Modelling the radiation balance of sparse forests with JULES

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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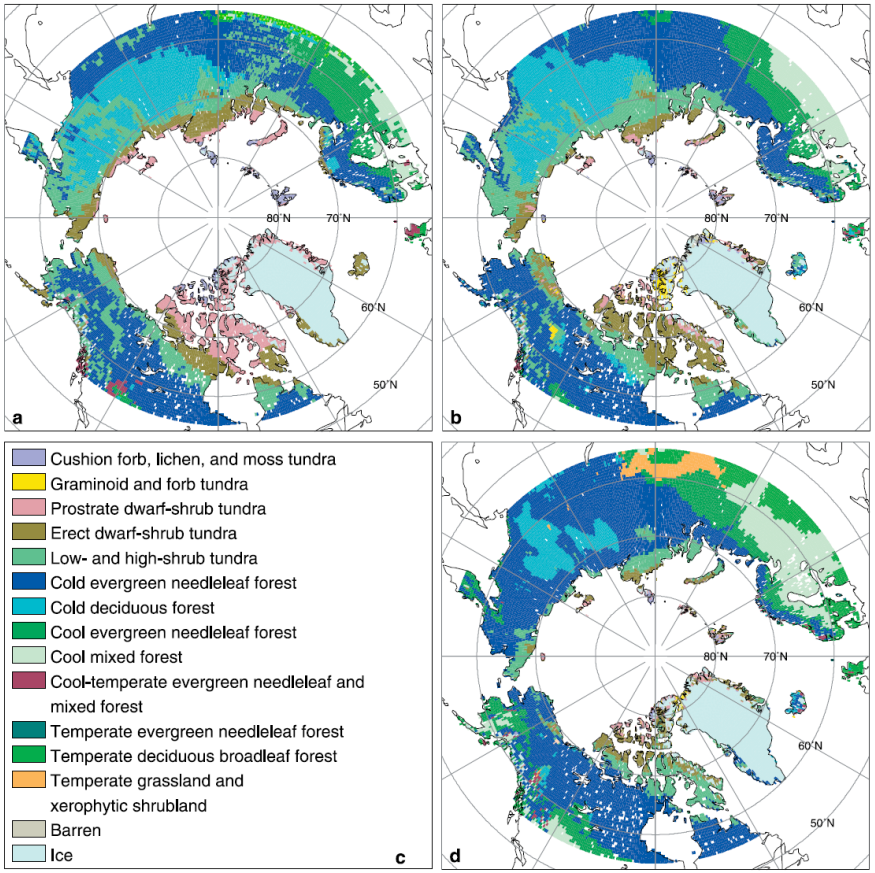
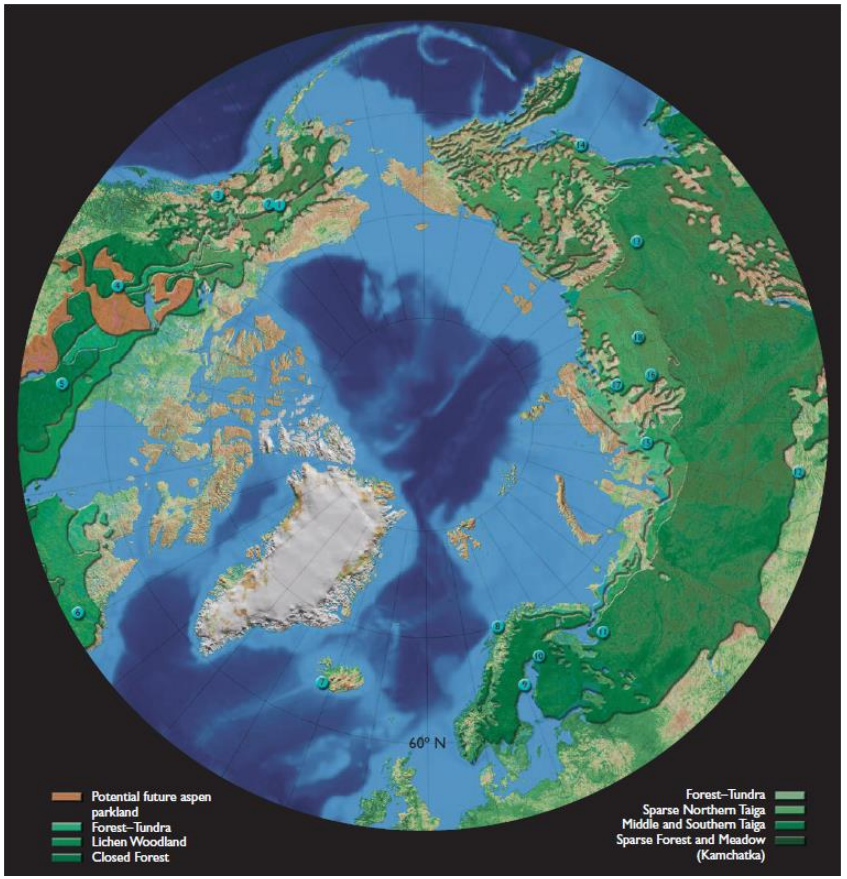
Why are sparse forests important?





So how does the forest effect snow-melt?

The spring snow cover reflects much of the incoming shortwave radiation.

The forest reduces the shortwave radiation to the snow surface.

The forest appears dark, and impenetrable at low solar angles. Long shadows are cast over the snow surface and the trees absorbs incoming shortwave radiation.

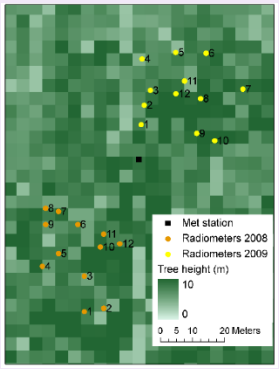
Observations

Meteorological data

Canopy

Hemispherical photos and tree temperatures

Below canopy radiation

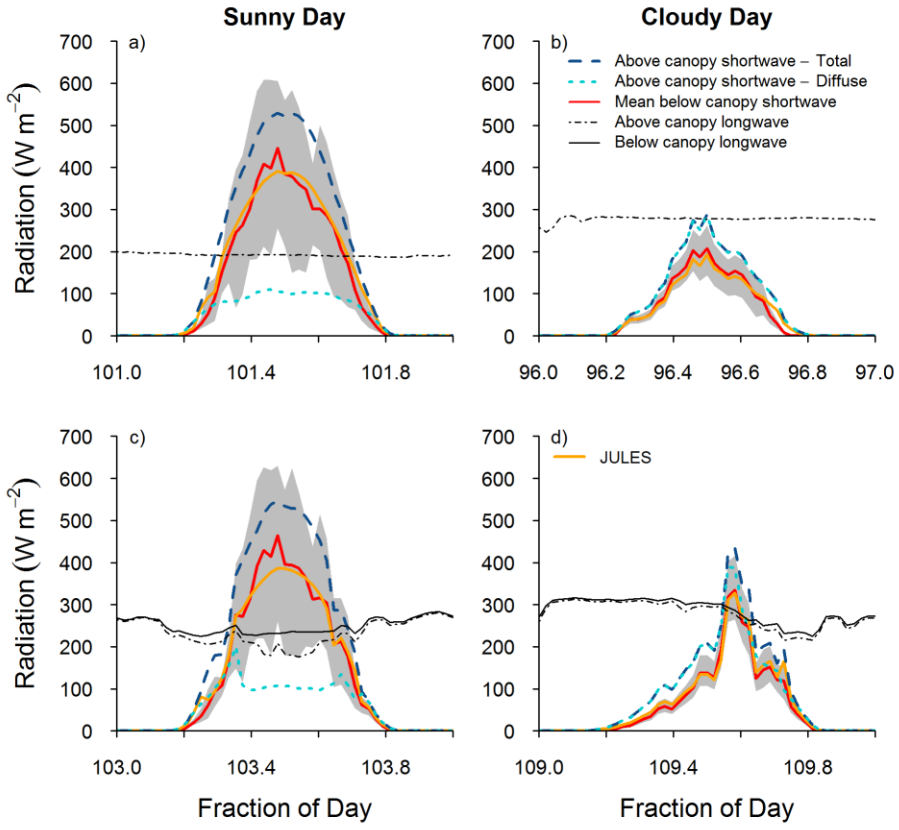


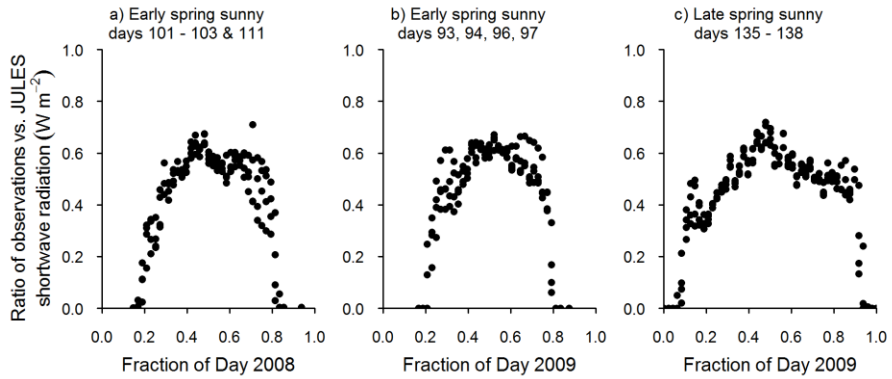
Pyranometers

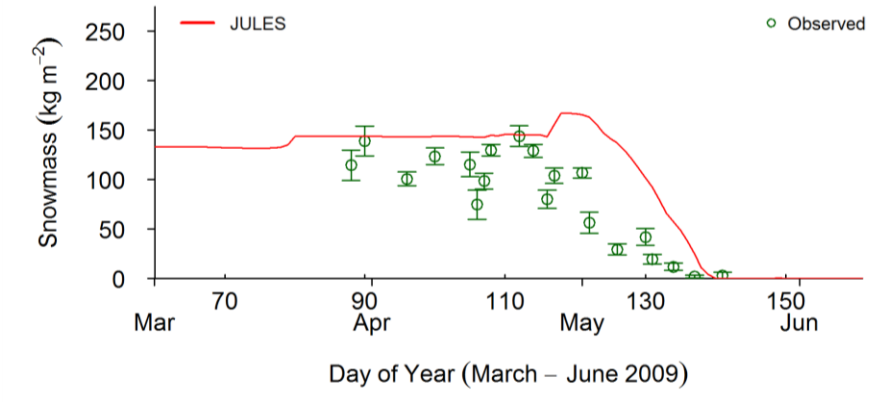
Snow

Snow surveys: Depth, density and temperature

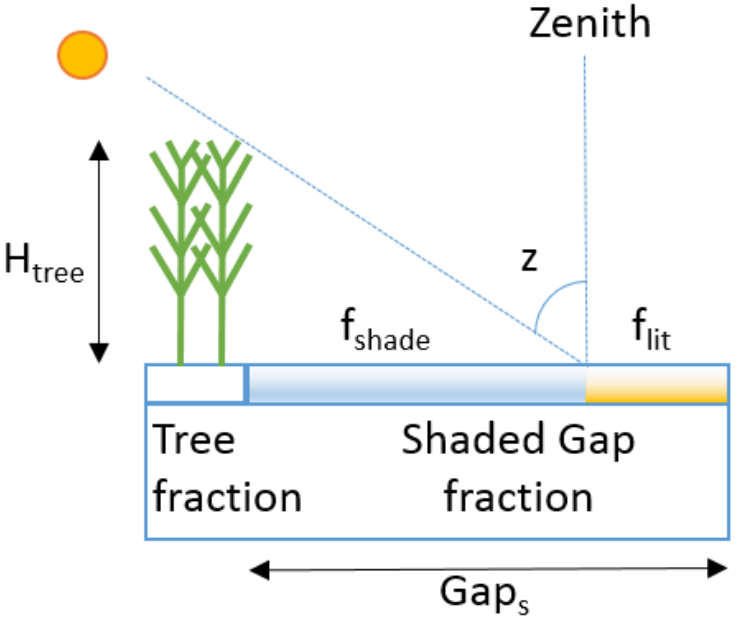
JULES – Is it getting it wrong?







Parameterising the Shaded gap shortwave radiation



Current SW

$$SW = (1-\alpha)SW_{\downarrow}$$

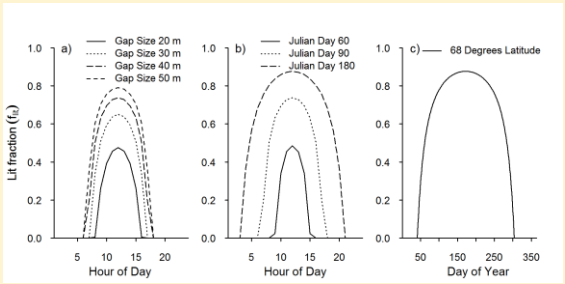
New SW below canopy

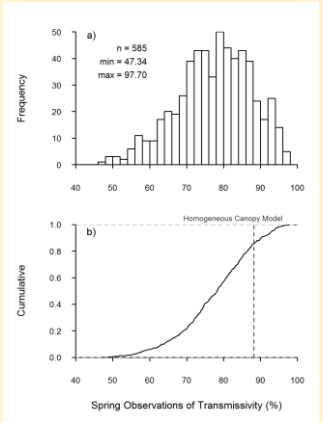
$$SW_{\downarrow} = f_{dif}\, f_v SW_{\downarrow} + (1 - f_{dif})\, f_{lit} SW_{\downarrow}$$

$$f_{lit} = 1 - \frac{ht_{tree} \tan Z}{Gaps}$$

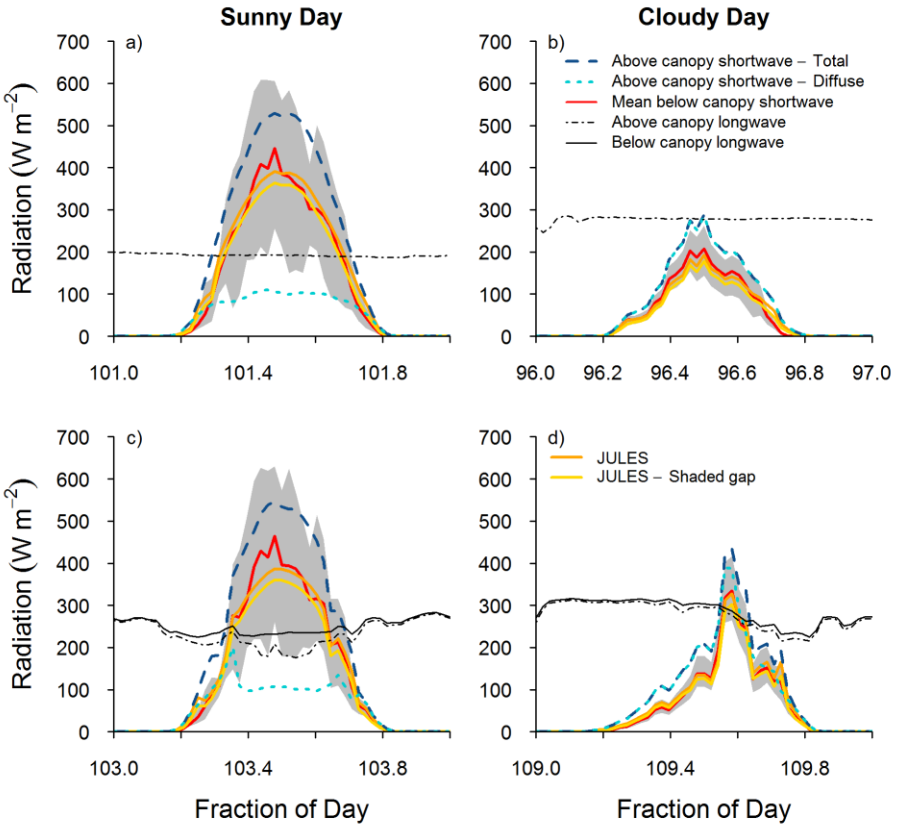
New parameters:

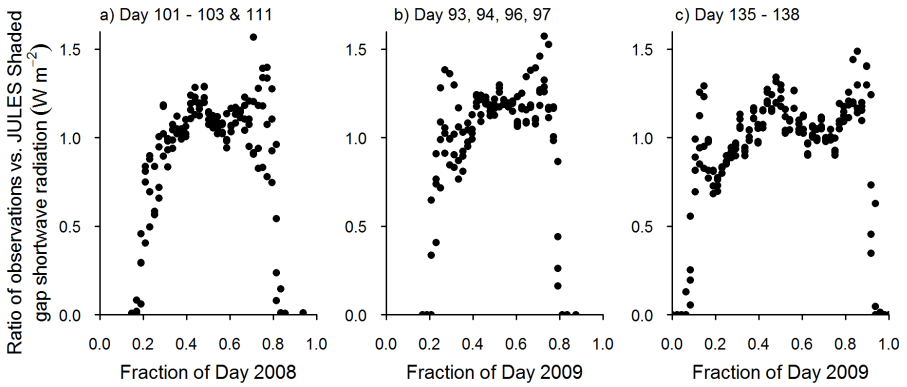
f_v, f_{lit} & Gap_s



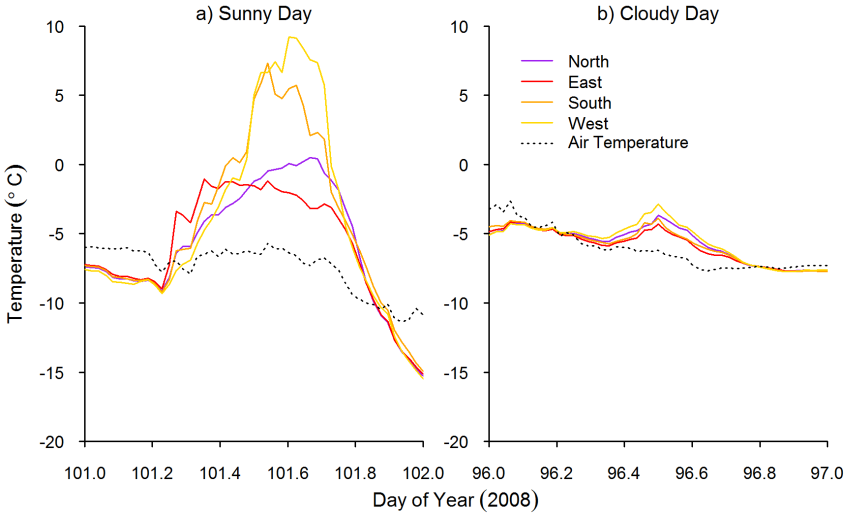


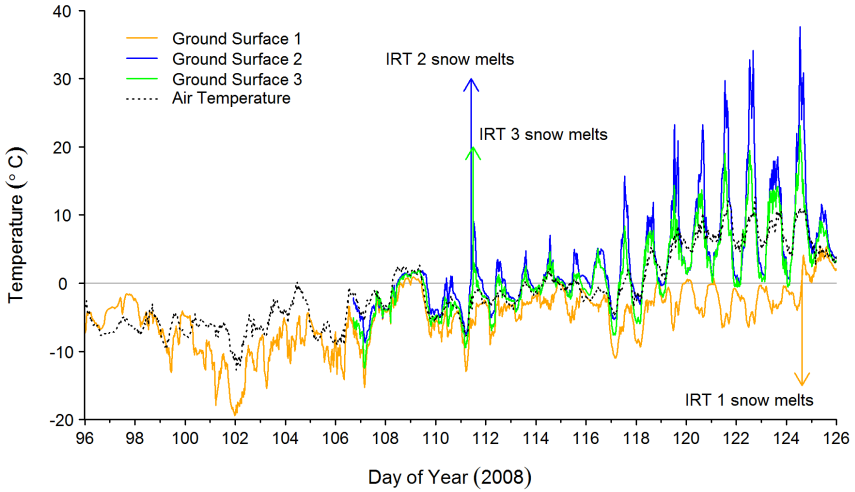
JULES Shaded gap SW – Results





Parameterising the Shaded gap longwave radiation





JULES Shaded gap LW_{T^*}

Current LW

$$LW_{net} = \varepsilon(LW_{\downarrow air} - \sigma T_{surf}^4)$$

New LW_{T^*}

below canopy

$$LW_{\downarrow bc} = f_v LW_{\downarrow air} + (1 - f_v)\varepsilon\sigma T_{surf}^4$$

JULES Shaded gap LW_{T^*} – Results

Current LW

$$LW_{net} = \varepsilon(LW_{\downarrow air} - \sigma T_{surf}^4)$$

New LW_{T^*} below canopy

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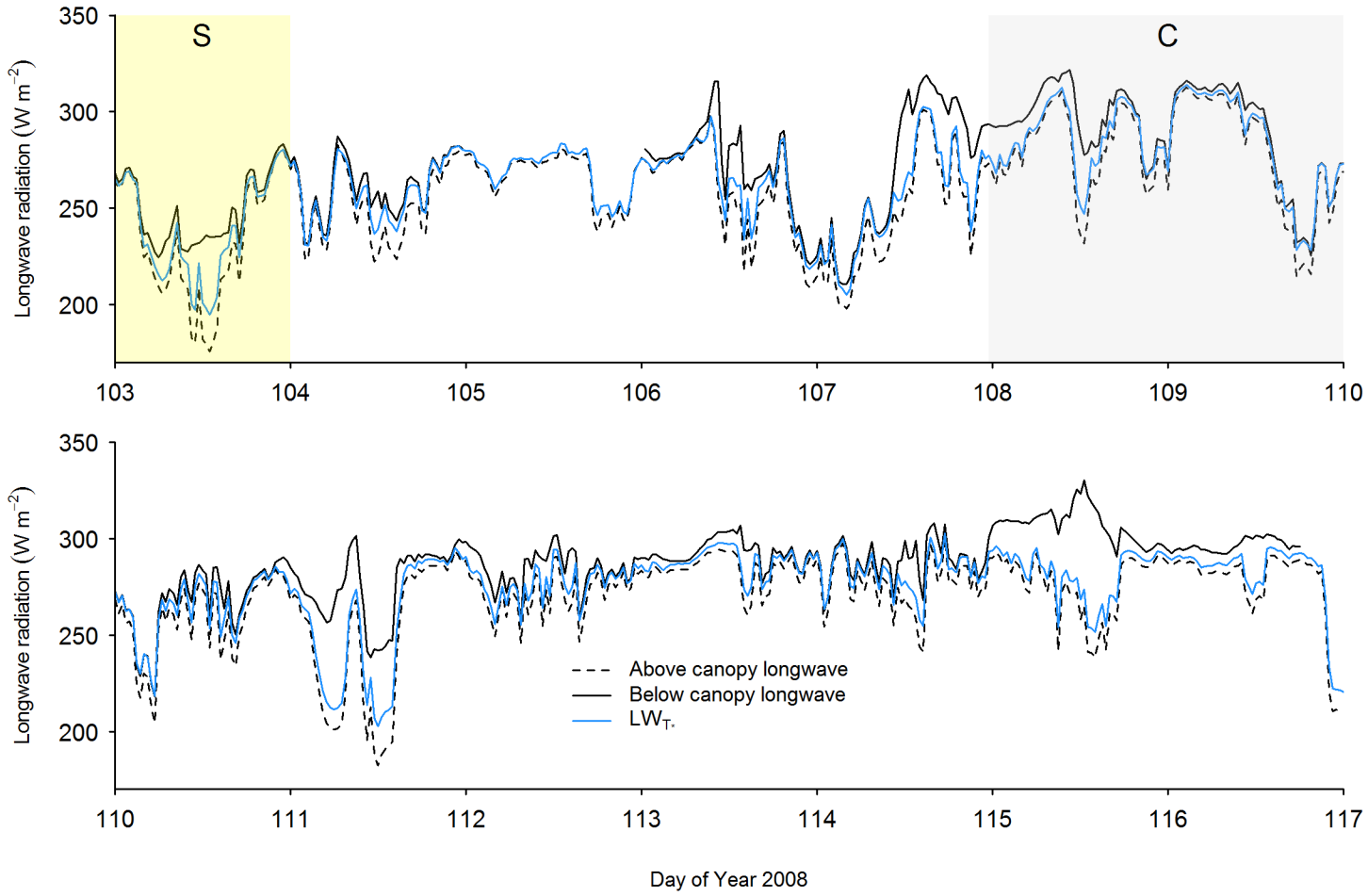
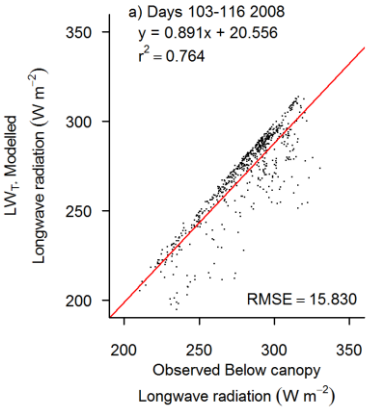
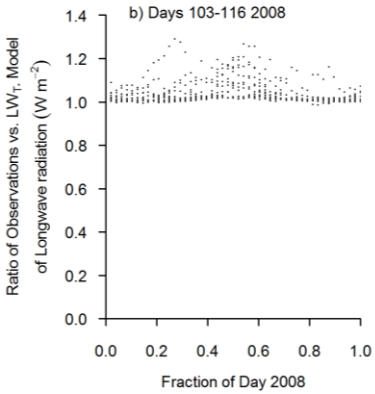






JULES Shaded gap LW_{tree}

Current LW

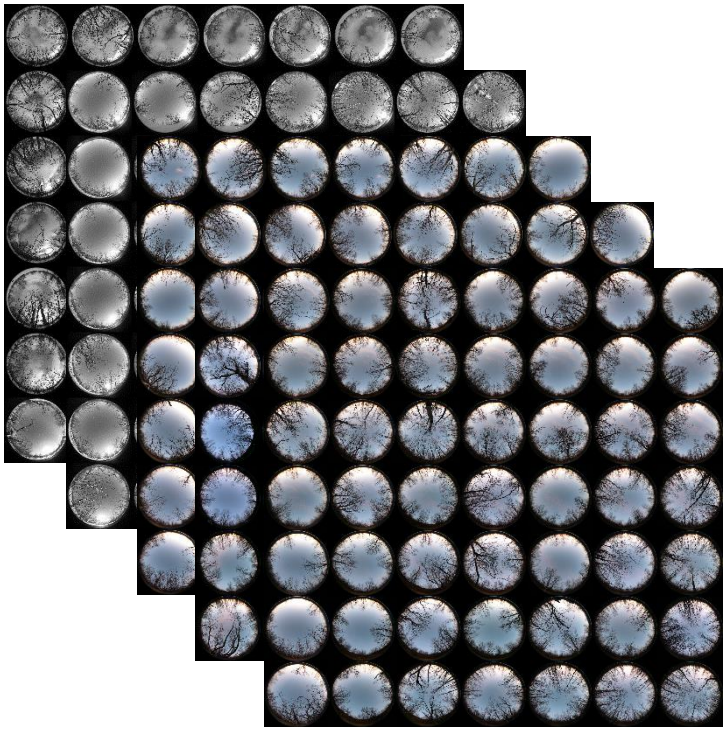
$$LW_{net} = \varepsilon(LW_{\downarrow air} - \sigma T_{surf}^4)$$

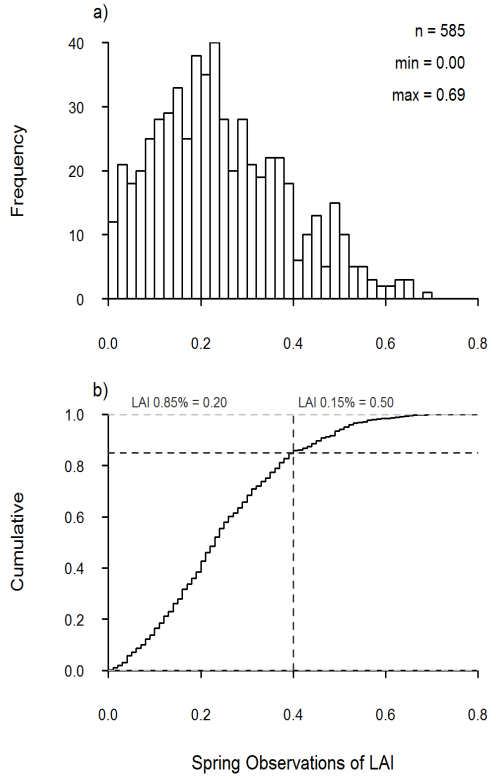
New LW_{tree} below canopy

$$LW_{\downarrow bc} = f_v LW_{\downarrow air} + (1 - f_v) LW_{\downarrow tree}$$

$$LW_{tree} = 0.5 LAI_{tree} f_v SW_{\downarrow} + LW_{\downarrow air}$$

Parameter: LAI_{tree}





JULES Shaded gap LW_{tree} – Results

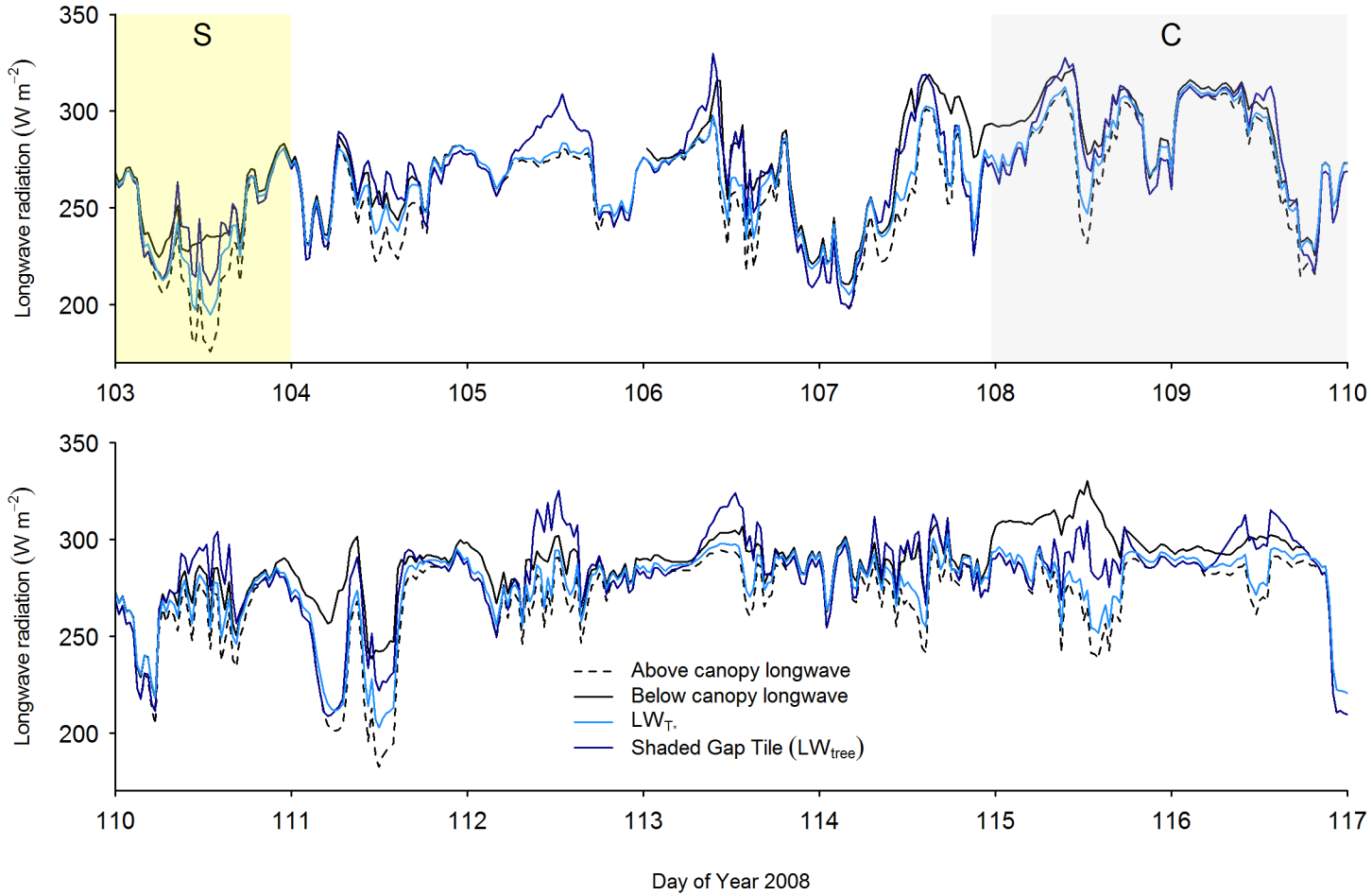
Current LW

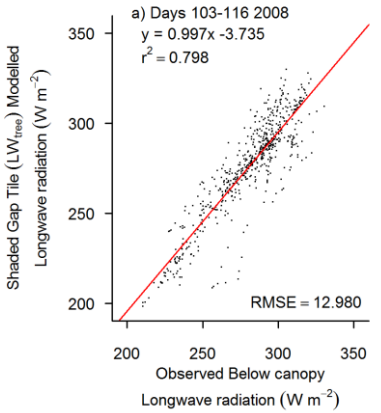
$$LW_{net} = \varepsilon(LW_{\downarrow air} - \sigma T_{surf}^4)$$

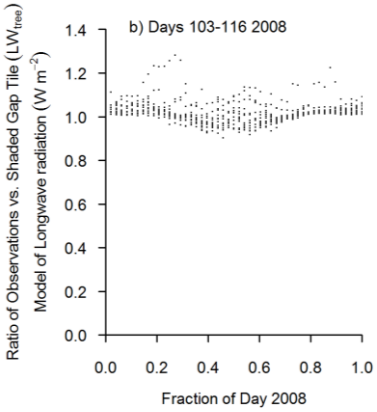
New LW_{tree} below canopy

$$LW_{\downarrow bc} = f_v LW_{\downarrow air} + (1 - f_v) LW_{\downarrow tree}$$

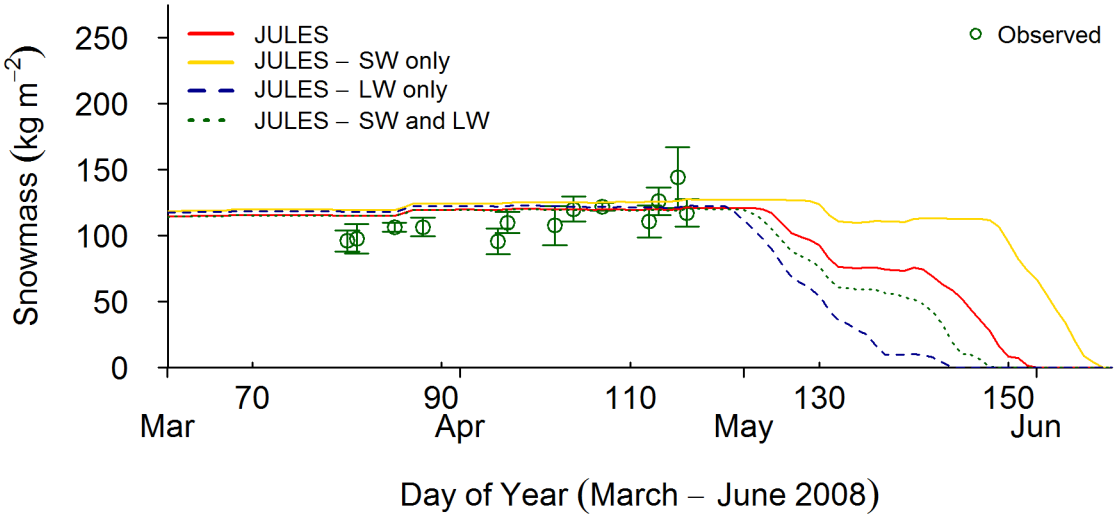
$$LW_{tree} = 0.5 LAI_{tree} f_v SW_{\downarrow} + LW_{\downarrow air}$$

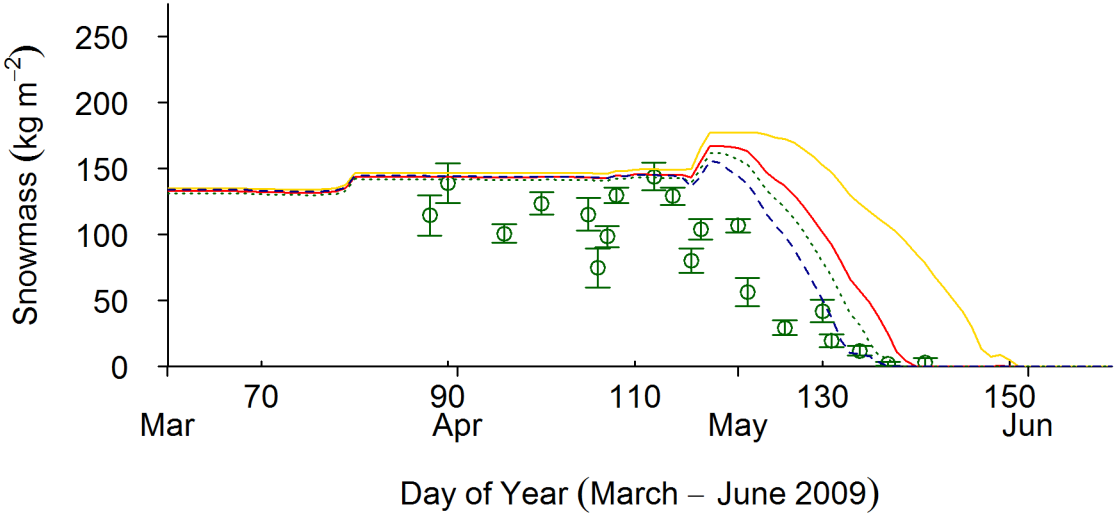




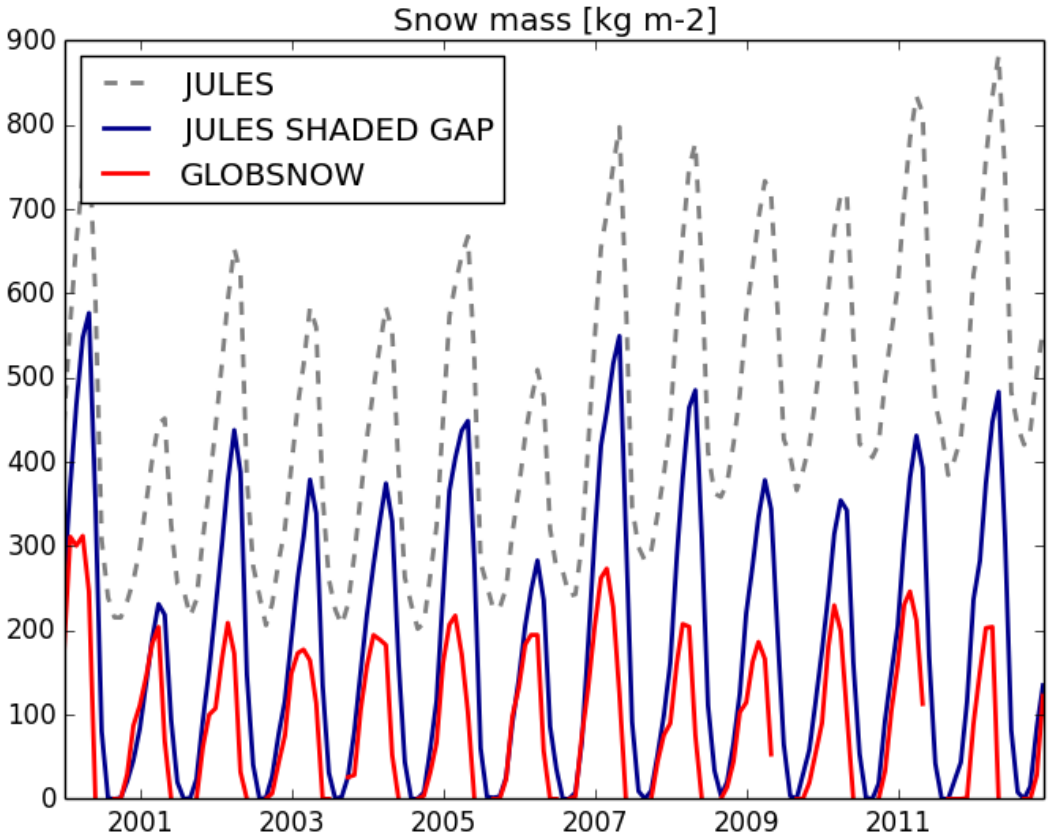


JULES Shaded gap snowmass – Results





JULES Shaded gap snowmass – Results



Observed and modelled snowmass (kg m^{-2}) for Abisko for 12 years.

Produced in collaboration with Alberto Martinez-de la Torre, CEH

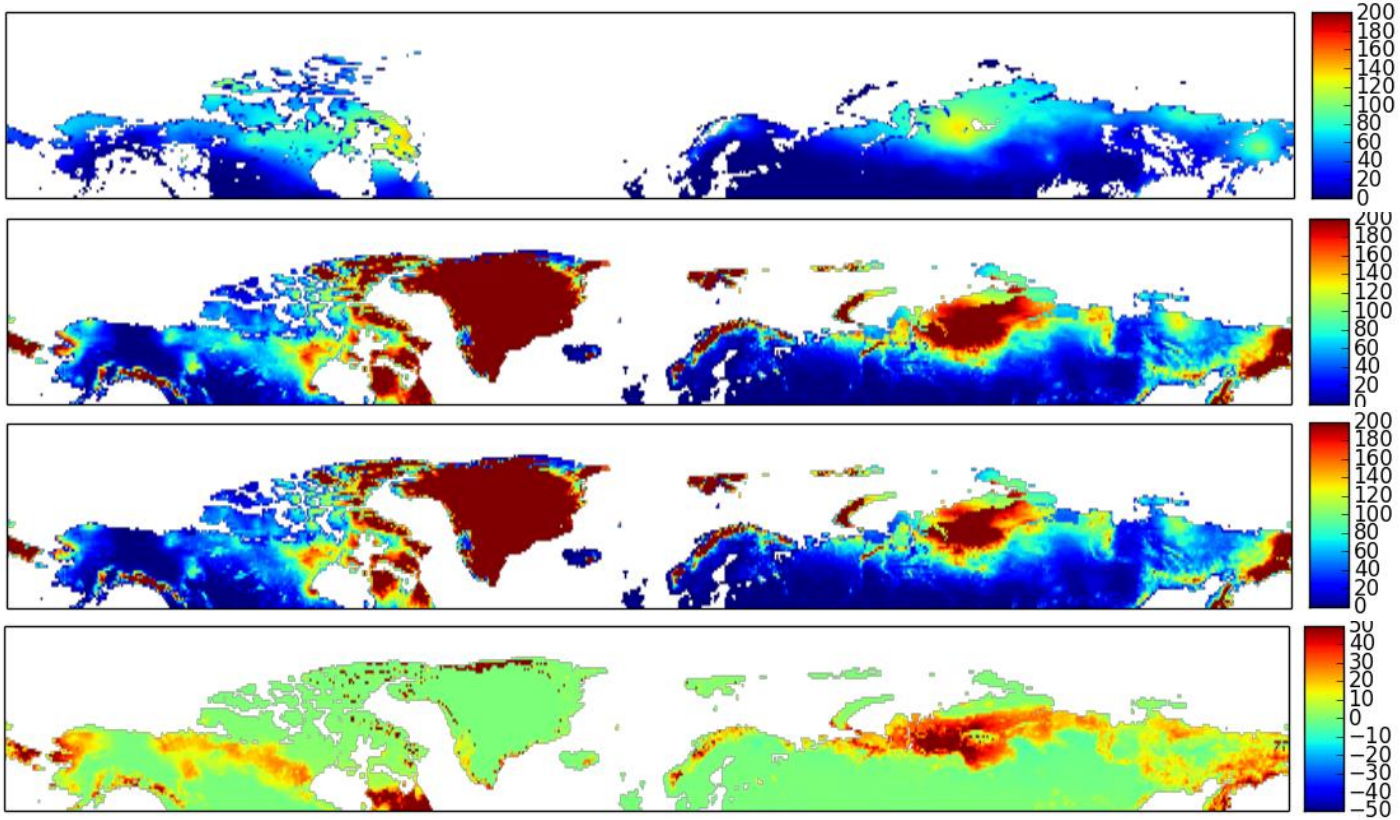
JULES Shaded gap snowmass – Results

Globsnow

JULES

JULES Shaded gap

Difference JULES – JULES Shaded gap



Twelve year (2000 – 2012) May mean observed and modelled global snowmass (kg m^{-2})

Produced in collaboration with Alberto Martinez-de la Torre, CEH

Conclusions: JULES Shaded gap

JULES Shaded gap reproduces the radiation balance of the highly heterogeneous sparse forests.

- New parameters: f_v, f_{lit} and Gap_{size}
- Includes time varying sunlit fraction
- Includes canopy longwave radiation from the incident shortwave radiation warming the trees
- Improves the modelled radiation balance (SW & LW)
- Improves the timing of the snowmelt with respect to observations both at the landscape and global scale