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Interactive comment on "Sensitivity of subglacial drainage to water supply distribution at the Kongsfjord basin, Svalbard" *by* Chloé Scholzen et al.

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This paper using the GlaDS subglacial hydrology model to examine the importance of channels and water pressure for ice dynamics of Svalbard glaciers. The study site has a good volume of support data for this type of project and the authors have tackled their research questions by running 4 experiments to test whether the location (and to some extent the volume) of water input has an impact on channelization and general drainage system development. The primary findings are that water pressure increases until the middle of the summer along with channelization and then both the pressure and channels diminish as the surface water inputs reduce in volume. Over winter the

pressure then drops down to a lower level. I appreciate the application of hydrology models to these glaciers which differ from other regions in that they have a low surface slope and less water input than many lower latitude glaciers and therefore can illuminate different controls on ice dynamics for these types of polythermal glaciers.

MAIN POINTS

This is a well written paper and there is some interesting analysis about the hydrology. I do, unfortunately, have a major concern, which is that the subglacial water pressure is far too low. It drops down to almost 0% of overburden during winter which is very unrealistic and then in the summer the mean pressure is less than 80%. From Figure 8, it looks like only a very small region of your domain gets to overburden pressure with the rest significantly lower. As a reference, boreholes that hit efficient systems often have pressure varying $\sim$ 20-60% overburden and that is considered low pressure. The distributed system should have high pressure, which would be anything above about 80% overburden.

The reason that you have the seasonal and channelization behaviour that you see is that the model is spending most of the season building up to a background level of pressurization, which you would normally assume it would already have at the beginning of the season. Instead, with the spring event, water inputs should be into a system already close to overburden pressure. The rapid ice acceleration during this time is because often the basal system will increase to pressures above overburden, hydraulically jacking up the ice and allowing fast flow. I notice that you don't note in the manuscript how you spin up the model. For GlaDS (and many other models), you have to have a spin-up period so that the system can adjust to the background inputs, which in this case should be whatever basal water is available. You then have to make sure your chosen parameters allow as realistic a system as possible for when you initiate you seasonal inputs. This is why sensitivity tests are often used to assess the variations that parameters will have on the system and, with GlaDS, the two most important parameters to test are the sheet and channel conductivities. Set either too high and the system won't pressurize and is unrealistic. Set either too low and the model will break because the system will become too pressurized. From those sensitivity tests you then have a range of applicable conductivity values to use as a starting off point for your four experiments. If you have a look at the GlaDS literature for the Antarctic (Dow et al, 2018; Dow et al, 2020) and from Greenland (Poinar et al, 2019; Cook et al, 2020), you'll see that the sheet and channels conductivity values used are much lower (<1e-4 and <0.1, respectively) than have been applied in your study, which explains the low pressures throughout your domain.

GlaDS also tends to have some issues with over-winter pressures if a spatially and temporally uniform basal sliding speed is used. This is because the basal sliding is applied in the cavity opening term. I would recommend taking the basal sliding rate as a percentage of the surface sliding rate to get the spatial variability, and then adjust this temporally using records of summer vs. winter velocity (if you have them). The latter doesn't have to be high temporal resolution but a lower sliding speed in winter causing less cavity opening will allow the system to repressurise (that's assuming that winter sliding speeds are lower than in the spring).

My final main point is that, on the assumption you have access to ice surface velocities for the region, that is the best way to test whether the model is correctly representing your study region. Even a spatially averaged mean velocity should generally match the mean water pressure records that you show in Figure 3b. If these have the same pattern it would make your arguments about the subglacial system evolution stronger.

SPECIFIC COMMENTS

61 - why would the hydraulic potential minimum seed channels normally?

157- "which participated". Also what do you mean by distributed model in this sentence?

178 – when you say HP 'set to zero' how do you apply that? As tidewater glaciers the

outlet boundary condition would be best set at overburden but it's not clear if you do this.

197 and 373 – need some references for this statement. Most recent subglacial hydrology studies do use moulin inputs.

206 – why only keep 10? How does this turn into 13?

265 – It would be useful to know what that input is in m3/s in addition to the cumulative input for the total catchment that you state.

270 – why are the moulins only higher up (I may have missed this)?

289 – state what output result it supports rather than what figure

314 – what kind of numerical artefacts? Why would these occur?

Data availability – model outputs not provided.

Figure 1 - more detail needed for your below-sea-level elevations in panel b)

Figure 2- you have a lot of moulins on boundary points. That might cause problems if you reduce the conductivity to get the system closer to overburden.

Figure 6 and 9 – These discharge fraction and hysteresis diagrams are a nice way to examine your results.

Table 1 – basal sliding speed would be better stated in m a-1 and match what you say in the text.

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