Snow and Vegetation

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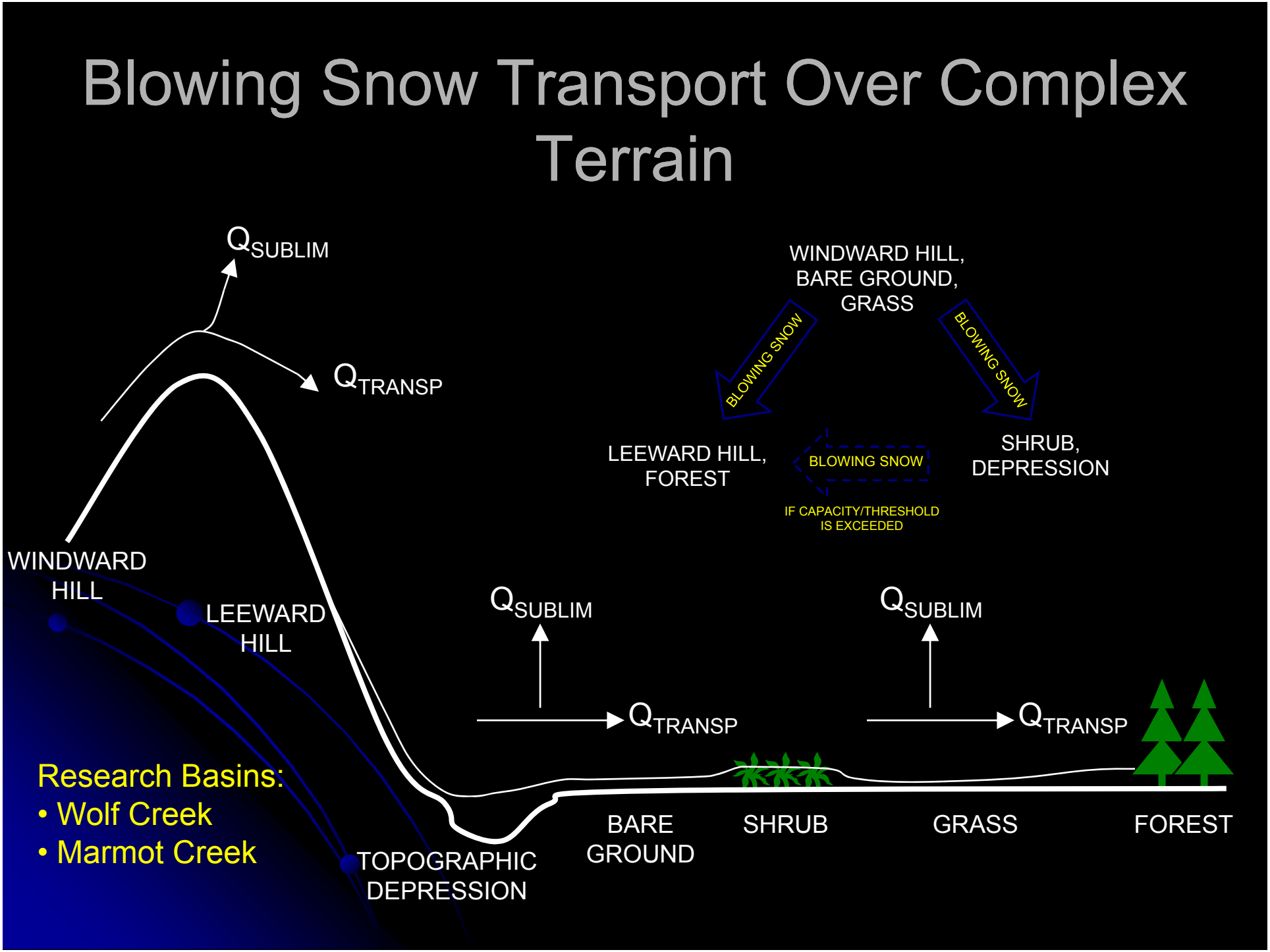
Snow Dynamics

- Snowfall Accumulation and Redistribution by Wind and Vegetation
- Snow Ablation by melt & sublimation
- Forest and shrub effects on accumulation and melt

Snow Regimes

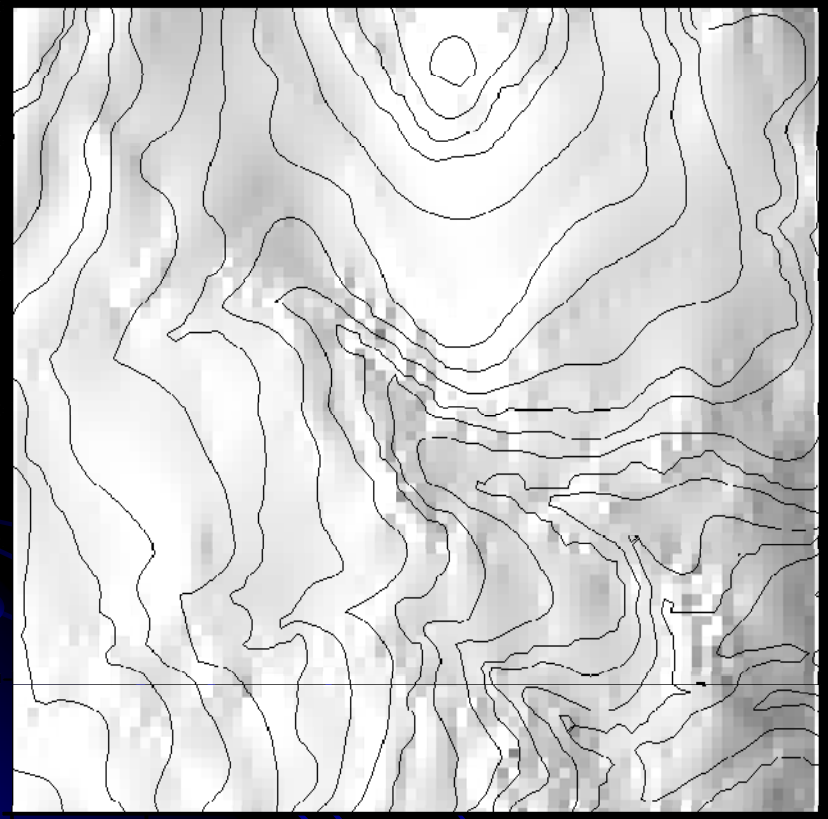
Forest Snow – Open Snow

Blowing Snow Transport Over Complex Terrain



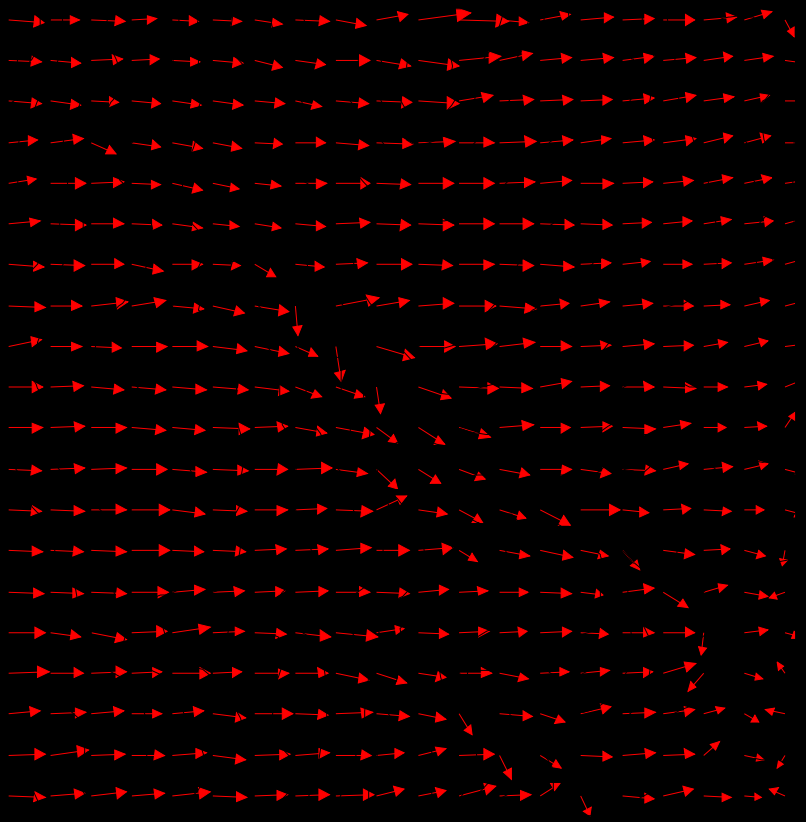
Linear simulation of westerly flow over Wolf Creek, Yukon

Windspeed



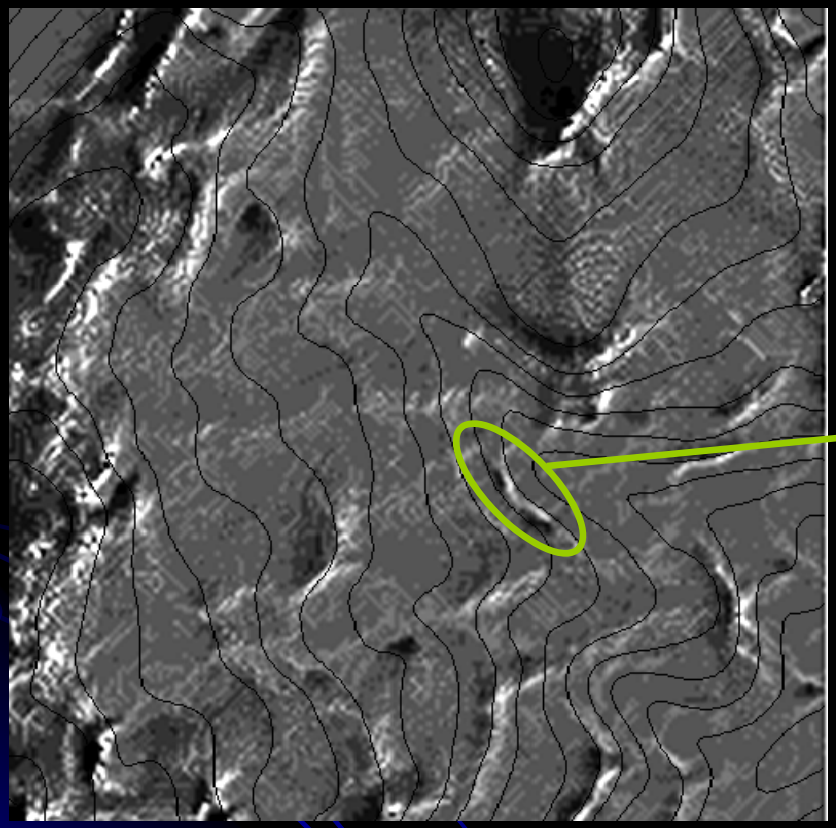
3 km

Direction



Essery and Pomeroy, *in preparation*

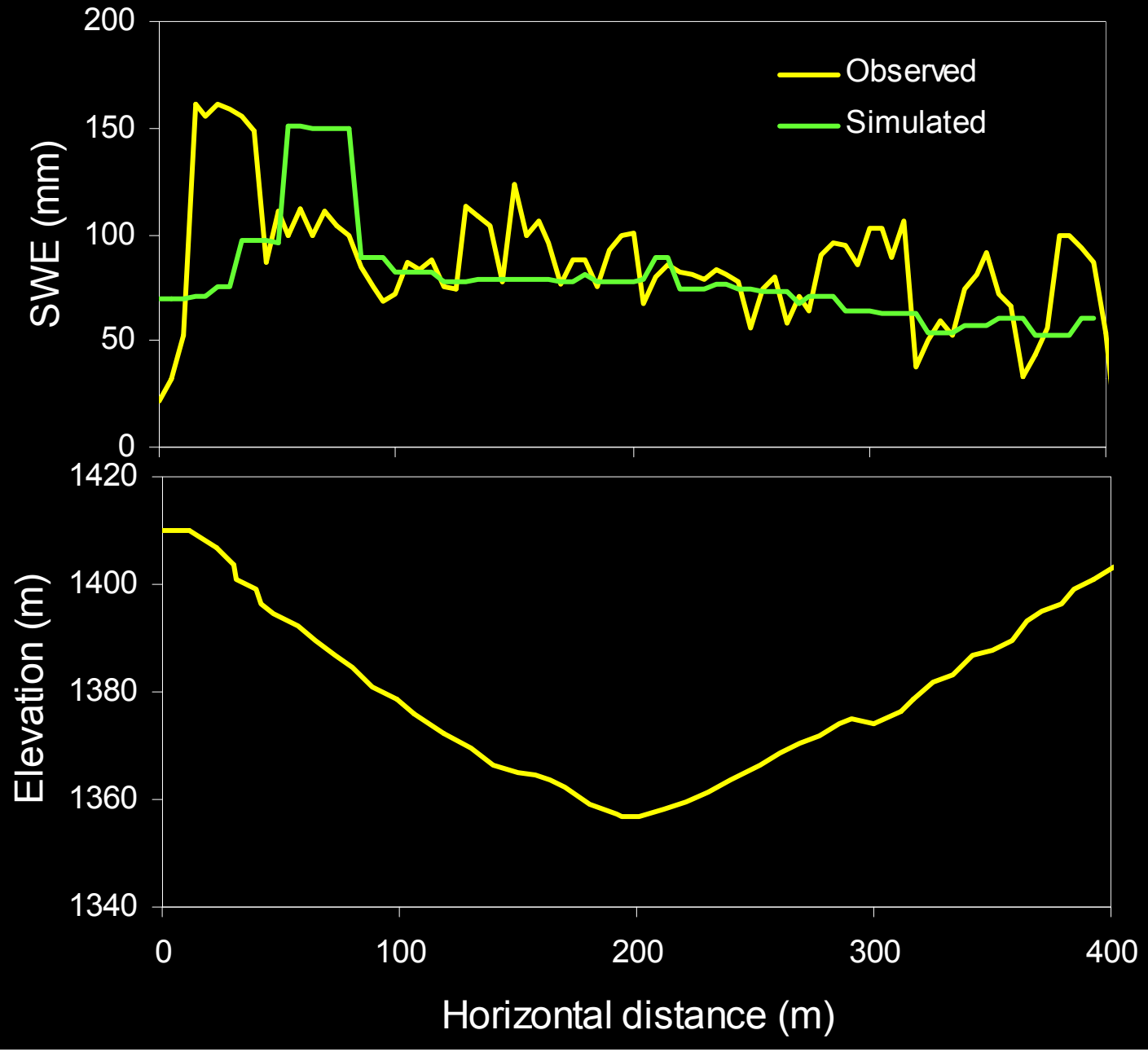
Simulation of Hillslope Snowdrift



3 km

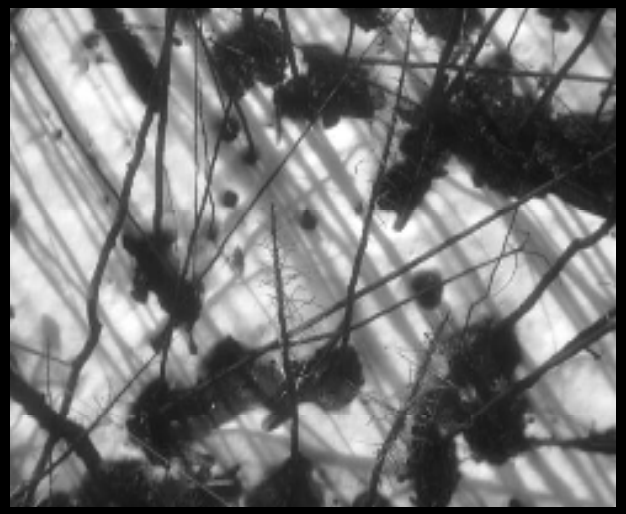
Distributed Blowing Snow Model

Snowdrift Simulation



Snowmelt Rate

- At a point controlled by energy inputs, snow internal energy and available snow mass
- Over some area controlled by the spatial distribution of snow mass (including snow covered area) and energy inputs
- Strong influence of topography and vegetation



Coupled Mass and Energy Equations for Snowmelt

- MELT of SWE, $S = Q_M / \lambda_f$
- Melt Energy $Q_M =$

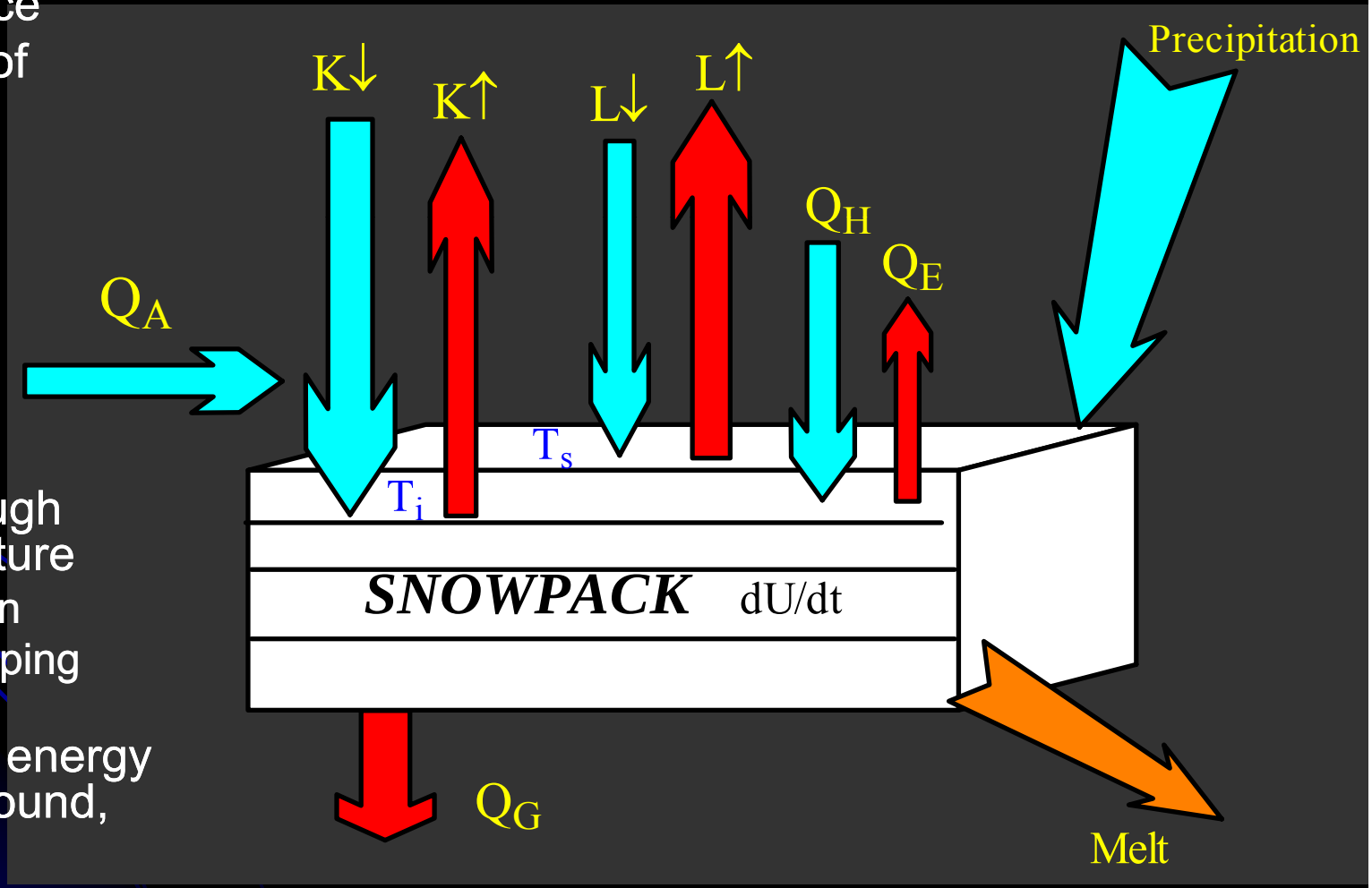
$$Q^* + Q_H - Q_E + Q_P - Q_G - dU/dt$$

  - Q^* Net radiation (+ to snow surface) (=K↓-K↑+L↓-L↑)
  - Q_H Sensible energy (+ towards snow surface)
  - Q_E Latent energy (+ away from snow surface)
  - Q_P Advected energy from precipitation (+ to snow)
  - Q_G Ground heat flux (+ downward from snow)
  - dU/dt Internal energy change (+ loss from melt)
  - λ_f latent heat of fusion

Real World Snowpacks

Snow Exchange Realistic View

- Longwave exchange only at surface
- Penetration of shortwave

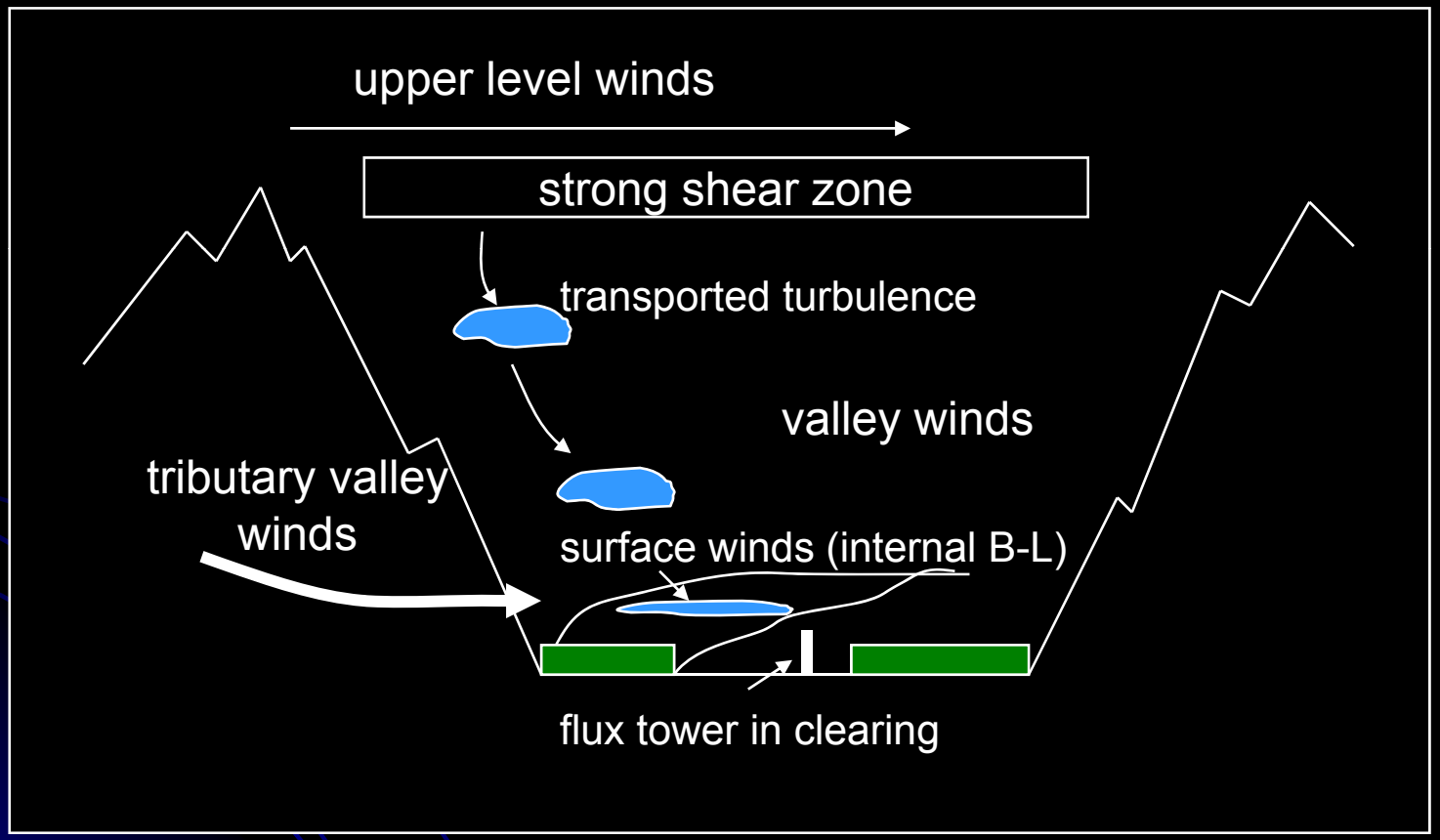


- Air flow through porous structure
  - Convection
  - Wind pumping
- Advection of energy from bare ground, plant stalks

Some Problems with Snowmelt Calculations

- Heterogeneity of atmospheric and radiative exchange
- Longwave exchange occurs at snow surface, shortwave exchange occurs in upper snow layers.
- ***Where*** are atmospheric exchanges occurring? Not only the snow surface
- Coupling between snow surface and internal energetics poorly understood.
- Mixture of “wet” snow preferential flow zones and impeding layers (~0 ^{o}C) and “cold” snow zones (<0 ^{o}C)
- Difficulty in coupling snow and frozen ground energetics, phase change and mass transfer

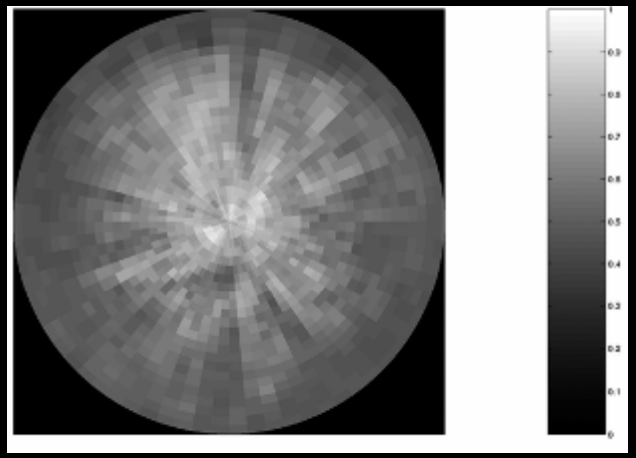
Turbulence generation mechanisms in mountains



$Q_H = -\rho\, c_p\, (T_s - T_a)\, f(u)$

$Q_E = -\rho\, \lambda_s\, (q_a - q^*(T_s))\, f(u)$, where surface saturated is at T_s

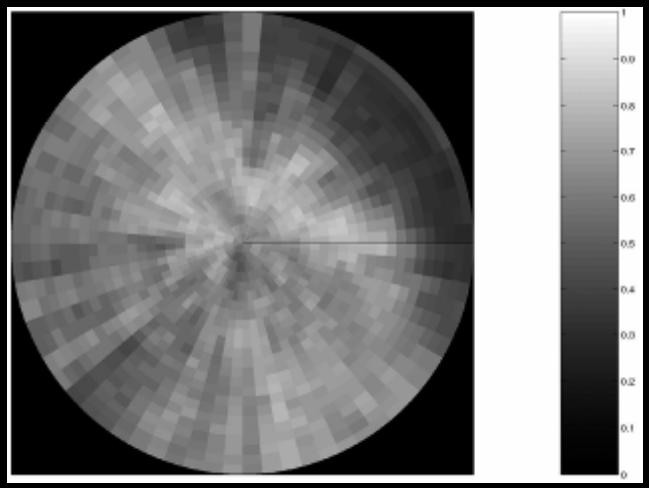
Slope Forest Transmissivity



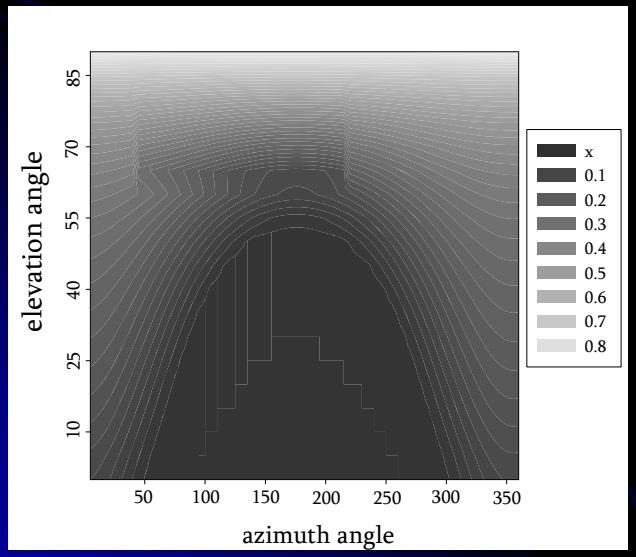
North Face Forest

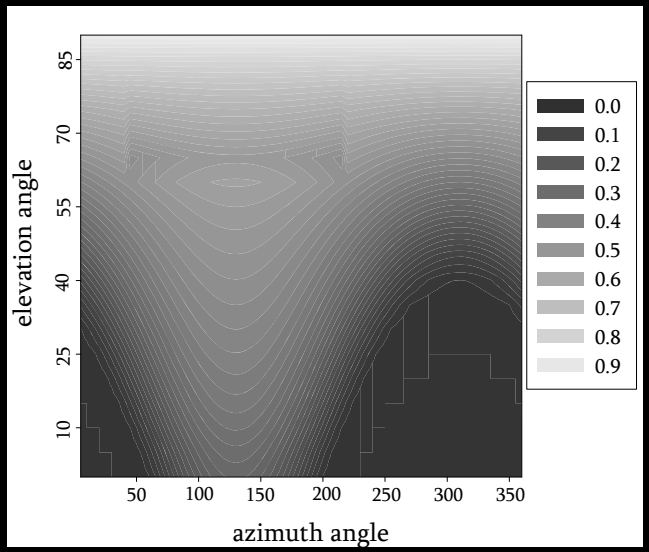
τ a function of
LAI,
Foliage inclination
Crown coverage
Slope,
Aspect,
Solar azimuth,
Solar elevation

Model of solar radiation transmission through continuous evergreen canopy on slopes

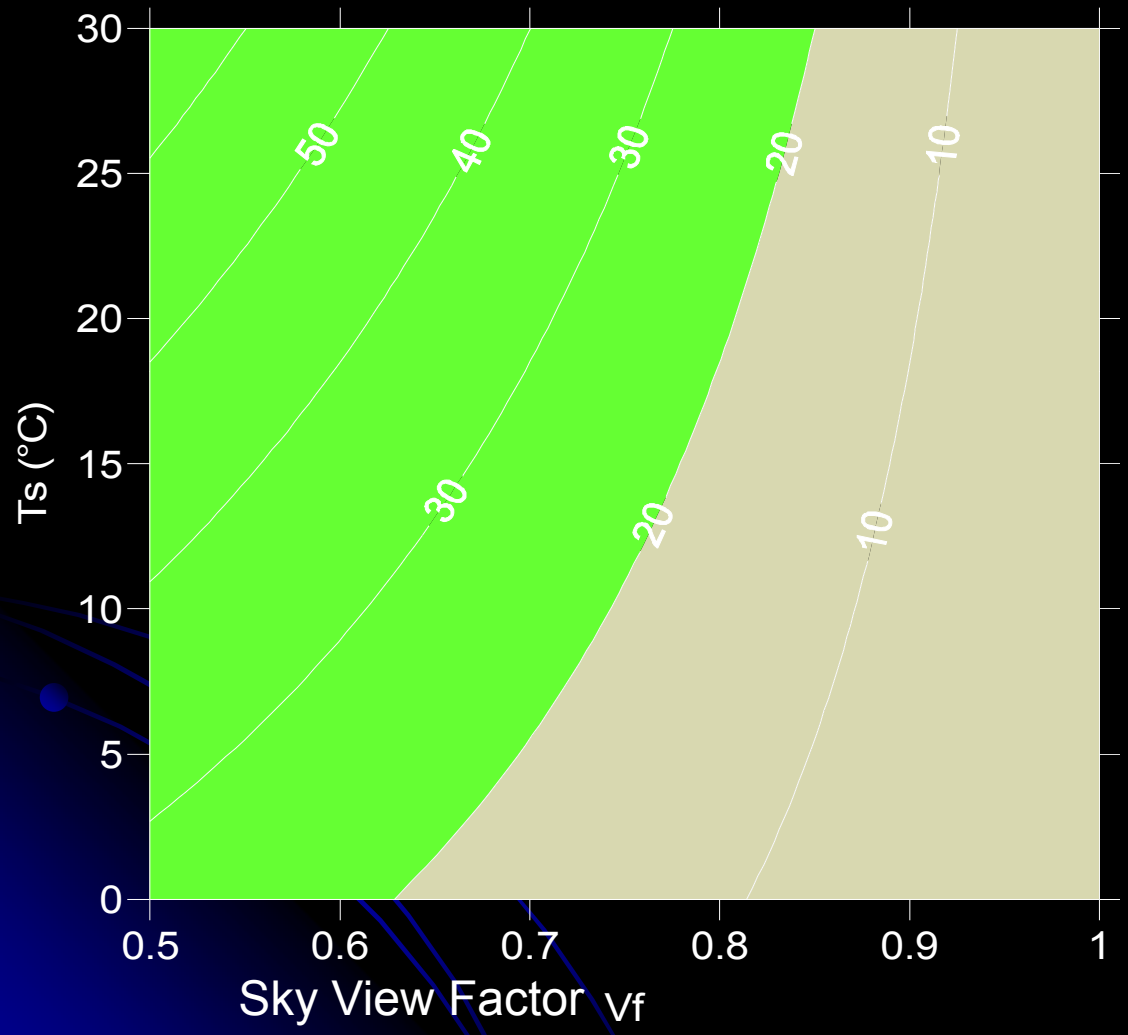


South Face Forest





Incoming Longwave in Mountains



Sicart et al. 2006 *Hydrological Processes*

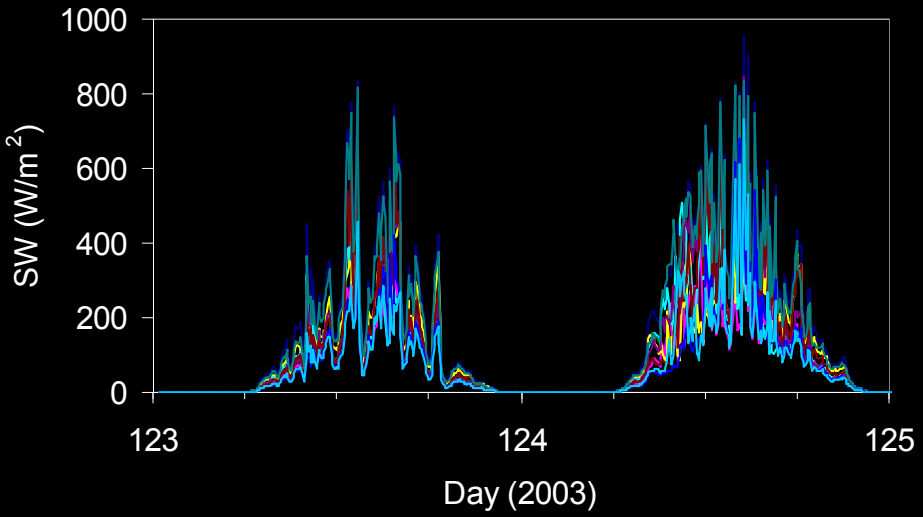
Percent increase in longwave irradiance due to terrain emission due to sky view factor (V_f) and surface temperature (T_s).

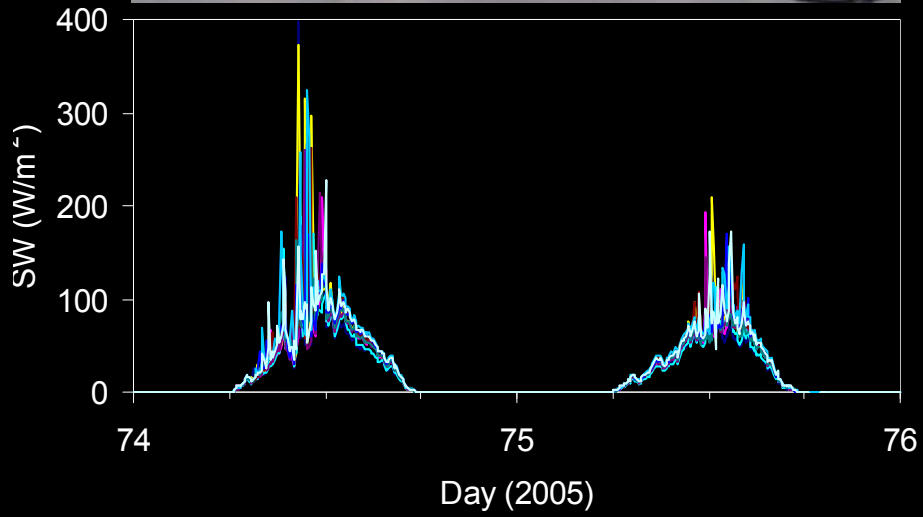
Air temperature is 0°C and the clear sky emissivity is 0.65

Solar radiation to snow beneath shrubs and trees

Wolf Creek shrubs

Marmot Creek level forest

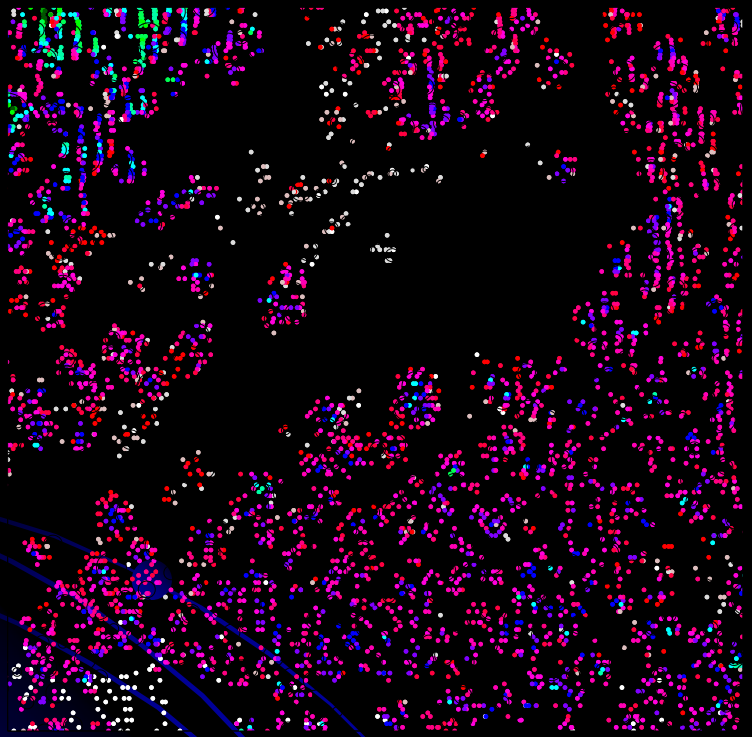




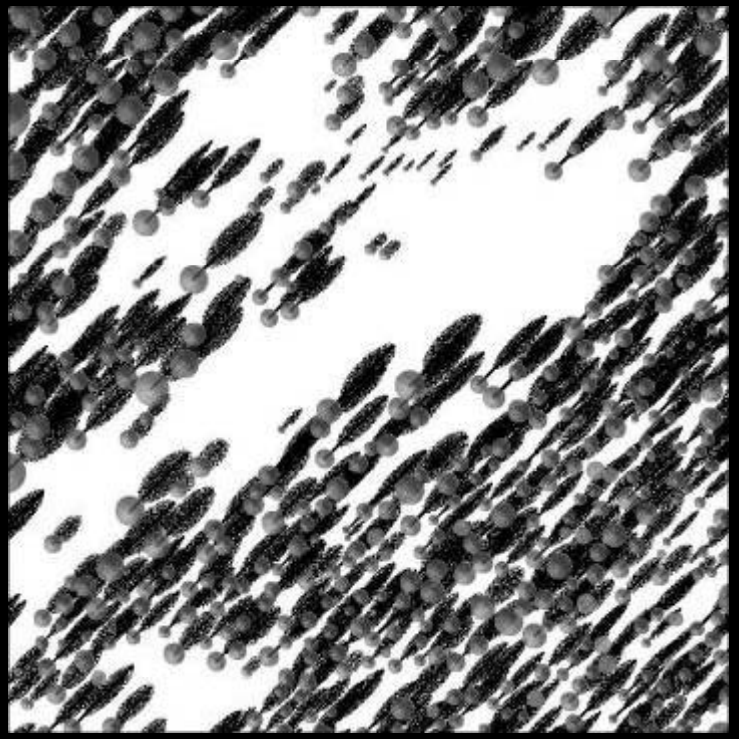
Pomeroy et al., *J Hydrometeorol*, 2008

Modelling Sub-alpine Shortwave Radiation

Lidar and canopy delineation



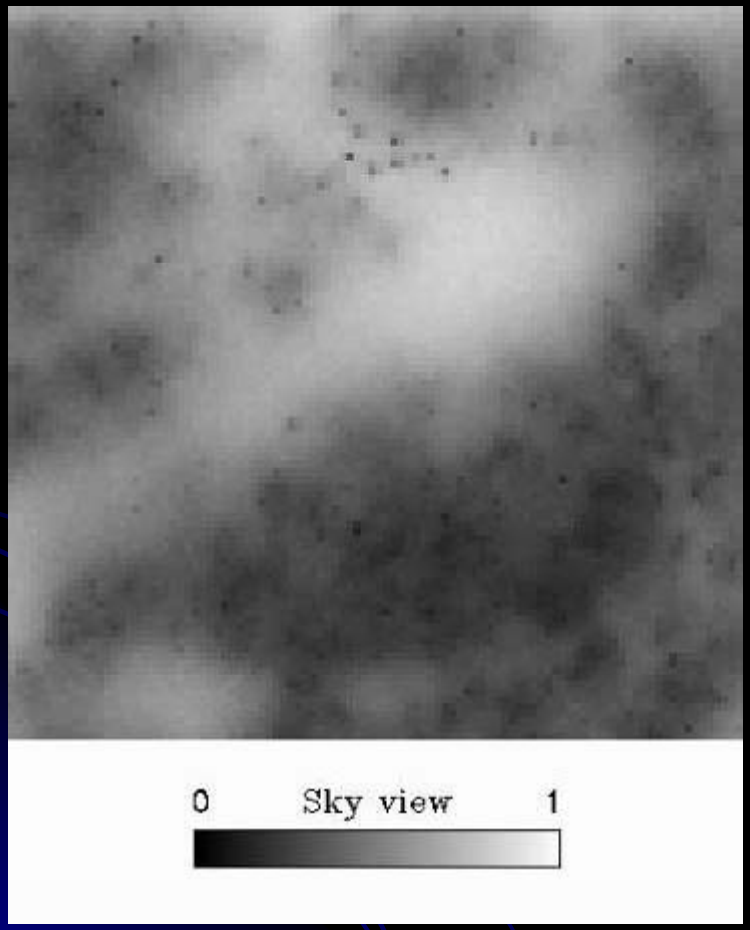
Shadow simulation



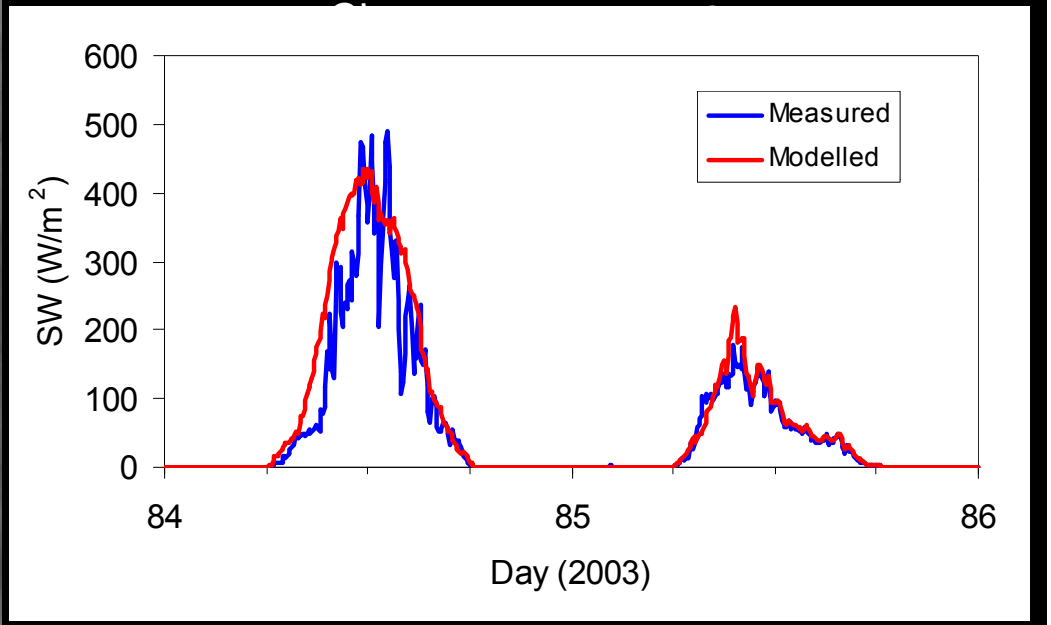
Essery et al. (2007). *Journal of Hydrometeorology.*

Upscaling Sub-alpine Shortwave Radiation

Simulated skyview

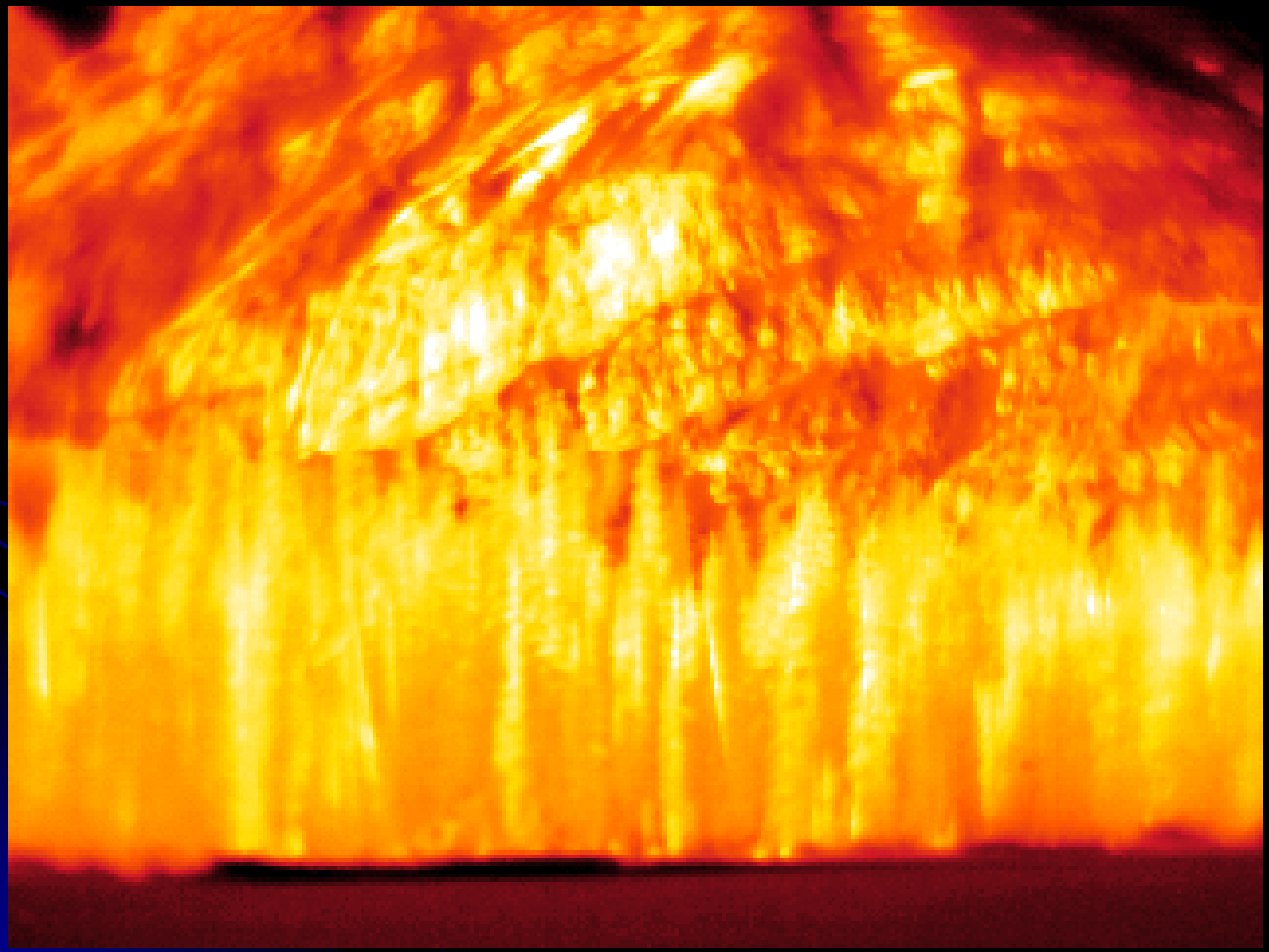


Simulated skyview

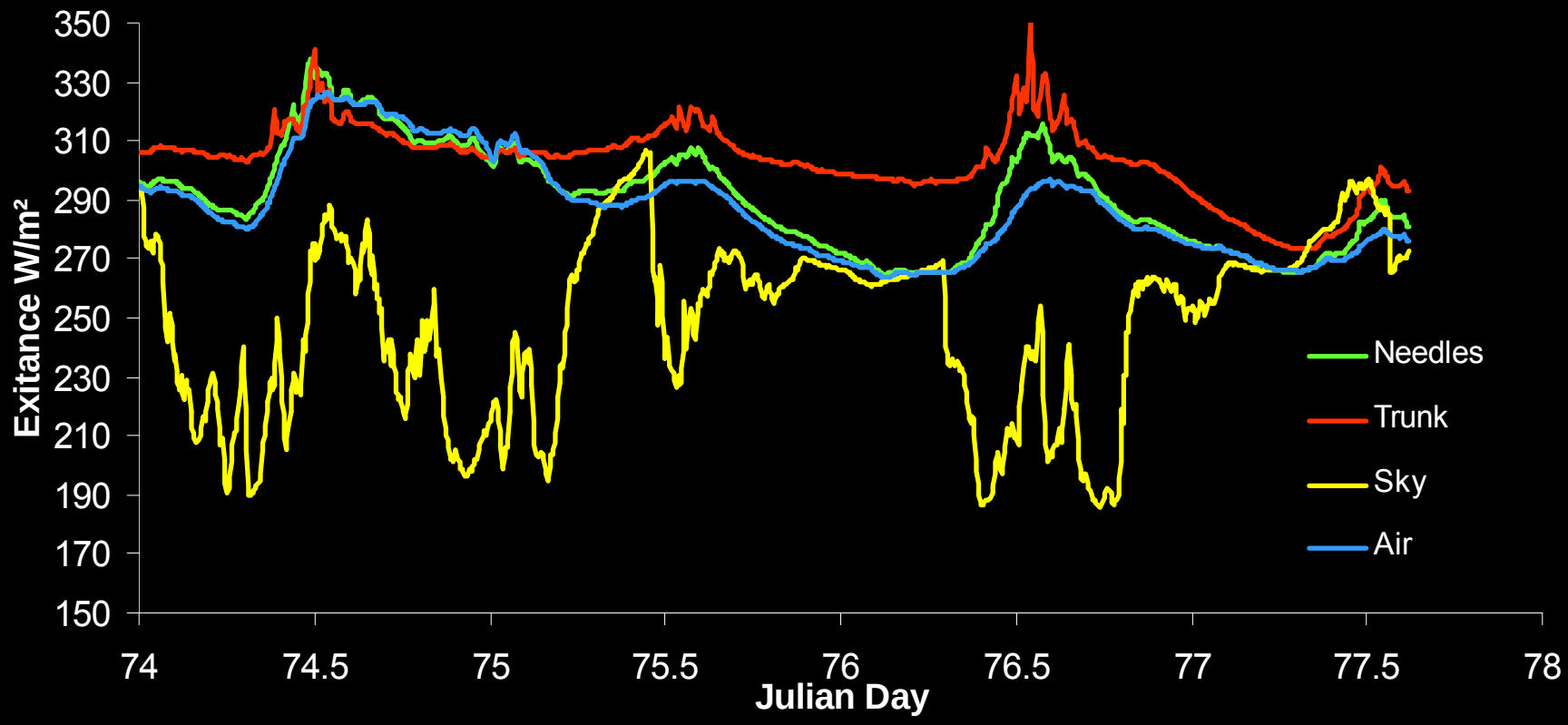


Essery et al. (2007). *Journal of Hydrometeorology.*

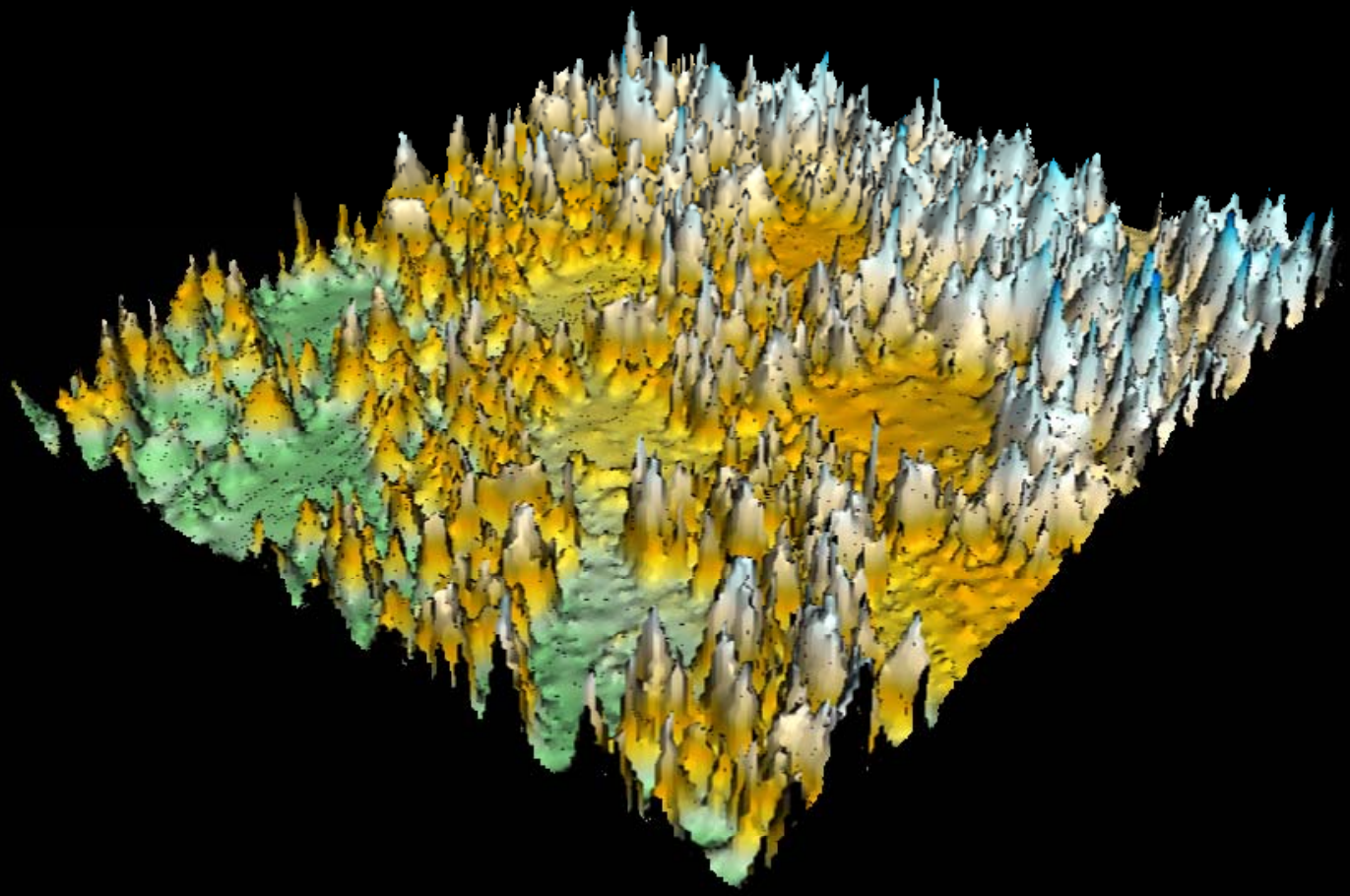
Hot Trees



Longwave Exitance Pine Stand



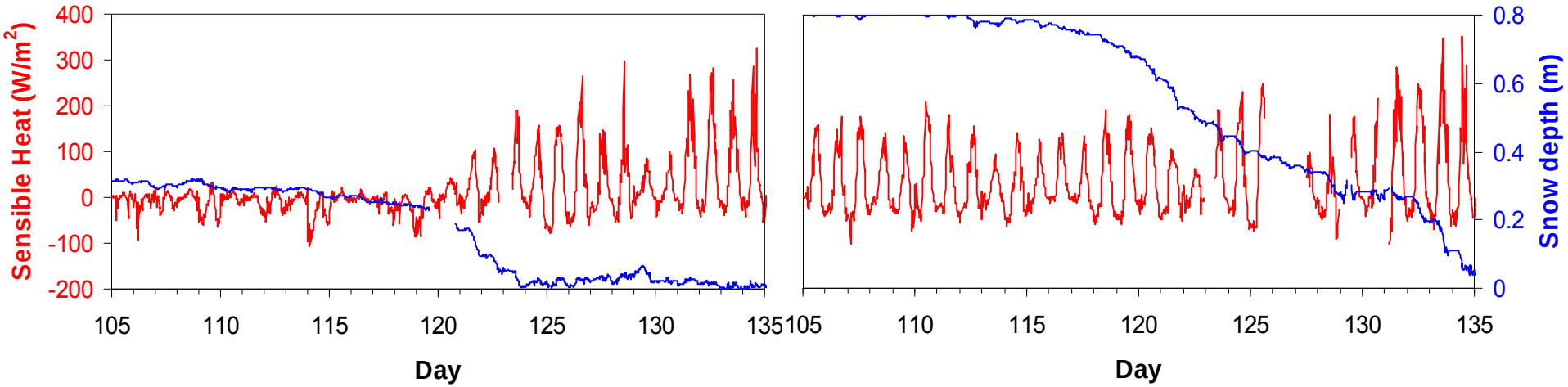
LiDAR



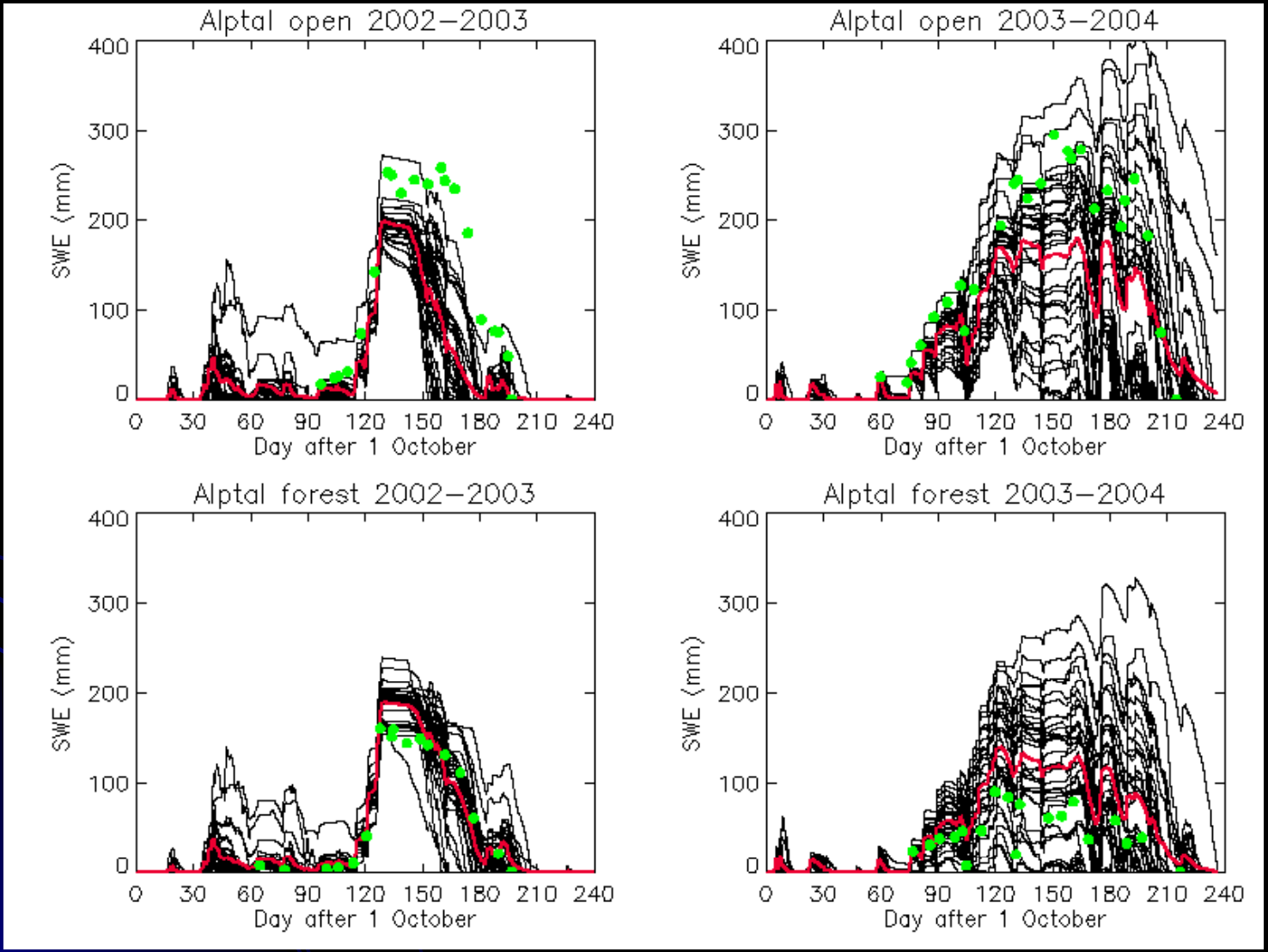
Marmot Creek “honeycomb” clearings and spruce forest

Plateau

Valley



How Well Do Models Simulate Snow?



Snowmip2 http://xweb.geos.ed.ac.uk/~ressery/SnowMIP2/results.html