Supporting Information for
"Uncovering a new current: the South-west MAdagascar Coastal Current (SMACC)"

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Introduction

This supporting information provides two tables and four figures in support of the results presented in the main article.

Table 1 summarises in-situ data used in the study. Table 2 recapitulates dates of drifters passage in the SMACC. Figure S1 shows a result from the Lagrangian experiment. Figure S2 shows how the South-west MAdagascar Coastal Current (SMACC) is represented in various surface current climatologies. Figure S3 shows complementary observations of the SMACC and its undercurrent. Lastly, Figure S4 shows the water mass properties of the SMACC.

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Text Table S1.

SADCP (Shipboard Acoustics Doppler Current Profiler) current measurements were collected during four research cruises in the Mozambique channel between 2007 and 2010 [Table 1]. SADCP data are used to confirm the direction and intensities of the southward flow at the south west of Madagascar. Conductivity, Temperature and Depth (CTD) profiles, collected from cruises operated in the region (Table 1) are also used to identify which water masses make up the SMACC.

Table 1. Description of in-situ data used in this study together with the associated dates, vessels and research cruises

Data used	Code	Vessel	Cruise name	Date
SADCP	260	R.V. Antea	MESOP 2010	07-04-2010/08-05-2010
CTD	260	R.V. Fridtjof Nansen	ASCLME 2009	09-08-2009/16-08-2009
SADCP	260	R.V. Fridtjof Nansen	ASCLME 2009	09-08-2009/16-08-2009
SADCP	300	R.V. Fridtjof Nansen	ASCLME 2008	24-08-2008/07-09-2008
SADCP	340	R.V. Algoa	ACEP 2007	10-09-2007/23-09-2007

Text Table S2

Table 2 shows the time periods corresponding to drifters passing through the rectangle in Figure 1 (lat: 19°S - 27°S ; lon: 41°E - 46°E).

Table 2. Time periods of drifters crossing the SMACC region

Number of drifter	Period
Drifter 17444	03/01/2001 - 02/02/2001
Drifter 18969	24/11/1997 - 15/02/1998
Drifter 20591	13/09/2002 - 17/02/2003
Drifter 45978	16/09/2005 - 15/12/2005
Drifter 57970	10/01/2007 - 03/03/2007
Drifter 70960	05/03/2009 - 31/03/2009

Text Figure S1.

126 particles are released every year inside the core of a coastal upwelling cell located south-east of Madagascar and defined in [*Ramanantsoa et al.*, 2018] as Core 2. The particles were released at 5 m depth intervals and within the upper 50 m of the water column. After back-tracking the particles over a period of 2 months, we find that 81 % of the particles reaching the coastal upwelling cell center come from the SMACC and 19 % arrive from the EMC (Figure S1 (top)). Between 2003 and 2013, the SMACC is the main source of water for the coastal upwelling region south-west of Madagascar, with the exception of years 2006 and 2011, when most of the water originates in the EMC region (Figure S1 (bottom)). This illustrates inter-annual variations of the SMACC which remain to be investigated.

Text Figure S2.

Figure S2 shows geostrophic velocities derived from 4 different mean dynamic topographies (RIO 2005 [*Rio and Hernandez*, 2004], CLS 2009 [*Rio et al.*, 2011], CLS 2013 [*Rio et al.*, 2014] and Maximenko 2015 [*Maximenko et al.*, 2009]) and the ARGO-based surface mean displacement [*Ollitrault and Rannou*, 2013]. Although similarities can be found between the different mean circulations, some disparities are observed in our region of interest. The structure of the SMACC is clearly defined in CLS 2009, Maximenko 2015 and the ARGO float displacement (ANDRO) datasets. Velocities derived from CLS 2009, Maximenko 2015 and ANDRO appear to be relatively similar. All products depict a poleward flow along the south-west coast of Madagascar. Velocities derived from RIO 2005 and CLS 2009 show a weak poleward current along the coast of Madagascar south of 25°S, but do not resolve any current north of 25°S.

Text Figure S3.

Figure S3 shows an alongshore transect of meridional velocity collected during the MESOP 2010 cruise on-board of R.V. Antea between 05/05/2010 and 07/05/2010. In Figure S3 (left), surface currents between 23°S and 25°S have a mean magnitude of 0.38 cm s^{-1} and flow predominantly in a south-easterly direction. Vertical cross-sections of the ocean currents' meridional velocity (Figure S3, right) show the presence of a coastal southward flow within the upper 100 m of the water column with peak velocities of 0.34 cm s^{-1}. This coastal southward current is the SMACC. SADCP observations show the presence of a countercurrent (equatorward) below the SMACC between 24.5°S and 25.5°S. Figure 3 (main manuscript) also provides evidence of this undercurrent.

Text Figure S4.

Water masses in the SMACC are identified using CTD data collected during 4 transects in 2009 (Table S1). T/S diagrams show that surface temperatures decrease from transect *d* toward transect *g*, in agreement with the section 3.1 in the main manuscript. Salinity in the surface layers increases slightly toward the south. The sampled water masses correspond to Subtropical Surface Waters (SSW) [*Donguy and Piton*, 1969; *Wyrtki*, 1971; *Sætre and Da Silva*, 1984].

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Figures

Figure. S 1. (Top) Longitudinal distribution of all Lagrangian particles released in the upwelling cell south of Madagascar after a 2-month backward integration period and for all years between 2003 and 2013. The black dash line shows the location were particles were released. (Bottom) Yearly percentage of upwelled particles originating from the SMACC.

Figure. S 2. Mean geostrophic currents derived from different mean dynamic topographies: RIO-2005 a- [*Rio and Hernandez*, 2004], CLS-2009 b- [*Rio et al.*, 2011], CLS-2013 c- [*Rio et al.*, 2014], d- [*Maximenko et al.*, 2009], and from ARGO floats surface displacement f- [*Ollitrault and Rannou*, 2013]

Figure. S 3. (left) Arrows are surface current directions and intensities measured using Ship-board mounted ADCP during the MESOP 2010 research cruise (Table S1). Contours are sea surface height from CLS AVISO averaged during the transect period from 05/05/2010 to 07/05/2010. (right) Vertical section of meridional velocity from the cruise transect shown in the left panel. Black lines represent the zero contour for the meridional velocities.

Figure. S 4. Temperature-Salinity (TS) diagram from conductivity, temperature, and depth measurements collected as part of the ASCLME cruise of 2009 (Table S1) and along the transects shown in Figure 2 (main article). Bold solid lines highlight the range of potential densities associated with the SMACC.