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Relationship between daily relative sunshine duration and relative sum of direct irradiance at Tartu-Tõravere meteorological station in 1967–2008

Kalju Eerme[a], Ilmar Ansko[a,b] and Uno Veismann[a]

[a] Tartu Observatory, 61602 Tõravere, Tartumaa, Estonia; kalju@aai.ee
[b] Institute of Physics, University of Tartu, Ülikooli 18, 50090 Tartu, Estonia

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Abstract. Solar radiation effects at any site depend strongly on the presence of direct sunshine and on solar elevation. The daily sum of direct irradiance S' on horizontal surface is a more appropriate measure of sunshine energy than the daily sunshine duration *Sundur*. The latter, however, is more frequently recorded. A long-term data set of both quantities at a typical Estonian rural site, at the Tartu-Tõravere Meteorological Station (58°16′N, 26°28′E, 70 m a.s.l.) is examined on the monthly level. The used daily values are expressed as the ratios relative to normal cloudless conditions S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ as well as their ratio $R = (S'/S'_{\text{clear}})/(Sundur/Sundur_{\text{clear}})$. The study was performed on the level of monthly totals and also of daily values meeting the condition $Sundur/Sundur_{\text{clear}} > 0.1$ integrated within each month. The minimum values of R, 0.80 for monthly totals and 0.75 for the amount of selected days, were found in July and August due to frequent convective clouds around noon. In March to September the estimated monthly relative direct irradiances using $Sundur/Sundur_{\text{clear}}$ and R agreed with the measured ones within ±10% in more than 70% of cases and within ±15% in about 90% of cases.

Key words: sunshine duration, solar direct irradiance, monthly totals, daily totals.

1. INTRODUCTION

The available amount of solar radiation is an important environmental factor having many different biospheric influences as well as technological applications like photovoltaic power generation and resistance of different manmade materials to damages. Information on solar irradiance is used in soil-vegetation-atmosphere transfer models. The solar radiation effects are stronger for direct irradiance and depend on solar elevation, with contribution from atmospheric total ozone and aerosol optical depth (AOD). The effects of solar radiation on atmospheric chemistry and living organisms as well as on manmade materials depend on the spectral composition of radiation. The most influential UVB (wavelengths below 315 nm) part of incident solar radiation is capable of breaking connections between atoms in organic molecules, and is therefore a reason for harmful and also beneficial effects for humans [1–4], mainly for people with working and leisure activities outdoors [5–8], but also for other biospheric species and ecosystems [9,10]. The oxidizing capacity and aerosol formation in the atmosphere are strongly influenced by solar UVB irradiance [11].

The reconstruction of UV radiation doses for past years is necessary for evaluating the solar radiation effects and ecosystem responses during longer periods. The potential proxies for reconstruction are direct irradiance and sunshine duration together with data on global irradiance, total ozone and AOD [12–16].

The variable contribution of clouds to global dimming and brightening is not always explicitly expressed and separated from the AOD influence [17]. Pyranometer records of global solar radiation covering the Earth are not uniform, besides most measurements have been performed during the last half-century. Sunshine duration has been recorded in more sites and the records often cover longer time intervals. Its availability and trends in Western Europe have been recently investigated [18]. Due to wider availability, sunshine duration has been used as a proxy for reconstruction of global irradiance on the annual and monthly as well as on the daily levels. In those reconstructions global solar irradiation is directly related to the sunshine duration through a linear model, which was first proposed by Ångström in 1924 [19]. Linear Ångström–Prescott regression [20] and its modifications have seen world-wide application in investigations concerned with solar irradiance at the surface [21–24]. Sunshine duration has been used also as a proxy for estimation of the availability of direct solar irradiance [25]. The exploration of seasonal differences in the relationship between both quantities is justified because often these are not considered. Direct solar irradiance in W/m^2 is recorded at few sites and the data are sparse in time and space as compared to the sunshine duration data. Its daily sum in J/m^2 characterizes the daily energy amount of direct irradiance and the sunshine duration the daily total time of sunshine. Sunshine duration is the length of time in which the solar irradiance, falling on a plane perpendicular to the solar beam, is greater than or equal to 120 W/m^2 [26]. Sunshine episodes may prefer certain solar elevation ranges and equal daily sunshine duration may correspond to different collected energy amounts. In Estonia the period from spring equinox to autumnal equinox contributes 87% of annual direct irradiance and 75% of annual sunshine duration on average [27].

In the present paper the relationship of the both mentioned quantities are investigated on the monthly scales at a typical rural site on a plain in Estonia which is partly covered by forests and partly by arable fields and grasslands. The aim was to quantify the seasonal differences. Presumably main features of the seasonality are similar in the neighbouring Northern European area where landscapes and weather conditions are to a great extent the same.

2. MATERIALS AND METHODS

The long-term data set of daily sunshine duration and sums of direct solar irradiance have been recorded simultaneously at a typical Estonian rural site, at the Tartu-Tõravere Meteorological Station (58°16′N, 26°28′E, 70 m a.s.l.). The daily direct solar irradiance is recorded since January 1955. Daily sums of direct irradiance on the horizontal surface S' are used in the present work. Direct irradiance, perpendicular to solar rays S is measured by sun-tracking pyrheliometer and the values transformed to the horizontal surface S' are calculated as

$$S' = S \sin h,$$

where h is the solar elevation angle. The local record of sunshine duration starts from January 1953, however, there is a gap in the years 1959–1966. In the present paper the data for 1967–2008 are analysed. Until 1996 the Yanishevski AT-50 actinometers were used, being then replaced by the Eppley Labor. Inc. pyrheliometers. The absolute accuracy of the Eppley Labor. Inc. pyrheliometers is ±1% and that of Yanishevski instrument is about ±2%. The field of view of the Yanishevski instrument was 10 degrees and that of the Eppley instrument 5.7 degrees. The difference in recorded summer half-yearly sums of direct irradiance reaches 1%. For recording global irradiance, the Savinov–Yanishevski M-115 pyranometers were used, being later replaced by Kipp & Zonen pyranometers. In the past, reglemented intercalibration of sensors was regularly performed at the Voeikov Main Geophysical Observatory (St. Petersburg, Russia), whereas now it is done at the World Radiation Center (Davos, Switzerland). Between the comparison campaigns, the absolute radiometer PMO-6 No. R850405 is used as a secondary standard for regular assurance of the calibration. The previous standard, Ångström pyrheliometer M-59-8 No. J-1981, has been in use during more than 20 years. The scales of old and new standards have been in agreement with the World Radiation Reference within ±0.1% [28]. During most of the analysed time interval, sunshine duration was recorded by the classical Campbell–Stokes heliograph. Since January 2004 the data recorded by sunshine duration sensor DSD3 (model 217078) with one minute resolution have been used. The daily differences in results of both instruments in 2004–2005 in the majority of cases were below ±7%. The daily sunshine duration, recorded by the new instrument, was nearly 4% shorter on average but in the minority of cases was also longer. The largest differences were met at small values, which are not considered in the present analysis. For the period before 2002, the AOD values for broad-band solar radiation from pyrheliometer measurements have been used and after that the cloud corrected AOD data from AERONET sun photometer, located at the study site. Reliable relationship was established between the broadband AOD and AERONET AOD at 500 nm [29]. The major part of AOD data are recorded in April to September. In February and November as well as often in October and March the amount of data is too small for statistical conclusions. In December and January almost no data have been recorded due to very low noon solar elevation.

The daily values of both quantities are expressed as the ratios S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ to the normalized clear day value of the same day number from the beginning of the year. The annual courses of the normalized clear day values for the daily sum of direct irradiance were derived empirically from the recorded data [15,30], considering the cloudless days with AOD values close to its seasonal median. For previous applications we calculated the $Sundur/Sundur_{\text{clear}}$ as the ratio of real sunshine duration to the length of day [14]. This ratio is always less than 1. In the present work it was corrected to get normalized value 1 of the ratio $R = (S'/S'_{\text{clear}})/(Sundur/Sundur_{\text{clear}})$ for seasonal median AOD conditions cloudless days. The correction factor for $Sundur_{\text{clear}}$ 1.095 with the standard deviation limits ±0.027 was detected from 149 values along the annual cycle in the years 1967–2008, distributed symmetrically with respect to the moving average. The study of both ratios relative to the normal AOD clear conditions S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ separately as well as of their ratio was performed on the level of monthly totals and on the daily level within each month, considering the days meeting the condition $Sundur/Sundur_{\text{clear}} > 0.1$. The monthly relative availability of direct irradiance as well as that of sunshine duration depends on the amount of days with available sunshine and on the cloud situations during these days. A minor contribution comes from the variations of AOD.

3. RESULTS

3.1. Monthly numbers of days when $Sundur/Sundur_{\text{clear}} > 0.1$

On overcast days both the S'/S'_{clear} and the $Sundur/Sundur_{\text{clear}}$ are zero and their ratio R is meaningless. In some cases the days when $Sundur/Sundur_{\text{clear}}$ as the less sensitive quantity is zero and S'/S'_{clear} exhibits a small value above zero were recorded. Such small values do not contribute significantly to the monthly amount of direct irradiance. When only short episodes of sunshine occur during a day, the values of the ratio R can vary within a wide range from 0.1 to 10 and show no regularity. At the values $Sundur/Sundur_{\text{clear}} > 0.1$, the ratio R stabilizes and remains in the range from 0.3 to slightly above 1. When the daily $Sundur/Sundur_{\text{clear}}$ approaches 1, the ratio R also approaches 1. In the cases $0.1 < Sundur/Sundur_{\text{clear}} < 0.8$, the ratio R tends to be significantly lower than 1 in summer months. For reliable statistical averaging, the number of points (days) within each studied time interval must be large enough. In Fig. 1 the monthly average numbers of days when $Sundur/Sundur_{\text{clear}} > 0.1$ and above 0.8, with the limits of extremes are presented. In April to September, the average number of days, meeting the first condition, was above 20. In several cases all days in a month met this condition. In March and October, around 20 days with $Sundur/Sundur_{\text{clear}} > 0.1$ were found in most cases; however, in a few exceptional years their amount did not exced 10. In November to February the average number of days, satisfying this condition often was below 10, being in some

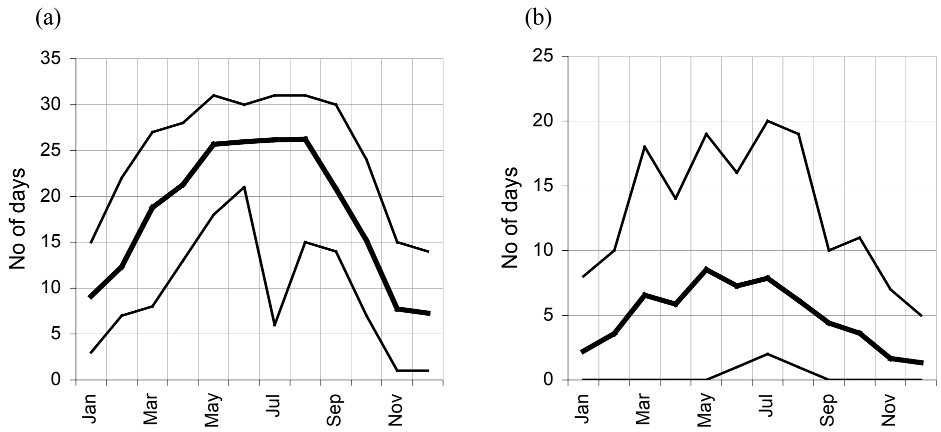

Fig. 1. Monthly numbers of days when $Sundur/Sundur_{\text{clear}}$ is above 0.1 (a) and above 0.8 (b).

cases only 3–4. The lowest number of days $Sundur/Sundur_{\text{clear}} > 0.1$ above 10 during the considered period was recorded in December and in November, in 11 and 14 years, respectively. The average monthly number of fine-weather days when $Sundur/Sundur_{\text{clear}} > 0.8$, remained below 10 in all months. In some very sunny summers it approached 20 in a few months.

3.2. Monthly ratios S'/S'_{clear}, $Sundur/Sundur_{\text{clear}}$ and R

Monthly availability of direct sunshine depends most substantially on the cloud amount with smaller contribution from the atmospheric transparency variations. The year-to-year variations in both quantities characterizing relative availability of sunshine are large. The smallest recorded availability of direct sunshine energy relative to the assumed normal cloudless value S'/S'_{clear} has been only 0.02 in one particular November and close to that in several cases in November to January. The largest particular values of $Sundur/Sundur_{\text{clear}}$ have reached levels around 0.80 in May, July and August in several cases. On average, the highest amount of direct irradiance, about 0.45 of the assumed cloudless value, is available in May. The relative sunshine duration is the highest in May to August, when it exceeds the level 0.50 of the assumed clear value. The monthly mean ratio R reaches its minimum, around 0.80, for monthly totals and 0.75 for the amount of days $Sundur/Sundur_{\text{clear}} > 0.1$, also in July and August and then increases to the level around or slightly above 1 in December to February. The ranges of its variation around the average monthly value are larger in more cloudy months. The average monthly values of S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ as well as the smallest and largest extremes are presented in Table 1. The smallest range of variation of both indicators of relative sunshine was found in June and the largest in November.

Table 1. Monthly average relative availabilities of direct irradiance S'/S'_{clear} and sunshine duration $Sundur/Sundur_{\text{clear}}$ with their minima and maxima

Month	S'/S'_{clear}			$Sundur/Sundur_{\text{clear}}$		
	Average	Min	Max	Average	Min	Max
January	0.183	0.038	0.384	0.164	0.033	0.315
February	0.262	0.107	0.521	0.257	0.123	0.486
March	0.365	0.095	0.756	0.375	0.120	0.690
April	0.373	0.116	0.627	0.437	0.166	0.651
May	0.451	0.244	0.767	0.528	0.348	0.813
June	0.435	0.222	0.631	0.528	0.354	0.744
July	0.429	0.202	0.704	0.529	0.296	0.778
August	0.405	0.153	0.737	0.502	0.241	0.793
September	0.323	0.113	0.598	0.387	0.163	0.658
October	0.248	0.069	0.518	0.271	0.095	0.509
November	0.134	0.020	0.356	0.136	0.024	0.382
December	0.144	0.029	0.308	0.139	0.024	0.282

The monthly values of S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ are highly correlated. The coefficients of linear correlation vary in the range from 0.92 to 0.99. The lowest correlation, 0.92, has been found in June and somewhat higher in April, May, July and August when the diurnal evolution of the cloud amount is strongly influenced by convection. The heating of the ground by solar radiation induces convection, reaching its maturity by the noon hours. Its intensity depends also on soil moisture. The highest correlation, 0.99, was found in March and the values close to that, 0.985, were met in September to November.

The probability density distributions of monthly S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ for the study period 1967–2008 in the most cloudy months since September tend to be unimodal and asymmetric with a tail toward larger values. The values of S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ in these months are predominantly small. In November and December about 85% of both values are below 0.20 and only 15% reach the level between 0.20 and 0.35. Their histograms of distribution for the most cloudy month November are presented in Fig. 2 together with that of the ratio R. With the increasing noon solar elevation the major body of distribution shifts toward larger values. In June to August the distributions of S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ manifest features of bimodality. The peaks of distributions in June are placed around the values of 0.35–0.40 and 0.50, and in July around 0.35 and 0.55, respectively. The distributions of S'/S'_{clear}, $Sundur/Sundur_{\text{clear}}$ and R for July are presented in Fig. 3. The bimodality of distributions of S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ in summer months expresses a quasiperiodic alternation of sunny and cloudy/wet summers due to the domination of different atmospheric circulation regimes. A similar tendency appears also in the seasonal global irradiance [30]. The time evolution of the monthly S'/S'_{clear} in July is presented in Fig. 4. One can see the interval of prevailing small values in 1976–1993 as well as different regimes of year-to-year variations before and after that interval. The tendency of systematic dimming in

January until the middle of the 1990s as well as that of brightening in recent years is also impressive (Fig. 5) but these smooth trends do not lead to the bimodality of distribution.

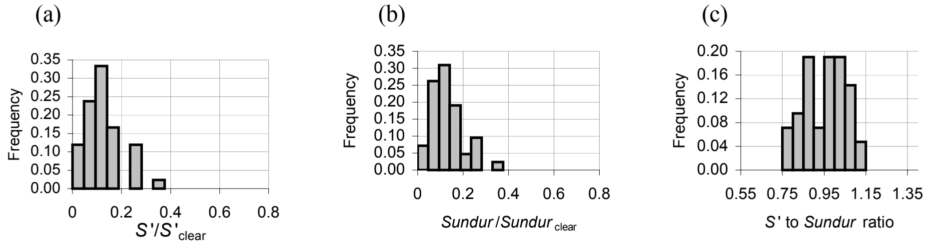

Fig. 2. Histograms of monthly mean S'/S'_{clear} (a), $Sundur/Sundur_{\mathrm{clear}}$ (b) and R (c) for November in 1967–2008.

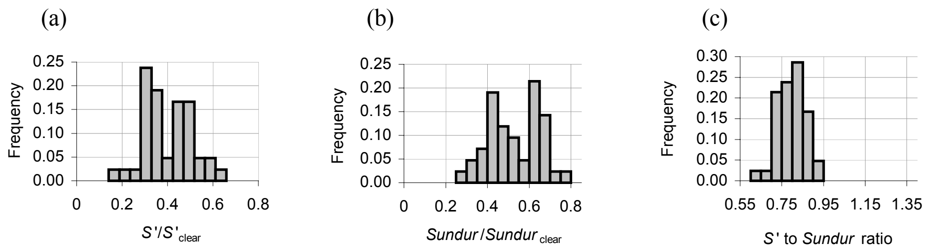

Fig. 3. Histograms of monthly mean S'/S'_{clear} (a), $Sundur/Sundur_{\mathrm{clear}}$ (b) and R (c) for July in 1967–2008.

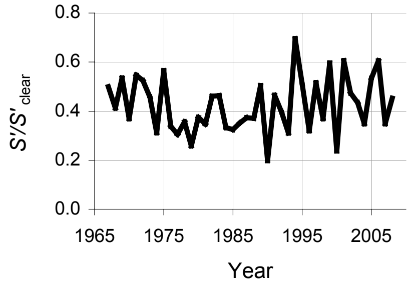

Fig. 4. Time evolution of monthly mean S'/S'_{clear} for July in 1967–2008.

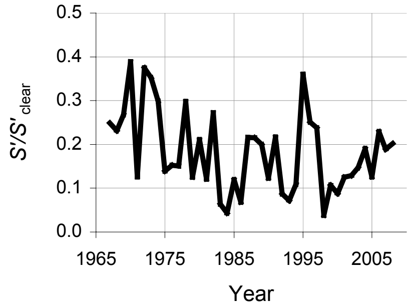

Fig. 5. Time evolution of monthly mean S'/S'_{clear} for January in 1967–2008.

3.3. Distribution of daily ratios S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$

Central tendencies of the studied quantities and their time evolutions on monthly scale depend on the changes in the probability density distribution of daily values within month. The monthly and bimonthly probability density distributions of the daily ratios S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ in March to October manifest similarity as did the monthly ratios discussed in Section 3.2. Most of the distributions were studied on the bimonthly level to include larger amount of points. The days with $Sundur/Sundur_{\text{clear}} < 0.1$ were excluded by the initial selection. The numbers of points (days) remained between 40 and 60. The extreme bimonthly distributions of both quantities in July + August for one of the cloudiest summers 1998 are shown in Fig. 6. Figure 7 presents bimonthly distribution for the most sunny summer 2002. The distributions of S'/S'_{clear} usually contain smaller values than these of $Sundur/Sundur_{\text{clear}}$ and include also some amount of values $S'/S'_{\text{clear}} < 0.1$. The opposite is valid for large values, which appear more frequently in the distributions of $Sundur/Sundur_{\text{clear}}$.

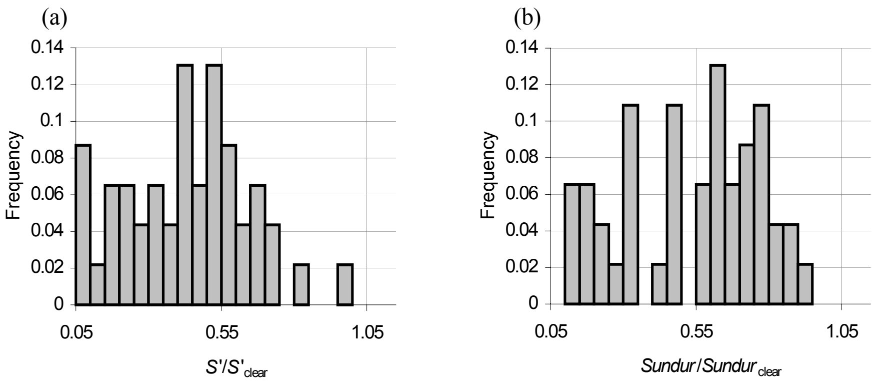

Fig. 6. Bimonthly (July + August) distribution of daily relative direct irradiance S'/S'_{clear} (a) and daily relative sunshine duration $Sundur/Sundur_{\text{clear}}$ (b) for the extremely cloudy summer 1998.

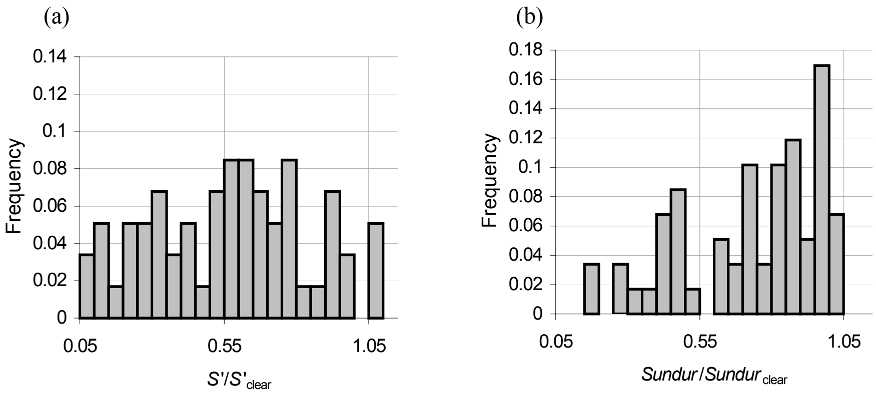

Fig. 7. Bimonthly (July + August) distribution of daily relative direct irradiance S'/S'_{clear} (a) and daily relative sunshine duration $Sundur/Sundur_{\text{clear}}$ (b) for the extremely sunny summer 2002.

3.4. Distribution of daily ratios R and the robustness of monthly values

On the bimonthly level the conventional mean is a relatively robust central tendency measure of the daily ratios R. For the whole studied period the mean, median and trimean agreed within ±1% on average with the largest deviations, reaching ±5%. The average ratio mean/trimean in 1967–2008 was 0.99. In Fig. 8 the ratios mean/trimean are presented for May–June and July–August. One can see that the values remain within the range from 0.98 to 1.02 with a few exceptions. Later the conventional mean is used as the central tendency measure.

In sunny and dry summer half years the monthly mean values of the ratio R tend to be somewhat larger than in wetter and cloudier conditions due to smaller amounts of convective clouds at noon hours. The ratio of relative direct irradiance to the relative sunshine duration is significantly correlated to the relative global irradiance falling to the horizontal surface. From April to September, the coefficients of positive correlation between the monthly relative global irradiance G/G_{clear} and ratio R were between 0.50 and 0.66. For the monthly average G/G_{clear} above 0.7 most of the values of R were between 0.80 and 0.83. For average G/G_{clear} below 0.65, the values of R were also smaller, between 0.70 and 0.76.

The sunny and cloudy periods at the study site differ more clearly in summer season than in spring [30]. The values of R in summers during cloudier periods tend to be smaller than those in sunny periods in July, August and September. The monthly mean values of R for two periods of sunny summers 1967–1975 and 1994–2007 as well as these for a cloudy period 1976–1993, are presented in Table 2.

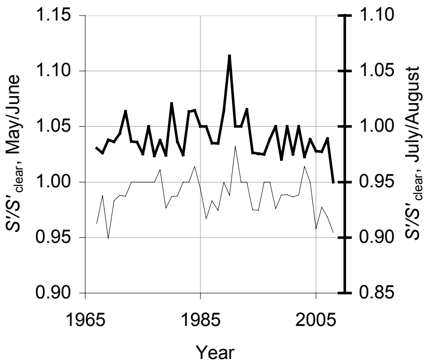

Fig. 8. Bimonthly ratios of mean/trimean of R for May–June (thin line, left axis) and July–August (thick line, right axis) in 1967–2008.

Table 2. Ratio of summer months average daily relative direct irradiance to the relative sunshine duration R in three time intervals, manifesting different average cloudiness

Time interval	Month		
	July	August	September
1967–1975	0.768	0.762	0.786
1976–1993	0.709	0.712	0.731
1994–2007	0.807	0.823	0.823

3.5. Estimation of monthly S'/S'_{clear} from the $Sundur/Sundur_{\mathrm{clear}}$

The monthly ratio R is proposed to be used as a transform factor for deriving the ratios S'/S'_{clear} from the $Sundur/Sundur_{\mathrm{clear}}$. The monthly values of S'/S'_{clear} were calculated as $S'/S'_{\mathrm{clear}} = R \cdot Sundur/Sundur_{\mathrm{clear}}$.

The transform factor R is to some extent dependent on the available sunshine. Logically the small monthly values of S'/S'_{clear} may be overestimated and large values underestimated. In reality the agreement between recorded and estimated values occurred quite similar in February to September when in 70% to 83.5% of cases the differences remained within ±10%, and in 86% to 95.5% of cases within ±15%. In the summer half-year the deviations, exceeding ±20%, occurred as very exceptional, on average in one out of 42 cases and they never exceeded the limits ±30%. In more cloudy winter half-year, the monthly values derived from measurement data are less reliable and year-to-year variation of monthly values are larger. The largest disagreement of recorded and estimated S'/S'_{clear} was found in December, when only in 55% of cases the differences were within ±10% and in 67% of cases within ±15%. The agreement between estimated and measured S'/S'_{clear} in July and September is illustrated in Fig. 9.

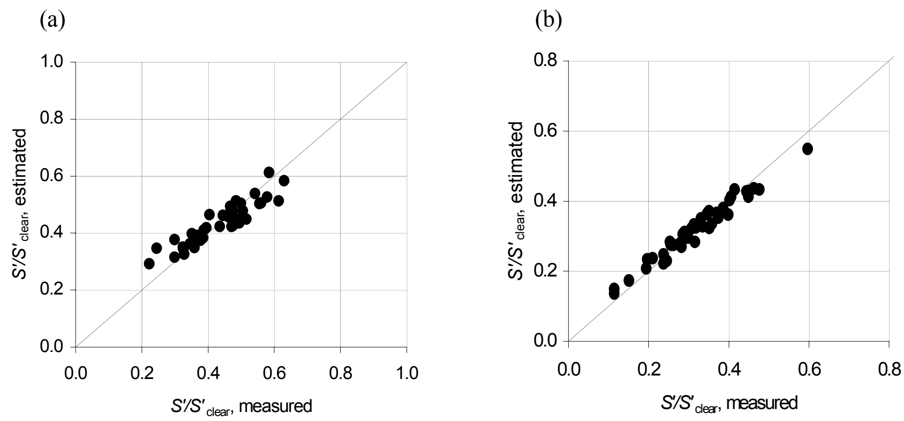

Fig. 9. Agreement of monthly measured and estimated S'/S'_{clear} in July (a) and September (b) in 1967–2008.

In months when the value of R approaches 1, there is no real need to estimate the ratios S'/S'_{clear} because then $Sundur/Sundur_{\text{clear}}$ itself is an appropriate measure of available energy of solar direct irradiance.

4. CONCLUSIONS

The data set of the daily relative sum of direct irradiance S'/S'_{clear} on the horizontal surface and the daily relative sunshine duration $Sundur/Sundur_{\text{clear}}$, collected at the Estonian Tartu-Tõravere Meteorological Station in 1967–2008, demonstrate that the monthly values of both relative sunshine characteristics at the study site and probably more widely in Northern Europe vary in wide ranges. The smallest year-to-year variations of both quantities were found in June and the largest in the most cloudy month November. The ranges of variation from April to September are almost similar and smaller than in winter months. In all these bright half-year months the ranges of variation of relative direct irradiance are to some extent larger than these of relative sunshine duration.

The quantities, expressing the monthly relative amount of sunshine, are strongly correlated. The monthly coefficients of linear correlation are the highest in March and in autumnal months October and November. From May to September, frequently developing convective clouds reduce available sunshine during noon hours when the solar elevation is high and the correlation decreases to some extent, being the lowest in June. The positive correlation between relative sunshine duration and relative global irradiance is significantly lower than the one between relative direct irradiance and relative sunshine duration.

The relative sum of direct irradiance is not directly proportional to the relative sunshine duration. Regular annual cycle is evident in the ratio R of the relative direct irradiance to relative sunshine duration, manifesting minimum in July and August and approaching 1 in winter months from November to March. The regular cycle of the ratio R allows to use its monthly values as transform factors to estimate the monthly relative energy of direct irradiance from the relative sunshine duration.

The reliability of the ratio R as a transform factor depends on the average number of days per month, satisfying the condition $Sundur/Sundur_{\text{clear}} > 0.1$. From April to September this number at the study site is regularly above 20. Also in March and October it is mostly around 20. From November to February, due to domination of overcast days, the transform is less reliable, but in this sunshine poor season the ratios S'/S'_{clear} and $Sundur/Sundur_{\text{clear}}$ are almost equal and there is no real need for transform.

At the study site, from March to September the monthly relative direct irradiance, derived from monthly relative sunshine duration applying transform factor R, agreed with the measured values within ±15% in approximately 90% of cases, being within ±10% in at least 70% of cases. Partly the disagreement is related to variations of dominating weather conditions. In dry sunny months the cloud amounts are smaller and the values of R tend to be somewhat larger than in more wet summers.

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Päevase suhtelise päikesepaiste kestuse ja suhtelise otsekiirguse päevasumma seosed Tartu-Tõravere ilmajaamas aastail 1967–2008

Kalju Eerme, Ilmar Ansko ja Uno Veismann

Päikesekiirguse mõju elus- ja eluta loodusele ning tehismaterjalidele sõltub oluliselt päikese otsekiirgusest ja kõrgusnurgast. Horisontaalsele pinnale langeva otsekiirguse päevasumma S' on adekvaatsem päikeseenergiaga varustatuse iseloomustaja kui päikesepaiste kestus *Sundur*. Viimast suurust on aga registreeritud ajaliselt kauem ja arvukamates kohtades. Seetõttu püütakse summaarse päikesekiirguse ja otsekiirguse energiahulki tuletada tihti just päikesepaiste kestusest. Tartu-Tõravere ilmajaamas (58°16′N, 26°28′E, 70 m ü.m.p.) on päikese otsekiirguse päevasummat ja päikesepaiste kestust registreeritud vaheaegadeta alates 1967. aastast. Artiklis on mõlema suuruse väärtused esitatud suhetena

vastava normaaltingimustes pilvitu päeva väärtuse suhtes, S'/S'_{clear} ja $Sundur/Sundur_{\mathrm{clear}}$, ning analüüsitud peamiselt nende omavahelise suhte $R = (S'/S'_{\mathrm{clear}})/(Sundur/Sundur_{\mathrm{clear}})$ käitumist. Seda nii kuu integreeritud väärtuste kui ka tingimusele $Sundur/Sundur_{\mathrm{clear}} > 0{,}1$ vastavate päevade kuu keskmiste väärtuste tasemel. Suhte R väärtus oli talvekuudel ligikaudu 1 ja suvekuudel oluliselt väiksem. Minimaalne väärtus, 0,80 üle kuu integreerituna ja 0,75 eelnimetatud tingimusele vastavate päevade keskmisena, esines juulis ning augustis keskpäeva paiku sageli ilmuvate rünkpilvede tõttu. Ajavahemikul märtsist septembrini oli kooskõla mõõdetud S'/S'_{clear} ja antud kuu keskmise suhte R alusel hinnatud väärtuse vahel 70% juhtudel ±10% piirides ning 90% juhtudel ±15% piirides.