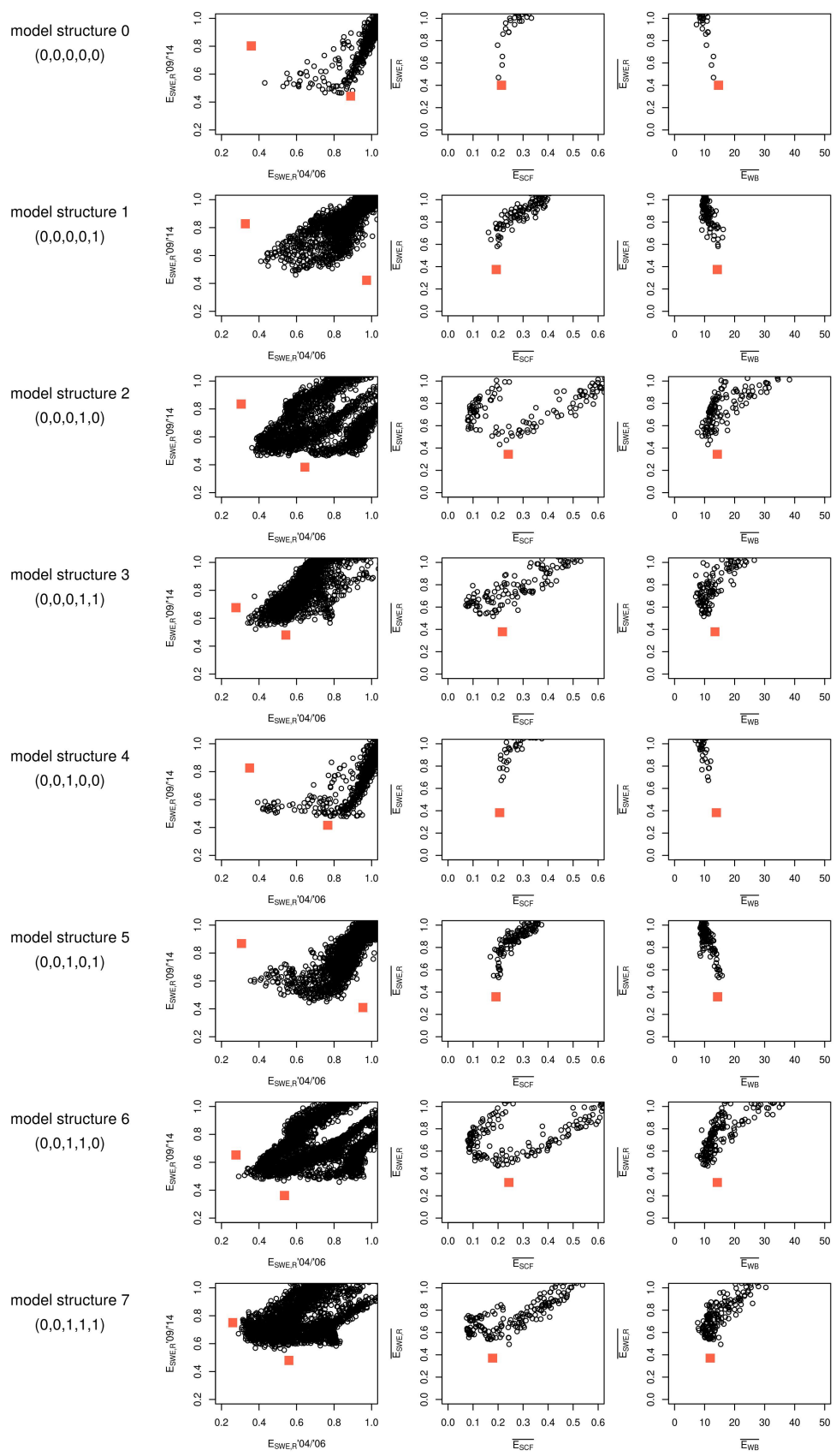
frontiers

Supplementary Material Including parameter uncertainty in an intercomparison of physically-based snow models

1 SUPPLEMENTARY TABLES AND FIGURES

Table S1: Perturbed model parameters and their ranges, adapted from (Günther et al., 2019). *Model configuration* indicates which parameter is used by which model options. Four parameters are used by all model configurations (*all*), all other parameters are either used by option 1 or 2 for the model switches for albedo evolution (*am*), thermal conductivity (*cm*), snow densification (*dm*), correction for atmospheric stability (*em*), and liquid water transport in the snowpack (*hm*)

source	unit	description	model configuration	range (min-max)	reference
z_{0s}	m	roughness length of snow-covered ground	all	0.001-0.0168	Helgason and Pomeroy (2011);Moore (1983)
α_{max}	-	maximum albedo for fresh snow	all	0.75 – 0.95	Singh and Singh (2001)
α_{min}	-	minimum albedo for aged snow	all	0.5 – 0.6	Pomeroy and Brun (2001)
h_f	m	snow cover fraction depth scale	all	0.05 – 0.2	no reference
T_α	°C	albedo decay temperature threshold	am=0	-4 – -0.1	no reference
S_α	kg m^{-2}	snowfall required to refresh albedo	am=1	1 – 10	Wang et al. (2013); Douville et al. (1995)
τ_{cold}	h	cold snow albedo decay timescale	am=1	750 – 1250	no reference
τ_{melt}	h	melting snow albedo decay timescale	am=1	50 – 150	no reference
λ_0	W m^{-1} K^{-1}	fixed thermal conductivity	cm=0	0.105 – 0.699	Sturm et al. (2002)
b_λ	-	thermal conductivity exponent	cm=1	1.9 – 2.1	no reference
ρ_0	kg m^{-3}	fixed snow density	dm=0	208 – 306	range of mean annual density recordings
ρ_f	kg m^{-3}	fresh snow density	dm=1	70 – 190	Pomeroy and Gray (1995)
ρ_{cold}	kg m^{-3}	maximum density for cold snow	dm=1	200 – 400	Singh and Singh (2001)
ρ_{melt}	kg m^{-3}	maximum density for melting snow	dm=1	400 – 650	Singh and Singh (2001)
τ_ρ	h	compaction timescale	dm=1	100 – 300	no reference
b_h	-	atmospheric stability adjustment parameter	em=1	4 – 6	Louis et al. (1982) b=5
W_{irr}	%	irreducible liquid water content	hm=1	3 – 8	Singh and Singh (2001)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model structure 1
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model structure 2
(0,0,0,1,0)
model structure 3
(0,0,0,1,1)
model structure 4
(0,0,1,0,0)
model structure 5
(0,0,1,0,1)
model structure 6
(0,0,1,1,0)
model structure 7
(0,0,1,1,1)
E_SWE,R '09/'14
E_SWE,R '04/'06
E_SCF
E_SWE,R
E_WB

model structure 8
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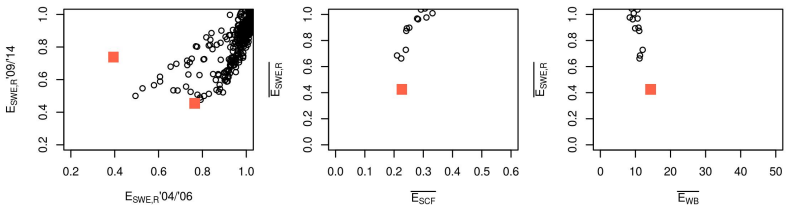

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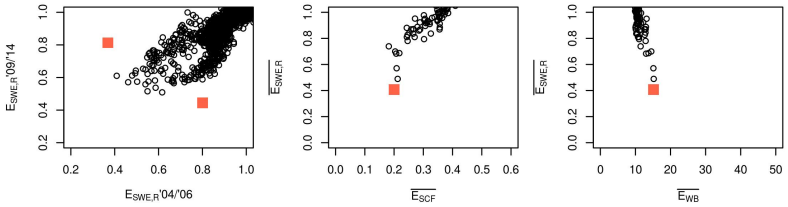

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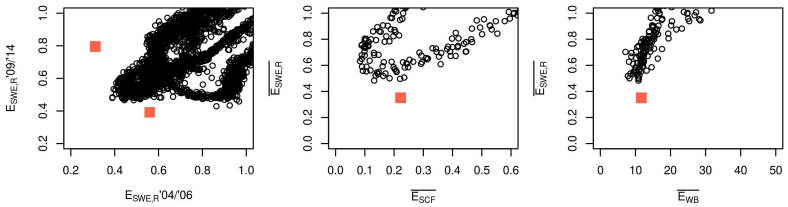

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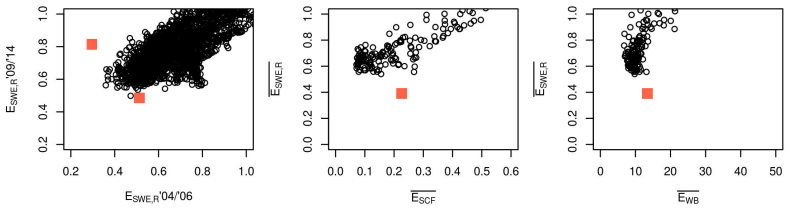

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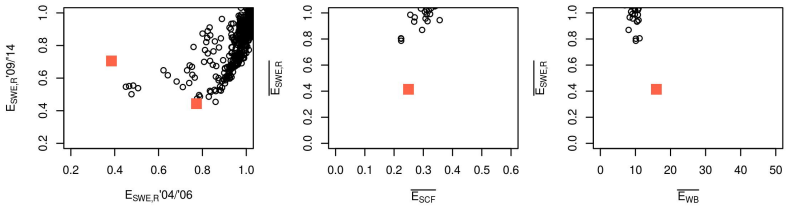

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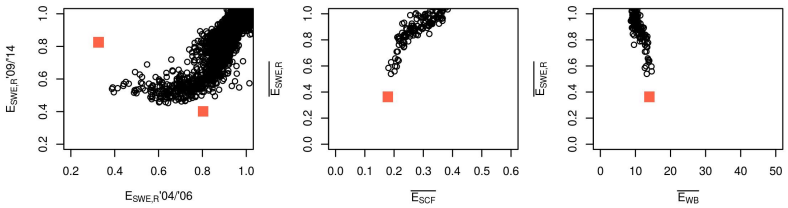

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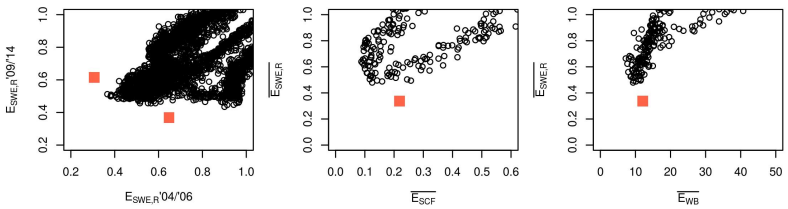

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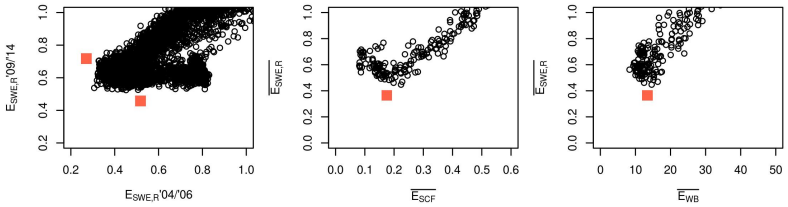

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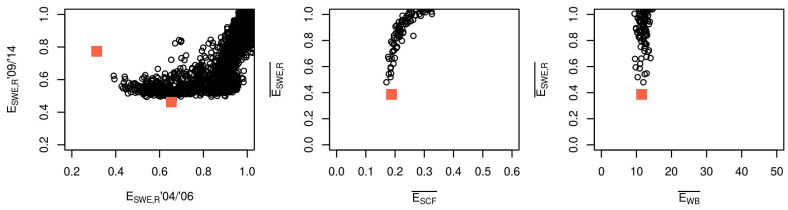

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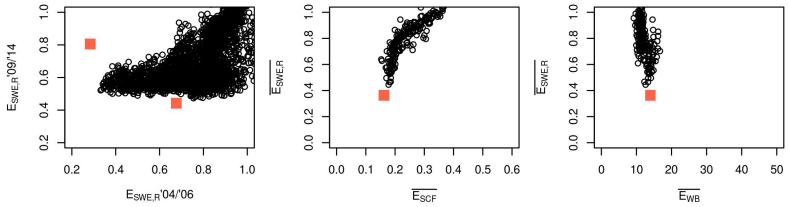

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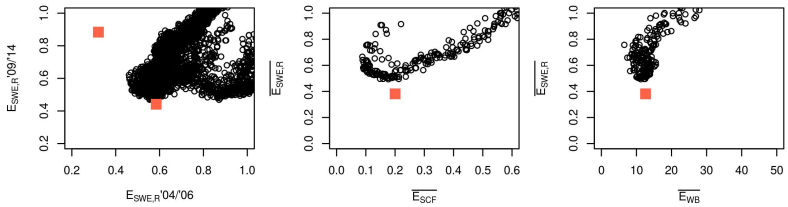

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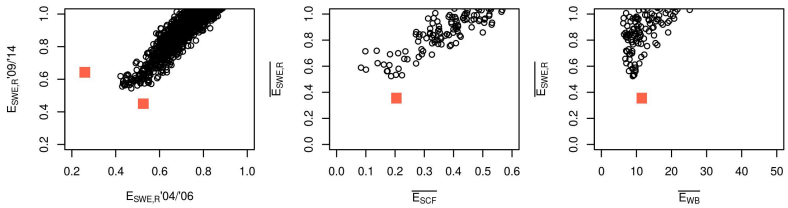

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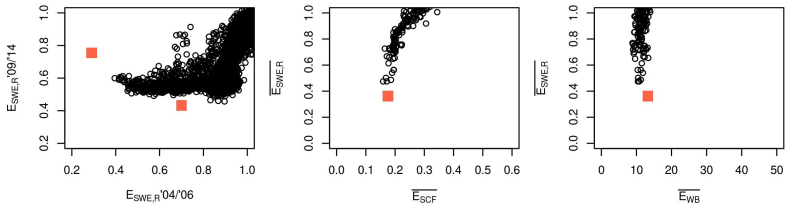

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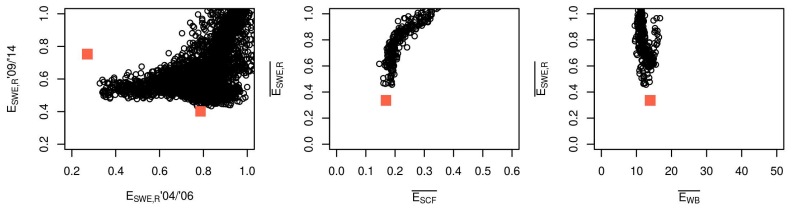

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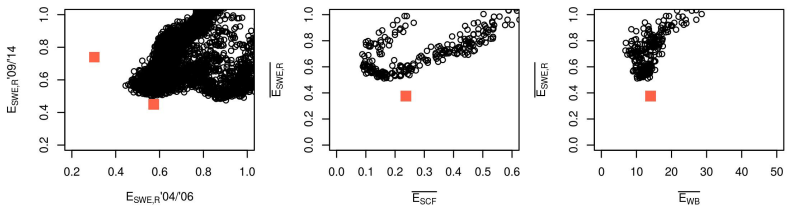

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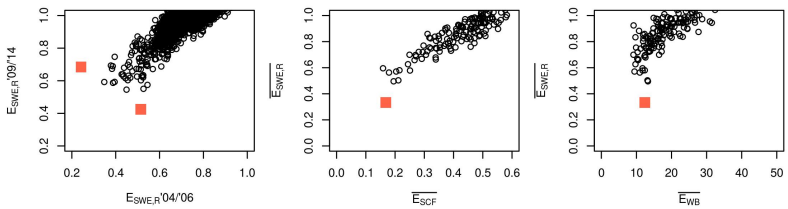

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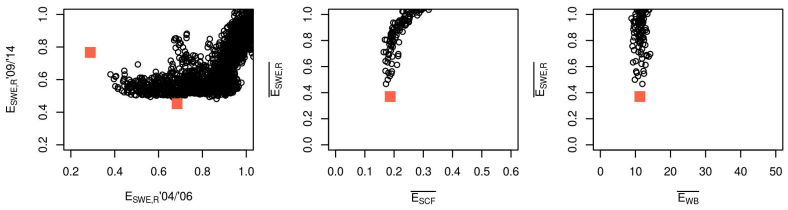

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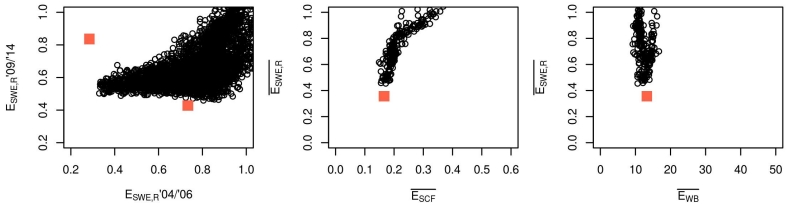

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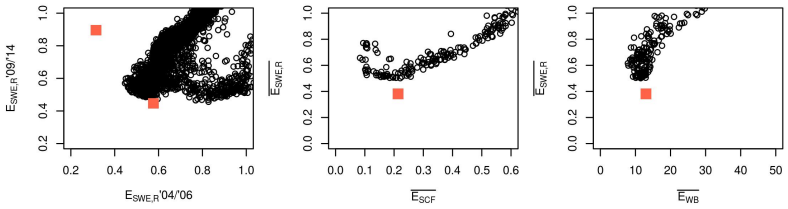

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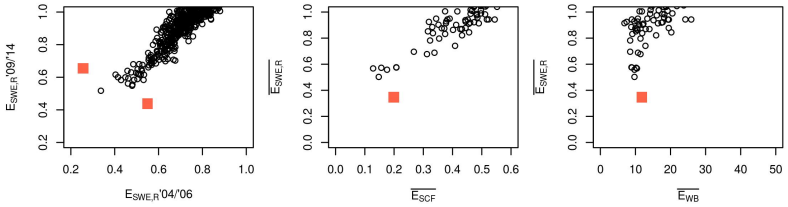

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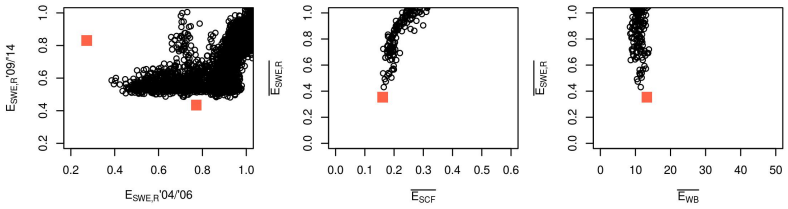

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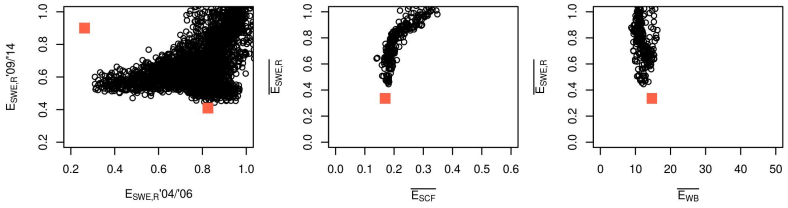

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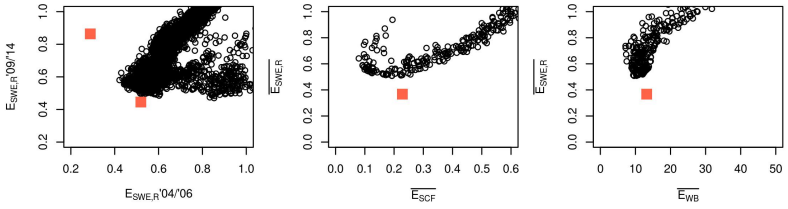

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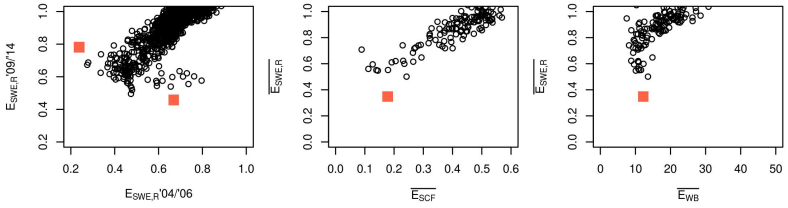

Figure S1: Model errors for point-scale snow water equivalent and snowpack runoff predictions in period 1 (2004/2006) against model skill in period 2 (2009/2014) (left column). Mean point-scale model errors (average errors from period 1 and period 2) against mean errors for catchment snow cover fraction (center column). Mean point scale model errors against mean errors for catchment spring water balance (right column). Black circles encompass model responses for a part of the parameter space as sampled from a latin hypercube. Red squares indicate evaluation errors when parameters have been calibrated at the point-scale. Each row represents one model structure with the corresponding model options indicated to the left of each row. The binary vector shows the option choice (0 or 1) for the five model switches for the albedo evolution, thermal conductivity, snow densification, correction for atmospheric stability and the liquid water transport in the snowpack.

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