Trends in Climate in Northern New York and Western Vermont

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global climate change in the 20th century

- Average air temperature has risen 0.6 ºC over the past century
- Very likely caused by anthropogenic activity
  - Greenhouse gas emissions
- Most abundant greenhouse gas is carbon dioxide (CO_2)
  - Current atmospheric CO_2 concentration ~380 ppm
  - Pre-industrial (1750) concentration ~280 ppm

IPCC. (2007). In Solomon S., et al (Eds.), *Climate change 2007: The physical science basis. contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

climate change in the northeastern US

- Collectively, the NE states are the world's seventh largest source of CO_2 emissions
- Observed warming of 1.1 ºC in the 20th century
  - Almost twice that of the observed global increase
- Since 1970, temperatures have risen 0.27 ºC per decade
  - Winter temperatures have risen 0.72 ºC per decade
  - Precipitation has increased 5-10% over 20th century
    - Multi-year drought in 1960s

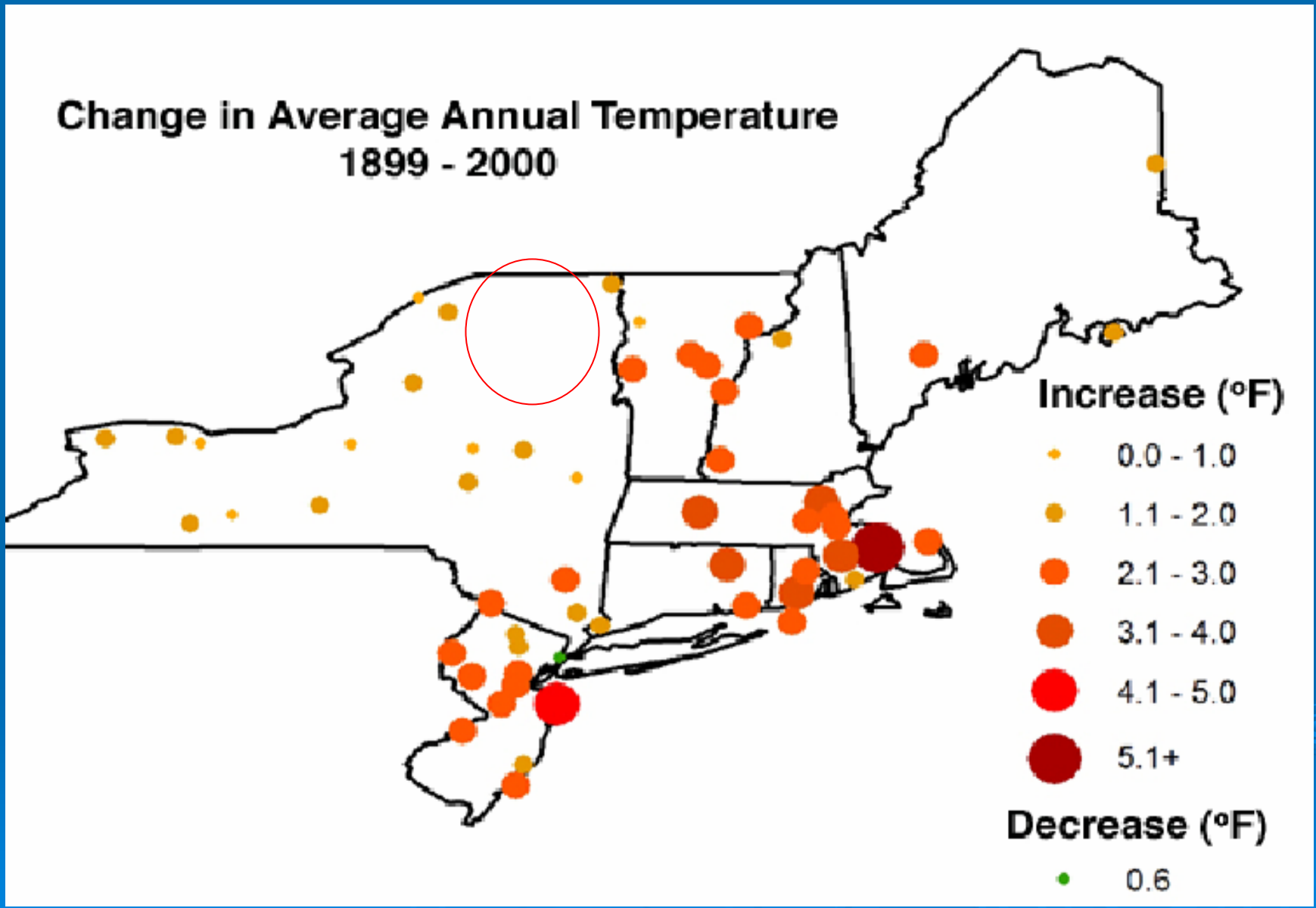
Frumhoff, P. C., McCarthy, J. J., Melillo, J. M., Moser, S. C., & Wuebbles, D. J. (2006). *Climate change in the U.S. northeast: A report of the northeast climate impacts assessment.* Cambridge, MA: Union of Concerned Scientists.

Frumhoff, P. C., McCarthy, J. J., Melillo, J. M., Moser, S. C., & Wuebbles, D. J. (2007). *Confronting climate change in the US northeast: Science, impacts, and solutions. synthesis report of the northeast climate impacts assessment (NECIA).* Cambridge, MA: Union of Concerned Scientists (UCS).

Hayhoe, K., Wake, C. P., Huntington, T. G., Luo, L., Schwartz, M. D., Sheffield, J., et al. (2007). Past and future changes in climate and hydrological indicators in the US northeast. *Climate Dynamics, 28*(4), 381-407.

Why study regional climate change?

- Localities need regionally accurate information for planning, mitigation and adaptation
- Northeast climate is highly variable
- Global models operate at a resolution too large for regional studies
  - Does not account for intricate changes in land use, topography and elevation



Wake et al. 2005

are there discernible trends in climate in the Adirondack region?

- Evaluate trends in temperature and precipitation
  - By station, climate division, and entire region
  - annually, seasonally, monthly
- Evaluate trends in “extreme” or 24-hour maximum precipitation
  - Daily

data sources

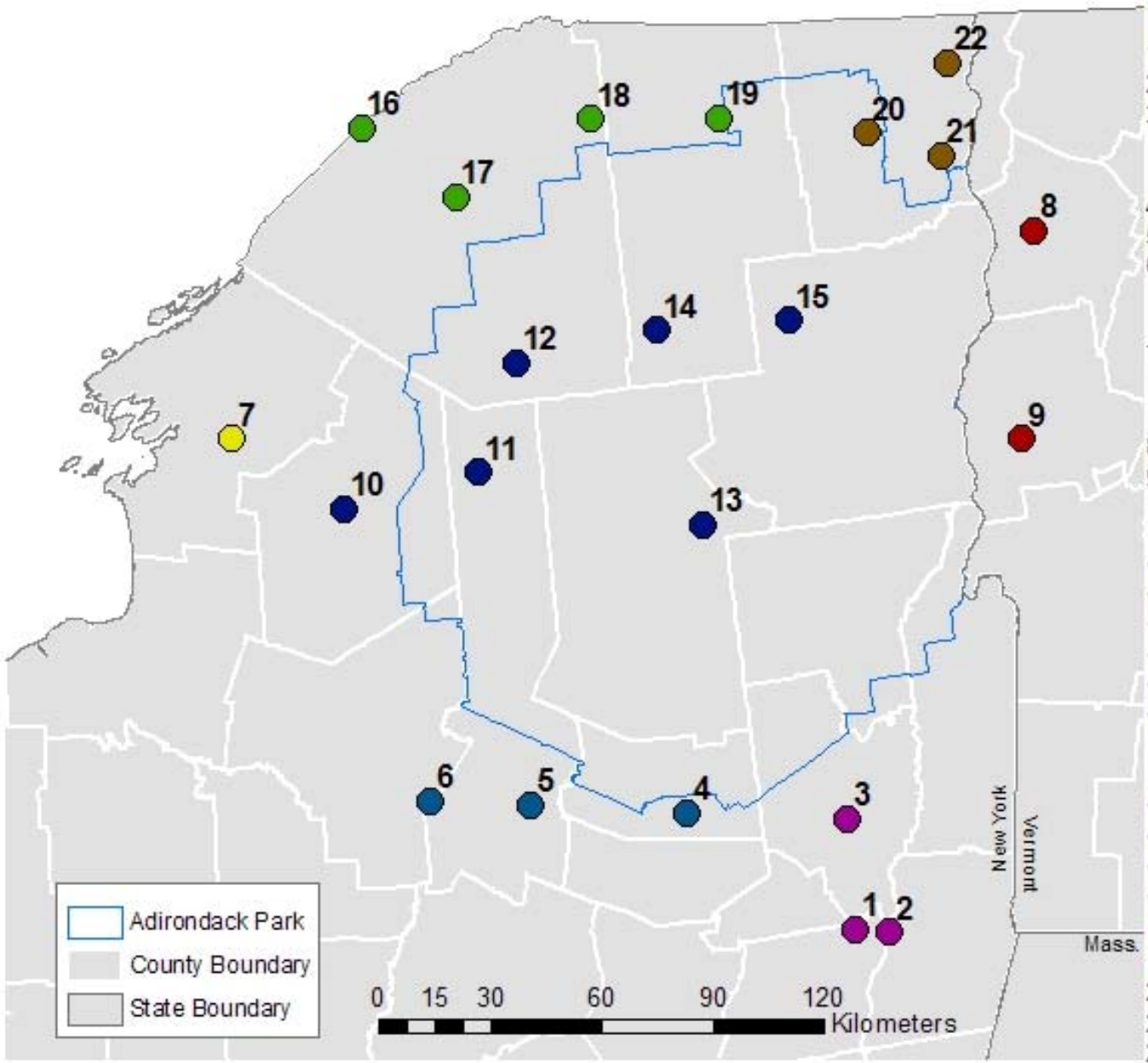
- United States Historical Climatology Network (USHCN)
  - Temperature and precipitation data
- USHCN is a subset of USCDD sites
- Recent climate studies advocate use of USHCN , as USCDD is prone to false trends in temperature and precipitation
- Corrected for:
  - Measurement technique
  - Min/Max temperature bias
  - Urban heat island effect
  - Station relocation

site selection criteria

- Period of record from 1950 - 2005
- Within 50km of Adirondack Park
- Site was eliminated if more than 3 consecutive months within a year were missing
- For daily analyses, record had to be 98% complete
- 22 sites analyzed for temp, 14 for precip, 9 for extreme precip

study area

- Predominately rural in nature
- 3 cities with a population of over 50,000
  - Albany, NY; Utica, NY; Burlington, VT
- All or portions of 17 counties in New York, 5 counties in Vermont
- 7 US Climate Divisions
- Encompass 46 “High Peaks”, at or above an elevation of 1,219 m
  - Highest pt in NYS - Mount Marcy: 1,629 m



Hudson Valley

1. Albany Airport (P)
2. Troy Lock & Dam (P)
3. Saratoga Springs 4SW

Mohawk Valley

4. Gloversville (P)
5. Little Falls City Reservoir (P)
6. Utica

Great Lakes

7. Watertown (P)

Western Vermont

8. Burlington Airport (P)
9. Cornwall

Northern Plateau

10. Lowville
11. Stillwater Reservoir (P)
12. Wanakena Ranger School (P)
13. Indian Lake 2SW
14. Tupper Lake Sunmount (P)
15. Lake Placid 2S (P)

St. Lawrence Valley

16. Ogdensburg 4NE (P)
17. Canton 4SE
18. Lawrenceville (P)
19. Chasm Falls

Champlain Valley

20. Dannemora (P)
21. Plattsburgh AFB
22. Chazy

(P) - Precipitation Data Available

regional climate

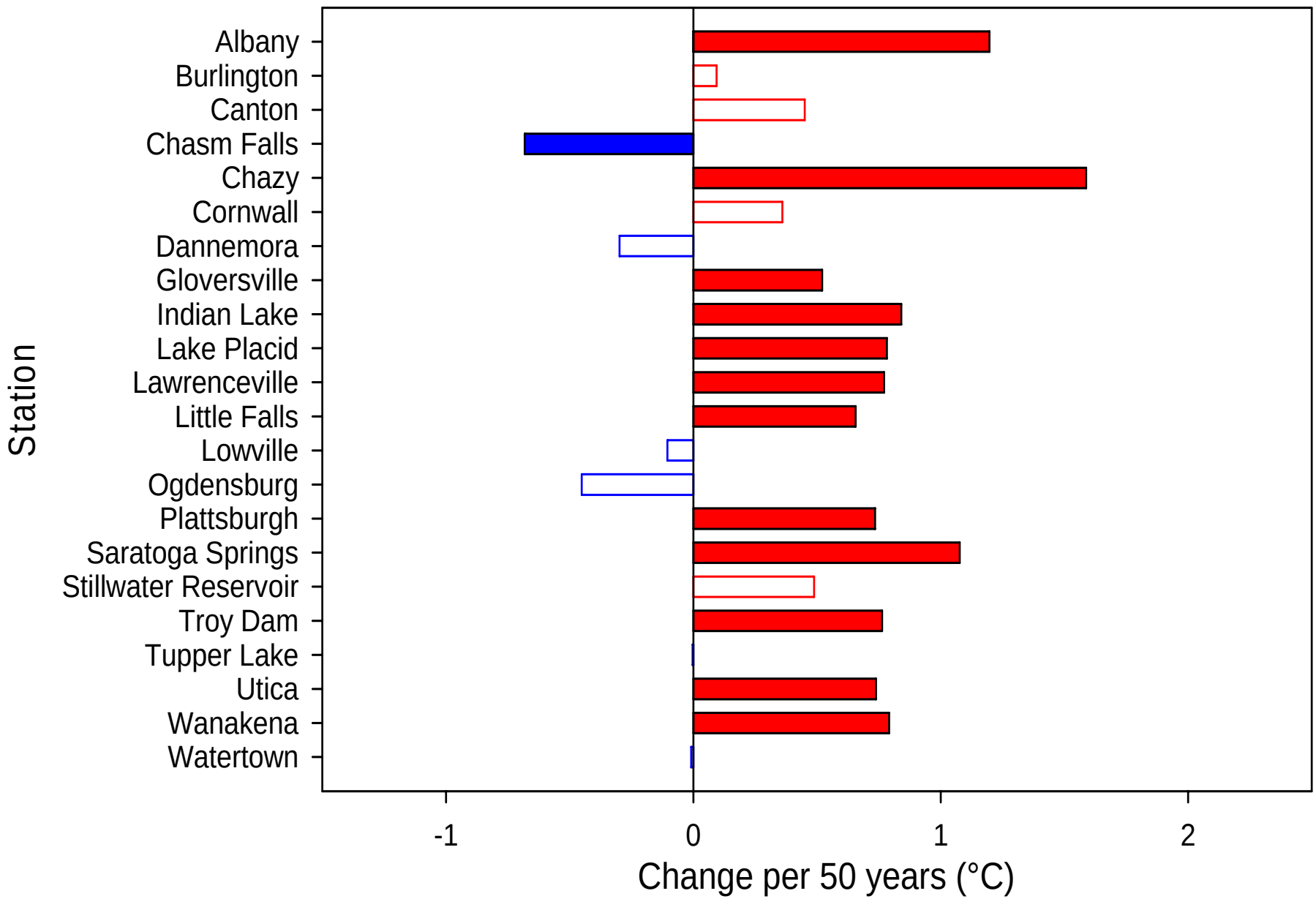
- Average temperature 1950-2005 (based on USHCN data)
  - All sites: 6.33 ºC
    - Range: 4.85 ºC (Northern Plateau) – 8.18 ºC (Hudson Valley)
- Average precipitation
  - Higher spatial variability than temperature
    - Ranges from ~760 mm (Lake Champlain area) – 1260 mm (Western Adirondacks)

results

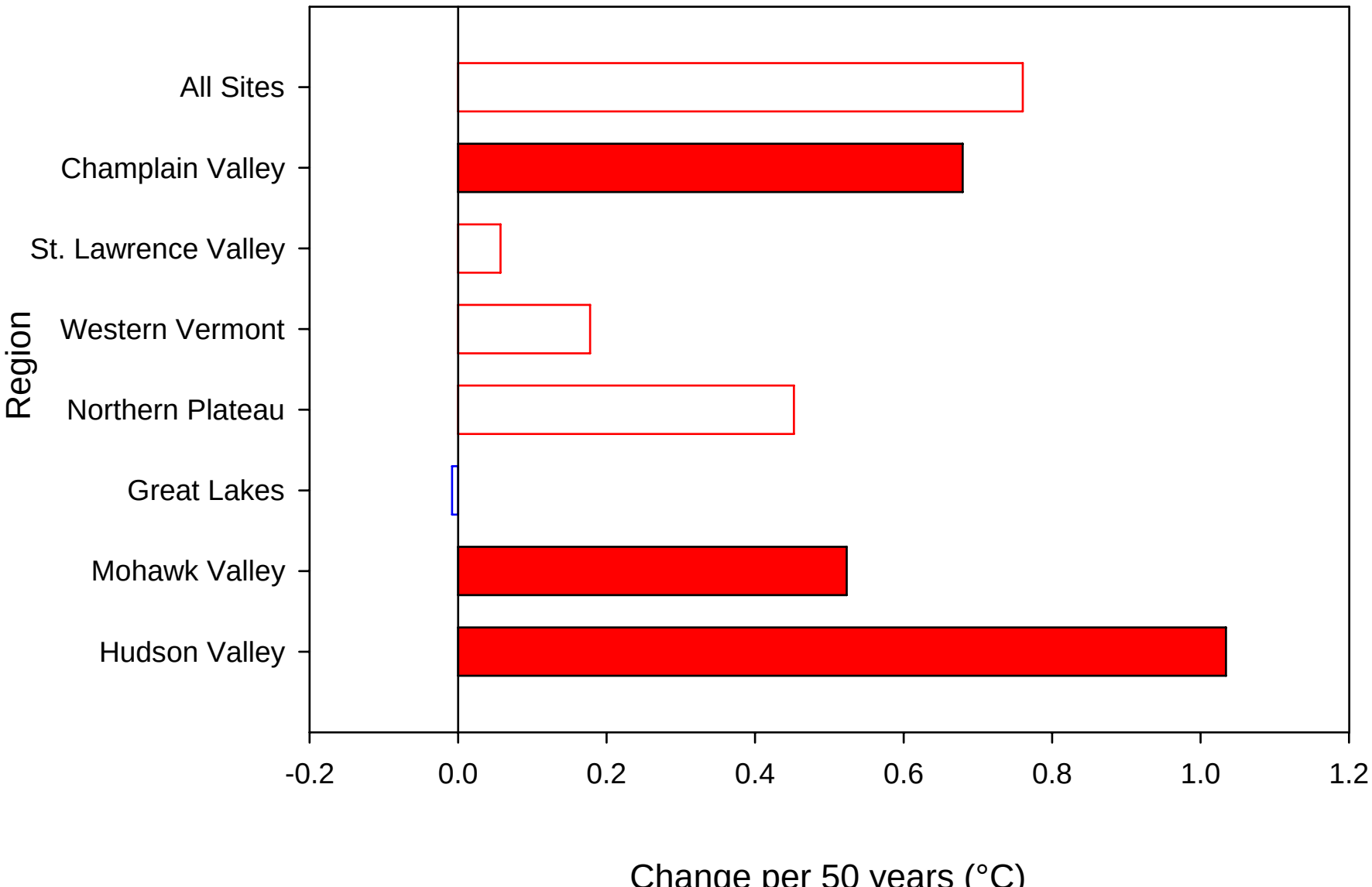
- Temperature
  - Annual (by station, regionally)
  - Seasonal
- Precipitation
  - Annual (by station)
  - Seasonal (by station)
- 24-hour max precipitation
  - 90^{th} percentile and precipitation exceedance
- Independence River

- Analyses:
  - Mann-Kendall test for trend (non-parametric), Sen's slope
    - Change per 50 and 30 years

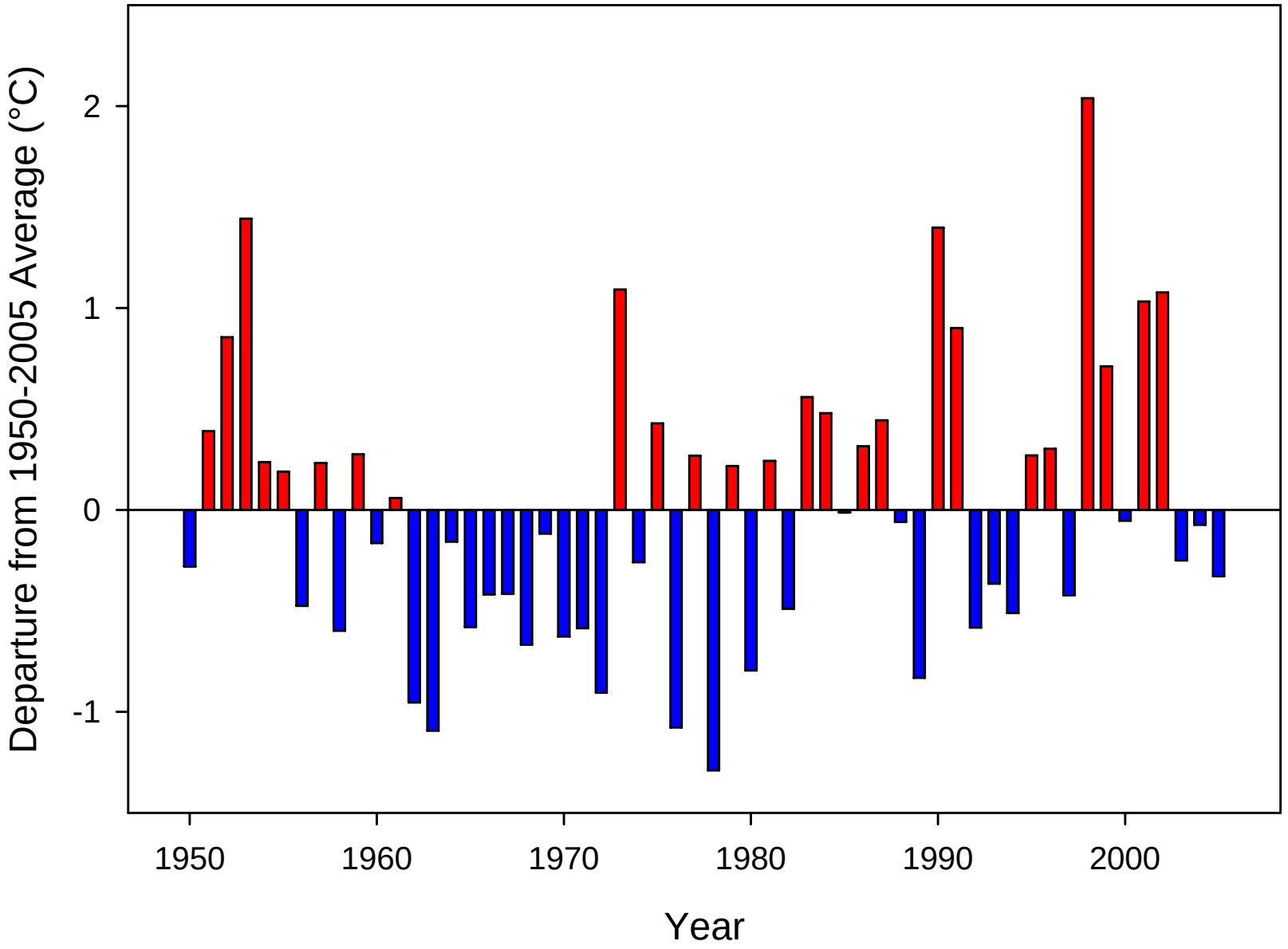
minimum temperature



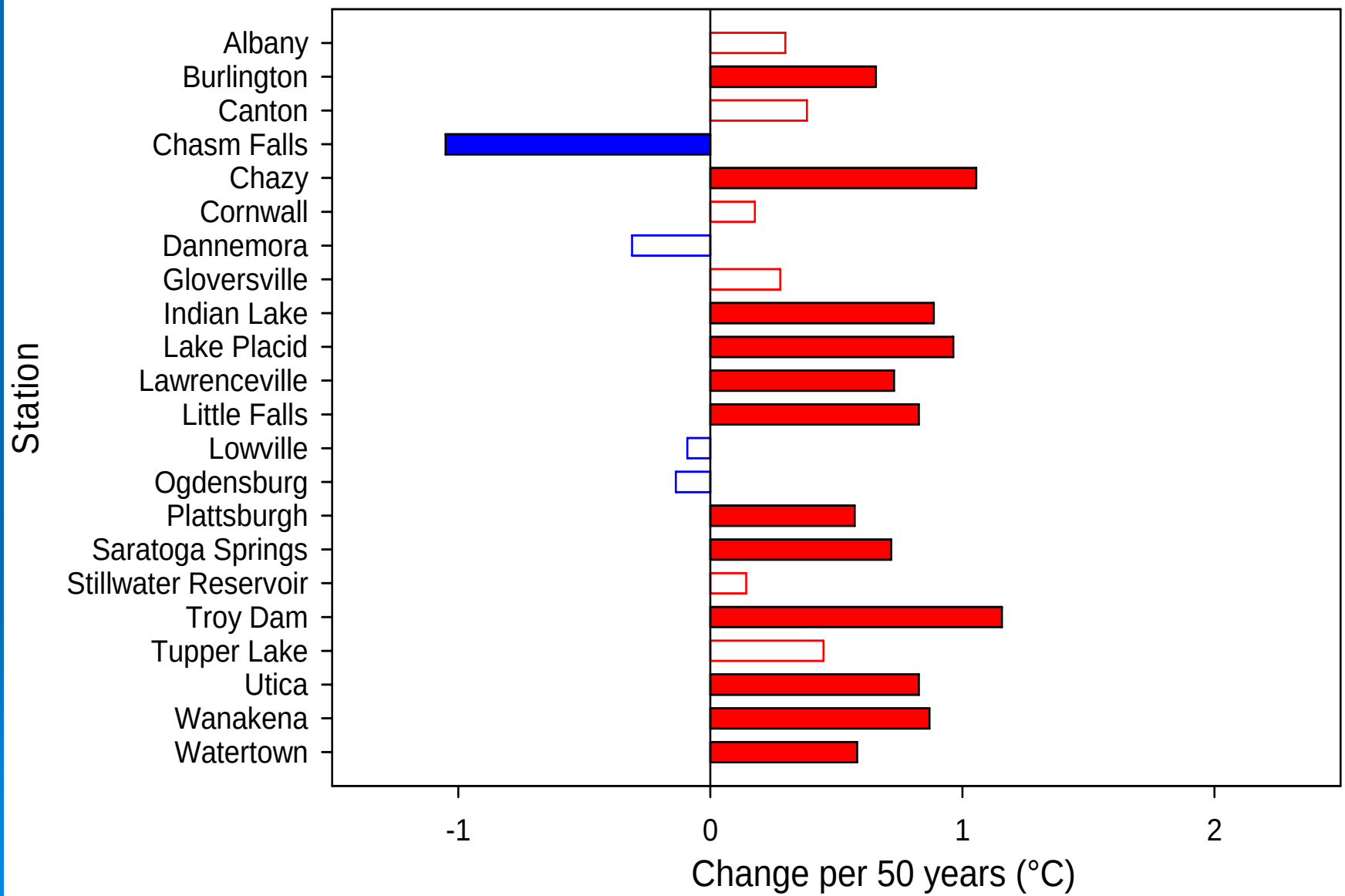
minimum temperature



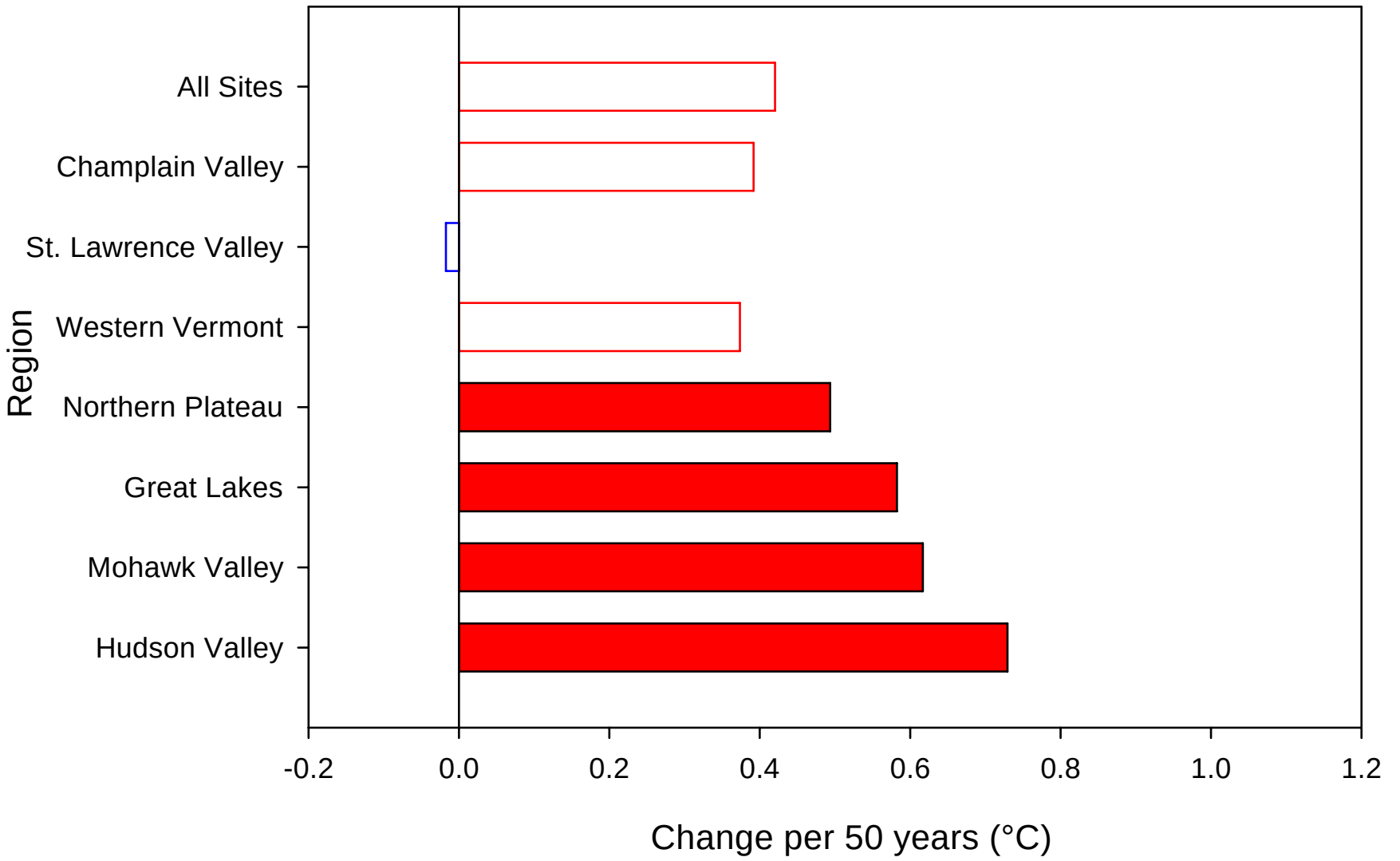
anomalies - minimum temperature



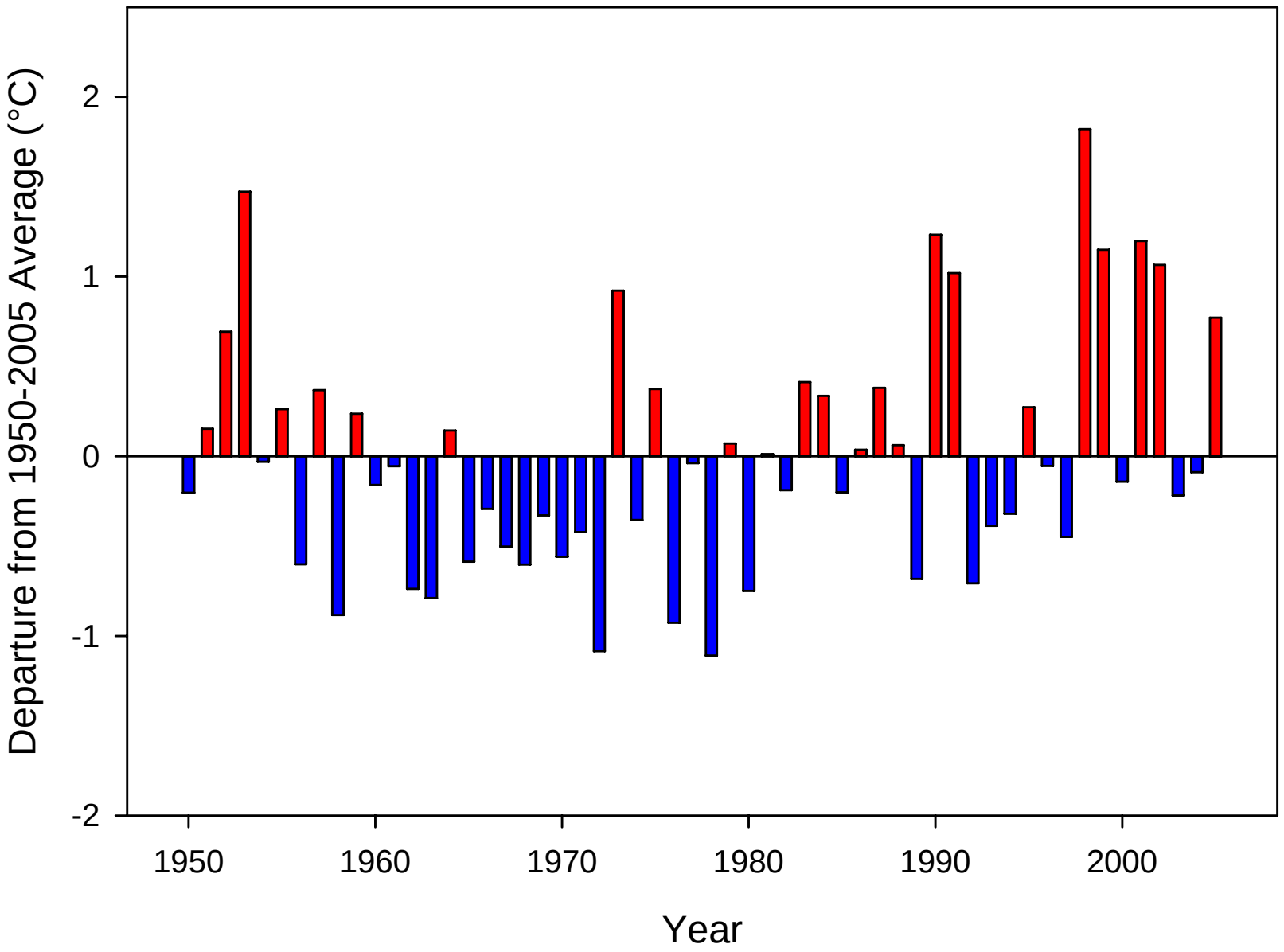
average temperature



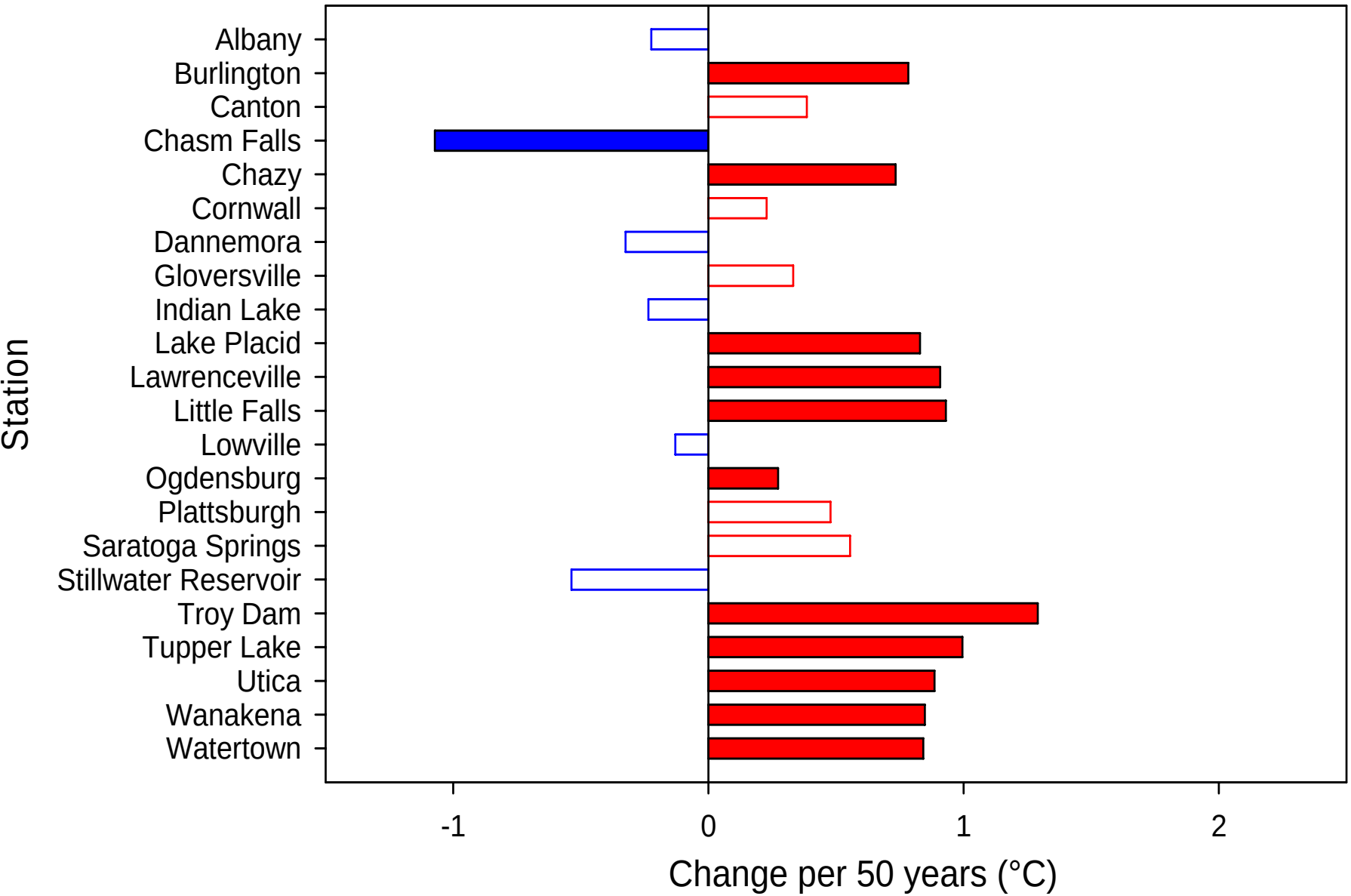
average temperature



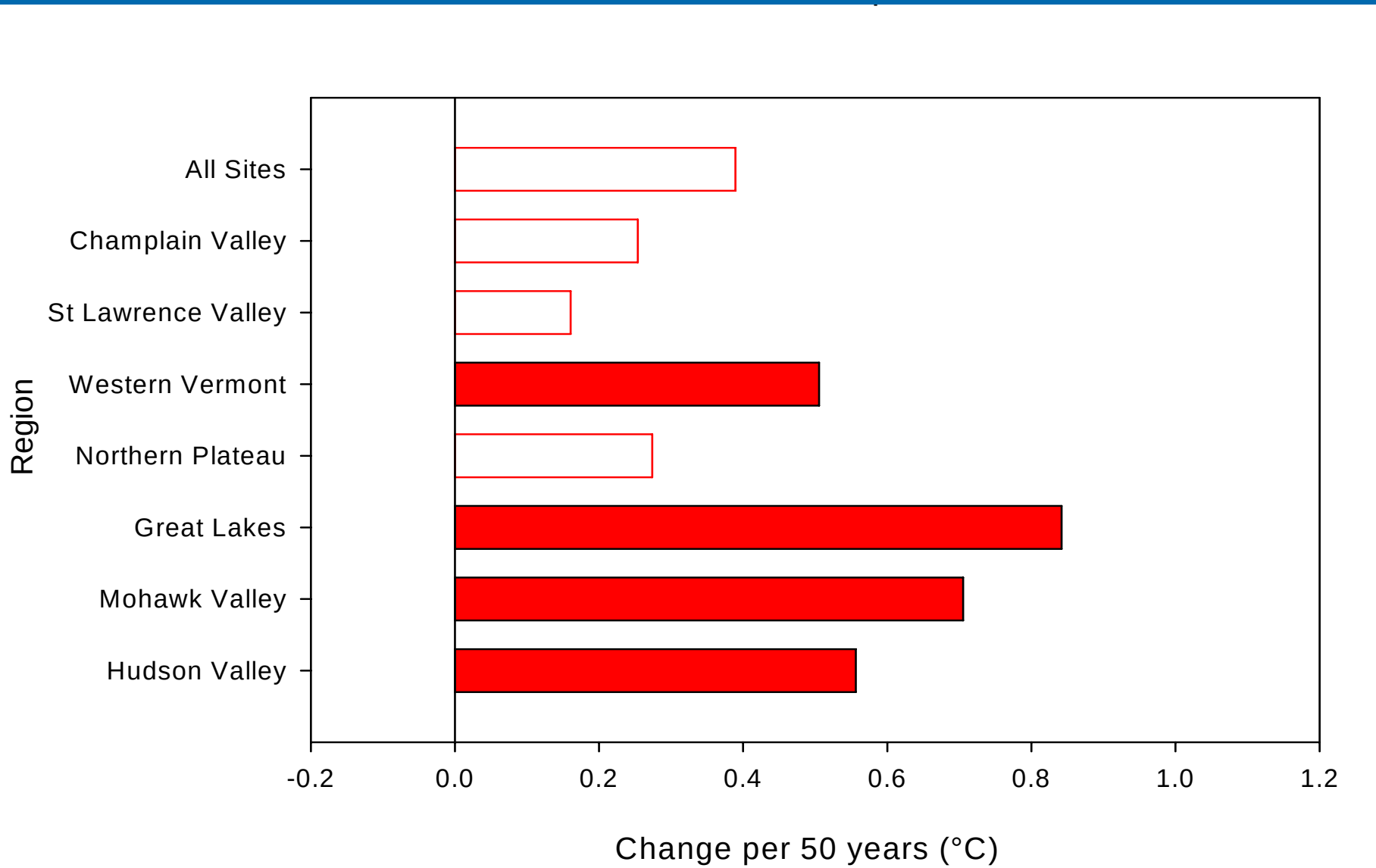
anomalies - average temperature



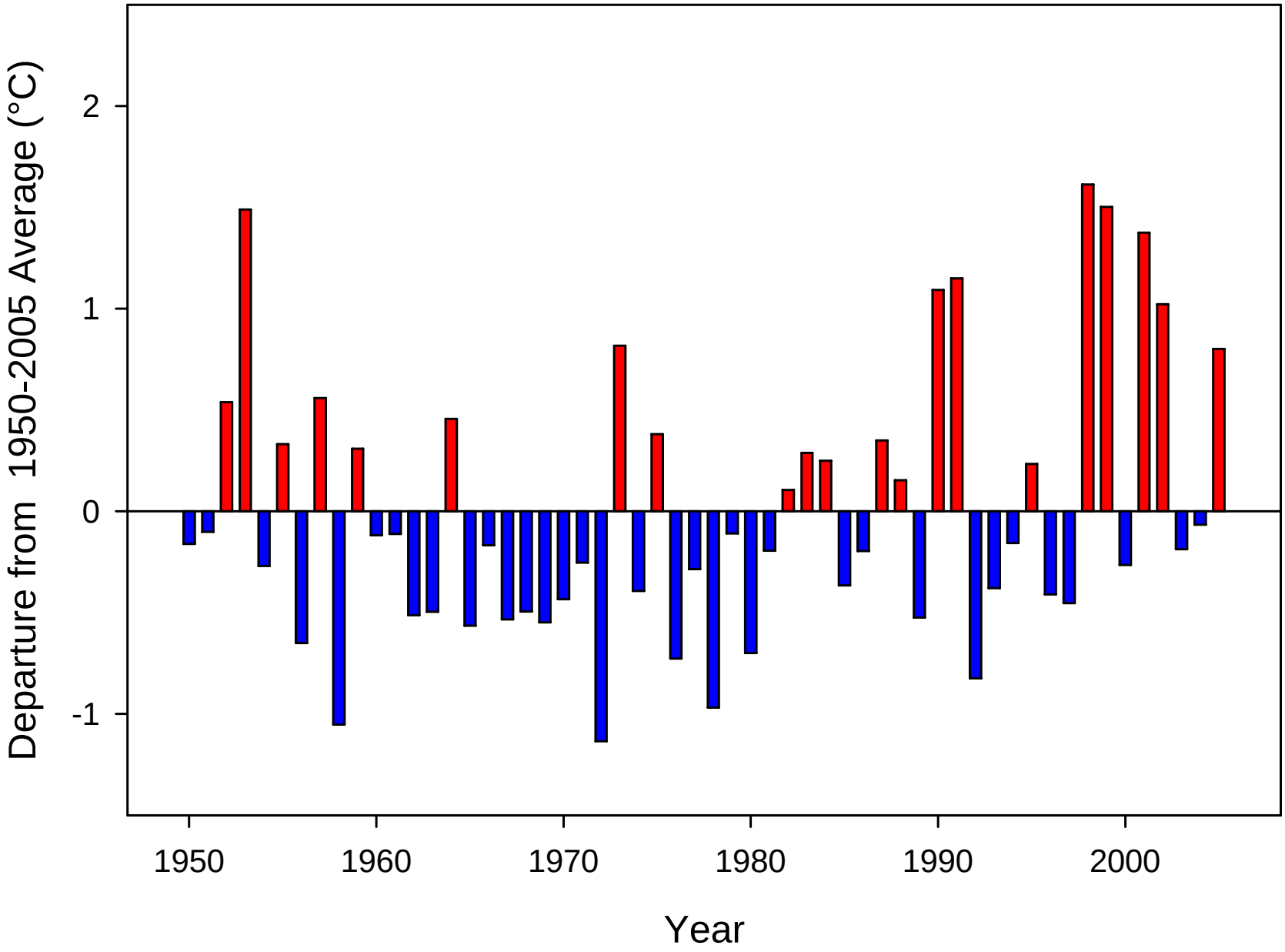
maximum temperature



maximum temperature

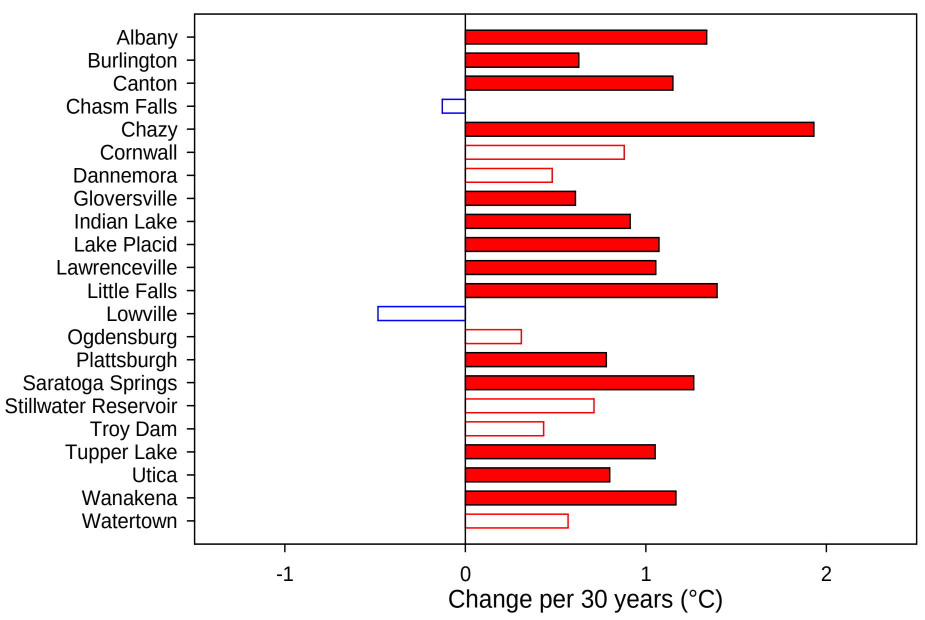


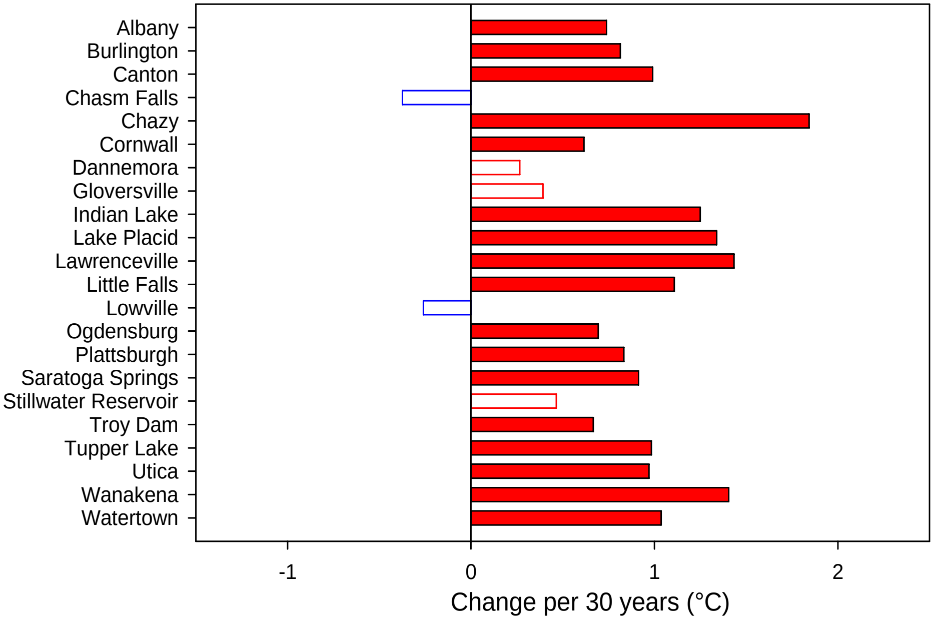
anomalies - maximum temperature

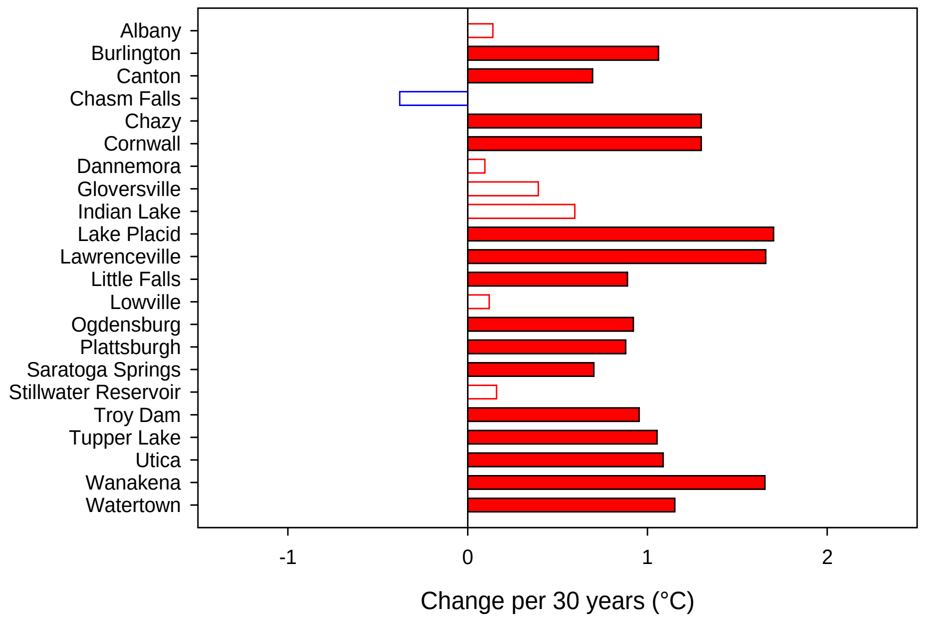


temperature: 1970-2005

clockwise, top to bottom
-minimum temperature
-average temperature
-maximum temperature

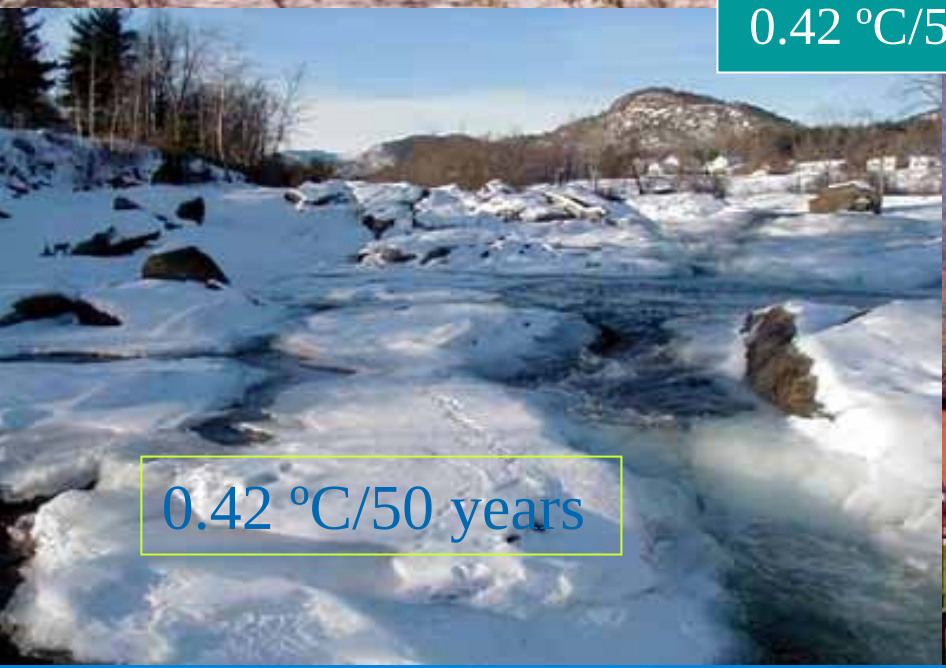






changes in average temperature in the region

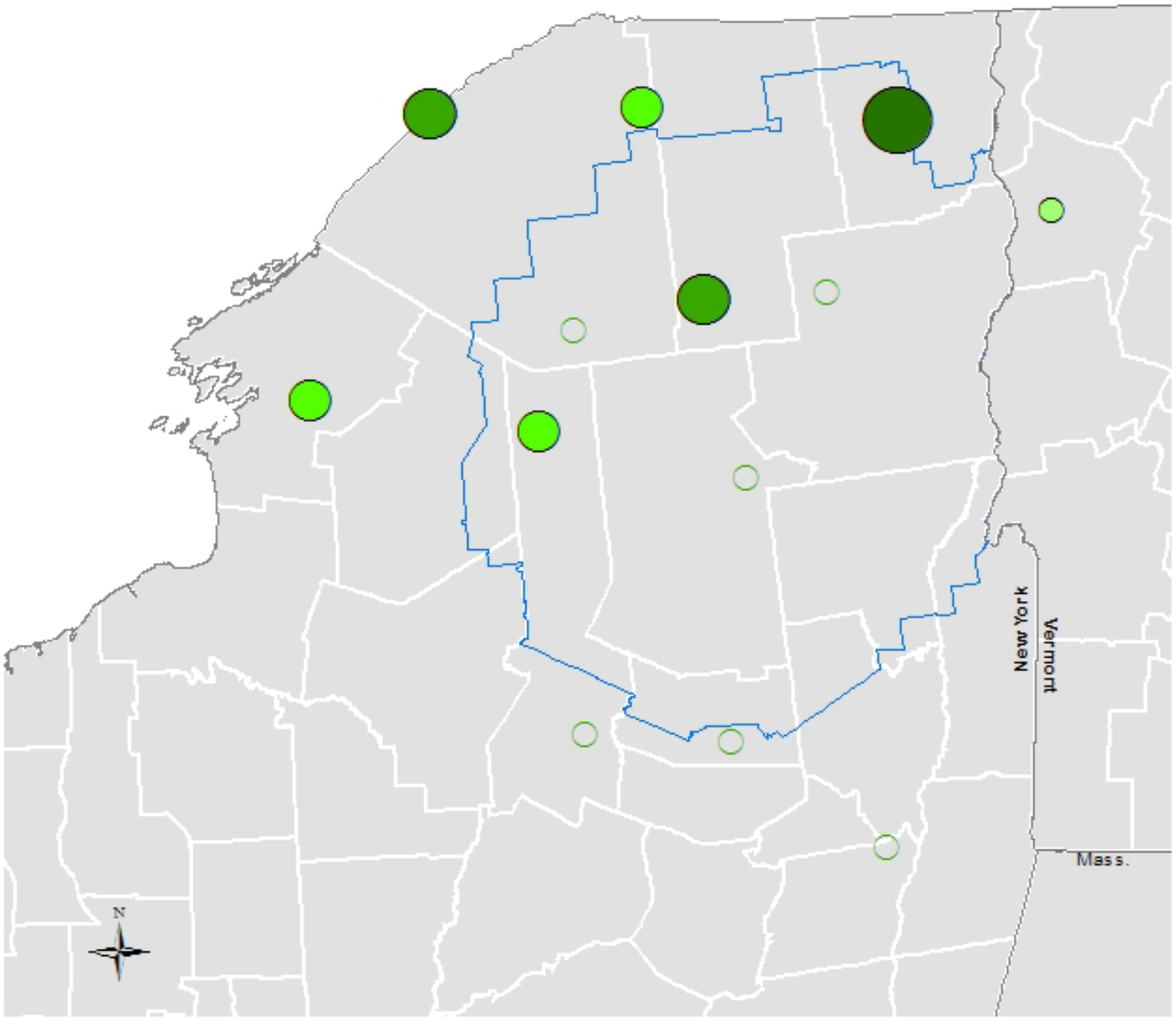
0.42 ºC/50 years



* Statistically significant @ 0.10 level

Clockwise, from top left: www.Cabinsatmillcreek.com, www.adkcamp.com, www.fortwilliamhenry.com,www.adirondackinns.com

Trends in Total Annual Precipitation, 1950-2005



Increasing Trend*

- 300+ mm
- 200-300 mm
- 100-200 mm
- 0-100 mm

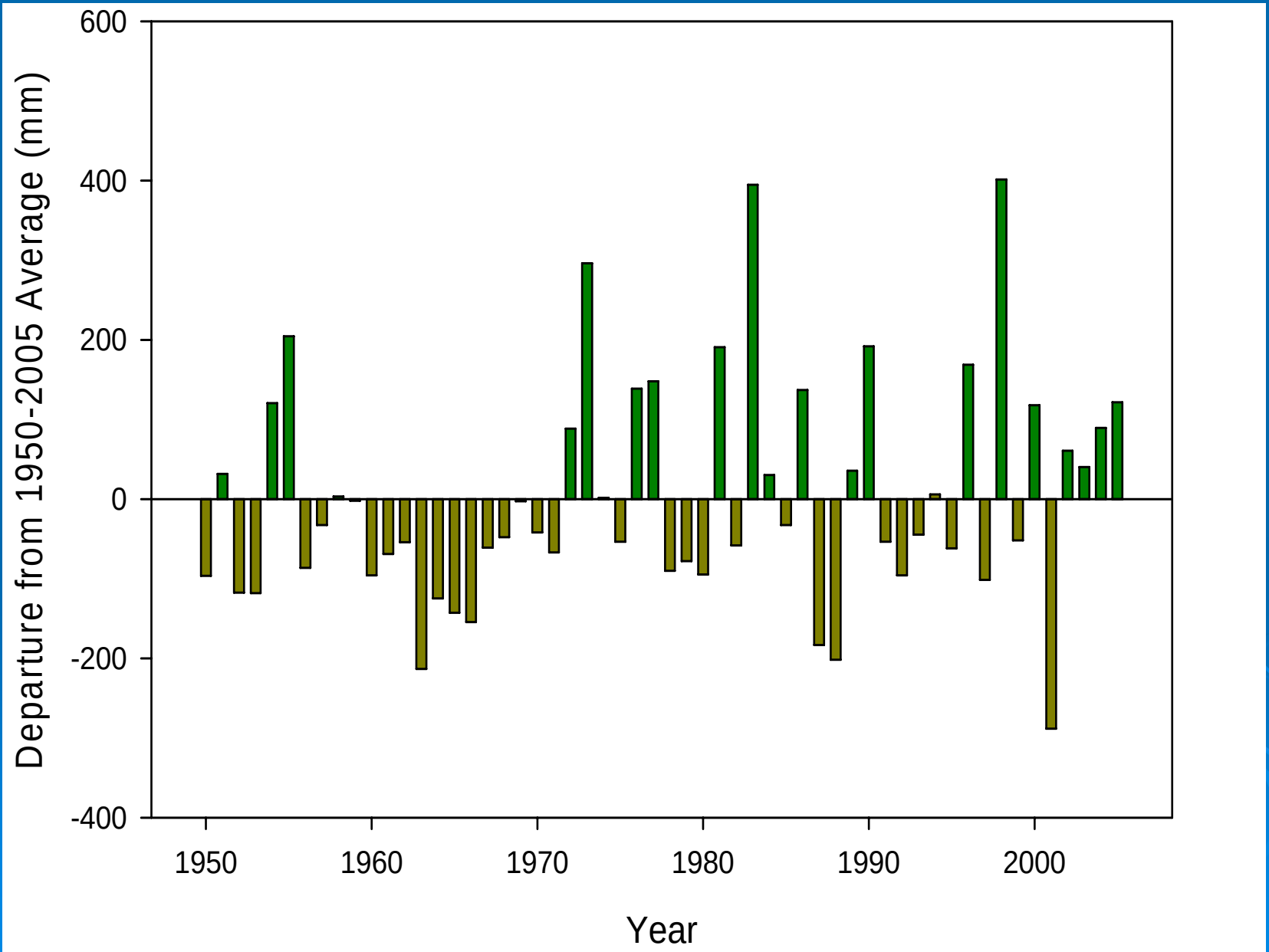
Decreasing Trend*

- 0-100 mm
- 100-200 mm
- 200-300 mm
- 300 + mm

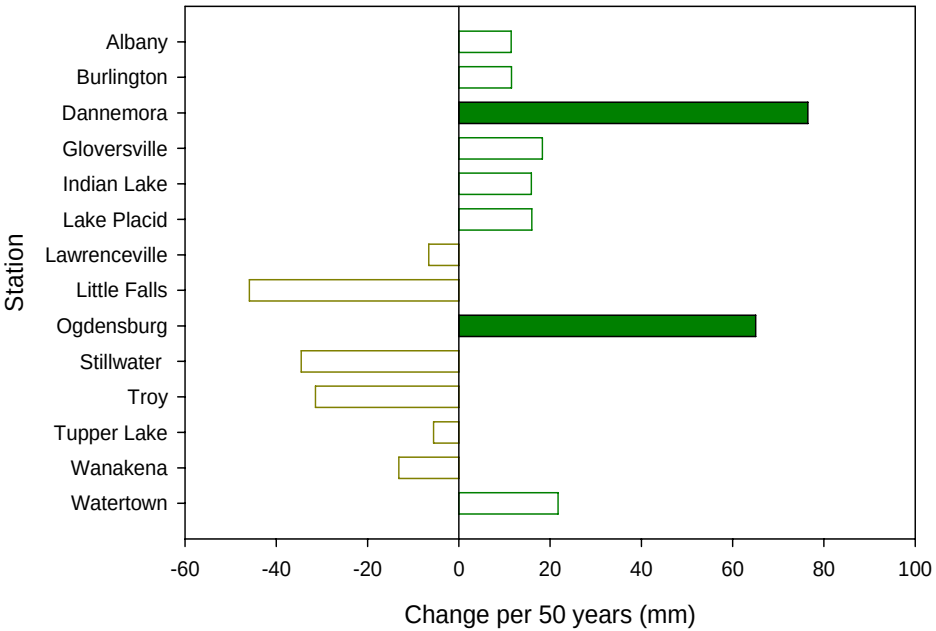
- Adirondack Park
- County Boundary
- State Boundary

*** Solid Circle: Statistically Significant p<.10**

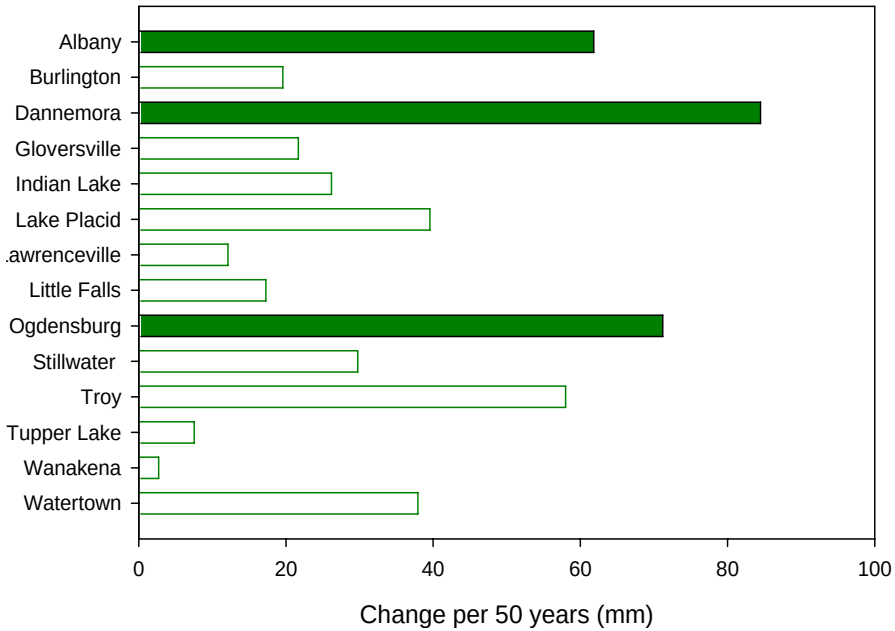
anomalies – precipitation



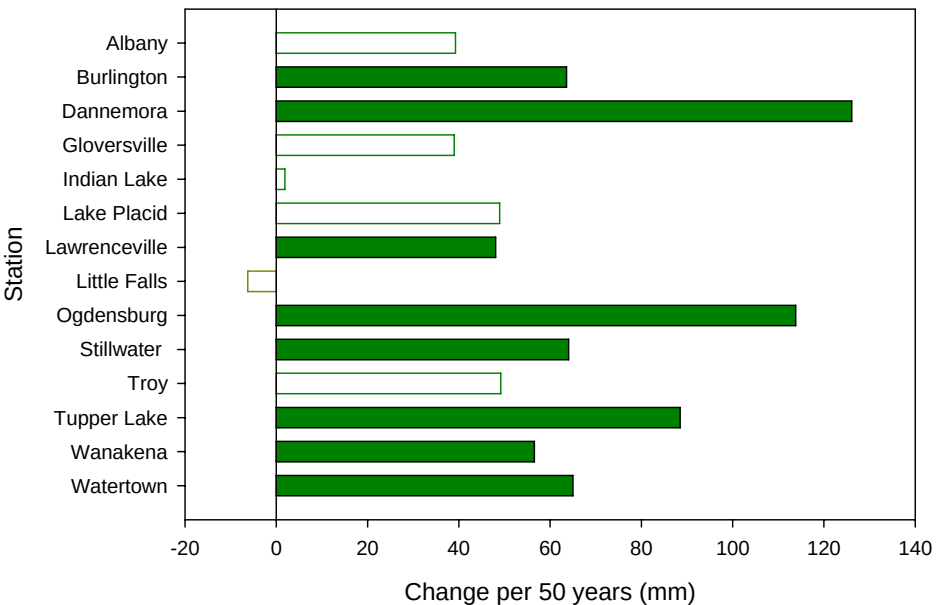
Total Spring Precipitation, 1950-2005



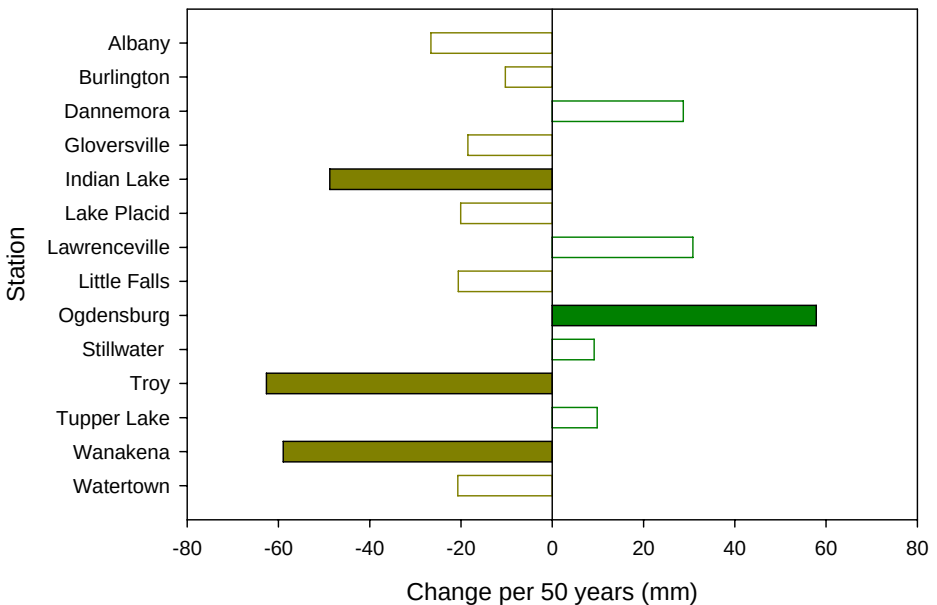
Total Summer Precipitation, 1950-2005



Total Fall Precipitation, 1950-2005



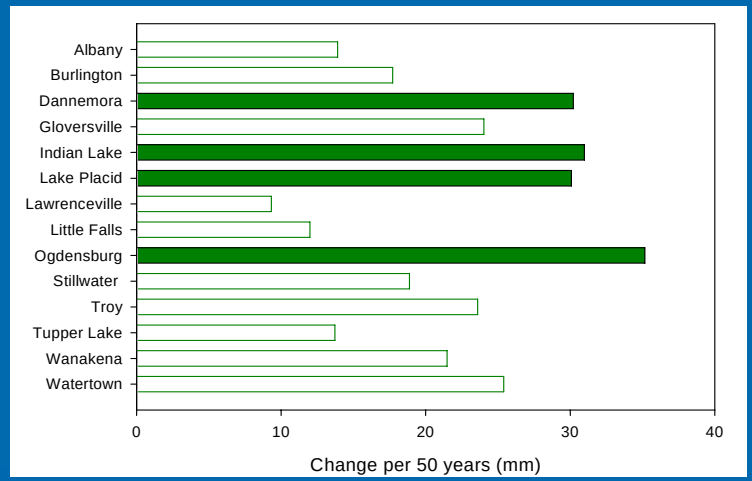
Total Winter Precipitation, 1950-2005

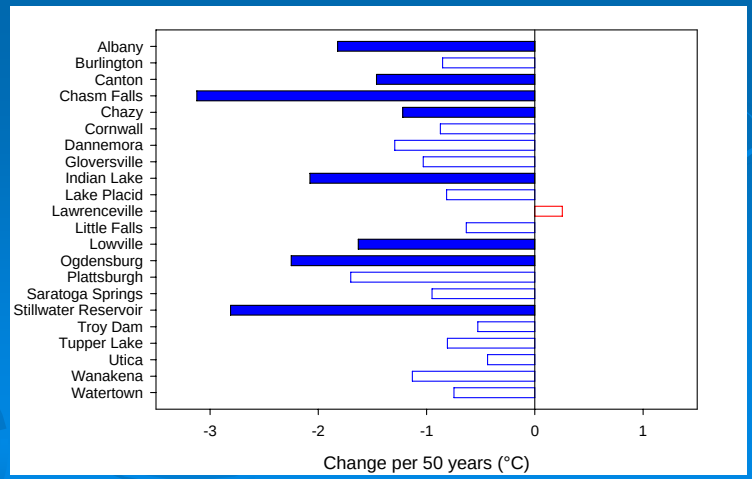


October: precip. vs. max temp.

- Spearman's rho calculated for stations with statistically significant increase in October precipitation

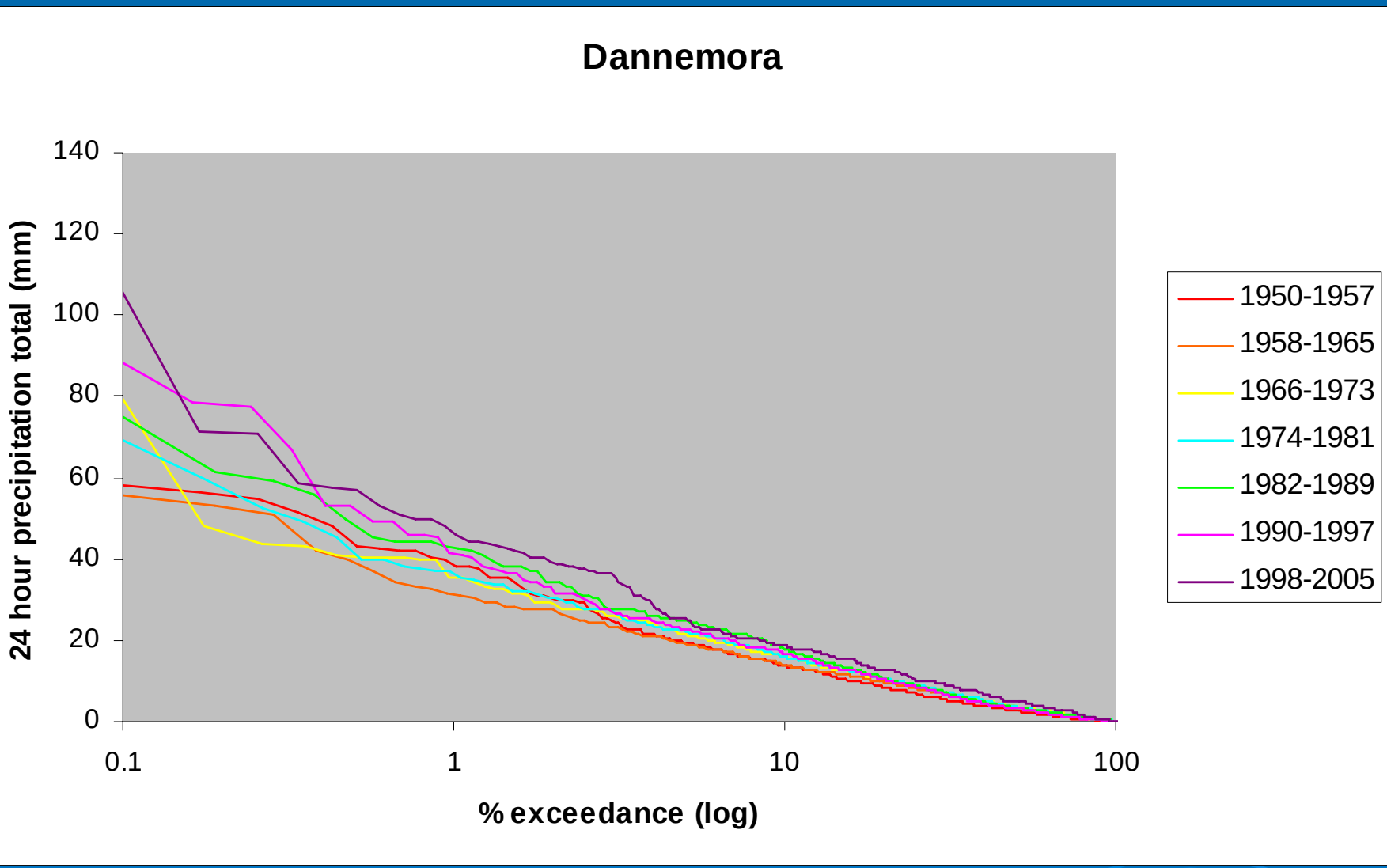
- Indian Lake (p<.01, -.356)
- Lake Placid (p<.05, -.331)
- Ogdensburg (p<.01, -.399)
- Dannemora (p<.01, -.388)



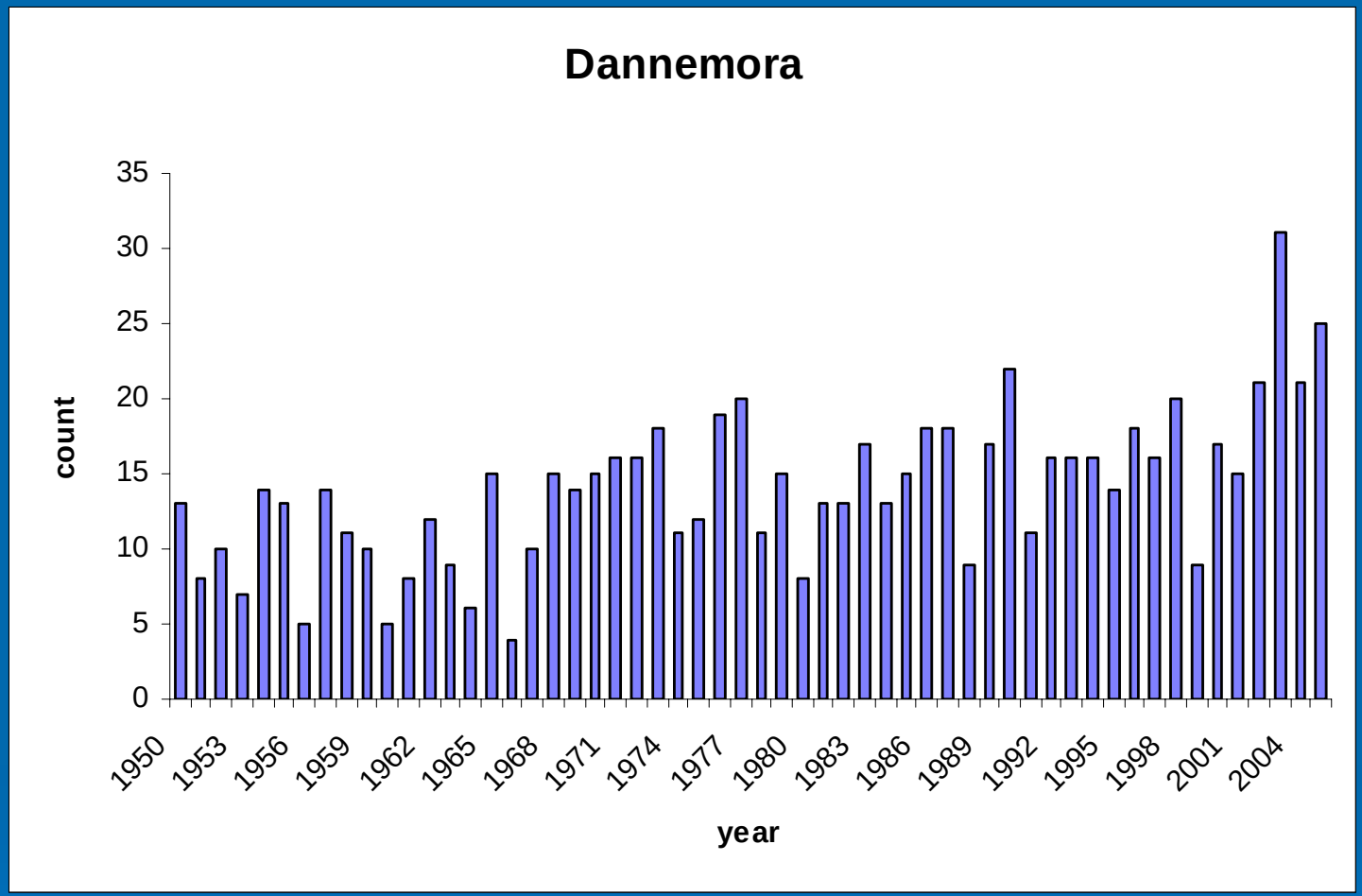


24-hour precipitation events

- 9 sites analyzed
  - 6: increasing, 4 significantly
    - From 2.75 days/50 years (Lawrenceville) to 9.2 days/50 years in (Dannemora)
  - 3: no change
- 3 largest increases on eastern side of basin, largest increase at highest latitude

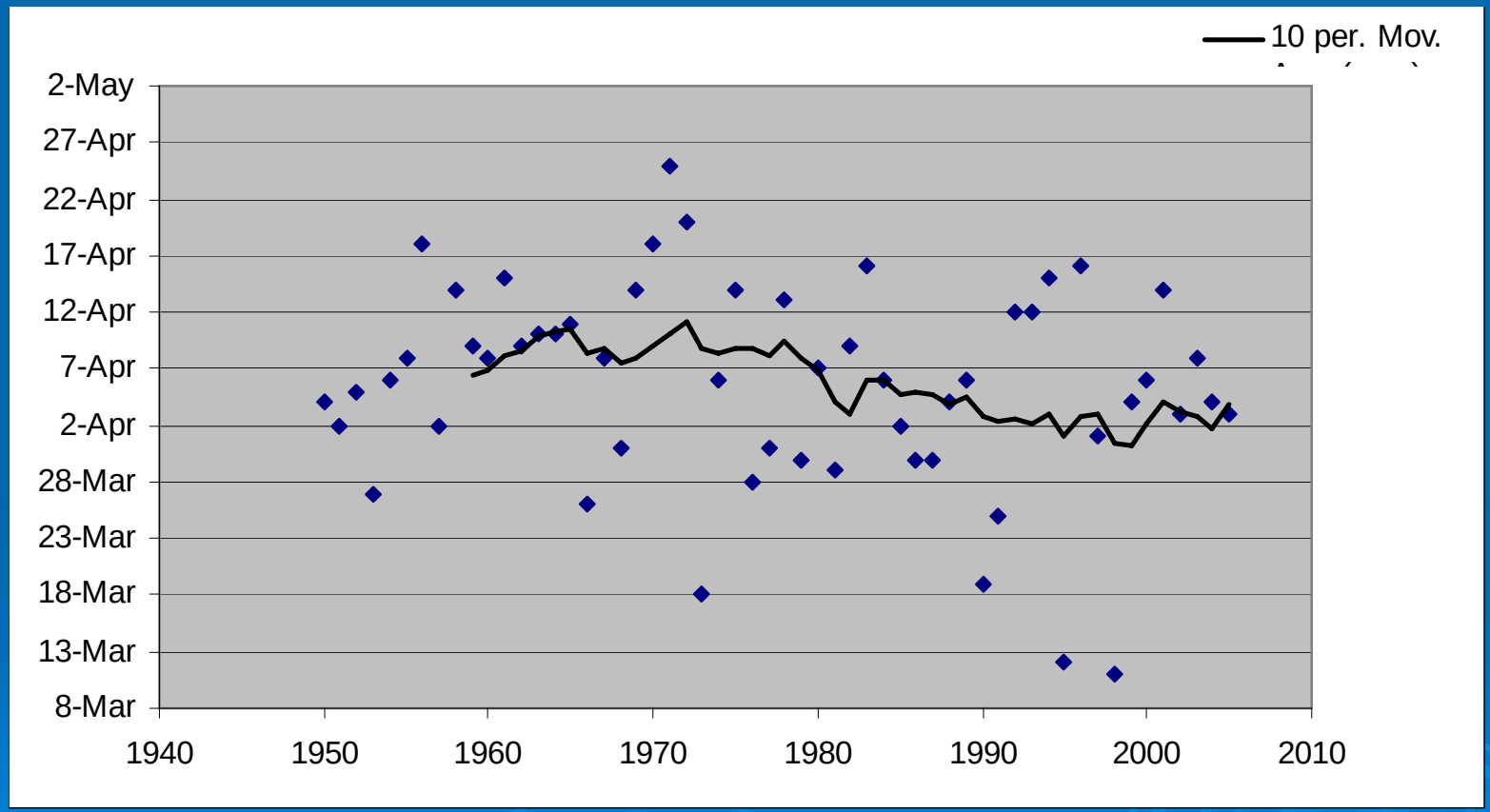


- Site with largest trend in precipitation per 50 years
- Highest values in 1998-2005, second 1990 - 1997



Days with precipitation over the 90th percentile value (~18mm) rose by 9.2 days/ 50 years ($p<.01$)

Independence River



Method adapted from: Hodgkins et al. 2003. Changes in the timing of high river flows in New England in the 20th century

conclusions

- Overall there are increases in temperature and precipitation
  - Especially from 1970-2005
- Largest increases occurred in annual minimum temperature
- Summer, not winter, warmed most
  - Contrary to Northeast
  - August
- Temperatures decreased in Fall
  - October
  - Regional average barely increasing, not SS

conclusions

- Site with largest increase in precipitation also had largest increase in 24-hour maximum precipitation
  - Dannemora
- Seems to be a relationship between maximum temperature and precipitation
- Number of 1-day large precip events increasing

What does this mean?

- Longer, hotter summers
  - Could be a mixed blessing for the summertime recreation industry
    - More recreation, more introduction of invasive species?
  - Affect ecosystem
    - Sugar maple, maple sugar production
    - Longer warm growing season, but many “cool weather” crops in NE
    - Dairy cattle perform best at 4 °C to 24 °C
- Shorter, warmer winters
  - Earlier spring snowmelt
  - Less snow, more dense snowpack
    - Bad for ski industry ($)
    - Ice fishing
    - More lake effect events occuring as rain?

Kunkel, K.E., Westcott, N.E., Kristovick, D.A.R. (2002) Assessment of potential effects of climate change on heavy lake-effect snowstorms near lake erie. *Journal of Great Lakes Research*, 28(4), 521-536

Wake, C., & Clean Air-Cool Planet. *Indicators of climate change in the northeast 2005*

United States Global Change Research Program. Climate Change Impacts on the US:Northeast. Accessed November 12, 2007 at http://www.usgcrp.gov/usgcrp/nacc/education/northeast/ne-edu-3.htm

What does this mean?

- Wetter summer/fall
  - But, observed droughts (2001)
  - Leaves covering sewers in the more urbanized areas can produce flooding
- Uneven distribution of precipitation may cause flooding or droughts
  - Requires significant resources for watershed management and planning

What does this mean?

- Lake Champlain not freezing over
  - Higher temp, lower dissolved oxygen
  - Other chemical and biological affects
    - Algal blooms
    - Runoff (nutrients)

Winslow, M. (2006). The heat is on. *Lake Champlain Committee Lake Look.* Retrieved November 11, 2007 from http://www.lakechamplaincommittee.org/cgi-bin/newspro/fullnews.cgi?newsid1158589838,15832

acknowledgments

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  - Dr. Andrei Lapenas
- NYSDEC

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