

Time evolution and trends of sunshine duration over the western part of Europe



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OBJECTIVE, DATA and METHODOLOGIES

- The main goal of this work is to show and analyze the temporal variability and trends of sunshine duration in the western part of Europe (WEU).
- Our database is constituted by 79 series of daily or monthly sunshine duration corresponding to meteorological stations placed in seven countries that approximately cover the western half of Europe (Fig. 1): United Kingdom, Germany, Spain, France, The Netherlands, Switzerland, and Austria. The series were obtained from the European Climate Assessment & Dataset project (ECA&D), the MetOffice, and the Instituto Nacional de Meteorología (INM).
- 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 analysis was limited to the 1938-2004 period over the whole WEU region. Also, we completed the study with a regionalization based on Principal Component Analysis (PCA) and the analysis of the winter sub-regional series.
- For each station we calculated the ratios between the values (in annual and seasonal resolution) and the mean over the 1961-1990 period. To obtain the mean series we computed the arithmetic mean over all available data.
- On the other hand, temporal trends were calculated as the slope of the line obtained by least-squares linear fitting; for detecting significant trends (with a confidence level higher than 95%) the method applied was the Mann-Kendall non-parametric test.

RESULTS

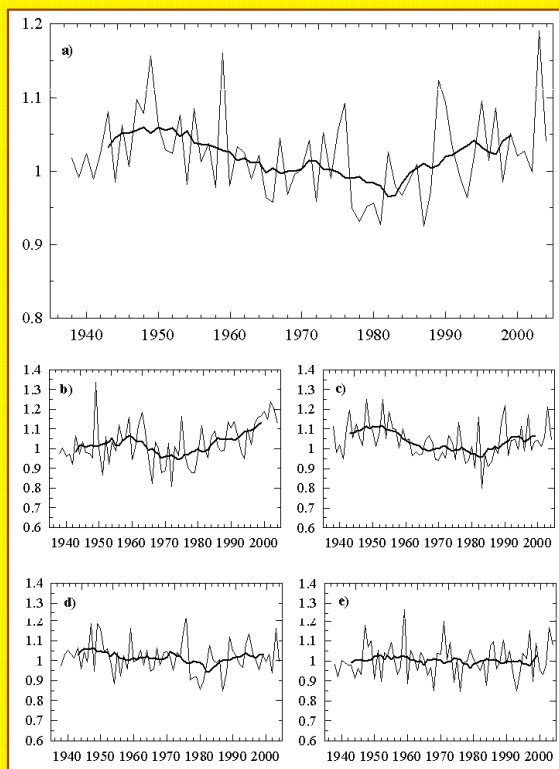
Time Evolution and Trends of Sunshine duration over WEU

□ The annual (Fig. 2a) time evolution of sunshine duration in WEU shows a clear decrease since the beginning of the 1950s until the first 1980s, with a short period (between 1960s and 1970s) of stabilization. Subsequently, sunshine duration keeps recovering until the end of the analyzed period. It is remarkable the 5 consecutive years (1977-1981) with low values, although the absolute minimum in the series is reached in 1987, while the maximum was recorded in 2003. The breakpoint between the "dimming" and the "brightening" tendencies is located in 1982-83. The overall linear trend is not statistically significant.

□ The winter (Fig. 2.b) series shows a positive and significant trend of +1.76% per decade. This is the result of an initial (1938-1960 approximately) increase followed by a decline in the 1960s-70s and a final important increase until nowadays. The inter-annual variability of the winter sunshine duration is the largest among all seasons, which gives a remarkable maximum in 1949 and an important minimum in 1972. Note that in agreement with the recent increase, all years since 1997 show values greater than the 1961-1990 mean.

□ The temporal behavior in spring (Fig. 2.c) is similar to the annual series, and also the trend is nonsignificant. In summer (Fig. 2.d), records have been much more stable during the analyzed period. The most remarkable fact is again the 5 successive years with minimum values (1977-1981) that was also evident in the annual series. As in spring, the trend is nonsignificant. Finally, the series corresponding to autumn (Fig. 2.e) is the most stable and there are no noticeable changes. The overall trend is nonsignificant.

Figure 2. Mean WEU sunshine duration series (1938-2004). (a) Annual; (b) Winter; (c) Spring; (d) Summer; (e) Autumn. Bold line is the 11-yr running mean. The series are expressed as relative deviations from the 1961-1990 mean.



Regionalization

□ The regionalization approach is based on PCA, which was applied in S Mode (starting from the correlation matrix), considering all the 12 months of the year, and using the monthly normalized anomalies on the sub-period 1951-2004, for which data availability is greater.

□ We selected the first six EOF (components) and these were rotated by means of a Varimax rotation.

□ The final result allows to identify the following regions (Fig.1): Central East (CE); North Central (NC); North East (NE); South West (SW); Central West (CW); and North West (NW).

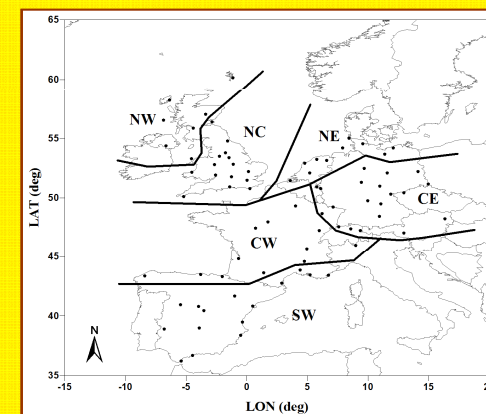


Figure 1. Location of the 79 sunshine duration stations (black dots) and the schematic regionalization based on PCA (bold lines).

Winter trends of sunshine duration over the sub-regions

□ In winter, significant and positive trends of around +3% per decade are found in CE (+2.45%), NC (+3.24%) and NE (+3.02%) sub-regions. Lower and nonsignificant positive trends are obtained for NW and CW sub-regions.

□ All these trends are in agreement with the positive and significant trend detected for the whole WEU, despite of the noticeable negative and significant trend (-1.36% per decade) for the SW sub-region, that corresponds with an area with Mediterranean climate.

□ These positive trends may be related with the measured decreased of anthropogenic aerosols emissions during the last decades due to air pollution regulatory actions in most developed countries (Streets et al. 2006) or with the significant increase of high-pressure circulation patterns in WEU (Stefanicki et al. 1998).

CONCLUSIONS

□ Over the WEU, an overall decrease in the annual sunshine duration since the 1950's until the first years of the 1980's is found, followed by an increase from then on. This behavior is in good agreement with the global dimming and brightening phenomena detected from surface solar radiation measurements and satellite estimations (Wild et al. 2005). As a result of this dimming-brightening evolution, the trend of the annual sunshine duration for the whole 1938-2004 period is nonsignificant.

□ When analyzing seasonal series, sunshine duration in spring shows the best correspondence with the annual series. Contrarily, winter has a clear, significant, positive trend, specially marked after the 1970's. This trend comes from remarkable trends in three sub-regions, and has the opposite sign over the Mediterranean climate area.

□ This work has shown the necessity of improving the knowledge about sunshine duration for a more definitive analysis of climate over Europe. In the future, our work will be devoted to investigate the quantitative relationship between sunshine duration and solar radiation in Europe; to analyze possible explanations to variability and trends of sunshine duration, in particular by assessing low frequency circulation patterns and circulation patterns changes over Europe; and to extend as much as possible (both in space and time) the series of sunshine duration.

References:

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Acknowledgments: This research was supported by the Spanish Ministry of Education and Science (MEC) project NUCLIER (CGL2004-02325). The first author was granted a predoctoral scholarship by the same MEC. The sunshine duration was provided by the European Climate Assessment & Dataset Project, the MetOffice (United Kingdom), and the Spanish Instituto Nacional de Meteorología (INM). We also thank Dennis Wheeler and Germán Solé for providing part of two series. Finally, we are grateful to Dr. Gerald Stanhill, who encouraged us to carry out and publish this research.