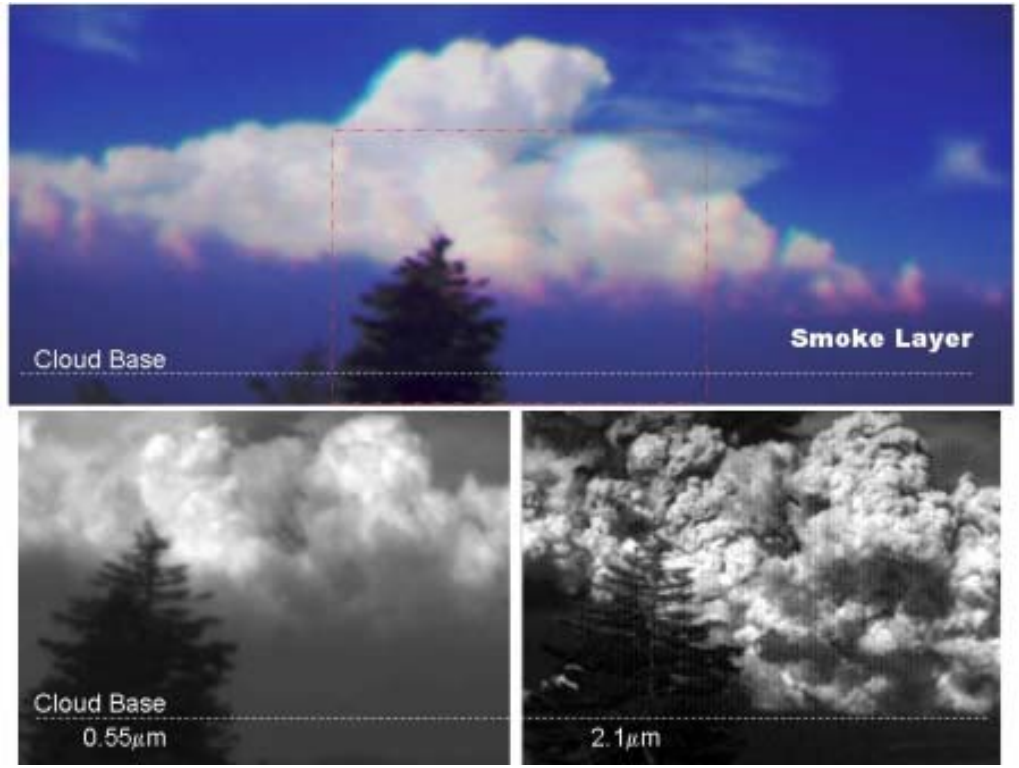
Cloud side science:
2007 contributions to NASA Goddard 613.2's Image of the Week

Where is cloud base?
Oct 21, 2007 (J. Vanderlei Martins)

The top image is a color composite of blue (410nm), green (550nm) and red (670nm) images with a thick smoke layer from forest fires near the ground. The cloud base is obscured by the smoke and the smoke itself is confused with the blue sky and the horizon. The two pictures on the bottom contain (a) visible (550 nm) and (b) near infrared (2100 nm) pictures of a piece of the same cloud (red box in the top image). The visible picture shows cloud structure as we normally think we see it. The 2100 nm picture shows two very distinct characteristics as compared to the visible one:

1- It penetrates the smoke and clearly shows a much lower cloud base, which is completely missed by a naked eye observer or by any analysis of the visible picture. This is because smoke particles are much smaller than 2100 nm, and thus interact only weakly with light of this wavelength.

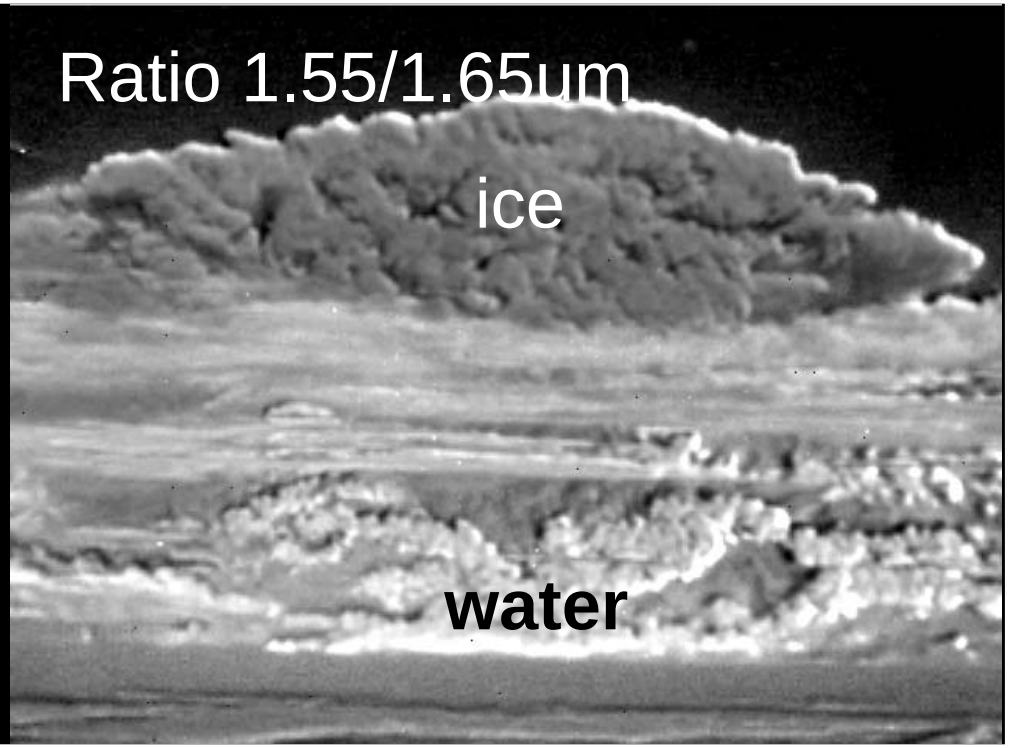
2- It shows enhanced details in the cloud structure that cannot be observed in the visible photo. The structure in 2100nm makes the cloud appear like a volcano or a smoke plume. This characteristic comes from the fact that light at 2100nm is "strongly" absorbed by cloud droplets and on average undergoes many fewer scattering events inside the cloud than light in visible wavelengths. Visible wavelengths are not absorbed by cloud particles and thus produce a much smoother picture. In reality, the 2100 nm picture shows the actual cloud dynamic and microphysical structure, which gets lost in the smoothing effect produced by visible light.

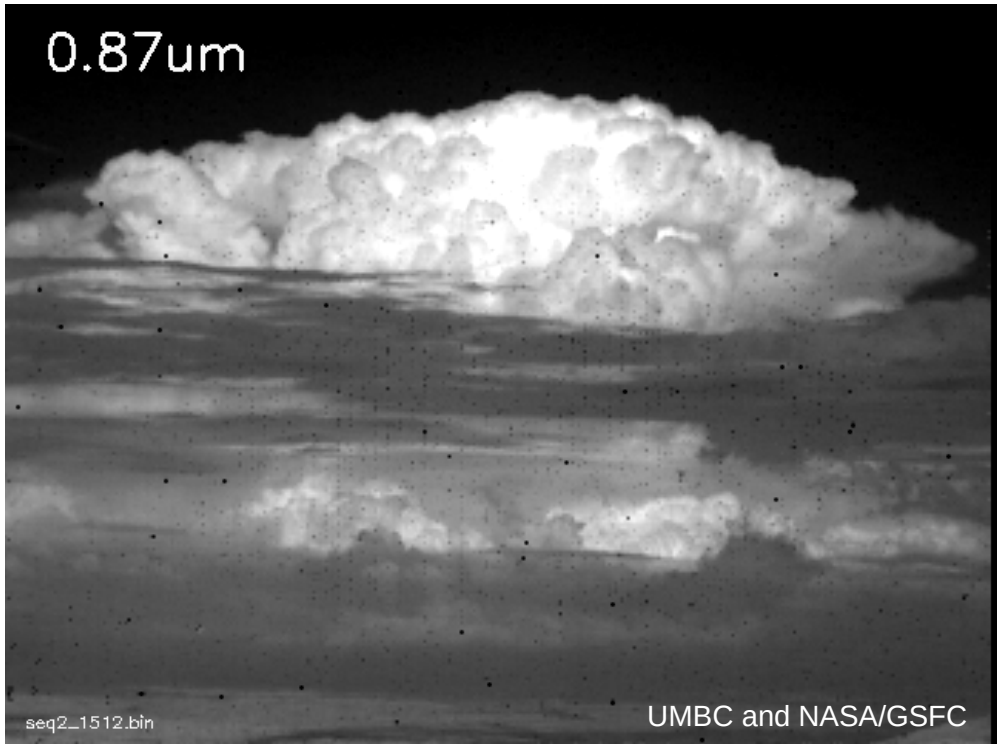


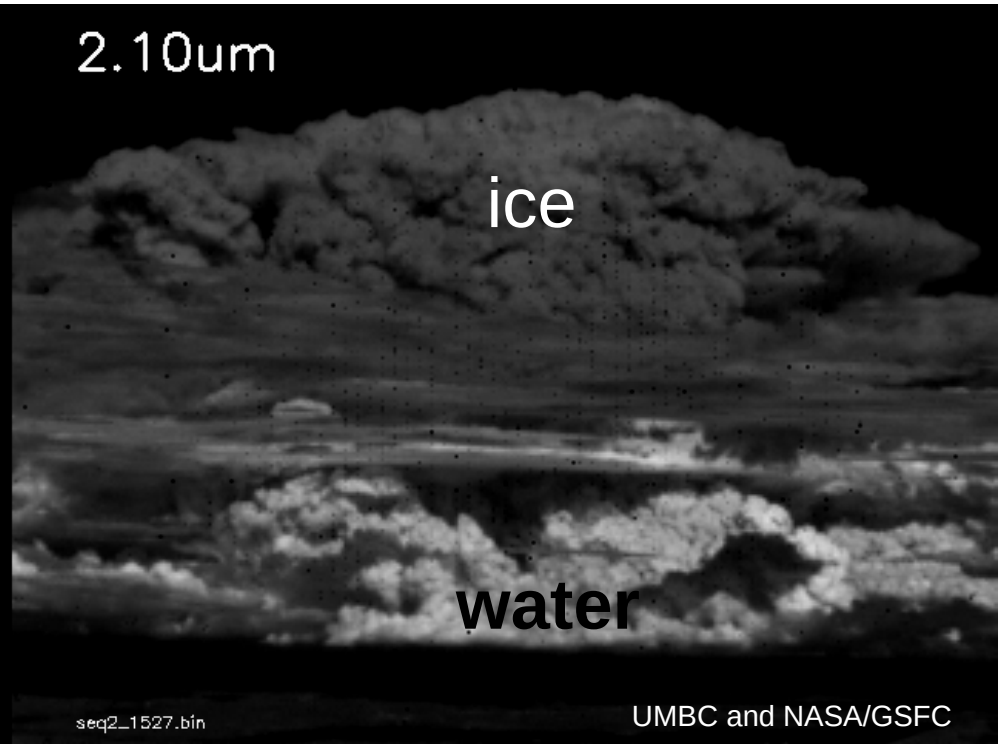
These pictures were taken in July 2007, during a field campaign in Mount Gibbes/Mount Mitchell, North Carolina, in collaboration with North Carolina State University. These were the first tests of the NASA Goddard/UMBC cloud side imagers. This system was designed for the study of the interaction between aerosol particles and clouds. There is strong evidence in the literature showing how man made pollution and other aerosols can affect clouds and precipitation. The system also allows for quantitative measurements of the size of the cloud droplets, and for the discrimination of the cloud thermodynamic phase.

Cloud Scanner Measurements

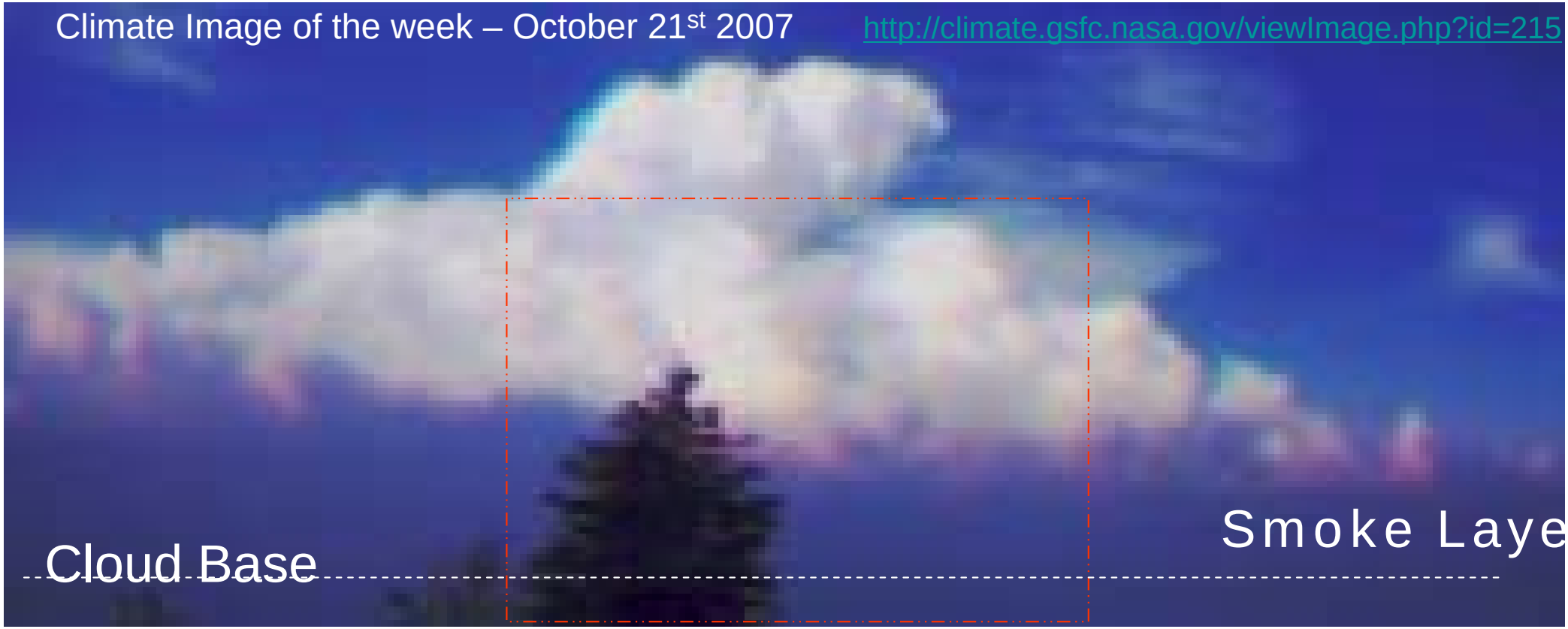
Mount Gibbes Experiment
July/2007

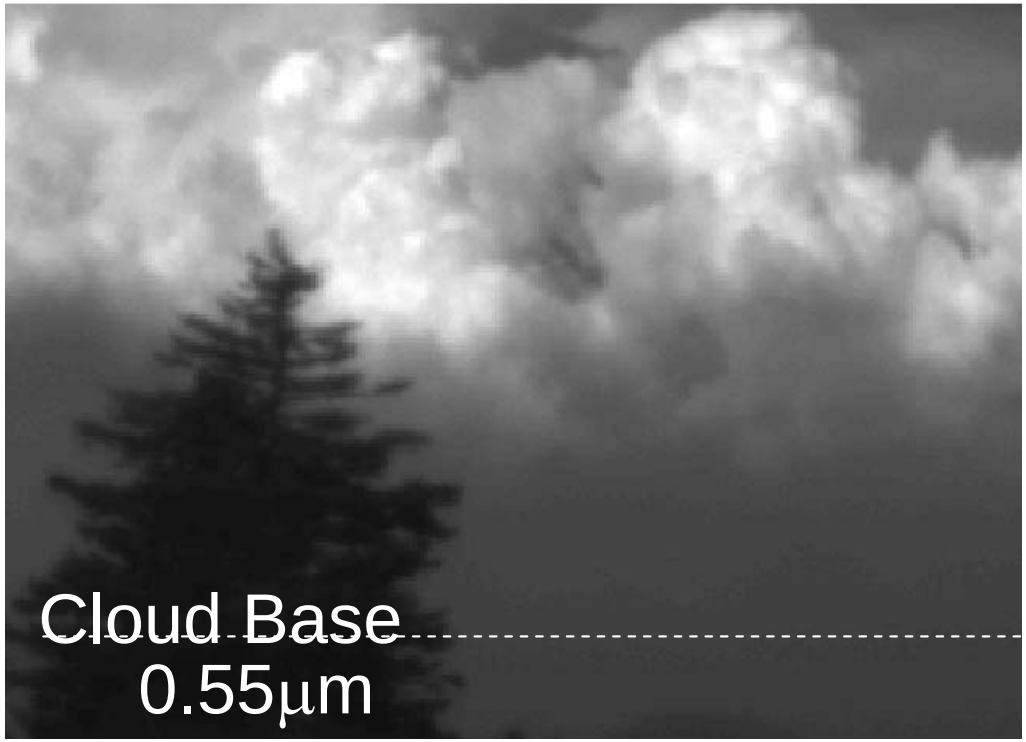


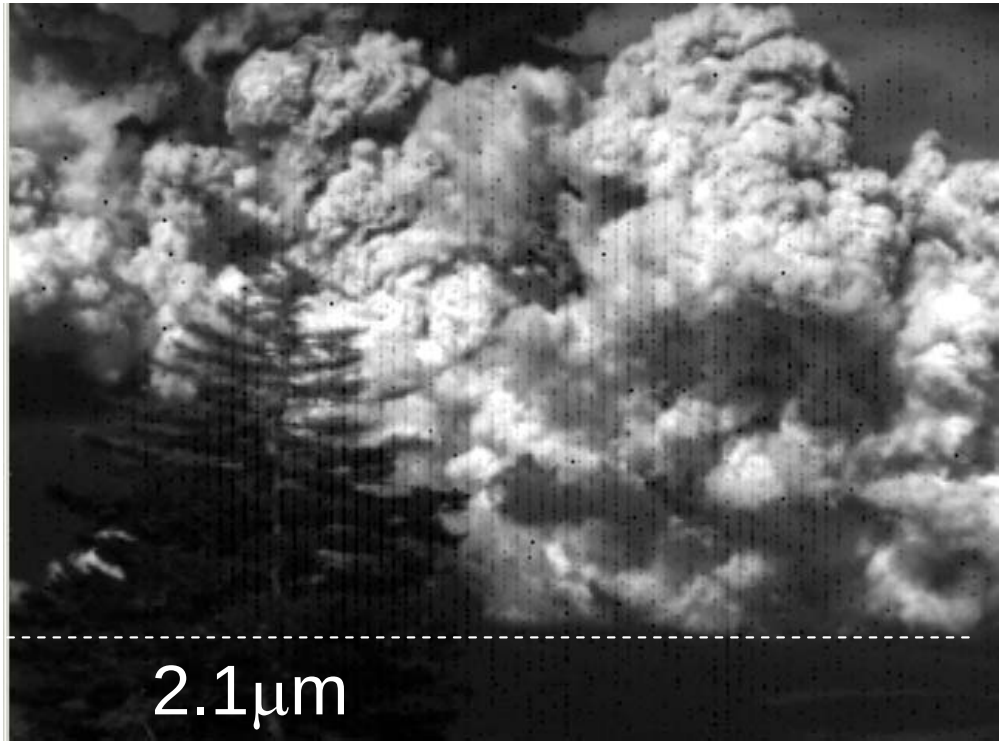




Climate Image of the week – October 21st 2007 http://climate.gsfc.nasa.gov/viewImage.php?id=215







Remote sensing of cloud sides of deep convective clouds
Dec 7, 2007 (Tobias Zinner)

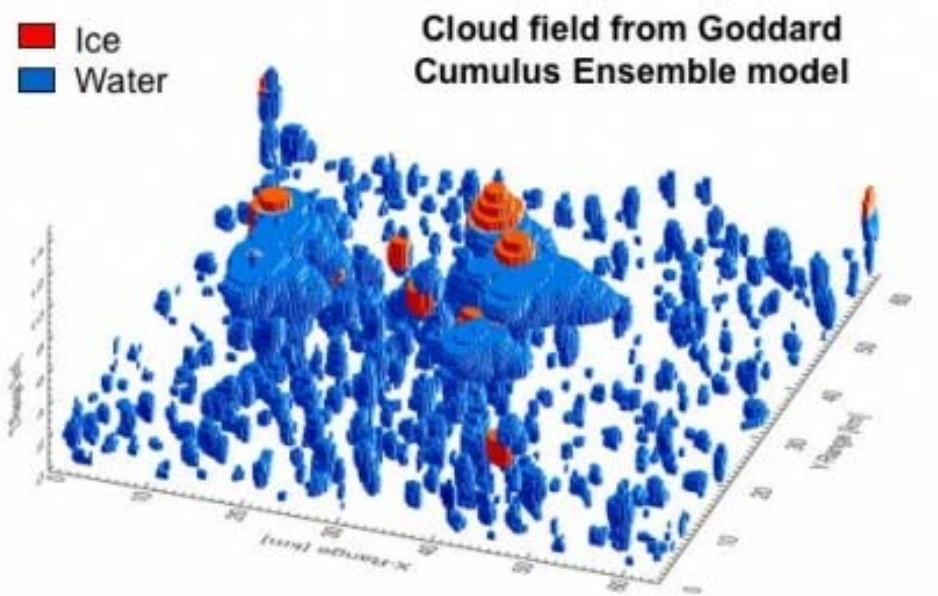
CLAIM 3D – a 3D cloud and aerosol interaction mission -- is a satellite sensor combination proposed by scientists from NASA's Climate and Radiation Branch and the University of Maryland Baltimore County. It combines measurements of aerosol characteristics in the vicinity of clouds and profiles of cloud-side microphysical characteristics. Such a set of collocated measurements will allow new insights into the cloud-aerosol interactions affecting directly the development of clouds and precipitation, especially in convection. A core instrument is the Cloud Scanner (see October 21, 2007 Image of the Week) which measures radiance reflected or emitted by cloud sides at several wavelengths. A profile of cloud phase and particle size at a spatial resolution of a few hundred meters will be retrieved from these measurements.

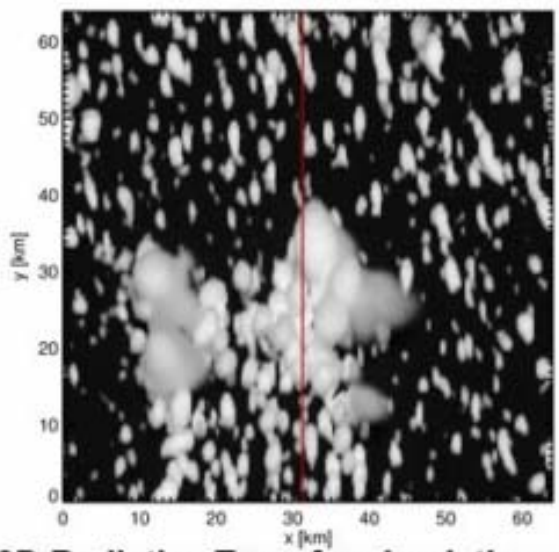
For this sensor an experimental retrieval was developed and successfully tested. The retrieval accounts statistically for the complexity of cloud structures and 3D radiative transfer at high resolution. These figures present the test of the proposed retrievals using a synthetic test bed. Cloud fields from Wei-kuo Tao's Goddard Cumulus Ensemble model (top image) were used as input to a 3D radiative transfer model which simulates the cloud scanner observations (bottom left image). The Bayesian retrieval of particle size distribution was then applied to the simulated data. The retrieved vertical profiles of cloud particle size and cloud phase were compared with the "true" data from the cloud model.

The bottom left image shows the simulated observation for the cloud structure above looking on the cloud scene at 60 degrees from the "south" of the scene. The plot on the right shows the true and retrieved cloud properties along the red line in the left image. Mostly cloud sides are observed showing small (up to 12 µm) water droplets and much larger (> 30 µm) ice particles. The results of comparison are very encouraging showing that the method is clearly capable of retrieving the cloud properties along the profile with a high accuracy.

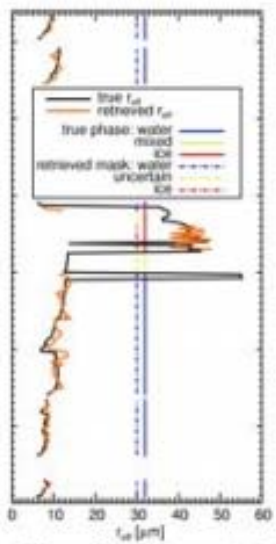
The results of this research have been submitted to Atmos. Chem. and Phys. Disc. Two other papers by GSFC Climate and Radiation Branch scientists also discuss cloud side remote sensing and the proposed CLAIM 3D mission.

(Tobias Zinner, former Deutsche Forschungsgemeinschaft Fellow at GSFC's Climate & Radiation Branch, is now at DLR Institut für Physik der Atmosphäre)





3D Radiative Transfer simulations



Cloud side retrieval