RC2:

This manuscript deals with the quantitative estimation of rainfall in the south-west Indian Ocean, more particularly on Réunion Island where the orographic enhancement of rainfall can be very significant. A polarisation diversity X-band research radar was installed and tested. The authors state that this is the first search radar of this type to be deployed in this region of the world. The authors chose as a case study the passage of cyclone Batsirai in February 2022. They propose to compare the rainfall estimates obtained by radar using data from 6 rain gauges available on the island as a reference. Two radar rain intensity estimators were tested: the first based on the radar reflectivity factor Z, the second on the specific differential phase Kdp. For the first estimator, which is very sensitive to attenuation by precipitation, two attenuation correction methods were applied and evaluated: the method of Hitschfeld and Bordan (1954) and the so-called phi-linear method of Bringi et al. (1990). The authors confirmed the results of the literature on the subject: the fact that the second correction method is more reliable than the first and that the estimate with Kdp is more efficient for intense precipitation than the Z estimator. A third method, directly deriving the rainfall intensity from Kdp is also used and compared.

This article does not provide any new knowledge per se, but reports on the first quantitative rainfall estimates using polarisation diversity search radar in the south-west Indian Ocean. Section 2 is interesting because it provides a detailed description of the differential phase shift pre-processing.

In my opinion, some points in the article need to be corrected or clarified, in particular certain equations. It is a pity that the operational radar data available from the National Meteorological Centre is not used (or that its use is not discussed) in this study. In addition, the study only covers one case study, which does not provide a robust assessment. The case chosen corresponds to a very specific cyclone situation. This is both a strength (the type of event is poorly documented, particularly the interaction with the terrain) and a weakness (there are doubts about the quality of the reference intensities provided by the rain gauges under these conditions, which makes it more difficult to compare radar and rain gauge estimates).

We thank the reviewer for the time devoted to evaluating our manuscript. The comments provided are highly valuable and have helped us to improve the clarity and accuracy of the work.

Questions and suggestions:

- **Page 2, Line 43: Are the S-band radar data usable? Could they have been used?**

S-band radars are operational in Reunion and the data are usable. However, the operational radar in southern Réunion (Piton Viler) is located at an altitude of 1,700 m, and the ESPOIRS radar at an altitude of 20 m. So, there is no measurement of operational radar bellow 1700m of altitude. In addition, the coverage of the operational radar is significantly affected by terrain blocking (see figure below). In our area of interest (southern Réunion), the radar beam is masked by the terrain. The mountain peaks, where precipitation has been most intense and where reflectivity attenuation is particularly significant, are mainly masked by more than 50%. These are the reasons why we rely exclusively on comparisons with rain gauges.

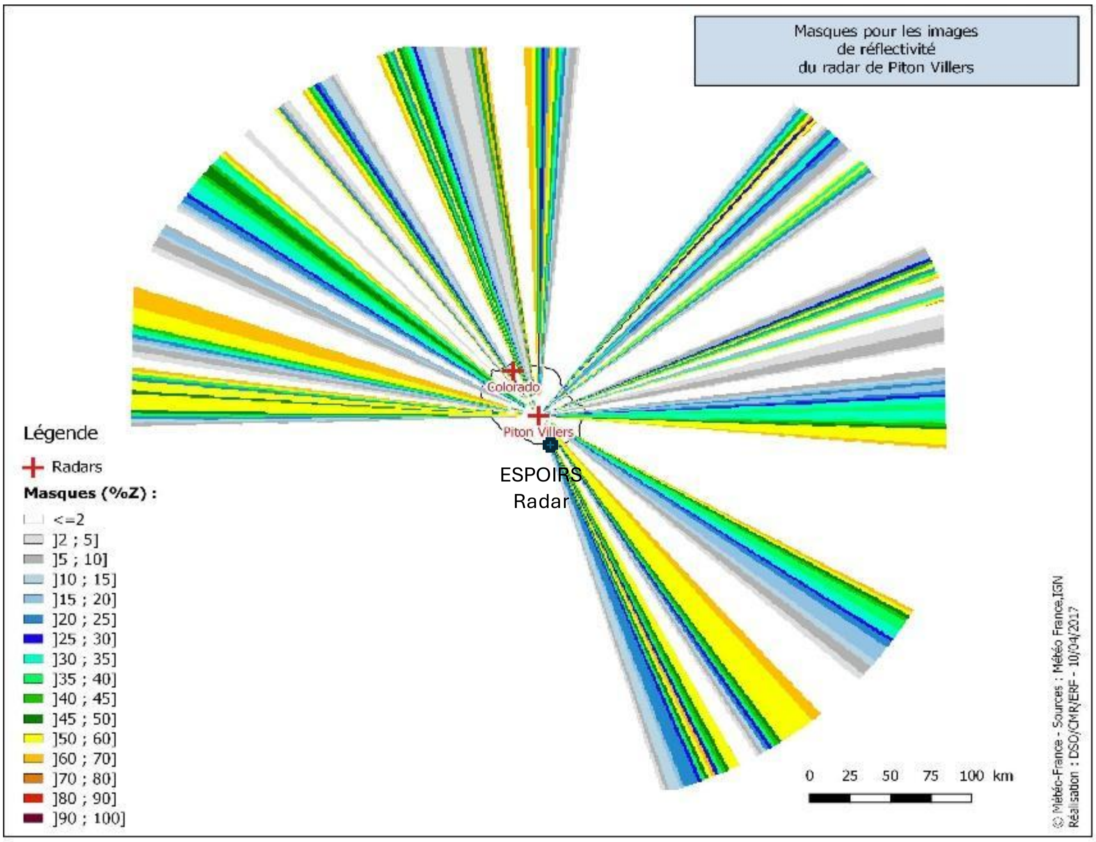

Figure 1.2: Mask of reflectivity (%) from two operational S-band radars. The primary purpose of these radars is to monitor tropical cyclones approaching Réunion Island.

- **Page 2, Line 53: The reference to Krämer and Verworn is only a conference paper, and therefore not peer-reviewed. Does it really provide information that would not be available in peer-reviewed articles published in peer-reviewed journals?**

  Indeed, in this paper, we cited the first version from conference. the DOI for the published paper is https://doi.org/10.2166/wst.2009.282, we will change this reference on revised manuscript.

- **Page 2, Line 58: define the variable (total differential phase shift) and make a reference to section 2.2.2.1**

  Well noted, thank you for the suggestion.

- **Page 2, Line 62: Isn't it too ambitious and sufficiently robust to reproduce this R-KDP law on a single case study?**

  We acknowledge that the sample considered in this study is limited. When applying the $R(K_{dp})$relationship from Beard and Chuang (1987), we observed an overestimation of rainfall. We hypothesize that this bias may be related to the specific characteristics of tropical cyclones, where the raindrop size distribution (DSD) differs from the climatological values used to derive the original $R(K_{dp})$coefficients. This motivated us to reproduce $R(K_{dp})$relationship based on our own observational data.

  (We have provided a detailed response in Reviewer 1's comment, as follow:

  At the outset of our study, we tested the standard relationship, because the R(kdp) for X-band radar for South West Indian Ocean has not yet been calculated:

  $$R = c' \left(\frac{K_{dp}}{f}\right)^{d} \quad (1)$$

  where f is the frequency of the radar in GHz (f = 9.40Ghz for the ESPOIRS Radar). We applied the parameters c' = 129 and d = 0.85, which are derived from drop equilibrium shape distributions (Beard and Chuang, 1987)*and have been validated for long-term French polarimetric radars* (Figueras I Ventura et al., 2012)*.*

  Equation 1 becomes:

  $$R = 19\left(K_{dp}\right)^{0.85} \quad (2)$$

  However, our results showed a clear overestimation with the radar-derived rainfall rates R(kdp), even for Group 2 rain gauges, where the highest rainfall intensities were recorded during the tropical cyclone.

Therefore, we calculated the coefficient of R(Kdp) from our radar observations. However, as noticed by the reviewer, the derived coefficients (a = 8.062, b = 0.49) fall outside the expected range for X-band radars (a = 14–20, b = 0.73–0.85) reported in Ryzhkov and Zrnić (2019). We acknowledge this discrepancy and provide the following explanations:

The coefficients of R(Kdp) relationships are highly sensitive to DSD characteristics, which vary significantly by precipitation regime (Unuma et al., 2025)*. Tropical cyclones exhibit distinct DSD properties compared to climatological rainfall: i) high concentrations of small and midsize raindrops; ii) relatively few large raindrops (exceed rarely 4mm); iii) elevated drop number concentrations at given reflectivity levels. These features have been documented in observational studies of Atlantic tropical cyclones* (Tokay et al., 2008)*.*

K_{dp} *is strongly influenced by both the size and number of drops* (Timothy et al., 1999)*.. Higher drop concentrations lead to larger* K_{dp}*values for a given rainfall rate.*

Therefore, the interpretation of R(kdp) coefficients proposed by this paper is as follow:

- *Lower coefficient a (8.062 vs. 14–20): high drop concentrations producing higher Kdp during tropical cyclone.*
- *Lower exponent b (0.49 vs. 0.73–0.85): a weaker power-law relationship, indicating less sensitivity of R to Kdp changes, which may reflect the more uniform DSD characteristics in tropical cyclone precipitation.*

Unfortunately, no disdrometer measurements were available during this event, we could not investigate the DSD.

We fully acknowledge the limited scope of our empirical derivation. Ideally, a comprehensive investigation across multiple tropical cyclone events would strengthen the robustness of TC-specific R(Kdp) relationship. However, the logistical constraints of the mobile radar deployment during this project precluded such extensive sampling (detailed bellow, P.8).

This finding opens promising research avenues for investigating tropical-cyclone-specific $R(K_{dp})$ *relationships for X-band radar, using disdrometer data and T-matrix scattering simulations. These theoretical calculations, based on observed TC-specific DSDs, provide an independent verification of* K_{dp} *behavior.)*

- **Page 5, line 100-105, table 2: It is preferable to specify how beamwidth is defined: 3 dB? 6 dB?**

  The beamwidth is defined with 3dB. This will specified in the revised version.

- **Page 7, figure 2: first sub-figure "Crête", the value of the vertical distance between radar beam and rain gauge should be 350 m and not 659 m. 659 m" should be replaced by "350 m" to be consistent with Table 2.**

  Well noted, we will correct it in revised version

- **Page 8, Lines 170, 172 and figure 3: make the information consistent. The text indicates phi_dp<0.85 whereas the figure indicates phi_dp >0.85. However, it is consistent for and SNRH >3 in both the text and the figure.**

  Thank you for pointing that out. We will correct it.

- **Page 8, Line 180: separate "to" and "derive"; Page 10, Ligne 231: « db » to be replaced by « dB »**

  Well noted and thank you, it will be corrected for the revised version.

- **Page 10, Line 231: give the unit of Z here (is it dBZ or mm-/m3 ?)**

  The unit of $Z\ is\ (mm^6 m^{-3})$.

- **Page 10, line 230-232: The equation and the values of c and d are not mentioned in the proposed reference of Berne and Uijlenjoet (2006). Please cite a reference that use this expression and these values. Moreover, usually, these coefficients c and d correspond to a relationship between specific attenuation (dB/km) and reflectivity factor expressed in mm6/m3 (and not in dBZ). Please mention clearly the units of each variable in all the equations.**

  This value was taken from Tridon(2011), page 125, first paragraph), where he reports alpha = 112000 and beta = 1.32, originally from (Berne and Uijlenhoet, 2006).

  The relationship between reflectivity factor Z[$mm^6\ m^{-3}$] and specific attenuation A[$dB\ km^{-1}$] is written as

  $$Z = \alpha A^{\beta} \tag{1}$$

  From equation 1:

  $$A = \left(\frac{Z}{\alpha}\right)^{\frac{1}{\beta}} = \alpha^{-\frac{1}{\beta}} Z^{\frac{1}{\beta}} \tag{2}$$

  Hitschfeld and Bordan (1954) express the specific attenuation as a power law of the form:

  $$A = aZ^{b} \tag{3}$$

By comparing equations 2 and 3, the coefficients a and b are expressed as:

$$b = \frac{1}{\beta} \quad ; \quad a = \alpha^{-\frac{1}{\beta}} \tag{4}$$

Since β = 1.32 and $\alpha = 112000$ as mentioned above:

$$b = 0.757$$

$$a = 1.49 \times 10^{-4}$$

- **Page 10, Line 235: I think relationship (3) is wrong. The prefactor c and the exponent d would be applied twice, which seems wrong to me.**

  We identified this mistake after submitting the manuscript, and we thank the reviewer for pointing it out. The corrected equation is provided below. However, this correction does not affect our results because the processing was performed using the open-source implementation in wradlib, which already uses the correct formulation.

  https://docs.wradlib.org/en/2.2.0/generated/wradlib.atten.correct_attenuation_hb.html#wradlib.atten.correct_attenuation_hb

$$PIA = \sum_{i=1}^{N} 2A_i \Delta r \tag{5}$$

  Where N is the number of the gate, Δr is the radial gate length or range resolution in [m], for each gate i :

$$A_i[\,dB\ km^{-1}] = aZ_i^b \tag{6}$$

  and $Z_i[mm^6\ m^{-3}]$ is the reflectivity factor.

  Thus, the full expression becomes:

$$PIA\ [dB] = \sum_{i=1}^{N} 2\left(aZ_i^b\right)\Delta r \tag{7}$$

- **Page 10, Line 245: Equation (6) is exactly the same as equation (4), so is it necessary to duplicate it?**

  Indeed, it is the same equation, and we have taken this suggestion into account for the revised version of the article.

- **Page 10, Line 258: "mie" -> "Mie".** Well noted, thank you

- **Page 14, Line 331-334: It is clear that only one event (cyclone Batsirai in early February 2022) is used to determine this R-Kdp relationship. This is very little to ensure a minimum of robustness. Moreover, it gives the impression that rain gauge data are used both to establish this relationship and to assess it. This raises the question of the independence between the rain gauge data used to establish the Kdp-R relationship and those used to evaluate the quantitative estimates made using this relationship: has the dataset been split in two to carry out these two operations?**

  We thank the reviewer for this important question. To ensure the independence of the data, we split it into training and test datasets.

  The calculation of $R(K_{dp})$was performed as follows:

  The rain-gauge data have a 6-minute temporal resolution, whereas the radar K_{dp}estimates are available every 10 minutes. To ensure a consistent comparison, both datasets were aggregated to a common 30-minute temporal resolution. A 30-minute interval was retained only if valid measurements were available for both rainfall and K_{dp}.

  Since K_{dp}values close to zero may correspond either to light precipitation or to unreliable estimates, only strictly positive K_{dp}values were considered. Any interval containing missing or non-positive K_{dp}values was discarded. After applying these filters and separating the data into training and test sets, only 82 samples met the quality criteria and were included in the analysis.

- **Page 15, figure 7: Put the units of the variables on the axes.**

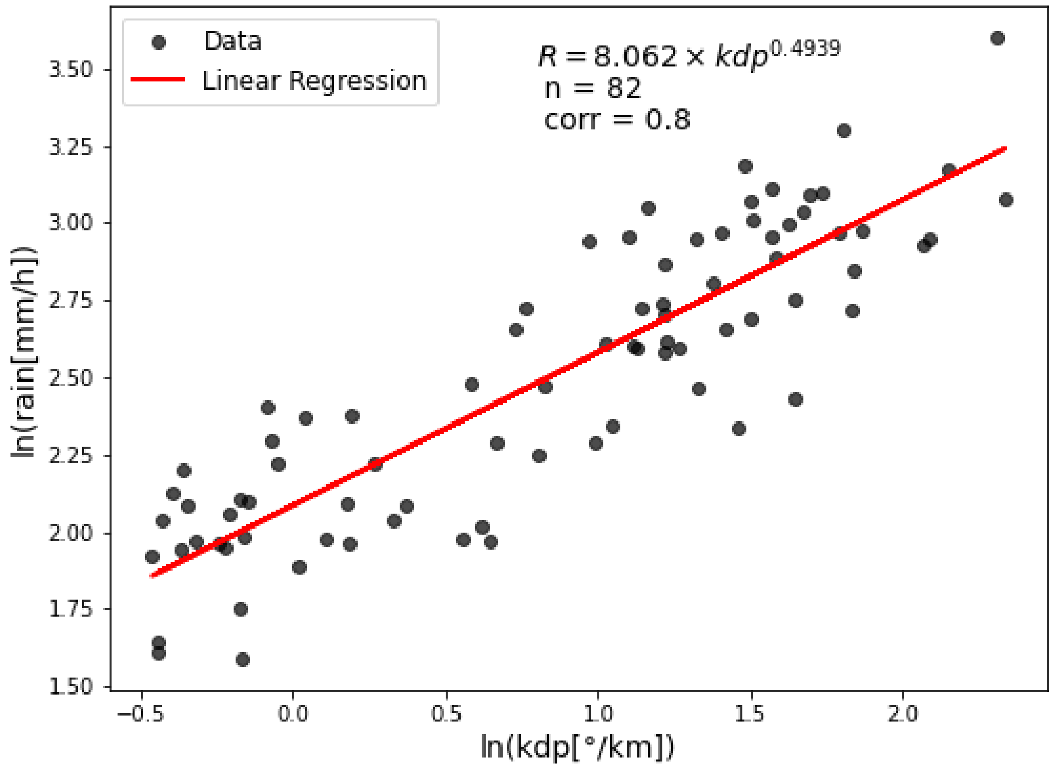

Figure 2.2: R(kdp) estimated from radar observation and rain gauge measurements

- **Page 16, table 3: What is the time step used? "Hourly" is in the title of the paper and mentioned for fig. 9 but should be also indicated in the text of section 3 and in the title of table 3 if it is this same timestep that is used.**

  The time step used is hourly, we will provide it in the text

- **Page 18, line 398: "the HB method exhibited a negative correlation coefficient, suggesting that radar rainfall estimates and rain gauge measurements were not related". It is rather the fact that the correlation coefficient is close to 0 that indicates an absence of link.**

  We will updated the manuscript accordingly, thank you for it.

- **Page 19, figure 9: What do you mean by " box " in the legend? Could you indicate which quantiles represent the limits of the boxes and whiskers in the boxplots?**

  The box spans the first (Q1) and third (Q3) quartiles, and whiskers extend from Q1 − 1.5×IQR to Q3 + 1.5×IQR, where IQR = Q3 − Q1.

- **Page 20, line 443: We can also imagine that there is a lot of wind, which must lead to a lot of errors in rain gauge measurement**

  We agree that the effect of wind in mountainous regions is not negligible and can contribute to measurement errors in rain gauges

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