Hail Climatology for Canada: An Update

BY

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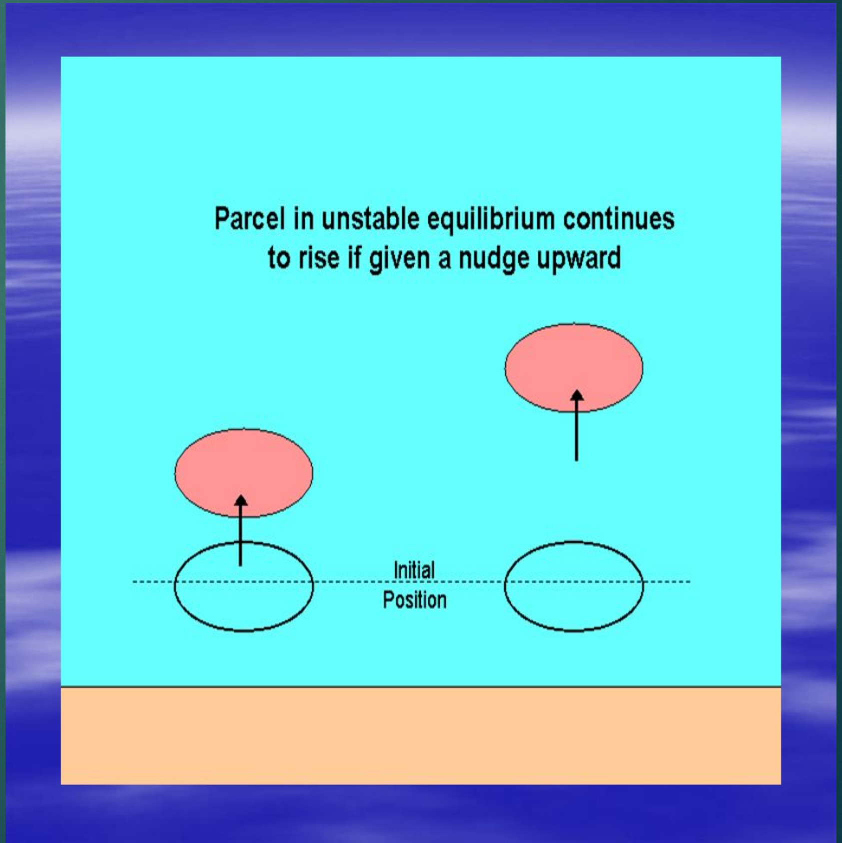
Primary ingredients for severe thunderstorms

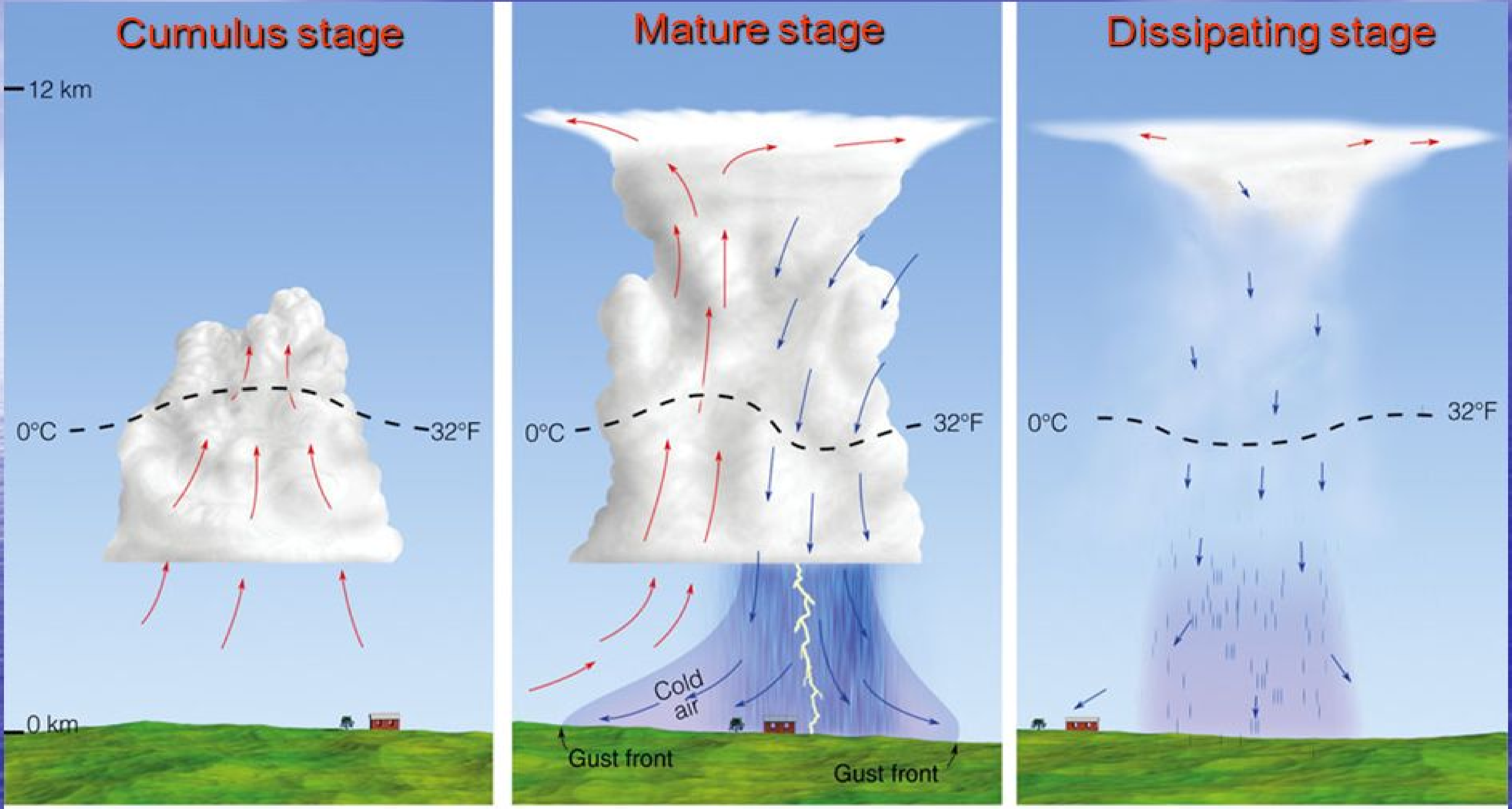
- 1. INSTABILITY
- 2. WIND SHEAR
- 3. LIFTING MECHANISM (trigger)

Instability

- A condition in which air will rise freely on its own due to positive buoyancy
- Moist, warm air in the lower levels
- Dry relatively cooler air in the upper levels



Life cycle of an ordinary thunderstorm



(a) Cumulus (b) Mature (c) Dissipating

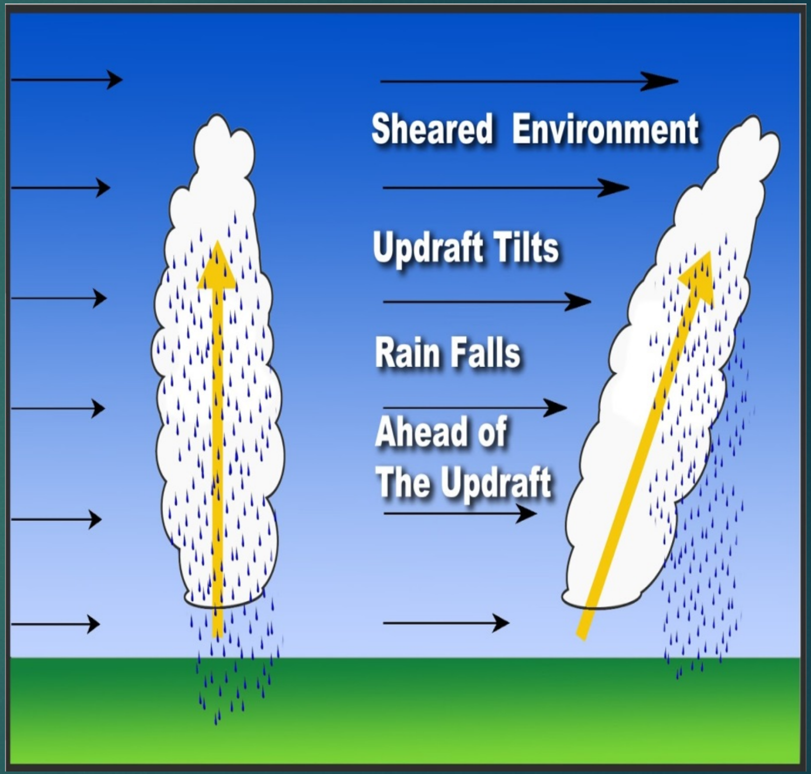
VERTICAL WIND SHEAR

- VERTICAL SPEED SHEAR- Significant increase of wind speed with height

- VERTICAL DIRECTIONAL SHEAR- Significant change of wind direction with height

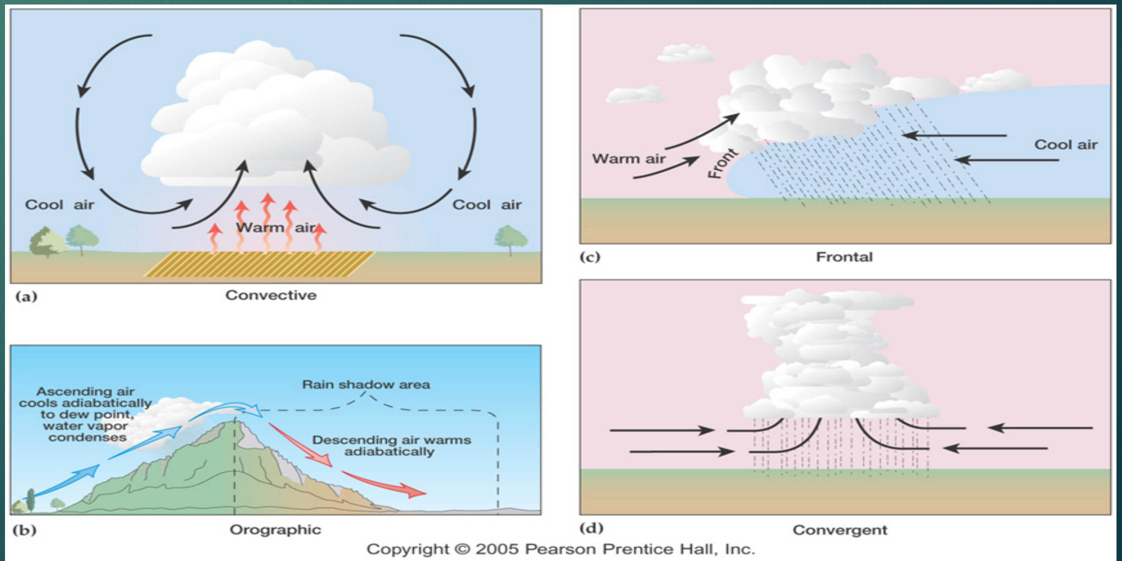
- 1. A significant increase of wind speed with height will tilt a storm's updraft. This allows the updraft and downdraft to occur in separate regions of the storm the reduces water loading in the updraft. The downdraft will not cut-off the updraft and actually it will even enforce it.

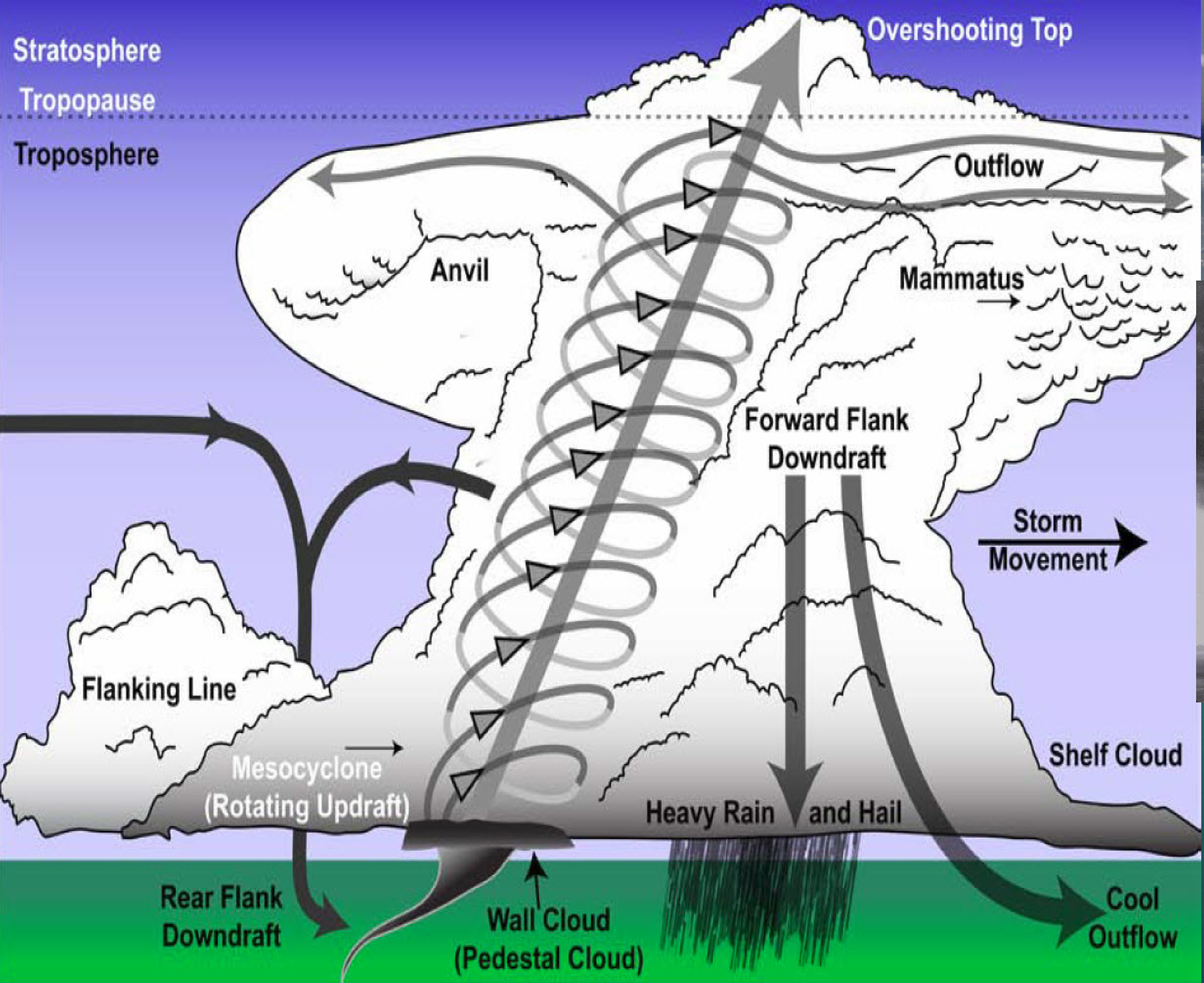
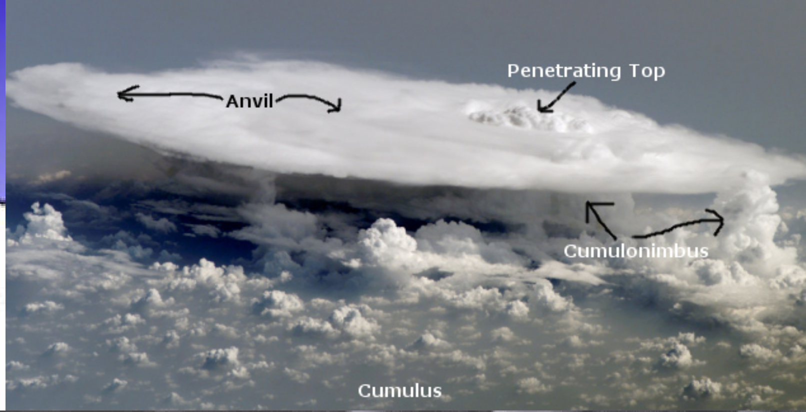
- 2. Strong upper tropospheric winds evacuates mass from the top of the updraft. This reduces precipitation loading and allows the updraft to sustain itself.



LIFTING MECHANISMS

- Frontal boundaries, dry lines and outflow boundaries (low level convergence)
- Upslope flow
- Low pressure system
- Differential heating along soil, vegetation, soil moisture, land cover boundaries (low level convergence)
- Jet Stream
- Gravity wave




Stratosphere
Tropopause
Troposphere
Overshooting Top
Outflow
Anvil
Mammatus
Forward Flank
Downdraft
Storm
Movement
Flanking Line
Mesocyclone
(Rotating Updraft)
Heavy Rain
and Hail
Shelf Cloud
Rear Flank
Downdraft
Wall Cloud
(Pedestal Cloud)
Cool
Outflow

Penetrating Top
Anvil
Cumulonimbus
Cumulus

Hail Formation

How does hail form? | Geography – Wild Weather with Richard Hammond

Warm moist air at low levels moves northward from the Gulf of Mexico.

Cooler dry air moves eastward At mid and higher levels from the west coast.

Development of troughs to the lee of the mountains

Previous Canadian Climatology

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **19**: 1357–1373 (1999)

A NOTE ON CANADA'S HAIL CLIMATOLOGY: 1977–1993

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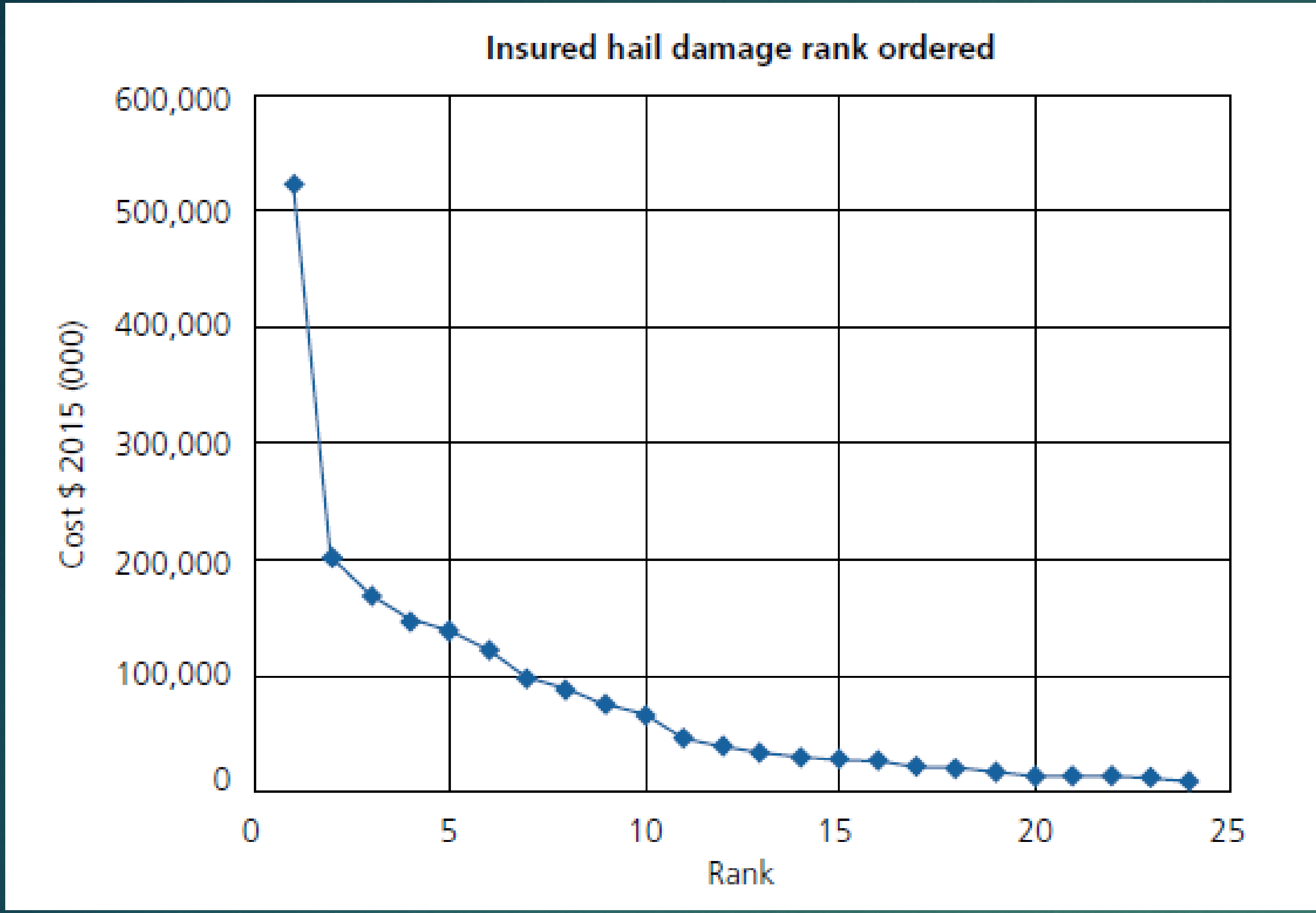
[b] *Department of Geography, University of North Carolina, Chapel Hill, NC, USA*

- 1977-1993 (… getting kind of old)
- Time for an update



Insured property hail damage in Canada (1981-2015).
Source: IBC (2016).

Rank 1 is the most expensive event (Calgary hailstorm of 1991) and dominates the dataset, comprising 27% of the total cost of the 24 events

Fat-tails

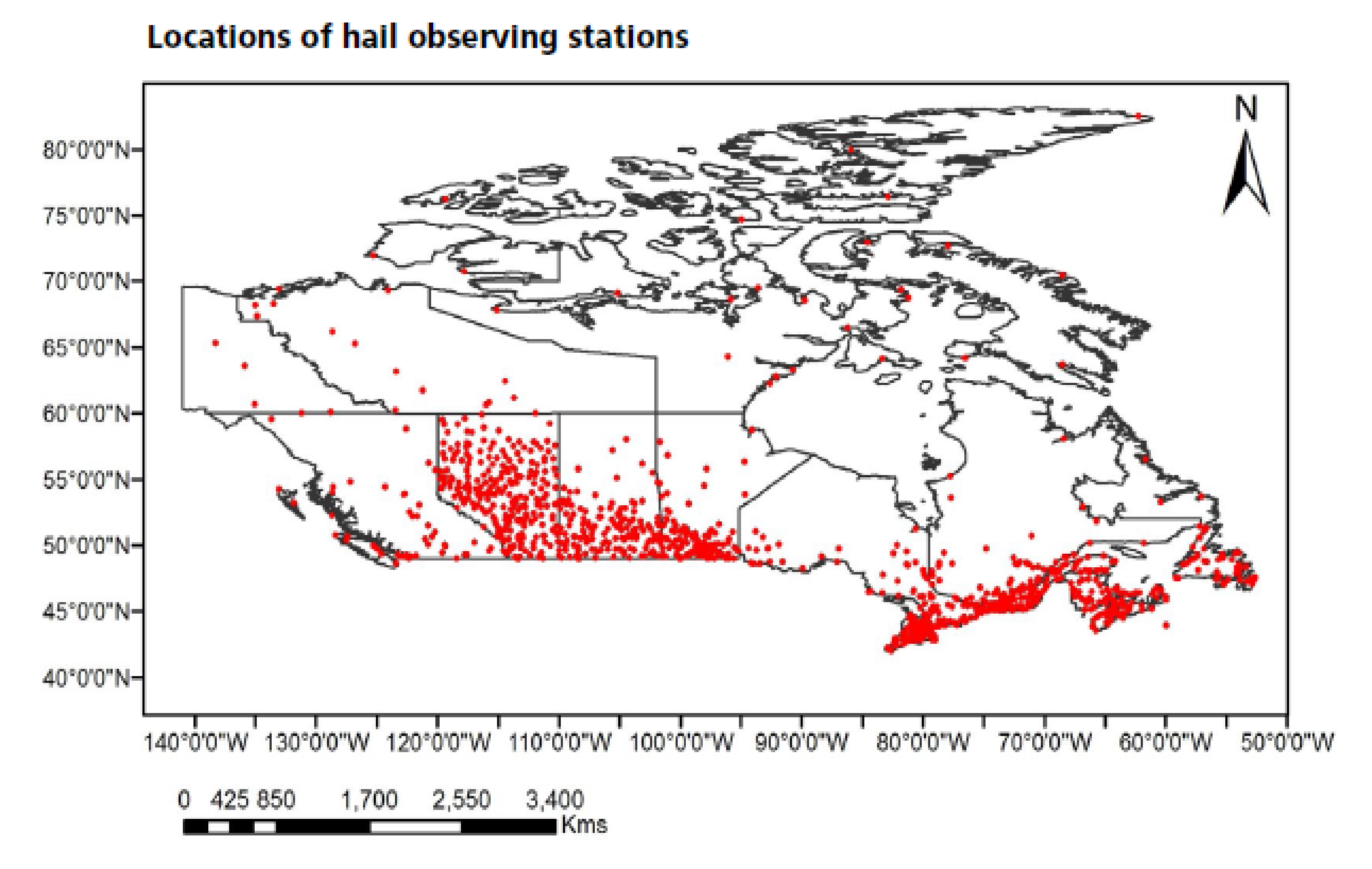
- A distribution with a fat tail is one where the frequency of large events fades slowly relative to a narrow tailed distribution
- Sablik (2015) notes that “disasters in general suffer from what economists call a “fat-tail” problem”.
- When a problem is fat-tailed, then a risk analysis must pay particular attention to worst case scenarios.

Flood Insurance Claims: A Fat Tail Getting Fatter

Apr 24, 2014 | Roger M. Cooke, Carolyn Kousky, Erwann Michel-Kerjan

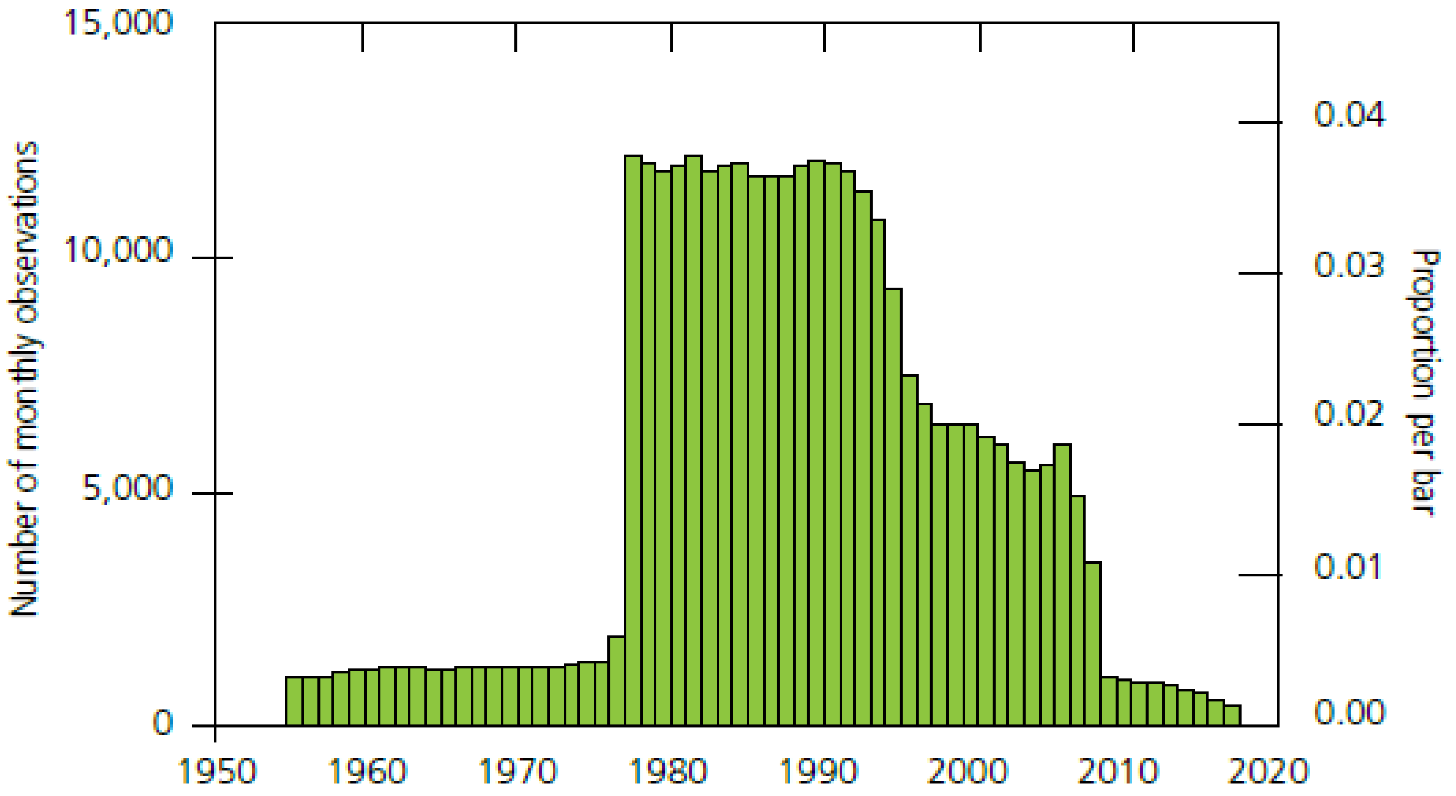
We cannot yet untangle what is driving this change in the distribution. Is it caused by changes in economic activity, more development in high-risk areas, changes in the composition of the NFIP, or climate-induced changes in the frequency or severity of flooding? Most likely some mix of all of these factors. What we do know is that if the tails of the distribution keep getting fatter (and particularly if these changes in insured losses mirror similar changes in total, society-wide damages), we may need to rethink our risk management strategies. Lower tail indices mean even more devastating flood disasters will come. New records will soon be set.

Environment Canada Weather Stations



Data Window: 1977 - 2007

Figure 6: Number of stations observing hail (May-September). Months with more than 3 missing observations and stations with less than 19 years of data are excluded.



Ontario Trend

Figure 7: Trends in hail frequency for Ontario. The vertical axis is mean number of hail days/station for the months of May-September.

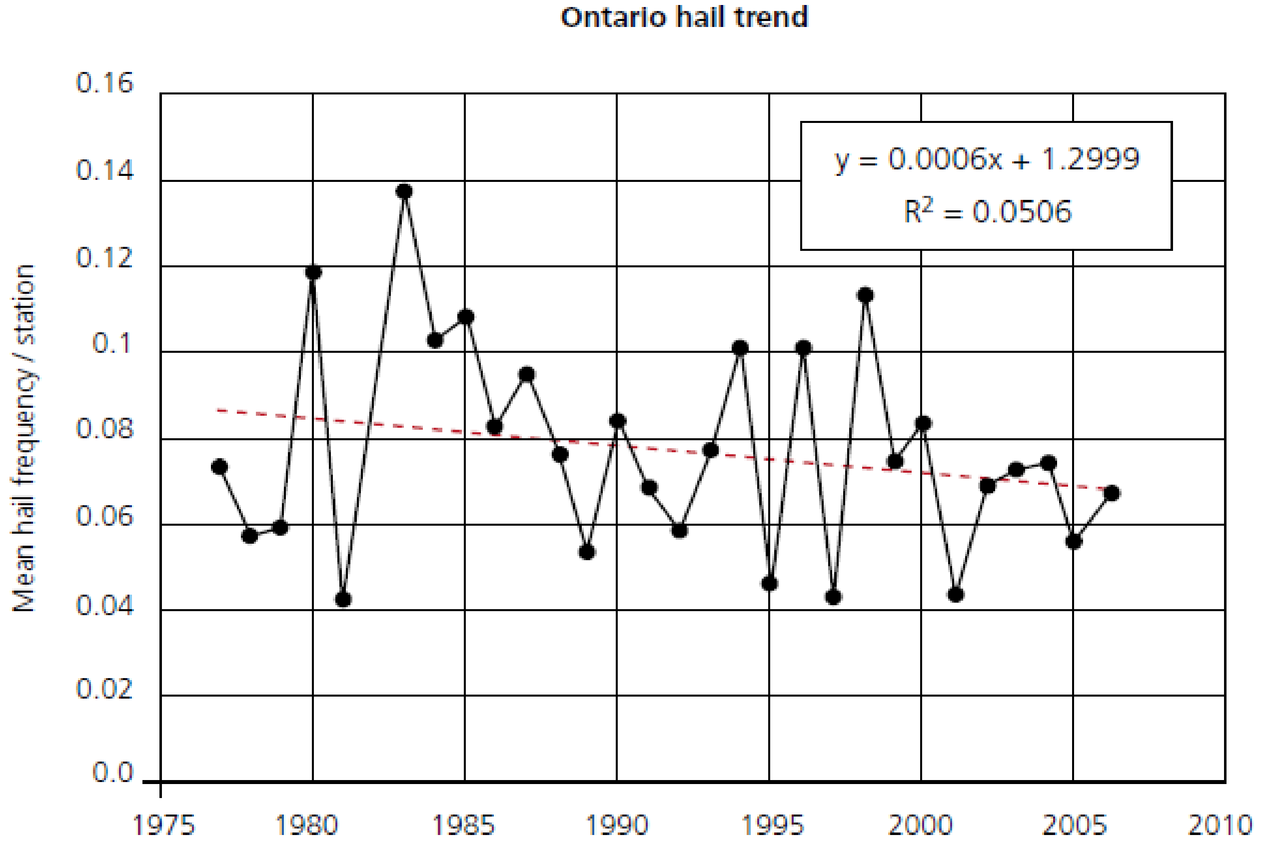
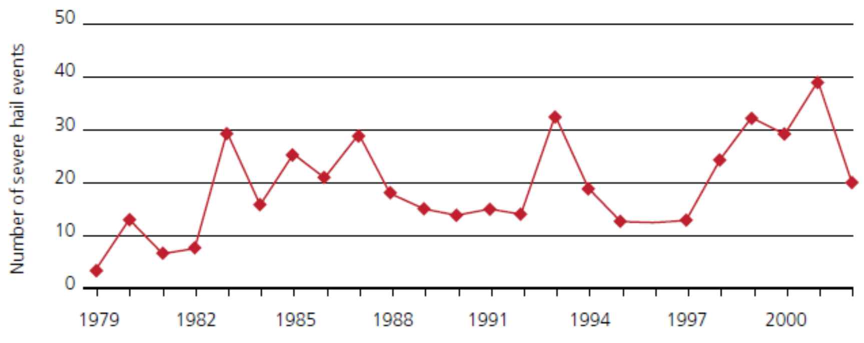
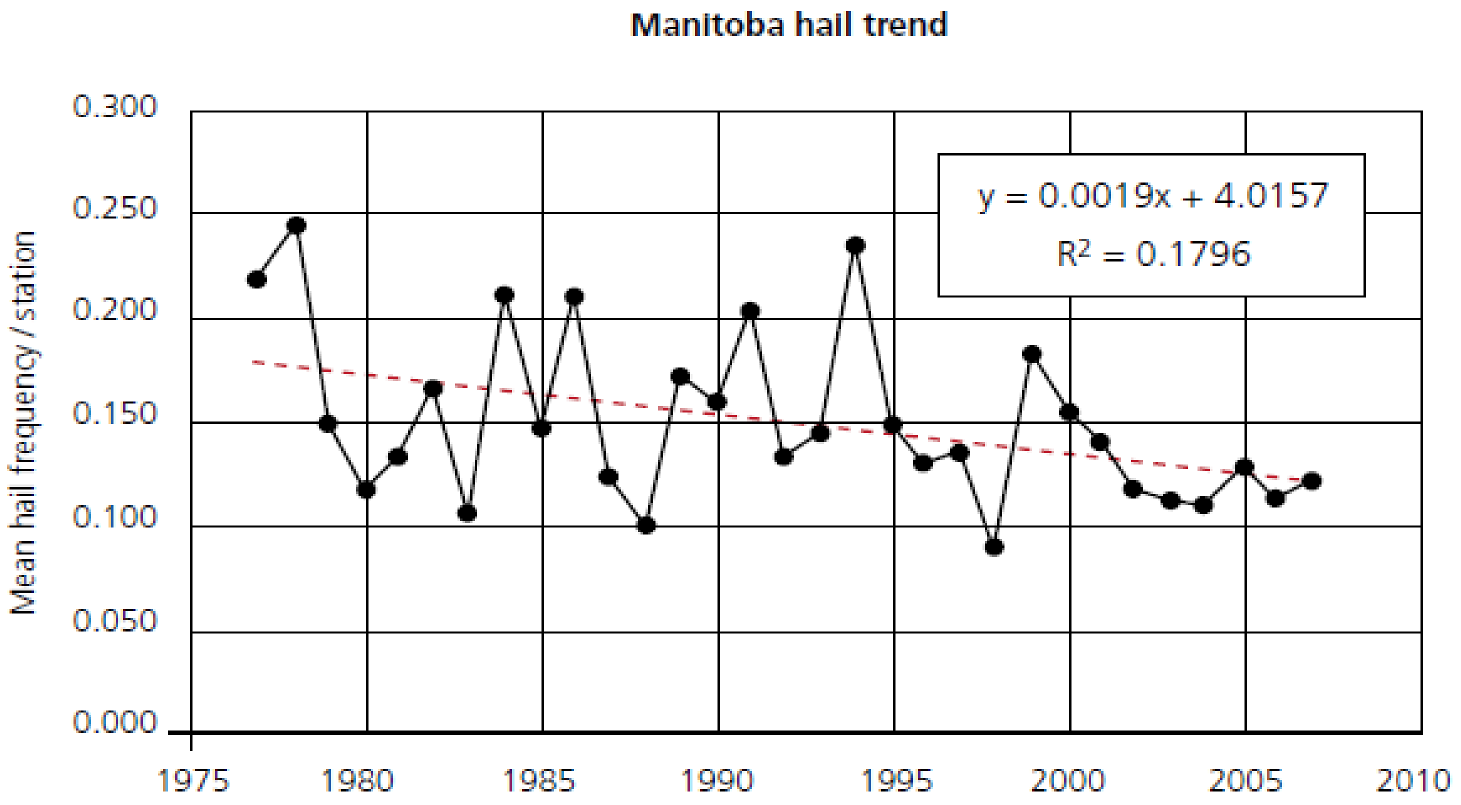


Figure 2: Number of severe hail events in Ontario from 1979-2002. Source: Cao (2008)



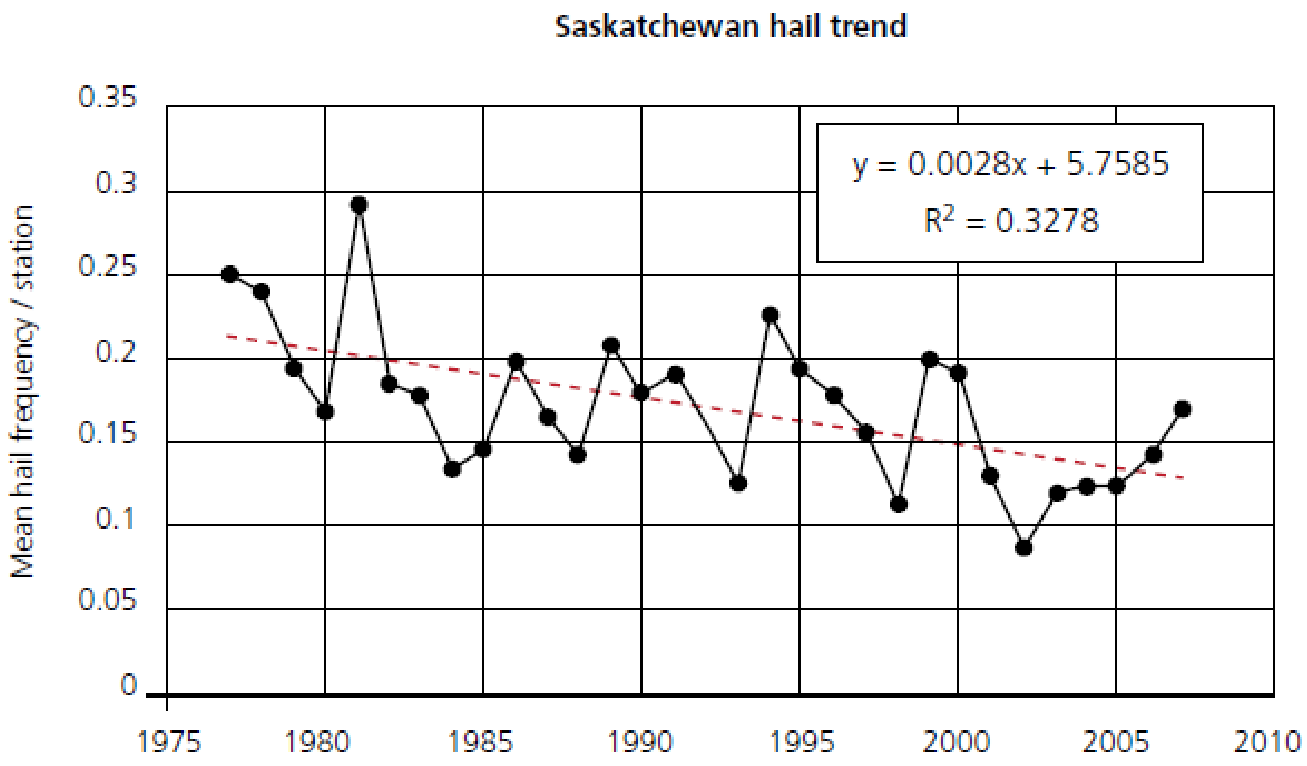
Manitoba Trend

Figure 10: Trends in hail frequency for Manitoba. The vertical axis is mean number of hail days per station for the months of May-September.



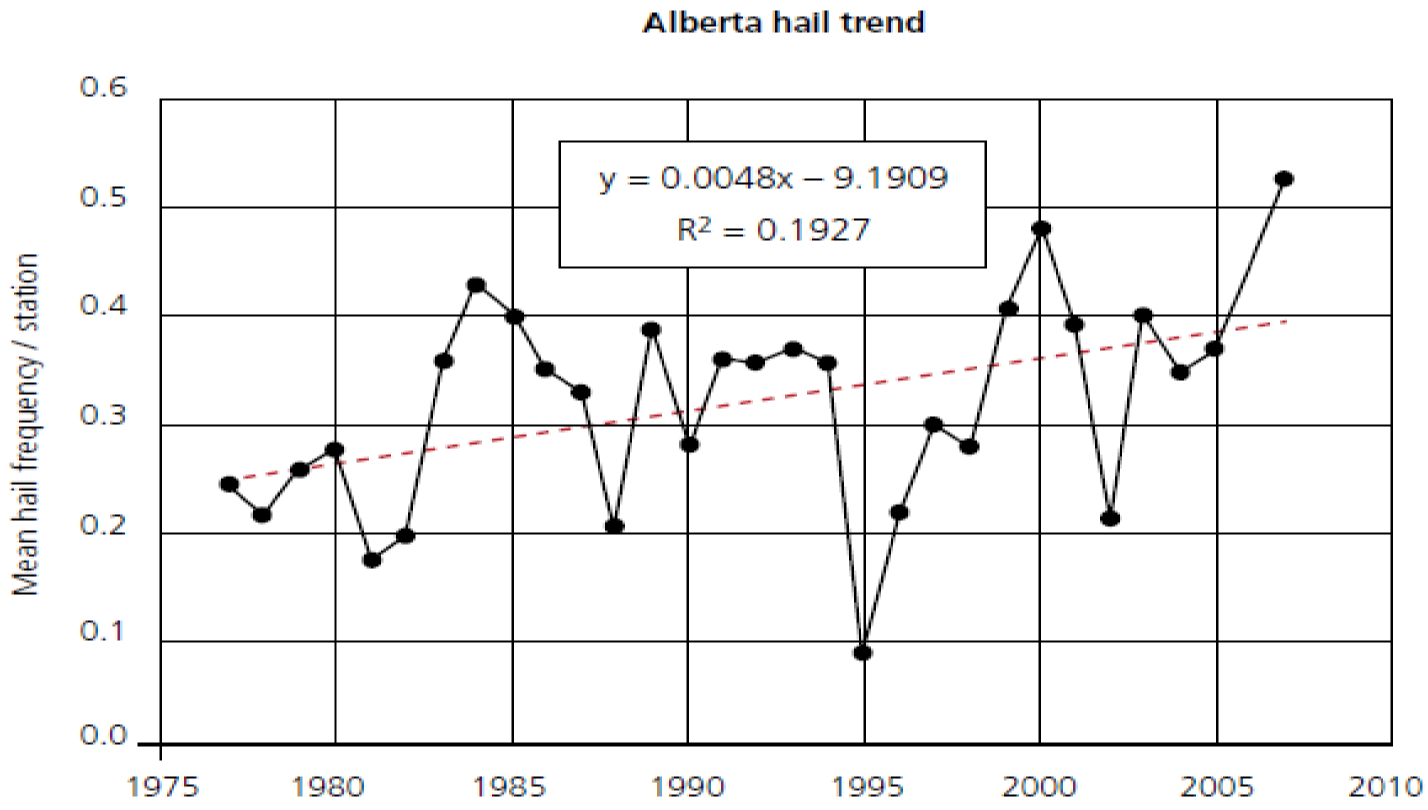
Saskatchewan Trend

Figure 9: Trends in hail frequency for Saskatchewan. The vertical axis is mean number of hail days per station for the months of May-September.

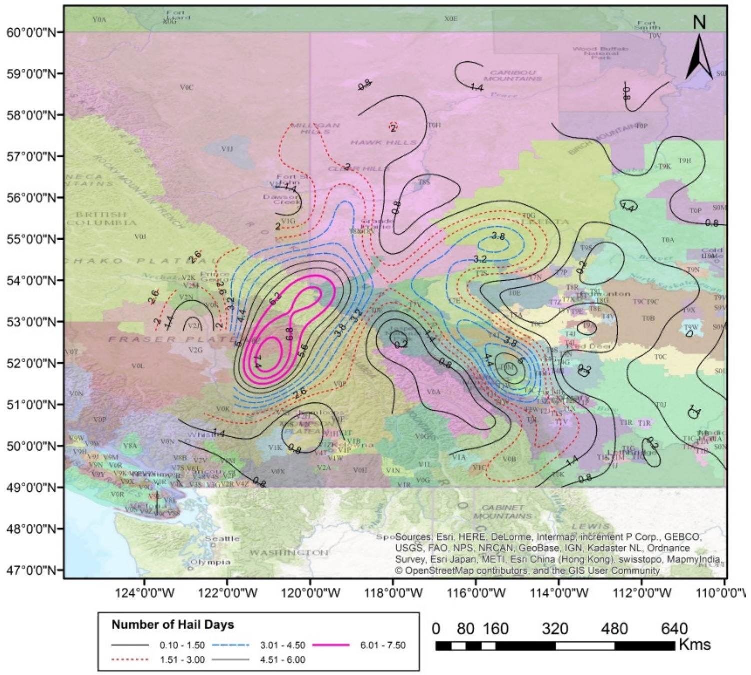


Alberta Trend

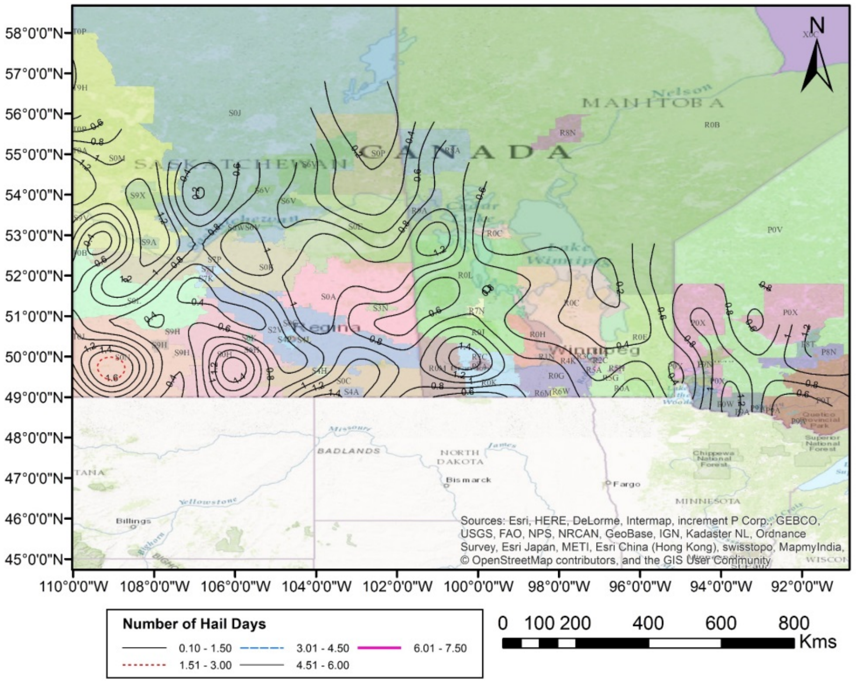
Figure 8: Trends in hail frequency for Alberta. The vertical axis is mean number of hail days per station for the months of May-September.



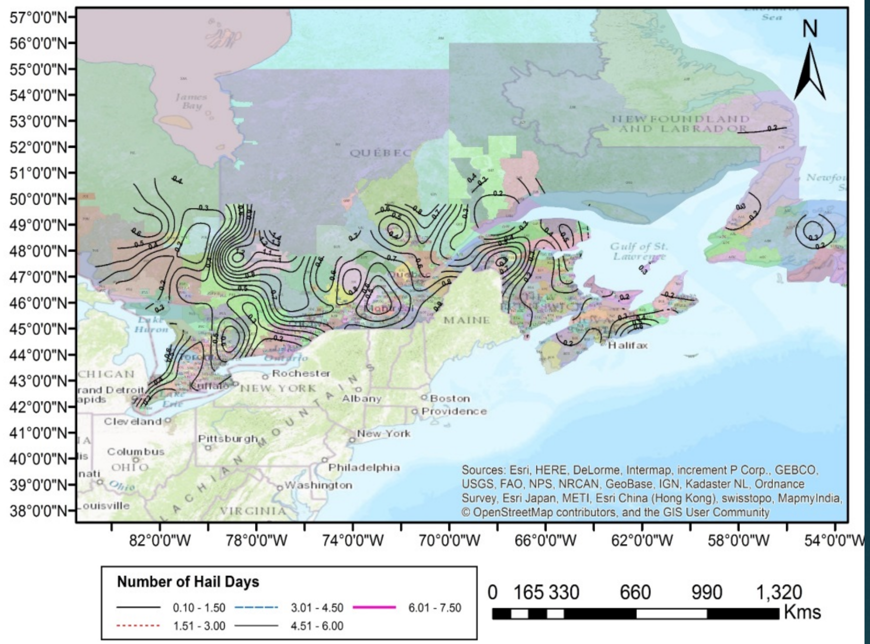
Warm Months Hail Frequency in Western Canada



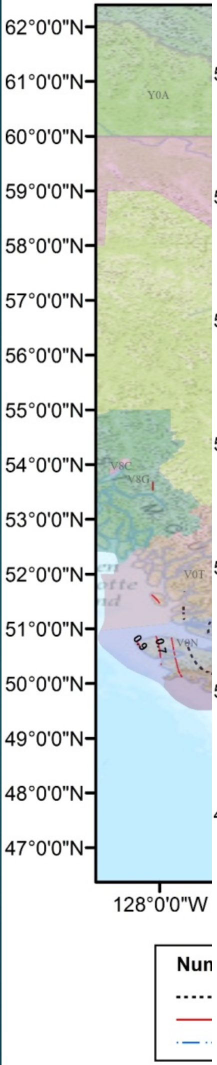
Warm Months Hail Frequency in Central Canada



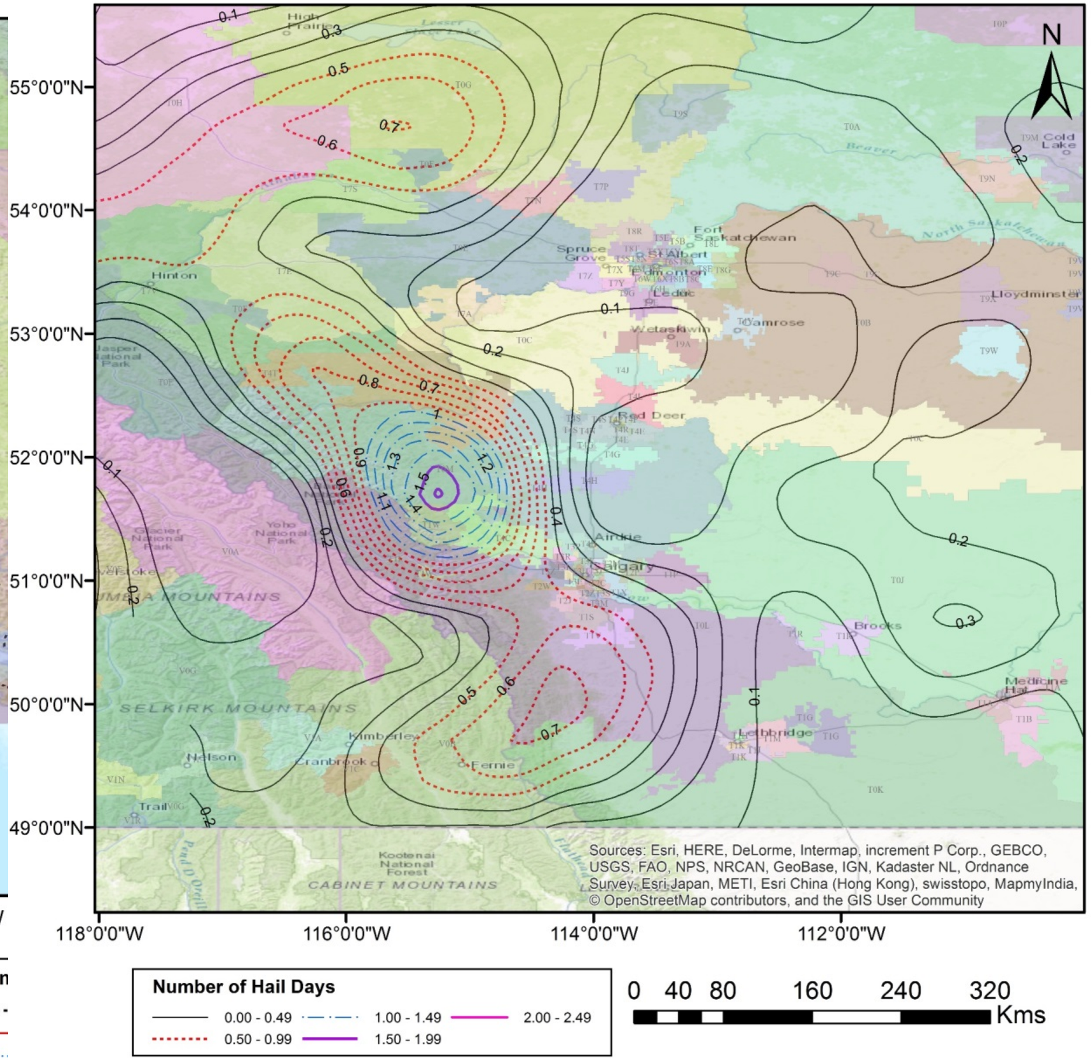
Warm Months Hail Frequency in Eastern Canada



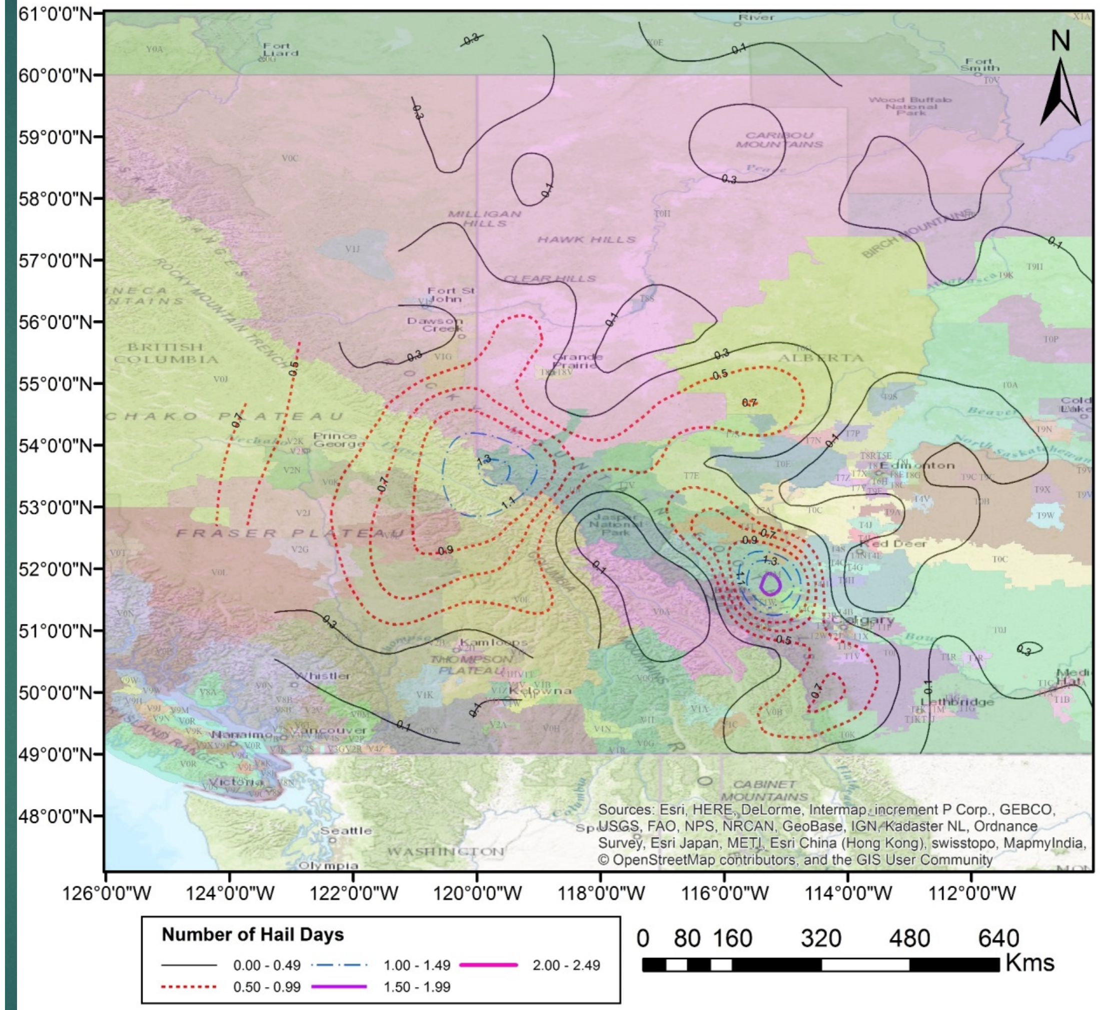
Note: Though topography is important for hailstorm formation, these maps only include an objective analysis of the observed data. Where station observations are sparse, topographic effects are not properly accounted for.



August Hail Frequency in Western Canada



August Hail Frequency in Western Canada



Searchable Excel Hail Database

Future Analysis

- Radar

Spatial and temporal distribution of hailstorm in the Alpine region: a long-term, high resolution, radar-based analysis

L. Nisi[1,2,3,4], O. Martius[1,2,3], A. Hering[4], M. Kunz[5], U. Germann[4]

4.1. Climatological frequency

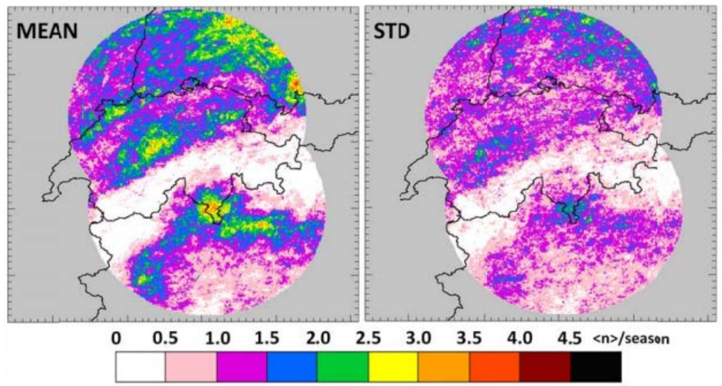
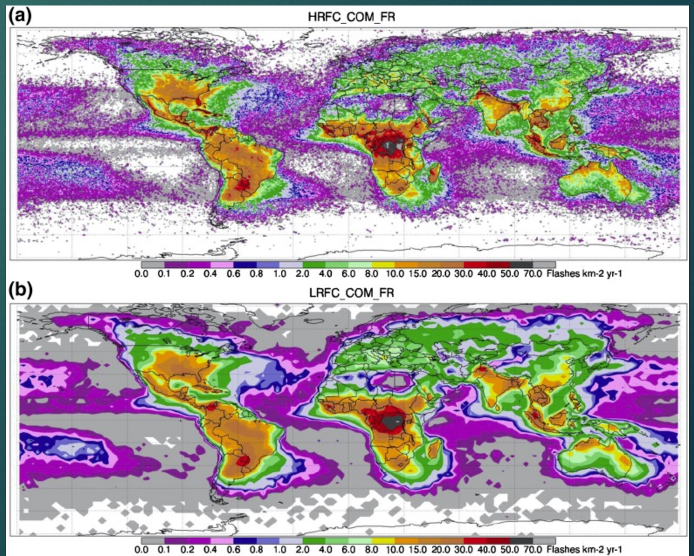


Figure 4. Left: average number of days with POH > 80% per season (April - September) and km^2 during the period 2002-2014; right: STD of the number of radar-derived hail days per season.

- Lightning

Gridded lightning climatology from TRMM-LIS and OTD: Dataset description

Daniel J. Cecil [a], Dennis E. Buechler [a], Richard J. Blakeslee [b]




QUESTIONS?
COMMENTS?