A SYSTEM FOR RECORDING PHYSICAL PROPERTIES OF CLOUDS

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INTRODUCTION - Characterization of the physical properties of clouds is an important objective of the FIRE Project intensive field operations (IFO) planned for 1990 thru 1992. Physical properties observed from satellites will be directly compared to ground based observations during this period. It is the purpose of this paper to provide the technical information required to record local cloud parameters such as type of clouds, direction of travel, layering, and cloud fraction data. Such information should be very useful in analyzing other cloud and meteorological data. A system of the type described in this paper was successfully deployed as part of the First Global Surface Radiation Budget Experiment in April 1989.

HARDWARE DESCRIPTION - A video-based system to monitor and record cloud properties during daylight hours was developed around state-of-the-art video equipment, a time-lapse format video recorder, and off-the-shelf optical hardware shown in figures 1, 2, 3, and 4. The optical system consists of a 28 mm auto-iris lens, and a mirrored acrylic hemispherical dome. The outdoor physical set-up, shown in figure 2, includes a tripod to support the solid-state video camera and it's weather proof housing. The electronic hardware including the ac power adapter, time-lapse recorder, and video monitor, should be located in a normal indoor environment.

Long term recording of video images of cloud movements is accomplished using an off-the-shelf video time-lapse recorder as shown in figure 3. This recorder uses standard VHS format video cassettes which are the same as used on home video cassette recorders. Recording speeds from 2 to 480 hours in 8 steps are possible on the AG-6050, however the 480 hour range has proven to be the most effective for recording cloud movements.

The solid state video camera, shown in figure 4, was selected for it's small size and automatic gain control feature. Equally important was the auto-iris lens which is available for this type of camera. The auto-iris automatically compensates for the wide range of light levels which will be encountered over a 14 hour data collection period. The combination of the auto-iris lens and the automatic gain control feature enable the camera to adjust to all light levels from early dawn, or heavy overcast conditions, to very bright sunlight.

Recording images of cloud movements over an entire local hemisphere required a "fish-eye" type view of the sky. This implied a set-up where the camera would be looking skyward. This was undesirable because relatively small droplets or other

contaminants could obstruct the cameras view and therefore would require frequent cleaning. To minimize these effects, an inverted camera and a dome shaped reflector were used.

FIELD EXPERIMENT AND OPERATION - The cloud imaging system was operated continuously for a period of 35 days in support of the First Global Surface Radiation Budget Experiment in April, 1989. The entire cloud imaging system was co-located with a cloud lidar ranging system. The cloud camera setup was installed on an elevated platform, shown in figure 2, to allow an unobstructed view of the hemisphere 10 degrees above the horizon. This prevented local site activity and buildings from blocking the cameras view above 10 degrees and also provided a measure of physical security for the system. The dome and camera window required cleaning only once a week and then only as a prudent operational requirement. Occasional bird droppings on the dome were seen, but only obscured a minute portion of the whole sky image. Salt spray build-up was not a problem from a video imaging standpoint but could be detected by visual inspection when cleaning the dome.

The format employed by the time-lapse recorder is not compatible with a standard VHS video cassette player. However, images recorded on the time-lapse recorder may be played back from that machine and re-recorded on a standard VHS machine for general distribution. The limitation to this procedure is that the playback speed must be chosen prior to conversion, and the multi-speed viewing capability of the time-lapse recording is not transferable to the VHS format. However, all playback features normal to a standard VHS player such as slow motion, stop action, and copying, will still be possible with the converted tapes. The time-lapse recorder can be programmed to turn itself on and off at pre-selected times which is a valuable feature for conserving tape and increasing storage capacity. The 480 hour recording rate combined with the on-off timer mode will allow over one month of sky data to be recorded on a standard T-120 two hour video cassette tape.

CONCLUDING REMARKS - Results are currently being studied and initial indications are that the system provided excellent data on cloud movements, multiple layers, and surface conditions such as dew, rain, and sea spray. When combined with lidar cloud height data, this system can also yield quantified estimates of cloud fraction at a spatial resolution similar to that of the satellite pixel. A graphic representation of this approach is shown in figure 5. The system is first calibrated to determine angular distribution within the near-hemispherical image. If the satellite view angle is known, the pixel centerline can be located on the video image. If cloud base is known along with satellite pixel size, trigonometry can be used to calculate the solid angle about the centerline which defines the effective satellite viewing area. The portion of clouds in this angular area of the image is then an indicator of cloud fraction in the same region of the sky as being viewed by the satellite.
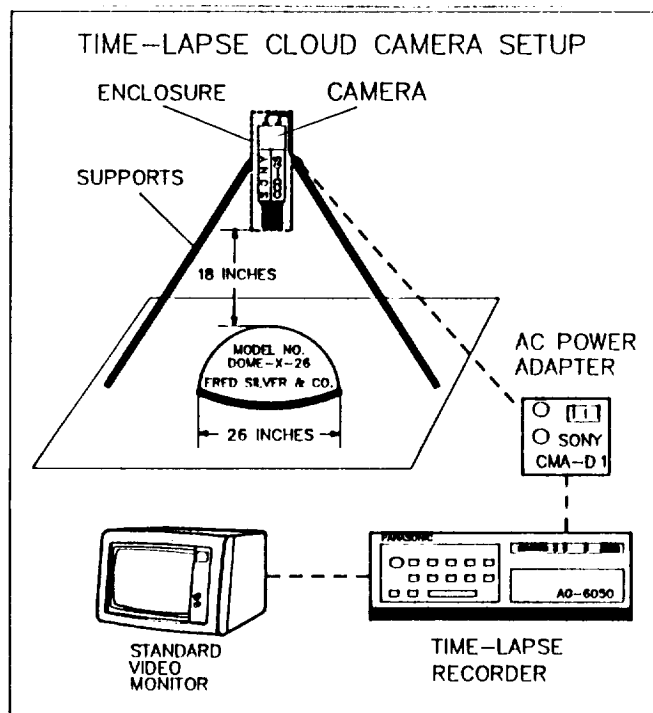
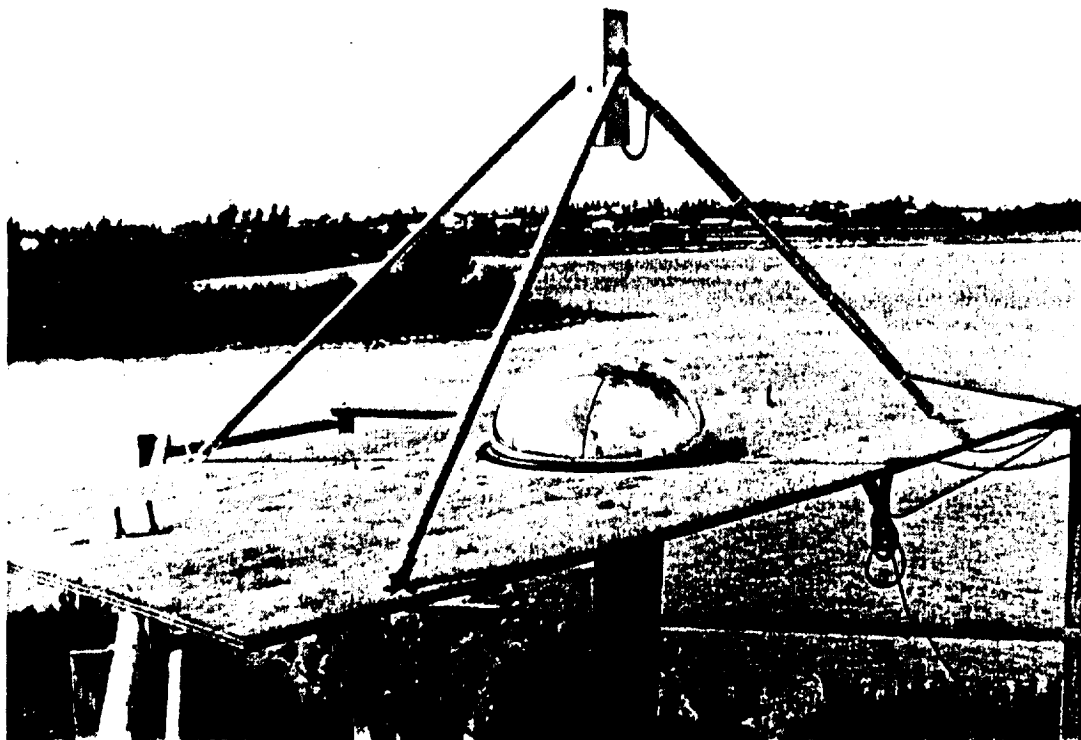Figure 1. Video equipment and associated hardware.

Figure 2. Outdoor physical set-up of camera and dome.
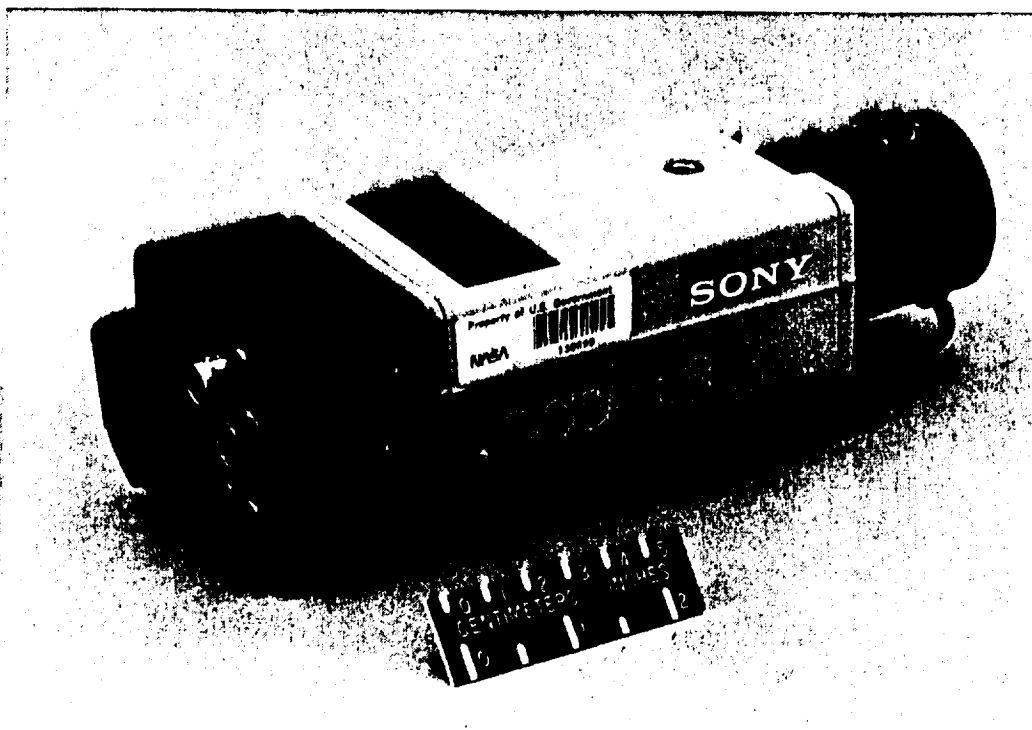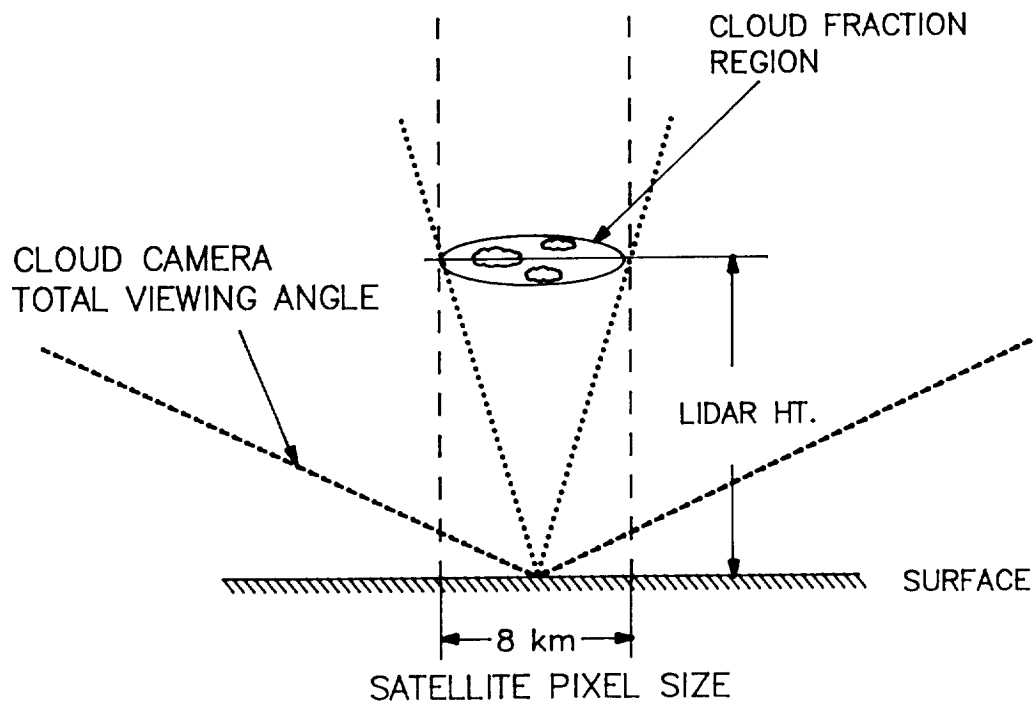
Figure 3. Panasonic time-lapse recorder model AG-6050.

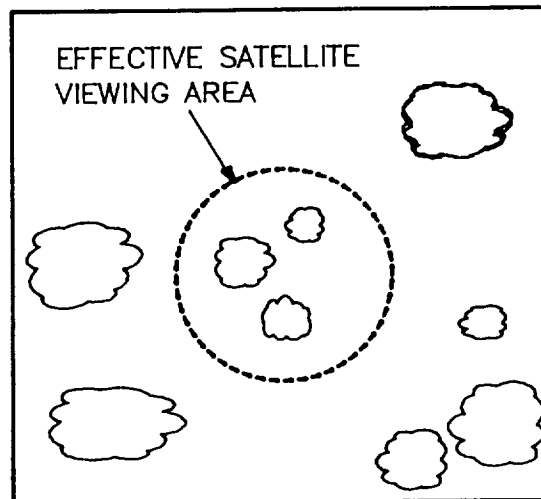Figure 4. Sony solid-state camera model CCD-G5.

POSSIBLE CLOUD FRACTION APPROACH

Figure 5. Graphic representation of cloud fraction approach.