OUR JOVIAN RAINFALL CYCLE

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The planet Jupiter completes one revolution around the sun in 11.86223 years. Since the Jovian orbit is inclined 6°6′ to the plane of the solar equator, in the course of each revolution this planet shifts through 12°12′ of heliographic latitude. When, as on February 15, 1936, the planet is in 250° heliocentric longitude, it is on the solar equator moving north. Five years and 223 days later, or on September 28, 1941, when in heliocentric longtitude 70° the planet was again over the solar equator but moving south. When in heliocentric longitude 342° Jupiter is 6°6′ north of the solar equator and in 160 degrees it is 6°6′ south. There is accordingly in each Jovian revolution an orderly latitudinal shift in the locus of maximum tidal pull on the sun analagous to that of the sun relative to the earth, which causes our seasons and also, along with the moon, influences the height of tides on the earth.

Professor Arthur Schuster (1911) advanced the hypothesis that the gravitational pull of the planets, in their revolution around the sun, might give rise to sun-tides analogous to the tides produced on the earth through the gravitational pull of the moon and sun. If such solar tides actually exist, an influence on the output of solar radiation and hence upon terrestrial climate is to be expected.

Henryk Arctowski (1916) presented evidence of a relation between sun spot areas and the gravitational pull of the earth on the sun. Researches of the late H. H. Clayton (1916) gave confirmation of the findings of Arctowski and further showed that when the planets Earth and Venus were nearest together in their highest heliographic latitudes sun spot activity was increased.

Since evidence had been found of an 11 (plus) year, four phase cycle in radiation and of rainfall in Oklahoma (Bollinger, 1935; 1945), associated with sun spot activity, it appeared that these cycles might be related to the heliographic pull of the planets.

By the law of gravitation the force acting on any particle is directed toward the sun-s center and is jointly proportional to the masses of the particle and of Jupiter, and inversely proportional to the square of the distance between the particle and of Jupiter's center. The tidal relationship[a] is expressed by:

$$F = \frac{M}{d^3}$$

The mass of Jupiter is 314.5 times that of the earth, including its satellite the moon, and since its mean distance from the sun is only 5.2 times that of the earth, its tidal influence on the sun must be greater than that of the earth as appears in Table I.

TABLE I

Relative Mean Tidal Pull of Major Planets on the Sun
(Data from the American Ephemeris)

		% OF TOTAL
Mercury	0.9464	14.666
Venus	2.1350	33.086
Earth	1.0	15.497
Mars	0.03014	0.0467
Jupiter	2.2330	34.605
Saturn	0.10836	1.6793
	6.4529	99.58

It will be noted that Jupiter at mean distance from the sun has greater tide-raising force than any other planet, though it is rivaled by Venus. The influence of Mars is less than 5/100 of one per cent and may be neglected. The earth accounts for 15.5% of the total tide forces but since it is constant from year to year, may also be neglected in investigating longer cycles.

Since the heliographic latitude of the planet is also a factor in sun spot activity, and presumably radiation, the following formula was employed in computing heliographic tide-pull indices:

$$I = 100 \; (m/r^{3} \text{ Sin B})$$

B is the heliographic latitude of the planet, *m* its mass relative to the earth and *r* its radius vector relative to the mean radius vector of the earth.

The nodal and maximum north and south index values thus derived are given in Table II; the larger value for north heliographic latitudes arises from the fact that Jupiter's north heliographic position is associated with perhelion position whereas its most southerly position is associated with aphelion.

TABLE II

Highest and Lowest Index Phases

PHASE	HELIOGRAPHIC LAT.	HELIOCENTRIC LONG.	INDEX
JNP	6°6′ N	342°9′	26.99
	0.0	69°0′	0
JSA	6°6′ S	154°37′	21.12
	0.0	250°5′	0

MEAN JOVIAN INDEX: 360°L = 15.2

In each Jovian revolution the surface of the sun comes under the varying influence of these four Jovian phases. The four phases of the Jovian Revolution period differ in duration as well as intensity. This is due in part to the eccentricity of its planetary orbit (0.048, 4043). If the Jovian phases are defined according to index values being larger or smaller than the mean, 15.2, the phase lengths are as follows:

TABLE III

Duration of the Jovian Revolution Phases

			%
JNP	288° 26′ to 35° 42′	3.29041 years	27.74
	15° 42′ to 109° 24′	2.31233 years	19.49
JSA	109° 24′ to 202° 36′	3.29589 years	27.78
	202° 36′ to 288° 26′	2.96438 years	24.99
TOTAL		11.86223	100.00

It will be noted that the high-latitude high-index phases of Jupiter are of approximately equal duration and are relatively long. The two high-index phases combined comprise over 55% of the period. These phases are approximately four months longer than the ascending node low-index phase and 11.8 months longer than the low-index descending node phase.

Thus in summary an 11.86223 year Jovian cycle with four phases is indicated:

1. A Very Low Index Period centering on the ascending node of 2 years, 358 days duration with Minimum Index O.
2. A North Perihelion Very High Index Period of 3 years, 103 days duration with Maximum Index 26.97.
3. A Short, Very Low Index Period centering on the descending node of 2 years and 114 days duration, Minimum Index O.
4. A South Aphelion High Index Period of 3 years, 103 days duration with Maximum Index 19.49.

The nodal transition and culmination dates for these phases for the 15 Jovian Cycles occurring between 1803 and 1980 are given in Table IV.

The Jovian North Perihelion phase with a maximum index value of 26.97, or 27% greater than the maximum of the South Aphelion phase, should be the one having the greatest effect on climatic deviations. The fact that the wettest year on record in Oklahoma, 1915, when state rainfall averaged 142.2% of normal, occurred when both Jupiter and Venus were in their culminating high-latitude high-index positions in the middle of May, the normally wettest month, can hardly be considered a random coincidence.

To date, Jovian indices have been computed for the months March-August for the years 1892-1948. Thorough investigation cannot be made until indices for the months September-February are also available. Monthly mean index values were determined by averaging nine specific determinations for the 3rd, 5th, 8th, 12th, 15th, 18th, 23rd, 25th, and 28th of each month. Since there is a considerable lag, the monthly indices were averaged and weighted by $\frac{a + 2b}{3}$, in which a is the average index value for the months March to August of the preceding year, and b the averages for the same months of the current year. The years were then classified into four groups according to magnitude of the indices as given in Table V along with the Oklahoma average rainfall, May-August.

It will be noted that during the twelve years in which the Jupiter sun-tide index averaged 6.38 or 41.97% of normal, the May-August rainfall in Oklahoma averaged *only* 82.81% of normal and that 83.3% of the seasons had below normal rainfall; whereas in the ten years with a mean index of 23.59 or 55.2% above normal, the average Oklahoma rainfall was 114.63% of normal and on 70% of the years the rainfall was above normal.

Since the sidereal period of Jupiter is 11.86223 tropical, or ordinary years, one Jovian revolution cycle requires approximately 50 days less time than 12 earth revolutions. As a result, corresponding phases of Jupiter recur approximately 50 days earlier in successive revolutions. Seven Jupiter revolutions require 83.03561 years or 13 days more than 83 earth revolutions, i.e., years. Thus insofar as controlled by Jupiter, the climate of a year should approximately repeat that of 83 years earlier. The rainfall in St. Louis, Missouri, in 1853 was 30.89", 77.8% of normal; in 1936, 83 years later, it was 26.14", 65.8% of normal. In 1844 the rainfall at St. Louis was 45.8", 115.4% of normal; in 1927, 83 years later, it was 56.7" or 142.8% of normal. On both of the dry years, 1853 and 1936, Jupiter had its Bo ascending node 0 index between January 30 and February 12, while on both of the 83 year period recurrent wet years, 1844 and 1927, Jupiter was in its perihelion N, high-index phase between March 12 and March 25. These cases illustrate. They do not prove the existence of an 83.03561 year cycle. Furthermore, it must be remembered that Jupiter is only one of the components of our planetary Heliographic-Climatic System.

It appears, however, that a low Solar Sun Tide Index in the fall months, September-November inclusive, and a high Jovian index in the months December to May both give rise to wet years in Oklahoma and other interior Mississippi Basin states and vice versa. Since the Oklahoma rainfall records are relatively short, 1892 to date, whereas the record for St. Louis, Missouri, extends back to 1837, the annual rainfall of this station has been grouped on the above Jovian heliographic sun tide phase and precession cycle basis. Table V is given for the wet phase years and Table VI for the dry phase years.

TABLE IV

Heliographic Cycle Phases of Jupiter, 1803-1980

JSI:	15.2	0	15.2	26.97	15.2	0	15.2	21.23
PHASE:		Bo		NP		Bo		SA
HCL:	202°36′	250°5′	288°26′	242°9′	35°42′	69°57′	109°24′	155°32′
CYCLES								
I-1	Dec. 18, 1803	Aug. 19, 1805	Dec. 2, 1806	Aug. 10, 1808	Mar. 18, 1810	Apr. 2, 1811	July 9, 1812	Feb. 14, 1814
2	Oct. 29, 1815	June 30, 1817	Oct. 12, 1818	June 20, 1820	Jan. 26, 1822	Feb. 10, 1823	May 20, 1824	Dec. 26, 1825
3	Sept. 9, 1827	May 11, 1829	Aug. 23, 1830	May 1, 1832	Dec. 8, 1833	Dec. 22, 1834	Apr. 31, 1836	Nov. 5, 1837
4	July 20, 1839	Mar. 21, 1841	July 4, 1842	Mar. 12, 1844	Oct. 18, 1845	Nov. 2, 1846	Feb. 8, 1848	Sept. 16, 1849
5	May 31, 1851	Jan. 30, 1853	May 15, 1854	Jan. 21, 1856	Aug. 29, 1857	Sept. 13, 1858	Dec. 20, 1859	July 28, 1861
6	Apr. 11, 1863	Dec. 11, 1864	Mar. 26, 1866	Dec. 1, 1867	July 9, 1869	July 24, 1870	Oct. 31, 1871	June 8, 1873
7	Feb. 19, 1875	Oct. 22, 1876	Feb. 3, 1878	Oct. 12, 1879	May 20, 1881	June 4, 1882	Sept. 10, 1883	Apr. 18, 1885
II-1	Dec. 31, 1886	Sept. 1, 1888	Dec. 15, 1889	Aug. 23, 1891	Mar. 31, 1893	Apr. 15, 1894	July 22, 1895	Feb. 27, 1897
2	Nov. 4, 1898	July 13, 1900	Oct. 25, 1901	July 3, 1903	Feb. 8, 1905	Feb. 24, 1906	June 2, 1907	Jan. 8, 1909
3	Sept. 18, 1910	May 24, 1912	Sept. 5, 1913	May 14, 1915	Dec. 20, 1916	Jan. 5, 1918	Apr. 13, 1919	Nov. 18, 1920
4	July 27, 1922	Apr. 3, 1924	July 19, 1925	Mar. 25, 1927	Oct. 31, 1928	Nov. 15, 1929	Feb. 21, 1931	Sept. 29, 1932
5	June 8, 1934	Feb. 12, 1936	May 28, 1937	Feb. 3, 1939	Sept. 11, 1940	Sept. 26, 1941	Jan. 2, 1943	Aug. 10, 1944
6	Apr. 15, 1946	Dec. 27, 1947	Apr. 7, 1949	Dec. 14, 1950	July 22, 1952	Aug. 6, 1953	Nov. 13, 1954	June 21, 1956
7	Feb. 24, 1958	Nov. 4, 1959	Feb. 16, 1961	Oct. 26, 1962	June 2, 1964	June 17, 1965	Sept. 23, 1966	May 1, 1968
III-1	Jan. 13, 1970	Sept. 14, 1971	Dec. 28, 1972	Sept. 5, 1974	Apr. 13, 1976	Apr. 28, 1977	Aug. 6, 1978	Mar. 12, 1980

TABLE V

Relation of May-August Rainfall in Oklahoma to Jovian Heliographic Sun Tide Indices in 55 Years, 1892-1948

Jovian Indices		Mean Index	Mean Precip. % of Normal	Driest Season	Wettest Season	Rainfall Seasons % Below Normal
Under 9	12 years	6.38	82.81	51.0	133.3	83.3
9-15	12 "	11.31	98.60	70.0	122.8	58.3
15-21	21 "	18.48	101.49	57.4	156.8	52.4
Over 21	10 "	23.59	114.63	73.8	155.7	30.0

The Jovian Precession Cycle (83.03561 Tropical Years)

TABLE VI

Annual Precipitation St. Louis, Mo. in Wet Phases of Jovian Cycles (83.035 Year Precession Cycles and 11.86223 Year Revolution Cycles)

I Precession Period December-May

Revolution Cycle Phase	Date	Inches Current Year	Inches Next Year	Percent of Normal Current Year	Percent of Normal Next Year
JNP:					
(Jup.Hel.:342°9′)	1915 May 14	49.28	41.80	124.1	105.3
(Index: 26.97)	1927 Mar. 25	50.83	38.61	128.0	97.4
High Index 3yr,106d	1939 Feb. 3	40.15	25.00	101.1	63.0
Phase Average		46.75	35.14	117.8	88.5
JSA:					
(Jup.Hel.:155°32′)	1885 Apr. 18	45.59	44.34	114.8	111.7
(Index: 21.23)	1897 Feb. 27	40.17	49.20	101.2	123.9
High Index 3yr,108d	1909 Jan. 8	47.50	37.31	119.6	94.0
Phase Average		44.42	43.62	111.9	109.9

TABLE VII

Annual Precipitation St. Louis, Mo. in Dry Phases of Jovian Cycles' (83.035 Year Precession Cycles and 11.86223 Year Revolution Cycles)

I Precession Period September-November

Revolution Cycle Phase	Date	Inches Next Year	Inches Plus 2	Percent of Normal Next Year	Percent of Normal Plus 2
JNP:					
(Jup.Hel.:342°9′)	1879 Oct. 12	26.70	34.06	64.7	87.3
(Index: 26.97)	1891 Aug. 23	30.53	41.62	76.9	104.8
Phase Average		28.12	38.14	70.8	96.1
JSA:					
(Jup.Hel.:155°32′)	1920 Nov. 18	31.53	41.10	79.4	103.5
(Index: 21.23)	1932 Sept. 29	38.01	34.77	95.7	87.6
Phase Average		34.76	37.94	87.6	95.6

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