# Soil Temperature and Thaw Response to Manipulated Air Temperature and Plant Cover at Barrow and Atqasuk, Alaska

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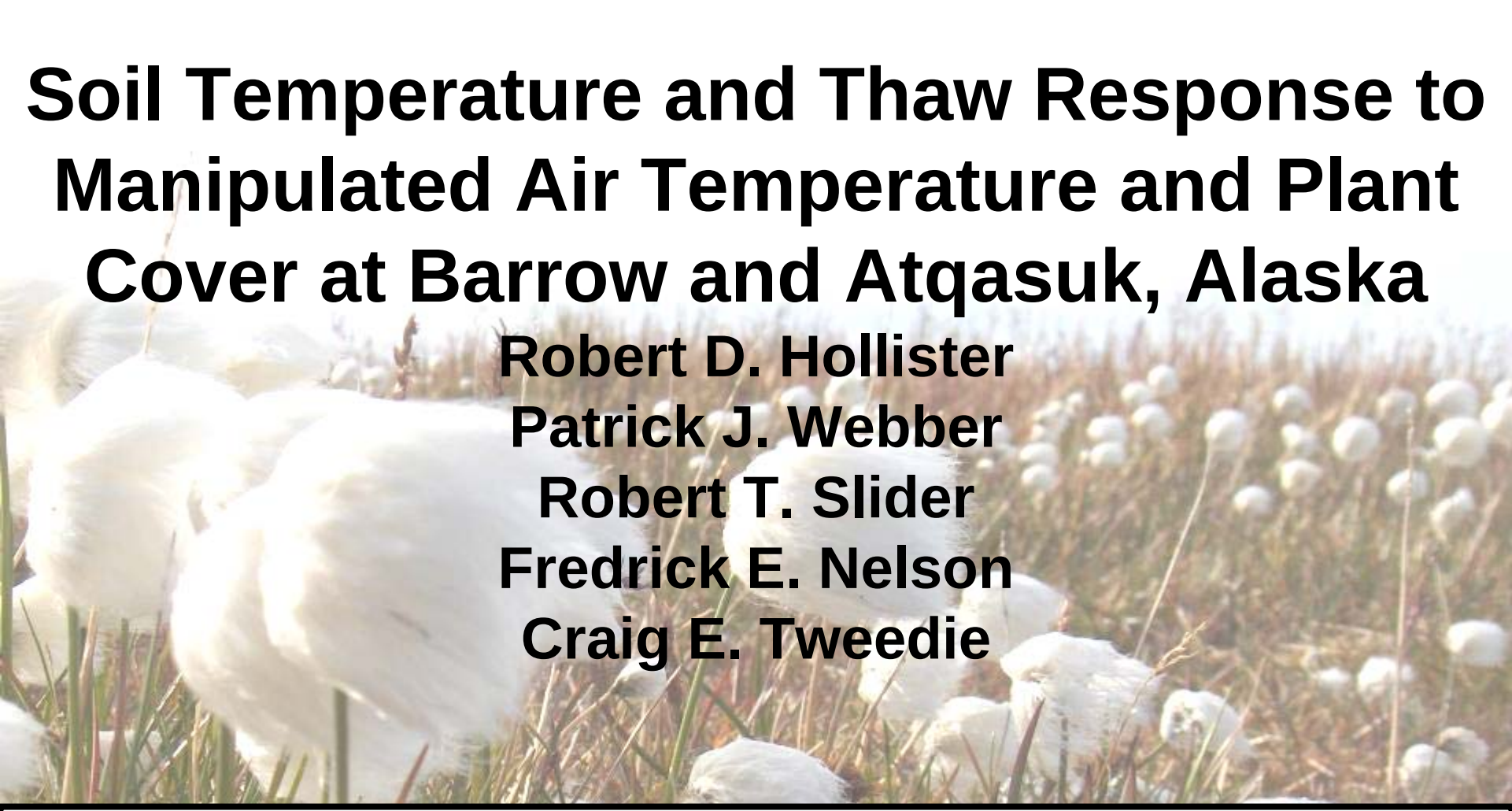
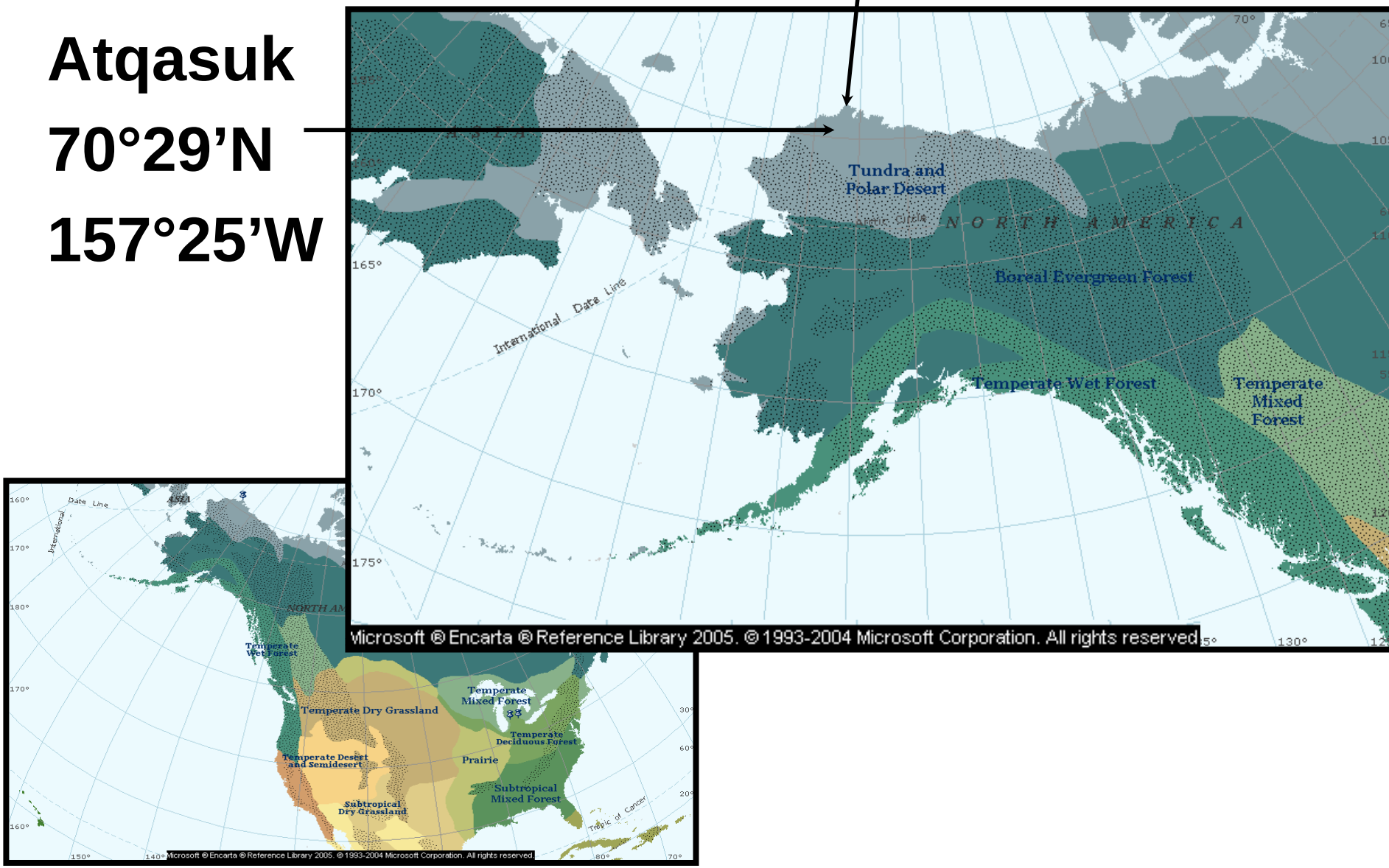


# ITEX

- Looks at plant community changes under simulated warming conditions

**Barrow 71°18’N**
**156°40’W**

**Atqasuk**
**70°29’N**
**157°25’W**



# Barrow

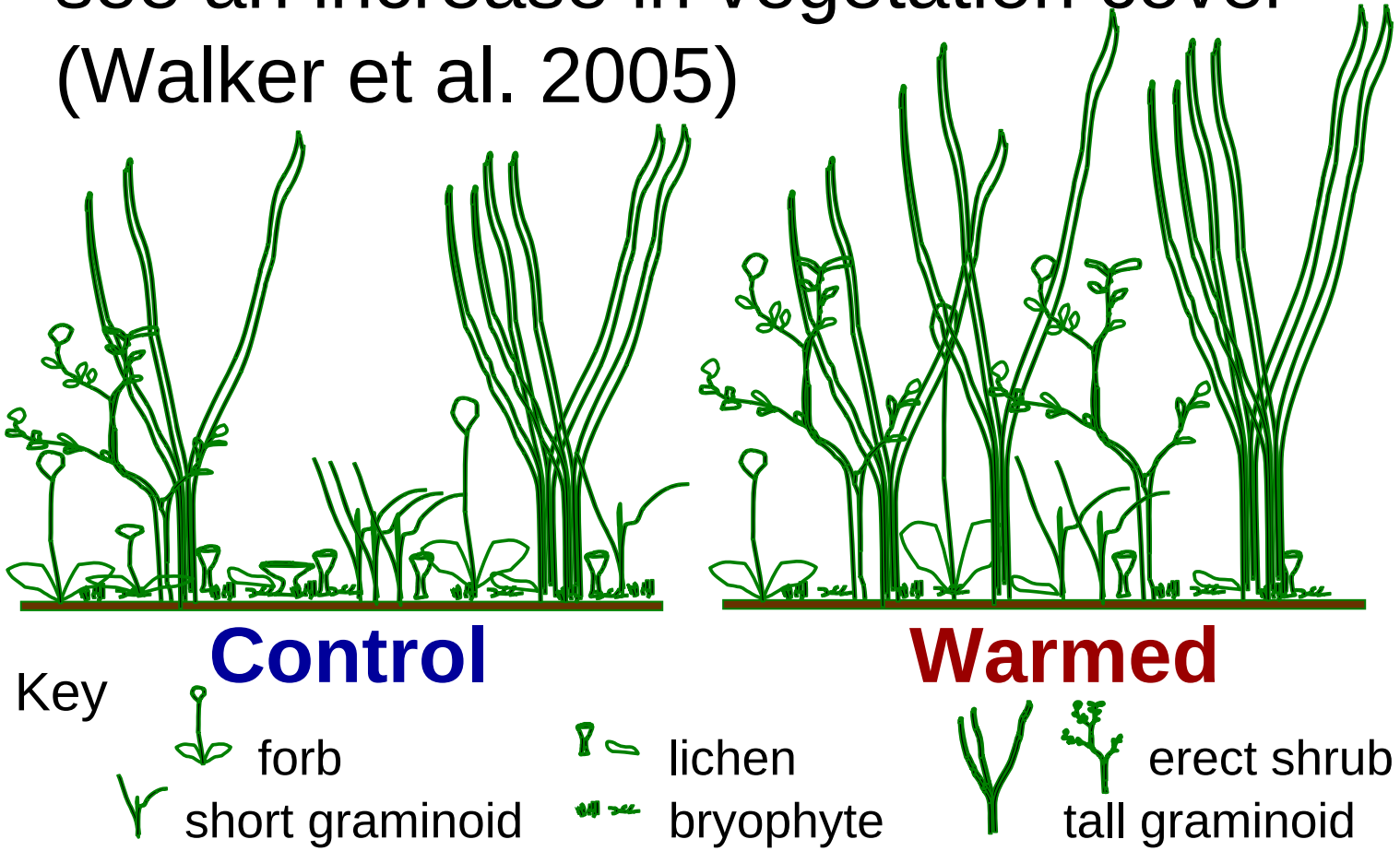
DRY

WET

# Atqasuk

# OTC's on Plants

Under simulated warming conditions we see an increase in vegetation cover (Walker et al. 2005)

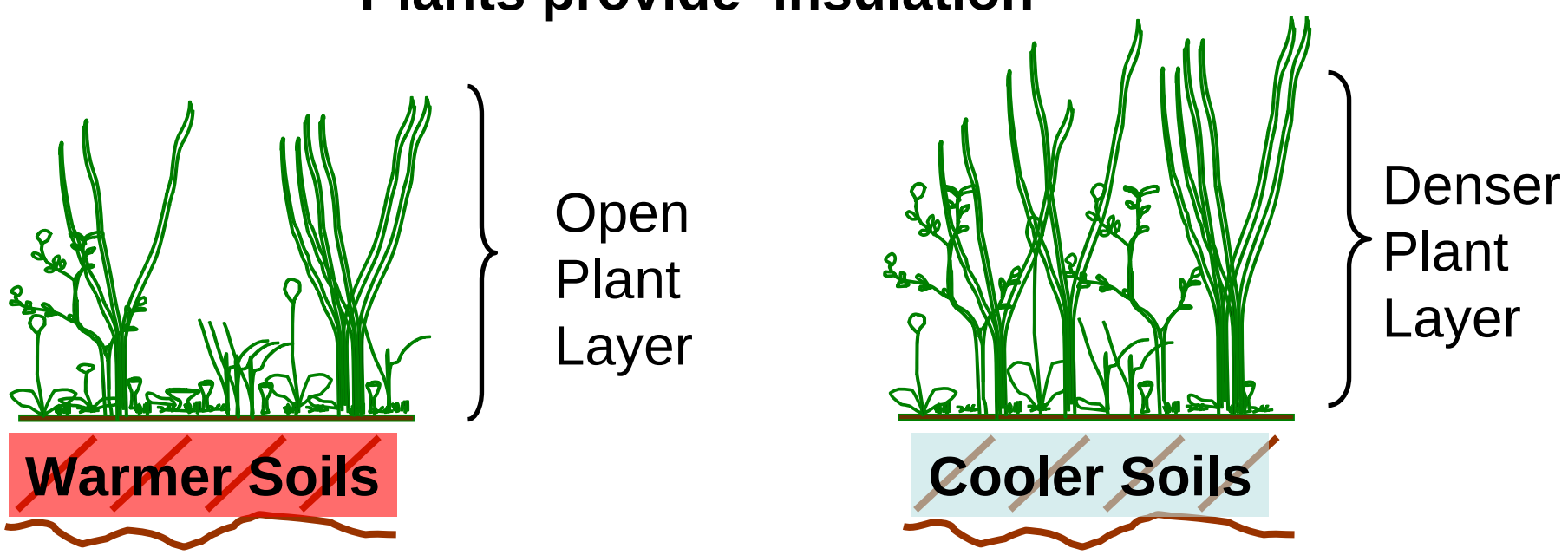


# Plants, Soil, and Temperature

Changes & Interactions in the Arctic

In 2006 Hollister et al. suggested that an increase in cover may yield a greater amount of thermal resistance

**Plants provide insulation**



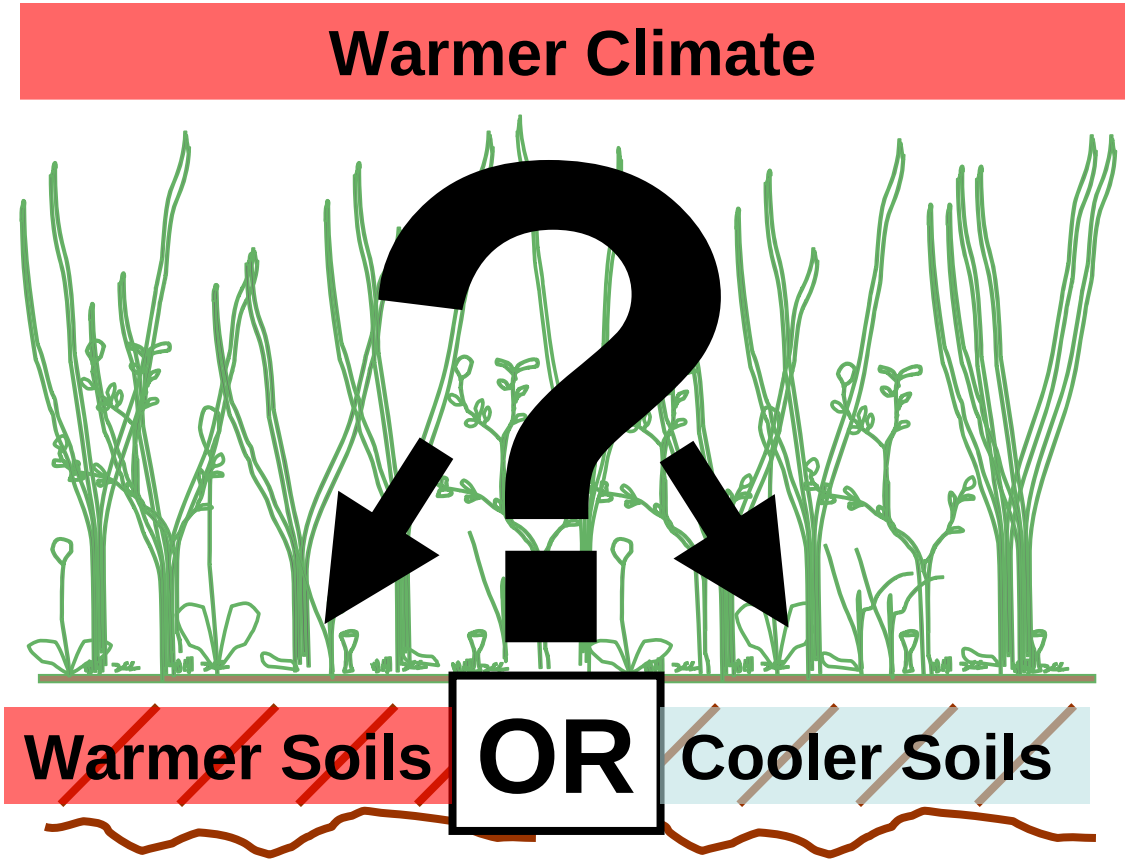
# The Big Question

How much does vegetation influence soil temperature?

**Warmer soils by Warmer air?**

**OR**

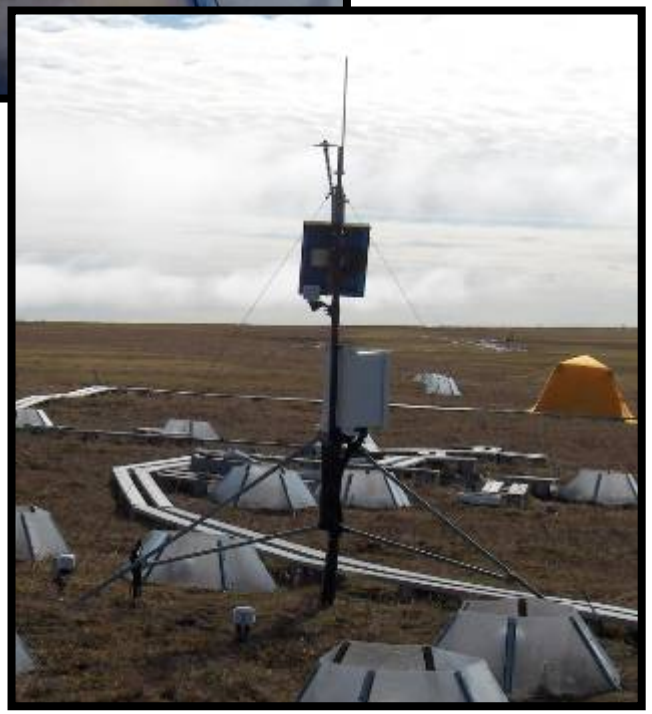
**Cooler Soils by greater Insulation?**



# Measurements

- Thaw Depth
  (end of season using graduated metal rod)

- Air and Soil Temperatures
  (using Campbell Data Loggers)



# OTC's on Thaw

**Thaw depth in cm**

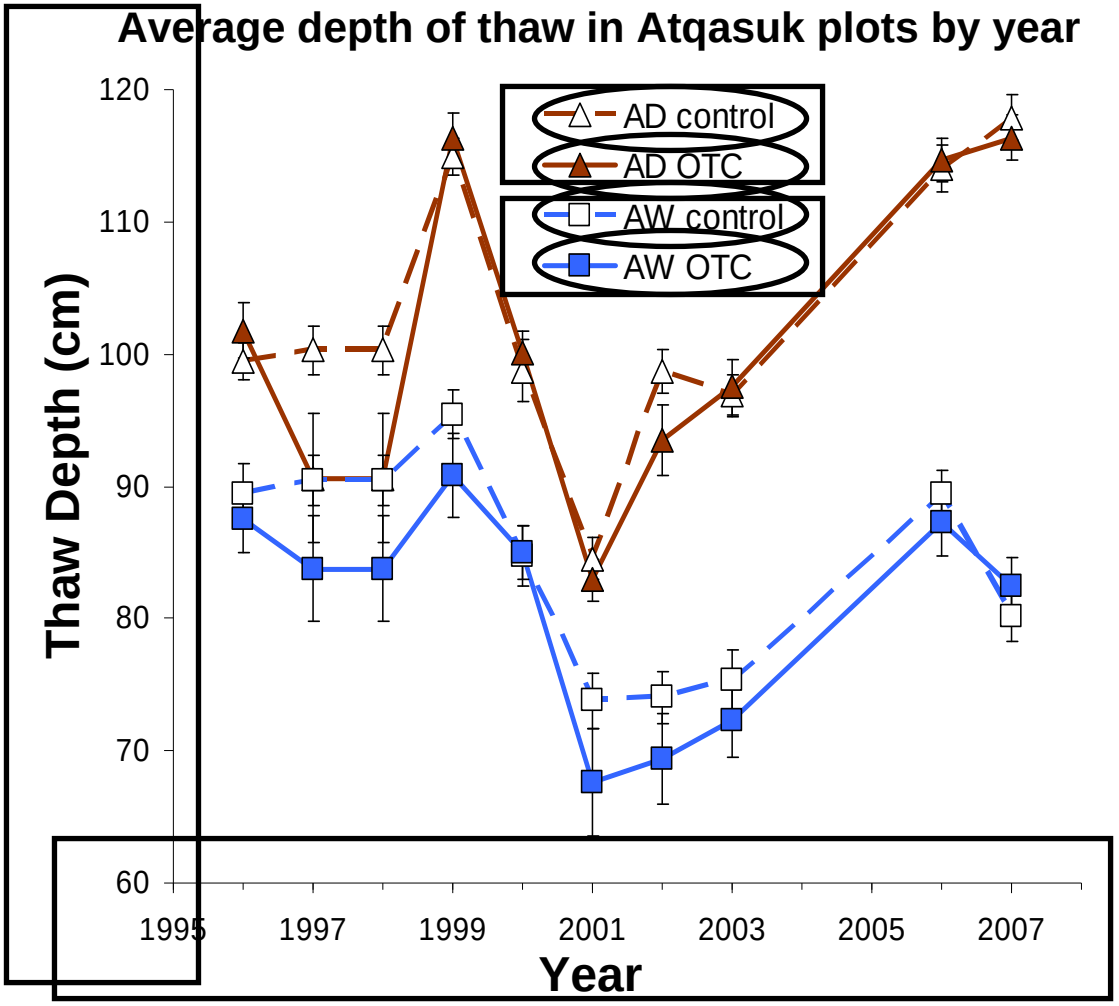
**Year**

**Dry Site**

**Wet Site**

**OTC Plots (averaged)**

**Control Plots (averaged)**



# OTC's on Thaw

**August average depth of thaw by site and year**

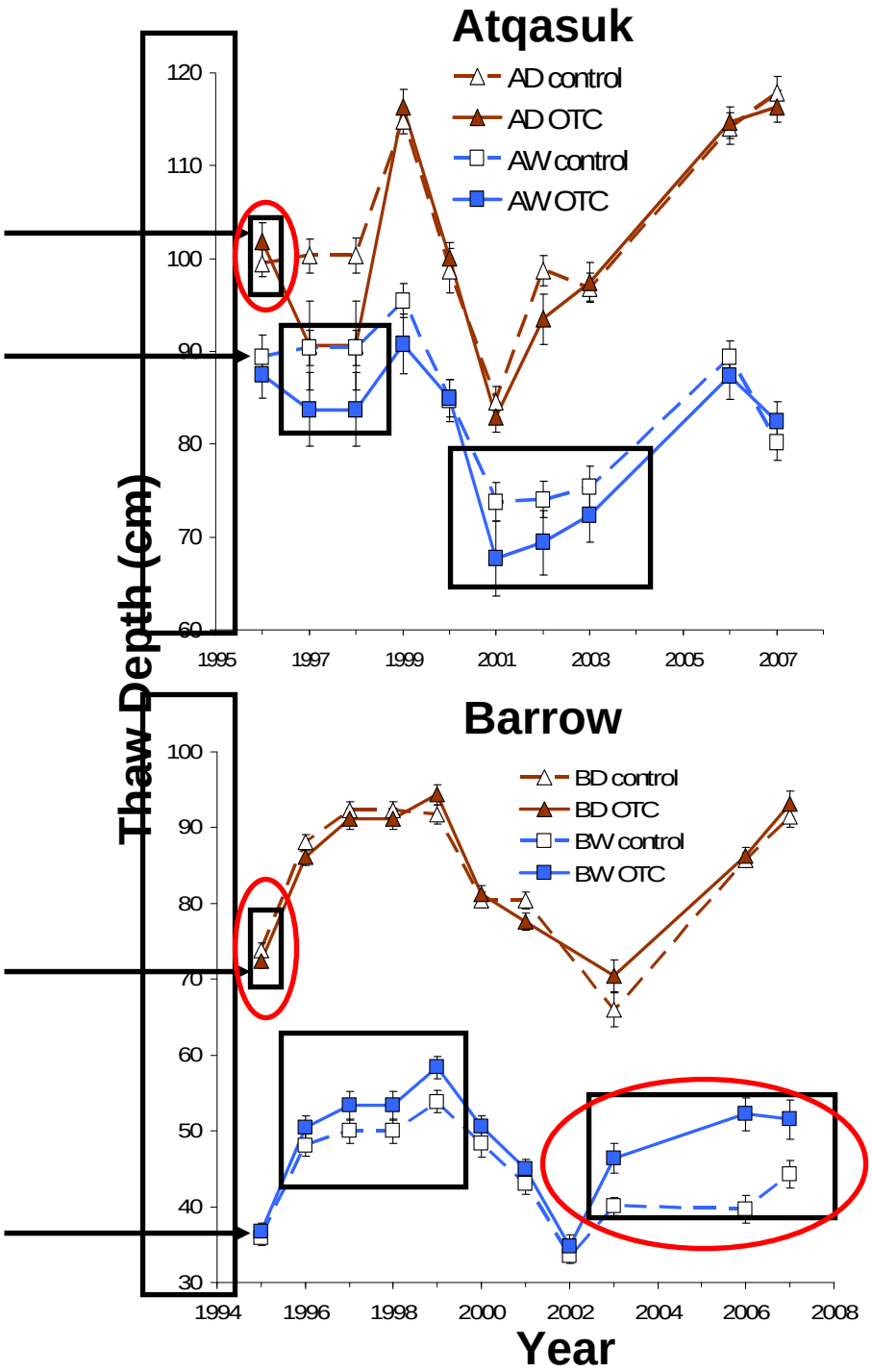
**-Thaw Deeper in Atqasuk than Barrow**

**-Dry sites deeper than wet**

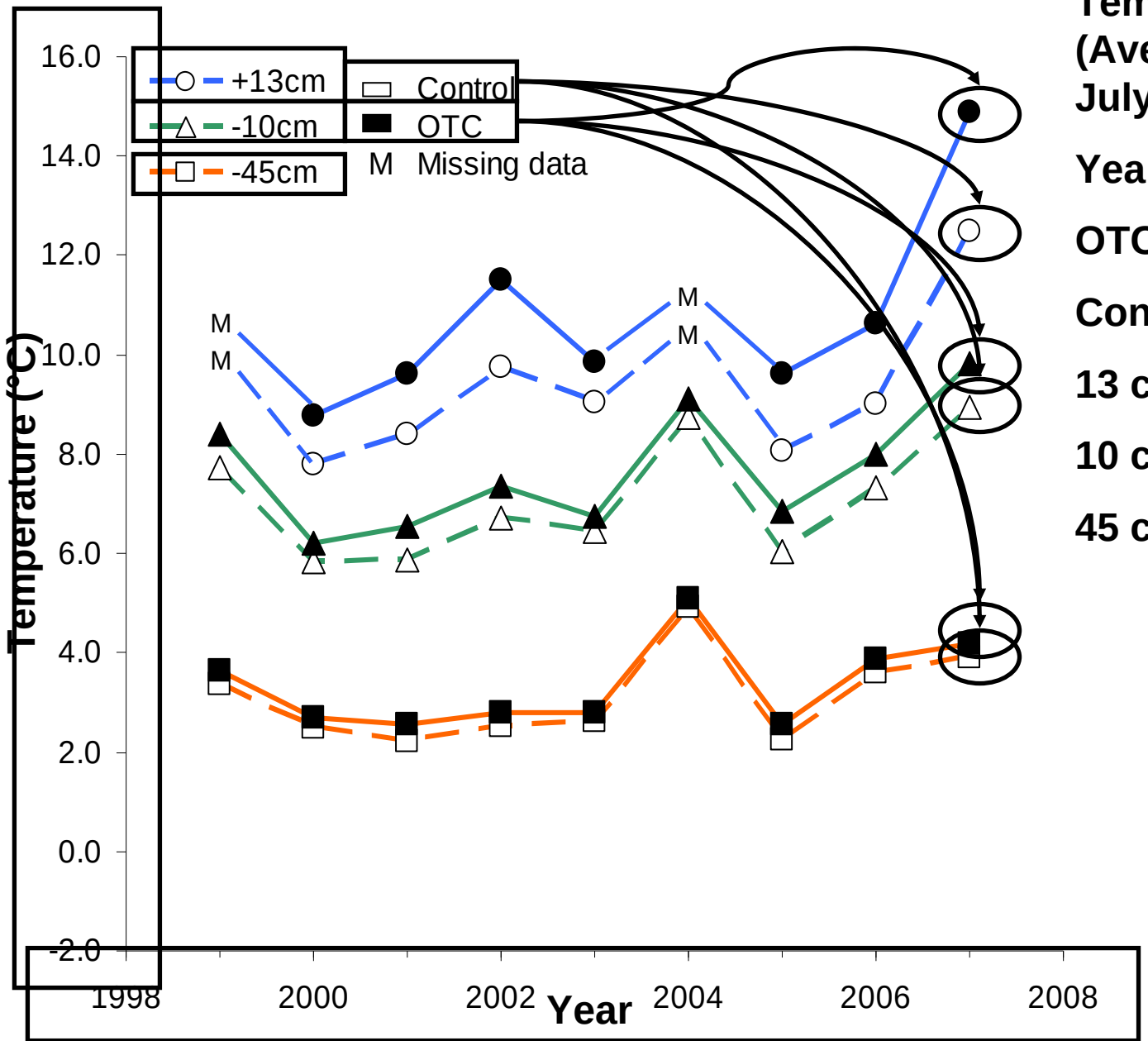
**-In Dry Sites Thaw Depth did not show much difference between OTC and Control**

**-Wet sites showed more significant differences between OTC and Control**

**-Barrow Wet showed greater difference between CTL and OTC in recent years**



# Soil and Air Temperature




**Temperature in C (Averaged for month of July)**

**Year**

**OTC plots**

**Control plots**

**13 cm above ground**

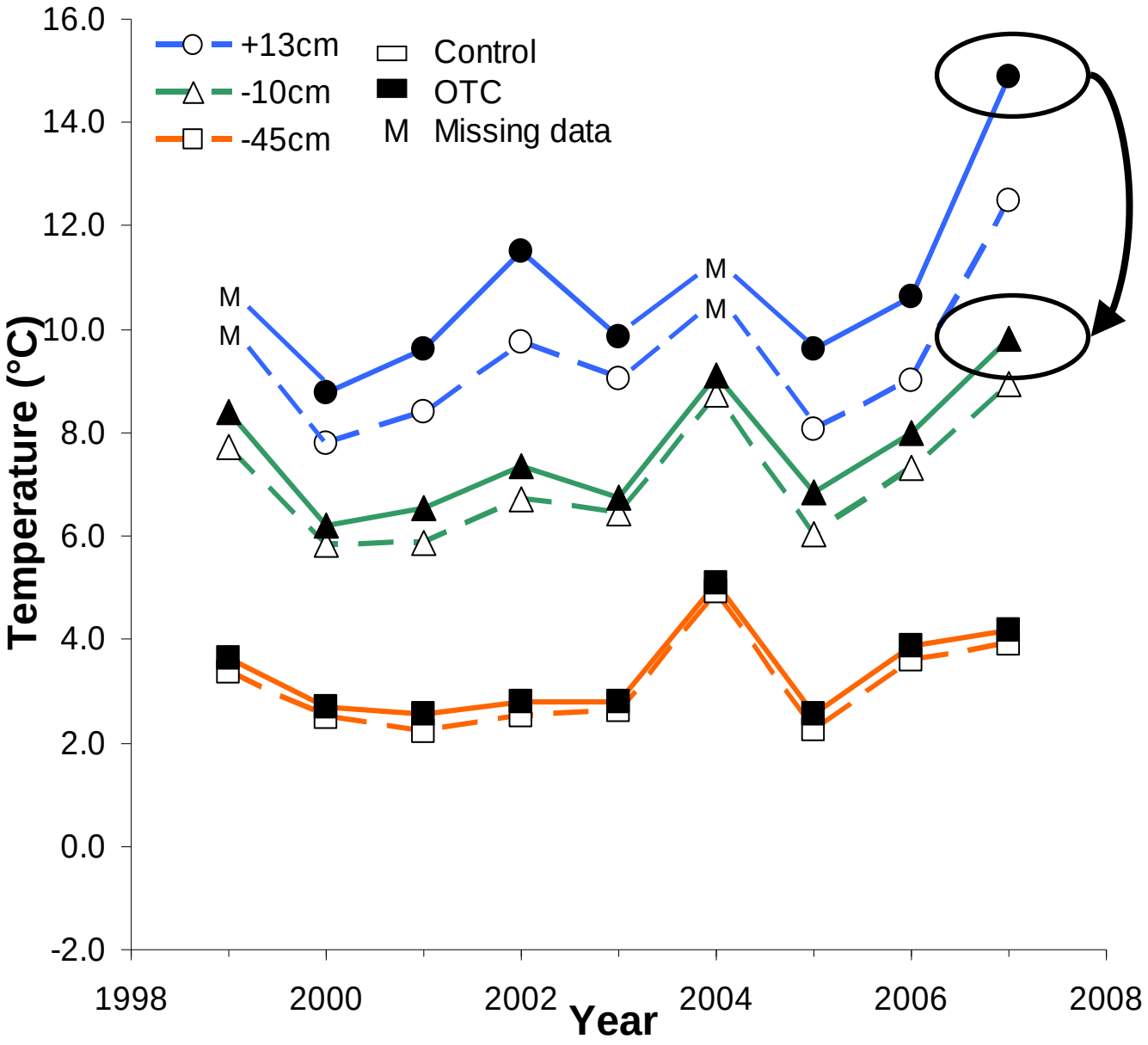
**10 cm below ground**

**45 cm below ground**

# Atqasuk Dry

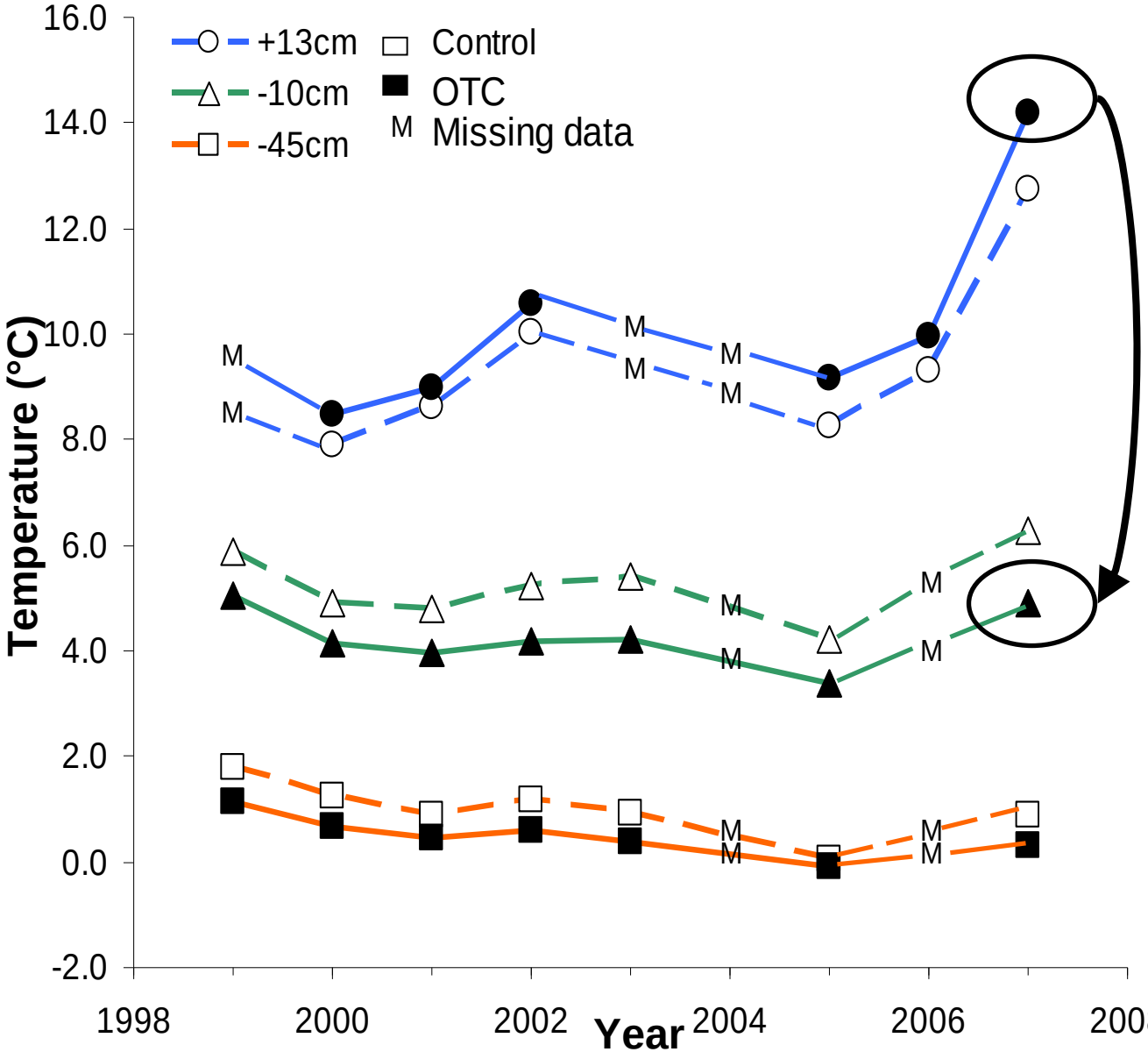
**Average July temperature for plots by sensor height and treatment**

**OTC's Warmed Soils**



# Atqasuk Wet

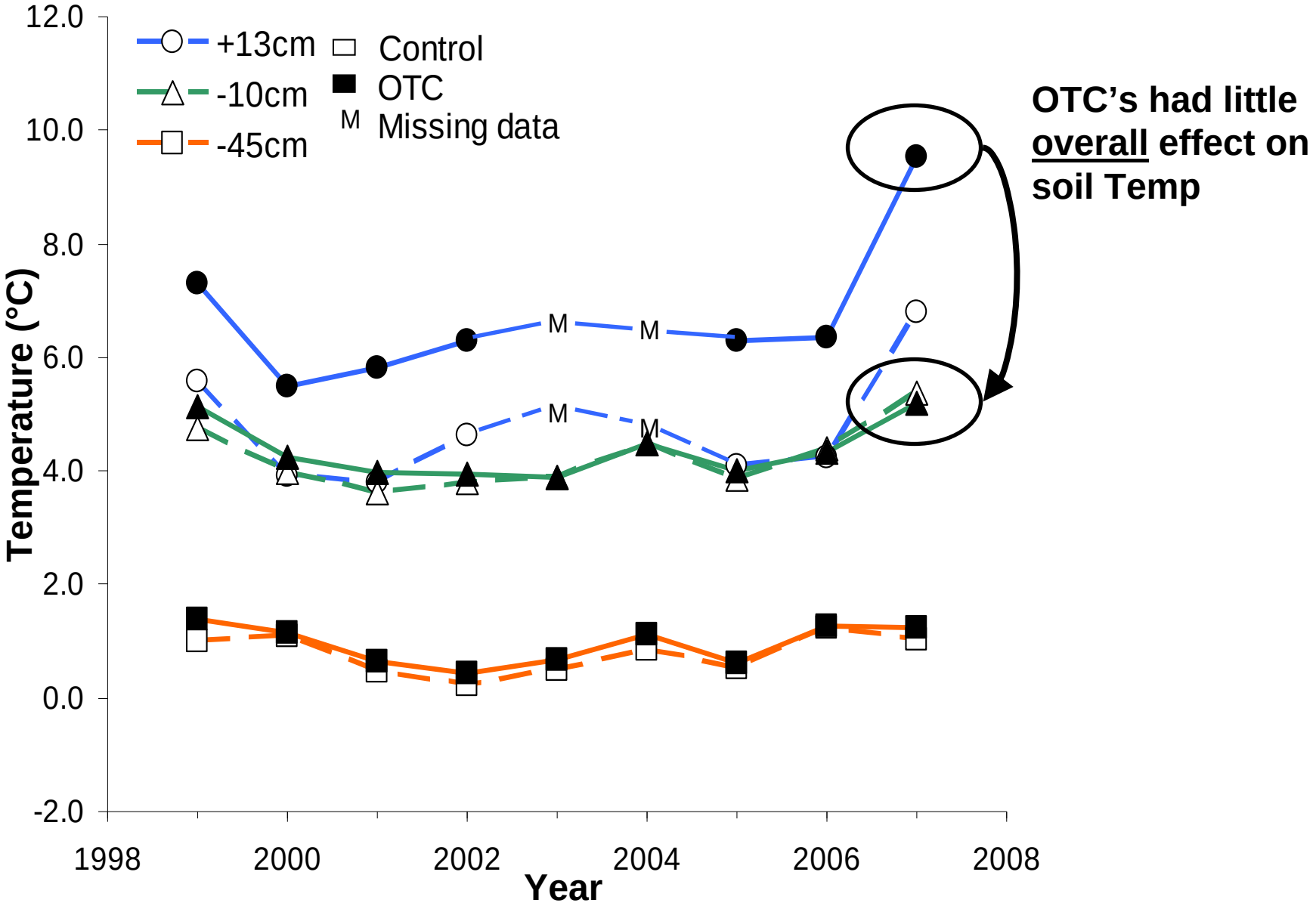
**Average July temperature for plots by sensor height and treatment**




**OTC's Cooled Soils**

# Barrow Dry

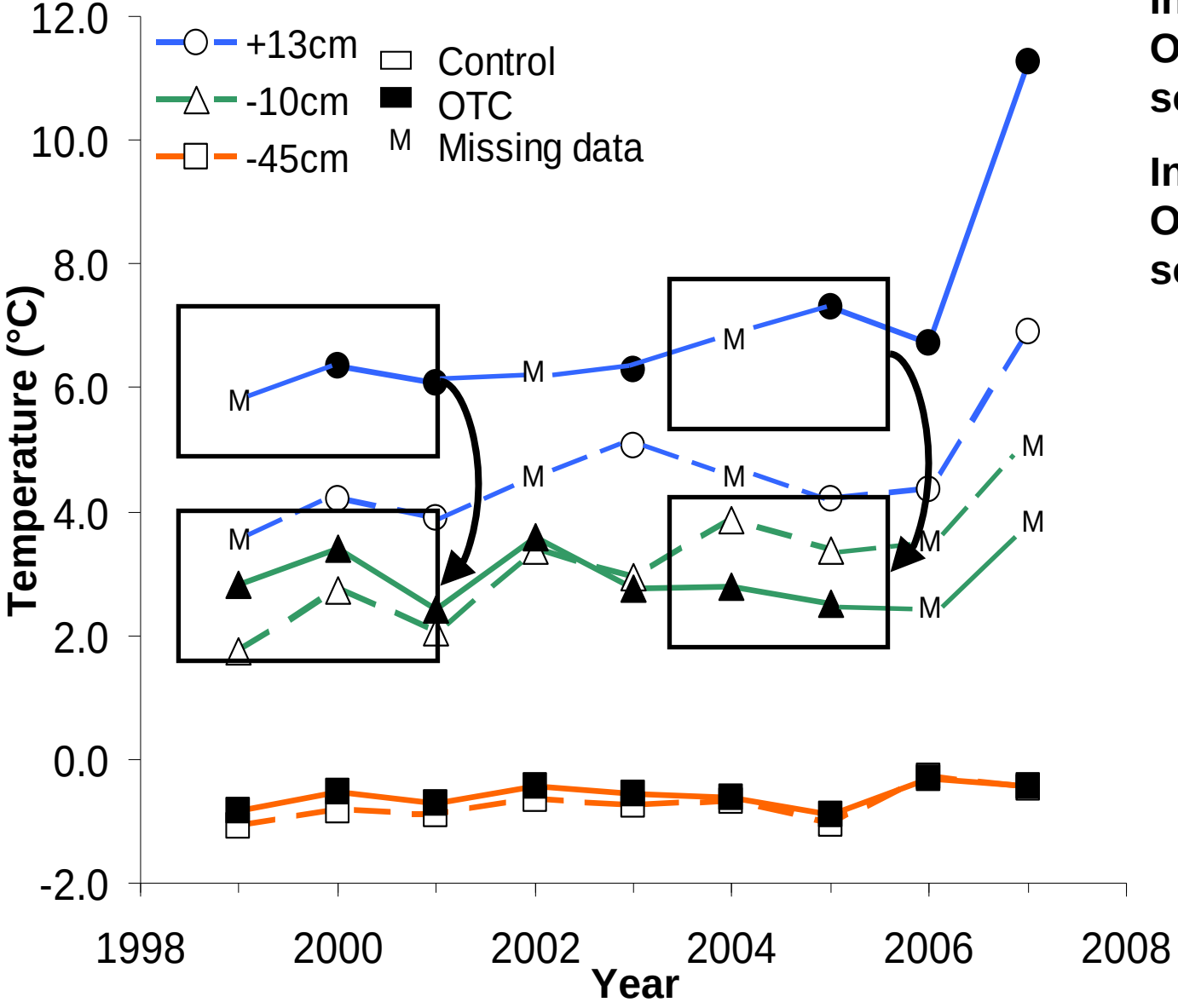
**Average July temperature for plots by sensor height and treatment**




**OTC's had little <u>overall</u> effect on soil Temp**

# Barrow Wet

**Average July temperature for plots by sensor height and treatment**

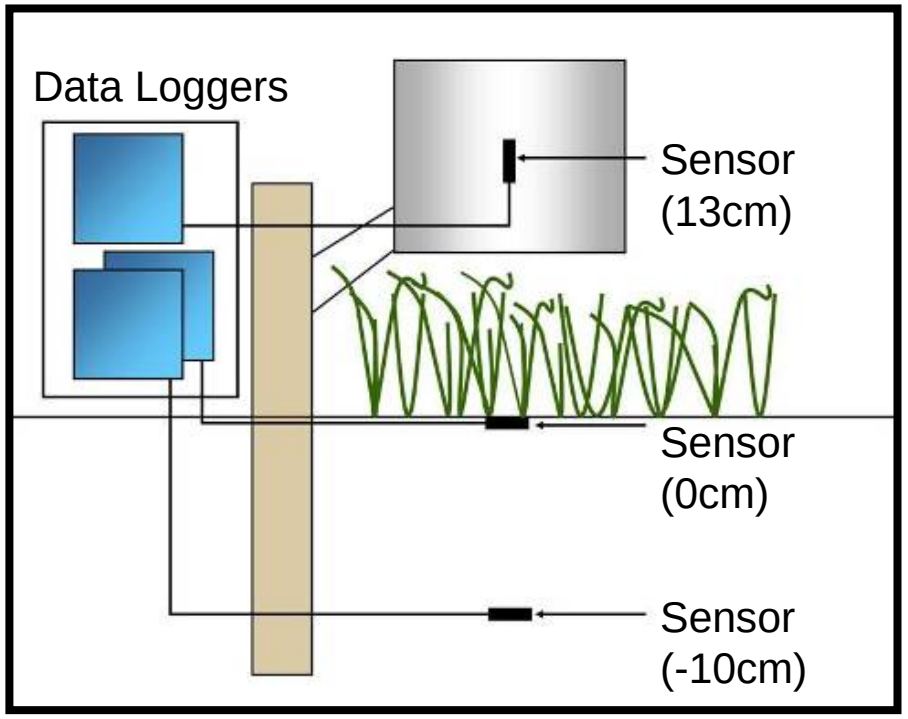



**In early years OTC's warmed soils**

**In later years OTC's cooled soils**

# Vegetation Manipulation

**Temp. probes at 13cm, 0cm, and -10cm**




**Vegetation <u>added</u> or <u>removed</u> in 10cm diameter**

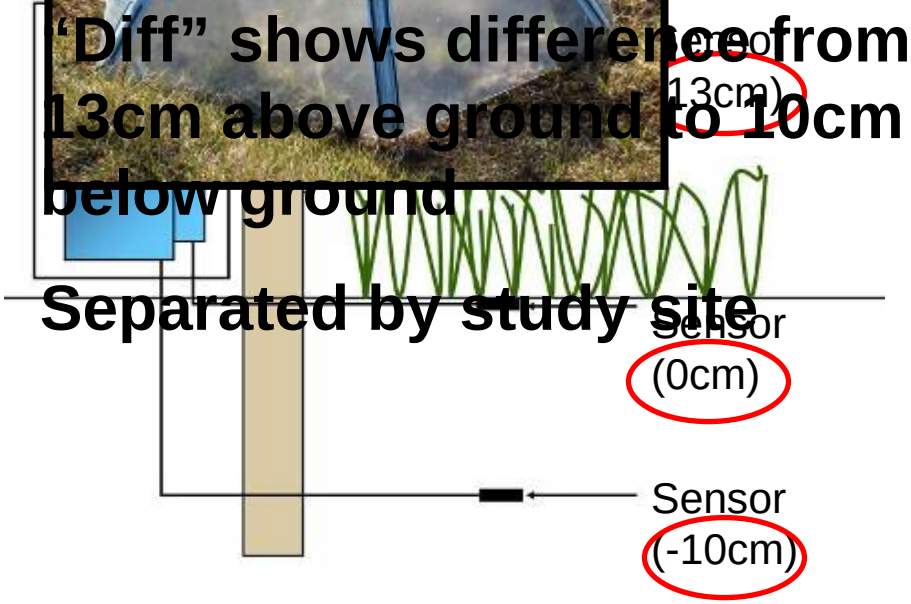
# Vegetation Manipulation

**“Warmed” are plots with OTC’s on them**

**Left column displays average temp. for July at height from ground level**

**“Diff” shows difference from 13cm above ground to 10cm below ground**

**Separated by study site**




| | Control | Warmed: Bare | Warmed: Added | Warmed: 9 Years |
|---|---|---|---|---|
| | Atqasuk Dry Heath (AD) | | | |
| 13 | 12.5 | 13.4 | 14.3 | 14.9 |
| 0 | 14.4 | 12.8 | 11.1 | 15.6 |
| -10 | 8.9 | 9.8 | 8.9 | 9.8 |
| Diff | 3.5 | 3.6 | 5.4 | 5.1 |
| | Atqasuk Wet Meadow (AW) | | | |
| 13 | 12.8 | 10.1 | 13.4 | 14.2 |
| 0 | 12.8 | 6.7 | 7.2 | 11.1 |
| -10 | 6.3 | 4.5 | 3.8 | 4.9 |
| Diff | 6.5 | 5.6 | 9.7 | 9.3 |
| | Barrow Dry Heath (BD) | | | |
| 13 | 6.8 | 8.6 | 8.4 | 9.5 |
| 0 | 10.4 | 8.2 | 4.5 | 8.2 |
| -10 | 5.4 | 5.4 | 3.1 | 5.2 |
| Diff | 1.4 | 3.2 | 4.7 | 4.3 |
| | Barrow Wet Meadow (BW) | | | |
| 13 | 6.8 | 8.9 | 9.7 | 11.0 |
| 0 | --- | 10.3 | 4.6 | 11.5 |
| -10 | --- | 3.7 | 3.0 | 4.4 |
| Diff | --- | 5.3 | 6.7 | 6.6 |

--- no data due to instrument malfunction

Temperature (°C) at height/depth (cm) from ground by site and treatment

# Findings and Discussion

## Active Layer

**1) At -10cm Added treatments were cooler than Bare**

| | | Warmed | | |
|---|---|---|---|---|
| | Control | Bare | Added | 9 Years |
| | Atqasuk Dry Heath (AD) | | | |
| 13 | 12.5 | 13.4 | 14.3 | 14.9 |
| 0 | 14.4 | 12.8 | 11.1 | 15.6 |
| -10 | 8.9 | 9.8 | 8.9 | 9.8 |
| Diff | 3.5 | 3.6 | 5.4 | 5.1 |
| | Atqasuk Wet Meadow (AW) | | | |
| 13 | 12.8 | 10.1 | 13.4 | 14.2 |
| 0 | 12.8 | 6.7 | 7.2 | 11.1 |
| -10 | 6.3 | 4.5 | 3.8 | 4.9 |
| Diff | 6.5 | 5.6 | 9.7 | 9.3 |
| | Barrow Dry Heath (BD) | | | |
| 13 | 6.8 | 8.6 | 8.4 | 9.5 |
| 0 | 10.4 | 8.2 | 4.5 | 8.2 |
| -10 | 5.4 | 5.4 | 3.1 | 5.2 |
| Diff | 1.4 | 3.2 | 4.7 | 4.3 |
| | Barrow Wet Meadow (BW) | | | |
| 13 | 6.8 | 8.9 | 9.7 | 11.0 |
| 0 | --- | 10.3 | 4.6 | 11.5 |
| -10 | --- | 3.7 | 3.0 | 4.4 |
| Diff | --- | 5.3 | 6.7 | 6.6 |
| --- no data due to instrument malfunction | | | | |

Temperature (°C) at height/depth (cm) from ground by site and treatment

# Findings and Discussion

## Active Layer

1) At -10cm Added treatments were cooler than Bare

2) **Greatest difference in temp. from 13cm to -10cm was seen in Added treatments**

| | Control | Warmed | | |
|---|---|---|---|---|
| | | Bare | Added | 9 Years |
| | Atqasuk Dry Heath (AD) | | | |
| 13 | 12.5 | 13.4 | 14.3 | 14.9 |
| 0 | 14.4 | 12.8 | 11.1 | 15.6 |
| -10 | 8.9 | 9.8 | 8.9 | 9.8 |
| Diff | 3.5 | 3.6 | 5.4 | 5.1 |
| | Atqasuk Wet Meadow (AW) | | | |
| 13 | 12.8 | 10.1 | 13.4 | 14.2 |
| 0 | 12.8 | 6.7 | 7.2 | 11.1 |
| -10 | 6.3 | 4.5 | 3.8 | 4.9 |
| Diff | 6.5 | 5.6 | 9.7 | 9.3 |
| | Barrow Dry Heath (BD) | | | |
| 13 | 6.8 | 8.6 | 8.4 | 9.5 |
| 0 | 10.4 | 8.2 | 4.5 | 8.2 |
| -10 | 5.4 | 5.4 | 3.1 | 5.2 |
| Diff | 1.4 | 3.2 | 4.7 | 4.3 |
| | Barrow Wet Meadow (BW) | | | |
| 13 | 6.8 | 8.9 | 9.7 | 11.0 |
| 0 | --- | 10.3 | 4.6 | 11.5 |
| -10 | --- | 3.7 | 3.0 | 4.4 |
| Diff | --- | 5.3 | 6.7 | 6.6 |

--- no data due to instrument malfunction

Temperature (°C) at height/depth (cm) from ground by site and treatment

# Findings and Discussion

## Active Layer

1) At -10cm Added treatments were cooler than Bare

2) Greatest difference in temp. from 13cm to -10cm was seen in Added treatments

**3) 9 Years and Added showed similar temperature differences**

| | Control | Warmed | | |
|---|---|---|---|---|
| | | Bare | Added | 9 Years |
| | Atqasuk Dry Heath (AD) | | | |
| 13 | 12.5 | 13.4 | 14.3 | 14.9 |
| 0 | 14.4 | 12.8 | 11.1 | 15.6 |
| -10 | 8.9 | 9.8 | 8.9 | 9.8 |
| Diff | 3.5 | 3.6 | 5.4 | 5.1 |
| | Atqasuk Wet Meadow (AW) | | | |
| 13 | 12.8 | 10.1 | 13.4 | 14.2 |
| 0 | 12.8 | 6.7 | 7.2 | 11.1 |
| -10 | 6.3 | 4.5 | 3.8 | 4.9 |
| Diff | 6.5 | 5.6 | 9.7 | 9.3 |
| | Barrow Dry Heath (BD) | | | |
| 13 | 6.8 | 8.6 | 8.4 | 9.5 |
| 0 | 10.4 | 8.2 | 4.5 | 8.2 |
| -10 | 5.4 | 5.4 | 3.1 | 5.2 |
| Diff | 1.4 | 3.2 | 4.7 | 4.3 |
| | Barrow Wet Meadow (BW) | | | |
| 13 | 6.8 | 8.9 | 9.7 | 11.0 |
| 0 | --- | 10.3 | 4.6 | 11.5 |
| -10 | --- | 3.7 | 3.0 | 4.4 |
| Diff | --- | 5.3 | 6.7 | 6.6 |
| --- no data due to instrument malfunction | | | | |

Temperature (°C) at height/depth (cm) from ground by site and treatment

# Findings and Discussion

## Active Layer

1) At -10cm Added treatments were cooler than Bare

2) Greatest difference in temp. from 13cm to -10cm was seen in Added treatments

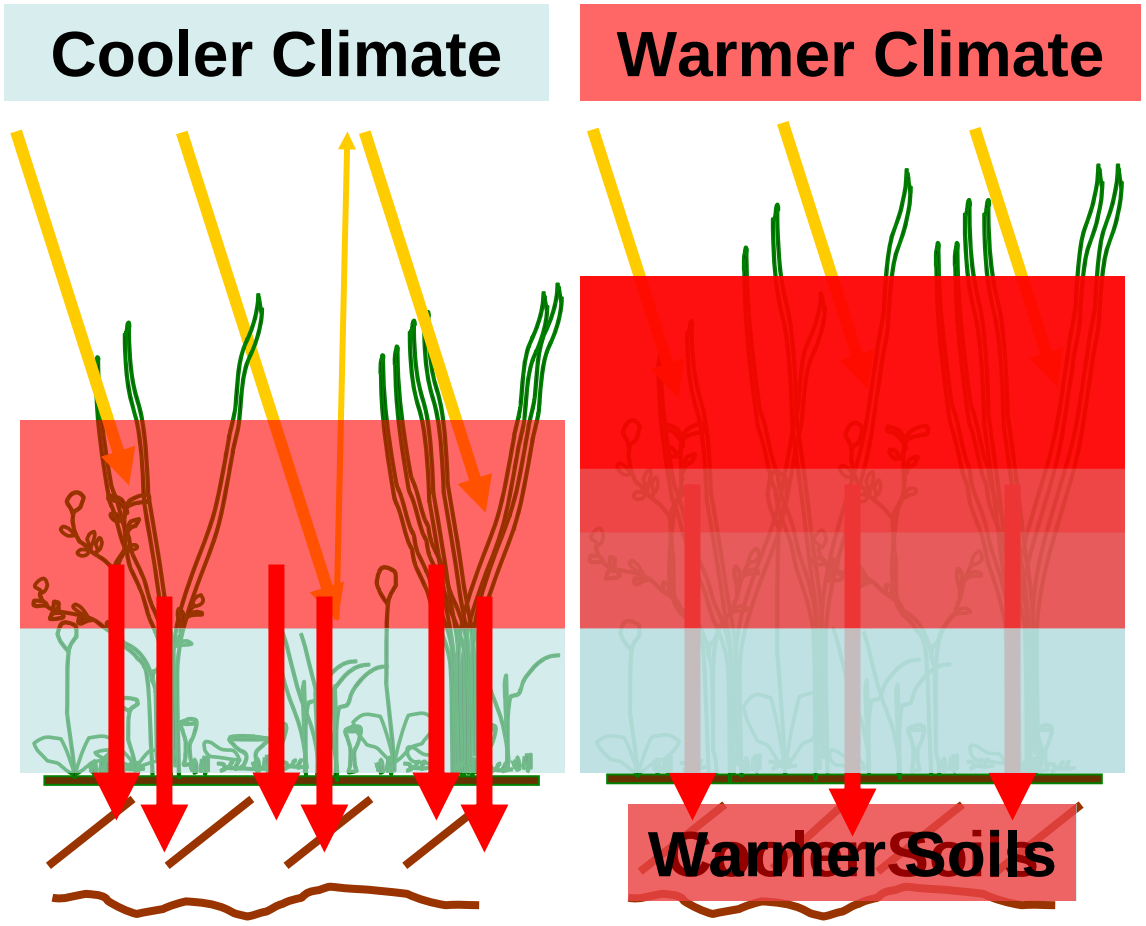
3) 9 Years and Added showed similar temperature differences

**4) Thicker vegetation did not always lead to cooler temperatures at -10cm**

| | | Warmed | | |
|---|---|---|---|---|
| | Control | Bare | Added | 9 Years |
| | Atqasuk Dry Heath (AD) | | | |
| 13 | 12.5 | 13.4 | 14.3 | 14.9 |
| 0 | 14.4 | 12.8 | 11.1 | 15.6 |
| -10 | 8.9 | 9.8 | 8.9 | 9.8 |
| Diff | 3.5 | 3.6 | 5.4 | 5.1 |
| | Atqasuk Wet Meadow (AW) | | | |
| 13 | 12.8 | 10.1 | 13.4 | 14.2 |
| 0 | 12.8 | 6.7 | 7.2 | 11.1 |
| -10 | 6.3 | 4.5 | 3.8 | 4.9 |
| Diff | 6.5 | 5.6 | 9.7 | 9.3 |
| | Barrow Dry Heath (BD) | | | |
| 13 | 6.8 | 8.6 | 8.4 | 9.5 |
| 0 | 10.4 | 8.2 | 4.5 | 8.2 |
| -10 | 5.4 | 5.4 | 3.1 | 5.2 |
| Diff | 1.4 | 3.2 | 4.7 | 4.3 |
| | Barrow Wet Meadow (BW) | | | |
| 13 | 6.8 | 8.9 | 9.7 | 11.0 |
| 0 | --- | 10.3 | 4.6 | 11.5 |
| -10 | --- | 3.7 | 3.0 | 4.4 |
| Diff | --- | 5.3 | 6.7 | 6.6 |
| --- no data due to instrument malfunction | | | | |

Temperature (°C) at height/depth (cm) from ground by site and treatment

# Predicted Changes Under Warmer Climate




- Warmer air will cause an increase in plant cover

-Increased plant cover will reduce heat transfer from air to soil

-In some cases the increased plant cover due to air warming may cause soil cooling (despite air warming)

-In other cases air warming may cause soil warming

# Acknowledgements

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- International Tundra Experiment (ITEX)

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Jeremy May
Amanda Snyder
Jean Galang
Jenny Liebig

# Questions?

**Contact**

| | |
|---|---|
| **Email** | **sliderr@student.gvsu.edu** |
| **Lab Website** | **http://faculty.gvsu.edu/hollistr/** |


## Resources


- **Hollister, R.D., P.J. Webber, F.E. Nelson, C.E. Tweedie 2006. Soil thaw and temperature response to air warming varies by community: Results from an open-top chamber experiment in northern Alaska. *Arctic Antarctic and Alpine Research* 38: 206-215.**

- **Hollister, R.D., P.J. Webber, R.T. Slider, F.E. Nelson, C.E. Tweedie *2008. Soil Temperature and Thaw Response to Air Warming Varies with Changing Vegetation.**

- **Walker, M.D., C.H. Wahren, R.D. Hollister, G.H.R. Henry, L.E. Ahlquist, J.M. Alatalo, M.S. Bret-Harte, M.P. Calef, T.V. Callaghan, A.B. Carroll, H.E. Epstein, I.S. Jónsdóttir, J.A. Klein, B. Magnusson, U. Molau, S.F. Oberbauer, S.P. Rewa, C.H. Robinson, G.R. Shaver, K.N. Suding, C.C. Thompson, A. Tolvanen, Totland, P.L. Turner, C.E. Tweedie, P.J. Webber, P.A. Wookey 2006. Plant community responses to experimental warming across the tundra biome. *Proceedings of the National Academy of Sciences of the United States of America* 103: 1342-1346.**


***In print**

Light Exposure

Active Layer Depth

Arctic Plant

Limitations

Temperature

Nutrient Availability

# OTC's on Soil

**Shows temperature difference between OTC and Control**
**By year and depth for each site in Barrow**

**Shows Winter and Summer results**

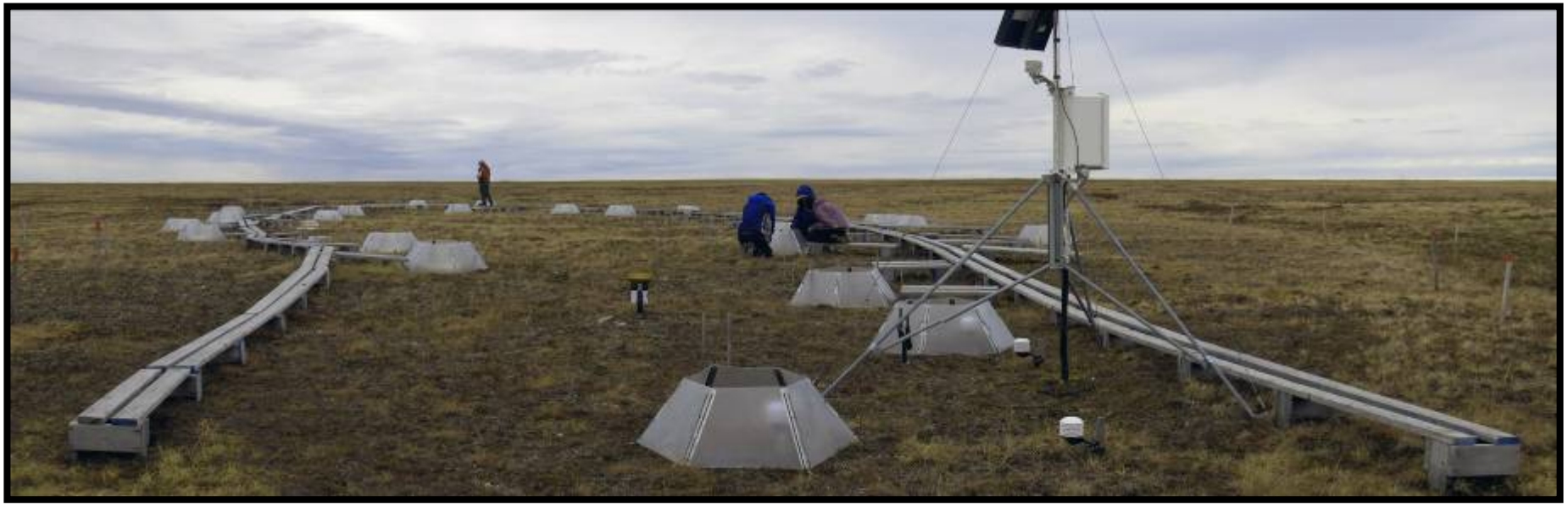
**-OTC's warmer in the winter**

**-OTC's cooler in the summer**

**-Effect more pronounced in recent years**

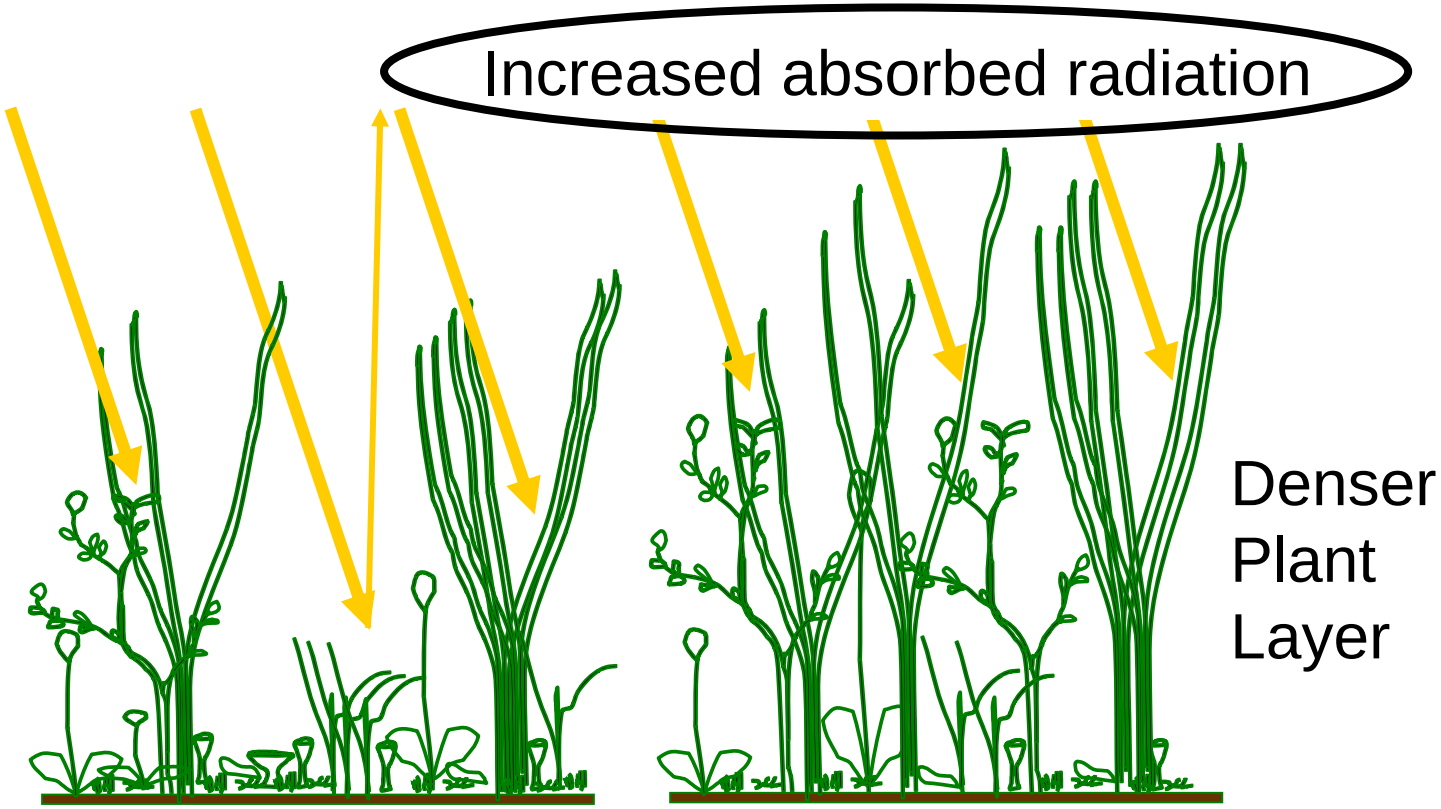
| | BD Site | | | BW Site | | |
|---|---|---|---|---|---|---|
| Year | 0cm | -10cm | 45cm | 0cm | -10cm | 45cm |
| | Winter (September-May) | | | | | |
| 1998 | 0.5 | 0.5 | 0.3 | 0.1 | 0.1 | 0.2 |
| 1999 | 0.7 | 0.7 | 0.4 | 0.5 | 0.2 | 0.2 |
| 2000 | 0.3 | 0.4 | 0.3 | 0.3 | 0.1 | 0.2 |
| 2001 | 0.4 | 0.5 | 0.2 | 0.5 | 0.1 | 0.1 |
| 2002 | 0.5 | 0.5 | 0.3 | 0.4 | 0.0 | 0.1 |
| 2003 | 0.4 | 0.4 | 0.3 | 0.4 | 0.1 | 0.2 |
| 2004 | 0.5 | 0.6 | 0.3 | 0.4 | 0.2 | 0.2 |
| 2005 | 0.3 | 0.4 | 0.2 | 1.0 | 0.1 | 0.2 |
| 2006 | 0.3 | 0.4 | 0.3 | — | — | — |
| 2007 | 0.7 | 0.7 | 0.5 | — | — | — |
| | Summer (June-August) | | | | | |
| 1998 | -0.1 | -0.1 | 0.1 | 0.3 | 0.3 | 0.4 |
| 1999 | 0.2 | 0.2 | 0.1 | 1.3 | 0.6 | 0.3 |
| 2000 | -0.2 | 0.1 | 0.1 | 0.6 | 0.3 | 0.2 |
| 2001 | -0.1 | 0.3 | 0.1 | 0.0 | 0.0 | 0.1 |
| 2002 | -0.8 | 0.2 | 0.2 | 0.0 | 0.1 | 0.2 |
| 2003 | -0.7 | 0.0 | 0.1 | -0.3 | -0.2 | 0.1 |
| 2004 | -1.1 | 0.0 | 0.2 | -1.6 | -0.9 | 0.0 |
| 2005 | -0.9 | 0.0 | 0.1 | -0.6 | -0.8 | 0.1 |
| 2006 | -1.5 | -0.1 | 0.0 | — | — | — |
| 2007 | -2.0 | -0.1 | 0.1 | — | — | — |

- Use Open Top Chambers (OTC's) to warm 1m$^2$ plots
- Four sites with 24 Control and 24 Experimental plots in each
- Ongoing project established in 1994



# Effects of Change

Less Albedo → Higher Temperatures




**Chapin et al. XXXXX**

ITEX