September 2023

Figure 1: September, 2023 at UVic.

Temperature

This year September was really average. What more can be said about it? Figure 2 tells the main part of the story. The monthly average was 14.97 °C, (basically) indistinguishable from the 21 year average of 14.93 °C (the standard deviation of the monthly averages is 0.75 °C).

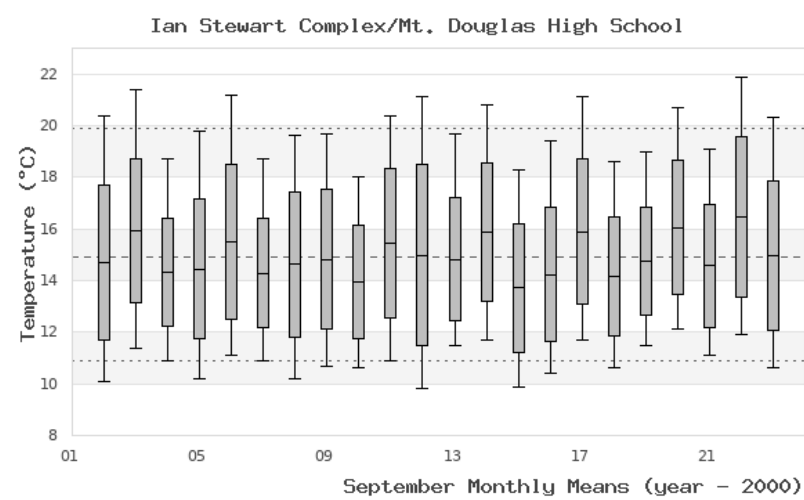

Figure 2: September Monthly Averages.

One characteristic of September is rapid decrease in the amount of insolation (energy from the sun). The noon-sun angle changes most rapidly around the time of the Equinoxes. Two effects are important. The first is the result of the reduction in the height of the sun (at noon).

This decreases the angle of incidence of a beam of light at the Earth's surface, spreading the available incoming short-wave radiation over a larger ellipse. There's less energy available per unit area. The other is the movement of the sun along the horizon toward the south. The length of the path it takes through the daytime sky is shrinking and the the length of the *day* is decreasing. The sun is up for fewer hours every day. At the beginning of the month the daylength is 13:24 (13 hours and 24 minutes). At the end of September it's 11:43, one hour and nineteen minutes less.

All of that *lost* solar radiation means a large reduction in the daily average temperature. Remember, the long-wave emitted throughout the day depends on the surface temperature which is no longer in equilibrium with the incoming solar radiation: it's too warm. Figure 3 shows this effect. The cooling trend through the month is -0.12 °C per day on average (since 2002). This downward trend slows but continues through December when, at UVic, temperature stabilizes around 5 °C until mid-February.

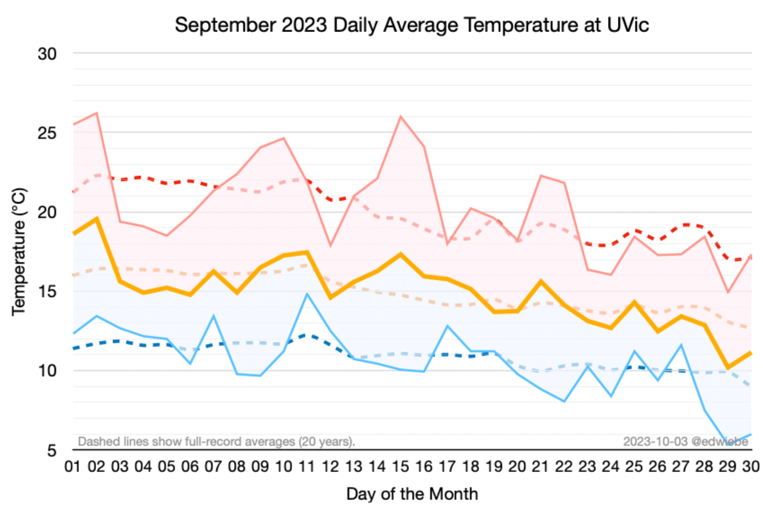

Figure 3: Daily temperatures.

Looking at the cooling trend in the month made me wonder if there's any kind of trend in the averages over the past 21 years. The left panel in Figure 4 shows all of the monthly averages and monthly average extreme temperatures against year. By eye it does appear there is a trend in the minimums (and averages?). If this were true it might be an indication of long-period climate variability or climate change. A simple linear fit to the minimums does result in an upward sloping line but the R^2 is low. It suggests the trend only explains 13% of the variability in the data. Yet, it looks quite promising. What's going on?

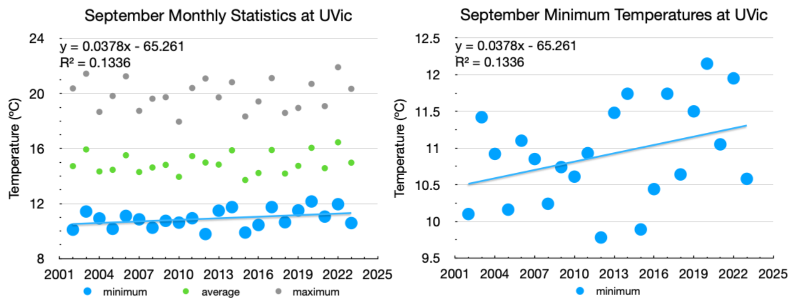

Figure 4: Monthly statistics and a trend?.

This is a good teachable moment. We can't rely on our eyes to spot meaningful trends. So much depends on the scale at which the data are plotted. In the right panel of Figure 4 I plotted the minimums again and calculated the same linear trend. The scatter of points in this chart, shown at a scale that gives greater visibility to the variability from year to year makes it much more difficult to believe the trend is there, if I hadn't plotted the line. Always take the time to consider the character of data being examined before jumping ahead to things like trend analysis.

Early Fall Storm

The one bit of weather drama this past month was that we observed an early fall storm at the end of the month. The classic mid-latitude cyclone grew over the Pacific Ocean and reached us on the night of the 24–25 September. The forecasts spotted this storm a few days earlier and warnings were ready. Strong winds at this time of year can be very damaging. Most trees still have their full complement of leaves and the wind load is much greater.

Figure 5 shows a forecast chart for the early morning on 25 September, 2023.

This storm intensified rapidly, and met the threshold to be declared a *bomb* cyclone. Such a storm has a low pressure that reduces in pressure by at least 24 hPa in a 24 hour period. More precisely the low reduces by $(24\ sin(\text{latitude})/sin\ 60)$ hPa in that time. The bomb part of the name is hyperbole cooked up by meteorologists studying the phenomenon starting in the 1940s and on. The process by which they grow is called *Explosive cyclogenesis*. The fundamental picture is a boundary (front) between warmer and cooler air masses, with the cooler to the north (northern hemisphere). This front near the surface can be disturbed by other activity higher up in the atmosphere. Once perturbed the disturbance can grow. The result is a growing low pressure region with cyclonic winds around it, strong vertical motion, and a wrap-

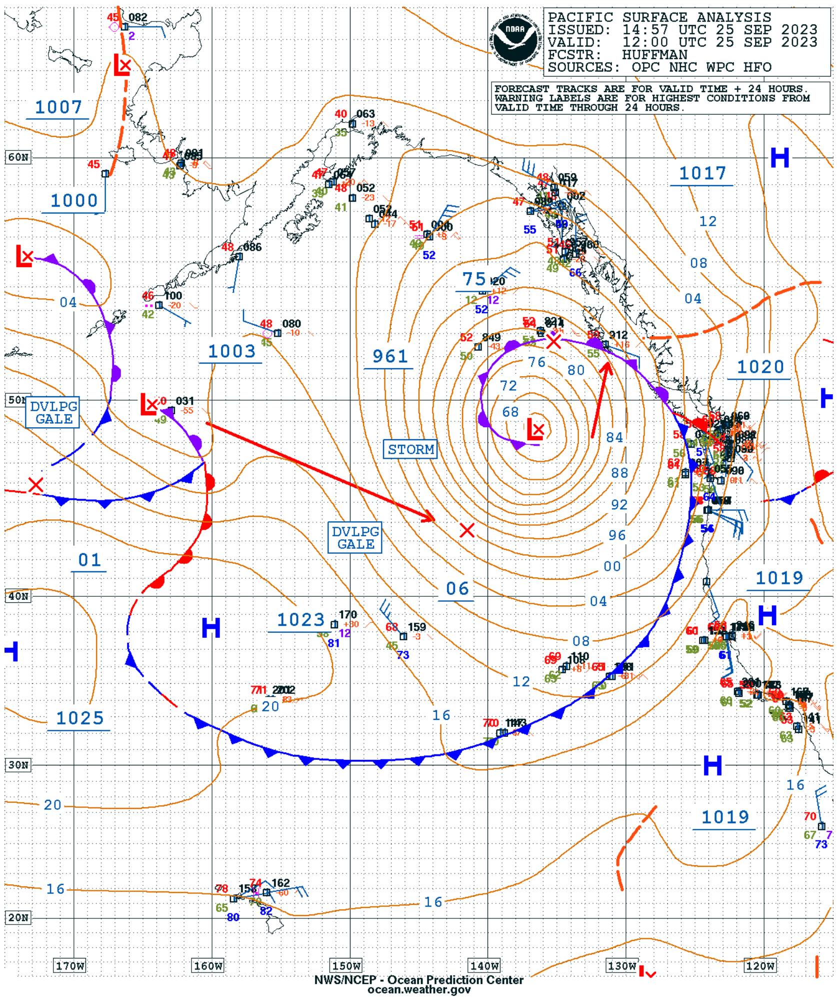

Figure 5: Early fall storm.

ping up of the front in a spiral. Ultimately the process rearranges the warm and cooler air masses so that the warmer air is above the cooler, instead of them being beside each other.

In Figure **??** the strong low is prominent in the centre of nested 'circles' of constant pressure. The cold front (shown with blue triangles) has pushed far to the south before being wrapped up around the low. At this point the warm front (marked with red semicircles) has been pulled around the storm and is almost gone. The storm is near its end here.

Winds are counter-clockwise around a low in the northern hemisphere. The winds are stronger were the orange isobars (lines of constant pressure) are closer together. The pressure gradient is *steeper* there. This is analogous to the contour lines on a hiking map. Near the surface the winds tend to blow in toward the low as well.

Vancouver Island is hidden by jumbled text on that chart but you can see the important details. As is common with the fall storms (mid-latitude or extra-tropical cyclones) that reach us at UVic the winds tend to come from the south or southeast. Winds from this direction can be impeded by the Olympic mountains but can also blow undisturbed across the relatively wide Salish Sea. This can build large short-period waves that strike the south and east coasts of Greater Victoria.

In the end the local wind was not too extreme. The highest speed recorded at Trial Island (1 km south of Oak Bay, a great site away from land) was 101 km/hr. At UVic we recorded the strongest gust speeds listed in Table 1.

Station	**Speed** (km/hr)	**Elevation** (m)
UVicISC	50	47
UVicSci	56	57
UVicSngequ	69	110
TrialIsland	101	30

Table 1: Maximum wind speeds and station heights at UVic.

The last station in the table is on Sngequ House[1], the newest student residence building, and the tallest building on campus. It's nice how the three sites show the effects of friction on the wind speed. Near the ground the wind blows across and around more and more obstacles, a rougher surface. The maximum wind speed slows and the flow becomes more turbulent, there are more and more eddies at different scales and orientations. Trial island shows the strongest wind speed, even though the anemometer is lower because the ocean is smooth and flat. The *true* wind reaches closer to the surface at such a site.

[1] I haven't figured out how to render the proper name with LaTeX

I know that storms and strong winds are rare in summer and early fall at UVic. How rare are they? Figure 6 shows the frequency of

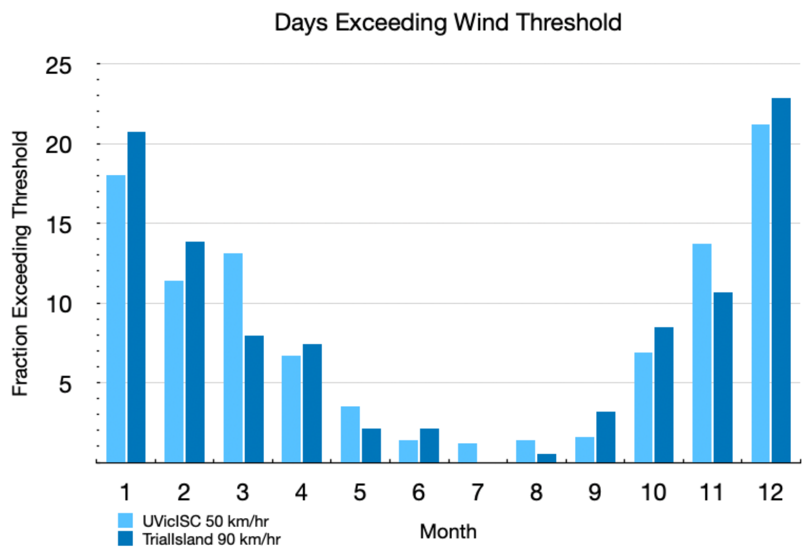

Figure 6: A figure.

occurrence of winds stronger than a minimum threshold at two sites, Trial Island with a threshold of 90 km/hr and UVicISC at 50 km/hr. I simply counted the days in each month in the record (21 years for UVic and 10 years at Trial Island) that met the test.

Strong winds are most common in December and January but increase in likelihood through the Fall months. They are quite unusual in September.

Rainfall

I still want to touch on rain. Rain is probably the most variable, from September to September, of the common weather variables we talk about. It's also very important. We rely on the rain to restore our drinking water reservoir and to end the usual Summer drought. This past year rain has been well below average in general so it's good to see some arrive.

The total rain in September at UVic was 10.4 mm. That's not nothing, but it is below the 21 year average of 19 mm. How much rain we get in a month like this depends on a lot of factors. The extreme amounts shown in 2021, for example, came mostly during two events a week apart. These may have been atmospheric river phenomena. Otherwise small daily totals are the usual.

The final Figure, 8, shows the count of days with recorded rain for each year. This year was pretty usual, but each day's amount was small. Every little bit helps.

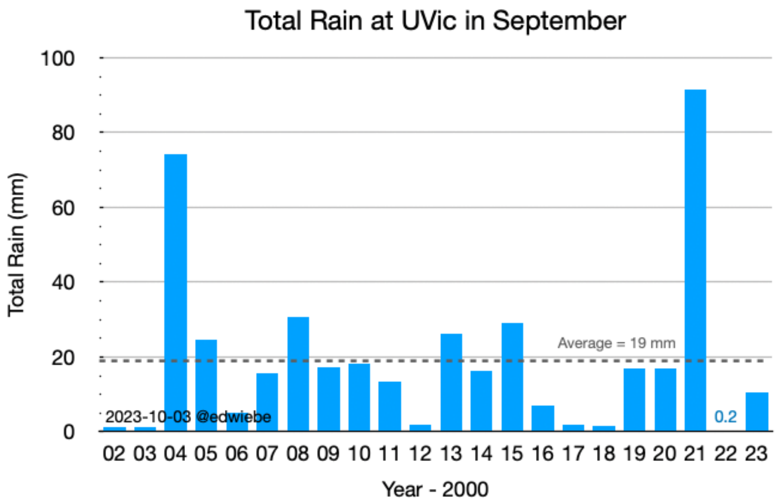

Figure 7: September rain.

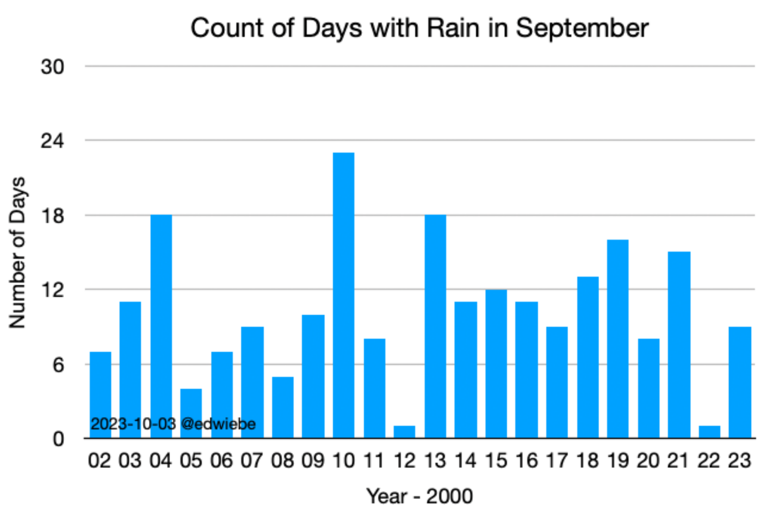

Figure 8: Number of days with rain in September at UVic.

Finally, Figure 9 is a chart showing the current drinking water reservoir level. It's usual for the level to be low in the early fall. This year it's just at the five-year low level. Whether it continues to fall, stabilizes, or rises again depends on the timing of the onset of fall storms and rain. At this point we are still confident that winter rains will arrive each year. This is likely to continue even while climate change continues to push our local climate away from the long-term patterns of the past. The reason is that at 48° N we lie in the *mid-latitude storm track*. This is a band of latitudes where the global circulation tends to generate storms and weather that drive heat and moisture, energy and momentum north (poleward), and to the east. Will this pattern continue forever? There is already evidence that the storm track is shifting poleward, especially in the North Pacific region. There's a review of the discussion and research on this topic in Catto, *et al* (2019).

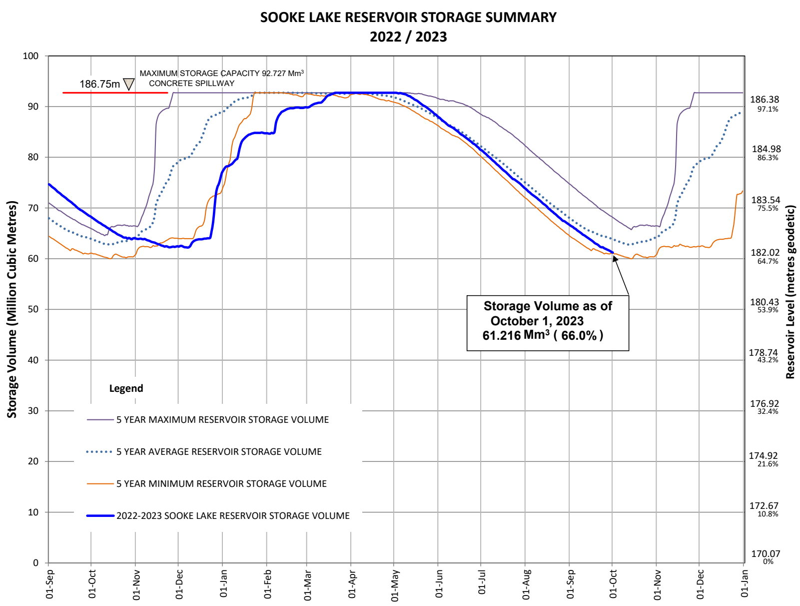

Figure 9: CRD Reservoir level.

References

Catto, J.L., Ackerley, D., Booth, J.F. *et al*. The Future of Midlatitude Cyclones. Curr Clim Change Rep 5, 407–420 (2019). `https://doi.org/10.1007/s40641-019-00149-4`