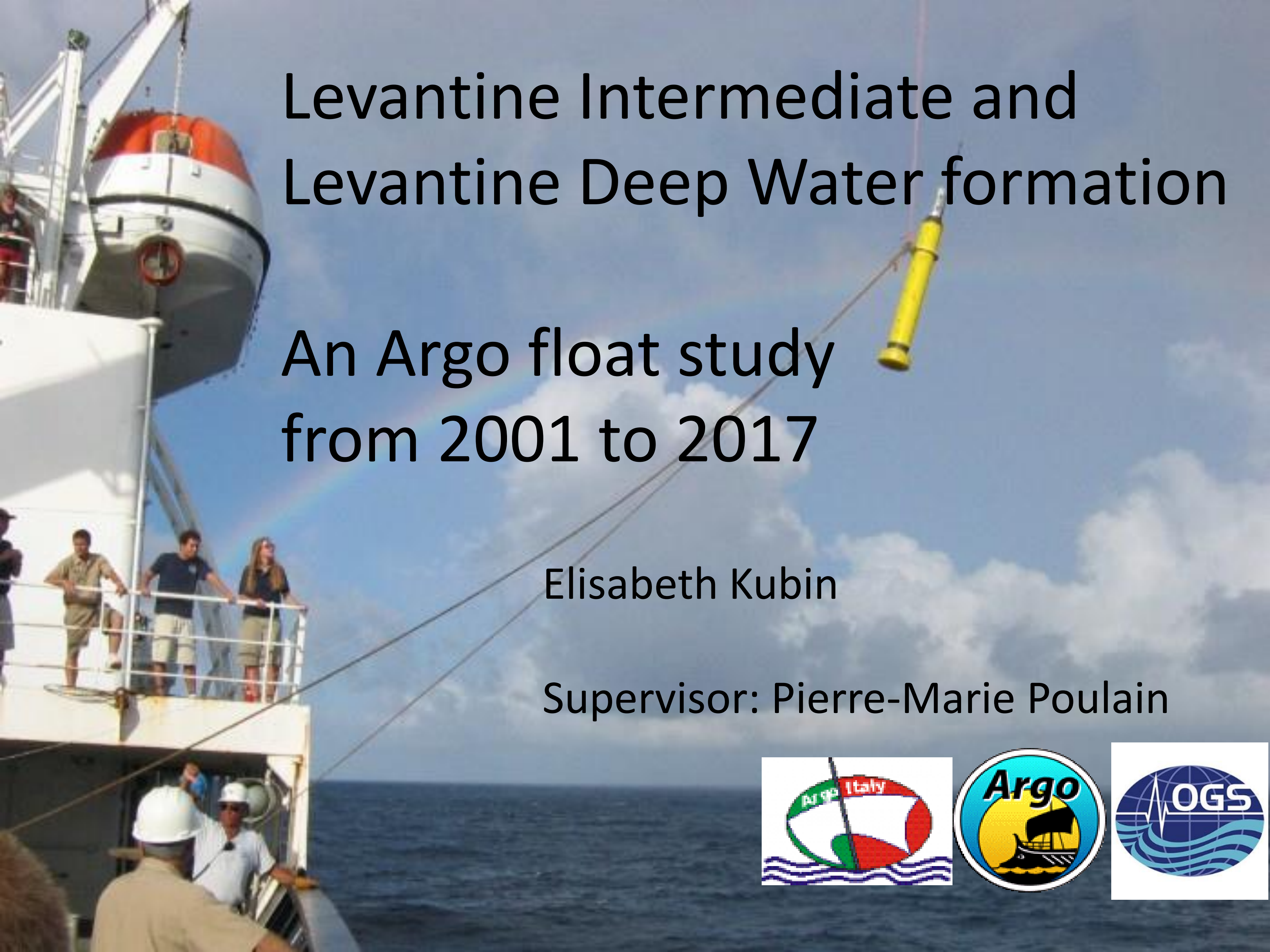

Levantine Intermediate and Levantine Deep Water formation

An Argo float study from 2001 to 2017

Elisabeth Kubin

Supervisor: Pierre-Marie Poulain

Outline

1) Description of the area of study

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2) Description of the Argo float data set: 2001-2017

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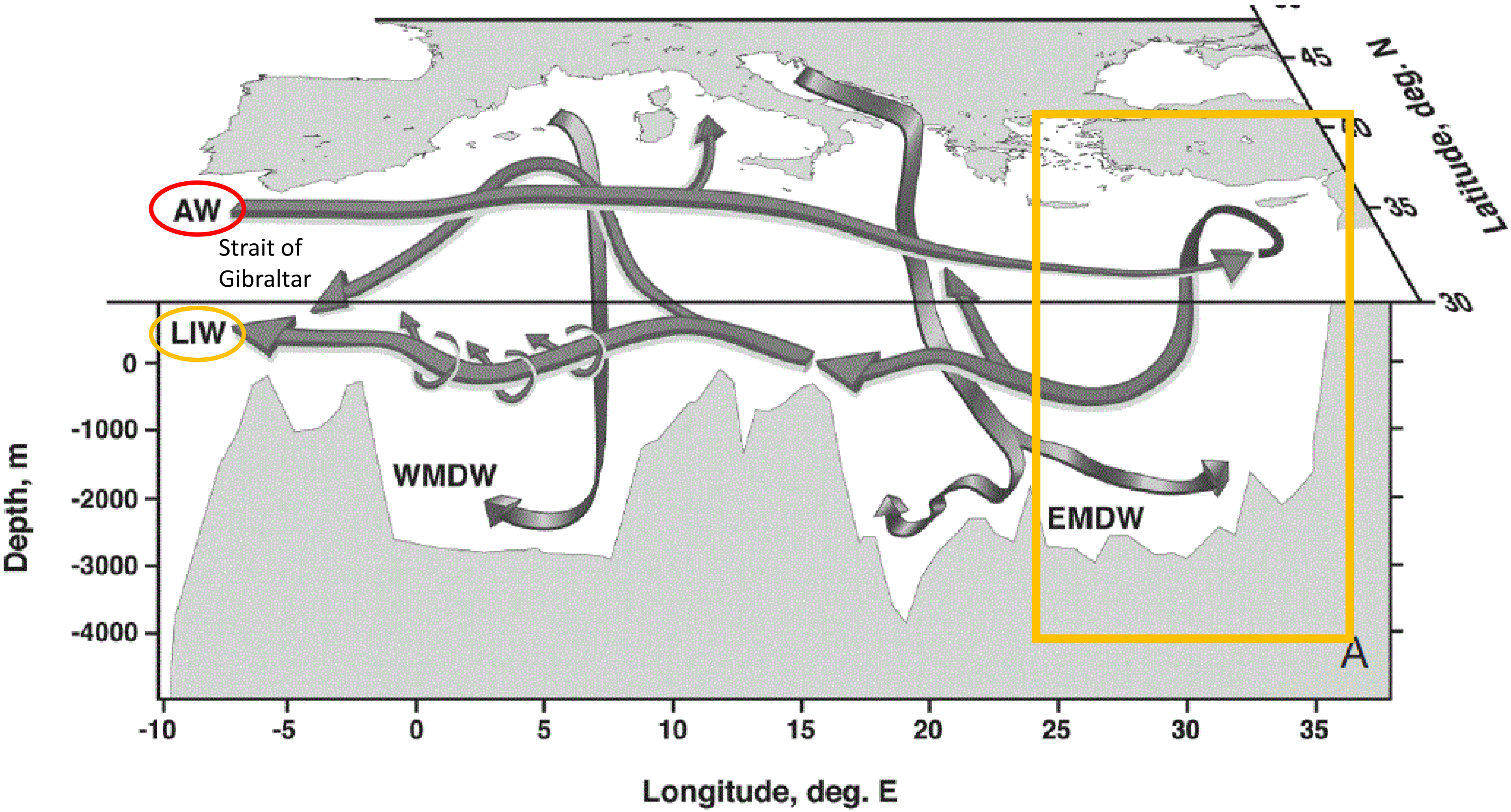
4) Events of Levantine Intermediate and Levantine Deep Water formation

5) Conclusions

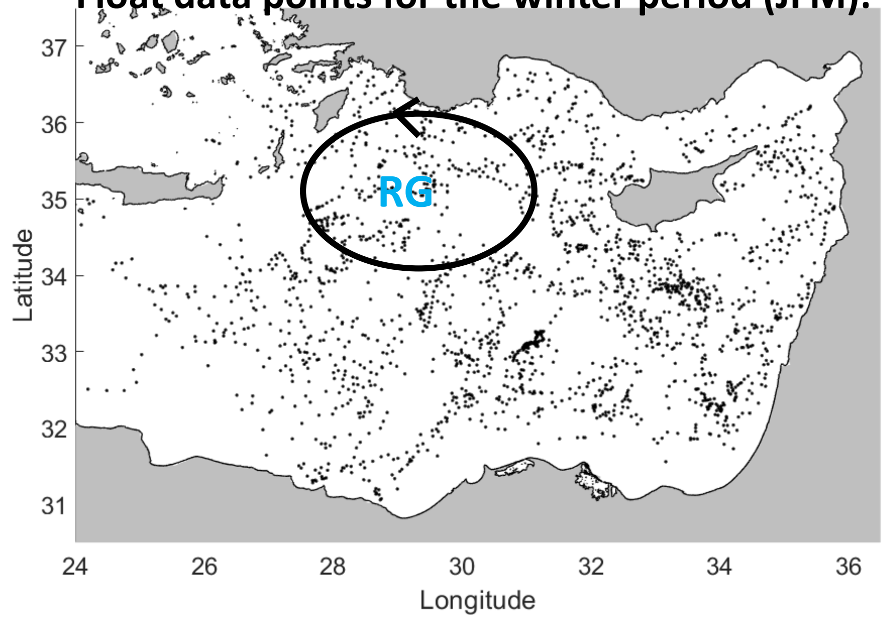
General concept of the Mediterranean Thermohaline circulation



Adapted from Tsimplis et al., 2006

→ According to general literature LIW formation occurs mainly within the **cyclonic Rhodes Gyre (RG)** within winter months

Float data points for the winter period (JFM):



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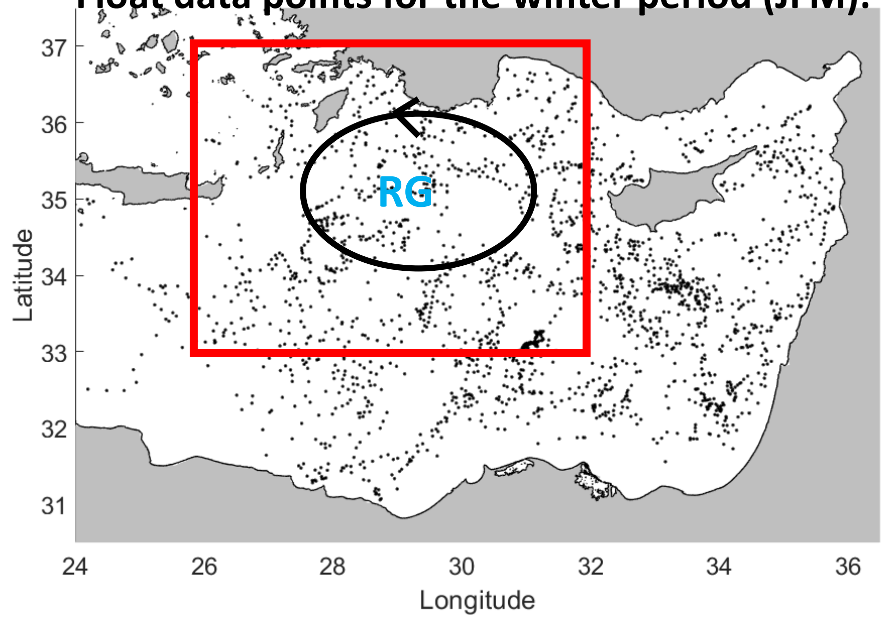

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→ **879** profiles of 20 Argo floats in the Northwestern Levantine Sea for winters from 2001 to 2017 were analyzed visually to find events of dense water formation.

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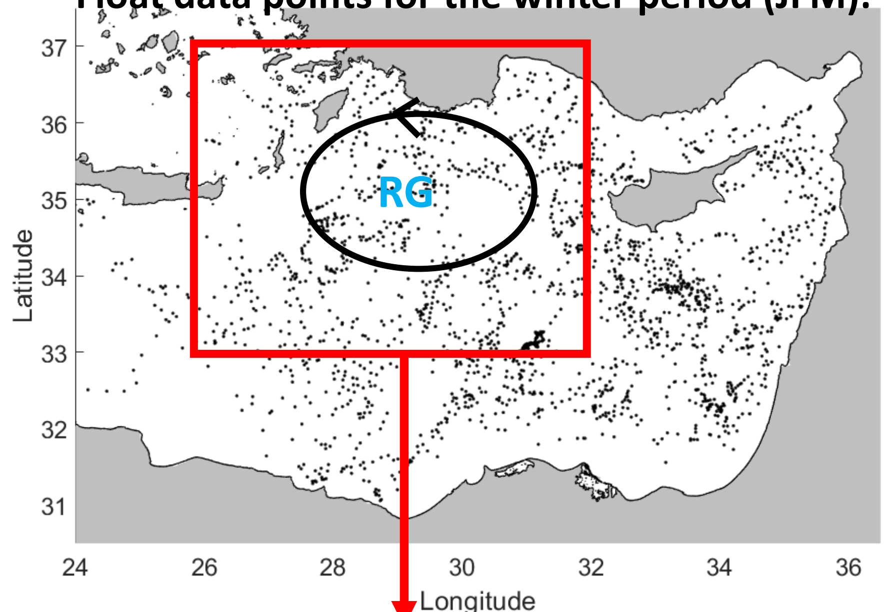

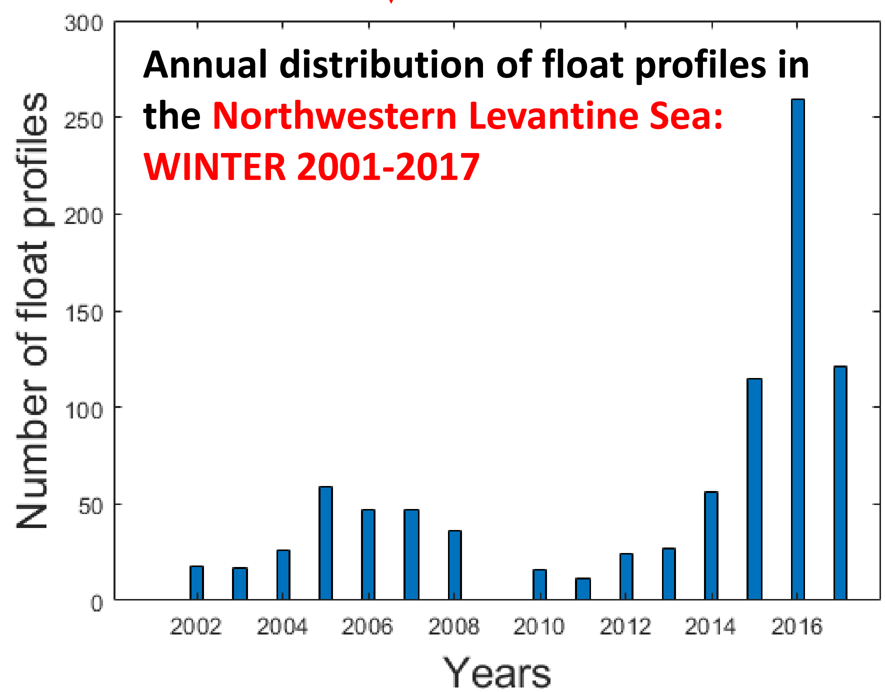

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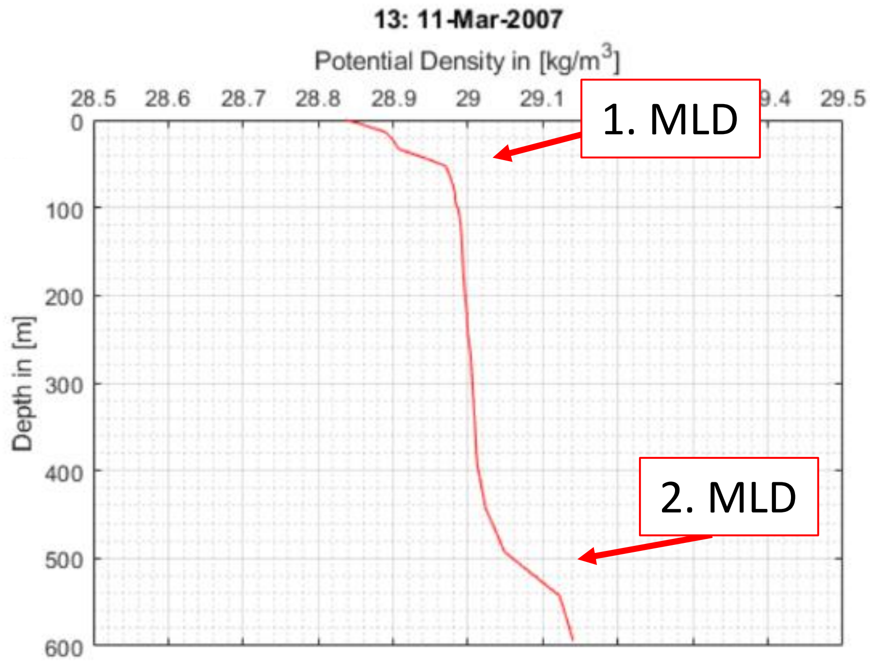
→ … one example along the coast
1. MLD about 50 m
2. MLD about 550 m

→ In such a case, MLD detection algorithms indicate the newly formed, shallow MLD, but do not represent the mixing or convection events before;



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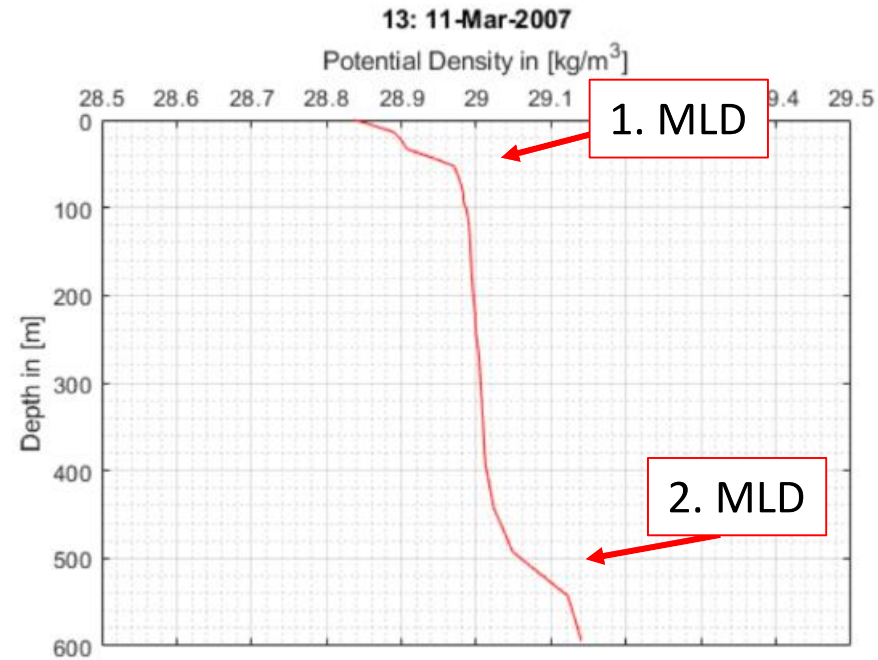

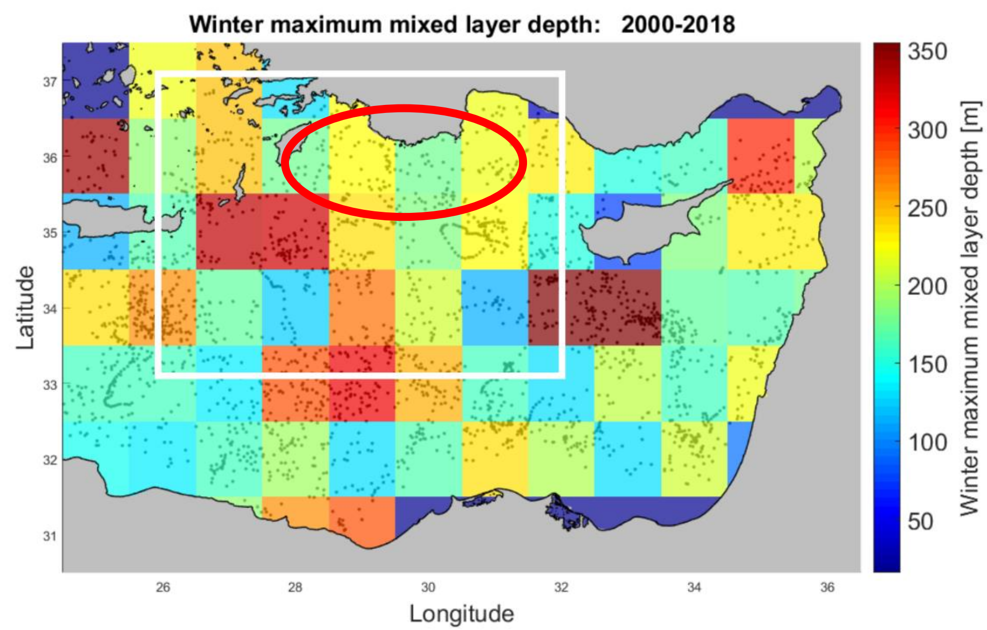

Buoyancy fluxes within the center of Rhodes Gyre

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$$B = \underbrace{\alpha \times g \times (Cp \times \rho_0)^{-1} \times Qnet}_{\text{Thermal buoyancy flux}} - \underbrace{\beta \times S_0 \times g \times (\rho_0)^{-1} \times (E-P)}_{\text{Haline buoyancy flux}}$$

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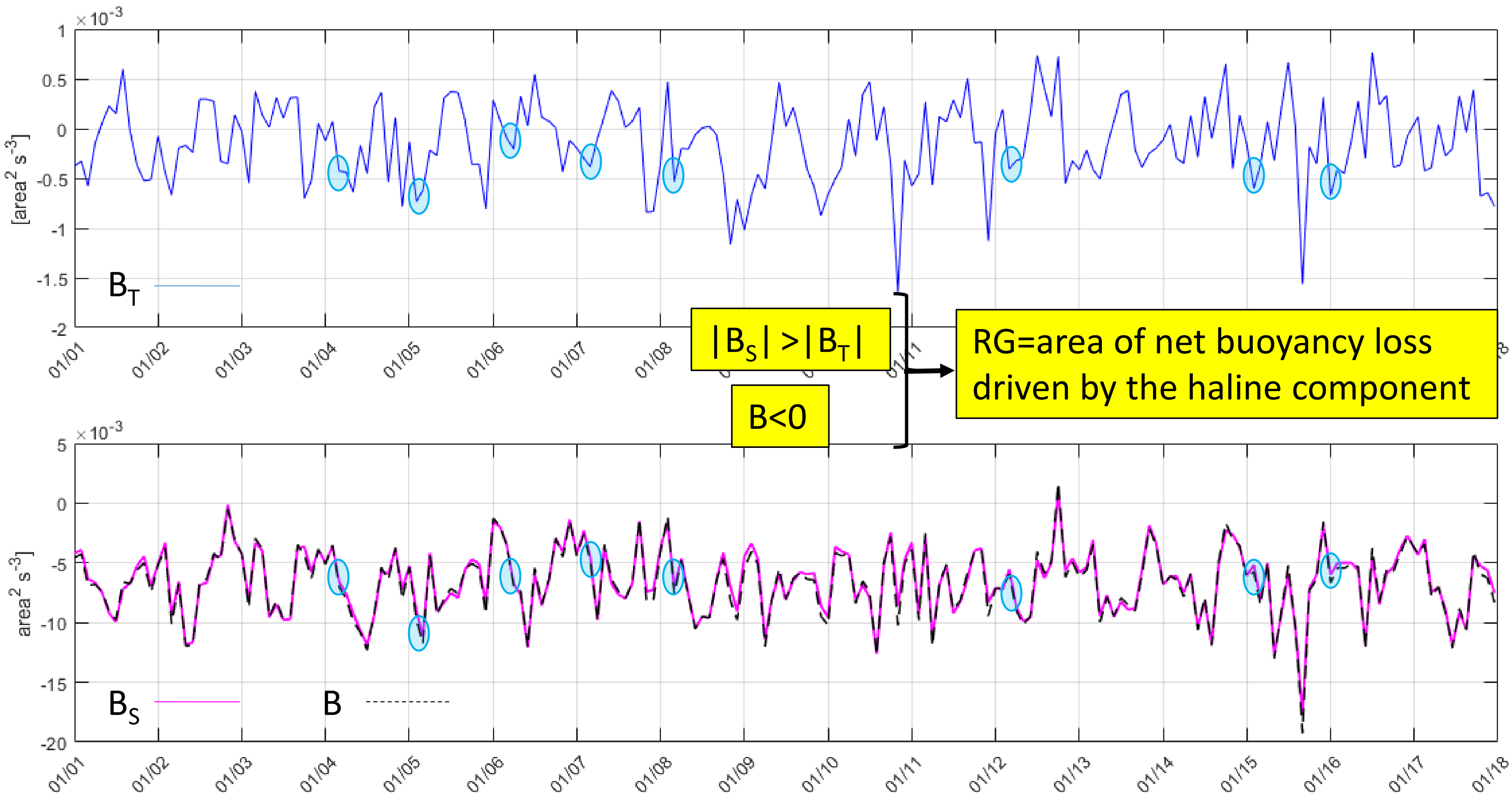
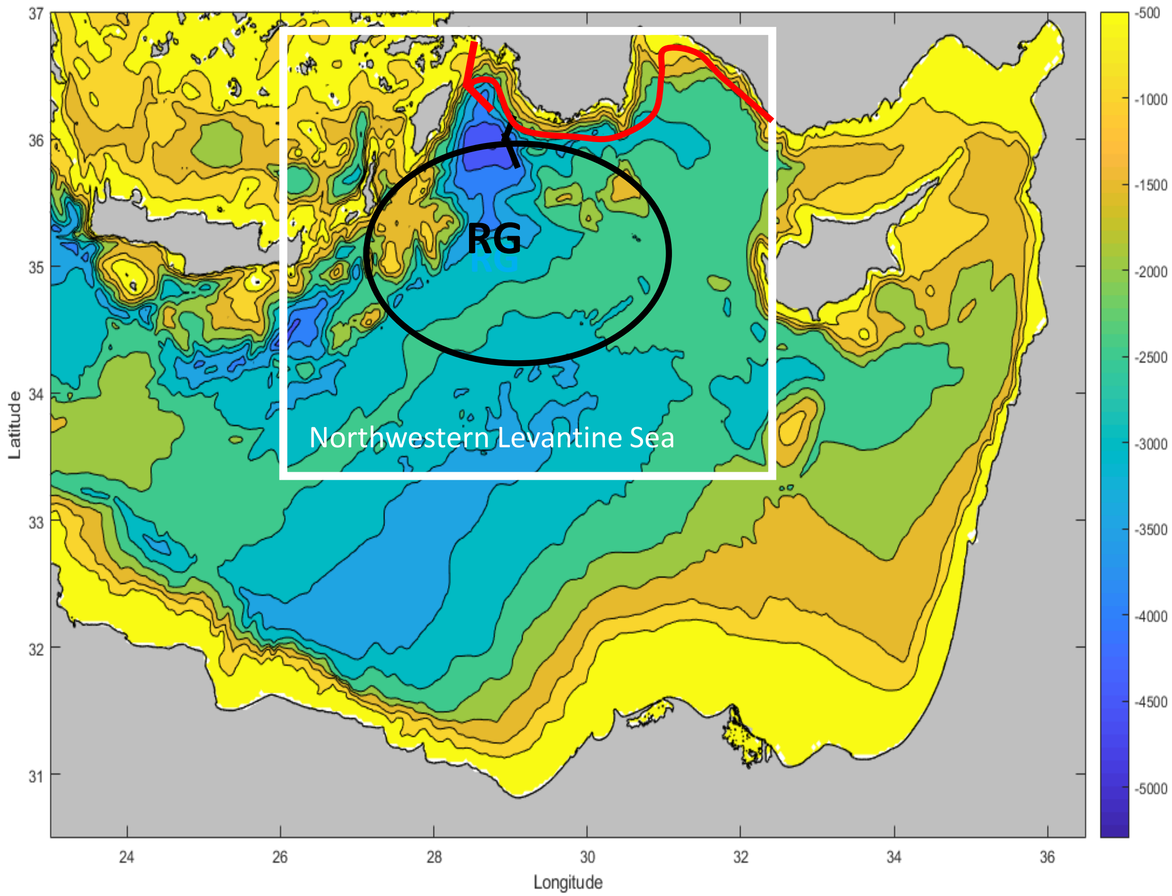




Bathymetry of the Levantine Sea

→ Pronounced dense water formation events, i.e. with a MLD deeper than 250 m, occurred only within the **center of Rhodes Gyre** and along the **Northern coastline**.

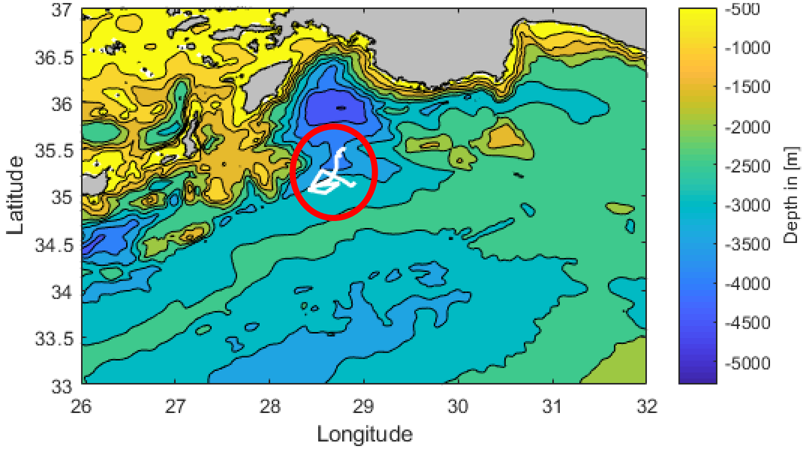
→ **2 examples:**

→ One example of dense water formation **within Rhodes Gyre**

→ One example of dense water formation **along the Northern coastline**

Example of **LDW formation** within the **Rhodes Gyre**: Winter 2006

Bathymetry and winter (JFM 2006) float trajectory



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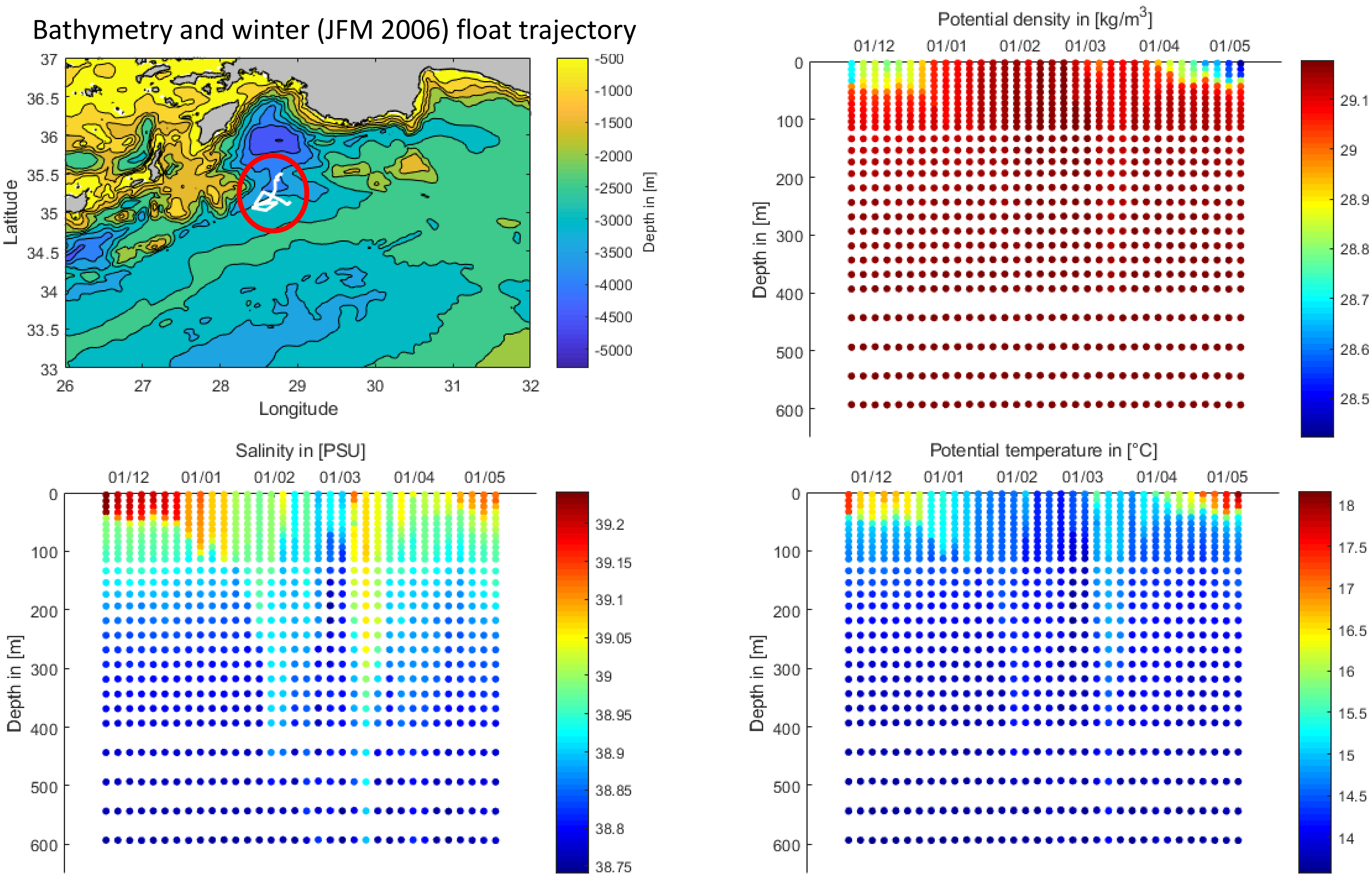

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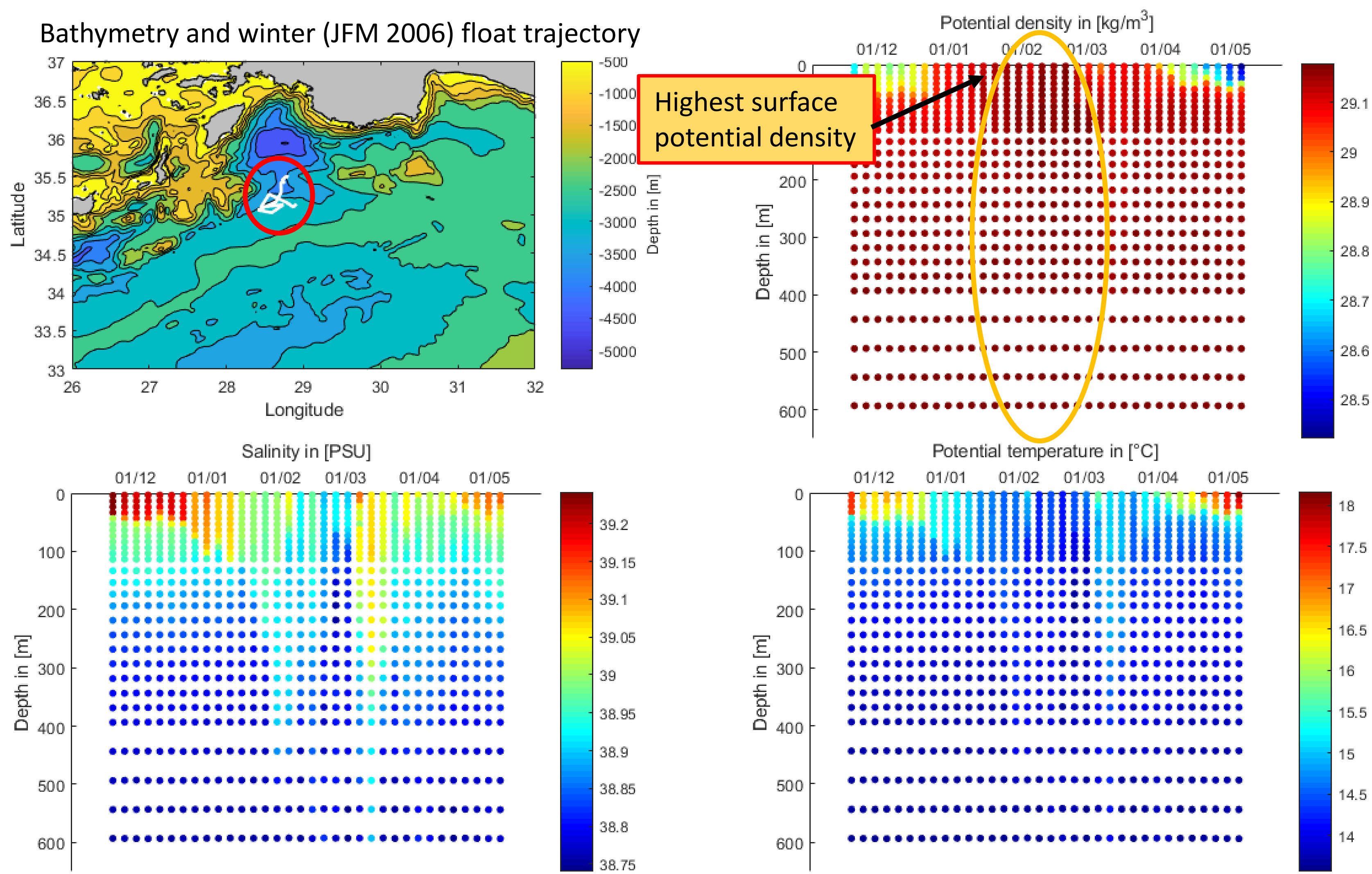

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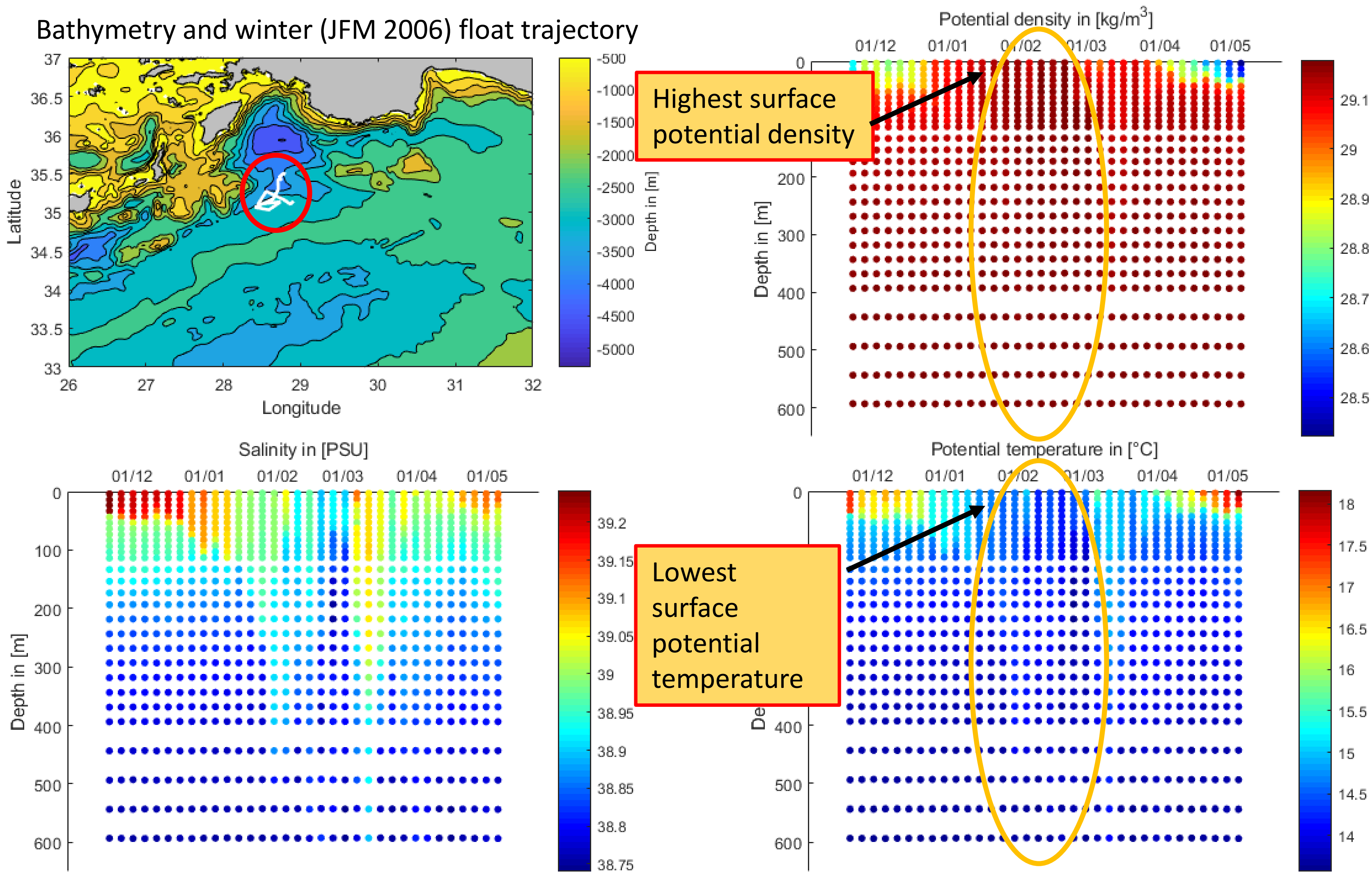

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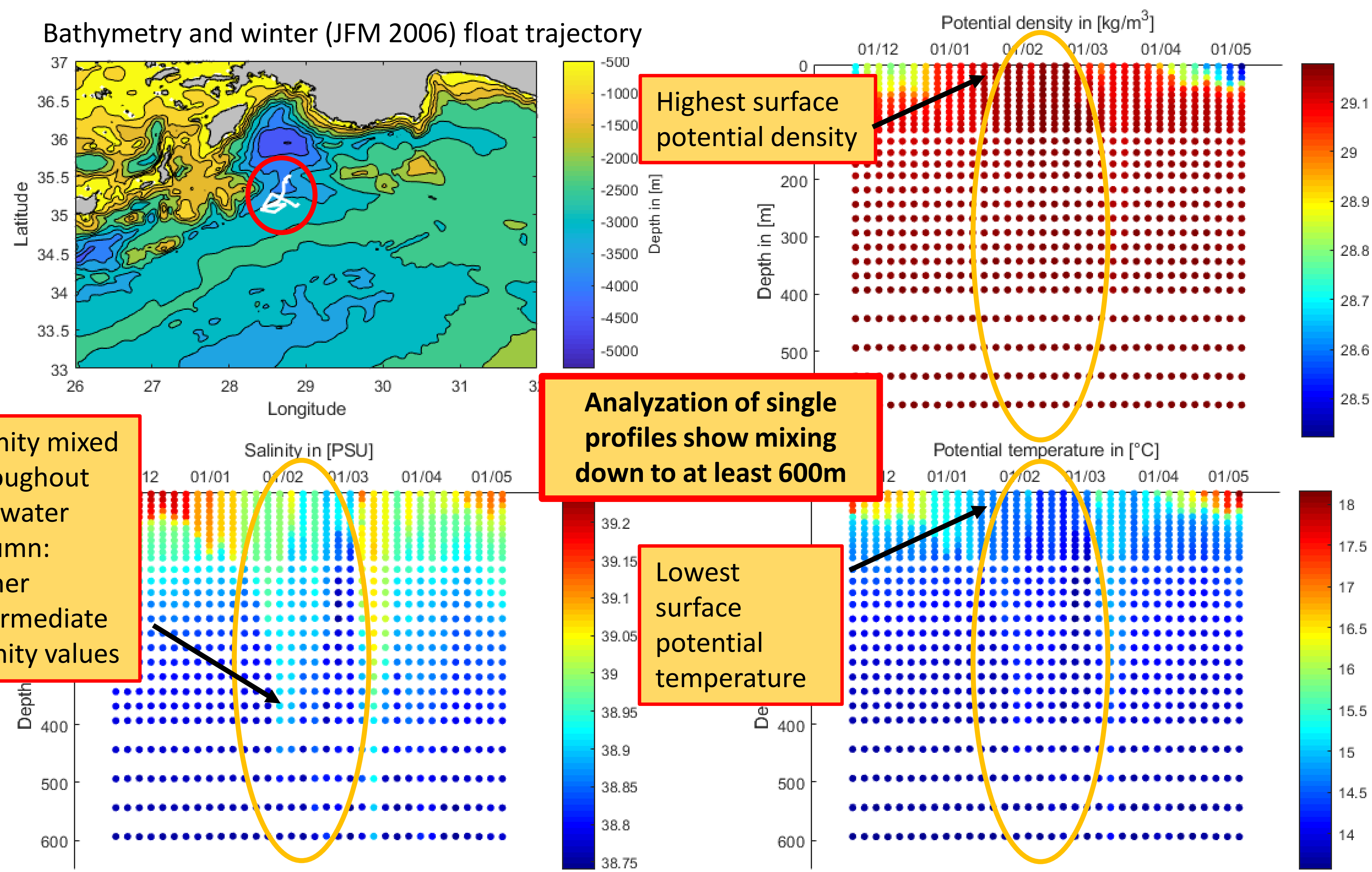
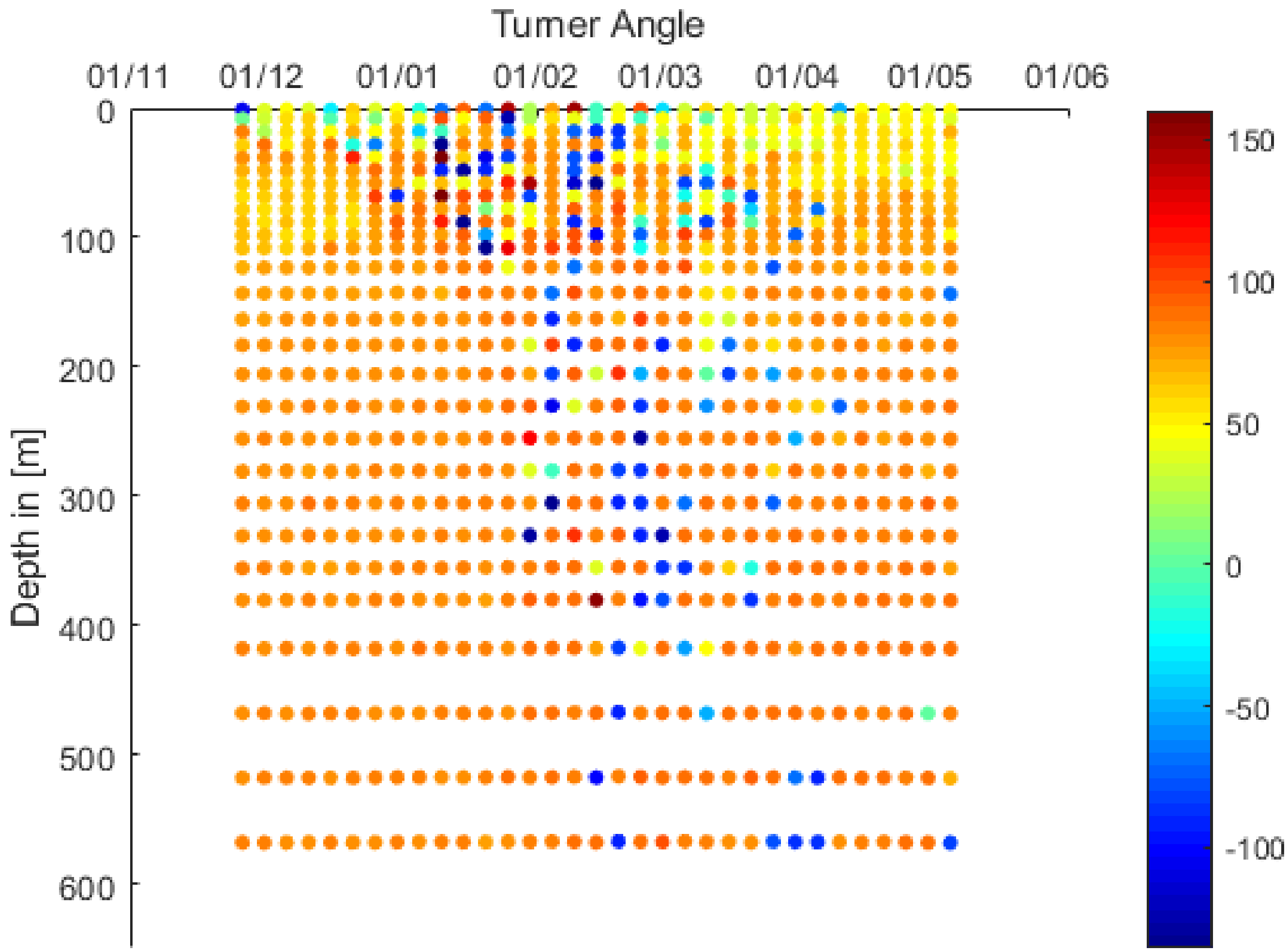




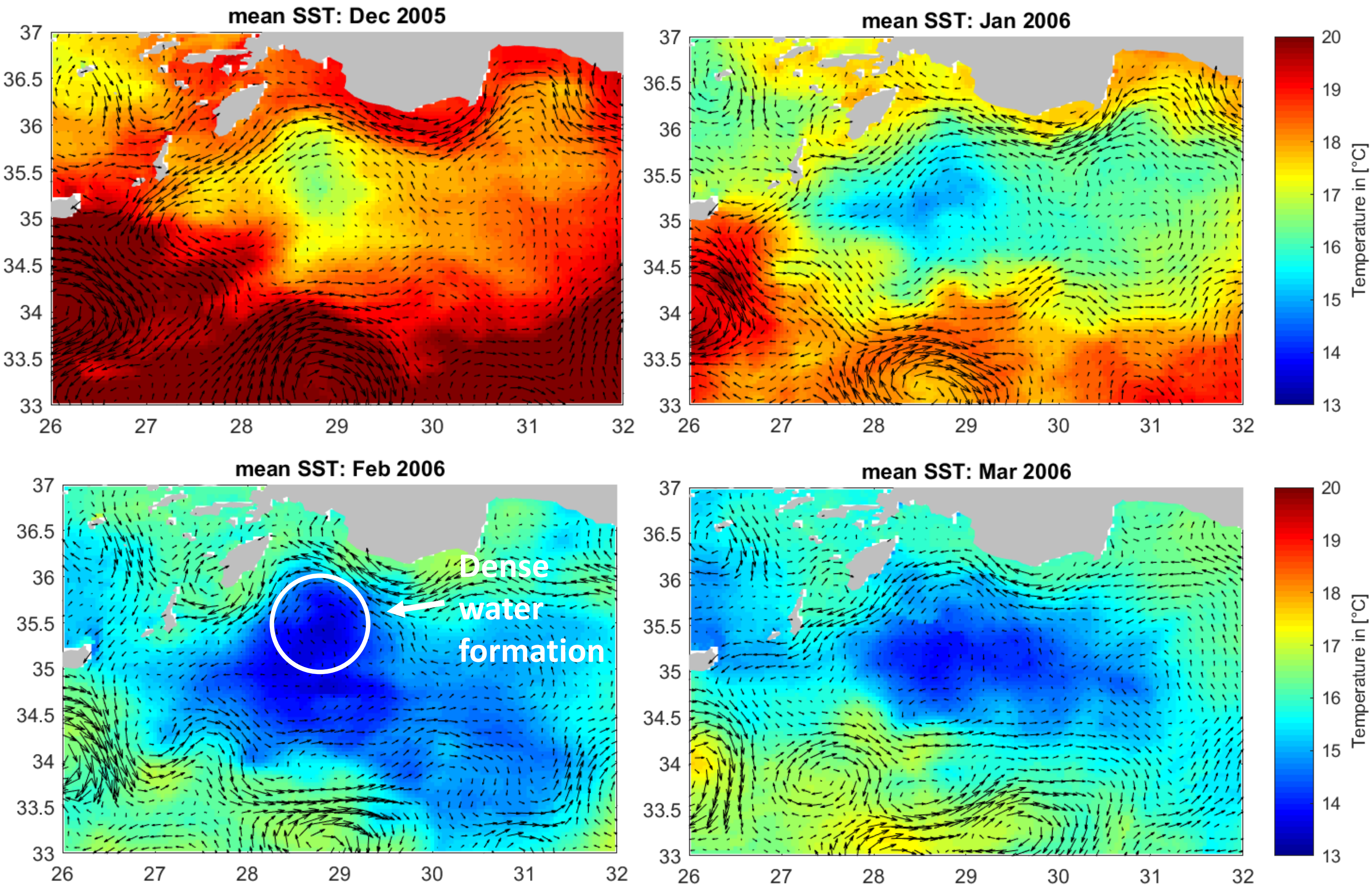
→ Turner angle: Contribution of the salinity and temperature gradient to the density gradient

→ statically unstable conditions (|Tu|>90°) from mid-January to the end of March

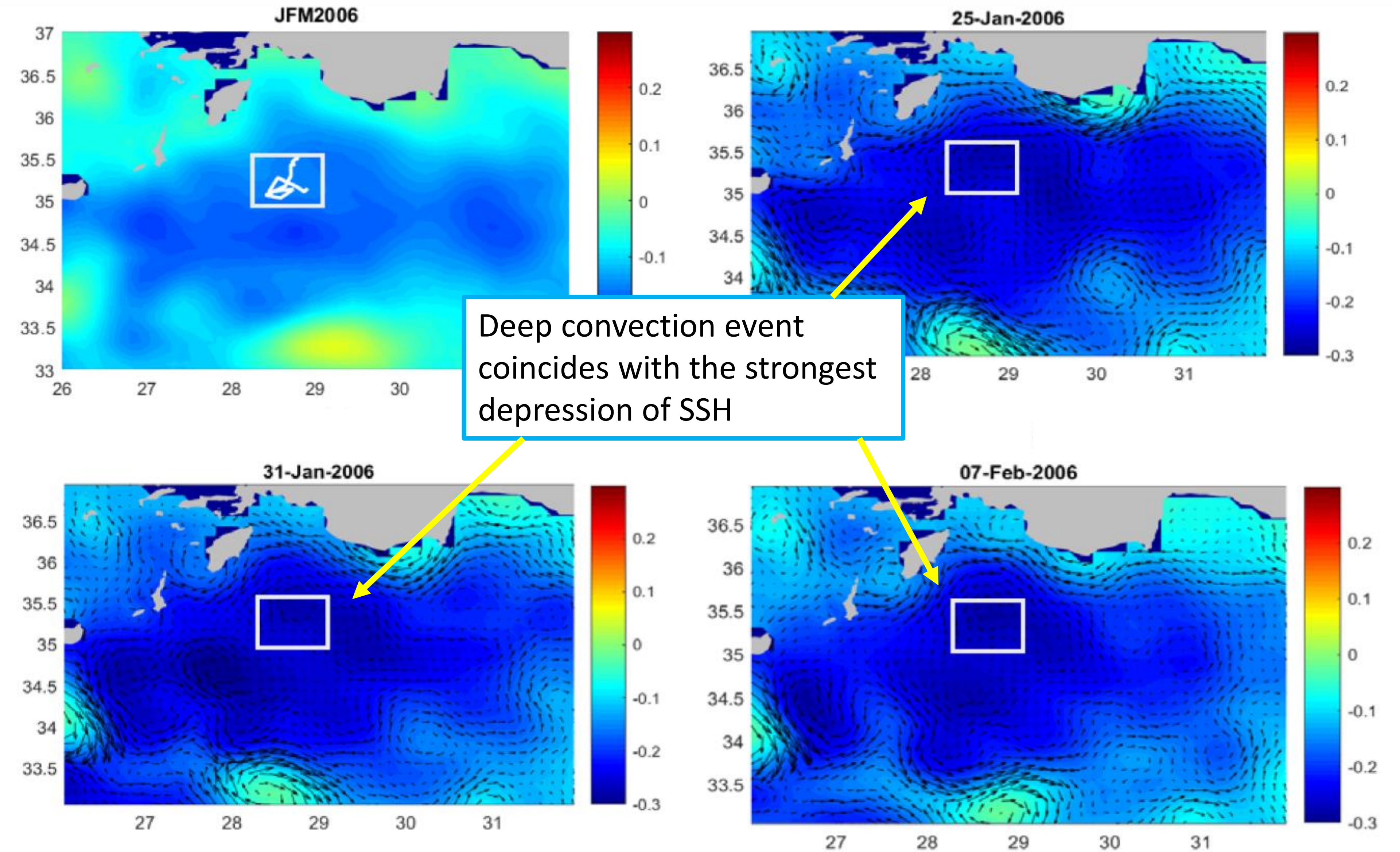
→ salinity is the main contributor to the stable stratification in December (45°<Tu<90°)

→ Deep dense water formation events characterized by a stronger contribution of the temperature gradient (-45°<Tu<-90°)

Monthly mean Sea Surface Temperature and absolute geostrophic current: Winter 2006 (Satellite data)

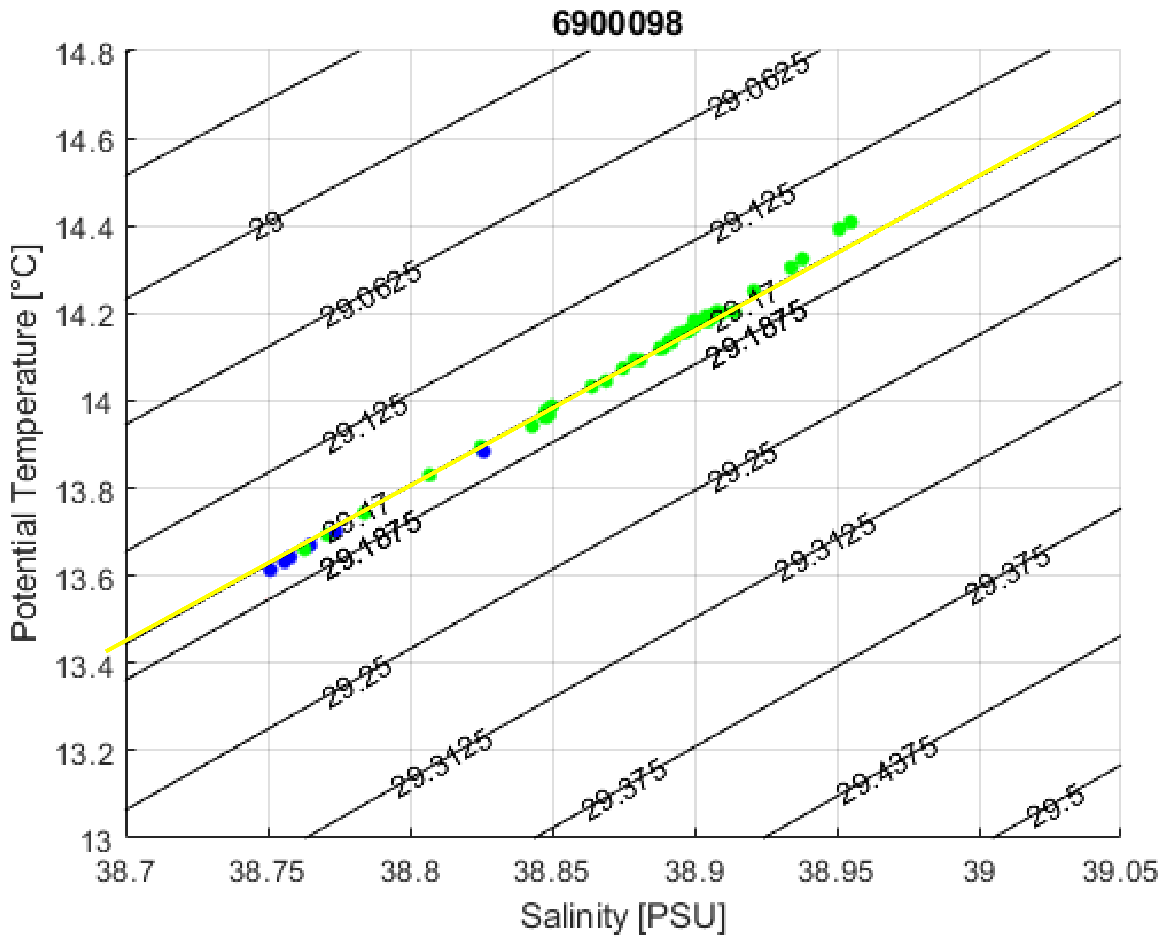


Sea Surface Height and absolute geostrophic current: Winter 2006 (Satellite data)



Mesoscale eddy diameter: ~60 km

T/S plot for JF 2006:



→ Levantine deep water formation:
13.7 °C < potential temperature < 14.5 °C, 38.8 psu < salinity < 38.9 psu

→ Additional potential density line corresponds to approximately **1000 m** depth

Example of **LIW formation** along the **coastline**: Winter 2007

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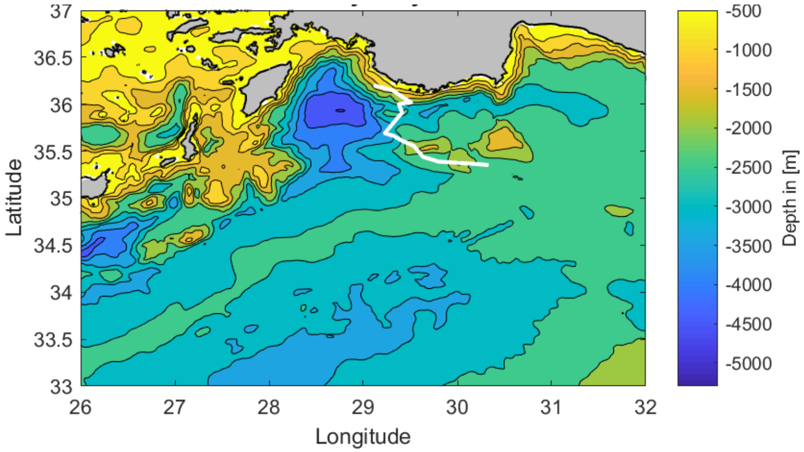

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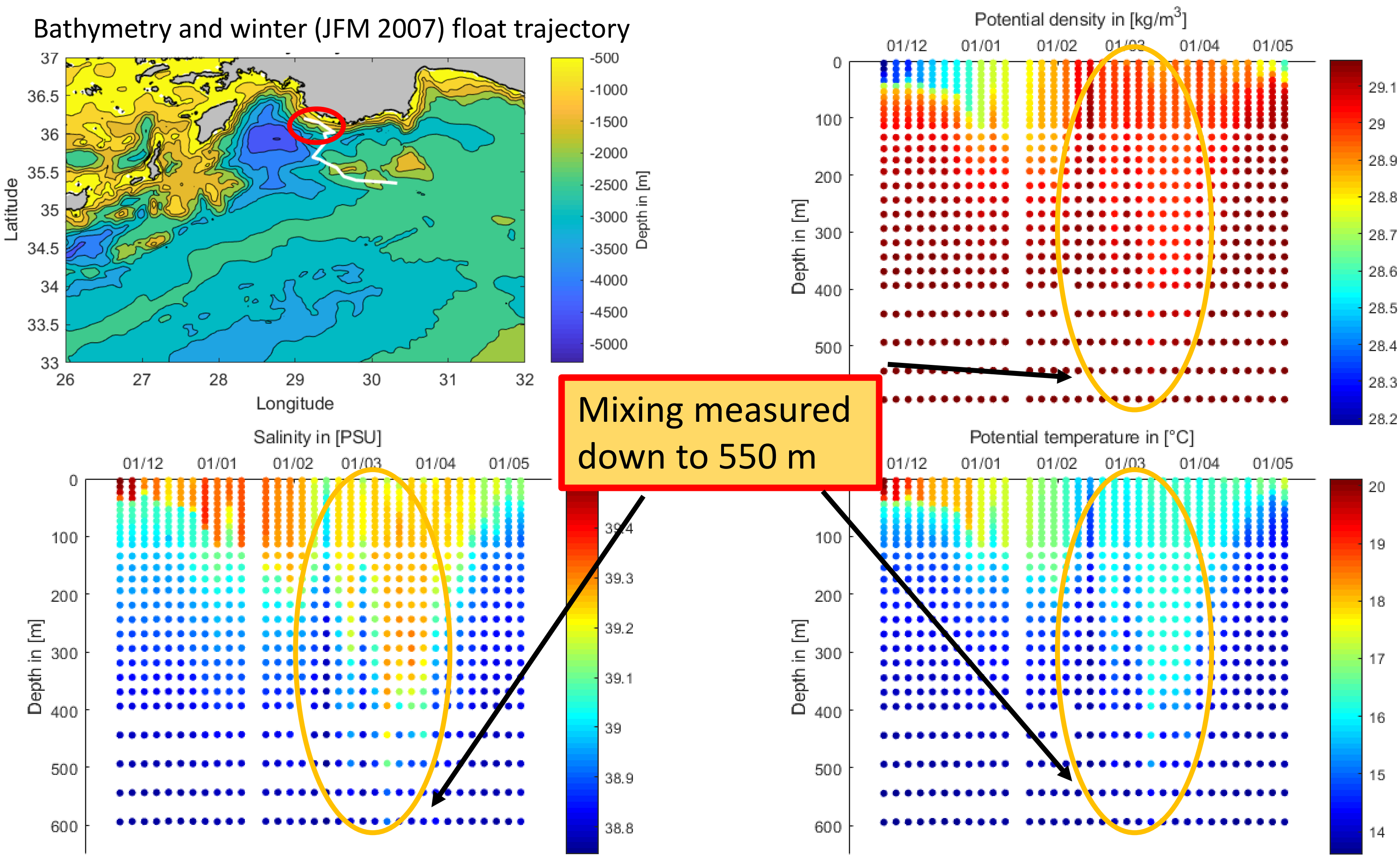

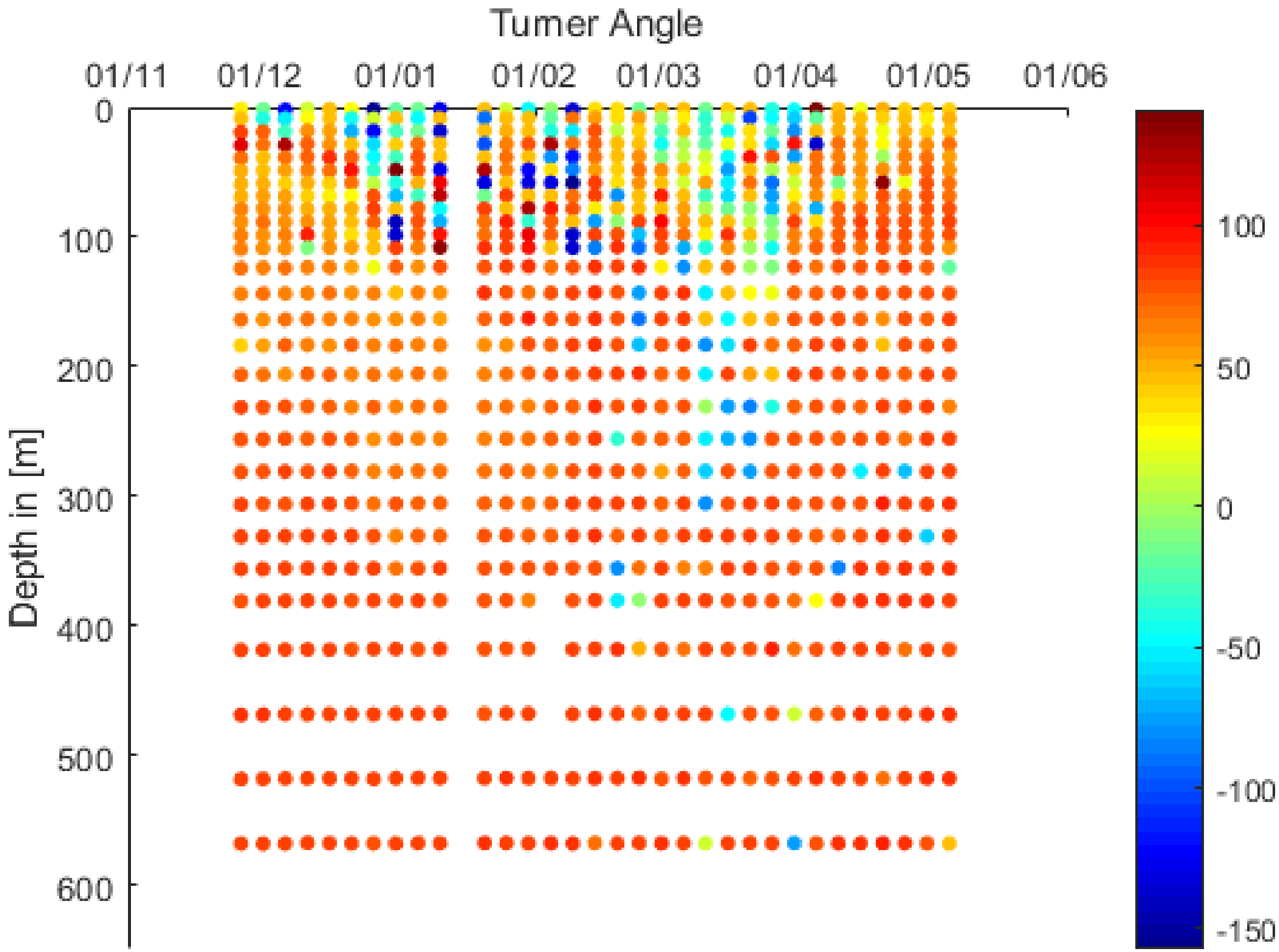

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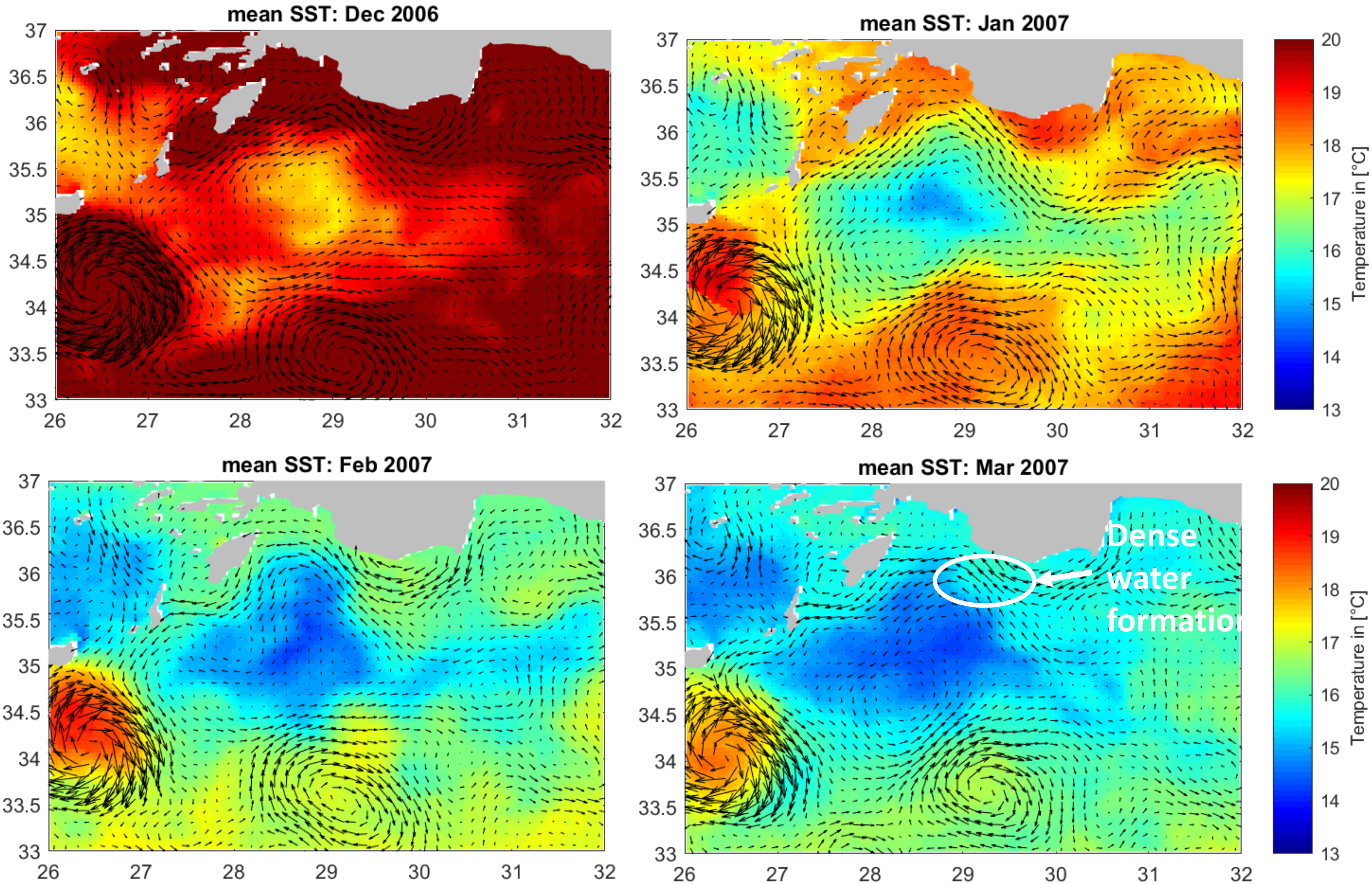
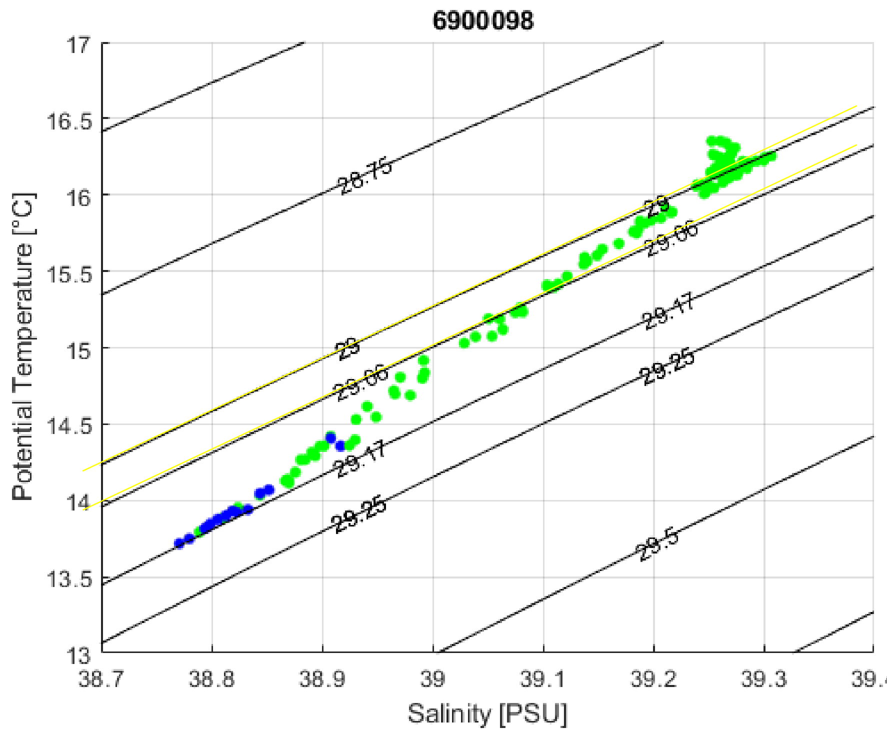


T/S plot for the dense water formation event in March 2007:



→ Levantine intermediate water formation:
potential temperature > 15 °C
salinity > 39 psu

→ The additional potential density lines represent the potential density range of **typical LIW**

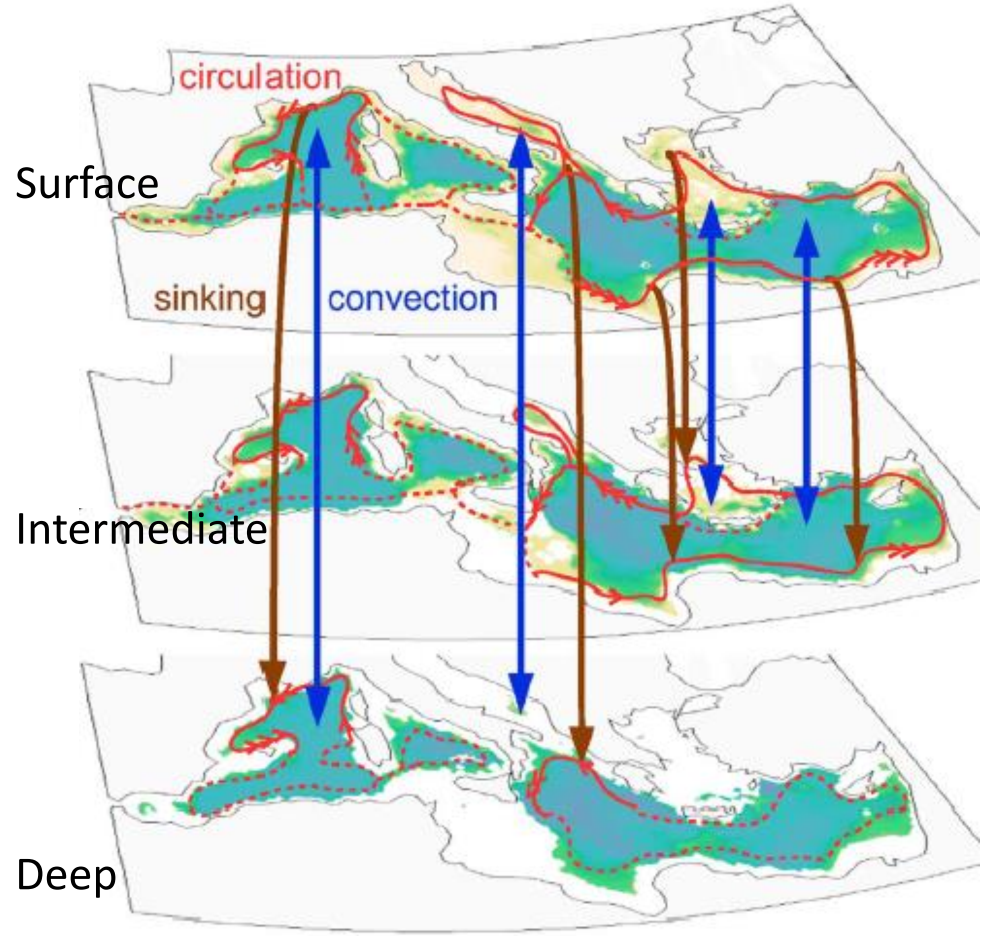
‘Overturning the Mediterranean Thermohaline Circulation’:

→ **Findings of the model:**

- Little to no **net** sinking takes place at convection sites (mean from 1980 to 2013 for all seasons),
- While boundary layer currents undergo **net** intense sinking.

- Vorticity dynamics:

$$q = \frac{f+\zeta}{H}$$

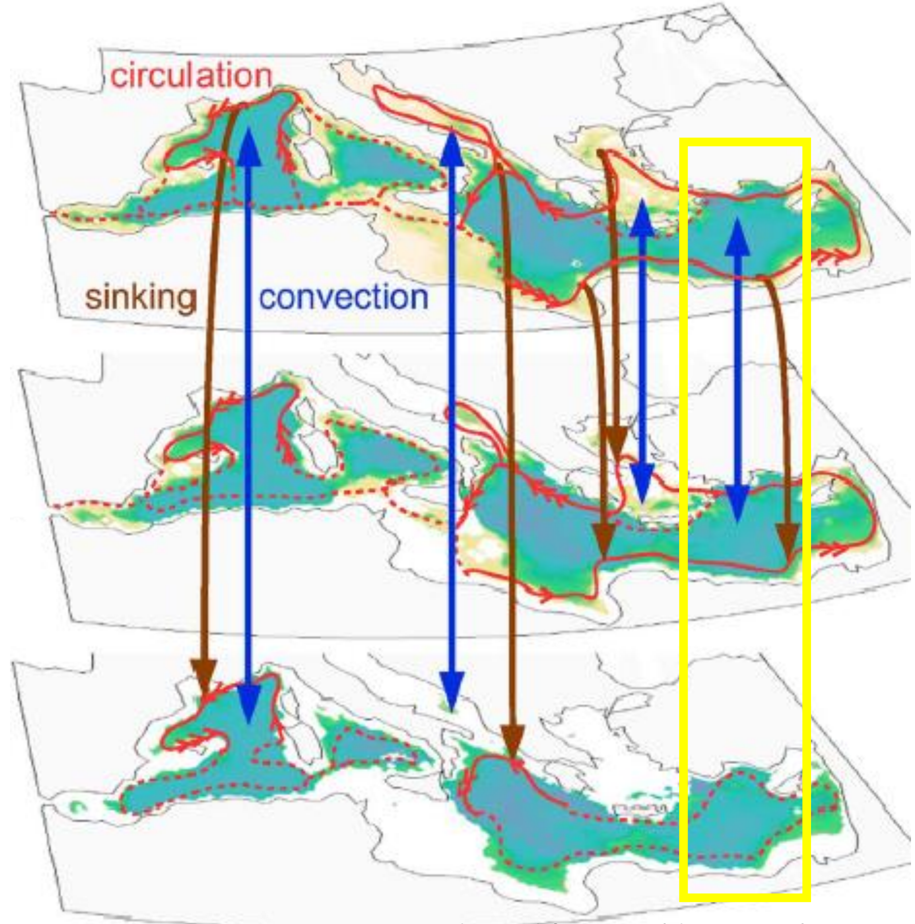


Adapted from Waldman et al, 2018

- Potential vorticity q has to be conserved. If f=const, i.e. if lat=const, then the relative vorticity ζ has to increase:

→ Only lateral or bottom friction can balance the vortex stretching induced by sinking.

Results and Conclusions



Adapted from Waldman et al, 2018

→ ***Adapted figure*** *for the winter season summarizes the obtained results for the Northwestern Levantine Sea*

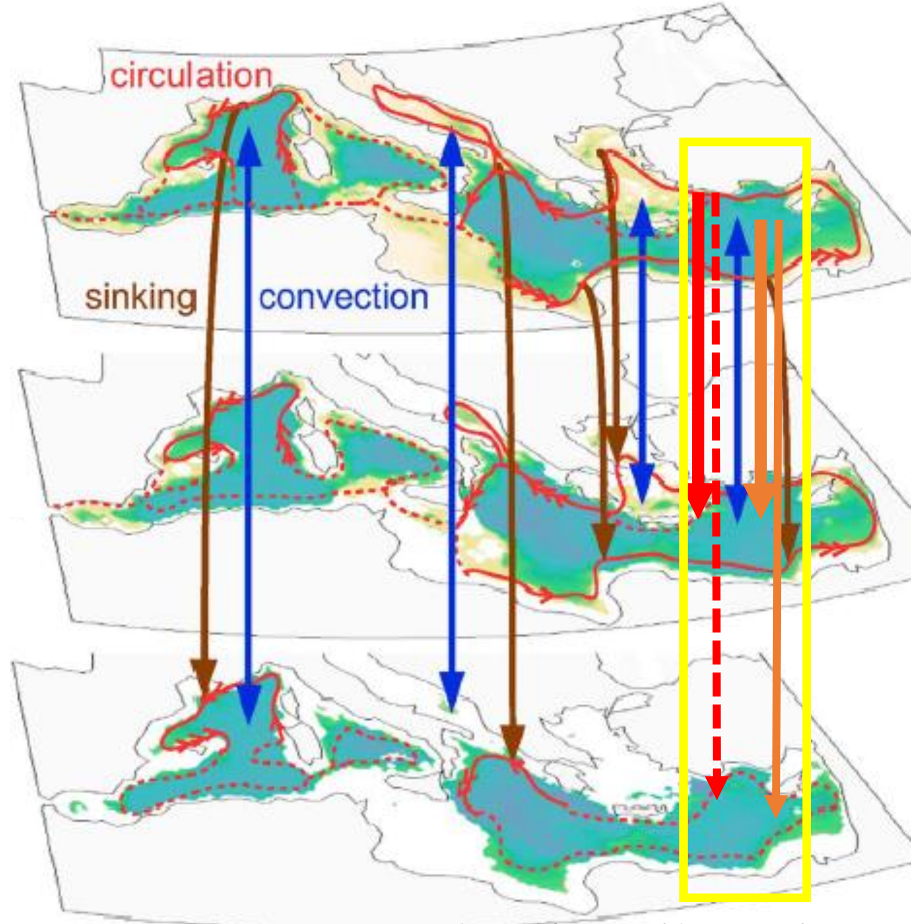
Results and Conclusions

→ **Typical LIW** (potential temperature>15°C and salinity>39 psu) formation occurred **along the Northern coastline**, reaching depths down to 550 m.

→ **LDW** (13.7 °C<potential temperature<14.5 °C, 38.8 psu<salinity<38.9 psu) and 'lower range' LIW (potential temperature about 15 °C and salinity about 39 psu) formation took place within mesoscale eddies (diameter ca. 60 km) in the **center of Rhodes Gyre**, reaching depths down to 1000 m.

→ The Argo float data confirmed the findings of recent theoretical models: boundary currents contribute to the LIW formation.

→ Therefore, the drivers and sources of the Mediterranean thermohaline circulation have to be rethought not only within the Levantine, but also within the Mediterranean Sea.



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Thank you for

your attention !

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