Journal: Climate of the Past Discussions
Title: Increasing cloud cover in the 20th century: review and new findings in Spain
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Response to Referee #2

General comments

The paper concerns the long-term trends in total cloud cover. It gives a review of existing papers on such trends all over the world and analyses the trends in Spain in the period 1866-2010. The paper addresses relevant scientific question because cloud cover exert a strong impact on short- and long-wave radiation reaching the Earth surface.

We appreciate the reviewer's comments.

The general and specifics comments are addressed below.

The scientific methods are valid but it is not clear how many variables are taken into account in PCA analysis: 39 stations x 12 months or 39 stations with monthly values. Are total cloud cover anomalies calculated relating to average from all months or relating to specific calendar months (i.e. the annual course is partially removed).

We have slightly changed this paragraph in order to clarify the method applied to define the different regions over Spain by means of a Principal Component Analysis. Summarizing, the method uses a matrix of 39 original variables corresponding to each of the 39 stations (columns) and 1164 rows (97 years x 12 months). Thus, 39 stations with monthly anomalies values are used, and these anomalies are computed as differences to mean for each month during the 1971-2000 period, in order to remove the annual course in the total cloud cover.

In the revised manuscript the paragraph now reads as: "In order to study the trends of TCC in different regions of Spain with similar decadal variability, a regionalization was performed by means of an S-Mode Principal Component Analysis (PCA) (e.g. Sanchez-Lorenzo et al., 2007). The analysis was applied to the 39 series, which correspond to the number of original variables, but considering all 12 months of the year and using the series of monthly anomalies for each of these series (obtained as differences to the 1971-2000 mean for each month). The PCA was calculated starting from a correlation matrix and using the data of the period 1913-2010, which is complete without missing values, comprising 1,164 rows (97 years x 12 months) for each of the 39 original variables. The use of all months of the year is justified in order to obtain more robust statistical results, and produces only one representative regionalization of the whole year, which avoids the confusion that occurs if different regions are defined for each month or season."

The increase of total cloud cover in the period from the beginning of record up to 1960s was shown with the decrease from 1970s to the end of the record. The changes of total cloud cover in Spain are in line with those in Europe and other regions of the world. However such widespread increase in total cloud cover should have an influence on radiation. In the discussion the worldwide relation of the increase (decrease) of total cloud cover on increase (decrease) of total precipitation and decrease (increase) of diurnal temperature range. In the case of Spain only the impact on a number of rainy days is mentioned but without more detaily discussion.

We have considered the reviewer opinion in Section 5, where we have added a brief discussion regarding the possible impact of the observed cloud cover trends on worldwide surface solar radiation, as well as over Spain. In the revised manuscript this paragraph now reads as follows: "The decadal increases in the TCC during the last century have been worldwide related to an increase in precipitation and reduction in diurnal temperature range (DTR) (Karl et al., 1993; Dai et al., 1997, 1999). Equally, the evidence of an increase (decrease) in TCC from the 1950s to the 1980s (1980s to the 2000s) has been suggested as a contributing factor of the widespread decrease or *global dimming* (increase or *brightening*) in surface solar radiation observed around the same period. Nevertheless, changes in the transmissivity of the Earth's atmosphere, as consequence of the trends in the aerosol anthropogenic emissions since the mid-20th century, is considered the most likely cause of the dimming/brightening periods (Wild, 2009; 2012). On the other hand, for Spain a systematic assessment of the DTR trends for the whole 20th century is still lacking, to our knowledge. Nevertheless, the TCC trends reported here are in line with the generalized increase (decrease) in the number of rainy days during the first (second) half of the 20th century in Spain (Gallego et al., 2011). Regarding the observed trends since the 1950s, a large discrepancy between sunshine duration and TCC has been shown, which suggests that the most likely cause of the dimming/brightening in Spain is also dominated by aerosol effects (Sanchez-Lorenzo et al., 2009)."

Specific comments:

1) 5400 land stations instead of 54000 mentioned in the text were analysed in Warren et al. (2007) paper (page 1136, line 26).

We have corrected the error.

2) It should be Tuomenvirta instead of Toumenvirta (page 1140, lines 20 and 24) and Matuszko instead of Matusko (page 1140, line 29 and page 1155, line 11).

Done.