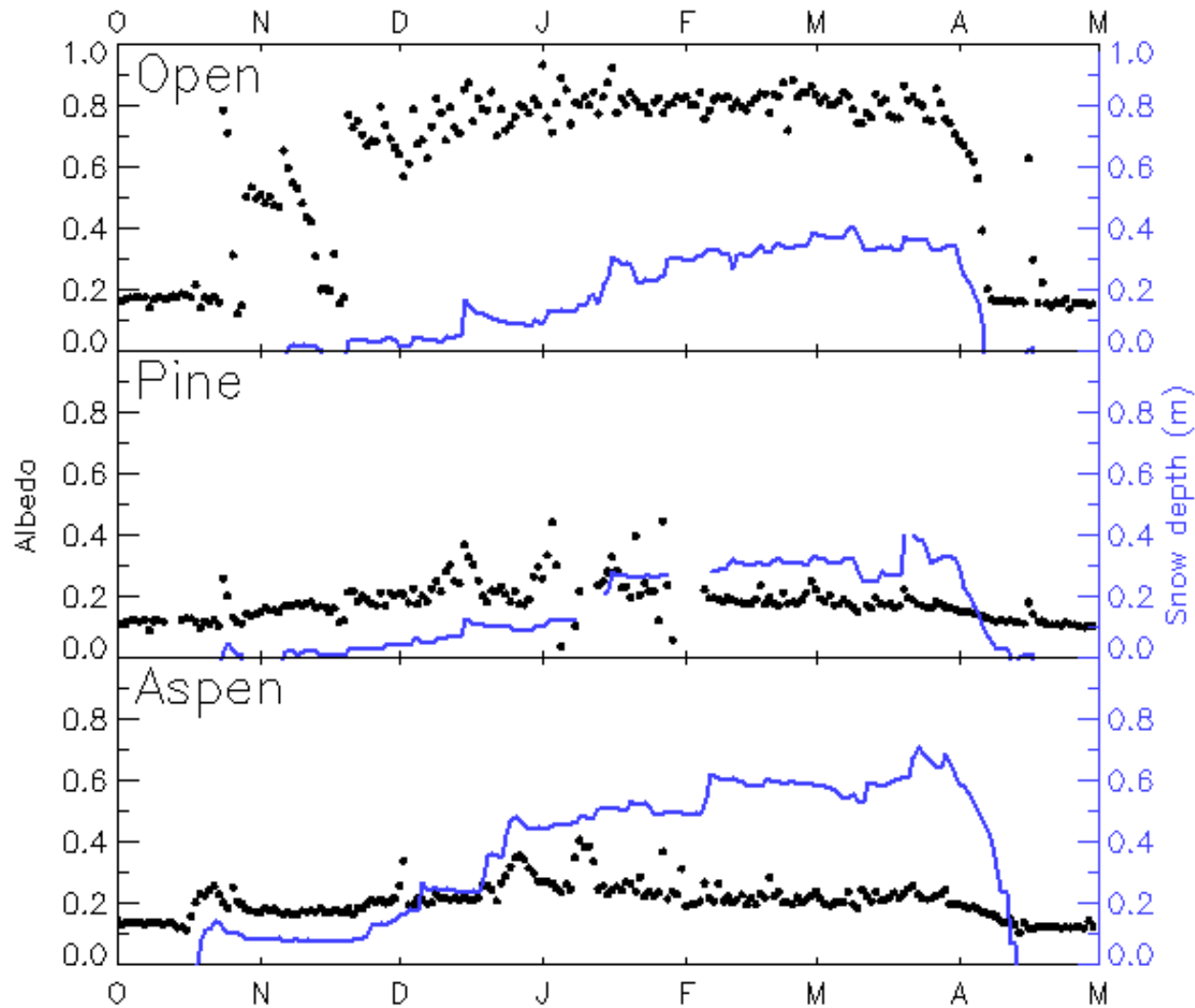


Masking of snow albedo by forests
in JULES and other models

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Snow albedo masking by forests



Data from Alan Barr and Paul Bartlett, Environment Canada

Snow albedo masking by forests

Maximum albedo



Barlage et al. 2005. *GRL*, **32**, doi:10.1029/2005GL022881

JULES nlt fraction

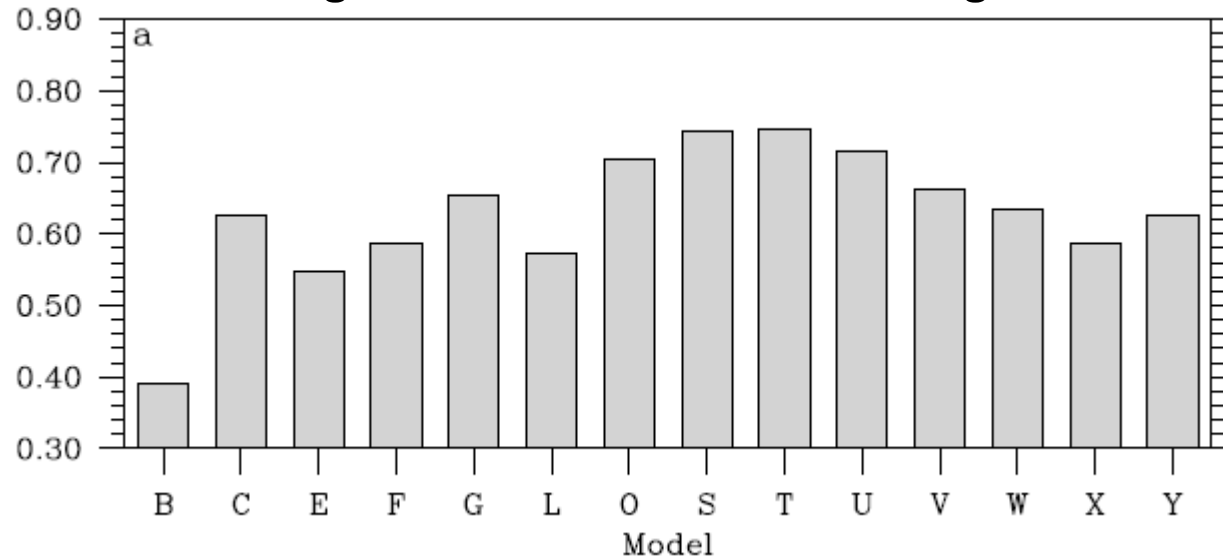


CLM nlt fraction

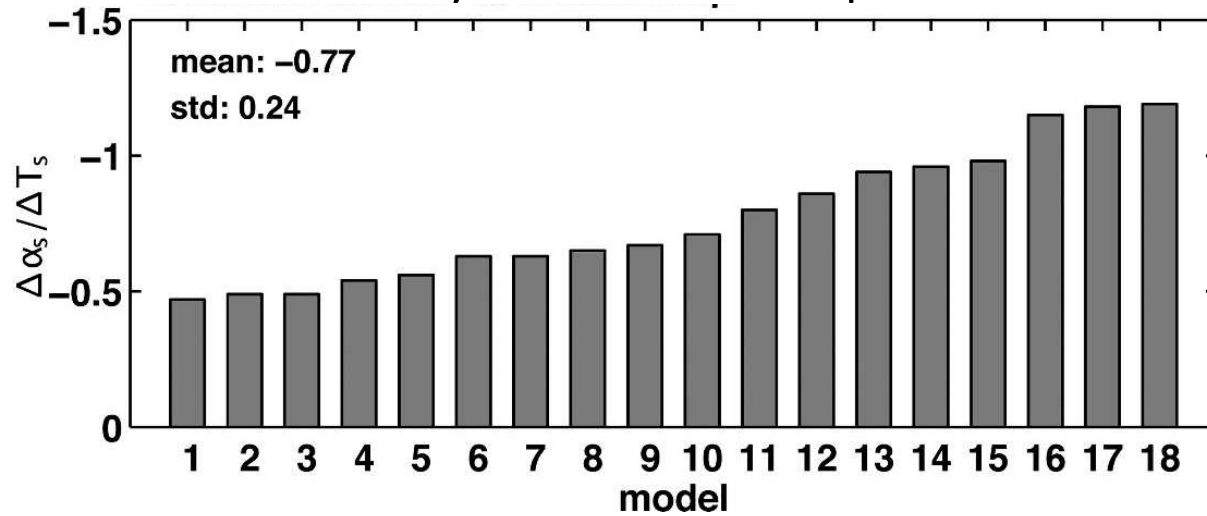


Snow albedo in CMIP models

Average albedo of snow covered regions



Sensitivity of albedo to temperature



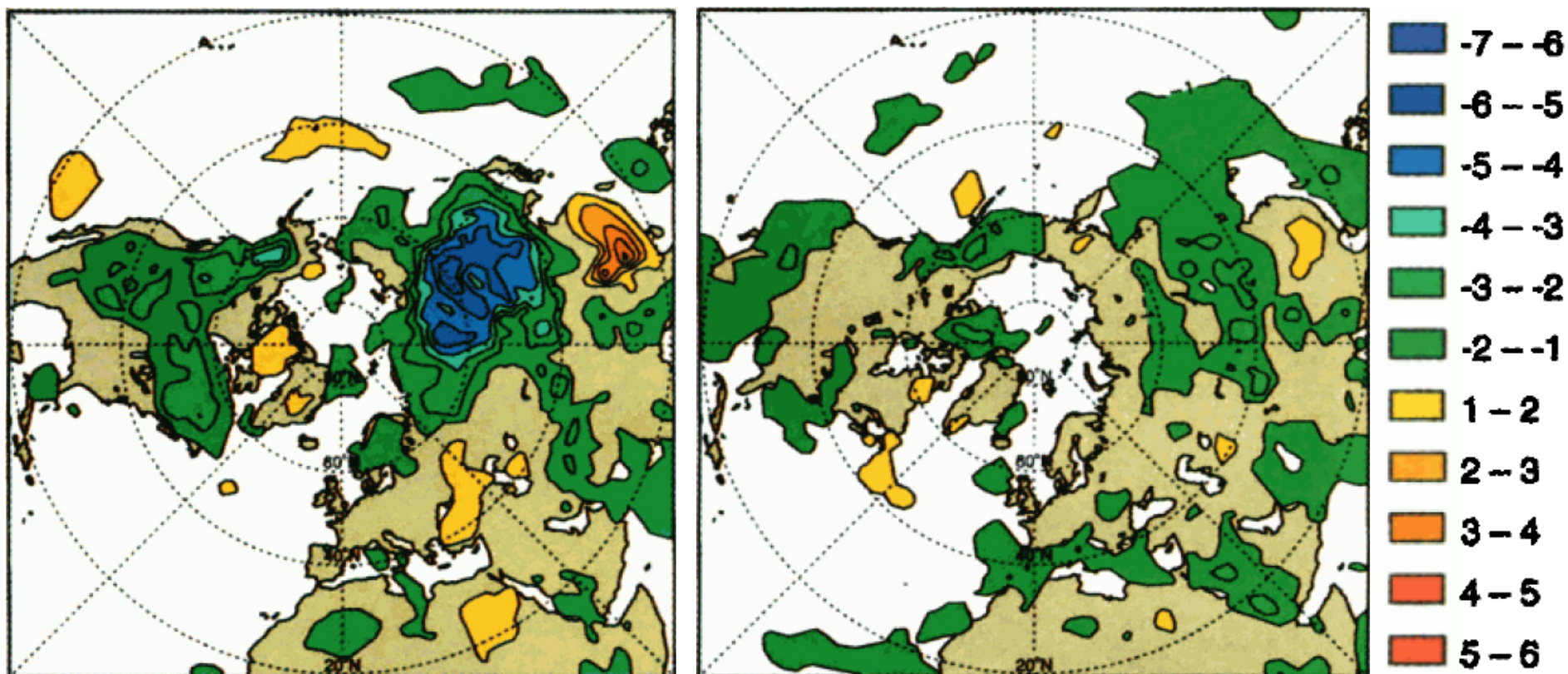
Hall and Qu, 2006. *GRL*, **33**, doi:10.1029/2005GL025127

Albedo masking model option 0: do nothing

– a really bad idea

March – April 1996

March – April 1997



ECMWF 850 hPa temperature day 5 error

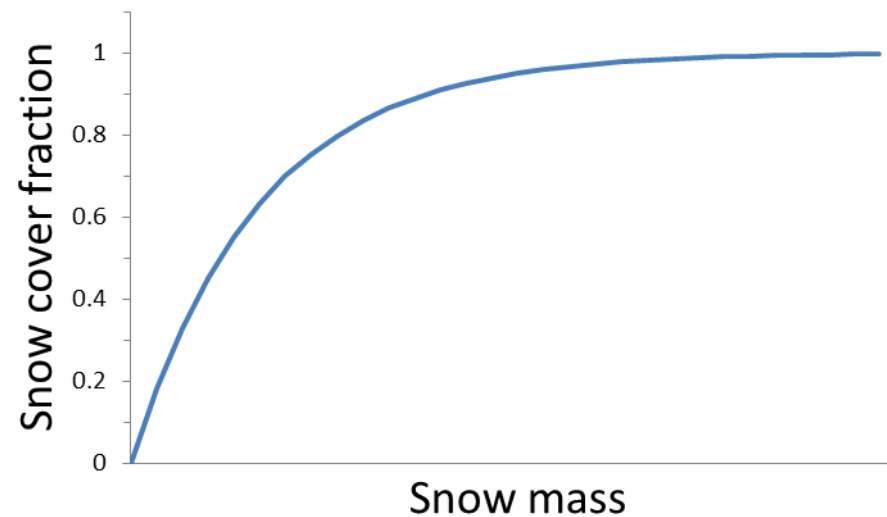
Viterbo and Betts, 1999. *Journal of Geophysical Research*, **104**, 27803 – 27810

Albedo masking model option 1: weighted average

– very, very simple

Snow-free albedo α_0 and deep-snow albedo α_s depend on vegetation type weighted by snow cover fraction

$$\alpha = (1 - f_s)\alpha_0 + f_s\alpha_s$$



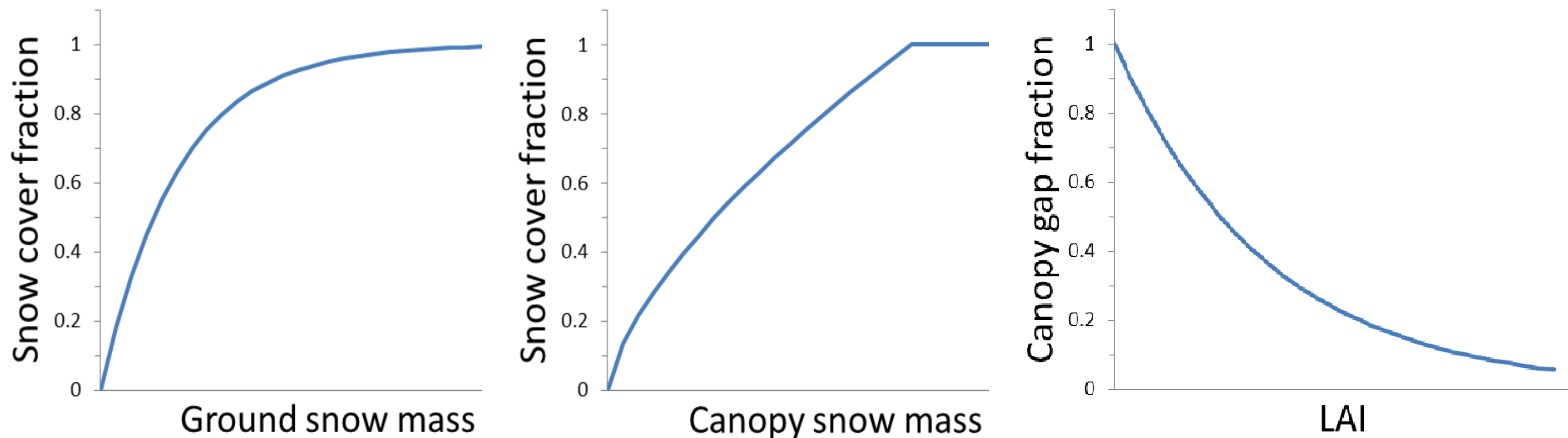
e.g. HadCM3, JULES `I_spec_albedo = F`

Albedo masking model option 2: gap fraction

– pretty simple, many variants

Albedos for snow-free and snow-covered ground and canopy weighted by ground snow cover fraction, canopy snow cover fraction, canopy gap fraction

$$\alpha = f_g[(1 - f_s)\alpha_{g0} + f_{sg}\alpha_{sg}] + (1 - f_g)[(1 - f_{sc})\alpha_{c0} + f_{sc}\alpha_{sc}]$$



e.g. CLASS, ECHam

Albedo masking model option 3: two-stream approximation

– quite complicated, quite a lot of parameters, quite common

Radiative transfer equations for scattering between downwards and upwards beams of diffuse radiation in an isotropic random medium

$$-\bar{\mu} \frac{dI^\uparrow}{d\Lambda} + [1 - (1 - \beta)\omega]I^\uparrow - \omega\beta I^\downarrow = \omega\bar{\mu}k\beta_0 \exp(-G\Lambda/\cos\theta)$$

$$\bar{\mu} \frac{dI^\downarrow}{d\Lambda} + [1 - (1 - \beta)\omega]I^\downarrow - \omega\beta I^\uparrow = \omega\bar{\mu}k(1 - \beta_0) \exp(-G\Lambda/\cos\theta)$$

e.g. CLM, JULES `I_spec_albedo = T`

Albedo masking model option 4: ray tracing

– way too complicated for large-scale modelling



Radiation transfer Model Intercomparison (RAMI)

<http://rami-benchmark.jrc.ec.europa.eu>

Snow cover and albedo simulation



jun

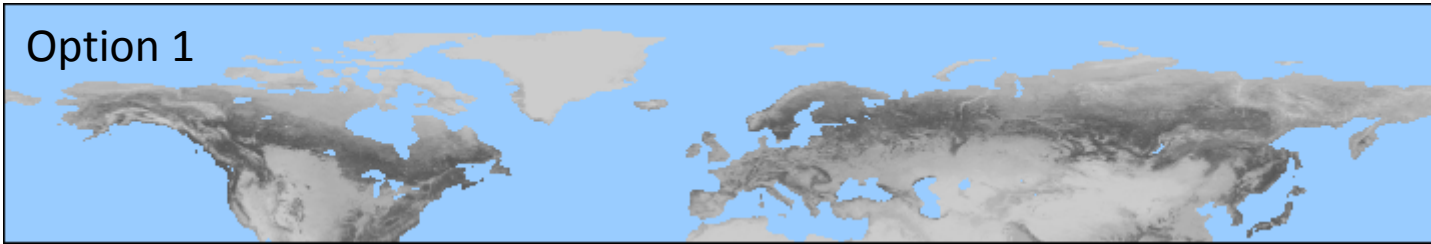


Maximum albedo

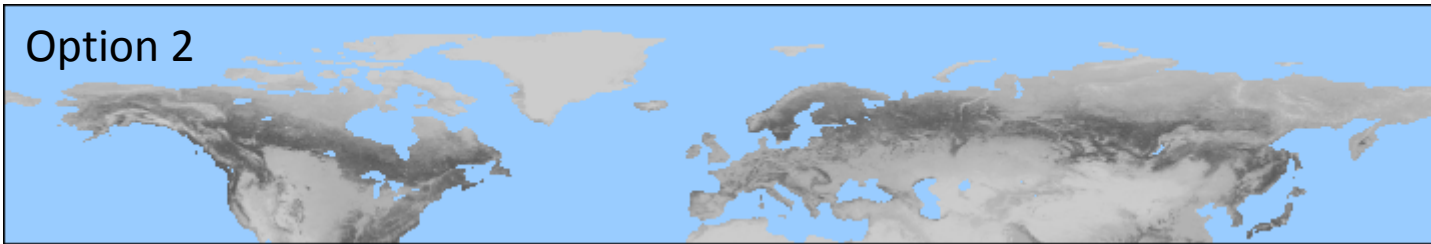
Observed



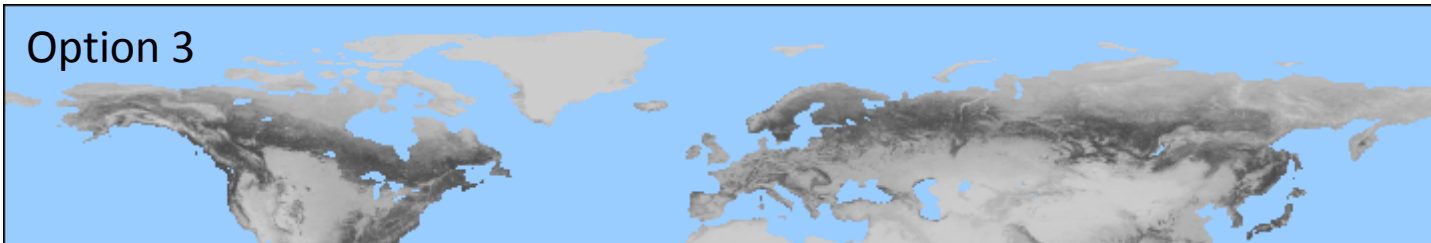
Option 1



Option 2

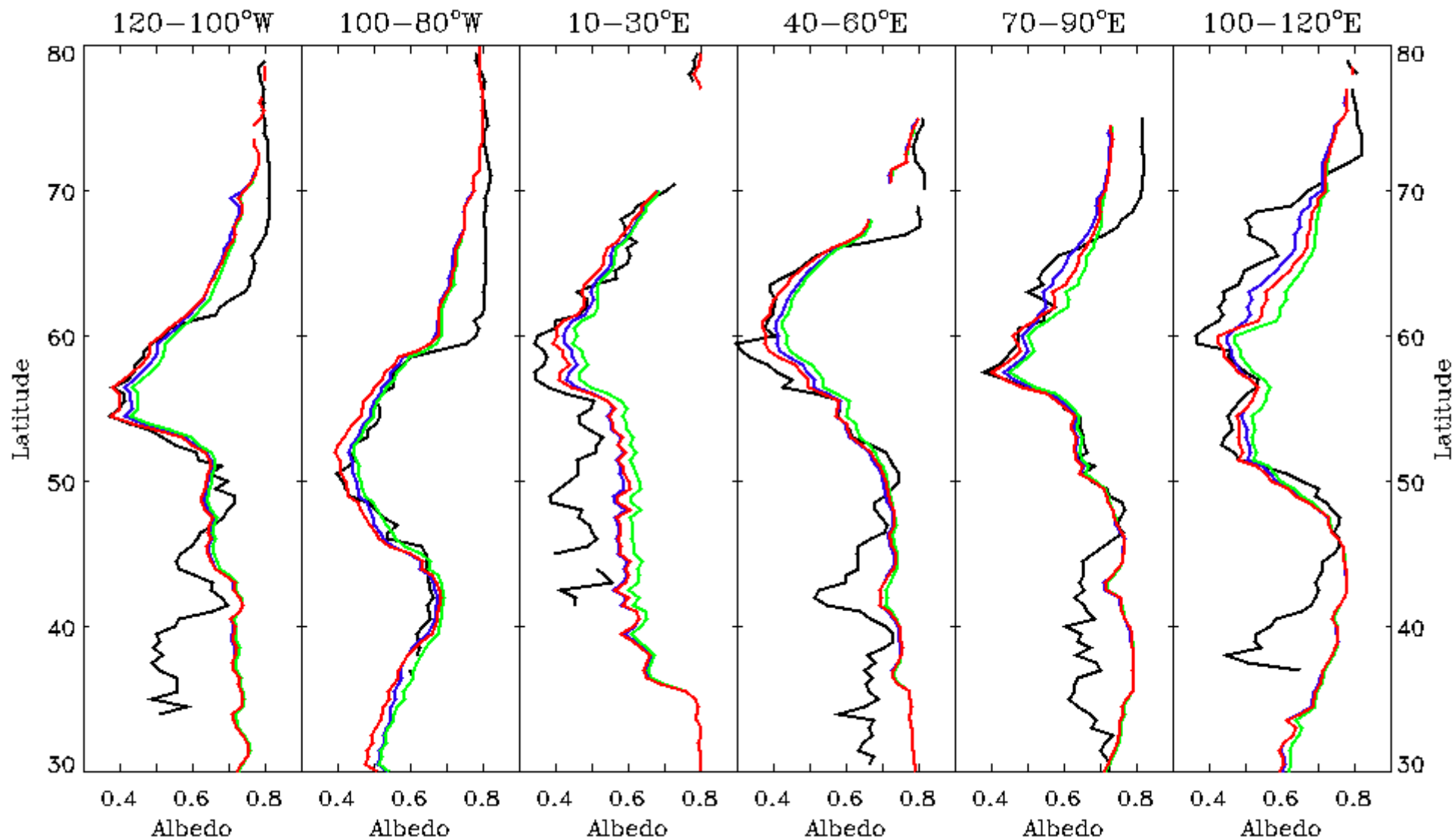


Option 3



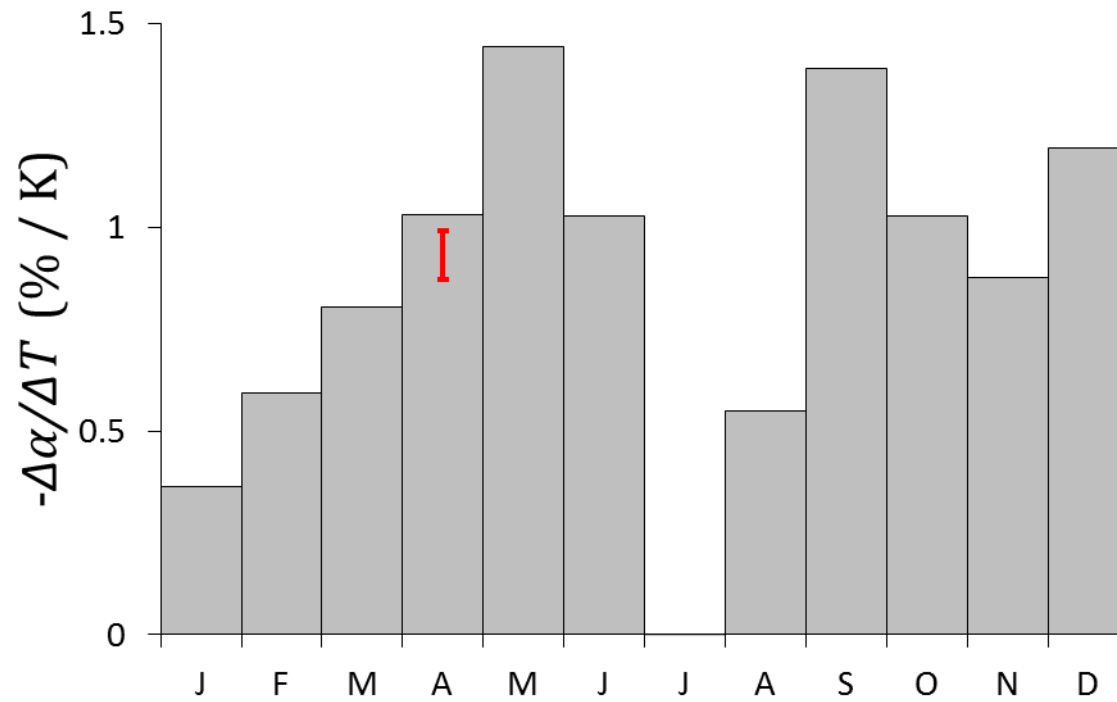
Maximum albedo

Observed Option 1 Option 2 Option 3



Sensitivity of albedo to seasonal temperature cycle

Option 1 simulation and **observed**



Conclusions

- surprisingly little difference between albedo models of differing complexity
- despite IPCC concerns, masking of snow albedo by forests can be simulated well by existing models
- good vegetation maps are required
- deep-snow albedo for shrub pft is probably too low (Cécile has a solution)
- deep-snow albedo for larch is probably too high
- JULES canopy albedo isn't too bad, but canopy transmission isn't consistent with it. We need `can_model = 5`