UNIVERSITY OF MANITOBA

Observations of Northern Latitude Ground-Surface and Surface-Air Temperatures

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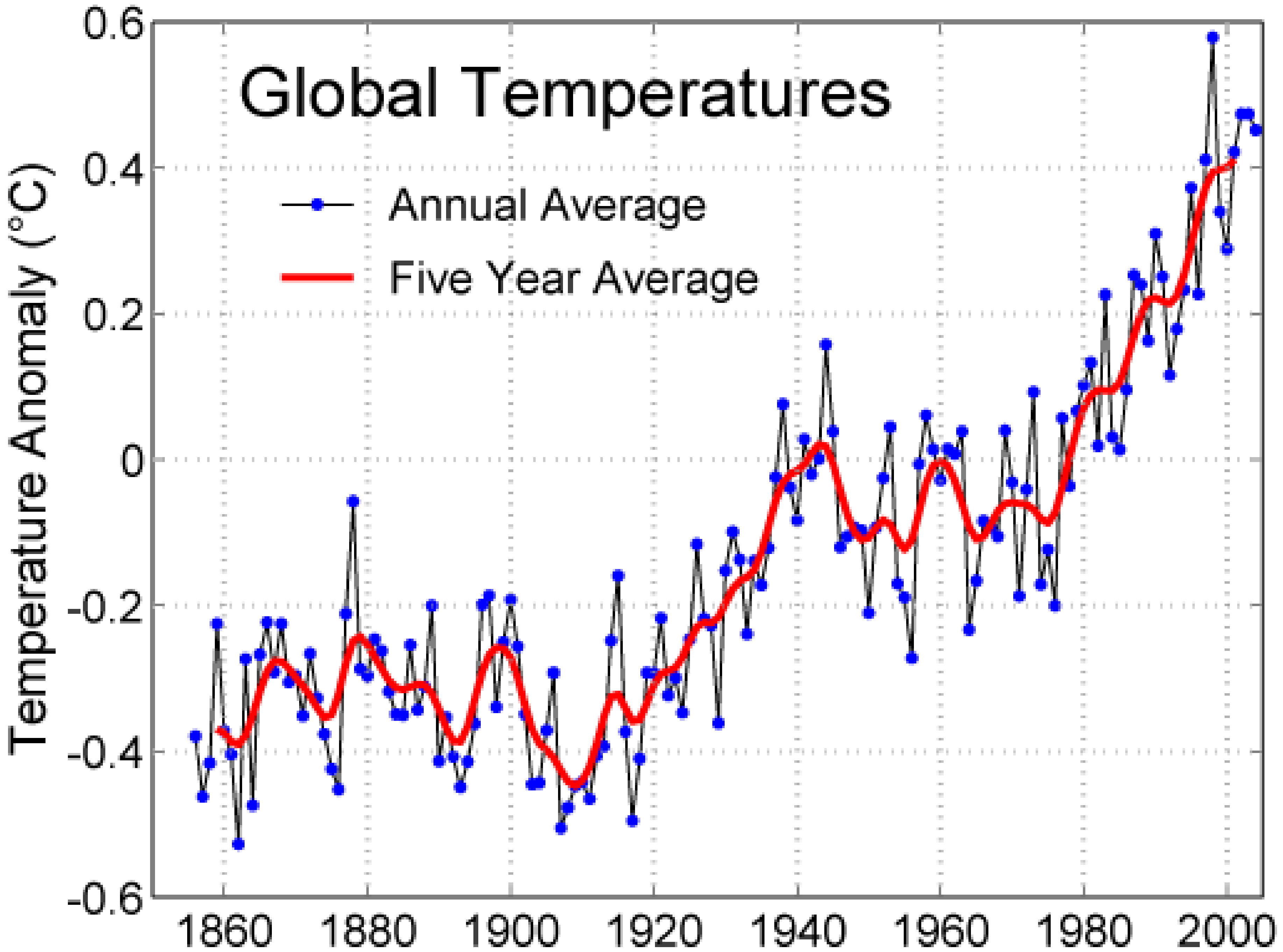


Climate Research Centre, U. East Anglia: Jones, P.D. and Moberg, A., 2003,Hemispheric and large-scale surface air temperature variations: An extensive revision and an update to 2001, *Journal of Climate*, **16**, 206-223.

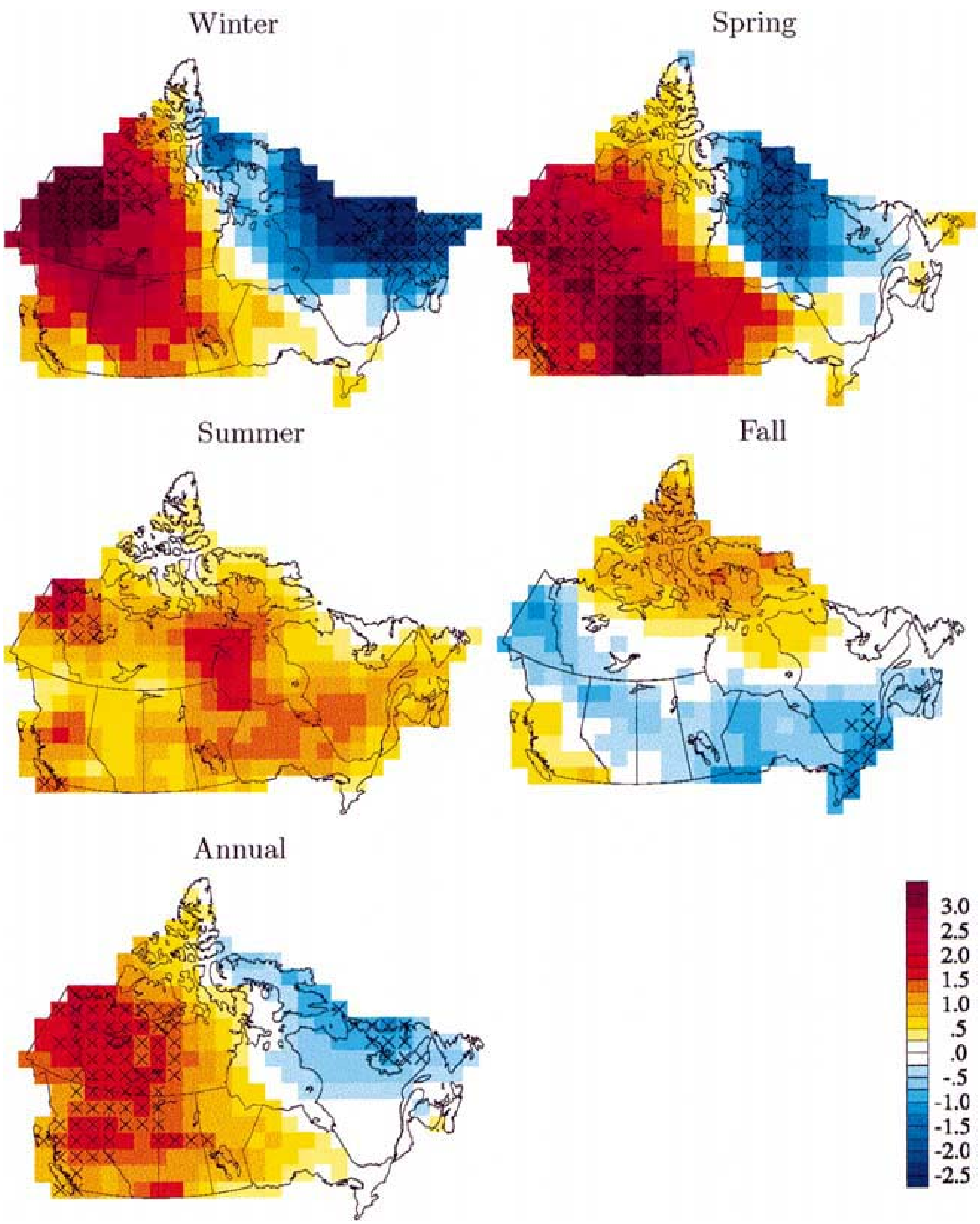
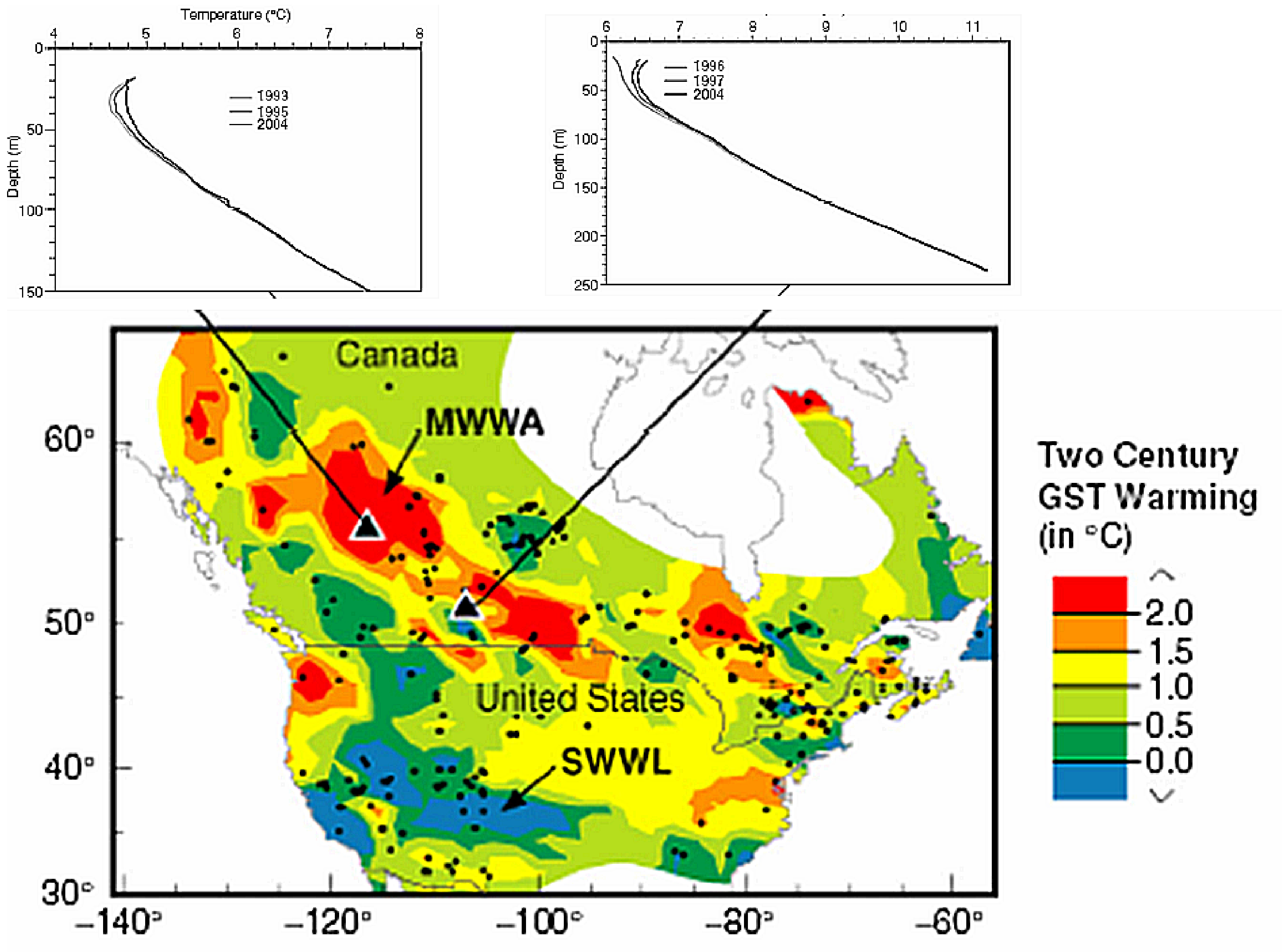


Fig. 10 Trends in daily maximum temperature from 1950–1998. Units are degrees C per 49-year period. Grid squares with trends statistically significant at 5% are marked by crosses. Xuebin Zhang,* Lucie A. Vincent, W.D. Hogg and Ain Niitsoo , *ATMOSPHERE-OCEAN 38 (3) 2000.*



Majorowicz, J., and J. Safanda, 2005, Measured versus simulated transients of temperature logs: a test of borehole climatology, *J. Geop. Eng.* ,2, 1-8.

Northern B.C. Warming Rates

- GST reconstructions (i.e. Majorowicz et al., 2004) show about 0.8^{o} C from 1901-1992,
- Zhang et al. (2000), based on the SAT record for a period of 1950-1998, show about 1.1^{o} C,
- (Lewis et al., 2003) suggested that ground surface warming and propagation at depth has not occurred.

Mysteries of Northern Climate Change

- Why are GSTs from “old” boreholes not showing climate change?
- Compare new sets (2006) to 1960’s – 1970’s readings in GSC boreholes in northern B.C., Yukon

56 25.1N, 129 0.92W
British Colum
Dundas Island
Prince Rupert
Digby Island
Porcher Island
16
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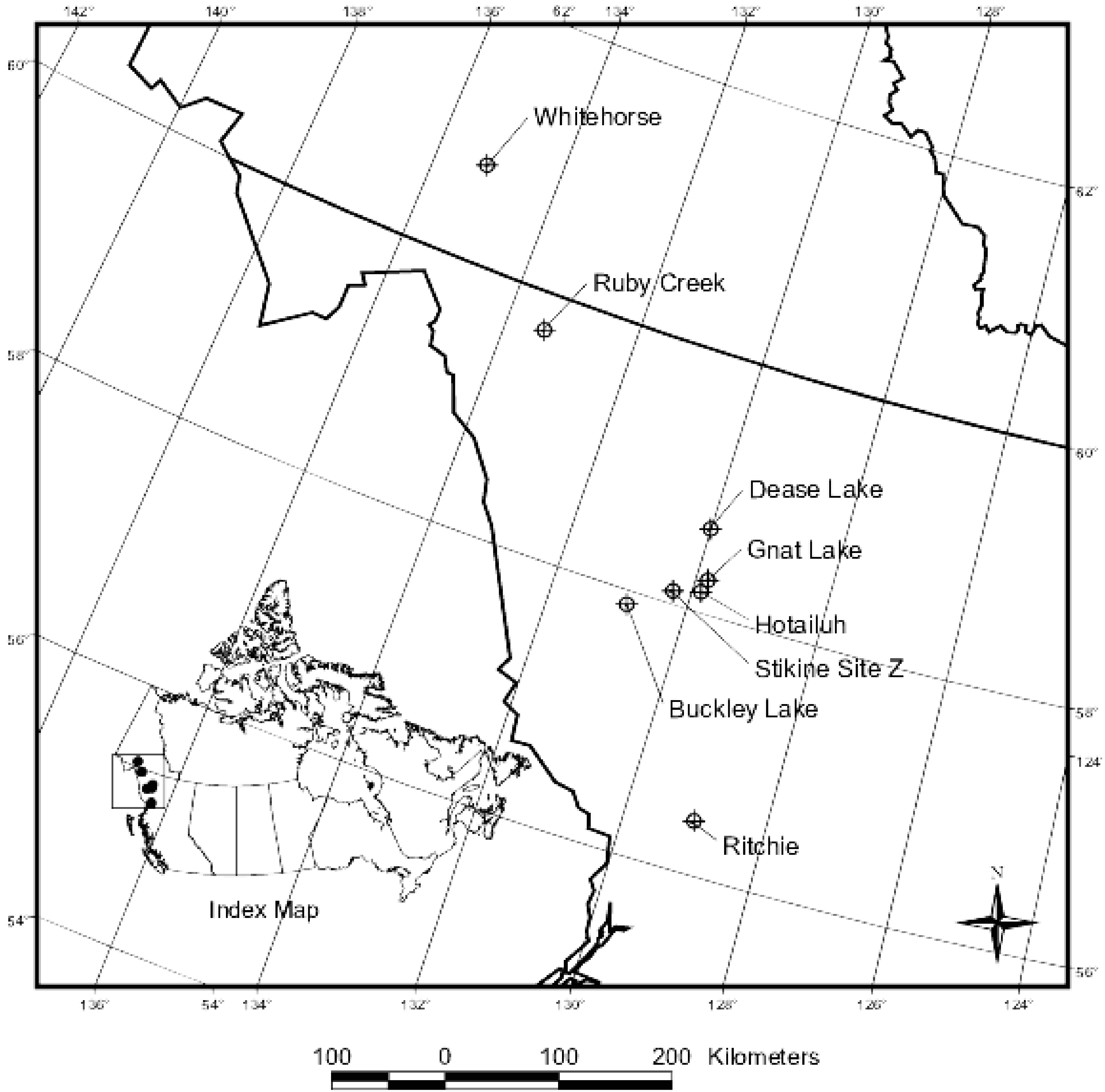

Whitehorse
Ruby Creek
Dease Lake
Gnat Lake
Hotailuh
Stikine Site Z
Buckley Lake
Ritchie
Index Map
N
100 0 100 200 Kilometers

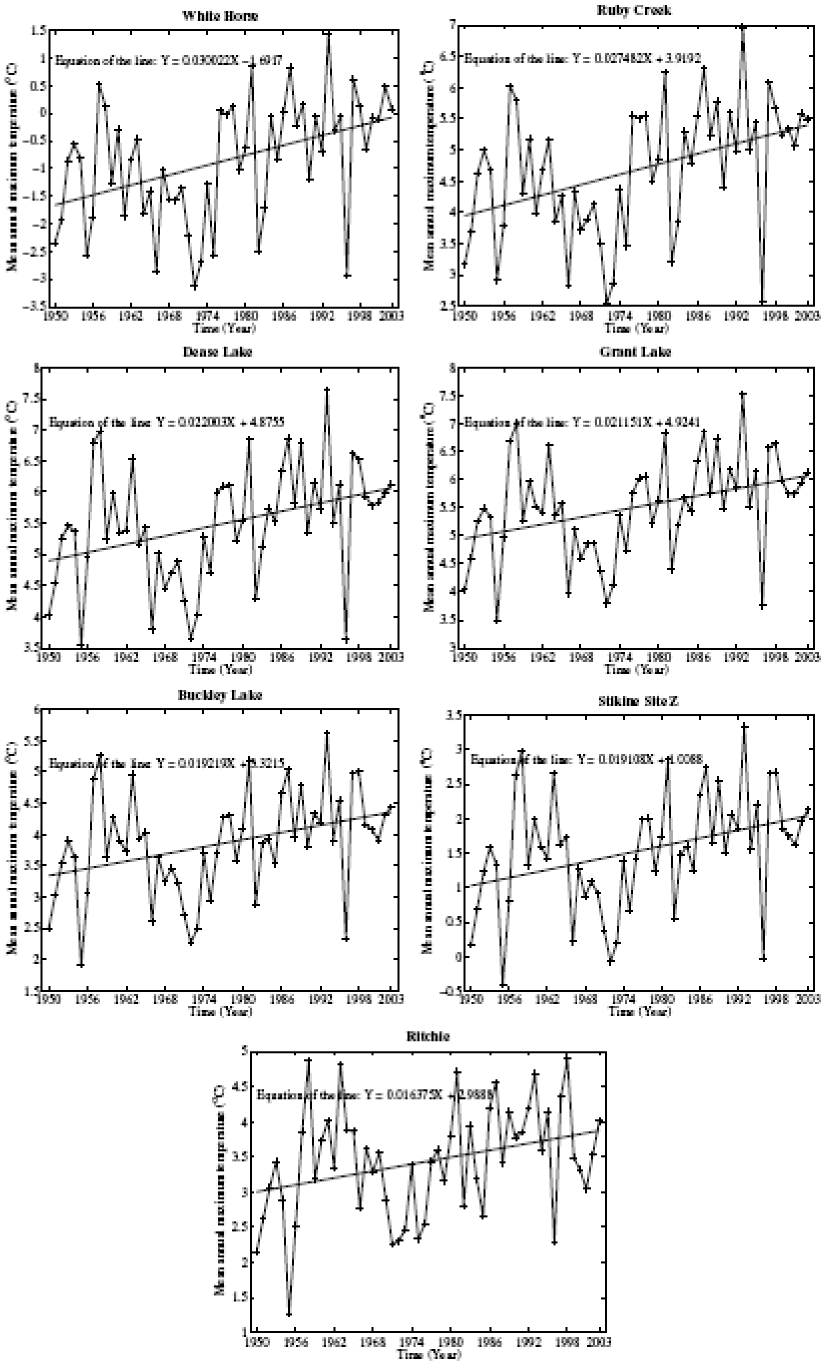


Figure 8. Mean annual maximum temperature (°C) trend for seven stations [White Horse, Ruby Creek, Dease Lake, Grant Lake, Buckley Lake, Stikine Site Z, and Ritchie].

CANGRID dataset (Zhang et al., 2000)
Source: Woodbury et al., 2008 (submitted)

Atmospheric temperature Trend Analysis

All eight sites show a statistically significant increasing trend, > 95% in most cases, in annual mean minimum and maximum temperatures.

Over the 54 year period, the increase in minimum temperatures has been between 1.1 and 1.5 C and the increase in maximum temperatures has ranged between 0.8 and 1.5C over the eight stations

All stations, except for Whitehorse, have larger increases in minimum temperatures compared to maximum temperatures, which is consistent with Zhang et al. (2000)

Analysis suggests that the annual mean trends are significantly influenced by winter (DJF) and spring (MAM) temperature trends as opposed to summer (JJA) and autumn (SON).

Mean annual winter minimum temperature trends range 2 - 4 C over the 54 year period, while mean annual winter maximum temperature trends range over 1.9 - 4.2 C, all being statistically significant to > 90% confidence.

Atmospheric temperature Trend Analysis

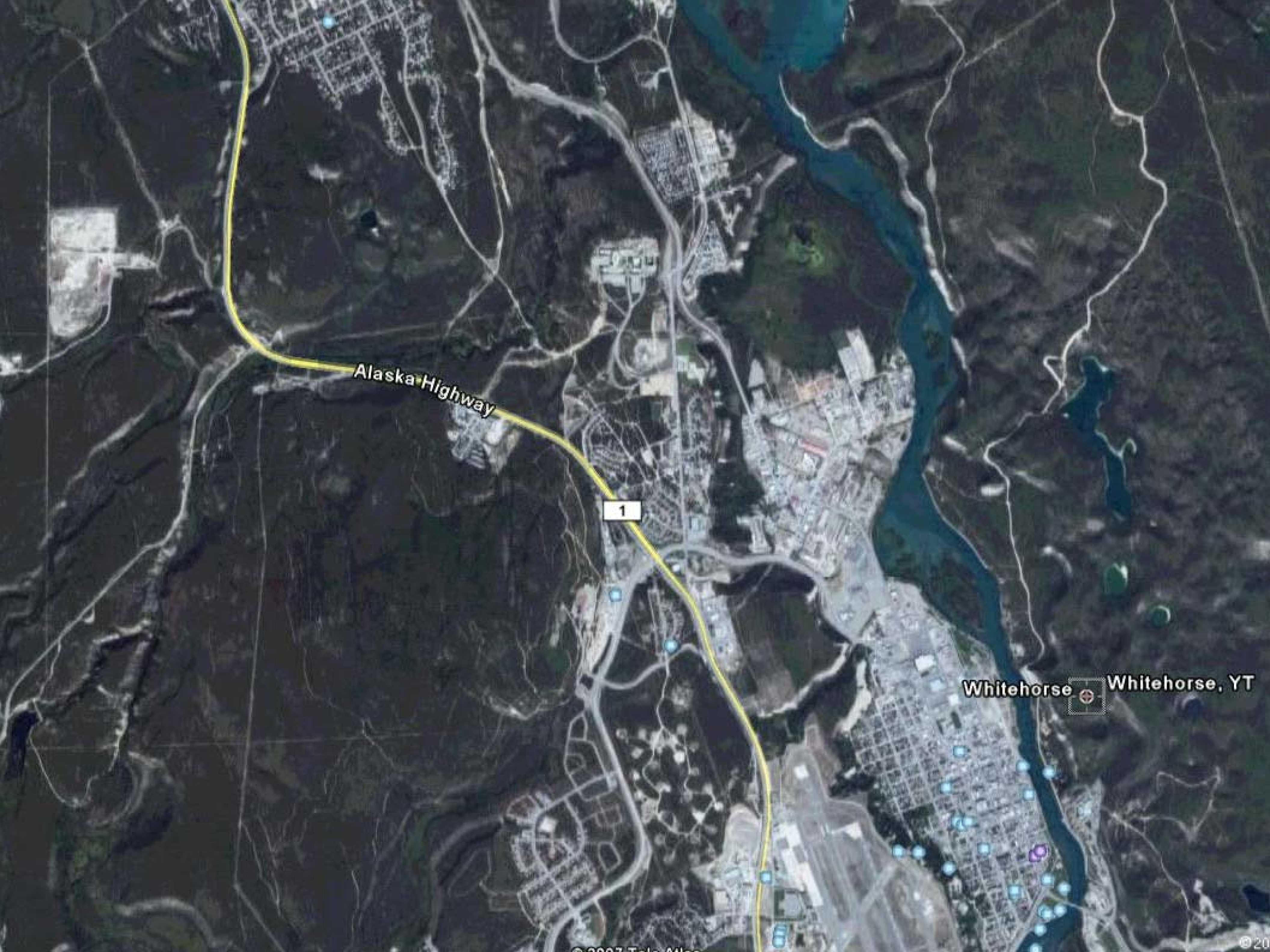
The minimum temperature trends tend to be slightly larger than the maximum temperature trends at most stations.

The spring temperature trends are much smaller than the winter trends, however, spring trends still remain all positive with most of them statistically significant at the 90% level.

Results indicate that summer and autumn do not have any statistically significant temperature trends.

New Borehole Surveys

- Platinum RTD, calibrated to ±0.01° C
- Fit straight line to linear portion of hole.
- "Ramp" - average GST increase 1800 - 1900 of 0.44 C and 0.71 C from 1900 to 1950, followed by another linear increase based on the SAT records at each site
- The temperature at surface is assumed constant before 1800 (Beltrami et al., 2003)



Alaska Highway
1
Whitehorse
Whitehorse, YT
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N
Image © 2008 DigitalGlobe
Image © 2008 TerraMetrics
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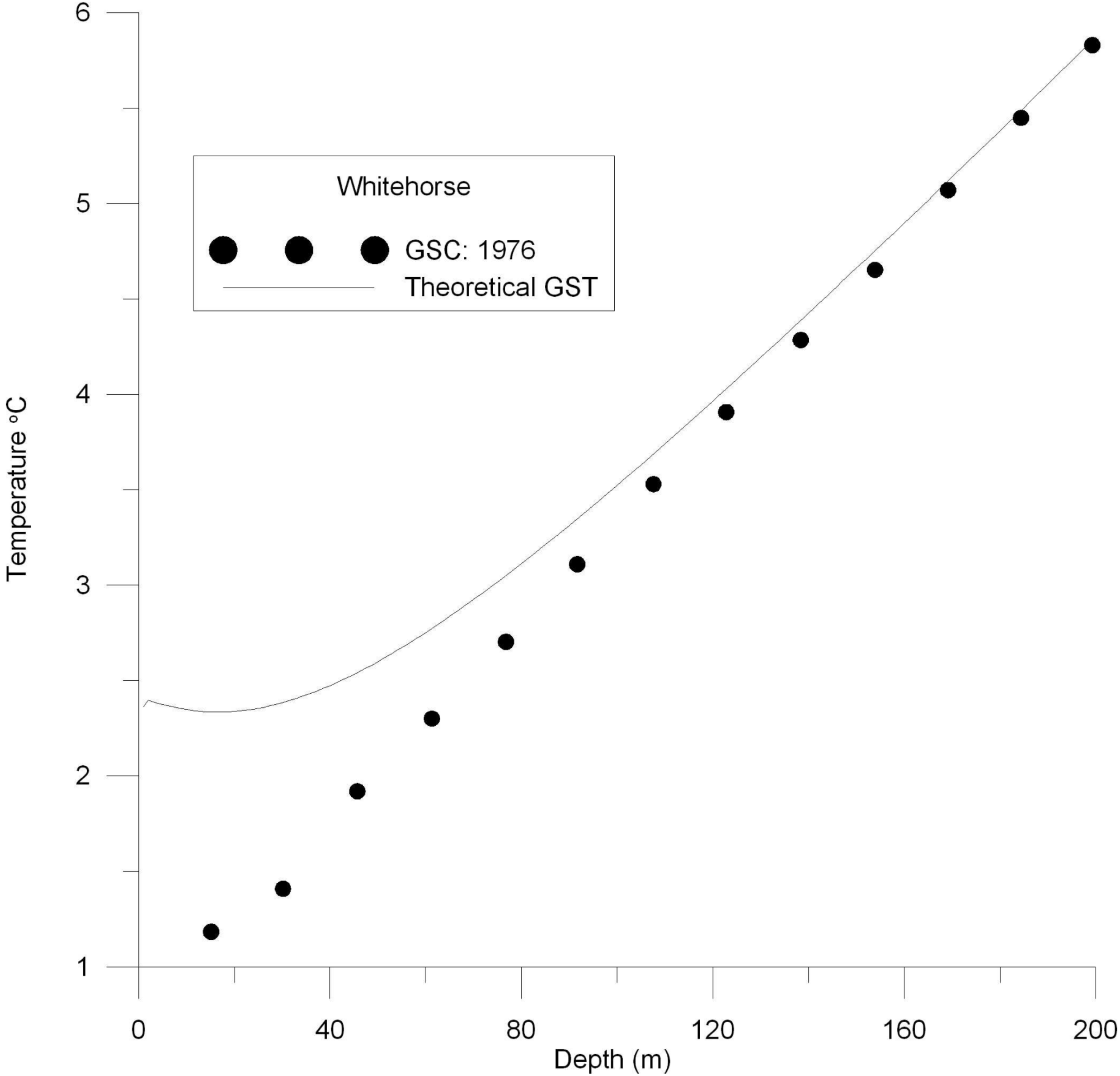
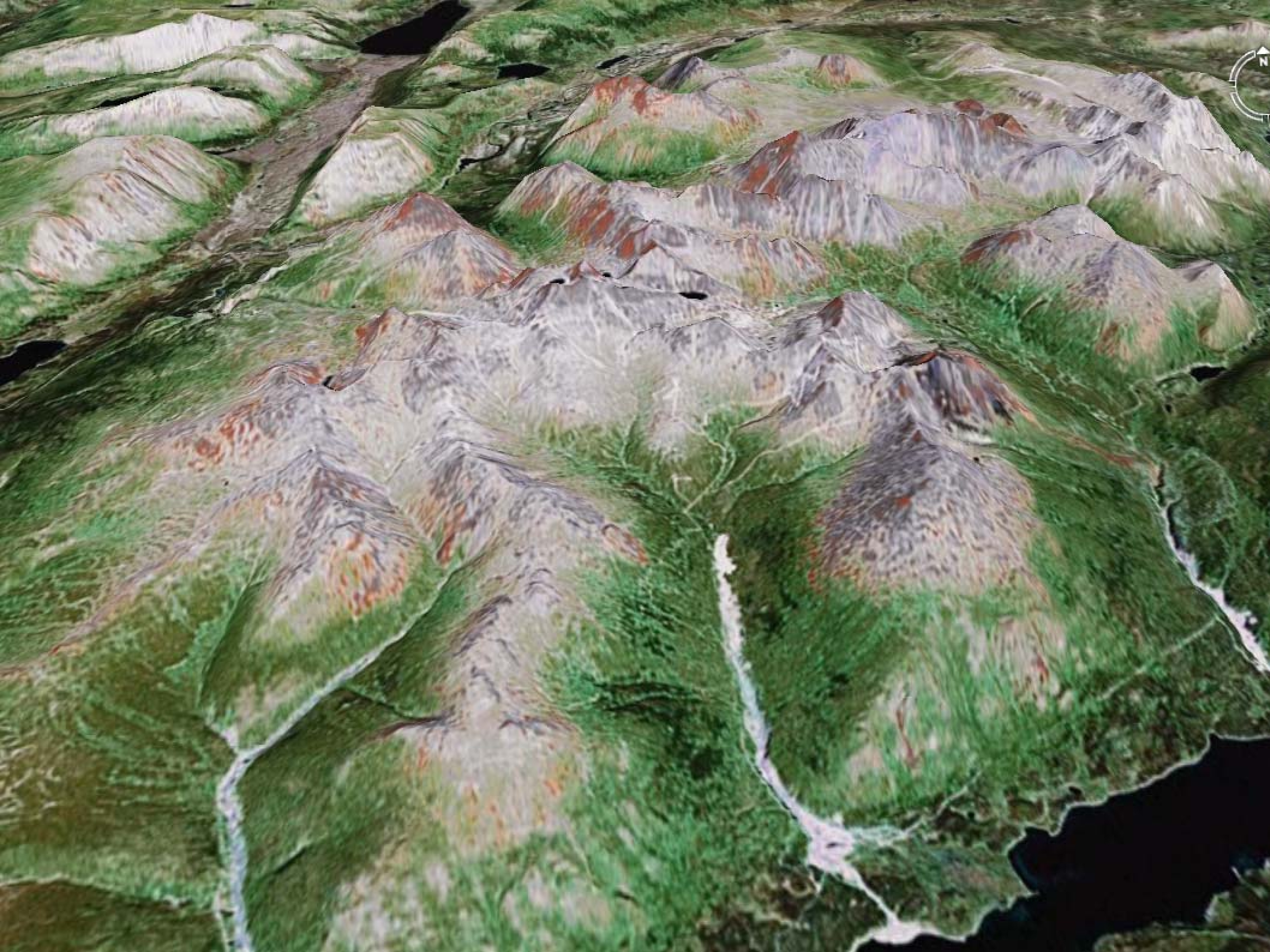
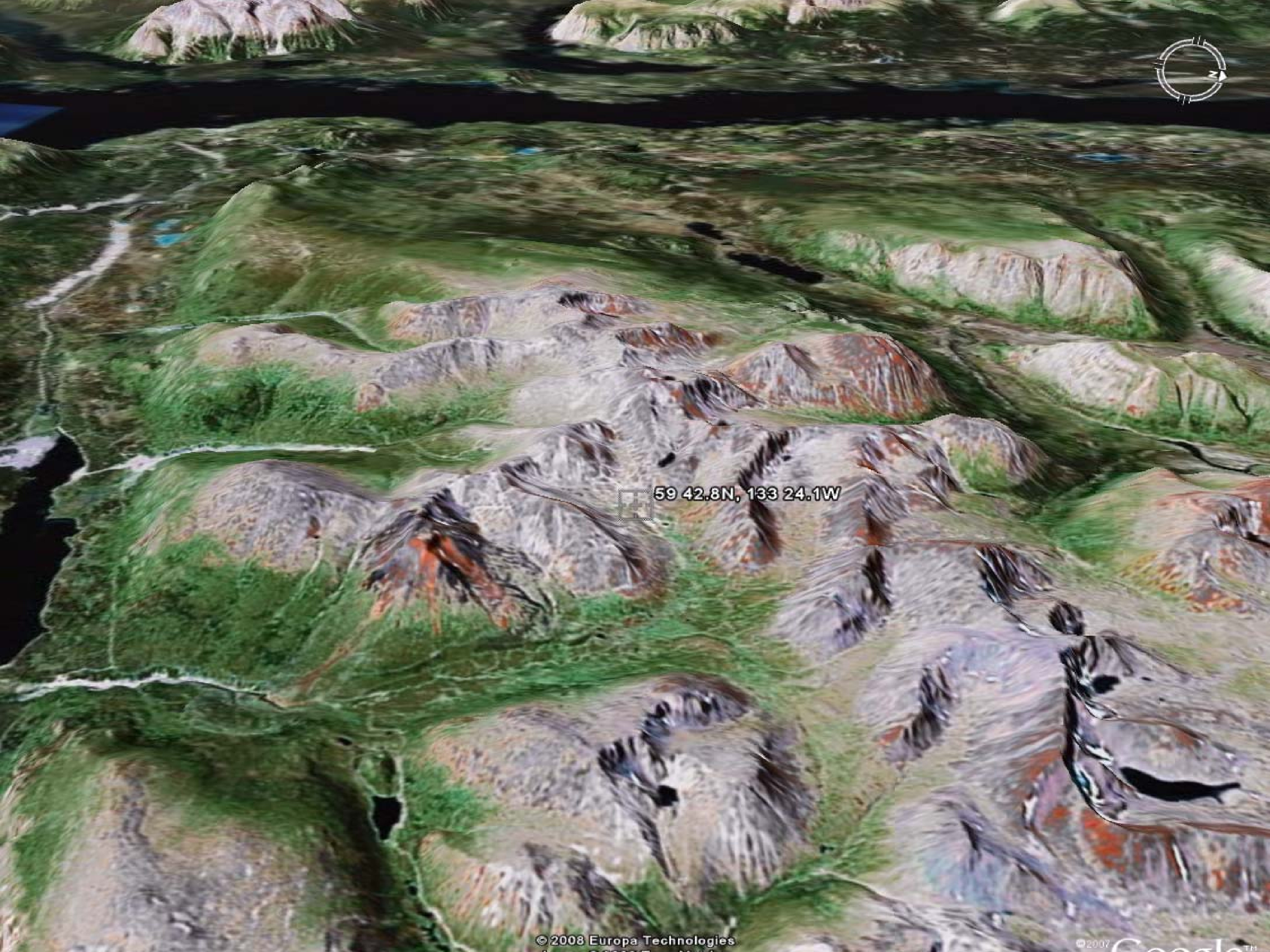
©2007 Google
Pointer 8 V 490217.81 m E 6734733.38 m N elev 833 m
Streaming 100%
Eye alt

N
60 45.0N, 135 11.0W
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
© 2008 Tele Atlas
©2007 Google™
Pointer 8 V 490006.44 m E 6734955.69 m N elev 842 m
Streaming |||||||||| 100%
Eye alt 1.64 km


Whitehorse
GSC: 1976
Theoretical GST
Temperature °C
Depth (m)
6
5
4
3
2
1
0
40
80
120
160
200




59 42.8N, 133 24.1W
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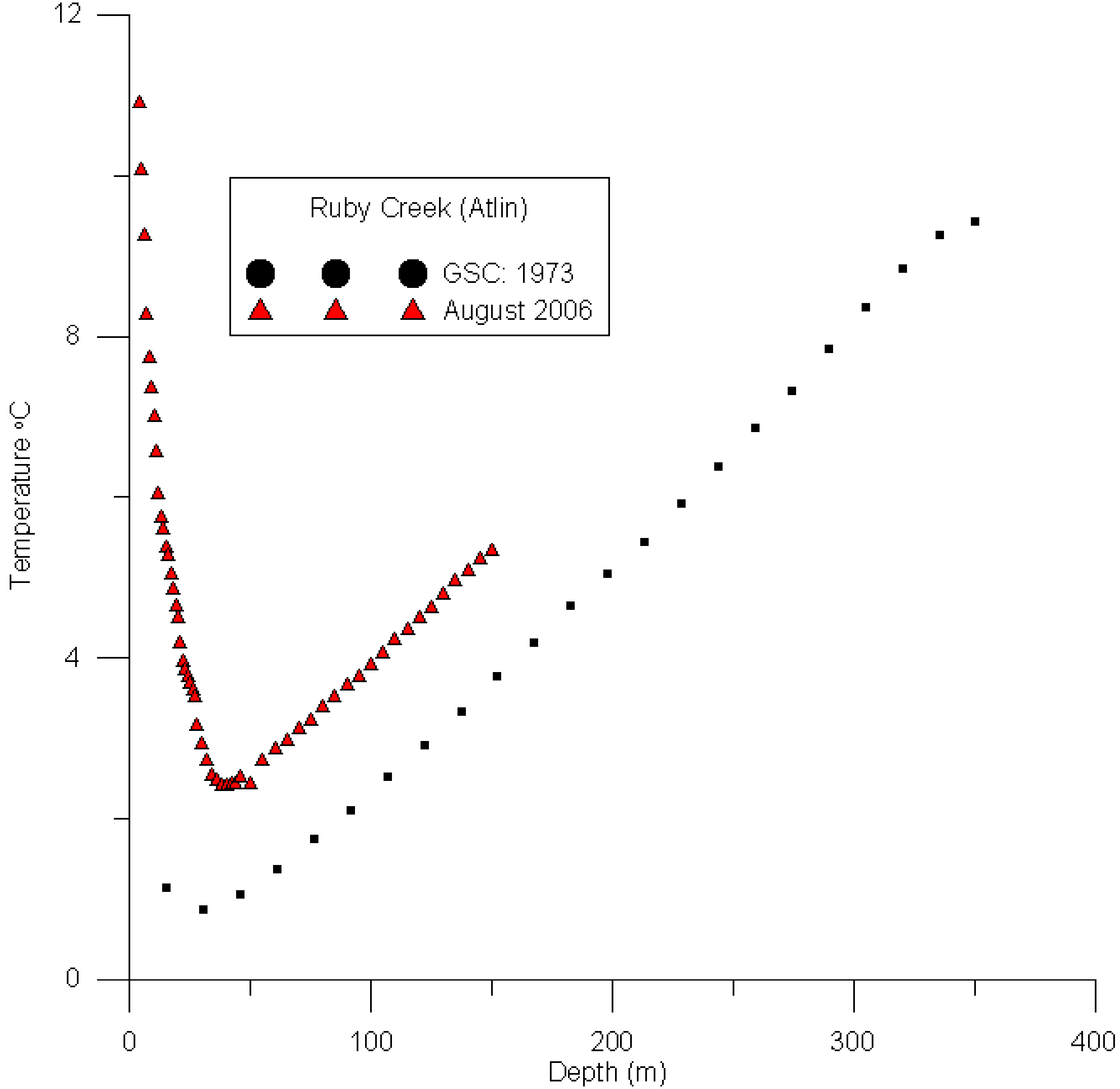
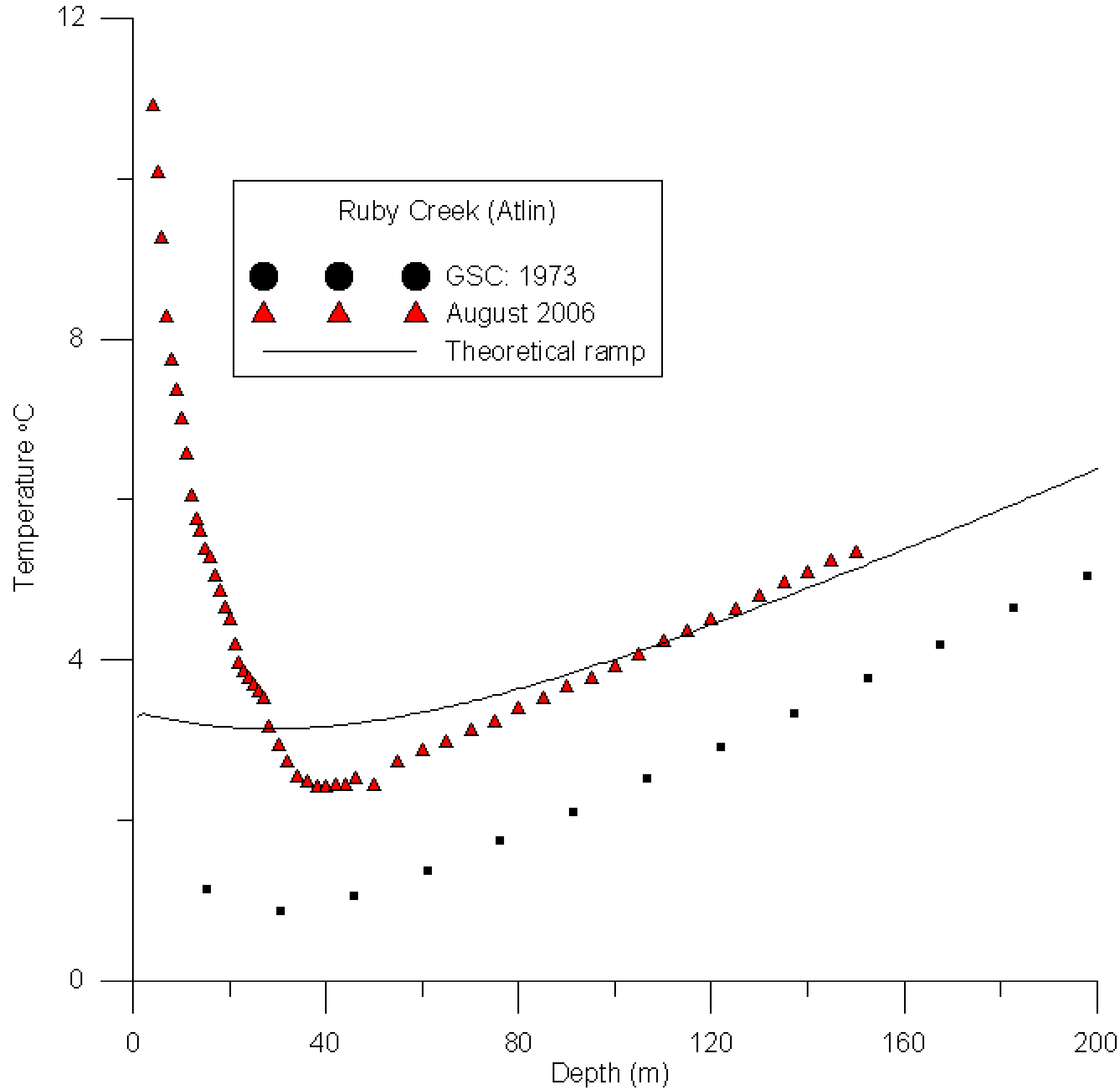
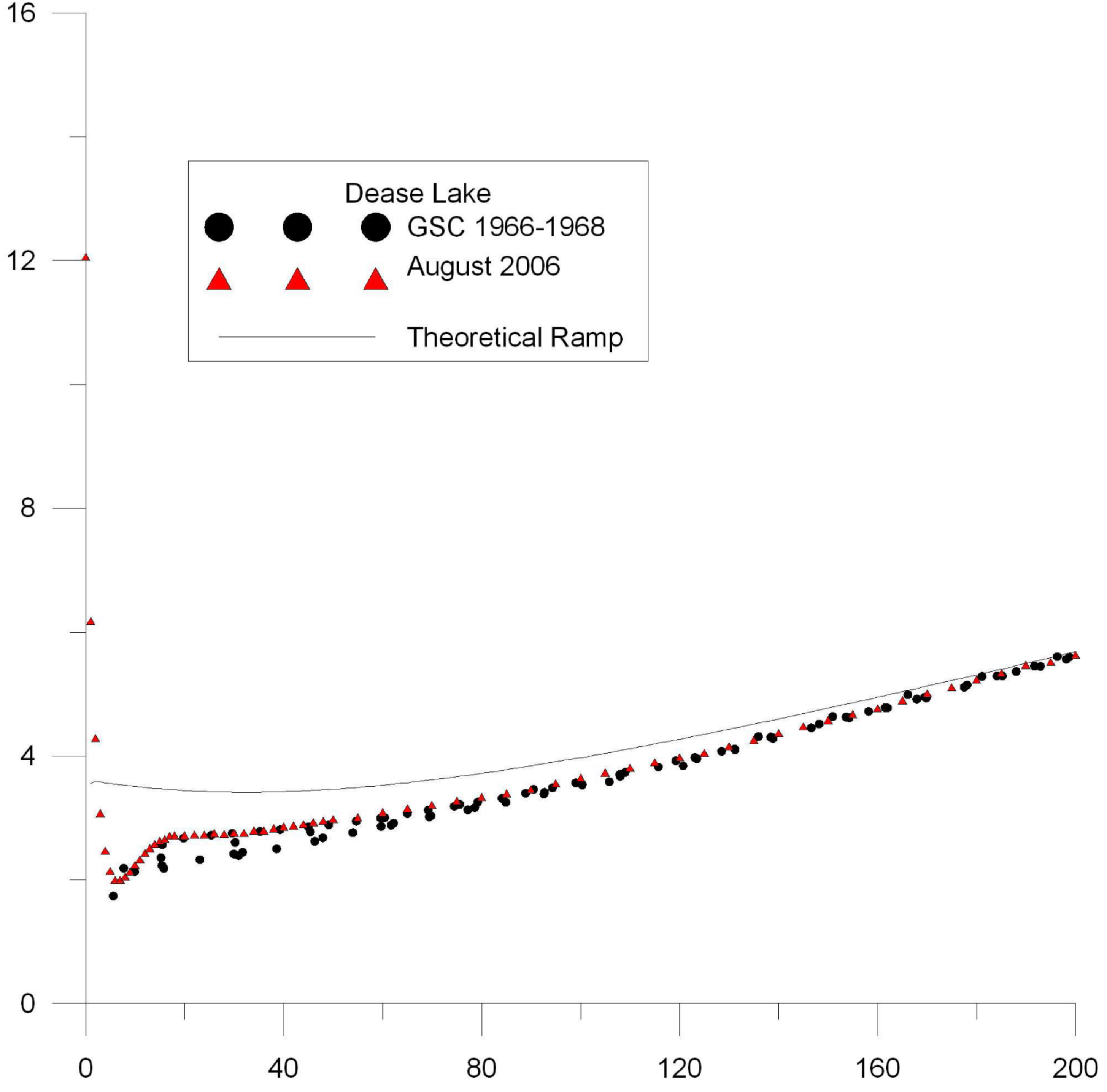

Ruby Creek (Atlin)
GSC: 1973
August 2006
Temperature °C
Depth (m)
12
8
4
0
0
100
200
300
400



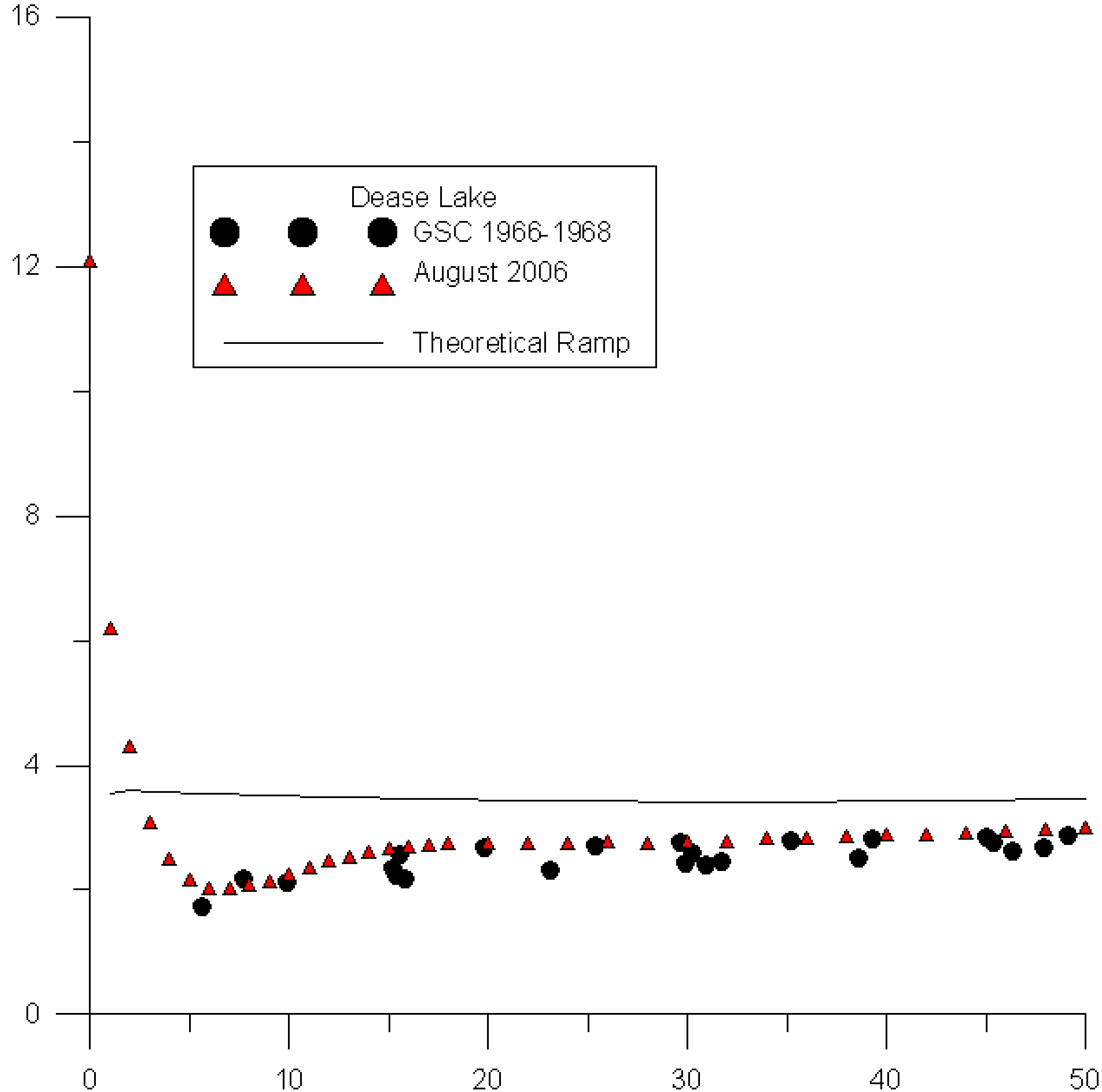
Ruby Creek (Atlin)
GSC: 1973
August 2006
Theoretical ramp
Temperature °C
Depth (m)
0
4
8
12
0
40
80
120
160
200

37
Cassiar Highway
Dease Lake

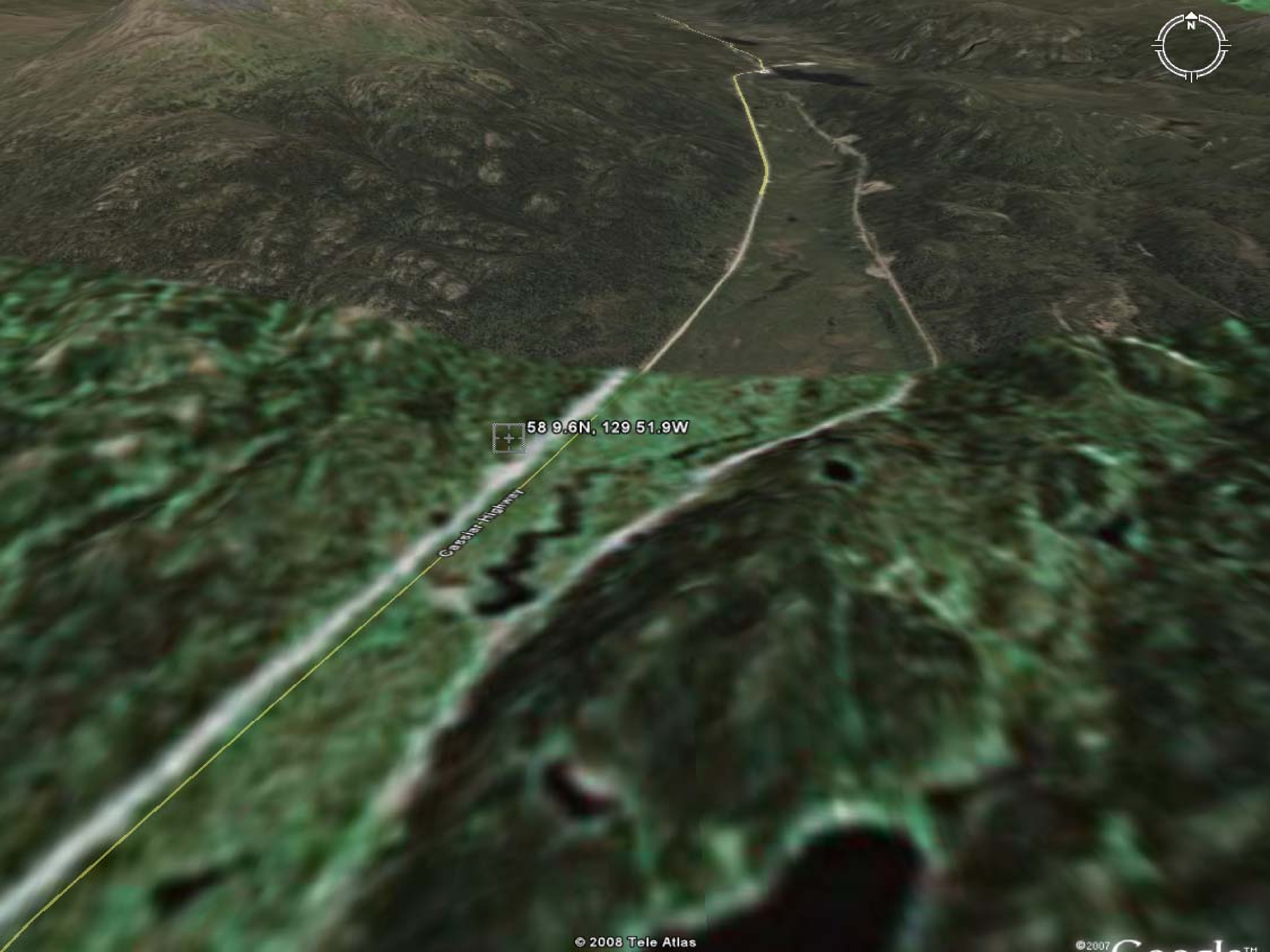

58 38.9N, 130 0.6W
© 2008 Europa Technologies
Image © 2008 TerraMetrics
© 2008 Tele Atlas
Image © 2008 DigitalGlobe
©2007 Google
Pointer 9 V 441383.95 m E 6501333.65 m N elev 841 m
Streaming 100%
Eye alt 6.37 km



16
12
8
4
0
0
40
80
120
160
200
Dease Lake
GSC 1966-1968
August 2006
Theoretical Ramp



16
12
8
4
0
0
10
20
30
40
50
Dease Lake
GSC 1966-1968
August 2006
Theoretical Ramp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Cassiar Highway
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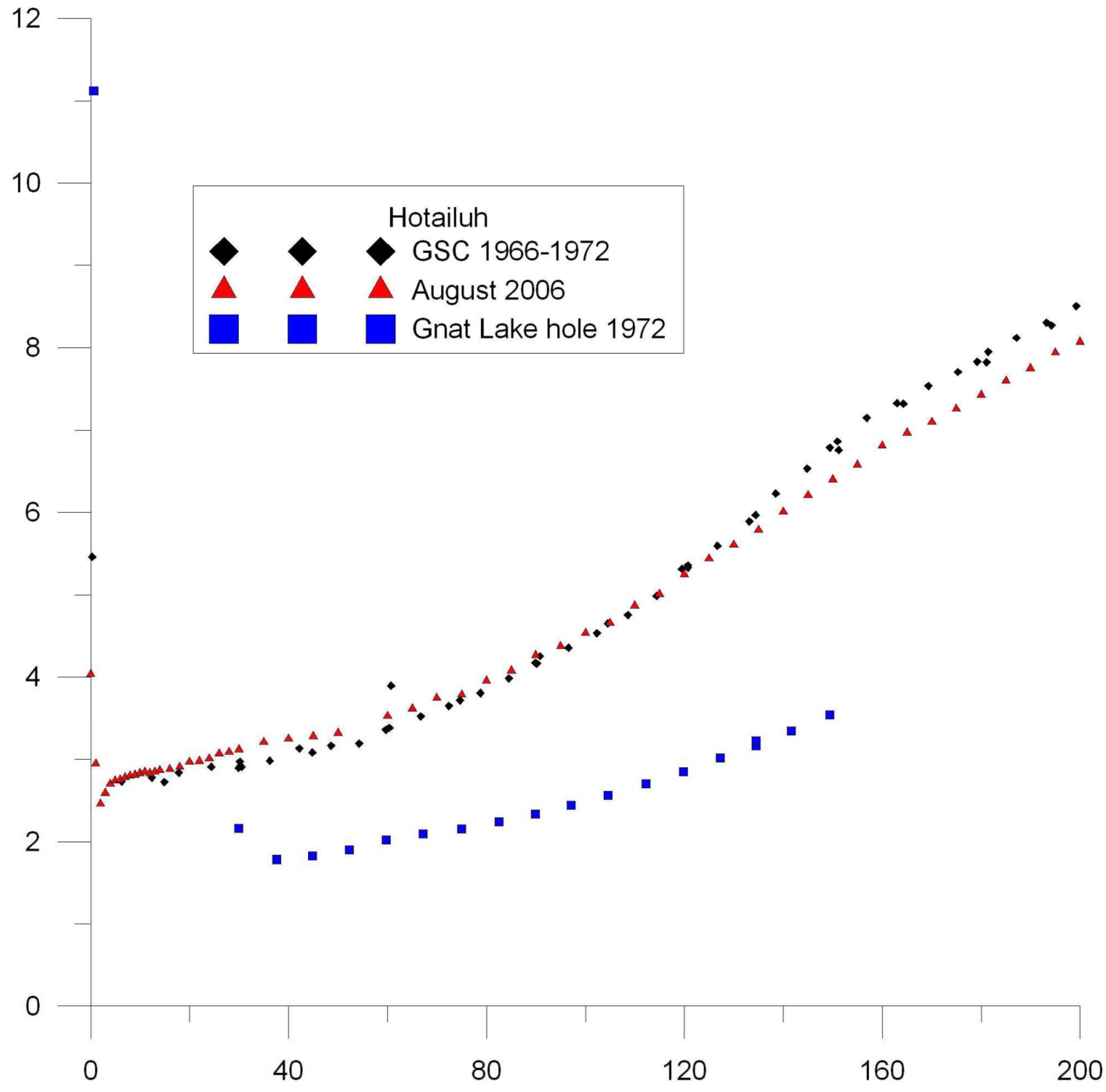
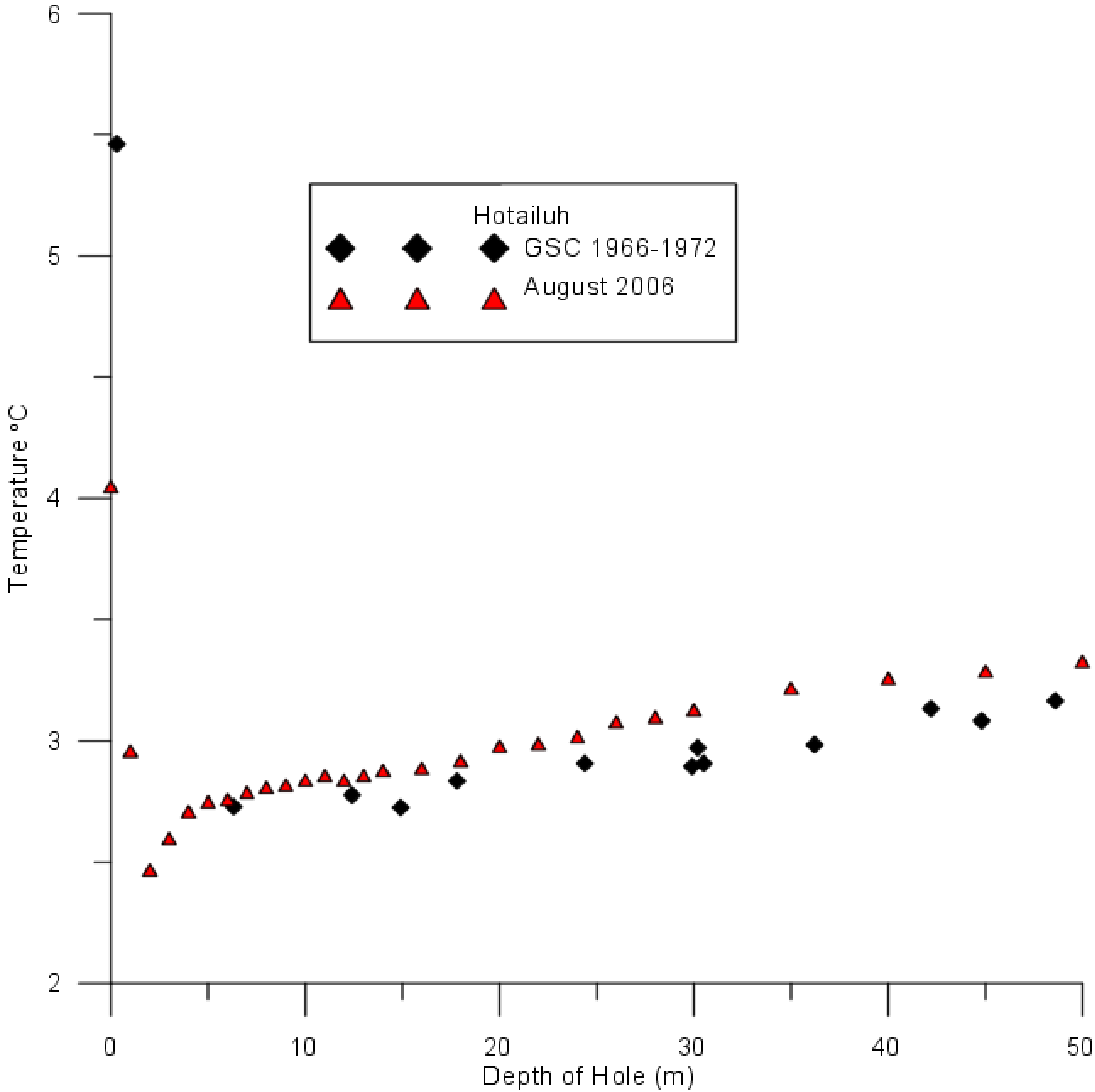
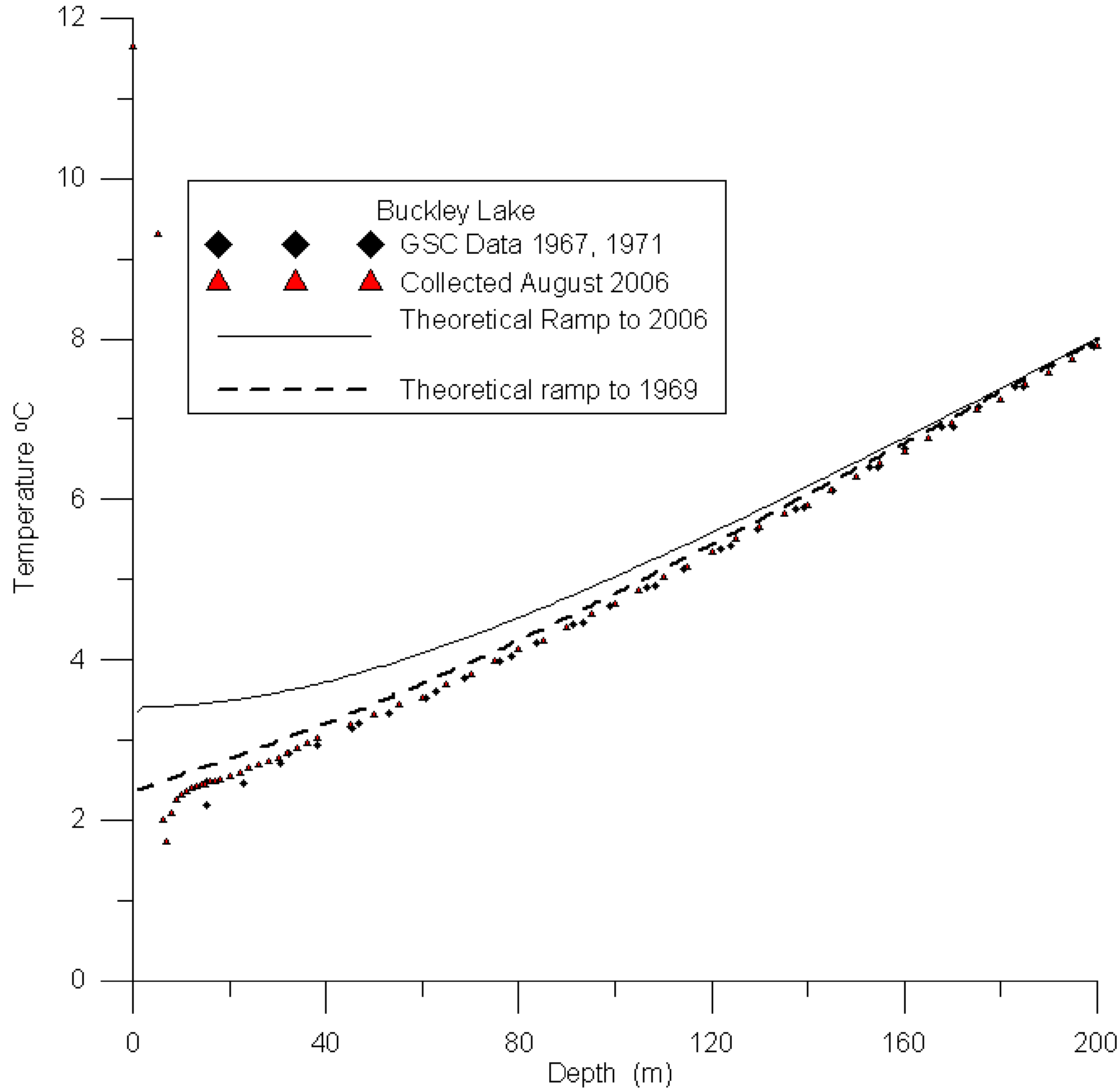


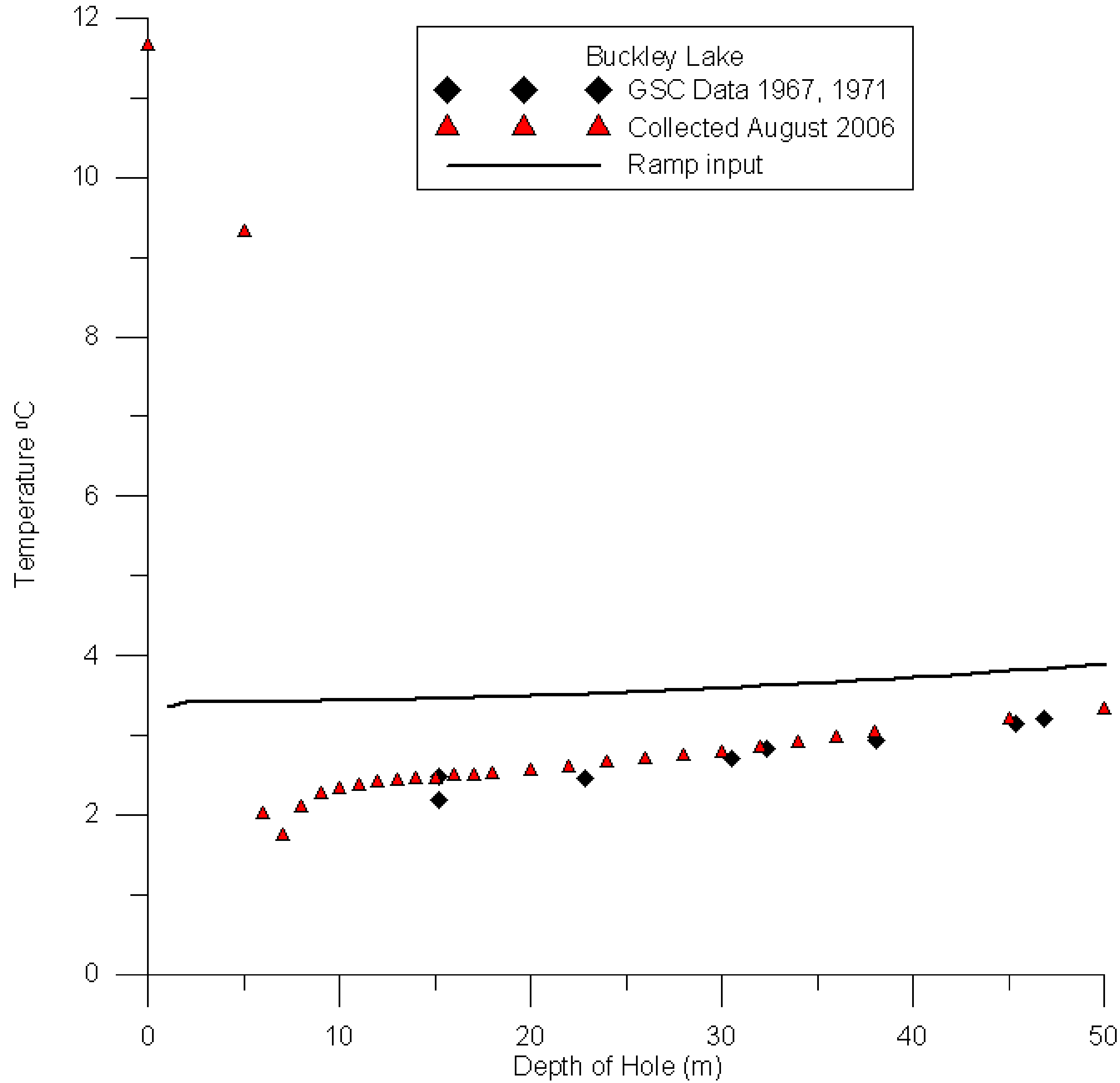
Hotailuh
GSC 1966-1972
August 2006
Gnat Lake hole 1972
0
2
4
6
8
10
12
0
40
80
120
160
200

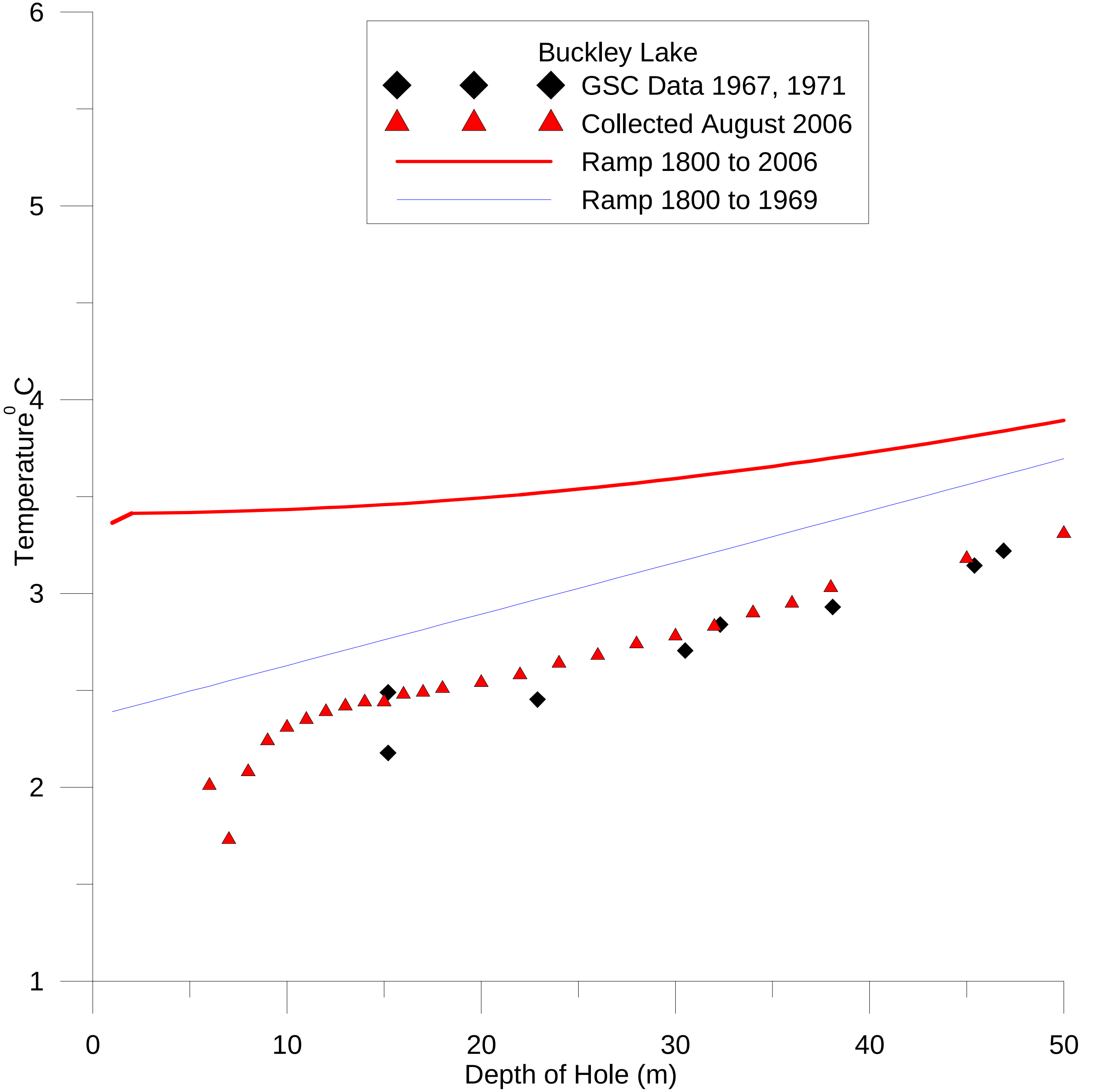

Hotailuh
GSC 1966-1972
August 2006
Temperature °C
Depth of Hole (m)
6
5
4
3
2
0
10
20
30
40
50


N



Buckley Lake
GSC Data 1967, 1971
Collected August 2006
Theoretical Ramp to 2006
Theoretical ramp to 1969
Temperature °C
Depth (m)
0
2
4
6
8
10
12
0
40
80
120
160
200

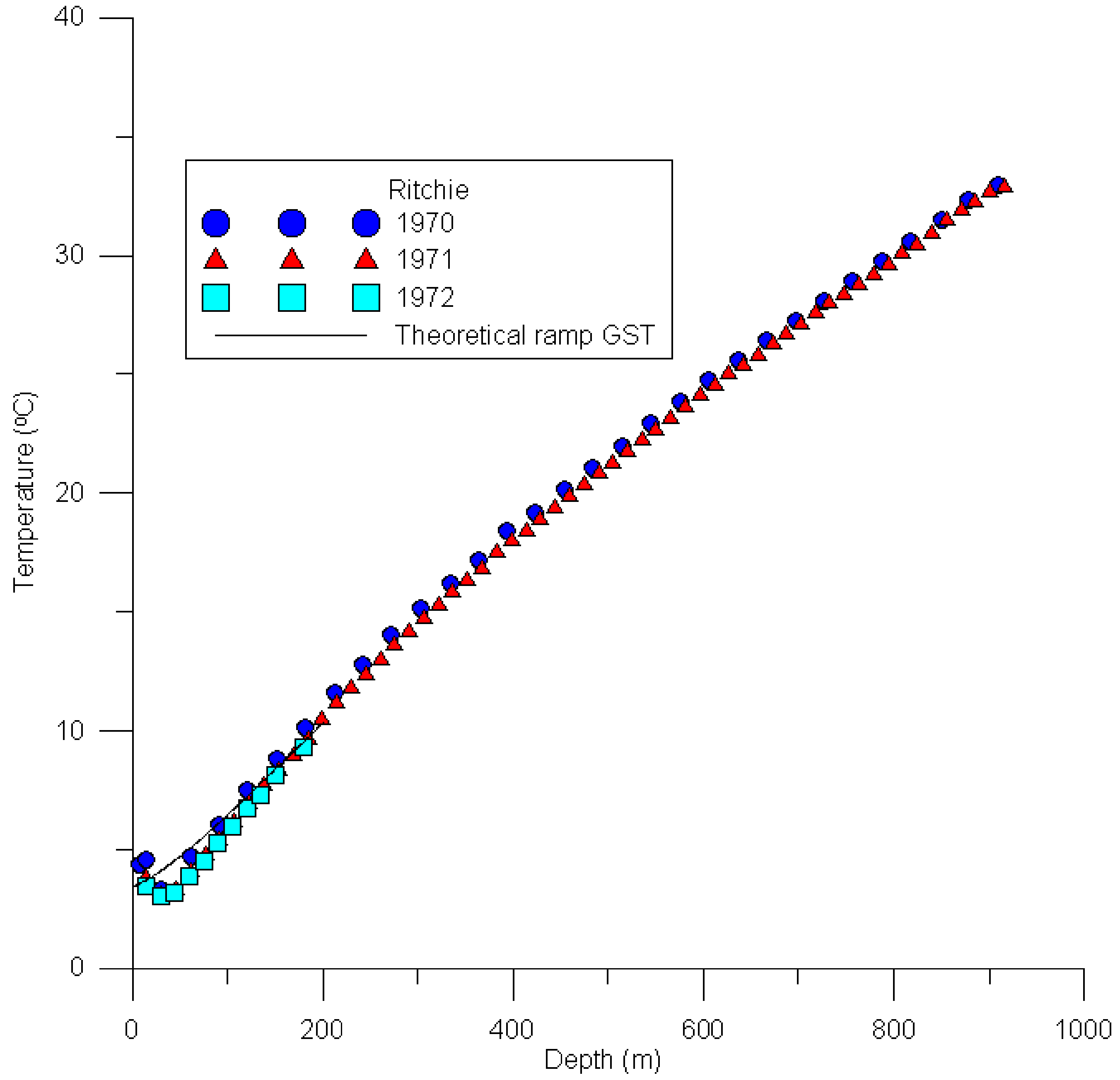

Buckley Lake
GSC Data 1967, 1971
Collected August 2006
Ramp input
Temperature ºC
Depth of Hole (m)
0
2
4
6
8
10
12
0
10
20
30
40
50



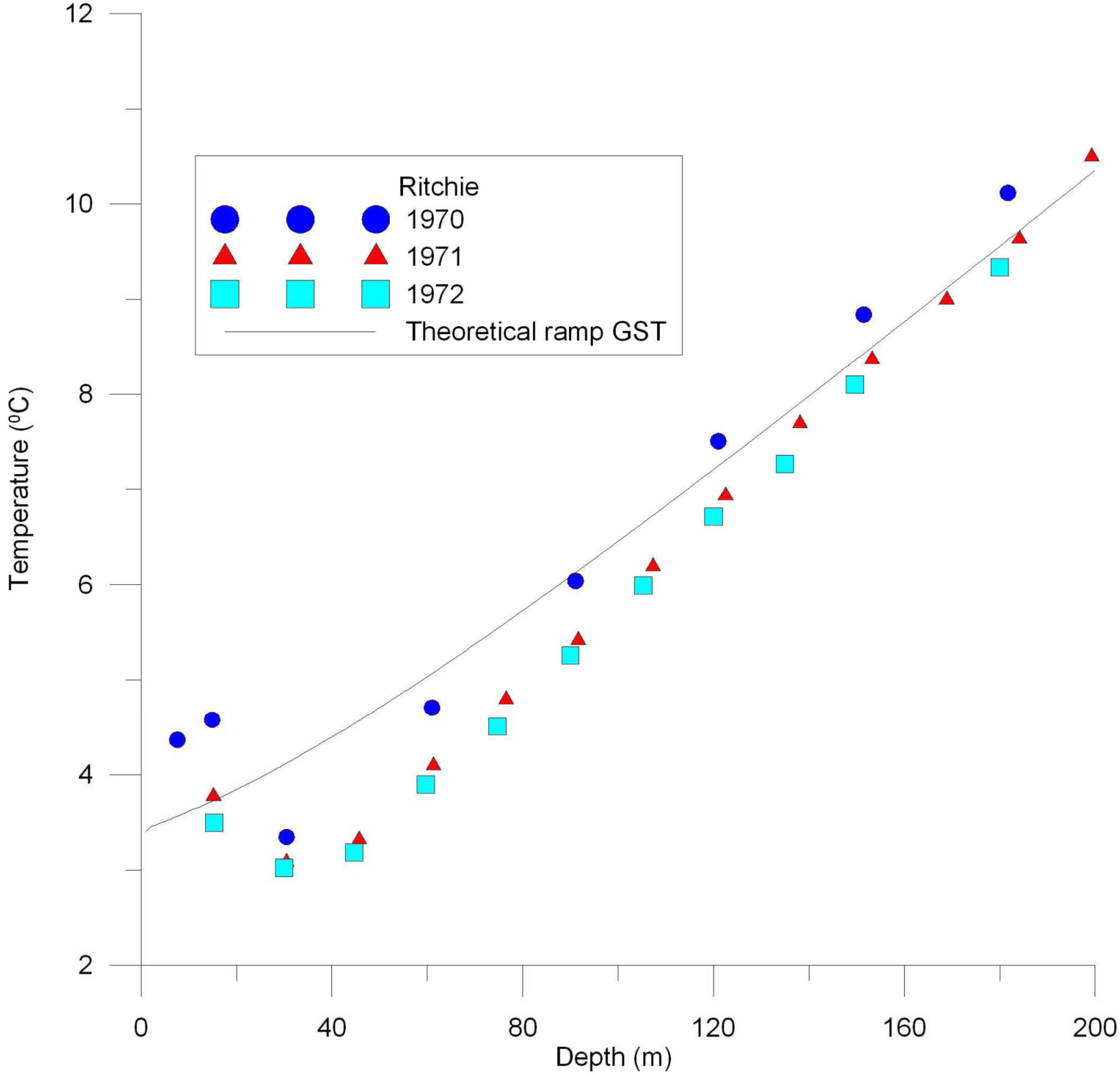
Buckley Lake
GSC Data 1967, 1971
Collected August 2006
Ramp 1800 to 2006
Ramp 1800 to 1969
6
5
4
3
2
1
Temperature ^{0}C
0
10
20
30
40
50
Depth of Hole (m)

56 25.1N, 129 0.92W
N

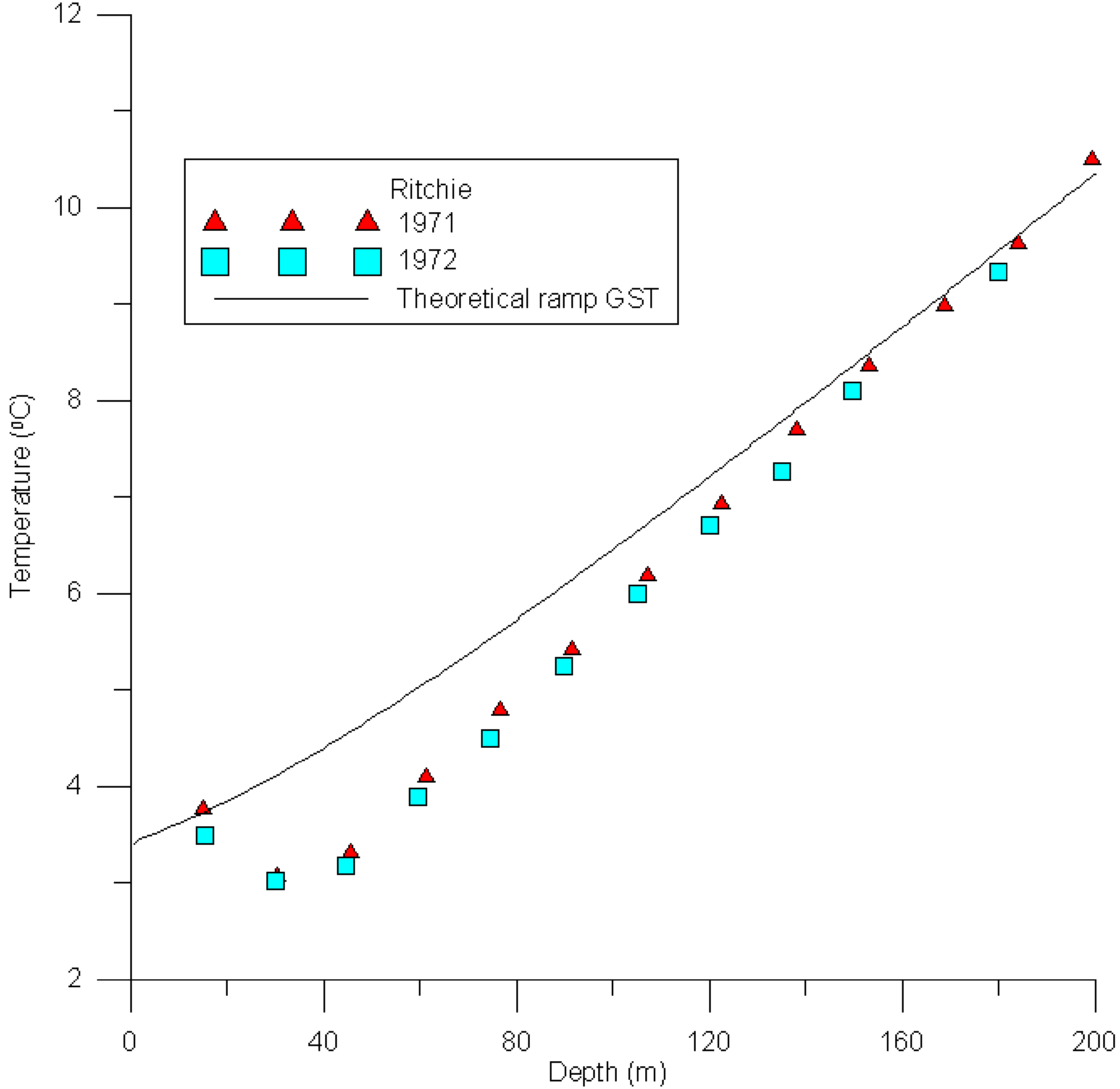

56 25.1N, 129 0.92W



Ritchie
1970
1971
1972
Theoretical ramp GST
Temperature (ºC)
Depth (m)
0
10
20
30
40
0
200
400
600
800
1000



Ritchie
1970
1971
1972
Theoretical ramp GST
Temperature (^{0}C)
Depth (m)
2
4
6
8
10
12
0
40
80
120
160
200



Ritchie
1971
1972
Theoretical ramp GST
Temperature (ºC)
Depth (m)
12
10
8
6
4
2
0
40
80
120
160
200

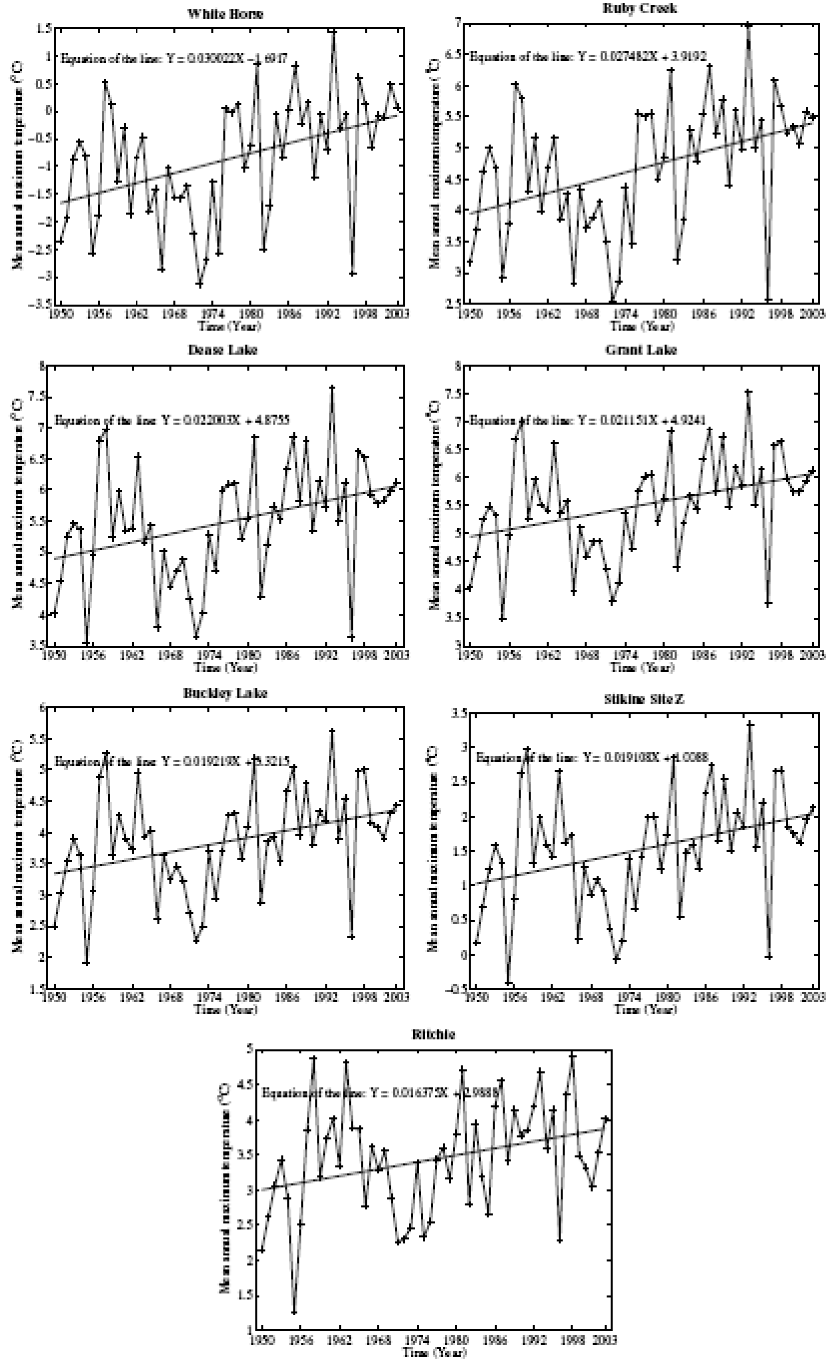


Figure 8. Mean annual maximum temperature (°C) trend for seven stations [White Horse, Ruby Creek, Dease Lake, Grant Lake, Buckley Lake, Stikine Site Z, and Ritchie].

Summary

- This research shows that the known climate signal determined from the SAT record over a large portion of north-west British Columbia and the southern Yukon has not propagated an anomalous temperature signal to depth as predicted by a conceptual model of 1-D diffusive heat transport.
- Good comparison to older GSC temperature records
- Little or no changes in land cover at any of the sites, since 1960’s

Snowmelt energy balance

Latent heat of fusion (L_f) = 334 kJ kg^{-1}

$$Q_\theta = Q_s(1 - \alpha) + Q_{lw} + Q_h + Q_e + Q_p - Q_m$$

Q_m: energy used to melt snow
Q_s: incoming shortwave radiation
Q_{lw}: longwave radiation into the snowpack.
Q_h: sensible heat transfer into the snowpack.
Q_e: latent heat transfer into the snowpack.
Q_p: energy input by rain on the snowpack.

Q_θ: change of energy in the snowpack.

Energy Flow in is + out is -

Source: Dunne and Leopold (1978), Water in Environmental Planning.

Hypotheses

- Our hypothesis is that the observed disconnect between the SAT and GST signals at eight of our sites is caused by an increase in snow cover in early winter, followed by a trend to an earlier snow melt in the region.

- A trend in our area towards late snow accumulation and early thaw are masking the increase in SAT temperatures. The snow cover leads to a disconnect between SAT and GST over the autumn and winter months.

- The important summer months, at least from the perspective of signal coupling, shows a flat or statistically insignificant SAT response.

Acknowledgements

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  - NSERC
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- Gary Woodbury, Juan Benitez, Scott Dunbar, Willie Williams, Jim Reed
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