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

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Intended for: programmatic meeting



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The Arctic Terrestrial Simulator

Predicting Climate Impacts and Feedbacks in the terrestrial Arctic

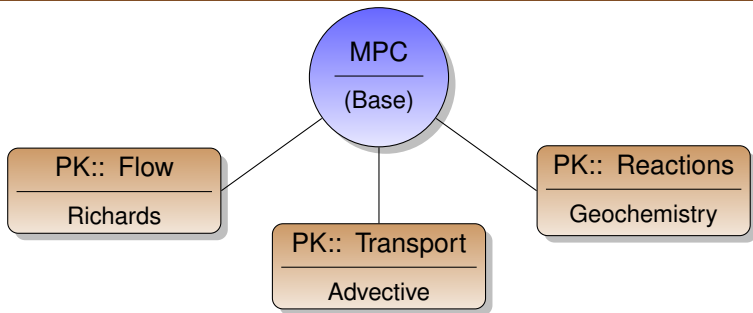
Ethan Coon
Rao Garimella
Daniil Svyatskiy
Scott Painter

Markus Berndt
Gianmarco Manzini
J. David Moulton

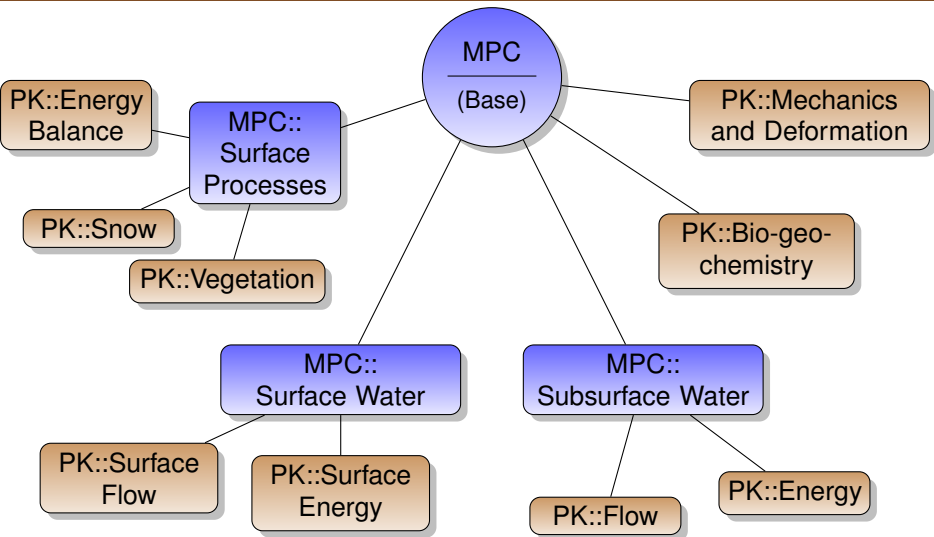
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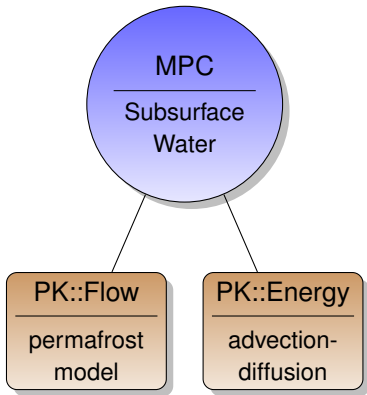
November 15-16, 2012

Amanzi Design



ATS Process Kernels





Flow:

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

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

Energy:

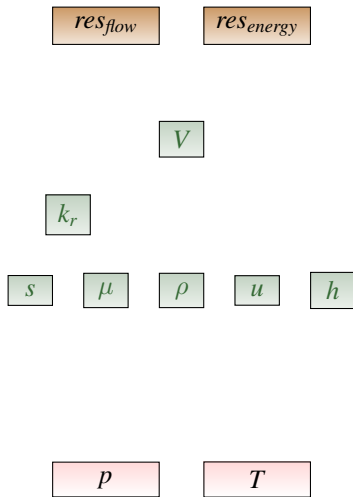
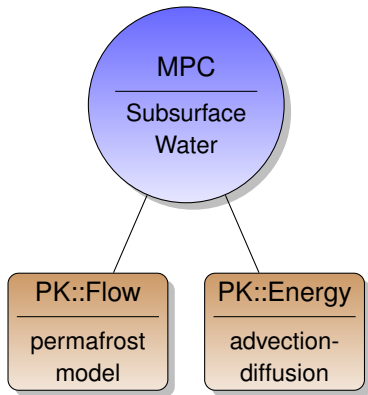
$$\frac{\partial}{\partial t} [\phi(\rho_l s u_l + \rho_g(1 - s)u_g)$$

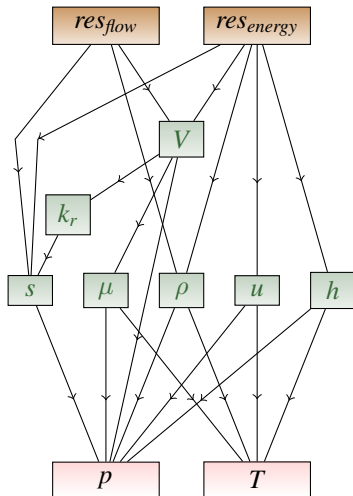
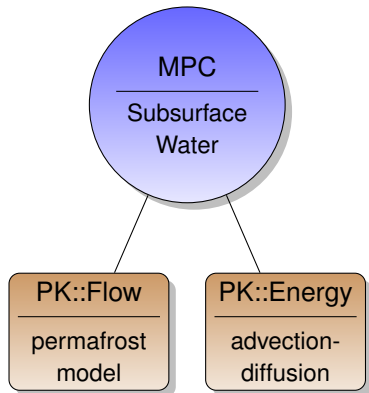
$$+ (1 - \phi)\rho_{rock}u_{rock}] \\ = -\nabla \cdot (\rho_l h_l \mathbf{V}) + \nabla \cdot \mathcal{K}_E \nabla T$$

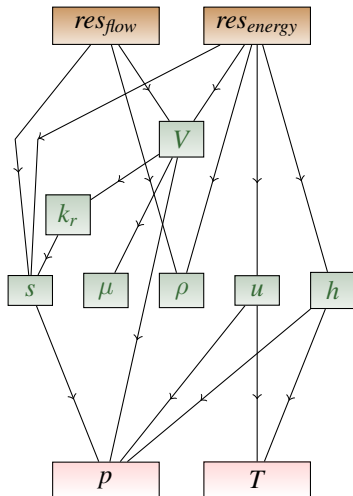
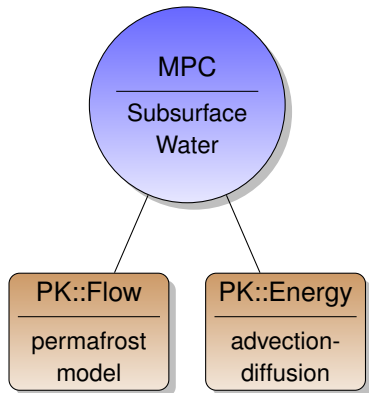
Constitutive Relations:

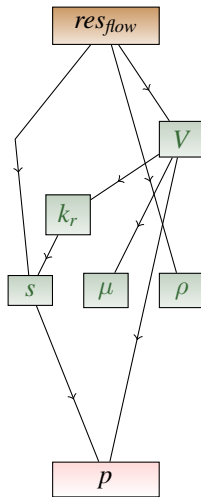
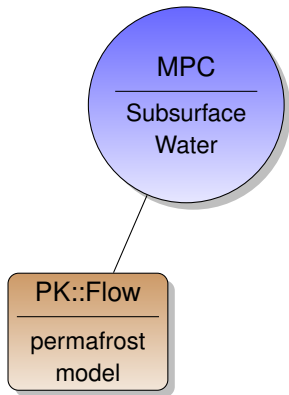
$$s = s(p) \qquad \rho = \rho(T, p)$$

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

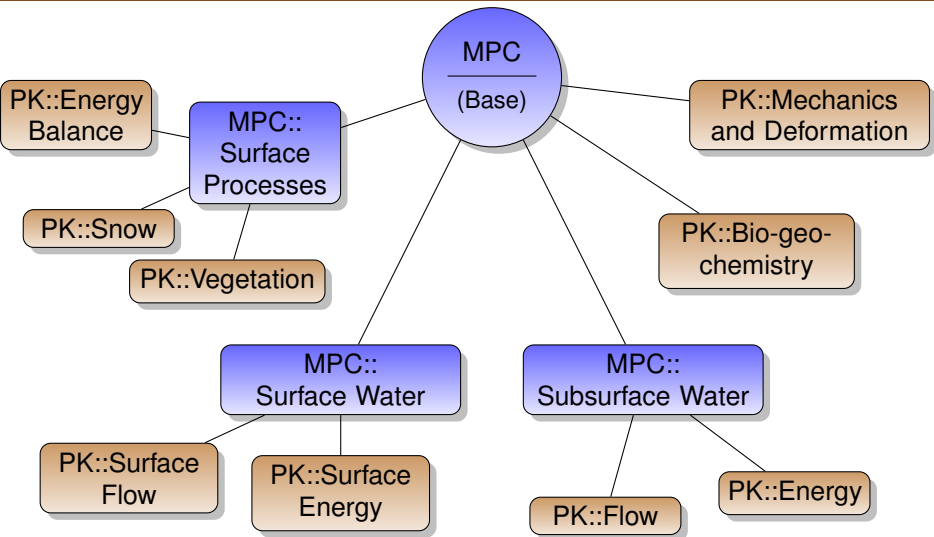




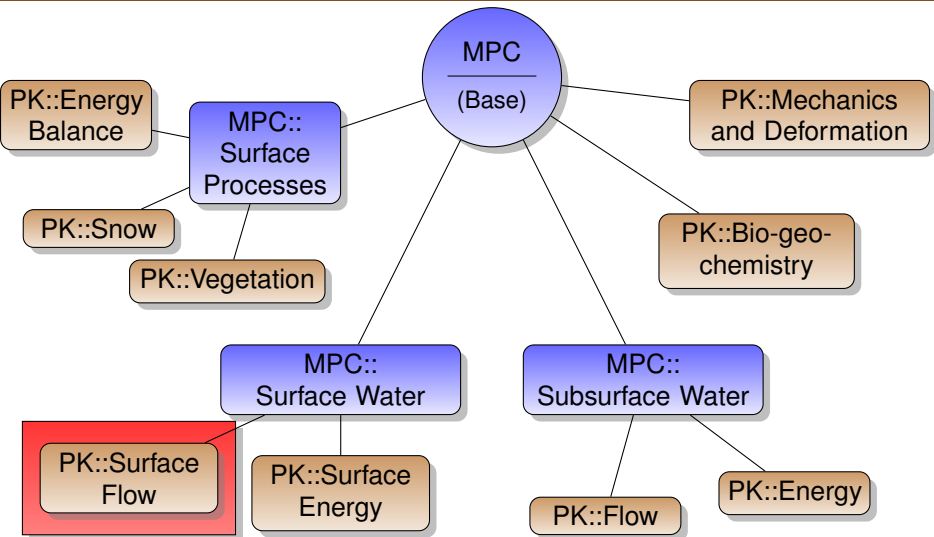




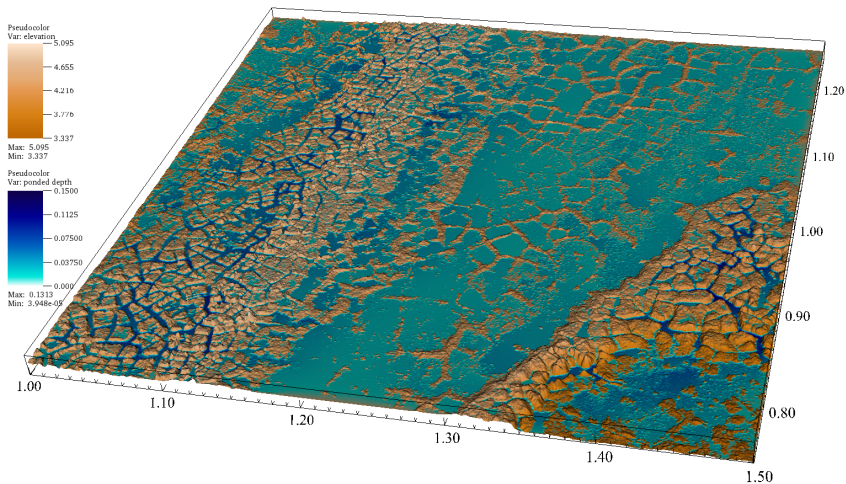
ATS: versatility builds trust



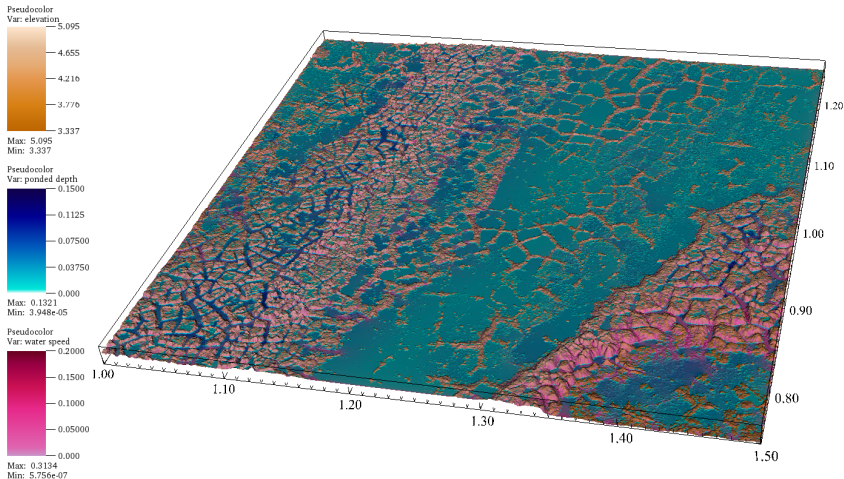
Snowmelt ponding at thaw



Snowmelt ponding at thaw

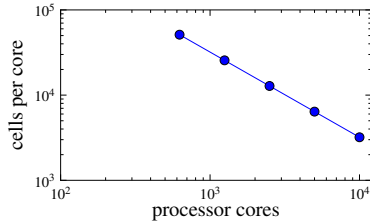
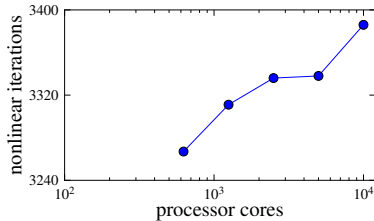
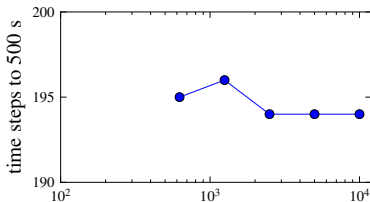
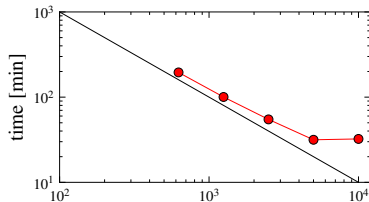


Snowmelt ponding at thaw

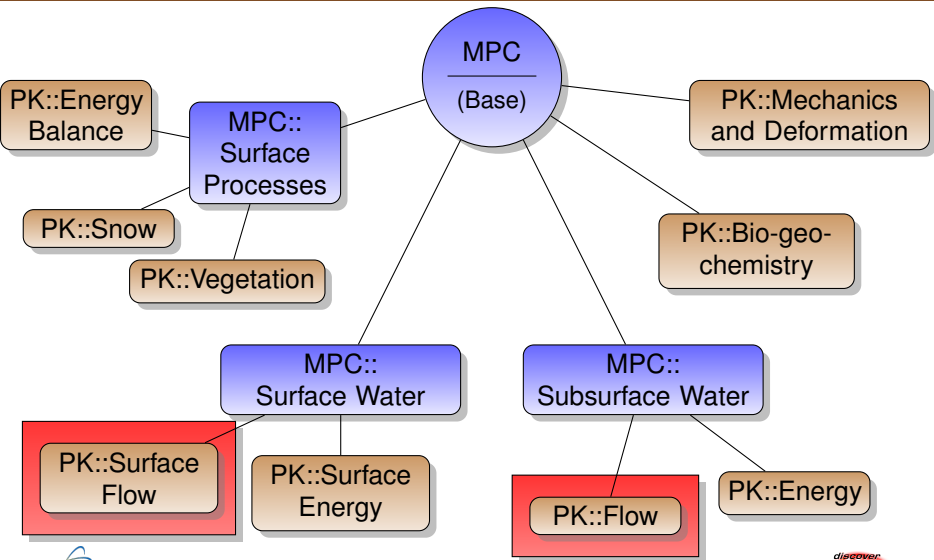


Scaling of ATS

Overland flow with 32 million cells

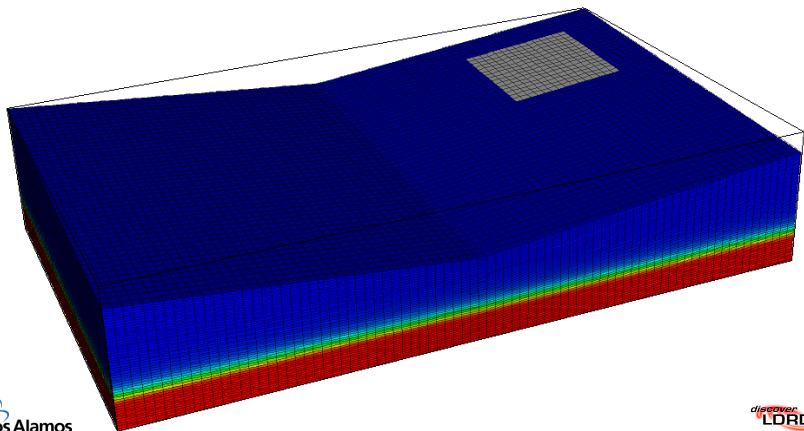


Coupled surface-subsurface flow



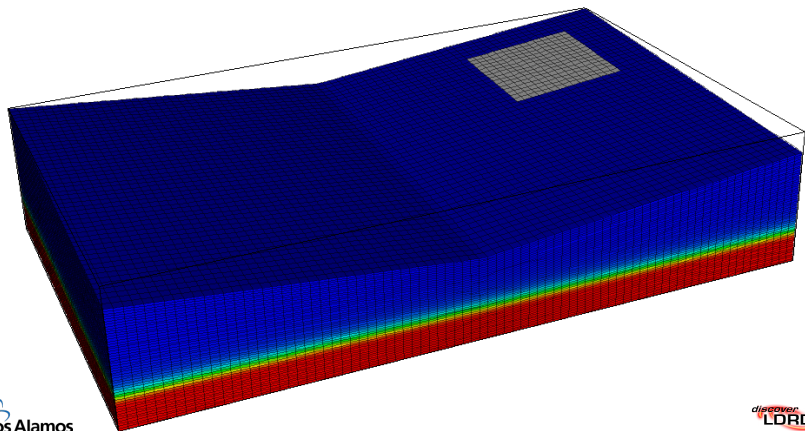
Coupled surface-subsurface flow

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

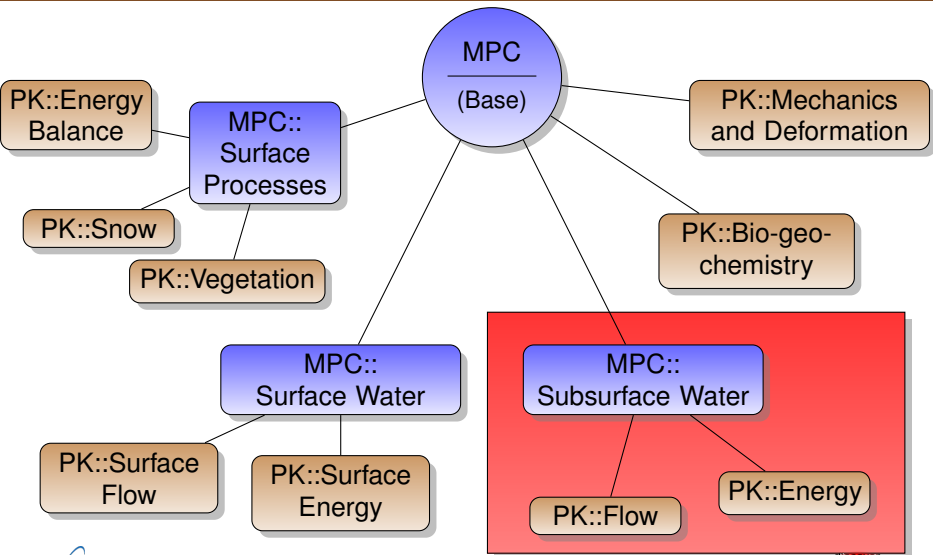


Coupled surface-subsurface flow

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

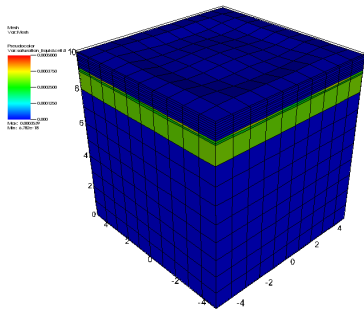


Permafrost model: coupled flow and energy

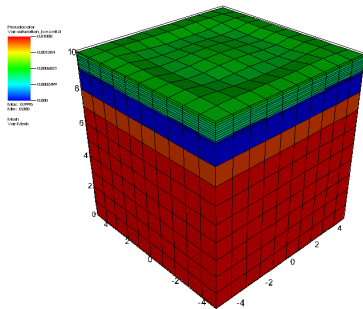


Permafrost model: coupled flow and energy

Freezing



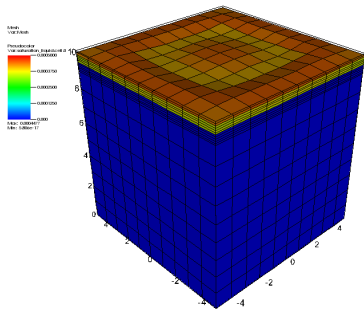
water saturation



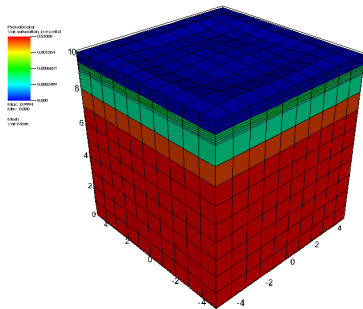
ice saturation

Permafrost model: coupled flow and energy

Thawing

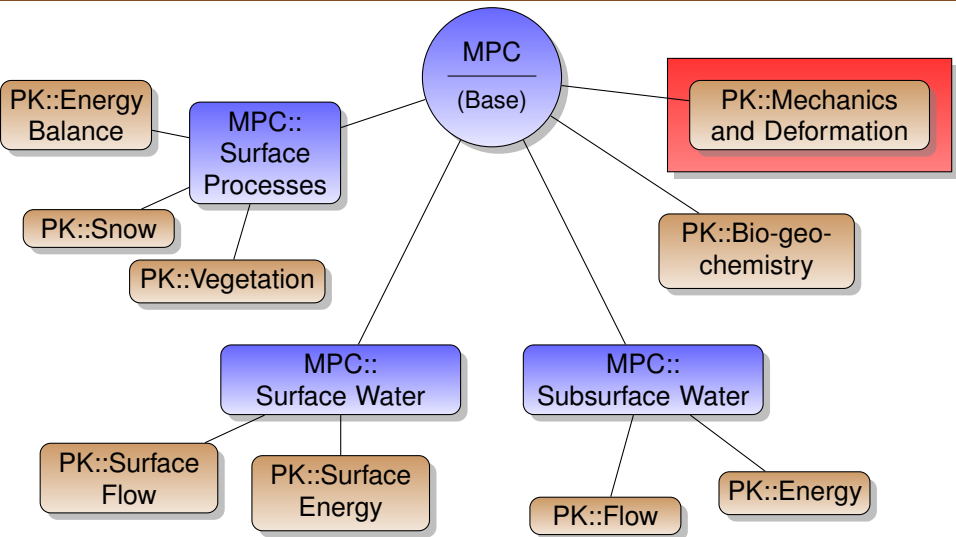


water saturation

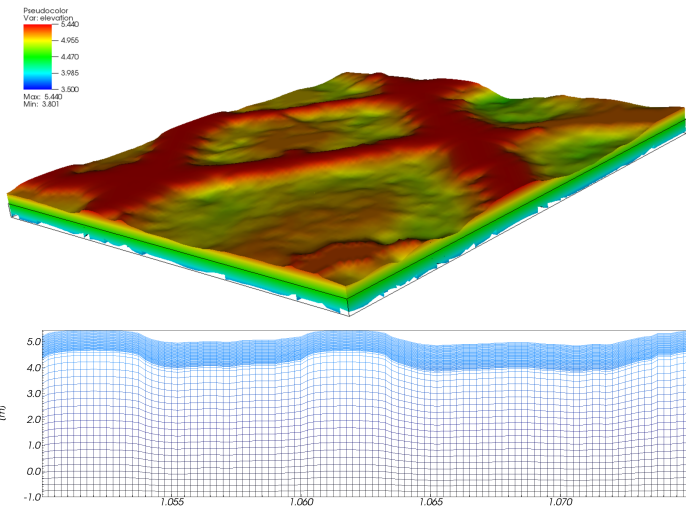


ice saturation

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.