Trend Assessment of Global, UVB, UVA Irradiation and Dry Bulb Temperature at the Lowest Terrestrial Site on Earth: Dead Sea, Israel

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Research Article

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Abstract

The Dead Sea basin is lowest terrestrial site on the globe. A meteorological station monitoring the global, UVB and UVA irradiation and the dry bulb temperature was established in 1995 in conjunction with a study of bio-climatological properties of the region with regard to photoclimatherapy treatment of dermatological diseases. The availability of such irradiation and dry bulb temperature databases has been utilized to perform a study to determine if any trends regarding either irradiation or dry bulb temperature exist at this unique site. There was no indication of any trends, based upon a p-value analysis, regarding the global, UVB and UVA irradiation. The global irradiation database included the time interval 1995-2020; whereas the corresponding time interval for the UVB and UVA irradiation databases was 1995-2018. The dry bulb temperature database consisted of the time interval 1995-2020 and, once again, no trends were observed throughout the year with the exception of the nocturnal time interval, between 18:00 to 06:00, during the month of October which exhibited a warming trend of 0.78°C/decade

Introduction

The Dead Sea is one of the saltiest bodies of water known, with 345 g mineral salts per liter (Steinhorn and Gat, 1983; Even-Paz and Efron, 1996). It is situated between the Judean mountains in Israel and the Moab mountains in Jordan and is the lowest terrestrial site on the globe, approximately 400 m below mean sea level.

The Dead Sea basin is recognized internationally as a photoclimatherapy center for the treatment of psoriasis, atopic dermatitis, vitiligo and other skin and rheumatic diseases (Dostrovsky and Sagher, 1959; Avrach and Niordson, 1974; Abels and Kattan, 1985; Sukenik, 1994; Even-Paz, et al., 1996). Its highly regarded status as a photoclimatherapy center is based upon its unique UVB spectrum resulting from being located at the lowest terrestrial site on the earth; resulting in a relatively longer optical path length within the earth's atmosphere and an enhanced spectrally selective attenuation of the UVB irradiation. This attenuation is inversely proportional to the wavelength, consequently, the erythema range (~ 300 nm) is most strongly attenuated, whereas the therapeutic UVB range, e.g., for psoriasis (~ 311 nm), is attenuated to a lesser degree (Kudish, et al., 1997, 2003).

A second unique bio-climatological property of the Dead Sea basin is its terrestrial barometric pressure, the highest on the earth. The is a result of it being located at the lowest terrestrial site on earth and having the tallest atmospheric air column above its surface. It varies between 3.7 (July and August) and 5.2% (January and December) above that at mean sea level (Kudish and Evseev, 2016). Consequently, the Dead Sea basin is characterized as possessing the highest natural terrestrial oxygen density on the earth. It is an ideal location to bring patients suffering from chronic obstructive pulmonary diseases (COPD), end-stage lung disease with chronic hypoxemia, cystic fibrosis, coronary artery disease and congestive heart failure after healing of acute myocardial infarction, especially during the winter months (Kramer, et al., 1998; Berkovits, et al., 1999).

In the latter part of 1994 Professor Avraham Kushelevsky and one of the authors (AIK) were invited by the Regional R&D for the Dead Sea to establish a meteorological station at the Dead Sea basin to determine if it possessed any unique bio-climatological properties for the treatment of psoriasis and other dermatological diseases.

We believe that as a result of the uniqueness of the Dead Sea basin and its status as an internationally recognized center for the photoclimatherapy treatment of skin and rheumatic diseases, it is of interest to assess if any trends exist with regard to the global, UVB and UVA irradiation incident at the Dead Sea basin and also the dry bulb temperature.

Measurements

The Dead Sea basin meteorological station was established on the roof of the building housing the Neve Zohar Regional Council and became operable in January/February 1995. The meteorological station site parameters are as follows: 31.12°N latitude; 35.22°E longitude; -375m m.s.l.

The Neve Zohar meteorological station measures global irradiation with a Kipp & Zone, Model CM11. The UVB irradiation is measured utilizing a Solar Light Co. Inc., Model 501A UVBiometer, whereas the UVA irradiation is measured using a Solar Light Co. Inc., analog UVA version of Model 501A UV-Biometer.

A Campbell Scientific Instruments data-logger, a Model CR21, monitors and stores the data at 10 minute intervals, i.e. the meters are scanned at 10 second intervals and average values at 10 minute intervals are calculated and stored. The data are transmitted periodically from the data-loggers to the Solar Energy Laboratory, located on the ED Bergmann Campus of the Ben-Gurion University of the Negev in Beer Sheva, via modem. The data refer to Israel Standard Time (GMT + 2h).

The global irradiation measurements were initiated at Neve Zohar in January 1995 together with the dry bulb temperature, whereas the UVB and UVA irradiation measurements were initiated at Neve Zohar in January 1995 and July 1995, respectively. They have been monitored continuously except for interruptions; both scheduled to enable on-site (global irradiation) and factory calibration (UVB and UVA) checks and random ones caused by power failures.

The Neve Zohar meteorological station is part of the national network of meteorological stations and is also connected by modem to the Israel Meteorological Service, located at Bet Dagan.

Data analysis

The purpose of this study is to determine if there exist any trends, increasing or decreasing, in the monitored parameters; viz., global, UVB and UVA irradiations or the dry bulb temperature. The monthly average daily global irradiation during the time-interval between January 1995 and December 2020 is reported in Table 1. In addition, the monthly average daily irradiation and its corresponding median, standard deviation, coefficient of variation (%), maximum and minimum values are reported for each month. Trend assessment is based upon the p-value determined for each month; viz., a p-value ≤ 0.005 indicates that a trend exists during the time period under study. The monthly average daily UVB irradiation between January 1995 through December 2020 is reported in Table 2 and underwent the same statistical analysis as performed on the global irradiation. The same statistical analysis was performed on the UVA irradiation monitored between July 1995 and December 2020 and is reported in Table 3.

The monthly average dry bulb temperature was analyzed on a daily (00:00–24:00), diurnal (day between 06:00–18:00) and nocturnal (night between 18:00–06:00) basis. The same statistical analysis performed on the irradiation data was performed on dry bulb temperature database defined above and the results are reported in Table 4.

Results

The monthly average daily global irradiation exhibits a maximum value of 7932.2 Wh/m^2 in June and a minimum value of 2950.6 Wh/m^2 in December, cf., Table 1. The corresponding monthly average and median values are very similar throughout the year, i.e., on the average differ by 0.50%; maximum and minimum deviations 1.10 and 0.06%, respectively. This is indicative of an even distribution of daily values around the average. The magnitude of the coefficient of variation (Cv%) is a measure of the width of the spread of the individual values around the average monthly value and it is relatively low throughout the year; having a maximum value of 7.33% in January, viz., the variation of individual values during a particular month is inversely proportional to the magnitude of the Cv%.

It is apparent from the monthly p-values that there is no apparent trend regarding the global irradiation during the time period under investigation (26 years).

The monthly average daily UVB irradiation has a maximum value of 1.571 Wh/m^2 in June and a minimum value in December of 0.341Wh/m^2, cf., Table 2. The deviation between monthly average and median values for the individual months are in the range of 0.62% (January) to 3.74% (March); the average deviation is 1.93%. The Cv% exceeds 10% throughout the year; an indication of a greater monthly variation of the magnitude of the daily UVB irradiation for individual months relative to that for global irradiation.

Once again, based upon the monthly p-values there is no apparent trend regarding UVB irradiation during the time period being studied (24 years).

The UVA irradiation exhibits a monthly maximum of 400.58 Wh/m^2 in June and monthly minimum of 133.90 Wh/m^2 in December, cf., Table 3. The individual monthly average and median values differ between 0.10% (January) and 2.41% (March); the average deviation being 0.61%. The Cv% exceeds 10% only during February (11.11%) and is in the range of 1.82% (August) to 9.58% (May).

There is no indication of an apparent trend regarding UVA irradiation, based upon the individual monthly p-value analysis for the time period studied (24 years).

The statistical analysis of the dry bulb temperature was performed for the abovementioned three different time intervals:

- Diurnal- between 06:00 to 18:00
- Nocturnal- between 18:00 to 06:00
- Daily- between 00:00 to 24:00

The results of the individual statistical analysis can be summarized as follows, cf., Table 4:

Diurnal dry bulb temperature-

1. maximum temperature 35.8°C in August; minimum temperature 18.4°C in January;
2. deviation between monthly average and median temperatures is between 0.12% (November) and 2.97% (July); average monthly deviation 0.93%;
3. average monthly Cv% is 6.53% and it exceeds 10% only during July (11.10%).

Nocturnal dry bulb temperature-

1. maximum temperature 32.3°C in July; minimum temperature 16.4°C in January;
2. deviation between monthly average and median temperatures is between 0.08% (March) and 1.57% (August); average monthly deviation 0.78%;
3. average monthly Cv% is 5.71% and does not exceed 10% throughout the year.

Daily dry bulb temperature-

1. maximum temperature 34.2°C in July; minimum temperature 17.4°C in January;
2. deviation between monthly average and median temperatures is between 0.07% (May) and 1.51% (August); average monthly deviation 0.76%;
3. average monthly Cv% is 5.75% and does not exceed 10% throughout the year.

It is observed from the p-value analysis, applied to the three different time intervals studied, that there is no apparent trend regarding the dry bulb temperature during the time interval under investigation (26 years) with the exception of the nocturnal dry bulb temperature during the month of October, viz., p-value = 0.005. The month of October exhibits a positive nocturnal trend of 0.78°C/decade.

Discussion

The statistical analysis of the global, UVB and UVA irradiation measurements that were initiated at the Dead Sea basin in 1995 gave no indication of any trends during the past 26 years for global) and 24 years for UVB and UVA. The same irradiation measurements are performed in Beer Sheva, on the campus of the Ben-Gurion University of the Negev, as part of the ongoing research program regarding the bio-climatological properties for the photoclimatherapy treatment of psoriasis and other dermatological diseases at the Dead Sea (Kudish, et al. 1997, 2003). Beer Sheva is approximately 65 km from the Dead

Sea and at an altitude of 315 m m.s.l. The same statistical and trend analyses were applied to the global, UVB and UVA irradiation Beer Sheva databases for the same time intervals, viz., 1995–2020 for global and 1995–2018 for UVB and UVA. The results of the trend analyses were similar to those found for the Dead Sea basin databases, i.e., no trends were detected. The results of the statistical and trend analyses for the Beer Sheva irradiation databases are reported are reported in Tables 5–7.

An inter-comparison was also performed regarding the dry bulb temperature measurements at the Dead Sea basin and Beer Sheva during the time interval 1995–2020. The authors have recently published a study on the statistical analysis of the dry bulb temperature measurements for Beer Sheva during the time interval 1988–2019 (Kudish and Evseev, 2021). A statistical and trend analysis was performed using this existing database after removing the years 1988–1994 and the addition of the year 2020. The results of these analyses are reported in Table 8. It is observed from Table 8 that warming trends were observed for three months:

- August- night 0.53°C/decade; daily 0.50°C/decade
- September- day 0.64°C/decade; night 0.74°C/decade; daily 0.64°C/decade
- October- night 0.74°C/decade; 0.74°C/decade

In the case of the Dead Sea basin a positive or warming trend was observed only in October during the night, 0.78°C/decade, which is essentially that observed in the case of Beer Sheva. It is observed from Table 4 that the p-values corresponding to the months of August, September and October are significantly lower than those values reported for the remaining months of the year.

It should be noted that when a trend analysis was performed on the original Beer Sheva database, viz., the time interval 1988–2019, the results were significantly different (Kudish and Evseev, 2021). Positive warming trends were detected for 7 months of the year; whereas the months of January, April, October, November and December did not exhibit statistically significant warming trends. The months of February, March, July, August and September exhibited positive trends during the day, night and daily time-intervals. The months of June and July showed positive trends during night and daily time-intervals. It has been demonstrated previously that the detection of a trend, either positive or negative, at a particular site can be a function of the time interval under investigation, e.g., Maugeri and Nanni, 1998.

Conclusions

The Dead Sea basin is unique; it is the lowest terrestrial site on earth. Consequently, it is of interest to determine if any trends exist in the intensities of the global, UVB and UVA irradiation and dry bulb temperature measurements. A meteorological station monitoring these parameters was established in 1995 at the Dead Sea basin as part of a study to explain the success of the application of photoclimatherapy in the treatment of psoriasis and other dermatological diseases. A trend analyses were performed on the three irradiation and dry bulb temperature databases and the results can be summarized as follows:

- Based upon the monthly p-values there is no apparent trend regarding the global, UVB and UVA irradiation during the time period studied, i.e., 1995–2020 for global irradiation and 1995–2018 for UVB and UVA irradiation.
- This is in agreement with the results of a trend analysis performed on corresponding irradiation databases measured at Beer Sheva for the identical time interval, viz., no trends were detected.
- The monthly p-values in the case of the dry bulb temperature databases indicated that no trends existed at the Dead Sea with a single exception of a warming trend of 0.78°C/decade for nocturnal temperatures (18:00–06:00) during the month of October.

Declarations

- Conflict of Interest- there are no conflicts of interest for either author.
- Funding Statement- the is no funding source for this study.
- Author's Contribution- the authors have contributed equally to this study.
- Availability of data and material- all data utilized in this study are reported in the tables and for any further information please contact corresponding author.
- -Code availability- not applicable
- Ethics approval- not applicable
- Consent to participate- not applicable
- Consent for publication- not required

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Tables

Due to technical limitations, table 1-8 is only available as a download in the Supplemental Files section.

Supplementary Files

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- Table1.xlsx
- Table2.xlsx
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