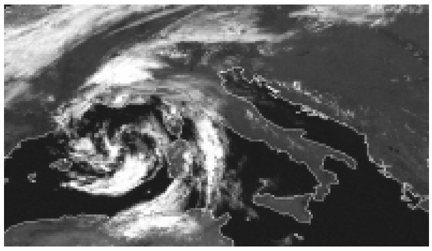
Satellight

Commission of the European Communities

Radiation Derivation from Meteosat Counts



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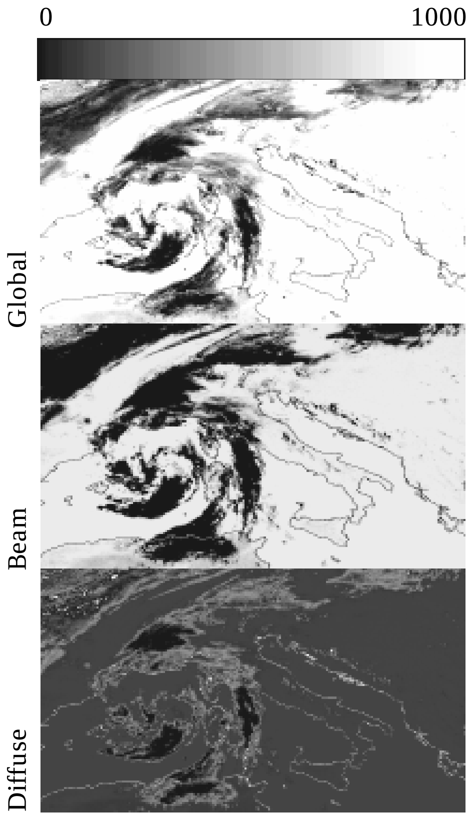

Working paper
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1. Introduction

Visible satellite images from geostationary satellites such as Meteosat are of high interest in the field of solar radiation and illumination resources. They are continuous in time, and provide a spatial coverage that cannot be achieved by ground networks. It is therefore important to assess the precision of methodologies converting these images into solar radiation resource information.

The direct way to convert meteosat images to the diffuse or beam radiation components has the definite advantage to be independent of the conversion to global radiation: the bias and the precision of the first model are not reported on the next steps.

We used data from four European sites to develop and evaluate our model and compared the results with the version used to derive the Satellight database (hereafter version 9) [Satellight, 1998].

2. Data

The ground and satellite data banks used in the present study are: Geneva (latitude 46.2N, longitude 6.1E, altitude 400m, April 1994 to march 1995 [IDMP CH1]), Vaulx-en-Velin (latitude 45.8N, longitude 4.9E, altitude 170m, 1994 [IDMP FRA2]), Freiburg (latitude 48.0N, longitude 7.8E, altitude 325m, 1994 [IDMP DEU2]) and Lisboa (latitude 38.8N, longitude 9.1W, altitude 106m, January to mid-November 1994 [IDMP PRT1]). Measurements available include global and diffuse radiation and the corresponding cloud index on a half hourly basis (hourly basis for Lisboa). We used a 2x2 pixels average for the cloud index.

3. Model derivation

In our approach the radiation component is normalized by the Kasten / Dumortier clear sky model and we use the cloud index and solar elevation as input parameters. The derivation of the diffuse radiation is illustrated in Figure 1, where the normalized radiation is represented against the cloud index for 12 different solar elevation categories; the graphs include the four stations' data. For each category, we divided the abscissa into 30 bins and reported the mean value surrounded by ± one standard deviation. We then made a two-parameter regression on the weighted points and obtained a cubic with cloud index correlation.

The same approach was used to derive the horizontal global and beam radiation component. The correlations are illustrated on Figure 2.

4. Evaluation of the model

We made a comparison between calculated and measured values for the three considered models and the four data banks. For the majority of the stations, the geographic location is not in the middle of a single pixel and a space misalignment and / or a time shift is also possible [Ineichen, 1998]. Therefore, we used the 2x2 average value of the surrounding

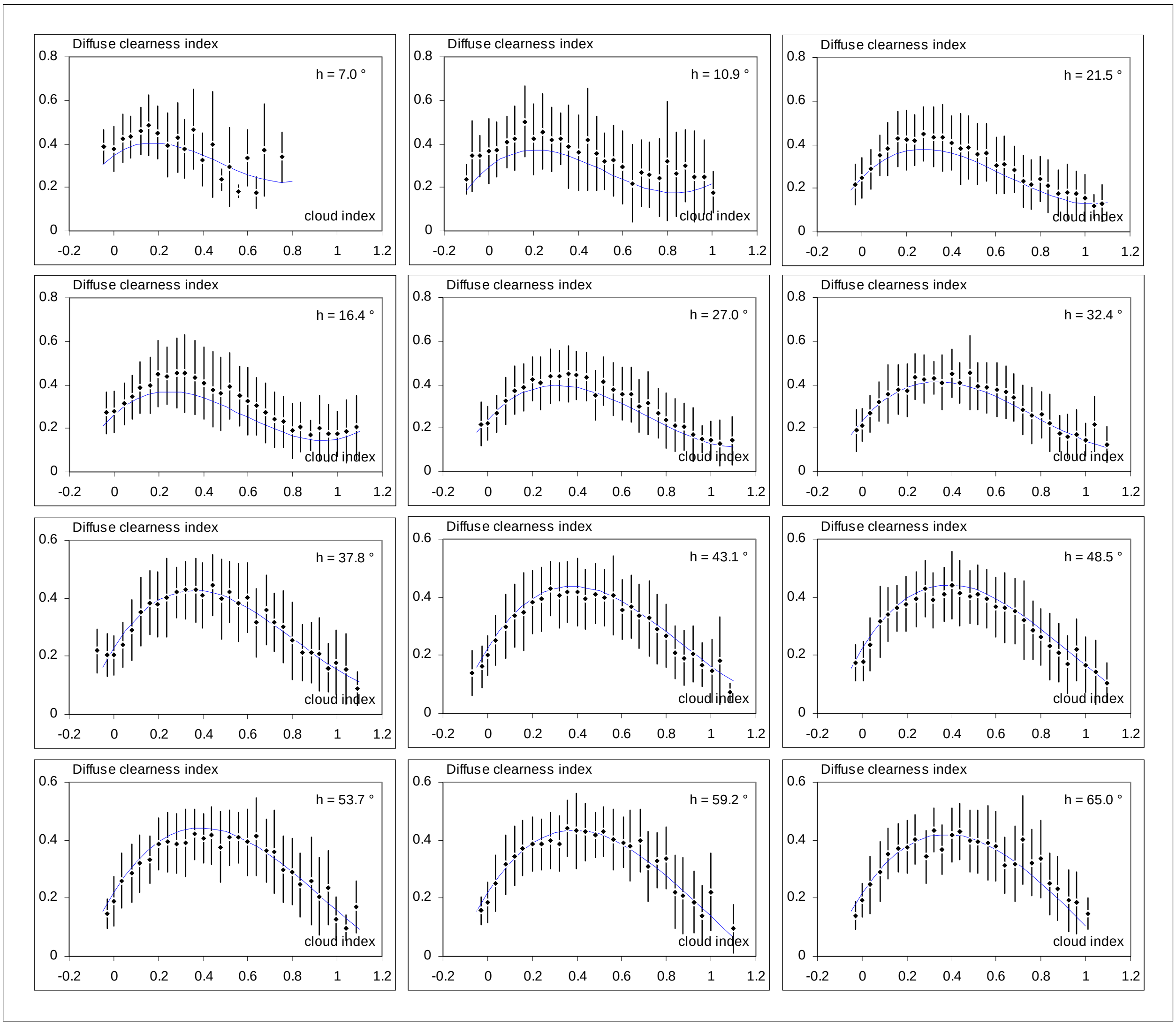


Figure 1 Diffuse radiation model derivation for 12 bins of solar elevation and for the four stations. The curves represent the 2 parameters correlation

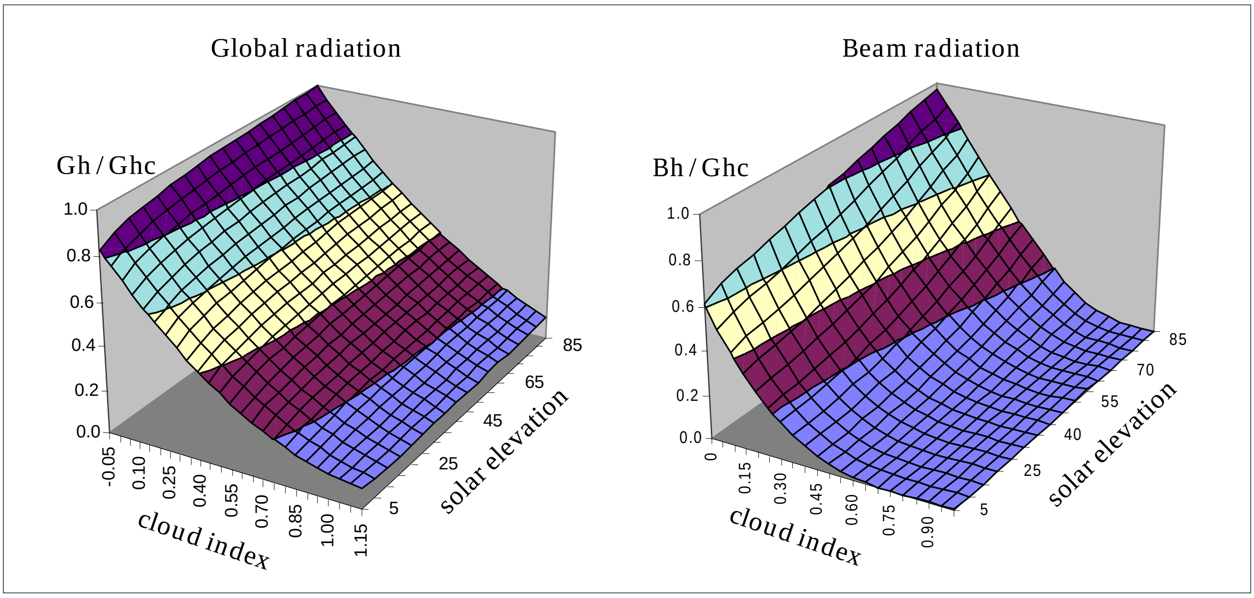


Figure 2 Global and beam radiation model: 2 parameters correlation obtained with the 4 data banks.

pixels' cloud index. The performance of the models will be compared to the Satellight version 9.

Depending on the final application of the evaluated radiation components, two kind of comparisons can be done: statistical (frequency of occurrence of a given radiation level) or mathematical (mean bias difference MBD and root mean square difference RMSD).

4.1 Mathematical evaluation

The results of the comparison are expressed as a mean bias difference (MBD) between model and measurements (calculation-measurements):

$$MBD = \frac{1}{n}\sum_{1}^{n}(calculation - measurement)$$

and a root mean square difference (RMSD) giving the fluctuation between the model and the measurements (precision of the model):

$$RMSD = \sqrt{\frac{1}{(n-1)}\sum_{1}^{n}(calculation - measurement)^2}$$

Figure 3 represents the comparison between version 9 + S&O model [Skartveit 1987] and our model. Except for the station of Lisbon where the clear skies are dominant, the biases and the precision are improved.

The graphs in Figure 3 give the results for different sky conditions, from overcast to blue

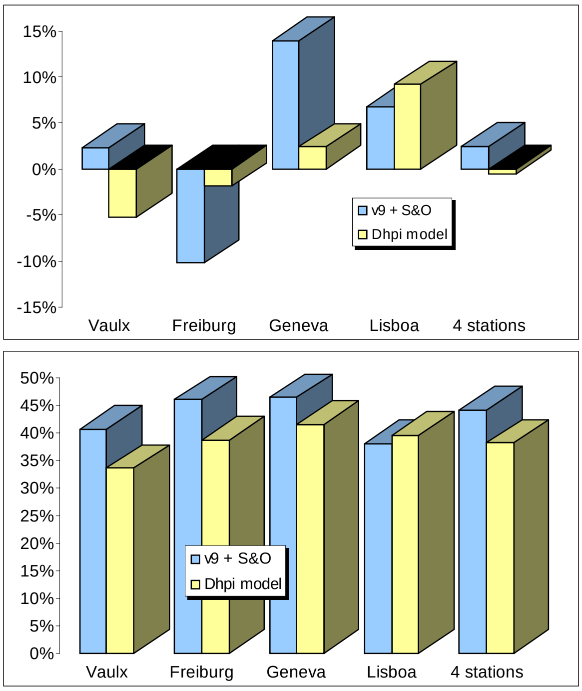


Figure 3 Evaluation of the diffuse model: MBD and RMSD for the 4 stations expressed in relative values.

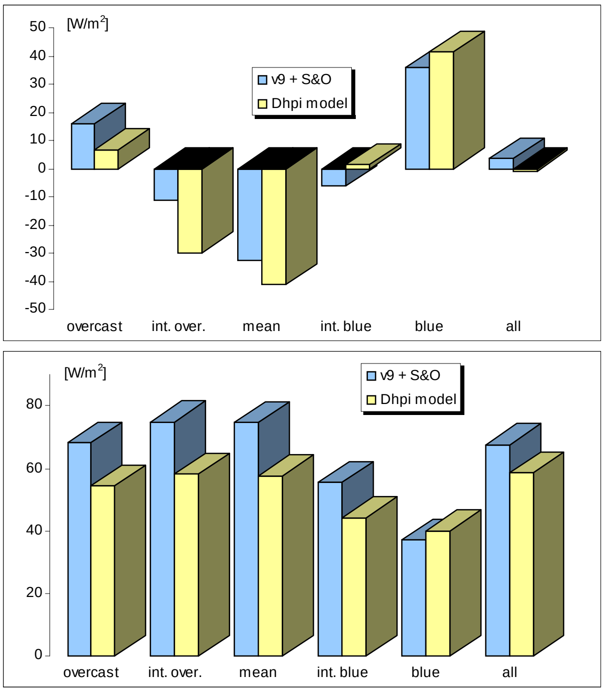


Figure 4 Evaluation of the diffuse model: MBD and RMSD for the different sky conditions and expressed in [W/m^2]

sky (the results are here expressed in absolute value). The sky types are selected with the Perraudeau index [Perraudeau, 1986] as follow:

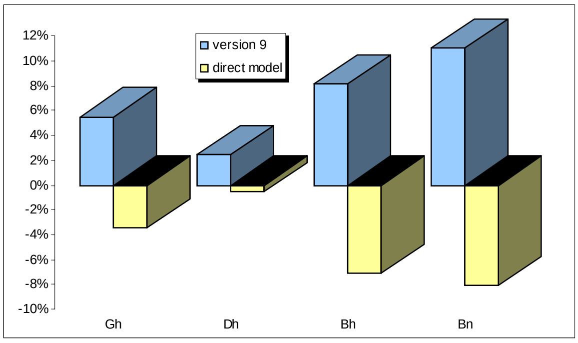
overcast			In	≤	.05
intermediate overcast	.05	<	In	≤	.2
mean	.2	<	In	≤	.7
intermediate blue	.7	<	In	≤	.9
blue	.9	<	In		

The results for blue-sky conditions confirm the values obtained for Lisboa where nice weather conditions are prevailing. Even if the MBD are higher for some sky conditions for the present model, the RMSD are better for all conditions, except for blue sky condition as seen before.

The MBD and RMSD for the other radiation components are given in Figure 5 and are also compared to the version 9. The direct way from meteosat images to radiation components give slightly better results in both terms of MBD and RMSD.

From the above figures the following conclusions can be drawn:

- the trends of the results are very similar for all the stations,
- the determination of the diffuse and the beam components gives good results if one keep in mind that the only input parameter is a reflectance,
- the diffuse radiation component is evaluated with a precision of 60 [W / m^2], the beam and the global with a precision of 100 [W / m^2].



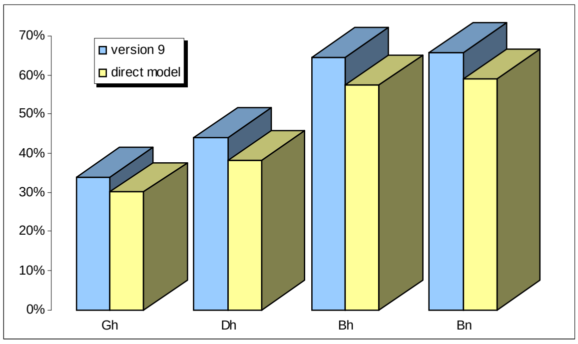


Figure 5 Evaluation of the models for the different radiation component in term of MBD and RMSD.

4.2 statistical evaluation

The statistical comparison between the measurements and the calculated values is done in term of frequency of occurrence. There are two ways to do the analysis: in term of radiation and in term of normalized radiation (clear sky index).

The former analysis gives the frequency of occurrence of the absolute radiation values and gives the probability to have a certain level of radiation: it is the parameter to use when the time distribution of the radiation is not a first priority.

If one considers the relative or normalized radiation (divided by the clear sky global radiation), the given probability is expressed in term of a radiation level that should occur for a given solar geometry or a given day of the year and time.

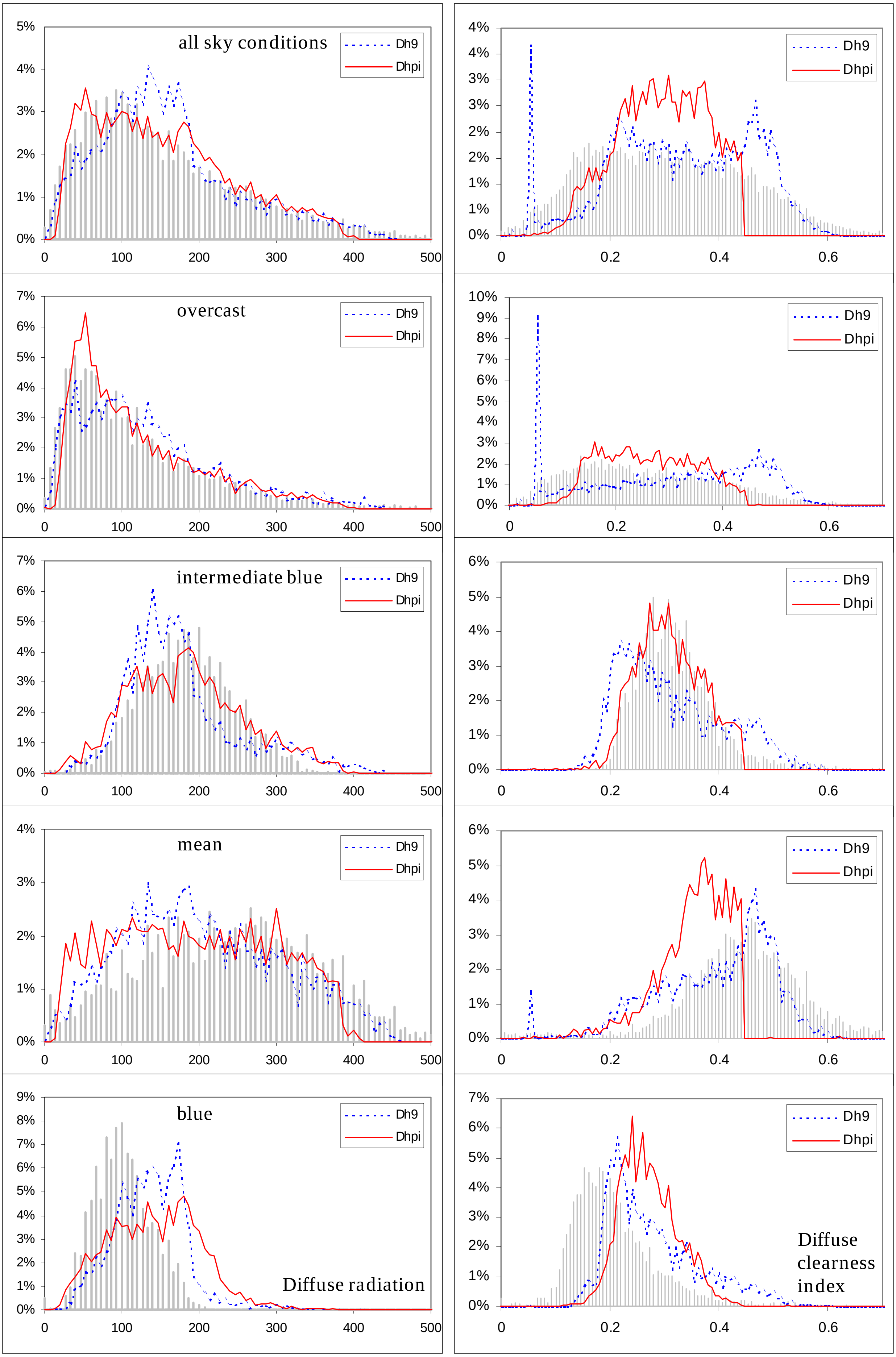


Figure 6 Frequency of occurence for the absolute (left) and relative (right) diffuse radiation. The bars represent the measurements, and the lines the two considered models.

Figure 6 illustrate these frequency occurrences for different sky conditions. These graphs show that depending on the sky type and the conditions of use for the evaluated radiation, one should use one or the other model. For all sky conditions and absolute radiation (left graphs), the present model fits nicely the measured frequency of occurrence. For mean conditions, the version 9 is better in term of relative frequency of occurrence (right graphs).

7. Conclusions

It appears that depending on the final application of the evaluated radiation, one should use direct model or cumulated models. The bias, the root mean square difference and the frequency analysis show that, apart from the time and space determination of the satellite counts that should be improved, work has to be done to better understand the climate and geographical dependency of the models. The models still have systematic biases and work has to be done to improve their precision.

8. References

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http://idmp.entpe.fr

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