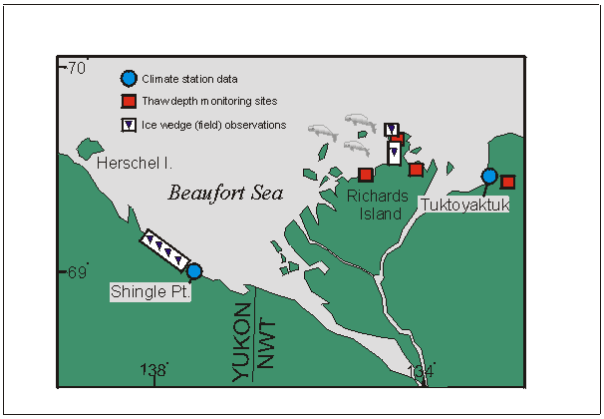
Recent Warming Impacts in Western Arctic Canada: Evidence from Air Temperatures, Active Layers, and Ice Wedges.

Stephen Wolfe
Terrain Sciences Division
Geological Survey of Canada

The results discussed in this presentation have been published in the January 24 issue of Current Research.

Increasingly, we are being encouraged to come up with comprehensive stories related to potential warming in study area, and to develop a story of what has been going on. The talk today is based on my work together with the work of Mark Nixon and Erica Kotler, who deserve a lot of the credit. In addition, the work has benefited from numerous discussions with Scott Dallimore, Larry Dyke, Fred Wright and Sharon Smith on the subject.



What I want to emphasize here is the integration of data: climate station data such as the AES from Tuktoyaktuk and Shingle Point; site monitoring data such as the GSC CALM network sites that Mark Nixon is responsible for (including almost 60 stations in the Mackenzie Valley); and regional field observations, usually obtained for specific geomorphologic process studies in this region.

Our overall statement of objectives in the context of monitoring is:

- To describe any discernible warming, and impacts on permafrost related to warming, in Western Arctic Canada.

Some of the questions that we are attempting to address:

- What are the recent climate trends?
- What are the recent trends in permafrost?
- Are the trends indicative of warming?

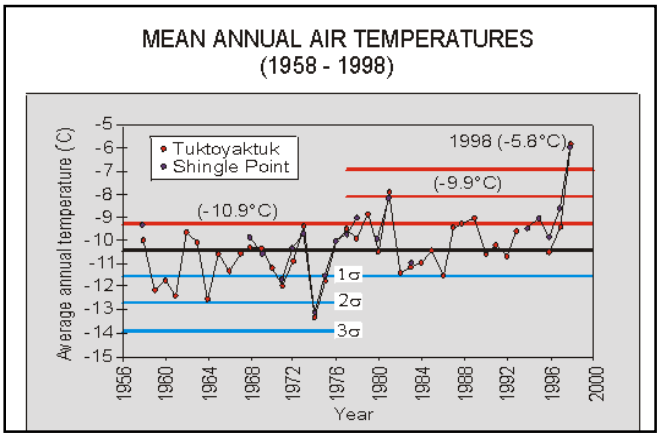
As I said, this study involves an integration of these data sources:

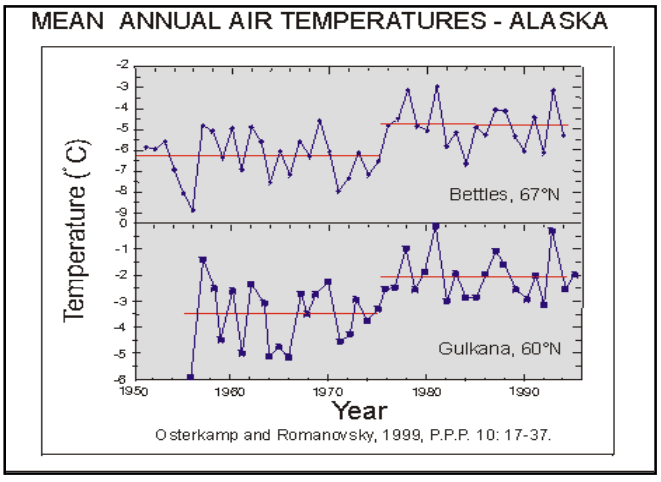
- Climatic records
- Permafrost/active layer monitoring
- Recurrent field observations

The Tuktoyaktuk and Shingle Point record is about 40 years (since 1958), and is the longest, most continuous record in this area, although the Shingle Point data include numerous gaps. Hopefully, AES can help fill some of the gaps in this region, and maintain a longer record over time. The active layer monitoring network has been active for about 10 years (since 1990). Finally, field observations in this case refer to ice wedge observations. The observations that Erica and I made were on northern Richards Island last summer, and along Shingle Point. Both of these have historic data sets available, allowing us to make comparisons: Mackay did a fairly comprehensive review of the depth to the top of ice wedges in 1974, including primary, secondary and tertiary wedges. He did so at the time in the context of recent climatic cooling since the 1940's. In the Yukon coastal region we made our observations in 1999, making comparisons to the work of David Harry, Hugh French and Wayne Pollard, who had looked at the depth to the top of ice wedges in 1984.

Summary of Air Temperature Trends:

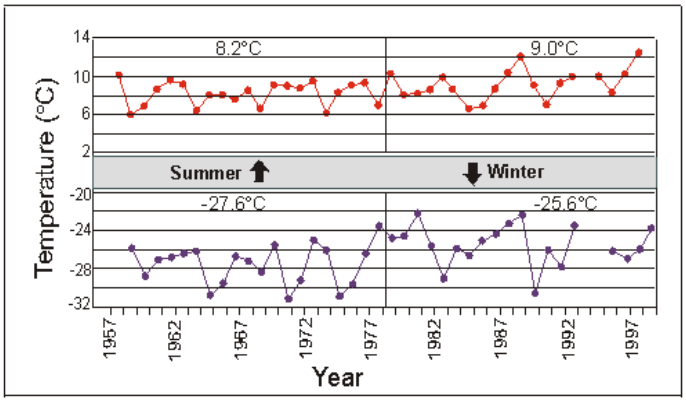
- An air temperature trend is evident in the western Arctic (Tuktoyaktuk NT and Shingle Point YT) that is similar to that observed in parts of Alaska.
- This warming appears as a step increase in mean annual temperature after about 1978, with warmer summer (+1^{o}C) and warmer winter (+2^{o}C) temperatures.
- 1998 was an extremely warm year in the western Arctic Canada (and was warm in all months). The average air temperature at Tuktoyaktuk (-5.8^{o}C) was equivalent to the 30-year average at Norman Wells in the discontinuous permafrost zone.



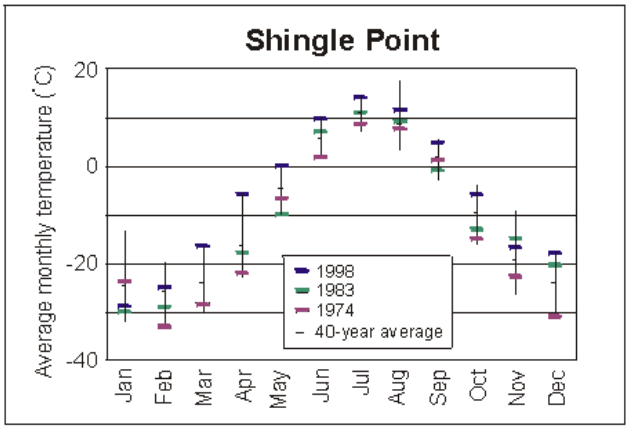


WINTER AND SUMMER TEMPERATURES

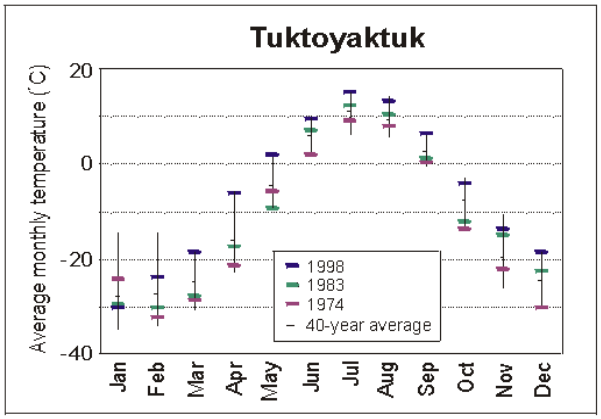
Tuktoyaktuk



AVERAGE MONTHLY TEMPERATURES



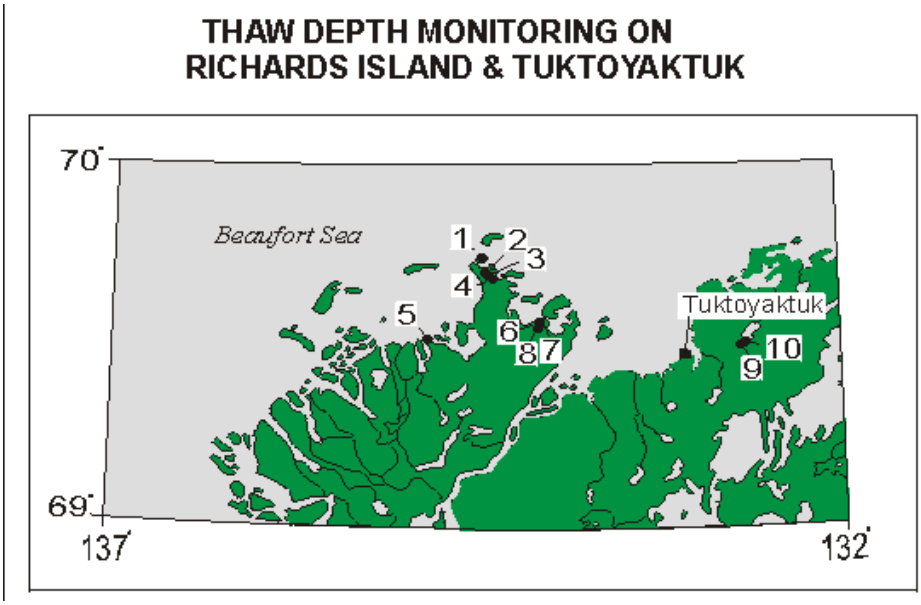
AVERAGE MONTHLY TEMPERATURES

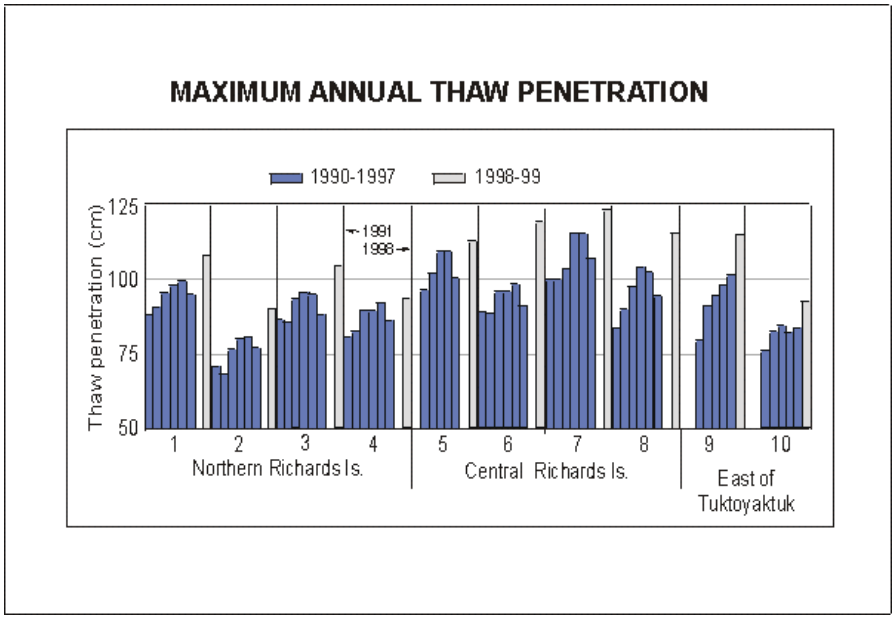


Wolfe

Summary of Active Layer Monitoring:

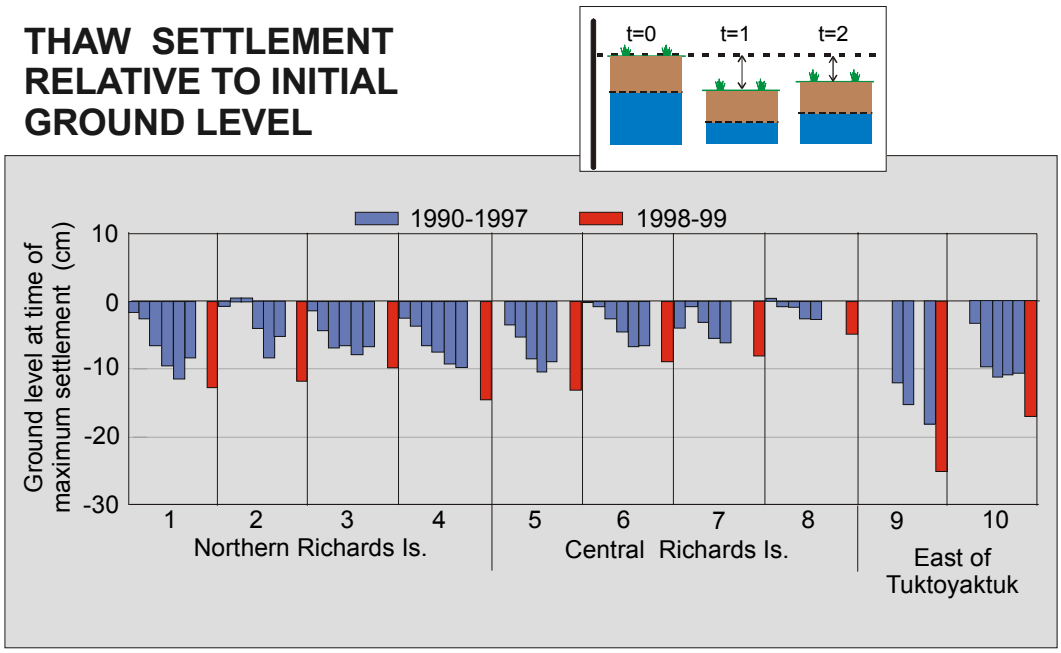
- Thaw penetration in the Tuktoyaktuk and Richards Island area has increased by 15 to 35 cm between 1991 and 1998. Thaw penetration was at a maximum in 1998.
- Total thaw settlement of 5 to 25 cm has occurred in this area between 1991 and 1998. Settlement was at a maximum in 1998.
- Ground Levels at the time of maximum heave have declined by 5 to 20 cm between 1991 and 1998 (indicating ground consolidation). This consolidation was at a maximum at nearly all sites in 1998.



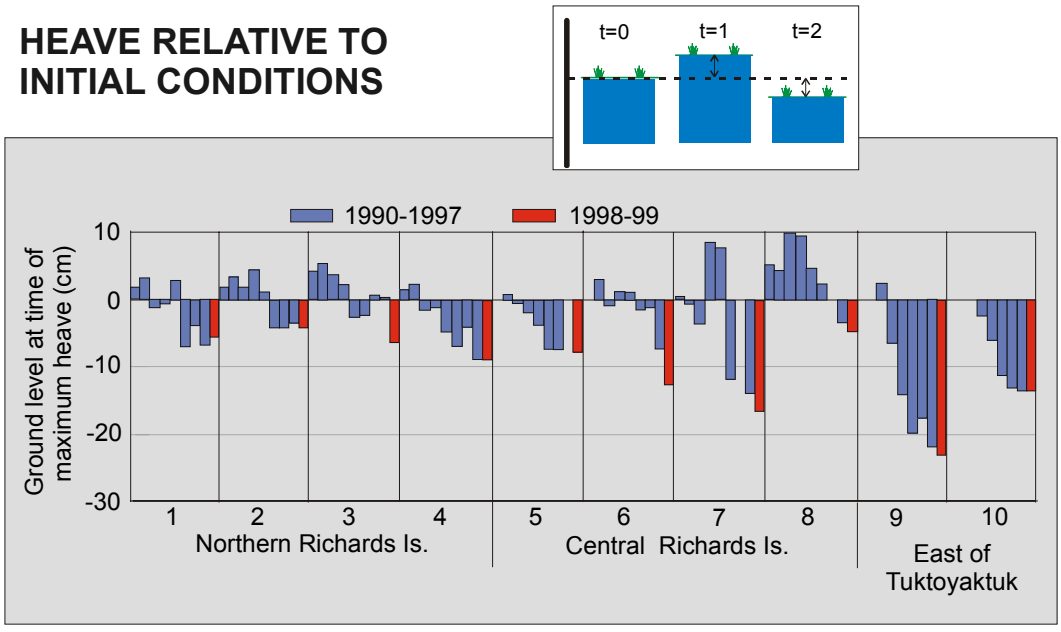


Wolfe

THAW SETTLEMENT RELATIVE TO INITIAL GROUND LEVEL



HEAVE RELATIVE TO INITIAL CONDITIONS

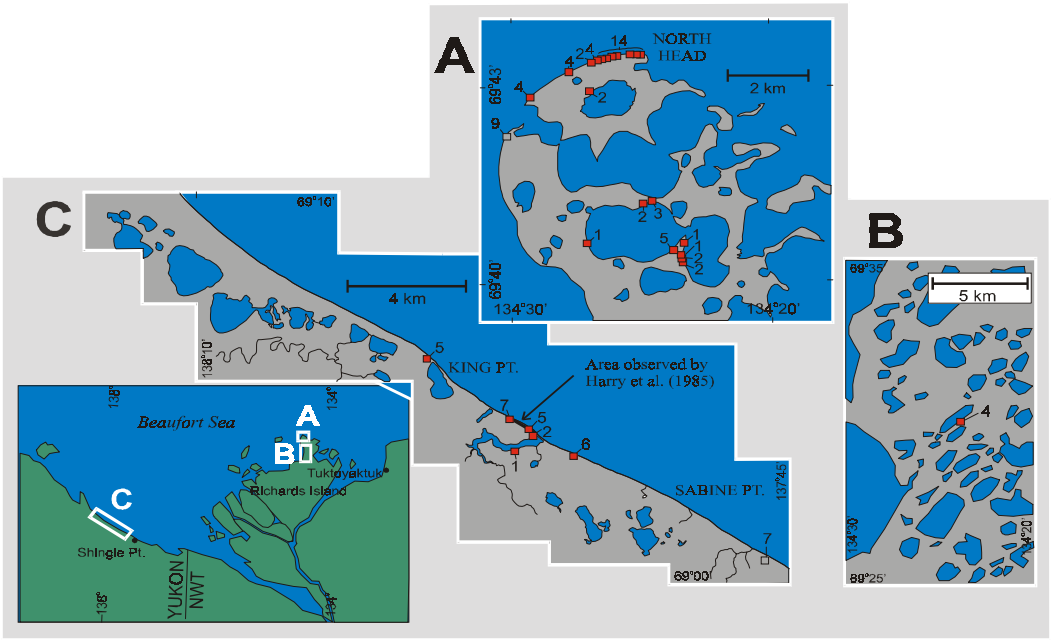


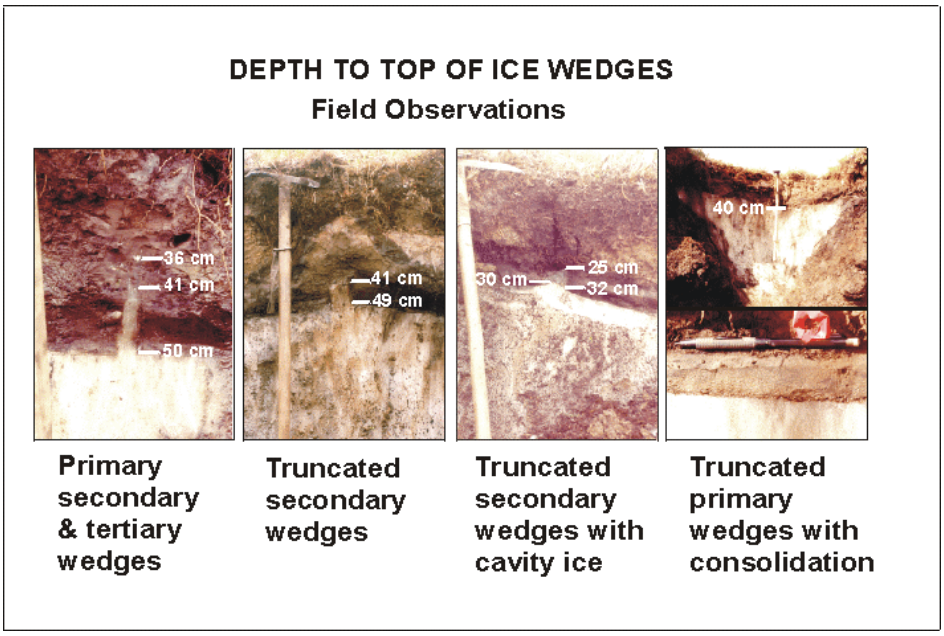
Wolfe

Summary of Ice Wedge Observations:

- Secondary and tertiary wedges have been truncated (by up to 25 cm) in the Richards Island area between 1975 and 1999.
- Secondary and tertiary wedges have been truncated along the Yukon Coast between 1985 and 1999. Truncation may have been accompanied by settlement (of up to 30 cm- but this may have been a local effect only).
- There was very little evidence of recent ice wedge cracking when observations were made in 1999.

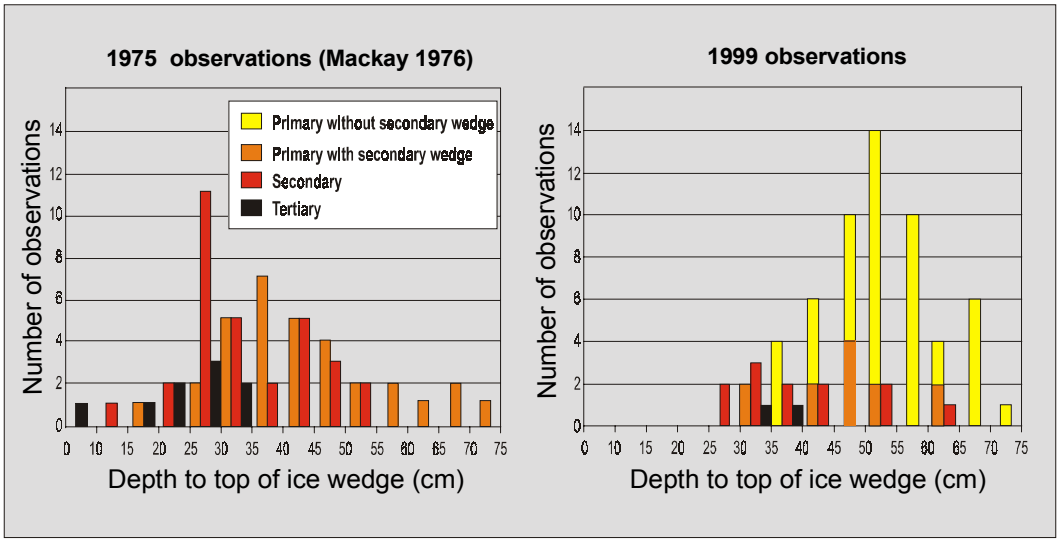
ICE WEDGE OBSERVATION SITES



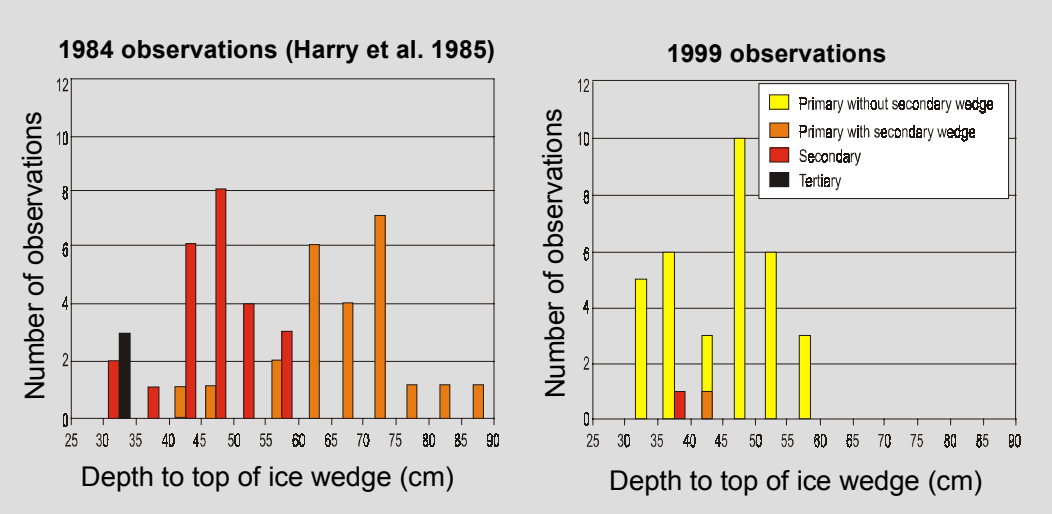


Wolfe

DEPTH TO TOP OF ICE WEDGES
Richards Island and Tuktoyaktuk areas

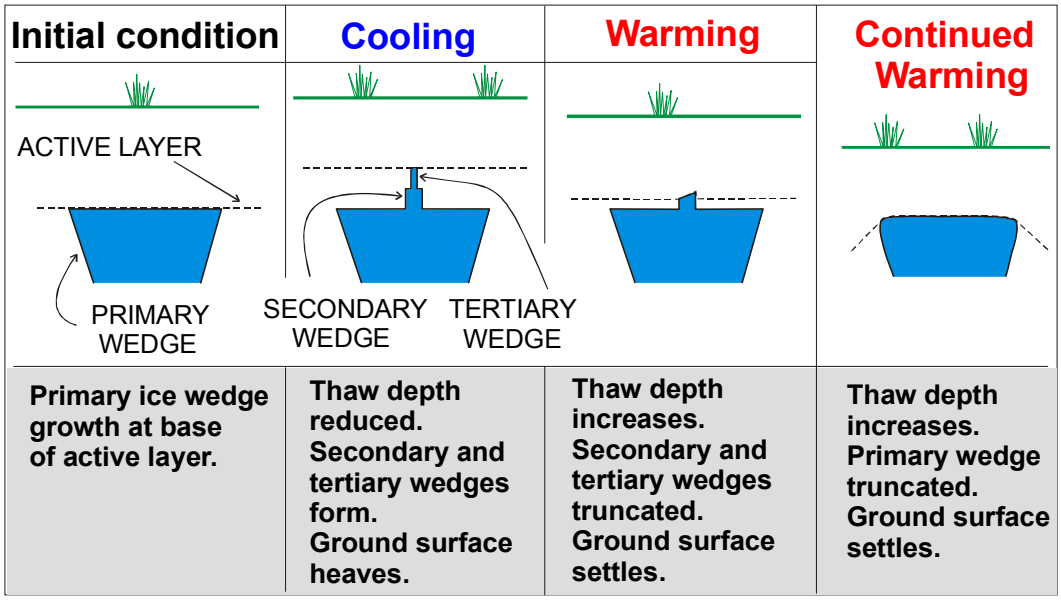


DEPTH TO TOP OF ICE WEDGES
Yukon Coast



Wolfe

ICE WEDGE RESPONSE TO CLIMATIC CHANGE



Points of Discussion:

- Only air temperature data from climate stations were examined. Other climatic parameters (eg. Precipitation) need to be examined.
-
- Climate station and monitoring site records contain missing data. We must stress the importance of continuous, long-term data sets.
- Monitoring sites providing a suite of variables are the most valuable. For example, we cannot rely on active layer thickness as a sole variable.
- Field observations need to be addressed in more detail; there is a need to monitor secondary effects and impacts.