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Title: The Arctic Terrestrial Simulator: Developing a Flexible Multiphysics Simulator based on Amanzi

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The Arctic Terrestrial Simulator

Predicting Climate Impacts and Feedbacks in the terrestrial Arctic

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Los Alamos National Laboratory

November 15-16, 2012

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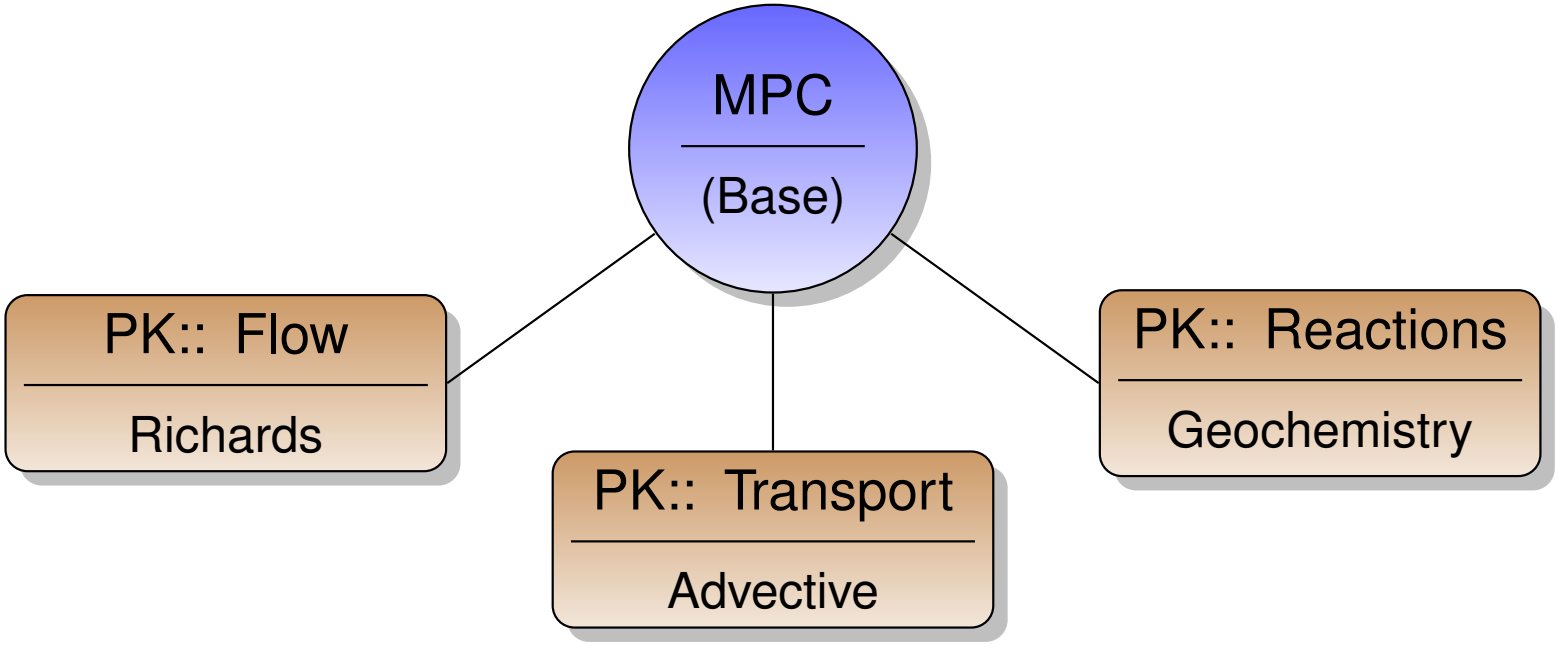
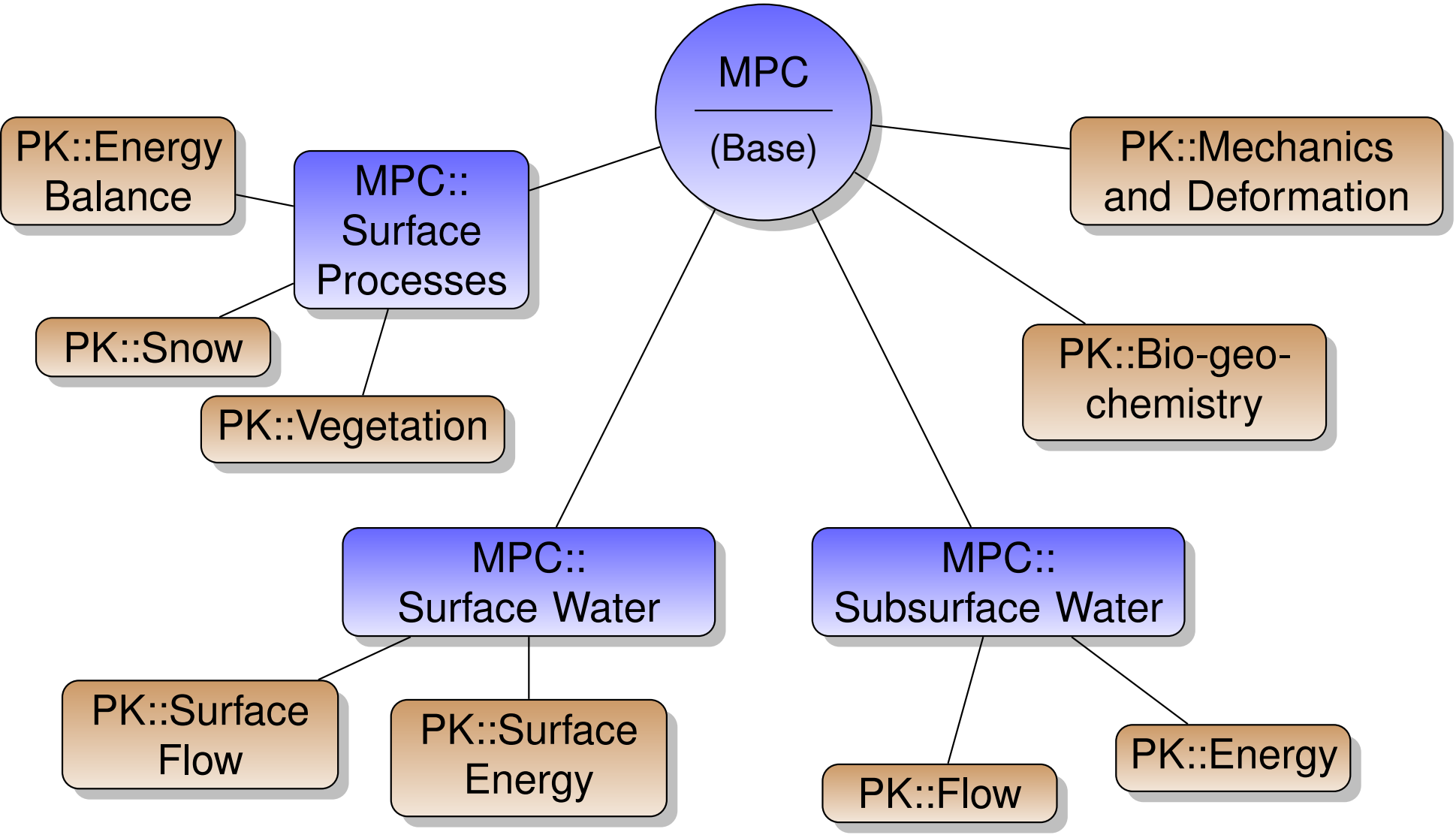
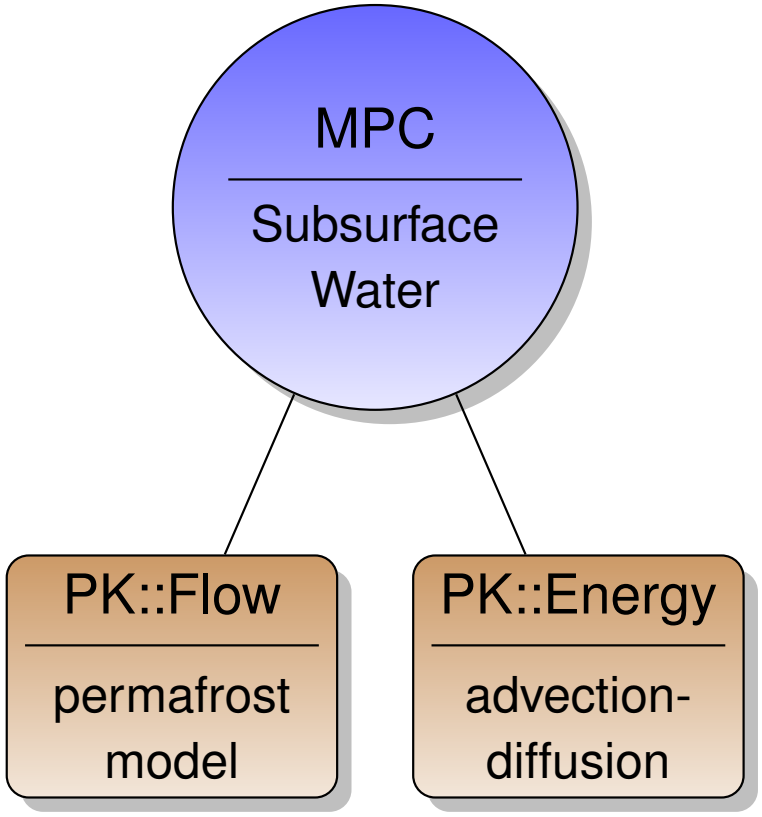
Amanzi Design



ATS Process Kernels





Flow:

$$\frac{\partial}{\partial t}\left[\phi(\rho_l s + \rho_g(1-s)\right] = -\nabla\cdot(\rho\mathbf{V})$$

$$\mathbf{V} = -k(s)\frac{\mathcal{K}(\mathbf{x})}{\mu}\nabla p$$

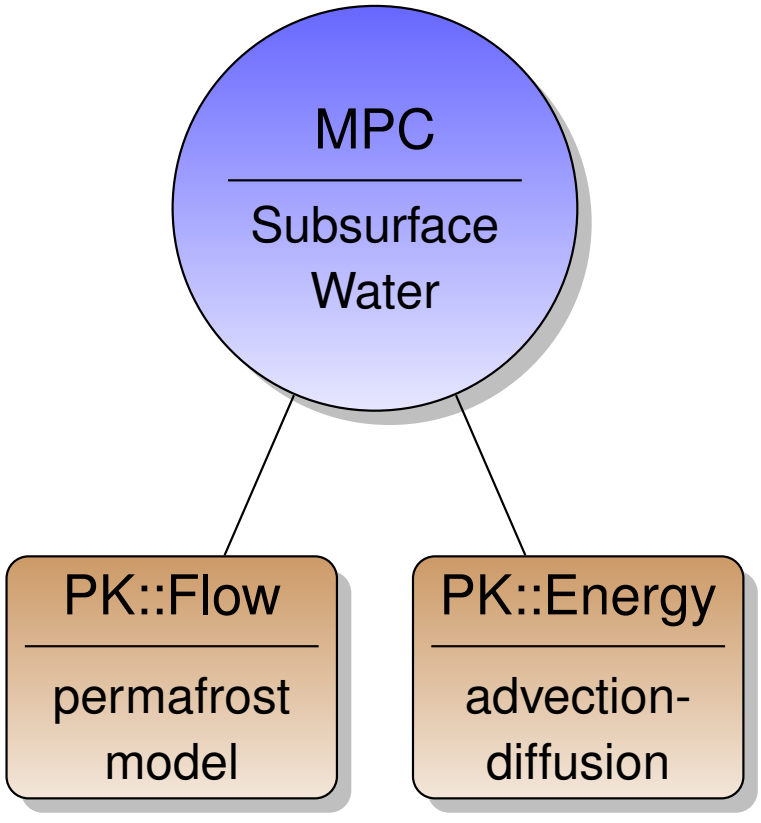
Energy:

$$\frac{\partial}{\partial t}[\phi(\rho_l\, s\, u_l + \rho_g(1-s)u_g) + (1-\phi)\rho_{rock}u_{rock}] = -\nabla\cdot(\rho_l\, h_l\, \mathbf{V}) + \nabla\cdot\mathcal{K}_E\nabla T$$

Constitutive Relations:

$$s = s(p) \qquad \rho = \rho(T,p)$$

$$u = u(T,p) \qquad h = h(T,p)$$



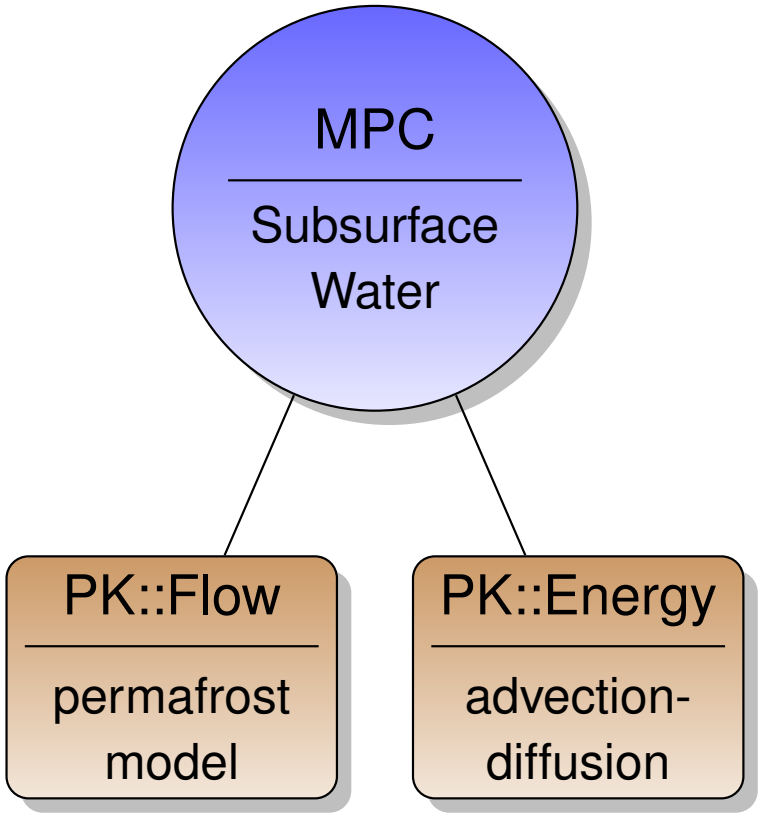
res_{flow} res_{energy}

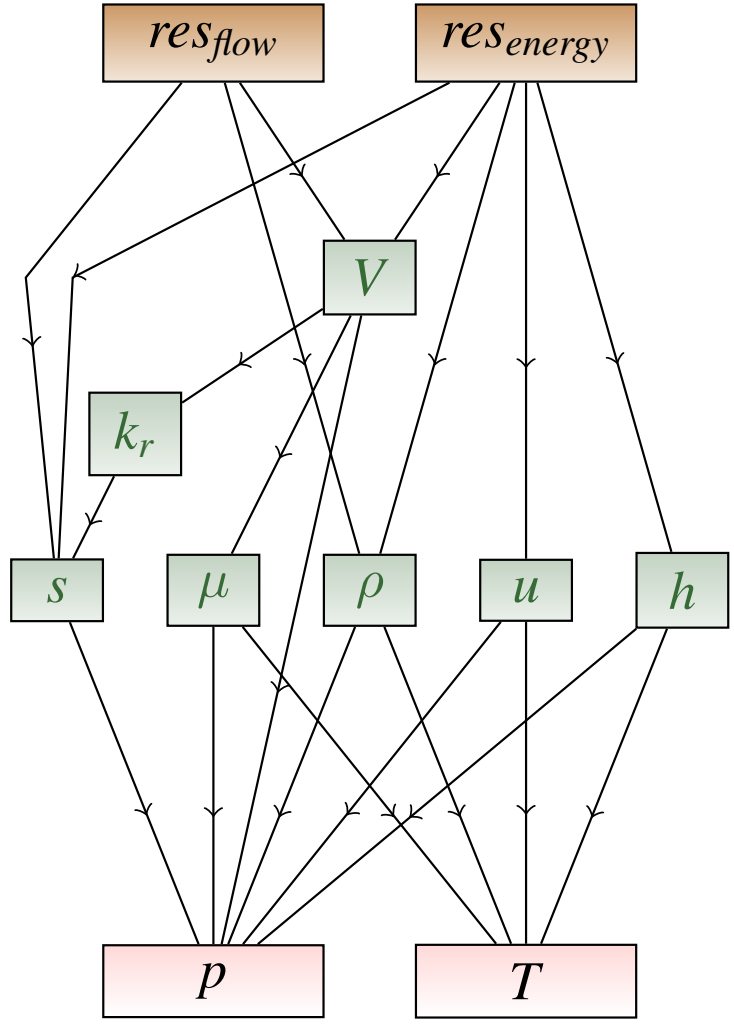
V

k_r

s μ ρ u h

p T


MPC
Subsurface
Water
PK::Flow
permafrost
model
PK::Energy
advection-
diffusion


res_{flow}
res_{energy}
V
k_r
s
μ
ρ
u
h
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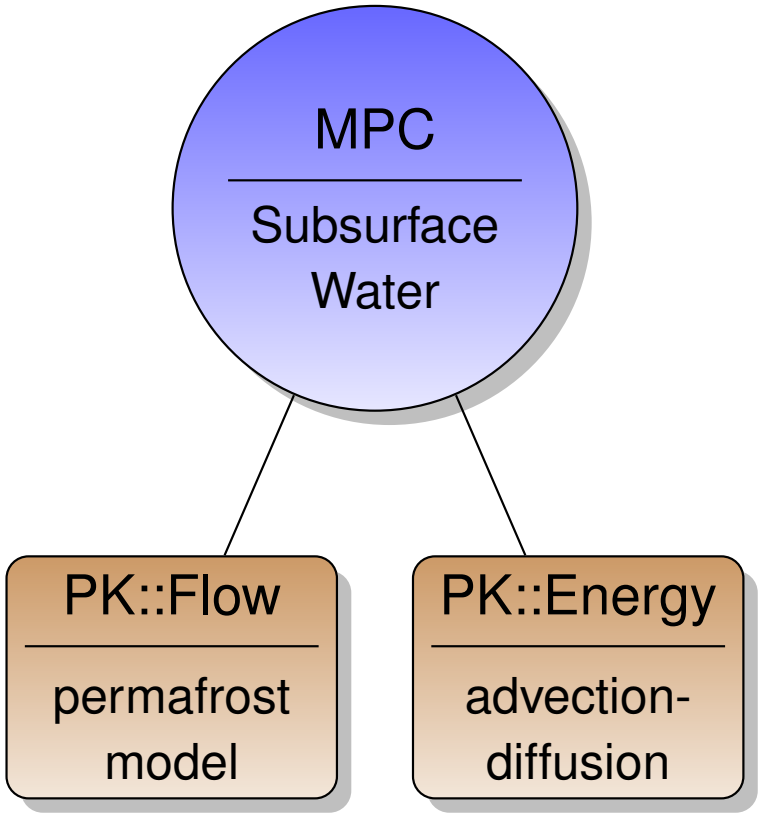
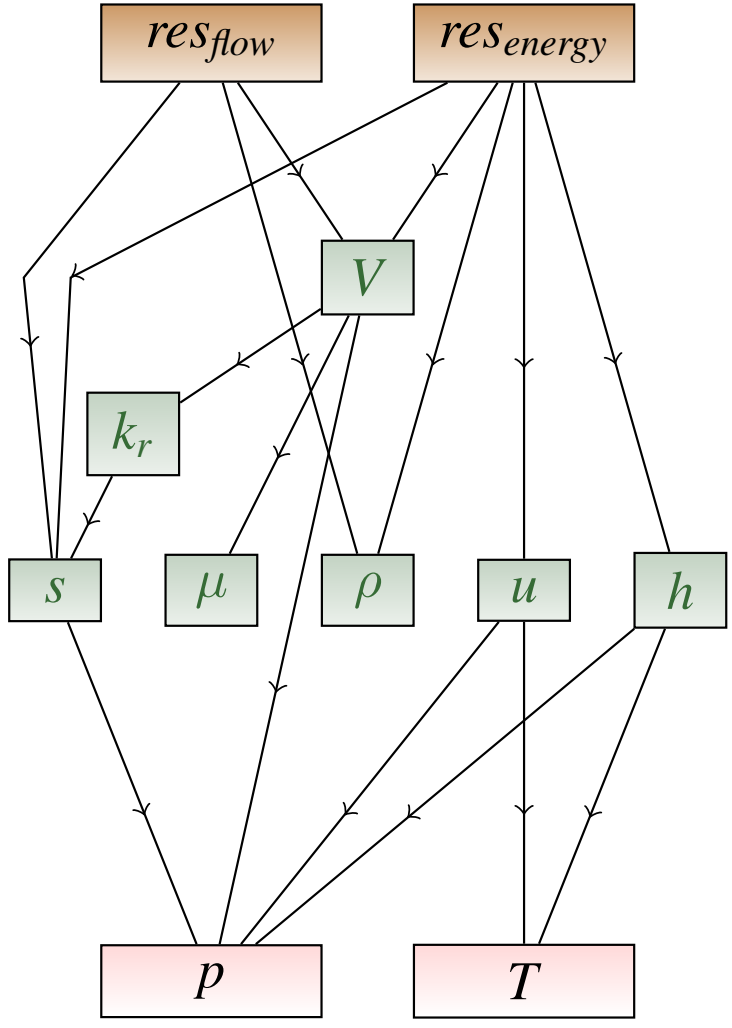
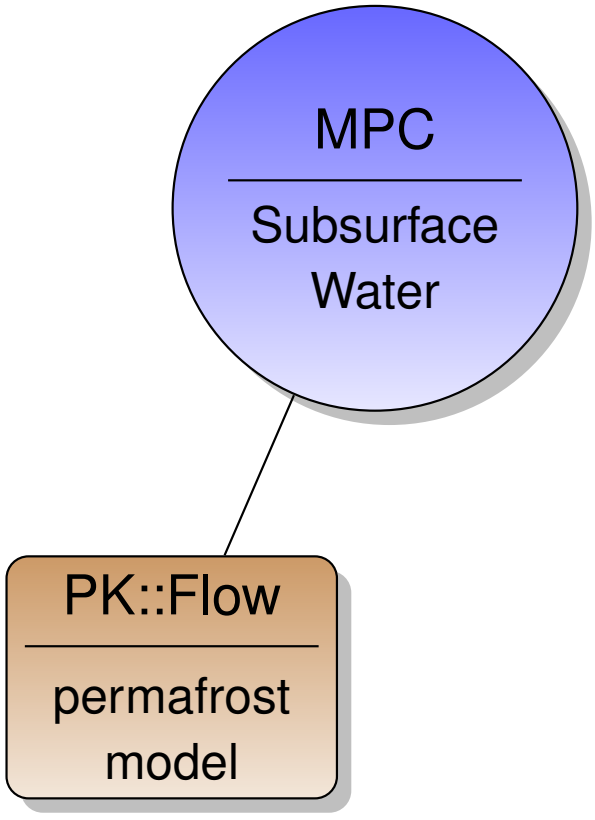
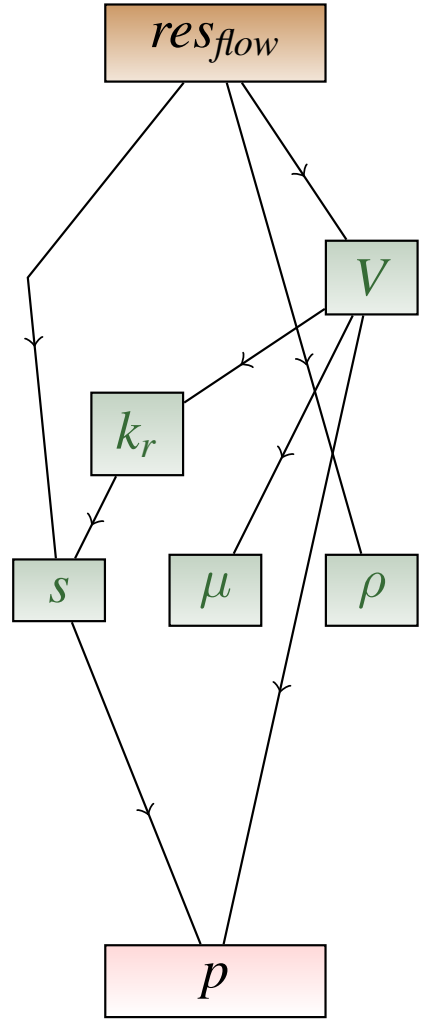
T


MPC
Subsurface Water
PK::Flow
permafrost model
PK::Energy
advection-diffusion


res_{flow}
res_{energy}
V
k_r
s
μ
ρ
u
h
p
T


MPC
Subsurface
Water
PK::Flow
permafrost
model


res_{flow}
V
k_r
s
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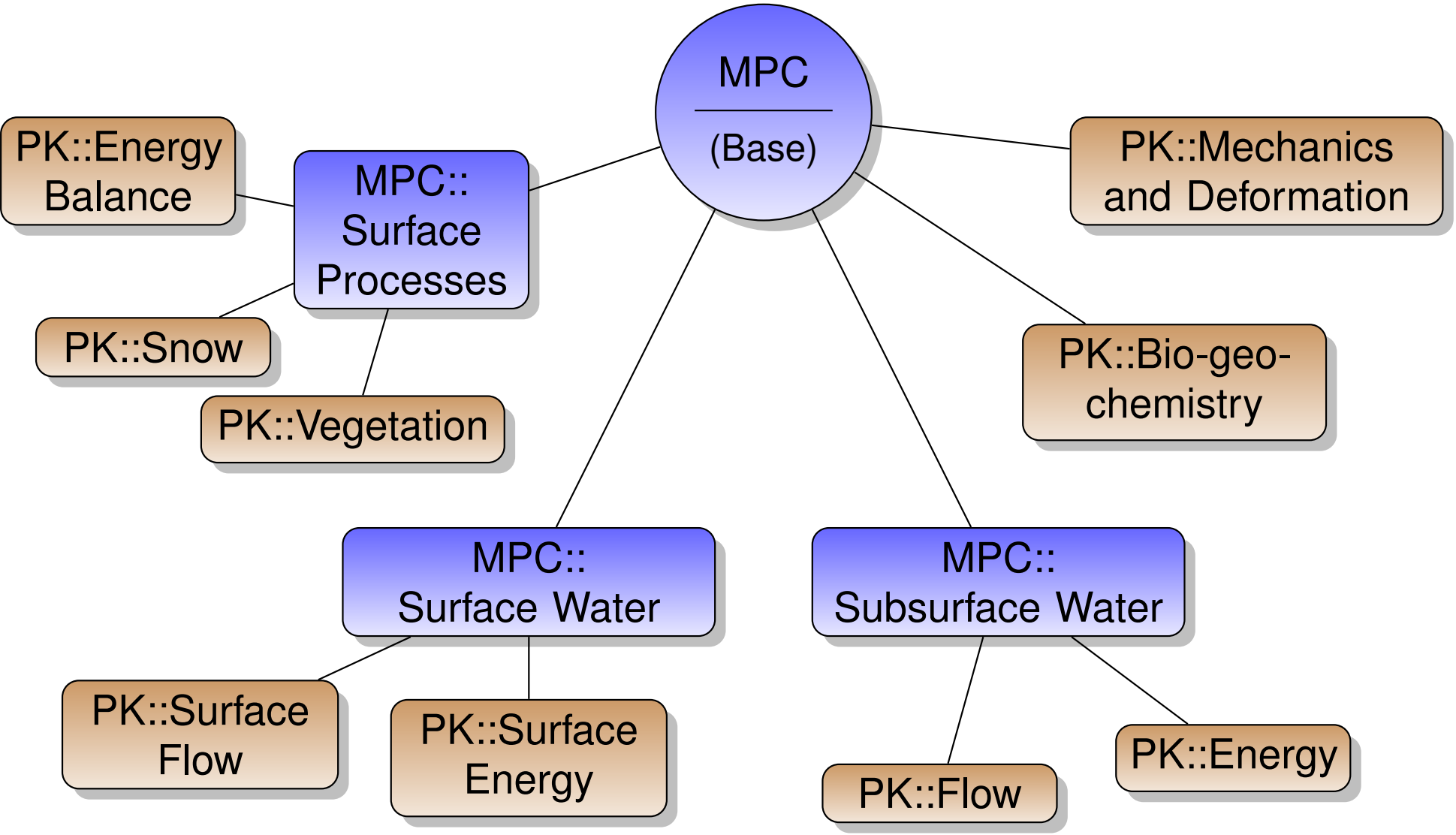
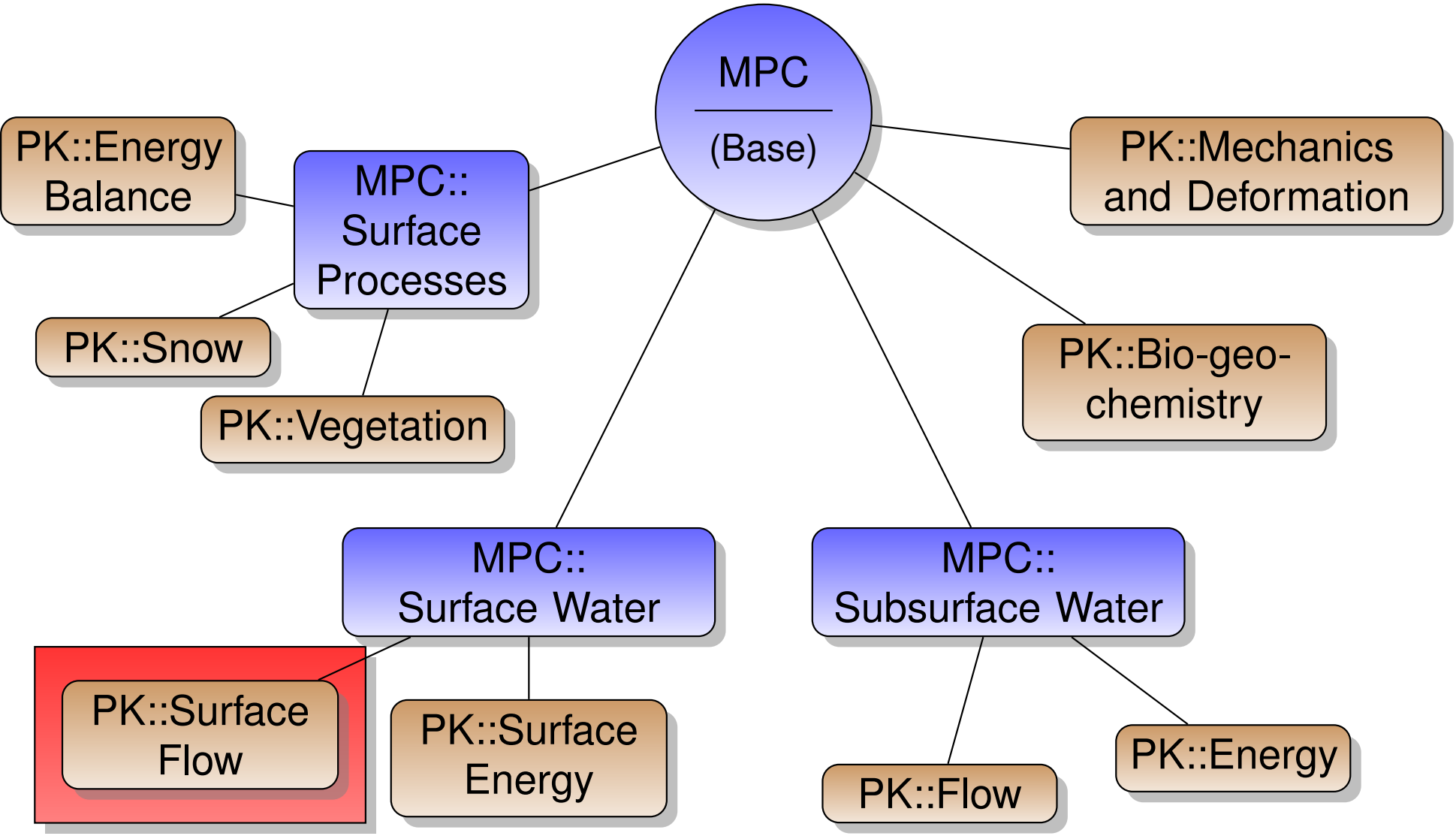
ATS: versatility builds trust



Snowmelt ponding at thaw



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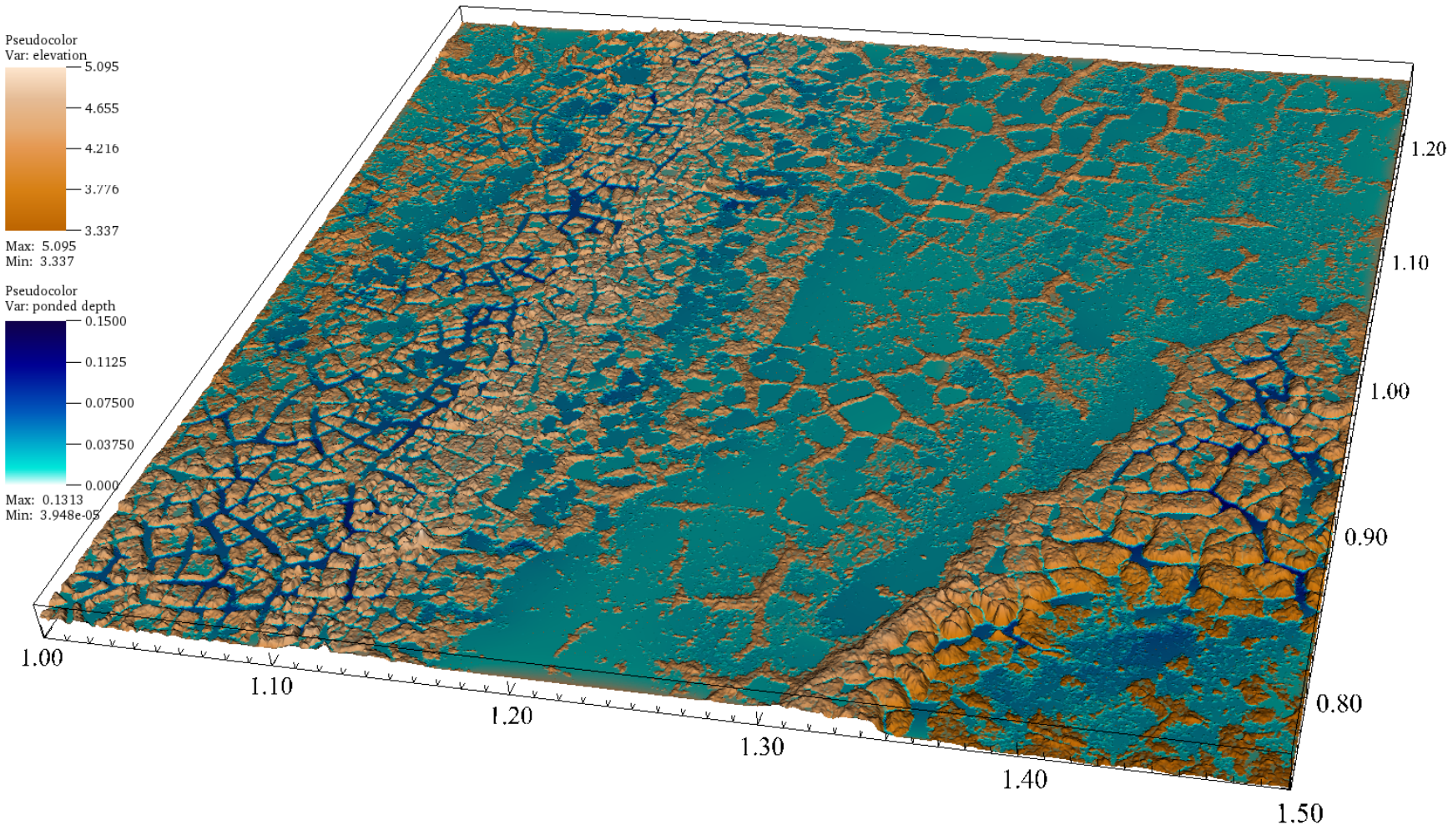
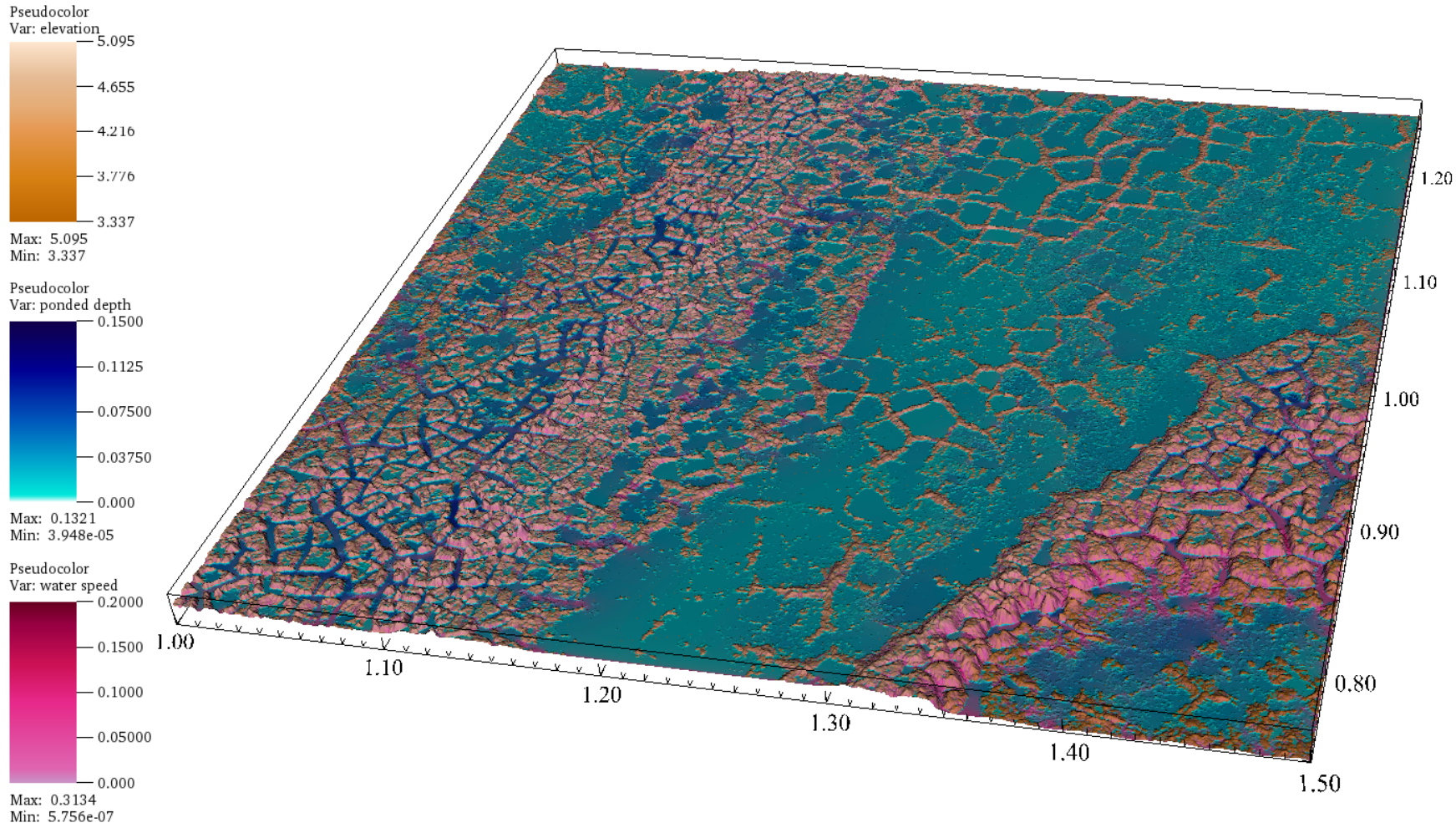
Snowmelt ponding at thaw



Snowmelt ponding at thaw



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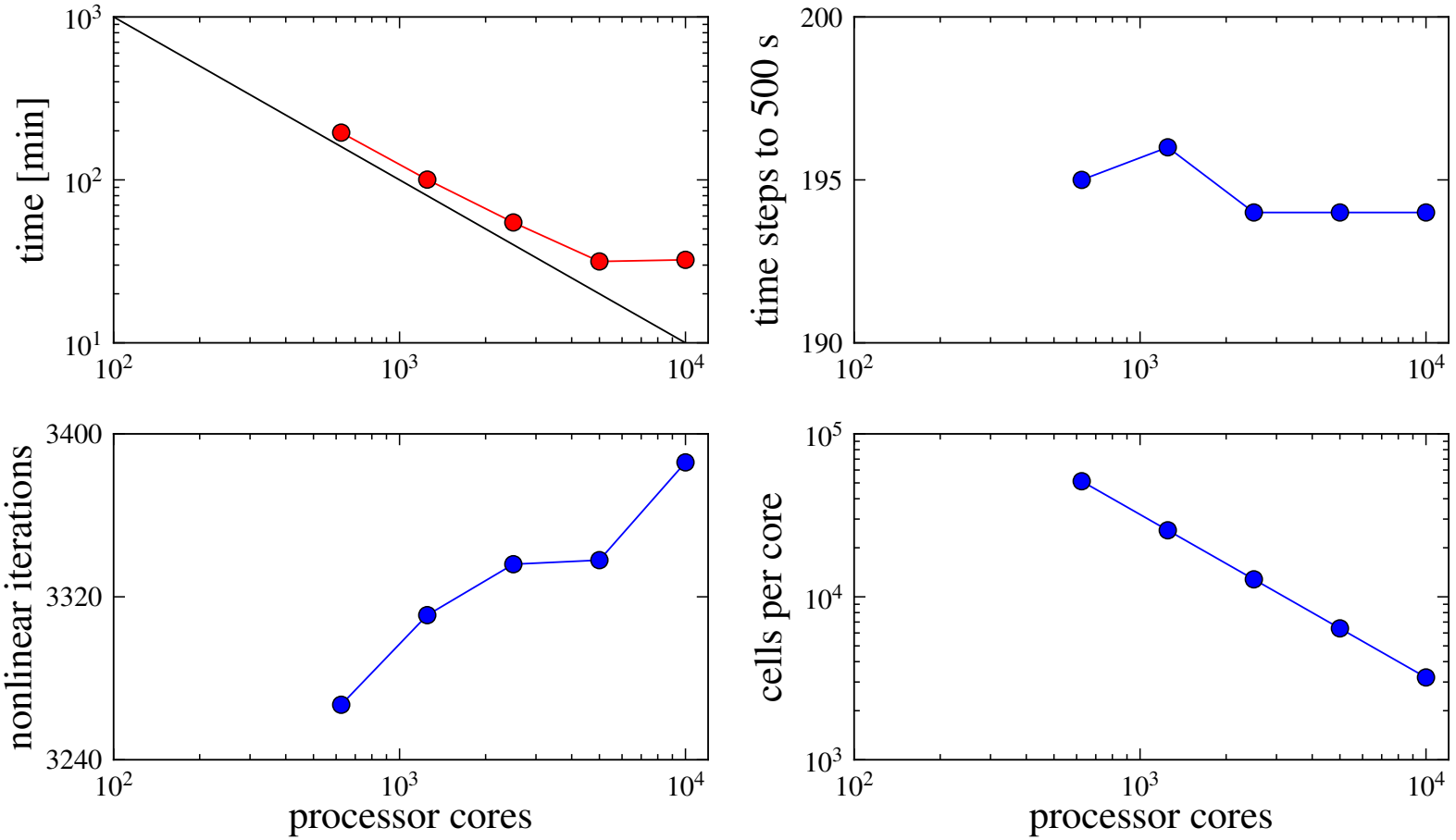
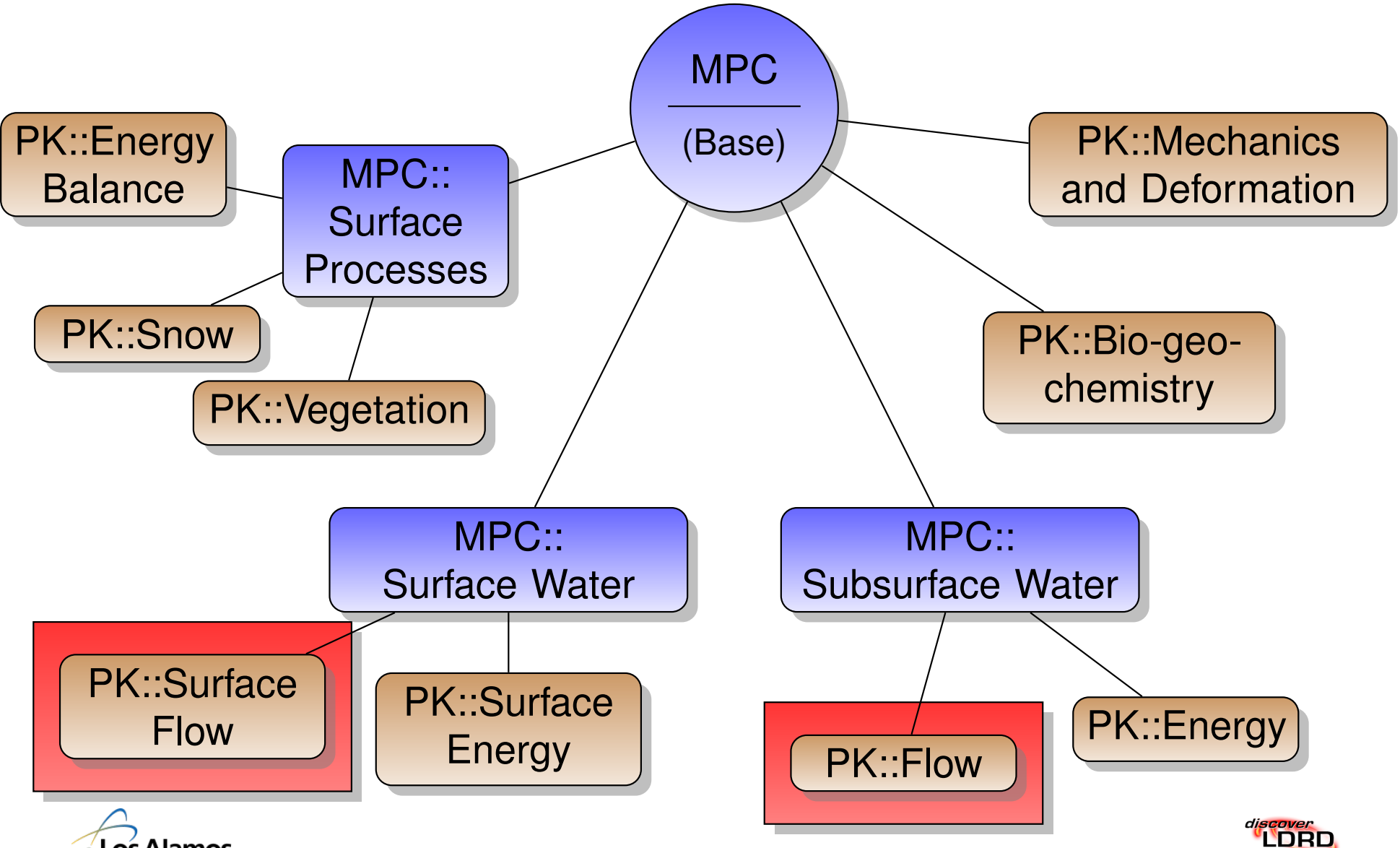
Scaling of ATS

Overland flow with 32 million cells

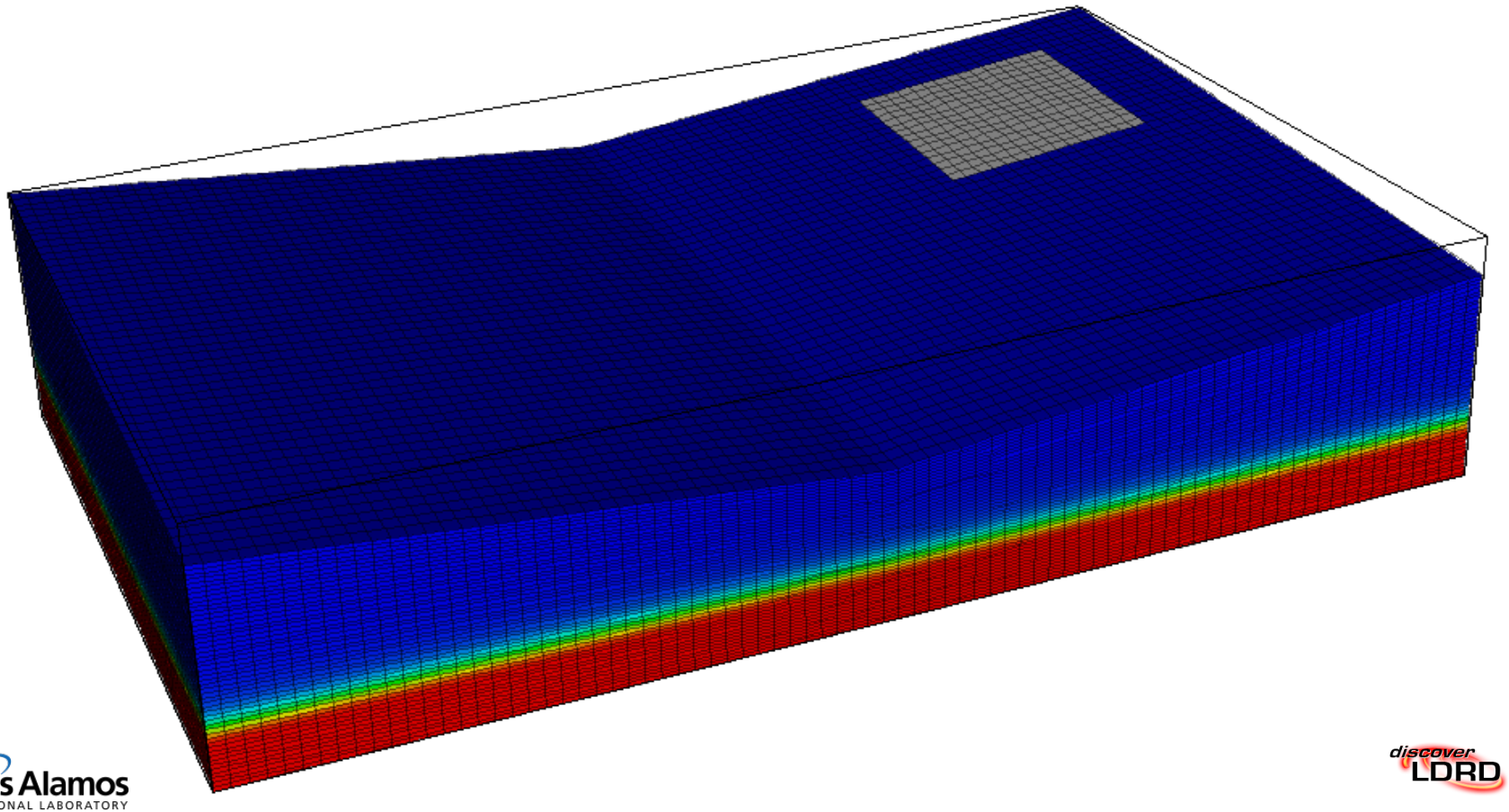


Coupled surface-subsurface flow



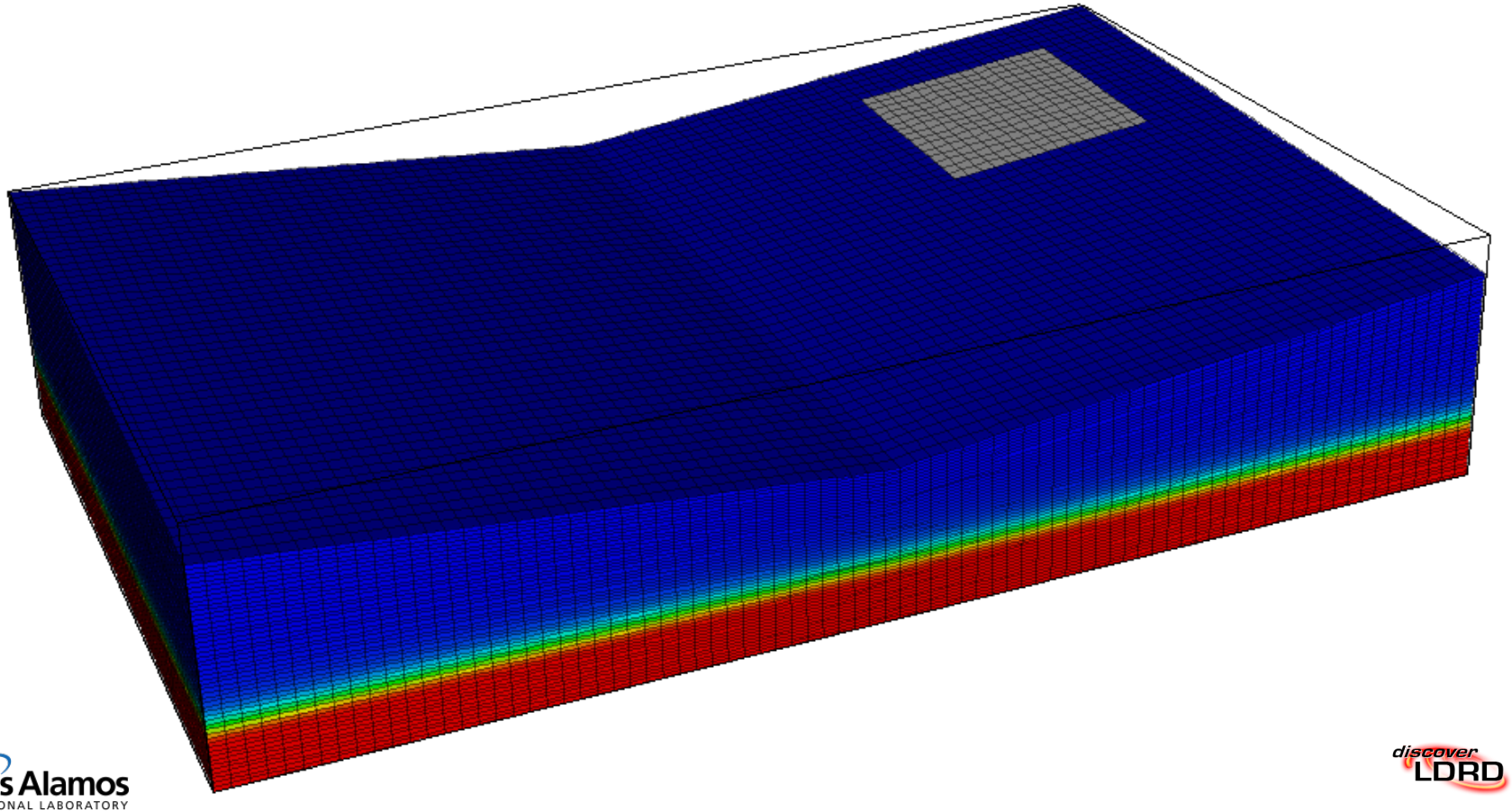
Coupled surface-subsurface flow

$K = 2.5 \times 10^{-10}$

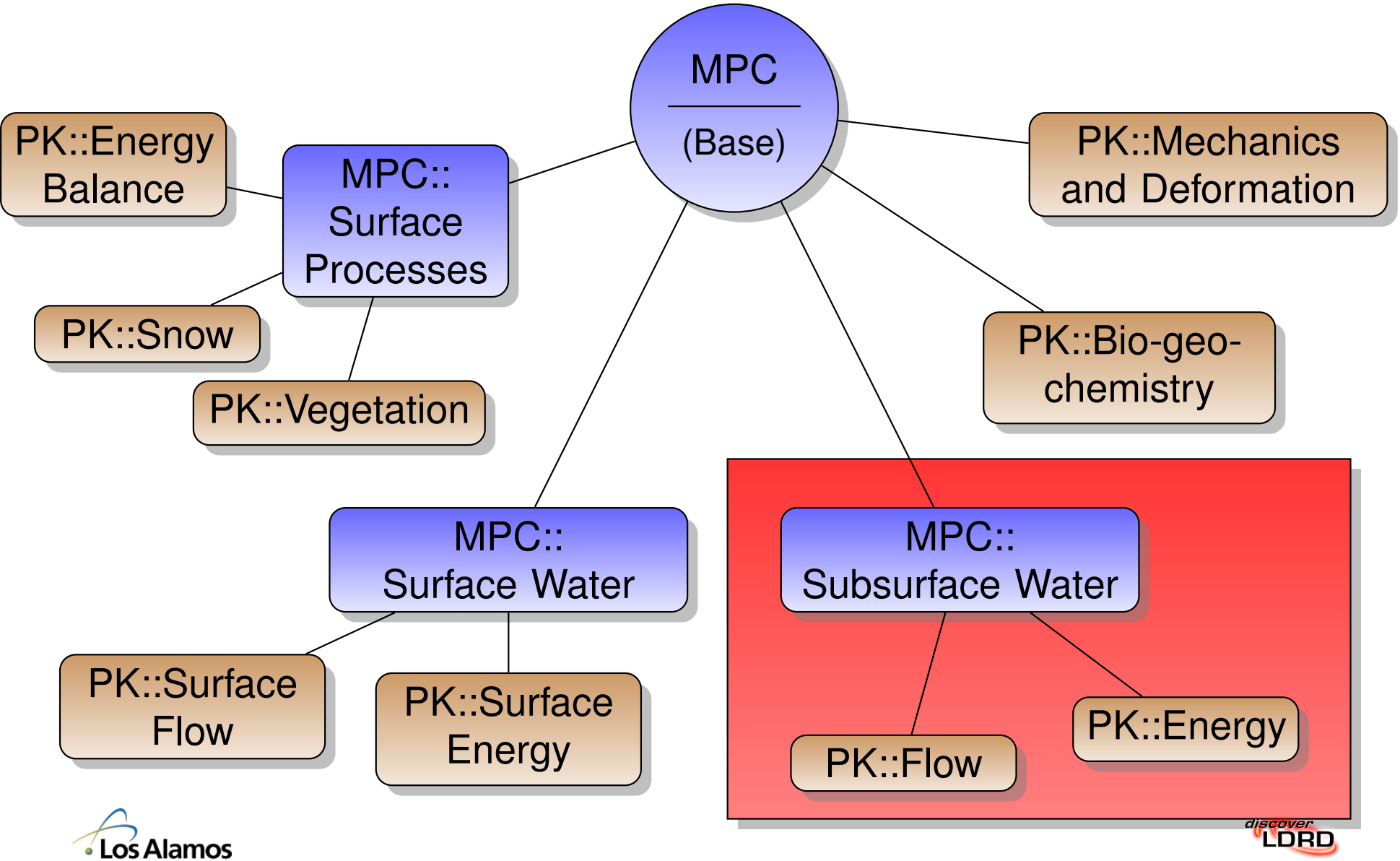


Coupled surface-subsurface flow

$K = 2.5 \times 10^{-12}$

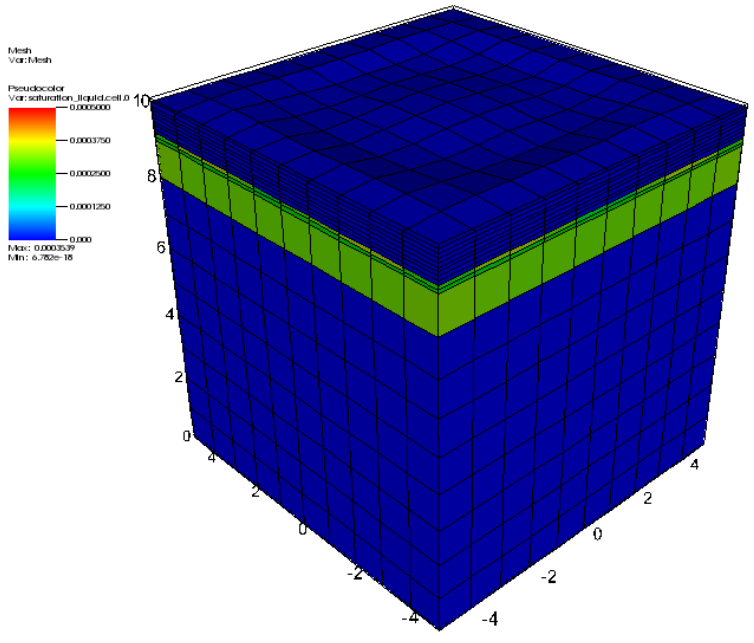


Permafrost model: coupled flow and energy

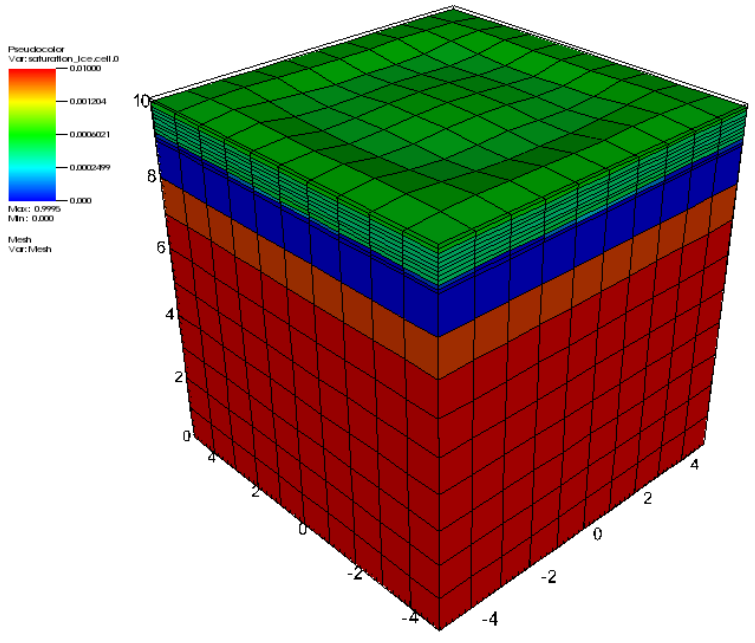


Permafrost model: coupled flow and energy

Freezing



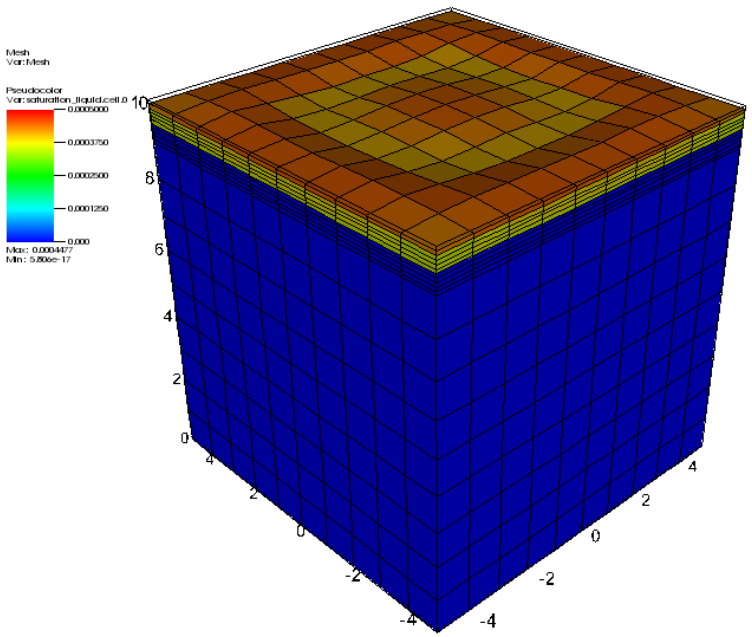
water saturation



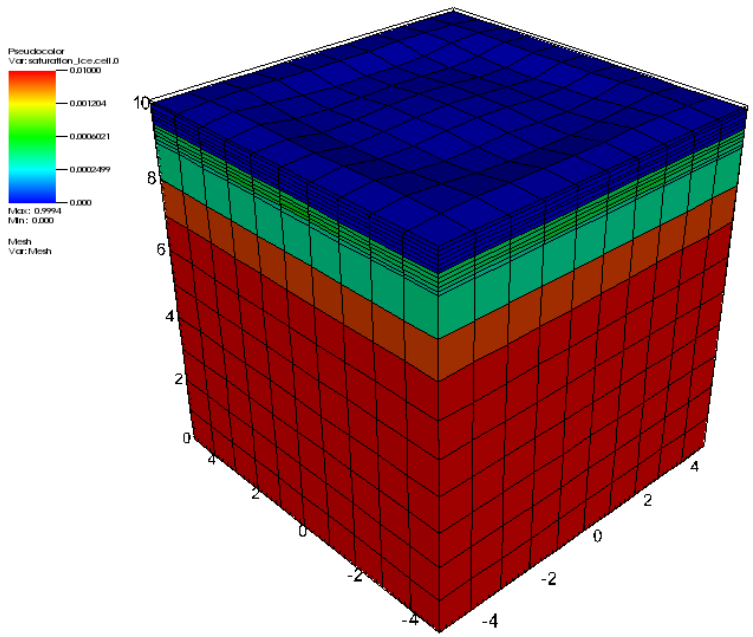
ice saturation

Permafrost model: coupled flow and energy

Thawing

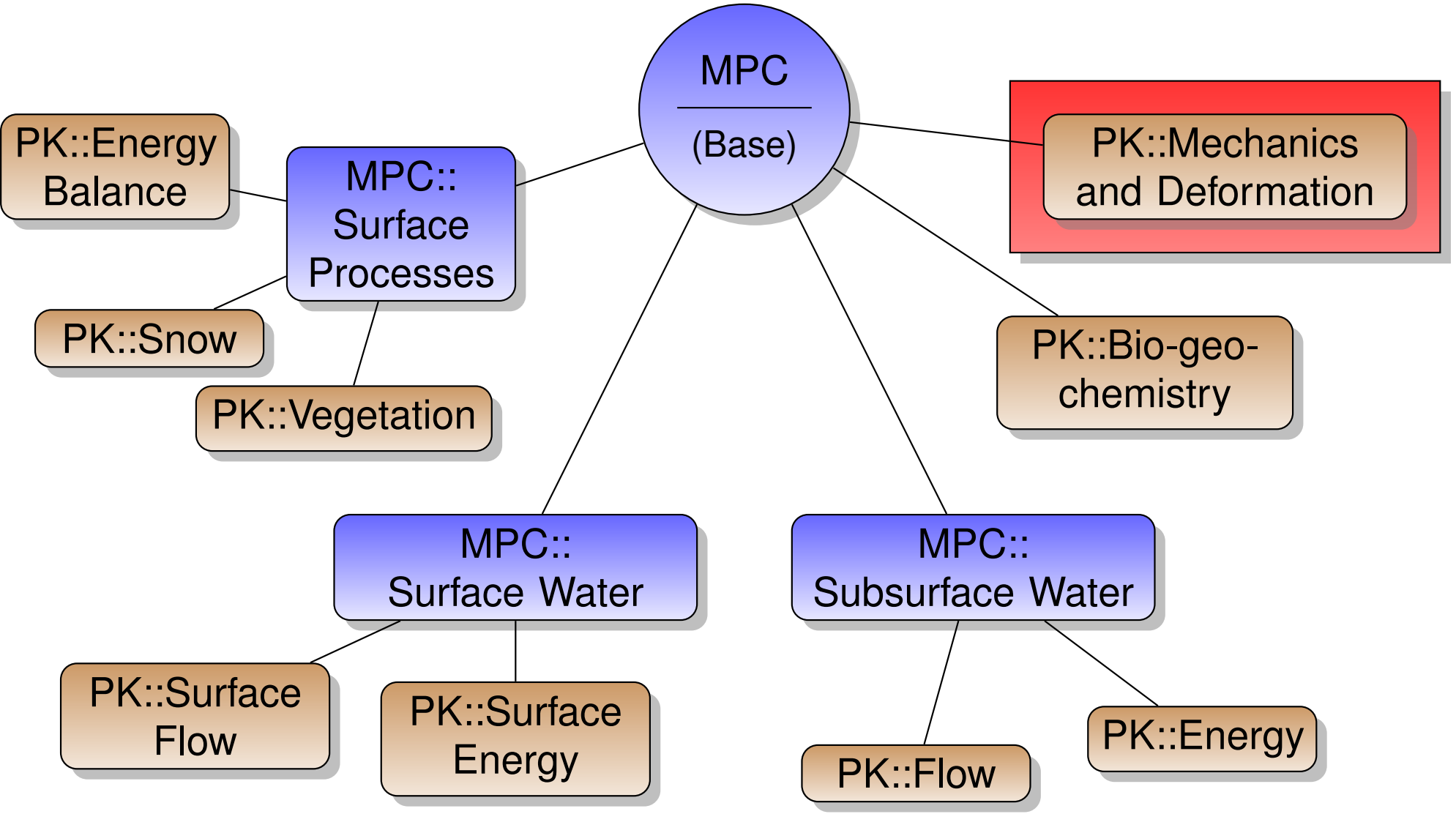


water saturation

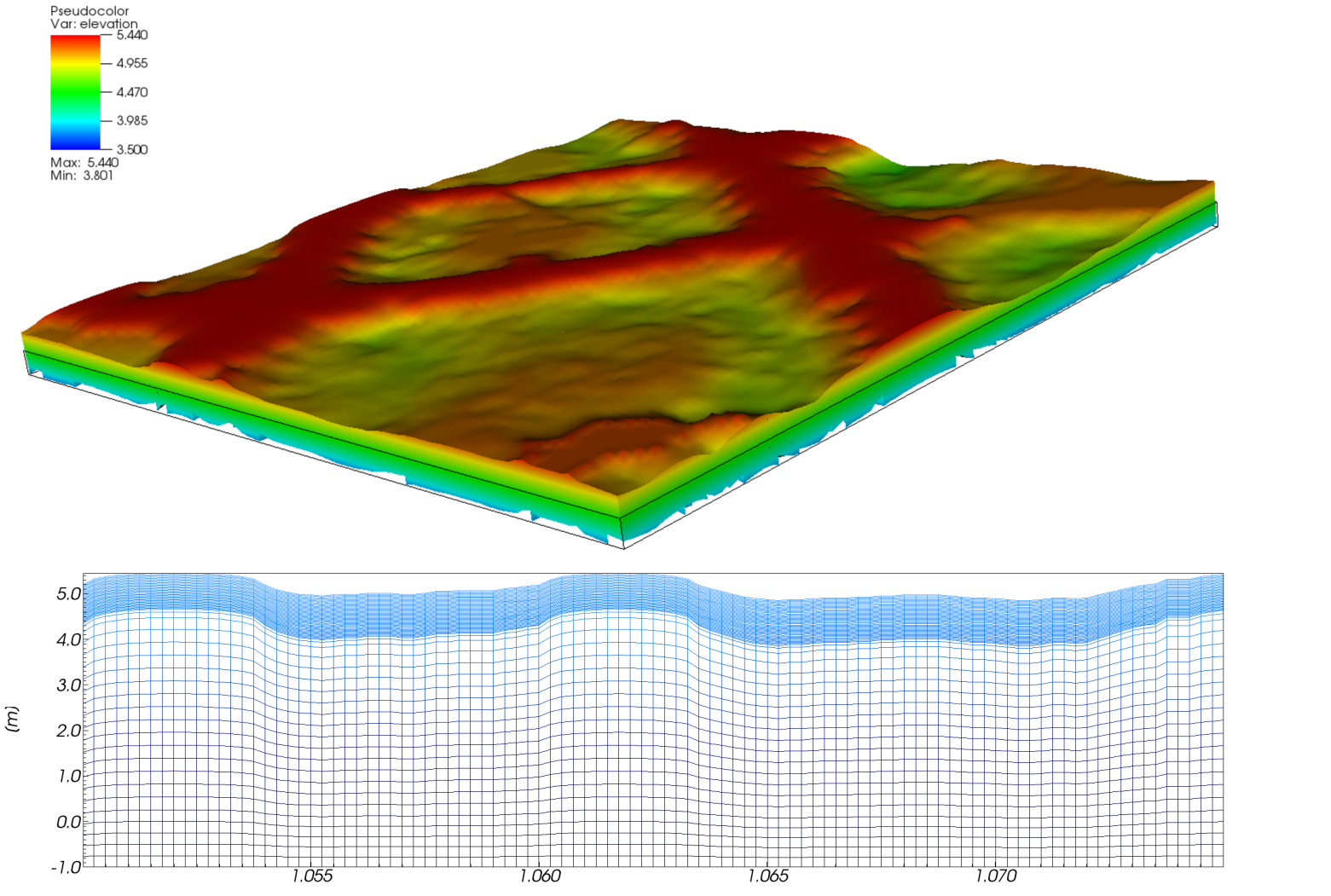


ice saturation

Mesh deformation



Mesh deformation



Conclusions

- ATS is developing a versatile multi-physics simulator for surface and subsurface processes based on Amanzi.
- The many, interacting processes of arctic require a simple yet versatile interface to enable easy validation and verification.
- Heirarchical coupling enables quick process kernel development and testing.
- A series of process kernels are being developed for the simulation of permafrost degredation.