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# *Interactive comment on* "Rapidly-changing subglacial hydrology pathways at a tidewater glacier revealed through simultaneous observations of water pressure, supraglacial lakes, meltwater plumes and surface velocities" *by* Penelope How et al.

**Anonymous Referee #3**

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This paper outlines a detailed and complementary suite of observations and modeling of the subglacial hydrologic system and associated glacier dynamics of a tidewater glacier in Svalbard. Time lapse photogrammetry is used to observe, in high temporal detail, the location and patterns of supraglacial lakes and meltwater plumes adjacent to the calving front. A coupled energy balance and snow model was used to determine the production and timing of melt and runoff delivered to the subglacial hydrologic system. Glacier velocities were monitored in high spatial resolution using feature tracking



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Discussion paper

of repeat-pass TerraSAR-X images to determine larger scale patterns in glacier flow. Calculations of hydraulic potential are made to illustrate potential pathways of meltwater routing at the base of the glacier. Finally, water level and pressure measurements made at a single borehole site were collected and related to the evolution of the other hydrologic components of the glacier.

The study is well written, well organized, and thorough in its analysis. The complementary observations are used to illustrate the dynamics and evolution of the hydrologic system of Kronebreen, which evolves in a number of interesting ways, both spatially and temporally. The evidence is strong for the conclusions that the southern portion of the glacier tongue is more dominated by a distributed, pressurized hydrologic system, whereas the central/northern tongue receives more meltwater and has a more stable efficient drainage system. Both the delivery of meltwater to the base of the glacier and the organization of the subglacial drainage system need to be taken into account to explain the observed evolution of plumes and glacier speeds. This study will be a welcome contribution to the growing field of coupled glacier dynamics and hydrology.

I have only minor recommendations, questions, and comments on the manuscript:

p2, line 8: if such observations are rare, this suggests that there are some. Can you provide reference(s) here?

Figure 1: it seems that you could change the aspect ratio of the figure to zoom in more on the study area. Areas to the north and south of Kronebreen aren't really necessary to include, other than to make room for your inset panels.

P6, lines 9-10: it's not clear exactly what you mean here, or why this is necessary. Why is it necessary to smooth an initially high-resolution DEM, and what do you mean by "homogeneous surface"?

Melt modeling: what is the spatial resolution of the model? Is the model driven solely by the weather station data from Ny Ålesund? Are there any metrics of model valida-

tion/calibration that you can discuss?

P8, line 31: It sounds here as if you're using a different surface DEM from the Norwegian Geodetic Survey DEM that you discussed above with respect to the photogrammetry. Is this the case? If so, how different are the two DEM's you used? Why not use the same DEM throughout the study? For example, how different would the hydraulic potential calculations be if you used the Norwegian Geodetic Survey DEM instead?

Borehole GPS: it seems surprising (even if true) that the borehole GPS didn't add anything insightful. Why not show this and demonstrate that this is the case? It seems that you could overlay the GPS-derived velocity on Figure 2d to show this.

Figure 4 caption: panels are not numbered clockwise as indicated.

Section 5.6: it's not clear how you arrived at a value of k=0.6 as a sort of threshold for routing of meltwater between the northern and southern sections of the glacier. You state that "results suggest" this, but don't specifically describe why. "Several scenario were considered" (line 15), but what do you mean by this? How do you arrive at the conclusion that flow routing changes between a value of k=0.5 and 0.6 (line 19)? This seems different than what you describe in line 18 about threshold routing above and below a value of k=0.6? I guess I'm just a bit confused about this section, perhaps it's just a matter of describing more specifically what you've done here.

Borehole pressure: the pressure variations you record indeed seem to suggest that you are not actually located to a connecting channel. I would expect more pressure variations if you were. You seem to suggest that you might not be located at a channel, but argue that you are "near" a connecting channel if not connected to a channel that is consistently full of meltwater (in which case I would still expect to see more pressure variations).

Section 6.2: you describe here a cyclic pattern of the plume surface area, and suggest that it may be related to internal cycles of storage and release within the glacier. You

describe the pulsing as having a “duration” of 4-5 days, what do you mean by “duration”? Is there a particular period of the cycling? It seems that there could be sources of cyclicity in fjord circulation or tides which could also play a role in the patterns you see.

P19, line 16: here (and in other places) you describe “storage” of water at the base of the glacier. I think you should define what you mean by storage. Does this mean that you think the water is held stationary beneath the glacier, or rather that it is just inefficiently drained? You actually provide a bit of a definition on p20 lines 3-4, but it might be worth defining this sooner.

P21, lines 18-19: you say here that runoff has a diurnal signal, but then state that plume pulsing is independent of meltwater inputs. Related to comments above, I think you should describe the cyclicity of the plume pulses in a bit more detail to support the claim that this pulsing is not related to diurnal meltwater inputs (unless I’ve missed something here).

P21, line 22 (and elsewhere): you describe in numerous places that pressure forces a channel to open. However, the prevailing theories for meltwater channels is that they represent a balance between creep closure due to ice overburden pressure and melting caused by water flowing against the channel walls. So are you really claiming that you have something different than this at Kronebreen, some kind of elastic deformation at the base of the glacier from water pressure forcing channels to open?

P21, lines 21-26: you imply here that marine dynamics such as tides may play a role in the periodic flushing of meltwater. However, this claim is not supported by subsequent sentences that describe supraglacial lakes and velocity signals. So what is the evidence for your claim that marine dynamics plays a role?

P22, line 24: can you describe what you mean physically by a “transient low-pressure wave”? What would be the source of such a wave, and how would it originate at the terminus?

P 24, line 3: here you list melt and runoff under “measurements of hydrologic components” but these are actually model outputs.

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