Supplementary material of :

“What can we learn from observed temperature and salinity isopycnal anomalies at eddy generation sites? Application in the Tropical Atlantic Ocean”

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1. **Argo Data quality control and interpolation**

A total of 144033 vertical temperature and salinity profiles acquired by Argo floats in the TAO and flagged as goof (Argo quality flag 1) were quality controlled following Chaigneau et al. (2011) and Pegliasco et al. (2015). First, we retained profiles for which: i) the shallowest data is not deeper than 15 m depth and the deepest acquisition is below 950 m depth, ii) at least 30 data are available between the surface and 950 m depth and iii) the depth difference between two consecutive data does not exceed a given threshold (25 m for the 0–150 m layer, 50 m for the 150–300 m layer, 75 m for the 300–500 m layer and 100 m below 500 m depth). Second, each profile was visually inspected and was systematically discarded if it presented a suspicious Θ/S profile. The remaining 114440 profiles, representing ~80% of the original database, were then linearly interpolated every 5 m from the surface to 300m, and every 10m from 300m of depth to the deepest available level. We here assumed that the shallowest values (within 0-15 m depth) were representative of the surface values.

2. **Weighted arithmetic means.**

Isopycnal Θ'/S' were computed for each profile by removing a local climatological profile representative of the large-scale background, also computed on density-coordinates. These local climatological profiles ($\bar{P}$) were obtained by weighted arithmetic means of all the available profiles (P_i) acquired outside eddies, within a radius of 200 km and separated by less than ±30 days (independently of the year) from the date of the considered profile.

Weighted arithmetic mean profiles ($\bar{P}$) were computed by equation E1:

$$\bar{P}=\frac{1}{\sum \Omega_i(r_i,t_i)}\sum \Omega_i(r_i,t_i).P_i(\rho) \qquad \text{(E1)}$$

where Ω_i are the weights, assigned to each profile, which depend on the distance (r_i) and time (t_i) of the profile P_i (outside eddies) from the considered profile (located inside the eddy):

$$\Omega_i(r_i,t_i)=e^{\frac{-1}{2}\left[\left(\frac{r_i}{\Delta R}\right)^2+\left(\frac{t_i}{\Delta t}\right)^2\right]} \qquad \text{(E2)}$$

where ΔR = 100 km and Δt = 15 days are the typical length and time scales. The choice of ΔR and Δt does not significantly alters $\bar{P}$ and the results presented in the study.

3. **Temperature anomaly threshold**

In order to determine whether Θ'/S' obtained within eddies are significant or not, a climatology of monthly isopycnal Θ' thresholds was computed on a 1°x1° longitude/latitude grid within surface and subsurface layers. The surface layer extends from the base of the mixed layer to the base of the seasonal pycnocline and the subsurface layer extends from the base of the pycnocline to the deepest isopycnal level (Fig. S1). As in de Boyer Montégut et al. (2004), the mixed layer depth was defined as the depth where the density increased by 0.03 kg.m

$^{-3}$ from its value at 10 m depth. The reference depth was chosen at 10 m in order to avoid the strong diurnal cycle that occurs in the first few meters of the ocean (de Boyer Montégut et al. 2004). The base of the pycnocline was determined as the depth of fluid layer possessing one half of the squared buoyancy frequency (see Cheng and Hsu, 2014). The square buoyancy is defined as :

$$N^2 = \frac{-g}{\rho}\frac{d\rho}{dz} \qquad (E_3)$$

where g, ρ and z, are gravity, density, and depth, respectively.;

In both the surface and subsurface layers (Fig. S_1), the monthly climatological Θ' thresholds was computed at each grid point as follows: first, we selected all the profiles within 200 km around the grid point, that surfaced outside eddies during the corresponding month (regardless of the year). Second, we computed for each profile, the square root of the quadratic mean of Θ' integrated over the layer thickness using equation E_4.

$$M_1 = \sqrt{\frac{1}{\sum h(\rho_i)} \cdot \sum h(\rho_i) \cdot \left(\theta'(\rho_i)\right)^2} \qquad (E_4)$$

where $h(\rho_i)$ and $\Theta'(\rho_i)$ are the thickness and the temperature anomaly of the isopycnal layer ρ_i . Third, we retained the 80th percentile of M1 values as the monthly Θ' threshold at the considered grid-point. This percentile was carefully chosen after a sensitivity study and is considered as significantly different from noise. For accuracy reasons, at least 30 monthly profiles are required around the grid-point to compute the threshold. Figures S_2 and S_3 show the monthly Θ' threshold distributions for the surface ans subsurface layers. Note the relatively high Θ' threshold within the frontal zone throughout the year in both layers. No strong seasonality was observed, except a slight increase of the Θ' threshold value in February in the surface layer (Fig. S1).

Isopycnal Θ' observed in an eddy is considered as significant if its M1 values in surface and/or subsurface are higher than the corresponding thresholds shown in Fig. S2-S3. In contrast if the M1 values in the eddy are lower than the corresponding thresholds in both the surface and subsurface layers, the eddy anomalies are classified as non-significant. When an anomaly is significant in a given layer, its sign is given by that of the mean Θ' computed over the layer, as follow:

$$M_2 = \frac{1}{\sum h(\rho_i)} \cdot \sum h(\rho_i) \cdot \theta'(\rho_i) \qquad (E_5)$$

where $h(\rho_i)$ and $\Theta'(\rho_i)$ are the same as for the E_4. A similar formula was used by Itoh and Yasuda (2010) to identify warm and cold eddies in the northwestern Pacific ocean.

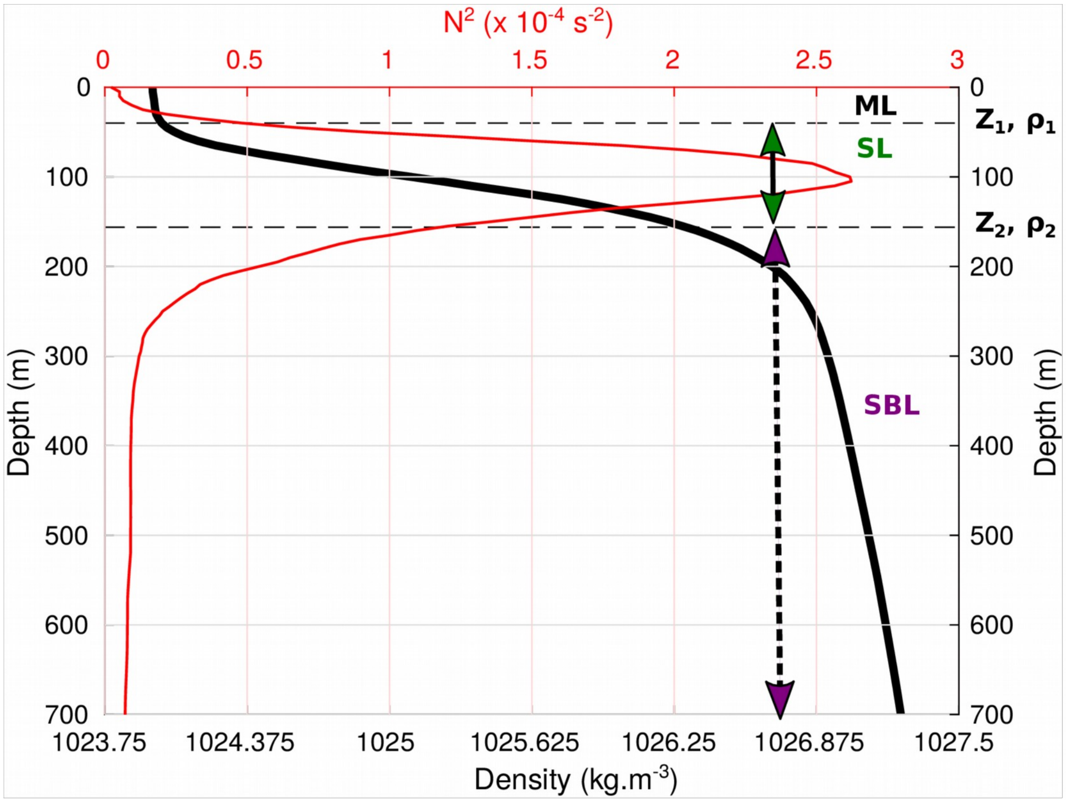

Figure S$_1$: Mean density (black curve) and square buoyancy frequency (red curve) profiles at a given grid point showing the mixed (ML), surface (SL) and subsurface (SBL) layers. (Z_1, ρ_1) and (Z_2, ρ_2) are the mixed layer and the base of the pycnocline depths and densities.

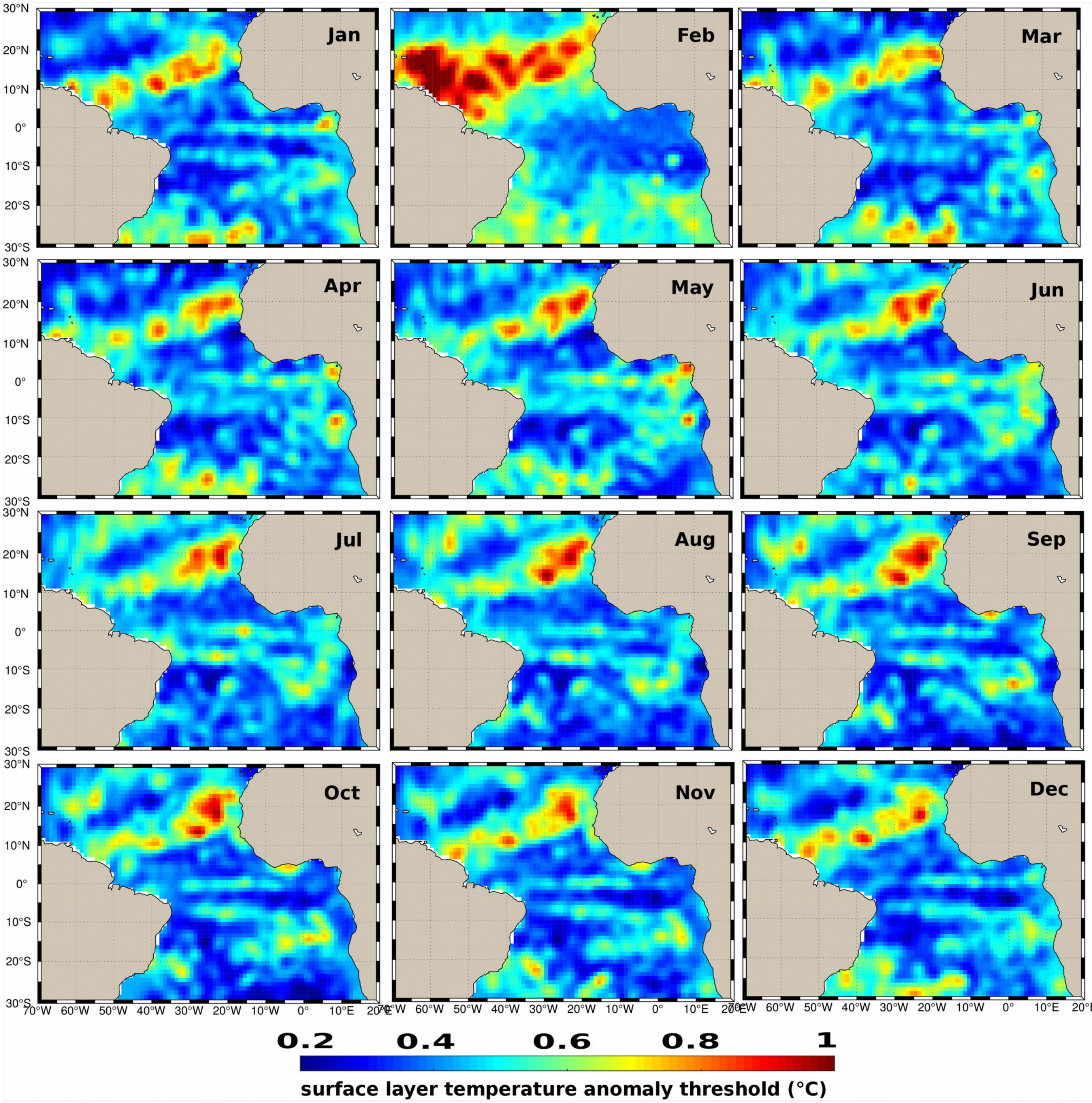

Figure S$_2$: Monthly mean of the temperature anomaly threshold within the surface layer.

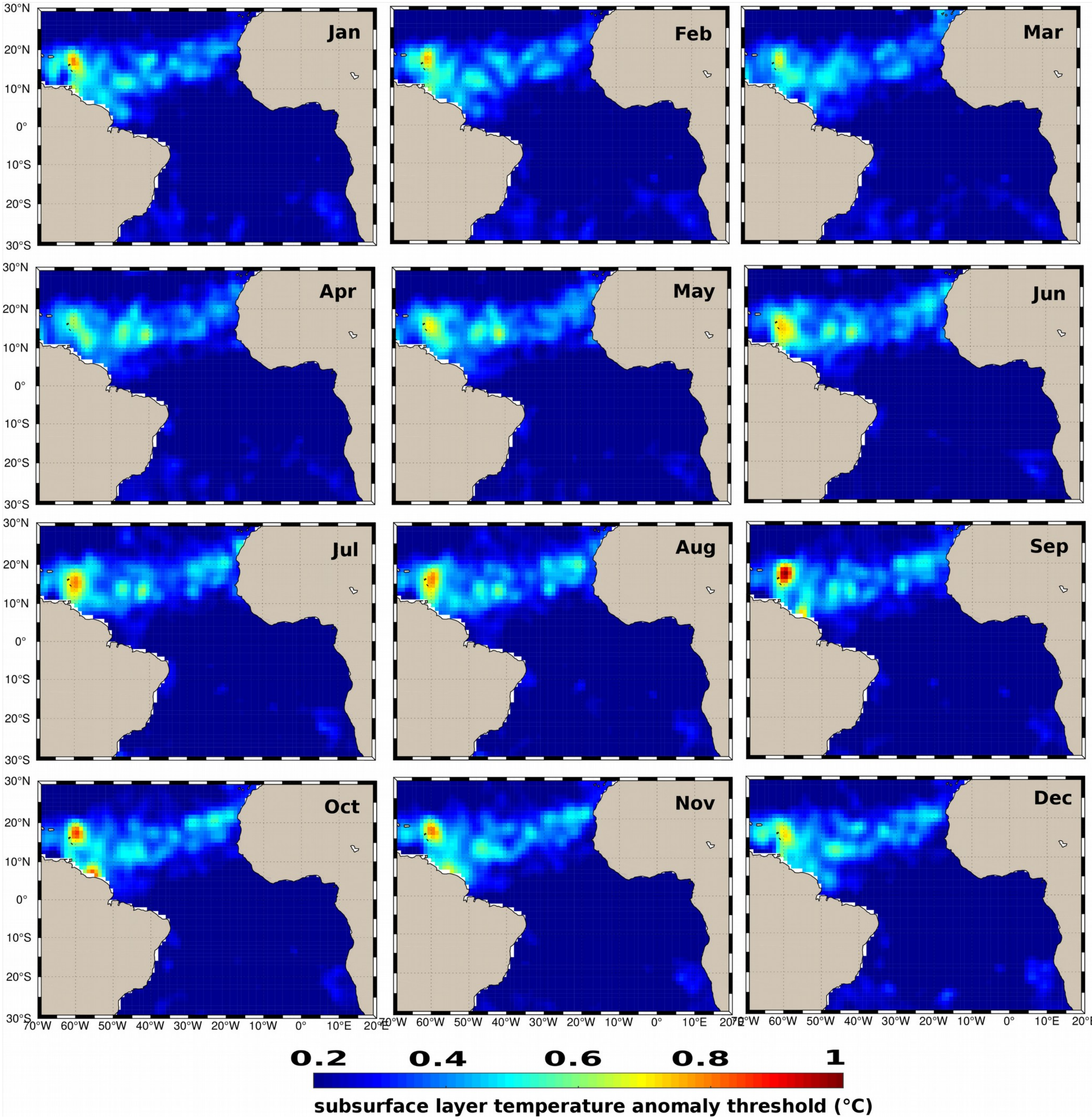

Figure S_3: Monthly mean of the temperature anomaly threshold within the subsurface layer.

References

Chaigneau, A., Le Texier A.,Eldin G., Grados C., and Pizarro O. (2011), Vertical structure of mesoscale eddies in the eastern South Pacific Ocean: A composite analysis from altimetry and Argo profiling floats, *Journal of Geophysical Research*, *116*(C11), doi:10.1029/2011jc007134.

Cheng, M.-H., and J. R.-C. Hsu (2014), Effects of varying pycnocline thickness on interfacial wave generation and propagation, *Ocean Engineering*, *88*, 34–45, doi:10.1016/j.oceaneng.2014.05.018.

de Boyer Montégut, C., G. Madec, A. S. Fischer, A. Lazar, and D. Iudicone (2004), Mixed layer depth over the global ocean: An examination of profile data and a profile-based climatology, J. Geophys. Res., 109, C12003, doi:10.1029/2004JC002378.

Itoh, S., and I. Yasuda (2010), Water Mass Structure of Warm and Cold Anticyclonic Eddies in the Western Boundary Region of the Subarctic North Pacific, *Journal of Physical Oceanography*, *40*(12), 2624–2642, doi:10.1175/2010jpo4475.1.

Pegliasco, C., Chaigneau, A., & Morrow, R. (2015), Main eddy vertical structures observed in the four major Eastern boundary upwelling systems: J. Geophys. Res. Oceans, 120, 6008- 6033.