OceanPredict COSS-TT meeting, Montréal, 2 May 2023

The importance of the land-sea breeze in driving coastal dynamics of the southern Benguela upwelling system

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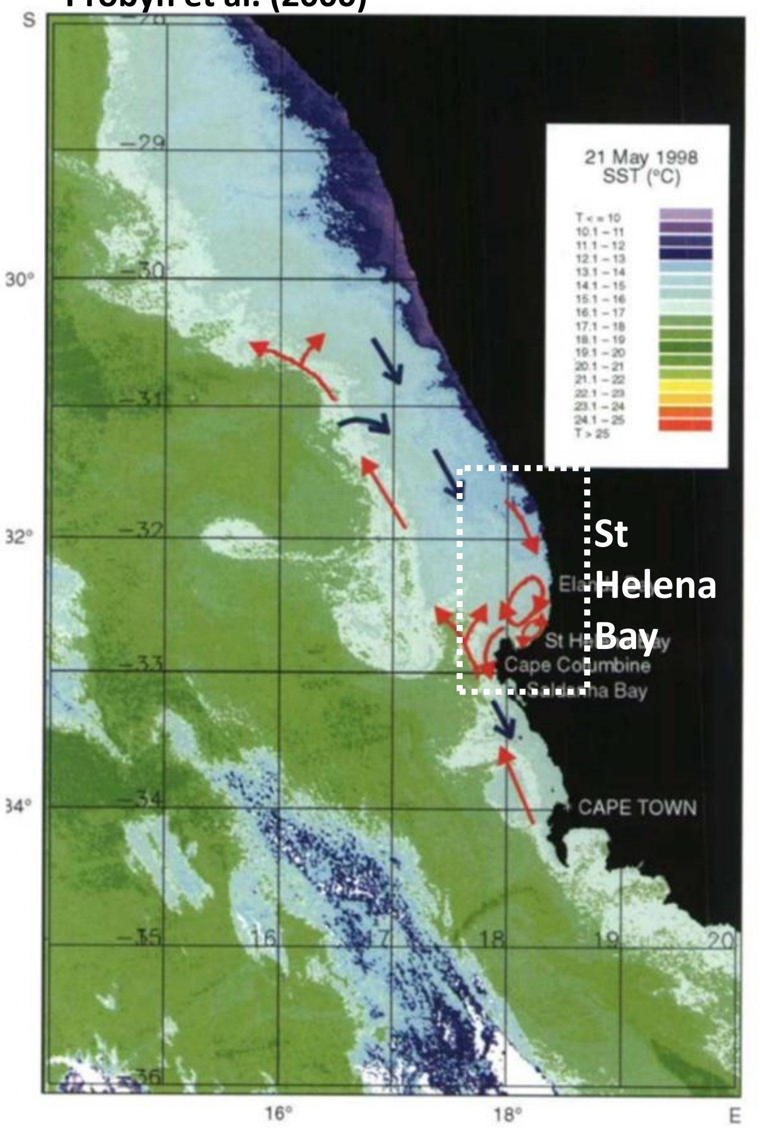
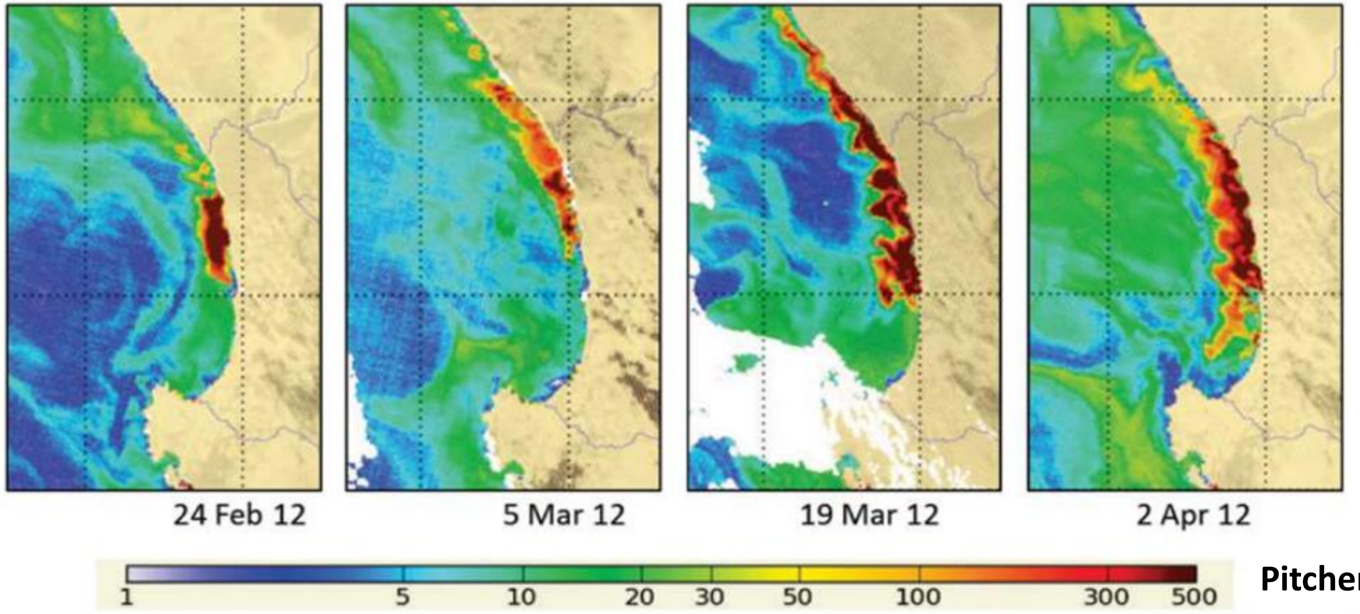


Probyn et al. (2000)

The context

- St Helena Bay is the most productive region of the southern Benguela upwelling system
- Physics and productivity is largely understood within the context of the upwelling-relaxation cycle - driven by wind variability with a time-scale of days to weeks
- The land-sea breeze has a time-scale of less than a day, so is it important in the predictability of the system?



Pitcher et al. (2014)

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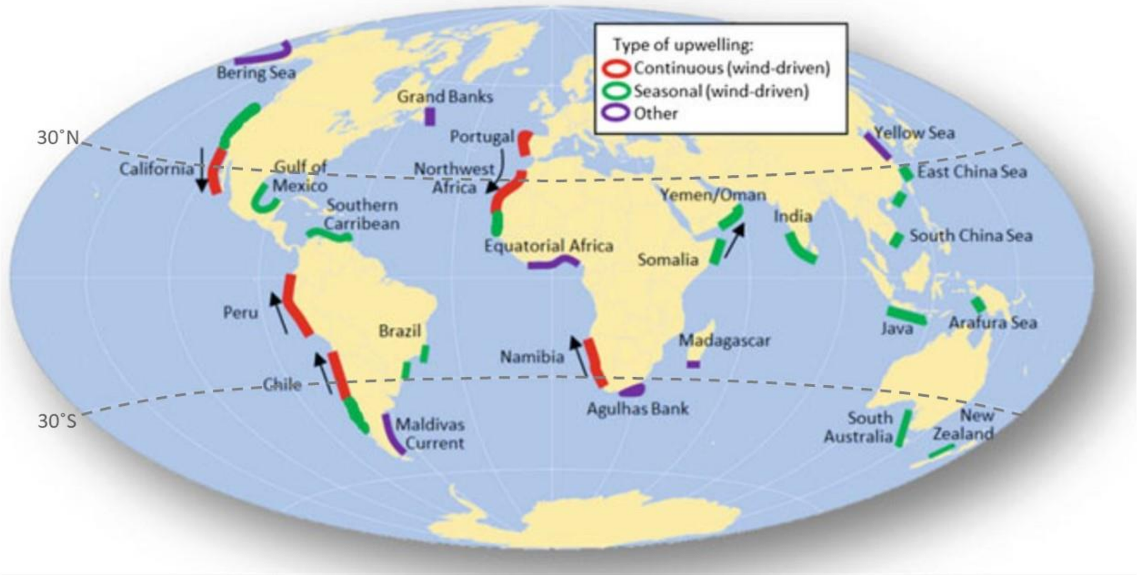
The forcing mechanism

- When latitude $\varphi = 30°$ N/S, $f = 2\Omega \sin\varphi = \Omega$ i.e. inertial frequency is diurnal $\Rightarrow$ resonant with the land-sea breeze

Adapted from Kämpf and Chapman (2016)



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- When latitude $\varphi = 30°$ N/S, $f = 2\Omega \sin\varphi = \Omega$ i.e. inertial frequency is diurnal $\Rightarrow$ resonant with the land-sea breeze
- Ocean response is largely driven by the amplitude of the diurnal anticyclonic rotary component of the wind stress (τ^{ac0})

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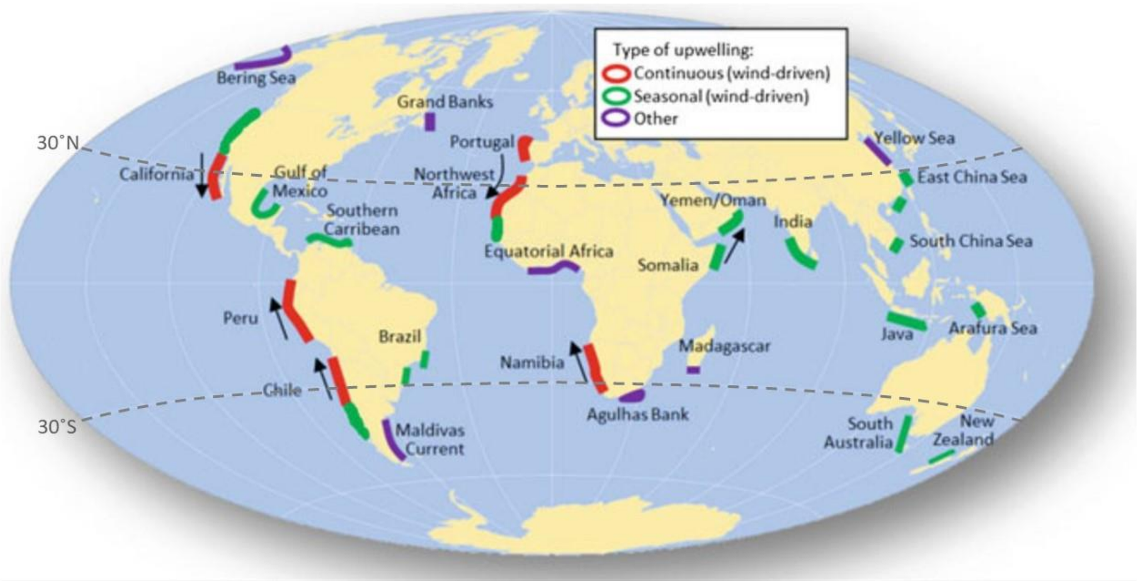

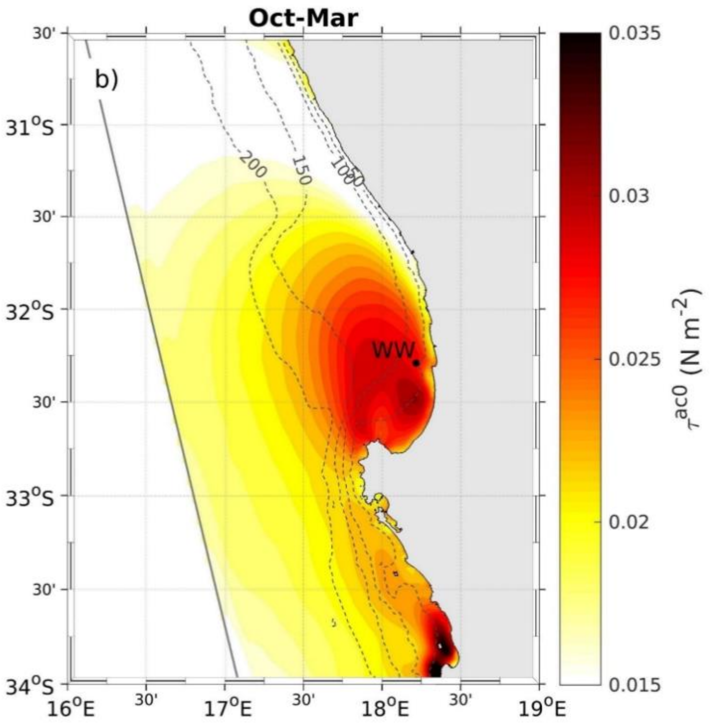

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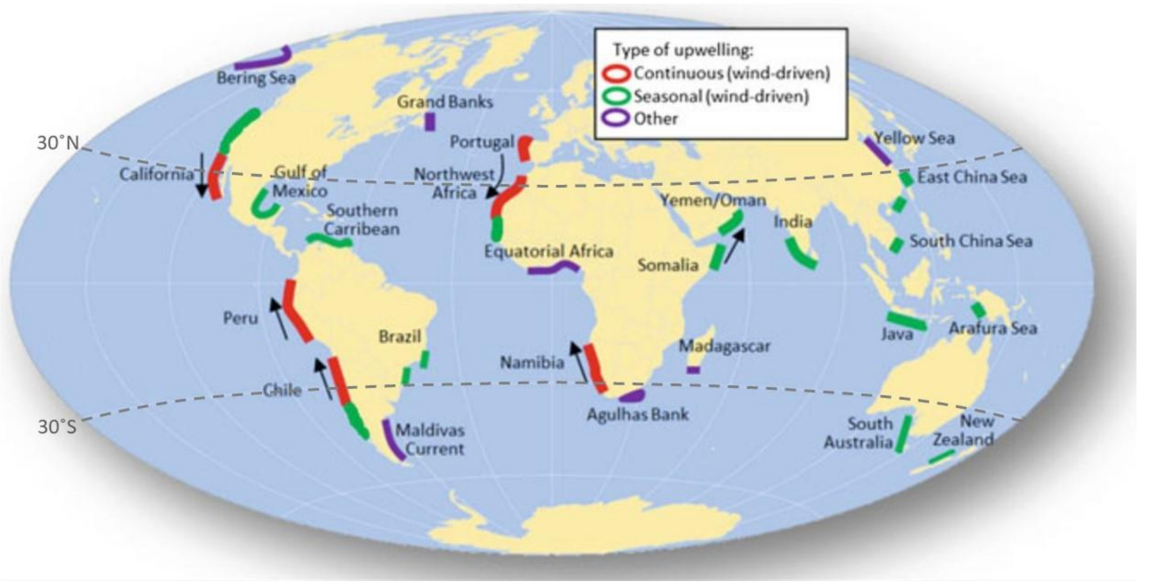
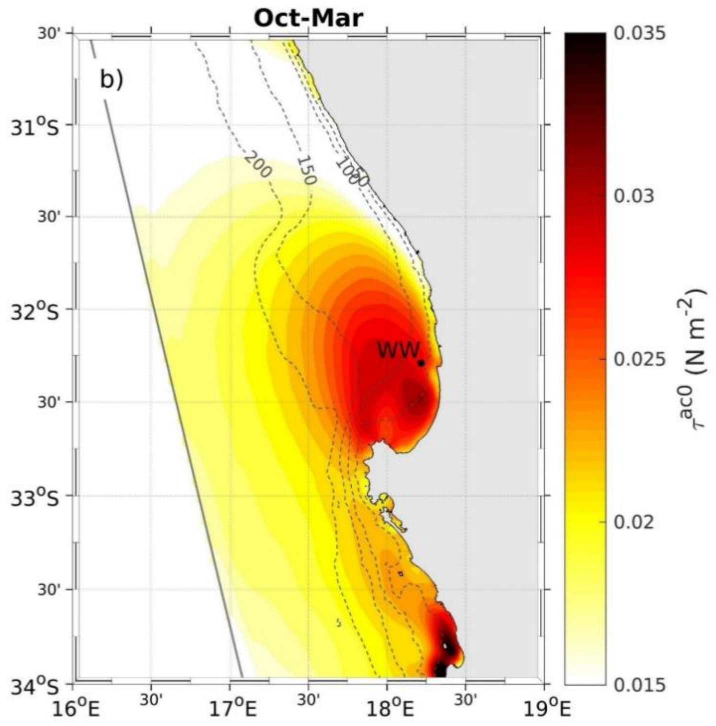
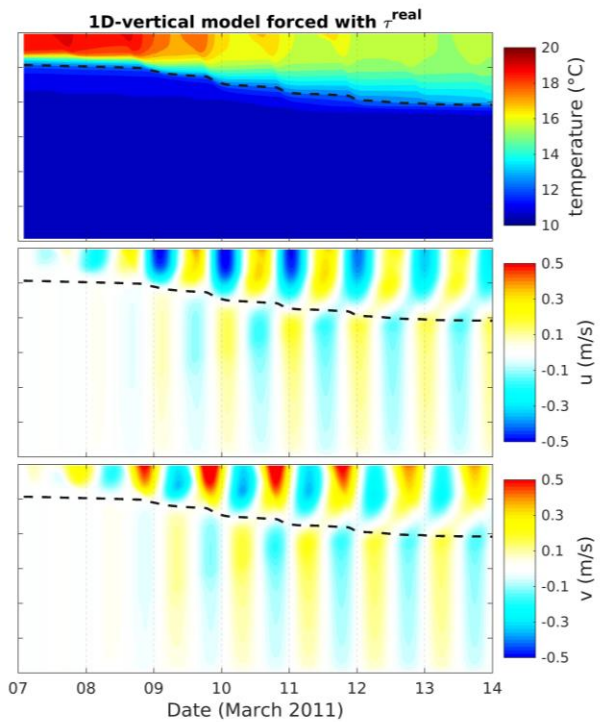
- Ocean response is largely driven by the amplitude of the diurnal anticyclonic rotary component of the wind stress (τ^{ac0})
- Locally forced vertical current structure can be produced with a simple 1D model (Fearon et al., 2020)

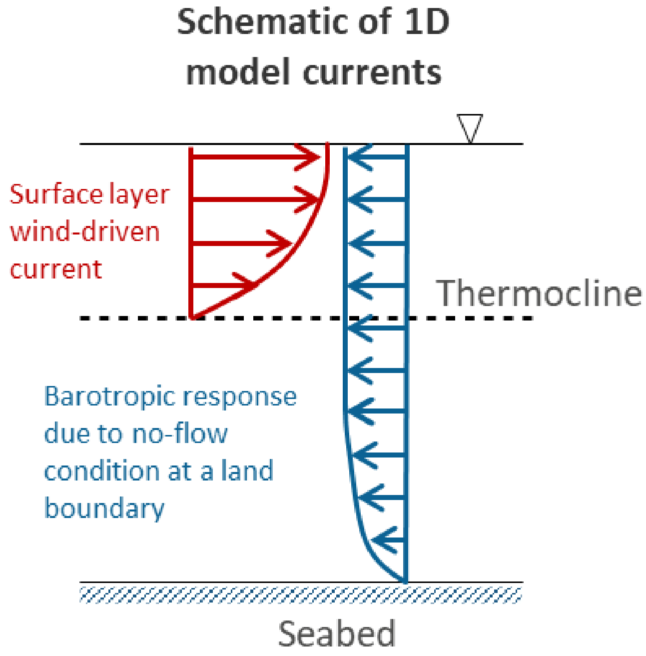
Adapted from Kämpf and Chapman (2016)



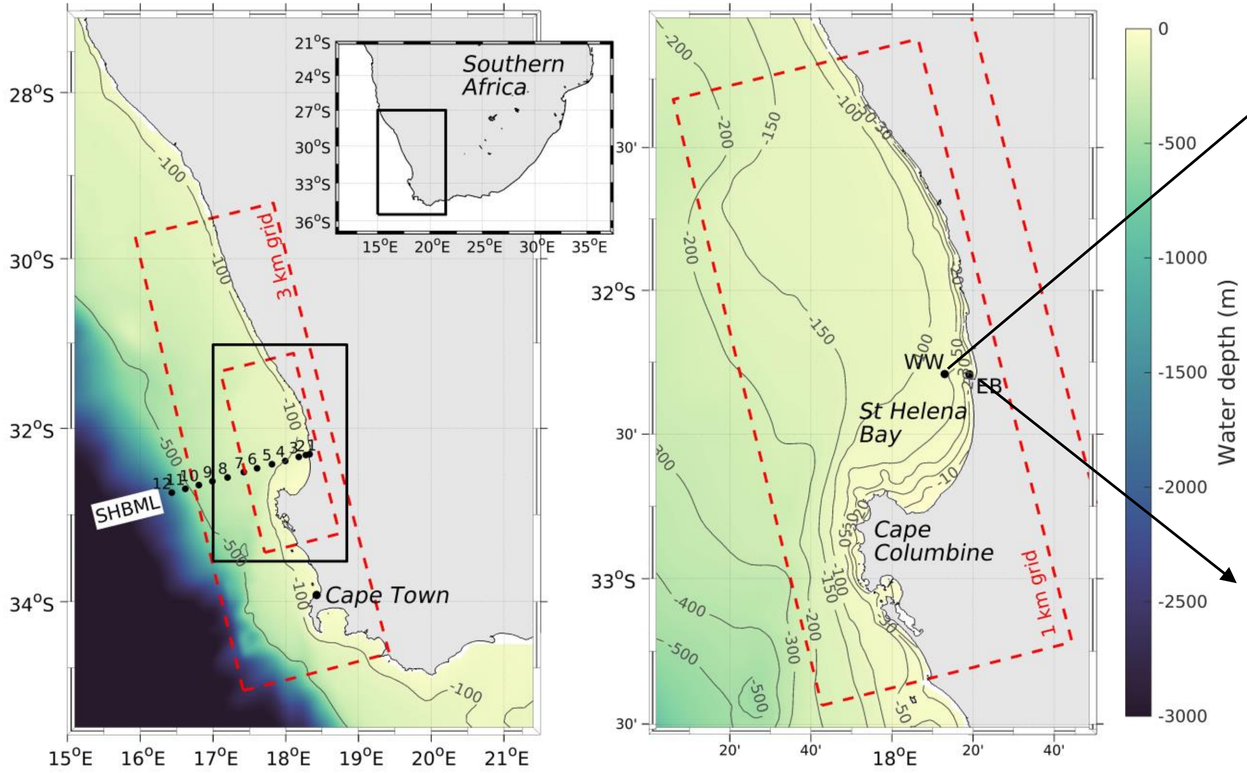


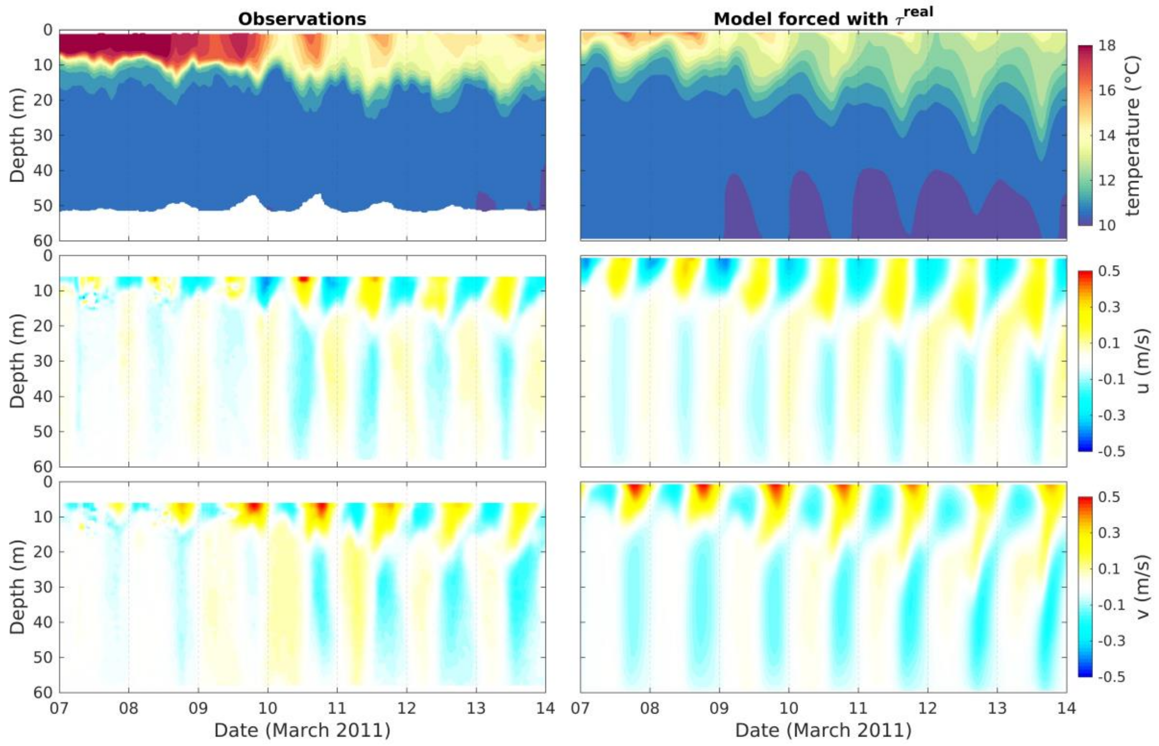
1D CROCO model (Fearon et al., 2020)

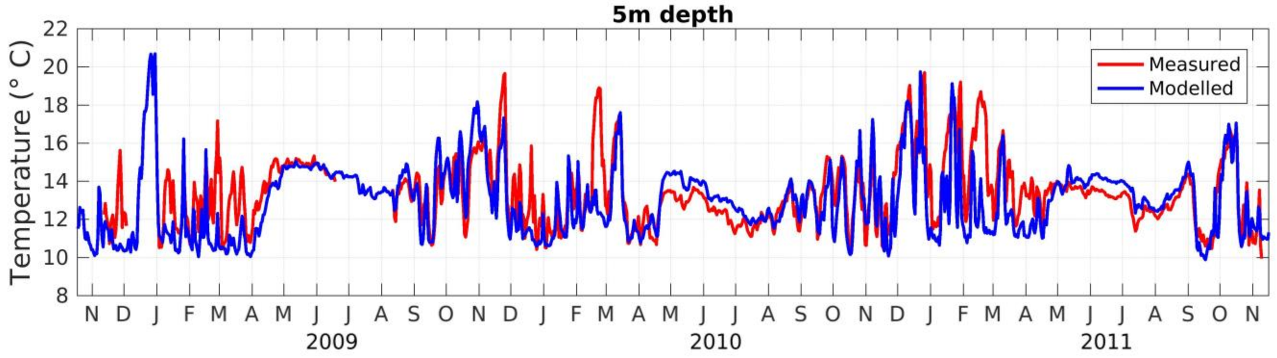




A 3D CROCO model for the southern Benguela upwelling system (hourly atmospheric forcing)

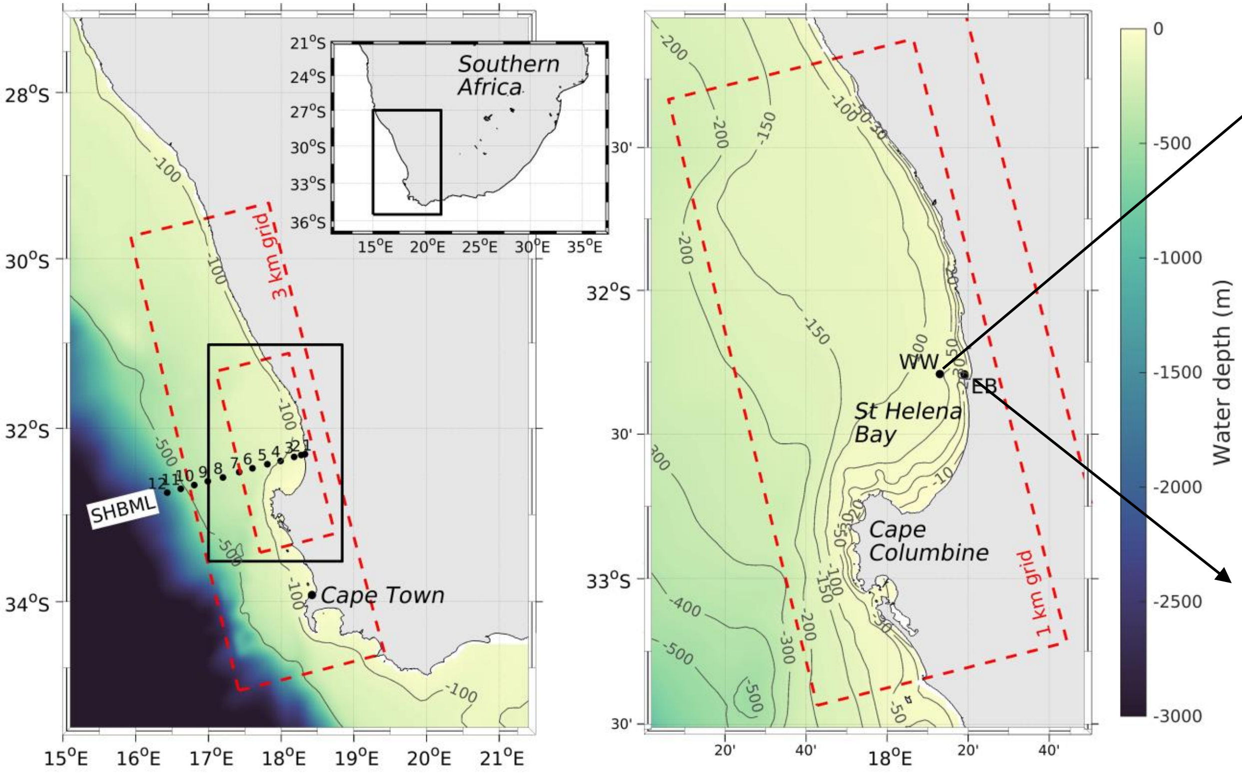


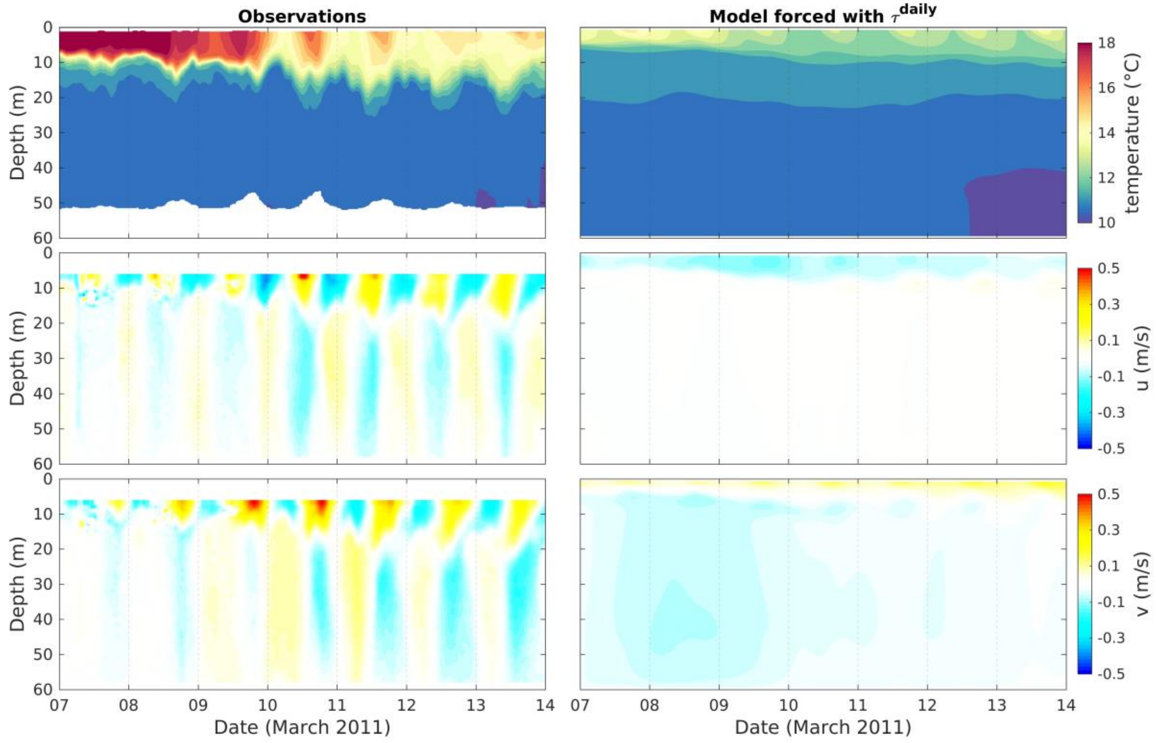


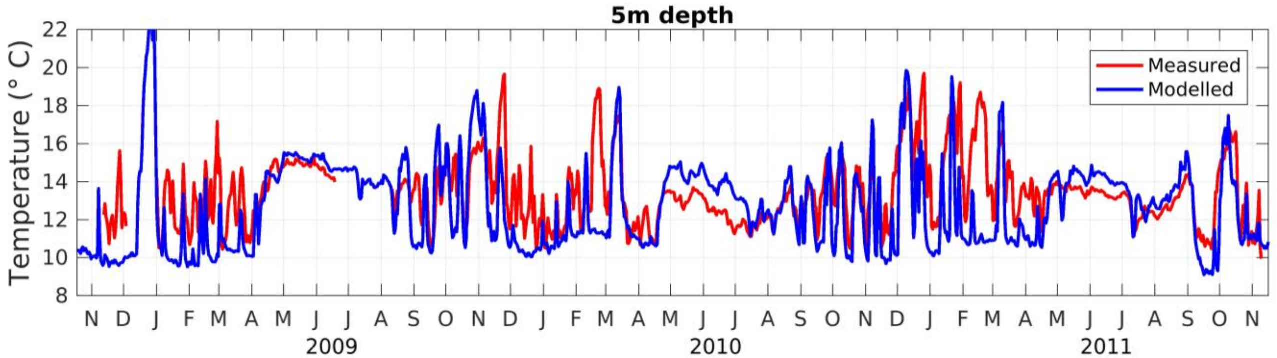


	Summer (DJF)	Winter (JJA)
Correlation	0.80	0.92
RMSD (°C)	1.42	0.49
Bias (°C)	-1.24	0.44

A 3D CROCO model for the southern Benguela upwelling system (daily atmospheric forcing)



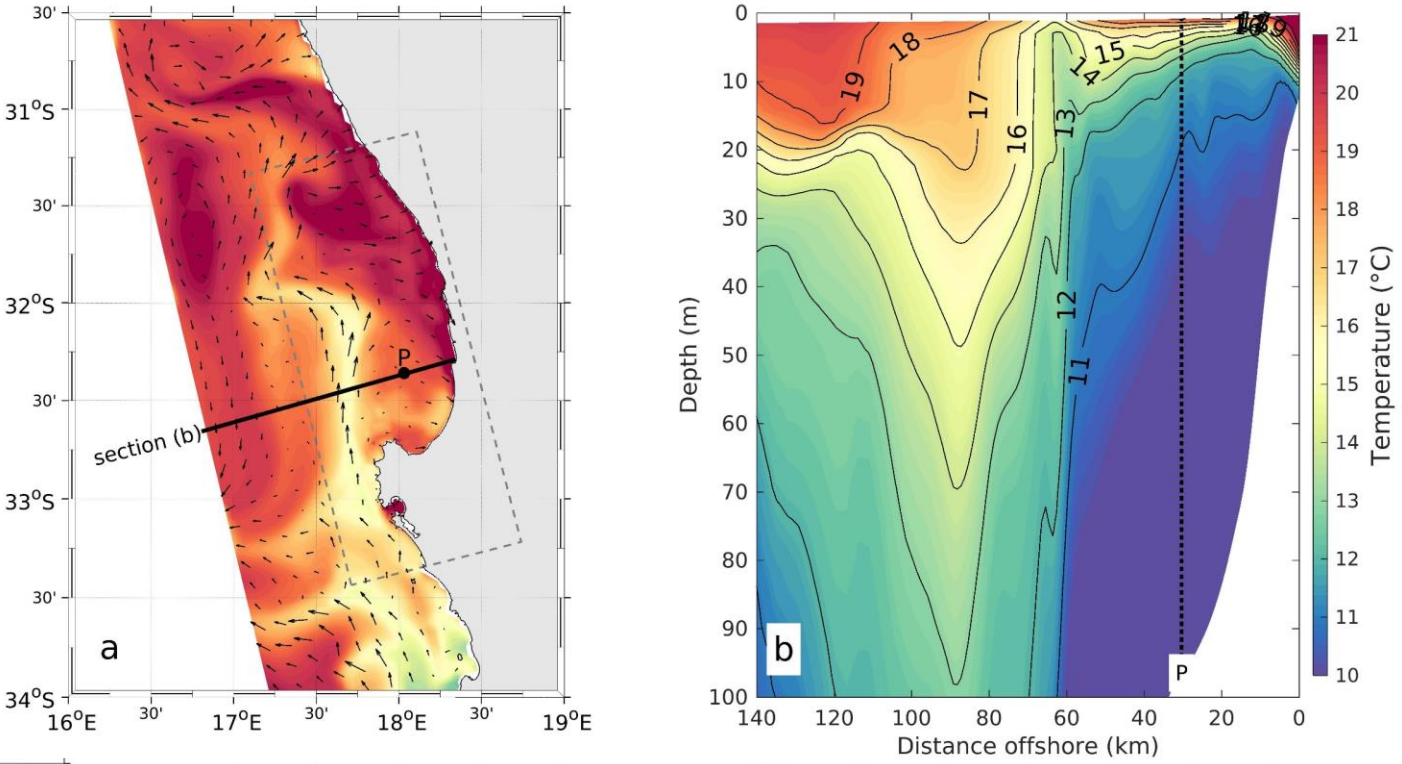


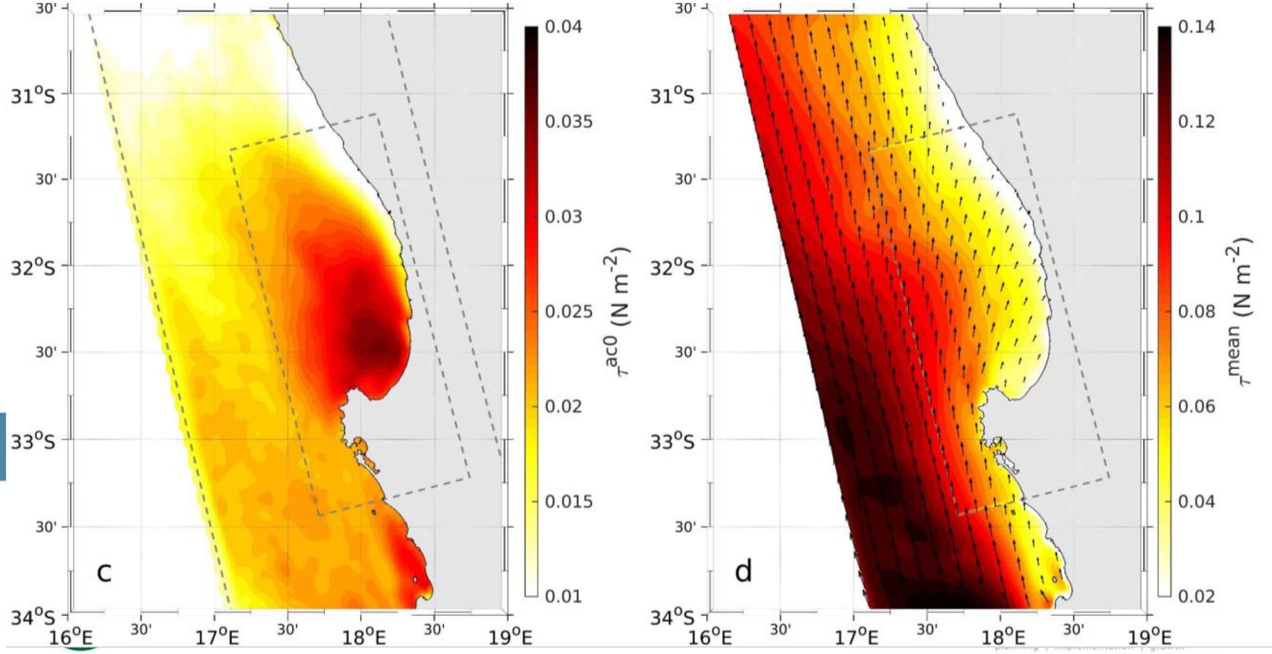


	Summer (DJF)	Winter (JJA)
Correlation	0.68 (-0.12)	0.83 (-0.09)
RMSD (°C)	1.85 (+0.43)	0.6 (+0.11)
Bias (°C)	-2.10 (-0.86)	0.68 (+0.24)

7 day vertical mixing experiment

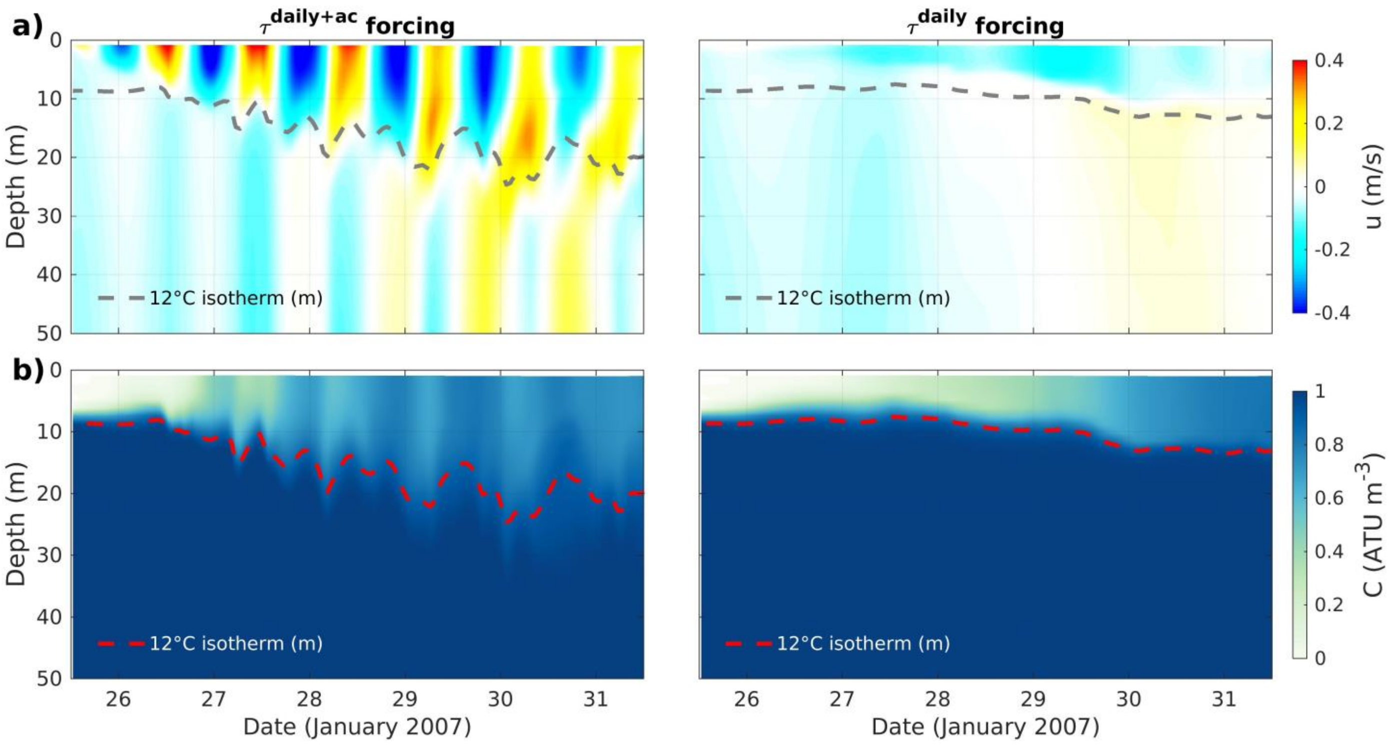
Initial condition taken at the end of a relaxation event →



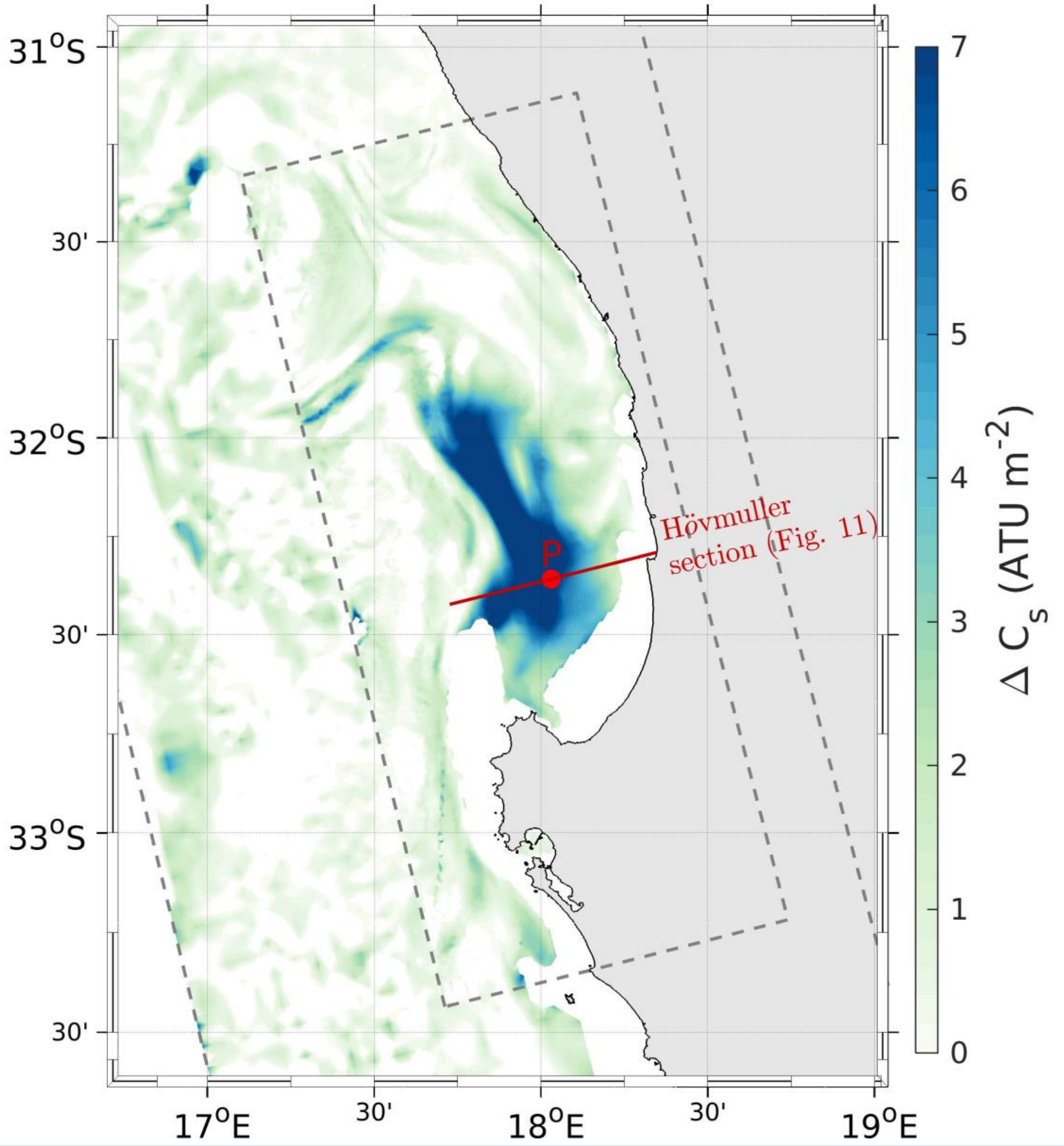


← Wind forcing over the next 7 days

7 day vertical mixing experiment

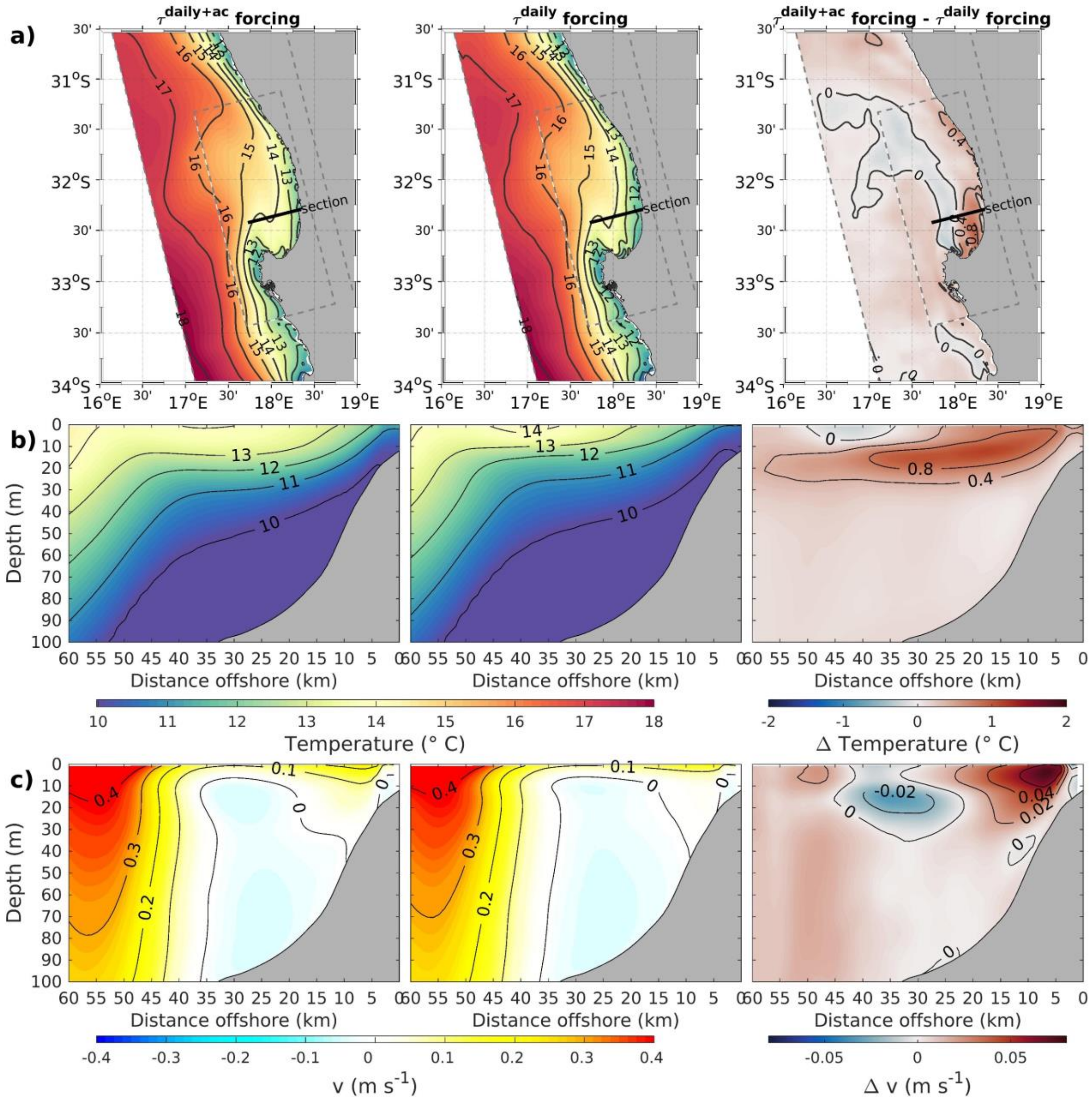


$$C_S = \int_{z_{12^\circ}}^{0} C\, dz \ , \qquad \Delta C_S = C_{S\_\tau^{daily+ac}} - C_{S\_\tau^{daily}}$$



Impact on the mean state

upwelling conditions



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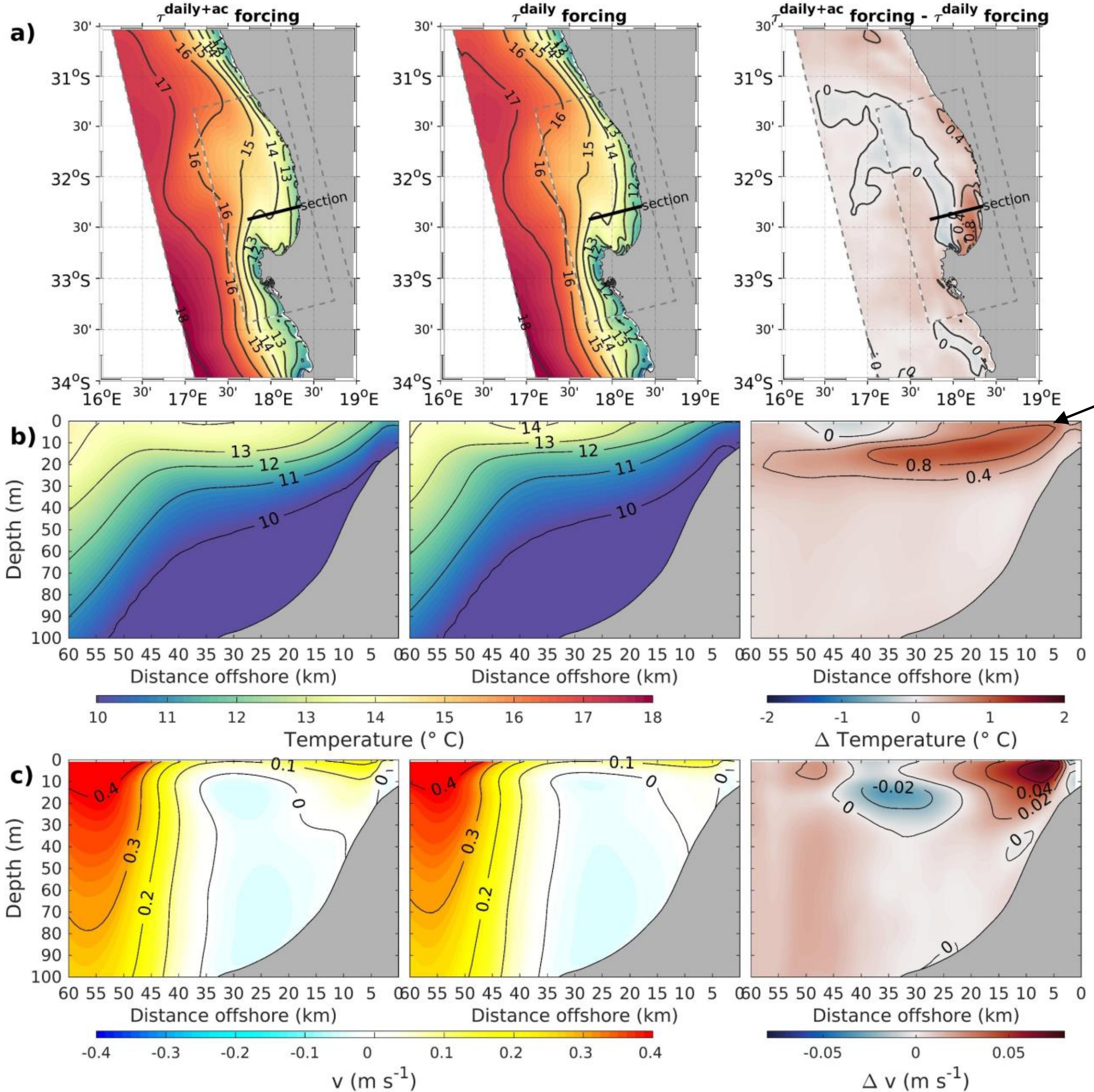
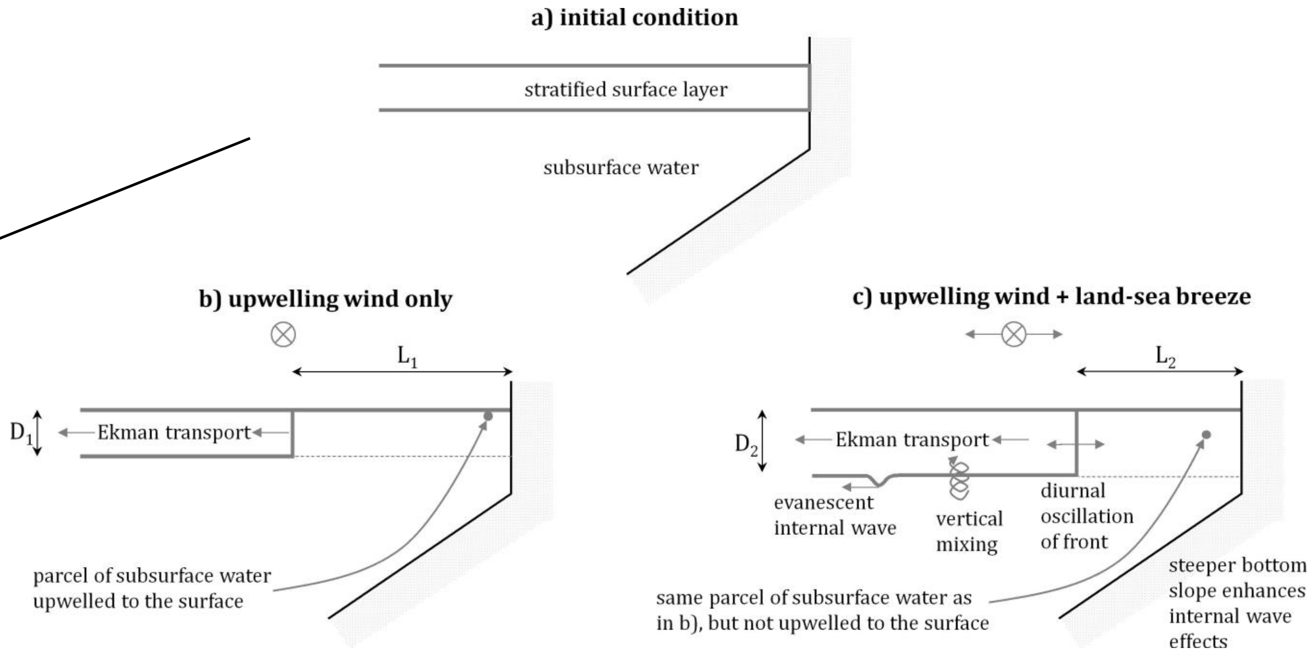


Upwelling front is retained closer to the coast, driving a net warming in the nearshore (Fearon et al., 2022)



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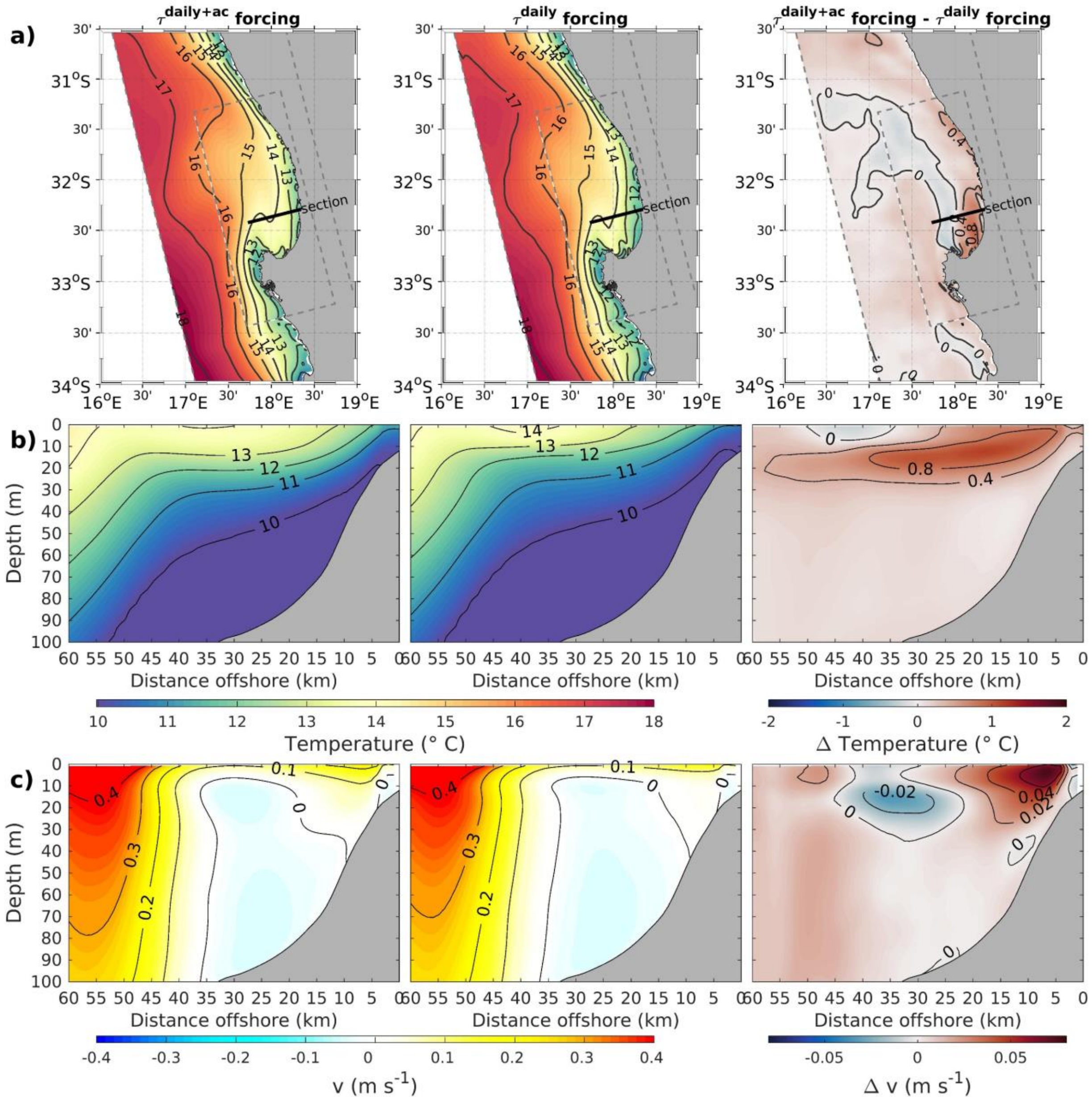
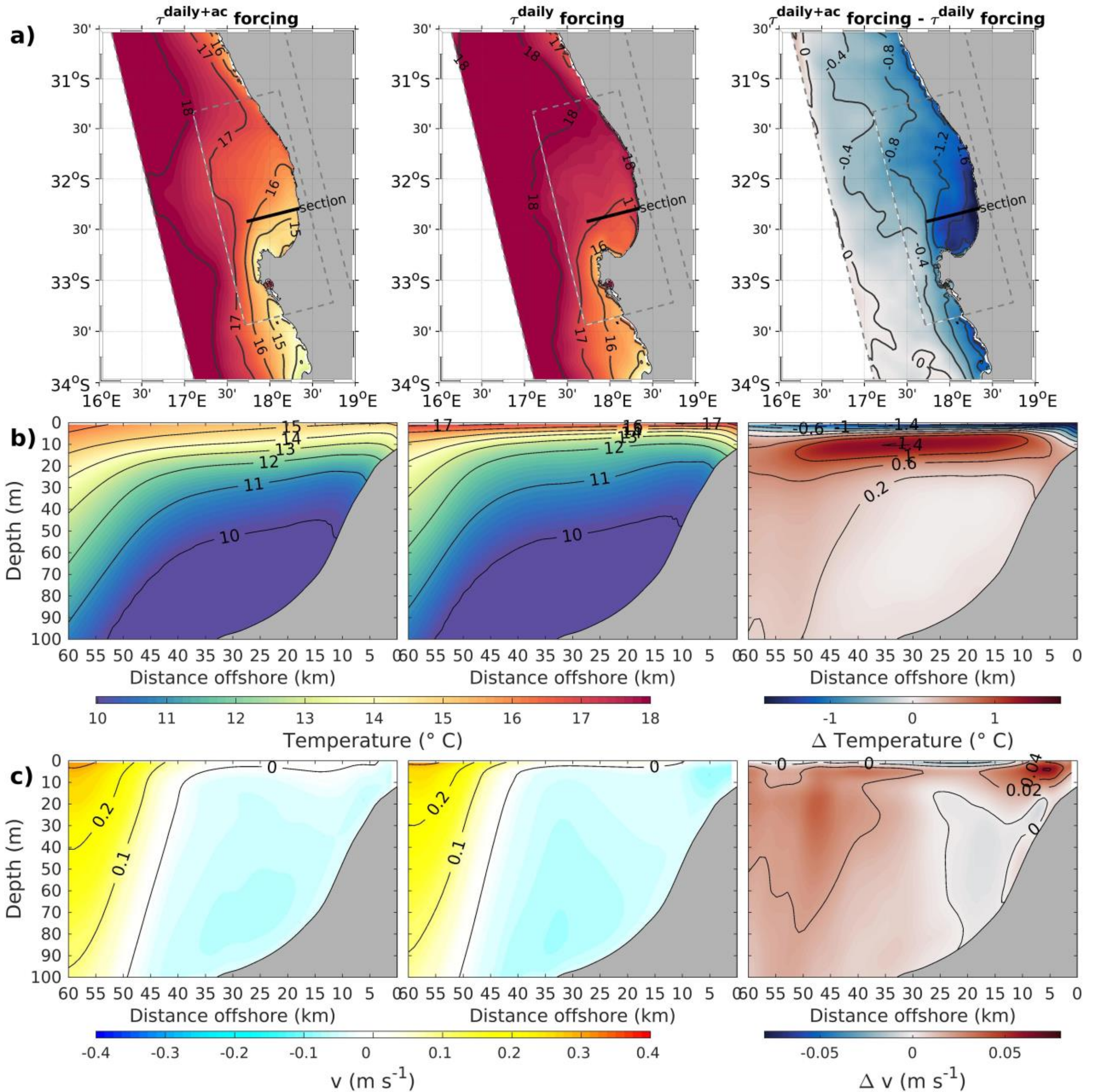


relaxation conditions



Summary

- St Helena Bay is a hotspot for eliciting diurnal-inertial oscillations and associated vertical mixing
- It seems likely that the land-sea breeze plays an important role in the enhanced productivity of the St Helena Bay
- The modification of the vertical water column structure impacts lower frequency upwelling and circulation
- Land-sea breeze effects should be considered in the development of operational forecast and climate scale models of this region, and in general other regions near 30° N/S

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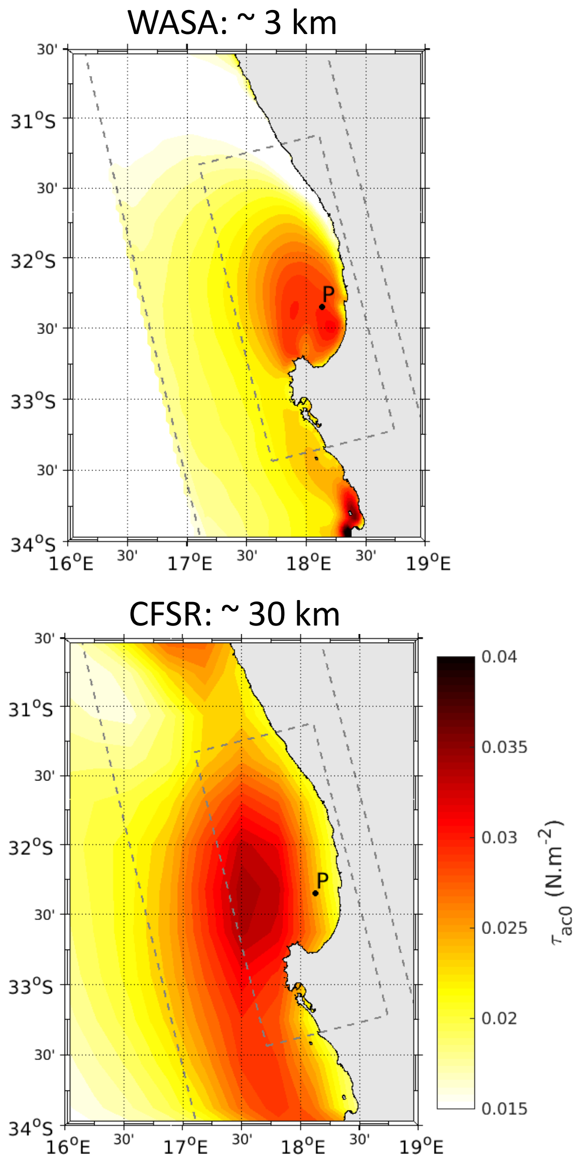

Thank you!

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