Reviewer 4:

Major comments:

R4.C1: **Attribution of the flood mechanism**

The authors should clarify more explicitly that the study does not confirm the existence of a subglacial water pocket and that the results represent potential storage capacity. It would also be helpful to discuss whether the estimated volume could realistically account for the magnitude of the observed flood.

A: We thank the reviewer for this important comment. We agree that the distinction between potential storage capacity and the *actual* subglacial water storage (not known) at Bonne Pierre should be clearly made in our manuscript. We believe that this clarification was already stated in the Abstract (*"In the absence of direct observations of water*

Pockets, [...]"), Introduction ("*The resulting volumes therefore represent a first-order estimate of the potential water storage capacity of hydraulic barriers prior to the June 2024 flood event, rather than a reconstruction of the actual filling or rupture processes associated with the flood*") and Conclusions ("*However, the lack of direct observations of water pockets and the steady-state nature of our numerical approach prevent a definitive attribution of the flood mechanism*"), but we added a sentence in the Discussion, in the subsubsection "Outlook: observations needed to discriminate between the two scenarios": "*In scenario 1, the volume of subglacial water (≈ 150×10^3 m^3) remains speculative because no direct observations confirm the long-term persistence of a large water pocket. [...]"*. This subsubsection is new and was added to better structure the Discussion (see also **R2.C3**).

We also added a new table (which summarizes the deterministic and stochastic water-pocket volumes, following a suggestion from R4, see minor comments), in which we clarify that *"[...] these volumes correspond to maximum potential water-pocket volumes for each configuration and cannot be confirmed due to the lack of in situ observations*".

R4.C2: Justification of the flotation fraction

The authors should provide stronger references supporting this assumption and discuss whether values exceeding the ice overburden pressure ($f > 1$) are realistic in the study area.

A: We acknowledge that the arbitrary choice of the flotation fraction *f* represents a major limitation in our study. In the initially submitted version, we explained our choice mainly in Appendix. We now moved these justifications in the Discussion, in order to explicitly discuss the likelihood of having $f > 1$ in a more relevant location of the manuscript. We also added a reference to the work by De Fleurian (2016), who shows $f \geq 1$ from borehole observation in Greenland, and the capability of numerical models (e.g. Werder et al, 2013) to reproduce spatial fluctuation of *f* with values temporarily above 1. We also recalled that the physical quantity of interest for the routing model is the hydraulic gradient, not the potential as such. The relevant text in Discussion now reads as follows:

" […] and f = 1.1 represents a pressurized drainage system with water pressure larger than ice overburden pressure, which may occur when subglacial water input exceeds outflow. Such conditions are considered realistic prior to and during the June 2024 flood at La Bérarde – at least locally – given the high water input from rainfall and snowmelt in the glacier catchment. Values of f > 1 have been locally observed for short periods in borehole water-level measurements (Harper et al., 2005; Huss et al., 2007; De Fleurian et al., 2016; Rada and Schoof, 2018) and have been reproduced in physically-based models of the subglacial drainage system (Werder et al., 2013). Under these overpressurized conditions, water could spread across the bed through linked subglacial cavities (e.g., Kamb, 1987) and/or flow upward through moulins or crevasses connected to the subglacial drainage system, eventually causing overflow at the surface. However, note that the quantity of interest to the routing model is420 the gradient of the hydraulic head, and therefore a value of f > 1 does not necessarily translate into a statement that the water pressure is greater than the ice pressure; rather, it states that the gradient downstream of a f > 1 area is larger than what the Shreve potential (f = 1) would predict."

Moreover, we added a forward reference at the end of Methods: "This arbitrary choice reflects the lack of direct measurements of basal water pressure and is discussed in Section 5.2." This makes it clearer that this important choice is discussed later in the manuscript.

R4.C3: Limitations of the steady-state hydrological mode

The authors should expand the discussion of the limitations associated with applying steady-state models to extreme flood events. In particular, it should be clarified that transient pressure changes and rapid drainage reorganization are not captured by the modelling framework used here.

A: We added such an explanation paragraph at the beginning of the Methods, in "methods overview", where we explicitly write that we don't capture transient pressure changes and rapid drainage reorganization (cf. answer to R2.C2):

Our numerical approach intentionally represents a steady-state configuration of the subglacial drainage network and does not aim to reproduce the highly dynamic, time-dependant physical processes occurring during the flood event (e.g., enlargement of subglacial channels, ice creep, and transient reorganization of the drainage network). While physically-based models capable of representing some of these processes exist (see Flowers, 2015, for a review), their outcomes would be highly sensitive to stochastic, small-

scale processes related to water routing that are neither directly observable nor straightforward to parameterize. The application of such models to real alpine glacier settings remains strongly limited by data availability (such as exact bedrock topography) and the difficulty of constraining initial and boundary conditions at the required spatial and temporal scales. Therefore, our approach focuses on estimating the maximum potential storage capacity of hydraulic barriers given the geometric inputs available for Glacier de Bonne Pierre.

R4.C4: Interpretation of GPR observations

The authors should discuss the detection limits of GPR and whether large water pockets could remain undetected due to signal attenuation or resolution limitations. This discussion is important given that the modelling results suggest the possible presence of a relatively large water volume.

A: Thanks for pointing out this limitation: the GPR acquisition indeed allowed for relatively good bedrock mapping, but was not sufficient to determine precisely (or to rule out) the presence of water pockets. We added the airborne-GPR profiles in grey in Figure 2c. Together with the bedrock reflection in that same figure, it highlights where in the glacier GPR reflection couldn't be identified. We then added two new sentences in Results (+ two references):

"*Note, however, that the absence of strong reflections in the radargrams does not necessarily imply the absence of subglacial water, water pockets or empty cavities, as the signal could be substantially attenuated by water inclusions (Ogier et al, 2023) and/or debris (Santin et al, 2024). This likely explains the large absence of specular reflections in the GPR profiles (grey lines in Fig. 2c). A denser network of GPR profiles would likely be required to resolve three-dimensional features such as a water pocket (Vincent et al, 2012) or an empty subglacial cavity (Ruols et al, 2024).*

R4.C5: Interaction between supraglacial and subglacial water systems

The authors should clarify whether hydraulic connections between the supraglacial lake and the subglacial system are observed or inferred. It would also be useful to discuss whether similar lake drainages have occurred in previous years and why the 2024 event might have been different.

A: Thanks for this suggestion. There are observations of such a hydraulic connection *after* the flood, but not *during the flood*. We clarify this in the Discussion, in the subsection "Scenario 1: Long-term water pocket formation and sudden rupture", by adding: "*Crevasses at the base of the supraglacial lake at Glacier de Bonne Pierre were observed a few days after the lake had emptied in 2024. However, it remains unknown whether such a connection* *between the suggested water pocket and the supraglacial lakeexisted prior to, or during, the supraglacial lake drainage.*"

Note that we already state in the section "The June 2024 La Bérarde flood" that this is the first glacier outburst documented for Bonne Pierre since the supraglacial lake has developed and drained annually: "*Since 2016, this lake has been observed to slowly drain subglacially and annually, but without any reported downstream impacts*". The description of the two flood scenarios in the Discussion presents hypotheses for why the 2024 event was different.

Minor:

1. **R4**: Terminology such as "water pocket", "subglacial reservoir", and "cavity" should be defined clearly and used consistently throughout the manuscript.
   A: The use of the words "water pocket", "subglacial reservoir", and "cavity" have been re-considered to avoid confusion and to improve consistency through the manuscript (see changes in PDF). The distinction between cavity (i.e., a space at the bed-ice interface) and a water pocket (i.e., a relatively large water-filled cavity) is now more precise in the manuscript.

2. **R4**: Section 5 (Discussion) is relatively long and could benefit from clearer sub-structure, for example by separating interpretation of results, flood mechanism scenarios, and model limitations
   A: We removed the subsection "Future work" in the Discussion because some of the content about the justification of the choice of the method is now presented earlier, in the Methods Section (see **R2.C2**). To make the Discussion more digest, we created a new Table to summarize the volumes estimates discussed in the Section, and we created a new subsubsection in the Discussion titled "Outlook: observations needed to discriminate between the two scenarios". This subsubsection better summarizes the available and missing field observations of the 2024 event.

3. **R4**: Some figures (particularly Figures 3 and 4) are visually dense and could be improved by increasing contrast between hydraulic contours, flow paths, and water storage areas.
   A: Thanks for the feedback. We improved contrast in Figure 3 and 4 by reversing the colorscale for the water pocket heights and by adding some transparency to the related layer. These changes make shallow water lighter and increase the visual contrast with the other elements. We also changed the contour color of water pockets from purple to black.

4. **R4**: The uncertainty analysis is valuable but somewhat difficult to follow. A summary table presenting deterministic estimates, ensemble means, and uncertainty ranges would improve readability.

   A: Thank you for this suggestion. We have added a summary table (Table 1) in the Discussion which presents the deterministic estimate together with the ensemble means and standard deviation for the different stochastic configurations. We believe that this addition improves the readability of the uncertainty analysis by providing a rapid overview of the results.

5. **R4**: Minor language editing would improve clarity in several sections where sentences are particularly long.

   A: Thanks for providing this feedback. See PDF with highlighted changes for small edits.