Configuration Uncertainty in Permafrost Modeling

Andrew G Slater
Arctic Modeling

…stressed that all of these models "are perfectly valid representations of what's going on in the Arctic."

“some models have more sophisticated representation of the biophysical processes important in the Arctic than others”
Range of Near-Surface Permafrost Area (1900-2100)

Slater & Lawrence (2013)
Soil Model Structure

- Number of layers
- Size of layers
- Phase change
- Numeric methods
- Time step

Slater & Lawrence (2013)
Two Example Sites

Mauze Gulch

Betty Pingo

Google Maps
Soil Surface Temperature

Betty Pingo: 70.27N, -148.88E

Soil Surface Temperature (°C)


NSIDC
Mauze Gulch

Photo: WERC, UAF
Soil Surface Temperature

Mauze Gulch: 65.46N, -164.64E

Soil Surface Temperature (°C)

Year

Experiment Set-up

- 95% saturation to 4.5m
- Bedrock 4.5m to ?
- 1000yr spin-up (1950-1959)
- UBC = Soil Surf. Temperature
- LBC = Zero Flux

\[ T = T_t \]

\[ \frac{dT}{dz} = 0 \]
Dealing with Phase Change

• No Phase Change

• Supply & Demand
  ▪ Overshoot 0°C

• Apparent Heat Capacity
  ▪ -1°C to 0°C = Lf

• Freezing Characteristic Curve
End of Spin-up
Betty Pingo: No Phase Change

Thaw of Near-Surface Permafrost at Betty Pingo: No Phase Change

IDEAL
CCSM4
INMCM4
MIROC5
MRI
GFDL
MPI
CANESM2
GISS
BCC
HADGEM2
ERA

Crank
Implicit

Year

NSIDC
National Snow and Ice Data Center
Betty Pingo: Supply & Demand

Thaw of Near-Surface Permafrost at Betty Pingo: Supply & Demand

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Year
1950
2000
2050
2100
Betty Pingo: Apparent Heat Capacity

Thaw of Near-Surface Permafrost at Betty Pingo: Apparent Heat Capacity

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1950  2000  2050  2100
Year

NSIDC
Mauze Gulch: No Phase Change

Thaw of Near-Surface Permafrost at Mauze Gulch: No Phase Change

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Year

1950  2000  2050  2100

Crank  Implicit

NSIDC - National Snow and Ice Data Center
Betty Pingo: Supply & Demand

Thaw of Near-Surface Permafrost at Mauze Gulch: Supply & Demand

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Betty Pingo: Apparent Heat Capacity

Thaw of Near-Surface Permafrost at Mauze Gulch: Apparent Heat Capacity

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‘Near-Surface’ Permafrost Layer

Soil Layer Thickness Closest to 3.5m

Soil Depth (m)

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Thaw Year: Numerics vs Phase Parameterization

Difference in Thaw Year Mauze Gulch

Difference in Thaw Year Betty Pingo

Thaw Year Difference due to Phase Change (Years)

Thaw Year Difference due to Numerics (Years)
Conclusions

• Deeper column acts as greater heat sink
  ▪ Ideally greater than zero annual amplitude

• ~20yr difference in Near Surface Permafrost

• Numerics as important as parameterization

• Greater sensitivity closer to phase temperature
  ▪ Thermal inertia of layer plays a role