

# Solar intensity estimation in a geographical region based on agents.

Ramos Hernanz, JA.<sup>1</sup>, Campayo Martín, J.J.<sup>1</sup> Zamora Belver, I.<sup>2</sup>  
Puelles Pérez, E.<sup>1</sup>, Zulueta Guerrero, E.<sup>3</sup>

<sup>1</sup> Department of Electrical Engineering  
E.U.I., Vitoria-Gasteiz, University of the Basque Country  
Nieves Cano, 12 01006 Vitoria-Gasteiz (Spain)  
Phone/Fax number: +0034 945014147, fax: +0034945013270  
e-mail: [josean.ramos@ehu.es](mailto:josean.ramos@ehu.es), [jj.campayo@ehu.es](mailto:jj.campayo@ehu.es), [eduardo.puelles@ehu.es](mailto:eduardo.puelles@ehu.es)

<sup>2</sup> Department of Electrical Engineering  
E.T.S.I., Bilbao, University of the Basque Country  
Alameda Urquijo, s/n 48013 Bilbao (Spain)  
Phone/Fax number: +0034 946014063, fax: +0034946014200 e-mail: [inmaculada.zamora@ehu.es](mailto:inmaculada.zamora@ehu.es)

<sup>3</sup> Department of Systems Engineering and Automatic  
E.U.I., Vitoria-Gasteiz, University of the Basque Country  
Nieves Cano, 12 01006 Vitoria-Gasteiz (Spain)  
Phone/Fax number: +0034 945014160, fax: +00349450 13270 e-mail: [ekaitz.zulueta@ehu.es](mailto:ekaitz.zulueta@ehu.es)

## Abstract.

Models based on multi-agents present numerous advantages to calculate the estimation of the intensity of solar radiation. Among the different existing options, the software of simulation NetLogo, is utilized in this work. In this estimation, the possible cloudiness and existing pollution are the main variables considered.

The work developed in the programming of a model based on multi-agents, followed by an analysis of the software used and of the characteristics of the proposed model are presented.

## Key words

Agent-based modeling, NetLogo, Solar intensity.

## 1. Characteristics of our ABM model

This model shows the random movement of clouds and pollution (in general, turtles) in a geographic region represented by patches.

Depending on the amount of clouds and the existing pollution, the evolution of the received solar intensity in the studied zone is shown.

One of the advantages of using these models based on multi-agents is the possibility to relate physical interaction to each particle or agent.

For the analyzed case we have considered that clouds and pollution follow a Brownian motion.

The Brownian motion is the random movement observed in some nanoscopic particles found in a liquid environment (for example, pollen in a drop of water or the specks of dust suspended in the air).

The random movement of these particles is originated because its surface is bombed incessantly by the fluid molecules submissive to thermal agitation. This atomic scale bombing is not always completely uniform and undergoes important statistical variations

## 2. Interface Tab

The Interface Tab is a screen where the user can watch how the model runs. It also has tools to inspect and alter what's going on inside the model. (Fig. 1)

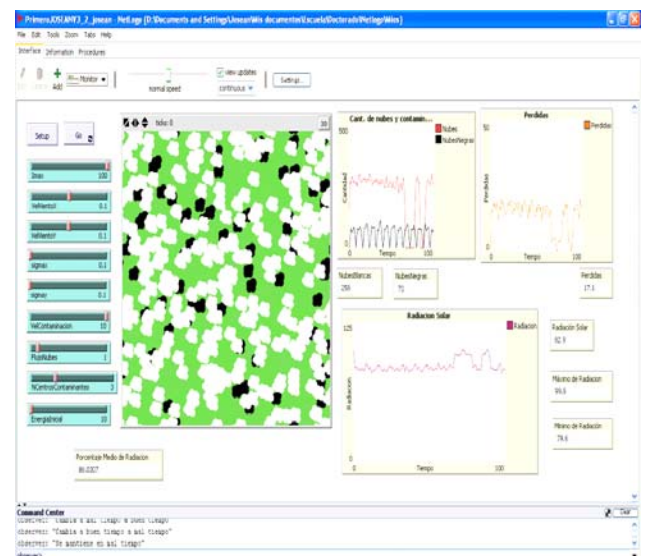


Fig 1. Interface Screen of the model

## 3. Information Tab

The Information tab, provides an introduction to the model and an explanation of how to use it, things to

explore, possible extensions and NetLogo features. It is very helpful when on user is first exploring a model.

Following, sections in which is divided the Information that explains the developed model are shown:

#### A. WHAT IS IT?

This model simulates the estimation of solar radiation in any geographic region, which is based mainly on the behaviour of clouds, weather and the amount of existing pollution.

#### B. HOW IT WORKS

The model generates clouds depending on weather conditions however, if weather is nice the model will not generate clouds until weather is worse. And then, more or less clouds will be generated.

For the weather variation, the model will take into account whether the previous weather is good or bad. The same weather will be repeated with a percentage of eighty percent and will change of time with twenty percent.

For the pollution generation the number of contaminants centers and the pollution generation speed will be taken into account. These centers only work during the week, from Monday to Friday, not contaminating during the weekend.

#### C. HOW TO USE IT

The program has two buttons, SETUP and GO, which control the model.

There are also nine sliders: I<sub>max</sub>, VelVientX, VelVientY, SigmaX, SigmaY, VelContaminacion, FlujoNubes, NCentrosContaminantes, EnergíaInicial.

In order to support that graphical representation, three types of monitor elements are able:

- Four monitors show the values, at every moment, of clouds, polluting clouds, losses and the percentage of the solar radiation.
- Two monitors offer the maximum and minimum values of solar radiation that exist during the execution of the model.
- A last monitor shows the average percentage of radiation during the execution time.

#### D. THINGS TO NOTICE

The result shown of the amount of black clouds resembles a sine wave, formed by only the positive half-cycles, because the centers of single contamination work five days a week and the remaining two rests.

The graphic that shows the losses depends, logically, on the present amount of clouds and pollution. As is the greater amount of existing clouds or contamination,

greater is the amount of losses of solar radiation. During a sunny day, clouds do not exist, therefore losses will only depend on contamination. Besides, if this happens during the weekend losses will be near to zero, because pollution also disappears as the weekend progress.

#### E. THINGS TO TRY

Initially allow to execute the model with the default values of the variables and subsequently it see the effects that produce the variation of different sliders, increasing the number of clouds, adding more polluting centers or varying the speed of contamination.

#### F. EXTENDING THE MODEL

In order to extend the model more variables that influence on the received solar radiation can be added as: different types of clouds, rain, different seasons, the cycle of a nocturnal period, etc...

#### G. NETLOGO FEATURES

For the programming has been preferred to use only a more extensive procedure so that the development of the program can be seen clearer.

#### H. RELATED MODELS

Gaslab\_Brownian\_Motion, Climate Change, Circular Particles, NetLogoGreenHouse

## 4. Conclusion

This paper presents an introduction to NetLogo environment, in order to develop models of NetLogo that analyse photovoltaic energy. For it a basic model of the solar intensity estimation in any geographical region has been made.

The model enables the user to give instructions to independent “agents” that are all operating concurrently, creating the target behaviour of the whole system. NetLogo environment is under rapid development. Its use is expected for both research and educational contexts since it significantly reduces complexity of the software development process. It is a very simple and clear way to see how behave the two variables that have been introduced in the model, allowing the variation of their performance at any time.

## References

- [1] U. Wilensky 1999. NetLogo. Center for Connected Learning and Computer-Based Modeling. Northwestern University, Evanston, IL. <http://ccl.northwestern.edu/netlogo>
- [2] NetLogo User Manual. <http://ccl.northwestern.edu/netlogo/docs/>