The Solar Cycle or El Niño Southern Oscillation (ENSO) as a Criterion for the Definition of Public Policies

Juan Manuel Rodríguez Torres* Gerardo Zavala Guzmán**

* e-mail: rodrito@ugto.mx; Departamento de Arquitectura; DAAD. Phone (52) 473-10-20-100 ext. 2237 fax 2234. ** e-mail: gzg@ugto.mx; Departamento de Estudios Organizacionales; DCEA. Phone (52) 473-7352900 ext. 2868, Universidad de Guanajuato, Guanajuato, Gto. México C. P. 36000

Theme: seeks to explore Global Water, a Resource for Development: Opportunities, Challenges and Constraints Sub-theme 7: Global Challenges for water governance

Introduction

We present a review of two phenomena studied as evidence of climate change on Earth: the first, as the determinant factor for general climate variations; the second – a consequence of the first – as the responsible for the significant variations of the Sea Surface Temperature (SST). The main objective of this work is to find correlations between the Solar Cycle (SC) and El Niño Southern Oscillation (ENSO) phenomenon; whether they have common aspects and from these results, define the possible criteria for public policies that might counteract the impact they could have on future physical, social, and economic issues, among others.

The study of El Niño Southern Oscillation was triggered by its discovery done in the first half of the XX Century by Gilbert Walker. Since then, it has been strongly associated to the discourse of Climatic Change during the last decades and addressed – with noticeably high frequency – by various instances, among them, the National Oceanic and Atmospheric Administration (NOAA).

With regard to the Solar Cycle and its relationship to meteorological phenomena on Earth, major contributions have been effected certainly by Johan R. Wolf and Wladimir P. Köppen, respectively.

Furthermore, more recently Friss-Christensen, Lassen and Svensmark claim to have found strong evidence for the role the sun plays on the Earth's climate change. Their main arguments: a striking correlation between i). global temperatures and length of the sunspot cycle during the period 1860-1986 and ii). cloud cover and solar activity, plus cosmic ray intensities (Hoyt: 1997). These correlations and their consequences, however, are highly controversial. A hard critic of these is P. Laut.

Methods

We start with the analysis of the way in which the Oceanic Niño Index (ONI) is determined and which considers the range from -0.5 to 0.5 °C as the variation range of the Sea Surface Temperature (SST).

This operational definition from the National Oceanic and Atmospheric Administration (NOAA) for El Niño and La Niña is based on the seasonal temperatures of 0.5 °C, warm (El Niño) or -0.5 °C, cold (La Niña) over (below) the normal temperature in the Central Tropical Pacific. A "season" means here any average period of 3 months: December-January-February, January-February-March, and so on. These ranges are shown in **Fig. 1**

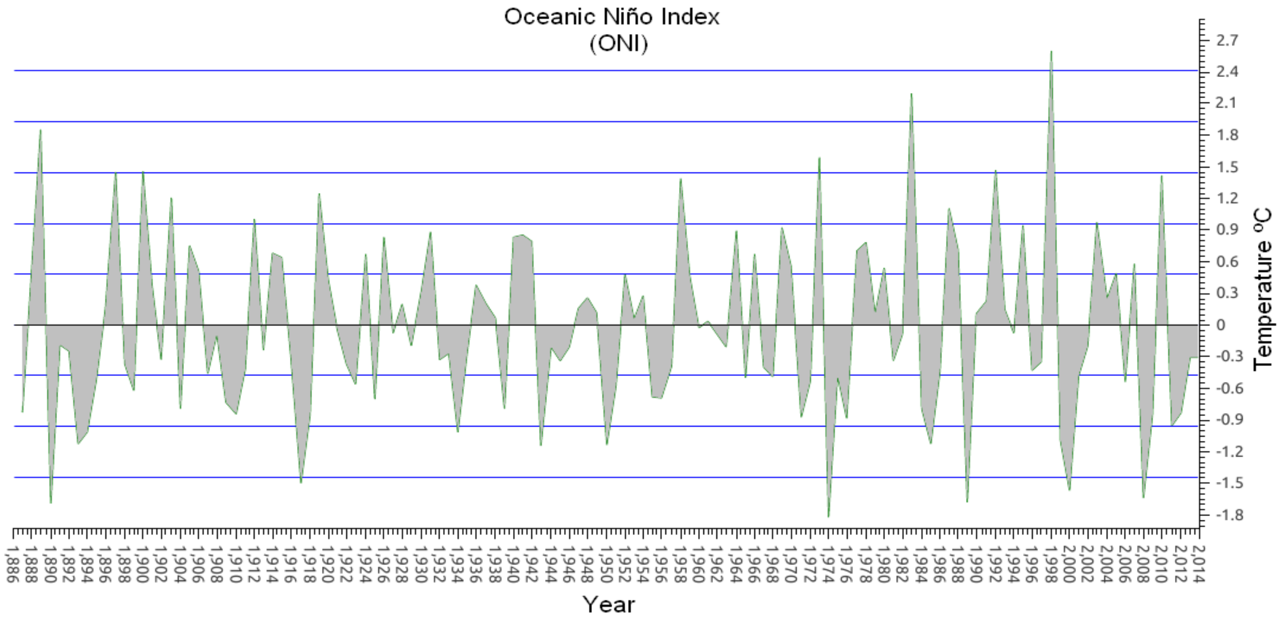

Figure 1. ONI variations for the period 1886-2014

On the other hand, we consider the Solar Cycle (SC) spanning a period of 11.2 years in average. This measurement is reported as the Sunspots Number and is measured daily, monthly and annually. These values are also called International Sunspot Numbers, and are available in the Sunspot Index and Long-term Solar Observations (SILSO) from the Solar Influences Data Analysis Center (SIDC), which in turn, is a dependence of the Solar Physics Research Department of the Royal Observatory of Belgium.

The graphs and tables for El Niño Southern Oscillation (ENSO) were created with data from the NOAA documentation for the Oceanic Niño Index (ONI). The monthly data for the analysis method is the same as the one published by NOAA and considered in the same manner comprising mean periods of 3 months, as it builds up on the period from 1886 to the early months of 2014, and the reference mean for the period 1981-2010.

Results

El Niño (La Niña) is a phenomenon in the Equatorial Pacific Ocean characterized by a period of five consecutive years and the mean Sea Surface Temperature (SST) for a 3-month period. An "anomaly" is the difference between the mean temperature of a 30-year period and the mean temperature of the 3-month cycle.

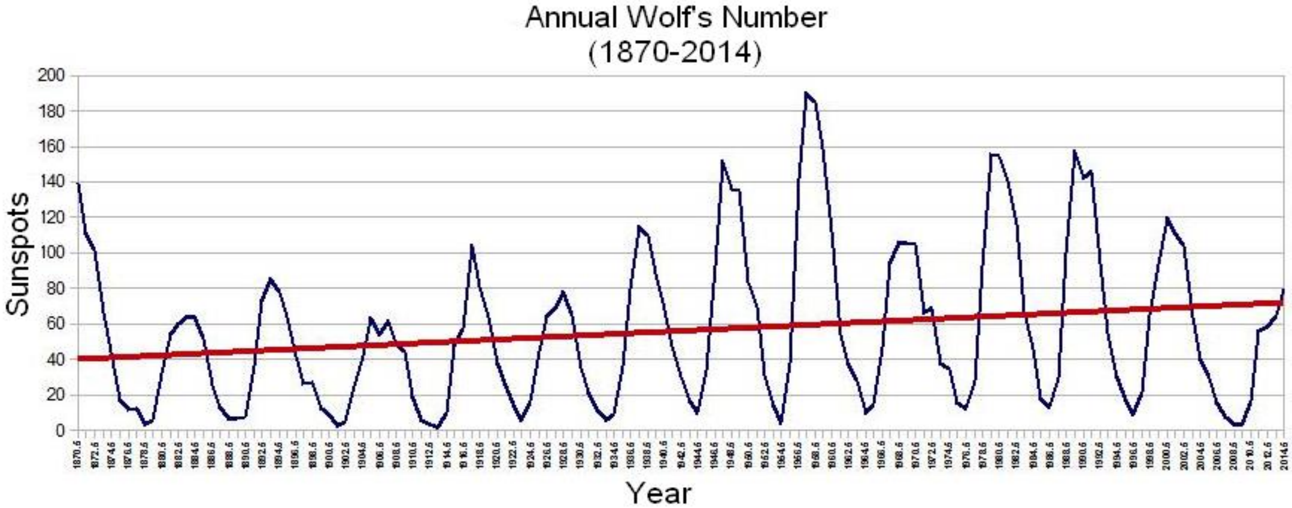

Figure 2. Wolf's Number behavior for the period 1870-2014

The mean values for the initial measurements were calculated for the period 1871-1900 and these cover up to the period 1981-2010 for the region El Niño 3.4 and is above (below) the threshold of +0.5°C (-0.5°C). This standard of measurement is known as the Oceanic Niño Index (ONI).

The regions for El Niño are defined in the following geographic ranges: El Niño-3 region in the eastern Pacific (Latitude: 5°S-5°N, and Longitude: 150°W-90°W), El Niño-4 region in the west-central Pacific (Latitude: 5°S-5°N, Longitude: 150°W-160°E), El Niño-3.4 region, which overlaps with both the El Niño-3 and El Niño-4 (Latitude: 5°S-5°N, Longitude: 170°W-120°W). The information mentioned above is provided by the documentation of NOAA and covers a period from 1950 until early 2014, it also builds upon the last reference period 1981-2010, and it is taken as the basis for comparison, in the region for El Niño 3.4. The Solar Cycle (SC) may occur in a period of 7 to 17 years whereas the average period is comprised of 11.2 years, but at the same time, this period can form composed larger cycles known as Minima of Gleissberg, which occur ca. every 85 years, period in which the solar activity decrease parallels the solarspots maximum as shown in **Fig. 3**.

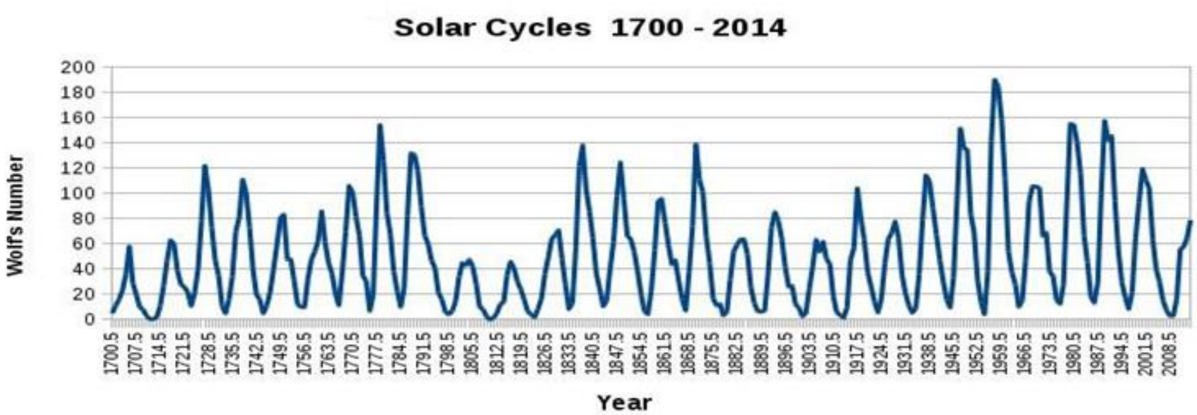

Figure 3. Solar Cycles for the period 1700 -2014 showing the Double Minimum of Gleissberg near 1810.

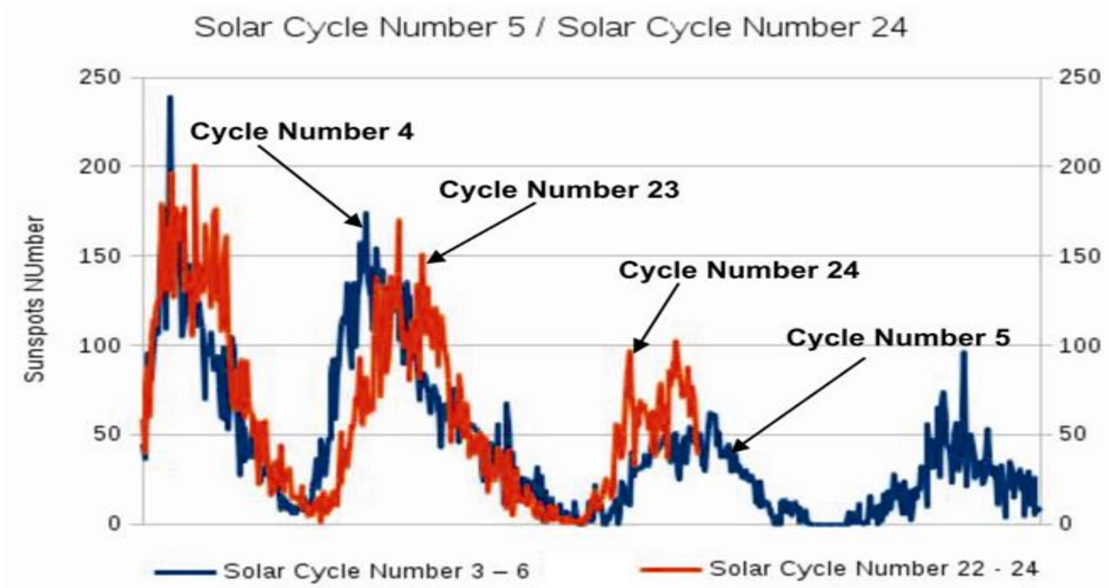

Figure 4. Solar cycles 5 and 24

The last Minimum of Gleissberg took place around 1910 and the previous one around 1810. The latter presented a larger decrease in solar activity than the former characterizing it as a Double Minimum of Gleissberg and suggesting that the next Double Minimum of Gleissberg should correspond to the Solar Cycle 24. This expectation is documented by the similarities in the behavior with the Solar Cycle 5 as depicted by **Fig. 4**.

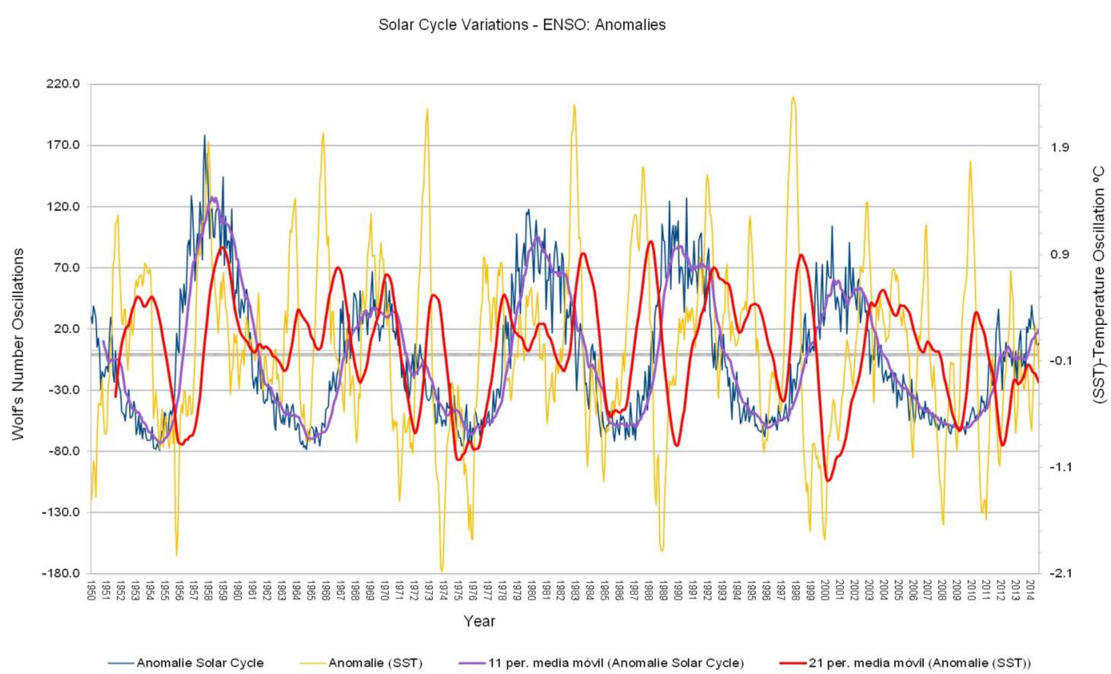

Figure 5. Wolf's Number and (ENSO) anomalies

Table 1 shows the variations of the Oceanic Niño Index (ONI). In **blue**, the values below -0.5 represent “La Niña” and in red, the values above 0.5 define El Niño”. On the other hand, the left column indicates those years considered solar maxima or minima based on the 13-month mean values described elsewhere (Hathaway, 2010).

Table 2 shows the information used to define the variations in Wolf's number, the maxima and minima solar activity oscillations, are shown for 5 consecutive years and the mean of a 30-year are comparable to the period of the Oceanic Niño Index (ONI). This is the equivalent to the “anomaly” defined above but based on the oscillations of Wolf's Number rather than on the mean temperature. These oscillations are measured in terms of the number of solarspots over 30 (shown in red) and below -30 (shown in blue).

Anomalies El Niño/Southern Oscillation (ENSO)

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1886		0.2	0.1	-0.1	-0.4	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.0
1887	-0.9	-0.7	-0.8	-0.9	-0.7	-0.5	-0.3	-0.2	-0.1	0.1	0.2	0.3
1888	0.5	0.7	0.7	0.7	0.7	0.8	0.9	1.0	1.2	1.7	2.0	2.1
1889	1.9	1.7	1.2	0.8	0.6	0.2	-0.3	-0.6	-0.8	-0.9	-1.0	-1.4
1890	-1.8	-1.7	-1.2	-0.8	-0.7	-0.6	-0.8	-0.9	-1.1	-1.0	-0.8	-0.6
1891	-0.2	-0.2	0.1	0.2	0.3	0.3	0.2	0.1	0.0	0.0	0.0	-0.1
1892	-0.3	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.7	-1.0	-1.4	-1.4	-1.3
1893	-1.2	-1.1	-1.1	-1.1	-1.1	-1.2	-1.2	-1.2	-1.3	-1.3	-1.2	-1.1
1894	-1.1	-1.0	-0.9	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9	-0.7	-0.7
1895	-0.5	-0.4	-0.2	0.0	0.0	-0.1	0.0	0.2	0.4	0.5	0.4	0.4
1896	0.2	0.3	0.3	0.2	0.1	0.3	0.6	1.0	1.3	1.4	1.5	1.6
1897	1.5	1.2	0.7	0.3	0.1	0.2	0.2	0.1	-0.1	-0.3	-0.4	-0.4
1898	-0.4	-0.5	-0.5	-0.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-0.4	-0.6
1899	-0.6	-0.5	-0.4	-0.1	0.1	0.2	0.4	0.5	0.9	1.1	1.4	1.5
1900	1.5	1.4	1.2	0.9	0.9	0.9	1.0	0.9	0.8	0.6	0.5	0.6
1901	0.4	0.5	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4
1902	-0.3	-0.3	0.0	0.4	0.7	1.1	1.3	1.5	1.5	1.6	1.5	1.5
1903	1.2	1.1	0.8	0.6	0.4	0.1	0.0	-0.3	-0.3	-0.5	-0.6	-0.8
1904	-0.8	-0.7	-0.6	-0.4	-0.1	0.4	0.7	0.6	0.7	0.5	0.7	0.6
1905	0.8	0.8	0.8	1.0	0.9	1.0	1.0	1.3	1.4	1.3	1.1	1.0
1906	0.5	0.8	0.8	0.6	0.4	0.0	-0.1	-0.5	-0.6	-0.6	-0.5	-0.4
1907	-0.5	-0.4	-0.3	-0.3	-0.3	-0.3	-0.4	-0.3	-0.2	0.0	-0.1	-0.2
1908	-0.1	-0.2	-0.2	-0.4	-0.2	-0.3	-0.3	-0.4	-0.4	-0.6	-0.8	-0.7
1909	-0.8	-0.5	-0.6	-0.3	-0.5	-0.7	-0.9	-0.9	-1.0	-1.1	-1.2	-1.1
1910	-0.9	-0.7	-0.7	-0.9	-1.0	-1.0	-0.8	-0.9	-1.0	-0.8	-0.6	-0.6
1911	-0.4	-0.7	-0.7	-0.8	-0.8	-0.5	-0.3	-0.1	0.0	0.4	0.6	1.1
1912	1.0	1.0	0.8	0.6	0.3	0.0	-0.2	-0.1	-0.2	0.0	-0.2	-0.2
1913	-0.2	0.0	-0.1	-0.1	-0.3	-0.1	-0.1	0.0	0.0	0.3	0.5	0.7
1914	0.7	0.6	0.7	0.5	0.4	0.3	0.6	0.7	0.6	0.4	0.4	0.6
1915	0.7	0.7	0.6	0.7	0.8	0.7	0.5	0.1	0.1	0.1	-0.1	-0.2
1916	-0.3	-0.5	-0.5	-0.3	-0.3	-0.5	-0.9	-1.3	-1.4	-1.5	-1.6	-1.7
1917	-1.6	-1.2	-0.6	-0.3	-0.1	0.0	0.1	0.1	0.0	-0.2	-0.4	-0.7
1918	-0.9	-0.9	-0.7	-0.4	0.0	0.1	0.2	0.2	0.5	0.8	1.1	1.3
1919	1.3	1.2	1.0	0.9	0.8	0.6	0.6	0.5	0.4	0.1	0.0	0.1
1920	0.4	0.6	0.4	0.2	0.1	0.2	0.2	0.2	0.3	0.2	0.1	0.1
1921	-0.1	-0.5	-0.8	-0.8	-0.4	-0.3	-0.1	-0.1	0.0	-0.3	-0.4	-0.7
1922	-0.4	-0.2	-0.1	0.1	-0.1	0.0	-0.4	-0.4	-0.4	-0.2	-0.3	-0.4
1923	-0.6	-0.7	-0.6	-0.4	-0.2	0.0	0.1	0.4	0.7	0.9	1.0	0.8
1924	0.7	0.5	0.4	0.0	-0.3	-0.7	-0.6	-0.7	-0.6	-0.7	-0.7	-0.9
1925	-0.7	-0.7	-0.4	-0.3	-0.2	0.2	0.5	0.8	0.9	1.0	1.2	1.4
1926	0.9	1.3	1.1	1.1	0.9	0.8	0.5	0.3	-0.1	-0.3	-0.4	-0.2
1927	-0.1	0.0	-0.1	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	0.0	0.1	0.1
1928	0.2	0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
1929	-0.2	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.3
1930	0.3	0.3	0.3	0.3	0.3	0.4	0.6	0.9	1.0	1.4	1.4	1.5
1931	0.9	1.3	1.2	1.0	0.7	0.6	0.4	0.1	-0.1	-0.2	-0.2	-0.3
1932	-0.3	-0.1	0.1	0.3	0.3	0.2	0.2	0.1	0.1	0.1	-0.1	-0.2
1933	-0.3	-0.2	-0.1	-0.1	-0.4	-0.5	-0.7	-0.7	-0.9	-0.9	-1.1	-1.1
1934	-1.0	-0.9	-0.7	-0.6	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2
1935	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.2	-0.1	0.2	0.3	0.2	0.4
1936	0.4	0.4	0.3	0.2	0.1	-0.1	-0.2	-0.1	0.1	0.2	0.4	0.2
1937	0.2	0.1	0.3	0.1	-0.1	0.0	0.0	0.2	0.1	0.3	0.2	0.1
1938	0.1	0.0	0.1	0.0	-0.3	-0.6	-0.7	-0.5	-0.5	-0.4	-0.6	-0.7
1939	-0.8	-0.8	-0.7	-0.4	-0.1	0.2	0.3	0.4	0.2	0.3	0.1	0.6
1940	0.9	1.3	1.1	0.9	0.7	0.5	0.7	0.5	0.5	0.5	0.9	1.2
1941	0.9	1.4	1.3	1.4	1.3	1.1	1.0	0.9	1.0	1.2	1.3	1.1
1942	0.8	0.5	0.4	0.3	0.1	-0.2	-0.5	-0.7	-0.9	-1.1	-1.2	-1.2
1943	-1.2	-1.2	-1.0	-0.6	-0.3	0.0	0.1	0.1	0.0	-0.2	-0.3	-0.3
1944	-0.2	-0.2	0.0	0.1	0.2	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.2
1945	-0.3	-0.5	-0.7	-0.6	-0.5	-0.4	-0.5	-0.6	-0.6	-0.5	-0.4	-0.3
1946	-0.2	-0.3	-0.4	-0.4	-0.1	0.1	0.1	0.0	0.0	0.2	0.2	0.2
1947	0.2	0.2	0.0	-0.1	-0.1	-0.1	0.0	-0.4	-0.5	-0.6	-0.2	0.0
1948	0.3	0.4	0.4	0.5	0.3	0.3	0.2	0.2	0.0	0.0	0.0	0.0
1949	0.1	-0.2	0.0	-0.1	-0.1	-0.2	-0.3	-0.2	-0.3	-0.6	-0.8	-1.0
1950	-1.2	-1.2	-1.2	-1.0	-0.9	-0.9	-0.6	-0.7	-0.6	-0.8	-0.8	-1.0

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1951	-0.6	-0.8	-0.5	-0.3	0.0	0.3	0.7	0.9	1.0	1.0	0.9	0.7
1952	0.5	0.3	0.3	0.1	-0.1	-0.4	-0.4	-0.3	-0.1	0.0	-0.1	-0.1
1953	0.1	0.3	0.4	0.5	0.6	0.5	0.4	0.5	0.5	0.6	0.4	0.4
1954	0.3	0.3	0.0	-0.2	-0.4	-0.6	-0.8	-0.9	-0.8	-0.8	-0.8	-0.8
1955	-0.7	-0.7	-0.8	-0.9	-1.0	-1.1	-1.0	-1.0	-1.1	-1.4	-1.5	-1.4
1956	-0.7	-1.0	-0.8	-0.7	-0.6	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6
1957	-0.4	-0.2	0.1	0.4	0.6	0.7	0.8	0.9	0.9	1.0	1.2	1.4
1958	1.4	1.4	1.0	0.6	0.4	0.4	0.4	0.2	0.2	0.2	0.3	0.4
1959	0.5	0.4	0.4	0.3	0.1	0.0	-0.2	-0.2	-0.1	0.0	0.2	0.1
1960	0.0	-0.1	-0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.0
1961	0.0	0.1	0.2	0.2	0.3	0.2	0.1	-0.1	-0.3	-0.2	-0.1	0.0
1962	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.2	-0.2
1963	-0.2	-0.1	0.0	0.2	0.2	0.5	0.8	1.0	1.0	1.0	1.1	1.1
1964	0.9	0.5	0.1	-0.3	-0.5	-0.5	-0.5	-0.5	-0.7	-0.7	-0.8	-0.7
1965	-0.5	-0.3	-0.1	0.1	0.4	0.7	1.1	1.3	1.6	1.8	1.8	1.6
1966	0.7	1.0	0.8	0.6	0.4	0.3	0.3	0.2	0.1	0.0	-0.1	-0.3
1967	-0.4	-0.4	-0.4	-0.2	-0.1	0.0	0.0	-0.2	-0.3	-0.3	-0.3	-0.4
1968	-0.5	-0.6	-0.5	-0.4	-0.1	0.2	0.4	0.4	0.4	0.5	0.7	0.9
1969	1.0	0.9	0.8	0.6	0.5	0.5	0.5	0.5	0.7	0.8	0.8	0.7
1970	0.6	0.5	0.4	0.3	0.1	-0.2	-0.6	-0.7	-0.7	-0.6	-0.8	-1.1
1971	-0.9	-1.3	-1.1	-0.9	-0.7	-0.6	-0.6	-0.6	-0.6	-0.7	-0.8	-0.7
1972	-0.5	-0.3	0.0	0.2	0.5	0.8	1.1	1.2	1.5	1.7	2.0	1.9
1973	1.6	1.1	0.6	0.1	-0.4	-0.7	-1.0	-1.1	-1.3	-1.6	-1.9	-2.1
1974	-1.9	-1.6	-1.2	-0.9	-0.7	-0.6	-0.4	-0.3	-0.4	-0.6	-0.8	-0.7
1975	-0.5	-0.4	-0.4	-0.6	-0.8	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6
1976	-0.9	-1.1	-0.6	-0.4	-0.1	0.0	0.3	0.4	0.6	0.8	0.8	0.8
1977	0.7	0.7	0.3	0.2	0.2	0.4	0.5	0.5	0.6	0.9	1.0	1.0
1978	0.8	0.5	0.2	-0.1	-0.3	-0.3	-0.4	-0.5	-0.5	-0.3	-0.1	0.0
1979	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.3	0.4	0.4	0.5	0.6
1980	0.6	0.4	0.3	0.3	0.4	0.3	0.2	0.0	-0.1	0.0	0.2	0.0
1981	-0.3	-0.4	-0.2	-0.1	-0.1	-0.2	-0.2	-0.1	0.0	-0.1	-0.1	-0.1
1982	-0.1	-0.1	0.0	0.3	0.7	0.8	0.9	1.1	1.5	1.9	2.1	2.2
1983	2.3	2.1	1.7	1.4	1.0	0.6	0.2	-0.2	-0.5	-0.8	-1.0	-1.0
1984	-0.8	-0.6	-0.5	-0.5	-0.7	-0.6	-0.5	-0.3	-0.5	-0.7	-1.2	-1.2
1985	-1.2	-1.0	-1.0	-0.9	-0.8	-0.7	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
1986	-0.5	-0.6	-0.5	-0.4	-0.2	0.0	0.2	0.4	0.6	0.9	1.0	1.1
1987	1.1	1.2	1.2	1.1	1.1	1.3	1.4	1.5	1.5	1.5	1.3	1.1
1988	0.7	0.5	0.1	-0.3	-0.9	-1.2	-1.4	-1.4	-1.6	-1.8	-2.0	-2.0
1989	-1.7	-1.5	-1.2	-1.0	-0.8	-0.5	-0.5	-0.4	-0.4	-0.3	-0.2	-0.1
1990	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3
1991	0.2	0.2	0.2	0.2	0.4	0.5	0.5	0.4	0.4	0.7	1.1	1.3
1992	1.5	1.5	1.5	1.4	1.1	0.7	0.2	0.0	-0.3	-0.3	-0.3	0.0
1993	0.2	0.3	0.6	0.7	0.8	0.6	0.4	0.2	0.2	0.2	0.2	0.1
1994	-0.1	-0.1	-0.1	0.0	0.1	0.2	0.3	0.3	0.5	0.7	1.0	1.0
1995	1.0	0.8	0.5	0.2	0.1	0.0	-0.1	-0.3	-0.6	-0.8	-0.9	-0.8
1996	-0.4	-0.6	-0.5	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4
1997	-0.4	-0.2	0.0	0.4	0.8	1.2	1.6	1.9	2.1	2.3	2.3	2.4
1998	2.7	2.7	2.5	1.8	0.9	0.2	-0.3	-0.3	-0.2	-0.2	-0.3	-0.7
1999	-1.1	-1.3	-1.0	-0.9	-0.9	-0.9	-0.9	-0.9	-1.0	-1.1	-1.3	-1.6
2000	-1.6	-1.5	-1.2	-1.0	-0.8	-0.7	-0.6	-0.4	-0.4	-0.6	-0.7	-0.8
2001	-0.5	-0.7	-0.5	-0.4	-0.2	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3
2002	-0.2	0.0	0.1	0.1	0.3	0.5	0.7	0.7	0.9	1.1	1.3	1.3
2003	1.0	0.7	0.4	0.0	-0.2	-0.2	0.0	0.1	0.2	0.3	0.4	0.3
2004	0.3	0.1	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.7	0.7	0.6
2005	0.5	0.4	0.3	0.3	0.3	0.2	0.1	0.0	-0.1	-0.2	-0.4	-0.7
2006	-0.6	-0.8	-0.6	-0.4	-0.1	0.0	0.2	0.3	0.6	0.8	0.9	0.9
2007	0.6	0.2	-0.1	-0.2	-0.2	-0.3	-0.4	-0.7	-1.0	-1.3	-1.5	-1.7
2008	-1.7	-1.5	-1.2	-0.9	-0.7	-0.4	-0.2	-0.1	-0.2	-0.3	-0.5	-0.8
2009	-0.9	-0.8	-0.6	-0.3	0.1	0.4	0.6	0.7	0.8	1.0	1.4	1.6
2010	1.5	1.2	0.9	0.5	-0.1	-0.5	-0.9	-1.3	-1.5	-1.6	-1.6	-1.6
2011	-1.0	-1.3	-1.0	-0.8	-0.5	-0.3	-0.4	-0.5	-0.8	-0.9	-1.0	-1.0
2012	-0.9	-0.7	-0.5	-0.3	-0.1	0.1	0.4	0.5	0.4	0.3	0.1	-0.1
2013	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.2
2014	-0.3	-0.3	-0.1	0.2	0.4	0.4	0.3	0.2	0.2			

Left Column 13-month Mean Minimum

Left Column 13-month Mean Maximum

Solar cycle MINIMUM – MAXIMUM

Table 1

Wolf's Number Oscillation

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1886		-4.1	-1.2	1.7	-8.4	-12.4	-17.1	-18.3	**-23.8**	-27.7	-28.9	-28.6
1887	-27.3	-32.5	-35.4	-31.8	-28.0	-22.1	-21.7	-23.7	-27.6	-30.9	-24.8	-23.1
1888	-25.9	-32.6	-36.9	-35.6	-35.8	-36.1	-37.5	-36.2	-34.9	-30.6	-29.7	-30.4
1889	-34.1	-36.4	-37.0	-37.7	-37.8	-35.7	-29.7	-29.0	-29.7	-34.9	-33.2	-32.4
1890	-35.2	-38.1	-41.1	-38.4	-39.6	-35.9	-34.7	-28.7	-27.1	-25.2	-26.7	-17.8
1891	-10.1	-17.2	-16.0	-9.1	2.5	14.7	11.5	13.7	11.8	15.4	9.3	16.3
1892	26.8	32.3	31.4	33.3	41.1	42.8	49.5	45.4	43.9	32.6	38.8	41.5
1893	43.3	38.6	41.9	46.4	53.5	53.0	67.4	63.8	61.4	44.0	50.3	52.5
1894	54.9	40.8	39.2	45.3	59.8	67.3	56.5	45.9	36.2	32.4	31.4	28.5
1895	31.2	31.2	34.7	35.4	37.9	27.6	27.5	23.3	30.5	24.0	29.3	18.2
1896	2.7	7.5	11.5	2.8	1.3	0.8	0.0	3.8	-0.6	3.9	-1.1	3.6
1897	-0.7	-5.6	-9.7	-11.7	-18.1	-20.2	-20.2	-8.2	-11.6	-15.1	-18.8	-12.8
1898	-4.9	-3.7	-9.8	-12.2	-18.0	-20.8	-19.5	-15.7	-6.1	-5.4	-11.5	-15.8
1899	-24.4	-23.0	-25.7	-25.0	-24.7	-25.9	-28.1	-32.5	-31.5	-29.0	-27.1	-27.5
1900	-27.0	-28.1	-26.8	-25.1	-24.4	-27.9	-32.2	-33.8	-31.1	-30.2	-31.6	-22.8
1901	-19.5	-27.8	-28.4	-25.1	-25.3	-26.5	-30.9	-33.4	-31.4	-29.0	-28.2	-26.6
1902	-28.8	-24.2	-26.6	-25.0	-29.3	-30.4	-31.8	-30.5	-24.5	-20.3	-21.4	-23.1
1903	-21.8	-17.3	-11.8	-12.0	-11.7	-12.5	-9.0	-11.5	-6.9	-0.2	12.3	10.9
1904	3.3	0.9	4.2	9.9	10.8	11.9	16.9	12.2	14.3	9.1	18.3	19.4
1905	34.4	35.5	29.8	17.9	14.8	24.6	26.9	28.1	31.0	48.6	49.8	34.2
1906	-0.6	7.8	10.9	19.8	18.2	32.2	27.7	25.1	-2.4	-3.5	0.7	21.5
1907	43.8	42.5	34.3	12.7	4.8	1.7	4.3	19.0	25.3	29.5	18.3	10.8
1908	0.8	-5.3	0.6	3.0	8.3	0.2	15.6	28.3	27.0	13.8	-0.7	8.7
1909	8.3	17.3	8.9	5.5	-10.2	-11.2	-16.6	-11.5	-2.8	9.9	16.4	6.9
1910	-1.9	-12.8	-19.1	-22.1	-26.2	-26.4	-31.2	-26.8	-17.6	-18.0	-23.4	-22.5
1911	-16.6	-25.6	-21.5	-21.0	-22.6	-28.9	-31.3	-31.7	-31.3	-31.0	-30.5	**-29.6**
1912	-31.0	-30.6	-29.5	-27.5	-27.5	-30.0	-32.1	-31.2	-30.0	-29.6	-29.5	**-28.6**
1913	-28.0	-30.4	-31.2	-31.6	-31.5	-33.2	-33.9	-34.5	-33.3	-33.0	-31.0	**-29.4**
1914	-28.8	-29.5	-25.0	-23.6	-20.5	-26.5	-26.4	-26.9	-25.3	-22.2	-17.9	-11.3
1915	-2.7	2.4	8.2	5.6	15.9	24.0	35.5	28.1	22.7	13.9	10.0	3.5
1916	7.9	16.9	26.1	32.8	32.7	24.5	10.9	3.3	3.2	13.5	16.2	25.2
1917	27.3	41.4	41.8	56.2	62.6	75.6	88.5	93.3	78.2	59.0	59.1	68.0
1918	57.6	38.8	34.0	38.1	33.6	40.5	48.3	55.1	48.4	42.5	35.7	24.3
1919	23.0	25.7	27.3	30.5	45.1	47.3	40.4	21.5	18.4	9.5	3.0	3.4
1920	7.4	19.4	7.6	1.1	-9.7	-7.5	-12.8	-13.6	-5.4	-2.6	-4.6	-7.8
1921	-5.1	-9.0	-8.3	-10.0	-8.3	-6.8	-6.3	-11.5	-18.3	-19.7	-18.5	-20.5
1922	-18.4	-6.8	-6.8	-12.6	-29.4	-31.1	-31.4	-31.7	-32.1	-31.5	-26.9	-27.3
1923	-30.1	-34.7	-33.8	-32.9	-31.6	-34.1	-34.8	-33.3	-29.5	-26.0	-29.1	-32.7
1924	-35.1	-35.3	-31.4	-25.8	-19.0	-15.1	-15.3	-14.9	-14.6	-13.2	-15.7	-22.3
1925	-22.9	-22.2	-13.2	-6.3	3.0	3.6	2.2	6.5	17.9	25.1	38.2	27.2
1926	17.9	24.2	12.7	10.5	12.0	14.5	13.3	10.7	18.7	19.7	25.6	29.9
1927	40.1	37.6	41.1	36.1	30.5	15.5	6.7	11.5	15.9	21.7	13.7	21.3
1928	22.9	37.0	35.6	36.4	36.2	40.0	41.9	43.0	32.4	22.6	12.1	15.4
1929	19.0	16.8	11.0	9.1	14.2	17.9	20.1	9.3	5.5	11.9	36.2	40.8
1930	29.9	6.2	-3.2	-8.0	-12.2	-19.7	-24.0	-21.2	-15.4	-10.5	-12.9	-9.5
1931	-11.9	-17.6	-12.3	-18.5	**-24.8**	-31.3	-35.7	-33.1	-34.3	-31.2	-31.8	-30.2
1932	-33.6	-35.5	-36.1	-33.7	-31.4	-33.9	-38.1	-42.8	-41.7	-40.0	-37.9	-35.9
1933	-31.9	-32.0	-35.4	-41.7	-44.7	-46.7	-48.2	-46.9	-45.5	-44.2	-46.0	-44.9
1934	-43.2	-41.7	-39.3	-35.4	-35.9	-38.5	-42.8	-42.4	-42.3	-40.9	-37.3	-32.1
1935	-28.9	-26.1	-28.5	-26.3	-20.1	-14.8	-14.4	-14.2	-6.5	6.1	12.4	10.4
1936	9.7	17.5	19.0	12.1	8.2	0.0	10.4	13.3	26.6	37.8	53.6	70.2
1937	73.6	61.1	50.8	46.5	60.4	71.8	78.3	69.3	63.7	44.3	40.4	33.6
1938	47.6	47.5	45.8	48.2	50.3	71.1	66.8	65.0	44.0	48.0	49.0	44.8
1939	28.9	20.2	27.3	40.6	51.1	46.7	42.1	46.8	44.7	33.9	10.4	0.0
1940	-3.9	10.5	11.4	9.4	8.0	9.7	26.2	21.3	18.2	4.3	4.9	5.5
1941	-7.3	-9.7	-16.2	-22.2	-20.1	-8.7	0.7	3.9	-2.0	-6.9	-17.2	-19.5
1942	-15.3	-7.7	-1.5	-11.8	-28.4	-42.7	-45.1	-42.0	-40.5	-34.8	-32.5	-33.5
1943	-34.7	-32.3	-30.0	-35.9	-44.8	-49.1	-48.1	-46.2	-47.0	-47.8	-44.4	-44.5
1944	-48.4	-50.1	-53.5	-53.8	-58.2	-56.6	-52.6	-48.4	-43.4	-43.1	-38.0	-36.2
1945	-36.2	-37.6	-35.4	-30.4	-27.8	-24.3	-26.6	-25.9	-16.2	-7.2	-9.3	-13.0
1946	-1.1	1.6	8.3	5.5	2.2	15.5	20.8	27.2	23.4	32.2	42.7	49.1
1947	53.5	57.7	66.5	86.7	95.8	98.3	92.1	93.3	96.0	79.0	62.8	46.3
1948	33.6	27.9	52.4	79.2	101.3	85.3	77.8	69.1	67.9	50.5	50.1	46.3
1949	76.4	84.4	91.1	63.3	49.1	41.8	45.6	52.9	55.6	65.5	57.6	49.6
1950	34.6	33.5	34.8	36.2	25.2	17.5	8.5	-2.9	-12.0	-18.9	-16.5	-12.3

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1951	-7.3	-12.3	-3.8	9.6	22.0	11.7	-6.1	-12.7	-15.2	-14.1	-24.1	-26.1
1952	-35.2	-42.4	-48.7	-51.3	-49.0	-45.5	-36.9	-40.5	-44.8	-51.8	-47.3	-44.8
1953	-50.1	-57.4	-59.4	-59.4	-57.9	-64.2	-62.5	-64.1	-63.5	-66.8	-69.9	-71.0
1954	-70.6	-67.0	-68.9	-71.6	-77.7	-76.6	-76.0	-76.4	-74.8	-70.6	-66.1	-59.1
1955	-54.5	-54.6	-61.0	-61.1	-54.7	-49.4	-47.4	-44.6	-33.2	-13.0	0.8	6.7
1956	17.9	32.9	43.8	45.0	43.2	49.9	60.3	78.0	86.9	100.6	108.4	112.5
1957	89.2	78.5	80.4	88.9	102.1	106.6	103.9	114.4	136.8	157.5	160.2	143.9
1958	129.0	113.6	109.9	110.5	102.9	101.8	109.6	118.3	115.2	102.3	99.3	112.1
1959	109.5	109.6	90.1	96.8	89.9	85.9	94.5	85.5	73.0	50.8	45.7	58.1
1960	52.5	45.7	36.1	37.7	39.2	39.6	43.9	48.4	35.6	23.8	11.5	9.1
1961	-15.9	-23.4	-23.3	-24.8	-18.4	-15.3	-13.8	-19.4	-29.2	-33.2	-39.1	-39.0
1962	-33.4	-30.8	-29.3	-34.7	-37.6	-45.6	-53.1	-51.0	-44.0	-38.6	-46.0	-52.7
1963	-53.9	-55.3	-53.2	-50.1	-45.6	-48.6	-52.1	-52.1	-45.8	-45.3	-51.3	-58.2
1964	-60.4	-59.2	-62.5	-68.4	-72.6	-74.2	-74.5	-76.9	-74.9	-71.8	-66.3	-62.7
1965	-60.8	-61.2	-65.8	-65.7	-66.0	-64.2	-69.4	-70.1	-66.3	-60.3	-58.2	-39.4
1966	-30.2	-44.7	-36.8	-32.1	-26.8	-24.4	-22.2	-23.4	-24.2	-20.7	-12.6	5.6
1967	18.3	34.8	22.0	17.4	0.4	7.5	14.6	15.8	13.6	10.8	28.8	40.2
1968	46.7	38.0	25.5	28.3	32.2	36.9	31.2	31.5	34.3	28.0	27.0	26.1
1969	38.2	49.6	51.4	49.0	36.9	33.3	26.2	19.3	17.9	17.9	21.5	27.0
1970	39.1	43.4	43.8	41.4	40.6	41.3	30.0	25.6	15.9	18.2	14.3	10.4
1971	2.6	-4.0	-10.0	-18.3	-22.0	-19.0	-16.9	-18.8	-28.9	-26.2	-14.1	-11.0
1972	-4.4	-4.3	-3.3	-7.0	-4.5	-0.1	-0.5	-10.6	-16.0	-25.6	-30.4	-36.6
1973	-37.9	-36.9	-31.7	-32.9	-35.2	-46.7	-51.5	-47.0	-44.8	-43.3	-53.8	-55.1
1974	-56.2	-56.0	-51.3	-47.9	-43.1	-38.0	-39.1	-39.8	-43.0	-43.8	-48.9	-58.5
1975	-64.8	-67.0	-71.2	-73.1	-73.2	-65.5	-54.5	-55.8	-62.4	-67.1	-67.7	-43.6
1976	-42.3	-57.6	-54.0	-51.5	-55.2	-61.0	-59.4	-60.3	-55.2	-57.3	-56.4	-56.5
1977	-52.2	-53.0	-54.1	-55.8	-46.3	-43.6	-39.6	-39.0	-32.8	-31.5	-31.4	-27.4
1978	-7.5	5.0	20.9	17.1	22.8	12.9	4.9	18.0	35.1	50.0	45.1	60.3
1979	71.8	78.3	56.6	55.4	58.8	78.0	80.8	92.5	100.2	115.5	111.8	104.3
1980	93.2	77.9	79.4	87.5	97.4	88.0	73.4	71.4	79.6	85.4	92.2	61.6
1981	31.9	51.8	67.0	64.7	50.3	45.3	55.1	80.1	85.4	80.4	73.5	57.1
1982	62.2	64.4	69.1	44.2	30.2	24.2	32.0	34.4	29.6	28.5	30.1	27.3
1983	8.0	-11.2	-11.3	7.0	15.7	15.4	5.7	-8.4	-18.1	-28.9	-35.6	-34.6
1984	-20.9	-3.2	2.2	1.4	-10.6	-22.1	-39.7	-50.3	-59.7	-58.5	-58.6	-56.5
1985	-62.4	-61.9	-60.9	-54.8	-52.0	-47.9	-54.0	-61.2	-66.2	-62.5	-59.1	-38.7
1986	-38.8	-57.0	-51.9	-53.4	-58.7	-60.4	-64.2	-63.4	-58.0	-53.9	-53.4	-59.6
1987	-65.3	-61.4	-51.9	-40.0	-39.8	-43.6	-43.4	-38.0	-29.1	-27.2	-30.0	-28.4
1988	-29.8	-12.2	-2.8	5.6	13.5	20.5	36.0	42.0	45.4	51.4	70.6	84.8
1989	96.7	82.0	71.5	64.4	85.3	82.5	90.9	84.3	94.8	97.7	93.5	101.6
1990	85.9	78.8	66.2	68.5	56.1	57.6	78.6	85.1	83.5	62.0	63.0	39.6
1991	52.1	74.8	75.6	61.2	69.4	79.4	95.9	81.3	70.5	49.0	54.8	59.2
1992	76.5	65.3	48.3	20.2	5.3	-0.6	-5.5	-5.8	-5.7	4.6	10.3	2.9
1993	2.3	-0.6	0.1	-8.8	-16.5	-19.2	-27.4	-36.3	-37.7	-38.7	-30.5	-27.5
1994	-28.0	-32.3	-46.4	-51.4	-53.6	-48.6	-48.8	-49.4	-47.3	-47.6	-48.0	-52.2
1995	-48.6	-45.5	-49.2	-53.4	-59.6	-60.7	-62.5	-63.6	-62.3	-62.9	-64.1	-44.4
1996	-36.0	-53.8	-56.3	-54.9	-54.2	-54.5	-53.7	-55.9	-57.6	-54.5	-51.3	-48.8
1997	-53.1	-54.8	-51.8	-47.2	-46.0	-49.1	-49.3	-35.3	-30.4	-23.6	-27.6	-23.8
1998	-24.1	-19.8	-12.9	-6.6	-1.5	1.6	11.4	19.9	16.9	12.9	8.5	11.5
1999	8.1	3.5	3.8	18.2	41.0	56.2	49.8	28.9	30.7	45.9	49.5	41.5
2000	33.9	51.7	63.2	67.1	62.4	75.9	76.7	72.8	49.9	44.0	41.6	29.6
2001	17.5	34.4	38.2	44.5	51.2	41.2	42.3	49.0	64.3	66.3	59.4	56.5
2002	56.0	44.5	46.4	51.9	48.3	39.9	36.3	44.5	44.6	39.6	29.3	24.2
2003	6.9	0.1	-6.7	-2.9	2.4	8.8	12.7	4.2	-1.0	-0.8	-2.2	-10.8
2004	-18.7	-18.1	-17.7	-18.1	-20.3	-17.7	-20.1	-24.1	-24.4	-21.5	-25.5	-30.2
2005	-35.8	-33.8	-36.5	-31.0	-26.2	-22.3	-26.5	-31.2	-40.9	-45.1	-39.4	-21.1
2006	-34.5	-51.9	-47.2	-40.4	-39.5	-46.8	-52.1	-50.8	-50.7	-45.8	-46.8	-43.9
2007	-48.2	-51.5	-56.2	-54.9	-52.5	-51.8	-55.9	-58.0	-60.2	-59.6	-57.7	-56.1
2008	-56.8	-57.3	-57.7	-56.3	-58.4	-60.5	-63.6	-63.2	-61.8	-58.6	-59.4	-59.1
2009	-60.8	-61.0	-61.5	-60.0	-59.4	-60.0	-63.1	-61.5	-60.2	-56.9	-55.4	-51.8
2010	-47.7	-46.4	-48.4	-50.7	-51.5	-50.2	-48.7	-43.7	-40.5	-37.9	-42.2	-28.8
2011	-25.1	-27.4	-15.8	-10.8	-17.3	-22.2	-21.3	-6.5	8.9	26.3	23.9	14.9
2012	-7.2	-10.3	-11.6	1.4	1.3	3.7	-0.5	-0.4	-4.0	-2.4	-10.0	-6.0
2013	-14.7	-9.2	-6.3	8.2	6.3	-0.2	-6.6	-10.7	-0.4	5.5	22.5	22.1
2014	29.5	29.8	30.5	22.5	15.4	9.9	7.6	5.0	2.8			

Left Column — 13-month Mean Minimum

Left Column — 13-month Mean Maximum

Solar cycle MINIMUM – MAXIMUM

Table 2

Conclusions

Based on our results, we propose the use of the Wolf's Number Oscillation Index (WNOI) – as a more uniform alternative to the ONI – in the range over 30 and below -30.

The analysis of the material presented and the arguments discussed allows us to define a possible relationship between phenomena related to Solar Cycle, the ENSO, climatic conditions, as well as some criteria for the stablishment of public policies for preservation and remediation of the environment in the long run.

We can conclude that solar activity oscillations impact the earth climatic conditions to such a extent that they become measurable only in the long run. The magnitud of the Solar Cycle – from 7 to 17 and a mean of 11.2 years – seems to support this statement.

Based on the similarities of the Solar Cycles 5 and 24 we can expect a longer period of cold weather for the years 2022 y/o 2034, corresponding to the Solar Cycles 24 and 25. An issue of higher importance for those countries located far away from tropical zones. Associated aspects are oil prices, environmental pollution, among others.

One of these criteria – resulting from the knowledge of the behavior of these phenomena – deals with energy issues. The apparently perceived expectations will have to consider a variety of proposals directed toward the conservation of energy resources whose timing and magnitud could be critical and could determine its effectiveness.

With this exercise we try to put the solar cycle in the perspective of the critical variable that determines the terrestrial climate.

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