SOLAR HEATING OF THE UPPER AIR
&
00Z-12Z TEMPERATURE CONVERGENCE

INTRODUCTION

The accepted theory of solar radiation and its effects on the atmosphere is that incoming radiation from the sun passes through the atmosphere with little interaction, except at the ozone layer where ultraviolet radiation from the sun is absorbed by ozone and heats that layer. The ozone layer is considered to begin about 15 kilometers above the earth and contains 90 percent of the ozone. The region below the ozone layer is the troposphere, and it contains the remaining ten percent of the ozone.

The global distribution of ozone affects the absorption of ultraviolet radiation, and therefore there are differences in heating from place to place. But that distribution is outside the thrust of this paper, and no attempt has been made to analyze such distribution.

A recent article by NASA reported that the thermosphere, a region of the atmosphere above 90 kilometers, had been warmed by ultraviolet radiation but was now cooling due to the reduced activity of the sun. We will show that this cooling, or lack of heating, can be seen down to the lower levels of the atmosphere.

DATA SOURCE

All data used in this article comes from balloon-borne radiosonde data obtained from https://www.ncdc.noaa.gov/data-access/weather-balloon/integrated-global-radiosonde-archive.

Most graphs are yearly average temperatures for the altitude indicated, and some are graphs of the difference between 00z and 12z observations. The temperatures at various levels vary widely from year to year, but the temperature differences between 00z and 12z are much more conservative and change little over the short term. For that reason, we use differences to determine the time of heating as it relates to the sun.

The National Weather Service measures the temperature aloft at regularly scheduled times of 0000z and 1200z. That is standard launch time, but in actual practice, the balloons are routinely launched 45 minutes to an hour earlier than the standard time. It takes about 45 minutes for a balloon to get to 100 MB after launch, so the 12z=local time on the graphs below are approximate. There is evidence that indicates some foreign countries launch at times up to two hours later.

Because of the quality of the data, we will be using observational data primarily from the United States and Canada.

DYNAMICS OF TEMPERATURE CHANGES IN THE UPPER TROPOSPHERE

All radiosonde observations are taken, more or less, simultaneously and as a result, they are taken at different local times, depending on the longitude of the observation site. A station at 90 degrees West longitude is taking the 12z observation near sunrise and the 00z observation near sunset. A station at 105 degrees west takes the 12z observation one hour before local sunrise and the 00z observation one hour before sunset.

By comparing the temperature from the 0000z observation with the temperature from the 1200z observation, we can view the effects of the sun on different levels of the atmosphere in relation to time. In effect, we use year-long averages to detect changes that occur within minutes and hours.

The dynamics of temperature changes in the upper troposphere are very interesting and somewhat surprising. As the sun rises in the east, it immediately heats the atmosphere from 20mb down to about the 200mb level (85,0000 to 40,000 feet) and as the earth turns this heat wave moves to the west at 1,000 miles per hour. Of course, the amount of heat varies with latitude, the intensity of the radiation, and the amount of ozone.

The surprising part is the speed of the heating. The accepted wisdom was that maximum heating would occur shortly after noon or later. At the higher levels, above 150mb, the air temperature increases very rapidly after sunrise and within minutes can increase by over one degree (see Table 1 below) and after two hours remains almost constant. Presumably, this is due to the ozone becoming saturated.

DIURNAL TEMPERATURE CHANGE AND SUNRISE

If one of the upper air observations coincides with day and the other at night, local time, the day temperature at 100 MB will be higher than the night temperature as shown in the graph for Brownsville, Texas. The convergence of the two curves in 2010 will be addressed later.

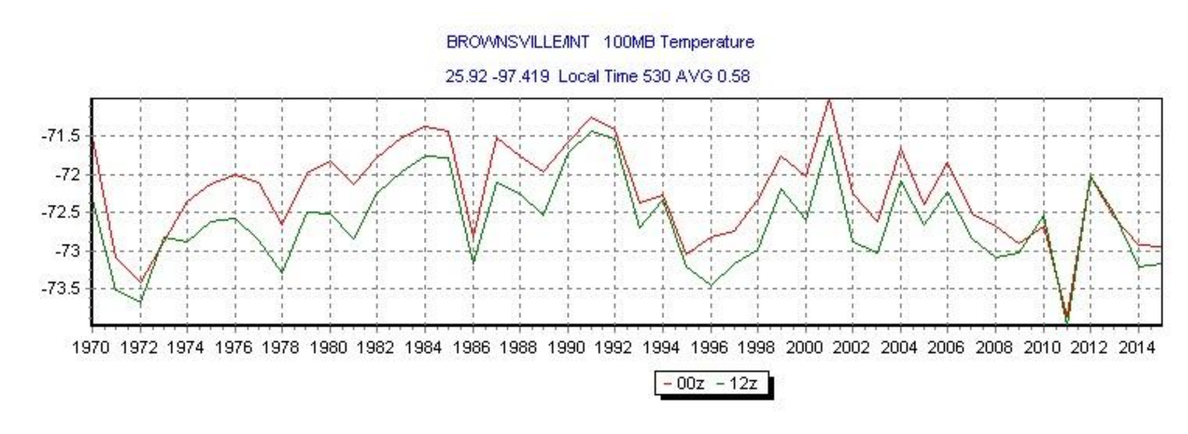

Fig 1. Brownsville, Texas 100mb

The graph for the 100mb temperatures at Brownsville shows that 30 minutes before local sunrise the 00z temperature is higher than the 12z temperature.

If one of the observations coincides with sunrise, the difference between the day and night temperatures will be zero, since if one observation is at sunrise, the other is, on average, at sunset and the air is receiving the same amount of ultraviolet radiation at the time of the two observations. The graph below illustrates the concept. Jackson's local time at 1200z is 05:59, which is very close to sunrise for that longitude, and the temperatures at 0000z and 1200z are almost identical at 20mb.

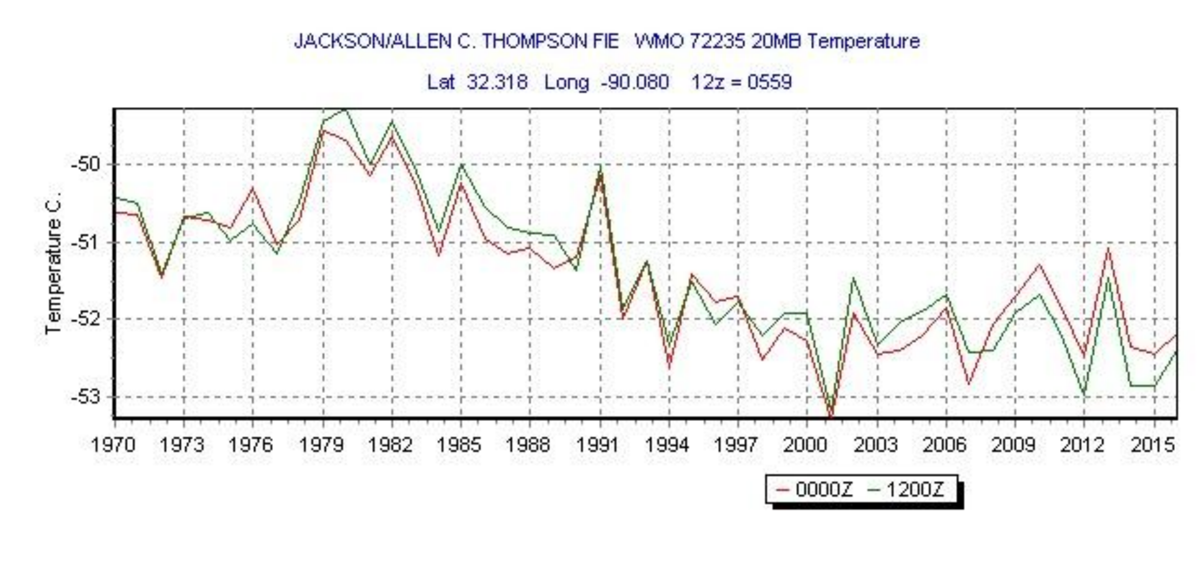

Fig 2. Jackson, MS 20 MB Temperature.

However, if we move to a station a little to the east of Jackson, like Key West, Florida, the 12z temperature rises substantially. Key West's local time at 1200z is 06:32, about 32 minutes after sunrise, and the temperature difference has climbed over one degree in 32 minutes. The 12z temperature is now higher than the 00z temperature. Ignore the convergence of the curves starting in 2011; we will address that later.

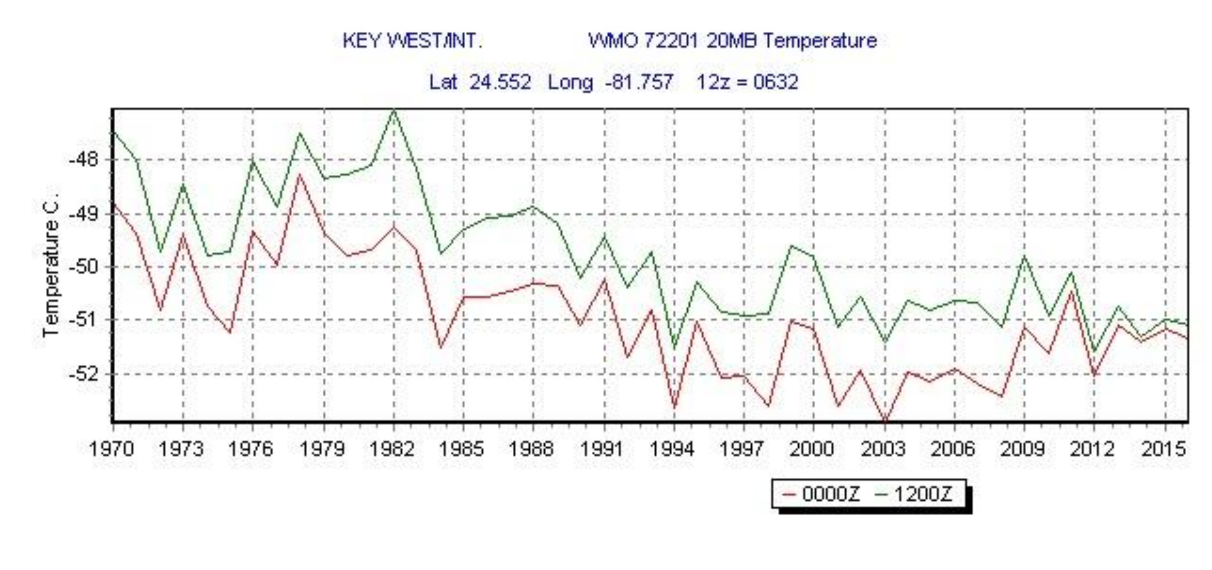

Fig 3. Key West, FL. 20 MB

At 32 minutes after sunrise, the heating gradually diminishes lower in the atmosphere, and at 100 MB the difference between the 1200z and 0000z temperatures at Key West is only about 3/10 of a degree, and at 200mb the heating has almost disappeared, but only for this time and place.

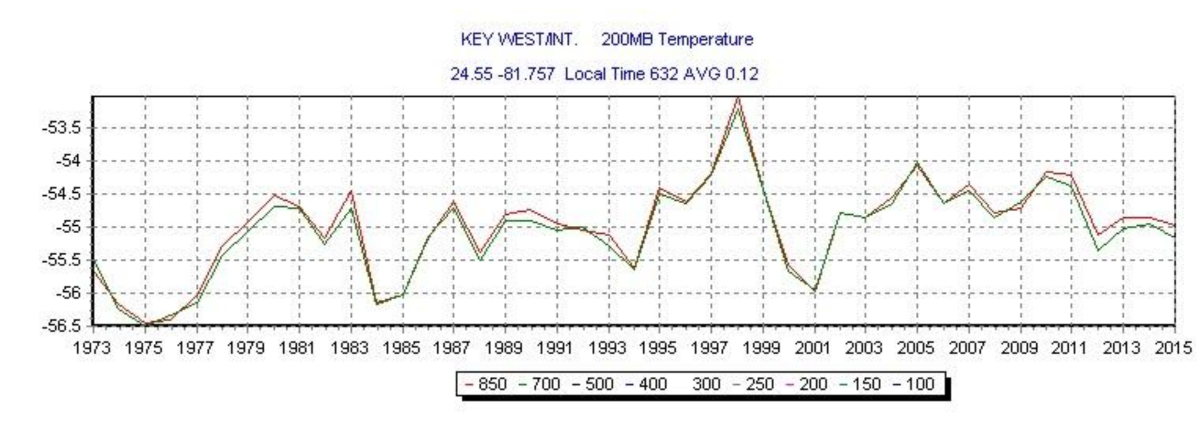

Fig 4. Key West 200mb 00z and 12z Temperature

MID LEVEL TEMPERATURE DIFFERENCES

Above 150mb, stations to the east of Key West exhibit increasing temperature differences for two hours following sunrise, reaches a plateau and then remains more or less constant. However, as the day progresses, the lower levels slowly heat and after several hours the heat can be seen down to the 700mb level. But to see this, we must look at data from upstream stations.

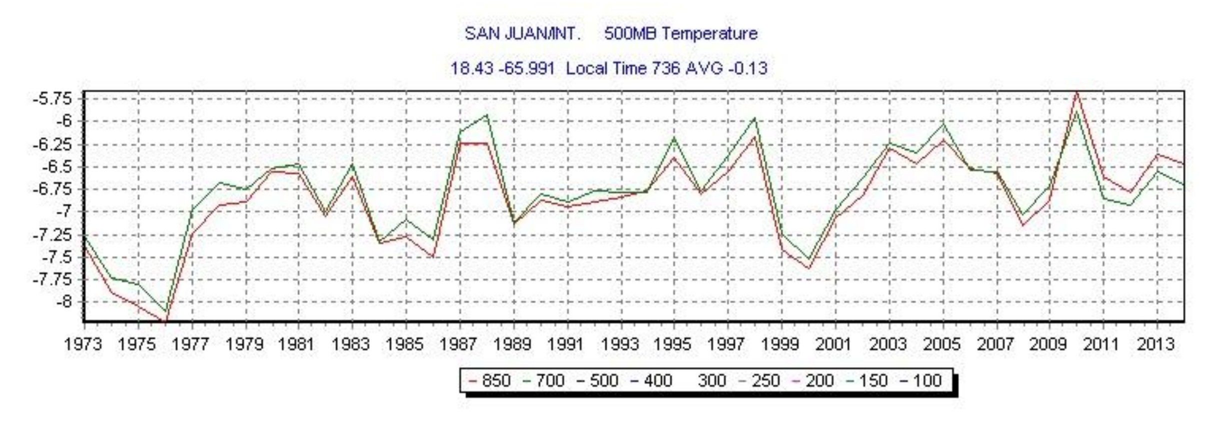

Fig 5. San Juan, PR. 500mb.

San Juan 12z observation 1 hour, and 36 minutes after sunrise and a small amount of heating can now be seen at the 500mb level.

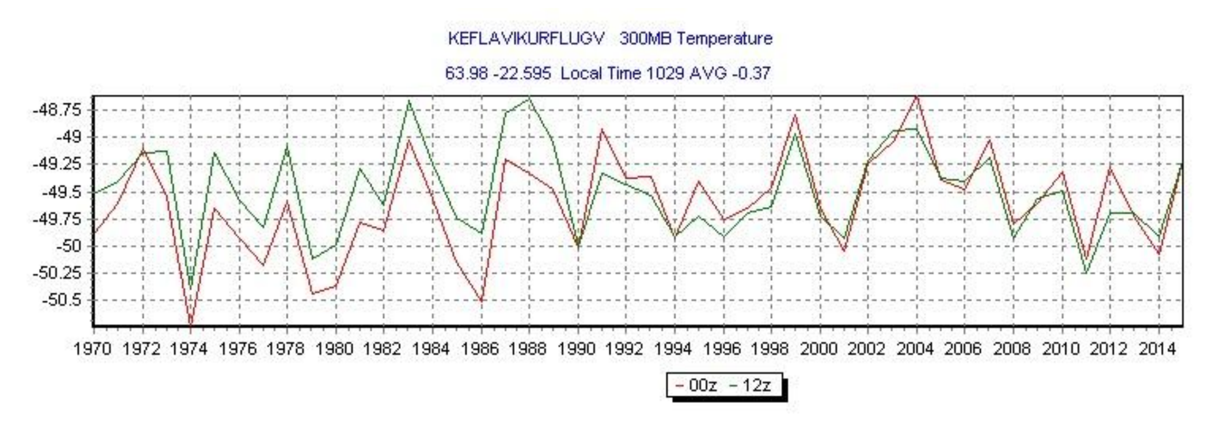

Fig 6. Keflavikurflug, Iceland 300mb

Keflavikurflug, Iceland, at 4 hours and 29 minutes after sunrise shows heating at the 300mb level. Further east we have Payerne, Switzerland with heating at the 700mb level 6 hours and 27 minutes after sunrise. Ignore the convergence after 1990.

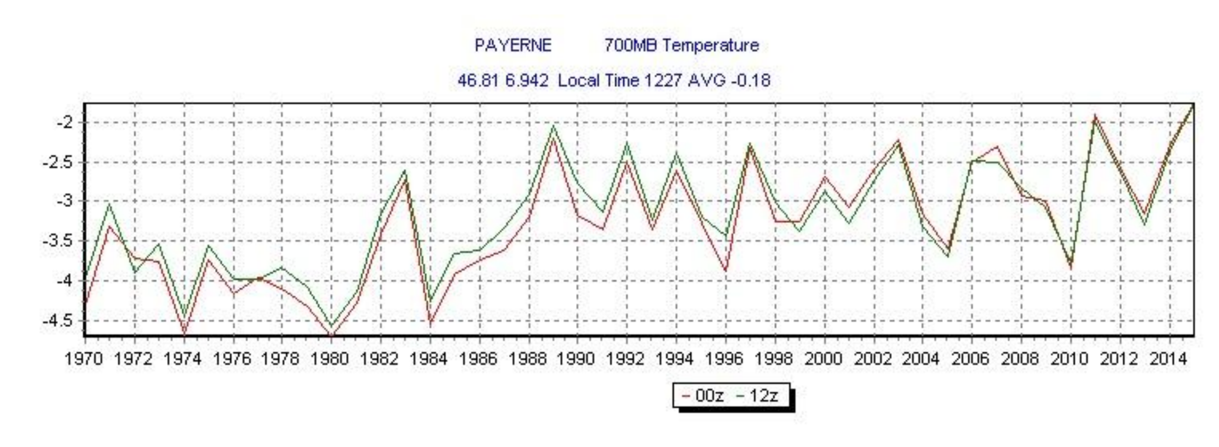

Fig 7. Payerne, Switzerland 700mb

In the following we will be using the difference between the 12z and 00z temperatures rather than the temperatures themselves, the reason is that the differences are much more conservative and change with local time.

The lower troposphere, at 850mb and to a less extent 700mb, is heated primarily by longwave radiation from the earth. But since the earth receives its heat from the sun during the day, we should see a variation in the 850mb 00z-12z temperature differences at stations with different longitudes.

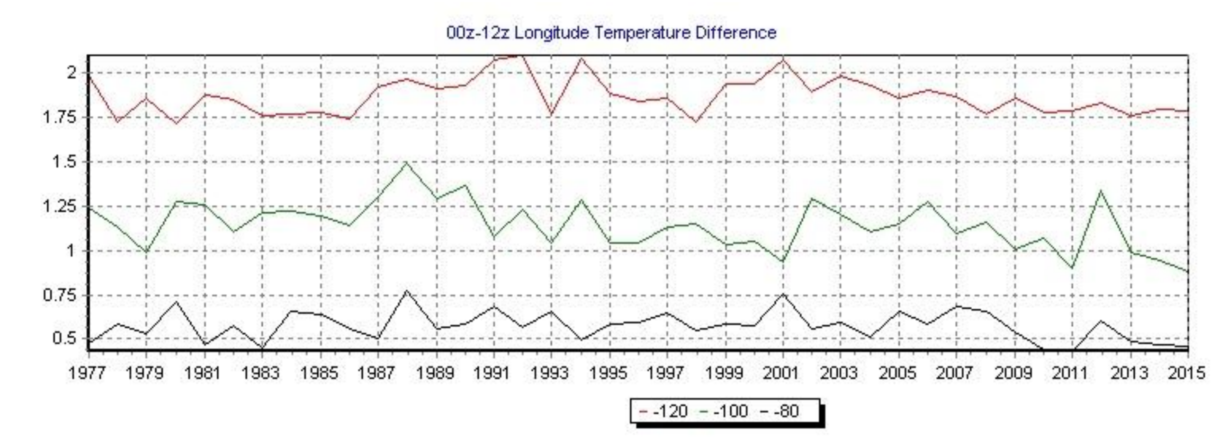

Fig 9. Changes in the 850mb temperature difference due to longitude.

In the above graph, the top line is the average temperature difference for stations centered around 120 West. The middle line for stations centered around 100 West and the bottom line for stations centered around 80 W. The heating does not saturate as it does for the higher levels and continues to increase during the day.

Another aspect of this phenomenon is the difference due to latitude. As expected, solar heating of the atmosphere is affected by latitude as shown in the graph below.

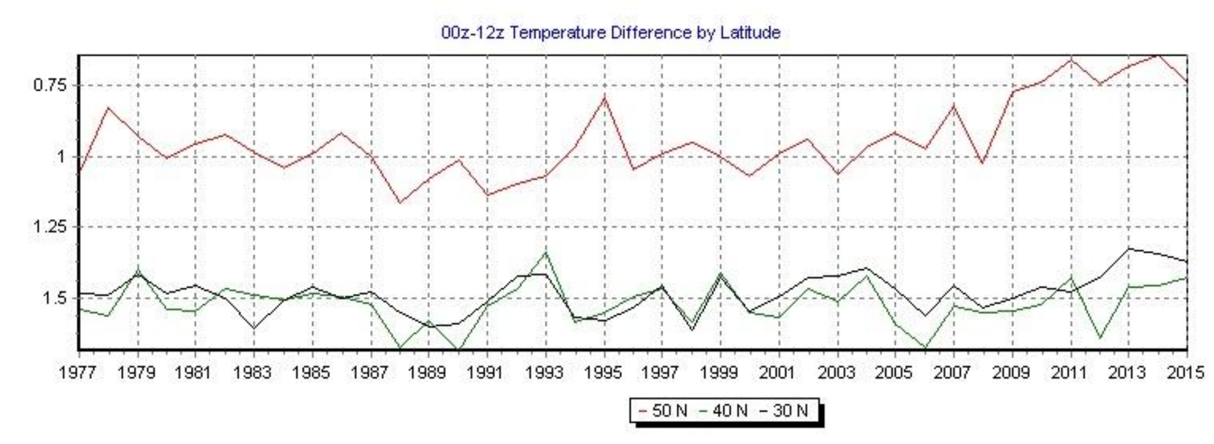

Fig 10. Changes in 850mb temperature difference due to latitude.

The red line is the temperature difference at 50 degrees north; the other two curves are the temperature difference at 40 and 30 north. There is little change going from 30 to 40 degrees latitude, but a large change going from 40 to 50 degrees latitude. Farther north at 50 to 70 degrees latitude the temperature difference approaches zero.

Temperature differences at 850mb are also affected by cloud cover, with temperature differences in the southwest United States much higher than those sites with more cloud cover.

STATISTICS

Longitude	**Time ***	**Stns**	850	700	500	400	300	250	200	150	100
80-95E	18:04	9	-1.64	-1.06	-.90	-.50	-.43	-.32	-.13	-.06	-.22
95-110E	19:06	19	-1.74	-1.06	-.47	-.27	-.61	-.55	-.35	-.30	-.27
110-125E	19:57	28	-.85	-.24	-.17	-.14	-.64	-.56	-.30	-.09	.06
125-140E	20:27	11	-53	-.09	0	.06	-.03	.02	.20	.42	.45
140-155E	21:28	5	-15	-.03	.05	.12	.11	M	.26	.51	.57
125-110W	4:15	4	2.52	.67	.62	.65	.77	.75	.74	.87	.92
110-95W	5:07	13	3.07	.84	.60	.58	.65	.68	.64	.61	.54
95-80W	6:07	8	.41	.36	.44	.42	.41	.34	.09	**-.15**	**-.11**
80-65W	7:18	6	.61	.27	.25	.24	.12	.18	**-.10**	**-.38**	**-.38**
65-50W	7:59	1	.29	.12	**-.01**	**-.07**	**-.10**	**-.14**	**-.41**	**-.55**	**-.72**
5-20E	13:10	1	**-.06**	**-.35**	**-.30**	**-.35**	**-.35**	**-.35**	**-.31**	**-.37**	**-.49**

Table 1. 00z minus 12z Temperatures at Different Longitude/Times.

*Approximate time for that longitude.

The table above is average 00z-12z temperature differences for stations located between latitude 25 and 40 degrees north. The way to read the table is to start at the top for a specific level and read down. The 850mb level begins at 6:04 pm and the negative difference rises until 7:06 pm, which indicates that maximum heating has occurred at that time. Going lower we see that the positive difference rises until 5:07 am which indicates maximum cooling has occurred at that time.

Looking at the 100mb level we have maximum heating at 7:59 am and maximum cooling at 4:15 am, about an hour before maximum cooling at the 850mb level. From the table above it is clear that heating from the sun affects atmospheric temperatures down to the 850mb level.

The statistics above are only for the 25 years 1977 through 1992. The intent was to get the average values before convergence occurred.

DAY AND NIGHT TEMPERATURE CONVERGENCE

The recent activity of the sun, with its low number of sunspots, has revealed that the sun has been heating the lower atmosphere all along, but it was not obvious until it quit doing so.

Recently the author discovered that the 0000 GMT and 1200 GMT temperatures were converging, and this convergence could be seen in the air column from 20mb down to the 400mb level and occasionally to lower levels. After convergence, there is no temperature difference between day and night observations.

In a chicken or egg situation, it might be difficult to decide whether the daytime temperature fell to match the nighttime temperature or the nighttime temperature rose to meet the daytime temperature. But consider, if the daytime temperature is substantially higher than the nighttime temperature and the two curves merge, we could say that daytime temperature cooled, if instead, we said that the nighttime temperature warmed, we would then have to explain the source of energy that caused the warming.

But there is a simpler way of determining which curve changed: Let's look at the Key West graph again.

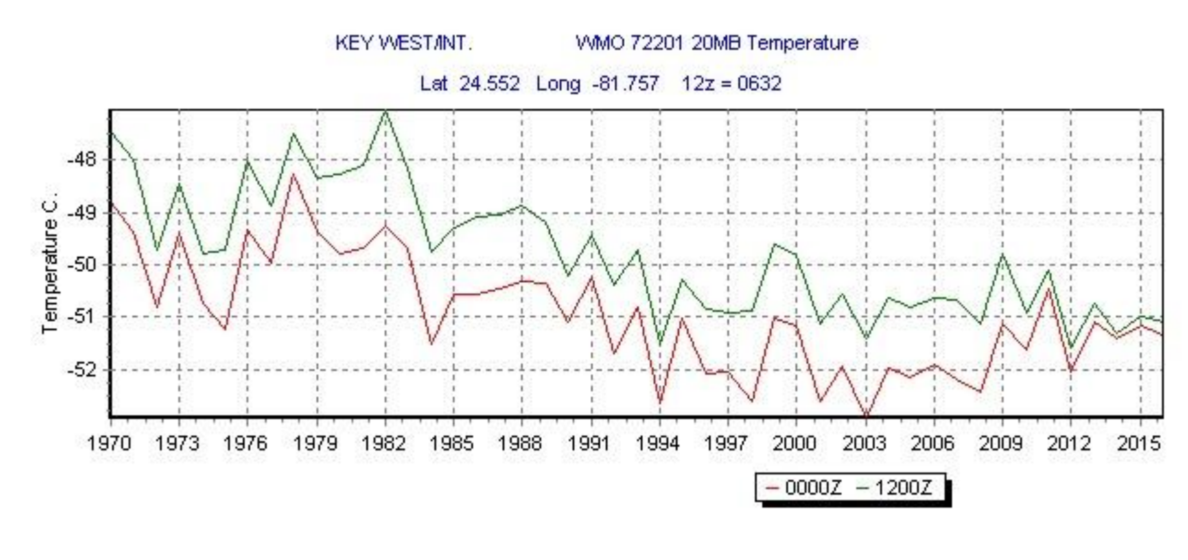

Fig 11. Key West 20 MB

We know that the difference between 12z and 00z in the above graph is due to heating after sunrise. So the convergence beginning in 2011 is simply a lack of heating because of a reduction in ultraviolet light from the sun or a reduction in the amount of ozone. Ultraviolet radiation and ozone are inextricably linked. A reduction in ultraviolet radiation would result in a reduction in ozone since the radiation creates ozone from oxygen.

NASA recently wrote that a reduction in ultraviolet radiation is causing a drop in temperatures in the thermosphere. According to numerous websites, ozone concentrations can vary widely in hours, and seasons and over large geographic regions. We have found that the beginning of convergence varies over wide geographic regions and most stations belong to a larger group. For example, almost all of Alaska stations experience similar years of convergence, 1995 to 1999. Other regions also exist such as Grand Junction, Albuquerque, Medford, Salem, Glasgow, Spokane, and Quillayute converge in the 2007 to 2010 time frame.

For an even simpler proof that convergence is due to a lack of heating, consider Tucson, AZ where the convergence beginning in 1996 is very evident.

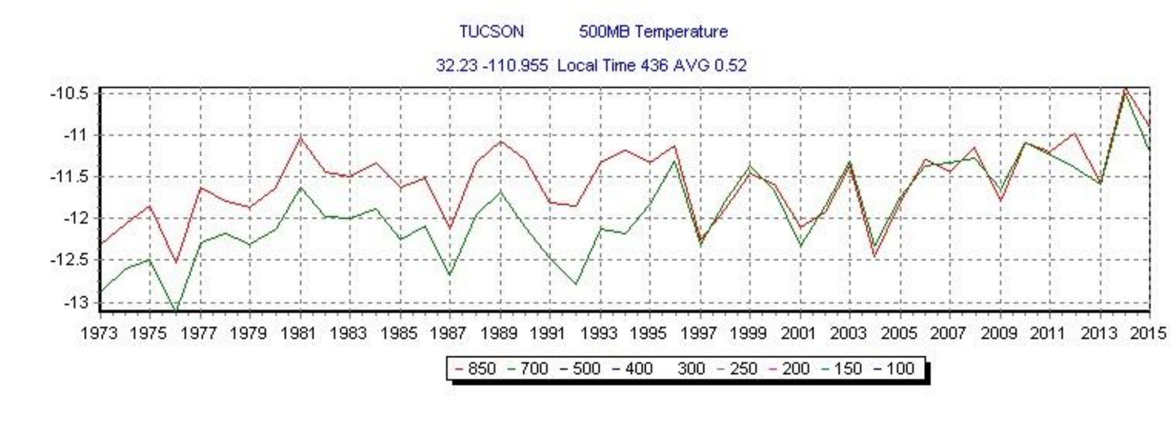

Fig 13. Convergence at 500mb at Tucson, AZ.

If we estimate the amount of heating before convergence, in this case, about 0.5 degrees, and apply it to the data points in the converged curve after 1995, voila, the convergence goes away.

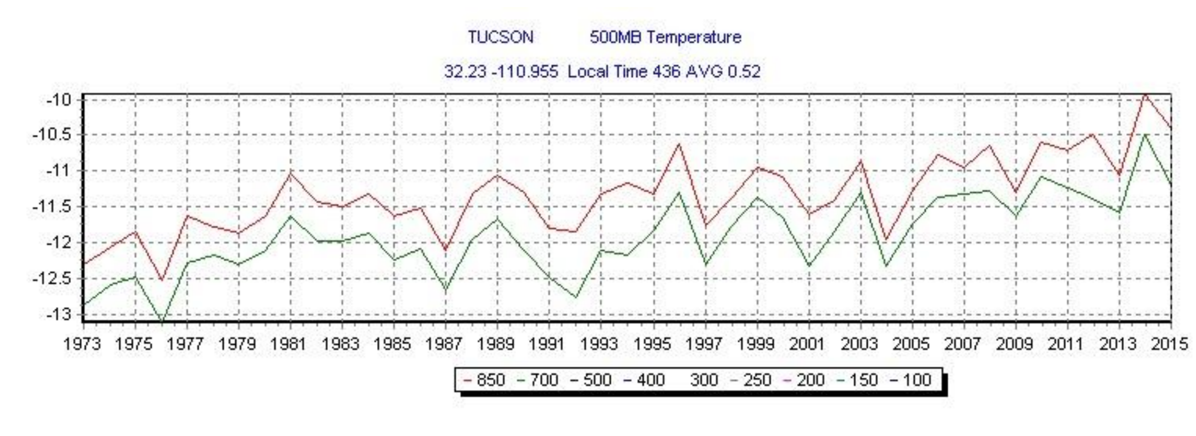

Fig 14. Temperature Adjustment + .5 Degree after 1995.

The fundamental difference between the heating of the lowest levels of the atmosphere and the upper atmosphere is that heating of the lower atmosphere is caused by the sun heating the surface and long-wave radiation from the surface heating the lower atmosphere, whereas the upper atmosphere heating is directly from the sun's ultraviolet radiation heating the ozone. However, the graph below shows that the cooling due to convergence also affects the 850mb level.

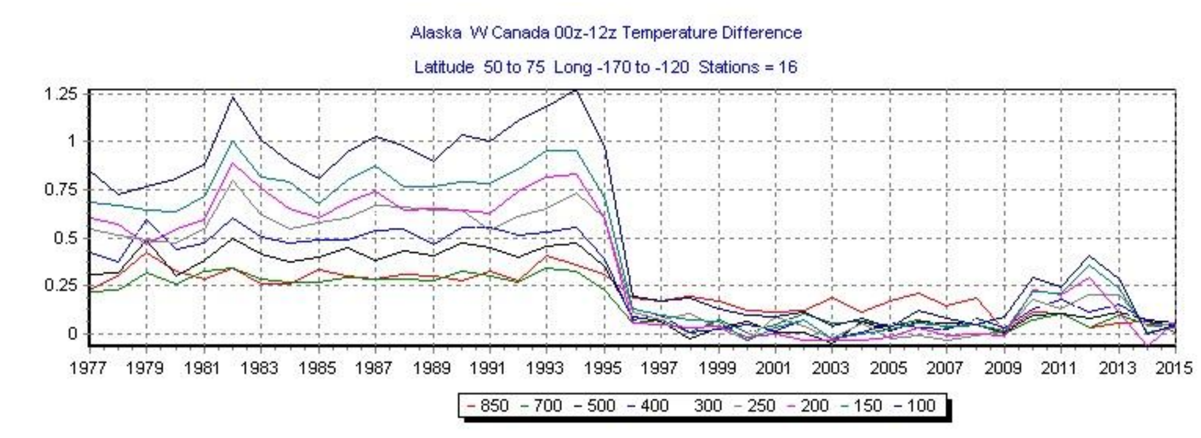

Figure 15. Alaska and Western Canada 00z and 12z Temperature Differences.

This unusual graph is due to the latitude of the 16 stations and the fact they all have a similar date of convergence. Note that the 850mb curve after convergence also shows a slight decline.

WORLD AVERAGES

It is interesting to look at the data by averaging all available stations:

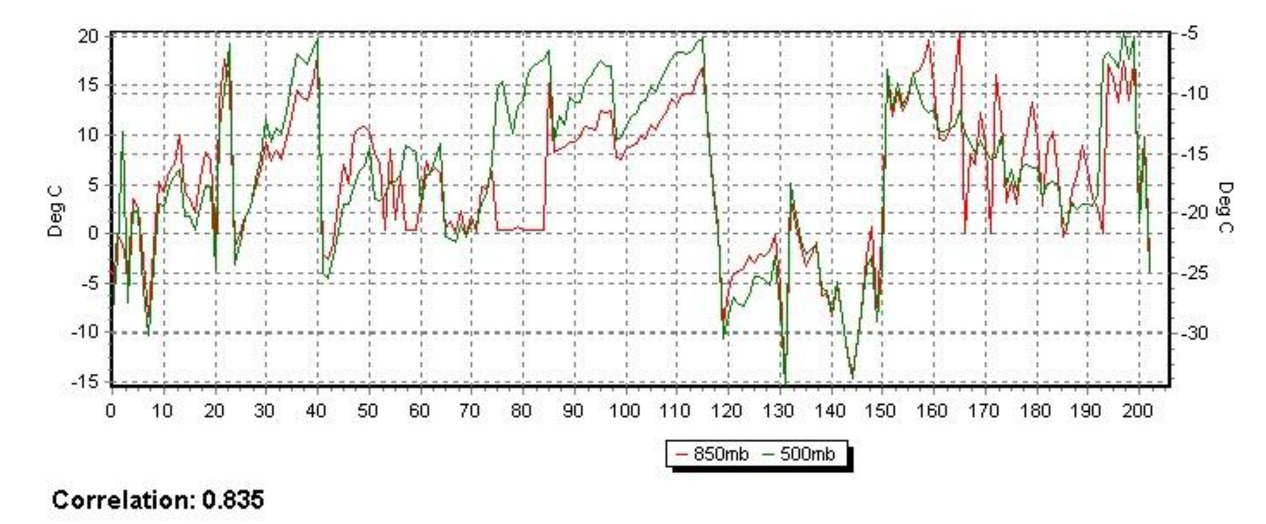

Fig 16. This graph shows the average temperature at 850 and 500mb for 204 stations. Note that the curves follow each other so that when one rises or falls, it is matched by the other, which merely reflects that both levels are heated by the same source, Long Wave Radiation from the earth. BTW, the curves from 120 to 150 are Alaska and Canadian sites, and the curve at 200 is Antarctica.

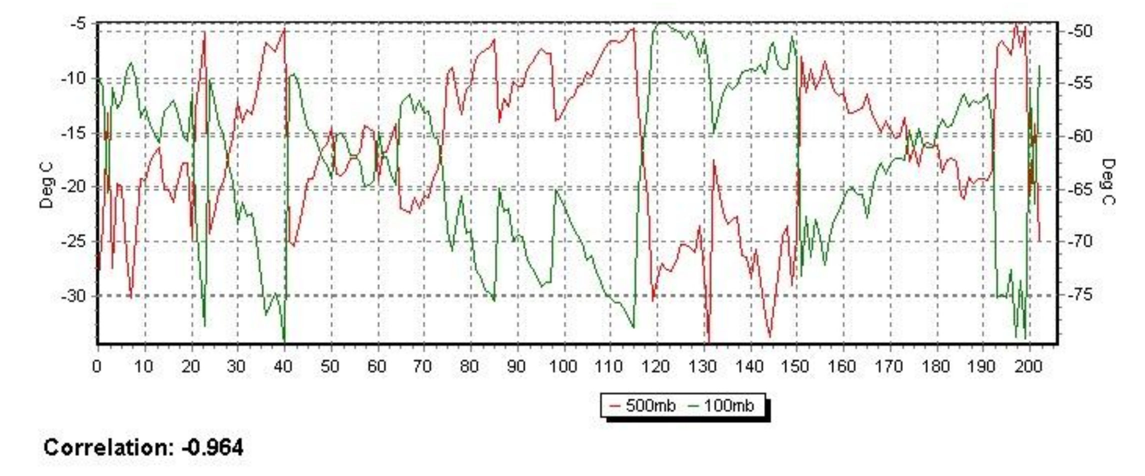

Fig 17. Average temperatures at 500mb and 100mb for 204 stations. This graph is the exact opposite of the previous graph so that when 100mb heat rises, the 500mb heat decreases and vice versa. As was shown previously, the air at 100mb is heated by the absorption of Ultra-Violet radiation from the sun by Ozone.

As mentioned earlier, 90 percent of the Ozone is above 100mb with the other ten percent in the lower atmosphere. We also showed that the heat became saturated above 100mb and allowed the heat to progress downward over time, which explains the graph in Fig 17.

One more graph:

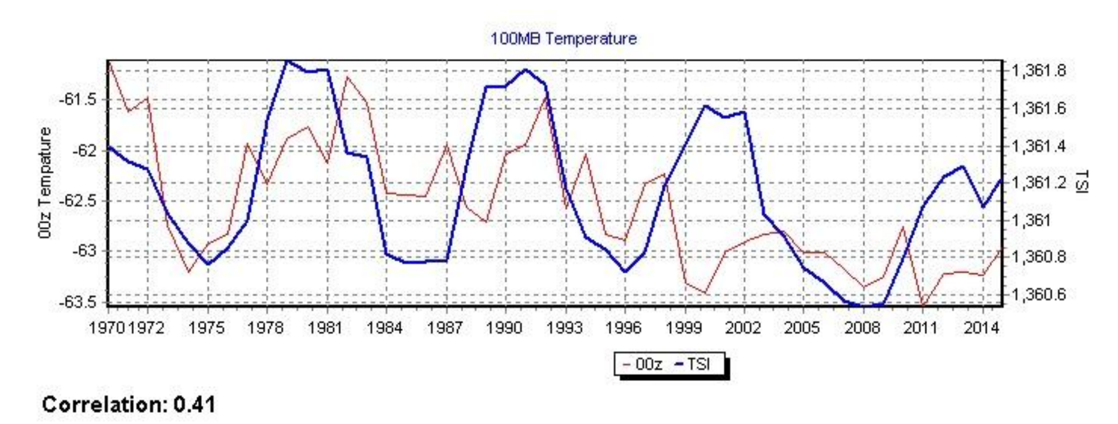

Fig 18. The red curve is the average 100mb 00z temperature for 204 stations, and the blue curve is Total Solar Irradiance.

As can be seen, the two curves strongly suggest that the temperature at 100mb is related to solar input.

FURTHER EXPLORATION OF THE TSI AND TEMPERATURE ALOFT:

Note in the following graphs; Total Solar Irradiance has been adjusted for the latitude of each station. TSI! = TSI * cos(latitude).

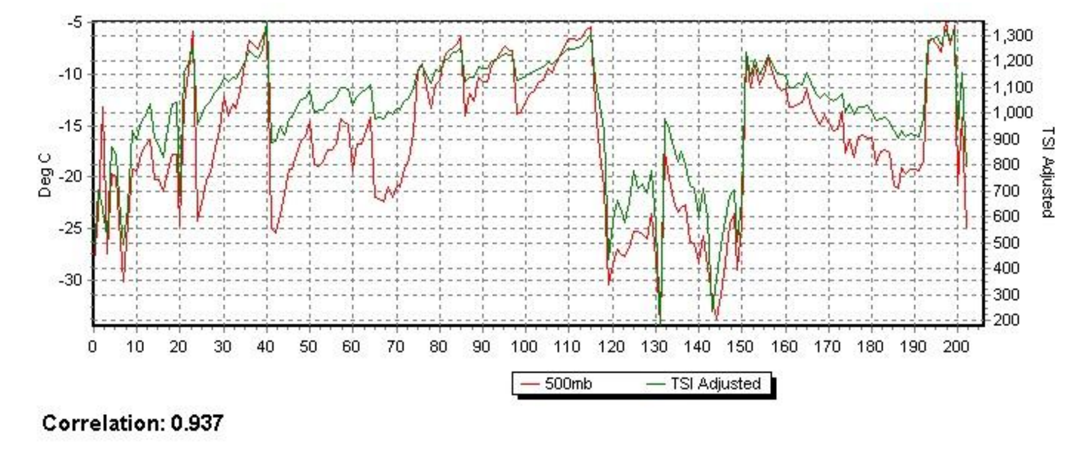

Fig 19. The adjusted Total Solar Irradiance curve is almost identical to the temperature curve at 500mb.

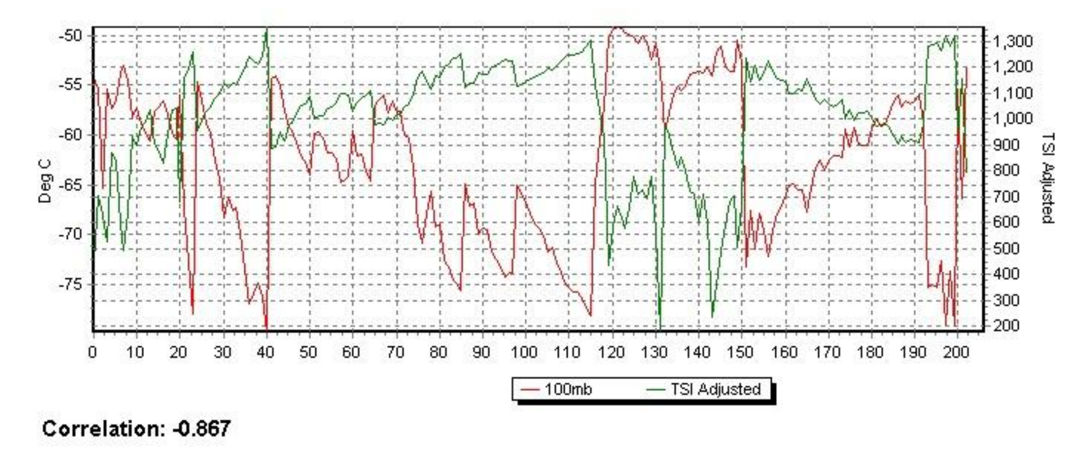

Fig 20. The curves for TSI and 100mb temperature are very different.

The above graph merely reflects the well known fact that temperatures at high altitudes are much colder in the tropics.

THE LITTLE ICE AGE

Many scientists deny that the sun has a large effect on the climate of the earth, which is so absurd it is difficult to comprehend.   A quiet sun, similar to what is occurring now, occurred during the *Maunder Minimum* and the earth went through a mini-ice-age.

From Wikipedia “The **Little Ice Age** (LIA) was a period of cooling that occurred after the Medieval Warm Period.[1] Although it was not a true ice age, the term was introduced into scientific literature by François E. Matthes in 1939.[2] It has been conventionally defined as a period extending from the 16th to the 19th centuries,[3][4][5] but some experts prefer an alternative time span from about 1300[6] to about 1850.[7][8][9] Climatologists and historians working with local records no longer expect to agree on either the start or end dates of the period, which varied according to local conditions.”

SUMMARY

The warming of the upper levels of the atmosphere, as measured by radiosonde, is caused by the absorption of ultraviolet radiation by ozone, or that is the theory. The absorption at the 10mb down to the 200mb is very fast and can be measured a few minutes after sunrise, but the temperature continues to climb slowly for the next two hours. At the 850mb level, the temperature reaches its maximum sometime between 7 pm and 8 pm and a minimum just before sunrise. See Table 1.

There is no doubt that the sun is responsible for the heating of both the lower and upper atmosphere, the lower atmosphere by land and sea absorbing all radiation from the sun and emitting long-wave radiation, which is absorbed by the air, and the upper atmosphere is heated by the absorption of ultraviolet radiation by Ozone. The air at mid levels is heated by both long-wave radiation (LWR) as well as absorption of ultraviolet radiation. When the mid-level air is heated only by LWR, the night-time and daytime temperatures will be the same, since that radiation occurs continuously. The only reason this is surprising is that it has never occurred before.

When the two daily observations occur when the sun is at the same angle, one observation early in the morning and the other 12 hours later in the early evening, there is no difference between the temperatures of the two observations. If convergence was caused by an outside influence, such as a change in sensors on the radiosondes, it should show up in these observations; it does not.

After looking at the graphs above, it would be difficult to claim that the sun does not affect the lower troposphere, but it will be claimed anyway.

We are entering a new and unknown era of climate change, where will it go from here?