Following advice from referee #2, we have revised the manuscript to include additional sensitivity analysis scenarios (relating to the duration of the EOF–ESP period, radii, and seasons analysed), clarify the terminology around the flood location and domains used, and de-emphasise statistical significance where necessary. The narrative has been slightly altered to reflect the speculative nature of the discussion regarding some of the physical processes that could influence our results. Furthermore, we have made our aims and the steps taken to achieved them more evident. Some figures have also been modified to account for these changes: sensitivity analysis (Figures 11, S8, S9, and Table S1); methodology (Figures 1 and 3); and statistical significance (Figure 6). Kindly see our responses to referees #1 and #3 for details on other modifications applied to the text.

Detailed responses to comments by anonymous referee #2 are given below, with the reviewer's comment in black and our response in blue. Quoted text from the revised manuscript is given in italics. The line and page numbers in the responses refer to the original version of the manuscript.

egusphere-2025-6192

Assessing the contribution of extratropical cyclones to river floods that caused property damage in Quebec, Canada

Responses to Anonymous Referee #2

This manuscript attempts to quantify the contribution of extratropical cyclones (ETCs) to damaging fluvial floods in southern Quebec from 1991–2020. The study combines reconstituted river outputs, government financial-aid claims, ERA5 precipitation, and the NAEC storm catalogue to identify 498 local flood events and characterize the ETCs associated with them. The paper's main findings are that most flood events occurred in spring, that most events had high to very high ETC contribution, and that flood ETCs differed from non-flood ETCs in their origins, lifetimes, and tracks.

Overall, I find the topic important and the dataset integration genuinely promising. The manuscript addresses a meaningful gap, particularly because it attempts to move beyond a few well-known case studies and to analyze damaging floods systematically across a broader set of watersheds, including ungauged areas. At the same time, I have substantial concerns about the robustness and interpretation of the attribution framework. In my view, the manuscript would benefit from major revision before it is suitable for publication. The key issue is that several central conclusions depend heavily on methodological assumptions whose justification and sensitivity analysis remain incomplete.

1. General comments

1.1 Robustness of flood timing definitions (SOF/EOF) needs to be addressed more directly.

A central concern is that the analysis relies on estimated Start of Flood (SOF) and End of Flood (EOF) dates derived from river sections exceeding the 2-year recurrence threshold, and the authors explicitly acknowledge that both SOF and EOF are crude estimates. These dates are then used to define the event search period and therefore directly affect the rainfall attributed to ETCs. The manuscript includes a sensitivity test for the spring SSP-to-SOF interval, but does not appear to test sensitivity to EOF despite the fact that ESP is set relative to EOF. This is a notable omission. The authors should either perform an analogous sensitivity analysis for EOF or provide a much clearer justification for why uncertainty in EOF is expected to have limited influence on the results.

Thank you for this important remark. Once the river flow drops below the 2-year recurrence flood value, we estimate that there will no longer be significant rainfall contributing to the flood event. This is why we were more interested into the SSP (start of the search period) – SOF (start of the flood) period. Nevertheless, we propose to include an additional scenario in the sensitivity analysis that prolongs the EOF (end of flood) – ESP (end of search period) for 24 h, referred to as the *days end* case. Kindly see our answer to comment 1.2 on pages 7–13 to see the results of this additional sensitivity analysis scenario.

More broadly, the manuscript should discuss how uncertainty in SOF/EOF estimation propagates into ETC contribution estimates and event classification.

We identified flood ETCs during the SSP–EOF period because we know that rainfall accumulated over a watershed can result in a delay between rainfall and subsequent streamflow increases. As the sensitivity analysis of a shorter SSP–SOF period showed, only three out of 160 flood ETCs were identified within the first five days of the SSP–SOF period for spring local flood events. This indicates that the initial definition of the SSP–SOF period was conservative (as discussed in section 4.4, p. 22, lines 437–439).

As for the SOF–EOF period, it is the most accurate indication of the timing of the flood event that the data can provide. We are aware that this does not pinpoint the exact moment of the flood (as discussed in section 3.1, p. 8–9, lines 171–180), but encompassing the entire rise and fall of the river flow above and below the 2-year recurrence flood value in the search period allows us to be more confident that the timing of the flood is included in the search period. For reference on the different relevant time markers (SSP, SOF, EOF, ESP), see the following Figure 2:

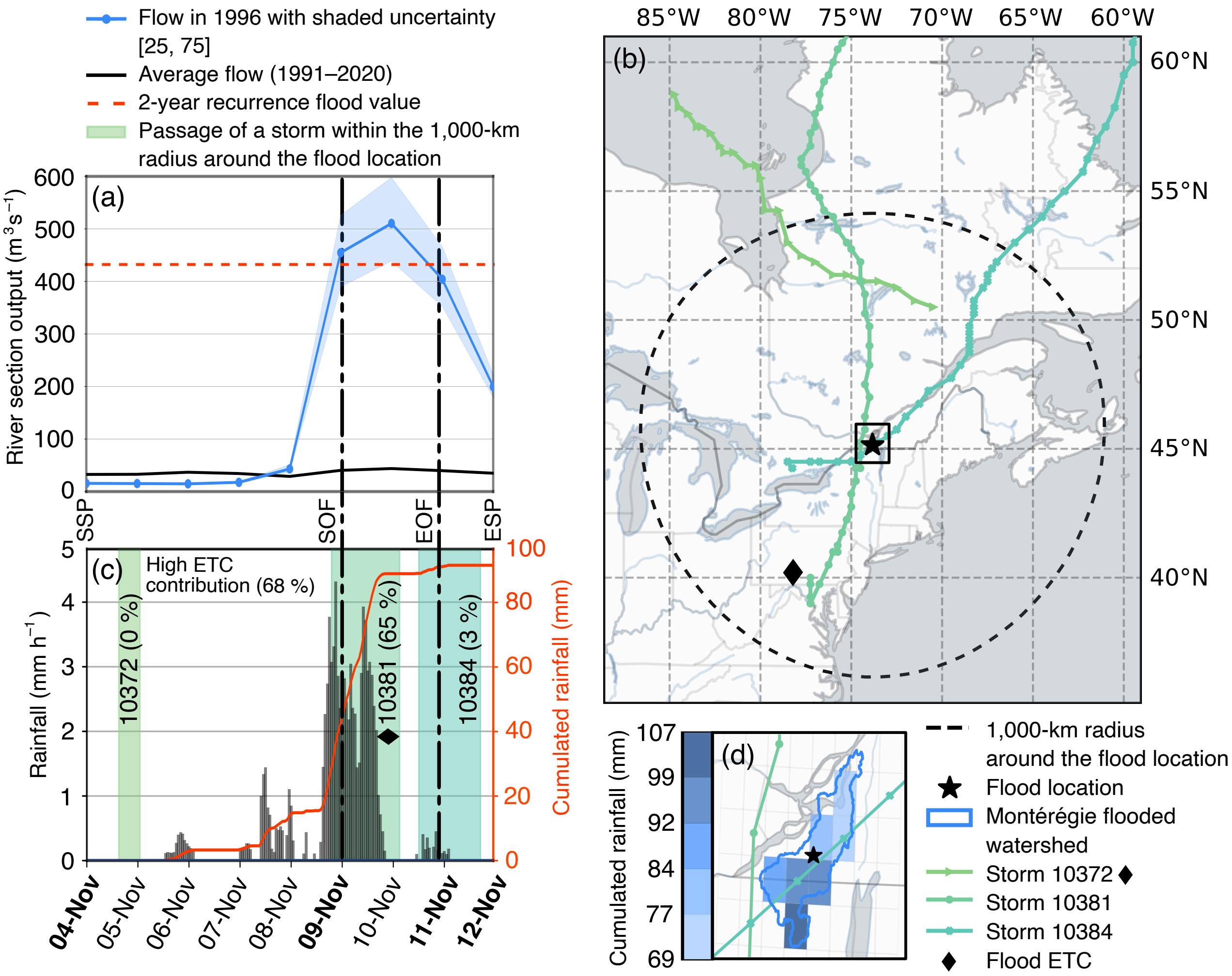

Figure 2. *Application of the methodology to the flood event of November 1996 in the Montérégie region. (a) River section discharge (blue) compared with the 2-year recurrence flood value (dashed red) for the flood event. (b) Storm tracks of ETCs entering the search domain (dashed black) between the SSP (start of the search period) and ESP (end of the search period) dates for the flood event and location of the flood (star). Tracks are shown for their entire lifetime (even components before and after they leave the domain). (c) Rainfall in the affected watershed for the local flood event with the contribution of the different ETCs and overall ETC contribution. The SSP, SOF (start of flood), EOF (end of flood), and ESP dates are shown in (a) and (c) and highlighted in bold in (c). The SOF and EOF dates are shown by the dash-dot lines in (a) and (c). The identified flood ETC is highlighted with a diamond (storm #10381) in (b) and (c). (d) Close up view of the Montérégie watershed affected by flooding, flood location* ***(centroid of the watershed)****, and cumulated rainfall during the search period.*

Of all the analysed flood events, the longest search periods were mostly found in spring. In such instances, it was more difficult for a given storm to accumulate enough rainfall to reach the minimum threshold required to be classified as a flood ETC. This demonstrates that the methodology had its limitations but was conservative for identifying flood ETCs.

1.2 The spatial attribution framework requires stronger justification.

> The manuscript defines local flood event locations by watershed centers and attributes flood-related precipitation to ETCs within a 1,000 km search radius around the affected watershed, assigning rainfall to the ETC closest to the watershed center when multiple ETCs are present. These are important modeling choices, but the rationale remains only partly convincing. It is not fully clear, for example, whether the relevant geometry is consistently defined relative to watershed centers or watershed edges across the different parts of the workflow.

Thank you for your comment. It is true that we used both the watershed edges and centers at different stages of our methodology, and perhaps this was not made clear enough in the paper. We used watershed edges to define the broader southern Quebec baseline domain and nowhere else in the analysis. Section 3.3.1 describes how the Baseline Southern Quebec domain was defined:

- p. 12, lines 247–248: *To achieve this, a broader search domain with a radius of 1,000 km was established around the edges of all the watersheds involved in the study.*

Watershed centers were used to define the 1,000 km radius for ETC search during the analysis of each flood event. However, the way this was explained in the text, using the formulation ‘around the watershed’, was confusing. To improve clarity, we propose the following modification to the text in section 3.2.3:

- p. 11, line 224: *Flood-related precipitation was attributed to ETCs by identifying ETC centers that were within 1,000 km* ***from the center of*** *the affected watershed.*

We also propose to the following modification to section 3.4 (kindly see the following pages 7–13 for more details on modifications to the sensitivity analysis):

- p. 13, lines 279–280: *The second scenario involved* ***decreasing the search radius to 600 km around the watershed centers,*** *referred to as the* ***radius1*** *case.*

> More importantly, the choice of a fixed 1,000 km radius seems somewhat arbitrary even if it is informed by prior ETC literature. A spring-only comparison with 750 km is useful, but it does not fully resolve the question of whether this radius is physically well matched to the flood attribution problem.

Thank you for your comment. We agree that using a single, fixed threshold of 1,000 km might not be appropriate for all flood ETCs, given that there are seasonal differences in the size of ETCs. One way to test the hypothesis that the radius was well matched was to conduct a sensitivity analysis on the 750 km radius for spring events (and flood ETCs). As discussed in section 4.4, p. 23, lines 453–457, the overall ETC contribution obtained for the control case (66.1%) is much closer to the percentages expected for precipitation associated with ETCs in our study area (70–85%) than the contribution obtained for the 750 km case (44.6%).

The sensitivity analysis also showed that, as expected, the number of flood ETCs identified for the spring case was lower (–29) with the 750 km radius than for the control case (radius of 1,000 km). However, the relative proportion of storms originating from the different clusters remained virtually unchanged, with maximum differences per cluster of around 2.5 % (as discussed on p. 22, lines 435–438).

Thus, we conclude that the fixed 1,000 km is therefore better suited than the 750 km for the analysis and is informed on previous literature, without being perfectly suited and adapted to each flood event given that it is not season-specific.

To show a wider range of scenarios, we have adapted the sensitivity analysis to include the fall season (second season with the most flood events), and 600 and 800 km radius alternative scenarios instead of only the 750 km (see details on pages 7–13).

> The authors should justify more explicitly why this choice is preferable to alternatives such as watershed-only precipitation, an edge-based or distance-weighted storm attribution scheme, or some physically motivated storm-footprint approach.

Thank you for your comment, the precipitation associated with the ETCs is indeed watershed only, as is explained in section 3.2.2:

- p. 11, lines 218–222: *Once the search period for studying floods had been defined, ERA5 precipitation data* ***were*** *gathered for the affected watershed of each local flood event. At each time step (hourly), the total precipitation and snowfall on the grid points within the watershed were averaged. This was done throughout the search period (between the SSP and ESP dates). The total cumulative values for snowfall, total precipitation, and rainfall were recorded for each analyzed event. Rainfall was calculated by subtracting snowfall from total precipitation.*

This is also mentioned in Section 3.2.3. However, the following modifications have been made to clarify this:

- p. 11, lines 224–228: *Flood-related precipitation was attributed to ETCs using a search radius of 1,000 km around the affected watershed. For each event, ETCs from the NAEC catalogue that entered the search radius during the search period were considered relevant, and all watershed precipitation was assigned to them for as long as they remained within the domain. If there was more than one ETC within the search radius at any moment, the* ***watershed*** *precipitation was associated with the ETC closest to the centre of the studied watershed.*
- p. 11, lines 233–236: *The following variables were recorded for each storm occurring during a flood event: time interval in the search radius, quantity and percentage of total precipitation, snowfall, and rainfall over the search period* ***inside the flooded watershed****. For each analysed flood event, the ETC contribution was defined as the* ***sum of*** *percentage****s*** *of the total rainfall associated with all* ***relevant*** *ETCs* ***recorded within*** *the search radius* ***during*** *the search period.*

> At a minimum they could present results from a wider range of buffers along with more justification as to why these buffers were chosen.

Methodological choices must be made in a study of this type. Although some of these choices may seem arbitrary, we have done our best to justify them and have conducted sensitivity analyses for those we considered most critical. The previous sensitivity analysis considered three alternative scenarios for the spring flood events, as shown in Figure 11, p. 23 as well as in Table S1 in the Supplement:

Table S1. Scenarios and their variables for the sensitivity analysis, differences in variables from the control case are shown in bold.

Scenario	Search radius (km)	Time interval between SSP and SOF (days)	Minimum threshold for flood ETCs	Number of flood ETCs identified	Median ETC Contribution to floods
Control	1,000	15	10 %	160	66.1 %
Radius	**750**	15	10 %	131	44.6 %
Days	1,000	**10**	10 %	157	63.9 %
Threshold	1,000	15	**15 %**	133	66.1 %

We propose to include the following additional scenarios for a more thorough sensitivity analysis:

- ○ Include fall flood events (second season with the most flood events after spring, $N = 58$)
- ○ Analyze two alternative radii (600 km and 800 km instead of the 750 km)
- ○ Include a "Days end" scenario, where we add one day to the EOP–ESP period (as discussed in comment 1.1)

Here is the revised Table S1, incorporating the new scenarios investigated in the sensitivity analysis with their results (number of flood ETCs identified and median ETC contribution):

Table S1. Scenarios and their variables for the sensitivity analysis, differences in variables from the control case are shown in bold.

Season	Scenario	Search radius (km)	Time interval between SSP and SOF (days)	Time interval between EOF and ESP (days)	Minimum threshold for flood ETCs	Number of flood ETCs identified	Median ETC Contribution to floods
MAM	Control	1,000	15	1	10 %	160	66.1 %
MAM	Radius1	**600**	15	1	10 %	105	34.1 %
MAM	Radius2	**800**	15	1	10 %	137	49.1 %
MAM	Days	1,000	**10**	1	10 %	157	63.9 %
MAM	Threshold	1,000	15	1	**15 %**	134	66.1 %
MAM	Days end	1,000	15	**2**	10 %	165	65.5 %
SON	Control	1,000	5	1	20 %	13	72.9 %
SON	Radius1	**600**	5	1	20 %	9	51.6 %
SON	Radius2	**800**	5	1	20 %	13	63.2 %
SON	Days	1,000	10	1	20 %	13	63.4 %
SON	Threshold	1,000	5	1	**25 %**	13	72.9 %
SON	Days end	1,000	5	**2**	20 %	14	71.9 %

We propose to add the following Figures S8 and S9 to the Supplement (to be inserted between the current Figures S7 and S8) to represent the additional sensitivity analysis on fall flood events. Current Figure S8 (on extratropical transition storms) would become Figure S10.

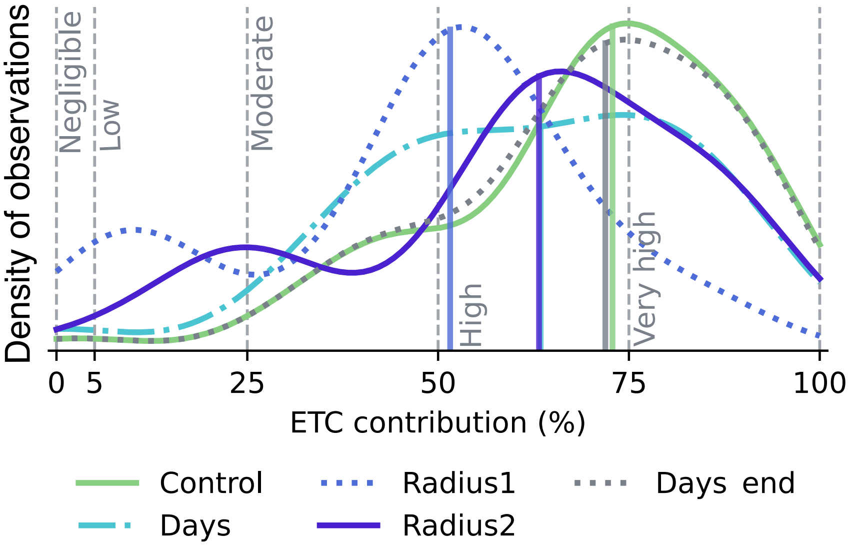

Figure S8. *Distribution of ETC contribution for four scenarios (days, radius1, radius2, and days end) compared to the control case for SON floods (N = 58). Medians (M) per distribution are indicated by the vertical lines.*

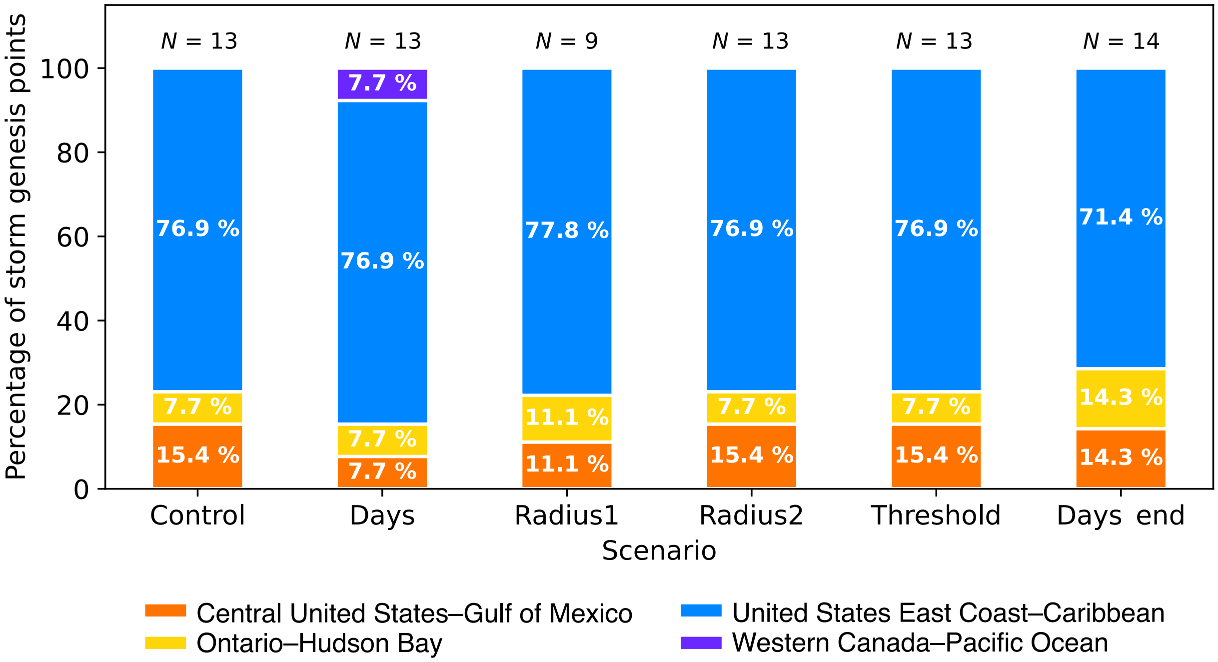

Figure S9. *Distribution of genesis location of flood ETCs identified in SON flood events for the control case compared to the five other scenarios.*

To keep with the current analysis of spring flood events, we also revised Figure 11 in the article as well as Figure S7 in the Supplement as follows:

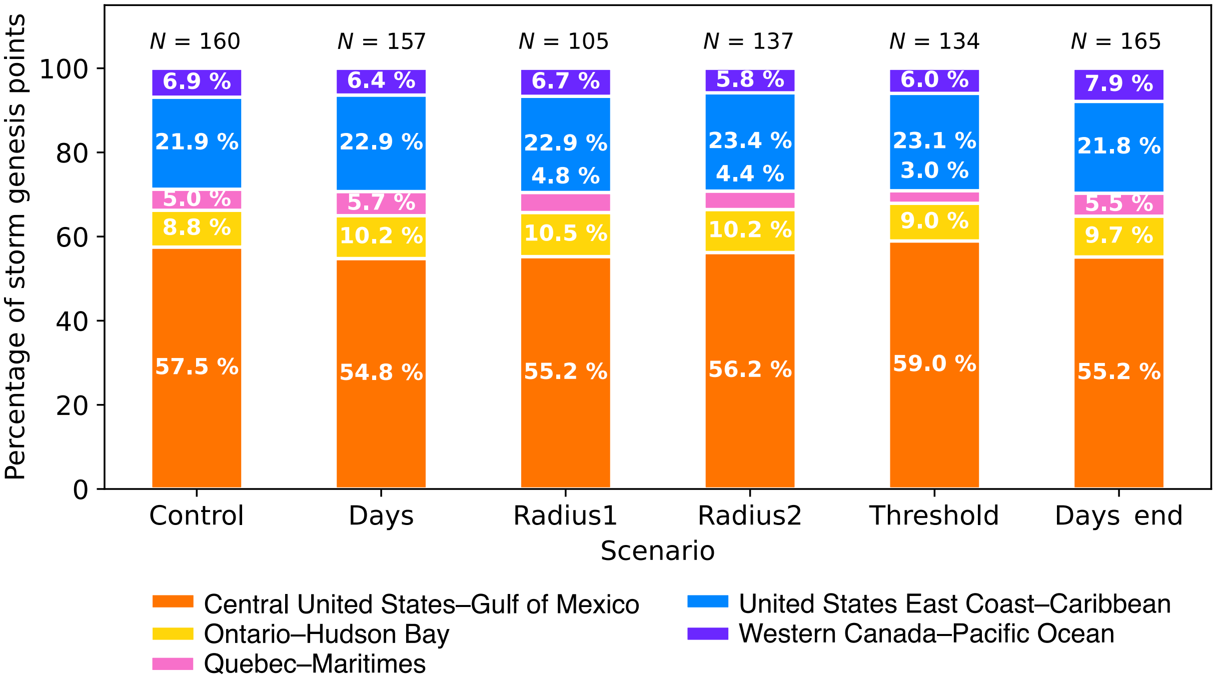

Figure 11. *Distribution of genesis location of flood ETCs identified in MAM flood events for the control case compared to the five other scenarios.*

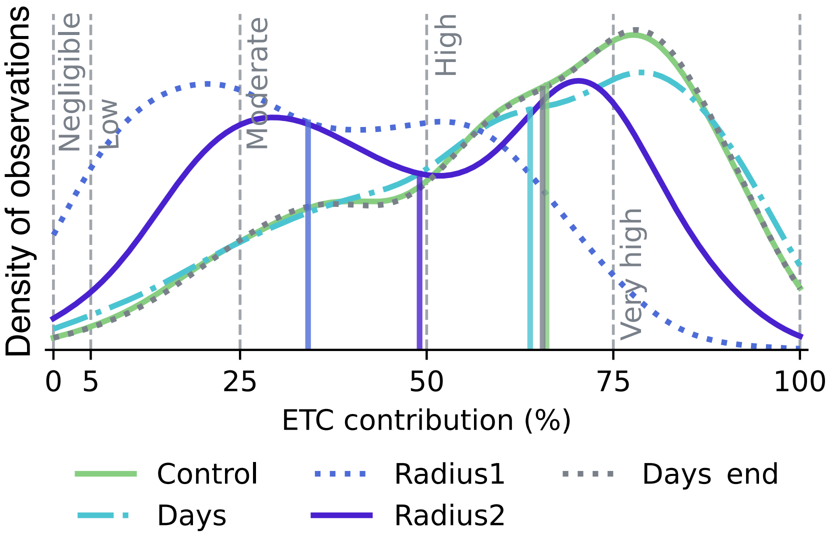

Figure S7. *Distribution of ETC contribution for* ***four*** *scenarios (days****, radius1, radius2, and days end****) compared to the control case for MAM floods (N = 372). Medians (M) per distribution are indicated by the vertical lines.*

To integrate the additional sensitivity analyses to the manuscript, we propose the following changes:

- Section 3.2.1, p. 10–11, lines 212–214: *Please note that we performed a sensitivity test* ***on the SSP–SOF period by setting it to 10 days for both spring and fall flood events (making the period shorter in spring, and longer in fall)*** *described in Sect. 3.4. For all seasons, the ESP date for the data search was set to one day after the EOF date.* ***A sensitivity test was also performed on a 2-day ESP–EOF period, described in Sect. 3.4.***
- Section 3.2.3, p. 11, lines 229–232:

  The choice of the search radius was made following several publications on ETCs over North America (Chen et al., 2024; Chen and Di Luca, 2025; Chen et al., 2022a; Hawcroft et al., 2012) and it was decided to keep it constant independently of the seasons, to simplify the method. The choice of a 1,000 km radius is discussed further and compared to smaller ***ones (600 and 800 km)*** *in Sect. 3.4.*
- Section 3.3.3, p. 13, lines 265–266: *This motivated the need for a different threshold in spring.* ***These*** *threshold****s are*** *compared to higher* ***ones (+5 %) for spring and fall cases*** *in Sect. 3.4.*
- Section 3.4, p. 13, lines 275–283:

  A sensitivity analysis was carried out on spring ***and fall*** *flood events to assess the impact of varying some key variables on identified flood ETCs and overall ETC contribution.* ***For each of the two seasons, five*** *different scenarios were studied, each with one key parameter varying from the default value, defined herein as the control case. The spring* ***and fall*** *season****s*** *w****ere*** *chosen for this analysis due to* ***their*** *higher number of flood events* ***(N = 372 and N = 58, respectively)****, allowing better comparison between the scenarios.*

  The first scenario involved ***setting*** *the number of days between the SSP and SOF dates* ***to*** *10 days, referred to as the days case.* ***For spring, the days scenario reduces the duration of the studied interval, as the SSP–SOF period is normally set to 15 days. The opposite is true for fall: the SSP–SOF period is normally set to five days, so the days scenario extends the duration of the studied interval.*** *The second scenario involved* ***decreasing*** *the search radius to* ***600 km around the watershed centers,*** *referred to as the* ***radius1*** *case.* ***Similarly, the third scenario involved decreasing the search radius to 800 km, referred to as the radius2 case.*** *The* ***fourth*** *scenario involved increasing the threshold* ***of cumulated rainfall during the search period necessary*** *for storms to be considered flood ETCs* ***by 5 % : going*** *from 10 % to 15 %* ***during spring floods and from 20 % to 25 % during fall flood events. This fourth scenario is*** *referred to as the threshold case.* ***Finally, the fifth scenario involved extending the EOF–ESP period by 24 h, referred to as the days end case.*** *The set of variables* ***as well as the results*** *associated with the* ***five*** *scenarios studied and those of the control case are shown in Table S1 in the Supplement.*

- Section 4.4:
    - Adding two subsections to section 4:

      4.4.1 Sensitivity analysis results on spring flood events

      4.4.2 Sensitivity analysis on fall flood events
    - p. 22, lines 434–435: *Figure 11 shows the percentage distribution of genesis location of flood ETCs, as identified through the* ***five*** *alternative scenarios and the control case, resulting from the application of the method to the 372 spring flood events.*
    - p. 22, lines 435–439: ***For spring, all five*** *alternative scenarios showed very little differences in the distribution of genesis location among identified flood ETCs: the majority of flood ETCs still came from the Central* ***United States–****Gulf of Mexico cluster, as can be seen in Fig. 11. The 'days' scenario only identified three fewer flood ETCs. This suggests that the chosen search period was conservative, since few flood ETCs were identified during the first five days of the search period for spring flood events.* ***Similarly, the 'days end' scenario had a minimal impact on the number of flood ETCs identified: only five more flood ETCs were identified through this scenario.***
    - p. 22, lines 440–443: *For* ***the other*** *scenarios, the number of identified flood ETCs were lower than for the control case, with* ***23 (14.4 %)*** *fewer flood ETCs identified in the* ***radius2*** *scenario, 26 (16.3 %) fewer in the threshold scenario****, and 55 (34.4 %) fewer in the radius1 scenario.*** *Differences between the control and* ***radius2*** *scenarios signify that a small proportion* ***(14.4 %)*** *of flood ETCs identified in the control case track relatively far – between* ***800*** *and 1,000 km – from the center of the flooded watersheds.*
    - p. 23, lines 453–455: *Differences in ETC contribution from the control to the 'days'* ***and 'days end'*** *scenarios were minimal, with the median ETC contribution falling from 66.1 % to 63.9 %* ***in the 'days' case and to 65.5 % in the 'days end' case*** *(see Fig. S7 in the Supplement). In contrast, but expectedly, reducing the search radius impacted ETC contribution, decreasing it from a median of 66.1 % in the control case to* ***49.1 %*** *in the* ***'radius2'*** *case****, and to 34.1 % in the 'radius1' case*** *(see Fig. S7).*

- Section 4.4 (continued):
    - Adding a section for results of the sensitivity analysis on fall flood events after line 457, on p. 23 (note that this section was not put in bold, for readability, but is a new addition):

4.4.2 Sensitivity analysis on fall flood events

Even though 58 flood events occurred in fall, only 13 flood ETCs were identified in the control case. For this reason, the results on the sensitivity analysis for the fall season are harder to interpret. Nevertheless, in fall, the distribution of provenance of flood ETCs changed very little for the different scenarios studied: storms originating from the United States East Coast–Caribbean cluster composed the majority of flood ETCs, representing between 71.4 % and 77.8 % of storms, depending on the scenario. This can be visualized in Figure S9 in the Supplement. Only the 'radius1' and 'days end' scenarios had different number of identified flood ETCs compared to the control case (–4 and +1, respectively).

Extending the EOF–ESP period ('days end' scenario) had a negligible impact on the median ETC contribution (went from 72.9 % in the control to 71.9 %). Interestingly, both the 'radius2' and 'days' scenario resulted in similar changes to the ETC contribution. By reducing the search radius to 800 km ('radius2' scenario), the ETC contribution lowered to 63.2 %. By increasing the SSP–SOF period from five to ten days, the ETC contribution lowered to 63.4 %, showing that little precipitation occurred during these additional five days at the beginning of the studied time intervals. As with the spring floods analysis, the radius1 scenario had the lowest median ETC contribution in fall, at 51.6 %.

1.3 The manuscript is primarily descriptive, and the conclusions should be aligned more carefully with that scope.

The study contains many interesting descriptive patterns, but at present the discussion sometimes pushes toward stronger attributional or explanatory conclusions than the analyses can fully support. This matters because the manuscript itself states that no formal statistical attribution was performed. I therefore encourage the authors to distinguish more clearly between descriptive association, statistical difference, and physical attribution.

Thank you for your comment, that is a valid point. We have revised the discussion to highlight the more speculative nature of certain statements. The changes are as follows:

- Section 3.2.3:
    - p. 11, lines 239–241: ***We hypothesize that the*** *precipitation not associated with ETCs (such as 31.9 % of the rainfall that occurred during the November 1996 flood) could be attributed to different phenomena,* ***such as*** *convective systems, ETCs with a radius of influence greater than 1,000 km, or weak systems not reaching the necessary MSLP and vorticity thresholds to be featured in the NAEC Catalogue.*
- Section 5.1: The explanations behind the ETC contribution in summer were not speculative enough. We propose the following changes:
    - 24, lines 469–476: *The number of local flood events with negligible ETC contribution was highest in summer, as can be seen in Fig. 6. In summer, high-intensity rainfall is often associated with smaller systems, such as mesoscale convective systems and isolated thunderstorms, which can lead to flash flooding (Alpizar et al., 2026; Bourgault et al., 2022; Prein et al., 2023).* ***We hypothesize that, in the cases of summer local floods with negligible to low ETC contribution, these processes could have been responsible for the additional precipitation that led to flooding.*** *Aside from the occurrence of sporadic extreme precipitation, summer is generally a season when flooding is less likely to occur, as river levels are low and can accommodate more rainfall****. Therefore,*** *significant rainfall* ***is*** *required* ***for flooding to occur in the summer****, which* ***could also*** *explain* ***why this season had*** *the* ***highest median*** *ETC contribution* ***to floods*** *(83.5 %****, very high****).*

The same was true on the explanations behind the lower ETC contribution in spring. As such, we propose the following changes:

- 24, lines 477–479: *The lowest average and median ETC contributions were recorded in spring, which is not surprising considering that other factors, such as snowmelt triggered by sudden temperature increases, can influence spring flooding.* ***We speculate that these processes could*** *reduce the importance of ETC-associated precipitation needed to trigger* ***spring*** *flooding.*

- Section 5.2:
    - p. 24, lines 506–508: *Forming within the Baseline Southern Quebec domain and typically tracking eastward, Quebec–Maritimes storms have shorter lifetimes (22 h less on average than Central* ***United States****–Gulf of Mexico storms, see Fig. 9c). This makes them poor flood ETCs candidates, which* ***could explain*** *their limited presence among flood ETCs.*

- Conclusions:
    - p. 26, lines 553–554: *It is suspected that the longer lifetime, known intensity, and increased cyclogenesis of these storms in spring – when most flooding occurs –* ***contributed to their larger proportions among*** *flood ETC****s****.*
    - p. 27, lines 568–571 (also discussed in our answer to comment 1.5): *Studying these flood ETCs in detail can provide valuable insight into the atmospheric causes of flooding and help understand* ***the types of storms associated with*** *past catastrophes****; in this case*** *those originating from the Central* ***United States–****Gulf of Mexico in spring.*

1.4 Statistical significance is emphasized more than effect size or practical importance.

Several comparisons are based on Kolmogorov-Smirnov tests or chi-squared tests. Those tests can be appropriate, but as currently presented they do not always communicate the magnitude or practical relevance of the differences. This is especially important for large samples, where null hypotheses are often easy to reject.

Thank you for your comment, we have revised parts of the manuscript where statistical significance was overemphasized, and propose the following changes:

- In section 4.2, the statistical significance of the difference in the JJA distribution compared to the MAM and SON is not essential. Instead, we propose the following changes:
    - We thus propose removing the following sentence:
      p. 15, lines 316–318: *The summer season also exhibited an ETC contribution pattern distinct from those of the spring and fall, with post hoc tests confirming a statistically significant difference with an adjusted α of 0.0083. In contrast, the summer ETC contribution did not differ significantly from that of winter.*
    - We propose the following modifications:
      p. 15, lines 315–320: *Summer recorded the highest proportion of local flood events with a negligible ETC contribution (14.6 % of all summer floods).* ***For all seasons, the mode of ETC contribution is very high****. Table 1 also shows that, overall, the mean ETC contribution for all seasons was in the high (50–75 %) range. However, summer was the only season with a median ETC contribution in the very high range (83.5 %)****, making this season the one with the highest percentages of both very high and negligible ETC contribution.***

- We also propose modifying Figure 6 and its caption to omit statistical significance:

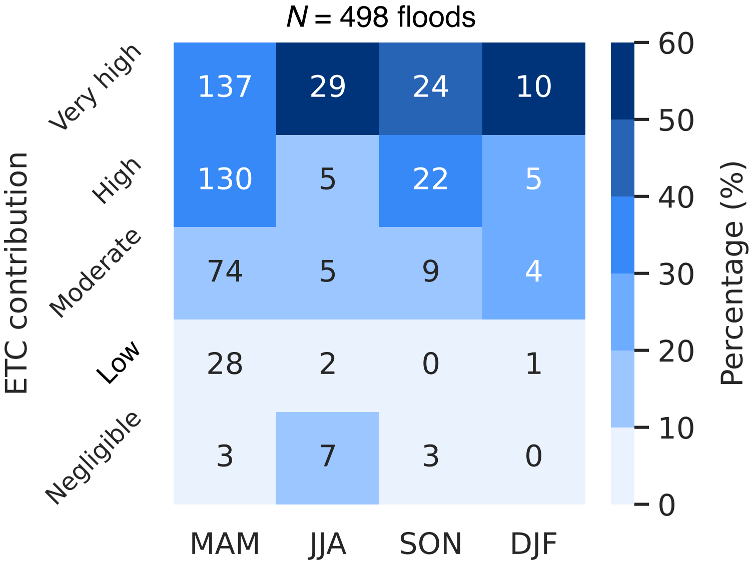

Figure 6. *Level of ETC contribution to local floods, shown as percentages of the total number of local flood events by season (in shades of blue) and absolute number of events in each category (numbers in the cells).*

- In section 4.3.2 (p. 19, lines 385–386), the differences in the regions of origin of flood vs non-flood ETCs from the United States East Coast–Caribbean and Ontario–Hudson Bay clusters were not described in detail due to them not being statistically significant. We have revised the following text as follows:
  - We plan on removing this sentence:
    However, the differences in the proportion of non-flood and flood ETCs originating from the US East Coast & the Caribbean, as well as for the Ontario & Hudson Bay clusters were not significant.
  - … and adding this sentence:
    Although these differences were not statistically significant, flood ETCs showed a higher proportion of storms originating from the United States East Coast–Caribbean (+3.7 %) and a lower proportion originating from the Ontario–Hudson Bay (–4.4 %) clusters than the non-flood ETCs.

- Section 4.3.2 (p. 19, lines 393–394) does not mention the sample sizes of flood ETCs in summer, fall and winter, despite discussing statistical significance. We believe that adding nuance to the results in this section would improve the text. Therefore, we have added the following:

  - p. 19, lines 393–394: *Finally, the differences were not significant in winter, which exhibited a more uniform distribution of origin among flood ETCs, ranging from 8.3 % (Quebec–Maritimes) to 33.3 % (Central United States–Gulf of Mexico).* ***It is important to note that the sample sizes of storms in the summer, fall, and winter seasons were small (as shown in Figure 7a), making the statistical significance of the results more difficult to interpret.***

1.5 The manuscript could benefit from a tighter central narrative.

At present, the paper has several partially competing aims: identifying flood events, attributing rainfall to ETCs, classifying flood and non-flood ETCs, clustering cyclogenesis regions, and discussing implications for flood preparedness. Each component is interesting, but together they make the paper feel somewhat diffuse. I think the manuscript would be stronger if the authors more clearly prioritized one primary contribution.

All of these specific aims (identifying flood events, attributing rainfall to ETCs, classifying flood and non-flood ETCs, clustering cyclogenesis regions) form part of a whole that led us to the paper's main objective: quantifying the contribution of ETCs to flooding. We agree that this should be more explicit in the text and propose several modifications:

We propose to add the following section between the sentences labelled A and B here on p. 3 to make the links between the steps clearer:

- A: lines 88–89: *More specifically, we investigate whether ETCs that trigger flood events have any common characteristics (e.g. cyclogenesis location, trajectories and lifetime).*
- Add the following sentences, lines 89–92: ***More specifically, we investigate whether ETCs that trigger flood events have any common characteristics (e.g. cyclogenesis location, trajectories and lifetime). Our aims can be achieved through a series of steps. First, we objectively and systematically identify flood events during the period of interest by combining data on governmental financial assistance with reconstituted river outputs. Government financial assistance data provide evidence of where and when floods caused damage, while reconstituted river output data allow us to cover ungauged watersheds. Next, we attribute rainfall to storms in proximity to the flooded watersheds during flood events, which enables us to classify storms as***

either contributing to flooding or not. Finally, clustering is performed on the genesis location of the studied storms to enable comparison, allowing us to investigate the characteristics of storms contributing to flooding.

- B: lines 92–93, make this sentence start a new paragraph: *As financial aid data depends on the presence of human populations, it should be noted that the study only focuses on river floods that caused property damage.*

We also propose to modify parts of Sect. 3 (Methods) as follows:

- p. 9, lines 177–180: *The SOF was always set at the beginning of the day, and the EOF at the end of the day, as this still placed the two time markers 23 h apart if they occurred on the same day (as daily river output values are used).* ***This crucial initial step of grouping financial aid claims in time and space makes it possible to quantify the contribution of ETCs to flooding later on.***
- p. 11, lines 243–244: *This section outlines the process of classifying ETCs. This involves distinguishing between storms that contribute to flooding (flood ETCs) and those that do not (non-flood ETCs), and grouping them according to where they originated.* ***This classification is needed to enable the comparison between the two groups of storms and identify unique characteristics of flood ETCs.***

We also propose to omit comments on flood preparedness, as it falls outside topics discussed throughout the paper. Hence, “and ultimately enhance flood preparedness” (p. 1, line 27) and “Ultimately, this could enhance flood preparedness.” (p. 27, line 571) were removed from the text, and the following sentences modified:

- p. 1, lines 25-27: *The method developed in this study could be applied to other regions or types of storms analysed (e.g. tropical cyclones and mesoscale convective systems) to further our understanding of the atmospheric causes of flooding* ***in northeastern North America.***
- p. 27, lines 568–571 (as shown in our response to comment 1.3): *Studying these flood ETCs in detail can provide valuable insight into the atmospheric causes of flooding and help understand* ***the types of storms associated with*** *past catastrophes****; in this case*** *those originating from the Central* ***United States–****Gulf of Mexico in spring.*

2. Minor comments

2.1 Figure 1 is informative but overly complex.

The methods overview is useful, but the figure is visually dense and difficult to parse quickly. I recommend simplifying the flow diagram or moving some of the process detail to the supplement.

Yes, we agree it is a bit dense and propose to replace the current Figure 1 with the following simplified version:

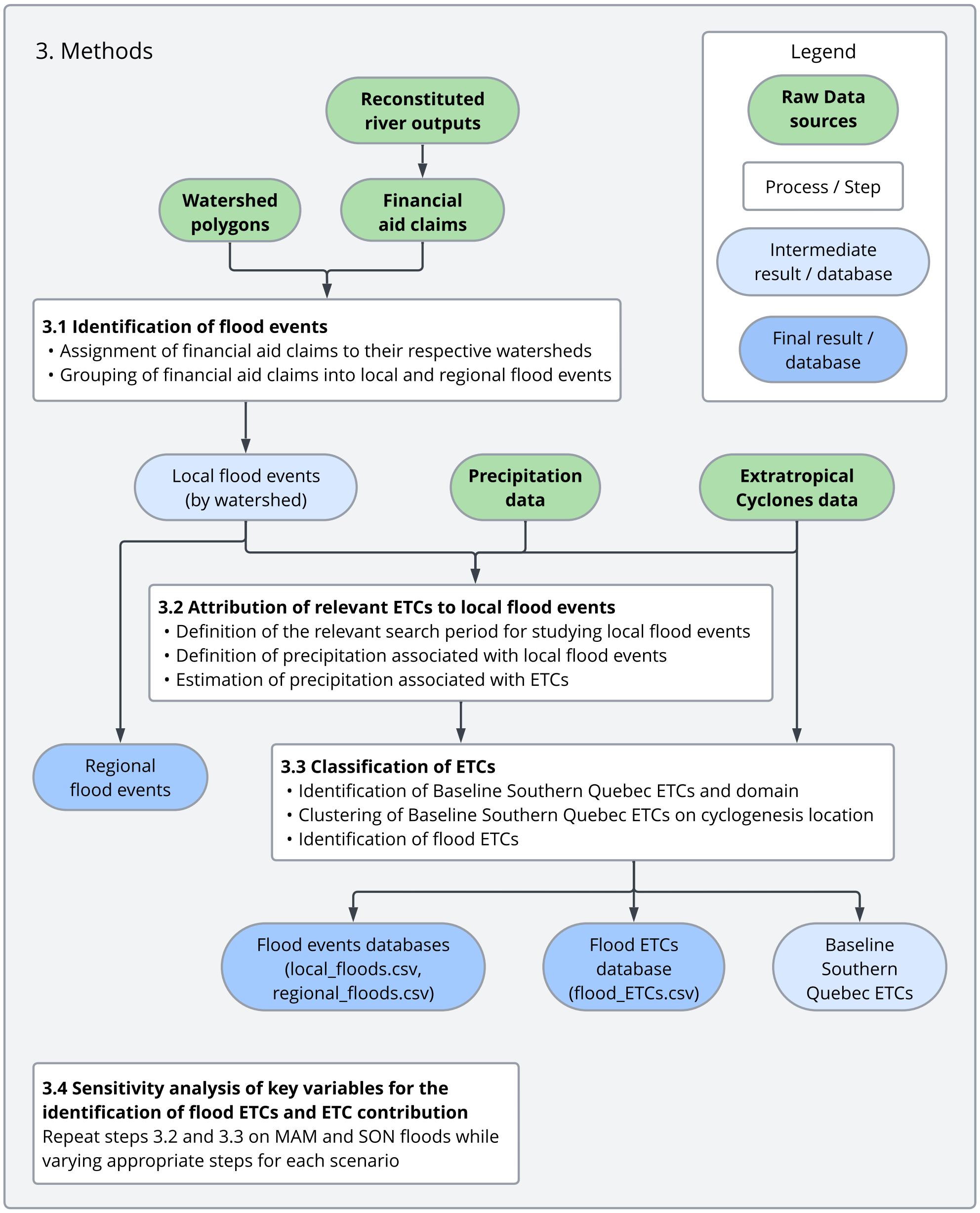

Figure 1. *Overview of the methodological steps (described in Sect. 3) and sources of data (described in Sect. 2) used in the study.*

2.2 Figure 4 would benefit from a scale bar.

Because spatial buffers and domain definitions are central to the paper, the map showing the Baseline Southern Quebec domain would be easier to interpret with a scale bar.

Thank you for your comment, while it is true that it could be useful, as the domain is quite large it would be difficult to make the scale bar accurate everywhere on the domain. Instead, we propose to modify the caption of Figure 4 to include a mention of the distance between the edges of the watersheds and the Baseline Southern Quebec domain. Here is Figure 4 with the modified caption:

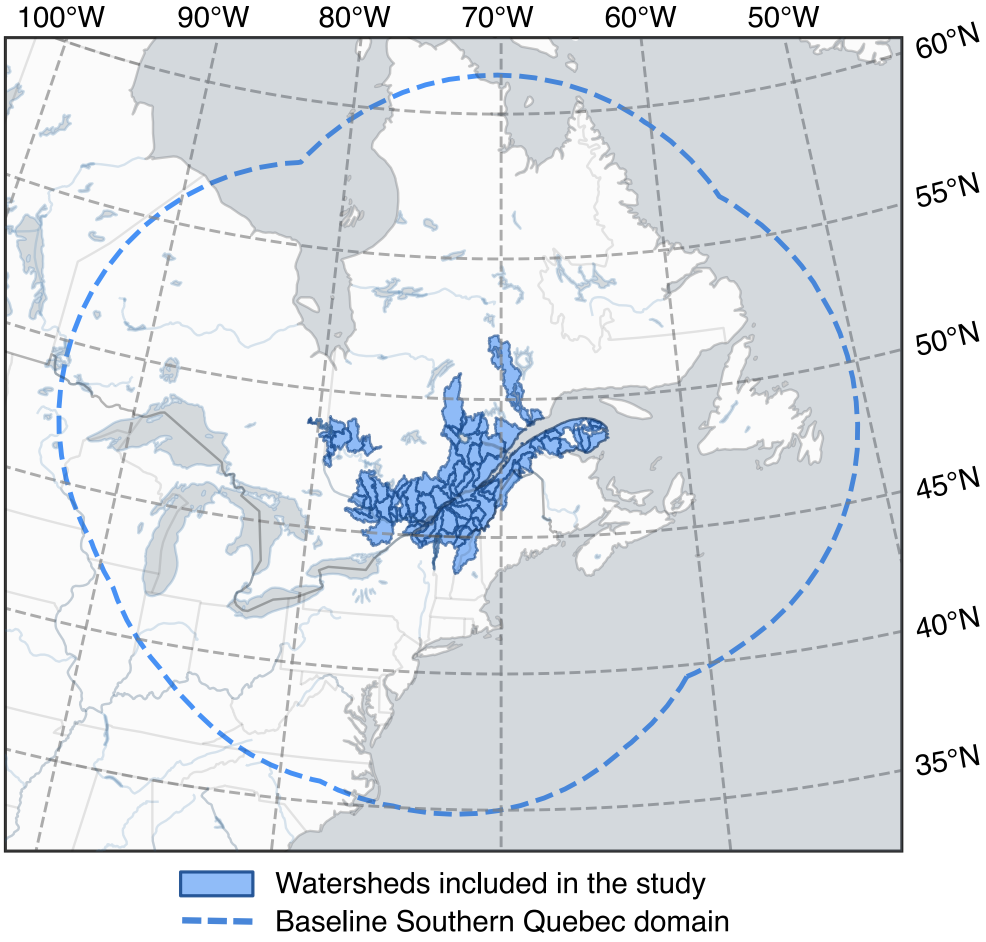

Figure 4. *Watersheds included in the study (filled blue), and the Baseline Southern Quebec domain (dashed blue).* ***Distance between the edges of the ensemble of watersheds and the Baseline Southern Quebec domain is 1,000 km.***

2.3 Clarify terminology around flood "location."

The manuscript states that local flood event locations are defined by watershed centers. Since floods are not point phenomena, this wording can be misleading. It would help to clarify consistently whether "flood location" refers to a representative centroid used for the search procedure, rather than the true geographic extent of flooding.

Thank you for your comment, it is true that the current phrasing can be misleading. We have revised the text as follows:

- p. 10, lines 198–199: *Finally**, to conduct the analysis, flood locations were defined as watershed centers, rather than the actual locations of the damaged buildings or the sections of the river involved (as shown in Fig. 3), in order to maintain the confidentiality of the data used.** This formed the basis of the search domain for ETCs related to the local flood.*

We also propose to include a marker for the center of the watershed in Fig. 3 to support this description, like so:

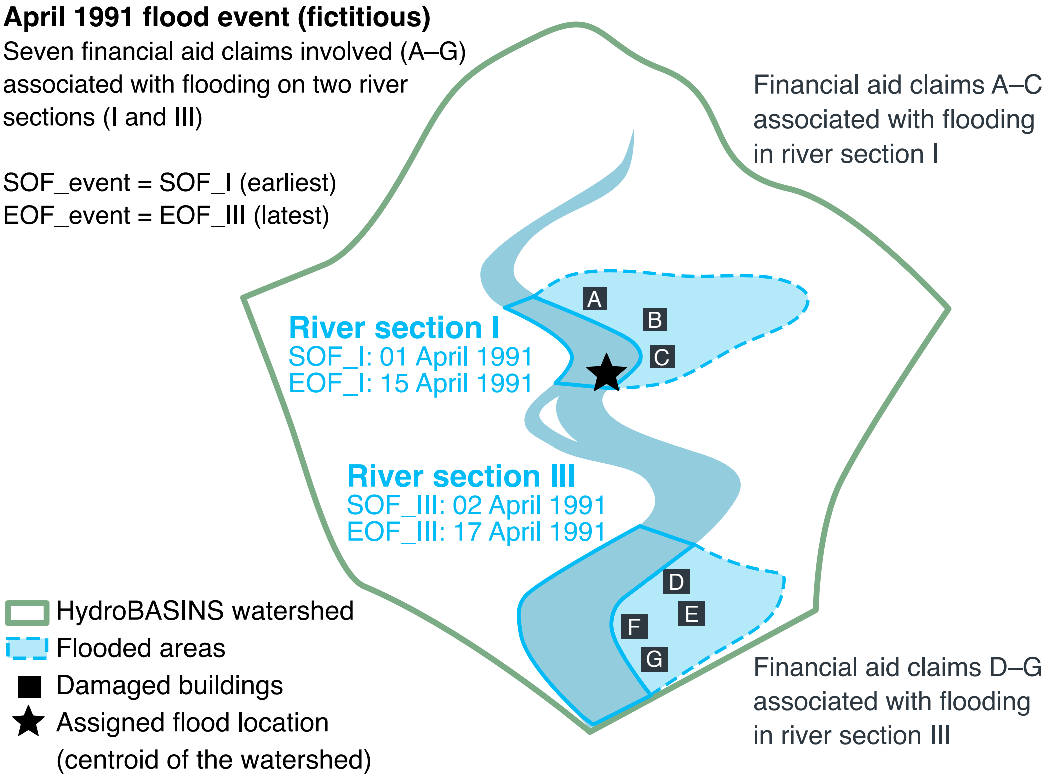

Figure 3. *Visual representation of grouping financial aid claims into a local fictitious flood and selecting the correct SOF and EOF dates among the flooded areas' associated river sections' dates.*

We have also revised part of the conclusion where flood location was mentioned as follows to be more precise:

- p. 27, lines 566–568: *This study proposes a methodology for systematically identifying extratropical cyclones that contribute to flooding (flood ETCs), using data characterizing damages (government financial aid claims) and reconstituted river outputs to determine the timing and location* ***(at the watershed level)*** *of floods.*