IMPROVED FULL SPECTRUM CLOUDY SCENE SIMULATION

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ABSTRACT

Remote hyperspectral and multi-spectral imagery (HSI and MSI) of the Earth has proven to be highly valuable for numerous applications, including mineral prospecting, environmental and land use monitoring. The quality of the data products depends critically on the accuracy of the atmospheric compensation, surface reflectance or emissivity/temperature retrieval, detection/identification and other algorithms. Thus, there is a need for accurate, robust, and efficient means for algorithm validation. For this purpose, simulated imagery can provide a practical alternative to field measurements, which are typically expensive, time consuming and impractical for covering the full range of anticipated atmospheric and surface conditions.

This paper will discuss recent improvements made to the MCScene [1,2] code, a high-fidelity HSI/MSI image simulation software package based on a Direct Simulation Monte Carlo (DSMC) approach for modeling the 3D radiative transport. With this approach, "ground truth" is accurately known through input specification of surface and atmospheric properties, and it is practical to consider wide variations in these properties. The method can treat land and ocean surfaces, effects of finite clouds, and other complex spatial effects, as indicated in Figure 1. The well-known drawback to the DSMC approach is the very large number of trial "photons" needed to achieve an accurate result, leading to very long computation times. However, recent advances in computing speed combined with convenient and affordable parallel processing systems are overcoming this limitation.

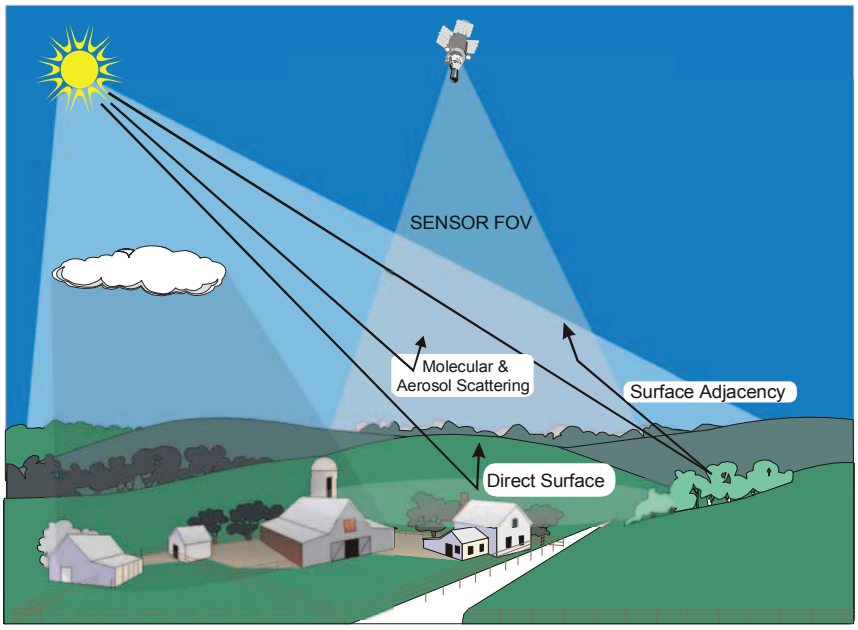

Figure 1. Important radiative transport effects for spectral image simulation in the reflective spectral domain highlighting different trial photon trajectories.

A potentially valuable application of the DSMC simulations is in modeling cloudy scenes. Very little data is taken under cloudy conditions, so scene simulations of partially cloudy scenes can be an important tool for

algorithm development and testing. The simulation components include surface reflectance values from an AVIRIS hyperspectral image of Virgin Mountains, Nevada. The simulation results shown in Figure 2 were based on clear line-of-sight radiance measurements combined with a USGS digital elevation map. A variety of synthetic cloud fields generated the Cloud Scene Simulation Model of Cianciolo and Raffensberger were inserted into the scene to produce the images below.. Clearly apparent in the figure are the shadows cast by terrain features and by the clouds. When the cloud is relatively thin, its shadow, as well as, ground features, are visible through the cloud.

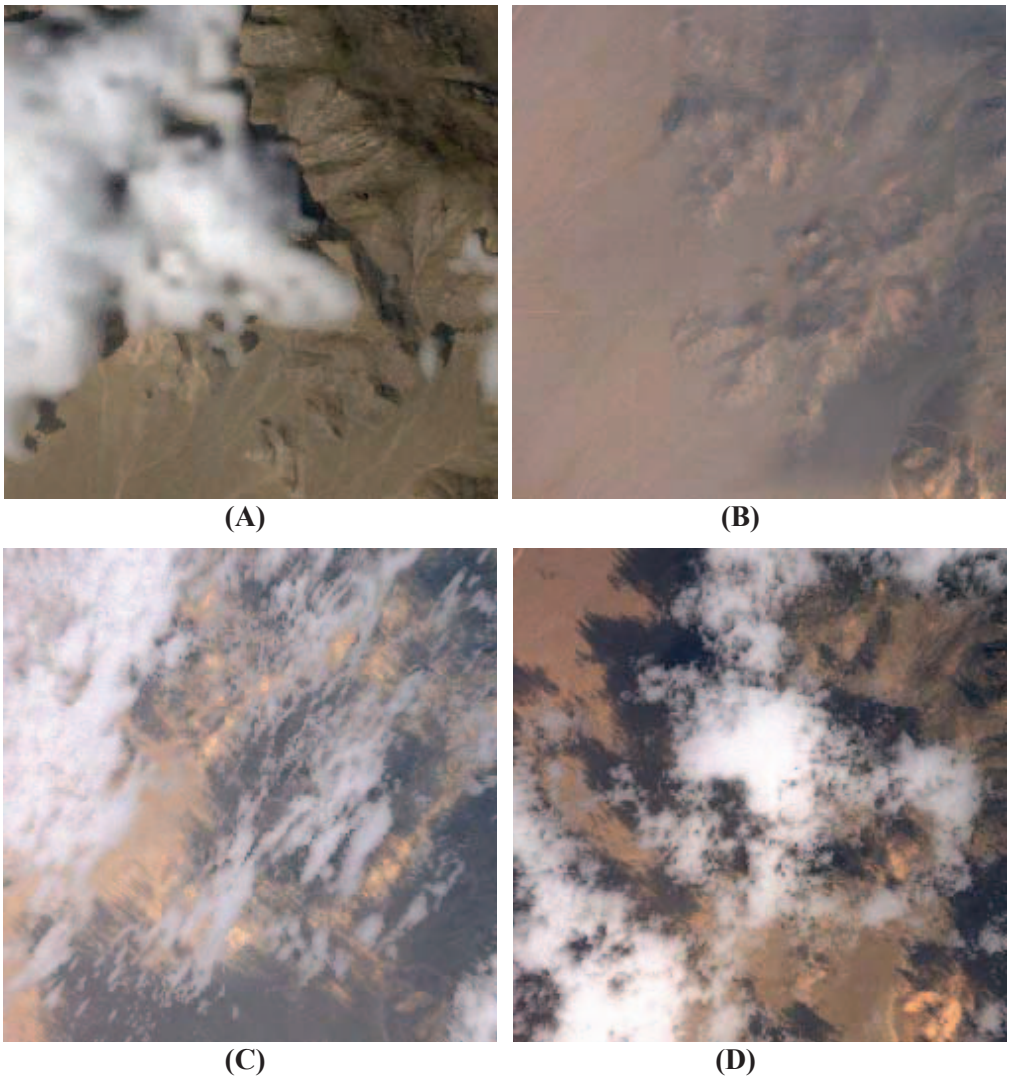

Figure 2. MCScene color composite simulation of a scenes containing significant 3D terrain structure four types of cloud fields: (A) nimbostratus, (B) cirrus, (C) cirrocumulus, and (D) stratocumulus.

REFERENCES

[1] Richtsmeier, S., A. Berk, S.M. Adler-Golden, and L.S. Bernstein, “A 3D Radiative-Transfer Hyperspectral Image Simulator for Algorithm Validation,” Proceedings of ISSSR 2001, Quebec City, Canada (June 2001).

[2] Richtsmeier, S., R. L. Sundberg, A. Berk, S. Adler-Golden, and R. Haren, "Full Spectrum Scene Simulation", Proceedings of the SPLE 5425-56, Orlando, Florida, (April, 2004)