Institute of Fluid Mechanics
and Environmental Physics
in Civil Engineering

Master Thesis Topic - Modelling subsurface thermal and hydraulic processes with freeze/thaw

First Examiner: apl.-Prof. Dr. Thomas Graf
Supervisor: MSc. Radhakrishna Bangalore Lakshmiprasad

Introduction

Qinghai-Tibet Plateau (also known as the 'Water tower of Asia') is threatened by climate warming. Due to its high elevation (average 4000 m.a.s.l), it experiences temperature twice the global average. The high temperatures results in permafrost degradation. The subsurface thermal and hydrological environment in cold regions is influenced by the change in permafrost distribution.

The permafrost thaws and freezes seasonally due to the influx of heat energy from the ground surface. The groundwater flow increases as the hydraulic conductivity in the active layer increases. The pore water phase change from liquid to ice causes variation in the thermal parameters of the soil. Snow deposition on the surface also influence the characteristics of the subsurface. Several models exist that can implement these cryohydrogeological processes.

ATS (Advanced Terrestrial Simulator) simulates cryohydrogeological processes: thermal and hydraulic subsurface processes with freezing/thawing, surface energy balance, overland flow with ice and snow deposition/melting processes. The model can also simulate the processes in the variably saturated zone.

The Master thesis main goal is to use the ATS model to simulate the subsurface hydro-thermal processes and carry out sensitivity analysis to identify the crucial parameters.

Research Questions

- What are the physical processes that govern the freeze-thaw cycles in the subsurface?
- What are the subsurface parameters that need to be considered for numerically modelling freeze-thaw processes using ATS?
- Which are the most sensitive hydraulic and thermal subsurface parameters?

Monthly Milestone Plan

- Literature review.
- ATS model learning
- ATS model implementation 1 - Hydraulic and thermal processes.
- ATS model implementation 2 - Coupling hydraulic and thermal processes.
- ATS model implementation 3 - Including freeze-thaw cycles.
- Thesis preparation - writing and presentation.

Beneficial Skills

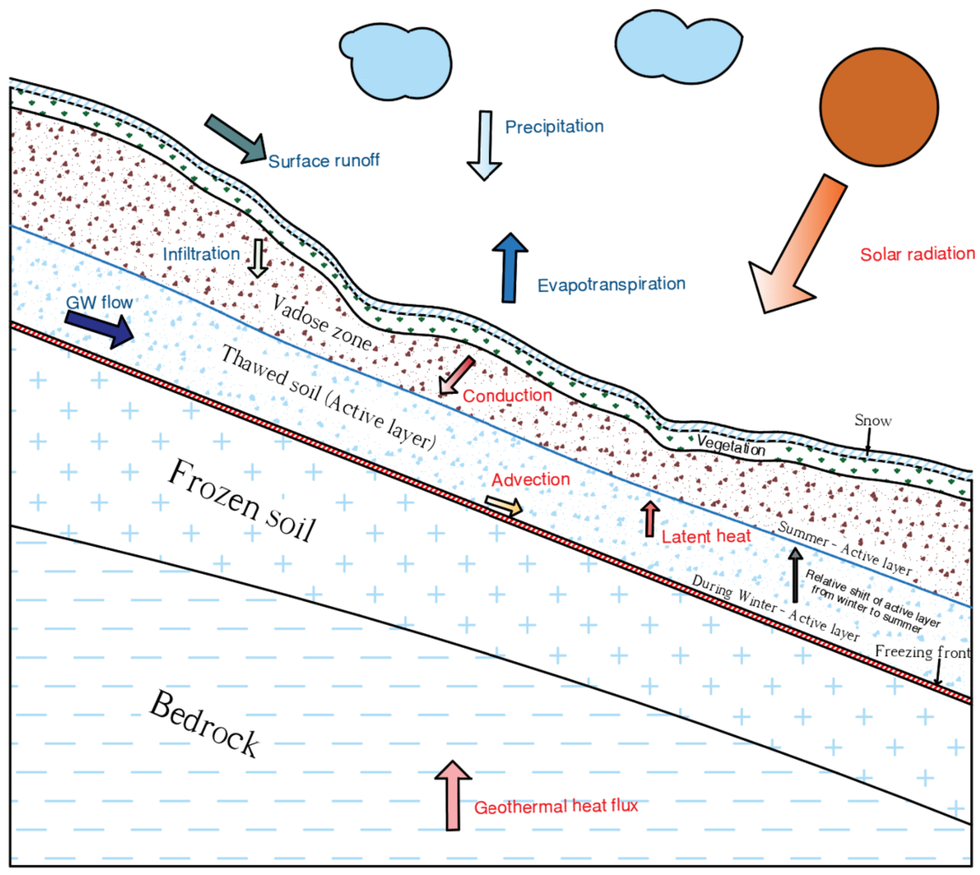
- Background knowledge - Hydrogeology and Numerical methods in fluid mechanics.
- Basic programming knowledge.

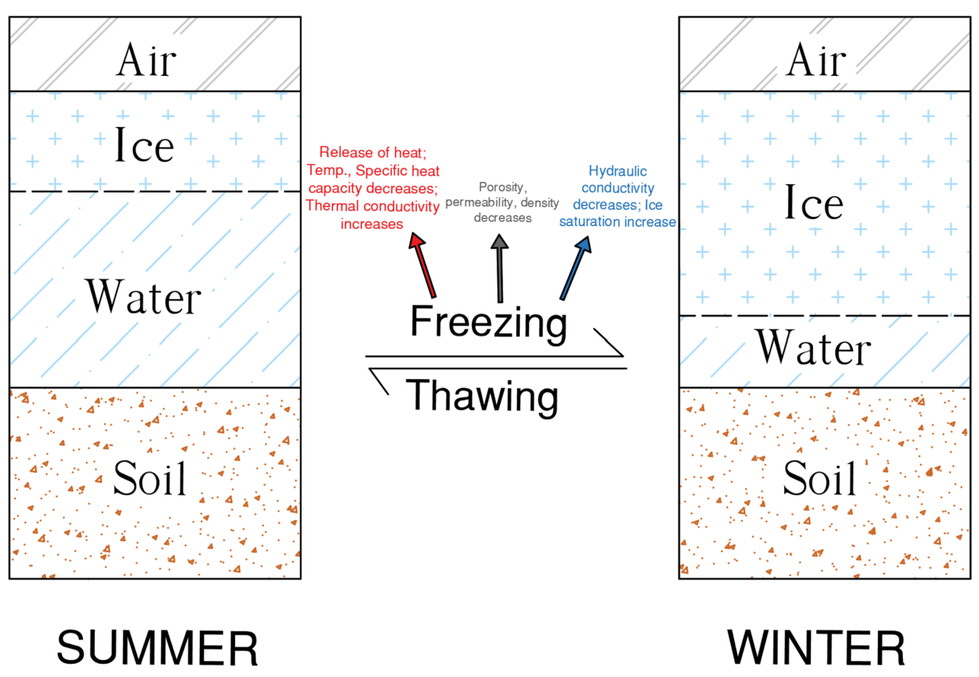
Contact Information

- radhakrishna@hydromech.uni-hannover.de
- Institute of Fluid Mechanics and Environmental Physics in Civil Engineering

TransTiP Project

The IRTG "Geoecosystems in transition on the Tibetan Plateau" (TransTiP) is an international research training program which grants German and foreign students an international education within the cooperative environments of Technische Universität Braunschweig, Leibniz Universität Hannover and Friedrich Schiller University Jena. TransTiP project main research interests are on Sediment fluxes, Carbon fluxes, Water fluxes and water quality. Our project focuses on water fluxes on different scales in alpine catchments.





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[3] S. L. Painter, E. T. Coon, A. L. Atchley, M. Berndt, R. Garimella, J. D. Moulton, D. Svyatskiy, and C. J. Wilson. Integrated surface/subsurface permafrost thermal hydrology: Model formulation and proof-of-concept simulations. *Water Resources Research*, 52(8):6062–6077, 2016.