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

Contributors
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Research Highlight

In order to better understand and predict shortwave radiation in realistic cloudy atmospheres, we need to specify the three-dimensional (3D) distribution of cloud liquid water. Also, statistical cloud retrievals that include 3D radiative transfer need to be trained on a large number of 3D cloud fields. 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 (or dynamical) 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. Stochastic cloud models are mostly two-dimensional (2D) because currently there are no techniques to measure a full 3D cloud structure.

For the last two decades many different cloud stochastic models have been developed. We can break them into two classes. The first class of cloud models 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. The second 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 current paper describes a simple stochastic model that belongs to the second class of cloud stochastic models. For given 2D fields of cloud optical depth and cloud top height (Fig. 1), the model generates realizations of these two fields with the same covariance of the cloud mask and the joint distribution as the original fields (Fig. 2). It does not generate 3D cloud liquid water fields but rather provides the x-y fields of cloud optical and geometrical thicknesses. To simulate the required autocorrelation function, it uses spectral models of homogeneous random fields rather than commonly used Fourier filtering. Another distinguishable feature of this paper is that it 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 from http://i3rc.gsfc.nasa.gov/Public_codes_clouds.htm.

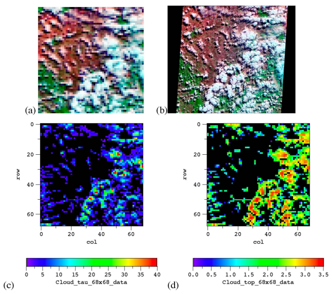

Fig. 1. A 68-km by 68-km region in Brazil centered at 17o S and 42o W collected on August 9, 2001, at 1015 local time. The solar zenith angle 410; the solar azimuth angle 23o (from the top). (a) moderate-resolution imaging spectroradiometer (MODIS) true color red, green, blue (RGB) 1-km resolution; (b) advanced spaceborne thermal emission and reflection radiometer (ASTER) RGB 15-m resolution; (c) retrieved cloud optical thickness; (d) retrieved cloud top height (in km).

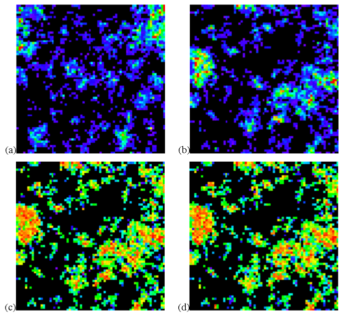

Fig 2. (a)-(b) Two realizations of cloud optical depth that have the same covariance function of the cloud mask and histogram as the one on Fig. 1a. (c)-(d) Two realizations of cloud top height distribution; they correspond to the cloud optical depth field shown in panel (b). All realizations have the same conditional distribution.

Reference(s)

Prigarin, S, and A Marshak. 2008. "A simple stochastic model for generating broken cloud optical depth and cloud top height fields." Journal of Atmospheric Sciences, in press.

Working Group(s)
Radiative Processes