Combined Passive and Active Laser Sensing of Clouds and Aerosol

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Over the last 15 years, the NASA ER-2 high altitude aircraft cloud observation experiment has employed combined lidar and passive sensing of atmospheric clouds and aerosol. An area of study has been the improvement in cloud microphysical and radiation parameter retrievals that are possible with combined active and passive measurements. Passive measurements the have been analyzed with the addition of lidar data include split window thermal infrared radiance measurement and high frequency microwave radiometry. The addition of active data is found to be especially important for the multi layer clouds, which are a major component of global cloud cover. The requirements of future cloud and aerosol space missions beyond EOS and ADEOS for addition of active laser sensing will be discussed.

Active & Passive Cloud & Aerosol Measurements

Satellite Mission Types
Relevance

1. Global Coverage Observations
   Data Assimilation to GCM's
   - Wide Swath Sensors
   - Long Term Data Sets
   - not appropriate for active sensing

2. Relational Studies
   Parameterization for Models
   Example:
   Cirrus Optical Depth Related to Mean Upper Troposphere WV

3. Zonal Mean Observations
   Validation for Model Reality
   Example:
   Latitudinal Distribution of Cloud Ice Water Path

Lidar/Radiometer Cloud Sensing from Aircraft

Examples:

- Profile of Radiation Parameters
- Improved Cloud n Physics
- A-band Mean Free Path
- Microwave WV & Cloud Parameters

Fig. 1 Summary of Active & Passive remote sensing mission types and outline of example topics from airborne remote sensing.

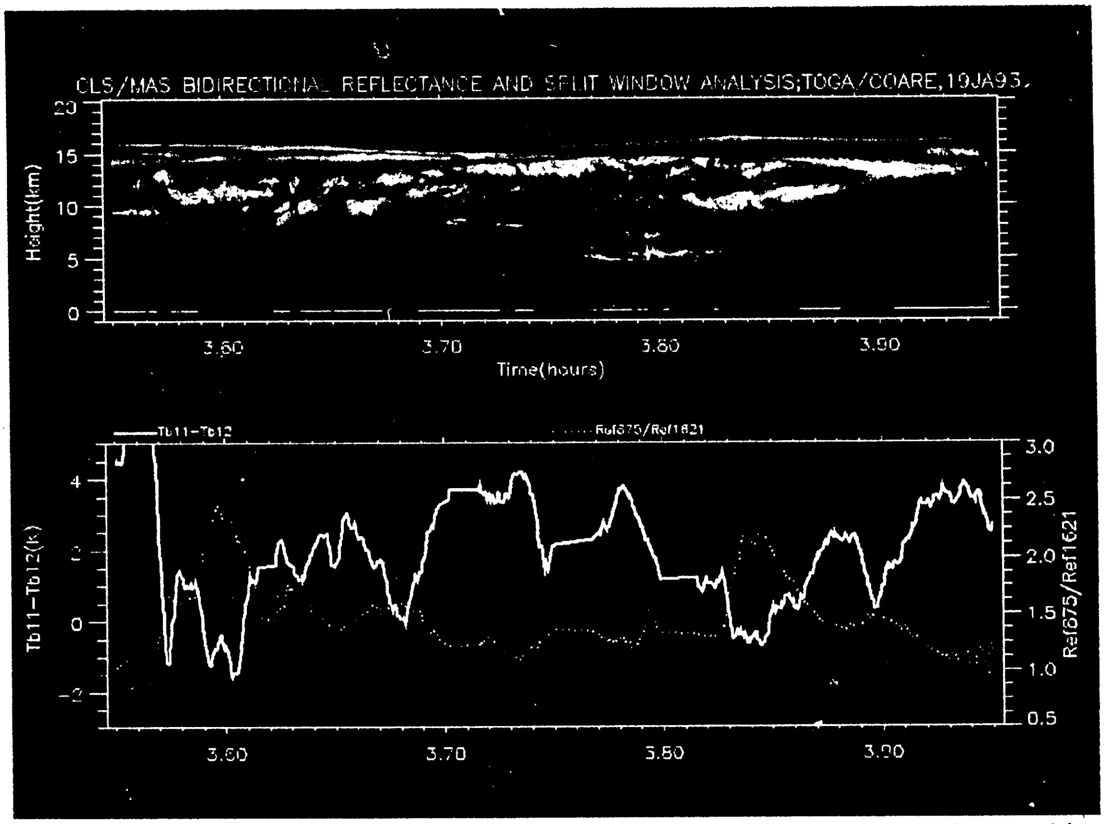

Fig. 2 Data from the NASA ER-2 high altitude aircraft showing results for combined remote sensing of tropical cirrus clouds with lidar and spectral thermal infrared measurements.

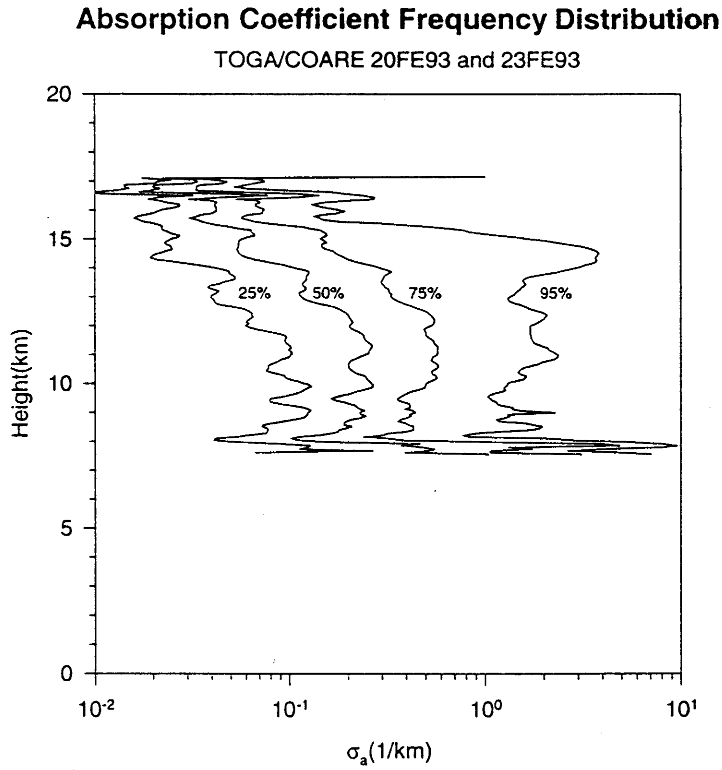

Fig. 3 One application of combined lidar and spectral thermal infrared sensing is to derive the IR absorption cross section as a function of height for cirrus. Such retrievals are not possible with passive sensing alone. The figure shows the frequency of observation as a function of altitude for tropical cirrus from ER-2 data. Each line represents the values for which the indicated percentage of cross sections were below the value.

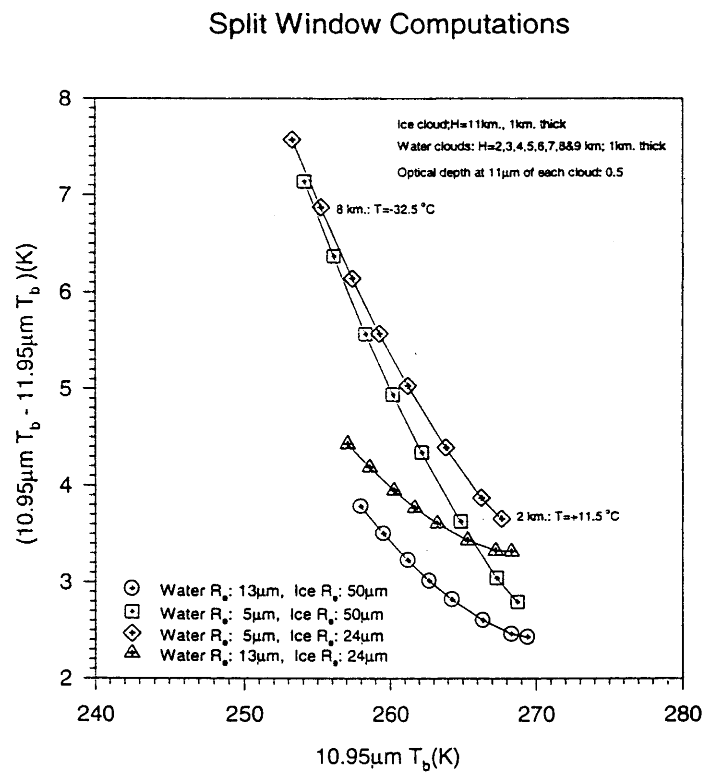

Fig. 4 The sensitivity of the split window equivalent brightness temperature of a two layer cloud system of cirrus over stratus. The spilt window brightness, from which particle size is often retrieved, is highly sensitive to the vertical structure of the cloud layers. The multiple layer conditions can not be retrieved from passive data.

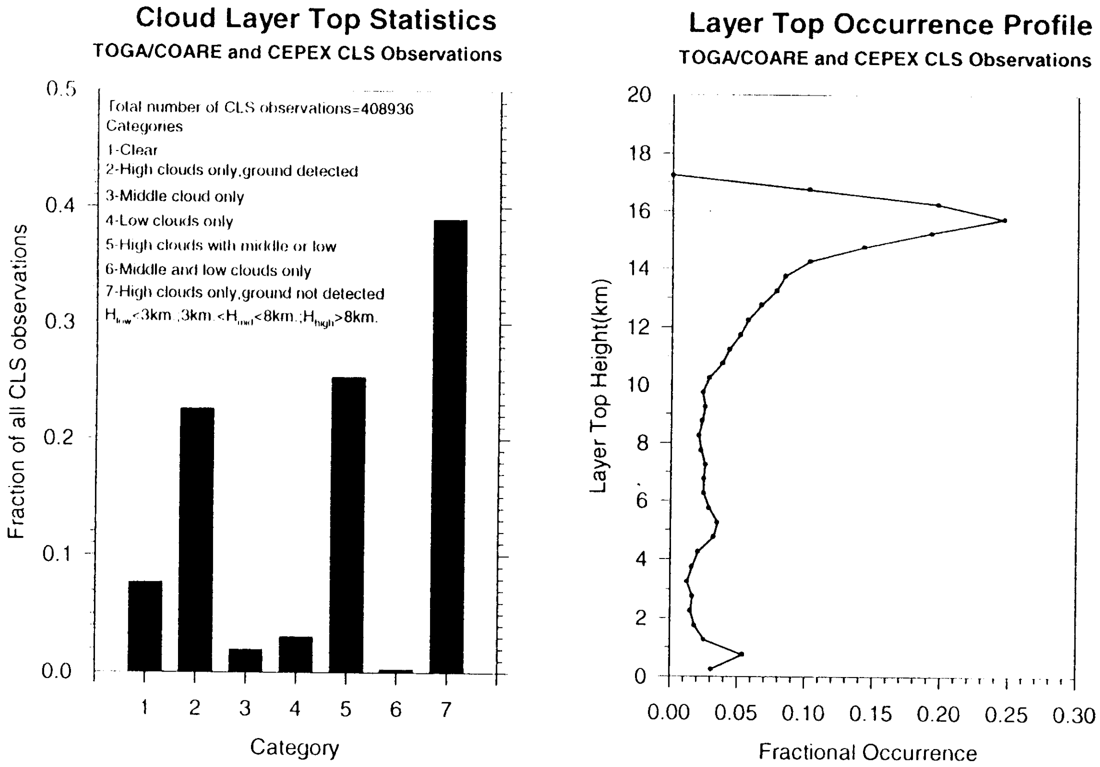

Fig. 5 Cloud height statistics from the ER-2 TOGA-COARE missions. Multiple layered clouds are a dominate cloud type.

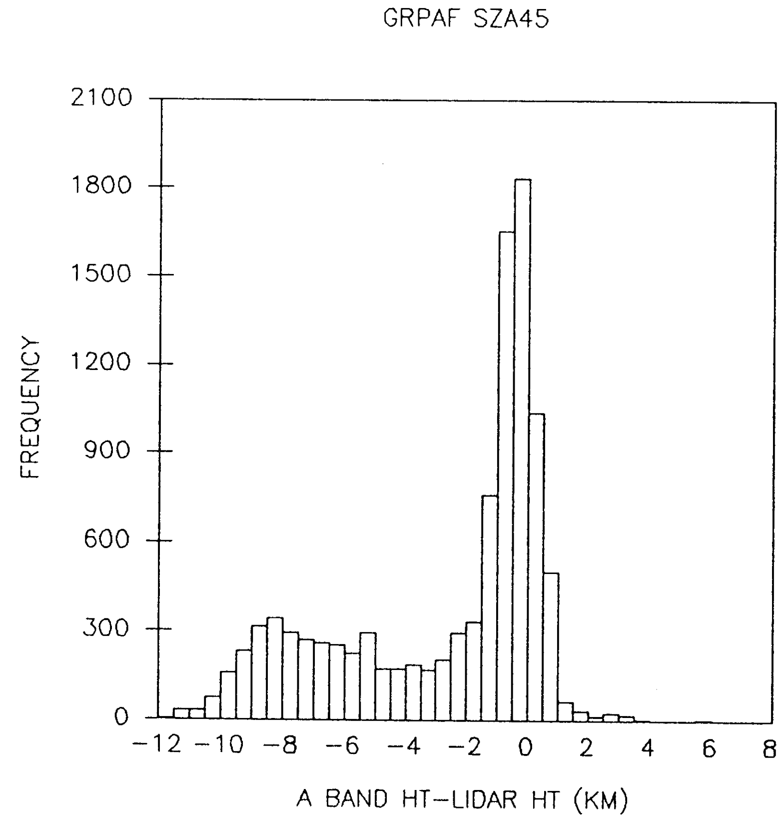

Fig. 6 A comparison of cloud heights derived from an experiment Oxygen A-band technique to direct measurements from lidar. Active measurements provide a direct means to obtain cloud height for comparison to passive retrievals.