

SUNDUIB: homogenised sunshine duration dataset in the Iberian Peninsula. Temporal variability and trends during the last decades

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OBJECTIVE and DATA

- The main goal of this work is to set up a high-quality dataset of sunshine duration over the Iberian Peninsula (IP) and analyze the temporal variability and trends of this variable.
- Our database is constituted by 72 series of daily or monthly sunshine duration corresponding to meteorological stations placed over the Iberian Peninsula (Fig. 1). The series were obtained from the Spanish Instituto Nacional de Meteorología (INM); the Portuguese Instituto de Meteorologia (IM); the European Climate Assessment & Dataset project (ECA&D), and the MetOffice.
- In general, we could not obtain accurate metadata about instruments used for measuring sunshine duration; however we assume that most data included in the database were measured by a Campbell-Stokes heliograph.
- The dataset covers the 1931-2004 period, but the linear trend analysis (Table 1) was limited to the 1951-2004 period (with more data availability).

RESULTS

Homogenization and gridded version of the database

- The relative homogenization of the station dataset was based on the Craddock test.
- Only 25% of the series resulted homogeneous. The mean adjustment curve averaged over all single series (Fig. 2) shows that the use of the original data can produce biased results.
- With the homogenized series, we generated a grid (1°x1°) based on an inverse-distance-Gaussian-weight and the angular-distance-weighted interpolation (Fig. 1). This grid was calculated starting from single station anomaly (obtained as ratio to the corresponding 1971-2000 mean). There is an excellent agreement between the two data modes ($r \geq 0.95$), and for this reason the further analyses were restricted to the gridded dataset.

Time Evolution and Trends of Sunshine duration over whole IP

- The IP annual series (Fig. 3.a) starts without relevant variations, followed by an increasing tendency in the 1940's until 1950's. Afterwards there is a negative trend until first years of the 1980's. The last decades are characterized by a new increase until the beginning of the 21st century. The linear trend is not significant.
- The mean series for spring (Fig. 3.c) and summer (Fig. 3.d) show a similar temporal behaviour as the annual series, while in winter (Fig. 3.b) and autumn (Fig. 3.e) sunshine duration was quite constant during the analyzed period. The unique significant trend for the IP series concerns the summer season, with a decrease of -0.9% per decade.

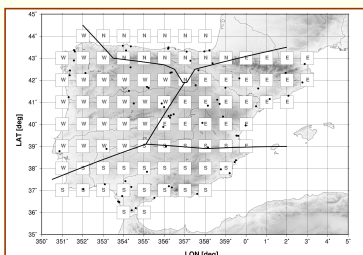


Figure 1. Location of the 72 stations (black dots) and of the generated grid points (boxes) with indication of the region assigned. The schematic regionalization based on PCA (bold lines) is indicated too.

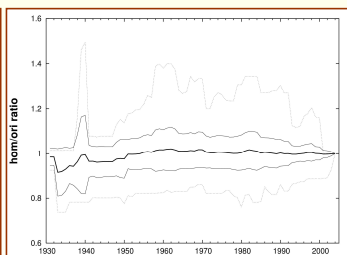


Figure 2. Mean annual adjustment obtained by calculating the yearly average ratios between the homogenized and the original series (bold line). Standard deviations (thin lines) and total correction ranges (dotted lines) are indicated too.

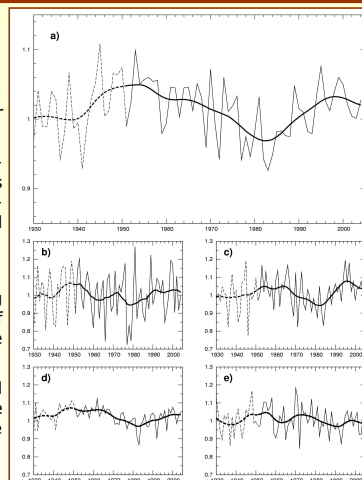


Figure 3. Mean IP series plotted with the 11-yr 3-year σ Gaussian low-pass filter. a) annual; b) winter; c) spring; d) summer; e) autumn. The series are expressed as relative deviations from the 1971-2000 mean. Dashed lines are used prior to 1951 owing to the lower availability of data.

Running trends analysis for the annual IP series

- To extract as much information as possible from the data and to have more comparable results in the future, trend analysis was also completed with a running trend analysis (Brunetti et al. 2006) for the IP series (Fig. 4).
- On annual basis the clearest result is the negative trend that appears at about all time scales longer than 40 years centred in the 1960-1980 period. Also, positive trends for windows of 20-30 years are centred on the 1940's and the 1980's. Spring and summer patterns are similar to the annual, with the main differences that summer shows significant negative trends also for time scales longer than 65 years and that the positive trends centred in the 1980's are stronger in spring. Winter and autumn trends show few significant trends.

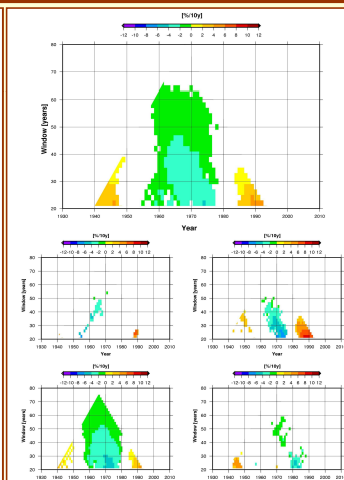


Figure 4. Running trend analysis for the IP annual (top) and seasonal (lower graphics, from left to right and from top to bottom: winter, spring, summer and autumn). Only trends having a significance level greater than 90% are plotted.

Regionalization and linear trends of the regional series

- The regionalization was based on a Principal Component Analysis (PCA), which was applied in S Mode (starting from the correlation matrix), considering all the 12 months of the year, and using the monthly ratios on the sub-period 1971-2004, for which data availability is greater.
- We selected the first four EOF (components) and these were rotated by means of a Varimax rotation. The final result allows to identify the following regions (Fig.1): the central-east (E); the north (N); the central-west (W); and the south (S).
- The most significant trend concerns W region, with a decrease (-1.0% per decade) on annual basis, mainly due to summer season (-1.2% per decade) and autumn (-1.9% per decade). Also, S region shows a negative trend (-1.1% per decade) in summer.

Sunshine duration and NAO/Sahel Rainfall variability

- We show the correlations, through Pearson's r , between the winter sunshine duration series and the winter North Atlantic Oscillation (NAO) index; and between the summer sunshine duration and the Sahel index (a measurement of the precipitation variability in the African Sahel).
- The winter NAOi was defined as the difference between the standardized sea level pressure at Gibraltar and Reykjavik. The Sahel index values were calculated for the June-October period (rainy period).
- Positive and significant correlations are obtained for the whole IP and regions, with values around 0.60 with both the NAO and Sahel indices. The best correlations were obtained with the S regional series, and the worst with the N regional series for the Sahel index, and surprisingly for the W regional series for the NAOi.

	IP	E	N	W	S
Year	-	+	-	-1.0±0.4	-
Winter	+	+	+	-	-
Spring	+	+	-	-	+
Summer	-0.9±0.4	-	-	-1.2±0.5	-1.1±0.4
Autumn	-	-	-	-1.9±0.8	-
NAO index	0.61	0.59	0.50	0.42	0.69
Sahel index	0.62	0.52	0.36	0.57	0.63

Table 1. Trends (% per decade) over the 1951-2004 period (2-5 rows). Correlations between winter (6 row) and summer (7 row) series and the NAO (DJF) and Sahel (JJASO) indices, respectively. Values significant at level $\geq 99\%$ in bold and $\geq 95\%$ in italics. For lower levels only the sign is indicated.

CONCLUSIONS

- We have presented a new dataset of sunshine duration over the IP, based on 72 monthly series covering the 1931-2004 period, that are subjected to an exhaustive quality control and relative homogenisation procedure. Also, a gridded version (1° resolution) was produced. This final dataset is kept in two different data modes (stations and grid), and has been named SUNDUIB (SUNshine DUration in the Iberian Peninsula).
- The temporal evolution of the annual IP sunshine duration shows a nonsignificant trend, as a result of an overall decrease since 1950's until first years of 1980's, and a later increase until the end of the 20th century. This evolution, confirmed also by the running trend analysis, is in good agreement with the global dimming and brightening phenomena detected from surface solar radiation measurements and satellite estimations (Wild et al. 2005).
- When seasonal series are analyzed, spring and summer show the best correspondence with the annual series, and the only significant trend is found in summer, with -0.9% per decade, which is mostly due to W and S regions.
- The preliminary analysis of correlation between the sunshine duration series over the IP and the NAO and Sahel rainfall variability confirms high and positive correlations for whole IP, although with spatial differences in these relationships.
- The future work will be devoted to study the relationship between sunshine duration and cloudiness data; investigate the quantitative relationship between sunshine duration and solar radiation in the IP; extend the series as much as possible into the past; and to obtain more robust results with different low frequency circulation patterns as El Niño/Southern Oscillation (ENSO); the NAO; or Sahel Rainfall variability.