NGEE Arctic
Next-Generation Ecosystem Experiments

Landscape structure and thermal-hydrology, Q1&Q5

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U.S. DEPARTMENT OF ENERGY | Office of Science

OAK RIDGE National Laboratory

Los Alamos NATIONAL LABORATORY

BERKELEY LAB

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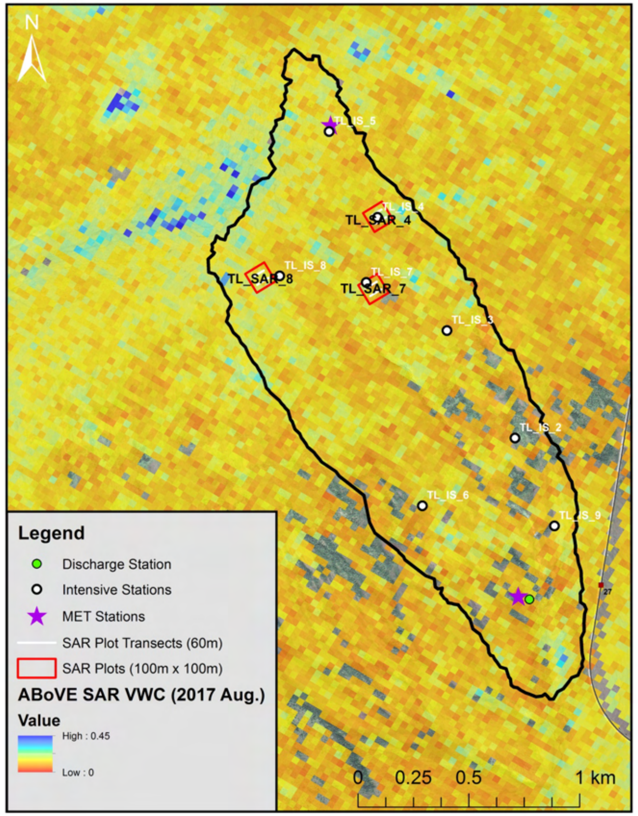
UNIVERSITY OF ALASKA FAIRBANKS

Q1 & Q5 Phase 3 Overarching Goal

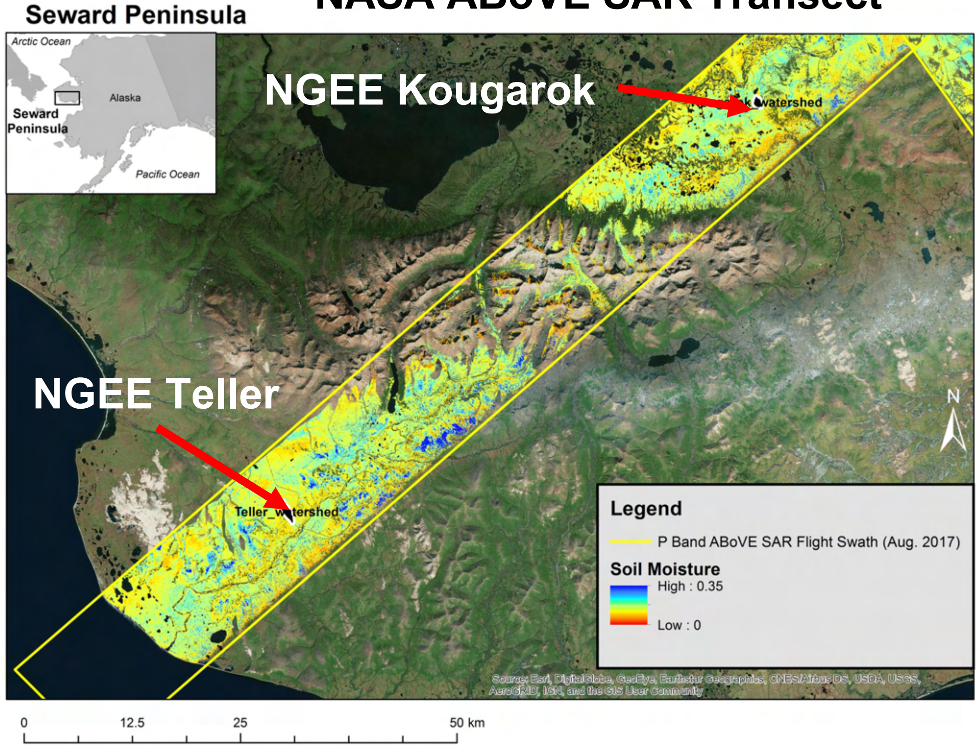
Improve the understanding and representation of the structure and properties of the landscape, its thermal-hydrological processes, and their interactions with ecosystem function across scales.

Teller Site TL_SAR_41

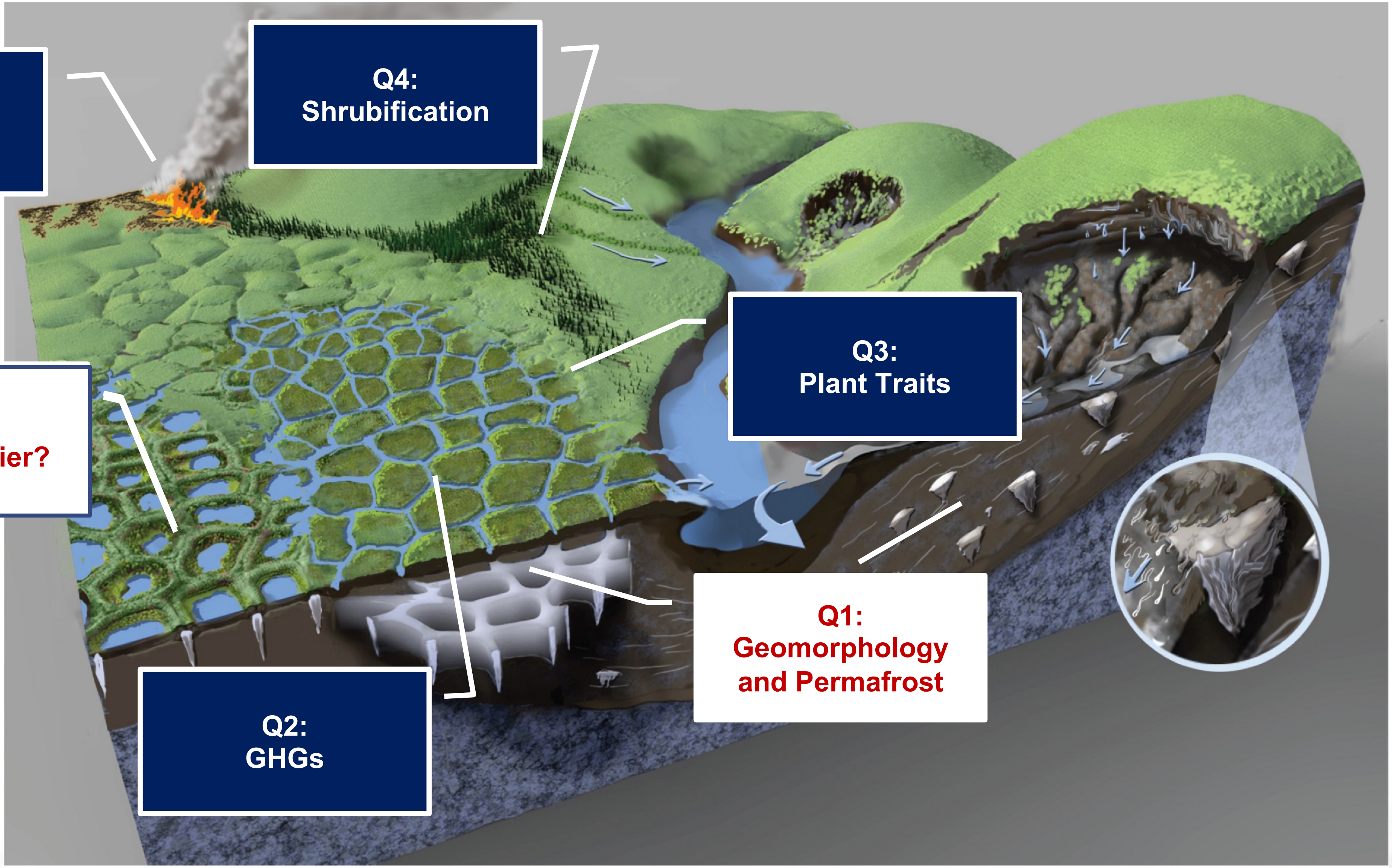
Teller Site



NASA ABoVE SAR Transect



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**Q6:
Disturbance**

**Q4:
Shrubification**

**Q3:
Plant Traits**

**Q5:
Wetter or Drier?**

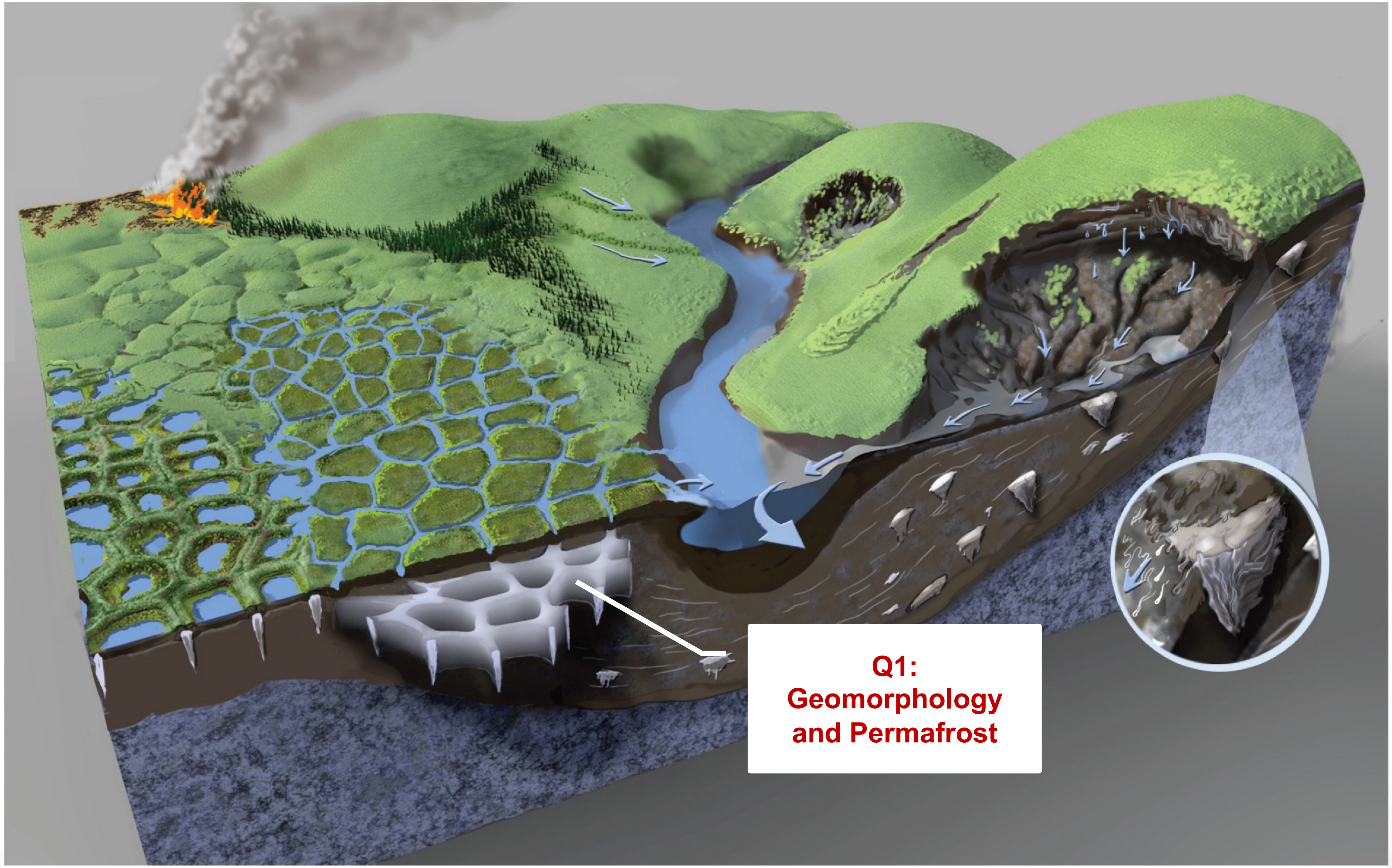
**Q1:
Geomorphology
and Permafrost**

**Q2:
GHGs**

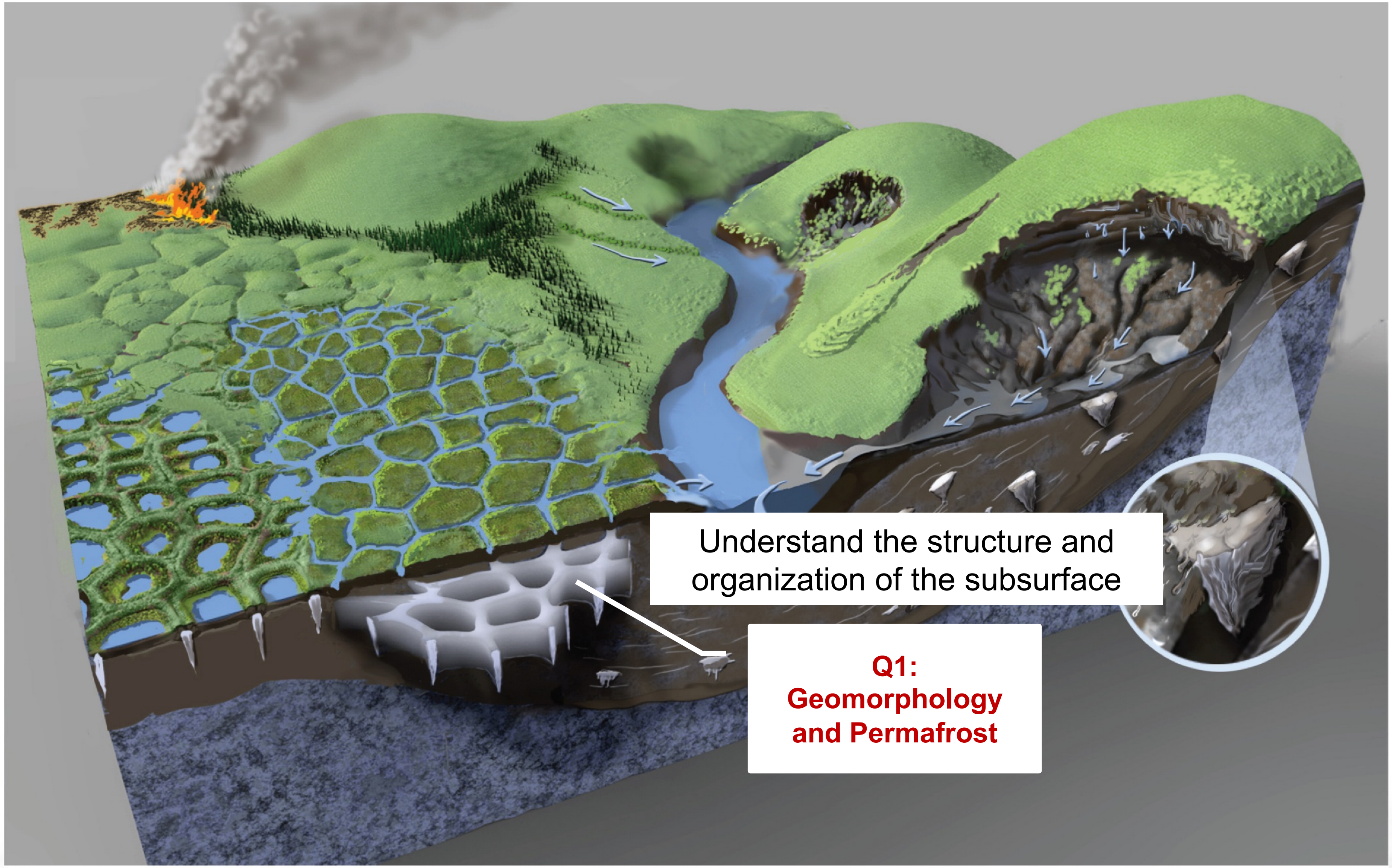
Schuur EAG, Mack MC. 2018.
Annu. Rev. Ecol. Evol. Syst. 49:279–301

Question 1

- How does the structure and organization of the landscape control permafrost evolution and associated C and nutrient fluxes in a changing climate?



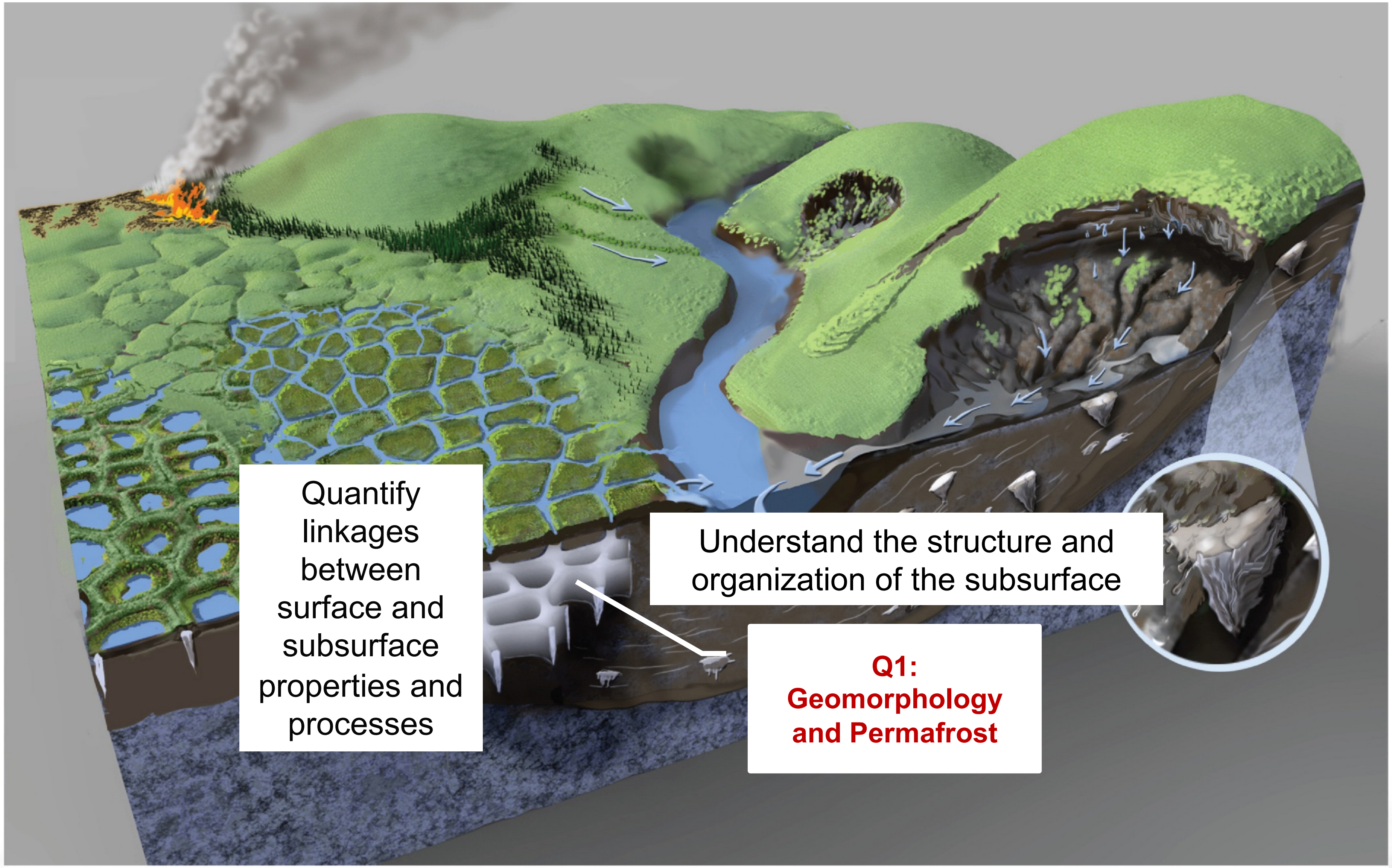
Schuur EAG, Mack MC. 2018.
Annu. Rev. Ecol. Evol. Syst. 49:279–301



Understand the structure and organization of the subsurface

Q1: Geomorphology and Permafrost

Schuur EAG, Mack MC. 2018.
Annu. Rev. Ecol. Evol. Syst. 49:279–301



Quantify linkages between surface and subsurface properties and processes

Understand the structure and organization of the subsurface

Q1: Geomorphology and Permafrost

Schuur EAG, Mack MC. 2018.
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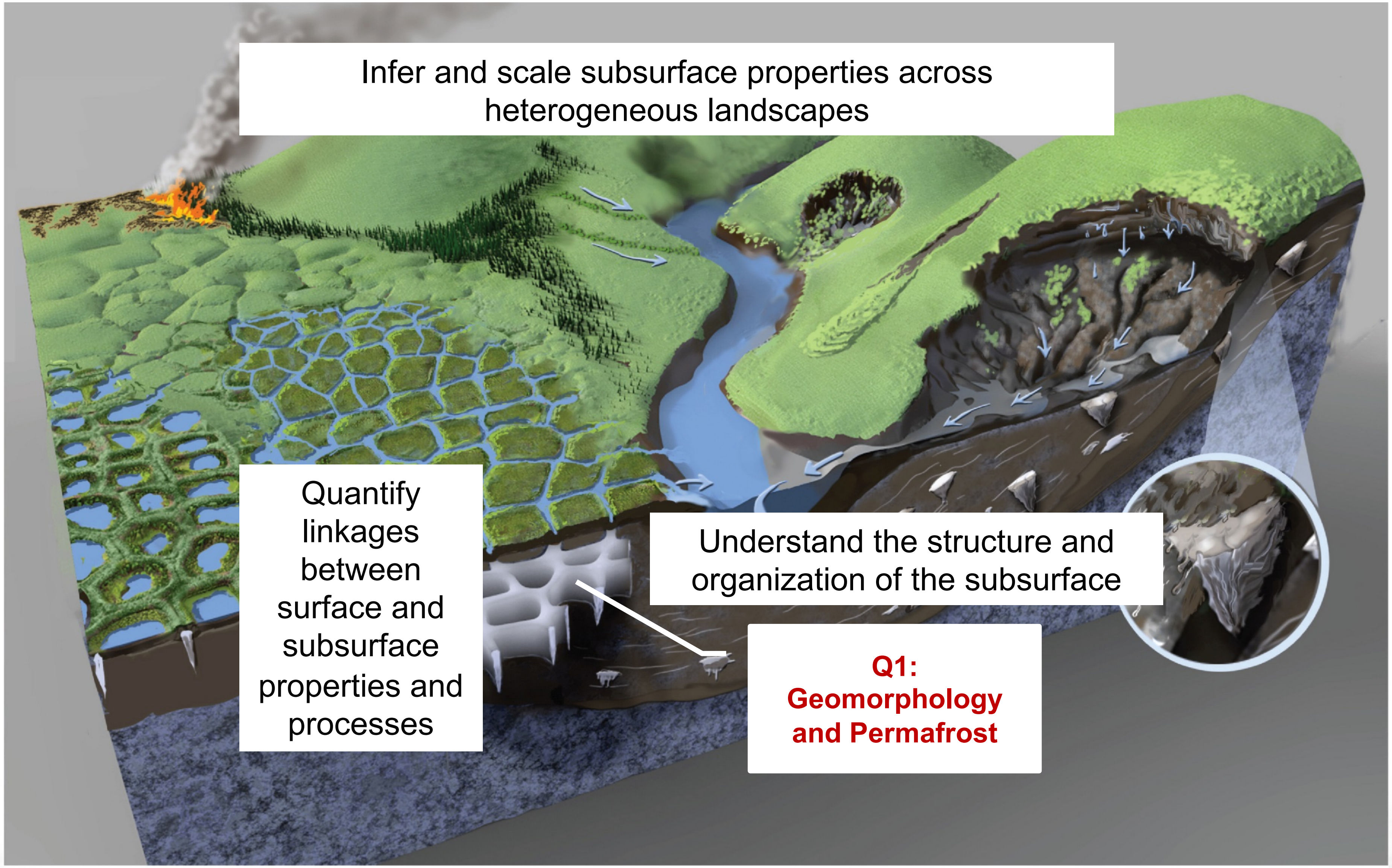

Infer and scale subsurface properties across heterogeneous landscapes

Quantify linkages between surface and subsurface properties and processes

Understand the structure and organization of the subsurface

Q1: Geomorphology and Permafrost

Schuur EAG, Mack MC. 2018.
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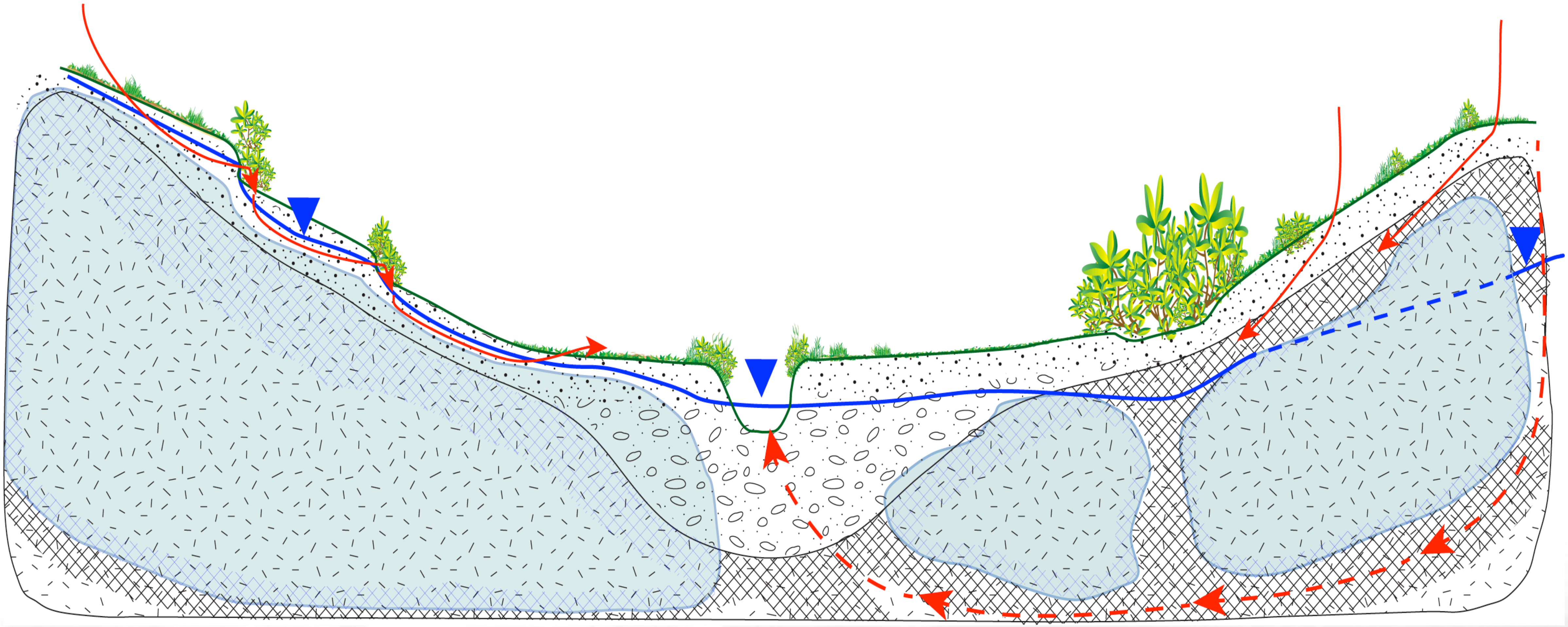
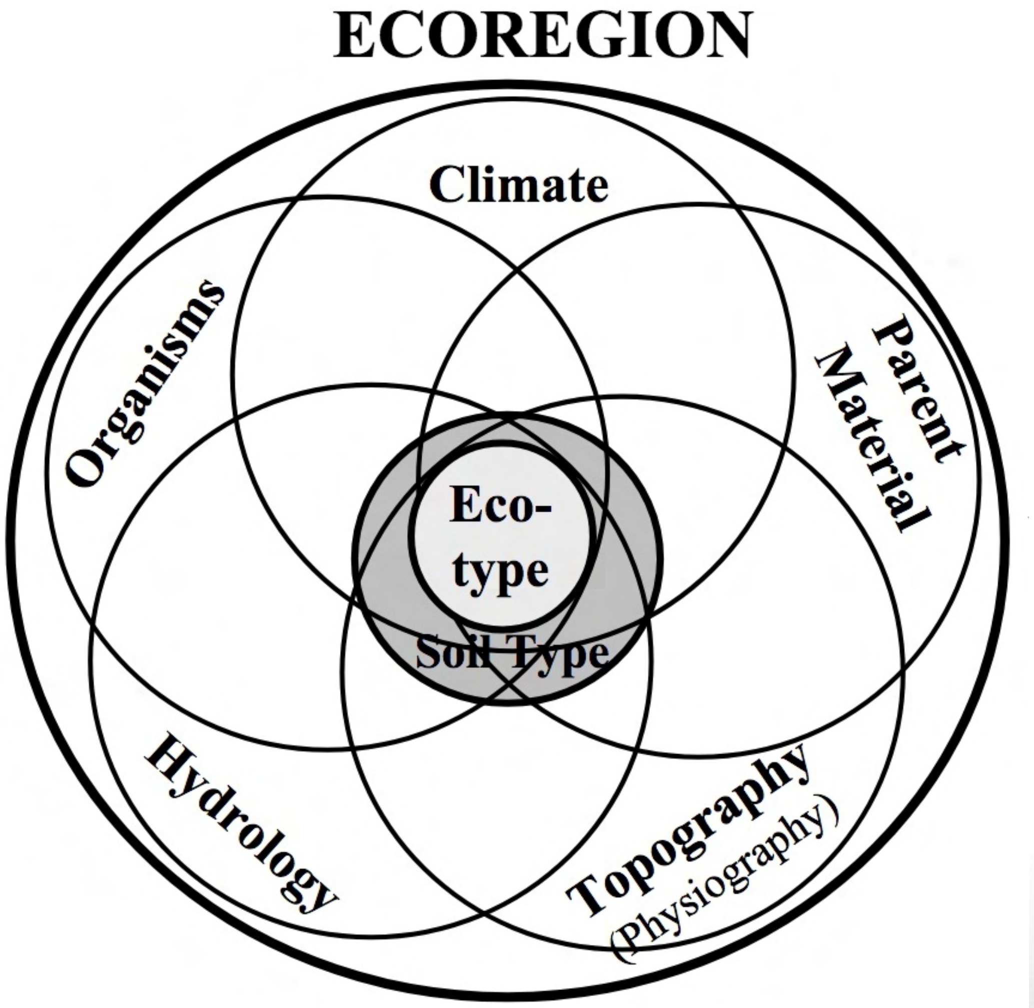
Large heterogeneity and uncertainty in the subsurface influences system processes and evolution



We use an ecosystem-type approach as the foundation for understanding and scaling heterogeneity in the subsurface



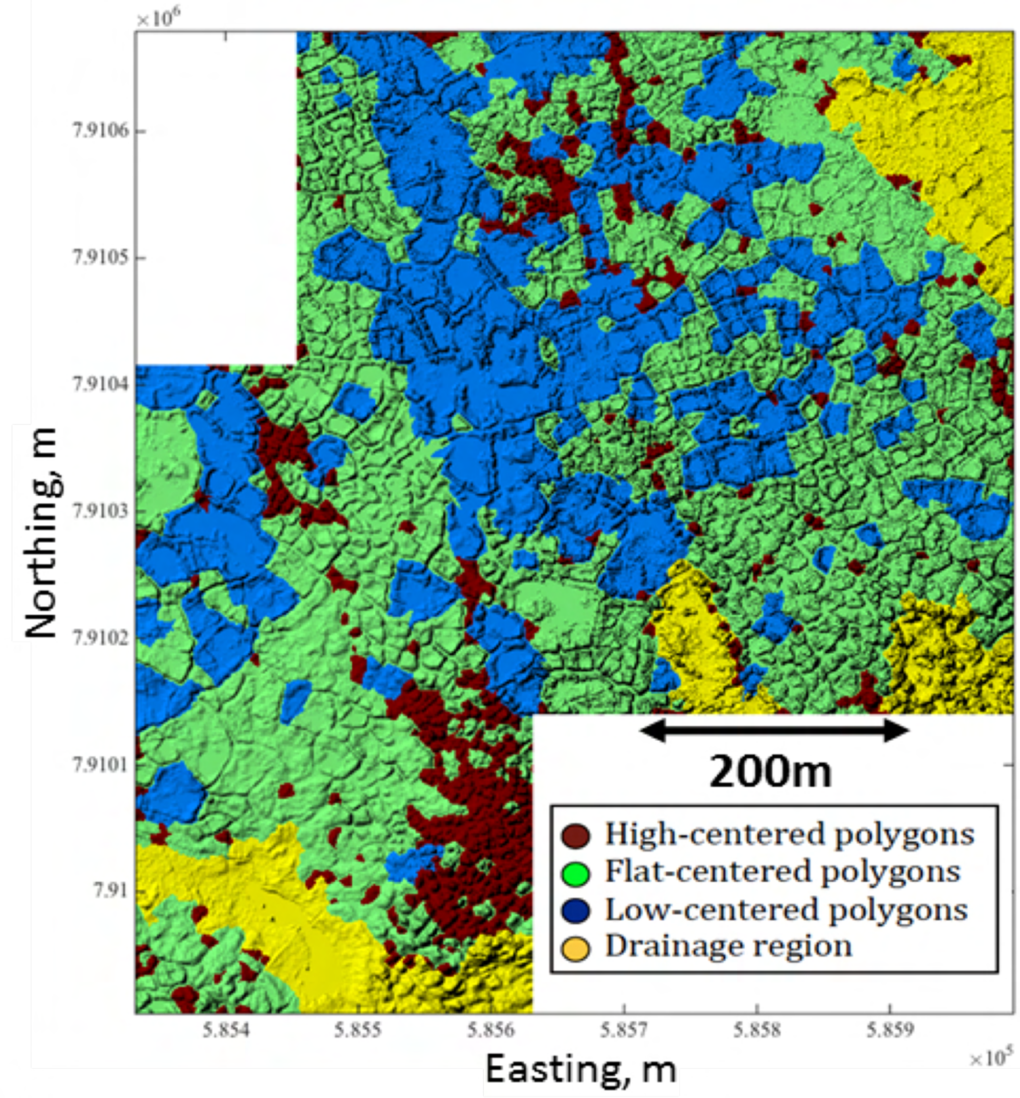
An Ecological Land Survey and Landcover Map of the Arctic Network

Jorgenson et al.

Natural Resource Technical Report NPS/ARCN/NRTR—2009/270

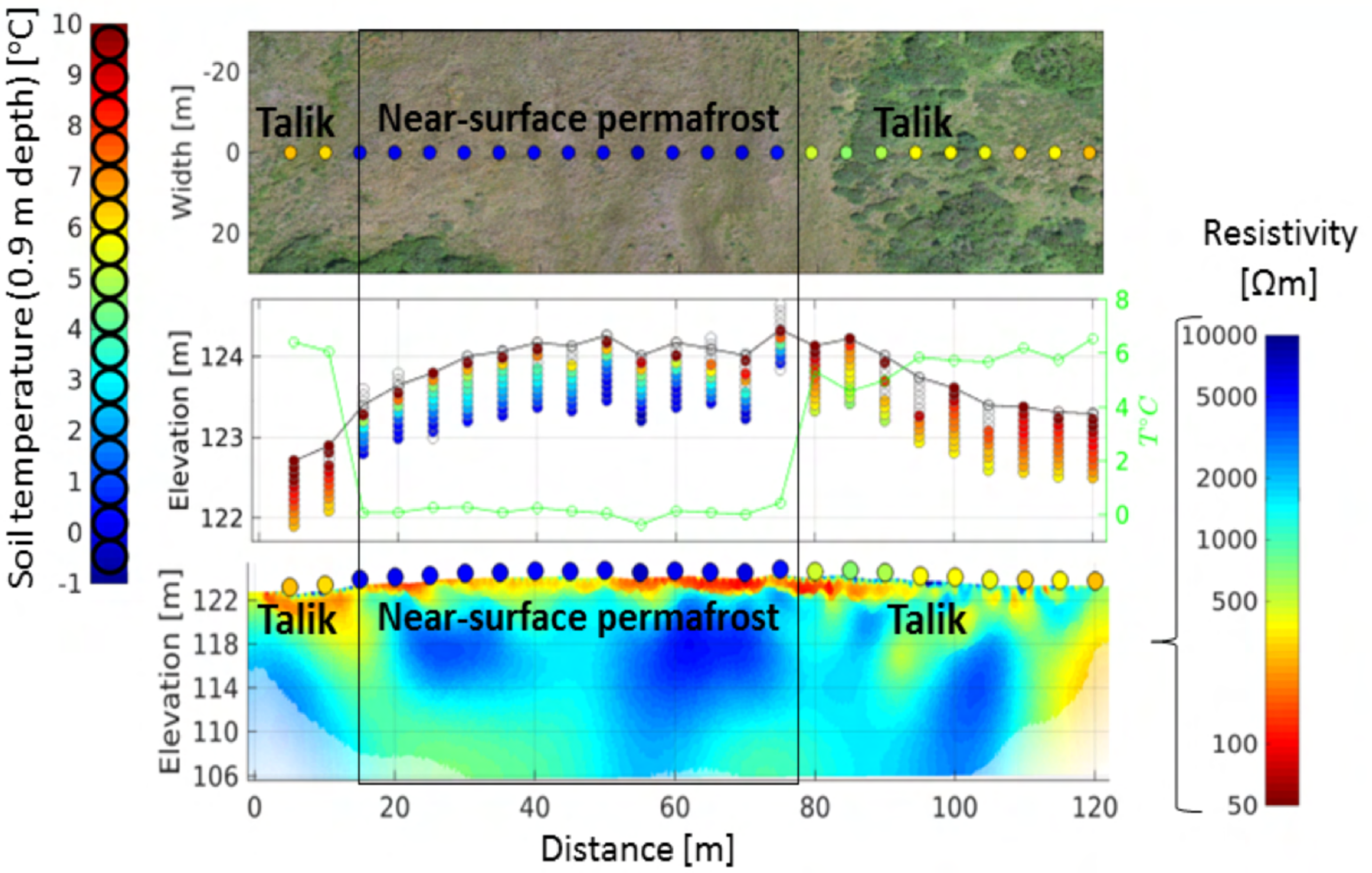
In Phase 2, we quantified relationships between micro-topography and ecosystem processes at Utqiagvik Poster 3

Wainwright et al., 2015; Liljedahl et al., 2016; Dafflon et al., 2017; Tran et al., 2017; Grant et al., 2017; Tas et al., 2018; Abolt et al. 2019



In Phase 2, we found strong relationships between vegetation, ground temperature and the state of near surface permafrost **Poster 3**

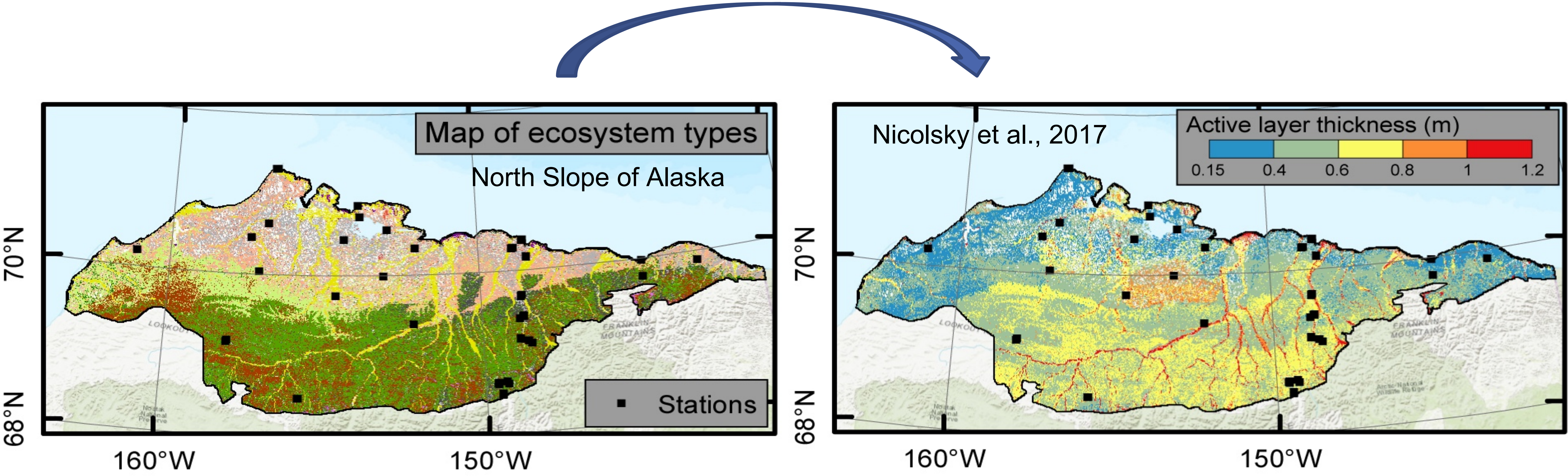
Seward Peninsula- Hilly, warm permafrost, shrub tundra landscape



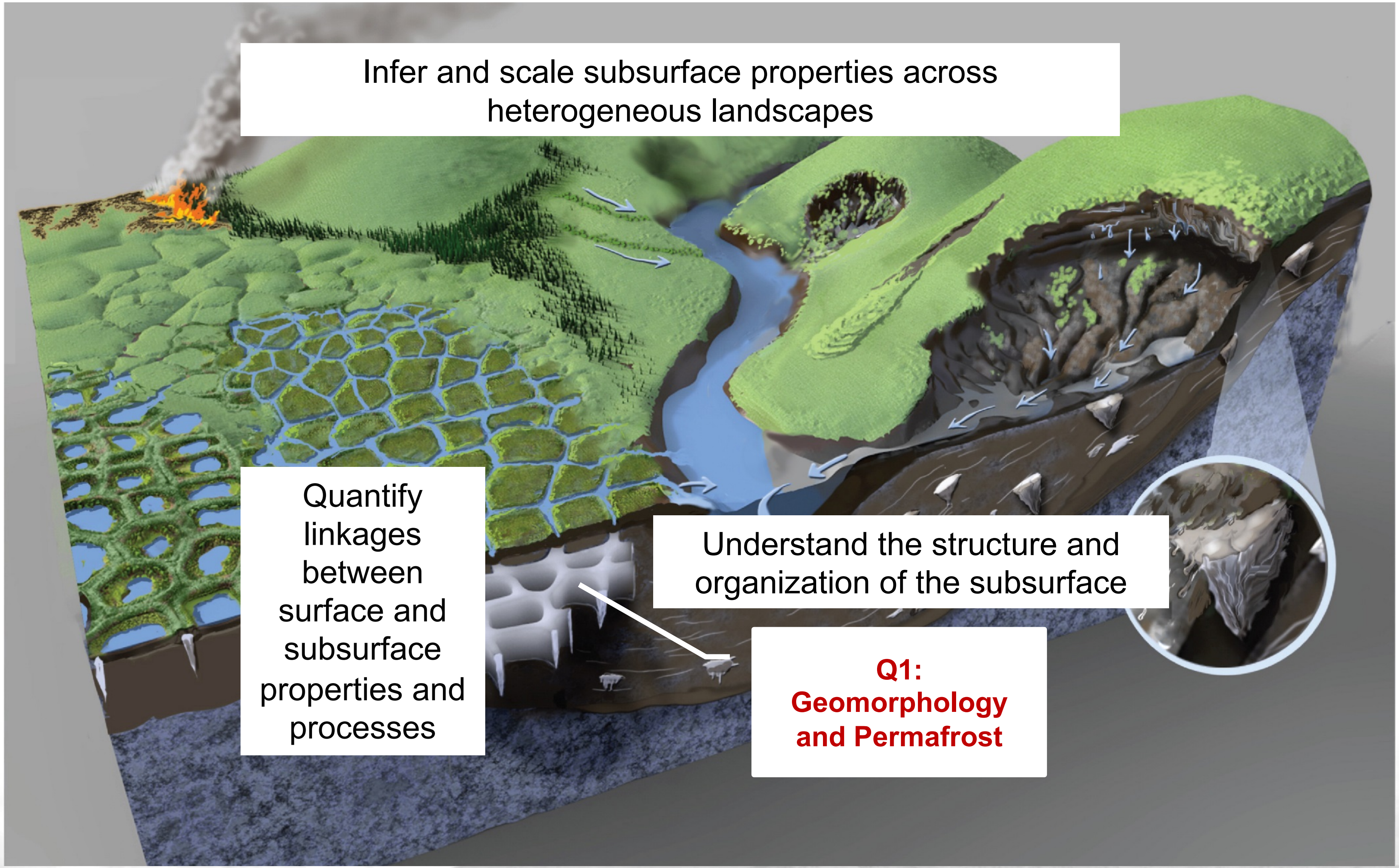
Teller Watershed

Leger et al., 2019

In Phase 2, we used an ecosystem-type approach to upscale soil thermal properties to predict permafrost dynamics



Q1 Phase 3



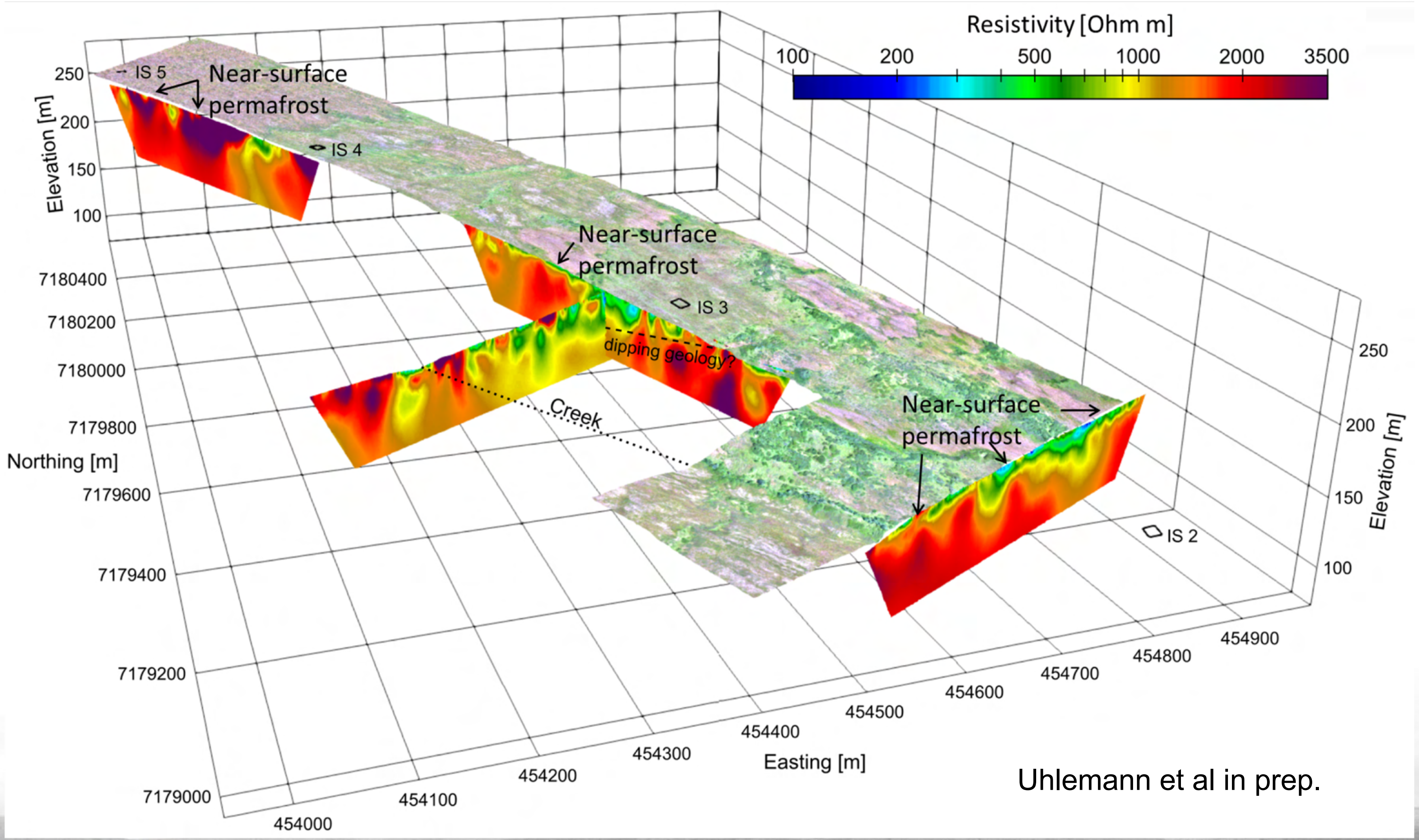
Infer and scale subsurface properties across heterogeneous landscapes

Quantify linkages between surface and subsurface properties and processes

Understand the structure and organization of the subsurface

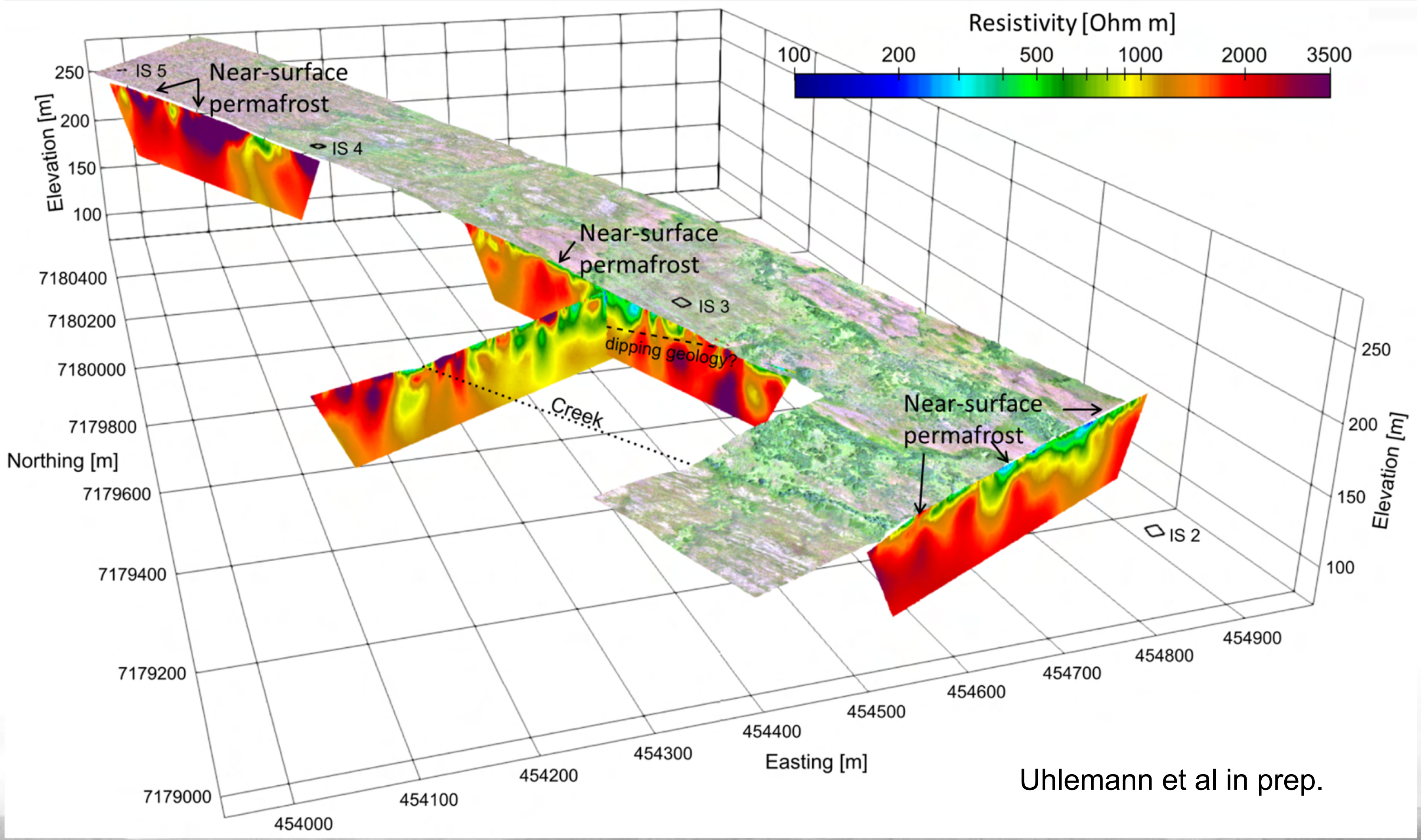
Q1: Geomorphology and Permafrost

Phase 3: Understand the structure and organization of soil, permafrost and bedrock properties and thermal behaviors



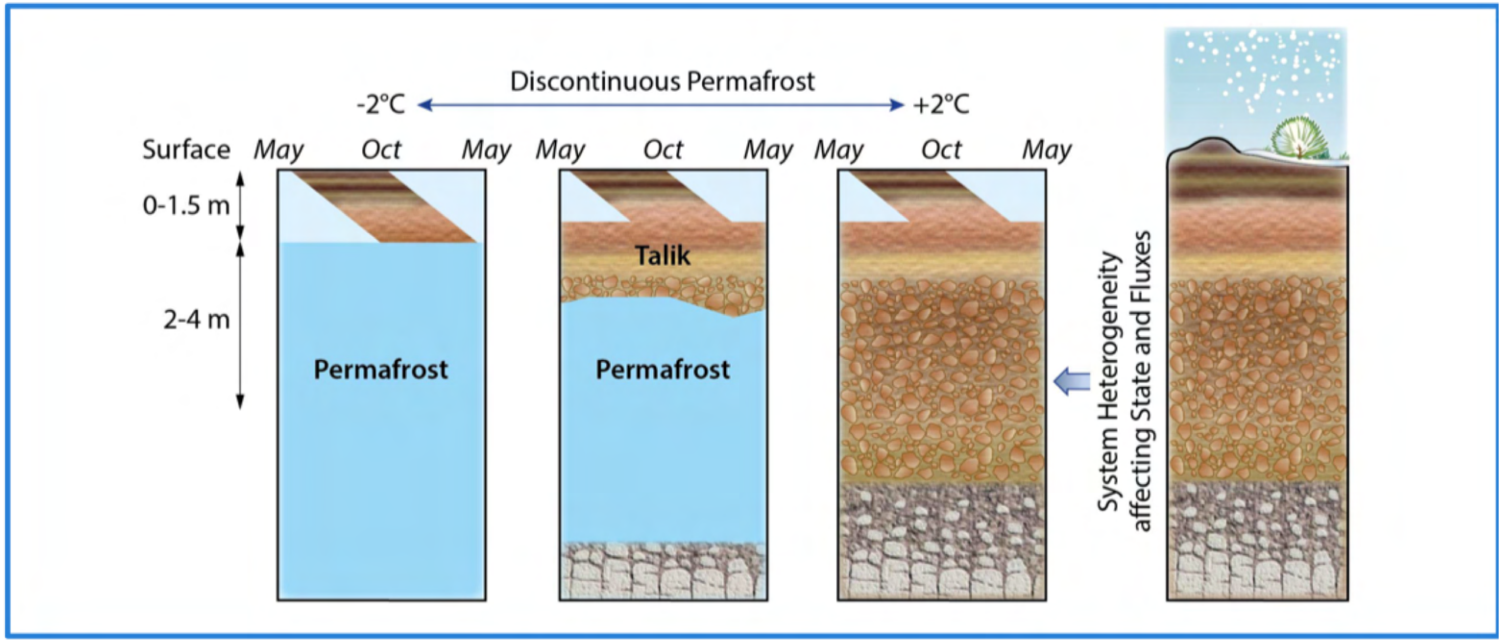
Uhlemann et al in prep.

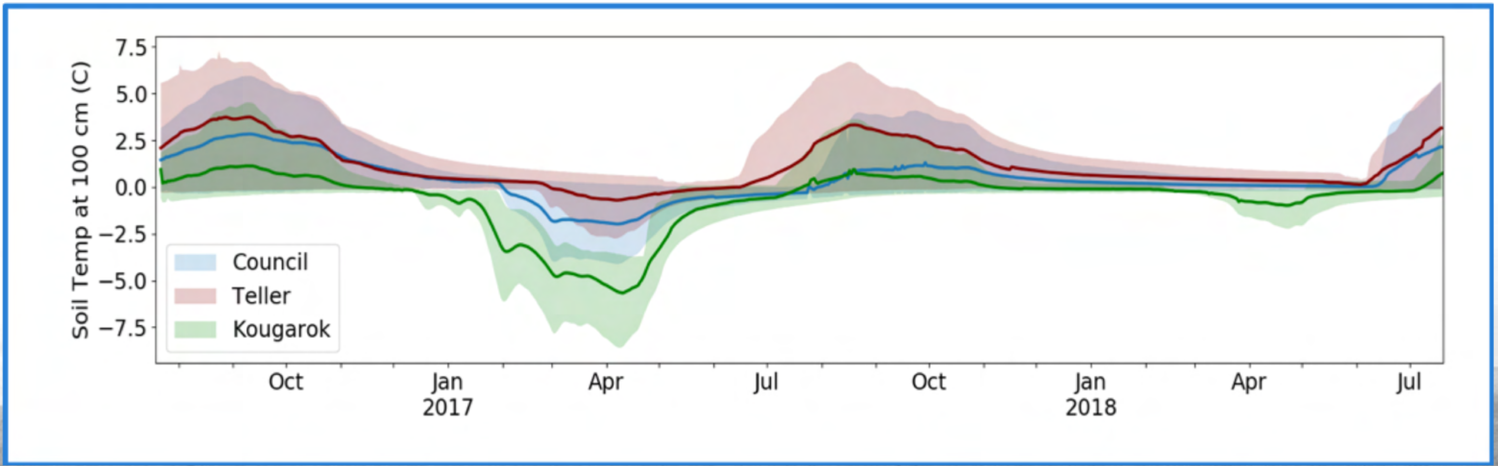
Phase 3: Quantify relationships between surface conditions and subsurface thermal properties



Uhlemann et al in prep.

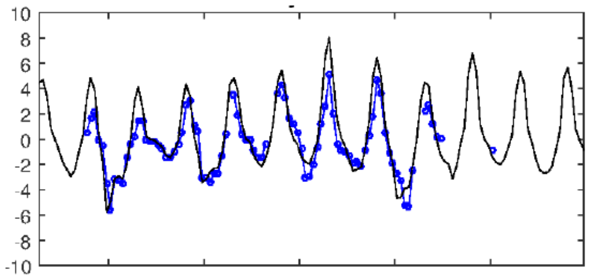
Phase 3: Understand controls on talik formation, its trajectory and influence on subsurface structure & process

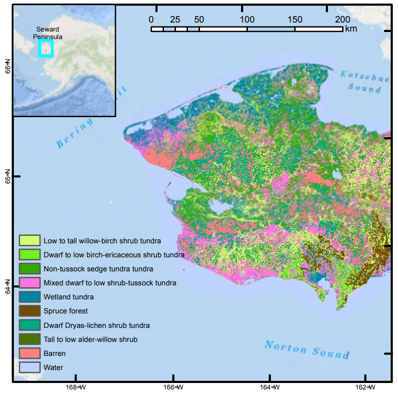




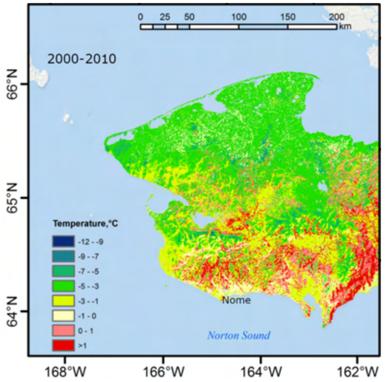
Phase 3: Extend ecosystem-type construct to the Seward Peninsula and evaluate its use for sub-grid properties in ELM

- Vegetation
- Micro climate
- Topography
- Soil properties
- Geology
- Data assimilation at monitoring sites





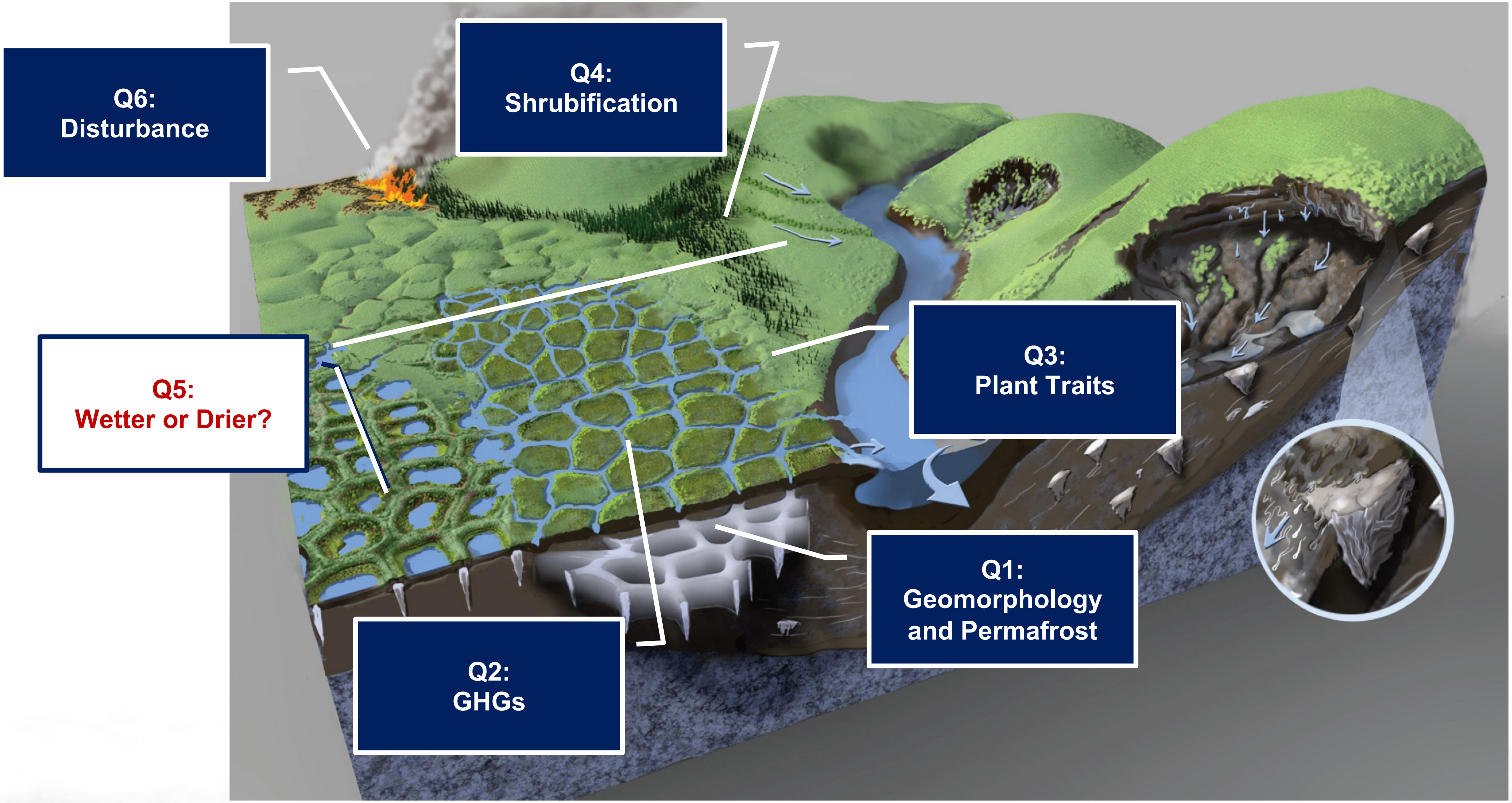
Ecosystem-types and parameters



High-resolution model prediction

Major Deliverables of Question 1:

- Improve predictive understanding of how subsurface (soil, bedrock and permafrost) characteristics co-vary with vegetation and topography at the watershed scale.
- Document the distribution and formation of talik areas, and their relationship to landscape heterogeneity and winter processes.
- Refine ecosystem-type definitions for discontinuous permafrost domains and development of ecosystem-type map of the Seward Peninsula to improve parameterization and decrease uncertainty in NGEE Arctic models.



Q6:
Disturbance

Q4:
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Q5:
Wetter or Drier?

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Q1:
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GHGs

Schuur EAG, Mack MC. 2018.
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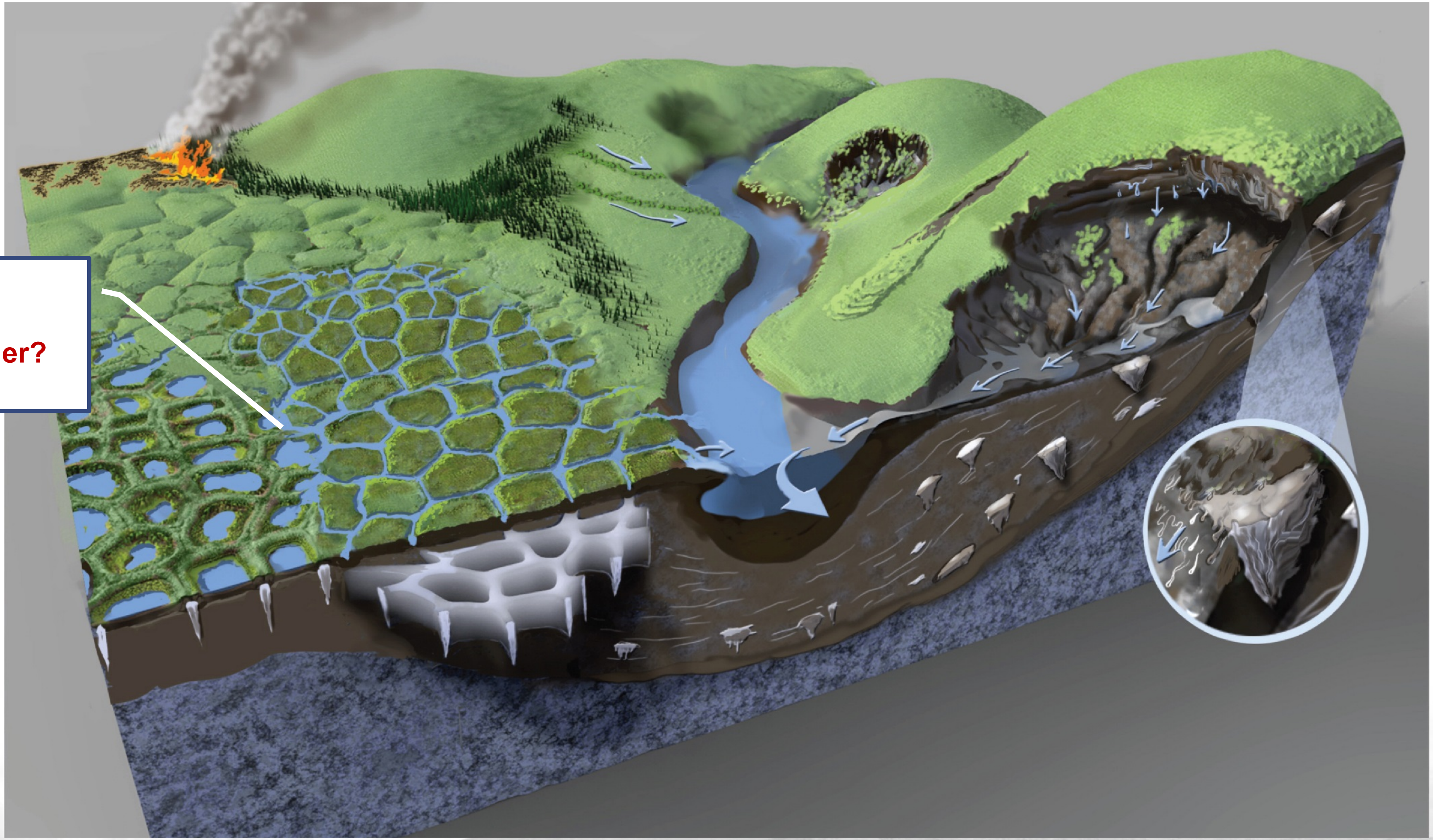
Question 5

Where, when, and why will the Arctic become wetter or drier, and what are the implications for climate forcing?

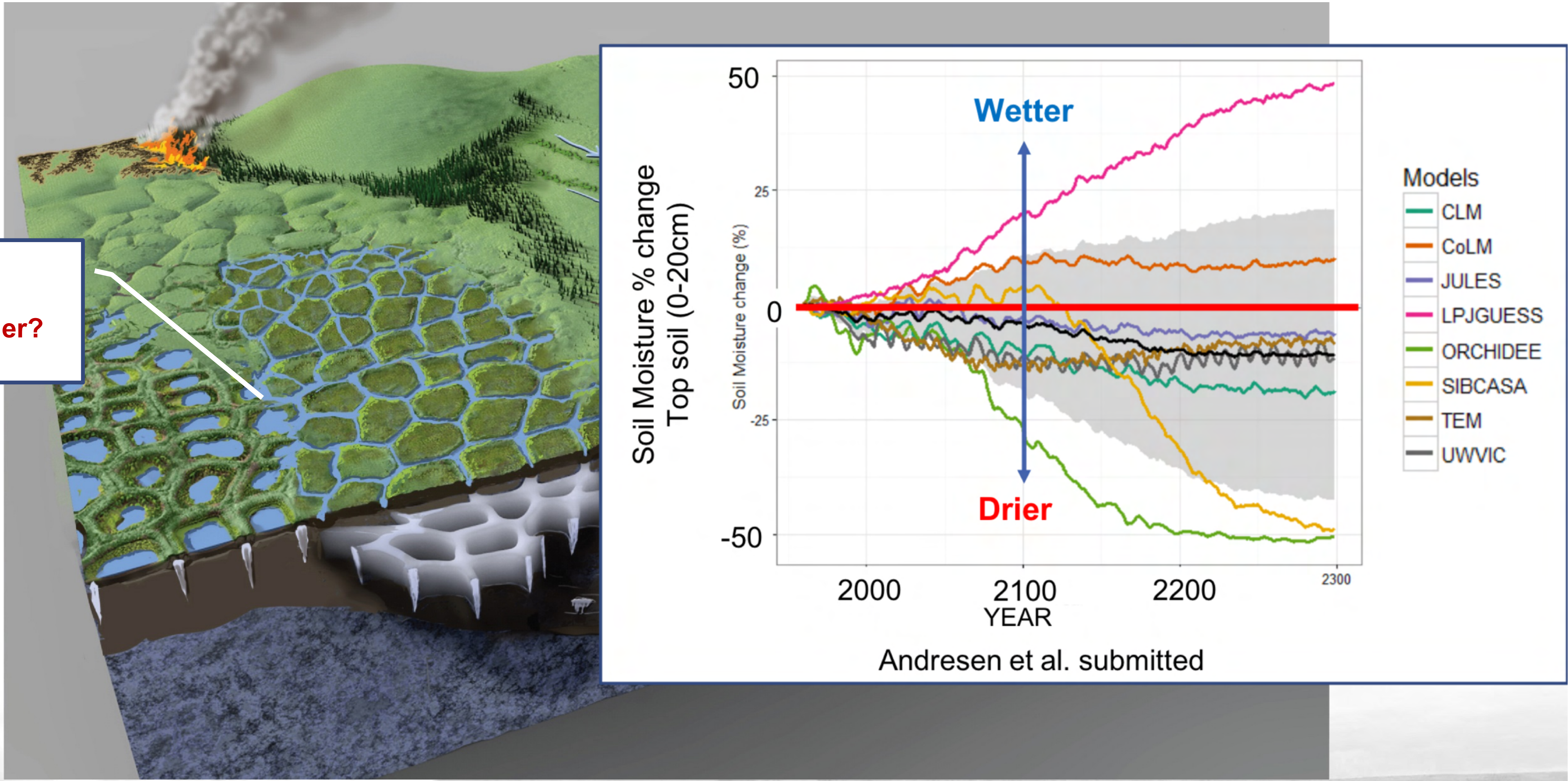
Improved representations of missing and poorly constrained processes for ELM



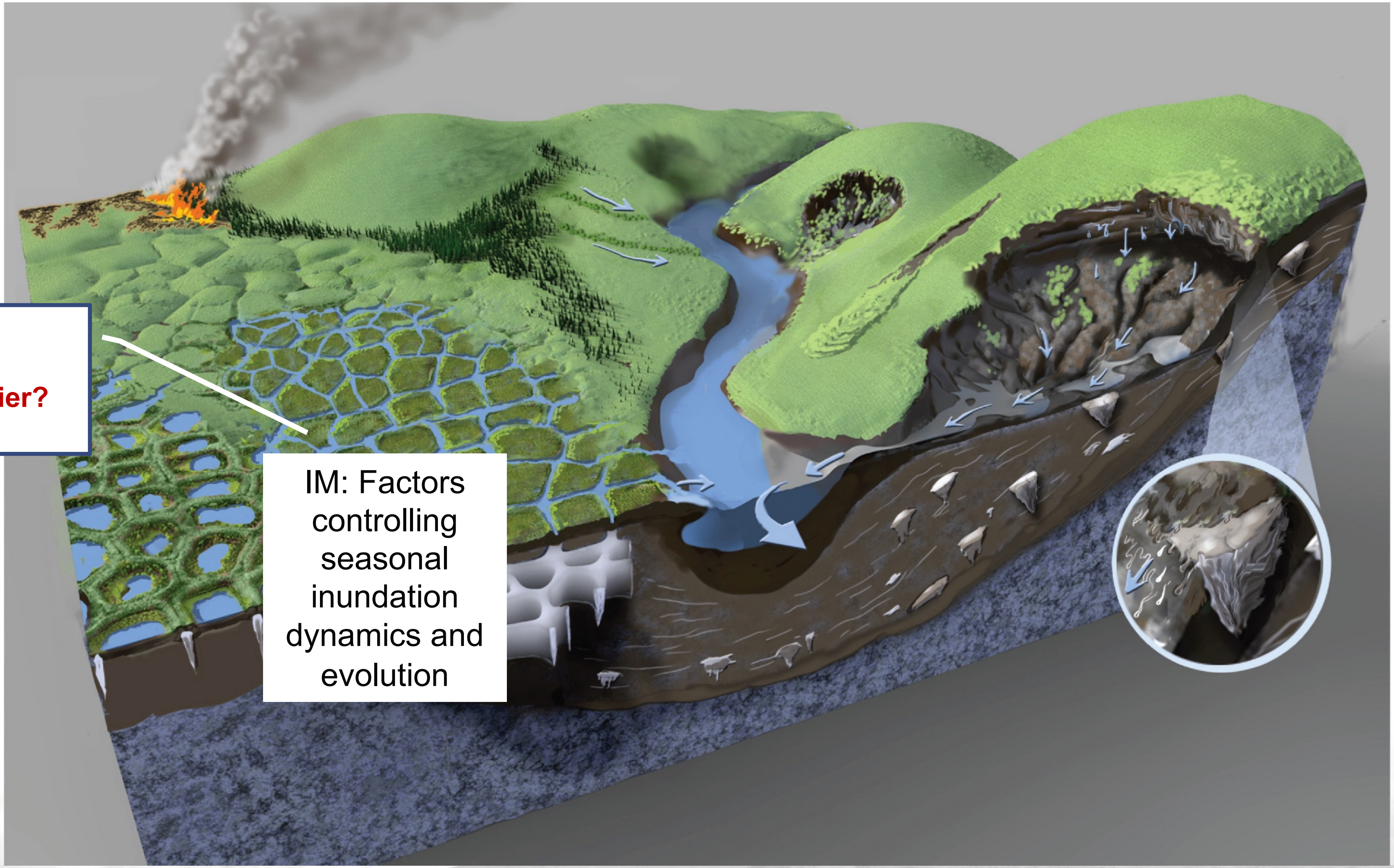
Q5:
Wetter or Drier?

Improved representations of missing and poorly constrained processes for ELM

Q5:
Wetter or Drier?

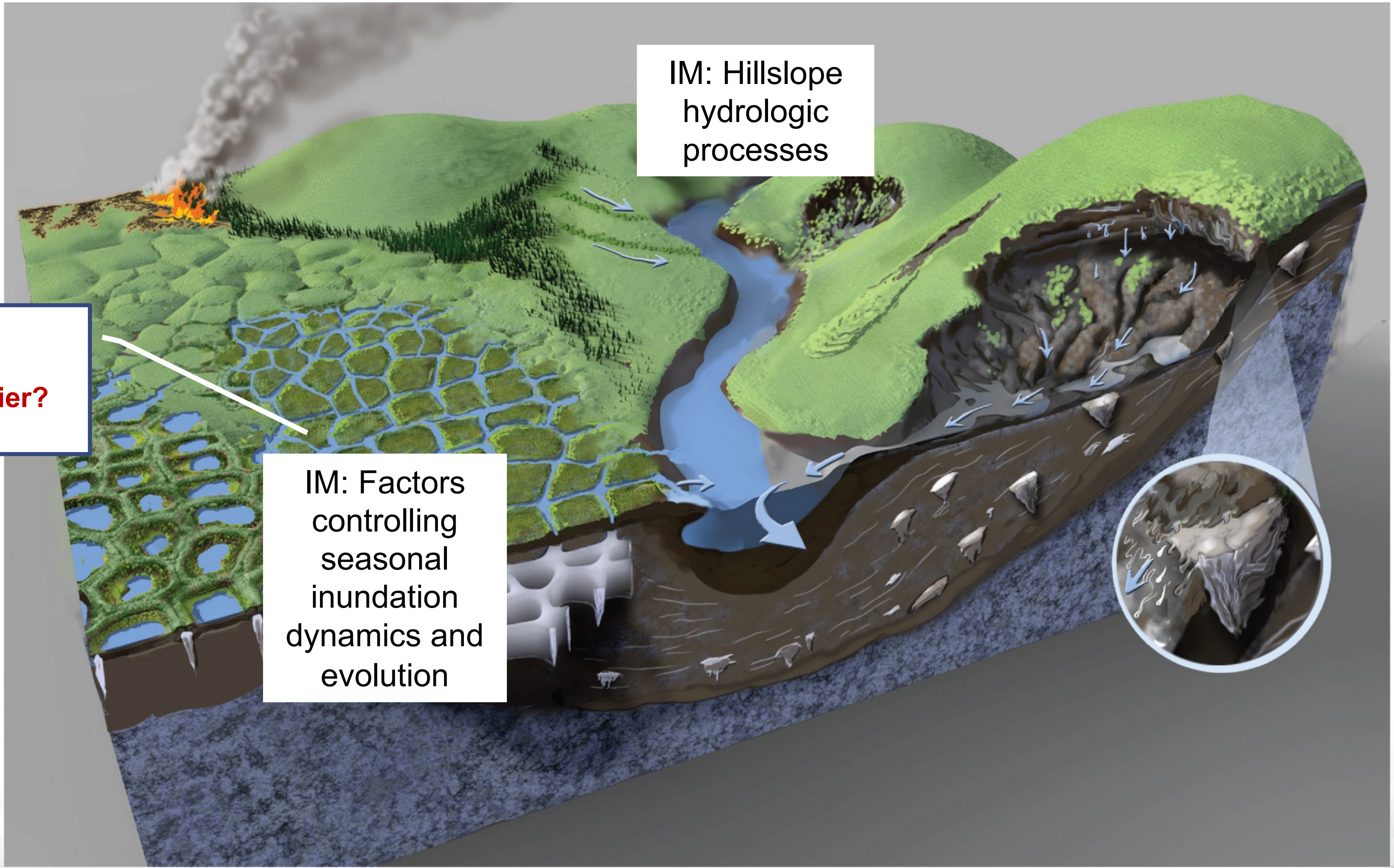


Andresen et al. submitted



Q5: Wetter or Drier?

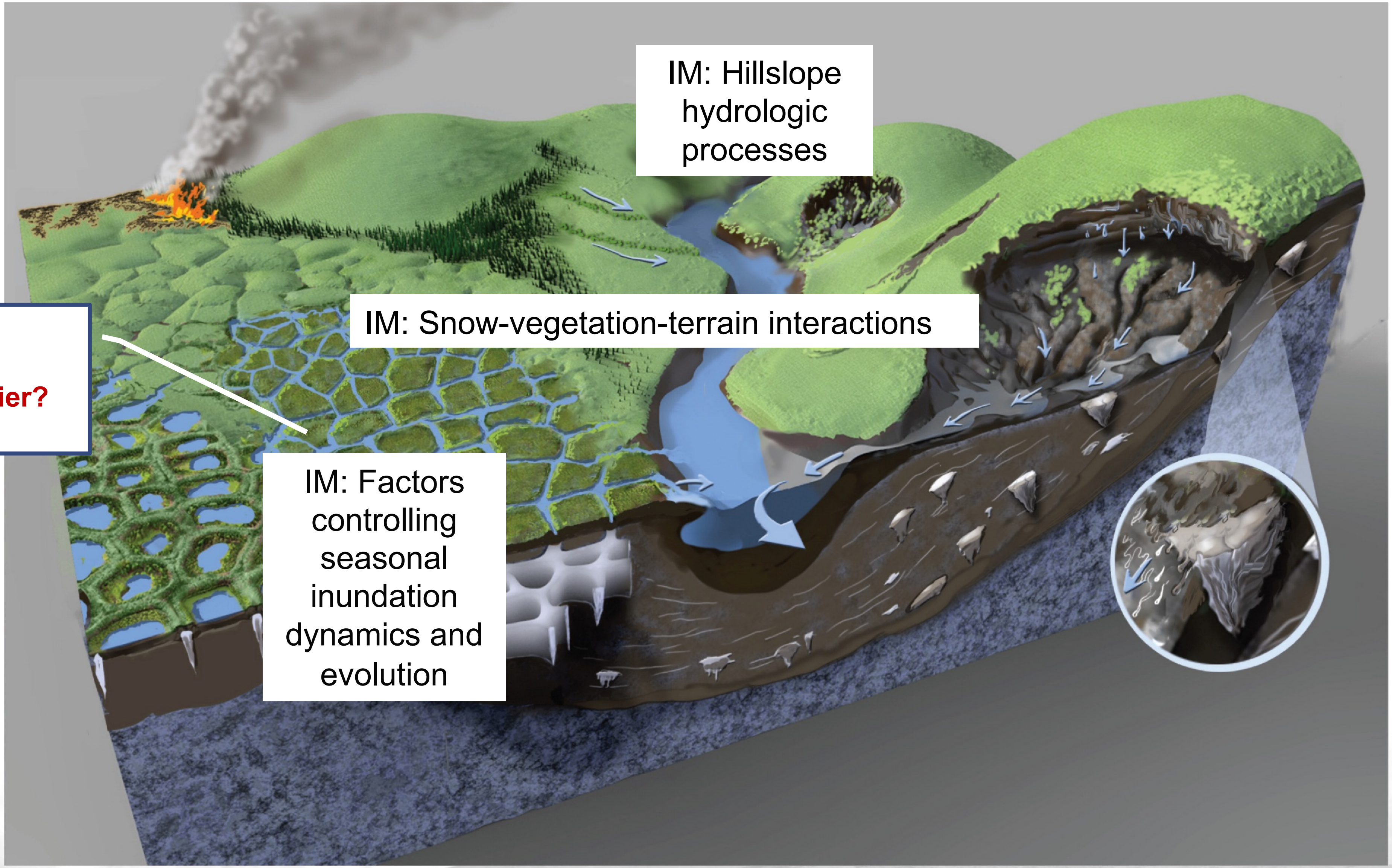
IM: Factors controlling seasonal inundation dynamics and evolution



IM: Hillslope hydrologic processes

Q5: Wetter or Drier?

IM: Factors controlling seasonal inundation dynamics and evolution



Q5:
Wetter or Drier?

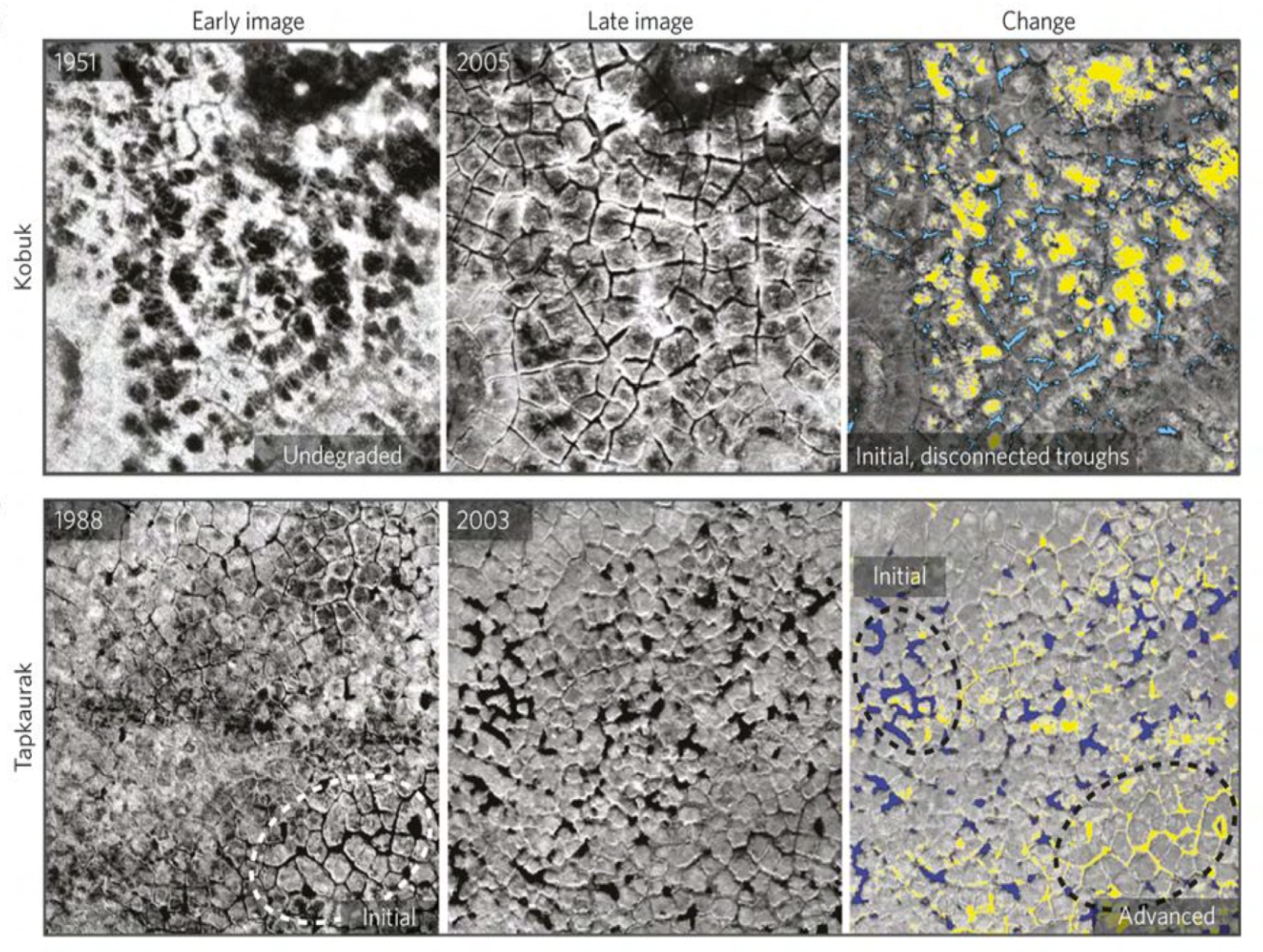
IM: Hillslope hydrologic processes

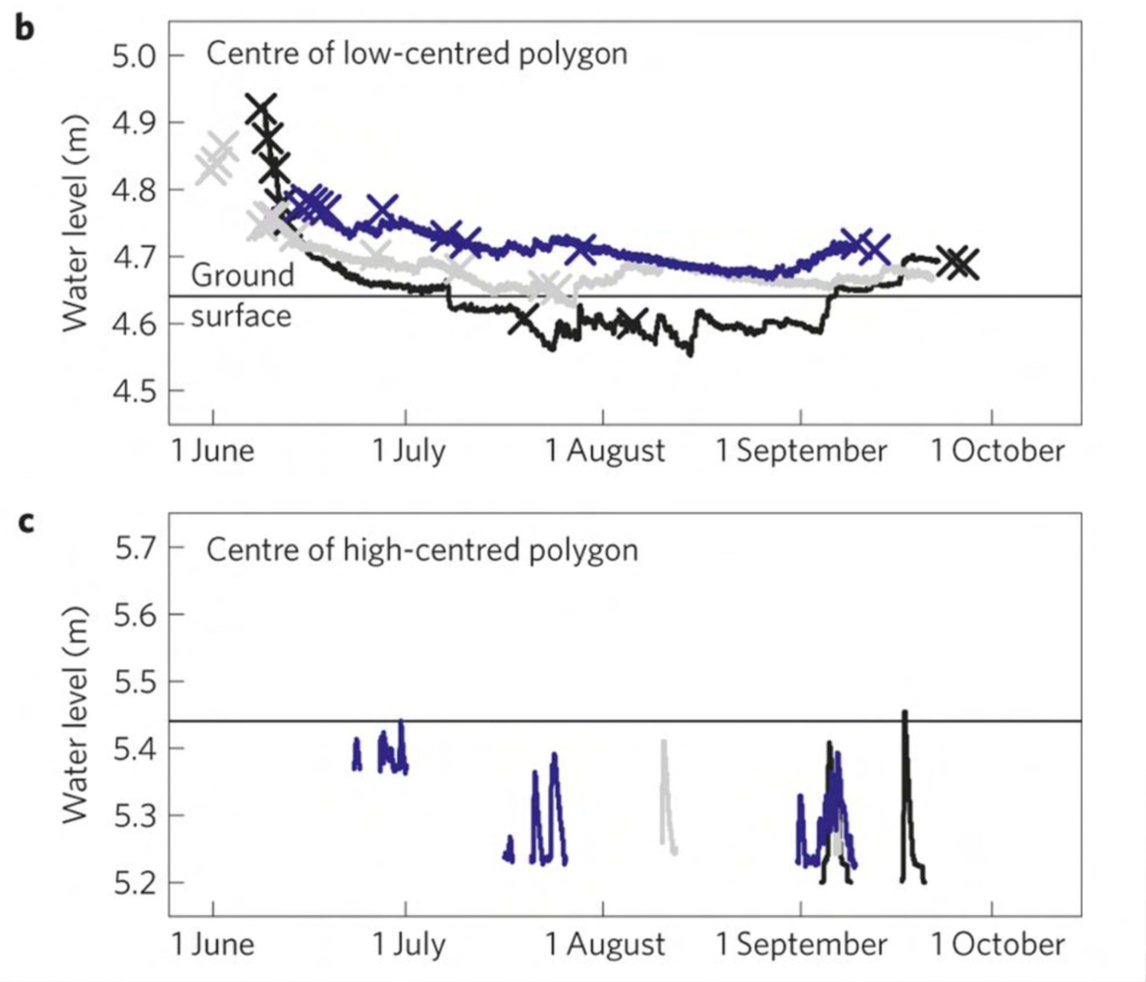
IM: Snow-vegetation-terrain interactions

IM: Factors controlling seasonal inundation dynamics and evolution

In Phase 2, we demonstrated the importance of ground subsidence in hydrologic behavior **Poster 9**

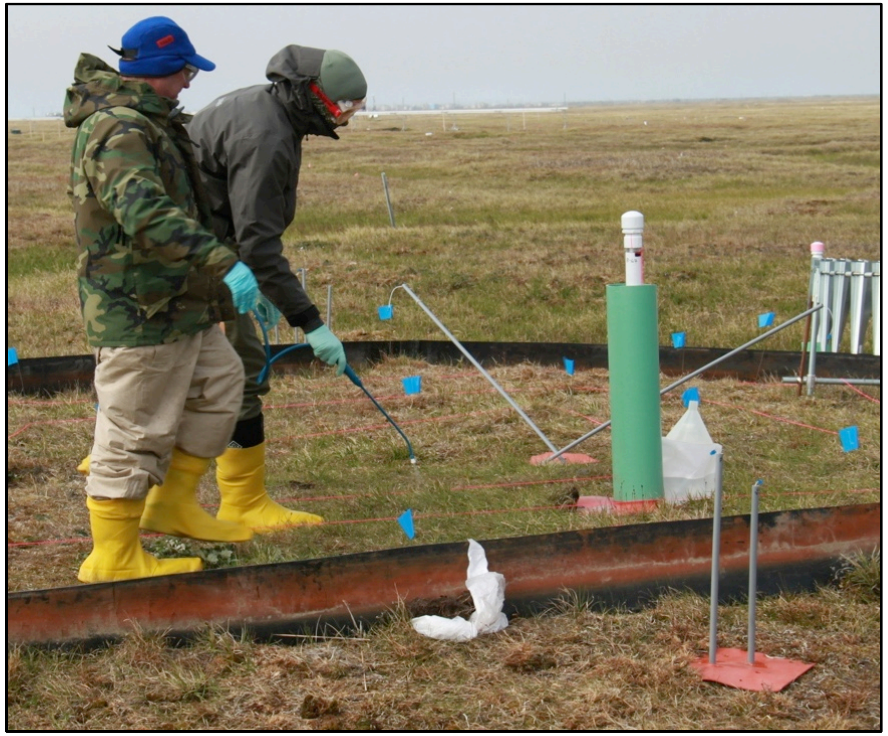
Liljedahl et al, 2016, Nature Geoscience



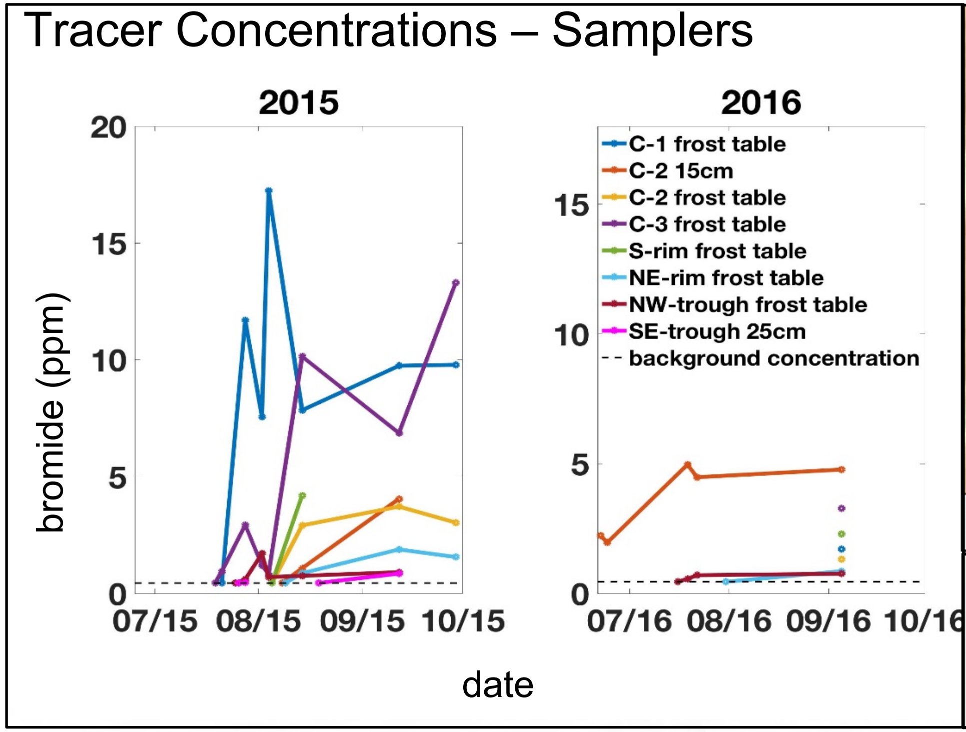


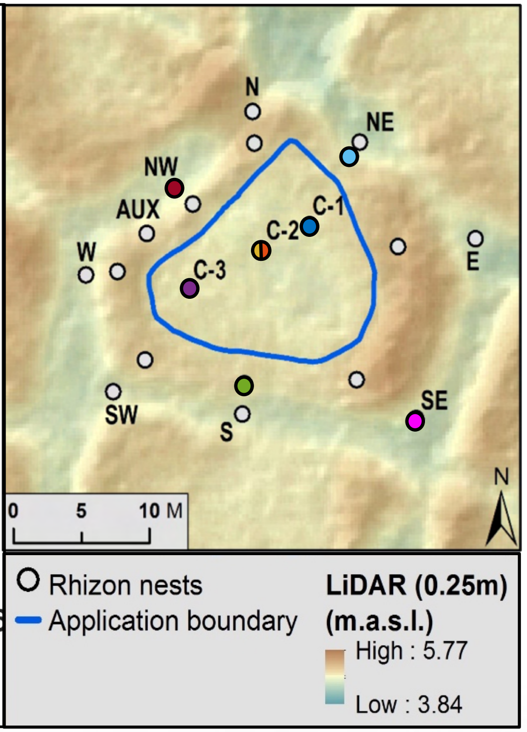
In Phase 2, we found that lateral subsurface heat and water transport are important in wet tundra systems

Posters 9 &10



Tracer Concentrations – Samplers

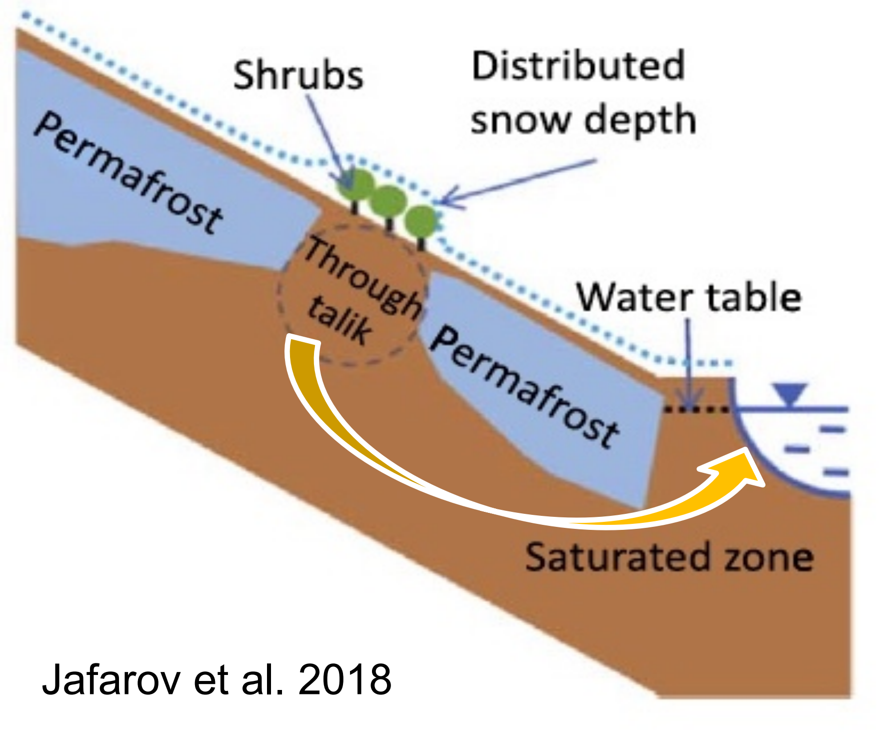




Wales et al. submitted, Svyatsky et al. in prep.

In Phase 2, we showed that snow-vegetation interactions drive through talik formation and shifts hydrology

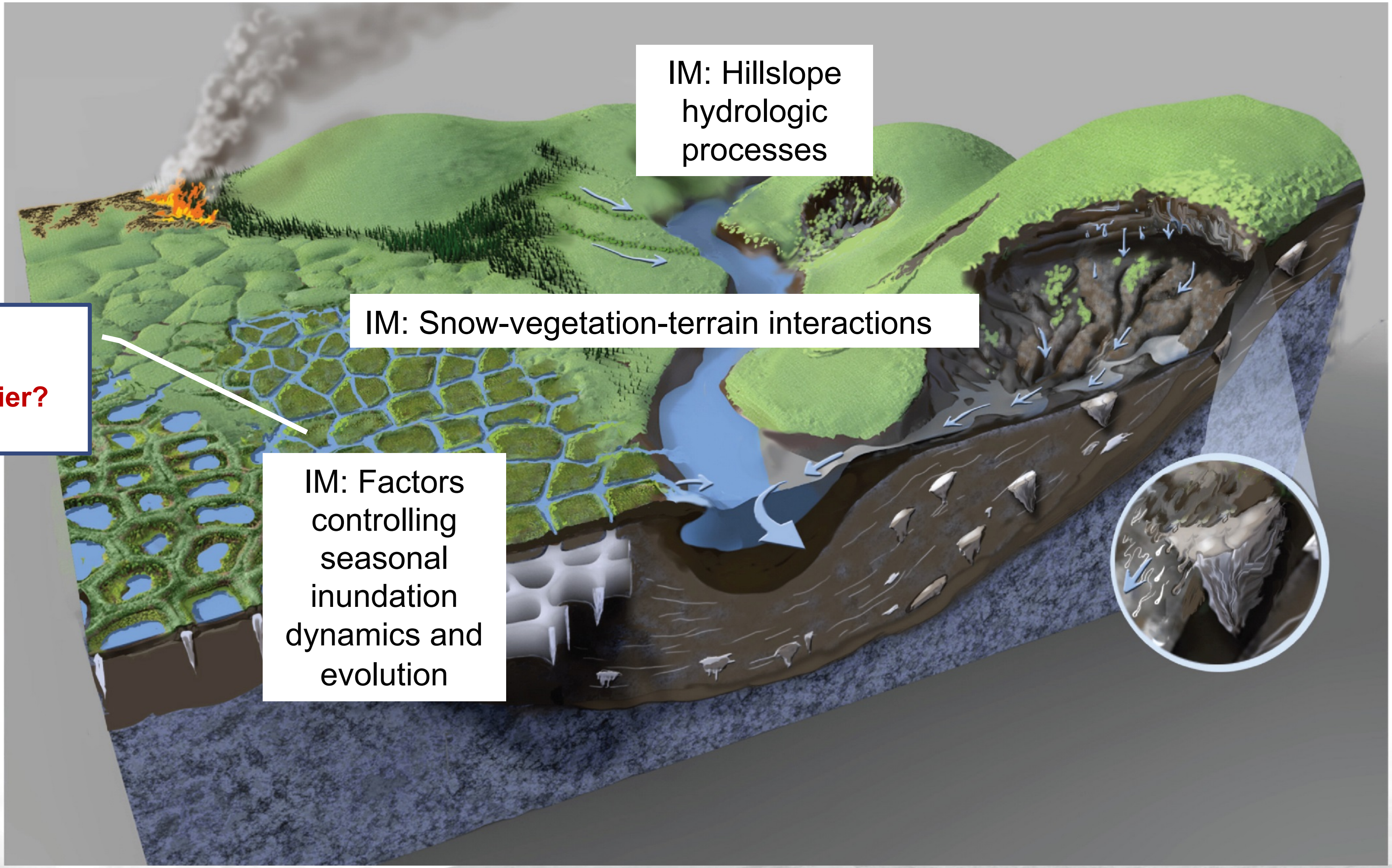
Posters 7 & 12



Jafarov et al. 2018

Greening may drive increased Winter baseflow

Q5 Phase 3



IM: Hillslope hydrologic processes

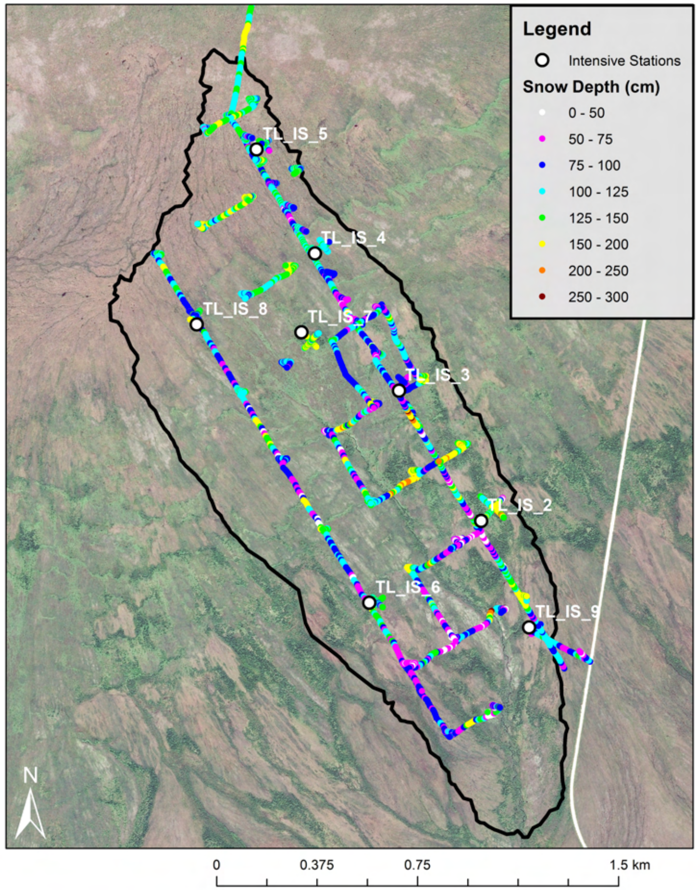
IM: Snow-vegetation-terrain interactions

Q5:
Wetter or Drier?

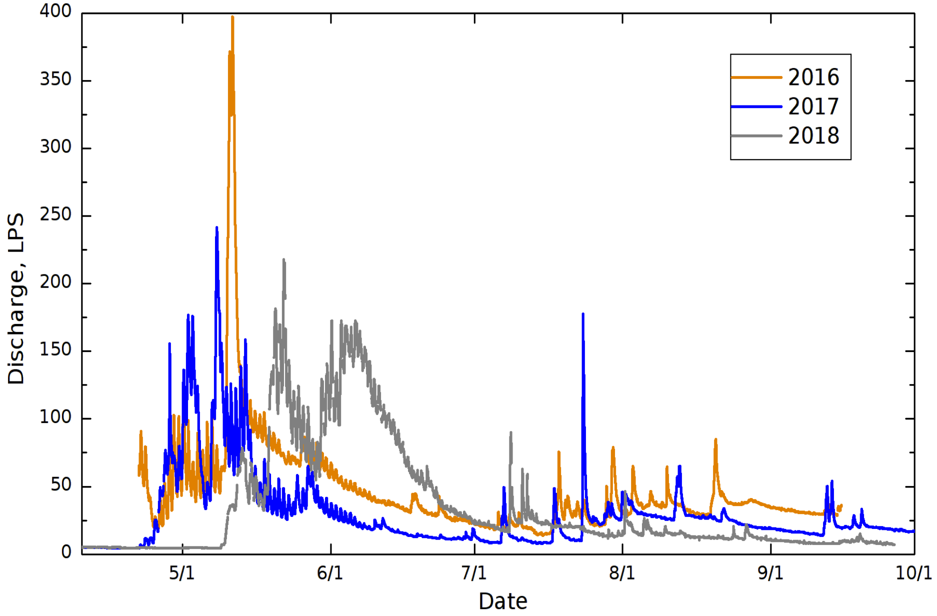
IM: Factors controlling seasonal inundation dynamics and evolution

Phase 3: Partner to develop and publish watershed to regional scale thermal-hydrologic benchmark data sets

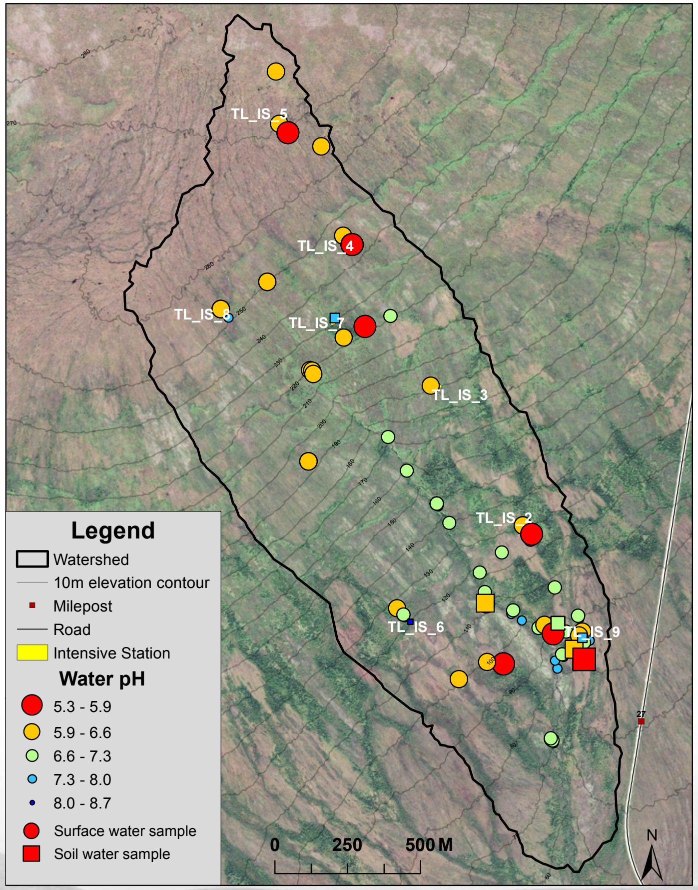
Teller End of Winter Snow Depth



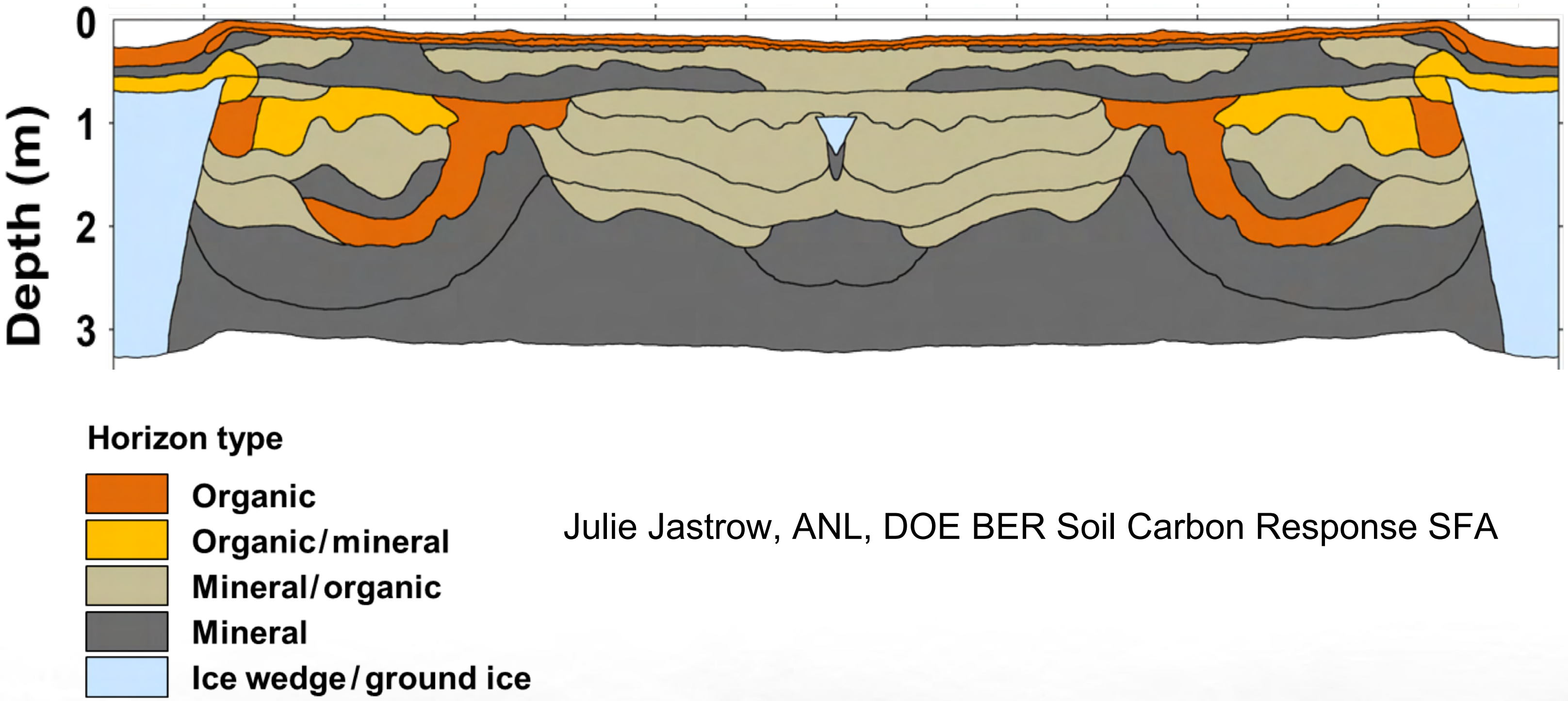
Teller Runoff



Teller Surface and Soil Water Geochemistry

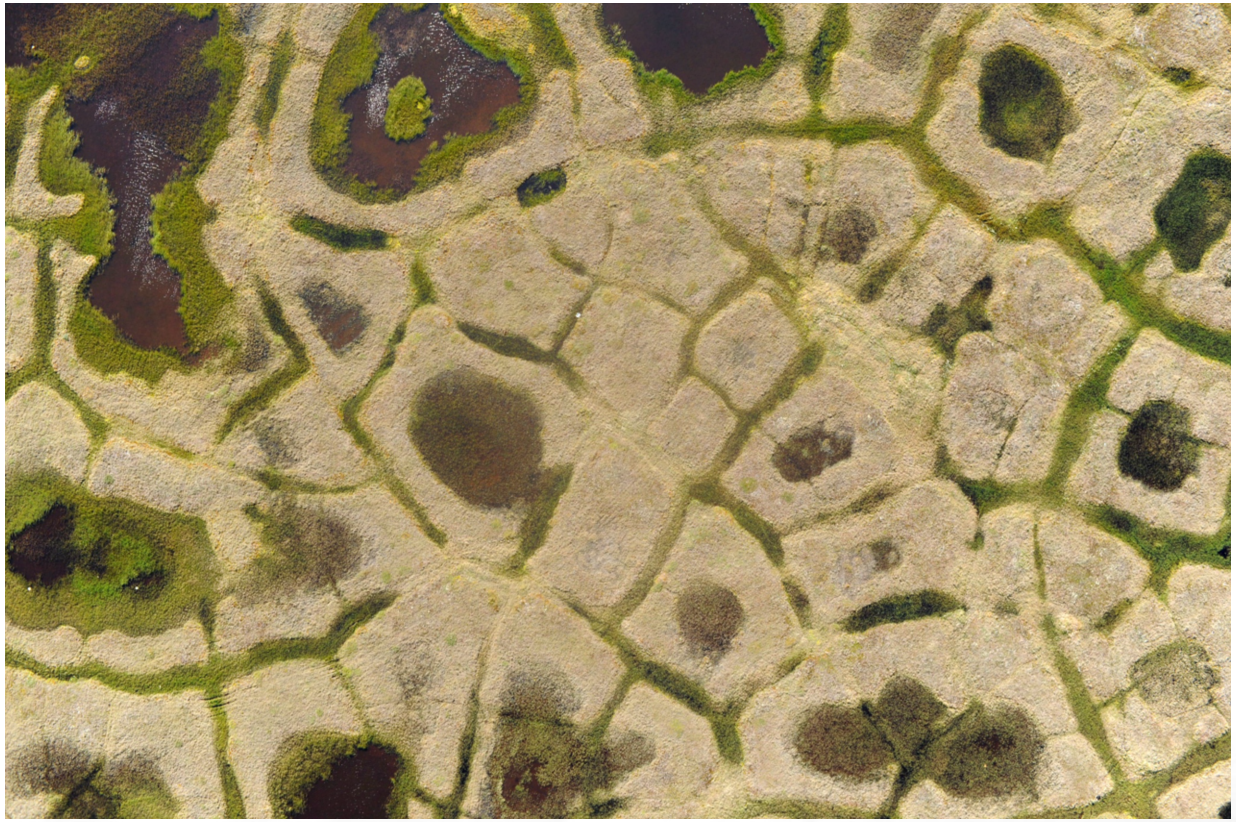


Phase 3: Improve inundation dynamics with new parameterizations of subsurface fast flow pathways



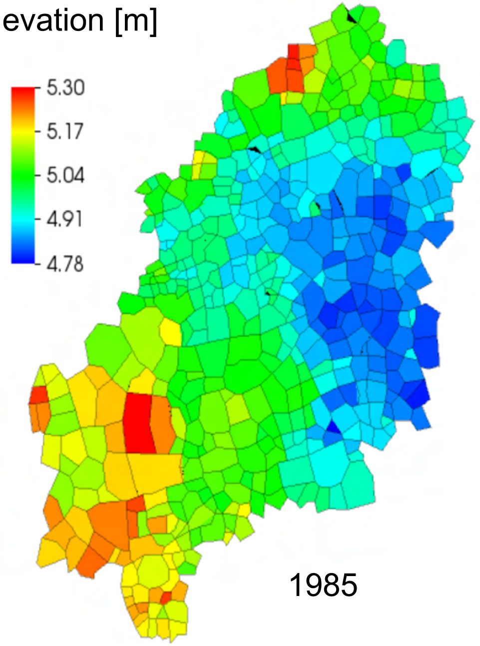
Julie Jastrow, ANL, DOE BER Soil Carbon Response SFA

Phase 3: Understand trajectories of landscape evolution and the impact on soil moisture and inundation dynamics

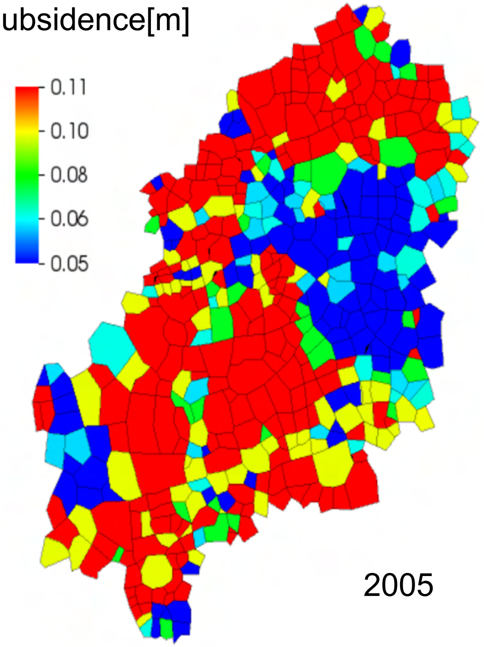


With new version of ATS, explore factors affecting subsidence and its influence on hydrology

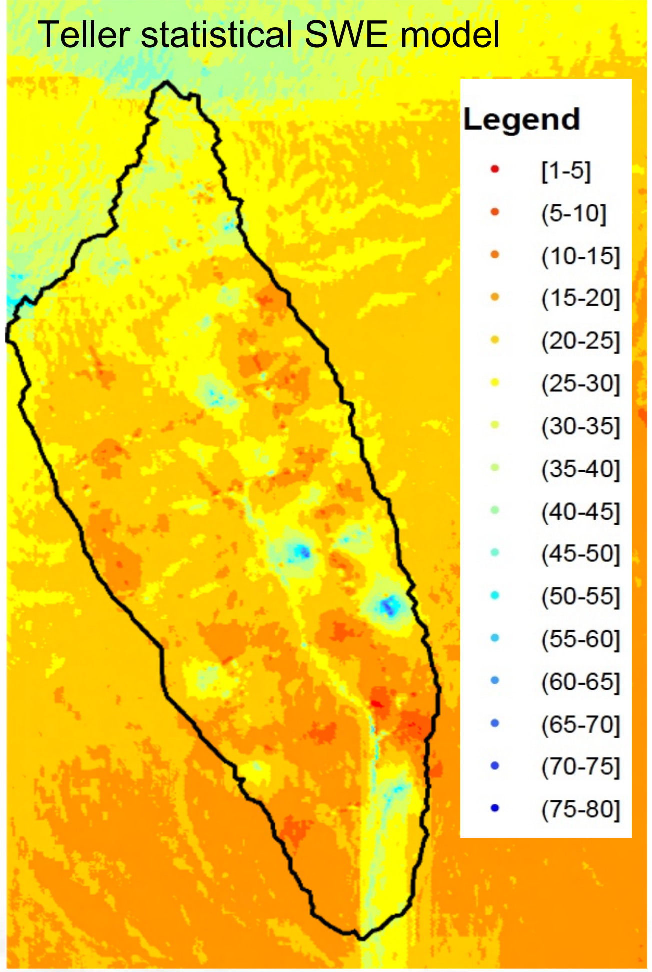
elevation [m]



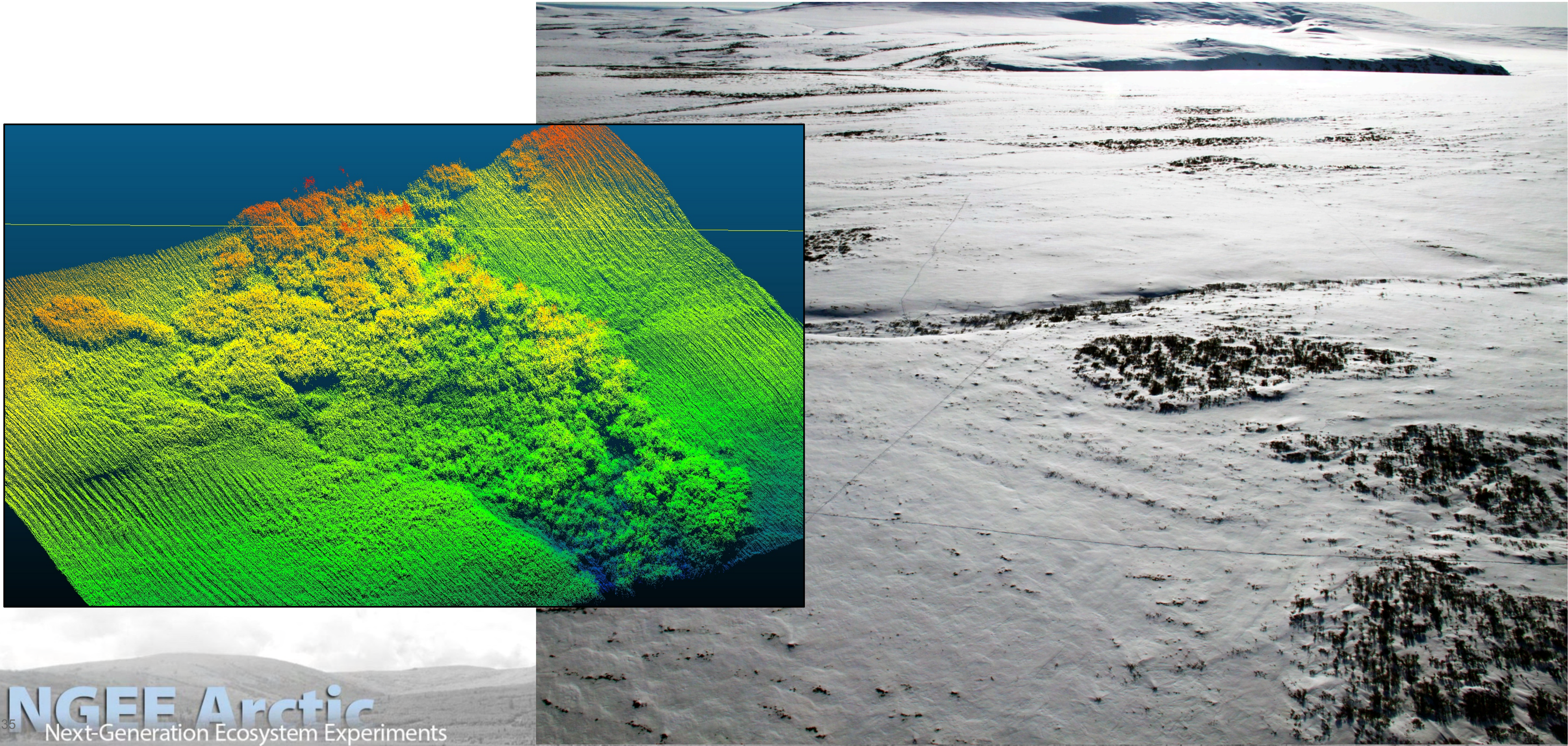
subsidence[m]



Phase 3: Develop dynamic snow model for ELM that accounts for topography, vegetation and weather



Phase 3: Inform snow model with shrub patch size, structure, density data



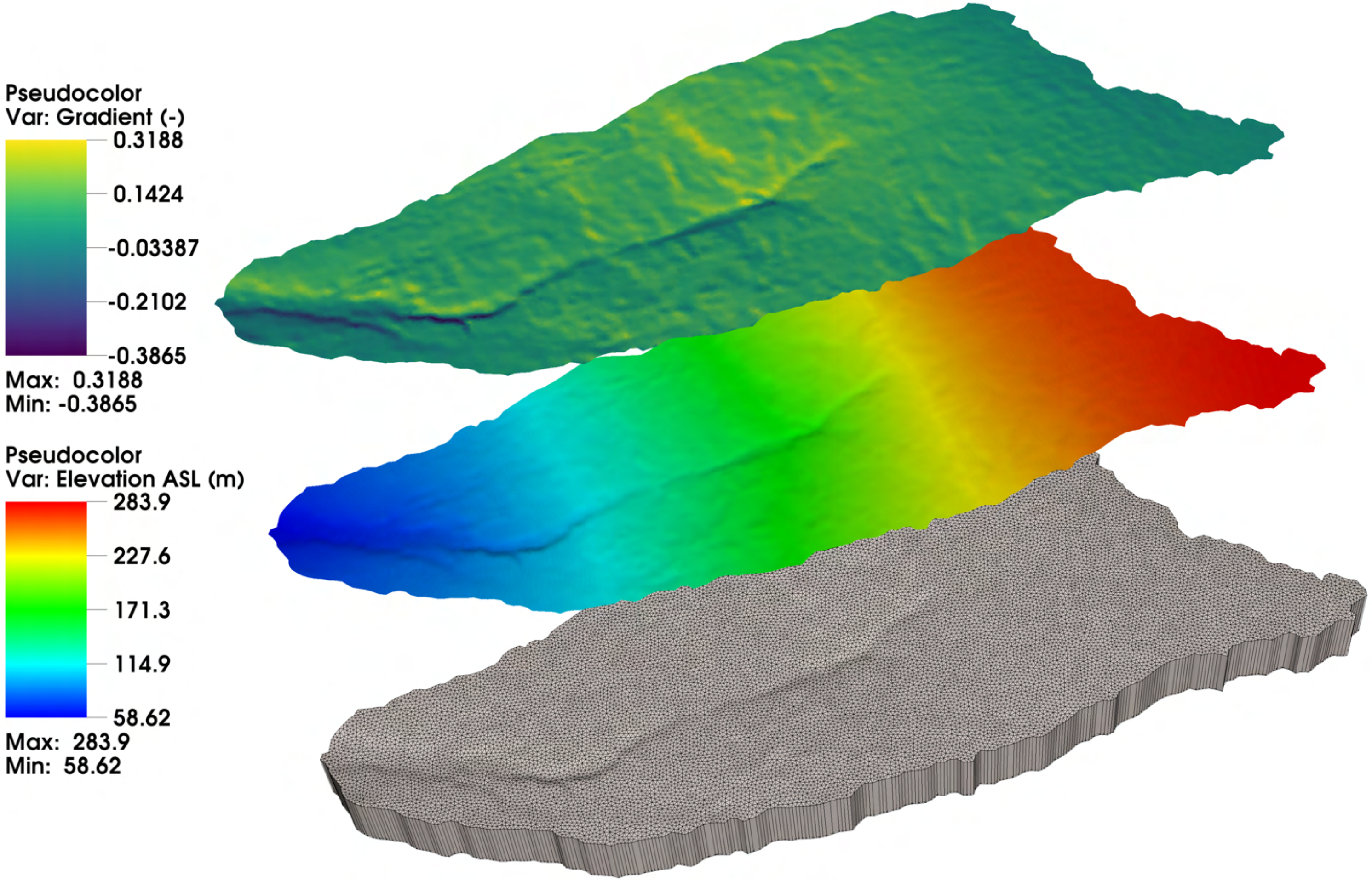
Phase 3: Apply data-informed watershed-models to quantify relative impacts of new process representations

Snow-shrub interactions

Permafrost continuity

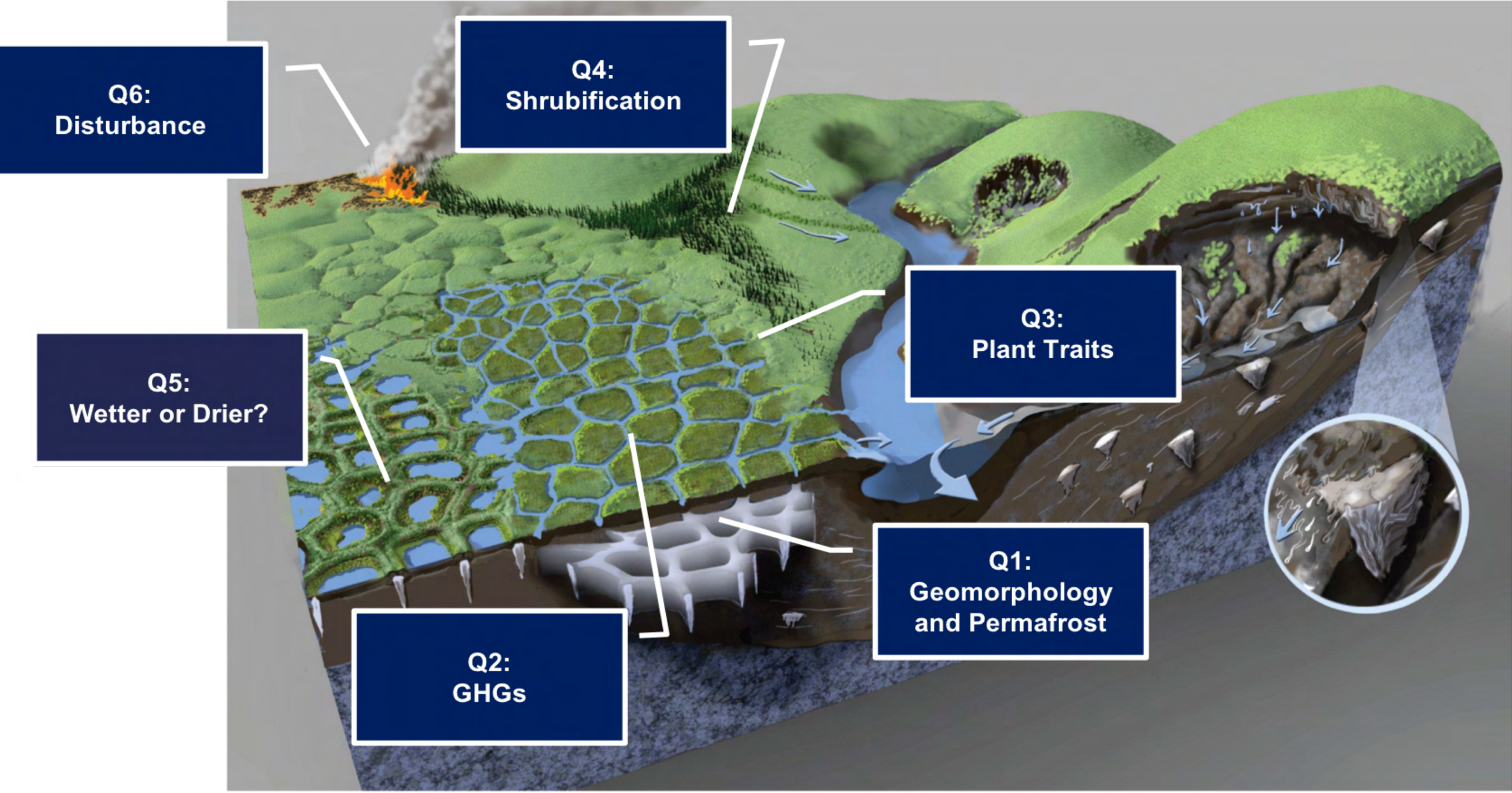
Lateral flow intensity

Topographic evolution and inundation



Major Deliverables for Question 5

- Watershed scale thermal hydrologic benchmark data sets to test model simulations.
- Improved representations of snow, hillslope hydrology and inundation processes in ELM.
- With Q1 through Q6, evaluate the impact of improved ELM thermal-hydrology on the climate system.



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