The June, 2021 Heat-Wave

and Potential Future Events

Can an atmospheric river contribute to a heatwave?

Sjoukje Y. Philip[1], Sarah F. Kew[1], Geert Jan van Oldenborgh[1,19], Wenchang Yang[2], Gabriel A. Vecchi[2,3], Faron S. Anslow[4], Sihan Li[5], Sonia I. Seneviratne[6], Linh N. Luu[1], Julie Arrighi[7,8,9], Roop Singh[7], Maarten van Aalst[7,8,10], Mathias Hauser[6], Dominik L. Schumacher[6], Carolina Pereira Marghidan[8], Kristie L Ebi[11], Rémy Bonnet[12], Robert Vautard[12], Jordis Tradowsky[13,14], Dim Coumou[1, 15], Flavio Lehner[16,17], Michael Wehner[18], Chris Rodell[20], Roland Stull[20], Rosie Howard[20], Nathan Gillett[21], Friederike E L Otto[5]

PACIFIC CLIMATE IMPACTS CONSORTIUM

UVIC UNIVERSITY OF VICTORIA

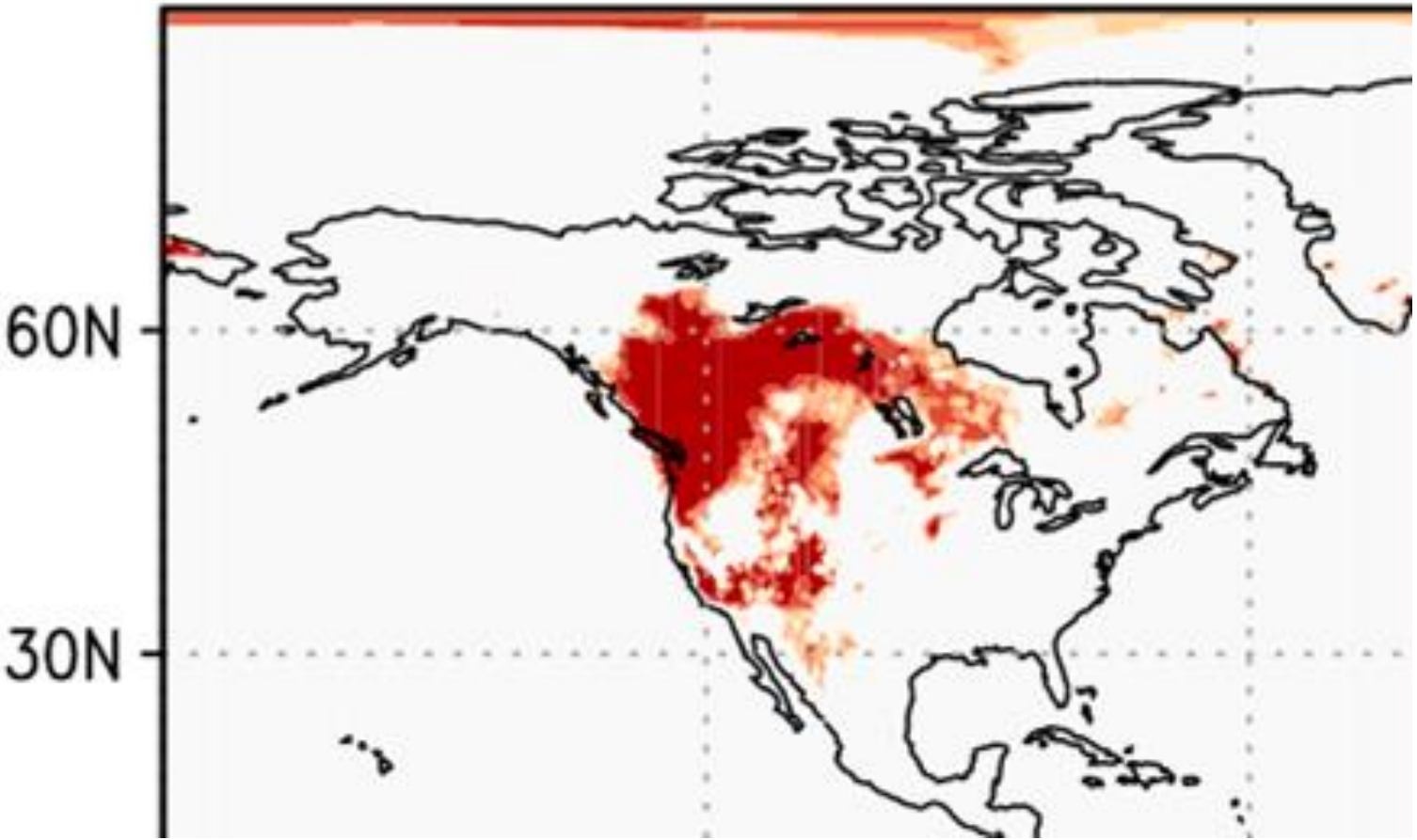
world weather attribution

Outline

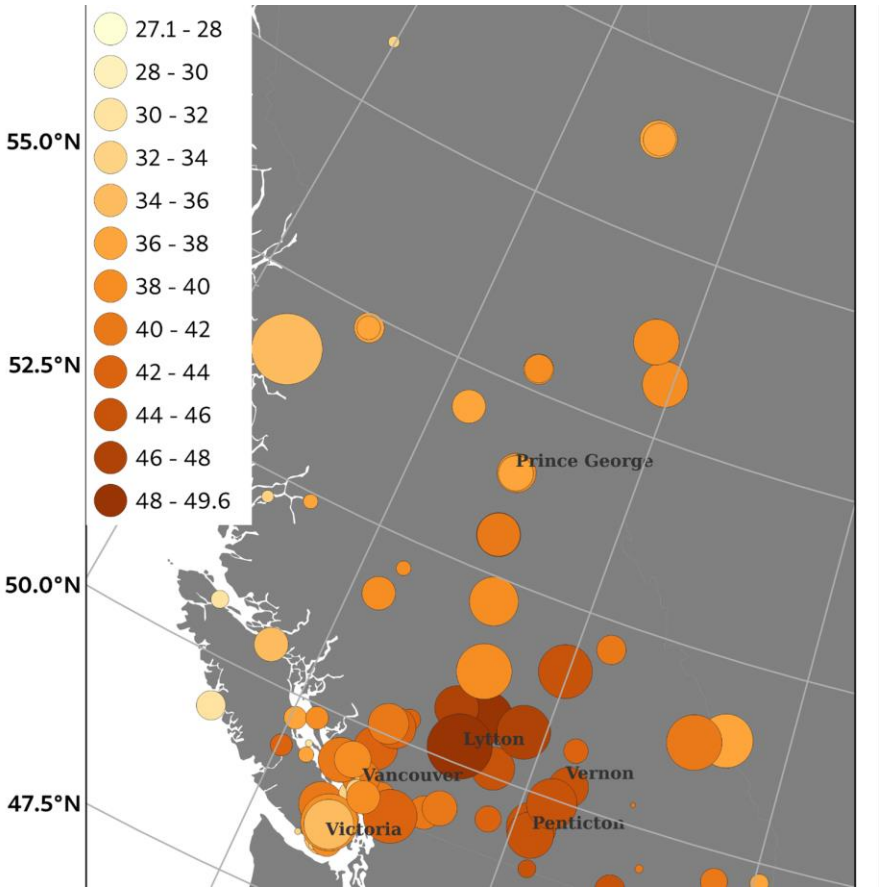
- What happened?
- Why did it happen?
- Was it climate change?
- What does this tell us about our future? Does it change our thinking?

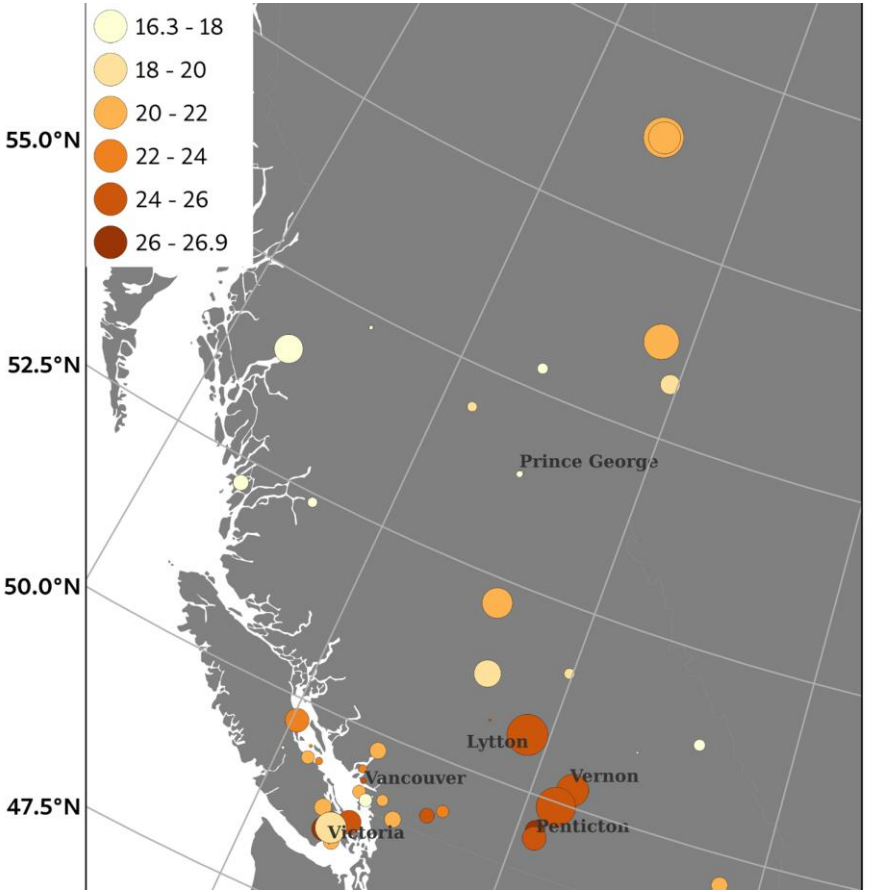
Conclusion: Under a global 2 °C climate, it’s likely that similar scale events will have annual odds of occurrence of 1 in 10 year to as high as 1 in 5 year.

What Happened?

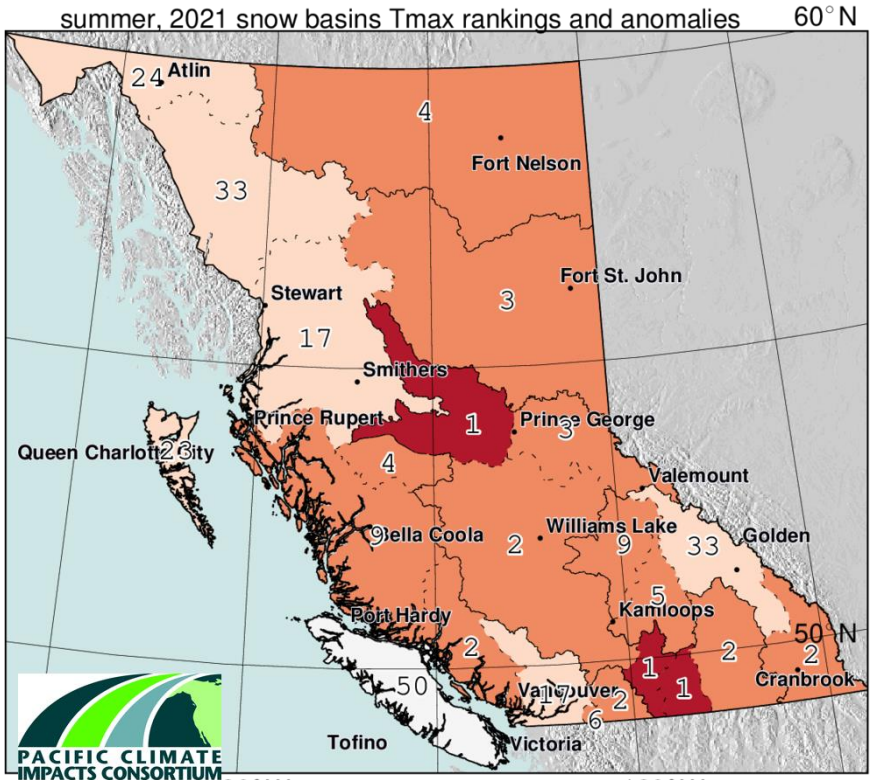

60N
30N

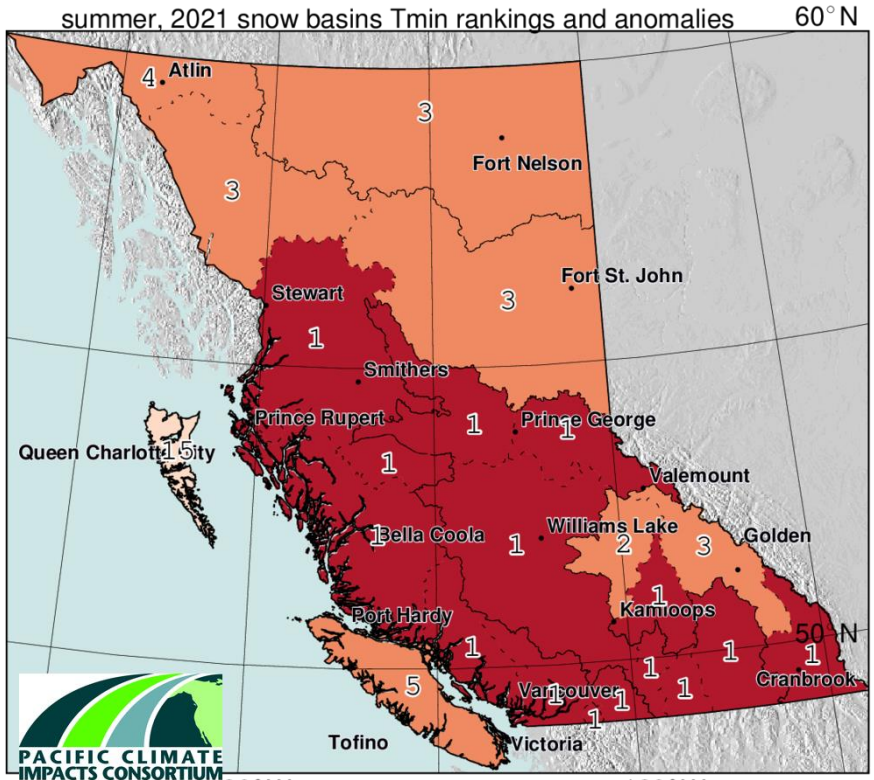
Record setting maximum and minimum daily temperatures

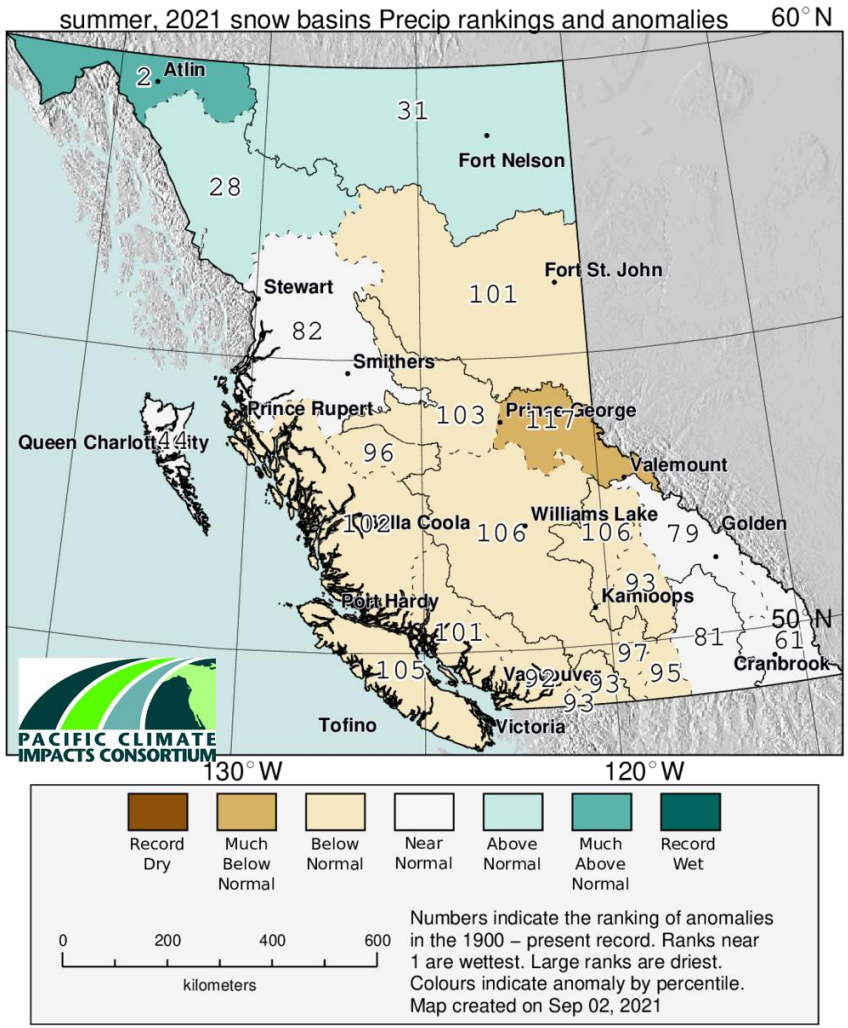





WORLDVIEW


summer, 2021 snow basins Tmax rankings and anomalies
60°N
Atlin
Fort Nelson
Fort St. John
Stewart
Smithers
Prince Rupert
Prince George
Queen Charlotte City
Valemount
Bella Coola
Williams Lake
Golden
Port Hardy
Kamloops
50°N
Cranbrook
Vancouver
Tofino
Victoria
PACIFIC CLIMATE IMPACTS CONSORTIUM
130°W
120°W
Record Cold
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warm
0
200
400
600
kilometers
Numbers indicate the ranking of anomalies in the 1900 – present record. Ranks near 1 are warmest. Large ranks are coldest.
Colours indicate anomaly by percentile.
Map created on Sep 02, 2021


summer, 2021 snow basins Tmin rankings and anomalies
60°N
Atlin
Fort Nelson
Fort St. John
Stewart
Smithers
Prince Rupert
Prince George
Queen Charlotte City
Valemount
Bella Coola
Williams Lake
Golden
Port Hardy
Kamloops
50°N
Cranbrook
Vancouver
Tofino
Victoria
PACIFIC CLIMATE IMPACTS CONSORTIUM
130°W
120°W
Record Cold
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warm
0
200
400
600
kilometers
Numbers indicate the ranking of anomalies in the 1900 – present record. Ranks near 1 are warmest. Large ranks are coldest.
Colours indicate anomaly by percentile.
Map created on Sep 02, 2021


summer, 2021 snow basins Precip rankings and anomalies
60° N
Atlin
2
31
Fort Nelson
28
Fort St. John
Stewart
101
82
Smithers
Prince Rupert
103
Prince George
117
Queen Charlotte
44
96
Valemount
Williams Lake
Golden
102
Bella Coola
106
106
79
93
Kamloops
Port Hardy
50° N
101
81
61
97
105
Vancouver
92
93
95
Cranbrook
93
Tofino
Victoria
PACIFIC CLIMATE IMPACTS CONSORTIUM
130° W
120° W
Record Dry
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Wet
0
200
400
600
kilometers
Numbers indicate the ranking of anomalies in the 1900 – present record. Ranks near 1 are wettest. Large ranks are driest.
Colours indicate anomaly by percentile.
Map created on Sep 02, 2021

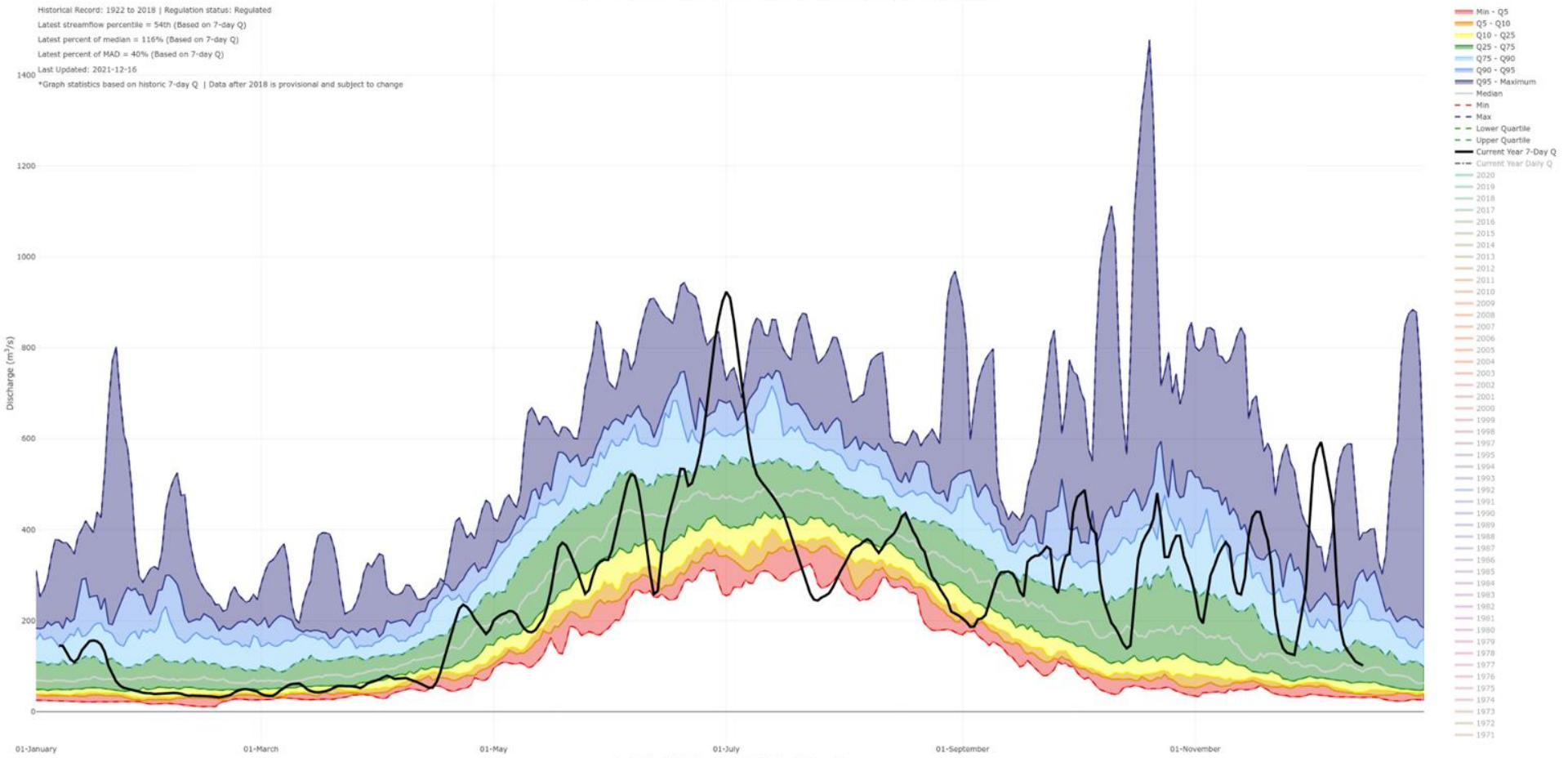
2021 DROUGHT LEVELS AT A GLANCE

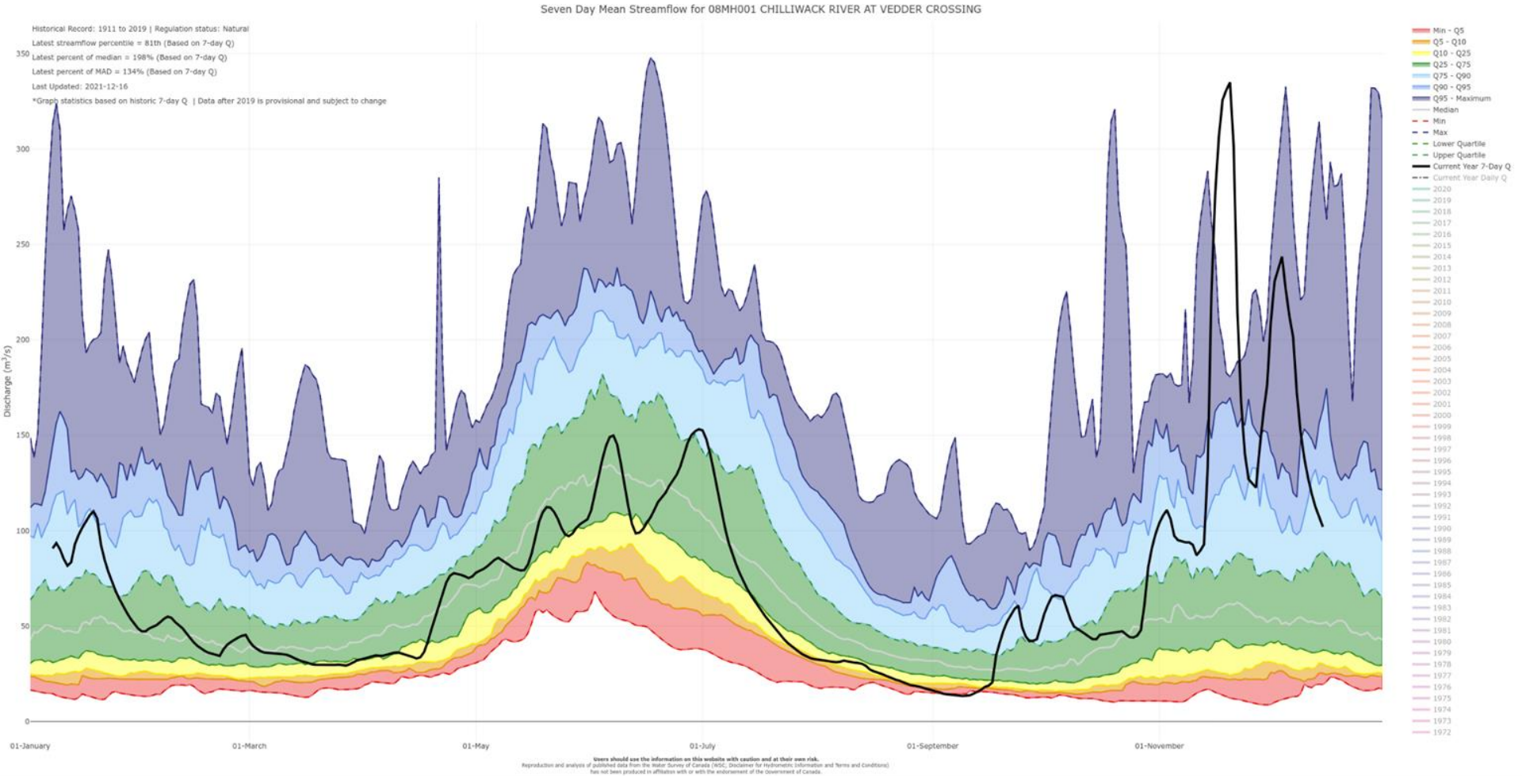
Drought Levels:	0		1		2		3		4		5

BASINS	26-May	09-Jun	23-Jun	07-Jul	14-Jul	21-Jul	28-Jul	04-Aug	11-Aug	18-Aug	20-Aug	25-Aug	01-Sep	08-Sep	15-Sep	17-Sep	22-Sep	29-Sep	06-Oct	20-Oct	28-Oct	01-Nov
Fort Nelson	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
East Peace	0	0	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
North Peace	0	0	0	0	2	2	2	2	2	2	2	0	0	0	0	0	1	1	0	0	0	0
South Peace	0	0	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Northwest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stikine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skeena-Nass	0	0	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Bulkley-Lakes	0	0	0	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Finlay	0	0	0	0	0	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Parsnip	0	0	0	0	0	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0	0	0
Upper Fraser West	0	0	0	2	2	2	1	1	1	1	1	1	1	2	2	2	1	1	1	0	0	0
Upper Fraser East	0	0	0	1	2	2	2	2	2	1	1	1	2	2	1	1	0	0	0	0	0	0
Upper Columbia	0	0	0	0	1	1	2	2	2	1	1	1	2	2	2	2	1	0	0	0	0	0
Lower Columbia	1	1	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	3	2	2	1	1
West Kootenay	1	1	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	3	2	2	1	1
East Kootenay	1	1	1	1	2	2	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
Kettle	1	2	2	3	4	4	4	5	5	5	5	5	5	5	5	5	5	4	3	3	2	2
Middle Fraser	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	0	0	0	0
North Thompson	0	0	0	1	3	3	4	4	4	4	4	4	4	4	4	4	3	3	3	0	0	0
South Thompson	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	4	4	4	3	1	1	1
-Salmon River	1	2	2	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	3	3	3
Nicola	1	1	2	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	1	1	2
-Coldwater River	1	1	1	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	1	1	1
Okanagan	1	1	1	3	3	3	3	3	4	4	4	4	4	4	4	4	3	3	3	2	2	2
Similkameen	0	0	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1
Skagit	1	1	1	1	2	3	3	3	3	3	3	3	3	3	3	3	2	1	0	0	0	0
Lower Fraser	1	1	1	1	2	3	4	4	4	4	4	4	4	4	3	3	2	1	0	0	0	0
South Coast	1	1	1	1	3	3	4	4	4	4	4	4	4	4	3	3	2	1	0	0	0	0
Central Coast	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	0	0	0	0	0	0
West Vancouver Island	1	1	1	3	3	3	4	4	4	4	5	5	5	5	5	4	2	0	0	0	0	0
East Vancouver Island	2	2	2	4	4	4	4	4	4	4	5	5	5	5	5	4	2	1	0	0	0	0
Haida Gwaii	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

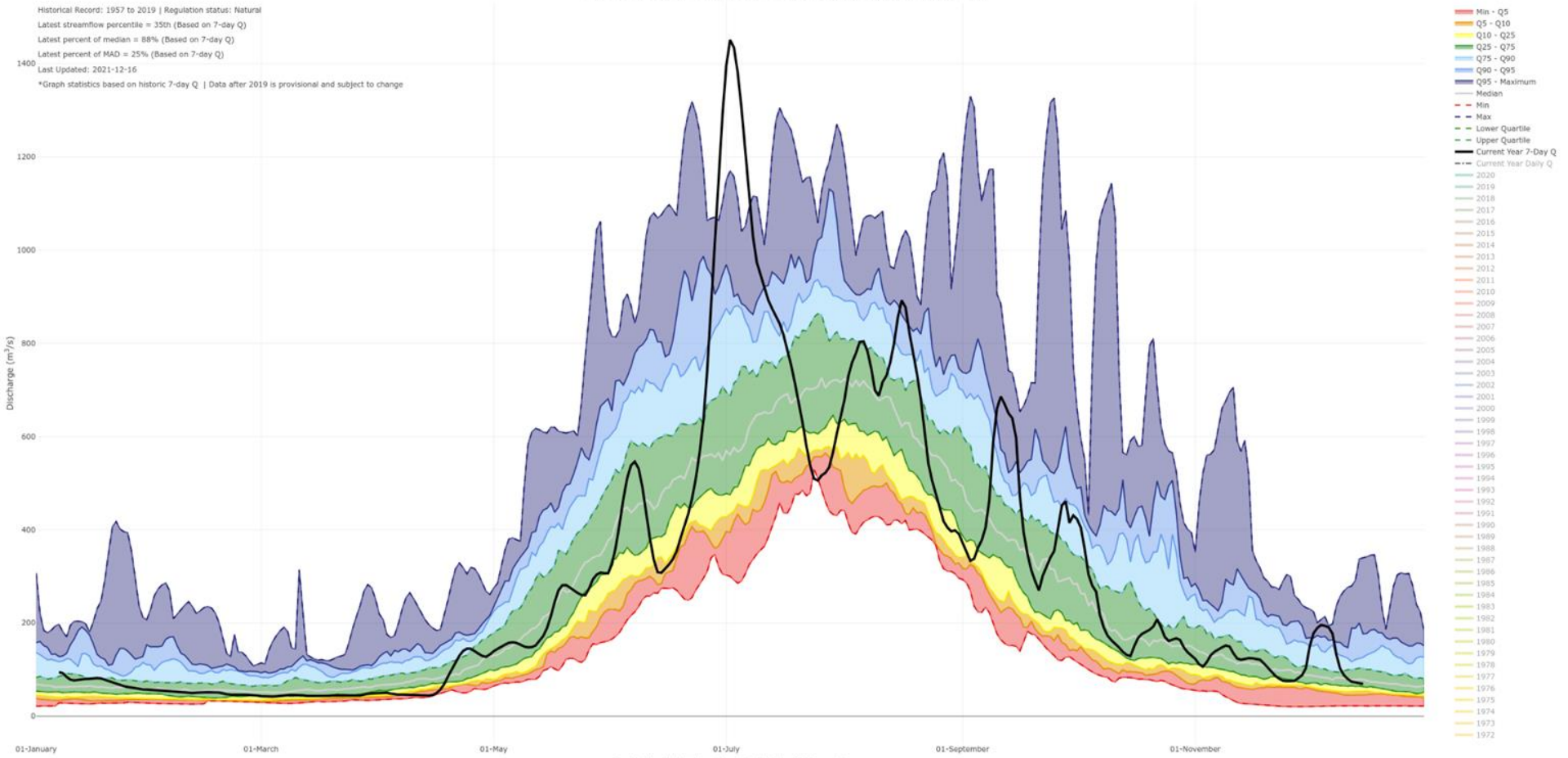
Prepared By: Water Management Branch - Ministry of Forests, Lands, Natural Resource Operations and Rural Development

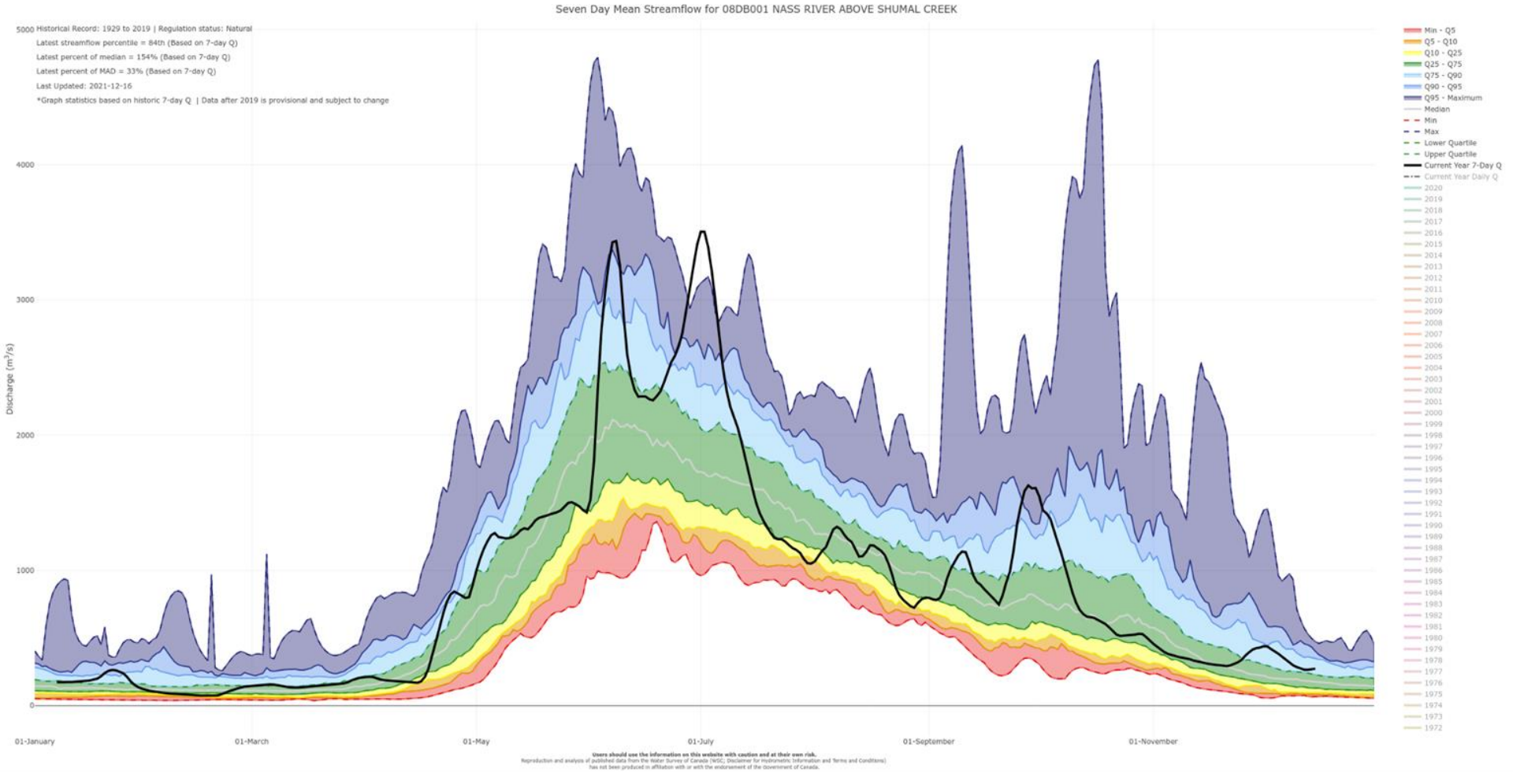
Seven Day Mean Streamflow for 08GA022 SQUAMISH RIVER NEAR BRACKENDALE

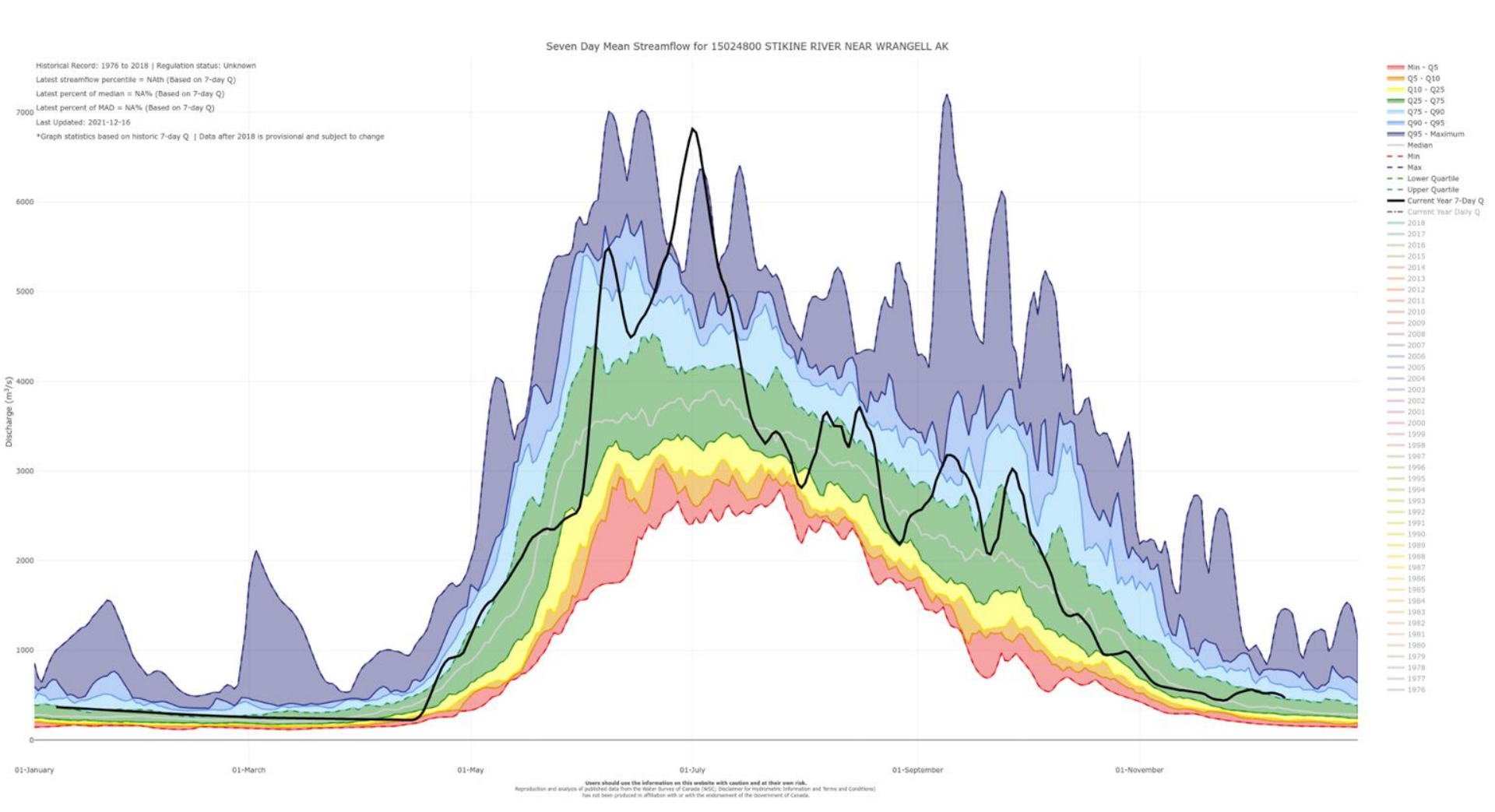




Seven Day Mean Streamflow for 08GD004 HOMATHKO RIVER AT THE MOUTH



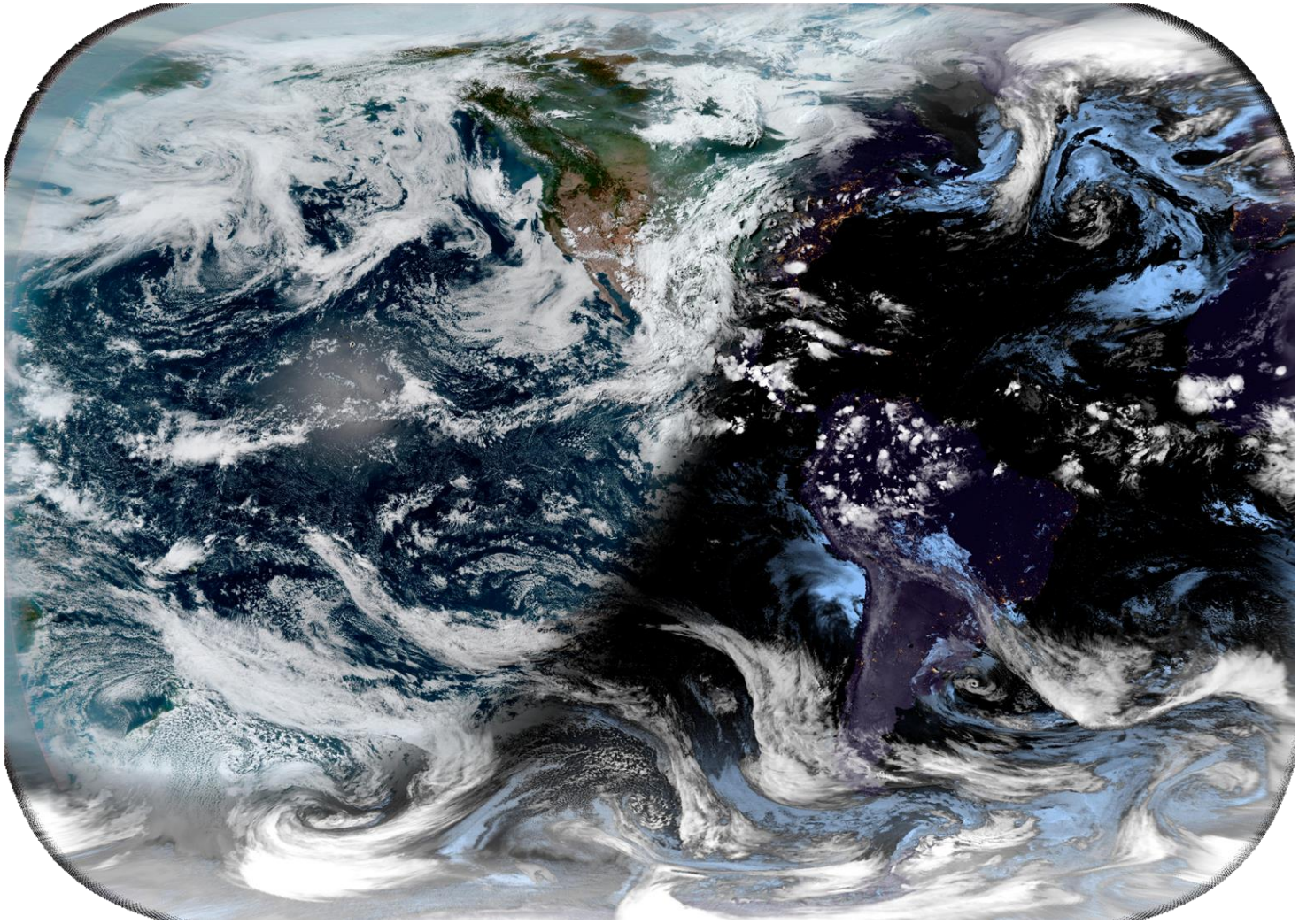




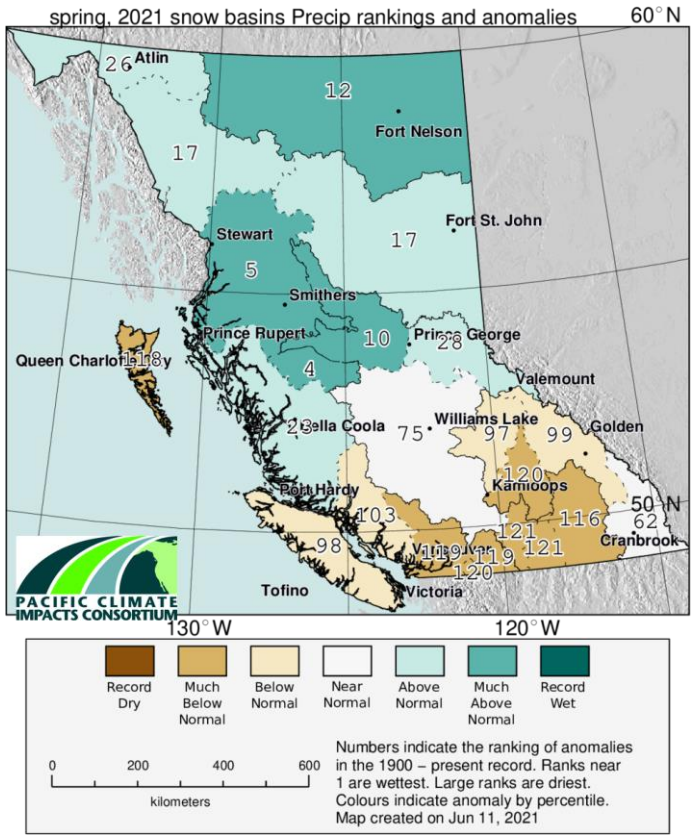
Impacts of the event

- Thousands were struck with heat-related illness and many hundreds died throughout Oregon, Washington and BC.
- Some evidence that the human impacts were disproportionate against lower income people.
- Yet uncounted losses to crops, livestock and worker productivity (many businesses closed during the peak of the heat).
- Energy demand in BC hit a new record.
- Kick started a very active wildfire season.
- Losses to glaciers and their water reserves were massive
- Remaining snow melted rapidly.
    - An earlier event during the spring freshet, the flooding consequences would have been massive. are yet to be determined and will feedback all summer.

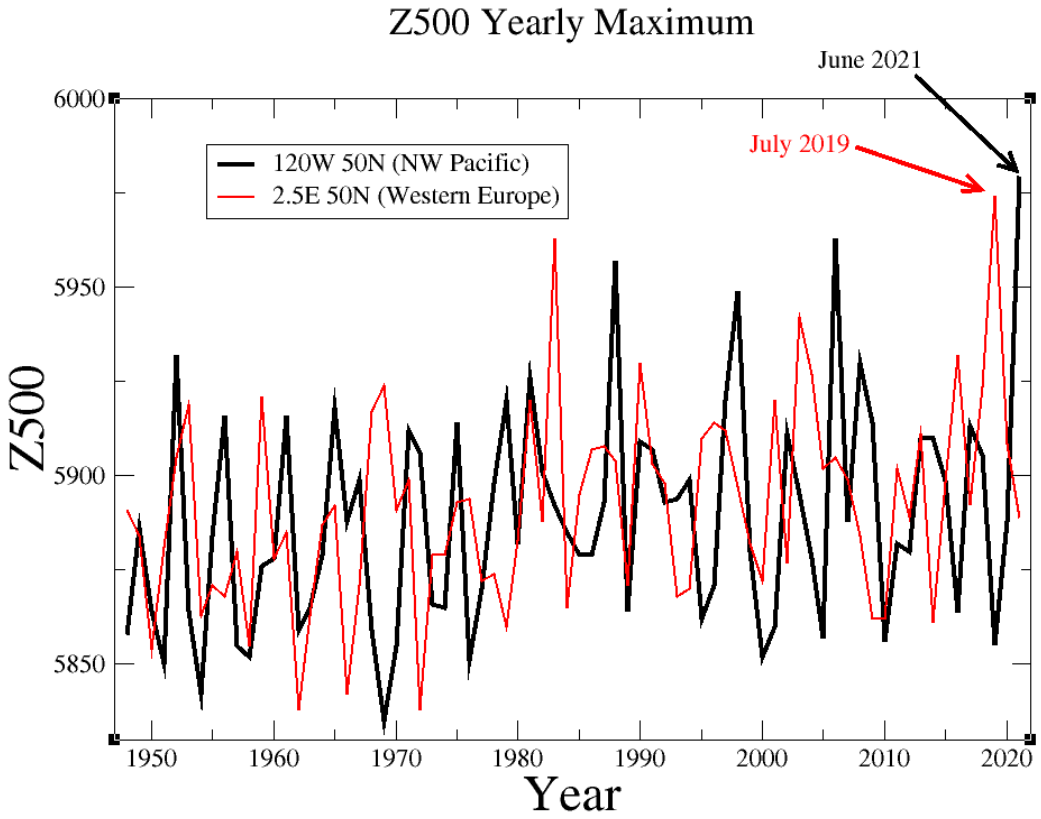
Why did it happen?



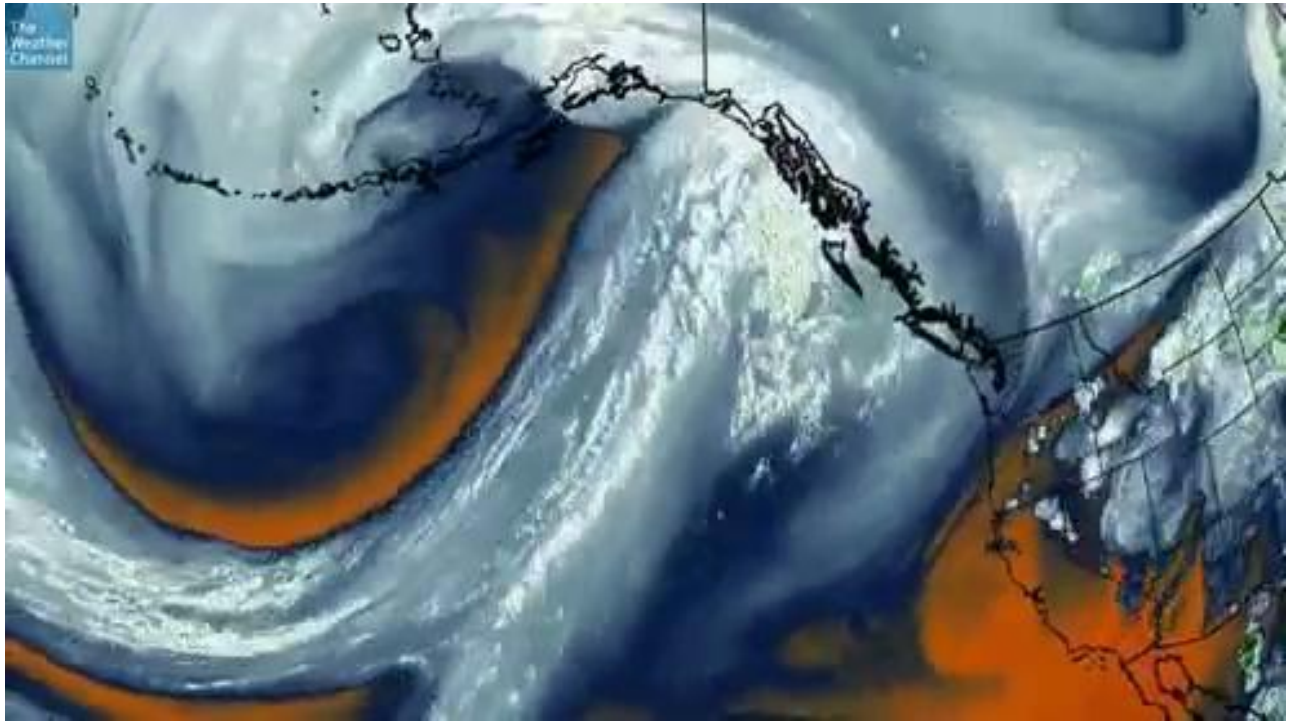
Very dry spring in southern BC and NW USA



Very high atmospheric pressures



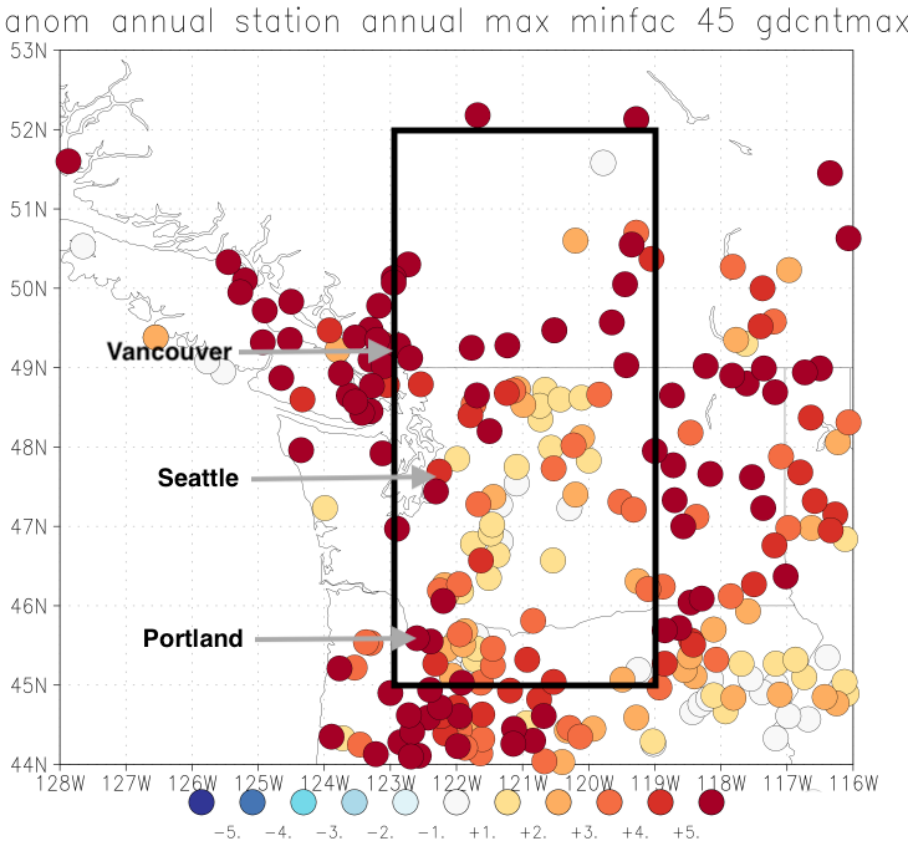
There was a lot of water vapour

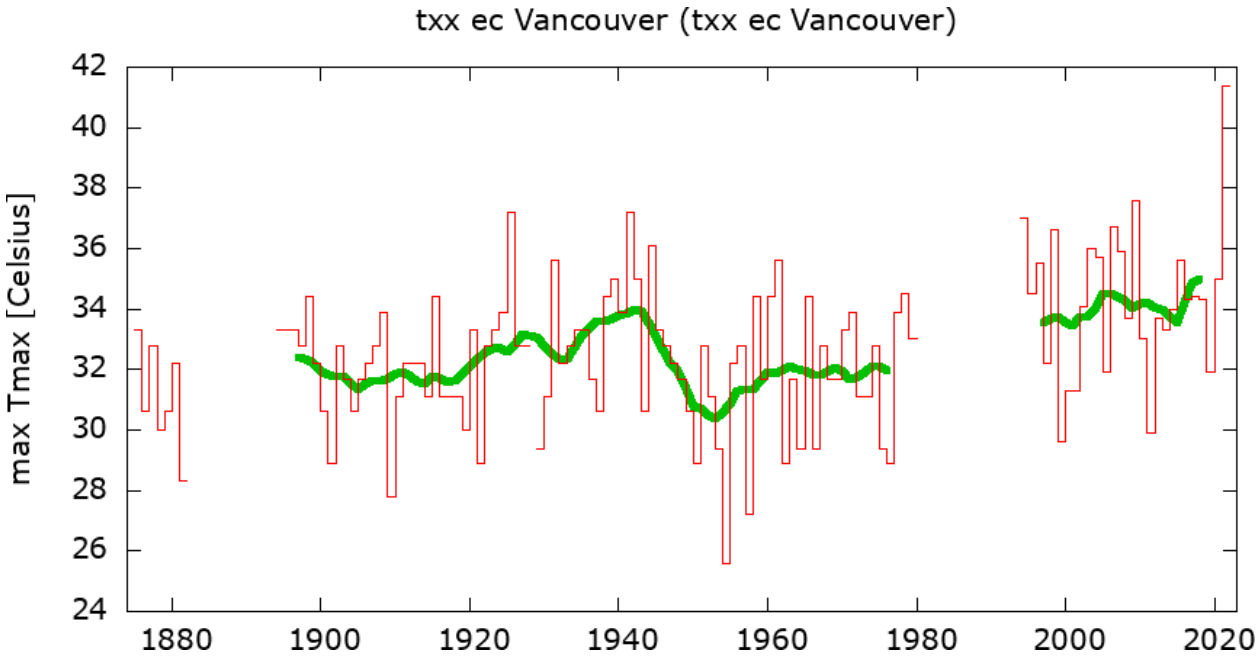


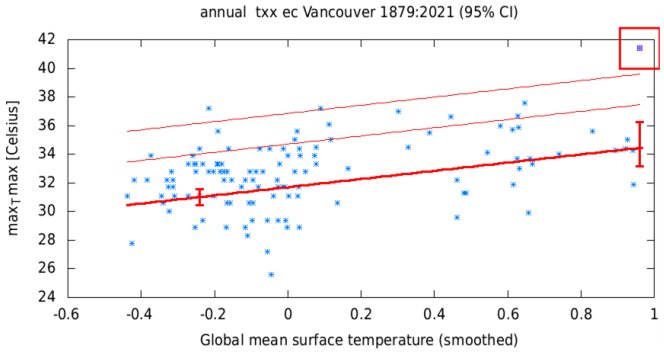
Was it climate change?

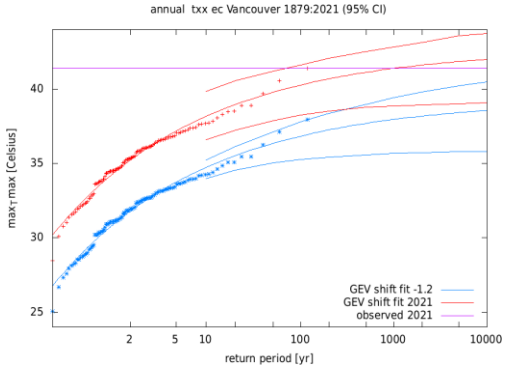
Define the Event

- Keep it simple!
- Focus on annual maximum of daily maximum temperature -- TXx.
- Define a small region that contains the bulk of regional population.

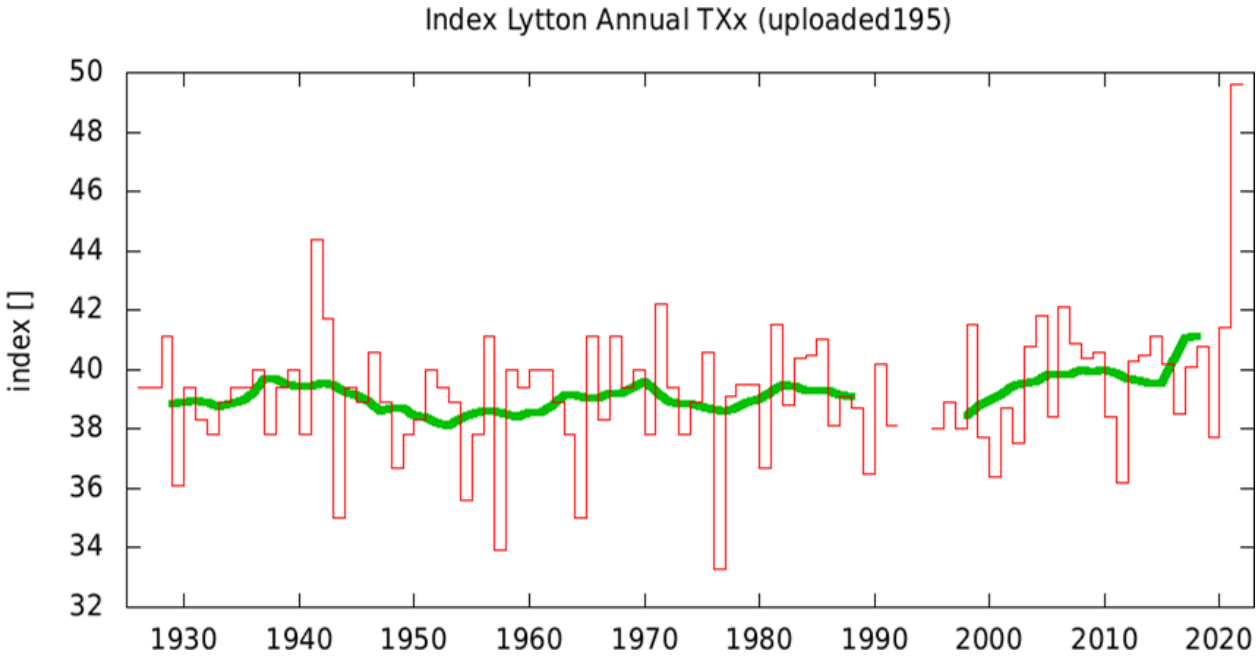


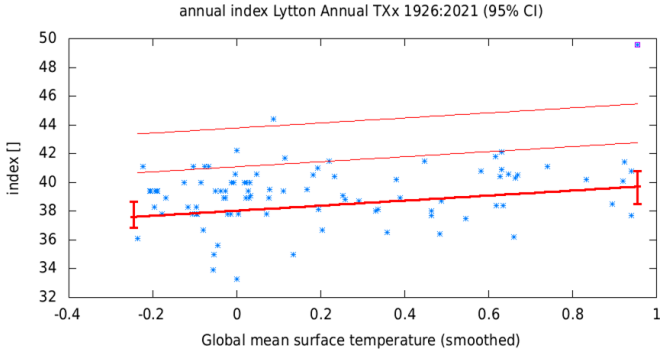


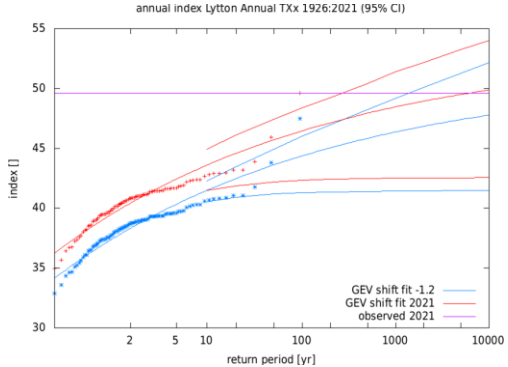




GEV Results for Vancouver	
Record Break	4 °C
Return Period	1000 years
Probability Ratio	> 170x
Pre-industrial delta	3.4 °C (1.9 - 5.5)







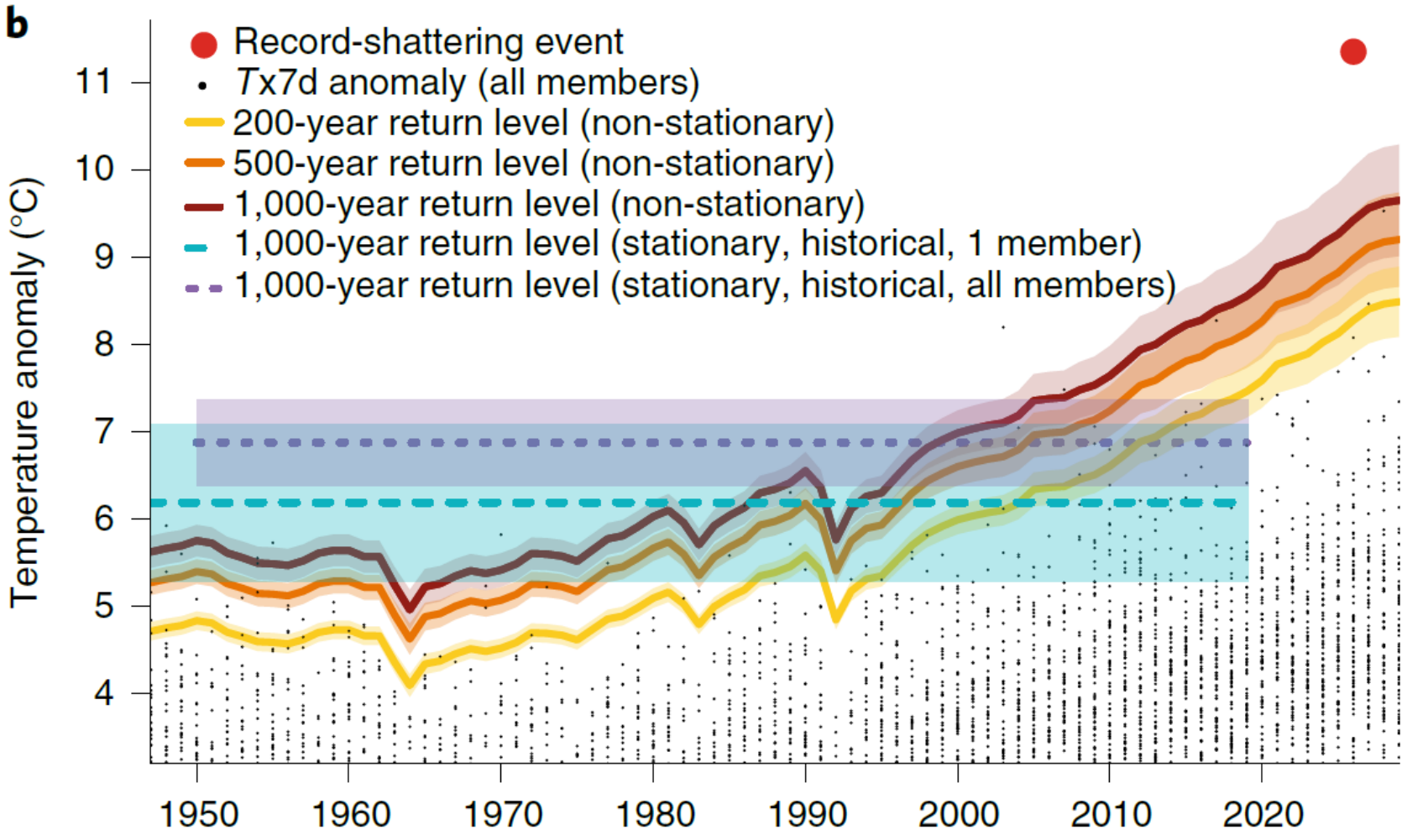
GEV Results for Lytton	
Record Break	5.2 °C
Return Period	6000 years
Probability Ratio	> 270x
Pre-industrial delta	2.1 °C (0.1 - 3.7)

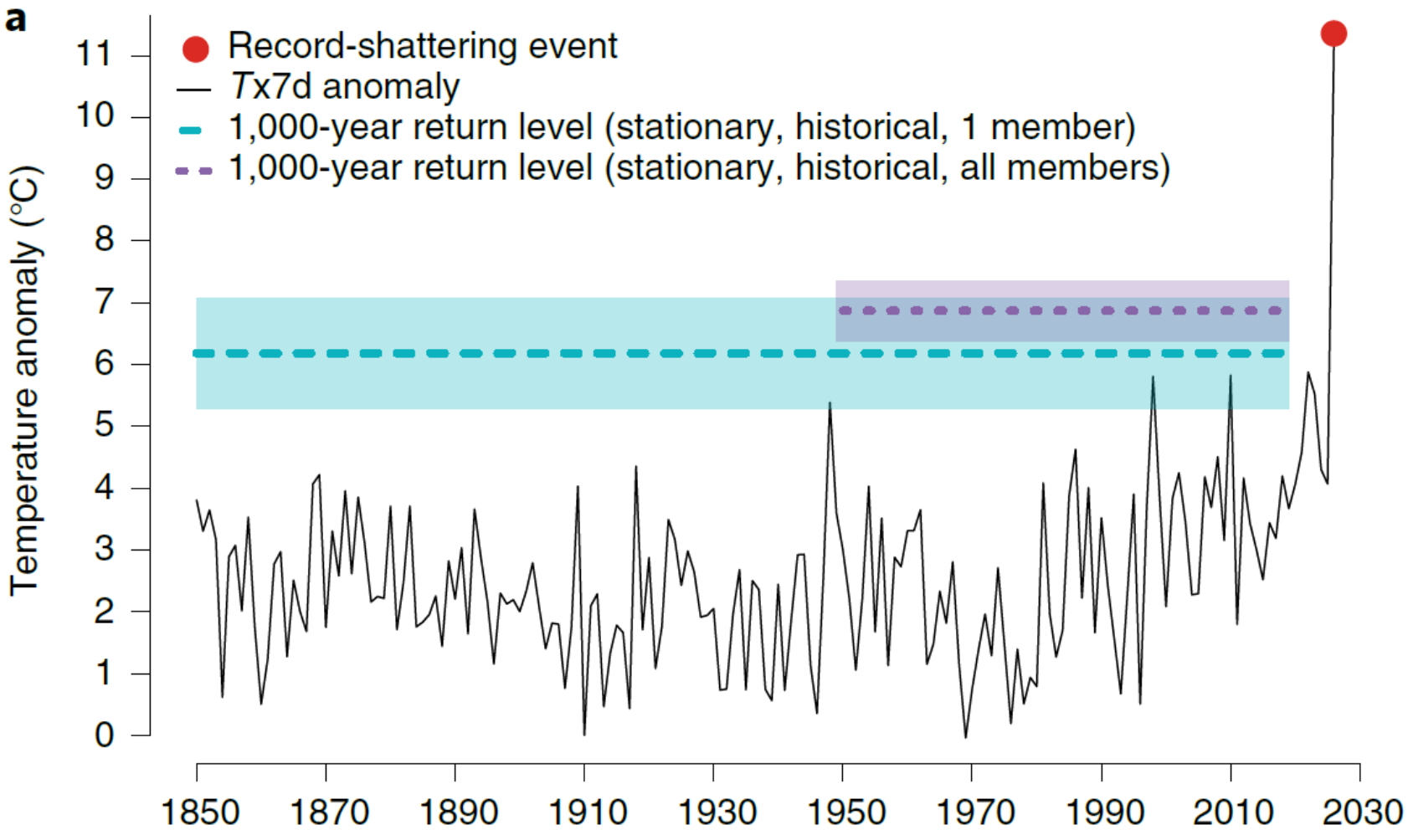
Conclusions from models

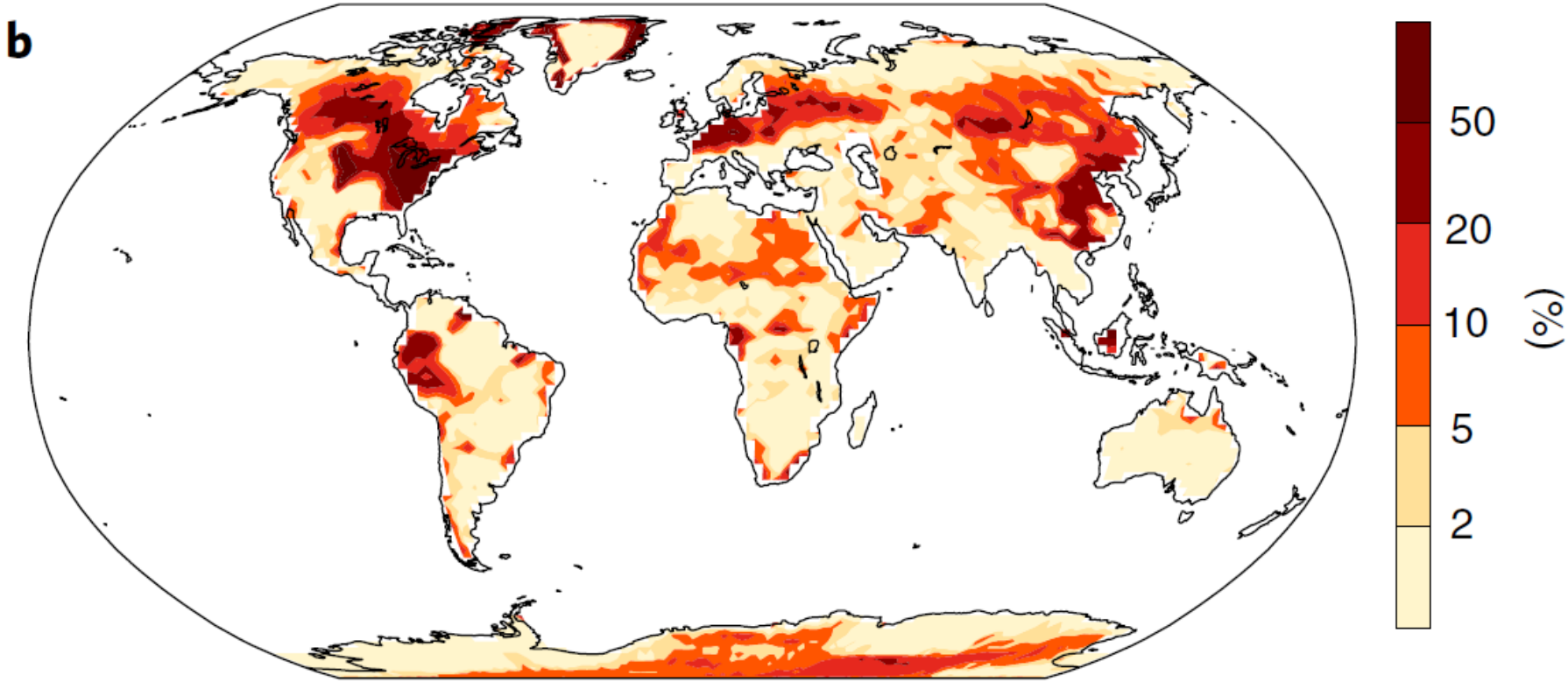
- They support the conclusions from the station observations. The event was made ~150 times more likely with anthropogenic warming and ~2 °C hotter.
  - Given that many records were broken by as much as 5 °C, global warming doesn't account for the entire signal.
- Under a global 2 °C climate, it's likely that similar scale events will have annual odds of occurrence of 1 in 10 year to as high as 1 in 5 year.

What does the event tell us about our future? Does it change our thinking?

- This analysis tells us that the event was the result of a very rare set of circumstances.
- The event would be very unlikely to happen again IF NOT FOR CLIMATE CHANGE.
- But with climate change it’s very likely to happen again before the end of the century. Most likely by the middle of the century.
- It changes our thinking in that we may need to look at how we assess heatwaves and what antecedent conditions may exist to contribute to them.


b
Record-shattering event
Tx7d anomaly (all members)
200-year return level (non-stationary)
500-year return level (non-stationary)
1,000-year return level (non-stationary)
1,000-year return level (stationary, historical, 1 member)
1,000-year return level (stationary, historical, all members)
Temperature anomaly (°C)
11
10
9
8
7
6
5
4
1950
1960
1970
1980
1990
2000
2010
2020


a
Record-shattering event
Tx7d anomaly
1,000-year return level (stationary, historical, 1 member)
1,000-year return level (stationary, historical, all members)
Temperature anomaly (°C)
0
1
2
3
4
5
6
7
8
9
10
11
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030


b
50
20
10
5
2
(%)

Conclusions from the June Heatwave

- What happened? **Record shattering heat leading to major human and economic impacts.**
- Why did it happen? **High pressure, clear skies, solstice, lots of moisture**
- Was it climate change? **Yes! Climate change to date made it more likely and future climate change will make it even more so.**
- What does this tell us about our future? Does it change our thinking? **This is a preview of events what will happen in our future a few times in our lifetimes. It changes how we think about defining and characterizing heat events.**