Preliminary Winter Accumulation Rates for Mass Balance Estimates of the Juneau Icefield using 400 MHz Ground-Penetrating Radar

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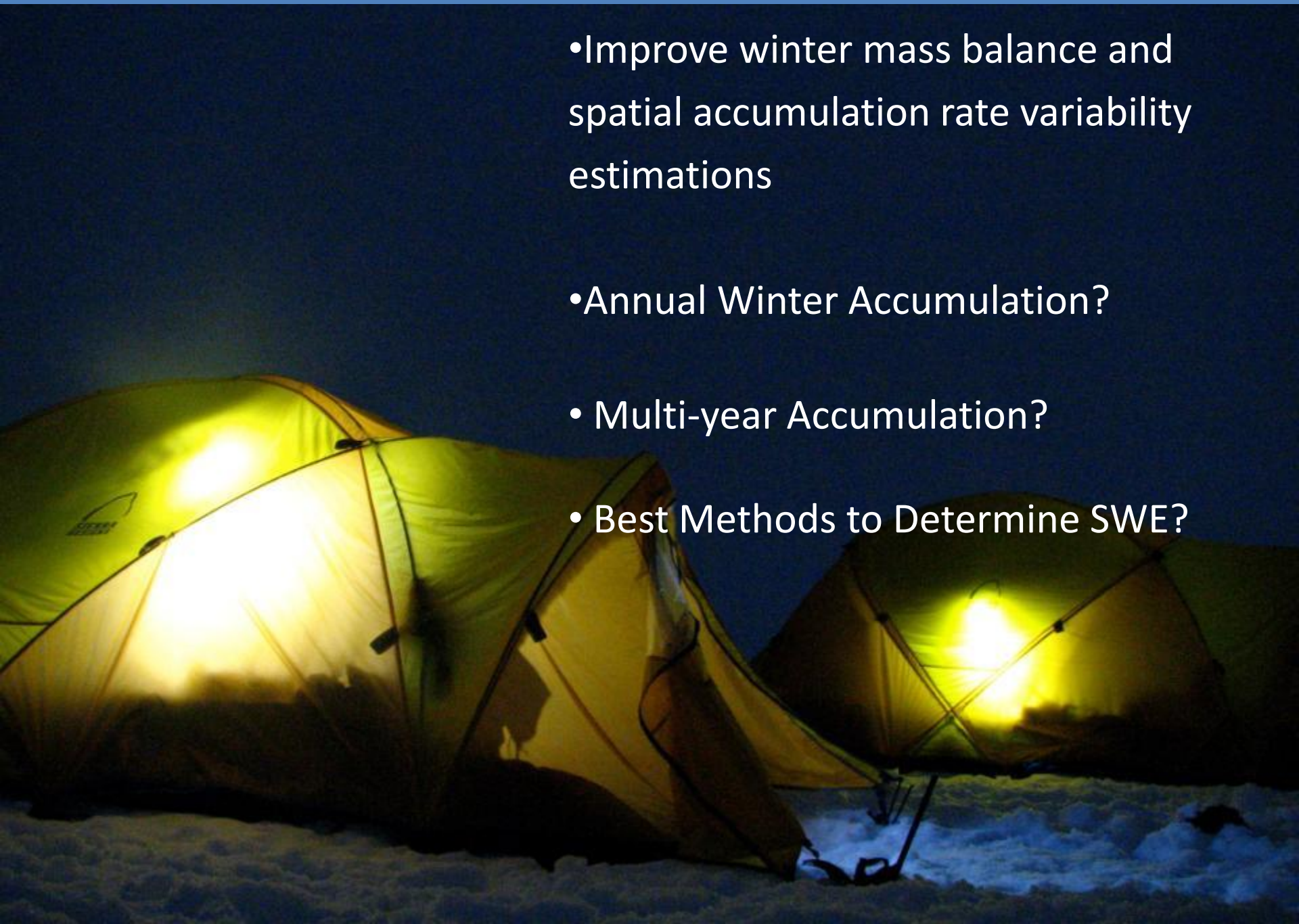
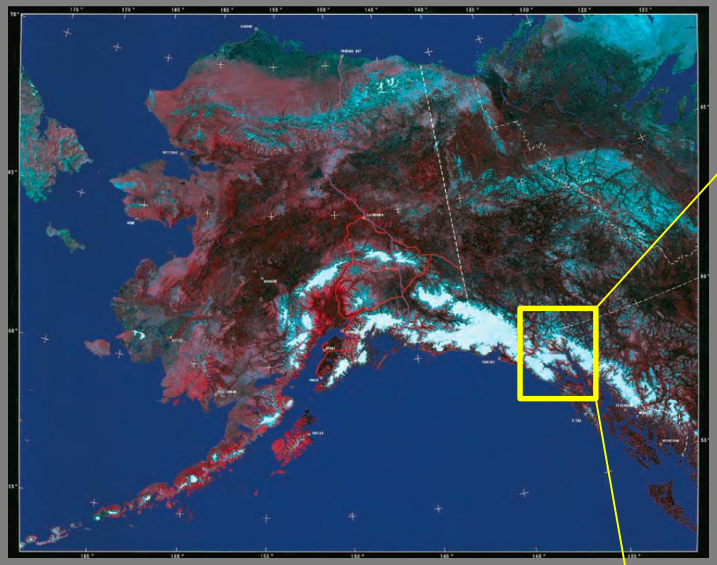
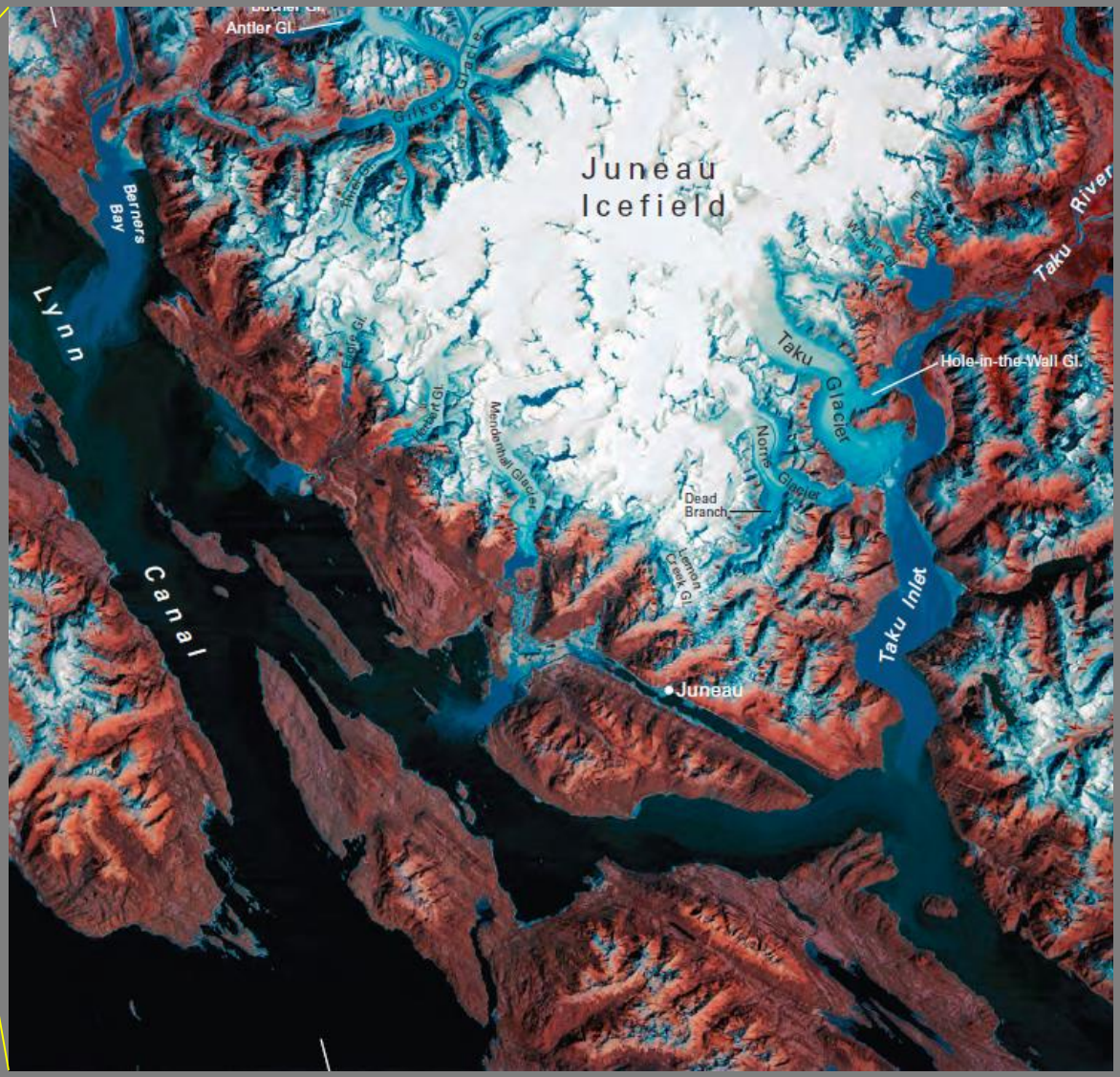


- Improve winter mass balance and spatial accumulation rate variability estimations
- Annual Winter Accumulation?
- Multi-year Accumulation?
- Best Methods to Determine SWE?





- 1,955km^2
- About 40 major and 100 minor glaciers
- Glaciers retreating with exception of Taku

Images from: SATELLITE IMAGE ATLAS OF GLACIERS OF THE WORLD: GLACIERS OF NORTH AMERICA— GLACIERS OF ALASKA (2008).

Radar Velocity:

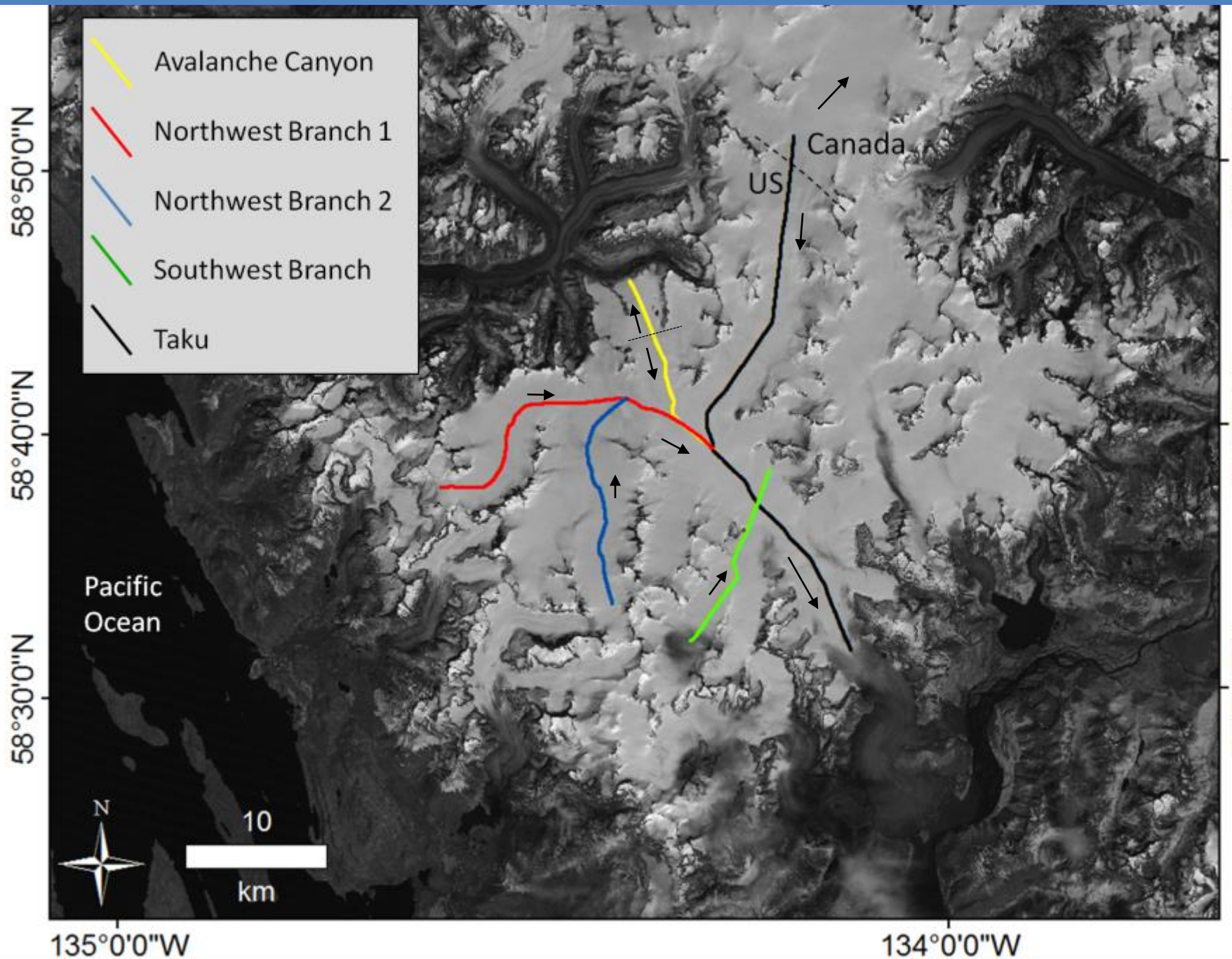
CMP (Annan et al. 1994)

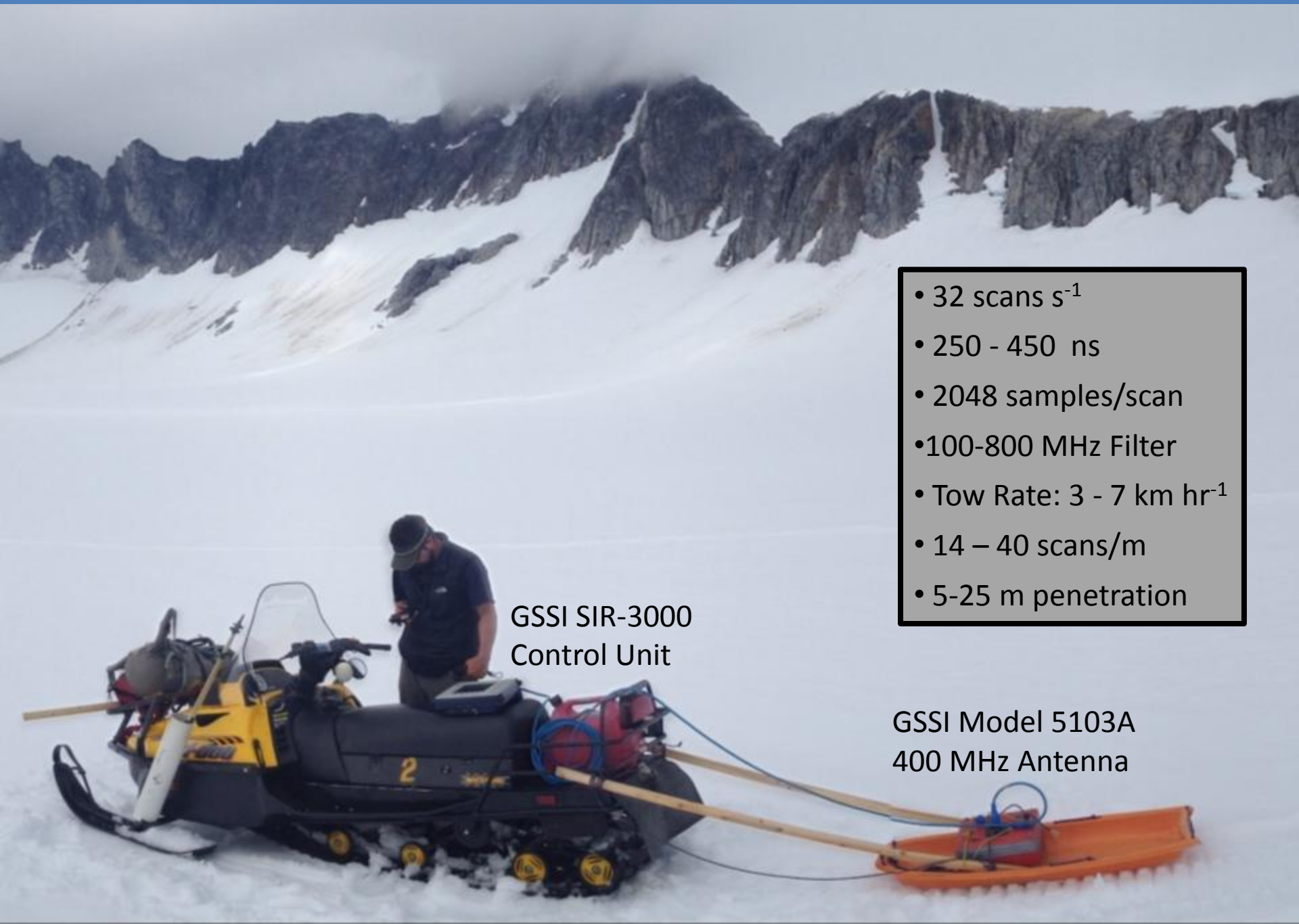
Ground Truth (Marshall et al., 2005)

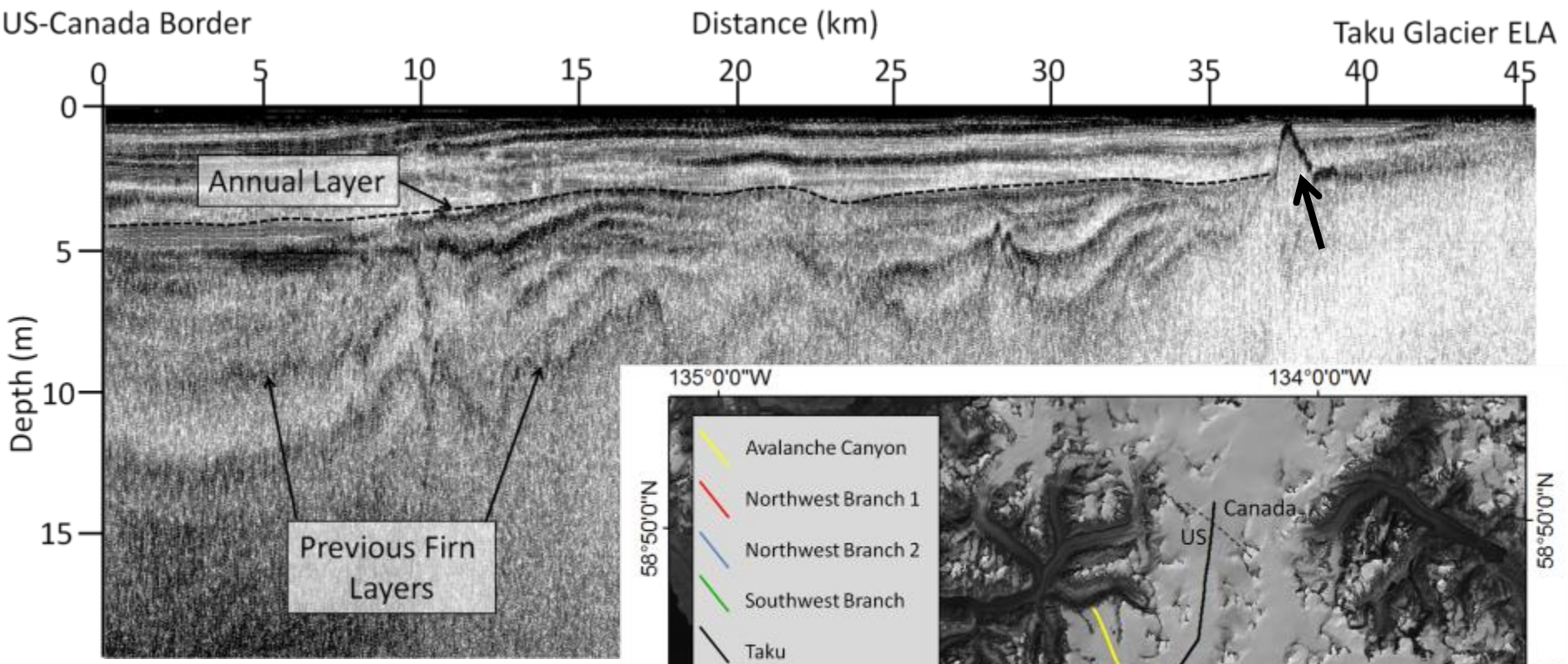
Hyperbola Matching (Bradford and Harper, 2005)

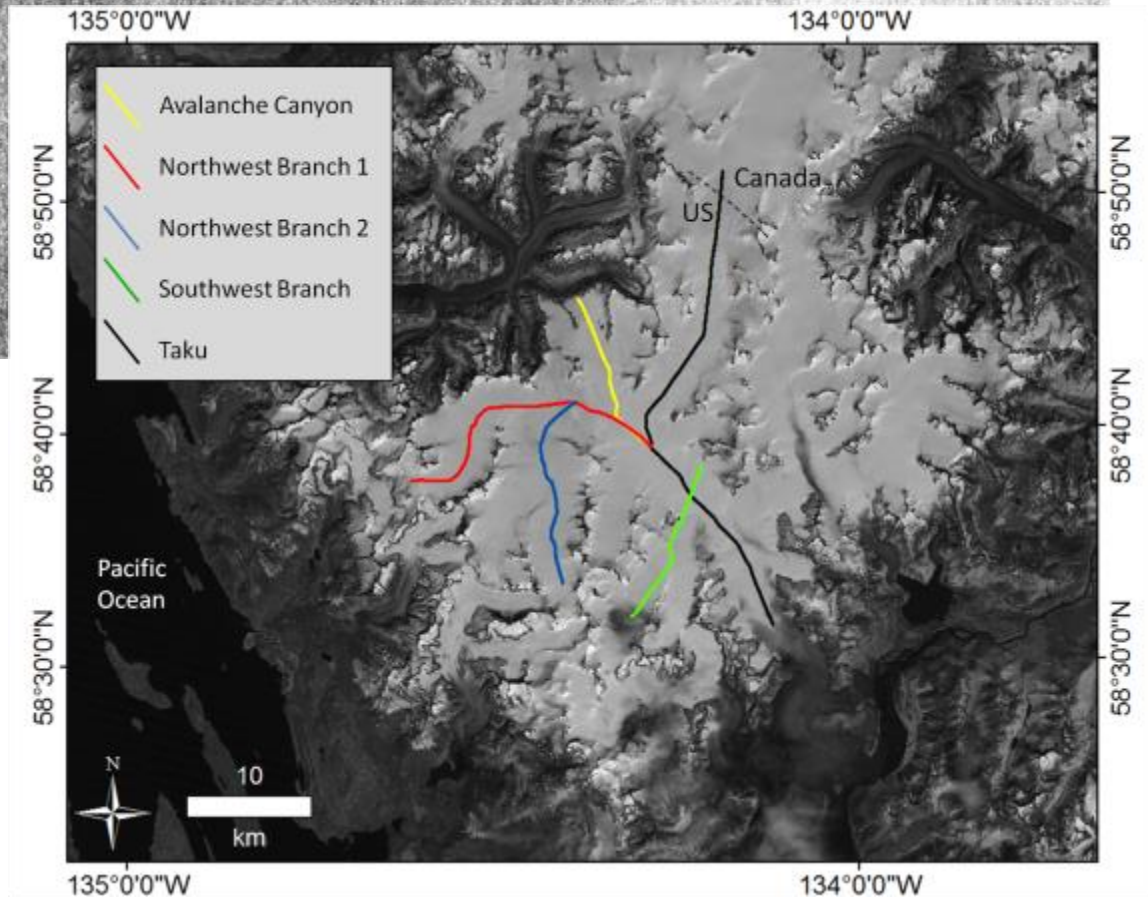
Reflection Tomography (Bradford, 2006)

Wave Velocity Depends on Density and Snow Wetness!

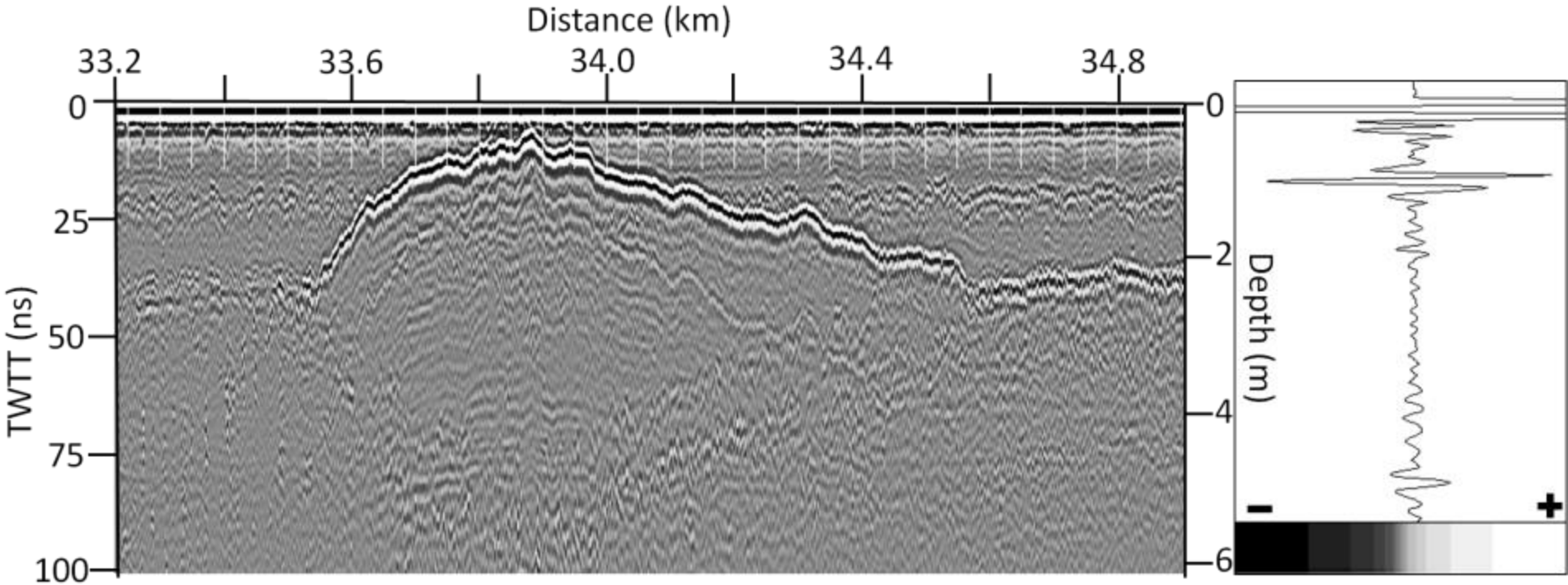

Avalanche Canyon
Northwest Branch 1
Northwest Branch 2
Southwest Branch
Taku
Canada
US
Pacific Ocean
N
10
km
58°50'0"N
58°40'0"N
58°30'0"N
135°0'0"W
134°0'0"W

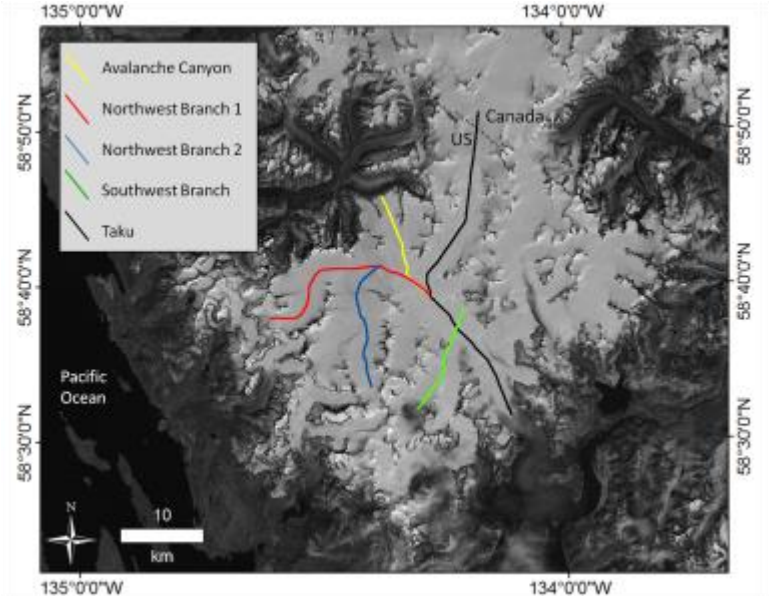

• 32 scans s^{-1}
• 250 - 450 ns
• 2048 samples/scan
•100-800 MHz Filter
• Tow Rate: 3 - 7 km hr^{-1}
• 14 – 40 scans/m
• 5-25 m penetration
GSSI SIR-3000
Control Unit
GSSI Model 5103A
400 MHz Antenna

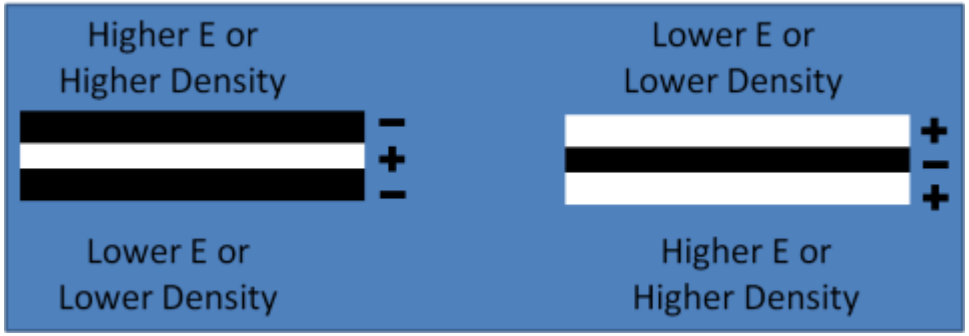




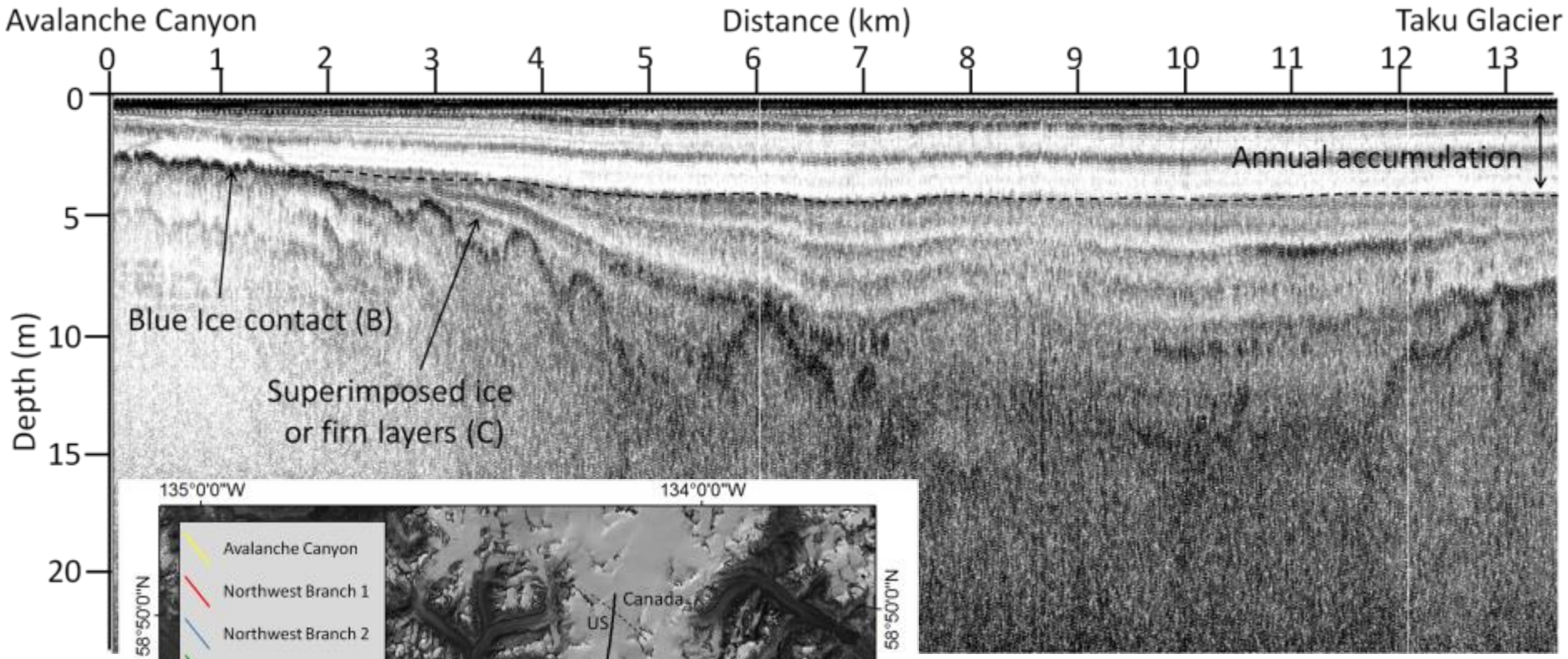
- Roughly 1000 m elevation drop from divide to ELA
- Volume scattering from free water
- Stacked 50x

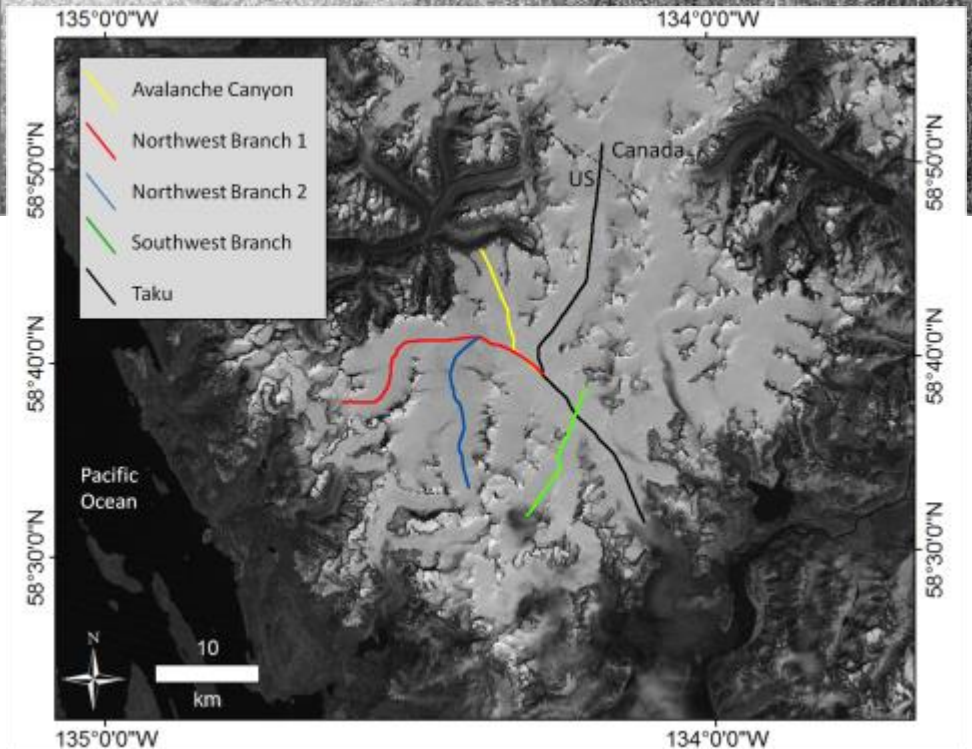




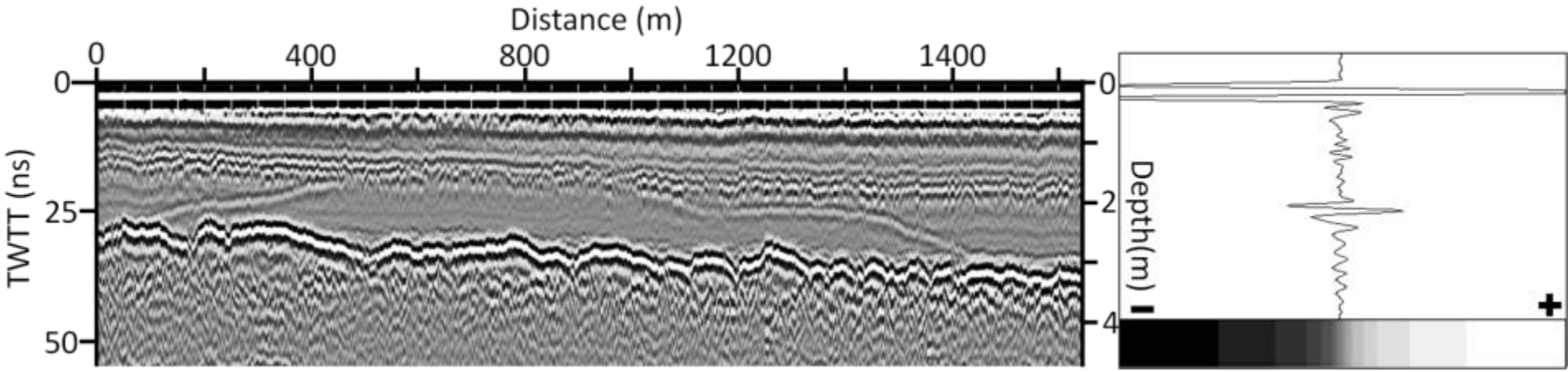


- +-+ GPR wave triplet (lower to higher permittivity)
- Water table resting on ice under snow

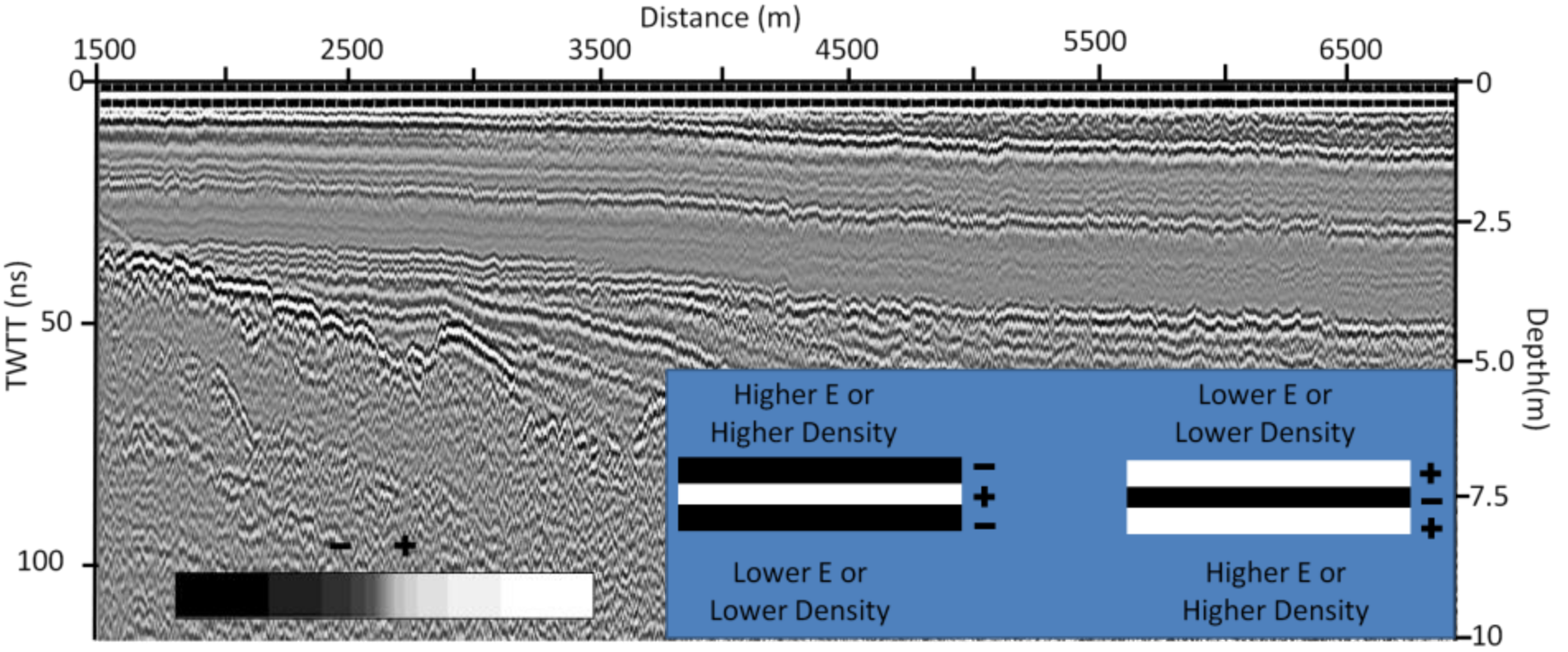


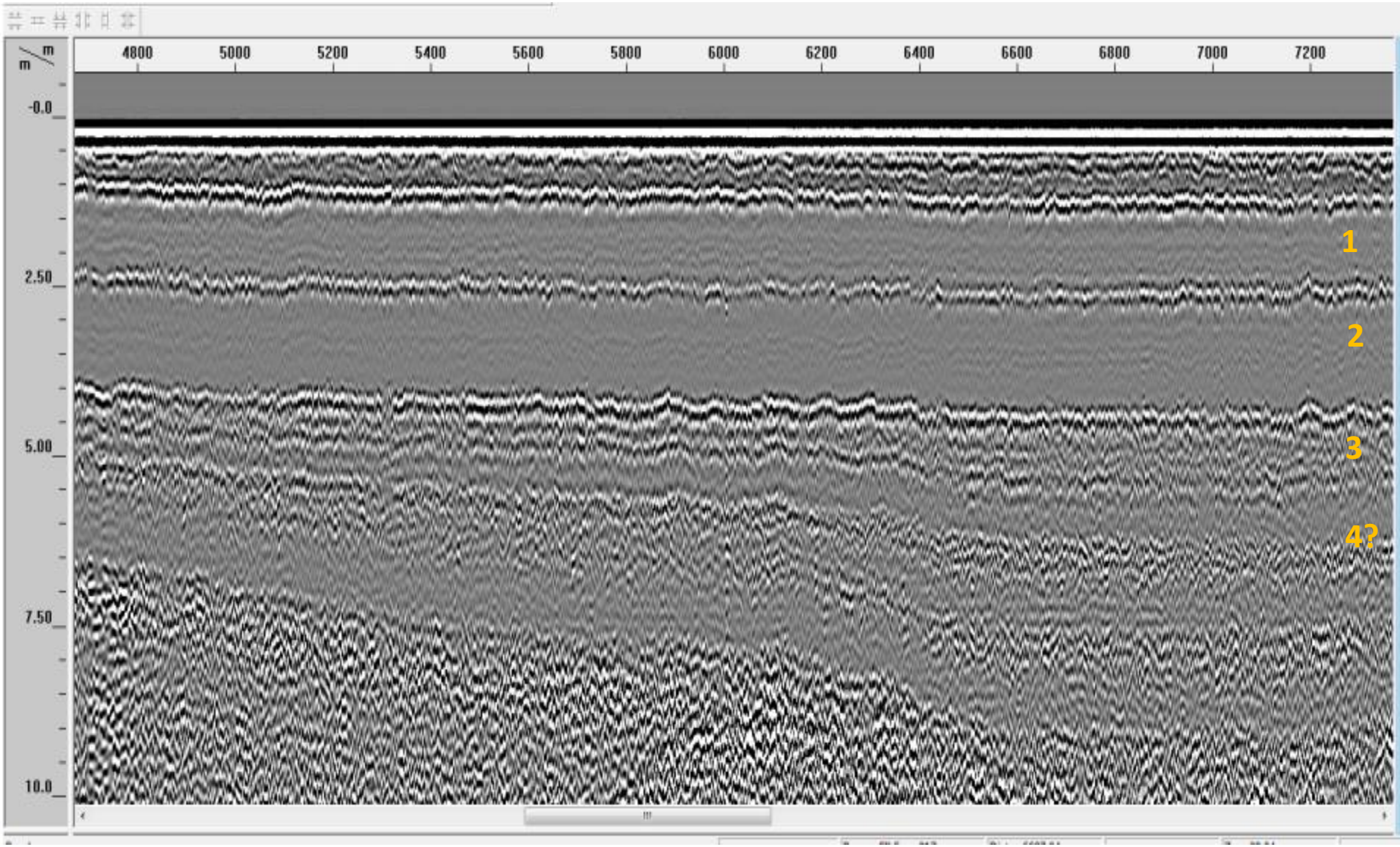


- Multiple ice lenses
- Stacked 20x



KEY POINT: Reverse Triplet Signature from dry snow over ice!




m
m
4800
5000
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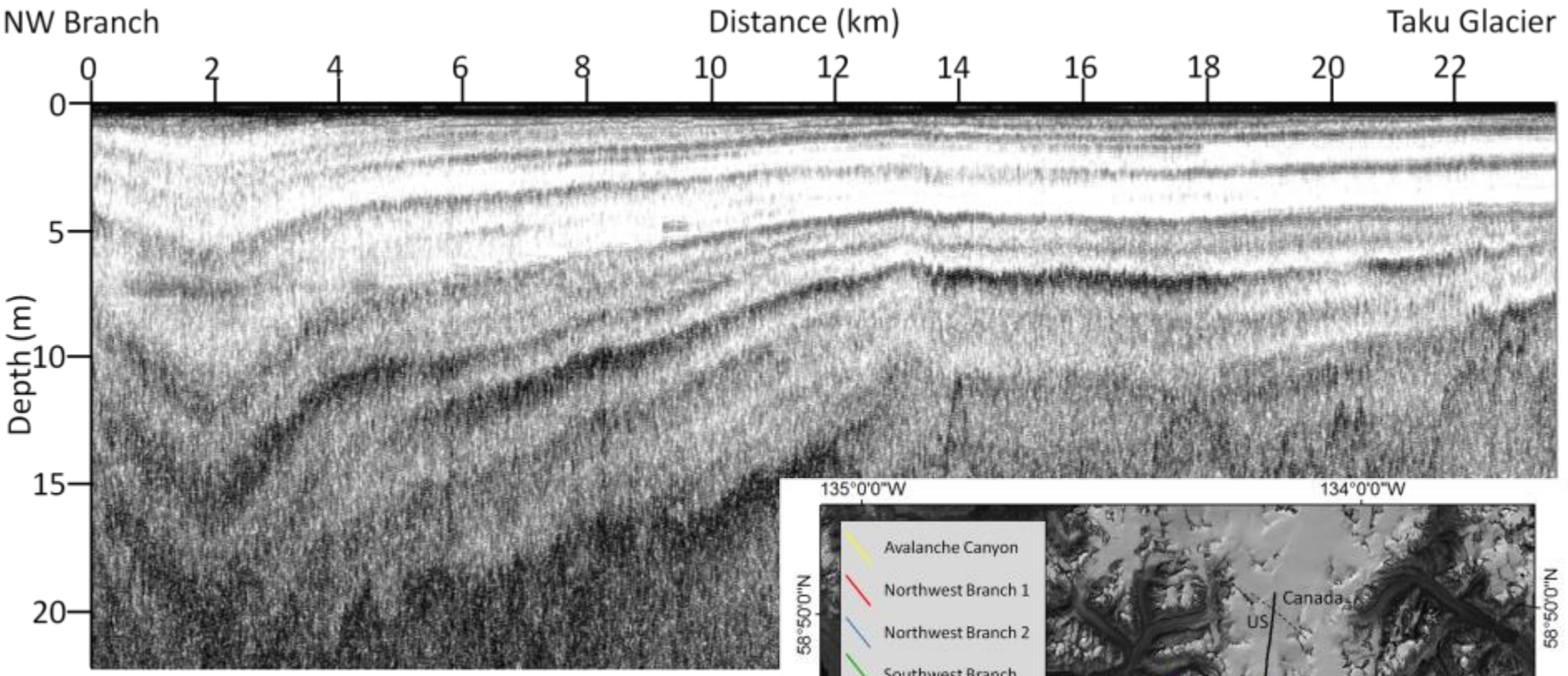
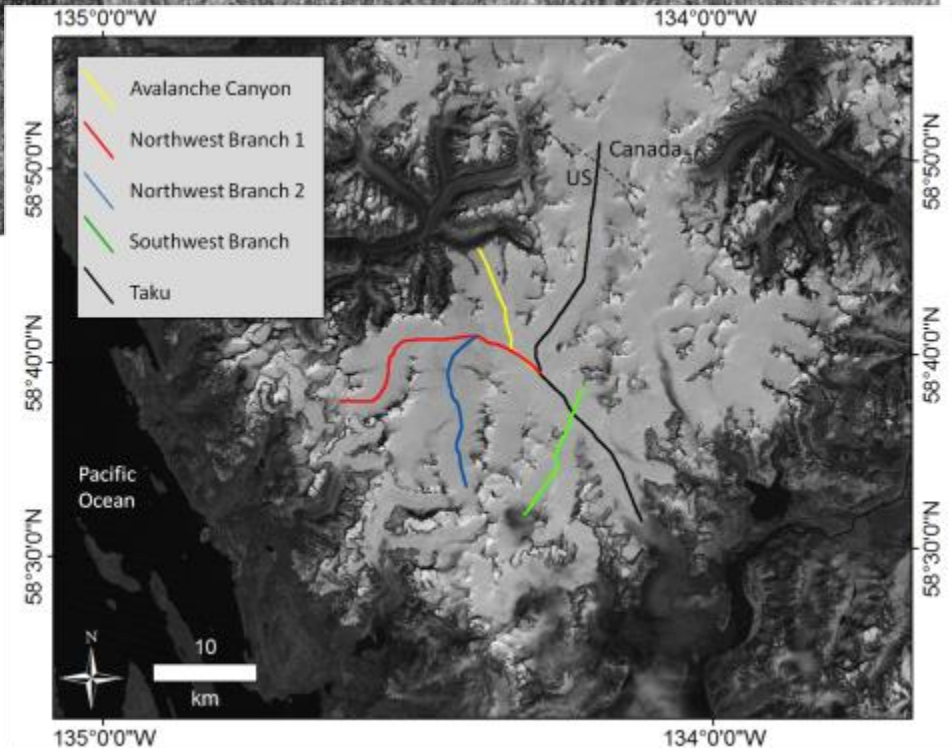
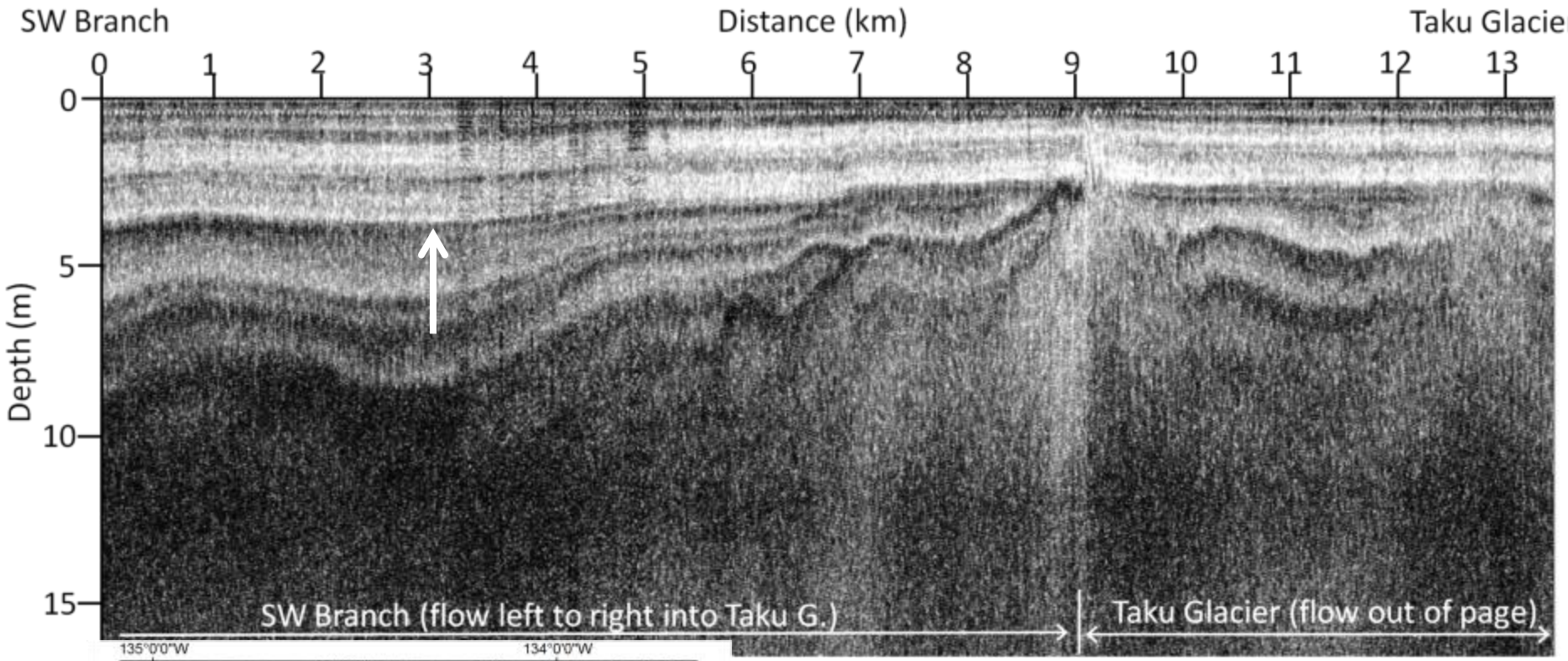
7.50
10.0
1
2
3
4?

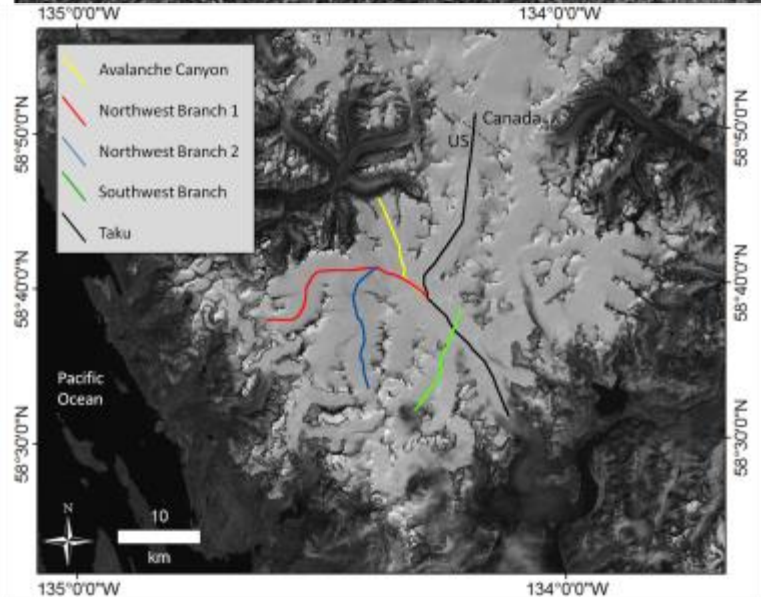




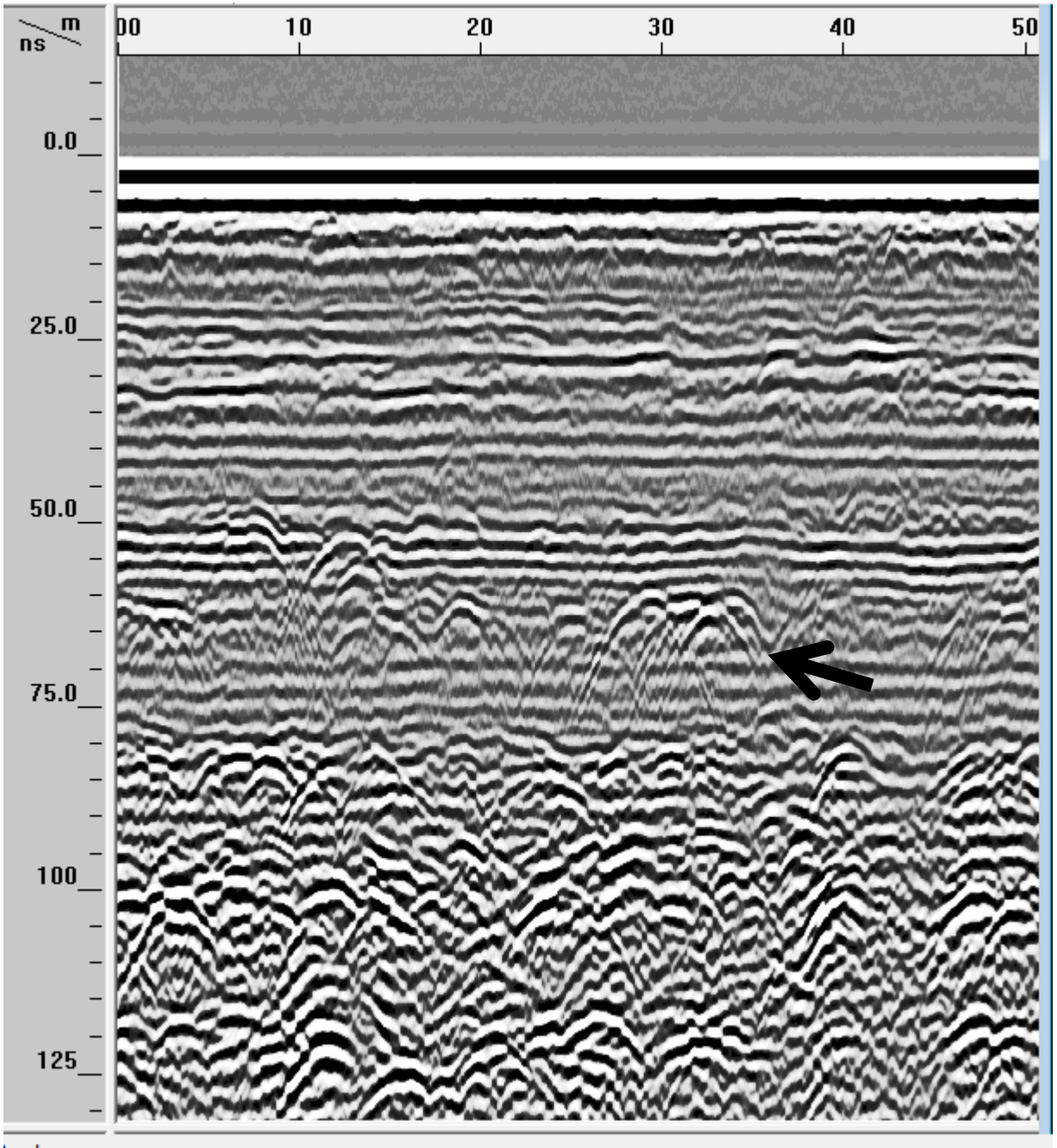
Northern NW Branch
Thinning Stratigraphy:

- Accumulation Gradient W to E
- Divide towards ELA
- Potential multi-year accumulation



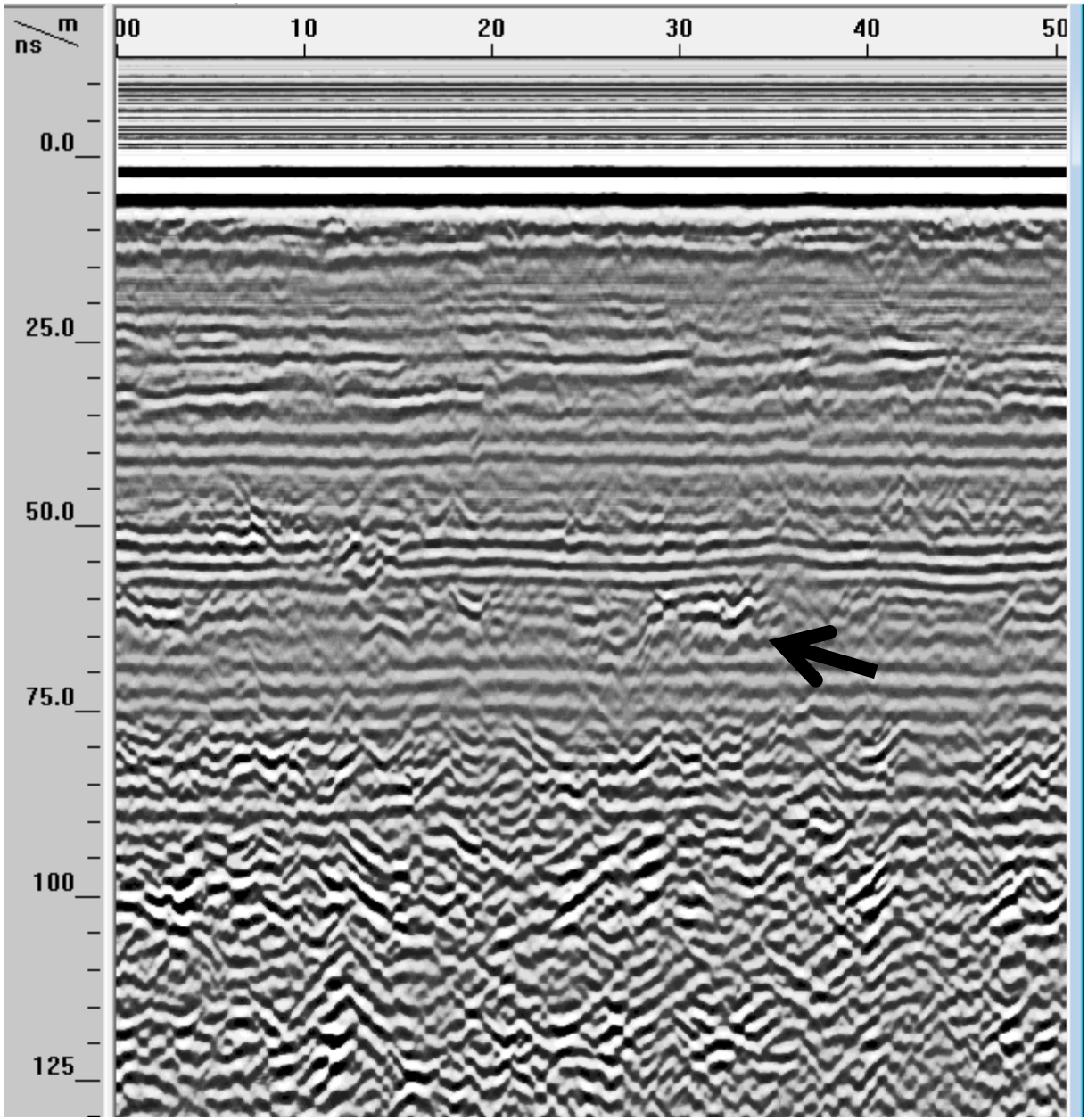


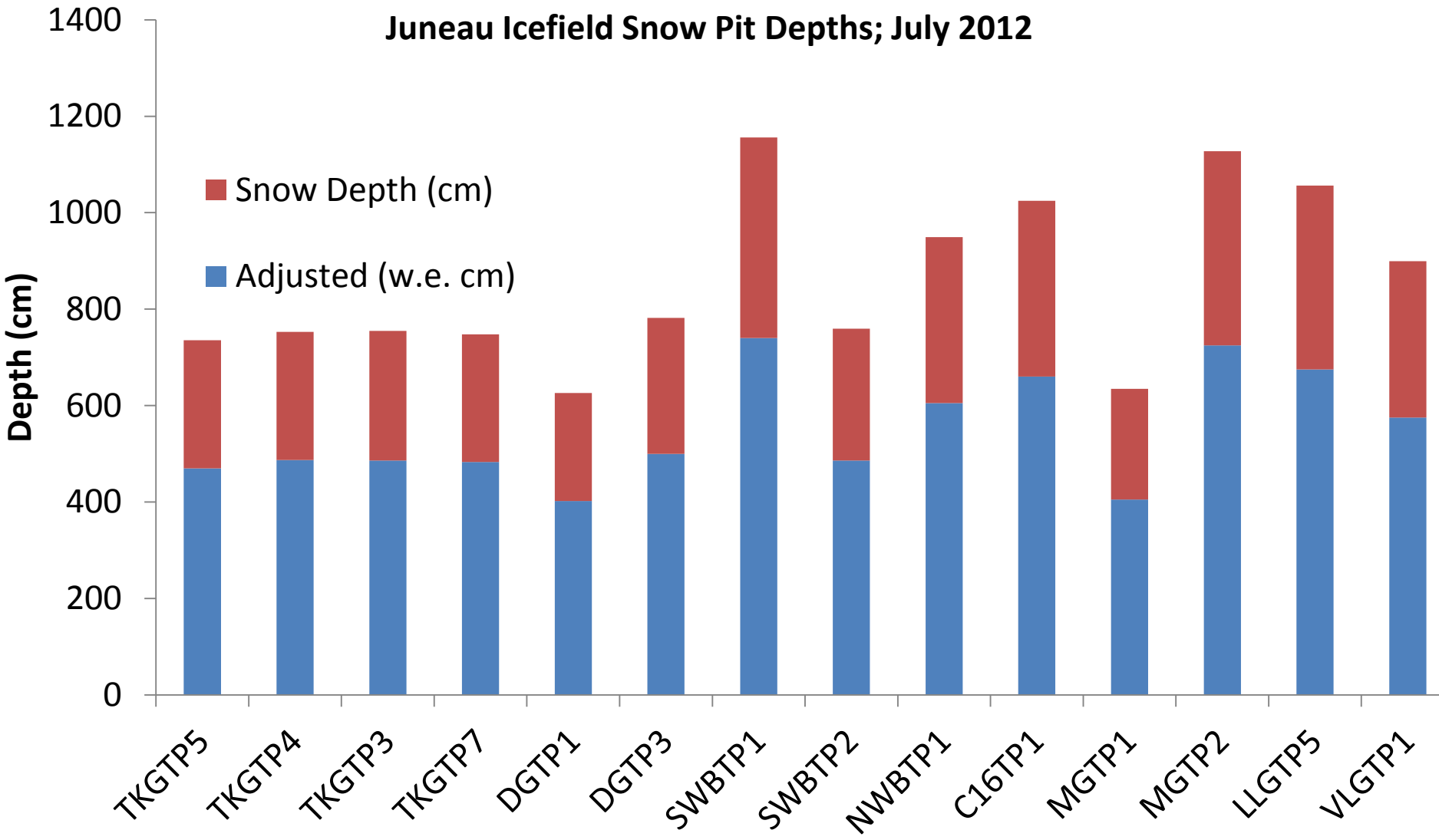
- Annual accumulation thinning from west to east
- Potential firn layers



Future work:

- Further processing to acquire accurate depth measurements using hyperbola migration


m
ns
00
10
20
30
40
50
0.0
25.0
50.0
75.0
100
125


Juneau Icefield Snow Pit Depths; July 2012
Depth (cm)
1400
1200
1000
800
600
400
200
0
Snow Depth (cm)
Adjusted (w.e. cm)
TKGTP5
TKGTP4
TKGTP3
TKGTP7
DGTP1
DGTP3
SWBTP1
SWBTP2
NWBTP1
C16TP1
MGTP1
MGTP2
LLGTP5
VLGTP1

Continuous stratigraphy (high stacking rates)

Strong seasonal horizon

Thinning gradient:
- Coast to inland
- Divide to ELA

High water content (reverse triplet vs. dry snow/ice)

Multi-year reflections?

Depth Estimates
- Pits vs. migrated GPR