Roles of Banda Sea to air-sea interaction over Indonesia, the existing oceanographic measurements and future plans of oceanographic observatories in the sea

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ITCZ (monsoon activities) and SST variability

August

February

(Qu et al., 2005)

Monthly climatology QuickSCAT
Consequences of seasonal variability in Indonesian Archipelago: Coastal upwelling

Characteristic of Coastal upwelling in Indonesian waters: Significance of Banda Sea Upwelling System

Ekman pumping: up to 2.5 Sv
average upwelling velocity = 2.36e-6 m/s

(Gordon & Susanto, 2005)
Tropical depression over Banda Sea

2011–12 Australian region cyclone season (1 November 2011 - 14 May 2012)

Duration: 7 May – 14 May
Peak: 55 km/h (35 mph)

Source: Bureau of Meteorology, Australia
Global oceanic inflow into Indonesian waters: **Indonesian Through Flow (ITF)**

**Characteristics:**

1. Found around 100-200 m (Field & Gordon, 1992)

2. Salinity maximum (c.a. 35 ‰, Field & Gordon, 1992; Gordon, 2005) and cooler (9°C, Gordon et al., 2003)

3. The flow is determined by ENSO: strong flows during La Nina due to significant pressure gradient (sea level difference) between Western Pacific Ocean and Eastern Indian Ocean (Gordon, 2005; Wyrtki, 1987)

4. Banda Sea prevails as a isolated topographic bowl to trap the sea water mass of ITF with the residence time up to 10 years (Postma & Mook, 1988)

(Gordon, 2005)
ITF-Banda Sea’s divergent (convergent) relationship

TABLE 1. The advection–diffusion model results. The constant, $K_{r}$, is characteristic of the amount of vertical mixing necessary to transform an NP or SP profile into an Indonesian basin profile. A larger vertical diffusivity, $K_{r}$, can be compensated by a shorter residence time, $\tau$. The mixing depth is the square root of $K_{r}$. 

<table>
<thead>
<tr>
<th>Indonesia Sea</th>
<th>Pacific source</th>
<th>$K_{r}$ (m²)</th>
<th>Mixing depth (m)</th>
<th>Residence time if $K_{r} = 1 \times 10^{-4}$ m² s⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Western Seas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulawesi</td>
<td>NP</td>
<td>600</td>
<td>24</td>
<td>2 months</td>
</tr>
<tr>
<td>Makassar</td>
<td>NP</td>
<td>1200</td>
<td>35</td>
<td>5 months</td>
</tr>
<tr>
<td>Flores</td>
<td>NP</td>
<td>1400</td>
<td>37</td>
<td>5 months</td>
</tr>
<tr>
<td><strong>Eastern Seas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halmahera</td>
<td>50% NP–50% SP</td>
<td>1700</td>
<td>41</td>
<td>6 months</td>
</tr>
<tr>
<td>Maluku</td>
<td>NP</td>
<td>3100</td>
<td>56</td>
<td>1.0 year</td>
</tr>
<tr>
<td>Seram</td>
<td>50% NP–50% SP</td>
<td>3400</td>
<td>58</td>
<td>1.1 years</td>
</tr>
<tr>
<td>Banda</td>
<td>NP</td>
<td>5300</td>
<td>73</td>
<td>1.7 years</td>
</tr>
<tr>
<td>Banda</td>
<td>50% NP–50% SP</td>
<td>27 600</td>
<td>166</td>
<td>8.7 years</td>
</tr>
<tr>
<td>Banda</td>
<td>SP</td>
<td>53 600</td>
<td>232</td>
<td>17.0 years</td>
</tr>
</tbody>
</table>

(Gordon & Susanto, 2005)

(Ffield & Gordon, 1992)

(Gentili, 1972)
ITF-driven climatic patterns over Indonesian Archipelago

According to Sprintall et al. (2014):

“During transit through the Indonesian seas, temperature and salinity stratified water from the Pacific is mixed and modified by strong air–sea fluxes, monsoonal wind-induced upwelling and extremely large tidal forces”

On the other hand, the mixing also modulates air-sea interaction, atmospheric convection and the monsoonal response;

ITF mixing with the Indonesian sea via monsoonal wind-induced upwelling cools SST by ~0.5 °C and rises ocean heat uptake by ~ 20 W/m² (i.e. change of precipitation) and reduces deep convection by approximately 20%
The Roles of Banda Sea

- Upwelling strength weaker during El Nino stronger during La Nina

- Rises ocean heat uptake
  - Monsoonal wind-induced upwelling + cool ITF

- Determining outflow discharge of ITF to Indian Ocean
  - Surface layer divergence and convergence
  - Monsoonal wind-induced downwelling + warm SST

- Tropical depression
Impacts from the ocean and atmospheric dynamics in Banda Sea

Dynamics of sea-air interaction in Banda Sea with the involvement of ITF:

1. The Rainfall pattern over Banda Sea is sensitively associated with the vertical diffusion of the Banda Sea

2. Tropical depression activities

Coastal hazards for small islands around Banda Sea

1. Decrease of atmospheric pressure in Banda Sea during upwelling can increase height of sea level conducting extreme coastal waves.

2. ENSO teleconnection to monsoon (ITCZ variability) due to climate change could play a significant role to the magnitude of Banda Sea’s upwelling which increases the sea level
The Absence of an adequate ocean observing system in Indonesian waters
The Absence of an adequate ocean observing system in Indonesian waters
The existing oceanographic measurement: Oceanographic Cruises

(Gordon, 2005)
LIPI’s Centre for Deep Sea Research
Required ocean observing system: time-series measurement

Upwelling strength weaker during El Niño, stronger during La Niña

Rises ocean heat uptake

Monsoonal wind-induced upwelling + cool ITF

Banda Sea

Surface layer divergence and convergence

Determining outflow discharge of ITF to Indian Ocean

Monsoonal wind-induced downwelling + warm SST

Tropical depression

http://tao.ndbc.noaa.gov/refreshed/siteArrayPlots.php
Planned ocean observing system for upwelling

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References


