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Recent summer sunshine duration variability and trends over the Iberian Peninsula: relation with changes in circulation patterns and teleconnection with the Sahel rainfall

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OBJECTIVE and DATA

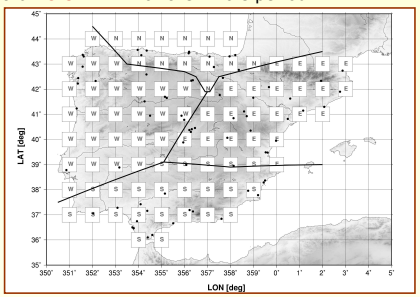
❑ The main goal of this work is to analyze the **summer** (July and August) temporal variability and trends of **sunshine duration** (SunDu) in the Iberian Peninsula (IP) and 4 sub-regions, over the **1961-2004 period**. We also investigate the summer **atmospheric circulation patterns** during the analyzed period, and relate these changes to the detected SunDu trends. Finally, we show the possible relationship between SunDu over the IP and the **Sahel rainfall** variability.

❑ We used the recently homogenized and gridded (1ºx1 resolution, latitude and longitude) **SUNDUIB database** (Fig. 1) (Sanchez-Lorenzo *et al.* 2007), as well as NCEP/NCAR reanalysis data and the Sahel Index values from 1961 to 2004.

RESULTS

Time evolution and trends of summer SunDu

❑ The IP SunDu summer series (Fig. 2) shows a decrease in SunDu from the 1960s to the early 1980s (with a clear minimum from 1982 to 1984), followed by a slight increase until the end of the 20th century. The linear trend is negative and significant (**-1.3%** per decade). This trend, converted to radiation units by using an adjusted Angström-Prescott formula corresponds to a decrease of more than **6.0 Wm^{-2}** for the whole period.



❑ The different sub-regions (Fig. 1) are based on a Principal Component Analysis (PCA) applied in *S* Mode (Sanchez-Lorenzo *et al.* 2007).

❑ SunDu in the 4 sub-regions shows negative trends, which are significant only in W and S, where the trends are of -2.1% and -1.4% per decade, respectively.

***Figure 1**. Location of the grid points and the schematic regionalization based on PCA (Sanchez-Lorenzo et al. 2007).*

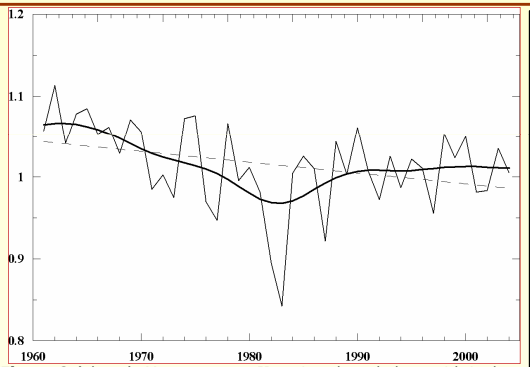


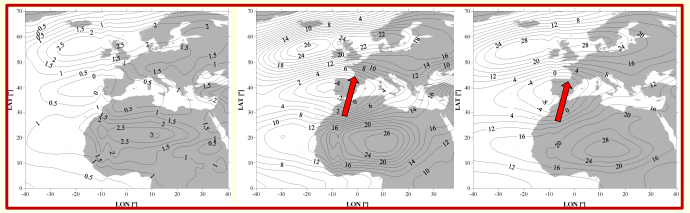
***Figure 2** (above). Mean summer IP series plotted along with its low-pass filtered series and its linear regression (dashed line). The series is expressed as relative deviations from the 1971-2004 mean.*

***Figure 3** (right). Composite of SLP (left), 850 hPa (center) and 700 hPa (right) anomalies differences for extreme negative and positive Sahel Index.*

Sunshine duration and Sahel rainfall variability

❑ The correlations between the Sahel Index (JJASO) and the summer SunDu series are **positive and significant** for the whole IP (r=0.61), but exhibit differences in the sub-regions: 0.65, 0.56, 0.55 and 0.28 (not significant) in regions S, E, W and N, respectively.

❑ We computed **composite** patterns of anomalies during **extreme** negative (≤-1) and positive (≥+1) Sahel Index **phases** (for the three levels considered: SLP, 850 and 700 hPa). Maps of these differences (Fig. 3) reveal a relative low (high) pressure system over western IP during the summers with very dry (wet) Sahel rainfall, maybe associated with a possible increase (decrease) of cloudiness and more (less) African dust intrusions.



Changes in the summer frequency of atmospheric circulation patterns

❑ All July and August days from 1961 to 2004 were classified applying a **PCA in T-Mode and** then a **Cluster Analysis** using k-means method as clustering algorithm (Romero *et al.* 1999), and using SLP and geopotential fields at 850 and 700 hPa from the NCEP/NCAR reanalysis.

❑ The **time series of absolute frequency** for 4 out of the 12 obtained patterns (not shown) are negatively and significantly correlated with the summer IP SunDu series (values between r=-0.38 and r=-0.66), while other 4 patterns are positively and significantly correlated (values between r=0.31 and r=0.52).

❑ **Grouping** together the absolute frequency of the circulation patterns with either negative or positive correlations, the correlations coefficients increase to r=-0.85 and r=0.73, and both frequency series show **significant trends** with opposite sign: +2.6 and -4.4 days per decade, respectively (Fig. 4).

❑ The maps of **mean** and **difference** SLP and 850 and 700 hPa, for all days classified in patterns with **negative** correlations (Fig.5.a), show a relative low pressure at 850 and 700 hPa levels over northwestern IP, with a predominant **south-southwestern flow**. The patterns with **positive** correlations (Fig. 5.b) show stronger **positive pressure anomalies** over the IP.

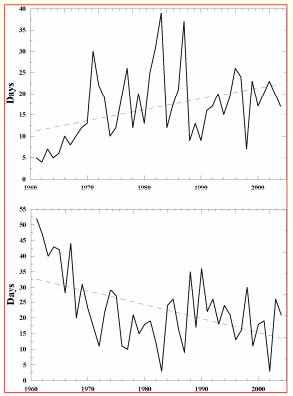
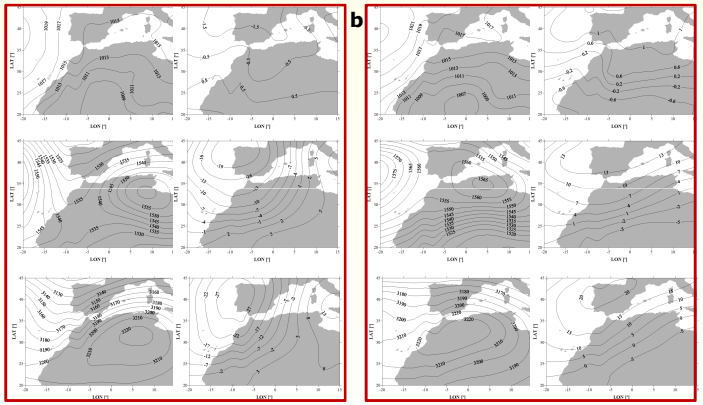


***Figure 4** (left). Absolute frequency of the 4 circulation patterns with negative (top) and positive (bottom) correlations with the summer IP SunDu series and their linear regression (dashed lines).*

***Figure 5** (right). Mean SLP and 850 and 700 hPa maps of the grouped patterns with negative (a) and positive (b) correlation with the summer IP SunDu series. The maps showing differences between these mean patterns and the mean for all the 1961-2004 period are also included.*



CONCLUSIONS

❑ The temporal evolution of the summer IP SunDu shows a negative significant trend, as a result of an overall decrease since the 1960's until first years of the 1980's, and a later slightly increase until the end of the 20th century that not compensate the previous decrease. This behavior is in good agreement with the global dimming and brightening phenomena described at annual resolution for other regions from solar radiation measurements (Wild *et al.* 2005).

❑ Our results suggest a possible link between the precipitation in the Sahel and the SunDu over the IP, due to an increase (decrease) in cloudiness and in African dust intrusions during the years with dry (wet) anomalies in the Sahel rainfall. This hypothesis maybe is related (as in Prospero and Lamb 2003) with the positive and significant correlations (r=0.52) obtained between Sahel Index and the mean summer Total Suspended Particles (TSP) series from 14 stations in Spain (1996-2004 period).

❑ The detected summer atmospheric circulations patterns changes confirm the importance of considering low-mid troposphere to understand the trends in summer SunDu over the IP.

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