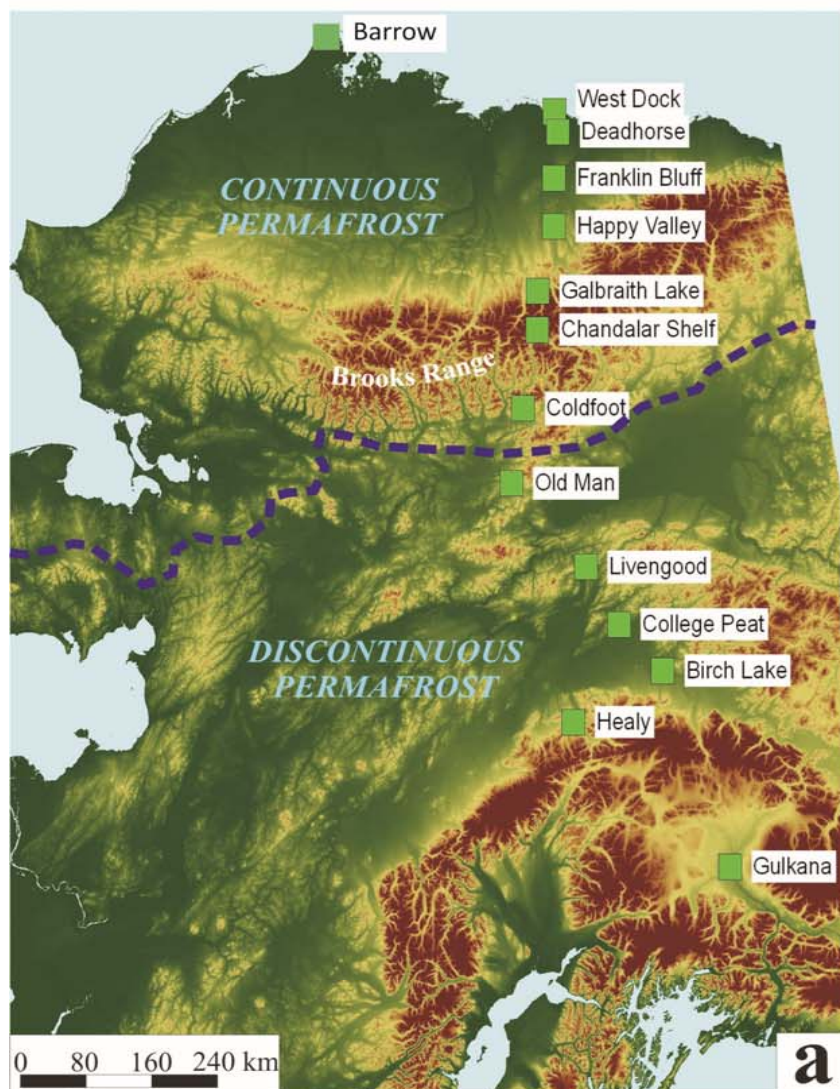


# ***Modeling Permafrost Characteristics With Very High Spatial Resolution***

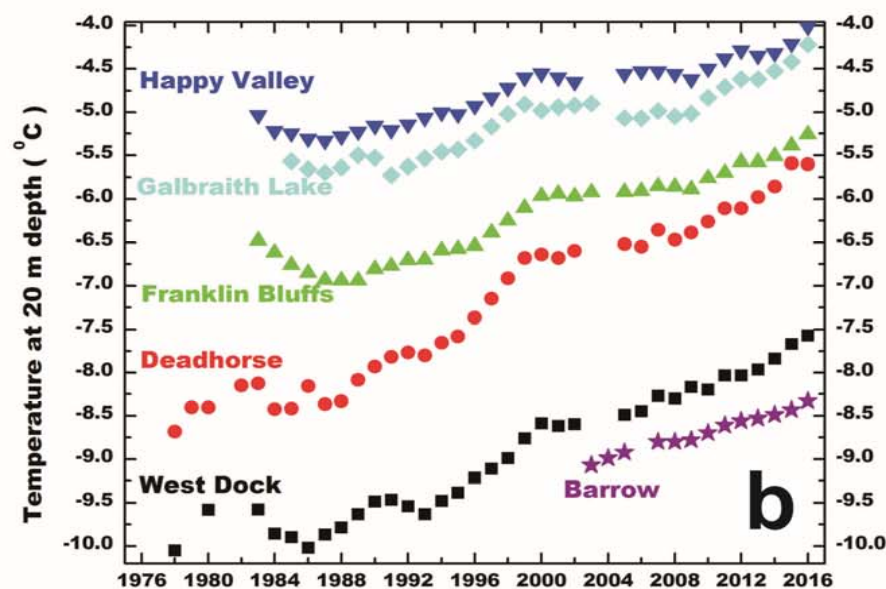
***V. Romanovsky, D. Nicolsky, W. Cable and S. Panda***  
*University of Alaska Fairbanks*



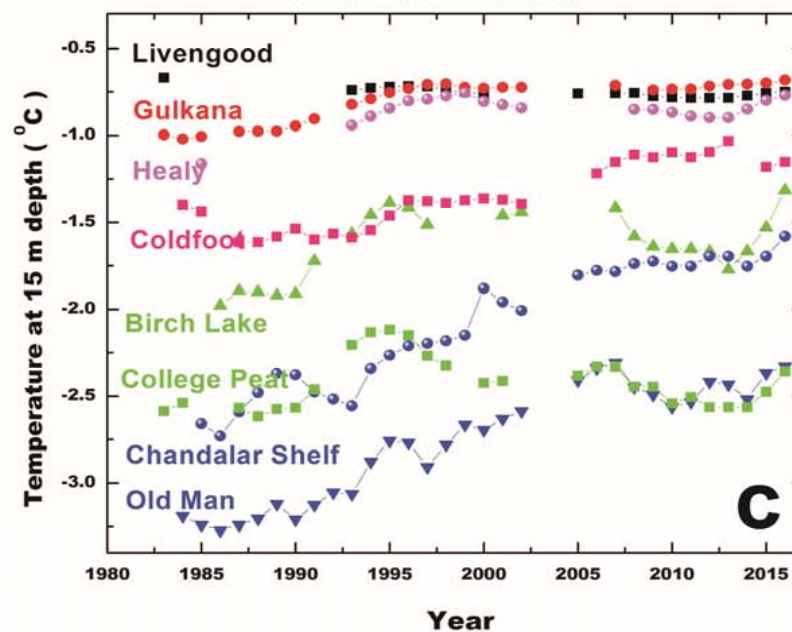




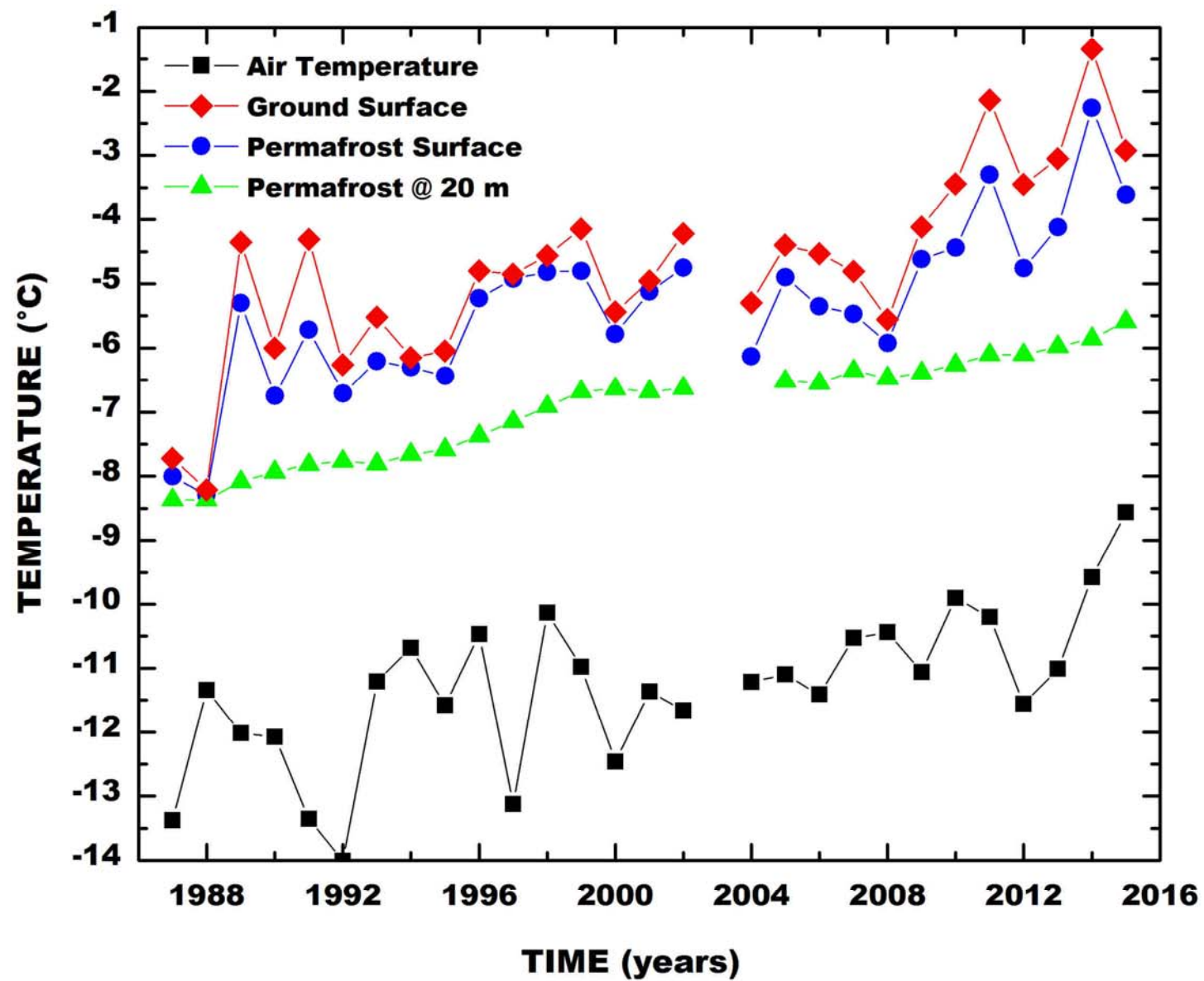
## Northern Alaska



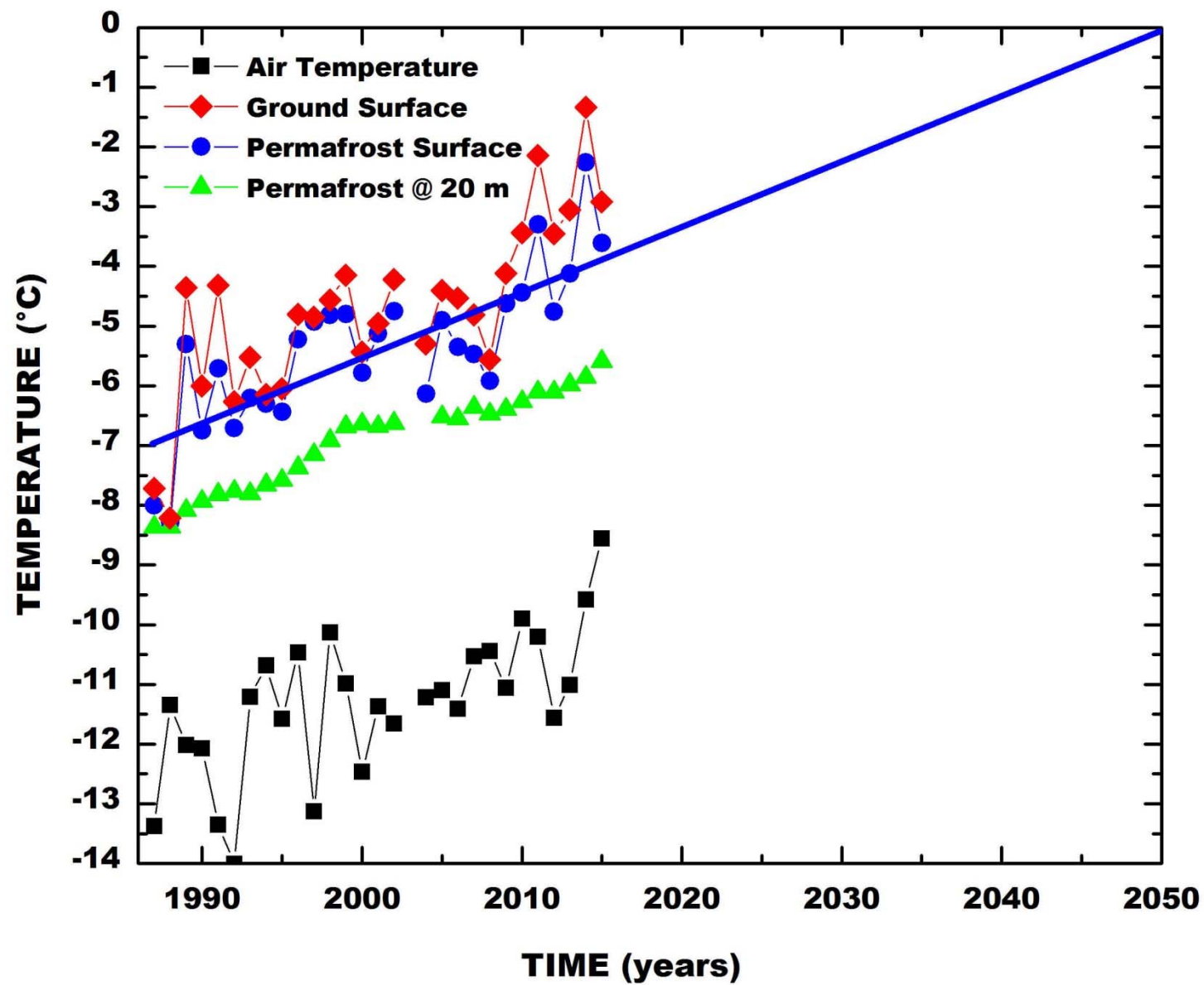
## Interior Alaska



## DEADHORSE, 1987-2015



## DEADHORSE, 1987-2050





# **Advances in Permafrost Science**

- **Became truly multi- and inter-disciplinary science**
- **New advanced observational methods:**
  - ground-based methods
  - remote sensing (both orbital and sub-orbital platforms)
  - combination of the two to optimize the observational network and to upscale the point observations
- **Advances in modeling of permafrost as an important component of the Climate and more generally Earth System**

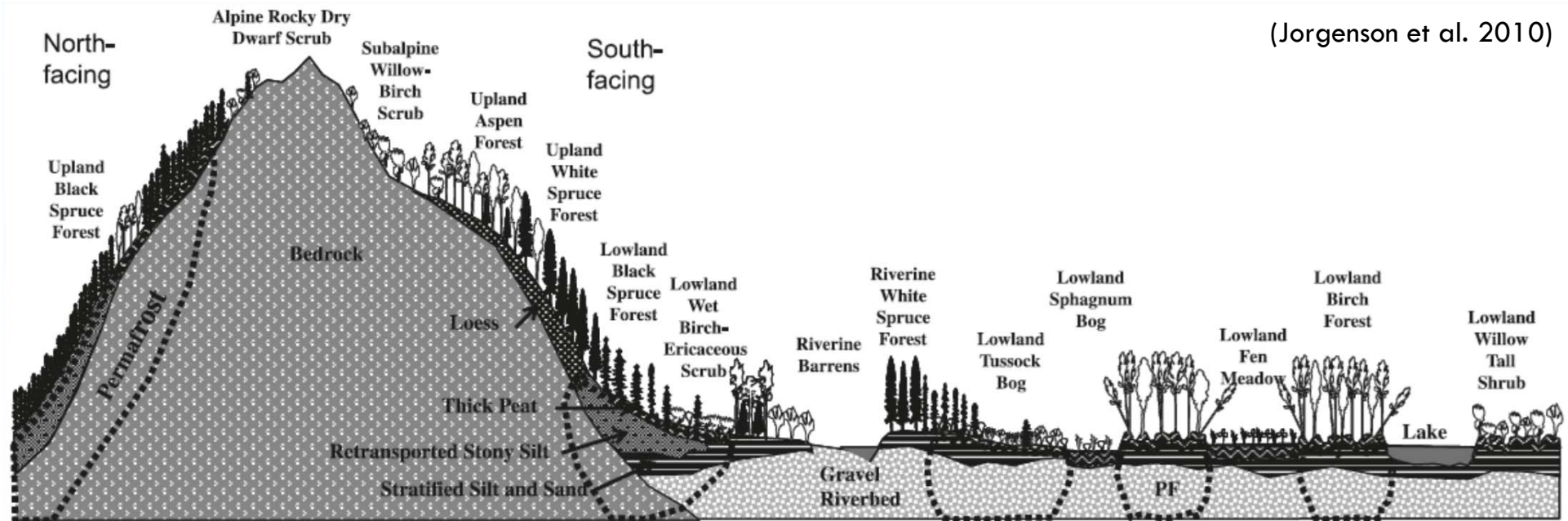
# Challenges

- **Assessment of vulnerability of permafrost to**
  - climate change
  - to natural disturbances
  - to human activities
- **Projections of the future changes in permafrost with very high spatial resolution**
- **High-resolution** mapping of the various environmental changes triggered by changes in permafrost
- **High-resolution** mapping of the societal impacts caused by changes in permafrost



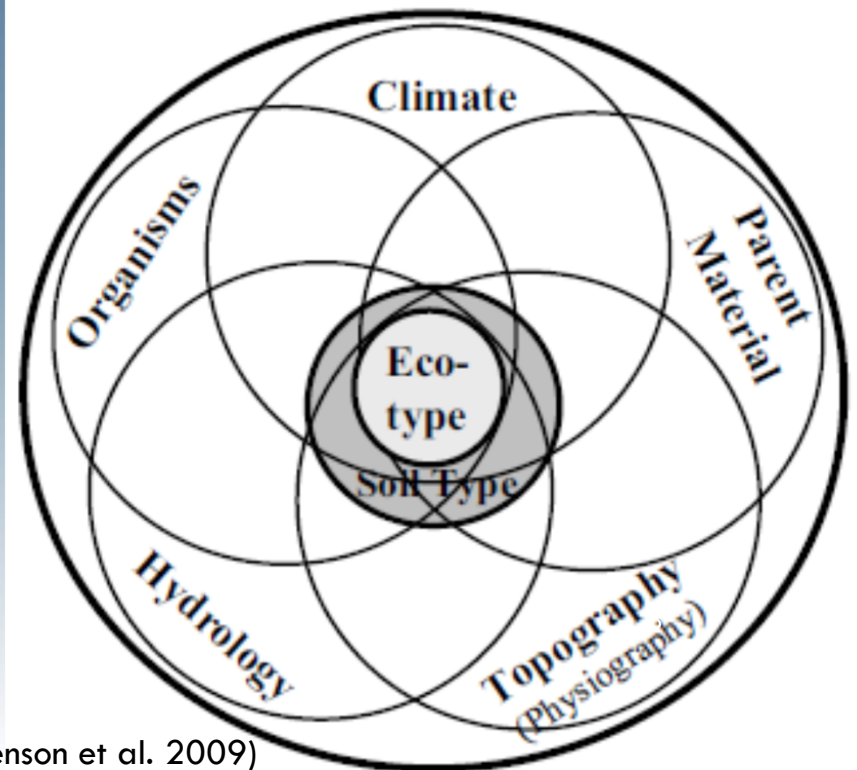
# Advances in Permafrost Science

- **Became truly multi- and inter-disciplinary science**
- **New advanced observational methods:**
  - ground-based methods
  - remote sensing (both orbital and sub-orbital platforms)
  - combination of the two to optimize the observational network and to upscale the point observations
- **Advances in modeling of permafrost as an important component of the Climate and more generally Earth System**

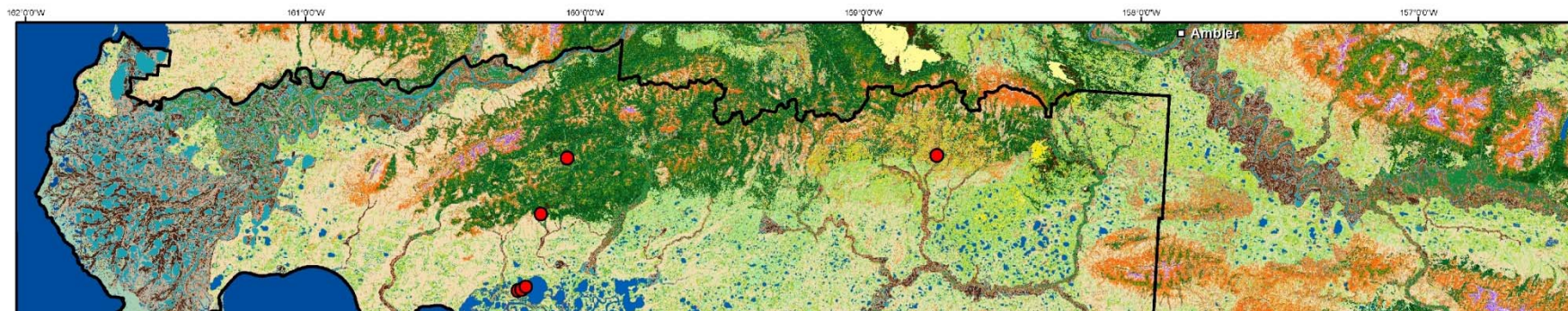


- Ecotypes

- Vegetation
- Climate
- Topography
- Hydrology
- Soil Type
- Snow Dynamics
- Permafrost Thermal Regime?





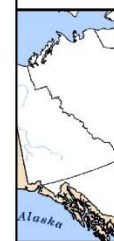


## Ecotype Class

Alpine Alkaline Barrens	Upland Spruce-Birch Forest	Riverine Willow Low Shrub
Alpine Alkaline Dryas Dwarf Shrub	Upland White Spruce-Willow Forest	Riverine Birch-Willow Low Shrub
Alpine Acidic Barrens	Upland White Spruce-Ericaceous Forest	Riverine Moist Willow Tall Shrub
Alpine Acidic Dryas Dwarf Shrub	Upland Sandy Barrens	Riverine Poplar Forest
Alpine Ericaceous-Dryas Dwarf Shrub	Upland White Spruce-Lichen Woodland	Riverine White Spruce-Poplar Forest
Alpine Cassiope Dwarf Shrub	Lowland Sedge Fen	Riverine White Spruce-Willow Forest
Alpine Wet Sedge Meadow	Lowland Ericaceous Shrub Bog	Riverine Wet Sedge Meadow
Alpine Lake	Lowland Birch-Ericaceous Low Shrub	Riverine Alder Tall Shrub
Upland Sedge-Dryas Meadow	Lowland Birch-Willow Low Shrub	Riverine Water
Upland Willow Low Shrub	Lowland Willow Low Shrub	Coastal Barrens
Upland Birch-Willow Low Shrub	Lowland Alder Tall Shrub	Coastal Brackish Sedge-Grass Meadow
Upland Birch-Ericaceous Low Shrub	Lowland Black Spruce Forest	Coastal Water
Upland Dwarf Birch-Tussock Shrub	Lowland Lake	Snow
Upland Alder-Willow Tall Shrub	Riverine Barrens	
Upland Birch Forest	Riverine Dryas Dwarf Shrub	

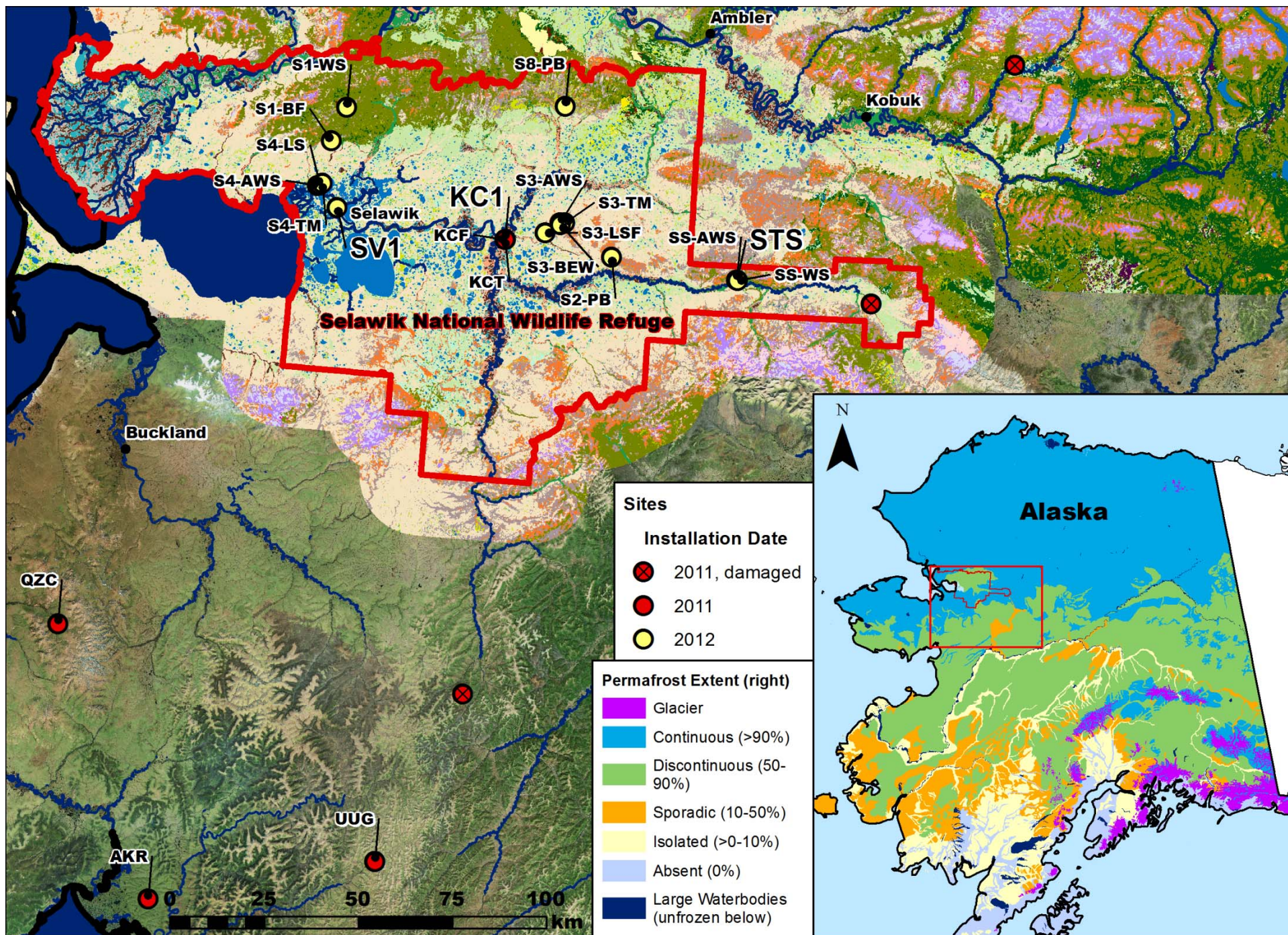
Ecotype Class

Map of Alaska showing Ecotype Class distribution

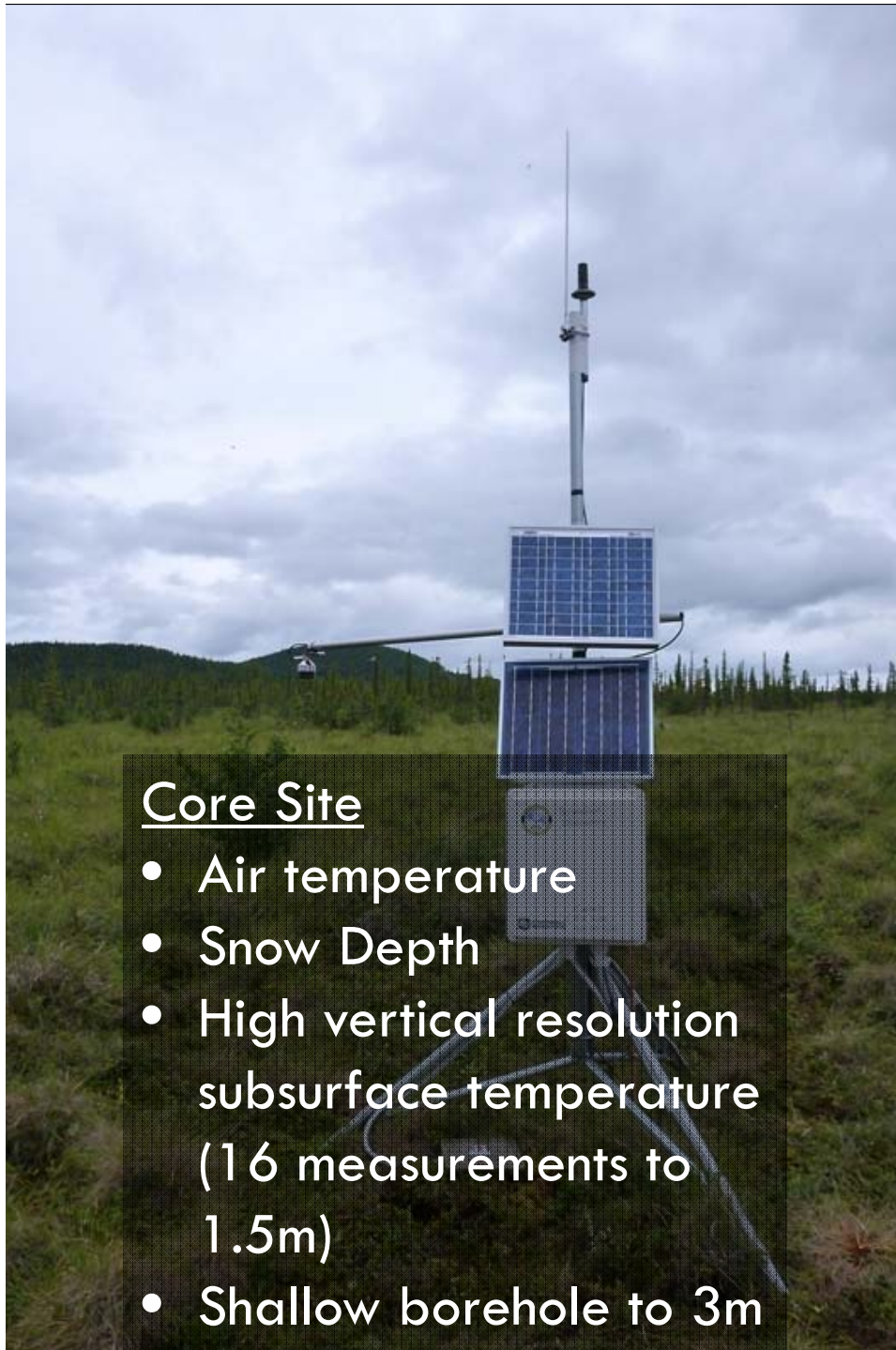


(Jorgenson et al. 2009)









### Core Site

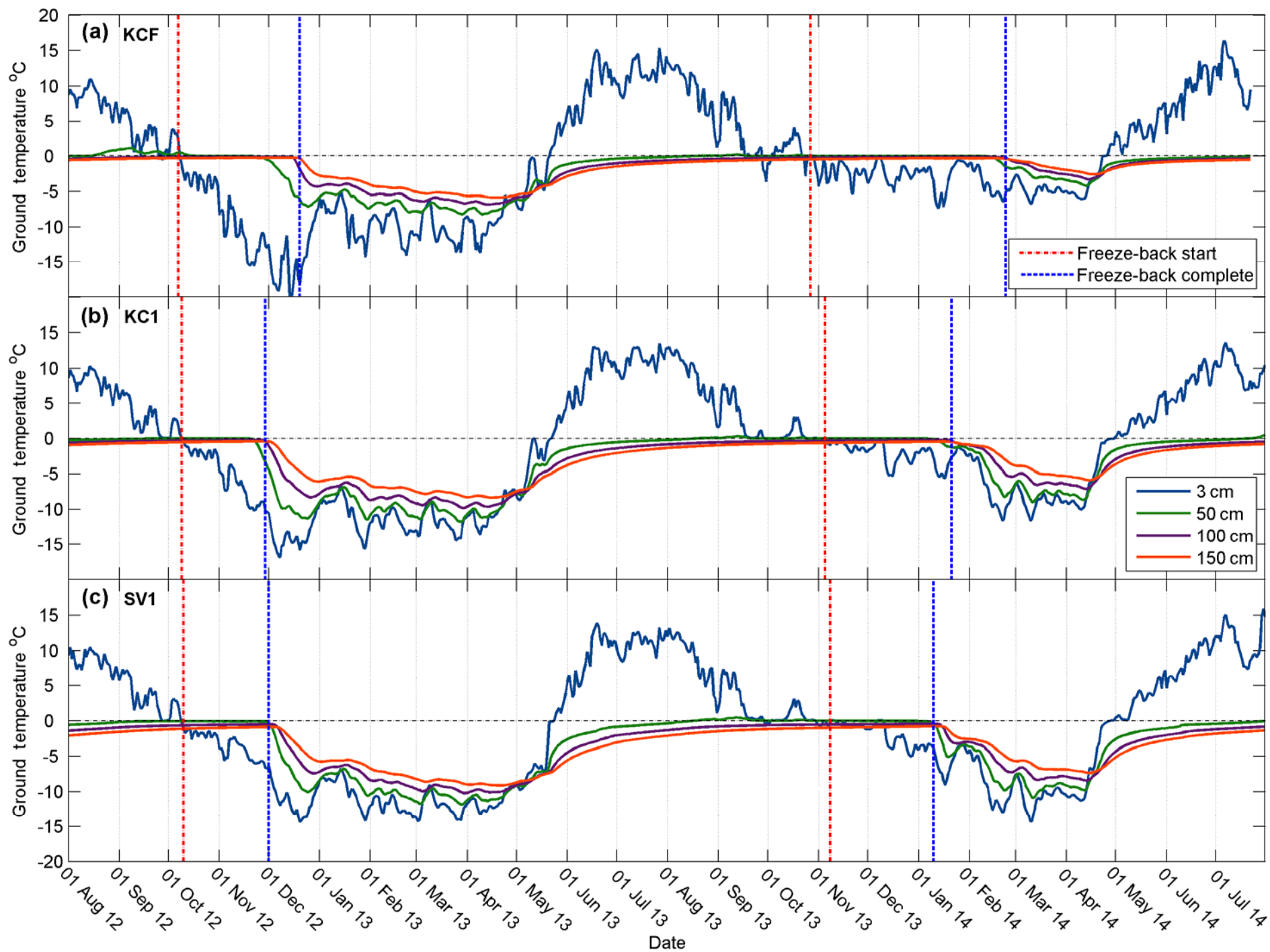
- Air temperature
- Snow Depth
- High vertical resolution subsurface temperature (16 measurements to 1.5m)
- Shallow borehole to 3m



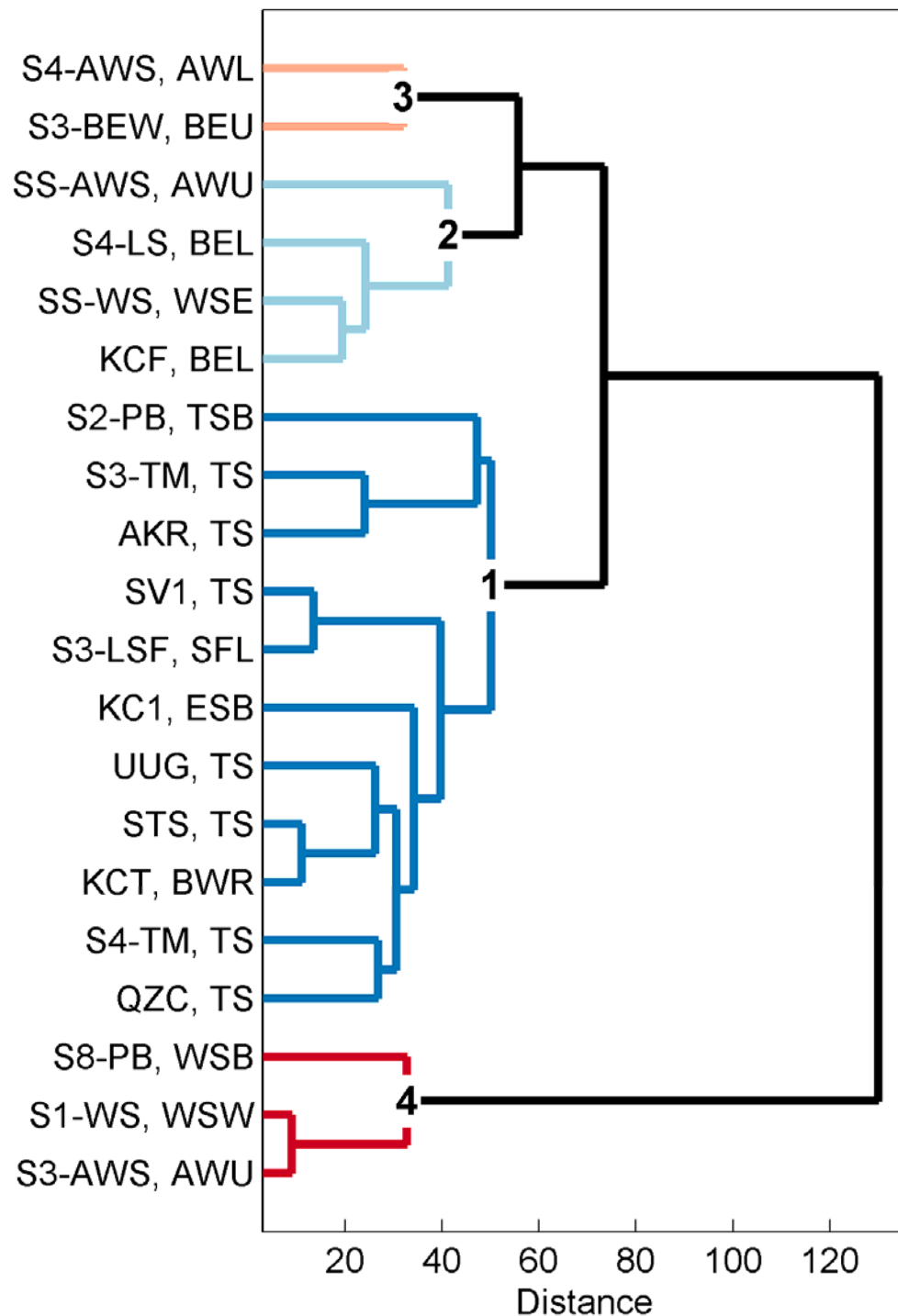
### Distributed Site

- Subsurface temperature measurements at 3, 50, 100, and 150 cm





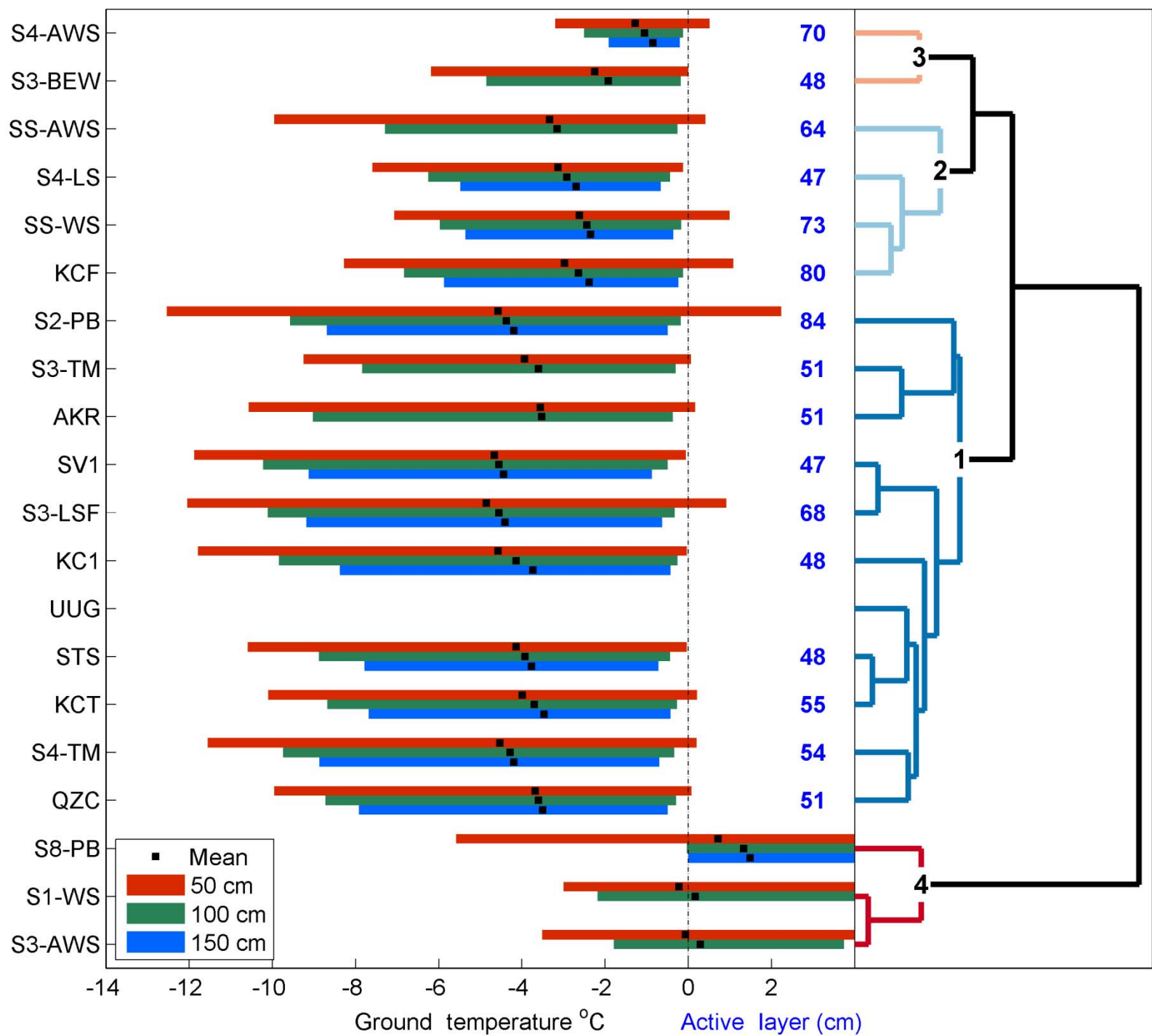




**Upland and Lowland Tussock Meadows,**  
 $T_{1 \text{ m depth}}$  = from  $-3.6^{\circ}\text{C}$  to  $-4.55^{\circ}\text{C}$

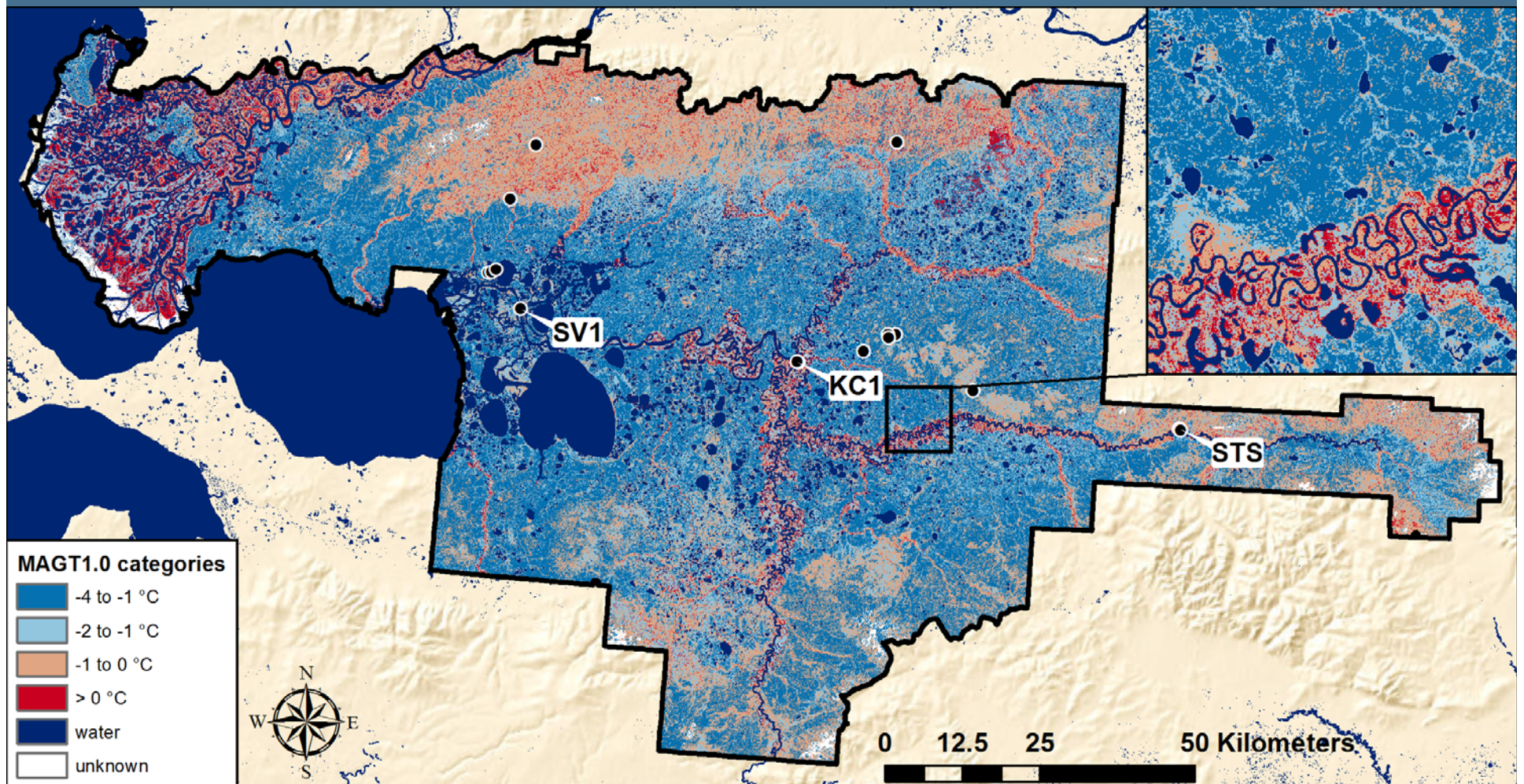


**Upland White Spruce Forest with Alder**  
 Temperature at 1 m depth:  $+0.17^{\circ}\text{C}$





# MAGT1.0 Category Map



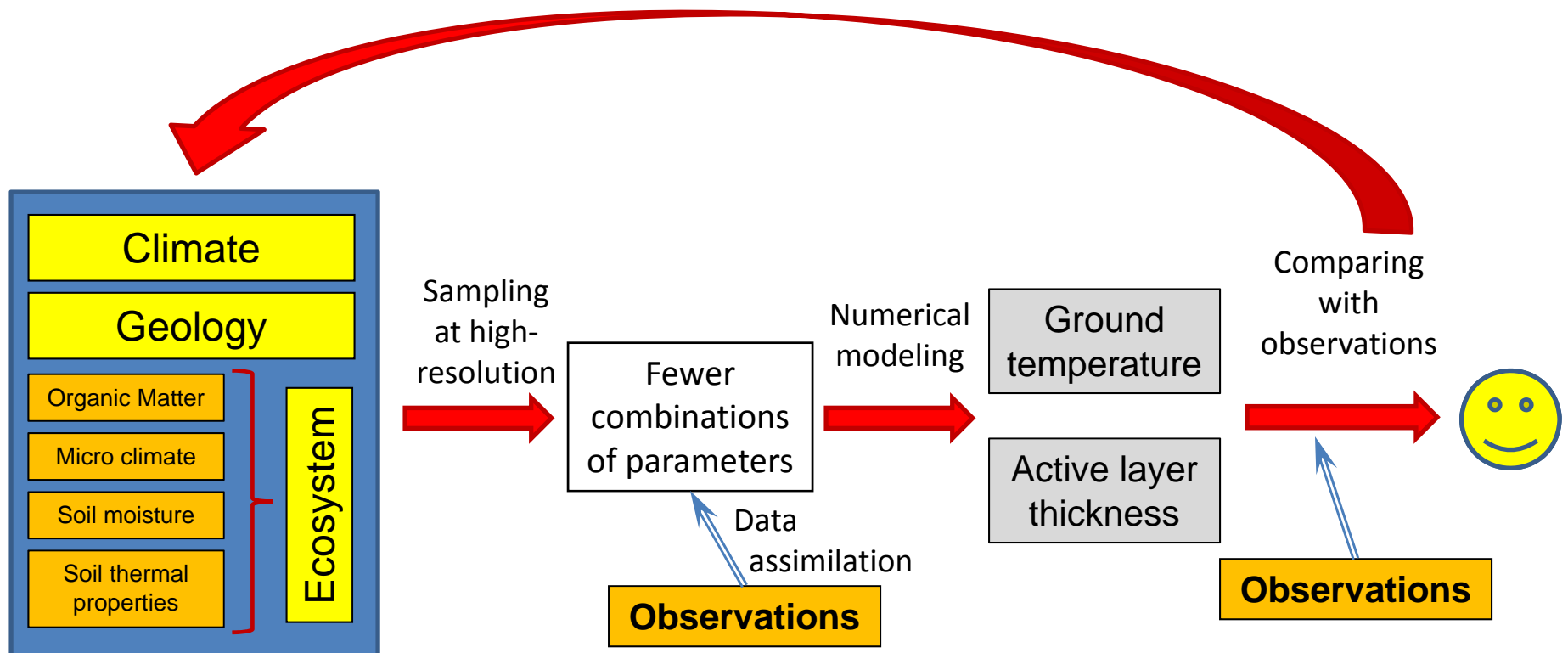


# Challenges

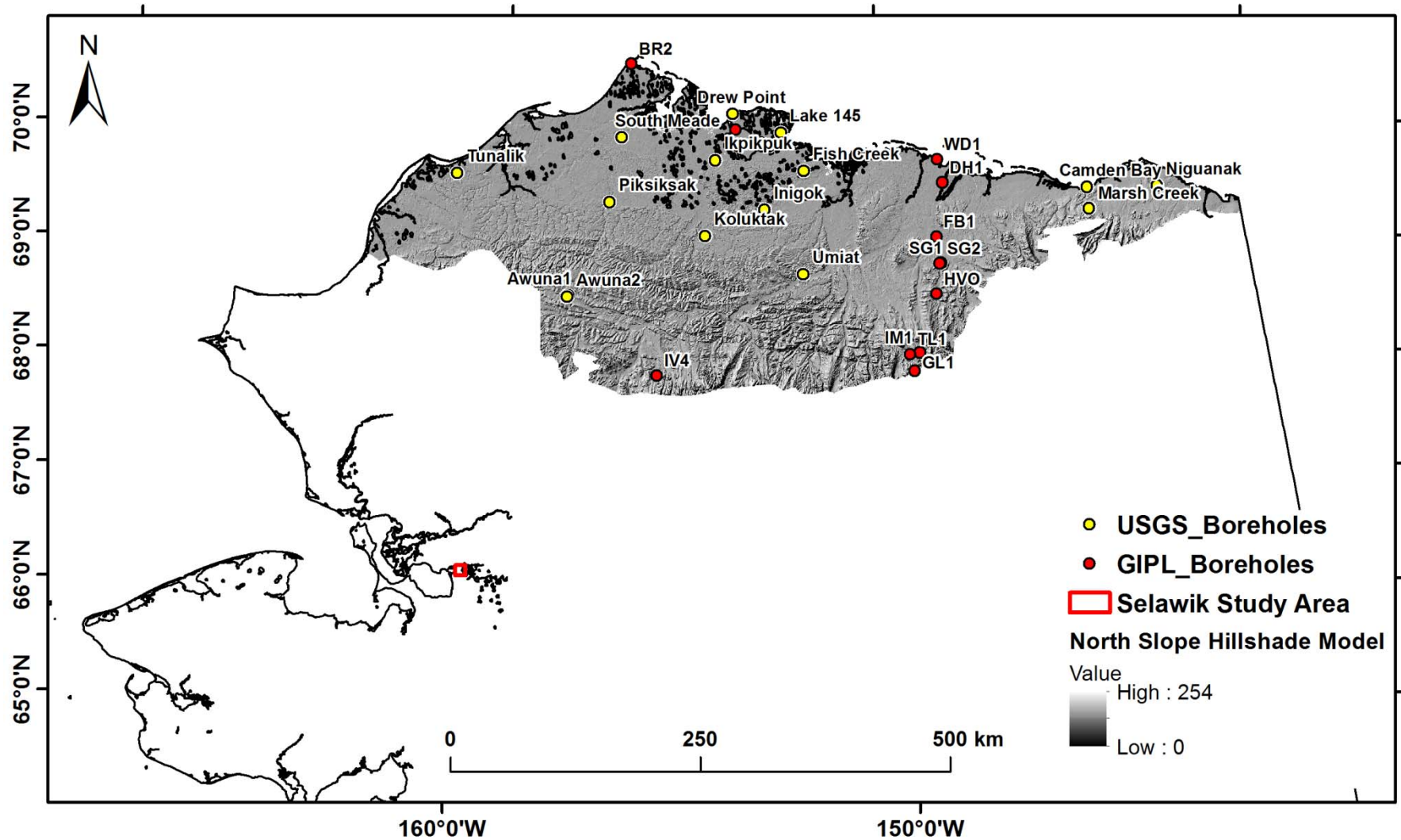
- **Assessment of vulnerability of permafrost to**
  - climate change
  - to natural disturbances
  - to human activities
- **Projections of the future changes in permafrost with very high spatial resolution**
- **High-resolution mapping of the various environmental changes triggered by changes in permafrost**
- **High-resolution mapping of the societal impacts caused by changes in permafrost**

# Permafrost characteristics by ecosystem type

**Goal:** Develop a high spatial resolution permafrost model for the North Slope of Alaska

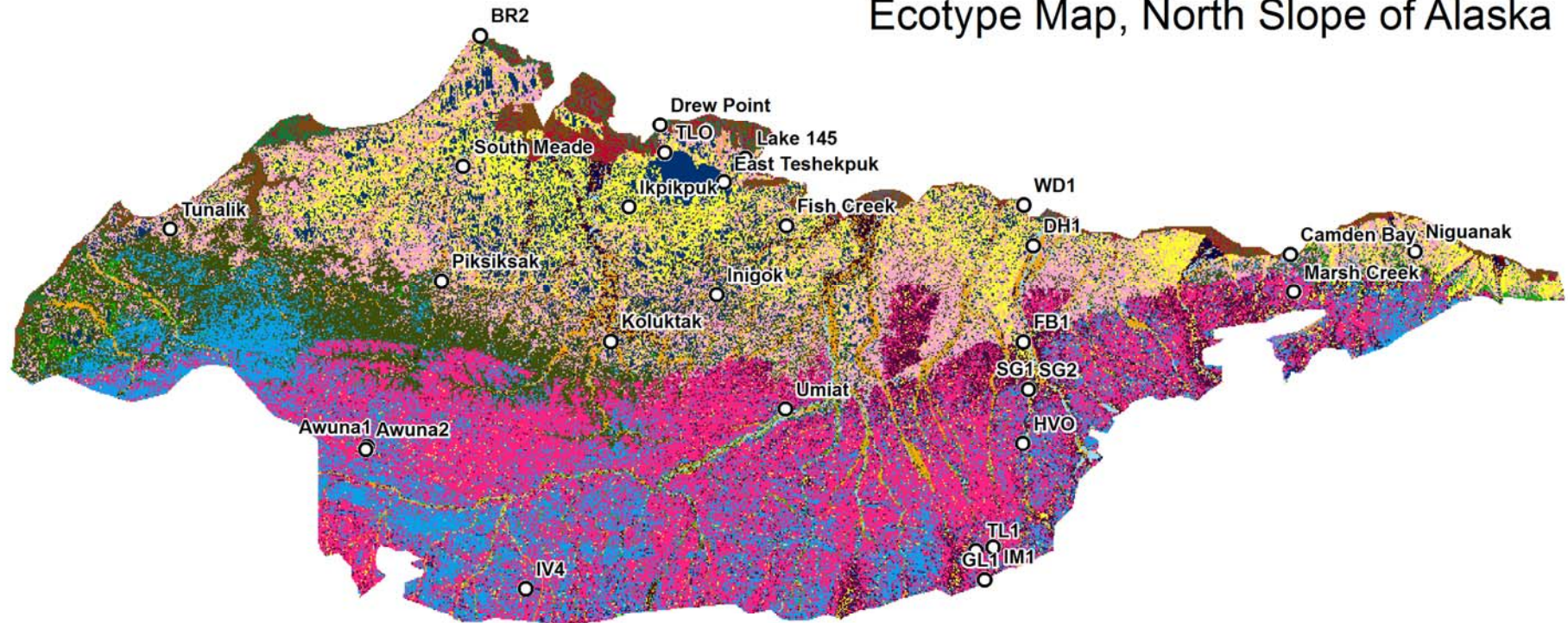


# Study Area





# Ecotype Map, North Slope of Alaska



## Class

1-Cloud, Ice (Indeterminate)	17-Upland dwarf scrub tundra (Dryas tundra)	25-Alpine carbonate Dryas DST
10-Riverine water	18-Upland shrubby tussock tundra (foothills)	3-Coastal wet meadow (sedge tundra)
11-Riverine dwarf scrub	19-Upland low scrub (shrub birch-willow tundra)	4-Coastal water
12-Lowland wet meadow (sedge tundra)	2-Coastal Barrens	5-Coastal grass & DST (dwarf scrub tundra)
13-Lowland lake	20-Upland moist meadow (sedge-shrub tundra)	6-Riverine Barrens
14-Lowland moist meadow (sedge-shrub tundra)	21-Upland tall scrub (alder scrub)	7-Riverine low & tall scrub (scrub tundra)
15-Lowland mixed scrub (shrub-birch scrub)	22-Alpine noncarbonate barrens	8-Riverine moist meadow (sedge-shrub tundra)
16-Upland tussock tundra	23-Alpine carbonate barrens	9-Riverine wet meadow (sedge tundra)
	24-Alpine noncarbonate Dryas DST	

### Ecotypes covered by permafrost boreholes

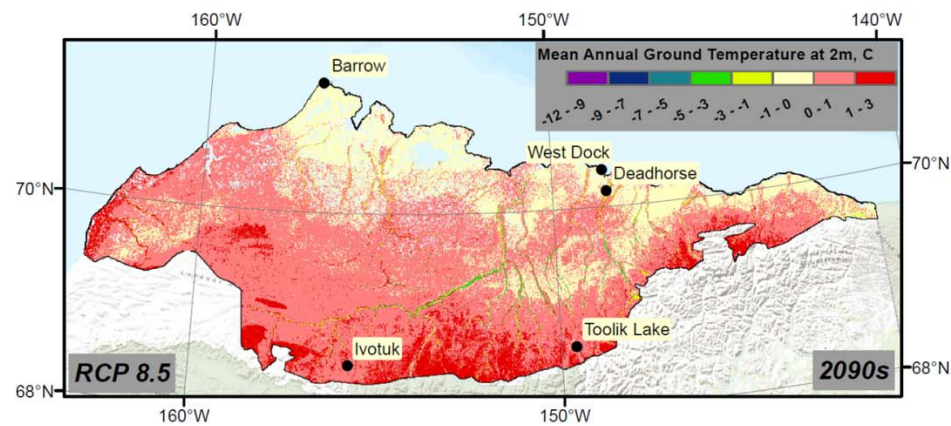
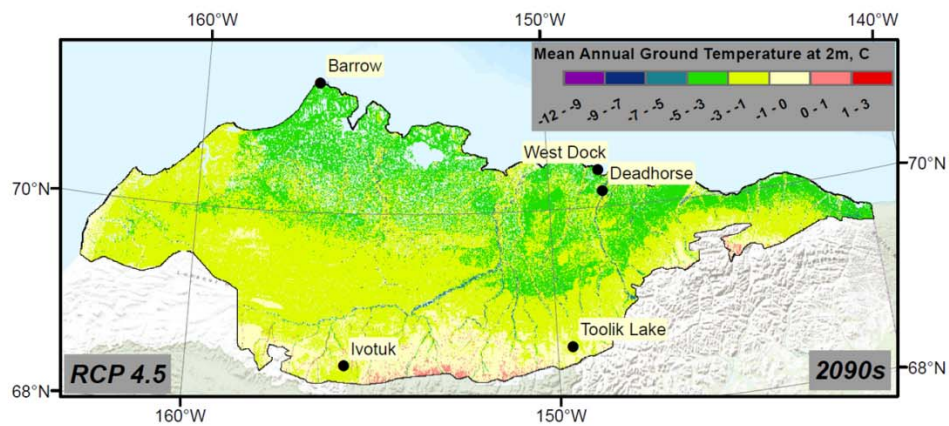
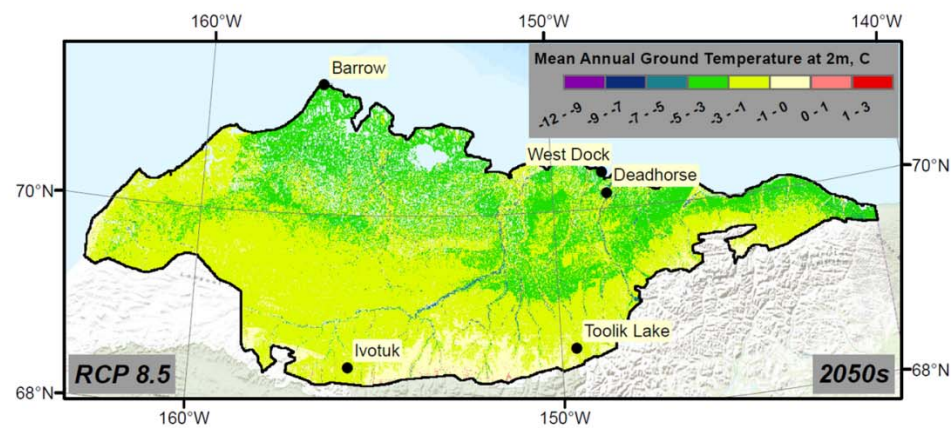
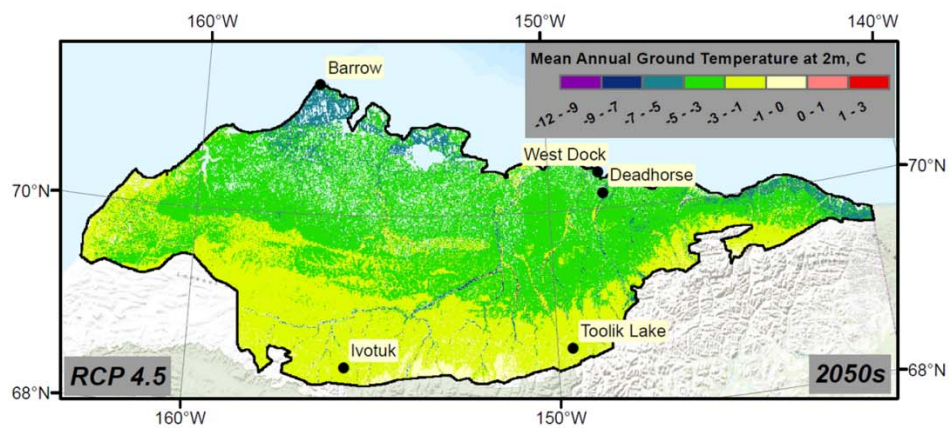
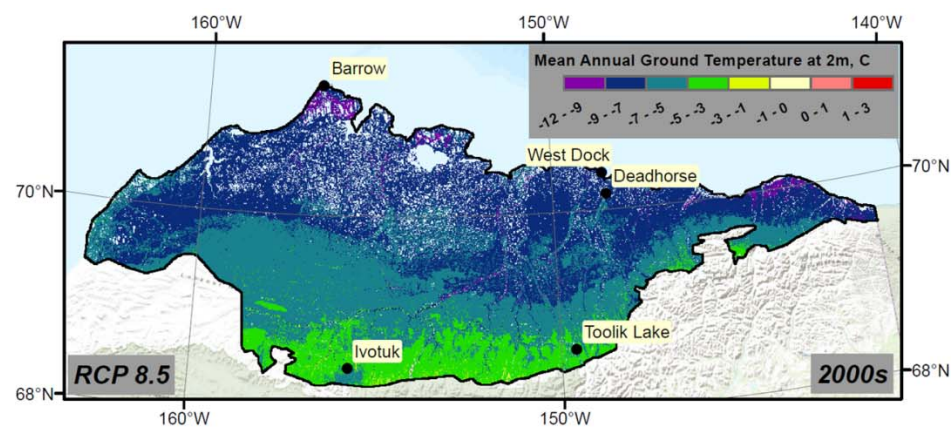
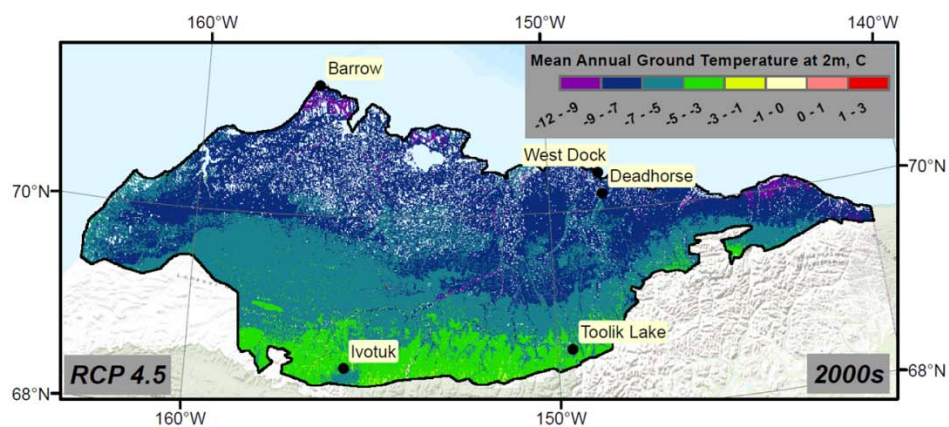
Ecotypes	% Cover
Coastal grass & dwarf shrub tundra	0.8
Riverine wet sedge tundra	1.1
Lowland wet sedge tundra	11.2
Lowland moist sedge-shrub tundra	13.4
Upland tussock tundra	11.3
Upland shrubby tussock tundra	24.7
Upland low birch-willow shrub tundra	14.2
Upland moist sedge-shrub tundra	5.3
<b>Total cover</b>	<b>82.0</b>

Coastal, river, and lake water bodies cover 9.3% of the study area excluded from permafrost modeling.

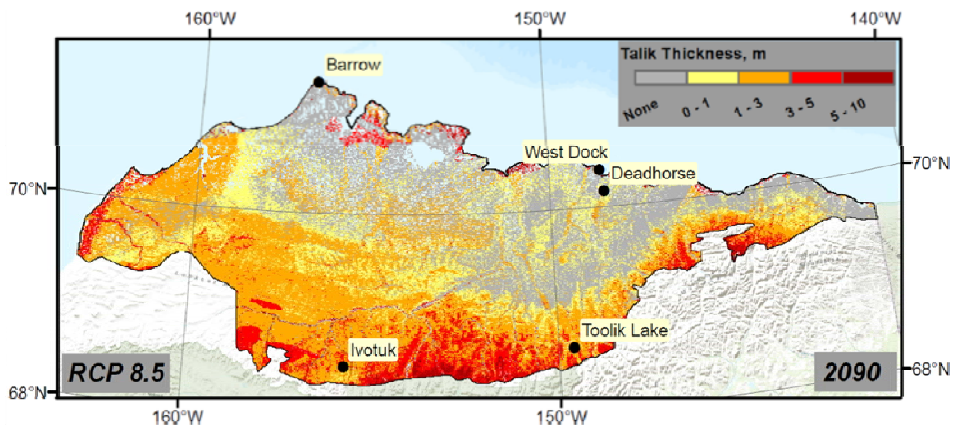
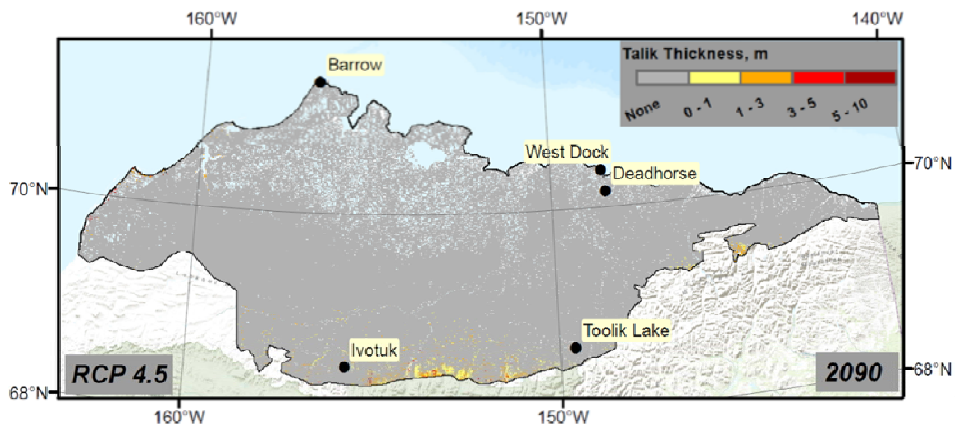
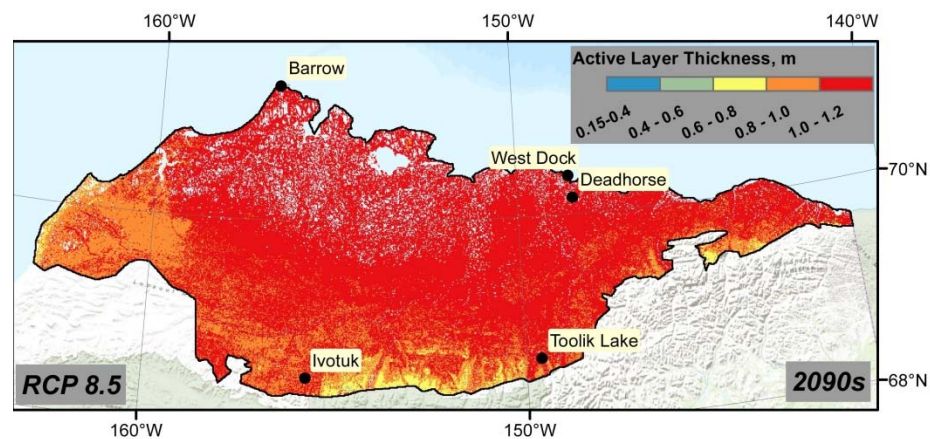
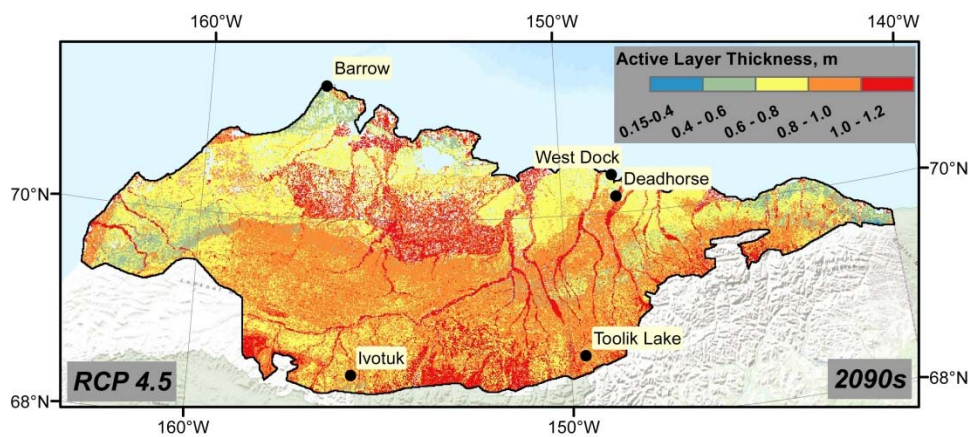
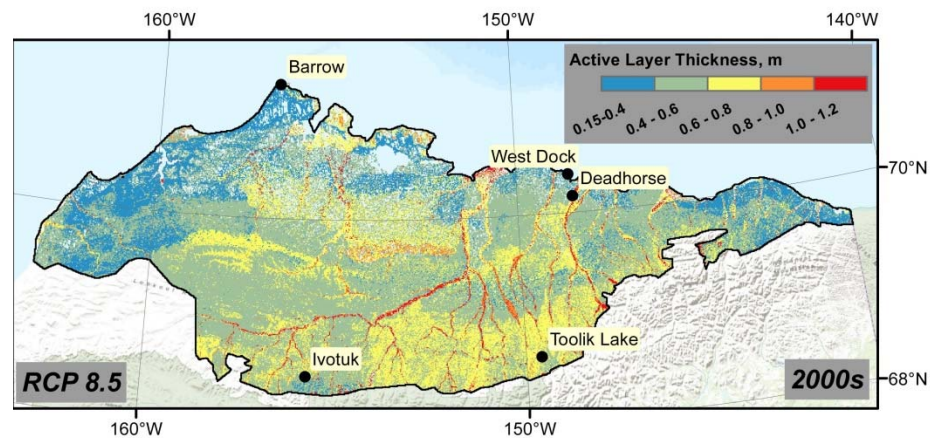
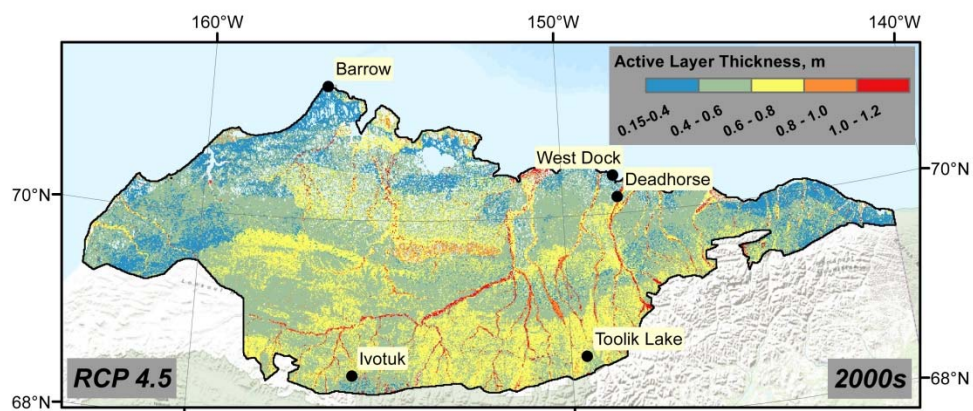
### Ecotypes NOT covered by permafrost boreholes

Ecotypes	% Cover
Coastal barrens	0.3
Coastal wet sedge tundra	0.9
Riverine barrens	1.2
Riverine low willow shrub tundra	0.8
Riverine moist sedge-shrub tundra	3.1
Riverine <u>dryas</u> dwarf shrub tundra	0.0
Lowland low birch-willow shrub tundra	1.3
Upland <u>dryas</u> dwarf shrub tundra	0.6
Upland tall alder scrub	0.0
Alpine non-carbonate barrens	0.0
Alpine carbonate barrens	0.0
Alpine non-carbonate <u>dryas</u> dwarf shrub	0.2
Alpine carbonate <u>dryas</u> dwarf shrub	0.0
<b>Total cover</b>	<b>8.7</b>







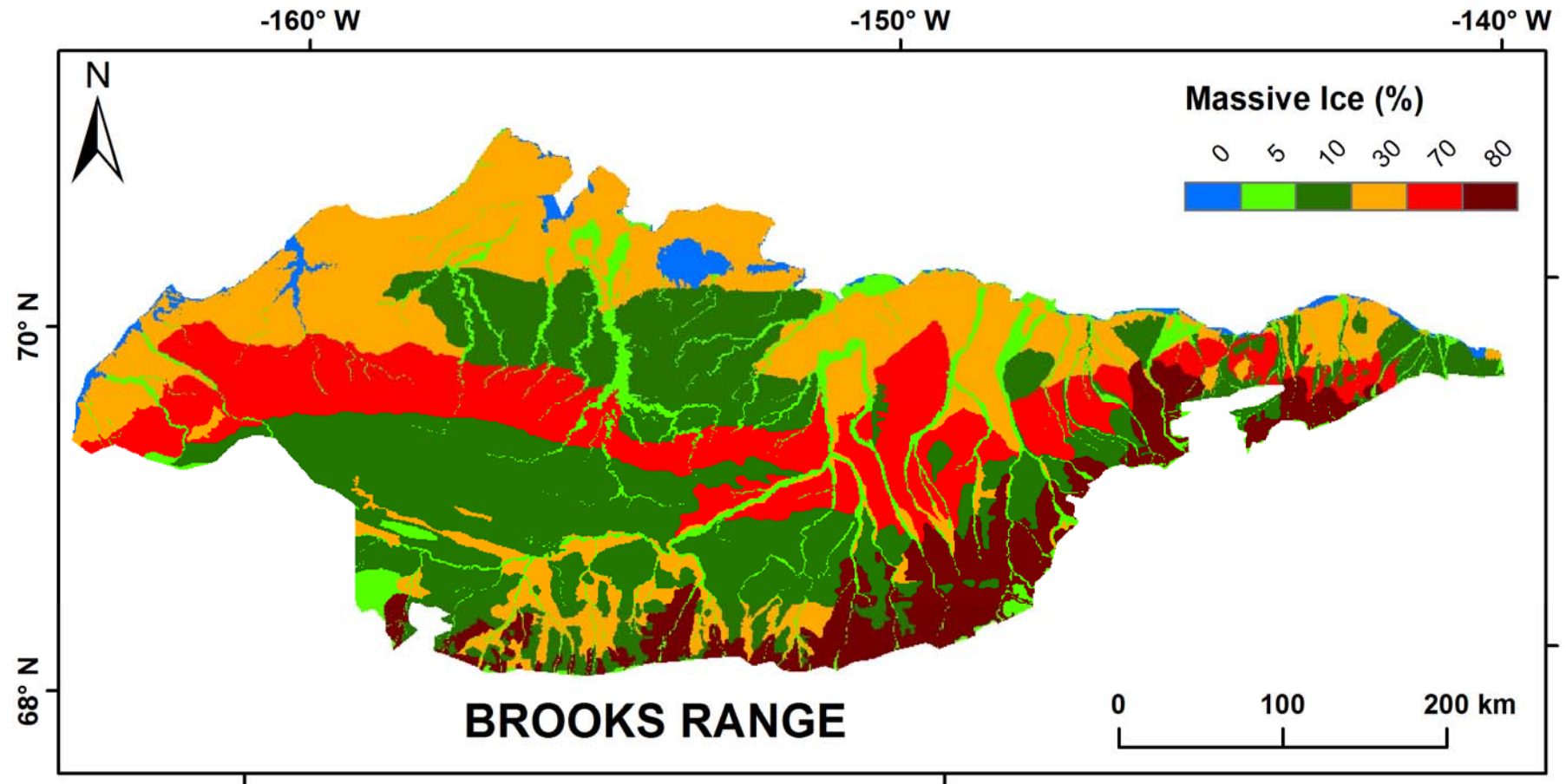




# Challenges

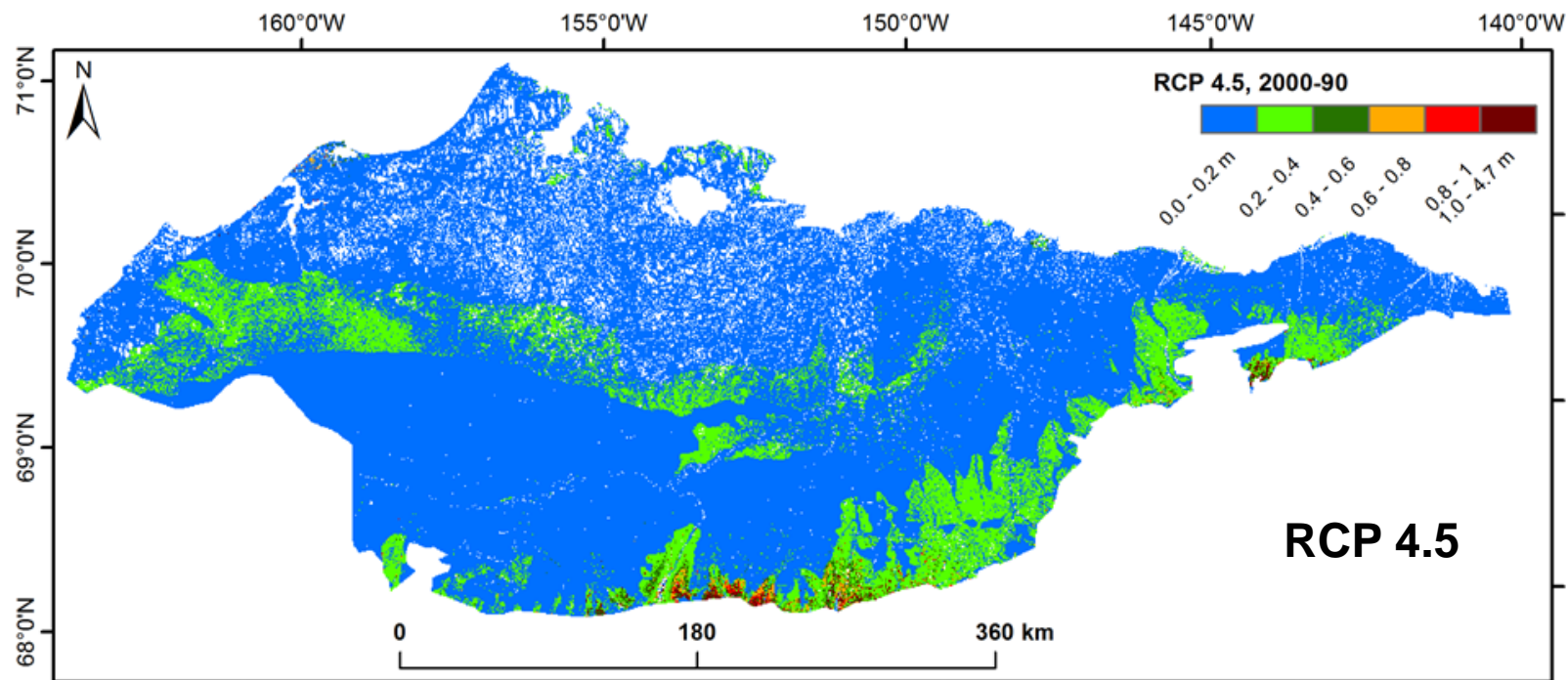
- **Assessment of vulnerability of permafrost to**
  - climate change
  - to natural disturbances
  - to human activities
- **Projections of the future changes in permafrost with very high spatial resolution**
- **High-resolution mapping of the various environmental changes triggered by changes in permafrost**
- **High-resolution mapping of the societal impacts caused by changes in permafrost**

# Massive Ice Distribution, North Slope of Alaska

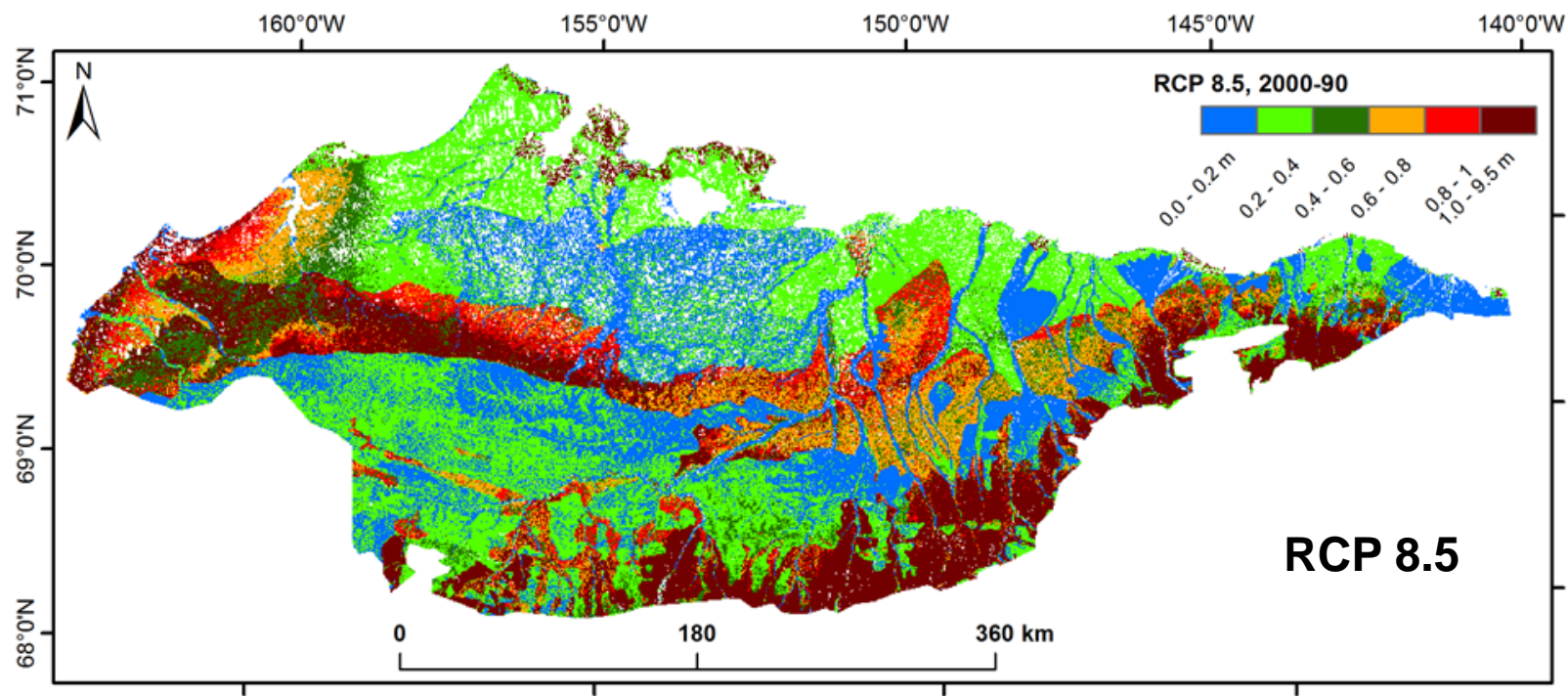


*Modified after Jorgenson et al. 2014*

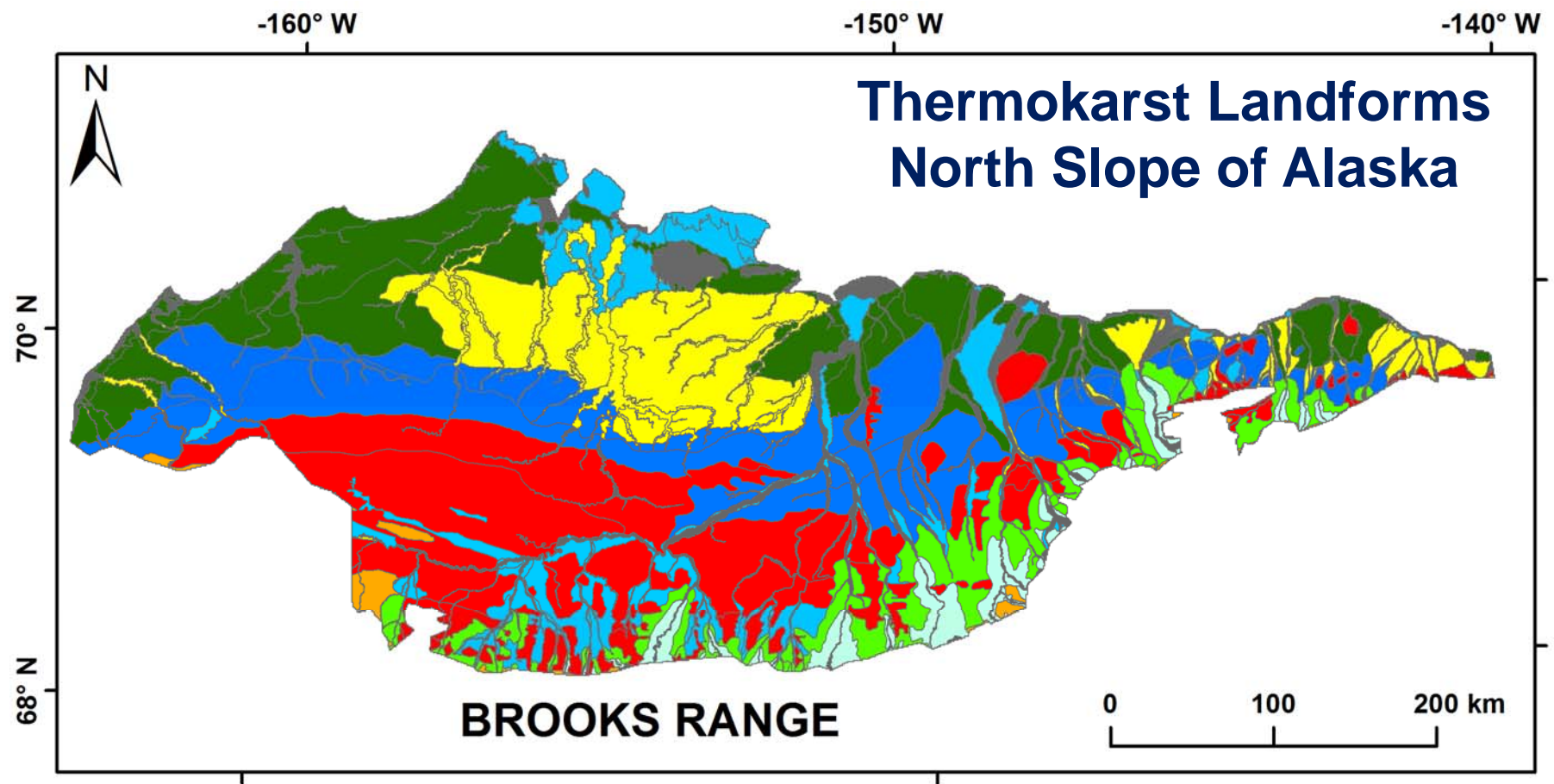




**Thaw settlement (m) between 2000 and 2090 from RCP 4.5. Maximum settlement is 4.7 m**



**Thaw settlement (m) between 2000 and 2090 from RCP 8.5. Maximum settlement is 9.5 m**



### Thermokarst Formation

- Deep Lakes, Drained-lake Basins, Conical Mounds, Pits and Troughs
- Deep Lakes, Drained-lake Basins, Pits and Troughs
- Deep Lakes, Slumps
- Deep Lakes, Slumps, Pits and Troughs
- Detachment Slides
- Detachment Slides, Pits and Troughs
- Negligible
- Pits and Troughs
- Shallow Lakes, Drained-lake Basins, Pits and Troughs

*Modified after Jorgenson et al. 2014*



# Challenges

- **Assessment of vulnerability of permafrost to**
  - climate change
  - to natural disturbances
  - to human activities
- **Projections of the future changes in permafrost with very high spatial resolution**
- **High-resolution mapping of the various environmental changes triggered by changes in permafrost**
- **High-resolution mapping of the societal impacts caused by changes in permafrost**

# Societal Impacts of Permafrost Degradation





# Impact on Infrastructure





# Changes in the ground surface







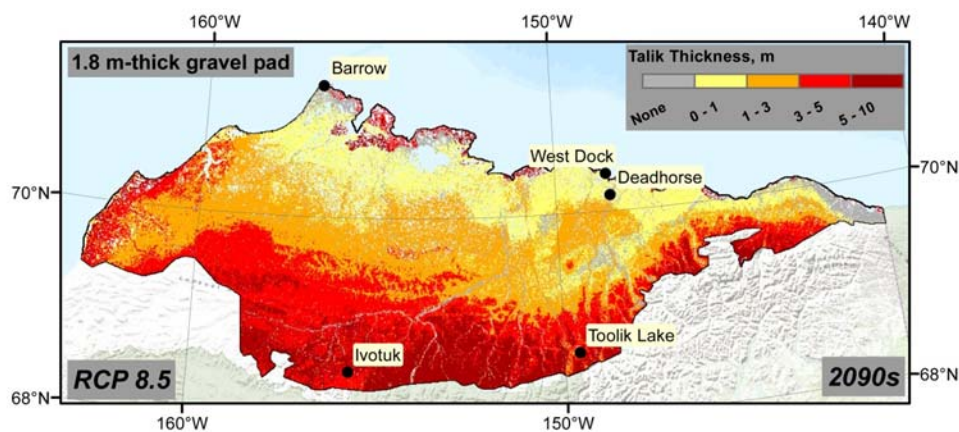
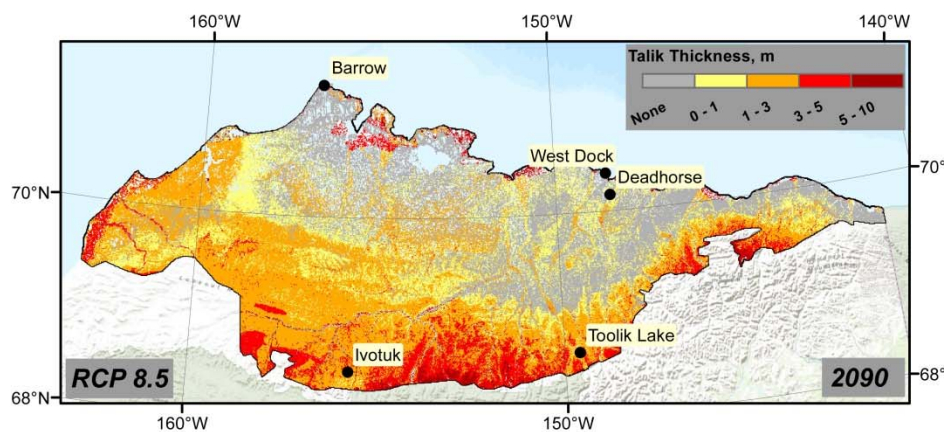
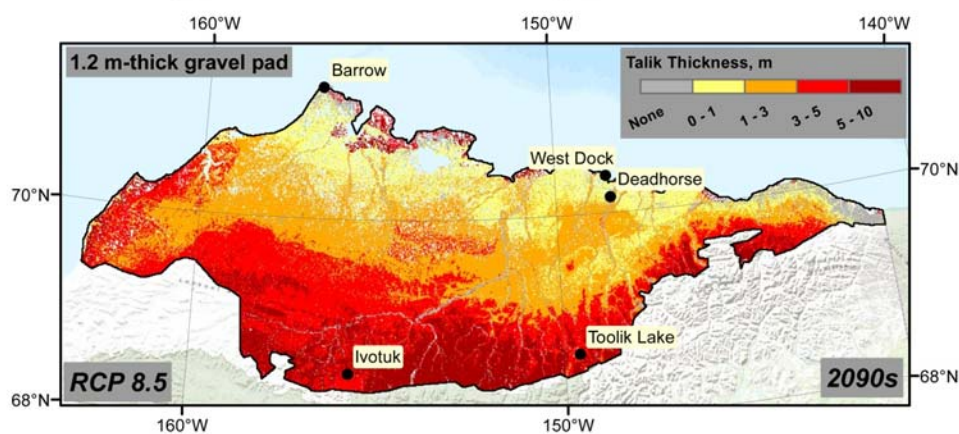
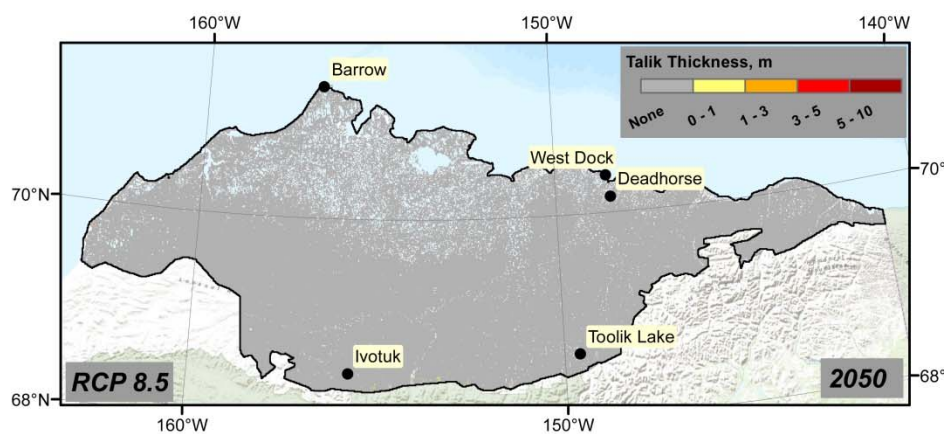
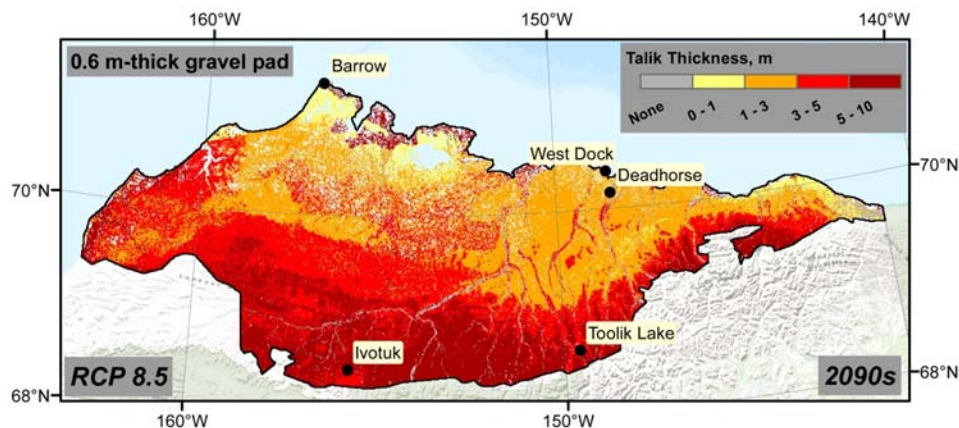
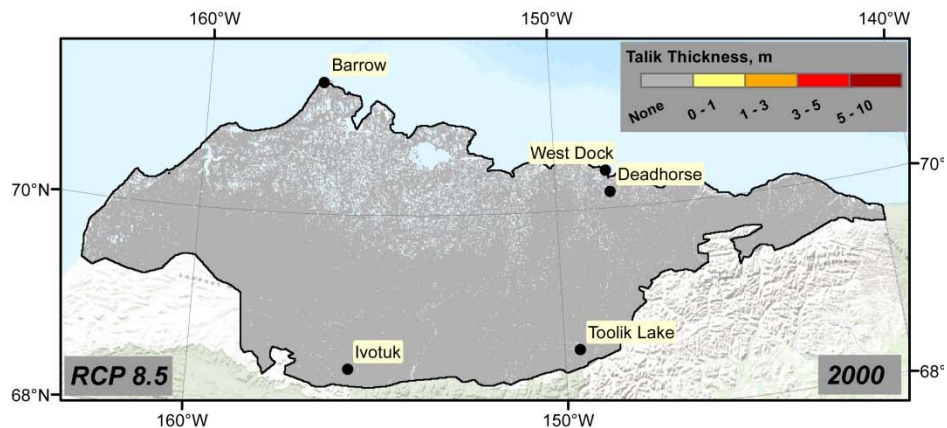
Photo provided by the Fairbanks DOT office



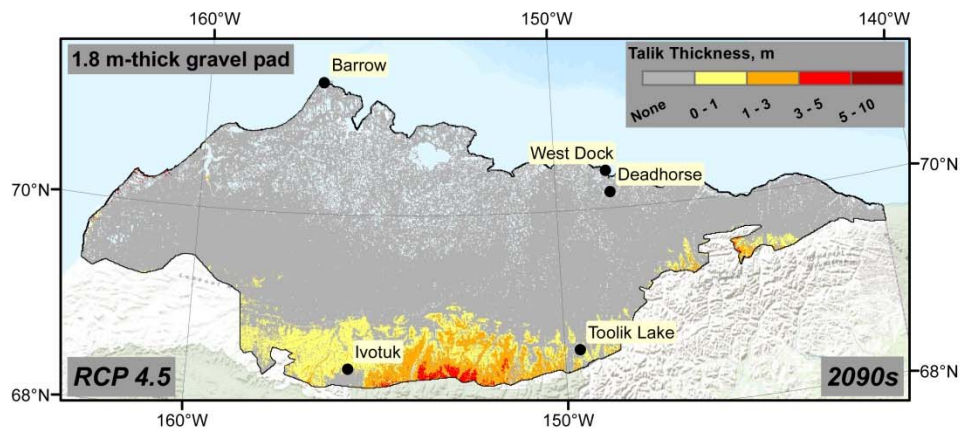
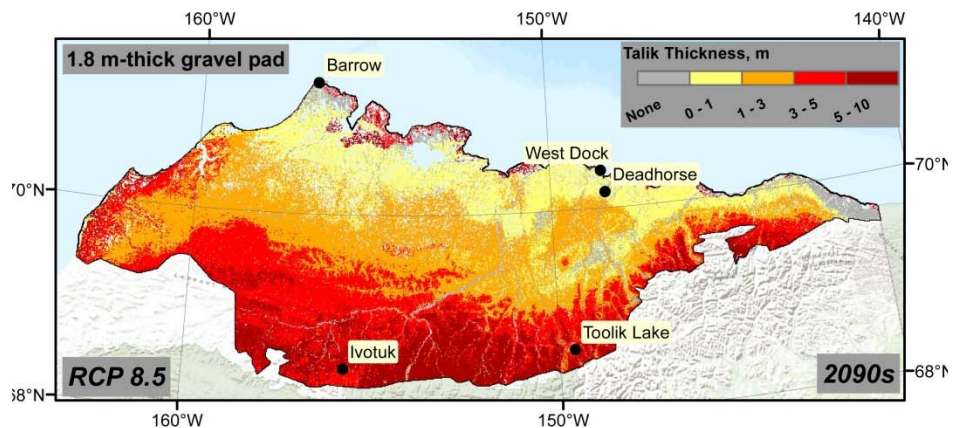
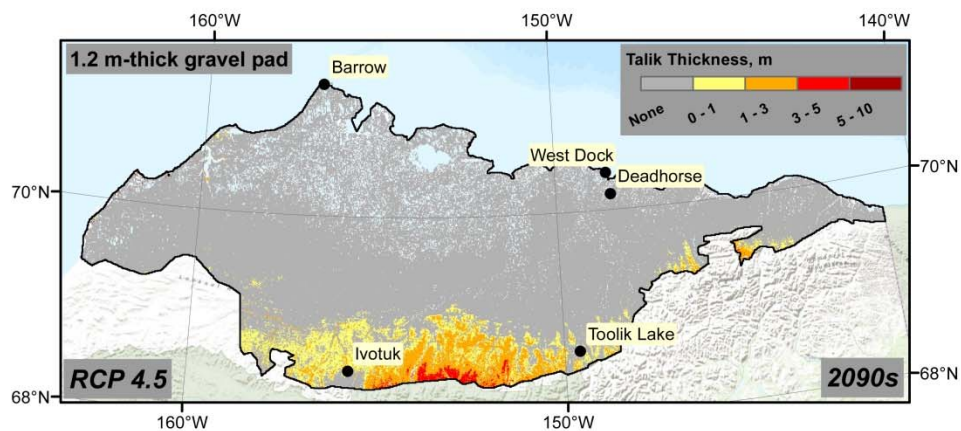
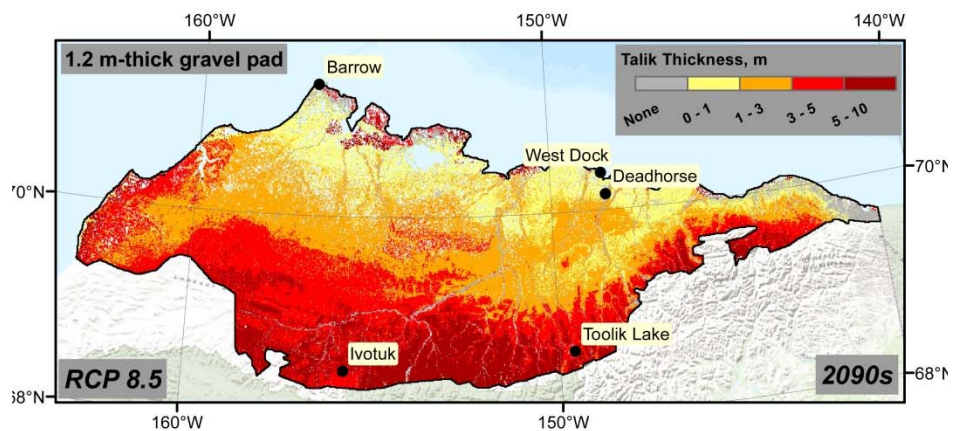
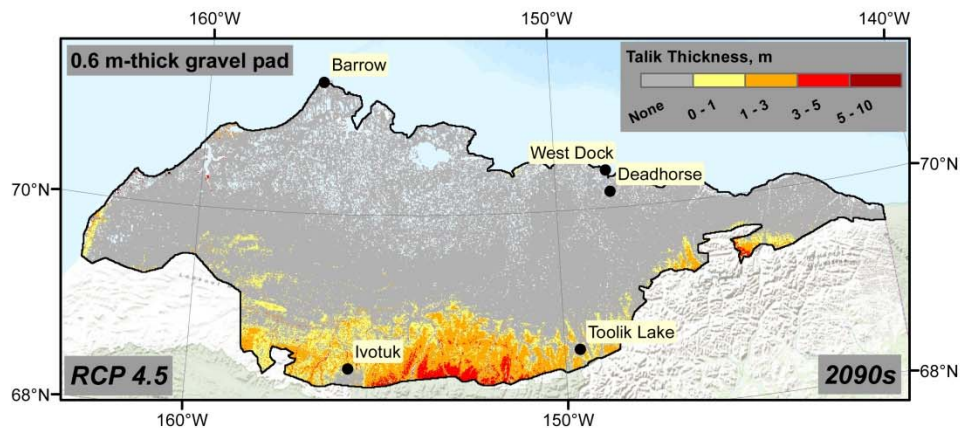
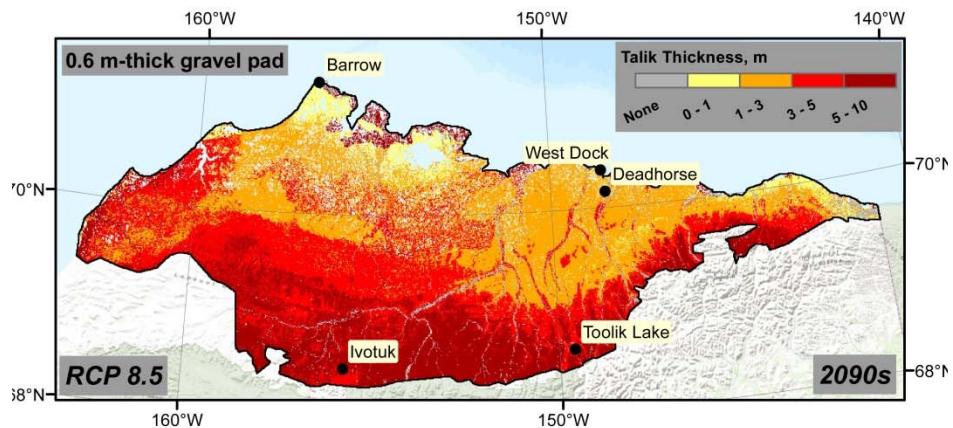


Photo provided by the Fairbanks DOT office



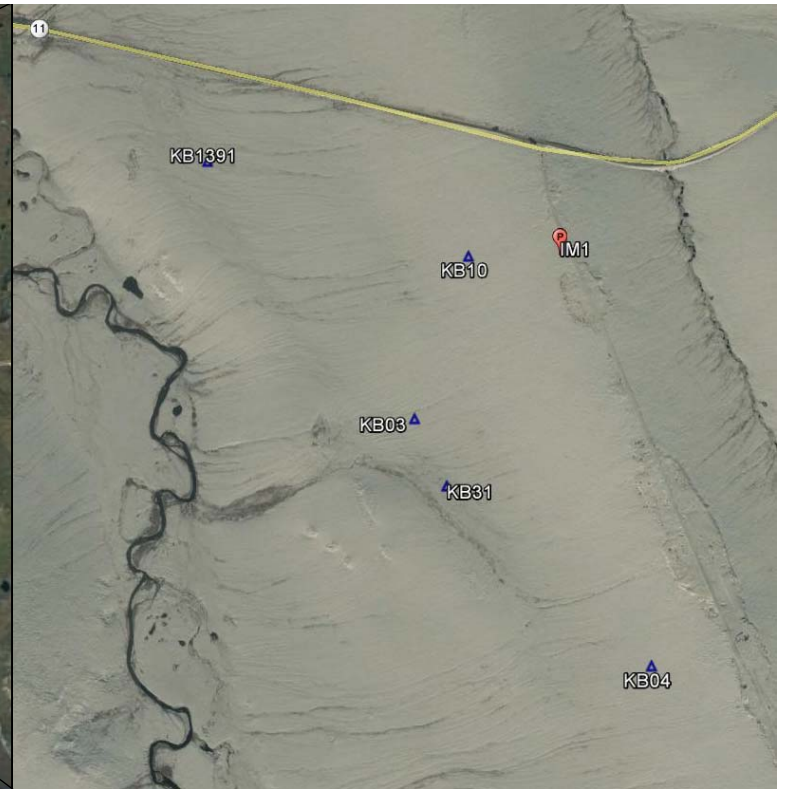
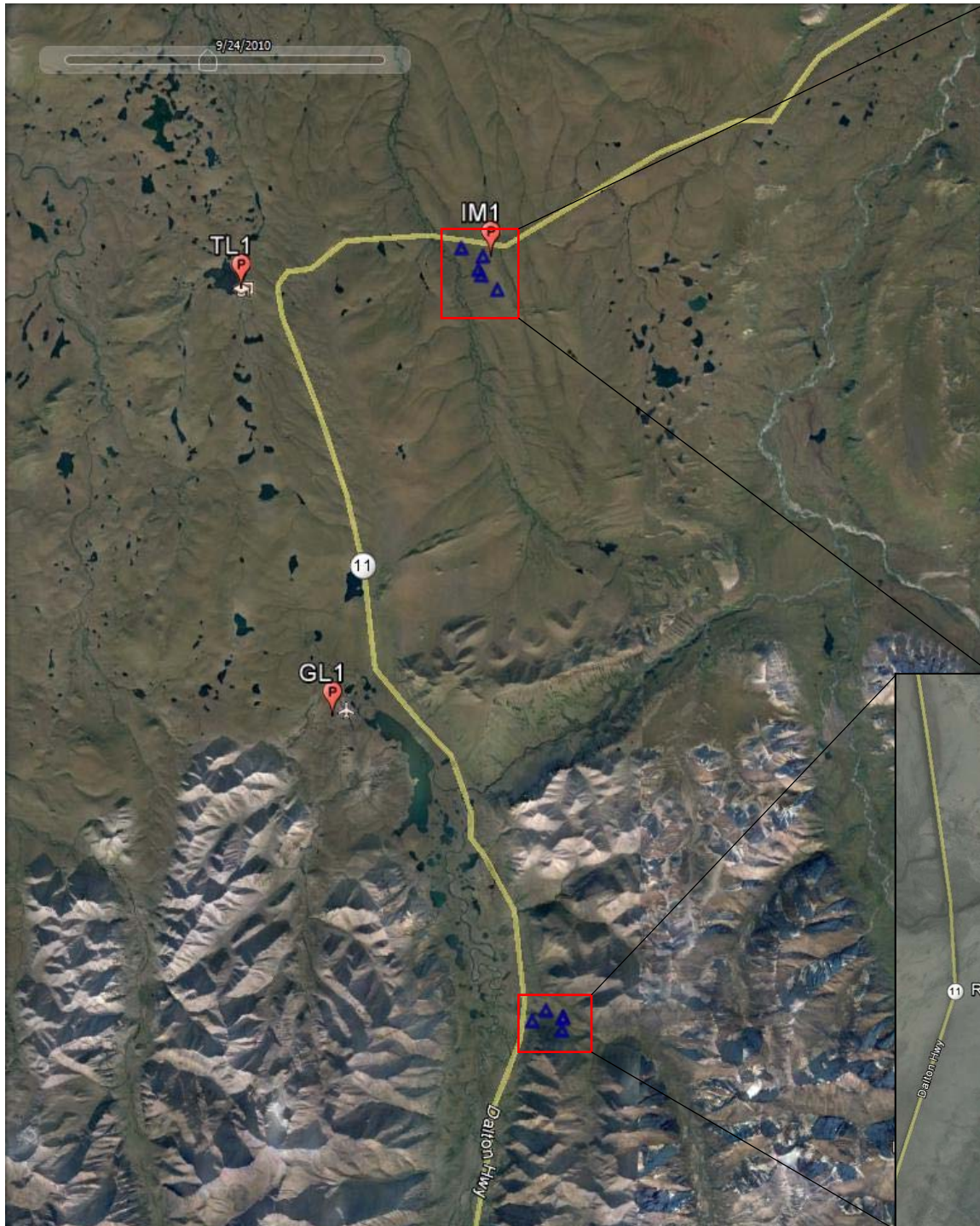




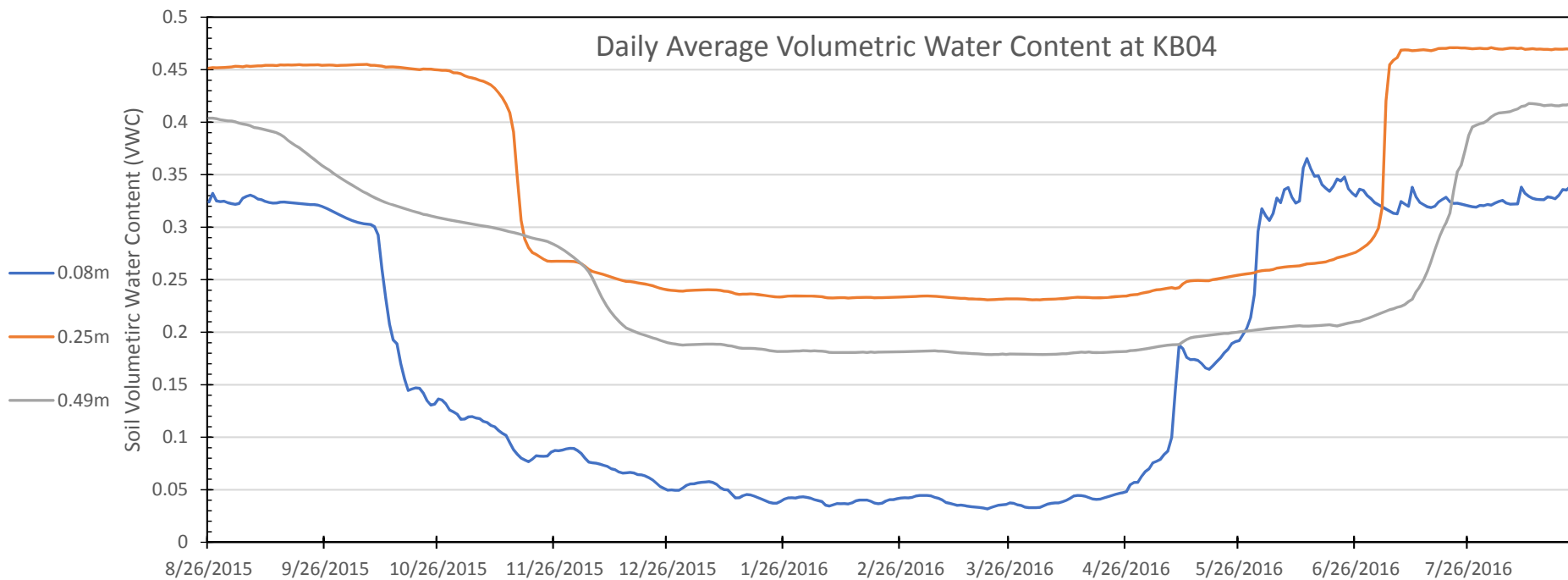
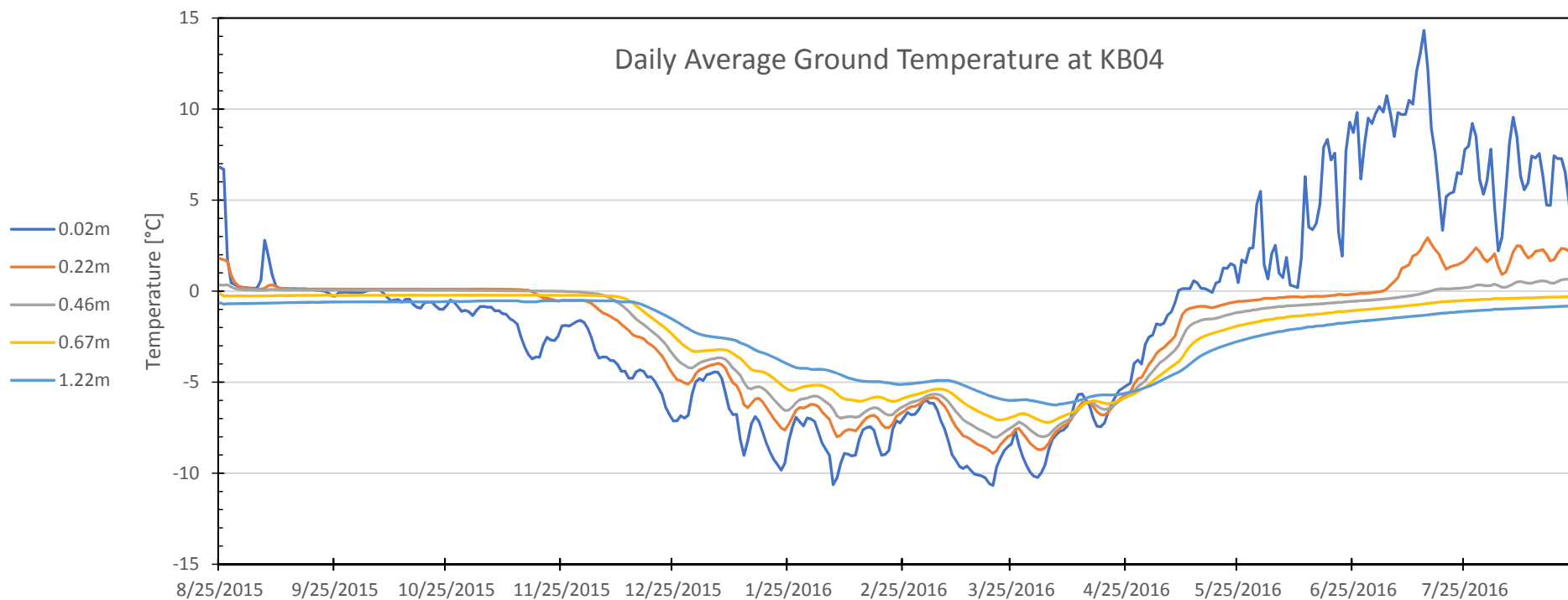




# Suggestion for Collaboration





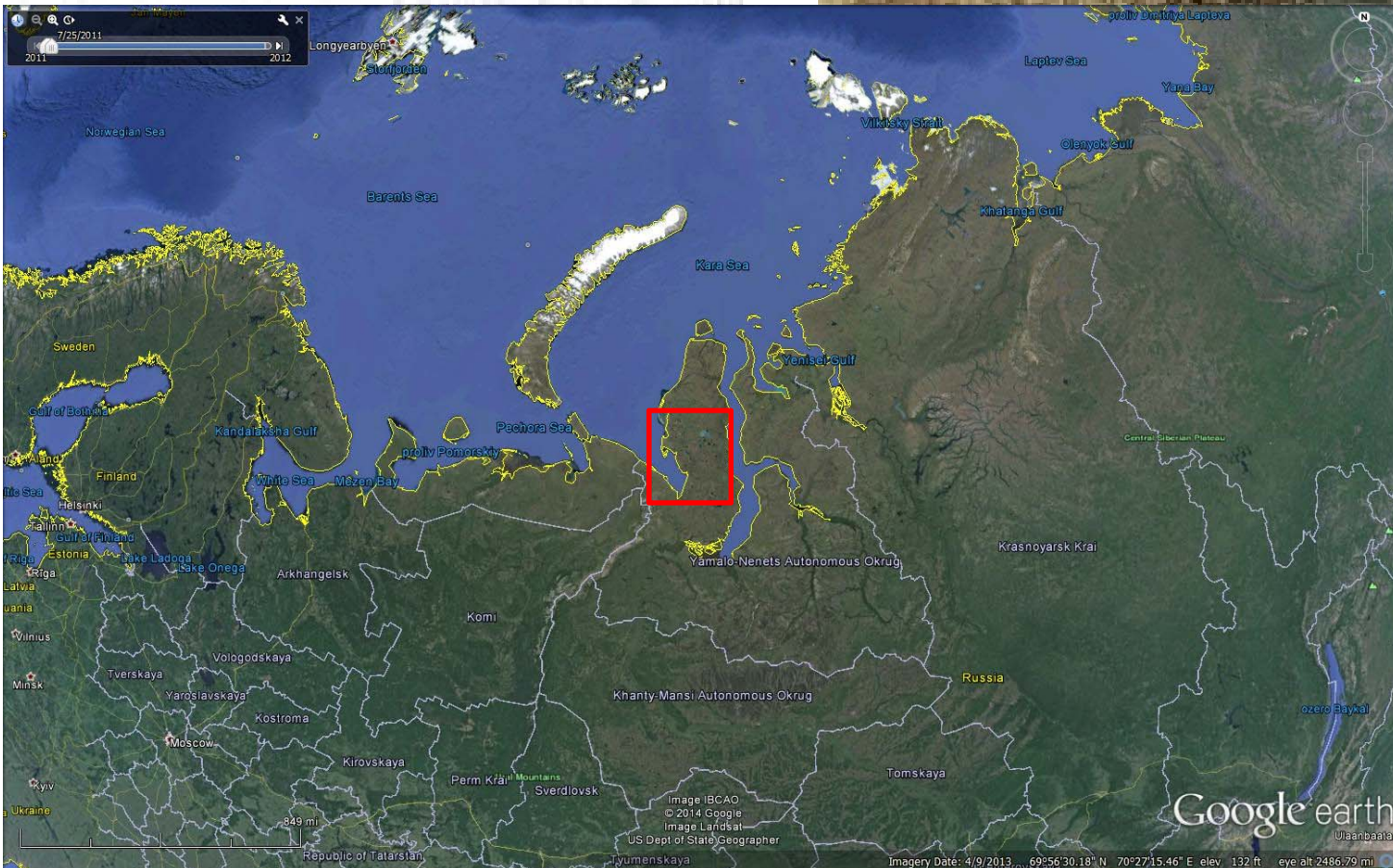


Thank you very much !

[www.permafrostwatch.org](http://www.permafrostwatch.org)







**A Mysterious  
Hole on Yamal  
Peninsula  
in Russia**

