Surface Solar Radiation in the United States from 1961 to 1990

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Introduction

Natural and anthropogenic aerosol variations affect the total amount of solar radiation received at the ground. However, the variability of the aerosol impact on the radiation budget and therefore on global climate is still unknown. Because satellite observations cover only the last two decades, additional analysis of long-term actinometric records is needed to fill the gap and help to understand aerosol effects on climate change.

Data

Broadband surface solar radiation records for the United States from 1961 to 1990 are archived in the National Solar Radiation Data Base (NREL 1992, 1995). The data base consists of hourly global solar radiation measurements (diffuse plus direct) and hourly meteorological parameters including cloud cover and horizontal visibility. None of the measurements cover the entire time period. The missing data are mostly in the 1980s, and the gaps are bridged with modeled data. For this study, only measured data were used and 18 records were selected (Table 1). The clear sky time series of global solar radiation for each station were selected by the hourly cloud cover data and the corresponding hourly mean global solar radiation. “Clear sky” is defined as 0/10 of total cloud coverage at the beginning and at the end of an hour. For the homogeneity testing, additional information from the horizontal visibility observations were used to determine extremely clear sky hours with maximum visibility. The extremely clear sky solar radiation data sets were normalized by removing the daily and seasonal cycles. The homogeneity of the residuals was determined by visual examination.

All Sky Results

Trend analyses of the annual means of global solar radiation showed statistically significant changes over the time period from 1961 to 1990 for 16 out of 18 stations. The interpretation of these results are somewhat problematic because only about two-thirds of the entire time period was actually covered by measurements. The results, however, are in agreement with the results from other authors. For example, Abakumova et al. (1996) report statistically significant declines in global solar radiation at 60% out of 160 time series from the former Soviet Union, and Liepert and Kukla (1997) report declines of about 10% during three decades at selected German stations.

Clear Sky Results

In order to avoid the problem of gaps in the time series, mean annual cycles of global solar radiation for 3-year intervals were calculated from the monthly averages of all clear sky hours. Four different time periods were compared: 1961 to 1963, 1968 to 1970, 1978 to 1980 and 1988 to 1990. Overall, 11 out of 17 analyzed time series show a decline in clear sky global solar radiation from the earliest period to the latest suggesting that the amplitude of the seasonal cycle for 1988 to 1990 is smaller compared to the other periods. Only one station at Fresno, California, shows a clear increase between the time periods in the 1960s and late 1980s. The seasonal cycles of the global solar radiation for the stations at Omaha and El Paso are shown in Figures 1 and 2. The difference between the annual means from 1961 to 1963 and 1988 to 1990 are 9 W/m^2 for both time series.

Conclusion and Future Work

The analysis of hourly global solar radiation at the surface showed declines in the clear sky case studies between the 1960s and late 1980s. It is hypothesized that the main reason for the observed declines might be the direct effect of sulfate aerosols on solar radiation, as suggested by several authors and summarized in the IPCC Report (1996). Comparisons of the U.S. results with that from radiation transfer calculations, based on a 3-D-tracer-transport-model, are currently under way.

Table 1. Records of broadband global solar radiation at the surface for selected U.S. stations from the National Solar Radiation Data Base.

Station		**Lat. N.**	**Long. E W/m^2**	**Mean W/m^2**	**Std.**
Albuquerque	NM	35.03	106.62	523	17
Bismarck	ND	46.77	100.75	393	15
Brownsville	TX	25.88	97.42	450	18
Caribou	ME	46.87	68.02	343	21
Columbia	MO	38.82	92.22	436	13
Dodge City	KS	37.77	99.97	475	12
El Paso	TX	31.78	106.40	545	11
Ely	NV	39.27	114.83	470	17
Fresno	CA	36.77	119.72	491	19
Great Falls	MT	47.47	111.37	390	26
Lake Charles	LA	30.12	93.22	455	13
Madison	WI	43.12	89.32	368	24
Miami	FL	25.78	80.27	458	22
Nashville	TN	36.12	86.67	432	20
Omaha	NE	41.37	96.52	410	23
Phoenix	AZ	33.42	112.02	527	17
Sterling	VA	38.95	77.43	312	15
Seattle	WA	47.45	122.30	408	18
mean	-	-	-	438	18

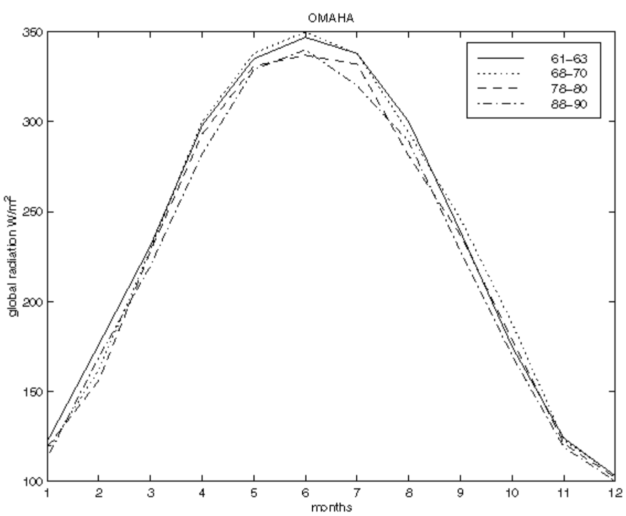

Figure 1. Monthly mean clear sky global solar radiation at Omaha, Nebraska, for selected time intervals.

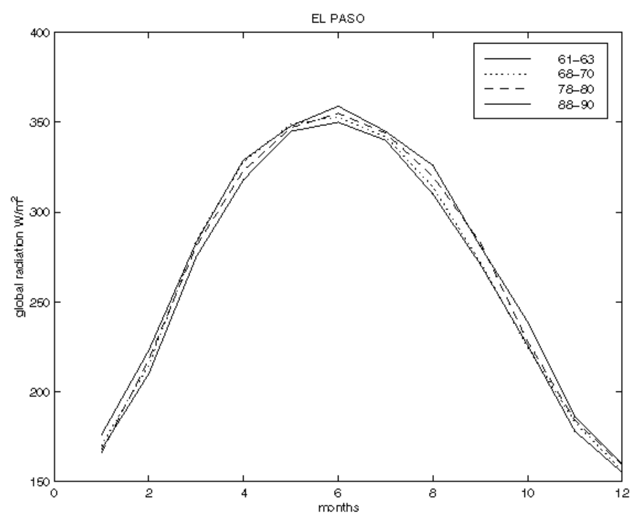

Figure 2. Monthly mean clear sky global solar radiation at Sterling, Virginia, for selected time intervals.

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