Cold regions hydrology: Developments and simulations in WaSiM

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Arctic Hydrology
Permafrost
Hydrologically Active Layer

- Snow
- Lichen
- Forbs
- Sedges
- Grasses
- Shrubs
- Mosses
- Water table
- Cracks
- Permafrost temperature
- Air temperature
- Annual ice lenses
- Freezing front
- Perennial ice lenses
- Water movement
Discontinuous Permafrost

Hydrology

Mineral soil with gravel bars
Permafrost Change
Soil Freezing and Thawing

Richard’s equation with Van Genuchten’s moisture characteristics
Latent Heat Release

Latent heat change $\frac{dE}{dT}$

for a soil with different relative water contents (Theta)
blue: saturated, red: partly saturated

$\frac{dE}{dT}$ (x0.01K), Theta=0.5
$\frac{dE}{dT}$ (x0.01K), Theta=0.18

$\frac{dE}{dT}$ in J/m$^3$

temperature in °C
Changes in Conductivity

- Effective thermal conductivity depending on total water content and temperature
- Temperature dependent hydraulic conductivity

Graphs show the change in conductivity with temperature and water content.
Permafrost Temperatures

- Air temperatures
  - N-factors
  - Snow
- Bottom boundary grid
  - Temperatures
  - Heat flux
- Initial temperature conditions
  - Linear
  - Spin up
Barrow Watershed Snow Distribution
Barrow Soil Moisture
Barrow Temperature Grids
Barrow Thaw Depth
Barrow Snow Temperature
Soil Temperature Time Series: Polygon Center

The graph shows time series data of soil temperatures at various depths (0.02m, 0.30m, 1.00m, 1.50m) measured at the polygon center from July 10, 2012, to December 27, 2014. The data points indicate fluctuations in temperature over time, with specific dates marking key data points.

- **VATP1_0.02m_center**
- **VATP1_0.30m_center**
- **VATP1_1.00m_center**
- **VATP1_1.50m_center**

The y-axis represents temperature in degrees Celsius, ranging from -40 to 20, while the x-axis represents time from July 10, 2012, to December 27, 2014.
Soil Temperature Time Series: Polygon Rim
Soil Temperature Time Series: Polygon Trough
Large Arctic Watersheds with Lakes

Surface routing efficiency
New Developments

Collapsing ground

Two aquifer systems in permafrost
Questions?