Changing climate: How it affects air travel in northern Canadian communities

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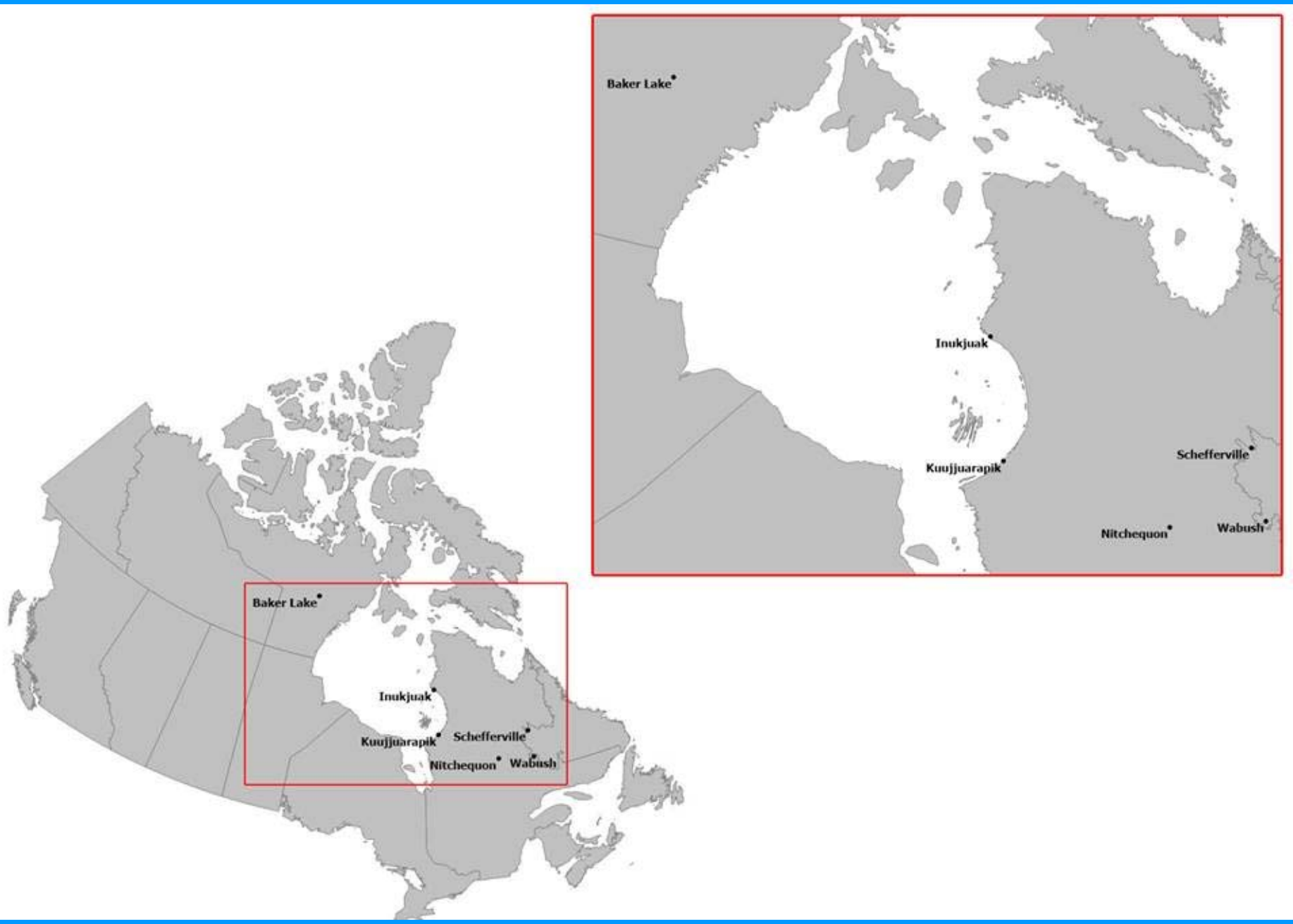
Why is air travel in the north important?

- Only year-round transportation and shipping in many northern Canadian communities
  - Some use sea-lift in summer or ice road in winter
- Issues:
  - Higher skill expectation from pilots
  - Higher performance demand on planes
  - Airports are far apart and many lack advance navigation or landing aids for low visibility
  - Few SAR experts to cover large area

Hypothesis

1. To examine if local historical wind patterns changed over time
2. To determine if there are seasonal variations at these locations
3. If these changes were observed, what are the impacts on air travel and airport operations


Baker Lake
Inukjuak
Kuujjuarapik
Schefferville
Nitchequon
Wabush
Baker Lake
Inukjuak
Kuujjuarapik
Schefferville
Nitchequon
Wabush

Methods

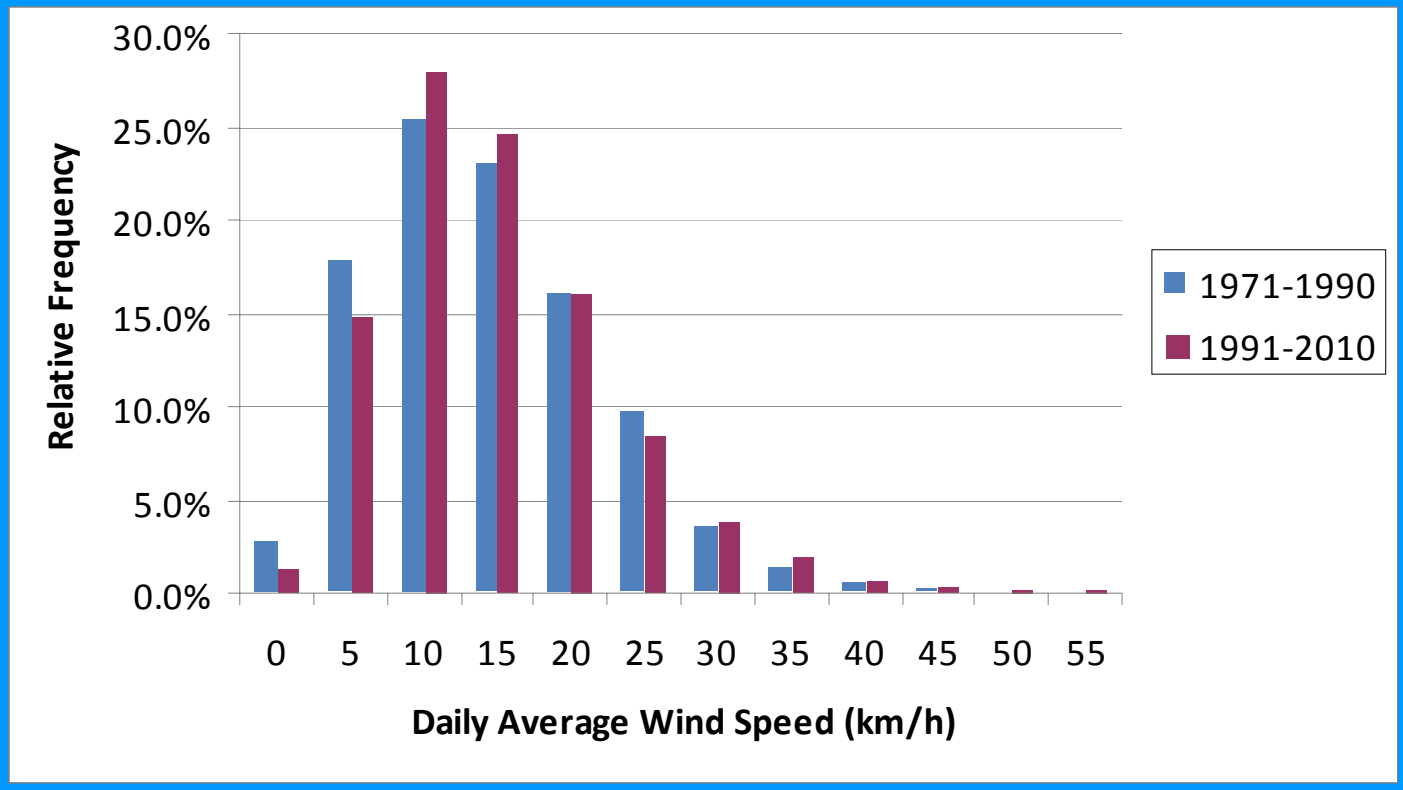
- Hourly wind speed and wind direction from 1971 to 2010 are obtained from Environment Canada's National Climate Archives
- Daily average wind speed and wind direction are calculated
  - Use R software's "circular" package for wind direction averaging

Methods

- Divide the data into two time series (1971-1990 & 1991-2010) and by four seasons
  - Winter: December to February
  - Spring: March to May
  - Summer: June to August
  - Fall: September to November

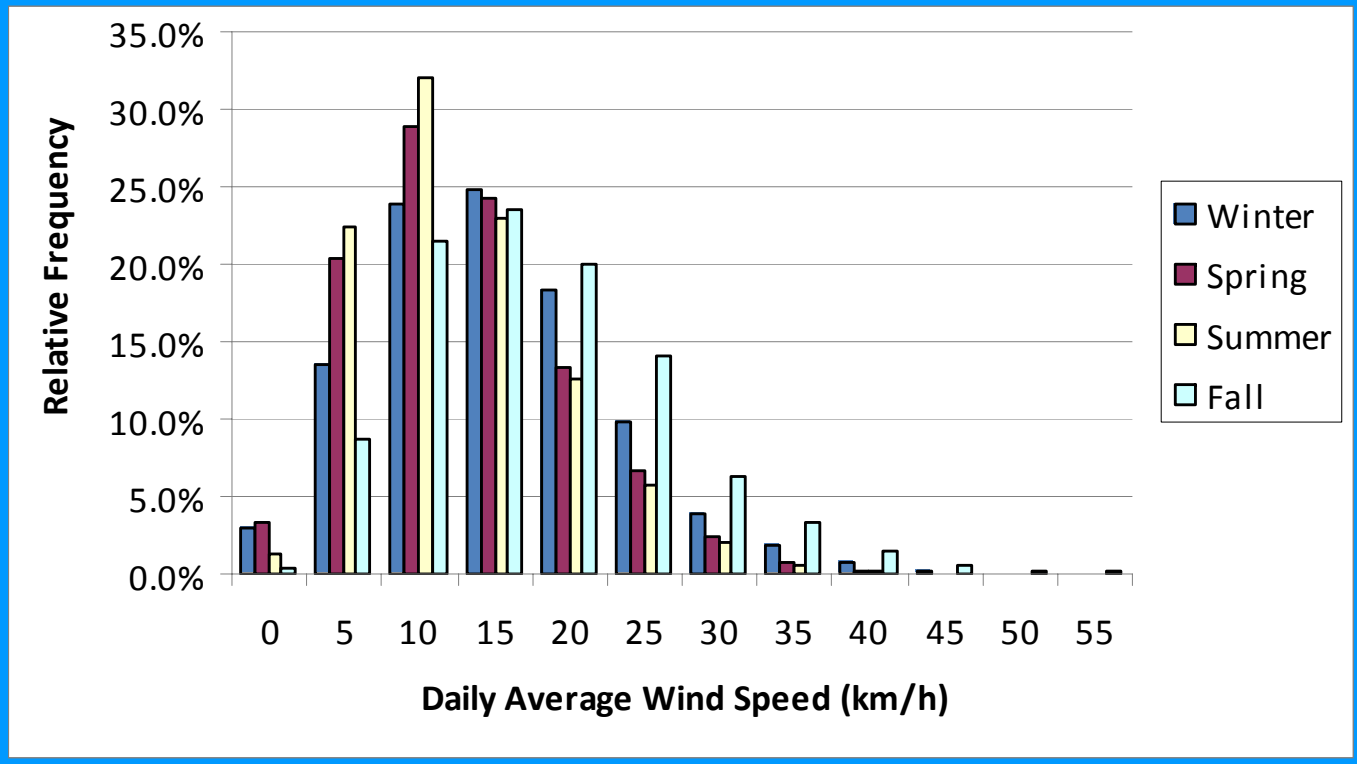
Wind speed

Location	Mean (1971-1990)	Mean (1991-2010)	T-value	Degrees of freedom	p-value
Baker Lake	21.42 km/h (11.57 knots)	21.37 km/h (11.54 knots)	0.2467	14435	0.805106
Inukjuak	20.96 km/h (11.31 knots)	21.01 km/h (11.34 knots)	-0.2880	14432	0.772591
Kuujjuarapik	16.79 km/h (9.07 knots)	17.31 km/h (9.35 knots)	-4.0144	14590	<0.0001



- Less calm wind
- More extremely windy days
- Sea ice has higher drag coefficient than open water

Seasonality



- Much less calm wind in summer & fall
  - Possibly due to onshore/offshore breeze
- Fall dominates in categories >20km/h
- Wind tends to be slower in winter

Seasonality

Kuujjuarapik	Mean (1971-1990)	Mean (1991-2010)	T-value	Degrees of freedom	p-value
Winter (Dec to Feb)	17.33 km/h	17.82 km/h	-1.8316	3608	0.0671
Spring (Mar to May)	14.93 km/h	15.88 km/h	-4.1038	3678	**<0.0001**
Summer (Jun to Aug)	14.98 km/h	15.38 km/h	-1.8592	3678	0.0631
Fall (Sep to Nov)	20.81 km/h	20.20 km/h	1.8416	3638	0.0656

Other locations

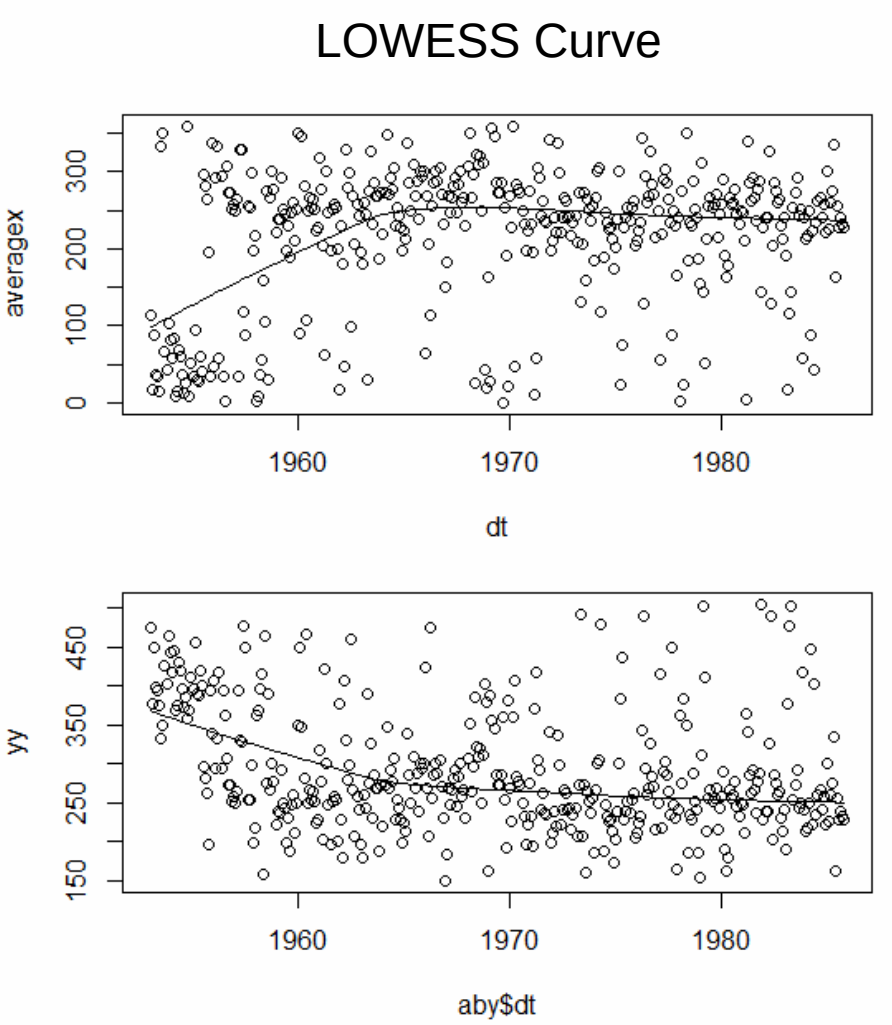
Baker Lake	Mean (1971-1990)	Mean (1991-2010)	T-value	Degrees of freedom	p-value
Winter (Dec to Feb)	23.91 km/h	20.04 km/h	10.939	3585	**<0.0001**
Spring (Mar to May)	21.69 km/h	22.64 km/h	-2.6682	3590	**0.00766**
Summer (Jun to Aug)	18.34 km/h	22.07 km/h	-11.424	3631	**<0.0001**
Fall (Sep to Nov)	21.77 km/h	20.77 km/h	3.0111	3623	**0.00262**

Other locations

Inukjuak	Mean (1971-1990)	Mean (1991-2010)	T-value	Degrees of freedom	p-value
Winter (Dec to Feb)	20.21 km/h	20.32 km/h	-0.3512	3582	0.72546
Spring (Mar to May)	20.30 km/h	21.18 km/h	-3.004	3590	**0.00268**
Summer (Jun to Aug)	20.83 km/h	19.99 km/h	2.4724	3631	**0.01347**
Fall (Sep to Nov)	22.52 km/h	22.52 km/h	0.0109	3623	0.99133

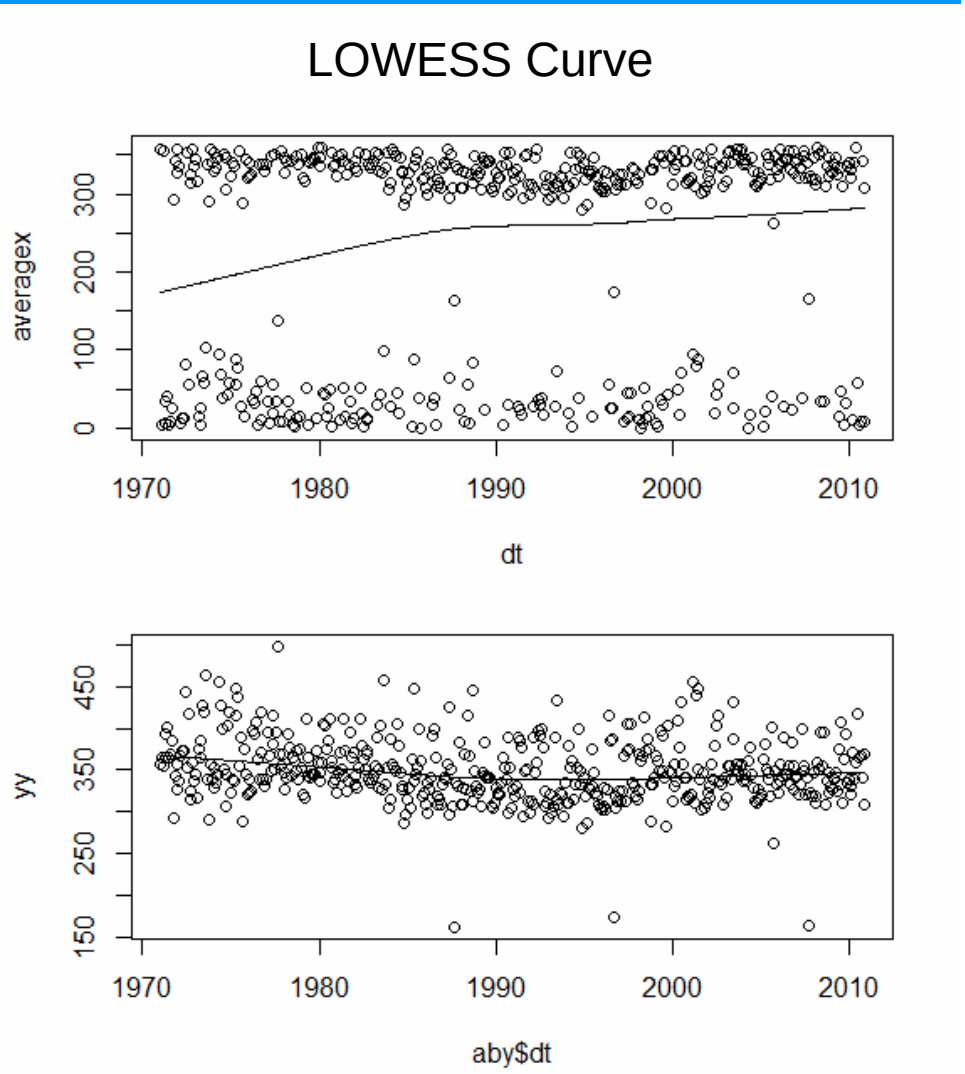
Nitchequon

- Testing if change in wind direction is significant with Mann Kendall test
  - tau = -0.205
  - p = 1.2494×10^{-9} (significant)



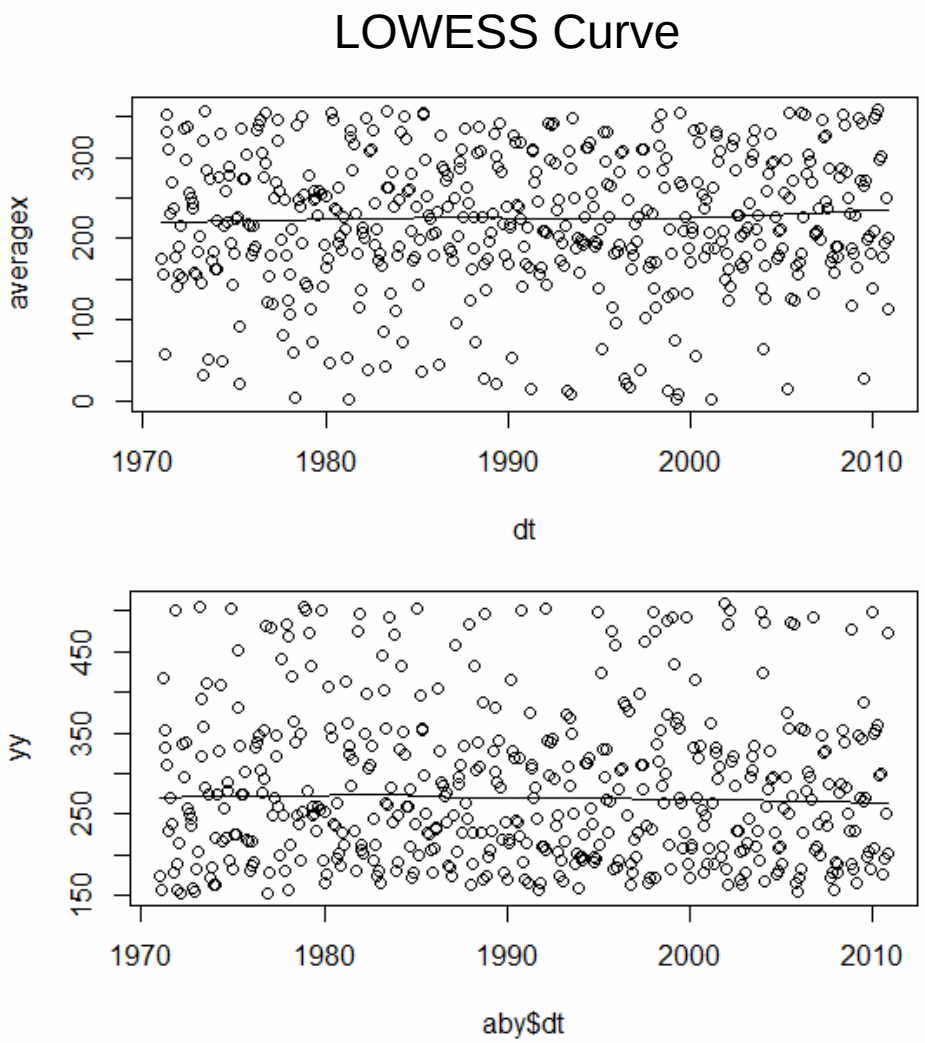
Baker Lake

- Mann Kendall
  - tau = -0.12
  - p = 8.2637 X 10^{-5} (significant)



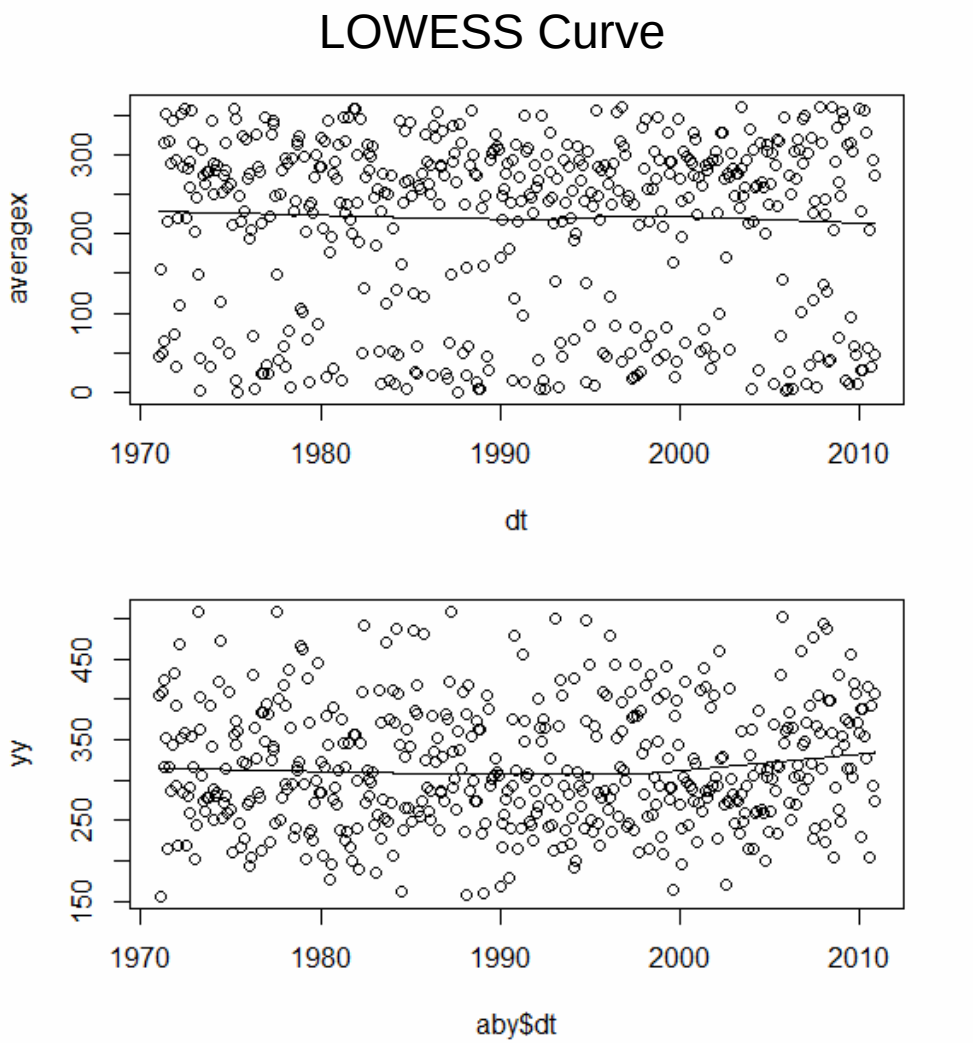
Kuujjuarapik

- Mann Kendall
  - tau = -0.0174
  - p = 0.56833
    (not significant)



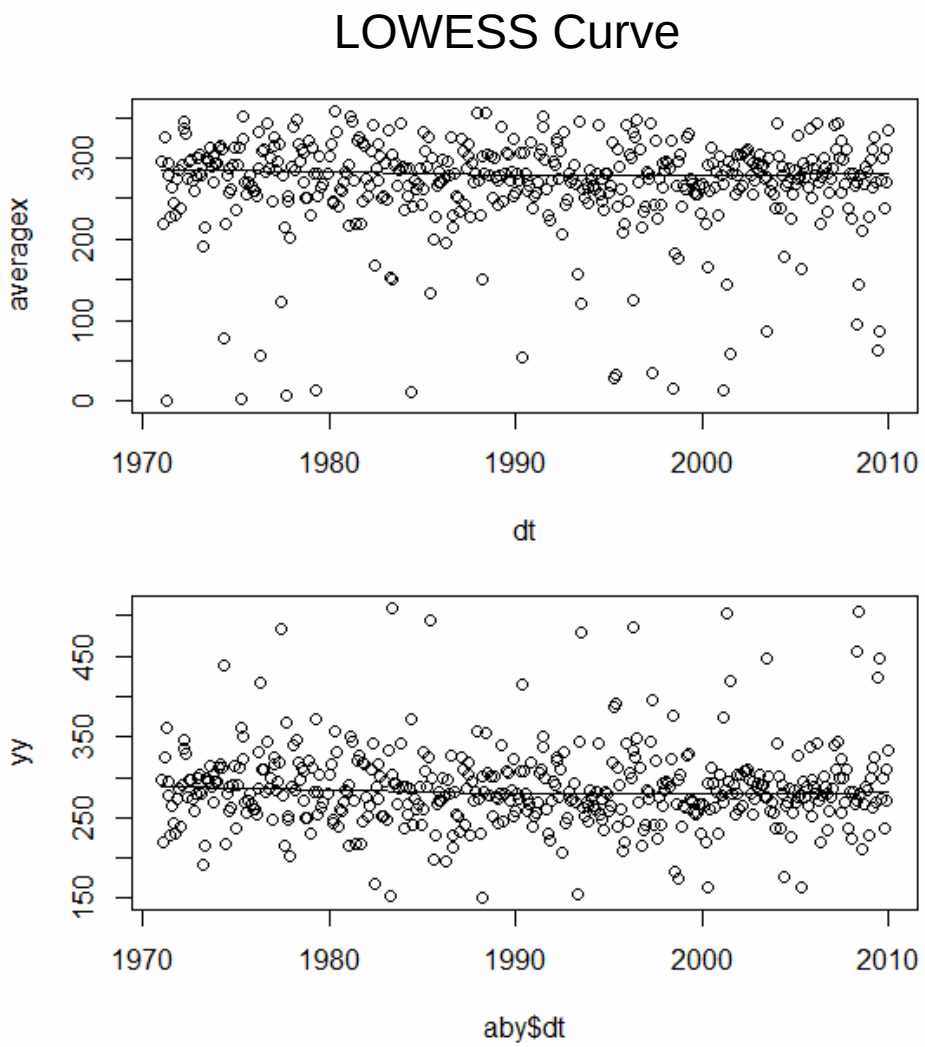
Inukjuak

- Mann Kendall
  - tau = 0.0343
  - p = 0.2627
    (not significant)



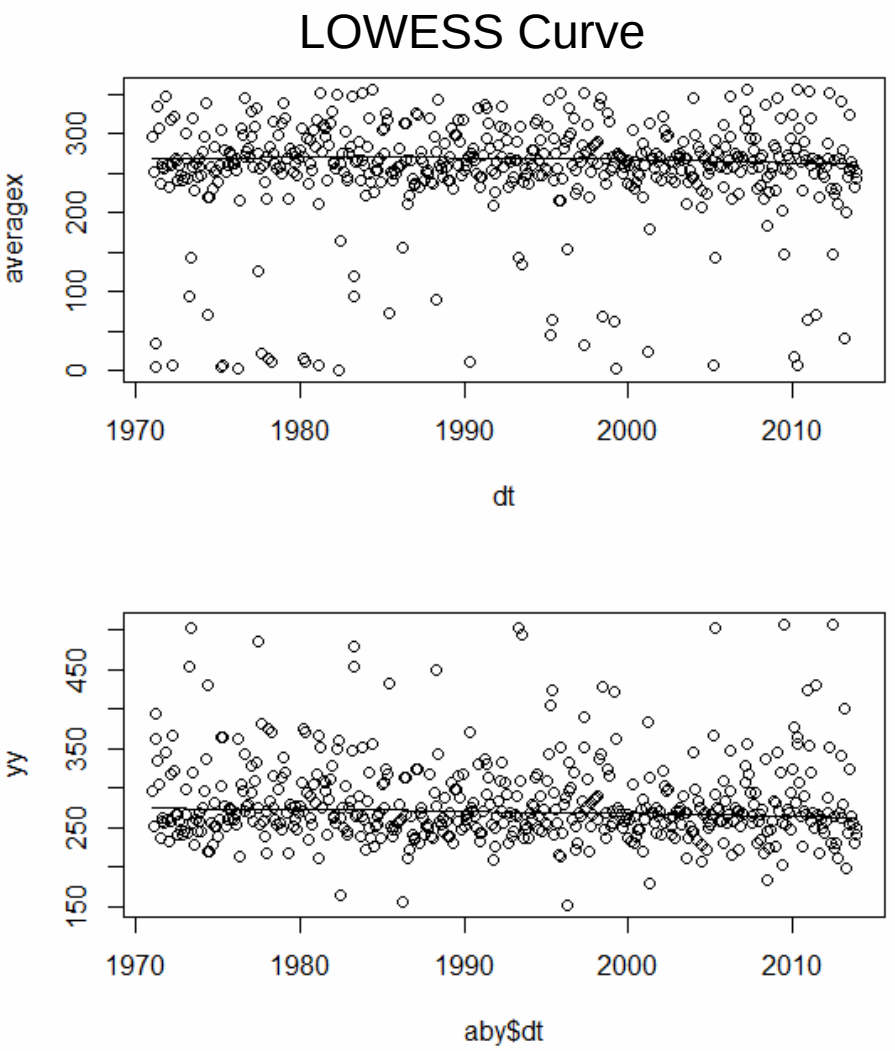
Schefferville

- Mann Kendall
  - tau = -0.0262
  - p = 0.39796
    (not significant)



Wabush

- Mann Kendall
  - tau = -0.0484
  - p = 0.10081
    (not significant)



Impacts

- Longer ice-free season altered local wind patterns
- Planes must land into the wind if wind speed ≥10 knots
- Increases the chance of experiencing crosswind takeoff and landings
  - Elevate the risk of crashes
  - Case study: First Air Flight 6560

First Air Flight 6560

- August 2011
- Boeing 737 flying from Yellowknife to Resolute Bay
- Crashed into a hill during landing, killing 12 and 3 survived
- Final report indicated that wind change was one of the factor that contributed to the crash

Adapting and Mitigating the Risk

- “Do nothing” approach
  - Wait until weather conditions improve
- Build another runway that faces into the predominant wind direction
  - May be lacking flat land to build another runway
- Install navigation system to assist with landing
  - Both are financially infeasible
- Train pilots for better preparation

Conclusions

- Wind direction was significantly changing towards south-westerly wind in 2 locations
- Average wind speed at some locations (or seasons) are significantly increasing
- Focus on the average wind speed value, not on the statistical significance or the magnitude of change