Comparison of meteorological data from different sources for Bishkek city, Kyrgyzstan

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Abstract

Meteorological data from different sources (a local weather station, Meteonorm 5.1 and 6.0 as well as own measurements) have been compared with each other for Bishkek, Kyrgyzstan. It was identified that Bishkek city in Meteonorm 5.1 and 6.0 has wrong altitude (2111 m instead of 760 m), which leads to significantly lower ambient temperatures. Therefore, it is necessary to define Bishkek manually as a new site with the correct coordinates. In this case the ambient temperatures are in agreement with those measured by the weather station Frunze. Annual global solar irradiation from own measurements (≈1500 kWh/m²a) and weather station Frunze (1572 kWh/m²a) are in a good agreement, while its values from Meteonorm 5.1 and 6.0 are approx. 20% lower. Furthermore, monthly sums of global solar irradiation generated with Meteonorm 5.1 have an untypical trend in summer, having two local maximum points. This is inconsistent with irradiation data from other sources and with the sunshine duration in the relevant period. The data from Meteonorm should be proved on plausibility, particularly for sites or stations in developing countries.

1. Introduction

For designing and dimensioning of solar plants and prediction of solar gains it is important to have precise meteorological data, i.e. data of solar radiation, ambient temperatures and wind velocity. Meteorological data for different places can be taken from own measurements, reference books, weather stations or generated with special software (e.g. Meteonorm[1]).

For Bishkek, the capital of the Kyrgyz Republic in Central Asia, basically, three sources of meteorological data are available: a local weather station Frunze, a software Meteonorm (only versions 5.1 and 6.0 are considered in this study) and own measurement data (only radiation). Geographical coordinates of Bishkek are 74.5°E longitude, 42.8°N latitude (comparable with Rome) and 760 m altitude. The climate is strong continental (hot summer, cold winter, high number of sunny days).

The objective of this investigation is to compare these sources of meteorological data with each other regarding average annual ambient temperatures and solar radiation data.

2. Meteorological data

2.1 Meteorological station “Frunze”

[1] www.meteonorm.com

The central administrative board on hydrometeorology of the Ministry of Emergencies of the Kyrgyz Republic is entitled to measure meteorological and hydrological data in the Kyrgyz Republic. There are in total 31 weather stations and 75 hydrological stations. One of the weather stations "Frunze" is situated in the west part of Bishkek. The measurement equipment is remained from the USSR period. An actual value of global and diffuse solar radiation is measured 5 times a day at 6.30, 9.30, 12.30, 15.30 and 18.30. Till 1993 daily solar irradiation on horizontal surface was measured by an integrator. This device is, however, absent since 1993 for technical reasons. Therefore, since 1993 daily solar irradiation is estimated by linear interpolation of solar radiation between 5 measured points taking into account the time of sunrise and sunset (the so-called trapezium method). The central administrative board on hydrometeorology claims the accuracy of this method to be in the range of 10% for monthly sums of solar radiation.

2.2 Meteonorm program

Meteorological data can be generated with Meteonorm using a database with long term monthly average measurement data from different stations. In the recent software versions there are more than 7000 meteorological stations worldwide available. If no meteorological station is available in the database for a desired site, meteorological data will be interpolated based on the data of the nearest stations. The accuracy of the generated data depends on the accuracy of measurements of used stations in the database, the distance to the next stations and the interpolation method.

A density of weather stations in the program database is relatively low for Central Asia compared to Europe. In total, about 100 stations are available in the program database (5.1 and 6.0) for Central Asia with data for ambient temperature, humidity, velocity and wind direction, precipitation and only 3 stations with solar radiation data. The mentioned station Frunze in Bishkek is available in the program database, but without solar radiation data. The nearest database station to Bishkek with solar radiation data is about 600 km away in Tashkent, Uzbekistan. Unlike previous versions, Meteonorm 6.0 uses satellite-derived solar radiation data additionally to the weather stations for interpolation of solar radiation.

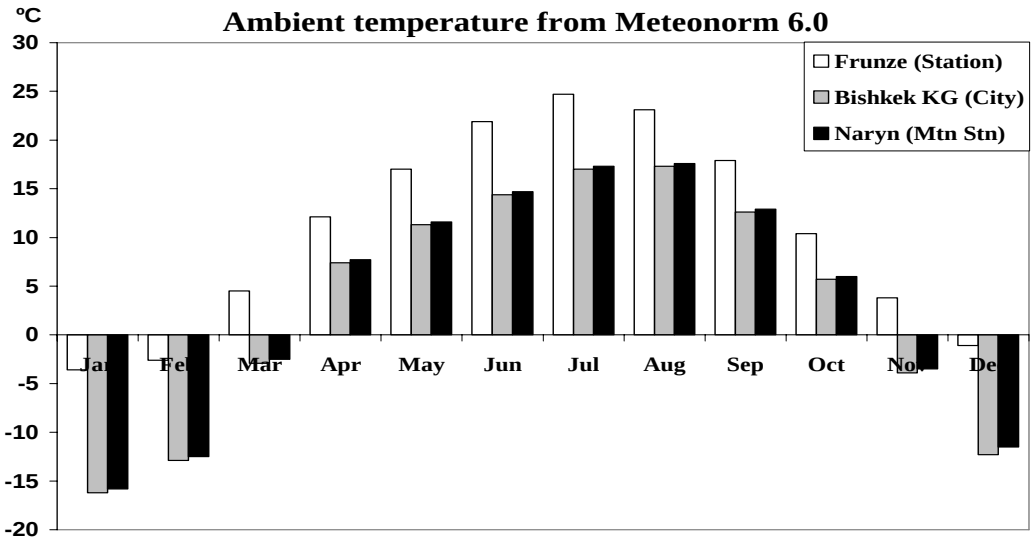

Fig.1. Long-term monthly average ambient temperatures from Meteonorm 6.0 for Bishkek city (predefined in Meteonorm), weather station Frunze and Naryn available in the program database.

Bishkek city is already defined in Meteonorm 5.1 and 6.0 but with a wrong altitude of 2111 m instead of 760 m. This leads to significantly lower ambient temperatures compared to the measured

values at the weather station Frunze (Fig 1). Because of the wrong altitude, ambient temperature for Bishkek was obviously interpolated by Meteonorm using data from a station Naryn (about 300 km away) with a similar altitude of 2041 m. Thus, it is necessary for further investigations to define Bishkek in Meteonorm manually as a new site with the correct coordinates.

2.3 Own measured data.

A multicomponent solar thermal system was installed in Bishkek to preheat water for a district heating net in the context of a joint research project of Kassel University (Germany) and Kyrgyz State Technical University in Bishkek (Kyrgyzstan). For detailed investigations different parameters including solar radiation are measured since autumn 2004 with very accurate sensors every 15 seconds to generate one-minute mean values. Solar radiation is measured with pyranometer Kipp&Zonen CM11 with an accuracy of 1.5% of the measured values. For some periods, however, the measurement data is missing for different reasons (e.g. technical problems with the sensor power supply unit or no power supply at all). For this study mean values of monthly solar irradiation were generated from the available measurement data for the period 2005 – 2007.

3. Comparison of meteorological data

The focus of this study is to compare values of ambient temperature and solar irradiation from the mentioned sources because these two parameters are the most important for estimation of solar energy gains. The following abbreviations are applied for the sources of meteorological data:

- FrunzeM – measurements from weather station Frunze
- Met 5.1 and Met 6.0 – Meteonorm 5.1 and Meteonorm 6.0 respectively
- MD – own measurement data

A fluctuation of mean annual ambient temperatures measured by the local meteorological station Frunze since 1928 and long term mean ambient temperatures are shown in Fig. 2.

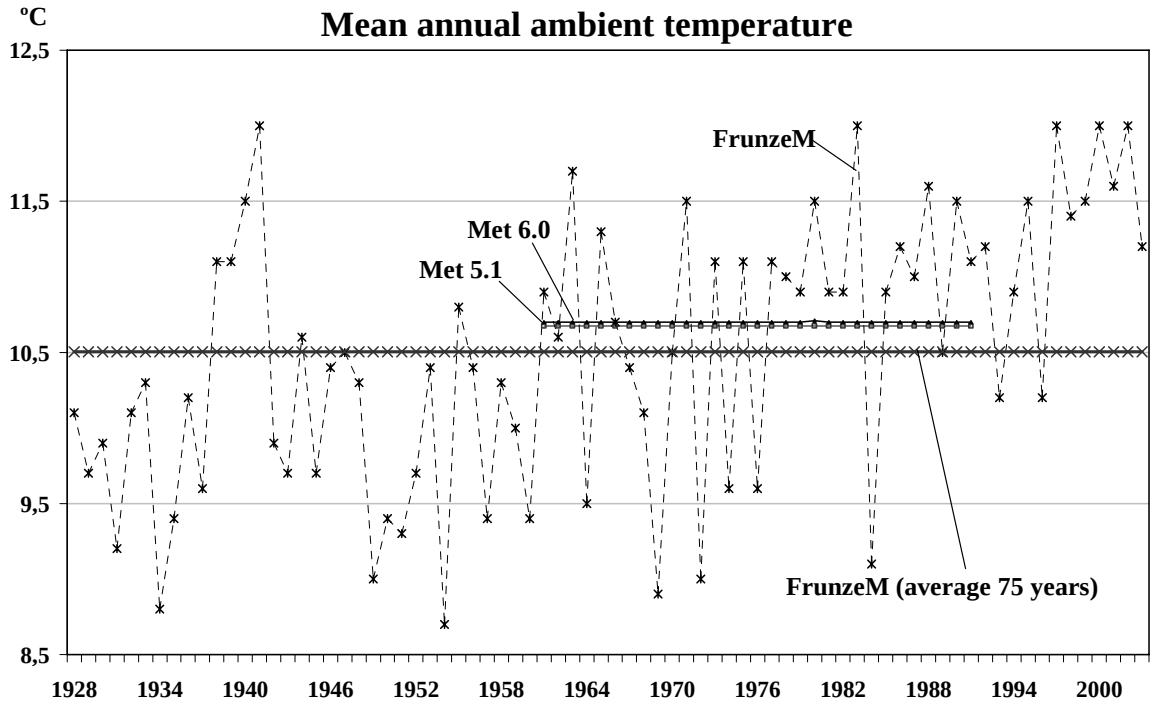

Fig. 2. Long-term mean temperatures and the change of annual ambient temperatures from different sources.

A long term mean temperature from both versions of Meteonorm is about 0.2 K higher than that measured by the station Frunze. The difference results from different periods considered. In Meteonorm a long-term mean ambient temperature is calculated for the period from 1961 till 1990 (30 years), while a mean temperature from the station Frunze is calculated for the period from 1928 till 2003 (75 years). For the same period 1961-1990, mean temperatures from the station Frunze and Meteonorm are in agreement (see Table 1).

Table 1. Long-term mean ambient temperature in ºC for Bishkek in the period 1961-1990.
1) Meteonorm 5.1, 2) Meteonorm 6.0, 3) Frunze meteostation.

№	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year
1)	-3.6	-2.6	4.5	12.1	17.0	21.9	24.7	23.1	17.9	10.4	3.8	-1.1	10.7
2)	-3.6	-2.6	4.5	12.1	17.0	21.9	24.7	23.1	17.9	10.4	3.8	-1.1	10.7
3)	-3.8	-2.6	4.5	12.1	17.0	22.0	24.7	23.4	17.8	10.4	3.6	-1.1	10.7

A fluctuation of annual global solar irradiation and its mean values from different sources are shown in Fig. 3. The annual global solar irradiation from the station Frunze for the years 2003-2007 is estimated from 6 solar radiation measurements per day (see section 2.1).

Annual global solar irradiation from own measurements (≈1500 kWh/m²a) and the weather station Frunze (1572 kWh/m²a) are in a good agreement, while its values from Meteonorm 5.1 and 6.0 are approx. 20% lower (see Fig. 3) and even out of the fluctuation range.

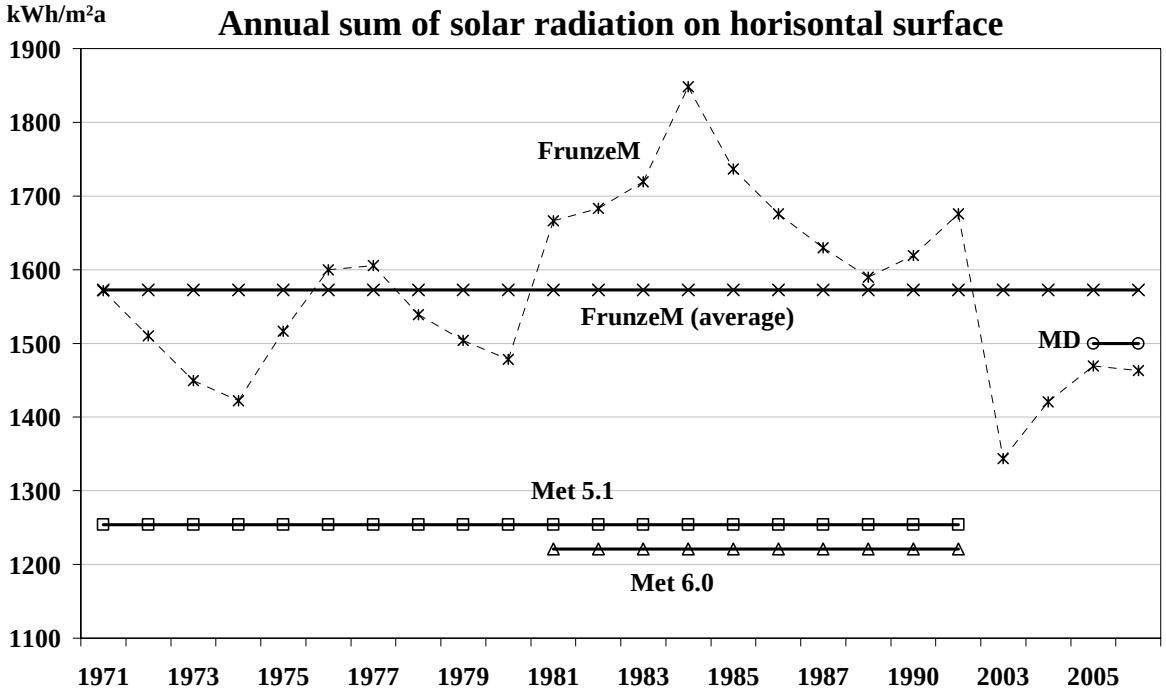

Fig. 3. Annual solar irradiation on horizontal surface for Bishkek from different sources.

As shown in Fig. 4, the solar irradiation from Meteonorm and other sources are in a good agreement in winter. In the period March – September the monthly diffuse solar irradiation values generated with Meteonorm are higher than the measured values, which leads to lower global solar irradiation values. The higher values of diffuse solar irradiation in Meteonorm are probably caused

by admitting higher cloudiness or air pollution. Furthermore, the concavity in summer of the monthly global solar irradiation generated with Meteonorm 5.1 is not typical for a continental climate. It is also inconsistent with the monthly sunshine duration for Bishkek (see Fig. 5), which has no concavity or only one maximum point.

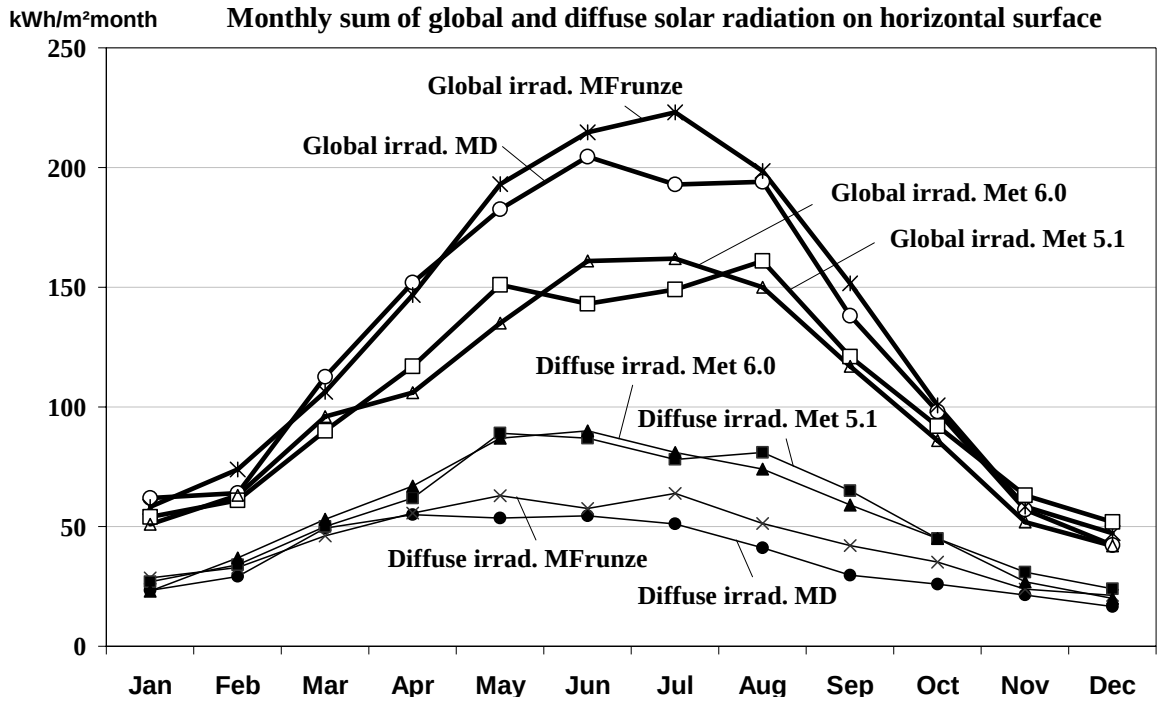

Fig. 4. Monthly global and diffuse solar irradiation for Bishkek from different sources.

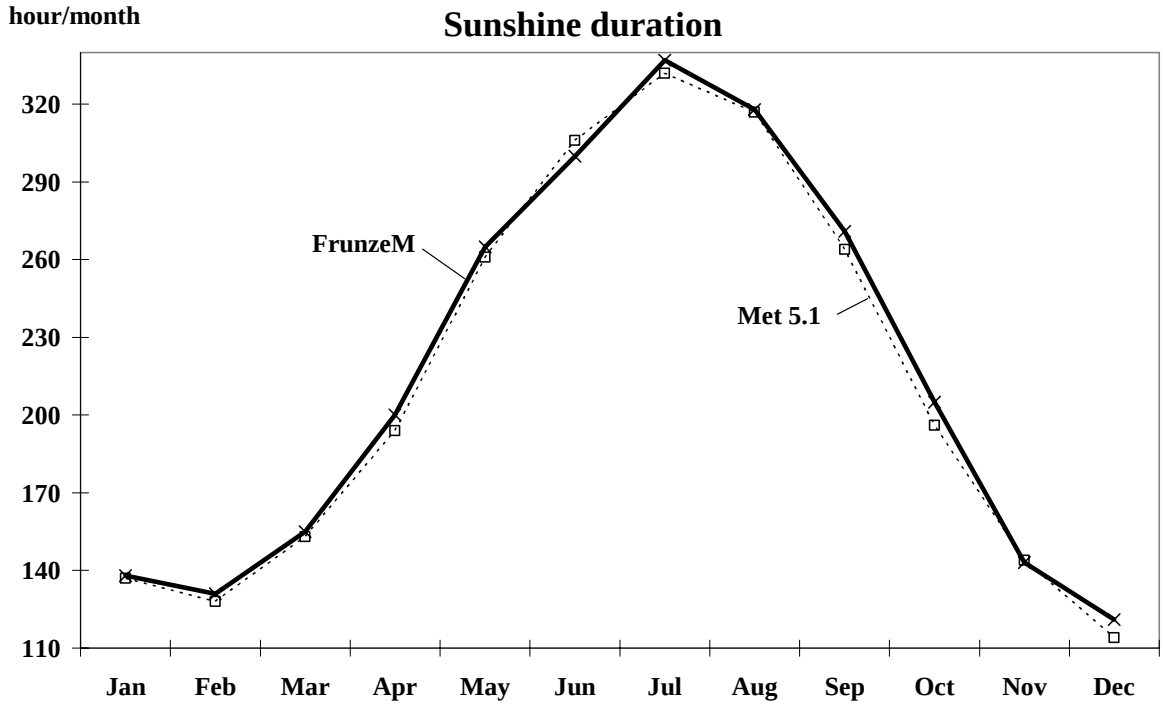

Fig. 5. Sunshine duration for Bishkek city.

If the latitude of Bishkek in Meteonorm 6.0 is changed from 42.8°**N** to 42.2°**N**, annual global irradiation increases to 1466 kWh/m²a (+20%) and annual diffuse irradiation decreases to

618 kWh/m²a (-7%). Thus, the radiation data for 42.2°**N** latitude is in the same range with the measurement data from the local weather station Frunze and the research project (MD). The same tendency occurs if the latitude of Bishkek is changed from 42.8°**N** to 43.4°**N** (1468 and 625 kWh/m²a or +20% and -6% respectively). This high change in the radiation data for a little change in the location is probably caused by the interpolation method of Meteonorm.

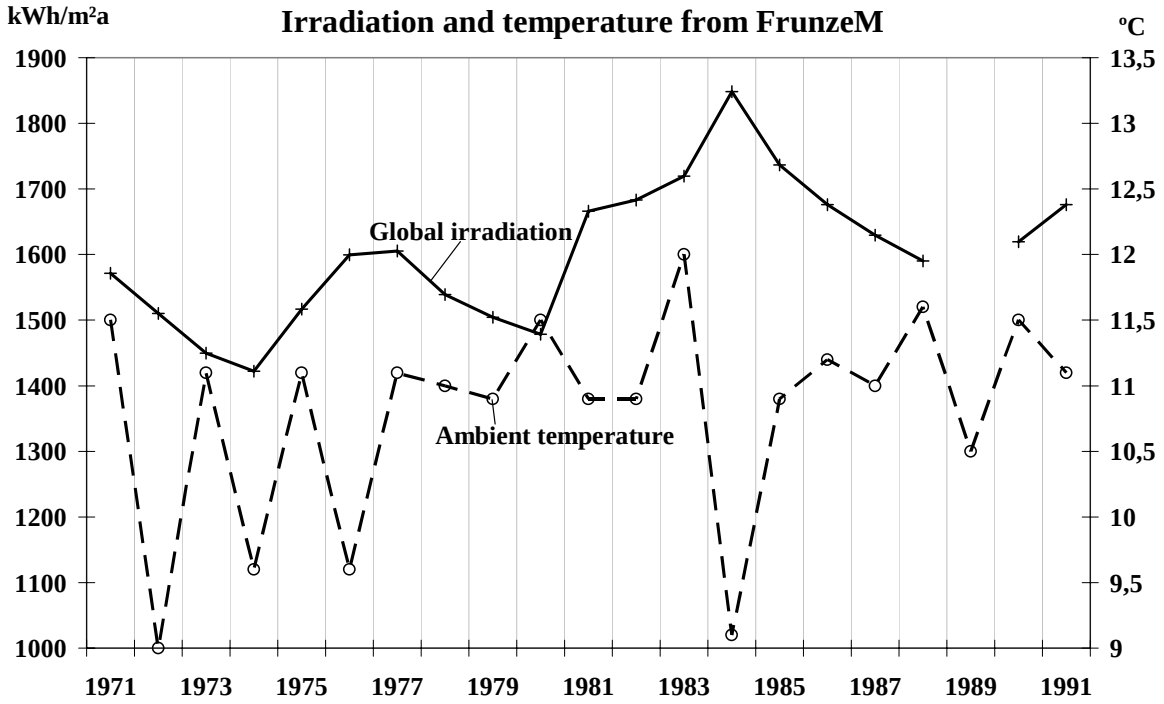

Fig.6 The annual solar irradiation on horizontal surface and the mean annual ambient temperature measured on the weather station Frunze in the period 1970 – 1991.

As shown in Fig. 6, the annual global solar irradiation and the mean annual ambient temperature measured at the weather station Frunze in the period 1970 – 1991 are not positively correlated. The seasons (summer, autumn, winter, spring) and single months have the same tendency. The reason is that the weather and the ambient temperature in Kyrgyzstan are influenced not only by solar radiation but also by 17 weather processes [5], e.g. Siberian anticyclone brings cold air from Siberia.

4. Conclusion

Solar radiation and ambient temperature data from different sources (a local weather station, Meteonorm 5.1 and 6.0 and own measurements) have been compared with each other for Bishkek, Kyrgyzstan in this study. It was identified that the altitude of Bishkek city in Meteonorm is wrongly defined (2111 m instead of 760 m), which leads to significantly lower ambient temperatures. Therefore, it is necessary to define Bishkek manually as a new site with the correct coordinates. In this case the ambient temperatures are in agreement with those measured by the weather station Frunze.

Annual global solar irradiation from own measurements (1500 kWh/m²a) and weather station Frunze (1572 kWh/m²a) are in a good agreement, while its values from Meteonorm 5.1 and 6.0 are approx. 20% lower. Correspondingly, the ratio of the direct and diffuse solar irradiation is much lower in the Meteonorm data (approx. 1) than in the weather station Frunze data and own

measurement data (approx. 2). Furthermore, monthly sums of global solar irradiation generated with Meteonorm 5.1 have an untypical trend in summer, having two local maximum points. This is inconsistent with irradiation data from other sources and with the sunshine duration in the relevant period.

Such differences in solar radiation data can lead to significantly different solar gain predictions, especially if the solar irradiation on a tilted surface shall be calculated. Thus, the source of meteorological data shall be carefully selected. For sites, close to weather stations with relevant data available in the Meteonorm database, data generated with Meteonorm can be applied. If no weather station with relevant data close to the desired site available in Meteonorm database, other sources should be considered too, e.g. satellite-derived radiation rata, local meteorological stations or own measurements. In both cases, the data from Meteonorm should be proved on plausibility, particularly for sites or stations in developing countries.

Acknowledgements

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