

High Altitude Observatory
of the
University of Colorado
Boulder and Climax, Colorado



Observing station at Climax

QUARTERLY RESEARCH REPORT
1955-3

1 July 1955 through 30 September 1955

by

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Director

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SUMMARY

After many years of planning, we have finally completed and installed a new 5-inch patrol coronagraph at Climax. Associated with it is a new spectrograph of great speed and flexibility, specially designed and built for the needs of the Climax observing program. It greatly adds to the number of research projects that can profitably be undertaken.

We added another observer, Mr. Keith Watson, to the Climax staff to cope with the increased observational program presented by the recent extensions of the Climax program. To provide housing for him we modified a small building formerly used for cosmic ray research. We shall need, however, to provide more suitable permanent housing another year.

One highlight of the summer program of the Observatory was Dr. Herbert Riehl's seminar on problems of the large scale circulation of the earth's atmosphere, and his consultation and research on solar-weather effects. Another highlight was Dr. Malcolm Correll's work on the motion fields of large active region solar prominences, many of which show striking resemblance to magnetic dipoles.

Dr. James Warwick began work on a radio noise interferometer to use for studies of changes in refraction and absorption in the earth's ionosphere, caused by solar variations. This program will take several years for completion.

Three members of the HAO staff participated in the meetings of the International Astronomical Union in Europe, where plans were laid for international cooperation in all branches of astronomy. In particular, plans were laid for cooperative solar observations during the forthcoming International Geophysical Year in 1957-58, in which the HAO will be vitally interested both as a contributor and a user of scientific data.

program of prominence-motion analysis, using the library of Climax corona-graph films. This work indicated that the trajectories of large scale motions in solar prominences of active region type resemble a dipole magnetic field in shape. This in turn suggests that the patterns of the solar atmospheric magnetic field near a large active region are sometimes like a dipole field. The position of the field is such that the dipole is submerged about two-tenths of a solar radius below the sun's surface, and is directed radially outwards from the sun's center. This result, if confirmed, will be most important in understanding the origin of radio noise at radar frequencies from the sun, and in predicting the beams of ejected solar corpuscles responsible for terrestrial magnetic storms.

The complement of graduate students for the summer included our two University of Colorado students, Mr. Sanford Schwartz and Mr. James Axtell, and two summer visitors, Miss Martha Hazen from the University of Michigan Observatory, and Mr. John Bahng from the University of Wisconsin Observatory.

B. Research in Progress

1. Solar-Terrestrial Relationships -- Ionosphere.

Dr. James Warwick began to develop and build experimental equipment for detecting refraction and absorption effects in the D-region of the ionosphere, caused by solar activity. Dr. Warwick plans to observe these effects by means of interferometers that measure the changes in signal strength and direction from discrete radio noise "stars", which emit signals at about 15 to 20 mc/s, where the ionospheric effects are likely to be most readily discovered. This work is supported by the Electronics Directorate, Air Force Cambridge Research Center, and involves the close scientific consultation of Dr. Jules Aarons of the Electronics Directorate.

Dr. Sadami Matsushita, who joined us in June, with the support of Research Corporation, and whose work has been carried out cooperatively with the NBS, has been studying the behavior of the "sporadic E" (E_S) ionization of the ionosphere, which lies at about 100 kms. altitude. He has classified and studied an unusual characteristic type of layer formation now called "sequential E_S ," which is particularly noticeable at 20° to 30° from the magnetic equator. The sequential E_S forms at high altitudes (about 200 km), then moves downwards until it joins the normal E layer at about 100 km. It does so without losing its sharpness as seen in the reflections of radio signals on the ionograms made at various ionospheric sounding stations. The phenomenon occurs in the presence of magnetic disturbances as well as at times of magnetic quiet. It suggests to Dr. Matsushita that an ionized mass of air actually moves vertically downwards, and has a substantial lifetime as it descends until finally it merges with the normal E layer. The observations seem consistent with earlier suggestions that the normal E-region is maintained by turbulent air motions.

We plan to ask Dr. Matsushita to continue this interesting work in the coming year, if the formal arrangements to extend his stay at HAO can be worked out.

2. Solar-Terrestrial Research -- Weather.

With the help and guidance of Dr. Riehl, we carried through some calculations of the transport of air mass across the auroral circle at upper air levels (500 mb). This material, covering the first portion of 1955, shows interesting time trends, but it is too early, and the sample too small, for us to draw any general conclusions. The data, coupled with other aspects of the solar-weather problem, suggest the great importance of world wide wind measurements at higher levels, even at levels such as 50 mb or 10 mb, where the relations might be expected to be more direct. We have some hope that deflections or intensifications of flow of the arctic jet stream can be tied in with solar activity changes. Analysis of the summer's calculations will be continued by Dr. Riehl in Chicago.

In early July Dr. Julius London, of the Department of Meteorology of New York University completed his seminar discussions with the HAO research staff on problems of the effects of variable solar ultraviolet light on the highest meteorologically important levels of the earth's atmosphere. These seminars were sponsored, as mentioned in the last report, by a grant by the American Petroleum Institute.

Dr. R. G. Athay and Mr. G. Wm. Curtis investigated rainfall patterns in Colorado east of the Rockies, in pursuit of a clue suggesting that rainfall appeared, in conjunction with substantial cold polar outbreaks, in 27-day periods in early 1955, and that these periods might be related to the 27-day recurrence in geomagnetic disturbances. Weather data suitable for the study were not yet available for 1955, so they attempted an analysis for the past solar minima near 1944 and 1934. The results were negative, so far as discovery of real periods were concerned, suggesting that the relationship suspected this spring was accidental, or that there are other unevaluated factors (such as the number of long waves on the polar front) that distinguished this spring from the others. When 1955 data become available, in a few months, we will attempt an objective analysis of the January to June pattern to see if the suspected relationship can be objectively verified. Discussion of this and other solar-weather problems was held in October with Dr. Ralph Shapiro of Air Force Cambridge Research Center, and will be reported in the next period.

3. Solar-Terrestrial Research -- Geomagnetism.

Our work with the NBS research staff on problems of prediction of geomagnetic disturbances continued. Our forecasts, for this phase of the solar activity cycle, have been very poor, showing that we have not yet correctly isolated the causative factors. However, our effort to do so is continuing. Dr. Constance Warwick, in particular,

is adding her attention to the problem.

4. Observation of the Electron Corona.

One component of the sun's corona does not show on the usual photographs of the coronal emission spectrum lines. This is the so-called K-corona, or electron corona, which astronomers generally believe to be the result of light scattered near the sun by electron clouds in the solar atmosphere. Its detection, nonetheless, is highly important. We think that it may have time-variations and space distributions that differ appreciably from those of the spectrum lines of the corona, and we believe that these differences will be of great significance when we try to understand the formation of the corona and its earth-effects.

The K-corona is much fainter than the spectrum lines, and so may be harder to detect. The thing that suggests to us that we can observe it is the fact that its light is polarized in characteristic fashion, as we know from eclipse photographs and from the efforts made by Dr. Lyot in the 1930's to observe it from day to day. As mentioned in our last report we have begun construction of an electronic photometer to detect this faint polarized light in the presence of the other scattered sunlight which is not so polarized. At the end of September the instrument was well along towards completion. Target date for testing is in December 1955. The instrumental development is carried under a grant from the National Science Foundation for the International Geophysical Year program. Our RCA research contract, as mentioned in the last report, sponsored Mr. Axtell's research towards this goal.

5. Solar Activity Observing.

On the first page of this report, we have described an important addition made this quarter in our observing facilities at Climax. With the new instrument we are continuing our observing program with the support of the National Bureau of Standards. We are materially extending it to include studies of the distribution with height of the coronal line intensities for all important centers of coronal activity. We are also beginning special studies of the variations of the breadth of the coronal lines from place to place on the sun, and from day to day. The line breadth variations, we believe, are symptomatic of temperature changes.

6. Temperatures and Motions in the Corona.

Work on this project, which is supported by the Office of Naval Research, is proceeding smoothly. Mr. Schwartz, who is planning to complete his Ph.D. thesis in this field, drew up a formal statement of the problem for submission to the University of Colorado physics department for approval as a thesis project. This has been issued as a Solar Research Memorandum from HAO. Dr. Zirin has joined in consultation with Dr. Donald Billings and Mr. Schwartz, and will supervise

much of the day to day progress.

7. Solar Granulation Analysis.

The sun's face, seen in the white light with a sufficiently powerful telescope under steady atmospheric conditions, is not a simple smooth surface. Instead, it presents a most complex appearance of brighter and darker regions. The scale of this brightness structure ranges from the smallest detectable details, which are actually under 500 miles in diameter, to vary large ill-defined cloud-like areas many tens of thousands of miles in diameter. Full understanding of the time changes and the velocities associated with this structure would be of utmost value in solar research. Consequently, great effort has been made by astrophysicists to observe and to discuss these "granules" and "dark clouds."

HAO's work in the field has been rather recent, and confined principally to study of photographs made by Dr. William Miller of Radio Corporation of America Laboratories solar observatory at Rocky Point, Long Island. During the summer Dr. Gerard Wlérick and Mr. Curtis made tracings from Dr. Miller's plates, using the new, highly sensitive HAO microphotometer. From these they analyzed the brightness fluctuations of the granules and dark clouds. Their work is still incomplete, but it suggests that the dark and bright areas are exactly complementary, showing the same distributions of sizes -- a result in conflict with some of the classical studies of granulation, but in agreement with recent results from Princeton University Observatory. We will have further reports on this problem later. This work is supported under a research contract with RCA Laboratories.

8. Eclipse Research.

Dr. Athay commenced a two-semester leave from HAO to the Harvard College Observatory, where he will work with Dr. R. N. Thomas on interpretation of the data from the Khartoum eclipse. He will also attempt to extend the interpretation to the observations made by Dr. D. H. Menzel at the 1936 eclipse, which have largely gone unreduced.

Plans are also being laid for observing the 1958 eclipse at Danger Island, in the South Pacific, near Samoa. Whether such plans can be accomplished will depend on the availability of adequate funds.

III. RELATED PROGRESS AT OTHER INSTITUTIONS

A. Solar-Weather Research.

We have gained new confidence in the reality of certain specific solar effects on upper air flow patterns as a result of discussions in July with Dr. Glenn Brier of the U. S. Weather Bureau and Mr. E. D. Farthing of Trans World Airlines. Mr. Farthing described the solar-weather analysis that he

has now completed, using solar coronal indices from Climax and Sacramento Peak. He finds that the 500 mb. flow pattern appears to be influenced by regions of the sun that exhibit strong coronal line intensity. Six individual time periods during last winter, classed according to solar activity, indicated a progressive strengthening of the westerly flow patterns and the development of a pronounced trough over the Great Basin Area with high activity, with subsequent eastwards progression of the trough later. The westerly wind component over TWA's domestic air routes showed a definite rise with the well-defined coronal maxima. The rainfall and temperature relationships previously found at Kansas City appear to fit this upper level behavior. Moreover, similar relations are found elsewhere on the globe. Farthing's work was presented at the Stillwater meeting of the American Meteorological Society late in September, and the full paper is available from TWA as a reprint. The results, though still not completely conclusive, are most suggestive of a real solar-weather effect, and one that is apparently separate from that found by Dr. Shapiro and mentioned in earlier reports (for example, 1955-1, p. 1).

Dr. Brier's work relates to earlier years, and unfortunately to years when coronal observations were not possible on a day to day basis. However, because of the relationship of coronal activity to sunspots, the results can probably be safely regarded as independent confirmatory evidence for Mr. Farthing's conclusions. Dr. Brier's work, briefly noted, showed that surface temperatures in winter months at Devil's Lake in North Dakota fell by large amounts, on the average, when the sunspot activity was rising. In general, the picture following increased solar activity suggested the formation of a blocking high pressure area over Alaska, with a subsequent southward outbreak of cold polar air across North Dakota. Dr. Brier is continuing his efforts to isolate the statistical effects, so that they can be tested in unambiguous fashion.

It must be emphasized that these relationships cannot be regarded as sufficiently general to permit their use in weather forecasting, except on an experimental basis. Far more research must be done before their reality can be put beyond reasonable doubt, and their explanation can be put on a sound physical basis. But they leave no question as to their great potential usefulness, and the need for a vigorous and a sustained research attack on the problem. This is one of the principal goals of HAO's plans for an Institute of Solar-Terrestrial Research, for which we are seeking private sponsorship for a four-year period beginning in 1956. About 80% of the funds needed to launch this program are now assured.

B. Solar Research.

Because this report is already very long, we defer until a later report a discussion of other solar research developments.

IV. CONFERENCES AND DISCUSSIONS

Three members of the HAO staff, Drs. Roberts, Athay, and J. Warwick,

attended European scientific meetings during August and September. Dr. Roberts attended the Jodrell Bank Symposium on Radio Astronomy from August 24th through August 27, near Manchester, England, and then went on to Dublin, Ireland, to the meeting of the International Astronomical Union (IAU) on August 29 through September 5. He also attended the meeting of the Mixed Commission of the International Council of Scientific Unions on Solar and Terrestrial Relations in Dublin on September 6, after which he returned to U.S. Dr. Roberts served on Commissions 10 and 11 of the IAU and presided over the meeting of Commission 11A, which deals with world cooperation for cinematography of the solar chromosphere and prominences. Extensive planning was done in this meeting for the International Geophysical Year. Drs. Athay and Warwick also attended the IAU meetings.

Dr. Roberts was reappointed president of Commission 11A; Dr. Athay was elected to Commission 13 on Eclipses of the Sun; and Dr. Warwick was elected to Commission 10 on Solar Photospheric Phenomena. After the IAU meetings Drs. Athay and Warwick made separate visits in Europe for consultation on specific research problems. Dr. Roberts' trip was sponsored in part by the National Science Foundation; Drs. Athay and Warwick received support for the trip from our contracting agencies, including transportation to and from Europe via MATS.

Dr. Gordon Newkirk, who will join the HAO staff in December also attended the Dublin IAU meeting. He is presently serving on a tour of duty in the U.S. Army, and is stationed in the atmospheric analysis program of the Signal Corps laboratories at Fort Monmouth, New Jersey.

Numerous discussions and conferences were held during the summer. Two conferences (one on July 18 to 23, and one from September 28 to 30) were held with Dr. Miller of RCA Laboratories. These dealt primarily with the joint research on solar granulation, and covered particularly the difficult problem of objective analysis of the size distribution of significant solar granules and dark clouds, as discussed earlier in this report.

A particularly fruitful conference was held early in July, involving Dr. Roberts and Dr. Riehl from HAO, and Dr. Vincent Schaefer and Mr. Vernon Crudge of Munitalp Foundation. We talked over plans for our summer research program, in some detail, and also longer range plans for cooperation in solar-weather work.

From July 21 to 24 there was a meeting on Sacramento Peak of the informal Solar Associates group, which includes Drs. Menzel, Thomas, and Fred L. Whipple of Harvard College Observatory and Smithsonian Astrophysical Observatory; Mr. Alan H. Shapley from NBS; Dr. John W. Evans from Upper Air Research Observatory; and Dr. Roberts of HAO. These meetings are for informal discussion of the research in progress at our institutions, and for program planning and coordination, and are of utmost usefulness.

The results of our conference with Dr. Brier of the U. S. Weather Bureau and Mr. Farthing of TWA are reported above, on page 8. It occurred at the end of July.

On September 27 through 29, Dr. Roberts met with the Meteorological Subcommittee of the Air Transport Association of America, at Asheville, North Carolina, where he had the opportunity to discuss in detail the HAO's interests in solar-weather research with a number of the meteorologists from the airlines, and from government agencies.

V. PUBLICATIONS FROM HAO DURING THE QUARTER

1. W. O. Roberts: "Can We Blame the Sun for Stormy Weather?", Popular Mechanics, Vol. 103, p. 65, June 1955 (popular).
2. W. O. Roberts: "The Sun, the Weather....and You", The Reclamation Era, Vol. 41, p. 57, August 1955 (popular).

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The new 5-inch patrol coronagraph and spectrograph at Climax. Mr. Keith Watson, Climax observer, shown at the controls of the all-reflection spectrograph and automatic scanning slit mechanism.