COMPARISON OF CM-SAF SIS AND SURFACE RADIATION DATA IN TURKEY FOR THE YEAR 2006

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ABSTRACT

In this study, CM-SAF remote sensing SIS (Surface Incoming Solar Radiation) and Turkish in-situ surface radiation data have been compared for Turkey for the year 2006. According to sunshine duration and radiation data measured by TSMS from 1971 to 2000, Turkey's annual mean total sunshine hours are 2573 (daily mean is 7h) and mean total radiation is 1474 KWh/m²-year (daily 4 KWh/m²). CM-SAF SIS products of the year 2006 have been extracted by using the IDL based CM-SAF GUI available from the CM SAF webpage. Surface radiation data unit was cal/cm²/day and CM-SAF SIS data unit was W/m². These two units have been converted to KWh/m².

Geographic variables are measured at certain points, and prediction map for the entire area is been obtained by Inverse Distance Weighted (IDW) spatial interpolation method. Data have been designed and calculated by using Excel. ArcGIS 9.3 is used for spatial interpolation, raster calculation and mapping activities.

According to residual map, in the western part of the country CM-SAF SIS values are greater than in-situ observation while mountainous eastern part and around Afyon, Burdur, Cankırı, Kayseri, Nigde and Karaman CM SAF SIS values are smaller. Correlation coefficient has been found as 0.71 between two series.

Keywords: Turkey, CM-SAF, SIS, radiation, comparison.

Introduction

Small portion of the incoming solar energy into the world is sufficient to meet human needs. For this reason nowadays to use renewable energy sources is very important to protect atmosphere. Spatial distribution of geographic data can be obtained only from this data and also prediction map can be obtained by using secondary variables which have spatial relationship with the measured values (Bostan, P. A., et al, 2007). This study is related to comparison of annual radiation of CM-SAF SIS and Turkish in-situ surface radiation data for the year 2006.

Material and Methods

In this study 157 Turkish climatic stations' radiation data were used. CM-SAF SIS products of the year 2006 have been extracted by using the IDL based CM-SAF GUI available from the CM SAF webpage. Data have been designed and calculated by using Excel. ArcGIS 9.3 is used for spatial interpolation and mapping activities.

To obtain descriptive information about the data, correlation coefficient and residual map have been calculated, imaging and interpolation studies were applied. Two maps have been generated by using ArcGIS 9.3 Spatial Analyze Inverse Distance Weighted (IDW) interpolation technique. Inverse distance weighted methods are based on the assumption that the interpolating surface should be influenced most by the nearby points and less by the more distant points. The interpolating surface is a weighted average of the scatter points and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases. Several options are available for inverse distance weighted interpolation. After that residual map have been generated by using raster calculation in spatial analyze.

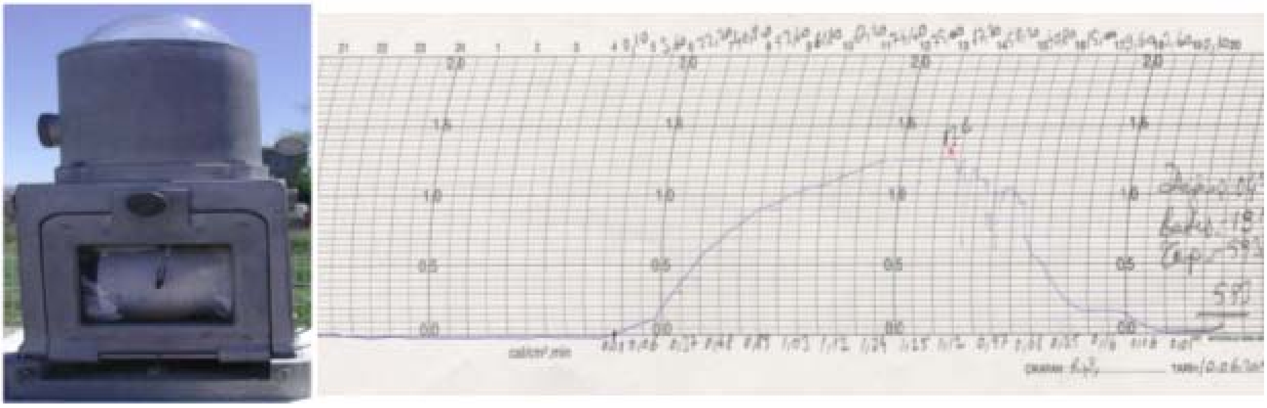

Figure 1. Robitzch Actinograph and its actinogram. 1 minute radiation couldn't be greater than 2cal/cm². Two points values select to calculate hourly radiation and average of them multiply by 60. If line isn't properly due to cloudiness, average of 5 points values multiply by 60.

Turkish surface radiation data has been observing via actinography (Fig. 1) which unit is cal/cm²/day. In Turkey there are 161 Actinograph to observe solar radiation.

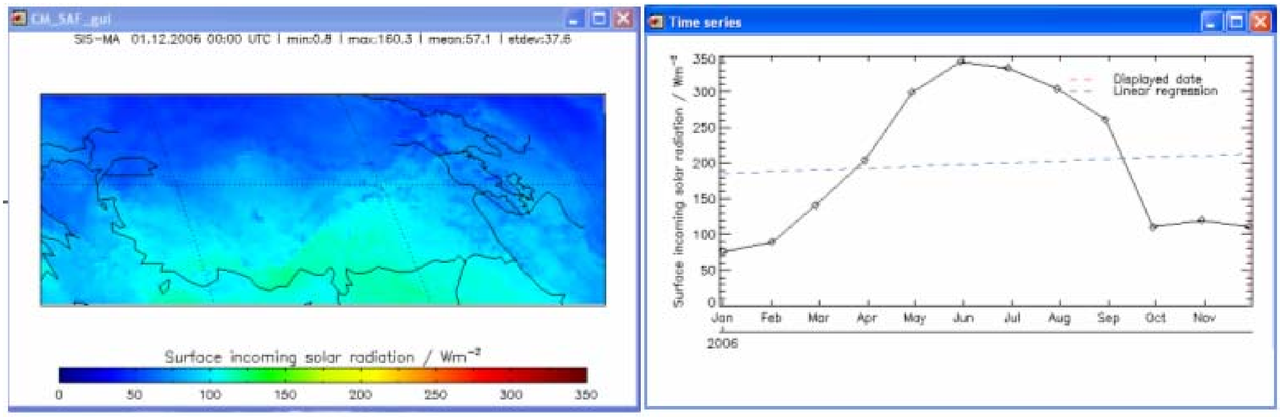

Figure 2.CM SAF Surface Incoming Solar Radiation (SIS), extracted using the IDL based CM SAF GUI. Monthly Mean of December 2006 (right); annual cycle of 2006 (left).

CM SAF SIS data unit is W/m² (Fig. 2). These two units have been converted to KWh/m²/year by using below formula (Url 4):

$$kWh/m^2/year = \left(\sum_{i=1}^{12} MonthlyMean[cal/cm2]\right) * 365/1000 * 11.63 \quad \text{(for TSMS data)}$$

$$kWh/m^2/year = \left(\sum_{i=1}^{12} MonthlyMean[W/m2]\right) * 365 * 24/(1000 * 12) \quad \text{(for CM-SAF SIS data)}$$

Correlation coefficient has been calculated by below formula:

$$\rho_{x,y} = \frac{Cov(X,Y)}{\sigma_x \cdot \sigma_y}$$

where;

$$-1 \leq \rho_{xy} \leq 1$$

and

$$Cov(X,Y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu_x)(y_i - \mu_y)$$

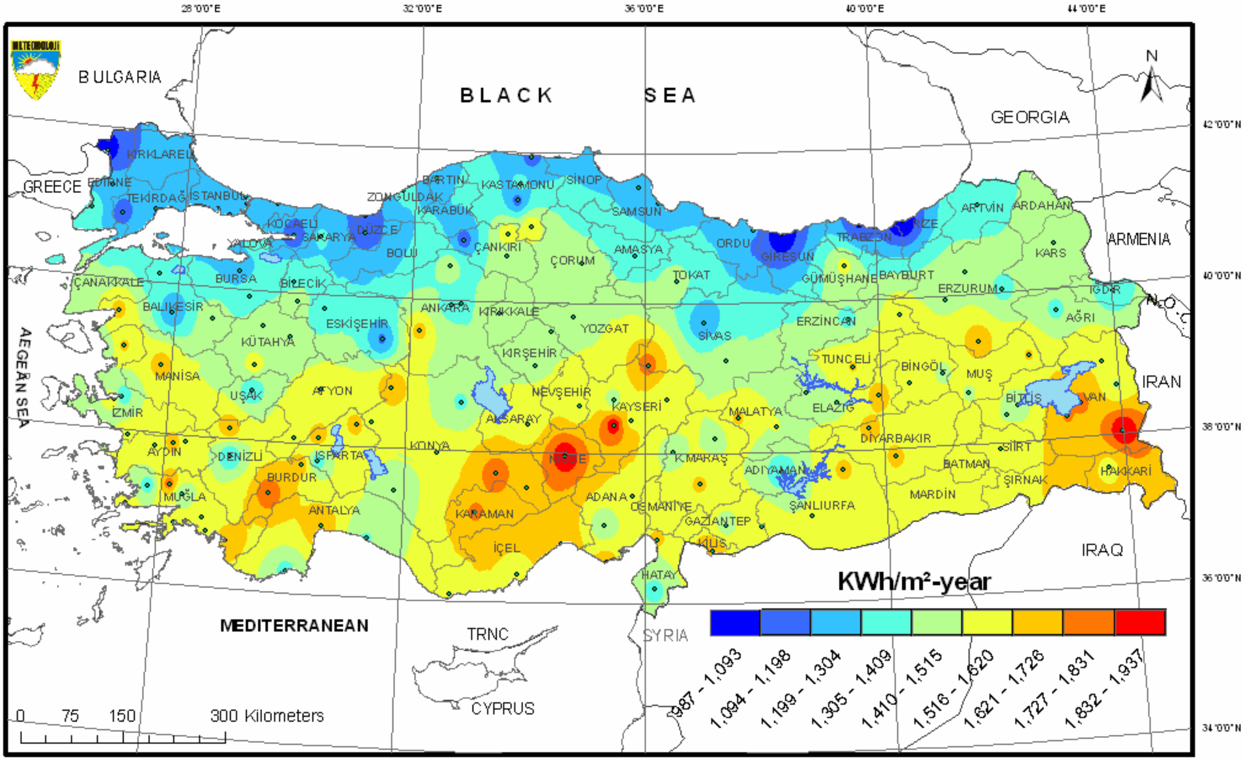

Figure 3. Surface radiation map for the year 2006 based on the Turkish actinography network

Surface radiation map have been generated by using ArcGIS 9.3 Spatial Analyze Inverse Distance Weighted interpolation technique (Fig. 3). Inverse distance weighted methods are based on the assumption that the interpolating surface should be influenced most by the nearby points and less by the more distant points.

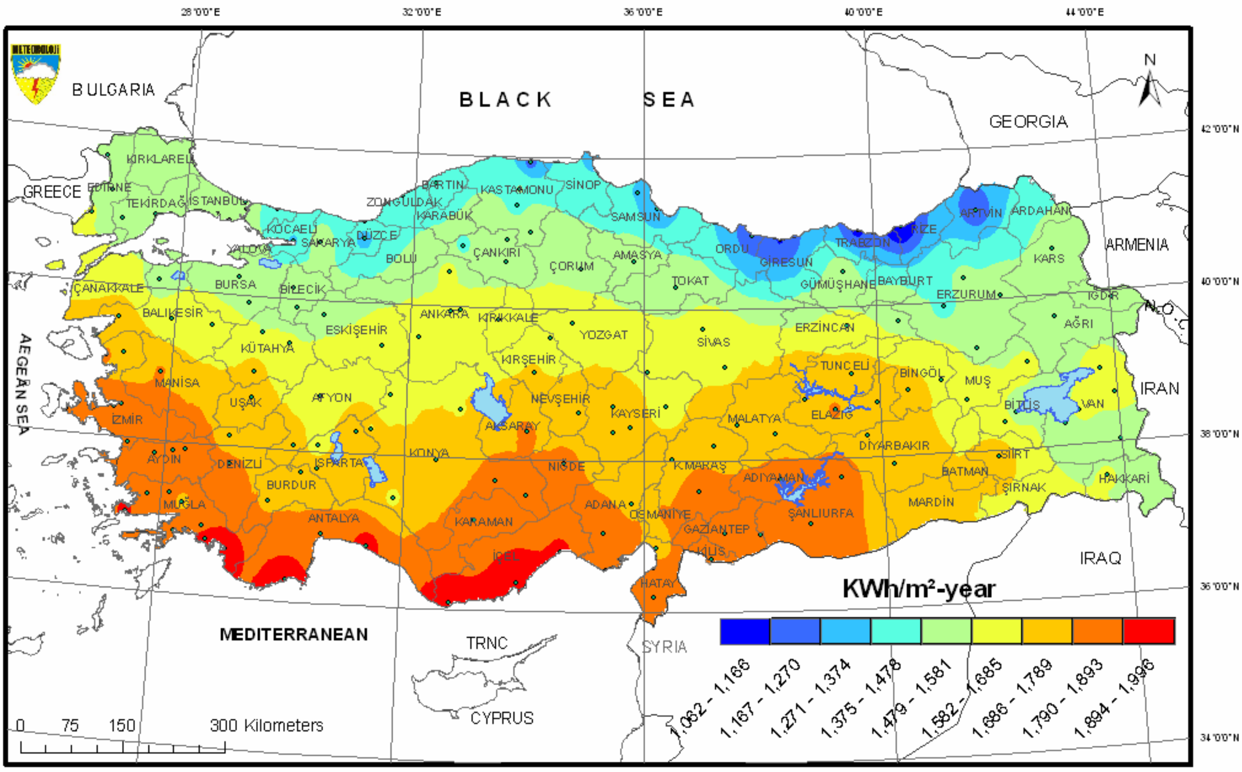

Figure 4. Surface radiation map for the year 2006 based on CM-SAF SIS data

CM-SAF SIS map have been generated by using ArcGIS 9.3 Spatial Analyze Inverse Distance Weighted interpolation technique (Fig. 4).

Results

Surface radiation data unit was cal/cm²/day and CM-SAF SIS data unit was W/m². These two units have been converted to KWh/m² (Url 4).

Table 1. Comparison of surface radiation data via satellites

Longitude	Latitude	Station	Surface Radiation 2006-Kcal	Surface Radiation 2006-KWh/m2	CM-SAF SIS 2006-KWh/m2	Differences
35.34	37.04	ADANA	122.0	1418.7	1821.4	402.7
38.28	37.74	ADIYAMAN	113.3	1318.1	1850.6	532.5
30.54	38.73	AFYON	136.8	1591.3	1595.1	3.7
43.04	39.71	AGRI	119.5	1390.3	1503.8	113.5
34.04	38.38	AKSARAY	131.7	1531.8	1799.5	267.7
35.84	40.64	AMASYA	119.5	1390.3	1569.5	179.2
32.86	39.96	ANKARA	119.2	1386.3	1602.4	216.1
36.16	36.19	ANTAKYA	117.5	1366.4	1850.6	484.2
30.67	36.91	ANTALYA	147.2	1711.9	1854.2	142.3
41.81	41.18	ARTVIN	116.1	1350.1	1215.5	-134.7
27.83	37.83	AYDIN	134.1	1559.4	1865.2	305.8
27.93	39.61	BALIKESIR	103.1	1199.1	1580.5	381.4
32.34	41.63	BARTIN	109.6	1274.3	1390.7	116.4
29.97	40.14	BILECIK	118.8	1381.7	1522.1	140.4
40.49	38.86	BINGOL	135.1	1571.2	1719.2	148.0
42.09	38.36	BITLIS	129.8	1509.6	1609.7	100.0
30.29	37.71	BURDUR	145.2	1688.7	1730.1	41.4
29.01	40.23	BURSA	105.1	1222.6	1529.4	306.8
26.39	40.13	CANAKKALE	122.5	1424.5	1642.5	218.0
33.61	40.61	CANKIRI	124.0	1442.6	1562.2	119.6
34.92	40.54	CORUM	124.0	1442.1	1551.3	109.2
29.09	37.76	DENIZLI	111.6	1297.9	1792.2	494.3
40.19	37.89	DIYARBAKIR	139.8	1626.0	1752.0	126.0
31.14	40.84	DUZCE	100.3	1166.3	1354.2	187.8
26.54	41.68	EDIRNE	89.0	1034.5	1518.4	483.9
39.24	38.64	ELAZIG	125.9	1463.9	1795.8	331.9
39.49	39.74	ERZINCAN	119.2	1386.9	1602.4	215.5
41.16	39.94	ERZURUM	129.8	1509.4	1452.7	-56.7
30.51	39.81	ESKISEHIR	112.5	1308.7	1576.8	268.1
37.34	37.04	GAZIANTEP	126.8	1474.9	1825.0	350.1
38.38	40.91	GIRESUN	86.1	1001.5	1160.7	159.2
39.46	40.46	GUMUSHANE	132.5	1540.8	1544.0	3.1
43.73	37.56	HAKKARI	137.1	1594.2	1584.1	-10.1
44.04	39.91	IGDIR	113.1	1315.9	1511.1	195.2
30.56	37.78	ISPARTA	114.0	1326.1	1719.2	393.1
29.05	41.14	ISTANBUL	112.1	1303.4	1544.0	240.6
27.08	38.39	IZMIR	136.4	1586.1	1817.7	231.6
36.92	37.59	KAHRAMANMARAS	140.6	1634.9	1846.9	212.0
33.21	37.19	KARAMAN	149.3	1736.8	1806.8	70.0
43.09	40.61	KARS	123.7	1439.1	1496.5	57.4
33.78	41.36	KASTAMONU	99.3	1155.4	1452.7	297.3
35.48	38.71	KAYSERI	124.6	1448.9	1704.6	255.6
37.11	36.69	KILIS	148.6	1728.0	1887.1	159.0
33.51	39.84	KIRIKKALE	125.1	1455.1	1638.9	183.8
34.14	39.16	KIRSEHIR	127.9	1487.8	1690.0	202.2
29.91	40.76	KOCAELI	95.5	1111.2	1361.5	250.3
32.54	37.97	KONYA	130.8	1521.6	1737.4	215.8
29.97	39.41	KUTAHYA	126.5	1471.7	1587.8	116.0
38.21	38.34	MALATYA	130.4	1516.5	1686.3	169.8
34.63	36.79	MERSIN	148.4	1726.5	1909.0	182.5
28.36	37.21	MUGLA	121.8	1416.6	1759.3	342.7
41.48	38.68	MUS	129.7	1508.8	1675.4	166.5
34.68	37.96	NIGDE	166.2	1932.6	1810.4	-122.2
37.89	40.97	ORDU	103.5	1204.2	1233.7	29.5
40.49	41.03	RIZE	84.9	986.9	1062.2	75.3
30.39	40.76	SAKARYA	113.2	1317.0	1522.1	205.1
36.24	41.34	SAMSUN	104.9	1219.6	1295.8	76.1
38.78	37.14	SANLIURFA	130.6	1518.9	1821.4	302.5
41.94	37.91	SIIRT	137.6	1600.1	1781.2	181.1
35.14	42.03	SINOP	104.1	1210.9	1354.2	143.2
37.01	39.74	SIVAS	103.8	1207.2	1631.6	424.3
27.49	40.97	TEKIRDAG	111.2	1293.0	1562.2	269.2
36.56	40.29	TOKAT	123.8	1439.6	1522.1	82.5
39.74	41.00	TRABZON	93.3	1085.3	1146.1	60.8
39.54	39.11	TUNCELI	139.9	1626.6	1719.2	92.6
29.39	38.66	USAK	112.7	1310.9	1719.2	408.2
43.34	38.46	VAN	150.7	1752.9	1606.0	-146.9
29.28	40.66	YALOVA	115.2	1339.8	1481.9	142.1
34.79	39.81	YOZGAT	121.6	1413.9	1635.2	221.3
31.78	41.44	ZONGULDAK	114.0	1325.9	1416.2	90.3

Correlation coefficient : 0.71

Usually satellite radiation data are greater than in-situ. Big differences have been found for some cities (yellow color). Also negative differences have been found in Van, Artvin, Niğde, Hakkari and Erzurum. Correlation coefficient has been found as 0.71 between two series.

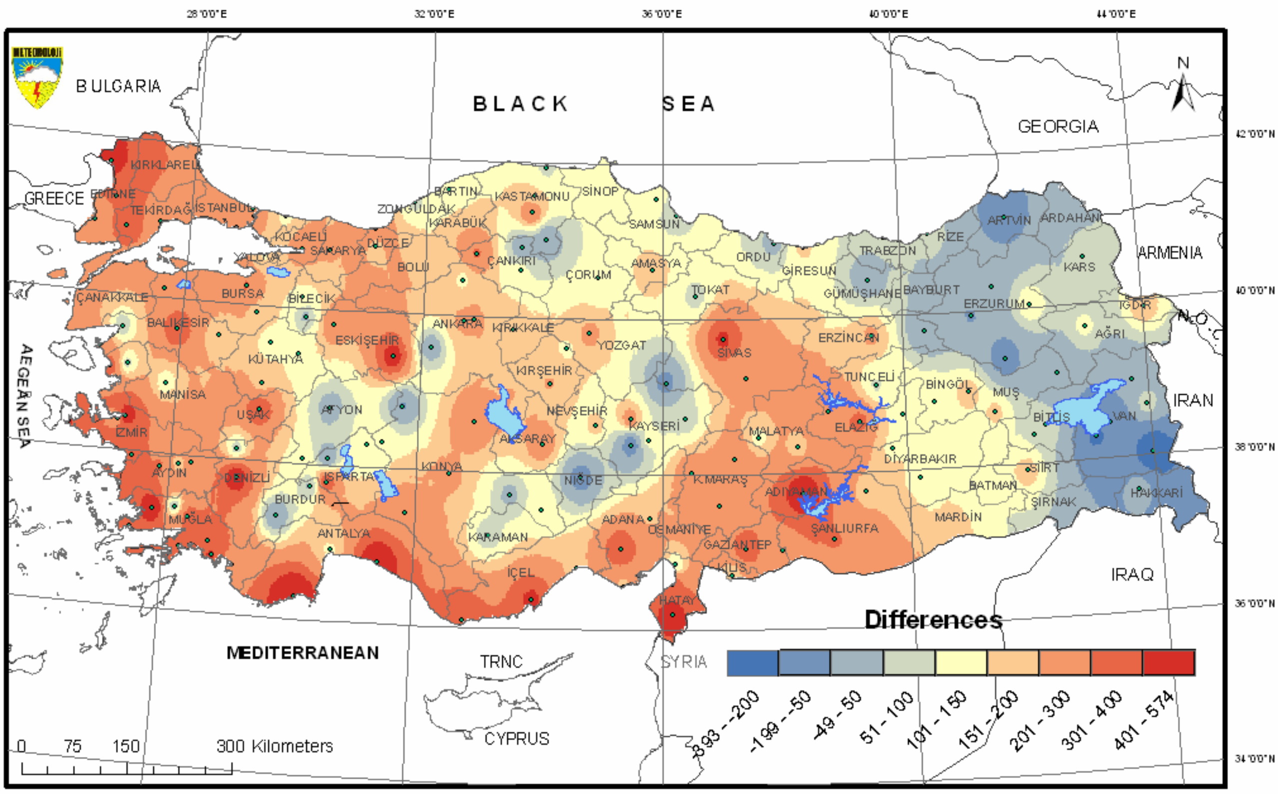

Figure 5. Differences between CM-SAF SIS and surface radiation data for the year 2006 (CM SAF – ground). Positive values indicate that CM SAF data is larger, negative values indicate that ground measurements are larger. Residual map have been generated by using raster calculation tool in the spatial analyze (Fig. 5).

Correlation coefficient has been found as 0.71 between two series. According to residual map, in the western part of the country CM-SAF SIS values are greater than in-situ observation while mountainous eastern part and around Afyon, Burdur, Cankırı, Kayseri, Nigde and Karaman CM SAF SIS values are smaller (Fig. 5). While surface radiation values are in between from 987 to 1937 KWh/m²/year (Fig 3), satellite observation values (CM-SAF SIS) range are from 1062 to 1996 KWh/m²/year (Fig 4) in 2006.

Conclusion

This study is aimed to compare annual radiation of CM-SAF SIS and Turkish in-situ surface radiation data for the year 2006. It has been found that satellite based CM-SAF SIS (Surface Incoming Solar Radiation) values are greater than surface data in the western part of the country. But especially in the mountainous eastern part and around Afyon, Burdur, Cankırı, Kayseri, Nigde and Karaman CM-SAF SIS data has been found below surface irradiance data retrieved from actinography observations. Muneer (1997) reported that the Robitzch actinograph, even with all the modifications to improve its accuracy, provides an accuracy of around 10% for daily sums, which is in line with the manufacturer specifications. Significantly higher errors in the order of 30% for monthly means are reported by Stanhill and Calma (1994) for Australia. General limitations of actinograph observations are discussed in detail in Maxwell et al. (1999) evaluated and discussed actinograph observations in Saudi-Arabia. They found significant differences between actinograph and pyranometer especially during varying cloud conditions. As a result of the high uncertainty of actinograph observations reported in these publications it is expected that the accuracy of the satellite-based irradiance is significantly higher than that of actinometer observations. However, limitation of satellite based irradiance over snow-covered mountainous regions has to be considered for the interpretation of the results. In snow-covered mountainous regions the accuracy of the satellite-based irradiance drops down to15 W/m² for monthly means.

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