High resolution process modelling of a high latitude catchment

Andy Wiltshire, Jon Bennie
Brian Huntley, Bob Baxter
CLASSIC
Aim

• To understand the role landscape heterogeneity plays in the heat, water and carbon cycle.

• From this, develop surface tiling scheme and surface parameterisations to improve the seasonal heat, water and carbon fluxes.
Landscape Snow Heterogeneity
Abiskojokk Catchment

- Seasonally frozen catchment
- Approx 600km²
- Spans elevation range of 340 to 1800m
- Model simulations 50m resolution
- Approx. 240,000 grid points
- 3 years: 2003-2005
Topography

Slope

Aspect
Dark Red/Blue - N Facing
Blue – E Facing
Red – W Facing
White – S Facing

Sky-View Factor

Derived from 50m DEM
Vegetation Cover

% Tree cover

% Grass/Shrubs

Survey data suggests ratio of Shrubs to Grass is 95:5

% Bare Ground

Interpolated from 500m MODIS vegetation cover data
Distributed Model Driving Data

• Driving data distributed across the catchment according to topography

• Downwelling Shortwave Radiation
  – Observations split into Direct/Diffuse using estimate of cloud index
  – Direct and diffuse solar radiation fluxes calculated for each point
  – Diffuse radiation adjusted for sky-view factor
  – Direct radiation adjusted for slope, aspect and shading, including self-shading

• Downwelling Longwave Radiation
  – Adjusted for sky-view factor, where the radiating temperature of surrounding topography assumed equal to air temperature

• Air temperature
  – Lapse rate – 0.39K per 100m derived from AWS observations
Distributed Model Driving Data

• Humidity
  – Kept uniform across domain, but prevented from becoming super-saturated

• Windspeed
  – Held uniform

• Precipitation
  – Gauge corrected observations indicate a 20% increase in precipitation per 100m
  – Air temperature used to split precipitation into solid and liquid components
Topographic Shading

Hours of shade

Equinox

Midsummer
Direct Radiation

24hr Integrated Solar Index

Equinox

Midsummer

No field code
at 0000 14/09/1752

No field code
at 0000 14/09/1752
Soil Freeze-Thaw

Soil Thaw DOY

Soil Freeze DOY
Days of Snow and Frozen Soil
River Discharge

Discharge
m3/s

Jan 2003
Jan 2004
Jan 2005
Jan 2006
Sensible Heat Flux (W/m²)

JFM

AMJ

JAS

OND
Further work

• Validate model against river discharge data and MODIS snow cover data
• Analyse the relationship between surface exchange and topography
• Model development of tiled topography and parameterisations of heterogeneity