Answer Referee 2:

We thank the reviewer for their constructive feedback. The comments certainly contribute to making our study more robust and comprehensive. In the following, the reviewer's comments are reproduced, in light grey and in italic, before each reply.

In this paper, the authors highlight the large-scale environmental conditions that are specific to the formation of warm-core Mediterranean Tropical-Like Cyclones (MTLCs) compared to the more typical cold-core Extra-Tropical Cyclones (ETCs) that form over the same basin. To do so, they composite the structure and environment of ETCs, intense ETCs and MLTCs from ERA5. This paper offers a good and comprehensive analysis of environmental factors related to MTLCs in the Mediterranean, utilizing a systematic climatological analysis that has been largely lacking in the Mediterranean Cyclones literature to date. As such, this is an important paper that fits within the scope of WCD. Should my main concerns be addressed, I would recommend it for publication.

We would like to draw the reader's attention to the fact that in the following response, with respect to the original manuscript, we use indifferently the terms Deep Warm Core Cyclones (DWCC) for MTLC, Weak Extratropical Cyclones (WETC) for normal ETC, and Strong Extratropical Cyclones (SETC) for Intense ETC to take in consideration some concerns of the first reviewer. Those terms - DWCC, WETC, SETC - are the definitive names in the revised version of the manuscript.

Major Comments

1. My main concern is that composites, on which the paper relies for a significant portion, can be challenging and misleading, especially given the large number of samples. Indeed, a large number of samples are at risk of blurring out information when averaged. Here are suggestions to improve the robustness of the analysis:

• Highlight significant areas, e.g. areas where the difference in a given variable between Intense ETCs and MTLCs is significant, or areas where an anomaly is significantly different from zero.

We agree with the reviewer that highlighting areas of statistical significance enhances the clarity and robustness of the results. We have therefore implemented this suggestion across all 2D composites presented in the manuscript, with examples provided in the revised figures.

The main spatial patterns discussed in the manuscript remain valid, as they either show significant differences between intense ETCs and MTLCs (e.g., SST in fig. R4, PI in fig. R8, precipitation in fig. R6) or exhibit anomalies that are significantly different from zero (e.g., PI decomposition in Fig. R1). In other cases the differences are not significant, for fields that were indicated to be similar between the two classes (e.g., surface wind in fig. R5, or PV anomaly fig. R7).

The significance of the differences between IETC and MTLC is further discussed afterward.

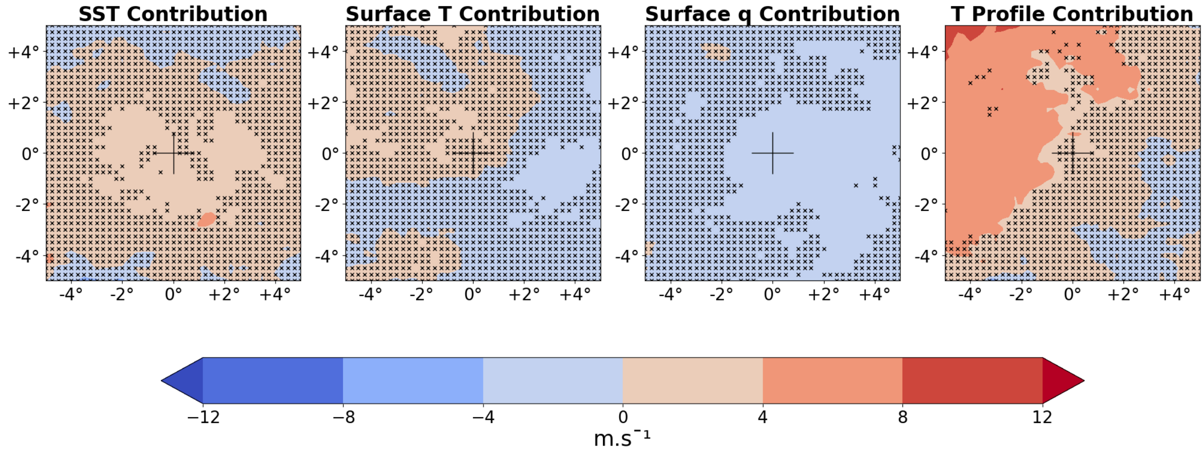

Figure R1: Composites of the contribution of different anomalous terms (as indicated in titles) to the PI anomaly with respect to climatology, through their effect on the CAPE difference term, for MTLC 36h before minimum SLP. The markers indicate the anomalies that are not significantly different from 0 at a 95% confidence level.

• Provide composites of land-sea mask (in SI) to give an idea of how much land is included in these snapshots.

We thank the reviewer for this suggestion. We have prepared the requested figure, both for the time 36 hr prior peak intensity (fig. R2) and for the time of peak intensity (fig. R3) and we have added them to the supplementary material of the manuscript.

In computing the SST and PI composites over the previously mentioned, 10° by 10° areas, grid cells that were over land have been excluded. Then, we also performed a sensitivity test by assigning PI = 0 m/s in grid points over land areas. While this adjustment significantly reduces the box-averaged PI values, the results of the analysis remain qualitatively unchanged, indicating that the general conclusions of the work are not sensitive to the way in which land points are treated.

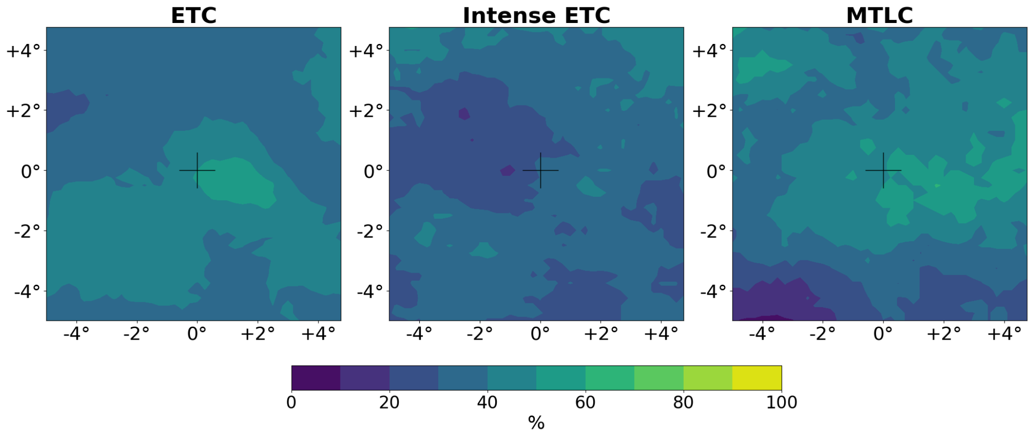

Figure R2: Portion of cyclones' points over the sea 36h before the time of the minimum SLP.

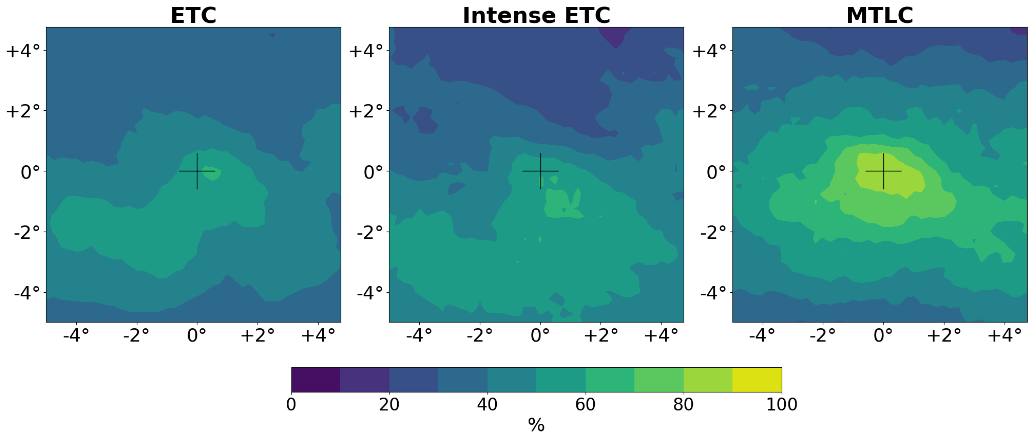

Figure R3: Portion of cyclones' points over the sea at the time of minimum SLP.

• Does it make a difference if you orient the snapshots along the direction of propagation?

We thank the reviewer for this comment. We performed the computation of the 2D composites aligned with the cyclones' direction of propagation (figures R4-R8).

The main message remains unchanged: in terms of potential impacts, MTLC exhibit similar intensity to intense ETC in terms of wind speed, but they are associated with stronger precipitation. From a process-oriented perspective, MTLC are linked to the same type of PV intrusions as intense ETC, but they develop over much warmer SST and are therefore associated with a higher PI.

We chose to retain the longitude–latitude orientation, as it facilitates the interpretation of certain variables, such as PV, and avoids introducing artifacts related to the interpolation required for rotation. This consideration is particularly important given the relatively coarse resolution of the ERA5 data.

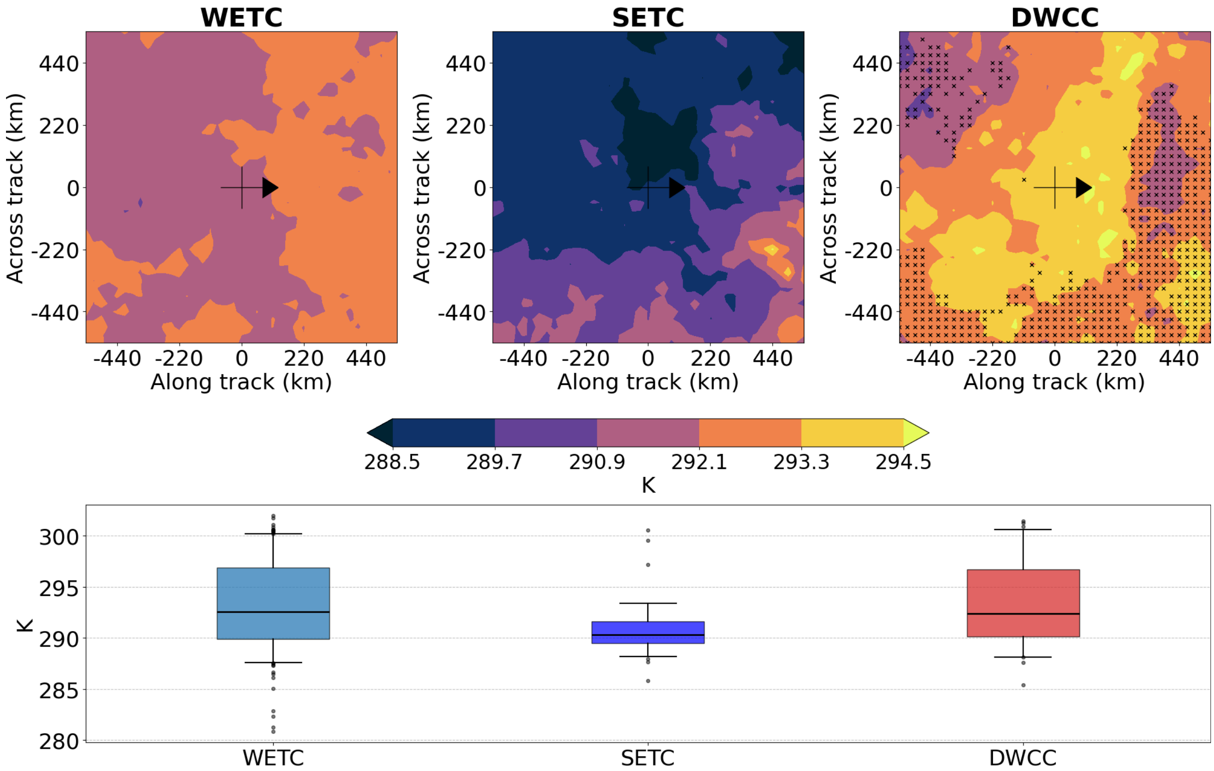

Figure R4: SST for the different cyclone classes. Top: 2D composites centered on the cyclones and oriented along the direction of propagation of the cyclones, 36h before the time of minimum SLP. The markers in the right panel indicate regions where MTLC composited SST is not significantly different from SETC (95% confidence level).Bottom: boxplots of the mean SST for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

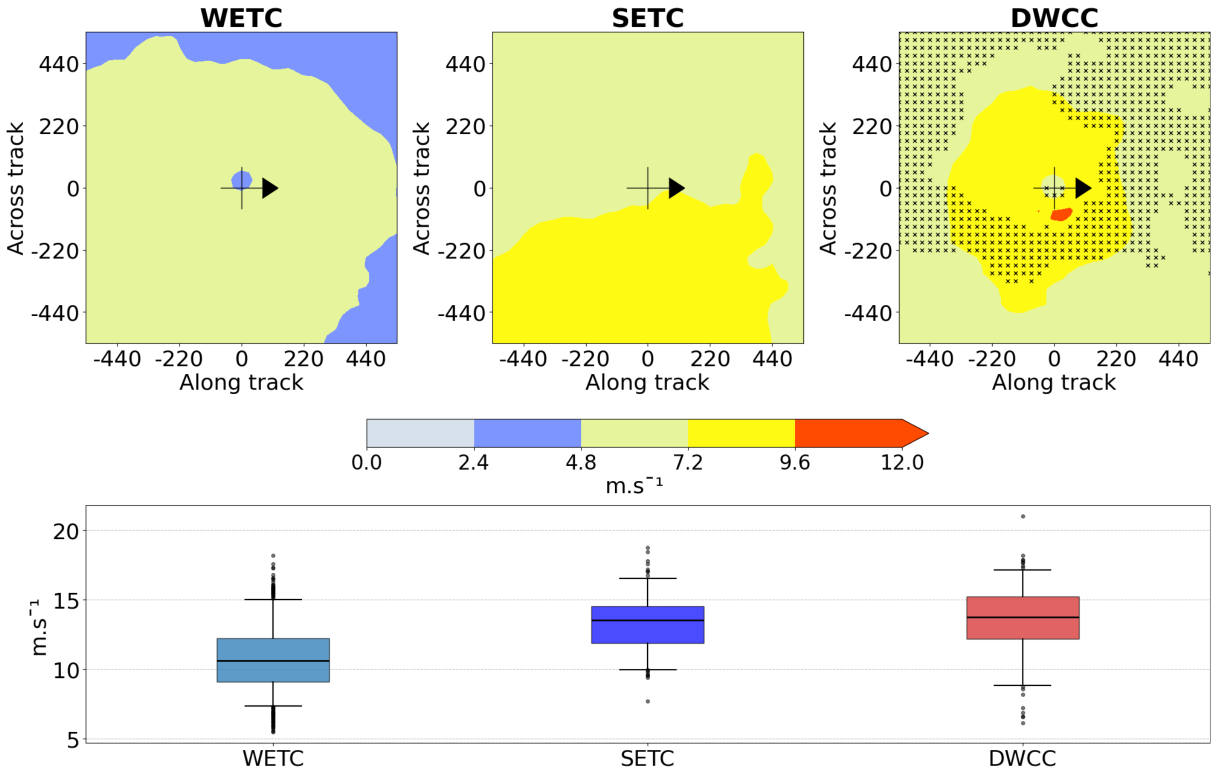

Figure R5: Surface wind for the different cyclone classes. Top: 2D composites centered on the cyclones and oriented along the direction of propagation of the cyclones, at the time of minimum SLP. The markers in the right panel indicate regions where MTLC composited surface wind is not significantly different from SETC (95% confidence level). Bottom: boxplots of the mean surface wind for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

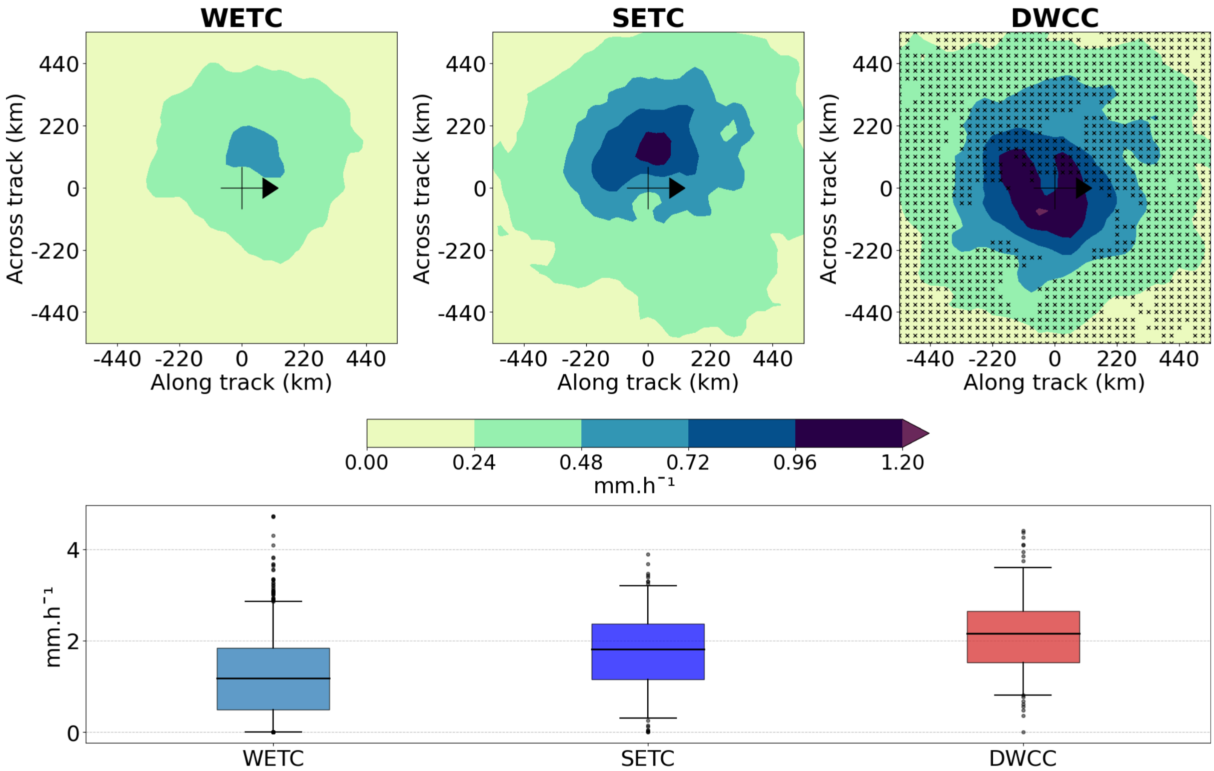

Figure R6: 24h accumulated precipitation for the different cyclone classes. Top: 2D composites centered on the cyclones and oriented along the direction of propagation of the cyclones, at the time of minimum SLP. The markers in the right panel indicate regions where MTLC composite accumulated precipitation is not significantly different from SETC (95% confidence level). Bottom: boxplots of the mean 24h accumulated precipitation for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

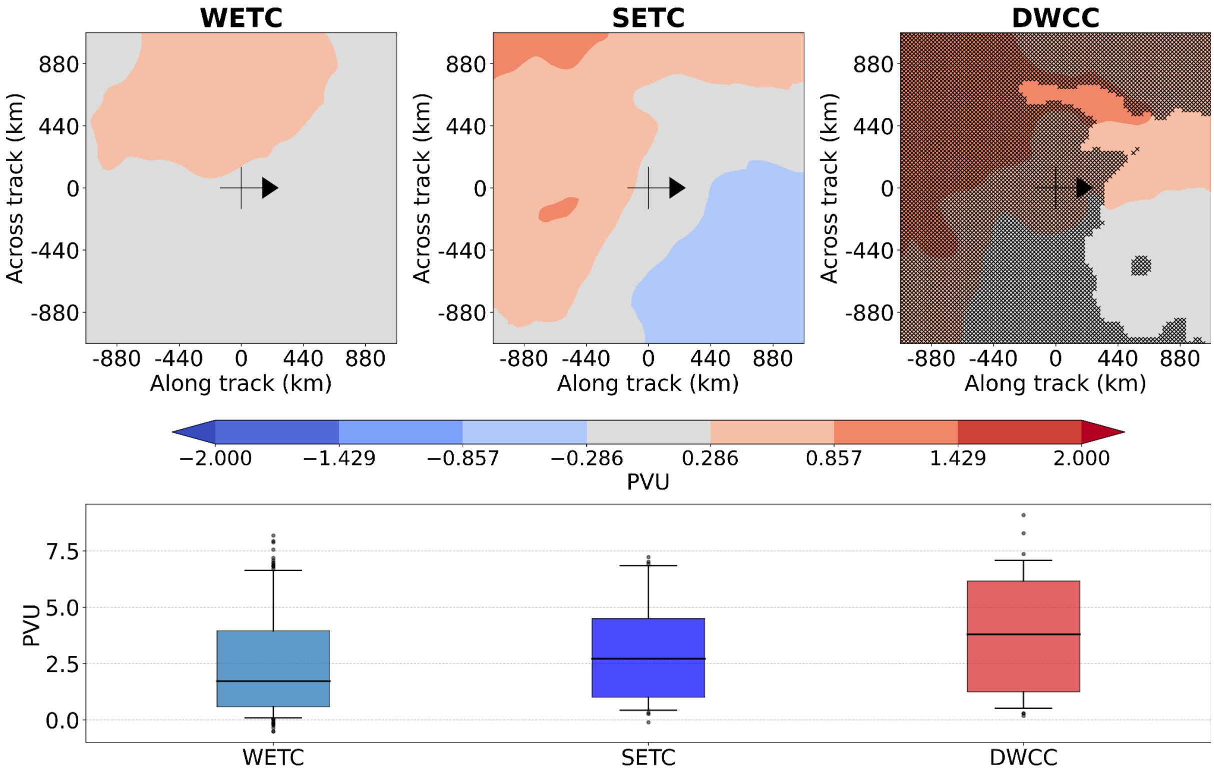

Figure R7: PV anomaly for the different cyclone classes. Top: 2D composites centered on the cyclones and oriented along the direction of propagation of the cyclones, 36h before the time of minimum SLP. in the right panel indicate regions where MTLC composited PV anomaly is not significantly different from SETC (95% confidence level). Bottom: boxplots of the mean PV anomaly for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

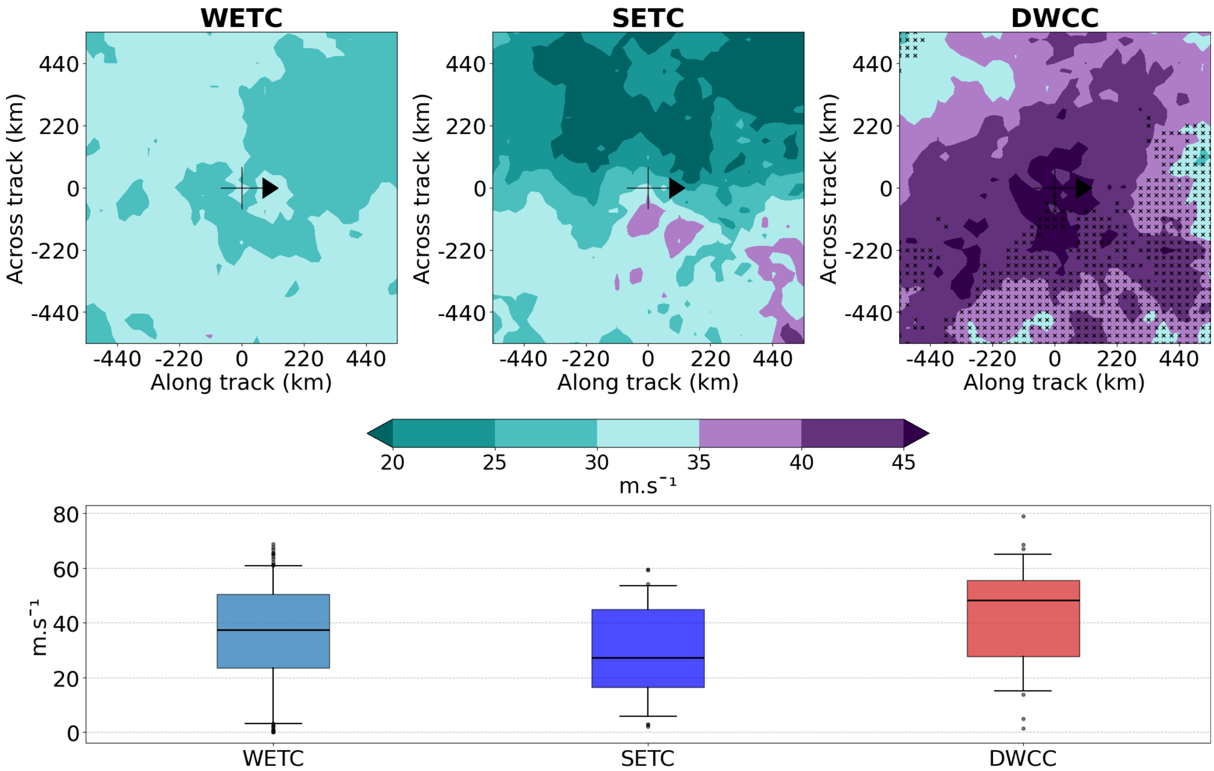

Figure R8: PI for the different cyclone classes. Top: 2D composites centered on the cyclones and oriented along the direction of propagation of the cyclones, 36h before the time of minimum SLP. The markers in the right panel indicate regions where MTLC composited PI is not significantly different from SETC (95% confidence level). Bottom: boxplots of the mean PI for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

• The 10° box is quite large for the Mediterranean, where it corresponds to the whole width of the basin, and the cyclones usually span a few hundreds of kilometers. Could you justify this choice? While averaging over a large area for environmental factors makes sense, I don't think it does for characterizing the cyclone itself (in particular when defining intensity).

We thank the reviewer for this comment.

We present maps over a large box, but we now compute the mean, for each cyclone, only over the 10% highest values of the 10°x10° box shown in the top panels. The selection of the 10% highest values is motivated by the fact that the 10°x10° box is very large, as the reviewer pointed out, and it includes areas that are not representative of the cyclone conditions; selecting a smaller area at a fix location with respect to the cyclone center is however not appropriate as different variables express anomalous values at different places (eg wind speed is typically larger in the southwest quadrant while precipitation maxima are on average larger to the north of the center and PV intrusion is in the northwest quadrant). For those reasons, we use a fixed-size area (covering 10% of the 10°x10° box) defined by selecting the largest values, regardless of their position in the box.

Boxplots are then created for those mean values over all cyclones in each of the three classes and shown in the figures above. Boxplots show the median value (horizontal line), the interquartile range (colored area), the 5th and 95th percentiles (whiskers) and outliers. These boxplots indicate that the intraclass spread is large and show substantial overlap among the different classes. However, important signals emerge, as detailed in the following.

Regarding 10m wind speed at the time of peak intensity (fig. R5), the mean values for DWCC and SETC are not significantly different (all statistical outcomes in this note, obtained with a two-sided t-test, are defined at the 95% confidence level).

For hourly rainfall at the time of peak intensity (fig. R6), we looked into the values of all percentiles from the 1st to the 99th, and they are all larger for DWCC than for both SETC and WETC. The mean values of the three classes are significantly different, indicating that, on average, rainfall is smaller for WETC, higher for SETC, and highest for DWCC. Still, very intense rainfall can be present in some cold-core cyclones, with 30% of SETC and 15% of WETC having values larger than the DWCC median value.

In comparing SETC and DWCC at time -36hr prior to the time of peak intensity, we report that their mean PV anomaly values (fig. R7) do not significantly differ, but their SST (fig. R4), PI and climatological PI (fig. R8, R9), and wind shear (fig. R10) do. Clearly, given the large intraclass spread, none of those variables is sufficient per se to unambiguously differentiate MTLC/DWCC from intense ETC, but they shed light on the environmental characteristics that favor the development of a deep warm core.

This supports our main conclusion: while MTLC/DWCC and intense ETC share similar mean surface wind speeds at their peak intensity and are associated with PV intrusions of the same strength, MTLC/DWCC are favored by warm SSTs, low vertical wind shear, high PI, and typically produce more intense precipitation.

2. Emanuel et al. 2025 used a modified version of the PI for identifying CYCLOPs, justifying that it was better suited for similar cases. Why not use it?

We appreciate the reviewer's observation. Emanuel et al. (2025) introduced a modified version of the Potential Intensity (PI) specifically designed to better capture the thermodynamic conditions leading to the development of CYCLOPs. The modification addresses an underestimation of PI that may occur in such cases when using the original formulation. It is however associated to an overestimation of PI, considering that all the sea level pressure anomaly is -in the modified PI- assumed to be due to the warming of the air column rather than partially driven by upper level divergence. The actual PI would be somewhere in between the usual PI metric and the modified PI metric.

We thus acknowledge the potential value of the modified PI for a more detailed investigation of the different types of DWCC, which include CYCLOPs, “real” tropical cyclones, and warm seclusions and plan to explore this in a dedicated follow-up study that will specifically distinguish them. We think however that introducing the modified PI framework in this manuscript is unnecessary and potentially confusing.

In any case, we have added in the Discussion section a reference to this modified PI.

3. While I understand the CPS is the most commonly accepted way to classify MTLCs at the moment, you need to acknowledge ongoing debates in the Mediterranean Cyclones community and beyond regarding the limitations of the CPS.

We agree with the reviewer that the use of Cyclone Phase Space (CPS) diagrams, while widespread, is not without limitations and remains a subject of debate within the Mediterranean cyclone community. Several studies have highlighted that CPS diagnostics may not always distinguish between true diabatically driven warm cores and warm seclusions (e.g., Mazza et al., 2017; Fita and Flaounas, 2018, Miglietta et al., 2025), and that the original formulation by Hart (2003) may need adaptation for smaller Mediterranean systems (Miglietta et al., 2013, Picornell et al. 2014, Cioni et al., 2016, and de la Vara et al., 2021, Cavicchia et al., 2014 and Noyelle et al., 2019, Ragone et al., 2018). Despite these acknowledged limitations, the CPS framework remains, as the reviewer points out, the most widely used and provides a consistent and objective basis for comparison across studies, ensuring continuity with previous work on Mediterranean cyclones. We have added a comment on this in the manuscript, in the discussion section at lines 324-333.

4. Would your results change if you used wind instead of pressure for classifying the intensity?

To answer to the reviewer comment, we classified SETC based on maximum wind speed rather than minimum sea level pressure (SLP). Our main conclusions are not affected by this different methodology. The key signals—particularly the strong differences in potential intensity (fig. R13), sea surface temperature (fig. R9), and precipitation (fig. R11)—remain consistent regardless of whether the defintion of intensity is based on minimum SLP or maximum wind speed.

In addition, we performed a two-sample *t*-test comparing the mean values of the main variables for intense ETCs defined by SLP and those defined by wind. For all variables, the differences between the two groups were statistically insignificant, confirming that our results are robust to the choice of intensity metric.

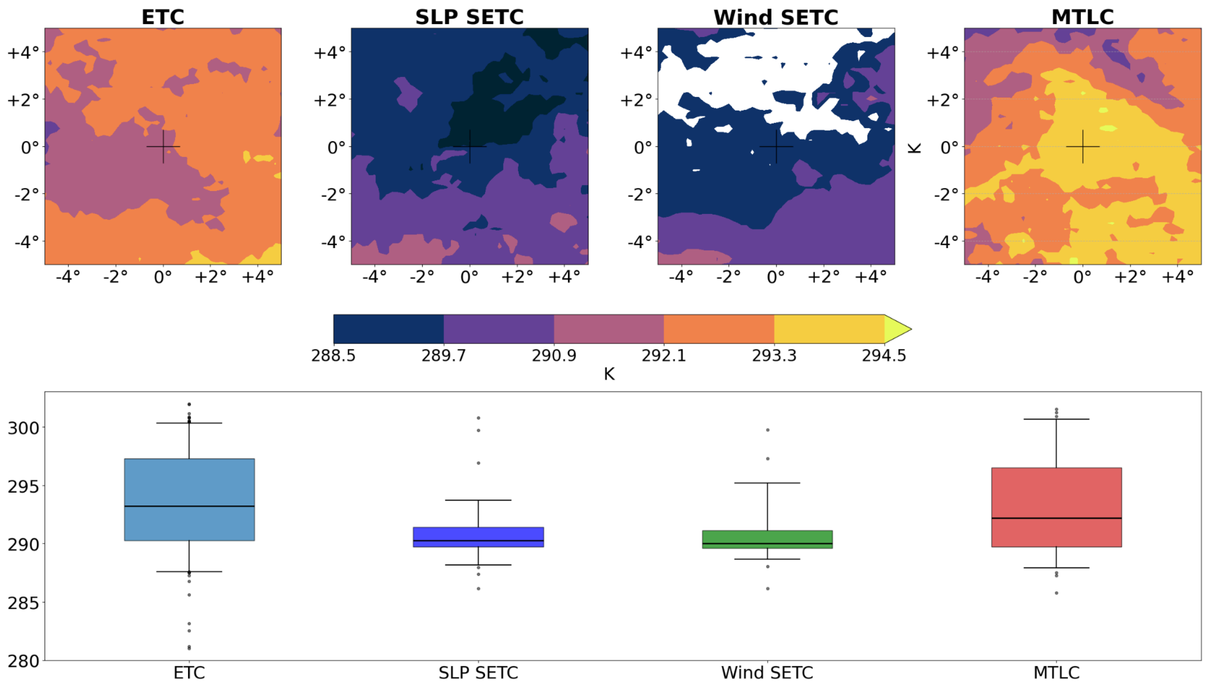

Figure R9: SST for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean SST for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

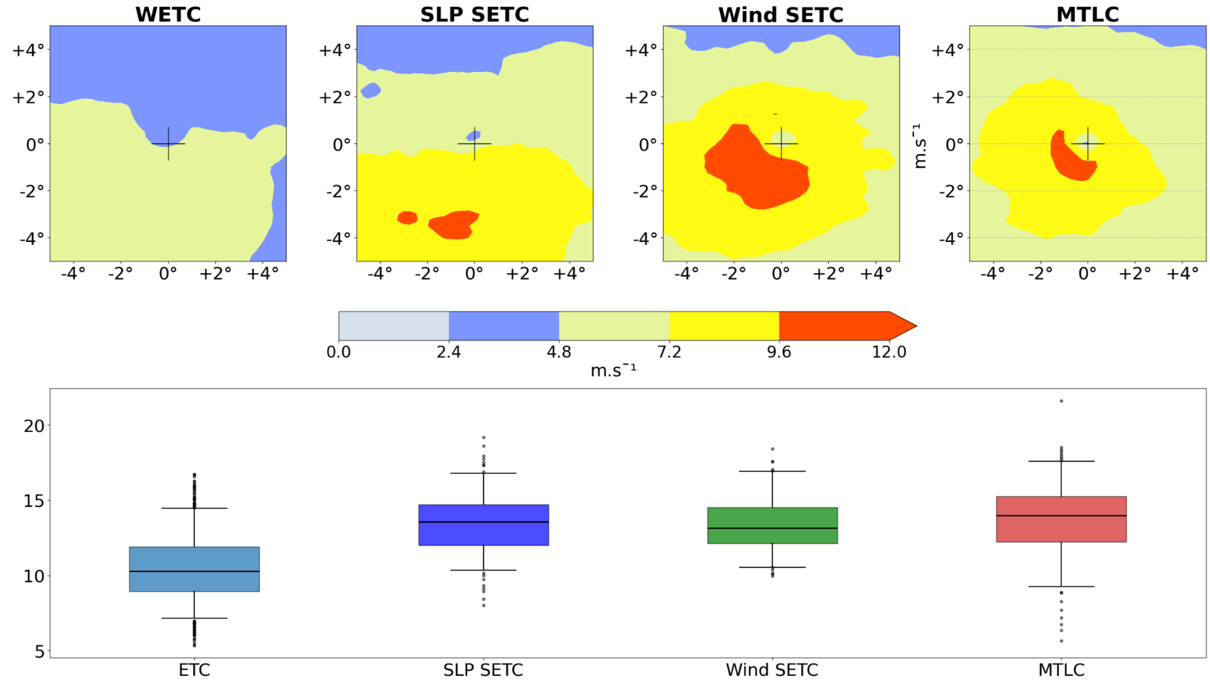

Figure R10: 10m wind for the different cyclone classes. Top: 2D composites centered on the cyclones, at the time of minimum SLP. Bottom: boxplots of the mean 10m wind for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

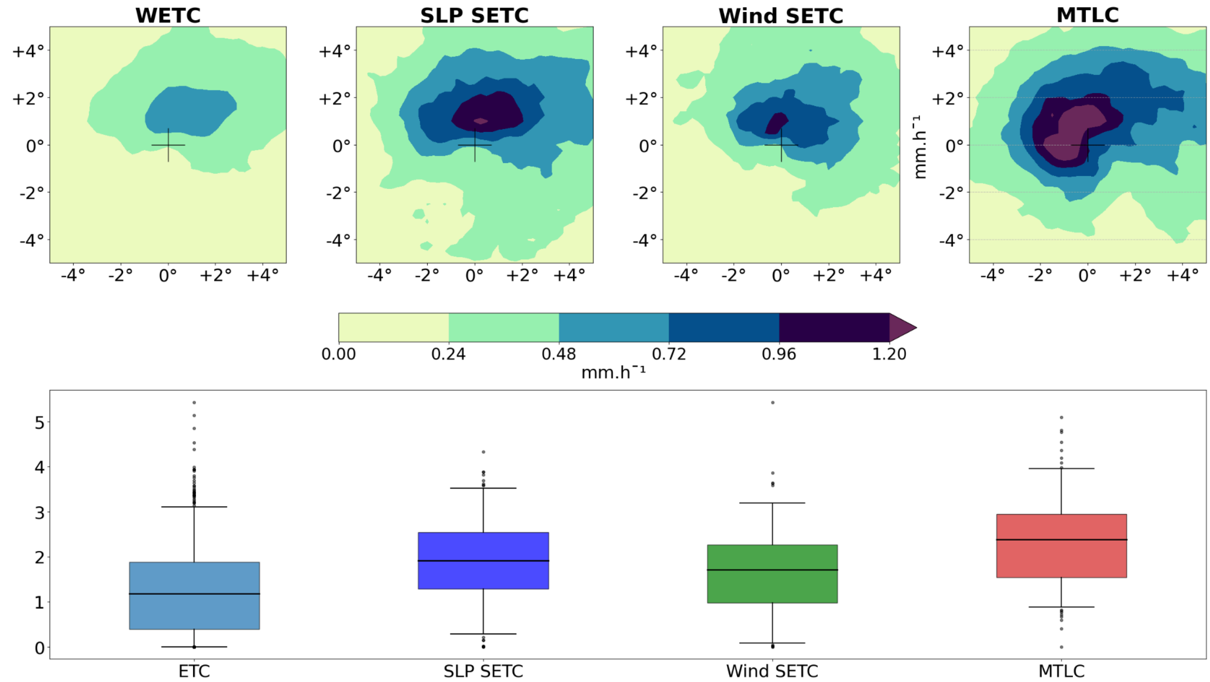

Figure R11: 24h accumulated precipitation for the different cyclone classes. Top: 2D composites centered on the cyclones, at the time of minimum SLP. Bottom: boxplots of the mean 24h accumulated precipitation for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

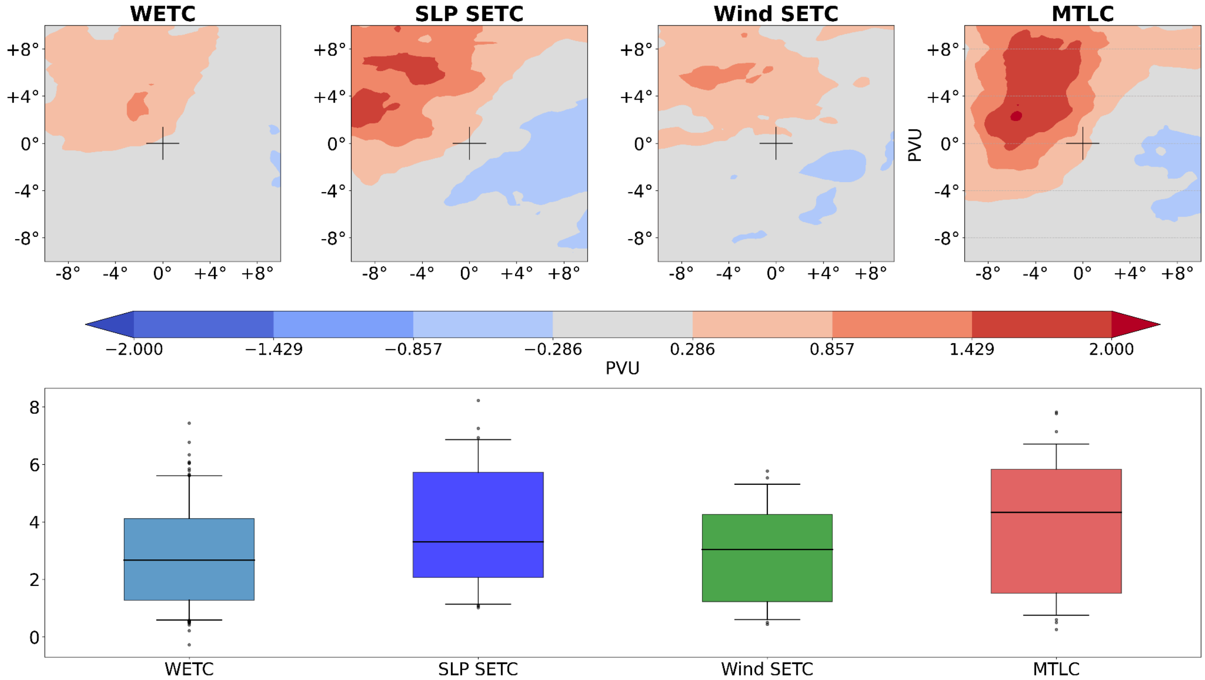

Figure R12: PV anomaly for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean PV anomaly for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

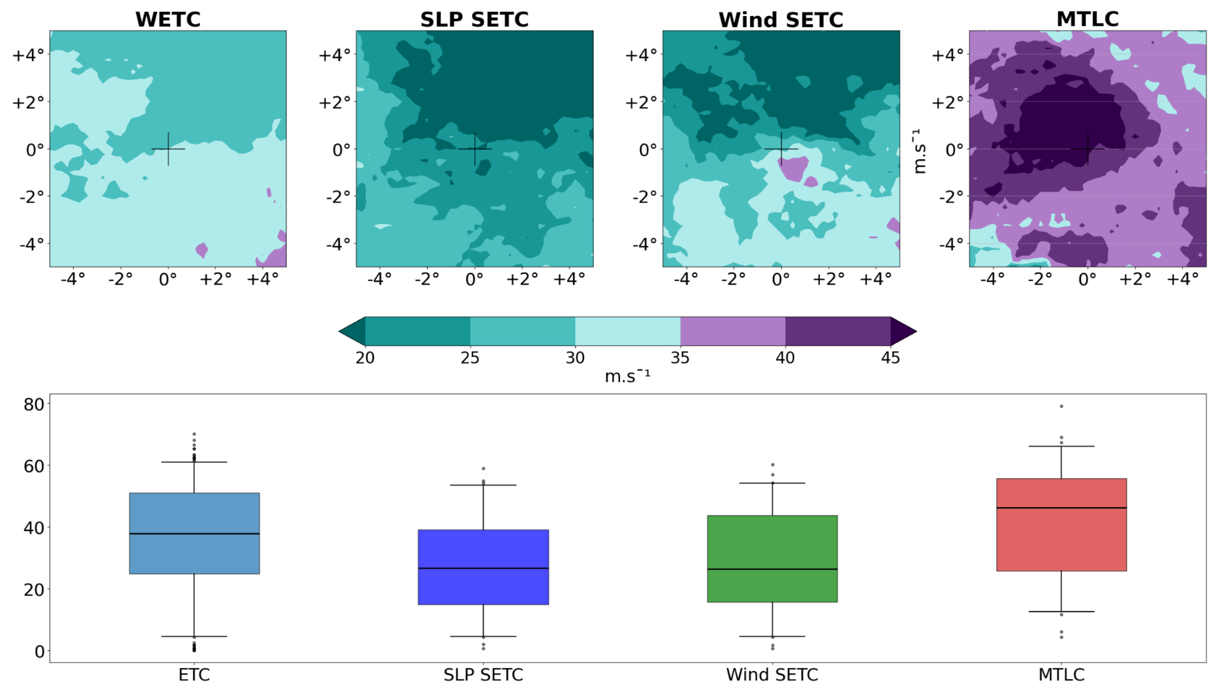

Figure R13: Total PI for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean PI for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

<u>Minor Comments</u>

10. *L. 96-98: Can you explain your choice to add a tolerance for $-Vu$ only? Why not $-Vl$? And why six hours?

We thank the reviewer for this comment, which led us to identify and correct a mistake in the manuscript.

In our analysis, MTLC are defined as cyclones for which both −Vl and −Vu are positive for at least six consecutive hours while the system remains over the sea. ETC are defined as systems with a cold core, i.e., negative values for both −Vl and −Vu throughout their lifetime. They are 607 cyclones verifying this conditions. We also classify as ETC cyclones which occasionally have a short-lived positive −Vl lasting less than six hours (not −Vu as it was erroneously written in the first manuscript). 352 cyclones verify this condition, taking the total number of cyclones labeled as ETC to 959.

Some cyclones exhibit a warm core aloft and a cold core near the surface (positive −Vu and negative −Vl). These are classified as hybrid systems, which we do not investigate further in this study, as their physical interpretation remains unclear in this context. 92 cyclones are in this category (negative -Vu and short lived positive -Vl for less than 6 hours). Compare to the total number of ETC, this represent a 10% variation in the sample size, which we do not believe to make a significant difference.

The six-hour tolerance criterion follows the approach used in previous studies (e.g., Cavicchia 2014a,b; Hart 2001). It ensures temporal robustness in the classification, preventing systems from switching categories due to short-term fluctuations. However, we did not perform a sensitivity study on this temporal requirement.

15. *L. 141: How long does the warm core itself last for?

On average, 13.5h. We have added this information to the manuscript in line 162.

17. Figure 1:a. *For the “intense ETCs” lines : the fact that numbers drop sharply on each side on the peak suggest to me that a small but significant portion of them have their maximum intensity at the very beginning or very end
of their track. This might not be desirable. Can you investigate this?

We thank the reviewer for this relevant observation and have investigated this point in more detail.

To verify whether a non-negligible fraction of cyclones reach their maximum intensity near the beginning or end of their lifetime, we performed the following analysis. For each intense ETC, we identified the time step of minimum sea-level pressure (*t*□□□) and analyzed whether it was near the start or the end of its track.

Out of 144, only 8 cyclones reached their minimum SLP within the first 3 h of their lifetime and have beenexcluded from the composites (as we analyzed composites at −36 h relative to the time of minimum SLP). Only 6 systems reached their minimum SLP within the last 3 h of their lifetime, meaning they may not have fully reached their maximum intensity within the analysis domain. In such cases, although the exact −36 h point may not correspond to a time strictly preceding the true peak intensity, it still falls within the cyclone’s intensification phase and thus remains relevant for our analysis.

We therefore conclude that the observed shape in Fig. 1 does not affect the robustness of our results.

19. *L. 166: I would expect the maximum in intense ETCs to be in winter. Can you explain why it is not the case? Please compare to other references with similar analyses.

We thank the reviewer for this interesting observation. While it may seem intuitive to expect the maximum occurrence of intense extra-tropical cyclones (IETC) during winter, our results are consistent with several previous studies indicating that the climatology of Mediterranean cyclones does not necessarily peak in winter but rather during the transition seasons.

For instance, Lionello *et al.* (2016) reported that Mediterranean cyclone activity reaches its maximum in March–April–May (MAM), highlighting that spring conditions favour cyclogenesis in this region. Similarly, Trigo *et al.* (1999) showed that the seasonal distribution of cyclones strongly depends on the sub-region, with several Mediterranean basins exhibiting peaks in the transition seasons rather than in winter. More recently, Kotsias *et al.* (2023) also found that cyclone frequency is high in April and May, attributing this to enhanced land–sea thermal contrasts and upper-air disturbances. Flaounas *et al.* (2021) further demonstrated that spring cyclogenesis is particularly active in northwestern Africa and along the northern African coastlines, from which systems often propagate eastward toward the central and eastern Mediterranean.

These findings collectively indicate that the transition seasons provide favourable conditions for intense cyclogenesis, driven by a balance between sufficient baroclinicity, increasing surface temperatures, and enhanced atmospheric moisture availability. In contrast, winter months, though characterized by strong baroclinicity, often feature limited moisture, which may restrict the intensity of some systems.

It is worth noting, however, that other studies have reported a winter maximum in intense cyclone activity. For example, Flaounas *et al.* (2013, 2015) showed that the most intense cyclones—identified by high relative vorticity—tend to occur during the winter months (November–February). The key difference between this study and those previously mentioned lies in the datasets and methodologies employed: Flaounas *et al.* (2015) tracked cyclones in pure numerical simulations, whereas Lionello *et al.* (2016), Trigo *et al.* (1999), Kotsias *et al.* (2023), and Flaounas et al. (2021) based their analyses on reanalysis products. In addition, the different studies used different criterias to define “intense cyclones”.

Indeed, Flaounas *et al.* (2013) demonstrated the sensitivity of the seasonal cycle of Mediterranean cyclogenesis to the boundary conditions used in numerical models. Using the WRF model with both ERA-Interim and IPSL-CM5 as boundary forcings, they found that the downscaling driven by ERA-Interim reproduced a spring maximum in cyclone activity, while the downscaling driven by IPSL-CM5 simulated a clear winter peak. Moreover, comparing Flaounas *et al.* (2013) and Flaounas *et al.* (2015) show the sensibility of the climatology to the criterias used to define intense cyclones. Those two studies use the same numerical setup but different threshold of intensity, and they found a different climatology.

This suggests that the simulated seasonal distribution of cyclone activity can depend strongly on the characteristics of the driving data and the specific thresholds used in the selection of the cyclones to be analyzed.

We have added a short discussion along this line in the manuscript (see lines 186-200), comparing the seasonality shown in fig. 3 to previous works.

23. *L. 196: This is a very large box compared to the typical cyclone size, especially over the Mediterranean sea, where cyclones' size are usually a few hundreds of kilometers, and given 10° is basically the width of the whole basin. Taking the average is also disputable since you may average more or less land depending on the position of the storm. Can you explain these choice? A usual choice is to take the maximum within 2° of the cyclone's center. Why not do this? I would recommend using a box no larger than 5° in any case, and also preliminarily masking all winds over lands, as they may be spuriously high due to orography, or overall low due to friction.

We thank the reviewer for this valuable comment, which helped us clarify the methodology and improve the manuscript. There was indeed some confusion in the original text regarding the averaging domain. In our analysis, different box sizes were used depending on the variable: a 4° × 4° box for heat fluxes and Potential Intensity (PI), and a 10° × 10° box for wind composites. We corrected this in the new version of the manuscript by homogenizing the size of the boxes over which the mean is performed.

We confirm that all computations were performed with land areas masked, as mentioned in the legends.

The choice of the 4° × 4° box was based on inspection of the two-dimensional composites, which show that this region typically encompasses the area of maximum wind and surface flux intensities around the cyclone center. A smaller box (e.g., 2° × 2°) would exclude part of this high-intensity region for many systems, while a larger one would risk including unrelated environmental signals. To assess the sensitivity of our results to this choice, we repeated the calculations using box sizes ranging from 10° × 10° (figures R14 and R15) down to 2° × 2° (figures R18 and R19). The resulting evolution of wind, heat fluxes, and PI was very similar across all cases, confirming the robustness of our findings.

In particular, even with a smaller averaging box, the results consistently show that while intense ETCs exhibit stronger absolute winds than classical ETCs, their surface heat fluxes remain comparable. In contrast, MTLCs display a stronger early-stage intensification linked to enhanced latent and sensible heat fluxes, supporting the role of the wind-induced surface heat exchange (WISHE) feedback in their development. We have clarified these methodological details in the revised manuscript to avoid any further confusion.

Wind composites:

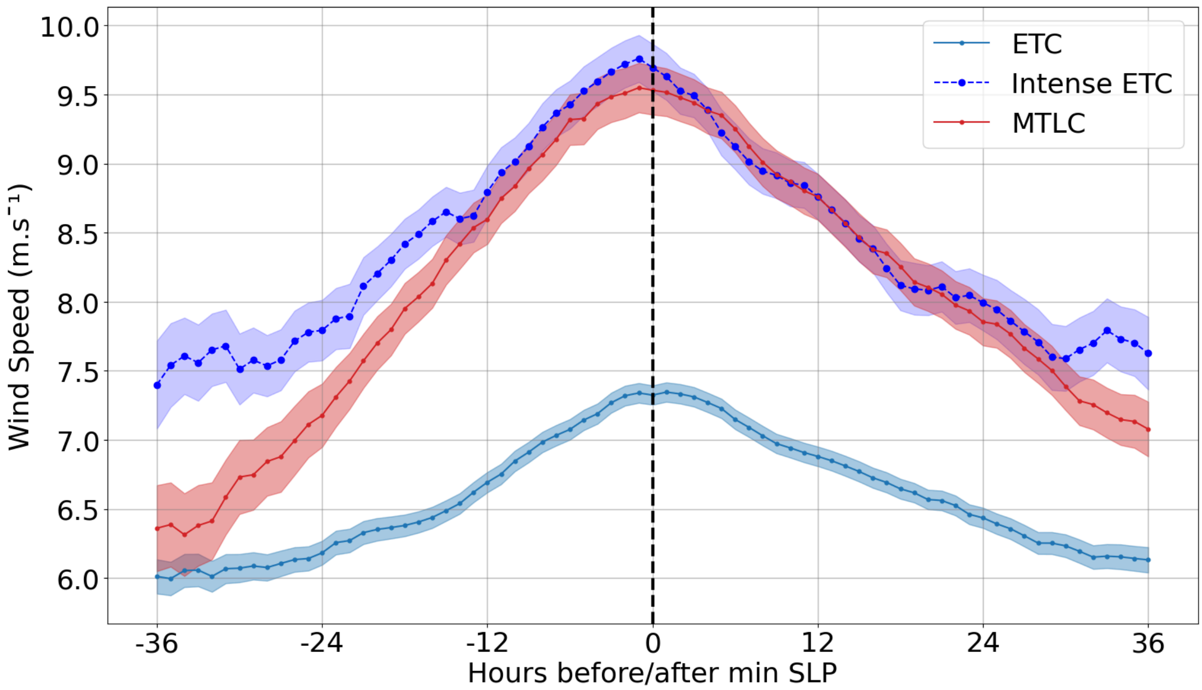

Figure R14: Composite time evolution of mean 10m wind in a 10° by 10° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

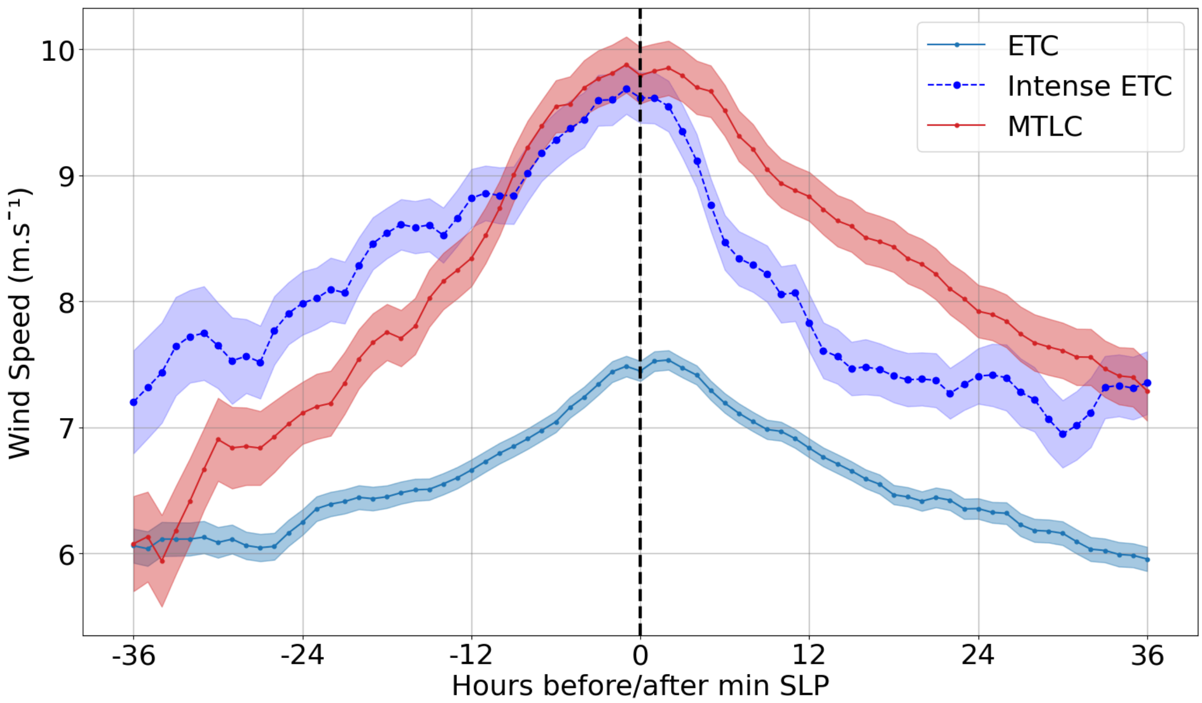

Figure R16: Composite time evolution of mean 10m wind in a 4° by 4° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

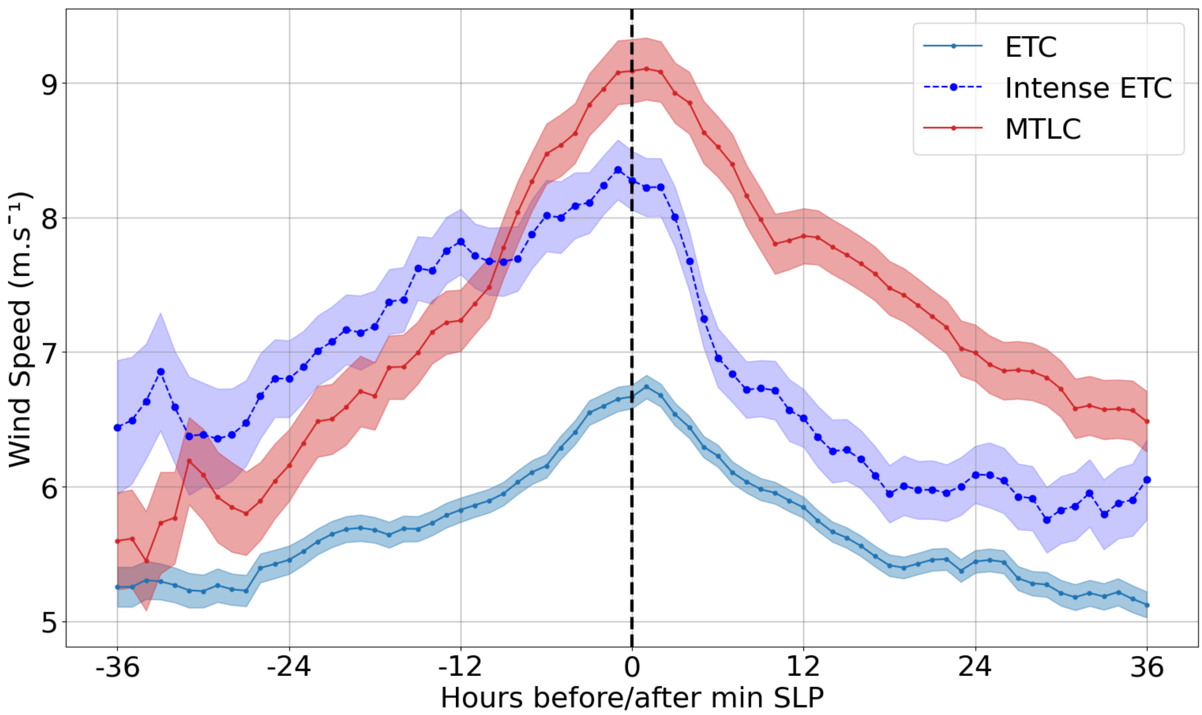

Figure R18: Composite time evolution of mean 10m wind in a 2° by 2° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

Heat fluxes composites:

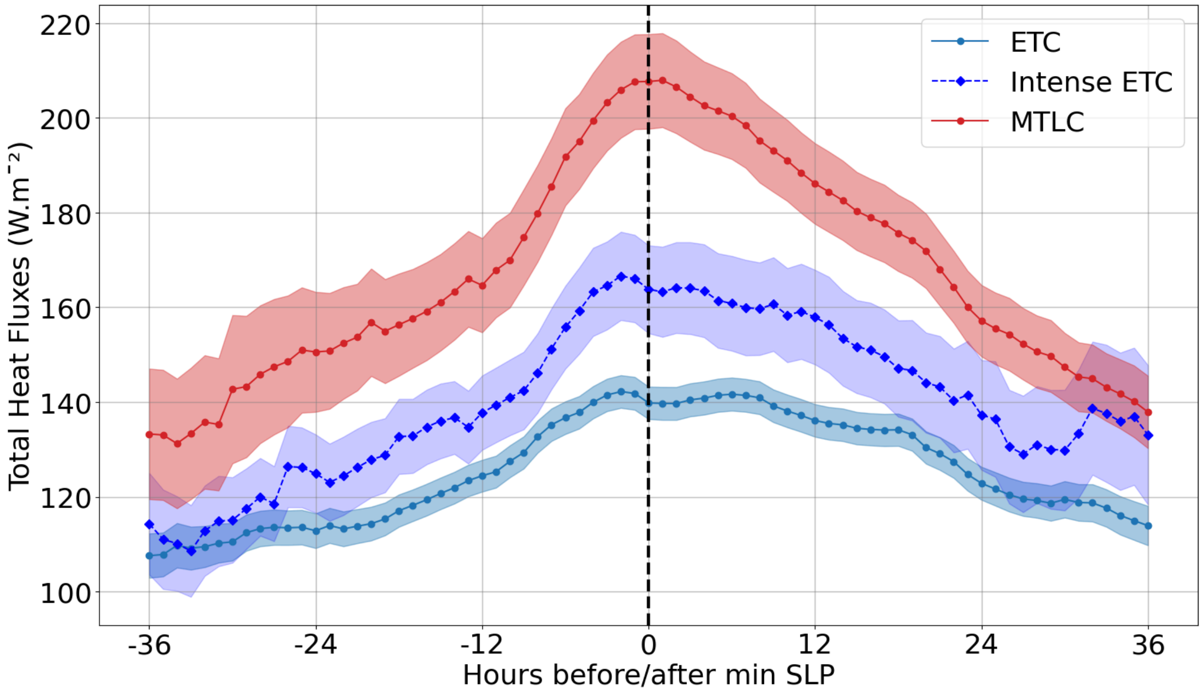

Figure R15: Composite time evolution of mean air-sea total (latent and sensible) heat flux in a 10° by 10° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

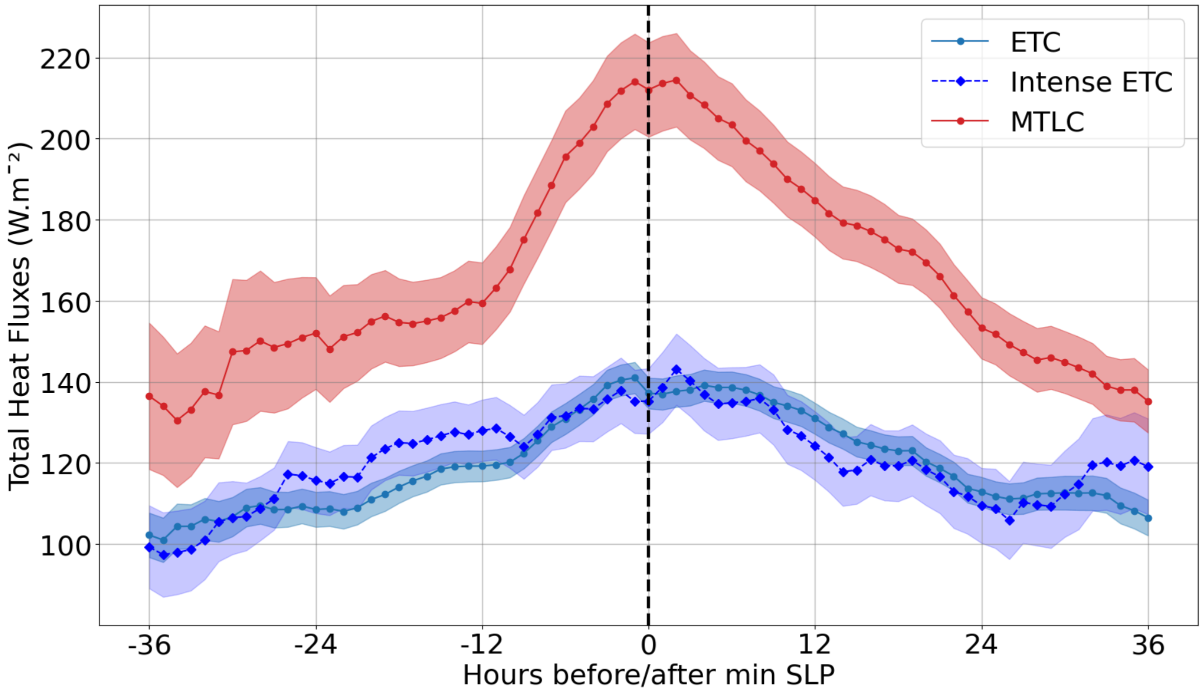

Figure R17: Composite time evolution of mean air-sea total (latent and sensible) heat flux in a 4° by 4° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

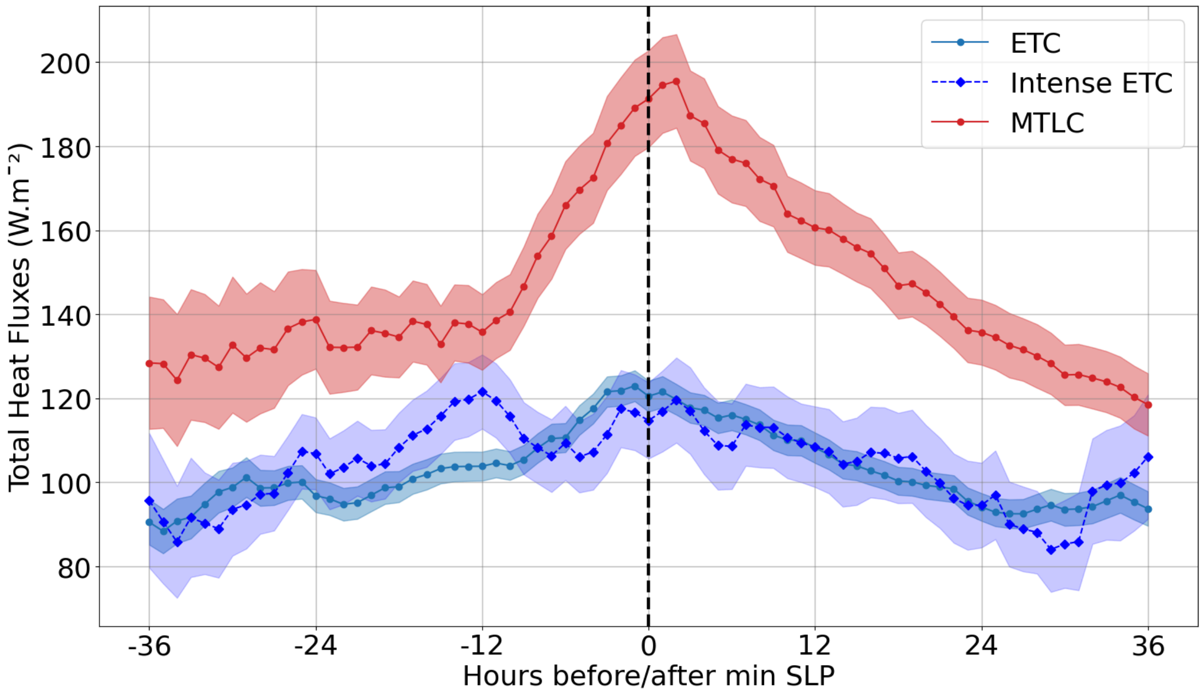

Figure R19: Composite time evolution of mean air-sea total (latent and sensible) heat flux in a 2° by 2° box centered on the cyclone. Only the points over the sea are considered to compute the composite.

References:

Cavicchia, L., von Storch, H., & Gualdi, S. (2014). A long-term climatology of medicanes. *Climate dynamics*, *43*(5), 1183-1195.

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Answer Referee 1:

[The following comments have already been uploaded during the open discussion phase of the review process.]

We thank the reviewer for their constructive feedback. The comments certainly contribute to making our study more robust and comprehensive. In the following, the reviewer's comments are reproduced, in italic, before each reply. The mentioned figures are available in the supplementary file of the answer.

The paper classifies Mediterranean cyclones into three categories and describes the mean and standard deviation of their characteristics 36 hours before their maximum intensity. The paper sorely lacks arguments to convince the reader that the three categories of cyclones have consistent characteristics and that the framework around the maximum intensity is relevant for analyzing such a diversity of cyclones.

We propose to integrate the manuscript in a manner that better describes those aspects. More details on how we plan on doing this are provided in the following, in response to the specific comments below.

Major comments

1) The title "Environmental Characteristics Associated with the Tropical Transition of Mediterranean Cyclones" is misleading. The paper compares ETC, intense ETC and MLTC over a 72-h period centered on the first minimum sea level pressure (SLP). It therefore deals with the intensification of the three types of cyclones, not the tropical transition of Mediterranean cyclones.

We agree that the title might have been misleading and propose to change it to: "Environmental characteristics associated with the development of tropical-like features in Mediterranean Cyclones". In this work, we identify the anomalous properties (with respect to climatologies) that characterize Mediterranean cyclones that develop a deep warm core. We then compare them with those that characterize cyclones that do not develop a deep warm core (ETC and intense ETC), highlighting similarities and differences to distinguish specific characteristics that are associated with the formation of a deep warm core. This will be better explained in a revised version of the manuscript. We will also clarify that, rather than focusing on the processes responsible for the TT, such as in Davis and Bosart 2004, we aim at identifying the synoptic scale (or environmental) conditions that are found in cyclones that develop a deep warm core.

2) With regard to tropical transition (TT), the authors should refer to cyclones for which "a fundamental dynamic and thermodynamic transformation of an extratropical precursor (of baroclinic origin and initially considered a cold-core system) is required to create a warm-core tropical cyclone" (Davis and Bosart 2004). In other words, TT deals with ETCs that transform into MLTCs. These transformed cyclones correspond to your definition of hybrid cyclones, which are not included in the study. Under these conditions, I do not understand how the study can actually address TT.

We thank the reviewer for this important remark. We would like to clarify that in our classification, *hybrid cyclones* are not equivalent to systems undergoing tropical transition. Hybrid cyclones, as we defined them, are systems that either exhibit a shallow warm core, only in part of the troposphere, or develop a deep warm core only for a very short time (less than 6 hours). The intent here is to discard cyclones that are not clearly fully cold core nor deep warm core for any substantial time. This distinction should have been stressed more clearly in the manuscript, and we propose to revise the text accordingly.

In our study, we used the term *tropical transition* to describe the evolution of cyclones that begin their lifecycle in the cold-core phase of the Hart phase space diagram and subsequently evolve into a deep warm-core phase for at least 6 hr, in line with the Davis and Bosart (2004) definition cited above. We propose to clarify this important point in the revised manuscript.

3) Line 26, it should of interest to cite Miglietta et al. (2025) "A medicane is a mesoscale cyclone that develops over the Mediterranean Sea and displays tropical-like cyclone characteristics: a warm core extending into the upper troposphere, an eye-like feature in its center with spiral cloud bands around, an almost windless center surrounded by nearly-symmetric sea-surface wind circulation with maximum wind speed within a few tens of km from the center."

We thank the reviewer for the suggestion. We will quote the definition of Medicanes proposed by Miglietta *et al.* (2025) in the new version of the manuscript. We'll also be more careful in the use of the Medicane term and in the MTLC term (see comment 4 below) throughout the manuscript.

4) Line 95, Mediterranean Tropical-Like Cyclones (MTLC) ("also known as Medicanes", Line 19), are defined as cyclones that during part of their lifetime develop a deep warm core for at least six hours while they are over the sea. This corresponds to the first criterion in the definition by Miglietta et al. (2025). The other criteria are therefore discarded. This could partly explain the difference in the number of occurrence reported in Section 3.1, i.e. about 1.5 Medicanes per year *compared to 3.4 cyclones per year of MLTC. It also means that the MLTC you have defined are not Medicanes. They should therefore be named "Deep Warm-Core Cyclones (DWCD)."*

We thank the reviewer for this comment. We agree that the use of the term *Medicane* would indeed be misleading to describe the structures analyzed in our study, as this label refers to a more specific set of criteria, and it is still debated across the community. For this reason, we initially chose the term *Mediterranean Tropical-Like Cyclones (MTLC)*, to emphasize some features these systems share with tropical cyclones—namely the warm core and the symmetry—while avoiding the more restrictive definition of *Medicane*. It was our mistake to say the two were equivalent.

We acknowledge that the term *Deep Warm-Core Cyclones (DWCC)*, as suggested by the reviewer, may better reflect the definition we adopted. Our initial hesitation in using this phrasing was that these cyclones are not characterized by a deep warm core throughout their entire lifetime, but only during part of it. Nevertheless, considering this comment, we are open to adopting it in the revised version of the manuscript for greater clarity and consistency with the literature.

5) Section 2.2. The use of a different radius to calculate the B and V parameters (100 km versus 125 km) must be justified. Furthermore, these radii are well below 200 km, as used by Chaboureau et al. (2012), or 250 km, as used by Fita and Flaounas (2018). The use of a small radius must also be justified. As noted by Miglietta et al. (2025), these small radii "may be misleading for the diagnosis of symmetric or upper warm-core structures. These considerations need to be taken into account in future studies."

We thank the reviewer for this comment. There is a mistake in the manuscript: the radius is the same in all cases, and the correct value is 137.5 km (or 5 ERA5 grid points, i.e., a radius of 1.25°). This will be corrected.

Regarding the choice of radius, several studies have shown that the original 500 km radius of Hart (2003) is too large for Mediterranean cyclones. For instance, Miglietta et al. (2013), Picornell et al. (2014), Cioni et al. (2016), and de la Vara et al. (2021) reduced the radius to 150 km, while Cavicchia et al. (2014) and Noyelle et al. (2019) used 100 km. Ragone et al. (2018) reviewed different approaches and performed sensitivity tests, reporting that choosing values between 70 km and 150 km did not make significant changes in the categorization. Gutiérrez-Fernández et al. (2024) also demonstrated that results obtained with 150 km are consistent with those obtained at 300 km. Importantly, we note that, also in Miglietta et al. (2025), despite their cautionary remarks, the CPS diagram presented in their work was computed using a 150 km radius.

In this context, our choice of 137.5 km falls within the range commonly adopted in the literature and is consistent with the reduced spatial scale of Medicanes. We understand that using a small radius could be a limitation for the diagnosis of cyclone symmetry, but this issue is partly mitigated by the fact that most tracking algorithms used in Flaounas et al. (2023) already apply explicit symmetry criteria when identifying a cyclone. On the other hand, we are less certain about how the radius size would affect the determination of the upper-level core temperature.

6) Section 3.1. The threshold of 20% chosen for the classification of intense ETC must be justified. In addition, this section (or the next one) should include a description of the distribution of SLP and track length for the three categories.

We thank the reviewer for this insightful comment. The motivation for creating the “intense ETC” category was to obtain a sample of comparable size to that of the MTLC. We realize, thanks to this comment, that selecting the 15% most intense ETC (Figure R1) would have produced a sample size even closer to that of the MTLC (Figure R3).

We therefore repeated the analysis using the 15% most intense ETC (see the last comment for the updated figures). The main message remains unchanged: in terms of potential impacts, MTLC (or DWCC) exhibit similar intensity to intense ETC in terms of wind speed, but they are associated with stronger precipitation. From a process-oriented perspective, MTLC are linked to the same type of PV intrusions as intense ETC, but they develop over much warmer SST and are therefore associated with a higher PI.

Finally, the analysis of track-length distributions shows that, on average, MTLC last longer than both ETC and intense ETC (Figure R2).

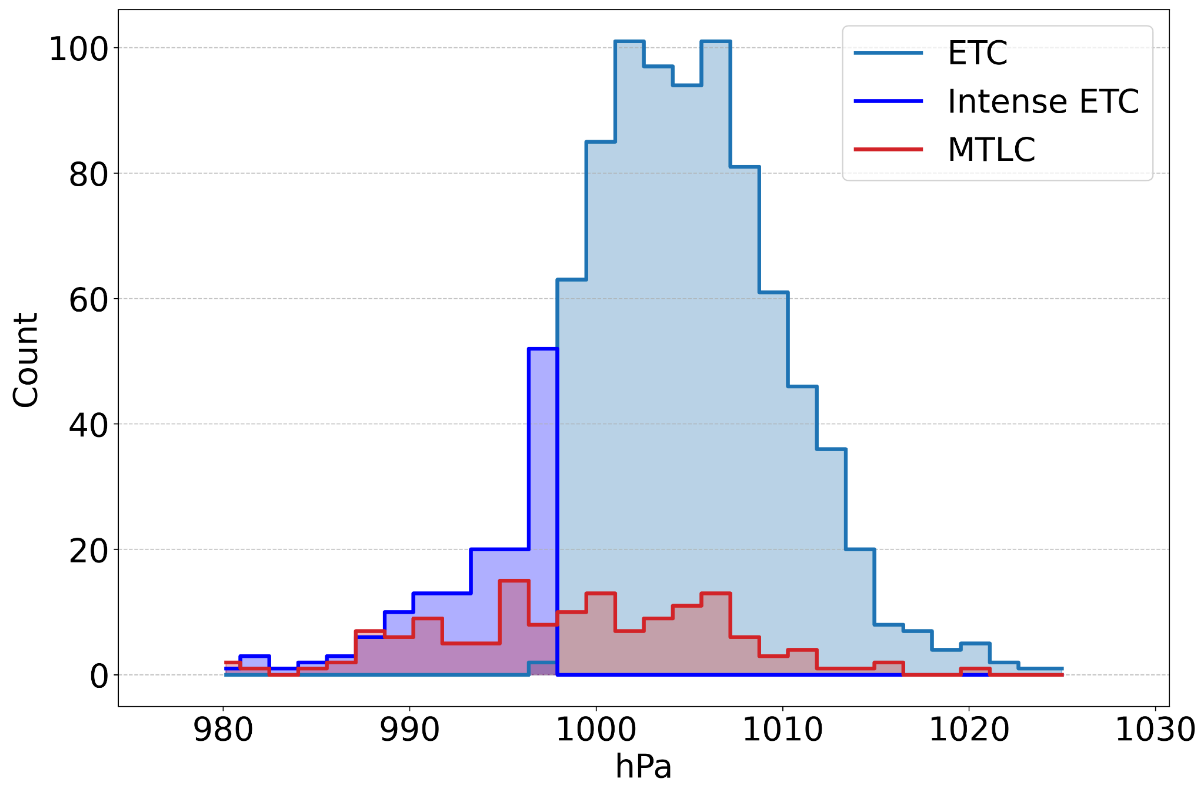

Figure R1: Probability density function of the sea level pressure associated with the center of ETC (blue) and MTLC (red) at the time of their maximum intensity.

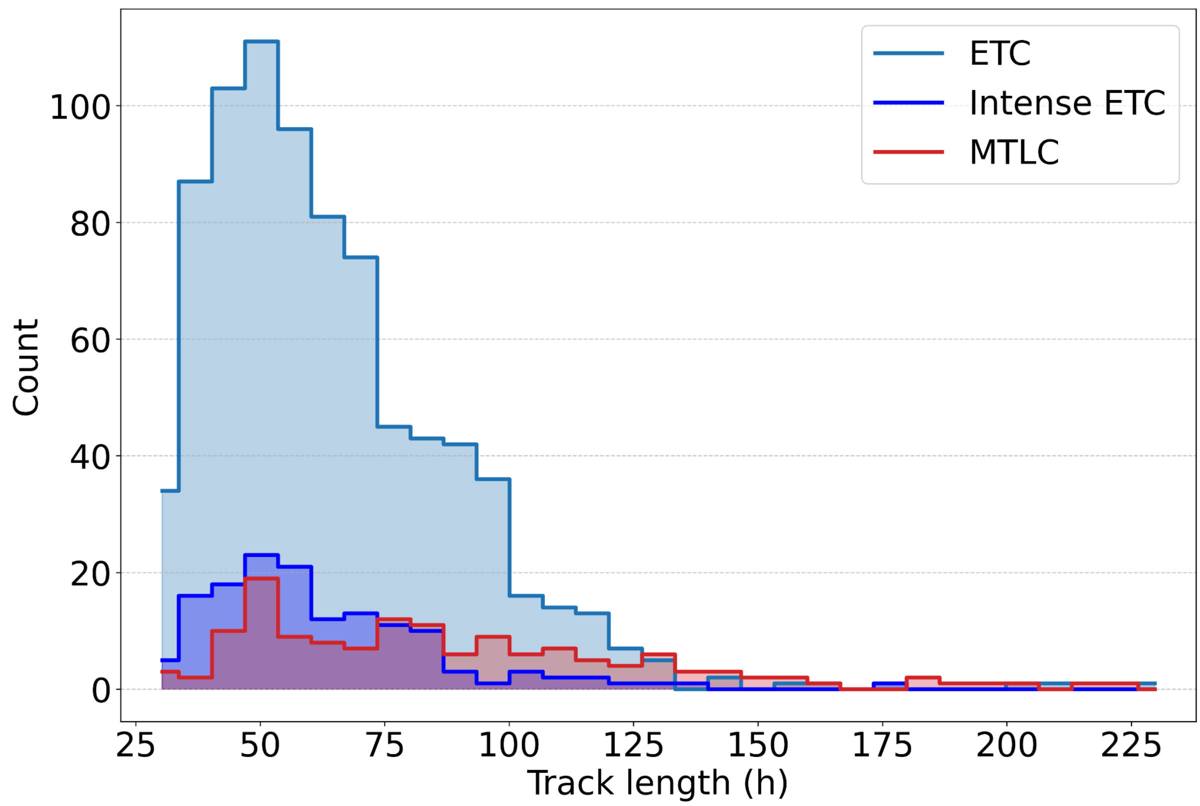

Figure R2: Probability density function of the track length of ETC (blue) and MTLC (red).

7) Figure 1, line 144, "About one-third of MTLC have a full warm core at the time of peak intensity." In other words, about two-thirds of MTLC do not have a full warm core at the time of peak intensity, meaning that they are not MTLC at that moment. This shows that the time of peak intensity is not the TT time for two-thirds of the MLTC. This implies a broad TT spectrum for the MLTC set.

We thank the reviewer for this comment. We would like to clarify that we never intended to equate the time of peak intensity with the time of tropical transition. We agree that, for many MTLC, the development of a full warm core does not coincide with their peak intensity, and we will explicitly state this in the revised manuscript. Indeed, at the time of peak intensity, only 42% of cyclones exhibit—or have already exhibited—a deep warm core. We also note that the median of the first time a cyclone has a deep warm core is 1-3 hours before time 0 (see Figure 3, which will substitute Figure 1 in the manuscript). Our choice of peak intensity as the reference time (t = 0) was motivated by the need to construct composites with a consistent temporal reference across all cyclones. Using the minimum SLP provides such a common anchor point.

We recognize that part of the confusion may stem from terminology, particularly around the use of "tropical transition." Our focus was not to determine the exact TT timing of MTLC, but rather to investigate the environmental conditions associated with cyclones that eventually develop warm-core structures. We will clarify this point in the manuscript to avoid misunderstandings.

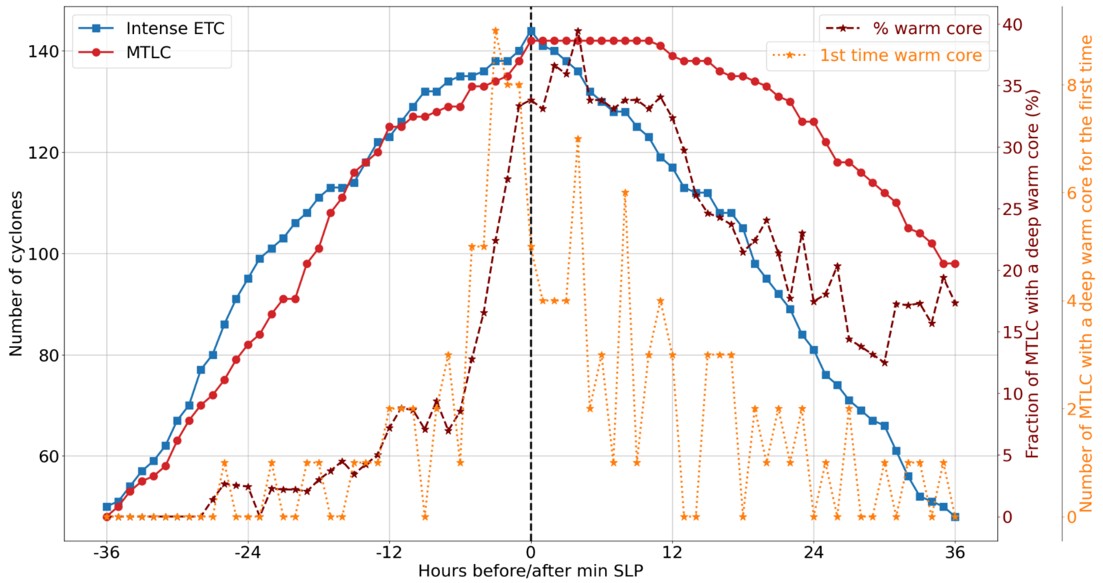

Figure R3: Time evolution with respect to minimum SLP of the number of intense ETC (blue solid line) and DWCC (red solid line), proportion of DWCC that have a warm-core at each time step (maroon dashed line), and number of DWCC that have a deep warm core for the first time (dotted orange line).

8) In most figures, the mean and standard deviation of several variables are shown. This suggests that these variables have a Gaussian distribution, which is certainly not the case. Instead, the median and interquartile values should be shown. The 5th and 95th percentiles and outliers should also be added to the lower panels of Figures 4, 5, 6, 9, 10, 13 and A5.

We thank the reviewer for raising this important point. We realize that in the submitted version, it was not clearly indicated what the error bars represent. These are not standard deviations, but rather the standard error of the mean. They therefore quantify the confidence in the mean values, but they do not represent the spread of values across cyclones.

Consequently**,** as suggested by the reviewer, we produced boxplots for the different variables. For each cyclone, we computed the mean over the 10% highest values over the 10°x10° box shown in the top panels. The selection of the 10% highest values is motivated by the fact that the 10°x10° box is very large, and it includes areas that are not representative of the cyclone conditions; selecting a smaller area at a fix location with respect to the cyclone center however is not appropriate as different variables express anomalous values at different places (eg wind speed is typically larger in the southwest quadrant while precipitation maxima are on average larger to the north of the center and PV intrusion is in the northwest quadrant). For those reasons, we use a fixed-size area (covering 10% of the 10°x10° box) defined by selecting the largest values, regardless of their position in the box. [We also performed a sensitivity analysis over the used area fraction (5% and 25%, other than the 10% reported here), reaching similar conclusions to what is reported in the following.]

Boxplots are then created for those mean values over all cyclones in each of the three classes and shown in the figures below. As foreseen by the reviewer, these boxplots indicate that the intraclass spread is large and show substantial overlap among the different classes. However, important signals emerge, as detailed in the following.

Regarding 10m wind speed at the time of peak intensity (fig. R5), in 90% of MTLC/DWCC the value is larger than the median value of ETC. Also, the mean values for MTLC/DWCC and intense ETC are not significantly different (all statistical outcomes in this note, obtained with a two-sided t-test, are defined at the 95% confidence level).

For hourly rainfall at the time of peak intensity (fig. R6), we looked into the values of all percentiles from the 1st to the 99th, and they are all larger for MTLC/DWCC than for both intense ETC and ETC. The mean values of the three classes are significantly different, indicating that, on average, rainfall is smaller for ETC, higher for intense ETC, and highest for MTLC/DWCC. Still, very intense rainfall can be present in some cold-core cyclones, with 30% of intense ETC and 15% of ETC having values larger than the MTLC/DWCC median value.

In comparing intense ETC and MTLC/DWCC at time -36hr prior to the time of peak intensity, we report that their mean PV anomaly values (fig. R7) do not significantly differ, but their SST (fig. R4), PI and climatological PI (fig. R8, R9), and wind shear (fig. R10) do. Clearly, given the large intraclass spread, none of those variables is sufficient per se to unambiguously differentiate MTLC/DWCC from intense ETC, but they shed light on the environmental characteristics that favor the development of a deep warm core.

This supports our main conclusion: while MTLC/DWCC and intense ETC share similar mean surface wind speeds at their peak intensity and are associated with PV intrusions of the same strength, MTLC/DWCC are favored by warm SSTs, low vertical wind shear, high PI, and typically produce more intense precipitation.

We also note that the SST (fig. R4), PI (Fig. R8), and wind shear (fig. R10) distributions of MTLC/DWCC and ETC are quite similar. This, together with the fact that ETC are too weak to activate WISHE, might be responsible for the different evolution of ETC and MTLC (a mechanism discussed in Davis and Bosart 2004 to differentiate between tropical transitions in strong extratropical cyclones and in weak extratropical cyclones).

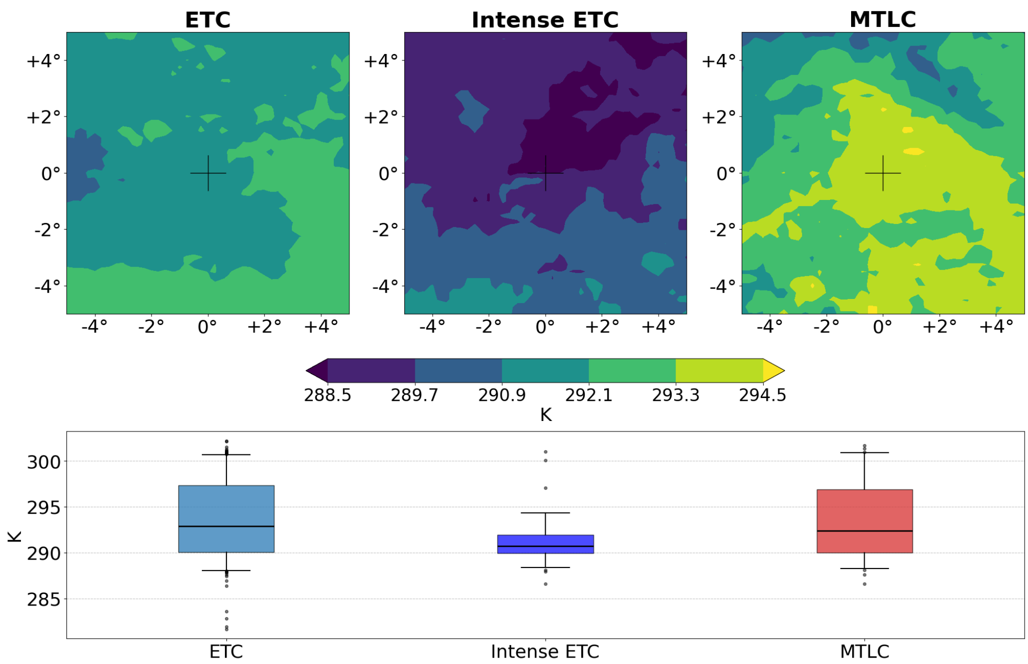

Figure R4: Sea Surface Temperature for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean SST for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

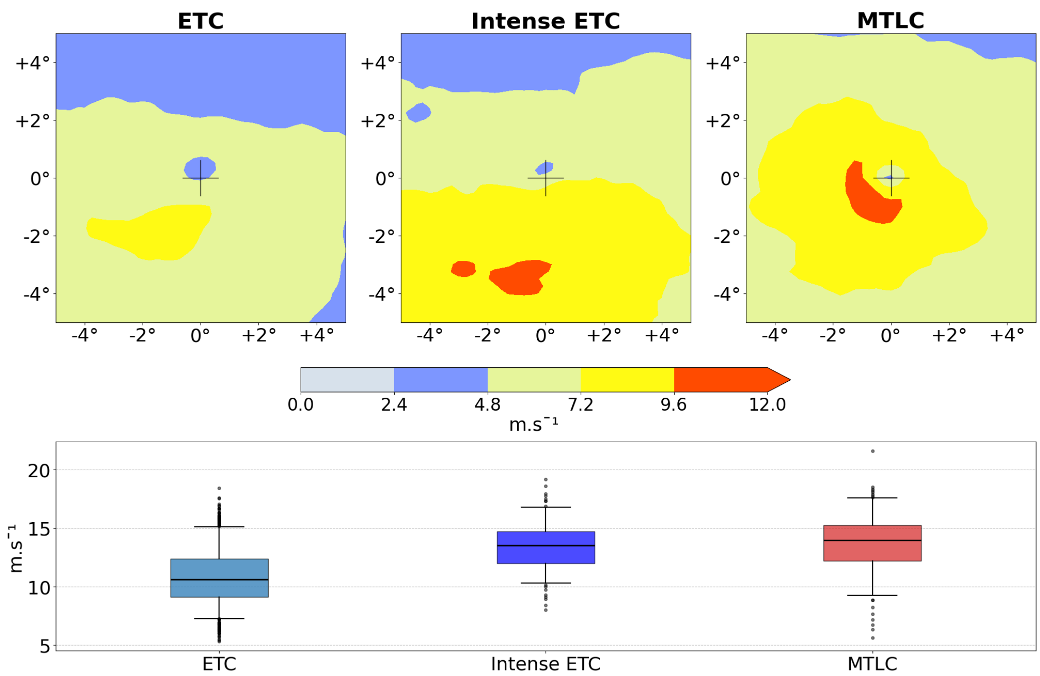

Figure R5: 10m surface wind for the different cyclone classes. Top: 2D composites centered on the cyclones, at the time of minimum SLP. Bottom: boxplots of the mean 10-m wind speed for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

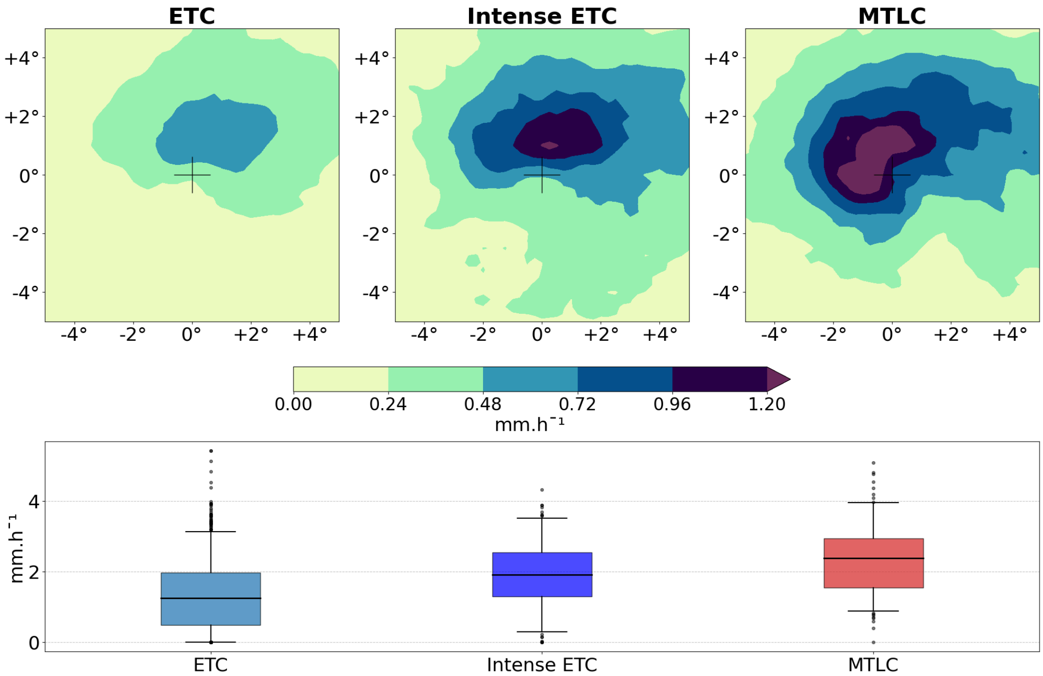

Figure R6: Hourly precipitation for the different cyclone classes. Top: 2D composites centered on the cyclones, at the time of minimum SLP. Bottom: boxplots of the mean 1-h accumulated precipitation for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

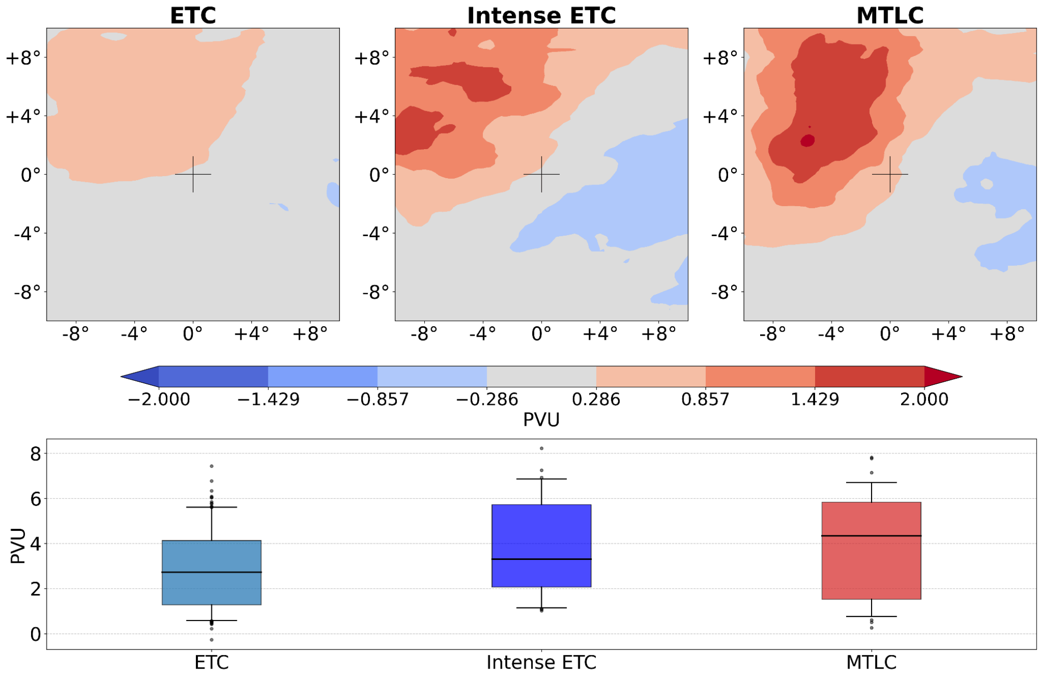

Figure R7: PV anomaly for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean PV anomaly for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

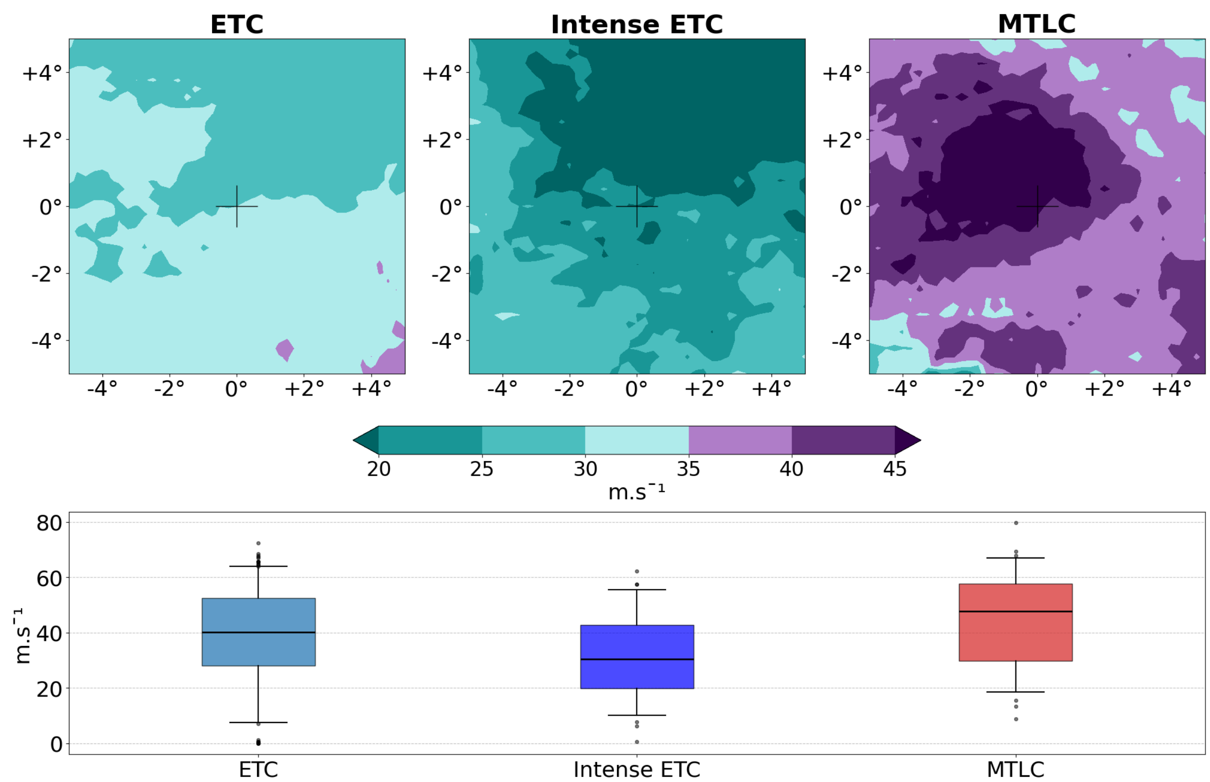

Figure R8: Total PI for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean PI for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

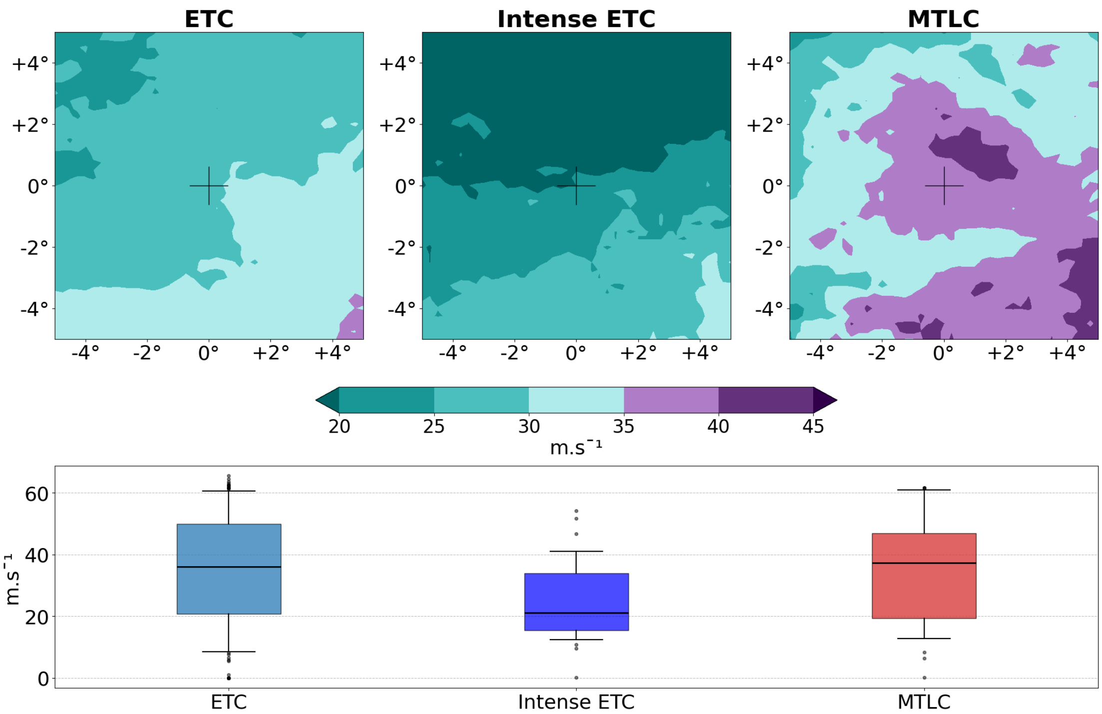

Figure R9: Climatological PI for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean climatological PI for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

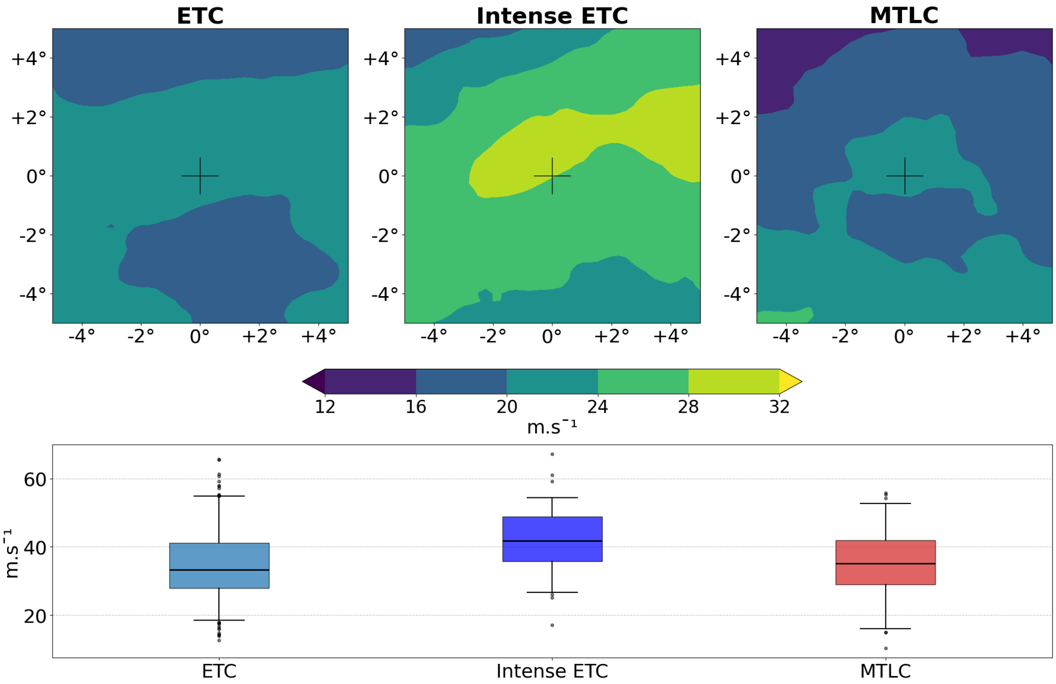

Figure R10: Wind shear for the different cyclone classes. Top: 2D composites centered on the cyclones, 36h before the time of minimum SLP. Bottom: boxplots of the mean wind shear for each cyclone, where the mean is computed on the 10% highest values over the 10°x10° box for each cyclone. Whiskers show the 5th–95th percentiles.

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