

Piazzzi Smyth and the Solar Constant

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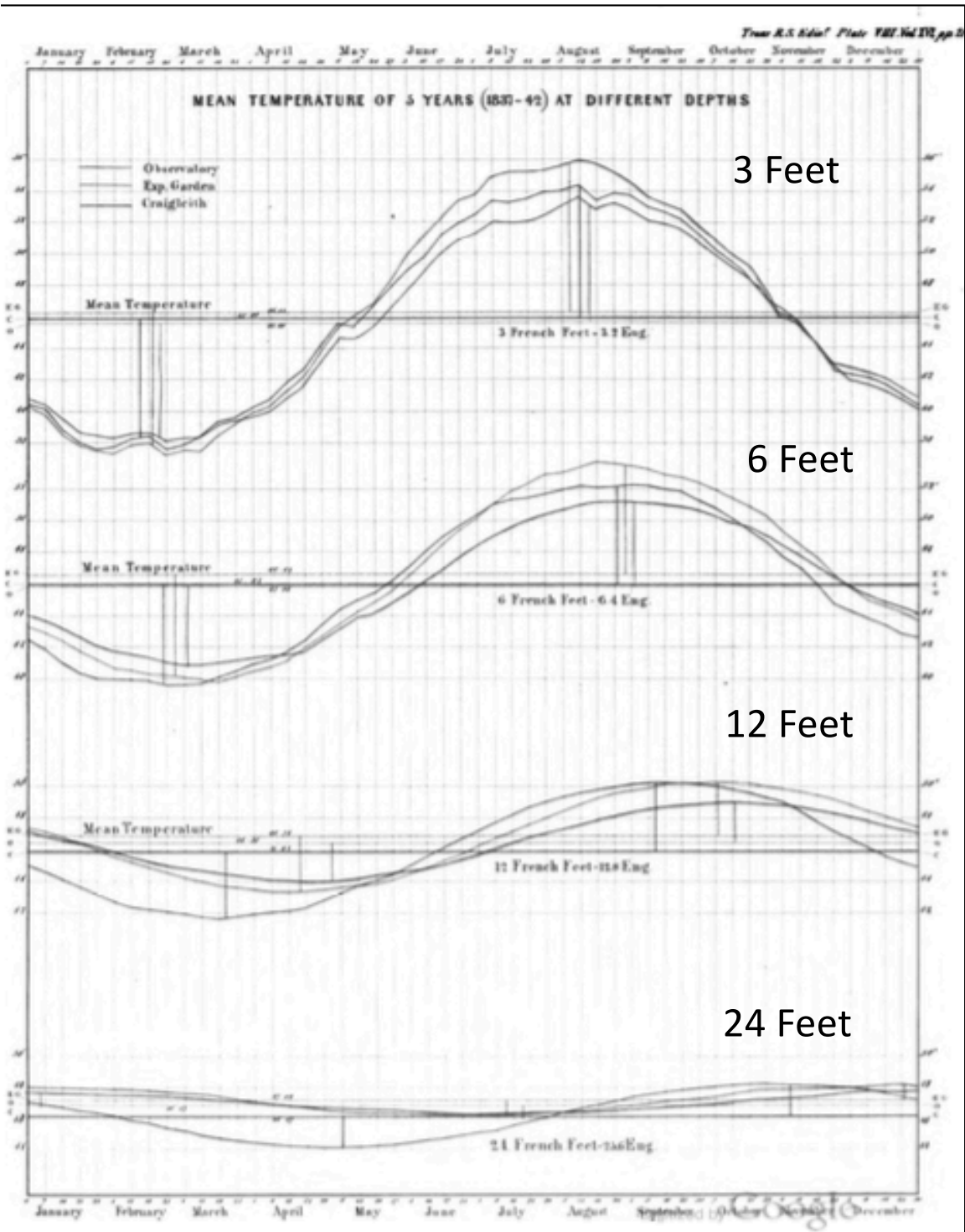
- Solar background information
- The Calton Hill “Rock Thermometers”
- Development of Piazzzi Smyth’s ideas
- Sun/climate relationships in the modern era

Herschel and the IR, AD 1800



The Calton Hill “Rock Thermometers”

- One of three sets of very long thermometers, set in the porphyry rock of Calton Hill, by Prof. J. D. Forbes (University of Edinburgh).
- The Calton Hill measurements continued for many years, beginning prior to Schwabe’s discovery.
- Such experimental thermometers were common enough, and permitted the study of depth variations on different time scales (e.g., diurnal and annual).

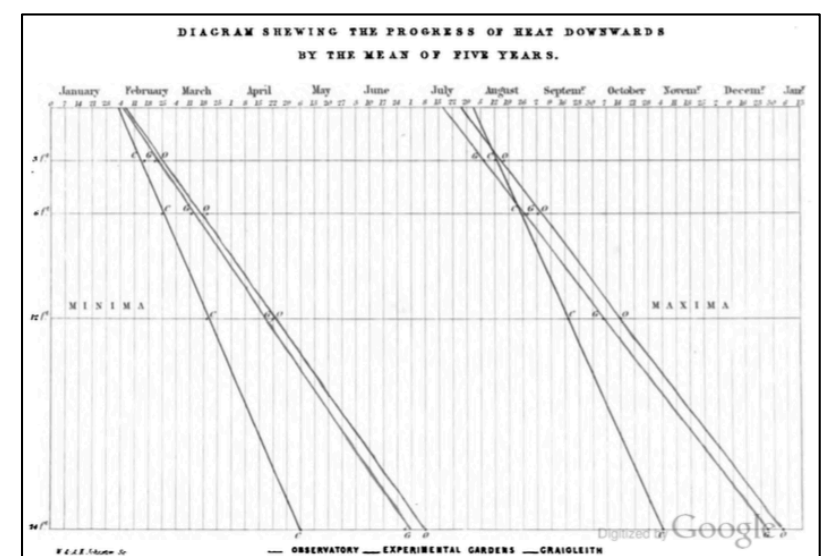


“Account of Some Experiments on the Temperature of the Earth”

Forbes, J.D., Trans. RSE XVI, II (1846)

- Three sites intercompared.
- Note use of “French feet” and Fraunhofer’s temperature scale.
- Rather illegible Victorian graphics.

Below: the annual heat wave into the interior depends upon the character of the soil.



CPS: Let's use these data to observe variations of the “solar constant”

- In modern parlance, the solar constant is the total solar irradiance (TSI): the integrated energy flux from the Sun incident upon the Earth, normalized to 1 AU.
- Calton Hill itself, with its massive thermal inertia, could serve as a low-pass filter of the solar variability; the deepest thermometers would show the longest time scales.
- It is not clear whether a quantitative analysis of the conversion ever was attempted.

Note on the Constancy of Solar Radiation.
 By Professor C. Piazzi Smyth.

MNRAS 16, 220, 1856

3-foot thermometer has its maximum in August.				
6	—	—	—	September.
12	—	—	—	October.
24	—	—	—	December.

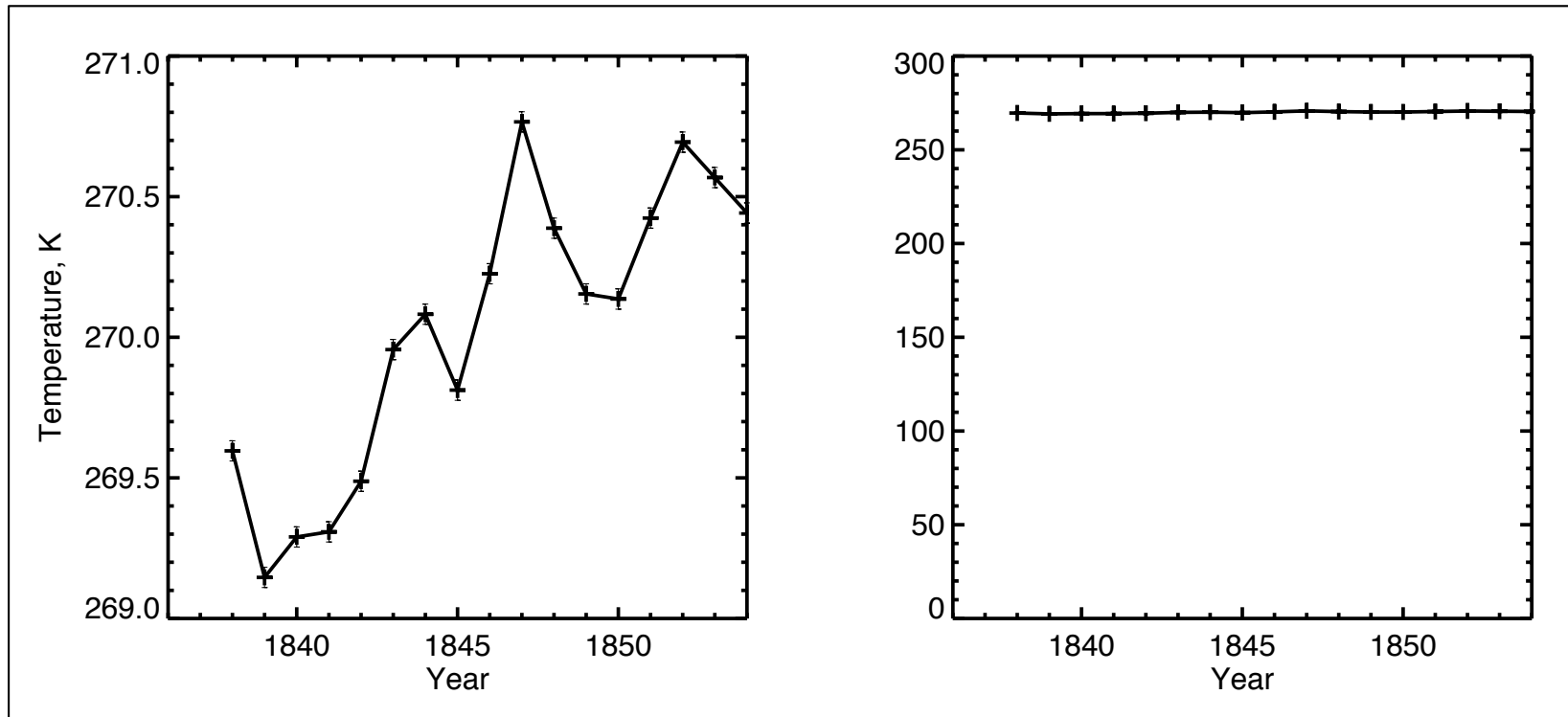
3-foot thermometer, annual range, 15°				
6	—	—	—	9·8
12	—	—	—	4·6
24	—	—	—	1·2

t_4 ,	3-foot thermometer	..	46·27
t_3 ,	6 — —	..	46·55
t_2 ,	12 — —	..	46·94
t_1 ,	24 — —	..	47·24

How good were the data?

- For the first 17 years, the RMS fluctuation of annual means was 0.3 K, (~ 0.15 K for random error).
- For comparison, global warming gets serious at 1 K.
- As an example of stellar photometry (the first?) this corresponds to about 0.003 magnitudes – very good even up to the invention of CCDs and satellites.
- A reference thermometer, checked at its freezing point over 9 years, drifted no more than 0.02 F. The thermometer data were quite redundant.

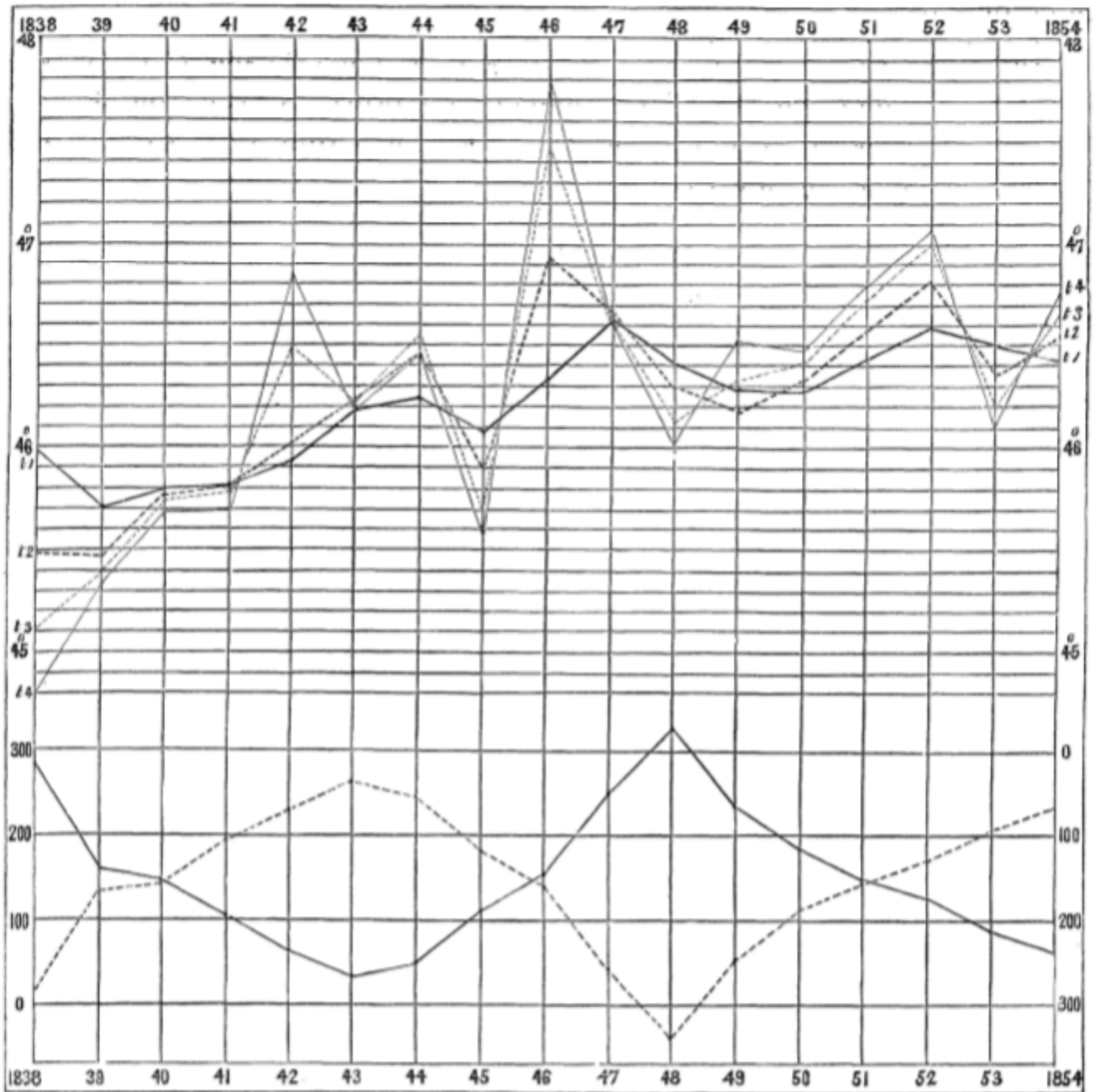
How good was the pyrliometry?



- These are 17 years of Calton Hill data.
- The trend is about 0.03% per year, increasing.
- There is no suggestion of an 11-year wave.

Can the Earth be used as a low-pass filter for input on long time scales?

- The Calton Hill data had extended for many years, showing great stability.
- The orderly progress of the annual wave nicely reflected the effects expected from thermal inertia.
- The data confirmed the presence of an internal heat source, well accepted at this time, competing with the solar influence.
- Sunspot counts (“German sources”) were now available for comparison.



Temperatures

Spots (+-)

The Sun, CPS, and the Weather

- “Note on the Constancy of Solar Radiation” (1856-57)
- “On supra-annual Cycles of Temperature in the Earth's Surface-crust” (1870)
- “Sun-Spots and the Weather” (1879), mostly a diatribe in favor of an Indian observatory
- “Recent Scottish Meteorology Compared with Simultaneous Sun-Spot Cycles” (1989)

CPS 1856 opinions

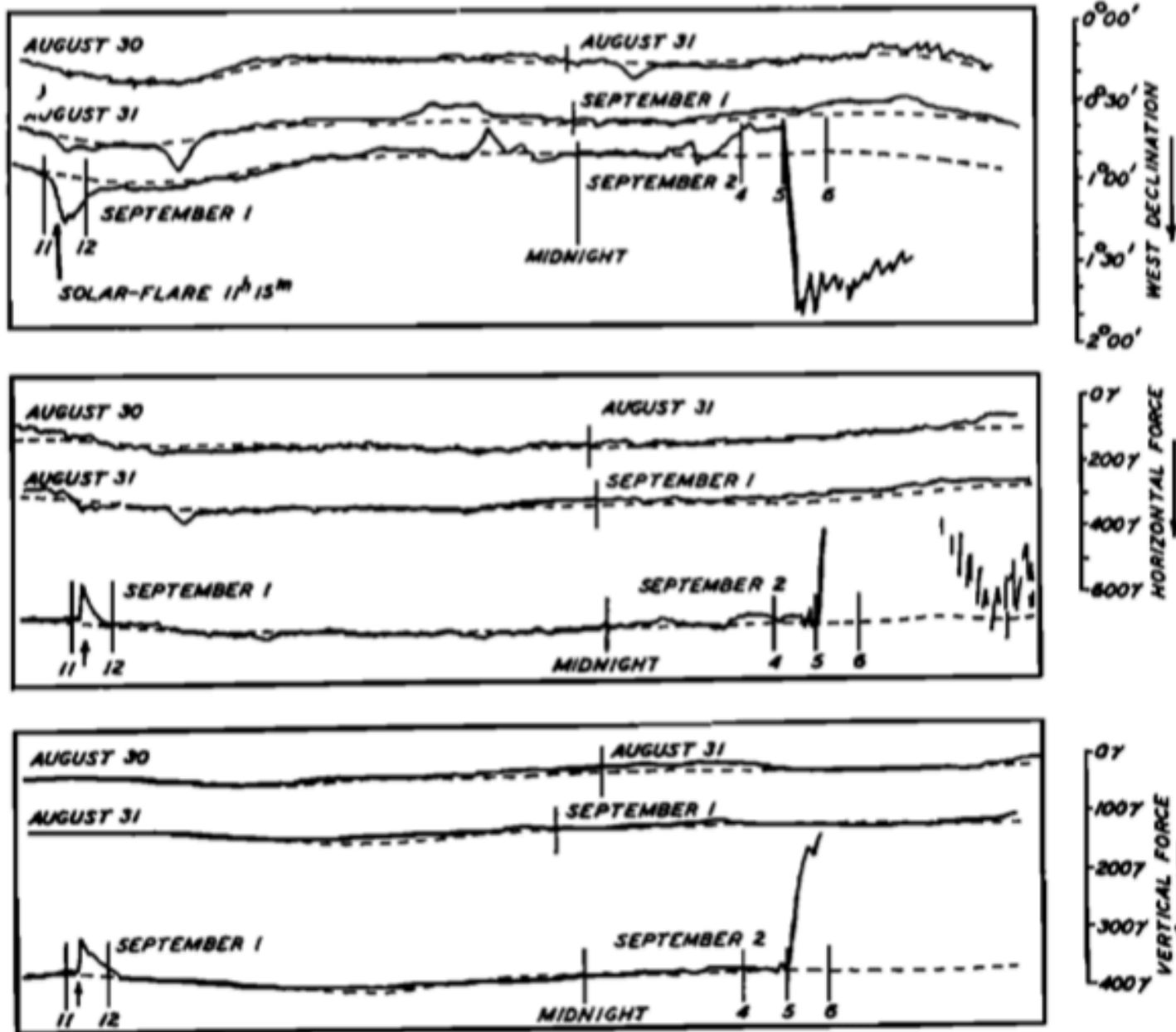
If, then, we can depend on our observations being strictly cleared of every instrumental and terrestrial cause of disturbance which can logically affect their accuracy, we have at once an indication of our Sun being amongst the number of variable stars. Can we, then, depend on them to this extent? The only possible room that I can see for doubt is the

Unfortunately, there *was* other room for doubt...

Now something like this whole sequence of effects has just been experienced in Madeira, all in the course of this week, subsequent to the restored energy of sun-spot manifestation and the earth-answering electric cloud of last Sunday, as I wrote to you next day.

Yes – a magnetic “crochet” had appeared at the time of the Carrington flare.

The Carrington flare, geomagnetically



CPS 1881 opinions

thermometer observations on the Calton Hill. That is to say, that a certain eleven-year heat-wave shown by those thermometers coincided with, not the *maximum*, but the *minimum* spotted state of the sun ; subject however to what the lecturer termed “a slight,” but in reality a two or three year “lagging behind” the visible solar phenomenon.

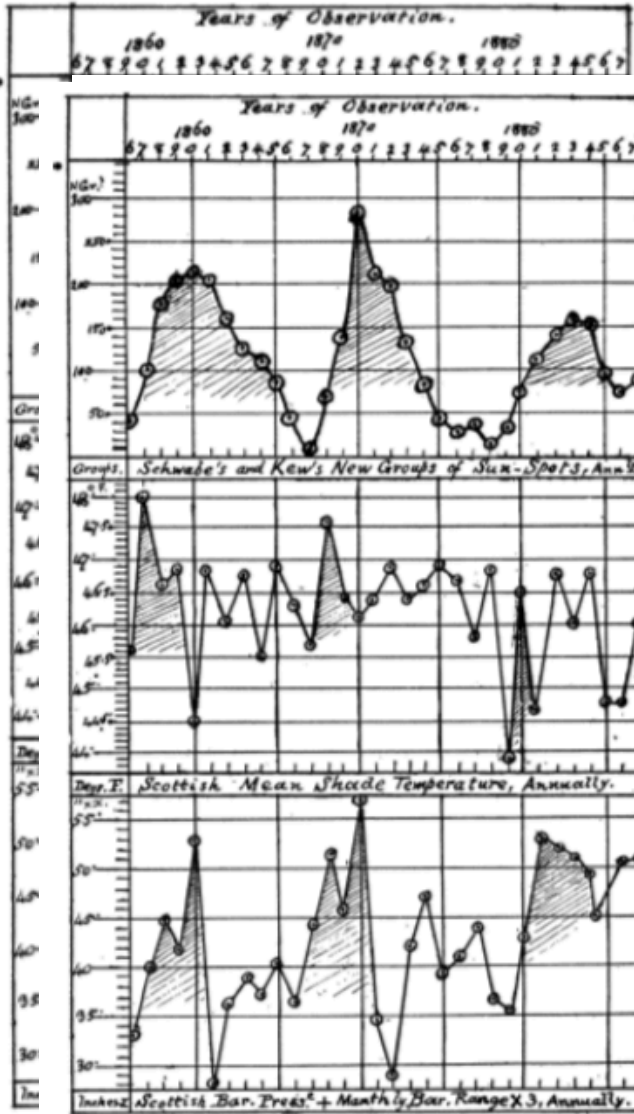
Yes – for the Sun, bolometric maximum is at sunspot minimum.

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CPS 1889 (Scottish Data)

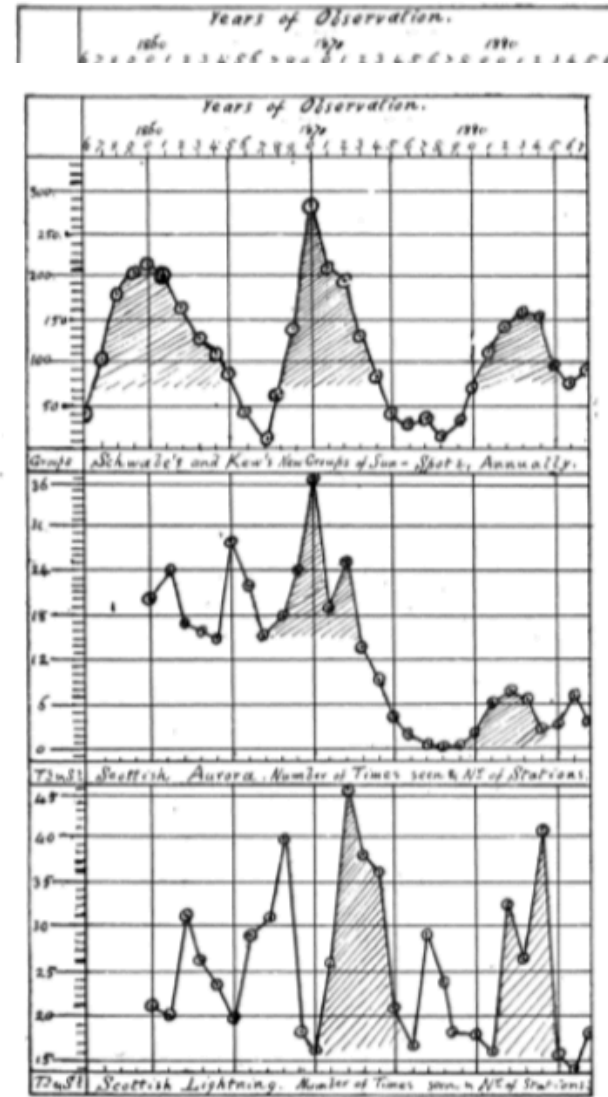
Sunspots



Temperature

Pressure

Temperature, pressure



Sunspots

Aurora

Lightning

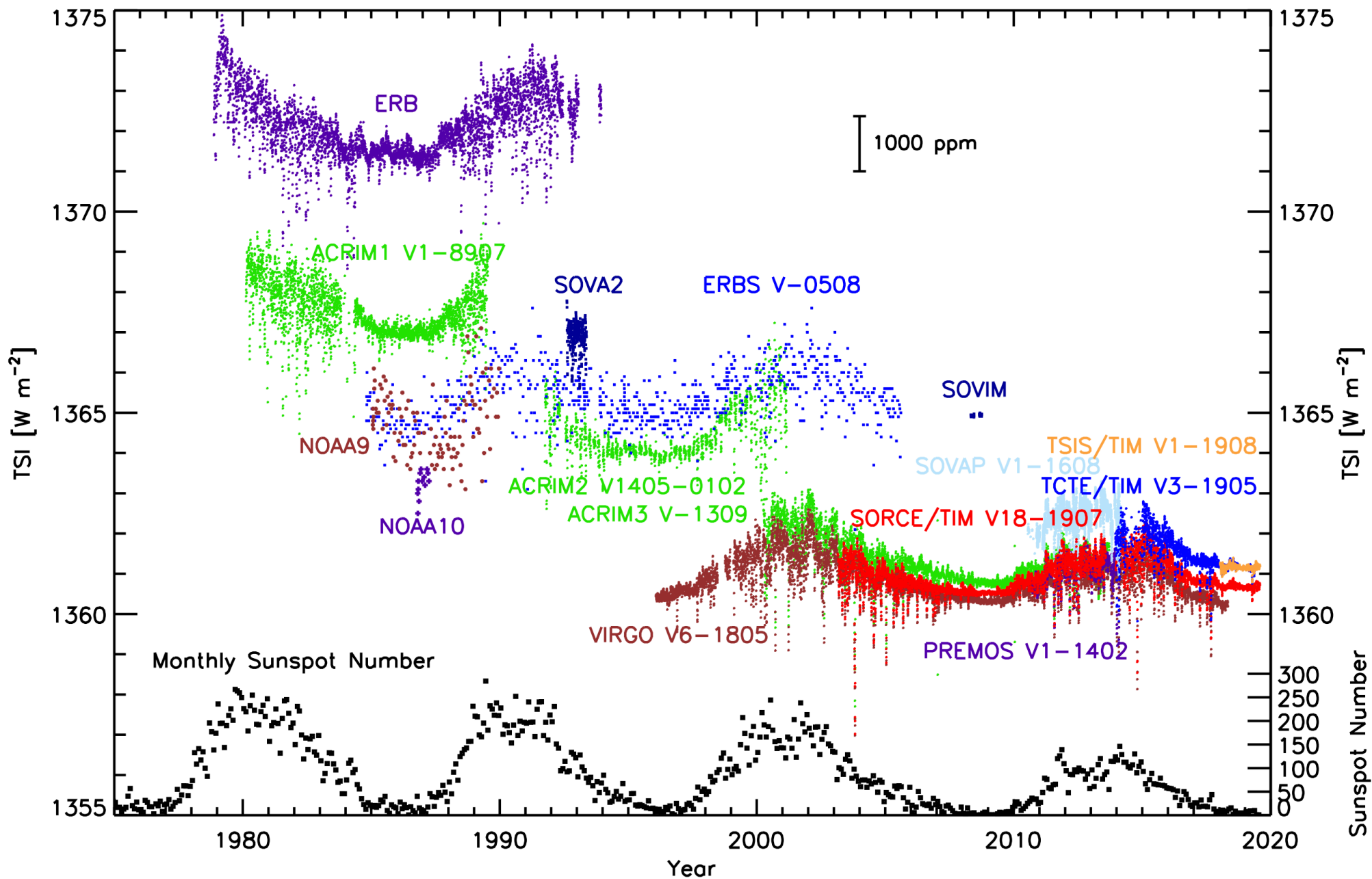
Aurora, lightning

CPS 1889 opinions

monometers. Also that the chief manifestations of terrestrial air-temperature were by no means simultaneous with the greatest tabulated areas of sun-spots; but were, on the contrary, singularly coincident with something that rapidly took place in the sun, during the first or second year only, or near the very beginning of each new eleven-year cycle of spot-making and growing; and testifying to a violent variation of the solar radiating energy then taking place.

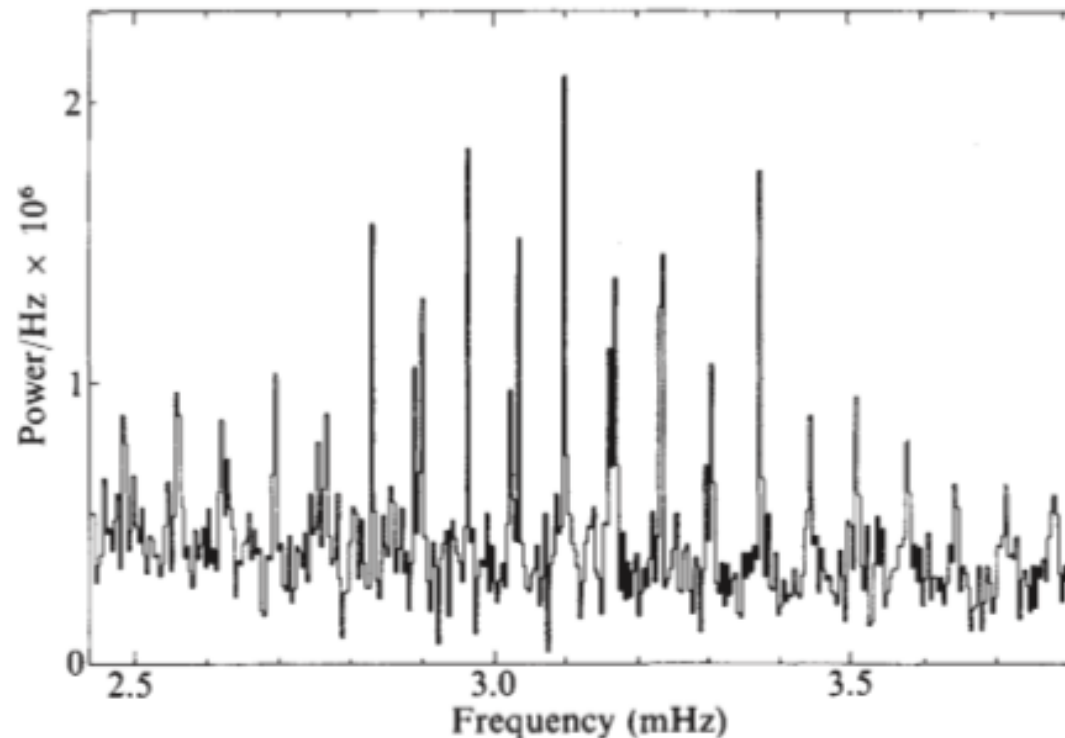
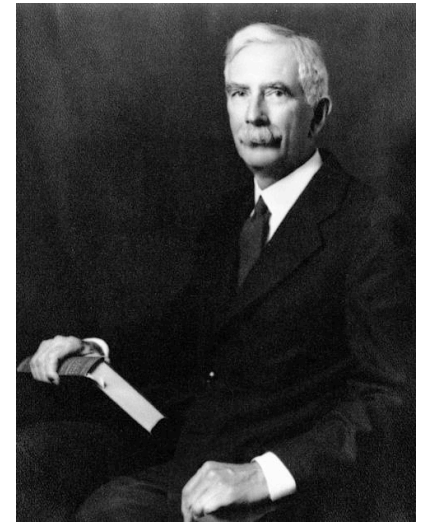
Viewed optimistically, this suggests that CPS was seeking alternatives, presumably in his retirement...

Total Solar Irradiance Data Record

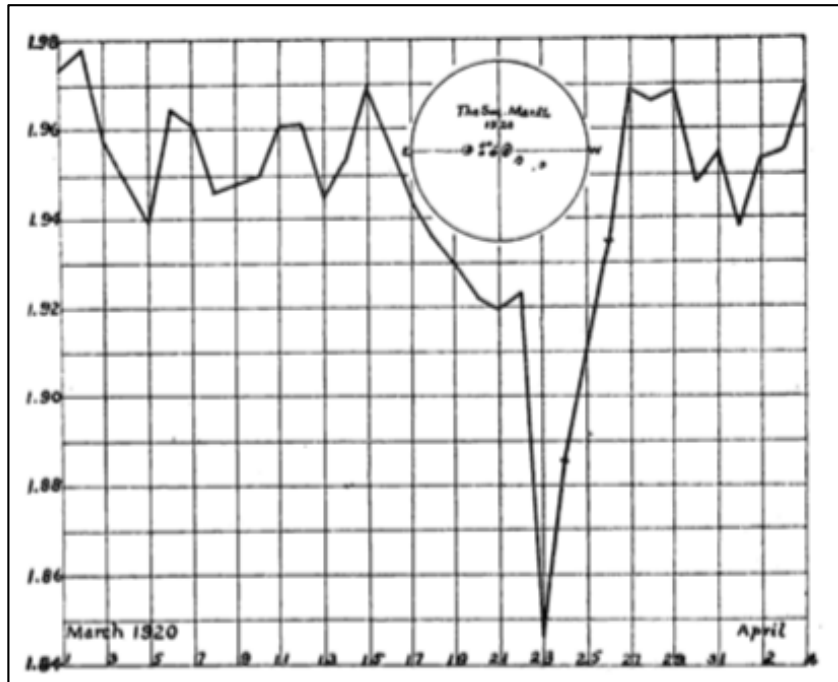


The Aftermath

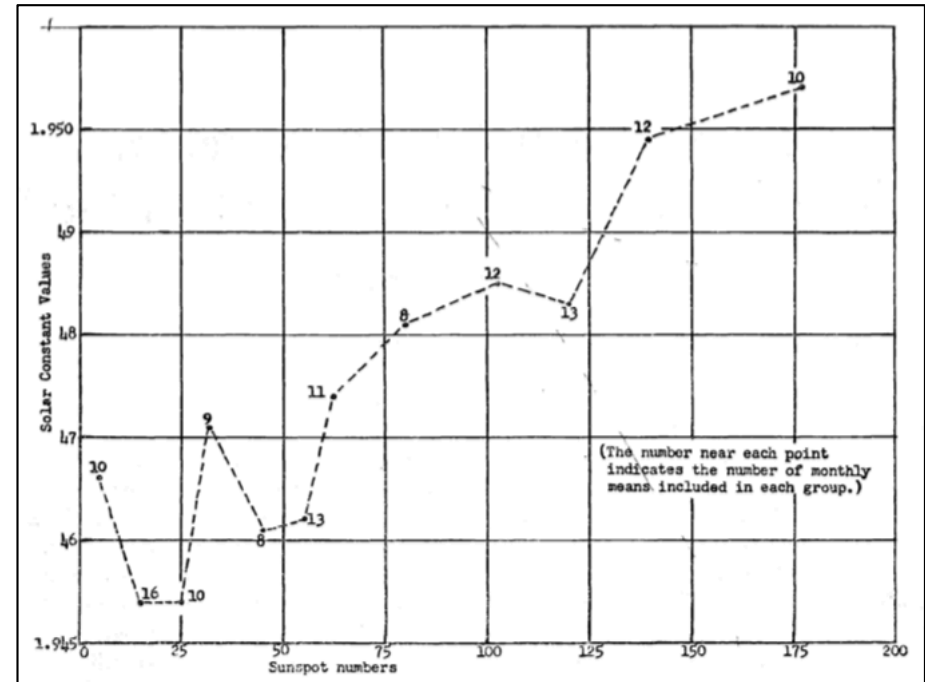
- Charles Greeley Abbot, 1872-1973, followed Langley's CFA program.
- ACRIM and modern solar/stellar photometry



Abbot's wrong results



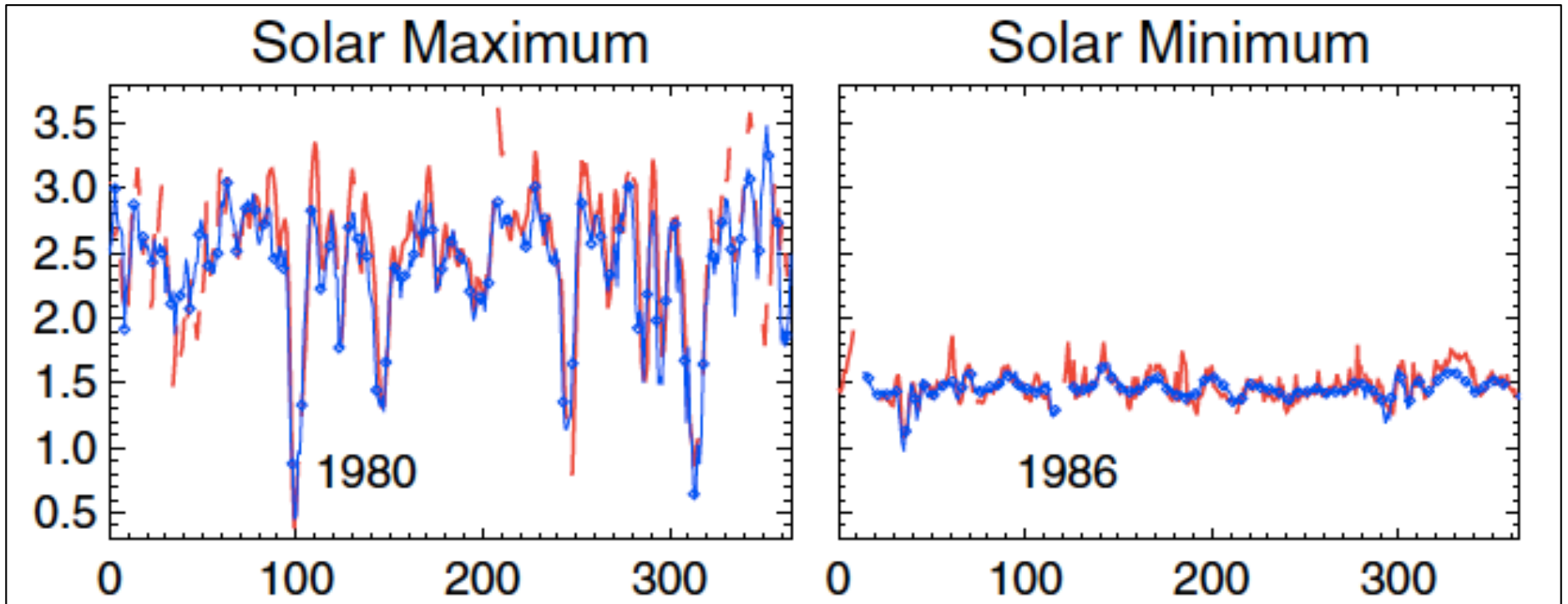
A sunspot “dip”? No; it is much too deep; also note rms $\sim 0.4\%$



The activity correlation? No; it has the wrong sign and is too large.

From Abbot, 1958, following Sterne & Dieter, 1958: “The Constancy of the Solar Constant”

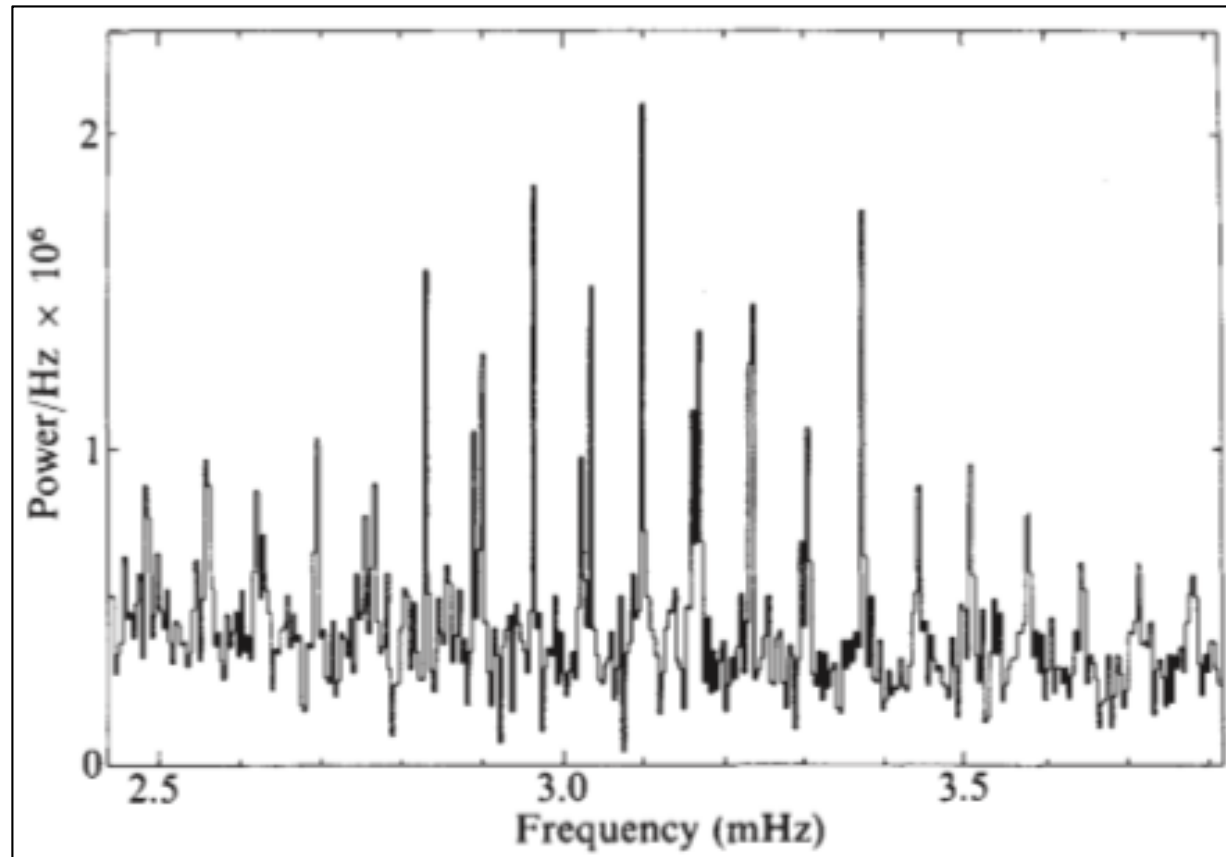
Sunspot deficits, facular excesses



Frohlich & Lean, 2004

CPS got the sign right!

The Beginning of “Astero-seismology”



Woodard & Hudson, 1983

Conclusions

- The search for Sun/weather/climate correlations has a long and rich history, in which CPS played a major role.
- Modern data show that there are no useful correlations on any time scale.
- But there is “space weather”, again a legacy of Charles Piazzi Smyth.

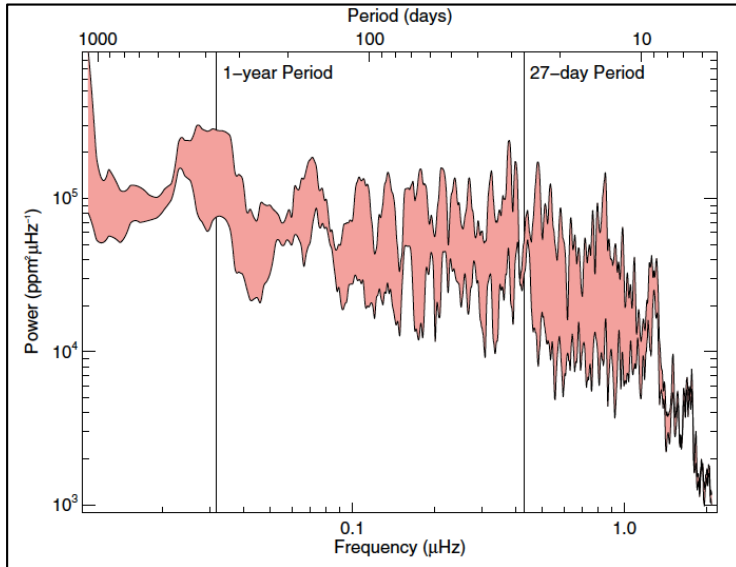
Postscript

- Time-series analysis, seeking correlations, has confounded many excellent scientists.
- Global-warming skeptics still make use of these too-flexible tools.

Personal remarks

- As a novice in the history of science, I was surprised at how difficult the reconstruction of the actual facts was.
- We do better nowadays, in terms of traceability, but there are few opportunities for scientists to do the tracing...

How does the Sun vary?



Fröhlich & Lean, 2004

Variability occurs on many scales:

- p-modes (few min)
- Convection (min to hours)
- Local magnetism (days)
- Rotation (~27 d)
- Hale cycle (22 years)
- *Holocene (warming skeptics)*
- Secular (eons)

Note the “Maunder minimum” of the 17th century.

