Ocean Dynamics (2010) 60:731–742
DOI 10.1007/s10236-010-0290-6

A numerical investigation of eddy-induced chlorophyll bloom in the southeastern tropical Indian Ocean during Indian Ocean Dipole—2006

Iskhaq Iskandar · Hideharu Sasaki · Yoshikazu Sasai · Yukio Masumoto · Keisuke Mizuno

Received: 7 September 2009 / Accepted: 12 April 2010 / Published online: 2 May 2010

Abstract An eddy-resolving coupled physical–biological model is used to study the effect of cyclonic eddy in enhancing offshore chlorophyll-*a* (Chl-*a*) bloom in the southeastern tropical Indian Ocean during boreal summer–fall 2006. The results demonstrate that the offshore Chl-*a* blooms are markedly coincident with the high eddy kinetic energy. Moreover, the vertical variations in Chl-*a*, nitrate, temperature, and mixed-layer depth (MLD) strongly imply that the cyclonic eddies induce surface Chl-*a* bloom through the injection of nutrient-rich water into the upper layer. Interestingly, we found that the surface bloom only occurs when the deep Chl-*a* maximum is located within the MLD. On the other hand, the response of subsurface Chl-*a* to the eddy pumping is remarkable, although it is hardly observable at the surface.

Keywords Chlorophyll-a · Upwelling · Coupled physical–biological model · Indian Ocean Dipole · Southeastern tropical Indian Ocean

Responsible Editor: Jin-Song von Storch

I. Iskandar · Y. Sasai · Y. Masumoto · K. Mizuno
Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan

I. Iskandar
On leave from Jurusan Fisika, FMIPA, Universitas Sriwijaya, Palembang, Sumatra Selatan, Indonesia

H. Sasaki
Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan

Y. Masumoto
Also at Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, Tokyo, Japan

I. Iskandar (✉)
NOAA/PMEL,
7600 Sand Point Way, NE,
Seattle, WA 98115, USA
e-mail: Iskhaq.Iskandar@noaa.gov

1 Introduction

The southeastern tropical Indian Ocean (SETIO) between the Lesser Sunda Islands and the northwestern Australia represents a water mass crossroad, as several different water masses from the Indian Ocean, the Pacific Ocean, and the Indonesian seas meet in this area (Fieux et al. 1994). The oceanic circulation in the SETIO region is mainly driven by the seasonally varying monsoonal winds (Quadfasel and Cresswell 1992). During the southeast monsoon season, prevailing southeasterly winds drive offshore Ekman transport off south Java and Sumatra resulting in cold sea surface temperature (SST) there. Satellite observed surface chlorophyll-*a* (Chl-*a*) shows that this upwelling circulation, through the supply of nutrient-rich subsurface water, elevates Chl-*a* concentrations (Asanuma et al. 2003; Susanto et al. 2006). The situation reverses for the northwest monsoon season.

The SETIO region is also influenced by an interannual air–sea coupled climate mode inherent in the tropical Indian Ocean, so-called the Indian Ocean Dipole (IOD) (Saji et al. 1999; Webster et al. 1999; Murtugudde et al. 2000). A positive IOD event is characterized by a pattern of cool SST anomalies in the eastern Indian Ocean and warm anomalies in the west associated with anomalously strong easterly along the equator and southeasterly along the southern coast of Sumatra and Java. The IOD event is