Saltbush Solar Activity Watch

December 2018

The first connection between solar activity and climate was made by the Greek astronomer Meton in the 5th century BC. Meton had noticed a correlation between higher sunspot activity and higher rainfall. The correlation was rediscovered in the 19th century by William Jevons who compared solar data with historic wheat prices. The correlation between solar activity and the wheat market in medieval Europe was confirmed by two Israeli researchers in 2004. The most recent affirmation is Nir Shaviv's testimony to the German Parliament in November 2018. Exhibit one is his graph of the rate of change of sea level with the change in the solar constant:

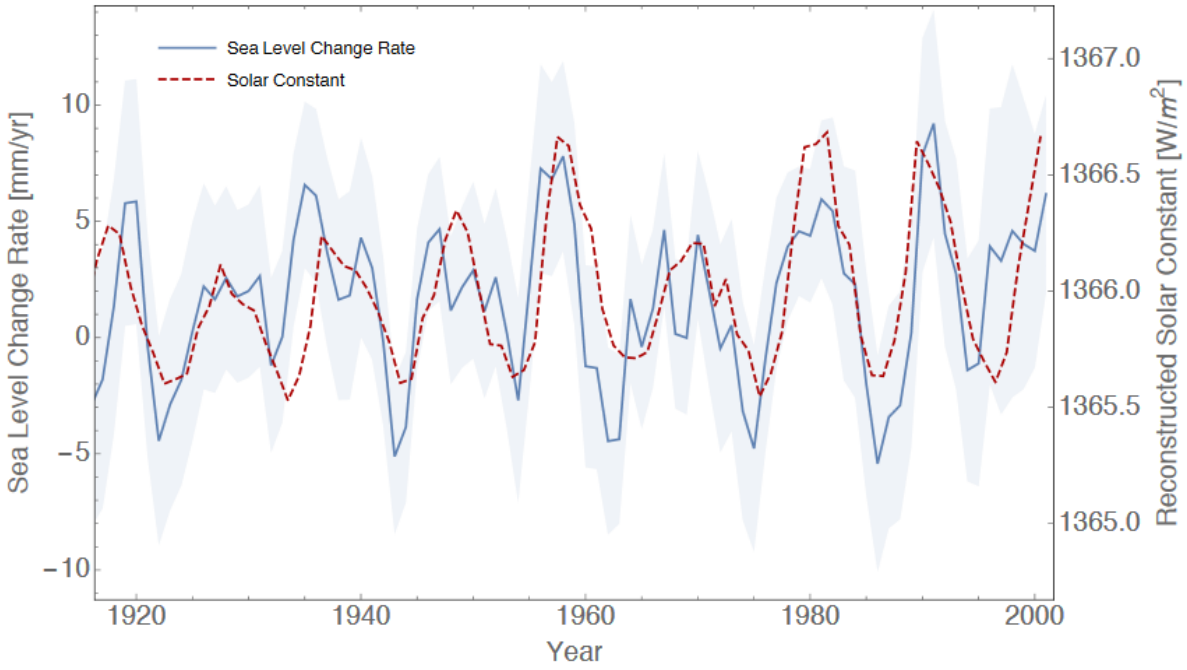

Figure 1: Quantifying the solar forcing

The control of climate by solar activity has a scientific pedigree going back over two and half thousand years. From here it is just a case of explaining mechanisms, backtesting relationships and making predictions of solar activity levels.

One of the bigger mechanisms, elucidated by the Danish researcher Henrik Svensmark, is the stronger solar wind during high solar activity pushing galactic cosmic rays away from the inner planets of the solar system. That means fewer neutrons reaching the lower troposphere and thus fewer nucleation sites for cloud droplets. In turn less cloud means more solar radiation reaches the Earth's surface instead of being reflected back into space.

One of the best bits of evidence for Svensmark's theory is the ^{10}Be from Antarctic ice cores:

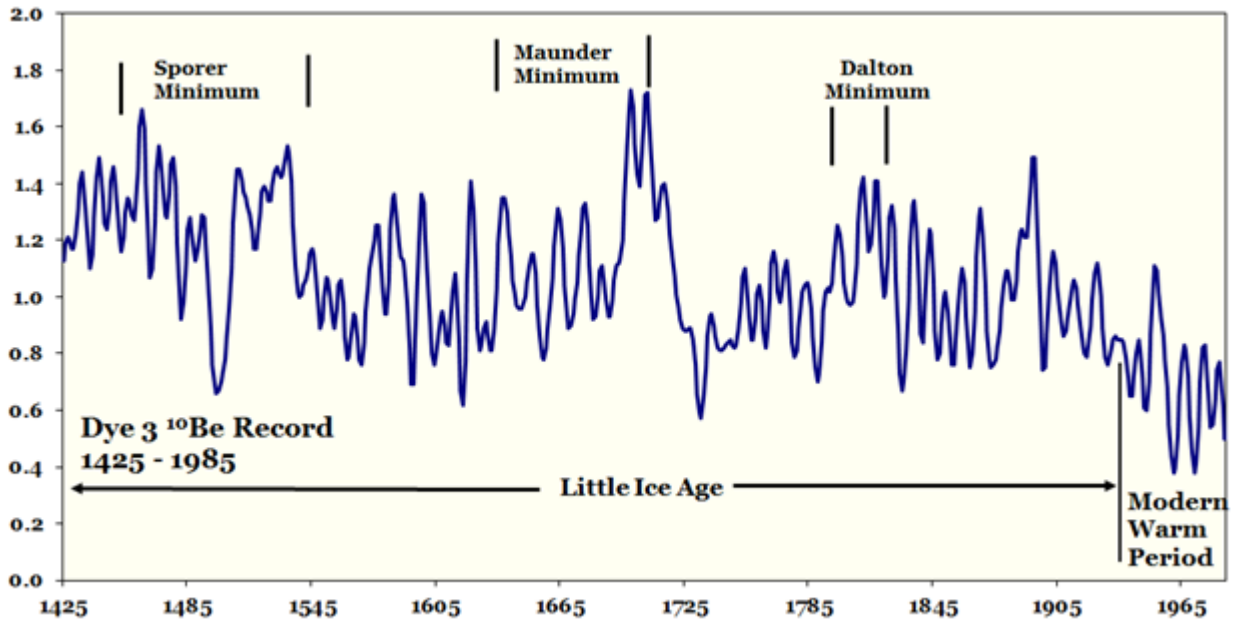

Figure 2: Dye 3 Be10 record 1424 to 1985

The upward spikes correlate with the cold periods over the last 600 years. The spike at the Maunder Minimum was particularly brutal, killing off 30% of the populations of some of the Baltic states. As with a lot of natural systems, the reality is a lot more complex. For example this article explains the contribution of length of day (LOD) and notes a four year lag from changes in LOD to changes in sea surface temperature.

As the low ^{10}Be figures for the second half of the 20th century in Figure 2 attest, the mild warming of the planet that got some people hot and bothered was due to higher solar activity. That period of higher solar activity ended in 2005 as shown by a sharp break in some solar activity parameters. One of the best of these is the aa Index which has been measured since 1868:

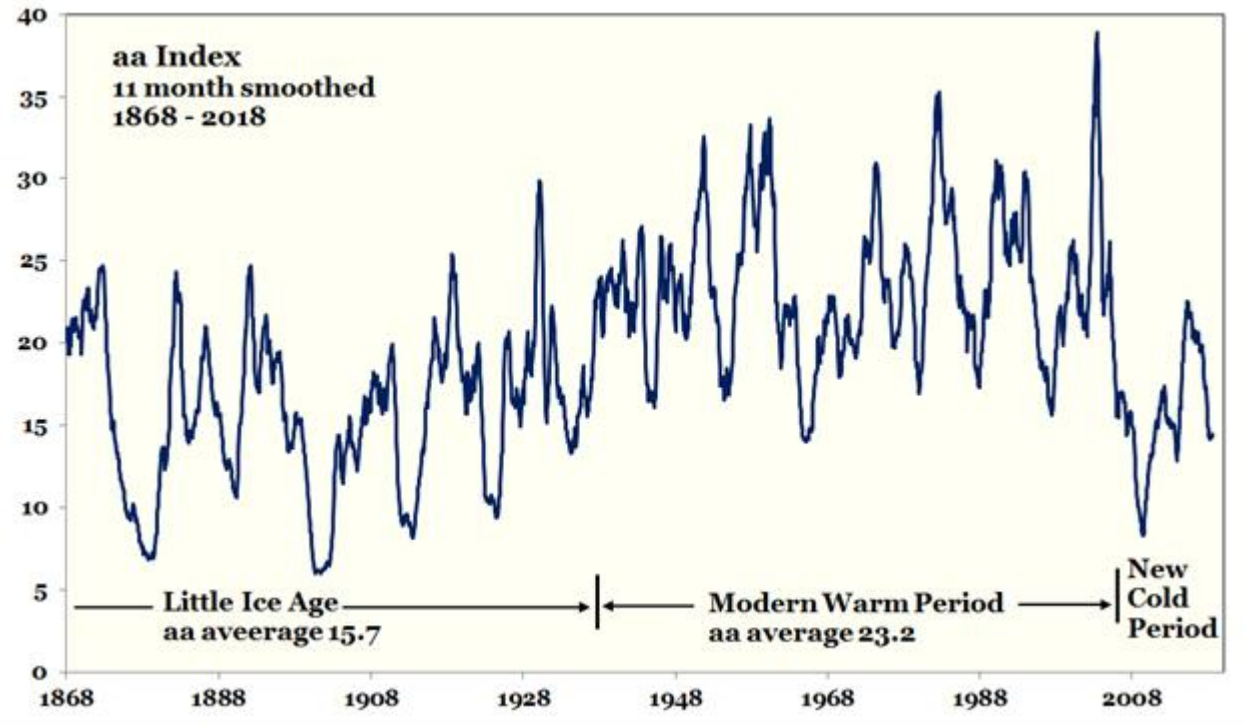

Figure 3: aa Index 1868 – 2018

Figure 3 shows clear breaks between levels and the type of activity from the Little Ice Age to the Modern Warm Period. We are now 12 years into the New Cold Period. The beginning and end of the Modern Warm Period are confirmed by plotting departure of the aa Index from its long term average as shown in Figure 4:

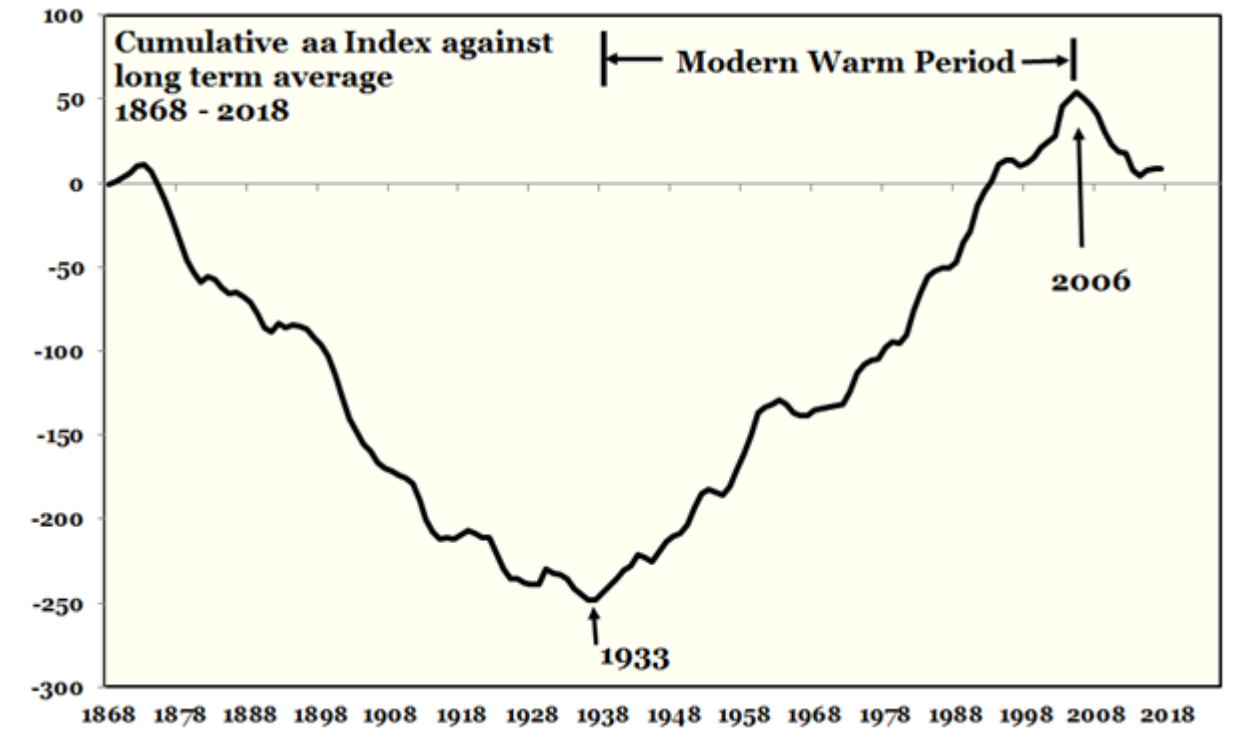

Figure 4: Cumulative aa Index against the long term average 1868 – 2018

We have established where we have been. So where are we headed? The data to date suggests the Sun is heading back to 19th century-like levels of solar activity. We are now in the last year of Solar Cycle 24 which was much smaller in amplitude than the last few cycles of the Modern Warm Period:

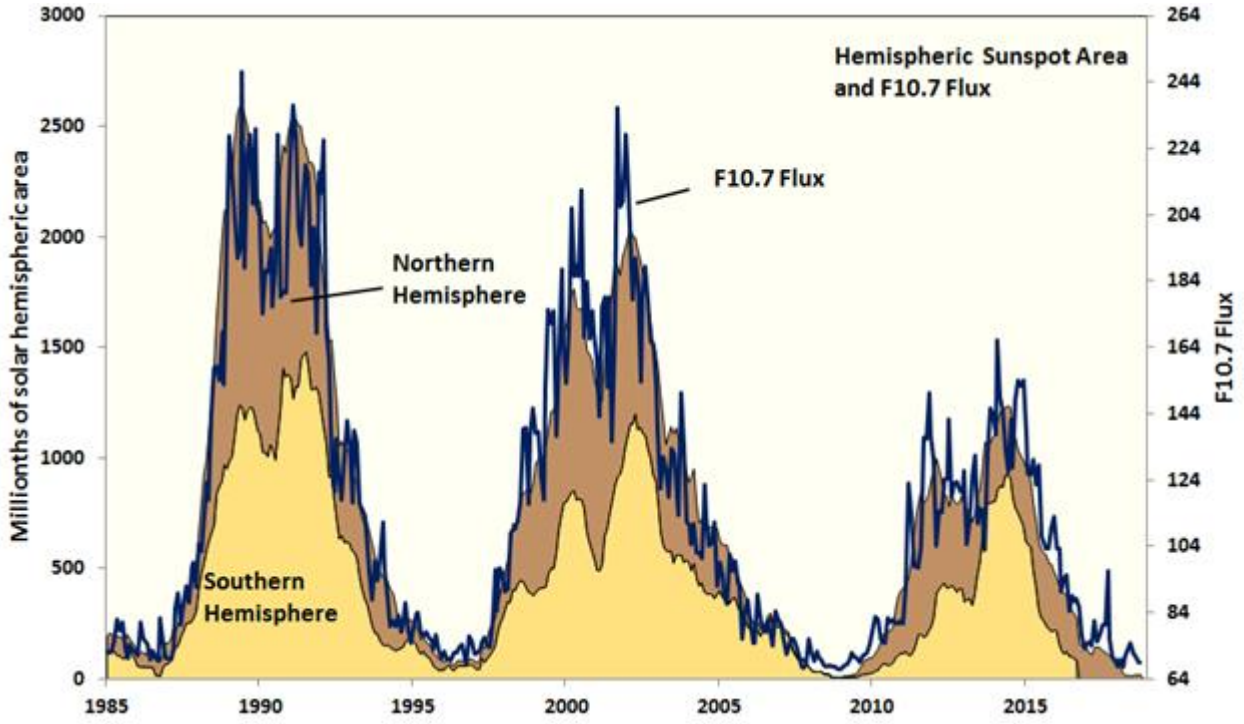

Figure 5: Hemispheric sunspot area and F10.7 flux 1985 – 2018

Sunspot area equates to the F10.7 flux. The solar hemispheres have different trends in activity which can hold for decades.

It is said that a solar cycle isn't over until the heliospheric current sheet tilt angle flattens. That data, shown in Figure 6 following, points to September 2019 being the month of minimum between Solar Cycles 24 and 25:

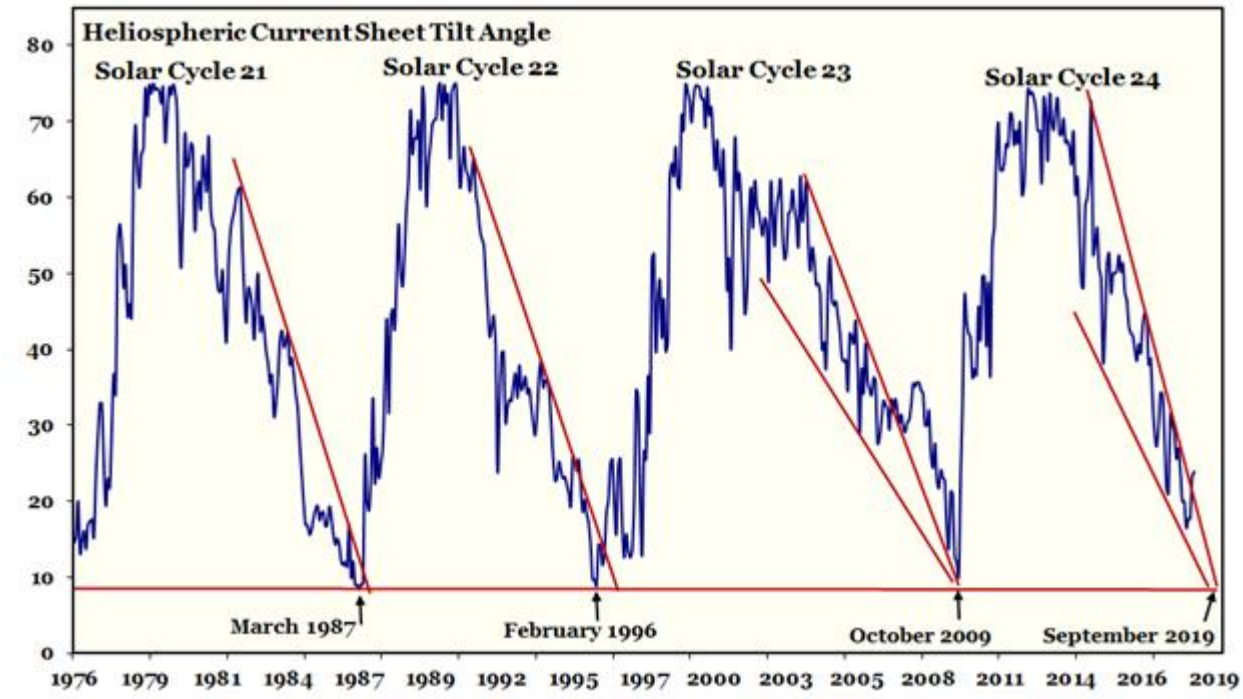

Figure 6: Heliospheric Current Sheet Tilt Angle 1976 – 2018

As we are less than a year out from minimum, estimating the amplitude of Solar Cycle 25 from the solar polar field strength can be made with a lot of confidence:

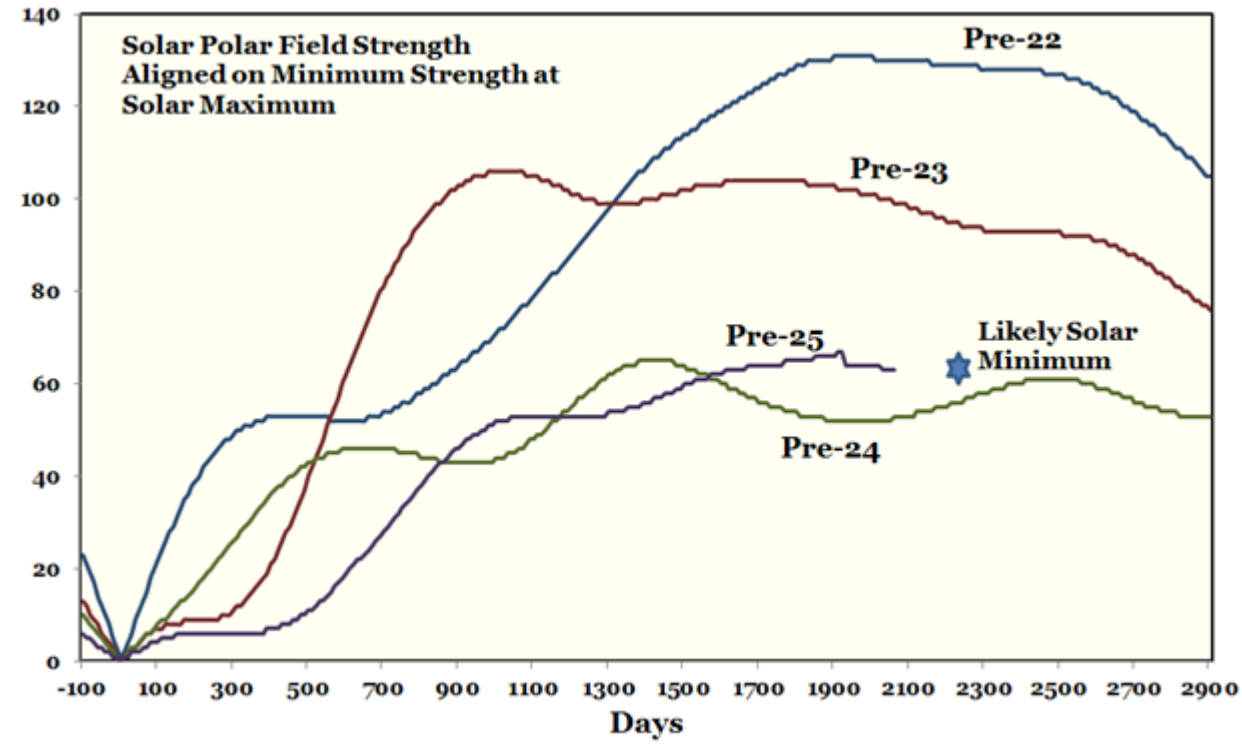

Figure 7: Solar Polar Field aligned on minimum for Solar Cycles 22 – 25

The amplitude of the solar polar field strength at solar minimum is predictive of the amplitude of the next solar cycle. After starting out weak, this activity has been tracking that of the lead up to Solar Cycle 24 and it looks like 25's amplitude will be

much the same as 24's. But beyond that? There is no indication that we are headed for a major low in solar activity. It looks more like a return to the sort of activity from the end of the Dalton Minimum in 1823 to the beginning of the Modern Warm Period in 1933. Climate will become less boring; there will be more late Spring frosts to play havoc with emergent crops in the mid-latitudes.

Where to from here? There are a couple of known unknowns which would be good to sort out. First up, what causes the hemispheres of the Sun to have different multidecadal forcings? As shown in Figure 8, the peaks of activity for the northern and southern solar hemispheres plot on straight lines:

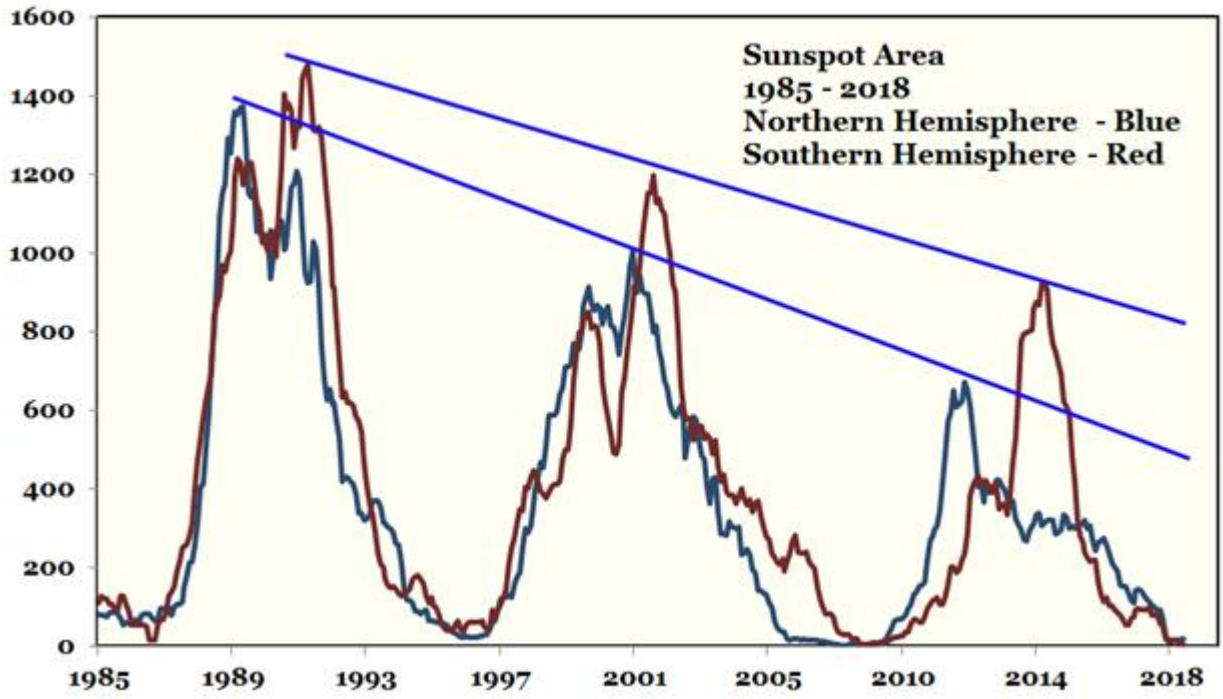

Figure 8: Solar hemispheric sunspot area 1985 – 2018

For a sloppy old ball of plasma, the Sun shows a lot of discipline. Activity for both hemispheres has bounced off their respective blue lines above which implies some multidecadal forcing. A similar thing happened for four solar cycles from the late 19th century:

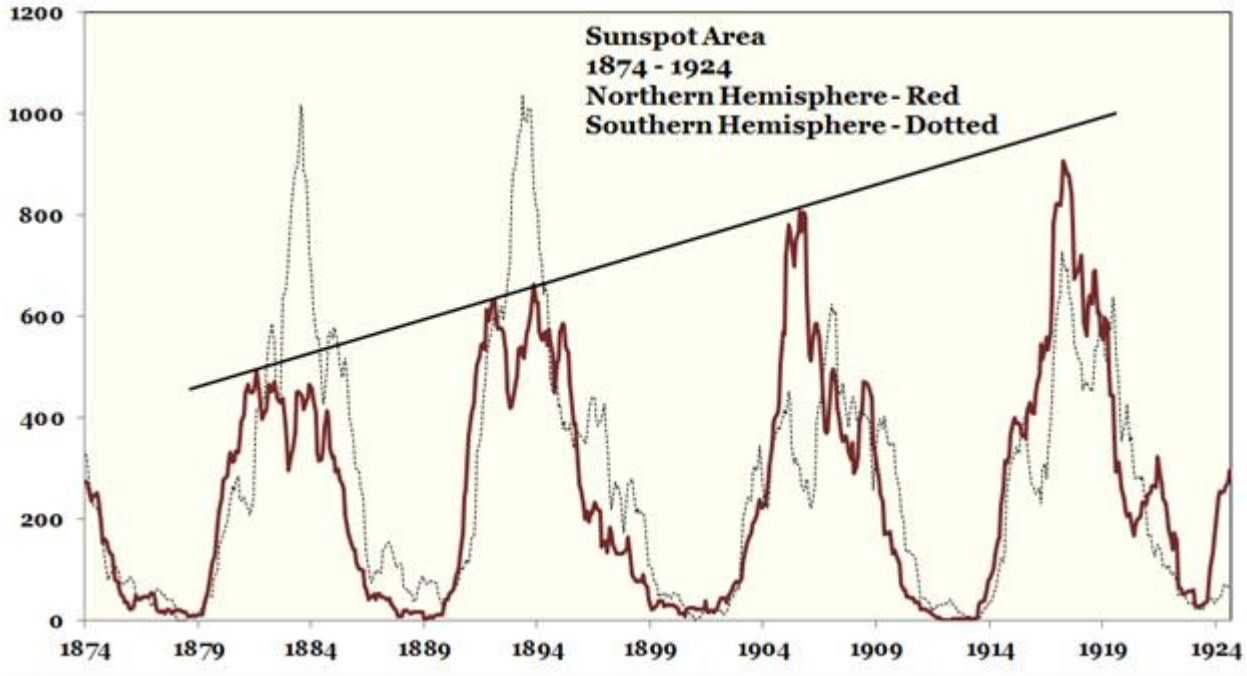

Figure 9: Sunspot Area 1874 – 1924

Similarly to Figure 8, there was a four decade period from the late 19th century during which the northern solar hemisphere sunspot area was driven by a consistent multidecadal forcing. The likely cause of the solar hemispheres having different drivers is likely to be the fact that the major gas planets' orbital inclinations are different, 1.3° for Jupiter and 2.5° for Saturn.

Secondly there have been a few major studies of cyclicities in tree rings and sediment layers. For example in 1979 U.S. researchers Leona Libby and Louis Pandolfi used tree ring data from Kings Canyon to make a prediction that the climate would warm to the year 2000 and then become much cooler after that. Almost 30 years later Finnish forestry researchers produced this graphic:

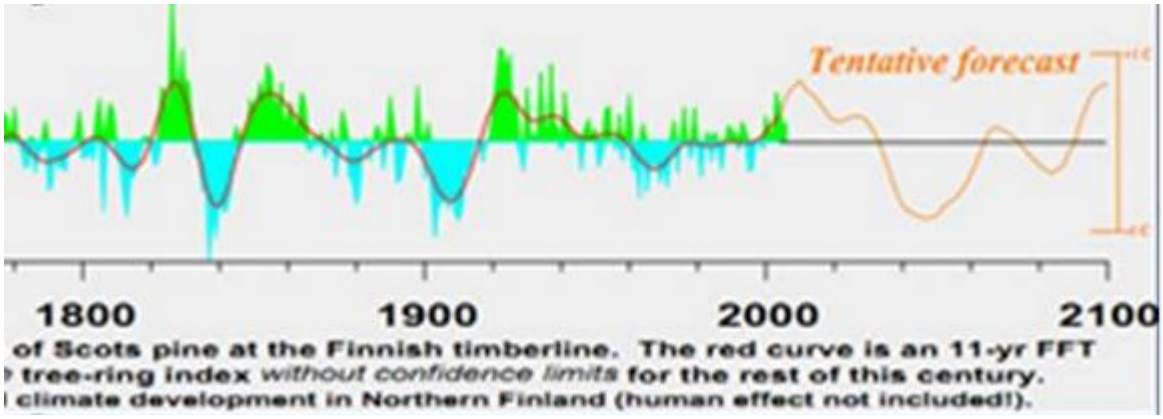

Figure 10: Finnish climate prediction based on Scots pine data

The tree ring readings of the Finnish foresters are predicting a large decline in temperature bottoming out in about 2045. The downturn you see on the right hand side of the graph is larger than any other in the last 500 years. A cold period longer

and deeper than any other in the last 500 years would have lots of real world consequences. That would be worth following up on, wouldn't it?

Lastly, did carbon dioxide make any contribution to the pleasant, mild and much-appreciated warming of the second half of the 20th century. It very likely did according to our understanding of the logarithmic heating effect of carbon dioxide:

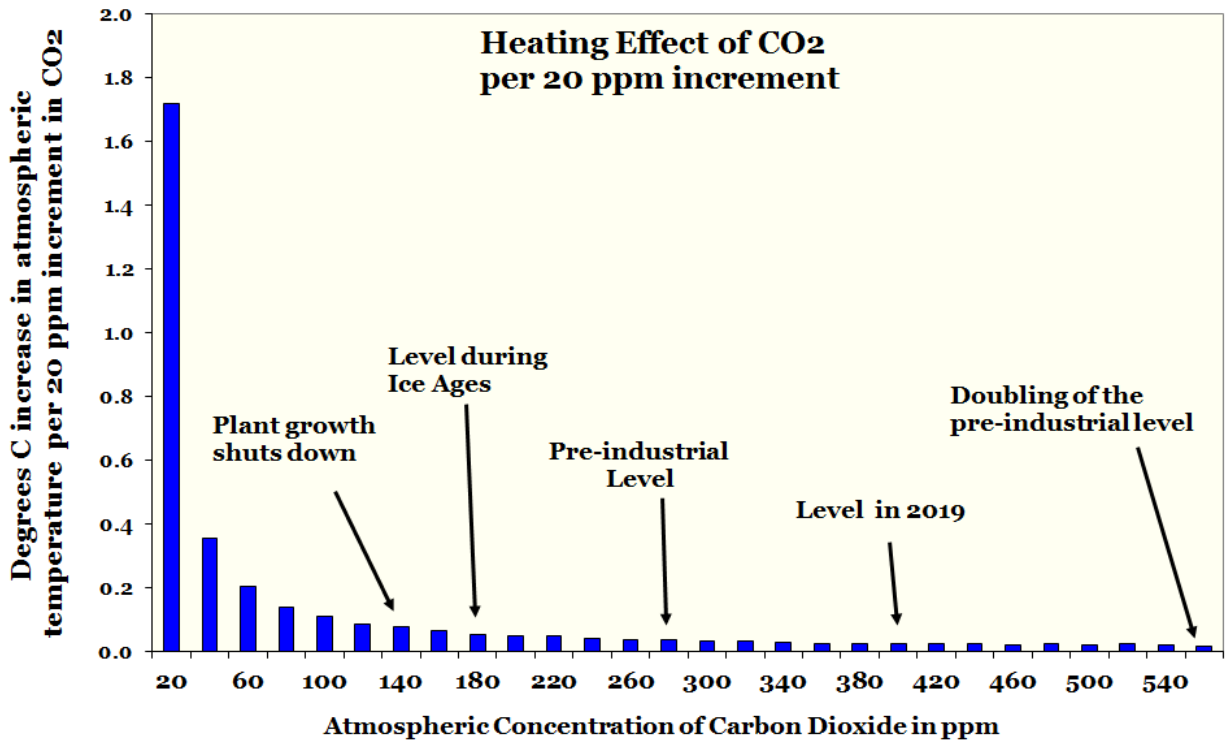

Figure 11: Logarithmic heating effect of carbon dioxide

The 100 ppm of carbon dioxide added to the atmosphere since 1950 would have increased the global temperature by 0.1° C. We are on trend to add another 100 ppm to the atmosphere over the next fifty years which will bring with it a 0.1° C increase in temperature. This will not be enough to offset the solar-driven decline in temperature coming.

David Archibald is the author of *American Gripen: The Solution to the F-35 Nightmare*