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Optimal seasonal classification of global oceanic stratification

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Context

After a test case of density classification to investigate the impact on internal tides variability in two regions (Barbot et al. 2021), we extend the classification on global density field using GREP (ensemble of reanalysis). The clustering enables us to process equivalently areas with different spatio-temporal scales. This approach is a major step toward the production of a new time-dependent internal tide atlas and could also benefit other ocean studies from global to regional scale.

Results

Seasonal and inter-annual 3D density patterns can be identified using a single method (Fig. 4 as example). The temporal classification can then be applied to temperature and salinity fields for further investigations.

Data access during poster session

→ Thursday 2 June 4:30 pm

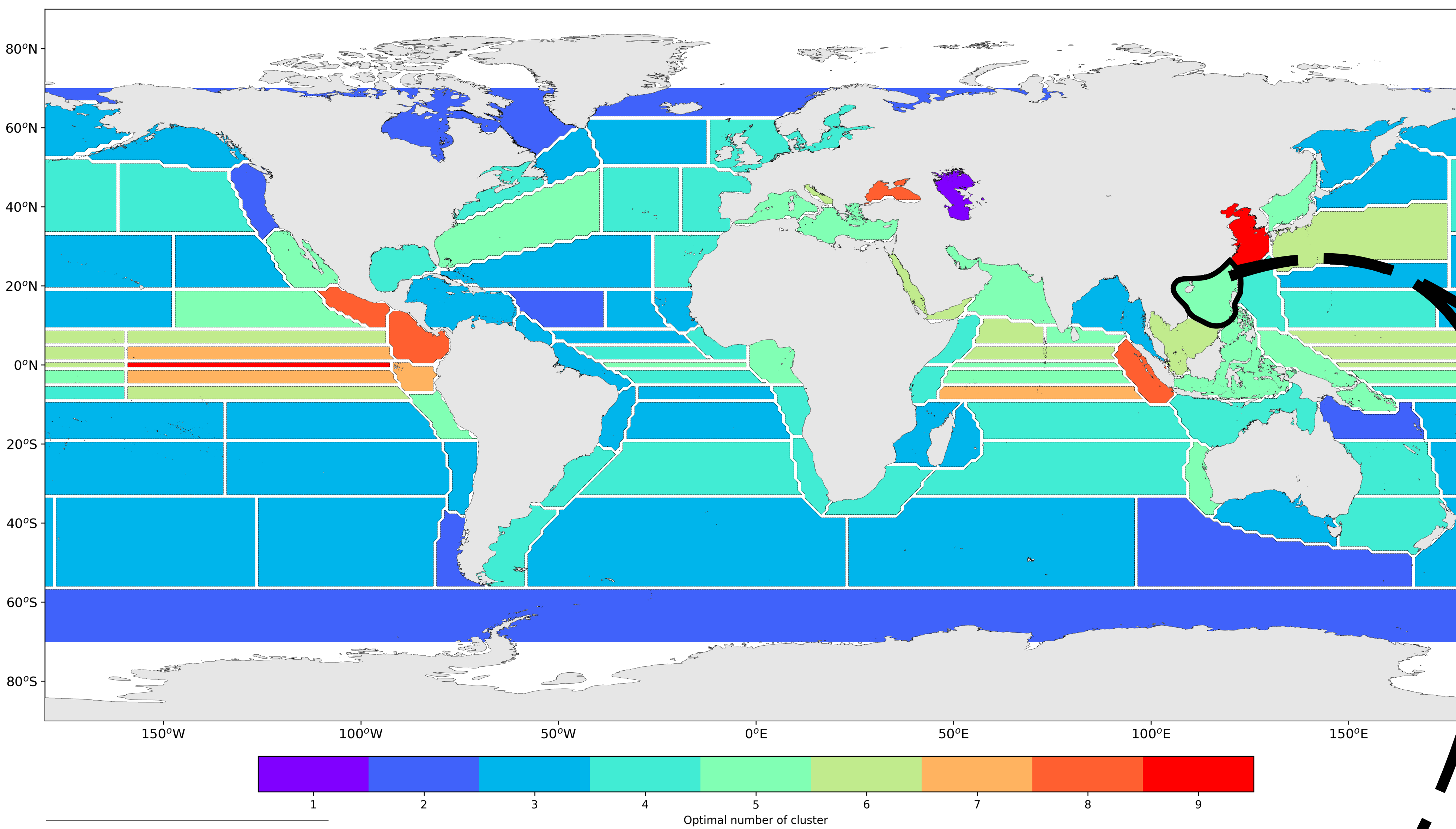


Figure 1: Optimal number of clusters for each investigated area applying the same threshold of $9 \text{ kg}\cdot\text{m}^{-3}$ on the Ward dendrogram. A high number of clusters means that the area shows very diverse 3D density patterns in time (either because of seasonality or inter-annual variability).

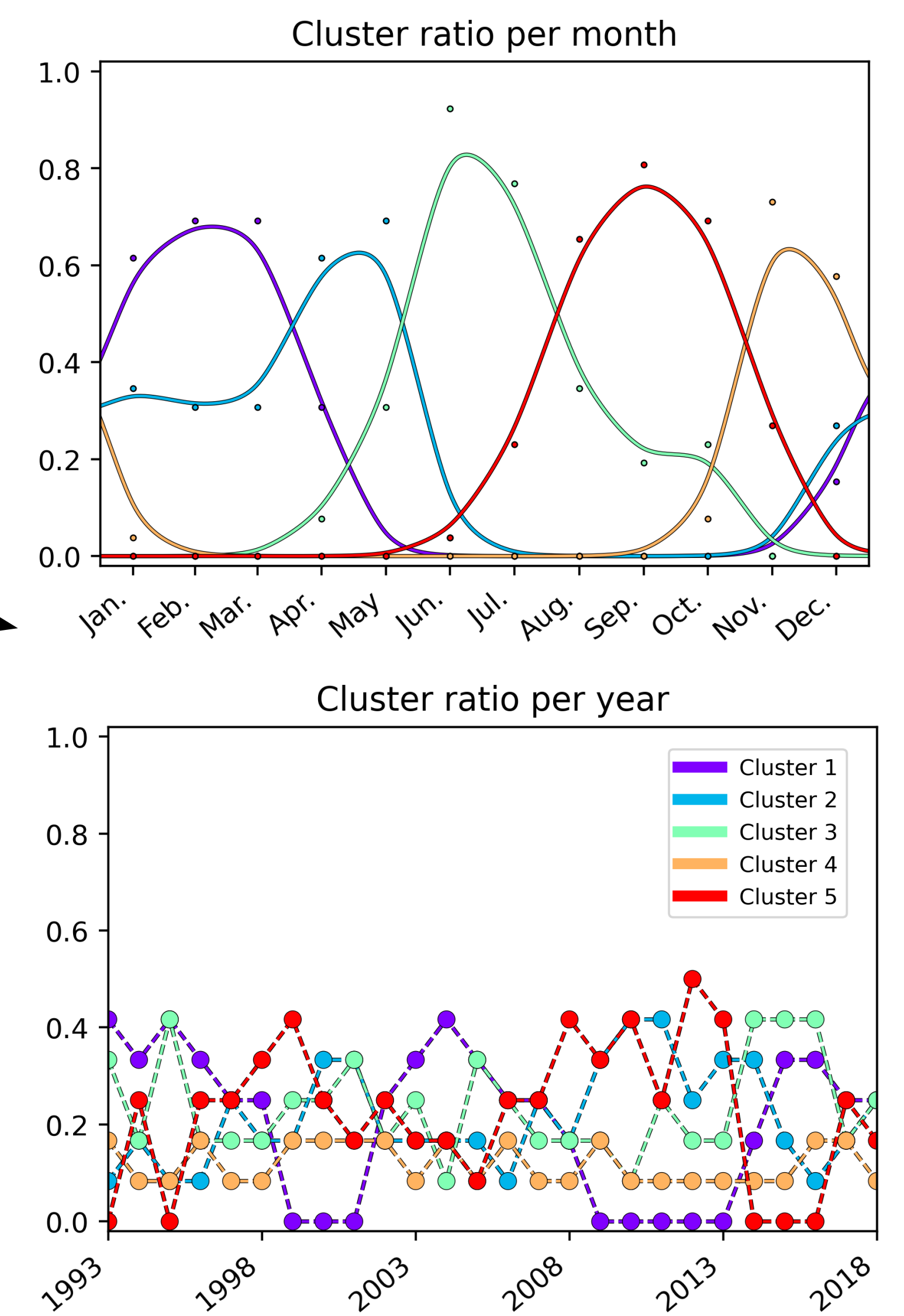


Figure 4: Time distribution of the cluster in the northern part of South China sea. In this area both seasonal and inter-annual variability can be quantified using a single method.

Methodology

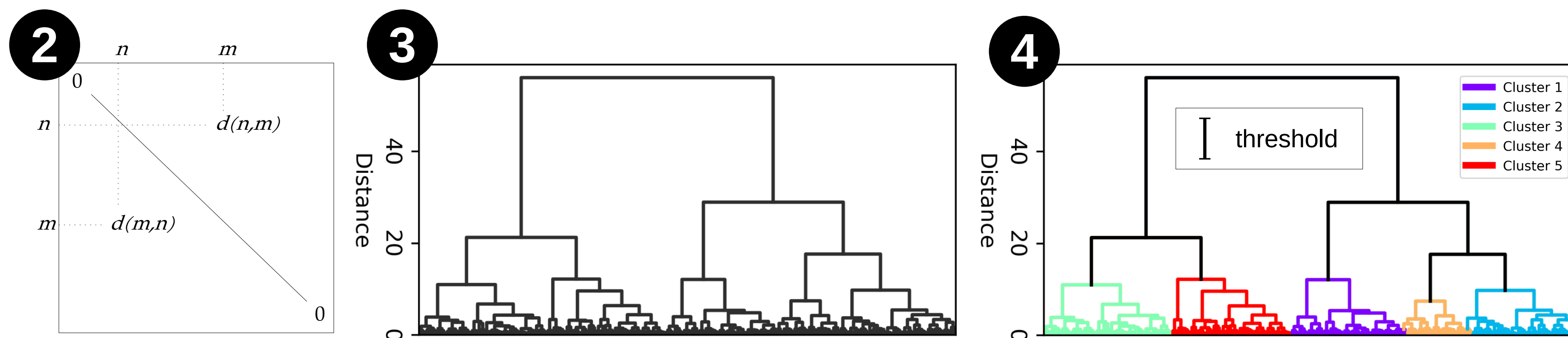


Figure 2: Successive process of the 3D density states (n,m): schematic distance matrix, full dendrogram of the linkage and final clusters by using a distance threshold.

- 1 Flatten the parameters (each point of the spatial grid).

$$\rho(nt, nz, ny, nx) \longrightarrow \rho(nt, nz \times ny \times nx)$$

- 2 Normalized distance matrix from any time occurrence to every other (physical meaning of the distance and comparability of areas with different volumes ; Fig. 2).

$$d(n, m) = \sqrt{\frac{1}{nz \times ny \times nx} \sum_{i=0}^{nz \times ny \times nx} (\rho(n, i) - \rho(m, i))^2}$$

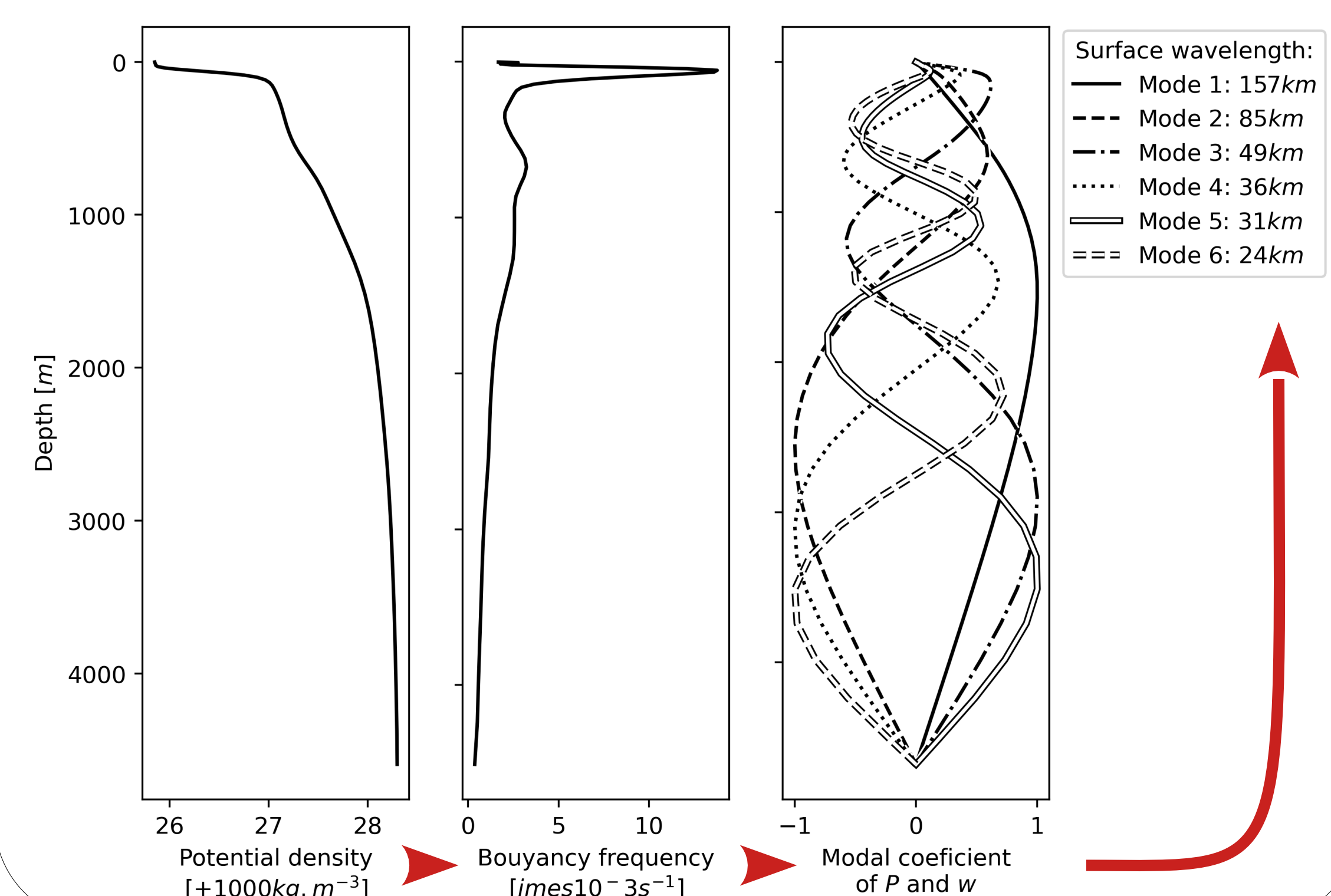
- 3 Hierarchical agglomeration by minimizing the variance inside each cluster (Fig. 2 ; Ward & Hook, 1963).

- 4 Apply a threshold of $9 \text{ kg}\cdot\text{m}^{-3}$ to stop the agglomeration (Fig. 2).

Perspectives

From a density profile, specific IT surface wavelengths of each vertical mode are calculated (Fig. 5). The wavelength constraint enables the extraction of more IT signals from the altimetry (Ubelmann et al., 2022). The present classification provide both time periods when ITs are similar and the associated wavelengths leading to a potential time-dependent IT atlas from altimetry.

Figure 5 : The vertical structure of the mode shifted toward the surface due to the strong stratification (pycnocline).



References :

GREP: Global Ocean Ensemble Physics Reanalysis, <https://doi.org/10.48670/moi-00023>
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 Ubelmann, C., Carrere, L., Durand, C., Dibaroure, G., Faugère, Y., Ballarotta, M., Briol, F., and Lyard, F.: Simultaneous estimation of ocean mesoscale and coherent internal tide sea surface height signatures from the global altimetry record, *Ocean Sci.*, 18, 469–481, <https://doi.org/10.5194/os-18-469-2022>, 2022.
 Ward, J. H. and Hook, M. E.: Application of an hierarchical grouping procedure to a problem of grouping profiles, *Educ. Psychol. Meas.*, 23, 69–81, 1963.