

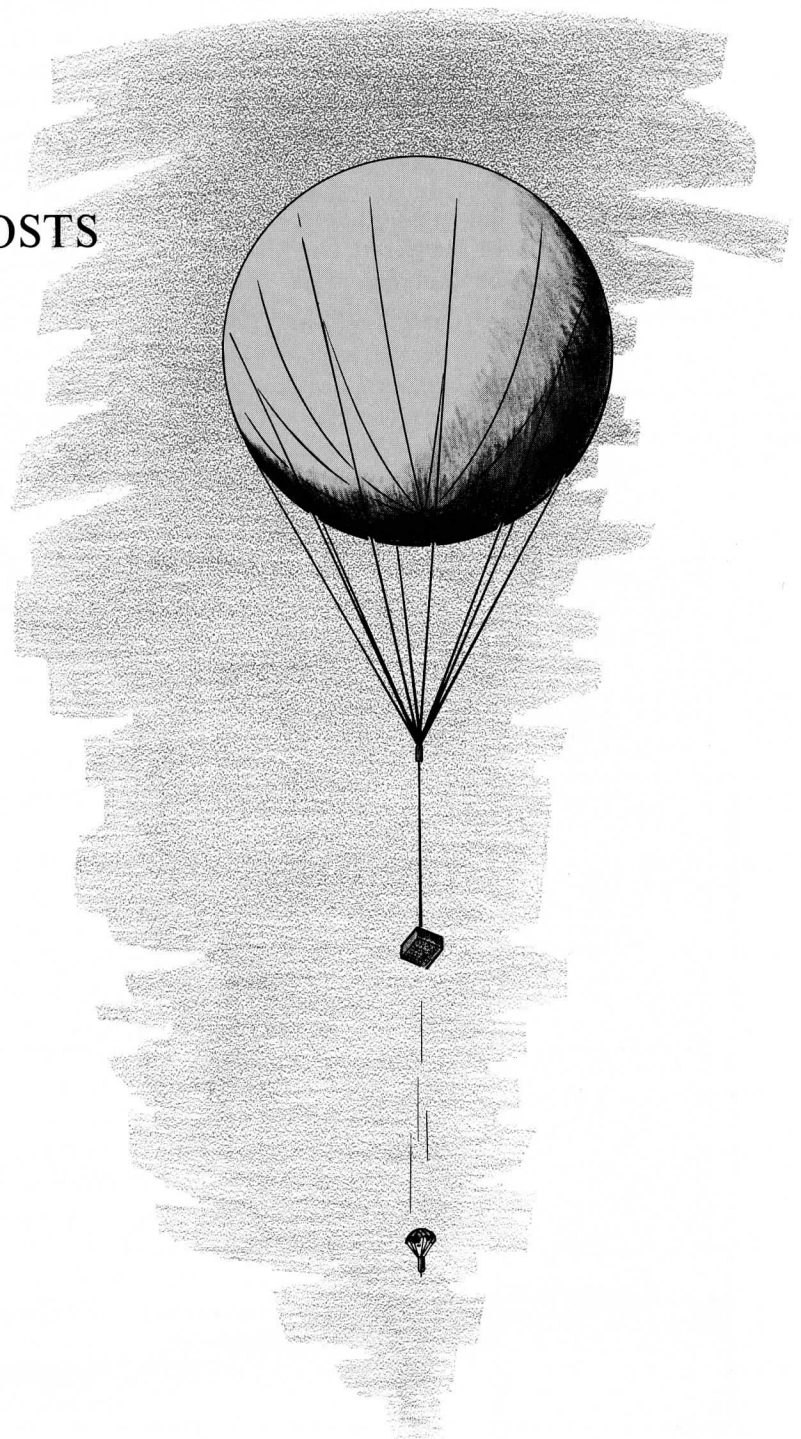
GHOSTS and Mother GHOSTS

In 1967 the *NCAR Quarterly* predicted optimistically that "systems involving long-lived superpressure balloons will soon report worldwide atmospheric conditions at several levels above the earth." The superpressure balloon concept, and early development of the GHOST system at NCAR and of the French EOLE system, raised hopes that here indeed was the means for obtaining weather data for the 85% of the earth's atmosphere not well represented by surface or rawinsonde observations.

Several hundred test flights have indicated, however, that this concept is not without its problems. In addition to difficulties from gas loss, gradual deterioration of balloon films, and failure of electronics, a major problem has been icing of balloons at elevations of 3 - 10 km.

Various devices, all of which must be nonhazardous to aircraft, were tried in attempts to prevent ice formation, to shake ice loose, or to control the altitude and allow balloons to survive icing periods. Balloons were strengthened with glass filaments, or coated with silicone or wax to shed moisture droplets; mechanical devices agitated the balloons, changed their shape or size, or temporarily raised them above the icing level. But none of these methods significantly prolonged the lives of balloons flying below 10 km.

Because of these difficulties, and because Nimbus-type satellites can now obtain

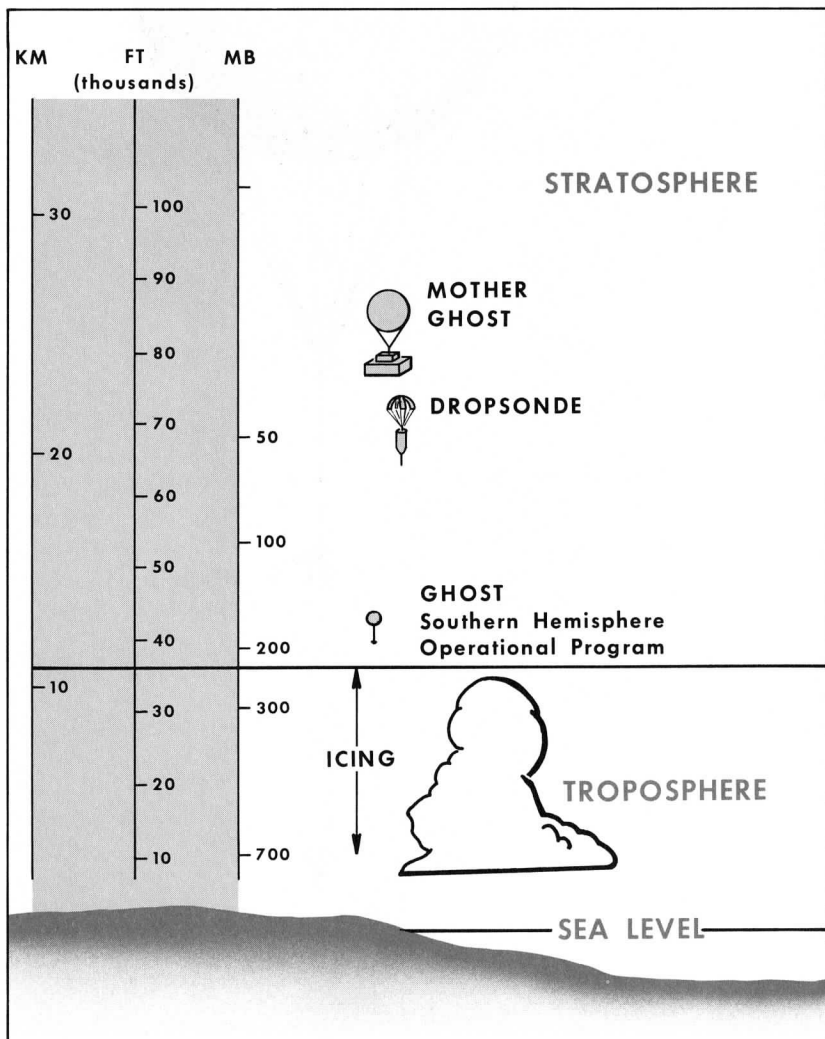
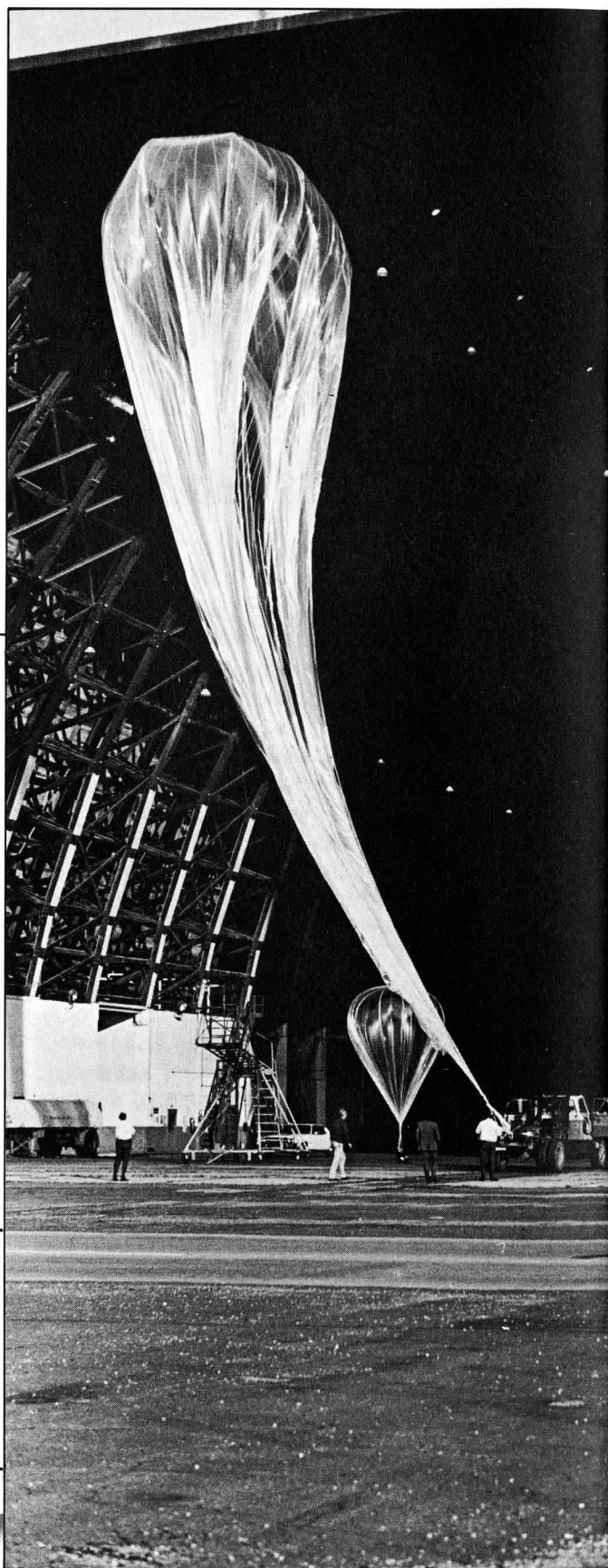


complete temperature profiles in middle latitude areas, some rethinking has been done on the use of balloons for gathering worldwide weather data for GARP, the international weather data for GARP, the international scientific study planned for the 1970s. The primary measurements needed for GARP are wind, temperature, pressure, and humidity. Ideally, data should be in the form of profiles from the surface to about 25 km, but measurements from several discrete atmospheric levels would be acceptable.

Satellite Sensors for Middle Latitudes

Infrared sensors on polar-orbiting satellites can now produce adequate temperature soundings. At middle latitudes, wind and pressure data can be derived from these

A 22 - m GHOST balloon, inflated in a blimp hangar at Lakehurst, New Jersey, is brought out for launching. A small tow balloon will provide supplementary lift for the first few thousand feet. The size of a GHOST balloon is determined by the amount of lift necessary to carry its load to the desired flight level.



soundings, *provided precise measurements are available from one reference level.* Herein lies the role of GHOST balloons at middle latitudes: they will gather temperature, wind, and pressure data at this reference level, probably 12 km (200 mb), at least in the southern hemisphere. Such a reference level could be defined by a network of about 300 small constant-level balloons, in combination with a satellite location and data collection system. Northern hemisphere middle latitudes will be adequately covered by land-based and sea-based radiosondes and surface observations.

Mother GHOST in the Tropics

According to present GARP requirements, wind velocities in the tropics must be known on at least four levels. These measurements are required to provide adequate information for input into numerical models of the tropical atmosphere, the crucial "heat engine" of atmospheric circulation.

However, in the tropics, winds cannot be inferred mathematically from satellite data. Although satellite photos of cumulus and cirrus clouds may help to define winds at two of the four levels, we must still rely on balloons for the other levels and for areas without clouds. To obtain measurements in spite of icing problems, a new concept has been developed by the Global Atmospheric Measurements Program at NCAR — the concept of the Mother GHOST balloon.

Mother GHOST is a carrier balloon, designed to drift in the stratosphere at 24 km, well above the critical 10-km level (and also above SST and other aircraft altitudes), carrying 100 or more small, light-weight dropsondes. Each balloon will tend to remain close to its launch latitude, following the zonal flow characteristic of tropical stratospheric winds. On commands from geostationary satellites (fortunately part of the basic GARP system already planned), it will release dropsondes. Each dropsonde, falling earthward on its own small parachute, will transmit temperature and density measurements by radio back to

its "mother" GHOST balloon, which will translate them for relay to a satellite, which in turn transmits them to ground stations. Drift (and thereby wind data) will be indicated by relay of an Omega navigation signal from the dropsonde to the balloon.

Most of the components of the Mother GHOST system are adaptations of previous designs, and have already been tested. Balloons will measure 22 m in diameter. A successful Mother GHOST balloon was launched from Lakehurst, New Jersey, in July 1970; in September, October, and November 1970, others will be tested from NCAR's Scientific Balloon Flight Station at Palestine, Texas, and from Christchurch, New Zealand, headquarters for the GHOST test program.

One of the complications that has arisen with the Mother GHOST concept is that as the balloons release their dropsonde loads they become lighter, and rise above their normal flight elevation. Because of the weight loss, the balloons will climb during flight from 24 to 26 km over a three-month period. As they rise, overpressure becomes a danger; each balloon must be equipped with a valve arrangement which allows gas to vent when overpressure exceeds safe limits.

Southern Hemisphere Operational Program

Further plans in the southern hemisphere relate to a useful operational system defined as the Southern Hemisphere Experimental Operational Program. An attempt will be made to keep about 50 GHOST balloons in the air at 12 km to provide weather data from the Indian Ocean-Australia-South Pacific area. These balloons, the first of which will be launched in September 1970, will carry modified GHOST electronics packages with both sun-angle and magnetometer locating devices, as well as radio altimeters. Thus provided with accurate location capability, they will relay data twice daily to the World Meteorological Center in Melbourne, Australia, for use in southern hemisphere weather analyses.

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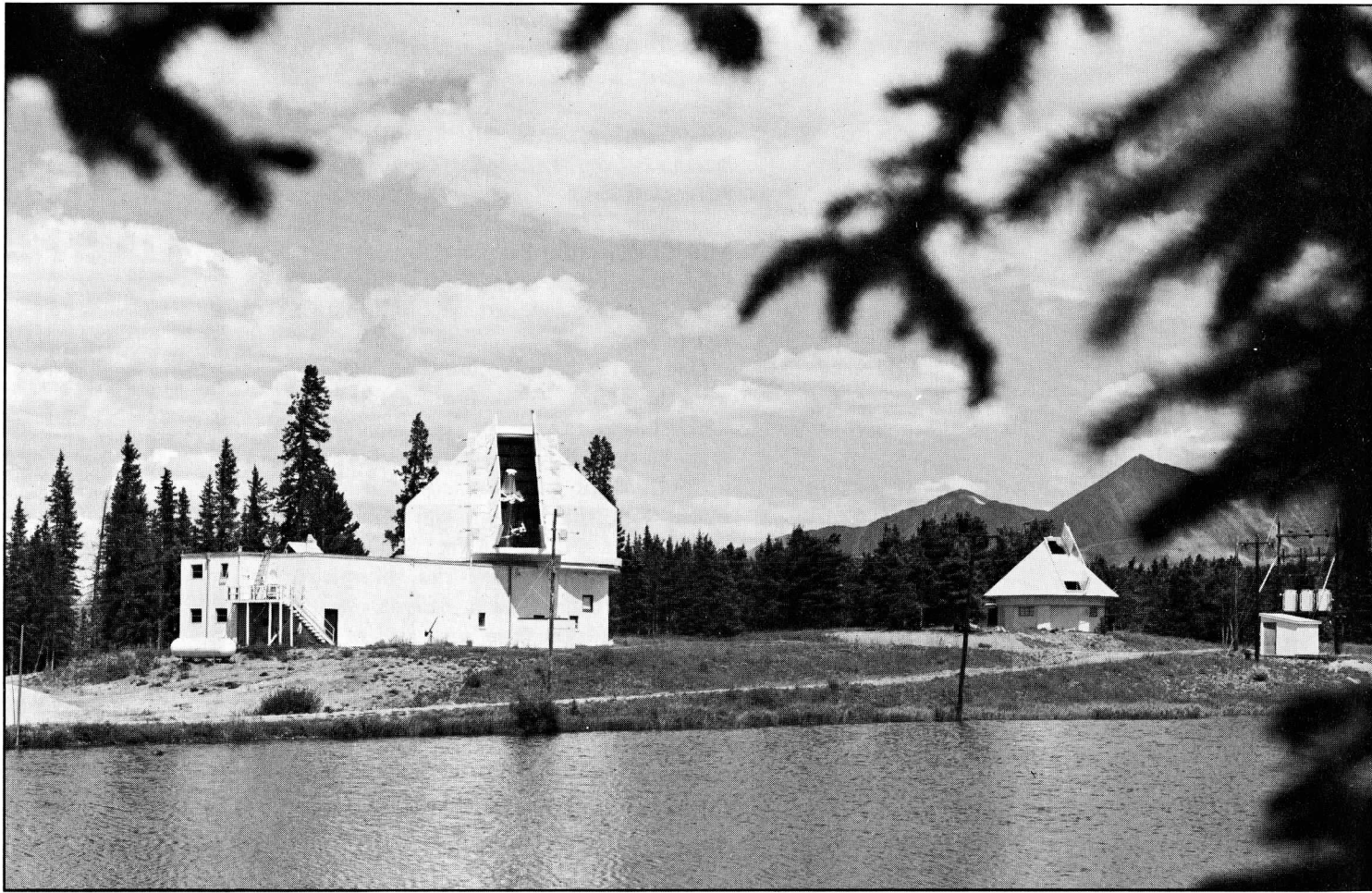
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The National Center for Atmospheric Research was established in 1960 to conduct and foster basic research in the atmospheric sciences, to supplement and augment the research and educational programs of universities and research groups in the United States and abroad, and to work toward increasing the effectiveness of atmospheric research efforts as a whole. It is operated by the University Corporation for Atmospheric Research, a private nonprofit organization, and sponsored by the National Science Foundation.

NCAR is comprised of four scientific divisions: the Laboratory of Atmospheric Science, the High Altitude Observatory, the Facilities Laboratory, and the Advanced Study Program. NCAR receives primary support from the National Science Foundation. Contracts, grants, and gifts are also provided by other government agencies, and by individuals, corporations, and foundations.

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Climax Observing Station

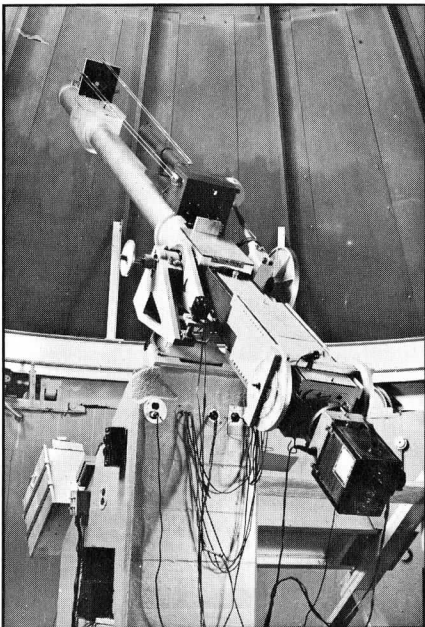
NCAR's high altitude site for solar research.



The first coronagraph in the western hemisphere was erected in 1940 by Harvard College Observatory in the mining town of Climax, Colorado. Walter Orr Roberts, later the first Director of NCAR and now President of UCAR, was resident scientist at the infant observatory.



The station was on the Continental Divide at an elevation of 3500 m (11,500 ft), where reduced atmospheric scattering favors studies of the solar corona. Land was donated by the Climax Molybdenum Company.



The original Climax coronagraph was a 13 - cm instrument built at Harvard. An occulting disk can be inserted to block the image of the photosphere, the brilliant disk of the sun. This occulting disk, when combined with a complex optical system, forms an artificial eclipse, and enables observers to study and photograph the corona, the sun's luminous outer atmosphere, without waiting for natural eclipses.

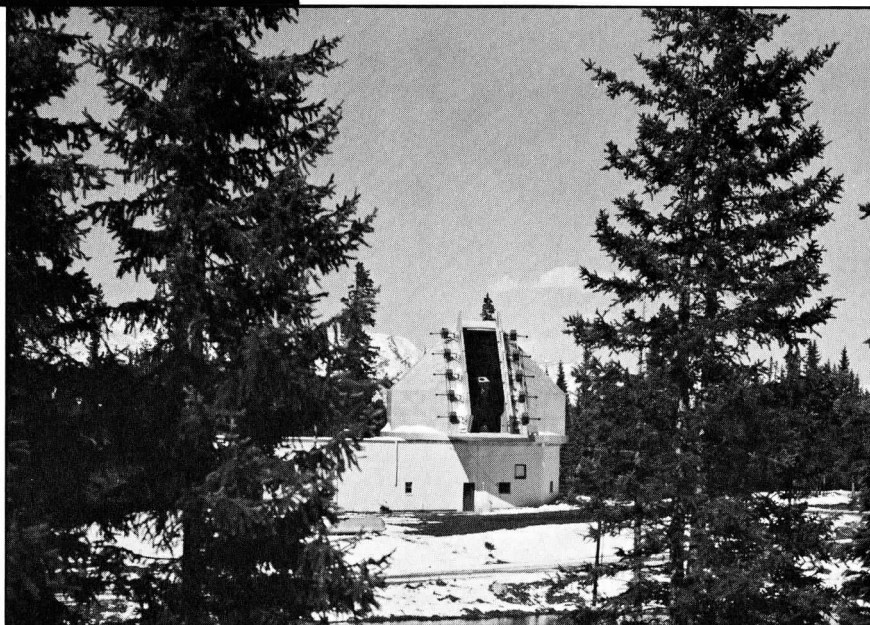


In 1946, the Climax station became an independent research organization, the High Altitude Observatory, affiliated with Harvard University and the University of Colorado. It was moved in 1952 to a new location 3 mi north of the town of Climax, where a new larger dome was also built. In 1961 the High Altitude Observatory became a research division of NCAR.



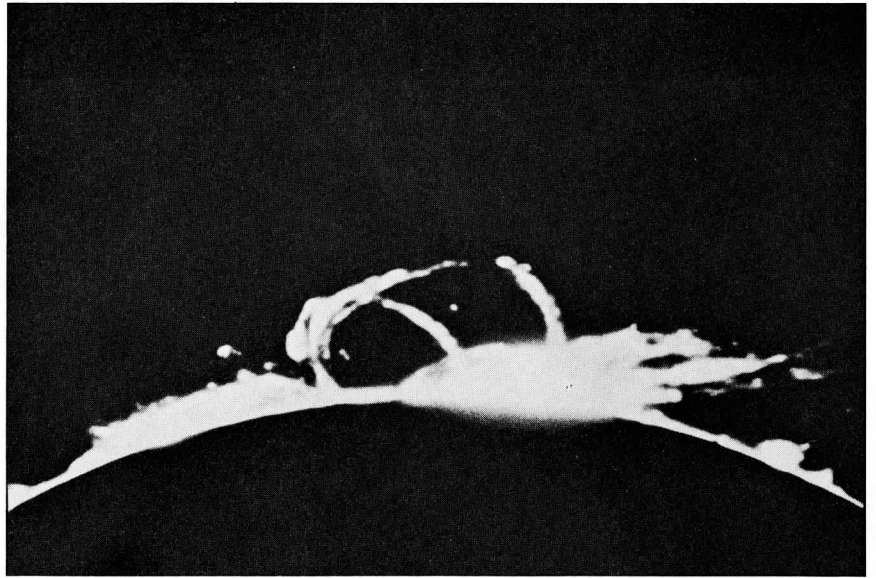
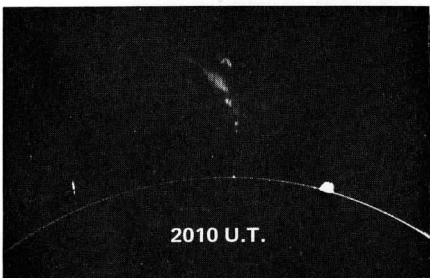
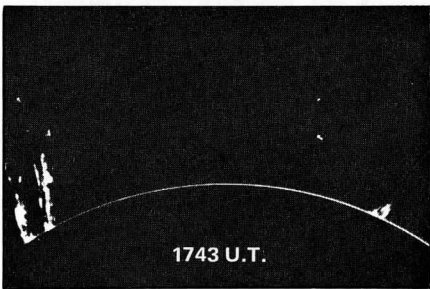
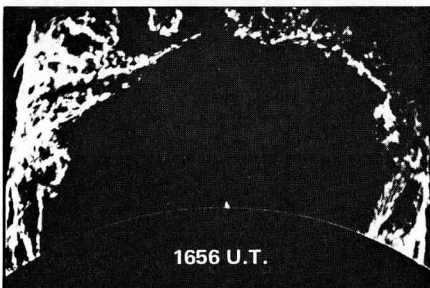
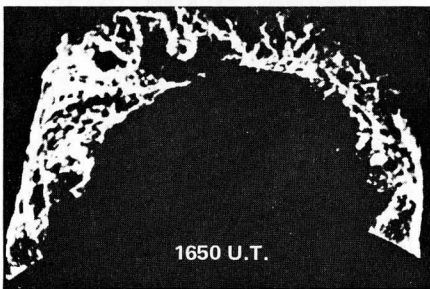
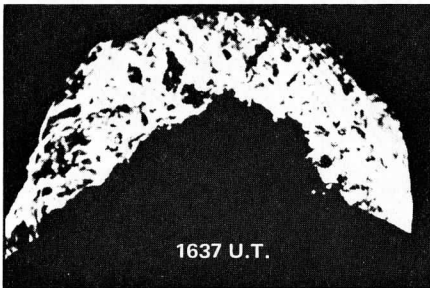
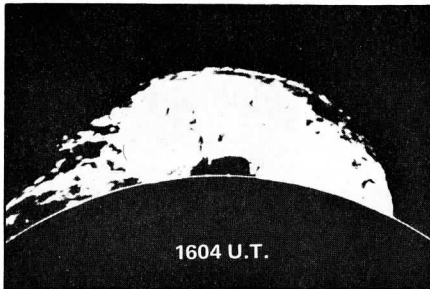
The small dome now contains a new and versatile 13 - cm coronagraph-spectrograph, and a flare-patrol telescope used during the IGY (1957 - 58) and for many years thereafter as part of a 43 - station world network watching for and recording solar flares.

A large dome houses a 40 - cm coronagraph-spectrograph and a magnetograph, as well as offices, library, darkrooms, and a machine shop.





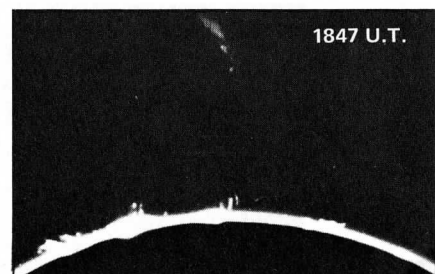
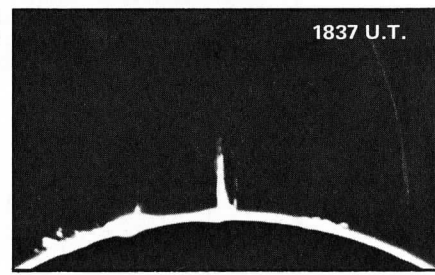
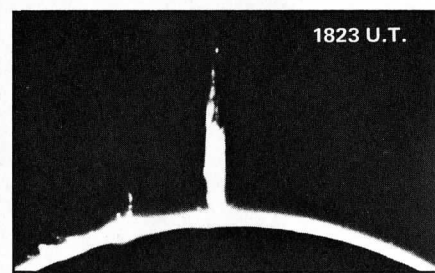
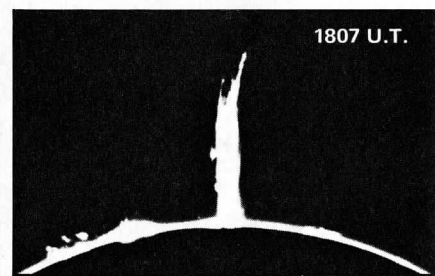
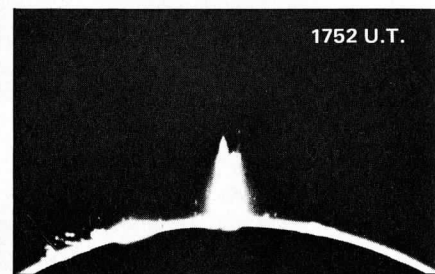
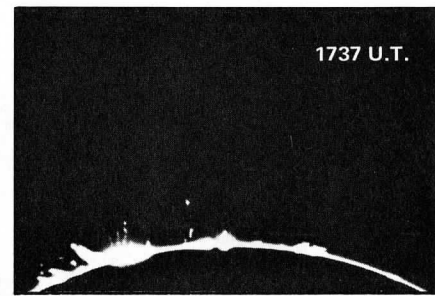
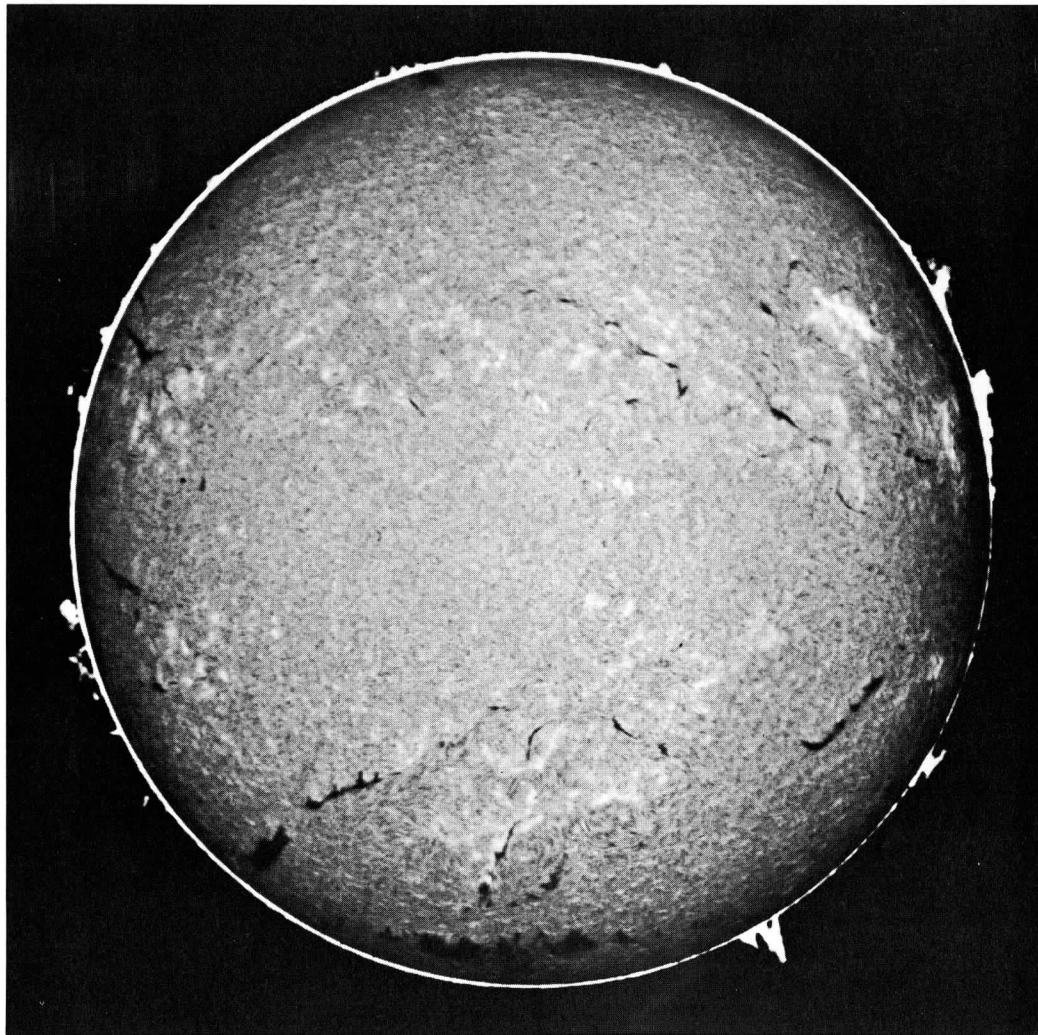
The 40 - cm coronagraph at Climax is mounted on an 8 - m steel spar automatically aimed at the sun. This instrument is used for day-to-day studies of the solar atmosphere and limb features, especially the magnetic fields in prominences, spectra of solar spicules, and active coronal features.



Photographs of the sun's atmosphere in the red light of hydrogen ($H\alpha$) show many spectacular features, such as this loop prominence, formed of incandescent gases. Time-lapse movies taken at Climax show that motion of gases within the loop is downward, although the loop itself expands upward.

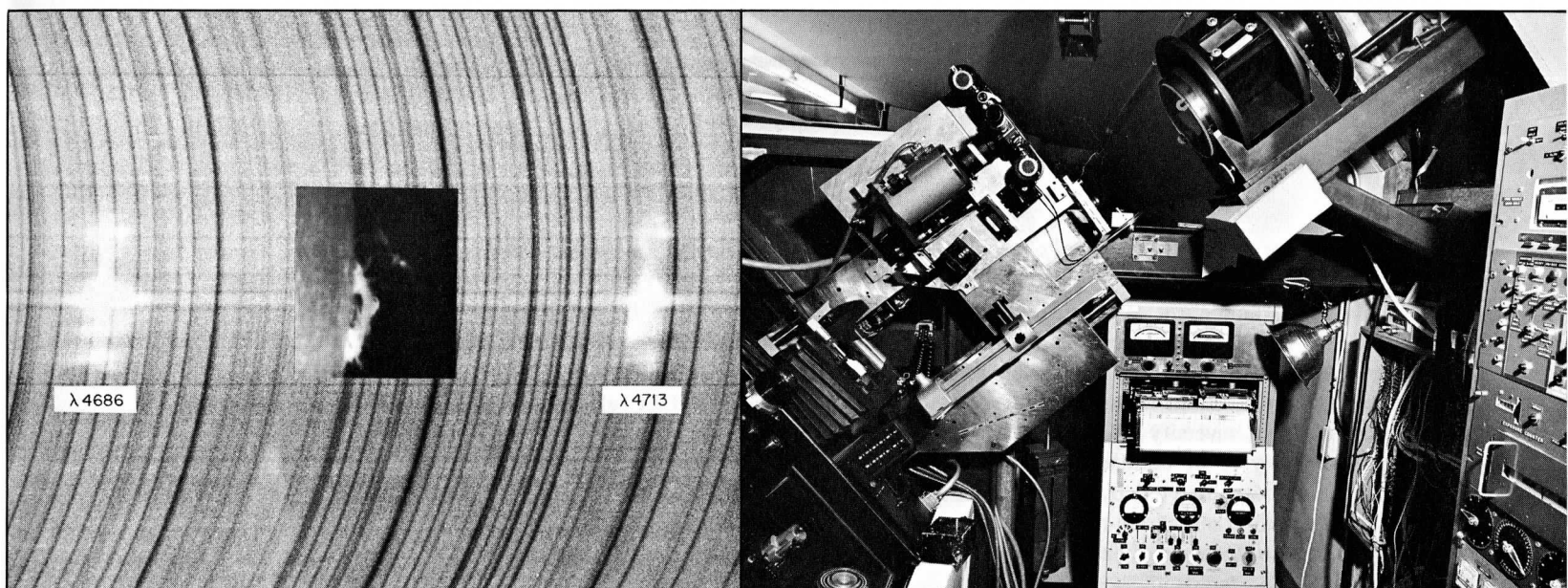
The largest solar prominence ever recorded was photographed from Climax on 4 June 1946. In less than an hour, a huge incandescent gas cloud, moving at 160 km (100 mi) per second, rose to about 320,000 km (200,000 mi) above the sun's disk.

Photographs of the face of the sun can be made through special filters which exclude all light except that of a single spectral color. In this picture, a filter admits only the red light of hydrogen gas. The light patch is a solar flare which exploded suddenly and brilliantly on 1 July 1968. Radiation particles from large flares reach and interact with the earth's high atmosphere, generating auroras and causing fluctuations in the earth's magnetic field and shortwave radio fade-outs.



When flares occur near the edge of the sun spectacular surges of gas can be seen spurting far into the solar corona. This sequence of pictures, selected from a coronagraph movie taken at Climax on 12 June 1946, shows surges 240,000 km (150,000 mi) high.

Modern solar research depends heavily on the interpretation of the solar spectrum. Each element found in the sun's atmosphere emits a characteristic pattern of bright or dark lines. In this photograph, the arcs correspond with the edge of the sun; bright spots along the arcs show where, in respect to the edge of the sun, the gas responsible for the line is emitting strongly. Here, two spectral lines record the prominence shown in the central insert.



Solar astronomy often involves intricate gadgetry, such as that in the observer's station below the large dome at Climax. The image of the sun enters the image rotator (upper right) from the 40 - cm coronagraph, and is viewed or photographed at the lower left. The magnetograph (center) records traces of magnetic signals from the portion of the sun's atmosphere being studied. The telescope control panel is at the right.

Notes

Solar History from Lunar Rocks – II

Following completion of the successful Apollo 11 and 12 lunar landing missions, Julian Shedlovsky of NCAR's Atmospheric Chemistry Department worked for some months at the University of California, San Diego, on analyses of radioactivity in lunar rocks. The study, directed by James R. Arnold, was aimed at measuring radionuclides in lunar rocks as a function of depth. The group identified the radioactivity produced by "hard" or high-energy galactic cosmic radiation, which occurred throughout the rock samples. They were then able to recognize the excess near-surface radioactivity in the uppermost 1 cm of the rocks as being produced by lower-energy protons from solar flares.

Studies of this excess radioactivity involved analyses for 11 selected isotopes having a wide span of half-lives. Data for short-lived species such as Co^{56} were found to be consistent with solar flare proton fluxes as measured by satellites during known recent flare events. Long-lived species such as Al^{26} and Mn^{53} demonstrate that during at least the last 1 - 2 million years solar flare activity has been comparable to that at present, and that there is no evidence of long-period fluctuations in solar activity that might relate to long-period climatic changes on earth.

Rainstorm Microwave Noise Confirmed

Several years ago Doyne Sartor, Alan Miller, William Atkinson, and Claire Shelden of NCAR's Laboratory of Atmospheric Science showed that electric discharges, accompanied by measurable microwave radio noise, occur between colliding charged water droplets in the laboratory. Presumably these discharges also occur as droplets collide during rainstorms, and Sartor and Atkinson predicted that the radio noise should be detectable in rainstorms, and should vary with the meteorological properties of the clouds involved.

A. A. Penzias and R. W. Wilson of Bell Telephone Laboratories have now reported actual observations of microwave noise from rainstorms at frequencies similar to those observed in the NCAR laboratory. Their observations, made during heavy rainstorms and extended periods of light rain, did not yield values as high as those predicted by Sartor and Atkinson, but did fall within the range of possible values.