The impact of spatially varying ice sheet basal conditions on sliding at glacial time scales – Supplement

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ABSTRACT. The supplement contains plots of the results of our test experiments.

For figures S1-S9, there are a number of comparisons between different idealized circular ice sheet model experiments, with a one year time series. In all cases, there is a strip with reduced sediment cover, which is denoted as a blue line. On the opposite side of the ice sheet is a comparison with a 100% sediment covered location at the same distance from the center of the ice sheet, which is indicated by a red line. All comparisons are done at the 25 000 year point in the simulation, which is 5000 years after the coldest point in the simulation, and approximately when the ice sheet reaches its largest extent and thickness. Due to differences in the evolution of the ice sheet, the ice sheet configuration (*i.e.* the thickness and distance from the edge of the ice sheet) at this time is somewhat different in each experiment. There also can be some differences in the amount of water produced, since the PDD method adds white noise to the climate forcing to simulate natural variability. Aside from the tests with variable water input, the percentage of the surface runoff that reaches the basal hydrology system is 80%.

For Figure S9, the model time stepping was changed from monthly to weekly time steps. In the version of PISM used in these experiments, the climate forcing has monthly time steps. The PDD scheme calculates the surface melt and accumulation at smaller weekly substeps, and averages the value to according to how long the model time step is. In the case of monthly model time steps, this results in 4-5 substeps in the PDD model. For weekly model time steps, this results in a single PDD substep. The climate forcing is not linearly interpolated in the PDD scheme, so the variability within a month is a result of the white noise added to the forcing. As demonstrated here, the velocity is not significantly different between the weekly and monthly time stepping case, though this obviously might not be the case if the forcing was linearly interpolated.

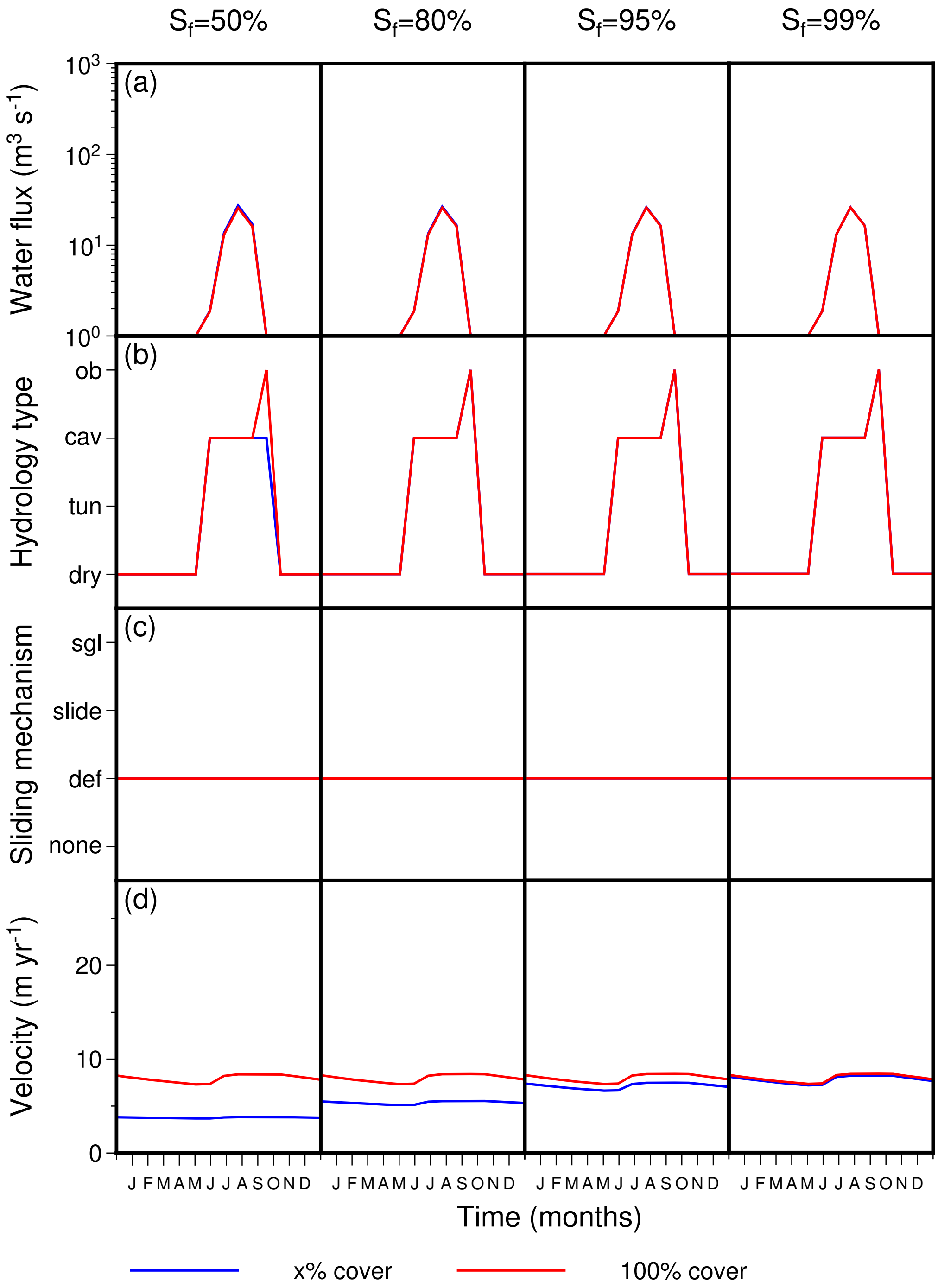

Fig. S1. Experiments comparing the effect of variable sediment cover. For each experiment, there is a strip with less than S_f =100% sediment cover, with $\gamma_{rc} = 15$ for areas with bare rock, and $\gamma_{sc} = 5$ for areas covered in sediment. The shear friction angle for sediment deformation is $\phi_{sed} = 30$. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

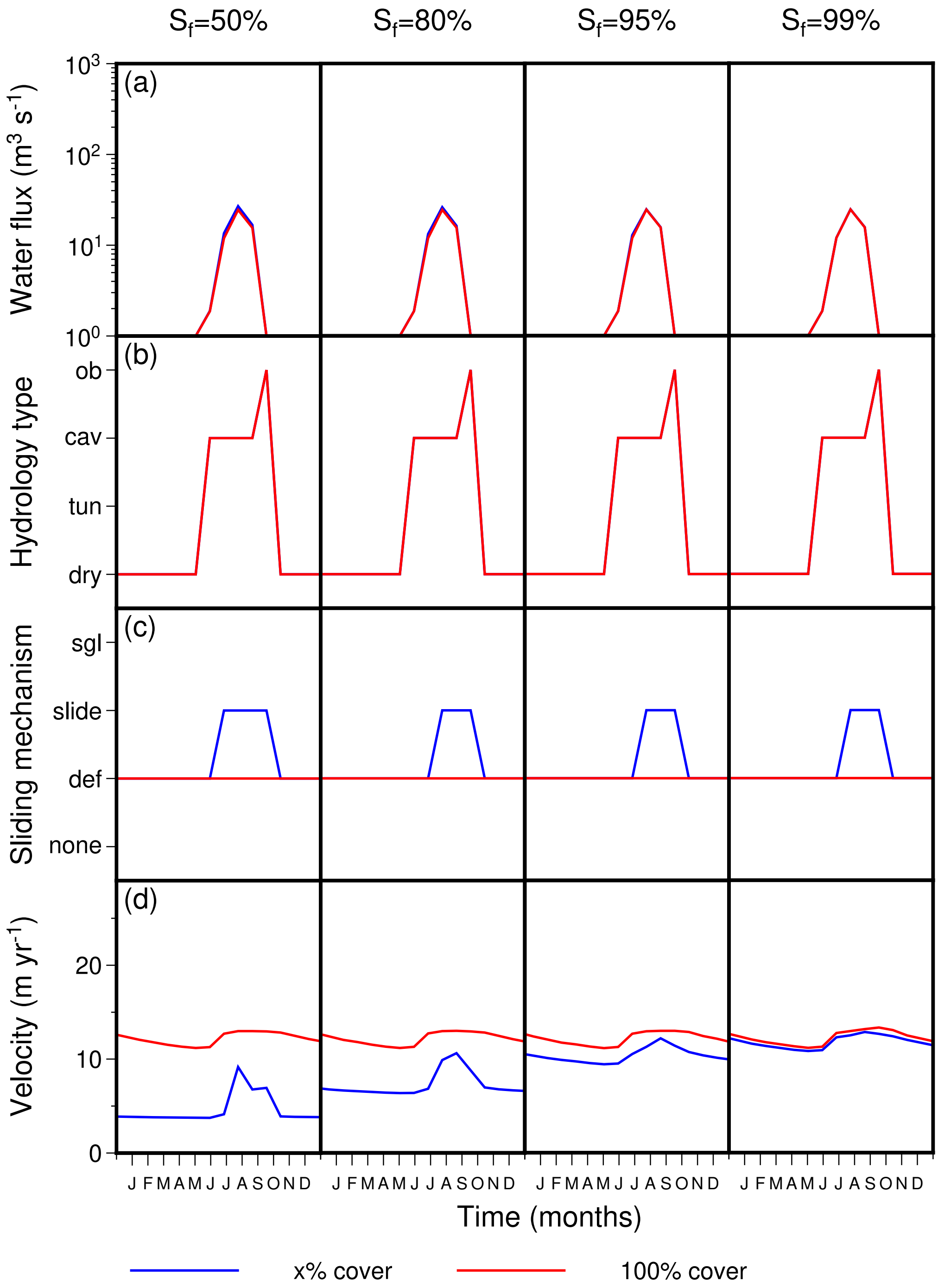

Fig. S2. Experiments comparing the effect of variable sediment cover. For each experiment, there is a strip with less than S_f =100% sediment cover, with $\gamma_{rc} = 2$ for areas with bare rock, and $\gamma_{sc} = 1$ for areas covered in sediment. The shear friction angle for sediment deformation is $\phi_{sed} = 20$. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

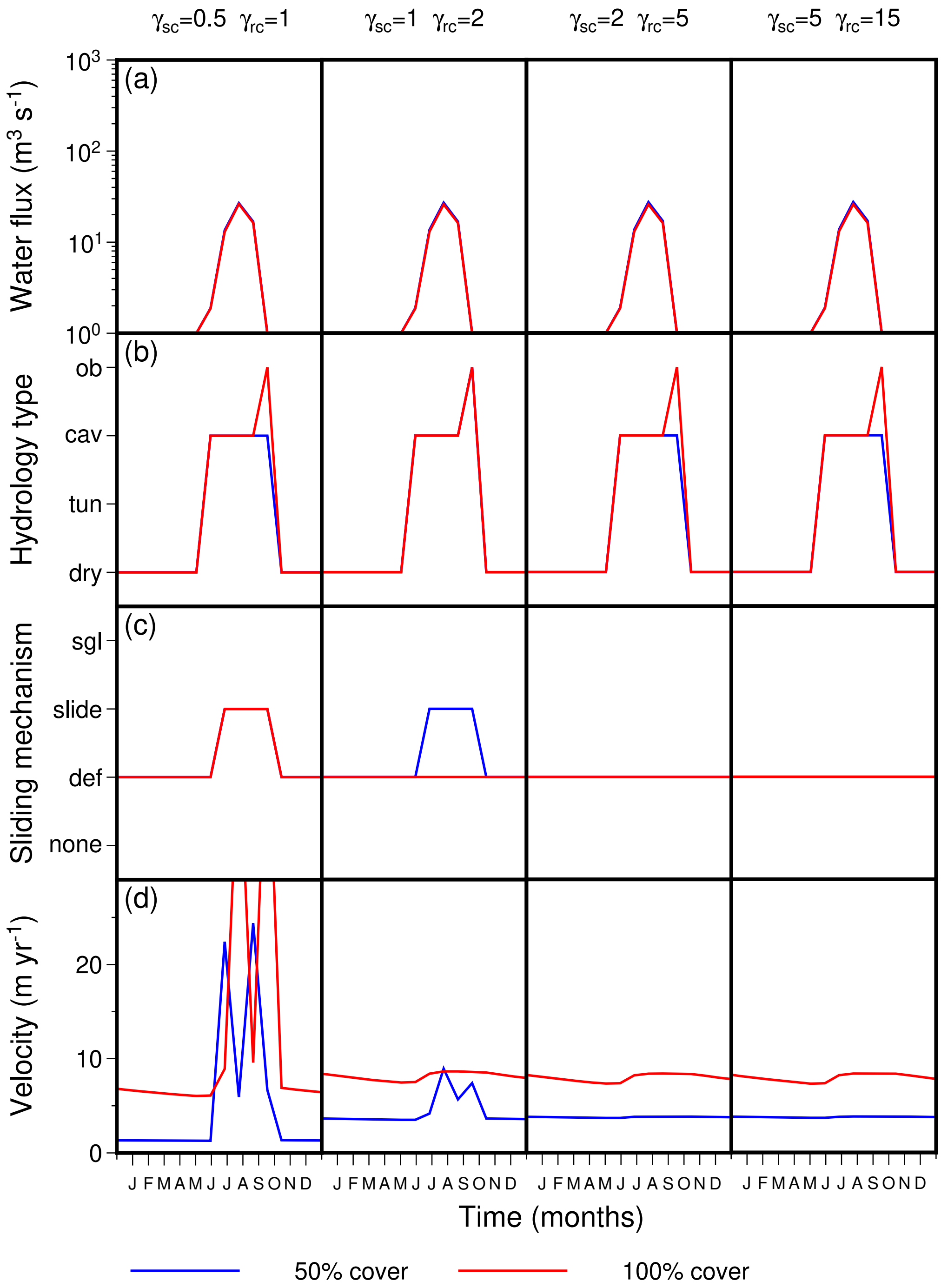

Fig. S3. Experiments comparing the effect of variable γ value in the hydrology model. For each experiment, there is a strip with than S_f =50% sediment cover. The shear friction angle for sediment deformation is $\phi_{sed} = 30$. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

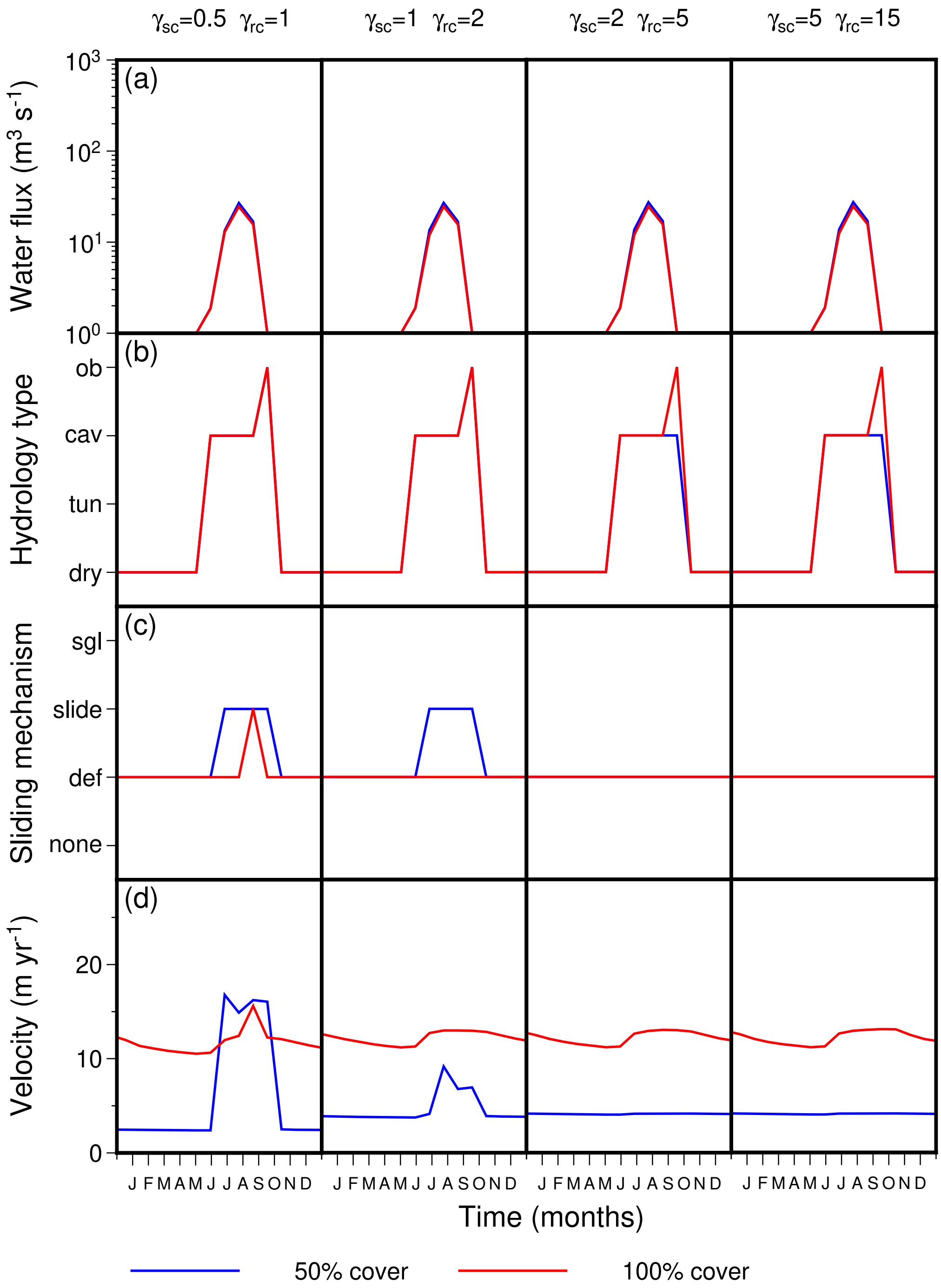

Fig. S4. Experiments comparing the effect of variable γ value in the hydrology model. For each experiment, there is a strip with than S_f =50% sediment cover. The shear friction angle for sediment deformation is $\phi_{sed} = 20$. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

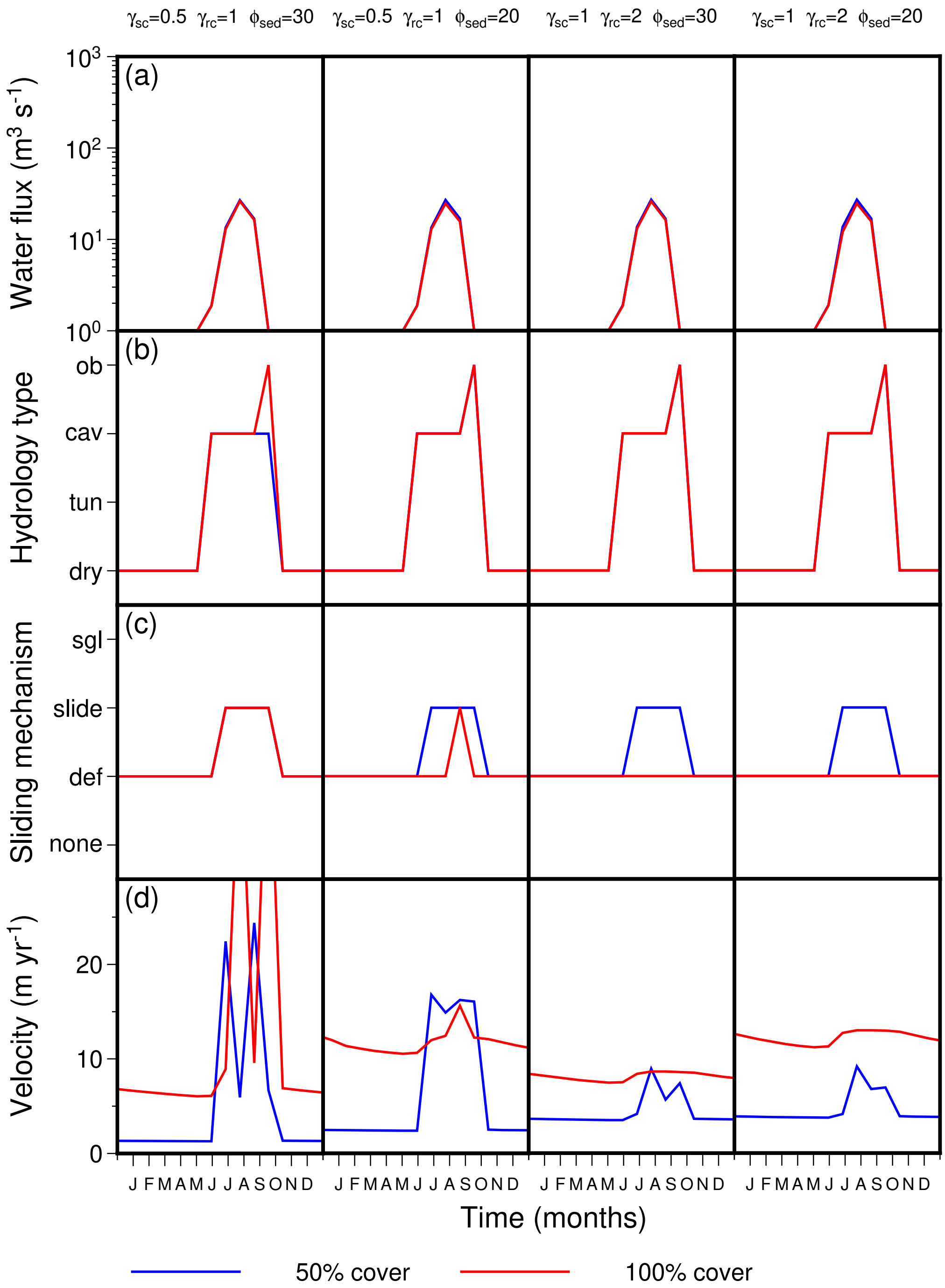

Fig. S5. Experiments comparing the effect of variable ϕ_{sed}. For each experiment, there is a strip with less than S_f =100% sediment cover. The results are shown for two values of γ_{rc} and γ_{sc}. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

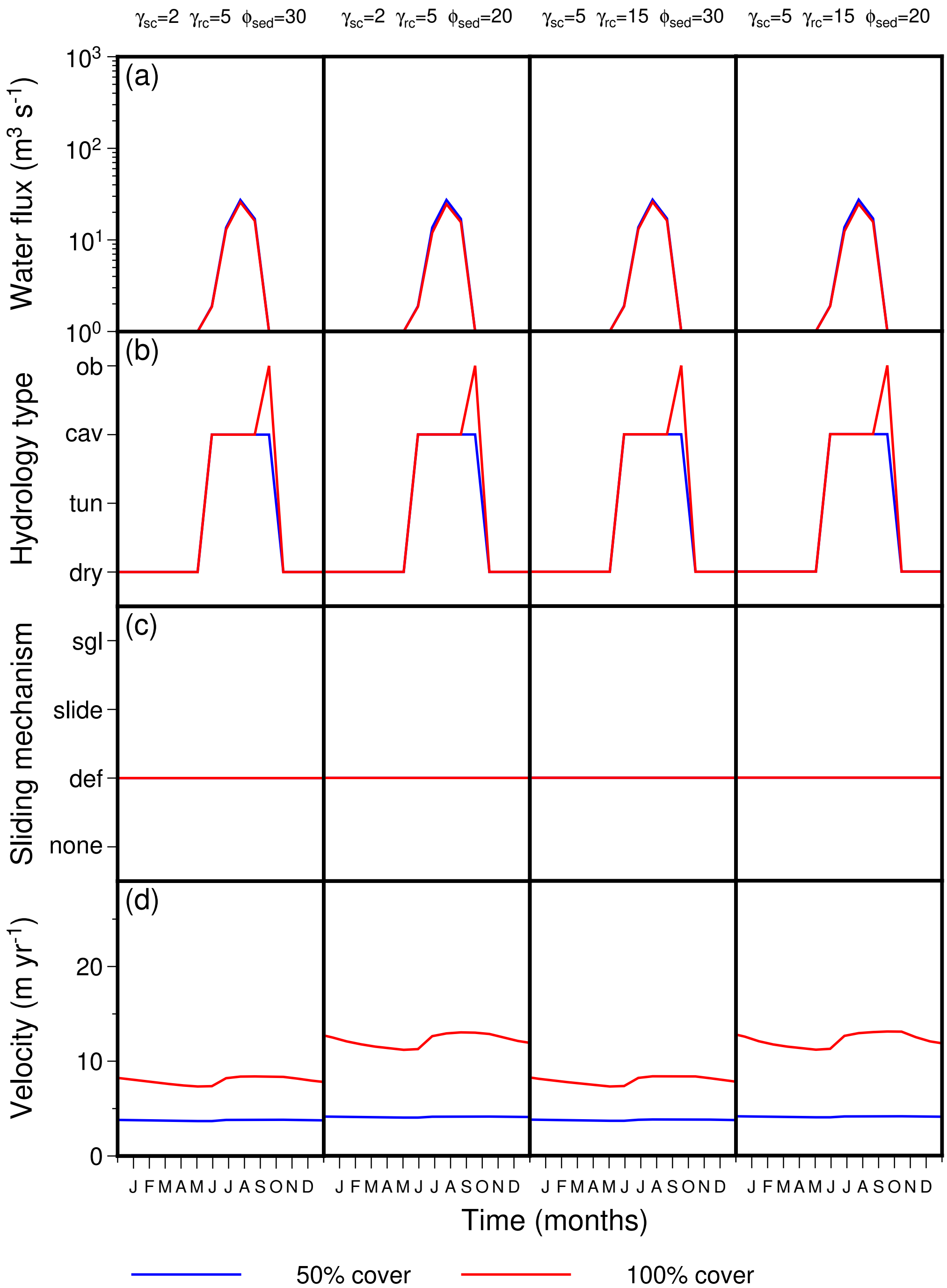

Fig. S6. Experiments comparing the effect of variable ϕ_{sed}. For each experiment, there is a strip with less than S_f =100% sediment cover. The results are shown for two values of γ_{rc} and γ_{sc}. The percentage of surface meltwater reaching the base is 80%. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

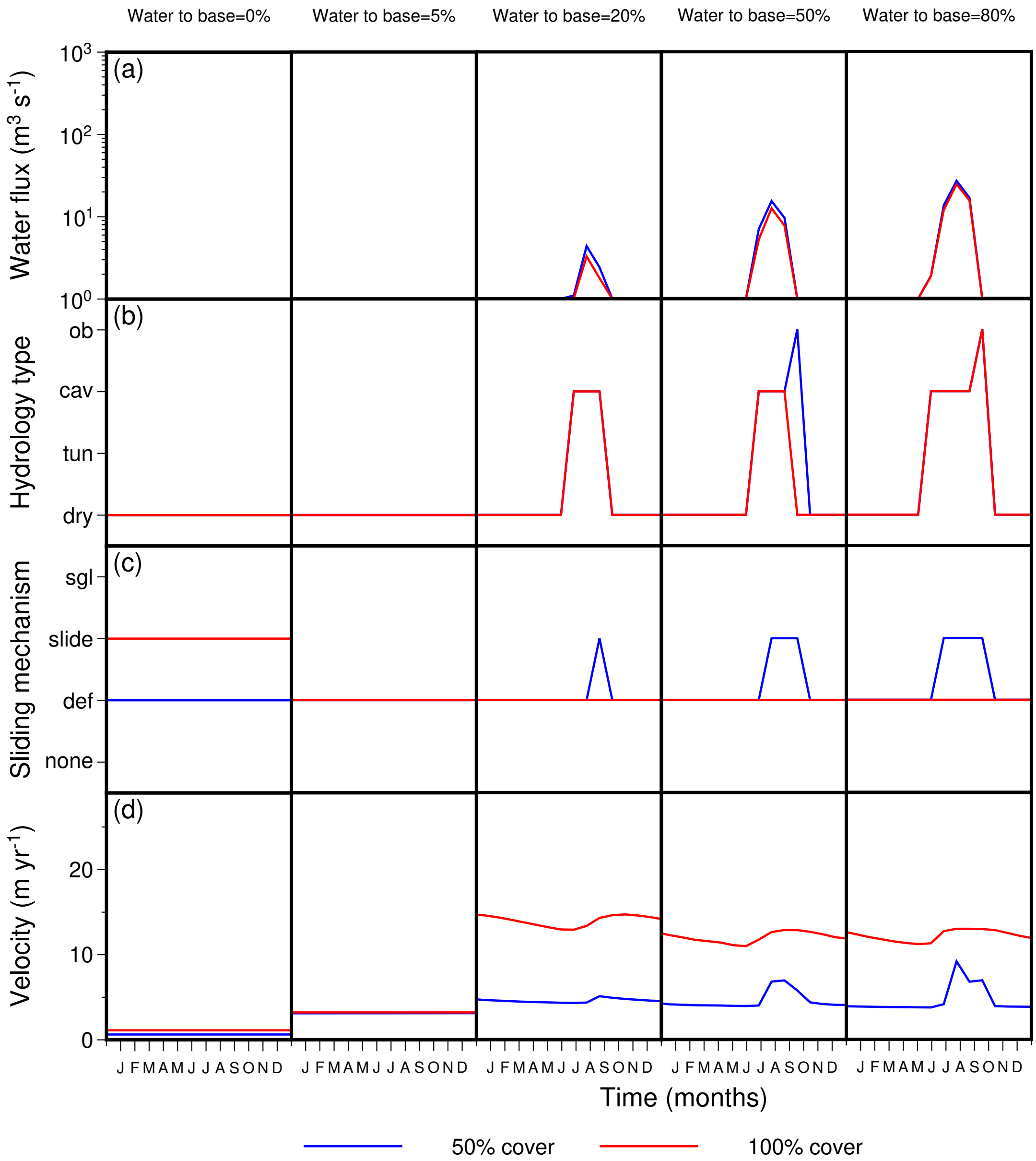

Fig. S7. Experiments comparing the effect of variable amounts of surface meltwater reaching the ice-base interface. For each experiment, there is a strip with S_f =50% sediment cover. All experiments use $\gamma_{rc} = 2$ for areas with bare rock, and $\gamma_{sc} = 1$ for areas covered in sediment. The shear friction angle for sediment deformation is $\phi_{sed} = 20$. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

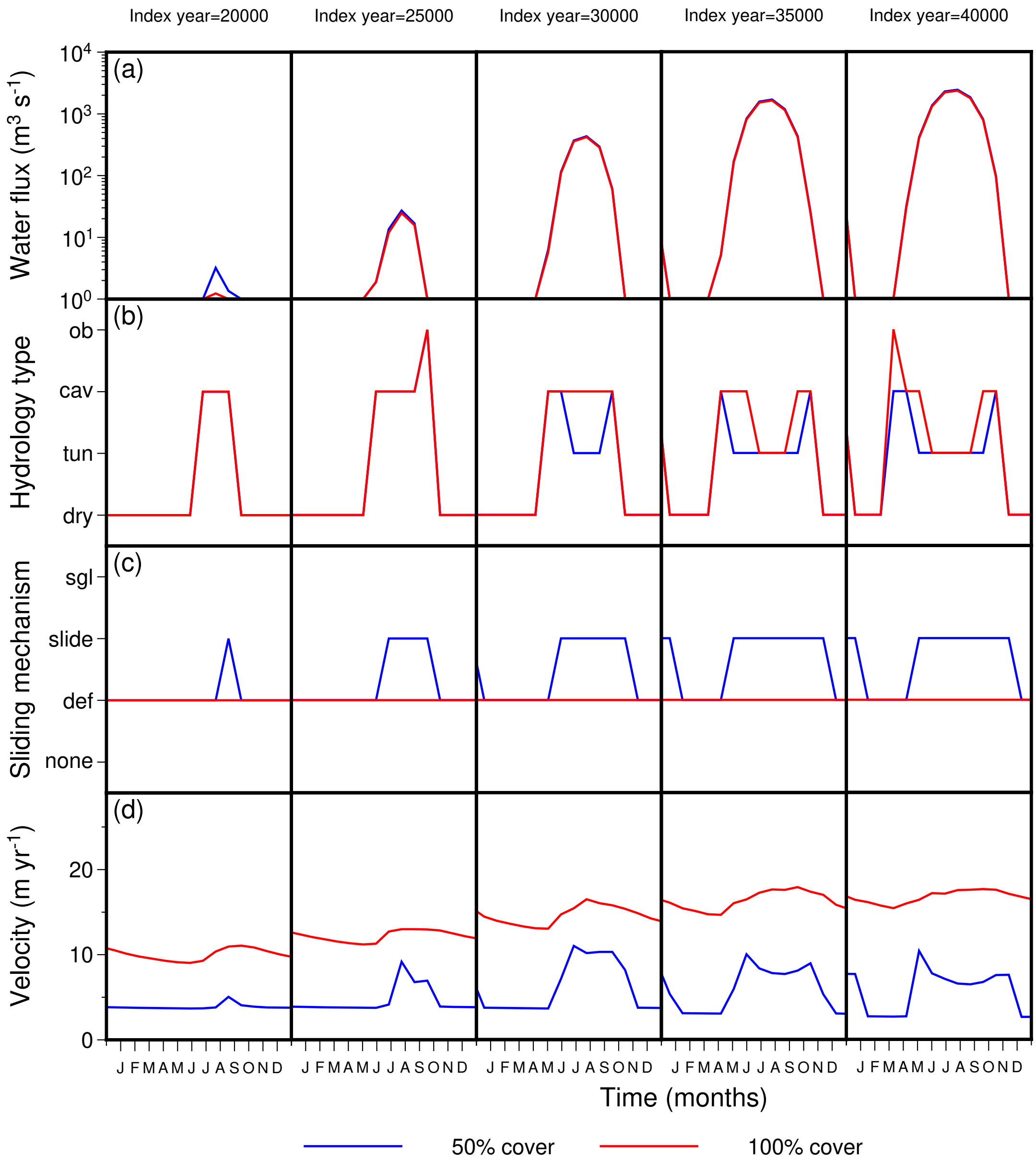

Fig. S8. Experiments comparing the effect of variable amounts of surface meltwater reaching the ice-base interface. In this case, the index was artificially shifted from 25 000 years, to be the equivalent time stated. For each experiment, there is a strip with S_f =50% sediment cover. All experiments use $\gamma_{rc} = 2$ for areas with bare rock, and $\gamma_{sc} = 1$ for areas covered in sediment. The shear friction angle for sediment deformation is $\phi_{sed} = 20$. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. Note that the scale is different than the other figures. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

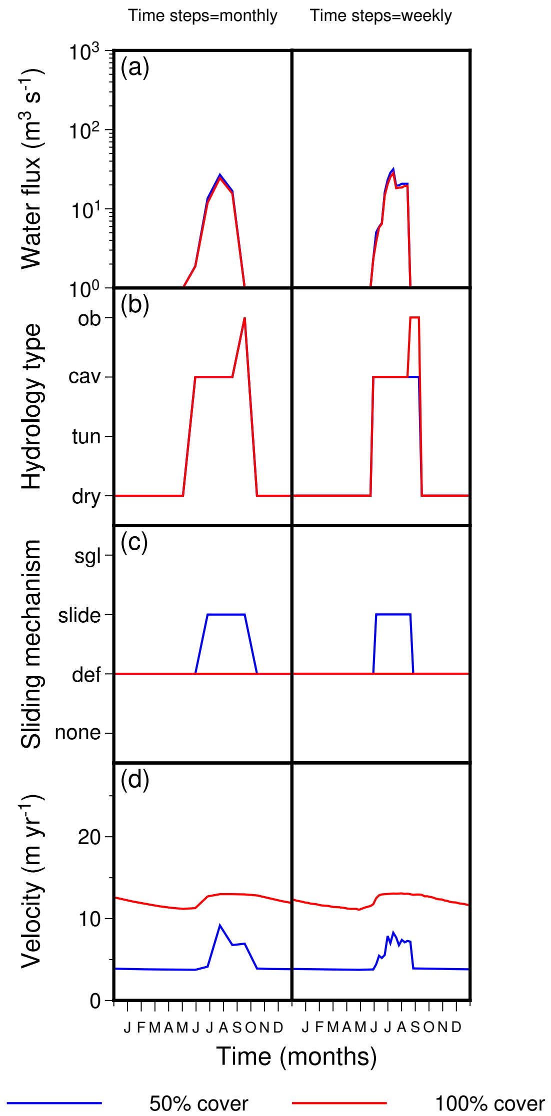

Fig. S9. Experiments comparing monthly versus weekly time steps. For each experiment, there is a strip with S_f =50% sediment cover. All experiments use $\gamma_{rc} = 2$ for areas with bare rock, and $\gamma_{sc} = 1$ for areas covered in sediment. The shear friction angle for sediment deformation is $\phi_{sed} = 20$. (a) Amount of water flux in the subglacial drainage system at the ice-bed interface. Note that the scale is different than the other figures. (b) Type of water routing at the base of the ice sheet that determines the effective pressure. ob - overburden, cav - cavities, tun - tunnels/channels, dry - no water in the system. (c) Sliding law method used by PISM. sgl - slippery grounding lines, slide - modified sliding law that takes into account both sediment deformation and sliding at the ice-bed interface, def - sediment and ice deformation, none - no sliding (i.e. no ice is present). (d) Surface velocity magnitude.

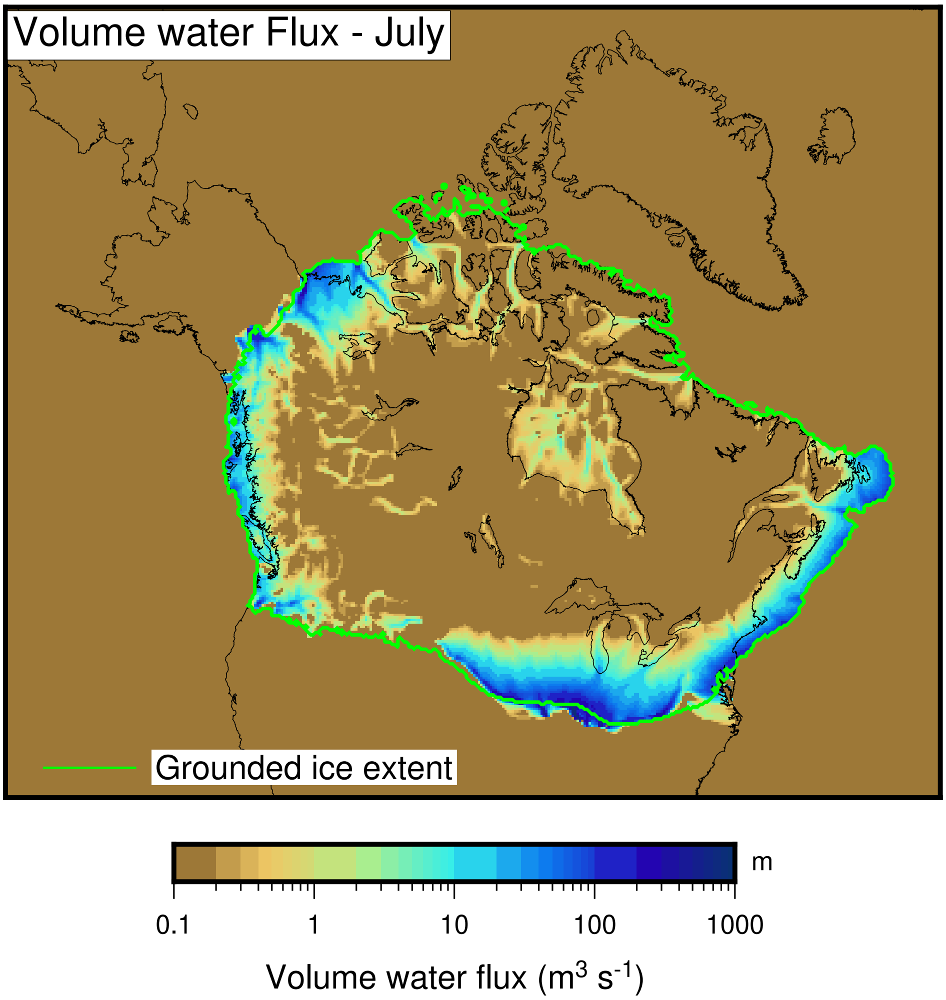

Fig. S10. Volume water flux of subglacial water during July at 20000 yr BP in the basal simulation.

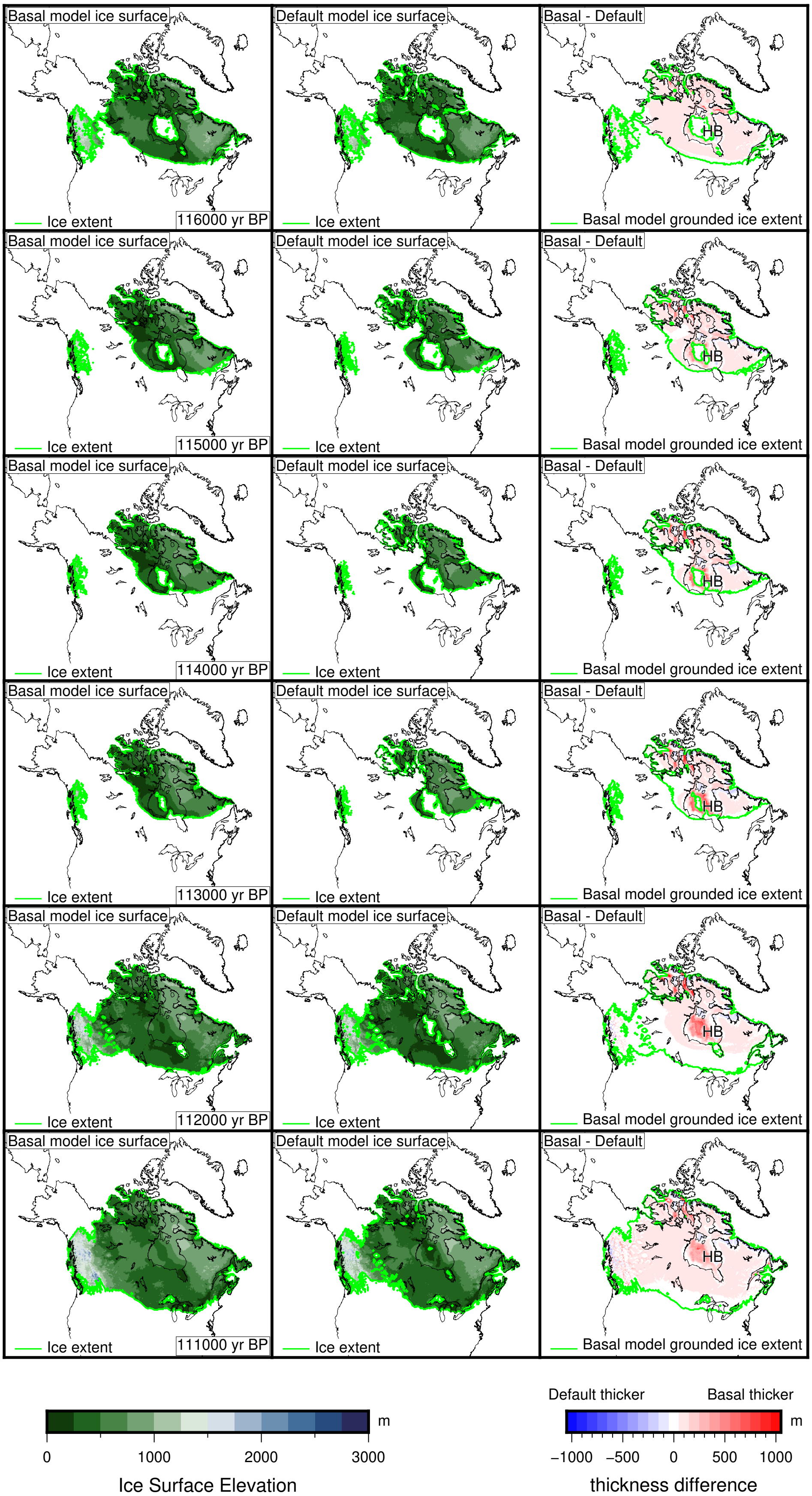

Fig. S11. Early ice advance into Hudson Bay (HB) in the basal simulation between 116000 and 111000 yr BP. **Left** - The ice surface elevation of the basal simulation. **Middle** - The ice surface elevation of the default simulation. **Right** - The absolute value of the difference between the basal and default grounded ice thickness.