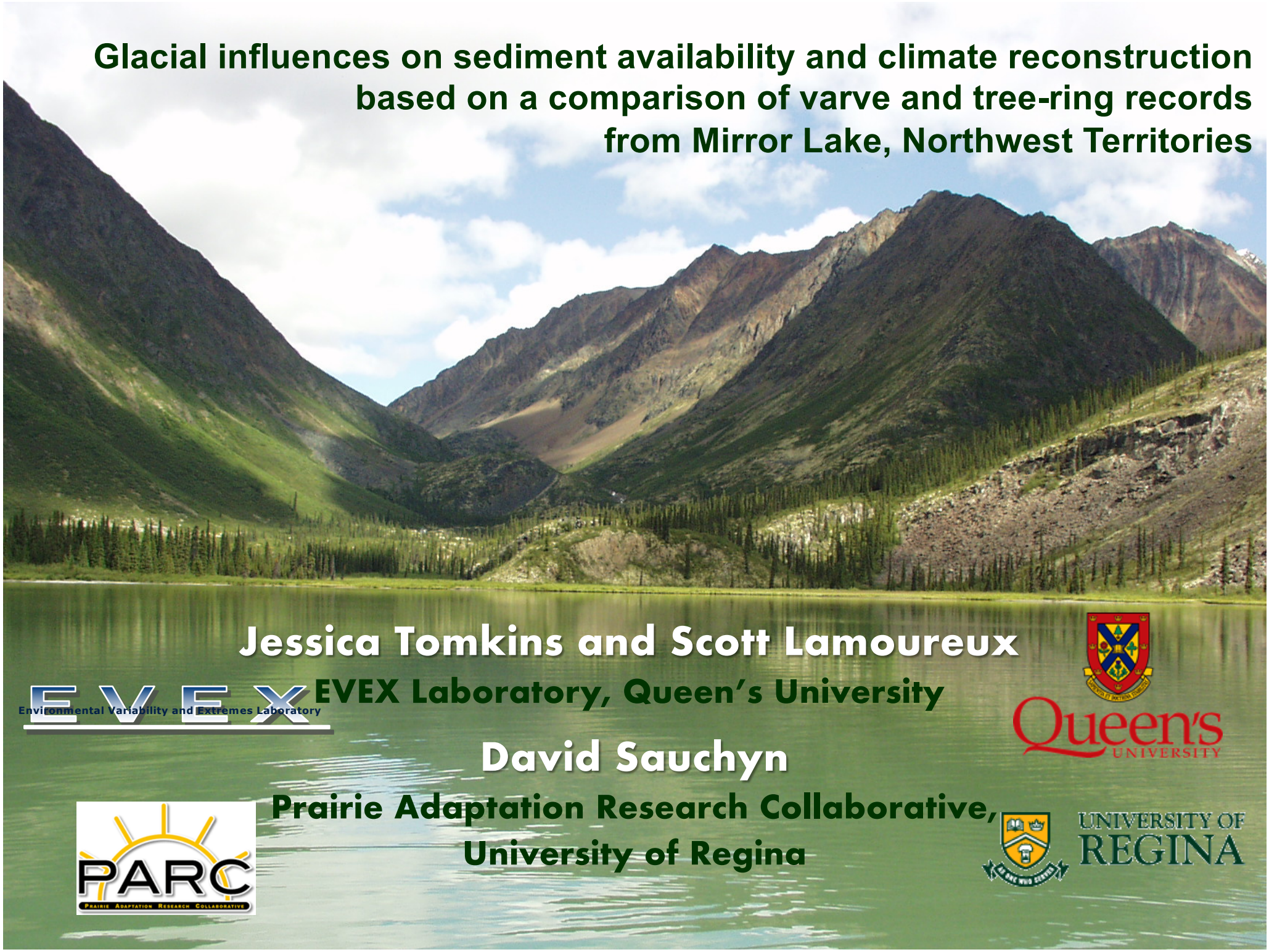
Glacial influences on sediment availability and climate reconstruction based on a comparison of varve and tree-ring records from Mirror Lake, Northwest Territories



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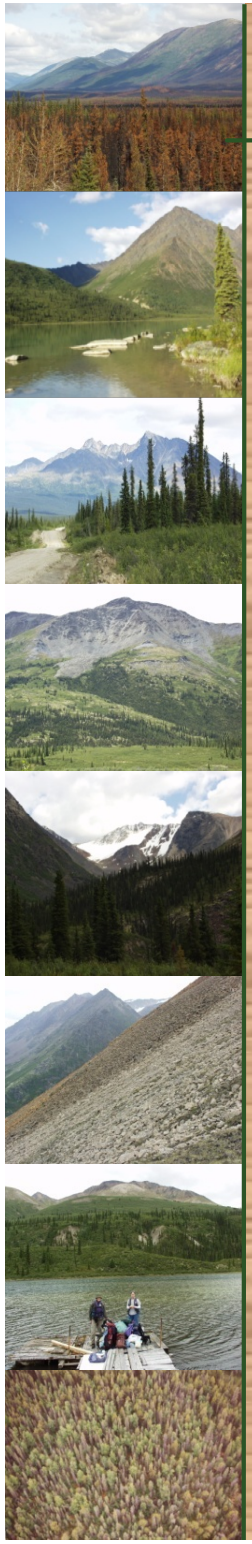
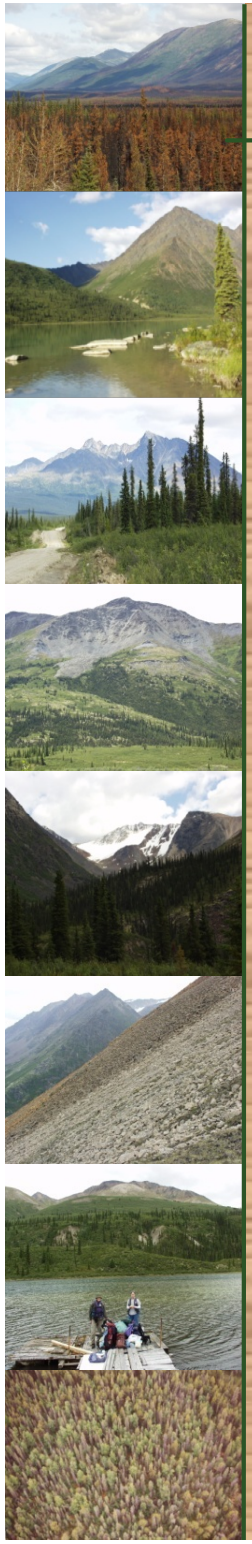


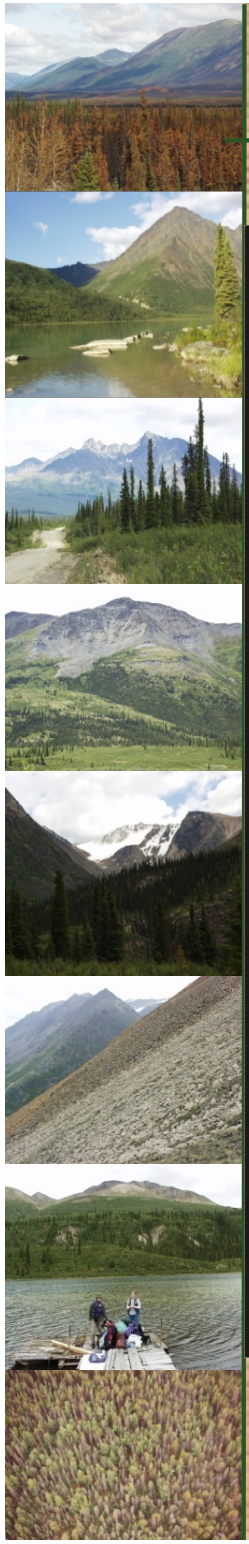
Introduction

- **Instrumental climate records are often temporally and spatially limited, especially in remote locations**
- **Proxy (indirect) climate records can extend the instrumental climate record**
  - e.g., tree rings and annually-laminated (varved) lake sediments
- **Each proxy is subject to non-climatic and climatic influences**
- **Using multiple types of proxy records can not only aid in reconstruction verification but can also identify parts of records with strong non-climatic influences (weaker climate signals)**

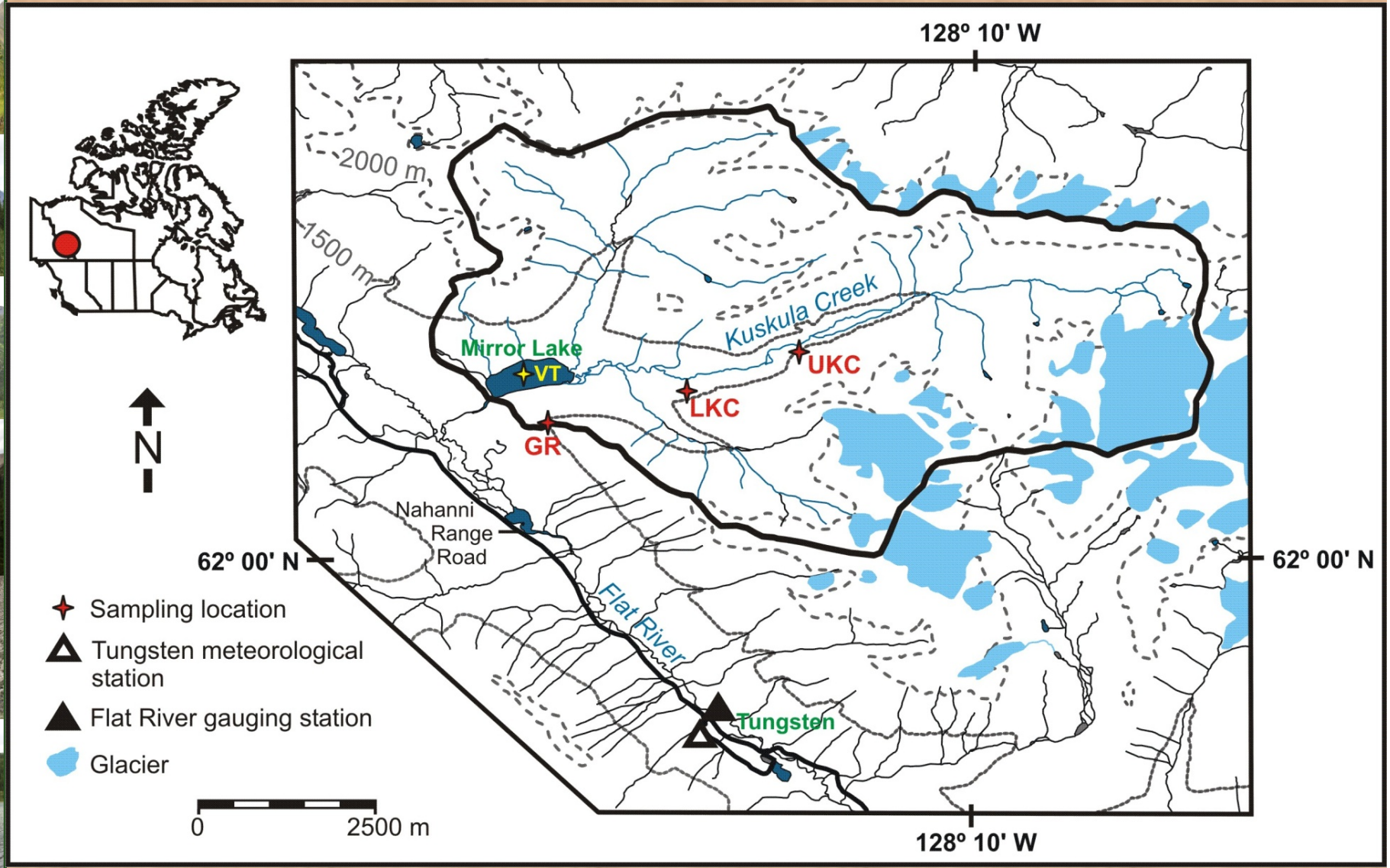


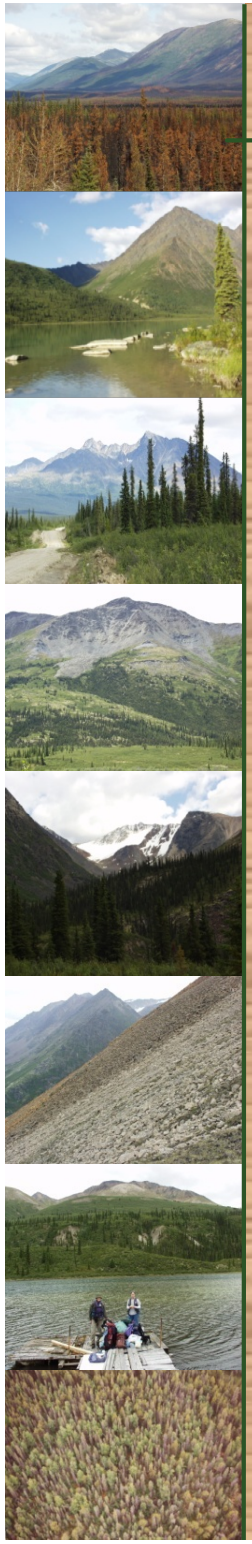
Study Objective

- **To use adjacent tree-ring and varve records within close proximity of instrumental records not only to develop a long-term climate record for the study area but, more importantly, to explore the similarities and differences between the records**
  - Identify effective methodology for comparing proxy records
  - Examine causes for discrepancies between the records



Study Site

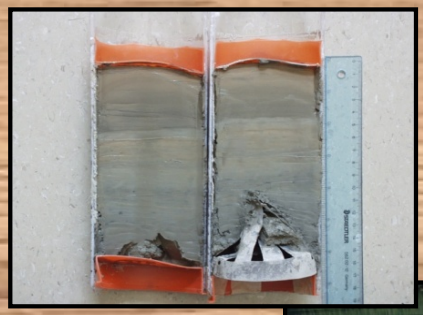

128° 10' W
2000 m
1500 m
Kuskula Creek
Mirror Lake
VT
UKC
LKC
GR
Nahanni
Range
Road
62° 00' N
62° 00' N
Flat River
Tungsten
N
Sampling location
Tungsten meteorological station
Flat River gauging station
Glacier
0
2500 m
128° 10' W

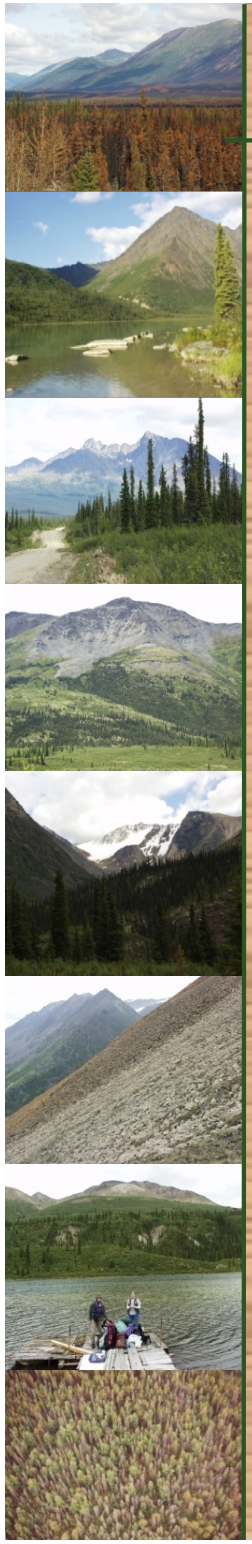


Methods

- **Lake sediments:**
  - Field: Five surface and two long (up to 2 m) cores collected from Mirror Lake in August 2002
  - Laboratory: Subsampling for thin sections and ^{137}Cs and density measurements
  - Varve thickness measurements from thin sections (resolution: 0.001 mm)

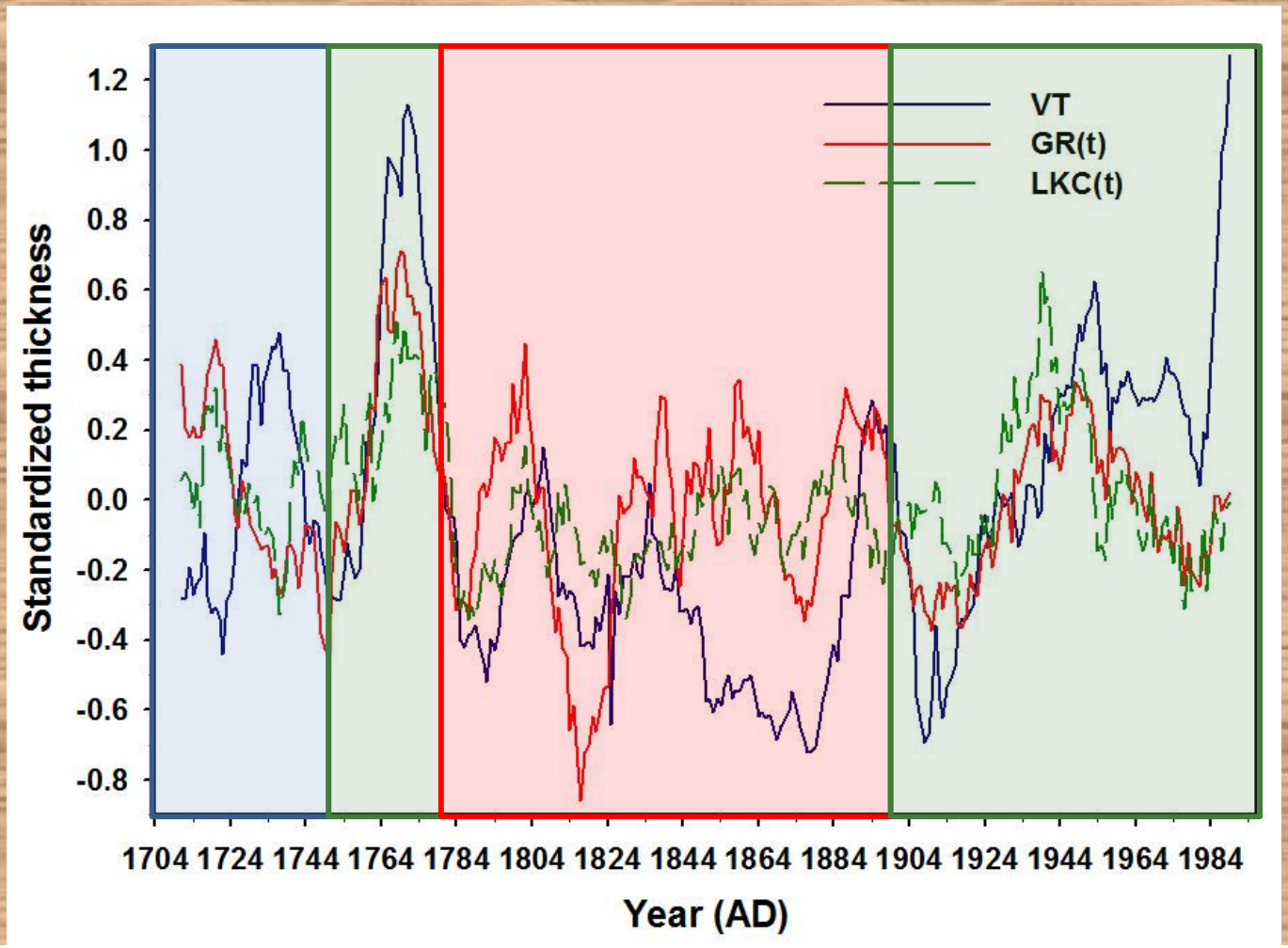
- **Tree rings:**
  - Field: Cores collected from 13 to 25 trees at each of three sampling sites near treeline in the Mirror Lake catchment
  - Laboratory: Ring width measurements (resolution: 0.001 mm)
  - Ring width series detrended to account for age and size trends

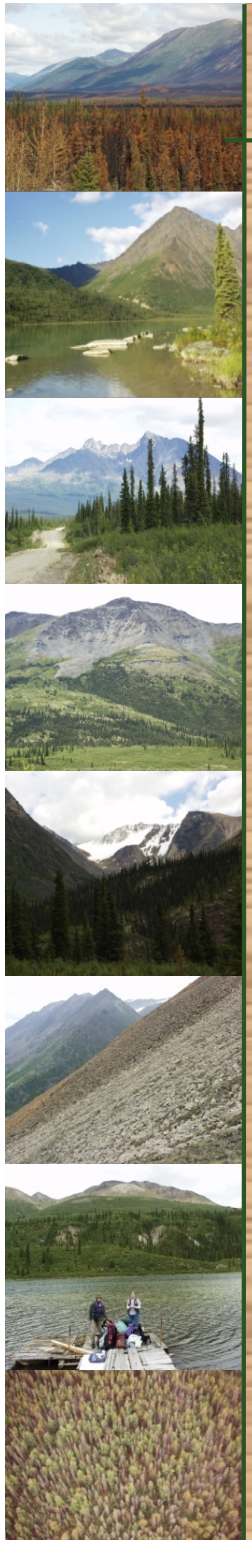




Comparison of Proxy Series

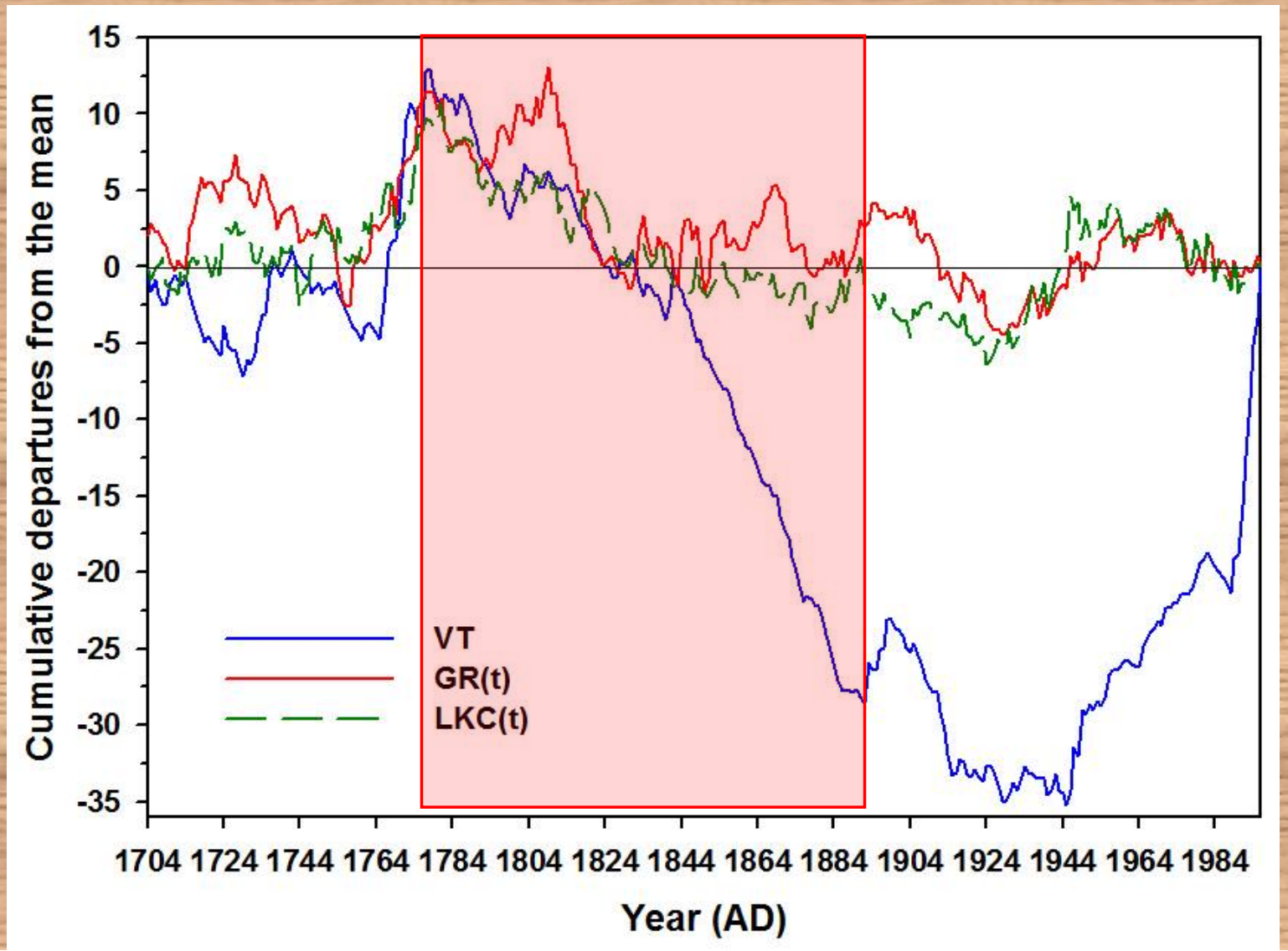
- Limited high-frequency (interannual) correspondence during period of overlap (AD 1704-1996)
- Filtered data (15-year unweighted moving mean) showed low frequency (decadal) similarities

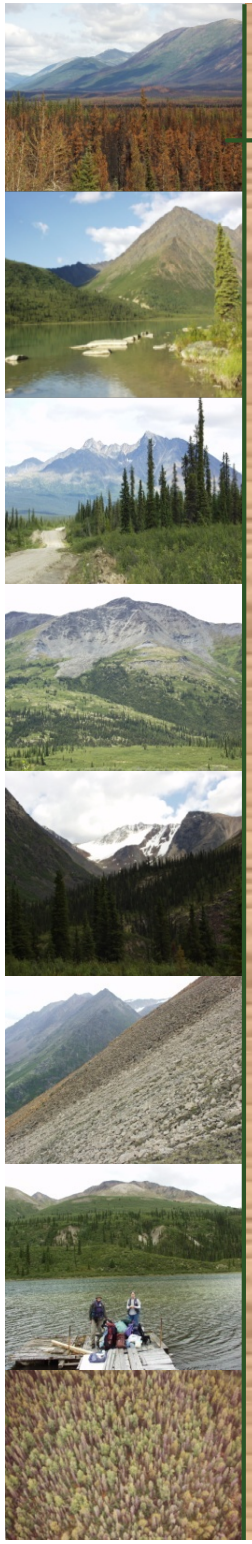




Comparison (continued)

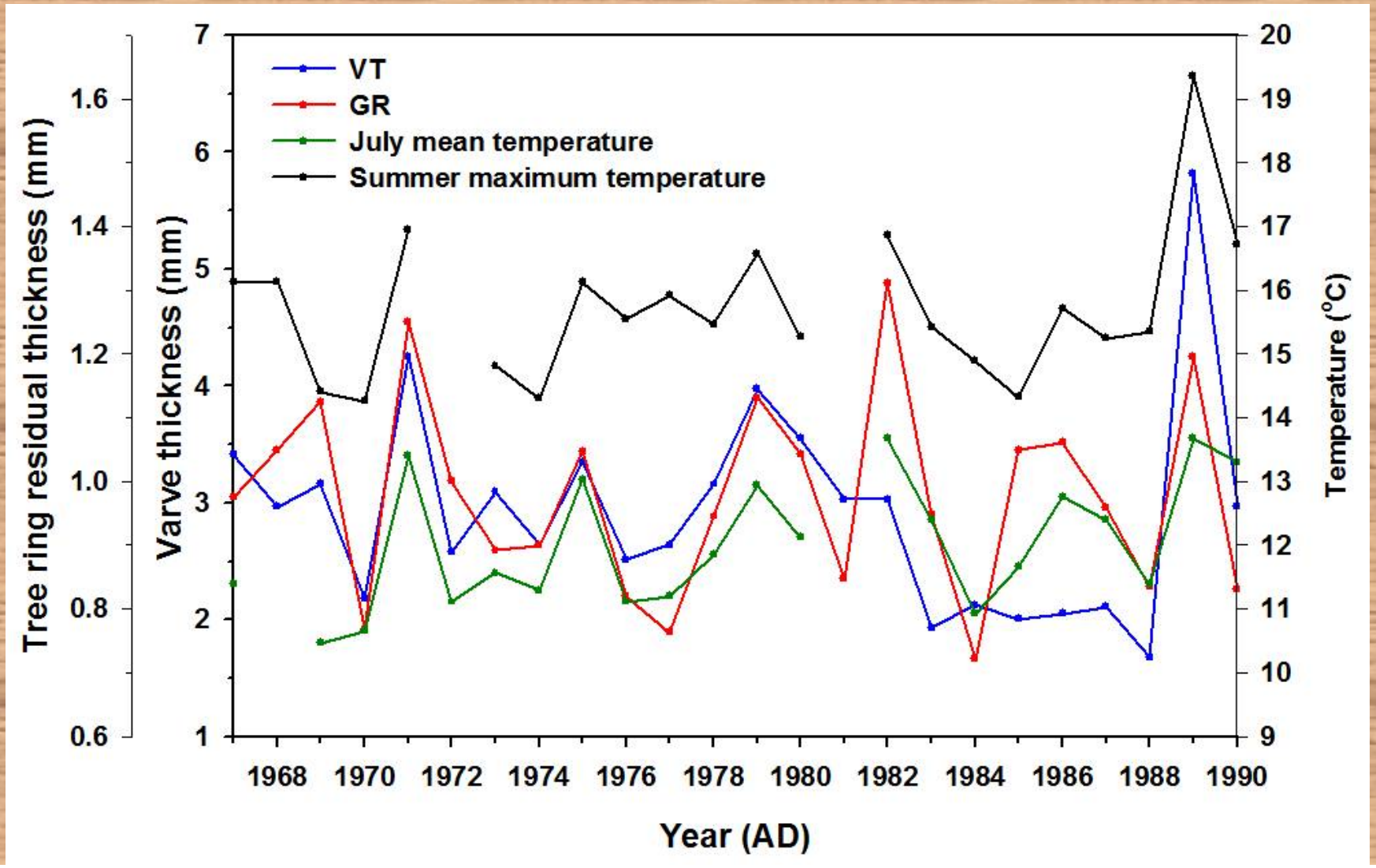
- **Cumulative departures from the mean indicated an extended period of below-mean varve thicknesses (AD 1778-1892)**
  - Non-climatic influences on varve record during 1800s?

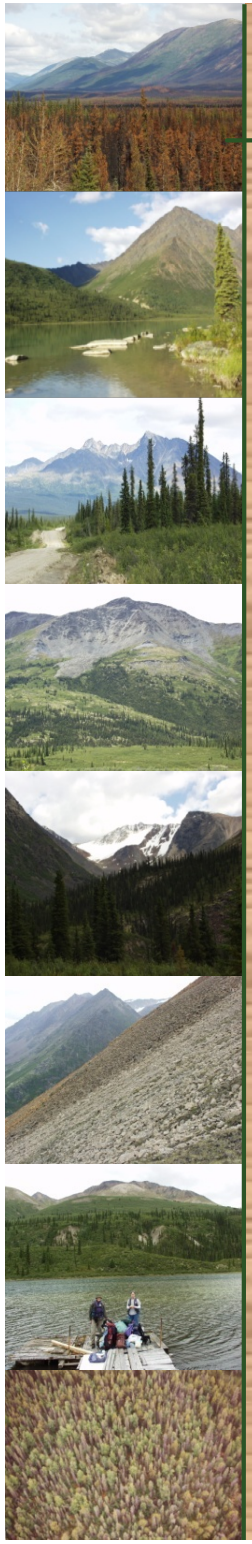




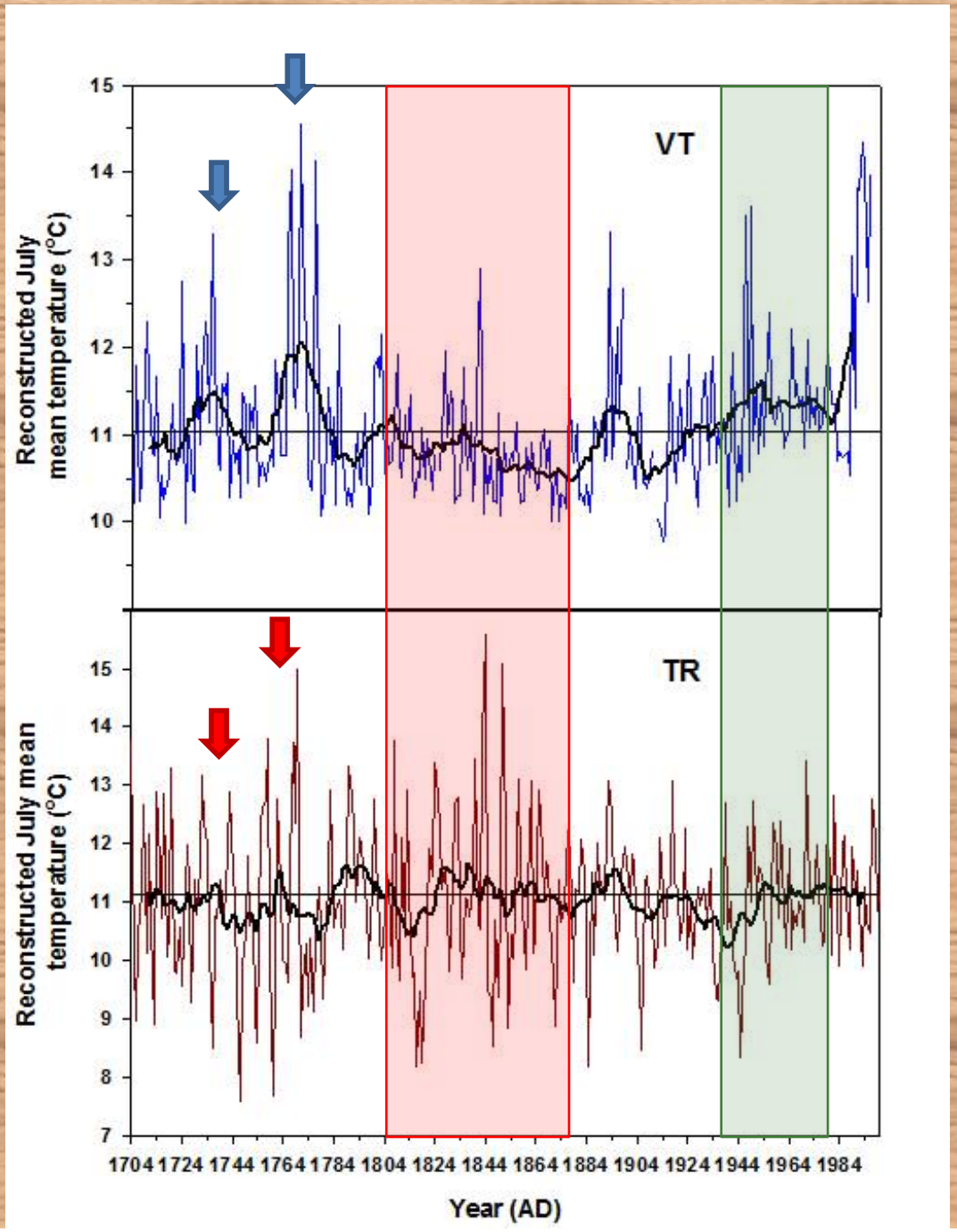
Proxy Relationships to Climate

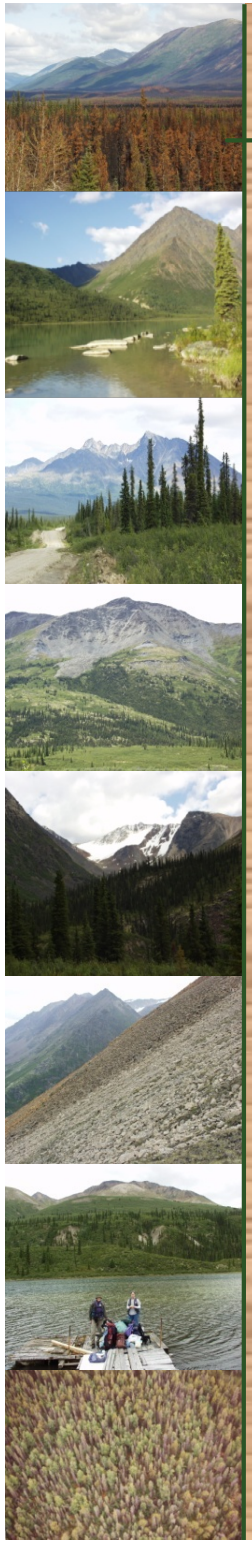
- **July mean temperature chosen for reconstructions**
  - **Strongest climatic influence on tree-ring series and constant influence on varve series**





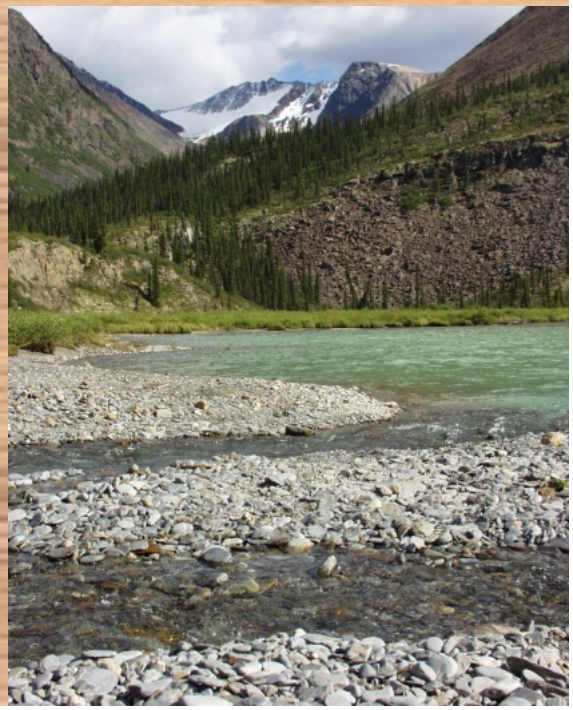
July Mean Temperature Reconstructions

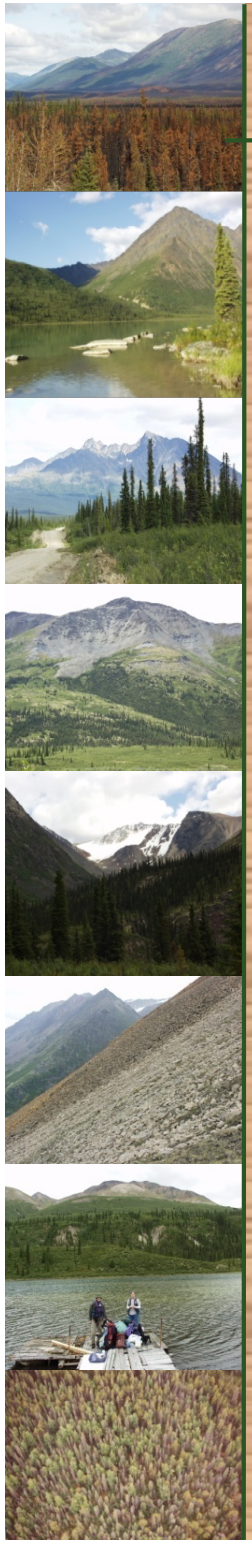




Glacial Influences on Varves

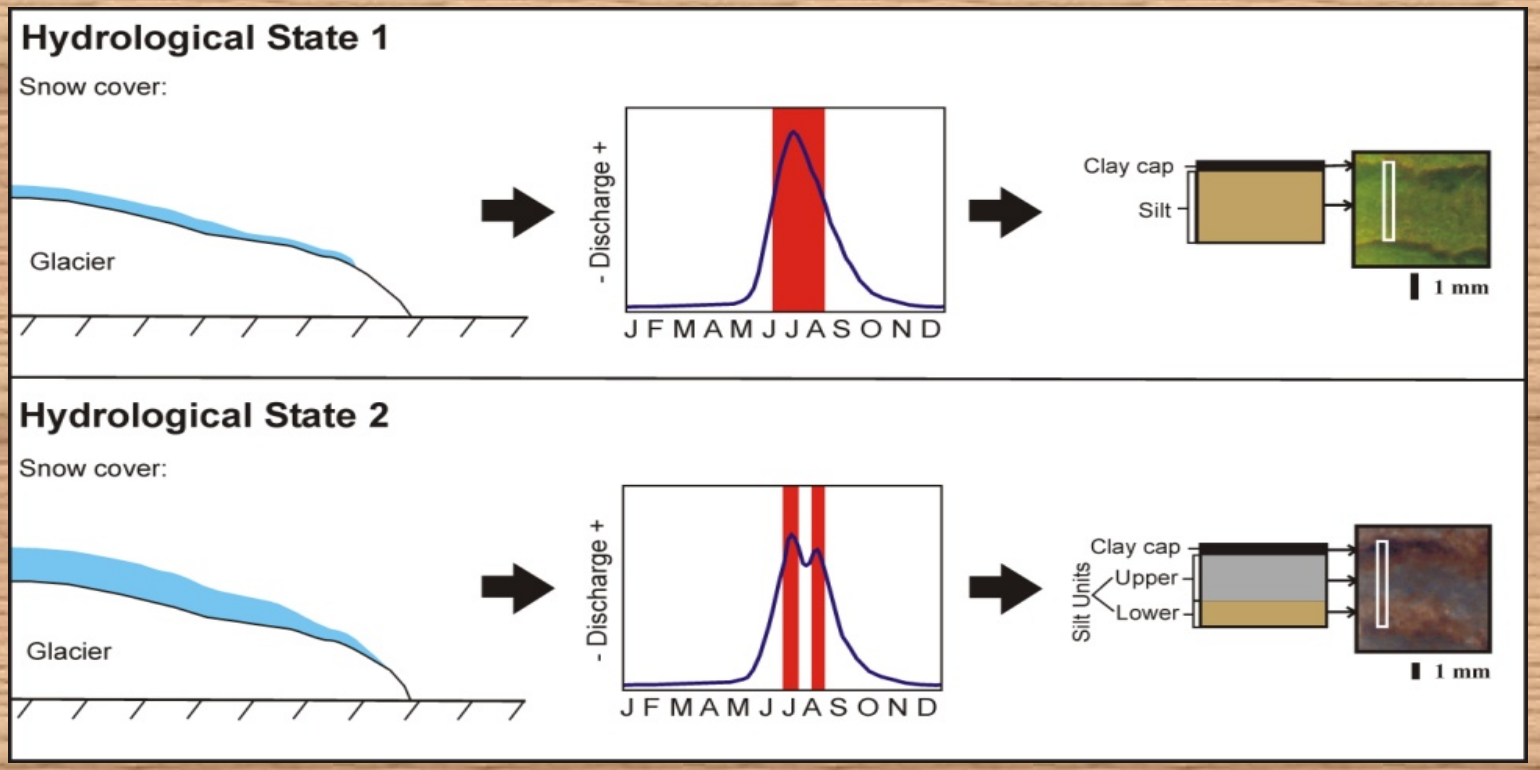
- **Proglacial varve series typically contain melt season temperature signals, in addition to variability due to non-climatic influences (primarily glaciers)**
- **Prolonged periods (i.e., up to the centennial scale) with decreasing sedimentation can indicate stagnant ice (Leonard, 1985)**
  - Minimized erosion, reduced meltwater due to less ablation
- **Increasing varve thickness trends indicate periods of rapid advance or retreat**
  - Increased erosion, increased sediment supply
- **Reduced sedimentation in Mirror Lake during the 1800s may represent a high ice stand, possibly the Little Ice Age maximum in the study area**



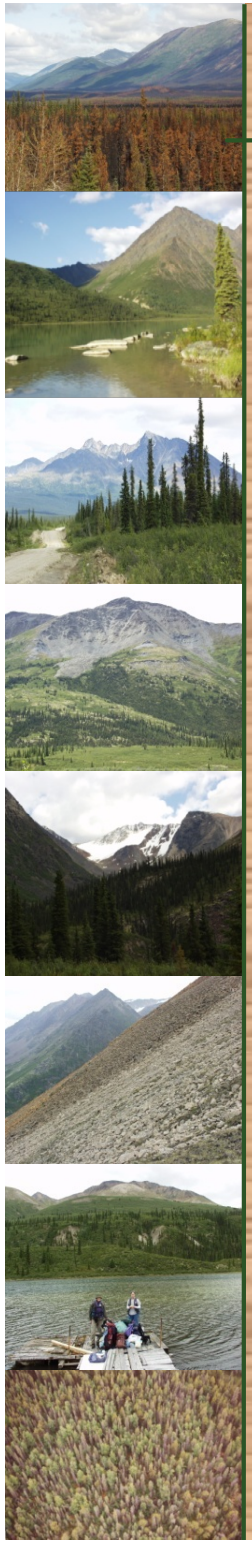


Glacial Influences (continued)

- **The varve record contains two varve types:**
  - Type I: forms during drier years when melt season temperature is strongly recorded in the sedimentary record
  - Type II: forms during years with high spring snowpack, causing delayed glacier ablation, two peaks on the hydrograph and a two-silt-unit varve (Tomkins and Lamoureux, 2005)

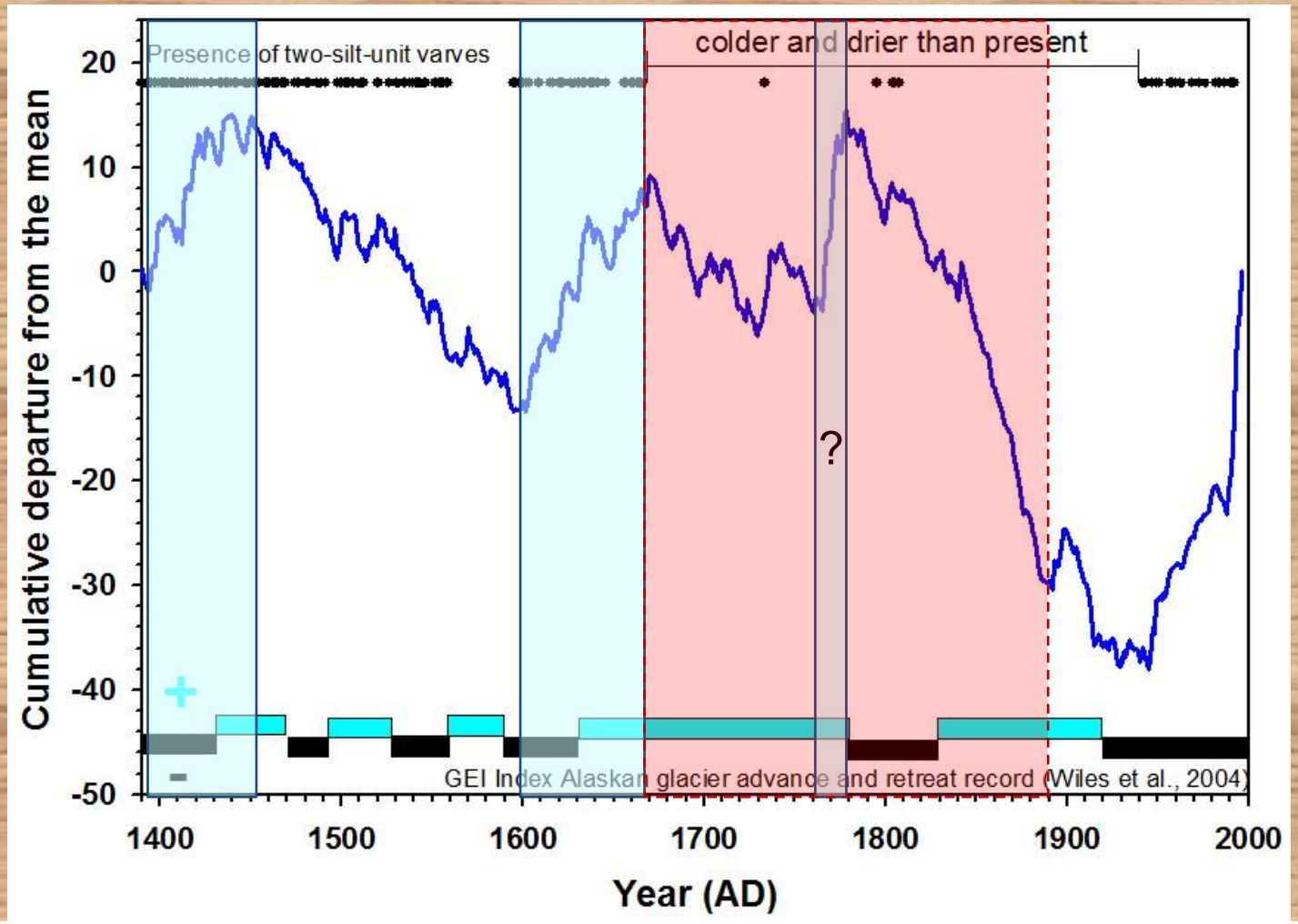


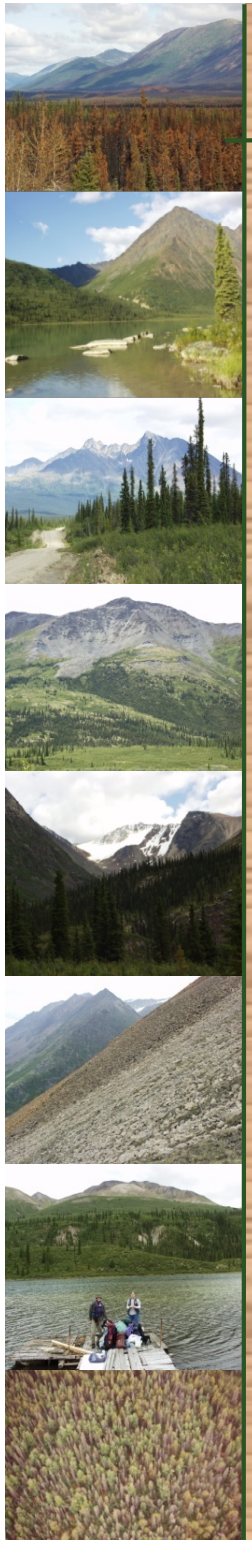
- **The two-silt-unit varve is largely absent from AD 1669-1941, suggesting colder, drier conditions.**



Glacial History

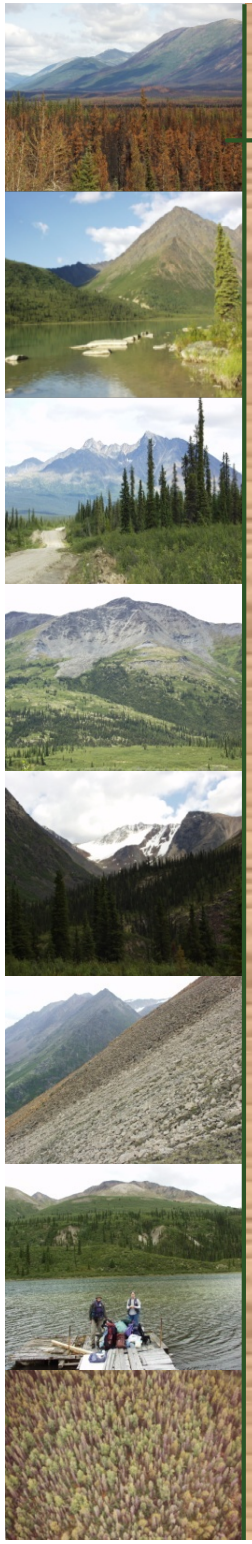
- Inferred ice advances: late 1300s to 1450, AD 1600 to 1670
- High ice stand (possibly Little Ice Age maximum) inferred during 1800s
- Recession in 1900s





Conclusions

- **Despite limited high-frequency correspondence, the varve and tree-ring series had good low-frequency correspondence**
- **The July mean temperature reconstructions showed:**
  - 1700s: decadal variability about the mean
  - 1800s: cold period at the beginning and mean to below-mean temperatures throughout rest of the century
  - First half of the1900s: decreasing temperatures from late 1800s to early 1900s followed by discrepancies in records until ~1940 after which both records show increases
  - Last half of the 1900s: above-mean temperatures with the varve reconstruction showing substantial warming after AD 1983
- **Glacial influences on varve record during 1800s likely led to underestimated temperatures during this century**
- **Little Ice Age high ice stand is inferred during the 1800s, along with glacier advance periods from the 1300s to 1450 and AD 1600 to 1650**



Overall Message

- No single proxy record can be accepted uncritically
- Comparing multiple proxy records from the same location prior to developing climate reconstructions can aid in identifying departures between the records, indicating times when one proxy record may have been strongly influenced by non-climatic influences

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