IMOS Integrated Marine Observing System

State and Trends of Australia's Oceans | Report

1.3 | East Australian Current Variability

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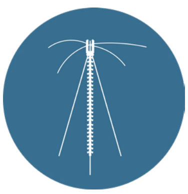
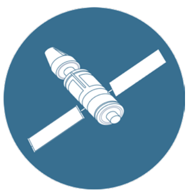
Summary

The East Australian Current (EAC) is the complex and energetic western boundary current of the South Pacific Ocean, influencing the lives and economies of people on the eastern seaboard. It is the dominant mechanism for the redistribution of heat between the ocean and atmosphere and has a strong influence on the weather and seasonal climate, coastal ocean circulation and marine ecosystem affecting nearly half the Australian population. IMOS' long-term monitoring of the EAC provides a comprehensive data set that will enable improved understanding and modelling to determine the impact of the EAC on the regional weather and climate, coastal circulation and marine ecosystem.

Key Data Streams



Ocean Radar



Satellite Remote Sensing

Deep Water Moorings

State and Trends of Australia's Ocean Report
www.imosoceanreport.org.au

Time-Series published
10 January 2020
doi: *10.26198/5e16a23f49e75*

Rationale

The East Australian Current (EAC) is the highly energetic western boundary current of the South Pacific Ocean gyre, estimated (27°S) to transport 22.1 ± 7.5 Sverdrups (Sv; 1 Sv=$10^6 m^3 s^{-1}$) of warm tropical water southward (Sloyan, Ridgway, & Cowley, 2016). Any changes in the EAC in both the short-term or long-term will impact waters along south-eastern Australia – Australia's most populated coastline – and the Tasman Sea.

Low frequency (>2 year) variability of the EAC reflects changes in the wind and buoyancy forcing over the South Pacific Ocean (Hu et al., 2015). However, local and regional wind and buoyancy forcing drives higher frequency variability (<1-2 years) of the EAC (Bull, Kiss, Jourdain, England, & van Sebille, 2017). Due to the narrow shelf, EAC meandering has an immediate impact on the shelf circulation. Downstream of the EAC separation zone (~30-31.5°S, Cetina-Heredia, Roughan, van Sebille, & Coleman, 2014), mesoscale eddies are shed, which dominate shelf circulation. Exchange of heat, salt and plankton between the shelf and open ocean is achieved via EAC intrusion, submesoscale and mesoscale eddies, and complex boundary layer and frontal dynamics. Therefore, although the EAC transports oligotrophic Coral Sea water, several key processes still stimulate enrichment, including upwelling associated with the dynamics of the EAC (Roughan & Middleton, 2002), mixing associated with frontal and mesoscale eddies (Roughan et al., 2017), and the dynamic exchange of shelf and boundary current water. These enrichment processes influence the entire marine ecosystem, from planktonic production (Armbrecht, Schaeffer, Roughan, & Armand, 2015), and invertebrate and fish larvae to the distribution of large pelagic fish.

Methods

To summarise the EAC variability, we combine observations from the Integrated Marine Observing System (IMOS) EAC mooring array and satellite sea surface temperature and velocity at 27°S between May 2015 and April 2018. The IMOS EAC mooring array consists of six moorings in water depths of 500 to 4800 m across 152.94 km, from the continental shelf to the deep abyssal plain. In the upper 1200 m, current profiling instruments provide vertical velocity profiles and below 1200 m, point source velocity instruments provide data at discrete depths. IMOS EAC mooring data were interpolated onto a standard vertical grid and time period and the velocity was rotated to the along-, across-slope coordinate frame. We use the Wijffels et al. (2018) annual mean Sea Surface Temperature (SST) and the night-time satellite sea surface temperature to determine the SST anomaly. Sea surface height (SSH) anomaly was from the IMOS gridded satellite product DM00 GSLA.

A high frequency surface radar system is maintained by IMOS centred at 30°S downstream of the EAC mooring array and upstream of the typical EAC separation region. Surface current data were gridded to 1.5 km resolution over a 100 km square area since 2010. Full details of the radar data and its processing are available from Mantovanelli et al. (2017) . EAC jet core speed and position were calculated from the radar derived current data using the methodology of Archer et al. (2017).

Results and interpretation

There is considerable variability of SSH and SST between 2015 and 2018 at 27°S (**Figure 1**). These surface anomalies can extend across the longitudinal extent from the coast to the abyssal basin or partially across the region. There are times when SST and SSH anomalies co-vary, and other times when anomalies are opposed (**Figure 1**).

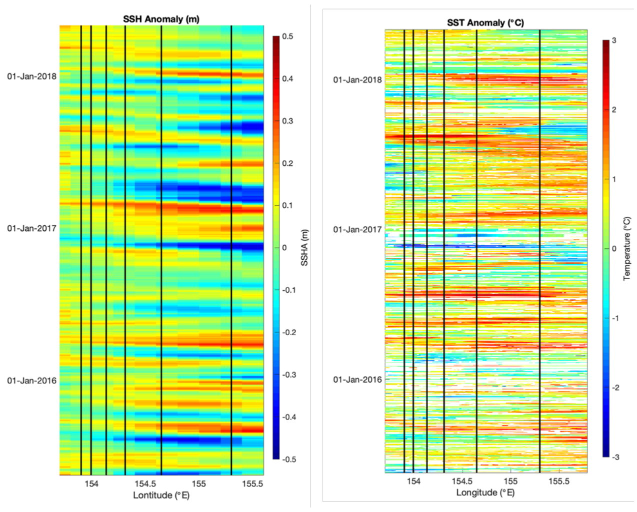


Figure 1. Hovmöller plots (longitude versus time) of the (left) Sea Surface Height (SSH) anomaly and (right) Sea Surface Temperature (SST) anomaly for a region surrounding the IMOS EAC mooring line (~27°S). Thick black lines identify the location of the IMOS EAC mooring array.

To understand the surface anomalies in terms of the EAC, we compare these data with data from the EAC mooring. The mean along-slope velocity vectors show poleward velocity dominates from 60-1500 m. (**Figure 2**). The strongest southward flow is found over the continental shelf, decreasing in strength in deeper water. The variance ellipses show that the largest variability in EAC transport is in the along-shore direction. This indicates that the EAC variability is dominated by the movement of the EAC on- and off-shore. The EAC thus maintains its jet structure as it meanders onshore and offshore adjacent to the continental slope.

While the mean along-shore velocity vectors provide a picture of the mean 3-year EAC, the time series of velocity show that the EAC has a complex and highly variable structure (**Figure 3**).

The EAC 2000 m mooring is located on the continental slope and measures the EAC core (negative along-slope velocity).

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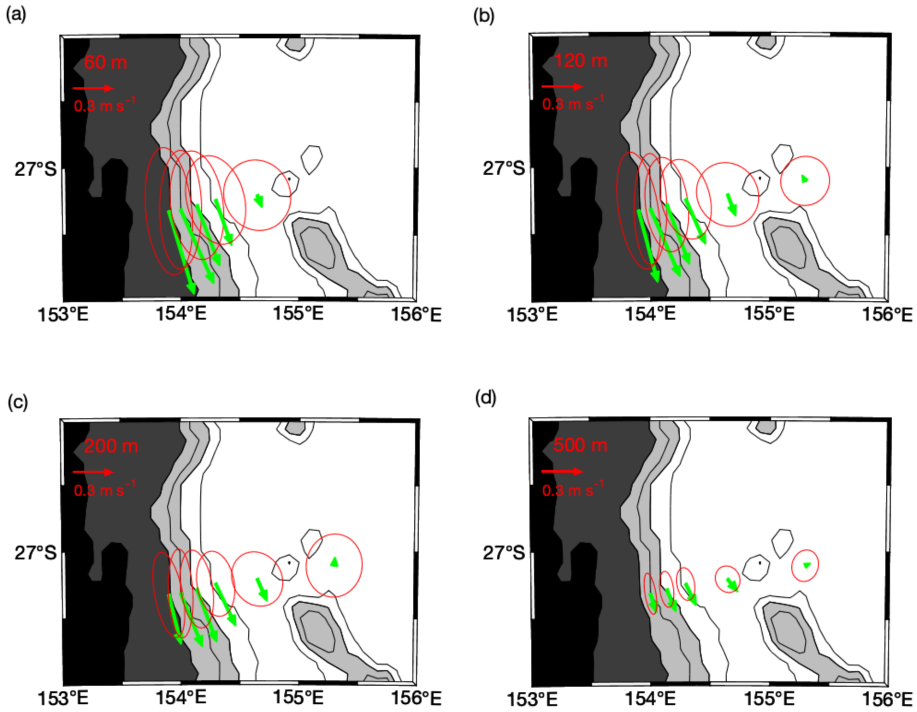

Figure 2. Three-year (May 2015-April 2018) mean along-slope velocity (m/s, green arrow) and velocity variance ellipse (red circle) for (a) 60 m, (b) 120 m, (c) 200 m, and (d) 500 m. The 1000-m, 2000-m, 3000-m, and 4000-m isobaths are contoured and topography shallower than 3000 m is shaded.

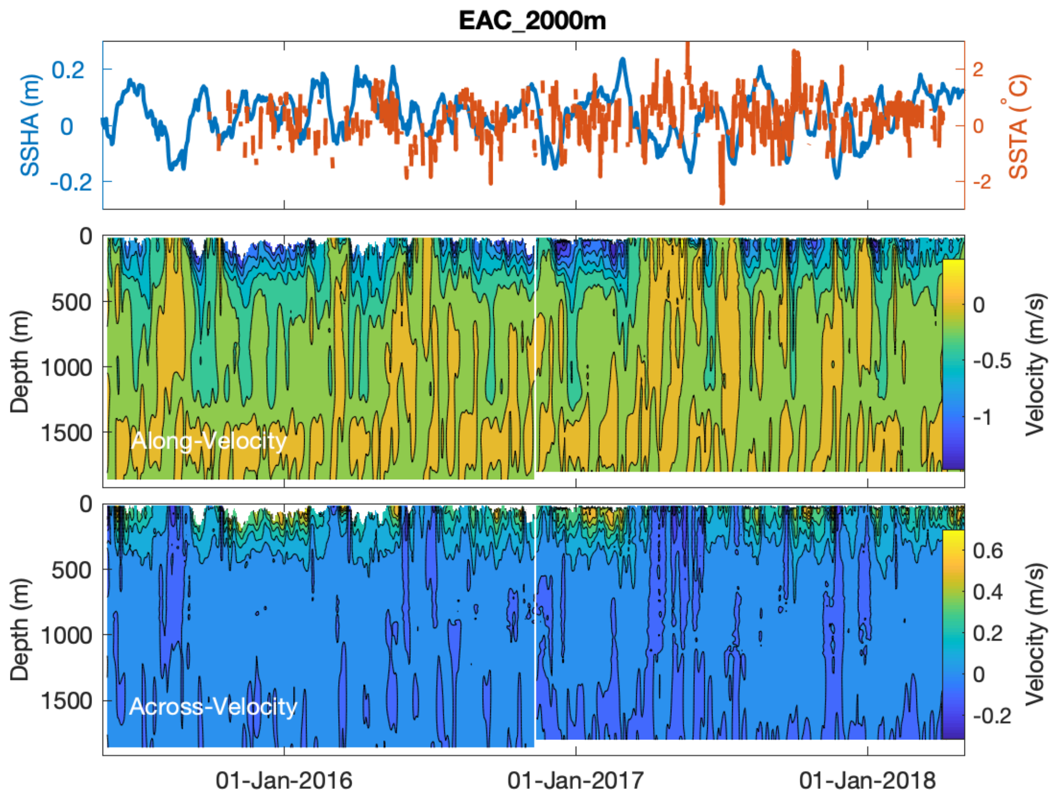

Figure 3. Time series (April 2015-May 2018) of the (top) SSH anomaly (m) and SST (°C) anomaly, (middle) Along-slope velocity (m s-1) and (bottom) Across-Slope velocity (m s-1) at ~ 27°S.

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The strong southward flow is associated with off-shore flow (positive across-slope velocity). While mostly measuring the EAC core, we see times where the flow is northward (positive along-slope velocity). This northward velocity is due to the shelf flow extending from the coast and is generally associated with on-shore flow (negative across-slope velocity). These changes in the direction and strength of the velocity are driven by cyclonic eddies inshore of the jet, and have significant influence on the exchange between the open ocean and shelf waters.

The Coffs Harbour HF Radar shows that the mean EAC jet lies above the 1500 m isobath, ~50 km offshore (Archer et al., 2017). However, the EAC jet strength is highly variable (**Figure 4**, top), with maximum surface velocities >2 m/s, and maximum speed in summer and minimum in winter (Archer et al., 2017) . The EAC meanders onshore and offshore adjacent to the continental slope, covering an offshore excursion of >100 km (**Figure 4**, bottom). The EAC has eastward displacements every 65-100 days, similar to that at 27°S (Sloyan et al., 2016), and is associated with meso-scale eddy shedding at the EAC separation.

Implications for people and ecosystems

The combination of surface and interior observations of the EAC confirm that this current is highly variable and its positions on the shelf influences the exchange between the open and shelf ocean. The interaction between the EAC jet and eddies with prominent topographic features and wind induced upwelling enhances the exchange of nutrient-rich sub-surface water between the open and coastal ocean. These exchanges have a significant influence on the biology of eastern Australian shelf waters and western Tasman Sea.

The long-term EAC mooring arrays at Brisbane (~27°S), Coffs Harbour (~30°S), Sydney (~34°S) and Narooma (~36°S) and the HF radar system at Coffs Harbour provide, unprecedented, comprehensive and valuable information about the EAC and its variability. Although the time series from the EAC mooring array is relatively short currently, over the longer term these observations of temperature and transport will be critical for informing us about how the ocean is responding to climate change, as well as for assessing climate models. The continuation of these observations, coupled with ocean modelling, will improve our understanding of EAC influences on climate, leading to more reliable ocean forecasts for eastern Australia and coastal communities, and help inform management of east coast fisheries.

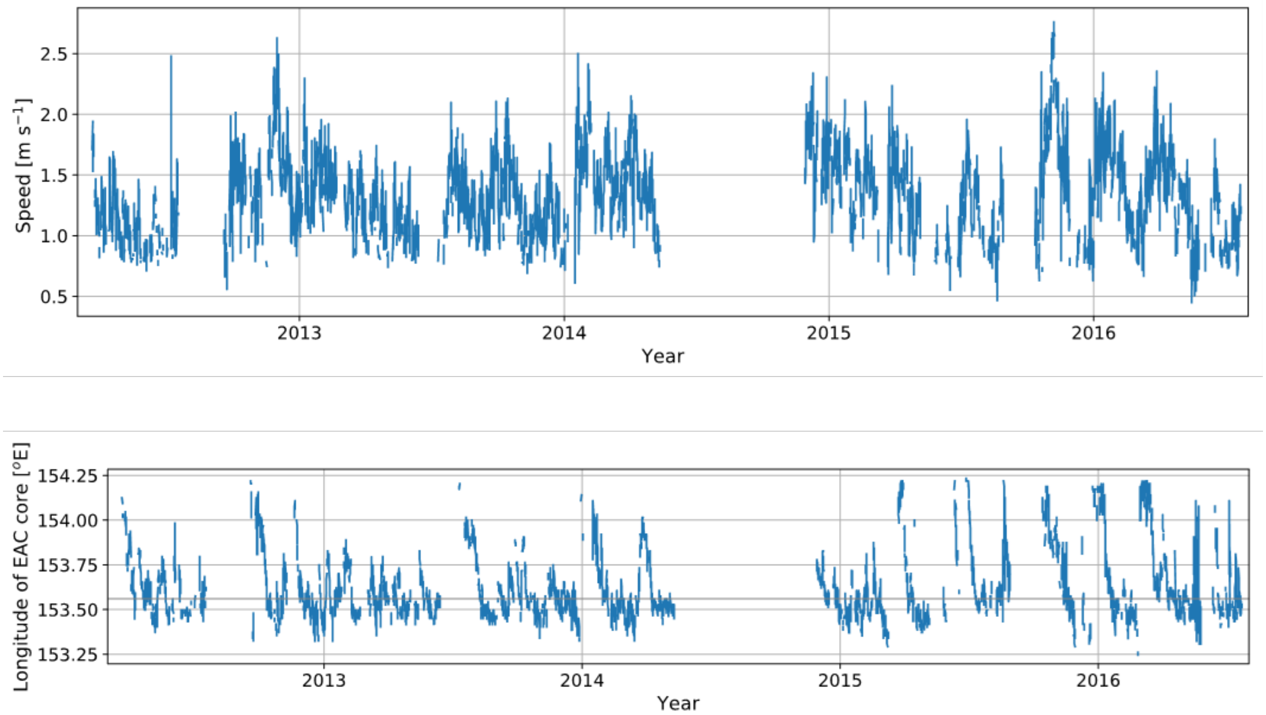

Figure 4. (Top) Speed of the core of the EAC jet calculated from HF radar derived surface velocities centered at 30°S, in a flow following framework (Archer et al. 2017) and (bottom) the position of the core of the EAC jet.

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Acknowledgements

Data was sourced from Australia's Integrated Marine Observing System (IMOS) which is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS).

Data Sources

IMOS Ocean Raddar.
http://imos.org.au/facilities/oceanradar/

IMOS Satellite Remote Sensing.
http://imos.org.au/facilities/srs/

IMOS Deep Water Moorings.
http://imos.org.au/facilities/deepwatermoorings/

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