A new method for assessing surface solar irradiance: Heliosat-4

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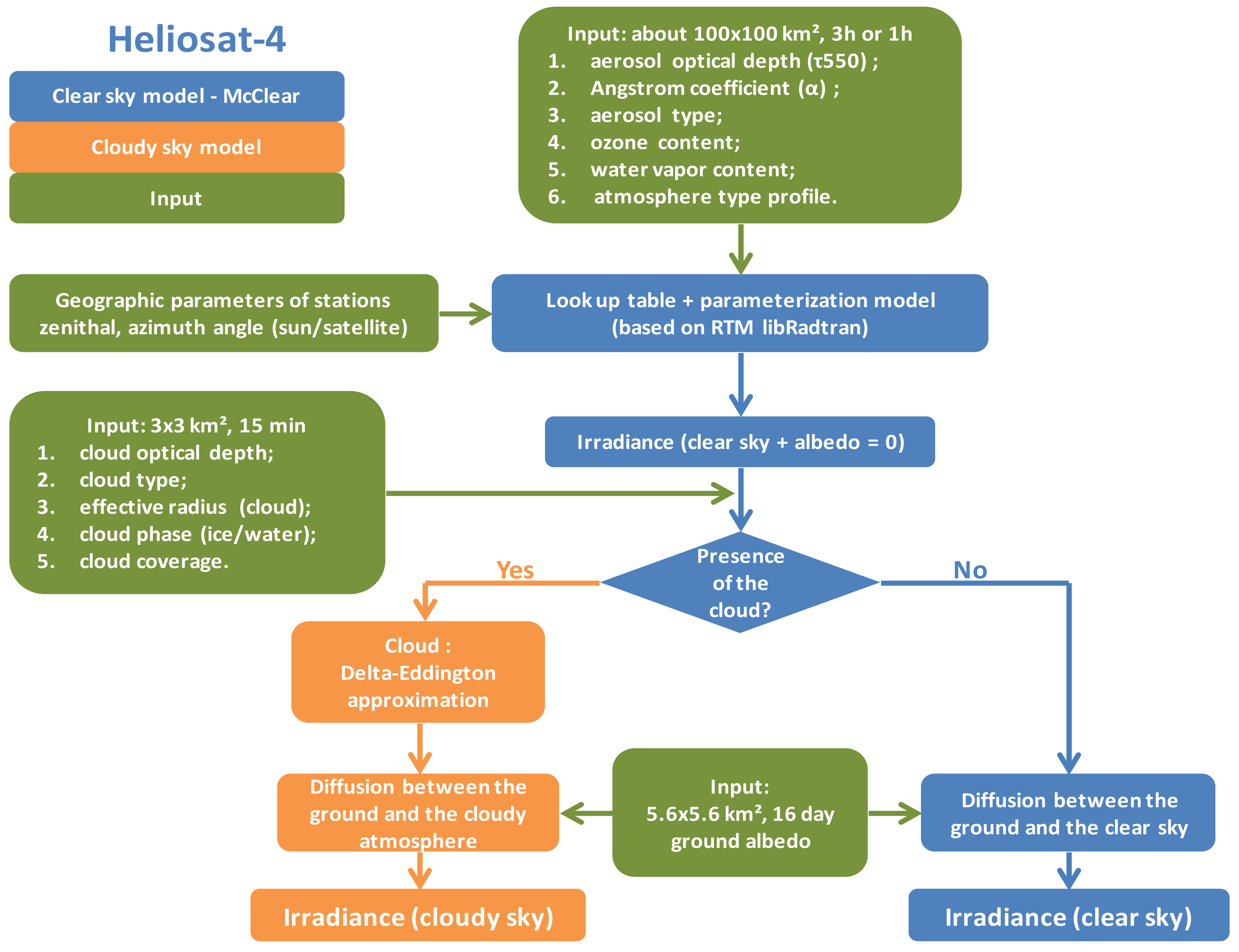
1. Heliosat-4

Assessment of surface solar irradiance:

✓global irradiance and its direct and diffuse components;

✓quick to calculate (apply to pixels of SEVIRI images of Meteosat for every 15 min)



There will be possibly changes for the cloudy sky model to use look up table based on RTM libRadtran.

2. Input data

Variable	Data sources	Temporal resolution	Spatial resolution
Aerosols properties and type	MACC (EU FP7) / MATCH (DLR)	3 h / 1h	1.125° / 1.9°
Cloud properties and type	APOLLO (DLR)	15 min	3-10 km
Total ozone column	MACC (EU FP7)	3 h	1.125°
Total water vapor column	MACC (EU FP7)	3 h	1.125°
Ground albedo	MODIS (NASA)	16 d	5.6 km

- Both aerosol properties from MACC (Monitoring atmospheric composition & climate, FP7) and MATCH (provided by German Aerospace Centre - DLR) are tested.
- APOLLO (AVHRR Processing scheme Over cLouds, Land and Ocean, provided by DLR) is used as the cloud product. It is adapted to the images of SEVIRI instrument of Meteosat.
- Both ozone and water vapor quantities are retrieved from MACC products.
- For the ground albedo, we use MODIS (MODerate-resolution Imaging Spectroradiometer) BRDF/Albedo Snow-free Quality product (MCD43C2).
- The daily mean values of ozone, water vapor quantities and aerosol properties are used in the clear-sky model McClear (about McClear: Lefèvre et al., oral presentation, AS3.12, Wednesday 11:00–11:15).

3. Validation

We validated Heliosat-4 for 4 stations within the network of the Baseline Surface Radiation Network (BSRN) which provide high quality ground measurements of surface solar irradiance.

Station	Country	Latitude	Longitude	Elevation (m)
Carpentras	France	44.0830°N	5.0590°E	100
Payerne	Switzerland	46.8150°N	6.9440°E	491
Sede Boqer	Israel	30.9050°N	34.782°E	500
Tamanrasset	Algeria	22.7800°N	5.5100°E	1385

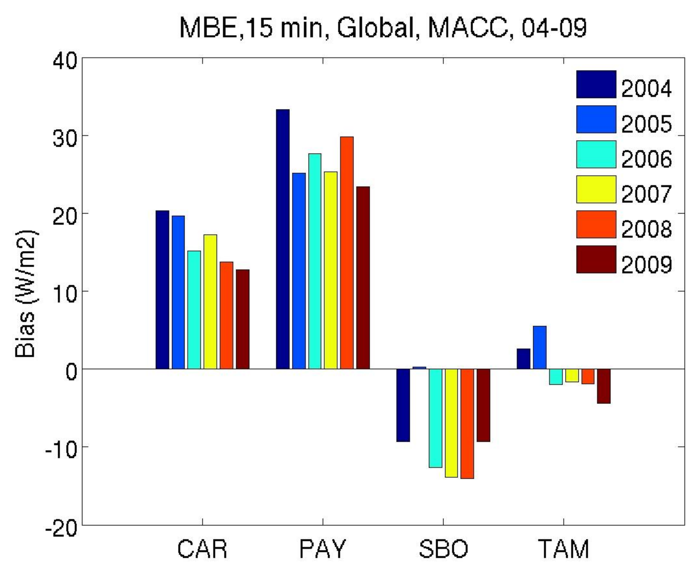
Quality check is performed for the BSRN ground-based measurements (Espinar et al., poster presentation, XY175) to ensure that we only compare Heliosat-4 results with the reliable ground pyranometric measurement.

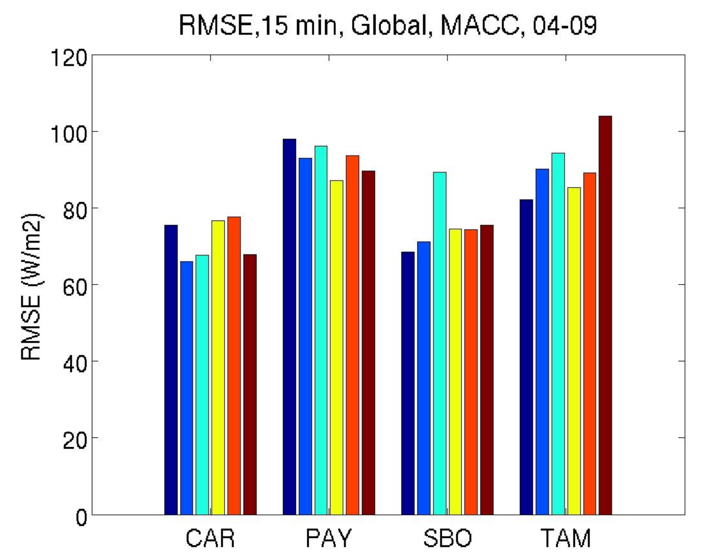
BSRN stations measure surface irradiance for every minute. In this study, 15 min data (mean values) are compared between the ground measurements and Heliosat-4 outputs.

4. Results (1)

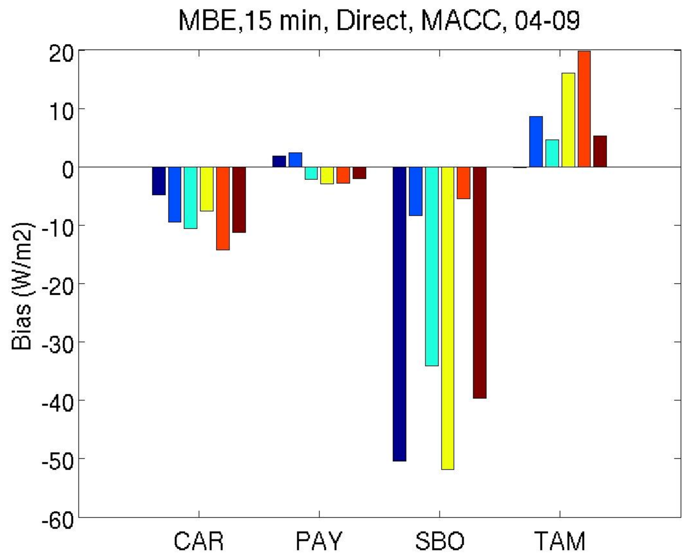
The figures below show the bias and the RMSE in W/m² (15 min data, global and direct irradiances are calculated for the horizontal plan) for each station for the period 2004-2009 where MACC aerosol data is available.

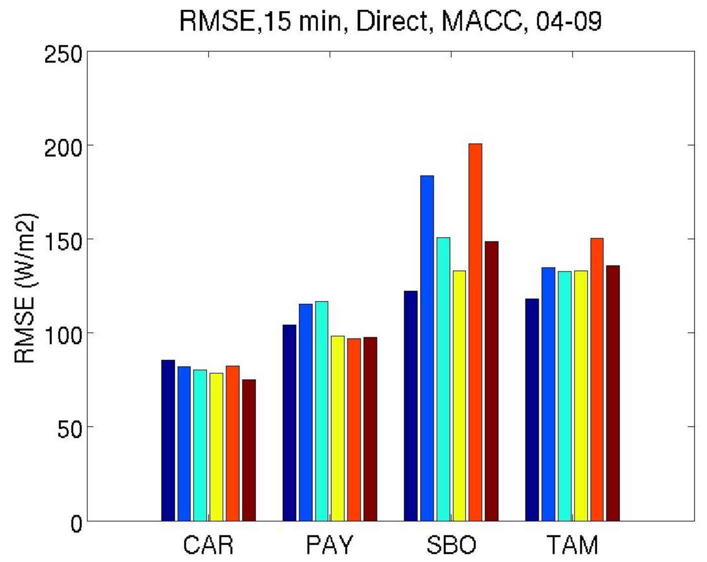
Global horizontal irradiance:





Direct horizontal irradiance:





5. Results (2)

Bias and RMSE in W/m² and relative value (comparing to the mean value of the ground measurements) for each station (15 min data from 2004 to 2009):

Global horizontal irradiance:

Station	Mean (W/m2)	Bias (W/m²)	Bias (%)	RMSE (W/m²)	RMSE (%)
Carpentras	362.91	16.57	4.57	72.16	19.89
Payerne	294.38	27.34	9.29	92.87	31.55
Sede Boqer	485.87	-9.90	-2.04	75.87	15.62
Tamanrasset	540.64	-0.34	-0.06	91.21	16..87

Direct horizontal irradiance:

Station	Mean (W/m2)	Bias (W/m²)	Bias (%)	RMSE (W/m²)	RMSE (%)
Carpentras	241.78	-9.65	-3.99	80.77	33.41
Payerne	154.54	-0.97	-0.63	105.08	67.99
Sede Boqer	342.51	-31.38	-9.16	159.41	46.54
Tamanrasset	358.27	9.26	-2.59	134.73	37.61

Global performances for all the stations and all the years:

Type	Mean (W/m2)	Bias (W/m²)	Bias (%)	RMSE (W/m²)	RMSE (%)
Global	421.63	8.35	1.98	83.74	19.86
Direct	274.36	-8.11	-2.95	124.07	45.22

6. Conclusion

Heliosat-4 exhibits state-of-the-art performances. These performances depend on the station and show little variations with year for a given station.

Large RMSEs in W/m² for the two desert station, Sede Boqer and Tamanrasset, are mainly due to the difficulties in aerosol properties estimation. Good results could be found for the station Carpentras, however, Heliosat-4 has a lower performance for the station Payerne. We assume that it is probably due to the frequent presence of the scattered clouds.

Using aerosol properties from MATCH data in Heliosat-4 (results not shown) gives similar results for the three stations : Carpentras, Payerne, Sede Boqer, but higher RMSEs for Tamanrasset.

Pyrheliometers used in the network of BSRN have an angular apeture of 5°. A part of the diffuse radiation, named circumsolar, is included in the measured direct normal irradiance. Therefore, the direct irradiance calculated by Heliosat-4 is not exactly what measured by BSRN. The proportion of this circumsolar irradiance is low in clear-sky, but can reach 50% of the direct normal irradiance, in the presence of thin ice clouds. This explains partly the negative bias for all the four stations

The performance of Heliosat-4 is equivalent to the existing cloud index methods, and with a strong potential of improvement, in particular, in its ability to decompose the surface solar irradiance into the direct and diffuse components.