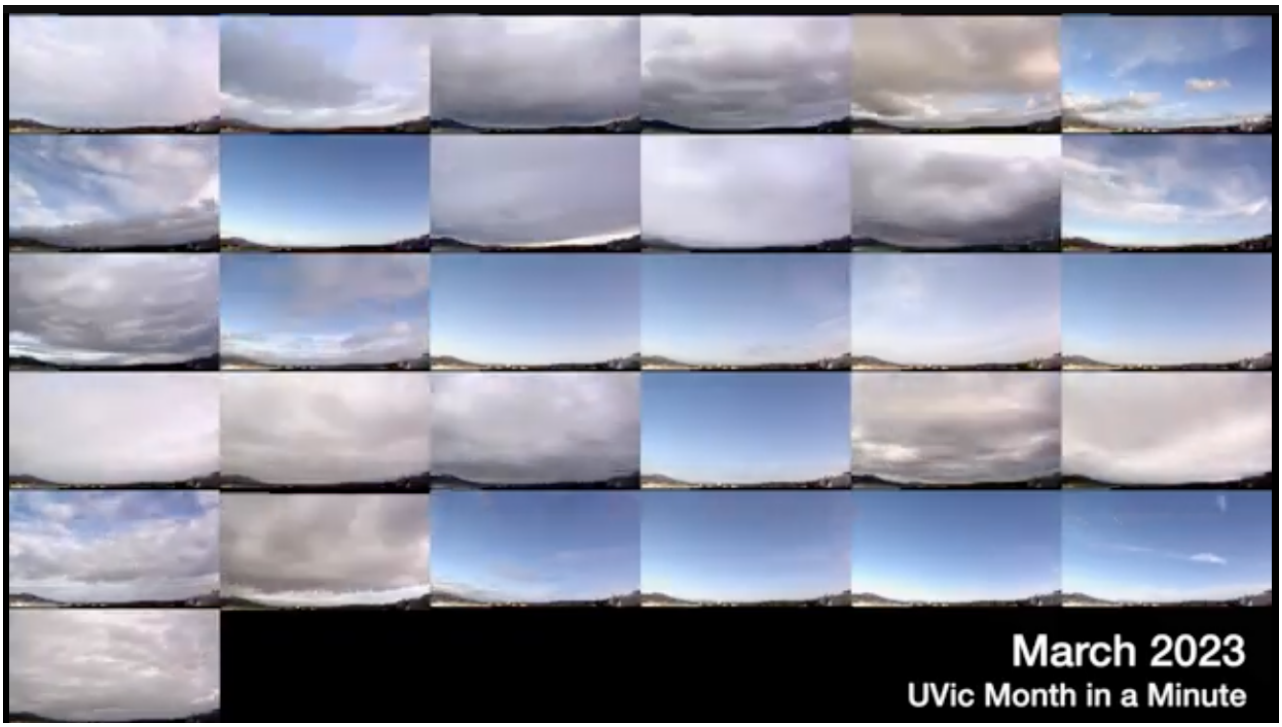

Figure 1: March 2023 cloudscape.

March 2023

See March's Month in a Minute video on the Youtube: `https://www.youtube.com/watch?v=g-y_92yKhME`. A one-minute timelapse video of the view looking north from UVic where each day of the month is presented in a grid.

March is a transition month here at UVic. Students are finishing their classroom work and preparing for exams. Spring begins and with it we see new weather patterns. The sun is in the sky for longer and the rate of increase of daylight length is at its maximum (a bit more than three and half minutes per day). The height the sun reaches in the sky each day is important for two reasons. The higher the sun reaches, the more time it has to shine short-wave radiation on a given location. As well, the radiation intensity increases with the noon sun angle. Let's explore that a bit.

Diversion to fundamentals of the Sun's movements in the sky.

The noon sun angle is the elevation of the sun at noon on a given. It can be calculated from the latitude of a location and declination of the sun. At UVic, the latitude is 48.462°. The sun's declination tells

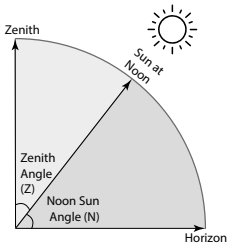

Figure 2: The zenith angle and the noon sun angle always add up to 90°.

us the latitude where the sun will be directly overhead (at the zenith) at noon and depends on the day of the year. If you want to see the sun overhead at noon each day you could start by standing on line of the Tropic of Cancer (23.4°latitude) on the June Solstice. Moving a bit south each day you would cross the equation on the September equinox. You'd reach the Tropic of Capricorn (-23.4°) on the December Solstice. The sun starts moving north again then, and reaches the equator on the March equinox.

The noon sun angle is calculated with Equations 1 and 2. z is the zenith angle, L is the latitude, d is the declination of the sun, N is the noon sun angle.

$$z = |L - d| \tag{1}$$

$$z + N = 90° \tag{2}$$

$$\text{Radiation Intensity Factor} = sin(N) \tag{3}$$

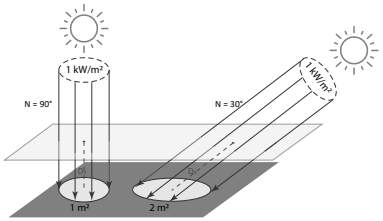

Figure 3: The noon sun angle affects the radiation intensity at the Earth's surface (eqn. 3).

Day	d °	z °	N °	Intensity %	Length hours
01 March	-7.8°	56.3°	34°	56	11.0
21 March	0.0°	48.5°	42°	67	12.2
31 March	3.9°	44.6°	45°	71	12.8

Table 1: Noon Sun Angle (N) and other information on some March days at UVic.

There are a couple things to note. First, the sun's zenith angle (the angle between the sun and the point directly overhead) at noon is equal to the latitude where you are observing *on an equinox* when $d = 0°$. In fact, if you have a way to measure solar angle and you know the declination from the trusty tables you carry, you know your latitude. The second thing is that the sun's angle relative to the ground strong effects how much radiation will reach the surface, per unit of area. Take a look at Figure 2. The amount of energy in the beam of light is the same in both cases shown, but when the beam is tilted the energy is spread over a larger area than when the sun is overhead. The solar intensity is 100% when the sun is directly overhead. In all other situations it's reduced. There's a actually a third effect as well. A low sun angle means that the light that does reach the surface passes through a greater length of atmosphere first. Atmospheric effects on short-wave radiation are not negligible. We all enjoy the colourful splash of a pretty sunrise or sunset.

The day (lit) length increases by one hour and 48 minutes in March. This is very welcome after a long dark winter. Notice too that the solar intensity increases by 15%. We notice this when we're outdoors. The sun starts to feel warm against our skin and begins to warm up the ground. For reference, the solar intensity reaches its maximum on the June solstice, 90.7% at UVic when the sun is 65°high at noon.

Temperature Summary

We see the effects of the increased insolation (incoming solar radiation) in March with a general trend to warmer daily average temperatures. Fig. 4 shows the averages. The longterm (20 year) averages are given in the background lines and shading. This year is shown on top.march started colder than expected, the first day started off at -2 °C. Daily averages increased steadily from that point until 22 March. A short cold period followed. This was accompanied by light frosts. That is, there was frost present on the grass and rooftops but air temperatures stayed just above freezing. A couple of warm days followed and we saw our maximum temperature for the month, 16.1 °C in the late afternoon on the twenty-first. The highest temperature I've recorded at UVic (since 2002) was 22.5 °C on 29 March in 2004. I hope by now it will be clear why the highest temperature of March is more likely at the end of the month.

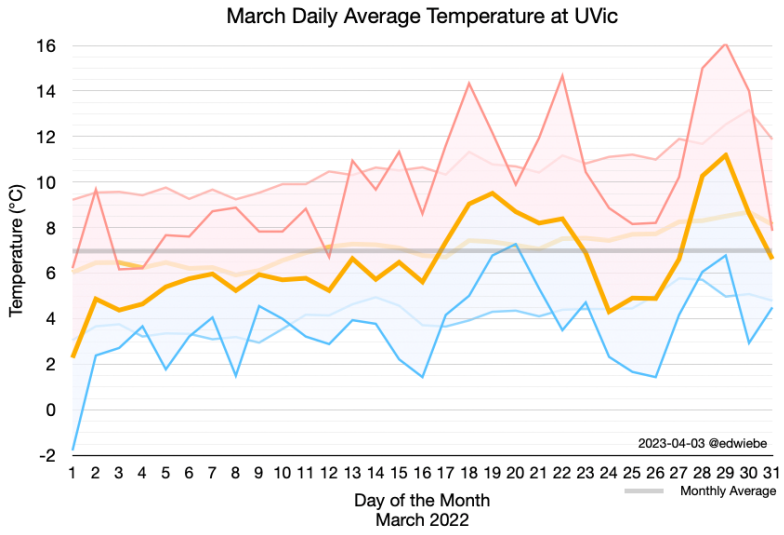

Figure 4: Daily temperature averages for March, 2023 overlaid on the long-term record. Blue gives minimums, orange averages, and red maximums.

Monthly averages are shown in Fig. 5. March 2023 was in the cooler half of 22 observed years. The monthly average characterises a month as warmer or cooler or expected but it's not as useful as the data could

be. Let's look next at the idea of a Degree Day and what it can be used for.

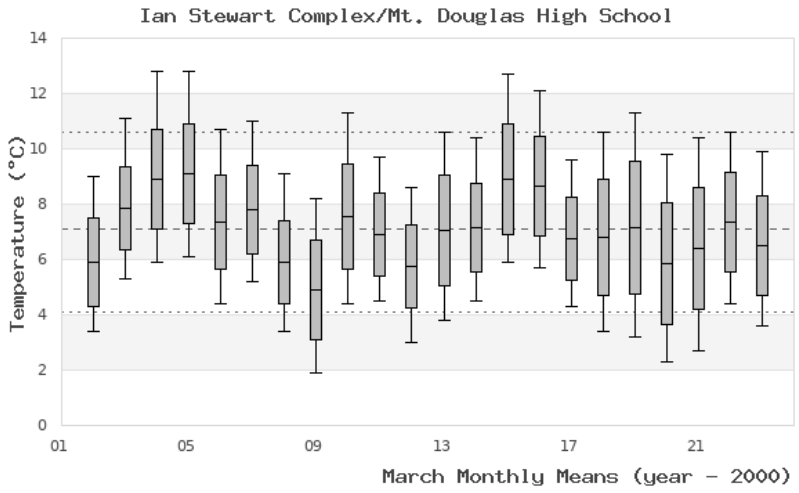

Figure 5: Monthly average temperatures for all observed Marches at UVic.

Heating Degree Days

Calculating Heating Degree Days are a way of producing an easily digestible summary of how much heat is likely required for a building, given the outside temperature. The principle is simple. Compare the daily average outside temperature to threshold temperature. When the temperature is less than that threshold heat is (likely to be) needed to maintain a conventional building at a comfortable temperature. It's a way to better understand and model the power required for heating. The threshold used in Canada is 18 °C. Degree days in general are most easily estimated using daily average temperature data. However, data collected at finer time resolution can give a more accurate result.

Equation 4 gives the general formula for degree days. D is the number of degree days, T_i is the measured temperature over some time interval Δt, and T_R is the reference threshold temperature. Many kinds of degree days are possible. Cooling degree days and Growing degree days are commonly used.

$$D = (T_i - T_R) \times \frac{\Delta t_i}{1\,day} \tag{4}$$

One way that degree days are used is to accumulate them over a span of time. In this way, temperatures over a longer span of time can be summarised by a single value. This is very commonly done, for example, with Growing degree days. The total of Spring and Summer can be compared from place to place to help to determine the suitability of a region for specific crops.

$$D_H = \sum \left((T_i - T_R) \times \frac{\Delta t_i}{1\,day} \right) \tag{5}$$

Heating degree days at UVic were calculated using average daily temperatures (the simplest method) and are shown in Fig. 6. Three curves are shown. March 2023 may be compared to the long-term average and to one of the warmest March I've recorded, 2016. The trend in the average is clear. We expect to require less heat from the beginning of the month to the end. The effects of short-term weather events are clear. Remember that heating degree days show colder days as an increase in value.

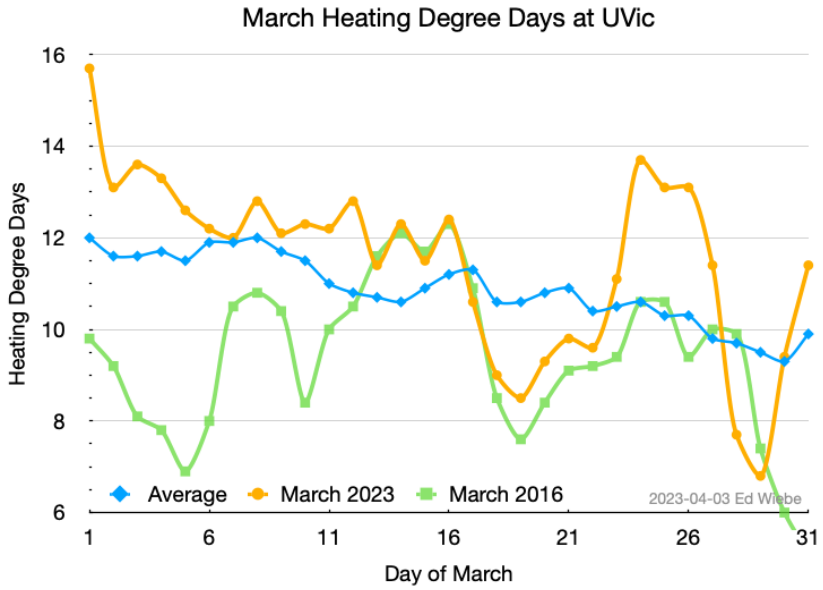

Figure 6: Heating Degree Days at UVic in March.

Using Equation 5 I show how the cumulative sum of the heating degree days changes throughout the month. I've compared March 2023 and 2016 to the average values to give a heating degree day anomaly. The values for 31 March are the cumulative total for the month. The difference between a warm a cool month is large and means that more energy was required for heating in 2023 than in 2016.

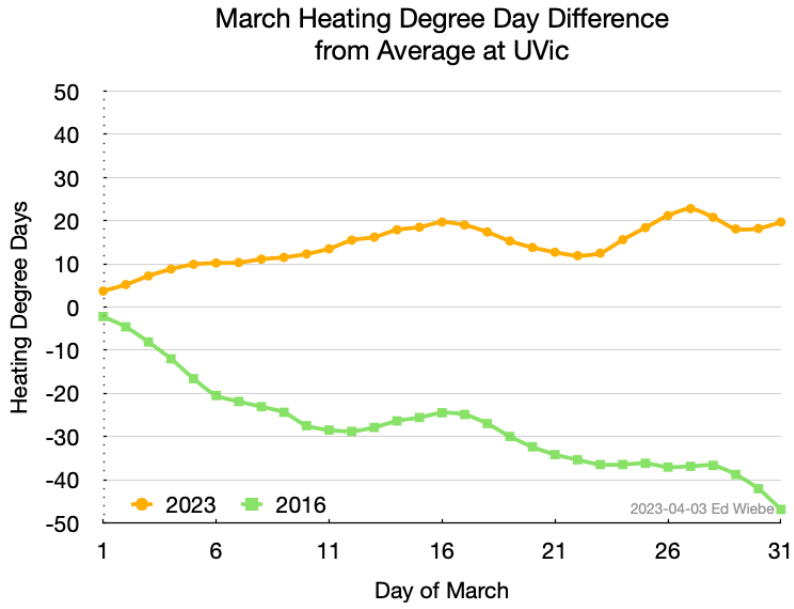

Figure 7: Comparing Heating Degree Days in March, 2023 with a warm March (2016).

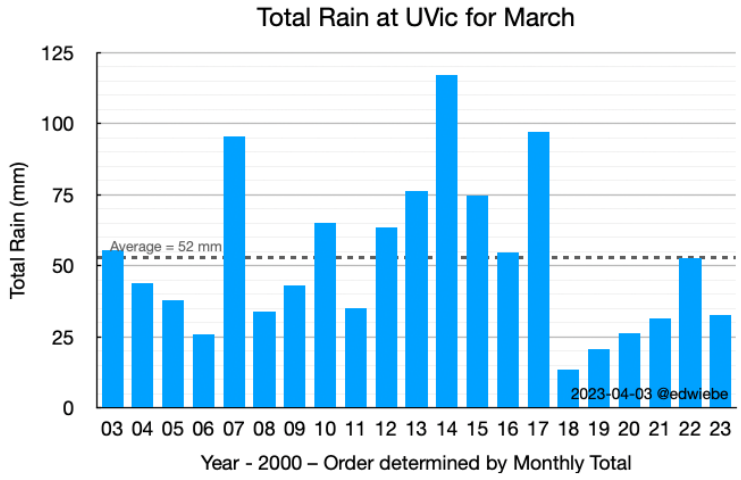

Figure 8: Total rain in observed Marches at UVic.

Rain Summary

Total rain observed at UVic in March, 32.8 mm was well below the 20 year average of 52 mm. This is, in general, continuing the pattern of the past 9 months. Figure 8 gives March total rainfall observed at UVic since 2003. Figure 9 gives the total rain amount from July through March over the same period. The low rain total in the past nine months occurred unexpectedly with an ongoing La Niña state in the

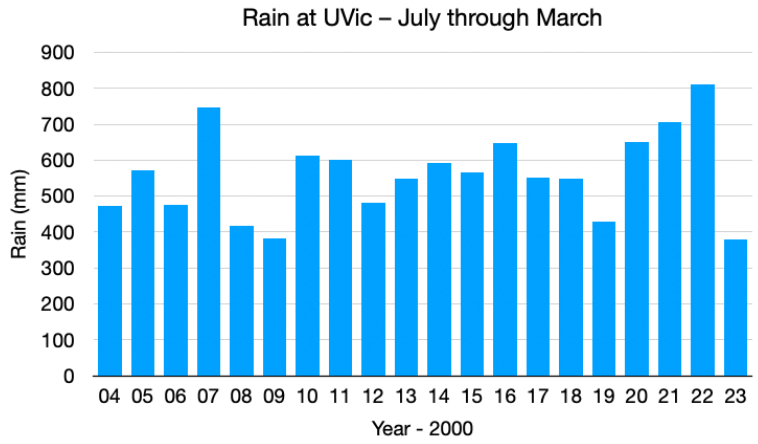

Figure 9: Total rain, July through March, at UVic.

Eastern Pacific Ocean. We are now transitioning to a La Niño pattern when we expect to see dryer conditions in Greater Victoria. The current ENSO forecaster consensus is here: `https://www.climate.gov/news-features/blogs/march-2023-enso-update-no-more-la-ni%C3%B1a`. Figure 10 shows the forecast probabilities for three month periods starting in February, 2023.

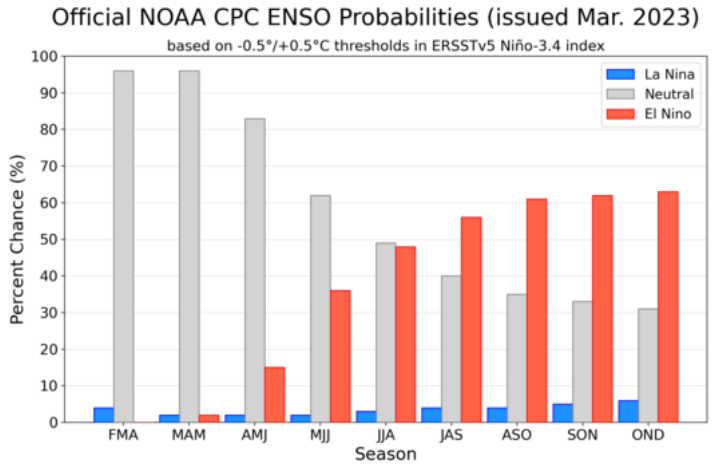

Figure 10: ENSO forecast probabilities, February to December, 2023.

Finally, we see the count of days in March, 2023 where rain was recorded in Figure 11. Rain is recorded in 0.2 mm increments. Fewer than expected days were rainy this year.

That's it for March 2023. You can send me questions or comments at ecwiebe@uvic.ca or find me on the Mastodon at @edwiebe@mstdn.ca.

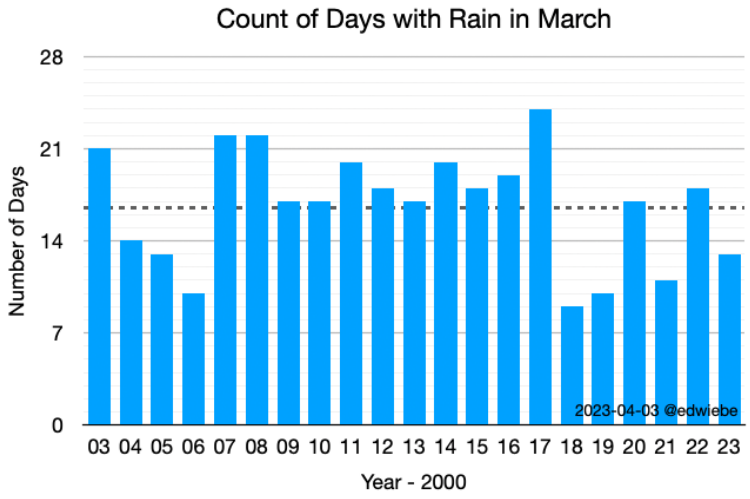

Figure 11: Days with rain in March, at UVic. The average is shown with a dashed line.