Response to comments from Reviewer 1:

We thank the reviewer for the useful comments, analyses and proposed corrections. We humbly apologize for the inconvenience caused by repeated delays in our response since the publication of reviews.

Tournadre et al. developed a new way to estimate downwelling surface solar irradiances (DSSI) from satellite images for Heliosat-V. Similar to previous Heliosat algorithms, the cloud index is needed in the DSSI estimation. In this new method, the maximum and minimum reflectances needed in the cloud index calculations are simulated using radiative transfer model instead of taking from archives of satellite images. The authors have demonstrated that the DSSI derived using this new method have good agreement with the CAMS and HelioClim3 DSSI. The new method is very promising. It has the advantage to be applied to both geostationary and polar orbiting satellites to get a global consistent DSSI data set using the same algorithm. The long term global DSSI data set will be interested by the solar energy and climate related communities. The authors have described the algorithm and results clearly. I think it is a good paper for AMT.

Specific comments

1) Line 19, ' plus a diffuse component due to scattering caused by the atmosphere (clouds, gases, aerosols) … '

Please also add 'absorption' in the sentence. In Fig. 2 you showed the gas absorptions by O2, O3, H2O.

> The purpose of the sentence is to specify that we only look at the hemispherical integral of the radiation reaching the surface and not its decomposition in beam and diffuse components. We propose to clarify by "*DSSI considers the irradiance coming from all directions of the hemisphere above the surface: the irradiance coming from the direction of the Sun, usually referred to as beam horizontal irradiance, plus a diffuse component due to scattering caused by the atmosphere (clouds, gases, aerosols) and reflection by the surface, usually referred to as diffuse horizontal irradiance.*"

2) Line 22 'renewable solar energy industries, …'

Is 'renewable' needed here?

> We removed the term.

3) Line 41-42. This sentence can be combined with the paragraph from Line 43.

> We applied the modification.

4) Line 50, Please add the following paper in the reference list because they also use cloud properties to derive DSSI.

Retrieval and validation of global, direct, and diffuse irradiance derived from SEVIRI satellite observations

Greuell J. F. Meirink P. Wang https://doi.org/10.1002/jgrd.50194

We added the reference Greuell et al. (2013).

5) Line 100-101 , ‘the upper boundary variables Xmax and Xmin’

Change to ‘the upper and lower boundaries …. ‘

We added the missing elements.

6) Line 165 . This paragraph describes the MACC reanalysis used in the LUT. It is not clear if the MACC reanalysis has day, monthly or yearly AOD and which AOD is used.

The following sentences are added: “*Data from MACC are extracted from the McClear service (http://www.soda-pro.com/web-services/radiation/cams-mcclear). MACC values are originally given on a 3-hour time step and with a spatial resolution of about 80 km (Inness et al. 2013; Lefèvre et al., 2013). The McClear service applies to MACC data a bilinear spatial interpolation onto the considered location, and a linear interpolation in time to a 1-min time step (Lefevre et al., 2013).*”

7) Lines 184-185 can be combined with the paragraph below it.

We merged two paragraphs.

8) Line 212 ‘ Heliomont’ Is it a typo?

We added the uppercase correction “HelioMont” (which is the algorithm described in Stöckli (2014))

9) Line 233 “ant”, typo?

We corrected the typo.

10) Table1. What are the cloud base heights?

We added cloud base heights in Table 1: 200 m for low thick cloud, 2 km for high thick cloud.

Please also add a table for the clear-sky LUT, including the BRDF, aerosols settings etc.. It is not complete if only having the table for the cloud LUT.

We added such a table. Infos sur la resolution de srtm nécessaire → benoit g.

11) Line 258 ‘….for solar zenith angles lower than 80°’

Why do you use solar zenith angle until 80 degree in the validation? In the LUT, the solar zenith angle is until 85 degree. Is it possible to extend the solar zenith angle until 90 degree in the LUT?

We change this sentence for: "*As the work is exploratory on a new method, we limit ourselves to conservative situations with solar zenith angle lower than 80°, covering most cases. For higher SZA, some effects not considered by the method can occur, including shadowing and high parallax effects*."

It would be possible to extend the LUT until SZA=90°. Since the preprint submission, we extended the LUT until 88°. For this paper, we considered 85° sufficient as it is already beyond the range used for validation.

12) Line 268 'However reflectance in the near infrared 0.8 µm channel are significantly higher, so is the absolute value of STD.' Readers might want some explanations why the reflectances at 0.8 micron channel is larger than the 0.6 micron channel. Actually it is explained in the discussion section. This happens also in other paragraphs in the results section.

The sentence line 268 has been removed because oversimplify the description. Part 3 has been reorganized to emphasize the different origins of errors on the computation of the cloud index, notably with the following paragraph:

"The validity of cloud index components, ρ_{sat}, ρ_{clear}, and ρ_{ovc}, defines the accuracy of n. From Equation (3), the uncertainty on the cloud index can be written as:

$$\delta n = \left(\frac{\partial n}{\partial \rho_{\text{sat}}}\right) \delta\rho_{\text{sat}} + \left(\frac{\partial n}{\partial \rho_{\text{clear}}}\right) \delta\rho_{\text{clear}} + \left(\frac{\partial n}{\partial \rho_{\text{ovc}}}\right) \delta\rho_{\text{ovc}} \qquad (9)$$

This leads to

$$\delta n = \frac{1}{\Delta}\left(\delta\rho_{\text{sat}} - (1-n)\,\delta\rho_{\text{clear}} - n\,\delta\rho_{\text{ovc}}\right) \qquad (10)$$

Where $\Delta = \rho_{ovc} - \rho_{clear}$. It appears that the "clear-sky error" $(1-n)\,\delta\rho_{clear}$ will be more significant in clear-sky conditions (i.e., n is close to 0), and the "overcast-sky error" $n\,\delta\rho_{ovc}$ will be more important in overcast conditions (i.e., n is close to 1). Besides, the error on cloud index will be inversely proportional to Δ, the difference between overcast and clear-sky TOA reflectances. Because of this relationship between the errors on cloud index and reflectances, the discussions in this section are focused on absolute values of reflectance errors."

The origin and impact of the contrast between overcast and clear-sky reflectances are illustrated in additional figures and discussed in section 3.1.4:

"*The difference Δ between overcast and clear-sky reflectances is bigger when the overcast reflectance is relatively low and clear-sky reflectance is relatively high. High values of Δ mean a good quality of cloud index estimation (cf. Equation 10). We study the dependencies of Δ with the simulated reflectances to identify conditions that will cause high uncertainties on the computation of the cloud index. In general, we observe that the computed value of Δ is higher for the 0.6 µm channel than for 0.8 µm, as a combination of surface, cloud and clear atmosphere spectral signatures. This is illustrated in Figure 9 for stations SMS and CAM. We observe however for the desert stations TAM and SBO that both channels present similar values of Δ (Fig. B4). Δ depends also on the viewing and solar geometries because of ρ_{ovc} and ρ_{clear} different angular signatures. It leads for example for SMS station and channel 0.8 µm to low values of Δ in January morning and high values of Δ in the evening, which can be* *explained by the strong forward scattering of clouds occuring in these conditions."*

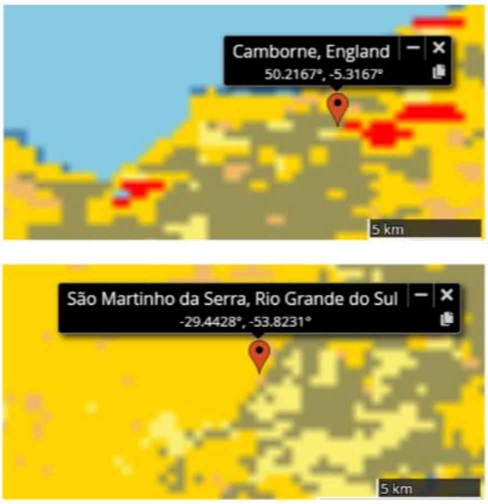

Figure B3. Land cover types around measurement stations São Martinho da Serra (Brazil, upper panel) and Camborne (United Kingdom, lower panel) for 2011. In red: urban and built-up lands; in gray: croplands/natural vegetation mosaics; in light yellow: croplands; in dark yellow: savanna; in beige: grasslands; in blue: water bodies. Data from Terra + Aqua MODIS product MCD12Q1 version 6, following the International Geosphere-Biosphere Programme classification scheme. Credit: NASA Worldview

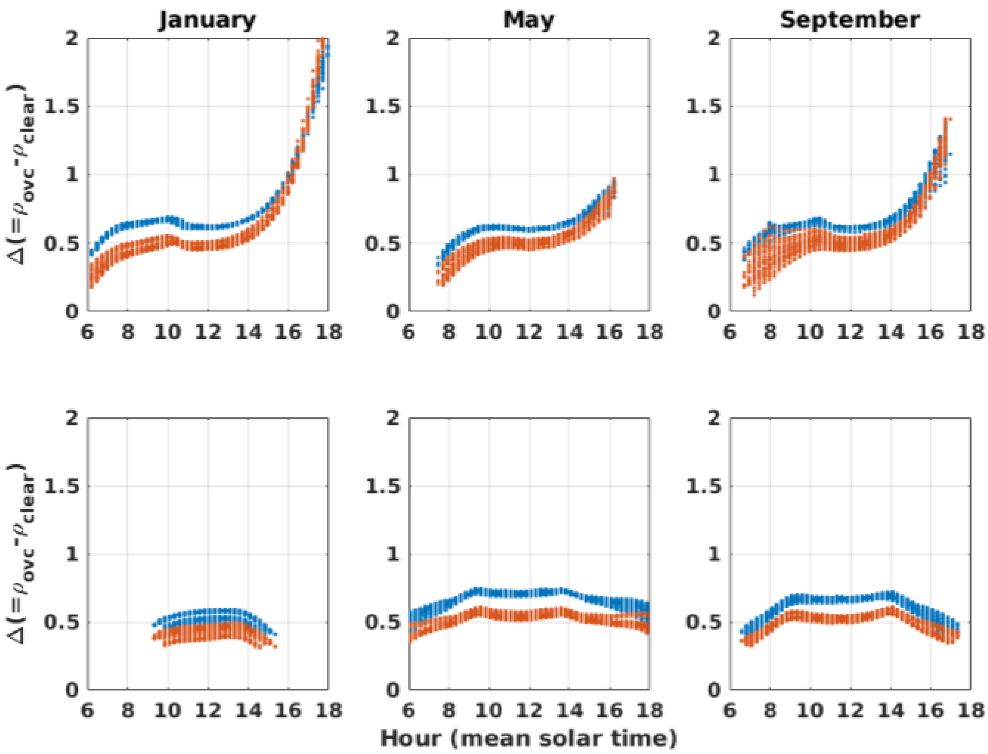

Figure 9. Difference between simulated reflectances at the top of the atmosphere in overcast and in clear-sky conditions $\Delta = \rho_{\mathrm{ovc}} - \rho_{\mathrm{clear}}$ for São Martinho da Serra (Brazil, upper row) and Camborne (United Kingdom, lower row) locations and for January, May and September calendar months (three columns from left to right). In blue dots: MSG 0.6 μm channel ; in red dots: MSG 0.8 μm channel.

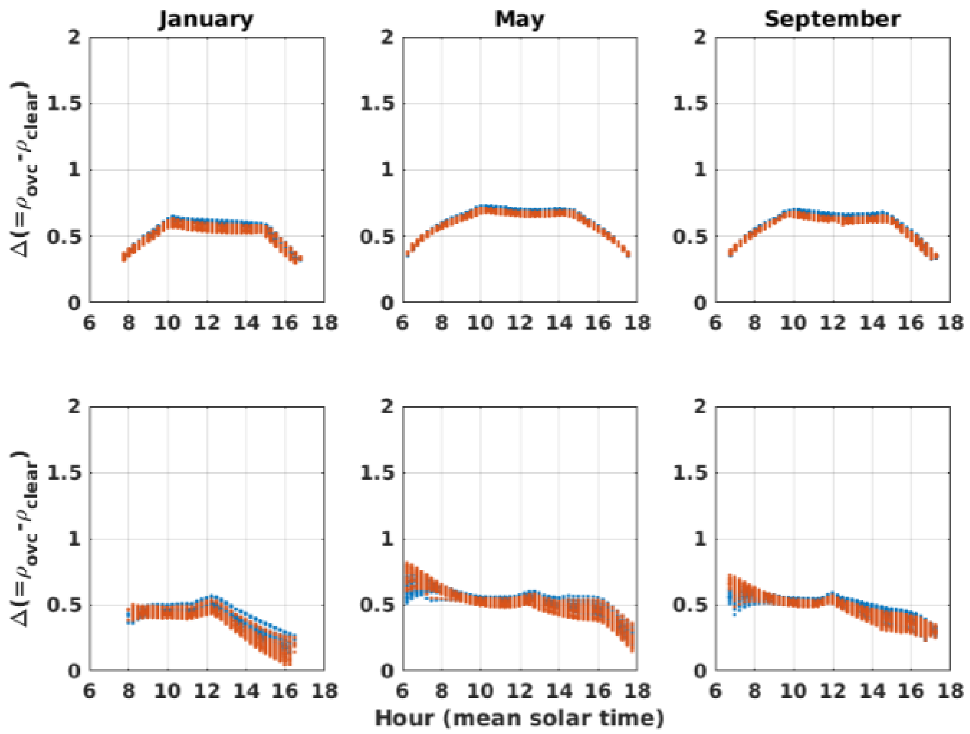

Figure B4. Difference between simulated reflectances at the top of the atmosphere in overcast and in clear-sky conditions $\Delta = \rho_{\mathrm{ovc}} - \rho_{\mathrm{clear}}$ for Tamanrasset (Algeria, upper row) and Sede Boker (Israel, lower row) locations and for January, May and September calendar months (three columns from left to right). In blue dots: MSG 0.6 μm channel ; in red dots: MSG 0.8 μm channel.

13) Lines 272 – 275. Figure 7 shows the results compared to measurements at the PAY and CAM SMS stations. Please provide some information about the surface type of the stations used in the figure. When it is clear-sky, the surface type, aerosols are more import.

A description of land cover type is added and a figure for SMS and CAM land cover types is provided in appendix (also below):

"*Both SMS and CAM are surrounded mainly by various types of vegetation and some urban area for the case of CAM (Figure B3).*"

We also add a discussion on the role of aerosols on reflectance variability simulated in clear-sky conditions in section 3.1.2.:

"*For CAM, some higher values of ρ_{clear} are observed in January. This can be attributed to high aerosol optical depth during this period, as illustrated in Figure 8. It shows that ρ_{clear} is not only sensitive to time variations of surface properties but also to atmospheric composition* *changes.*"

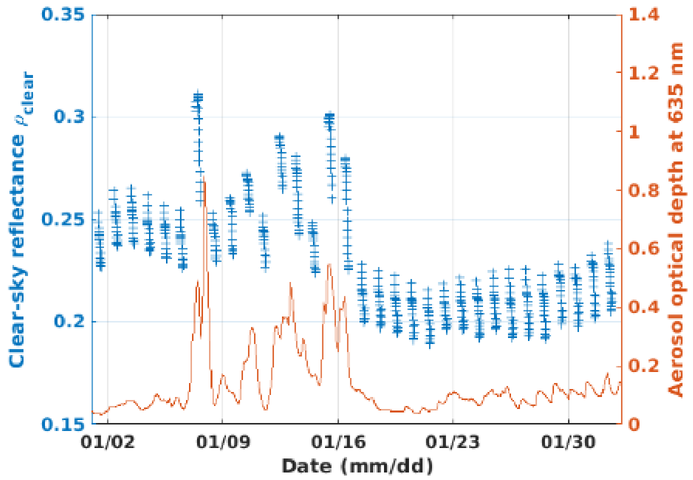

Figure 8. Blue plus signs: simulated reflectances at the top of the atmosphere in clear-sky conditions ρ_{clear} in January 2011 at Camborne station (CAM) and for MSG 0.6 μm. Red line: aerosol optical depth at 635 nm used for simulations.

Please also note we focus the analysis of reflectance variabilities on SMS and CAM stations on Figure 7. PAY is mentioned in the text being the station with the highest mean bias for the channel 0.6 µm, but it is not represented on Figure 7.

14) In line 272, Figure 7 should be Figure 6.

Since BRDF is an important feature in the clear-sky LUT, it would be nice to show a figure at PAY, CAM, SMS with diurnal cycle for a clear-sky day. Please use 0.6 and 0.8 channel both when there are green grass on the ground surface.

The Figure 7 in the first submitted manuscript emphasizes the diurnal variations of reflectances, which are not an obvious signal in the 2D histograms of Figure 6. We add a figure in appendix showing the diurnal cycle for simulated and measured clear-sky reflectances (see below), referred to in the section:

"*We observe that simulations are able to reproduce partly the diurnal variability observed in clear-sky conditions (also refer to Figure B2 for channel 0.6 µm and 0.8 µm under different surface conditions)*"

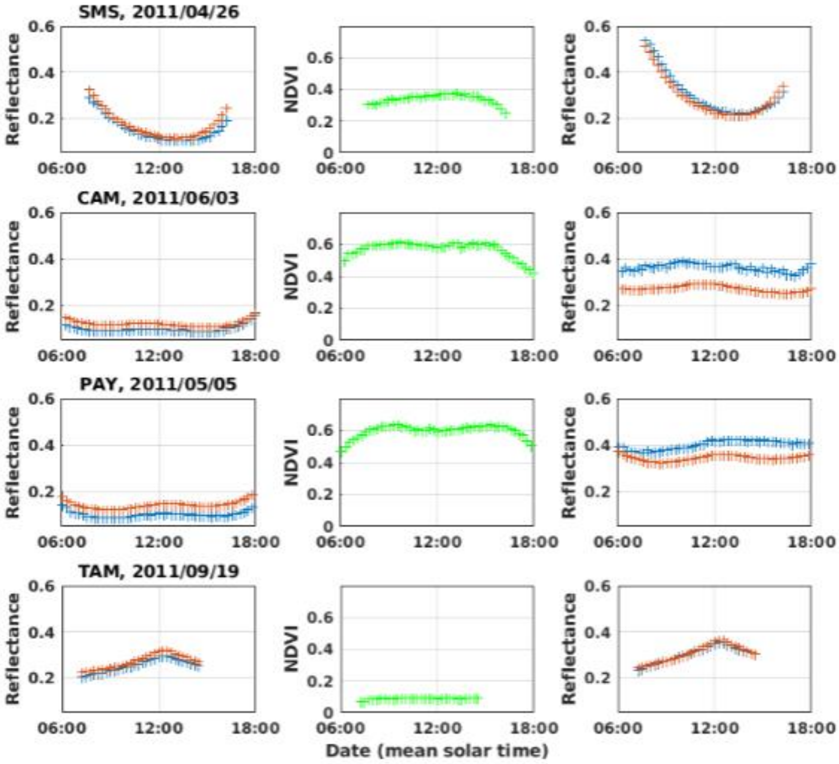

Figure B2. Comparison between simulated (red plus signs) and measured reflectances (blue plus signs) at the top of the atmosphere for one day in clear-sky conditions, for 0.6 μm (first column) and 0.8 μm channels (third column). NDVI computed from satellite measurements is shown on second column. Rows from top to bottom: locations of São Martinho Da Serra, Camborne, Payerne and Tamanrasset BSRN stations.

15) Line 280 'Figure 6' should be Figure 7.

We corrected the error.

16) Fig. 7 Why the simulated reflectances have better agreements with measured reflectances at SMS than at CAM?

It might not be due to the calibration of MSG because it would have the same bias in the full disk image. It seems the ice cloud LUT has similar diurnal cycle to the 99 percentiles of the measurements but the simulated reflectances are larger than the measurements at CAM. It could be at CAM the cloud are less brighter than at SMS. Does it suggest the simulated maximum reflectance should depend on location?

We change the following sentence as the analyse is not sufficient to assess an agreement, "The first row of Figure 7 shows a good agreement between most reflective satellite scenes of the São Martinho da Serra pixel and ρ_{ovc}" and replace it saying, "Some patterns are similar in simulated ρ_{ovc} and 99th percentile of measurement: in the forward scattering conditions (evening on the West edge of Meteosat disc) where both agree on increased values of ρ_{ovc}". It is difficult to assess biases of the simulated overcast reflectances because of significant uncertainties on calibration gains.

... This percentile approach is however not reliable in all cases. For example, at Sede Boker in May and September, we cannot consider that the 99th percentile correspond to thick clouds conditions, because of the very dry climate and low reflectances observed.

17) Line 320.

Fig. C1. Why there are some outliers with large reflectances in McClear? Is it due to the model or the aerosol data? I would expect the outliers on two sides of the 1:1 line.

McClear is the model computing surface solar irradiance in clear-sky conditions notably from the description of atmospheric composition in aerosols, ozone, water vapor etc. (see section "The clear-sky model of surface irradiance McClear"). The outliers are probably due to some cloud contamination that were not identified in the satellite measurements. We prefer to remove the figure, as these outliers could influence the mentioned "3%" value of McClear's bias. We refer to McClear v3 publication Gschwind et al. (2019) to discuss its uncertainties: "Gschwind et al. (2019) report for example relative mean biases of the McClear model from -3.6% (Barrow, Alaska, USA) to +3.2% (Payerne, Switzerland), when compared to BSRN irradiance measurements."

Please note also that the Discussion section is merged with Results section in order to present more smoothly.

18) The authors did not mention direct irradiances in the paper. Are there any plans about the DNI?

The estimation of direct irradiance would sure be of interest. For now, we are focusing on estimating the cloud index.