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# Statistical analysis and inter-comparison of the solar UVB, UVA and global radiation for Beer Sheva and Neve Zohar (Dead Sea), Israel

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With 7 Figures

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## Summary

A statistical analysis and inter-comparison of the solar UVB, UVA and global radiation for Beer Sheva and Neve Zohar (Dead Sea) are presented utilizing data measured from January 1995 through December 2002. Beer Sheva is located approximately 65 km to the west of and ~700 m above Neve Zohar. The monthly average hourly and daily values for all radiation types at both sites are reported. The standard errors of the monthly average daily values have been calculated in order to ascertain whether the average daily radiation intensities are representative, i.e. if the magnitude of the standard error is less than the inherent measurement uncertainty of the instruments, and, thereby, justify an inter-comparison between the two sites. The relative magnitude of the global, UVB and UVA radiation intensity at the two sites is attributed to the enhanced scattering of the incident solar radiation at the Dead Sea location due to the longer optical path length it must traverse to arrive at the Dead Sea, the lowest terrestrial point on earth. The degree of attenuation of solar radiation due to the scattering phenomena is inversely proportional to the wavelength raised to some power and, consequently, it is greatest for UVB and negligible for global radiation.

## 1. Introduction

In recent years there has been growing interest in the monitoring of terrestrial solar ultraviolet radiation due to the increasing evidence of global depletion of stratospheric ozone. Any reduction in the thickness of the stratospheric ozone layer will result in an increase in the ultraviolet radiation intensity reaching the earth's lower atmosphere and incident on its surface. Ultraviolet radiation affects many chemical and biological processes and any increase in the radiation intensity is of concern, because of the potential deleterious effects on the biosphere, tropospheric air quality and on materials such as wood and polymers. The Dead Sea is a salt lake located between Israel and Jordan. It is one of the saltiest bodies of water known (345 g mineral salts per liter) and is situated at the lowest terrestrial point on earth, about 400 m below mean sea level. Ashbel (1939) was the first to report on the influence of the Dead Sea on the climate of its surroundings. The solar radiation intensity at the Dead Sea is of interest due to the uniqueness of this site. Stanhill (1970, 1987) and Stanhill and Ianetz (1997) have reported upon global radiation intensity measurements in the Dead Sea basin. Kudish et al. (1997, 2000) have reported upon ultraviolet, both UVB and UVA, and global radiation measurements at the Dead Sea. These ultraviolet radiation measurements are of special interest since the Dead Sea region is an internationally recognized photoclimatherapy center for the treatment of psoriasis, atopic dermatitis, vitiligo and other skin and rheumatic diseases, cf., Dostrovsky and Sagher (1959), Avrach and Mordson (1974), Abels and Kattan (1985) and Sukenik (1994).

Kudish et al. (1997) studied the attenuation of the UVB and UVA radiation intensities between Neve Zohar (located on the western shore of the Dead Sea) and Beer Sheva. The Beer Sheva site is located ca. 65 km to the west and is approximately 700 m above the Dead Sea. The results of the study showed that the UVB radiation was attenuated to a much greater degree than the UVA radiation. This is in accordance with radiation scattering theory, viz., the degree of attenuation by scattering phenomena is an inverse function of the wavelength, i.e. $\lambda^{-n}$. Bener (1972), Reiter et al. (1982), Blumthaler (1992) and Piazena (1996) have all reported similar findings for the attenuation of ultraviolet radiation intensity with decreasing altitude in the Alps and Andes mountains.

Kudish and Evseev (2000) analyzed the data from these two sites to determine whether the ultraviolet radiation could be correlated with the global radiation both on a monthly and a seasonal basis. The database was broader than that in the first publication as a result of the ensuing time interval between publications. It was observed that the hourly global and UVA radiation at both sites were highly correlated. In the case of the UVB radiation the correlations were found to be poor. This is not unexpected, since the UVB radiation is attenuated significantly by the scattering phenomena, whereas the attenuation of the global radiation is negligible. The high correlations between UVA and global radiation are explained by the fact that the UVA radiation is affected by the scattering phenomena to a much lesser degree than the UVB.

In the present study we have extended the analysis of the data for the global, UVB and UVA radiation at the two sites to determine if the extant databases are sufficiently large to calculate monthly average daily values that are representative of each site. Viz., to determine if the standard errors of the monthly average daily values are less than the inherent instrument measurement uncertainty and, thereby, justify the intercomparison of radiation intensities at both sites. Ianetz (2000) has applied a similar statistical analysis to the global radiation data for Jerusalem during the time interval 1954–1979.

## 2. Measurements

The radiation data on which this study is based are being monitored at two meteorological stations: one located on the western shore of the Dead Sea, at a site called Neve Zohar; the second is located in Beer Sheva, on the campus of the Ben-Gurion University of the Negev. The site parameters for the two stations are listed in Table 1. The instrumentation utilized to measure the UV radiation at both sites is identical. It consists of a Solar Light Co. Inc., Model 501A UV-Biometer for the measurement of UVB and a Solar Light Co. Inc., analog UVA version of Model 501A UV-Biometer for the measurement of UVA. A Kipp & Zone, Model CM11 and an Eppley, Model PSP pyranometer measure the global radiation at Neve Zohar and Beer Sheva, respectively. The accuracy of both pyranometers, which are secondary standard instruments, is ±3%.

A Campbell Scientific Instruments data-logger, located at each site (a Model CR21 at Neve Zohar and a Model CR10 at Beer Sheva), 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 Beer Sheva meteorological station is located on the roof of the Poster Building on the main campus of the Ben-Gurion University of the Negev and the Neve Zohar station is located on the roof of the building housing the Tamer Regional Council. The roof surfaces at both sites are similar, viz., have essentially the same albedo values, and the horizon has no influence on meter view factors throughout the year at

**Table 1.** Site parameters for the two meteorological stations

| Site | Latitude | Longitude | Altitude (m m.s.l.) |
|---|---|---|---|
| Neve Zohar | 31°12′N | 35°22′E | −375 |
| Beer Sheva | 31°15′N | 34°45′E | +315 |

either site. The data are transmitted periodically from the data-loggers to the Solar Energy Laboratory, located on the ED Bergmann Campus of The Institutes for Applied Research of the Ben-Gurion University of the Negev in Beer Sheva, via modem. The data refer to Israel Standard Time (GMT + 2).

The UVB and UVA measurements were initiated at Neve Zohar in February 1995 and have been monitored continuously except for interruptions; both scheduled to enable factory calibration checks and random ones caused by power failures. The UVB measurements were inaugurated at the Beer Sheva site in May 1994 and that for UVA in June 1995 and have been monitored continuously except for the abovementioned interruptions. The global radiation measurements were initiated at Neve Zohar in January 1995, whereas in Beer Sheva the global radiation has been continuously monitored since September 1976. These two meteorological stations are part of the national network of meteorological stations and are also connected by modem to the Israel Meteorological Service, located at Bet Dagan. The databases utilized in the present analysis consists of all days between January 1995 through December 2002 for which there is a one-to-one correspondence between the measurements, viz., any day for which an hourly value for one of the sites was missing is rejected and not included in the analysis for that particular radiation type.

The Model 501A UV-Biometer measures UVB radiation in units of Minimum Erythema Dose per Hour (MED/H). This unit is calculated by the cross-multiplication of the irradiating flux in the UVB spectral range and the Erythema Action spectra (McKinley and Diffey, 1987). Consequently, the UVB biometer has a spectral response normalized to that at 297 nm (i.e. the normalized spectral response at 297 nm is equal to unity) and the logarithm of the normalized spectral response degrades linearly with wavelength and is ~0.01 at 320 nm and ~0.001 at 330 nm. One MED/H is defined as that dose which causes minimal redness of the average skin type 2 after one hour of irradiation, i.e. 21 mJ $\mathrm{cm}^{-2}$. The accuracy of the UVB meter is ±5% for the daily total.

The analog UVA version of Model 501A UV-Biometer measures the irradiating flux in the UVA spectral range in units of $\mathrm{Wm}^{-2}$. The relative spectral response is normalized to that at ~370 nm and is >0.2 in the range of $320\,\mathrm{nm} \leq \lambda \leq 390\,\mathrm{nm}$. The spectral response decreases rapidly outside this range. The accuracy of the UVA meter is also ±5% for the daily total.

The pyranometers undergo periodic field calibration by the technical staff of the Israel Meteorological Service. The UVB and UVA meters are returned annually to Solar Light Co., Inc. for factory calibration.

## 3. Data analysis and results

### *3.1 Monthly average values*

The monthly average hourly and daily radiation at both sites for the global, UVB and UVA are reported in Tables 2–4, respectively. Also, the monthly average daily standard deviations of the global, UVB and UVA at both sites are reported in Table 5. In addition, the monthly average daily coefficient of variation values for all radiation types at both sites are shown in Fig. 1.

### *3.2 Statistical analysis*

The first task in the analysis of these six databases, viz., three radiation types at the two sites, was to determine if the monthly average daily values are representative of the two sites. This is necessary in order to justify the inter-comparison of the corresponding radiation types at the two sites, i.e. to establish that the average values are based upon a sufficiently broad database. This was accomplished by determining the magnitude of the standard error of the monthly average daily values at the two sites for a specific radiation type and showing that the magnitude of the standard error is less than the inherent uncertainty involved in the measurement of the radiation intensity by the specific meter.

The standard absolute and relative errors of the mean and root-mean-square deviations can be determined by utilizing either

$$\sigma_{\mathrm{x(avg)}} \approx \sigma/(\mathrm{n}-1)^{0.5}, \tag{1}$$

$$\sigma_{\sigma} \approx \sigma/(2\mathrm{n}-1)^{0.5}, \tag{1a}$$

or

$$\sigma'_{\mathrm{x(avg)}} \approx 100\mathrm{C_v}/(\mathrm{n}-1)^{0.5}(\%), \tag{2}$$

$$\sigma'_{\sigma} \approx 100\mathrm{C_v}/(2\mathrm{n}-1)^{0.5}(\%), \tag{2a}$$

**Table 2.** Monthly average hourly and daily global radiation for Beer Sheva and Neve Zohar (Wm$^{-2}$)

| Month (days) | Site | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14–15 | 15–16 | 16–17 | 17–18 | 18–19 | Daily |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan (219) | BS | 0.0 | 4.3 | 80.1 | 221.6 | 368.7 | 456.9 | 483.3 | 473.4 | 393.1 | 280.8 | 155.6 | 38.5 | 0.1 | 0.0 | 2956.4 |
|  | NZ | 0.0 | 4.6 | 90.2 | 228.7 | 381.4 | 481.7 | 524.7 | 492.4 | 428.6 | 318.9 | 177.3 | 35.9 | 0.1 | 0.0 | 3164.5 |
| Feb (216) | BS | 0.0 | 16.1 | 129.0 | 302.1 | 456.0 | 564.5 | 597.7 | 568.1 | 506.4 | 388.8 | 246.4 | 94.2 | 6.0 | 0.0 | 3875.3 |
|  | NZ | 0.1 | 19.3 | 145.9 | 324.0 | 487.0 | 592.2 | 631.5 | 610.4 | 522.1 | 408.1 | 261.3 | 96.8 | 5.6 | 0.0 | 4104.3 |
| Mar (243) | BS | 1.7 | 63.7 | 221.8 | 411.2 | 574.4 | 667.7 | 720.0 | 711.6 | 626.8 | 501.3 | 336.8 | 162.9 | 26.0 | 0.0 | 5025.9 |
|  | NZ | 2.1 | 74.9 | 246.8 | 444.8 | 591.3 | 692.9 | 742.7 | 727.2 | 658.6 | 529.9 | 362.1 | 175.1 | 22.3 | 0.0 | 5270.7 |
| Apr (227) | BS | 24.5 | 153.5 | 341.4 | 537.4 | 692.6 | 800.2 | 841.0 | 805.8 | 724.2 | 588.4 | 414.7 | 223.7 | 58.2 | 0.5 | 6206.1 |
|  | NZ | 31.0 | 176.7 | 370.2 | 551.4 | 703.9 | 797.5 | 843.3 | 816.8 | 737.4 | 602.6 | 427.2 | 227.7 | 52.0 | 0.6 | 6338.3 |
| May (242) | BS | 65.4 | 230.2 | 440.3 | 647.9 | 808.6 | 910.0 | 944.5 | 920.0 | 822.8 | 678.3 | 498.3 | 296.3 | 105.7 | 6.8 | 7375.1 |
|  | NZ | 81.6 | 261.6 | 465.0 | 648.0 | 809.5 | 909.5 | 932.4 | 899.5 | 816.3 | 675.9 | 491.6 | 292.4 | 93.2 | 6.2 | 7382.7 |
| June (231) | BS | 81.5 | 259.5 | 468.3 | 677.3 | 844.0 | 955.4 | 998.7 | 968.8 | 877.7 | 740.6 | 561.5 | 354.9 | 149.8 | 19.2 | 7957.2 |
|  | NZ | 106.0 | 299.6 | 505.1 | 689.5 | 838.6 | 940.3 | 981.1 | 959.1 | 873.6 | 733.1 | 554.2 | 351.2 | 137.0 | 14.1 | 7982.5 |
| July (242) | BS | 56.7 | 211.6 | 416.7 | 635.0 | 807.4 | 925.4 | 971.6 | 947.2 | 866.3 | 733.6 | 553.9 | 348.4 | 146.6 | 18.2 | 7638.6 |
|  | NZ | 74.4 | 253.4 | 458.7 | 646.2 | 802.8 | 904.5 | 950.3 | 934.1 | 854.6 | 717.8 | 541.5 | 341.9 | 134.3 | 12.9 | 7627.4 |
| Aug (221) | BS | 31.0 | 170.1 | 372.1 | 587.5 | 766.9 | 891.7 | 942.0 | 912.6 | 819.3 | 679.6 | 495.6 | 286.4 | 94.1 | 4.4 | 7053.3 |
|  | NZ | 39.1 | 203.6 | 412.5 | 615.2 | 773.5 | 880.2 | 927.0 | 905.7 | 819.0 | 676.1 | 489.4 | 281.3 | 81.3 | 2.2 | 7106.1 |
| Sept (227) | BS | 13.2 | 135.1 | 333.8 | 535.2 | 702.0 | 816.3 | 849.8 | 815.9 | 715.8 | 564.1 | 371.9 | 168.4 | 25.6 | 0.0 | 6047.1 |
|  | NZ | 17.5 | 157.0 | 364.5 | 561.2 | 718.8 | 818.9 | 852.9 | 822.2 | 755.5 | 567.9 | 376.6 | 165.2 | 19.0 | 0.0 | 6197.2 |
| Oct (246) | BS | 2.5 | 85.0 | 257.8 | 443.4 | 583.8 | 675.6 | 698.4 | 648.2 | 539.5 | 393.7 | 222.3 | 62.8 | 1.1 | 0.0 | 4614.1 |
|  | NZ | 1.4 | 92.9 | 274.4 | 454.2 | 604.3 | 691.0 | 712.6 | 669.7 | 565.2 | 411.3 | 226.8 | 58.5 | 0.0 | 0.0 | 4762.3 |
| Nov (238) | BS | 0.0 | 32.4 | 165.3 | 329.9 | 468.2 | 549.2 | 580.7 | 530.8 | 432.3 | 288.1 | 129.1 | 16.6 | 0.0 | 0.0 | 3522.6 |
|  | NZ | 0.0 | 40.3 | 186.1 | 342.8 | 492.6 | 571.1 | 593.3 | 549.7 | 445.8 | 305.9 | 136.6 | 15.3 | 0.0 | 0.0 | 3679.5 |
| Dec (245) | BS | 0.0 | 8.3 | 96.1 | 232.5 | 355.1 | 441.8 | 476.6 | 456.1 | 381.1 | 253.8 | 115.1 | 14.8 | 0.0 | 0.0 | 2831.3 |
|  | NZ | 0.0 | 6.9 | 100.1 | 233.4 | 376.1 | 459.3 | 485.4 | 456.6 | 381.8 | 258.7 | 113.8 | 10.2 | 0.0 | 0.0 | 2882.3 |
| Annual average | BS | 23.0 | 114.2 | 276.9 | 463.4 | 619.0 | 721.2 | 758.7 | 729.9 | 642.1 | 507.6 | 341.8 | 172.3 | 51.1 | 4.1 | 5425.3 |
|  | NZ | 29.4 | 132.6 | 301.6 | 478.3 | 631.7 | 728.3 | 764.8 | 737.0 | 654.9 | 517.2 | 346.5 | 171.0 | 45.4 | 3.0 | 5541.5 |

**Table 3.** Monthly average hourly and daily UVB radiation for Beer Sheva and Neve Zohar (MED)

| Month (days) | Site | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14–15 | 15–16 | 16–17 | 17–18 | 18–19 | Daily |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan (172) | BS | 0.00 | 0.00 | 0.06 | 0.27 | 0.66 | 1.04 | 1.22 | 1.15 | 0.85 | 0.47 | 0.17 | 0.02 | 0.00 | 0.00 | 5.91 |
| | NZ | 0.00 | 0.00 | 0.07 | 0.27 | 0.61 | 0.96 | 1.15 | 1.08 | 0.83 | 0.48 | 0.19 | 0.04 | 0.00 | 0.00 | 5.68 |
| Feb (148) | BS | 0.00 | 0.01 | 0.12 | 0.46 | 1.00 | 1.57 | 1.84 | 1.74 | 1.37 | 0.84 | 0.37 | 0.08 | 0.01 | 0.00 | 9.41 |
| | NZ | 0.00 | 0.01 | 0.13 | 0.42 | 0.88 | 1.37 | 1.64 | 1.58 | 1.24 | 0.79 | 0.38 | 0.11 | 0.01 | 0.00 | 8.57 |
| Mar (231) | BS | 0.00 | 0.04 | 0.27 | 0.80 | 1.52 | 2.13 | 2.47 | 2.40 | 1.90 | 1.21 | 0.57 | 0.16 | 0.02 | 0.00 | 13.50 |
| | NZ | 0.00 | 0.05 | 0.26 | 0.72 | 1.32 | 1.87 | 2.18 | 2.12 | 1.74 | 1.15 | 0.58 | 0.19 | 0.03 | 0.00 | 12.20 |
| Apr (224) | BS | 0.01 | 0.15 | 0.56 | 1.30 | 2.15 | 2.85 | 3.17 | 2.95 | 2.38 | 1.58 | 0.80 | 0.26 | 0.04 | 0.00 | 18.20 |
| | NZ | 0.02 | 0.15 | 0.53 | 1.17 | 1.92 | 2.52 | 2.74 | 2.57 | 2.06 | 1.35 | 0.67 | 0.22 | 0.04 | 0.00 | 15.96 |
| May (241) | BS | 0.05 | 0.28 | 0.88 | 1.82 | 2.83 | 3.59 | 3.88 | 3.65 | 2.95 | 2.02 | 1.09 | 0.42 | 0.09 | 0.01 | 23.55 |
| | NZ | 0.05 | 0.28 | 0.78 | 1.55 | 2.37 | 3.00 | 3.23 | 3.02 | 2.44 | 1.63 | 0.85 | 0.32 | 0.07 | 0.00 | 19.58 |
| June (231) | BS | 0.06 | 0.35 | 1.00 | 2.01 | 3.09 | 3.93 | 4.27 | 4.04 | 3.34 | 2.39 | 1.37 | 0.57 | 0.14 | 0.01 | 26.58 |
| | NZ | 0.07 | 0.35 | 0.93 | 1.78 | 2.68 | 3.38 | 3.67 | 3.48 | 2.84 | 1.96 | 1.08 | 0.45 | 0.12 | 0.01 | 22.80 |
| July (241) | BS | 0.04 | 0.28 | 0.85 | 1.82 | 2.90 | 3.76 | 4.14 | 3.94 | 3.31 | 2.38 | 1.37 | 0.57 | 0.14 | 0.01 | 25.51 |
| | NZ | 0.05 | 0.28 | 0.79 | 1.57 | 2.44 | 3.13 | 3.44 | 3.30 | 2.73 | 1.90 | 1.05 | 0.44 | 0.12 | 0.01 | 21.25 |
| Aug (205) | BS | 0.02 | 0.20 | 0.70 | 1.59 | 2.63 | 3.50 | 3.88 | 3.66 | 2.98 | 2.06 | 1.12 | 0.42 | 0.08 | 0.00 | 22.83 |
| | NZ | 0.02 | 0.20 | 0.65 | 1.39 | 2.24 | 2.92 | 3.23 | 3.07 | 2.48 | 1.66 | 0.86 | 0.31 | 0.06 | 0.00 | 19.09 |
| Sept (205) | BS | 0.01 | 0.13 | 0.55 | 1.33 | 2.26 | 3.01 | 3.29 | 3.03 | 2.34 | 1.47 | 0.68 | 0.19 | 0.02 | 0.00 | 18.30 |
| | NZ | 0.01 | 0.13 | 0.51 | 1.17 | 1.93 | 2.53 | 2.76 | 2.54 | 1.94 | 1.18 | 0.52 | 0.14 | 0.01 | 0.00 | 15.37 |
| Oct (164) | BS | 0.00 | 0.07 | 0.37 | 0.95 | 1.66 | 2.22 | 2.39 | 2.10 | 1.49 | 0.82 | 0.31 | 0.05 | 0.00 | 0.00 | 12.42 |
| | NZ | 0.00 | 0.07 | 0.33 | 0.82 | 1.41 | 1.87 | 2.00 | 1.77 | 1.27 | 0.69 | 0.25 | 0.04 | 0.00 | 0.00 | 10.52 |
| Nov (170) | BS | 0.00 | 0.02 | 0.19 | 0.61 | 1.10 | 1.53 | 1.69 | 1.48 | 1.07 | 0.54 | 0.16 | 0.01 | 0.00 | 0.00 | 8.40 |
| | NZ | 0.00 | 0.03 | 0.18 | 0.51 | 0.95 | 1.29 | 1.38 | 1.20 | 0.81 | 0.41 | 0.12 | 0.01 | 0.00 | 0.00 | 6.89 |
| Dec (133) | BS | 0.00 | 0.01 | 0.08 | 0.30 | 0.66 | 0.98 | 1.14 | 1.04 | 0.75 | 0.36 | 0.11 | 0.01 | 0.00 | 0.00 | 5.44 |
| | NZ | 0.00 | 0.00 | 0.08 | 0.28 | 0.60 | 0.89 | 1.01 | 0.91 | 0.64 | 0.32 | 0.10 | 0.01 | 0.00 | 0.00 | 4.84 |
| Annual average | BS | 0.02 | 0.13 | 0.47 | 1.11 | 1.87 | 2.51 | 2.78 | 2.60 | 2.06 | 1.35 | 0.68 | 0.23 | 0.04 | 0.00 | 15.84 |
| | NZ | 0.02 | 0.13 | 0.44 | 0.97 | 1.61 | 2.14 | 2.37 | 2.22 | 1.75 | 1.13 | 0.55 | 0.19 | 0.04 | 0.00 | 13.56 |

**Table 4.** Monthly average hourly and daily UVA radiation for Beer Sheva and Neve Zohar ($Wm^{-2}$)

| Month (days) | Site | 5–6 | 6–7 | 7–8 | 8–9 | 9–10 | 10–11 | 11–12 | 12–13 | 13–14 | 14–15 | 15–16 | 16–17 | 17–18 | 18–19 | Daily |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan (172) | BS | 0.00 | 0.30 | 3.74 | 9.98 | 17.09 | 21.89 | 23.55 | 22.63 | 18.86 | 13.36 | 7.34 | 2.18 | 0.06 | 0.00 | 140.98 |
| | NZ | 0.00 | 0.34 | 3.90 | 9.79 | 16.50 | 21.59 | 23.85 | 22.42 | 19.25 | 13.76 | 7.44 | 2.08 | 0.03 | 0.00 | 140.95 |
| Feb (132) | BS | 0.00 | 0.99 | 6.10 | 13.94 | 21.79 | 28.40 | 30.62 | 29.13 | 25.49 | 19.22 | 11.88 | 4.88 | 0.55 | 0.00 | 192.99 |
| | NZ | 0.00 | 1.03 | 5.93 | 13.35 | 20.91 | 27.18 | 29.70 | 28.63 | 24.63 | 18.83 | 11.72 | 1.84 | 0.60 | 0.01 | 184.36 |
| Mar (209) | BS | 0.18 | 3.16 | 10.05 | 19.24 | 28.04 | 33.36 | 36.47 | 36.01 | 31.68 | 24.81 | 16.24 | 7.77 | 1.66 | 0.01 | 248.68 |
| | NZ | 0.18 | 3.41 | 10.46 | 19.72 | 27.62 | 33.68 | 36.41 | 35.25 | 31.33 | 24.29 | 15.64 | 7.31 | 1.44 | 0.00 | 243.33 |
| Apr (197) | BS | 1.38 | 6.95 | 15.66 | 25.77 | 34.47 | 40.62 | 43.27 | 41.45 | 36.98 | 29.35 | 20.06 | 10.55 | 3.17 | 0.13 | 309.81 |
| | NZ | 1.51 | 7.27 | 15.96 | 25.29 | 33.58 | 39.20 | 42.00 | 40.64 | 35.94 | 28.21 | 18.81 | 9.48 | 2.74 | 0.08 | 300.71 |
| May (208) | BS | 3.41 | 10.60 | 20.75 | 31.80 | 41.00 | 47.03 | 49.21 | 47.91 | 42.28 | 34.15 | 24.32 | 14.01 | 5.35 | 0.62 | 372.44 |
| | NZ | 3.57 | 10.93 | 20.67 | 30.65 | 39.08 | 44.88 | 46.77 | 45.12 | 40.06 | 32.02 | 21.99 | 12.27 | 4.59 | 0.47 | 353.07 |
| June (215) | BS | 4.17 | 11.98 | 22.30 | 33.64 | 43.25 | 49.91 | 52.91 | 50.95 | 45.83 | 38.08 | 28.00 | 17.02 | 7.44 | 1.37 | 406.85 |
| | NZ | 4.50 | 12.52 | 22.82 | 33.13 | 41.92 | 47.98 | 50.44 | 49.02 | 43.86 | 35.59 | 25.43 | 15.05 | 6.44 | 1.14 | 389.84 |
| July (241) | BS | 3.09 | 9.98 | 19.76 | 31.26 | 41.08 | 48.01 | 50.84 | 49.54 | 44.96 | 37.38 | 27.43 | 16.65 | 7.23 | 1.30 | 388.51 |
| | NZ | 3.34 | 10.57 | 20.33 | 30.49 | 39.37 | 45.45 | 48.21 | 47.18 | 42.37 | 34.39 | 24.49 | 14.56 | 6.27 | 1.08 | 368.10 |
| Aug (223) | BS | 1.80 | 8.07 | 17.51 | 28.67 | 38.80 | 46.05 | 49.05 | 47.53 | 42.18 | 34.32 | 24.28 | 13.63 | 4.89 | 0.43 | 357.21 |
| | NZ | 1.99 | 8.58 | 18.16 | 28.82 | 38.95 | 44.30 | 46.97 | 45.71 | 40.47 | 32.12 | 21.88 | 11.88 | 4.19 | 0.33 | 344.35 |
| Sept (205) | BS | 0.85 | 6.32 | 15.37 | 25.87 | 35.09 | 41.64 | 43.87 | 41.99 | 36.32 | 27.95 | 17.88 | 8.15 | 1.60 | 0.02 | 302.92 |
| | NZ | 0.96 | 6.54 | 15.61 | 25.69 | 34.43 | 40.26 | 42.37 | 40.54 | 34.79 | 26.09 | 16.15 | 7.15 | 1.31 | 0.00 | 291.89 |
| Oct (248) | BS | 0.24 | 3.95 | 11.60 | 20.85 | 28.76 | 34.08 | 35.60 | 32.90 | 26.95 | 19.11 | 10.61 | 3.35 | 0.16 | 0.00 | 228.16 |
| | NZ | 0.25 | 3.95 | 11.28 | 19.76 | 27.51 | 32.43 | 33.85 | 31.60 | 25.94 | 18.07 | 9.64 | 2.94 | 0.11 | 0.00 | 217.33 |
| Nov (231) | BS | 0.02 | 1.80 | 7.64 | 15.28 | 22.46 | 26.90 | 28.71 | 26.25 | 21.06 | 13.74 | 6.44 | 1.20 | 0.00 | 0.00 | 171.50 |
| | NZ | 0.01 | 1.87 | 7.60 | 14.72 | 21.73 | 25.94 | 27.18 | 25.07 | 19.85 | 13.03 | 6.01 | 1.05 | 0.00 | 0.00 | 164.06 |
| Dec (181) | BS | 0.01 | 0.71 | 4.65 | 10.60 | 16.57 | 21.01 | 22.76 | 21.67 | 18.01 | 11.91 | 5.86 | 1.26 | 0.07 | 0.01 | 135.10 |
| | NZ | 0.00 | 0.57 | 4.46 | 10.21 | 16.44 | 20.69 | 22.15 | 20.94 | 17.04 | 11.21 | 5.29 | 0.87 | 0.00 | 0.00 | 129.87 |
| Annual average | BS | 1.26 | 5.40 | 12.93 | 22.24 | 30.70 | 36.58 | 38.91 | 37.33 | 32.55 | 25.28 | 16.70 | 8.39 | 2.68 | 0.32 | 271.26 |
| | NZ | 1.36 | 5.63 | 13.10 | 21.80 | 29.84 | 35.30 | 37.49 | 36.01 | 31.29 | 23.97 | 15.37 | 7.21 | 2.31 | 0.26 | 260.94 |

**Table 5.** Monthly average daily global, UVB and UVA radiation standard deviation values for Beer Sheva and Neve Zohar

| Month | Global radiation ($Wm^{-2}$) | | UVB radiation (MED) | | UVA radiation ($Wm^{-2}$) | |
|---|---|---|---|---|---|---|
| | Beer Sheva | Neve Zohar | Beer Sheva | Neve Zohar | Beer Sheva | Neve Zohar |
| Jan | 811.5 | 801.0 | 1.75 | 1.53 | 35.74 | 32.26 |
| Feb | 1020.0 | 1109.6 | 2.92 | 2.68 | 50.98 | 52.58 |
| Mar | 1169.3 | 1167.2 | 3.85 | 3.26 | 57.28 | 54.37 |
| April | 1237.0 | 1264.7 | 4.49 | 4.07 | 59.91 | 57.84 |
| May | 882.9 | 922.8 | 3.68 | 3.44 | 49.21 | 48.16 |
| June | 355.6 | 292.4 | 2.13 | 2.05 | 18.08 | 18.15 |
| July | 408.6 | 400.6 | 2.13 | 2.43 | 23.59 | 22.46 |
| Aug | 361.9 | 296.6 | 2.05 | 2.20 | 19.71 | 17.86 |
| Sept | 458.6 | 420.2 | 1.92 | 1.86 | 24.72 | 25.30 |
| Oct | 699.8 | 671.6 | 2.35 | 2.03 | 34.57 | 30.91 |
| Nov | 623.3 | 615.9 | 1.60 | 1.33 | 28.26 | 25.94 |
| Dec | 707.6 | 744.5 | 1.34 | 1.19 | 31.38 | 28.62 |

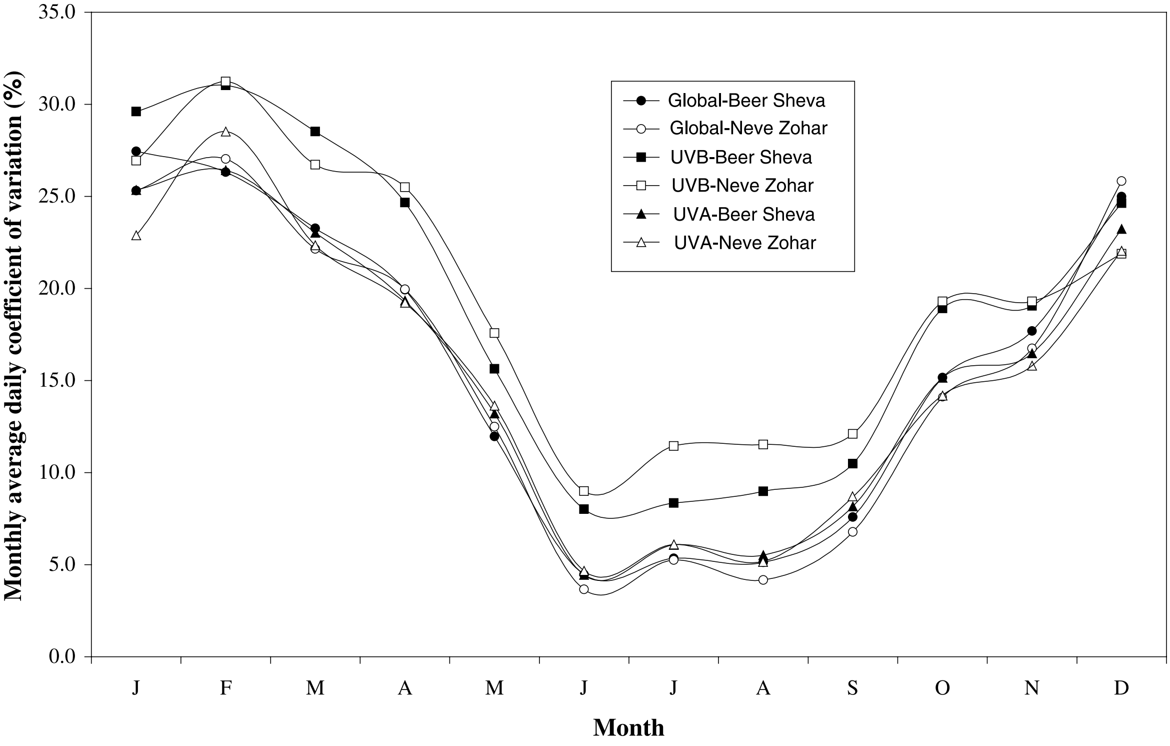

**Fig. 1.** Monthly average daily coefficient of variation $C_v$ for global, UVB and UVA radiation for Beer Sheva and Neve Zohar

where $\sigma$ is the standard deviation, n is the number of observation in the set and $C_v$ is the coefficient of variation. The application of the above sets of equations, i.e. either Eqs. (1 and 1a) or Eqs. (2 and 2a), requires that the observations are independent, if not they are subject to the more stringent condition that they exhibit a normal distribution (cf., Kendall and Stuart, 1962; Brooks and Carruthers, 1953).

The radiation measurements under discussion in this analysis do not the fulfill the abovementioned conditions, viz., that the observations be either independent or normally distributed, consequently, neither set of equations can be applied.

The error estimation of the mean and root-mean-square deviations of a set of dependent observations have been reported upon by numerous investigators, e.g. Bayley and Hammersley (1946), Brooks and Carruthers (1953), Slutzky (1960) and Marchenko (1965). The formulae developed in these studies for a set of dependent observations are as follows:

Brooks and Carruthers (1953)

$$\sigma_{\mathrm{x(avg)}} = \sigma[\{1 + 2\mathrm{r}(1 - (1 - \mathrm{r}^{\mathrm{n}})/ (\mathrm{n}(1 - \mathrm{r}))/(1 - \mathrm{r}))\}/\mathrm{n}]^{0.5}, \tag{3}$$

Rozgdestvenskii and Chebotaryev (1974)

$$\sigma_{\mathrm{x(avg)}} = \sigma[\{1 + 2\mathrm{r}(\mathrm{n} - (1 - \mathrm{r}^{\mathrm{n}})/(1 - \mathrm{r}))/ ((1 - \mathrm{r})\mathrm{n})\}/\{1 + 2\mathrm{r}(\mathrm{n} - (1 - \mathrm{r}^{\mathrm{n}})/ (1 - \mathrm{r}))/((1 - \mathrm{r})(1 - \mathrm{n})\mathrm{n})\}/\mathrm{n}\}]^{0.5}, \tag{4}$$

and an approximate form

$$\sigma_{\mathrm{x(avg)}} \approx \sigma[(1 + \mathrm{r})/(1 - \mathrm{r})]^{0.5}/(\mathrm{n} - 1)^{0.5}. \tag{5}$$

It is apparent that Eq. (5) is the least complex of the above three formulas.

The root-mean-square deviation error is then determined from the following equation

$$\sigma_{\sigma} \approx \sigma[(1 + \mathrm{r}^2)/(1 - \mathrm{r}^2)]^{0.5}/(2\mathrm{n} - 1)^{0.5}. \tag{6}$$

In the above relationships the variable r ($0 \leq \mathrm{r} < 1$) is the coefficient of autocorrelation between adjacent terms of the respective series. It should be noted, that in the case of a series of independent observation, $\mathrm{r} = 0$, Eqs. (3–5) reduce to Eq. (1) and Eq. (6) reduces to Eq. (1a).

We have observed that the differences in the respective magnitudes of the values for the standard error of the average value calculated by utilizing Eqs. (3–5) were negligible for r values in the range of 0.20 to 0.95, i.e. the differences between the values calculated manifest themselves only for $\mathrm{r} \geq 0.95$.

The coefficient of the autocorrelation function for the average daily values for particular months must be determined prior to calculating their standard error. It is calculated as the average autocorrelation function, $\mathrm{r}_{\mathrm{kl}}$, for a particular month for all the years in the database and is given by

$$\mathrm{r}_{\mathrm{kl(avg)}} = \mathrm{K}_{\mathrm{kl}}/[\sigma(\mathrm{t_k}) \cdot \sigma(\mathrm{t_l})]. \tag{7}$$

The autocorrelation function, $\mathrm{K}_{\mathrm{kl}}$, which characterizes the inter-dependence of the terms within a set of observations, for a particular month and radiation type is given by

$$\mathrm{K}_{\mathrm{kl}} = \sum_{\mathrm{i}=1}^{\mathrm{n}} [\mathrm{x_i}(\mathrm{t_k}) - \mathrm{x_{av}}(\mathrm{t_k})] \cdot [\mathrm{x_i}(\mathrm{t_l}) - \mathrm{x_{av}}(\mathrm{t_l})]/(\mathrm{n} - 1), \tag{8}$$

where k, l refer to the years comprising the database. The corresponding daily radiation intensities during the month for years k and l are given by $\mathrm{x_i}(\mathrm{t_k})$ and $\mathrm{x_i}(\mathrm{t_l})$, where i is the day of the month and t is the year. Similarly, the corresponding monthly average radiation intensities for years k and l are given by $\mathrm{x_{av}}(\mathrm{t_k})$ and $\mathrm{x_{av}}(\mathrm{t_l})$, respectively.

The results of this analysis are reported in Table 6 for the three radiation types at both sites. It is observed that the magnitude of the coefficient of the autocorrelation function is $\mathrm{r} \geq 0.20$ in all cases and that no value of $\mathrm{r} \geq 0.94$. Consequently, the use of the Eq. (5) is justified.

The standard errors ($\sigma_{\mathrm{x(avg)}}$) reported as a percent of the monthly average daily values for all radiation types at both sites are listed Table 7. It is observed that in the case of the global radiation measurements all standard error values are less than 3%. In fact, during the months April through November the standard error values are below

**Table 6.** Coefficients of the autocorrelation function of daily global, UVB and UVA radiation intensities values for Beer Sheva and Neve Zohar

| Radiation type | Site | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global | BS | 0.27 | 0.35 | 0.44 | 0.31 | 0.37 | 0.49 | 0.57 | 0.39 | 0.35 | 0.38 | 0.25 | 0.25 |
| | NZ | 0.26 | 0.35 | 0.36 | 0.21 | 0.39 | 0.38 | 0.7 | 0.49 | 0.43 | 0.54 | 0.30 | 0.32 |
| UVB | BS | 0.38 | 0.39 | 0.62 | 0.44 | 0.47 | 0.76 | 0.78 | 0.8 | 0.41 | 0.66 | 0.64 | 0.41 |
| | NZ | 0.44 | 0.37 | 0.52 | 0.40 | 0.63 | 0.87 | 0.89 | 0.94 | 0.74 | 0.65 | 0.44 | 0.44 |
| UVA | BS | 0.22 | 0.32 | 0.43 | 0.36 | 0.37 | 0.52 | 0.56 | 0.42 | 0.36 | 0.47 | 0.32 | 0.33 |
| | NZ | 0.19 | 0.26 | 0.34 | 0.23 | 0.38 | 0.58 | 0.71 | 0.56 | 0.55 | 0.45 | 0.31 | 0.32 |

**Table 7.** Standard errors (%) of monthly average daily global, UVB and UVA radiation intensities values for Beer Sheva and Neve Zohar

| Radiation type | Site | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global | BS | 2.46 | 2.60 | 2.39 | 1.85 | 1.14 | 0.51 | 0.65 | 0.52 | 0.73 | 1.45 | 1.48 | 2.05 |
| | NZ | 2.25 | 2.69 | 2.07 | 1.64 | 1.21 | 0.36 | 0.80 | 0.48 | 0.72 | 1.65 | 1.48 | 2.30 |
| UVB | BS | 3.37 | 3.86 | 3.86 | 2.65 | 1.67 | 1.43 | 1.53 | 1.14 | 1.13 | 2.80 | 3.30 | 3.32 |
| | NZ | 3.30 | 3.81 | 3.12 | 2.62 | 2.37 | 2.24 | 3.05 | 4.49 | 2.18 | 2.80 | 2.35 | 3.44 |
| UVA | BS | 2.41 | 3.20 | 2.52 | 2.01 | 1.35 | 0.53 | 0.78 | 0.58 | 0.83 | 1.61 | 1.51 | 2.43 |
| | NZ | 2.12 | 3.18 | 2.17 | 1.73 | 1.42 | 0.62 | 0.89 | 0.66 | 1.13 | 1.46 | 1.43 | 2.28 |

**Table 8.** Standard error (%) of monthly average daily standard deviation of the global, UVB and UVA radiation intensities values for Beer Sheva and Neve Zohar

| Radiation type | Site | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global | BS | 2.01 | 2.05 | 1.81 | 1.46 | 0.89 | 0.38 | 0.48 | 0.40 | 0.57 | 1.12 | 1.22 | 1.69 |
| | NZ | 1.84 | 2.11 | 1.62 | 1.39 | 0.94 | 0.28 | 0.57 | 0.36 | 0.54 | 1.21 | 1.19 | 1.83 |
| UVB | BS | 2.61 | 2.98 | 2.80 | 2.01 | 1.26 | 1.02 | 1.09 | 1.31 | 0.87 | 2.02 | 2.39 | 2.55 |
| | NZ | 2.51 | 2.96 | 2.31 | 2.02 | 1.72 | 1.59 | 2.16 | 3.17 | 1.56 | 2.03 | 1.78 | 2.61 |
| UVA | BS | 2.02 | 2.55 | 1.92 | 1.57 | 1.05 | 0.40 | 0.57 | 0.44 | 0.64 | 1.21 | 1.20 | 1.93 |
| | NZ | 1.81 | 2.61 | 1.71 | 1.44 | 1.10 | 0.46 | 0.64 | 0.48 | 0.83 | 1.11 | 1.15 | 1.81 |

2%. The maximum standard error occurs in February, i.e. it is 2.60 and 2.69% for Beer Sheva and Neve Zohar, respectively. The UVB and UVA measurements exhibit somewhat greater standard error values, nevertheless, only a single value exceeds 4%, viz., the maximum standard error calculated is 4.49% for the UVB radiation at Beer Sheva during the month of August. This is not unanticipated in view of the inherent lower accuracy of these instruments.

The standard error, reported as a percentage, of the monthly average daily standard deviation values ($\sigma_\sigma$) has also been determined and is listed in Table 8. The maximum value calculated is for the UVB radiation for February at Beer Sheva, 2.98%.

The results of the analysis of the standard errors justify the inter-comparison of the monthly average daily values for all radiation types at the two sites, since the standard errors are less than the inherent measurement error for all instruments.

## 4. Discussion

The results of the statistical analysis performed on the six databases utilized in this study justify the inter-comparison of the corresponding monthly average values measured at both sites. The two sites involved in this study are located at essentially the same latitude and differ very little in longitude, i.e. they are approximately 65 km distant from each other with Beer Sheva located west of Neve Zohar. Beer Sheva is situated in the northern fringe of the Negev desert, whereas Neve Zohar is located in the Judean desert on the western shore of the Dead Sea. The major difference between the two sites is the ~700 m difference in altitude. It is apparent from Fig. 1 that the behavior of a particular radiation type with regard to the magnitude and monthly variation of the average $C_v$ are similar at both sites. It is also observed that the global and UVA radiation exhibit very similar behavior with regard to the $C_v$. The similarity in behavior between the global and UVA radiation has been reported upon previously with regard to regression correlations between their radiation intensities, c.f. Kudish and Evseev (2000). The monthly average $C_v$ values for the UVB radiation exhibit higher magnitudes throughout the year, with the exception of January for Neve Zohar and December for both sites. The relatively higher magnitude of the monthly average $C_v$ values for the UVB

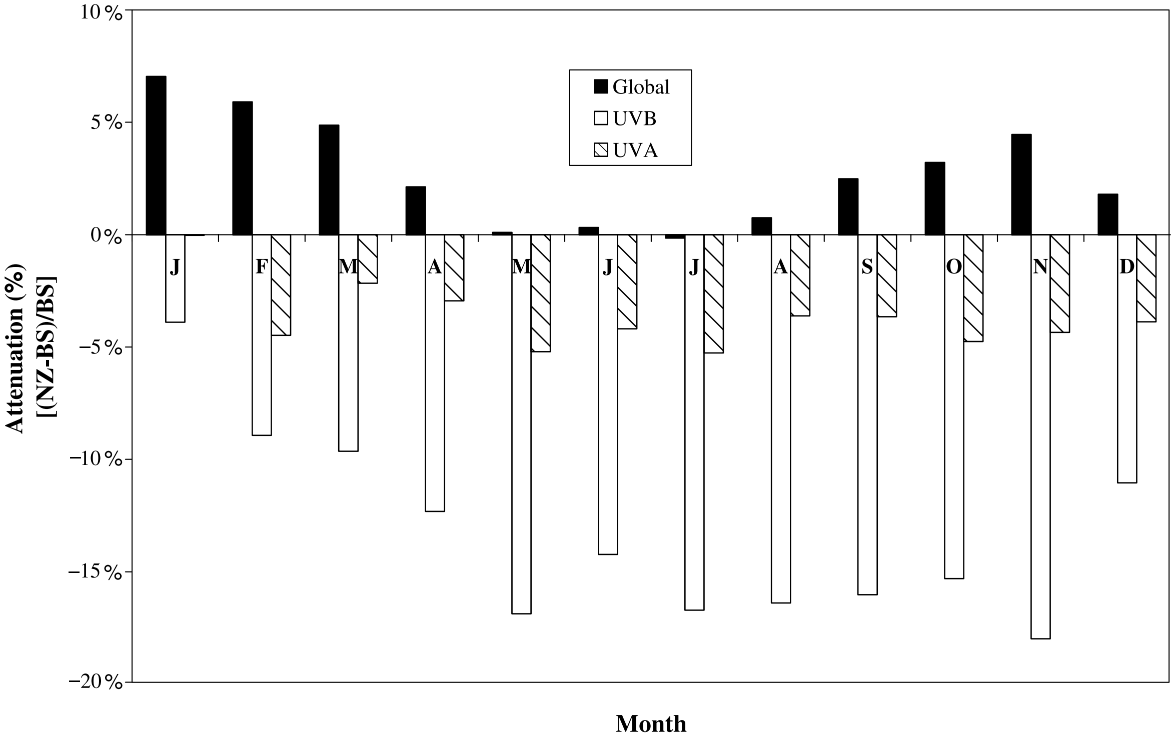

**Fig. 2.** Attenuation of global, UVB and UVA radiation intensities for Beer Sheva and Neve Zohar

radiation at both sites may be a result of the enhanced sensitivity of the UVB radiation intensity to attenuation by scattering phenomena, which is influenced by local climatic conditions, c.f. following discussion.

The monthly average attenuations for the three radiation types at both sites were determined in order to facilitate inter-comparisons. The attenuation, relative to that measured at Beer Sheva, is defined as

$$\%\,\text{Attenuation} = (X_{\text{Neve Zohar}} - X_{\text{Beer Sheva}})100/X_{\text{Beer Sheva}} \qquad (9)$$

where X is the radiation type, i.e. global, UVB or UVA. The results of this analysis are presented in Fig. 2. It is observed that the magnitudes of the global radiation intensities at both sites are similar from May through August and differ by up to 7% for September to April. The observation that the global radiation intensity is greater at Neve Zohar during the remaining months is due to differences in local climate conditions, e.g. Beer Sheva exhibits a higher degree of cloud cover relative to the Dead Sea basin and its mean annual rainfall is approximately five times greater than in the Dead Sea basin (Bitan and Rubin, 2000).

The difference in attenuation of UVB radiation between the two sites is a result of increased scattering in this spectral range, as Rayleigh, water molecules and aerosol scattering follow a power law with $\lambda^{-n}$ ($n = 4$ for Rayleigh, $n \sim 2$ for water molecules, $n \sim 0.75$ for aerosol scattering, cf., Moon (1974)). Consequently, the attenuation of the UVA radiation intensities is smaller than that for the UVB radiation for the sites. The minimum attenuation for both UVB and UVA radiation occurs during the month of January, which is the month exhibiting the greatest positive attenuation for the global radiation, i.e. the global radiation at Neve Zohar is 7% greater than that at Beer Sheva. We have previously reported upon the attenuation of the UVB and UVA radiation intensities at these two sites but the database utilized was much narrower, viz., it consisted of less than 2.5 years of measurements (Kudish at al., 1997). In addition, the present analysis also includes the global radiation and a more in-depth statistical analysis.

It is apparent from Tables 2–4 that both the monthly average hourly and daily radiation intensity values vary significantly throughout the year for all radiation types. The maximum midday, i.e. 11–12, and daily values occur in June, whereas the corresponding minimum values occur in December. The ratio of the maximum to minimum at midday is 2.1 (2.0), 3.8 (3.6) and 2.4 (2.3) at Beer Sheva (Neve Zohar) for global, UVB and UVA, respectively. The ratio for the daily values is 2.8 (2.8), 4.9 (4.7) and 3 (3) at Beer Sheva (Neve Zohar) for global, UVB and UVA, respectively. The magnitude of the range of monthly average values is similar at both sites and the range increases in the following order: global, UVA and UVB. The variation in the monthly average values is a function of the optical path length of the solar radiation and the UVB is most affected by this parameter.

It is of interest to compare the monthly average daily global radiation intensity values for Beer Sheva as determined from the database utilized in this study, i.e. from January 1995 through December 2002, to a much larger database available for Beer Sheva. The global radiation in Beer Sheva has been monitored by the Solar Energy Laboratory's meteorological station at its present location since January 1982. The monthly average daily global radiation values as determined from databases consisting of the year intervals 1982–1994, 1995–2002 and 1982–2002 are shown in Fig. 3, viz., the time interval prior to the database utilized in the present study, 1995–2002, and the overall, extant, database for this site. It is observed that the monthly values as determined from the database used in this study, 1995–2002, are representative for this site, viz., they are in very close agreement with those determined from the very much larger database consisting of 21 years of continuous measurements and for the database consisting of the 13 years prior to this study. It is not possible to perform this analysis for the UVB and UVA radiation, since the present database consists of all existing data.

The same type of analysis cannot be performed for the monthly average daily global radiation intensity values for Neve Zohar, since the database utilized in this study consists of all existing measurements at this site. Nevertheless, there exist a number of databases for the global radiation measured at other locations in the Dead Sea basin. Ashbel (1969) measured global radiation at

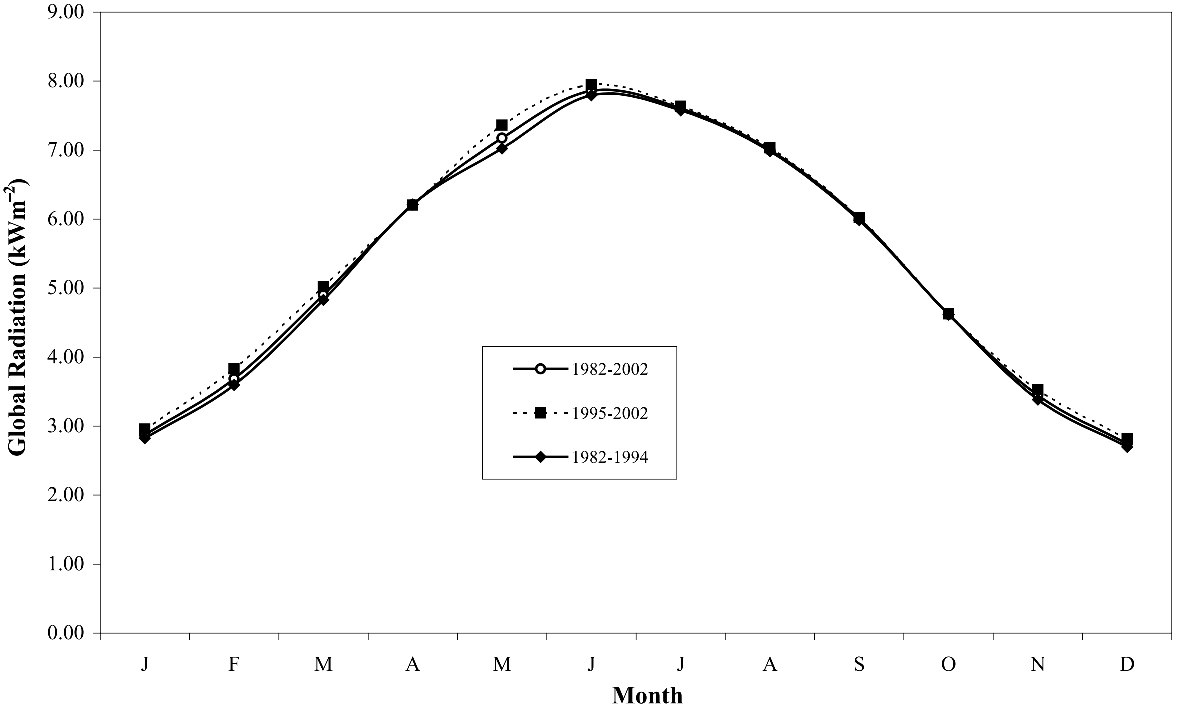

**Fig. 3.** Monthly average daily global radiation for Beer Sheva as determined from 1982–1994, 1995–2002 and 1982–2002 databases

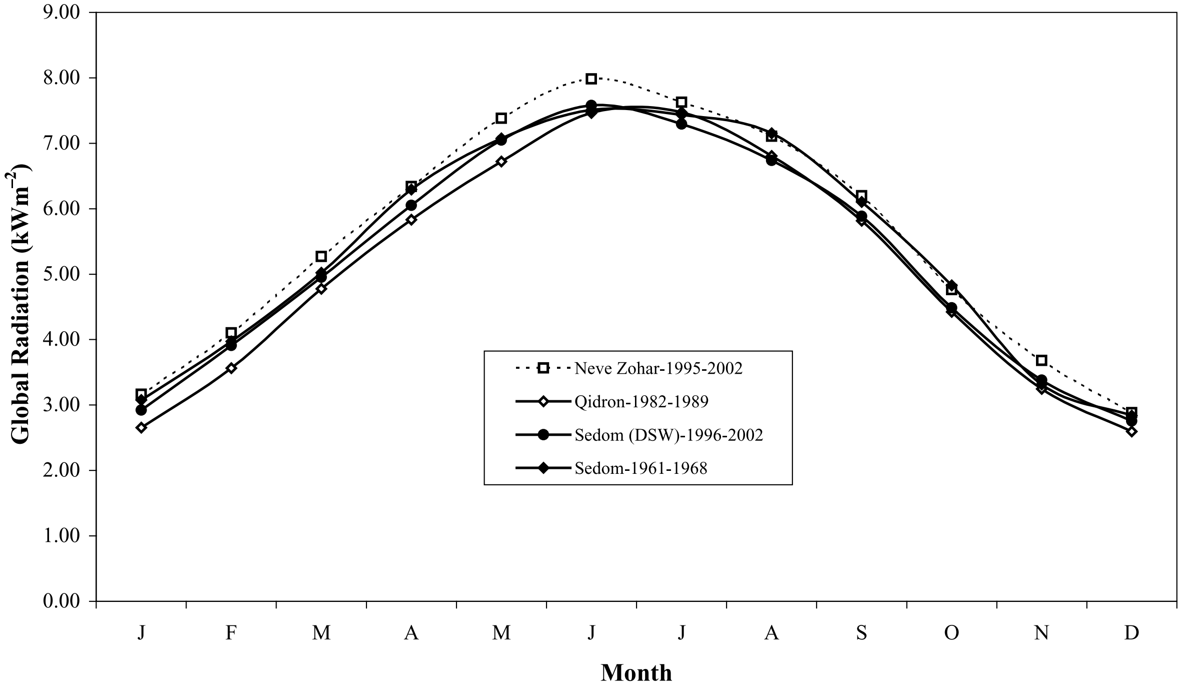

**Fig. 4.** Monthly average daily global radiation for the Dead Sea basin as measured at Neve Zohar, Quidron Dead Sea Works and Sedom

Sedom (31°41′N, 35°15′E and −392 m, m.s.l.) located on the western shore of the Dead Sea and Stanhill and Ianetz (1997) reported on the measurement of global radiation at Quidron located on the northern shore of the Dead Sea (31°40′N, 35°27′E and −390 m, m.s.l.). In addition, global radiation is also being monitored at Dead Sea Works (DSW), which is located in Sedom (31°04′N, 35°24′E and −395 m, m.s.l.). The monthly average daily values measured at Neve Zohar, Quidron, DSW and Sedom during the year intervals 1995–2002, 1982–1989, 1996–2002 and 1961–1968, respectively, are shown in Fig. 4. It is apparent from Fig. 4 that the level of agreement between the different sites is less than in the case of Beer Sheva. This is a result of the fact that the data were measured at three different sites by three different instruments and is therefore not unexpected. The observation that the monthly average daily values for DSW are lower than the corresponding values for Neve Zohar measured during essentially the same time interval may be caused by the location of the meter at the DSW plant adjacent to the evaporation ponds, viz., the DSW harvest the minerals from the salts in the Dead Sea utilizing evaporation ponds and the salts in the air may coat the meter.

It is also of interest to determine the average monthly maximum global, UVB and UVA radiation intensities at the two sites. These values are determined from the maximum daily values recorded for a particular month for each year within the database. Consequently, the maximum values for a particular month are independent and Eqs. (1 and 1a) can be applied to determine the standard error of the average. The standard error of the average monthly values was found to be for all cases less than the inherent measurement error of the corresponding instrument. The average monthly maximum global, UVB and UVA radiation intensities are shown in Figs. 5–7, respectively. The standard errors of the average maximum values are shown as error bars in the figures. The figures show that the trends of the magnitude of the maximum values are similar irrespective of site or radiation type. The relative magnitude of the average monthly maximum values for a particular radiation type at the two sites reflects the relative magnitude of the monthly average daily radiation at the two sites, viz., almost identical for global radiation,

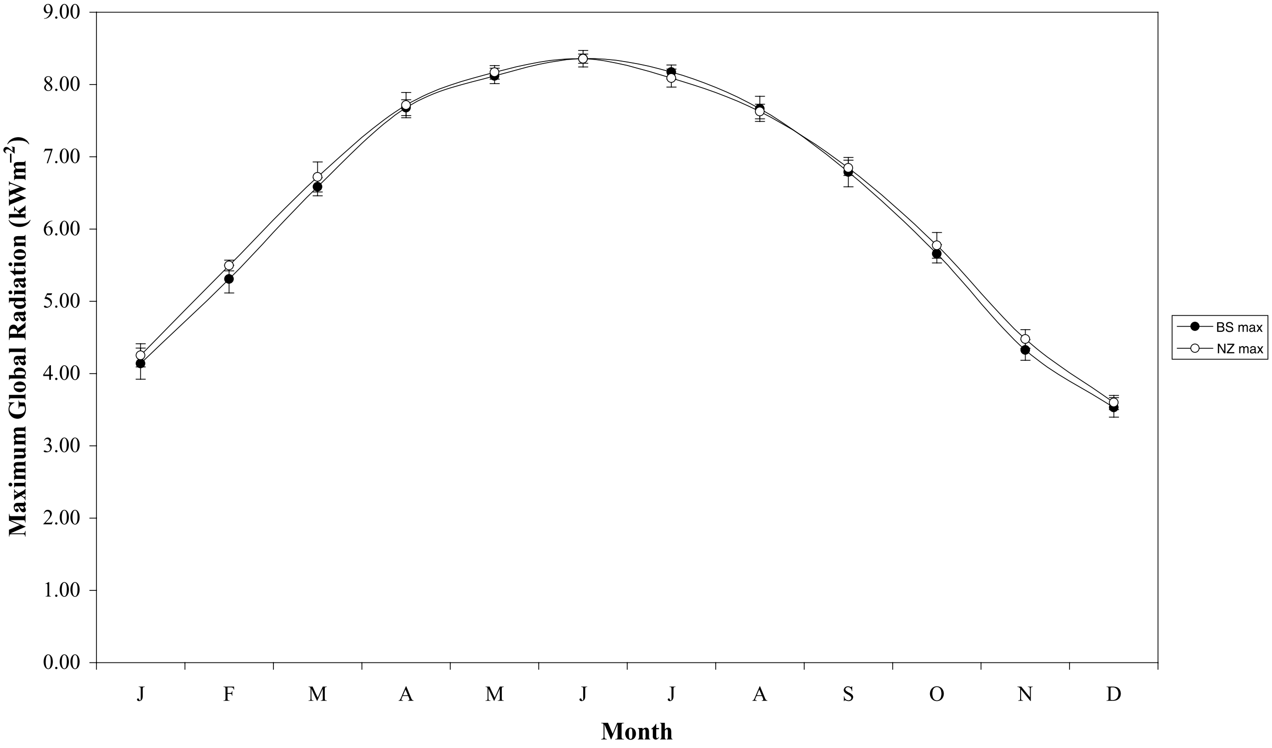

**Fig. 5.** Average monthly maximum global radiation for Beer Sheva and Neve Zohar

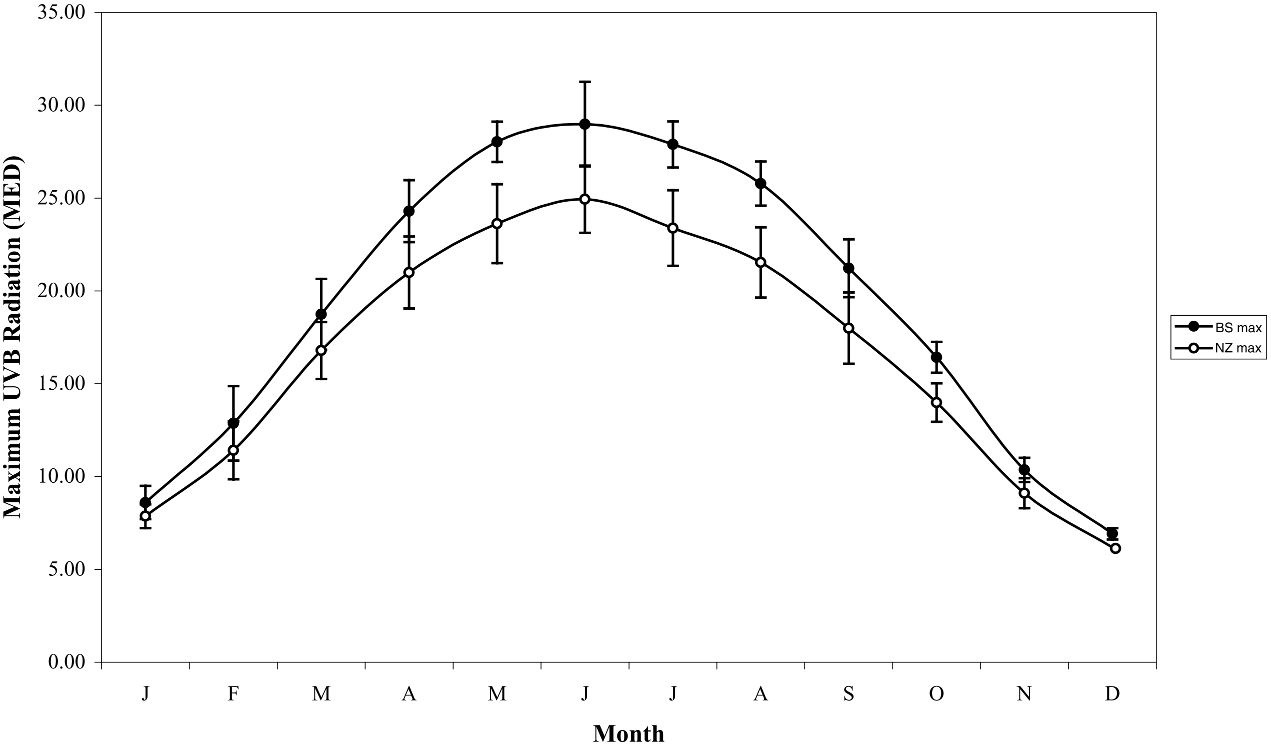

**Fig. 6.** Average monthly maximum UVB radiation for Beer Sheva and Neve Zohar

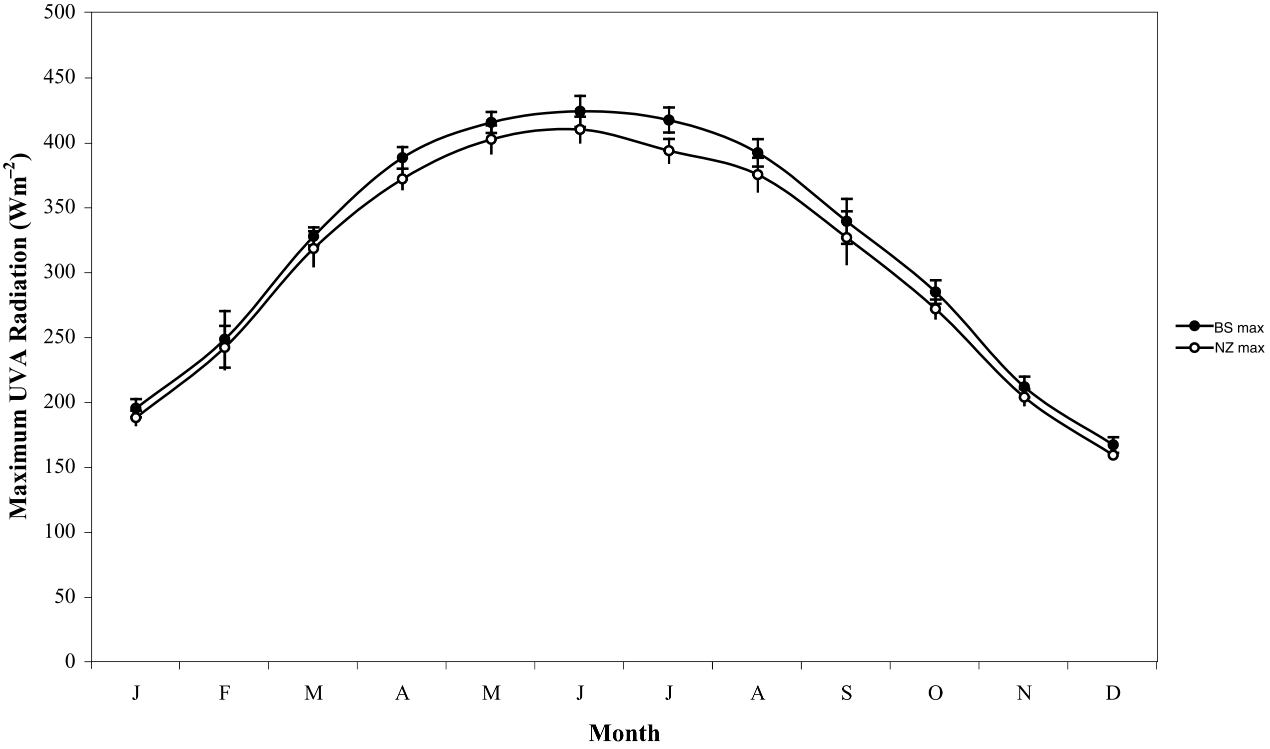

**Fig. 7.** Average monthly maximum UVA radiation for Beer Sheva and Neve Zohar

relatively close for UVA radiation and most dissimilar for the UVB radiation.

## 5. Conclusions

The global, UVB and UVA radiation intensities measured at two sites in Israel during the time interval of 1995–2002 have been analyzed in detail. Despite the proximity of the two meteorological stations, viz., Beer Sheva being ca. 65 km west of Neve Zohar, an inter-comparison of the corresponding radiation intensities is of interest due to the approximately 700 m difference in altitude between the sites. In addition, the Neve Zohar site is of interest due to its location in the Dead Sea basin, the lowest terrestrial point on earth. The results of this analysis can be summarized as follows:

- The monthly average hourly and daily radiation intensities have been shown to be representative of the two sites, viz., the standard errors are less than the inherent measurement error for all instruments.
- The attenuation of the radiation intensity by scattering phenomena is a function of the optical path length and is proportional to $\lambda^{-n}$. Consequently, the attenuation by scattering is greatest for the UVB radiation and has essentially no effect on the global radiation. The latter is influenced by local climatic conditions.
- The variation in the magnitude of the maximum values for all radiation types at both sites exhibit similar behavior. The relative magnitude of the average monthly maximum values for a particular radiation type at the two sites reflects the relative magnitude of the monthly average daily radiation at the two sites, viz., almost identical for global radiation, relatively close for UVA radiation and most dissimilar for the UVB radiation.

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