**Orographic impacts of Réunion Island and Madagascar on heavy rainfall during Tropical Cyclone Batsirai (2022)**

**By K. O. Lee et al.**

Reply to the referee's comments

In the following, the comments made by the referees appear in black, while our replies are in red, and the proposed modified text in the typescript is in blue.

| Referee #1 comments |
|---|

**Summary general comments**

The manuscript evaluates the impact of the orography on heavy precipitation, track and intensity of a typhoon in the Southwest Indian Ocean. The authors use the Meso-NH model in 2km resolution to conduct a control simulation with realistic topography, and three other runs with modified representation of the orography. The typhoon selected for the study is typhoon Batsirai that affected both Madagascar and Réunion island in 2022. Simulations outputs were compared to observational datasets including two C-band Doppler radars and rain gauges. Results show that orography enhanced precipitation over both islands and, in the case of Madagascar, also affected typhoon track and intensity.

The manuscript is well designed, clearly states the objectives and methodology, and the results are properly presented and discussed. Besides, it is important to the community due to its contribution to highlight the impacts of complex orography on typhoon track, intensity and precipitation over an area that has not received as much attention as Eastern Asia or the North Pacific. I recommend the paper for publication, although some comments should be addressed first.

We sincerely appreciate the time and effort you have devoted to reviewing our manuscript, as well as your insightful and constructive comments. We have carefully revised the manuscript in response to the reviewer's valuable suggestions. Our point-by-point responses to each comment are provided below.

**General comments:**

1. The authors mention that all simulations were initialized at 00 UTC on 1 February but did not mention the spin-up used to conduct these simulations. Later on, a 6 hour spin-up is mentioned in line 215 but these values are still used in the evaluation of the model. The authors should clarify which spin-up period was used and what the implications are of using it in the evaluation of the model. Is 6 hours of spin-up enough?

We agree with the reviewer's comment. Spin-up is a well-known and common feature of numerical modelling. To simulate Tropical Cyclone Batsirai, a series of numerical experiments was conducted using the convection-permitting regional model Meso-NH, with a horizontal grid spacing of 2 km, initialized with ECMWF analysis data at 9-km resolution. Using hourly model output, we confirmed that the atmospheric fields (e.g., wind, temperature, and humidity) stabilized and successfully reproduced Batsirai system within approximately 5 hours of initialization. Based on the authors' several years of experience simulating tropical cyclones, a spin-up period of 5-6 hours is typically required at the start of simulation at 2-3 km horizontal resolution when initialized with 9-km ECMWF analysis data. In this study, a 6 hour spin-up period was found to be sufficient; results from this period were therefore excluded from the analysis and from Figures. This point has been clarified in Section 2.4 (Numerical experiments) in page7 while data of spin-up period has been excluded in Figures 4 and 8.

♣ Page 7, lines 197–198

"[…] An approximately 6-hourly spin-up period was required at the beginning of the CTL run; results from this interval were therefore excluded from the analysis."

♣ Page 10, Figure 4

Data of numerical simulations (colored solid lines) during the spin-up period is excluded.

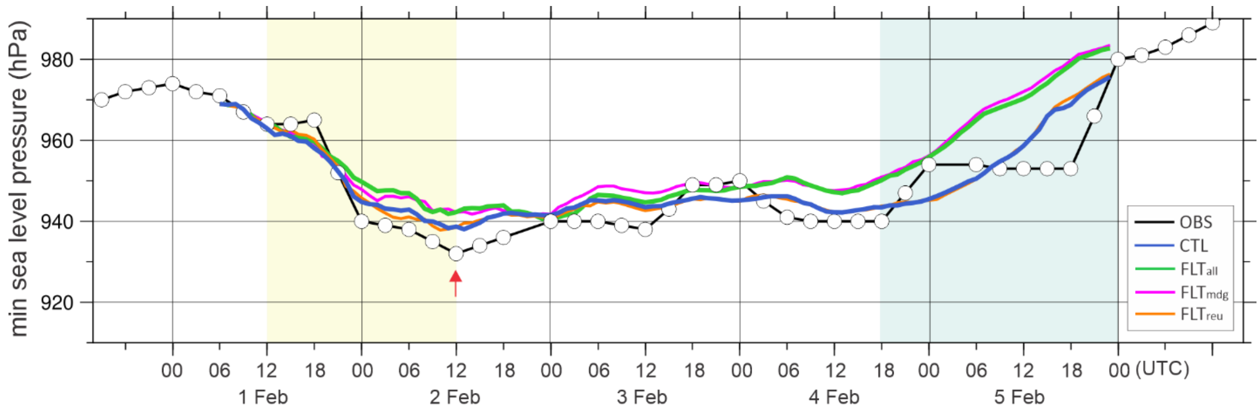



**Figure 4.** Observed and simulated temporal evolution of minimum sea level pressure (MSLP) for TC Batsirai. Observed 3-hourly MSLP values from IBTrACS are shown as a black line with white circles; note that data at 21 UTC of 2 February and 03 UTC on 5 February are missing. Simulated MSLP values from CTL, $FLT_{all}$, $FLT_{mdg}$, and $FLT_{reu}$ are shown in blue, green, magenta, and orange, respectively. The time of minimum observed MSLP is marked by a red upward arrow. Periods of intensification and decay of TC Batsirai are highlighted by yellow and blue shading, respectively. Results of the first 6 hours of the spin-up period were excluded from the analysis.

♣ Page 15, Figure 8

Data of numerical simulations during the spin-up period is excluded.

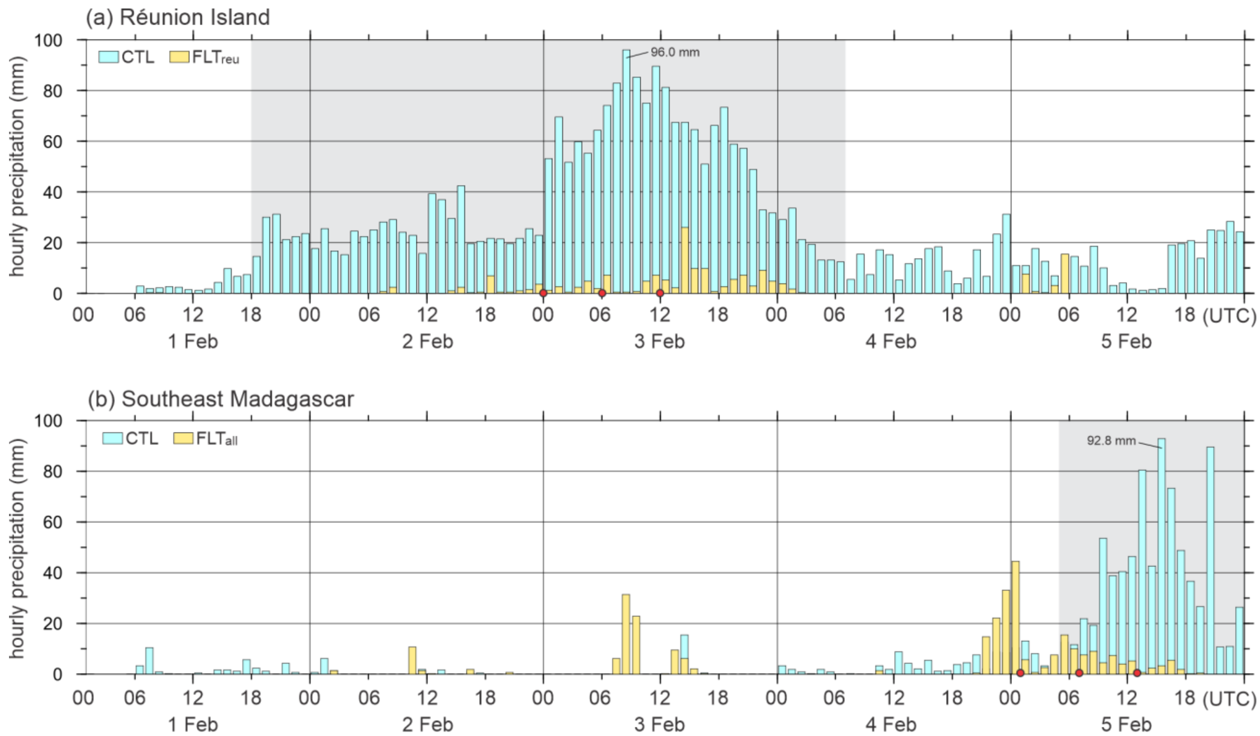



**Figure 8.** Temporal evolution of the simulated maximum precipitation within the analysis domains: (a) the Réunion Island region, from the CTL (light blue bars) and $FLT_{reu}$ experiments, and (b) the eastern Madagascar region, from the CTL (light blue bars) and $FLT_{all}$ (yellow bars) experiments. The horizontal extent of the analysis domains is shown by the boxes in Fig. 7. Red circles along the x-axis indicate the selected times presented in Figs. 9, 10, and 12. The grey-shaded areas highlight period during which precipitation ≥ 10 mm h$^{-1}$ persists. Results of the first 6 hours of the spin-up period were excluded from the analysis.

♣ Page 14, Figure 7

Precipitation area during the spin-up period is marked with a dashed ellipse.

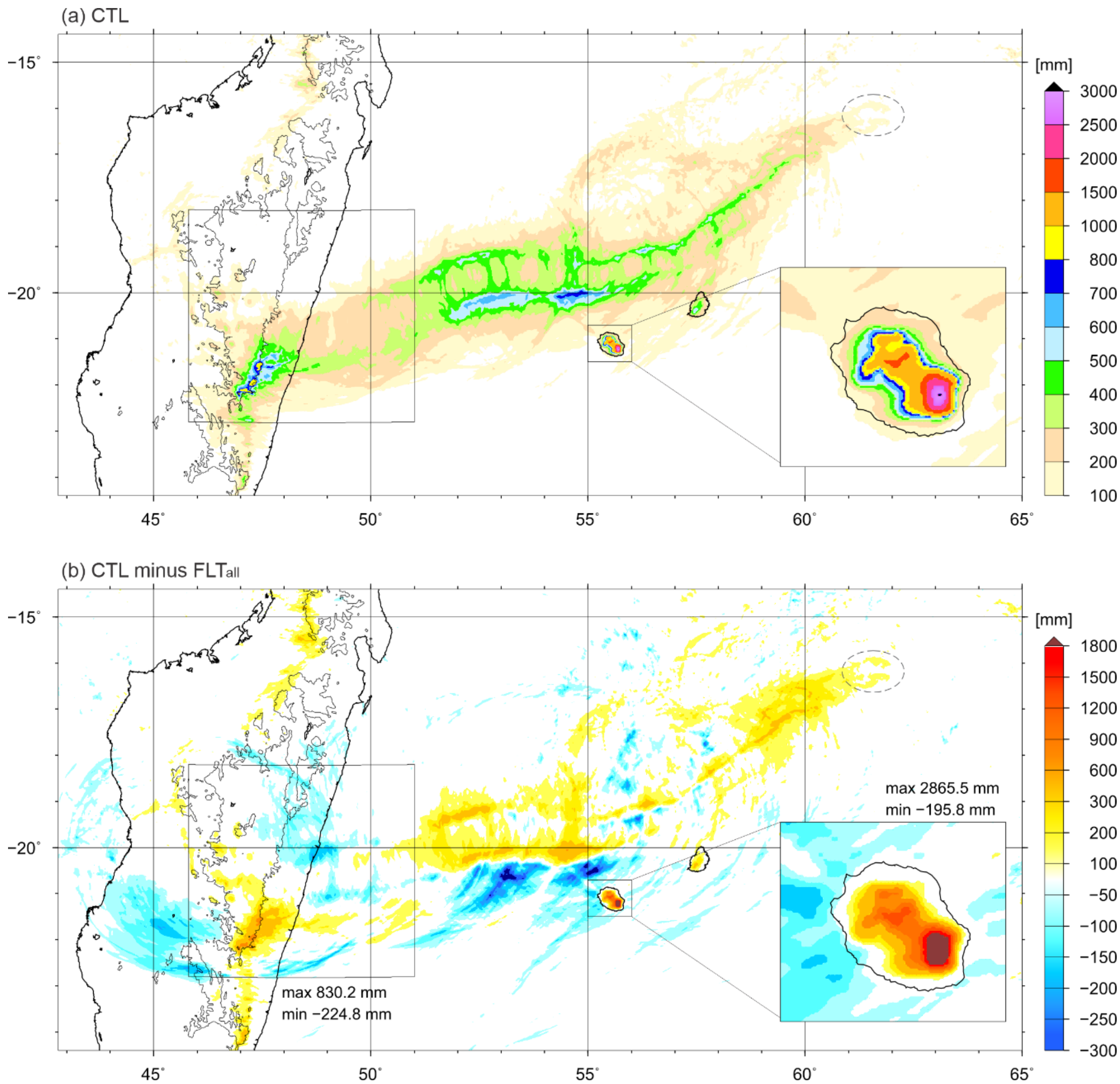



**Figure 7.** (a) Five-day accumulated precipitation simulated by CTL, and (b) the difference in five-day accumulated precipitation between CTL and $FLT_{all}$ experiments (CTL minus $FLT_{all}$), starting from 00 UTC on 1 February 2022. The two boxes indicate the analysis domains for the Réunion Island region (55–56°E, 20.8–21.5°S) and the eastern Madagascar region (45.8–51.0°E, 18.2–22.8°S), which are used in Figure 8. The rainfall area corresponding to the first 6 hours of the spin-up period is marked by a dashed ellipse.

2. Regarding the sensitivity experiments, all terrain elevations were reduced to 10 m, but this decision is not justify in the text. Why 10 meters and not a different height?

We agreed with the reviewer. Previous studies investigating the orographic effect on heavy precipitation events have employed numerical experiments with modified topography, such as flattened or reduced terrain. Terrain height has been artificially modified in various ways, for example by scaling elevation to a fraction of its original value (e.g., 0%, 50 %), removing terrain entirely over a target region, or smoothing it to sea level. In this study, we set the terrain elevation to 10 m, not only to eliminate the complex mountainous terrain in the target region, but also to preserve the general characteristics of the island (e.g., land-sea distribution and surface roughness contrast). This point has been added to the manuscript.

♣ Page 7, lines 193–195

"[...] In the sensitivity experiments, terrain elevations within the designated regions were uniformly reduced to 10 m in order to eliminate the influence of complex mountainous terrain, while still preserving the general characteristics of the island (e.g. land-sea distribution). All [...]"

3. Model validation is done using radar and rain gauges only for Réunion Island. Why not also for Madagascar? Besides, model validation is done only qualitatively and no evaluation metrics are shown.

We understand this point and fully agree on the importance of incorporating sufficient observational data to validate model results. However, model validation in this study was conducted primarily around Réunion Island, mainly due to the lack of quality-controlled ground-based observations (e.g., radar and rain gauges) over the Madagascar region. In this context, our research team (LACy, Laboratoire de l'Atmosphere et des Cyclones) installed an X-band dual-polarimetric radar in the eastern mountainous range of Madagascar during 2022/2023 cyclonic season, and in the Seychelles during the austral autumn of 2023 to collect valuable data during heavy precipitation events, as part of the FEDER ESPOIRES project (https://geosur.osureunion.fr/geonetwork/srv/api/records/4852ab1c-d3a9-408e-863b-0b935bcad844). We are currently analyzing observation data collected for several convective systems. These analysis results will be useful not only for assessing the performance of numerical simulations in representing reprecipitation, but also for improving our understanding of precipitation enhancement over the mountainous regions of Madagascar. Continued reinforcement of the observation network in the Madagascar region remains essential for obtaining more accurate data, particularly for rainfall.

In this study, we have therefore evaluated model performance with a particular focus on heavy rainfall around Réunion Island. Since the main objective is to demonstrate the model's ability to represent localized heavy precipitation over mountainous regions, as well as the large horizontal contrast relative to the coastal regions, authors consider a qualitative rainfall comparison to be essential in this context. A separate manuscript incorporating quantitative evaluation metrics is currently in preparation for submission to a journal.

Above points have been discussed in the manuscript.

♣ Page 28, lines 715–719

"[…] In order to extend our understand of rainfall enhancement mechanisms to major TC-affected regions in the southwest Indian Ocean basin, reinforcement of the ground-based observation network (e.g., radars, rain gauges), particularly in the Madagascar region, remains essential for obtaining accurate data. A test observation campaign was conducted using an X-band dual-polarimetric radar in the eastern mountainous region of Madagascar in 2023, as part of the ESPOIRES project. Continued efforts to expand this observation network through international collaboration are highly needed."

---

4. The authors discuss the impact of orography on precipitation, track and intensity attributing all changes to the modified orography. However, changes in orography affect many relevant processes in the atmosphere such as radiation, convection, gravity waves or low-level thermally-induced circulation. For example, what are the impacts of orography changes on the latent heat flux? How is this linked with the simulated precipitation? The authors should discuss this in the manuscript.

---

We agree with the reviewer's comment. Changes in topography influence several relevant processes, including convection, radiation, gravity waves, as well as local-scale, low-level, thermally-induced circulations and latent heat flux exchanges. Given the complex orography of Réunion Island which characterized by steep topography, valleys, and surrounding bathymetry, these processes can play an important role in modifying local rainfall. Additional sensitivity experiments involving percentage-based reductions or increases in topography (e.g. 50, 80, 150, 200 %) would be valuable for examining the effect of topography on low-level thermally-induced circulations, and the associated processes such as convection, radiation, and gravity waves. This point has been discussed in the revised manuscript.

♣ Page 28, lines 711–714

"[…] In addition, the influence of the complex orography of Réunion Island—including steep topography, valleys, and surrounding bathymetry—on the mechanisms enhancing localized intense precipitation over the southern part of the island warrants further investigation. Further detailed analysis of low-level, thermally induced circulations and latent heat flux exchange, along with the associated processes such as local convection activity, radiation, and gravity waves that are influenced by the complex orography, would be valuable. For such analysis, a series of additional sensitivity experiments involving percentage-based reductions or increases in topography would be useful."

**Minor corrections:**

Line 24: Hauro et al., 1969 is not included in the references, or at least, not with year 1969. Please revise.

---

I confirm that Hamuro et al., 1969 is listed in the reference with complete information.

♣ Page 31, lines 810–811

"Hamuro, M., Kawata, Y, Matsuda, S., Matsuno, T., Nakamura, N., Tak, T., Takeda, T., and Yanai, M.: . Precipitation bands of Typhoon Vera in 1959 (Part 1). J. Meteor. Soc. Japan. **47**, 298–308, doi:10.2151/jmsj1965.47.4_298, 1969"

Line 64: "… showed that the presence of the island showed…" reformulate to avoid repetition of "showed".

Original sentence was phrased with **showed** and **slowed**: "Jolivet et al. (2013) **showed** that the presence of the island **slowed** the intensification of landfalling TC Dina […] ". In order to avoid misreading, we rephrased as below:

♣ Page 3, lines 67–68

"[…] Jolivet et al. (2013) reported that the presence of the island slowed down the intensification of landfalling TC Dina […]"

Line 94: it is the first time that IBTrACS is mentioned in the text. For better clarity, I would suggest to define its meaning briefly in the caption or to move the figure after the first time IBTrACS is mentioned in the text.

Corrected.

♣ Page 4, lines 98–99 (caption of Figure 1)

"Figure 1. Topography of the SWIO region and the observed trajectory of TC Batsirai (2022) from International Best Track Archive for Climate Stewardship (IBTrACS) best-track data. […]"

Line 128: Add in the caption what the black contour represents.

Added.

♣ Page 5, lines 133–134 (caption of Figure 2)

"Figure 2. Three-day accumulated […] and the CTL simulation (shaded). Coastal line is contoured by black solid line."

Line 145: "….Three-days accumulated from…". Add rainfall before "from".

Added.

♣ Page 6, line 151

"[…] Three-days accumulated rainfall from rain gauges […]

Line 147: please, ad a link to SAR data either directly here or in the reference section.

As suggested, a link to SAR data is added directly in section 2.2.

♣ Page 6, lines 153–154

"Near-surface wind data were obtained from high-resolution C-band Synthetic Aperture Radar (SAR) measurement (https://cyclobs.ifremer.fr/app/tropical). […]"

Line 152: are the SAR-derived values used in this study corrected taking into account the bias mentioned in this line?

Yes, the SAR data used in this study was corrected following the methodology developed by Mouche et al. (2019). The relevant sentence has been improved.

♣ Page 6, lines 159–160

"Previous validation against Stepped Frequency Microwave Radiometer data indicates that SAR-derived wind speeds have a bias of ~1.5 m $s^{-1}$ and a root-mean-square of ~5 m $s^{-1}$ (Mouche et al., 2019). The SAR data used in this study are subject to this same level of uncertainty. […]"

Line 153: why only values at 01:45 UTC on 4 February? I guess it is the only observation that fits into the dates and domain used for the study, but it should be explain just for the shake of clarity.

As guessed, due to the orbital revisit cycle of the SAR satellite, only two SAR measurements were obtained during the 5-day analysis period: (i) around 01 UTC on 4 February, and (ii) around 15 UTC on 4 February. Both measurements were analyzed, and each showed results that closely matched the corresponding simulated tropical cyclone features. Since both measurements captured TC Batsirai during its weakening phase as it approached eastern Madagascar, only the first measurement is shown in the manuscript. Above information has been added.

♣ Page 6, lines 160–163

"Only two SAR measurements were acquired during the 5-day analysis period within the analysis domain, both of which captured TC Batsirai during its weakening phase. As both measurement showed closely matching results, in this study, we used only the C-Band SAR Tropical Cyclone Vortex Analysis product obtained at 01:45 UTC on 4 February. It provides a gridded wind field at high resolution […]"

Line 162: is 1st of February used as spin up period? Taking into account figures shown in the rest of the manuscript, it seems that the authors used also this date in their evaluation and do not discard it. Could you please clarify this?

As our reply to general comment #1, the explanation about spin-up period has been improved in manuscript.

♣ Page 7, lines 197–198

"[…] An approximately 6-hourly spin-up period was required at the beginning of the CTL run; results from this interval were therefore excluded from the analysis."

Line 172: there is no mention about the frequency of model outputs. Is it hourly. 6-hourly? Please specify.

Added.

♣ Page 7, line 176

"[…] All numerical experiments ran for 5 d, providing outputs every 1h."

Line 211: what does the green-dashed circle represent? There is no explanation in the caption.

Added in the caption.

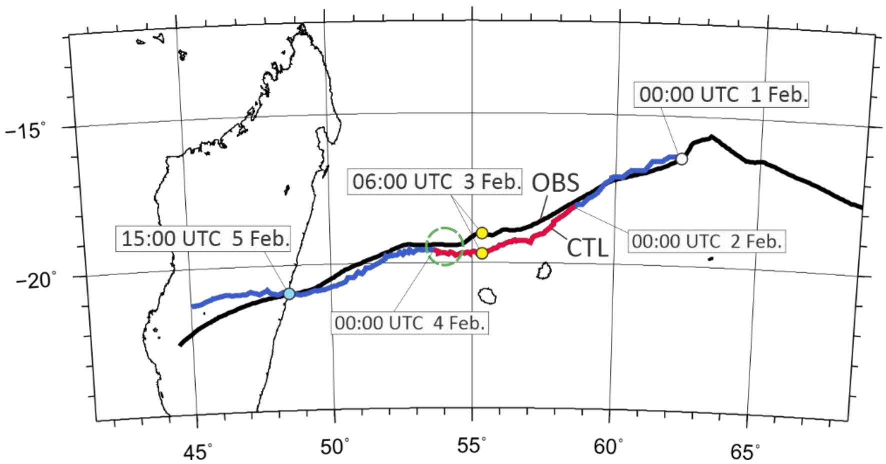
♣ Page 9, lines 234–235 (caption of Figure 3)

"Figure 3. […] The approximate position of TC Batsirai captured by SAR measurement at 01:45 UTC is marked by a green dashed circle."

Line 223: landfall time is mentioned here, but there is no label in Figure 3. Could you add it in the same fashion as for the other relevant dates shown there?

The observed landfall time is added in Figure 3, and the relevant explanation is added in the caption.

♣ Page 9, Figure 3




"Figure 3. […] and the blue dot shows the landfall of observed TC on the eastern coast of Madagascar. […]"

Line 252: why is the comparison done using different time for the model output than for the observation? And also why re wind profiles evaluated at 20 m?

In terms of time, the model output which contains the nearest position of TC center to observation has been selected. Lowest model level (e.g. 20 m) is used for comparison to avoid additional interpolation. Above information has been added in manuscript.

♣ Page 6, line 164–165

"[…] It provides a gridded wind field at high resolution, to identify the TC centre and wind distribution and to compare them with numerical simulations at 23 UTC on 3 February, whose TC position was closer to the observed one. The simulated horizontal wind field at 20-m altitude, the lowest model level, is used for comparison with the SAR data."

Lines 271-274: I suggest to delete these lines as it has been already mentioned in lines 262-268 and it seems repetitive.

Deleted as suggested.

Figure 6: please include in the caption an explanation of what the dashed line represents, as well as regions I, ii and iii (currently there is no mention to it in the caption) and also what figures a) and b) show. It is also a bit confusing to the reader that Figure 6 shows the two plots together but Figure 6b is not mentioned until page 20 when the authors focus their attention on Madagascar. Perhaps, it should be mentioned in the caption that Figure 6b will be explained later in the Madagascar section.

Added as suggested.

♣ Page 12, caption of Figure 6

"Figure 6. Observed and simulated trajectories of TC Batsirai. […] In panel (a), three sections (i, ii, and iii) are marked to indicate the changes in TC trajectory during its passage near Réunion Island (Section 4.1), while panel (b) shows the TC trajectories over eastern Madagascar (Section 4.2)."

Line 311: "...days; blueish areas...". Blueish is not a formal word for a manuscript. Please replace it with blue shades for example.

Revised as suggested.

♣ Page 13, line 342

"[…] with intense rainfall (~500 mm over five days; blue shades) in the southern part"

Line 319: "(not shown)". I am aware that the manuscript already has many figures, but it would be beneficial to see an example of the others changes in the orography, perhaps as supplemental material.

Added as supplemental material, Figure S1.

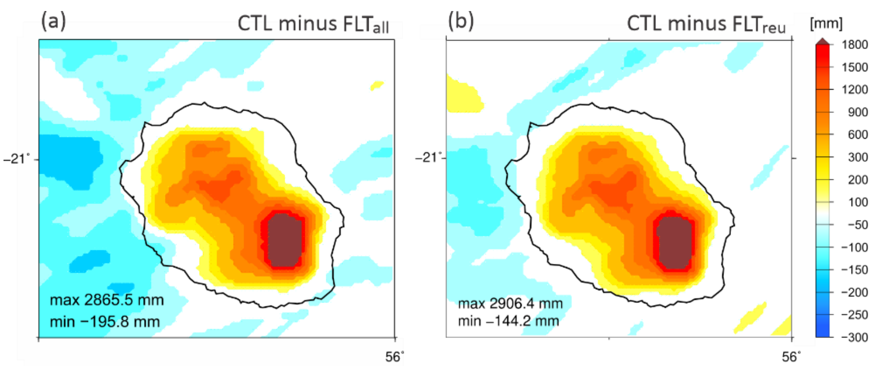



Figure S1. The difference in five-day accumulated precipitation (a) between CTL and $FLT_{all}$ (CTL minus $FLT_{all}$), and (b) CTL and $FLT_{reu}$ (CTL minus $FLT_{reu}$).

Figure 7: I suggest to show here just the differences and move the values of CTL to the supplement.

Revised.

Figure 8: replace “Reunion” with “Réunion” for consistency.

Corrected.

Line 345: seems to be a space between “regio” and “n”.

Corrected.

Line 348: in order to make it clear to the reader, please specify that the grey-shaded areas are just for the control simulation.

Corrected.

♣ caption of Figure 8

“[…] The grey-shaded areas highlight period during which precipitation ≥ 10 mm $h^{-1}$ persists in CTL experiment. […]”

Figure 9 and Figure 10: I suggest to combine Figure 9 and 10 into one single plot showing differences in the reflectivity between both simulations and then keep the plots showing low-level moisture flux as they are. Plots with the simulated reflectivity could be included in the supplement. Besides, the line with the cross section is difficult to see in its current color and the dashed lines in figure 9 are not mentioned in the caption. Please, add a brief explanation for clarity.

Thank you for the nice suggestions. In this study, however it is important to show that rainfall enhancement was actively and continuously occurred over the mountainous region of Réunion Island. Authors believe that by showing reflectivity distributions at three selected times, readers can understand better not only the consistent strong rainfall over the island in relation to TC movement, but also its link to the orographically modified low-level wind fields. Thus authors kindly propose to keep the figures as they are. In the meantime, the cross-section line has been depicted with a black solid line for better readability, while the dashed lines in Figure 9 are explained in the caption.

♣ caption of Figure 9

“[…] Figure 9. Horizontal distributions of CTL-simulated reflectivity at 3 km above sea level in panels (a)–(c) and low-level moisture flux convergence below 3 km in panels (d)–(f) at 12 UTC on 2 February, 00 and 12 UTC on 3 February 2022. The inner boxes in panels (a)–(c) indicate the domains shown in panels (d)–(f). The black solid line in panel (e) marks the location of the vertical cross-section along A–B used in Fig. 11. The green dashed ellipses in panels (d) and (e) indicate locally produced low-level wind convergence on the windward side, while the blue dashed ellipse in panel (e) indicates wind convergence on the lee side. The yellow ellipse in panel (a) shows the area of wind divergence on the windward side.”

Line 373: include a brief description of the Froude number is and how it is calculated.

Added.

♣ Page 17, lines 437–440

"[…] Relatively weak southeasterly flow (8–10 m $s^{-1}$) prevailed at low altitudes around the island, generating a relatively small Froude number ($Fr \leq 0.3$). $Fr$ is a dimensionless parameter defined as $Fr = U_0 / Nh$, where $U_0$ is the mean wind speed below the terrain height, $N$ is the Brunt-Vaisala frequency, and $h$ is the height of the mountain peak; $Fr$ is proportional to the square root of the ratio of upstream flow's kinetic energy required to lift a fluid parcel over the terrain. Under such small-$Fr$ condition, low-level winds flowed around the terrain, generating two distinct wind structures […]"

Line 377: change "In contract" for "In contrast".

Corrected.

Figure 11: change the color of the topography to brown, for example, to avoid having similar color as those included in the color bar for potential temperature.

Corrected.

♣ Page 19, Figure 11

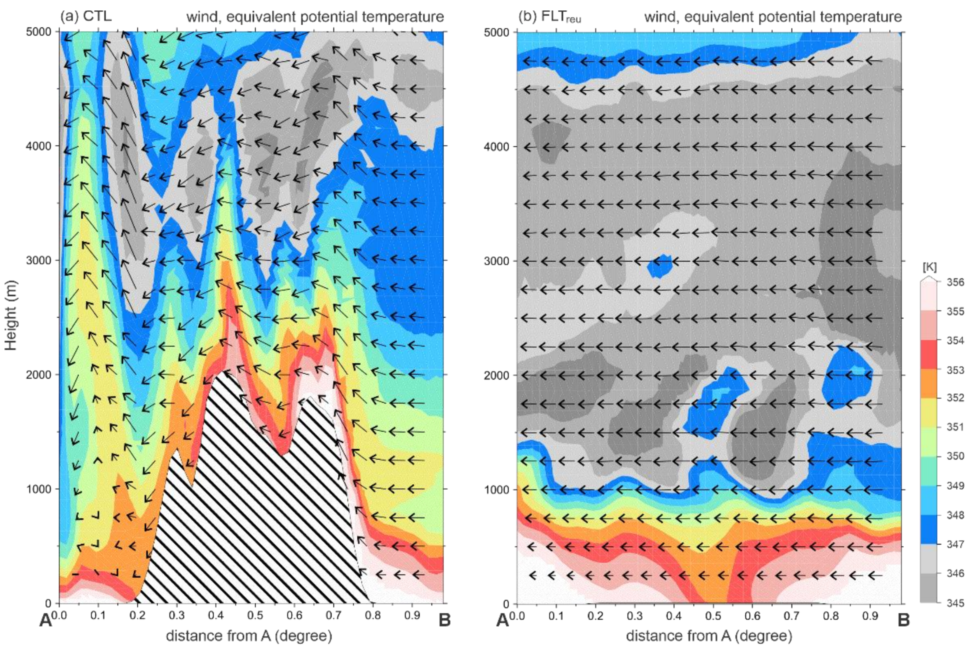



Figure 11. Vertical cross-sections of wind (u–w vectors) and equivalent potential temperature ($\theta_e$, shaded) along the A–B line, simulated by (a) CTL and (b) $FLT_{reu}$ at 00 UTC on 3 February. The location of the A–B line is shown by the green solid line in Figs. 9e and 10e for the CTL and $FLT_{reu}$ simulations, respectively. The hatched area in (a) represents the topography.

Line 483: “redish region...”. Same comment as in line 311.

Revised.

♣ Page 21, line 580

“[…] with strong low-level upward motion (≥ 1.5 m $s^{-1}$, red shades in Fig. 12d).”

Figure 12: the black dashed line is difficult to see now. Please consider changing color of thickness. For Figure 12 and 13, I suggest to do the same as I suggested for Figures 9 and 10. but here mentioning that the times taking for the comparison between CTL and FLT_all are different despite showing the same location.

The dashed line is thickened, while authors kindly propose to keep Figures 12 and 13 as they are with an identical reason for keeping Figures 9 and 11.

♣ Page 22, Figure 12

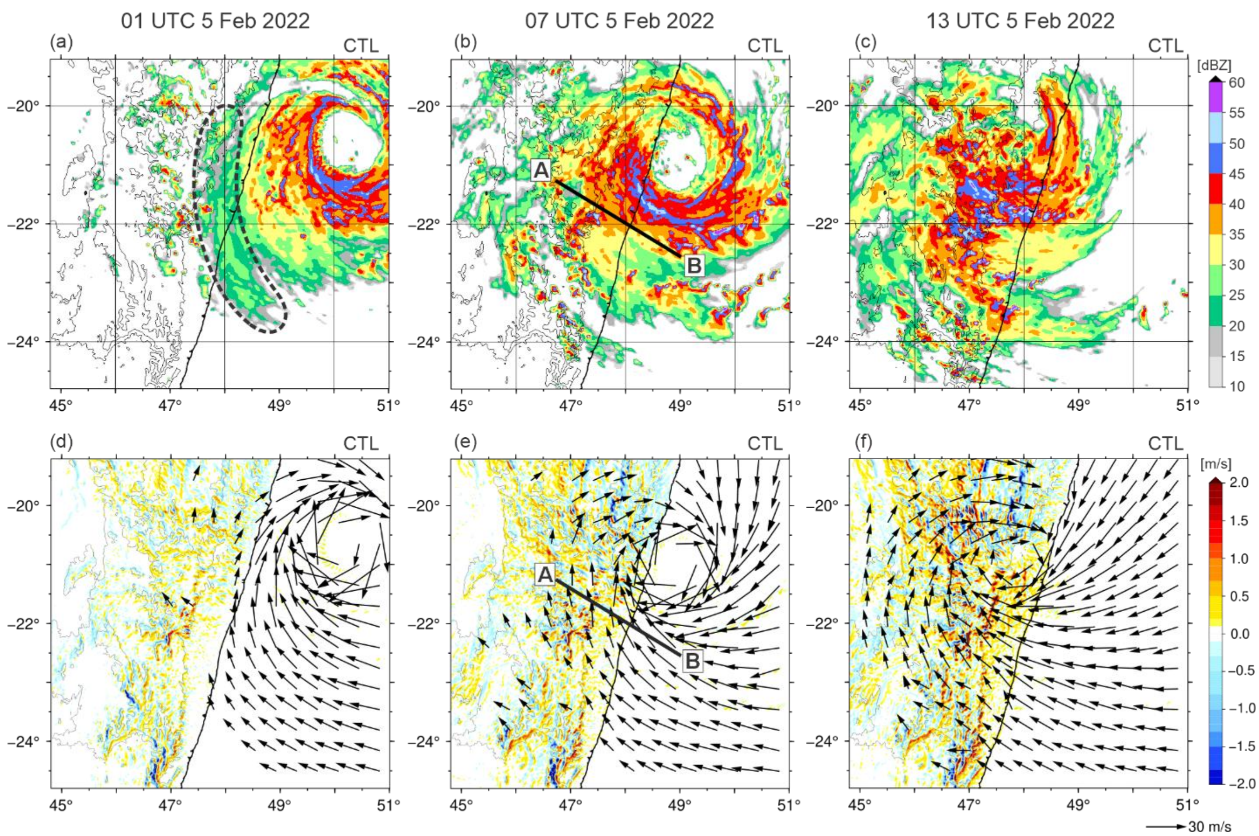



Figure 12. Horizontal distributions of CTL-simulated (a–c) reflectivity at 3 km above sea level and (d–f) vertical velocity at 20 m above sea level at 01, 07, and 13 UTC on 5 February 2022. The southeastern coastline of Madagascar is indicated by a thick solid line, and topographic contours at 500 m intervals are shown by thin solid lines in all panels. Horizontal wind vectors exceeding 10 m $s^{-1}$ are shown. The location of the vertical cross section along A–B used in Fig. 14 is marked by a black solid line in panels (b) and (e).

Figure 14: Same comment for the color of the topography as in Figure 11. The dashed line is also difficult to see. Please change its color or thickness.

Revised as suggested.

♣ Page 25, Figure 14

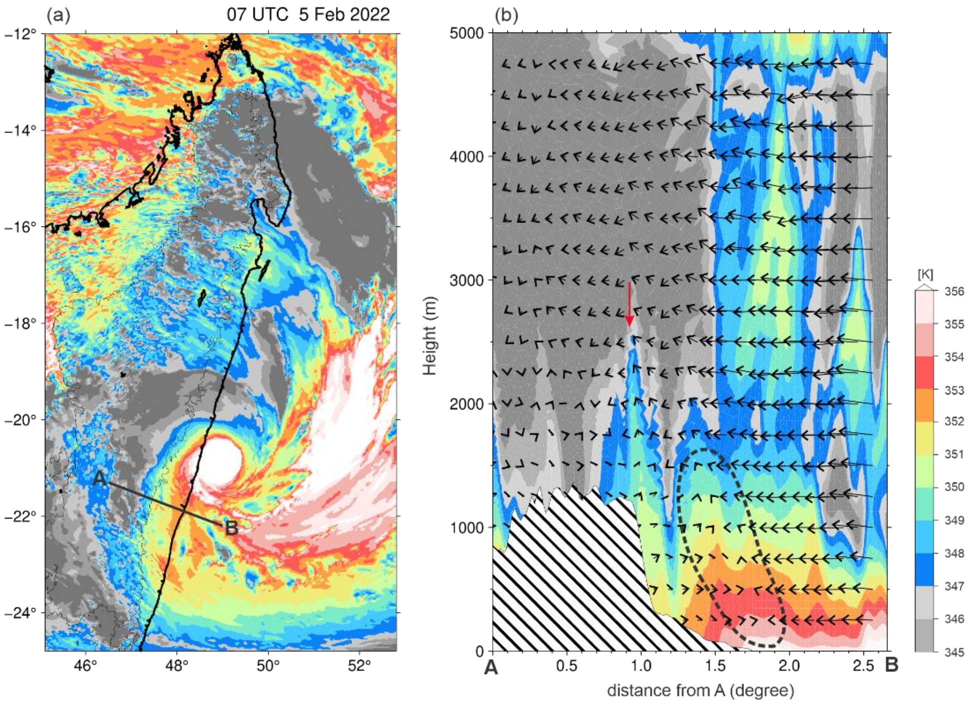



Figure 14. Horizontal and vertical distributions of CTL-simulated equivalent potential temperature ($\theta_e$) over the Madagascar region at 07 UTC on 5 February 2022. Panel (a) shows the horizontal map with the A-B line indicating the location of the vertical cross section, which is presented in panel (b).

Line 611: it would be interesting to see how the other modes affect the genesis of the typhoon. Perhaps in the supplement.

Right. Tropical cyclones developing in the southwest Indian Ocean basin are often strongly influenced by seasonal to sub-seasonal drivers such as monsoon-trough variability, MJO phases, ENSO/IOD modulation, subtropical-ridge position, equatorial Rossby wave, and Kelvin wave. Their effects on the TC life cycle, including genesis, intensification, and duration, have not been thoroughly examined to date. Within the framework of an EU project currently carried out by our team, we have been investigating this research objective and hope to share the results with the community in the near future.

Line 660: the DOI here does not belong to this citation.

Revised in line 774 (page 30).

Referee #2 comments

**Summary general Comments**

This paper investigates the orographic effects of a small island (Réunion Island) and a medium-sized island (Madagascar) on tropical cyclone (TC) track, intensity, and precipitation. The authors conducted a control experiment together with three sensitivity experiments with modified orography. The results show that the orography of Réunion Island has little impact on the TC track, while it plays an important role in controlling heavy precipitation over the island. In contrast, the orography of Madagascar slightly modifies the TC track and contributes significantly to heavy rainfall on the windward side of the island. The study clearly demonstrates the influence of island topography on TC behavior and associated precipitation. These findings are important for improving our understanding of orographic enhancement of TC-induced rainfall.

Overall, the manuscript is logically organized, and the scientific results are clearly presented. The reviewer finds the study valuable and believes that the manuscript has the potential to be accepted for publication. However, several issues should be addressed before publication. The reviewer kindly requests that the authors consider the following comments in revising the manuscript.

We sincerely appreciate the time and effort you have devoted to reviewing our manuscript, as well as your insightful and constructive comments. We have carefully revised the manuscript in response to the reviewer's valuable suggestions. Our point-by-point responses to each comment are provided below.

**Major issue:**

Lines 318-333: In this study, the authors compare the CTL experiment with the FLTall experiment and conclude that the peak precipitation and the duration of heavy rainfall are significantly reduced in FLTall. However, the reviewer believes that the comparison should be made between CTL and FLTreu rather than between CTL and FLTall. As shown in Figure 6, the storm tracks in CTL and FLTreu are very similar, whereas those in CTL and FLTall differ by approximately 40 km. According to Figures 9 and 10, such a difference appears to be important because it changes the relative position of Réunion Island with respect to the storm structure. In CTL, Réunion Island is located beneath the outer rainband, whereas in FLTall it is situated between the outer and inner rainbands. This suggests that the precipitation weakened more rapidly in FLTall, resulting in a shorter duration of heavy rainfall. Since CTL and FLTreu exhibit similar tracks and similar locations of the outer rainband, it is expected that the persistence of precipitation in FLTreu would be comparable to that in CTL. Therefore, the reviewer kindly recommends that FLTreu, rather than FLTall, be used for the comparison to isolate the effect of the orography of Réunion Island.

We fully agree with the reviewer's comment. Changes in the TC's position relative to Réunion Island between $FLT_{all}$ and $FLT_{reu}$ can affect local precipitation, particularly its timing, duration, and location. Because the TC trajectory in $FLT_{reu}$ closely resembles that in CTL, using $FLT_{reu}$ instead helps to more clearly isolate the terrain effect of Réunion Island on local heavy precipitation. As suggested, we have reproduced Figures 8a, 10, and 11 using $FLT_{reu}$ instead of $FLT_{all}$; the relevant explanations are revised.

♣ Page 15, Figure 8a

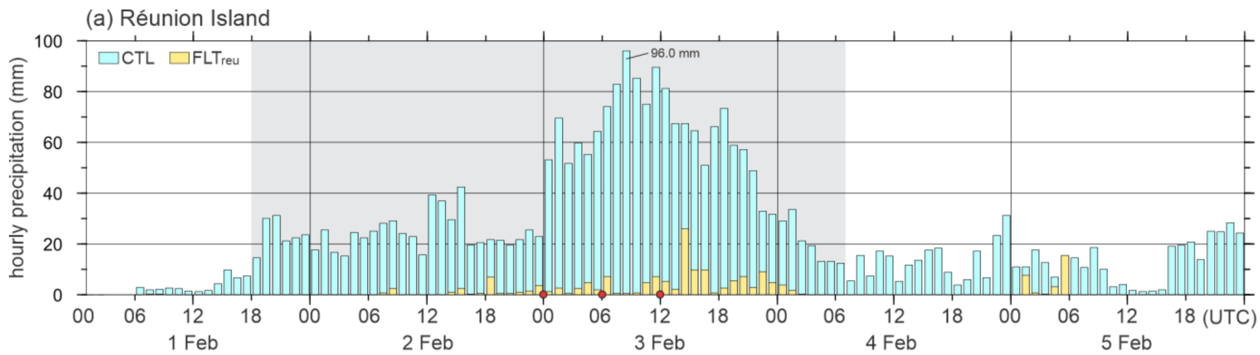



**Figure 8.** Temporal evolution of the simulated maximum precipitation within the analysis domains: (a) the Réunion Island region, from the CTL (light blue bars) and *FLT*$_{reu}$ (yellow bars) experiments, and (b) the eastern Madagascar region, from the CTL (light blue bars) and *FLT*$_{all}$ (yellow bars) experiments. The horizontal extent of the analysis domains is shown by the boxes in Fig. 7. Red circles along the x-axis indicate the selected times presented in Figs. 9, 10, and 12. The grey-shaded areas highlight period during which precipitation ≥ 10 mm h$^{-1}$ persists in CTL experiment. Results of the first 6 hours of the spin-up period were excluded from the analysis.

The two key message obtained from Figure 8a with *FLT*$_{reu}$ remain identical to those captured with *FLT*$_{all}$: (i) persistent heavy precipitation lasting about 60 hours in CTL, and (ii) only a few hours of heavy precipitation (3 hours in *FLT*$_{reu}$ *versus* 4 hours in *FLT*$_{all}$) simulated with the flat island.

♣ Page 13, lines 356–378

"A box centered on Réunion Island (55–56°E, 20.8–21.5°S; rectangle in Fig. 7) is used to analyze hourly precipitation over land during the passage of TC Batsirai. The five-day evolution of the maximum hourly precipitation over Réunion Island (Fig. 8a) reveals (i) persistent heavy precipitation (≥ 10 mm h$^{-1}$) lasting approximately 60 hours in CTL (light blue bars within the grey-shaded period from 18 UTC on 1 February to 07 UTC on 4 February), whereas (ii) only three hours of heavy precipitation are simulated in *FLT*$_{reu}$ (yellow bars from 14 UTC to 16 UTC on 3 February). During this period, the peak hourly precipitation reaches 96 mm h$^{-1}$ in CTL, compared to only 26 mm h$^{-1}$ in *FLT*$_{reu}$. A sharp increase in hourly precipitation to above 50 mm h$^{-1}$ occurs at 00 UTC on 3 February in CTL, and very intense precipitation (≥ 50 mm h$^{-1}$) persists for nearly one day while TC Batsirai passes near Réunion Island (section ii marked in Fig. 6a). After 4 February, when the TC moves away from the island, *FLT*$_{reu}$ produces little to no precipitation, whereas CTL continues to simulate weak to intense precipitation ranging from 2 to 30 mm h$^{-1}$. […]"

♣ Page 17, Figure 10

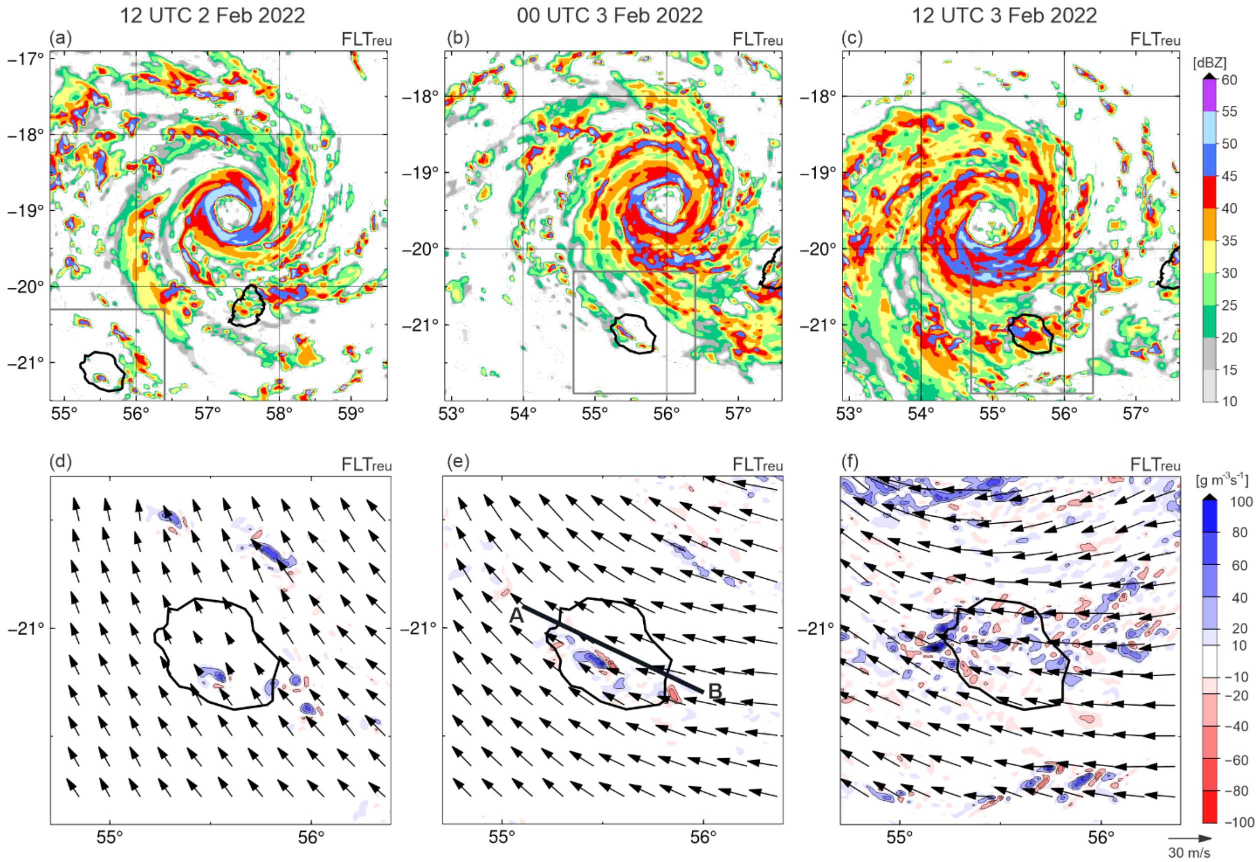



Figure 10. Same as Fig. 9, but showing horizontal distributions of reflectivity at 3 km above sea level (a–c) and low-level moisture flux convergence below 3 km (d–f) from the *FLT$_{reu}$* simulation.

The key message obtained from Figure 10 with *FLT$_{reu}$*, by comparing it with CTL, remains identical to that captured with *FLT$_{all}$*. While the positions of the TC center in CTL and *FLT$_{reu}$* were very close to each other, the orographically-induced low-level wind deflections simulated in CTL were absent in *FLT$_{reu}$*, as similarly seen in *FLT$_{all}$*.

♣ Page 18, line 446

"[…] In contrast, these wind structures are absent in FLT$_{reu}$ at the same time […]"

♣ Page 18, lines 46–464

"In contrast, the strong reflectivity cores and organized low-level moisture flux patterns evident in CTL at 00 UTC are absent in *FLT$_{reu}$* at the same time (Figs. 10b, e). While the positions of the TC center in CTL and *FLT$_{reu}$* were similarly located between 19° and 20°S (Figs. 9a–c, 10a–c), spiral rainbands passed over Réunion Island. Unlike in CTL, relatively strong reflectivity and pairs of convergence and divergence were seen in *FLT$_{reu}$* only where the convective clouds existed within the spiral rainbands."

♣ Page 19, lines 508–510

"[...] In contrast, in *FLT$_{reu}$* (Figs. 10b–c, 10e–f), the convective regions and orographically induced wind patterns observed in CTL are absent. Instead, increased reflectivity and wind convergences associated with convective clouds within the spiral rainbands are apparent as similarly produced in CTL (Fig. 9)."

♣ Page 19, Figure 11

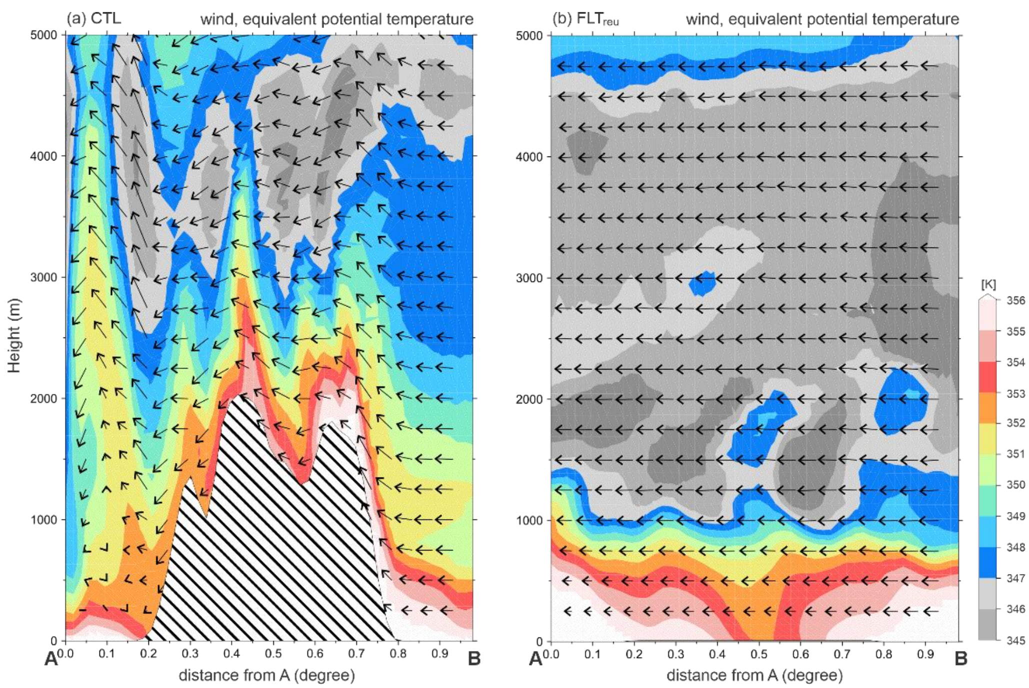



Figure 11. Vertical cross-sections of wind (u–w vectors) and equivalent potential temperature ($\theta_e$, shaded) along the A–B line, simulated by (a) CTL and (b) *FLT$_{reu}$* at 00 UTC on 3 February. The location of the A–B line is shown by the green solid line in Figs. 9e and 10e for the CTL and *FLT$_{reu}$* simulations, respectively. The hatched area in (a) represents the topography.

The key message saying the absence of vertically extended warm and moist air mass ($\vartheta_e \geq 352$ K) along the terrain from the surface up to about 4 km above sea level in *FLT$_{reu}$*, remains identical as seen in *FLT$_{all}$*.

♣ Page 19, lines 496–500

"[...] In contrast, in *FLT$_{reu}$* (Fig. 11b), the warm and moist air ($\vartheta_e \geq 352$ K) remains confined below 1 km, and is distributed relatively homogeneously along the cross-section, with a drier air mass ($\vartheta_e \leq 350$ K) above. The comparison between CTL and *FLT$_{reu}$* (Fig. 11) clearly demonstrates that the high terrain of Réunion Island plays a critical role in lifting the abundant low-level moisture advected by TC Batsirai to altitudes above 4 km on the windward side and near the mountain crest, thereby contributing to the intense precipitation over the mountainous region."

**Specific points:**

1. Lines12-13: The statement that "the terrain of Réunion and Madagascar enhanced localized rainfall by 94% (2800 mm) and 82% (830 mm), respectively" is unclear. Does this imply that the increase in rainfall from the FLTxxx experiments to the CTL experiment corresponds to 94% and 82% of the rainfall amounts in the FLTxxx experiments? If so, this interpretation does not appear to be consistent with the presented results. The reviewer kindly requests that the authors clarify the basis of these percentages and explain more explicitly what is meant by these values.

---

As suggested, we have reclarified the percentages. To estimate the rainfall enhancement over Réunion Island, we compared the maximum 5-day rainfall accumulation between the CTL and $FLT_{reu}$ experiments (3032 mm versus 126 mm, respectively), giving an enhancement of 95 %. Following another anonymous referee's suggestion, $FLT_{all}$ has been replaced by $FLT_{reu}$, as the latter produces a TC trajectory closer to CTL near Réunion Island.

For the rainfall enhancement over Madagascar, the same calculation was applied using CTL and $FTL_{all}$ experiments (1007 mm versus 177 mm, respectively), giving an enhancement of 82 %.

For readability, the corresponding sentence in the manuscript has been rewritten as below, and an additional Figure S1 has been added to the Supplement.

♣ Page 1, lines 12–14

"Relative to the flattened-terrain experiments, the presence of terrain increased localized rainfall by 95 % (2,906 mm) over Réunion Island (CTL versus $FLT_{reu}$) and by 82 % (830 mm) over Madagascar (CTL versus $FLT_{all}$)."

♣ Page 13, lines 346–349

"The simulated localized heavy precipitation over the mountainous region of Réunion Island is absent in $FLT_{reu}$, in a manner nearly identical to $FLT_{all}$. The difference in five-day accumulated precipitation between CTL and $FLT_{reu}$ (Fig. S1b) indicates that approximately 95% of the localized heavy precipitation (e.g. 2.906 mm) can be attributed to the steep terrain of Réunion Island."

♣ Supplement file

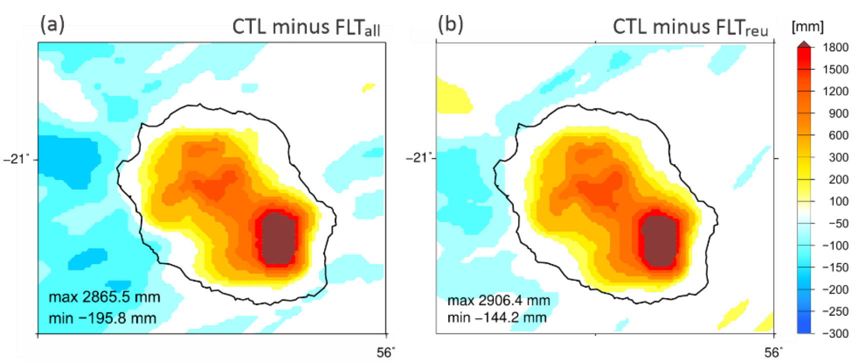



Figure S1. The difference in five-day accumulated precipitation (a) between CTL and $FLT_{all}$ (CTL minus $FLT_{all}$), and (b) CTL and $FLT_{reu}$ (CTL minus $FLT_{reu}$).

2. Line 169: What is "a monotonic Piecewise Parabolic Method"? a brief explanation is necessary for this.

---

As suggested, a brief explanation is included.

♣ Page 7, lines 179–183

"In conjunction with the leapfrog temporal scheme, momentum variables are advected using a centered fourth-order scheme, whereas scalar and other meteorological variables were advected using a monotonic Piecewise Parabolic Method (PPM; Colella and Woodward, 1984). The monotonic variant of PPM applies a limiter that constrains the reconstructed parabolic profiles, preventing spurious oscillations and negative values near sharp gradients and thereby ensuring physically realistic transport of scalars such as moisture and hydrometeors."

3. Line 199: The expression "the lee side of Réunion" is ambiguous. A more specific description should be provided to clearly indicate the region being referred to.

---

Improved.

♣ Page 8, lines 220–221

"After passing offshore of the northwest of Réunion Island […]"

4. Lines 267-270: The authors attribute the discrepancy between the observed and simulated precipitation amounts to an overestimation in the CTL simulation. However, another possible explanation should also be considered. The rain gauges located near the summit region of Réunion Island may have suffered from reduced catch efficiency under strong wind conditions, which could have resulted in an underestimation of the observed precipitation.

---

We totally agreed. An additional sentence is added in this context.

♣ Page 11, lines 295–297

"[…] It should also be noted that the rain gauge network in the mountainous region has a relatively coarse spatial resolution. Additionally, rain gauges located near the summit may have suffered from reduced catch efficiency under strong wind conditions, which could have led to an underestimation of observed precipitation."

5. Lines 331-333: This issue may be related to the major comment above. Why does the CTL experiment produce prolonged precipitation after 4 February? The authors should provide a physical explanation for the persistence of rainfall during this period.

---

An additional sentence for a physical explanation is added.

♣ Page 14, lines 377–381

"[…] After 4 February, when the TC moves away from the island, $FLT_{all}$ produces little to no precipitation, whereas CTL continues to simulate weak to intense precipitation ranging from 2 to 30 mm h$^{-1}$. Even with the TC at a distance, southwesterlies prevailed around the Réunion Island region, supplying low-level moisture toward the mountain slopes (data not shown). The consistent ascent of this moist air along the slope prolongs the precipitation. ”

6. Lines 426-427: This issue may also be related to the major comment above. The absence of convective regions in FLTall may be attributed to the different relative position of Réunion Island with respect to the outer spiral rainband compared with CTL.

By using $FLT_{reu}$ instead off $FLT_{all}$, the position of the TC center relative to Réunion Island in $FLT_{reu}$ remains very close to that in the CTL experiment. Thus, convective regions within spiral rainbands are produced similarly in $FLT_{reu}$ and CTL, allowing us to focus on the orographic effect of Réunion Island on precipitation and the corresponding local wind modification. The sentences have been revised (see our reply to the major comment above).

7. Line 454: The “minimum difference” may be “maximum difference”.

Corrected.

8. Lines 609-610: If the authors claim that equatorial Rossby waves play a dominant role in TC genesis, they should provide supporting evidence for this statement.

TCs developing in the SWIO basin are often strongly influenced by seasonal to sub-seasonal scale drivers such as Madden-Julien Oscillation (MJO), ENSO/IOD (Indian Ocean Dipole) modulation, subtropical-ridge, equatorial Rossby wave, and Kelvin waves (Bonnardot et al., 2022), particularly in terms of TC genesis and trajectory; however, their impacts on local heavy precipitation have not yet been examined. Prior to the genesis of TC Batsirai, we found that equatorial Rossby waves appeared to play a dominant role among the sub-seasonal drivers, compared with other modes such as the MJO. The influence of equatorial Rossby waves in modulating the genesis and trajectory of TC Batsirai would therefore be an interesting topic for future research. In the meantime, however, we decided to exclude this discussion here in order to keep the present study more focused and constructive.