Quantifying socioecological consequences of changing snow & icescapes

Natalie Boelman[1], Todd Brinkman[2], Glen Liston[3], Laura Prugh[4], and Adele Reinking[3]

[1]Lamont-Doherty Earth Observatory, Columbia University, [2]University of Alaska Fairbanks, [3]Colorado State University, [4]University of Washington

Collaborator(s)

Roisin (Roisin) Commane, Columbia University

Sophie Czetwertynski, Yukon Government

Joshua Fisher, NASA JPL

Mark Hebblewhite, University of Montana

John Kimball, University of Montana

J. (Bill) Munger, Harvard University

Amanda Price, Yukon Government

Joel Reynolds, National Park Service

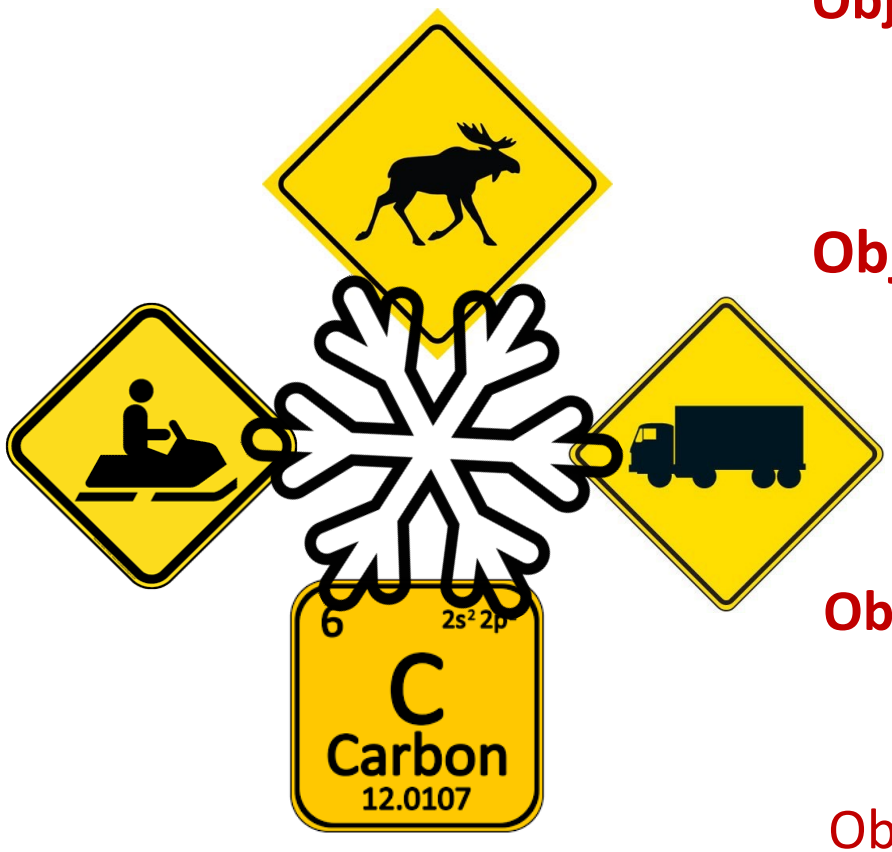
Steven (Steve) Wofsy, Harvard University

Participant(s)

Al Fitzgerald, NOR-EX Engineering Ltd

Kalin Seaton, Ruby Moon Consulting

Quantifying socioecological consequences of changing snow & icescapes



Obj. 1 Quantify snow & ice-scapes

- ✓ past
- ✓ present
- • future

Obj. 2 Natural resources & Subsistence opportunities

- ✓ the efficacy of moose survey methods
- • moose-vehicle collisions on roadways
- • moose hunt success rates

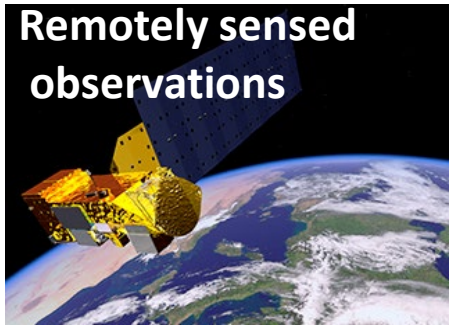
Obj. 3 Winter transportation networks

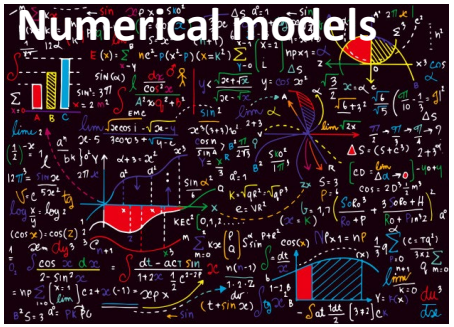
- ✓ roads
- • trails

Obj. 4 C cycling & Climate regulation

Quantification of spatiotemporal dynamics of snow- & ice-scapes to support Obj. 2 - 4

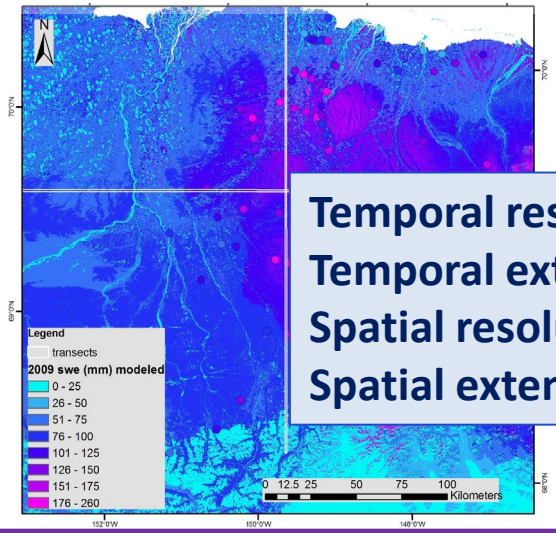
Obj. 1





Data-Model Fusion

Cold-Season Environmental Variables



Temporal resolution: 3 hourly to daily
Temporal extent: 1980 - 2100
Spatial resolution: 30-m to 1-km grids
Spatial extent: ABoVE Study Domain

Meteorology	Snow	Soils
Air temperature	Depth	Temperature
Relative humidity	Density	Ice content
Wind speed	Snow water equivalent (SWE)	Liquid water content
Wind direction	Collapse pressure	
Precipitation	Hardness	**Vegetation**
Solar radiation	Strength	Land cover type
		Leaf-off date
		Leaf-on date
		LAI
		Vegetation height
		Vegetation density
		NDVI
		Time-Invariant
		Elevation
		Surface roughness
Ice season length	Snow season length	Ruggedness
Snow on ice	Rain on snow events	Slope aspect
Snow-melt onset	Ice layers	Road/path type
Ice-melt onset	Thermal conductivity and resistance	

Glen Liston
Adele Reinking

Status of environmental variables

*As part of this work we are continually developing new variables tailored specifically for this project; the newest variables are still being developed and are not yet on this list.

Meteorology	Snow	Soils
Air temperature	Depth	Temperature
Relative humidity	Density	Ice content
Wind speed	Snow water equivalent (SWE)	Liquid water content
Wind direction	Collapse pressure	
Precipitation	Hardness	**Vegetation**
Solar radiation	Strength	Land cover type
Cloud fraction	Trafficability	Leaf-off date
Snowfall	Snow cover fraction	Leaf-on date
Rainfall	Snow patchiness	LAI
Time since last snowfall	Albedo	Vegetation height
Daylight duration	Stratigraphy	Vegetation density
	Grain size	NDVI
Lake Ice and River Ice	Grain type	
Ice thickness	Blowing snow mass flux	**Time-Invariant**
Ice-onset date	Snow-onset date	Elevation
Ice-free date	Snow-free date	Surface roughness
Ice season length	Snow season length	Ruggedness
Snow on ice	Rain on snow events	Slope aspect
Snow-melt onset	Ice layers	Road/path type
Ice-melt onset	Thermal conductivity and resistance	

= Variable has been developed and can be used in simulations

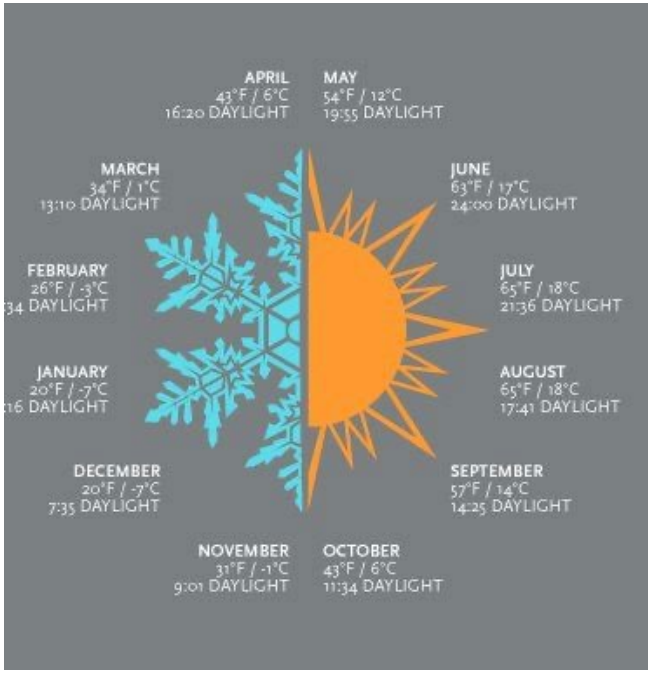
= Variable development is underway

= Variable development has not started

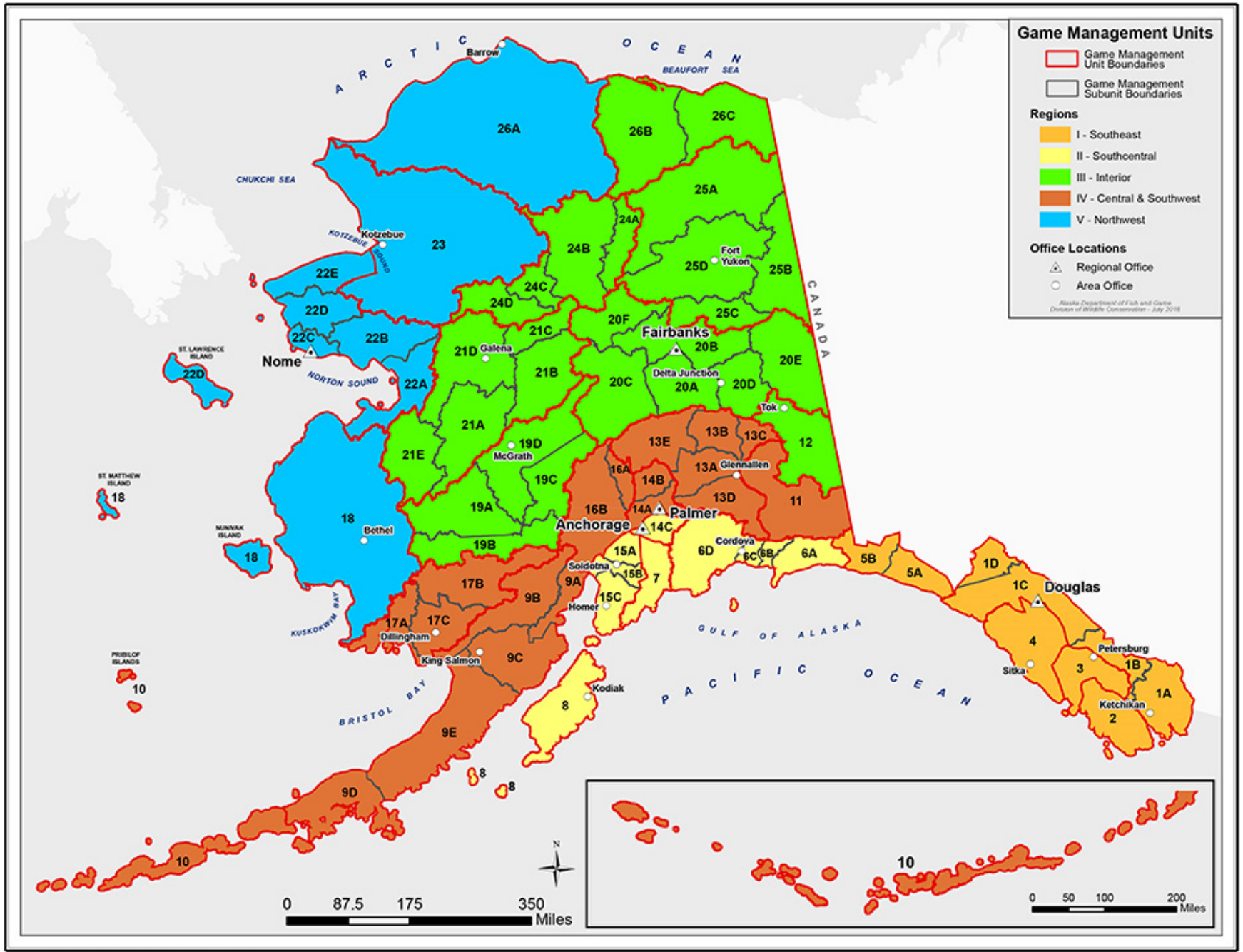
= Variable is publicly available

Poor snow conditions significantly hinder Alaskan wildlife agency ability to monitor moose populations

Obj. 2

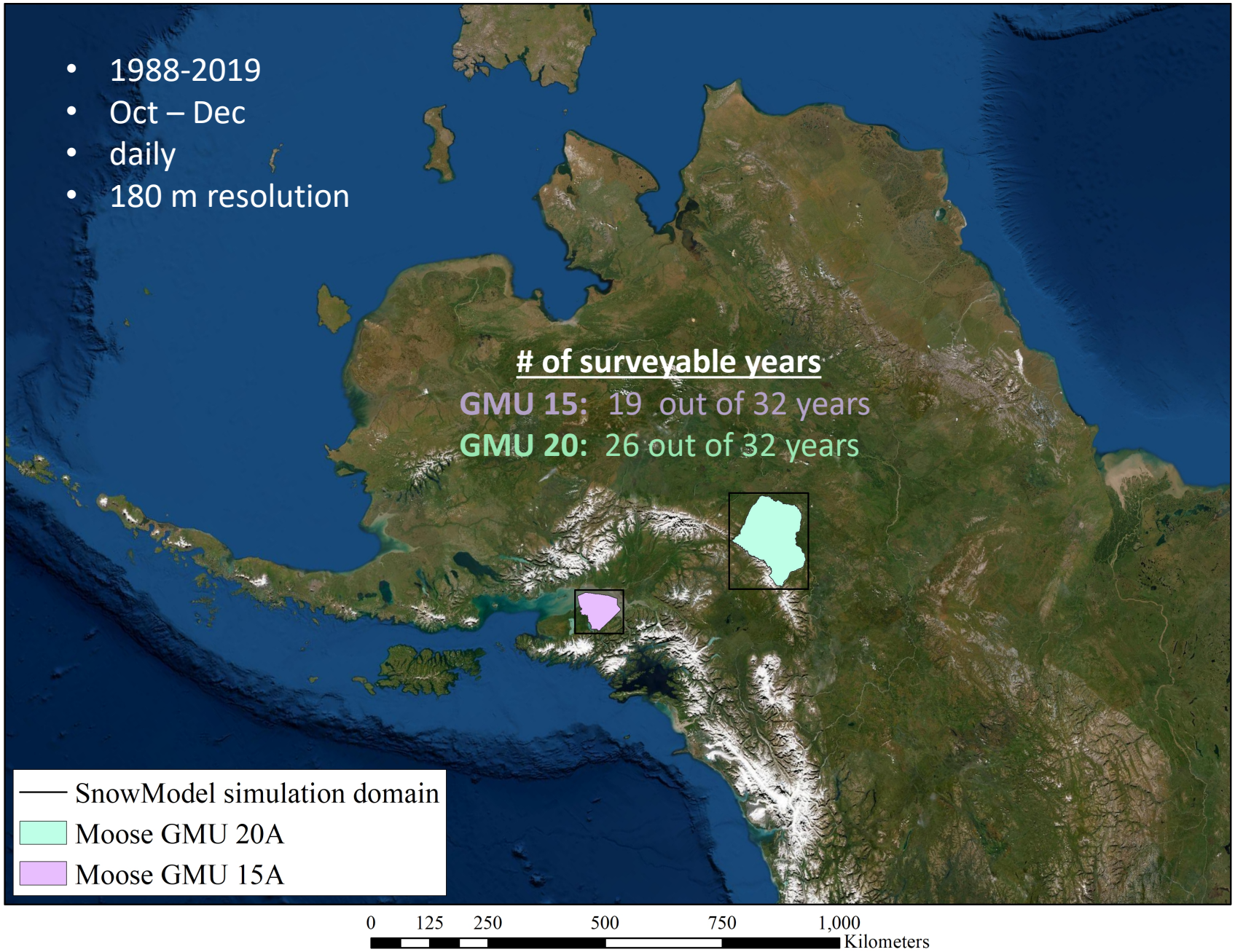


Alaska's Game Management Units (GMUs)



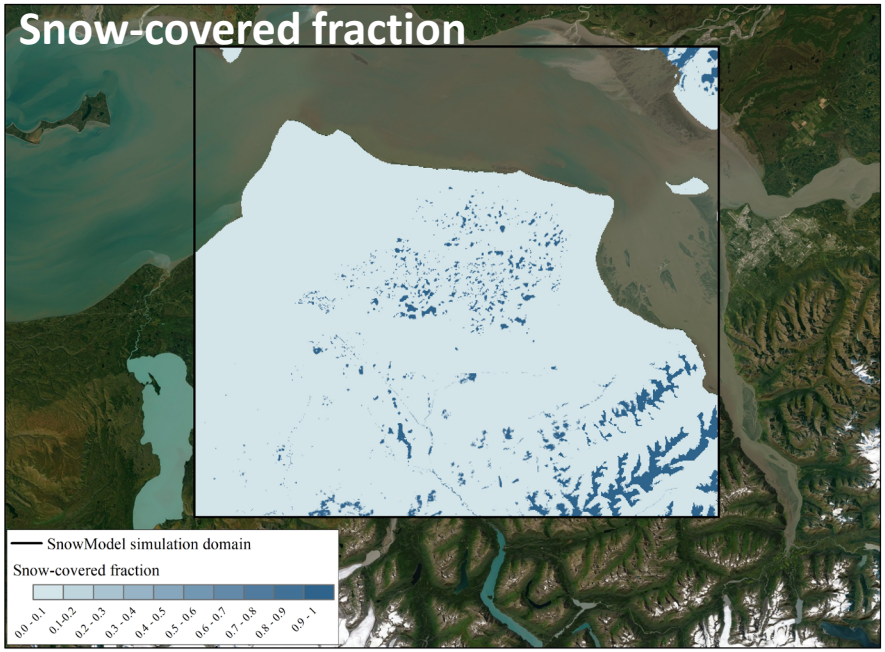
Fit for purpose SnowModel Simulations

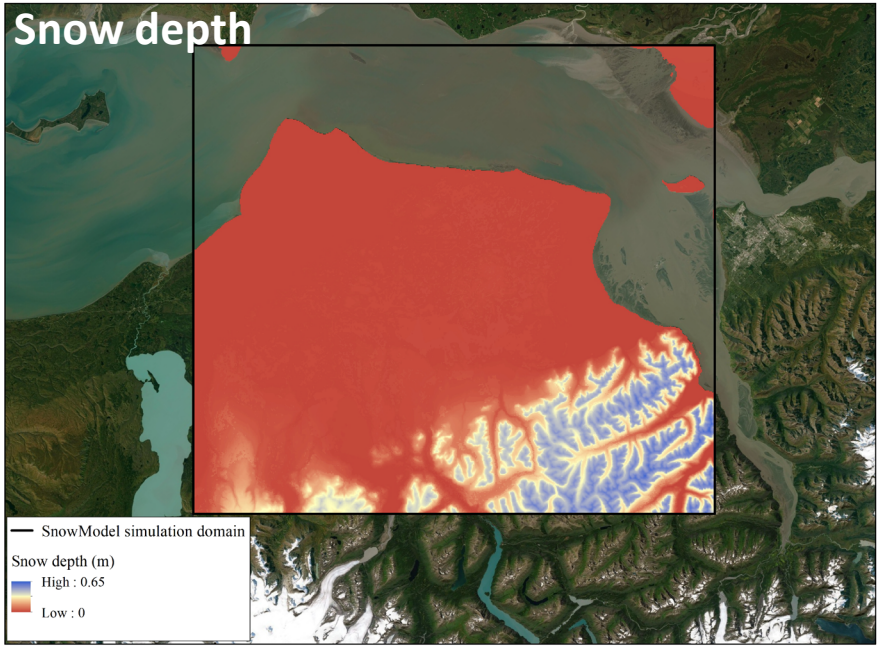
Adele Reinking

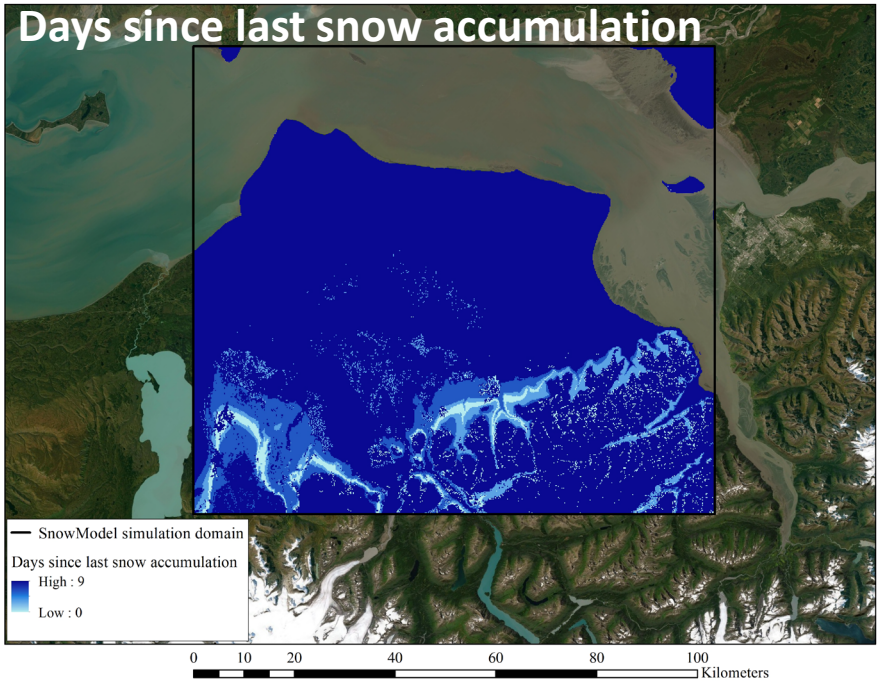


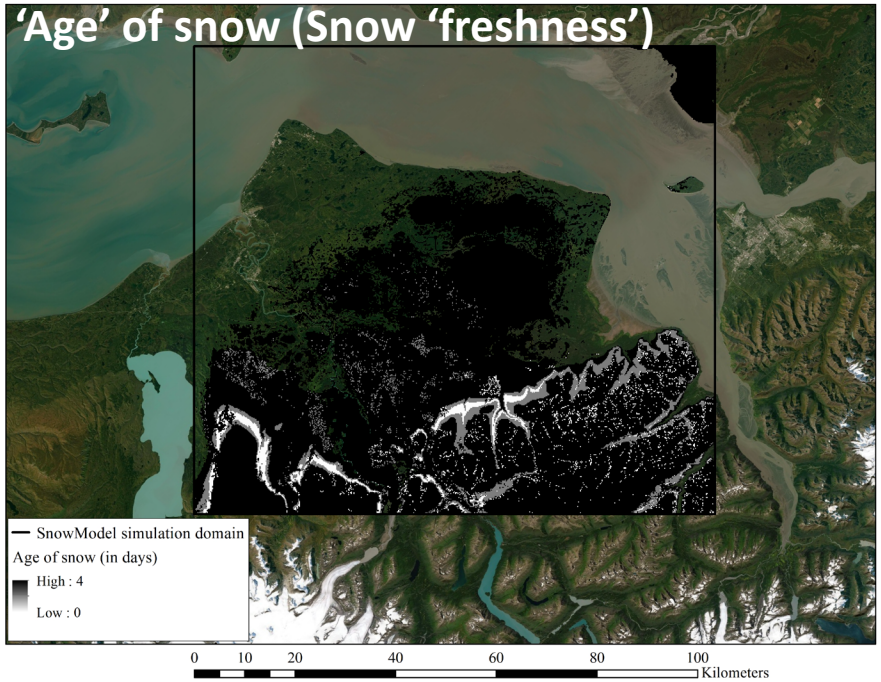
GMU 15A: Oct 31 1992

Adele Reinking



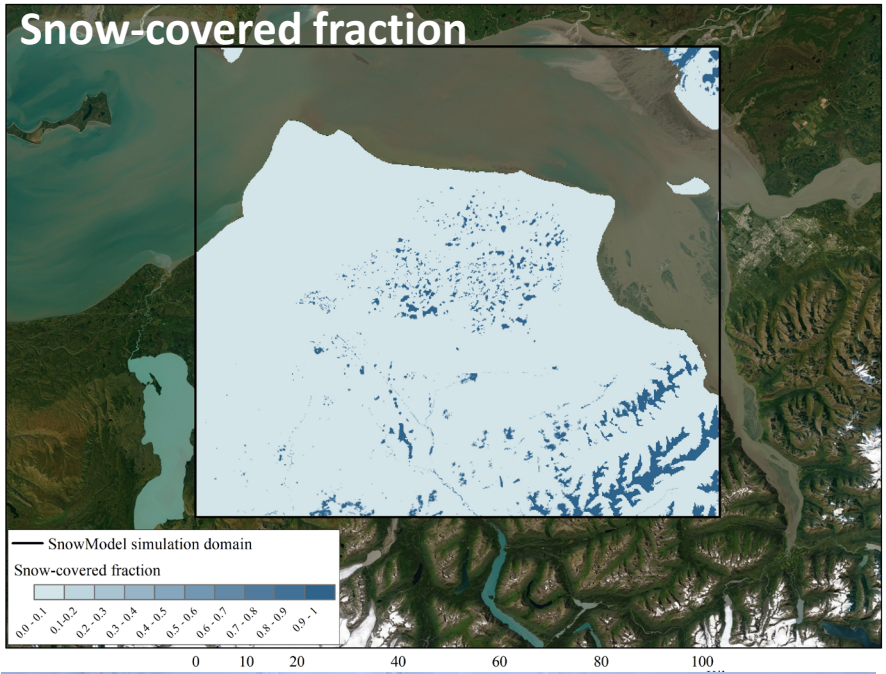


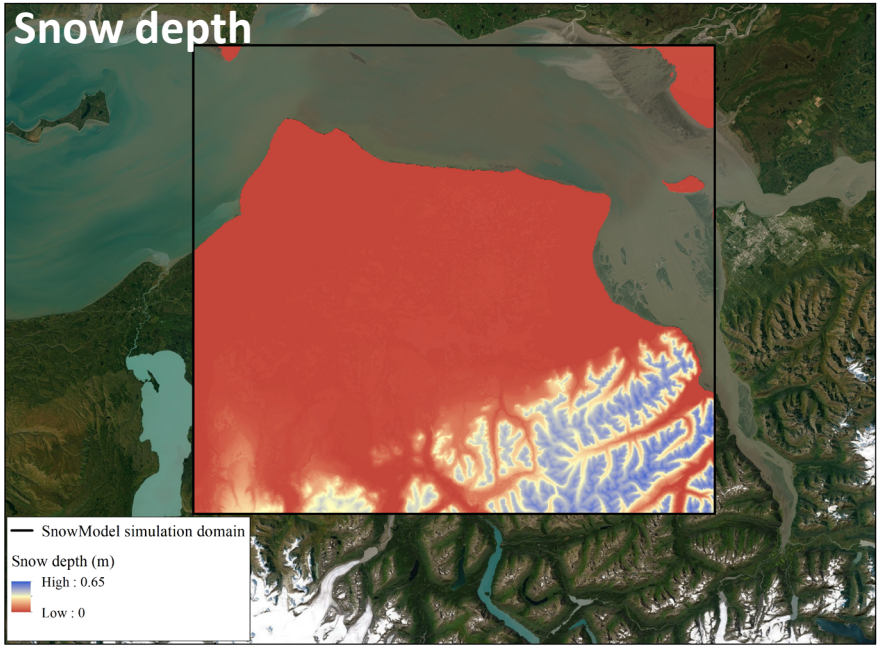


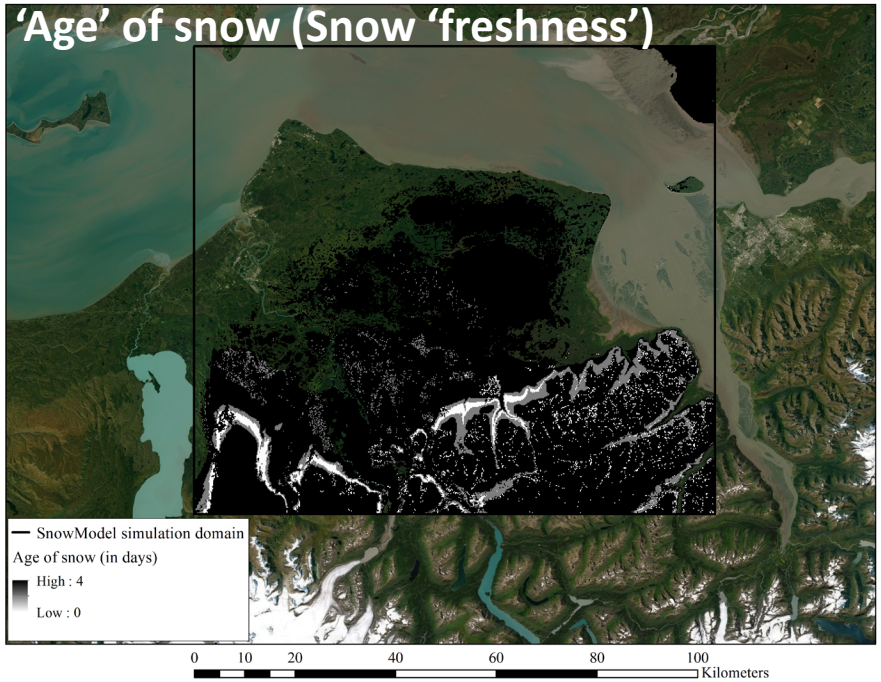


GMU 15A: Oct 31 1992

Adele Reinking







Todd Brinkman

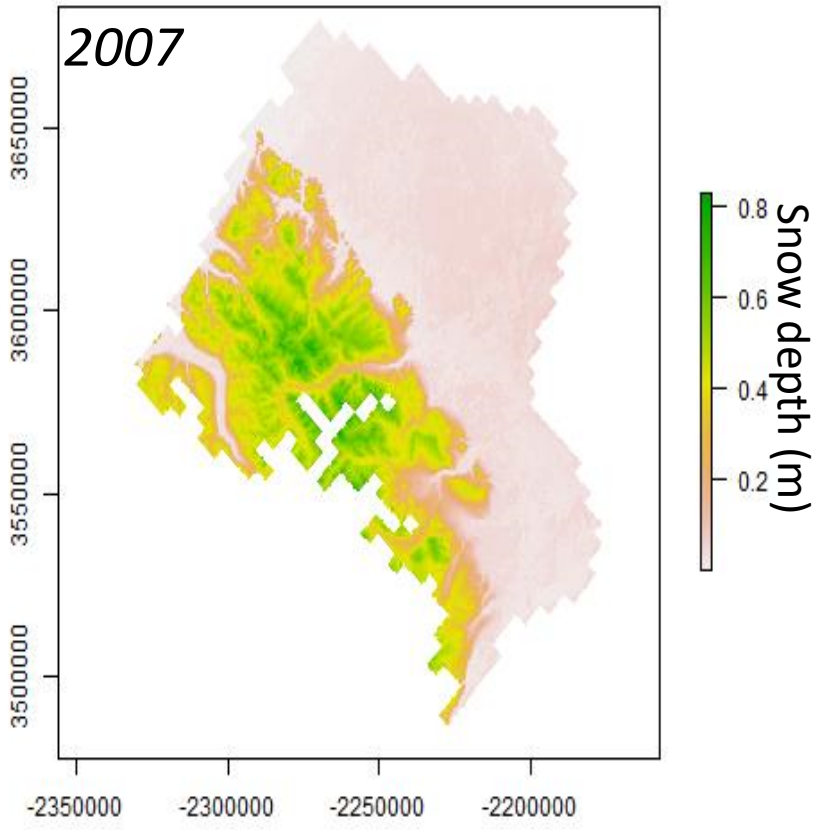
Assessing relationships among snow & moose surveys

GMU 20A: **Snow depth**

ADFG moose survey data

- 1988-2019
- Go/No Go

Deeper snow in higher elevations in 2007, but *much* of the GMU as a whole had very little!

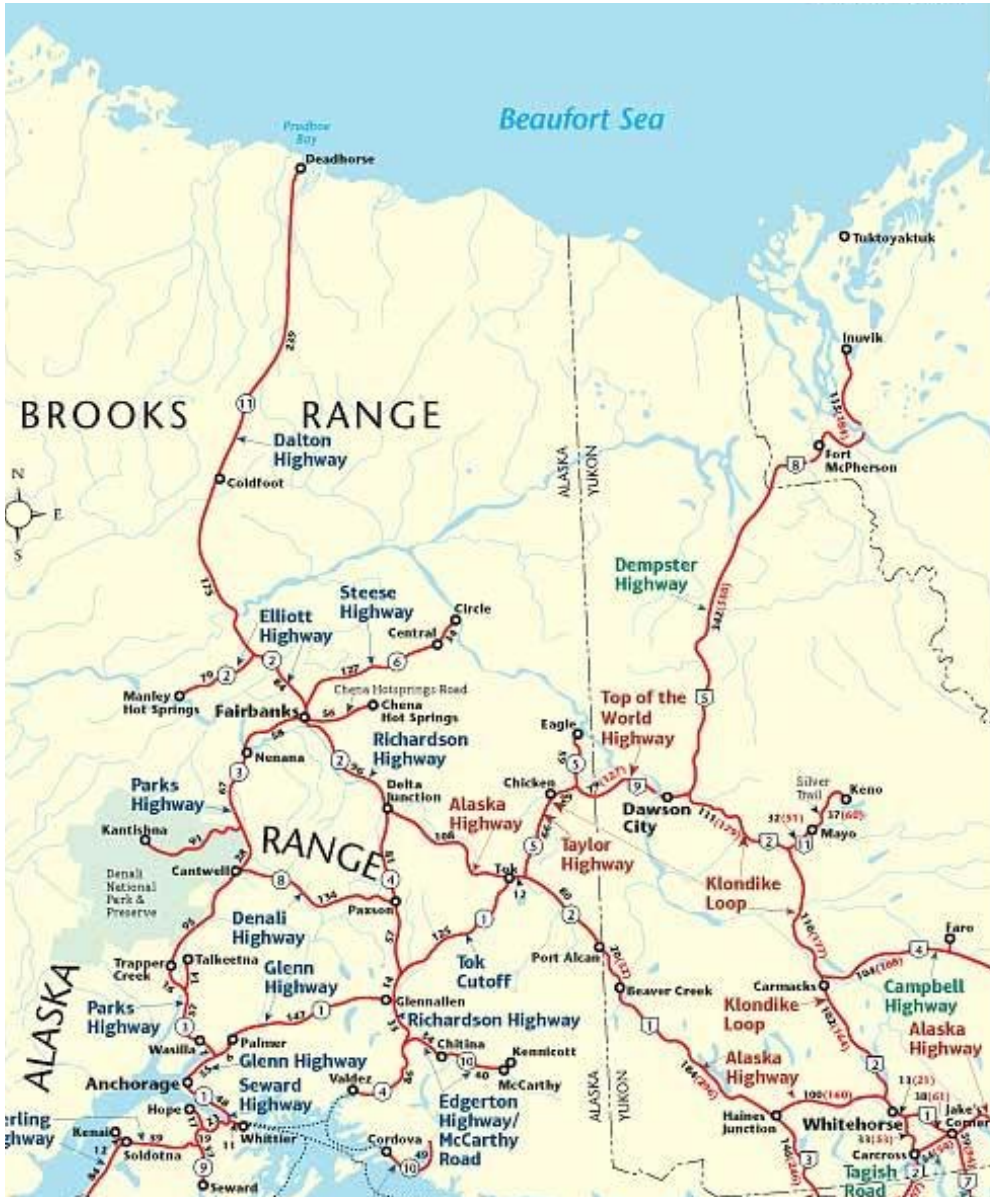


Anticipated products:

- estimates of snow variable thresholds required to conduct moose surveys
- statewide models & projections of survey probability based on snow conditions

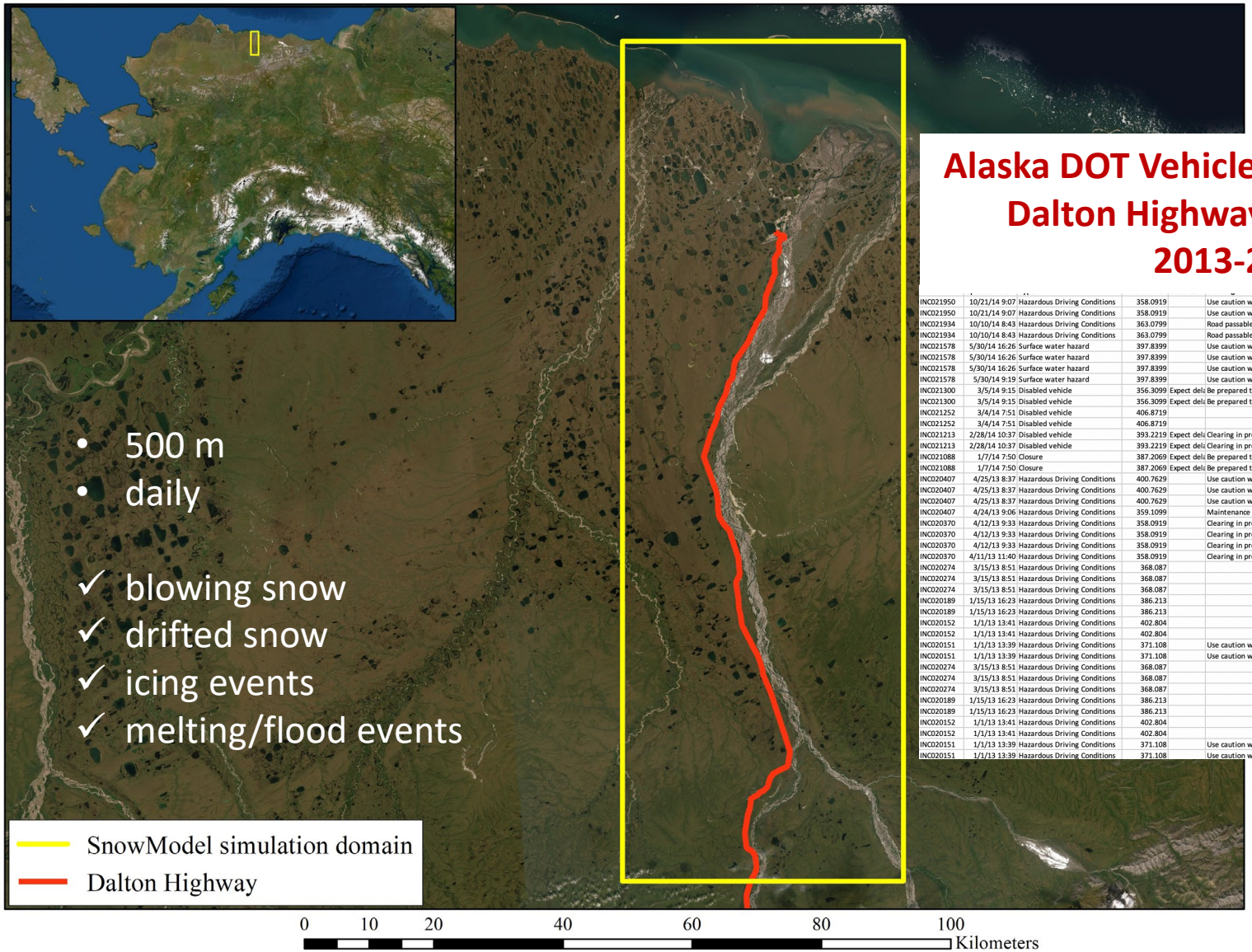
Dynamic snow and ice conditions on winter roads affect the seasonality, duration, and safety of travel along roads

Obj. 3



How do spatially and temporally explicit environmental conditions influence Dalton Highway transportation safety?

Natalie Boelman
Adele Reinking
Glen Liston



- 500 m
- daily

✓ blowing snow
✓ drifted snow
✓ icing events
✓ melting/flood events

Alaska DOT Vehicle Incident Reports
Dalton Highway MP 356-414
2013-2014

INC021950	10/21/14 9:07	Hazardous Driving Conditions	358.0919	Use caution when traveling thr	Reports of high winds, blowing snow, and zero visibility has made driving co
INC021950	10/21/14 9:07	Hazardous Driving Conditions	358.0919	Use caution when traveling thr	Reports of high winds, blowing snow, and zero visibility has made driving co
INC021934	10/10/14 8:43	Hazardous Driving Conditions	363.0799	Road passable with care,Use ca	Reports of black ice has made driving conditions extremely slick and hazardo
INC021934	10/10/14 8:43	Hazardous Driving Conditions	363.0799	Road passable with care,Use ca	Reports of black ice has made driving conditions extremely slick and hazardo
INC021578	5/30/14 16:26	Surface water hazard	397.8399	Use caution when traveling thr	
INC021578	5/30/14 16:26	Surface water hazard	397.8399	Use caution when traveling thr	
INC021578	5/30/14 16:26	Surface water hazard	397.8399	Use caution when traveling thr	
INC021578	5/30/14 9:19	Surface water hazard	397.8399	Use caution when traveling thr	
INC021300	3/5/14 9:15	Disabled vehicle	356.3099	Expect delay Be prepared to stop,Use cautior	There is a vehicle in the ditch and partially on the roadway (about 2') that l
INC021300	3/5/14 9:15	Disabled vehicle	356.3099	Expect delay Be prepared to stop,Use cautior	There is a vehicle in the ditch and partially on the roadway (about 2') that l
INC021252	3/4/14 7:51	Disabled vehicle	406.8719		A travel advisory has been issued for MP 404 Dalton Highway. A tractor tra
INC021252	3/4/14 7:51	Disabled vehicle	406.8719		A travel advisory has been issued for MP 404 Dalton Highway. A tractor tra
INC021213	2/28/14 10:37	Disabled vehicle	393.2219	Expect delay Clearing in progress,Maintenan	
INC021213	2/28/14 10:37	Disabled vehicle	393.2219	Expect delay Clearing in progress,Maintenan	
INC021088	1/7/14 7:50	Closure	387.2069	Expect delay Be prepared to stop,Use cautior	
INC021088	1/7/14 7:50	Closure	387.2069	Expect delay Be prepared to stop,Use cautior	
INC020407	4/25/13 8:37	Hazardous Driving Conditions	400.7629	Use caution when traveling thr	Reports of blowing and drifting snow, 1-3' drifts.
INC020407	4/25/13 8:37	Hazardous Driving Conditions	400.7629	Use caution when traveling thr	Reports of blowing and drifting snow, 1-3' drifts.
INC020407	4/25/13 8:37	Hazardous Driving Conditions	400.7629	Use caution when traveling thr	Reports of blowing and drifting snow, 1-3' drifts.
INC020407	4/24/13 9:06	Hazardous Driving Conditions	359.1099	Maintenance equipment on the	Reports of blowing snow, zero visibility, 40 mph gusts, extremely icy roads,
INC020370	4/12/13 9:33	Hazardous Driving Conditions	358.0919	Clearing in progress,Maintenan	Reports of blowing snow, heavy drifting snow, and poor visibility has made
INC020370	4/12/13 9:33	Hazardous Driving Conditions	358.0919	Clearing in progress,Maintenan	Reports of blowing snow, heavy drifting snow, and poor visibility has made
INC020370	4/12/13 9:33	Hazardous Driving Conditions	358.0919	Clearing in progress,Maintenan	Reports of blowing snow, heavy drifting snow, and poor visibility has made
INC020370	4/11/13 11:40	Hazardous Driving Conditions	358.0919	Clearing in progress,Maintenan	Reports of blowing snow, heavy drifting snow, and poor visibility has made
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020189	1/15/13 16:23	Hazardous Driving Conditions	386.213		The highway is passable, but due to drifts the road may be down to one lar
INC020189	1/15/13 16:23	Hazardous Driving Conditions	386.213		The highway is passable, but due to drifts the road may be down to one lar
INC020152	1/1/13 13:41	Hazardous Driving Conditions	402.804		Reports of high winds and 3'-5' drifts has made driving conditions very diffic
INC020152	1/1/13 13:41	Hazardous Driving Conditions	402.804		Reports of high winds and 3'-5' drifts has made driving conditions very diffic
INC020151	1/1/13 13:39	Hazardous Driving Conditions	371.108	Use caution when traveling thr	Reports of high winds and extremely low visibility has made driving conditi
INC020151	1/1/13 13:39	Hazardous Driving Conditions	371.108	Use caution when traveling thr	Reports of high winds and extremely low visibility has made driving conditi
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020274	3/15/13 8:51	Hazardous Driving Conditions	368.087		Reports of blowing snow and poor visibility has made driving conditions ext
INC020189	1/15/13 16:23	Hazardous Driving Conditions	386.213		The highway is passable, but due to drifts the road may be down to one lar
INC020189	1/15/13 16:23	Hazardous Driving Conditions	386.213		The highway is passable, but due to drifts the road may be down to one lar
INC020152	1/1/13 13:41	Hazardous Driving Conditions	402.804		Reports of high winds and 3'-5' drifts has made driving conditions very diffic
INC020152	1/1/13 13:41	Hazardous Driving Conditions	402.804		Reports of high winds and 3'-5' drifts has made driving conditions very diffic
INC020151	1/1/13 13:39	Hazardous Driving Conditions	371.108	Use caution when traveling thr	Reports of high winds and extremely low visibility has made driving conditi
INC020151	1/1/13 13:39	Hazardous Driving Conditions	371.108	Use caution when traveling thr	Reports of high winds and extremely low visibility has made driving conditi

Questions?