

# Impact of Expanding Urbanization on Toronto, Ontario's temperature record



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# Outline

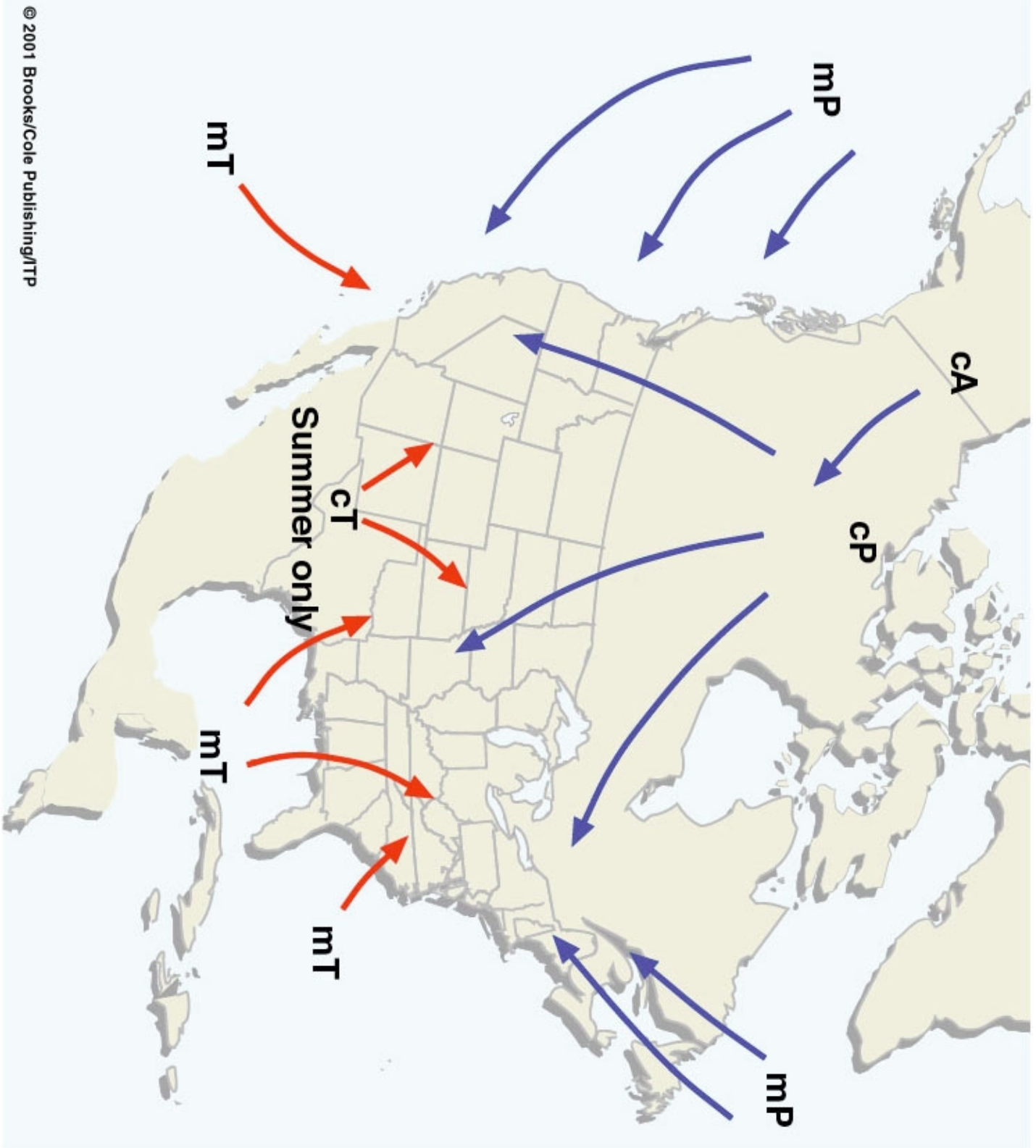
- Introduction
- Toronto's climate
  - Large and regional scale influences
  - Local scale influences - heat island, lake breeze
- Toronto's changing climate
  - Urban heat island
  - Diurnal temperature range
- Conclusions

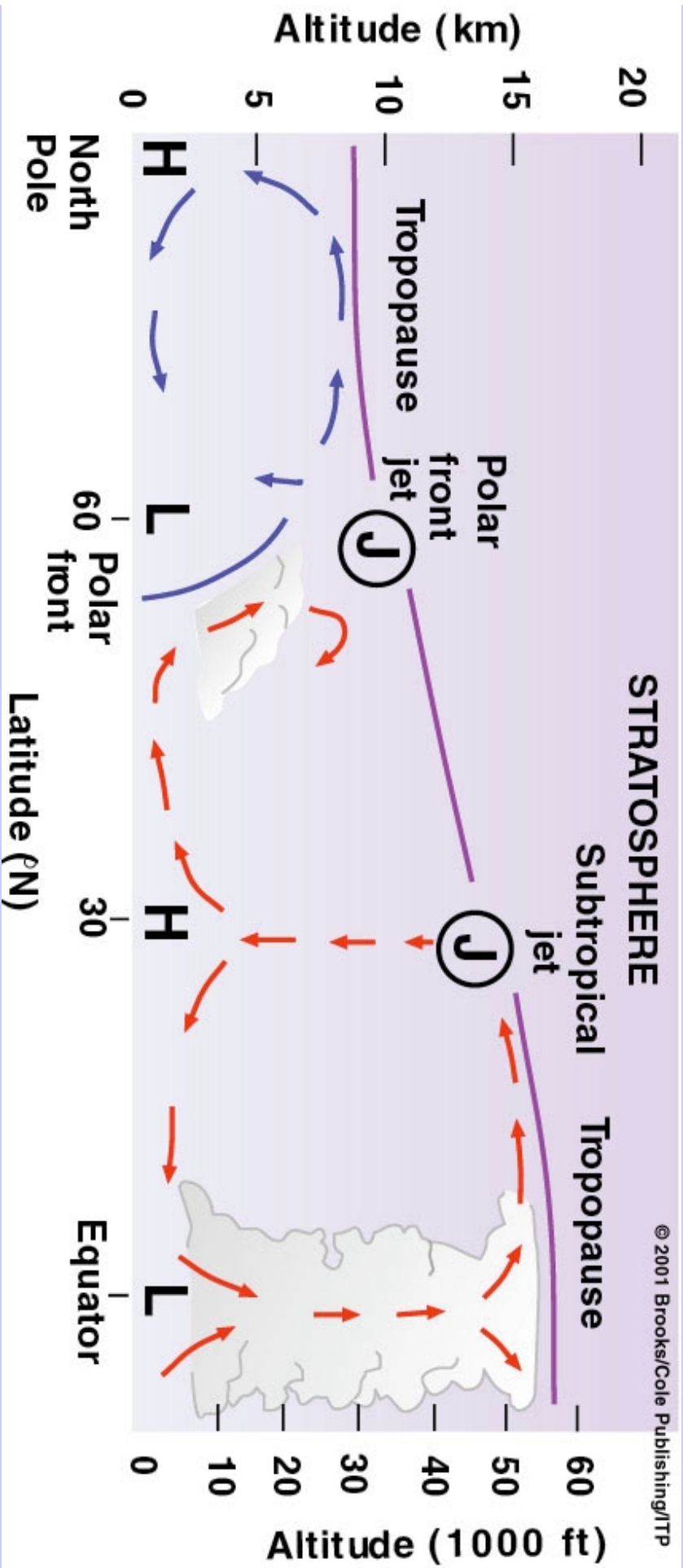
# Introduction

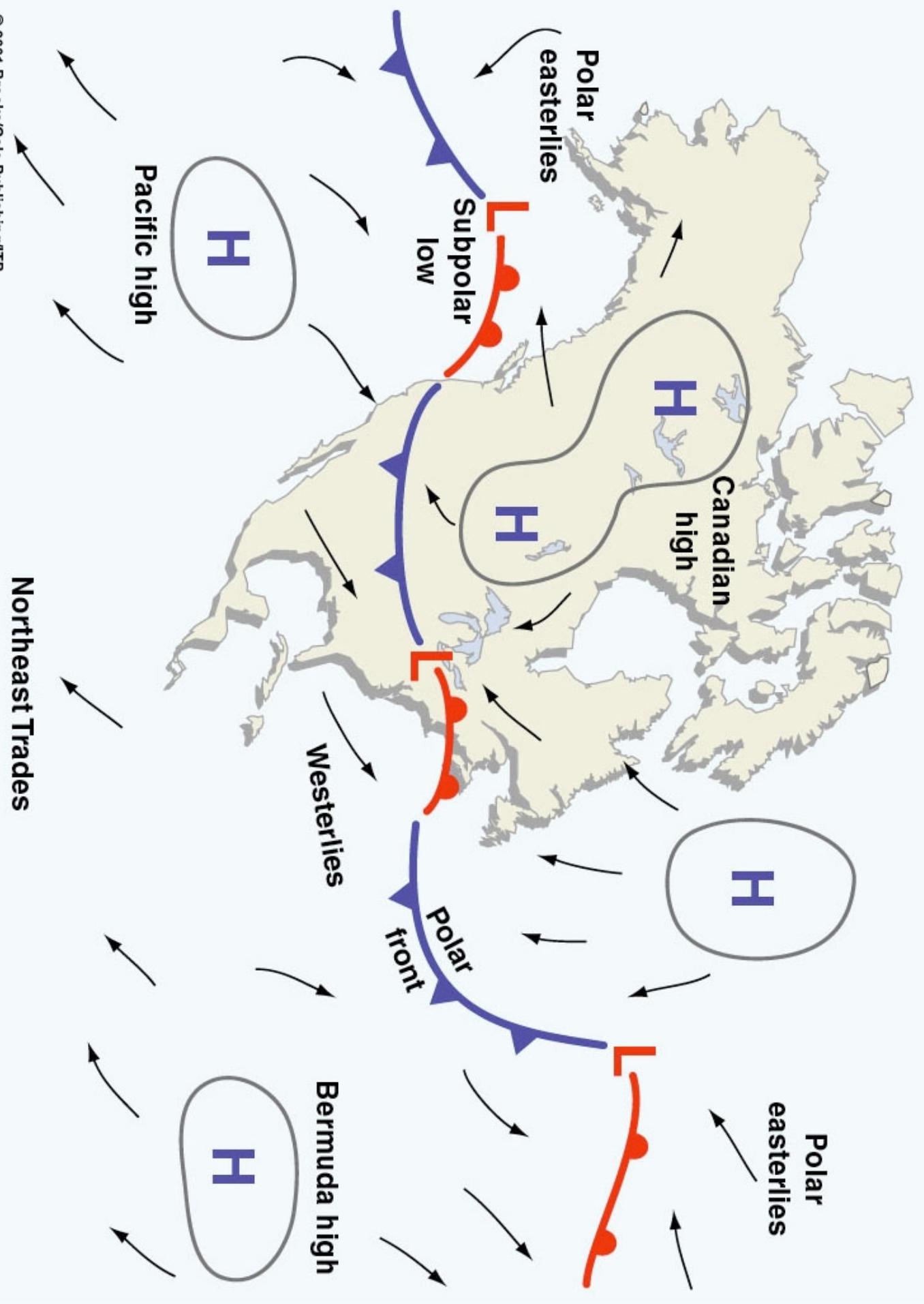
- Toronto's climate
  - large scale influences
  - regional influences
  - local influences
- Urban Heat Island

# Large Scale Influences

- Air mass analysis
- Three cell vertical structure
- Synoptic meteorology







# Regional Influences

- Great Lakes' effect
- presence of the Great Lakes modifies temperature and precipitation in the region



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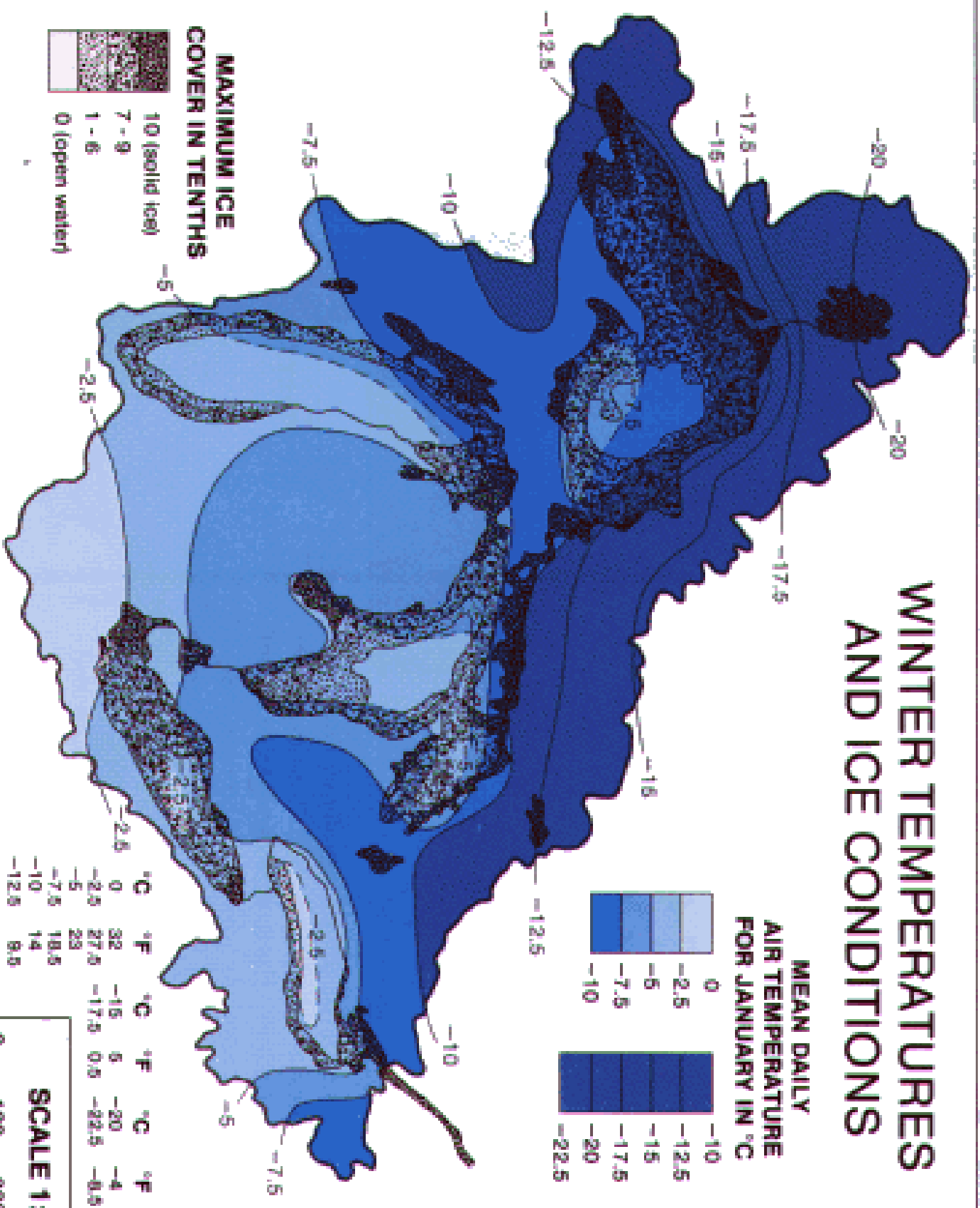
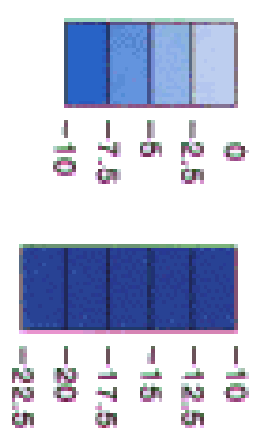
0 — 25mi 0 — 40km

# Great Lakes Effect

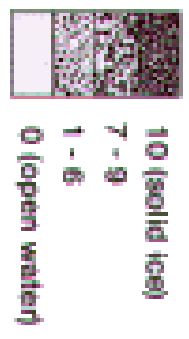
- What would the climate be without the Great Lakes?
  - Temperature modifications (mitigation)
  - Lake effect precipitation

# WINTER TEMPERATURES AND ICE CONDITIONS

MEAN DAILY  
AIR TEMPERATURE  
FOR JANUARY IN °C



MAXIMUM ICE  
COVER IN TENTHS

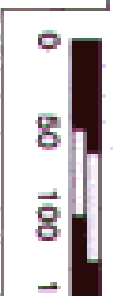


°C	°F	°C	°F	°C	°F
0	32	-15	5	-20	-4
-2.5	27.5	-17.5	0.5	-22.5	-8.5
-5	23				
-7.5	18.5				
-10	14				
-12.5	8.5				

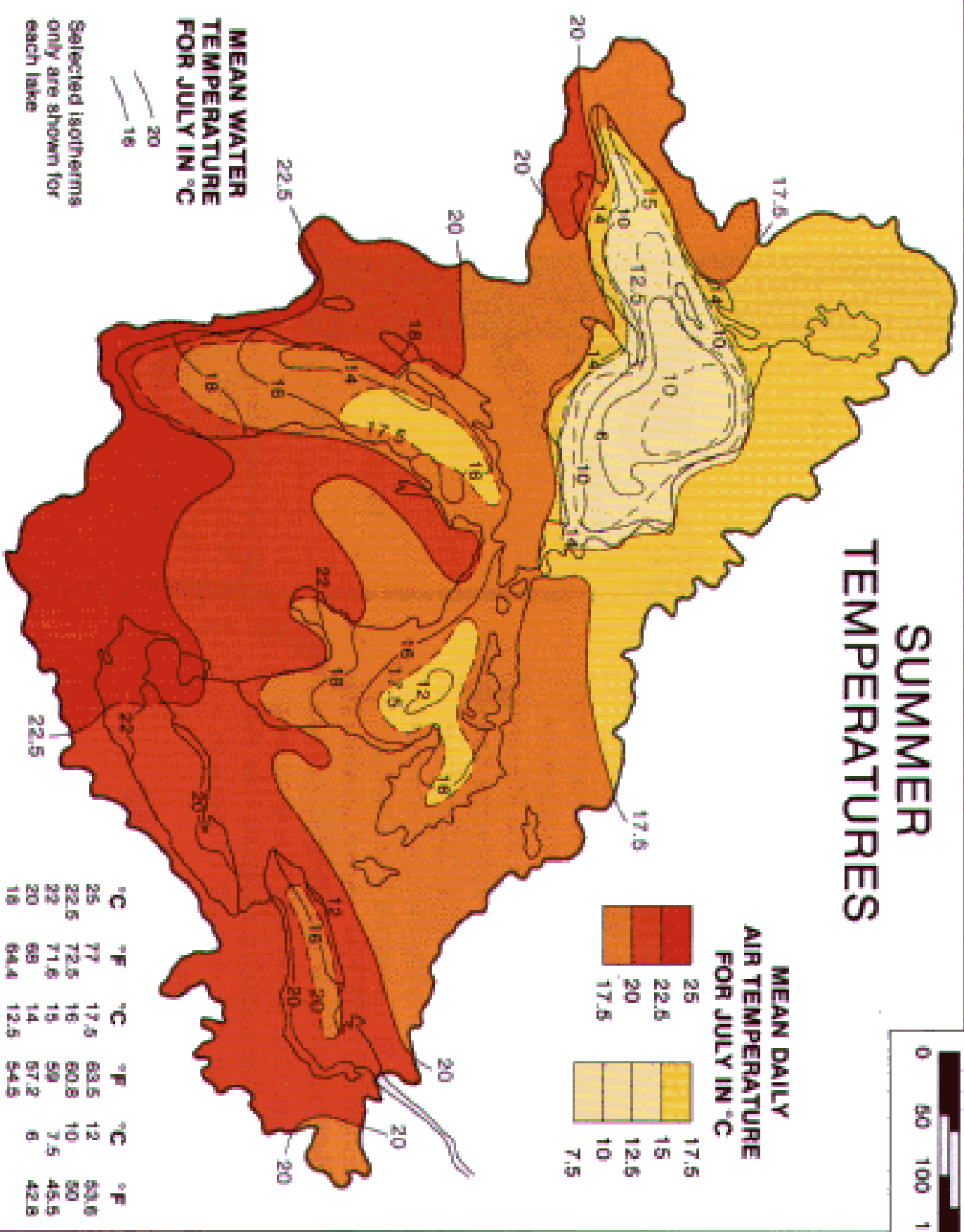
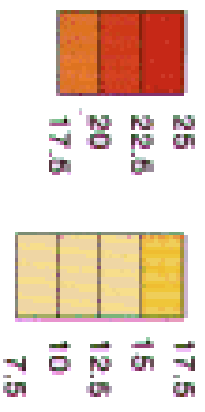
SCALE 1:1



# SUMMER TEMPERATURES



MEAN DAILY AIR TEMPERATURE FOR JULY IN °C



MEAN WATER TEMPERATURE FOR JULY IN °C

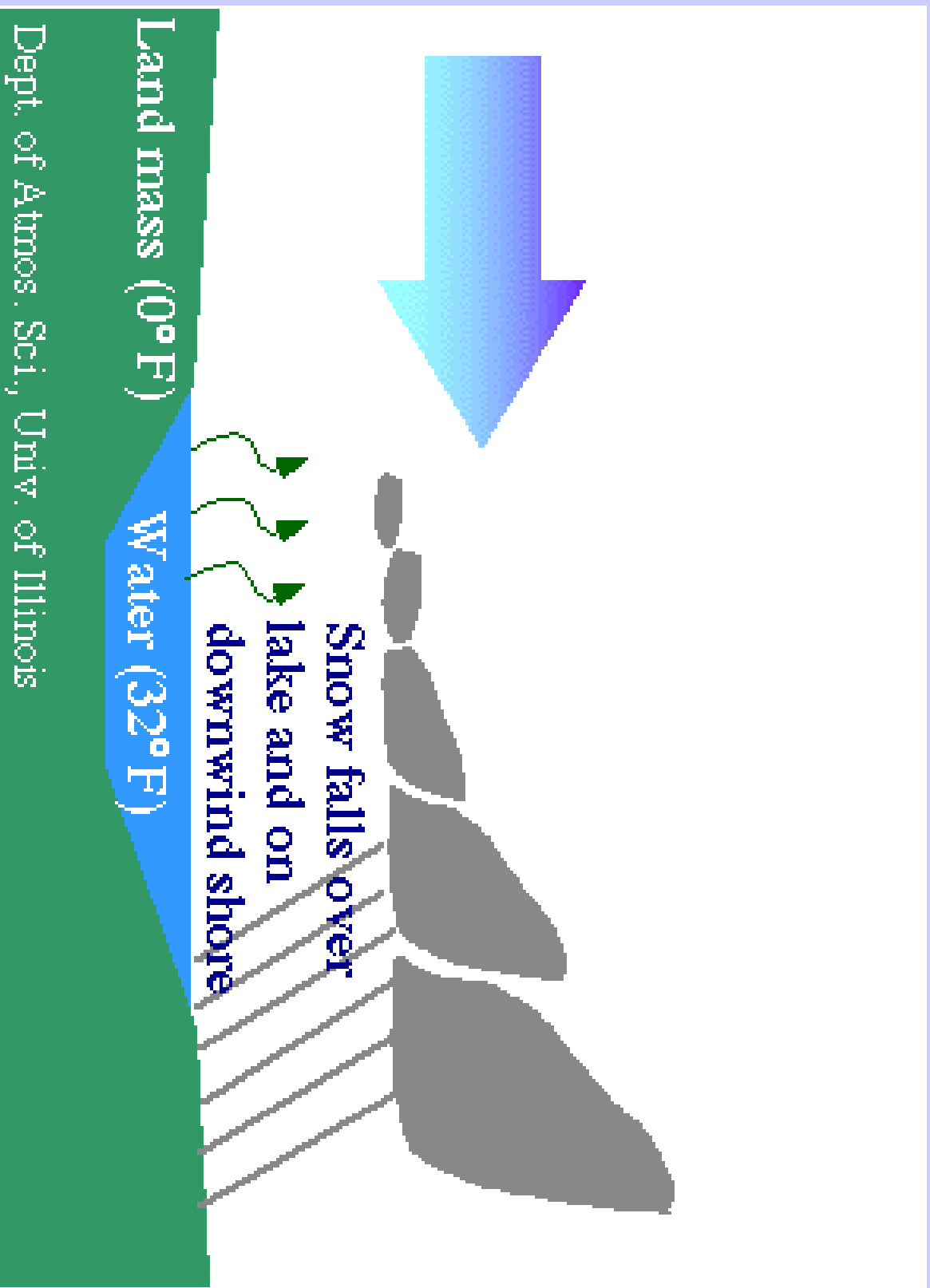


Selected isotherms only are shown for each lake

°C	°F	°C	°F	°C	°F
25	77	17.5	63.5	12	53.6
22.5	72.5	16	60.8	10	50
20	71.6	15	59	7.5	45.5
18	68	14	57.2	6	42.8
16	64.4	12.5	54.5		

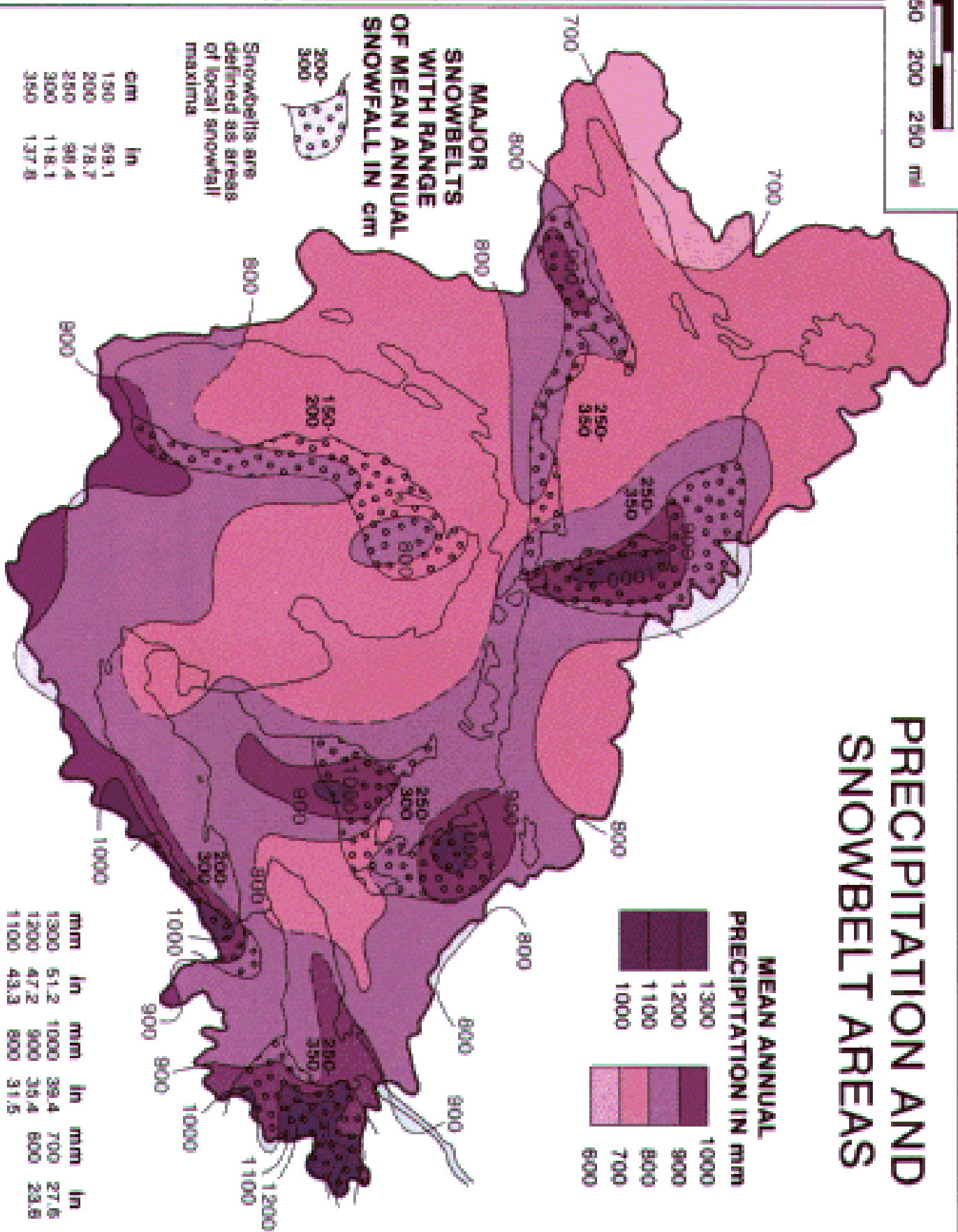
# Lake Effect Snow

- Cold, dry cP air moves in from northwest of the Great Lakes region
- as the air moves over a lake, it picks up moisture
- on the leeward side of the lake, the air rises, producing lake effect snow



Dept. of Atmos. Sci., Univ. of Illinois

# PRECIPITATION AND SNOWBELT AREAS



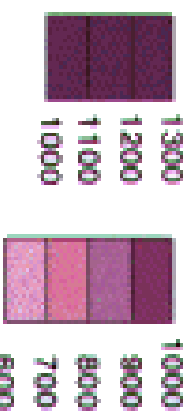
**MAJOR SNOWBELTS WITH RANGE OF MEAN ANNUAL SNOWFALL IN cm**



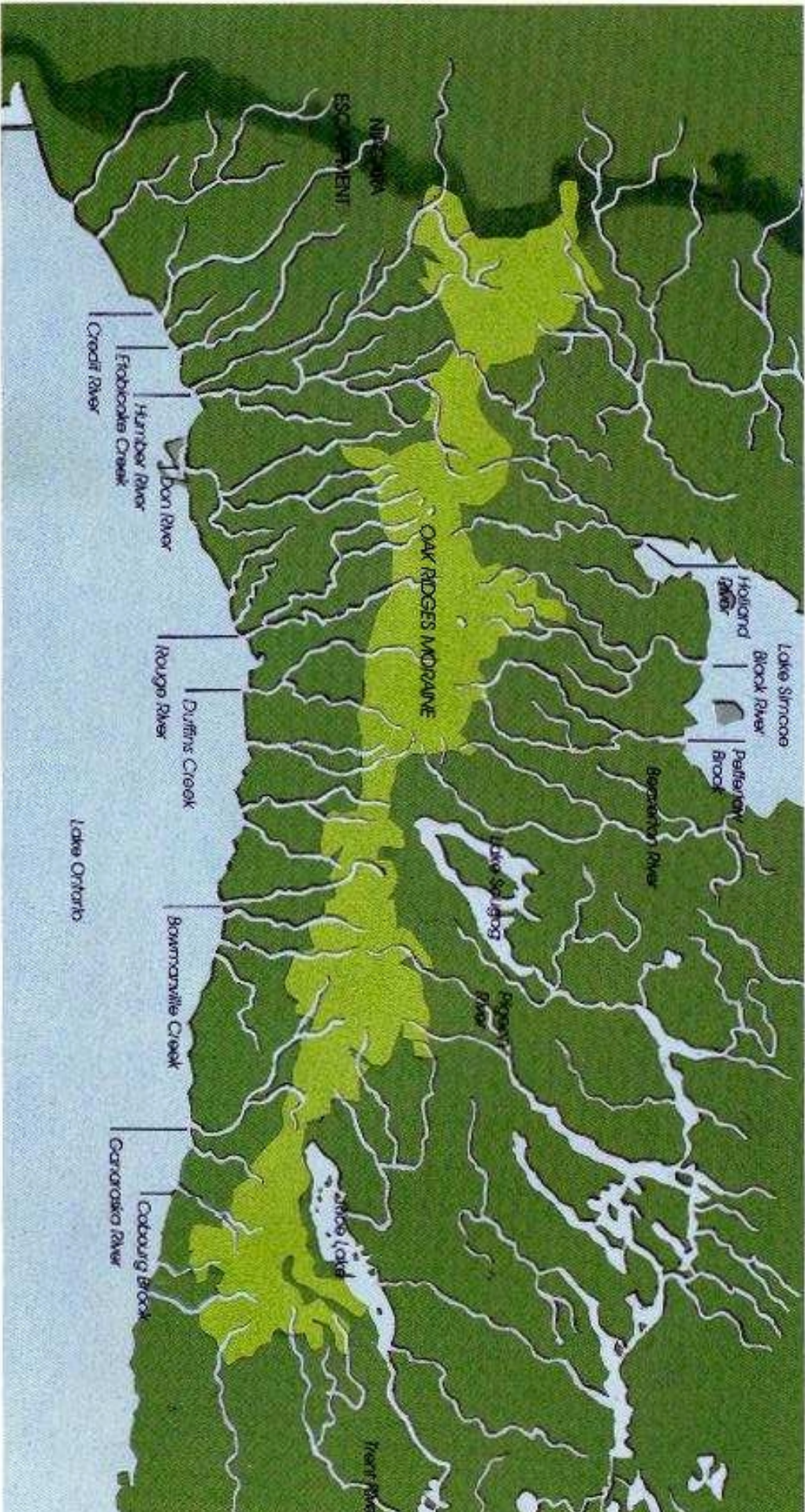
Snowbelts are defined as areas of local snowfall maxima

cm	in
150	59.1
200	78.7
250	98.4
300	118.1
350	137.8

**MEAN ANNUAL PRECIPITATION IN mm**



mm	in	mm	in	mm	in
13000	51.2	10000	39.4	700	27.6
12000	47.2	9000	35.4	600	23.6
11000	43.3	8000	31.5		

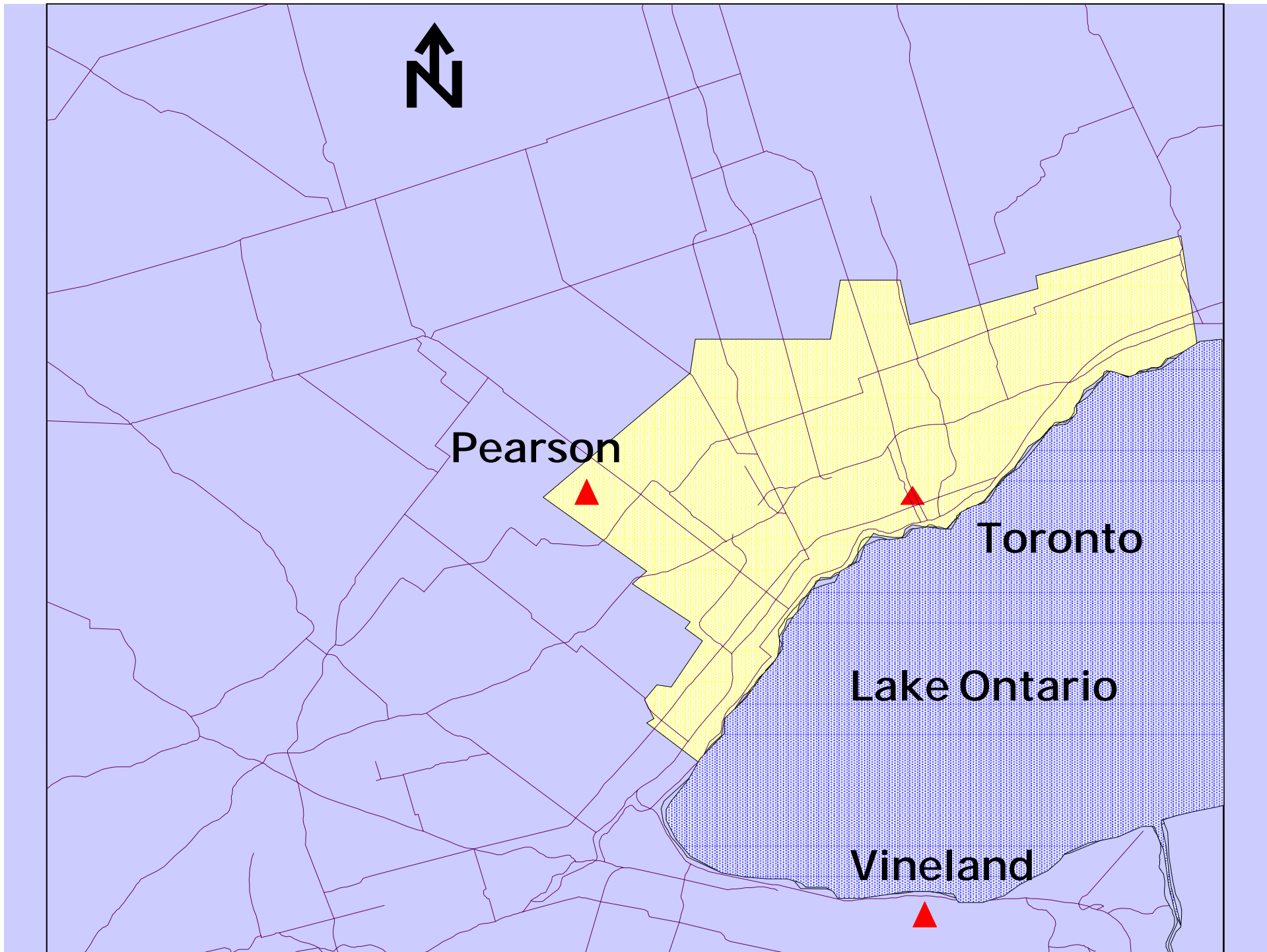


# Local Influences

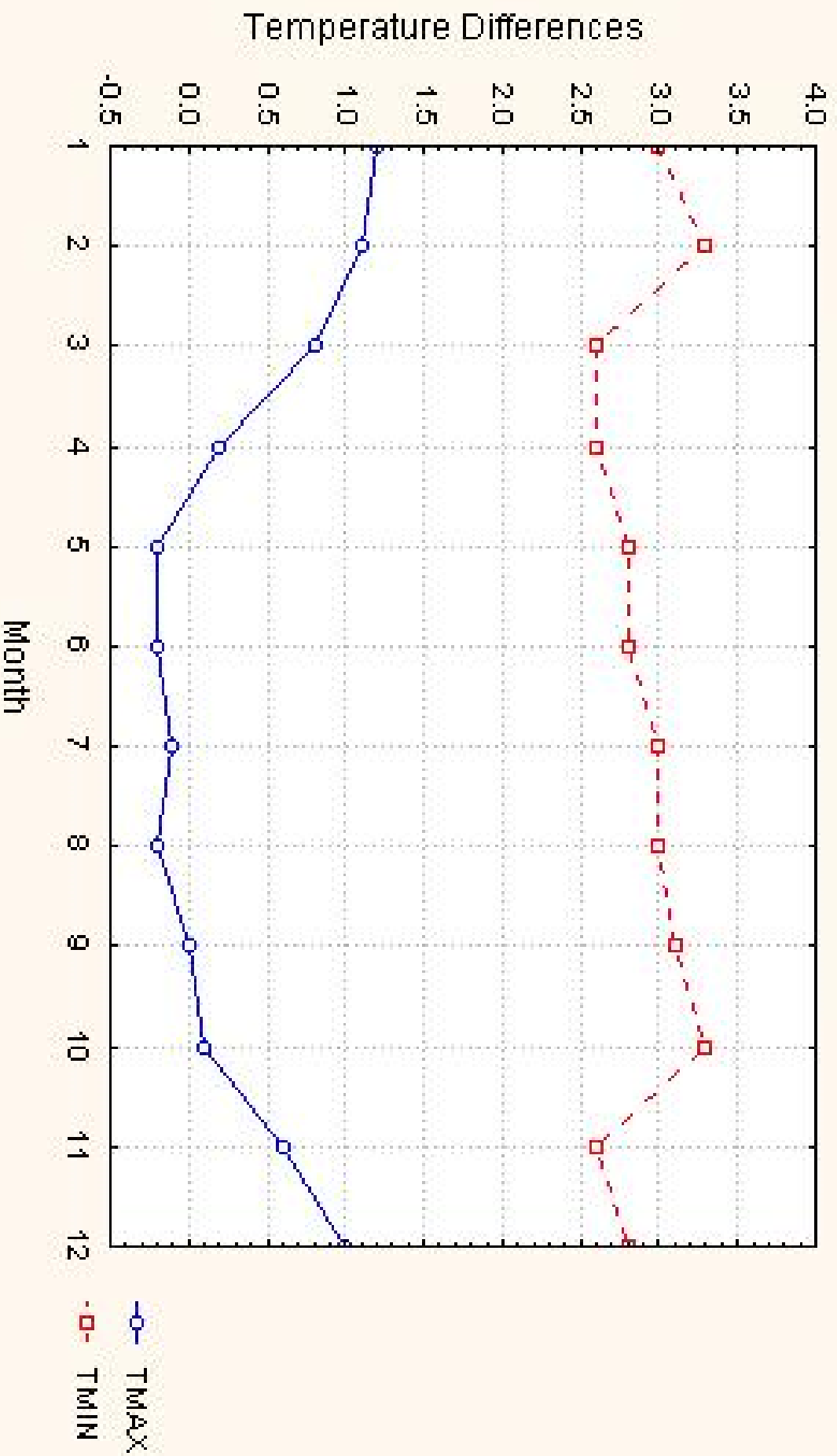
- Heat Island
- urbanization
  - reduction of evapotranspiration
  - heat storage in buildings and pavement
  - artificial heat generated
  - snow clearing - albedo
- Net warming of urban areas

# Heat Island

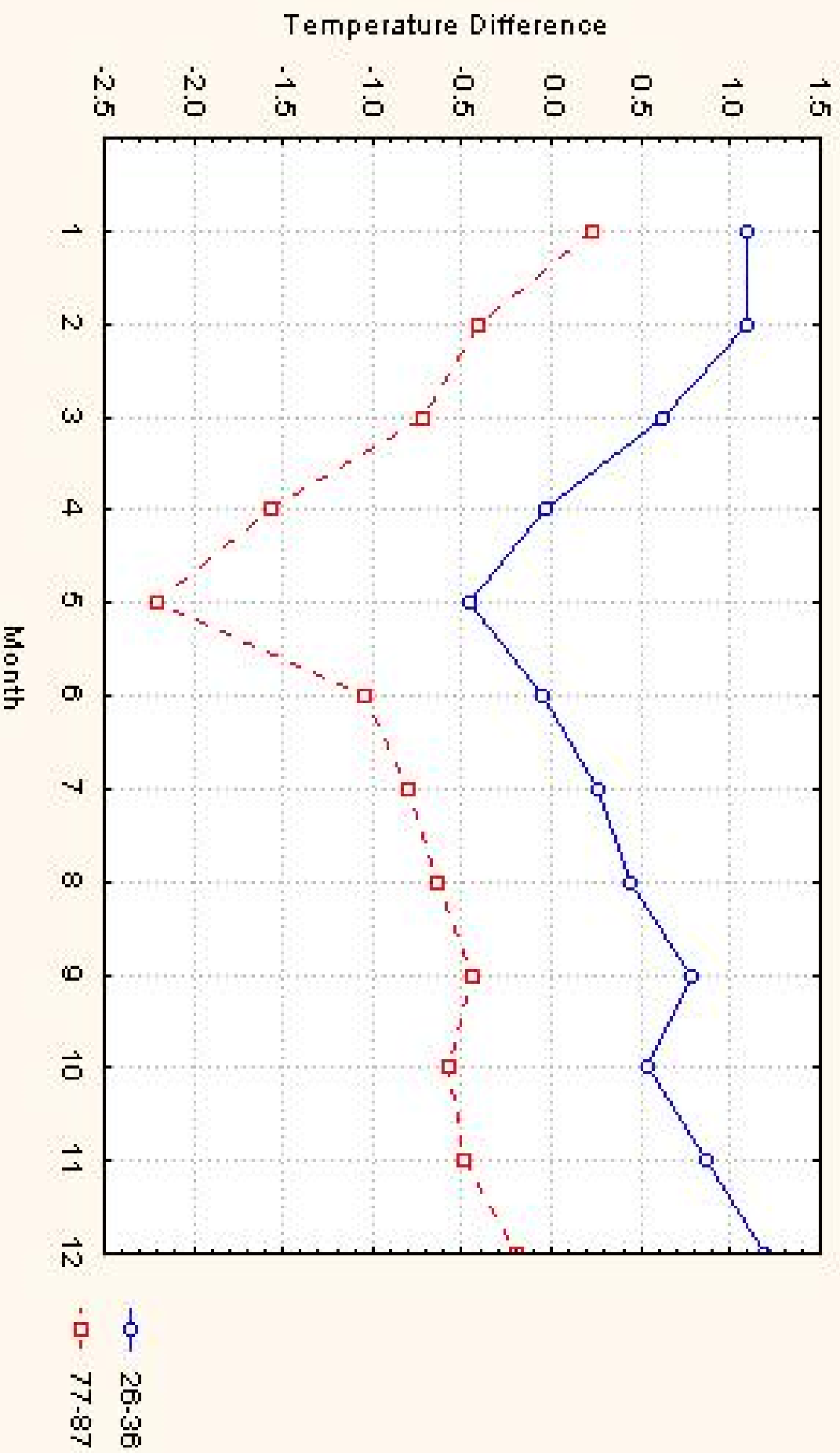
- Oke (1973)
  - linked heat island ( $\Delta T$ ) to log (Population)
- biggest difference is in daily minimum temperature
- Toronto example (Gough and Rozanov, 2001):
- Downtown / Pearson comparison
- Toronto / Vineland comparison



## Toronto / Pearson Temperature Differences



Toronto / Vineland Minimum Temperature Difference



# Local Influences

- Lake breeze
- Thermally induced circulation
- strongest - day time during the summer (maximum temperature)
- Toronto / Montreal comparison

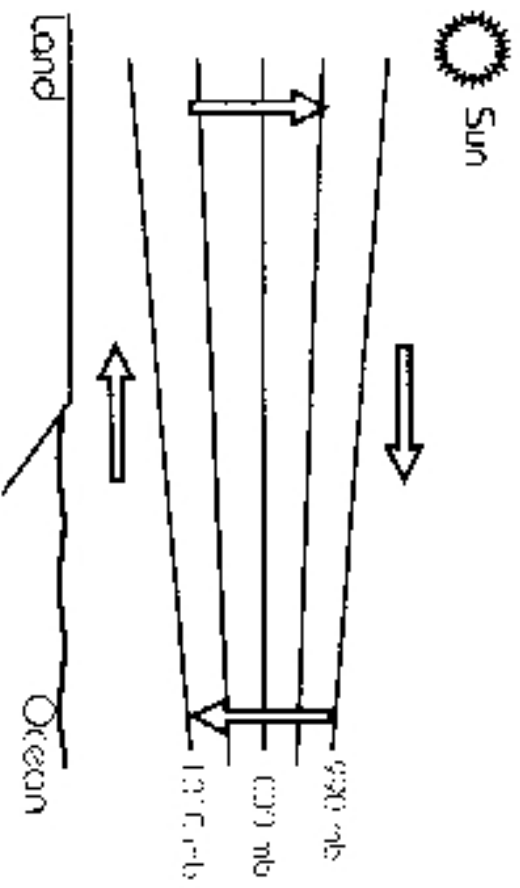
# Lake Breeze

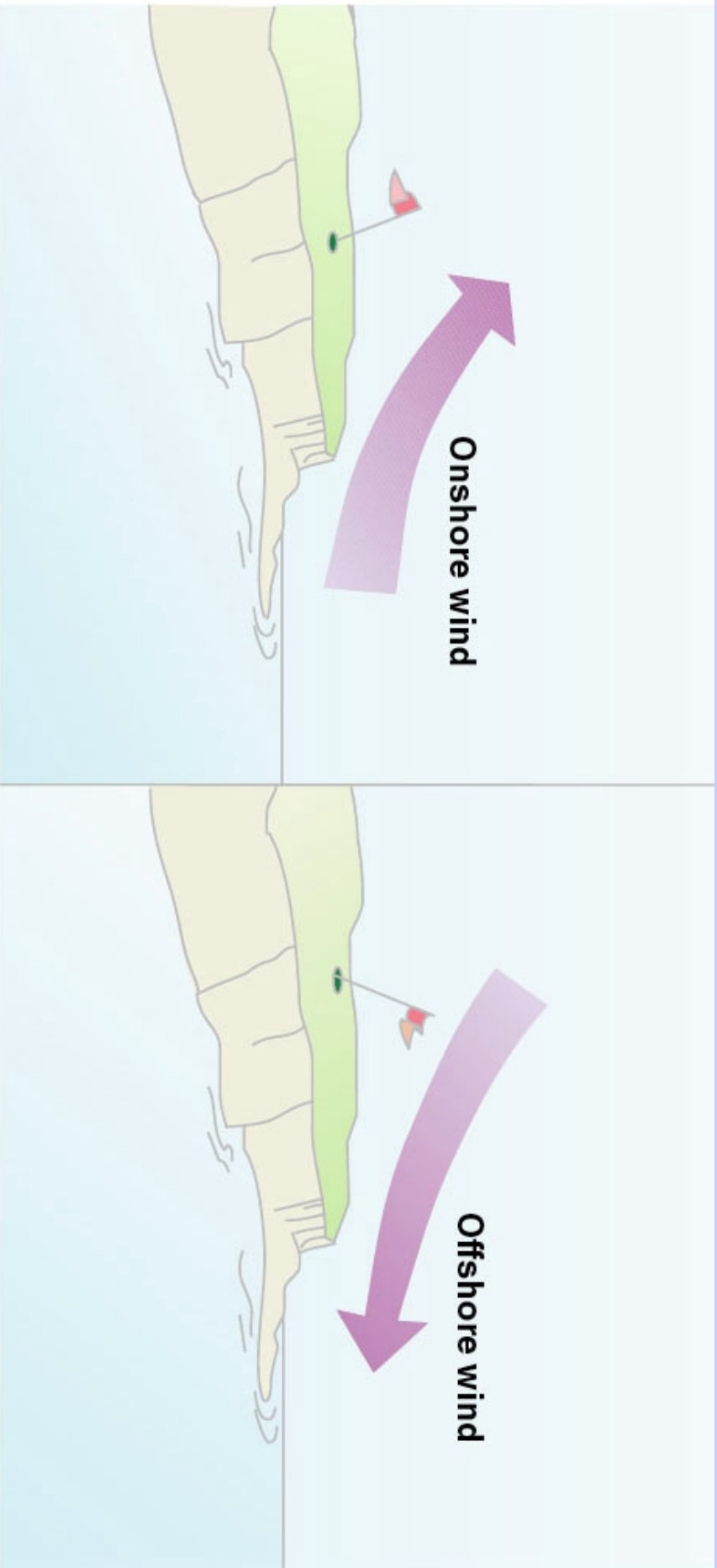
- Comparison of UHI of Toronto with Montreal
- Toronto/Pearson
- Montreal/Oka

(A)

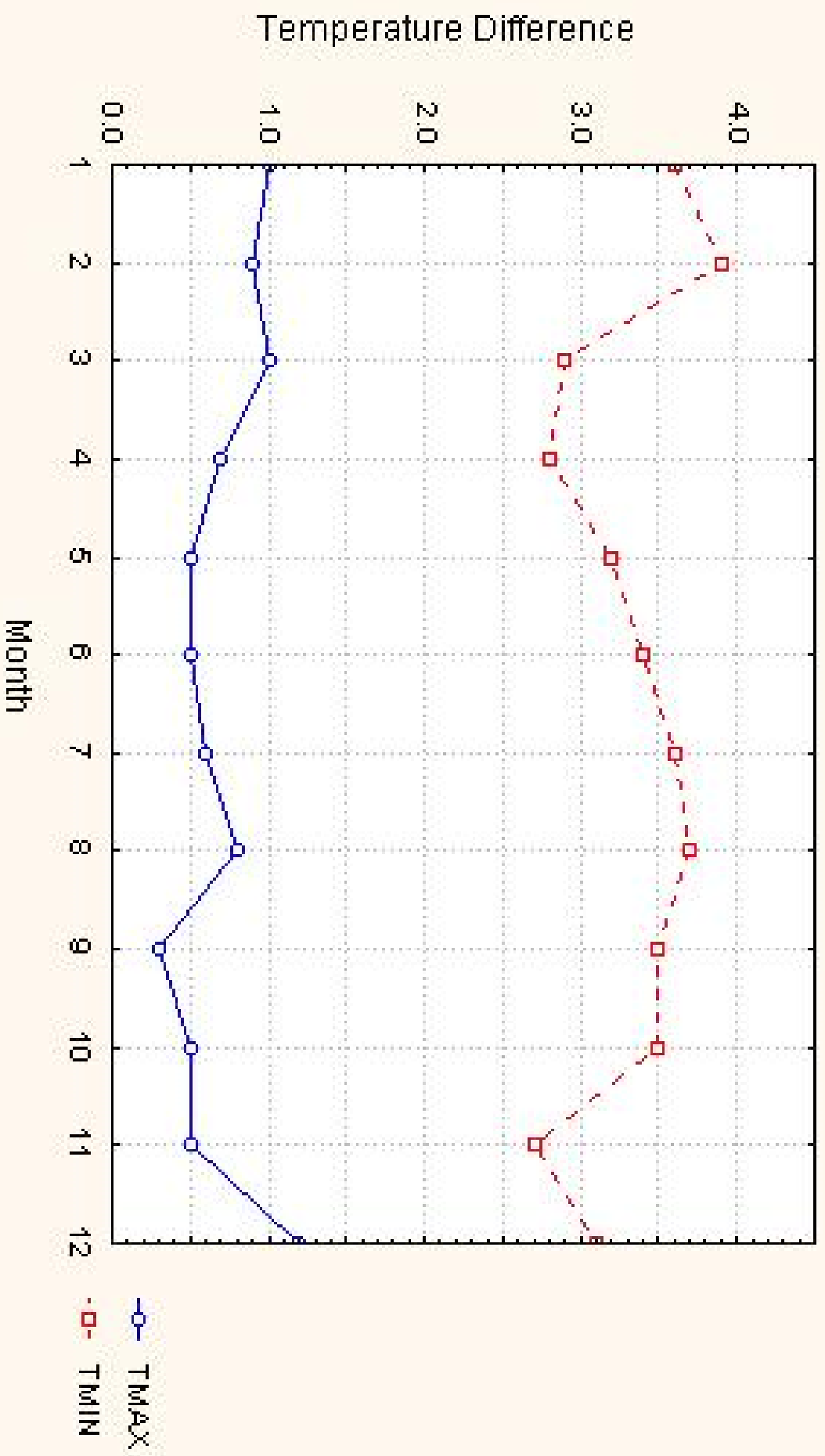


(B)

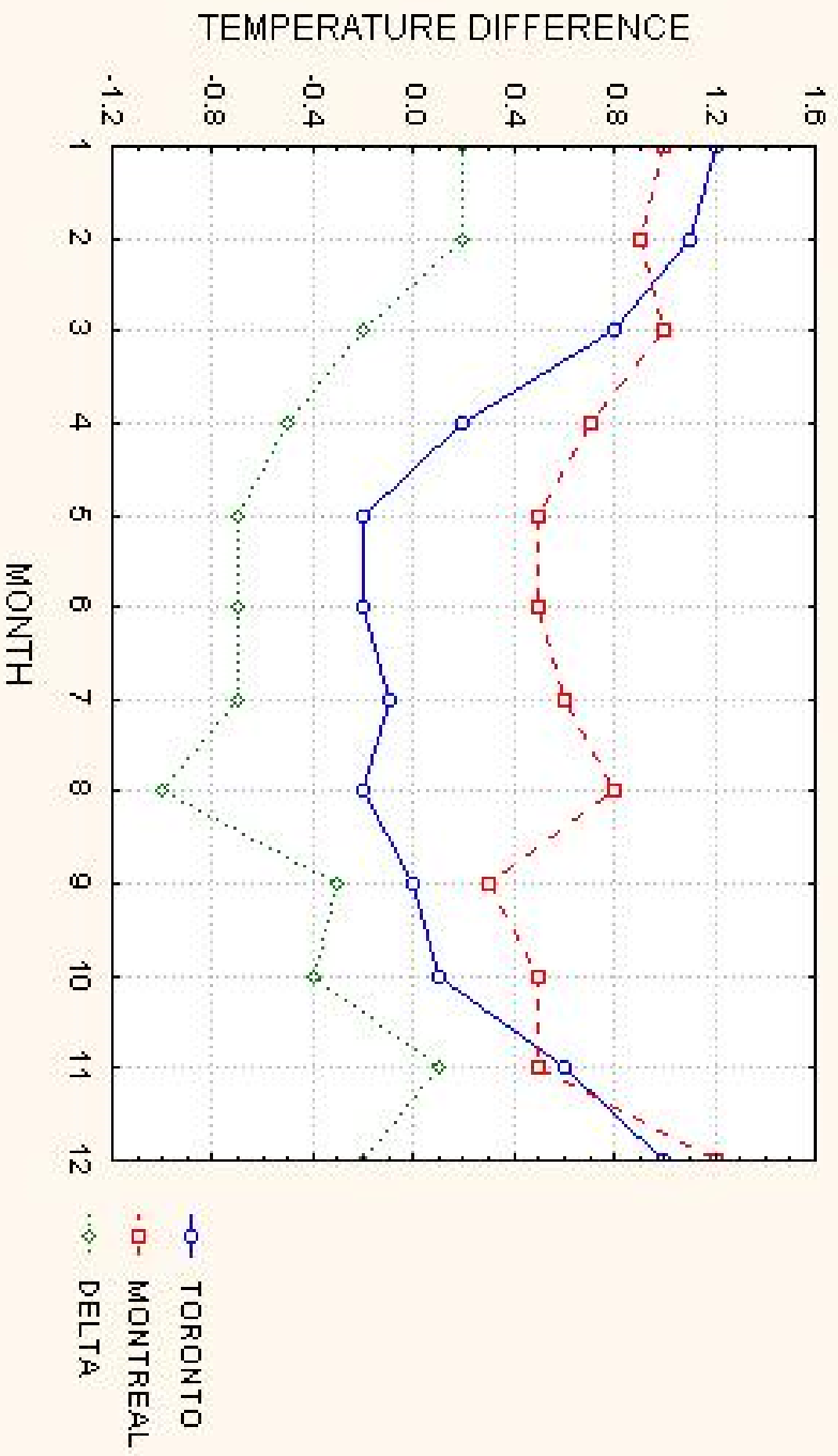




### Montreal / Oka Temperature Differences



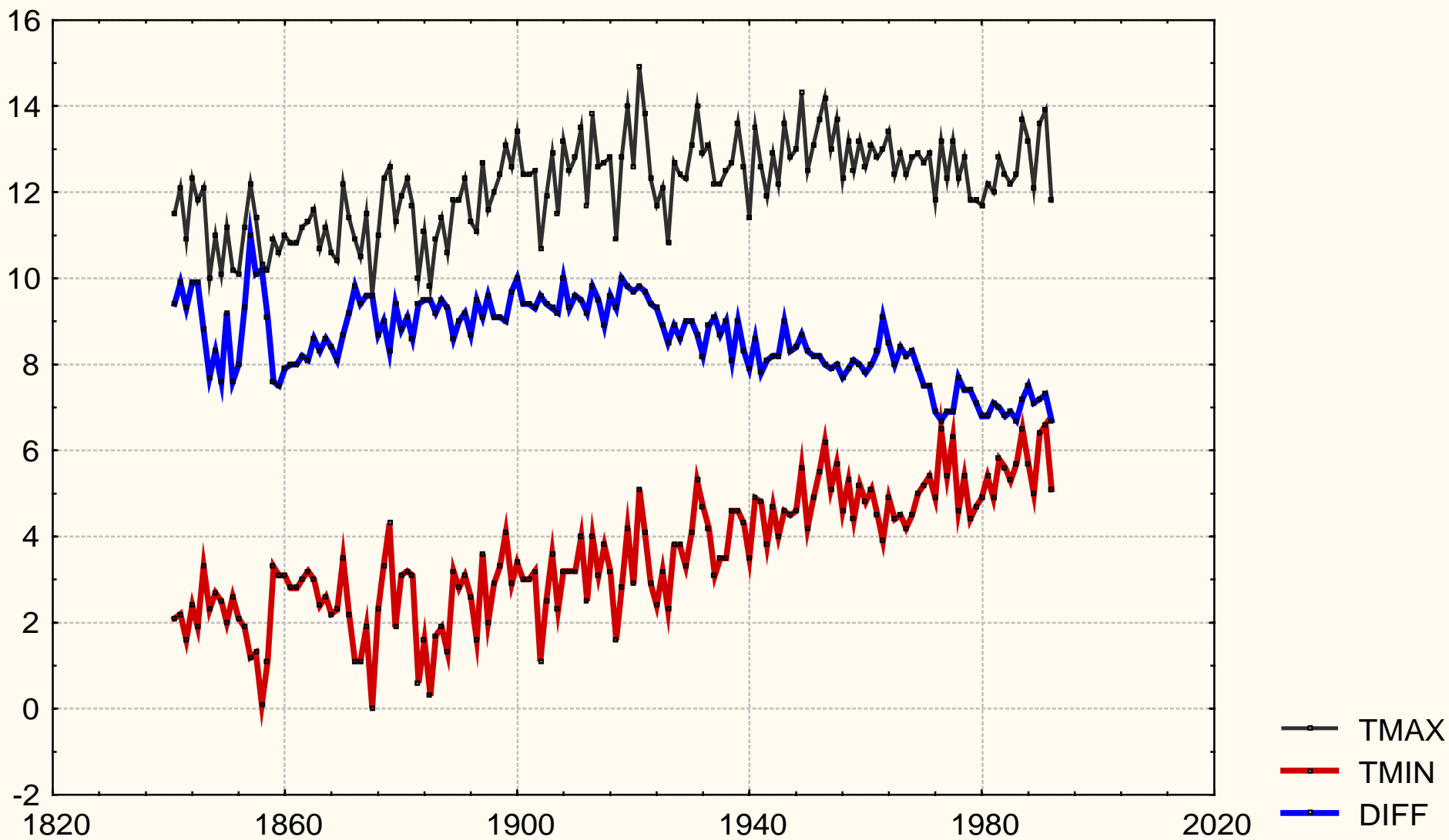
# TORONTO / MONTREAL DIFFERENCE TMAX

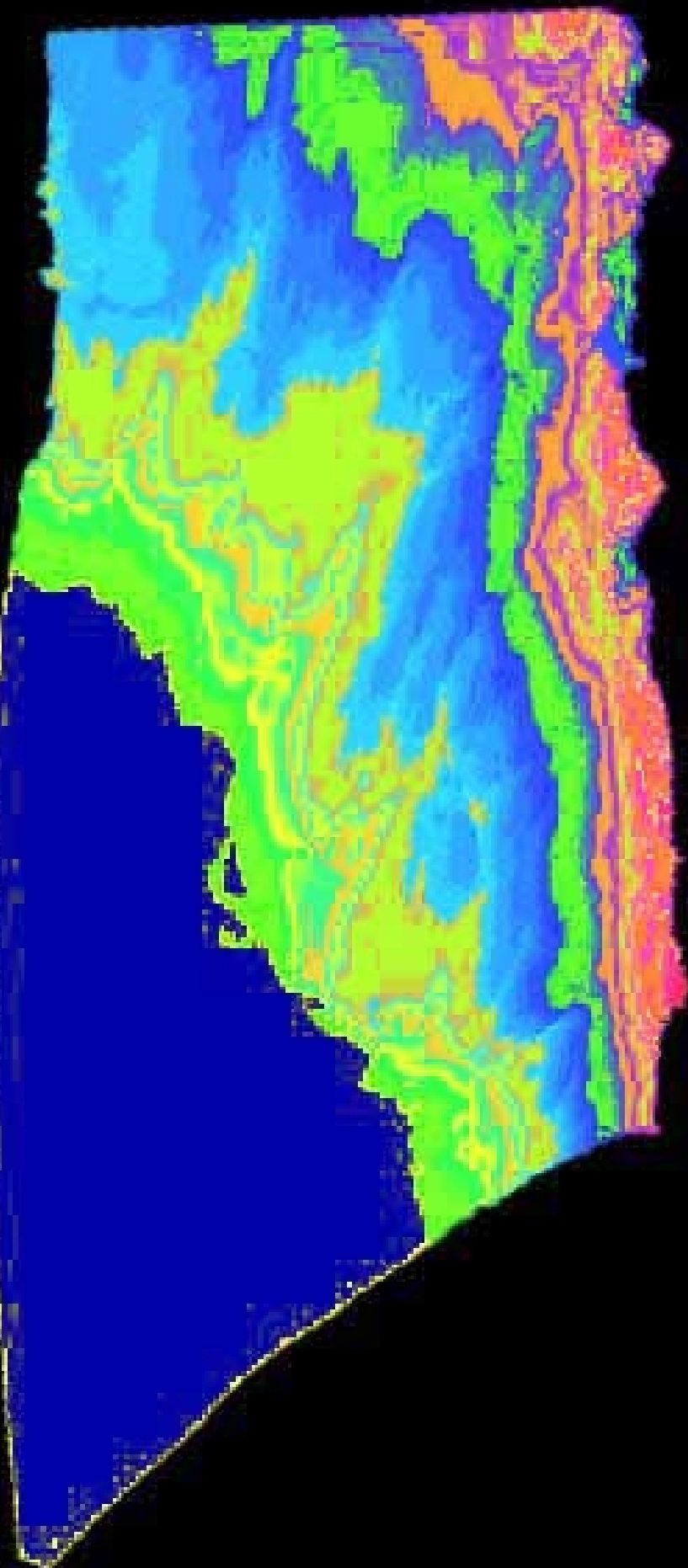


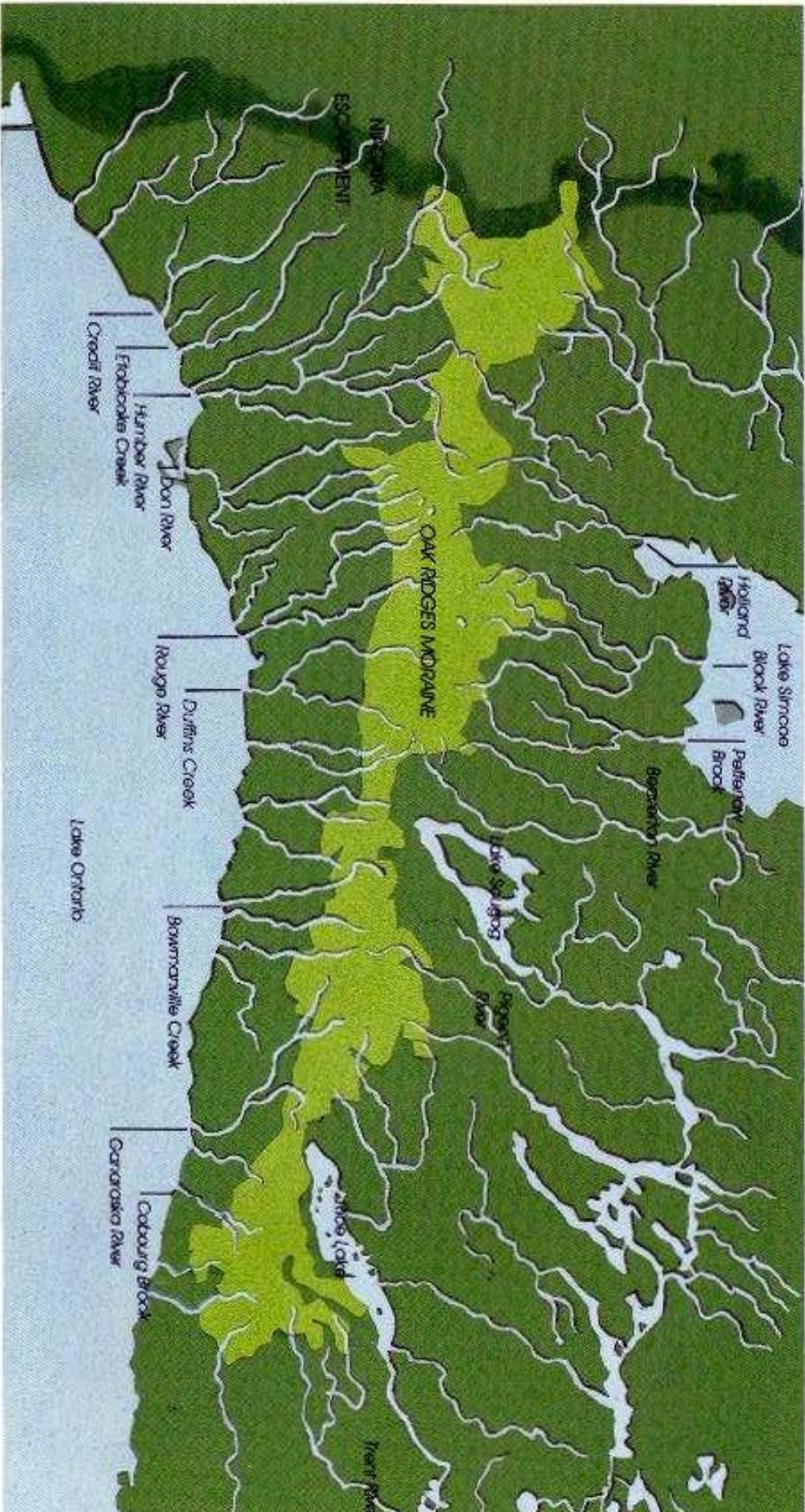
# Diurnal Temperature

- Time series from Toronto downtown station  
1840 - 2000
- Links to topography, urbanization

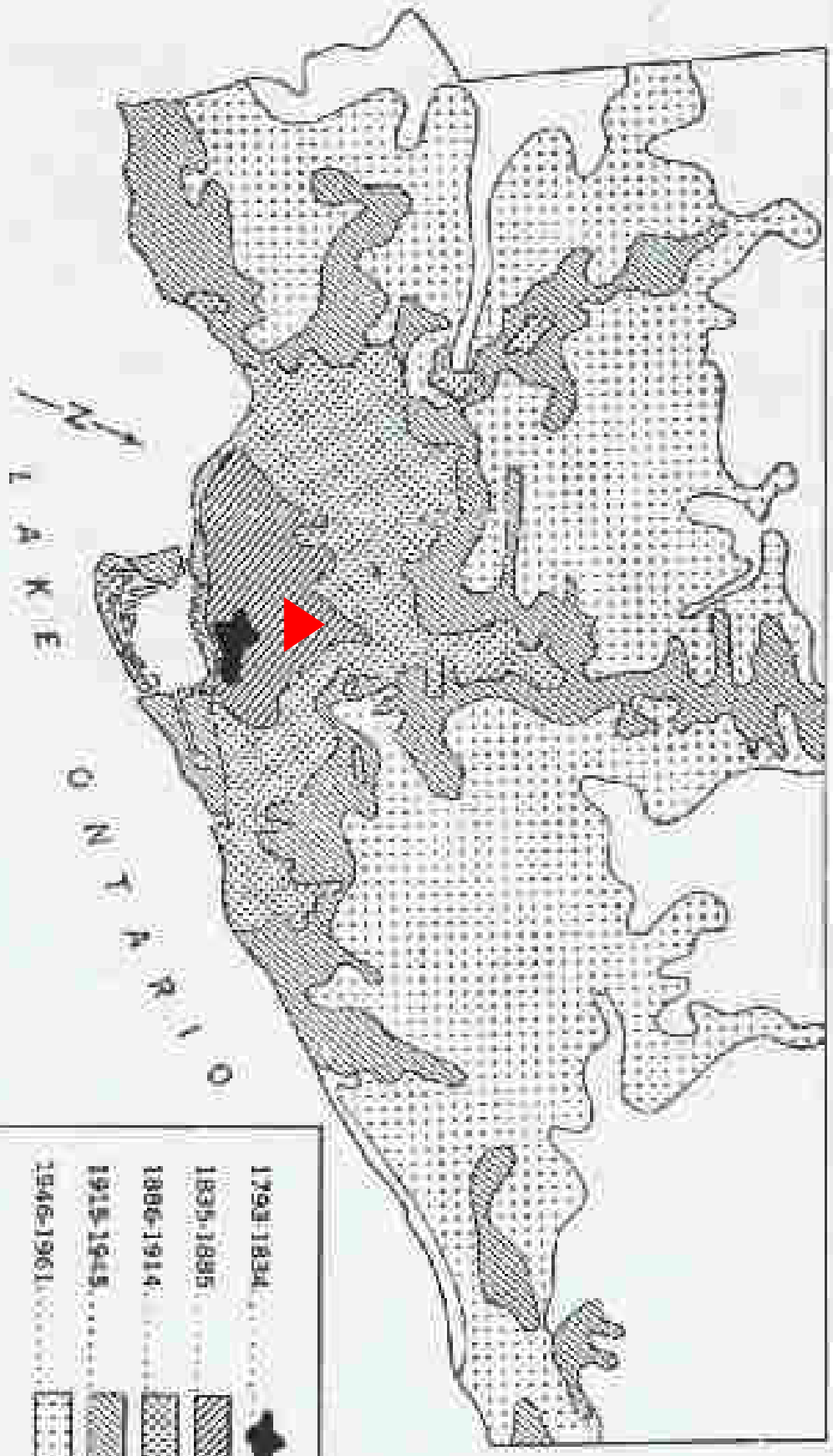
Different Tmax and Tmin in Toronto



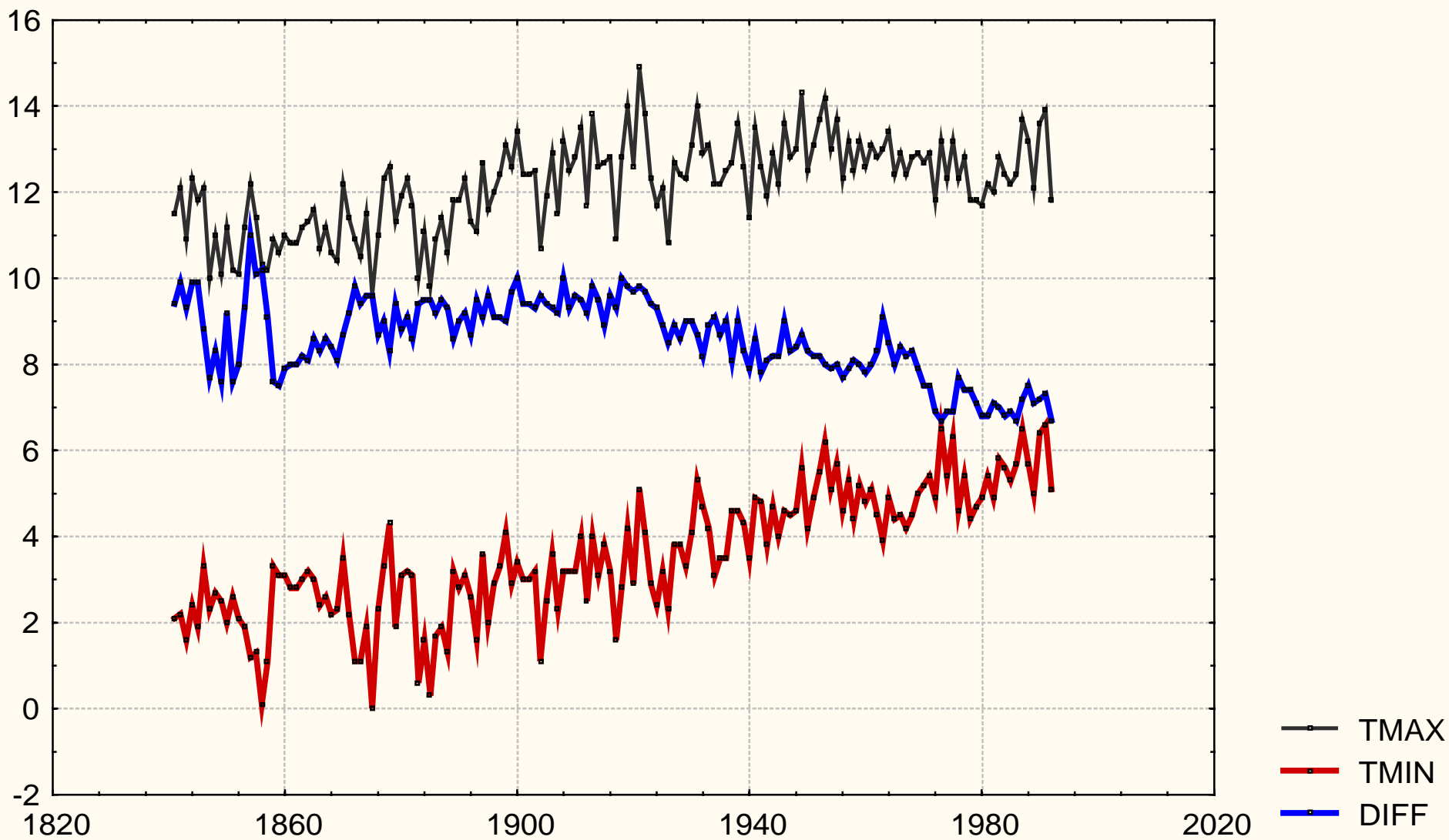




After N. Hopper, Metropolitan Toronto Planning Board and Field Surveys



Different Tmax and Tmin in Toronto



# Conclusions

- Intensifying UHI in Toronto
- Quantification of Toronto's lake breeze
- Changes in diurnal temperature
  - influence of expanding urbanization

