of Sciences (LIPI).

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