Geophysical Research Abstracts
Vol. 21, EGU2019-5902, 2019
EGU General Assembly 2019

Cryohydrogeologic systems analysis using numerical simulation

Clifford Voss
US Geological Survey, Water Mission Area, United States (cliff.voss@gmail.com)

Numerical simulators developed over recent years have the capability of simulating the physical subsurface processes that occur in cold regions associated with flow of water through geologic fabrics containing seasonal or permanent subsurface ice. These are the powerful tools required for analyses that develop basic understanding of cryohydrogeologic processes and to help understand possible impacts of human activities and infrastructure and changes in climate on water quantity, water quality, surface morphology, and ecosystems. One of the earliest-developed cryohydrogeology simulation tools is the U.S. Geological Survey (USGS) SUTRA saturated-unsaturated groundwater flow and energy transport code. SUTRA was first developed in the 1980's and was enhanced in 2006 to simulate saturated freeze/thaw processes and more-recently saturated-unsaturated freeze/thaw processes. This simulator is informally known as the SutraICE code, and it has been used in USGS cooperative projects with co-authors both within and outside USGS to study a variety of cold-regions systems in the ensuing years, as described below.

SutraICE has been employed to study seasonal ground ice in peatlands and bogs, groundwater discharge controlling fish habitats in streams (thermal refugia), groundwater discharge and baseflow in alpine watersheds (where quantity and timing may be impacted by climate change), and soil freezing dynamics at high latitudes. SutraICE has also been employed to study processes in permafrost terrains including lake formation and sub-lake taliks, permafrost-vegetation interaction, active-layer dynamics, groundwater flow and baseflow to streams, development of perennial thaw zones (taliks) and carbon mobilization potential, permafrost-groundwater-surface water relations and ecology in arctic water tracks, permafrost peatlands and bogs, climate change impacts on permafrost distribution and fate, and for basic studies of the dynamics of permafrost-groundwater processes. In addition, SutraICE is being used to study glaciers, firn and snow, focusing on firn aquifers in Greenland, and, meltwater recharge fate and ice-layer formation in firn. SutraICE also has had technological applications including freeze/thaw groundwater simulation code intercomparison and ground-truthing geophysical inversion approaches for defining subsurface ice content from electrical measurements.

These studies have provided basic new knowledge of cryohydrogeologic system dynamical behavior and have led to improved understanding of practical implications in a variety of cold-regions settings, highlighting the great value of numerical simulation approaches for cryohydrogeologic systems analysis.