A model for diffuse solar radiation in presence of some environmental parameters

Studio della radiazione solare diffusa in relazione ad alcuni parametri ambientali

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1. Diffuse solar radiation and models

Few energy production technologies have a little impact on the environment as solar energy technologies. The solar energy source is free and abundant and the energy generated by light does not produce any air pollution or hazardous waste. The most widespread solar energy technologies, which are currently in use, are the solar photovoltaics (PV) and the solar thermal energy. The use of free energy of the sun would allow to free us from dependence of unreliable sources of oil and would reduce the impact of power outages.

Actually, solar energy is not economically competitive with conventional alternatives if we consider capital costs, operating and maintenance costs and financial costs. However, considering the actual situation about the greenhouse effects and the oil depletion perspective, many countries passed laws that provide financial incentives to encourage an early adoption of solar energy technologies. However, with regard to PV for example, the next for the solar electricity is to be competitive without these incentives, reducing costs and making these systems more efficient, affordable and available.

To improve the performance of these technologies it is necessary both to outline the difference of sunlight quantity reached in different geographical areas, in order to develop specific systems that answer to local needs, and to maximize sunlight absorption by solar energy technologies. Identifying limitations do not mean that the approach is ineffective, only that it is more appropriate and effective under specific conditions. Correct site and climate conditions must be evaluated carefully in order to find the best approach or combination of approaches.

An enormous amount of solar radiations reaches the Earth's surface, but some of these radiations are *direct* and some others are *diffuse*: radiations are called direct if they pass directly through the Earth's surface, while are called diffuse if they are reflected and scattered by atmosphere and ground. The distinction is important because the amount of diffuse radiation affects the performance of most of the solar energy technologies. For example, some PV systems (like flat-plate systems) can use both forms of radiation, while solar concentrator systems can only use direct radiation.

The network of stations for diffuse solar radiation measurements is scarce through the world, while global solar radiations are available for many locations. Since 1960s, with the pioneer work of Liu and Jordan (1960), numerous studies have been developed to model diffuse fraction (*ratio of diffuse solar radiation at the surface to global at the surface*) on clearness index (*ratio of global solar radiation at the surface to solar radiation at the top of the atmosphere*). A comparative study, based on polynomial regression, has been proposed by Jacovides *et al.* (2006) and it corroborated, with the previous findings, that hourly values of diffuse solar radiation are not very well modeled by only clearness index, even though there is a strong relation.

On the other hand, in other studies, based on neural network techniques, the hourly values of diffuse radiation at the surface are satisfactorily estimated using clearness index and some environmental parameters such as latitude, longitude, time of the day, month, rainfall, air temperature, relative humidity and atmospheric pressure (i.e. Jacovides *et al.*, 2006 and Soares *et al.*, 2004). Even tough neural network techniques gives satisfactory results, they are not a user-friendly tool for non-experts.

In this work we propose a multiple linear regression, with a polynomial component and interacting factors, to model hourly values of diffuse solar radiation on the clearness index, on some environmental parameters available in conventional meteorological stations and on the particulate matter (PM10). In particular, temperature, relative humidity, atmospheric pressure were measured continuously during the entire year of 2002, in the city of São Paulo (Brazil), while hourly values of particulate matter (PM10) were measured at the surface in the Cerqueira Cesar station belonging to the air quality monitoring network of São Paulo State Environmental Protection Agency in 2002 (CETESB, 2006).

The regression model developed here works quite well with current data, but it is expected to improve by including the cloud effect explicitly. This will be accomplishing using hourly values of cloud cover (tenths) and type, since clearness index does not help in differentiating high from low clouds at short time scale. Clouds seriously affect the proportion of diffuse radiation on the total radiation, especially “in tropical regions, like Brazil, where cloud activity is a dominant feature of local climate” (Soares, 2004). Therefore, the first development of this work will be to find an appropriate representation of the cloud effect to overcome this lack of fit and a further development could be the introduction of latitude and longitude effects in a spatial context.

References

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