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ADAPTIVE NUMERICAL MODEL FOR SOLAR RADIATION

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ABSTRACT

Nowadays the solar power is one of the most appreciate renewable energies in the world. In order to maximise the solar radiation collection, many numerical models have been developed. There are three groups of factors that determines the interaction of solar radiation with the earths atmosphere and surface (see e.g. [1]):
a. The Earths geometry, revolution and rotation (declination, latitude, solar hour angle);
b. Terrain (elevation, albedo, surface inclination and orientation, shadows);
c. Atmospheric attenuation (scattering, absorption) by:
c.1. Gases (air molecules, ozone, CO_2 and O_2);
c.2. Solid and liquid particles (aerosols, including non-condensed water);
c.3. Clouds (condensed water).
If we consider the three factors of atmospheric attenuation (c) in the model, it will produce real-sky (overcast) radiation values. If we omit the cloud attenuation (c.3), clear-sky (cloudless) radiation values will be obtained.

The modelling of solar radiation has been carried out along the last three decades in order to optimise the solar resource management. In general, we find two main groups of models. On the one hand, those based on the study of data obtained from satellite observations; see e.g., [2]. Also statistical approaches may be included in this group. On the othe hand, those on astrophysical, atmosphere physical and geometrical considerations. In this later group we remark the work of Šúri et al [1].

In this work we propose some improvements to the model of Šúri et al [1] related to the second factor (b) that affect the solar radiation. Nevertheless, they can be also applied to other similar models for generating solar radiation maps. Specifically, we focus the study on the accurate definition of the terrain surface and the produced shadows by using an adaptive mesh of triangles. Previous studies on shadow detection are based on geometrical formulae but they are too expensive to apply in complex terrain; see e.g. [3,4]. The meshes are constructed by using a refinement/derefinement procedure in function of the variations of terrain surface orography and albedo.The adaptive triangulation of the terrain allows to obtain the shadow distribution in a region with a reasonable precision at a low computational cost. Thus, we propose to introduce in this field the mesh refinement/derefinement techniques that have been widely used in other scientific problems. Specifically, this model includes the implementation of the 4-T

Rivara's refinement and derefinement algorithms developed by Ferragut et al [5]. So, the model takes into account the effect of shadows for each time step, which are detected by analysing the crossing of the trajectory of the shaft of light with the triangles of the mesh. Then the solar radiation is first computed for clear-sky considering the different types of radiation, that is, beam, diffuse and reflected radiations. From the results of clear-sky radiation, the real-sky radiation is daily computed in terms of the clear-sky index. The maps of clear-sky index are obtained from a spacial interpolation of observational data that are available for each day at several points of the studied zone. Finally, the solar radiation maps of a month are calculated from the daily results. We illustrate the performance of the model with a numerical experiment in Gran Canaria Island.

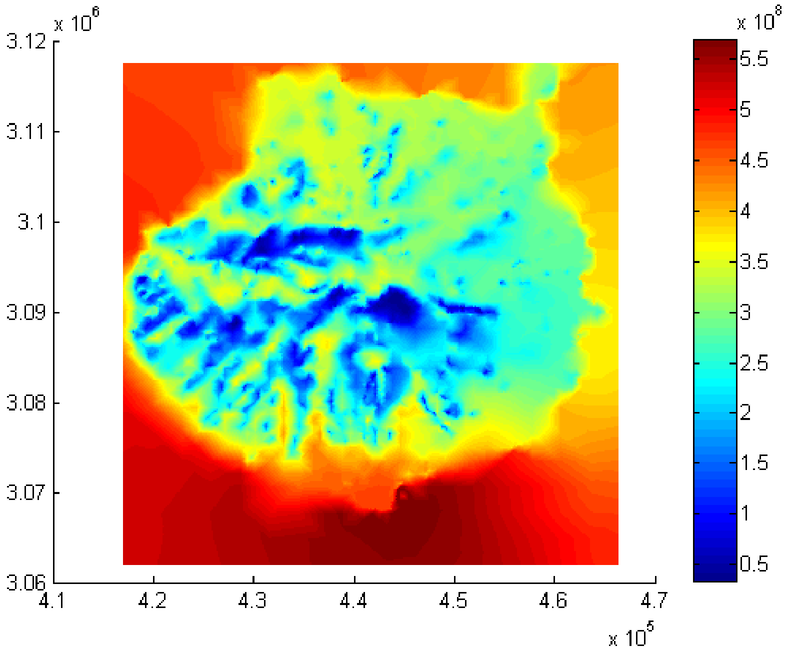

Figure 1: Overcast global solar radiation (J/m^2) map in the Island of Gran Canaria corresponding to April, 2007.

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