Interfrost Meeting

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Interfrost Meeting, 18-19 Nov 2014, Paris

People

At Stockholm University, Sweden:

- Georgia Destouni
- Steve Lyon
- Arvid Bring
- Romain Pannetier
- Ylva Sjöberg
- Johanna Karlsson

Key collaborations with:

- Jan-Olof Selroos, Emma Johansson, Patrik Vidstrand, SKB, Sweden
- Scott Painter, ORNL, USA
- Ethan Coon, Satish Karra, … LANL, USA

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Overall interests

- Cold regions hydrology and hydrogeology
- Climate change impacts & feedbacks
- How does permafrost change influence changes in hydrological and hydrogeological systems?
- How do those changes impact changes in nutrient and carbon transport?
- How to determine / quantify carbon transport-release and potential climate feedbacks?

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Codes

- MarsFlo (Scott Painter, ORNL, USA)
- PFLOTRAN (Satish Karra, …, LANL)
- ATS – Arctic Terrestrial Simulator (Ethan Coon, …, LANL)
  - Massively parallelized
  - Additional physics / processes, incl:
  - Surface flow processes
  - Surface energy balances
  - Soil deformation

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Previous studies (MarsFlo)

- Numerical model coupling mass and energy conservation equations for water transport in partially frozen ground
- Accounts for
  - Partitioning of water between the liquid, vapour, and ice phases
  - Advective transport in the liquid and vapour phases
  - Diffusive transport of vapour
  - Conductive and convective transport of heat

- Mass conservation equations

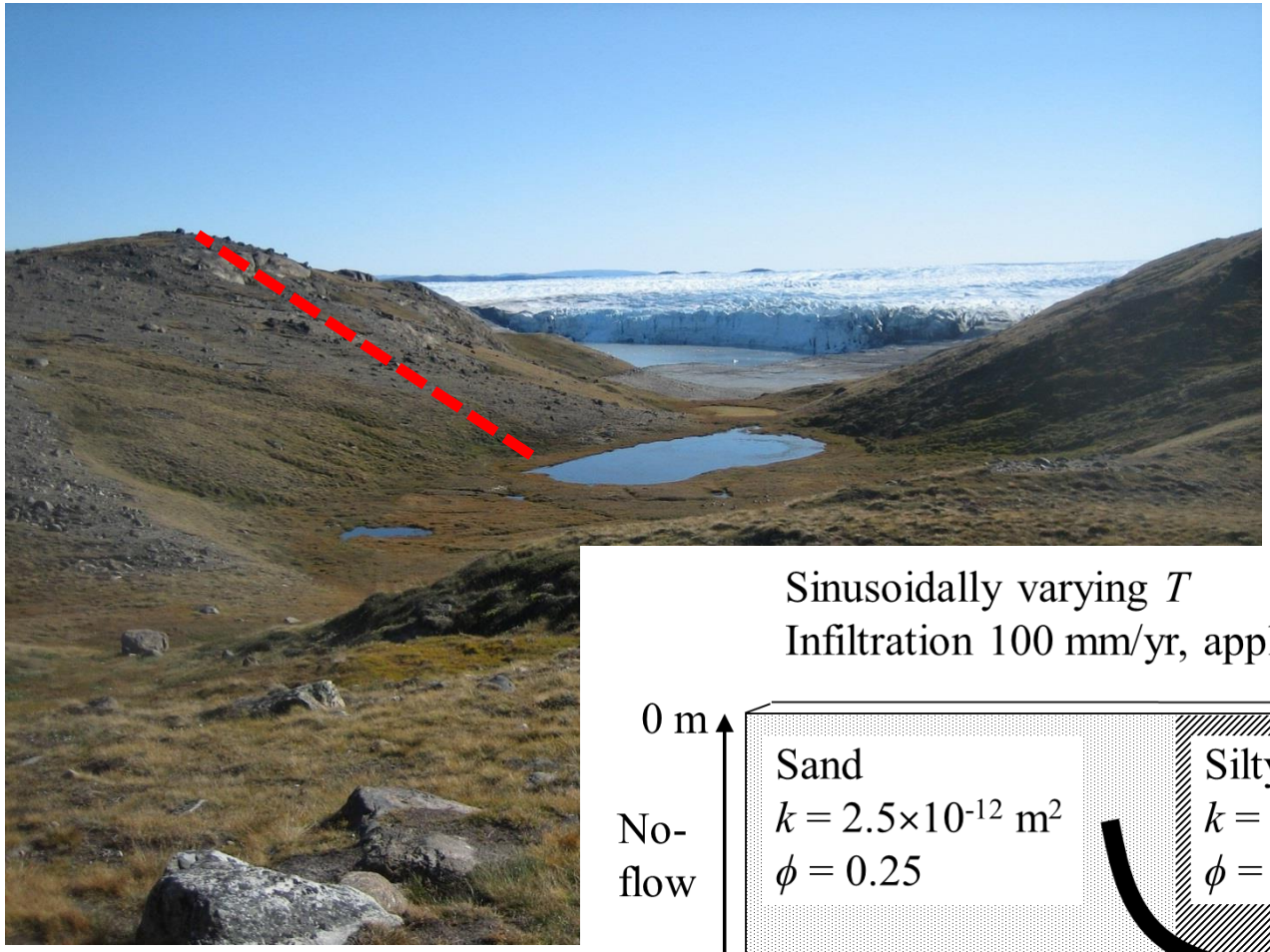
$$\frac{\partial}{\partial t}\left[\sum_{p=l,g,i}\phi\omega_p^\beta n_p s_p\right] = -\sum_{p=l,g}\nabla\cdot\left[\omega_p^\beta n_p \mathbf{V}_p\right] + \sum_{p=l,g}\nabla\cdot\left[\phi\tau_p n_p D_p \nabla\omega_p^\beta\right] + S^\beta$$

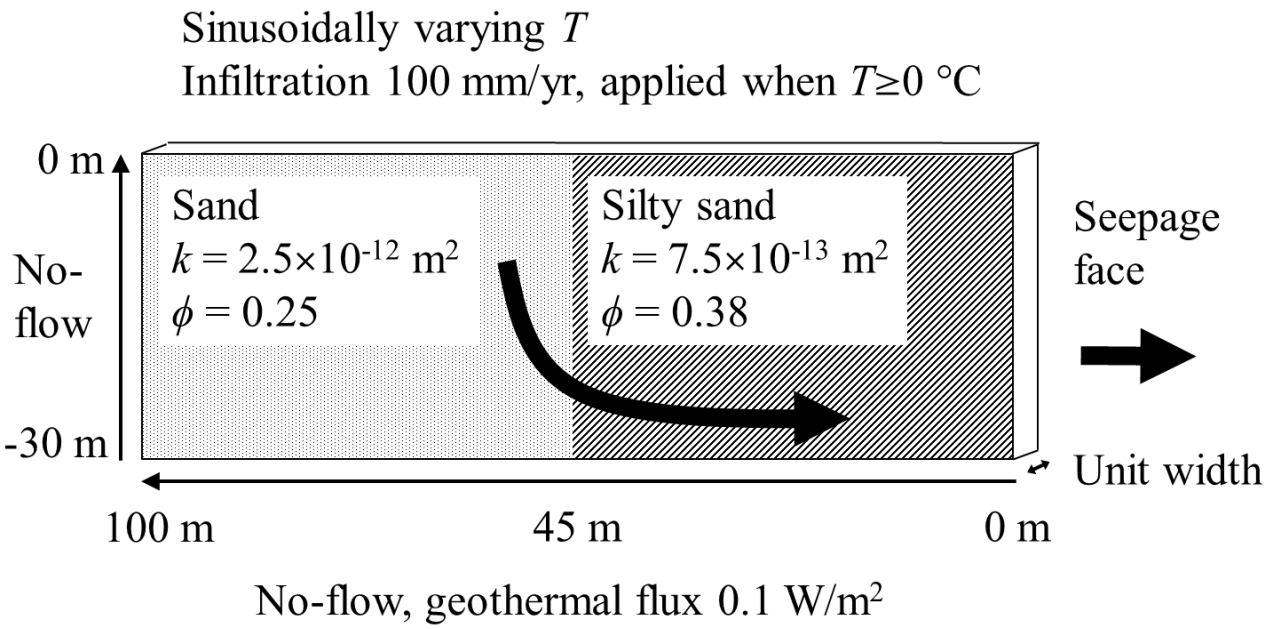
- Energy conservation equations

$$\frac{\partial}{\partial t}\left[\sum_{p=l,g,i}\left(\phi\rho_p s_p u_p\right) + \left(1-\phi\right)\rho_m u_m\right] = -\sum_{p=l,g}\nabla\cdot\left(\rho_p h_p \mathbf{V}_p\right) + \nabla\cdot\left[\kappa_e\nabla T\right] + S_E$$

Painter (2011) Comput Geosciences; Frampton et al (2011), J Hydrol; Frampton et al (2013), Hydrogeol J

Subsurface cross-section / 'hillslope'





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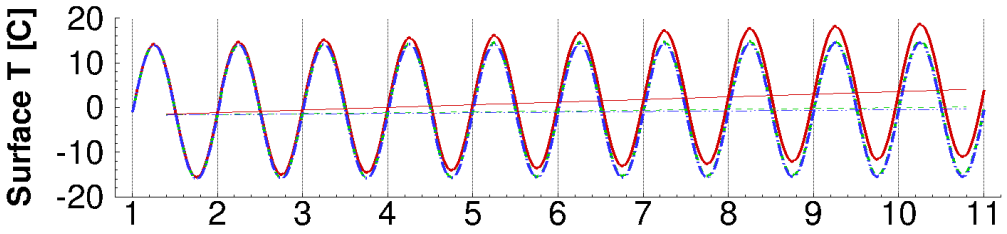
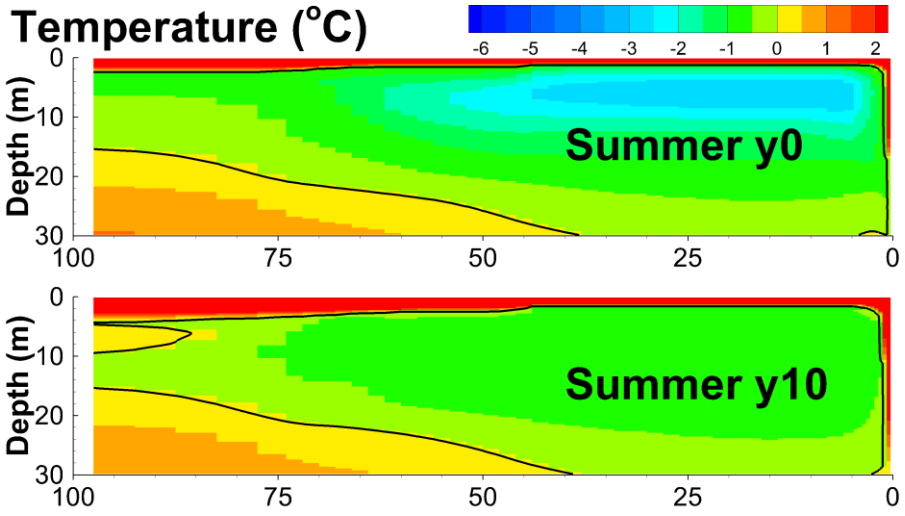
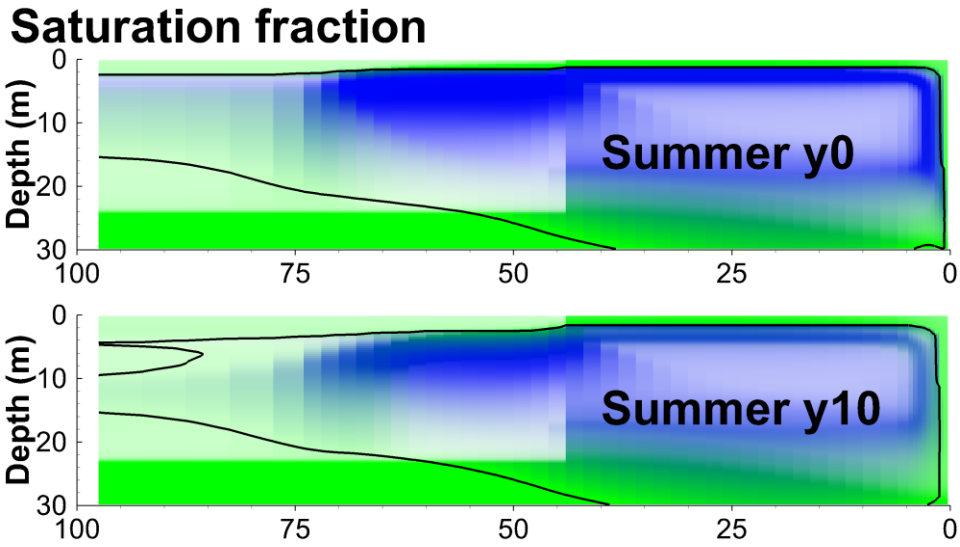
Resulting temperature and water/ice saturations

- Various warming trends
  0.5, 0.1, 0.05 °C/yr







How does subsurface discharge to surface water bodies change under climatic warming and associated permafrost degradation and active layer depth change?

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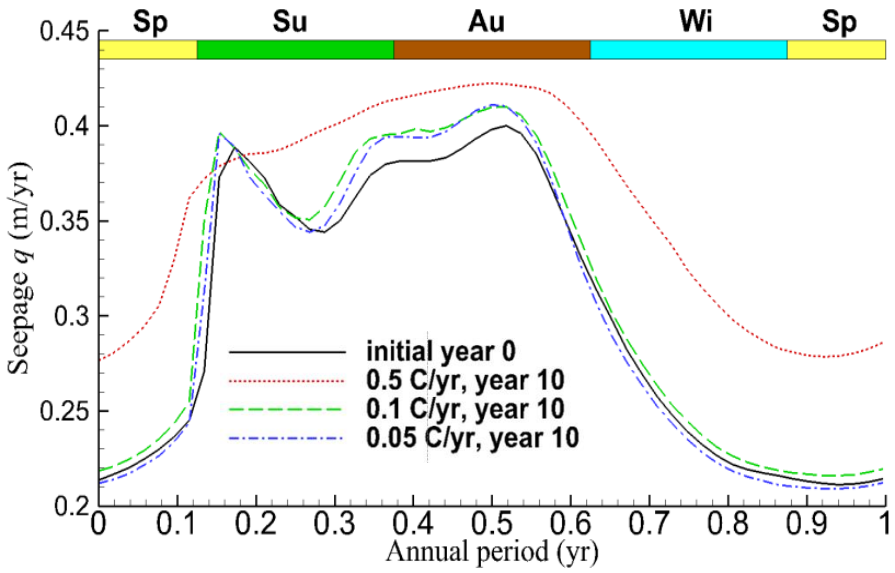
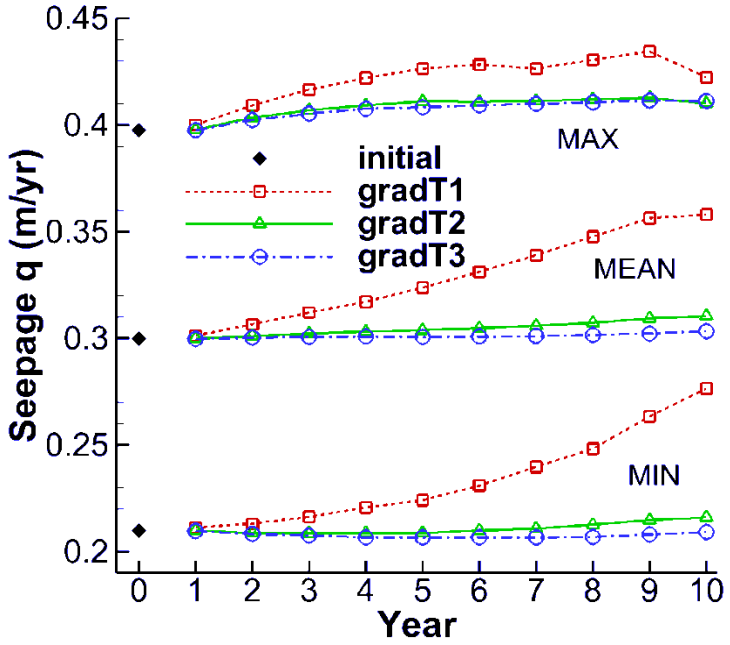
Hydrological indicators of permafrost change





Resulting changes in subsurface discharge:

- Seasonal variability decreases; peaks smoothen out
- Heterogeneity can impact amplitudes and shapes over seasons
- Trend of increasing winter and spring flows
- Trend of decreasing autumn flows
- Caused by an increase in flow path distances & residence times

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Interfrost Benchmark

- Interest in benchmark
  - Yes
- Time & resources
  - Hopefully
- Specific objectives
  - Good science
  - New experimental data at lab scale
  - Evaluation of reliability/applicability of code usage
  - Improved field application