tal movement which we detect by the motions of the clouds, and an ascending movement which is easily seen if we study the phenomena going on within the clouds. This ascending movement is very violent in thunderstorms and tornadoes; is always present in waterspouts, and in the general heavy rains attending areas of low pressure. In studying the thunderheads or great cumulus clouds of a thunderstorm we see a rapid ascension going on at the top of the cloud nearly over the region where hail and the heaviest rain occurs. Evidently the quantity of rain that falls upon any given area represents, not merely the vapor precipitated from the air over that area at any moment, but from the successive masses of air that flow over it during any given time. Thus at Cherrapunji, India, the heavy rains drop from a rapidly-moving southwest monsoon current flowing over the Khasia Hills. It is not improper to assume that the heavy rainfalls that we call local rains, are also due to the supply of moisture brought by rapid currents flowing over any given spot. Thus, in the hailstorm, and in the center of a large cumulus cloud the currents of air ascend rapidly, while in the general widely extended rains they ascend slowly. One can easily calculate the total depth of rainfall in the column of air extending from the ground to the upper limit of the atmosphere, with results as shown in the accompanying table, prepared in 1883, but published in the Smithsonian Report for 1888, page 410. These figures apply only to still air, and are to be modified to an indefinite extent if horizontal or vertical movements are taking place.

Height of column.	Depth of water in the atmosphere corresponding to the respective dew points at the earth's surface.			
	80°	70°	60°	50°
Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
6,000	1.3	1.0	0.7	0.5
12,000	2.1	1.5	1.1	0.3
18,000	2.5	1.8	1.3	0.9
24,000	2.7	2.0	1.4	1.0
30,000	2.8	2.1	1.5	1.1

THE JUNE RISE OF THE MISSOURI AND MISSISSIPPI RIVERS.

For many years it was a popular saying that the rising waters of the Missouri and Mississippi rivers during June are due to the melting snows in the Rocky Mountain region, but the regular reports and predictions of the river conditions that have been published by the Signal Service and Weather Bureau since 1872 have long since banished this error from the minds of those familiar with the weather map. Even before regular river work began, in January 1872, the present Editor, who did the "probabilities" or indications during the preceding year, frequently had occasion to point out the fact that the rains which occurred everywhere in the watershed of the Upper Mississippi and Lower Missouri rivers contributed far more to the June rise than any possible melting of snows in the mountains. The latter serves mostly to supply water for irrigation along the beds of the smaller tributaries of the eastern Rocky Mountain slope, whereas the floods of the Lower Missouri and Mississippi rivers depend almost wholly on the rain that falls on that portion of the watershed that is below the 2,000-foot contour line.

A METEOROLOGICAL LIBRARY.

The Editor takes pleasure in calling the attention of regular and voluntary observers to the fact that the extensive collection of text-books, periodicals, and treatises on meteorology belonging to the late Prof. H. A. Hazen, is now in the hands of his sister, Miss Mary S. Hazen, 1234 Tenth street, N.W., Washington, D. C., and those who desire to obtain any of them should correspond with her. It is very much to be hoped that some college or experiment station will obtain the whole of this collection. It is very difficult to complete broken files of rare works on meteorology, and the importance of a special library is always felt during the prosecution of any scientific investigation.

The development of agricultural libraries is admirably sketched in an article by Mr. Charles H. Greathouse, in the Yearbook of the Department of Agriculture for 1899, and his opening paragraph should be the motto of librarians in every department of science:

> To furnish the right book to the right man at the right time is a problem that faces every student of agricultural affairs who would help men to better ways of farming.

A well arranged library with a good index catalogue is not only a help but an incentive to study. The progress of meteorology is impeded by the absence of a comprehensive bibliography or subject index. Many a student wastes his time solving problems that have long since been solved by others and overlooks the questions that still demand investigation. A complete index to the literature of meteorology would remedy all this.

MONUMENT TO CANTONI.

The faculty of sciences of the University of Pavia, Italy, has taken the initiative in a subscription toward the erection of a memorial monument in the University Building, in honor of Signor Professor Giovanni Cantoni. The great work that Cantoni has done in Italy for meteorology and climatology considered as branches of exact physical science insure that the subscription lists will include the names of many meteorologists.

LECTURES ON METEOROLOGY.

On May 9 the Editor had occasion to lecture before one of the private schools of Washington, D. C., and took for his theme "The clouds." No more interesting topic could be suggested, and perhaps the following synopsis may be useful to other members of the service who may have occasion to lecture on this subject.

The clouds may be studied from various points of view, artistic, poetic, or scientific. In the latter study we must begin by giving them names so as to make sure of a definite record that can be understood by others. We naturally inquire, first of all, as to their general appearances, colors, shapes, and movements. Then we find methods of measuring their altitude and absolute velocity in miles per hour. We soon observe that the upper layers of clouds move in a different direction from those of the lower layers or the lowest wind. A short study brings out the fact that internal changes of structure are going on. Then we perceive that some kinds of clouds precede fair weather, others precede rain, or snow, or wind. We notice that some kinds diminish and disappear toward sunset, others begin to appear at that time. Some kinds of distant cloud banks indicate the approach of thunderstorms, others snowstorms, and still others belong to distant hurricanes. The colors of the clouds especially at sunset are the most gorgous displays ever witnessed by man. These colors may be caused either by absorption, dispersion, or diffraction of the sunlight, and their study offers many important problems in physical optics. Generally speaking the highest clouds are white while the lower clouds begin to be colored, but as the sun descends lower and lower the highest clouds become colored. Sometimes when minute particles of moisture exist in the upper atmosphere a fiery red light pervades the western sky long after the highest clouds have become invisible, as was seen throughout the northern hemisphere during 1883–1886. The color depends upon the number and size and distance apart of the particles of vapor and the lengths of the waves of light. The rainbows, halos, glories, or coronæ, mock suns, or sundogs offer another interesting series of optical phenomena depending upon the sunlight. The methods of formation of clouds form an exceedingly important study. In general, the moist air must be cooled down to its dew-point before a cloud can form, but the cooling may be effected either by a mixture of warm air with cold air, or by the radiation of heat from the warm air, or by the expansion of the warm air as it rises higher in the atmosphere. This expansion may be brought about in many ways, thus air may flow horizontally from an area of high pressure to one of low pressure, or it may be pushed up over a mountain, or over a resisting mass of denser air, or may even rise gently as it flows over an extended ascending prairie, or as it flows from the ocean over the lowlands that border a continent; again it may ascend more rapidly by virtue of its own lightness or buoyancy. At a moderate distance above the earth's surface, there is often a current of air blowing over a lower current of wind; at the boundary surface between these, great waves are formed with rollers and breakers that become visible to us whenever some of the air cools enough to form cloud. As the ascent of air cools it and forms cloud, so the descent of air compresses it, warms it up, and dissipates the cloud. It is curious that the condensation of vapor in clouds begins to take place around the innumerable particles of dust that are floating in the atmosphere and if all these could be brought to the ground, we should leave dustless air. It is much more difficult to form visible cloud particles in air that contains no dust, but still this can be done, and from the midst of the clouds great drops of water, snow flakes, and icicles appear thus to be formed. The study of a thunderstorm gives an exceedingly interesting picture of the complex combination of numerous cloud phenomena and their results. A lower current of air from the southwest is perhaps invaded by a cool, dry current from the northwest; the former is banked up, ascends, and overflows, forming great cumulus clouds upon which the sun shines, heating the illuminated half while the shaded half cools off and flows away. Below the cumulus, rain or hail falls, cooling the air and the ground, which was already cooling by reason of the absence of sunshine, and from the cool region thus formed the air flows outward at the surface of the ground, forming a special gust of cool air which advances with the moving cloud and its rainy region. Thus, an observer first sees in the west a cloud bank formed at the top of a distant cumulus, then he finds cirrus clouds floating overhead formed by the disturbance in the upper currents; then the edge of the strato-cumulus cloud passes eastward over his zenith, then the lowest layers at the base of the cumulus. By this time it has become quite dark and he sees in the distance a low cloud forming at the top of the upturned edge of the gust flowing out from the coldest part of the region and the descending column of cloud or rain. The study of clouds may be prosecuted experimentally, although but few physical laboratories are provided with conveniencies for such study. The observational methods include the use of the nephoscope and the balloon as well as the establishment of mountain stations. Especially has photography come to our aid in the study of the details of the internal motions of the clouds.

The total or solar eclipse of May 28 was the occasion of an excursion to South Carolina which afforded the Editor the long desired opportunity to become slightly acquainted with that section of the country. He saw the voluntary observers at Newberry and Rockhill, and Section Director Bauer at Columbia, and spent a week in the State; enough to make him realize how little one knows of any region that he has not visited in person. The awakened interest in manufactures and the remarkable rush for education, the kindly feeling of all toward the Weather Bureau and its work, the lively interest in the development of the resources of the State, the rapid recovery from the stagnation of twenty or thirty years ago, the development of cotton mills, good roads, public schools, and agriculture, the prospect of development of commerce, the restriction on the sale of liquor, the laws regulating cattle on the highways, requiring every man to take care of his own, and relieving farmers of the necessity for fencing in their property, are among the general features that impressed him favorably. Above all was the genial hospitality abounding on every side toward the scientific visitors from all parts of the world who came to study the solar eclipse, as seen from the South Atlantic States.

Fortunately, the Chief of the Weather Bureau was able to telegraph from Washington that a cloudless day might be expected along nearly the whole path of totality, and as it turned out, the solar corona was undoubtedly observed and photographed most successfully, although the duration of totality was very short. Although an eclipse is supposed to be a purely astronomical phenomenon, yet it has meteorological bearings, and it was, therefore, proper for the Weather Bureau to take an active part in the work of that eventful morning. After that was over Professor Bigelow and the Editor turned their attention to the specific work of the Weather Bureau, and in response to numerous requests they had opportunities to explain the history and the work of the service to appreciative audiences in Newberry, Columbia, Rockhill, and Charlotte. The following abstract of a talk on the history of meteorology, may interest some readers.

The history of modern efforts at weather predictions begins properly with the labors of Prof. J. J. Hemmer, Secretary of the Meteorological Society of the Palatinate, at Mannheim in Germany, just as the study of climatology begins with the distribution of meteorological apparatus in 1653, in Italy, by the Grand Duke of Tuscany, Ferdinand II. The Mannheim ephemerides were published in thirteen volumes for the years 1780–1792, and contain the daily meteorological observations in detail for thirty-six stations in Europe, and for three stations in America. The object of this extensive publication was to afford the means for studying the relation of the weather at distant places from day to day, but we do not find that such a comprehensive use of this data was made by the society itself. The printed volumes stood for years inviting the student to discuss the questions for which they were published. H. W. Brandes, Professor at the University of Breslau, was the first to compile from those volumes, daily maps of the weather for 1783 and published some that illustrated the progress of storms, first in his Beitrage zur Witterungs Kunde Leipzig, 1820, and afterward in his Dissertation de Repentinis Variationibus in Pressione Atmosphaerae Observatis. Lipsiæ, 1826. 4to.

About this time Prof. James P. Espy removed from Cumberland, Md., to Philadelphia, Pa., and began a series of publications upon a subject which he had long studied with great enthusiasm. He first clearly saw that the latent heat of the vapor that condenses to form cloud must be the important factor in the development of cumulus clouds, thunderstorms, and tornadoes, and he subsequently extended the application of this idea to the extensive rains, the great storms, and even the West Indian hurricanes of North America. His numerous lectures and articles in this country and Europe were followed by the publication of his Philosophy of Storms, Boston, Mass., 1842, after which he was appointed meteorologist to the United States Government and was assigned to duty, first in the War Department, afterward to the Navy Department, and eventually under the Smithsonian Institution. In 1836 he organized a joint committee of the American Philosophical Society and the Franklin Institute for the purpose of studying storms. This work was continued when he removed to Washington, D. C. Observations were gathered and numerous maps constructed, and extensive selections from these were published in his four successive reports, 1845–1860. While Espy dwelt especially on the mechanical theory of the development of storms, Redfield devoted himself to the collection of data illustrating the phenomena, and especially the general movement, of storm centers over the ocean. The general tendency of these two investigators was to establish the fact that individual features of the weather, as well as the storms, as a whole, move over the globe in such a manner that their arrival at any place can be predicted if we have at hand a series of maps showing their movement during the preceding few days. The spread of the electric telegraph throughout the United States during the years preceding 1848 suggested the possibility of compiling such weather maps regularly every day, and the first one was made, as a sample, for Prof. Joseph Henry, by Mr. J. J. Jones, of New York, in that year; but it was not until the next year that Professor Henry obtained from the telegraph companies a general concession for the free use of the telegraph lines for scientific purposes. Daily maps were made, for personal study, from that time forward for several years, and a large wall map, showing the condition of the weather day by day, began to be publicly displayed in the Smithsonian building from 1856 onward. This map was made the basis of frequent special predictions of the weather for the benefit of members of Congress and others who consulted Professor Henry. The success of these predictions furnished a strong argument for the establishment of a general weather service by the Government; but this was not effected until the demand for it came, not from the scientific meteorologists, but from the business interests of the country. In 1868 the Director of the Cincinnati Observatory was, at his own suggestion, authorized by the Cincinnati Chamber of Commerce to organize, at its expense and for the benefit of the merchants of that city, a system of daily weather reports and predictions. After this was done and in successful operation, the work was brought to the attention of the National Board of Trade, meeting at Richmond, Va., in November, 1869, and that body favorably indorsed a general memorial to Congress on behalf of all the commercial interests of the country. This memorial was prepared by Prof. I. A. Lapham and H. E. Payne, both of Milwaukee, Wis. The resulting joint resolution and the act signed by the President February 9, 1870, authorized the Secretary of War to establish a system of telegrams and reports for the benefit of commerce. This military service was transferred to the Department of Agriculture in July, 1891, and its duties were extended so as to include agriculture and all other interests affected by the weather.

When we compare among themselves the daily weather maps showing actual observations carefully made all over the country and presenting, as it were, a photograph of the atmospheric conditions twice or three times a day, one must be impressed with the fact that the predictions of the weather published by the Weather Bureau are based upon a solid foundation of facts and that its methods are radically opposed to those of the local weather prophets and the astrologers.

THE DRIFT OF THE GULF STREAM NEAR KEY WEST, FLA.

The Weather Bureau observer at Key West, Fla., Mr. W. U. Simons, communicates to the Chief of the Weather Bureau a card found in a well-sealed bottle in shallow water, half a mile east of Saddle Bunch Channel and about 12 miles north of east from Key West, about noon May 31. This card contained a notice to the effect that the bottle was deposited in the sea on April 18, in latitude 24° 18′ N. and longitude 84° 25′ W. The point of deposit was therefore about 150 miles distant, and west-southwest of Key West.

In accordance with the general policy of the Weather Bureau, the card picked up by our observer has been forwarded to the Hydrographic Office, United States Navy.

ECLIPSE SHADOW BANDS AND CORRELATED ATMOSPHERIC PHENOMENA.

The following note was prepared by the Editor for publication in 1887, and may still be of interest:

Meteorology has perhaps not much to expect from observations of the barometer and the wind during a total solar eclipse, but it has considerable interest in the shadow bands. It seems quite plausible that the explanation of these is to be found in the interference of two pencils of sunlight that have respectively passed through adjacent portions of air of slightly different densities. This should not be called a diffraction phenomenon, though it does occur when a thin sheet of light from the edge of the sun passes the edge of the moon at the moment preceding totality. Undoubtedly such a slender beam of light may cause diffraction phenomena, but if so, the diffraction bands would necessarily move onward over the earth's surface with the same relative speed as that of the moon and the earth, namely, approximately a mile a second, whereas the observed shadow bands have a velocity of only a few feet or yards per second. On the other hand, the bands may be considered as phenomena of interference of rays of light slightly inclined by reason of the irregular refractions in a nonhomogeneous atmosphere, and they must therefore have such characteristics as are impressed upon them by the condition of the atmosphere at the time; their horizontal movement must correspond nearly with that of the winds and upper currents in the atmosphere. In fact, we need not necessarily speak even of interference phenomena. Every small mass of descending dense air constitutes a rough sort of lens or prism, the beam of light that passes through it must be deflected and the atmospheric mass casts a shadow on the ground, like a lens or prism of glass. Such phenomena may be seen when the air is very much disturbed even in ordinary full sunlight but become much better defined when the sun's disk is reduced to a slender crescent, as during the few seconds preceding and following totality. If there be no small masses of rising hot and descending cold air, but if we conceive the layers of the atmosphere to have definite horizontal surfaces thrown into waves, then the refraction of the light as it passes through these waves would certainly produce beams of light having slight inclinations to each other, which would produce shadows and interferences when they intersect. All interference phenomena in sunshine under favorable circumstances give rise to bands of color rather than alternate bands of darkness and brightness. We are, therefore, inclined to speak of the shadow bands as really shadows produced by the irregular refractions of the atmosphere rather than as pure interference phenomena, although they may partake of the character of both, but they certainly have not the characteristics of diffraction bands, properly so called. Similar shadows contribute materially to the rather complex phenomena of twinkling or scintillation. When a very bright star is observed near the horizon, it not only flickers as to color and brightness, but actually disappears momentarily, due to the fact that its light is refracted so far away from the eye that none of it enters the pupil. The shadow bands