IMPROVING THE PARAMETERIZATIONS OF COLD REGION PROCESSES IN A LAND SURFACE MODEL

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1.Background
Snow is the single most important feature of land surface-atmosphere interactions at northern latitudes. Its inherent properties play a critical role in the hydrology, ecology and energy and carbon balances of the region.

Shrubs capture and hold more snow than other tundra vegetation types. Field observations, satellite remote sensing data and models show that the recent warming has provoked an increase in shrub distribution in the region. Shrubs have a strong impact on the surface energy balance in the Arctic. The means to attain this aim will be to:

• Assess the performance of the model against and remotely sensed observations. This will be performed at a single point then on grided runs at a small scale using existing studies then at the global scale.
• Improve cold region processes in JULES.
• Couple JULES with the climate analogue model IMOGEN (Integrated Model Of Global Effects of climatic anomalous), used to simulate a range of different climate warming scenarios run in forecast mode at the pan-Arctic scale.

3. Testing the snow models: Wolf Creek melt season 2004
Observational data was collected during the melt period of 2004 at the Wolf Creek Research Basin in Yukon Territory, Canada. Average shrub height was 120 cm. Snow model 2 improves the representation of snow processes during the melt season because:

• Snow model 2 is partitioned into interception by the canopy and throughfall to the ground.
• Intercepted snow may be removed from the canopy by sublimation, unloading or melting.
• The canopy layer shelters the ground snow. As a consequence, snow cannot be sublimated and is not removed by melt.

4. Model development: Frozen Soil Processes in JULES
JULES uses the Clapp and Hornberger equations for the soil hydraulic characteristics. The model includes a layered soil structure that allows for water storage and for heterogeneity in the landscape, and allows differences in snowmelt characteristics between seasons.

Gridbox snow mass (kg m⁻²)

Snow model 2

Snow model 1

Observational data were obtained from the PALS2006 experiment.

The figure opposite shows surface runoff rates at a single point with the existing frozen soil processes scheme and with a modified scheme that includes the implementation of a fractional permeable area (Niu and Yang, 2006). Preliminary results using a synthetic rainfall event from day 14 onwards show that the new scheme improves the infiltration of rain water in deeper soil layers while the existing JULES does not. Future work will assess the models' performance against observed streamflow in order to identify the most appropriate frozen soil scheme for large scale applications.

5. References
4 Liston, G. E., et al. (2002). Modelled changes in arctic tundra snow, energy and moisture flux due to increased shrubs, Global Change Biology, 8, 11-32.