to be discovered and applied. These will be described in a memoir which is being prepared on *Forecasting in Brazil.*

All the above services were started by the new office since June, 1921.

Agricultural meteorology.—Brounov's type of stations were set up for studying wheat, rice, corn, cotton, cane, vines, etc. There are now 8 in working order, and graphs are being made for each one's results. The whole work is carried out as in Russia, years ago, but Azzi's modern views are also considered throughout. The statistical method is being dealt with but we do not expect any appreciable result owing to lack of proper data. A 10-day bulletin is published in all the leading newspapers of the country setting out the conditions of the most important crops, pasture lands, rivers and roads, and how all of them were affected by the weather. Monthly abridged reports are published in magazines. Phenology as practiced in Canada and in England has been started with detailed sheets which are sent regularly every six months from many points of the country. None of these activities existed before June, 1921.

Rain and flood service.—All the rain data is being revised in view of the preparation of a special atlas which will be published this year. The atlas will contain normal deviation charts, normal and "reliability" charts, besides a general discussion of the different zonal dry and wet seasons.

A flood service for the Parahyba River was inaugurated, and the same work is under hand this year for the Amazon where the floods are very destructive to cattle caught unaware by the rising waters. Nothing of this was done by the old service.

Aerology.—Pilot-balloon observations are made at seven stations, including Rio. Two kite stations are being constructed, one in Alegrete (Rio Grande do Sul) and the other in Ceara. The first one will be inaugurated in a couple of months and should reveal interesting data of the secondary circulation in a region which we have denominated the turntable of moving "highs" and a frequent path of outgoing depressions. The Ceara station is expected to give us an explanation of the curious irregular droughts of northeastern Brazil, which to our mind can only be satisfactorily made clear by revealing unusual conditions of upper currents. Comparative climatology should show us later the origin of these unusual currents, and perhaps lead us to forecast their advent.

Aerology is also assisting aviation in Brazil, and we trust it will help the eminent meteorologists of the world in their search for the missing links of general dynamic theories of the atmosphere.

Aerological work in Brazil is beset with the enormous difficulty of rapid transportation. Hydrogen is only obtainable in Rio, so that pilot-balloon work in distant stations is impracticable until a cheap and convenient process of producing pure hydrogen locally is brought out.

No aerological work of any kind was done by the previous meteorological service.

In conclusion we may point out that meteorological activity in Brazil is surrounded by all kinds of difficulties. Brazil has a very refined and highly intellectual "elite"; but at the back of it exists an enormous mass of people with hardly any primary instruction. All cooperative work with volunteers is yet a dream. Any observer has to be paid and a very persistent action taken to instruct and train him conveniently. Another tremendous difficulty is the size of the country. One can imagine how and why this is so. Appropriations can not ever be sufficient. Considering Brazil is a new country with all kinds of financial and economical problems to solve, we can not expect Congress to exceed a certain budget, proportional to the capacities of the country, although small and modest from the point of view of the meteorologist who confined his thoughts to the development of his beloved science.

PRETECHNICAL METEOROLOGICAL STUDIES.[1]

By HOWARD E. SIMPSON.

[University of North Dakota, Grand Forks, N. Dak., December 20, 1922.]

A student contemplating meteorology as a profession has open before him three possible fields. These are (1) the United States Weather Bureau, (2) commercial meteorology, and (3) educational meteorology.

Commercial meteorology is as yet in a very undeveloped stage while educational meteorology, while occasionally given in a department of meteorology and climatology, is generally limited to courses offered in the departments of geology, geography, physics, or astronomy. There appears as yet no good reason for differentiating between the preparation for either of these or from that of the professional work of the Weather Bureau.

The United States Weather Bureau may be entered through civil service examination for (1) assistant observer, or (2) for observer and meteorologist. Only men are eligible for the latter examination.

For the position of assistant observer the examination is extremely elementary; little more than ordinary high-school subjects are required, the salary being insufficient to attract many college graduates.

The requirements include penmanship, English composition, arithmetic, algebra through quadratics, the geography of the United States, elementary physics and elementary meteorology. Meteorology is the only subject in the list not taught in the elementary public schools or standard high schools. A thorough study of Waldo's *Elementary Meteorology* is considered sufficient preparation for this elementary examination. Appointments to the Weather Bureau above the grade of messenger are made on the basis of an examination in these subjects.

By the more advanced examination it is desired to procure persons who both by education and experience are qualified for the broader work of the Weather Bureau. The examination for the position of observer and meteorologist have not been given for the last three or four years on account of funds not being available for making appointments at the higher salaries attached to these positions. It is hoped, however, that provision may early be made providing for regular promotion with increases of salary in the higher grades. This would enable the Weather Bureau to hold out more promising prospects to young men from the colleges and universities who may desire to follow meteorology as a profession.

The college subjects required for the higher examination are mathematics, including geometry, trigonometry, analytics, calculus, and the theory of statistics, physics,

[1] Read by title at Cambridge meeting of American Meteorological Society, Dec. 29, 1922.

astronomy, an English thesis, together with meteorology.

Applicants must show that they have had at least three years' training in a college or university of recognized standing and that such training included work in physics, mathematics, plant physiology or hydraulic engineering.

The thesis is limited to a subject in one of the following groups: (1) Physics, meteorology, hydraulics; (*b*) botany, plant physiology. It is also specified that special credit will be given under the heading of "training and experience" for special work on original investigation in meteorology, climatology, botany, hydraulic engineering, or physical laboratory work other than that required by the college course.

The observer's examination in meteorology is based primarily on standard college texts and while it is elementary and practical, is sufficiently comprehensive to require a mastery of the essentials of the subject.

The ideal pretechnical preparation for a meteorologist would be a complete four year college course in liberal arts leading to the degree of bachelor of arts or bachelor of science, with major work in physics and mathematics. A sound understanding of these two branches of learning is most essential but this should be supplemented by a broad knowledge of the natural sciences and such other courses in the liberal arts as will give breadth of mind and culture. The following list of subjects, while not intended to be rigidly followed, may be suggested as a guide to the student who is contemplating meteorology as a profession.

Subjects.	Semester hours.
Mathematics:	
Geometry, plain and solid in high school.	
College algebra	4
Trigonometry	4
Analytics	4
Calculus	8
Theory of statistics	4
	24
Physics:	
General physics	8
Mechanics	4
Heat	4
Light	4
Thermodynamics	2
Hydraulics	2
	24
English:	
Rhetoric	6
English, correspondence	2
Engineering English	2
	10
General sciences:	
Astronomy, descriptive	4
Geology, physiography	4
Geography, human geography	4
Chemistry	8
Botany and plant physiology	8
	28
Meteorology	4
Climatology	4
	8
Credit hours	94

There should be three years each of mathematics and physics and the latter should include the descriptive, laboratory, and experimental phase of the subject. Among the other sciences it is understood that these are all general courses except that the geology should include physiography and the geography should be geographic influences or human geography; and a half of the time in botany should be devoted to plant physiology.

The ability to read understandingly and to write a terse, accurate letter and a report in a precise, lucid style are highly essential to any scientist engaged in public service. A reading knowledge of both French and German is important, though one of these should be taken in the high school.

Of final importance and bearing most directly upon the professional work is meterology and climatology. One semester should be devoted to a good elementary course in meterology based upon Milham's *Meterology* or Moore's *Descriptive Meterology*, and a second semester to climatology with Ward's *Climate* or Hann's *Handbook of Climatology*, translated by Ward, as a text. While verging upon the technical, a second semester in Meterology using Humphreys' *Physics of the Air* as a basis is highly desirable though this may be left to be undertaken in the technical studies of the service after graduation. A suggested four-year course preparatory to technical meteorology follows:

	Elective.	Premeteor.	Total.
Freshman:			
English, rhetoric		6	
Physics, general		8	
Mathematics, algebra and trigonometry		8	
Foreign language (French or German)	6		
Electives	6		
	12	22	34
Sophomore:			
Physics		4	
Botany (general)		4	
Mathematics		8	
Science (chemistry)		8	
Foreign language (continued)	6		
Electives	4		
	10	24	34
Junior:			
Physics		4	
Botany (plant physiology)		4	
Mathematics		8	
Science (geology)		4	
Meterology and climatology		8	
English, correspondence		2	
Electives	4		
	4	30	34
Senior:			
Physics		8	
Science (astronomy)		4	
Science (geography)		4	
English, engineering		2	
Electives	16		
	16	18	34
	42	94	136

Practical observational work in connection with a meteorological station continuing throughout the upper years of the college course is of exceptional value to the student. It gives him a thorough appreciation of the relation of the several sciences to meteorology, assists him to assimilate the fundamentals, and cultivates his sense of observation. This can best be done by attaching oneself as voluntary observer or paid assistant to one of the several regular or special stations of the Weather Bureau located at institutions of higher learning.

Too great emphasis can not be placed on the sound judgment of Prof. W. M. Wilson, when he says concerning one contemplating a career in the Weather Bureau: "Aside from college training he would need adaptability, a liberal supply of good common sense, a willingness to begin at the bottom. I sometimes think that we stress the mind training to such a degree that we lose sight of these basic qualities upon which success is founded. The Weather Bureau can not use a young man, however highly trained, unless he has these qualities."

Acknowledgment is made to Prof. C. F. Talman, librarian of the United States Weather Bureau, and to my colleagues on the committee on meteorological instruction of the American Meteorological Society, Prof. Wilford M. Wilson, Cornell University; Willis I. Milham, Williams College; and Frank L. West, Utah Agricultural College, for helpful suggestions for this article. The author only, and not the committee, is responsible for all statements made.

DISCUSSION.

C. F. MARVIN, Chief, U. S. Weather Bureau.

The note by Professor Simpson is most timely and appropriate, with reference to opportunities of employment in meteorological lines of pursuit. The Chief of Bureau is pleased to encourage to the greatest possible degree the attainment of qualifications in meteorology for prospective service in the Weather Bureau. However, it does not seem amiss to say that under the schedules of the reclassification of Govenment employees the range of salaries is from $1,600 to maximums of $5,000 or $6,000, but it is quite obvious that the higher salaries go to a limited number of persons peculiarly qualified and occupied with difficult and specific lines of work. The greater number of employees of the Bureau are expected to perform extremely important duties in the administration of field work of the bureau concerned with forecasting, the conduct of stations in large and small cities, and the performance of a daily program of service to the public. Technical education, together with executive qualifications and keen business sense, are essential to the highest share of success.

It should not be supposed that employment in the Weather Bureau carries with it an assignment that represents only research work or investigation. However, notwithstanding this, the salary compensation for the effective performance of the immediate responsibilities at field stations, is attractive, and the tour of daily duties furnishes opportunities for those so qualified to engage in the pursuit of minor meteorological, climatological and forecasting researches whenever possible.

The foregoing comments are submitted with the belief that young men who are interested in the science and practical application of meteorology to human welfare will find a field of opportunity and prospect in the Weather Bureau that can hardly be surpassed elsewhere in congeniality and advantage.

VALUES OF THE SOLAR CONSTANT, 1920–1922.

By C. G. ABBOT and Colleagues.[1]

[Smithsonian Institution, Washington, D. C., March 29, 1923.]

INTRODUCTION.

Hitherto the Smithsonian Institution has promoted these researches on solar variation, as we may say, in faith. There were, to be sure, many fragmentary evidences, all pointing to the conclusion that the sun varies, and that its variations may be of importance for meteorology. But these variations are of so small a percentage range that it is only barely possible, by the most careful work in the most favorable climates, to make absolute determinations of the solar constant of radiation sufficiently accurate to reveal them. Evidences of solar variation collected in Volumes III and IV of the *Annals of the Astrophysical Observatory* seemed to have great probability. But the large expense, the sacrifice which the work cost, and the many years which we have devoted to it, combined to swell so heavy a debit account that no one of these individually hardly conclusive evidences, or even all of them together, could take away a load of deep anxiety. We could not help carrying in the back of our minds the misgiving lest this costly work should in the end prove wasted, except for the uninspiring result of proving a negative.

This is now past. We present the following results with confidence that they leave no reasonable doubt that the solar radiation varies, and that good work in well-established stations may be carried on with a continuously high-enough degree of accuracy to determine the variations. Confidence may now be assured that future observations at our two stations in the opposite hemispheres will accord even better than those made hitherto, and that they will disclose considerable variations of the sun. Arrangements are now completed to carry on these observations for several years.

This is our part. We think it will be an interesting and profitable task for meteorologists to examine what effects such solar variations produce on terrestrial weather conditions. Whether they will prove important forecasting evidences, the future will disclose.

THE NEW STATIONS.

Convinced of the unsuitability of Mount Wilson for a solar constant station to be occupied the entire year, inquiries were made through the United States Weather Bureau as to the most favorable station to be occupied in the United States. The desired qualities were (1) cloudlessness, (2) uniformity of sky, (3) high elevation above the surrounding country, (4) accessibility and habitability.

Professor Marvin, Chief of the United States Weather Bureau, very helpfully ordered a special research in connection with the matter. Two journeys were made by Mr. Edgar H. Fletcher, assistant observer at Phoenix, Ariz., to prospect for a suitable mountain location. He reported upon the following locations: Table Top Mountain and Montezumas Peak, near Maricopa, Ariz.; Black Peak, near Ajo, Ariz.; two peaks near Mohawk, Ariz.; the Chocolate Mountains, near Yuma, Calif.; San Jacinto Peak; the Calico Mountains, near Daggett, Calif.; Old Dads Mountain, near Bagdad, Calif.; Sugar-Loaf Peaks, near Barnwell, Calif.; Kessler Peak near Cima, Calif.; Crescent Peak near Crescent, Nev.; Mount Harqua Hala near Wenden, Ariz.

After consideration the stations Cima and Bagdad, Calif., and Wenden, Ariz., were selected as lying near accessible mountains which seemed most promising of those proposed. Chief Marvin caused daily observations of the amount and kinds of clouds, direction and velocity of the wind, and visibility of the mountains to be taken near Cima, Bagdad, and Wenden at the hours 7 and 9 a. m. noon and 3 and 5 p. m. These special observations were commenced in December, 1919, and continued until December, 1920. By June, 1920, it seemed clear that, on the whole, the station on Mount Harqua Hala, near Wenden, Ariz., had proved most advantageous of the mountain stations considered, and the Smithsonian Institution ordered the construction there of a suitable observing shelter. The original building, comprising two

[1] My colleagues, F. E. Fowle, L. B. Aldrich, A. F. Moore, L. H. Abbot, and J. A Roebling, have each and all contributed so largely in different ways to these results that their names are entitled to coauthorship. It is only to avoid cumbrous citations that they are omitted in the heading.

Only less valuable and indispensable for the research has been the conscientious painstaking, and enthusiastic work of Messrs. A. Kramer, P. E. Greeley, F. A. Greeley Mrs. G. M. Bond, and Miss M. A. Neill.

We owe, besides, much to the help of the Weather Bureaus of the United States, Chile, and Argentina, the Chile Exploration Co., and to many citizens of Wenden Ariz., especially Mr. W. B. Ellison and Mr. J. E. Matteson.