

THE UNPRECEDENTED PACIFIC NORTHWEST HEATWAVE OF JUNE 2021: CAUSES AND IMPACTS



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ROOCROFT, KATE R. WEINBERGER, GREG WEST**



Max: 18.289 • Min: -9.346 • Avg: 0.629

White et al. The Unprecedented Pacific Northwest Heatwave of June 2021, Nature Communications (2023)



**NSERC
CRSNG**



ALBERTA INNOVATES

Mitacs

BC Hydro

NEWS

First Nations communities disproportionately threatened by wildfires: study

More than four million people in Canada live near forests that are at increased risk of burning due to the climate crisis, according to new research published by Canadian government scientists



By Josie Kao

Aug. 10, 2021 4 min. read

British Columbia

Indigenous communities hit hard by B.C. floods say they received no warning, are getting little help



B.C. has not used the Alert Ready technology since it became available in 2018



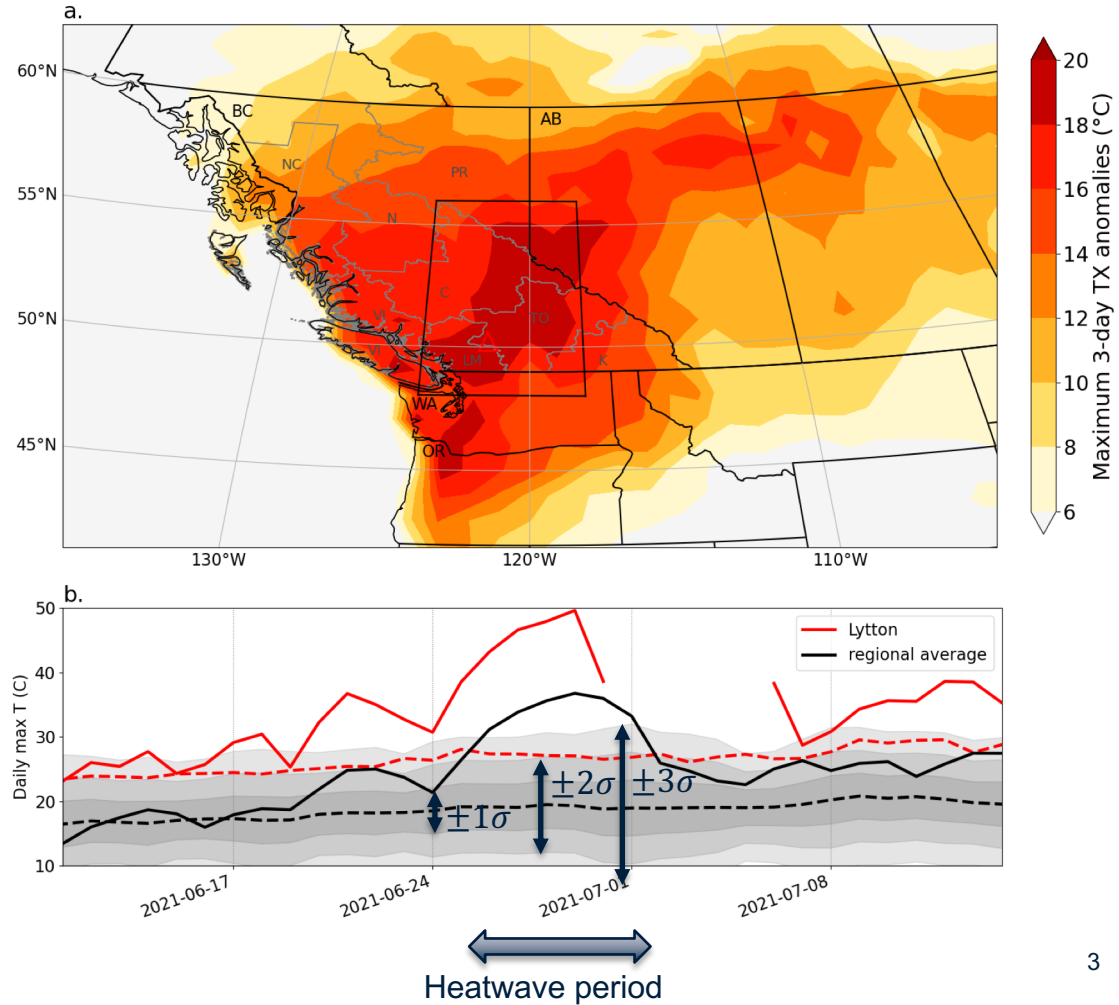
Wawmeesh Hamilton · CBC News ·

Posted: Nov 22, 2021 10:38 AM PT | Last Updated: November 22, 2021

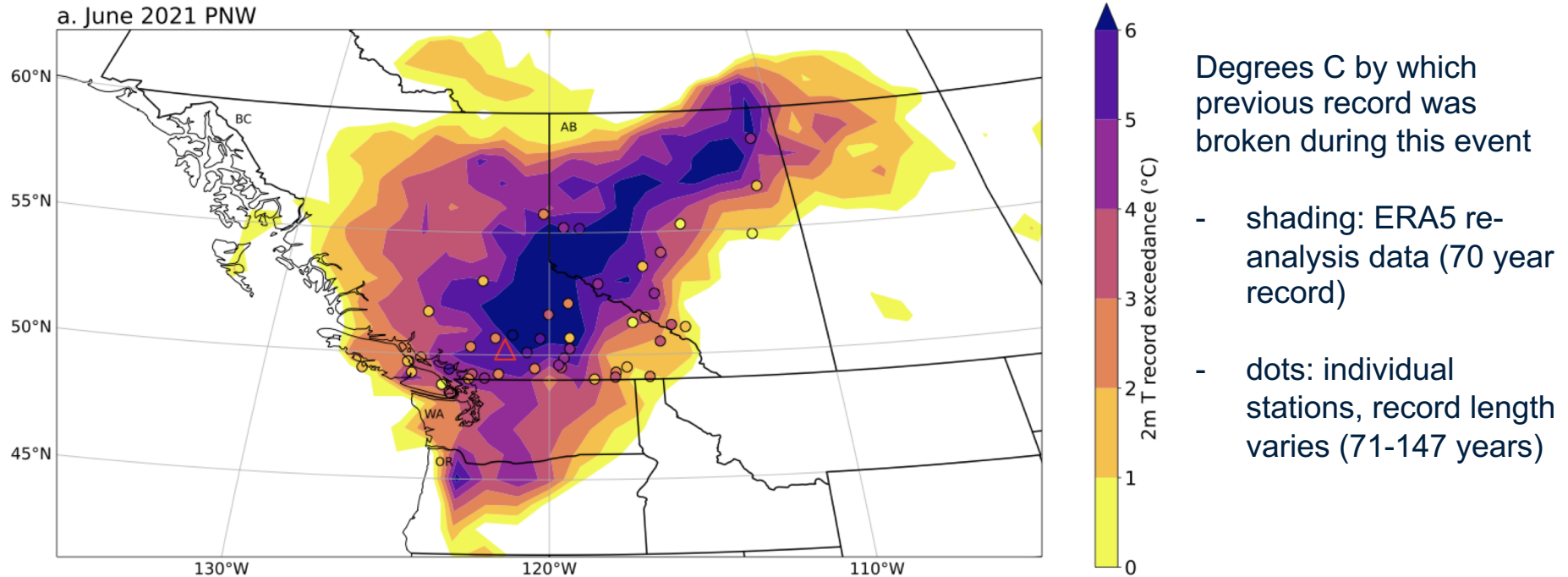
Meaningfully implementing these recommendations will require going beyond the common approach of attempting to 'integrate' Indigenous knowledge or practices into existing state-run institutions and programs: it means supporting, and ceding power and decision-authorities to, the true caretakers of Secwepemcúlcw.

THE JUNE 2021 HEATWAVE

- 16-20°C anomalies for the time of year
- Extreme temperatures lasted for around 5 days
- Anomalies were greater than 4σ (in agreement with Thompson et al. 2022)

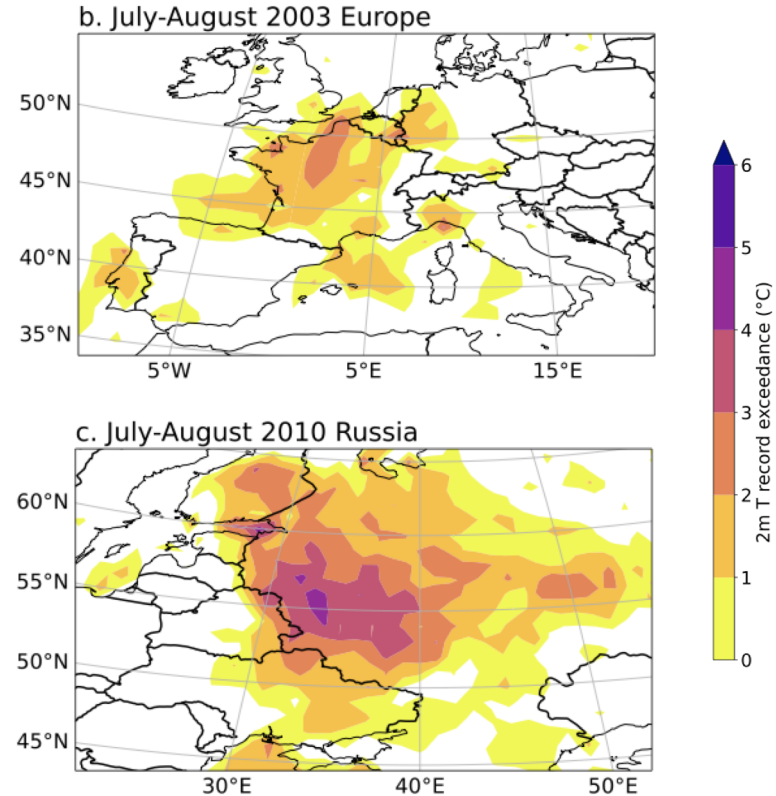
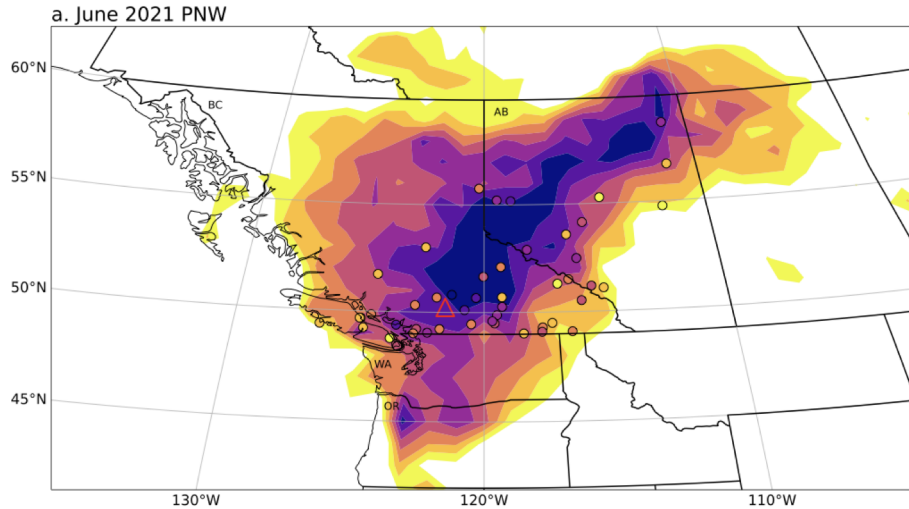


PREVIOUS RECORDS WERE BROKEN BY LARGE MARGINS



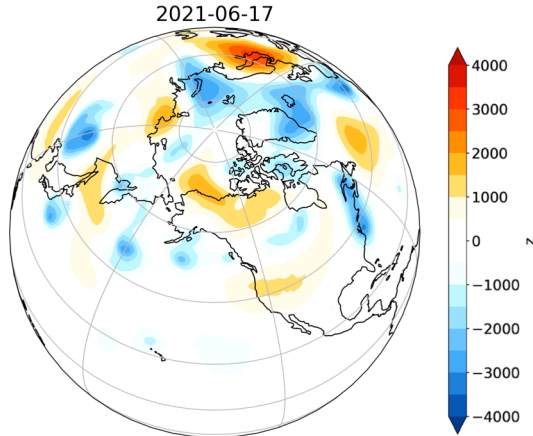
Canadian national temperature record broken by 4.6 °C

PREVIOUS RECORDS WERE BROKEN BY LARGE MARGINS

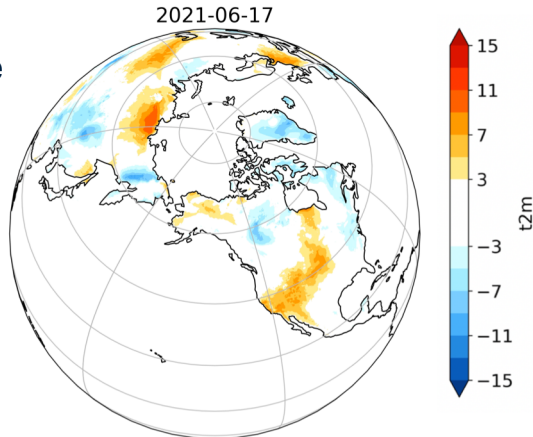


CAUSES OF THE HEATWAVE: METEOROLOGY

300hPa z
anomalies



Surface
temperature
anomalies



Atmospheric wave over Pacific becomes stationary and amplifies, creating a region of high pressure (a “ridge”)

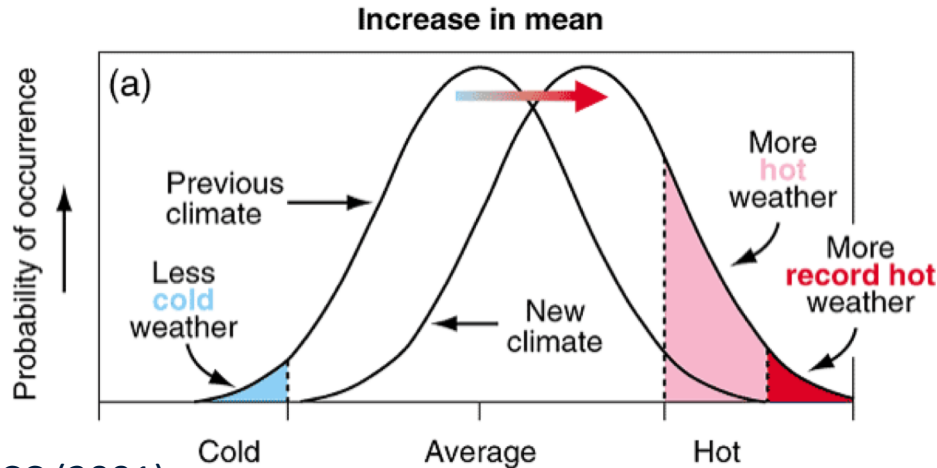
Backwards air parcel trajectory analysis shows:

- 70-80% of warming was from diabatic processes (upstream latent heating and clear sky radiative heating over land)
- 20-30% adiabatic processes: subsidence within high pressure ridge

See also: Overland (2021), Neal et al. (2022)

THE ROLE OF CLIMATE CHANGE

1. Thermodynamic effect: average temperatures are getting warmer



Over this PNW region, average summer (JJA) temperatures are about 1.0°C warmer than at the end of the 19th century

Consistent with Regional Climate Model experiments by Bercos-Hickey et al. (2022) showing anthropogenic warming caused a 0.8-1°C increase in temperatures of this heatwave

CLIMATE CHANGE AND DYNAMICS

2. Effect of climate change on atmospheric dynamics?

Effect of Arctic sea ice loss and changing sea surface temperatures resulting in a reduced equator-to-pole temperature gradient?

Analysis of two polar amplification experiments (PAMIP):

- no robust changes in measures of atmospheric waviness

Other hypotheses: role of soil moisture and non-linear interactions with atmospheric circulation (e.g. Bartusek et al. 2022); impact of increase in upstream latent heating; changes in tropical Rossby wave sources...

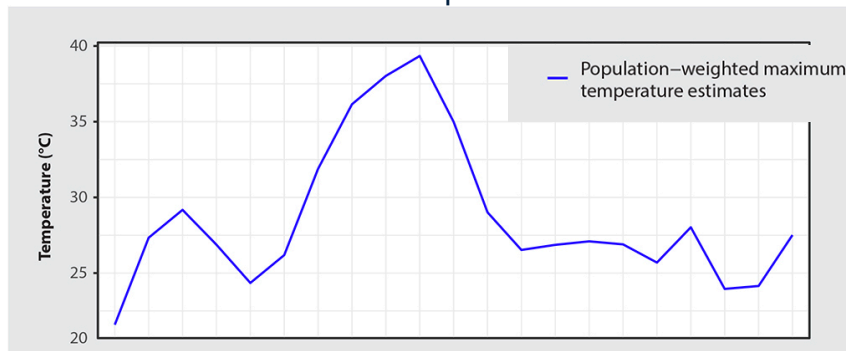


HEATWAVE IMPACTS

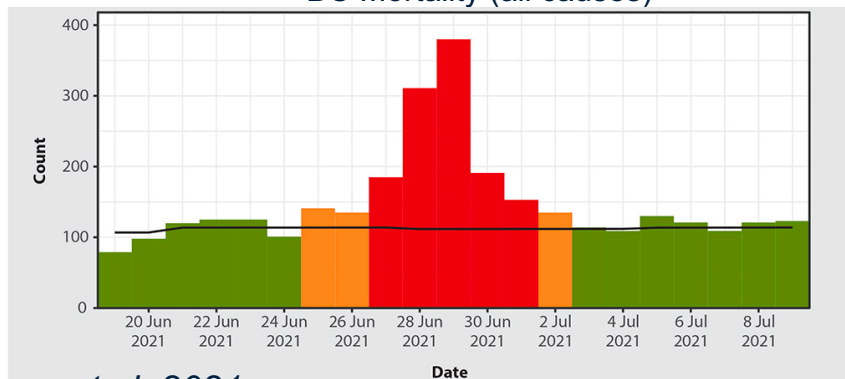


HUMAN HEALTH (KATE WEINBERGER, UBC; SARAH HENDERSON, BCCDC, UBC)

BC Temperature

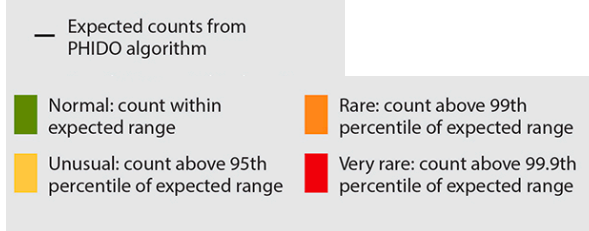


BC Mortality (all causes)

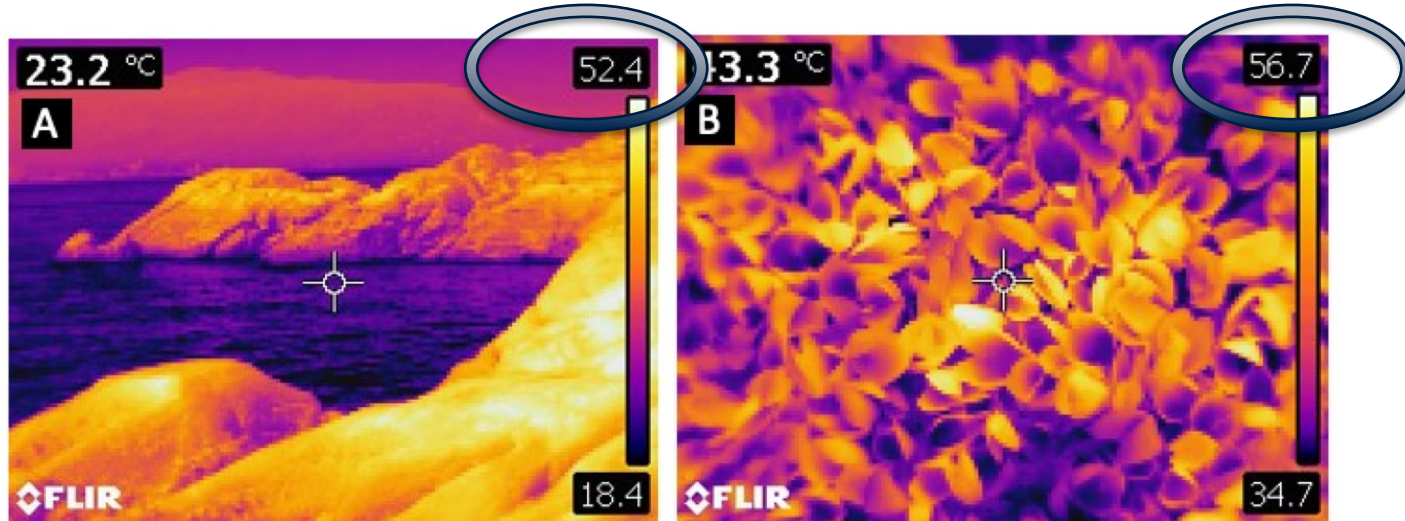


Based on recent reports (still likely to change), total preliminary estimate of at least 868 deaths across the PNW (Canada and US) attributable to this heatwave

White et al. 2022



MARINE INTERTIDAL LIFE (CHRISTOPHER D. G. HARLEY, UBC)



Thermal images showing extreme high surface temperatures during low tide on 28 June, 2021

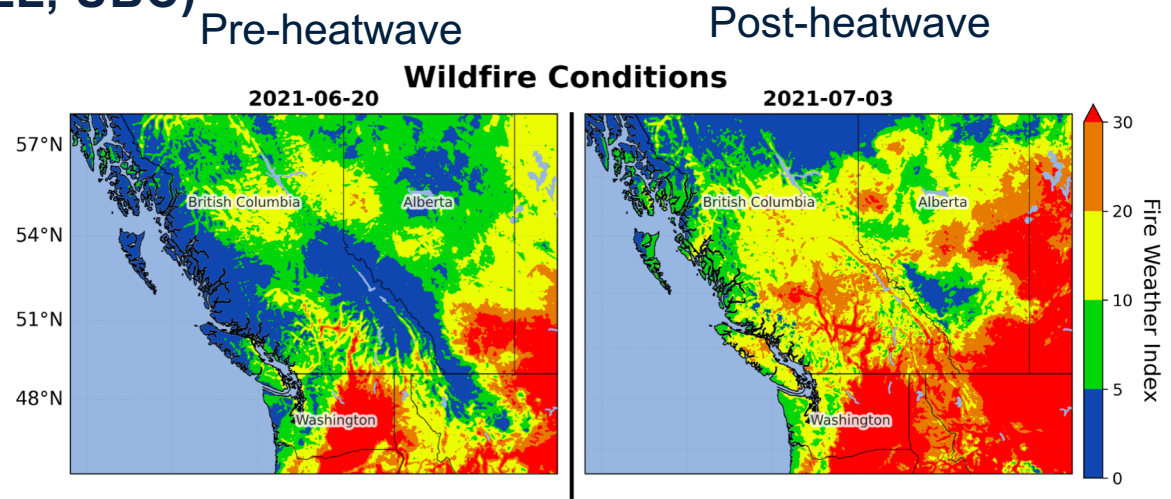
Estimated deaths of roughly 10 million barnacles along a single 100-m stretch of intertidal habitat

Estimated deaths of over one million mussels in a single 100-m stretch of shoreline

Total number of marine invertebrates killed was almost certainly in the billions.

WILDFIRES (CHRIS RODELL, UBC)

Conditions for wildfires substantially increased during the heatwave

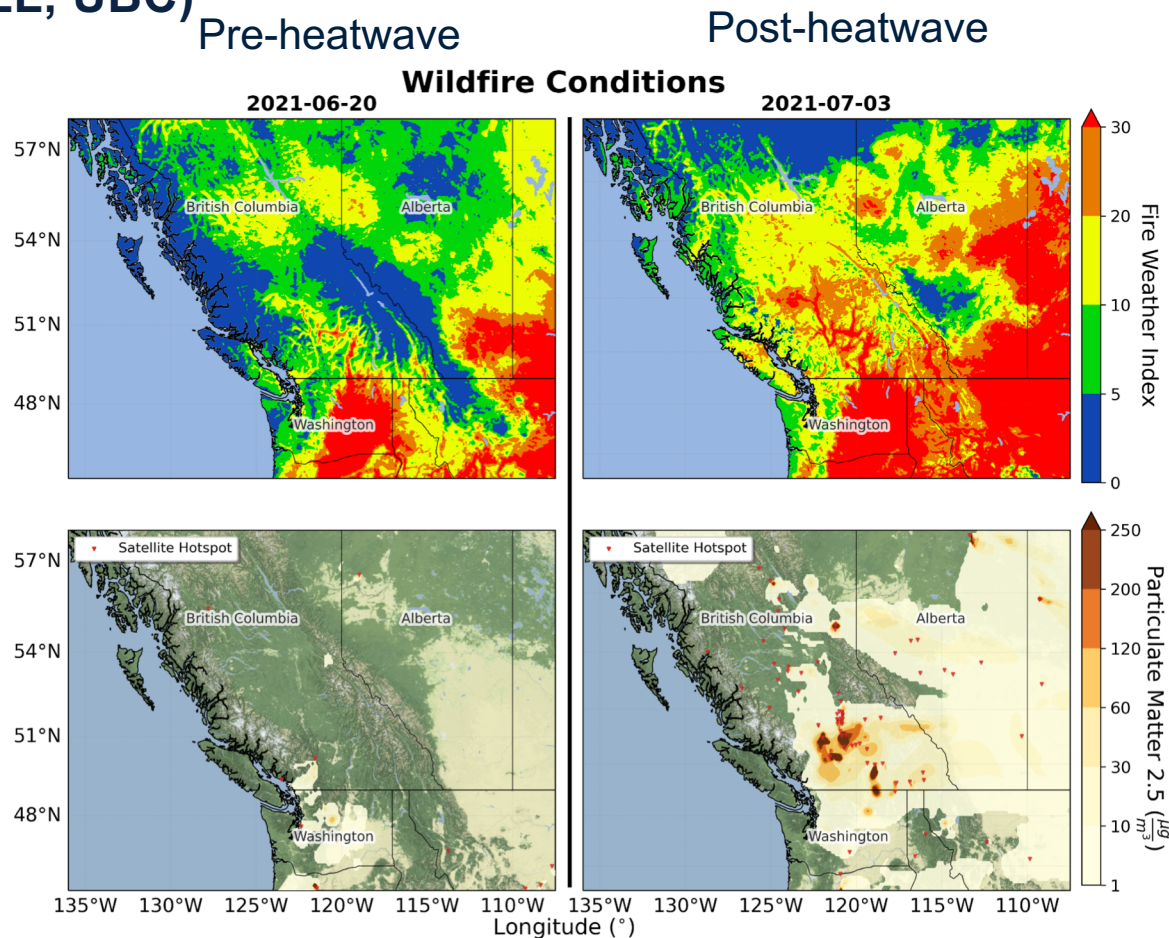


WILDFIRES (CHRIS RODELL, UBC)

Conditions for wildfires substantially increased during the heatwave

BC wildfires increased:

- Pre-heatwave: 6 active fires, (123 hectares burned)
- Post-heatwave: 175 active fires (78,939 hectares)



CROPS AND AGRICULTURE (GINNI BRAICH, UBC)

BC yield estimates: 2021 yield relative to predicted yield based on linear trends
 σ = one standard deviation of interannual variability



increase	0-1 σ reduction	1-2 σ reduction	$\geq 2\sigma$ reduction
Spinach +1.3 σ	Cabbage -0.9 σ	Squash and zucchini -1.1 σ	Radishes -3.3 σ
Sweetcorn +0.8 σ	Strawberries -0.6 σ	Green peas -1.5 σ	Tomatoes -2.3 σ
	Cranberries -0.1 σ	Lettuce -1.2 σ	Pumpkins -2.5 σ
	Blueberries -0.5 σ	Brussels sprouts -1.4 σ	Raspberries -3.6 σ
	Apricots -0.6 σ	Peaches -1.9 σ	Prunes and Plums -2.4 σ
	Oats -0.4 σ	Pears -1.6 σ	Grapes -2.3 σ
		Nectarines -1.2 σ	Cherries -2.2 σ
		Apples -1.3 σ	Barley -2.0 σ
		Spring wheat -1.9 σ	
		Canola -1.6 σ	

CROPS AND AGRICULTURE (GINNI BRAICH, UBC)

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increase

Spinach $+1.3\sigma$

Sweetcorn $+0.8\sigma$

0-1 σ reduction

Cabbage -0.9σ

Strawberries -0.6σ

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Blueberries -0.5σ

1-2 σ reduction

Squash and zucchini -1.1σ

Green peas -1.5σ

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Cherries -2.2σ

Barley -2.0σ

British Columbia

B.C. heat wave 'cooks' fruit crops on the branch in sweltering Okanagan and Fraser valleys



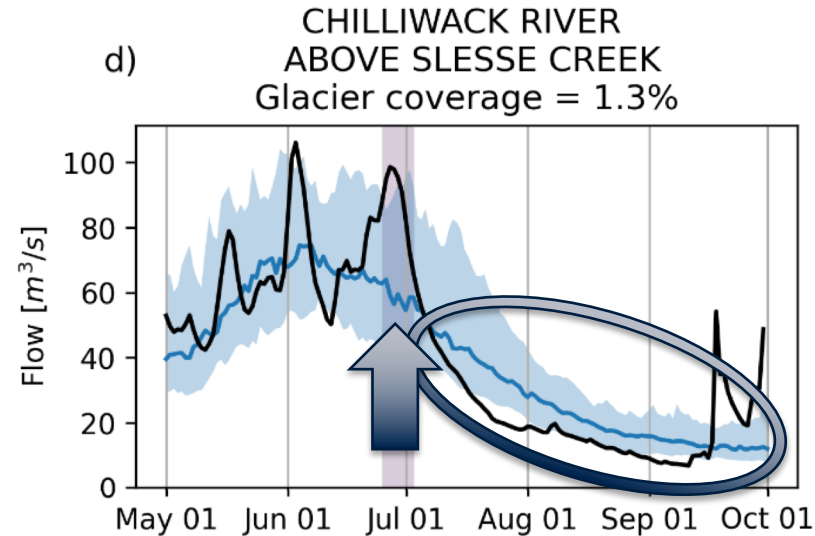
Up to 75% of some fruits too damaged to sell fresh, according to farmers



Michelle Gomez · CBC News · Posted: Jul 06, 2021 7:25 PM PT | Last Updated: July 7, 2021

CRYOSPHERE AND STREAMFLOW (SAM ANDERSON; CHRISTINA DRAEGER, UBC)

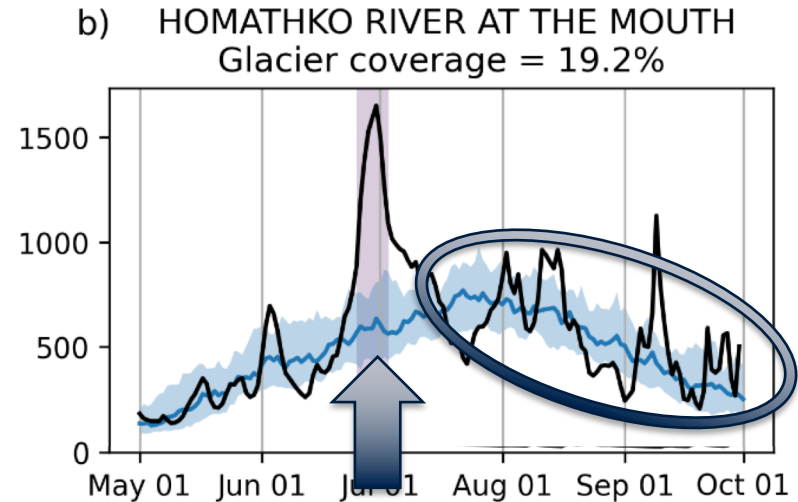
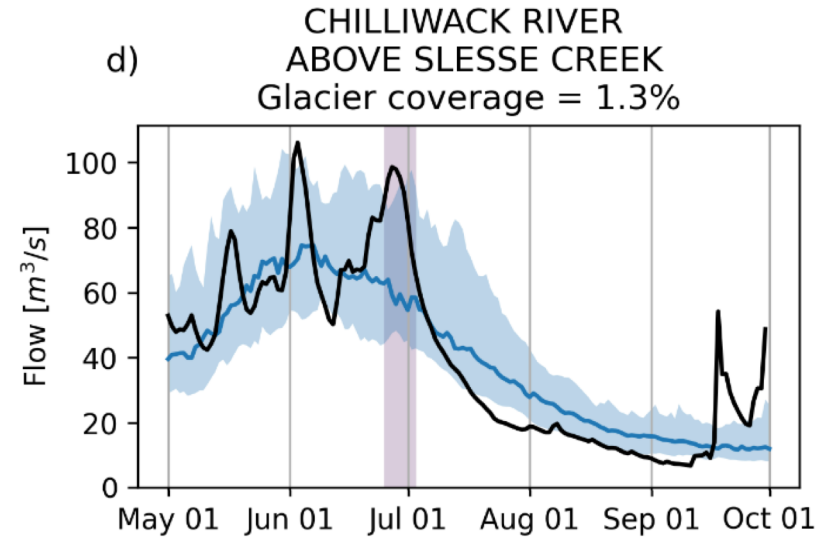
Basins with snow/glacier coverage: increased streamflow during heatwave



Black line = 2021 streamflow; blue line = 1979-2020 climatology; shading = $\pm 1\sigma$

CRYOSPHERE AND STREAMFLOW (SAM ANDERSON; CHRISTINA DRAEGER, UBC)

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Black line = 2021 streamflow; blue line = 1979-2020 climatology; shading = $\pm 1\sigma$

CRYOSPHERE AND STREAMFLOW (SAM ANDERSON; CHRISTINA DRAEGER, UBC)

Record streamflow in places, led to one evacuation order and numerous flood alerts:



Box 219, 1350 Aster Street
Pemberton, BC V0N 2L0
Ph. 604-894-6371, 1-800-298-7753
F: 604-894-6526
info@slrd.bc.ca www.slrd.bc.ca

EVACUATION ORDER FOR *ELECTORAL AREA C – PEMBERTON VALLEY*

June 26, 2021 effective at 2030 hrs

YOU MUST LEAVE THE AREA IMMEDIATELY

LANDSLIDES (MATTHIAS JAKOB, CARIE-ANN LAU, BCG)

- Wildfires known to increase the risk of landslides
- Landslides occurred in wildfire-affected watersheds in August 2021 and November 2021, particularly following some intense atmospheric river events in November



Post-wildfire debris flows, August 2021, in Nicoamen River watershed, BC

SUMMARY

Unprecedented heatwave: previous temperature records broken by very large amounts

Caused by a strong ridge of high pressure, with upstream latent heating playing an important role

Climate change made this heat wave worse (on-going research on how much).
(With? or) without climate change it was a very rare event.

Impacts were substantial, with effects across so many parts of our interconnected landscape and ecosystem....

