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METEOROLOGIE

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Where no photon has gone before... state-of-the-art 3D radiative transfer with MYSTIC

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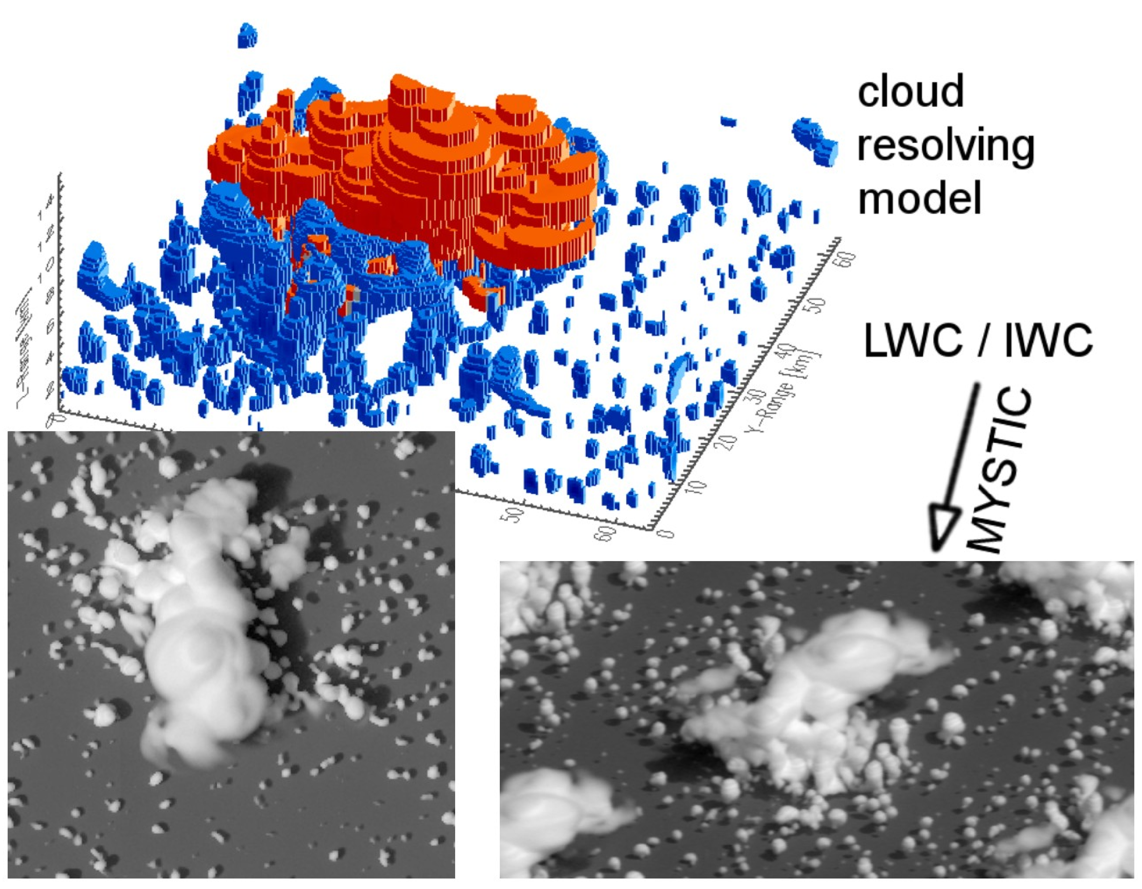
Motivation

Over the years, the 3D Monte Carlo radiative transfer solver **MYSTIC** has been developed to a state where it can simulate almost any radiation-related process in the atmosphere.

B. Mayer. Radiative transfer in the cloudy atmosphere. European Physical Journal Conferences., 1:75-99, 2009.

Variance reduction and scattering phase functions

Using the extremely efficient Variance Reduction „Optimal Options" Method (**VROOM**), it is now possible to perform radiance calculations without the need to truncate the forward peak of the scattering phase functions. Applications are radiance calculations in the circum-solar direction, and high precision radiance calculations (better than 1%).

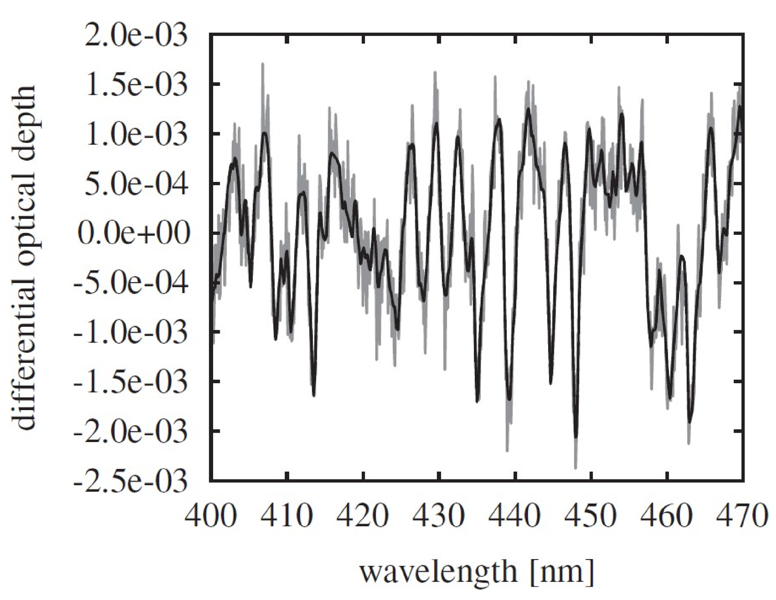


Simulations of a satellite view of a Cb cloud scene using **VROOM**. Each simulation took 45min on 300 CPUs (256^2 pixels, 10^4 photons).

R. Buras and B. Mayer. Efficient unbiased variance reduction techniques for Monte Carlo simulations of radiative transfer in cloudy atmospheres: the solution. JQSRT, 112, 434-447, 2011.

High spectral resolution simulations

Using Absorption Lines Importance Sampling (**ALIS**) high-resolution spectral calculations only need computation times comparable to those of simple 1D (DISORT) calculations. Application: Trace gas retrieval.



Simulation of differential optical thickness for NO_2 profile corresponding to medium polluted conditions. The black line corresponds to a Monte Carlo simulation using the **ALIS** method with 1000 photons (CPU time 0.9s), the gray line shows a Monte Carlo simulation without **ALIS** (10^7 photons for each wavelength CPU time 33h). The statistical uncertainty in the **ALIS** simulation is less than $4 \cdot 10^{-5}$.

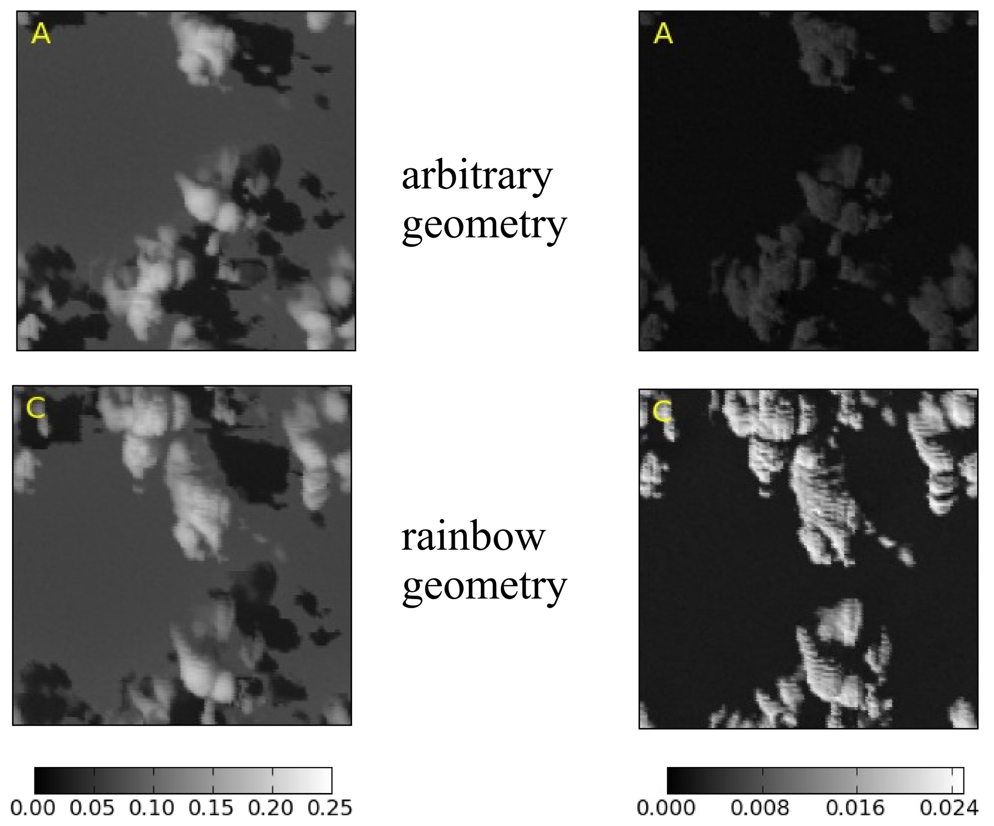
C. Emde, R. Buras, and B. Mayer. ALIS: An efficient method to compute high spectral resolution polarized solar radiances using the Monte Carlo approach. JQSRT, 112 (10) 1622-1631, 2011.

Polarization

Application: Polarized radiance measurements can provide additional information on aerosol type and cloud droplet size distribution. Of particular interest is the rainbow viewing geometry.

Right: Satellite view of cumulus field (unpolarized and polarized reflectances) for two different geometries.

C. Emde, R. Buras, B. Mayer & M. Blumthaler.
The impact of aerosols on polarized sky radiance: model development, validation, and applications. ACP, 10 (2) 383-396, 2010.



Topography and BRDF

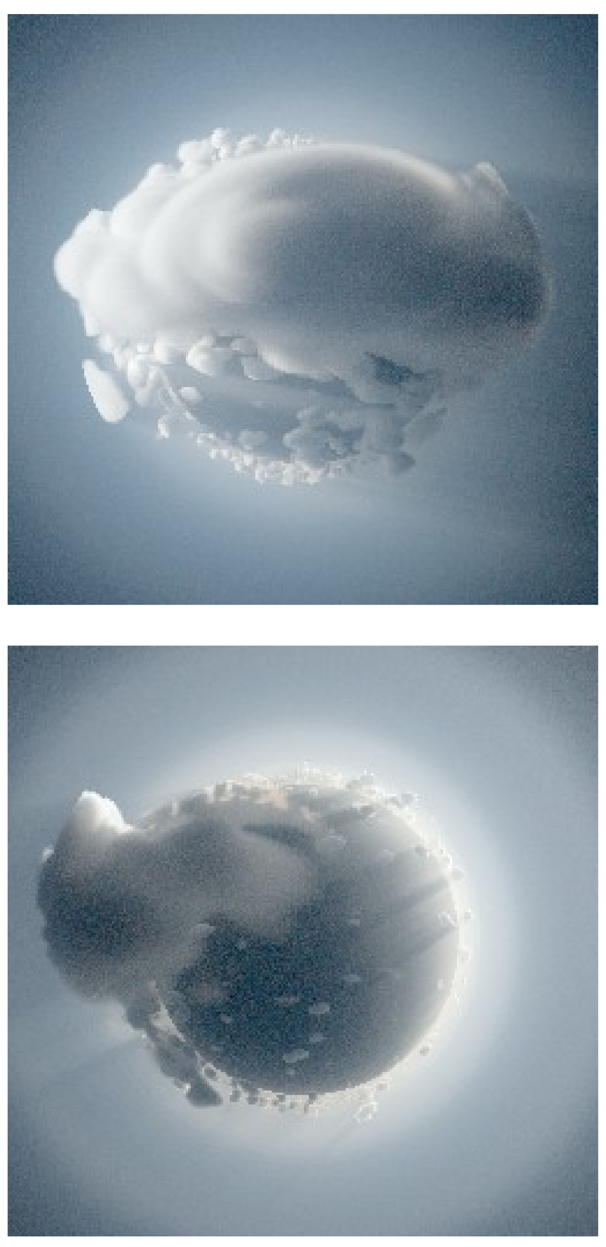
Application: Impact of topography and BRDF effects on measurements (e.g. ground-based irradiance).

Simulation of panoramic view from airplane over Ny Ålesund (Svalbard), sun zenith angle of 81 degrees, including snow BRDF, Cox&Munk ocean BRDF (with sunglint), and topography from a digital elevation model (Farr, T. G., et al. (2007), The Shuttle Radar Topography Mission, Rev. Geophys., 45, RG2004.).

B. Mayer, S.W. Hoch, and C.D. Whiteman. Validating the MYSTIC three-dimensional radiative transfer model with observations from the complex topography of Arizona's Meteor Crater. ACP, 10, 8685-8696, 2010.

Spherical 3D simulations

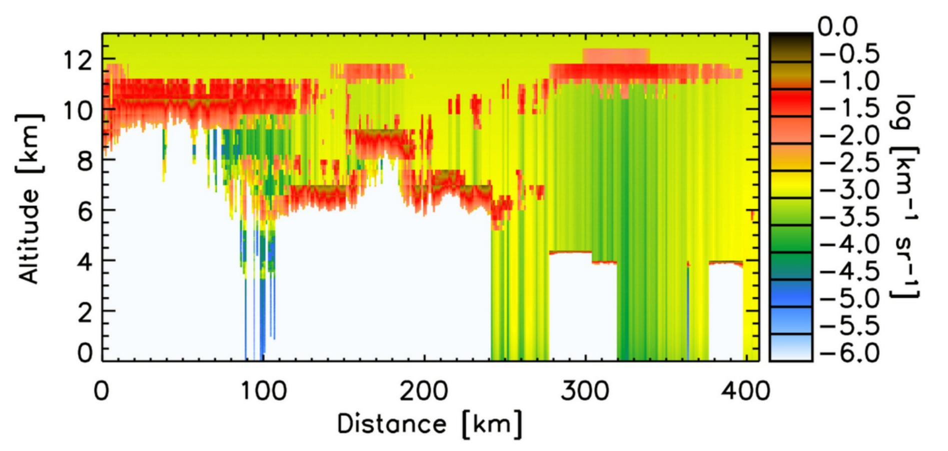
Application: Realistic simulations of satellite imagers.



Illustrative simulation of a Cb cloud above an „Earth" with radius 20km.

Lidar

Particularly for satellite lidars, multiple scattering can not be ignored. Using **VROOM**, this can now be calculated exactly.



Simulated lidar signal from EarthCARE overflight, input from COSMO-DE.

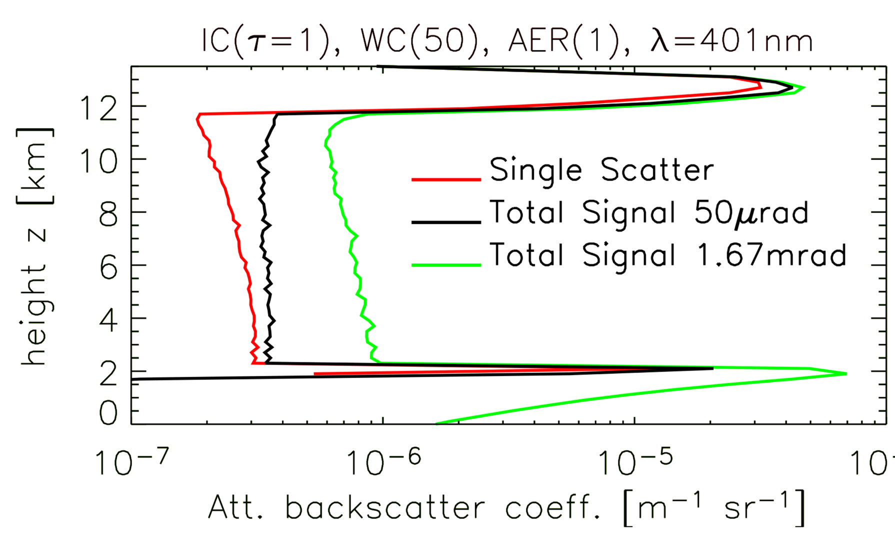


Illustration of multiple scattering effect for different FOVs.

Soon to come: Radar ● Lightning ● Topography in spherical geometry

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