

Wind-forced submesoscale symmetric instability around deep convection in the NW Mediterranean Sea

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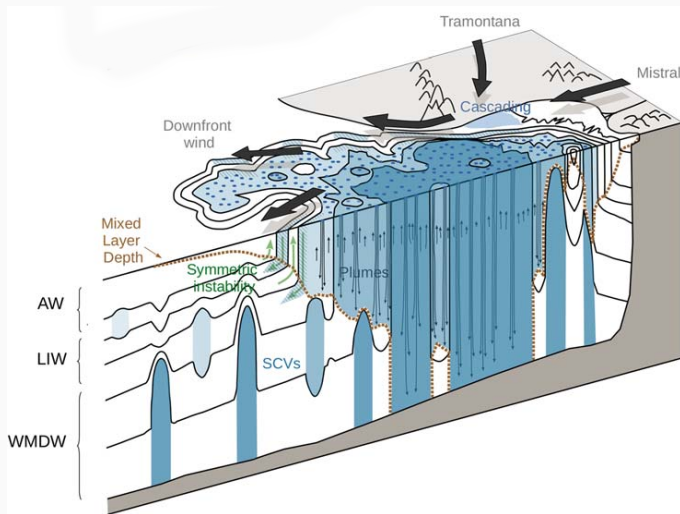
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Deep convection in the NW Mediterranean

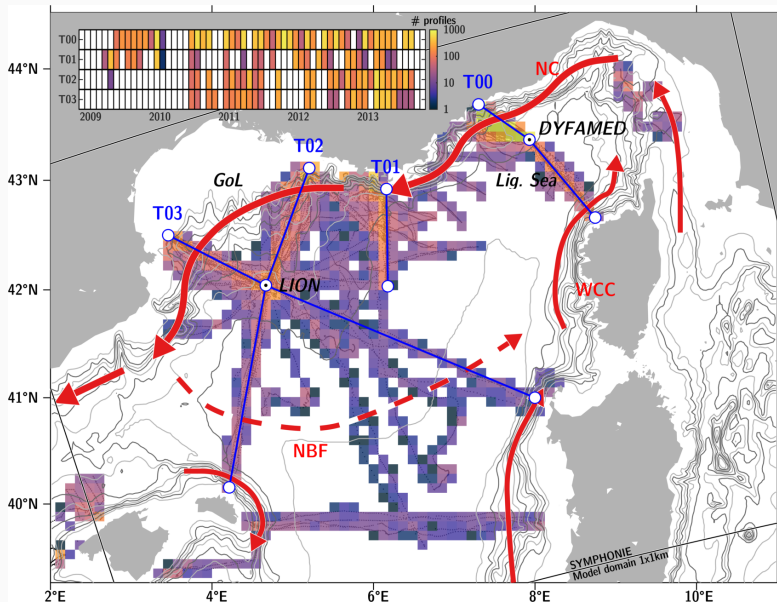


Schematics of deep convection in the Gulf of Lion (from Testor *et al*, JGR, 2018).

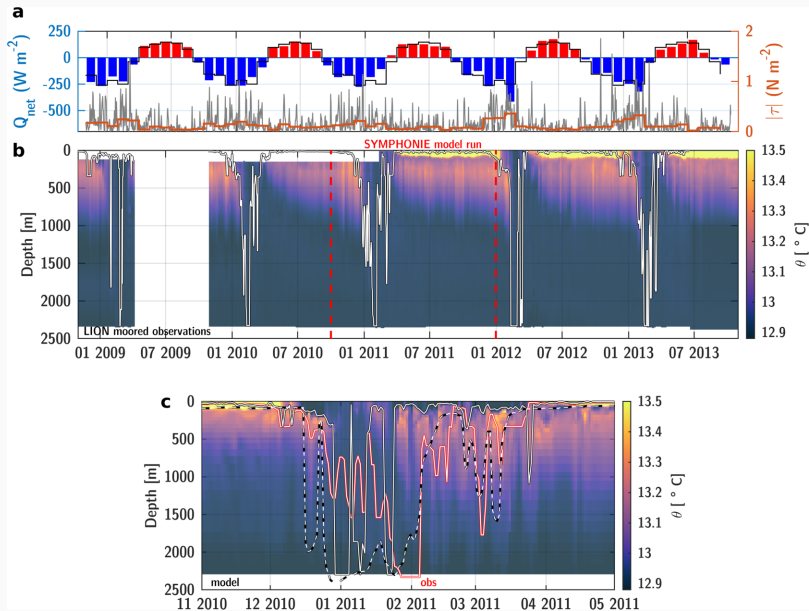
- Strong winds (Mistral) = winter ocean heat loss $O(1000 \text{ W m}^{-2})$
- Ocean preconditioning $\rightarrow$ MLD $> 2500\text{m}$ in 2009–2013 Houpert *et al*, JGR, 2017

$\rightarrow$ Interaction between winds and fronts along the convection zone?

Methods : synergy between observations and model

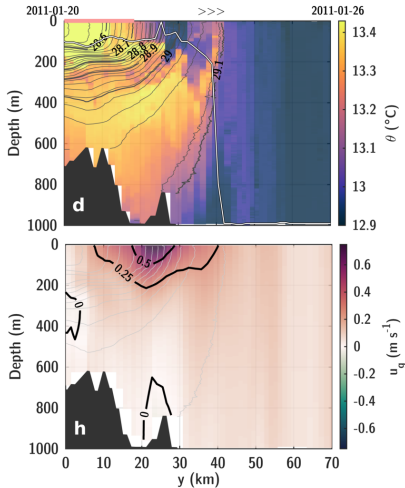
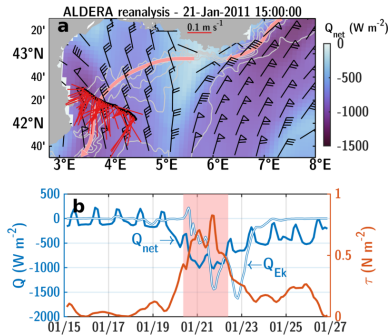


Results : Observed and modeled deep convection



(a) Monthly heat loss (ALDERA reanalysis) @ LION (b) observed and (c) modeled temperature with MLD.

Glider section of the Northern Current

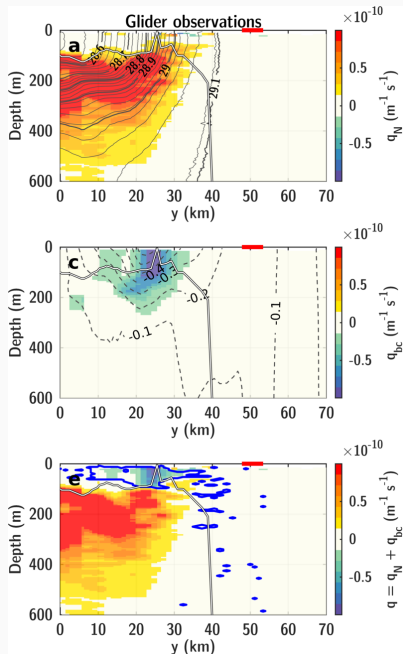


(a) Wind arrows and net heat flux from reanalysis with glider trajectory and depth-average currents, (b) Net and Ekman heat flux, wind stress along glider track; (d) Glider section of temperature; (h) geostrophic currents.

Ekman buoyancy flux (heat equivalent) : $Q_{Ek} = \frac{\rho C_p}{\alpha g} \vec{M}_e \cdot \vec{\nabla} b|_{z=0}$

→ Typical Mistral wind event trigger large Ekman buoyancy loss > heat loss

PV at front during a strong Mistral event



Glider estimation of PV

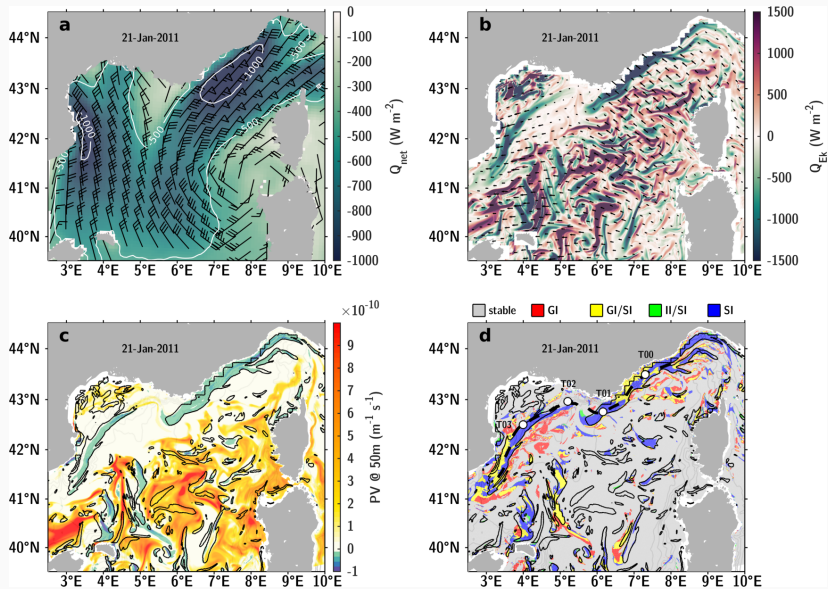
$$q = [(f - \partial_y u)N^2 + (\partial_y b)^2]/fg$$

$$q = q_N + q_{bc}$$

→ low stratification with deep ML
+ steep density fronts
= **NEGATIVE PV**

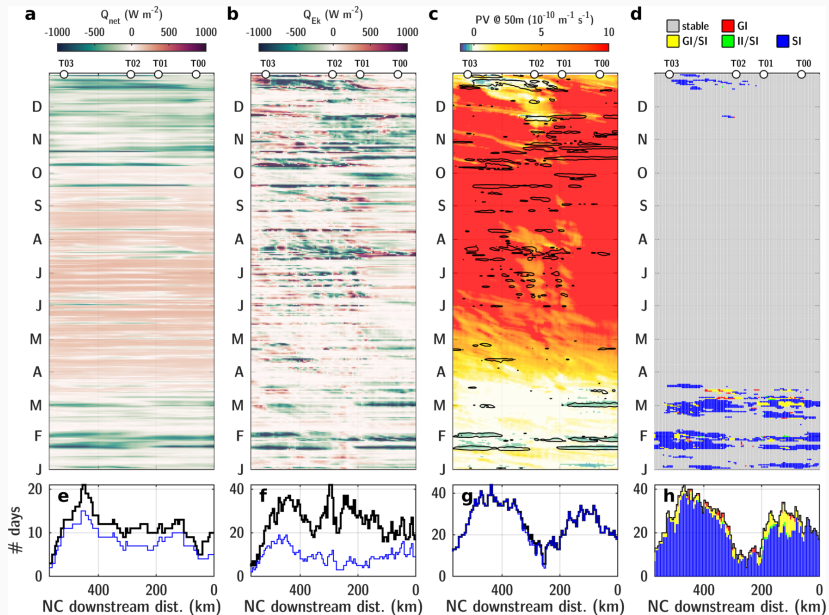
Hoskins, 1974 : A front characterized by $PV < 0$ (in NH) is unstable to **Symmetric Instability (SI)**.

Basin-scale view from SYMPHONIE model



(a) Wind arrows and net heat flux from reanalysis, (b) Ekman heat flux from model;
(c) modeled PV at 50m; (d) Instability regime (SI = blue).

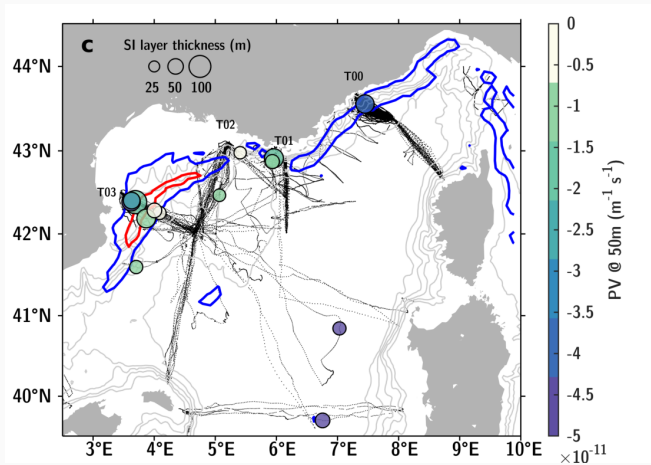
Seasonality of PV along the Northern Current



Hovmueller plot along the NC of (b) Ekman heat flux, (c) PV @ 50m, (d) instability regime;

Numbers of days with (e-f) heat flux $< -500 W m^{-2}$, (g) PV < 0 , (h) SI regime.

Hotspots of PV destruction



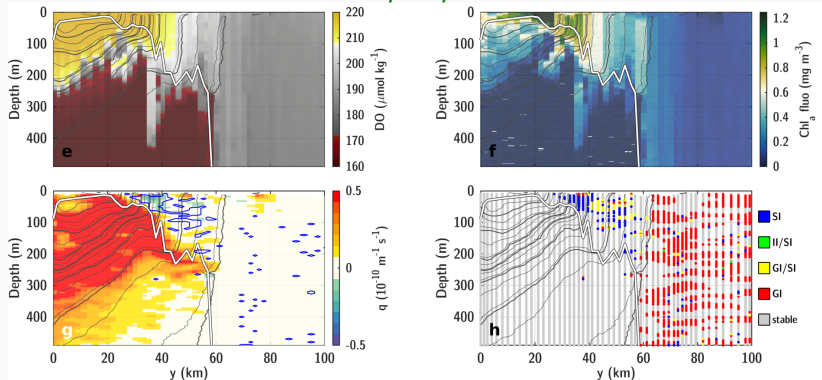
Location of observed SI events with contours of SI-days in the model per year (10 in blue, 20 in red).

Two hotspots of PV-destruction in winter and SI (from model) :
western part of the Gulf of Lion and Ligurian Sea.

Main results

- Observations and model show **PV<0** in winter along the NC
- Down-front wind is responsible for **Ekman heat loss $O(-1000 \text{ W m}^{-2})$**
- **SI** occurs especially at **two hotspots** linked to dominant winds.

Effect on BGC: ventilation, PP, carbon flux?



SI event across the NC during a down-front wind with oxygen and fluorescence observed by glider.

Read more : <https://doi.org/10.3390/fluids6030123>

Bosse, et al (2021). *Wind-Forced Submesoscale Symmetric Instability around Deep Convection in the NW Mediterranean Sea*. *Fluids*.