

Dear Authors

Thank-you for your revised manuscript. In view of the substance of some of their comments and the considerable ensuing changes, I intend to send your revised manuscript back to the reviewers in due course. However, I think there are some points that it is best to attend to first. Please see “Detailed comments” below.  
Yours sincerely

John Huthnance (editor)

**Response:** Thank you for your careful handling of our revised manuscript. We carefully responded to the detailed comments and revised the manuscript accordingly.

### **Detailed comments**

1. Lines 138-144 and 157. I think a reference specific to MVEOF would help. Your inserted text in section 2 states very little extra to what was previously in section 3.1 (c.f. Referee 1 comment)

**Response:** Thanks for the suggestion from reviewer. Following your suggestion, we give reference for MVEOF.

We use Multivariate Empirical Orthogonal Function (MVEOF) to extract the dominant coupled spatio-temporal modes shared by multiple, related variables (Dawson, 2016; Liang et al., 2018)

#### Reference:

Dawson, A.: eofs: A library for EOF analysis of meteorological, oceanographic, and climate data, J. Open Res. Softw., 4, 1, <https://doi.org/10.5334/jors.122>, 2016.

Liang, Y.-C., Mazloff, M. R., Rosso, I., Fang, S.-W., and Yu, J.-Y.: A multivariate empirical orthogonal function method to construct nitrate maps in the Southern Ocean, J. Atmos. Ocean. Tech., 35, 1505–1519, <https://doi.org/10.1175/JTECH-D-17-0201.1>, 2018.

2. Lines 143-144. If the maps are for individual variables, is the covariation in space only subjective by looking at two of the individual variable maps.

**Response:** The individual maps are presented for each variable; however, they are all derived from the same MVPC time series (i.e., the same mode). Each map reflects how a given variable spatially expresses the same underlying temporal pattern. As a result, the spatial patterns across variables represent a consistent, objectively derived co-varying structure—rather than a purely subjective visual comparison.

In the revised manuscript, we have clarified this point as follows: “These maps are derived from the same MVPC time series. The spatial patterns across variables reflect a consistent, objectively derived co-varying structure.”

3. Lines 158-159 and Figure 4 caption. Referee 2 comment m6 is implicitly pointing out that the number N of observations is not the correct starting point for determining degrees of freedom. If successive observations are correlated, because the time scale is longer than the sampling interval, then there are fewer degrees of freedom.

**Response:** Thanks for further clarification of this issue. We revised our response to Referee 2 and the manuscript accordingly.

Updated response to Referee 2:

“The degrees of freedom estimated are automatically computed by the MATLAB toolbox. For the simple linear regression  $Y = \beta_0 + \beta_1 X + \varepsilon$  with N observations, the model estimates two parameters (intercept and slope). Consequently, the residual degrees of freedom are N-2.

This calculation assumes independent temporal observations. Here we acknowledge that the temporal autocorrelation in the time series may reduce the effective degrees of freedom, thus affect the confidence level. In this study, our emphasis is on the broad spatial patterns of the regressed velocity vector anomalies and cross-isobath velocity anomalies, rather than marginal differences

at the confidence threshold. Nonetheless, we have added a note in the manuscript to acknowledge this uncertainty.

The caption of Fig. 4 now reads:

“Figure 4. Depth-averaged circulation and associated anomalies in the northern South China Sea: (a) mean velocity vectors ( $\text{cm s}^{-1}$ ) and (b) mean cross-isobath velocity ( $\text{cm s}^{-1}$ ) averaged over summers from 2000 to 2022, where positive cross-isobath velocity indicates flow from deeper to shallower waters; (c) regression map of velocity vector anomalies ( $\text{cm s}^{-1}$ ), and (d) regression map of cross-isobath velocity anomalies ( $\text{cm s}^{-1}$ ) during positive MVPC1 years (Table 1). Shaded areas in (c) and (d) denote regions where the 90% confidence level is not met, based on a two-tailed t-test using the estimated standard deviation and sample degrees of freedom. For the simple linear regression, the degrees of freedom are  $N-2$  ( $N$  is the number of observations), assuming independent observations. As temporal autocorrelation may reduce the effective number of independent samples, the reported regions with 90% confidence level may include uncertainties. The two-stage regression approach is detailed in Section 3.2. Positive values in (c) and (d) indicate flow toward shallower waters.”

”

4. Lines 205, 321. “inside/within the 100 m isobath” → “inshore of the 100 m isobath” (c.f. Ref.2)

**Response:** Corrected and thanks!

5. Line 219. “(70% runoff threshold of these years)” → “(70th percentile for these years)” and Lines 219-220 “while a sensitivity test of the selected thresholds is shown” → “while sensitivity to the choice of percentile is shown”

**Response:** Corrected and thanks!

6. Equation (2) and Line 314. Presumably  $\xi$  is relative vorticity but I miss explicit definition.

**Response:** Thanks for the reminder, the  $\xi$  is relative vorticity and we added the definition in the revised manuscript

“ $\psi$  is the transport streamfunction,  $\xi$  is the relative vorticity, and  $\vec{v}(\bar{u}, \bar{v})$  denotes the depth-averaged velocity, respectively”

7. Lines 317-318. In response to Referee 2 comment m8 I think you need to refer to the Supplement and figure S3 here, otherwise the reader does not see why GMF is excluded.

**Response:** Following reviewer’s suggestion, we clarify this in the revised manuscript

“The cross-isobath velocity anomaly contributed by the term GMF during positive MVPC1 years is negligible compared with the other terms (Fig. S3), thus it is excluded from the following discussion.”

8. Line 390. Better to omit “is strong or weak”

**Response:** Thanks for the suggestion and we omit it from the revised manuscript

9. Line 414. “is the exceptionally high core of density anomaly” → “is the core of exceptionally high density anomaly”?

**Response:** Corrected and thanks!