C31B-0599: A distributed drainage system coupled to ice flow
Teresa M. Kyrke-Smith (teresa.kyrke-smith@earth.ox.ac.uk)¹, Andrew C. Fowler²,³, Richard F. Katz¹
¹ Department of Earth Sciences, University of Oxford, U.K., ² MACSI, University of Limerick, Ireland, ³ OCIAM, University of Oxford, U.K.

1. Background and motivation
A major challenge in ice sheet dynamics is understanding water flow dynamics at the bed, and their effects on ice dynamics. For this we need two things:
• A model of water flow
• An understanding of how the ice flow over the bedload through the sediment

2. Ice flow
Depth-integrated mass conservation of mass
\[ \frac{D}{D\tau} \left( \rho \frac{dh}{D\tau} + \rho c \frac{Du}{D\tau} - \nabla \cdot (\rho c \mathbf{u}) \right) = 0 \]  

3. Governing equations for water-ice system

4. Stability and solution of water-ice system
Non-dimensionalisation and substitution [9] into (3) gives
\[ \frac{Dq}{D\tau} + \nabla \cdot (\frac{q}{\xi}) = 0 \]  

5. The water-ice system coupled with ice dynamics
Sliding law \[ q = q_{0}(m-1) \frac{\xi}{\eta} \]  

6. Governing equations for sediment-water-ice system
Consider an evolving bed surface:
Closure equation for sediment:
\[ \frac{Dq_{s}}{D\tau} + \nabla \cdot (\frac{q_{s}}{\xi}) = 0 \]  

7. 1D steady-state subglacial stream incised in sediment
We consider a 1D steady-state subglacial stream incised in sediment:
\[ \frac{D}{D\tau} \left( \frac{h}{\eta} \right) = \frac{\partial}{\partial x} \left( \frac{q_{0}}{\xi} \right) \]  

8. Generalising subglacial streams to 3D and future work
• Is there an instability in the 3D sediment-water-ice model which we suggest the system is unstable to the formation of subglacial streams?
• A linearised stability analysis seems to suggest this depends on concavity of ice (similar to subaerial river flow [Smith and Bretherton, 1972; Fowler et al., 2007]).

References