Validating the MYSTIC three-dimensional radiative transfer model with observations from the complex topography of Arizona's Meteor Crater

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The MYSTIC three-dimensional Monte-Carlo radiative transfer model has been extended to simulate solar and thermal irradiances with a rigorous consideration of topography. Forward as well as backward Monte Carlo simulations are possible for arbitrarily oriented surfaces and we demonstrate that the backward Monte Carlo technique is superior to the forward method for applications involving topography, by greatly reducing the computational demands. MYSTIC is used to simulate the short- and longwave radiation fields during a clear day and night in and around Arizona's Meteor Crater, a bowl-shaped, 165-m-deep basin with a diameter of 1200 m. The simulations are made over a 4 by 4 km2 domain using a 10-m horizontal resolution digital elevation model and meteorological input data collected during the METCRAX (Meteor Crater Experiment) field experiment in 2006. Irradiance (or radiative flux) measurements at multiple locations inside the crater are then used to evaluate the simulations. MYSTIC is shown to realistically model the complex interactions between topography and the radiative field, resolving the effects of terrain shading, terrain exposure, and longwave surface emissions. The effects of surface temperature variations and of temperature stratification within the crater atmosphere on the near-surface longwave irradiance are then evaluated with additional simulations.

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