

# Downward shortwave radiation trends in Europe since the 20th century: what we know from direct measurements and sunshine duration records?

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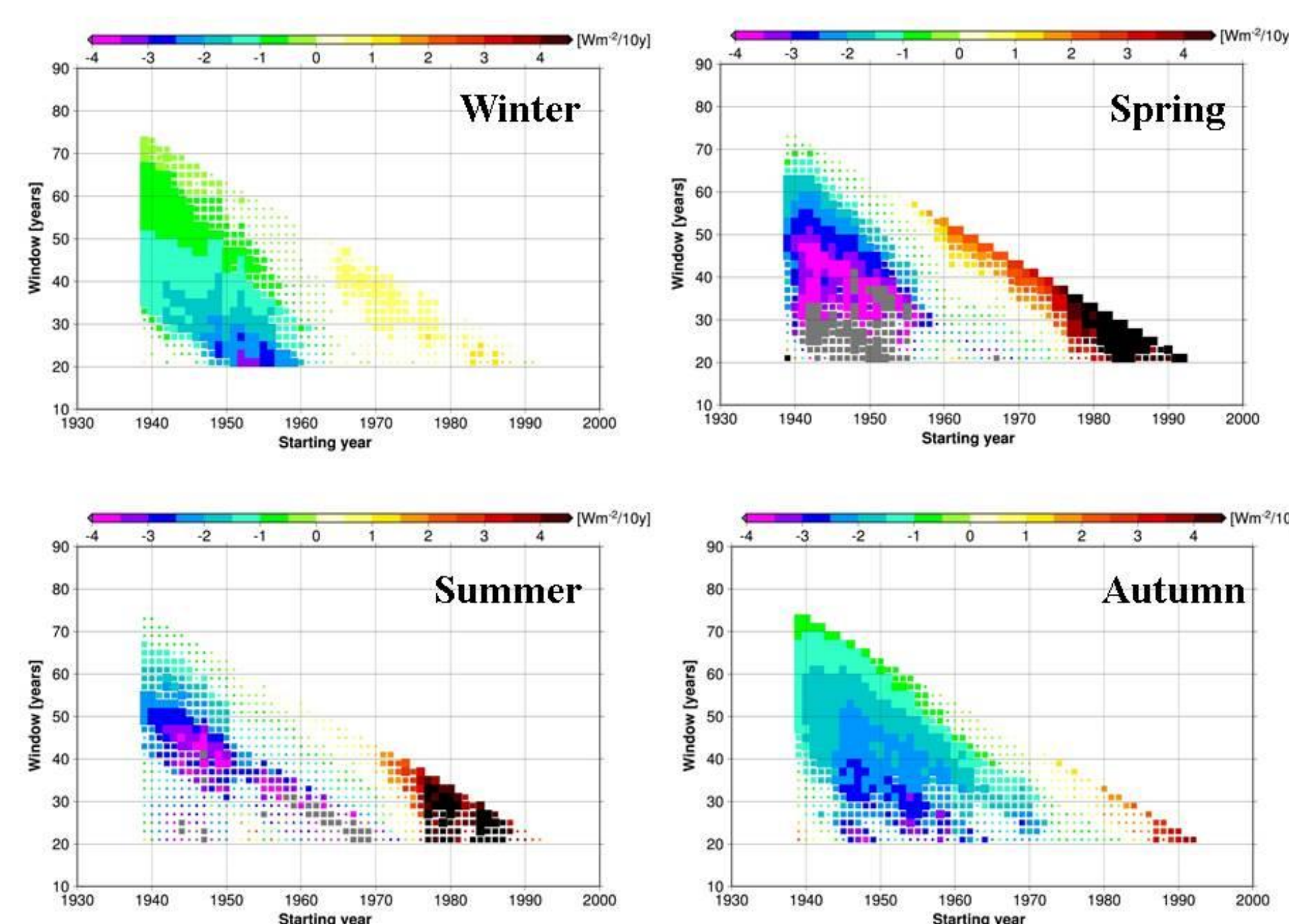
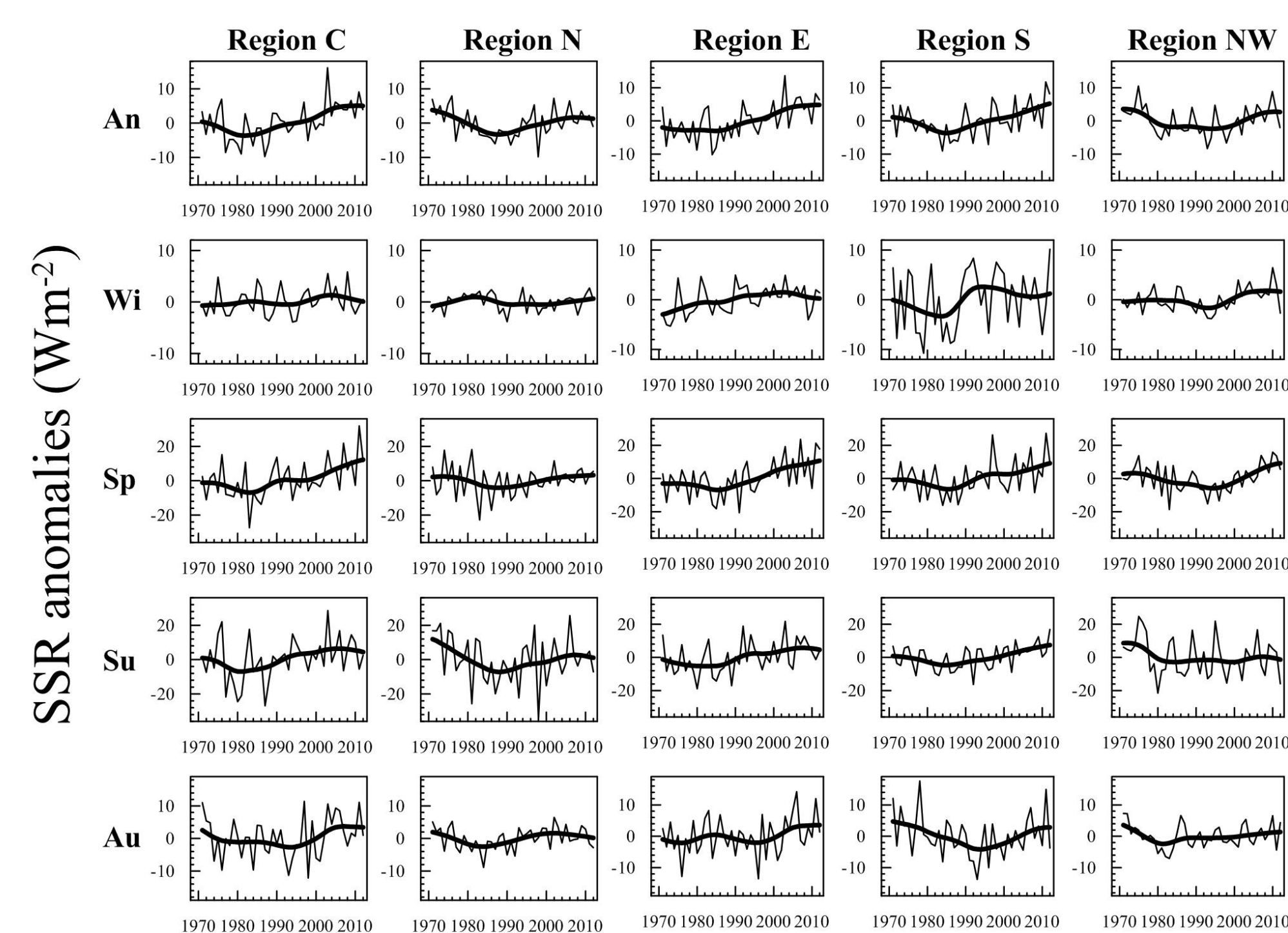
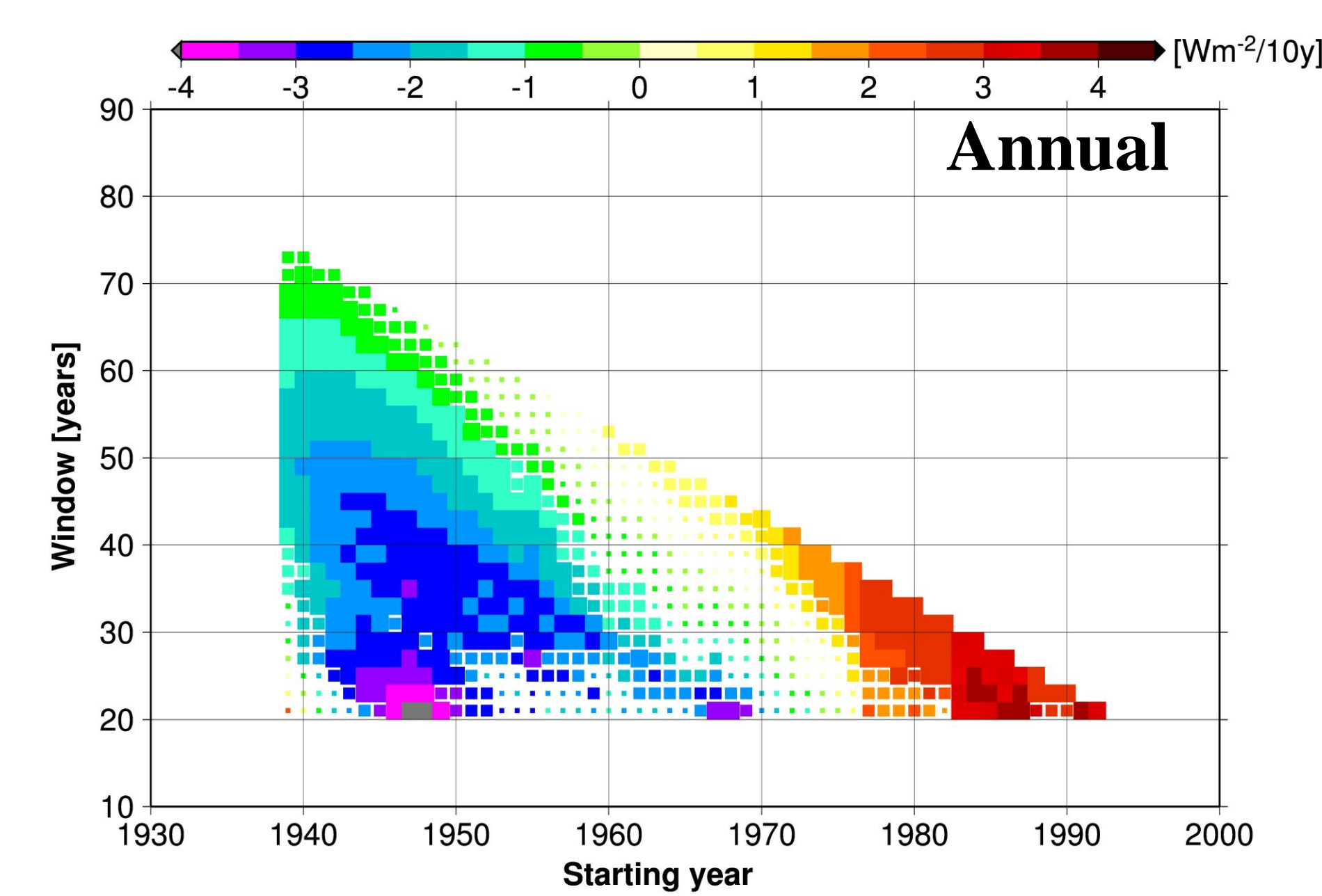
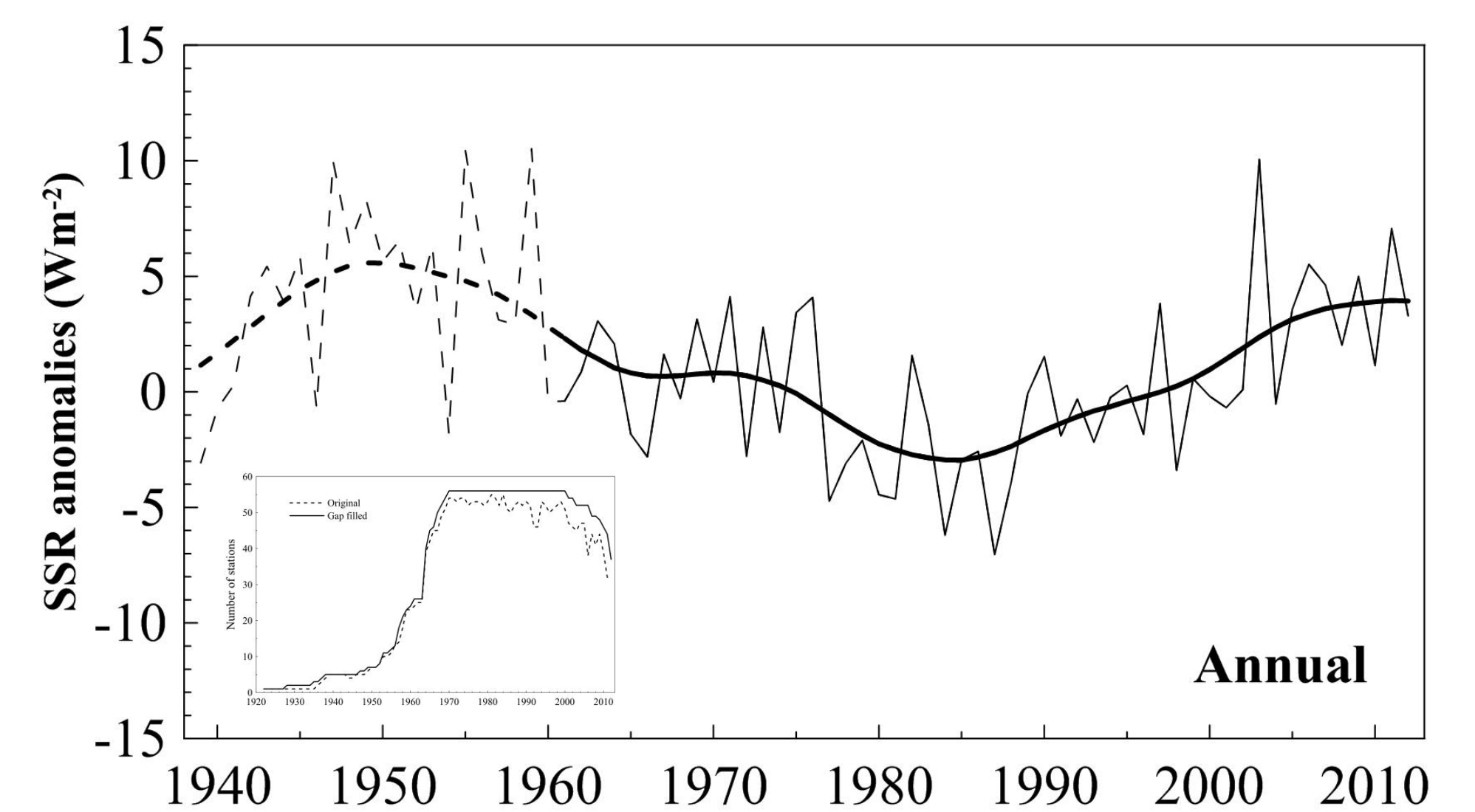
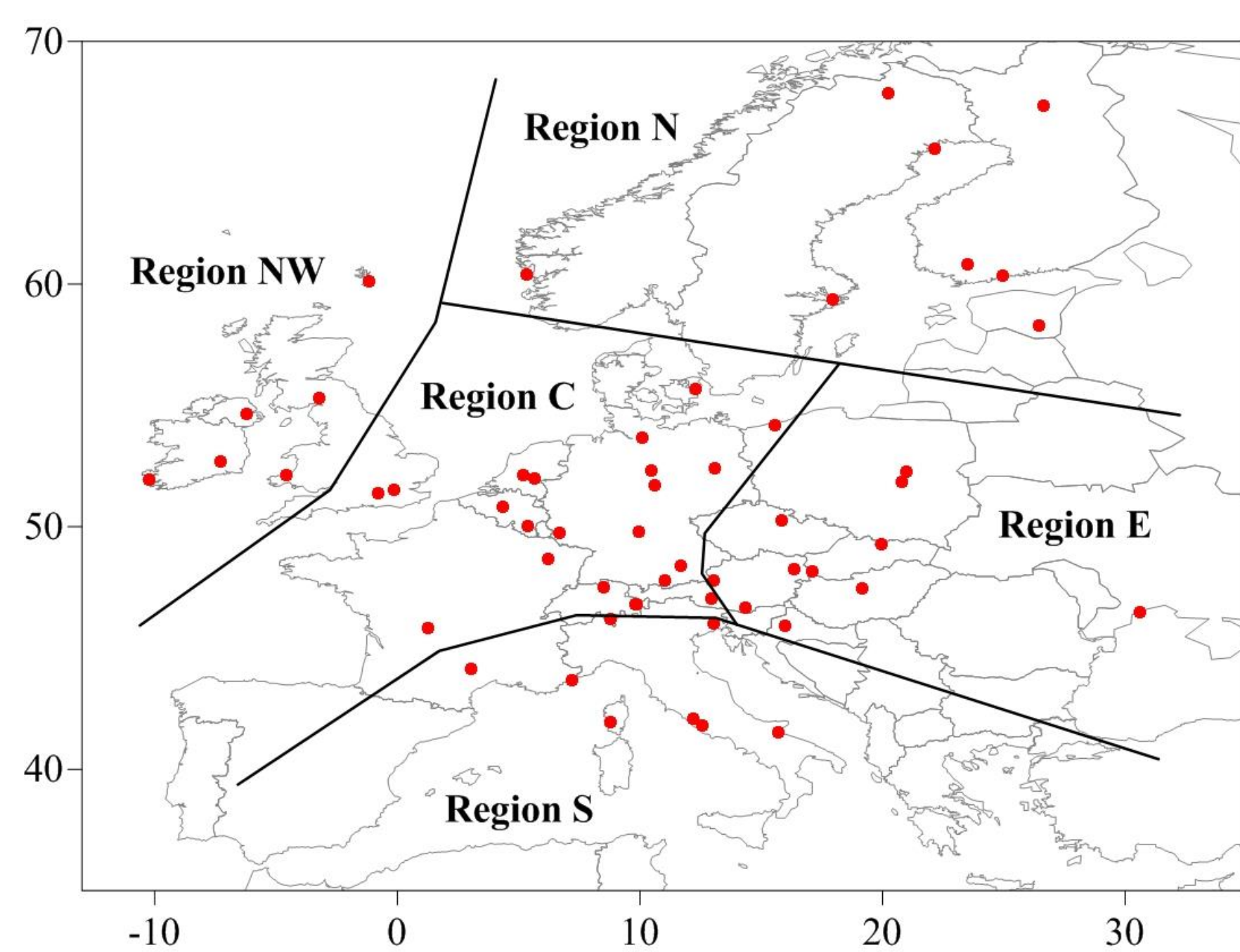


## 1. Introduction

A widespread reduction of downward surface shortwave radiation (SSR) has been well established and documented from the 1950s to the 1980s, and an opposite trend has been detected in many regions of the world since the 1980s. This decrease and increase in SSR has been defined as “global dimming” and “brightening” periods, respectively. Nevertheless, the importance of the availability of high-quality SSR data in order to estimate long-term trends is well known, particularly with respect to the temporal homogeneity of the databases. This work presents a reassessment and update until December 2012 of the trends in SSR over Europe, which is based on the 56 longest and homogenized series available at the Global Energy Balance Archive (GEBA). Unfortunately, there exists a substantial gap in direct measurements of SSR as few stations in Europe provide records before the 1960s. To overcome the lack of direct measurements, the analysis can be supported with other proxy variables more widely measured, such as sunshine duration records. Thus, in this work we also present the reconstructed SSR variations since late 19th century in Europe based on the longest sunshine duration series over Europe.

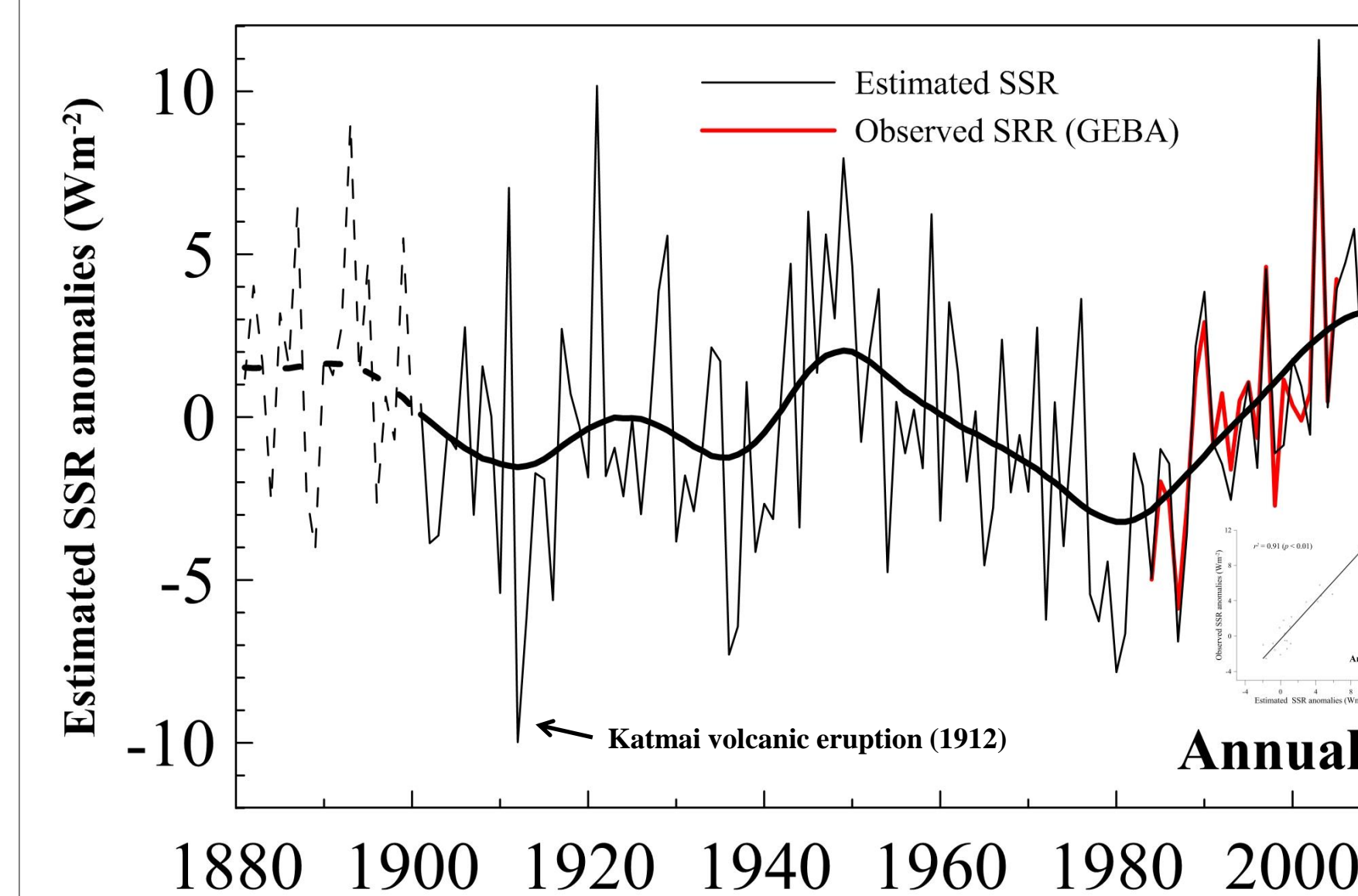
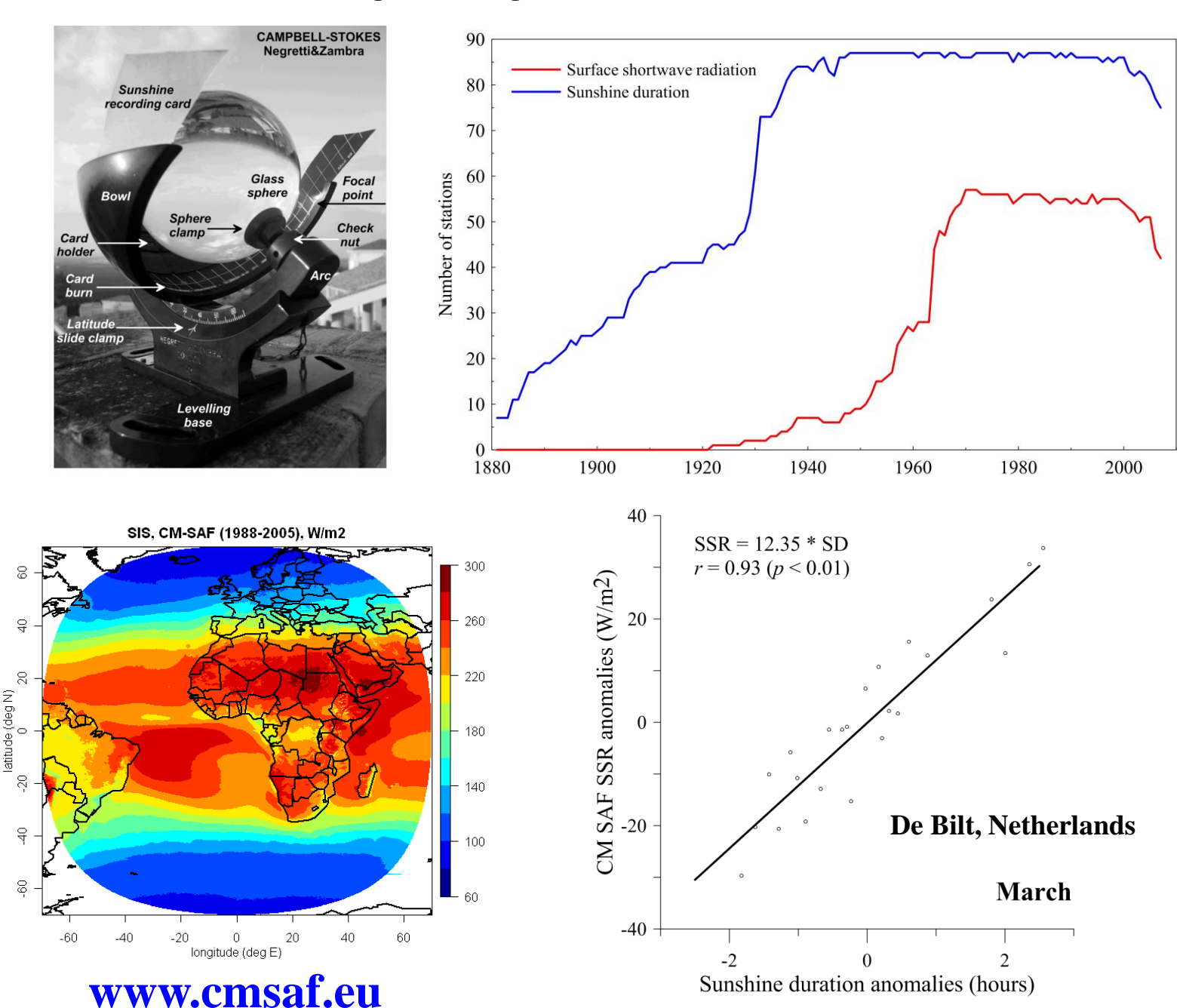
## 2. Trends in downward surface shortwave radiation (SSR) over Europe, 1939-2012

- The longest 56 series of SSR over Europe were selected. Only series starting before 1971, and containing at least 30 years of data up to 2012.
- The homogeneity of these SSR series has been tested on a monthly basis by means of the relative Standard Normal Homogeneity Test (SNHT).
- The regionalization was based on a Principal Component Analysis (PCA). Each of the stations was assigned to the PC with the highest positive loading.
- The composite annual SSR series shows an increase from 1939 to the early 1950s (i.e., early brightening), followed by a reduction until mid-1980s (i.e. dimming) and a subsequent increase up to the early-2000s (i.e., brightening), ending with a tendency to stabilization since the mid-2000s. Similar variations are obtained for most of the seasons and regions across Europe.
- Unfortunately, there exists a substantial gap in measurements of SSR as few stations in Europe provide records before the 1960s (move to Section 3).

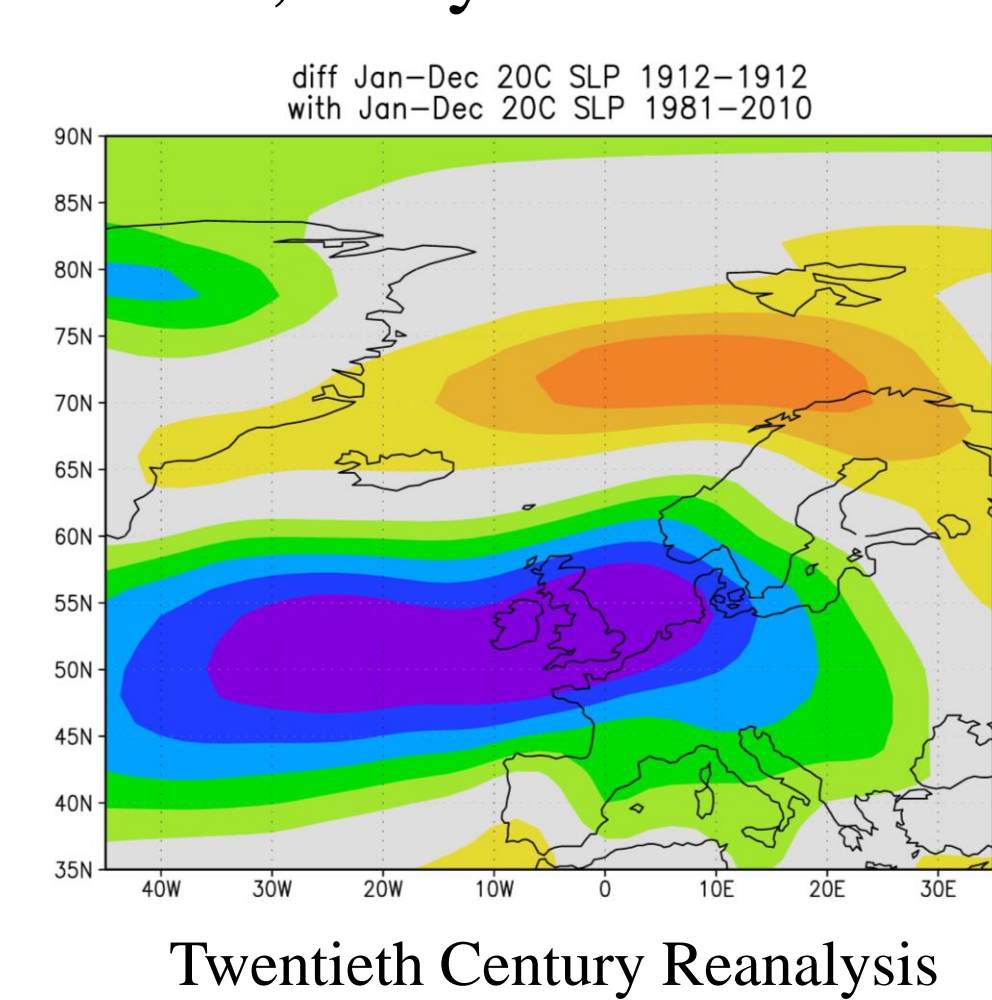


## 3. Trends in sunshine-derived downward surface shortwave radiation (SSR) since the 1880s

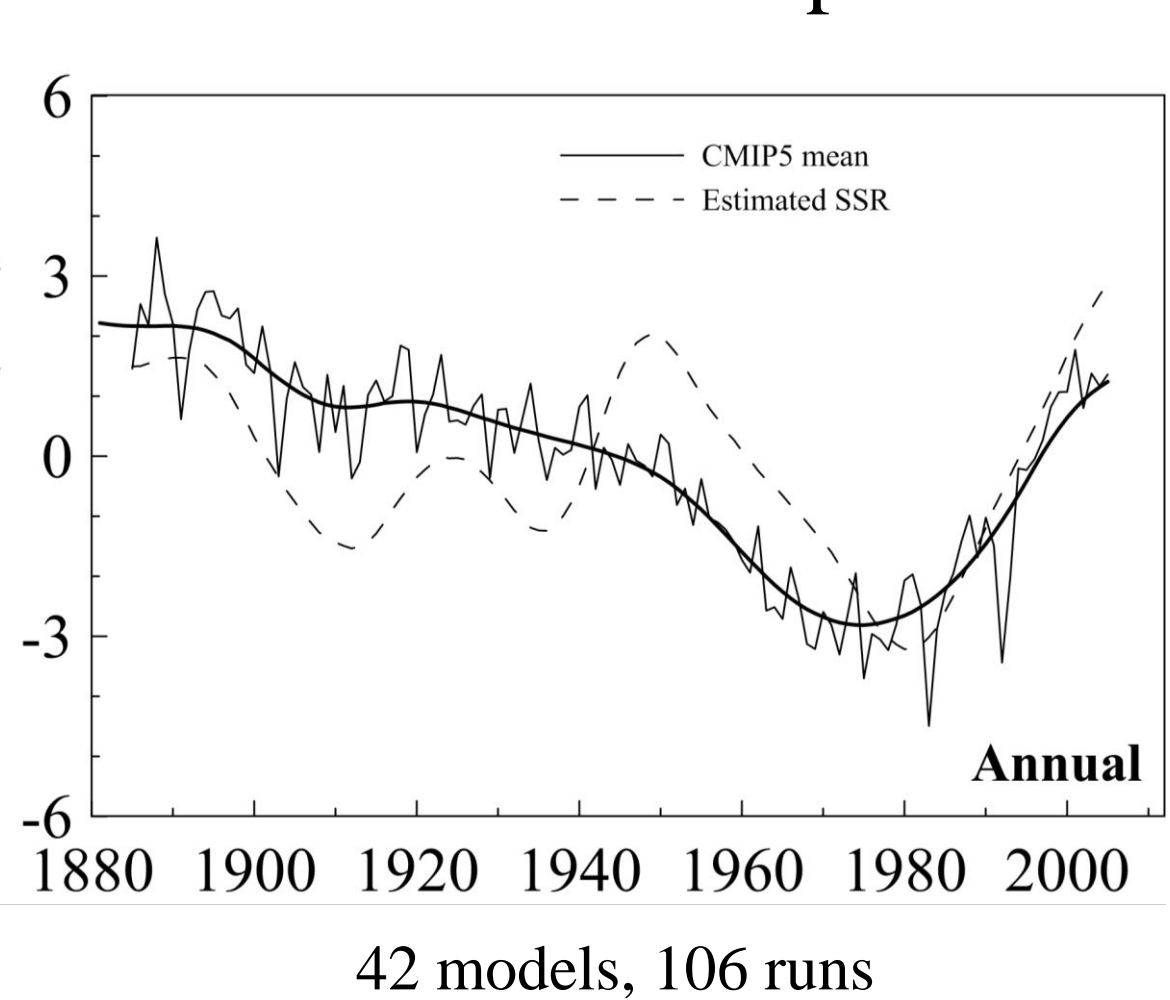
- The longest (>80 years of data) sunshine duration series over Europe were selected.
- The estimated SSR variations have been estimated by using the relationship found between the sunshine duration series and a satellite-derived SSR dataset (0.03 x 0.03 degrees of spatial resolution), provided by the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF), during the common subperiod 1983-2005. The reconstructed records have been validated by using the GEBA series described in the first part of this work.
- The temporal evolution of the mean SSR annual series starts with a decrease until the 1910s, followed by a period without relevant decadal variations between the early 1910s and the 1930s. A brief early brightening period is detected in the late 1930s and 1940s, whereas since the 1950s the series is characterized by the well-known dimming and brightening periods.
- The estimated SSR also highlights a minimum in 1912, which can be the signal of the Katmai volcanic eruption (i.e., largest volcanic eruption in the 20th century).
- The multi-model mean of the CMIP5 historical simulations reproduce the dimming and brightening periods (although earlier turnaround from dimming to brightening in the models), but do not reproduce the observed variations before the 1960s.



1912, the year without sun



CMIP5 historical experiment



## 5. Conclusions

- **Section 2:** The composite annual SSR series shows an increase from 1939 to the early 1950s, followed by a reduction until mid-1980s and a subsequent increase up to the early-2000s, ending with a tendency to stabilization since the mid-2000s. Similar variations are obtained for most of the seasons and regions across Europe. There is no statistically significant increase since the 1950s or before, which implies that the trend in SSR cannot be at the origin of the overall warming over Europe observed during this time.
- **Section 3:** Sunshine duration records have been used to estimate quantitatively SSR trends from the late 19th century up to the present. A dimming (brightening) is visible in estimated SSR during the 1950s–1970s (1980s–2000s), in line with observed SSR series. Equally, there is a brief early brightening period restricted to the late 1930s and 1940s, with a lack of significant decadal variations in the preceding period.

## References

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