

## ***Interactive comment on “Detection of dimming/brightening in Italy from homogenized all-sky and clear-sky surface solar radiation records and underlying causes (1959–2013)” by Veronica Manara et al.***

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Anonymous Referee #2 The authors presented a thorough analysis of daily solar radiation records based on ground-based data measured at 54 stations in Italy. The records cover a time period of 55 years while the data sets were homogenized and spatially gridded in order to obtain valuable scientific results. The techniques used in this research were well documented and justified.

We would like to thank the referee for his/her comments and suggestions. The minor revisions suggested by the referee are addressed below.

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I would like to point out some aspects that the authors should include into their revised manuscript:

1. REFEREE: The authors should include the necessary information about the instrumentation they used for their research and provide adequate description of the measurements themselves. Although they have the instrument type in table 1, no information is provided about the characteristics of the two types of solar radiation measuring instruments (Fuess-Robitzsch and CM11 Kipp & Zonen). So I expect this information to be provided in section 2 and not only mentioned in table 1 and line 131.

AC: The data that come from the Italian Air Force (Aeronautica Militare Italiana - AM) stations and from the meteorological observatory of Trieste were recorded with the Robitzsch bimetallic actinograph until the 1980s. This instrument was then replaced with the CM11 Kipp & Zonen pyranometer in the first case and with different types of CM Kipp and Zonen pyranometers in the second one; e.g. for more details about AM instruments and instrument changes see: <http://wrdc.mgo.rssi.ru/> while for more details about Trieste instruments see Stravisi (2004). The CM11 Kipp & Zonen pyranometer was also used in the stations included in the National Agro-meteorological Database (Banca Dati Agrometeorologica Italiana - BDAN) with the only exception of two stations that use the EP07 Middleton Instruments pyranometer. Finally, the data that come from METEO SWISS were measured with a CM21 Kipp & Zonen pyranometer. The main difference between the Robitzsch bimetallic actinograph and the Kipp & Zonen pyranometer is that in the first case the measure is mechanic while in the second one it is thermoelectric. Specifically, the Robitzsch pyranometer consists of a black metallic strip located between two white metallic strips. Due to differential absorption, a temperature difference is created between these strips which serves as a measure of radiation intensity. This temperature difference drives the position of a pen which allows recording radiation intensity on a strip chart. The sensitivity range covers the entire spectrum of solar radiation; only radiation above  $2\mu\text{m}$  is not included, this, however, contributes only very little to the solar irradiance. The Kipp & Zonen and Middleton

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Instruments pyranometers are based on a black-coated surface which is warmed up by solar radiation. The thermal energy is converted into measurable voltage which is used to measure the solar irradiance. These pyranometers are provided with an automatic acquisition system which allows recording solar irradiance on a digital support. The spectral range covers the interval 0.3-2.8  $\mu\text{m}$ . All this information will be provided in Section 2 of the revised manuscript as suggested by the referee.

2. REFEREE: The authors provide the SSR daily values in  $\text{W}/\text{m}^2$ . The CM11 instrument can provide measurements at high time frequency, therefore I expect a description of the original data time frequency and the steps towards obtaining the daily values (are they daily mean values?).

AC: Unfortunately, we have access only to daily values. However, we know that a daily value is determined only in case the data for all hourly intervals of the daytime period are available. If at least one hourly value is missing, the daily value is not calculated (Petrarca et al., (2000); <http://wrdc.mgo.rssi.ru/>).

3. REFEREE: For the stations where Fuess-Robitzsch were replaced by CM11 pyranometers, are there any intercomparisons for any available common period of deployment? Having all this information into section 2 will set the need for homogenization into a more solid basis.

AC: Unfortunately, we do not have records measured with the two instruments over a common period, which would have allowed us to use a direct homogenization method. Therefore, we homogenized the records only by means of statistic techniques (indirect homogenization methods) and metadata (i.e. information on station relocations, recalibrations and instrument changes) were used only to support this procedure. The method we adopted for homogenization, resulted as one of the best performing within a study performed to compare different homogenization techniques in the framework of a European Union COST action program (Venema et al., 2012).

4. REFEREE: Please check for consistency the comment in lines 258-259. In line 257

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you firstly provide a positive trend and then a negative, so it should be brightening for the first trend and dimming for the second.

AC: The comment concerns the following sentence: "As previously shown, the trend over the whole period under analysis (1959-2013) is significant only in summer in the North (+3.1 $\text{Wm}^{-2}$  per decade) and in autumn for both regions (-1.5 $\text{Wm}^{-2}$  and -2.2 $\text{Wm}^{-2}$  for the North and the South respectively), as a consequence of a weak dimming period in the first case and a weak brightening period in the second one."

We consider that the sentence is right. In summer in the North, until the mid of 1980s, the record shows a weak (and not significant) dimming while in the following period the record shows a significant brightening. As a consequence, the trend over the whole period under analysis (1959-2013) is mostly driven by the increasing tendency of the second period resulting positive and significant. In autumn for both the regions, the behavior is opposite. The record shows a significant dimming until the end of the 1990s and a not significant brightening in the following period. As a consequence, the trend over the whole period under analysis is mostly driven by the decreasing tendency of the first period resulting negative and significant. In the revised version of the manuscript we will revise this sentence in order to make it clearer.

5. REFEREE: Line 149: "at least six monthly...", do you mean daily? please revise.

AC: The comment concerns the following sentence: "We filled the gaps in each monthly record using a procedure similar to that described in Manara et al., (2015). In particular, the median of a set of five estimated values, corresponding to the five highest correlated reference records, was selected in order to avoid outliers resulting from peculiar climatic conditions of the reference station. When less than five reference records fulfilling the requested conditions (distance within 500 km from the record under analysis and at least six monthly values in common with it in the month of the gap) were available, the median was calculated with the available reference series."

It is worth mentioning that the gap-filling procedure is performed on a monthly time

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scale. As for the previous comment, in the revised version of the manuscript we will revise this sentence in order to make it clearer.

6. REFEREE: Line 219: "As a consequence the series shows only some windows of less than 30 years and starting in the 1960s ...". please revise because the flow of the sentence is not coherent. I guess that you only detected time windows of less than 30 years with statistical significant trends ...

AC: The reviewer is right. Thus, the windows that show a significant trend are less than 30 years long. Those that start in the 1960s have negative sign while those that start in 1980s have positive sign. In the revised version of the manuscript, we will revise this sentence in order to make it clearer.

7. REFEREE: Line 222: "The spring season has a pattern similar to the year with..." I suggest to change year to annual although you use year into the figures.

AC: Yes, the reviewer is right as "annual" is better than "year". We will change it in the revised manuscript.

8. REFEREE: General comment: please have your manuscript revised by a native English speaker. Small errors were found (e.g. line 126 "...at (in a) monthly time scale", line 173 "...for 82% of (the) original...", line 251 "...were calculated (by) averaging...", line 352 " At this purpose..." is not a common expression, ...)

AC: We will revise the manuscript with a native English speaker in order to improve it.

9. REFEREE: References: please provide some references for the examples used in lines 32-33 and for the digital elevation model referred in line 254, if any.

AC: The references for the examples used in lines 32-33 are: Hartmann et al. (1986) and Wild (2009, 2012) The reference for the Digital Elevation Model is USGS (1996). We will add them in the revised version of the manuscript

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