

Permafrost scenario & mean annual air temperature modelling

-1 K ← 0 K → +1 K → +2 K → +5 K

Philip P. Bonnaventure

Antoni G. Lewkowicz

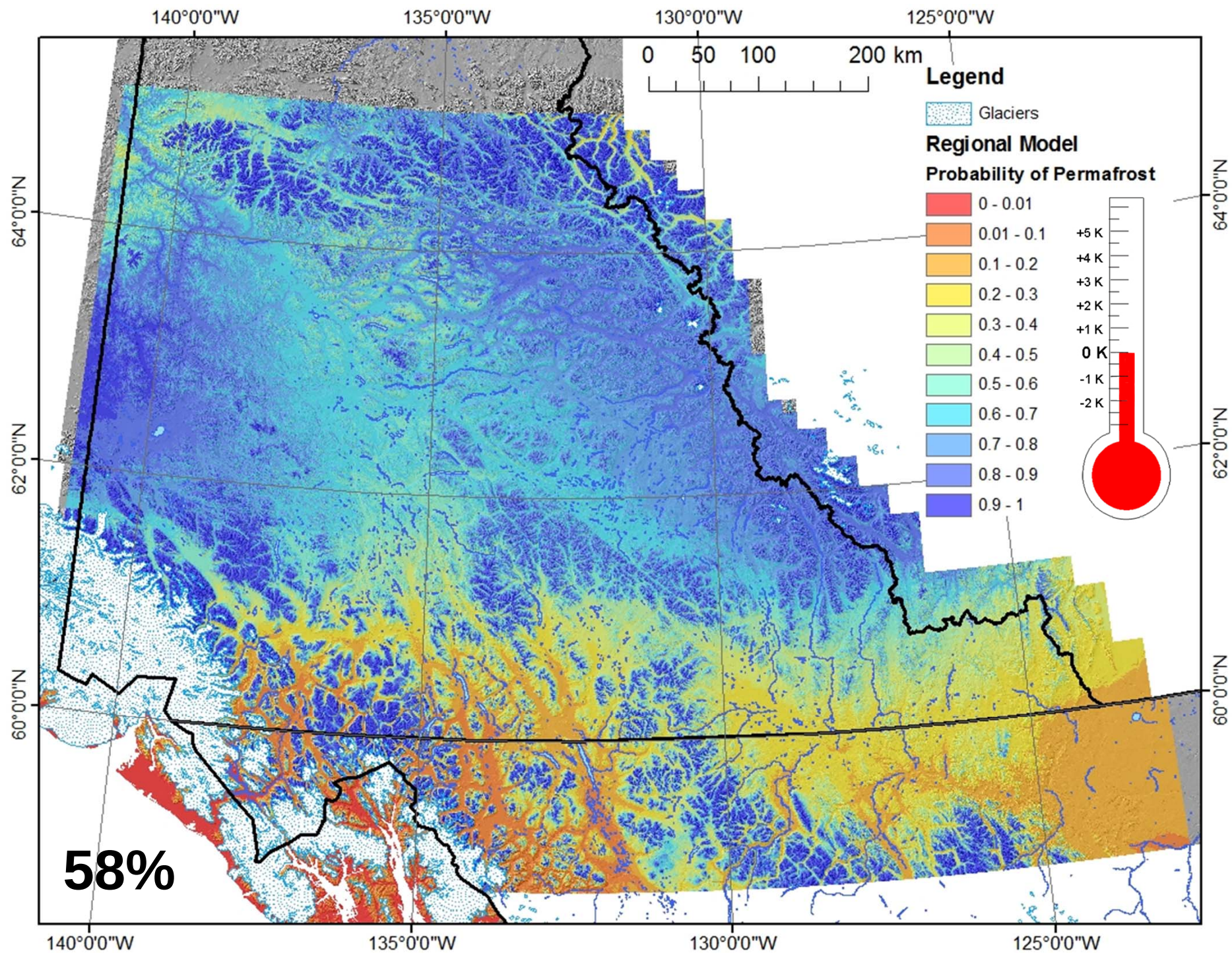
Graham Pope



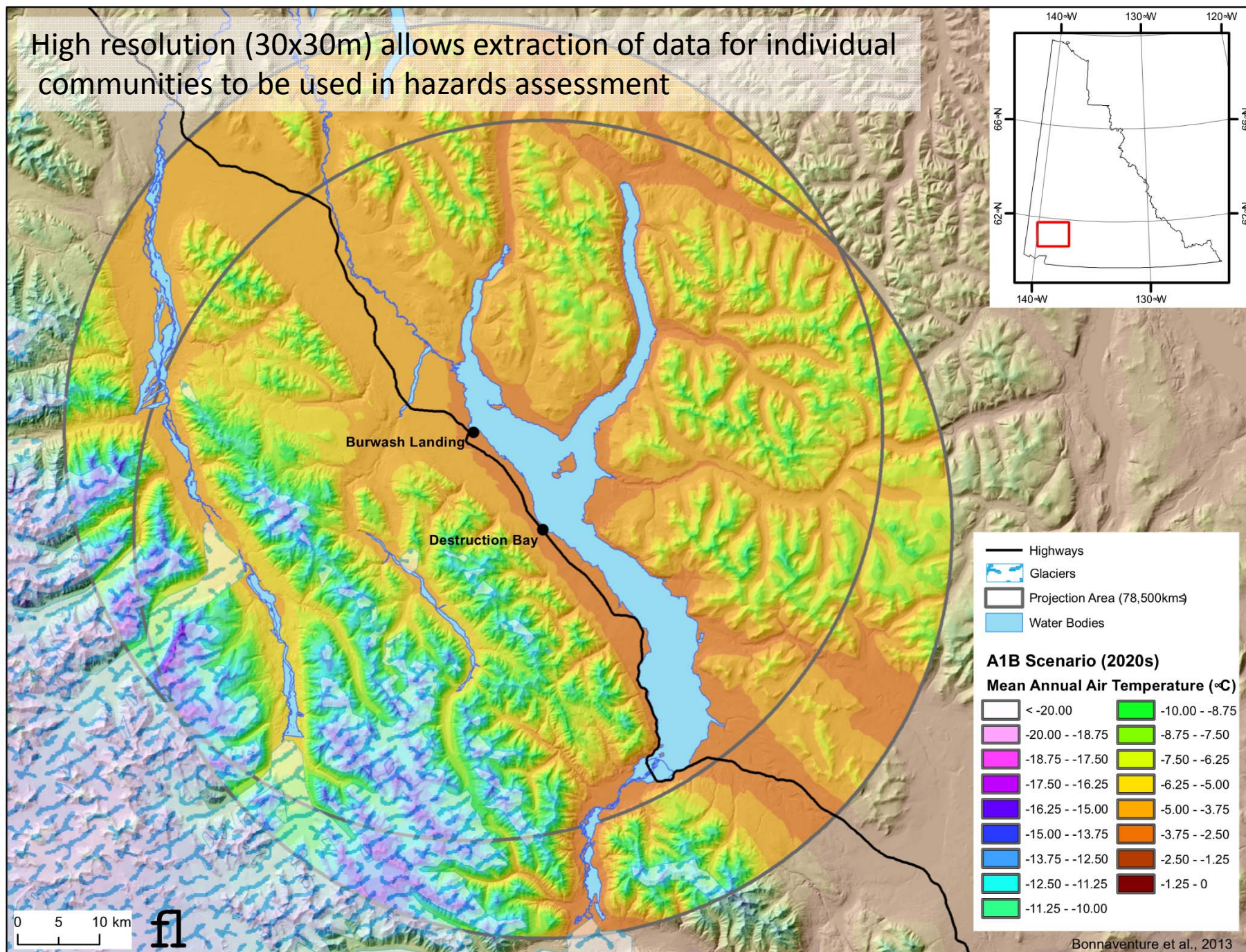
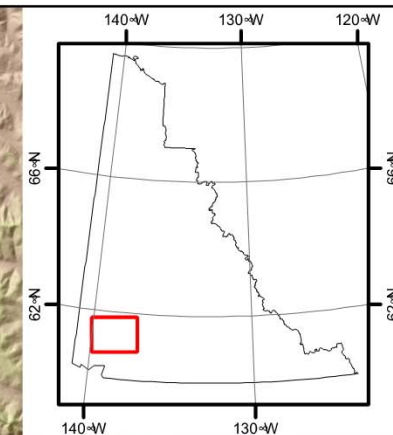
uOttawa
L'Université canadienne
Canada's university

Presentation context

- Mountainous “**discontinuous**” permafrost
- Characterize the spatial morphology of potential permafrost loss for the area of the Regional Model (Bonnaventure et al., 2012)
- Assess how loss occurs as conditions warm for individual communities and the region as a whole
- Linking air temperature and permafrost

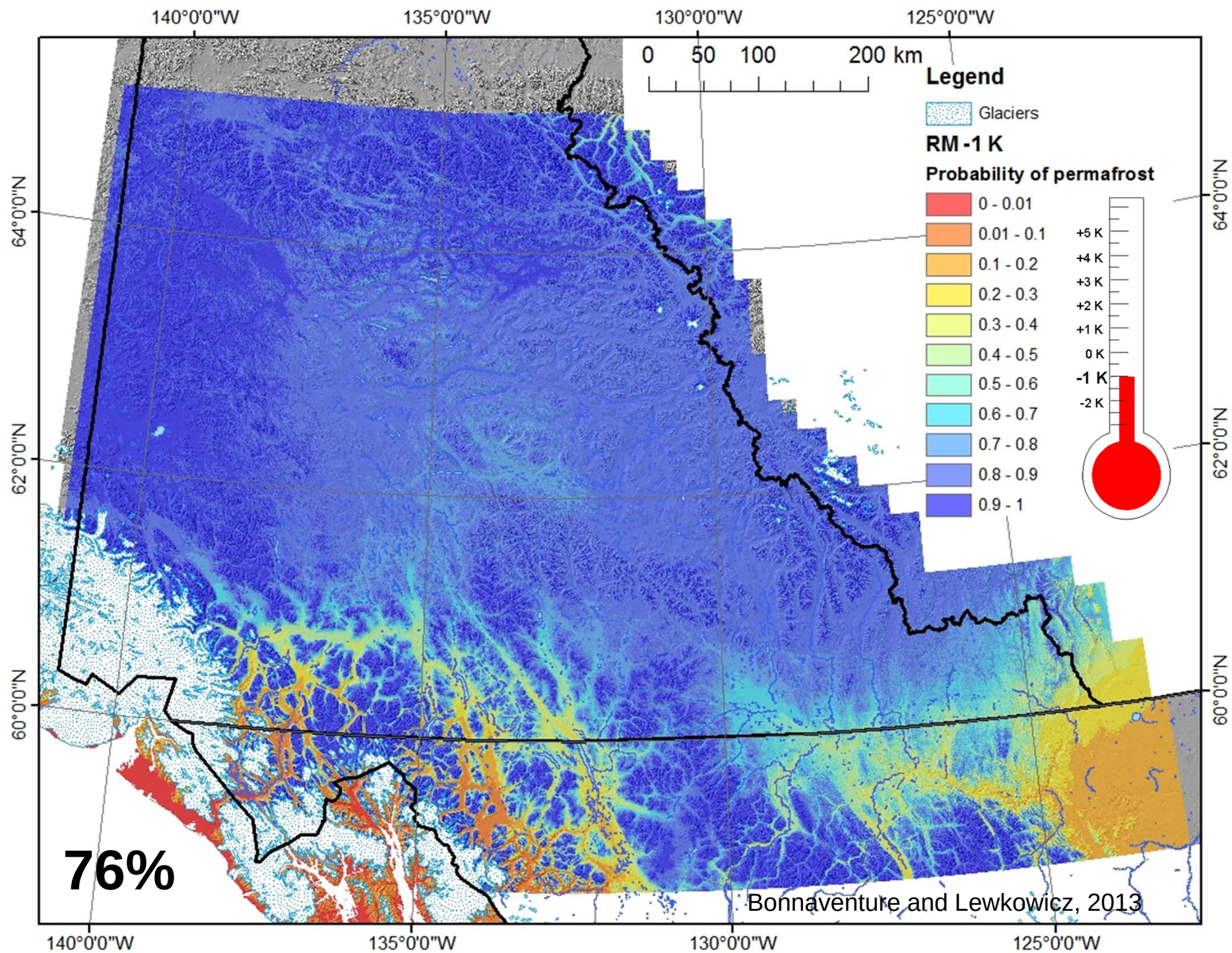


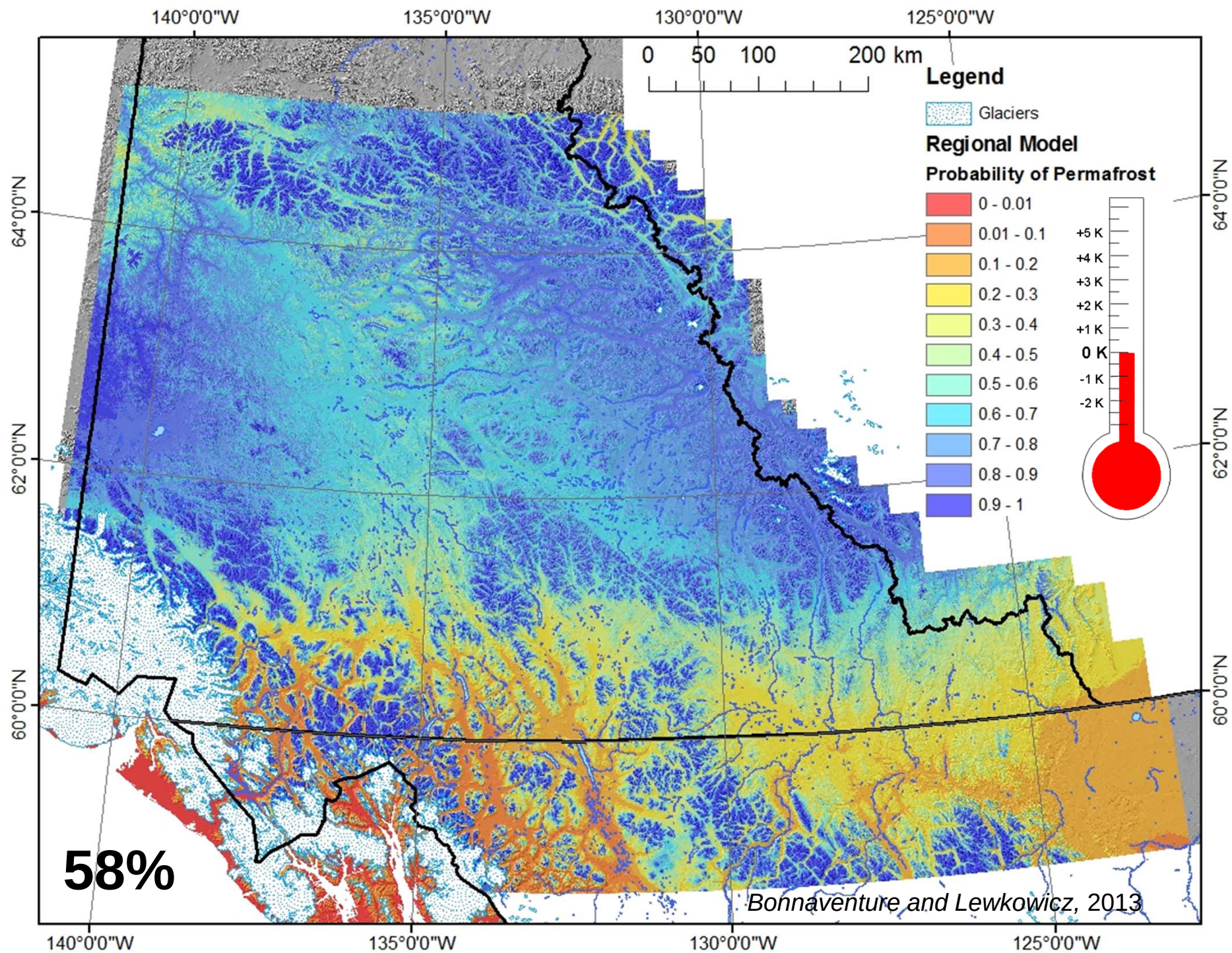
High resolution (30x30m) allows extraction of data for individual communities to be used in hazards assessment

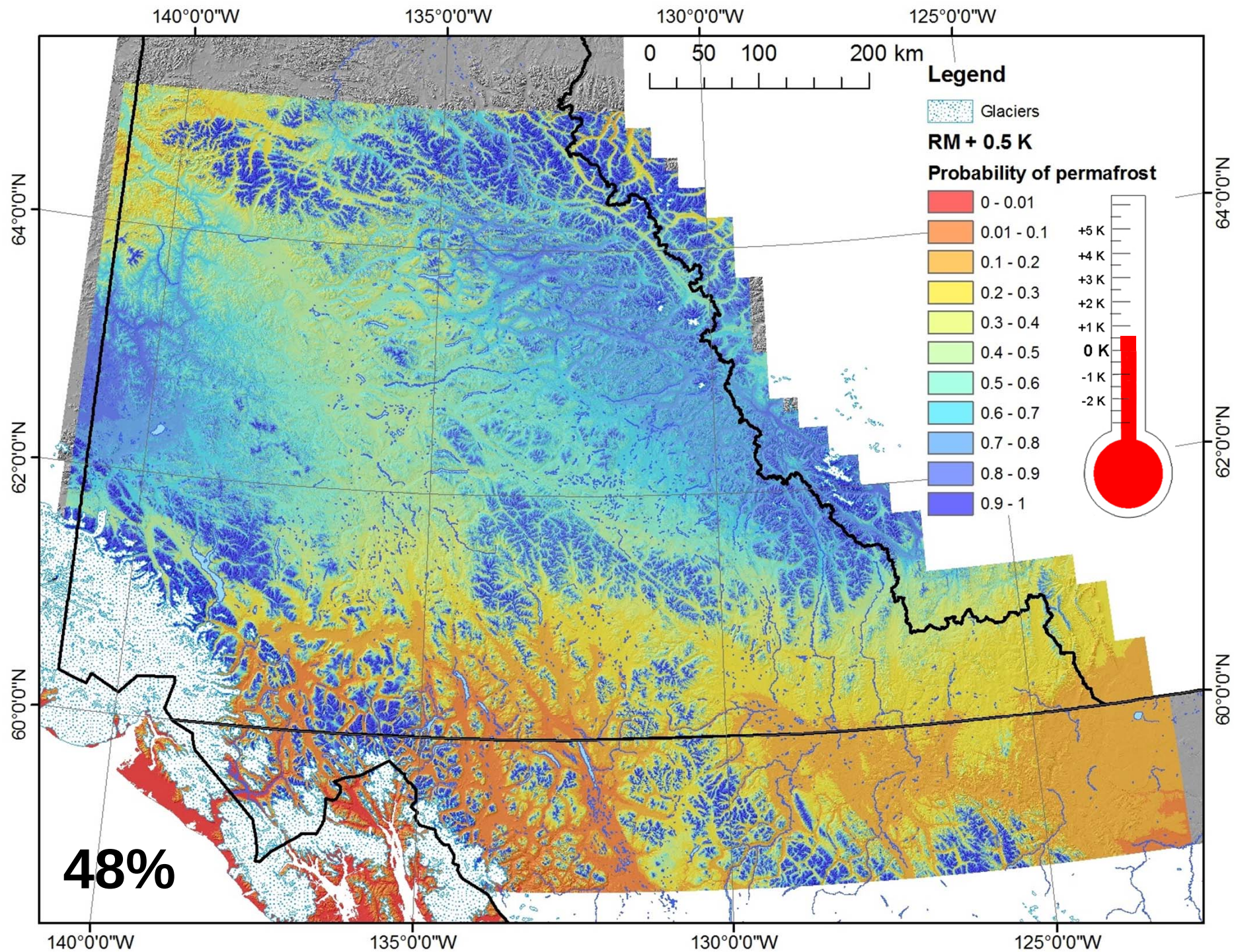


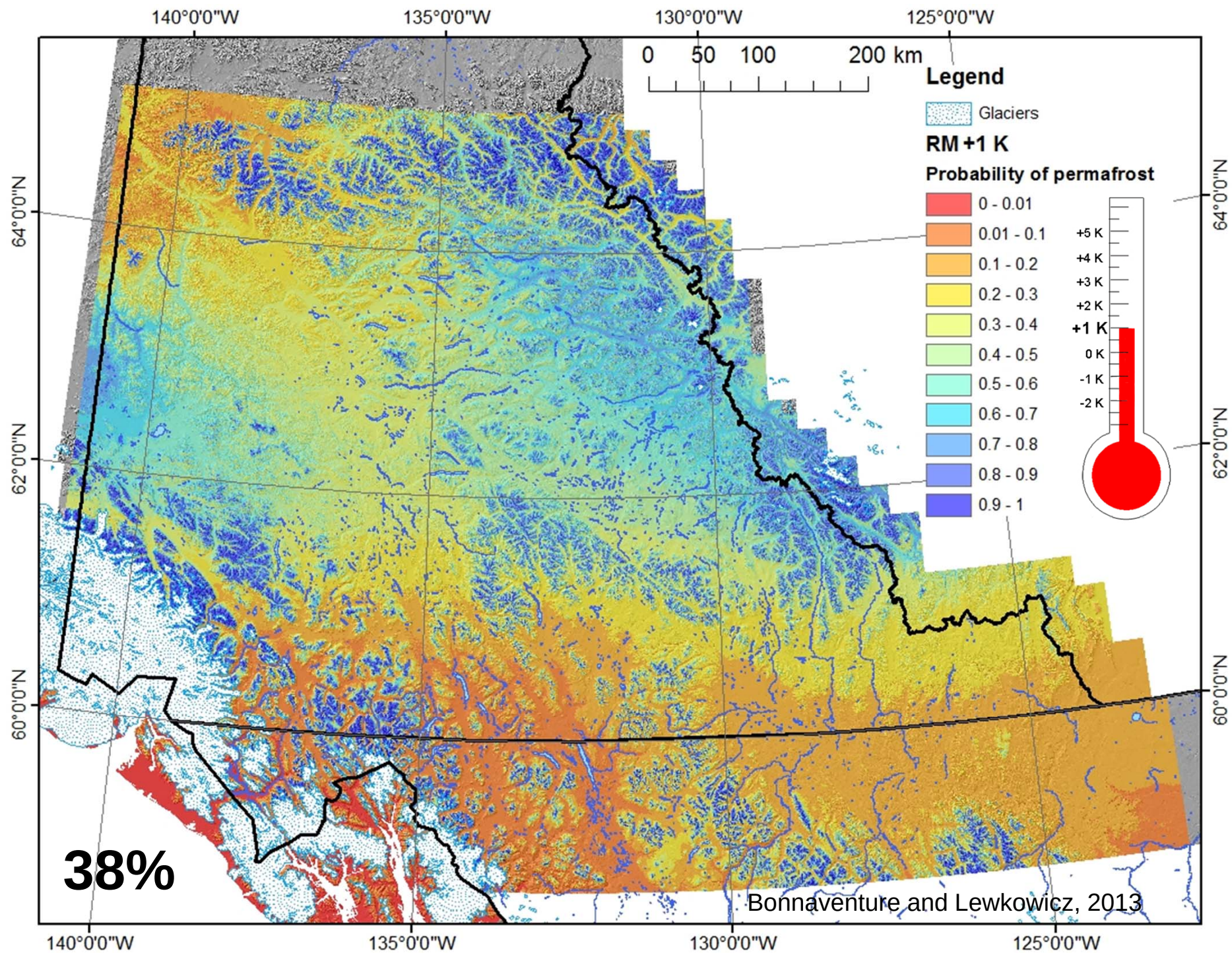
Exploring Changes in Models

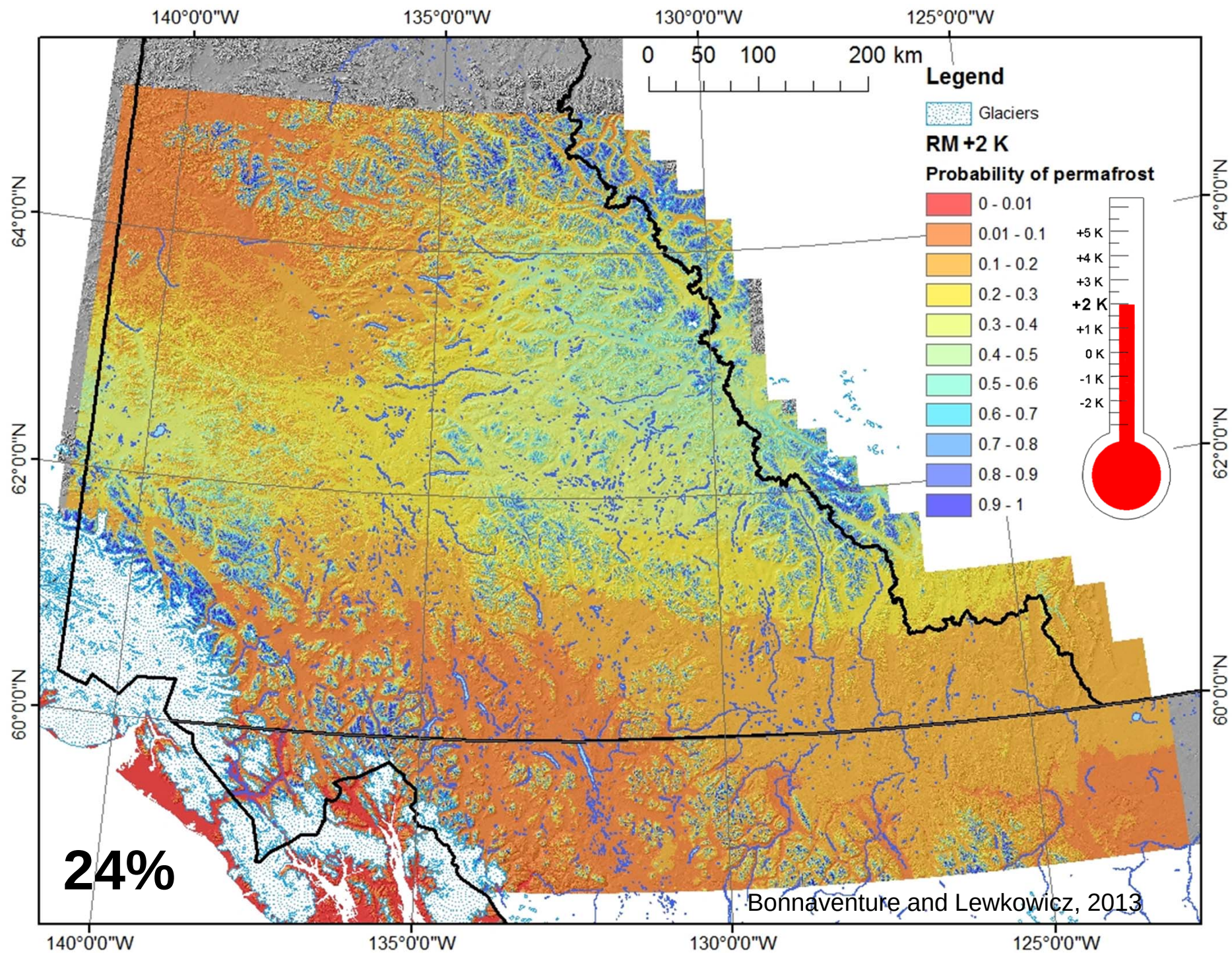
- How will climate change drive permafrost distribution?
- Additions to the equivalent elevation surface reflect colder conditions while subtractions reflect warmer conditions
- Scenarios reflect probabilities of permafrost under equilibrium conditions for MAAT climate changes of $\pm 1^{\circ}\text{C}$, $+2^{\circ}\text{C}$, $+3^{\circ}\text{C}$, $+4^{\circ}\text{C}$ and $+5^{\circ}\text{C}$

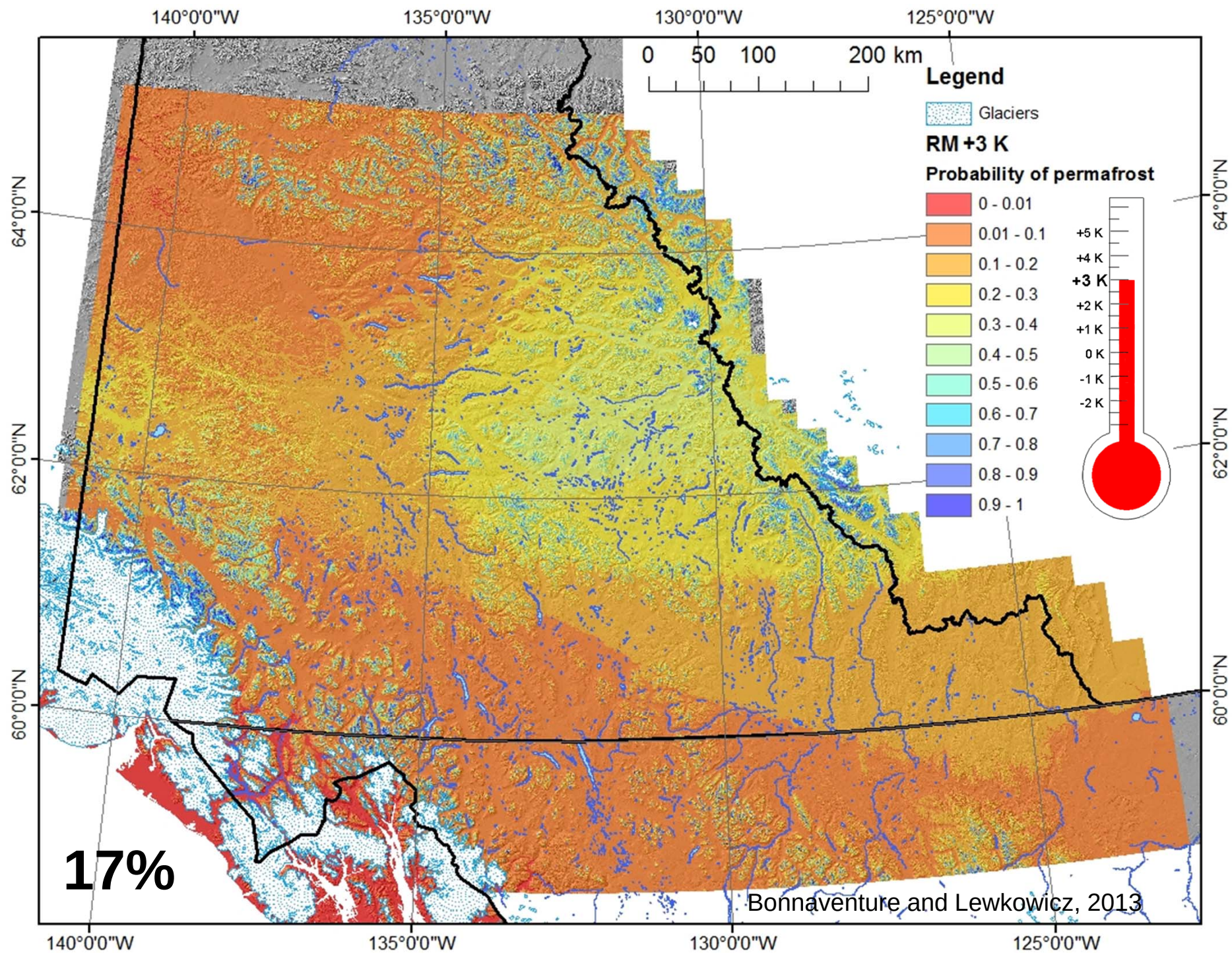


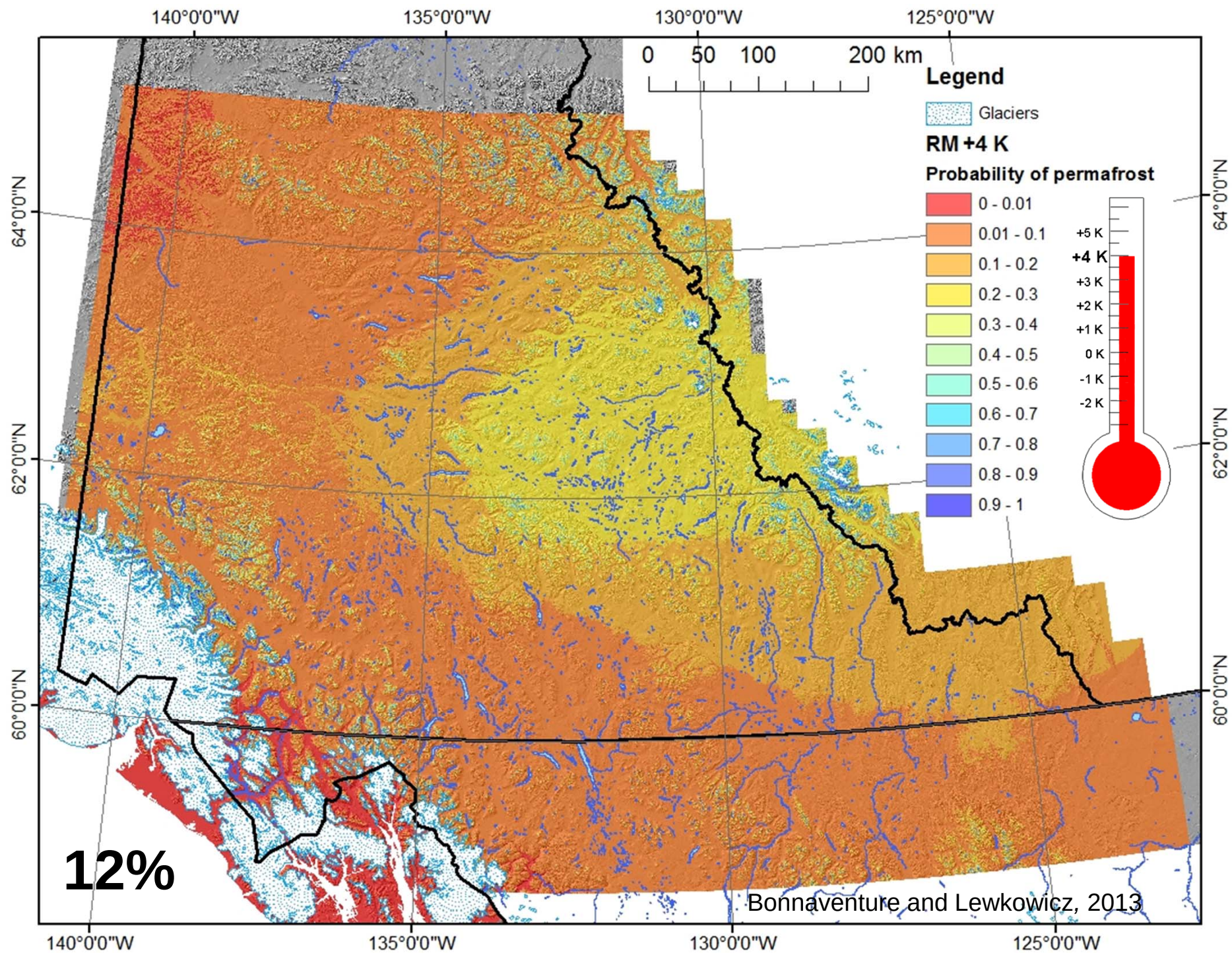


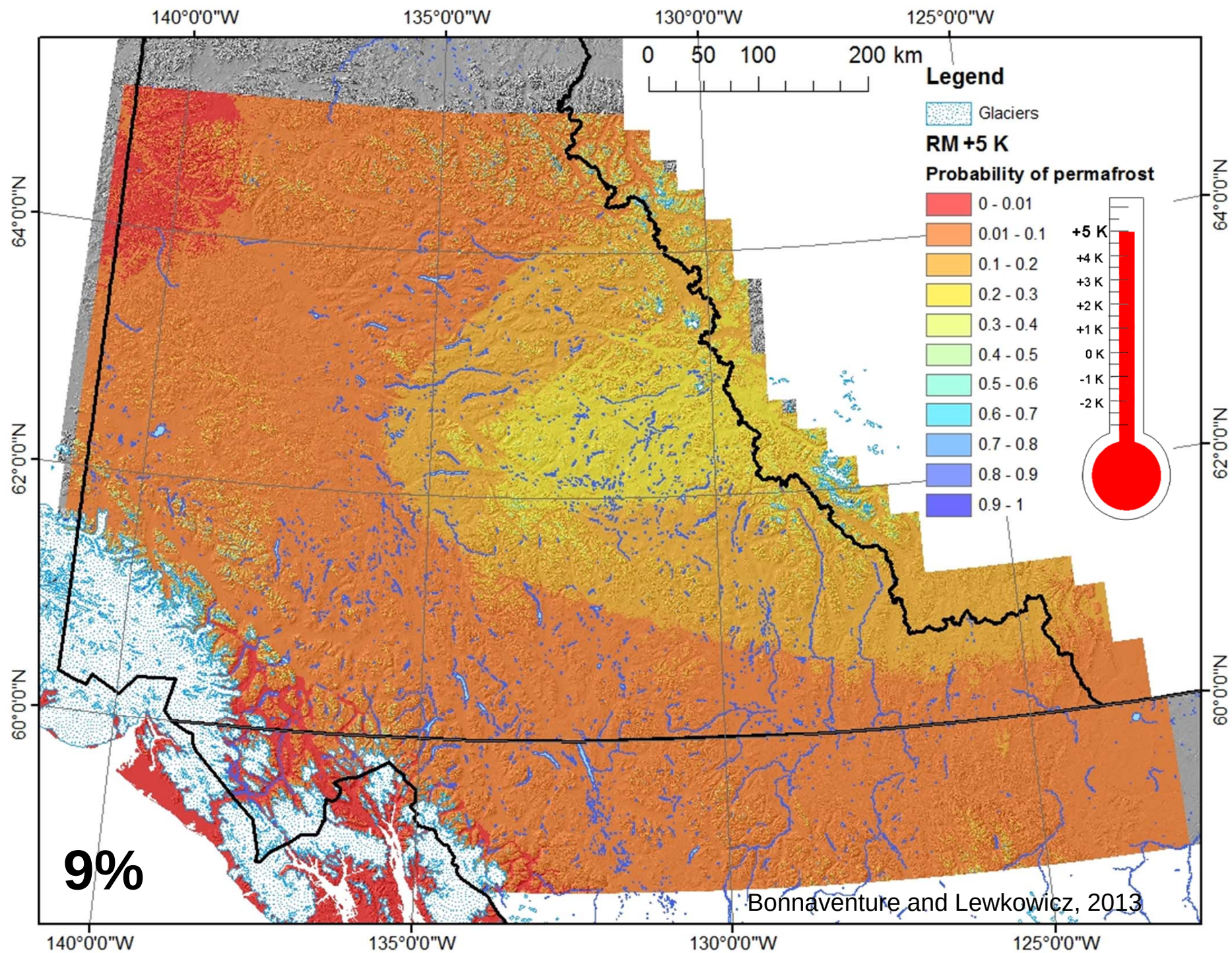




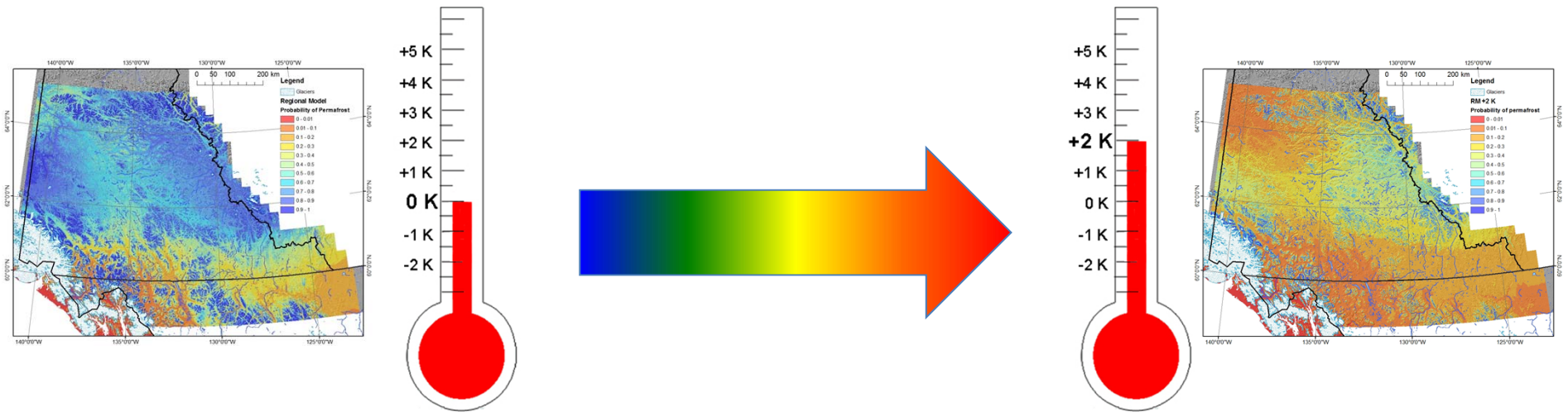








Geographic Loss Patterns

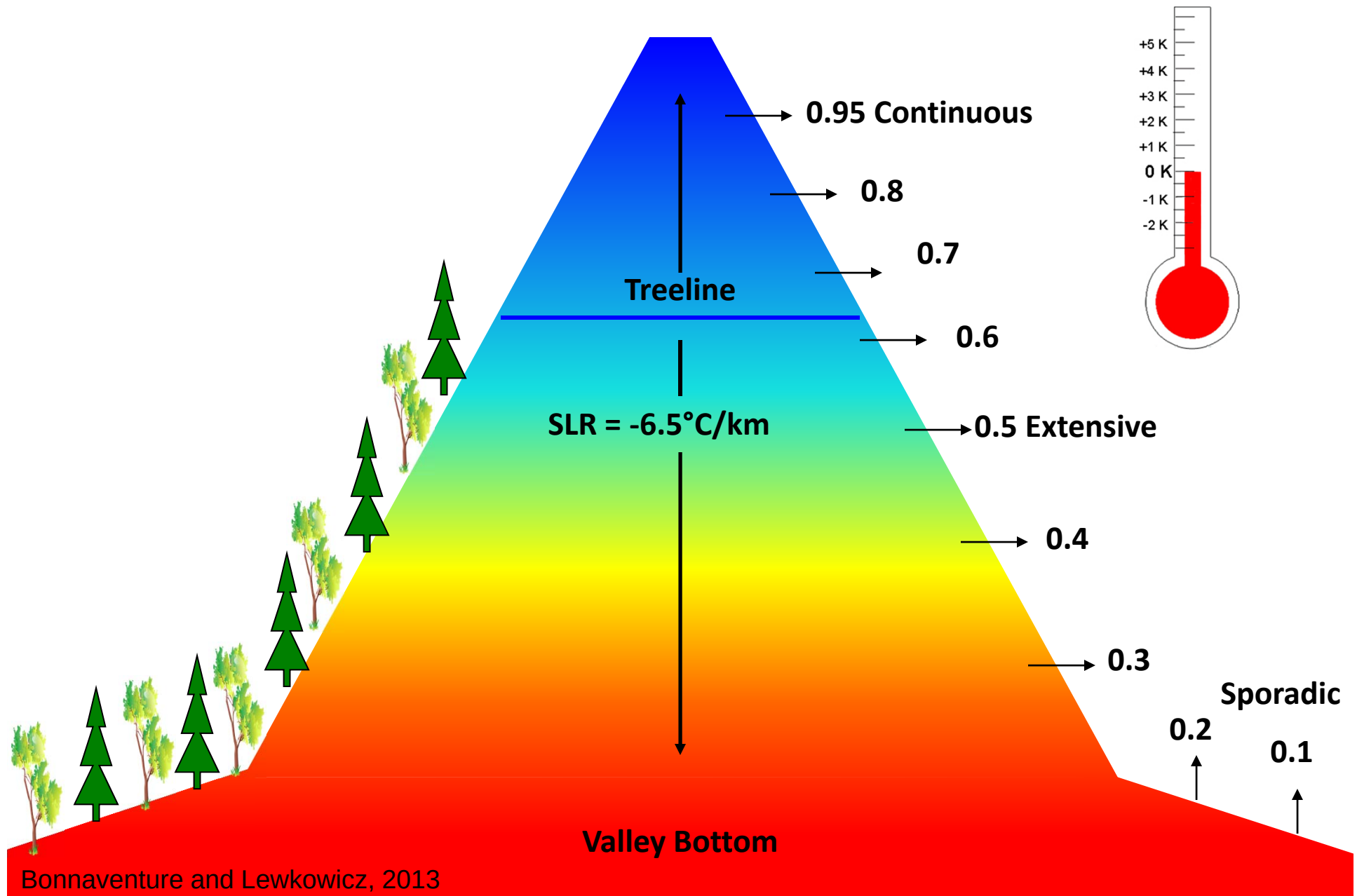


- Understanding spatial loss occurs is critical to understanding how the system will evolve
- Loss appears to be complex & act differently according to geographic area (SLR)

Analysis & types of permafrost loss

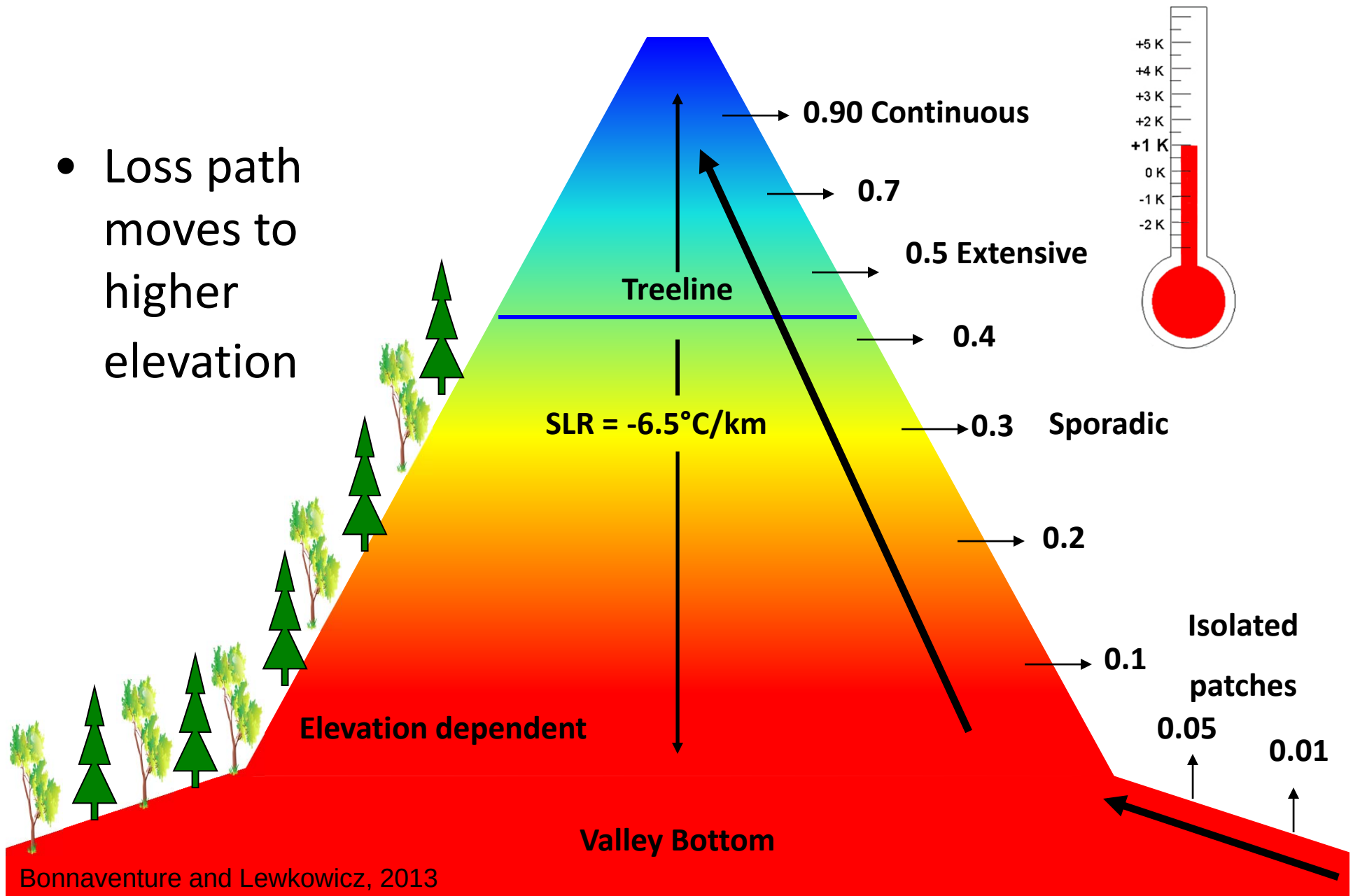
- **Simple Unidirectional Spatial Loss (SUSL)**
 - Loss path moves up the mountain according to one lapse rate (-6.5° C/km)
- **Complex Unidirectional Spatial Loss (CUSL)**
 - Loss path moves up the mountain above & below treeline but according to different SLRs (-6.5° C/km above treeline & negative but gentle below treeline)
- **Bidirectional Spatial Loss (BSL)**
 - Loss path moves up the mountain above treeline (-6.5° C/km) & down the mountain toward the valley bottom below treeline (positive but gentle)

Simple Unidirectional Spatial Loss (SUSL)

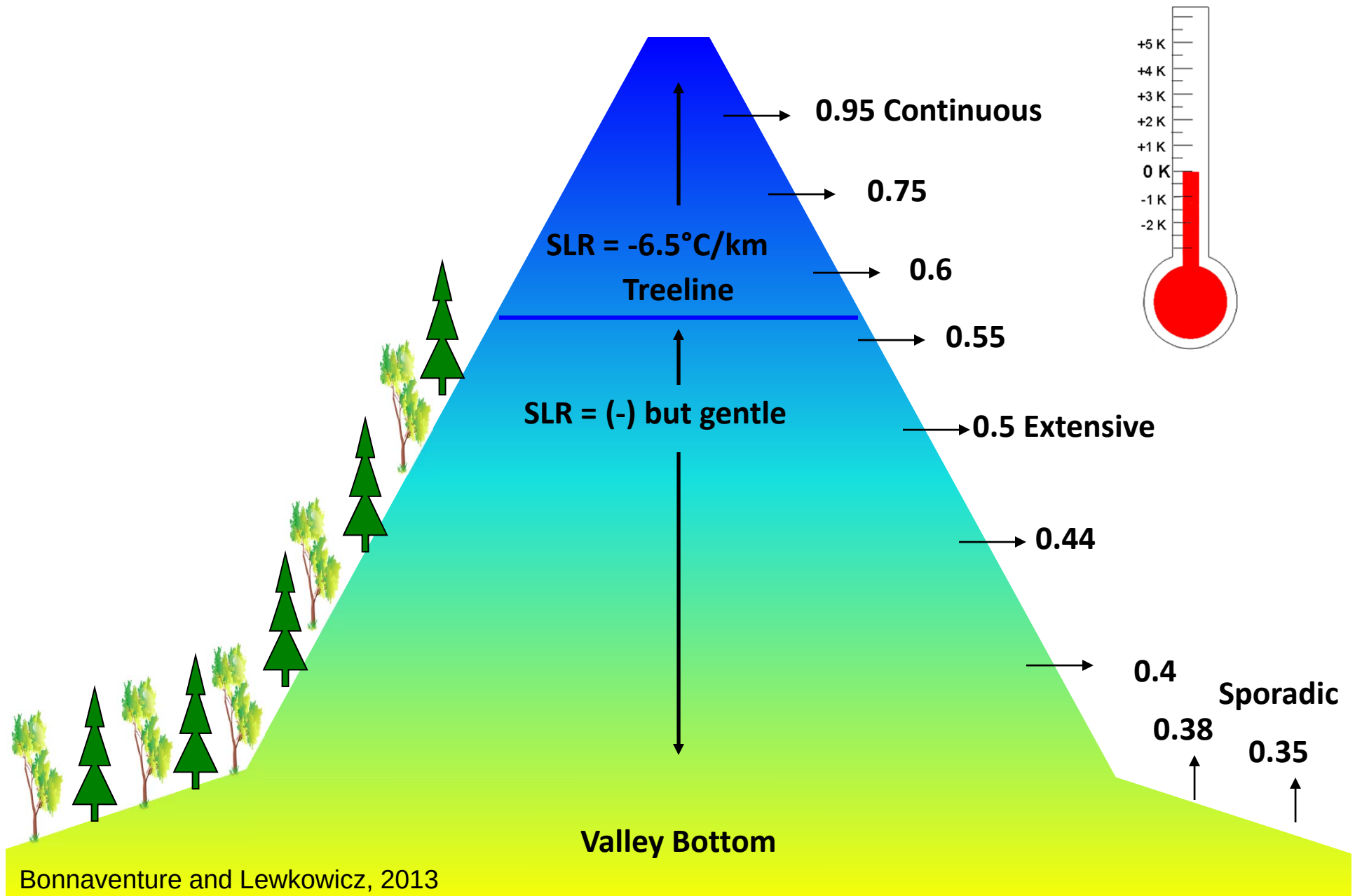


Simple Unidirectional Spatial Loss (SUSL)

- Loss path moves to higher elevation

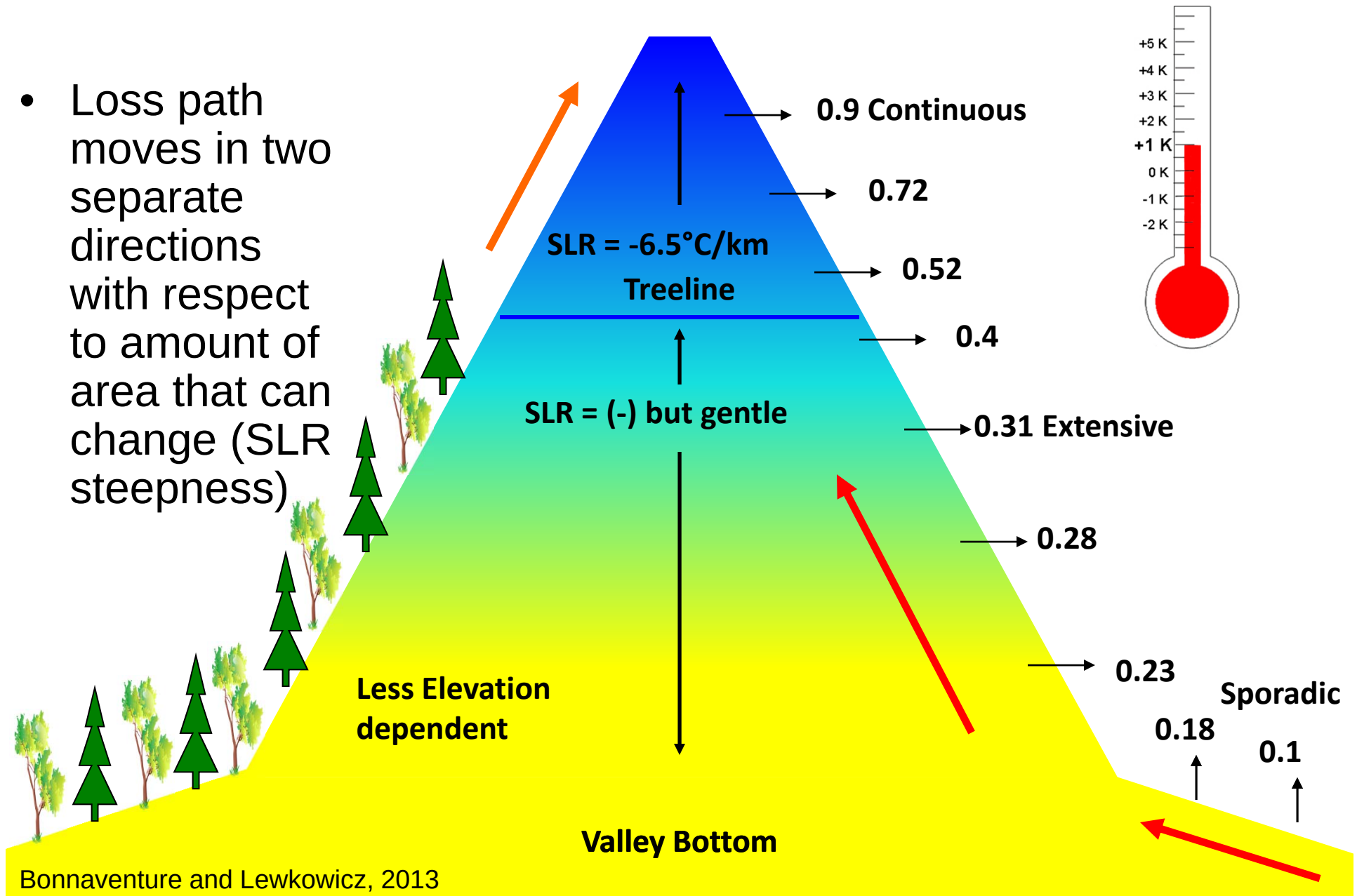


Complex Unidirectional Spatial Loss (CUSL)

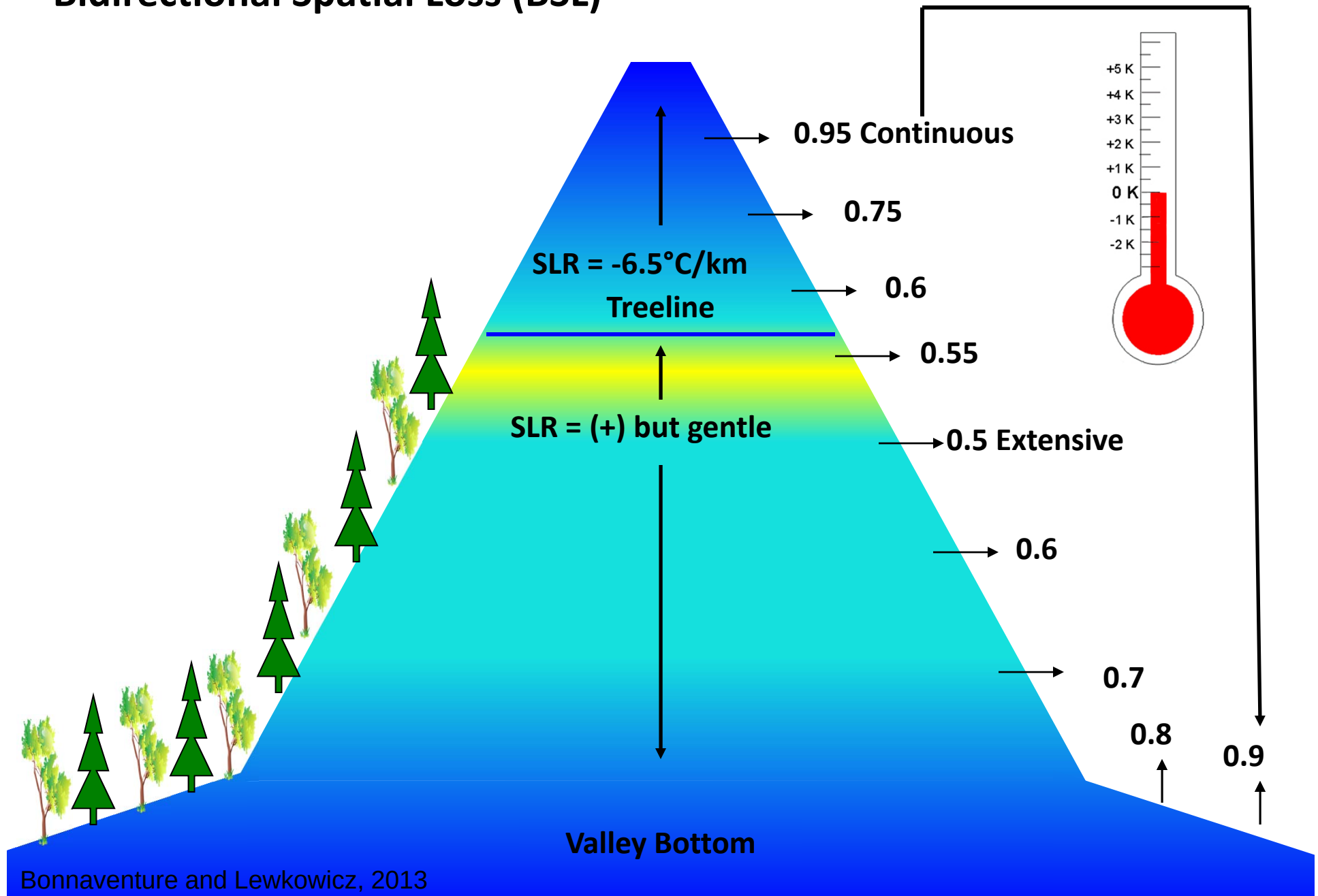


Complex Unidirectional Spatial Loss (CUSL)

- Loss path moves in two separate directions with respect to amount of area that can change (SLR steepness)

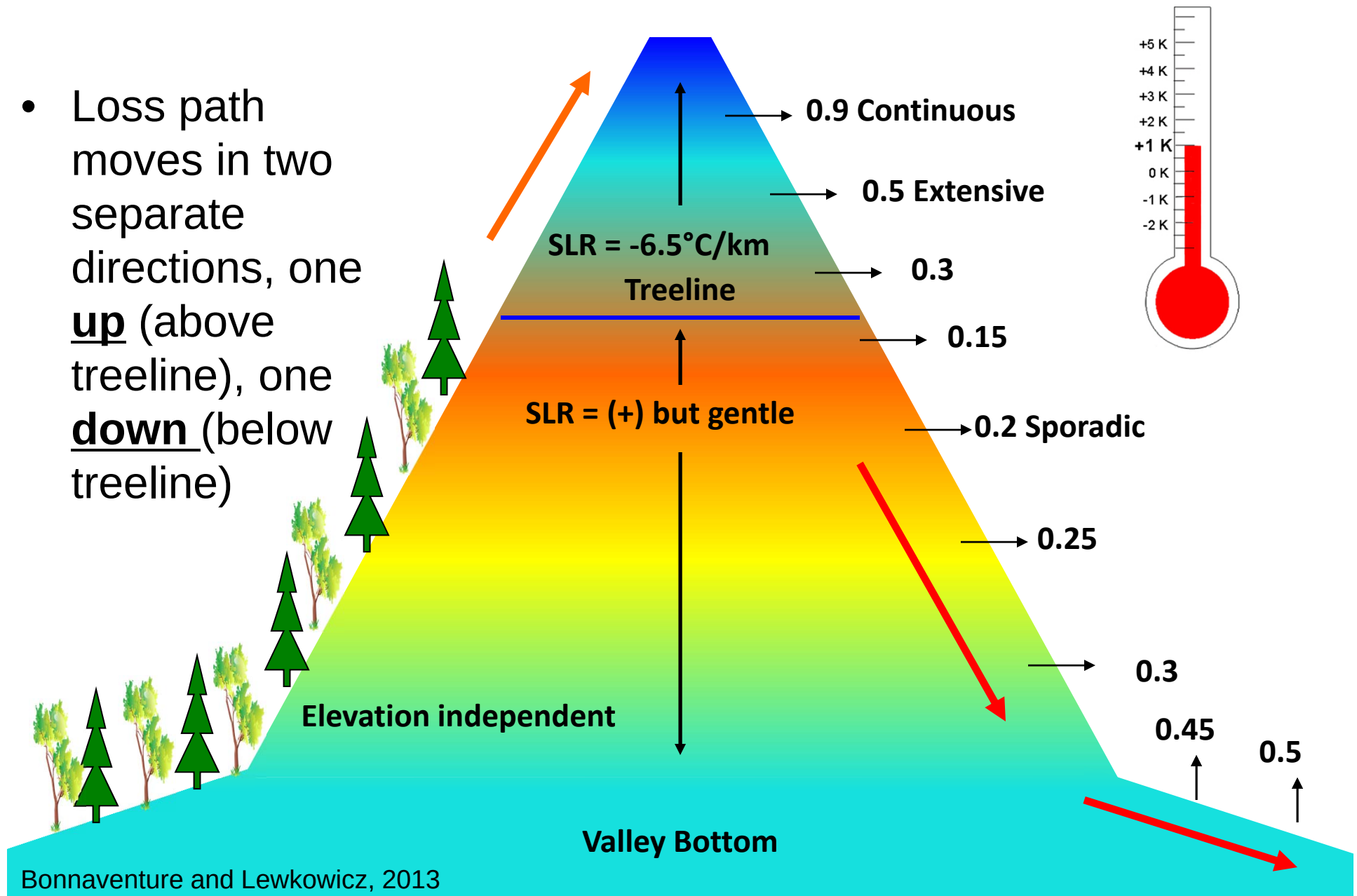


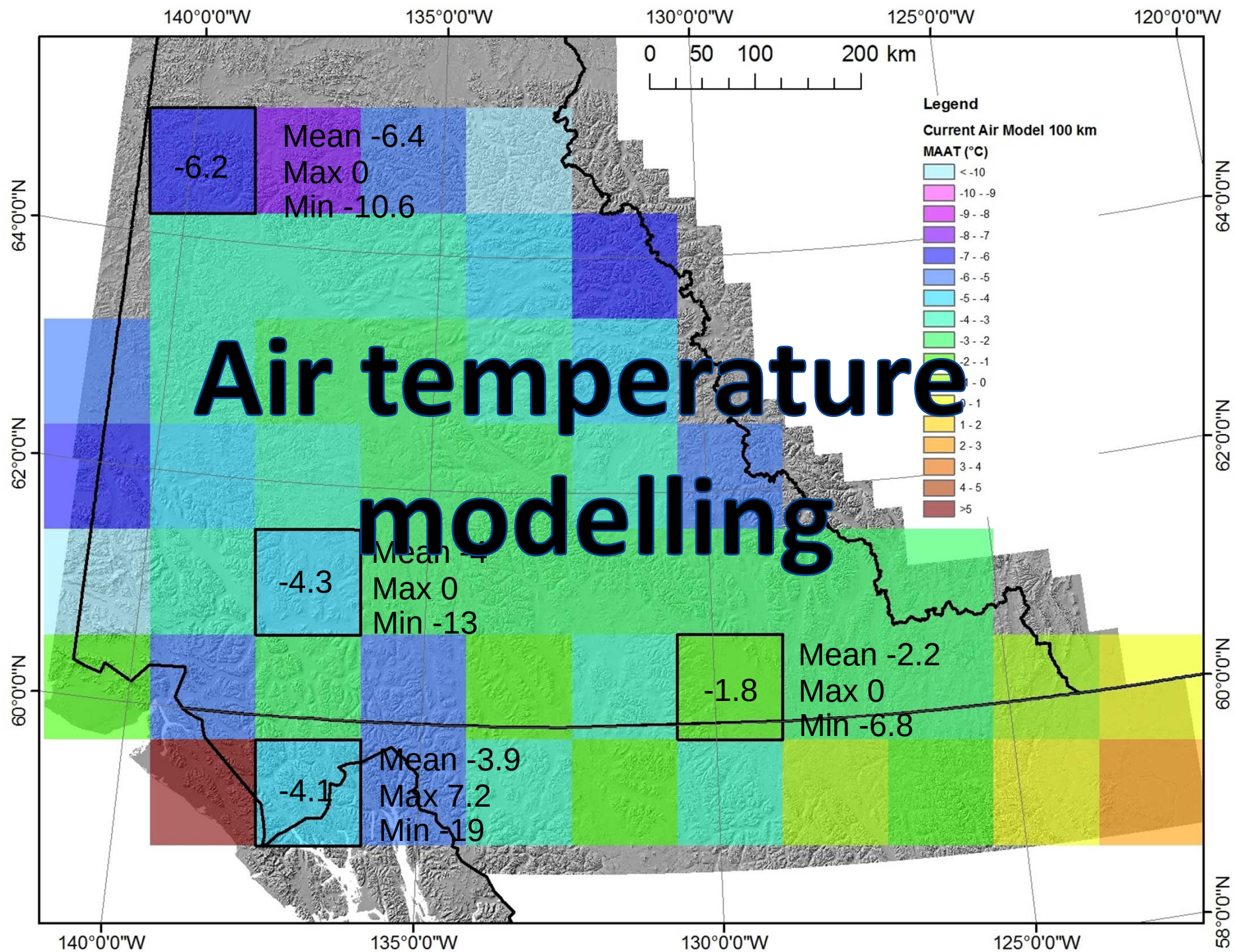
Bidirectional Spatial Loss (BSL)



Bidirectional Spatial Loss (BSL)

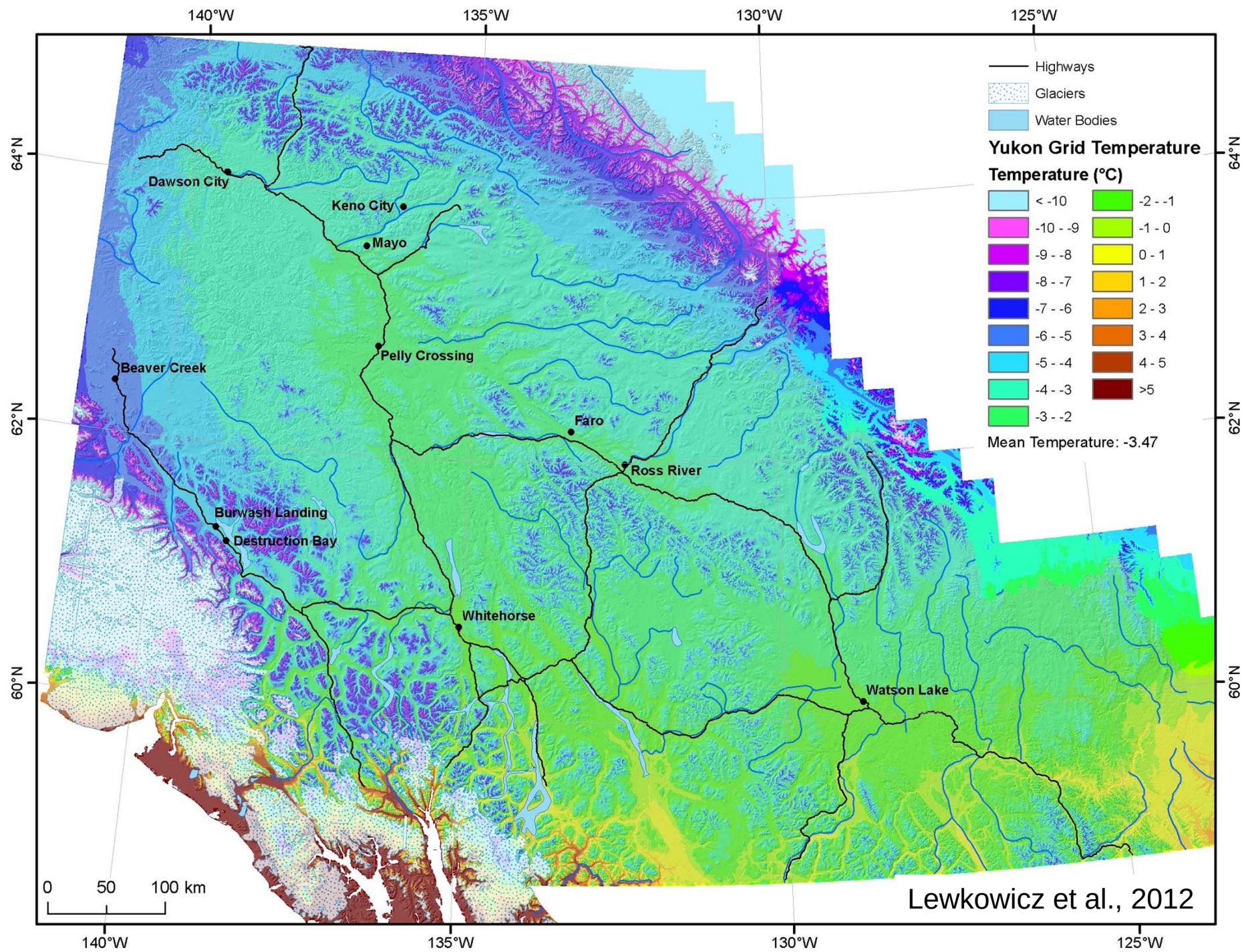
- Loss path moves in two separate directions, one up (above treeline), one down (below treeline)





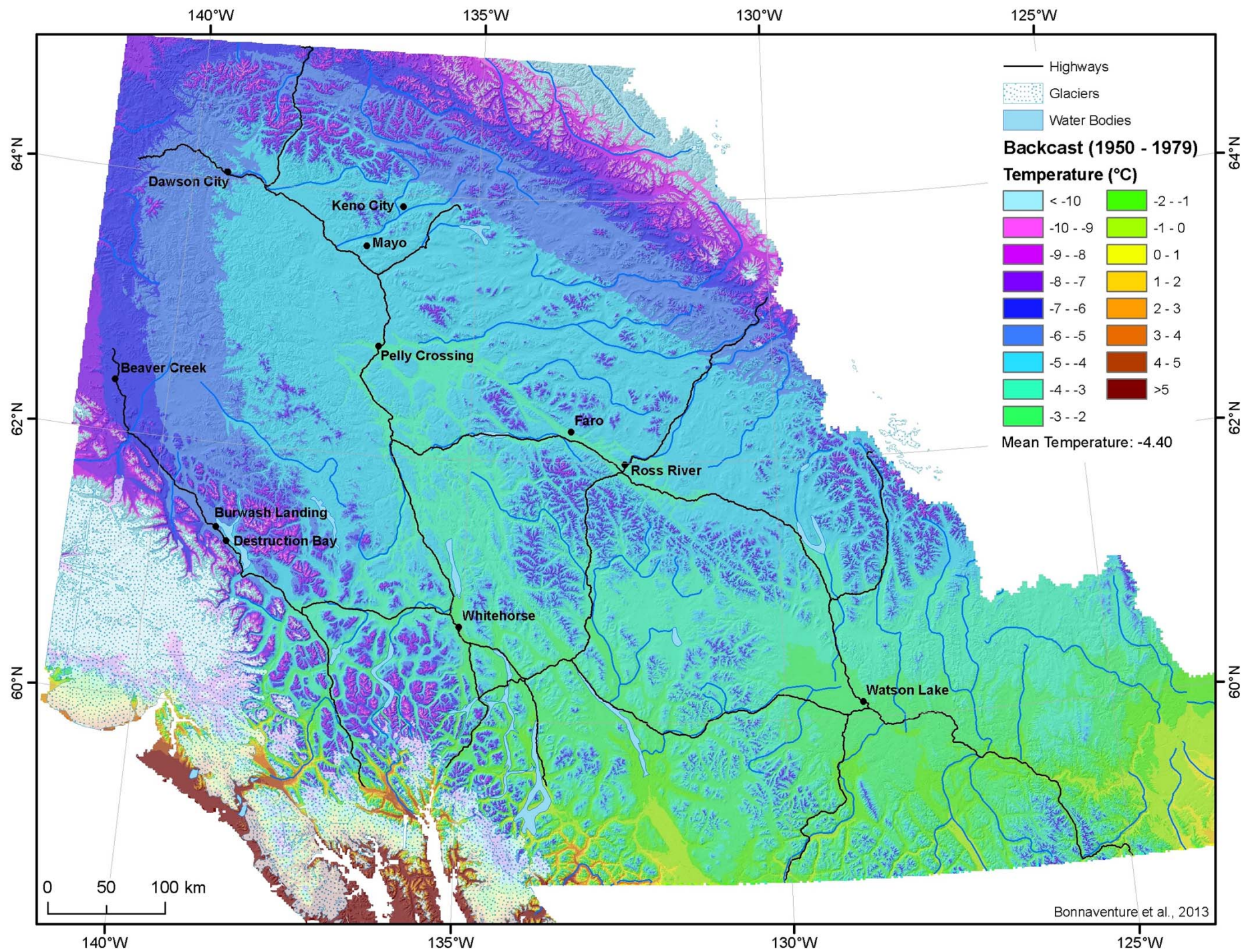
Mean Annual Air Temperature Modelling

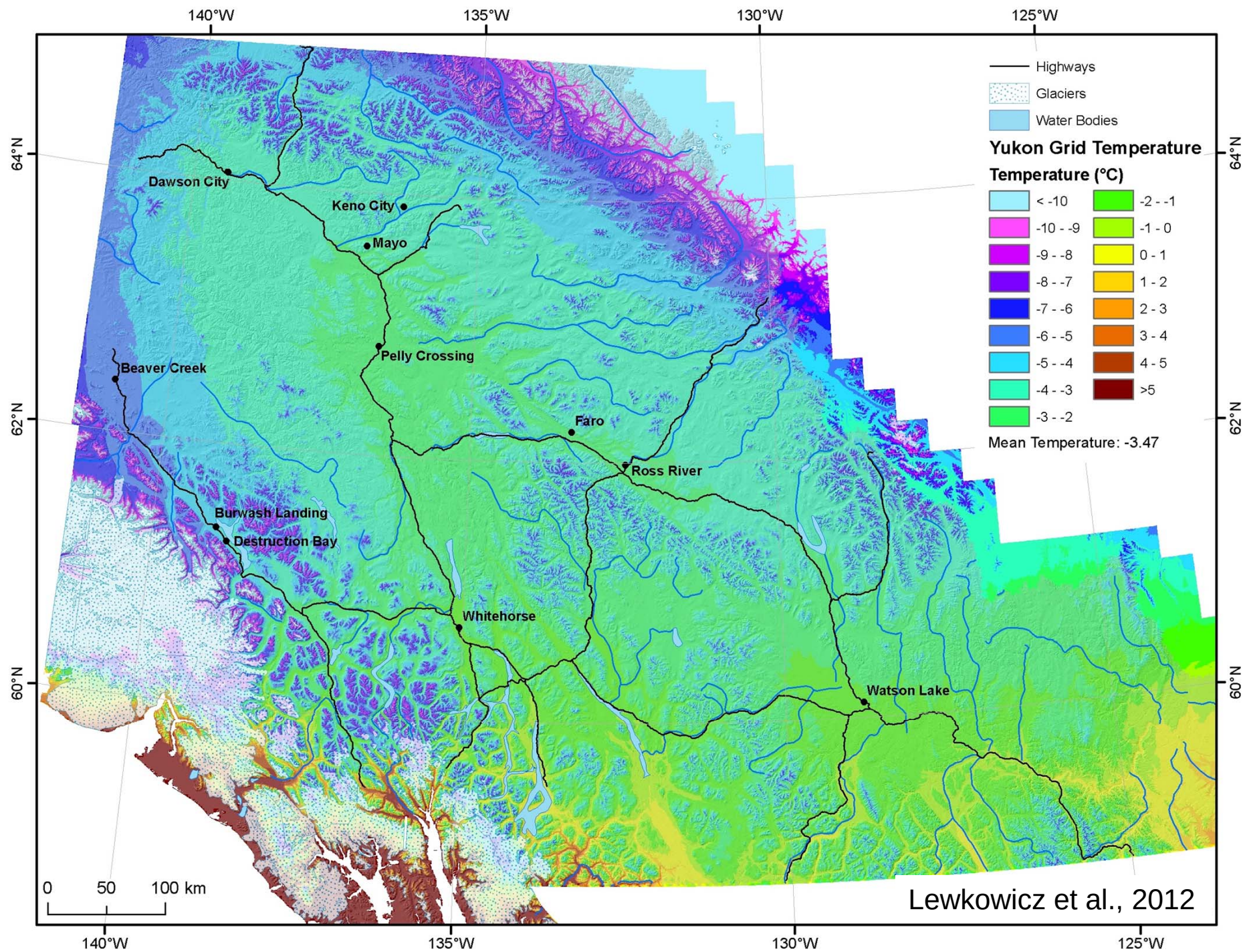
- How are these related?
- Efforts to this point have used fixed scenario changes in MAAT
- Build a more precise climate model
- With knowledge of the trends controlling permafrost distribution (elevation, treeline, latitude) MAAT can also be modeled
- Involved using our climate stations and 18 Environment Canada climate stations in the region



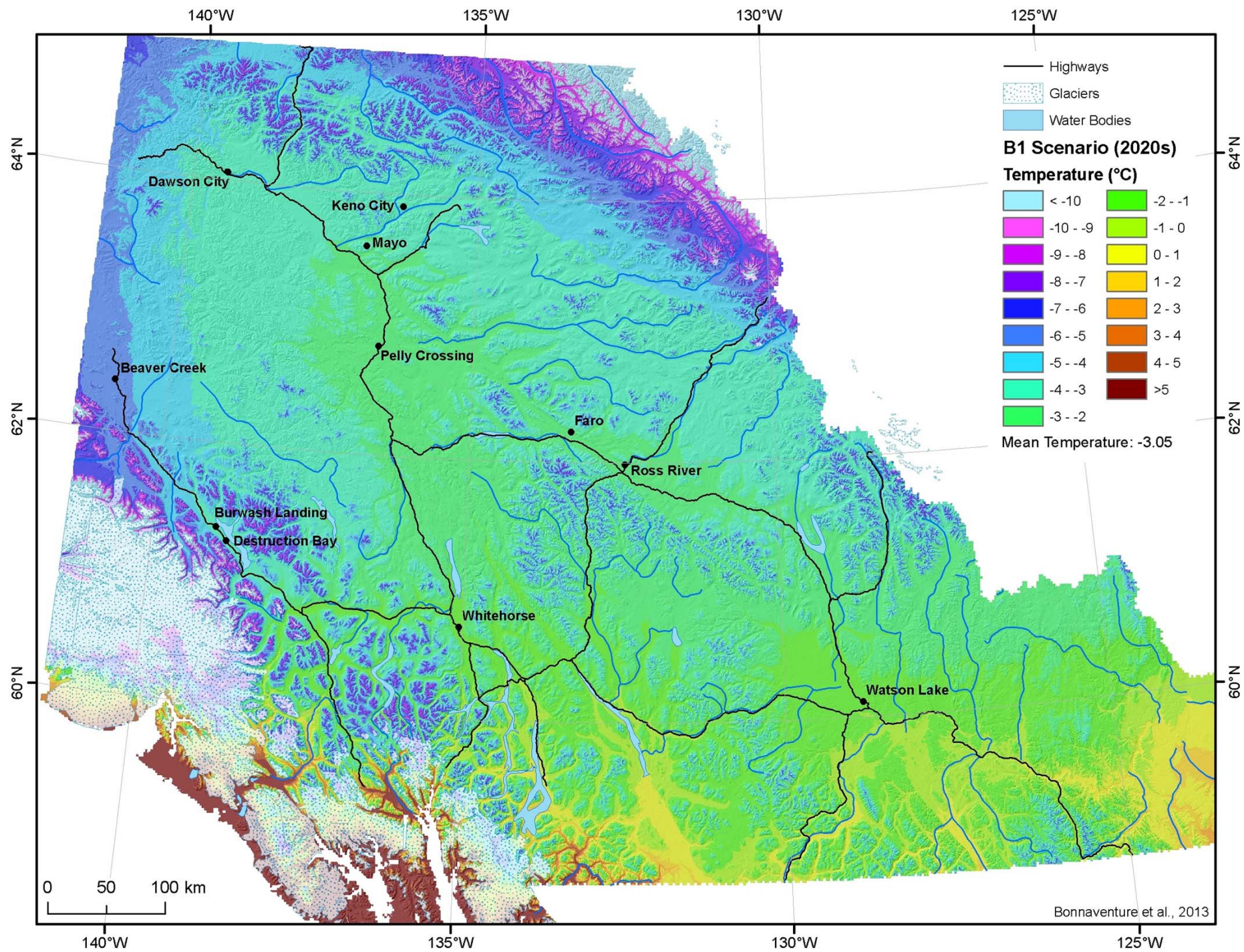
Perturbing for climate change

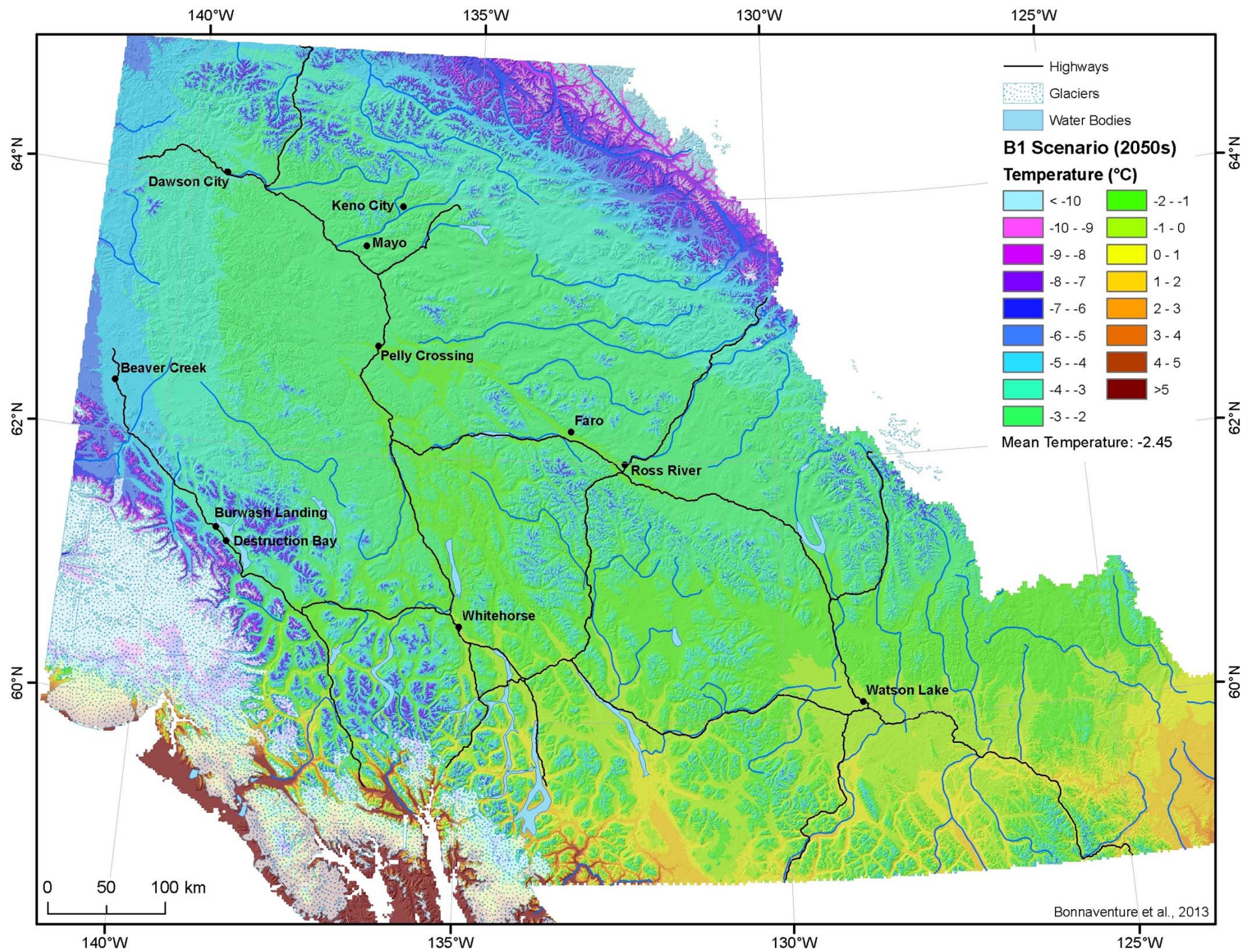
- Using the current map of MAAT, an adjustment is applied linking GCM predictions to our finer resolution models
- Scenarios Network for Alaska and Arctic Planning (SNAP) (A1B, A2 and B1)
- This preserves the topographic controls on MAAT while using the macro changes

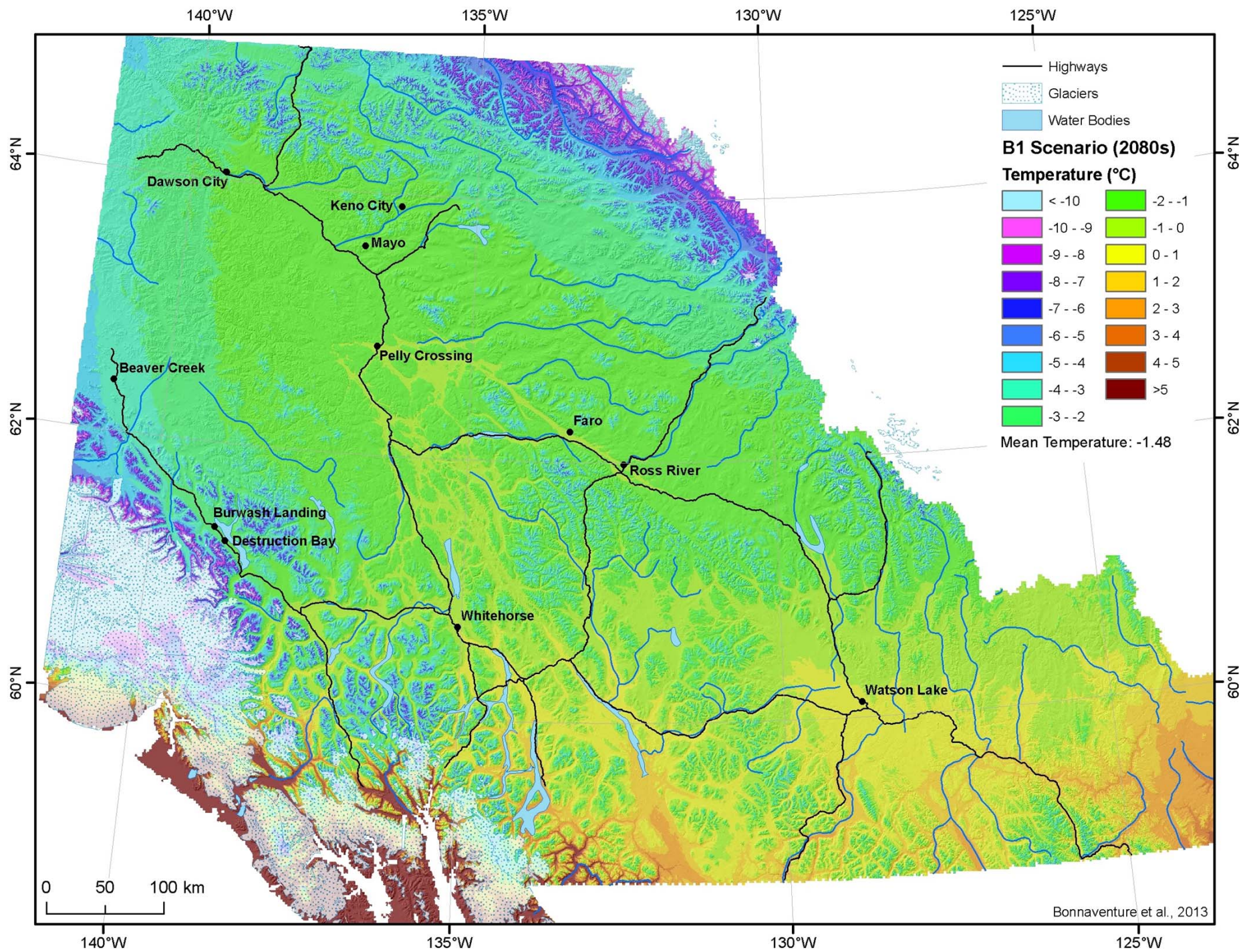


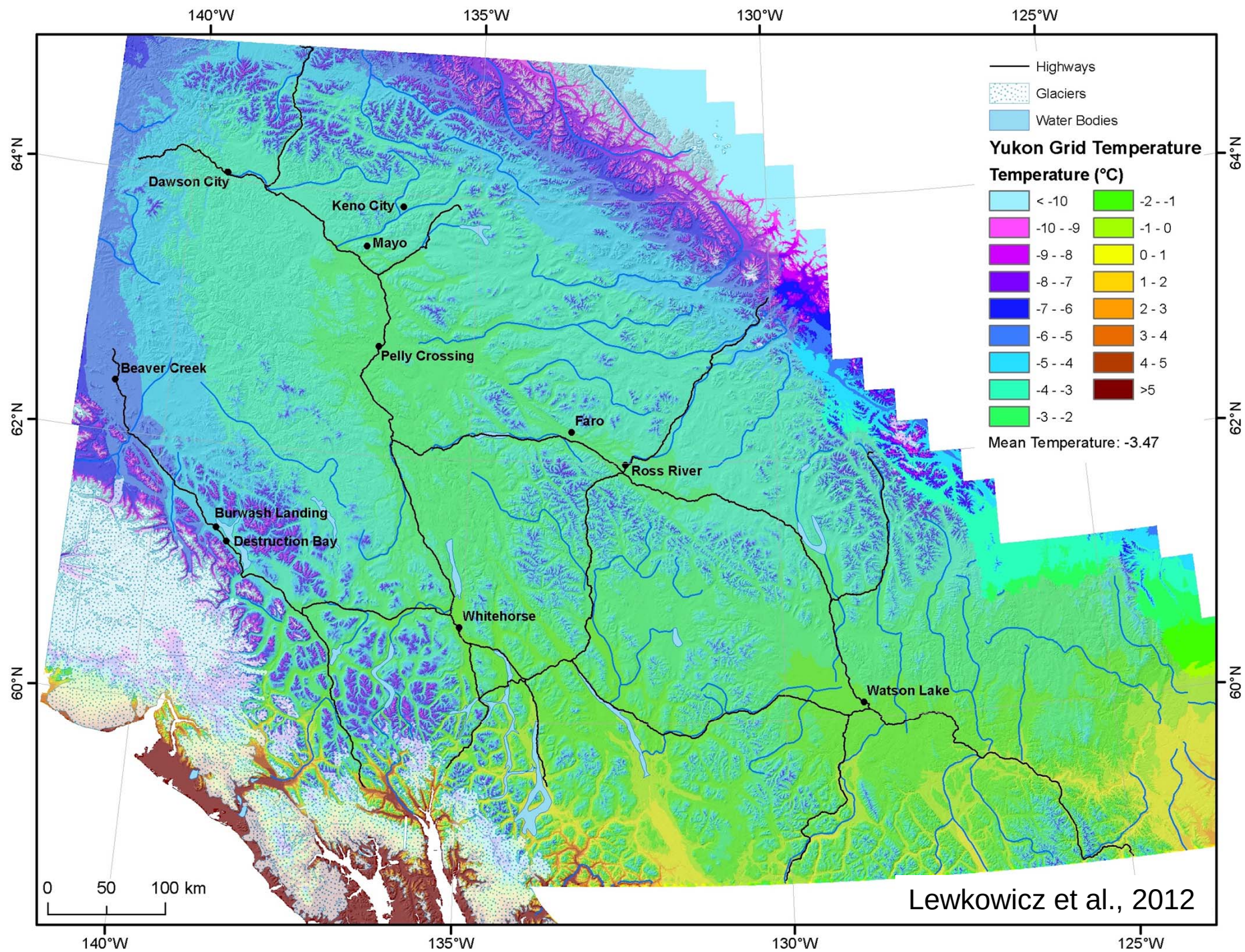


Lewkowicz et al., 2012

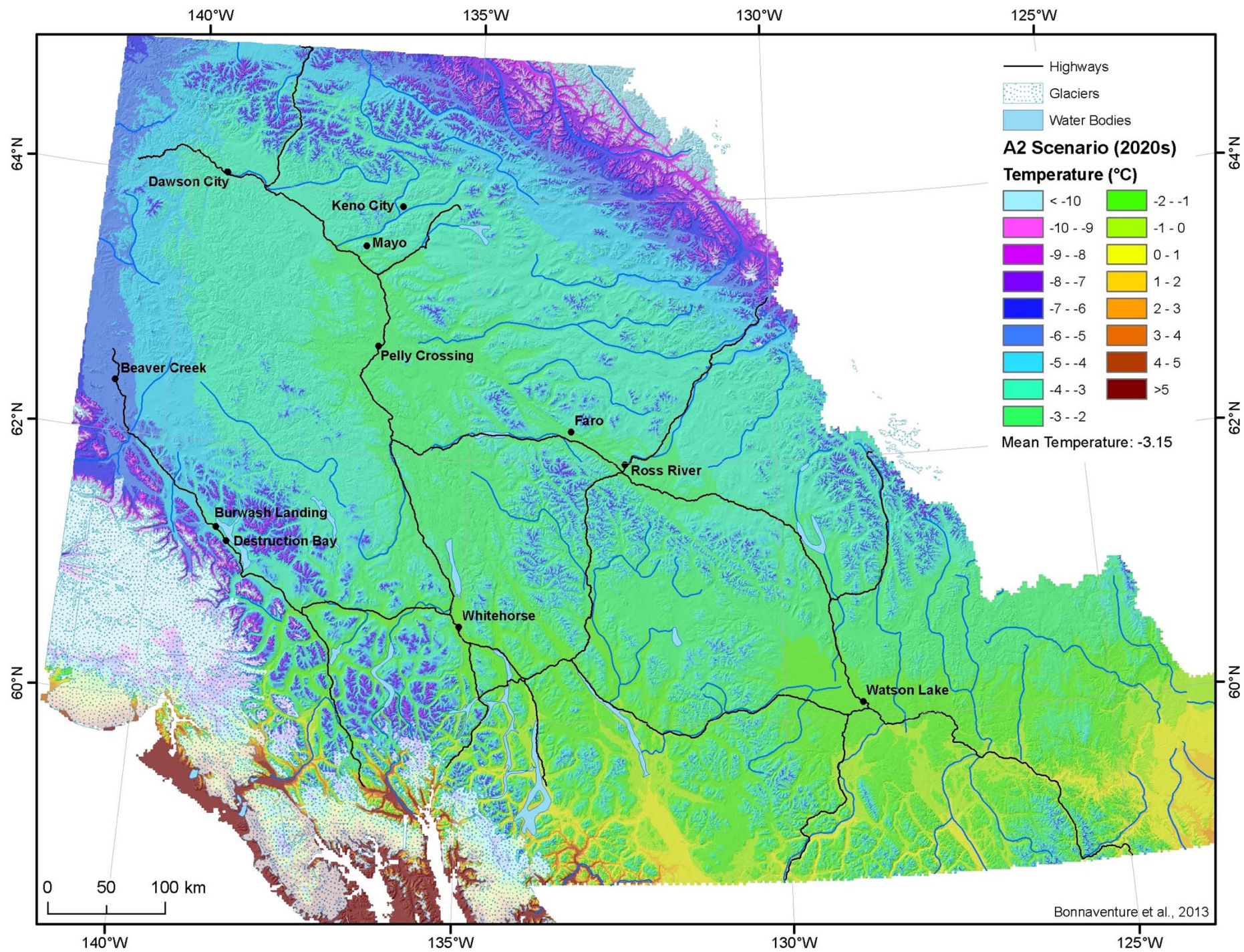


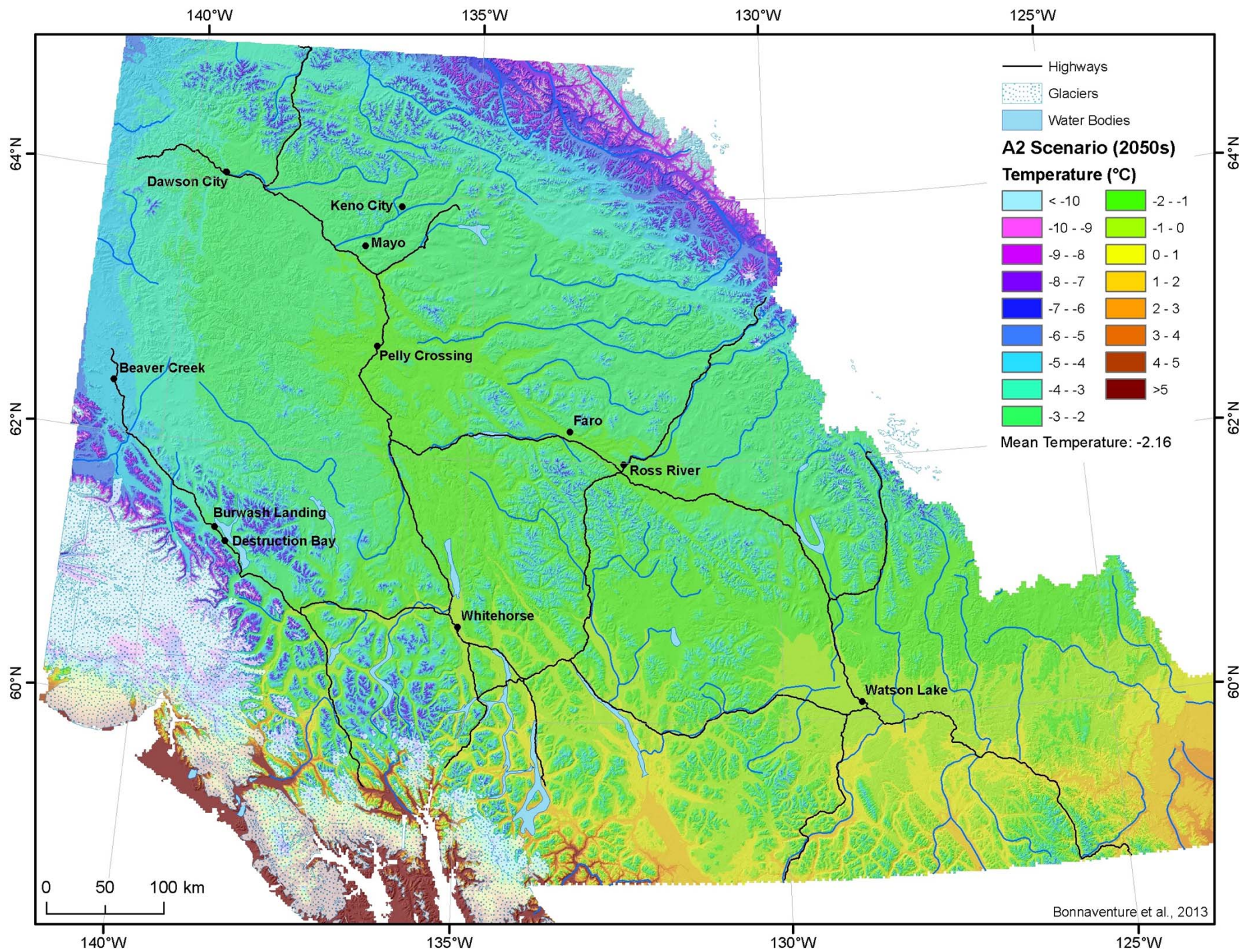


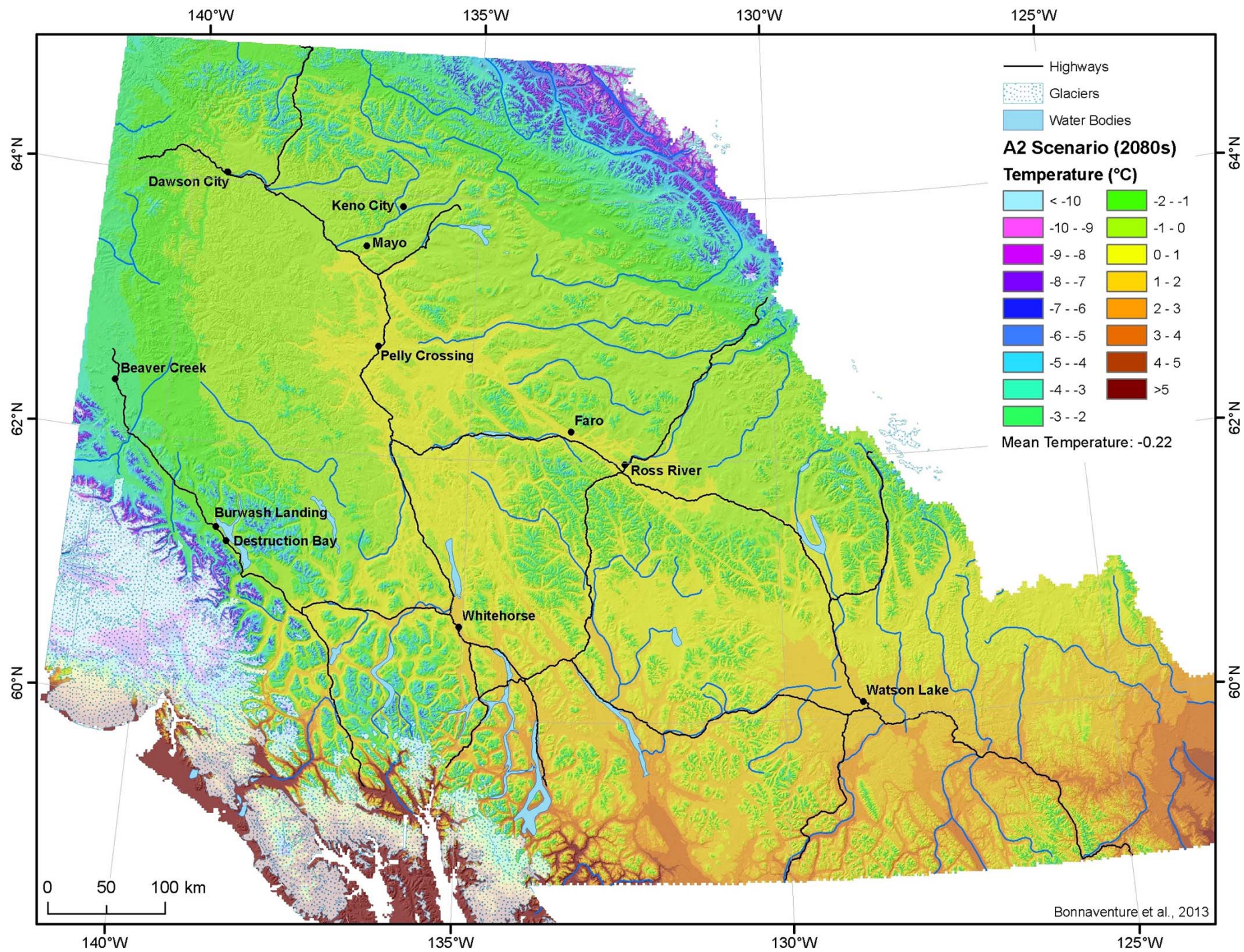




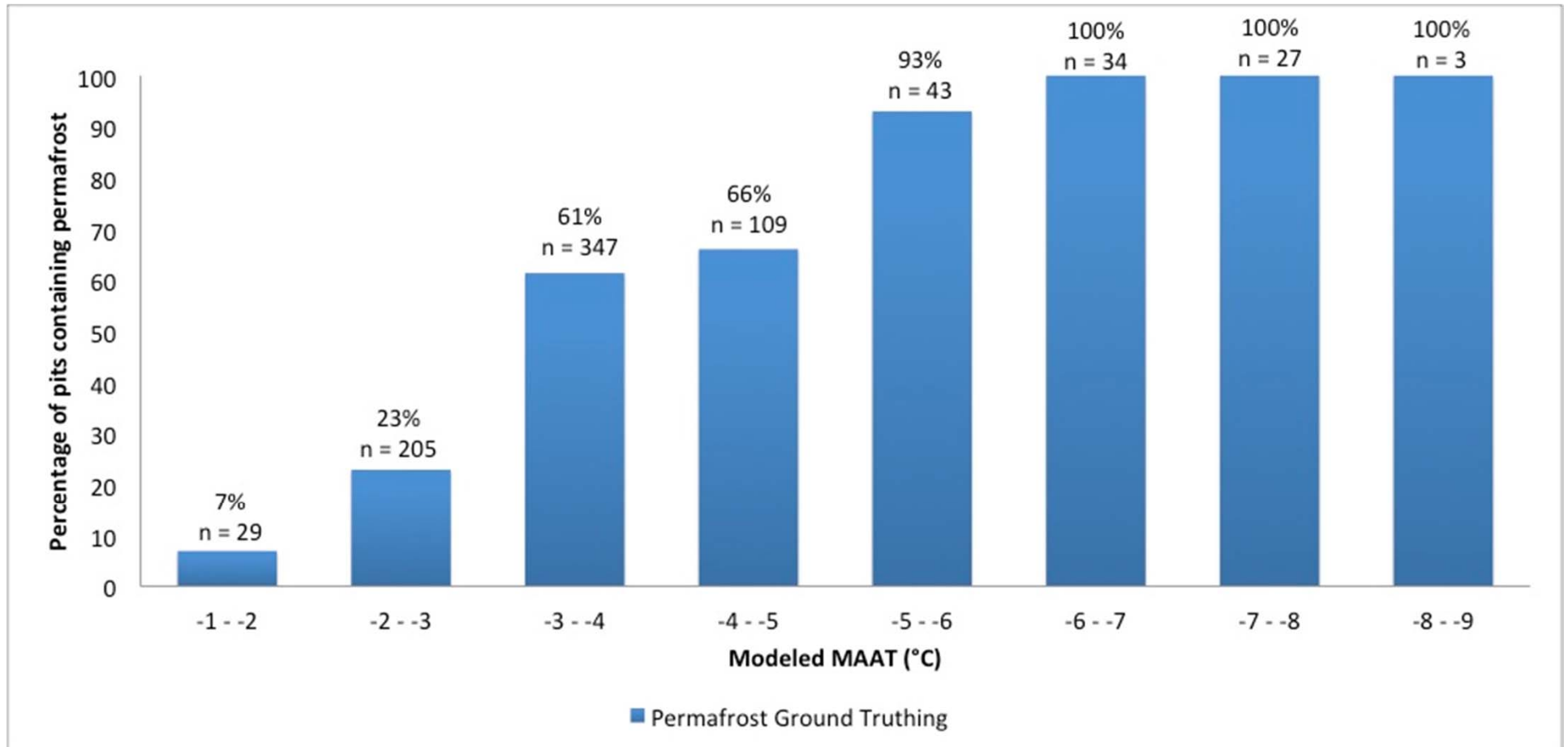
Lewkowicz et al., 2012







Comparing Permafrost & MAAT



Environmental indicator for scenario models

Logistic Curve Permafrost according to MAAT

Critical MAAT thresholds for permafrost

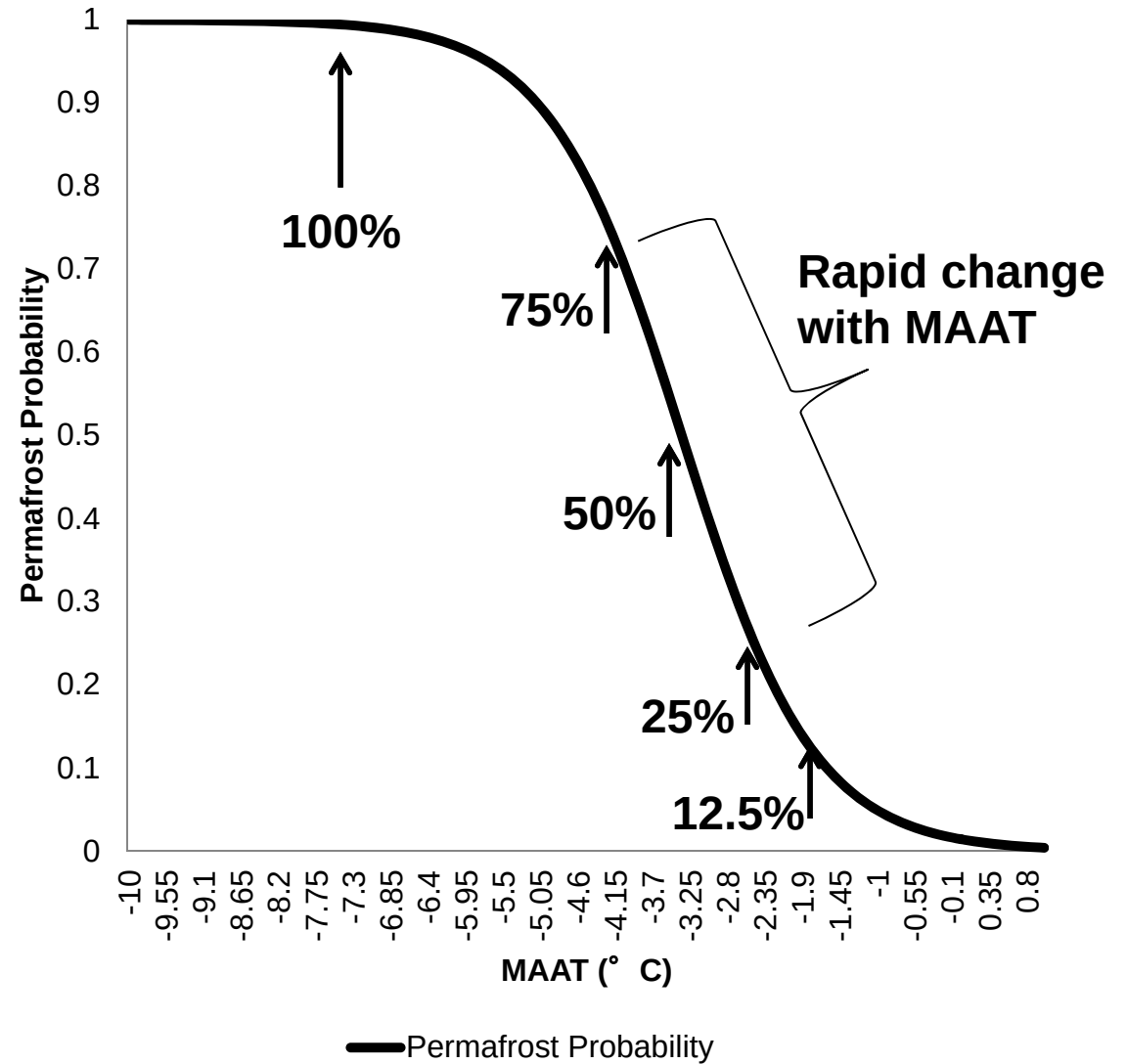
100% Probability at MAAT = -7.5°C

75% Probability at MAAT = -4.25°C

50% Probability at MAAT = -3.35°C

25% Probability at MAAT = -2.5°C

12.5% Probability at MAAT = -1.8°C



Conclusions

- Areas most prone to thaw happen where:
- SLRs are close to $0^{\circ}\text{C}/\text{km}$
- Display bidirectional spatial loss behavior
- Occur in areas with MAATs -2.5 - -4.25°C
- The results of this modelling should be used in conjunction with other ecosystem modelling in the area



Thank you



uOttawa

L'Université canadienne
Canada's university

