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Atmospheric and oceanic forcing of coastal deoxygenation along a western boundary

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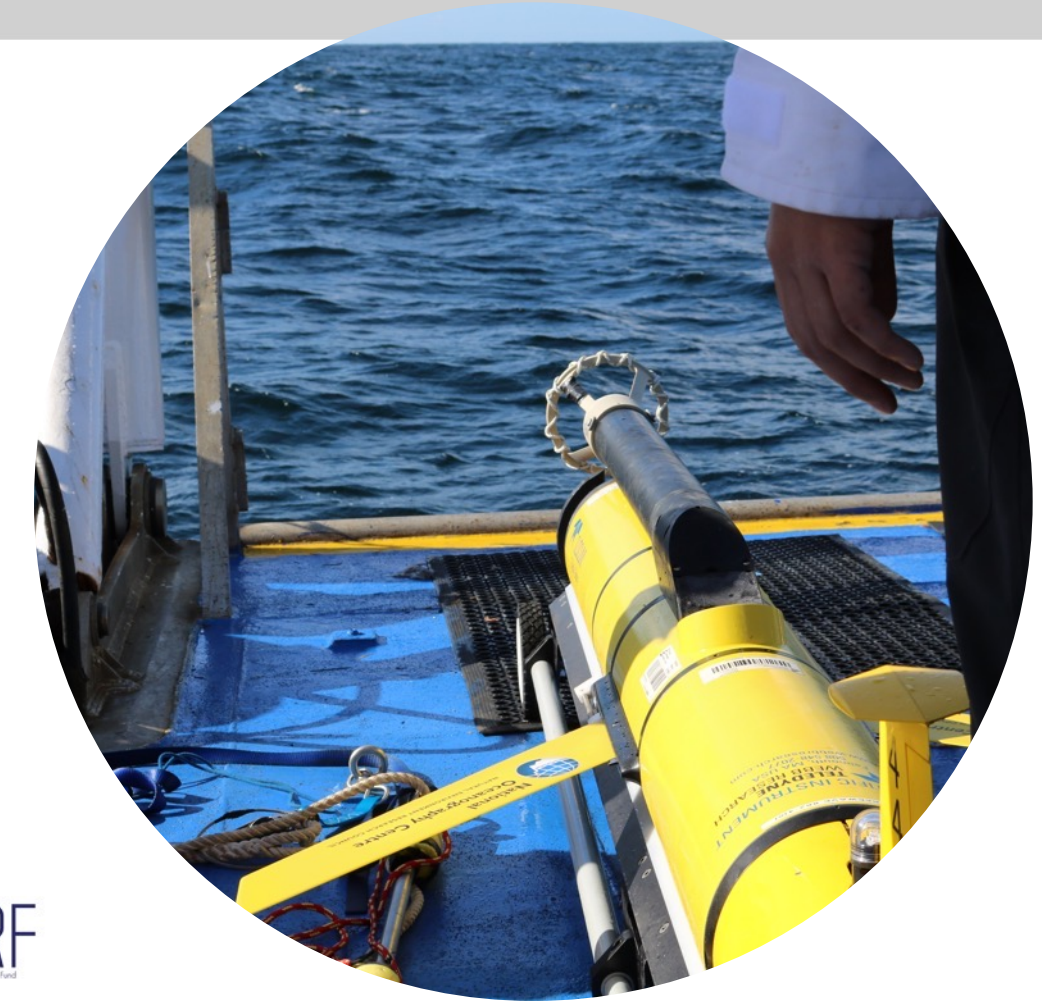

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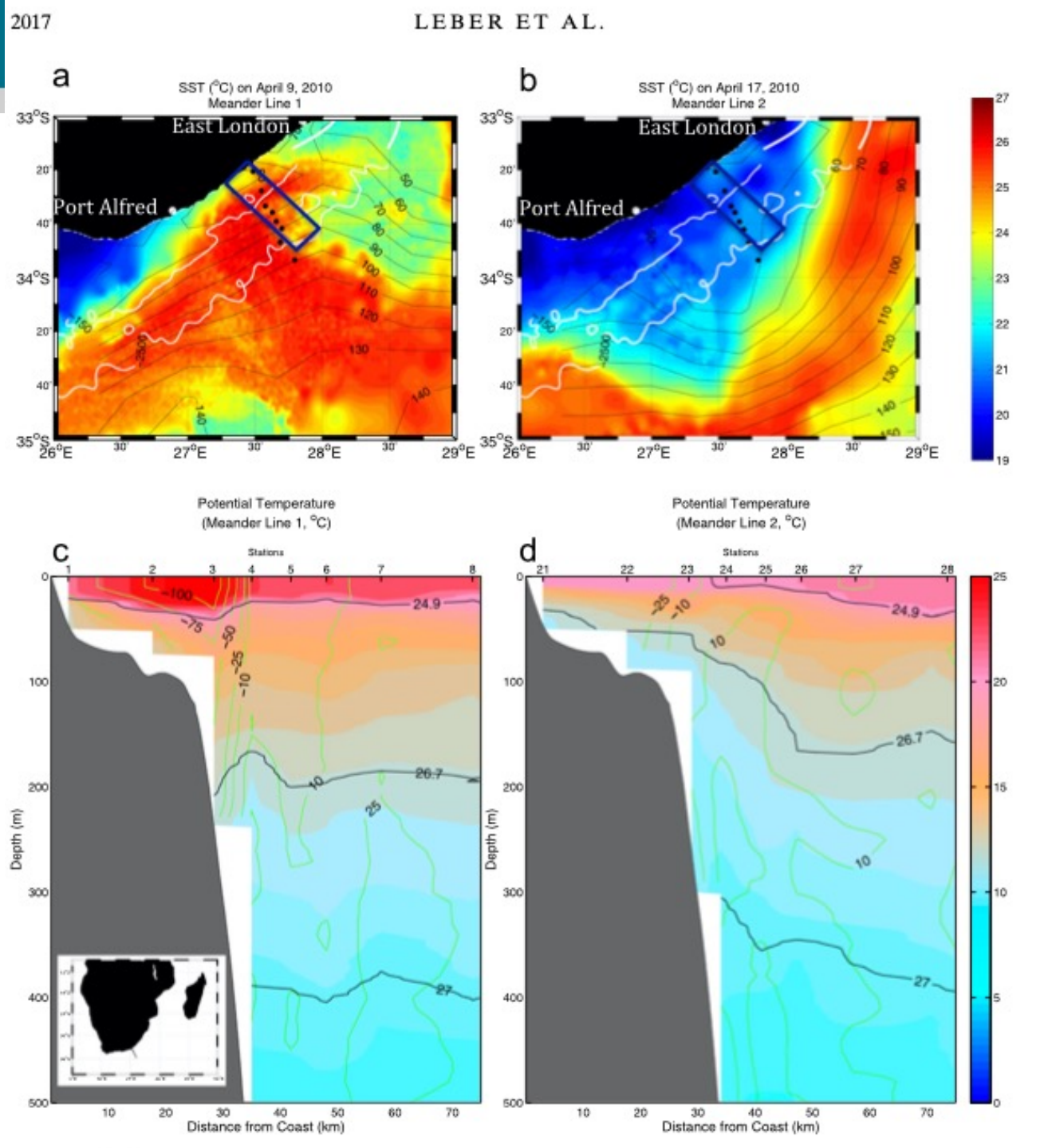
UKRI Natural Environment Research Council

GCRF Global Challenges Research Fund

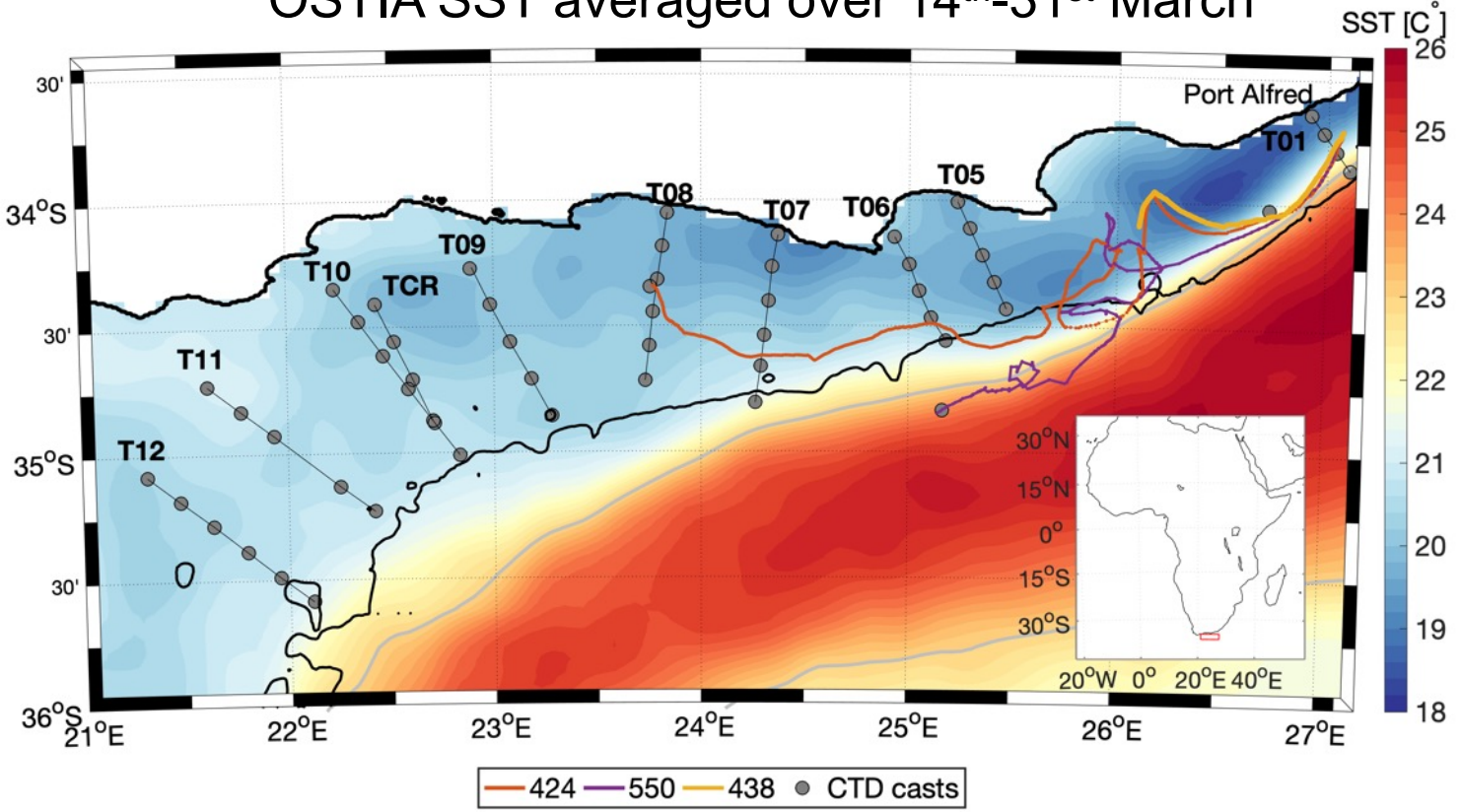
Motivation

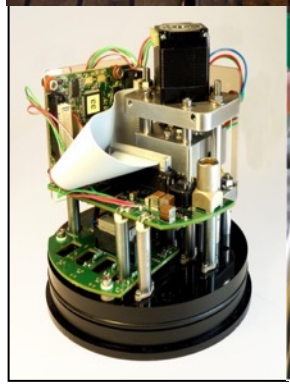
- Impact of climate change on food security in the Western Indian Ocean
- Agulhas Current enables exchange of shallow shelf with open ocean
- Oxygen dynamics of the eastern and central Agulhas Bank are poorly understood and lack of understanding poses threat to food security



Fieldwork Autumn 2019

OSTIA SST averaged over 14th-31st March



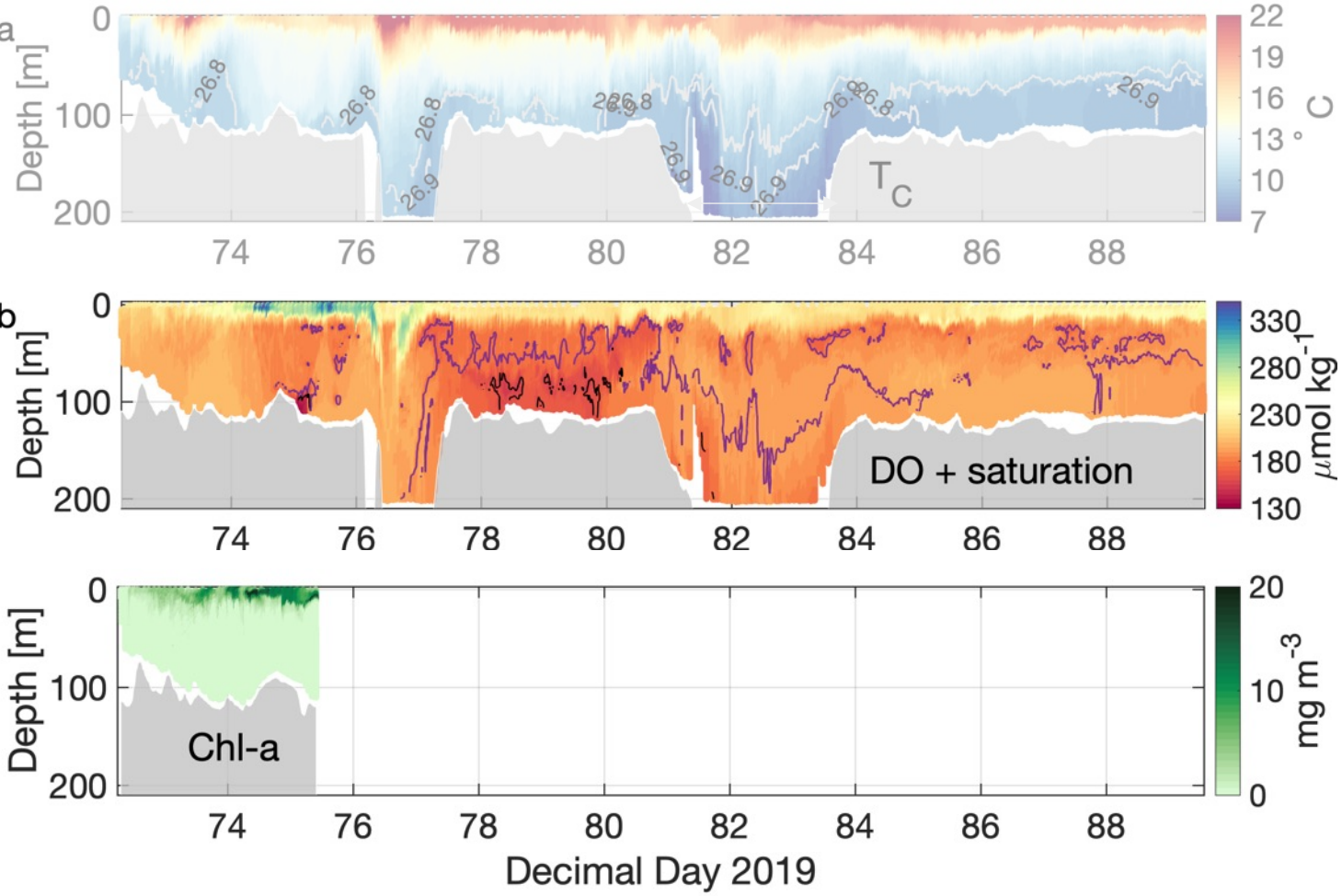


R/V Ellen Khuzwayo - CTD survey
20th March – 1st April 2019

CTD, Chl-a, DO, NO_x,
TKE dissipation

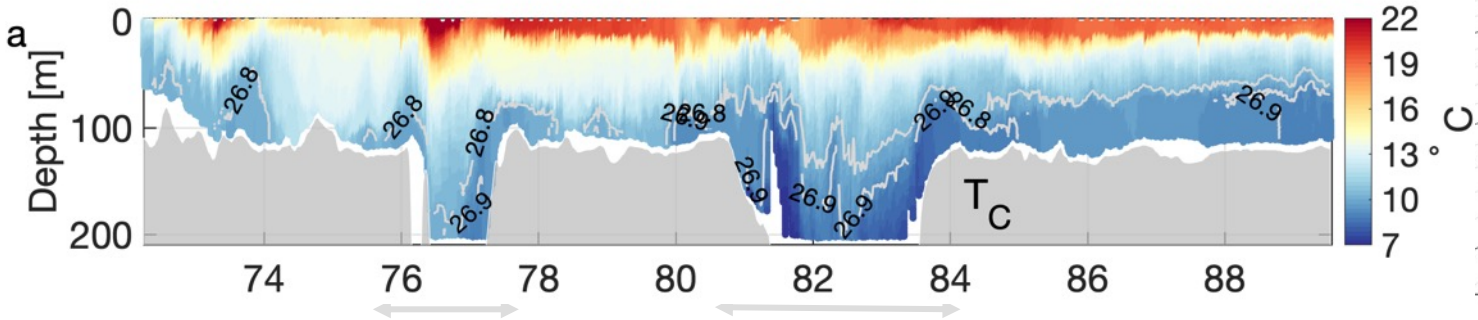
Cross shelf glider transect using 2 shallow Slocums and 1 Seaglider
14th March – 31st March 2019

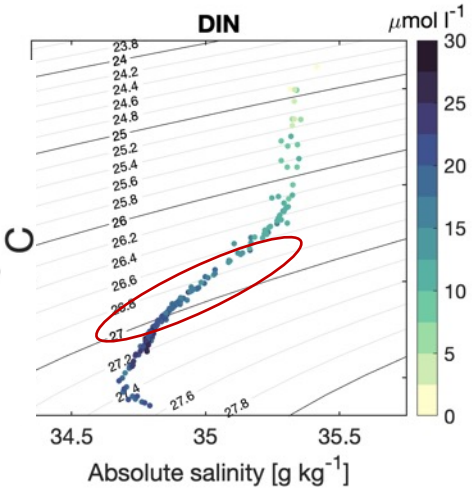
Results

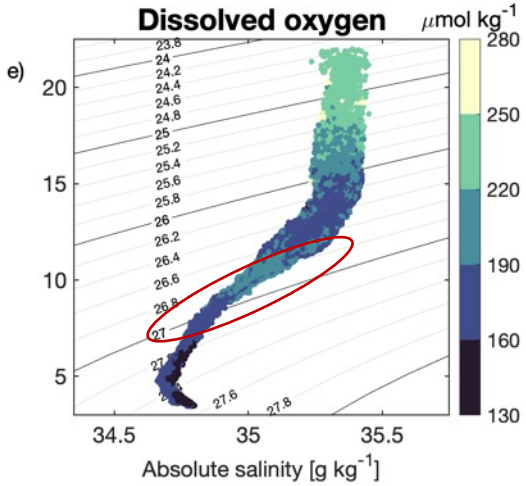


- Dissolved oxygen concentration are spatially variable across the Eastern Agulhas Bank
- General westward and inshore decrease of DO concentrations
- Evidence of low DO originating at the shelf break
- Observed maximum values of 455 µmol kg^{-1} (192% saturation) south of Algoa Bay --> active PP fuelled by supply of nitrate to euphotic zone
- Observed lowest DO concentration to date on EAB: 119.7 µmol kg^{-1}, which is below the habitat threshold of commercially important local fishery
- Only observed by gliders following high PP in the coastal region south of Algoa Bay

Results - stratification

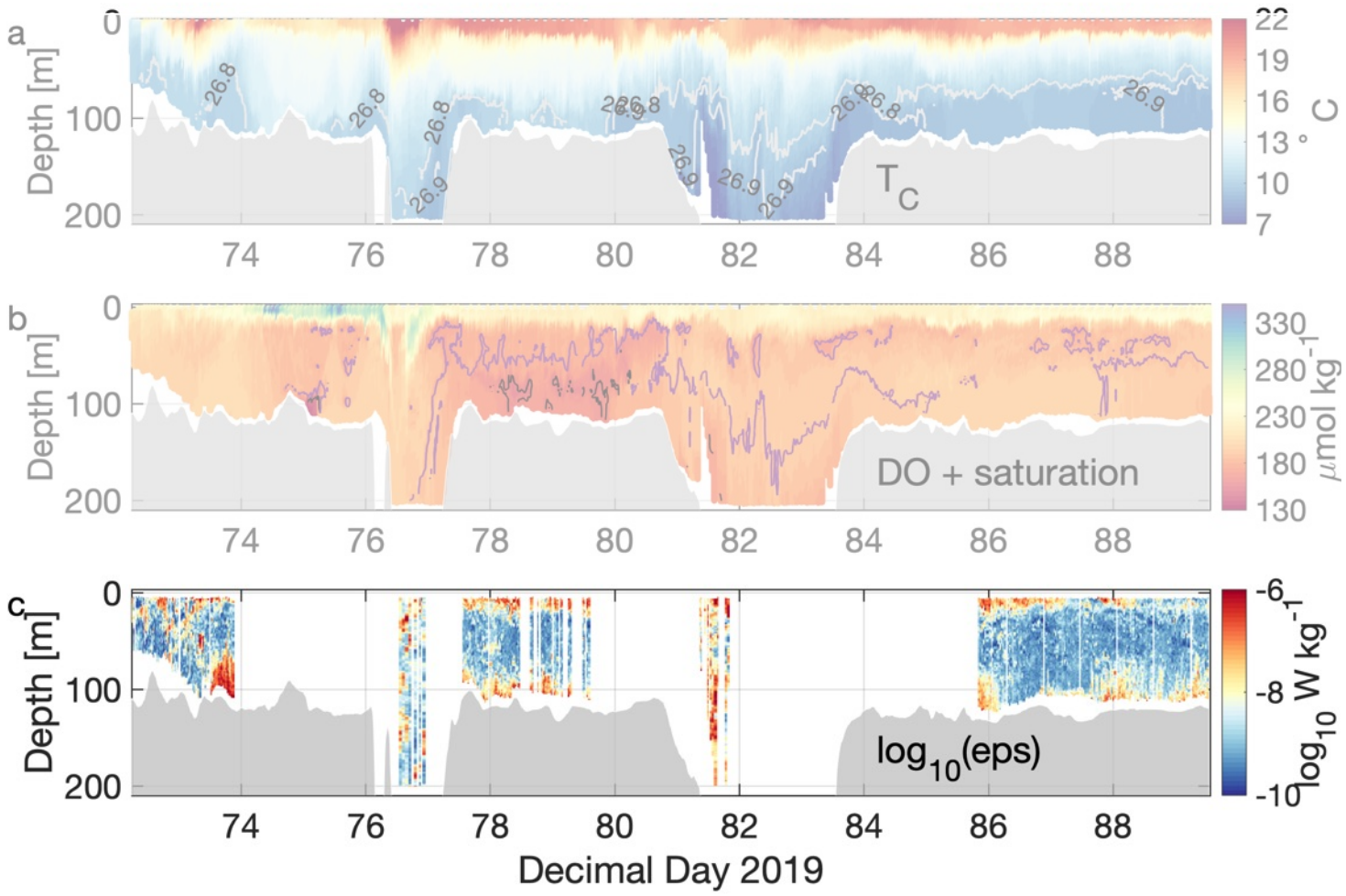






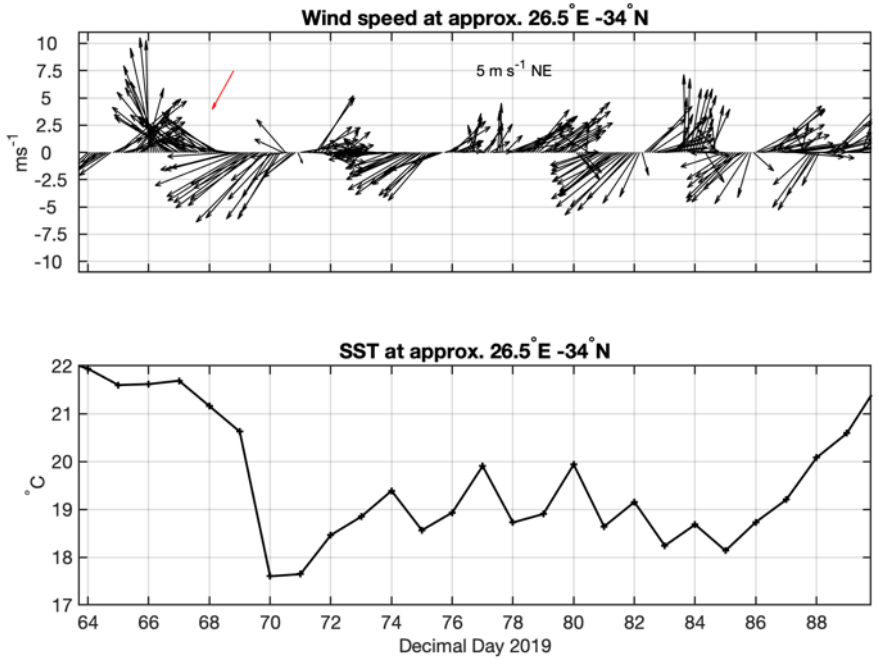
- Westward and offshore increase in stratification and SST
- Warmest SST (23.6˚C) are found in offshelf waters (> 200m depth) indicative of edge of Agulhas Current that sat off the shelf edge
- Coldest SST and weakest stratification was found near deployment site, vertical structure likely indicates active or recent upwelling onto the shelf
- Active upwelling onto the shelf at dd 76-77 and 81-83 contributes to strong stratification away from the coast
- Upwelled water is South Indian Central Water

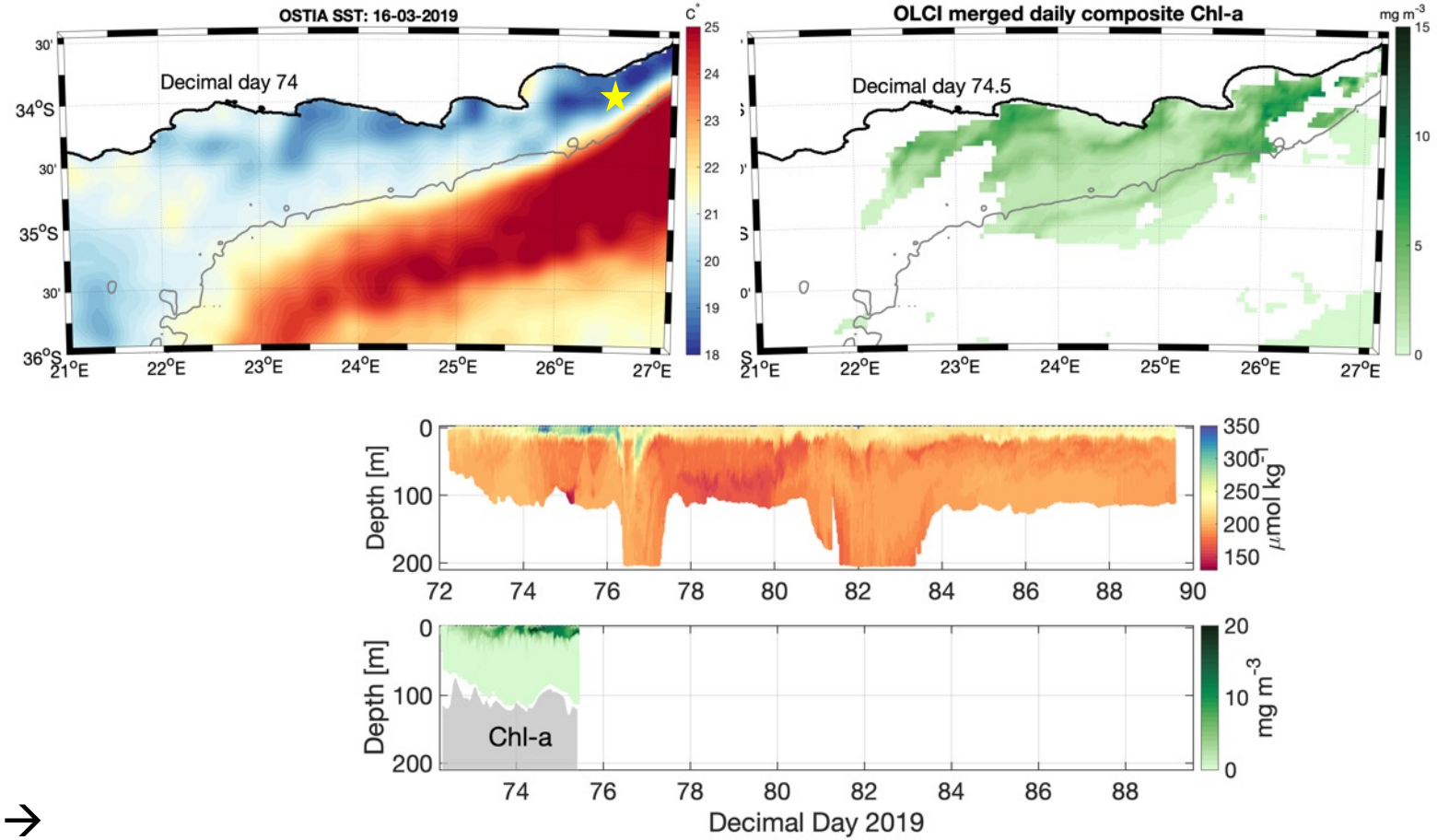
Vertical mixing



- High levels of background noise during thruster operation – data removed
- Average vertical diffusion rate at the base of the euphotic zone:
  K_{Eup}= 7 x 10^{-5} m^2 s^{-1}
  - Order of magnitude less than other comparable continental shelves
- Low background mixing levels with potential for episodic mixing events, but likely not of first order importance to supply nutrients to the euphotic zone or ventilate BML

Wind driven upwelling

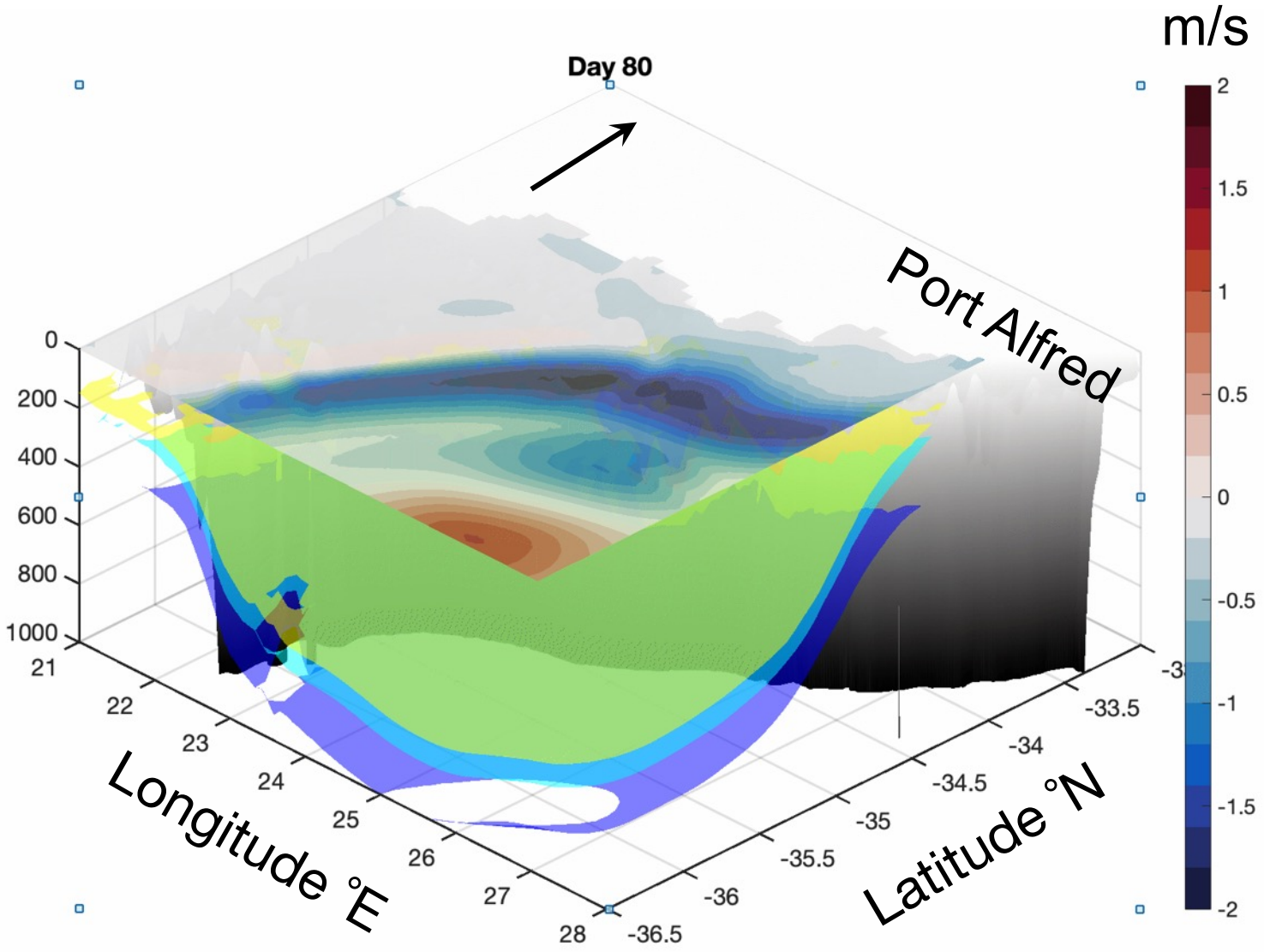




Easterly winds or negative wind stress curl → Ekman suction/upwelling

Results

- 1/12˚coupled physics-biogeochemical NEMO-MEDUSA
- 1990-2015
- Broadening of Agulhas Current is associated with increased cross-shelf exchange



Jacobs et al 2020

Summary

- New observations show upwelling of South Indian Central Water primes the shelf with cold, nutrient rich but oxygen depleted waters

- Wind driven circulation appears to exert a first order control on the vertical water column structure and the supply of nutrients to the euphotic zone on the shelf

- Agulhas Current has been observed to be broadening due to increased EKE and is projected to widen further with climate change
  - This could result in intensification of shelf edge upwelling with the potential to strengthen stratification further and increase the nutrient load onto the shelf and its deoxygenation even more