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An approach to calculate solar radiation fluxes on the Martian surface

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Abstract

MetNet is an atmospheric science mission to Mars, which includes a Solar Irradiance Sensor (MetSIS), designed to measure solar radiation in several bands below 1200 nm. Here we present some preliminary results of a radiative transfer model that we have developed to simulate the solar radiation on the Martian surface in the same spectral bands measured by MetSIS.

1. Introduction

One goal of the Mars MetNet Mission is to measure solar radiation at the Martian surface with a Solar Irradiance Sensor (MetSIS), which will measure solar radiation in several bands below 1200 nm.

The model we have developed can be useful to carry out the tasks of the different phases of the mission. Before the launch, it is important to know the radiation that would reach the instrument at each band under different possible scenarios in order to determine the expected variations of the irradiance due to changes in the atmospheric composition. Once the *in situ* data are obtained, it is interesting to determine the conditions under which those measurements are taken.

2. Methods

We have developed a comprehensive model that includes the effects of scattering and absorption by the dust and the gases CO_2, N_2, Ar, O_2 and O_3.

The model uses two different schemes to calculate the radiation that reaches the surface. The first scheme relies on the Monte-Carlo method. By using a statistical approach, the model simulates the paths of a high number of photons and their interactions with the atmosphere and the surface [1]. This method is suitable to solve a great amount of different radiative transfer problems because it allows to define specific outputs that cannot be provided by other methods. On the other hand, it becomes computationally expensive when high accuracy in the radiation at the surface is required because this is achieved by increasing the number of simulations.

The second scheme relies on the delta-Eddington approximation [2]. This approach, also used by [3], is less time-consuming than the Monte-Carlo method, making it suitable for some of the model outputs. We have introduced more recent dust properties ([4], [5]) and scattering ([6]) and absorption ([7], [8], [9], [10]) cross sections of the gases. Also the spectral interval has been extended to include longer wavelengths. By scaling the single scattering albedo (ω_0), the asymmetry factor (g) and the optical depth (τ), accuracy is increased compared to similar approximations when g is high.

Both methods allow to calculate the direct and diffuse components of the surface irradiance. This is very important when comparing the model results with measurements in order to obtain information about the radiative properties of the atmospheric components.

The main advantage of having introduced two different methods is that the user can choose the one that best meets the requirements of the desired output.

3. Model inputs

The model needs the following inputs to be initialized: local time (hour angle), surface albedo, solar longitude, latitude, wavelength range (below 1200 nm), abundance of each gas, surface pressure, dust optical depth , and other dust radiative properties like the single scattering albedo and the asymmetry factor.

4. Results of the model

As an example of the performance of the model, here we show the diurnal evolution of the total radiation (red) in the band 315-400 nm (UVA) that reaches the surface and its direct (dark blue) and diffuse (green) components. The light blue curve represents the incident radiation at the top of the atmosphere in that band. Two different optical depths at 500 nm (τ_d) have been considered: 0.4 (Figure 1) and 2 (Figure 2).

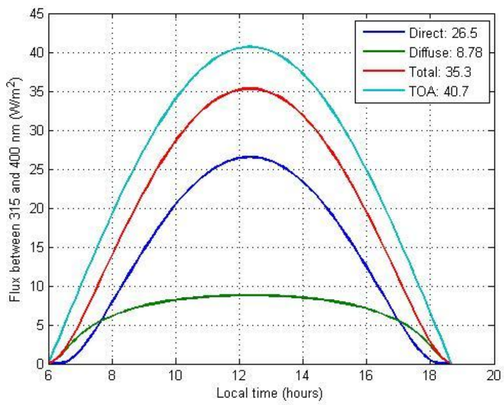

Figure 1: Diurnal variation of solar flux in the UVA at 5ºS for a solar longitude of 270^o and τ_d=0.4. The numbers in the legend indicate the maximum of each component, expressed in W/m^2.

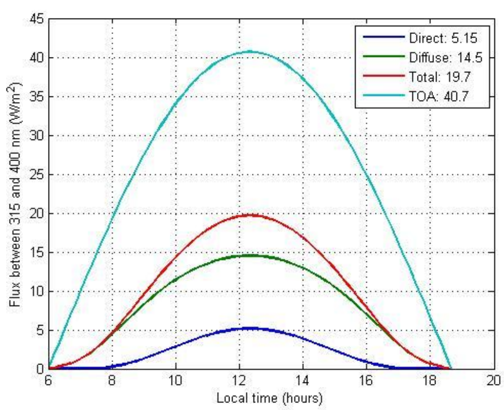

Figure 2: Same as in Figure 1 but τ_d = 2.

REMS UV Sensor is measuring solar radiation in six UV bands. The results provided by the model are also important nowadays because a comparison between model results and those measurements is possible by selecting the desired band.

5. Summary and Conclusions

A solar radiative transfer model is presented herein, which allows to calculate the solar radiation that reaches the Martian surface in the spectral range below 1200 nm in two different ways, depending on the requirements of the desired output. By modifying the inputs of the model, we can define a high number of different scenarios and obtain several model outputs which provide information about the solar radiation that reaches the surface at the desired band under some previously defined conditions.

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