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The Colorado/Missouri 1989 Cirrus Mini IFO

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A series of experiments with aircraft are planned for November and December 1989 to study cirrus ice crystal nucleation mechanisms and to test new aircraft instrumentation. The measurements will be conducted using the NCAR Sabreliner (Drs. Don Hagen and Andy Heymsfield) and King Air (Dr. Al Cooper). Sampling will be conducted near Boulder, Colorado, in lenticular (mountain wave) clouds, and over Missouri in cirrus generating cells. Field samples of aerosol and ice crystal replicas and melt-water from these cirrus clouds will be collected and studied in Prof. Hagen's laboratory.

One of the limitations of FIRE Phase I was the inability to collect particles from the Sabreliner and estimate their shape; shape is important for estimating ice water content and ice particle scattering properties. A sampler similar to that used on the King Air during FIRE Phase I (a rod containing a coated slide) will be extended through the skin of the Sabreliner. Owing to the comparatively high speed of the Sabreliner, the collection area is reduced from the probe used on the King Air to improve collection efficiency. Our initial tests of this collection apparatus indicates that oil on the slides is stripped-off in the high velocity air. Therefore, we will use other collection media. Soot-coated slides will be used as the impressions can be used to discern particle phase (Fig. 1A, particles in cirrus from the Sabreliner, Fig. 1B, water droplets in the laboratory, courtesy Nancy Knight). (Water droplets cause soot to concentrate at their centers and leave diffuse edges, ice particles leave streaked impressions). Gelatin-coated slides containing dye can also be used to decipher phase. We will also use replication techniques as these proved to provide high quality images of ice particles during FIRE phase I. Collections will also be made from the King Air, as was done during FIRE Phase I.

A major limitation of the FIRE Phase I microphysical data set was the lack of measurements of particles below 50 microns with the Sabreliner and below 25 microns with the King Air. A new instrument currently being fabricated which collects particles in oil on a continuously moving belt and then photographs them with a video camera will be tested on the King Air and possibly the Sabreliner as well. The minimum detectable crystal size is about 7 microns, with 1 micron resolution. The device will fit within a Particle Measuring Systems (PMS) 2D probe cannister and thus will be interchangeable between aircraft. (However, removal of a 2D probe is required, and consequently 2D data from will be lost). A photograph of a prototype of the instrument appears in Fig. 2 and imaged ice crystals in the laboratory appear in Fig. 3. We hope to obtain ice particle concentration data continuously down sizes much smaller than previously possible with aircraft.

Relative humidity, crucial to understanding ice particle growth and vertical motion in cirrus, was poorly measured by aircraft during FIRE Phase I. A new cryogenic hygrometer which is purported to provide high accuracy relative humidity measurements down to temperatures below −50°C will be tested. This instrument has been fabricated at NCAR using a design developed by NOAA to measure relative humidity from balloons. The instrument is contained within the aircraft cabin, and air

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is drawn in to the sensing area using a metal bellows pump. Flights in lenticular clouds are ideal to test the accuracy of this device since the leading edge of the cloud will contain water droplets (approximately 100% relative humidity) and humidities upwind of the cloud are easily calculable. Flights in and below cirrus generating cells which contain liquid water can also be used to test the accuracy of the measurement.

Improved methods for measuring the vertical velocity from the aircraft will be tested as vertical velocities during FIRE Phase I could only be reliably measured to 50 cm s^{-1}. The method involves using Lagrangian-type spiral descents. The horizontal velocity lateral to the aircraft is measured in each loop of the spiral. Divergence values are found for each loop, and the equation of continuity is integrated to find the vertical velocity distribution with altitude. It is necessary to define the boundary conditions at the cloud top before integrating the equation of continuity. We hope to test various methods for obtaining the upper boundary condition, possibly by making a circular, constant altitude track immediately at or immediately above cloud top from which a divergence value can be obtained.

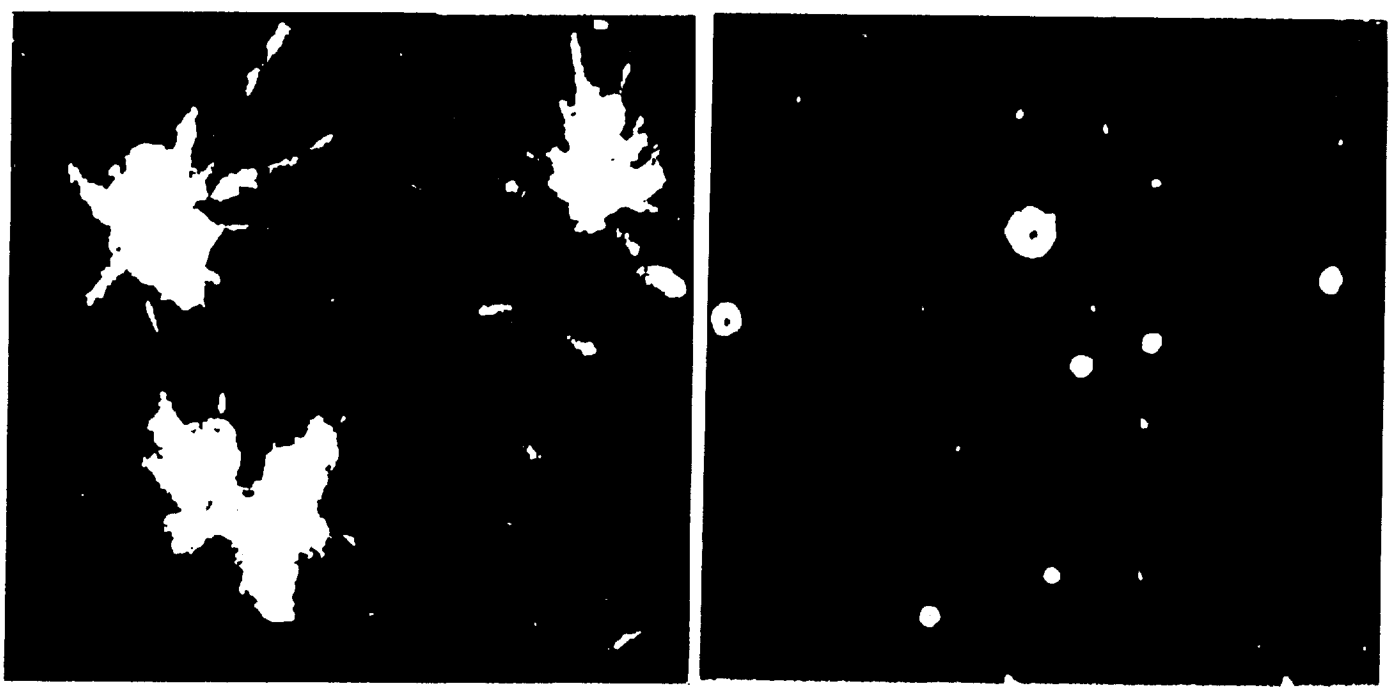

Figure 1. Microphotographs of images of particles collected in soot-covered slides **A:** Ice particles with the Sabreliner in cirrus. Note the columnar images at the center of the each impression. These particles were about 120 microns. **B:** Water droplets in the laboratory. The droplets forming these impressions were 10 to 50 microns diameter. This data is courtesy Nancy Knight.

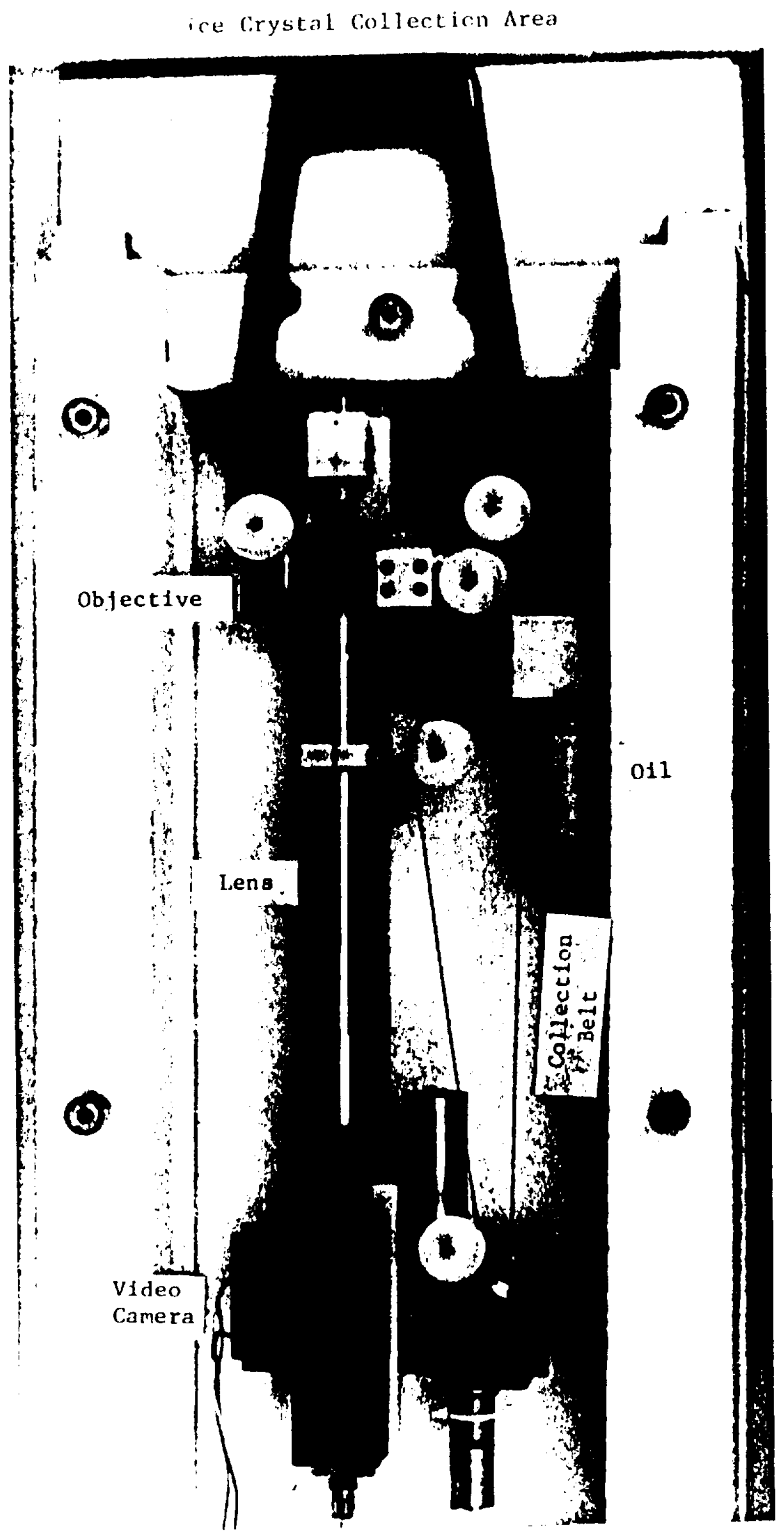

Figure 2. Prototype of continuous ice particle sampler.

Another unknown from FIRE Phase I was the cloud condensation nucleus (CCN) spectra and nuclei composition; further understanding of cirrus crystal nucleation and cirrus crystal concentrations requires such knowledge. Air samples will be collected in mylar bags from the aircraft. Air will be pumped (metal bellows pumps) into the aircraft through a manifold with an inlet beyond the aircraft's sphere of influence. Following sample collection, the bags will be transported rapidly to the Rolla airport and the CCN spectrum and composition will be characterized. Decay of the CCN spectrum due to collection on the walls of the bag, expected to be small, will be evaluated by experiments.

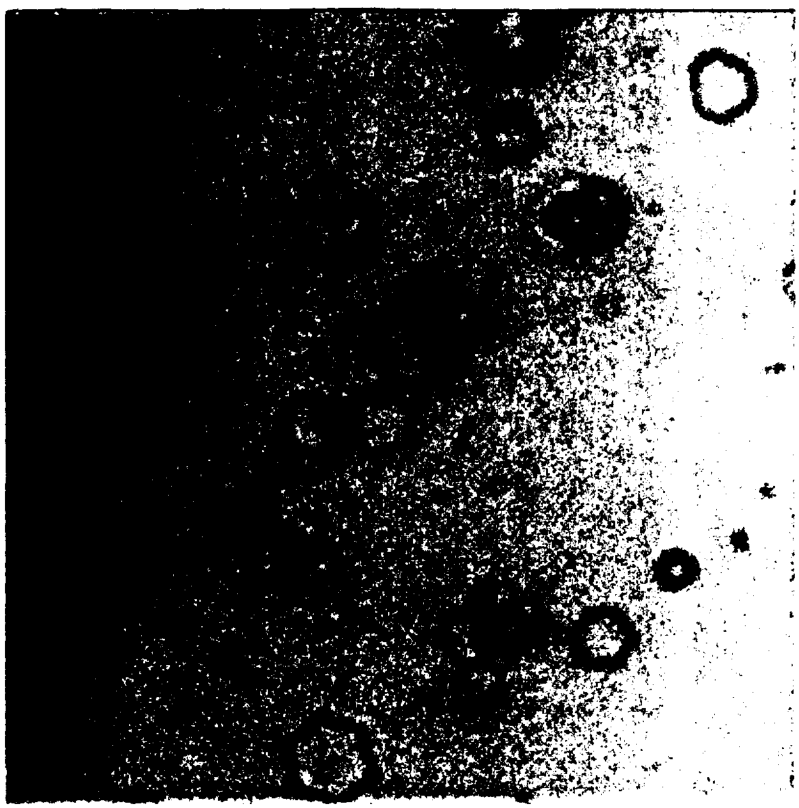

Figure 3. Photograph of ice particles imaged with sampler in the laboratory. Crystals are approximately 20 microns diameter.