Radiative distribution over complex topography

José L. Flores Rojas, Hugo A. Karam, Edson P. Marques Filho

Universidade Federal do Rio de Janeiro (IGEO-UFRJ)
e-mail: josesar68@hotmail.com

Resumo

Neste trabalho utilizam-se três diferentes parametrizações para calcular a radiação global e difusa incidente sobre a superfície terrestre. Propõe-se a utilização dessas metodologias para investigação do papel da topografia sobre a incidência do fluxo radiativo de onda-curta e sobre o sombreamento associado a horizontes locais de terrenos complexos.

Abstract

In this work, direct, diffuse and global radiation over the complete solar spectrum incident on the earth's surface was calculated using three parameterization methods. The topography effects on solar irradiance are associated with variations in illumination angle and shadowing due to the local horizon of complex terrains.

1. Introduction

Incident solar radiation is a driving force for many ecological and hydrological processes [1, 2], its influence over the energy and water balances of the earth surface, affects processes like air and soil heating, evapotranspiration, photosynthesis, wind, snow thawing, etc. Solar radiation energy depends mostly on incidence angle, which is defined by astronomical and surface parameters. The sky is usually not completely clear, so a set of meteorological variables must be considered. Despite the importance of topographical features to radiative and hydrological distributions they are rarely represented properly in mesoscale modeling nowadays.

2. Broadband method for short-wave solar radiation

For most energy balance problems and other meteorological applications, determining of radiation over the complete solar spectrum is required. The parameterization method calculates rapidly the radiant energy for clear sky, under specified atmospheric parameters. In the parameterizations, an overall spectrally integrated transmittance for each atmospheric constituent is employed to compute the total transmittance of the atmosphere, as a broad band approach over the short-wave range. We have used three parameterizations here called A[3], B[4], and C[5]. All of these approachs propose separate expressions for direct, diffuse and global irradiance. For each one, the global irradiance on a horizontal surface can be written by $I = I_n \cos(\theta_z)+I_{dn}+I_{da}+ I_{dm}$, where I is the global irradiance incomming on a horizontal surface; I_n is the normal direct irradiance, θ_z is the zenith angle of Sun, and I_{dn}, I_{da} and I_{da} are, respectivelly, the broadband diffuse irradiance on the ground due to the Rayleigh scattering, aerosols scattering and absorption, and also multiple reflections between surface and atmosphere. Further, geometric equations[3] for director cosines of the Sun and the normal to tilted planes are employed (not shown here) for the topography of the Metropolitan Area of Rio de Janeiro (MARJ).

3. Conclusions and perspectives

Three radiative schemes for short-wave have been prepared to use in high resolution mesoscale simulations over complex terrains addressed to research in micro and hydrometeorology. The irradiance schemes are verified against available curves in the solar radiation literature (Figure 1). In Figure 1(a) and 1(b) the irradiances are indicated by: top of the atmosphere value (ib); Rayleigh scattering contribution (ir); aerosol scattering (ia); terrain reflections (idt), and the resulting surface value (itot). In Figure 1(c) and 1(d) the atmospheric transmitance are modified by Rayleigh scattering (tr), Ozone absorption (to), mixture of gases effects (tg), water vapor absorption (tw), aerosol scattering and absorption (ta), resulting the surface value (ttot).

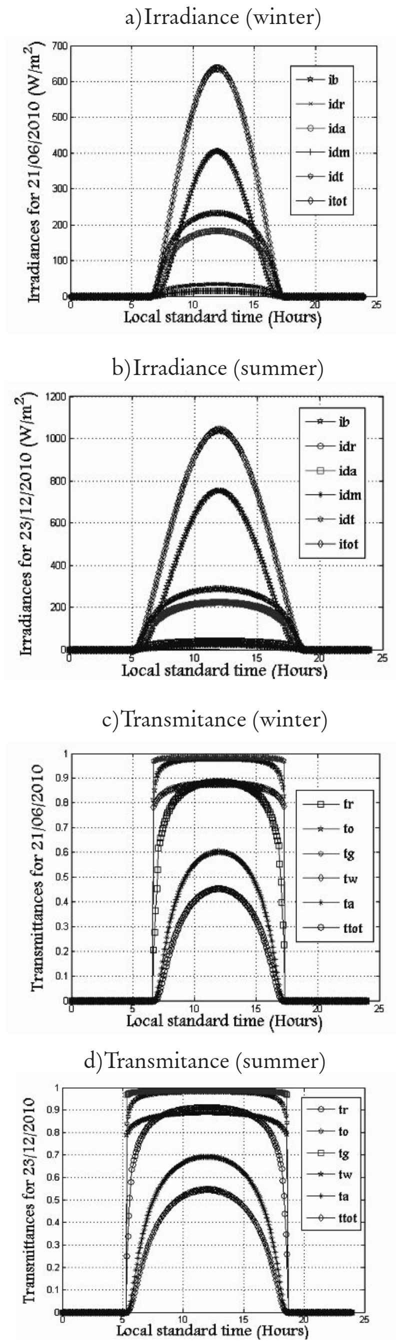

Figure 1. Modeled direct, diffuse components and global solar irradiances and atmospheric transmittances for a clear sky, in the soltices of winter and summer at MARJ.

References

[1] Berninger, F., 2004: Simulated irradiance and temperature estimates as a possible source of bias in the simulation of photosynthesis, Agric. Forest Meteorol. 71, 19-32.

[2] Jacobson, M.Z., 1999: Fundamentals of Atmospheric Modeling, Cambridge Univ. Press.

[3] Paltridge, G.W., Platt, C.M.R., 1976: Radiative Processes in Meteorol. and Climatology, Elvesier.

[4] Sasamori, T., London, J., Hoyt, D.V., 1972: Radiation budget of the Southern Hemisphere. AMS. Mon. 13, 9-23.

[5] Bird, R., Hulstrom, R.L., 1981: A simplified clear sky model for direct and diffuse insolation on horizontal surfaces.