Satellite-observed Spatiotemporal Variability of the East Australian Current Encroachment : Implications for Upwelling and Shelf Circulation

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Introduction

- The EAC is a highly dynamic Western Boundary Current system (warm current)
- Himawari-8 SST data (geostationary/10min/2km)
- Topographic Position Index (TPI) mapping technique
- A comprehensive (both temporally and spatially) mapping study on the EAC

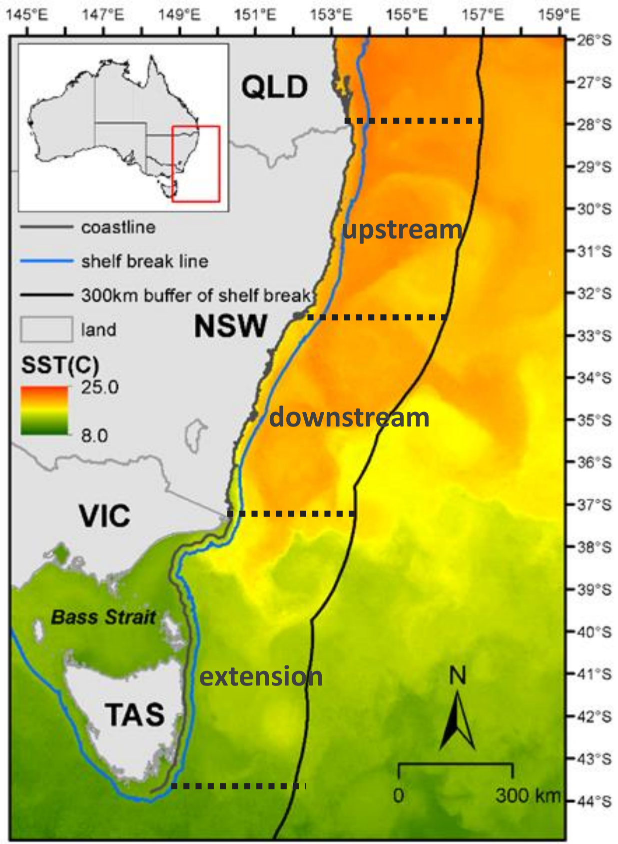
➡ Objectives: 1) Map the EAC's surface structure

2) Quantify the EAC encroachment

3) Analyse the cross-shelf movement of the EAC system

4) Discuss its impacts on coastal ocean dynamics

1) Study area and materials



6-day composite Himawari-8 SST image

2) Methodology

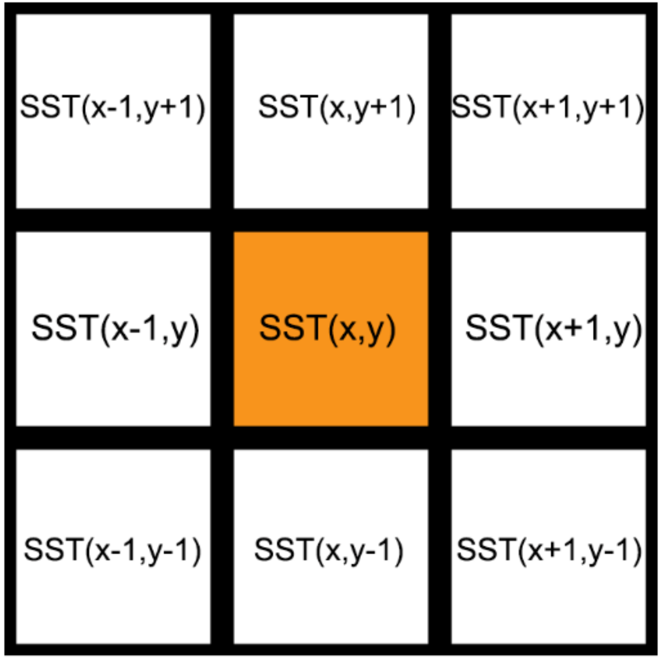
Step 1 Topographic Position Index (TPI)

$$\mathrm{TPI(x,y) = H(x,y) - M_H(x,y)}$$

$$M_H(x,y) = \frac{\sum_{j=-n}^{n}\sum_{i=-n}^{n} H(x-i,y-j)}{N^2}$$

$$n = \frac{N-1}{2}$$

$$\mathrm{TPI(x,y) = SST(x,y) - M_{SST}(x,y)}$$



2) Methodology

Step 2 image classification

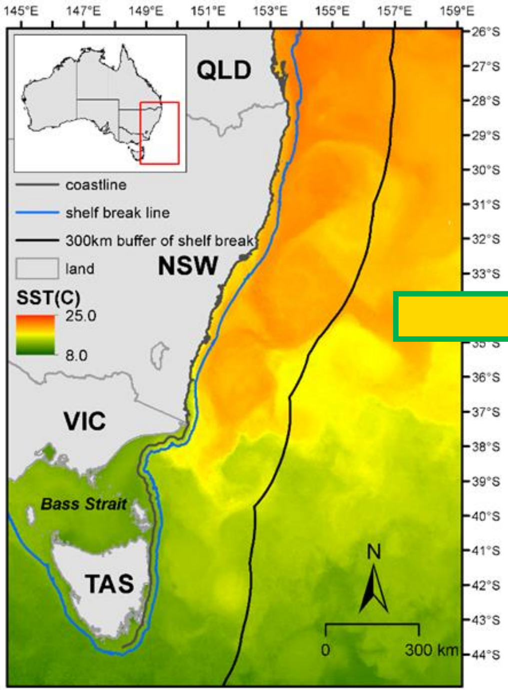


Fig.1 Himawari-8 SST image

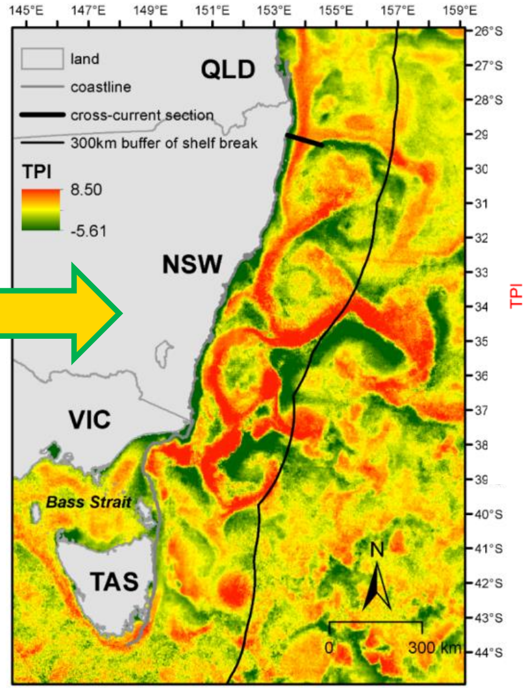


Fig.2 Topographic Position Index (TPI)

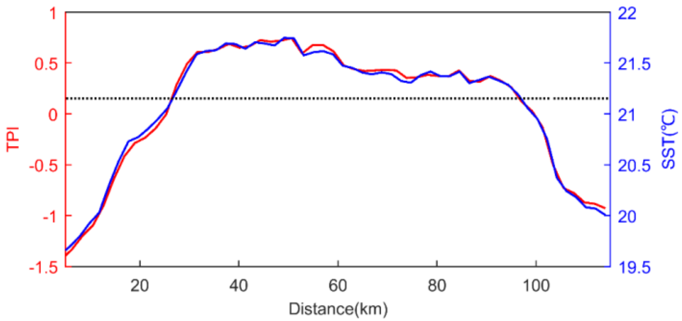


Fig.3 Classification threshold $\theta = \text{mean} + 0.5\text{STD}$

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3) Mapping product

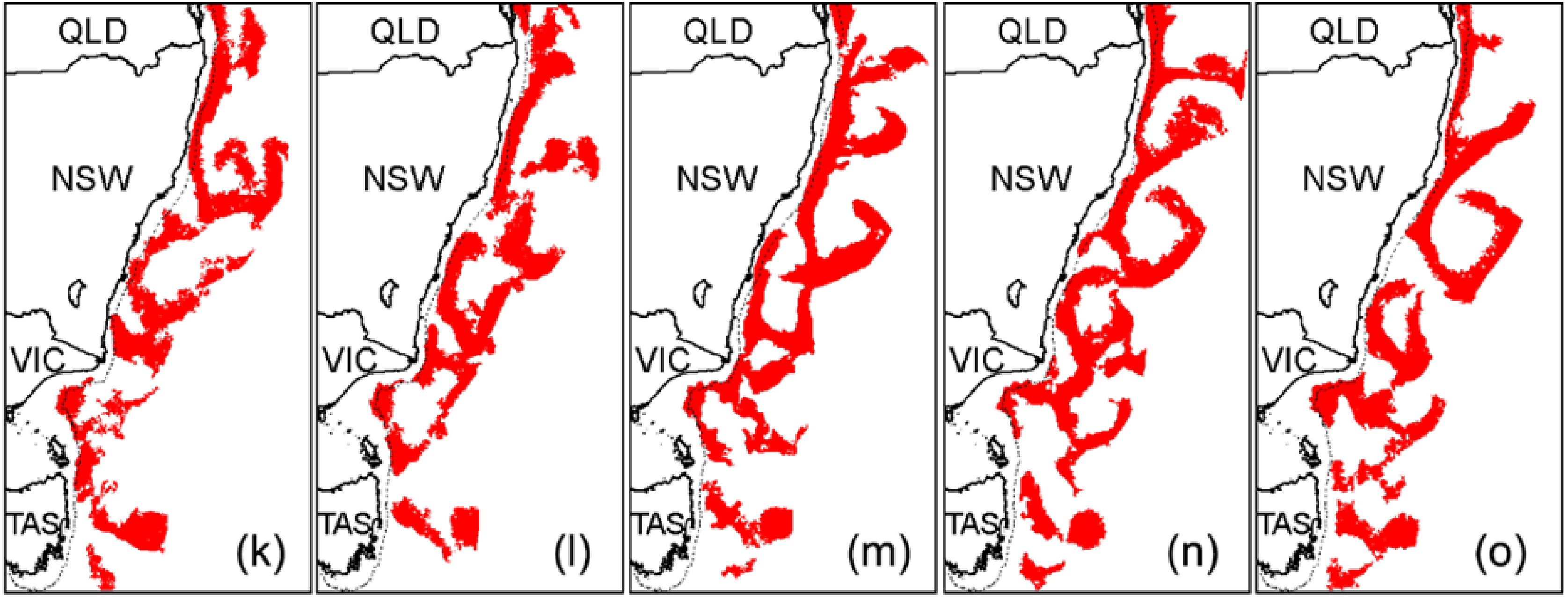


Fig.4 Maps of the EAC system, 6-day composite, for the period of August, 2016.

4) Mapping validation

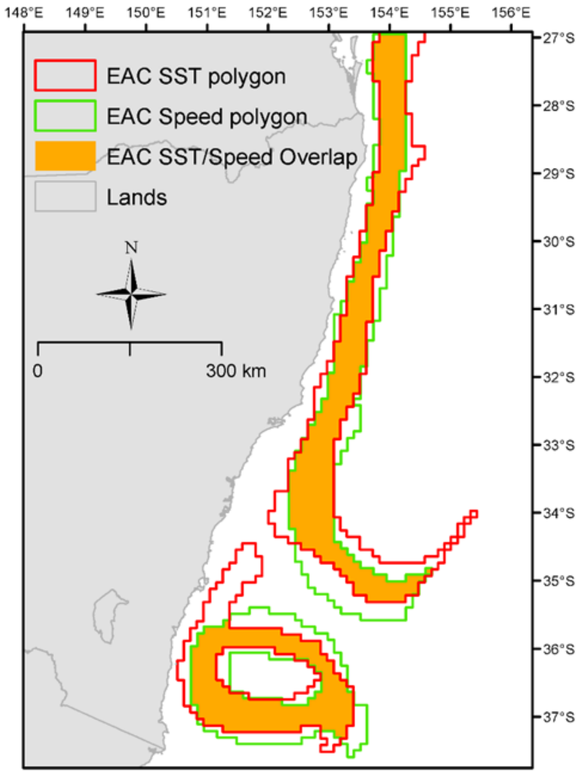
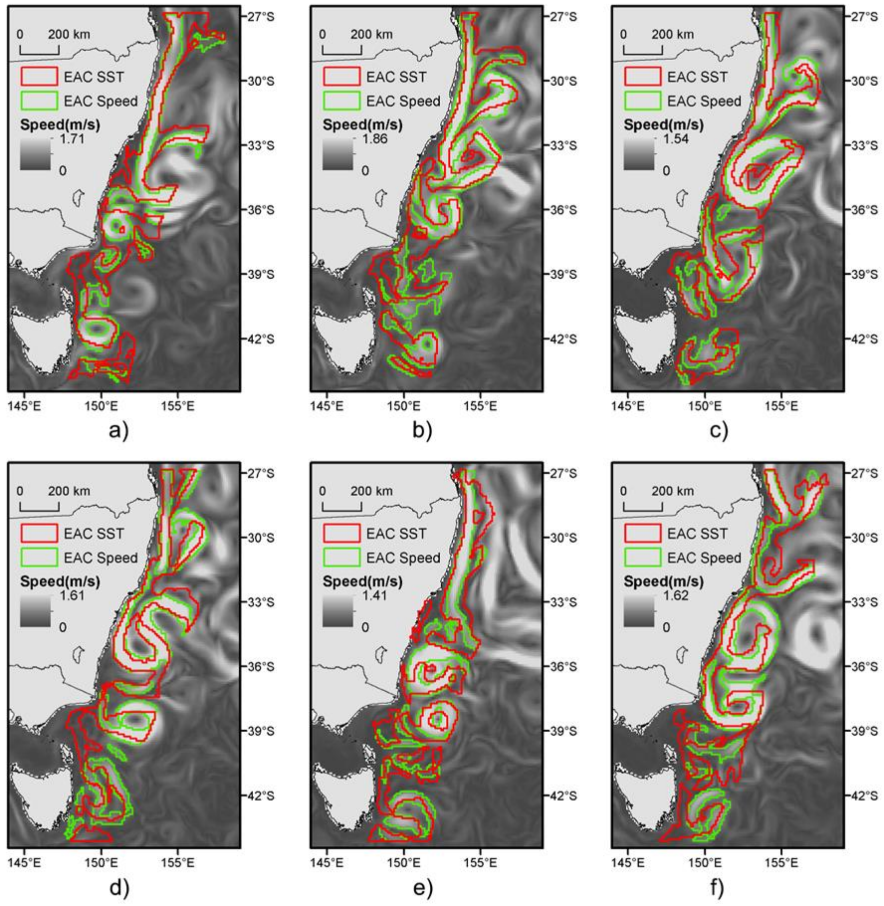


Fig.5 SST VS Speed



Overall area ratio of overlap: 60%

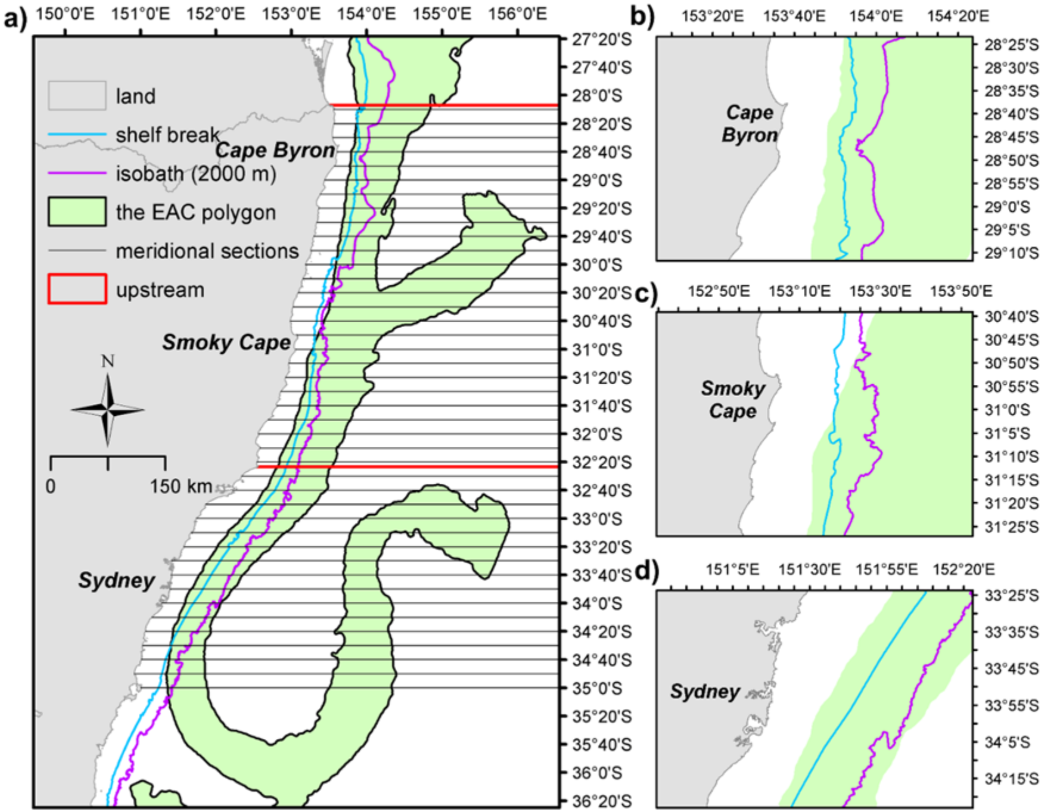
Overall mean speed: 0.66 m/s

Max 0.84 m/s 201602

Min 0.53 m/s 201607

Bluelink ReANalysis (BRAN3.5) model output (Oke et al., 2013)

5) Quantifying the EAC encroachment



Two indexes:

1) EAC encroachment area

and areal ratio

2) EAC-to-coast distance

Fig.6

6) Demonstrating the EAC encroachment

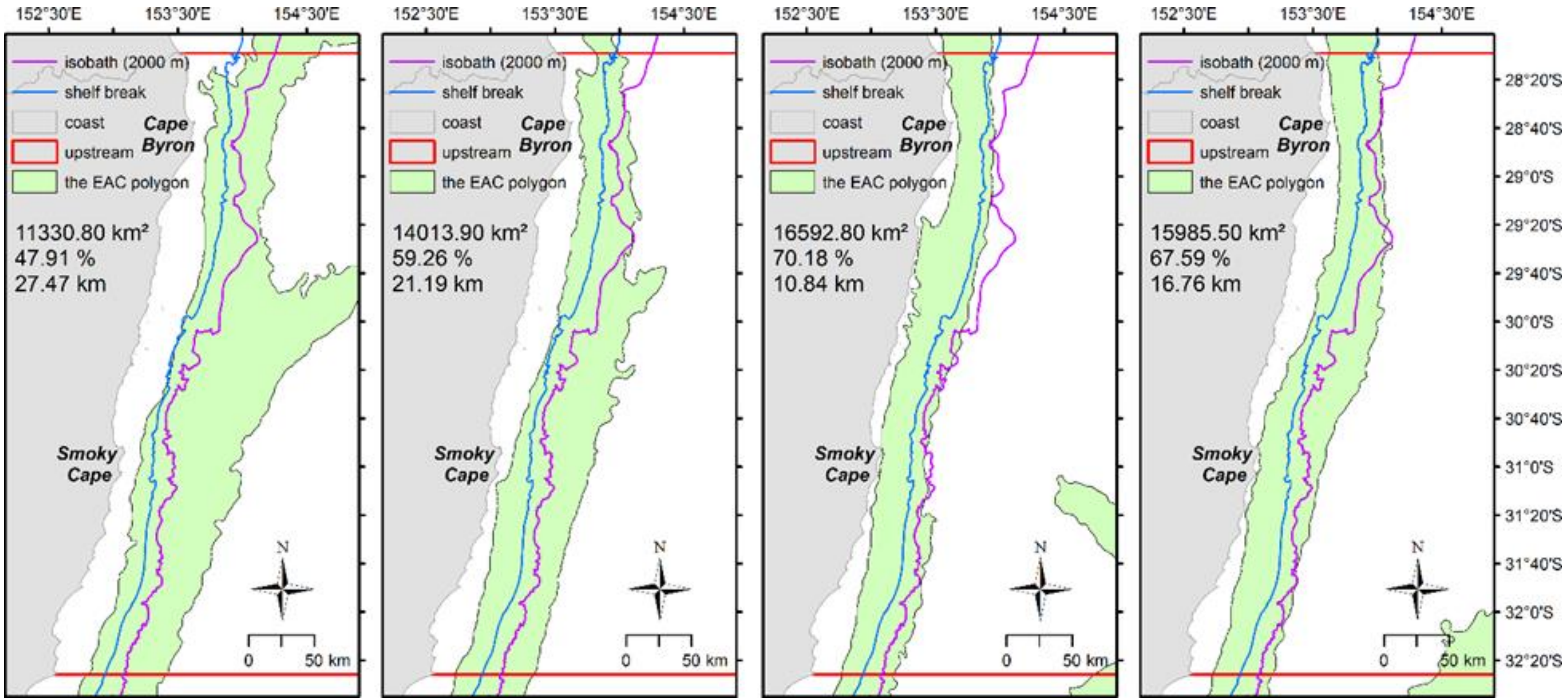
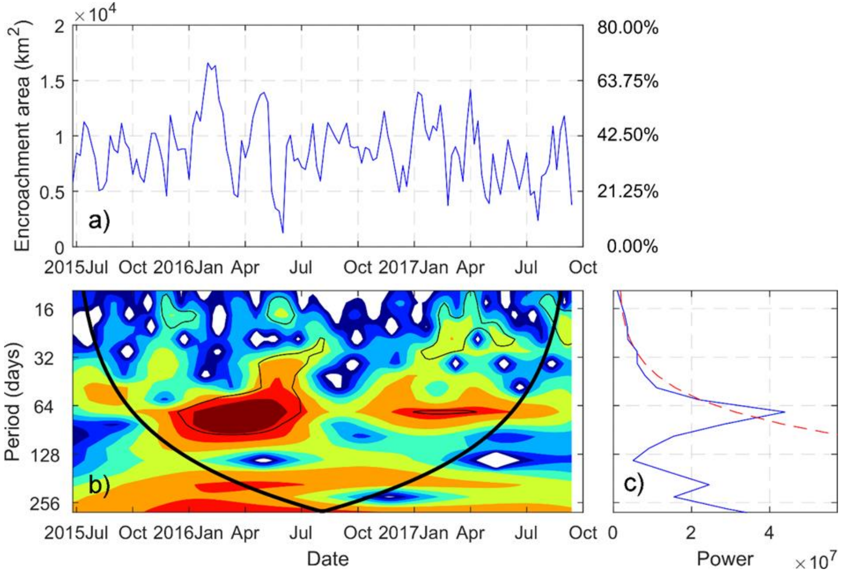


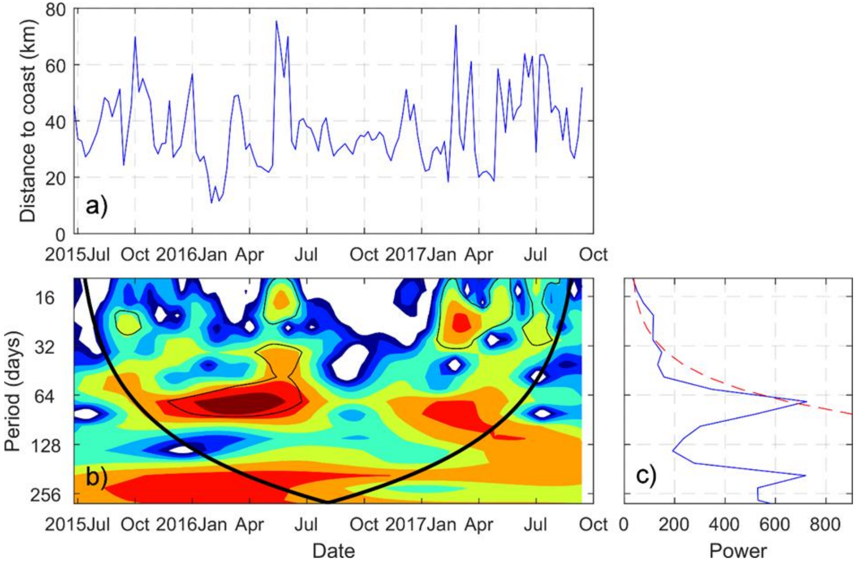
Fig.7 Maps of EAC encroachment for the period 1~24th, Feb 2016

7) Wavelet analysis of EAC encroachment time-series

a. Upstream (sub-monthly / EAC eddy-shedding period 65~80 days)

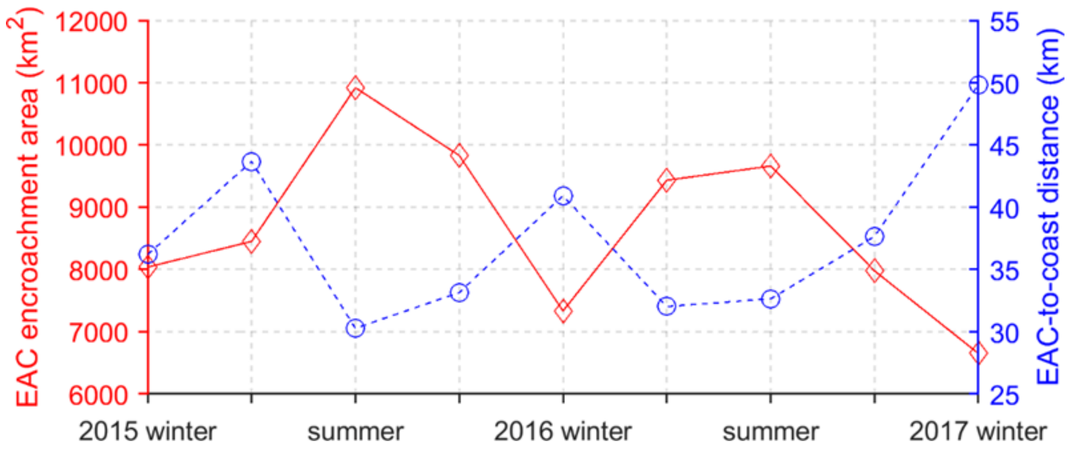


EAC encroachment area



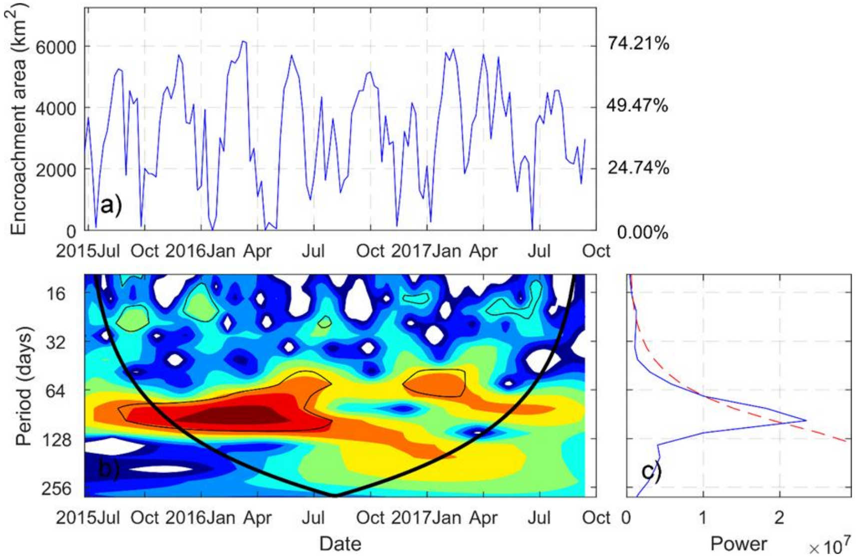
EAC-to-coast distance

a. Upstream (seasonality)

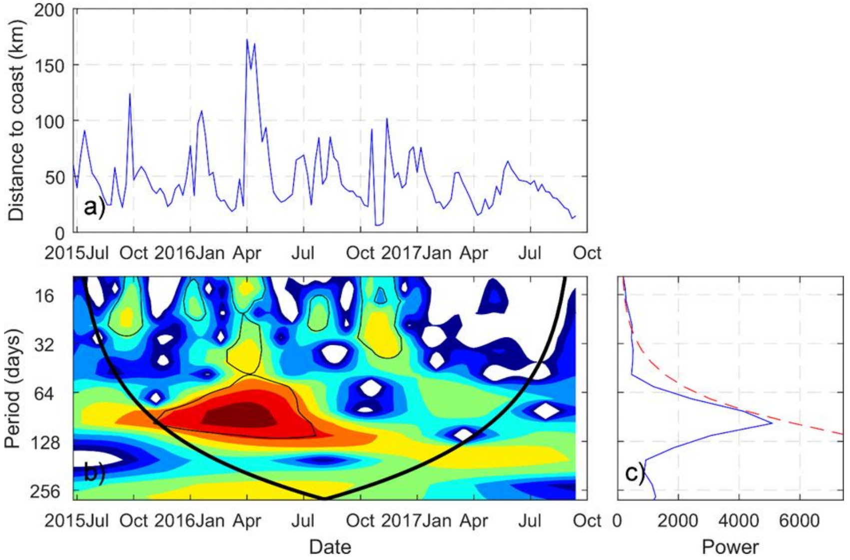


Wavelet analysis

b. Downstream (sub-monthly / EAC eddy-shedding period 90-100 days)

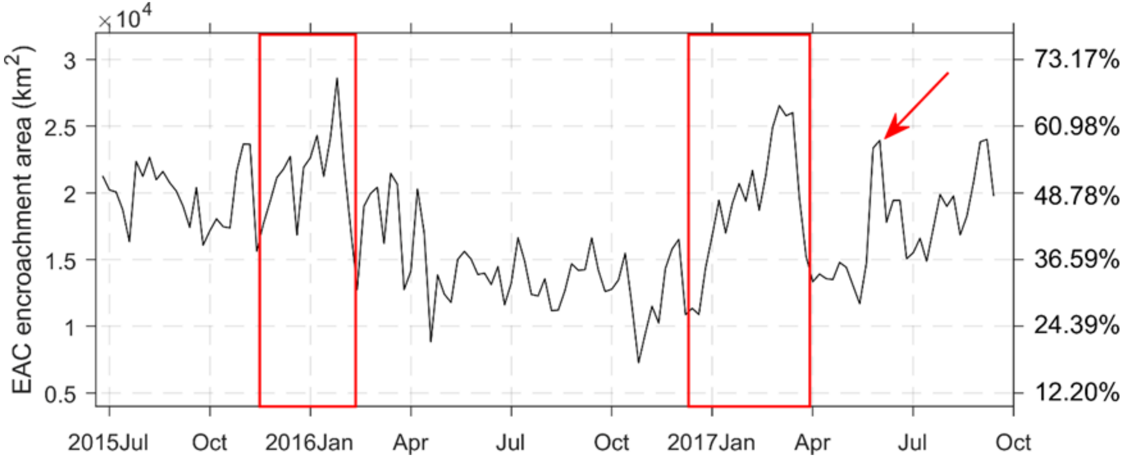


EAC encroachment area (Sydney)



EAC-to-coast distance (Sydney)

c. Extension Zone off eastern Tasmania (summer pulses of EAC intrusions)



Discussion: Implications for coastal ocean dynamics

1. Coastal upwelling

- ***Upstream***: “encroach and accelerate” mode;

  all year round upwelling with summer outburst.

- ***Downstream***: “encroach and decay” mode;

  less likely to induce and sustain bottom water uplift.

EAC’s “encroach and accelerate” mode

bottom stress+

bottom boundary layer shut-down time+

induces and sustains upwelling

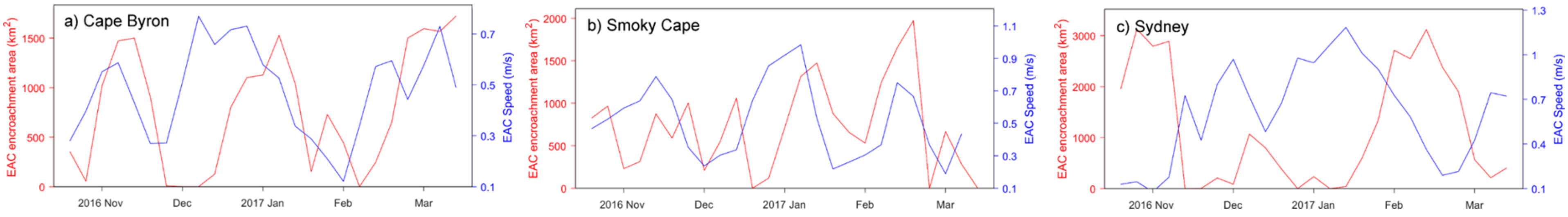
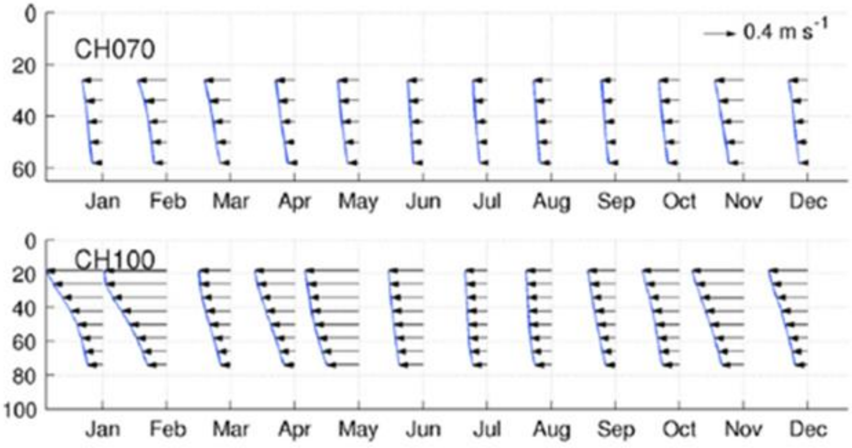


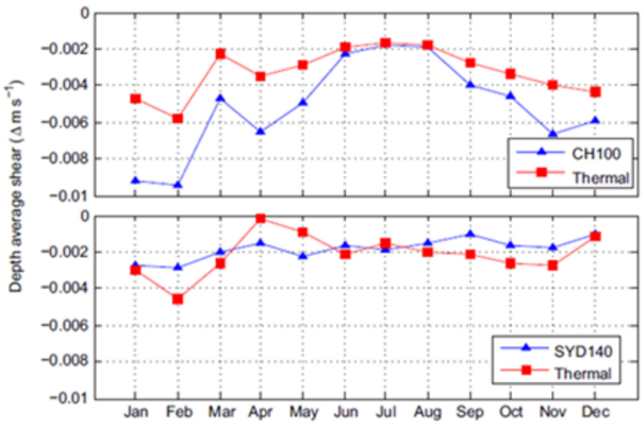
Fig.8 EAC encroachment vs EAC speed

Discussion: Implications for coastal ocean dynamics

2. Shelf Circulation

- *Upstream*: Strong vertical current sheer forms in summer





Thermal wind theory $$\frac{dv}{dz} = -\frac{g}{\rho f}\frac{d\rho}{dx}$$

(Wood et al.,2016)

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Summary and Conclusions

1. First quantitative mapping of a Western Boundary Current system using Himawari-8 SST data; Wide application to other WBCs

2. EAC encroachment: sub-monthly, eddy-shedding timescale (*upstream 65~80 days and downstream 90~100 days*); Seasonality (*upstream*); In the *extension zone*, summer pulses of the EAC encroachment identified;

3. *Upstream*: "encroach and accelerate" mode; Strong current driven upwelling; Summer outburst
   Downstream: "encroach and decay" mode; Weak current driven upwelling

4. *Upstream*: seasonal current sheer on the shelf; a combined effect of stronger EAC encroachment and enhanced temperature difference between shelf and EAC waters (thermal wind effect) in summer

Thank you !

Questions?