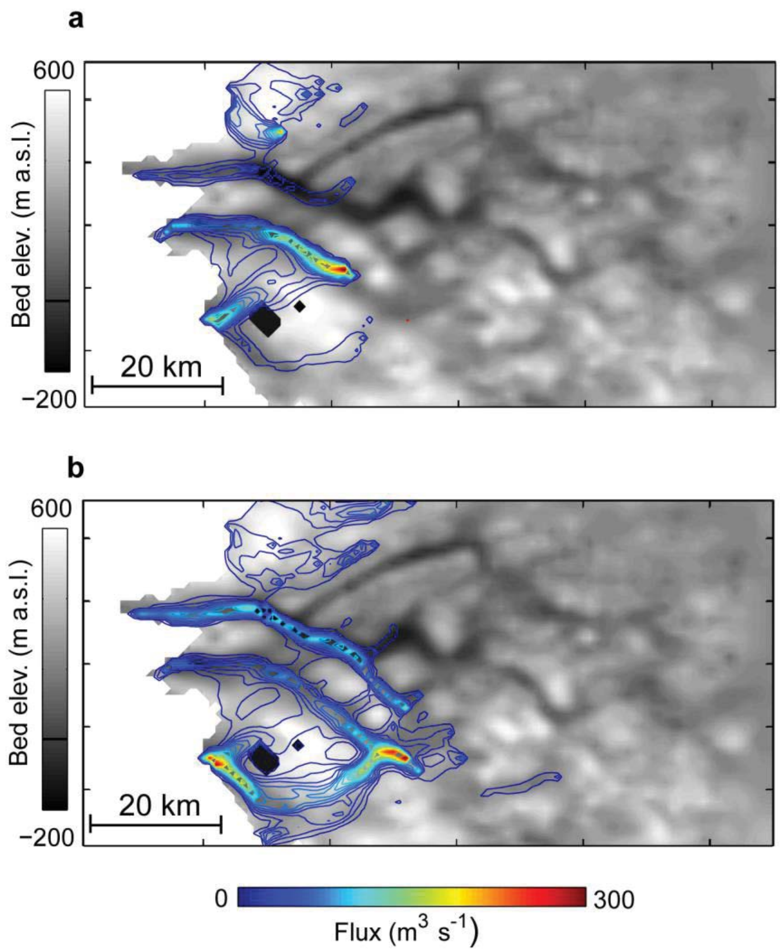
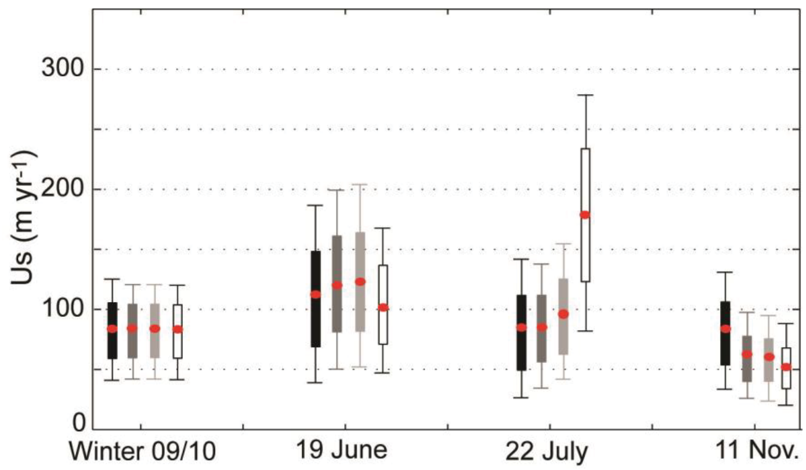
SUPPLEMENTARY INFORMATION



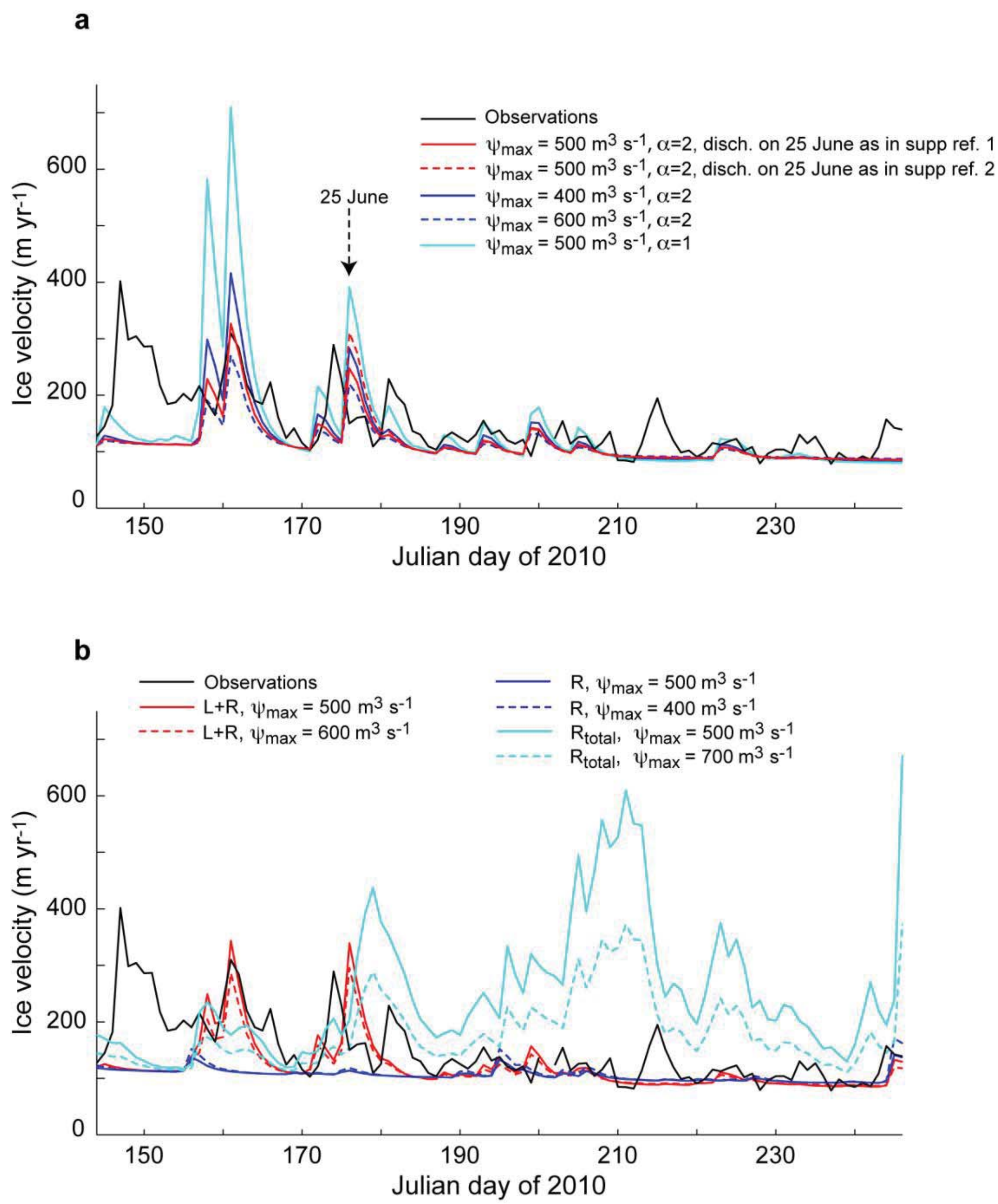
Supplementary Figure 1: Modelled water fluxes on 24 May and 27 May 2010

Bed elevation (m a.s.l., grey scale) overlain with subglacial water fluxes calculated on **(a)** 24 May and **(b)** 27 May.



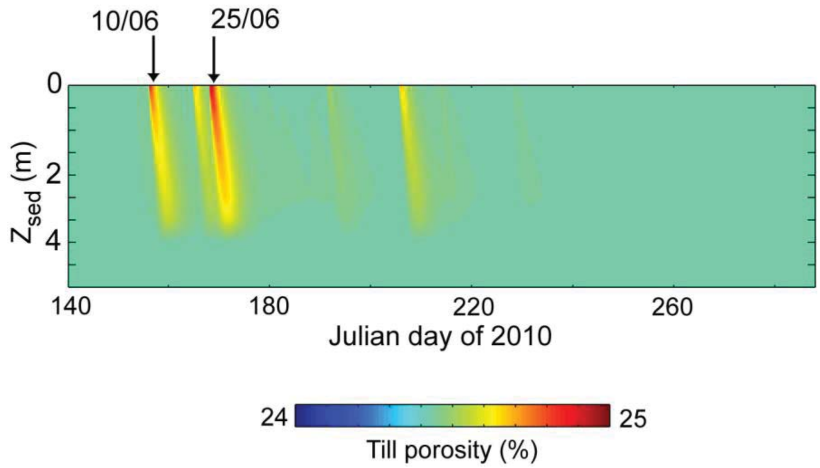
Supplementary Figure 2: Distribution of observed and modelled velocity map values

Distribution of mapped velocity values from satellite observation (black, see maps on Figure 1b-1e), model run driven with SGL-only volumes (dark grey, see maps on Figure 1f-1i), model run driven with SGL volumes plus runoff rates (light grey), and model run driven with absolute runoff volumes (white). The red dots indicate the domain-averaged mean value. The solid bars indicate the 25 to 75 percentiles, and the thin bars indicate the 10 to 90 percentiles.

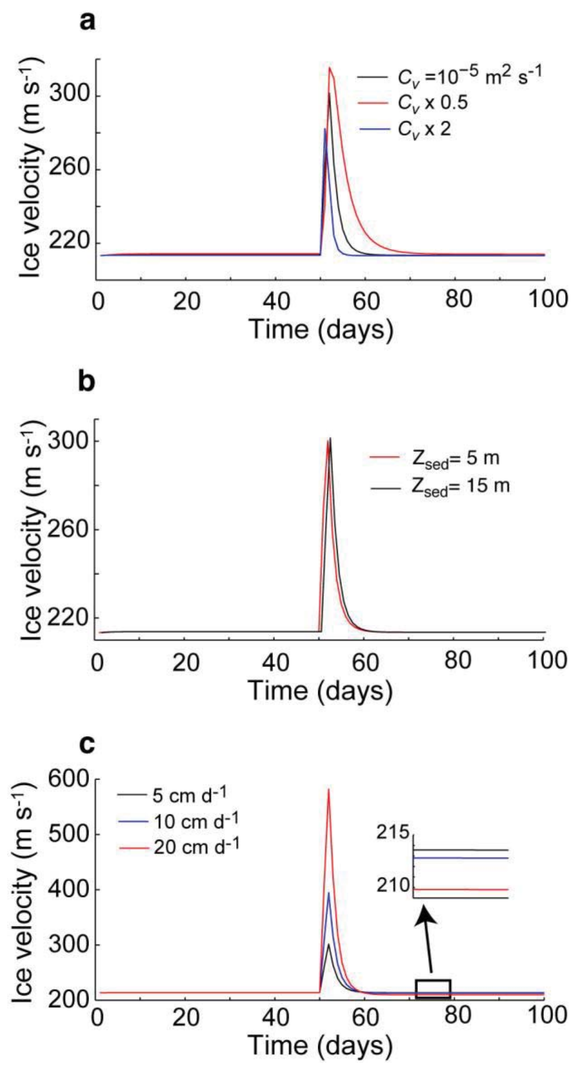


Supplementary Figure 3: Sensitivity tests on model parameters and surface water forcing type

Timeseries of observed mean daily velocity acquired with GPS are SHR site (black), and comparison with model output at the same location. (a) Runs forced with SGL-only volumes, using values for α and ψ_{max} as indicated on the legend. (b) Runs forced with total runoff estimates[3] (R_{total}), with daily increase in runoff volume (runoff rates, R), and with a combination of SGL and runoff rates (L+R). Tested values of α and ψ_{max} are indicated on the legend.

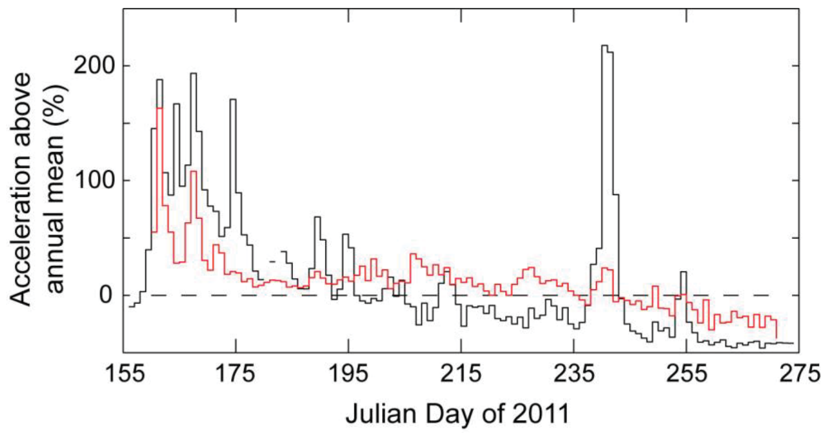


Supplementary Figure 4: Evolution of the subglacial sediment porosity
Evolution of the porosity distribution (%) in the sediment layer (Z_{sed}), at the SHR location. Lake-tapping events on 10 June and 25 June are clearly visible, with up to just 5% increase in porosity.



Supplementary Figure 5: Ice flow sensitivity to sediment properties and surface melt rate

Output from a 1D version of the ice-dynamic/subglacial sediment model, showing the ice flow sensitivity to **(a)** sediment hydraulic diffusivity, using a surface melt rate of 5 cm d^{-1} applied for 2 hours. Results are shown for a typical coarse-grained value of C_v=10^{-5} m^2 s^{-1} (black), as well as diffusivity twice as low (red) and high (blue). **(b)** Model sensitivity to sediment thickness. **(c)** Model sensitivity to surface melt rate, using a sediment hydraulic diffusivity of 10^{-5} m^2 s^{-1}. High values lead to higher peak velocity and subsequent velocities decreasing with increasing melt rates (see inset).



Supplementary Figure 6: GPS record of ice flow on RG and ISG in 2011

GPS records are compared for 2011, as no data was available at ISG for 2010. We show the flow acceleration (% above annual mean value), recorded at SHR site (black), and at I14 site, located ~14km up glacier on ISG (red).

Supplementary Table 1: Comparison of GPS-acquired velocities and model output

	June			July			August			June/July/Aug.		
	obs	L	L+R	**obs**	L	L+R	**obs**	L	L+R	**obs**	L	L+R
Mean (m yr^{-1})	**186**	155	168	**124**	106	111	**109**	91	91	**139**	117	123
Diff (%)		-17%	-10%		-15%	-10%		-16%	-16%		-16%	-12%
1 σ (m yr^{-1})	**53**	56	65	**25**	12	14	**24**	5	6	**49**	43	50
r^2		0.4	0.32		0.34	0.22		0.17	0.1		0.63	0.60
r^2 (Mov. Av)		0.67	0.57		0.34	0.25		0.1	0.25		0.83	0.79

Timeseries of GPS-acquired velocities compared to model output (L for SGL-only volumes, L+R for lakes plus runoff rates as defined in the text). We show (1) the time-averaged velocity value for periods indicated, (2) the difference between observed and modelled velocities (%), (3) the standard deviation σ, (4) the correlation coefficient (r^2) between observed and modelled velocity timeseries, (5) the correlation coefficient using a moving-average over 3 days, to account for timing uncertainties in lake volume loss (see Figure 2b).

Supplementary Table 2: Model parameters and variables

Physical constants	
g, constant of gravity	9.8 m s^{-2}
ρ_i, ice density	917 kg m^{-3}
ρ_w, water density	1000 kg m^{-3}
μ, water viscosity	1.787 10^{-3} Pa s
Sediment properties	
C_v, sediment hydraulic diffusivity	10^{-5} m^2 s^{-1}
K_h, sediment hydraulic conductivity	10^{-8} m s^{-1}
e_o, sediment reference value of void ratio	0.3
N_o, reference value of effective stress	500 kPa
ϕ, sediment internal friction angle	30°
Tuned variables	**Tested values [set to]**
f	0.1-0.5 [0.25]
ψ_{max}	400-700 [500] $m^3 s^{-1}$
α	1-2 [2]

Supplementary References

1 Doyle, S. H. *et al.* Ice tectonic deformation during the rapid in situ drainage of a supraglacial lake on the Greenland Ice Sheet. *Cryosphere* **7**, 129-140, doi:10.5194/tc-7-129-2013 (2013).

2 Fitzpatrick, A. A. W. *et al.* A decade (2002-2012) of supraglacial lake volume estimates across Russell Glacier, west Greenland. *The Cryosphere* **8**, 1-15, doi:doi:10.5194/tc-8-1-2014 (2014).

3 van As, D. *et al.* Large surface meltwater discharge from the Kangerlussuaq sector of the Greenland ice sheet during the record-warm year 2010 explained by detailed energy balance observations. *The Cryosphere* **6**, 199-209, doi:doi:10.5194/tc-6-199-2012 (2012).