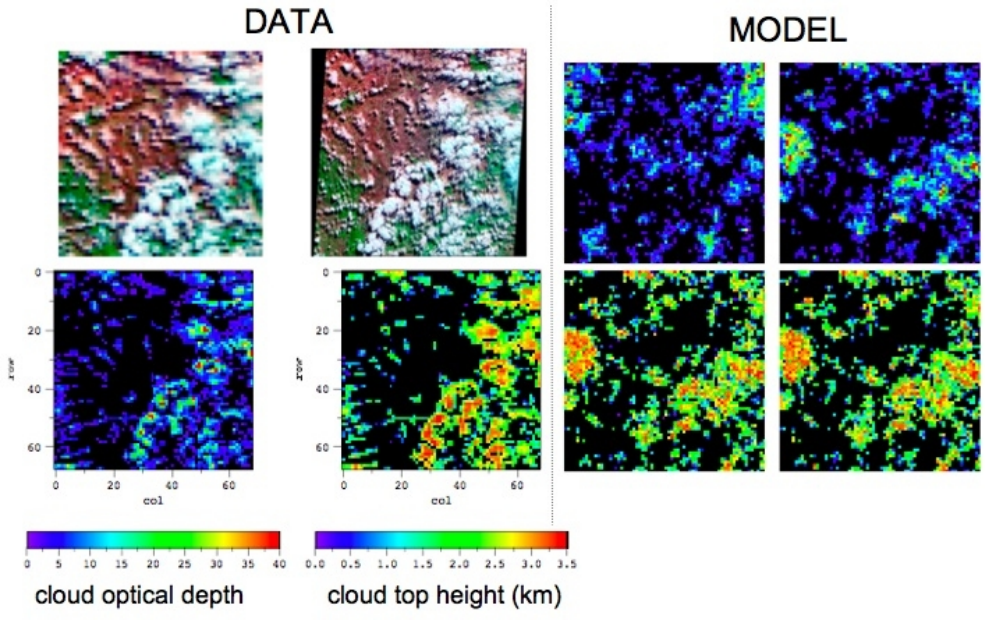
A Simple Stochastic Model for Generating Broken Cloud Optical Depth and Cloud Top Height Fields



In order to better understand and predict shortwave radiation in realistic cloudy atmospheres, we need to specify the 3D distribution of cloud liquid water. Realistic cloud fields and spatial distributions of cloud liquid water can be obtained from either dynamical or stochastic cloud models. Based on cloud dynamics, physical cloud models such as a large eddy simulation or a cloud resolving model are physically consistent but require specification of a lot of atmospheric parameters and often are computationally expensive. On the other hand, stochastic cloud models based on aircraft, satellite or ground measurements of cloud structure are computationally inexpensive and can output a much larger range of scales than dynamical models. For the last two decades many different cloud stochastic models have been developed. There are two classes of cloud stochastic models. One class uses only a few parameters to simulate the main aspects of the realistic cloud fields like mean, standard deviation and correlation often assumed to be a power-law. These models are very simple and are generally used to test hypothesis and better understand cloud-radiation interaction. Another class of cloud stochastic models provides a statistical reconstruction of an observed field and generates the detailed cloud structure. They are also called statistical cloud generators. The images on the right show an example of stochastic fields simulated by one of these generators. Four images on the left show a 68 km by 68 km region in Brazil centered at 17oS and 42oW collected on August 9, 2001 at 10:15 local time by MODIS with 1 km resolution (upper left) and ASTER with 15 m resolution (upper right). Two lower images illustrate cloud optical depth (lower left) and cloud top height (lower right) obtained by the MODIS operational cloud retrieval algorithm. The four images on the right show two realizations of cloud optical depth (upper plots) and two realizations of cloud top height (lower plots) that correspond to the 2nd realization of cloud optical depth. The generated fields have the same statistical characteristics (covariance of the cloud mask, histograms, and joint conditional distribution) as the original fields on the left. The images on the right are generated by a simple stochastic cloud model described in the paper published in the Journal of the Atmospheric Sciences in January 2009. The paper provides a theoretical background to the publicly available software “Simulation of a two-component cloud field” that has been recently released and can be freely downloaded here.

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