TOWARDS A NEW PHYSICS OF GLOBAL WARMING AND CLIMATE SCIENCE: EVIDENCE FOR A SIMPLE RELATION BETWEEN THE AVERAGE LOCAL TEMPERATURE AND PRECIPITATION ACROSS THE GLOBE

By V. Laxmanan, Sc. D.

Abstract

The average temperature-precipitation data for the US, UK, Germany, Australia, Malaysia, Ecuador (with equator passing through) and Singapore (1° 22'N, just north of the equator), reveals a simple relation, P = aT + b, between the average local temperature T and the maximum precipitation P. The slope "a" is negative in all cases. Hence the preponderance of the observational evidence indicates that lower average (local) temperatures favor higher precipitation. It is conceivable that further research might reveal other countries/regions where a positive P-T slope is observed. If so, one would be lead to theorize that there is a maximum point on the graph of precipitation versus temperature, with only one portion of this more general curve being revealed here. This is currently being investigated.

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Introduction

As we all know, water can exist either in the form of a solid (ice), liquid (most commonly observed all over the earth) or a gas or vapor. The gaseous form is

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known as steam when it is produced by boiling water. The term vapor is used when the gaseous form is produced at much lower, ordinary, temperatures, well below the boiling point, by the process called evaporation. This is the reason why water spilled on the ground, or the floor at home, will, in due course, simply "disappear", even if it is not wiped off. The higher the ambient temperature, the faster this evaporation occurs. The latter process also results in the formation of clouds that affect many climate related phenomena.

Precipitation is the opposite of evaporation and refers to the natural formation of both rain and snow - the renewed transformation of water evaporated from large bodies of water on the surface of the earth like the seas, oceans, lakes (example, the five Great Lakes located in the North American continent), and rivers. Depending on the thermal conditions prevailing in the atmosphere, water vapor (contained in the clouds) is transformed either back into its liquid form – producing rain - or into the solid form – producing snow - which shower down upon the earth, sometimes with devastating effects. It is such devastating effects, or extreme weather patterns, that are great societal concern in the 21st century and the subject of a great ongoing debate in the scientific community, with obvious social, political, and economics overtones; see some references cited [1-25].

The purpose here is to stay clear of these divisive debates and focus instead on an analysis of the large body of observational data being collected almost daily all over the world. This has been the subject of several recent articles by the author [26-34], some of which have been shared with several leading climate scientists (via emails sent out on January 29, 2014, and responses are eagerly awaited) and have also been shared via brief posts made on my Facebook page in the group named Global Warming for the Layman [35] and more recently on Wordpress.com, see links given below.

1. Facebook group https://www.facebook.com/groups/GWforlayman/ created on January 5, 2014
2. At Wordpress.com http://vlaxmanan.wordpress.com/2014/02/03/evidence-for-a-universal-

law-describing-the-temperature-time-relation-for-the-earths-climate-ststem/ Evidence for a Universal Law Describing the Temperature-Time Relation for the Earth's Climate System.
3. http://vlaxmanan.wordpress.com/2014/02/03/the-historical-climate-data-for-yakutsk-russia-one-of-the-coldest-cities-on-earth/ The Historical Climate data for Yakutsk, Russia, one of the coldest cities on Earth.

Temperature and the Transformation of water

Water does NOT start freezing exactly at 0°C. Often the liquid state persists to much lower temperatures. The same is true for almost all liquids, which must generally be supercooled (or undercooled, or subcooled) below the theoretical freezing (or melting) point for the solid phase (ice) to nucleate and start growing. The same is true for the process of transformation of vapor back into the liquid form. Microscopically small water droplets, called nuclei, begin to form which then grow to produce either rain or snow. This is the reason why clouds are sometimes "seeded" with crystals having internal structures that favor the nuclei formation in the clouds to produce rain artificially in the event of a severe drought. Likewise, in iron foundries, the iron is "inoculated" with the addition of certain tailored chemical compounds to control the growth process of the solid and encourage it to freeze in a favorable manner. The same practice is known by other names, such as grain refinement, in steel making and in the production of aluminum alloys. The temperature of the cooling melt, and the exact temperature at which it undergoes the liquid to solid phase transition, the cooling curve, are monitored and bear the "signature" of a well-controlled manufacturing process.

The main point of this brief discussion is that the atmospheric temperature, likewise, plays an important role in precipitation. It appears that there is a simple, linear, relation between the MAXIMUM amount of precipitation observed in a given location on the earth's surface and the average local temperatures, a relation that seems to hold over wide regions, in many cities, and across countries and continents. The reader is also encouraged to review the short appendix where it is shown that a nonlinear function can, in the limit, behave like a linear function. The climate system is, no doubt, more complex than one might be led to conclude from a superficial reading of the conclusions to be presented in what follows here.

Table 1: UK Climate Data (Average temperature and precipitation)

City	Average temp [°C]	Average temp [°F]	Precipitation [mm]
Lerwick, Shetland Islands 60° 9'N	7	45	1003
Lerwick, 60° 8'N	7	44	1209
Orkney Islands, 58° 57'N	8	47	948
Stornoway, Outer Herbidies, 58° 13'N	8	46	1173
Kinloss, 57° 39'N	8	47	623
Aberdeen, Scotland, , 57° 12'N	8	46	784
Dalwhinnie, Scotland, 56° 56'N	6	43	1217
Tiree, 56° 30'N	9	48	1172
Edinburgh, Scotland, 55° 55'N	8	47	668
Glasgow, Scotland 55° 52' N	9	48	1109
Eskdalemuir, Scotland 55° 19' N	7	45	1538
Belfast, Northern Ireland, 54° 39' N	9	48	846
Manchester, England, 53° 23' N	9	49	810
London, England, 51° 28' N	10	51	594
Cardiff, Wales, 55° 30' N	10	49	961
Bournemouth-Hurn, 50° 47' N	10	50	789
Plymouth, England, 50° 21' N	11	51	982
St. Mary's Isles of Scilly, 49° 56' N	12	53	844
UK Average, 54° 2' N	9	48	865

Data source: http://www.united-kingdom.climatemps.com/ February 5, 2014. Only 18 of the 35 cities considered to get the UK average are listed in this table.

All data can be accessed by clicking on different countries.

UK Temperature-Precipitation Relation

The relationship between the average temperature and the MAXIMUM precipitation, can be expressed as P = aT + b where P is the *maximum* precipitation (in mm) and T is the average temperature, in degrees Fahrenheit. This is most noticeable with the UK climate data, as illustrated in Figure 1. The temperature and precipitation data was obtained on February 5, 2014 from climatemps.com (see http://www.united-kingdom.climatemps.com/ or click here) and has been summarized in Table 1.

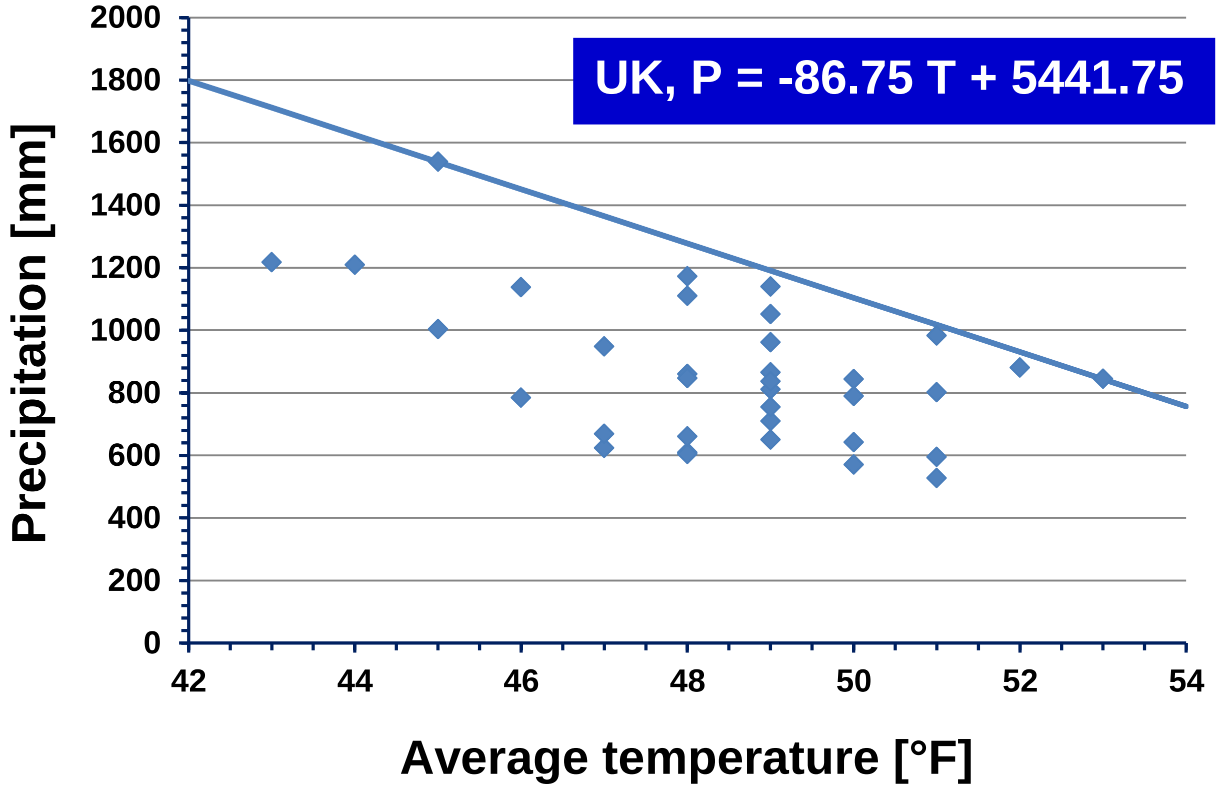

*Figure 1: The average temperature and precipitation data for **35 cities in the UK**, obtained on February 5, 2014 from http://www.united-kingdom.climatemps.com/). At any given temperature, depending of many complex factors such as the latitude, altitude, distance from a large body of water (lakes, seas, oceans, etc.) there is a range of precipitation values. However, the maximum precipitation observed seems to decrease with increasing average temperatures. The same relation is also observed if we examine the data for other countries such as the USA, Australia, Germany, and Malaysia, which have been studied to date by the present author. All data reported here was obtained on Februray 4 and 5, 2014. The slope "a" and the intercept "b" are determined by considering the two points that envelop the data; i.e., all (or almost all) data points must fall below the line governing the P-T relation. For UK, P = -86.75T + 5441.75, obtained by considering the two extreme data for Eskdalemuir, Scotland (45, 1538) and St. Mary's Isles of Scotland (53, 844).*

The reason why lower temperatures can actually lead to higher precipitation can be understood by nucleation and growth processes alluded to already. This is based on knowledge gained by the author from many years of studying such phase transformations during his professional career and also a part of his training as a student of Mechanical Engineering and Materials Science and Engineering. Nucleation, boiling, solidification, freezing and precipitation problems are all integral to these disciplines. The precipitating phase (rain or snow) must first nucleate and this requires a certain amount of undercooling, or subcooling. Furthermore, the extent of this undercooling provides the "driving force" needed for the new phase to grow after it has nucleated.

A quick word now about using temperature in degrees Fahrenheit, instead of degrees Celsius commonly used in climate science. The reason for this choice is obvious from Table 1. The same temperature in degrees Celsius separates out into more than one degree if the Fahrenheit scale is used. For example 7°C could be either 45°F or 44°F and one must start using decimals with the Celsius scale. Simple whole numbers can be used with the Fahrenheit scale.

USA Temperature-Precipitation Relation

The US average temperature and precipitation data for 756 cities is plotted in Figure 2 and was obtained from the same website on February 4, 2014. Aberdeen, in the northwestern state of Washington (53, 21010) and West Palm Beach, on the opposite coast, in the "diagonally opposite" southeastern state of Florida, define the slope for the US.

The precipitation for all the other cities in the list is lower than given by this line. There are 11 cities in this list, located in various states and latitudes, which have an average temperature of 40°F. The precipitation for these cities varies from varies from 276 mm to 869 mm, as illustrated. There are 31 cities with an average temperature of 50 °F, with the precipitation ranging from 193 mm to 1285 mm. However, there is a maximum precipitation associated with each temperature and that always falls below this defining line.

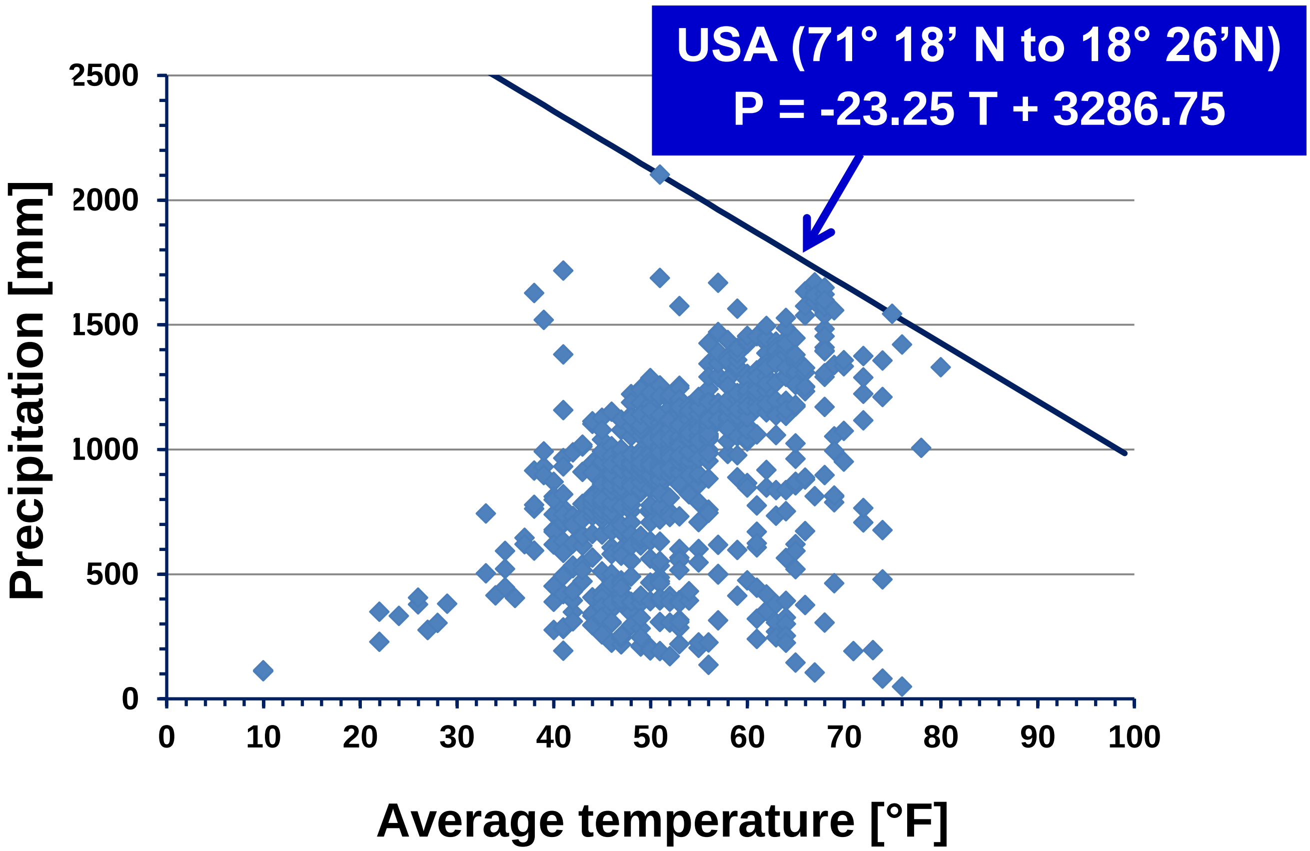

*Figure 2: The average temperature and precipitation data for **756 cities of the US**, obtained on February 4, 2014 from http://www.usa.climatemps.com/. **Hawaii is not included in this list.** At any given temperature, depending of many complex factors such as the latitude, altitude, distance from a large body of water (lakes, seas, oceans, etc.) there is a range of precipitation values. However, the maximum precipitation observed is always less than given by the defining line with the negative slope as indicated here.*

Australia Temperature-Precipitation Relation

Exactly same trends are also seen for Germany, Australia, and Malaysia. Australia and Malaysia practically neighbors across the Pacific Ocean and are both located in the eastern hemisphere of the earth, with Malaysia being just above the equator and Australia, a huge continent, being below the equator.

The Australian data examined here covers a latitude range of 44 degrees (10 to 54 degrees) on the south of the equator whereas the US data covers a latitude range of 53 degrees (18 to 71 degrees) in the northern hemisphere.

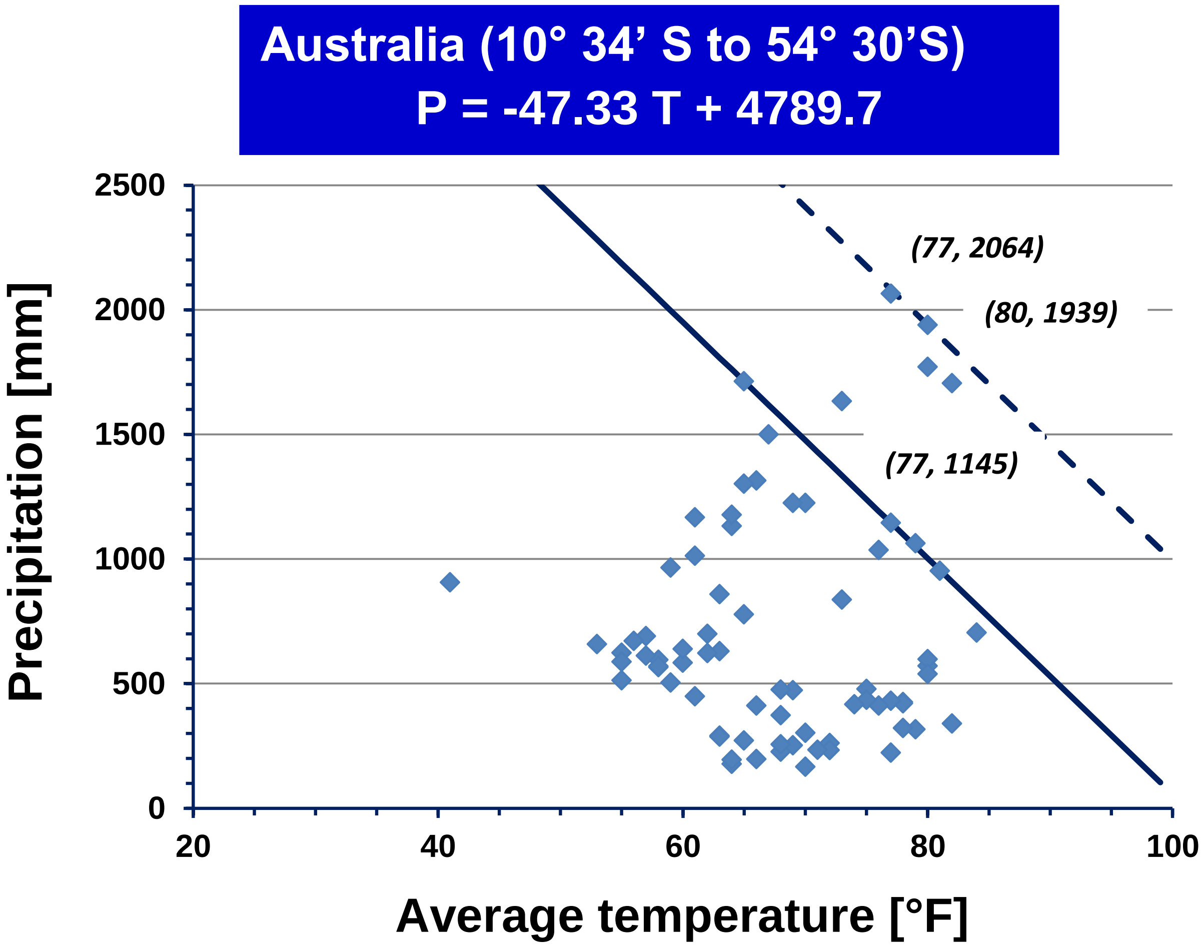

*Figure 3: The temperature-precipitation data for **74 cities in Australia** distributed across the continent (see http://www.australia.climatemps.com/). To illustrate the temperature-precipitation relation, the defining (solid) line is chosen to exclude the four stations with the highest precipitation. Coffs Harbour (65, 1713) and Coen, Queensland (77, 1145) are used to determine the slope and the intercept in the relation P = aT + b. The data for several cities lie on, or close to, this line. A parallel with the same slope can be imposed (see dashed line) to*

pass through the cluster of four points with the higher precipitation. This dashed line with a= -47.33 passes through the data (80, 1939) for Cocos Island, A. M. O., latitude 12° 11'S, longitude 96° 50'E in the northern part of Australia. Cairns (latitude 16° 52'S, longitude 145° 45'E), with coordinates (77, 2064) on this graph falls practically on this parallel and is directly above the Coen data point.

The equator-to-poles latitude range is 90 degrees and so these two countries cover one-half of this range, on both sides of the equator. The simple temperature-precipitation relation seen for both countries must therefore be considered to be a very significant one providing valuable observational relations that can be incorporated into more sophisticated climate models.

Germany Temperature-Precipitation Relation

The data for 32 cities across Germany (source climatemps.com) is plotted in Figures 4a and 4b. In Figure 4a, we consider the data for all 32 cities. As indicated, all of the data fall below the defining line, joining Hohenpeibenberg (44, 1211) and Zugspitze (23, 2004). The latter is the only station reporting a subzero temperature (-5 °C) in the list of 32 cities.

In Figure 4b we consider the data that appears to be clustered around the temperature of 48 °F. Several cities have virtually the same average temperature but different values of the precipitation. A very narrow average temperature range from 46 °F to 51°F is observed with varying precipitations. Nonetheless, the trend of increasing precipitation with decreasing temperatures (related to the nucleation and growth processes for the precipitating rain or snow) is quite evident. Furthermore, all of the data fall below the defining line of Figure 4a.

It is clear that lower average temperatures favor precipitation in the form of rain and/or snow. It is of interesting to note that the northern most latitude considered for Germany is (numerically) the same as the southernmost latitude considered for Australia.

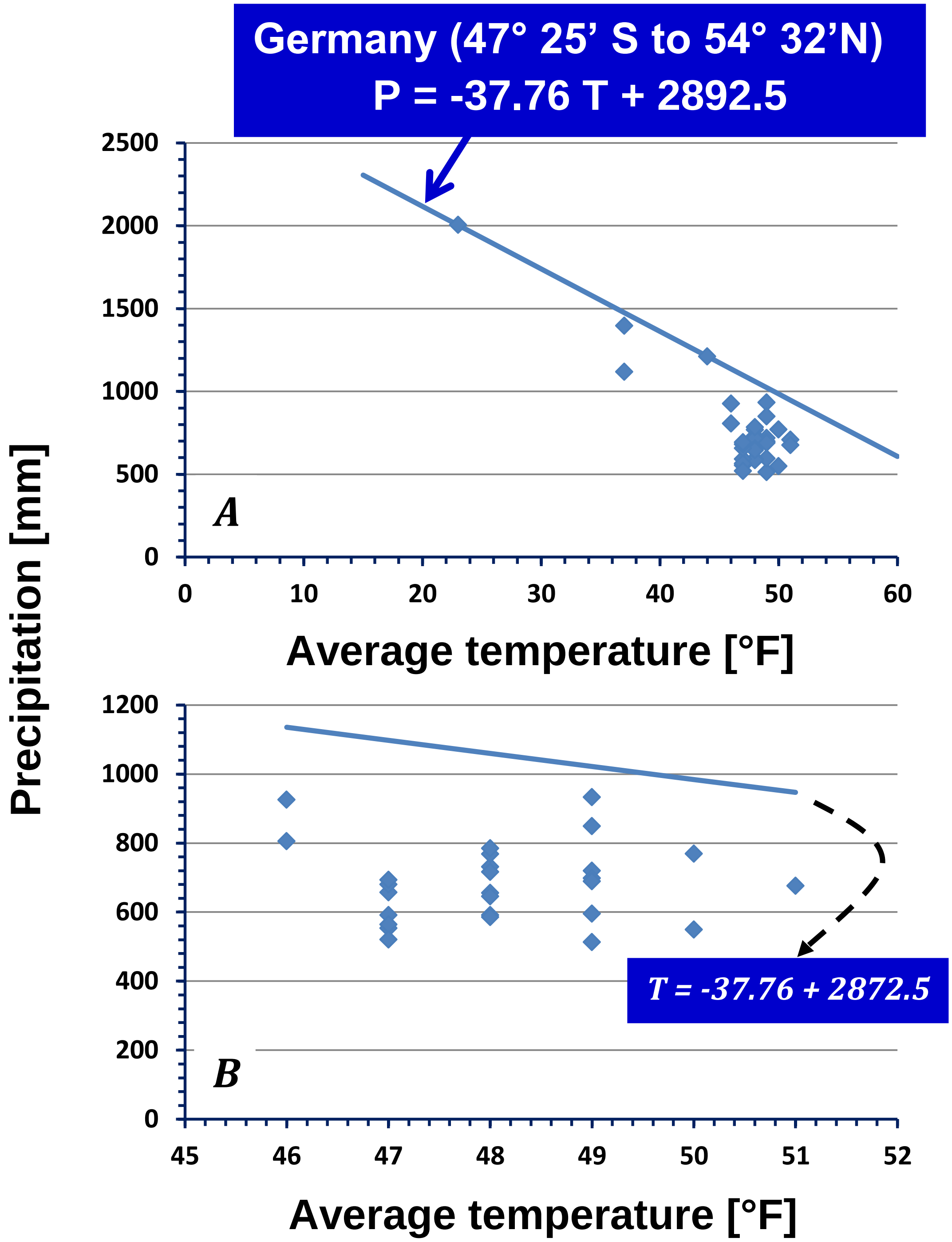

Figure 4: The temperature-precipitation data for ***32 cities of Germany*** *is considered in (A) above (see http://www.germany.climatemps.com/). A smaller selection is considered in (B) using an expanded temperature scale. Again, the relation between the MAXIMUM precipitation observed and the average local temperatures is quite clear.*

Malaysia Temperature-Precipitation Relation

Next, we consider Malaysia, a small country just north of the equator, in the same general vicinity of the Australian land mass. Malaysia is of interest, since my early analysis of the climate data for individual cities (which was reported on my Facebook page in the Global Warming group) showed that the city of Kuala Lumpur, one of the most populated cities of Malaysia, has a remarkably flat year-round temperature profile; see Figure 5.

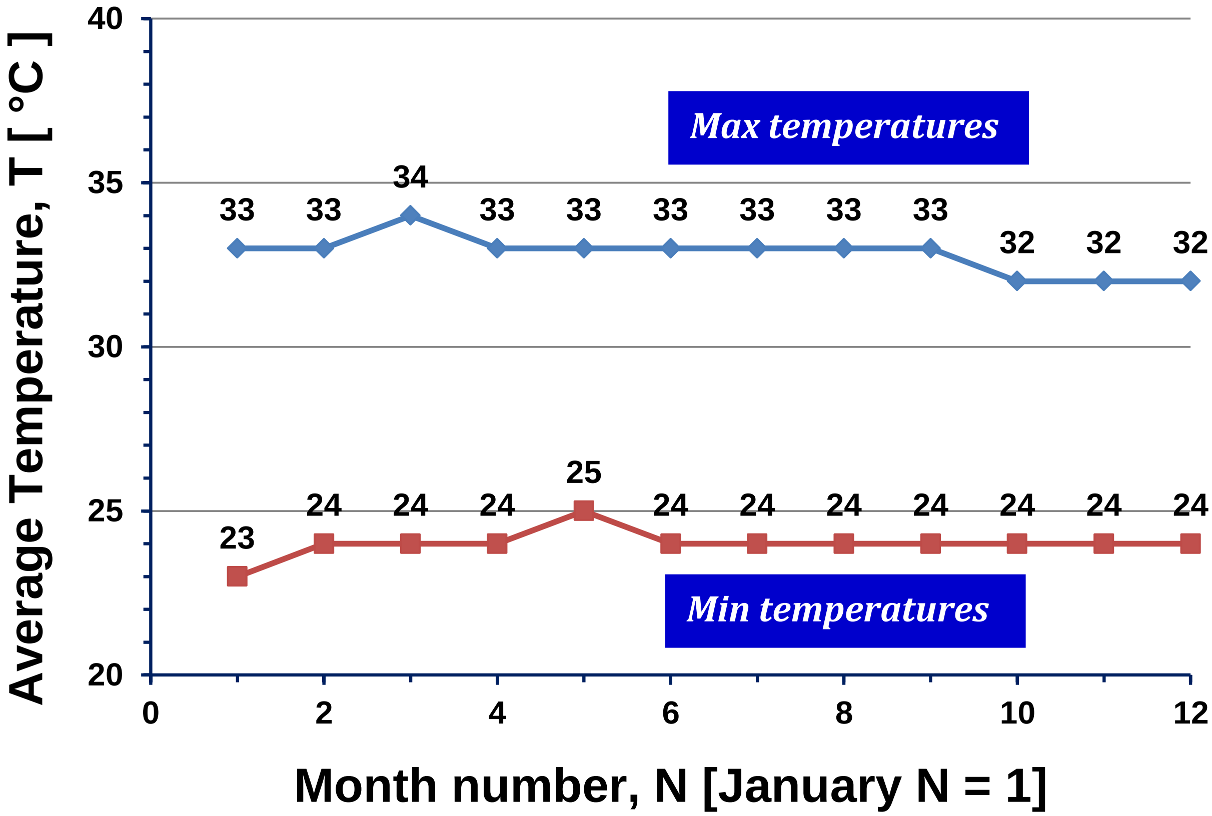

Figure 5: Virtually flat temperature profile for ***Kuala Lumpur*** *through the years. This is monthly average values for several years, obtained from a popular travel site, and the period over which averaging was done is not given. More rigorous review of this data and attention to period of averaging is clearly possible but is not deemed necessary for the purpose of our present discussion. The analysis of the historical climate for cities like Kuala Lumpur and Yakutsk, Russia (one of the coldest cities on earth) will yield valuable insights about the*

effects of global warming/ climate change. The historical temperature data for both these cities has been analyzed and made available on the internet and on my Facebook page. The universal law relating temperature-time data, as noted in the Wordpress.com posts is observed also for Kuala Lumpur. Data source: http://www.worldweatheronline.com/Kuala-Lumpur-weather-averages/Kuala-Lumpur/MY.aspx the temperature-precipitation relation is considered below.

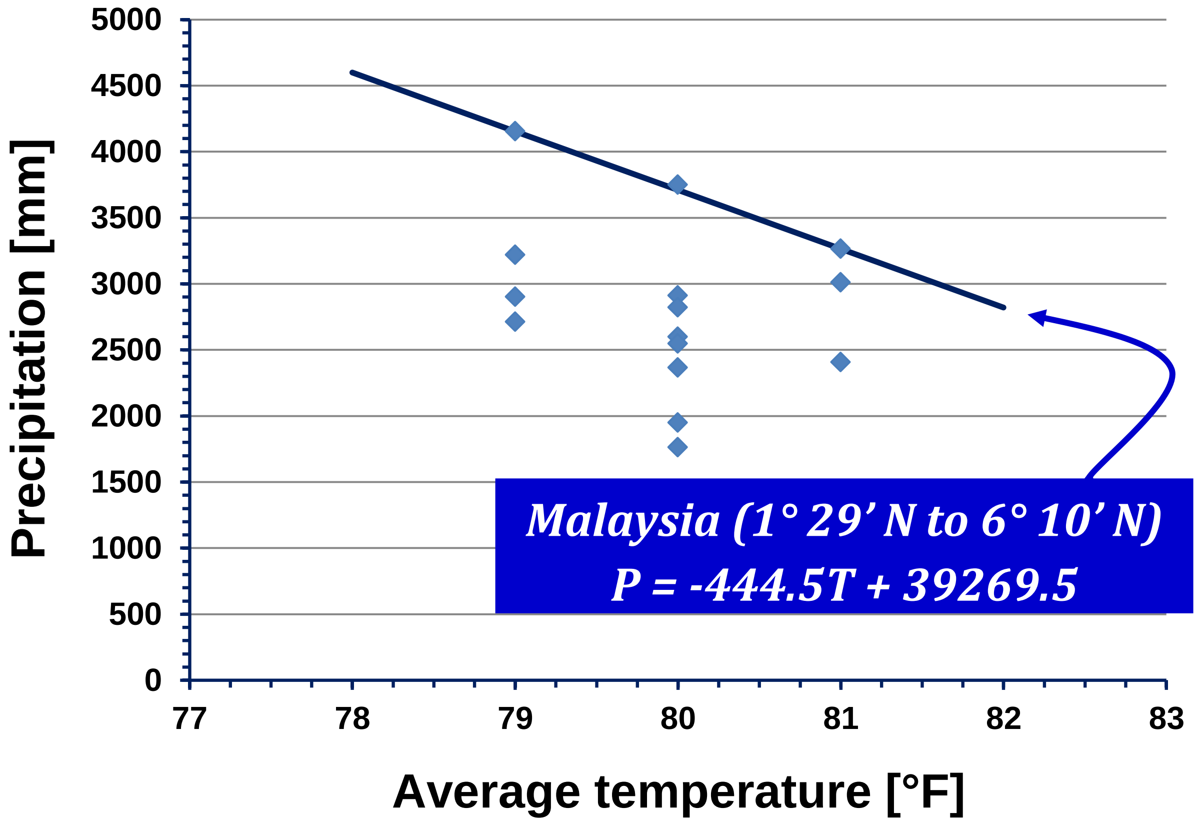

Figure 6: The linear relation between the MAXIMUM precipitation and the average temperature is again confirmed by the ***Malaysian data*** *(see http://www.malaysia.climatemps.com/). This country, a virtual neighbor of Australia, across the ocean and just north of the equator, reveals the same relation that is observed for Australia. Fifteen (15) cities were considered in the dataset, which includes Kuala Lumpur (average annual temperature of 80°F = 27°C). The precipitation varies depending on the latitude, altitude, and other geographical factors. However, the law relating the maximum precipitation and the average temperature is the same, P = aT + b.*

Singapore and Ecuador temperature-precipitation data

Against this background, let us now consider Singapore, a city nation which practically lies on the equator (1°22'N, 103°59'E, 16 m (52 ft), see http://www.singapore.climatemps.com/). Since we are dealing with a small city state, we will consider the variation of the average temperature and precipitation during the course of a year with a month being the time variable.

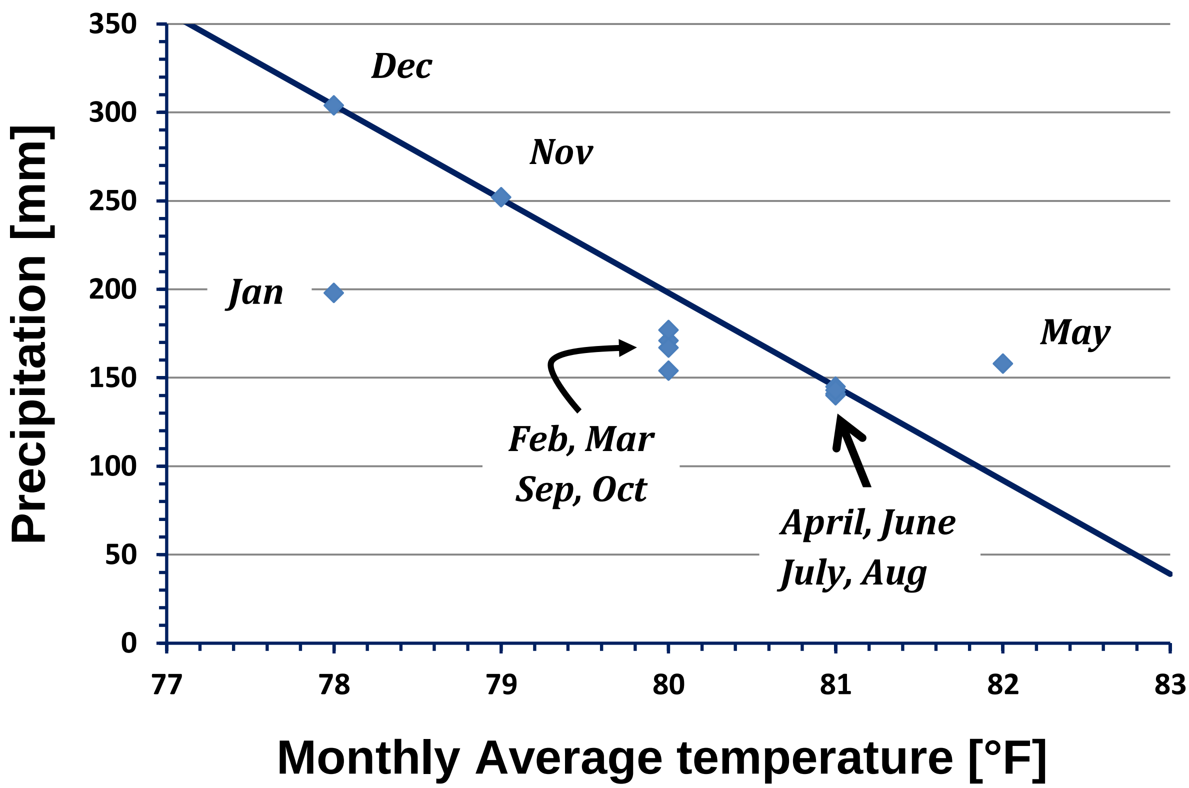

Figure 7: The linear relation between the MAXIMUM precipitation and the average temperature is confirmed by the ***Singapore data*** *(see http://www.singapore.climatemps.com/). The line joining the December (78, 304) and July (81, 145) data points, T = -53T + 4438, also virtually passes through the November data (79, 252), with the precipitation P predicted as 251 mm, versus the actual 252 mm.*

For Singapore, the temperatures vary over a very narrow range, from a low of 78 °F in the months of December and January to a high of 82 °F in May. The

Singapore data, for a highly localized area, offers an amazing confirmation of the observations thus far, over much larger regions and countries, Figure 7.

Brief Discussion of the Significance of the Intercept and the Generalized Work function of Einstein

The July data point was used in the Singapore analysis since it is the MAXIMUM precipitation for the cluster of four months, with T = 81 °F and P = 140 to 145 mm. One could have joined the May-Dec points as well, but two points can always be joined by a straight line and this would NOT be a confirmation of the simple linear law, P = aT + b. Hence, the July-Dec line, along with the November data point, provides a better confirmation of the new law revealed by the present analysis.

The significance of the nonzero intercept, the constant "b", can be appreciated by appealing to the generalized idea of a work function conceived by Einstein to explain the photoelectric effect [36].

This has been discussed elsewhere within the context of the global average temperature-time relations, and also within the broader context of its applications to the vast body of observations being accumulated to understand many other complex problems from the financial, economic, social, political, medical, sports, and environmental systems [37, 38]. The brief posts at Wordpress and the two documents uploaded on my Facebook page provide the needed discussion of the significance of this work function and why it can be generalized to problems beyond physics, where it was first conceived. The data Ecuador, considered in Figure 8, provide yet another confirmation of this idea of a work function.

If we observe data moving along a family of parallels¶, it can be concluded that a work function exits, akin to the work function in the photoelectricity experiments, where we see a movement along parallels (when experiments are performed with different metals, see references cited [39-45].

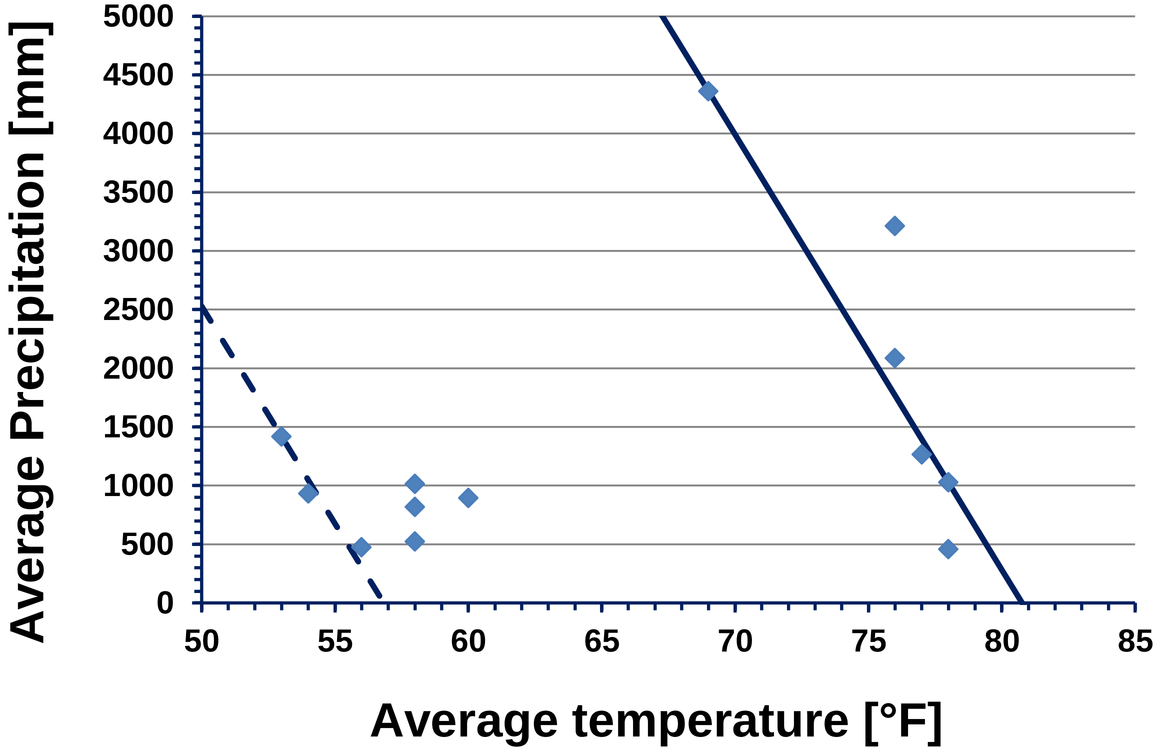

*Figure 8: The average temperature-precipitation diagram for **Ecuador** (see http://www.ecuador.climatemps.com/), in South America, through which the equator passes. The data for 12 cities (only P value is given for one station; lacks the T data) is plotted here and fall along the two parallels as illustrated. Four of 12 cities lie within 1 degree north or south of the equator. The other 8 are inside the 4 degrees South parallel. The solid line with the equation, P = -370.44T + 29920, joins Puyo (69, 4360) and Guayaquil (78, 1026), which are less than one degree latitude apart, to the south of the equator, and two degrees apart in longitude. The dashed line is an exact parallel through Izobamba (53, 1418), which is practically on the equator. Two other data points fall practically on this line. A family of parallels can be envisioned to, likewise, pass through the cluster of data points between the two parallels indicated here.*

¶ *Choose any two (x, y) pairs and find the slope, preferably the steepest slope. Then find two more (x, y) pairs that are joined by a line with the exact same slope. This proves the existence of actual parallels sweeping through the data.*

This is observed with the Ecuador data. One can also envision a family of parallels sweeping through the remaining data points for Singapore. It may be harder to visualize the same with the data for ***ALL*** the other countries considered here (requiring a giant leap of faith), but the Ecuador data, nonetheless, provide the needed insights to make this mental transition.

As noted in discussions of the global average temperature-time relation and the meaning of the work function in the context of climate science [26-35], new and fundamental insights can be gained when one looks at complex problems by studying them at the most elementary level and looking at the individual components of the problem. Millikan was able to deduce the absolute magnitude of the electrical charge q on a single electron by studying the motion of a single oil drop, under the combined action of the earth's gravity field and an externally applied electrical field. Prior to Millikan's work, J. J. Thomson (who discovered the electron in his famous cathode ray experiments and deduced the mass/charge = m/q ratio of this elementary particle) and his coworkers had developed other methods to determine q, by essentially studying a cloud of falling electrified water drops but these proved to be unsatisfactory and led to inconsistent results for q.

Likewise, Millikan was able to derive the numerical value of the Planck constant h, from the photoelectric measurements, by considering individual (x, y) pairs in his dataset, without invoking any statistical arguments. Also, he was careful to determine the ***maximum*** kinetic energy of the electron, a requirement also emphasized by Einstein in his 1905 paper. ***Only a determination of the maximum energy of the electron would yield an accurate value for the Planck constant h.***

Thus, the focus here on the maximum precipitation, when a range of precipitation values are observed, in similar to Millikan's focus on the maximum kinetic energy of an electron. A range of electron energies is also observed in the photoelectricity experiments, as discussed in detail in the introduction of his the first of the two 1916 papers [42]. ***They were all rejected by Millikan in favor of the maximum.*** Likewise, we must reject the other lower values of the precipitations observed if we wish to gain insights into the behavior of the earth's climate system. The Ecuador and Singapore data, along with the data for the other countries distributed across the globe, provide stunning confirmation for the law P = aT + b, relating the maximum precipitation P to the "local" average temperature T.

Likewise, in the fascinating filed of dendritic growth (a snowflake is an ice dendrite with dendrite being the name given to the complex, highly branched, tree-like structure, assumed by the solid phase, that is seen to grow into the liquid when it begins to freeze), new and fundamental insights were gained by isolating and studying as single dendrite [46-52], instead of the forest of dendrites that materials scientists (and dendrite physicists) observe during a liquid to solid phase transition. If no two snowflakes are alike, it is because of the complex heat and mass transport process that govern the growth of each and every snowflake, or ice dendrite. The laws governing this process can only be understood by considering one dendrite at a time [48, 54-57].

It appears that climate science can also benefit from a similar approach, by considering climate observations for a single city, or a nation, before we venture into the infinitely more complex arena of modeling the entire global climate system. Or, to put it differently, Kepler reduced Tycho Brahe's observations into simple, empirically deduced, mathematical laws and only then were the deep insights gained from Newton's theory, and ultimately Einstein's theory, of the Universe possible; see Longair's treatise on theoretical concepts in physics [59] and also the work of Shamos [60].

In summary, the brief review of the climate data here, which surveys many countries on the eastern and western as well as the northern and southern hemispheres, reveals a remarkably simple relation, of the type P = aT + b, between the average local temperature T and the maximum precipitation. Lower temperatures actually favor higher precipitation, contrary to widely held notion that higher temperatures will lead to higher evaporation rates and therefore higher precipitation and thereby also promote more extreme weather patterns. As is well known from practical experience, extreme cold spells do not lead to precipitation (it is always warmer when it is snowing) and neither do we see precipitation in extremely hot weathers, or desert environments (because of the hot temperatures that reduce precipitation).

Further research might even lead to countries, or regions, where a positive slope is observed with precipitation increasing with increasing average temperatures. (Climate data for the Democratic Republic of Congo, studied after this article was finished, seems to be an example, see appendix, but more confirmation of the positive P-T slopes with additional example; the equator passes, in the African continent, through the DRC.) If so, one would be lead to theorize that there is a maximum point on the graph of the temperature versus precipitation, with only one portion of this more general curve being revealed here. The present author will continue to provide updates as this fascinating study continues.

The implications for climate science and climate models are obvious and it is hoped that the findings here will prove to be useful in the quest to understand climate change, of great concern in the 21st century.

APPENDIX: A SIMPLE FUNCTION WITH A MAXIMUM POINT

The parabola with the general equation $y = ax^2 + bx + c$ is an example of a function which exhibits a maximum point, the location of which can be determined readily by differentiation to yield $dy/dx = 2ax + b$. Hence, the maximum point will occur when $x = - b/2a$, corresponding to $dy/dx = 0$.

Another example of a simple function with a maximum point is $y = ax + (b/x)$ where the function includes both a linear and a nonlinear component. Hence, if x is large, the nonlinear term b/x becomes negligibly small compared to the linear term. The maximum point will occur when $dy/dx = a - (b/x^2) = 0$ or when $x = x_m = (b/a)^{1/2}$. Thus, we write $y_m = ax_m + (b/x_m)$. Hence, the difference between y and y_m , looking at both sides of the maximum point is given by $y - y_m = a(x - x_m) + b[x^{-1} - x_m^{-1}]$. A linear behavior will thus be observed if the system is operating past the maximum point and the term containing the constant "b" becomes vanishing small.

This would explain the apparently counterintuitive observation of decreasing precipitation with increasing temperatures, following a simple linear law. A positive slope is revealed by the climate data for the Democratic Republic of Congo, see Figure 9. However, this is the only such data that the author has come across to date and more examples of such a positive trend are required.

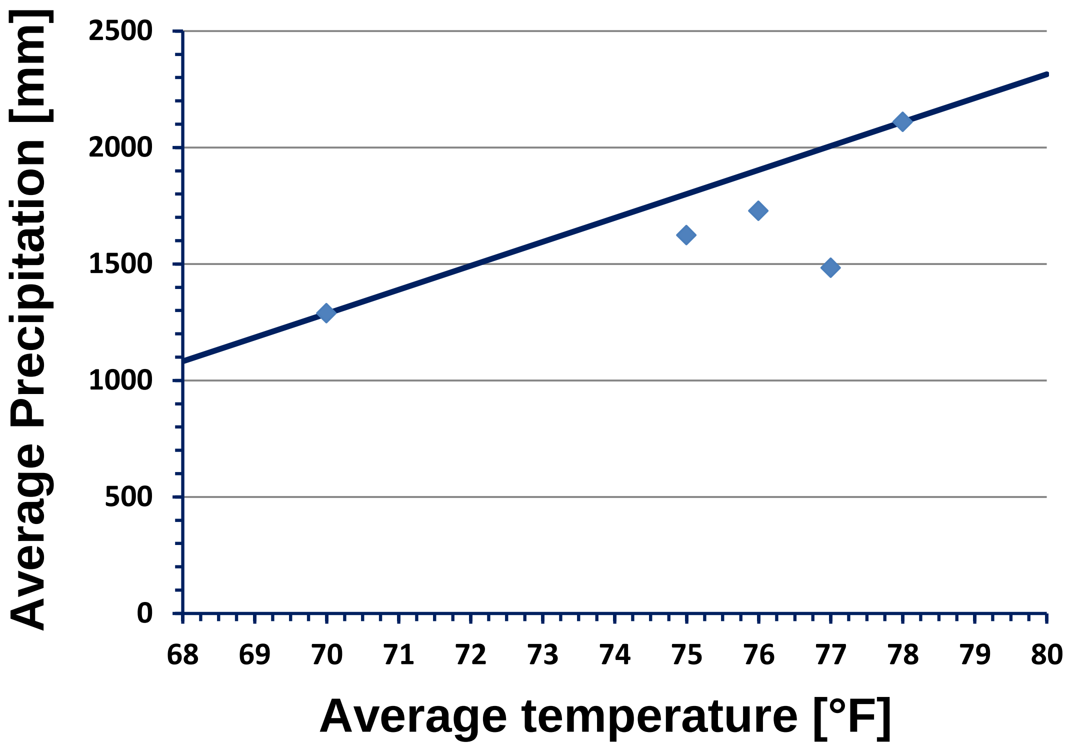

Figure 9: Climate data for the ***Democratic Republic of Congo*** *(see http://www.dr-congo.climatemps.com/) through which the equator passes in the African continent. The two extremes for Lubumbashi (70, 1287) and Boende (78, 2109) are joined by a line with a positive slope, P = 102.75 T -5905.5. The two points just below this line are joined by the line P = 104T – 6166, which has virtually the same slope. Hence, we can postulate that the point lying further below is also on a parallel to the lines revealed here, if one accepts the idea of a generalized work function, following its conception by Einstein to explain the photoelectric effect.*

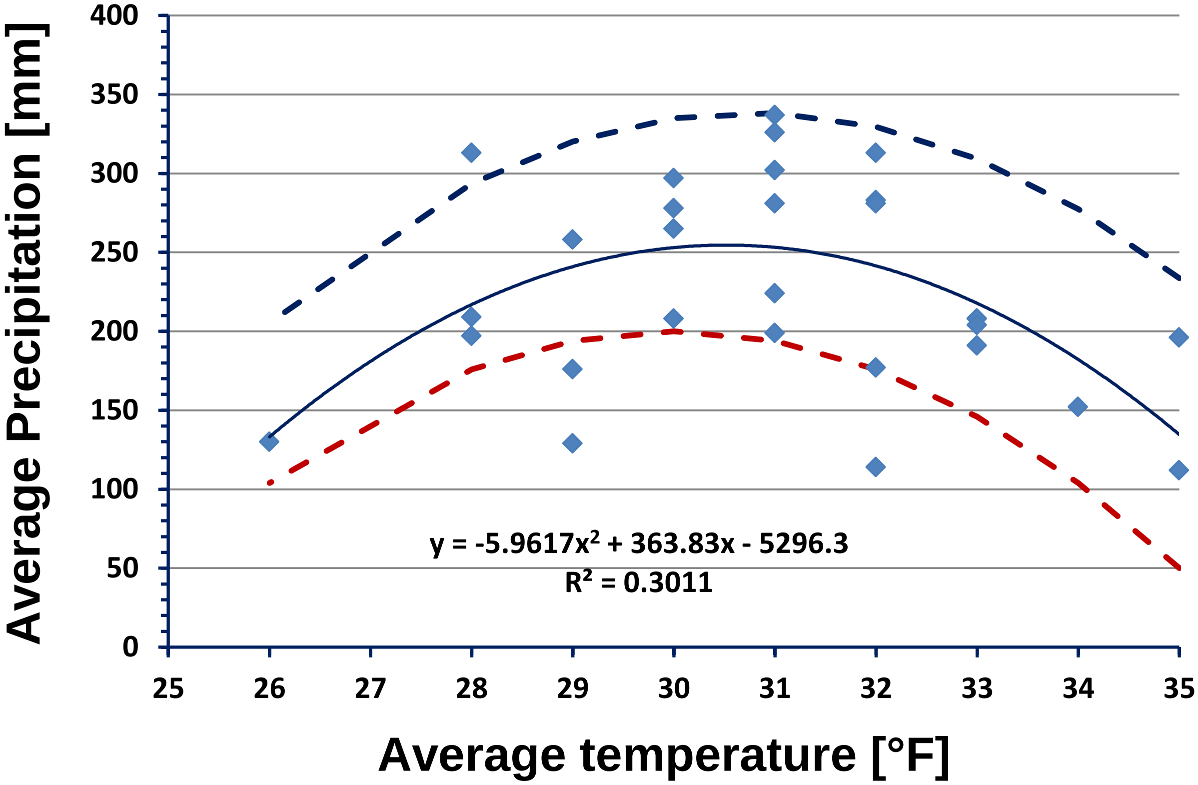

Figure 10: The temperature-precipitation graph for Mongolia showing a maximum point at 31 °F. The middle curve is the regression curve generated by Microsoft Excel program. The two curves above and below are obtained by adjusting the numerical values of the constants in the equation $y = ax^2 + bx + c$.

Now, why would there be a maximum point on such a graph?

We expect evaporation rates to increase with increasing temperature. Does that mean precipitation will also follow same trend? That is, will precipitation, as observed locally, increase with increasing local average temperatures? As already noted in the introduction to this article, precipitation is the opposite of evaporation - water coming back to the earth as rain or snow. For this we see both types of trends, precipitation increasing with increasing temperature, and precipitation decreasing with increasing temperatures and also a maximum point on the graph of precipitation versus the average temperatures; all deduced empirically. The existence of a maximum point on the P-T graph implies that there is an optimum temperature for precipitation.

Since this article was completed, the opposite trend with the positive slope has been confirmed (prompting this note in the appendix), quite unmistakably, with the data for China. And, both the Russia and Mongolia data show positive and negative slopes with a maximum point on the graph of temperature-precipitation graph.

So, why is there is a maximum point? Perhaps, this is analogous to the appearance of a maximum point of the blackbody radiation curve. As is well known, the attempts to explain this maximum point, theoretically, led to the birth of quantum physics.

Following this train of thought would lead us to a new physics for global warming, or the science of climate change. In his new theory, Planck essentially describes a method of determining the average value $U = U_N/N$ of some property of interest where N is the number of microscopic entities and U_N is the total value of the property of interest. In Planck's original theory, the microscopic entities are called resonators and U is the average energy of the resonators and U_N their total energy with N being a very very large integer.

A generalization of the Planck-Einstein ideas, well beyond physics, to many other branches is possible, if we recognize that Planck is trying to determine the average value of some property for a very complex system [59, 60]. This has been discussed by the present author in several articles which have been made available in non-peered publications [37, 38].

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For lithium V_0 = 0.4126 f – 3.593, from 1st paper published in 1916
For lithium V_0 = 0.4223 f – 3.922, from 2nd paper published in 1916
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