SMART Ground-based Remote Sensing and Modeling Studies of Cirrus Clouds during CRYSTAL-FACE

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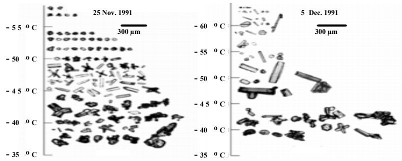
❑ Background

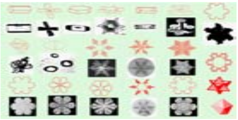
Cirrus clouds are characterized by their large areal extent and long persistence. As such, these clouds strongly modulate the radiative energy exchange in the earth-atmosphere system and are a significant component of the earth's climate.



Replicator measurements (courtesy of Drs. L. Miloshevich and S. Aulenbach, National Center for Atmospheric Research) of cirrus ice crystals during FIRE field campaign in Kansas in 1991.

Three distinct regimes of ice crystals are evident from the replicator data. In the uppermost layer (~ -60 ºC), small non-spherical particles (or the so-called quasi-spheres) are predominant; in the middle layer, primarily pristine ice crystals with well-defined hexagonal shapes or bullet rosettes; and in the bottom layer, mainly larger but irregular aggregates. The edges of these irregular ice crystals seem to be rounded (or rough surface), perhaps due to the effect of sublimation.

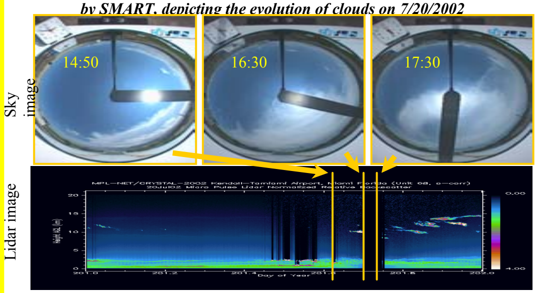
Cirrus anvils viewed from space courtesy of Shuttle Mission STS111



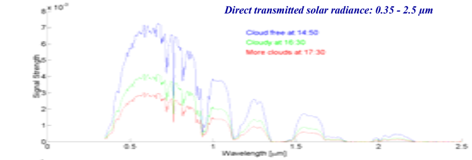
In our past work, we have developed state-of-the-art numerical models to simulate the single- and multiple-scattering and absorption within cirrus clouds by accounting for particulate morphology and orientation, size distribution, and vertical inhomogeneity of ice crystals.

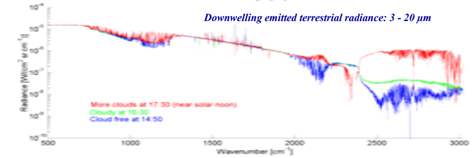
➢ ***Observations from space-borne remote sensing often suffer from the contamination of surface signatures. Thus, measurements from ground-based remote sensing, where signals come directly from the sun or interact with the atmosphere, provide additional information content for comparisons that confirm quantitatively the usefulness of the integrated ground, aircraft, and satellite data sets.***

Shown below is an example of some of the measurements taken by SMART, depicting the evolution of clouds on 7/20/2002



The sky imager and the micro-pulse lidar show that there were some cloud-free periods at zenith in the morning. High clouds started to move in around 15:00 (UTC), and by 16:30, about half of the sky was covered. The micro-pulse lidar was turned off around solar noontime to avoid gazing into the bright sun and damaging the detector. The data from the interferometer and the spectroradiometer reveal the effect of clouds on solar and terrestrial radiation (see below).





❑ Instrumentation and Deployment

During the CRYSTAL-FACE campaign, the SMART data were published real-time over the Internet, providing up-to-date information on the status of the atmosphere. These real-time data from the micro-pulse lidar and the sky imager were provided to help to make flight plans.

Cirrus anvils viewed from SMART

Hazy sky viewed from SMART

The SMART facility consisted of the following set of instruments

Instrument Type (Instrument Name)	Measured Variable(s)/Task
• Sun Photometers (Cimel, MFR)	direct and diffuse solar radiation at discrete spectral wavelengths
• Broadband Radiometers (PSP, NIP, PIR, etc.)	hemispherical global/direct/diffuse irradiance (uv, solar, terrestrial)
• Spectroradiometer (ASD)	transmitted and reflected solar spectrum (0.35 ~ 2.5 µm)
• Interferometer (AERI)	absolute infrared spectral radiance of the sky (3 ~ 20 µm)
• Scanning Microwave Radiometer (SMiR)	atmospheric precipitable/liquid water
• Micro-Pulse Lidar (MPL)	profiling vertical structure of aerosol and cloud layer
• Total Sky Imager (TSI)	monitoring and documenting sky conditions
• Meteorological Sensors	pressure, air temperature, relative humidity, wind direction and speed
• Guest instruments	collocated measurements for other research groups