GWF Precipitation Extremes: Heavy Rain and Hail

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Background

- Events of heavy rain and hail economic impacts
  - Rain: Toronto Aug 2005 & Jul 2013 & May 2017 / Calgary 2013
  - Hail: Calgary Aug 2012 & Jul 2010 & Aug 2014
- What we know
  - climatology and synoptic patterns?
  - Hunter et al Vanguard
  - Szeto et al GPLLJ
  - Y. Li et al (Calgary event)
  - Sills et al Toronto event
  - U.S. MCS/heavy rain and flash flood event (Schumacher et al)
- Some events complicated – mesoscale interactions and processes (e.g. Vanguard & Toronto)
- Heavy rain in future? (Stone et al 2000; Donat et al 2016; Erler & Peltier 2016)
- Hail in the future? (Brimelow et al 2017)

Main Objective

- Create products and information relevant to insurance industry on future changes in warm season heavy rain and hail potential

Datasets

- CatIQ and ICLR events databases
- Precipitation Observations of selected events
- Available previous studies of events (e.g. Vanguard, Calgary, Toronto) and climatologies (e.g. Hogg & Hogg)
- Reanalysis Products:
  - For larger scale depictions of events and develop climatological patterns for larger impact events – to observe patterns
- 4km WRF PGW runs – NCAR and UofS
- Available RCMs to compare to WRF runs
- Other RCMs for longer projections (beyond mid-century)?

Trends in Canadian Short-Duration Extreme Rainfall: Including an Intensity–Duration–Frequency Perspective

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ABSTRACT *Short-duration (5 minutes to 24 hours) rainfall extremes are important for a number of purposes, including engineering infrastructure design, because they represent the different meteorological scales of extreme rainfall events. Both single location and regional analyses of the changes in short-duration extreme rainfall amounts across Canada, as observed by tipping bucket rain gauges from 1965 to 2005, are presented. The single station analysis shows a general lack of a detectable trend signal, at the 5% significance level, because of the large variability and the relatively short period of record of the extreme short-duration rainfall amounts. The single station 30-minute to 24-hour durations show that, on average, 4% of the total number of stations have statistically significant increasing amounts of rainfall, whereas 1.6% of the cases have significantly decreasing amounts. However, regional spatial patterns are apparent in the single station trend results. Thus, for the same durations regional trends are presented by grouping the single station trend statistics across Canada. This regional trend analysis shows that at least two-thirds of the regions across Canada have increasing trends in extreme rainfall amounts, with up to 33% being significant (depending on location and duration). Both the south-west and the east (Newfoundland) coastal regions generally show significant increasing regional trends for 1- and 2-hour extreme rainfall durations. For the shortest durations of 5–15 minutes, the general overall regional trends in the extreme amounts are more variable, with increasing and decreasing trends occurring with similar frequency; however, there is no evidence of statistically significant decreasing regional trends in extreme rainfall amounts. The decreasing regional trends for the 5- to 15-minute duration amounts tend to be located in the St. Lawrence region of southern Quebec and in the Atlantic provinces. Additional analysis using criteria specified for traditional water management practice (e.g., Intensity-Duration-Frequency (IDF)) shows that fewer than 5.6% and 3.4% of the stations have significant increasing and decreasing trends, respectively, in extreme annual maximum single location observation amounts. This indicates that at most locations across Canada the traditional single station IDF assumption that historical extreme rainfall observations are stationary (in terms of the mean) over the period of record for an individual station is not violated. However, the trend information is still useful complementary information that can be considered for water management purposes, especially in terms of regional analysis.*

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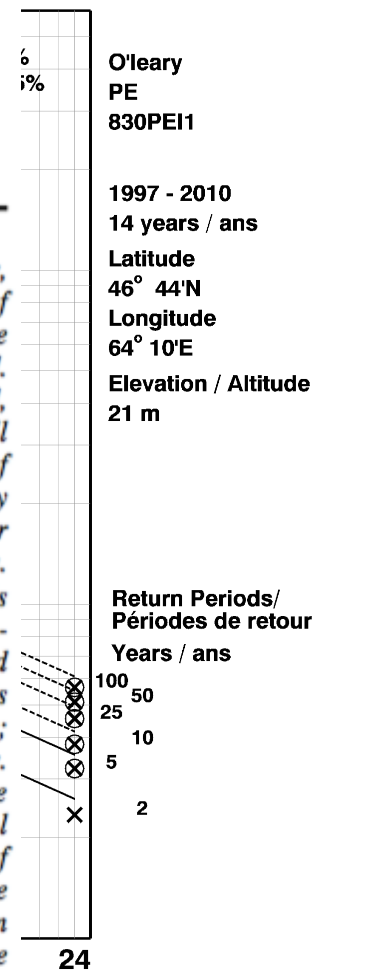

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Heavy Rain

Vincent & Mekis 2006

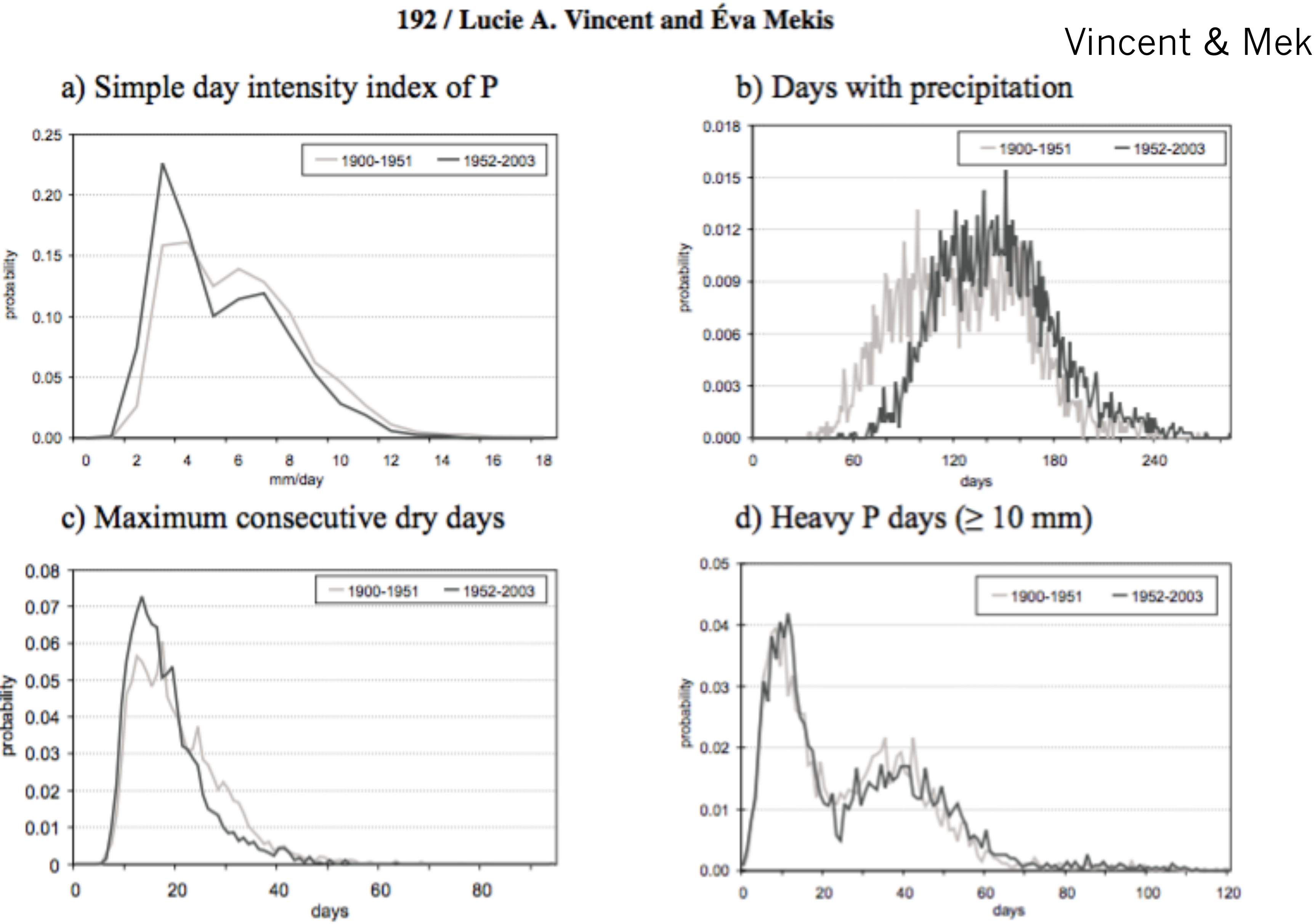

Fig. 11 Probability density functions for the periods 1900–51 and 1952–2003.

Rainfall

https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#rainfall

Table 13. Alerting parameters for a Short Duration Rainfall (Heavy Downpour) Warning

Alert Type	Location	Threshold Criteria
Warning	Alberta, Saskatchewan, Manitoba, Ontario, and Quebec (except Nunavik*)	When 50 mm or more of rain is expected within one hour.
Warning	Interior dry sections of British Columbia	When 15 mm or more of rain is expected within one hour.
Warning	Remaining sections of British Columbia, Yukon, Northwest Territories, Nunavut, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador	When 25 mm or more of rain is expected within one hour.

Table 14. Alerting parameters Environment Canada uses for issuing a Long Duration Rainfall Warning in the Summer

Alert Type	Location	Threshold Criteria
Warning	National, except Nunavik* and portions of British Columbia, as specified below	When 50 mm or more of rain is expected within 24 hours; or When 75 mm or more of rain is expected within 48 hours.
Warning	NEW - Interior dry sections of British Columbia	When 25 mm or more of rain is expected within 24 hours.
Warning	Inland Vancouver Island, West Vancouver Island, North Vancouver Island, Central Coast - coastal sections, and North Coast - coastal sections	When 100 mm or more of rain is expected within 24 hours.

Brimelow et al 2017

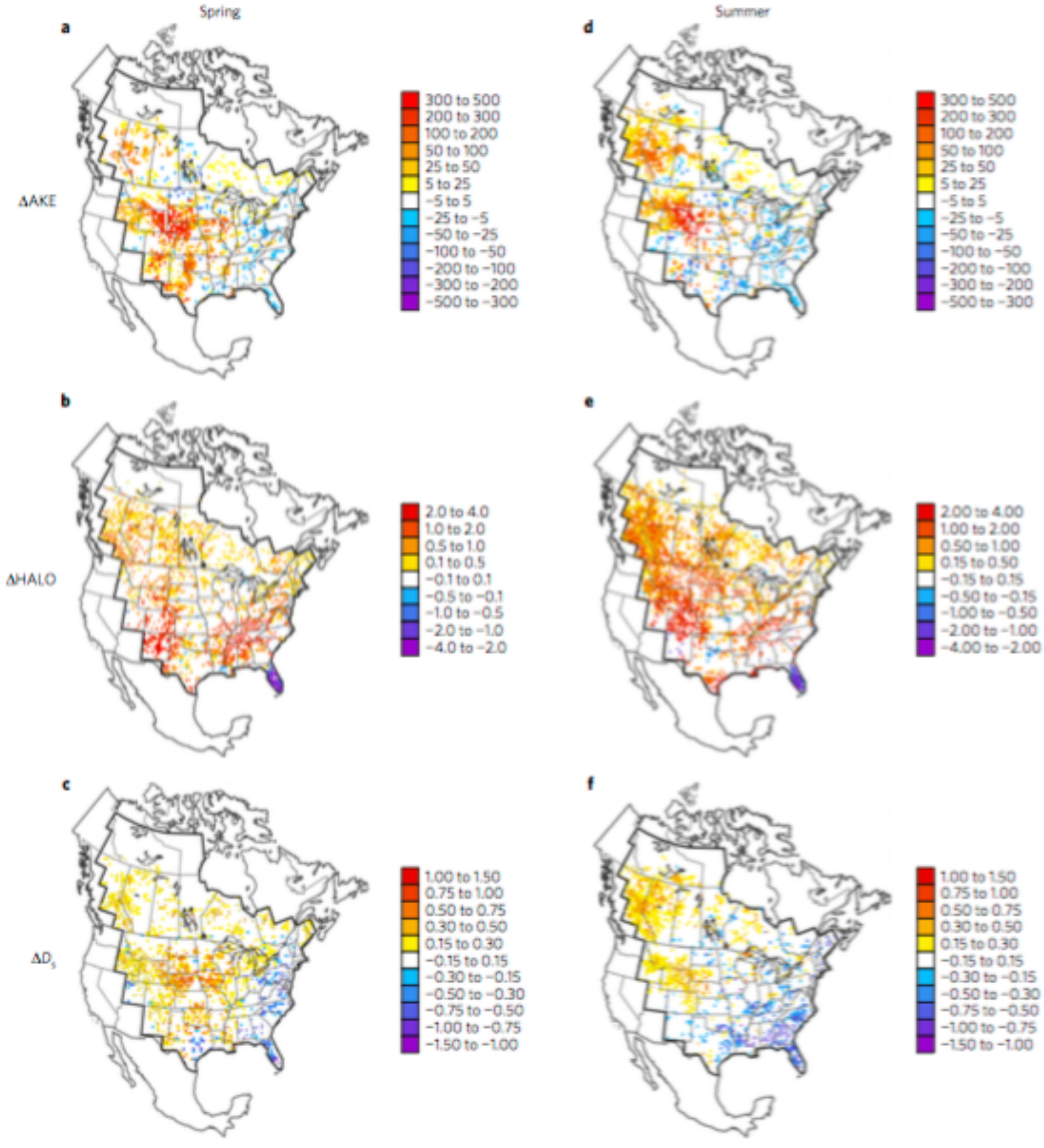

Figure 2 | Spatial changes in hail metrics for spring and summer. a–c, Mean multi-model changes in future (2041–2070) minus present (1971–2000) for spring accumulated kinetic energy (AKE) in joules per season (**a**), days with hail aloft only (HALO) per season (**b**), and maximum diameter at the surface (D_s) in centimetres (**c**). **d–f**, The same variables as for **a–c**, except for summer. The colouring is the same as for Fig. 1.

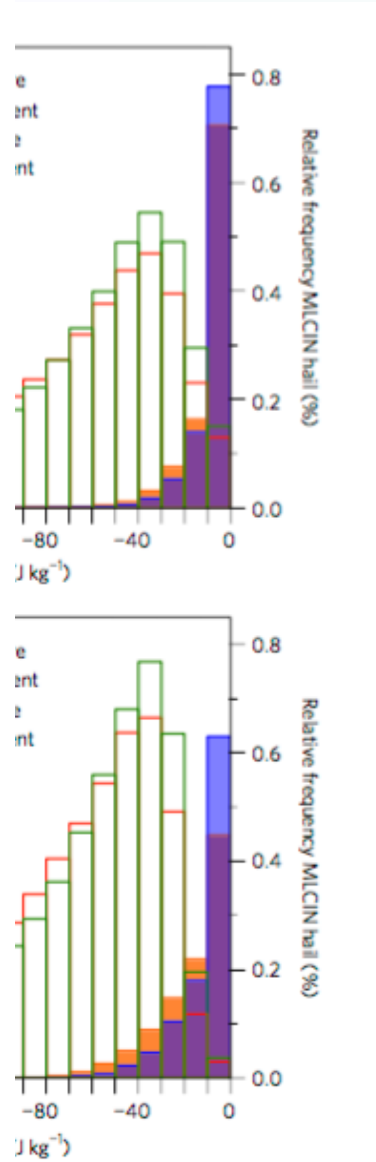

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Table ES-3 Summary of Projected Future Weather Compared to Today

Weather Type	Parameter	2000-2009	2040-2049
Extreme Precipitation	Maximum in One Day (in mm)	66	166
	Number of Days with more than 25 mm	19	9
	Mean Annual Daily Maximum in mm	48	86
	100 year Return Period Maximum Daily (in mm)*	81	204
	10 year Return Period Maximum Daily (in mm)	62	135
	10 year Return Period Maximum Hourly (in mm)	20	39
Extreme Rain	Maximum in One Day (in mm)	66	166
	Number of Days with more than 25 mm	16	9
Extreme Snowfall	Maximum in One Day (in cm)	24	18
	Number of Days with more than 5 cm	16	3
Extreme Heat	Maximum Daily (in °C)	33	44
	Number of Day with more than 30 °C	20	66
Extreme Cold	Minimum Daily (in °C)	-17	-11
	Number of Days with less than -10 °C	24.6	0.3
	Number of Days with minimum less than 0 °C (frost days)	128	70
Wind Chill	Extreme Daily	-24	-17
	Number of Days with less than -20 °C	12	0
Degree Days	Number of Degree Days Greater than 24 °C (air conditioning required)	10	180
	Number of Degree Days Greater than 0 °C	3452	4857
	Number of Degree Days Less than 0 °C (extra heating required)	440	66
Extreme Wind	Maximum Hourly Speed in km/hour	92	48
	Maximum Gust Speed in km/hour	130	75
	Number of Days with Wind Speed Greater than 52 km/hour	0.9	0.0
	Number of Days with Wind Speed Greater than 63 km/hour	0.3	0.0
Humidex	Maximum (in °C)	48	57
	Number of Days greater than 40 °C	9	39
Storms	Average Number of Storms per Year	30	23
	Average Number of Summer Storms in One Year	17	17
	Average Number of Winter Storms in One Year	14	6
	Average SRH (vortices potential) in One Year	1281	691
	Average CAPE (convective energy potential) in One Year	3841	4097
	Average EHI (combination if SRH and CAPE) in One Year	3.6	4.3

* underestimate due to length of record

Next Initial (Year 1) Steps

- Continue (and grow) collaborations amongst our Pis interested in heavy rain and hail
  - Working with Yanping, Mary & Julian thus far
  - Define heavy rain plans & products
  - Continue hail model runs
- Select various impactful events (why were they so?)
- Extract available observational and reanalysis data to examine events in more detail
- Gather and analyze WRF-PGW data for comparison to observations
- Collaborate with Partners (CatIQ / ICLR) to scope potential useful products