

CLIMATE CYCLES OF WESTERN WASHINGTON

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REVISIONS AS OF MARCH 2021

TWO WEEK – FOUR WEEK CYCLES AND LUNAR – SOLAR EFFECTS UPON PACIFIC NORTHWEST WEATHER

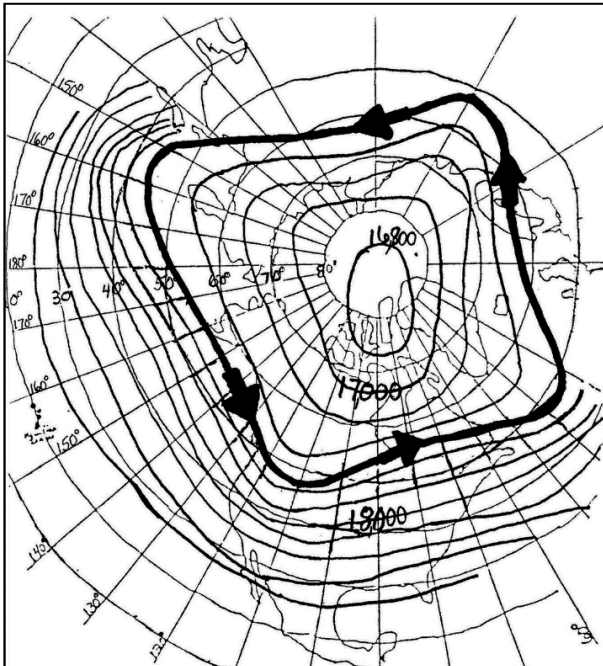
By Gary Morris 2020

NOTE: SEE “
Two Week and Four Week Climate Cycles”
FOR FULL REPORT.

POSITIVE PHASE–ARCTIC OSCILLATION STRONG VORTEX- STRONG WESTERLY FLOW

Lower Arctic Air Pressure
EXTREMELY COLD AIR CONFINED TO ARCTIC
WARM MIDDLE LATITUDES

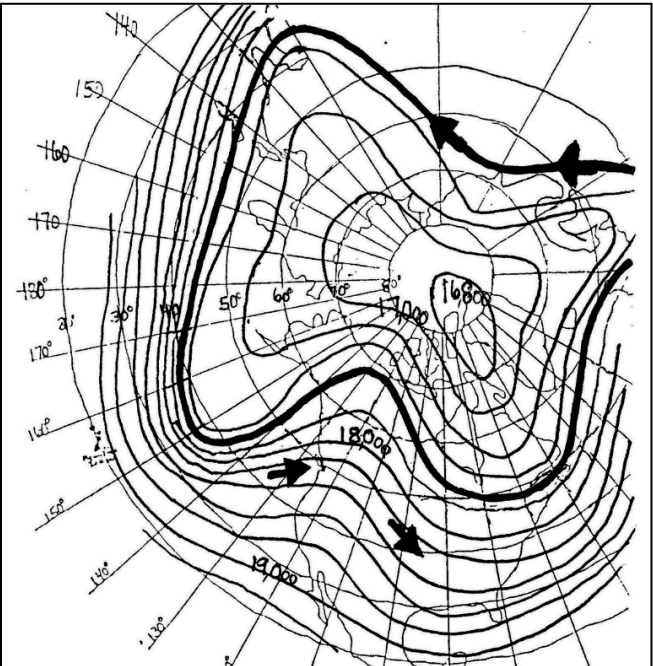
COLD PACIFIC NORTHWEST
About 18,00 feet altitude (500 mbar)



NEGATIVE PHASE–ARCTIC OSCILLATION WEAK VORTEX – WEAK WESTERLY FLOW

Higher Arctic Air Pressure
COLD AIR SPILLS INTO MIDDLE LATITUDES
WARM MIDDLE LATITUDE AIR SPILLS INTO ARCTIC

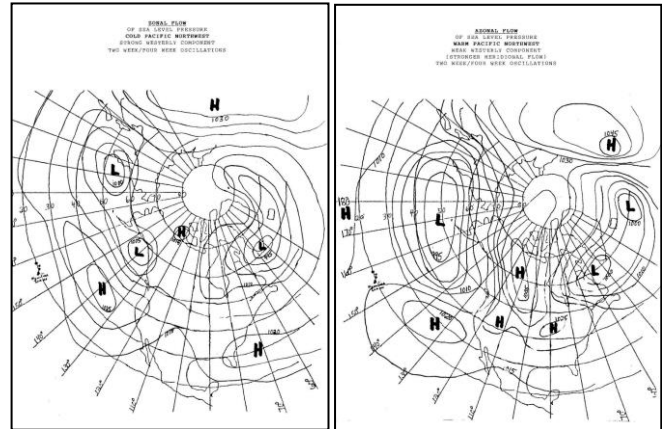
WARM PACIFIC NORTHWEST
About 18,000 feet altitude (500 mbar)



CLIMATE CYCLES OF WESTERN WASHINGTON

Lower Polar pressure indicates increased momentum and High Zonal flow, whereas, High Polar pressure indicates reduced momentum and Low Zonal flow.

The two week and four week cycles are similar in character, being associated with planetary wave patterns varying from increases or decreases in the flow of upper level westerlies. During weak upper level westerlies (weak zonal flow), a ridge of high pressure develops over North America and low pressure develops over the Pacific, bringing a southwesterly flow of air and warmer temperatures over our area. When the upper level westerlies are strong (high zonal flow) the low pressure over the Pacific is weakened, allowing a more westerly/ Northwestly flow of air and cooler temperatures.



**Sea Level Pressure
Arctic Positive Phase**

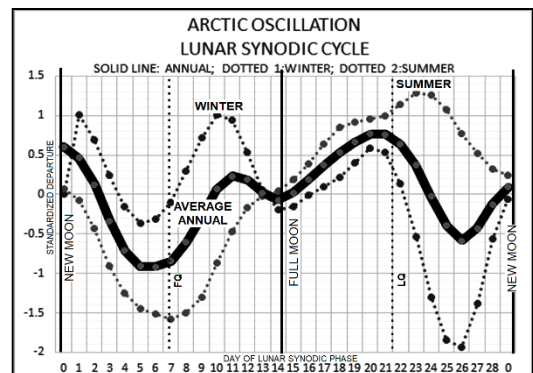
**Sea Level Pressure
Arctic Negative Phase**

Atmospheric winds at the 500 MB level (about 18,000 feet) follow a somewhat circular path around the North Pole during high zonal flow, whereas during weak winds, atmospheric flow is more easily perturbed by continental barriers. In the Northern Hemisphere, the two Continental masses divert incoming winds in a northerly flow around and over the Continent, with high pressure on the lee side of mountain ranges, and lower pressure in front. This creates two main atmospheric waves in the Northern Hemisphere known as Rossby Waves (Planetary Waves of orographically forced nature), with the greatest amplitude via the jet stream flow. The pattern of variation resembles a mobile cyclonic wave train originating in the jet stream entrance region. Northern Hemisphere response is greatest over the North/Northeast Pacific and dissipates as the wave travels Southeastward across North America and into the tropics, or moves into Western Europe.

The Arctic Oscillation appears as a circular pattern of sea-level pressure anomalies centered at the poles. The continents and large landmasses disrupt the circular structure at the Arctic Pole, but anomalies around the Antarctic pole are nearly circular.

ARCTIC OSCILLATION - LUNAR CORRELATION

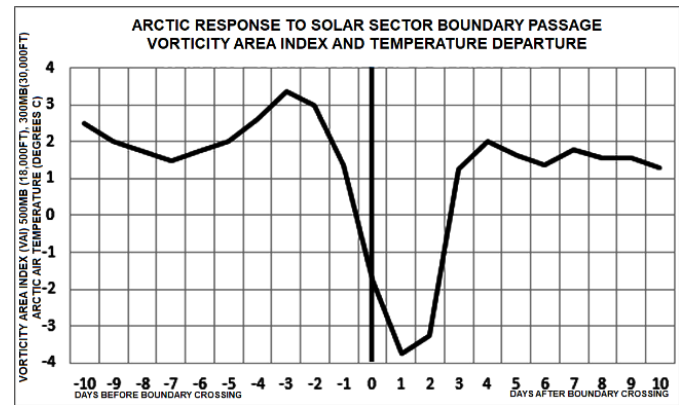
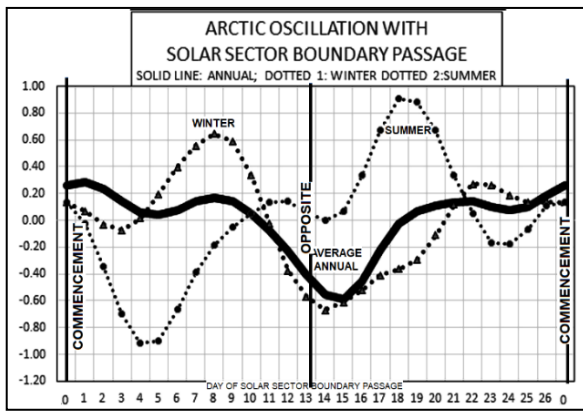
Polar regions exhibit strong lunar phase modulation with higher temperatures occurring near full moon and lower temperatures at new moon.



SOLAR SECTOR BOUNDARY CORRELATION

SOLAR SECTOR BOUNDARY PASSAGE AND THE TROPOSPHERIC TEMPERATURE RESPONSE IN NORTHERN HEMISPHERE WINTERS. The polar temperature reaches a minimum on the first half-day after the passage of SSBs in Winter, below the 500mb level, and this variation spreads to 70°N. The whole heating in middle latitudes (60-35°N) is almost equal to the whole cooling in the polar region (90-65°) at each le

CLIMATE CYCLES OF WESTERN WASHINGTON



AVG Winter Arctic Response to Solar Sector Boundary Passage
Northern Hemisphere Vorticity Area Index (VAI)
and Arctic Temperature (500mb) Departure

Vorticity Area Index (VAI) is a measure of low pressure troughs in Northern Hemisphere at latitudes >20 deg. The greatest winter Stratospheric winds are in the upper Stratosphere (or higher – above 100,000 feet). The appearance of the Stratospheric polar vortex each winter is in response to the large-scale temperature gradients between the midlatitudes and the pole.

TRANSMISSION FROM SPACE TO THE SURFACE OF THE EARTH

The solar induced response at the earth has the greatest coherency over the geomagnetic North Pole above about 50,000 feet to the Magnetosphere. The Solar response is also transmitted via UV radiation in the earth's mesosphere and stratosphere. Above about 50,000 feet the response resembles the same two dimensional scale as the polar vortex itself, with strongest amplitude and coherency centered over the North Pole, weakening considerably, or a 180 degree phase transition centered near mid-latitudes (40 - 60 North).

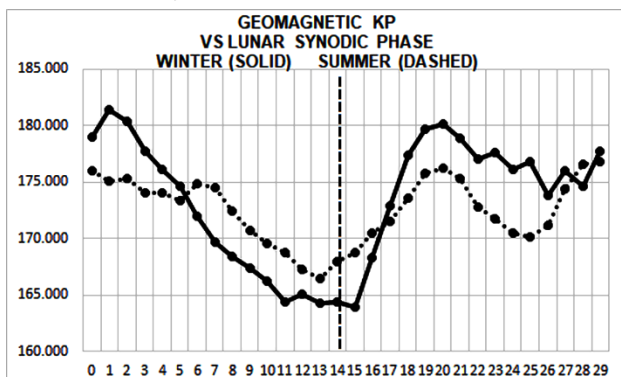
One way that earth can be affected by the sun or moon is the influence of cosmic rays on cloud formation. The amount of cosmic rays can vary with the intensity of activity of the solar wind, not allowing so many cosmic rays to reach earth. Few cosmic rays mean fewer clouds will be formed; therefore, the Earth will be warmer. During less activity, more cosmic rays can come in, meaning more clouds, reflecting sunlight, and a cooler Earth.

The current density in the global circuit is large at the surfaces of clouds. The charge transfers to droplets, some of which evaporate at the cloud-clear air boundary. Mixing of the charged evaporation nuclei forms more droplets in several types of clouds.

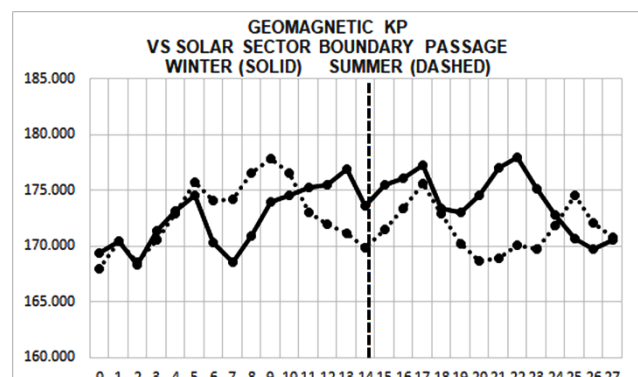
The main effect of geomagnetic disturbances would be to increase westerly zonal winds from the North Pacific. In the Troposphere, an increase of Zonal winds to the lee of continental mountain ranges (eastern Canada), increases or decreases in response to geomagnetic events.

Geomagnetic Correlation (1932-2001)

In Winter the Solar Sector Boundary is only about 2/3 the intensity as the Lunar effect on the earth's geomagnetic field. In the summer they are about equal.



LUNAR SYNODIC ROTATION



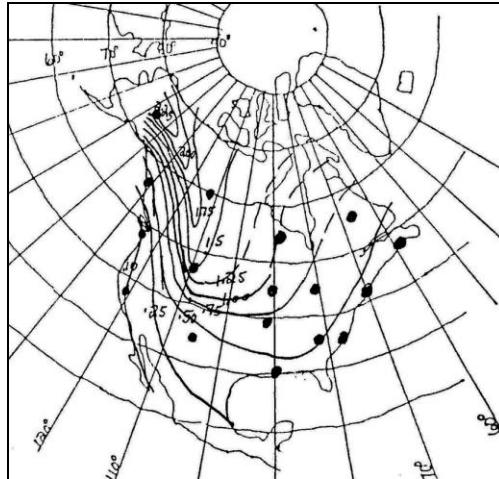
SOLAR SECTOR BOUNDARY PASSAGE

CLIMATE CYCLES OF WESTERN WASHINGTON

LUNAR

When the moon is overhead, its gravitational pull causes Earth's atmosphere to bulge towards it. This pull increases the weight or pressure of the atmosphere on this side. **The Moon's force is trying to suck the Earth's atmosphere closer to it, while affecting the amount of air inside it at the same time.** According to the study, higher atmospheric air pressure increases the temperature of air particle on earth, which increases the amount of moisture that those particles can contain. This moisture capacity affects the amount of rain and lower humidity is less likely to result in precipitation.

The side of the planet closest to the moon is sucked in by the orb's gravity, overcoming inertia that pulls in the opposite direction. On the other side, further away from the moon's tug, the pull of inertia is greater than the pull of gravity and another bulge is formed.



AMPLITUDE OF TWO WEEK AND FOUR WEEK SURFACE TEMPERATURE (WINTERS 1931-1965)

Extracted from Polowchak and Panofsky 1968)

[illegible]

BASIC THEORY OF HOW CLIMATE CYCLES WORK

The ability to forecast climate has intrigued man for millennia. It has been only in the past several decades that we have accumulated a vast understanding of how and why climate varies. It is now apparent that most climate variation is not some disorganized and random behavior, but varies, for the most part, in a very systematically arranged and cyclic pattern. These cycles are associated with variations in the average temperature, precipitation (and cloudiness), wind and atmospheric pressure. They can be cycles a few days to a few millennia in length.

Climate variations are induced primarily by solar variations, and to a lesser extent, lunar variations. Solar variations come in two basic forms: Solar radiation and magnetic field variations. While solar radiation variations disrupt the earth's ozone layer and heat at the earth's surface, solar magnetic field variations disrupt the particles of earth's magnetic field. Particle disturbances in the middle and upper atmosphere can be transferred to earth's surface via wave coupling in the atmosphere. Short term solar variations are found primarily in the 13 and 27 day range, and longer term variations primarily at 11 year, 88 year, 200 year, 400 year and longer (and other variations are clearly evident). Lunar Variations are found primarily at 14 and 29 days, and a longer variation at 18.6 years.

The sun itself rotates in a 27 day period just as the earth rotates in 24 hours. The sun's interplanetary field forms a disc which passes through the earth at half that interval. Recent understanding of why there are solar variations 11 years and longer, support the theory that the gravitation rotation of the planets around the center of mass of the solar system, accounts for 11 year and longer variations. The moon rotates around the earth in a 29 day period, and oscillates north and south in an 18.6 year period.

While the variations of the sun and earth are quite obvious and predictable, the timing effects upon earth's atmosphere are not always predictable, but still quite visible in the climate record. Long term fluctuations in climate appear to be more predictable than short term climate variations on the order of a few days to a month or so, and the reason seems quite obvious: The sun and the moon are affecting the earth at periods that intertwine at 27 and 29 days, 13 and 14 days, and their fluctuations produce half cycles during transitions at 6 and 7 days. There may be another induced half cycle at about 22 days, 11 days and 5.5 days (a product of an equatorial 45 day cycle). Thus, the short term variations become very complicated to identify.

Most all climate cycles vary in period length and amplitude according to the phase of longer term cycles. A general rule which can be applied to most Pacific NW Climate oscillations is that the period length and amplitude of a cycle (especially temperature) will usually be longer and larger during the warm phase of longer period cycles, and shorter and smaller during the cool phase of longer period cycles. The simple variation of these cycles greatly increases the probability of identifying a cycle. For instance, since the 4-8 day amplitude and period length follows an about 13-15 day rhythm, this makes three ways to identify the two week oscillation.

Short term cycles (less than about 2 months) are generally traveling waves in the atmosphere that propagate eastward (flow with the westerlies), whereas longer term cycles generally are geographically fixed fluctuations (remain stationary). In the Pacific Northwest, these longer term cycles are predominantly associated with mass increases or decreases in Pacific Pressure, with a central point of tendency near the Aleutian Low during winter months, and Pacific High Pressure in summer. Lower Pacific Pressure brings in a southwesterly flow of warm air to our area, whereas higher Pacific Pressure brings in a northwesterly flow of cool air. Short term cycles originate near the mid Pacific to Western Pacific at about the midlatitudes in response to upper air disturbances (two and four week) and tropospheric heating displacement (one week).

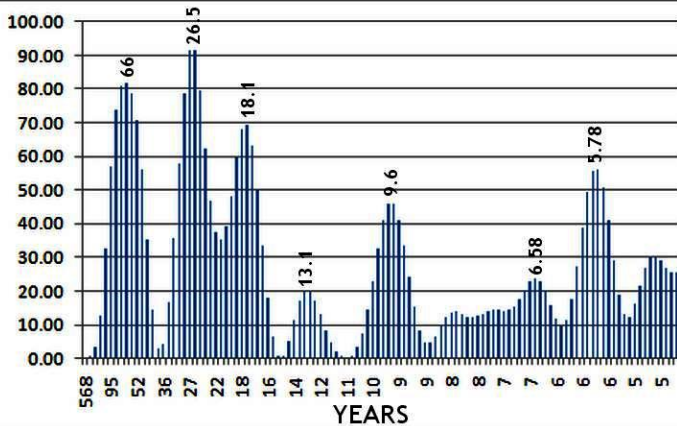
PERIOD LENGTH OF PACIFIC NORTHWEST CLIMATE CYCLES

PERIOD	CYCLIC INFLUENCE	TEMP BAND- WIDTH	TEMP °F	PROBABILITY OCCURRENCE	PRECIP- ITATION	COMMENTS
DAYS						
5-7	5-7 DAY	0.53	2.25			
5.5	1/4 22 DAY					
6.82	1/4 SOLAR ROTATION					
7.384	1/4 LUNAR SYNODIC					
2 WEEK	TWO WEEK	0.55	2.4		90+-4AMP	
11	1/2 22 DAY					
13.63765	1/2 SOLAR ROTATION					
14.768	1/2 LUNAR SYNODIC					
3 TO 4 WEEK						
22 DAY	??					
27.2753	SOLAR ROTATION	0.37	1.58			
29.530589	LUNAR SYNODIC	0.37	1.58			
45 DAYS (30-60)	MADDEN JULIEN OSCILLATION		2.48		67+-33AMP	
YEARS						
1.3	EARTH?			32+-10	2.42	
2.1-3.0	QUASI BIENNIAL OSCILLATION	0.45	0.60		2.50	17+-8AMP
3.2+-0.1		0.45	1.61		~2.5	7.72"
8.8	MOON	0.22		80+-20		NOT VISIBLE IN NW CLIMATE?
5.53175	SOLAR GEOMAGNETIC	0.22	.78/1.0	95.00	~.95	3.74" (SOLAR TORQUE?)
11.0635	SUNSPOT CYCLE (SCHWABE)					
18.612944	MOON NUTATION		0.47	1.68	38.00	0.93 8.04"
22.127	SUNSPOT CYCLE (HALE)					
33	SOLAR CYCLE (BUCKNER)	0.37		54+-16		~6.28"?
56.1	SOLAR CYCLE			0.90		
~71	EARTH'S DECLINATION	0.39			1.07	6.76" NO EFFECT NW TEMP? (1925-
1970)						
88.60	SOLAR SECULAR (GLEISBERG)					SOLAR
206.82	deVries cycle (or Suess)					SOLAR
400 (166-665)	SOLAR SUPER SECULAR	0.26	0.93		4.34"	SOLAR
793+-71	EARTH *INT/INC/DEC	0.40	1.42	44+-18		~6.8" (1200 AD, 1600 AD)
1467+-148	EARTH *INT/INC/DEC	0.40	1.42	44+-18		(800AD, 1550 AD)
2300	SOLAR Hallstatt cycle					NON DIPOLE PART-
GEOMAGNETIC FIELD						
3022+-356	EARTH *INT/INC/DEC	0.41	1.46	50+-23		(734AD/766BC)
6500	EARTH MAGNETIC INTENSITY	0.41	0.18	48+-16	7.0"	SOLAR INDUCED
23,000+-2900	EARTH PRECESSION	1.00	3.58	52+-24		(-)6440BP (+)7065AD
MILANKOVITCH 41,000+-2100	EARTH OBLIQUITY			0.38 3.19	49+-12	(+)5650AD (-
)16850BP MILANKOVITCH						
98,700+-5500	EARTH ECCENTRICITY	0.97	3.48			(+)4750AD (-)46600BP
NOTES: SECULAR VARIATION/DECLINATION ~1 DEGREE F = ~4.8" PRECIPITATION						
*INT/INC/DEC = INTENSITY/INCLINATION/DECLINATION						
AVG JULY TEMP CA 4 DEG PER 10 DEG LATITUDE						
PAC NW MEAN ANNUAL BANDWIDTH IS 58.7% OF AVG JULY TEMP.						

CLIMATE CYCLES OF WESTERN WASHINGTON

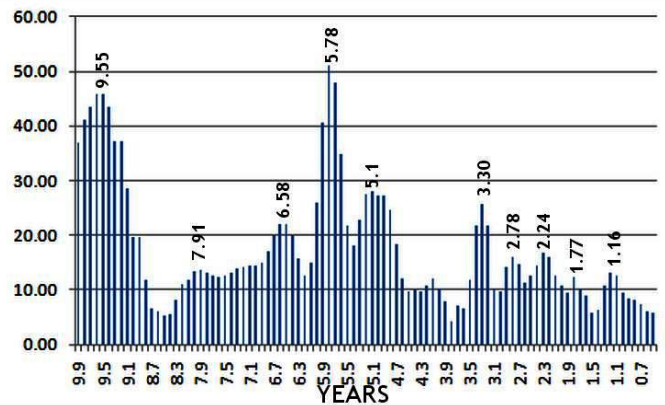
Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 5 to 100 years
 Note: Solar Gleissberg Cycle (66yrs) and Solar Bruckner (27yrs)
 Lunar Cycle at 18.6 and half cycle at 9.3 yrs
 and Solar Sunspot half cycle at 5.5 years (and associated 6.6 yrs)



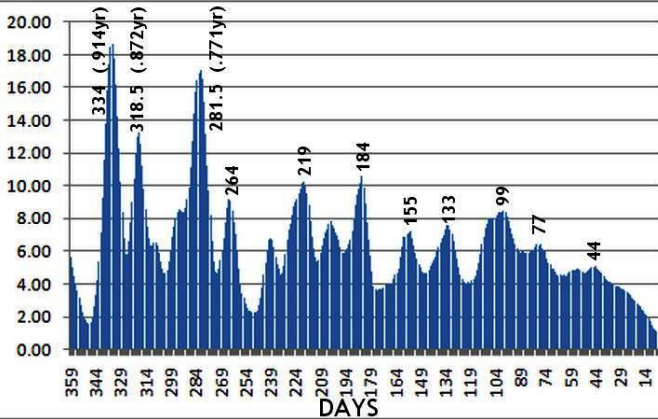
Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 0 to 10 years
 Note: Dominate Solar 1/2 cycle at 5.5 years
 and associated 5.1 and 6.6 years on the side
 QBO 2 year and QTO 3.3 year cycles (solar 1/4 cycles?)



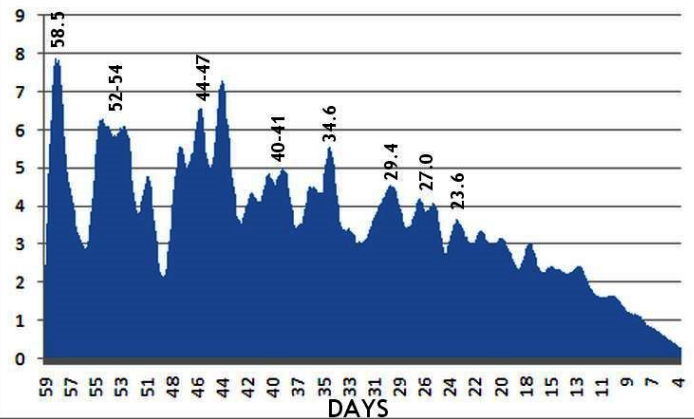
Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 2 to 365 days
 Note: Analysis pending



Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 5 to 60 days
 Note: El Nino type (Madden) cycle at 30-60 days
 Solar 27.3 and Lunar 29.5 day cycles



Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 10 to 20 days
 Note: Solar 13.6 day and Lunar 15 day cycles

Spectrum analysis of Western Washington

Average Daily Temperature 1931-2001, 3 to 12 days
 Note: Small peaks at 7.7 (Lunar 1/2) and 6.6 (solar 1/2) cycles

RECURRENT LARGE-SCALE ATMOSPHERIC CIRCULATION PATTERNS

ANALYSIS OF SUMMER CLIMATE CYCLES

An analysis was made of June, July, and August daily temperature and daily relative sky cover (temperature amplitude) for the period 1931 to 2001 (10 sites in Western Washington). It was hoped to find some indication of cycles, connectivity, and long term (over the years) relationships.

First, for each summer, a spectrum of cycles was computed. The average spectrum shows only a few major peaks at 27.3, 6.4, and 71 days.

Next, using the spectrums, each day (2-90 days) was analyzed to see if any cycle was visible (using 1/5th of the data - 14 of the highest correlated years per relative cycle). A preliminary analysis suggests that there are cycles at days: 5.5, 6.8, 7.4, 11, 13.6, 14.8, 22, 27.3, 29.5, 38, 42, 58, 64, and 71 days.

Next, for each of the above listed cycles, a correlation between cycle spectrums was made, analyzing their behavior over the 71 year period. This suggested cycle groupings of 71/64/58, 42/38 with 22-11-5.5, 29.5 with 14.8 and 7.4, and 27.3 with 13.6 and 6.8 days. These relationships are likely, but tentative.

Next, an analysis of each cycle's spectrum was made to see what long term response (in years) for each cycle, in terms of a spectrum in years. This suggested the following: The 71/64/58 day cycle is most active (correlated) during an 18.6 and 9.3 year cycle (the moon's notation), along with the 2.8 QBO and a 68 year cycle. The 44 and 38 day cycle is most active during the 2.8 year QBO. The 29.5/14/7 day cycles are most active during a 22 year and 3.4 year cycle. The 27.3/13.6 and 6.4 day cycles are most active in an 8, 22, and QTO (3.4) year cycles. The 22/11/5.5 day cycles are most active (correlated) during QBO (2.2, 2.8, 3.4 years).

ANALYSIS OF MONTHLY TEMPERATURE CLIMATE CYCLES

An analysis was made of Monthly temperature for the period 1900 to 2010 (7 sites in Northwestern Washington). It was hoped to find some indication of cycles, connectivity, and long term (over the years) relationships.

First, a spectrum of cycles was computed for each 18 month period, covering 110 years. Then a spectrum was computed for 2 year mean, and then a spectrum of each 6 year mean, at 3 year intervals, for the 110 year period.

CLIMATE CYCLES OF WESTERN WASHINGTON

Next, for each of the above listed cycles, a correlation between cycle spectrums was made, analyzing their behavior over the 110 year period. This suggested cycle groupings which were highly correlated to each other at: 3.21 and 3.5 years, and 2.7 and 3.4 years. The 2.28 month (69.5) day cycle showed that a positive correlation to the 5.6 month cycle, and a negative correlation to the 3.21 and 3.5 month cycles (indicating that when the latter two were inactive, the 2.28 month was more active). As well, but to a lesser degree, the 5.6 month cycle, when inactive, showed that the 3.21 and 3.5 month cycles were more active. The 2.7 and 3.4 year cycles were extremely highly correlated to each other, indicating differing time periods of the same cycle.

Next, an analysis of each cycle's spectrum was made to see what long term response (in years) for each cycle, in terms of a spectrum in years. This suggested the following:

2.28 month (69.5 day) correlated highest with the QBO and QTO (2.3 year, 2.5 and 3.4 year), then an unrecognized cycle at 8.3 and 16.7 years, the 21.8 double solar cycle, and probably Solar Gleissberg cycle (>62 year).

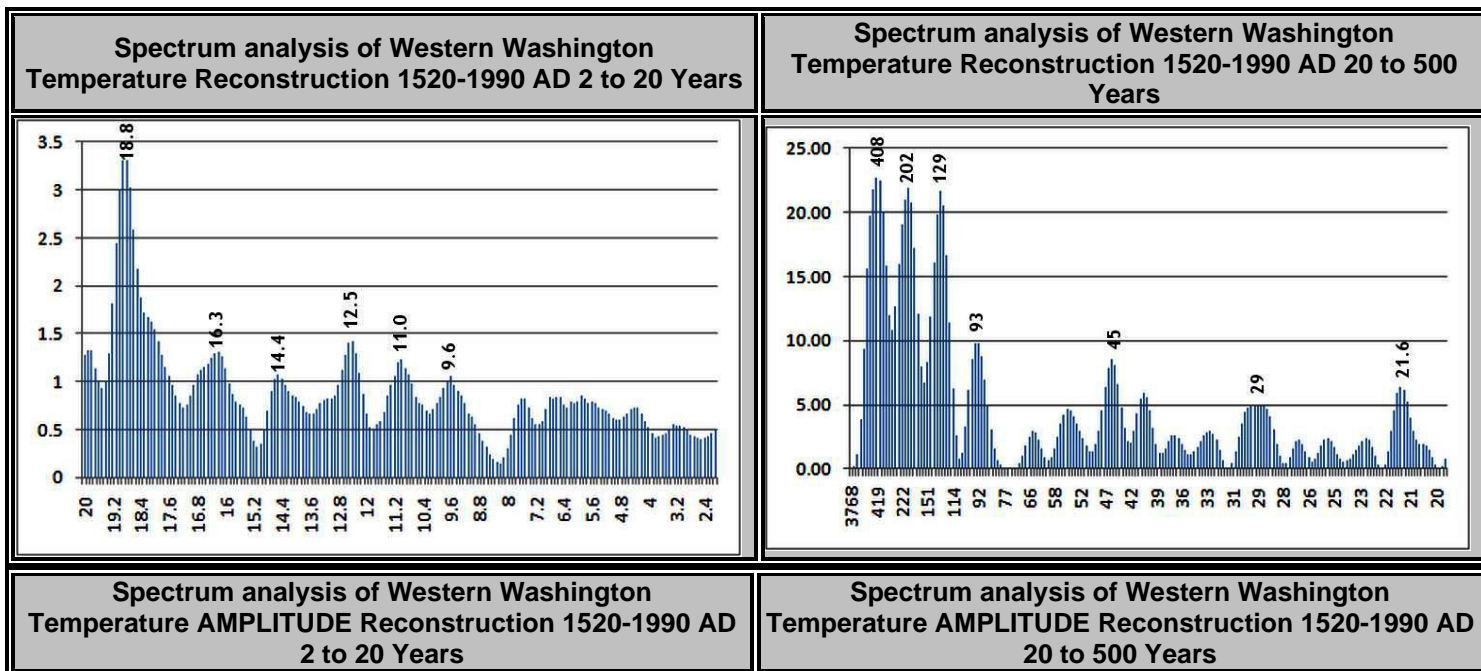
3.21 and 3.5 months correlated highest with QBO and QTO at 3.7 and 2.7 years, then with a 15 to 18.8 year cycle.

5.6 month cycle correlated to an unknown 4.13 year cycle, then to the QBO/QTO at 2.6-2.9 years, and then to an unknown 8-10 year cycle. This is similar to the 1.33 year cycle.

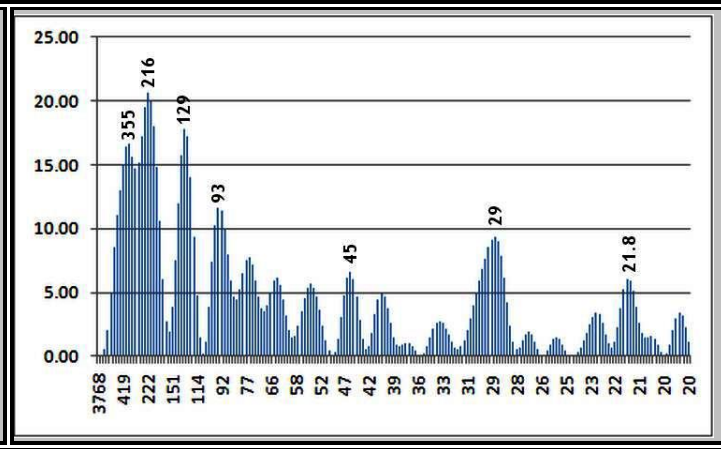
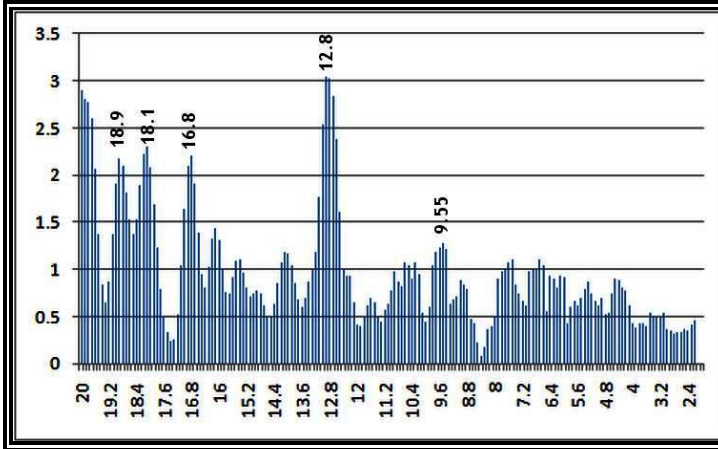
1.33 year cycle correlated with the QBO/QTO at 2.6-2.9 years, and then to an unknown 8-10 year cycle (similar to the 5.6 month cycle).

2.7 and 3.4 year cycles are responding highly to about a 6.5 and 11.5 year cycles, and it is very likely that this is the 11 year solar cycle, 1/2 cycle, and the 2.7 is a quarter cycle.

WESTERN WASHINGTON CLIMATE CYCLES OF THE PAST 500 YEARS RECONSTRUCTED FROM TREE RINGS



CLIMATE CYCLES OF WESTERN WASHINGTON



5-7 DAY ATMOSPHERIC CIRCULATION PATTERN

The five to seven day wave has its greatest occurrence over Western Washington during summer and weakest during winter (based on a two year sample). This appears to be due to the North—South displacement of the jet stream position during the annual cycle. The five to seven day wave propagates eastward with a phase speed comparable to the 700 mb wind (10,000 foot level) steering flow over mountain regions. It is most pronounced near and just to the north of the jet streams (slightly pole ward and downstream of the climatological mean jet streams), with wavelengths on the order of about 4000 km (wave number 6), and axes oriented along the climatological mean flow (Blackmon et al 1984). These waves are thought to be caused by variations in the South to North displacement of heat (Speth and Madden 1983). They are known as baroclinic waves, a result of meridional temperature gradients and thermal winds, and produce “strong westward tilts of the axes of the waves between the earth’s surface and the 500 mb level.” The amplitude is largest in the middle and upper troposphere, and is confined to the troposphere.

The period length varies from about 3.5 to 8.5 days. Larger amplitudes and longer period lengths occurring near the warm interval of the two-week cycle. The 5—7 day cycle also varies somewhat with the 45-day cycle.

The cause of such waves appears to be associated with changes in the two and four-week cycles, perhaps storms and frontal systems, associated with the build-up and break down of westerly flow patterns.

OCCURRENCE AND AMPLITUDE

TWO-YEAR sample of Western Washington:

	PERCENT OCCURRENCE	AVERAGE AMPLITUDE
JAN	20%	3.47°F
FEB	22	4.00
MAR	31	2.61
APR	44	4.19
MAY	37	3.64
JUN	37	3.85
JUL	48	5.65
AUG	54	4.92
SEP	32	4.71
OCT	43	3.38
NOV	42	3.32
DEC	22	4.27

SUMMER CYCLES TIMING AND VARIABILITY

Western Washington

Least amount of random variability at phase 0 (warm of 5-7 day cycle with warm of two week and warm of 4 week cycle), but also similar little variation during two-week transition to cold to warm.

Greatest amount of random variability during transition of two week warm to cold, or closely approaching the cold.

Longer, followed by larger, amplitudes approaching the warm of the two week cycle, and shorter, followed by smaller amplitudes approaching, or near, the cool part of the 2 week cycle.

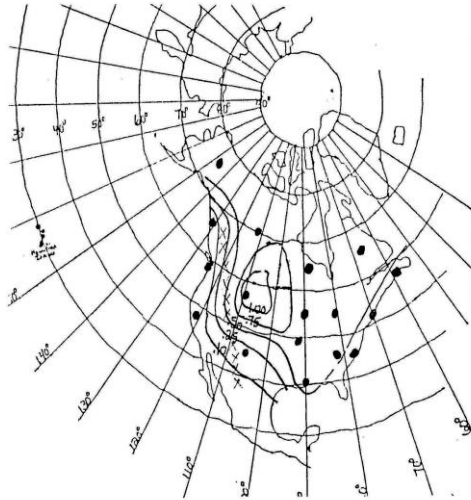
Warmer and drier amplitudes at or near maximum and minimum of 2 week cycle, versus cooler and moister during transition events of 2 week cycle (perhaps indicating cold fronts and warm fronts).

The correlation between (summer) clouds and temperature varies during the two week cycle. GENERAL RULE: Peak maximum of cloud density lags temperature by about phase 45° (1 day) during the warm phase of the two week cycle, and leads temperature by about phase 45° during the cool phase.

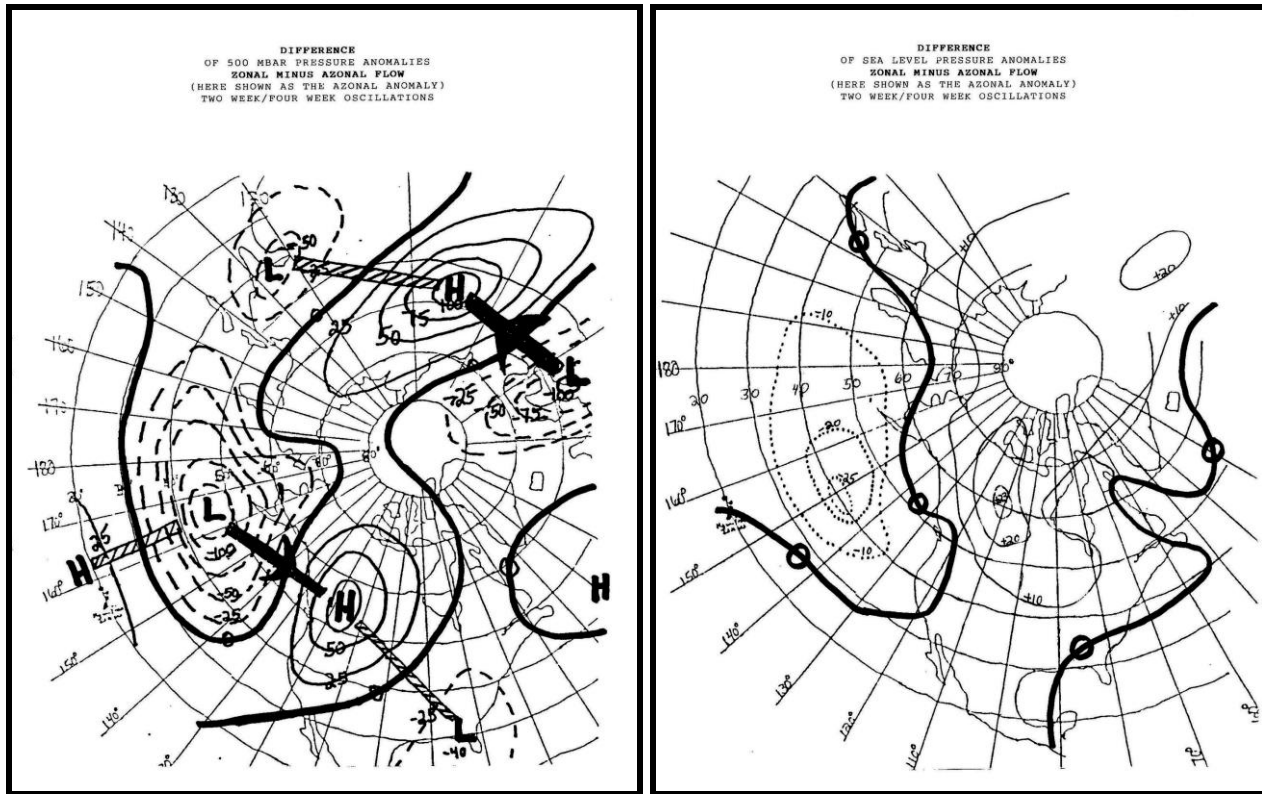
CLIMATE CYCLES OF WESTERN WASHINGTON

Warm, wet vs. cool, dry, oscillations in winter half of year. Cold, wet vs. warm, dry, oscillations in summer half of year. Gradual or rapid transition (a few weeks to a month or two) during spring and fall. THEORY: Storm cells follow the jet stream; south around Aleutian Low in winter, and North around High pressure in summer half.

AMPLITUDE
OF 5 TO 7 DAY SURFACE TEMPERATURES
(WINTERS 1931-1965)
(Extracted from Polovchak and Panofsky 1968)



TWO WEEK AND FOUR WEEK ATMOSPHERIC CIRCULATION PATTERNS



45 DAY OSCILLATION

The 45 (30-60) day oscillation of temperature (and precipitation) was first inferred from computer analysis of Washington temperature over 30 years ago (Flexer 1960), and later found in tropical meteorological parameters by Madden and Julian (1971). It has been only recently that this oscillation has been intensively analyzed (Anderson et al 1984; Murakami et al 1986).

The **characteristic features** of the 30-60 day wave indicates a systematic eastward propagation of low—frequency modes between about 60°E and the date line (Indian Ocean-Western Pacific) where they are most dominant (Murakami et al 1986). They are most commonly associated with a single wave (wave number 1) traveling around the earth in 30-60 days, but are also associated with two waves (wave number 2) originating over the Indian Ocean and Eastern equatorial Pacific. These waves not only propagate eastward, but pole ward and downward in phase with the tropical Indian and Pacific Oceans. They have their strongest coherency at about 30,000 feet (250 mb level) between the equator and 10° latitude.

CLIMATE CYCLES OF WESTERN WASHINGTON

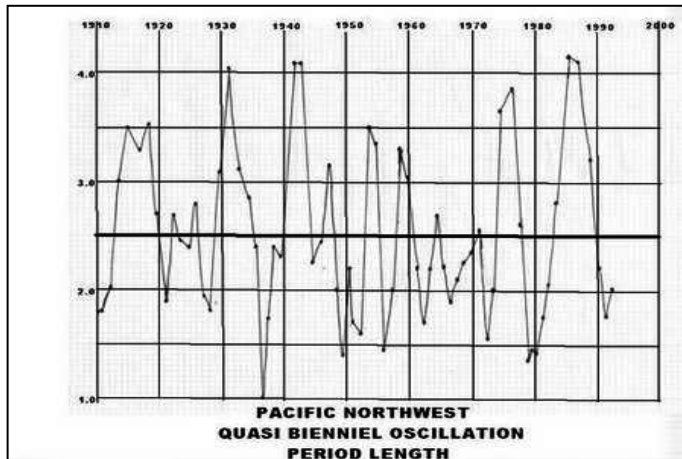
There are no known associated solar, lunar, or magnetospheric oscillations to account for the 30-60 day oscillation.

The **variation of period length and amplitude** of the 30-60 day wave shows a surprisingly, reoccurring pattern associated with solar induced equatorial waves of about 50—90 years (?) (Gleissberg Cycle), 11 years (solar cycle), 5.62 years (solar induced 1/2 cycle), 2.815 years (solar induced 1/4 cycle), 1.408 years weak (weak, solar induced 1/8 cycle), and 0.676 (0.703?) year (solar induced 1/16 cycle). At each of these equatorial oscillations, the warm period is associated with longer period lengths and larger amplitudes of the 30-60 day oscillations. Likewise, cold periods are associated with shorter period lengths and smaller amplitudes of the 30-60 days oscillation. It is also interesting to note that the intensity of amplitudes and period length of 30-60 day oscillations is greatest at .703 year and decreases with longer oscillations (11 year).

The **seasonal amplitude** of the 30-60 day wave over the equator is negligible, but over Western Washington, larger amplitudes occur in winter. It is interesting to note that in summer, cold departures are rather small, and warm departures rather large. This suggests that in summer, short duration, large, warm departures are followed or preceded by long intervals of near normal temperatures.

QUASI BIENNIAL OSCILLATION

It has been known for several decades that a Quasi Biennial Oscillation (about 2 years) exists in at least some meteorological parameters. The most prominent peak in North American temperature and Northern Hemisphere Sea Level Pressure (SLP) is at about 2.1-2.2 years, although oscillations up to 3 years are known (Quasi Triennial). A temperature oscillation in Western Washington matches the QBO (Quasi Biennial Oscillation), while



precipitation is somewhat variable (e.g., cold, dry vs. cold, wet variations).

The QBO is influenced by the 11 year solar cycle, and begins in the upper Troposphere over the Equator (30 N to 30 S). It is very pronounced as an oscillation in the stratospheric winds, about 14 months of westerly winds and 14 months of easterly winds (AVERAGE CYCLE OF 2.33-2.37 YEARS IN LENGTH). The QBO begins at the 10 MB level in the Equatorial Stratosphere, and descend to the 100 mb level, propagating down as time progresses, very gradually, at about 0.72 miles per month, and

decrease in magnitude as the height decreases. The amplitude is 40 to 50m/s at the 20mb level. It may be that equatorially trapped Kelvin waves provide the westerly momentum and Rossby-gravity waves provide easterly momentum to produce the QBO oscillation. The period of the oscillation is 21 to 35 months with a mean of around 28 months. Easterlies are the norm wind direction in the upper Troposphere, whereas Westerlies result in a weakened atmosphere. Easterlies are generally stronger than westerlies. Westerly winds last longer than easterly winds at higher levels while the converse is true at lower levels. The westerlies move down faster than the easterlies. The equatorial mid stratosphere shows descent from the 10MB to 100MB in about 1.2 years, a gradual descent of about .72 miles per month. On the average the QBO Stratospheric winds take .89 years to change from Max East to West, and 1.46 years to change from max West to East! The spectrum period length of the cycle shows distinct cycles of about 12 and 19 years, whereas the spectrum of lag from a set rhythm (2.366 years, base year 2001.07) shows very distinct cycles at about 11.5 and 19-30 years.

Pacific Northwest QBO events are not directly influenced by the Equatorial QBO, but rather, from the Polar Vortex. The Polar Vortex is influenced indirectly, being conveyed through planetary waves and their mean circulation. There is a northward displacement of the Rossby Waves during the easterly phase of the Equatorial QBO, and vice-versa. The anomalies in the Northern Hemisphere Polar Vortex reflects the pole ward eddy fluxes of zonal momentum in the upper troposphere, and the induced meridional circulations that are felt at the earth's surface. The QBO period is shortened near solar max and lengthened near solar min. However, during the mid-late phase of the solar cycle, westerlies persist twice as long, lengthening the QBO to almost 36 months.

Northern Hemisphere winters are in phase with solar activity when the Equatorial QBO (e.g. - at 50MB) is westerly: The lower the sunspot number, the lower is the temperature. Polar temperature varies out of phase with solar activity for winters when the QBO is easterly. At solar minimum the polar-night vortex appears more

CLIMATE CYCLES OF WESTERN WASHINGTON

disturbed and warmer during QBO easterlies than during QBO westerlies. During winter, planetary waves propagate upward from the troposphere, disturbing the polar-night vortex from radiative equilibrium, yielding warmer temperatures over the pole, depending on the direction of the equatorial wind. At solar maximum the vortex is more disturbed and warmer during QBO westerlies than during QBO easterlies.

The QBO of temperature follows two dominant patterns over the United States: West America opposite in sign to the East, or a general N-S gradient opposite in sign N-S of midlatitudes (Rasmusson et al 1981). The dominant pattern of Northern Hemisphere SLP anomalies associated with the QBO is a large pressure amplitude over the North Pole opposite in sign to the North Pacific and N or NE Atlantic (Trenberth and Shin 1984). This pattern includes elements of the North Pacific Oscillation (NPO), North Atlantic Oscillation (NAO), Pacific-North American (PNA) Oscillation, and Southern Oscillation (SO).

The period length of the QBO in temperature over Western Washington from 1891 to 1993 averages 2.157 ± 0.50 years. When the QBO is set to a consistent rhythm of 2.157 years, the actual temperature amplitudes vary from the set rhythm by ± 0.294 years (using a base year of 1945.00).

Although the QBO begins in the upper level Equatorial Stratosphere, it is relayed to the Pacific Northwest indirectly, via wave propagation to the North Pole, and back via the Polar Vortex. The Pacific Northwest QBO period length is dominantly controlled by an 11 year cycle, in phase with the Solar cycle, with minimum sunspot numbers followed by PNW short QBO's about 1.23 ± 2 years later, and maximum sunspots occurring about the same time as PNW QBO long periods ± 2 years. The short period following the solar minimum average 1.6 ± 0.28 years in length, and the long period at about the solar maximum sunspots averages 3.53 ± 0.58 years in length.

[WEATHER/images_cycles/19_pnw_qbo_period_length.jpg](#)

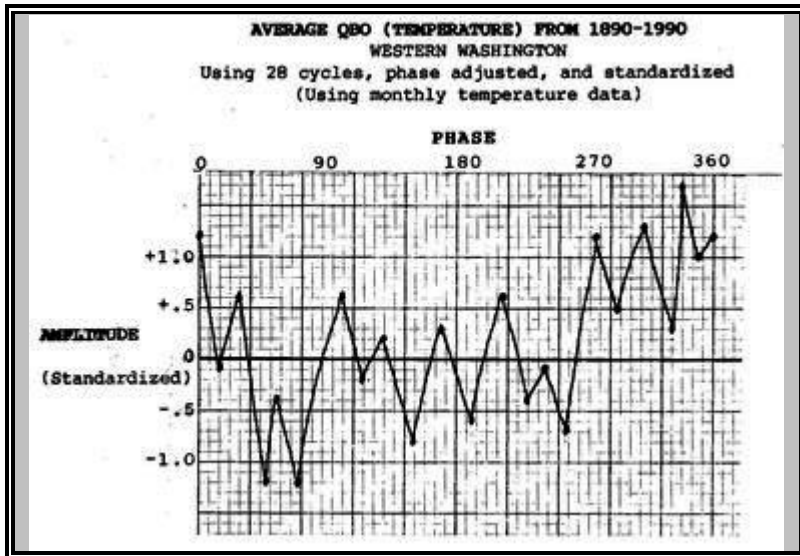
The QBO lag from a set rhythm shows an 11 year cycle that lags sunspot cycles by 2.40 ± 1.18 years. High sunspot numbers are followed by least lag (2.40 years later) of $+0.55 \pm 0.39$ years, and low sunspot numbers are followed by a long lag (2.40 years later) of -0.5 ± 0.39 years. The QBO is thus somehow directly responding to the 11 year solar cycle. Note that there may be several shorter oscillations associated with the QBO, such as 0.7 years, and perhaps a 0.2 year (see graph).

By comparing the Pacific Northwest QBO with the Equatorial mid-Stratosphere QBO (correlations with lag one, two, and three cycles before and after) reveal a strong correlation (.44 warm amplitude) with the equatorial mid Stratosphere (30MB) QBO occurring 1.17 ± 0.68 yrs before Pacific NW QBO events (westerlies before Pacific NW Warm, and peak easterlies before NW colds). This is a strong correlation (analysis 1953 to 2001).

The Equatorial El Nino events are related to longer westerly QBO events and some shorter easterly events (75 vs. 25%).

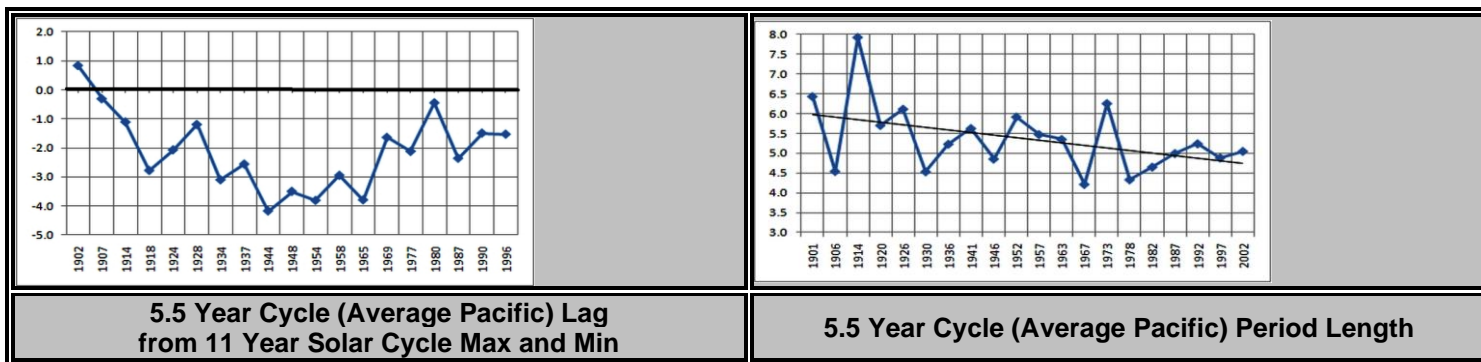
QUASI BIENNIAL OSCILLATION

CLIMATE CYCLES OF WESTERN WASHINGTON



THE 5-6 YEAR PACIFIC (SOUTHERN) OSCILLATION

Known as the Pacific or Southern Oscillation, the 5-6 year oscillation is a half cycle of the 11 year solar oscillation. Earth's geomagnetic index shows a strong 5.5 year cycle about 1.32 years after each Min or Max of the 11 year Solar Cycle (and at about the same time as earth's geomagnetic 11 yr Max and Min). The North Pacific Warms and Equatorial Pacific Negative Index (NPO and SOI) lag the 5.5 year geomagnetic index by about 1 year (.98 and 1.13 years, respectively). Pacific NW warms lag the Pacific Warms and Equatorial Pacific (neg) by about .17 years (2 months). In general, temperatures are in phase from the equatorial Pacific to Alaska, along the American West Coast to the Rockies, and generally opposite in sign along the east coast from the Gulf of Mexico to Greenland, in Siberia and NE Asia, and apparently the Western Pacific.



("OLD DATA?"): The timing of the Pacific Oscillation is in tune with the 11 year sunspot cycle as it varies with the longer term secular (Gleissberg or 80 year) cycle. Pacific oscillation cold intervals lag the 11 year sunspot cycle extrema by 1 -3 years at the Gleissberg minimum, and 7-8 years at the Gleissberg maximum, indicating a flip-flop — warm intervals occurring shortly after the 11 year sunspot extrema. The Pacific Oscillation period length varies gradually between 4 and 7 years during a 20 year period, nearly the same as the sunspot cycle period length variation during 20 years (a result of the 22 year solar Hale magnetic cycle).

Temperature is more often in phase than precipitation. In general, warm periods are associated with wet tropics, dry subtropics, dry California to Washington and a wet British Columbia. However, Western Washington has become warm and wet vs. cold and dry from about 1972 to about 1985, or more recently. California precipitation was opposite in sign prior to 1919, and so was British Columbia from 1917 to 1932.

Recent interest has brought attention to El Nino/Southern Oscillations (Equatorial Pacific) that have a prominent effect upon circulation over North America. One or two El Nino episodes occur at or near each warm of the Pacific Oscillation. Actually, El Nino episodes usually occur when shorter term warm oscillations (e.g. - Quasi Biennial and Quasi Triennial Oscillations) occur near the warm of the Pacific Oscillation.

As in most temperature oscillations, Pacific NW warms are associated with lower pressure over the N/NE Pacific (bringing in a general southwesterly flow of air), and cold periods are associated with higher pressure over the same region (bringing in a general northwesterly flow of air). At the extrema of the 11 year mid continental temperature oscillation, a general S-N or N-S flow of air up and down midcontinent creates lower pressure and blocking over the Rockies or midcontinent. This tends to divert the westerlies towards the south on the windward

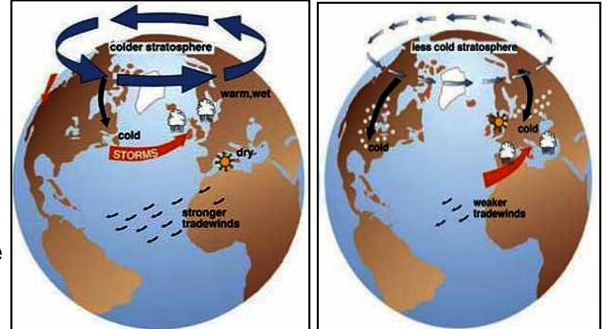
CLIMATE CYCLES OF WESTERN WASHINGTON

side of the Rockies. When the 11 year temperature amplitude reaches near zero value, westerly flow of air is allowed to penetrate farther east over the continent. The circumpolar vortex is also more strongly activated.

EL NINO:

There are several main processes that contribute to the EL NINO / SOUTHERN OSCILLATION (ENSO) in the Pacific. These include the Coriolis force, Walker Cell circulation (which produces the trade winds), Meridional cell circulation, and the Southern Oscillation.

The Coriolis force effects the traversing of the Kelvin and Rossby waves in the Pacific Ocean. Because of the Earth's rotation, a force is always pushing the wind to the right of the direction of motion in the Northern hemisphere and to the left in the Southern Hemisphere. Kelvin waves move in the relative direction of the Coriolis force (which effectively moves to the right, or towards South America). The Rossby waves, however, must move against this prevailing west-to-east motion and thus travel much more slowly.

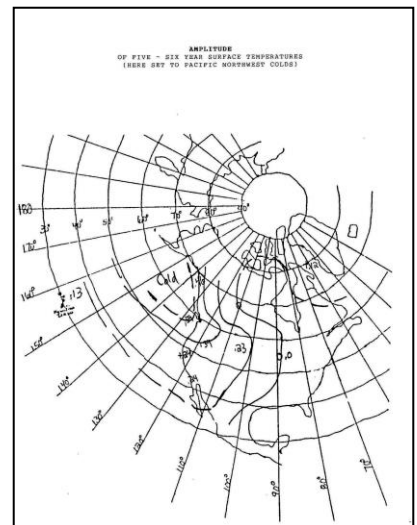


The trade winds are caused by a cycle called Walker cell circulation. Waters in the western Pacific are much warmer than those in the east. The warmer air over waters in the west is consequently less dense than the air over waters in the east. As a result, by convection, the western air moves across the Pacific, losing altitude as it slowly cools. Lower air moving from the east to the west, on the other hand, rises when it is heated by the warmer eastern shores. Thus, these disparate temperatures cause a circulation of air which produces the trade winds. El Niño, however, changes that.

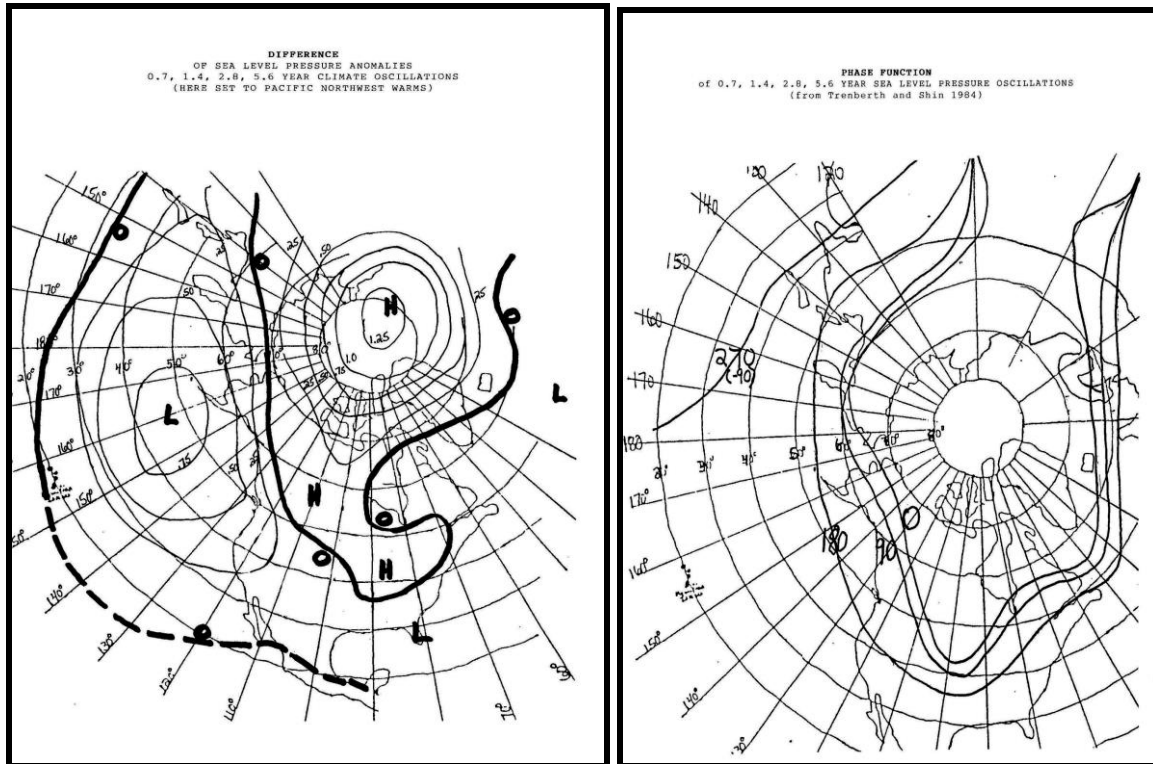
Meridional cell circulation: Although air tends to rise near the equator, as it moves pole ward it radiates heat into outer space and eventually cools and sinks at about 30 degrees latitude. Similarly, cold air that sinks at the poles tends to be warmed as it flows along the surface of the Earth toward the equator and begins to rise near 60 degrees latitude.

Trade winds. The 'westerlies' in the Northern and Southern Hemispheres flow from the west because of deflection from the rotation of the earth. As the Earth's circumference decreases, the eastward rotation becomes slower. Moving north or south will give apparent eastward movement because of this slower rotation.

When El Niño brings its warmer waters to the South American coast, it raises the air temperature. In so doing, it brings the temperature of the east about even with that of the west. Consequently, there is nothing to fuel Walker cell circulation, and the trade winds decline dramatically. The absence of a greater pressure difference also means that warmer waters can stay on the coast. As a result, this part of the ENSO cycle serves as positive feedback by encouraging the prevailing El Niño (or lack thereof) conditions.



CLIMATE CYCLES OF WESTERN WASHINGTON



11 YEAR CYCLE

The 11 year solar cycle directly influences earth's climate by changes in the amount of solar radiation received at the earth's surface. Since the amount is very small, and is cumulative, the effect is most noticed where heat absorption and retention is greatest, such as the center of the North American continent on the leeward side of the Rockies.

Currie (1981) has analyzed dozens of temperature records and finds that the large amplitudes around the Great Lakes lag the solar cycle by about 5-6 years. Currie (1980) has also shown that the 11 year signal is found in length of day and the earth's rotation speed. Length of day is in phase with sunspot number. Earth's rotation lags length of day by about 2.7 years, and the temperature signal is out of phase with the sunspot cycle, and the significance of such phase relations is unknown.

An 11 year signal is also found in Pacific NW temperature and precipitation. Temperature is 180° out of phase with the midcontinent, our cold maximum occurring within a year of their warm. At this same time, the NW Interior experiences their drought. Western Washington maximum wet period occurs about 2.5 years after temperature, indicating a transitional effect. The Equatorial Pacific warm, wet period Southern Oscillation may occur up to a year before any other Northern Hemisphere Climate effects, or at the same time as the midcontinent warm.

The significance of Pacific NW temperature being out of phase with mid-continent and equatorial Pacific is as yet unknown. The 11 year cycle long term variance in Pacific NW temperature amplitudes follows the long term trend of the sunspot cycle more closely. During the 1940 epoch, the Pacific NW temperature was nearly 180° out of phase, and in phase with mid-continent. It is here suggested that the out of phase relationship is a result of changes in atmospheric circulation induced by the mid—continent oscillations. It is also possible that an 11 year cycle in the geomagnetic field may influence climate via the intensity of the North Pacific Low.

11 YEAR SOLAR CYCLE:

THE SUNSPOT CYCLE AND THE LOWER ATMOSPHERE K. LABITZKE and H. van Loon Based on data of 4 solar cycles, we have examined the global structure of the signal of the 11-year sunspot cycle (SSC) in the stratosphere and troposphere, using correlations between the solar cycle and heights and temperatures at

CLIMATE CYCLES OF WESTERN WASHINGTON

different pressure levels. We expanded this work to show the differences in the geopot. Heights between maxima and minima of the SSC. We show the global signal, stress the differences between the hemispheres, and point out that the solar signal in the lower northern winter stratosphere is strongest during January/February in the east phase of the QBO.

CHARACTERISTICS OF SHORT-TERM AND LONG-TERM VARIATIONS OF THE ARCTIC POLAR VORTEX H. NAKANE

Variables to describe the properties of the polar vortex in each winter/spring season were introduced based on the Ertel's potential vorticity maps, which are the strength, duration, radius and unstableness of the vortex. The vortex indices for the winter/spring from 1959 to 1997 were calculated using the NCEP reanalysis data. Positive trends are clearly found in the strength, duration and radius, and a negative trend is shown in the unstableness of the polar vortices. Short-term variations are closely connected with the QBO and long-term variations are made by coupling of the 11-yr solar cycle and the QBO; the Arctic polar vortex was strong, large and stable in the solar inactive phase. Meanwhile, a correlation between the QBO and vortex indices is weak or weakly negative in the solar active phase. Timing between the vortex periods and QBO also modulated the variations of the vortex indices. Vertical structures of the polar vortices and their changes will be also presented.

SOLAR ACTIVITY INDUCED CHANGES IN THE LOWER AND MIDDLE ATMOSPHERE K. MOHANAKUMAR

Influence of solar activity in the 11-year cycle in atmospheric parameters and the circulation pattern of the lower and middle atmosphere has been studied based on radiosonde and rocket observations for at least two solar cycle periods. Further detailed studies using NCEP/NCAR reanalysis data have also been carried out at selected levels in the troposphere and stratosphere at various latitude zones. Atmospheric pressure is found to be highly sensitive to solar changes, which is positive at all height levels. The response of temperature to solar activity is directly associated in the region of positive lapse rates (troposphere and mesosphere) and is inversely in the stratosphere. The changes in temperature associated with solar activity is lower in the dense troposphere and higher in the mesosphere. The temperature changes from its mean value of the order of 1-2 % in the troposphere, whereas it changes to 6-8 % in the mesosphere for a change of 100 units of solar radio flux. The circulation pattern of the lower and middle atmosphere also found to be affected in accordance with the solar activity. The study reveals that there is an external forcing exist during the period of high solar activity which compresses the earth's atmosphere. When the atmosphere is forced externally, the relatively less dense upper layers affected more than the dense lower layers.

THESE ARE NOTES I DID SEVERAL YEARS AGO ON

THE PHASE PRECIPITATION/TEMPERATURE OF THE SOLAR 11 YEAR CYCLE ON THE CLIMATE PACIFIC NW

(NOTE THAT PRECIPITATION/TEMPERATURE HAS A 11 YEAR HALF CYCLE AND 1/4 CYCLE [5.6 YEAR AND 2.8 YEAR]

AND THAT TEMPERATURE DAILY AMPLITUDE HAS 1/5 SOLAR CYCLES [QBO - 2.2 YEAR]

THIS DATA OF 100 YEARS OF DATA, WAS PHASE ADJUSTED TO SHOW THE MINOR CYCLES ROUGHLY IN PHASE)

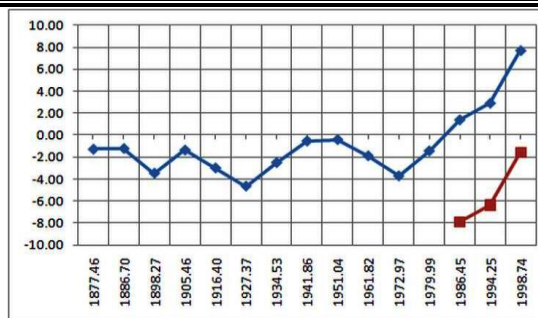
18.6 YEAR LUNAR NODAL (Mn) OSCILLATION

The 18.6 year Lunar Nodal Mn Oscillation has a strong influence on temperature and drought conditions over North America. Temperature variations over North America are largely confined to the midlatitude region where the jet stream is strongest, especially the Northwest and Northeast United States. Temperatures are opposite in phase between these two areas (NW cold and NE warm during the Mn maximum effect), with the Rocky Mountains as the isotherm barrier. The immediate leeward side of the Rockies shows little temperature response to the Mn term.

The physical mechanism whereby the moon influences climate cannot, as yet, be pinpointed. Sea Level pressure anomalies reveal higher pressure over the Pacific and Atlantic, and lower pressure over midcontinent (centered over Kansas, Nebraska, and South Dakota). Higher pressure over the Pacific allows for cooler, northwesterly air to flow over the Pacific Northwest. The amplitude of the North American temperature and precipitation extrema varies over a period of about 100 years, judging from historical records and Pacific Northwest tree ring records going back 400 years.

When the Lunar Nodes are at Maximum (farthest north), there is higher pressure over the North Central Pacific, and Low pressure over continental North America, creating a flow of cooler NW winds to the Pacific Northwest, and when the Lunar node is at Minimum (farthest south), there is lower pressure over the Pacific, and higher pressure over North America, bringing in warmer SW winds to the Pacific Northwest.

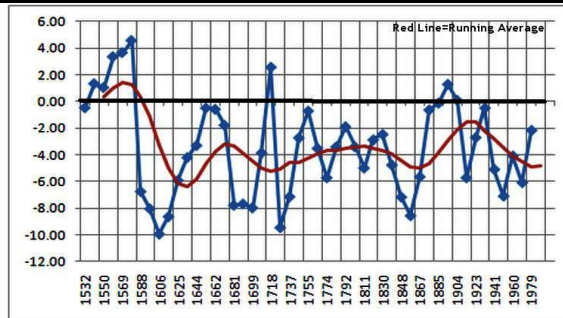
An analysis of Western Washington Temperature shows an interesting correlation with the Lunar Nodal 18.6 year oscillation. For the period from 1870 to 1980, Western Washington COOL and WET lagged the Mn Lunar Max, and WARM and DRY lagged the Mn Lunar Min by about 2 years (2.13 years average). However, since 1980, the trend seems to be reversing so that COOL and Wet lag the Mn Lunar Min and vice versa. This needs a little more research.



PHASE LAG OF TEMPERATURE AND SKY COVER (PRECIPITATION) from the Lunar Nodal Mn Cycle (in years)
 (NW Washington Wet and Cold just after Lunar Nodal Max, and Dry and Warm just after Lunar Nodal Min)
 NOTE: From 1870 to 1980 our weather lagged the Mn Lunar Cycle by about 2 years.
 Since 1980 the trend seems to have reversed, so that we have wet and cold after the Lunar Min, and dry and warm just after the Lunar Max
 (needs a little more research, to see what is actually going on).

CLIMATE CYCLES OF WESTERN WASHINGTON

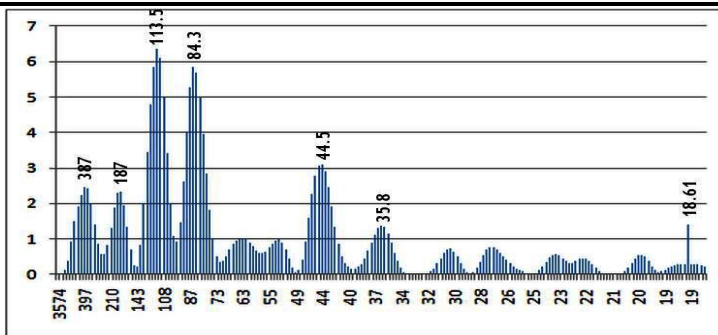
An analysis of the Lunar Mn 18.6 year cycle in tree rings reveals a strong pattern from 1500 to 1980 AD. The reconstructed temperature record suggests that from 1870 to 1980 warms have lagged the Lunar Mn Max by an average of 2.72 year (note that this conflicts with the actual temperature record, where warms lag the Lunar Mn Min, not Max). From 1650 to present trees have lagged by 3.73 years, and since 1500, they have lagged by 3.29 years. Note that in the 1500s and early 1600s, a wide variation might have occurred.



PHASE LAG OF RECONSTRUCTED TEMPERATURE FROM TREE RINGS 1500 TO 1980 AD

THE LUNAR NODAL 18.6 YEAR CYCLE

Lag of Temperature from the lunar cycle (Warms from Max, and Colds from Mins)

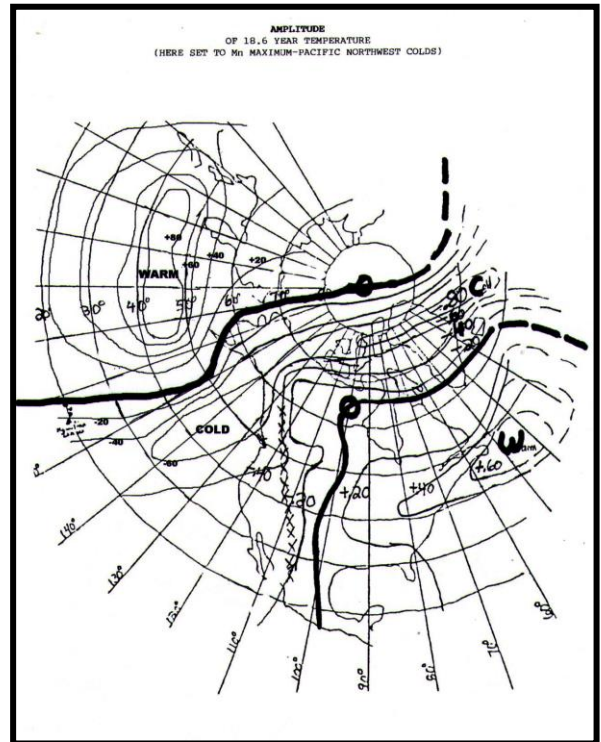
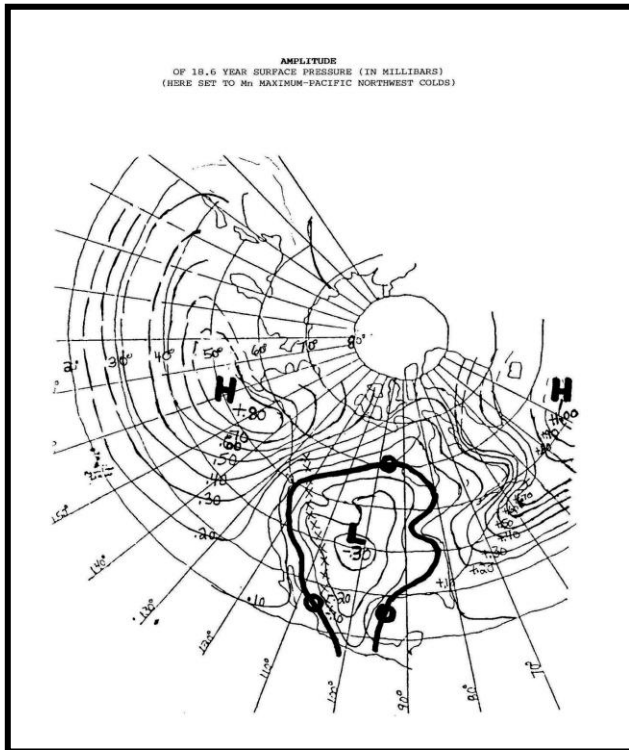


This spectrum reveals that the timing of the Lunar Mn cycle in Western Washington

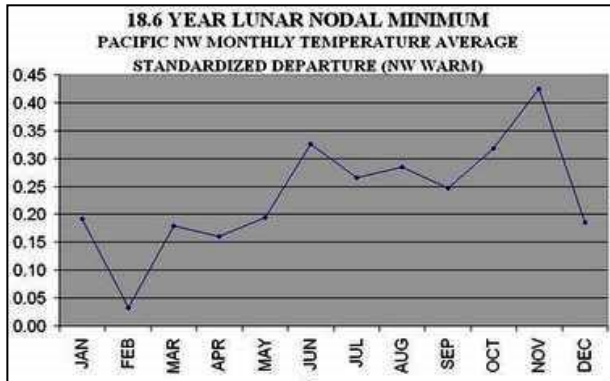
tree rings vary with a 44 year, 86 year (Gleissberg cycle), 200 year (well known), and 400 year cycle. I am not sure what the 113 year cycle is, but it is rather large

Nodal cycle, and with 7 cycles, it shows interesting sub cycles which really need further examination. The results strongly suggest that the 18.6 year cycle produces its own sub cycles: 1/4, 1/8, and 1/16th cycles, which, interestingly match up to several other known cycles. The visible QBO cycle is suggested to be about 2.3 years, and also, a half cycle of 1.17 years, matching the timing of the earth's wobble and length of day. Cycle of 1.17 years, matching the timing of the earth's wobble and length of day.

CLIMATE CYCLES OF WESTERN WASHINGTON



CLIMATE CYCLES OF WESTERN WASHINGTON



At the lunar Nodal Minimum, when Pacific NW temperatures are at the warmest of the nodal cycle, there is an interesting tendency for temperature to decrease at mid-winter, and then gradually warm from March to November!:
The polar position changes in the x and y directions of the pole of ecliptic. The pole position changes from about 0.1 to 0.3 arc degrees, a displacement of some 5-15 m.

NORTHWEST WASHINGTON
AMPLITUDE CYCLES 1900-2010
5 cycles 1917 to 2001:

NW WA Wet cycles lag lunar Max -4.2+-2.3 years
NW WA Dry cycles lag lunar Min -3.3+-1.0 years

LUNAR NODAL CYCLE:
(18.6134 YEARS) OR PROBABLY CLOSER TO: 18.612944

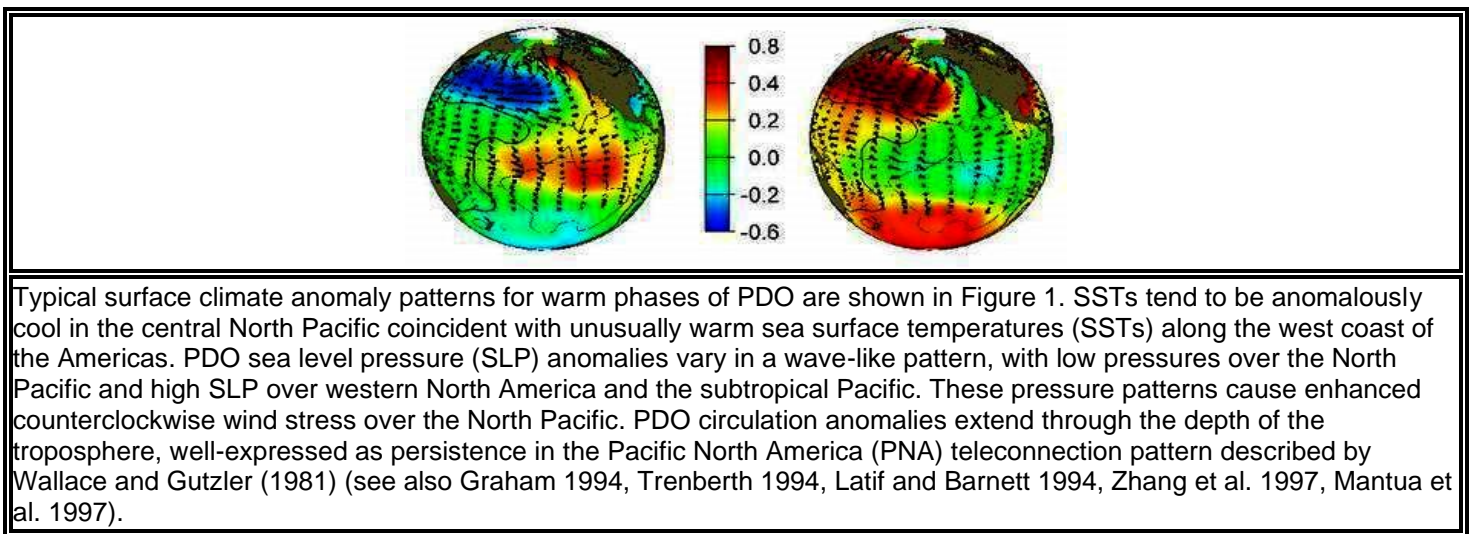
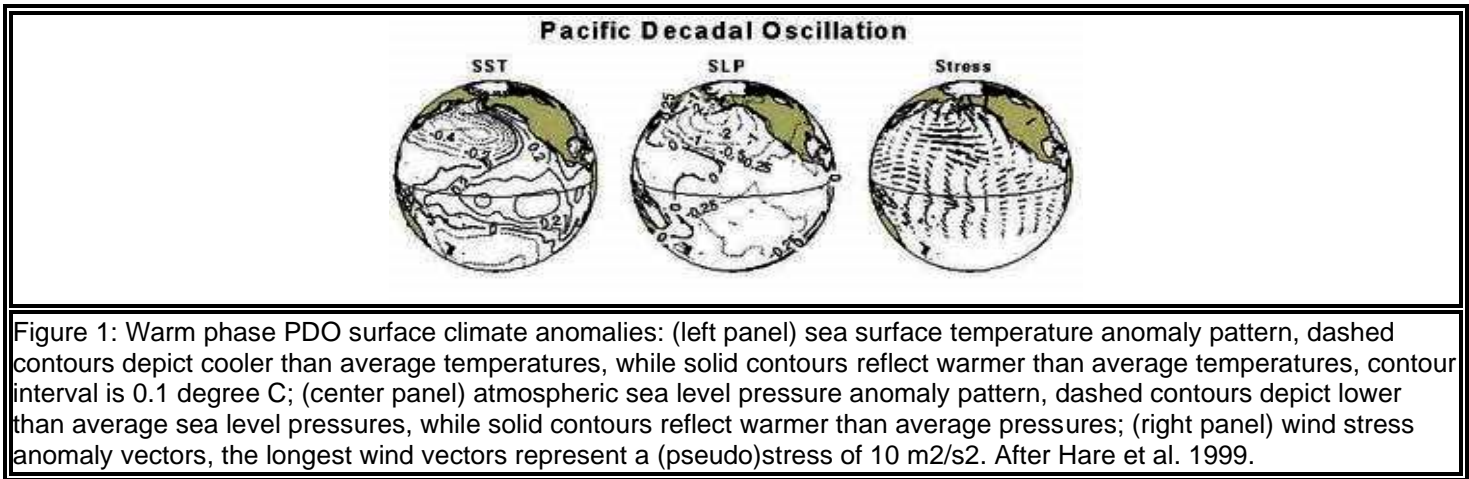
MAX	MIN
1857.559	1866.865
1876.172	1885.478
1894.785	1904.091
1913.399	1922.705
1932.012	1941.318
1950.626	1959.932
1969.239	1978.545
1987.852	1997.158
2006.466	2015.772
2025.079	2034.385
2043.693	2052.999
2062.306	2071.612

	AMPLITUDE (STANDARDIZED DEPARTURE)	PERIOD LENGTH	SHOULD BE
18.6 YEAR	.15		
1/2 CYCLE			
1/4 CYCLE	.07	4.67 YRS	4.652 YRS
1/8 CYCLE	.13	2.69 YRS	2.326 YRS
1/16 CYCLE	.15	1.237 YRS	1.163 YRS

THE 1/4 CYCLE LENGTH LONG AT 18.6 YR MIN (55-90 MONTHS) AND SHORT AT 18.6 YR MAX (25-250 MONTHS)

THE 1/16 CYCLE PERIOD LENGTH VARIES WITH THE QBO 12+-2.1 MONTHS VS 19.1 +-3.1 MONTHS.

CLIMATE CYCLES OF WESTERN WASHINGTON



VERY LONG CLIMATE CYCLES

775 YEAR CYCLE

The 775-yr periodicity might thus be regarded as a harmonic period of the 1500-yr cycles.

1000 YEAR CYCLE

Holocene oxygen isotope data from the GISP2 ice core reveal temperature oscillations in Greenland with a periodicity of ~900 y, which can be correlated to climate perturbations in northern and central Europe. We suggest that the 900-y climate fluctuations are generated within the climate system, and are probably triggered by negative salinity anomalies in the North Atlantic. A simple template is used to show that two such triggering events centered at ~8.3 and 4.7 ky BP are required to explain temporal evolution of 900-y climate cycles between ~3.5–8.5 ky BP as sequence of damped oscillations. Although pacing of the 900-y cycles by changes in the Earth's orbit cannot be ruled out, we regard this scenario as unlikely.

900 YEAR PERIODICITY:

Orbital forcing: A ~900-y periodicity in eccentricity variations of the Earth's orbit, which modulates incoming solar radiation. Accordingly, it might be possible that the observed 900-y climate fluctuations are linked to this external forcing. The amplitude of the ~900-y component of summer insolation at 65°N is less than 1 mW m⁻², that is, two orders of magnitude smaller than the estimated radiative forcing resulting from solar output variability (~300 mW m⁻²). The effect of the latter on Earth's climate is probably rather small, making it unlikely that the extremely small 900-y insolation variations should affect climate directly. Nevertheless, one could envision that internal oscillations of the climate system are paced by the orbital variations, resulting in a phase-lock between forcing and climate variations. (IN: Holocene Climate Variability on Centennial-to-Millennial Time Scales:1. Climate Records from the North-Atlantic Realm)

1500 YEAR CYCLE

From more recent analysis of historical sunspot and aurora records, Alpine glaciers and high-resolution paleoclimatic records, there is evidence of long-term cycles of about 2500 and 1500 years in the Holocene. The most pronounced abrupt shifts in climatic conditions are repeated with an about 2400-year period. The less pronounced changes in climatic conditions occur every about 1500 year.

:::The mysteriously regular 1,500-year climate cycles are linked with the oceanic circulation and not with variations in solar output.

CLIMATE CYCLES OF WESTERN WASHINGTON

1600-year cycle is recorded during the Holocene in the residual $\delta^{14}\text{C}$ excepted during 5500-0 years exactly when the 1500-year cycle of Bond' series is well expressed. Thus, the occurrence of this 1500-year cycle in the IRD series records a forcing other than solar activity.

The results display a dominant 1700 years variability (Fig. 3) evidencing the influence of ocean activity on the overlying low-altitude atmospheric configuration.

(1600-year cycle, dominant during 5500-0 years cal)

The most pronounced cyclicities of the millennial scale are about 2400 and 1500-years.

∴The 1500-year cyclicity in climate change can be mainly due to oceanic processes (changes in circulation and overturning in the ocean).

∴The origin of the 1500-year climate cycles in Holocene North-Atlantic records M. Debret et al

∴The 775-yr periodicity might thus be regarded as a harmonic period of the 1500-yr cycles.

∴The cold portion of each 1500 year cycle corresponds to a period during which the energy (heat and light) emanating from the sun is at a lower level than during the warm phase of the cycle. This relation is based on the fact that maximum production rates of the cosmogenic isotopes Carbon14 and Beryllium10 correspond in time to the cold phases of each cycle. These radioactive elements are produced by cosmic rays streaming from the sun and colliding with atoms of Nitrogen and Oxygen in the outer part of the atmosphere. These new isotopes then fall to the Earth and are incorporated in growing plant and animal tissue (C14) or into soil and rocks (B10) . During periods when the sun is more active, and thus emitting more energy, an extensive magnetosphere prevents these cosmogenic elements from reaching Earth. This important fact demonstrates that the main forcing agent or trigger for cyclical climate change is variation in the sun's irradiance, although a complex association of poorly understood feed-back mechanisms involving other reactions may well be linked to the actual changes in temperature. A closely related discovery is that the energy from the sun has been increasing during the past 150 years, and that most of the surface temperature increase recorded over this period can be attributed to this cause. Data presented by Kevin Pang and Kevin Yau (EOS, v. 83, no. 43, October 22, 2002) and Peter Foukal (EOS, v. 84, no. 22, June 3, 2003), clearly demonstrate the close correlation between change of temperature and change in solar activity.

2500 YEAR OSCILLATION

∴∴∴From more recent analysis of historical sunspot and aurora records, Alpine glaciers and high-resolution paleoclimatic records, there is evidence of long-term cycles of about 2500 and 1500 years in the Holocene. The major oscillations are at 8500-7800 cal year BP, 5400-4700 cal year BP, 2680-2200 cal yr BP and 1100-400 cal yr BP with ~2400-year periodicity between them. The most pronounced abrupt shifts in climatic conditions are repeated with an about 2400-year period. The less pronounced changes in climatic conditions occur every about 1500 year.

∴∴∴The most pronounced cyclicities of the millennial scale are about 2400 and 1500-years. Similarities between the glacier data from different latitudes and Greenland records pointing to 2400-year cyclicity of cooling events indicate that this large-scale cyclicity in climate is a global climate effect.

∴∴∴1. Climate during the past 10,000 years (Holocene Period) has not been uniform as previously thought, but instead shows the same pattern of warm to cold cyclical behavior characteristic of the last major glacial period (late Pleistocene), but with more muted response. These cycles have a frequency of about 1,500 years and result in major changes in extent of glacial ice, surface and deep-water oceanic currents, and global temperatures. These 1,500 year oscillations are termed Dansgaard-Oeschger (D-O) cycles, named after their discoverers, and

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are readily recognized by an increase in ice-rafted material in sedimentary cores recovered from the ocean floor. A related but more severe phenomenon called "Heinrich events" with a frequency of 6,000 to 8,000 years has not yet been recognized within the Holocene Period. The "Little Ice Age" that attained its coldest culmination at about the year 1400 AD is the youngest manifestation of the cool portion of a D-O cycle. As shown in the figure below, the global climate has been warming since 1400 and we are now near or at the crest of the warm part of the curve. Global cooling may well be well-advanced within the next 100 years or so, as we slide down into another mini ice-age which may culminate in 700 to 800 years. A full-blown deep ice age with return of continental glaciers is still off in the dim distant future. But it will come.

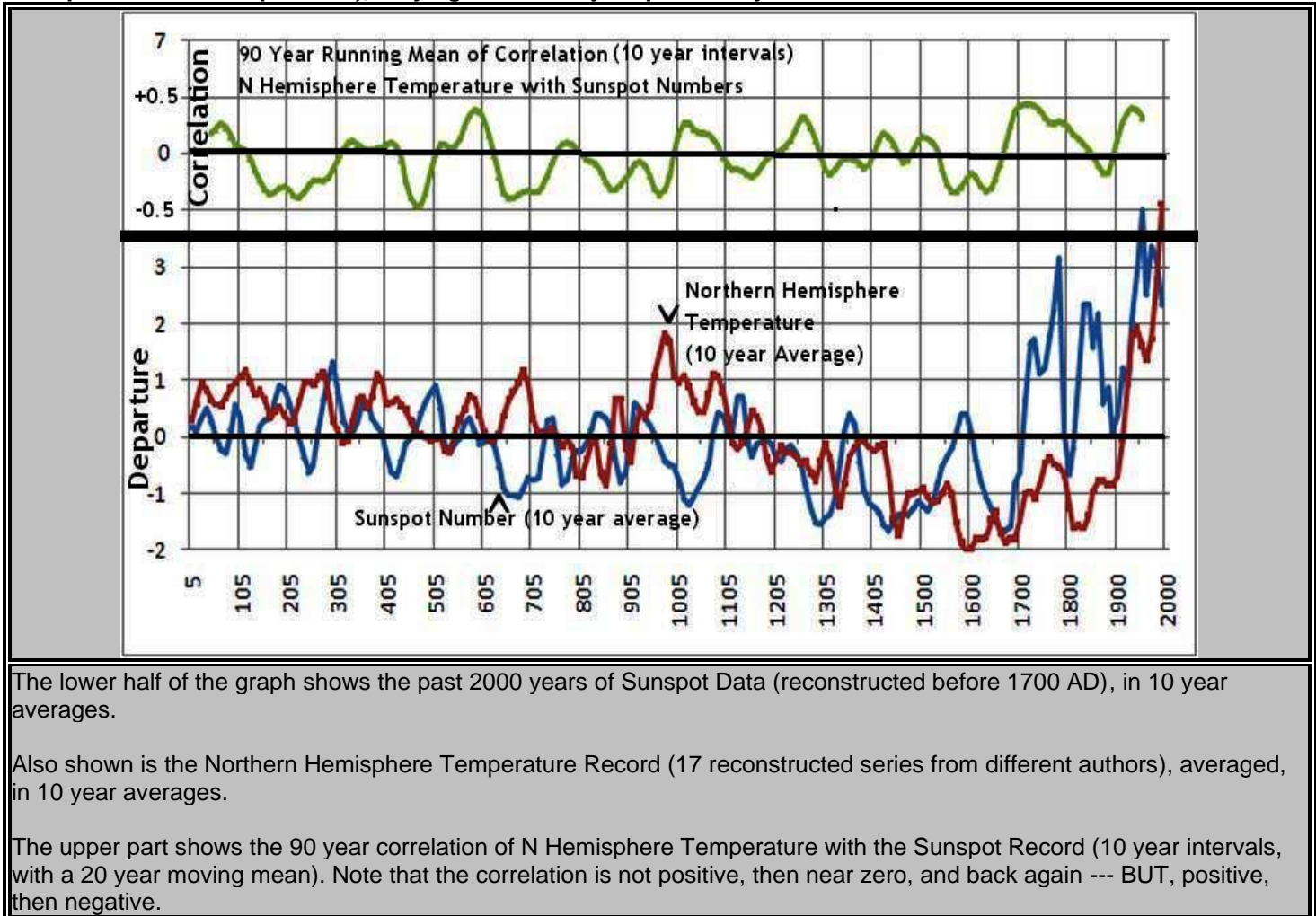
LONG TERM CLIMATE CYCLES:

- Milankovitch Cycles - Gravitational forces modulate these cycles related to Earth's eccentricity, obliquity, and precession.
- Solar Cycles - Magnetic cycles internal to the Sun regulate frequencies of 27 days, 11 years (Schwabe cycle), 88 years (Gleissberg cycle), and 208 years (Suess cycle).
- Geomagnetic Cycles - The solar cycles act as the primary modulators of magnetic cycles on Earth. However, a semi-annual cycle, the eclipse cycle, and the lunar cycle also play minor roles in geomagnetic oscillations.

EARTH'S CLIMATE AND SUNSPOTS THE PAST 2000 YEARS

The Northern Hemisphere Temperature of the past 2,000 years shows no correlation with sunspot number during the past 2,000 years ($R=.04$)

BUT!! -- Northern Hemisphere Temperature is actually higher correlated ($R=.42$) to the Sunspot record when it is revealed that earth's climate varies with the sun (more sunspots - warmer temperature, vs more sunspots - cooler temperature), varying with a 200 year periodicity.



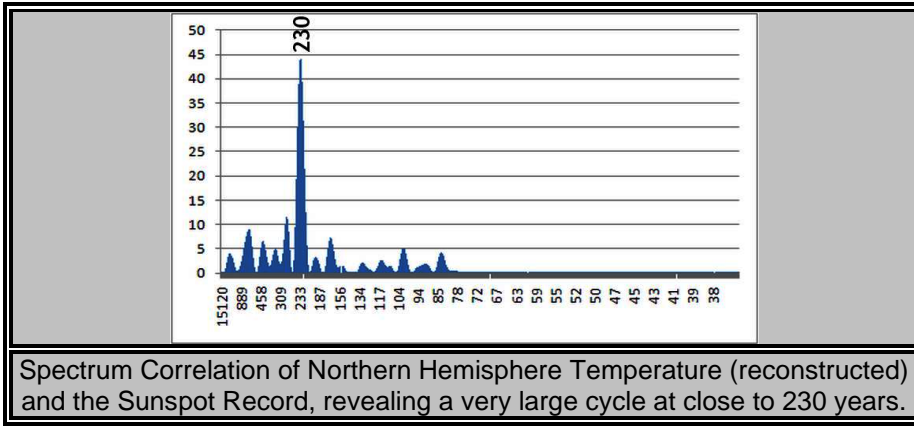
The lower half of the graph shows the past 2000 years of Sunspot Data (reconstructed before 1700 AD), in 10 year averages.

Also shown is the Northern Hemisphere Temperature Record (17 reconstructed series from different authors), averaged, in 10 year averages.

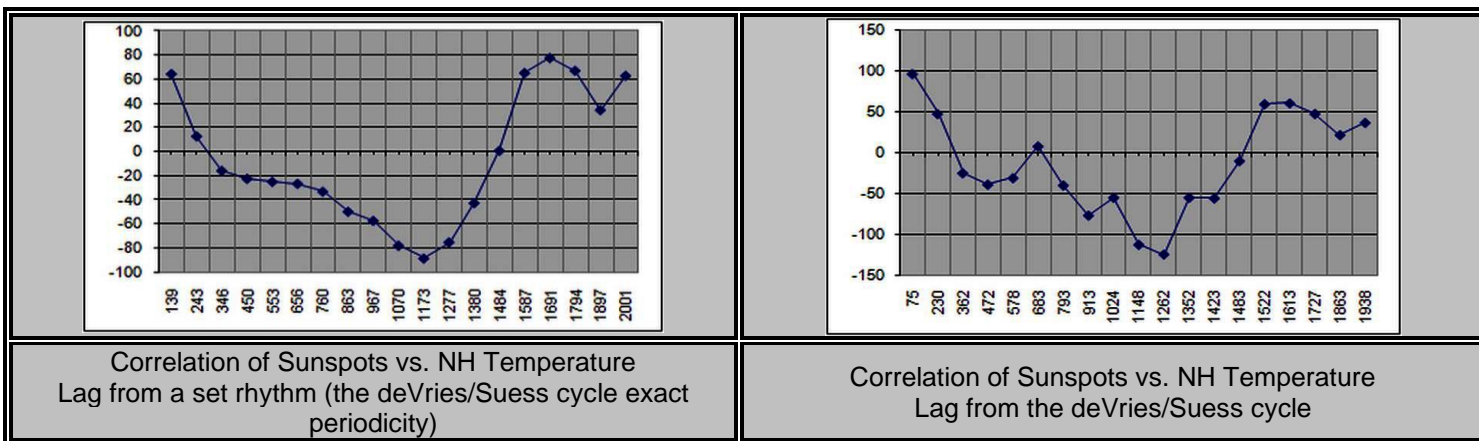
The upper part shows the 90 year correlation of N Hemisphere Temperature with the Sunspot Record (10 year intervals, with a 20 year moving mean). Note that the correlation is not positive, then near zero, and back again --- BUT, positive, then negative.

A close look at the graph above of Northern Hemisphere Temperature (similar to worldwide temperature) vs. Sunspot Data (reconstructed prior to 1700 AD), reveals a somewhat mixed correlation. However, the top graph reveals that the correlation of the two swings back and forth between Warm intervals - more sunspots, vs. more sunspots - cool intervals.

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The Spectrum of the Correlation above reveals that Northern Hemisphere Temperature is varying between negative correlation and positive correlation in a period of about 230 years, and is the same Solar Cycle as the well observed 206 year de Vries cycle or Suess cycle.



The above graphs reveal that the 200 year correlation variation, varies over a long period of time, very likely with the 2300-2500 year Hallstatt Cycle. Since the variation with the actual Hallstatt Cycle (graph on right) does not lag the same as the Sunspot record of the Hallstatt cycle, it must be that Earth's climate is responding to another aspect of Solar Variation, rather than just the sunspot record (perhaps geomagnetic variation, or solar system gravitational changes).

The correlation with the sun varying with a 200 year periodicity between more sunspots - warm temperature vs. more sunspots - cool temperature *is a newly observed feature of our temperature record that has not been emphasized before, and thus needs much more intense analyzation.*

AMPLITUDE AND PERIOD LENGTH MODULATION

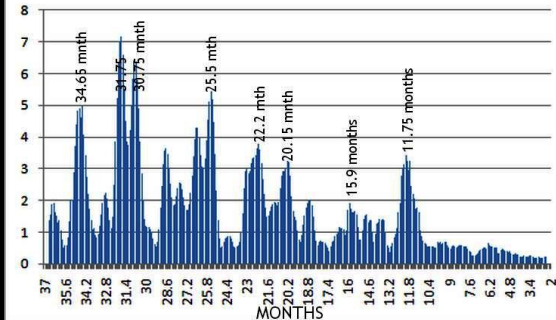
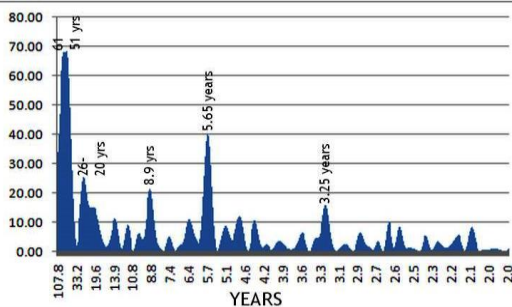
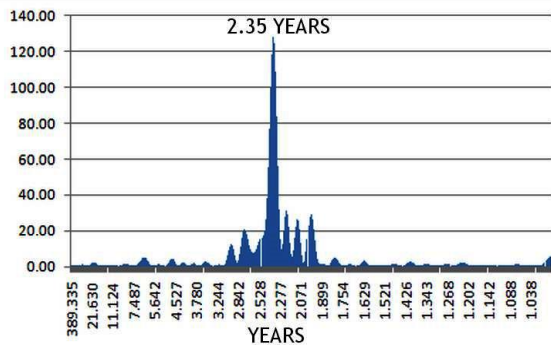
The 45 to 11 year cycles show a distinct 50% reduction in amplitude (intensity) with increasing longer periods. For example, the modeled precipitation amplitude is as follows: 45 day $67 \pm 33\%$, 0.7 year $33 \pm 16\%$, QBO $17 \pm 8\%$, 5-6 year $8 \pm 4\%$, and 11 year $4 \pm 2\%$. The two week cycle is about $90 \pm 40\%$. Temperature is less discernible: 45 day (2.48°F), 0.7 year (0.9°), QBO (0.6°), 5-6 year (1.0°), and 11 year (0.6°).

Cycle period lengths are not directly in phase, and after lag has been removed, have a standard deviation (correlated value) or $\pm 18\%$ of the period length. This is logical, in that it infers a model value of 16.67% and a $1/3$ period warm, $1/3$ period cold, and $1/3$ period transition (1.0 period divided by $3=33.3\%$, or amplitude $\pm 16.7\%$ or period). It is noted that at about 5-6 years the amplitude approaches ± 1.0 year.

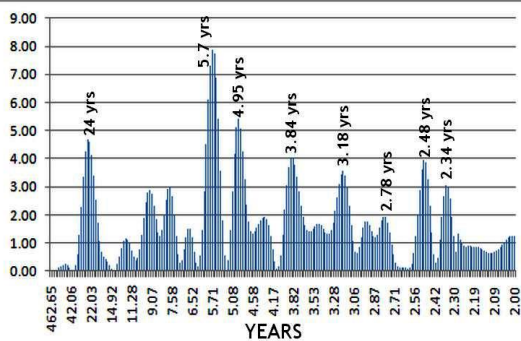
*Based on original manuscript 1987 "Forecasting Pacific Northwest Climate: The Theory Behind How Climate Cycles Work" by Gary J. Morris

SPECTRUM OF PACIFIC AND EQUATORIAL OSCILLATIONS:

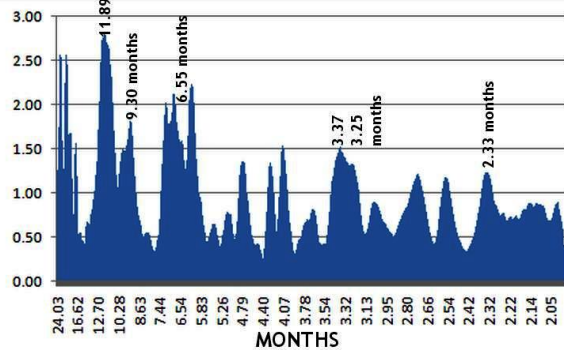
**Spectrum analysis of ZONAL WIND INDEX
at Upper levels of Equatorial Pacific 1953 to 2001,
1 to 100 years. NOTE: The one dominant peak**



**Spectrum analysis of PACIFIC NORTH AMERICA Pattern
1950 to 2007, 2 to 100 years**



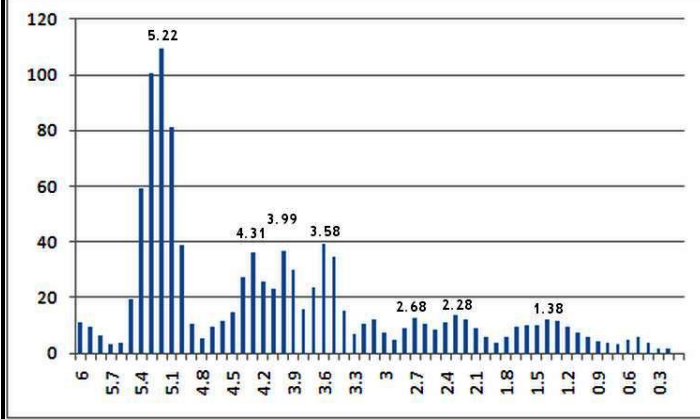
**Spectrum analysis of PACIFIC NORTH AMERICA
Pattern
1950 to 2007, 2 to 24 months**



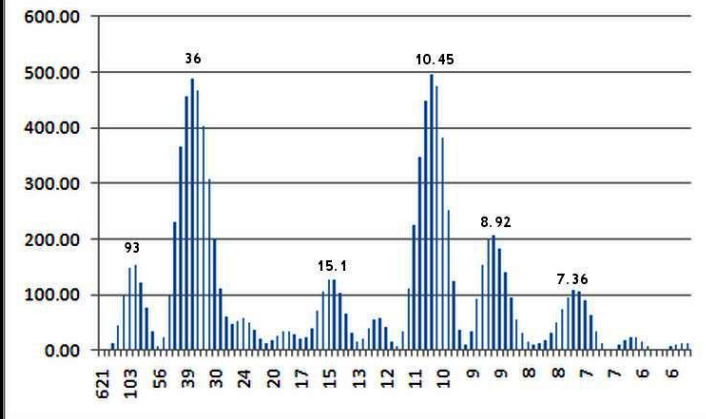
**Spectrum analysis of PACIFIC NORTH AMERICA Pattern
1950 to 2007, 3 to 365 days**

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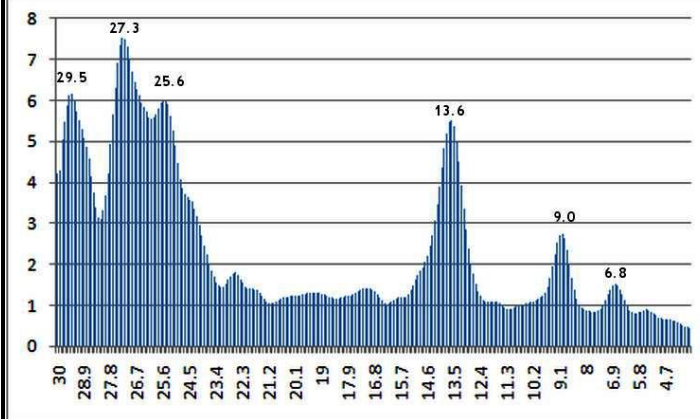
**Spectrum analysis of Geomagnetic Activity 1932 to 2010
AD,
0 to 6 year cycle lengths**



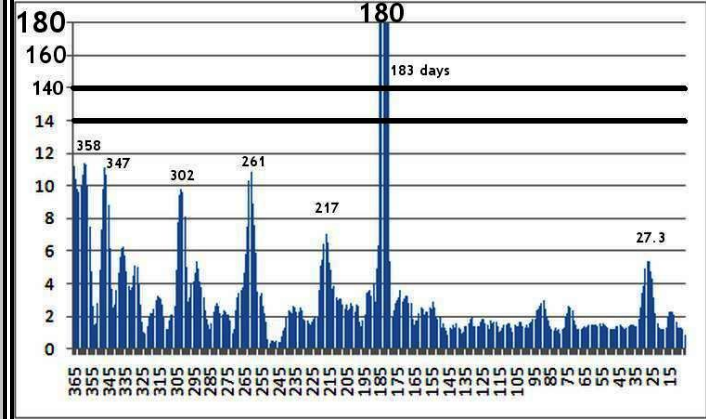
**Spectrum analysis of Geomagnetic Activity 1932 to 2010
AD,
6 to 80 year cycle lengths**



**Spectrum analysis of Geomagnetic Activity 1932 to 2010
AD,
4 to 30 day cycle lengths**



**Spectrum analysis of Geomagnetic Activity 1932 to 2010
AD,
3 to 365 day cycle lengths**



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