

# The 'instant' mooring in the Lifamatola passage

Hendrik M. van Aken

During the international INSTANT programme the strength of the Indonesian through-flow was determined with an array of current meter moorings in the main sea straits of the Indonesian seas. NIOZ was responsible for the measurement of the deep throughflow of cold deep water through the Lifamatola Passage.

The flow of water masses from the Pacific Ocean towards the Indian Ocean through the waters of the Indonesian Archipelago has important effects on the climate of Indonesia and the Indian ocean. The Indonesian throughflow is also assumed to contribute to the warm return flow of the oceanic thermohaline circulation. From 2004 until 2006 an international research programme INSTANT (International Nusantara Stratification and Transport) was organized to measure the Indonesian throughflow at several sea straits, covering both the main inflow paths into the Indonesian Seas and the main outflow paths towards the Indian Ocean (Fig. 1). In this programme scientists from Indonesia, the USA, Australia, France, and the Netherlands were involved.

The Lifamatola Passage (Fig. 1c) is the only deep entrance (>1000 m) of the Indonesian seas. It is therefore the only deep source of the cold deep water encountered in the Ceram Sea and Banda Sea. Already in 1985, during the Snellius II Expedition, NIOZ was involved in current measurements in the Lifamatola Passage to determine the throughflow of cold water. Then the result of the measurements was a throughflow of cold water of 1.5 Sverdrup (1 Sv =  $10^6 \text{ m}^3/\text{s}$ ). However, the observational period in 1985 lasted only 3 months, and did not cover a complete annual cycle, nor an El Niño cycle. When invited to participate in the INSTANT programme, it was realized that here was an opportunity to redress the weaker points of the mooring setup from 1985. A current meter mooring was deployed from the Indonesian RV Baruna

Jaya I at 2000 m near the sill in the Lifamatola Passage from January 2004 until December 2006. Halfway the measuring period, in July 2005, the mooring was recovered, serviced and re-deployed. Then it was discovered that because of unexpected strong currents the mooring suffered serious blow downs. Therefore it was shortened in mid-term with about 300 m. After recovery the velocity data were interpolated at regular vertical and time intervals for further analysis.

The mean current in the lowest 500 m of the water column followed the direction of the deep channel in the Lifamatola Passage (128°). This agrees with the direction of the deep passage. The current in that direction appeared to be quite variable in a large range of time scales. The dominant spectral peaks were

\*Corresponding author: aken@nioz.nl

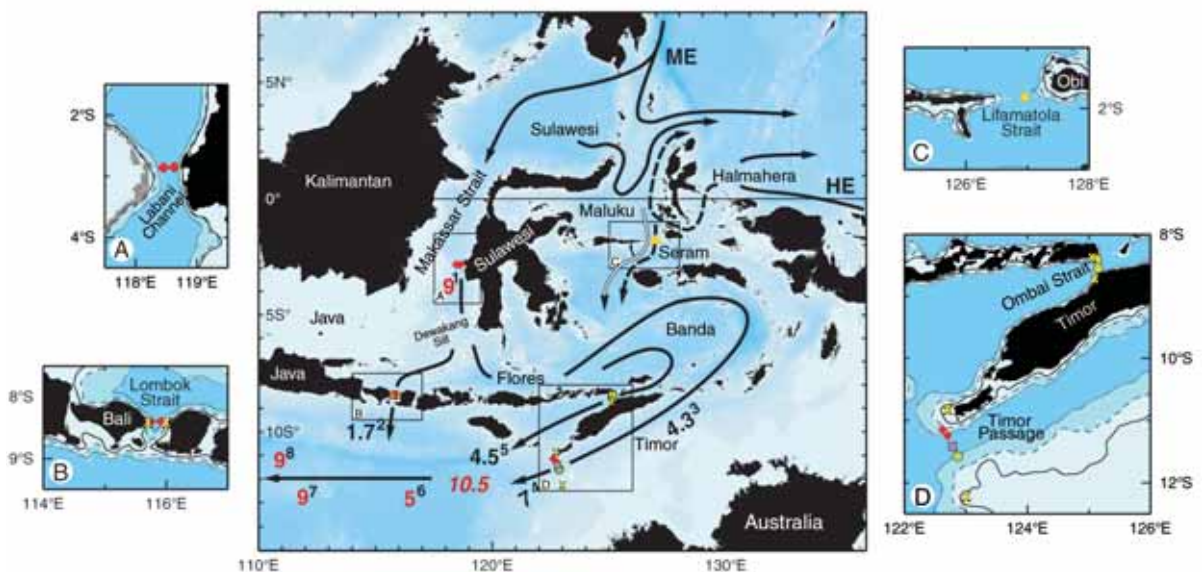


Fig. 1. Schematic of the Indonesian throughflow. The blue arrows represent North Pacific thermocline water; the red arrows represent South Pacific lower thermocline water and the deeper overflow of dense Pacific water across the Lifamatola Passage into the deep Banda Sea. Transport values in Sv (1 Sv =  $10^6 \text{ m}^3/\text{s}$ ) are given in black. Inserts A-D [with 100, 500, and 1000 m isobaths] show positions of INSTANT moorings.

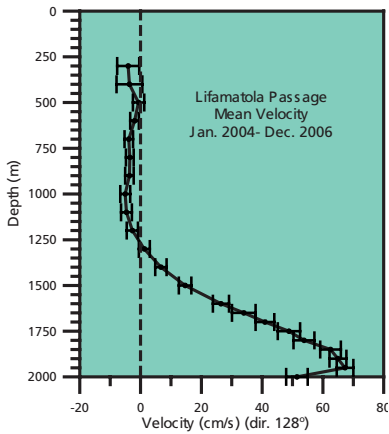


Fig. 2. Mean velocity profile in the Lifamatola Passage in the S-E direction (128°). The local depth was 2010 m.

at the diurnal and semi-diurnal frequencies tidal frequencies, while also at the lunar fortnightly frequency a significant peak was observed. Vertical changes of the amplitude and phase lag at these frequencies suggest that these tides have a strong baroclinic character, probably generated by the barotropic tidal flow over the Lifamatola sill. Additionally irregular velocity variations at a large range of frequencies were observed. However no significant annual cycle was observed between 300 and 2000 m depth, despite the strong monsoonal wind forcing of the sea surface. The 3 years averaged current profile (Fig. 2) showed a strong SE ward flow below 1250 m. The strongest mean velocity (67 cm/s) was observed at 1950 m depth, about 60 m above the bottom. The volume transport of the deep SE-ward flow amounted to 2.9 Sv, nearly twice the earlier estimate from the Snellius II Expedition. The transport weighted mean temperature of the deep flow was 3.1°C. Between 250 and 1250 m depth the flow was significantly NW-ward



Schematic impression of a mooring. From bottom to top: Iron anchor weight, acoustic release, sediment trap, current meter, Acoustic Doppler Current Profiler (ADCP), and a sub-surface buoy to keep the mooring upright during the measurements and to lift it to the sea-surface after detachment from the anchor weight by means of an acoustic signal from the research vessel.

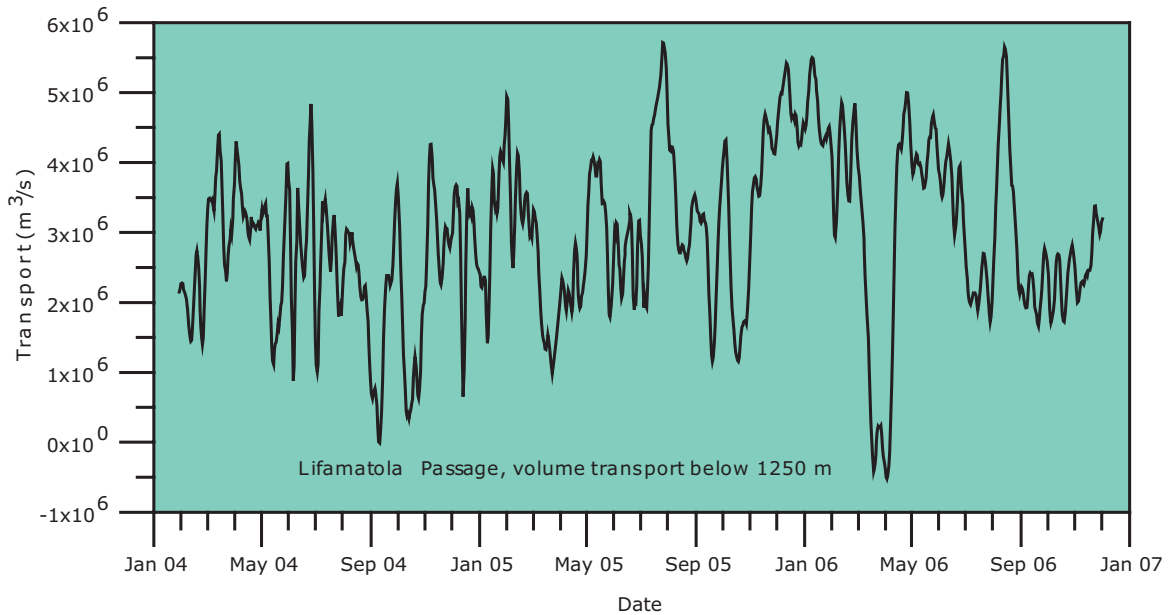


Fig. 3. Time series of the SE-ward (128°) volume transport through Lifamatola Passage below 1250 m. The data are low-pass-filtered, suppressing the semi-diurnal and diurnal tides.

(average velocity 3.3 cm/s). If this flow is representative for the whole width of the Lifamatola Passage, it maintains a transport of 1.4 Sv from the Ceram Sea towards the Molucca Sea. From the interpolated current meter data, a time series was obtained of the deep volume transport through the Lifamatola Passage (Fig. 3). It appears

that the presence of the Mf tide causes a significant transport variation at fortnightly time scales. Apart from these tidal variations, "eddy" variability of the transport was observed at all lower frequencies. A first analysis of these variations has shown that the transport minimum during March-April 2006 coincided with the passage of a deep ther-

mostad through the passage. No clear annual nor ENSO variability could be observed in the transport rate. Apparently the deep density structure which maintains the driving pressure gradients, is not strongly influenced by such dominant air-sea interaction frequencies.