AUTHOR COMMENT AC3

Response to Community Comment CC2
“Detailed critique of Beltrán’s response”

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1 General Introduction

The present reply addresses the points raised by the commenter in a specific manner, distinguishing between the conceptual aspects of the MCP, the operational components of the MIT-Q model, documentary availability, hydrological validation, and the spatial scope of the procedure.

Several of the criticisms raised appear to arise from a reading that does not sufficiently distinguish between the different levels of the work: the variational core of the MCP, the generative implementation of MIT-Q, the compatibility conditions with official IDF curves, and the regional scaling components. For this reason, this response clarifies the role of each of these levels and defines the scope of the manuscript more precisely.

With regard to verifiability, additional supplementary material corresponding to scanned historical documents is incorporated in order to strengthen the traceability of the sources used. As for the methodological and spatial observations, each point is addressed individually, specifying what falls within the current scope of the manuscript and which aspects constitute reasonable lines for future development.

2 Initial Comment

2.1 Objection to the Abstract and the MIT-Q simulation

2.1.1 Scope of the simulation and lack of peer review

“The original abstract mentions a «*MIT-Q simulation application*» which, according to the author’s response, is used to generate 500 years of synthetic events. However:

> •The MIT-Q model **has not been subjected to independent peer review**. The cited references (Beltrán, 2023; Beltrán, 2022) are works not published in indexed journals or are inaccessible degree theses.
>
> •The choice of Weibull and truncated exponential distributions is presented without any verifiable justification. No goodness-of-fit tests (Kolmogorov-Smirnov, AIC, etc.) are provided against other distribution families (gamma, GEV, generalised Pareto).
>
> •Simulating 500 years of extreme events from a single station (Quito-Observatory) and extending the results to an area of 2500 km² is methodologically unsustainable.
>
> The spatial variability of precipitation in Andean terrain with altitude gradients exceeding 20% cannot be captured with a single historical record, no matter how long.”

2.1.2 Response to the comment “Scope of the simulation and lack of peer review”

Regarding the selection of probability distributions, these were adopted in two stages. In a first stage, an inferential analysis was carried out using 289 historical storms recorded at the Quito–Observatory station during the period 1916–1992. For the intradaily storm duration variable

(DT), the quadratic truncated exponential formulation used in MIT-Q showed behaviour consistent with the observed data. For the accumulated precipitation variable (PRE), the Weibull distribution showed an adequate fit to the analysed sample.

The 289 historical storms used in this first stage were incorporated into the *Supplementary_Data_MITQ* material, in the sheet “A2-SEVERE_STORMS-QOBS-1916-1992”. Thus, the pluviographic database used to evaluate the initial distributions of $DT$and $PRE$is made available for verification and reproduction of the analysis.

In a second stage, once the complete model had been constructed, the parameters adopted in MIT-Q were not defined solely from the best marginal inferential fit of the variables $DT$and PRE, but through a hydrological calibration process of the complete model. For this purpose, a sensitivity analysis was performed on the parameters associated with the distributions used, finally selecting those values that minimise the error between the intensities simulated by MIT-Q and the official IDF curves of the Quito–Observatory station published by EPMAPS for the Metropolitan District of Quito.

In this sense, the final model parameters should be interpreted as hydrologically calibrated parameters within the MIT-Q scheme, and not exclusively as independent statistical estimators of the original random variables.

Regarding the use of synthetic series derived from the Quito–Observatory station and their application over a 2500 km² domain, it is important to clarify that MIT-Q does not directly extrapolate a single point rainfall series over the entire study area. MIT-Q is also not fitted station by station through a classical multipoint statistical regionalisation scheme. The procedure is different: the model performs a 500-year spatial stochastic simulation, storm by storm, over the 2500 km² domain, generating synthetic rainfall fields associated with individual events.

In spatial terms, each synthetic storm $i$is represented as a precipitation raster $R_i(x, y)$, which is iteratively subtracted from an annual precipitation residual raster $A_j(x, y)$, constructed from the official isohyets. This process continues until the annual precipitation residual raster reaches minimum remnant values, making it possible to reproduce spatially the annual precipitation field through the aggregation of individual synthetic events.

The simulation generates a single spatial database of synthetic storms over the entire 2500 km² domain. During calibration, the simulated values at the virtual Quito–Observatory station are extracted from this database and fitted against the official IDF curves of the real station. Subsequently, for validation, the same synthetic storm database is used, and the simulated maxima are extracted at the locations of the independent stations. Therefore, calibration and validation do not correspond to two different simulations, but to two spatial readings of the same stochastic run, evaluated at different points of the domain.

Each synthetic storm generated within the domain, including those that do not produce precipitation over the virtual Quito–Observatory station, is stored for subsequent use in spatial validation. To validate a station $i$located at (x_i, y_i), the stored synthetic storms are used and the simulated maxima are extracted at that same point, then compared with the corresponding IDF curves of the station.

The model assumes that the basic structure of intense storms, defined by the stochastic pair (PRE, DT) and by the truncated exponential temporal pattern, can be considered representative within the analysed domain for intense convective events. Spatial differentiation is not introduced through arbitrary changes in the internal structure of each storm, but through two complementary mechanisms: the spatial frequency of occurrence and the preferential direction of event displacement. In MIT-Q, storm frequency is controlled by the spatial field of mean annual precipitation defined by the isohyets in the DMQ; therefore, areas with higher annual precipitation present a higher frequency of simulated events, whereas drier areas present a lower frequency. For example, in sectors with mean annual precipitation close to 600 mm, approximately 70 events with precipitation greater than 0.1 mm are obtained, while in sectors with annual precipitation of around 1300 mm the number of events may reach 280. Independently, the preferential direction of trajectory displacement is established from the spatial gradient of the isohyets, so that storms tend to move from regions of maximum pluviometric values towards regions of lower annual precipitation.

This methodological description is important for understanding that MIT-Q simulates intense storms under regional hydrological constraints, whose structure is mainly associated with convective events because of the high intensities involved. In elevated sectors of the Pichincha volcano, precipitation has a relevant orographic component associated with the mechanical uplift of moist air masses; in contrast, at the Quito–Observatory station, located on the valley floor, the recorded precipitation is predominantly convective, because the inter-Andean geometry partially limits the direct entry of stratiform orographic precipitation into the urban centre. However, many intense convective storms affect both valley and mountain areas simultaneously. Severe convective events, including hailstorms on the slopes of Pichincha, have been recurrently observed in the study region. This suggests that, although orographic processes are relevant in elevated areas, convective storms continue to play an important role in generating intense precipitation both in the valley and in mountain sectors.

Under this interpretation, the regional representativeness hypothesis adopted by MIT-Q is more consistent for the simulation of intense convective storms than for the detailed reproduction of all spatial precipitation mechanisms present in the region. Therefore, as distance from Quito–Observatory increases and the dominant precipitation-generating mechanisms change, the representativeness of the model may decrease. This is precisely why the procedure is not limited to a direct transfer of data from Quito–Observatory, but generates a spatial database of synthetic storms over the study domain, incorporates an integral calibration of the model, and evaluates its consistency through spatial validation against the official IDF curves of meteorological stations of the Metropolitan Public Water Supply and Sanitation Company of Quito (EPMAPS).

2.2 Validation against IDF curves, not against observed data

“The author claims to validate the model by comparing its simulated intensities with «*official IDF curves of the DMQ*» (Metropolitan District of Quito). However:

> •IDF curves are **statistical approximations** derived from historical series, not raw data. Validating a model against another approximation is a methodological circularity.
>
> •No comparison is presented with real high-resolution rain gauge records (5-minute data) that have existed in the DMQ for more than 20 years. The author deliberately ignores this information.

•Validation with only 4 stations (Izobamba, Inaquito, La Tola, DAC-Aeropuerto) for a domain of 2500 km² is grossly insufficient. The control density is less than 0.002 stations per km².”

2.2.1 Response to the comment “Validation against IDF curves, not against observed data”

We agree that IDF curves are not direct observed data, but statistical representations derived from historical series of extreme precipitation. Precisely for this reason, official IDF curves constitute the main hydrological product used for urban drainage design within the Metropolitan District of Quito. The objective of MIT-Q was not to reproduce individual instantaneous rainfall records, but to evaluate the model’s ability to reproduce the statistical structure of extreme intensities synthesised in the official IDF curves published by EPMAPS.

From this perspective, the comparison carried out should not be interpreted as a validation between “model and model”, but as an assessment of consistency between the intensities simulated by MIT-Q and the official statistical representation operationally used for the analysis of extreme events in the study region.

Regarding the availability of recent high-temporal-resolution pluviographic records, namely 5-minute data, we acknowledge the importance of such monitoring networks. However, the present study prioritised consistency with the historical series used in the construction of the official IDF curves for the DMQ, which integrate extreme information over considerably longer periods than those available at many recent automatic stations. The Quito–Observatory station has particular value because of the temporal continuity and historical depth of its extreme rainfall records.

With regard to the number of stations used for spatial validation, we acknowledge that four stations are not sufficient to represent exhaustively the full spatial complexity of precipitation within the study domain. However, the purpose of the validation was to evaluate the model’s performance using complementary information independent of the dataset used for calibration.

The results obtained at stations with different pluviometric characteristics — Izobamba, Iñaquito, La Tola and DAC–Aeropuerto — suggest that the modelling approach maintains regional hydrological consistency within the analysed domain. The validation presented should be understood as an assessment of the model’s ability to reproduce regional patterns of extreme intensities outside the calibration dataset, through the structure proposed in Equation 15 and its random truncated exponential trajectories.

Finally, we acknowledge that future applications of the model could benefit from denser pluviographic networks and additional validations based on high-temporal-resolution records. This would allow a more detailed exploration of the spatial stability of the structural hypothesis proposed by MIT-Q. Nevertheless, we consider that these limitations do not invalidate the scope or the specific objectives of the present work.

3 Comment 1: Statistical independence and unverifiable references

3.1 Lack of demonstration of independence

“The author replaces the term *independence* with *weak linear dependence* but does not correct the underlying conceptual error:

> •A coefficient of determination $R^2 \leq 0.64$ does not imply absence of dependence, not even linear. The author does not present independence tests (such as Spearman’s rank correlation test, mutual information or chi-square test).
>
> •At no point is it shown that daily and sub-hourly intensities are independent; it is only shown that linear correlation is low for very short durations (5-10 min). This is an expected and well-known result, not a novel finding.”

3.1.1 Response to the comment “Lack of demonstration of independence”

We agree that a low coefficient of determination does not constitute a formal demonstration of statistical independence. As already indicated in the AC1 response to Comment CC1 published in the manuscript discussion, the term “independence” will be corrected and reformulated in the revised version of the article in order to avoid statistical interpretations stronger than those actually addressed in the study.

The purpose of the analysis presented was not to demonstrate strict statistical independence between daily and sub-hourly intensities, but to show that the observed linear dependence decreases significantly for short durations, particularly at the 5–10 minute scales. We acknowledge that this behaviour has been previously reported in hydrological studies and does not, by itself, constitute a novel finding.

For this reason, the manuscript does not interpret these results as evidence of strict statistical independence, but rather as evidence of low linear association between daily and sub-hourly intensities within the scope of the analysis performed. In the revised version, expressions that could be interpreted as demonstrations of formal statistical independence will be avoided, specifying instead that the results obtained correspond to relationships of limited linear dependence within the analysed dataset.

3.2 Circular and unverifiable references

“The author includes graphs and statements based on:

- Beltrán (1995, pp. 138-139): unpublished civil engineering thesis, no public access. The pluviographic data used are not deposited in any verifiable repository.
- Andrade (1997, p. 33): proceedings of a national congress, not available online and without DOI. It cannot be consulted or verified.
- The author promises to include these data in supplementary material; however, upon reviewing this documentation, no raw data exist. What exists is a series of files

> corresponding to MIT-Q simulations (*Supplementary Data MITQ Calibration Validation.xlsx*), but this was not materialised independently before the review. In science, claims must be verifiable without relying on the author's goodwill.

Therefore, the reader is forced to *believe* without being able to verify, which violates basic principles of reproducibility."

3.2.1 Response to the comment "Circular and unverifiable references"

The references Beltrán (1995), Andrade (1997), Blandín (1989), Pourrut and Leiva (1989), and other historical documents cited in the manuscript correspond to technical works developed before the existence of open digital repositories and modern traceability mechanisms such as DOI. We acknowledge that their current public availability is limited and that this partially hinders the independent verification of part of the information historically used in the development of the MIT-Q scheme.

In order to strengthen the reproducibility and traceability of the study, the file *Supplementary_Data_MITQ* was shared in the AC2 response to CC1. This file includes the sheets A1-EXTREME INTENSITIES-QOBS and A2-SEVERE_STORMS-QOBS-1916-1992, together with a README sheet describing the structure and organisation of the information provided. The sheet A1-EXTREME INTENSITIES-QOBS contains the observed extreme intensities for durations ranging from 5 minutes to 24 hours, corresponding to the period 1916–1992 at the Quito–Observatory station. The sheet A2-SEVERE_STORMS-QOBS-1916-1992 contains the 289 historical severe storms used in the inferential analyses and model calibration.

Additionally, in the present reply, the file *Supplementary_Data_2_MITQ* is incorporated. This file includes digital scans of Beltrán (1995), Andrade (1997), Beltrán (2003), Blandín (1989), and Pourrut and Leiva (1989), with the purpose of providing direct access to the historical documents used as part of the methodological development of the MIT-Q scheme.

The information related to the annual number of rainy events used in the model calibration was based primarily on the climatological records compiled by Blandín (1989), where historical tables of the number of days with precipitation are presented for the Quito series from 1891 to 1980. Complementarily, Pourrut and Leiva (1989) allowed the spatial differences in rainfall frequency within the study area to be contextualised.

The historical development process of MIT-Q began with the analysis of the historical severe storm records from the Quito–Observatory meteorological station used in the thesis by Beltrán (1995). Subsequently, the intra-event temporal structure was explored in Beltrán's master's thesis (2003), where a first modellable mathematical representation of the storm was obtained. This constituted the initial seed of the MIT-Q scheme and was later formally interpreted within the PCM framework.

4 Comment 2: The Maximum Certainty Principle (MCP) is equivalent to MaxEnt

4.1 Formal equivalence with MaxEnt

"The author denies that the MCP is a reformulation of MaxEnt, but the mathematical demonstration shows otherwise. The proposed functional is:

$$\mathcal{F}[f] = \int [C(t)f(t) - f(t)\ln f(t)]\,dt$$

with $f(t)$ probability density and $C(t)$ the so-called *knowledge potential*. Unconstrained maximisation (or with the constraint $\int f = 1$) leads to:

$$f(t) = \frac{e^{C(t)}}{\int e^{C(t)}dt}$$

which is exactly the form of a Gibbs distribution (or maximum entropy distribution) with a prior $e^{C(t)}$. The author introduces no additional non-trivial constraints; therefore, the MCP is mathematically identical to MaxEnt with an arbitrary prior. Renaming it does not constitute an advance."

4.1.1 Response to the comment "Formal equivalence with MaxEnt"

The functional presented in the comment, $F[f]$, differs from the Certainty functional $\aleph[P(t)]$ of the PCM, because it is not formulated over the same variational object. In the PCM, the formulation is developed over the cumulative function $P(t)$, with the density $f(t)$ being a derived quantity:

$$f(t) = P'(t).$$

The Certainty functional is:

$$\aleph[P(t)] = \int_0^{DT} [C(t)P'(t) - P'(t)\ln\, P'(t)]\,dt.$$

In this formulation, the fundamental variable is not the isolated density, but the cumulative evolution of the event $P(t)$, defined over the complete interval of the process, with explicit boundary conditions:

$$P(0) = 0, P(DT) = 1.$$

It is true that, if the functional is reformulated directly over the density $f(t)$ and a normalisation condition is imposed through Lagrange multipliers, a normalised exponential expression for $f(t)$ may be obtained. However, in that formulation the problem corresponds to a constrained maximisation of a density. In the PCM, by contrast, the problem is formulated as a variational extremalisation of a functional defined over the cumulative trajectory $P(t)$.

The central difference lies in the variational interpretation of the problem. The direct formulation over $f(t)$ optimises a distribution over the temporal domain; the PCM formulation over $P(t)$ allows the event to be interpreted as a complete temporal trajectory over the interval:

$$0 \le t \le DT.$$

Since the Certainty Lagrangian depends on $P'(t)$, but does not depend explicitly on $P(t)$, the Euler–Lagrange equation leads to:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial P'(t)}\right) = 0,$$

therefore:

$$\frac{\partial L}{\partial P'(t)} = C(t) - \ln\, P'(t) - 1 = \text{constant.}$$

This constancy condition arises as an internal result of the extremalisation of the trajectory $P(t)$, not as a condition imposed externally on an isolated density. Therefore, although the PCM may lead to a functional form compatible with Gibbs-type expressions, its formulation is centred on the cumulative trajectory of the event and not solely on the density.

In operational terms, MIT-Q generates complete cumulative trajectories $P(t)$, expressed hydrologically as $Pre(t)$, from which maximum intensities for different durations are subsequently derived.

4.2 Variational derivation and Noether's theorem

"The author justifies the constancy of $\aleph_{\max}$ by the independence of the Lagrangian with respect to $P(t)$. He shows that:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial f}\right) = 0 \quad \Rightarrow \quad C(t) - \ln f(t) = \text{constant}$$

This is a simple application of the Euler-Lagrange equation, not a consequence of Noether's theorem. Invoking Noether requires an explicit continuous symmetry (translations, rotations, etc.) that leaves the action invariant. The author does not identify any symmetry; the independence from $P(t)$ is a property of the Lagrangian, not a symmetry of the system. Therefore, the reference to Noether is pseudo-scientific and should be completely removed."

4.2.1 Response to the comment "Variational derivation and Noether's theorem"

As indicated in AC1 and further specified in section 4.1.1, the constancy obtained in the PCM derives directly from the Euler–Lagrange equation applied to the Certainty functional, whose Lagrangian does not depend explicitly on the cumulative function $P(t)$.

The variational structure of the problem leads directly to an internal constancy condition, without requiring the direct invocation of Noether's theorem. For this reason, the revised version of the manuscript will remove the direct reference to that theorem, while retaining the derivation in terms of the Euler–Lagrange equation, which is sufficient to support the result presented.

4.3 Ad hoc choice of C(t) = −λt

For the case of storms, the author chooses $C(t) = -\lambda t$ without physical or empirical justification beyond «*it works*». This choice leads to a truncated exponential distribution, which is a classic model (Eagleson, 1978; Rodr´ıguez-Iturbe et al., 1987). There is no derivation from first principles; it is an embedded parametric adjustment.

$$f(t) \propto e^{-\lambda t} \Rightarrow \text{truncated exponential temporal structure} \quad (1)$$

Thus, the MCP adds nothing new.

4.3.1 Response to the comment "Ad hoc choice of C(t) = −λt"

As discussed in Comment 2, section 2.1.2, of the AC1 response, the choice of a linearly decreasing form $C(t) = -\lambda t$ corresponds to the need to represent a temporal process consistent with the dissipative character of precipitation events. This form provides a simple representation of the temporal evolution of the event within the proposed framework, without implying that it is the only possible representation.

It is important to note that this formulation differs from classical stochastic rainfall models, in which the start times, durations and intensities of events are generated randomly from point processes (Eagleson, 1978; Rodríguez-Iturbe et al., 1987). In the PCM, by contrast, the potential $C(t)$ directly defines the temporal structure of the event, giving rise to a set of possible trajectories.

The probabilistic component of the PCM is not introduced through the generation of elementary events, but through **the selection of complete trajectories** within that set, which is carried out by means of a selection-without-replacement scheme from a truncated random variable. In this way, the model remains probabilistic, but at a different level from classical approaches.

Therefore, $C(t)$ does not act as a fitting parameter, but as the element that defines the temporal structure of the event within the PCM.

5 Comment 3: The MIT-Q model: calibration, validation and spatial contradictions

5.1 Calibration with unverifiable data

"The author lists calibration sources:

1. *Official IDF curves of the DMQ*: they are approximations, not observed data.
2. *Annual number of events ¿0.1 mm* from Pourrut and Leiva (1989): however, I have read the cited works for a long time and they do not provide numerical tables, only graphs; there is no access to the original records, which makes verification difficult.
3. *Intra-event temporal structure via quartiles* (Beltrán, 1995): unpublished thesis, no accessible data.

None of these sources is independently verifiable. The author promises to include them in a supplement, but to date there is no public repository with such data."

5.1.1 Response to the comment “Calibration with unverifiable data”

The observations related to verifiability, traceability, availability of historical information and the use of official IDF curves have already been addressed in the responses to sections 2.1.2, 2.2.1 and 3.2.1.

The historical information, severe storm records and technical documents used in the methodological development of the MIT-Q scheme are incorporated in the files *Supplementary_Data_MITQ* and *Supplementary_Data_2_MITQ*, as described in the response to section 3.2.1.

Therefore, we consider that the observations related to calibration and verifiability are substantially addressed through the supplementary material incorporated in the present revision.

5.2 Validation with only 4 stations and against IDF curves

“The author claims to validate the model at four «*nearby*» stations. However:

> •The simulated domain is 2500 km²; four stations amount to a density of 0.0016 stations/km², insufficient to capture convective and orographic processes. • The comparison is made against the IDF curves of those stations (derived product), not against real hourly or sub-hourly records. This hides adjustment errors in extreme quantiles.
>
> •At the DAC-Aeropuerto station, the MAPE reaches 68% for a duration of 360 minutes (see author’s response, p. 12). The author minimises this discrepancy by attributing it to «*low intensities*», but an error of 68% is unacceptable in any hydrological modelling context.”

5.2.1 Response to the comment “Validation with only 4 stations and against IDF curves”

The observations related to the spatial density of stations, the use of official IDF curves and the scope of the validation have already been addressed in the response to section 2.2.1.

As previously indicated, MIT-Q was validated by assessing its ability to reproduce the statistical structure of extreme intensities under different pluviometric conditions and outside the dataset used for calibration. The comparison with official IDF curves corresponds to the use of the operational hydrological representation employed for hydrological design within the study region, as already discussed in section 2.2.1.

It is important to clarify that both calibration and validation compare official inferential extreme intensities, represented by IDF curves, with synthetic datasets generated by MIT-Q through prolonged stochastic simulations of the storm process. Under this approach, increasing the number of simulated years makes it possible to generate larger and statistically more stable synthetic samples for the estimation of extreme quantiles. For this reason, the model used 500-year simulations to validate only return periods less than or equal to 50 years and durations shorter than 6 hours, corresponding to the operational validity range of the official EPMAPS IDF curves.

In the specific case of the DAC–Aeropuerto station, the MAPE value of 68.1% corresponds to the point comparison between MIT-Q and the P10 DAC–Aeropuerto curve of Palacios et al. (2015) for the 6-hour duration. This curve was used in the validation because, in general, it is consistent with the intensities generated by MIT-Q over most of the analysed range. Specifically, for the 6-hour duration, a significant discrepancy is observed. However, for that same duration, the intensities generated by MIT-Q show an adequate fit with respect to the historical DAC-M055 equation (Old DAC Airport, EPMAPS technical standard), with a MAPE of 6.5%. Therefore, the value of 68.1% should be interpreted as a point discrepancy associated with a specific IDF reference, and not as a representative measure of the model's overall performance.

5.3 Contradiction between spatial adjustment to annual precipitation and generation of convective events

The author describes that the model generates individual storms and iteratively aggregates them until reproducing the field of *annual isohyets* (annual accumulated precipitation). This approach is problematic for two reasons:

1. **Equifinality**: Many combinations of different event types (short convective vs. long stratiform) can yield the same annual precipitation. Adjusting only to the annual sum does not guarantee that the temporal distribution of extreme intensities is correct.

2. **High mountain areas (¿3500 m a.s.l.)**: In the Andes, above 3500-4000 m a.s.l., low-intensity, long-duration rainfall (orographic type) predominates, with very few intense convective events. The MIT-Q model, by forcing an adjustment to annual precipitation, could be generating false convective events where there are none (overestimating extreme intensities) or, conversely, underestimating the contribution of prolonged rainfall.

The author does not address this issue in his response. He also does not present any sensitivity analysis or validation at high-moorland stations (e.g., stations above 4000 m a.s.l.).

5.3.1 Response to the comment "Contradiction between spatial adjustment to annual precipitation and generation of convective events"

The comment addresses two distinct aspects that should be separated: the equifinality associated with fitting the annual accumulated precipitation, and the possible representation of intense convective events in areas where orographic or stratiform mechanisms may predominate.

Regarding equifinality, we agree that multiple combinations of events may produce the same annual precipitation total. This in itself does not constitute a limitation in stochastic models. MIT-Q does not seek to reconstruct a unique sequence of historical storms, but to generate a family of synthetic events statistically compatible with the descriptive information from historical storms and with the inferential references used in the calibration.

The second issue, referring to the possible differentiation between intense convective rainfall and longer-duration orographic or stratiform rainfall, is more relevant for applications in high-mountain areas. As indicated in section 2.1.2, MIT-Q mainly simulates intense storms whose structure is associated with convective events because of the high intensities involved. In extreme páramo areas, especially above 4000 m a.s.l., the relative frequency of persistent orographic or stratiform events may be higher; therefore, future applications of the model could incorporate specific validations and sensitivity analyses aimed at distinguishing these mechanisms in greater detail.

Complementarily, the exploratory consistency obtained in applications under contrasting altitudinal and climatic conditions, from high Andean stations such as M-141 El Labrado (~3335 m a.s.l.) to low-altitude coastal stations such as M-072 Machala Aeropuerto, can be observed in the file *Supplementary_Data_MITQ* (1 BASE_IDFP_ECUADOR-2026). These results do not imply that the physical mechanisms of rainfall formation are equivalent between regions, but rather that intense storms, regardless of their dominant origin, may present a recognisable temporal organisation, with phases of initiation, development, maximum structuring and dissipation.

Therefore, the objection regarding high-mountain areas identifies a relevant aspect for future applications, but does not invalidate the evaluation presented within the altitudinal domain covered by the available IDF references. The specific evaluation of extreme páramo areas would require additional pluviographic information, IDF curves representative of those elevations, and application criteria consistent with the hydrological use of such curves.

5.4 The parameter α0 and its variability

The author defines $\alpha_0 \approx 10$ as a dimensionless parameter «*maximum temporal structuring capacity*». However, he admits that when advection is considered, α_p varies between 2 and 35 depending on the station (see Fig. 8 of the manuscript). This variability contradicts the interpretation of an intrinsic model parameter and suggests over-parameterisation. Moreover, the previous references to gravity («*gravity (g) induces information*») have been removed, but no alternative physical explanation is offered.

5.4.1 Response to the comment "The parameter α_0 and its variability"

The observations regarding the interpretation of the dimensionless parameter were partially addressed in the AC1 response, section 3.1.2, where it was clarified that α_0 does not represent a fixed number of observable pulses in each storm, but rather a maximum capacity for temporal structuring within the MIT-Q scheme.

In the manuscript, storm time is represented by a truncated exponential random variable T, defined over the interval $0 \leq t \leq DT$, where DT corresponds to the maximum possible value of that variable. This variable represents the residence time of the event under optimal conditions until reaching an unsustainable point.

Under the truncated exponential formulation of Equation 13 of the manuscript, with:

$$\lambda = \frac{\alpha_0}{DT},$$

the expectation of T is:

$$E[T] = DT\left[\frac{1}{\alpha_0} - \frac{e^{-\alpha_0}}{1 - e^{-\alpha_0}}\right].$$

Therefore, the characteristic number of internal partitions or sub-events $m$can be interpreted as the ratio between the maximum possible value of T and its expectation:

$$m = \frac{\max(T)}{E[T]} = \frac{DT}{E[T]} = \frac{1}{\frac{1}{\alpha_0} - \frac{e^{-\alpha_0}}{1 - e^{-\alpha_0}}}.$$

For large values of α_0, the second term in the expression for $E[T]$ is practically negligible, so that:

$$m \approx \alpha_0.$$

Consequently, $\alpha_0 \approx 10$ should be understood as an approximate structural measure of the maximum temporal partitioning capacity of the event. It does not imply that ten pulses are necessarily observed in every storm; rather, under the adopted temporal distribution, the total interval DTmay contain approximately ten expected mean durations of development time.

Additionally, α_0 may also be interpreted as an indicator of the earliness of the temporal structure of the dissipative process. High values of α_0 reduce the relative expectation $E[T]/DT$, so that the development time tends to be concentrated towards the initial part of the event, generating preferentially early patterns. In the limit $\alpha_0 \to 0$, the truncated exponential distribution tends towards a uniform distribution over the interval $[0, DT]$, representing a state with no dominant temporal preference.

It is important to distinguish between α_0, α_v, and α_p. The parameter α_0 corresponds to the base temporal structure of the event. When advective effects are incorporated, this structure is modified through α_v, which represents the temporal reorganisation associated with the spatial displacement of the storm.

Under this interpretation, both α_0 and α_v may be understood as dimensionless measures of temporal similarity within the PCM/MIT-Q scheme. The former defines the base temporal structure of the event, whereas the latter expresses that structure once advective effects have been incorporated. In particular, since $\alpha_v = \lambda_v DT$, this parameter expresses the accumulated temporal structuring of the event and contributes to maintaining a geometric similarity of the normalised trajectory $Pre(t)/PRE$ with respect to t/DT, even when the total duration DT and the structuring rate λ_v vary in a compensatory manner. This interpretation is consistent with the classical hydrological practice of representing storms in dimensionless form, as in Huff curves, where the temporal distribution is expressed through cumulative percentages of storm rainfall and storm duration in order to compare events of different scales.

The parameter α_p, by contrast, is obtained from the transition storm and from the condition:

$$Pre_p(t_1) = Pre_v(t_2),$$

where $Pre_v(t_2)$ corresponds to the accumulated precipitation (mm) of the transition storm, described by Equation 15 of the manuscript with α_v, at duration t_2. Meanwhile, $Pre_p(t_1)$ corresponds to the precipitation (mm) that a potential structure, described by the same Equation 15 but with α_p, can develop at the optimal time $t_1 = t_d$.

Thus, α_p expresses a potential capacity for temporal reorganisation towards earlier states. It represents the value of the parameter that allows the precipitation reached by the transition storm at t_2 to be potentially developed at the optimal development time t_1. Its value depends on the relationship between t_1, t_2, DT, α_v, and the local geometry of the IDF curves of each station.

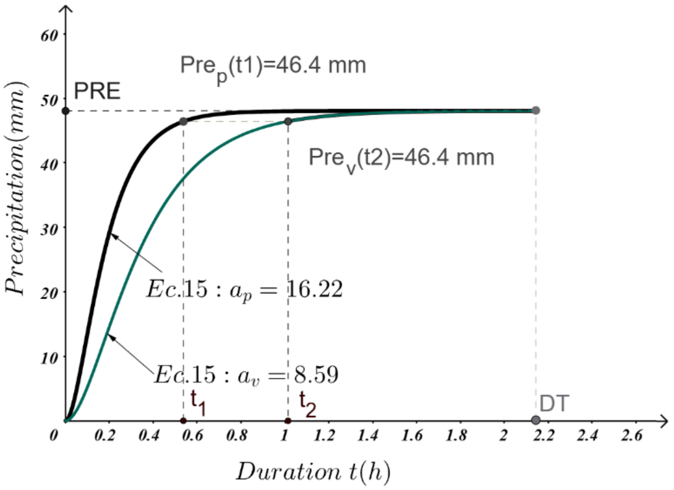

Figure 1. Transition storm with $\alpha_v = 8.59$ and potential storm with $\alpha_p = 16.22$ at the M003 Izobamba meteorological station for $T_r = 50$ years.

For this reason, the variability of α_p between stations does not contradict the interpretation of α_0. The comment directly compares two different levels of the model: a base structural capacity and a potential parameter derived from a temporal reorganisation condition. In the MIT-Q scheme, the conceptual relationship is:

$$\alpha_0 \rightarrow \alpha_v \rightarrow \alpha_p.$$

In this case, α_p does not constitute over-parameterisation, because it is derived from an explicit equality condition between two temporal states of the same functional family. Its variability therefore reflects differences in the local IDF geometry and in the potential capacity for temporal intensification at each station.

6 Comment 4: Regionalisation and potential IDF curves

6.1 Opaque derivation of τ

The author adds an Appendix C in his response. Although some algebraic steps are shown, the derivation remains conceptually weak:

- Mean and instantaneous intensities are equated at a tangency point t_1 without justifying why that point corresponds to a regime change.
- The resulting equation (C6): $2t_1\frac{e^{-t_1}}{1-e^{-t_1}} = 1 - b_1$ implies that t_1 is a function of b1, but the author defines τ as constant for all durations. How is this constancy reconciled with the dependence on b_1? It is not explained.

- Equations (C8)-(C14) introduce ad hoc variables (τ_1, τ_2, DT_1, DT_2) that do not arise naturally from the MCP. They remain an algebraic fitting exercise, not a derivation from first principles.

6.1.1 Response to the comment "Opaque derivation of τ"

The comment allows Appendix C, shared in Discussion AC1, to be clarified and the role of τ to be specified more precisely within the coupling between the temporal storm structure of the PCM/MIT-Q and the two sections of the INAMHI IDF curves.

First, t_1 is not introduced as an arbitrary regime-change point. Within the MIT-Q scheme, t_1 corresponds to the characteristic storm development time:

$$t_1 = t_d$$

The complete storm, described by Equation 15 of the manuscript, constitutes an optimal trajectory from $t = 0$ to $t = DT$ within the model framework. This structure presents two phases: a development phase up to $t_1 = t_d$, and a subsequent decay or dissipative phase up to DT.

Second, it is useful to clarify the meaning of τ. τ_i does not represent a constant for all durations. For each section $i$of the IDF curve — short durations $i = 1$ and long durations $i = 2$— the equation

$$2\tau_i \frac{e^{-\tau_i}}{1 - e^{-\tau_i}} = 1 - b_i$$

establishes that τ_i is determined by the exponent $b_i$of the corresponding section of the INAMHI IDF curve. Consequently, τ_1 is associated with the short-duration section and τ_2 with the long-duration section.

For each section i, at the corresponding tangency point, the following holds:

$$\tau_i = \alpha_{v_i} \frac{t}{DT}$$

Therefore:

$$\frac{t}{DT} = \frac{\tau_i}{\alpha_{v_i}} = \text{Constant}_i \qquad (6.1.a)$$

This relationship does not imply that $t$is constant throughout the section, but rather that the duration considered t and the total storm duration DT scale while maintaining a constant relative position within the normalised temporal structure.

For short durations, where $0 \leq t \leq t_1$, the tangency condition is governed by α_{v_1}, expressed through Equation 27 of the manuscript. In this section, the storm is in its development phase and the temporal behaviour is controlled by the characteristic number of bursts or internal sub-events:

$$\frac{t}{DT} = \frac{\tau_1}{\alpha_{v_1}} = \frac{\ln\left(\frac{\alpha_{v_1}}{1 - e^{-\alpha_{v_1}}}\right)}{\alpha_{v_1}} = \text{Constant}_1 \qquad (6.1.b)$$

For long durations, where $t_2 \leq t \leq DT$, the durations considered also incorporate the decay or dissipative phase after t_d. In this case:

$$\frac{t}{DT} = \frac{\tau_2}{\alpha_{v_2}} = \text{Constant}_2 \qquad (6.1.c)$$

In the long-duration regime, τ_2 is determined by the exponent b_2, but α_{v_2} requires an additional transition condition. This condition is obtained from the property of the transition storm of being tangent to the two IDF curves at t_1 and t_2.
In a transition storm, at t_1:

$$\frac{t_1}{DT_1} = \frac{\tau_1}{\alpha_{v_1}}$$

and at t_2:

$$\frac{t_2}{DT_2} = \frac{\tau_2}{\alpha_{v_2}}$$

Furthermore, since this is a single transition event:

$$DT_1 = DT_2$$

and:

$$\alpha_{v_1} = \alpha_{v_2}$$

Therefore, α_{v_1} is not only constant for the transition storm, but also for both the short-duration and long-duration sections. In this sense, α_{v_1} acts as a structural parameter of the meteorological station over the duration spectrum considered. This constancy does not imply that the tangency point occupies the same relative position in both sections, but rather that the same structural capacity organises two distinct temporal states of the storm: the development regime and the dissipative regime.

Under this condition, the constant of the long-duration section can be expressed using the known parameters τ_2 and α_{v_1}:

$$\frac{t}{DT} = \frac{\tau_2}{\alpha_{v_1}} = \text{Constant}_2. \qquad (6.1.d)$$

In this way, while τ_1/α_{v_1} defines the relative position of the tangency point in the short-duration regime, τ_2/α_{v_1} defines the corresponding relative position in the long-duration regime. The constancy of α_{v_1} makes it possible to link both regimes within the same station-specific temporal structure, without requiring the relative tangency positions to be identical.

Thus, τ_1, τ_2, DT_1, and DT_2 are not introduced as free parameters or as ad hoc elements, but as auxiliary magnitudes necessary to distinguish the two duration regimes and to establish the tangency and continuity conditions imposed by the transition storm.

Consequently, the procedure does not constitute an arbitrary algebraic fit. The PCM provides the temporal form of the storm, while the tangency and continuity conditions allow this structure to be linked to the INAMHI IDF curves.

6.2 Transition storm: artifice without evidence

The author explicitly admits that the transition storm «*is not a physically independent or directly observable event*» (p. 15 of his response). It is therefore a *conceptual construct* introduced solely to ensure continuity between two duration regimes. In science, postulating unobservable entities is justified only if they produce testable predictions.

The author presents no prediction that can be independently tested. The transition storm is a mathematical artifice without empirical support.

6.2.1 Response to the comment "Transition storm: artifice without evidence"

The comment allows the interpretation of the transition storm to be clarified. In the AC1 response, it was stated that the transition storm should not be understood as a physically independent storm or as a directly observable event. This should be understood as a reference to the high difficulty of identifying it directly in pluviographic records, not as an impossibility of observation or testing.

Within the MIT-Q scheme, the transition storm is interpreted as a particular extreme configuration within the family of optimal trajectories described by Equation 15 of the manuscript. Its distinctive property consists in simultaneously satisfying two tangency conditions with the IDF curves of the same station: one in the short-duration regime, at $t_1 = t_d$, and another in the long-duration regime, at t_2. These requirements considerably restrict its direct identification in observed records.

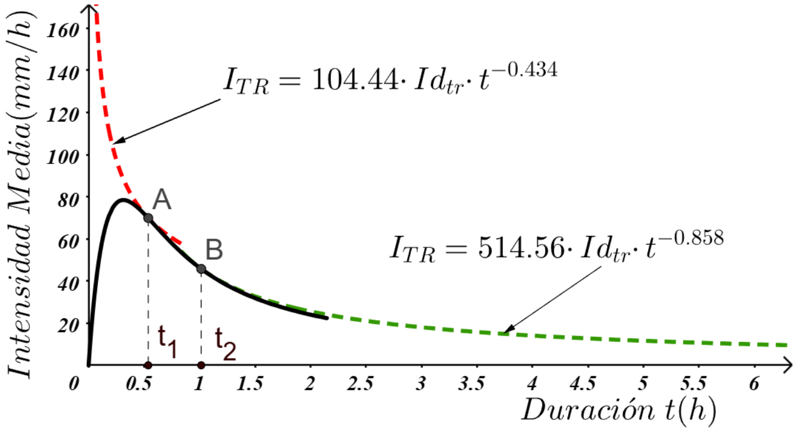

Figure 2. Transition storm at the Izobamba station for $T_r = 50$ years, $DT = 2.14$ h, $PRE = 48.03$ mm.

However, its presence could be evaluated indirectly by comparing observed maximum intensities for durations between t_1 and t_2. If the annual extreme intensities within this interval show high dependence or linearity, this would suggest that those durations are being controlled by the same storm structure or by physically related events. In the case of Quito–Observatory, for example, where MIT-Q estimates approximately $t_1 = 24$ min and $t_2 = 50$ min, the coefficient of determination R^2 between annual maximum intensities of 20 min and 30 min is 0.89. High coherence between the maximum intensities in this range would be consistent with the existence of storms capable of maintaining extreme conditions between the development phase and the dissipative phase.

Consequently, the transition storm does not constitute an arbitrary algebraic artifice. It is an extreme design configuration, defined by tangency and continuity conditions, which makes it possible to connect the development phase and the dissipative phase of an optimal storm with the two duration regimes of the IDF curves.

6.3 Scale factor ϕ(b) = b−0.237: empirical regression not derived from the MCP

The author acknowledges that this relationship is «*empirical*» and is not derived from the MCP. It is obtained by fitting a power law to 66 INAMHI stations (R^2=0.968). However:

- No confidence intervals are reported, nor is cross-validation performed. A high R^2 is expected when the relationship is nearly linear; it does not imply that the model is predictive for new stations.

- The regression is independent of the rest of the variational theory. Therefore, the MCP plays no role in the most relevant part of the regionalisation. The work is hybrid: an ornamental variational theory and a conventional empirical fit.

6.3.1 Response to the comment "Scale factor $\boldsymbol{\phi(b) = b^{-0.237}}$: empirical regression not derived from the MCP"

The comment allows the role of the scale factor $\phi(b)$ within the regionalisation procedure to be clarified. As indicated in the AC1 response, the relationship

$$\phi(b) = b^{-0.237}$$

was obtained from the analysis of 66 INAMHI meteorological stations, with $R^2 = 0.968$ and a MAPE close to 1.2%. It was also explicitly acknowledged that this relationship does not constitute a direct derivation from the Maximum Certainty Principle, but rather a regional relationship obtained from the parameters of the available IDF curves.

The PCM does not seek to derive all regional components of the procedure. Its role is to provide the temporal structure of the event. In particular, the PCM/MIT-Q makes it possible to define the temporal form of the storm, the development time t_d, the transition storm, and the tangency conditions that link the temporal structure with the IDF curves.

The factor $\phi(b)$, by contrast, should be understood as a regional scaling relationship, not as the foundation of the PCM. Its function is to allow the temporal structure obtained through the PCM/MIT-Q to be linked with the regional variability expressed by the parameters $b$of the INAMHI IDF curves. In this sense, $\phi(b)$ does not constitute the variational core of the model, but rather a regional scaling factor that allows the temporal structure of the PCM/MIT-Q to be adapted to the spatial variability represented by the INAMHI IDF curves.

The relationship $\phi(b)$ is not presented as an independent prediction for new stations, but as a reproducible way of organising the results obtained from the set of stations analysed. For this reason, the reported R^2 and MAPE values should be interpreted as measures of consistency of the regional fit within the dataset used, not as a demonstration of universal predictive capacity. From an applied perspective, $\phi(b)$ may also be interpreted as a regional hydrological scaling factor for the design of hydraulic works exposed to flood hazards, particularly in areas where the station network is sparse and local extreme intensities may not have been directly recorded. Its function is not to replace official IDF curves or observed information, but to provide a complementary tool for evaluating potential extreme intensities that are difficult to capture at specific observation points.

Consequently, the approach should not be interpreted as a decorative variational theory accompanied by a conventional regression, but as an explicitly composite scheme: a temporal structure derived from the PCM/MIT-Q, complemented by a regional scaling relationship required for its spatial application.

6.4 Maps and lack of uncertainty

"Figure 9 presents maps of the scale factor without any uncertainty propagation. The spatial interpolation method is not specified. The author claims that altitude is implicitly included in the station parameters, but this is not true: interpolation between stations must explicitly consider topography, especially in regions with gradients exceeding 20%. Ignoring orography is a serious omission."

6.4.1 Response to the comment "Maps and lack of uncertainty"

The objective of the maps presented in Figure 9 is more limited: to graphically report the values of the regional scale factor $\phi(b)$at the spatial locations of the available meteorological stations. Figure 9 serves a descriptive reporting function within the manuscript. It does not seek to construct a new spatial regionalisation of extreme intensities.

With regard to altitude and orography, Figure 9 does not correspond to a spatial interpolation model. The results are displayed graphically at their spatial locations, over the background of the official regionalisation of INAMHI rainfall isointensity zones in Ecuador and over a digital elevation model with shaded relief. The influence of climatic, topographic and regional conditions is indirectly reflected in the parameters $\left(a, b, I_{\text{daily}}\right)$ of the IDF curves of each meteorological station, and should not be confused with an explicit incorporation of orography. Consequently, no spatial uncertainty propagation was applied, since the figure does not correspond to an interpolated field or to a continuous prediction of extreme intensities.

In the revised version of the manuscript, this scope will be clarified to avoid Figure 9 being interpreted as a complete spatial interpolation of extreme intensities.

7 Comment 5: Exaggerated discussion and conclusions

The author modifies the phrase «*modifies the inferential interpretation*» to a more moderate one, but still claims that the MCP «*provides an alternative framework*». No quantitative comparison is presented with standard methods (L-moments, maximum likelihood, two-state Poisson models). Nor is it demonstrated that the *potential* IDF curves improve upon existing official curves. The conclusions therefore lack empirical support.

7.1 Response to Comment 5 "Exaggerated discussion and conclusions"

The comment revisits an aspect already addressed in the AC1 response, section 5.1, where it was clarified that the PCM/MIT-Q is not presented as a replacement for established statistical methods for extreme-value analysis, such as L-moments, maximum likelihood or Poisson models, but rather as a complementary perspective based on the temporal organisation of rainfall events. In AC1, the initial expression concerning "modifying the inferential interpretation" was also reformulated in order to better delimit the actual scope of the work.

The expression “alternative framework” should not be understood as a claim of methodological superiority or as a replacement for classical inferential procedures. Its meaning is more specific: the PCM/MIT-Q proposes a structural-temporal representation of the extreme event, in which the complete form of the storm is obtained as the solution of a variational problem defined over the total interval of the event, and not as the result of a local optimisation instant by instant:

$$0 \leq t \leq DT.$$

The central point of this representation is the extremalisation of the PCM functional, from which an optimal temporal trajectory $P(t)$ emerges. Therefore, the contribution of the manuscript does not lie primarily in the direct estimation of a point maximum or in the fitting of an extreme-value distribution, but in the formulation of the complete temporal structure of the event, including its development phase, its maximum organisation and its dissipative phase within a single trajectory.

A quantitative comparison with L-moments, maximum likelihood, GEV or Poisson models would be relevant if the manuscript claimed superiority in the estimation of extreme quantiles. That is not the claim being made; the contribution lies in the complete temporal representation of the extreme event and its link with intensity–duration–frequency relationships.

Regarding potential IDF curves, these are likewise not presented as substitutes for official curves or as a demonstrated improvement over them. Their purpose is to explore potential intensities derived from the generative temporal structure of MIT-Q, especially in contexts where the spatial representation of extremes may be limited by station density.

Therefore, we consider that the manuscript does not claim methodological superiority over classical inferential approaches. Nevertheless, to avoid ambiguous interpretations, the revised version will reinforce this delimitation in the conclusions: the PCM/MIT-Q will be presented as an alternative representation in a structural-temporal sense.

8 Comment 6: Reproducibility and cross-validation

The author limits himself to including MAPE as an additional metric. The following are not presented:

- Cross-validation (e.g., leaving one station out).
- Confidence intervals for extreme intensities (e.g., bootstrapping).
- Residual analysis or goodness-of-fit tests for the tails.
- Comparison with the traditional GEV approach fitted to the same data.

Reproducibility is impossible because the primary sources (Beltrán 1995, Andrade 1997, etc.) are not publicly available. The author promises to include them «*in the supplementary material*», but during the review process they have not been provided in a permanent repository.

8.1 Response to Comment 6 “Reproducibility and cross-validation”

Reproducibility was addressed in the response to section 3.2.1. In the present reply, the file *Supplementary_Data_2_MITQ* is incorporated, including the scanned historical documents used in the methodological development of the model.

With regard to validation, MAPE was incorporated in AC1 as a quantitative metric for calibration and validation, including the calculation of errors by station and duration.

As explained in section 2.1.2, MIT-Q is not fitted station by station through a classical multipoint statistical regionalisation scheme. The model generates a single spatial database of synthetic storms through a 500-year stochastic run over the 2500 km² domain. Calibration is carried out by extracting the simulated results at the virtual Quito–Observatory station and comparing them with the official IDF curves of the real station. Validation uses the same synthetic storm database, but extracts the simulated maxima at the locations of independent stations, in order to compare them with their respective IDF curves.

For this reason, a leave-one-station-out cross-validation is not directly equivalent to the MIT-Q procedure, since there is no prior multipoint fit from which one station is removed in order to evaluate its reconstruction from the remaining stations. Calibration and validation correspond to different spatial readings of the same stochastic run, evaluated at different points of the domain.

We emphasise that MIT-Q is not calibrated or validated against raw data, but against official hydrological references that already incorporate extreme-value selection, probabilistic fitting and inference. In the case of INAMHI, for example, at the Izobamba station, Gumbel and lognormal probability distributions are used depending on the duration analysed.

Consequently, formal comparisons with the Generalised Extreme Value (GEV) distribution or other classical inferential approaches could be developed as independent methodological studies, provided that the objective is to contrast extreme-value inference procedures. However, this is neither the procedure applied by MIT-Q nor the declared scope of the present manuscript, which is centred on the formulation and initial evaluation of a generative temporal structure for extreme storms, calibrated at a base station and spatially contrasted against official IDF references.

9 Comment 7: Overall conceptual contribution – synthesis of criticisms

“Overall, the work suffers from the following insurmountable problems:

1. **Lack of theoretical novelty**: The MCP is MaxEnt with an arbitrary prior. No new distribution is derived, nor are results obtained that cannot be obtained with standard methods.
2. **Circular references and unverifiable data**: Most of the cited data and previous works are inaccessible (theses, congress proceedings, technical reports without DOI). This violates the principle of reproducibility.

3. **Insufficient validation**: Only 4 stations, against IDF curves (not real data), with very high errors at some stations (MAPE 68%). No comparison with alternative methods.
4. **Spatial contradictions**: Adjusting to annual precipitation does not guarantee a correct simulation of extreme convective events, especially in high mountain areas.
5. **Abuse of mathematical terminology**: References to Noether's theorem and variational calculus without genuine application, only as rhetorical ornament."

9.1 Response to Comment 7 "Overall conceptual contribution – synthesis of criticisms"

The comment summarises objections that have been addressed individually in the preceding responses. We do not consider the points raised to constitute insurmountable problems in the manuscript, but rather aspects that have allowed the theoretical, methodological and operational scope of the PCM/MIT-Q to be specified more precisely.

1. Regarding the alleged equivalence between PCM and MaxEnt, it has already been clarified that the PCM is not formulated as an entropy maximisation problem with external constraints, nor as the introduction of a new distribution in itself. Its central contribution consists in extremalising a functional defined over the temporal trajectory of the event, from which an optimal temporal structure $P(t)$ emerges. Therefore, the contribution does not lie in replacing existing statistical distributions, but in representing the extreme storm as a complete trajectory over the interval $0 \leq t \leq DT$.

2. Regarding reproducibility, the limitations associated with historical sources without DOI, printed theses and technical documents of difficult access were addressed through the incorporation of supplementary material. In particular, the file *Supplementary_Data_MITQ* was included, and in the present reply *Supplementary_Data_2_MITQ* is incorporated with the scanned historical documents used in the methodological development of the model. Therefore, documentary traceability is substantially strengthened.

3. Regarding validation, it has already been clarified that MIT-Q is not validated against raw data, but against official hydrological references that incorporate extreme-value selection, probabilistic fitting and inference. Validation was carried out through comparison with complementary stations, and MAPE was incorporated as a quantitative metric. The specific case of the high MAPE at DAC–Aeropuerto was discussed as a discrepancy associated with a particular IDF reference, and not as a representative measure of the overall performance of the model.

4. Regarding spatiality, the manuscript does not state that annual precipitation alone determines the temporal structure of extreme storms. In MIT-Q, annual precipitation functions as a spatial constraint associated with the frequency of occurrence and the preferential displacement of trajectories, while the temporal structure of the event is defined through the variables PRE, DT and the temporal formulation of the model. It was also acknowledged that future applications in extreme páramo or high-mountain areas could benefit from additional specific validations.

5. Finally, regarding the use of mathematical terminology, the revised version more precisely delimits the role of the analogy with Noether and reinforces the variational formulation through the explicit derivation of the functional, the Euler–Lagrange equation, and the constancy condition of Maximum Certainty. The reference to Noether is not presented as a strict formal application, but as an interpretative analogy concerning the role of invariant quantities in variational formulations.

Taken together, the preceding responses define the structure of the work more precisely: the PCM provides the variational and temporal core; MIT-Q implements that structure as a generative storm model; and regional components, such as $\phi(b)$, act as complementary scaling factors. Therefore, the manuscript does not seek to demonstrate universal superiority over established inferential methods, but to present a structural-temporal representation of extreme storms and to initially evaluate its consistency against official IDF references.

10 Conclusion and final recommendation

For all the above reasons, it is concluded that the manuscript EGUSPHERE-2026-1317, as well as the author's response, do not remedy the fundamental deficiencies.

10.1 Response to the comment "Conclusion and final recommendation"

We do not share the conclusion that the observations raised have not been addressed. The present reply has made it possible to specify the actual scope of the manuscript, to correct formulations that could lead to excessive interpretations, and to strengthen documentary traceability through additional supplementary material.

The central point of the work is not to replace classical inferential methods or to substitute official IDF curves, but to present a structural-temporal representation of extreme storms, based on the extremalisation of the PCM functional and implemented through the MIT-Q scheme. From this perspective, the manuscript proposes a way of analysing the extreme event as a complete trajectory over the interval $0 \leq t \leq DT$, and not merely as a set of point maxima by duration.

We acknowledge that future research may broaden the comparison with other inferential approaches, incorporate additional validations using dense pluviographic networks, explore in greater detail the role of rainfall type — convective, orographic or stratiform — within the model, evaluate the observational identification of transition storms through coherence analysis between extreme intensities in the interval t_1–t_2, and further investigate the spatial uncertainty associated with regional applications. However, these extensions correspond to subsequent developments and do not invalidate the declared scope of the present manuscript.

Therefore, we consider that the revised version and the present reply address the substantive aspects of the comment, define the contribution of the work more precisely, and maintain a clearly defined methodological contribution within the stated scope.

Sincerely,
Franklin Beltrán
Jhoan Beltrán