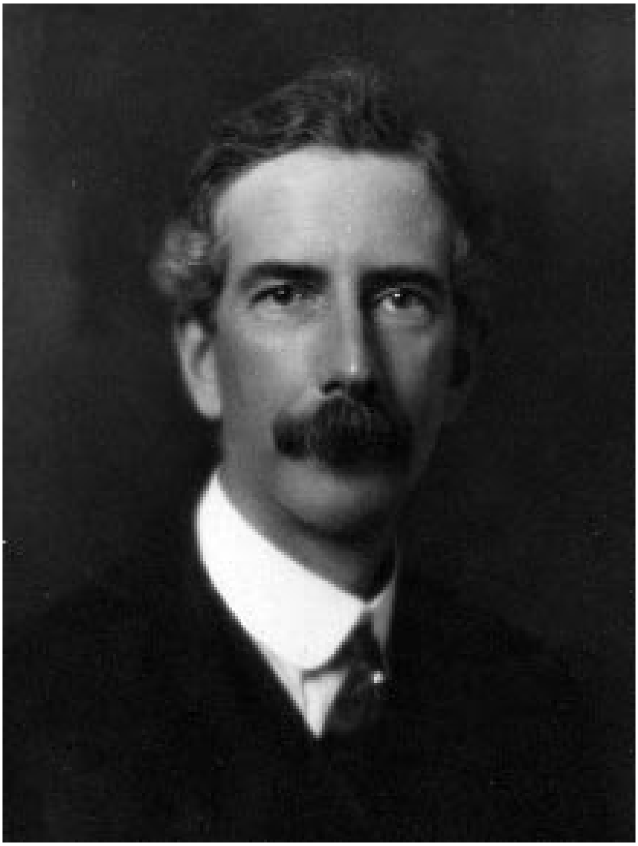
NATIONAL ACADEMY OF SCIENCES

CHARLES GREELEY ABBOT

1872—1973

A Biographical Memoir by
DAVID H. DEVORKIN

Biographical Memoir



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CHARLES GREELEY ABBOT

May 31, 1872–December 17, 1973

BY DAVID H. DEVORKIN

CHARLES GREELEY ABBOT was the second director of the Smithsonian Astrophysical Observatory and the fifth Secretary of the Smithsonian Institution. He was the second and last person to hold both posts simultaneously and is remembered today for his skill as an instrumentalist and his unshakable belief that the Sun is a variable star and that its variations had a measurable effect on the Earth's weather. He was elected to the National Academy of Sciences in 1915 and served as its home secretary from 1919 to 1923 under President Charles Doolittle Walcott, who was Abbot's predecessor as Smithsonian Secretary.

Abbot was born in May 1872 in Wilton, New Hampshire, the son and grandson of farmers. The youngest of four children of Harris and Caroline Ann (Greeley) Abbot, Charles Greeley attended public schools, but finished at Phillips Andover Academy. He then attended MIT, where he graduated in 1894 with a thesis in chemical physics. He expected to teach, but remained at MIT, studying osmotic pressure and earning an M.Sc. in 1895. Skilled at laboratory work, he came to the attention of Samuel Pierpont Langley, who was looking for an assistant at the Smithsonian's Astrophysical Observatory (APO). Abbot soon was hired, though he lacked any experience in astronomy when he arrived in Washington in June 1895. Langley, however, was not a traditional astronomer and Abbot was just the type of assistant he wanted to aid his mapping of the infrared spectrum of the Sun, adapting bolometers for photographic recording and determining dispersion standards for rock-salt and fluorite prisms to measure fundamental wavelengths in the infrared region of the solar spectrum.

Under Langley, Abbot flourished as a creative designer and builder of delicate devices for measuring solar radiation. As Langley focussed more and more on his aeronautical experiments, Abbot, working with F. E. Fowle, became responsible for maintaining the observatory's solar program, including an expedition to observe the 1900 solar eclipse in Wadesboro, N.C., where Abbot applied a vastly improved bolometer to take readings of the Sun's inner corona. He was also a leading member of the American eclipse expedition to Sumatra in 1901. He proved to be a reliable observer and impressed many astronomers who encountered him at these places.

Abbot was an affable fellow, deferential to his superiors while making significant contributions to the mission of Langley's institution. That mission, very much representative of the times, was to demonstrate the utility of government-supported science. Years later, in his rambling autobiographical essay *Adventures in the World of Science*, Abbot recalled Langley's words explaining why measurement of the heat of the Sun was important:

> If the observation of the amount of heat the sun sends the earth is among the most important and difficult in astronomical physics, it may also be termed the fundamental problem of meteorology, nearly all whose phenomena would become predictable, if we knew both the original quantity and kind of this heat.[1]

Certainly the idea that solar radiation governed the Earth's fate as an abode for life was not original with Langley. The key to Langley's mission, however, was to make the amount and character of that radiation "predictable" and thereby useful for planning strategies for agricultural management and control. Langley believed that solar radiation varied in a cyclic manner. As Smithsonian Secretary, however, Langley had other interests, but what may have been promotional rhetoric for him became a permanent and passionate conviction for his able, dutiful assistant.

Within a few weeks of Langley's death in February 1906, Abbot was made acting director of the APO, becoming its second director in 1907 under Secretary Charles Walcott. Astrophysical operations continued unabated, with Walcott providing advice and support that allowed Abbot to extend Langley's mission in two ways: first, by developing refined techniques for the specific determination of the solar constant; and second, by applying these techniques in a standardized manner to build a synoptic monitoring program that would search for solar variations. As under Langley, Abbot found Walcott wholly attuned to the progressive notion of useful science. Before he became the Smithsonian's fourth Secretary, Walcott was head of the U.S. Geological Survey, and campaigned for practical research in publicly supported agencies.

When Abbot became APO director in 1907, American astronomy's most significant strengths and potential lay in vast cataloguing projects centered at a few major observatories, including Harvard, Yerkes, and Lick. American astronomy was in the throes of organizing itself as a profession, and its standards and modes of conduct were in flux. Celestial mechanics and mathematical astronomy were still the strengths of the discipline, but now the photographic plate and the spectroscope were available for assessing the physical nature of the Sun and stars. Langley had practiced the new astronomy. Primarily an engineer, he had created an astrophysical program at the Allegheny Observatory in Pittsburgh, defining it by the use of new types of instruments, the bolometer and spectrobolometer, and brought both these instruments and their practice to the Smithsonian to establish the first and only federally funded astrophysical observatory in the United States.

When Abbot retired as APO director and as Smithsonian Secretary in 1944, setting a precedent as the first Smithsonian Secretary not to die in office, most but not all of the great cataloguing projects were gone and the discipline was undergoing profound change. Problem-oriented research, informed by modern physical theory, dominated the discipline. Yet the Smithsonian's Astrophysical Observatory pursued its single mission all along, elaborating on its purpose not by a broadening of its astronomical base but by refining its instrumentation and technique, searching for evidence that Earth's meteorology and biology were intimately connected to variations in the Sun's output of energy. Although he eschewed physical theory, Abbot was thoroughly modern in his problem-oriented approach to research. Thus, his failure to broaden the astrophysical scope of the APO during his long tenure has to be appreciated as due to a complex set of factors centered on his singular sense of mission, which transcended disciplinary lines between astronomy, geophysics, meteorology, and biology.

The amount and character of the Sun's radiation are basic quantities for a wide range of scientific and environmental concerns. Determining these quantities in practice, however, was far from simple. Astronomers long knew that the absorption of solar energy by the Earth's atmosphere was both selective and general. Langley's method of determining the solar constant was to take observations of the Sun as it rose in the sky, noting its increase in radiating power and then extrapolating to the top of the atmosphere. Given the vagaries of the atmosphere and the limitations of technology, the value of the solar constant could vary as much as 50%. Langley established the value 3.00 cal/cm^2/min outside the atmosphere as the Smithsonian standard and held to it tenaciously to the end of his life. But others who made different assumptions about atmospheric absorption coefficients or other variables came up with values between 1.5 and 4.0.

After some seven years working for Langley, Abbot knew that the Smithsonian value for the solar constant was too high, but he carefully avoided the issue until he was in charge. Then, he quickly announced results from observations at Mount Wilson, California, that reduced the solar constant first to 2.1 and then to 1.93, largely through the introduction of improved, standardized methods and better thermal isolation for his pyrheliometers and bolometers.[2] Abbot paid close attention to detail.

Abbot's revision, however, drew criticism from various quarters, mainly from a disgruntled and generally combative Langley protege, but also from two Europeans who argued that the way in which he accounted for atmospheric absorption was incorrect. Abbot met this criticism by returning to the highest mountain in the Rockies, following Langley's lead in 1881. Abbot cooperated with W. W. Campbell at the Lick Observatory and with the Sierra Club to build a sturdy field station on the summit of Mount Whitney. Abbot used the site sporadically in 1909 and 1910 to measure the solar constant and accompanied the Lick astronomers to study the spectrum of Mars.

Still harried by critics, however, Abbot turned to balloonsondes to reach greater heights. Collaborating with the Weather Bureau and Signal Corps, with Anders Knut Angstrom, who had been in residence for several years, and with the help of his chief assistant Loyal B. Aldrich, Abbot flew special pyrheliometers on balloons. He created a new type of robotic pyrheliometer out of parts from standard Weather Bureau meteorgraphs that was fully automatic and self-recording. Automatic techniques for meteorological observations from balloons were well developed by then. But Abbot was the first to use such automata in America for astronomical measurements.

Abbot's instruments, built by Andrew Kramer, were marvels of sophistication and planning. They were flown by Aldrich from the California coast in 1913 and 1914, and some of the balloonsondes reached over 25 kilometers; at least one of them returned clear evidence for thermometric and barometric variations that confirmed his terrestrial extrapolations and allowed him to determine the value of the solar constant at the top of the Earth's atmosphere. This technical feat, requiring the cooperation of the Weather Bureau and the Signal Corps, quieted criticism of the Smithsonian value for the solar constant. It helped to affirm Abbot's reputation and established the modern range for the solar constant.

Even before he assumed the directorship of the APO, Abbot was among the astronomical elite. In a 1903 census by the AAAS he was listed among the top thirty astronomers by his peers. Langley was among the first rank, and both scored even higher among physicists who were polled. Abbot won the prestigious Draper Gold Medal of the National Academy of Sciences in 1910 and the Rumford Medal of the American Academy of Arts and Sciences in 1916.

With his solar-constant critics vanquished, Abbot focussed more on Langley's ultimate goal: to search for evidence of variations in the solar constant and to show that these cycles influenced cycles in weather and climate. He believed that such evidence was already at hand from the findings of H. H. Clayton, the chief forecaster of Argentina and a colleague of A. Lawrence Rotch of the Blue Hill Meteorological Observatory outside Boston. Clayton had excitedly written Abbot in 1912 with what he believed was proof that changes in the world's weather correlated with changes in the solar constant that he had gleaned from published Smithsonian data. Clayton soon became one of Abbot's closest allies, and over the next three decades, confirming these clues would define Abbot's mission.

To confirm Clayton's findings Abbot had to account for local variations due to seasonal weather conditions, and so he set about searching for widely spaced observing sites where air transparency was constant. High mountains in desert regions spread over the accessible parts of the Earth became his target, and again, following a well-worn Smithsonian tradition, Abbot built these stations in the manner of field expeditions.

His first major permanent station was at George Ellery Hale's Mount Wilson Solar Observatory, which Abbot started visiting as it was being built in 1903 and 1904. Hale tried once to hire Abbot away from Langley, but soon accepted the Smithsonian man as an ally in Washington, where his own patron the Carnegie Institution of Washington was based. By 1915 Abbot had built a permanent field station on the south side of a spur of the mountain that emulated Hale's own tower telescopes. Abbot visited the station often and built a large solar cooker which his wife Lillian used to bake and roast to feed the local staff. The Smithsonian was a welcome neighbor on that mile-high mountain top.

With Walcott's backing, which included securing endorsements from astronomers around the world, Abbot soon gained additional funds to search for other sites to complement Mount Wilson. In 1911 and 1912 he and Angstrom set up a temporary station at Bassour in Algeria, where they observed the Sun and weather patterns using a wide array of sensors ranging from small portable pyrheliometers to Abbot's huge spectrobolometer, which sifted the Sun's radiation through a slowly rotating prism that focussed different parts of its spectrum onto a tiny platinum wire. The wire's electrical resistance was changed by the Sun's light heating it, and this caused a flow of current in a delicate galvanometer, which moved a tiny mirror supported by a quartz fiber. The moving mirror sent a beam of sunlight onto a strip of moving photographic film, which recorded the varying energy of the Sun as a function of wavelength.

Throughout World War I Abbot maintained the Mount Wilson station and hoped to establish a southern hemisphere site too. He also attended to various wartime activities. He patented a new way to rifle a bullet to improve accuracy and with Aldrich developed a portable searchlight, making great friends with General Electric in the process. Abbot also promoted Robert Goddard and pushed Army Ordnance to award the Smithsonian a lucrative contract for Goddard's continued work on solid rockets. But after the Armistice, Ordnance canceled the contract, to Abbot's great annoyance.

At the end of the war, Abbot reactivated his site search, looking for a place that would have clear weather during the poorer winter season in California. The new "place" had to be clear (weather) when his California site experienced cloudy weather. He had hoped to gain the cooperation of the Australian government, but eventually Wolcott approved the use of Hodgkins Fund income to build a station in South America, where the United States was building a strong mining base. The Guggenheims operated a huge copper mine at Chuquicamata, and were happy to host a U.S. government presence. The mining company provided a residence just south of Calama, on the eastern edge of the Atacama nitrate desert in the northern Chilean Andes. Manned by Alfred Moore and an assistant, it was a most desolate place, but it was not far from the Guggenheim operations and a small mining town where many Americans lived.

By 1920 expenses were rising at both the Mt. Wilson and Calama stations and Abbot, through Walcott, secured a modest increase in federal appropriation for the APO. More important were private gifts from John A. Roebling, heir to the designers and builders of large suspension bridges, including the Brooklyn Bridge. Roebling was a major Smithsonian benefactor; on the death of his father Washington Augustus Roebling, he presented his father's enormous mineral and gem collection to the Smithsonian, along with an endowment to manage it. Roebling was also sympathetic to Abbot's mission and its hope of practical application, not only for weather forecasting but for the use of solar energy.

As Abbot campaigned to keep his stations running, he found that the data coming from them were influenced by local weather. Mt. Wilson suffered from maritime air and local dust, and Calama was compromised by the dust from the huge open-pit mines. With Roebling's support, Abbot shifted the Mt. Wilson station to the Harqua Hala Mountains in southwestern Arizona, which C. F. Marvin, chief of the Weather Bureau, believed was a better site; it was clearer, had less dust, and was dryer than Mount Wilson. The Calama station was also closed and moved to 9,500-foot Mount Montezuma, about 12 miles from its original site. Harqua Hala, however, soon proved to suffer from the same inconsistent weather patterns that had plagued Calama; so again Abbot managed to obtain Roebling support to transfer Harqua Hala to a higher and more stable site on Table

Mountain in California, above the Mojave Desert at about 7,500 feet elevation and some 30 miles northeast of Mount Wilson. Among many logistical problems Abbot faced, seeking out the best sites was to keep members of his field staff willing to sacrifice their lives in these terribly isolated spots.[3]

As he sought the best sites, Abbot also constantly improved his equipment. One major problem was thermal stabilization for his spectrobolometers, which he solved by mounting them inside tunnels at Mount Montezuma and Table Mountain, what he later heralded as the "Smithsonian observing tunnel," a new form of observatory. The Montezuma station remained active for several decades. The observers were sensitive to local custom, and the site was used during World War II as a field station to study the effect of intense radiation on fabrics, one among many wartime studies Abbot's APO fostered.

By the mid-1920s Abbot believed he had confirmed Clayton's findings and began to report on solid connections between solar cycles and weather patterns, offering his results as proof that, with continued study, true long-range weather prediction was at hand. C. F. Marvin, however, worried about Abbot's claims and set his staff of statisticians to a re-analysis of the past two decades of Smithsonian data. They soon found that the variations Abbot had found in the solar constant were just as easily accounted for by the "diminishing amplitude of scatter as stations and methods of observations were improved." In the spring of 1925 Marvin warned Abbot that "*If* the 20 years of work of the Astrophysical Observatory on the solar constant shows anything at all it shows the variations of the sun are of the same or smaller order of magnitude as the unavoidable errors of observation."[4]

Marvin suggested that Abbot needed to make more observations, not only from remote stations, but through further improvements in technique, mainly doubling up his pyrheliometers and pyranometers to account for instrumental variation.[5] Abbot reacted to Marvin's critique with more bluster than scientific argument. He appealed to cooperation and loyalty between kindred government bureaus and tried to convince Marvin not to reveal his conclusions, assuring him that better data were now at hand. Marvin, however, was not convinced and, since Abbot was unable to face his statistics square on, did deliver his conclusions at a meeting of meteorologists in Washington. Abbot again defended his position with bluster, but privately accepted Marvin's suggestion to build redundant devices to search for instrumental error. This was only the first of many clashes between Abbot and traditional meteorologists. But Abbot knew how to play on the hopes of the day and was even able to keep Marvin as an ally, capitalizing on his suggestion that more observations were needed. In the 1920s, cycles were a fascination to students of nature. The Carnegie Institution hosted "cycles conferences" looking for correlations in all natural phenomena; there were many voices in support not so much of Abbot's conclusions but of his continued work, holding out the hope that his conclusions would be vindicated.

Turning any criticism into a challenge for support of a noble cause, Abbot found the means to improve his instruments and to establish a third outstation, since he knew that three independent stations were the minimum number he required for a definitive synoptic monitoring network. In 1925 he had little trouble convincing the Grosvenor family that the National Geographic Society should grant $55,000 to establish a third station somewhere in the eastern hemisphere. Abbot and the National Geographic Society chose Mount Brukharos in Southwest Africa. The expedition started in April 1926 under W. H. Hoover and Frederick Greeley, who had been at Harqua Hala and at Table Mountain for a few years. The National Geographic made much of the expedition, and back home Abbot mounted exhibits to keep people informed of the Smithsonian's far-flung research expeditions. They built another Smithsonian observing tunnel to thermally stabilize the most delicate instruments, and Abbot displayed a scale model of it in the Smithsonian castle. Abbot knew how to keep Smithsonian science in the news.

By 1930, however, wind-blown dust at Brukharos caused Abbot to search for a better site. Though by now he had succeeded Walcott as fifth Secretary of the Smithsonian, Abbot's focus remained on the Astrophysical Observatory and its programs. With support from the Research Corporation of New York he established a new Division of Radiation and Organisms in 1929. With Roebling and National Geographic Society support he closed Brukharos and mounted an elaborate expedition to build a new station above the monastery at the base of Mount St. Katherine on the Sinai Peninsula. By the summer of 1931 they had settled on a site 10 miles from the monastery on Zebil Gebir, a spur of the mountain in sight of Mount Sinai.

By 1936, however, the St. Katherine station had serious logistical and supply problems. Abbot was still able to secure gifts, but funds were harder to come by. Abbot decided to close St. Katherine in December 1937 in favor of a continental spot that would cover the months December through February, when his other two stations were usually clouded out. He eventually selected Burro Mountain in New Mexico, and sent the Gebir instruments and staff to what was the Tyrone station, where another Smithsonian tunnel was excavated into the mountain.

Abbot's construction of field stations demonstrates his tenacity and his considerable success in not only maintaining, but expanding, his focussed program to continuously monitor the Sun's radiation during a time when the Smithsonian itself was undergoing retrenchment. Up to 1930 the APO staff grew steadily, and maintained itself throughout the 1930s. All three stations plus the home station on the Mall in Washington, D.C., continued to operate without major breaks throughout the Depression. Abbot maintained a trustworthy and highly capable staff able to build instruments, use them, and reduce their data according to the systematic procedures Abbot created. Over the years the staff developed five distinct types of pyrheliometers, including the silver disk, water flow, water stir, improved Angstrom, and the automatic balloon device, all of which Kramer built. Kramer and his assistants also built Abbot's devices for reducing computational labor, such as a special ganged slide-rule extrapolator for determining atmospheric transmission factors quickly and efficiently. Abbot introduced time-saving methods and new computational devices whenever he could. Eventually, with a specially built differencing engine he called a "periodometer," Abbot unraveled what he believed was a complex nested set of some twenty-three cyclic variations in the Sun's energy output, all acting simultaneously.

Kramer also built many of Abbot's solar heaters and cookers, which Abbot used in lectures and in countless demonstrations to keep the importance of knowing about the Sun and its radiation before the public and his patrons. His solar heaters were reminders of the power of the Sun.

By the mid-1930s, while continuing to make claims before patrons and public that the means for weather prediction were at hand, Abbot realized that he needed more support to prove his contentions. His staff had made a detailed comparative analysis of the Montezuma, Table Mountain, and St. Katherine observations and felt that three stations were not enough. Willis Gregg, the new chief of the Weather Bureau, and a new blue ribbon panel Gregg had assembled, made up of Abbot's old friends, concluded that Abbot's findings were real and warranted not only continued support but a substantial increase. The Smithsonian had been in the business so long, Robert A. Millikan, K. T. Compton, and Isaiah Bowman argued, it would be a pity to stop. It was, after all, where solar constant studies had their longest history and their greatest advocate. Abbot's plan for a vastly expanded program, from three stations to ten, and synoptic balloonsonde programs would cost some $300,000 per year and passed the Senate with President Franklin D. Roosevelt's endorsement; but it lost in conference in 1936. Abbot therefore had to retrench for the first time. He closed the expensive St. Katherine station.

In 1918 Abbot was designated Assistant Secretary of the Smithsonian under Walcott with responsibilities for the Smithsonian library and the venerable International Exchange Service. The latter was a world-wide clearinghouse for the diffusion of scientific literature, which had been set in motion by Joseph Henry and fostered by Congress to keep open lines of communication between governments. Abbot succeeded Walcott in 1928 and guided the Smithsonian through the Great Depression and World War II. Despite Abbot's extreme focus on the APO, by the late 1930s the Smithsonian had weathered the Depression intact but not undamaged. Walcott's campaign for a $10 million dollar endowment was too short-lived to be effective and after his death was not supported by the Smithsonian Regents. The number of gifts to the general endowment did increase somewhat, but the amount and number rapidly dwindled in the 1930s, even as smaller gifts earmarked for the APO increased. When one looks at the fate of the Smithsonian overall during Abbot's tenure, one sees opportunities missed and paths not taken, which confirm that his interests were narrowly defined. His greatest missed opportunity was not securing Andrew Mellon's National Gallery of Art as part of the Smithsonian Institution. He also left the workings of the National Museum largely to his Assistant Secretary, Alexander Wetmore, who succeeded him as Secretary in 1944.

During the Depression, Abbot and his staff took advantage of a variety of federal job relief programs to support the Smithsonian. The National Zoological Park was significantly improved and completed through a $1.3 million dollar WPA program, largely as a result of effective campaigning by its director, William Mann. Most important, Abbot did whatever he could to insure that the Smithsonian continued to generate knowledge and diffuse the knowledge it generated. He parlayed the legacy of the International Exchange Service to make the Smithsonian's *Annual Reports* thicker, swollen in part by his own reprinted papers. But he also cannily included reprints from authors he knew would be sought out and read, and who could, in turn, aid the Smithsonian itself. Abbot's popular writings were florid and numerous. Beyond his many books, he also helped to create, under Walcott, the *Smithsonian Scientific Series* as a fund-raising venture, and wrote three of the dozen books in the series starting in 1929. Written by Smithsonian researchers largely about Smithsonian-related work and published in various editions by a New York publisher, the books averaged $25,000 in revenue a year for the next two decades after the Regents forced the publisher to relinquish a larger piece of the pie.[6] Abbot also fostered a radio program with WPA support, "The World is Yours," hiring actors to dramatize the world of science, bringing the Smithsonian into American homes during the 1930s.

During World War II, Abbot directed Smithsonian resources to the war effort, forming the Smithsonian War Committee to disseminate the Smithsonian's technical knowledge and expertise in fields such as aviation, entomology, geography, desert and Arctic conditions, and anthropology. The Smithsonian created a series of twenty-one pamphlets describing the lands where the war was being fought. Called "War Background Studies," they were published in the hundreds of thousands. The Smithsonian also joined the National Research Council, the State Department, and other governmental and private organizations to form the Ethnographic Board and the Institute for Social Anthropology, both housed at the Smithsonian, to use the social sciences for national goals.

Overall, Abbot was very successful at keeping the work of the APO and the Smithsonian before the public, through his writings, lecturing, and exhibits, as well as through his role on the Board of Trustees of Science Service and of the Research Corporation of New York, through endorsements from scientists and political contacts, and continuing support from patrons like Roebling. In the late 1940s as Abbot reached retirement and continued to work as a research associate of the institution, he never stopped searching for earthly correlations with his purported solar constant variations, corresponding widely with meteorologists, crop specialists, and even medical researchers. To the end of his long life, Abbot continued to publish revisions of his analyses of decades of solar constant data and always defended his belief that solar constant variations existed and could predict terrestrial weather changes. He met his critics head on whenever and wherever they appeared. One critic was close at hand, but spoke only in private. When Aldrich succeeded Abbot, he confided to an astronomical friend who was a member of the Smithsonian's "future policies committee" that, although he had the greatest affection and respect for his old boss, he knew that his correlations of solar variations contained systematic errors which Abbot refused to admit.[7] Aldrich carried on for several years as APO director until the Smithsonian closed its Washington observatory in favor of an alliance with Harvard.[8] Aldrich chose not to emphasize weather prediction, but turned to another facet of Abbot's mission—the practical utilization of solar energy—to foster science in service to mankind.

Abbot's ability to develop and maintain solar monitoring stations around the world for over forty years marks his tenacity and conviction for what was his mission in life. It demonstrates too his ability to secure support through professional relations, which he fostered and enjoyed with other like-minded institutions in scientific Washington, such as with the Weather Bureau, the National Geographic Society, the National Academy of Sciences, and the Carnegie Institution. Many forces were promoting Abbot's work. The "cycles conferences" already mentioned put Abbot's program at center stage. In the early 1930s the need for long-range weather forecasting was also a major concern of the Secretary of the Navy, who asked the National Academy of Sciences to look into its feasibility. John C. Merriam of the Carnegie Institution of Washington led a committee of ten, which included Abbot, Bowman, Compton, and Marvin. Abbot remained active within this small but influential circle of scientists and called upon them more than once to endorse his programs. The focus of Abbot's research during his long tenure required continual endorsement, and he received it at critical times from his colleagues in astrophysics as well as in geography, meteorology, and physics. His success at gaining patronage explains why the program was so long-lived and why the APO did not change its mission during the Abbot years, even though more than one influential astronomer tried to get Abbot to apply his techniques of spectrobolometry to the stars. Abbot did study the energy spectra of the stars sporadically in the 1920s, devising a radiometer using housefly wings that measured the distribution of energy in stellar spectra from the 60-inch reflector at Mount Wilson. It was an impressive technical feat, but for Abbot it was only a diversion.

The variations Abbot claimed to exist in the solar constant, ranging from 3% to 10%, were certainly due to varying weather conditions and flawed analysis, but his lifelong mission helped to keep the problem alive. A re-analysis in the 1970s of four decades of Smithsonian solar constant data did show evidence for minute variations, but it was not until satellite evidence became available that tiny variations were confirmed to exist, due to sunspot and faculae variations.

A music lover, Abbot sang and played the cello. He was a dedicated member of the First Congregational Church of Washington and served as deacon for years. Abbot's marriage to Lillian Elvira Moore on October 13, 1897, ended with her death on June 1, 1944, a month before his retirement. He married Virginia Andes Johnston in 1954. Abbot left no issue.

MATERIAL FOR THIS MEMOIR came from letters in the Charles Greeley Abbot papers, Smithsonian Institution Archives, which contains some 176 cubic feet of Astrophysical Observatory correspondence, data books and charts, photographs, manuscripts, speeches, and budgets. Also important are the Records of the Office of the Secretary, 1925-1949, which contains another 96 cubic feet documenting Abbot's role as Secretary. There are also oral history interviews at the Smithsonian Institution Archives and an Abbot biographical file in the archives of the National Academy of Sciences. Secondary sources were:

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NOTES

1. S. P. Langley. Report of the Mount Whitney Expedition. Quoted in Abbot, 1958, p. 17, above.

2. The pyrheliometer is a shielded thermometer that is exposed to direct sunlight through a carefully baffled tube. Bolometers are general purpose radiation detectors capable of sensing a broad wavelength range of energy.

3. See Burggraaf above.

4. Marvin to Abbot, April 21, 1925, Abbot papers, pp. 7-8. This agrees with contemporary assessments. See Hufbauer, chapter 9, above.

5. Abbot's pyranometers were designed to record the overall brightness of the daytime sky but were not exposed to direct sunlight. They were used in conjunction with pyrheliometers to determine the incident radiation from the Sun subtracted for sky brightness.

6. See Oehser, p. 176 and Hellman, p. 206 above.

7. Aldrich to Adams, circa January 30, 1946, Abbot papers, Smithsonian Institution.

8. See Doel above.

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1904

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1911

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1916

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1925

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1929

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