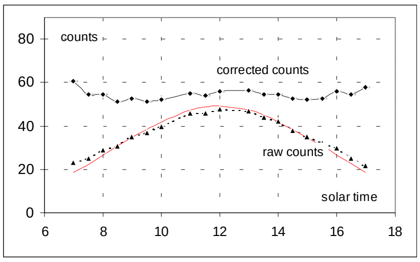
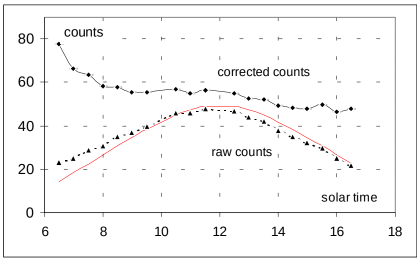
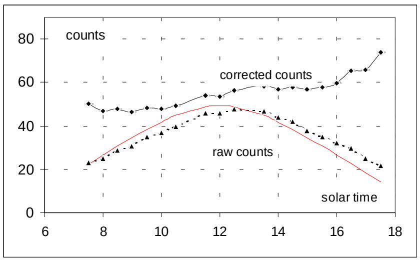
Satellight

Commission of the European Communities

Importance of Spatial and Temporal Determination of Meteosat Counts







Working paper
Pierre Ineichen
Groupe of Applied Physics - Energy
SatelLight meeting, Freiburg
September 1998

1. Introduction

The advantage of satellite derived ground radiation or illuminance data is their continuity in time and their spatial coverage that cannot be achieved by ground networks. In the first step of the conversion, the precision of the derived radiation from the satellite counts depends on the space and time accuracy of the satellite images. It is then dependent on the clear sky normalization and finally on the model used to convert the satellite counts.

This working paper attempts to quantify the influence of the spatial and temporal determination of the satellite counts.

2. The clear sky normalization and the cloud index

In a paper submitted to Theoretical and Applied Meteorology [Ineichen, 1998], we pointed out the importance of the optical air mass and the backscatter angle corrections. Applying these corrections to the satellite counts should allow producing a sun/satellite-geometry-independent count from which a cloud index, representing solely the insolation conditions may be derived.

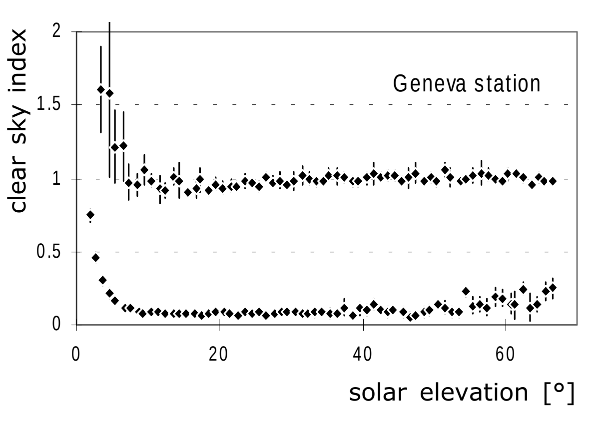


Figure 1 Variation of the clear sky index with solar elevation

In a second step, the ground global radiation should be normalized to obtain a solar-elevation-independent clear sky index. As shown in figure 1, the difficulties arise at low solar elevations and therefore become a source of errors for the radiation derivation for high latitude regions.

To avoid this dependence, the method consisting of directly relate an elevation dependent clearness index to the cloud index has a definite advantage; it can be generalized to address the clearness index of other solar radiation and illuminance components besides the global irradiance.

3. The space determination

At the latitude of Geneva, the spatial resolution of a meteosat image is about 8km x 5.5km. Figure 2 shows a ground image of the region of Geneva, with the corresponding meteosat pixels. The white dot represents the geographic location of the station. Taking into account that a pixel is not a rectangle and that there is an uncertainty in the positioning of the grid, each of the four surrounding pixels can be choose for the station of Geneva.

We tried to quantify the importance of the spatial determination in the radiation evaluation from meteosat images. We used a radiation derivation model and applied it to different pixels or averaged pixels in the region of Geneva:

- geographic pixel: the pixel in which the station is located,
- 3x5 average: a 25km x 25km region surrounding the station,
- 2x2 average: a 16km x 11km region,

- the single pixel located in the dominant wind direction,
- the best of 2x2 pixel: for each ½ hour, we kept the best of the 4 calculated radiations,
- the homogeneous cases: we limited the root mean square difference between the 2x2 cloud indices to 5%.

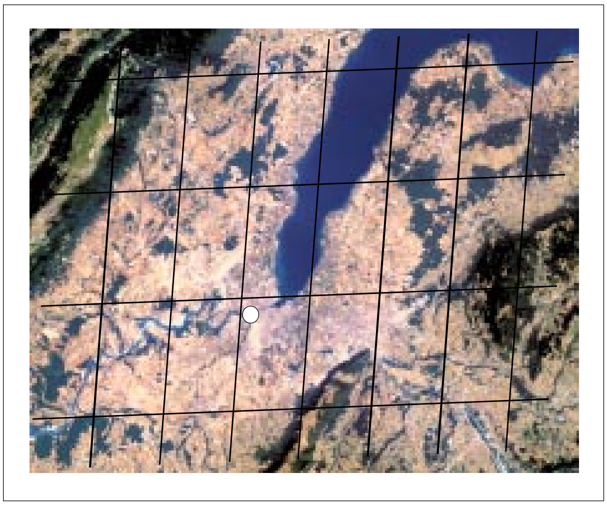


Figure 2 Image of the region of Geneva. The white dot is the geographic location of the ground station.

We then compared the root mean square differences (RMSD) for each cases and obtained the results shown on figure 3:

- 37% when the model is applied on the geographic pixel. This will be the reference value,
- as previously obtained in the satellight program, a slightly better result is obtained by the use of a 3x5 averaged cloud index for the model input. In the case of Geneva, the difference is not very marked because of the geographic characteristics of the region (Geneva is surrounded by two mountains and a lake within the 25km x 25km region). In this case, the accuracy of the pixel location determination is not so important,
- in the region of Geneva, due to the mountains, there are only two dominant wind directions and the highest probability is a west wind. Taking the next pixel in the wind direction or the 2x2 average allows gaining 2 to 3 points in the comparison,
- the choice of the best of 2x2 pixel is not realistic, but it gives the precision which could be achieved when knowing the clouds altitude, wind direction, etc. and which is the intrinsic precision of the model [Perez, 1998],
- the homogeneous case are represented on figure 3 to show a reference lower boundary for the considered model.

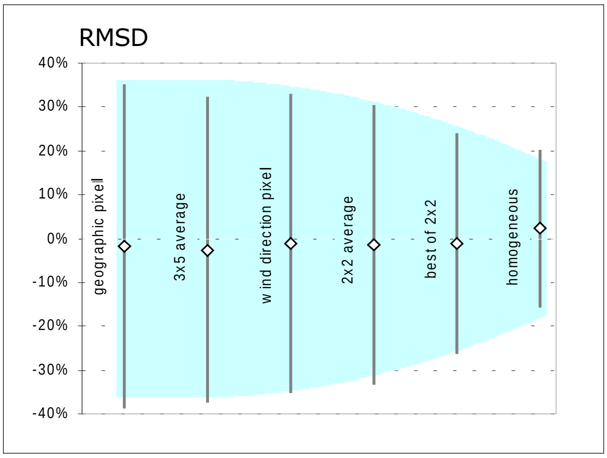


Figure 3 Root mean square difference between model and measurement for the considered cases.

The above considerations show that a shift in the spatial position of the pixel can reduce the model precision up to 5%.

4. The time determination

The time is the second parameter that has a great influence on the model determination and precision. The raw meteosat image has to be corrected for the geometric dependence and the time is the key parameter in this step. The influence of the time determination when applying the geometrical corrections on the raw counts will be quantified by the use of a clear and stable day.

To choose a clear and stable day, we considered a symmetric-to-solar-noon day in a good weather period and looked at the global radiation and the raw counts given by the corresponding meteosat images. Figure 4 shows the global radiation, clearness index, raw and corrected counts for a particular very clear day. From this figure, one can point out a nice symmetry for the global radiation and the raw satellite counts, and a good stability for the clearness index and the corrected counts. Figure 4C shows that even if the corrected counts have a slight variation during the day, one have a good symmetry between morning and afternoon. The curve on figure 4B is proportional to the solar elevation and is drawn to underline the symmetry. The same curve will be drawn on the next graphs.

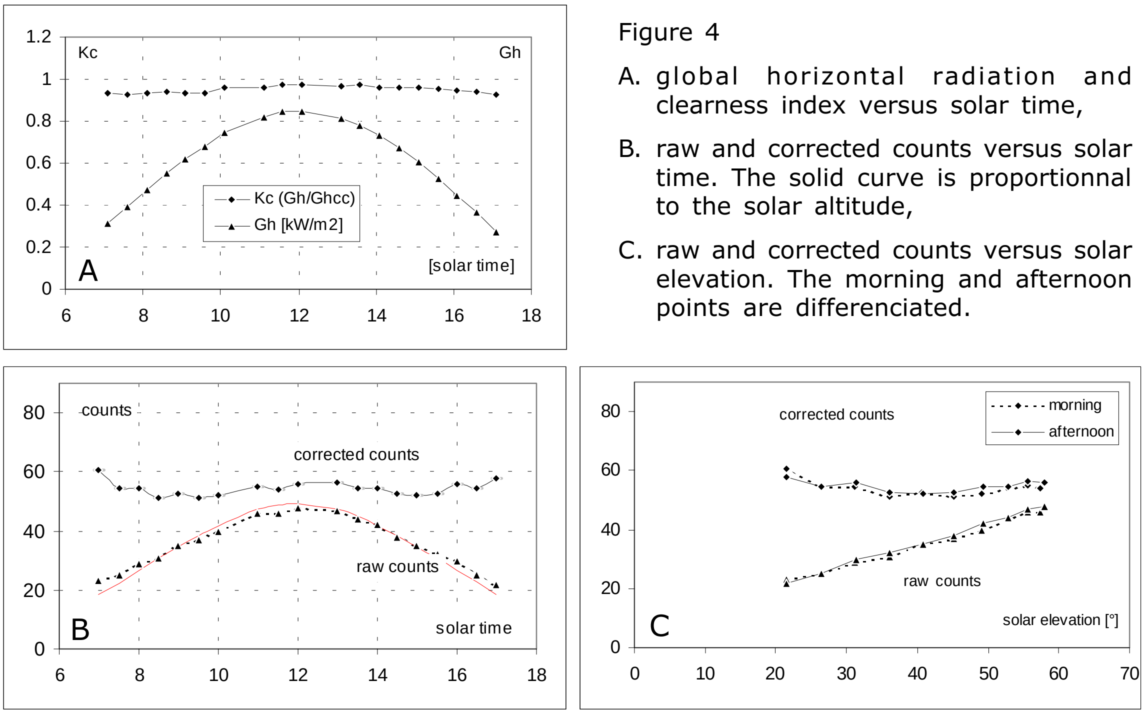


Figure 4

A. global horizontal radiation and clearness index versus solar time,

B. raw and corrected counts versus solar time. The solid curve is proportionnal to the solar altitude,

C. raw and corrected counts versus solar elevation. The morning and afternoon points are differenciated.

Let us now consider a shift of 30 minutes in both directions on the counts data base and draw again the same graphs: one will obtain Figure 5. The proportional-to-solar-elevation curve is drawn again, it is still symmetric to solar noon. It appears clearly on these graphs that a shift of 30 minutes in the time determination can produce an error of up to ±20% on the corrected counts.

Figure 5 shows artificial shifted data in order to quantify the error. If we consider data from Lisbon and Cagliari, we obtain respectively Figures 6 and Figure 7. The observation of the 3 graphs on Figure 6 shows a significant shift in time. It is not so obvious on Figure 7 for which we do not have the corresponding radiation and clearness index to compare with the corrected counts, but there is an asymmetry that can be attributed to a time shift. [Westerhellweg, 1998].

If a database is produced with such a time shift, a systematic asymmetry will be present in the corrected counts and even if the mean bias difference between the model and the measurements is low, it will have a negative influence on the precision of the model (RMSD).

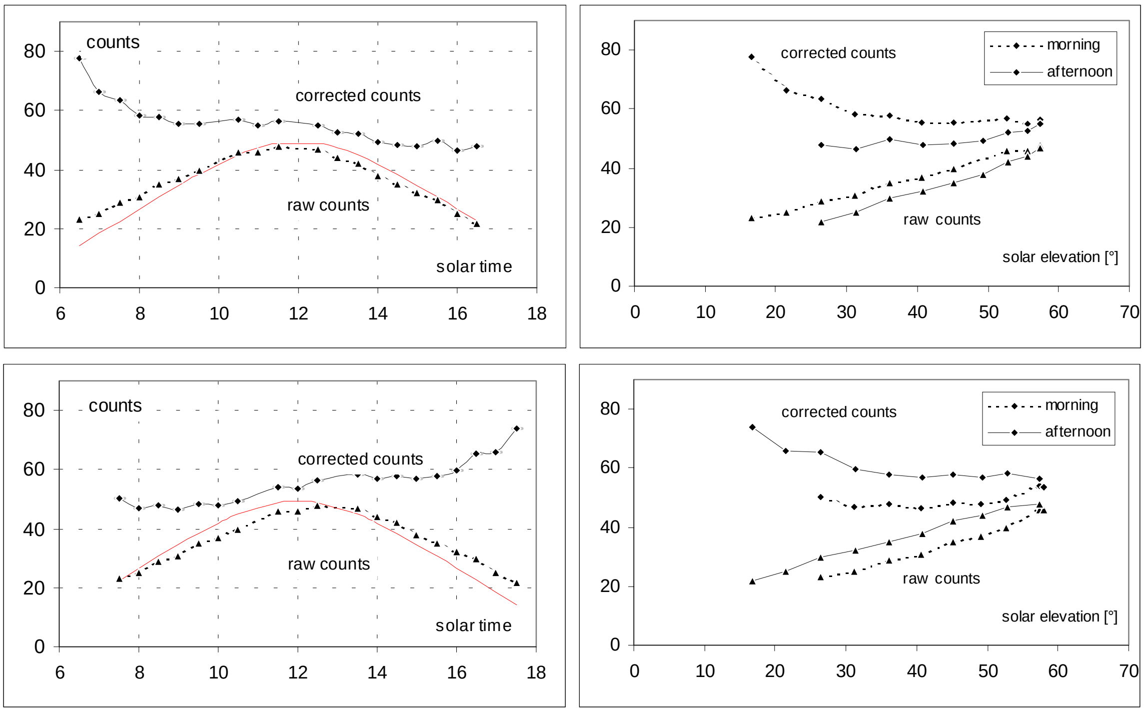


Figure 5 Same as Figure 4 B & C, but with a time shift of minus 30 minutes (top) and plus 30 minutes.

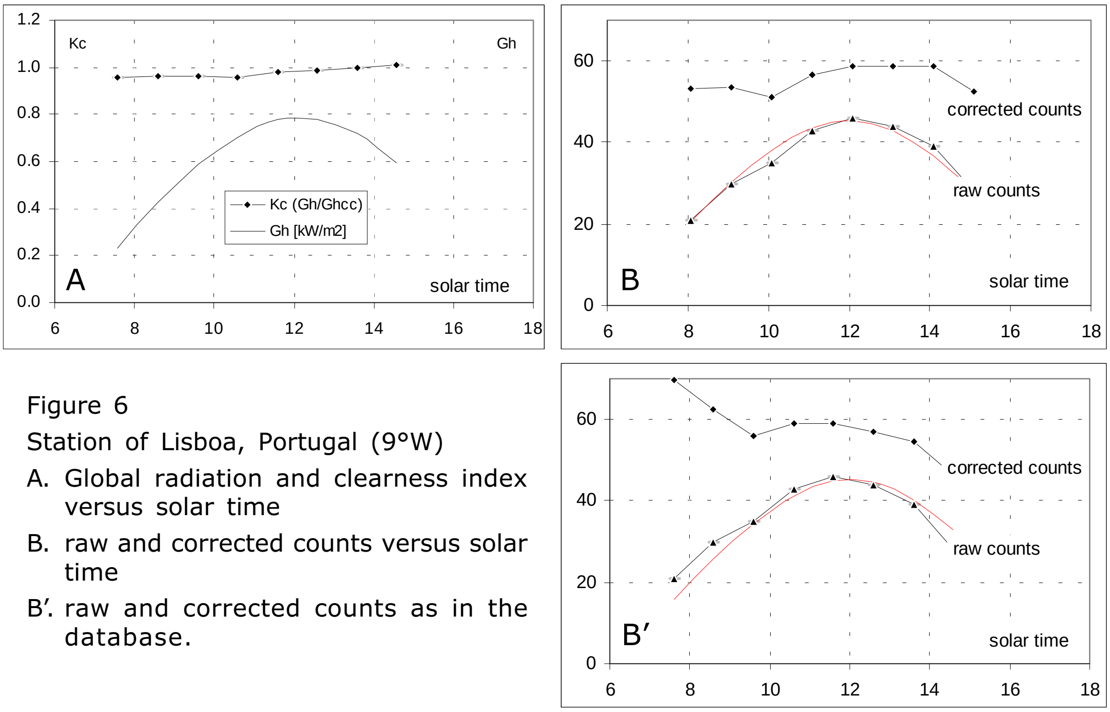


Figure 6

Station of Lisboa, Portugal (9°W)

A. Global radiation and clearness index versus solar time

B. raw and corrected counts versus solar time

B′. raw and corrected counts as in the database.

5. Conclusion

This working paper points out that it is of first importance to be very careful in the space-, time- and geometry-correction of the raw satellite counts.

For the case of Geneva, a space shift of 1 pixel induces a 5% higher dispersion in the evaluation of the global radiation. Due to its particular geographic situation, the station of Geneva is relatively slightly influenced by such a shift, and one can expect a higher dispersion for a flat country-station.

The time-determination of a specific pixel measurement is of very high importance. Indeed, geometric corrections have to be applied on the raw counts and a 30 minutes shift produces errors of up to 20% in the corrected counts. These errors are reported on the evaluated radiation.

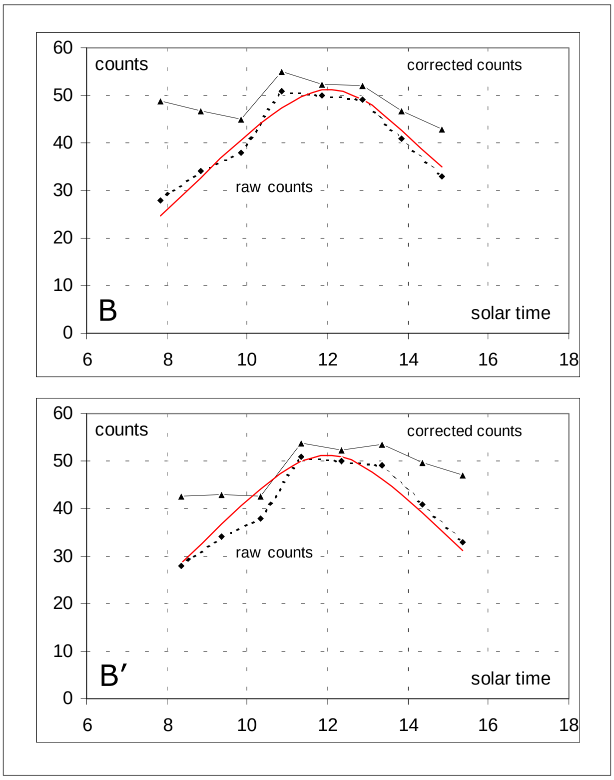


Figure 7

Station of Cagliari, Italy (9°E)

B. raw and corrected counts versus solar time,

B′. raw and corrected counts as in the database.

6. References

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