1

S589: Factors in Fire Weather Climatology

2

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Module Title Corbel 44pt
Section Title: Corbel 40pt

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Text level 2 = Arial 24pt

3

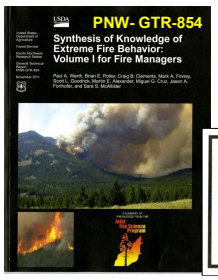
Objectives

- **Identify some climatic patterns that may affect fire regimes**
- **Look at some local factors**
- **Examine weather factors**
- **Construct a simple example climatology**
- ***Extreme fire behaviour is exciting but we are interested in all fires here***

4

Fire Weather Patterns

- The composite over time of the weather elements that affect fire business and behavior



Critical Fire Weather Patterns are defined as the atmospheric conditions that encourage extreme fire behavior resulting in large and destructive wild-land fires.

The four critical weather elements common to wildland fires exhibiting extreme fire behavior are low relative humidity, strong surface wind, unstable air, and drought.

5

Global Circulation Patterns

6

Some Ocean/atmosphere Oscillations

El Nino/Southern Oscillation (ENSO)

Pacific Decadal Oscillation (PDO)

Madden-Julian Oscillation (MJO)

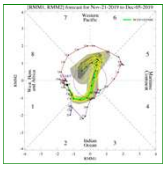
Arctic Oscillation (AO)

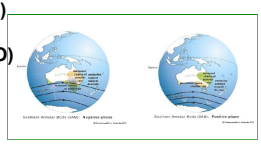
North Atlantic Oscillation (NAO)

Quasi-biennial Oscillation (QBO)

Indian Ocean Dipole (IOD)

Southern Annular Mode (SAM)





Some Oscillations directly affecting Canada

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El Nino/Southern Oscillation	Tropical
Pacific Decadal Oscillation	Mid latitude
Madden-Julian Oscillation	Tropical
Arctic Oscillation	Mid-high Latitude
North Atlantic Oscillation (NAO)	Mid-high Latitude
Quasi-biennial Oscillation (QBO)	All latitudes?

Fire in ENSO Springs

8

Large area burned
Virginia Hills, AB
Chisholm, AB
Kelowna, BC
Slave Lake, AB
Fort McMurray, AB
Big years in BC
Big years in BC

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1991	0.4	0.3	0.2	0.3	0.5	0.6	0.7	0.6	0.6	0.8	1.2	1.5
1992	1.7	1.6	1.5	1.3	1.1	0.7	0.4	0.1	-0.1	-0.2	-0.3	-0.1
1993	0.1	0.3	0.5	0.7	0.7	0.6	0.3	0.3	0.2	0.1	0.0	0.1
1994	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.4	0.6	0.7	1.0	1.1
1995	1.0	0.7	0.5	0.3	0.1	0.0	-0.2	-0.5	-0.8	-1.0	-1.0	-1.0
1996	-0.9	-0.8	-0.6	-0.4	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5
1997	-0.5	-0.4	-0.1	0.3	0.8	1.2	1.6	1.9	2.1	2.3	2.4	2.4
1998	2.2	1.9	1.4	1.0	0.5	-0.1	-0.8	-1.1	-1.3	-1.4	-1.5	-1.6
1999	-1.5	-1.3	-1.1	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.7
2000	-1.7	-1.4	-1.1	-0.8	-0.7	-0.6	-0.6	-0.5	-0.5	-0.6	-0.7	-0.7
2001	-0.7	-0.5	-0.4	-0.3	-0.3	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3
2002	-0.1	0.0	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.2	1.3	1.1
2003	0.9	0.6	0.4	0.0	-0.3	-0.2	0.1	0.2	0.3	0.3	0.4	0.4
2004	0.4	0.3	0.2	0.2	0.2	0.3	0.5	0.6	0.7	0.7	0.7	0.7
2005	0.6	0.6	0.4	0.4	0.3	0.1	-0.1	-0.1	-0.1	-0.3	-0.6	-0.8
2006	-0.8	-0.7	-0.5	-0.3	0.0	0.0	0.1	0.3	0.5	0.7	0.9	0.9
2007	0.7	0.3	0.0	-0.2	-0.3	-0.4	-0.5	-0.8	-1.1	-1.4	-1.5	-1.6
2008	-1.6	-1.4	-1.2	-0.9	-0.8	-0.5	-0.4	-0.3	-0.3	-0.4	-0.6	-0.7
2009	-0.8	-0.7	-0.5	-0.2	0.1	0.4	0.5	0.5	0.7	1.0	1.3	1.6
2010	1.5	1.3	0.9	0.4	-0.1	-0.6	-1.0	-1.4	-1.6	-1.7	-1.7	-1.6
2011	-1.4	-1.1	-0.8	-0.6	-0.5	-0.4	-0.5	-0.7	-0.9	-1.1	-1.1	-1.0
2012	-0.8	-0.6	-0.5	-0.4	-0.2	0.1	0.3	0.3	0.3	0.2	0.0	-0.2
2013	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.4	-0.2	0.1	0.3	0.2	0.1	0.0	0.2	0.4	0.6	0.7
2015	0.6	0.6	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.6
2016	2.5	2.2	1.7	1.0	0.5	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6
2017	-0.3	-0.1	0.1	0.3	0.4	0.4	0.2	-0.1	-0.4	-0.7	-0.9	-1.0
2018	-0.9	-0.8	-0.6	-0.4	-0.1	0.1	0.1	0.2	0.4	0.7	0.9	0.8
2019	0.7	0.7	0.7	0.7	0.5	0.5	0.3	0.1	0.2	0.3	0.5	0.5
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5				

El Niño:
- Warm, windy, dry in western Canada

La Niña:
- Arctic surface highs bring dry air, strong wind around edges
- Temperature *may* be cool

Summer fire problems may depend on other influences

Alberta: Distinctive Patterns

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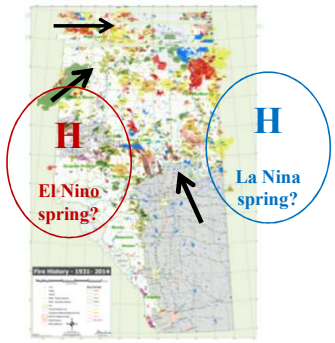

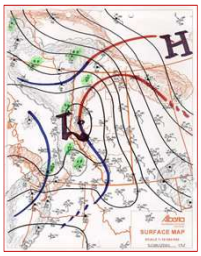

May 28 2001 - 0900

10

Non-weather/climate parameters

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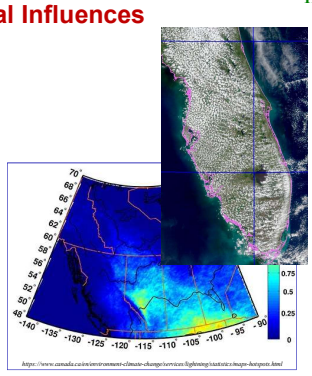
Local Influences

- Mountains/hills
- Lakes and oceans
- Soils
- Forest disturbance
- Lightning and human activity



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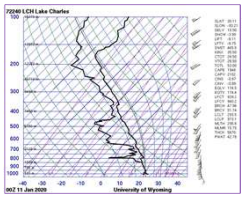
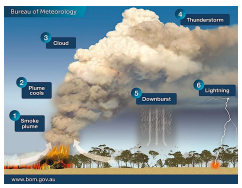
Instability

- May drive extreme fire behavior
- Synoptic pattern dependence
- Topography: mountains/hills, lakes, oceans
- More detail previously, and in Unit III-A





Lightning-caused vs Human-caused fires

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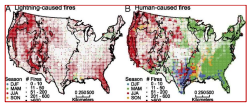
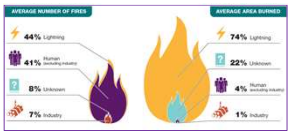
- Canada:
  - Lightning bigger starter in northwest
  - Time of year: spring fires are usually human-caused
- Climatology may differ between regions with dominant human-caused vs lightning-caused fires



https://www.pnas.org/content/114/11/2946



NRCan, 2007-17 data. See speaker notes for source

Regional Variation of Fire Seasons

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N/Central Alberta:	Mid-late spring peak
British Columbia:	Mid-July to August/Sept
Southeastern USA:	Winter
USA SW/S. Plains:	Early spring
Mexico:	February – May
Southeast Asia:	El Nino, esp. outside NE monsoon (Nov – Mar)

Weather Factors

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General Weather Factors

- Temperature
- Humidity
- Wind
- Precipitation
  - Snow cover
  - Drought
- Atmospheric pressure (optional)
- Lightning: an ignition agent
- Upper air height deviations (e.g., optional)
- CFFWIS

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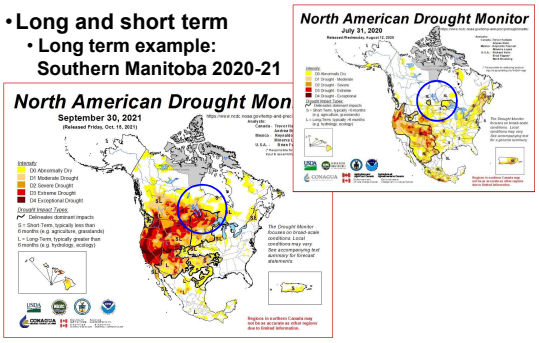
Drought

- Long and short term
  - Long term example: Southern Manitoba 2020-21



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Flash Drought

- Flash Drought
  - Event with rapid onset of one that intensifies rapidly
  - Recent examples BC 2017, 2018, 2021?
- Agricultural or hydrological drought can affect fire behavior and suppression
  - Fuel drying
  - Stream and lake levels

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Data Concerns

- What accuracy is needed in your study results?
- How much missing data can be tolerated?
- Do you have a good weather station history?
  - Have standard siting, instrumentation, and maintenance practices been followed?
  - Enough years of data?
  - What changes have occurred during the period?

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More Data Criteria

- Limit FWI records to stations with >= x% obs
  - We tried 95% available observations in CWFIS … too limiting for FWI at ECCC stations
  - Our Fort Smith example has better than 80% completeness
  - These are based on T, RH, wind, precip (obs/4*ndays)
- Some study types are more sensitive
  - Climate change studies need rigorous controls

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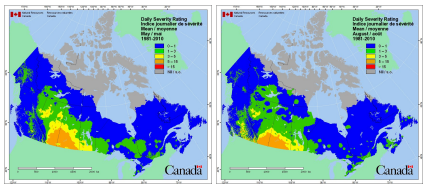
Uses of Averages (1/2)

- Helps determine the most likely month or season for active fire and/or severe behavior
  - Extreme fire behaviour often results from deviations from average climatic conditions



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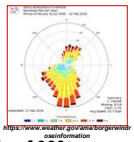
Uses of Averages (2/2)

- Fire weather indicators considered with averages:
  - Time-wise/seasonal distribution of rainfall
  - Snow cover arrival and departure dates
  - Favored wind speed/direction/drying (reflected in major runs?)
    - Careful not to average winds on either side of 360°



https://www.weather.gov/ama/borgerwindrosinformation

23

Let us Build a Sample Climatology

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Climatology Example

- We will only use one station location for our climatology
  - Fort Smith, NT ECCC stations
- Complex studies may use many stations from a larger area
- Many ways to display information
  - We will show some simple examples (scatter plots, histograms, trend lines, …)

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Problem!

- **Oh-oh! CWFIS has a problem in its FWI calculations: Ft Smith Upper Air station, not the Primary Surface station, appears in 1971-89 station tables, except 1975**
  - **Similar problem for 3-4 upper air locations – will fix in our next historical FWI update**
  - **Let's use 1991-2021 for the Fort Smith study**
  - **Is it long enough? Just**

26

Fort Smith ECCC Station History

- **Any changes in location, instrumentation?**

aes	wmo	id	name	lon	lat	elev	st_date	en_date	hly	syn	tmm	ua
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1953-07-01	1964-12-01	X	@	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1964-12-01	1965-11-01	X	@	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1965-11-01	1965-12-01	X	-	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1965-12-01	1966-06-01	X	@	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1966-06-01	1966-12-01	X	@	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1966-12-01	1968-02-01	X	@	@	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1968-02-01	1968-04-01	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1968-04-01	1971-05-01	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1971-05-01	1974-09-01	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	203	1974-09-01	1990-03-17	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.95	60.02	205	1990-03-17	1997-03-21	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	1997-03-21	1998-09-12	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	1998-09-12	2002-09-08	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2002-09-08	2004-11-04	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2004-11-04	2006-09-05	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2006-09-05	2013-01-10	X	@	-	
2202200	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2013-01-10	9999-09-09	X	@	-	
2202201	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2014-10-22	9999-09-09	-	-	-	
2202202	71362	CZSM	FORT+SMITH+CLIMATE	-111.933	60.03	203	2003-07-16	9999-09-09	H	@	-	
2202203	71934	CYSM	FORT+SMITH+A	-111.967	60.02	205	2015-11-03	9999-09-09	-	-	-	
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1967-11-01	1968-02-01	-	-	-	
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1968-02-01	1970-09-01	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1970-09-01	1971-05-01	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1971-05-01	1975-05-01	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1975-05-01	1979-03-01	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	-99	1979-03-01	1980-11-01	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	204	1980-11-01	2001-06-10	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	204	2001-06-10	2006-07-28	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	204	2006-07-28	2006-12-06	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	204	2006-12-06	2009-08-12	-	-	-	@
2202208	71934	CYSM	FORT+SMITH+UA	-111.933	60.03	204	2009-08-12	9999-09-09	-	-	-	@

27

Period of Study

- **Fort Smith, NT ECCC station assessment**
  - **2202200 – Good: ~98% observations complete**
  - **2202201 – No precipitation**
  - **2202202 – Climate station Nov 2003 --, ~84% complete**
  - **2202203 – No precipitation, visibility, weather type**
  - **When is the data missing? What parameters?**
  - **Assume ECCC runs new instruments at a site in parallel for 1-2 years before new site reports "official" observations**

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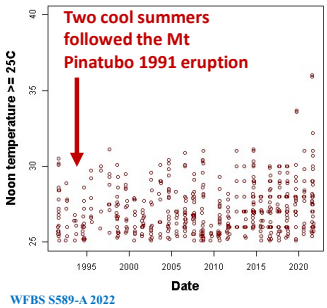
Fort Smith Area Fire History

- Fire history
  - Why are no fires near the town? Suppression, fuel types?

29

Noon Temperature >= 25C

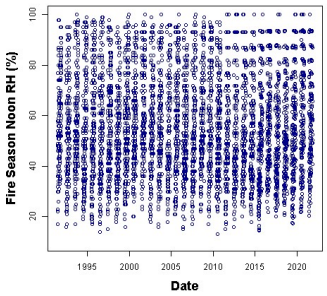
- Any apparent increasing or decreasing trends?
- Are the clusters increasing or decreasing in density?
- Big NT fire years in 2013-15, 2017



30

Noon Relative Humidity at 2202200

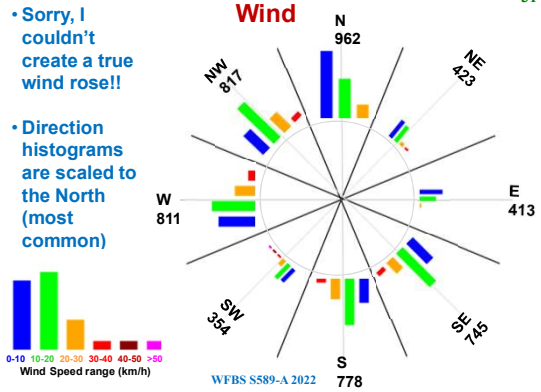
- Trends?
- Plot of all noon RH: Weird pattern in the 90-100% range post-2010



31

- Sorry, I couldn't create a true wind rose!!
- Direction histograms are scaled to the North (most common)

Wind



32

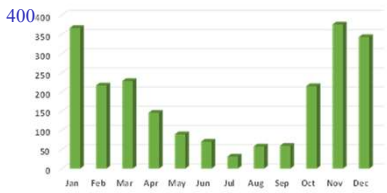
Precipitation Game

- Guess the approximate location of these annual precipitation profiles …
  - Shout out your answers!
  - I will advance the slide and the location will appear in blue under the graph title

33

Normal Monthly Precipitation (mm)

Port Alberni, BC

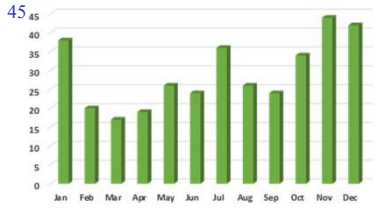


Normal Annual Precipitation – 2198 mm

34

Normal Monthly Precipitation (mm)

Lillooet, BC

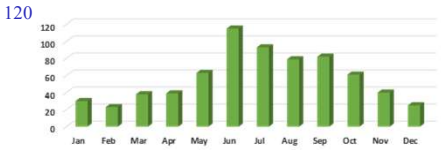


Normal Annual Precipitation – 349 mm

35

Normal Monthly Precipitation (mm)

Dryden, ON

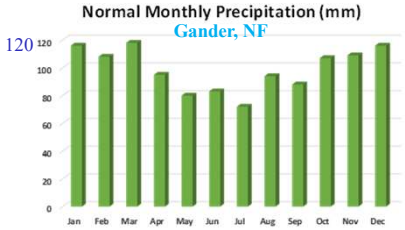


Normal Annual Precipitation = 688 mm

36

Normal Monthly Precipitation (mm)

Gander, NF



Normal Annual Precipitation – 1186 mm

37

Normal Monthly Precipitation (mm)

Fort Smith, NT

Normal Annual Precipitation – 354 mm

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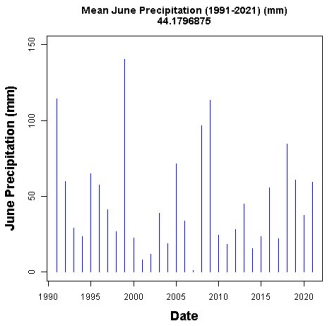
Precipitation Histogram - June

- Compare variation between June and July/August (next slide)
- Monthly means (previous slide) tell part of the story



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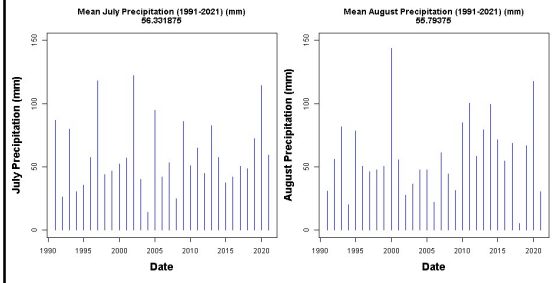
Precipitation Histograms – July, August

- Remember July's pattern for the BUI plot (next)



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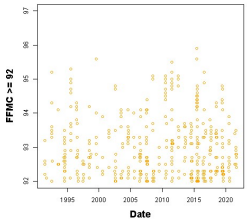
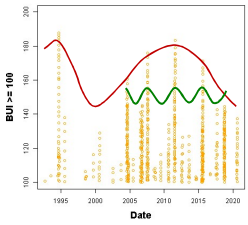
CFFWIS

- FFMC: A bit noisy?



- BUI: Somewhat regular cycles (the curves are my scribbles)



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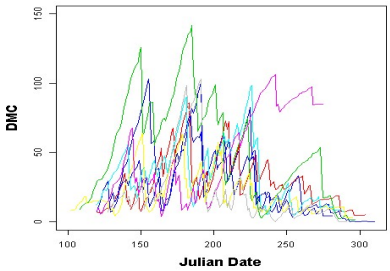
Duff Moisture Code

- Annual comparison (2013-2021 for "simplicity")



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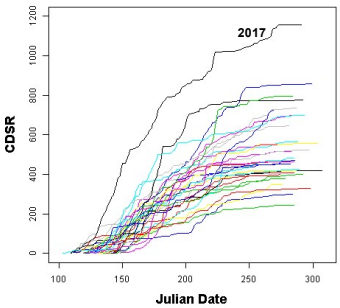
Cumulative DSR

- Calculations usually start April-May
- Fast early summer climb
- Curves usually flatten by August



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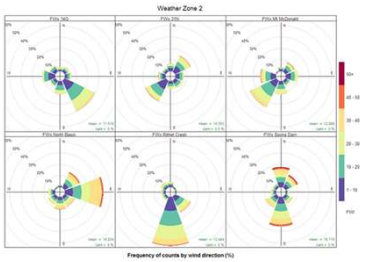
CFFWIS Roses – Vancouver Island

- Similar concept to wind roses can be used with FWI outputs



Fire Weather Index (FWI) Roses by station, showing frequencies of wind direction by FWI value class, grouped between Weather Zones 1 and 2. 'Calm' refers to instances of FWI<1.

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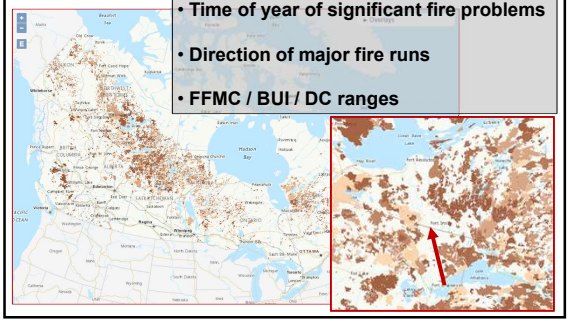
Outcomes

Recognizable in fire regimes

- Historical fire incidence
- Time of year of significant fire problems
- Direction of major fire runs
- FFMC / BUI / DC ranges



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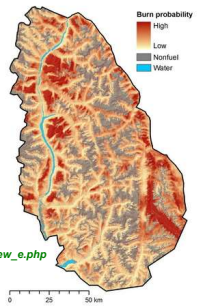
Burn P3

- Limited area simulation
  - Many thousands of fires simulated to determine areas most likely to burn
  - Data pool includes fire weather history of the region, fuels, topography, …



http://firegrowthmodel.ca/burnp3/overview_e.php
Accessed October 22, 2021

Summary

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- Fire climate is defined by influences driving repetitive or severe fire behavior
- Contributions from large-scale circulations, local weather patterns, and geographic situation
  - Discernable patterns in the fire landscape
  - Peak fire seasons in different regions may be at different times of the year
- Varied analysis techniques may be used to analyze required parameters

Exercise

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- Time allotment: x days
- Answer a few questions about the lightning data
- Construct a histogram plot of weekly lightning or some other factor (data supplied in a spreadsheet) … this covers small geographic areas so we don't need huge data sets

Contact Information

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