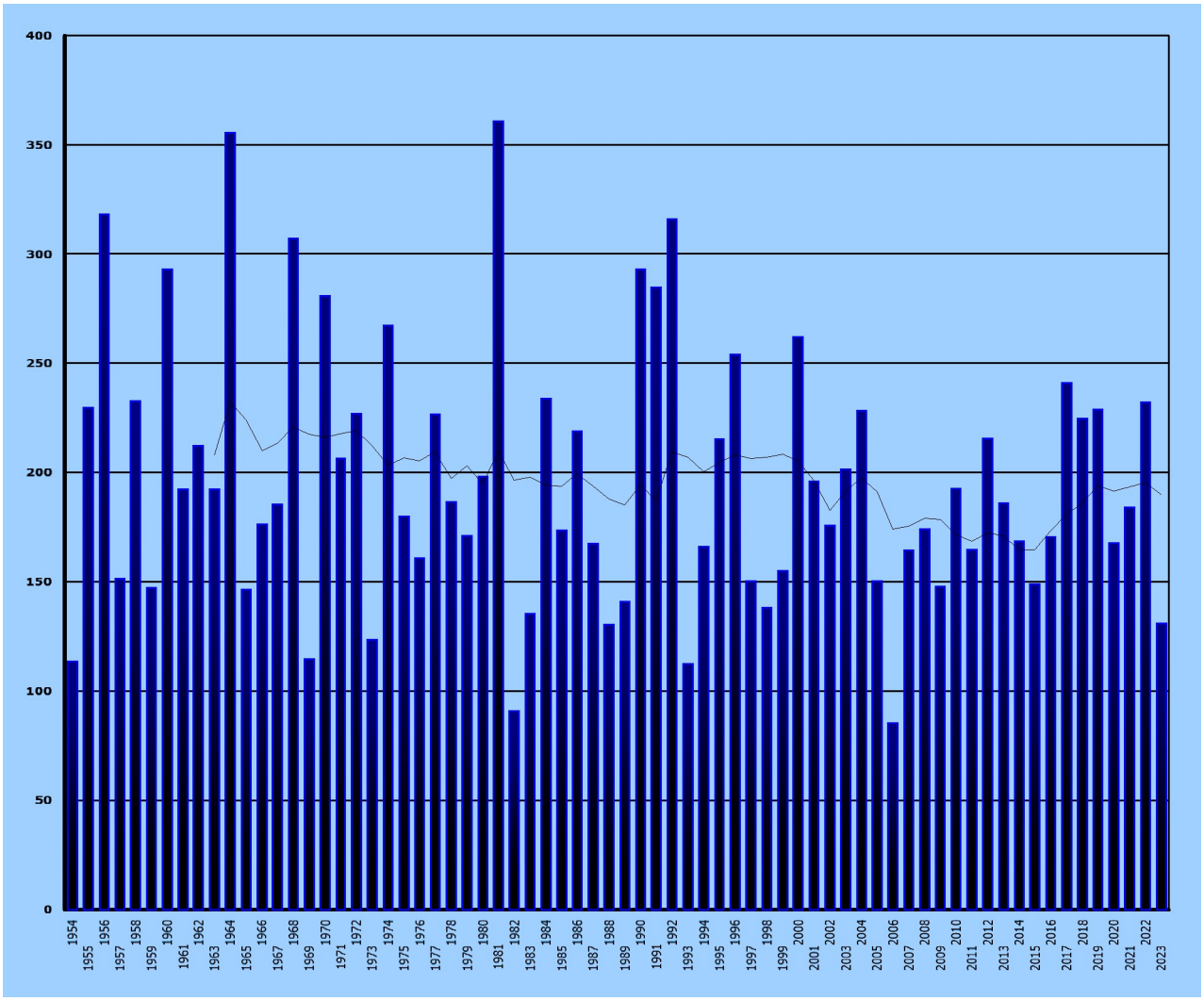
Snow worries: will climate change reduce skiing opportunities in the Snowy Mountains?

Recent reports[1] have suggested that the Australian ski season may be reduced by up to 55 days in 2050. It is already quite short. The official season is from early June (King's birthday weekend) to early October (Labour day weekend). In reality decent conditions only exist from July to early September.

Snowy Hydro, the operator of the Snowy Mountains hydro electricity system, measures snow depth in the Snowy Mountains every year. Records start in 1954. The data is published on their web site and displays the depth of snow for each month at Spencer's creek, altitude 1,800 metres, located close to the snow resorts of Perisher Blue, Charlottes Pass and Thredbo.

The maximum snow depth for each year from 1954 to 2023 at Spencer's creek is reported by the bars in the chart below, the line is a 10 year moving average.

The maximum depths recorded display a wide degree of variation. The descriptive statistics



are:

The average depth was 196.8 cm and the median was 185.7 cm. The year to year variation is quite high. Statistical measures that measure variation verify this observation. The standard deviation is 60.2 cms or 30.6 per cent of the average. The range from the highest to lowest is 275.6 cms.

Such large variations can obscure trends in the year to year numbers. Weather patterns are

complex and dependent on many factors, including El Nino events and volcanic eruptions. Snow falls depend on precipitation as well as cold air masses. Poor snowfalls are not always associated with drought conditions.

Is Australian Alpine snow decreasing?
The 10 year moving average displays three distinct phases. The first from 1961 to 1980 has it above 200 cms in almost every year, the second from 1981 to 2000 sees it hovering around 200 cms (either a bit above or below) and the third from 2001 to 2023 shows it to be quite a bit below 200 cms in every year. However, from 2016 to 2023 there was a recovery when it edged up tp 200 cm again. So yes, it has declined, but not a lot.

The big snow seasons where snow depth exceeded 300 cms were 1956, 1964, 1968, 1981 and 1992. None have occurred since 1992 and 1992 was the third "biggish season" in a row, often explained by temporary global cooling brought about by the eruption of Mount Pinatubo in the Philippines in 1991. Therefore, 26 years without a snow depth of 300 cms or more. Whereas, before then it occurred almost every 10 years. Again it suggests a decline in snowfalls, especially in the 21st Century.

Mt Pinatubo erupting in 1991, such eruptions can lead to temporary global cooling.

Table 1: Snow depths then and now

Period	1954 to 1963	2014 to 2023
Average depth	208.3	189.69
Standard deviation	64.0	38.9

The average snow depth for the most recent period (2014 - 2023) is 8.9 per cent lower than that of the earliest period. However, the variation as measured by the standard deviation from year to year is much less. Consequently snow depths have become more predictable.

So what does it all mean?
Firstly, we will be skiing for a few more years yet. The trend equation suggests that the ten year moving average of snow depths will decline by 0.67 cms a year, 6.7cms over ten years, or 67.00 cms over a century (see box below). These trend variations could be outweighed by other factors such as volcanic eruptions or other short term climatic changes. Also, the trend could change, the data only measures what happened over the last 70 years. What will happen over the next 70 may well be different. However, a decline could be abrupt as it snows at -0.5 degrees and rains at 0.5 degrees.

Also snow quality is important, colder air at temperatures below -5 degrees produces dryer crisper snow that is easier to ski/board on. "Wetter" snow produced by snow falls at around 0 degrees tends to be heavier and more difficult to transit.

Secondly, does it provide evidence of the Greenhouse effect and Global warming? It is certainly consistent with global warming predictions and the recorded higher world temperatures experienced in the 21st Century

Thirdly, it should not be forgotten that Australia's alpine areas are marginal. With low latitudes and altitudes any snow is almost fortuitous. It would not take much variation in climate to have a large adverse impact.

Getting deeper into statistical analysis Is there a real trend?
The bars in the chart may display a trend but it is hard to discern. However the 10 year moving average can iron out the large year to year variations. Is their a discernable trend? Yes, it can be identified in the chart but is it statistically significant?
A regression equation was calculated using time as the independent variable and the 10 year moving average (for each year) as the dependent variable provided the following equation:

Trend = 217.3 - 0.67 Year. R square = 0.58
(0.078)

t test of coefficient = -8.957 (it needs to greater than 1.96 to be significant at 5% level)

Both the R square and the t test suggest that there is a highly significant trend, the snow depth is declining (on average) by 0.85 cms a year.

In statistics, the **standard deviation** is a measure that is used to quantify the amount of variation or dispersion of a set of data values. A low standard deviation indicates that the data points tend to be close to the mean of the set, while a high standard deviation indicates that the data points are spread out over a wider range of values.

Terry Giesecke
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1. according to a report from the Australian National University and climate advocacy group Protect Our Winters