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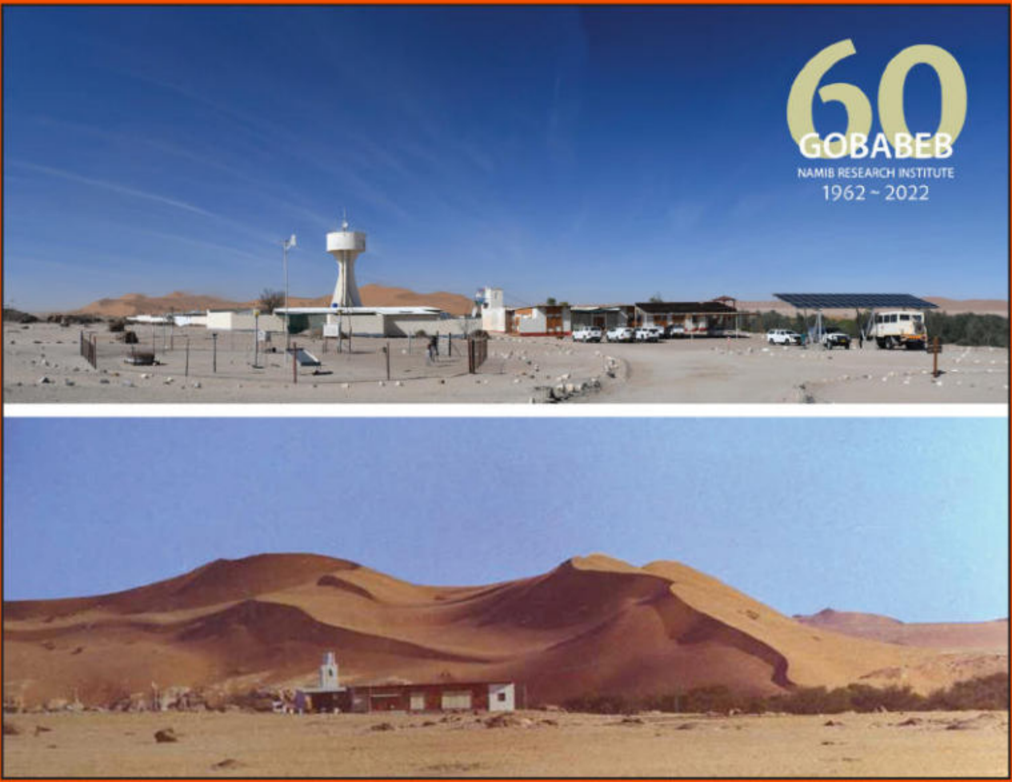

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A Decade of Solar and Terrestrial Radiation Monitoring at Gobabeb for BSRN

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Abstract

The Gobabeb Baseline Surface Radiation Network (BSRN) location was established a decade ago as part of a global network to provide standardised, high quality surface observations of radiation fluxes under the auspices of the World Meteorological Organisation. The Gobabeb BSRN measures the incoming and outgoing shortwave and longwave radiation at two locations in the Central Namib Desert. With a suite of instruments, radiative fluxes of shortwave downward radiation (*SWD*), direct solar radiation (*DIR*), diffuse radiation (*DIF*), longwave downward radiation (*LWD*), shortwave upward radiation (*SWU*) and longwave upward radiation (*LWU*) are recorded at 1-min intervals, together with relevant meteorological variables directly at the locations. As logistical issues prevent frequent calibration of instruments against World Radiometric standards, the measurements of *DIR*, *SWD* and *LWD* are duplicated to replicate radiation measurements as primary and redundant datasets. The two datasets are compared to each other to identify and exclude questionable data before being deposited in an open-access repository. The Gobabeb BSRN dataset is of very high quality, with less than 1% data missing for downward radiation. The upward radiation dataset has more missing data due to its becoming operational at a later date. As expected, climatic variables have the greatest influences on radiation fluxes at Gobabeb. Due to its location in a hyperarid desert, radiation is generally high throughout the year. Reflected radiation from rare cloud walls during the austral summer may, however, result in very high downward fluxes. The frequent incidence of fog due to onshore advection of stratus cloud banks over the nearby South Atlantic Ocean from August to February is distinctly visible in the dataset. Variation in the radiative fluxes of the different elements provides more detailed information on seasonal and daily incidence of fog, as well as seasonal changes in atmospheric aerosols. We briefly illustrate how high-quality BSRN data are used globally for validating solar energy resource assessments and evaluating differences between modelled predictions and actual surface performance.

1 Introduction

The sun is practically the only source of energy for the Earth system and is the basis of life on Earth. The energy comes as solar radiation, which, converted into different forms and redistributed by the rotating planet, drives the ocean currents and the general circulation of the atmosphere resulting in weather and climate. Of the 70% of the solar radiation absorbed by the planet, approximately two thirds reaches the Earth's surface (Wild et al. 2015) where net radiation is a crucial component of the surface energy balance both on ocean and land surfaces. Here, small changes in irradiance can "cause a profound change in climate" (BSRN 2021). While the solar input at top of the atmosphere is known with sufficient accuracy, knowledge about the irradiance at the Earth's surface, especially its spatial distribution—horizontally and vertically—is not sufficient to understand the present climate. As existing radiometric networks were not accurate enough for climate research, a new Baseline Surface Radiation Network (BSRN) was initiated more than 30 years ago by the World Climate Research Programme Radiative Fluxes Working Group to resolve this top-bottom discrepancy.

The BSRN stood out from existing measurements by special features such as: a commitment for the long-term operation of the stations under the guidance of radiation experts; measurements of basic radiation components in 1-min resolution; and traceable calibrations of the radiation instruments to the World Radiometric Reference, which is maintained at the World Radiation Center in Davos, Switzerland. For more details see McArthur (2005) or Driemel et al. (2018). Apart from monitoring the background shortwave and longwave radiative components[1] with the best methods available, BSRN also provides data for verification of satellite-based estimates of the surface radiation budget.

Although nowadays solar resource assessment is based mostly on satellite-based gridded solar radiation products, ground-based measurements from the BSRN continue to be essential and serve as benchmarks and anchor points.

Esterhuyze (2004) nicely summarizes how the BSRN radiometric network evolved in the 1990s. It is interesting to note that as early as 1989 Namibia was identified as the initial candidate country to represent southern Africa in the new radiometric network, called GBSRN at that time, that intended to reach global coverage (Esterhuyze 2004).

In the global distribution of BSRN stations, ocean areas and the southern hemisphere were and still are underrepresented (Figure 1). When the measurements in Gobabeb started in 2012 it was the only station in Africa south of the Equator. With its decade of measurements, it has now the longest continuous record for that area (the South African station in De Aar restarted in 2014). Another special feature of BSRN at Gobabeb is that south of the Equator, apart from stations in the Antarctic, it is one of only two stations measuring upward radiation fluxes, which allows the estimate of net surface radiation (Driemel et al. 2018) and the evaluation of ground surface reflectance models, for which Gobabeb BSRN data were used (Tuomiranta et al. 2021, 2022).

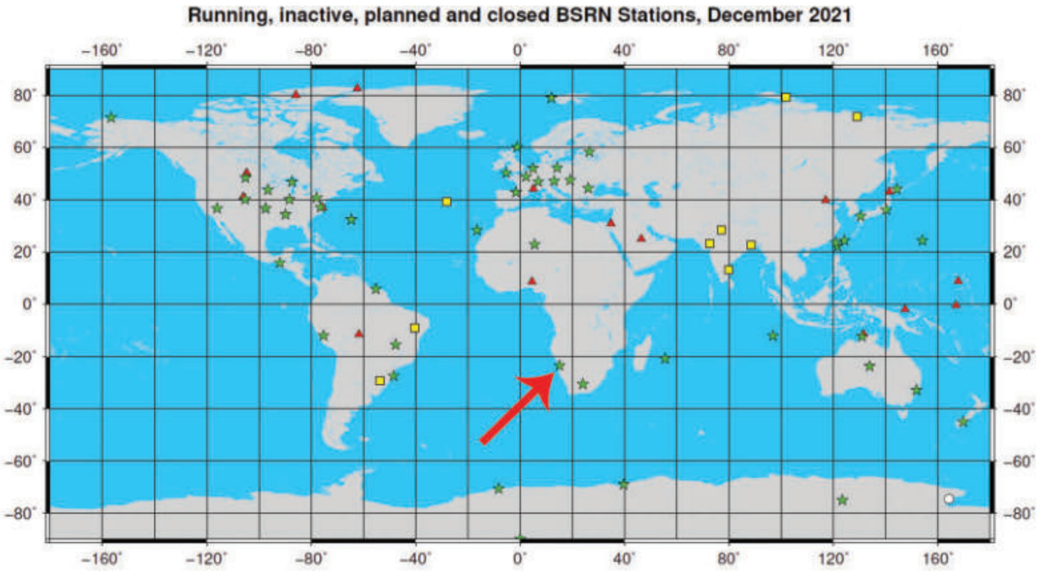

Figure 1: Overview map of BSRN stations. The arrow marks the station in Gobabeb.

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[1] In the context of meteorology, shortwave and longwave are used synonymously for solar and terrestrial radiation as there is only a small overlap (≈1%) around 4 μm due to the Sun-Earth distance.

Direct surface observations provide an important input for estimating the global annual mean energy balance, for which the latest estimates are summarized in Figure 2 arranged in energy budgets for top of the atmosphere (TOA), atmosphere and surface (Forster et al. 2021, Wild et al. 2015). *Incoming solar* corresponds to a quarter of total solar irradiance (also referred to as solar constant), which reaches on average the Earth's orbit at TOA and is distributed over the spherical surface. *Reflected solar* consists of solar radiation reflected back to space from the atmosphere (mainly from clouds) and the Earth's surface without being energetically relevant, while *thermal outgoing* is the longwave emission of the Earth. Upward and downward fluxes for each level sum up to zero (e.g. for the atmosphere: +80+82+21+398-342-239=0). The slight imbalances at TOA and surface are discussed in detail in Wild et al. (2015) and are not relevant in this context.

The BSRN measurements are therefore important to quantify the energy balance at the Earth's surface. In addition to the components of the surface radiation budget (Figure 2), the direct solar radiation plus the diffuse solar radiation are also measured and provide a relevant input for evaluating radiative transfer models.

The BSRN measurements at Gobabeb are presented in the following sections, together with selected initial results from the first decade.

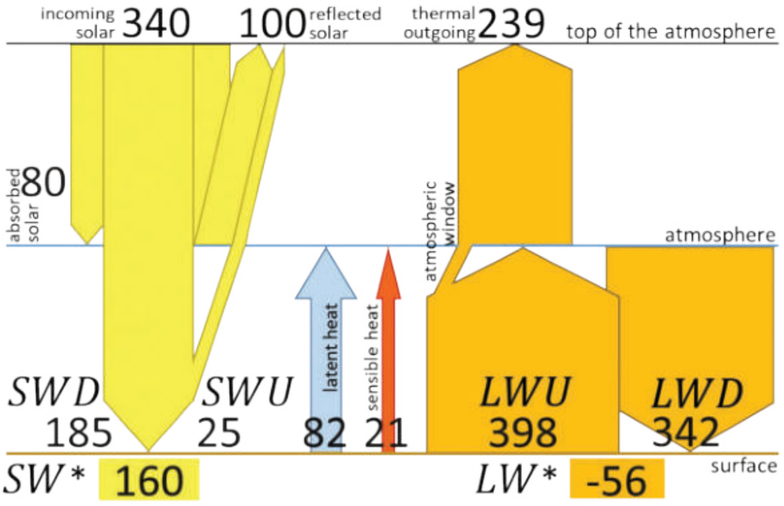

Figure 2: Schematic of global annual mean energy balance estimate based on figures from Wild et al. (2015). All energy fluxes in W m^{-2}. Variables indicate fluxes measured at BSRN stations. For abbreviations see Table 1 and text.

2 Description

2.1 The Gobabeb BSRN station

The station is a joint effort of the Gobabeb Namib Research Institute, the Karlsruhe Institute of Technology (KIT) and the University of Basel (UBAS). The latter provides the station manager.

Gobabeb meets the minimum requirements for BSRN stations with basic measurements of the downward radiation fluxes (Driemel et al. 2018). The downward radiation fluxes are measured 60 m north-east of the Gobabeb water tower on a 2.5 m high rock with the tracker base at 2.8 m height above ground (23.5614S, 15.042E 407 m a.s.l.). Power for the operation of the station comes from Gobabeb. Since the environment close to Gobabeb is not representative for a larger area, the upward fluxes are measured 6 km north-east at a homogeneous area on the gravel plains (23.5195S, 15.0832E, 460 m a.s.l.) at a site called Plains station where the downward oriented instruments are mounted at 5 m above ground.

2.2 Radiation flux measurement

Shortwave downward radiation *SWD* is also called global radiation and represents the incoming solar radiation incident on a horizontal surface. *SWD* is the sum of direct and diffuse solar radiation and is measured with a pyranometer, an instrument sensitive to solar radiation from the hemisphere that it is pointing to.

Direct solar radiation *DIR* is the radiation on a surface orthogonal to the sun's beam, therefore also called direct normal incidence, and the portion incident on a horizontal surface DIR_h contributes to *SWD*. *DIR* is measured with a pyrheliometer, a tube-like instrument pointed by a sun tracker towards the sun so that only the direct solar radiation from the disk of the sun is measured.

Diffuse radiation *DIF* is the part of *SWD*, which comes from the radiation scattered by the atmosphere. A ball positioned by a sun tracker at a distance in front of the disk of the sun (Figure 3a) shadows the pyranometer to block *DIR* for measuring *DIF*.

LWD is the thermal emission of the atmosphere incident on a horizontal surface and is measured with a pyrgeometer, an instrument sensitive only to longwave radiation by means of a longwave filter. The longwave component of direct solar radiation is also blocked by balls positioned by the tracker to measure only *LWD* from the atmosphere. Shadowing also prevents solar leakage through the filter and reduces thermal load on the filter.

The upward fluxes that are measured are *SWU*, the reflected part of global radiation, and *LWU*, the thermal emission of the surface. *SWU* and *LWU* are measured using an upside-down mounted pyranometer and pyrgeometer.

With these measurements of radiation components the net shortwave, net longwave and net radiation are calculated as $SW^* = SWD - SWU$, $LW^* = LWD - LWU$, and $Q^* = SWD - SWU + LWD - LWU$.

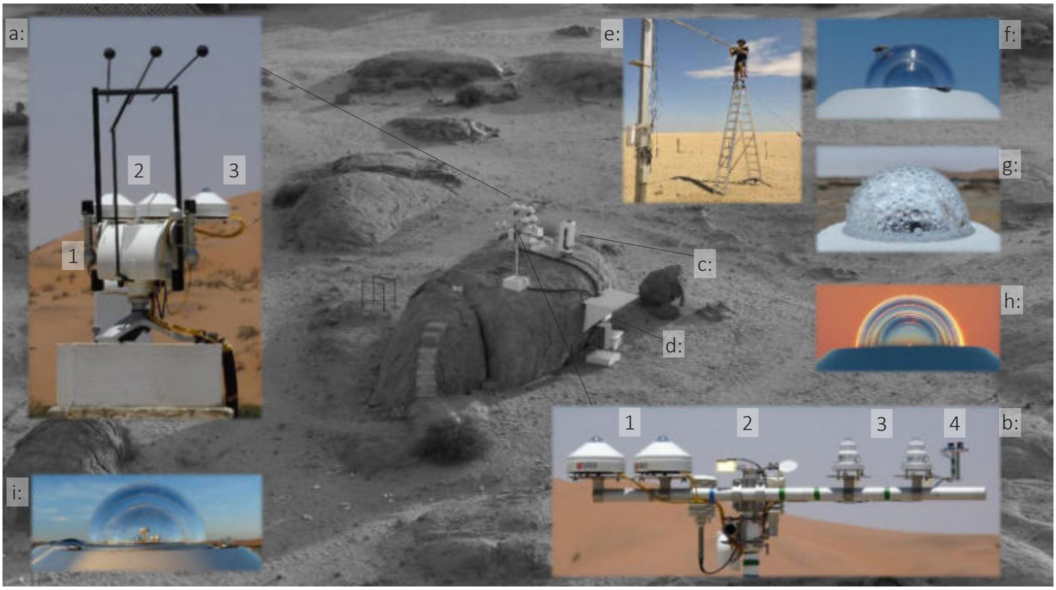

Figure 3: Grey background: View to the BSRN station on the rock with the downwelling flux measurements. a: Tracker positioning two pyrheliometers (1) and shadow balls for two pyrgeometers (2) and one pyranometer (3) with sun close to zenith. b: Boom holding two pyranometers (1), meteorological instruments (2), one UV-B pyranometer and one UV-A pyranometer (3) and two PAR sensors (4). c: Ceilometer. d: Data acquisition and power supply. e: upwelling flux measurements. f: a fly casting a shadow for qualiflying uncertainty. g: fog deposition on a dome. h: sunset in a pyranometer. i: Gobabeb water tower seen through the dome of the pyranometer for diffuse radiation.

The downward (upward) fluxes are sampled at 2s (3s) and stored as 1-min averages. More information on the measured quantities and instrument details are listed in Table 1. Figure 3 presents views of the setup and instrumentation.

2.3 Quality control and data management

For logistic reasons frequent calibrations, as recommended by BSRN, cannot be carried out. Therefore, to have a quality control measure, redundant *DIR*, *SWD* and *LWD* measurements are duplicated by instruments of the same type. In the strict sense, redundancy does not provide information on the accuracy of the measurement, but it is a good indication of long-term stability and helps to identify incorrect measurements. As an example, Figure 4 illustrates the differences of *DIR* values between the main and the redundant measurements for two sets of instruments. The difference is ±1%, which also applies to *SWD* and *LWD* (not shown). The differences were within the accuracy range claimed by the manufacturer, which is 1% of daily totals.

Table 1: Overview on instruments at the Gobabeb BSRN station. Upper part: radiation instruments and the corresponding measured variables/abbreviations. All instrument types are from Kipp and Zonen. Redundant instruments were exchanged in July 2013 (SWD, LWD) and November 2013 (DIR). Lower part: additional meteorological measurements.

Abbreviation/Variable (radiation)		Instrument/Type		Data base
SWD	shortwave downward	Pyranometer	CMP22	BSRN
SWD	redundant	Pyranometer	CMP22	
SWD	shortwave upward	Pyranometer	CMP22	BSRN
LWD	longwave downward	Shaded pyrgeometer	CGR4, T	BSRN
LWD	redundant	Shaded pyrgeometer	CGR4, T	
LWD	longwave upward	Pyrgeometer	CGR4	BSRN
DIF	shortwave diffuse	Shaded pyranometer	CMP22, T	BSRN
DIR	direct solar	Pyrheliometer	CHP1, T	BSRN
DIR	redundant	Pyrheliometer	CHP1, T	

T= instruments mounted on sun tracker SOLYS2, Kipp and Zonen
Data logger downward fluxes: CR3000, Campbell Sci.; upward fluxes: CR1000, Campbell Sci.

Variable	Instrument/Type
Air temperature	Aspirated Thermocouple. Campbell Sci.
Air temperature, relative humidity	HMP45AC, Vaisala
Weather Transmitter: Air temperature, relative humidity, wind speed, wind direction, air pressure, precipitation	WXT520, Vaisala
Leaf wetness sensor	Model 237, Campbell Sci.
UV-B global radiation	UV-S-B-T radiometer, Kipp and Zonen
UV-A global radiation	UV-S-A-T radiometer, Kipp and Zonen
Photosynthetic active radiation	LI-190R quantum sensor LI-COR Biosciences
Cloud base, aerosol backscatter	Ceilometer CS135, Campbell Sci.

The instruments on the rock are maintained daily early in the morning. This includes checking i) the soiling conditions of the domes and filters, ii) the levelling of the instruments, iii) the orientation of the tracker, and iv) the functioning of the ventilations. The status is protocolled, and cleaning and relevelling are carried out if necessary. This type of regular maintenance is crucial to ensure a continuous quality level. For technical reasons the maintenance of the upward fluxes cannot be done as frequently.

Data from the Plains station (*SWU*, *LWU*) are transmitted via a radio link and the ones from the rock via the Gobabeb WiFi to a laptop computer where the 1-min averages and statistics are stored. From there the data are copied to a server at University of Basel and

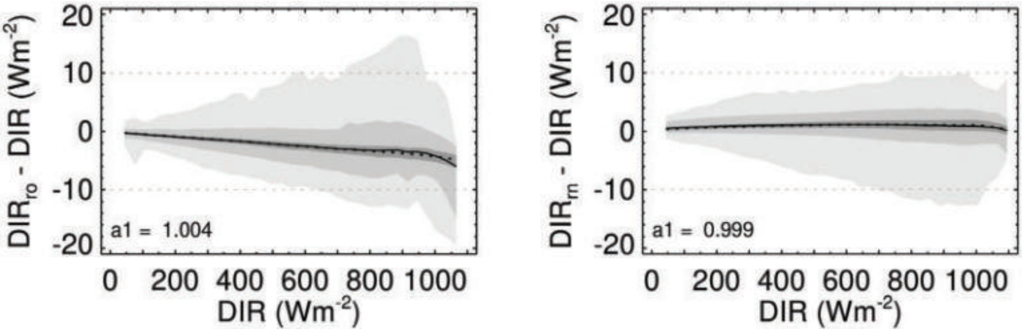

Figure 4: Differences in direct normal incidence between redundant measurements versus the BSRN instrument DIR*, which operated continuously since June 2012. Left: for* DIR_{ro} *(redundant, old) from June 2012 to October 2013. Right: for* DIR_{rn} *(redundant, new) from November 2013 to March 2020. 1-min averages, class width is 30 W m*$^{-2}$*, average/median = solid/dotted line, grey areas contain 50, 90 and 99% of differences.* a1 *indicates the regression factor.*

transferred to a MySQL database for further analysis. A visual inspection of data quality is carried out before submitting the data to the BSRN Pangaea database on a monthly basis. Visual inspection means that diurnal courses of all radiation components are plotted together with the differences relative to the redundant measurements. The dynamics of the undisturbed differences show a regular pattern, which makes it easy to identify obvious deviations such as those caused by cleaning of the domes/filters and/or shadows cast during maintenance. These erroneous values are flagged and are reported as missing values. Other causes of errors are insects/birds sitting on the instruments, wetting of the domes/filters from fog deposition (frequent), rainfall (less frequent) or dew (rare), and strong wind that prevents the tracker from maintaining its exact positioning. The redundant measurements are not reported to the BSRN database, but a summary of the visual inspection is included in the monthly data files. Finally, before submitting, the data are processed with the so-called BSRN Toolbox (Driemel et al. 2018), which provides a format check on the station-to-archive files and performs quality checks as outlined in Long and Dutton (2002). Less than 1% of data are missing for the downwelling fluxes, while the gaps for the upwelling are larger due to the later start at the end of October 2012 (see Table 2). The BSRN data are freely available from bsrn.awi.de.

2.4 Foggy climate

The Gobabeb BSRN site is located in the hyperarid Central Namib close to the Tropic of Capricorn, 56km from the coast and next to the Kuiseb River, the natural boundary between the Namib Sand Sea to the south and the Namib Gravel Plains to the north. The Namib is a coastal desert, with climate influenced by the cold upwelling water of the Benguela Current, accounting for its distinct fog/stratus climatology. Over the eastern

Table 2: Overview on the frequency of gaps in the Gobabeb BSRN data during the 10 years (3652 days). The measurements of the upward fluxes started only November 2012.

	% missing	in days	% ≤10min	% >10min ∧ ≤1h	% >1h	max. gap (days)
SWD	0.85	31.2	0.04	0.09	0.72	4.1
LWD	0.92	33.7	0.14	0.06	0.72	4.1
DIR	0.80	29.3	0.05	0.02	0.73	4.1
DIF	0.73	26.7	0.02	0.01	0.71	4.1
SWU, *LWU*	6.19	226.1	0.003	0.002	6.19	121.4

parts of the southern Atlantic Ocean, a quasi-permanent stratus deck forms that influences the coastal areas. The stratus deck is regularly transported inland by onshore winds, and depending on its cloud base height and thickness, occurs as fog where it intercepts the terrain ascending towards the Great Escarpment in the east. The seasonal changes in stratus height create a west-east gradient in the frequency of fog/stratus occurrence. At Gobabeb that means minimum values from April to July and a broad maximum from September to February. The fog/stratus events at Gobabeb typically start around midnight and dissolve in the morning hours, around three hours after sunrise (Olivier 1992, Seely and Henschel 1998, Spirig et al. 2019, Vogt et al. 2019).

The general climate is well described due to the long-term observations at the Gobabeb Namib Research Institute (Lancaster et al. 1984, Mendelsohn et al. 2009, Eckardt et al. 2013). During the decade of BSRN measurements the mean monthly air temperature for the period 2013 to 2022 can be compared to those in Lancaster et al. (1984) and Mendelsohn et al. (2009). It is interesting to note that summer values seem to have shifted one month later as the maximum now occurs in April instead of March with May the third-highest before a sharp decrease to June. The minimum monthly temperature in August, however, stays the same (Table 3).

Table 3: Mean monthly air temperatures for 06/2012 to 05/2022 for the BSRN station at Gobabeb and for 07/1976 to 06/1981 for Gobabeb according to Lancaster et al. (1984) (= LLS) in °C.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSRN	22.2	22.7	23.8	24.4	23.4	19.8	19.1	17.5	18.1	19.9	21.2	22.2
LLS	22.8	23.3	24.8	24.3	21.6	19.9	18.6	17.6	18.0	19.2	21.5	21.9

3 Results and Discussion

"Namibia is a country of sunshine" state Mendelsohn et al. (2009) in the Atlas of Namibia. The decade of global radiation measurements supports this statement very well. From Figure 5 it is obvious how regular and frequent clear sky days occur in Gobabeb. The more frequent deviations from clear sky days in the mornings as a consequence of fog/stratus events, which dissolve in the morning hours, are noticeable when comparing the two hours after sunrise with those before sunset. Even the seasonality in the occurrence of fog/stratus, with a minimum from April to July, is apparent in the global radiation values in Gobabeb (Figure 5).

Peak values of global radiation during clear sky days can reach up to 1200 W m^{-2} (max. 1224 W m^{-2}). Larger 1-min averages can occur during days with tall convective clouds when forward reflection from the cloud walls enhances solar irradiance. Rarely but regularly occurring values above 1200 W m^{-2} (4200 times) were observed, exceeding more than 500 times the TOA extra-terrestrial levels around 1360 W m^{-2}, with the absolute maximum value of 1651 W m^{-2}.

Gobabeb's geographical location in the celestial context sets boundary conditions for the radiation components. As an example, clear sky days around solstices and equinoxes illustrate the intra-annual variation (Figure 6). The lower (higher) values in June (December) are expected but the influence of atmospheric turbidity can mask such seasonality. Particularly, direct radiation is strongly affected by aerosol content: peak values of *DIR* can be around 100 W m^{-2} lower at the summer solstice than at equinoxes. Net radiation, which summarizes incoming and outgoing shortwave and longwave radiation

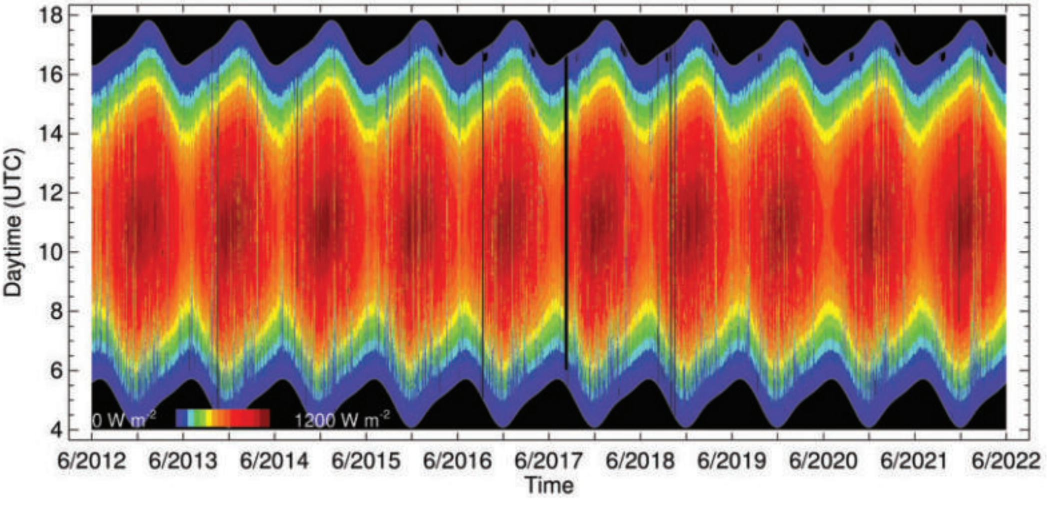

Figure 5: Shortwave downward radiation at the BSRN station Gobabeb based on 1-min averages. Diurnal courses plotted in color code on y-axis. Grey lines indicate times of sunrise and sunset.

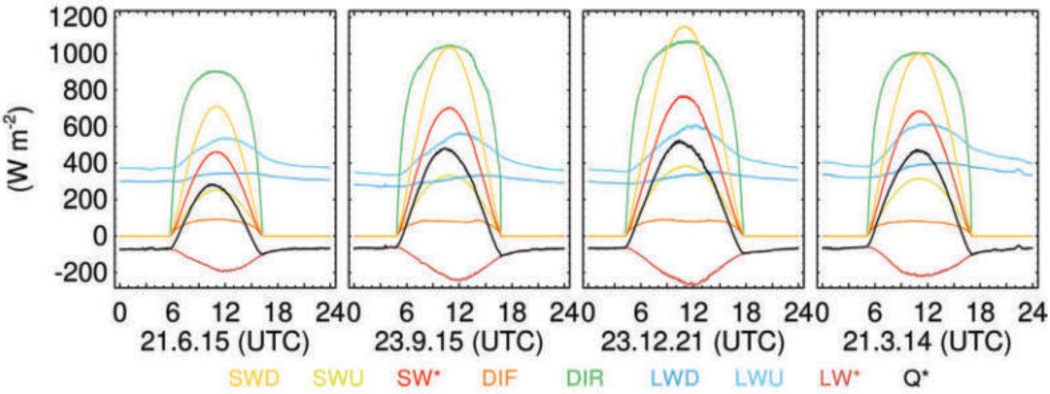

Figure 6: Example clear sky days around solstices and equinoxes for 1-min values of all measured components of radiation at the Gobabeb BSRN station.

fluxes, remains moderate especially in summer compared to mid-latitude values. Despite the strong solar input, peak values range only from a little below 300 to slightly above 500 W m^2. The causes for this are the high albedo and the strong loss in longwave radiation due to the high surface temperatures combined with clear skies above.

An overview on all radiation components derived from the BSRN measurements at Gobabeb is illustrated as monthly averages (Figure 7). All the radiation variables show regular annual courses except the jagged course of direct radiation that fluctuates from month to month. Cloudiness and atmospheric turbidity have a direct influence on *DIR*, but the increase in diffuse radiation compensates partly the reduction in *DIR* for *SWD* values. The monthly averages of net longwave radiation indicate a relatively constant loss of around -100 W m^{-2}, without any pronounced seasonality. When examining the data, the average annual course reveals the highest loss occurs in November (-112 W m^{-2}) and the lowest loss in January (-97 W m^{-2}). This can be explained by the relative lower occurrence of fog and low clouds in November, when surface temperatures are already high, while in January the highest frequency of stratus and low cloud occurrences reduces longwave loss (Vogt et al. 2019). There appears to be a weak decreasing trend in *Q**, which corresponds to slight increases in the outgoing radiation fluxes, especially in *SWU*. A possible explanation could be a reduction in the sparse vegetation since 2012, which decreased and actually disappeared during the last three years. This would cause an increase in albedo and surface temperature. However, further investigation is needed to ascertain that there are no instrument-related errors and by including satellite remote sensing (e.g. time series of surface reflectance from Sentinel-2).

The fog climatology, i.e. the regular occurrence of fog and stratus clouds, is a special feature of the Central Namib and can be tracked throughout the Gobabeb BSRN data. The presence of fog/stratus typically results in an increase of longwave downward radiation. The diurnal and seasonal influence on *LWD* is illustrated in Figure 8. In the absence of fog/

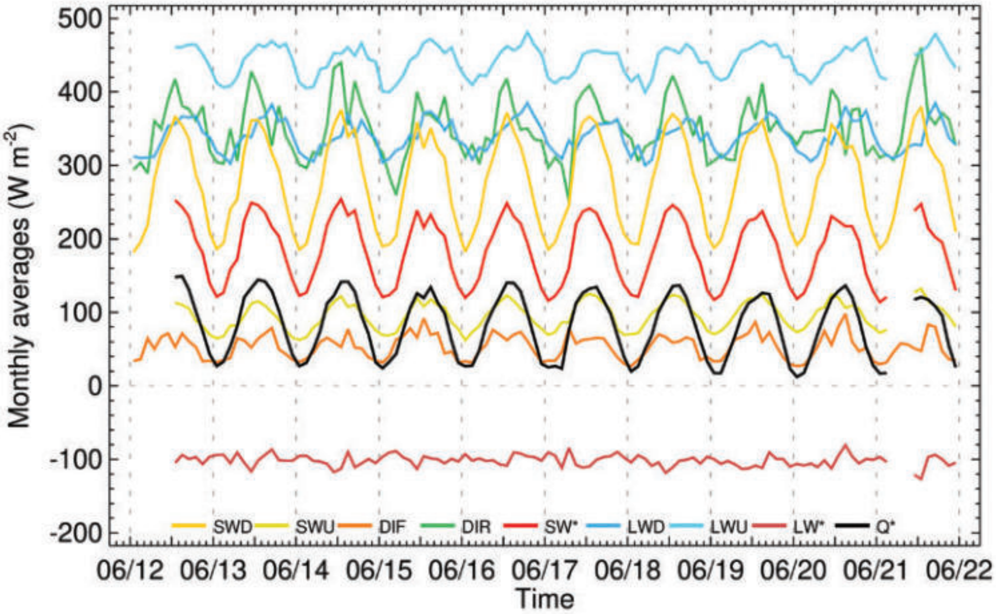

Figure 7: Monthly averages of all components of radiation measured at the BSRN station in Gobabeb from June 2012 to May 2022.

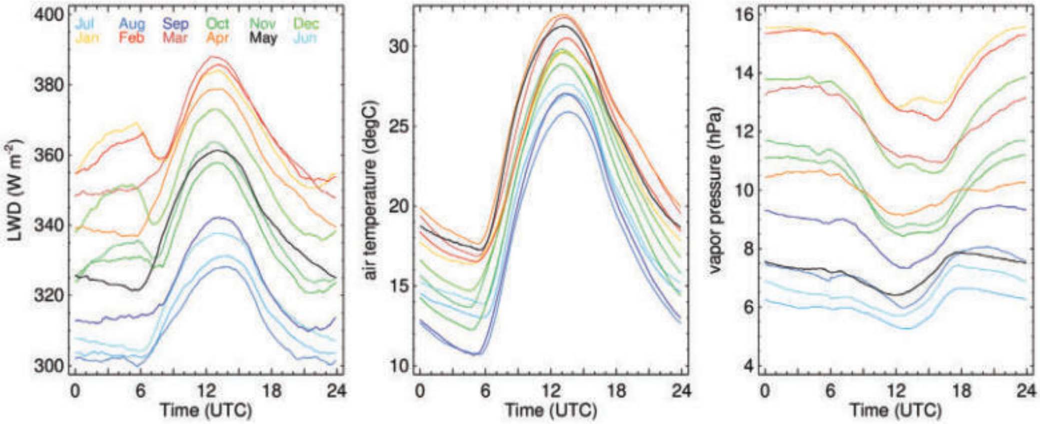

Figure 8: a: monthly average diurnal courses of longwave downward radiation measured at the BSRN station in Gobabeb based on the period June 2012 to April 2022. b: and c: same as a: but for air temperature and water vapor pressure.

stratus, the average diurnal courses of *LWD* are similar to those of air temperature, with a minimum around sunrise and a maximum during the afternoon before monotonously decreasing again towards the minimum. The courses when fog/stratus occurrence is rare, are good examples for that similarity. The nocturnal decrease towards sunrise during the transition July and August months is reduced. From September to February, the decrease of *LWD* after the afternoon maximum ceases during the first half of the night. *LWD* then increases until a sharp drop in *LWD* marks when the fog/stratus disappears. Daytime *LWD* in March is highest, although *LWD* during the second half of the night is much lower than during February. This indicates that the advected fog/stratus is on average much cooler then. The diurnal course of *LWD* during May is roughly in the medium range, while the air temperature is in the top three. This is likely related to the much lower water vapor partial pressure, which contributes to *LWD* during clear sky conditions.

As global interest increased in greater use of renewable energy, the application of BSRN data have proved to be valuable to solar energy engineers. Knowledge about solar radiation is essential to evaluate the potential of particular sites for generating renewable energy, whether by using photovoltaics, concentrated solar power, or both (Salmon et al. 2021). Accurate measurements provide the base for such an evaluation, which should ideally cover at least 10 years or more to capture year-to-year variability. Although models, based on satellite observations combined with climate reanalysis data, can generate solar radiation data at high spatial and temporal resolution (Salmon et al. 2021), surface measurements data provide crucial input to validate model data (Yang and Bright 2020). To illustrate such application, the Gobabeb BSRN data are compared to *SWD* and *DIR* values extracted from the PVGIS database (PVGIS 2022).

In that comparison (Figure 9) the overall agreement for the average daily *SWD* is very good with a measured value of 6.7 kWh m^{-2} compared to the PVGIS value of 6.6 kWh m^{-2} (-1.7%). For *DIR* the deviation is larger with a measured daily average of 8.4 kWh m^{-2} compared to the PVGIS value of 7.8 kWh m^{-2} (-7.4%). The absolute differences ΔSWD show no correlation with the magnitude of *SWD* (Figure 9a) but there is a slight dependence on time of the year (Figure 9b) with a minimum in March/April and a maximum in August/September. However, ΔDIR increases with the magnitude of *DIR* (becomes more negative) and it shows a similar seasonal course to that of *SWD* but with a larger amplitude. This variation in *DIR* is likely linked to the seasonal change in atmospheric turbidity (Salmon et al. 2021) over southern Africa, which is apparently not properly represented in models (Di Napoli et al. 2020). The aerosol load is high during austral spring due to biomass burning (Formenti et al. 2019) and relatively low in autumn. The values above 5% in Figure 9b are all from August/September 2017 when clear sky *DIF* was particularly high due to high atmospheric turbidity.

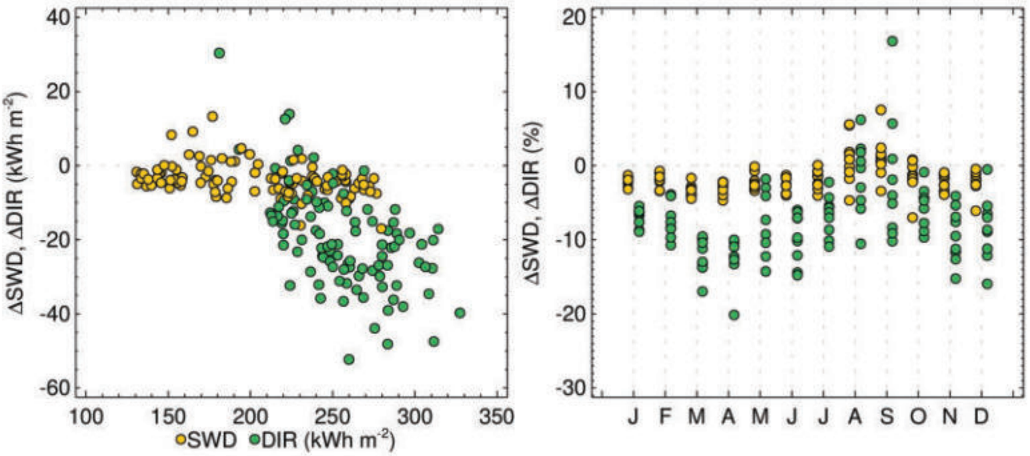

Figure 9: Absolute (a) and relative (b) differences between modelled (PVGIS) and measured monthly averages (BSRN) for SWD and DIR. Measured values are subtracted. Modelled "Global horizontal irradiation" (=SWD) and "Direct Normal Irradiation" (DIR) were downloaded from PVGIS (2022) for coordinates of Gobabeb.

4 Summary and Conclusions

The Baseline Surface Radiation Network (BSRN) is the largest research-grade solar radiation monitoring network world-wide and has been operational since 1992. The Gobabeb BSRN location has been operational since 2012, with two sites in the Central Namib to measure downward and upward radiation fluxes respectively. It is operated jointly by the University of Basel, Gobabeb - Namib Research Institute, and the Karlsruhe Institute of Technology. The Gobabeb BSRN is exceptional as it has provided the longest continuous dataset in sub-Saharan Africa south of the Equator. Excluding Antarctica, it is also one of only two Southern Hemisphere locations to provide both downward and upward radiation data. Although logistical issues do not allow the recommended frequent calibration of instruments, data collection and verification protocols include replication and comparison of measurements to detect and exclude unreliable data. A central repository provides open access to BSRN data at bsrn.awi.de.

The Gobabeb BSRN data is of exceptional quality, hence variations in the various elements of radiation reveal the effects of the nearby cold South Atlantic Ocean and its associated stratus clouds, as well as seasonal fluctuations in atmospheric aerosols transported from the interior of southern Africa over the ocean. Stratus clouds advected inland intersect the rising topography, resulting in fog during the night and early morning, which affects the BSRN radiation measurements. Seasonal and daily patterns in fog incidence is clearly detectible in the BSRN data. Similarly, analysis of the different data elements shows the seasonal effects of high-altitude aerosols on solar radiation, which has its greatest effect on the radiation data at Gobabeb BSRN during August and September. The BSRN data not only helps in the understanding of Earth's energy budget, the high-quality data are also valuable for solar resource assessments to estimate potential energy production and economic feasibility of solar energy investments.

Beyond its global purpose, the Gobabeb BSRN data also can help understand variability and processes in Namibia's climate, as well as Namibia's potential for solar energy production. Frequent and continued use of Gobabeb BSRN data has already proved its international value. In Namibia, however, this resource is still not being used as it might, even a decade later. We can only hope that after ten years of operations, the future will bring greater local interest and involvement in a rich and outstanding resource.

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