FROZEN PLANET
More than just ice-caps and polar bears

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JULES *Hydrology*

1. Incoming moisture is split into runoff and water absorbed. Runoff is diverted in rivers.

2. There is a constant redistribution of water within the soil column as it tries to reach a state of equilibrium. This is determined using the Darcy's law :

$$q = K\left(\frac{\partial \Psi}{\partial z} + 1\right)$$

3. At the bottom of the soil layers (3m), water is taken out at a rate assuming only gravitational effects – free drainage.
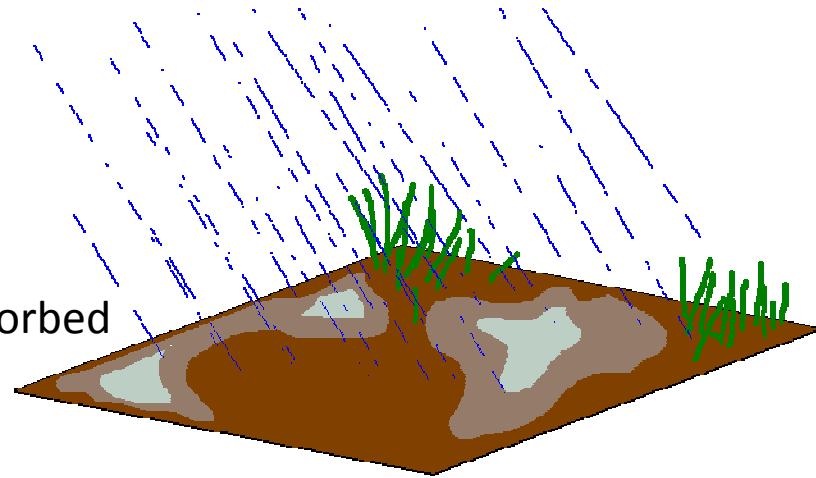
$$q = K$$

This drainage joins the surface runoff in rivers.

Rainfall

Snowmelt

Surface runoff

Subsurface runoff
*free drainage*
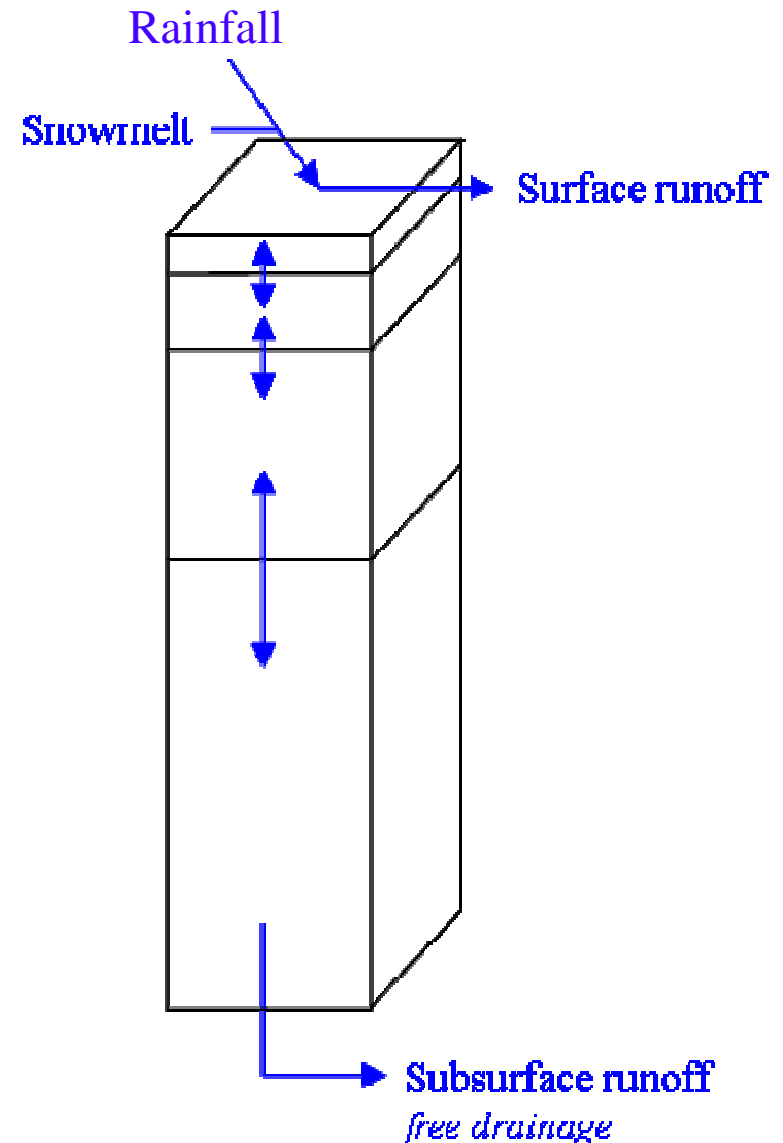
The missing process

Process

1. Soil moisture freezes in patches
2. Rain runs off the frozen soil and is absorbed elsewhere
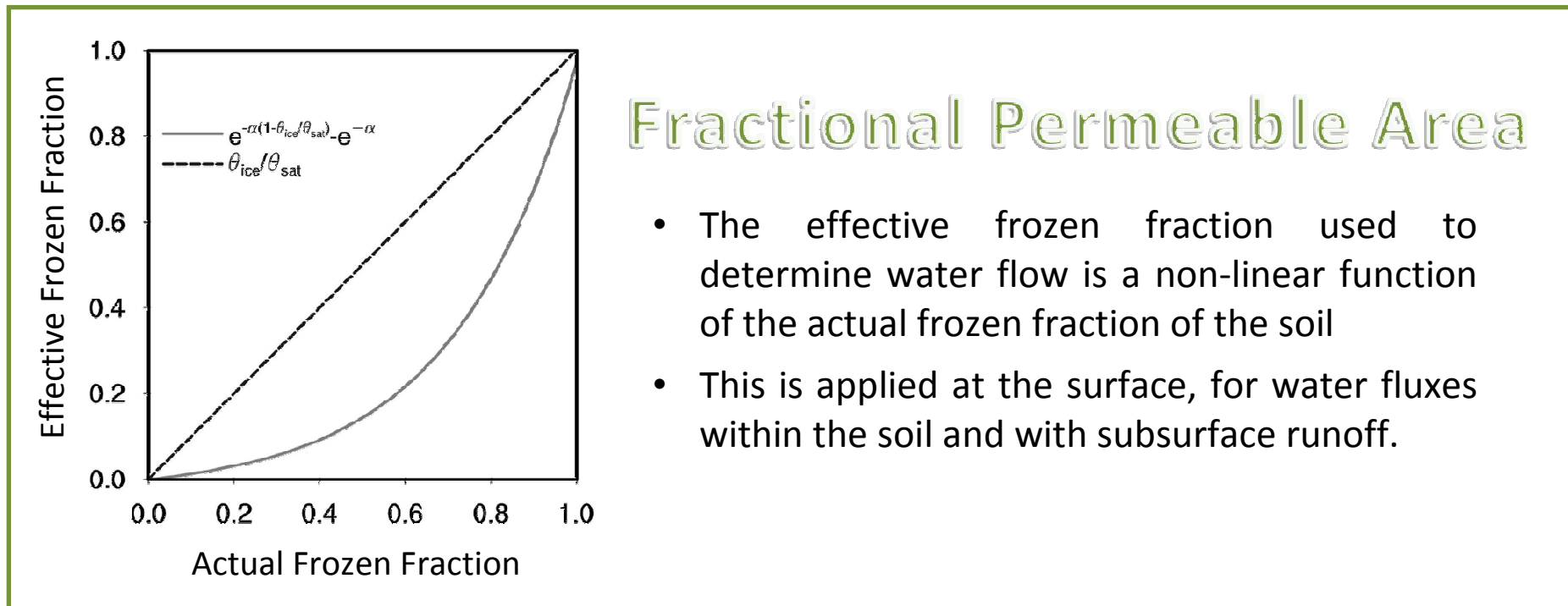
Model

1. The model cannot account for the process because it uses averages
2. Too much water is channelled off the gridbox into the rivers
3. Inaccuracies arise in river flow and in land variables such as temperature and plant growth
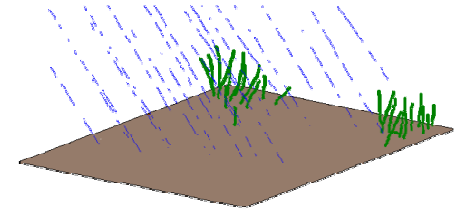
Parameterization of the process

Niu and Yang, 2006

Effects of frozen soil on snowmelt runoff and soil water storage at a continental scale

Fractional Permeable Area

- The effective frozen fraction used to determine water flow is a non-linear function of the actual frozen fraction of the soil

- This is applied at the surface, for water fluxes within the soil and with subsurface runoff.

An additional component called TOPMODEL must also be used with JULES.
A TOPMODEL control in addition to a control run without will distinguish its effects.
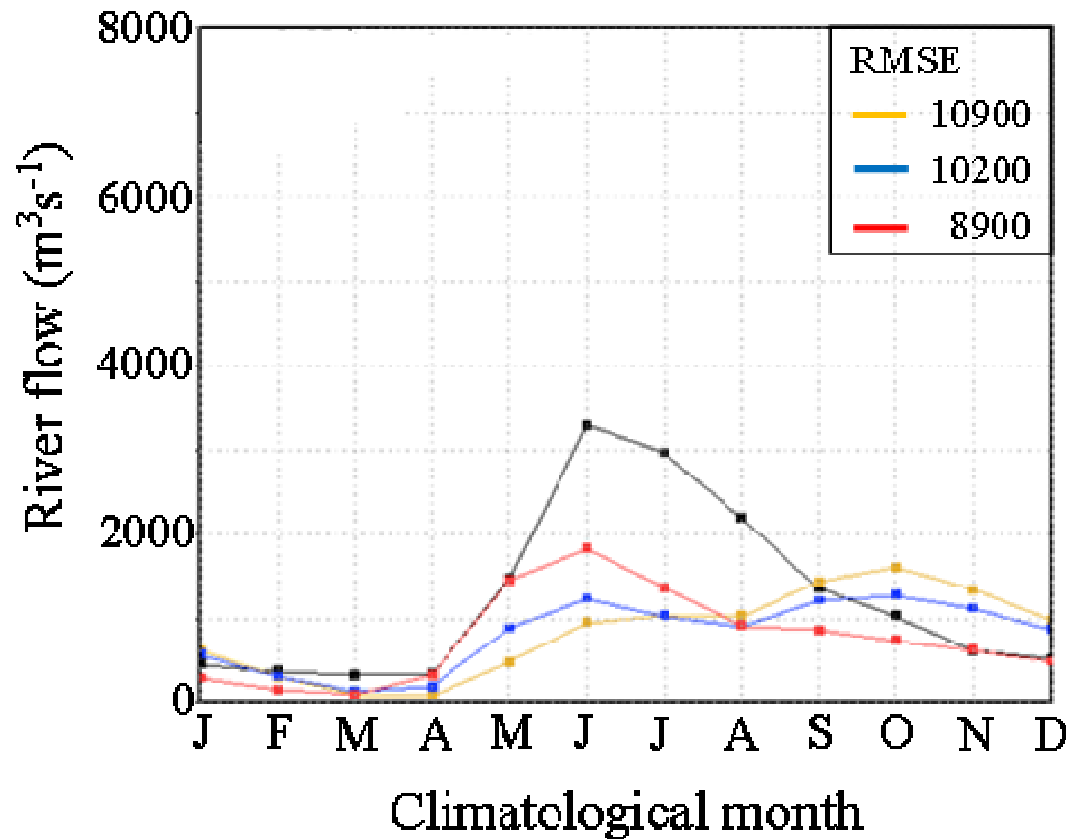
Siberia and the River Ob

© George Shpikalov 2009

Contribute 50% freshwater to the arctic ocean
and cover 60% of Siberia

Experience seasonal effects
of freezing and thawing river/soil water

Results: River flow of the Ob

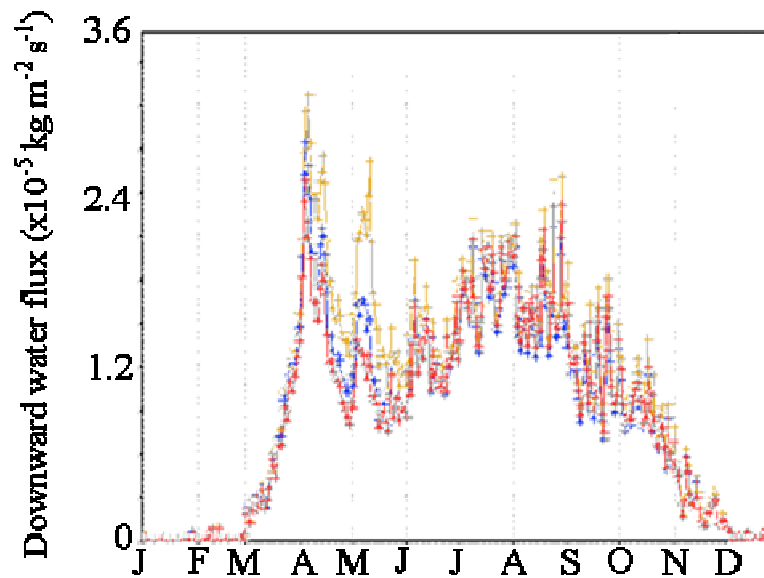**Observations**

Standard JULES

JULES with TOPMODEL

JULES with Niu/Yang parameterisation

Only the new model has managed to capture the shape; a high June peak with smaller flows through the rest of the year.
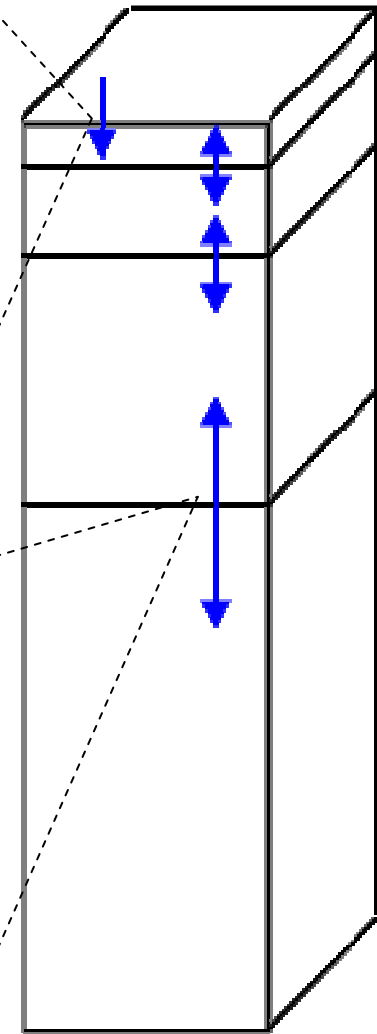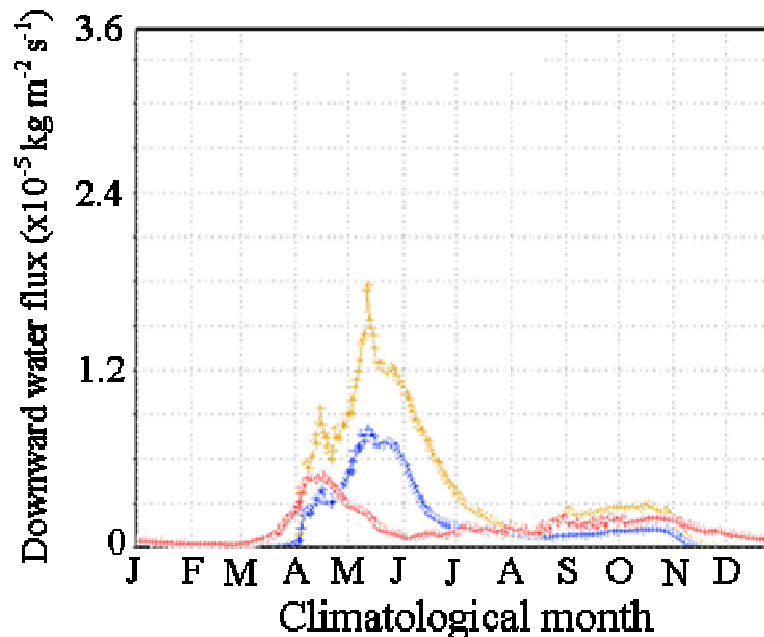
All the models seriously underestimate the peak.
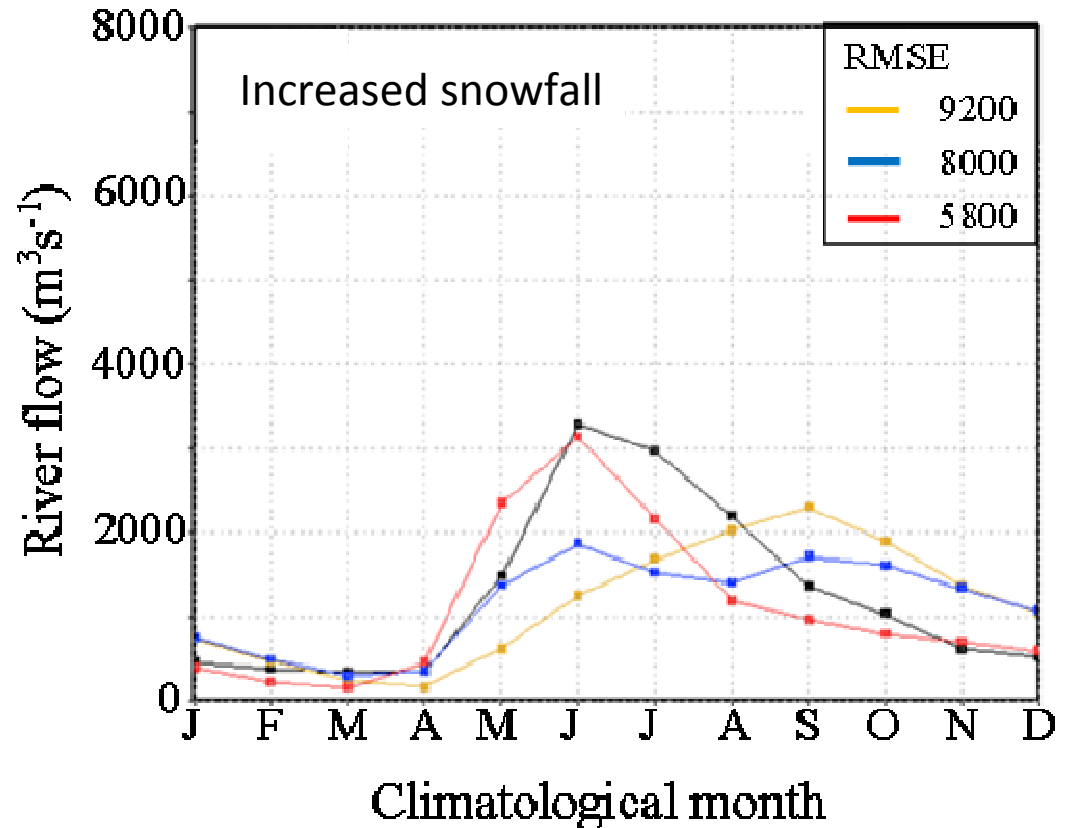
Results: The change in model physics

Approximately the same surface absorption

Much earlier flux into the bottom layer by the new model
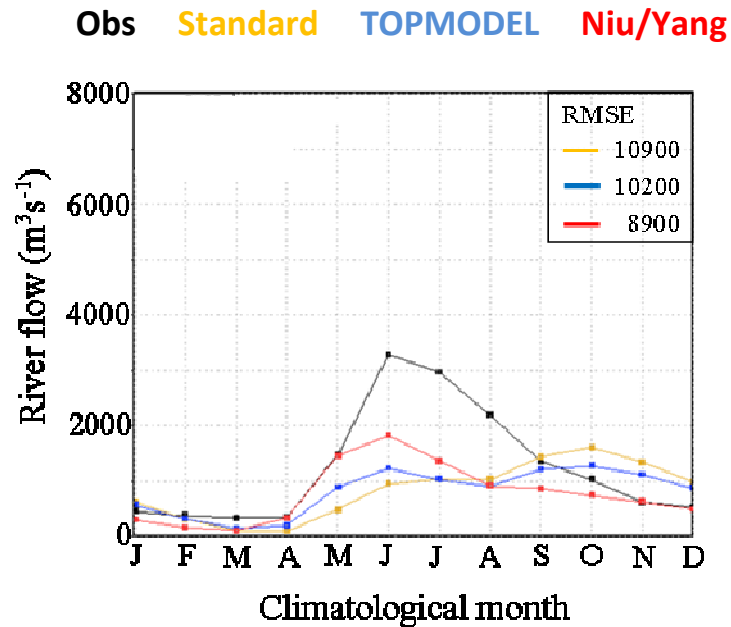
Still only the new model has managed to capture the shape.

The June peak is of the same magnitude. Only the skew remains incorrect. This is possibly due to applying a spatially-constant scaling factor.

Finney, D.L.; **Blyth, E.**; **Ellis, R.**. 2012 Improved modelling of Siberian river flow through the use of an alternative frozen soil hydrology scheme in a land surface model. *The Cryosphere Discussions*, 6 (1). 309-340