Impacts of Forest Clearing on Radiation and Snowmelt in Marmot Creek, Alberta, Canada

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Improved Processes & Parameterisation for Prediction in Cold Regions







- Snowmelt timing controlled by energy to snow
- Forest cover suppresses turbulent energy fluxes
- Snowmelt energy dominated by shortwave and longwave radiation exchanges...

Forest-snow energy balance



 $Q^* = Qm + \frac{dU}{dt} = K + L + \lambda E + H + G$



Radiation to forest snow

* 'Radiation paradox'









Level terrain



Mountain terrain

Forest cover impacts on mountain snowmelt

- MCRB watershed treatment
 (Golding & Swanson): total of
 28% of the basin cut
- * 1977-1979: 2103 circular clearings of ${}^{3}\!\!\!/4h \rightarrow 4h$ created
- …assess impacts on
 magnitude and *timing* of
 snowmelt runoff



Field Observations



Field observations: Opposing Spruce slopes



Large divergence in melt timing between SF and NF forest gaps (clearings)

Close synchronization of melt between SF and NF slopes with <u>intact</u> forest cover



Large divergence in melt timing between opposing slopes with forest gaps attributed to their differing radiation inputs...



Simulations: Adaptation of *CRHM* for forest gaps



- Twin Ck & Middle Ck consist mostly of opposing south-facing and northfacing slopes:
- Scenario 1: intact forest cover across slopes:



Ellis, Pomeroy and Link, WRR (in press)

 <u>Result</u>: forest cover masks SW radiation differences caused by slope orientation; melt is driven mainly by LW causing <u>synchronized melt</u> across slopes:

Cumulative melt across Twin and Middle Ck under 4 forest cover scenarios:



- <u>Result</u>: Cold radiation holes on NF slopes delays melt compared to intact forest cover (as well as increased snowmelt due to lower interception losses):
- <u>Scenario 2</u>: remove forest cover on NF slopes (creating gaps):



Ellis, Pomeroy and Link, WRR (in press)



 <u>Result</u>: earlier melt on SF slopes advances the melt period compared to intact forest cover

 <u>Scenario 3</u>: remove forest cover on SF slopes only (creating gaps)



Ellis, Pomeroy and Link, WRR (in press)



- <u>Result</u>: cold radiation hole in NF gaps delays melt
- Earlier melt in SF gaps combined with later melt in NF gaps <u>extends</u> <u>the melt period</u>
- Scenario 4: remove forest cover on SF & NF slopes (creating gaps on both)



Ellis, Pomeroy and Link, WRR (in press)

MCRB: Effects of Basin Orientation



Influence of Basin Orientation on forest cover scenarios

<u>Original basin orientation</u>: topography has much high influence on forest cover effects:



<u>Basin rotated 90°</u>: Topography has little influence on forest cover effects:







Conclusions



- Forest cover effects on radiation to snow and snowmelt in mountain environments are highly variable and strongly dependent on: (i) seasonal meteorological conditions (ii) local slope/aspect
- With appropriate parameterisation of site characteristics, physically-based modelling approaches may be useful in representing forest-snow processes with changing forest cover and meteorological conditions
- Strategic forest harvesting practises may provide an useful management tool for altering the *timing* and *magnitude* of snowmelt

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