Parameterising Heterogeneous Snowcover in JULES

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Outline

- Introduction
  - Heterogeneous Snow
  - JULES Snow Model
- Model Developments – snow tiling scheme
- Offline model Application
  - Small seasonally frozen catchment
- Ongoing Development, Application and Validation

Heterogeneous Snow Cover at Sub-grid Scales

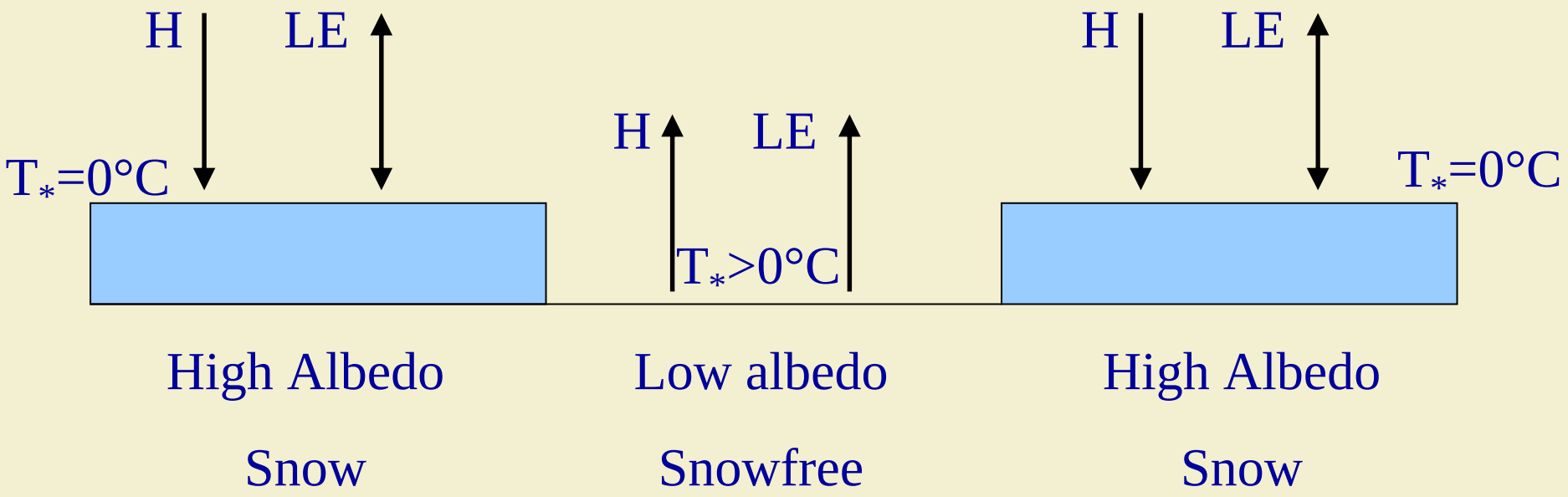
Elevation

Aspect

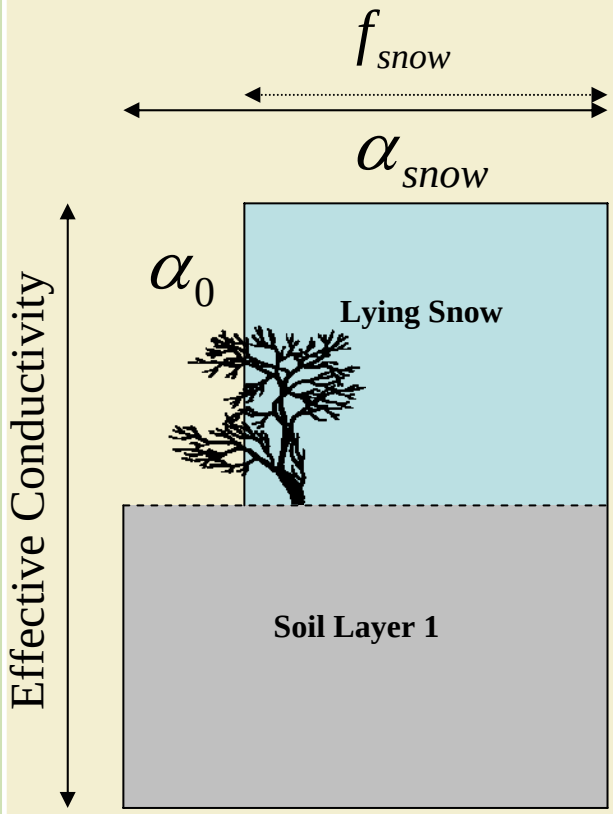
Vegetation and Complex Topography

Topography

Surface Energy-Balance of Melting Patchy Snow Under High Radiation



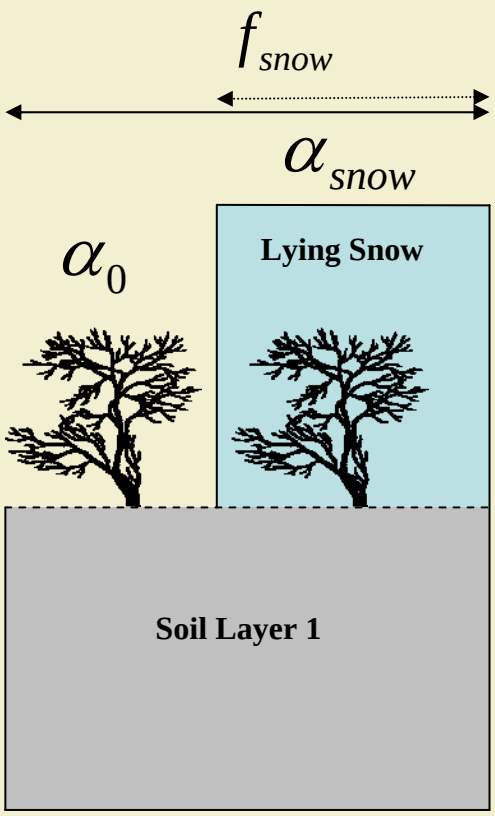
JULES Snow Model



$$\alpha_{effective} = f_{snow}\alpha_{snow} + \alpha_0(1 - f_{snow})$$

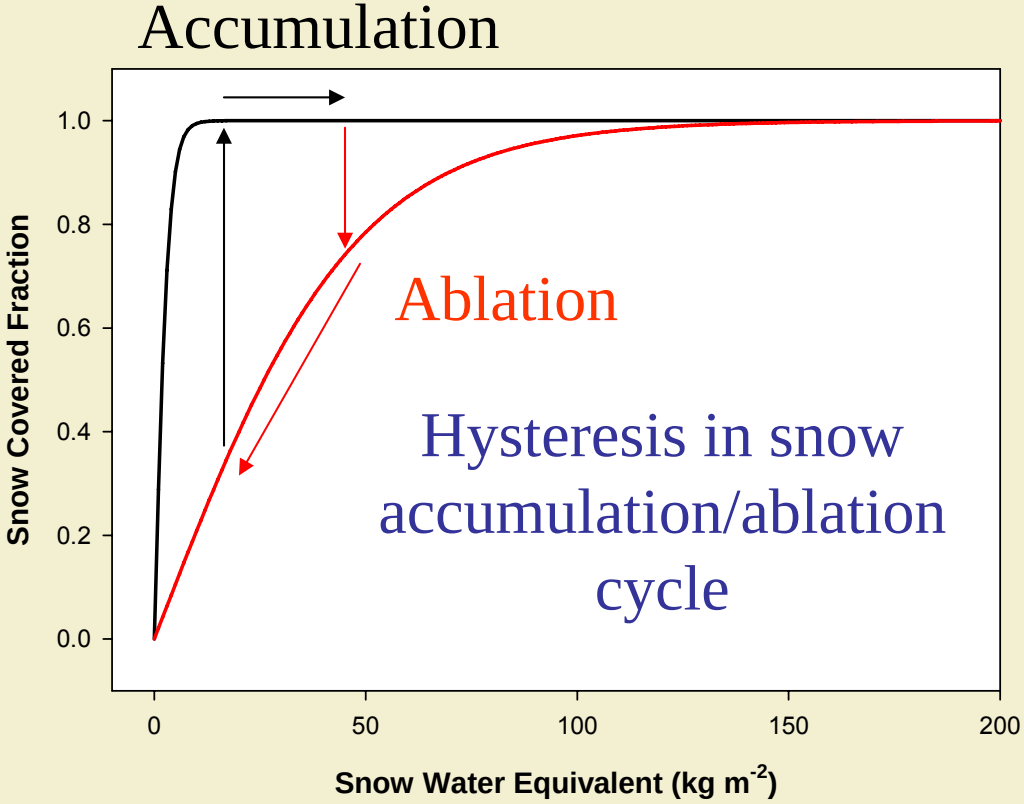
- Uniform snow layer across surface tile extent (GCM 2.5° by 3.75°)
- Effective albedo used to account for vegetation exposed above snow layer and snow-free ground
- Surface Temperature limited to less than or equal to 0°C whilst snow is on the ground
- Snow layer is a composite layer with top soil layer
- No representation of snow hydrology

Modified JULES Snow Model



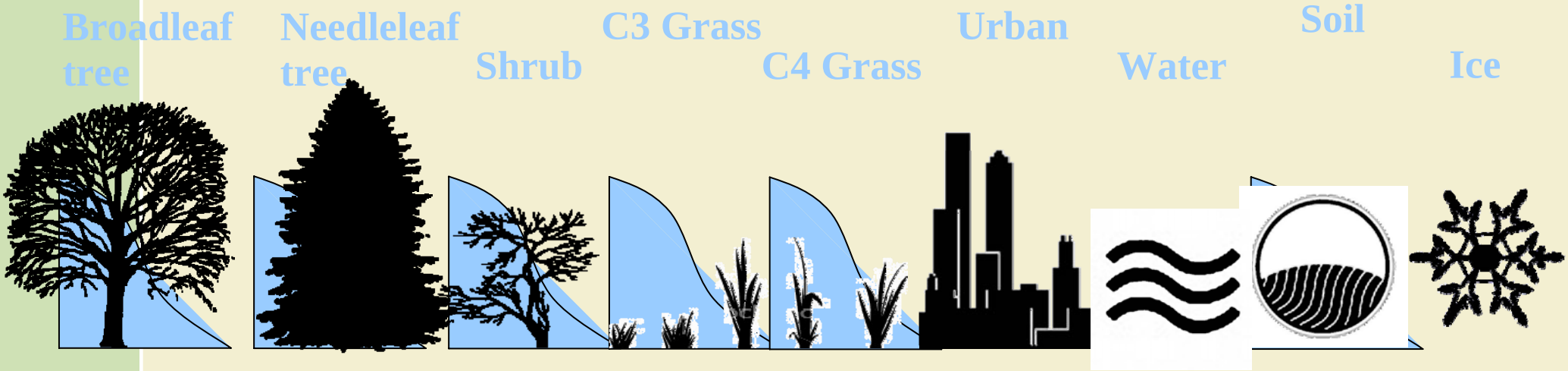
Separate energy balances for snow and snow-free tiles

- Each surface tile has a separate energy balance for snow and snow-free sub-tiles.
- The extent of each sub-tile is defined by snow covered fraction curves



Modified JULES Snow Model

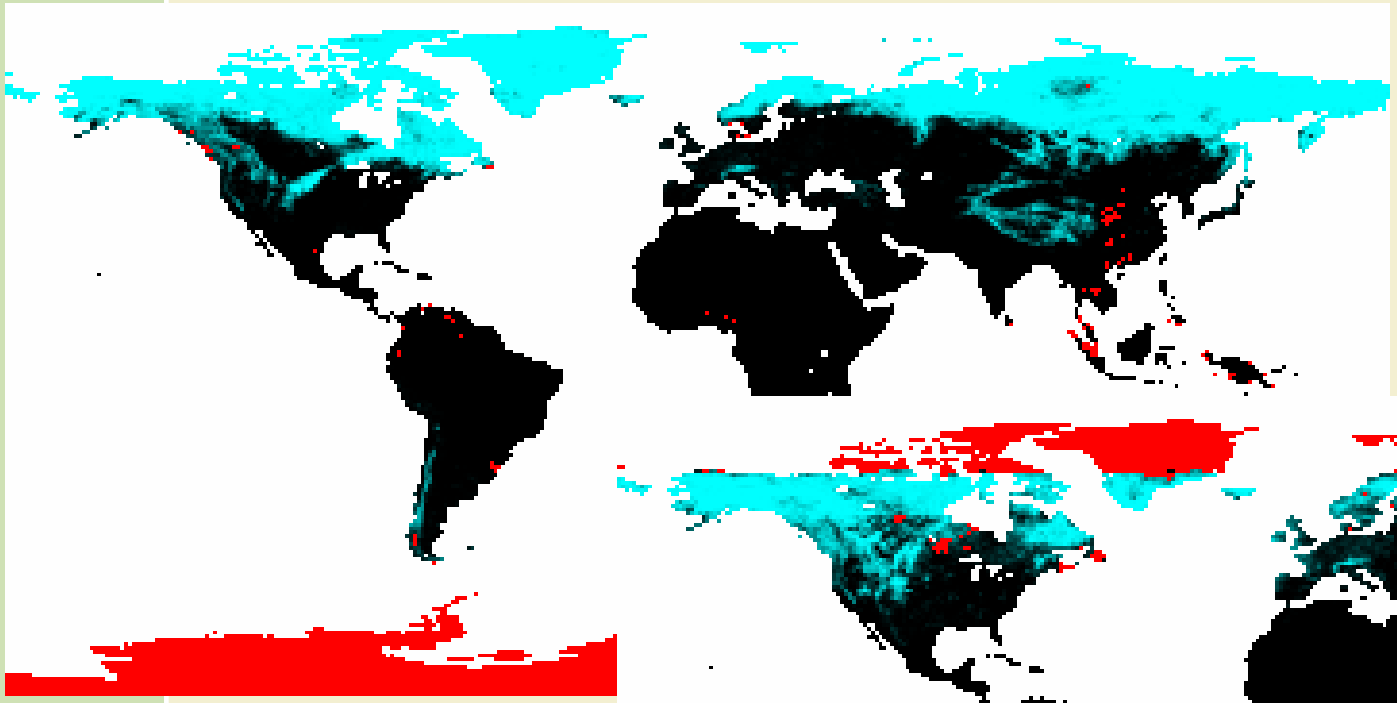
- JULES has 9 surface types
- Snow-tiling implemented on the 5 PFTs, and the soil tile
- JULES extended snow tiling scheme has 15 tiles
- Different accumulation and ablation curves for tall (trees) and short surfaces (shrubs, grasses and bare soil)



Defining Curve Parameters

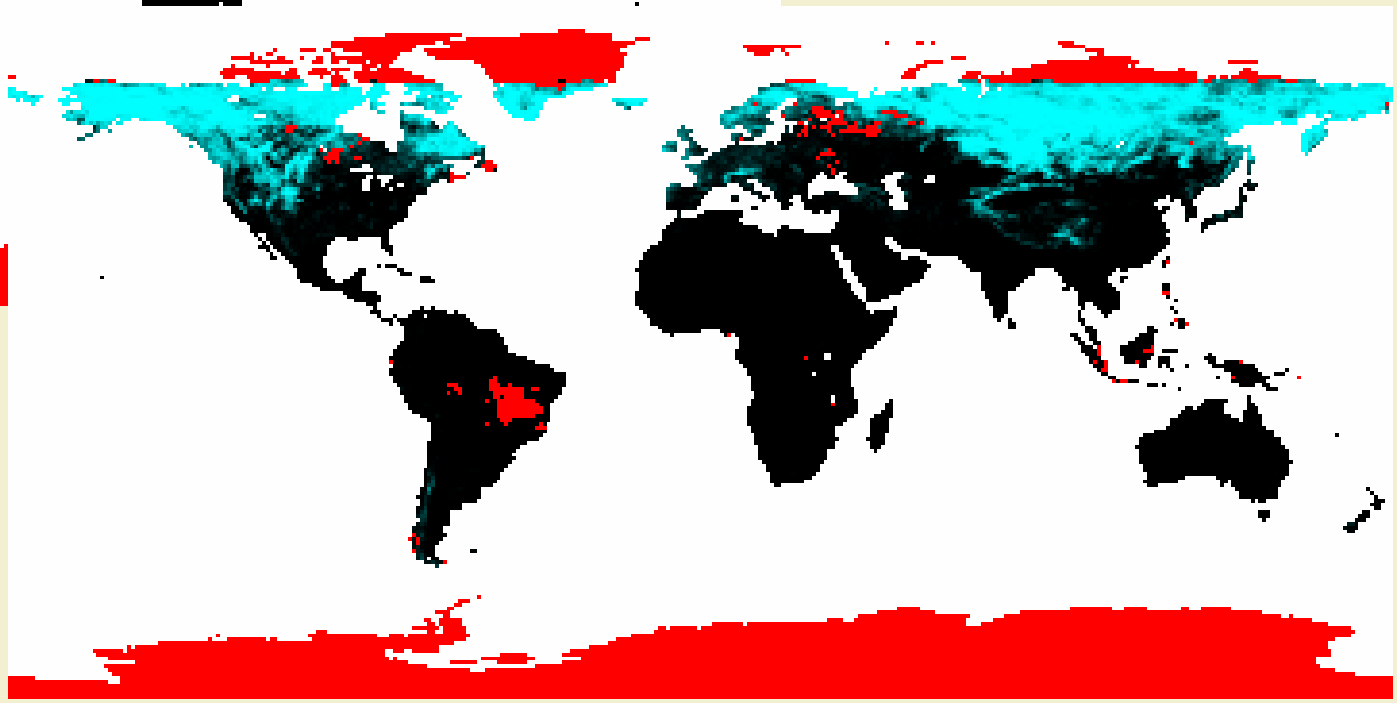
- Curve parameters need to be globally applicable
- Curves fitted to EO SWE and Snow Cover data using least squares fitting
- Earth Observation Data sets:
  - MODIS MOD10 0.05º 8-day Snow Cover
  - SMMR and SSM/I Monthly Snow Water Equivalent
  - MODIS MOD44B Vegetation Continuous Field
  - GTOPO 1 km Elevation Data

Heterogeneous Snow Cover – 1degree



Accumulation:

2000, DOY 305

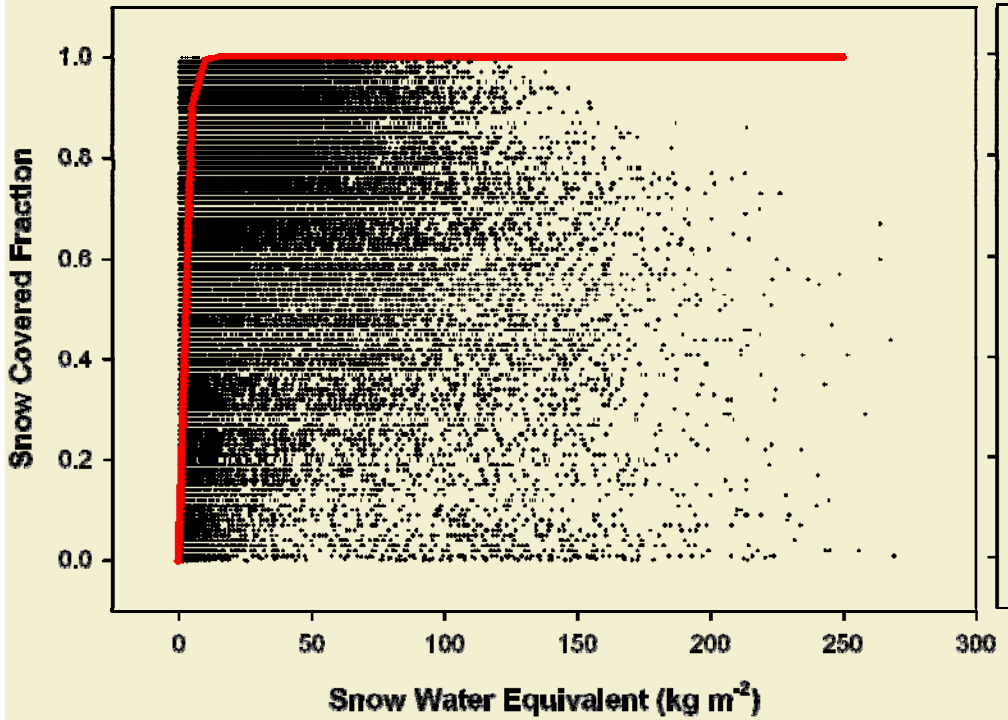


Ablation:

2001, DOY 113

Short Vegetation Curves

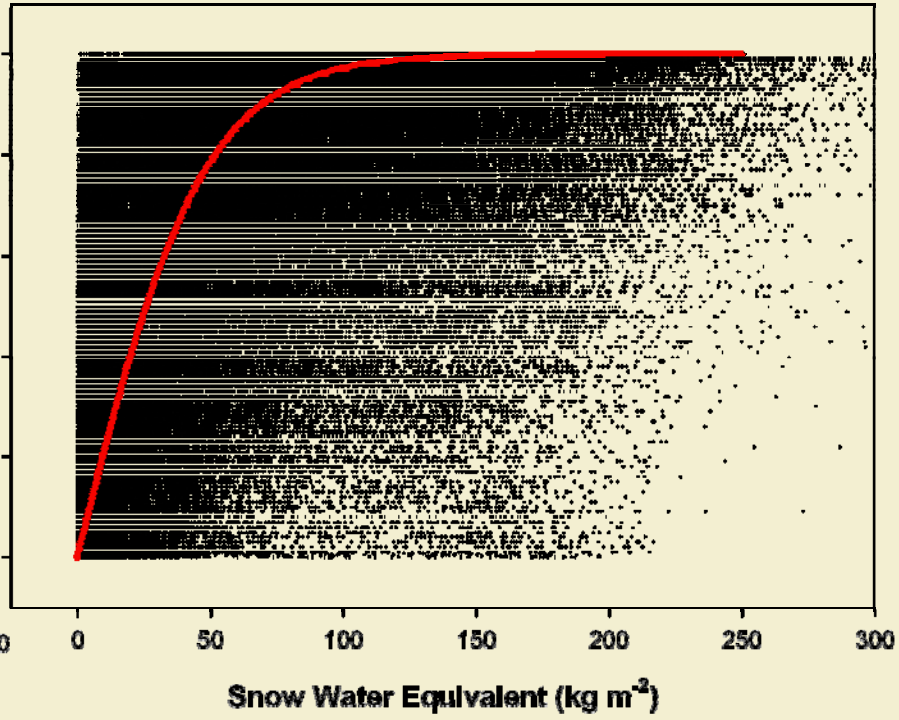
Accumulation



RMSE=0.35

N=58568

Ablation

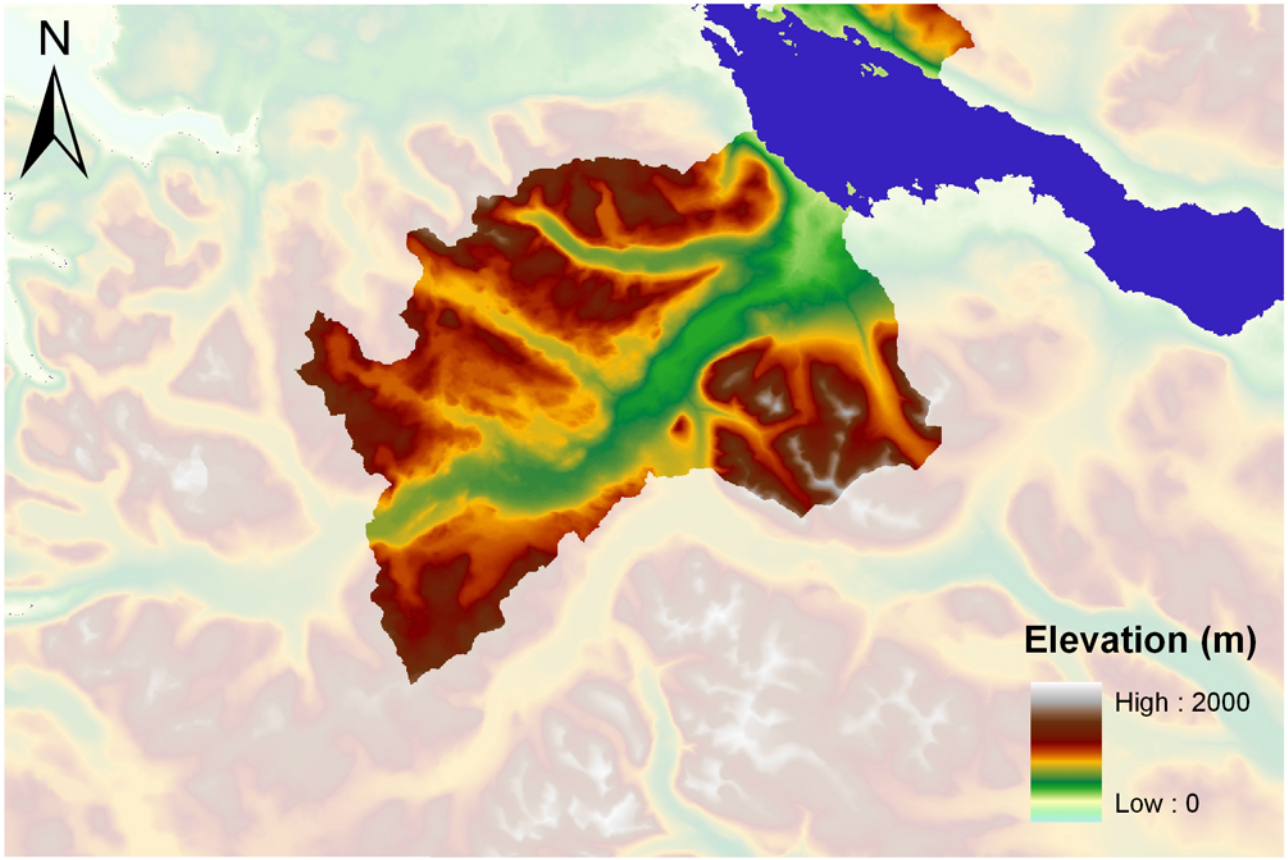


RMSE=0.30

N=145972

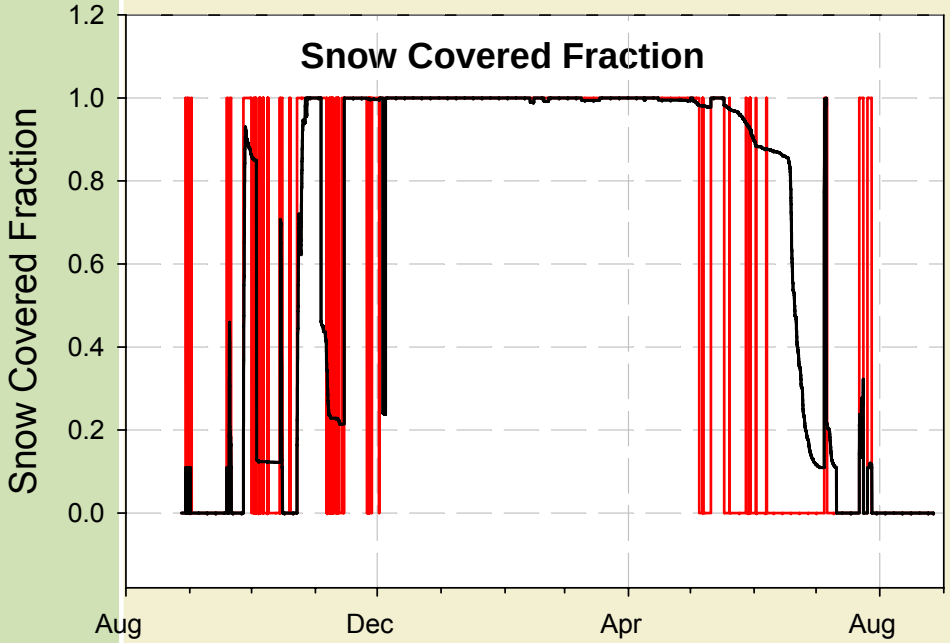
$$f_{snow} = \tanh(\alpha)$$

Abisko Catchment



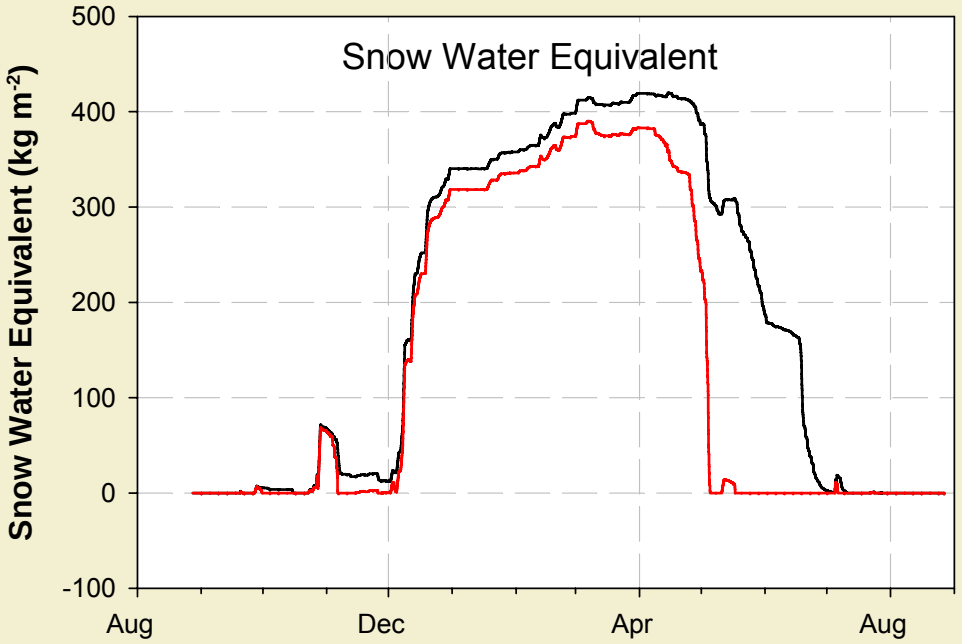
- Small, gauged, seasonally frozen catchment in northern Sweden
- Size = 555 km^2

Results – Snow State

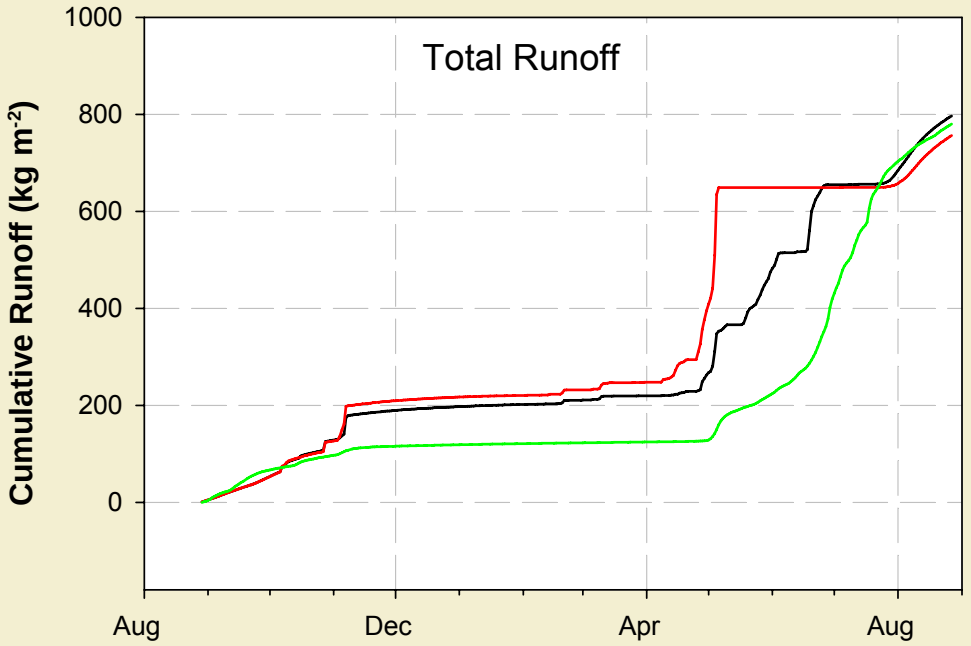


Red – Standard Model

Black – Tiled Model



Results – Surface Hydrology

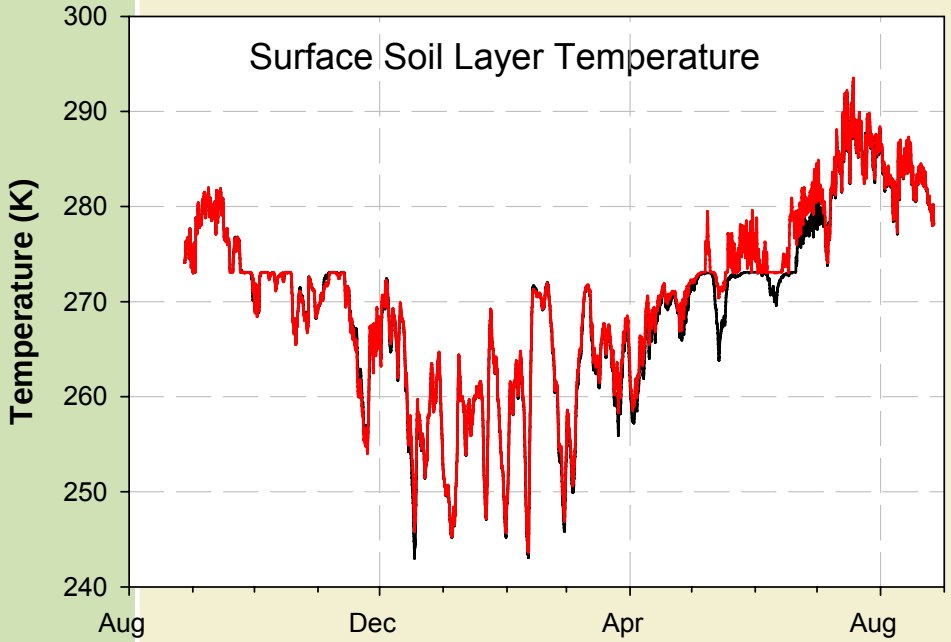


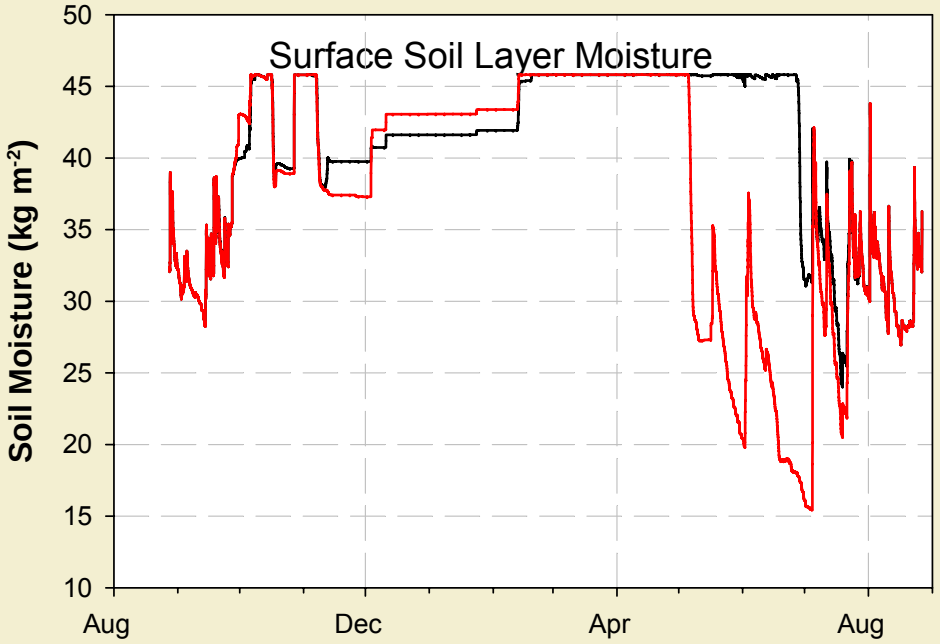
Red – Standard Model

Black – Tiled Model

Green - Observations

Results – Soil State

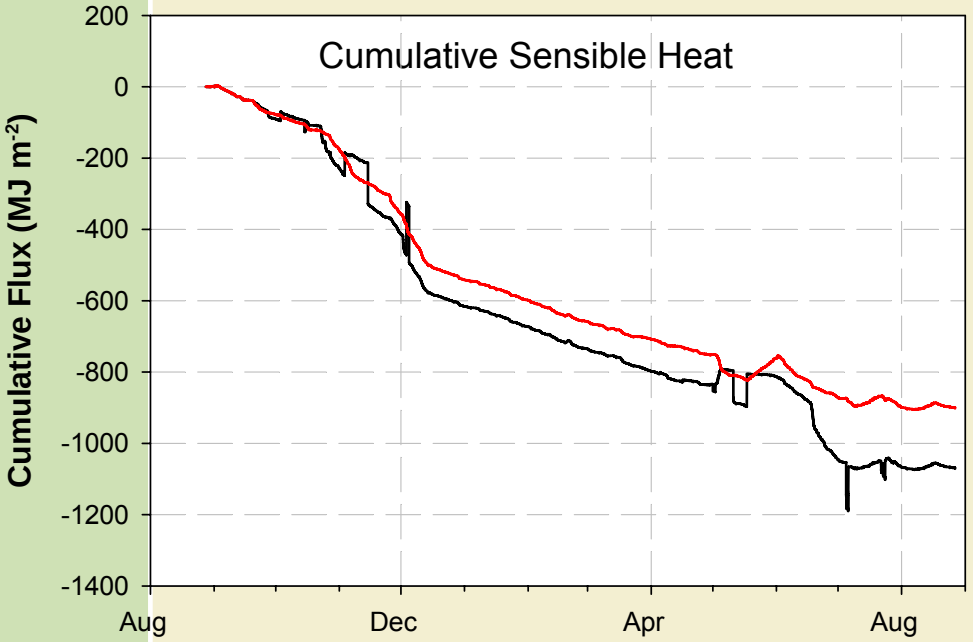




Red – Standard Model

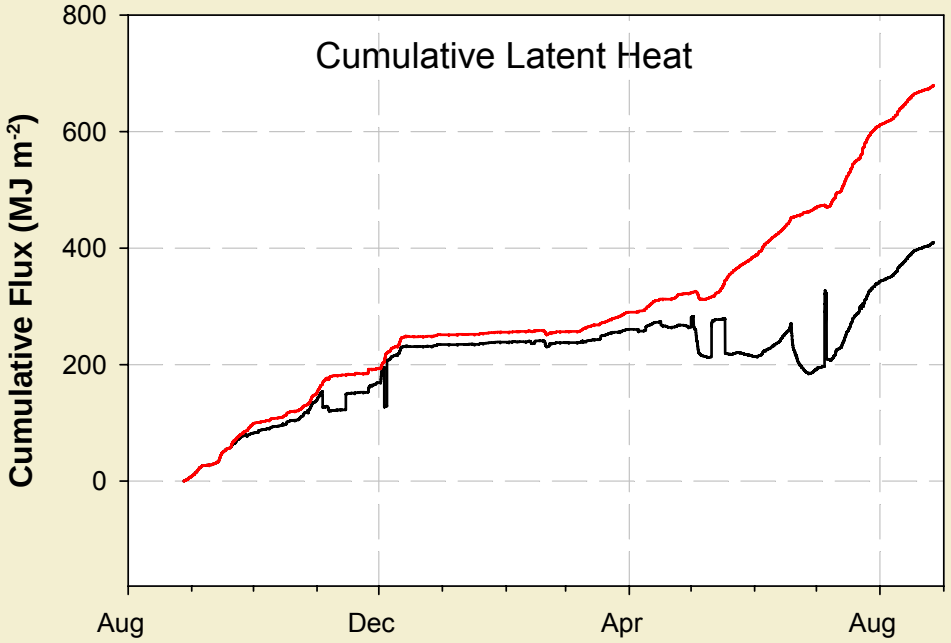
Black – Tiled Model

Results – Turbulent Fluxes

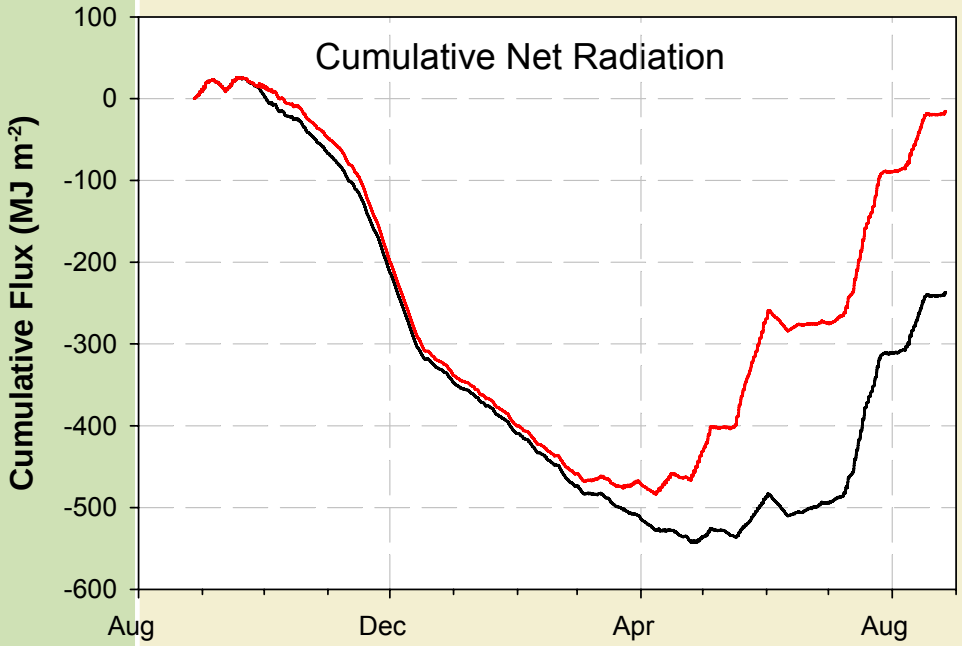


Red – Standard Model

Black – Tiled Model



Results – Radiative Fluxes



Important result –

In coupled models the change in surface albedo will have feedbacks on air temperature and humidity most likely enhancing the differences between the models

Red – Standard Model

Black – Tiled Model

Conclusions

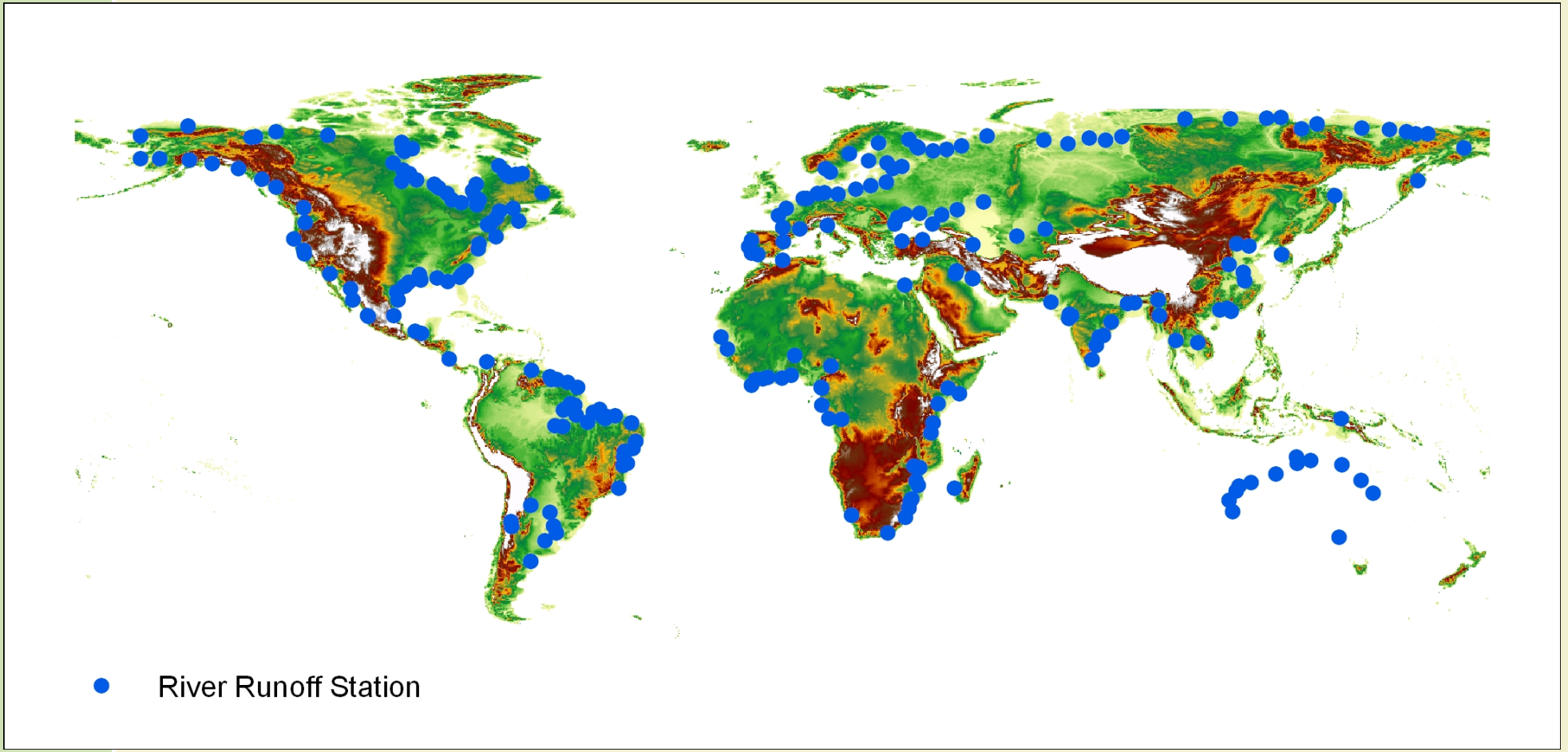
- Surface feedbacks to the atmosphere for seasonally snow-covered regions are sensitive to the parameterisation of heterogeneous snow cover
- The main feedback to the atmosphere is through the albedo effect of heterogeneous snow
- Also, there are secondary feedbacks through the effects on the water balance.

Future Plans

- Test the model globally using GSWP2 1º driving data.
- Validation using river runoff data from the major river basins of the world
- **Coupled simulations??**

- Further model development:
  - Topography Tiles – Slope, Aspect, Elevation
  - Dynamic Snow-Vegetation Model

Global Runoff Validation



Global Runoff Data Centre (2005): GIS Layers of Major River Basins of the World. GRDC in the Bundesanstalt fuer Gewaesserkunde, 56068 Koblenz, Germany, http://grdc.bafg.de