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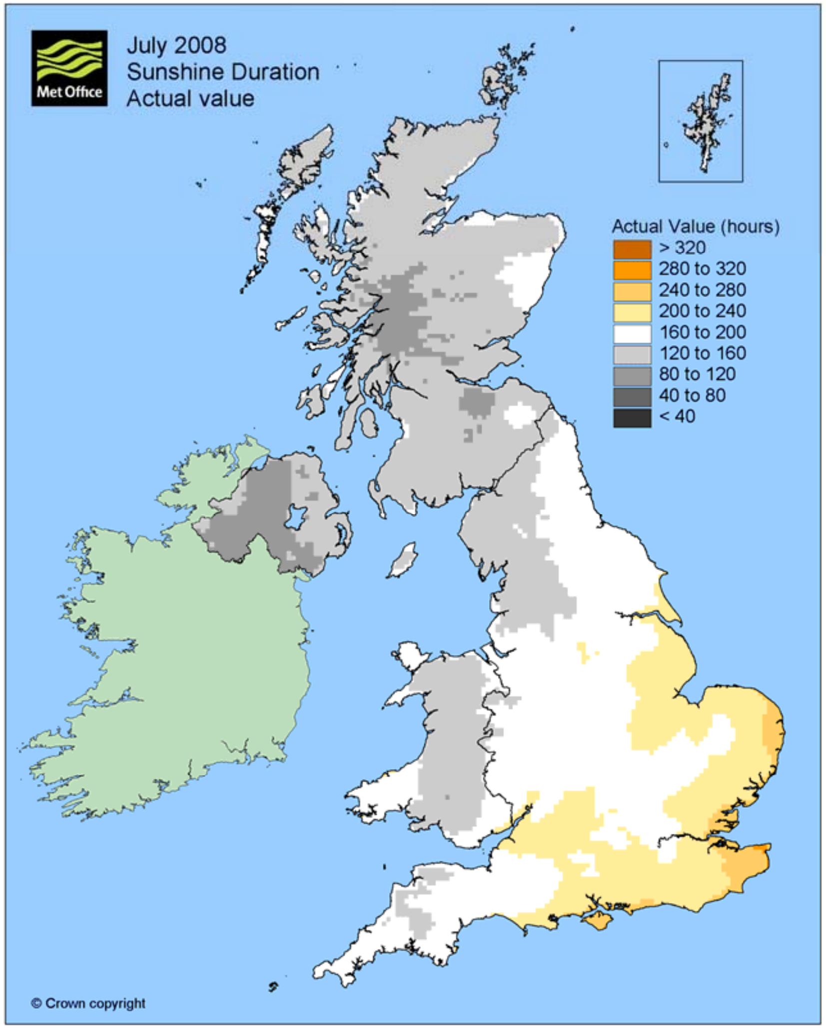
Using satellite data to improve the interpolation of monthly sunshine duration

As part of its public service commitments, the Met Office produces maps of the monthly duration of bright sunshine and makes these available via the web. The quality of these maps, particularly in near-real time, is known to be poor for two reasons – the in situ observations come from two types of instrument with different response characteristics, and the network of real-time stations is both sparse and unevenly distributed. Work is underway to improve the spatial interpolation of the in situ data by incorporating geostationary satellite data in the analysis. In the first phase of the work, Spinning Enhanced Visible and Infra Red Imager (SEVIRI) observations have been used to estimate daily sunshine duration for 2007 and 2008 for each land pixel over the UK. The analysis uses the operational SEVIRI cloud mask produced by the EUMETSAT Satellite Application Facility for Support to Nowcasting and Very Short Range Forecasting (NWC SAF). Agreement between the satellite-derived sunshine durations and collocated surface observations is best in winter. In summer, the satellite estimates tend to be lower than the corresponding in situ data, with more variance in the differences than in winter. Work is ongoing to understand how the agreement between the two data types varies with season, geographical location, in situ instrument type, land surface type and cloud mask. Preliminary results from using the satellite data to interpolate monthly sunshine totals will also be presented.

Using satellite data to improve the interpolation of monthly sunshine duration

Lizzie Good and Dan Hollis



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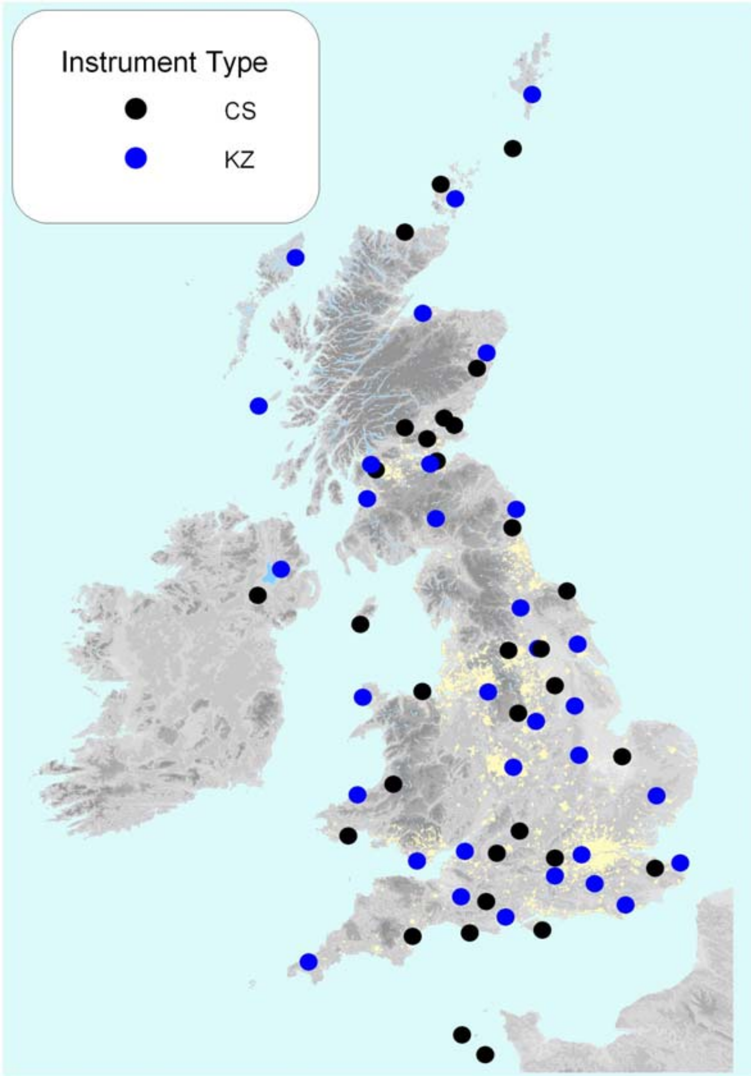

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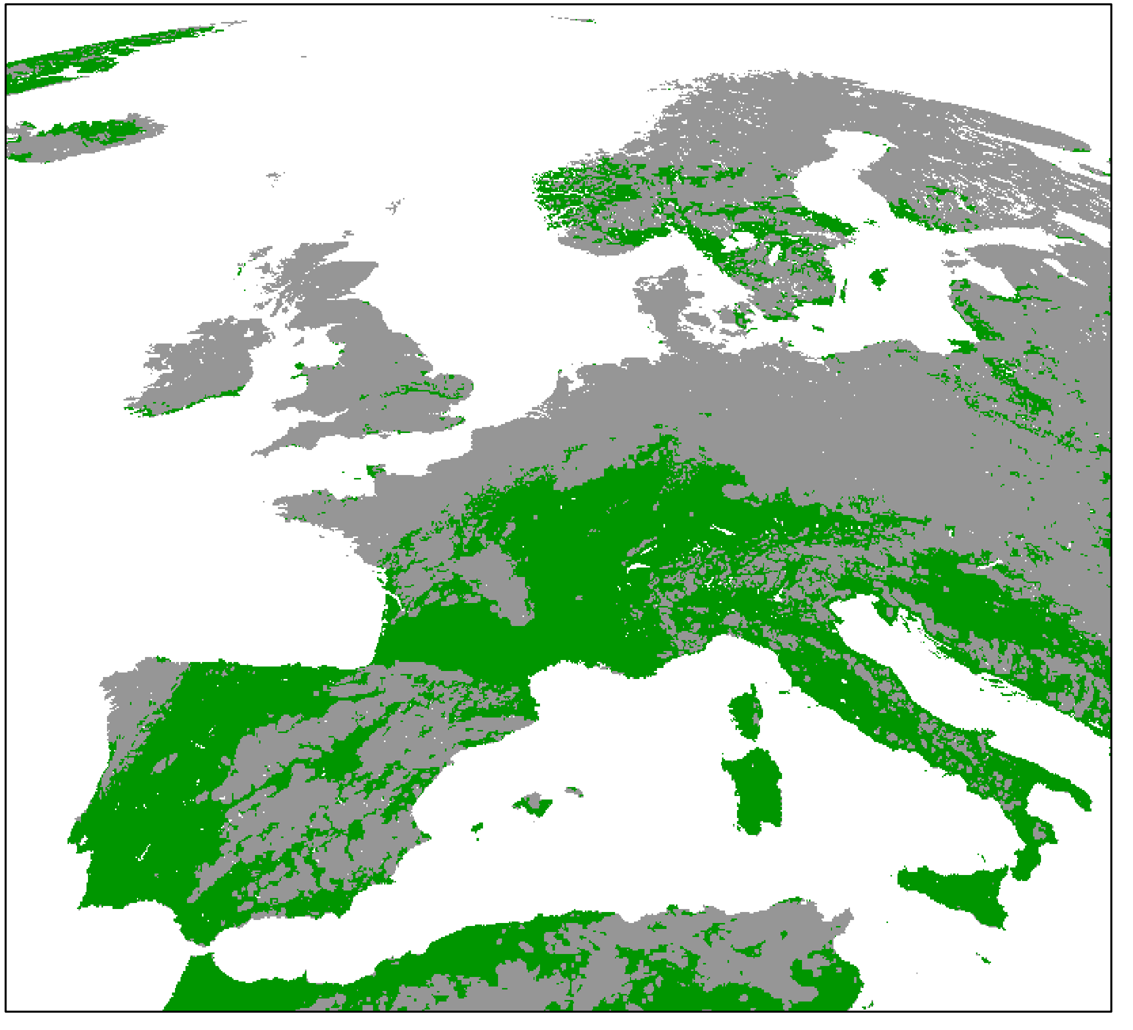

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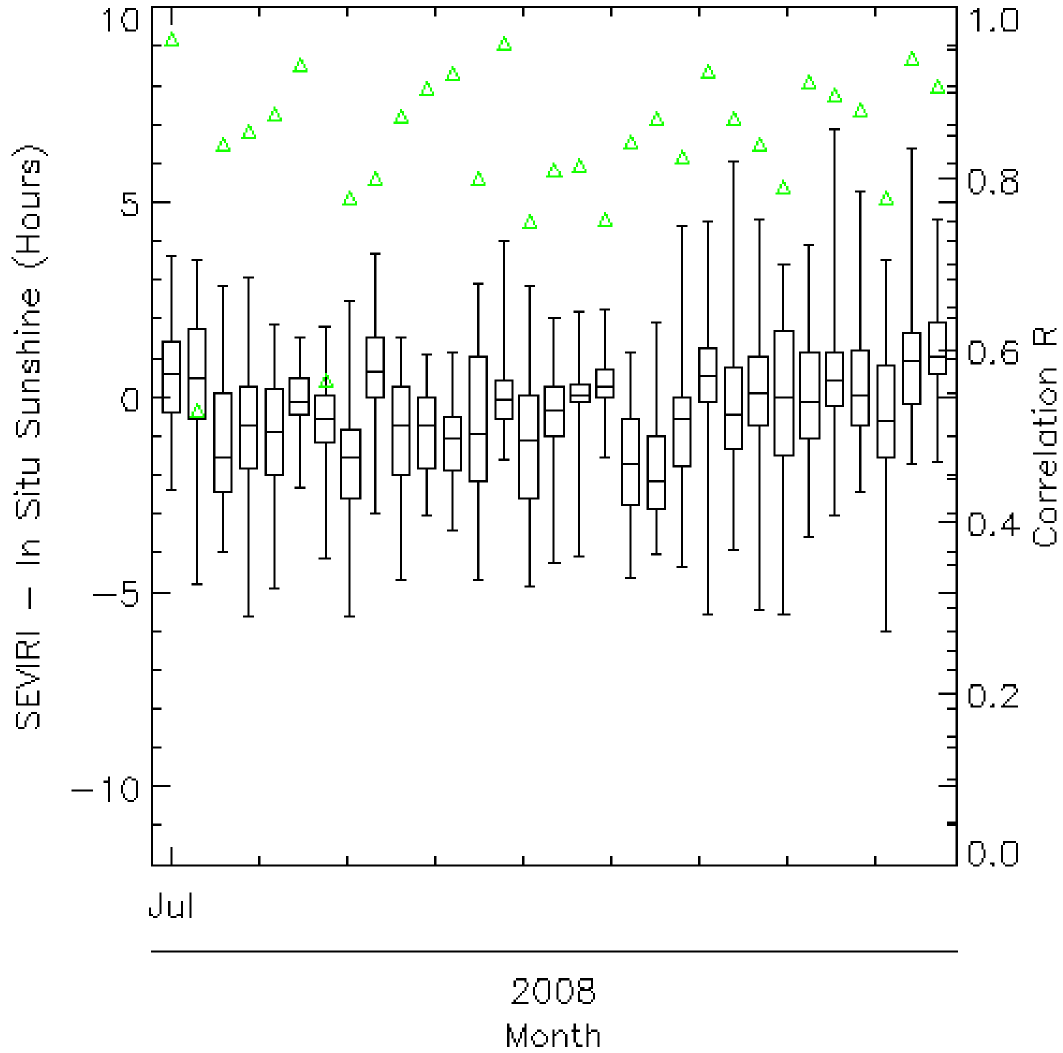

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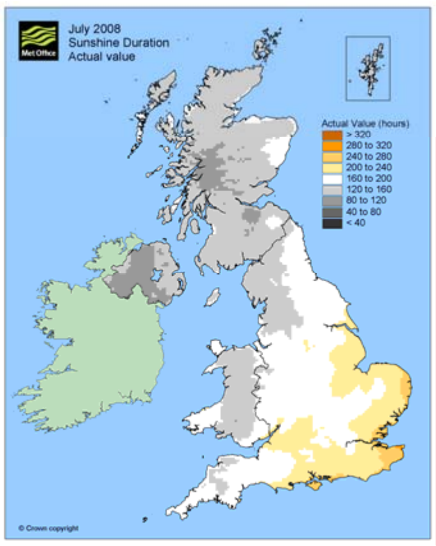
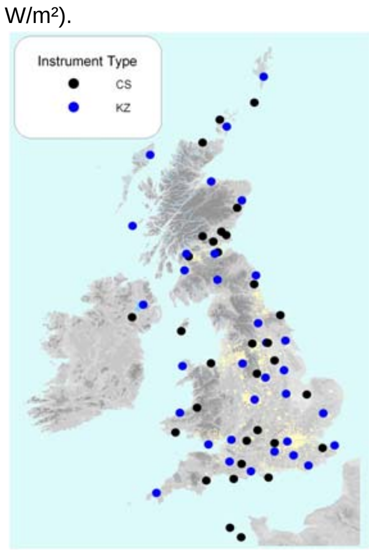


As part of its national **climate monitoring activities**, the Met Office produces maps and regional averages of monthly sunshine duration for the UK. These maps and regional values are derived from 5 km resolution gridded data sets that have been generated by interpolating in situ observations of sunshine duration.

A provisional version is produced at the end of each month using data available in near-real time. This is updated a few months later using additional data from non-real time climate stations and after the observations have been fully quality controlled.

There are two **issues** that affect the quality of the monthly sunshine products:

A) The network includes **two types of instrument**: (1) the traditional Campbell-Stokes sunshine recorder (which uses a glass ball to burn a trace on a piece of card), and (2) the Kipp & Zonen CSD-1 sunshine duration sensor (which uses photo-diodes to determine when insolation exceeds 120 W/m²).



B) Currently there are approximately 90 Campbell-Stokes (CS) and 35 Kipp & Zonen (KZ) instruments deployed across the UK. However, there are only around **65 stations that report in near-real time**. This means that the density of stations is low and extensive interpolation is required to produce a spatially-complete data field.

The **proposed solution** is to use satellite data to improve the interpolation of the in situ data.

In this study, observations from the geostationary Spinning Enhanced Visible and Infrared Imager (SEVIRI) have been used to estimate daily sunshine duration. SEVIRI provides observations every 15 minutes with a resolution of 5-6 km over the UK. The computation for an individual pixel for an individual day is shown in the flow diagram.

Valid observations between sunrise and sunset are collected and counted

↓

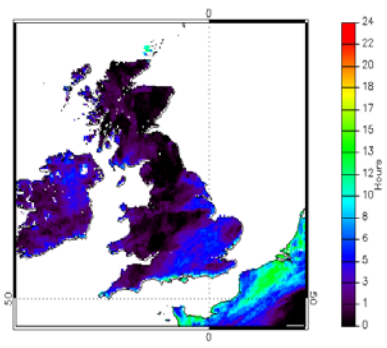
The proportion of cloud-free observations (P) is calculated

↓

The maximum possible sunshine duration (L) is determined (= day length)

↓

The actual sunshine duration (D) is estimated
D = P x L



Example of sunshine duration estimated from SEVIRI data for 10 July 2008.

Note 1: Observations close to sunrise and sunset are excluded because the CS recorders (which form the majority of the in situ network) do not record sunshine at very low solar elevations.

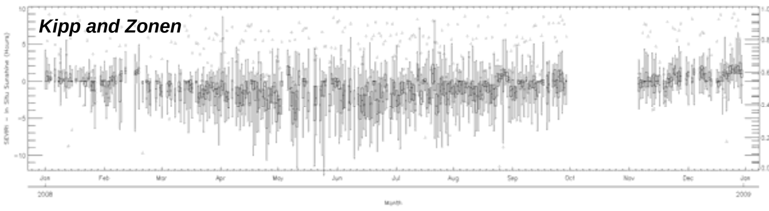
Note 2: A daily sunshine duration is only produced if at least 90% of the potential SEVIRI observations are available.

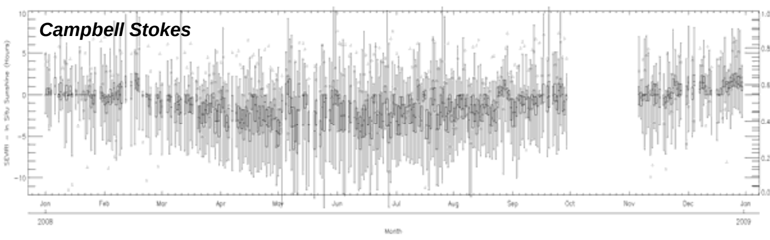
Three **methods** for identifying cloud-free pixels have been tested:

- Using the **standard cloud mask** produced by the Satellite Application Facility for supporting NoWCasting (SAFNWC).
- Using an in-house method for converting satellite radiances into an **optical thickness** – pixels with a thickness below a fixed threshold are assumed to be cloud-free.
- Using the SAFNWC **cloud type** product – semi-transparent cirrus is regarded as 'cloud-free' and observations of 'fractional cloud' contribute 0.5 to the sum of cloud-free pixels.

Example of SEVIRI cloud mask over Europe for 10 July 2008 12:00

Comparisons have been made between the SEVIRI sunshine durations and collocated in situ data:





The plots on the left are based on the standard cloud mask. They show the median and inter-quartile range (boxes) and maximum and minimum values (whiskers) of the difference between the SEVIRI and in situ data for each day in 2008.

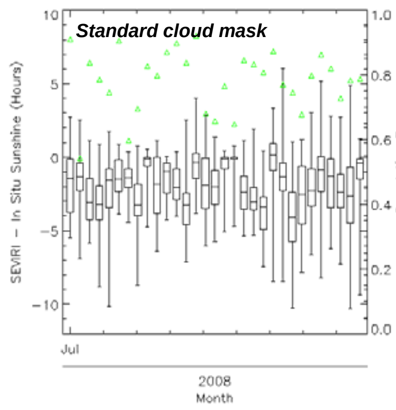
There is very good agreement in winter. The agreement is less good in summer – the SEVIRI estimates tend to underestimate the in situ measurements and there is increased variance.

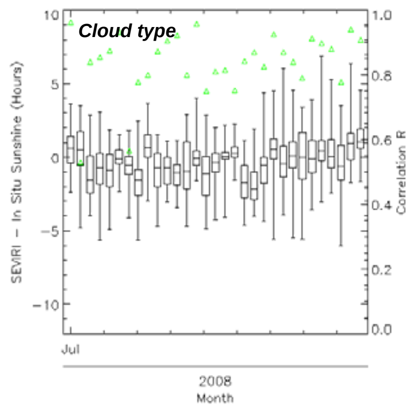
The SEVIRI data agree better with the KZ data than with the CS data.

The plots on the right compare the results for July 2008 from two of the methods for determining cloud-free pixels.

The differences between the SEVIRI and in situ data (boxes & whiskers) are plotted against the left-hand axis. The correlation coefficients (green triangles) are plotted against the right-hand axis.

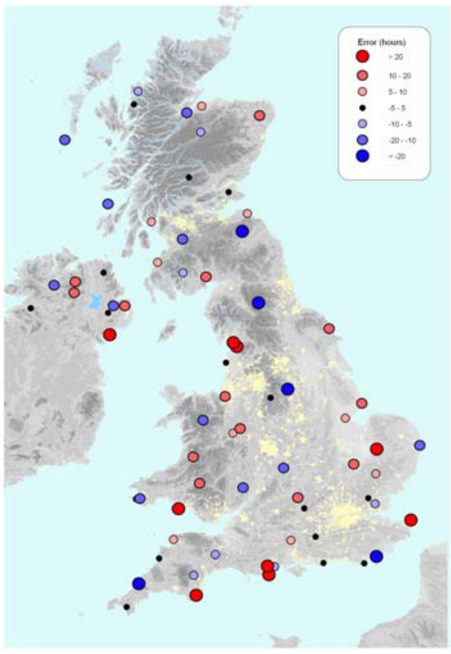
The level of agreement is clearly better for the sunshine durations based on cloud type than for those based on the standard cloud mask. The results for optical thickness (not shown) have the lowest level of agreement.



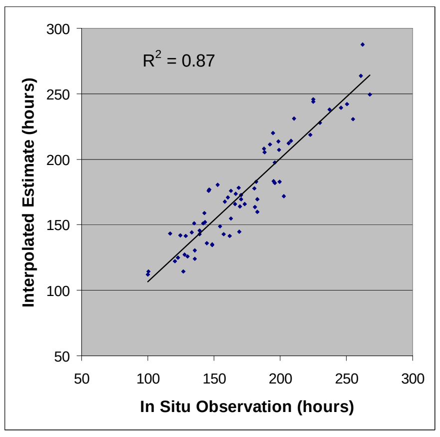


The **application** of the SEVIRI sunshine durations to the interpolation of monthly in situ data has been tested using observations for July 2008. In the existing approach the in situ data are converted to percentages of the 1961–1990 normal and then interpolated using inverse-distance-weighted averaging. The new approach uses linear regression to relate the in situ data to the SEVIRI data. This regression model is then evaluated at each grid point.

Each approach has been used to generate a grid of monthly sunshine duration based only on data from stations that report in real time. The two grids have been evaluated by comparing with independent data from non-real time stations.



The map and graph show the results for the new approach. Only a small improvement over the existing approach is observed.



Conclusions

Estimates of daily sunshine duration from SEVIRI cloud-type data agree well with in situ observations.

The accuracy is greatest in winter. A tendency to underestimate the in situ data in summer may be due to higher frequencies of broken cloud, which is an issue for both the cloud-identification algorithm and for the Campbell-Stokes recorder (due to 'over-burning' of the card).

Initial attempts to use the SEVIRI data to interpolate in situ observations of monthly sunshine duration have shown very modest improvements in skill. However this result is based on just a single month of data.

Further testing is underway using data for a winter month (January 2008). The possibility that variations in performance may be linked to factors such as land surface type, proximity to the coast, altitude and latitude is also being studied.

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