INDONESIAN THROUGHFLOW (ITF)

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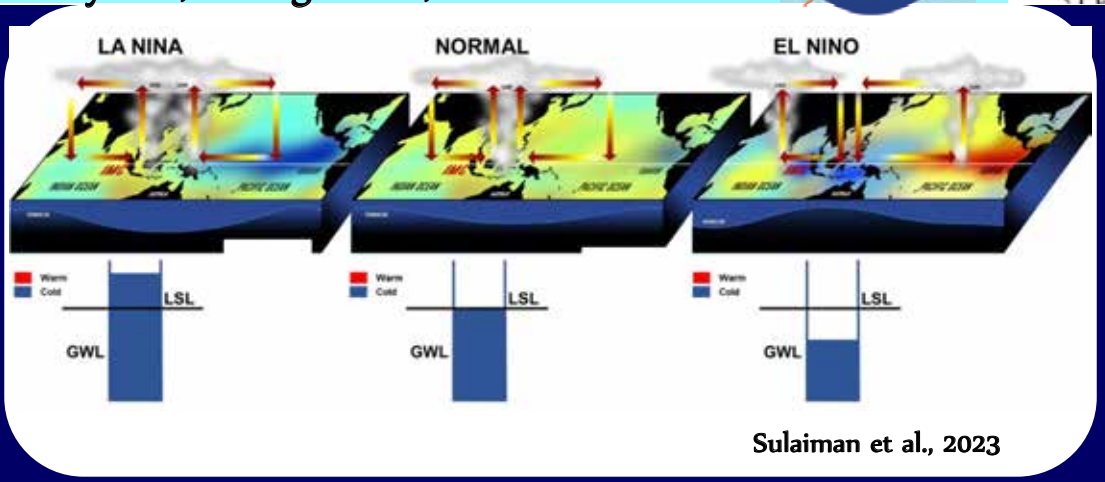


Sulaiman et al., 2023

- ✓ ITF influences heat and freshwater budgets
- ✓ ITF may couple with ENSO and monsoon phenomena, altering global ocean circulation and climate.
- ✓ Change in ITF magnitude is expected to alter the SST, and therefore altering the ocean-atmosphere fluxes.
- ✓ ~15 Sv of ITF water flushes the Indian Ocean thermocline waters, boosting transport of the Agulhas Current [by ~15%], increasing southward ocean heat flux across 20-30° S over the no-ITF condition, thus altering the meridional overturning of the Indian Ocean
- ✓ To get the ITF amplitude and variability right are challenge for numerical models.

- ITF magnitude & variability
- Heat & freshwater & biogeochemical fluxes associated with ITF
- Stratification & Mixing & Upwelling in the EIOURI

TRIUMPH: Throughflow Indonesian Seas, Upwelling & Mixing Physics

Multinational and multidiscipline collaborative program among scientists:

- Indonesian Institute of Sciences (LIPI) : Dr. Zainal Arifin and Dr. Augy Syahailatua
  now: Research and Innovation Agency (BRIN): Dr. Ocky Radjasa

- First Institute Oceanography (FIO)-China: Dr. Zexun Wei
- Univ of Maryland, College Park, USA : R. Dwi Susanto, PhD.

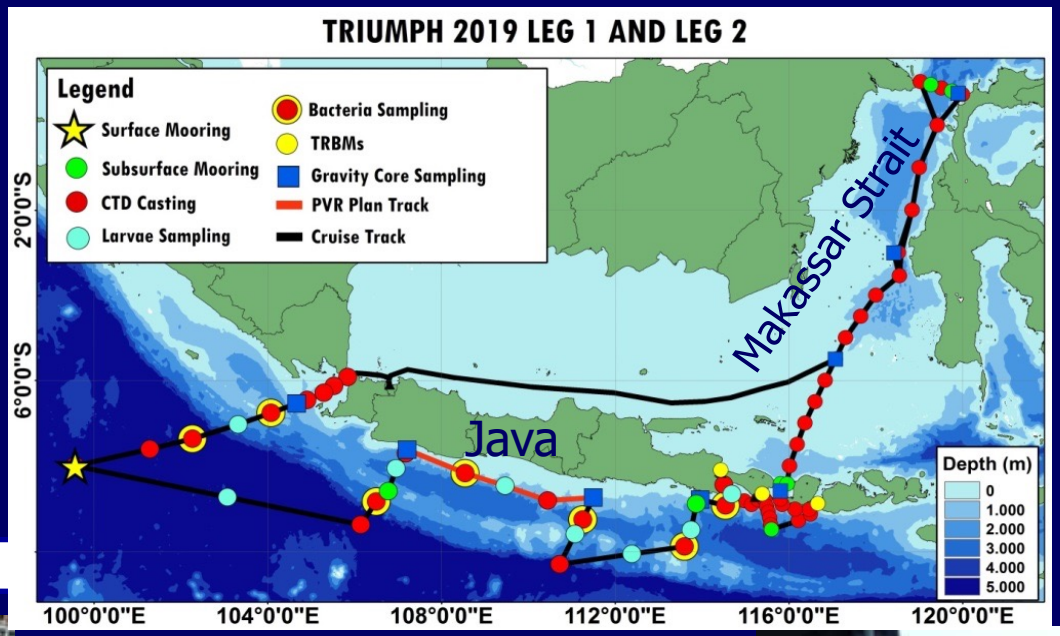
Multidisciplinary:

- ✓ Physical Oceanography: Throughflow/ITF and water properties, mixing, upwelling
- ✓ Biogeochemistry: Nutrients, Chlorophyll-a, Plankton, microplastics
- ✓ Fisheries : larva/bongo net
- ✓ Geology : sediment trap, sediment core
- ✓ Climate : monitoring IOD development
- ✓ Atmospheric science/air sea interaction: total aerosol depth

TRIUMPH: 1st CRUISE in 2019

Deployment of all surface and subsurface moorings, (two in north Makassar Strait, two in Lombok Strait, one in Alas Strait and three in Indian ocean), TRBMs, and carried out CTD/water sample, PCO2, plankton, biogeochemistry

Surface mooring



Sediment core

6 Subsurface Mooring

3 TRBMs

Microstructure

XCTD

54 Water sample Bacteria, microplastic, pCO2, biogeochemistry

Aerosol

By Dwi Susanto, onboard Baruna Jaya VIII

TRIUMPH: 2nd CRUISE in 2021

- ✓ Turn around recover and redeploy subsurface moorings in the Makassar and Lombok Strait
- ✓ Recover TRBMs in the Badung, Alas, and Bali Straits (failed)
- ✓ Replace the Alas Strait with short subsurface mooring
- ✓ Mixing cruise: south Lombok Strait
- ✓ No Upwelling cruise

6 Subsurface Mooring

3 TRBMs

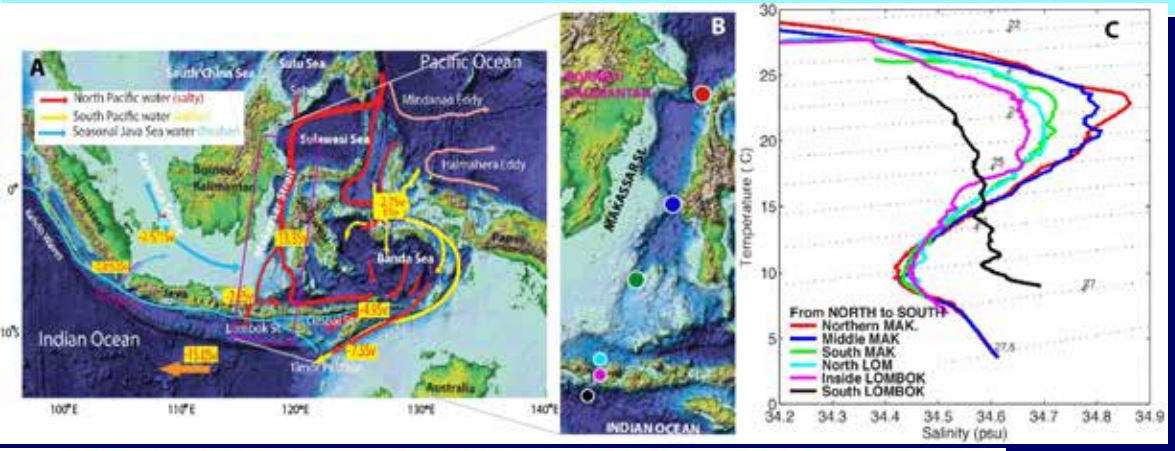
Microstructure

Sediment cor

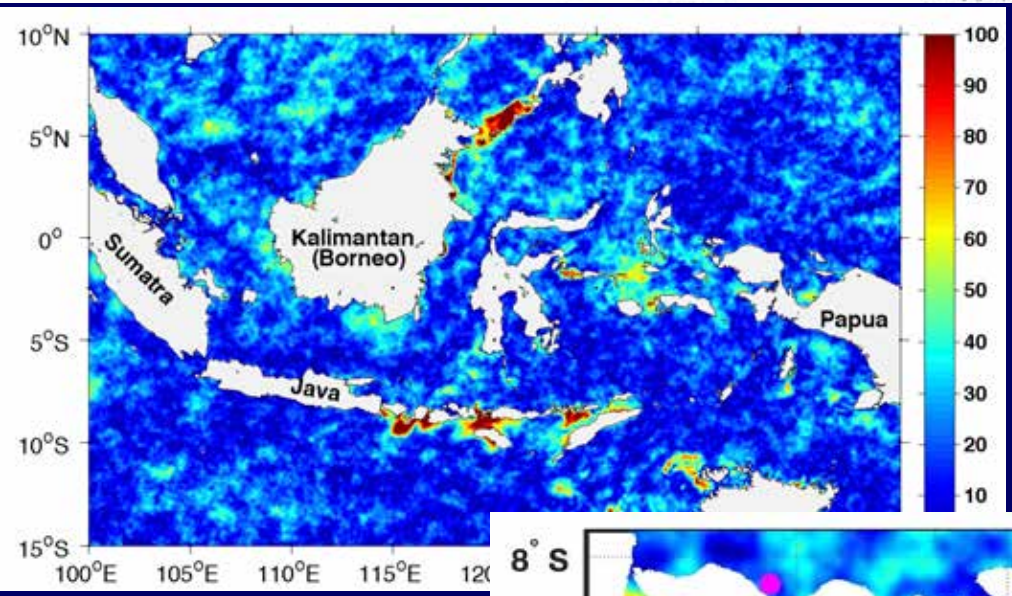
54 Water sample Bacteria, microplastic, pCO2, biogeochemistry

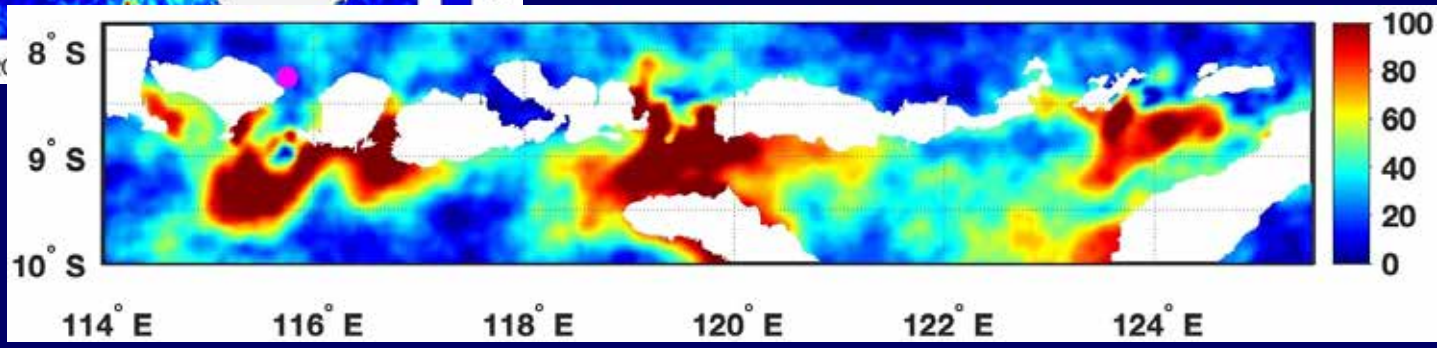
By Dwi Susanto, onboard Baruna Jaya

Tidal Mixing in Indonesian Seas

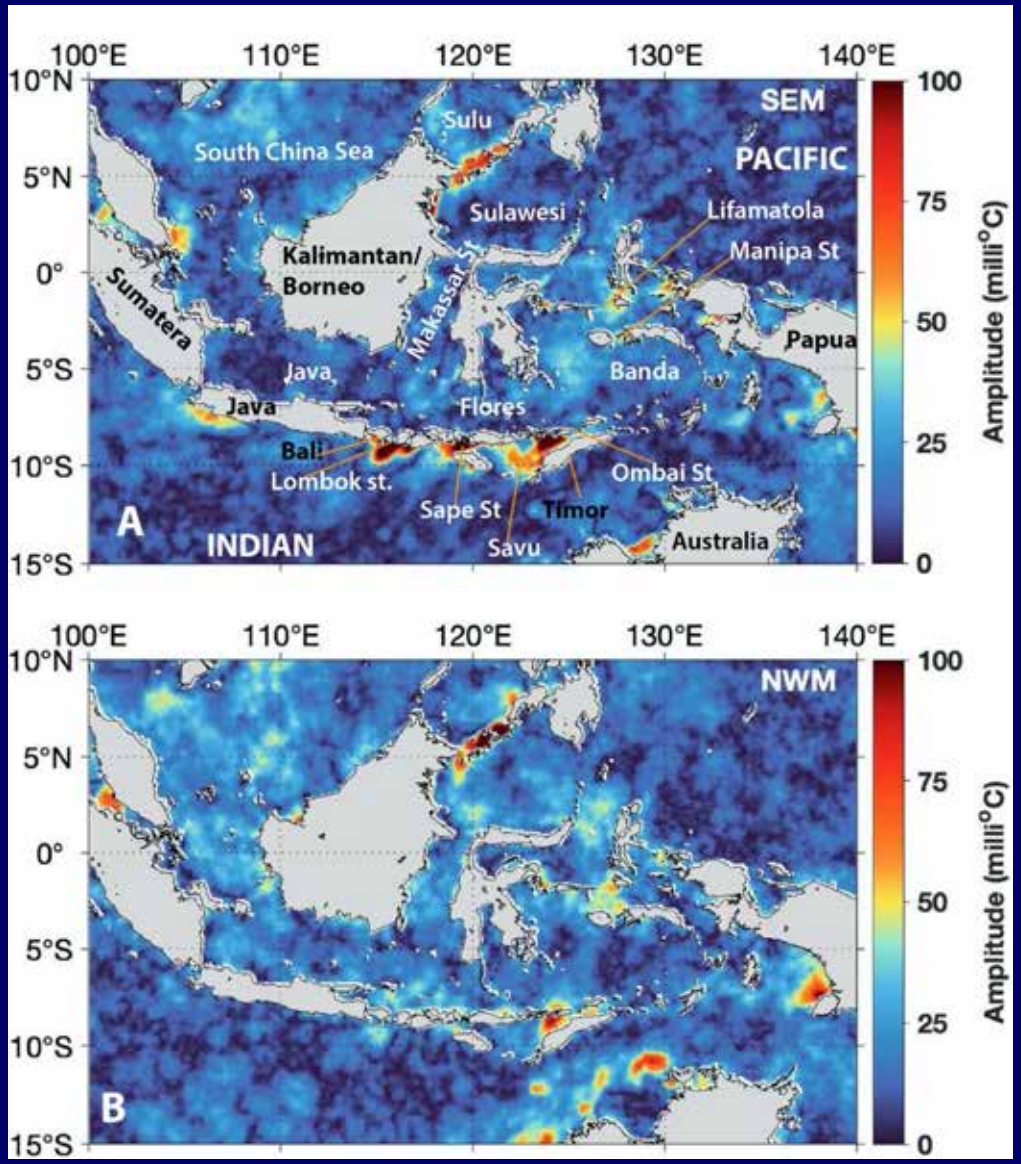


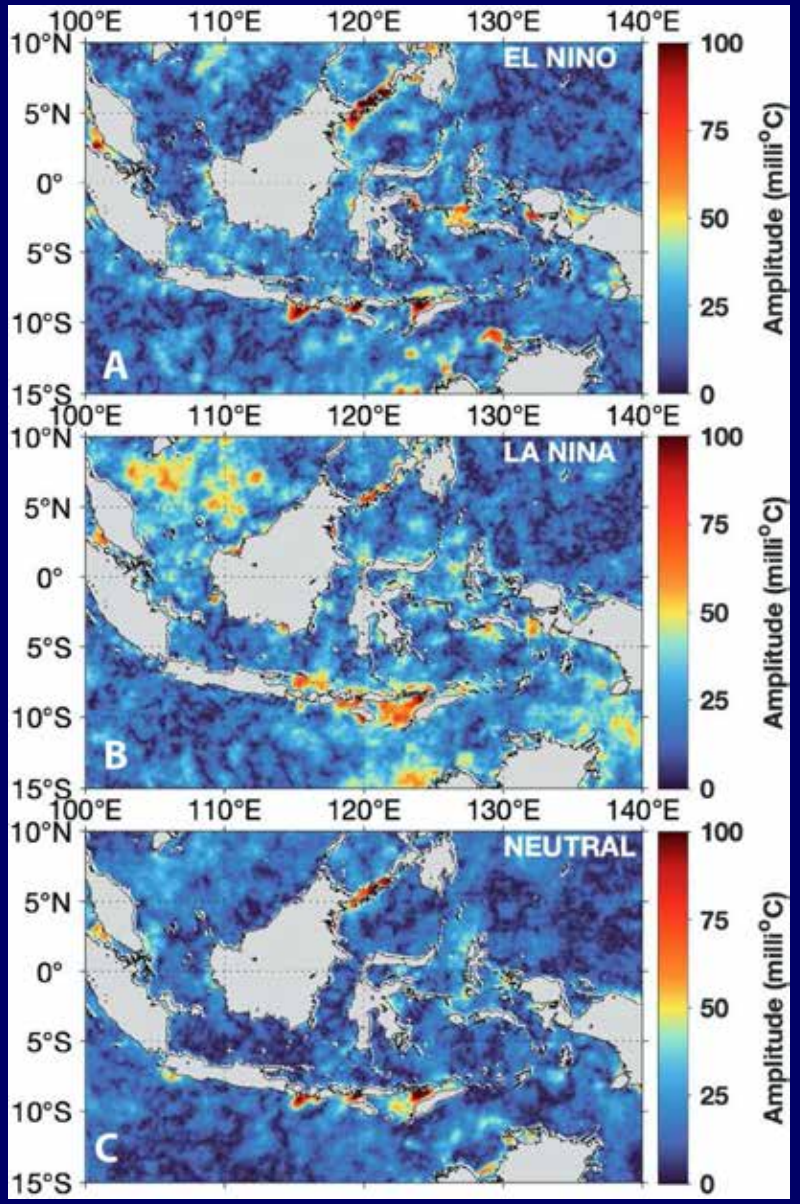
Susanto et al., 2013; 2019
Ray & Susanto, 2016; 2019
Susanto & Ray 2022





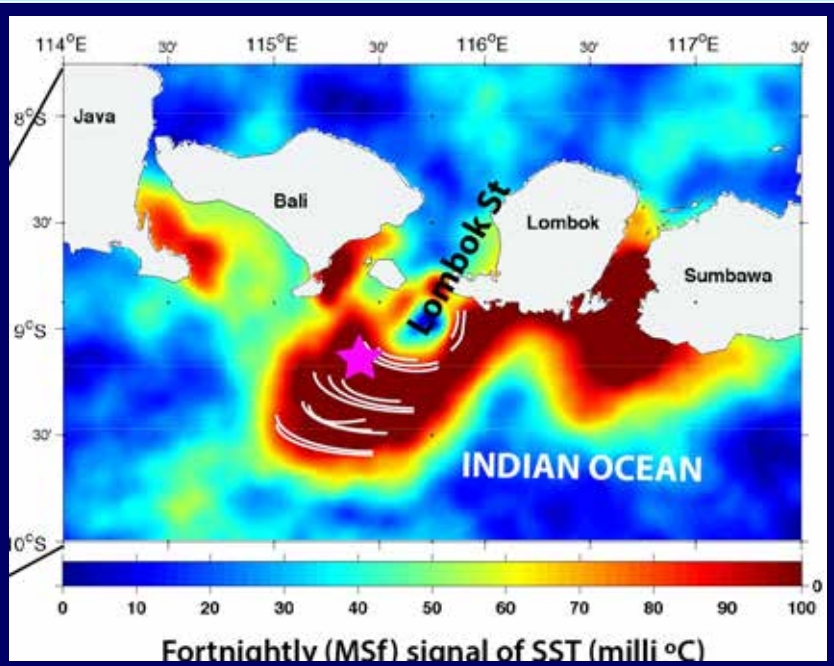
SEASONAL & INTERANNUAL MIXING





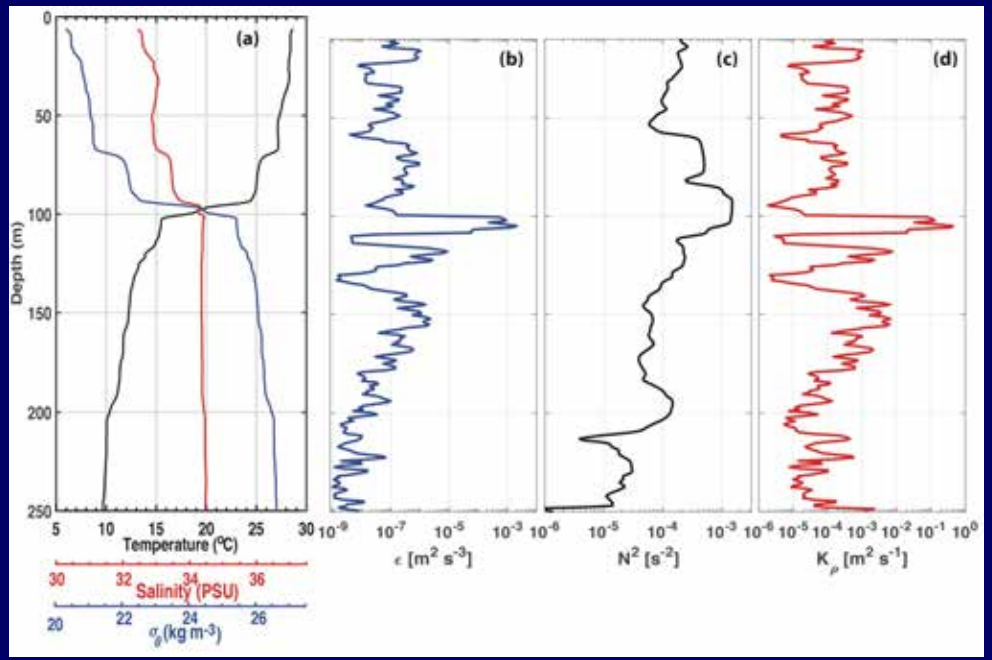
Susanto & Ray, 2022

VALIDATION OF TIDAL MIXING



MSS60

15 days every 3 hours
3 casts every 3 hours



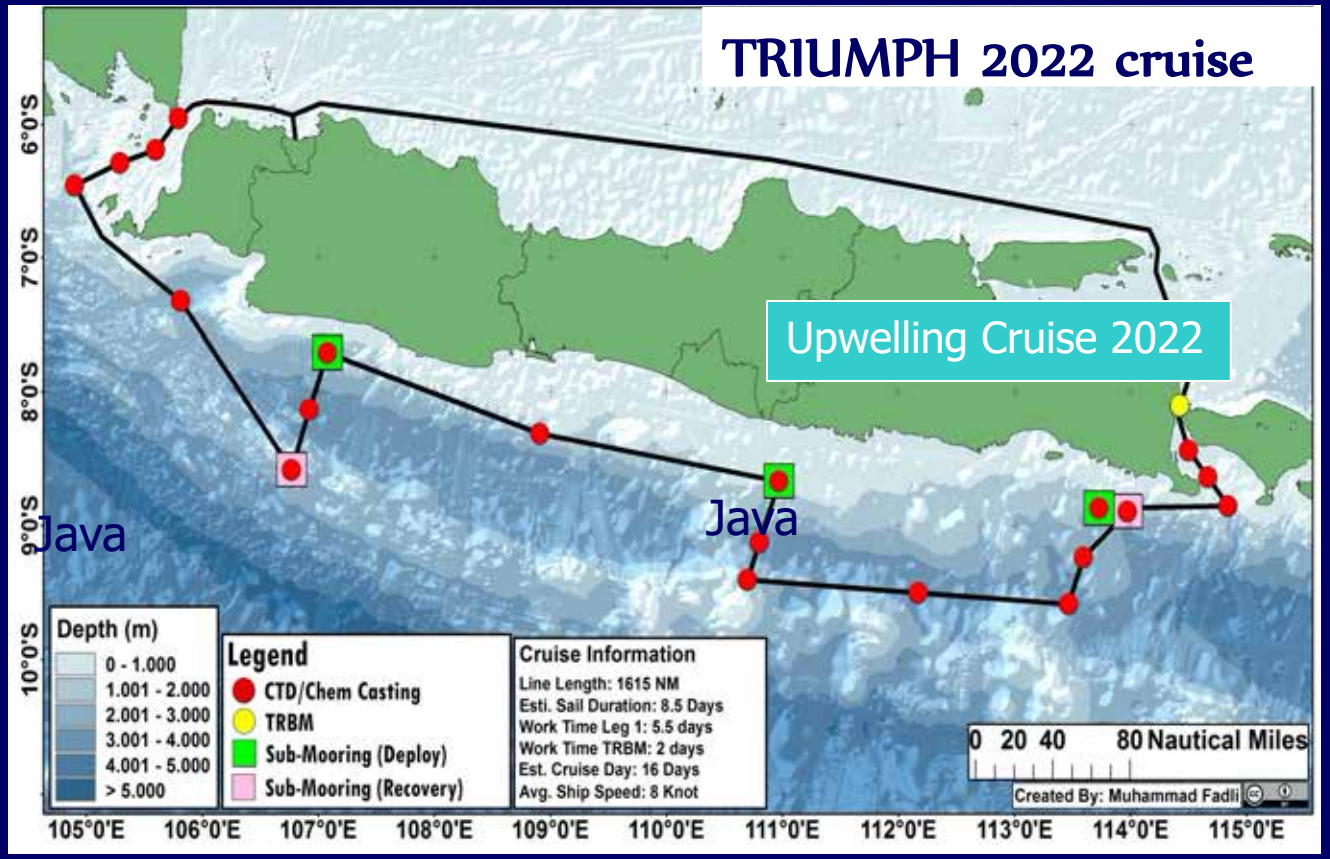
Susanto et al., 2023
(In prep.)

Indeed, strong mixing are observed as inferred from SST analysis

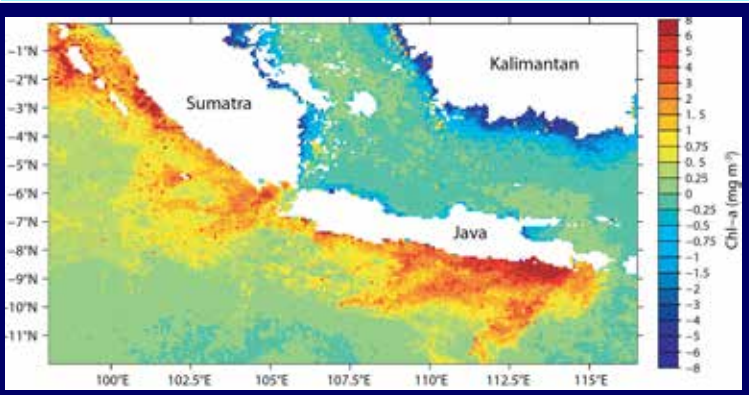
TRIUMPH: 3rd Cruise TRIUMPH Upwelling in the Eastern Indian Ocean

Originally, December 2021-January 2022, postponed to July 2023

- Recover one TRBM in the Bali Strait (failed)
- Recovered two moorings south of Java. (able to recover 1 mooring)
- Deploy new mooring in south of Java

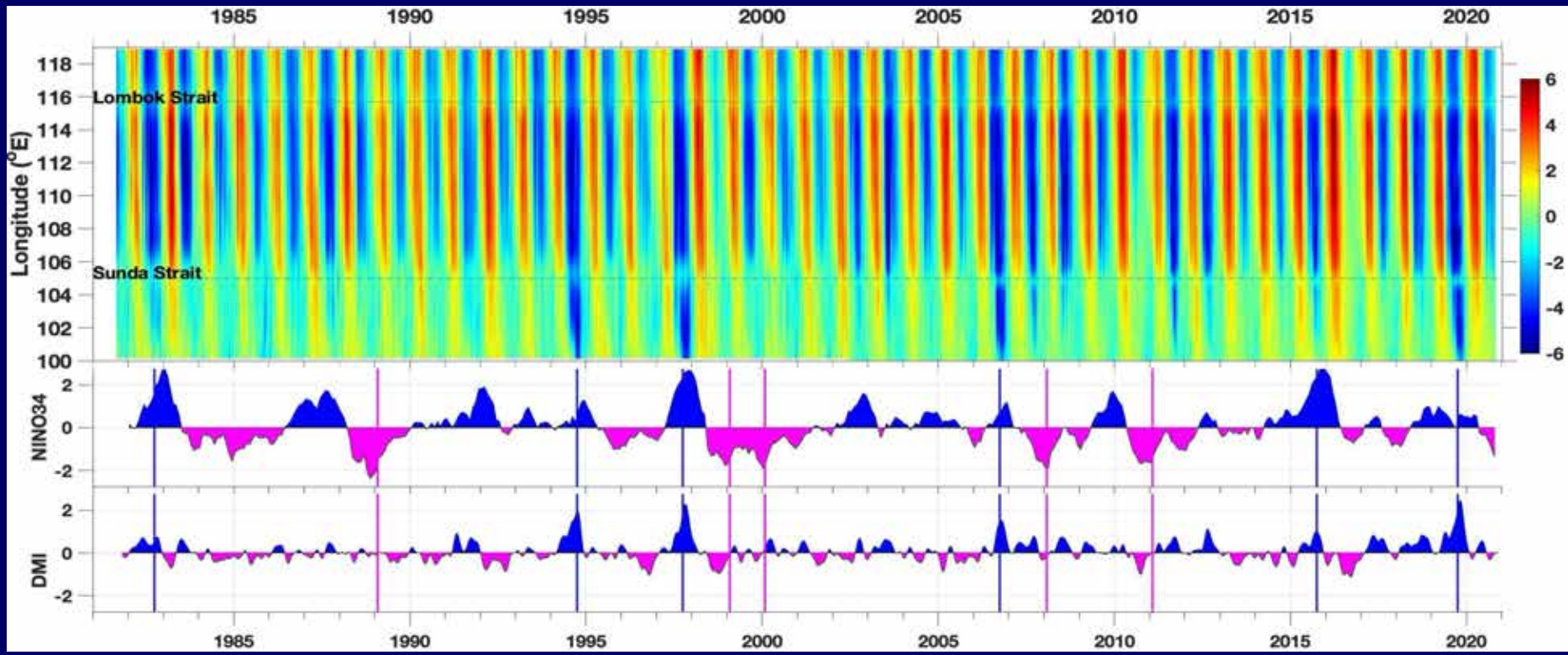


Upwelling in EIOURI, ENSO & IOD



Seasonal and interannual upwelling

- ✓ Boreal summer monsoon
- ✓ Modulated by ENSO & IOD
- ✓ Extend northwestward to Sumatra during El Nino and/or IOD+
- ✓ Need in situ observation for validation



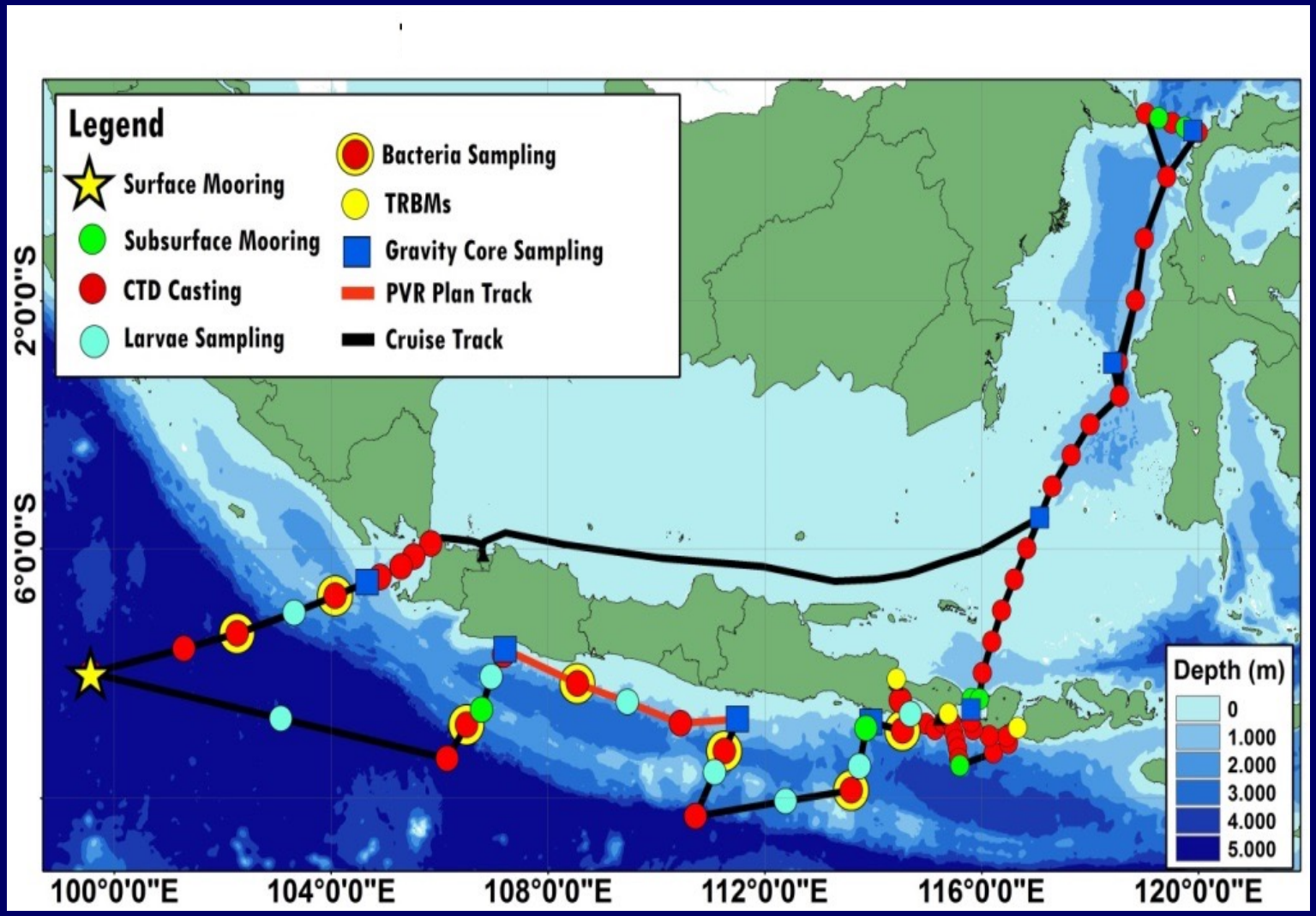
Susanto et al., 2001 (updated)

TRIUMPH: 4th. Throughflow and Upwelling and Underway Mixing 2023

- ✓ New MOU with BRIN/Indonesia – FIO/China – Univ of Maryland/USA

  National Agency for Research and Innovation(BRIN)

  PIs: Dr. Ocky Radjasa & Dr. A. Sulaiman; Dr. Zexun Wei and Dr. R. Dwi Susanto



SUMMARY

- ✓ Indonesian seas play important role in global ocean circulation and climate (especially the Indian Ocean) and may venerable to climate swings associated with ENSO and IOD. Long term observation of ITF is necessary.
- ✓ Tidal mixing in the Indonesian seas is more localized, it is not in the Banda Sea but in Sulu Sill, Lifamatola/Ceram sea, and along the lesser Sunda islands (Bali to Timor)
- ✓ Tidal mixing vary with monsoon and modulated by IOD & ENSO
- ✓ Mixing dictates T-S characteristic of ITF water into the Indian Ocean
- ✓ To understand Indian Ocean variability (stratification and water mass properties, physics and dynamics, as well as biogeochemistry) we have to understand the ITF, stratifications, and mixing variability in the exit passage of Indonesian seas/entrance/gate into the Indian Ocean.

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Thank You