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QUANTIFYING THE EFFECT THAT NITROGEN, OXYGEN AND WATER HAVE ON NIGHT-TO-DAY WARMING TRENDS AT GROUND LEVEL

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ABSTRACT

The first global map of the available heat energy from the Sun for warming air and water molecules at ground level has been generated for the month of January. The available heat energy was extracted from calibrated thermometer daily and monthly minimum night-time temperatures, Tmin, and maximum day-time temperatures, Tmax, by taking the difference between the two readings. The difference between Tmax and Tmin on a given day or for a given month reflects the amount of the heat energy that is available to the molecules of air (primarily N2 and O2) that surround the thermometer. What this paper has found is that irrespective of the huge amount of available heat energy from the Sun outside our atmosphere, only a limited amount of that energy reaches ground level thermometers. The loss of the heat energy is proportional to the amount of the three molecules, N2, O2 and H2O, in the atmosphere that protect our planet from overheating during the day and their ability to absorb the heat. Daily and mostly monthly Tmax/Tmin data from over 40 weather stations across the globe have been analysed for January and, in terms of the available heat energy (AHE), there seems to be two thermodynamic systems that define the boundaries of the AHE space. At one extreme are weather stations based on very small islands surrounded by oceans where the water molecules exert the maximum effect and, therefore, greatly reduce the heat energy left available to warm up air molecules surrounding the thermometer. At the other extreme are weather stations surrounded by continental land masses and also in the middle of deserts where the water molecules exert a minimal effect. The general pattern seems to be that all weather stations either surrounded by, or next to large volumes of water have an AHE mean below 10 kJ/kg, while those in the middle of a continental mass have an AHE mean above 10 kJ/kg. The most striking finding presented is that the amount of the heat energy available at ground level has no correlation with the latitude of the weather station, but is highly dependent on the amount of water that surround those thermometers. The currently accepted latitude-dependent climate zones will need to be modified to accommodate the far-reaching findings of this paper.

Keywords: thermometer, available heat energy, climate zones, global warming, Tmax, Tmin

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INTRODUCTION AND BACKGROUND

For this paper to be fully understood a very brief summary of the global alarms that have been reported on practically a daily basis by the global media is needed. In the 1970s the alarm was associated with global cooling and predictions of the imminent arrival of a new ice age and was based on the observations of exceptionally cold winters with snow covering parts of the globe where sub-zero temperatures and unusually cold summers were not usually encountered
[1].

The much warmer temperatures experienced in the 1980s prompted groups of scientists to propose the arrival of an alarming level of global warming and to suggest that the cause of that unprecedented and catastrophic trend was due to the burning of fossil fuels. The main difference between the global cooling and global warming alarms is that the former is based on physical observations including thermometer readings, while the latter is based on trend analysis of a purely theoretical number called 'annual global temperature', a single number supposedly representing the global temperature patterns for a single year. The main problem with use of annual global temperatures is that they cannot be measured and therefore they cannot be proven either to be right or wrong. The paper that best summarises the theory of this putative catastrophic anthropogenic global warming (CAGW) is the now infamous 'Hockey Stick' paper by Mann in 1998 [2] which was totally discredited by many papers, notably those by Essex [3], Kramm-Dlugi [4] and Butina [5].

The main objective of this paper is to analyse the warming-cooling trends using data generated by calibrated thermometers which are in the public domain and freely available for independent validation purposes. For the first time, the relationship between thermometer readings and the Available Heat Energy (AHE) from the Sun will be established and the role that three molecules, N2, O2 and H20 have in keeping our planet habitable will be quantified.

For the scientific accuracy of this paper some definitions have to be declared.

The operation of a calibrated thermometer is based on the thermal equilibrium between two sets of molecules – the molecules inside thermometer, mercury (Hg) for example, and the molecules surrounding the thermometer (air or water):

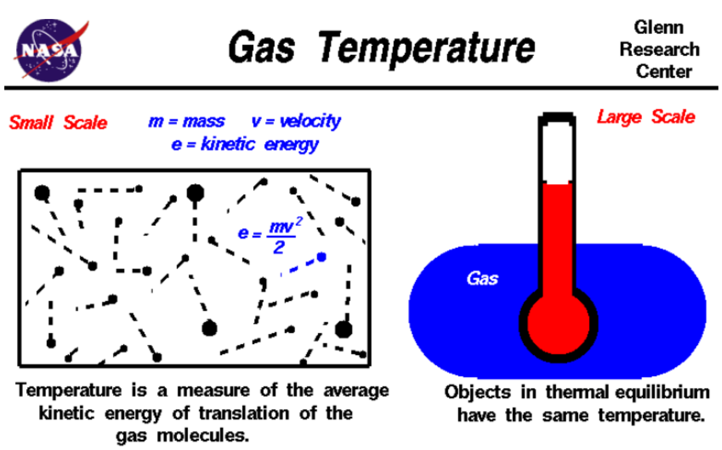

Figure 1. Molecules in the thermometer are in thermal equilibrium with the molecules surrounding it as depicted by NASA engineers on their website.

Since a calibrated thermometer records the kinetic energy of the molecules that are surrounding it, it follows that *the difference between two temperature readings is equivalent to the energy of the system that was either gained or lost*.

If one records the minimum temperature during the night, i.e. when the molecules of air *are not* heated by the sun, and the maximum temperature reached during the day, i.e. when the molecules of air *are* heated by the sun, the difference between the two readings will be equivalent to the heat energy available to the molecules surrounding the thermometer. If that thermometer is placed in a rural environment, away from any additional heat energy that might have been generated by human activities, this night-to-day warming reflects the available heat energy (AHE) from a single source – the Sun. It follows that Tmax/Tmin thermometer-based data gives direct access to the amount of the Sun's heat energy that is able to reach ground level~~s~~ thermometers:

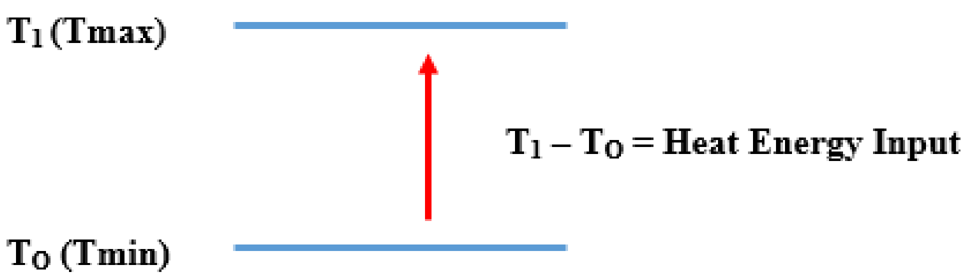

Figure 2. Difference between the two energy states, T_1 and T_O is equivalent to the amount of heat energy absorbed by the system needed to bring T_O to T_1.

Every molecule has the ability to absorb heat energy. This property, known as heat capacity, is defined as 'the amount of heat energy in kilo joules, kJ, needed to warm 1 kilogram, 1 kg, of the molecules by 1 degree Celsius, 1^{O}C'. When the heat capacity is measured at constant pressure it is represented by the symbol Cp, while when measured at constant volume it is represented by the symbol Cv. *Throughout this paper we will use only heat capacity measured at constant pressure, Cp*.

Air has Cp = 1.0 (kJ/kg per 1^{O}C) and it follows that if the observed night-to-day warming (Tmax-Tmin) was say 10^{O}C, the AHE from the Sun would be 10 kJ per 1 kilogram of air. In other words, the difference between Tmax and Tmin in degrees Celsius is the equivalent to the AHE in kJ, i.e. 1^{O}C = 1kJ.

Next we need to define what constitutes the Earth's surface, a term often misused by the proponents of global warming. What chemistry has taught us is that everything that has mass is made of atoms (elements) and molecules. When it comes to the Earth's atmosphere, the top of the atmosphere (TOA) starts at an altitude of +100 km and represents our planet's primary surface or the first protective shield against any incoming physical objects from space, such as asteroids or the huge amount of heat energy generated by the Sun.

What chemistry also tells us is that our atmosphere is primarily composed of two molecules, N2 (78%) and O2 (21%), plus a large number of molecules, called trace gases, that make up the remaining 1% of the atmosphere. Here, for all practical purposes and simplicity, the atmosphere will be viewed as a mixture of two molecules, N2 and O2, in a 4:1 ratio (80% N2 and 20% O2 respectively).

So what do we know about our secondary surface that is the one at ground level (sea level)? Our ground level (secondary) surface consists of approximately 30% land mass and 70% water. Therefore, the third molecule that exerts a major effect on absorption of heat energy from the Sun is H20.

The following are some hard-and-fast numbers which explain the relatively moderate impact that the Sun has on the molecules that make-up the ground level surface of our planet, in comparison with the impact that the Sun has on the Moon which lacks an atmosphere and water. *The mass of our atmosphere is estimated to be 5.0x11^{18}kg [6 and 7]; Cp for air is 1kJ/kg and therefore 10^{18} kJ of heat energy from the Sun will be needed to warm the atmosphere by just 1^{O}C; when the remaining heat energy from the Sun reaches the surface at ground level, an estimated hydromass (the oceans, lakes and rivers) of 10^{21} kg of water will further absorb the Sun's heat energy at the rate of 4.2 kJ per kilogram of water; the water temperatures at the oceans' floor is just above water's freezing point of 0^{O}C, while the hottest oceans' surface temperatures are around 30^{O}C indicating the oceans' huge capacity to store heat energy.*

Datasets and Statistics

This experimental part of this paper describes preparation of the daily and monthly datasets generated by calibrated thermometers and introduces the statistical functions that will be used to analyse these datasets.

Datasets

Two types of datasets have been used in this paper: daily Tmax/Tmin datasets from the Armagh Observatory site (UK) [8] and forty monthly Tmax/Tmin datasets mainly obtained from the KNMI Climate Explorer [9].

Daily Tmax/Tmin data from Armagh

The archive data are freely available at the Observatory's home page and come in two separate files, Tmax and Tmin datasets, each covering 161 years of daily data between 1844 and 2004. The detailed re-formatting protocol can be found in the paper by Butina [5] which was published in this journal in 2012, and summarised as follows:

- Any column (day) in the daily Tmax or daily Tmin dataset (160 rows x 366 columns each) that had missing datapoint(s) (labelled as -999) was removed
- Only columns in Tmax space that had the corresponding Tmin data were retained. For example, if a single Tmax31, for the 31st January, did not have the matching Tmin31 reading, the Tmax31 column was removed as well

This data reduction process produced the starting dataset consisting of 310 (out of 365) daily Tmax/Tmin datapoints covering all years between 1844 and 2004.

KNMI Monthly Tmax/Tmin Datasets

The KNMI software allows search of the database either by using an interactive global map or by specifying latitude/longitude grid point. The user then defines whether to search for Tmax or Tmin data and specifies how many weather stations close to the target latitude/longitude intersection are wanted. Each weather station is described by classifiers like rural/urban, near water, forest, desert and elevation above sea level. Those classifiers were then double-checked using Google Earth for all forty weather stations selected for the analysis. Any year that had missing datapoints, labelled -999, was removed. This meant that different datasets might have different gaps of one or more years. However, since the main objective of this paper was to look for some general patterns in the local/regional AHE space it was more important to use only observed data rather than contaminate the dataset by using some sort of replacement algorithm.

Please note that the complete master table for 40 weather stations used in this paper can be obtained by contacting the author at darkobutina@l4patterns.com.

Statistics

The following standard functions available in Excel were used:

max, min, stdevp (the standard deviation for population) and average (the mean)

rsq (R-squared or the squared correlation coefficient) that when multiplied by 100 indicates the percentage of the variance between two variables that has been explained.

Variance or anomaly (the latter is a term commonly used in climate sciences) expresses the distance of the observation from the population mean: variance = X – mean. Dividing the variance by the standard deviation produces the z-score.

z-score, the distance of the observation from the mean in standard deviation units, calculated using formula:

$$z = (X - \text{mean})/\text{standard deviation}$$

where X is individual datapoint like Tmax, Tmin, the difference between Tmax and Tmin or the Available Heat Energy, AHE. All the observed values that fall between +/- 1.96 standard deviations from the mean, also known as the 95% confidence interval are labelled as 'normal', while the observations outside that range are labelled as 'extreme'.

Terminology Used in this Paper

Sigma range is an equivalent to standard deviation range

Referencing molecular structures:

N2, O2 and H2O are the same as N_2, O_2 and H_2O

Referencing latitudes:

Latitude at 80N is the same as $80^{O}N$

Available Heat Energy (AHE) from the Sun at the Armagh Observatory (1844 - 2004)

The Armagh Observatory (latitude 54N; longitude 6W) lies approximately 1 km northeast of the centre of the ancient city of Armagh. It is situated 64 m above the mean sea level at the top of a small hill in an estate of natural woodland. The observatory is still largely surrounded by countryside similar to that which has existed since its foundation in 1790. Together with the fact that the population of Armagh (when compared with other Irish and UK cities) has increased relatively little since the late 18th Century, its rural environment has ensured that the observatory suffers from little or no urban micro-climatic effects, Coughlin and Butler [10]. In addition, with a relatively exposed site, in a fairly windy maritime climate, any urban climatic effects that did exist would be expected to be minimized.

January 1, Tmax, Tmin and AHE

We will start the numerical analysis with the first day of the year, January 1, by extracting out Tmax1/Tmin1 data from the starting dataset that covers daily readings for period between 1844 and 2004, and populate the resulting table with the relevant derivatives (Table 1).

Table 1. Sample table consisting of Tmax1 and Tmin1 readings and the difference between the two, the AHE

Year	Tmax1	Tmin1	AHE-1	AHE-z-1	AHE-variance-1	mean	standard deviation	Max positive variance
y1844	1.9	-2.4	4.3	-0.39	-0.9	5.2	2.3	4.5
y1845	5.0	1.7	3.3	-0.83	-1.9			Max negative variance
y1846	5.9	2.1	3.8	-0.61	-1.4			-4.4
y1847	7.2	4.4	2.8	-1.04	-2.4			
y1848	6.8	-0.4	7.2	0.87	2.0			
y1849	4.2	0.7	3.5	-0.74	-1.7			
y1850	5.4	0.9	4.5	-0.30	-0.7			

The following is a brief description of Table 1: column 1 contains the year's label, columns 2 and 3 contain the Tmax1 and Tmin1 thermometer readings, while column 4 contains the difference between Tmax1 and Tmin1 which is the equivalent of the available heat energy from the sun, AHE. Columns 5-9 are all derivatives of the AHE-1 values: z-score, variance, the mean, the standard deviation and finally maximum positive and negative variances from the mean. *Please note that the original dataset uses the Julian calendar notation where a calendar year consists of day1 through to day365. Therefore, the index 1 represents is January 1, the index 31 corresponds to January 31 and so on*.

Throughout this paper the years are always displayed from the oldest (at the top in tables or to the left in graphs) to the youngest. The maximum positive and negative variances in AHE space are, respectively, the largest positive and negative distances between an individual AHE value and the AHE's mean.

Figure 3 below depicts the variations in the AHE for January 1 between 1844 and 2004.

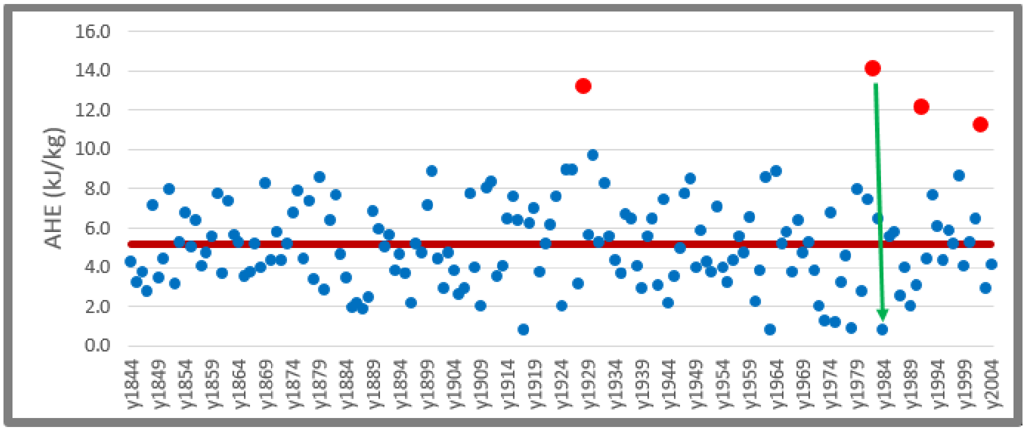

Figure 3. AHE on January 1 between 1844 and 2004 with the mean equal to 5.2 kJ.

The first thing to notice is the large variation in the AHE space, from a minimum of 0.8 kJ (in 1917, 1963 and 1984) to a maximum of 14.1 kJ in 1982. Note also that in 1982 the largest amount of the AHE observed at Armagh on January 1 was 14.1 kJ/kg, while 2 years later only 0.8 kJ/kg of the AHE was available on the same day and in the same place (as indicated by the green arrow in Figure 3).

From observations made over 161 years the AHE was outside the 95% confidence interval (+/- 1.96 z-score) only on 4 occasions: 1928, 1982, 1991 and 2002 (as shown by the red circles Figure 2). The same data can be plotted in terms of the variance from the mean (the anomaly) to identify any obvious warming-cooling trends (Figure 4).

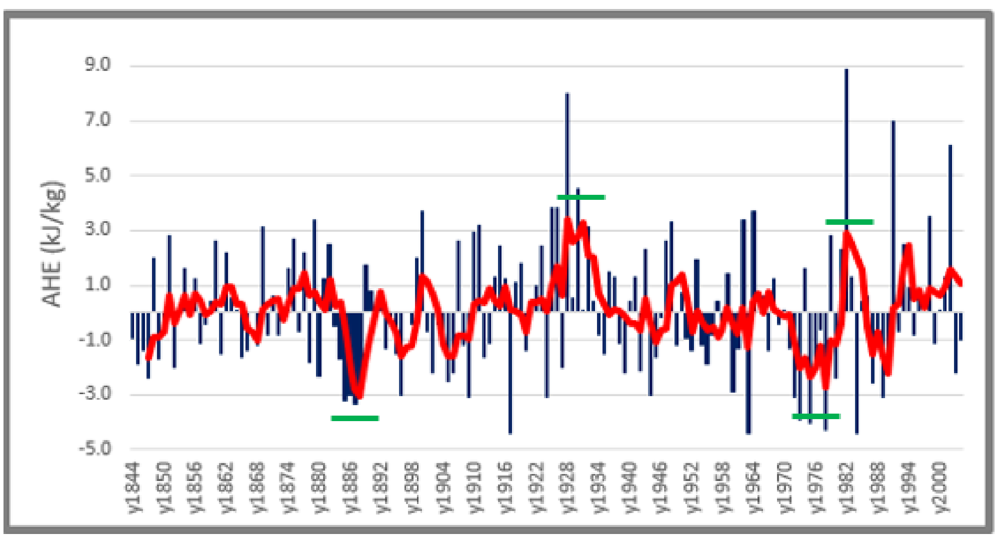

Figure 4. Variance in AHE space around the mean of 5.2 for January 1 between 1844 and 2004 expressed as 5-year running average. The two most prominent positive and negative variances are highlighted by the green lines.

As can be seen from Figure 4, the variance can be as high as 9 kJ above the mean and as low as 5 kJ below the mean with the major positive variances cantered around the years 1930 and 1982 with two major negative variances centred around 1886 and 1976.

Let us briefly digress here to highlight the huge difference that our atmosphere is having in preserving the water on our planet. As we can see from the table below, the mean of the AHE is 5.2 kJ and the mean of Tmin is 1.9^{O}C (Table 2).

Table 2. Minima, maxima and means for Tmax1, Tmin1 and AHE-1

max-tmax	13.1	1851
min-tmax	-1.4	1979
mean Tmax	7.1	
max-tmin	10.5	1917
min-tmin	-9.4	1979
mean Tmin	1.9	
max-AHE	14.1	1982
min-AHE	0.8	1917, 1963, 1984
mean-AHE	5.2	

If we assume that the nearby ocean's surface temperature during the night is approximately same as the mean of the Tmin1, say 2.0^{O}C, with the heat capacity for water being 4.2 kJ/kg per 1^{O}C and with only 5.2 kJ of the heat energy from the sun being available for warming, it follows that 1 kg of water molecules can be warmed during day time by maximum 5.2/4.2=1.2^{O}C, to 3.2^{O}C. The cooling process starts again during the next night and the whole cycle repeats itself again the following day.

So let us return to Table 2 and perform the following exercise. So far, it has been established that, on average, some limited amount of the AHE is available at ground level for night-to-day warming and that the observed Tmax will be pre-determined by the starting Tmin and the AHE on a given day of a given year:

$$Tmax_{(i)} = Tmin_{(i)} + AHE_{(i)} \quad \text{(Equation 1)}$$

The *maximum Tmax* value was observed at 13.1^{O}C in *1851* when the night-to-day warming started with Tmin at 5.1^{O}C (the *maximum Tmin* of 10.5 was observed in *1917*) and the AHE was 8 kJ (the *maximum AHE* of 14.1 was observed in *1982*), as listed in Table 2. *In other words, the maxima of each of the three parameters' occurred in different years*. It follows that if the maximum Tmin, 10.5^{O}C, had occurred in the same year as the maximum AHE of 14.1 kJ, the theoretically achievable Tmax for January 1 could be as high as 24.6^{O}C:

MAX Tmax = max Tmin + max AHE = 10.5 + 14.1 = 24.6 (MAX = theoretical ceiling for Tmax)

Conversely:

MIN Tmax = min Tmin + min AHE = -9.4 + 0.8 = -8.6 (MIN = theoretical floor for Tmax)

In percentage terms, the observed maximum Tmax is still 35% below its theoretical ceiling, while minimum Tmax observed is still 22% above its theoretical floor (Figure 5).

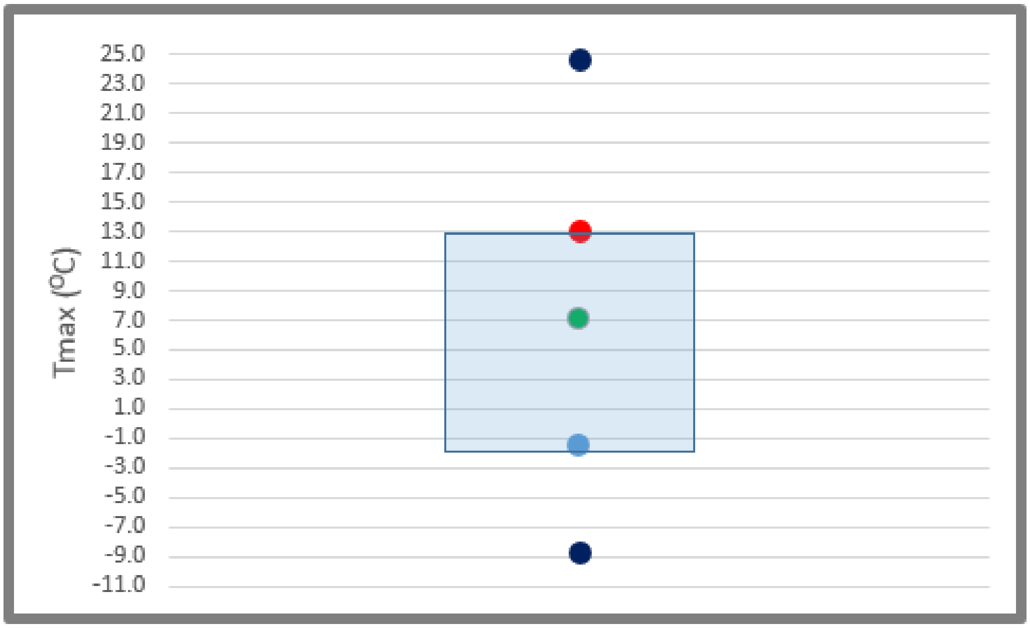

Figure 5. Observed vs. possible Tmax ranges on January 1: observed max-Tmax (red) and min-Tmax (light-blue) plus mean-Tmax (green) in the shaded area; theoretically possible MAX-Tmax (top-dark blue) and MIN-Tmax (bottom-dark blue).

So, when a question like ‘How unusually hot is January 1 at the Armagh Observatory at 13.1^{O}C in 1851 (or unusually cold at -1.4^{O}C in 1979)?’ is being asked, the answer would be that both extremes have not been reached so far and that the z-scores for those two extremes would, in both directions, be over 5 standard deviations away from the current mean!

Predicting Future Warming Trends for January 1 at the Armagh Observatory

All the statistical analysis done for January 1 covered the period between 1844 and 2004. However, the Armagh Observatory is still on-line and ‘live’ and therefore another 9 years of observations are available and can be used as an independent test set to test the findings so far. The 1844-2004 dataset was partitioned into 4 bins based on the AHE’s z-scores and the distribution is presented in the Table 3.

Table 3. Distribution of the AHE across four bins: neg-3S (negative, within 3 sigma), neg-2S (negative, within 2 sigma), pos-2S (positive, within 2 sigma) and pos-3S (positive, within 3 sigma) regions

Bins	number(1844-2004)	%(1844-2004)
neg-3S	0	0.0
neg-2S	83	51.6
pos-2S	74	46.0
pos-3S	4	2.5

In percentage terms, the AHE on January 1 was 0% *outside* 2 standard deviations below the mean, 51.6% *within* 2 standard deviations below the mean, 46% *within* 2 standard deviations above the mean and 2.5% *outside* 2 standard deviations above the mean. Therefore, if the future trends follow those observed for the past 161 years the distribution patterns across the four bins for the years 2005 to 2013 should be similar. The data demonstrating this are presented in Figure 6.

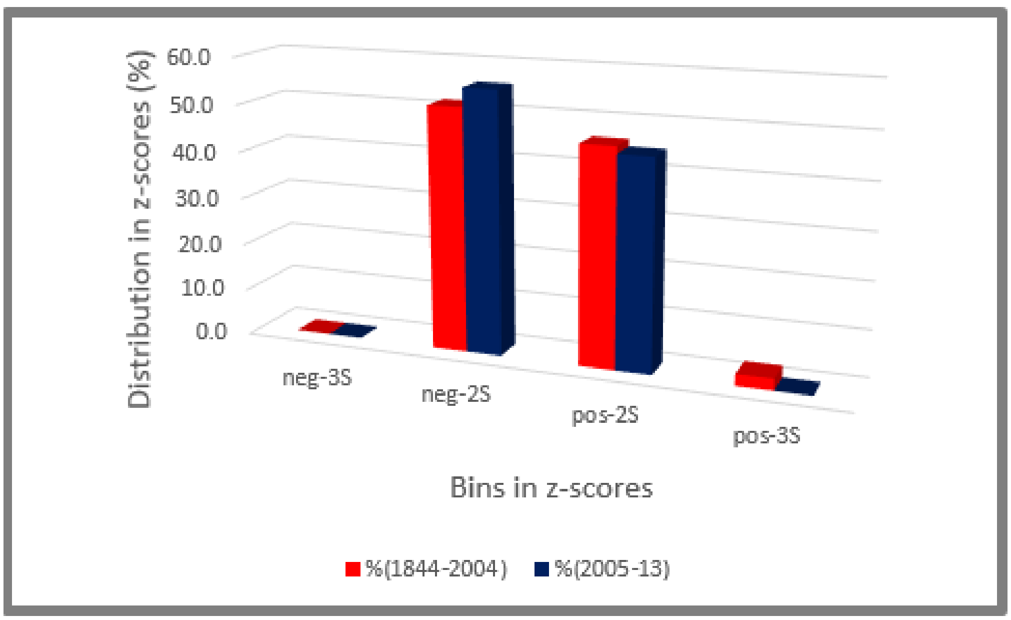

Figure 6. Distribution of the AHE across four bins for 1844-2004 (red) vs. 2005-2013 (dark blue).

Note the absence of the AHE in either positive or negative 3 sigma extreme regions for the 2005-2013 period, i.e. all the recent AHE data are well within the 95% confidence interval calculated for the 1844 to 2004 period.

Table 4. Distribution of the AHE across 4 bins for 1844-2004, in numbers (#) and percentages (%), followed by the AHE distribution for the years 2005-2013 that was NOT part of the period used to calculate the AHE mean and standard deviation

Bins	#(1844-2004)	%(1844-2004)	#(2005-13)	%(2005-13)
neg-3S	0	0.0	0	0.0
neg-2S	83	51.6	5	55.6
pos-2S	74	46.0	4	44.4
pos-3S	4	2.5	0	0.0

The table above is displayed as a 3D graph in Figure 6 with the main point to note being that the ratio of the years below and above the mean is maintained within the two major bins.

Twelve AHE Profiles at 30-Day Intervals

Two important facts about Tmax1, Tmin1 and AHE-1 are the magnitude of the natural variations within their respective ranges (Table 5) and total randomness in their individual patterns (Figure 7).

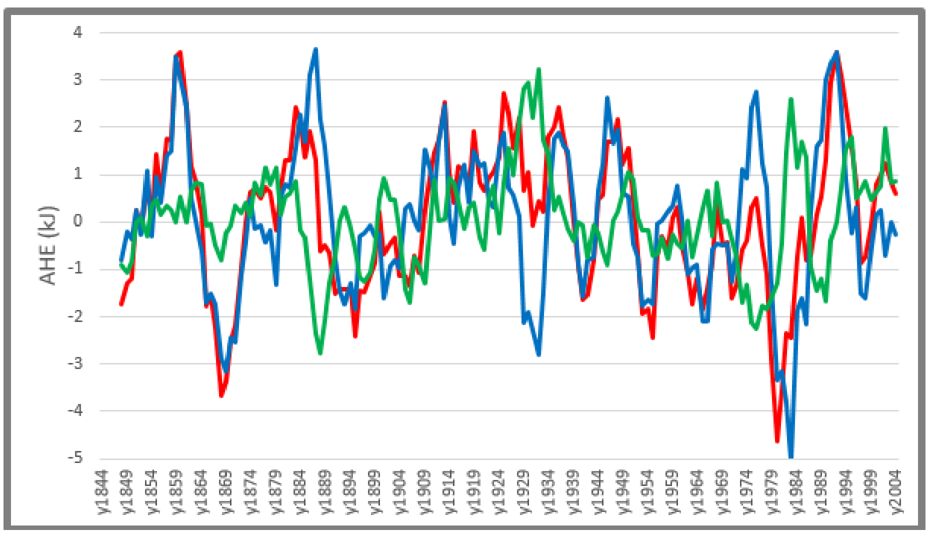

Figure 7. Chaotic variance in the 5-year moving averages for Tmax1 (red), Tmin1 (blue) and AHE (green).

In view of a very low correlation between any of the three observed parameters it was important to establish and compare the monthly/seasonal trends in Tmax1 and AHE-1. The mean values for Tmax and AHE were calculated at twelve 30-day intervals and, in the case of Armagh, the maximum in AHE precedes the maximum in Tmax by 60 days (Figure 8).

Table 5. Natural variations in Tmax1, Tmin1 and AHE-1 in their key derivatives, the mean and the variance around the mean

	mean	pos var	neg var	tot var	tot var/mean
Tmax1	7.1	6.0	-8.5	14.5	2.0
Tmin1	1.9	8.6	-11.3	19.9	10.5
ahe-1	5.2	8.9	-4.4	13.3	2.6

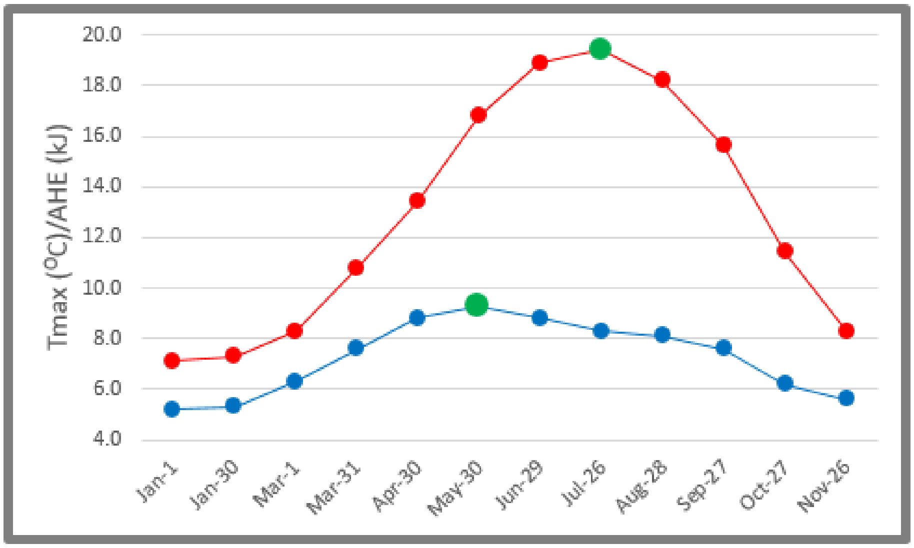

Figure 8. Annual distribution of Tmax (red) vs. AHE (blue) with the AHE reaching maximum on May 30 (green) while Tmax reaching maximum 60 days later, on July 26 (green).

The figure above highlights the problems with using warming-cooling trends in Tmax space as the evidence of either local or global warming patterns, while totally ignoring the real driver behind those patterns, the AHE.

Interpretation of the Daily Tmax/Tmin Observations

The analysis of the daily Tmax/Tmin/AHE observations so far was based on a simple statistical interpretation of the numbers without taking into account the physical meaning of those numbers and without asking the key question – is it possible to explain those huge natural variations in the AHE at ground level using our knowledge of the physicochemical properties of the molecules that makeup our atmosphere?

The first step in this process is to identify all the major parameters that can influence amount of the AHE that is warming the molecules surrounding the thermometer every day, and the second step is to define each of those parameters as a 'constant' or a 'variable'. A simplistic starting scheme can be best explained by the figure below (Figure 9).

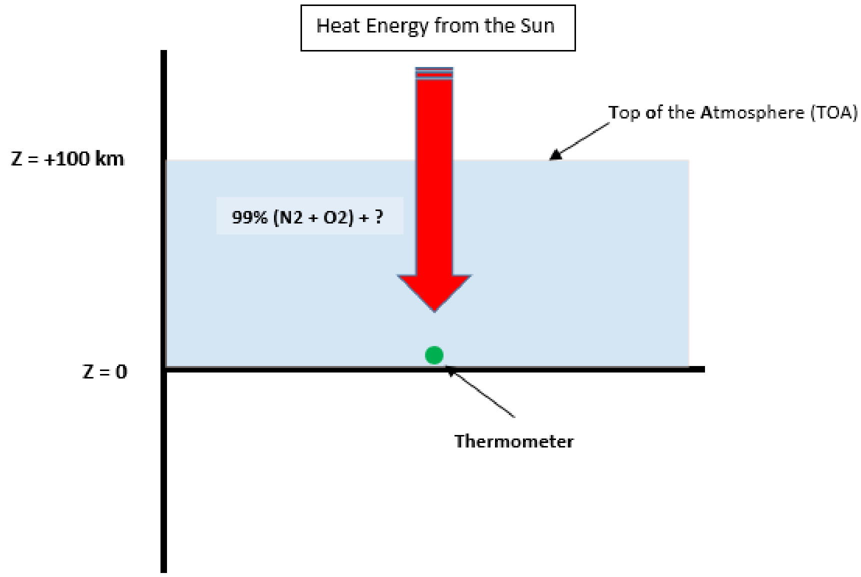

Figure 9. The loss of the Sun's heat energy caused by the warming of huge amount of molecules that absorb that heat between the TOA at Z=+100km and the ground thermometer at Z=0.

The constant parameters that have pre-defined the statistical analysis of the Armagh's dataset so far are:

- The thermometer fixed at the same grid point
- The heat output from the Sun
- The constant amount of N2 and O2 molecules in our atmosphere

Since all those parameters are approximately constant we should be observing approximately the same amount of the heat energy being available to the air molecules surrounding the thermometer – but we don't. Therefore, it must follow that there is another molecule causing such large variations in the observed AHE and that the answer has to lie in the physicochemical properties of that other molecule, water. Water molecules cover over 70% of the Earth's surface; it has a heat capacity, Cp, of 4.2 kJ/kg (that is a capacity to absorb heat 4.2 times greater than that of air which has Cp=1.0 kJ/kg); it is present in the air in all three states, gaseous state (humidity), liquid state (rain, clouds) and solid state (snow, clouds). Furthermore the clouds can cover up to 80% of the surface and by its reflection and high density (liquid-ice), water will have a major influence on the amount of the Sun's heat energy that is able to reach the ground level thermometer.

If the dataset observed at the Armagh Observatory is now viewed not as a local dataset, but as a dataset from a location surrounded by huge masses of water, a very different picture of the AHE will emerge. The widely accepted climate zones that are based on latitude position alone might have to be re-adjusted so that 'surrounded-by-water' or 'surrounded-by-land' attributes could be added.

In the case of Armagh, the AHE patterns and variations will be driven by two major factors: the proximity of the ocean where the water molecules in their liquid state use 4.2

times more of the AHE than the air molecules and, obviously, the cloud cover resulting from evaporation of the water.

In summary, based on the analysis of the daily AHE patterns at the Armagh Observatory the following conclusions can be made:

- To understand daily Tmax patterns, one needs to understand the key driver of Tmax patterns, the AHE and the corresponding Tmin patterns
- The AHE patterns for January 1 vary each year from 0.8 kJ to 14.1 kJ with a total range of 13.3 kJ and with a mean of 5.2 kJ
- The total variation (13.3 kJ) is *2.6 times larger* than the mean (5.2 kJ)
- Of the three molecules that are responsible for the very limited amount of the available heat energy from the sun to reach the ground thermometer, two are approximately constant (N2 and O2), while H20 is the main cause of the observed variance in the AHE space

One way to quantify the effect of the H2O molecules on the variance in the AHE is to find the weather stations that range from the ones completely surrounded by water, like very small islands in the middle of oceans, to the ones completely surrounded by continental land mass.

Monthly Tmax/Tmin and AHE across the Globe

A dataset that should show very similar trends and patterns to the Armagh dataset is called Central England Temperatures (CET) [11] and was created by averaging 30 different weather stations across central England. In geographical terms, the two sets are separated by 2 degrees of latitude but both are part of the British Isles and could be labelled as 'surrounded by water'.

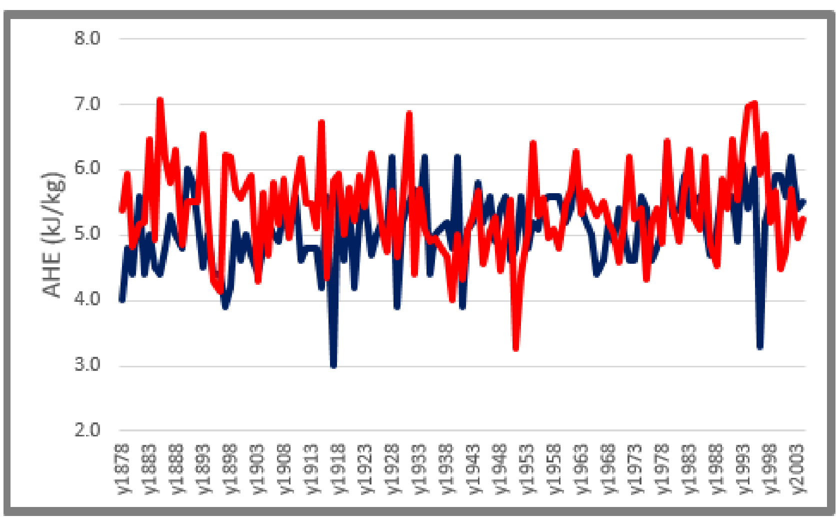

Figure 10. AHE for January 1878-2004; CET (blue) and Armagh (red); AHE-mean for CET is 5.1 kJ and 5.4 kJ for Armagh.

One problem in comparing the two sets is that the CET dataset is based on monthly Tmax/Tmin averages, while the Armagh dataset is based on the daily Tmax/Tmin thermometer readings. To overcome this problem all daily Tmax/Tmin data for January (day1 to day31) from Armagh were averaged into a monthly January Tmax/Tmin dataset. In order to make comparison as close as possible, the identical end points between the two sets were used – the years for the two sets start in 1878 (the starting year for CET) and end in 2004 (the end year for the Armagh 'training' set), Figure 10.

As it can be seen from Figure 10, the overall AHE patterns and the means of the two datasets are very similar despite the latitude separation and thus far confirm the influence that the water is having on the AHE reaching ground level for thermometers that are 'surrounded by water'.

The obvious next step to take was to look for weather stations that are in the middle of continental land masses, where the water influence would only come from clouds and the surrounding biomass. During this exercise monthly Tmax/Tmin data were extracted from 40 different weather stations across the globe and a small sample table of this data is displayed below (Table 6).

Table 6. Sample table: AHE extracted from monthly Tmax/Tmin row data using KNMI software

order	weather-station	land-water	Latitude	N/S	AHE-mean-Jan	mean-Tmin
1	batkanu-9N	forest	9	N	13.4	20.3
2	usa-N40	land	40	N	14.9	-10
3	bermuda-32N	water	32	N	4.3	15.8
4	canada-50N	land	50	N	12.8	-25.6
5	canada-82N	artic-water	82	N	7.6	-35.8
6	cet-53N	water	53	N	5.1	5.1
7	china-49N	land	49	N	13	-14.1
8	ireland-54N	water	54	N	5.5	1.2
9	australia-33S	desert	33	S	14.6	3.3

The first 2 columns are needed for lookup and sorting purposes, the column 3 is based on the labels that KNMI software uses, the Latitude (column 4) and Latitude label (column 5) are self-explanatory, the column 6 is the AHE for January and the last column is the mean of the January's Tmin values.

As it can be seen, even from this small sample, the AHEs connected with water (highlighted in blue) have means below 10 kJ, while those connected with land have means above 10 kJ. Due to the sheer size of the master table and number of weather stations, 40, only a few key weather stations will be discussed further in this paper.

Weather Stations Surrounded by Land Mass

The variance patterns for four weather stations that are surrounded by land mass are displayed in Figure 11.

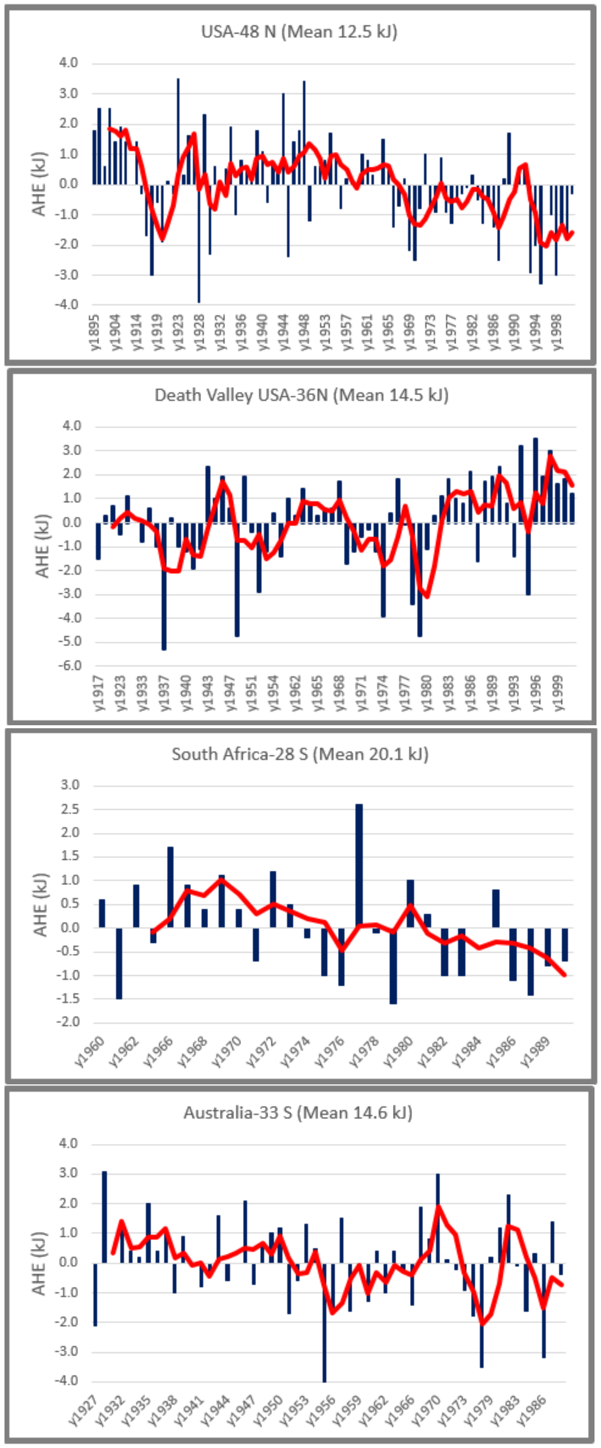

Figure 11. The variance and AHE means for the land-surrounded weather stations: USA at 48N (top), Death Valley 36N (second), South Africa 28S (third) and Australia 33S (bottom). The thick red line is the 5-year moving average while the number preceding 'N' or 'S' is the latitude.

It is noteworthy that the weather stations surrounded by land mass are receiving between 12 to 20 kJ of heat energy from the sun with the total variance around the mean between 5 and 10 kJ.

Weather Stations Next to and Surrounded by Water

For weather stations near to, or surrounded by, water the AHE means for both types are smaller than those for weather stations surrounded by land (previous section), Figure 12:

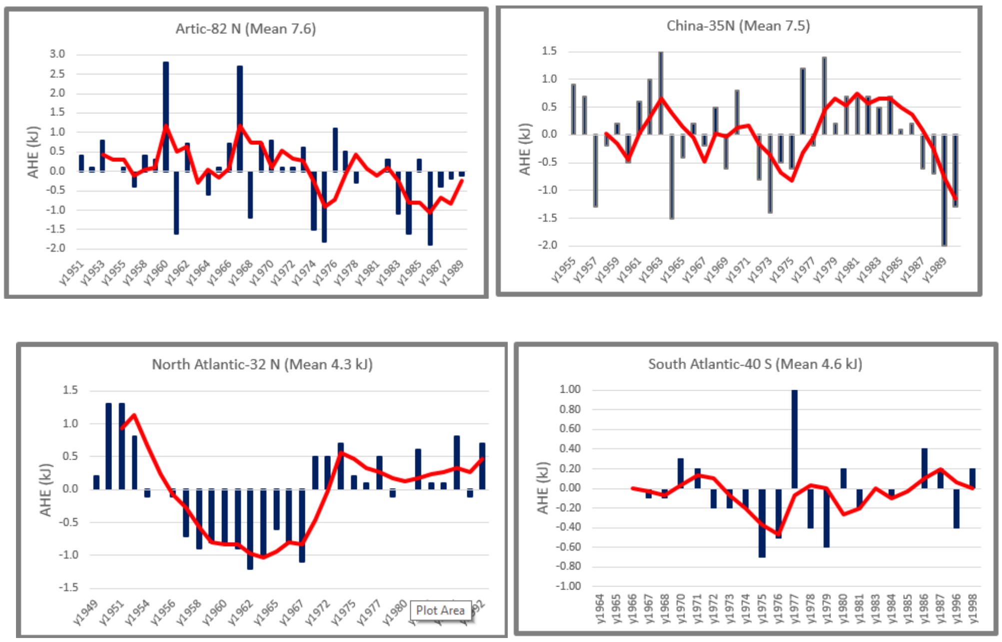

Figure 12. Weather stations *next* to water, Artic at 82N (top left) and China 35N (top right); Weather stations *surrounded* by water, North Atlantic 32N (bottom left) and South Atlantic 40S (bottom right). The thick red lines are the 5-year moving averages.

The weather stations *near to water*, in the Artic and in China receive on average 7.5 kJ of heat energy with total variance around the mean between 3.5 to 5 kJ, while those *surrounded by* water (small islands) only receive around 4.5 kJ of heat energy with total variance between 2 to 3 kJ.

The AHE at the Ground Level across the Globe – the Summary

Total of 40 weather stations across the globe were analysed and the AHE mean was plotted on a single graph (Figure 13).

Let us look at Figure 13 in more detail. The vertical line (in red) separates the weather stations labelled as ‘land’ from those labelled as ‘water’, while the horizontal (red) line separates the weather stations with the AHE > 10 kJ (upper left quadrant) from the weather stations with the AHE < 10 kJ (lower right quadrant). The two horizontal (yellow) lines are the means of the means in the respective occupied quadrants, with the land weather stations' mean around 14 kJ while the water weather stations are grouped around 6 kJ mean. There are 3 obvious outliers that need explanation: two (red diamonds) in the lower left quadrant, and one in the upper left quadrant (green circle).

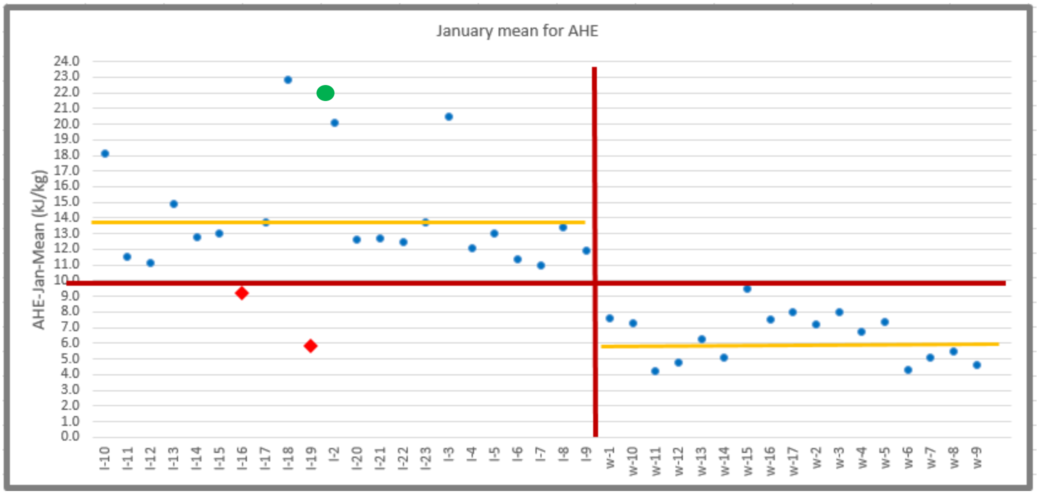

Figure 13. January means for the available heat energy, AHE, detected at the 40 weather stations across the globe.

The two outliers in the bottom left quadrant are labelled as l-16 and l-19 in the lookup table where 'l' stands for land, but their AHE means suggest water-based weather stations! The 'land' label was assigned to those two weather stations by the KNMI software from which the data was extracted (with the exact location subsequently being double-checked using Google Earth).

The lower outlier, l-19, with an AHE at 6 kJ is a weather station in Russia at latitude 67N (Arctic Circle) having a mean of 6 kJ which would strongly indicate the presence of water. However, inspection with Google Earth shows that the nearest ocean is over 300 kilometers away.

Going back to the original data in the KNMI software, another label describing that weather station was found, 'marshes' or 'marshlands', i.e. land surfaces covered by water, which would explain the observed AHE patterns.

The second outlier, l-16, was much easier to explain – it is desert-based weather station (Pakistan 25N) and it is 10 km from the coast (water) and therefore the surrounding land is competing with the nearby mass of water for the AHE and pushing the mean closer to those weather stations based on land.

The outlier at the top of the left-top quadrant (green) with a mean of 23 kJ was introduced into this otherwise rural dataset with a very specific purpose. The whole basis of this paper is to determine the amount of the heat energy from the sun that is available to the air molecules at ground level and, therefore, the weather stations used in this paper had to be rural, i.e. they could not be affected by heat energy generated by human activities. The weather station in question here is based inside a major city in Poland with a population of 2 million and, therefore, a contribution to the AHE is made by the extra heat generated by this population.

DISCUSSION AND CONCLUSION

The current practice in the climate science community is to look for trends in warming or cooling in either the purely theoretical space of annual global averages where a single number represents 'the annual global temperature', or in local/regional Tmax space which is typically based on monthly averages. However, what this paper clearly shows is that Tmax is pre-determined by the starting kinetic energy of the air molecules at night, Tmin, and the available heat energy from the sun during the day, the AHE. Furthermore, it has been shown that the AHE varies from day to day, year to year and is highly dependent on the location of the thermometer.

For the first time, the amount of the heat energy from the sun that reaches the ground level thermometer has been determined and mapped across the globe and a completely different view of the warming/cooling trends has emerged.

What we can see from Figure 13 in the previous section is that out of 40 different weather stations the minimum AHE mean for January was 4.2 kJ at Midway Island in North Pacific (28N, 177W), while the maximum AHE for the same month was 20.5 kJ at El Fasher desert in Sudan (14N,25E). Those two weather stations were screen-captured from Google Earth to highlight the differences in their respective surroundings (Figure 14).

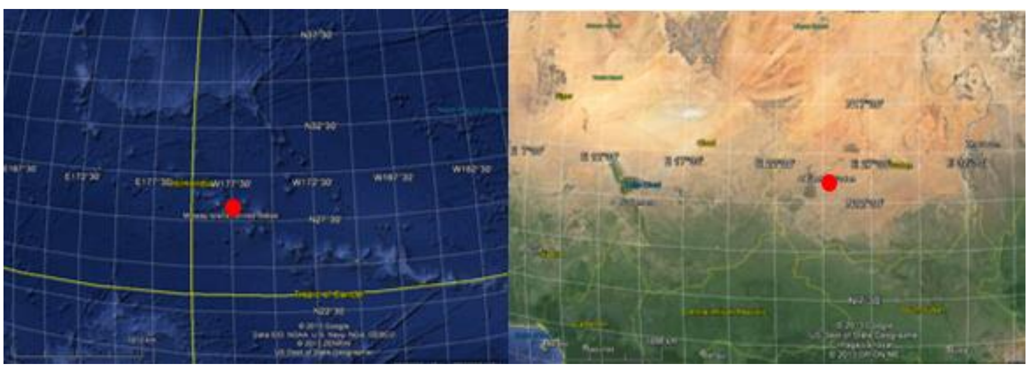

Figure 14. A weather station, Midway Island, with an AHE mean of 4.2 kJ for January (left) and one in the El Fasher desert in Sudan, with a January AHE mean of 20.5 kJ (right).

Since those two datapoints represent extreme AHE mean values, one could use them as two extreme thermodynamic systems that define the global boundaries of available heat energy from the Sun:

Thermodynamic System Water, TS-Water, where the ground thermometer is based on a very small island and surrounded by water for over 1000 km in any direction.

Thermodynamic System Land, TS-Land, where the ground thermometer is surrounded by the land mass for over 1000 km in any direction.

TS-Water is relatively easy to explain since all three molecules that define that system can be described as the constant parameters: the air molecules, 80% N2 and 20% O2 are in the thermal equilibrium with the thermometer and they absorb 1kJ per kilogram of the heat energy to warm up by 1^{O}C. Molecules that form the island's solid surface can be totally ignored since the real 'ground' consists of huge mass of water molecules and, therefore, in this case, the H2O molecules can also be considered as a 'constant'. In thermodynamic terms, there is competition between the air molecules (with Cp = 1 kJ/kg/1^{O}C) and the H2O molecules (with Cp = 4.2 kJ/kg/1^{O}C) for the available heat energy from the Sun in which H20 is having a major effect, in absorbing the AHE at much faster rate. What further complicates TS-Water dynamics is the fact that at the bottom of the oceans the temperature is just above O^{O}C and therefore a very steep temperature gradient will be further increasing the heat capacity of water and decreasing the mean of AHE for the small island.

TS-Land is a much more complex system since the molecules that form the 'ground' will vary greatly depending on the location. However, if we follow the main argument of this paper, which is that while the air molecules are constant, the water molecules are not and therefore one would expect the highest AHEs in places with minimal amounts of water, the land-surrounded deserts. Furthermore, it should also follow that the variance around the mean of the land-based deserts should be smaller.

As it can be seen from Figure 14, a thermometer in a desert environment is fixed to ground that contains minimum amount of water molecules, while the air above the thermometer is also free of sources of water, like clouds or humidity. The absence of H2O molecules explains why the AHE mean is almost 5 times larger (at 20.5 kJ) for land-based deserts than for tiny islands in the middle of an ocean (Table 7).

Table 7. Two sets of extreme AHE means detected globally for January

weather-station	land-water	Latitude	N/S	AHE-mean-Jan	Tot Var	Tot Var/mean	mean-Tmin
north-pacific-28N	water	28	N	**4.2**	2.5	**0.6**	17.0
bermuda-32N	water	32	N	**4.3**	2.5	**0.6**	15.8
south-africa-28S	desert	28	S	**20.1**	4.2	**0.2**	-1.2
sudan-13N	desert	13	N	**20.5**	7.2	**0.4**	9.9

The table above highlights the two key points discussed so far: the difference in AHE means between the small islands and continental deserts and the variance index (variance/mean) for water- or land-based weather stations.

Let us follow this line of argument a bit further. *The observed Tmax depends on the AHE, and the AHE depends on proximity of water. Therefore, the observed Tmax will be pre-determined not by latitude but the amount of water that is around the thermometer. It has to follow that identical or very similar AHEs should be observed irrespective of latitude.*

Table 8 is snapshot of the weather stations that have January AHE mean between 7.2 and 8.0 kJ, i.e. within a 0.8 kJ range.

What is common to all the weather stations in Table 8 is that they are based on land but in the vicinity (within a few kilometers) of large masses of water/snow/ice and all have an AHE mean within 0.8 kJ around the mean of 7.5 kJ.

However, those weather stations are very different in every other aspect: the most northerly thermometer is in the Arctic at latitude 80N, the most southerly one is in Melbourne at 38S and the most central one in China at 35N; the mean of the Tmin (night-time temperatures) varies between -40.3^{O}C in the Arctic and +6.4^{O}C in Melbourne.

Table 8. Weather stations with January AHE means between 7.2-8.0 kJ

weather-station	land-water	Latitude	N/S	AHE-mean-Jan	mean-Tmin
artic-80N	artic-water	80	N	7.2	-40.3
melbourne-38S	water	38	S	7.3	6.4
russia-74N	artic-water	74	N	7.4	-29.3
china-35N	water	35	N	7.5	-4.3
canada-82N	artic-water	82	N	7.6	-35.8
greenland-76N	artic-water	76	N	8.0	-28.1

Table 9. Weather stations with AHE mean for January between 11.1 and 11.9, all land based

weather-station	land-water	Latitude	N/S	AHE-1	Tot range	Tot Range/mean	mean-Tmin
sudan-4N	forest	4	N	11.1	2.8	0.3	11.1
australia-20S	desert	20	S	11.4	5.9	0.5	25.0
russia-tudra-61N	forest	61	N	11.5	6.4	0.6	-37.5
russia-tundra-58N	forest	58	N	11.9	5.0	0.4	-33.0

For the weather stations on land, Table 9, the AHE means are between 11.1 and 11.9 kJ range and based on latitudes between 61N (Russia) to 20S (Australia) with Sudan near Equator (4N) in between. While the AHE is very similar, their night-time temperatures vary from -37.5^{O}C in Russia to +25.0^{O}C in Australia.

So, the weather station based in tundra region of Russia at the latitude of 61N which has an average Tmin mean at -37.5^{O}C will warm up to -26.0^{O}C during the day-time after receiving 11.5 kJ of heat energy from the Sun, while the weather station in the Australian desert at the latitude of 20S with the average Tmin of +25.0^{O}C will warm up to +36.4^{O}C after receiving almost identical amount of the heat energy from the Sun, 11.4 kJ.

In terms of Tmax temperatures, those two weather stations are a huge 62.4^{O}C apart and yet the overall distribution of N2, O2 and H2O molecules is making them virtually identical in terms of AHE.

What the thermometer data is telling us is that to understand the trends in Tmax temperature patterns, we must first try to understand the trends and patterns of the heat energy available locally at ground level, and that to understand the AHE trends and patterns we must have good quality *daily* Tmax/Tmin data from which to extract the AHE. What this paper has also shown is that even using monthly Tmax/Tmin data of different length and year periods, very clear global patterns are emerging and that longitude/latitude based climate zones need to be modified to incorporate the influence of water.

In terms of the importance of the three molecules, N2, O2 and H2O this paper has simply quantified the physical connection and interplay between those three molecules. If it was not for the heat capacity of N2 and O2, the water molecules would evaporate completely from our planet and there would be no life. However, H2O in tandem with N2 and O2 is controlling the amount of the heat energy received from the Sun ensuring that the Earth does not overheat during the day and does not overcool overnight, a fact known to physical sciences long before the ‘invention’ of global warming.

FUTURE WORK

Since this paper is the first one to look into the thermometer-based warming patterns in terms of the available heat energy from the Sun at the ground level, and since only one month, January, was analysed, future work will include looking at the key seasonal variations in AHE space.

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