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Pathways of intraseasonal variability in the Indonesian Throughflow region

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ABSTRACT

The recent INSTANT measurements in the Indonesian archipelago revealed a broad spectrum of time scales that influence Indonesian Throughflow (ITF) variability, from intraseasonal (20–90 days) to interannual. The different time scales are visible in all transport and property fluxes and are the result of remote forcing by both the Pacific and Indian Ocean winds, and local forcing generated within the regional Indonesian seas. This study focuses on the time-dependent three-dimensional intraseasonal variability (ISV) in the ITF region, in particular at the locations of the INSTANT moorings at the Straits of Lombok, Ombai and Timor. Observations from the INSTANT program in combination with output from the Bluelink ocean reanalysis provide a comprehensive picture about the propagation of ISV in the ITF region. The reanalysis assimilates remotely sensed and *in situ* ocean observations into an ocean general circulation model to create a hindcast of ocean conditions. Data from the reanalysis and observations from the INSTANT program reveal that deep-reaching subsurface ISV in the eastern Indian Ocean and ITF is closely linked with equatorial wind stress anomalies in the central Indian Ocean. Having traveled more than 5000 km in about 14 days, the associated Kelvin waves can be detected as far east as the Banda Sea. ISV near the Straits of Ombai and Timor is also significantly influenced by local wind forcing from within the ITF region. At the INSTANT mooring sites the ocean reanalysis agrees reasonably well with the observations. Intraseasonal amplitudes are

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about ±1.0 °C and ±0.5 m/s for potential temperature and velocity anomalies. Associated phases of ISV are very similar in observations and the reanalysis. Where differences exist they can be traced back to likely deficits in the reanalysis, namely the lack of tidal dissipation, insufficient spatial resolution of fine-scale bathymetry in the model in narrow straits or errors in surface forcing.

1. Introduction

1.1. Background

The Indonesian Throughflow (ITF) is an integral part of the global climate system and thermohaline circulation (e.g. Gordon, 1986), providing a low-latitude pathway for the transfer of warm, low salinity Pacific waters into the Indian Ocean. The heat and freshwater carried by the ITF impacts the basin budgets of both the Pacific and the Indian Oceans (Wijffels et al., 2002). Within the internal Indonesian seas, observations and models indicate that the primary ITF source is North Pacific thermocline water flowing through Makassar Strait (sill depth of 650 m at Dewakang Sill downstream of 'M' in Fig. 1) (Gordon, 2001). Additional ITF contributions of lower thermocline water and deep water masses of direct South Pacific origin are derived through the eastern routes, via the Maluku and Halmahera Seas, with dense water overflow at Lifamatola Passage (sill depth 1940 m). The ITF exits into the eastern Indian Ocean through the major passages along the Lesser Sunda Island chain: Ombai Strait ('O' in Fig. 1; various exit sill depths between 800 m and 1250 m from Savu Sea downstream of Ombai Strait), Lombok Strait (sill depth 300 m, 'L' in Fig. 1), and Timor Passage (sill depth of 1200 m upstream of 'T' in Fig. 1). The complex topography of the region, with multiple narrow constrictions connecting a series of large, deep basins, leads to a circuitous ITF pathway within the Indonesian seas. En route, Pacific inflow waters are modified by mixing, upwelling and air-sea fluxes before being exported to the Indian Ocean (Koch-Larrouy et al., 2007).

To help fully resolve temporal variability and characteristics of the ITF transport and property fluxes, a multi-year comprehensive measurement program was required. The INSTANT program addressed

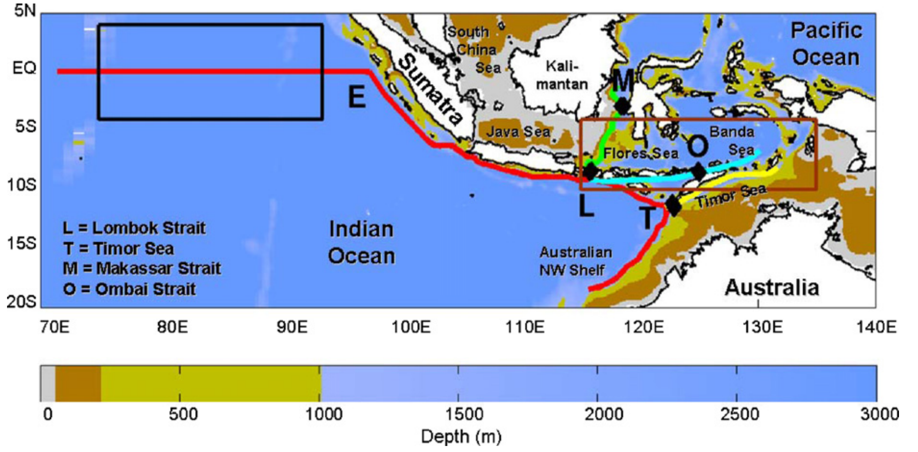

Fig. 1. Bathymetry of Indonesian region (m). Lines denote location of ray paths (coloured lines) and black diamonds denote INSTANT moorings. Bifurcation point of path lines is at approximately 116°E, 9°S. Black box denotes area of Indian Ocean zonal wind stress anomalies and brown box denotes area of ITF wind stress anomalies. See text for further details. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)