Response to Referee #2

In this manuscript, an innovative approach is presented to analyze the long-term trend of SSI. The proposed concept is based on the synthesis of trends of SSI, cloud cover, cloud optical depth and humidity into a single quantity called “climate regime”. The methodology is applied to satellite derived cloud properties and SSI from CLARA-A3 over Europe. The paper is very interesting, well-written and represents a very relevant contribution to readers of EGU sphere as well as the solar energy community to better quantify the effect of climate change on the solar resource.

I suggest the following minor revisions.

We thank the referee for appreciating our approach and for the encouraging remarks. Please find below point by point reply to your comments.

Line 173: “covering the 1982-2020 period » Please precise that according to recent works on SSI trends, a steady brightening is expected over this period.

Added.

The term “climate regimes” can be misleading in the context of the paper as it can lead to confusion with large-scale circulation regimes. I would suggest using a different term such as e.g. “multi-variable trend class”.

In the hindsight, we do agree as well. It is probably misleading or confusing. This issue is raised by both referees. The term “climate regime” is now replaced by “climatic trend regime” since we are indeed presenting the dominant, emerging composites of long-term trends in climate variables.

Since aerosol and water vapor are affecting SSI, it would be important to clearly explain how these are treated in the retrieval of the cloud property (atmospheric correction) in section 2.1.

The retrievals of SIS consider the atmospheric state, including the total integrated water vapour, based on the ERA5 reanalysis data. The details can be seen in the Algorithm Theoretical Basis Document here: https://www.cmsaf.eu/SharedDocs/Literatur/document/2023/saf_cm_dwd_atbd_clara_rad_3_3_pdf.pdf?__blob=publicationFile&v=2

With regard to aerosols, the algorithms attempt to separate heavy aerosol loadings from clouds. Subsequently, in the cloudy scenes, aerosols are not considered. This is justified because aerosols are usually below the clouds and have a negligible optical depth compared to the clouds, although there are exceptions, e.g., absorbing aerosol above clouds, dust-infused clouds.

In lines 219-220, the authors wrote “The shortwave solar radiation reaching the surface is regulated by a number of atmospheric components and their feedbacks in the backdrop of increasing greenhouse gases. Among them, the most important are clouds and aerosols,… ». The absorption by water vapor is very important for SSI calculation but it is not mentioned in

this paragraph and not treated in section 4. In contrast, it is addressed in section 5. This is confusing and I think that reconsidering the organisation of these two sections would improve the flow of the text.

As mentioned in the reply above, the SIS retrievals consider the total column water vapour. The purpose behind Section 5 is to present the meteorological context, and to investigate if the climate trend regimes presented in Section 4 and the meteorological context presented in Section 5 show similar spatial coherence for the favourable conditions for exploiting solar energy.

SSI trends are assessed but it is not clear from the text if a statistical significance test has been applied. (it is briefly mentioned in L174-175). More details on this aspect would be helpful.

Yes, the statistical significance is applied to all trends presented in manuscript. This is mentioned in the figure captions.

Figure 5 and Figure 6 show the trend considering liquid and ice water COD respectively. It is unclear whether the dataset have been split or not for generating these two figures. This makes the maps not easy to interpret.

Both Figures 5 and 6 use daytime cloud fraction together with trends in liquid and ice cloud optical thickness separately. This is further clarified in the revised version.