

Response to reviewers

Revision on “*Synoptic climatology of extratropical transition of tropical cyclones over the Southern Hemisphere*”

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First, we would like to thank the editor and reviewers for their constructive comments and suggestions, which have helped improve the quality of this manuscript. The resubmitted manuscript has been thoroughly revised according to the reviewers' comments. In this document, point-by-point responses to reviewers' comments are listed.

Reviewers' comments are shown in black, and authors' responses are shown in blue. The indicated line numbers refer to those in the clean version of the revised manuscript.

Reviewer 1

Major Comments & Structural Suggestions

1. Introduction Structure and Narrative Flow

The Introduction provides an excellent and thorough synthesis of existing ET literature. However, the narrative arc currently struggles with structural flow. Specifically, the establishment of the central knowledge gap—that SH ET cases are understudied compared to the Northern Hemisphere (NH)—is introduced and reiterated multiple times, causing the text to loop back on itself and disrupt the logical progression.

For instance, the lack of SH studies is explicitly stated in Line 57 ("However, most studies focus on basins in the Northern Hemisphere..."), repeated in Line 75 ("There are substantially fewer studies of ET in the Southern Hemisphere..."), and stated a third time in Line 95 ("To our knowledge, only a handful of studies have investigated the climatology..."). Furthermore, the text jumps from SH/NH case studies (Lines 35–55), to the SH knowledge gap (Lines 56–59), back to NH basin climatologies (Lines 60–74), and then back to the SH gap (Lines 75–89).

Recommendation: To strengthen the narrative arc and improve readability, reorganize the Introduction into the following sequence: 1) Broad Concept & Physics, 2) Hazards & Downstream Impacts, 3) Established NH Climatologies, 4) The Knowledge Gap & Existing SH Literature, and 5) Methodological Gap & Paper Objectives.

Thanks for your comments. The Introduction section has now been restructured in the revised manuscript following your based valuable recommendations.

Specifically, the improved flow highlights the scarcity of ET studies in the Southern Hemisphere and the limitations of the CPS framework and subjective ET definitions. These gaps together motivate the present study, which applies a state-of-the-art objective cyclone tracking and classification framework to ERA5 reanalysis and focuses on synoptic processes during ET and their diversity.

2. Methodology Organization

ET Detection Flow: The methodology used for ET detection is robust, but the flow of Section 2.3 is slightly disjointed. The text goes through the conceptual definitions of the new parameters, the quantitative thresholds, a specific case study (TC Debbie), the total event count, and then the traditional Cyclone Phase Space (CPS) framework. Since CPS parameters are the foundation of past ET work and are analyzed later in this study, the introduction to this section could start with CPS to help ground readers first. Then, the RH-DeepShear method could be introduced and discussed within that established context.

Section 2.3 is reorganised as suggested above in the revised manuscript.

Clustering Methodology Placement: The paragraphs detailing the clustering methodology (Lines 289–302) currently reside in the Results section. These should probably be moved to the Methods section. In Lines 293–296, the authors mentioned that the optimal cluster number ($K=4$) was determined via the silhouette score and Davies-Bouldin index, but state "(figures not shown)." To ensure transparency and traceability, this reviewer recommends adding these validation plots to a Supplementary Material document.

The K-means clustering methodology has now been placed into Section 2.4 in the revised manuscript. The justification for the selected optimal number of clusters, along with the corresponding figure, is shown here and also included in the Supplementary Material.

The Silhouette score decreases rapidly for $k < 4$ and remains at low values for $k > 4$; the Davies-Bouldin index has the lowest value at $k = 2$ and the second lowest value at $k = 4$ (Figure R1.1). Considering both metrics, $k = 2$ or 4 is a sensible choice, as they maximise the Silhouette coefficient while minimising the Davies-Bouldin index. However, $k = 2$ accounts for less variability in ET-associated synoptic patterns; therefore, $k = 4$ is considered the optimal cluster number.

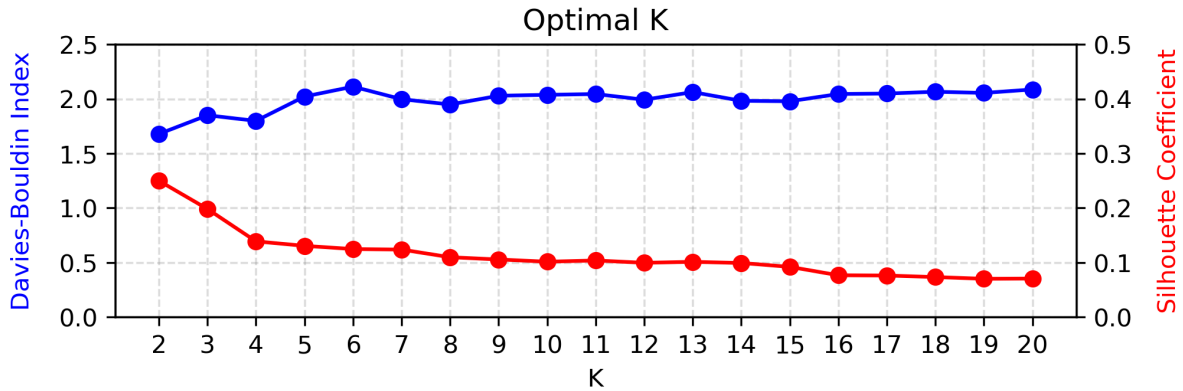


Figure R1.1 Silhouette score and Davies-Bouldin index for determining the optimal cluster number k.

3. Results Section Structure

The current placement of Section 3.2 ("Precipitation and wind") is out of place and disrupts the logical flow of the results. It separates related concepts and would be better consolidated with other lat-lon composites (currently in Section 3.3.2).

Recommendation: Consider adopting the following structure: 3.1 Climatology and seasonality; 3.2 Mean Characteristics (3.2.1 Evolution of cyclone structure and background environment and 3.2.2 Composite analyses of ET structure (consolidating current 3.2 and 3.3.2 here); 3.3 ET Morphologies & Clusters.

In the revised manuscript, Section 3 has now been reorganised as:

- 3.1 Climatology and seasonality
- 3.2 Mean structural characteristics and mechanisms
 - 3.2.1 Evolution of cyclone structure and background environment,
 - 3.2.2 Synoptic characteristics
 - 3.2.3 Precipitation and wind
- 3.3 ET Morphologies
 - 3.3.1 Geographic location and structure evolution
 - 3.3.2 Synoptic characteristics
 - 3.3.3 TC-jet interaction

Figures are reordered based on the new structure.

Specific and Minor Comments

1. Line 191 & Figure 4: The SST contours are a bit dense, making it hard to see the 26°C contour lines. They could be thickened or highlighted in other ways.

In Figure 4, 26°C lines are thickened and labelled only (Figure R1.2). Figure 4 is updated in the revised manuscript.

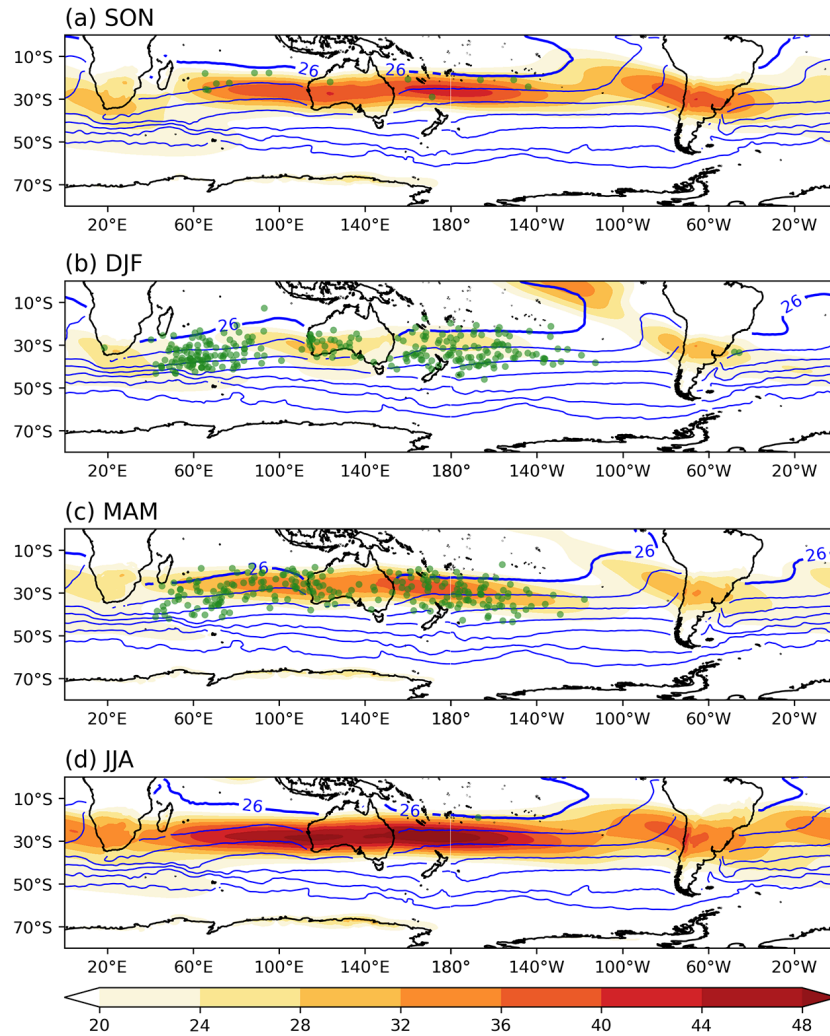


Figure R1.2 Seasonal climatologies of vertical wind shear (in m/s; shaded as per the colourbar) and SST (in°C; blue contours every 4 °C starting from 2 °C) for (a) September-October-November (SON), (b) December-January-February (DJF), (c) March-April-May (MAM), and (d) June-July-August (JJA) over the Southern Hemisphere. Green dots mark the positions of ET. A thick blue line highlights the 26°C contour. The seasonal climatologies are based on the period 1979-2021.

2. Lines 238–239: The mean values of B and low-level shear are consistent with the ET definition using the CPS. However, their spreads around the critical thresholds suggest the ETs detected via RH-DeepShear are not perfectly aligned with the ETs identified with the CPS (Line 239). A note explaining why would add physical depth here. Additionally, this would be a good place to discuss why the CPS method (N=600; Line 164) yields ~20% more ETs than the RH-DeepShear method (N=506; Line 153).

The RH100MAX-DEEPSHEAR method does not perfectly align with the CPS-based approach, as the two approaches evaluate different aspects of ET. The RH100MAX-DEEPSHEAR emphasises changes in the background environment (moisture availability and large-scale baroclinicity), whereas the CPS framework focuses on cyclone structural changes on a smaller scale (asymmetry and lower- and upper-level thermal structure within a radius of 500 km).

A TC may have already become asymmetric and cold-cored at a relatively lower latitude during the transition, where the environmental vertical wind shear remains weak, or deep convection is still active. In such cases, the transition may be identified by the CPS framework but not by the RH100MAX-DEEPSHEAR method.

In addition, the objectively-detected TC tracks in ERA5 are often longer than those in IBTrACS, which are used to identify ET events in previous studies (e.g., Kitabatake, 2011; Wood and Ritchie, 2014; Bieli et al., 2019). In the early stage of some ERA5 tracks, systems may still have an asymmetric structure and may not be warm-cored in the lower troposphere, presumably causing some false ET identification by the CPS framework. This likely explains the larger number of ET events detected by the CPS-based method, compared with the RH100MAX-DEEPSHEAR.

A brief discussion of the discrepancy between the RH100MAX-DEEPSHEAR and CPS approaches is added to Lines 432-442 in Section 4.1 of the revised manuscript.

3. Section 3.4.3 Title: The section title ("Mechanisms") is vague. Please consider specifying whether it describes the mechanisms of extratropical transitions or downstream impacts.

Agree, we have changed this to "TC-jet interaction" for Section 3.4.3 in the revised manuscript.

4. Lines 395–396: "The reduced divergent flow..." The text refers to subplots of C3 instead of C1. Please check whether the right plots were referred to.

The sentence should refer to C1 (Figures 11c and 12a). This is corrected in Lines 415-416 in the revised manuscript.

5. Cluster Summary: It might be highly beneficial to provide a summary table that consolidates the key findings and characteristics of the four distinct clusters.

A table of Clusters and their characteristics has now been added in the Discussion section.

Table R1 Characteristics of ET clusters

	C1	C2	C3	C4
Number of events (percentage)	177 (35%)	103 (20%)	55 (11%)	171 (34%)
ET latitude	28 °S	37 °S	38 °S	29 °S
Structural changes	Slow transition, warm-core structure remaining at ET	Rapid transition	Rapid transition, with slower decrease in -VLT compared with C2	similar to C1
Precipitation and wind	Weak wind and low precipitation	Left-track-side strong wind and elongated precipitation field	Largely expanded wind and precipitation fields	Weaker wind and moderate precipitation
Surface pattern	Similar to “cradle” pattern in Foley and Hanstrum (1994)	Merged by the surface trough flanked by two highs	Stronger downstream high	Similar to C1, with larger amplitude
Upper-level pattern	Weak upstream trough	Strong upstream trough, straight and strong downstream jet	Upstream trough wrapping cyclonically, highly-amplified downstream ridge	Moderate upstream trough and weak downstream ridge

6. Lat-Ion Composite Analyses (General): Could the statistically significant anomalies be highlighted in these lat-Ion composite plots?

The significance test is performed for 200-300-hPa PV anomalies in individual ET clusters (Figure 11b, e, h, and k), using a Monte Carlo method. The Monte Carlo method is commonly used to test statistically significant anomalies in composites (e.g., Quinting et al. 2016).

The test is done as follows. For each ET cluster, 1000 random composites of PV anomaly are created. Each composite has the same number of events as in that cluster. Each date consists of a randomly selected year from the period 1979-2021 and a randomly selected day and month from a 14-day window around each ET time that is incorporated into the ET composite. We choose the upper and lower 2% percentiles of the Monte Carlo composites, and the PV anomaly is significant if it is either greater or less than these percentiles. As shown in Figure R1.3b, e, h, and k, upper-level PV anomalies around the transitioning TC are statistically significant for all ET clusters.

Figure 11 is updated, and the description of the Monte Carlo method is added in Lines 349-354 in the revised manuscript

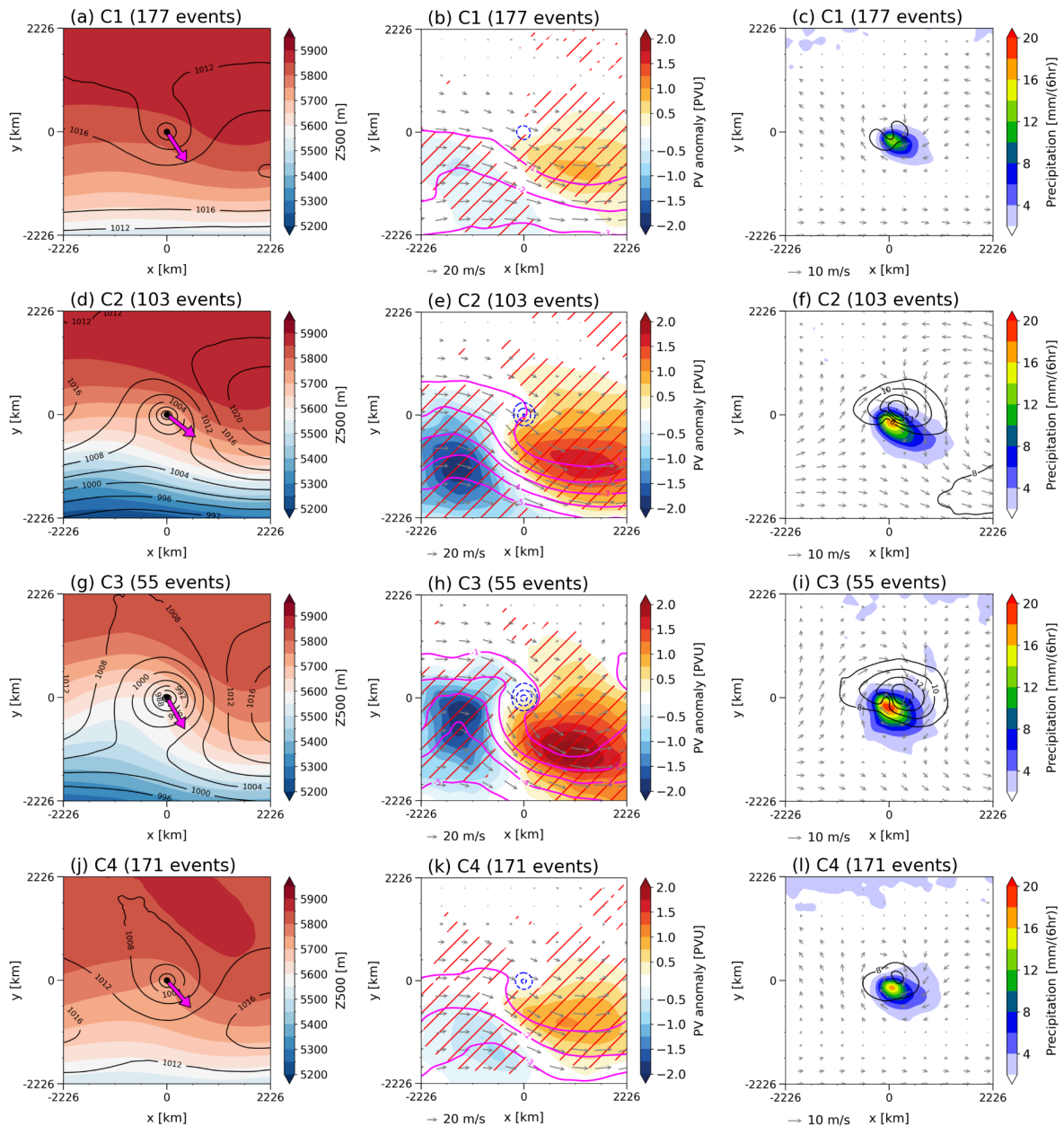


Figure R1.3 Composite fields at ET time for Clusters (a-c) 1, (d-f) 2, (g-i) 3, and (j-l) 4. (a, d, g, j) show MSLP (black contours every 4 hPa) and Z500 (shaded as per the colourbar). (b, e, h, k) show 200-300-hPa averaged PV anomaly (shaded as per the colourbar), PV (magenta contours every 1 PVU), and wind (arrows), and 700-900-hPa averaged negative PV anomaly (dashed blue contours every 0.5 PVU). (c, f, i, l) show 6-hourly accumulated precipitation (shaded as per the colourbar) and 10-m wind speed (black contours every 2 m/s) and vector (arrows). Magenta arrows indicate the direction of the cyclone in (a, d, g, j). PV anomalies are calculated relative to the 30-day running mean. Statistically significant 200-300-hPa averaged PV anomalies (upper 98th percentile and lower 2nd percentile) are hatched. Coordinates are in km relative to the cyclone centre. The bottom (right) of the composites aligns with south (east).

7. Figure 2: The track density appears quite smooth for an analysis using 1.25-degree grid boxes. Was any smoothing applied to this data? Please clarify in the text or caption.

In Figure 2, the track densities are smoothed by a Gaussian filter with $\sigma = 1.25$. The clarification is added to the caption of Figure 2 in the revised manuscript.

8. Figure 5: ERA5 data are known for their biases (e.g., 10-m wind speeds being too low for TCs) and limitations (e.g., precipitation not being directly constrained by observations). It would be helpful to briefly acknowledge these issues in the text.

The limitations of TC-associated wind and precipitation are noted as follows, and added in Lines 464-466 and 458-460 respectively in the Discussion section of the revised manuscript.

Lines 469-471

...Nonetheless, it should be noted that ERA5 is less reliable for capturing TC-induced wind (e.g., peak intensity, radius of maximum wind, and inner-core wind structure), which yields underestimated TC strength and delayed timing of maximum intensity, compared with IBTrACS (e.g., Dulac et al. 2024)...

Lines 463-465

...However, caution should be taken when interpreting TC-related precipitation in ERA5, as intense TC-related precipitation can be underestimated and spatially smoothed (Ascenso et al., 2024)...

9. Figure 6i and 10: Consider rotating this plot by 90 degrees so that its x-axis is aligned with the other subplots in the figure.

Figure 6i is rotated to align the x-axis with the other panels, shown in Figure R1.4. Figure 6 is updated in the revised manuscript. Figure 10i is rotated to align the x-axis with the other panels, shown in Figure R1.6. Figure 10 is updated in the revised manuscript.

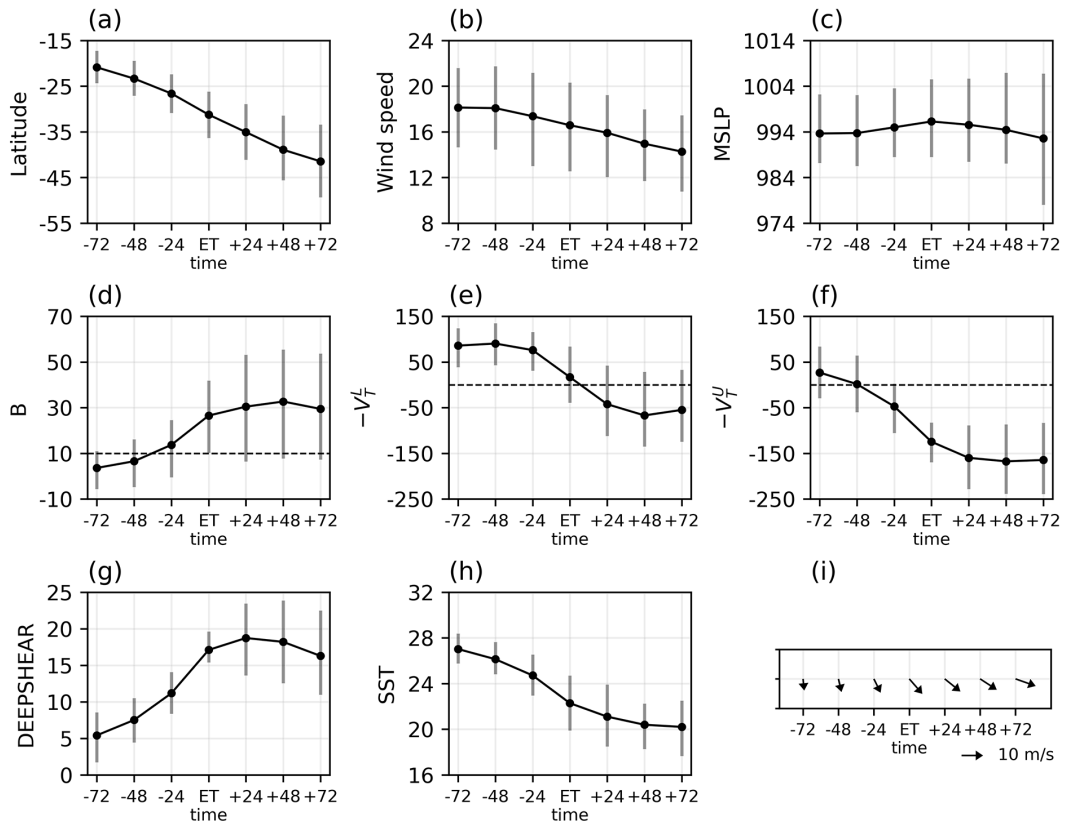


Figure R1.4 Evolution of (a) latitude, (b) wind speed (in m/s), (c) central pressure (MSLP, in hPa), (d) B, (e) $-V_{LT}$, (f) $-V_{UT}$, (g) vertical wind shear (DEEPSHEAR, in m/s), (h) SST (in $^{\circ}\text{C}$), and (i) cyclone speed (in m/s) and direction from 72 hours before to 72 hours after ET. Dots denote the mean, and whiskers mark the 25th and 75th percentiles. Dashed horizontal lines in (d-f) mark the thresholds for ET in the CPS framework. The bottom (right) aligns with south(east) in (g).

10. Figure 8: Could the lead-lag composites be extended to include adjacent time steps, similar to the other composite plots? Also, please specify in the caption whether the thick magenta contours indicate -2 PVU.

Lead-lag composites for the vertical cross-section are made in the same period as in Fig. 7 (i.e., -24 hr, ET and +24 hr). Figure R1.5 shows that TC and its warm-core structure and associated ascent weaken, while the downstream upper-level ridge amplifies substantially. During the transition, the TC moves into an increasingly baroclinic environment, indicated by steeper isentropic slopes on the poleward side (Figure R1.5d-f).

Figure 8 is updated in the revised manuscript. The specification of thick magenta contours indicating -2 PVU is added in the figure caption. The text description is extended to include the patterns in adjacent timesteps in Lines 281-294 in Section 3.2.2.

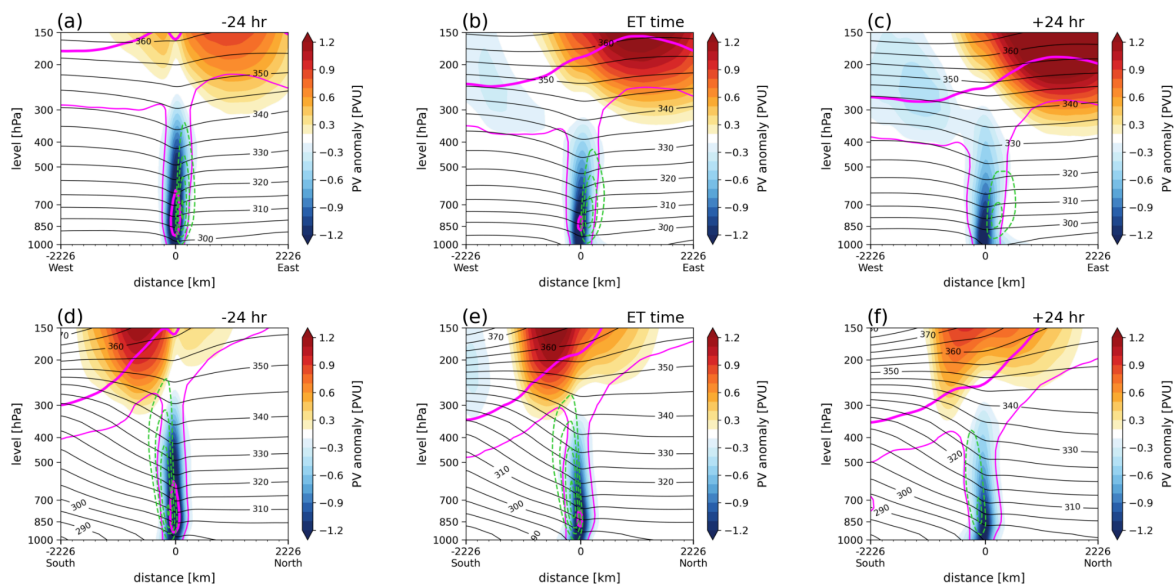


Figure R1.5 Lead-lag cross section composites in (a-c) west-east and (d-f) south-north direction for PV anomaly (shaded as per the colourbar), PV (magenta contours at -2 and -0.7 PVU), potential temperature (black contours every 5 K), and vertical velocity (dashed green contours every -0.1 Pa/s, only negative values displayed). PV anomalies are calculated relative to the 30-day running mean. A thick magenta line highlights the -2 PVU contour. Coordinates are in km relative to the cyclone centre.

11. Figure 10: Are there any reasons for excluding SST and DeepShear from this figure, unlike Figure 6?

There are no reasons to exclude DEEPSHEAR and SST in Figure 10. The evolution of DEEPSHEAR and SST for individual clusters is shown in Figure R1.6 and added to Figure 10 in the revised manuscript.

As shown in Figure R1.6g, all clusters feature rapidly enhanced vertical wind shear, particularly between -24 hr and ET. In C1 and C4, wind shear remains high post ET, whereas the values drop substantially for C2 and C3. For all clusters, TC lies over warm SSTs (around 26 to 27 °C) at -72 and -48 hr, while the surrounding SSTs drop rapidly 24 hours before ET (Figure R1.6h). The transitioning cyclone in C1 and C4 lies above a warmer ocean compared with C2 and C3.

The interpretation of Figure R1.6g and h is added to Lines 332-336 in Section 3.3.1.

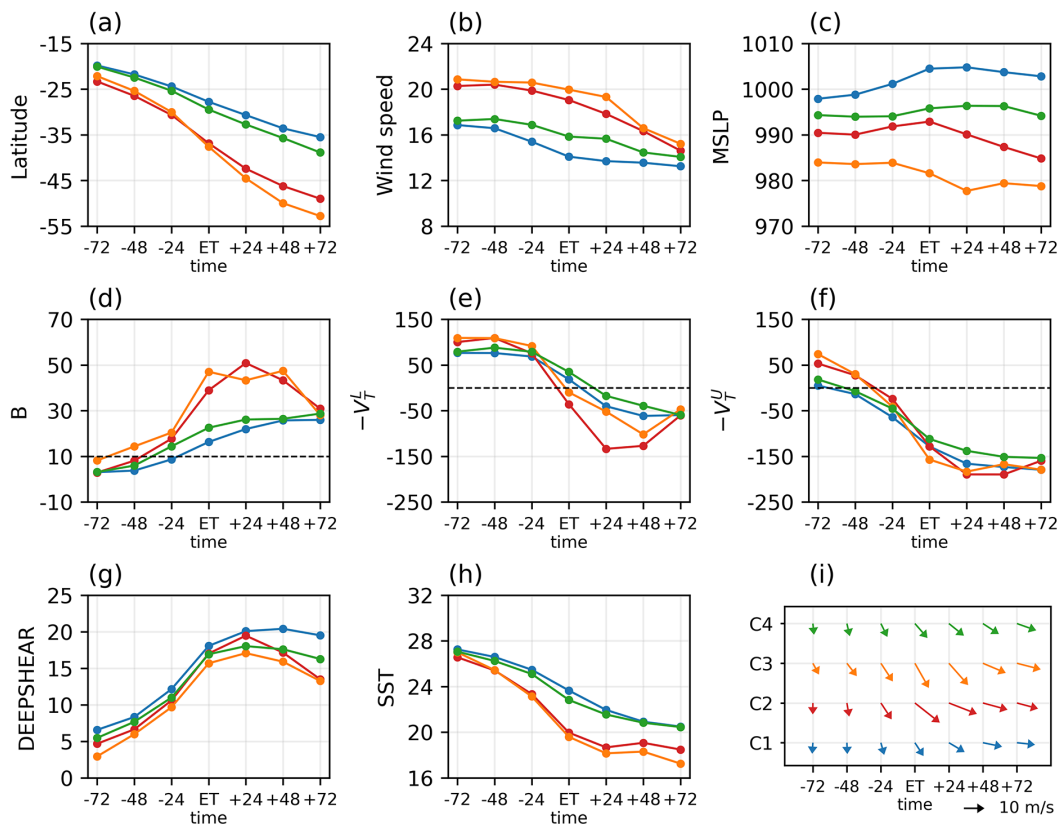


Figure R1.6 Evolution of (a) latitude, (b) wind speed (in m/s), (c) central pressure (MSLP, in hPa), (d) B, (e) $-V_{LT}$, (f) $-V_{UT}$, (g) vertical wind shear (DEEPSHEAR, in m/s), (h) SST (in °C), and (i) cyclone speed (in m/s) and direction from 72 hours before to 72 hours after ET for individual clusters. Dashed horizontal lines in (d-f) mark the thresholds for ET in the CPS framework. Clusters 1, 2, 3, and 4 are marked by various colors (blue, red, orange, and green). The bottom (right) aligns with south(east) in (g).

12. Figure 13: Please specify the vertical level of the divergent flow in the caption or text.

In Figure 13, PV, wind speed, and divergent wind are all vertically averaged between 200 and 300 hPa. This is specified in the figure caption as well as in Lines 411-412 in Section 3.3.3.

Reviewer 2

Major Comments

This manuscript describes a comprehensive climatology of extratropical transition events in the Southern Hemisphere from 1979-2021 based on the ERA5 reanalysis, which includes alternative metrics for defining whether a TC undergoes ET and its starting time. The authors find that ET takes place in similar places to previous studies, though they find a slightly larger number of ET events relative to previous studies. Furthermore, they document the seasonal cycle of ET and structural modifications that take place during the process of ET using composite analysis. Finally, the authors cluster ET events based on the combination of the MSLP and 500 hPa height fields around the storm. This method identifies four different types of ET, all with different structural evolutions and impact on the downstream midlatitude states.

Overall, I believe this is a good objective climatology of ET events in the Southern Hemisphere, which there are relatively few. The author's methods are sound and their results and conclusions are reasonable based on the evidence provided here. As the authors note, there have been previous studies that look at ET, but I don't think the authors have made it clear as it could be how this work differs from the previous work and what is the motivation for undertaking this work. There are pieces of it within the introduction, but I think a more assertive set of statements would be helpful. In addition, I have a few comments on the clustering methodology and interpretation of the results. I don't think any of my comments should be difficult to address.

Thanks for your comments. One important motivation for the current study is to conduct a comprehensive synoptic climatology of extratropical transition over the Southern Hemisphere, to illustrate the general characteristics of synoptic patterns during ET, and also to show the diversity of these patterns. The latter goal is achieved by using K-means clustering on surface and upper-level fields, in order to reflect both lower-tropospheric surface structure and mid-tropospheric upstream flow structure. This has now been emphasised in the Introduction Section in the revised manuscript.

The Introduction is restructured according to comments from Reviewer 1. Point-to-point responses to minor comments are listed below.

Minor comments:

1. Line 15: I think it would be helpful to have a brief statement on what the clusters are based on. Clustering is always sensitive to how you do it, so a brief phrase about how clusters are created is helpful.

A brief summary of the clustering method is provided as follows. Case-to-case variability in synoptic configurations at ET is examined by applying K-means clustering on surface and upper-level cyclone-centred fields, which identifies four distinct ET clusters. This is added to Line 15 in the revised manuscript.

2. Lines 57-59: These two sentences are awkward. Might be better to merge them into one sentence that states that Griffen and Bosart are one of a small number of studies that looked at ET in the SH

The two sentences are restructured in Lines 74-75 in the revised manuscript.

3. Lines 163-164: Do the authors have any insight into what might be leading to the differences? Are the CPS values not valid in the SH?

The RH100MAX-DEEPSHEAR method does not perfectly align with the CPS-based approach, as the two approaches evaluate different aspects of ET. The RH100MAX-DEEPSHEAR emphasises changes in the background environment (moisture availability and large-scale baroclinicity), whereas the CPS framework focuses on cyclone structural changes on a smaller scale (asymmetry and lower- and upper-level thermal structure within a radius of 500 km).

A TC may have already become asymmetric and cold-cored at a relatively lower latitude during the transition, where the environmental vertical wind shear remains weak, or deep convection is still active. In such cases, the transition may be identified by the CPS framework but not by the RH100MAX-DEEPSHEAR method.

In addition, the objectively-detected TC tracks in ERA5 are often longer than those in IBTrACS, which are used to identify ET events in previous studies (e.g., Kitabatake, 2011; Wood and Ritchie, 2014; Bieli et al., 2019). In the early stage of some ERA5 tracks, systems may still have an asymmetric structure and may not be warm-cored in the lower troposphere, presumably causing some false ET identification by the CPS framework. This likely explains the larger number of ET events detected by the CPS-based method, compared with the RH100MAX-DEEPSHEAR.

A brief discussion of the discrepancy between the RH100MAX-DEEPSHEAR and CPS approaches is added to Lines 432-442 in Section 4.1.

4. Lines 167-168: This sentence is a repeat of something already said and can be removed.

The sentence is removed in the revised manuscript.

5. Lines 229-231: Do the authors have any concern about the ERA5's ability to resolve the wind field during the tropical phase? In my experience, small radii storms are not well represented in the ECMWF/ERA5 models, so it is possible this could be associated with some of the wind variation (i.e., as the storm undergoes ET, its wind field expands and makes it easier to resolve).

As also suggested by Reviewer 1, the underestimated TC-associated wind and the discussion of wind expansion related to a better representation of winds in a broader cyclone are noted as follows and also in Lines 469-473 in the Discussion section.

...Nonetheless, it should be noted that ERA5 is less reliable in representing TC-induced winds (e.g., peak intensity, radius of maximum wind, and inner-core wind structure), leading to underestimated TC strength and delayed timing of maximum intensity compared with IBTrACS (e.g., Dulac et al. 2024). Therefore, the observed wind field expansion may be associated not only with the cyclone's structural change during ET, but also with better-resolved winds as the cyclone becomes broader...

6. Lines 292-293: In this sentence, the authors say that the MSLP and 500 hPa height fields are standardized before clustering. Could you provide more details of how this is done. Do the authors remove a climatological mean and standard deviation that is a function of location and time of the year, or something else? This would make the most sense, but it would be nice to receive confirmation of this point.

Prior to clustering, the cyclone-centred MSLP and Z500 fields at ET time are extracted for a total of 504 detected ET events. The standardisation is performed separately for MSLP and Z500. For each variable, the mean and standard deviation are calculated at each grid point across all ET events. Then, the fields are normalised by subtracting the corresponding mean and dividing by the corresponding standard deviation. Considering the following equation:

$$X_{n,i,j}^* = \frac{X_{n,i,j} - \overline{X_{i,j}}}{\sigma_{i,j}}$$

where X represents either MSLP or Z500 field, k represents an index for the event ($n = 1, 2, \dots, 504$), and i and j are the indices for the grid point. $X_{n,i,j}^*$ denotes the normalised anomaly, $\overline{X_{i,j}}$ is the mean across the total 504 ET events, and $\sigma_{i,j}$ is the

corresponding standard deviation. The interpretation is added to Lines 180-182 in the revised manuscript.

7. Lines 304-310: This paragraph does not have a great flow to it. It has a formulaic tone to it as the first four sentences are essentially a copy/paste of each other. Can you please integrate this information into either a better written paragraph, or just list the number of cases in the legend of Fig. 9 and just discuss this plot.

The paragraph is rewritten:

...Among the four clusters, C1 is the largest, comprising 177 events and accounting for about 35% of the 506 ET events. C2 contains 103 events, while C3 is the smallest cluster (accounting for only around 11%). C4 has a sample size comparable to that of C1 (Table 1). The ET locations vary across the four clusters. As shown in Fig. 9, C2 and C3 feature a more poleward location compared with those in C1 and C4. Geographically, ET events in C2 and C3 preferentially occur in the southwestern Indian Ocean, whereas they are less common in the Australian region (between 100 and 160° E)...

This is modified in Lines 316-320 in Section 3.3.1. The number of ET events in each cluster is added to the legend of Figure 9 and also described in Table 1 in the manuscript.

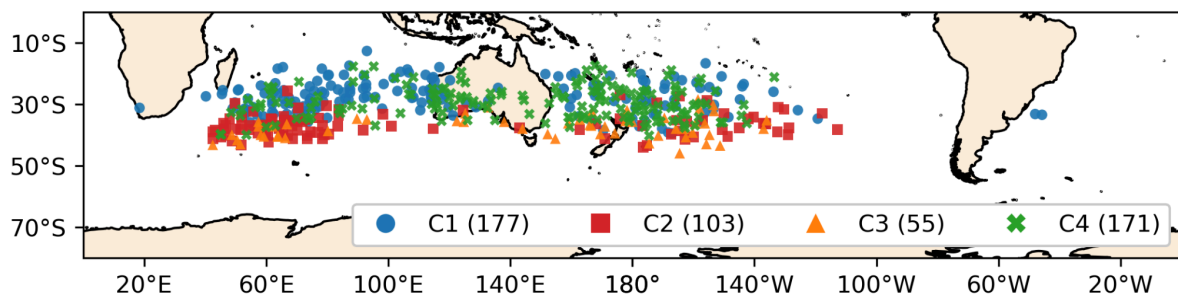


Figure R1.7 Geographic locations of TCs at ET time for clusters 1, 2, 3, and 4. Numbers in parentheses denote the number of ET events in each cluster.

8. Lines 312-314: This sentence is a bit awkward. I assume the authors are referring to the latitude where transition takes place. That phrasing would be easier to understand. Is there an actual statistical distinction between the C2/C3 and C1/C4 clusters? This statement appears to be based on visual inspection.

Lines are rewritten as follows and modified in Lines 322-324 in Section 3.3.1.

...On average, cyclones in C2 and C3 undergo transition over a broader latitudinal range (25-55° S), whereas those in C1 and C4 transition within a narrower and more equatorward latitudinal band (Fig. 10a)...

The statistics of ET latitude for individual clusters are summarised in Table R2. During the 144-hour window centred on ET time, the cyclones in C4 undergo transition over a border latitude range (between 20.1 and 38.9° S), compared with those in C1 (between 19.8 and 35.5° S). Between -72 and -24 hr, the cyclones in C2 are at higher latitudes compared to those in C3. However, after ET, the cyclones in C3 are located at higher latitudes than those in C2.

Table R2 Evolution of latitude from 72 hours before to 72 hours after ET for individual clusters.

	-72	-48	-24	ET	+24	+48	+72
C1	19.8° S	21.8° S	24.4° S	27.8° S	30.7° S	33.6° S	35.5° S
C2	23.3° S	26.5° S	30.6° S	36.8° S	42.4° S	46.2° S	49.0° S
C3	22.1° S	25.4° S	30.0° S	37.6° S	44.5° S	50.0° S	52.8° S
C4	20.1° S	22.4° S	25.3° S	29.4° S	32.7° S	35.7° S	38.9° S

9. Lines 329-330: It appears that the B parameter becomes much larger in C2 and C3. Does that imply that ET cyclones are moving into a more baroclinic environment for these cases?

To confirm that cyclones in C2 move into a stronger baroclinic environment than those in C3, we use the vertical wind shear (between 200 and 850 hPa) and the Eady growth rate (EGR; Lindzen and Farrell 1980) to measure the background baroclinicity. Following Besson et al. (2021), the EGR is calculated in a discretised form as follows:

$$EGR = 0.31 \frac{f}{N_{500-850}} \cdot \left[\left(\frac{u_{500} - u_{850}}{z_{500} - z_{850}} \right)^2 + \left(\frac{v_{500} - v_{850}}{z_{500} - z_{850}} \right)^2 \right]^{1/2}, \text{ with } N = \left(\frac{g}{\theta} \frac{\partial \theta}{\partial z} \right)^{1/2}$$

where N is the Brunt-Väisälä frequency, and $N_{500-850}$ is a pressure-weighted average of N in a layer between 500 and 850 hPa. u , v , and z are the horizontal wind

components and geopotential height at pressure level, f is the Coriolis parameter, and θ is the potential temperature.

Figure R1.8 shows the composites of vertical wind shear, EGR, and 200-300-hPa averaged wind for C2 and C3 at ET and +24 hr. At ET time, the cyclones in C3 are surrounded by a stronger vertical wind shear than those in C2, whereas the differences in EGR between the two clusters are relatively small (Fig. R1.8a and c). After ET, however, C2 features stronger lower-level baroclinicity compared with C3 (Fig. R1.8b and d).

Lines 344-345 are modified in the revised manuscript, and the analysis is added to the supplementary materials.

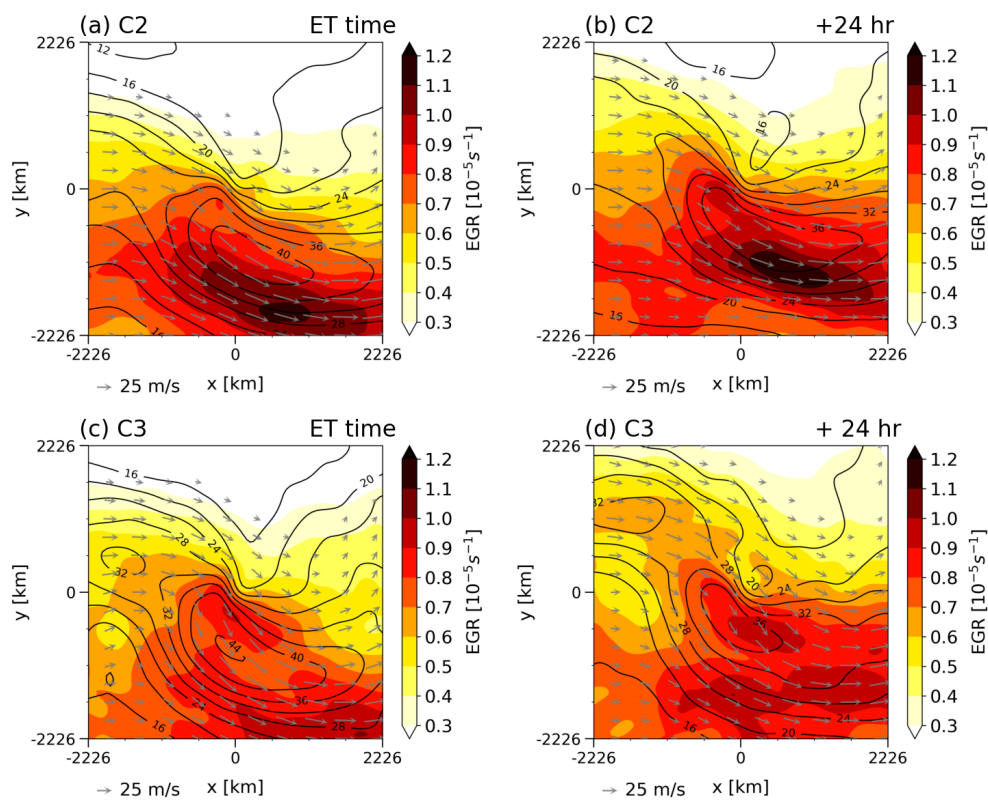


Figure R1.8 Composite fields at ET time and +24 hr for (a-b) C2 and (c-d) C3. Vertical wind shear between 200 and 850 hPa is marked in black contours (every 4 m/s). EGR are shaded as per the colourbar. 200-300-hPa averaged wind is shown in vectors (only for magnitude greater than 10 m/s). Coordinates are in km relative to the cyclone centre. The bottom (right) of the composites aligns with south (east).

10. Line 374: I assume there should be a km after 400?

Line 374 describes a weak cyclonic PV anomaly vertically ranging from 200 to 400 hPa. The sentence is revisited in Line 393 in the revised manuscript.

11. Lines 391: I am not familiar with this methodology. Do you only consider vertical levels where the RH > 80% when computing the integral? Can you please elaborate here.

The latent heating approximation is calculated following Berman and Torn (2019) and Teubler and Riemer (2021). From the water continuity equation, latent heat release is proportional to the integrated horizontal water vapour transport (IVT) convergence under saturated conditions and in the absence of ice processes (Berman and Torn, 2019; Teubler and Riemer, 2021). The latent heating approximation is calculated as follows:

1. For each pressure level from 1000 to 500 hPa, northward and eastward components of moisture transport (q_u , q_v) are calculated for each grid using u , v , and q , only where RH exceeds 80%
2. The IVT is calculated by integrating the q_u and q_v from 1000 to 500 hPa
3. The horizontal convergence of IVT is calculated served as an approximation for latent heat release

12. Lines 400-401: The authors should use more careful wording here. While the maximum LH in C2 is larger than C3, there appears to be a larger area of moderate LH release in C3, which when you aggregate over space could be similar to C2.

Lines are modified as follows and updated in Lines 420-421 in the revised manuscript as follows.

...Compared with C2, C3 features a weaker downstream jet, a lower maximum latent heat release, but a stronger and broader divergent wind (Fig. 13c)...

13. Section 4.1: I thought this section was fairly long and repeated a lot of information that is already present in the manuscript. I think it would be better if this section was shortened and more focused on new results and/or focused on where the results from this study differs from previous ET studies.

Section 4.1 has now been shortened and restructured in the revised manuscript. Specifically, we focus on: (1) ET seasonality and the role of SSTs in affecting ET frequency, (2) structural changes of ET, (3) post-transition behaviour, and (4) interaction with midlatitude flow.

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