Title
A. E. Douglass (1867 - 1962) and Solar Cycles in Tree Rings

Author
Berger, Wolfgang H

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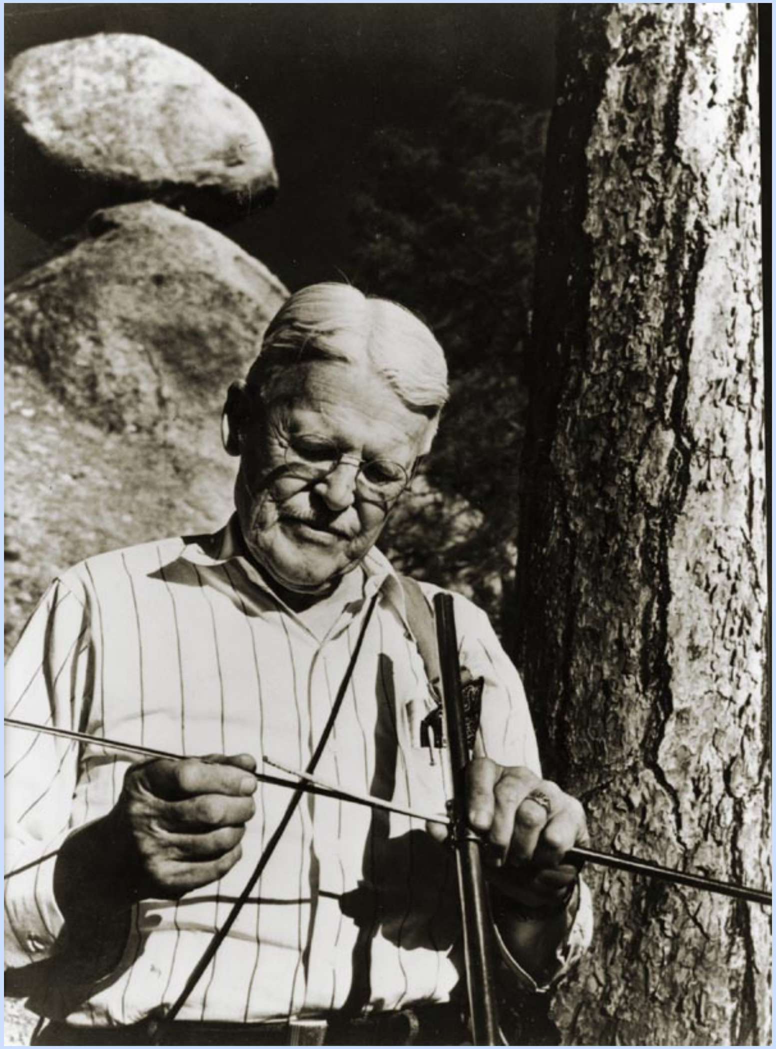


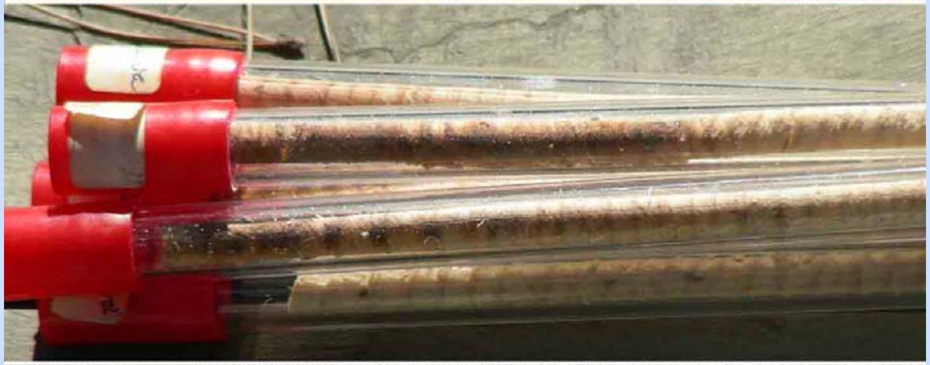
A.E. Douglass (1867-1962) and solar cycles in tree rings

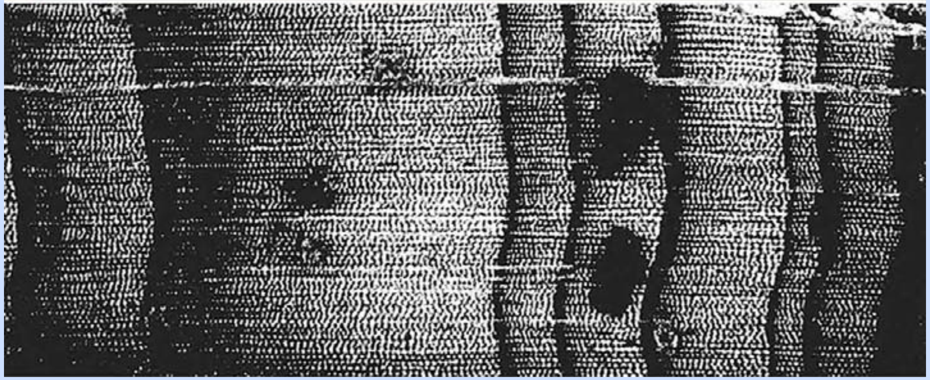
W.H. Berger, Scripps Institution of Oceanography, UCSD

MtnClim Conference, Oregon, June 2010

Douglass favorite target was the Ponderosa Pine or “Yellow Pine.”

The methods he introduced are now generally in use.





The methods work best with the soft wood of pine, spruce, and fir, as he pointed out. Oaks break the borers.

Douglass was especially interested in working with very ancient trees.

Douglass is best known for his role in dating the ancient ruins in the Southwest.

Pueblo Bonito, Chaco Canyon,
11 th century CE

Beam section from the
Balcony House, Mesa Verde,
13 th century CE

The focus of Douglass's studies was not the age of ancient ruins, but the behavior of the sun through time. Many of his publications emphasize this fact, and he reported prominently on reconstructing solar (sunspot) cycles from climate cycles seen in tree growth histories.

Summaries of this work are in three volumes published by the Carnegie Institution:

Douglass, A. E., 1919. *Climatic Cycles and Tree-Growth*, Volume I, Carnegie Institution, Washington, 127 pp.

Douglass, A. E., 1928. *Climatic Cycles and Tree-Growth*, Volume II, Carnegie Institution, Washington, 166 pp.

Douglass, A. E., 1936. *Climatic Cycles and Tree-Growth*, Volume III, Carnegie Institution, Washington, 171 pp.

The first of these publications has extensive tables in the Appendix, with tree-ring data, which are the data base for the analyses here presented. The question is, can we verify Douglass's claim that solar information is ubiquitous in his tree-ring records.

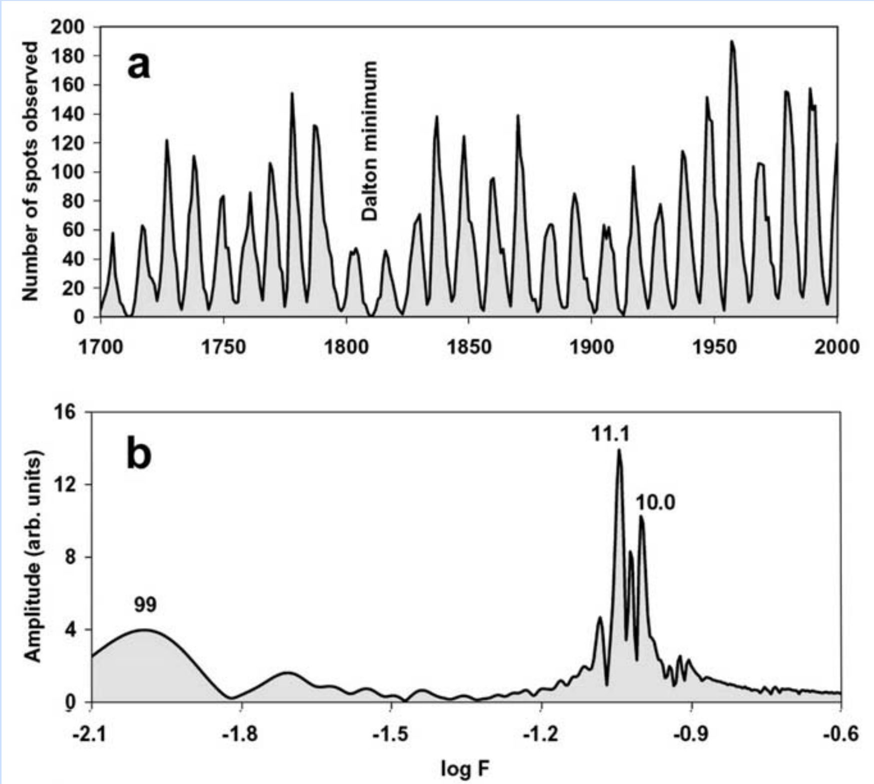
Douglass's interest was in the interaction of solar and climate variation.

As a solar astronomer, he wished to make trees give up climate information linked to solar activity.

He did much detailed work in pursuit of this goal.

He claimed he found abundant evidence for solar activity, notably a cycle with a period close to 11.4 years.

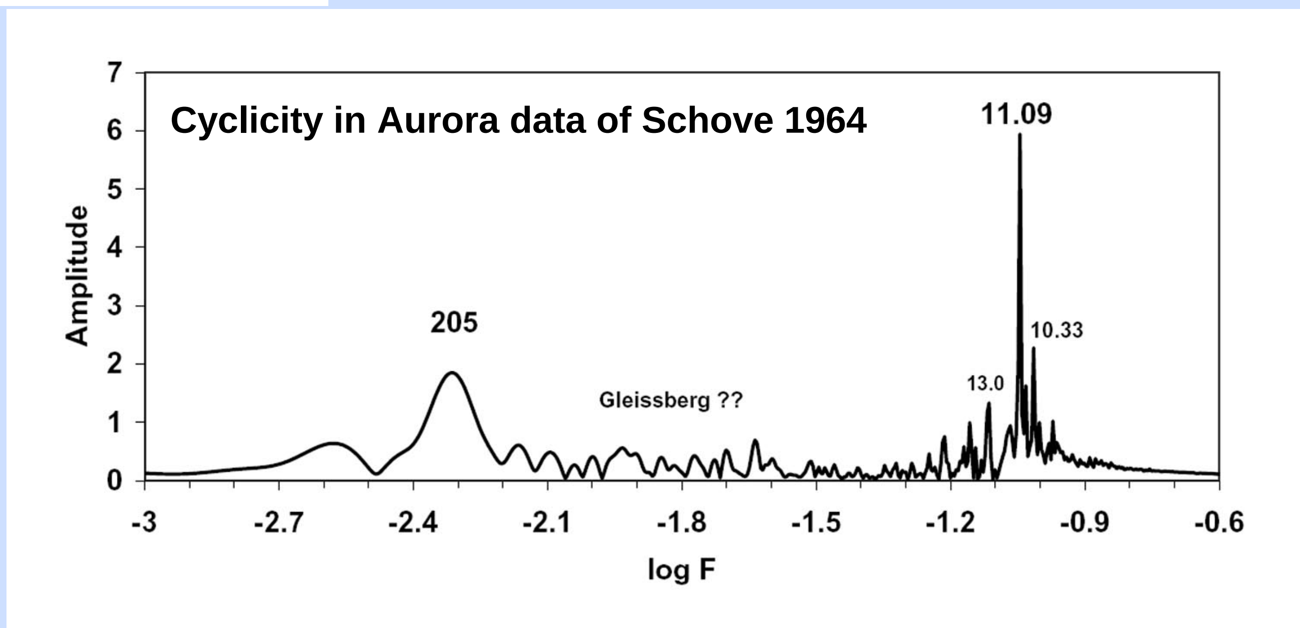
Unfortunately, neither the solar activity nor his tree rings show evidence for a cycle of precisely that period. A cycle 11.1 years long would have fit the available data on sunspot cycles (for the last 300 years).



11.1 not 11.4

This is what we know about sunspots.

Data Royal Observatory in Belgium



This is what aurora observations look like, for the last ca. 1400 years.

Douglass's means of displaying his data were primitive by today's standards.

He used visual matches to document correlation of sunspots and ring widths.

CORRELATION WITH SUNSPOTS. 75

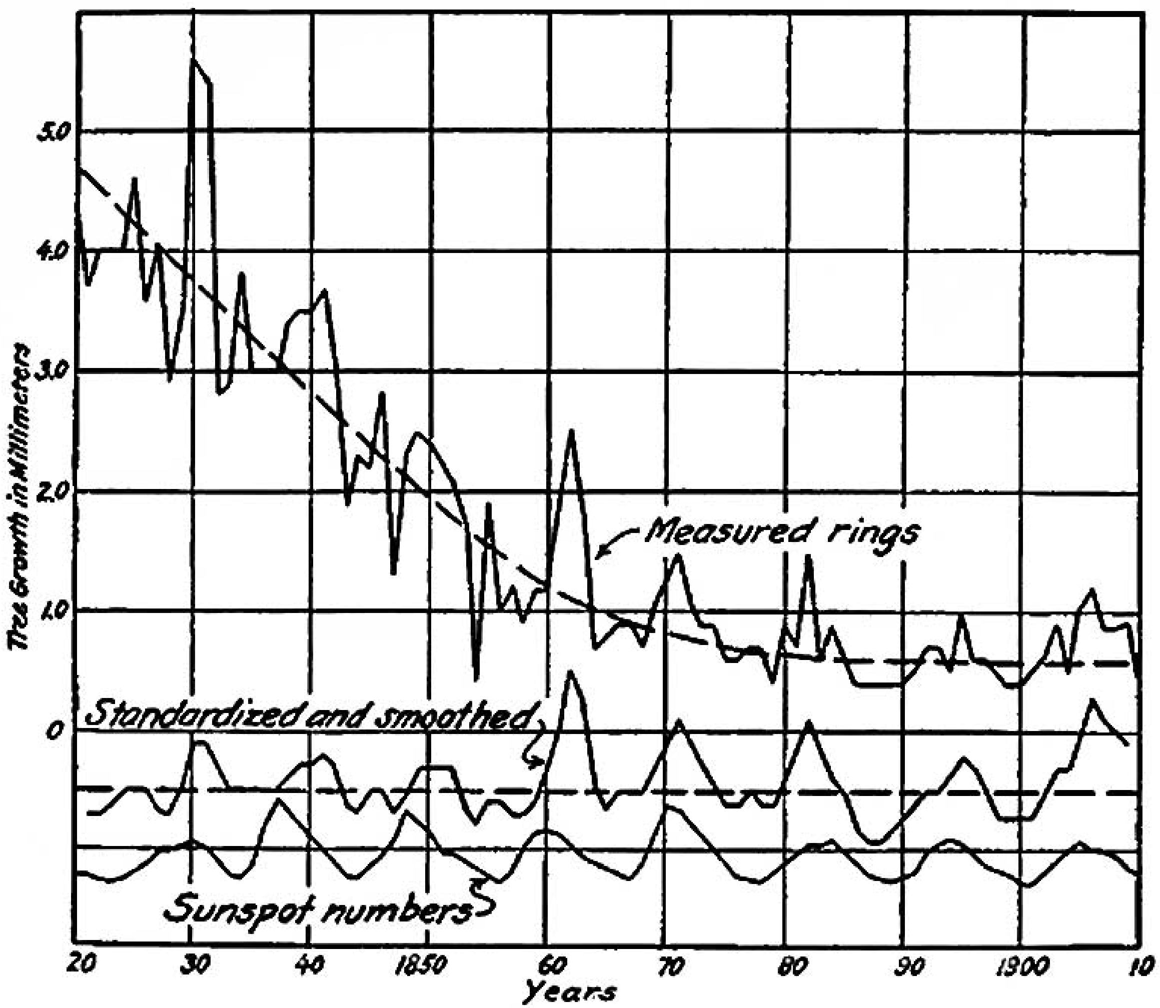


Fig. 22.—Sunspot numbers and annual rings in spruce tree from south Sweden.

Douglass did indeed find solar cycles.

10.7

Counting the cycles in his standardized series from southern Sweden, we find 7 cycles for 1831-1906; that is, for 75 years. The average length, therefore, is 75/7 which is 10.7 (which is the sunspot period for much of the 20th century).

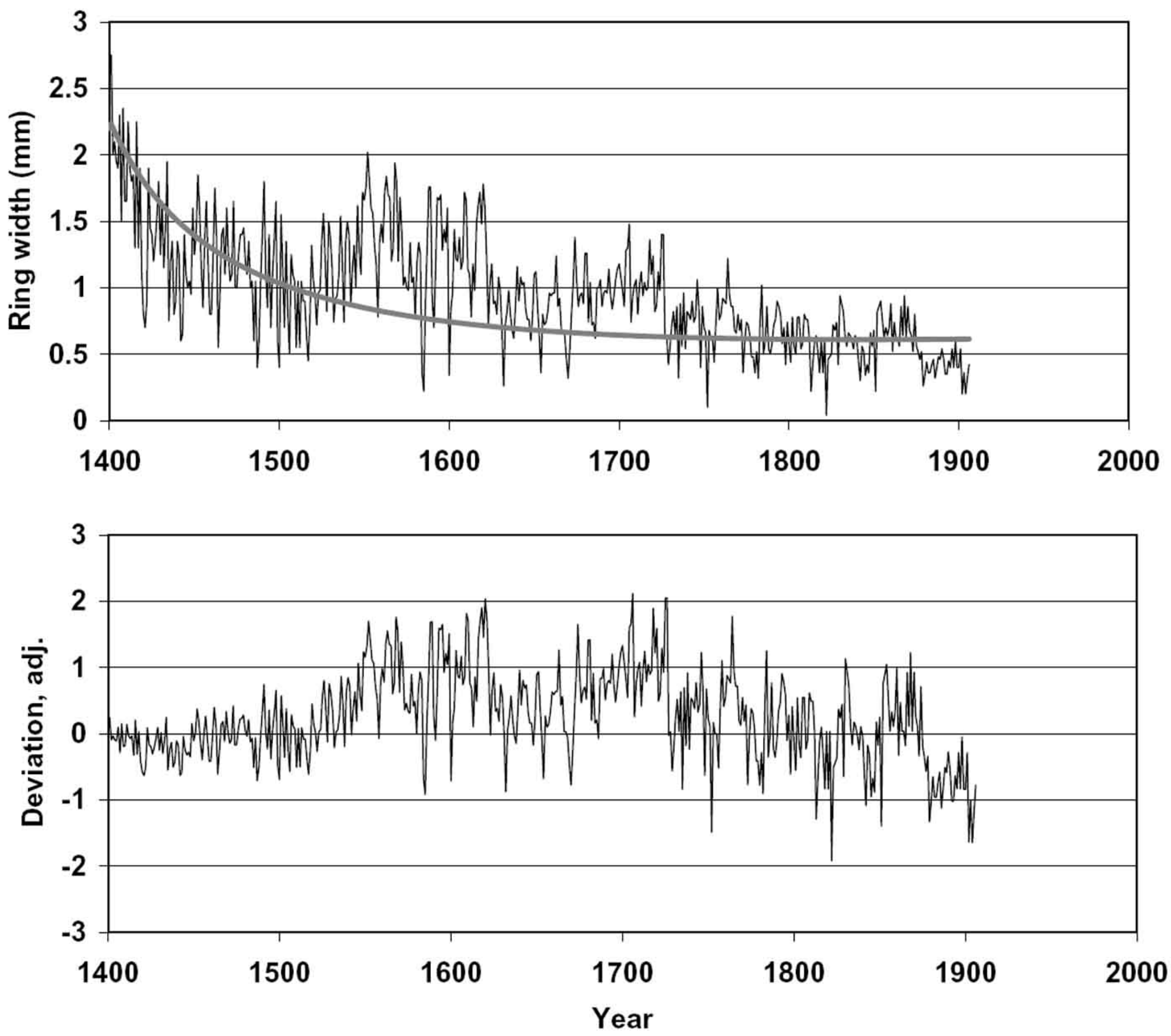
Sequoia record: Group of 1915; 11 trees—continued.

A. D.	0	1	2	3	4	5	6	7	8	9
490	1.48	1.47	1.60	1.52	1.76	1.92	1.94	1.51	1.50	1.88
500	1.55	1.48	1.44	1.61	1.85	1.70	1.52	1.31	1.47	1.62
510	1.61	1.92	1.39	1.27	1.19	1.26	1.39	1.07	0.68	1.10
520	0.94	1.33	1.45	1.14	1.02	1.15	1.08	1.11	1.24	1.29
530	1.14	1.27	1.24	1.26	1.18	1.27	1.30	1.33	1.21	0.78
540	0.94	0.99	0.86	0.91	0.96	1.19	1.15	1.16	1.08	0.98
550	0.97	1.03	0.72	0.48	0.45	0.82	1.09	0.79	1.07	1.34
560	1.61	1.23	1.45	1.21	1.20	1.07	1.13	1.27	1.08	1.14
570	0.84	0.98	1.03	1.08	1.16	1.04	0.99	0.92	0.94	1.09
580	0.94	1.04	0.78	0.99	0.99	0.98	0.77	1.29	1.16	1.12
590	1.16	0.95	1.22	1.09	1.06	1.10	1.27	1.00	0.98	0.95
600	1.17	1.19	0.97	1.29	1.22	1.27	1.12	1.06	1.45	1.30
610	1.36	1.40	1.02	1.28	1.54	1.52	1.61	1.74	1.67	1.72
620	1.28	1.46	1.62	1.71	1.35	1.30	1.23	1.54	1.53	1.20
630	1.28	1.24	1.28	1.24	1.47	1.35	1.36	1.28	1.26	1.14
640	0.84	1.10	1.16	1.45	1.64	1.43	1.30	1.36	1.50	1.62
650	1.22	1.07	1.38	1.52	1.49	1.57	1.31	1.27	1.46	1.03
660	1.23	1.21	1.57	1.78	1.37	1.51	1.41	1.50	1.52	1.32
670	1.54	1.39	1.49	1.44	1.49	1.51	1.21	1.10	1.41	1.07
680	1.54	1.55	1.53	1.14	1.20	1.19	1.25	1.35	1.28	1.21
690	1.33	1.15	1.53	1.67	1.49	1.36	1.17	1.22	1.38	0.55
700	1.20	1.58	1.37	1.41	1.50	1.47	1.60	1.01	1.29	1.30
710	1.30	1.34	1.22	1.16	1.04	0.93	1.15	1.23	1.00	0.74
720	1.08	1.18	0.97	1.09	0.96	1.25	1.19	1.08	0.80	1.14
730	1.27	1.24	1.33	1.49	1.32	1.27	1.33	1.59	1.34	1.10
740	1.25	1.22	0.84	1.41	1.31	1.51	1.13	1.22	1.08	1.24
750	1.16	0.87	1.04	0.96	0.88	0.90	1.04	1.08	1.19	1.20
760	0.88	0.96	0.56	0.82	0.75	1.00	0.91	0.95	0.94	1.10
770	1.16	1.39	1.48	1.29	1.20	1.50	1.34	1.39	1.47	1.17
780	1.62	1.12	1.04	1.23	1.36	1.17	0.96	1.11	0.87	1.10
790	1.40	1.13	1.16	1.12	0.99	1.18	1.39	0.75	1.17	1.20
800	1.19	1.11	1.18	1.19	0.88	1.01	1.42	1.04	1.11	0.73
810	0.99	1.22	1.23	1.15	1.24	1.28	1.26	1.17	1.02	0.83
820	1.10	1.17	1.32	0.89	1.09	1.08	1.25	1.30	1.29	1.16
830	1.10	1.24	1.38	1.07	1.18	1.26	1.25	1.32	1.27	1.13
840	0.99	1.10	1.10	1.35	1.19	0.97	1.21	0.92	1.23	1.23
850	1.15	1.16	1.16	1.22	1.09	0.99	1.06	1.01	1.13	1.14
860	1.19	1.00	1.04	1.04	1.12	0.67	1.23	1.20	0.63	1.14
870	1.32	1.08	1.03	0.97	1.18	1.10	0.98	1.12	1.17	1.18
880	1.24	1.35	1.41	1.13	1.22	1.53	1.42	1.08	1.29	1.15
890	1.00	1.05	1.33	1.33	1.10	1.13	1.24	1.31	1.11	1.21
900	1.03	1.25	1.10	1.07	1.12	1.13	1.03	1.01	1.10	1.00
910	1.06	1.15	1.10	0.84	1.17	0.97	1.15	1.28	1.06	1.09
920	1.20	1.08	1.24	1.05	0.87	1.04	1.09	1.09	1.03	0.90
930	0.74	0.98	1.00	0.72	1.05	1.01	1.02	1.29	1.05	1.21
940	1.24	1.20	1.15	0.99	0.91	1.06	1.19	1.28	1.01	1.01
950	1.20	1.09	0.94	0.97	0.47	0.91	1.08	0.71	0.89	1.07
960	1.22	0.87	0.92	1.15	1.06	1.07	0.98	1.16	1.33	1.28
970	1.50	1.14	1.09	1.22	1.15	1.01	1.08	1.14	1.00	0.82
980	0.62	0.76	0.92	0.96	1.19	1.36	1.15	1.24	1.21	1.33
990	1.28	1.41	1.36	1.40	1.17	1.04	1.04	1.39	1.42	1.24
1000	1.30	1.44	1.45	1.55	1.35	1.20	1.46	1.36	1.35	1.31
1010	1.11	1.34	1.22	1.20	1.20	1.37	1.58	1.54	1.36	1.60
1020	1.49	1.38	1.38	1.56	1.56	1.10	1.31	1.32	1.16	1.13
1030	1.14	1.08	0.98	1.10	1.19	1.08	1.12	1.22	1.21	1.06
1040	1.00	1.23	1.28	1.03	0.99	1.20	0.99	0.88	0.93	0.95
1050	1.02	1.02	0.76	0.70	0.79	0.84	0.94	0.81	0.82	0.58
1060	0.58	0.91	0.89	0.92	1.19	1.17	1.08	1.25	1.36	1.13
1070	0.90	1.24	0.99	1.08	1.21	1.32	1.30	1.15	1.08	1.16

Data Douglass 1919

Douglass published his tree-ring counts for the giant Sequoia and for a number of projects involving trees from Europe. This greatly facilitates checking his results.

To the left: data from his Sequoia records, obtained in 1915 (mainly from tree stumps).



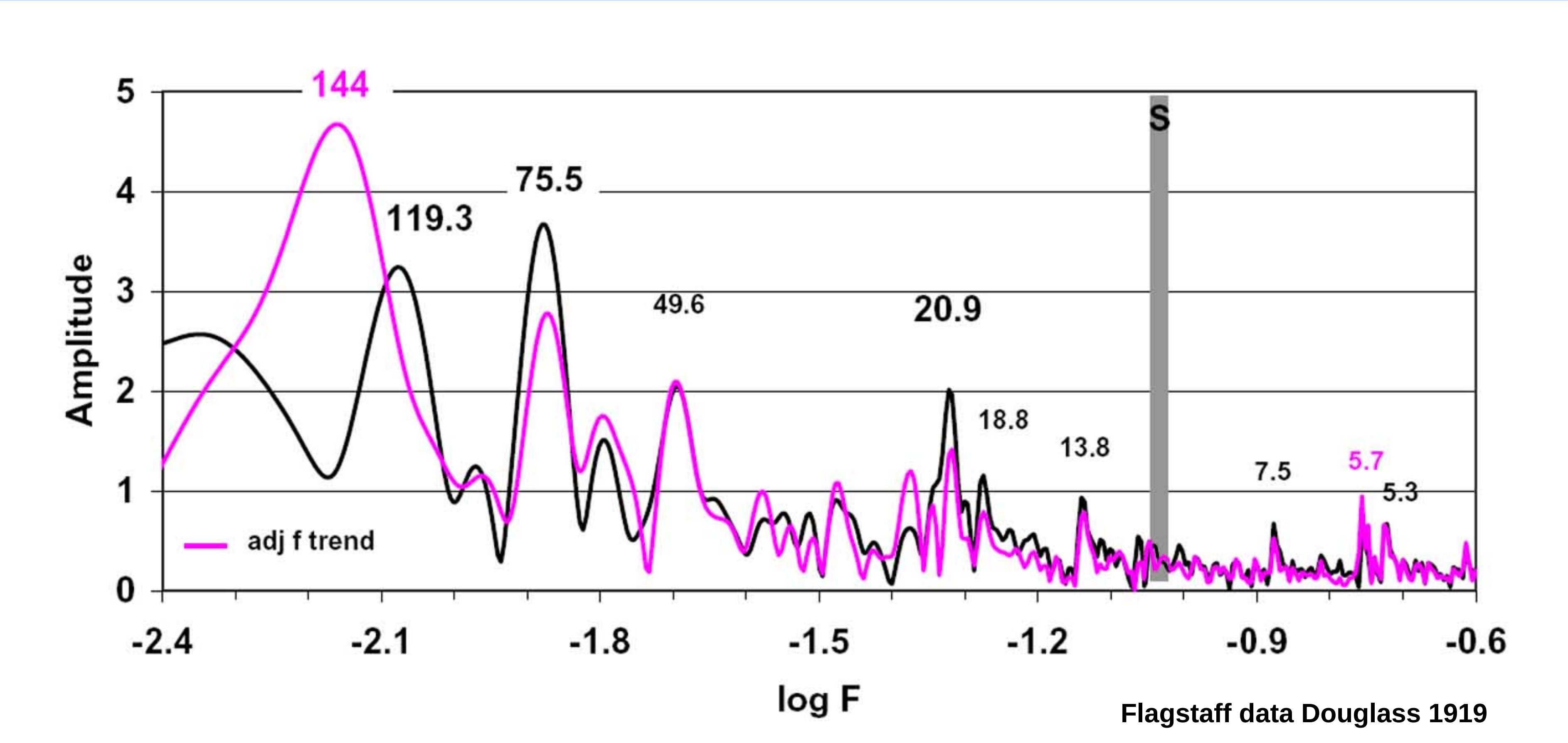
Flagstaff data

Douglass 1919

Original data fitted by generalized decay curve (by eye)

Detrended data, with variability adjusted to local background (as suggested by Douglass)

Armed with modern desk-top computing power, we can readily check his data for evidence for the presence of solar cycles.



The solar line (marked S) is conspicuously empty in the Flagstaff "periodogram" (a term used by Douglass). The closest is a line at 20.9 (twice the average solar cycle length) and one at 5.7 (one half the Douglass cycle of 11.4). Black line: raw data. Pink line: after de-trending and adjusting variability to background level.

Note the two prominent multiples of ~25.

Flagstaff series main periods

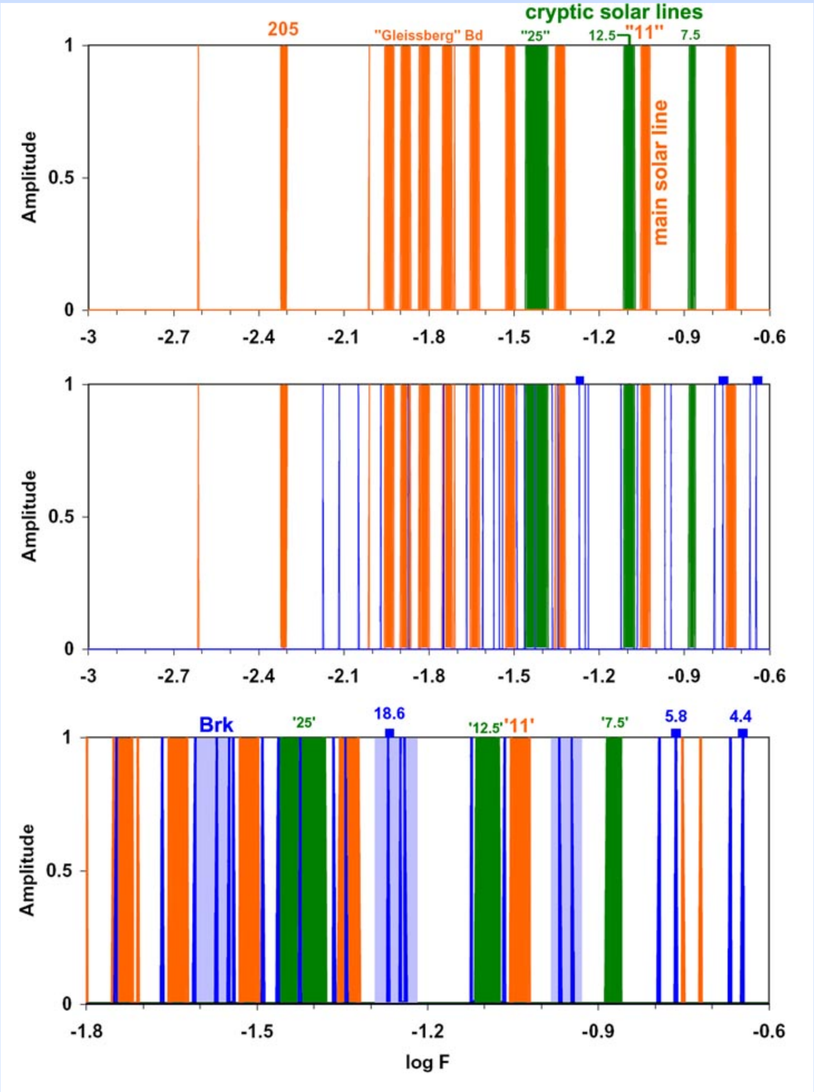
		adj f tide	Interpretation
119.3		117.97	?
75.5		74.66	multiple of "25"
49.6		49.05	multiple of "25"
20.9		20.67	2xsol or 5x perigee
18.82	set	18.61	nodal tide
13.8		13.65	4xperigee? (13.6)
7.5		7.42	NAO (11#4.4)
5.7		5.64	1/2 solar?
5.3		5.24	1/2 solar?

solar

tidal

solxtid

Summarizing the Flagstaff results, we see that a direct solar influence, if present, is minor (orange color). Apparently there are tidal cycles (coded blue). Also, there are multiples of ~**25** (a cycle prominent in the Santa Barbara Basin, and in a coral from Bermuda). Suspected solar-tidal interference cycles are coded green. Over-counting of 1% is suggested if 18.81 is taken as the tidal line **18.61**.



Three types of periods are proposed to be potentially present in the periodograms based on tree-ring data: (1) solar cycles (simple and multiples, as suggested by Douglass) ***orange***, (2) tidal cycles (as suggested by R.G. Currie and by R. Fairbridge) ***blue***, and interference lines between the two (as suggested by H.H. Lamb and by Cook, Meko and Stockton, 1997, and by Berger, 2008) ***green***.

solar

tidal

solxtid

If one considers only periods <40 y long, the distribution of the three types is plain: "**11**" and its simple multiples (**33, 22, 5.5**); **18.6** and **4.4** and their multiples; ~**25**, ~**12.5**, and ~**7.5**, which arise from interference of sun and tide.

Flagstaff series main periods

Evaluation of possible solar presence

If multiples of "25" is correct:
we have 74.66/3=24.89 ~ 10.65 with 18.61
49.05/2=24.50 ~ 10.58 with 18.61
If "NAO" is solunar: 7.42 ~ 10.96 w 4.424
If "5.24" is 1/2 sol: 10.48
average: 10.67 (typical for 20th century)
std dev: 0.21

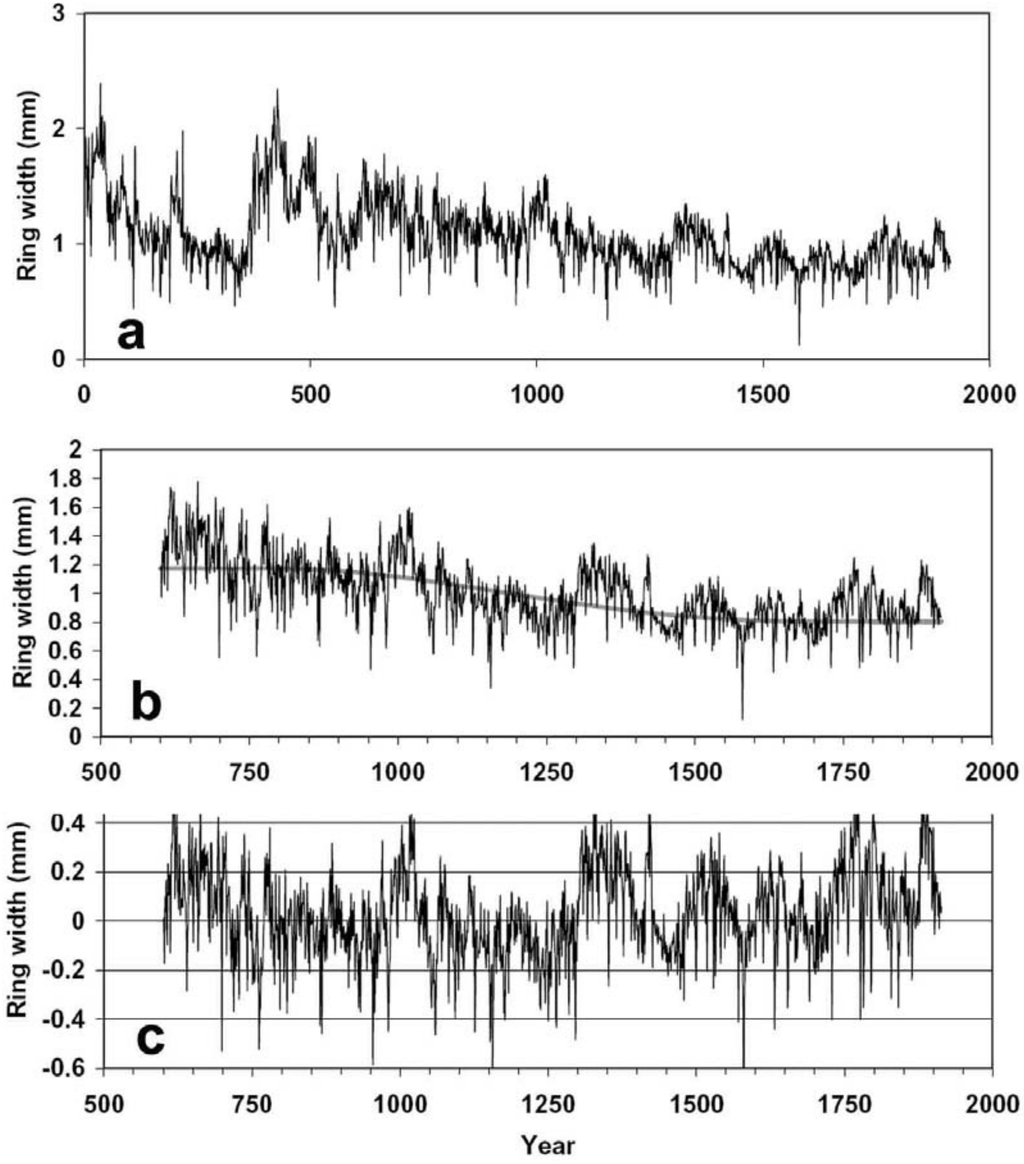
solar
tidal
solxtid

Of the three types, two are directly reflective of solar activity; hence, the length of the solar cycle is implicit. For the multiples of ~25 we get, by deconvolution, 10.65 and 10.58 as estimates of solar cycle length. For the "NAO" we get 10.96. The overall estimate is 10.7±0.2 -- the value for much of the 20th century. Thus, the Flagstaff data of Douglass suggest long-term stability of the solar cycles, for several centuries, if read in the manner here proposed. If not read in this fashion, they present puzzling evidence for some kind of chaos.

Next we evaluate the Douglass data based on the Sequoia project in 1915.

Douglass collected data for thousands of years into the past, using the giant sequoia trees.

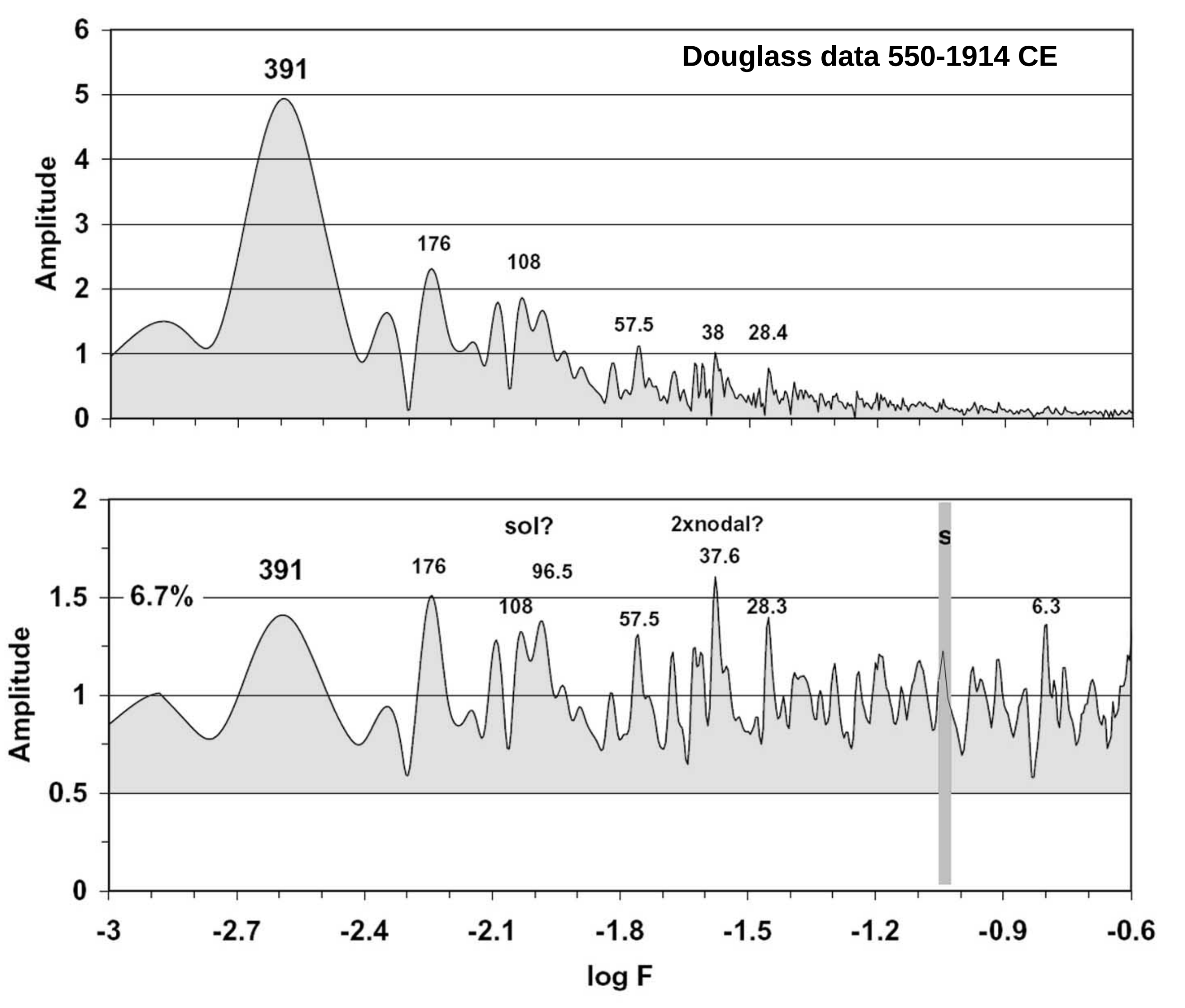
He used stumps left from logging.



The Sequoia data (here shown for the last 2000 years) seem complicated before 500 CE.

I have omitted the complicated portion.

After 550 CE the detrending and variability adjustment, based on a general sinusoidal trend, seem straightforward.



The periodogram of the Sequoia data shows a strong red bias. By calculating the position of each point relative to mean and std. dev. of a window of a factor of 3, one can eliminate the bias. Note that the solar line is extremely weak and remains inconspicuous against background of factor-of-three.

Periods of strength above mean peak amplitude

	notes		precise	
57.5	56.89	3x18.6	55.83 nodal tide	**>1 stdev**
37.6	**37.20** set	2x18.6	37.22 nodal tide	**>2 stdev**
28.3	28.00	11.18 cryp	w 18.61 solxtid	**>1 stdev**
24.5	24.24	10.53 cryp	w 18.61 solxtid	<1 stdev
21.3	21.07	5x4.424	21.12 perigee	<<1 stdev
19.8	19.59	9.3#17.7	19.596 tidal	<1 stdev
17.4	17.21	???		<1 stdev
15.8	15.63	6.2#4.424	15.43 tidal	<1 stdev
12.5	12.37	18.6#7.43	12.37 tidxNAO	<1 stdev
11.08	10.96	7.43 w pg 10.95	10.96 solar	**~1 stdev**
9.4	9.30	0.5x18.6	9.305 nodal tide	<1 stdev
8.2	8.11	???		<1 stdev
7.05	6.98	???		<<1 stdev
6.3	6.23	0.33x18.6	6.2 nodal tide	>1 stdev
5.73	5.67	?	5.8 tidal	<1 stdev

Conclusion: more info about tides than about the sun

Nevertheless, what information there is points to a solar cycle of 10.9, on average.

solar

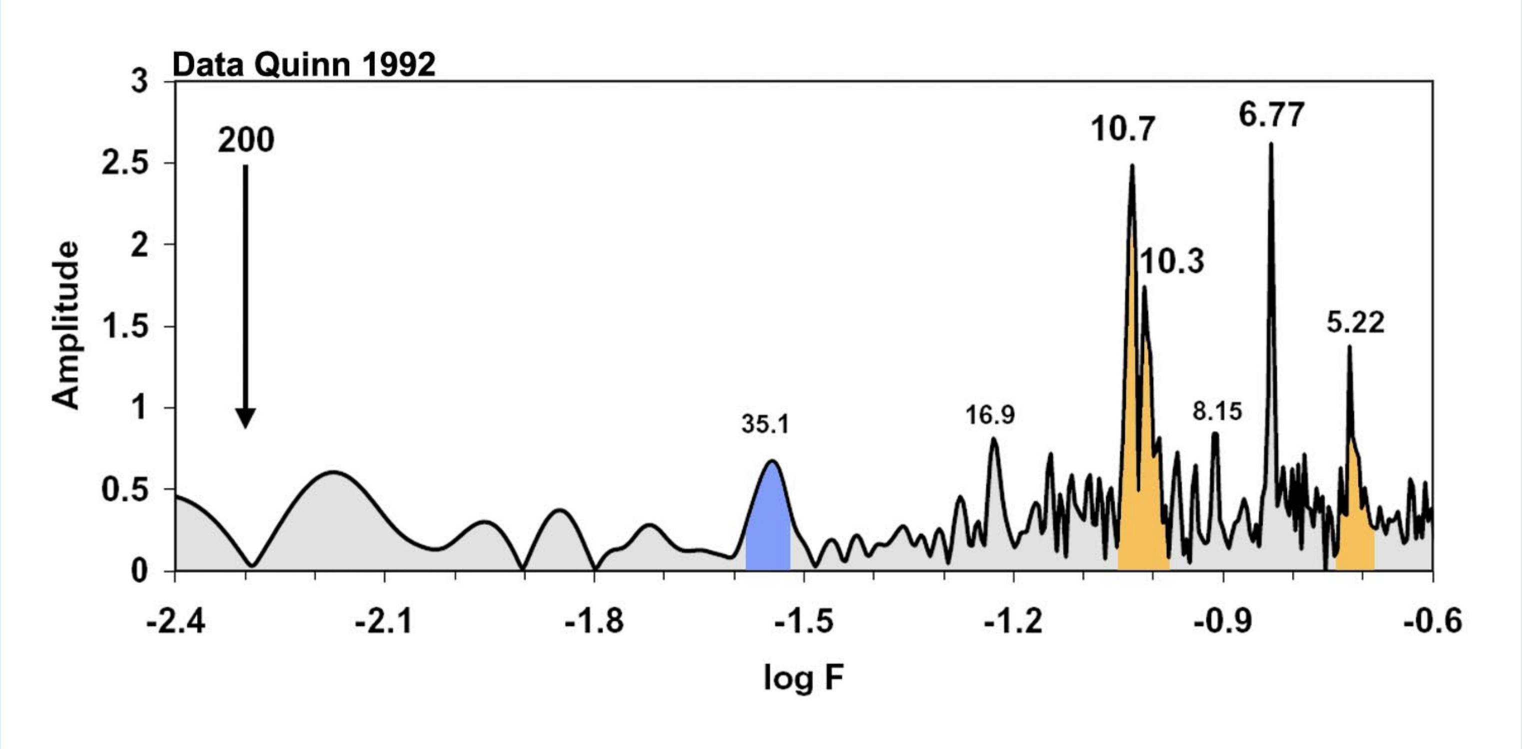
tidal

solxtid

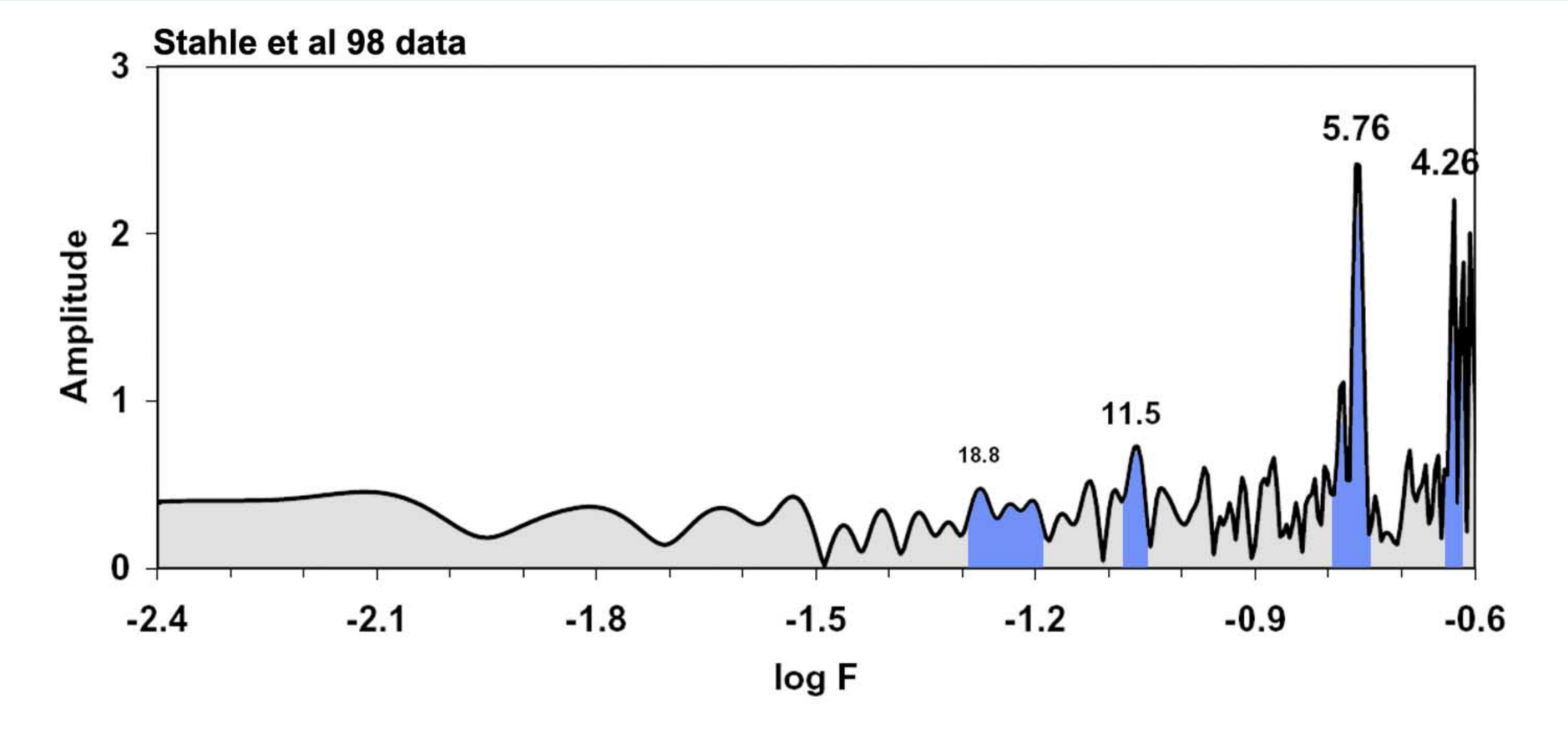
An evaluation of the periodogram of the Sequoia data with respect to the 3-types hypothesis suggests a predominance of tidal information, especially after setting 37.6 to 37.2 (twice the nodal cycle, assuming over-counting of rings by ~1 percent).

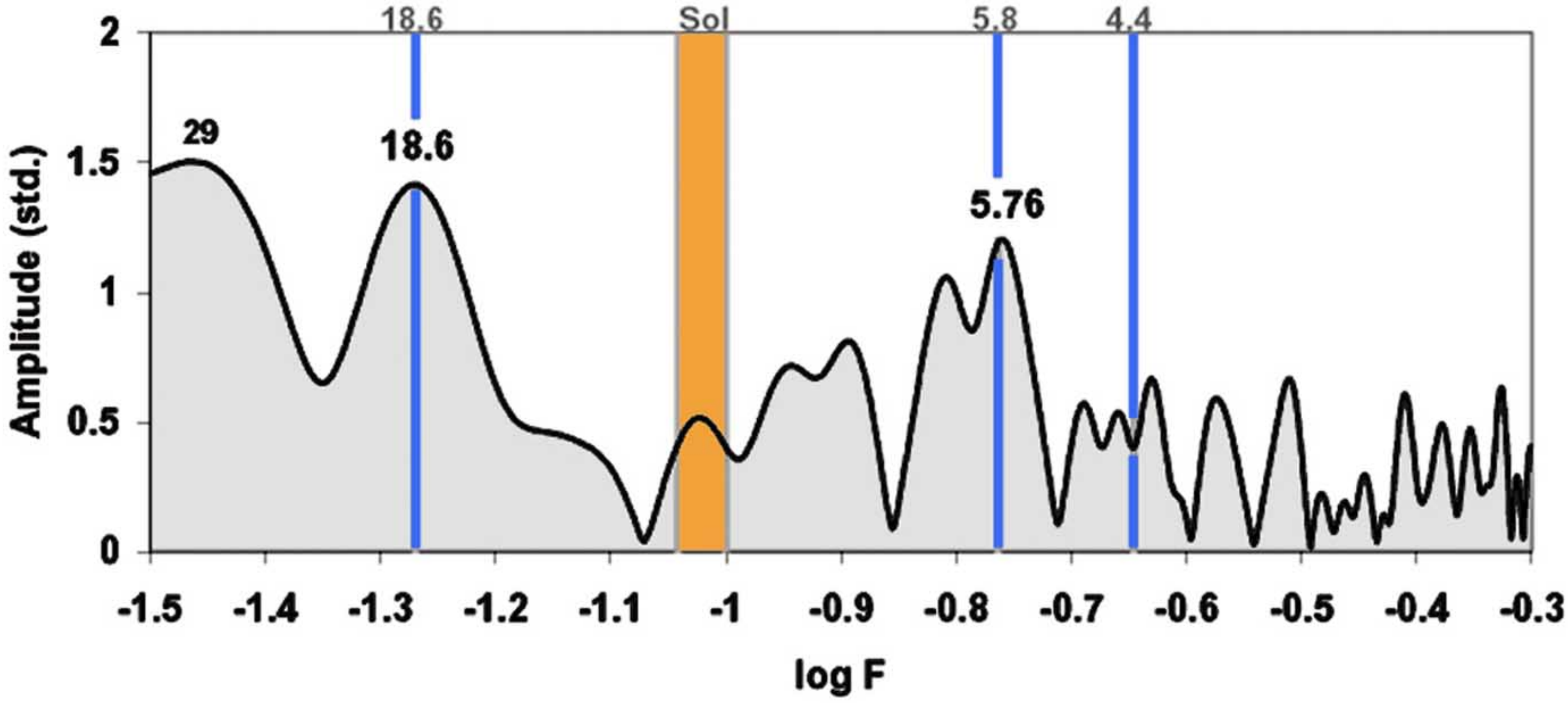
The question arises what might be the sources of the three types of cycles seen.

The Quinn 1992 data (500 years of ENSO events) suggest that the ENSO delivers solar-cycle information (as well as something near 6.8 years whose origin is obscure). (Nothing of note is seen at ~100 or ~200, incidentally, where sunspot and aurora observations suggest solar power.)



The Stahle et al. 98 ENSO reconstruction, from northern Mexico and U.S. SW tree rings, shows no solar information whatever, unless one wishes to class 5.76 as solar (it is here considered to represent the 5.80 tidal cycle).





Data Mantua et al., 1997

To check whether the PDO influences tree-ring series in Sequoia, the PDO series itself is analyzed here. It is available for the 20th century. Within the range of identifiable lines (4 to 25) it seems entirely dominated by tidal information. Solar cycles are not evident.

luna cycle → / sol cycle ↓	perigee 4.424	nodal cycle 18.61	
10.0	7.934	21.61	
10.1	7.872	22.08	
10.2	7.812	22.57	
10.3	7.755	23.06	
10.4	7.699	23.57	
10.5	7.645	24.09	
10.6	7.593	24.62	
10.7	7.543	25.17	x
10.8	7.494	25.73	
10.9	7.446	26.30	
11.0	7.400	26.89	
11.1	7.356	27.50	
11.2	7.312	28.12	
11.3	7.270	28.76	
11.4	7.230	29.42	D

In conclusion, because of the strong tidal signals coming from the sea and influencing precipitation patterns, we need to study the *interference patterns* between solar and tidal cycles. The expectation ("x") (based on the last 300 years of sunspot observations) is that lines near 7.5 and 25 should be strong. If Douglass was right about a strong 11.4-year cycle, we should see 7.2- and 29-year beat cycles with perigee and nodal cycles (marked "D").

The point is, if we have no expectation with respect to the cycles observed, we are limited to confusion and chaos.

Douglass had an expectation.

Sources of data and graphs, and references cited

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