Temperature Statistical Analysis – Extreme Weather

Disclaimers:

- Facts are stubborn, but statistics are more pliable. *Mark Twain*

- Facts speak louder than statistics *Justice Streatfield*

- Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write. *H.G.Wells*

- Statistics: The only science that enables different experts using the same figures to draw different conclusions. *Evan Esar*

- If there is a 50-50 chance that something can go wrong, then 9 times out of ten it will. *Paul Harvey*

- Statistics are no substitute for judgment. *Henry Clay*

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Terms

- Causation: *Indicates that one event is the result of the occurrence of the other event; i.e. there is a causal relationship between the two events*
- Correlation: *Any statistical relationship, whether causal or not, between two random variables or bivariate data*
- Quantitative Analysis: *The collection, organization, analysis, interpretation and presentation of data*
- Qualitative Analysis: *Descriptive, expressed in terms of language rather than numerical values.*
- Percentile: *The comparison value between an individual value and the values of a set*

Statistics: Lies and Truth

Statistics: Lies and Truth

- Which pile of sand is bigger?

Application to data – 'Extreme' – what is it?

1 in 20

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Data Set: Wenatchee Temperature 2000-2024

- 1 in 20 max is 84°F
  - Yes, but also...
- 1 in 20 max is 92°F
  - Yes, but also ...
- 1 in 20 max is 102°F
  - Yes, but also ...
- 1 in 20 max is 108°F
  - Yes, but also ...

All those are VALID 1 in 20 temperatures!

- Remember the sand? This represents sample size.

- Remember statistics? For every $\underline{\textbf{\textit{n}}}$ events, what is my likelihood of value $\underline{\textbf{\textit{m}}}$?

- For a 1 in 20 event, for a given sample set, what is the likelihood I will draw a certain value, or value in a certain range?
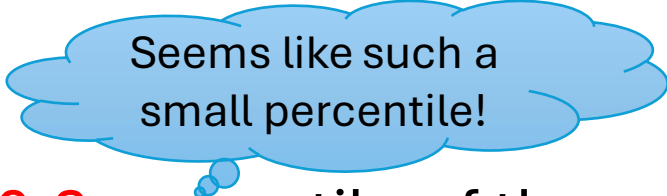
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Data Set: Wenatchee Temperature 2000-2024

- 1 in 20 max is 84
  - Set is all hours all years – BIG sample set – 211,342 values
- 1 in 20 max is 92
  - Set is all summer hours, all years – 52,992 values – more focused to 'hot'
- 1 in 20 max is 102
  - Set is max of each summer hour across all years - 2,208 values
- 1 in 20 max is 108
  - Set is max of each year, across all years – 24 values

KEY OBSERVATION – the smaller the sample set, the higher the 1 in 20 temperature

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NERC ECWT (and EHWT)

NERC developed a term "Extreme Cold Weather Temperature" (ECWT), effective 10/1/2024

Seems like such a small percentile!

Definition: The temperature equal to the lowest 0.2 percentile of the hourly temperatures measured in December, January, and February from 1/1/2000 through the date the temperature is calculated.

The purpose is to determine an unusually cold operating condition. A similar concept may be applied to hot weather in summer, but is not a NERC term - "Extreme Hot Weather Temperature" (EHWT), for June, July, and August.

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So – what sort of a statistic is ECWT?

- ***Qualitative*** analysis – tell me a story to understand

- Data study of temperatures in Western and Central Washington

- ECWT and EHWT worked out to be roughly same as 1 in 2 yearly max/min (single hour)

- So NERC's "Extreme" is not terribly extreme – it would be exceeded approximately once every 2 years, for one hour.

- Why isn't this more extreme? Sample size – "big pile of sand" ~ 52k values
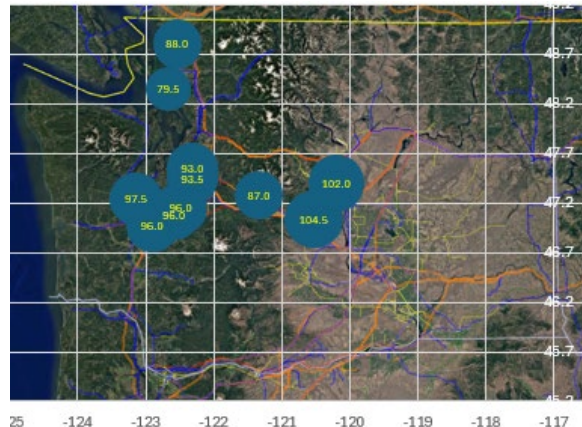
| Location	Est ECWT	1 in 2 Cold	Est EHWT	1 in 2 Hot
Bellingham	13.0	14.0	87.0	88.0
Whidbey NAS	17.0	20.0	77.0	79.5
Boeing Field	19.0	19.0	92.0	93.0
SeaTac	21.0	22.0	93.0	93.5
Stampede Pass	-3.0	7.0	89.0	87.0
Ellensburg	-1.0	1.0	103.0	104.5
McChord AFB (Tac)	14.0	12.5	95.0	96.0
Gray Army Field (Tac)	15.0	15.0	95.0	96.0
Olympia	16.0	14.0	95.0	96.0
Shelton	14.0	15.0	96.0	97.5
Wenatchee	2.0	5.0	102.0	102.0

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# What do we want? What is the 'right' thing?

- Extreme isn't defined, but study scope requested 1 in 20 ***loads***.

- 1 in 20 typically means you'd only serve that level of loading once every 20 years, for one hour. Loads don't _cause_ temperature, and temperature doesn't _cause_ load (causation), but there's good correlation (relationship) for this that we can demonstrate at the maximum and minimum temperature extremes.

- For a 1 in 20 temperature, given 20 years of temperatures, you are only likely to see that hot or cold of temperature for one hour.

- One potential approach for WPP study: Take Max (or Min, for cold) temp for each year as the set; go back x years (for team discussion, NERC went with back to 2000); apply whatever increase or decrease may be appropriate for climate changes by 2030 (6 years away); and take the 1 in 20 value of this data set to help advise what 'extreme' could look like for major load centers (Seattle, Portland, Spokane, Boise, etc.)

Where are the load centers?

Heat Map – WPP 30HS
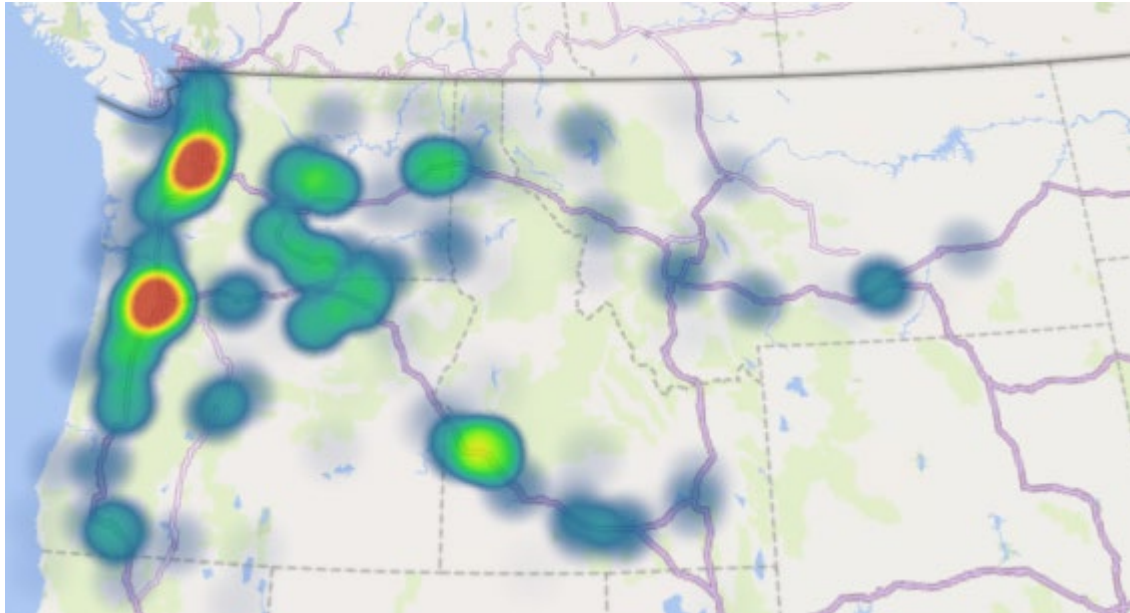
Heat Map – WPP 30HW

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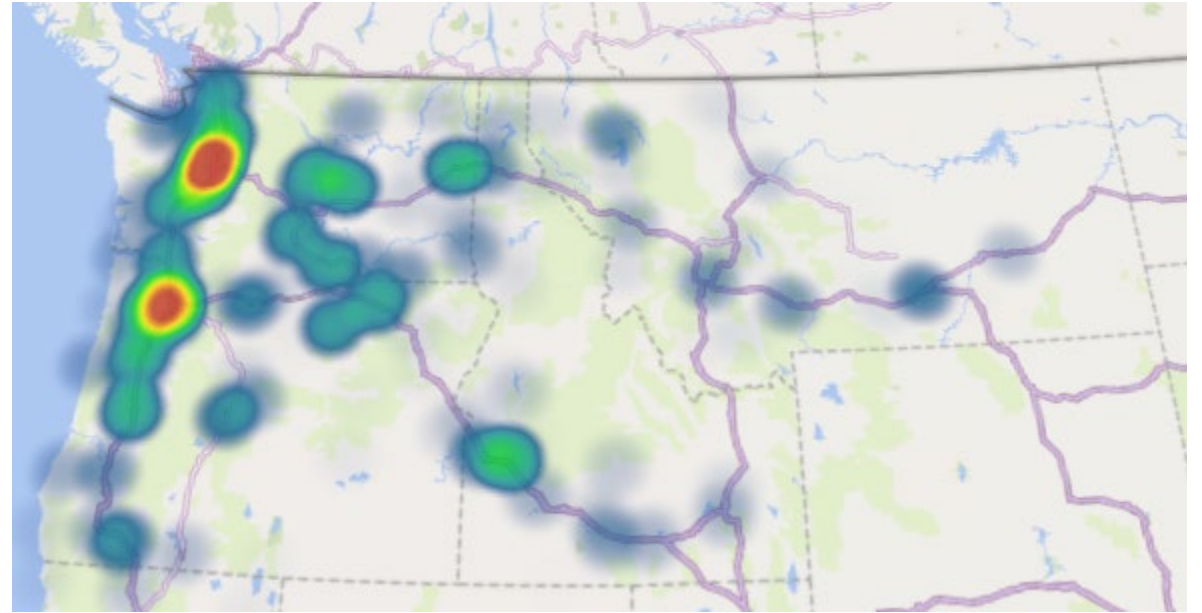
Where are the load centers?

AVA	Avista	Spokane
BPA	Bonneville Power Administration	Everett (SNPD), Portland, Vancouver, Longview, Boardman, Eugene (EWEB), Salem, Richland
CHPD	Chelan PUD	Wenatchee
MATL	Montana-Alberta Tie Line	Great Falls
IPC	Idaho Power Company	Boise, Idaho Falls
NWMT	NorthWestern Energy	Billings, Missoula, Great Falls, Bozeman
PGE	Portland General Electric	Portland, Salem
PSE	Puget Sound Energy	Sea/Tac
SCL	Seattle City Light	Sea/Tac
SNPD	Snohomish PUD	Everett
TPWR	Tacoma Power	Sea/Tac

What are the 1 in 20 temperatures at the load centers?

Hot Weather
1 in 20 values

	Spokane	Everett	Portland	Vancouver	Longview	Boardman	Eugene	Salem	Richland	Wenatchee	Great Falls	Boise	Idaho Falls	Billings	Missoula	Great Falls	Bozeman	Sea/Tac
1 in 20 - to 2000	105	100	108	106	105	110	106	107	112	109	103	110	101	107	104	103	100	102
1 in 20 - to 1900	104	92	105	103	104	109	105	107	112	107	104	110	101	107	104	104	99	99
2023	102	92	108	104	101	106	105	105	109	106	101	105	101	101	103	101	97	95
2022	102	92	102	97	98	105	102	103	112	109	102	106	100	103	104	102	99	95
2021	109	100	116	112	107	113	111	117	115	113	99	107	99	107	102	99	96	108
2020	102	100	100	98	96	106	101	100	111	106	99	105	98	102	100	99	93	98
2019	98	87	98	94	97	100	101	100	103	101	98	102	97	99	96	98	92	95
2018	103	89	100	97	98	107	98	99	107	103	102	110	98	103	104	102	100	94
2017	99	88	105	101	101		102	107	106	101	101	104	99	100	101	101	95	96
2016	97	89	100	97	100	105	104	104	105	101	97	102	96	99	95	97	92	95
2015	105	94	103	100	100		105	105	111	104	100	110	101	99	102	100	96	95
2014	100	91	99	97		110	101	99	109	104	95	104	97	100	98	95	93	96
2013	99	86	97	94		108	96	96	107	104	101	110		99	101	101	92	93
2012	98	88	102	100	100	105	101	103	107	104	102	108	98	103	100	102	97	94
2011	94	81	96	93	90	98	94	96	99	97	99	103	97	100	98	99	94	87
2010	95	91	98	97	101	104	101	101	104	99	96	104	97	101	99	96	94	96
2009	101	100	106	106	105	107	106	107	109	106	95	106	97	100	100	95	94	103
2008	103	88	102	100	95	103	100	101	105	105	98	105	97	103	100	98	95	92
2007	101	90	102	99	95	105	101	103	105	103	104	105	100	104	107	104	100	98
2006	102	90	104	103	102	109	105	105	112	107	100	107	99	103	102	100	96	97
2005	97	86	96		98	104	98	98	104	102	98	107	97	106	99	98	98	89
2004	97	91	103	102	103	102	103	104	104	104	99	104	95	100	100	99	94	96
2003	100	89	100	99	100	108	101	101	107	103	103	108	100	107	103	103	99	93
2002	102	86	102	99		105	104	104	109	103	102	110	101	108	104	102	100	94
2001	99	84	98	97		102	98	96	105	100	100	106	97	103	97	100	96	88
2000	99	84	98	96	99	99	95	99	106	101	100	102	100	102	100	100	98	88

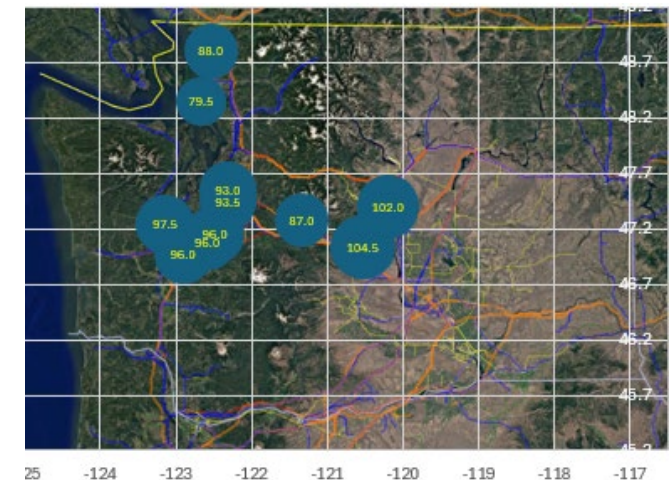From https://www.extremeweatherwatch.com, based on NOAA data

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1 in 20 vs. Max/Min

- As shown in the earlier sample size example, the much smaller sample set produced more extreme temperatures (qualitative).

- Data set below shows 1 in 20 and yearly max/min back to year 2000, no climate compensation used for forecast future adjustments.

Location	Est ECWT	1 in 2 Cold	1 in 20 Cold	Min Cold	Est EHWT	1 in 2 Hot	1 in 20 Hot	Max Hot
Bellingham	13	14	8	4	87	88	96	99
Whidbey NAS	17	20	11	10	77	80	86	87
Boeing Field	19	19	15	14	92	93	103	104
SeaTac	21	22	15	14	93	94	102	107
Stampede Pass	-3	7	-7	-12	89	87	98	101
Ellensburg	-1	1	-12	-13	103	105	108	114
McChord AFB (Tac)	14	13	10	8	95	96	105	109
Gray Army Field (Tac)	15	15	10	8	95	96	104	110
Olympia	16	14	7	7	95	96	100	109
Shelton	14	15	8	6	96	98	104	110
Wenatchee	2	5	-6	-9	102	102	108	113

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- KEY TAKEAWAY – 1 in 20 is a fair representation for cold weather; due to the 2021 heat dome event, 1 in 20 'hot' was notably cooler in many locations than the maximum 'hot' recorded at the location. Other statistical analysis finds the heat dome event was roughly between a 1 in 1,000 and 1 in 10,000 type of event – **EXTREMELY EXTEREME**. Use of statistical techniques gives us a means to describe the level of 'extreme' during this event.

- Secondary takeaway – this exercise also helps demonstrate some of the temperature variability across even a small portion of the WPP study footprint.

Location	Est ECWT	1 in 2 Cold	1 in 20 Cold	Min Cold	Est EHWT	1 in 2 Hot	1 in 20 Hot	Max Hot	1 in 20 as % of EHWT	Max as % of EHWT	Increase 1 in 20 to Max
Bellingham	13	14	8	4	87	88	96	99	110%	114%	4%
Whidbey NAS	17	20	11	10	77	80	86	87	112%	113%	1%
Boeing Field	19	19	15	14	92	93	103	104	112%	113%	1%
SeaTac	21	22	15	14	93	94	102	107	110%	115%	5%
Stampede Pass	-3	7	-7	-12	89	87	98	101	110%	113%	3%
Ellensburg	-1	1	-12	-13	103	105	108	114	105%	111%	6%
McChord AFB (Tac)	14	13	10	8	95	96	105	109	111%	115%	4%
Gray Army Field (Tac)	15	15	10	8	95	96	104	110	110%	116%	6%
Olympia	16	14	7	7	95	96	100	109	105%	115%	10%
Shelton	14	15	8	6	96	98	104	110	108%	115%	7%
Wenatchee	2	5	-6	-9	102	102	108	113	106%	111%	5%

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Discussion?