THE SUN-SPOTS AS HURRICANES OF THE DUMB-BELL VORTEX TYPE.

The sun-spots occur on the outer surface of the photosphere and extend inward toward the center of the sun. They consist visibly of a nucleus which is practically structureless, and a penumbra which is striated radially with much regularity. The observed movements[5] of the material composing the penumbra are from the outer edge of the disturbed area in the photosphere toward the umbra, and the radial striæ usually terminate in ends which are bent downward toward the interior of the sun. The motion of a particle starting on the outer edge of the penumbra is primarily inward and then rather suddenly downward. This corresponds so closely to the motion in the upper levels of a dumb-bell-shaped vortex where the circulation is downward, that it seems proper to suggest this explanation of the origin and structure of the sun-spots. Referring to MONTHLY WEATHER REVIEW, XXXV, October, 1907, p. 475, fig. 3, the sun-spots would correspond to the layers between the sections $az = 180°$ and $az = 170°$, if the circulation is downward. In this limited region there is practically little rotary velocity v, the vertical velocity w becomes important only when approaching the abrupt curvature which is here assumed to be on the outer edge of the umbra, but in the penumbra the radial velocity u is conspicuous. The sun-spot may be caused by layers of matter inside the sun's photosphere operating to draw material downward, warm layers being superposed upon cold layers at the section which corresponds with the lower plane of the sun-spot vortex. There are reasons for considering the sun-spot belts to be cooler areas than those nearer the poles, so that the general circulation would require downward motion from the surface toward the interior. If these views are correct it will become possible to compute the entire vortex system from a few measurements of the radii ϖ and the radial velocity u in the upper layers of the vortex in the region of the surface of the photosphere. If the penumbra is composed of vapors condensed at a certain temperature, their disappearance as visible cloud forms in the hotter layers, as they fall inward and downward, is readily understood. A large series of thermodynamic problems is clearly suggested by this theory, it may properly become the subject of an important research.

NOTES ON WEATHER AND CLIMATE MADE DURING A SUMMER TRIP TO BRAZIL, 1908.

By Prof. R. DeC. WARD, Harvard University. Dated Cambridge, Mass., October 15, 1908.

The teacher of climatology should travel. He should, by personal observation, gain some acquaintance with weather types and with climatic conditions in different parts of the world. If he travels equipped with a few portable meteorological instruments and with his eyes open, he will return from each journey to his class-room better equipped as a teacher and better able to interest and instruct his students. The writer has experienced the truth of these assertions very fully in his own case. He hopes that some of his colleagues may be interested in the following more or less haphazard notes which were jotted down at odd intervals during a recent trip to Brazil. This trip was made as a member of the Shaler Memorial Expedition to South America. The writer accompanied the party without official duties, and largely for reasons of his own health. The start from New York was made on June 20, 1908, and Rio de Janeiro was reached July 8. Six weeks were spent in Brazil. On the return voyage the steamer left Rio on August 19, and reached New York September 6. Short stops were made at Bahia and Barbados.

Instrumental equipment.

The instrumental equipment was simple and portable. The following list of instruments is given in the hope that others may find it useful: 2 sling psychrometers; small-size Richard barograph[1]; portable maximum and minimum thermometers[2]; 3-inch rain-gage[3]; nephoscope[3]; Dines's patent portable pressure anemometer[4]; Rotch's instrument for obtaining the true direction and velocity of the wind at sea[5]; a pocket compass. In addition, charts of the North and South Atlantic and a United States Hydrographic Office Pilot Chart of the North Atlantic Ocean for June, 1908, were taken. This equipment proved satisfactory, and as complete as the conditions of ordinary travel warrant.

THE ATLANTIC VOYAGE.

No study of pilot charts or of text-books can give the clear understanding and appreciation of the great wind systems of the world which the traveler who takes an ocean voyage can secure by keeping his eyes open. In June, the month in which the writer started from New York, summer conditions are well established over the North Atlantic. The Pilot Chart shows that the dominant high-pressure area is somewhat to the southwest of the Azores, and covers the central and southern portions of the ocean. From this center, as is well known, the winds blow out spirally.

The prevailing westerlies of the North Atlantic.

To the north of the anticyclone their direction is generally from the southwest, and we have the *prevailing* or *stormy westerlies*. These are often interrupted by cyclones, which cause changes of wind direction to southeast or south with foul weather and rain, followed by a shift to the southwest and west or northwest with clearing weather and higher wind velocities. In these westerlies the pressure changes from day to day are irregular, and often reach 0.50 inch or more. The winds, while generally strong, are variable both in direction and velocity. During the colder months the storms increase in number and are more violent; the shifts of wind are more frequent; the periods of rainy and cloudy weather come oftener and the winds have higher velocities. Because the "Atlantic Ferry" runs thru the latitudes of the stormy westerlies, the passage is apt to take a steamer thru one or more storms, especially in the colder months. There are fewer changes in weather and in pressure on the eastward voyage than on the westward. This is because the storms themselves move eastward, and the

[5] A summary of these papers on the vortices in the atmosphere of the earth was read before the National Academy of Sciences at the meeting in Washington, D. C., April 18, 1907.

The photographs of the sun-spot regions secured by Prof. G. E. Hale at the Mount Wilson Solar Observatory in the summer of 1908 are interesting and suggestive in this connection. The curved lines, perhaps paths of motion, there shown probably belong to other levels in the vortex than that herein described, since curvature in the horizontal plane increases with the distance from the asymptote plane. Measures of the angles and velocities should be made with the dumb-bell-shaped vortex in mind.—*F. H. B.*

[1] A most interesting traveling companion on an ocean voyage. The barograph was hung from the ceiling of the stateroom by a spiral spring, and was prevented from swinging too violently by means of a string fastened to the side of the room. This same instrument accompanied the writer in 1897–98 on a voyage around South America, and gave a continuous and most interesting record from New York back to New York again.

[2] Not used because of difficulty of proper exposure.

[3] Modified Fornioni pattern (see Cleveland Abbe: Report of Chief Signal Officer for 1887, Part 2, p. 330–331, Pl. XXXII, fig. 86), specially constructed for the writer by Mr. S. P. Fergusson, of Blue Hill Observatory. This nephoscope measures 5½ inches in diameter, and has an adjustable eye-piece in two sections. When used at sea, if the vessel is rolling or pitching, some difficulty is experienced in making an observation, but in smooth seas, such as those met with on the voyage to Brazil, this trouble is reduced to a minimum. For a description of a marine nephoscope mounted on gymbals, see Cleveland Abbe: The Marine Nephoscope. U. S. Weather Bureau Bulletin No. 11, Pt. I, sec. III, p. 161–167, and Pl. VI.

[4] An excellent instrument for use on land. On a moving steamer it is impossible to obtain the true wind velocity directly from anemometer readings. The instrument is made by Casella of London.

[5] A very useful and interesting instrument, described by Prof. A. L. Rotch in the Quart. Journ. Roy. Met. Soc., Vol. XXX, p. 313. The angle between wind direction and the ship's course on these particular voyages to and from Brazil was usually so small that this instrument could not be satisfactorily employed during most of the time.

steamer travels along with them. On the westward voyage the ship moves toward the approaching storms and in a given number of days is therefore likely to pass thru more of such disturbances than when she travels eastward. On the westward voyage observer and storm approach one another at a rate equal to that of the westward velocity of movement of the steamer *plus* the eastward velocity of the storm. On the eastward voyage the rate of approach of observer and storm is equal to the difference of these velocities. The weather of the northern North Atlantic is characteristically boisterous, and the sea is apt to be rough.

The voyage across the latitudes to the south of the dominant anticyclone takes the traveler thru very different conditions. Here the winds blow from a prevailing northeast direction (the northeast trades) toward the equator. The trade winds blow over a region where the distribution of pressure is very uniform, and where the decrease of pressure with decrease of latitude is slight. Hence, these winds have a moderate but very constant velocity, and are remarkably steady in direction. The Pilot Chart shows clearly enough that the region of gales is in the northern part of the ocean, in the belt of prevailing westerly winds, while the trade wind latitudes are not subject to gales.

The first two or three days after leaving New York the weather may be unpleasant, especially in winter, but as the steamer takes a course very nearly southeast (passing to the west of Bermuda) until she is off Cape San Roque, she soon runs out of any temporary stormy conditions near the coast, and a day or two of fine weather, with generally light and variable winds, is encountered. In summer, calm sea and fine weather are likely from the start, with southwest winds for the first four or five days. These southwest winds are a part of the general spiral outflow from the permanent anticyclone near the Azores. They are clearly shown on the *Challenger* isobaric and wind chart for July, over the western portion of the North Atlantic. The Pilot Chart also shows them well in the "squares" around Bermuda. The steamer on which the writer was a passenger carried these southwesterly winds and fine weather for four days and a half after sailing from New York. The clouds were mostly of the cumulus type (cumulus, alto-cumulus, strato-cumulus), sometimes reaching cumulo-nimbus development in the afternoon and giving short, squally showers, but disappearing about sunset. The clouds came from about southwest thruout this time, except the cirrus which came from more nearly west. The lofty tops of the cumulo-nimbus were often observed to bend forward and topple over, dissolving as they descended below the level of previous condensation. This breaking off of the cumulo-nimbus tops frequently gave the remaining portion of the cloud a strato-cumulus appearance.

The Horse Latitudes of the North Atlantic.

The barograph curve showed a very steady rise after leaving New York, reaching its highest reading (30.25 inches) southeast of Bermuda, where the axis of the tropical high-pressure belt ("Horse Latitudes") was crost June 23–24. The noon position on June 24 was latitude 26° 00′ north, longitude 60° 32′ west. The southwesterly winds noted above became very light and even failed altogether in this part of the voyage, and typical Horse Latitude calms were experienced. It was thus easy to see why this particular portion of the ocean is avoided, when possible, by sailing ships. The old stories about vessels being becalmed in the Sargasso Sea and drifting around amid great masses of seaweed until they rotted away, were associated with these latitudes of the tropical calms. The diurnal variation of the barometer first became noticeable on June 22 and grew more marked with decreasing latitude, being a regular feature of each day's barograph curve during the remainder of the voyage and most marked near the equator. The temperature rose gradually as the ship went farther south, but remained under 80° during these first four days. The relative humidity averaged about 80 per cent. (D. B. 77.5°, W. B. 73.0°.)

The northeast trades.

Late on the afternoon of June 23 (noon position lat. 29° 46′ north, long. 63° 44′ west), during a calm, some fracto-cumulus clouds were observed coming from south 25° east, showing the presence of a wind from that direction at about a mile above sea-level. In half an hour the northeast trade began to blow, at first from about southeast. On the following day the wind was fresh from east-southeast. It was noted that this wind began about 3° or 4° north of the northern limit of the northeast trade, as shown on the June Pilot Chart, but when the steamer was already in a "square" where east and southeast winds are shown to be prevalent. On June 24 (noon lat. 26° 00′ north) the charted "northern limit of the northeast trades" was reached. For six days the weather conditions were ideal. Fresh easterly winds blow day and night with just enough white caps to keep the sea from being "dead;" beautiful trade cumulus clouds, like our own summer clouds at home, but usually more delicate and much more slender, shine brilliantly in the tropical sun by day, growing larger in the later afternoon hours, when as cumulo-nimbus they often give brief showers, and fading away after glorious sunsets; temperatures never vary more than 2° or 3° above or below 80°, but one is perfectly comfortable owing to the fresh breeze and fairly low relative humidity (about 75 per cent). Sailing under such conditions is certain to make even the most blasé traveler enthusiastic over the sea.

Short rain squalls, lasting five or ten minutes, were by no means infrequent in the northeast trades. These squalls were accompanied by a considerable freshening of the wind. In one case a slight, sudden increase in pressure was noted on the barograph curve, and a fall of temperature of 4° was observed at another time. Lightning was noted only once. Most of the showers came in the late afternoon, evening, and night. Fairly well-developed cumulo-nimbus clouds were not uncommon even in the early morning hours. This fact, together with the occurrence of showers at night, suggests that radiation aloft, from the clouds themselves, is an important cause of atmospheric instability in these latitudes.

The pressure changes from day to day are very small in the trades. Storms are rare, and are limited to certain seasons. The voyager over these seas may therefore be sure[6] of a succession of beautiful days, so much alike that he soon acquires the habit of the Tropics and stops talking about the weather. When day after day brings the same conditions, with which everyone soon becomes familiar, to talk about the weather is as aimless as to greet everyone with the exclamation, "The sun rose this morning!" In extra-tropical latitudes, where weather changes are frequent, the weather is naturally and will always remain a stock subject for conversation.

Several observations of flying-fish showed that these fish can remain above water a surprisingly long time. While the average duration of their flight was between six and eight seconds, it extended to eighteen seconds in one case. The sea during these observations was smooth. Over rough water, the duration of flight may be longer.

The heat equator.

On June 25 the sun was vertically overhead at noon. It was interesting to note that the maximum temperature recorded on the voyage (81°) was not reached until June 26, i. e., farther south. This suggests the fact that the heat equator, in its migrations, lags behind the sun. As the steamer proceeded farther southward, the temperatures began to average some-

[6] Except in the hurricane season and hurricane belt.

what lower and had fallen to 75° by the time Rio de Janeiro was reached. It was clearly seen that the temperatures within 5° or 10° north of the equator were somewhat higher than those the same distance south of "the line."

The doldrums.

Thruout the six days during which the steamer was traversing the northeast trades, the wind was persistently from the east. The Pilot Chart for June shows that in these latitudes the prevailing wind is northeast, but that east winds are also frequent. In the summer of the Northern Hemisphere the northeast trades end between latitudes 5° and 10° north. The ship ran out of the northeast trades and into the doldrums at almost exactly the latitude indicated on the chart. The doldrum belt, with its characteristic heavy cumulo-nimbus clouds, its frequent heavy showers and squalls, its high temperature and damp air (relative humidity 80 per cent or over), was crost in about twenty-four hours. This indicates a width of 300 miles, more or less. The wind continued from the east during much of this time, but was often interrupted by calms.

Cloud movements in the doldrums.—Much interest attaches to the directions of cloud movement in the doldrum belt, because of their bearing on the theory of the general circulation of the atmosphere. On June 29, at 2:30 p. m. (noon position, lat. 8° 46′ north, long. 44° 47′ west) cirrus was observed coming from the east, cirro-cumulus from east 20° south, and fracto-cumulus from the southeast, the wind being from the east. At 3 p. m. cirrus and cirro-cumulus were observed moving from the east. The east–west drift near the equator is here clearly indicated. These observations were taken near the southern limit of the northeast trade. On June 30 (lat. 5° 26′ north, long. 41° 21′ west) cirrus was noted coming from east 10° south, the vessel being then in the doldrum calms. The transition from doldrums to southeast trade was gradual, at about latitude 4° north. The lower clouds came from the southeast before the wind began to blow from that direction. In latitude 2° 39′ north, longitude 37° 39′ west, alto-cumulus was observed coming from southeast by east, and also from east 10° south.

The southeast trades.

For six days more, nearly to Rio de Janeiro, the delightful tradewind conditions already described were again experienced; six days more of ideal temperature, wind, sea, and sky, where simply to sit on deck is unalloyed satisfaction, and where, with the fresh, balmy trades blowing into one's open door and port-holes, sleep comes readily to those who, when ashore, dread the wakeful hours of the night. No high clouds were noted in the southeast trades. On July 3 the "green ray" was seen at sunset. The sun went down behind a heavy mass of trade cumulus, but the base of these clouds was about 10° above the horizon, so that the whole disk of the sun was visible as it set. After passing Cape San Roque the steamer's course took her not far offshore and it was noted that showers became more frequent. This is a characteristic phenomenon on windward coasts in the trades. Pernambuco, it will be remembered, has winter rains. It was also observed that near land the trades were less steady in direction. The development of heavy cumulus clouds over the land was clearly shown.

These same conditions were noted in these waters on the return voyage. After passing the northern tropical high-pressure belt, the barograph curve showed a general fall until the doldrums were reached, when a gradual rise began again as the steamer proceeded southward. The diurnal variation continued well marked, but less regular as higher latitudes were reached. The last day before reaching Rio de Janeiro the wind was northwest off the land.

THE STOP AT RIO DE JANEIRO.

Three weeks were spent in Rio de Janeiro (July 8–22, August 13–20). This period, altho short, gave a fair opportunity to study the winter weather types in the Brazilian capital. The winter climate of Rio is justly praised by the inhabitants. During the spells of fine weather, which are the dominant type, the early mornings are apt to be foggy, especially over the harbor and the lower portions of the city. This fog soon "burns off" and rises, breaking up into fracto-stratus clouds which later disappear. The days are fine, usually with a considerable development of cumulus or even cumulo-nimbus clouds, and the evenings are again clear. The temperatures as taken by the writer at his hotel averaged about 68° between 7 and 8 a. m., and 75° to 78° in the noon hours. During the heat of the day people wisely seek the shady side of the street and use sun-umbrellas. The mean temperature of Rio in July is 69.4°. The mornings and evenings are sufficiently cool to be delightful. Light overcoats are often comfortable when riding on the electric cars at night. The sight of the motormen enveloped in thick ulsters, running their cars thru streets lined with palm trees and illuminated by electric lights gives one a very singular impression of incongruity. In most of the Rio houses the windows are never shut. In fact, the "windows" usually have glass in the upper half only. The lower half is a louvered panel thru which the air is free to circulate. The prevailing winds are north-northwest by night and south-southeast by day thruout the year; but the night wind lasts until late in the morning. In the interval between these two winds calms prevail. Nephoscope observations during these intervals showed an almost perfect stagnation of the atmosphere. In general, the clouds at Rio were found to move from about west-southwest, a direction which accords quite well with theory. On one occasion, during the clearing off of a storm, some alto-cumulus were observed coming from west 10° north.

Winter is not the rainiest season in Rio, but occasional short spells of cooler, cloudy, and rainy weather interrupt the succession of fine days. The rains are generally light and do not last more than a day. A fairly heavy rain on July 16–18, which caused some damage in parts of Rio, gave an opportunity to see what weather map conditions[1] preceded and accompanied the storm. The pressure at Rio rose from July 14 to 18, and the writer's barograph showed a higher pressure at 10 a. m. on July 18 than at any other time during the period July 8–22. The diurnal variation remained fairly well marked during all these days. On July 15 Santos, 180 miles south of Rio, had rain in the morning, and Paranagua, about 150 miles farther south, reported fresh southwest winds on the preceding afternoon with rain on the morning of the 15th. At 9 a. m. July 16 the wind at Rio was northwest; Santos reported rain with a south wind; Paranagua had rain and a southeast wind. Rain began at Rio on the afternoon of the 16th, after a rapid clouding, and continued fairly heavy at times until noon of the 18th. These rains came in connection with a weak cyclonic area. The cyclone moved up from the southwest, in a general easterly direction, and then apparently past off to sea to the north of Rio.

The climate of Rio is unquestionably favorable to the development of the *anopheles* mosquito, and for long years yellow fever was prevalent in the city. But recently, thru the strenuous efforts of the sanitary authorities, the disease has been practically driven out. At the little English Hospital up on the hills above the city, the English nurses talk about "the old days of the fever." Petropolis, that charming little town 2,700 feet up among the Organ Mountains, need no longer rest its reputation upon the fact that to spend one's evenings and nights there insures safety from yellow fever. The cool nights, the attractive villas and gardens, and the surrounding mountains are sufficient to insure the popularity of Petropolis in the future.

[1] See also Monthly Weather Review, XXXVI, September, 1908, Chart IX.

THE CAMPOS OF SAO PAULO AND PARANA.

A hurried trip across the campos of southeastern Brazil (July 29–August 12), made partly by rail and partly in a rude form of buckboard drawn by four mules and known in Brazil as a "trolley," gave an opportunity to see something of a region which is destined to be of great economic importance in the not distant future. This journey led from Rio de Janeiro in a general southwesterly direction across the State of São Paulo and about half way across the State of Paraná, which adjoins São Paulo on the south. This portion of the country is seldom visited by tourists. Owing to the exigencies of travel, the amount of baggage had to be reduced to a minimum, and for most of the time the sling psychrometer was the only instrument at hand. Our route followed the Sorocabana Railway from São Paulo to its terminus at Buri. We crost the campos by "trolley" via Faxina to Itararé, took the São Paulo and Rio Grande Railway from Itararé to Punta Grossa, and then the Paraná Railway to Curityba. See the map, fig. 1.

FIG. 1.—Sketch map of the State of São Paulo, Brazil.

Campos, not dense tropical forests, are characteristic of most of Brazil. Fully three-quarters of the country are occupied by these wonderful rolling plains, here stretching as far as the eye can reach without other vegetation than tufts of coarse "goat's beard" grass, perhaps interspersed now and then with large brakes or stemless palms; here sparsely covered with scattering scrubby, gnarled trees, giving an appearance much like that of an old apple orchard whose trees are dead or dying; there again covered with a dense growth of trees and shrubs, all entangled with vines and creepers, and covered with long gray moss ("old man's beard"). Monotonous these Brazillian campos certainly are. They are vast. They are grim. But the monotony becomes variety to the observing traveler who catches the spirit of the place; who notes the change from open country to woodland, and from woodland to the sparsely-treed sections. There is infinite variety in the constant change of color; in the succession of forest and field; in the shifting cloud-shadows and bright sunlight. Very striking are the sudden transitions from open campo to dense forest: as sudden as if due to human agency, but in reality the work of nature or of fire. Fire has had much to do in determining present conditions on the compos. As one travels across these stretches by train or on horseback, the blackened fields and bare tree-trunks, furnish abundant evidence of the work of fire. In the dry season, scarcely an hour of the day or night passes without revealing the smoke or flame of a fire in progress—a fire which may have been burning for days.

The region crost by the writer is to-day very sparsely settled. A few small towns, at great distances apart; occasional scattering fazendas (ranches), or small huts built of adobe or wood, separated often by tens or twenties of miles—that is the present condition of occupation by man. Herds of cattle, horses, mules, and hogs are occasionally seen scattered over the immense streatches of open fields. Here and there, around the towns or where some settler has placed his lonely cabin, a little rude cultivation is attempted; some beans, manioc, and corn are raised, and where conditions are favorable, bananas, oranges, sugar cane, or rice may be seen. On the whole, the campos of this portion of southeastern Brazil are to-day examples of colossal waste—waste of sunshine, waste of rainfall, waste of soil. For leagues and leagues there are no houses, no cultivation, no human beings. In the State of Paraná, where there is more rainfall, one sees more cattle and horses; and there are more forests. Hence, lumbering and various industries which depend upon lumber, attract the attention of the traveler. There is no more interesting question in Brazil today, from the point of view of the development of the country, than that which concerns the future of these campos. What shall be done with them? Can they be made to produce good

pasturage? Can they be used for cereals? Are they to be a farming country?

The climate of the Brazilian campos.

The climate of these interior campos of São Paula and Paraná (average elevation about 2,500–3,000 feet above sea-level) is continental, with the modifications due to altitude. It is cooler and less humid and more desirable in every way for European immigrants than the seacoast, or the campos of the more northern states of Brazil nearer the equator. It is therefore natural that Europeans have settled so largely in the southern states, and it is inevitable that these states will become the most important, industrially and economically, in the country. The climatic conditions will bring about that result.

The campos of southeastern Brazil unquestionably have a winter climate which deserves the praise it has generally received from those who know it. Clear or fair days, with a strong diurnal range of temperature, were the dominant weather type in the latter part of July and early in August. The fresh, crisp, cool air and cloudless skies of early morning[8] are succeeded by a warm noon and early afternoon, with fresh southeast wind showing a distinct diurnal variation in velocity, and with a considerable development of cumulus clouds. The direction of the prevailing wind is clearly shown by the unsymmetrical growth of trees in exposed locations. Toward sunset the temperature begins to fall rapidly; the clouds dissolve, and clear, or perhaps foggy, nights follow with light wind or a calm. During winter nights, even in the northern part of the State of São Paulo, frost is by no means uncommon and the coffee plants are liable to injury on that account. The writer saw banana trees frost-bitten in a valley bottom in São Paulo at an elevation of about 2,000 feet above sea level. Farther south, owing to the increasing danger from frost, the coffee is planted at greater elevations on the hillsides. In Paraná, the minimum winter temperatures are a few degrees below freezing, and occur on nights following rains and southwest winds. During fine weather in winter the conditions are ideal for health and pleasure.

The rainfall on these campos is at a maximum in summer, but rains are evidently not wholly absent in the so-called "dry season." During the two weeks and a half spent by the writer on these campos rain fell on three occasions. On two of these the precipitation was cyclonic. The first storm began late one afternoon, with thunder and lightning, and continued about twelve hours as a heavy general rain with northerly winds, clearing off thru southeast and south to southwest, with somewhat lower temperature. The second storm was experienced in Paraná, farther south. It began at noon on August 1 as a very light, drizzling rain, following a clear sky on July 31. The wind was southeast, light, all day, and the temperature between 50° and 60°. A thunder-storm preceded the general rain, as in the case just referred to above, and the sky remained overcast about twenty-four hours, with a fine mist during most of that time. This storm cleared off with a west-northwest wind.[9] As soon as the cloud sheet broke up, about noon, the temperature rose about five degrees, reaching 55.5° at 2.30 p. m. The general rain clouds were soon succeeded by cumulus clouds.

The third rain was from cumulo-nimbus clouds. This thunder-storm was encountered in the open campo south of Buri about 5 p. m., July 25. It came up from the southwest, a magnificent anvil-shaped mass, with a long gray rolling squall-cloud below, advancing as an arched squall across the campos. A rough estimate gave the storm a width of about 30 miles. The lightning was vivid and constant. Only the northern edge of the storm reached the writer. A heavy fall of hail lasted about ten minutes, accompanied by a torrential downpour of rain. The average hailstones were about the size of small marbles; a few were larger. The hailstones collected in hollows to such a depth in some places that they could have been shoveled up. For an hour after the storm the wheels of the vehicle crunched thru hailstones at different points on the road. The bombardment was so heavy during the storm that the mules refused to face the wind, the leaders deliberately turning their heads to leeward in spite of all the driver could do. The rain washt the road badly on all slopes, gullies 2 or 3 feet deep being worn out in a few minutes. In the deeper hollows the water and mud and hail collected to a depth sufficient to make the crossing difficult. Unfortunately it was too dark to make any minute examination of the hail. The wind blew with considerable velocity toward the advancing storm for about a minute before the rain began, and the storm was followed by a calm, and close, muggy air.

At Jaguariahyva, the present northern terminus of the São Paulo and Rio Grande Railway, the meteorological record kept at the railroad offices showed the following conditions of rainfall: In February, rain on one whole day, two three-quarter days, two one-half days, and five one-quarter days; in April, rain on one whole day, and on three three-quarter days; in June, rain on one one-half day, and one whole day; in July, rain on three whole days in succession, on one one-half day, and one three-quarter day, the latter in succession. The record at this station covers rainfall only, recorded in the manner here given. Curityba (lat. 25° 25′ south, long. 49° 15′ west, altitude 908 meters), the capital of the State of Paraná, well illustrates the climatic conditions of the southern part of the campos where the writer crost them. At this place the maximum temperatures of early August are not far from 70°, while the minima fall to 45° or 50°, and sometimes lower. The prevailing winds were northeast and southeast; the relative humidity about 80 per cent. No rain fell during the writer's stay in Curityba, but the winter months are by no means rainless, July and August having mean rainfalls of 2.48 inches and 3.81 inches, respectively. The days were fine, with a predominance of cumulus clouds; and the diurnal temperature variation was very marked, with cool mornings and nights and warm afternoons. Nocturnal radiation fogs are evidently common in winter.

The fertility of the campos.

It is clear that the climatic conditions of the campos of southern Brazil are on the whole very favorable for the future utilization of this immense area. The soil is also, in the main, very good. Of course, conditions of climate and of soil vary in different parts of these campos. In some places the rainfall of the dry season is probably insufficient for agriculture without irrigation; in other places the soil is doubtless less fertile. But in the large, the Brazilian southern campos are better off than much of our own western country which now yields good returns in cattle and crops. The replacement of the "goat's beard" tufted grass by the native "catingueiro" provides excellent pasturage for cattle and horses. When the former grass is burned off, the soil plowed or dug under, and the "catingueiro" planted, the latter has been able to maintain itself, especially where the rainfall is abundant. In some places European grasses have been successfully sown, and it is almost certain that with proper care alfalfa or some other supplementary forage crop can be grown where necessary in order to provide fodder during the dry season. As to cereals, it is too early to venture any reasonable forecast. Vegetables have succeeded well where proper care has been given them, Some light is thrown on the latent possibilities of the country by the success which has been attained at the

[8] Observations made at odd times by the writer, but usually taken between 7 and 8 a. m. The readings in the early afternoon (12–2) gave 75°–80°.

[9] This was probably a local wind direction.

agricultural experiment station at Piracicaba in the State of São Paulo. Prof. J. William Hart, one of the corps of instructors at the station, reported to the writer that at this *Fazenda Modele* rather remarkable success has been attained in the cultivation of corn, barley, rice, cotton, alfalfa, and other crops. Again, at a ranch owned by a Frenchman, not far from Ponta Grossa, similar success with many different kinds of crops is reported. The best utilization of the campos is simply a question of time, of hard work, and of continued experimentation with different kinds of crops. Experiment stations should be established at several different points on the campos, and at each station every effort should be made to discover what kinds of crops will succeed best. At present the people are acting largely without intelligence, even when they make an effort to raise vegetables or other crops. They are not adapting their crops or their labor, which is very haphazard, to the climatic conditions. Cereals can doubtless be found which will succeed, possibly without, possibly better with, irrigation, Certainly in the more southern parts of the campos, e. g., over much of Paraná, there is abundant water for irrigating an immense number of farms.

No one who crosses these campos of southern Brazil to-day can for a moment doubt that the country has a splendid future. It may be almost wholly a cattle country; it may be most valuable for sheep raising; it may perhaps be best utilized for corn, or wheat. To the writer it seems likely that the campos of the states of São Paulo and Paraná, and probably also of Santa Catharina and Rio Grande do Sul, might be best utilized as a country of small farms, where horse and cattle raising will be supplemented by crops of alfalfa, sorghum, or corn for the animals, and of vegetables and some cereals for local consumption. Irrigation will doubtless be found desirable, even necessary in places. Climatic obstacles such as hailstorms, drought, sudden heavy rainfalls, and frost, must be reckoned with here as in other parts of the world. The ants must be kept under. Prairie and forest fires must be prevented. Man nowhere finds himself without some such hostile manifestations of nature. The cuts and embankments of the railroads of these campos are prophetic of the future. In imagination the traveler may already see the thru trains between Rio de Janeiro and Montevideo crossing the campos, and may picture to himself this wonderful country, now so striking an example of colossal waste, a settled, peaceful, and prosperous agricultural community.

Supposed climatic changes.

The fact of climatic change has often been regarded as established in cases where certain cereals or fruits formerly successfully raised in a certain locality, later no longer grow there. In Brazil the writer happened upon two cases of this kind which illustrate very clearly the danger of jumping at conclusions in such matters. The first case concerns coffee; the second, cotton. The traveler between Rio de Janeiro and the city of São Paulo may to-day see from the train miles and miles of abandoned coffee plantations on the hills, with the fazendas of fifty years ago falling to ruins in the midst of the old plantations. Whoever looks at these barren hillsides, especially in winter when they are dry and dusty, may easily be tempted to conclude that a change of climate has made coffee growing in this district impossible. Such is not the case. The fact is that coffee has been found to succeed so much better farther south in the State of São Paulo that it no longer pays to keep up most of these old plantations in the State of Rio de Janeiro.

In the second case, that of the cotton, the writer was told that this staple used to be successfully grown along the line of the Sorocabana Railway during our civil war. To-day the three or four cotton factories in and near Sorocabana find the local production of cotton insufficient for their own use, and import the raw material from the north, chiefly from Pernambuco. No change of climate has taken place here. The cultivation of cotton in the United States since 1865 has eliminated the American market. Cotton succeeds better and is produced more cheaply in the north of Brazil; and coffee has been found to yield larger returns than cotton in the State of São Paulo. These three reasons are more than sufficient to account for the abandonment of most of the cotton fields along the line of the Sorocabana Railway.

CLIMATIC CONTRASTS IN BRAZIL.

Two short railroad trips in Brazil furnished striking evidence of climatic contrasts resulting from the presence of mountain barriers. The first, from Curityba, at an altitude of 908 meters, to Paranaguá, at sea level, is made in about five hours. Starting from Curityba, which is situated in a typical campo region, in a cold early morning fog, and crossing the gently rolling, open campos to the east, the train crost the coast range, or Serra do Mar, at an altitude of about 3,000 feet, within two hours. Descending the eastern or seaward slopes by a splendid series of tunnels, viaducts, and embankments, the train reached Paranaguá in about three hours more. The contrast between the campos and the sea-level conditions is remarkable. The seaward slopes of the mountains are densely covered with the most luxuriant vegetation. The trees are overhung with moss, creepers, and parasitic plants of all kinds. The undergrowth is a tangled mass of low shrubs, bamboos, and brakes. Palms, which are absent on the campos, are seen soon after commencing the descent. Then come banana trees, at first singly and scattering; then more and more thickly. On the lower slopes, and especially on the lowlands near sea level, sugar cane, banana groves, guavas, and papaws, furnish striking evidence of the change from the cooler and drier interior upland campos to the warmer and rainier seaward slopes where frost is unknown. The change in temperature and in humidity during the descent is very striking. It was significant that the freight carried was cattle on the campos, while on the seacoast lowlands cars full of bananas were attached to the train.

A second case of marked climatic contrast was obtained on the railroad trip from Santos, the famous coffee port about 200 miles south of Rio de Janeiro, to the city of São Paulo, on the campos. This journey takes the traveler by an inclined plane cable road up to an altitude of a little less than 3,000 feet in a horizontal distance of five miles across the Serra de Mar. The trip, while less picturesque than that from Curityba to Paranaguá, is well worth taking. On the seacoast lowlands there are flourishing plantations of bananas. As the train ascends the densely-wooded seaward slopes of the Serra the bananas are soon left behind, and after the crest is past the well-known features of the campos are again met with. The best time to take this trip is on the 4:30 p. m. train from Santos, for it is then that the change from the hot, steamy atmosphere of Santos to the cool upper slopes and crests of the mountains is most striking. The rainfall on the seaward slopes of the Serra is very heavy. Some years it exceeds 160 inches, and the annual mean at the summit station is 140 inches. The mean temperature at the summit station is 64.4° as against 71.2° at Santos. The engineers of the São Paulo Railway have an incessant struggle to keep their road in repair. The trip from Santos to São Paulo is well worth taking as an illustration of marvelous engineering work in the face of great odds. The whole face of the mountain up which the railroad runs is in places walled up with brick and masonry, and brick or concrete drainage ditches and canals have been built up and down and across the mountain slopes in all directions. One of the engineers of the road made the statement that the ambition of himself and of his colleagues is to know what becomes of every drop of water that falls on the seaward slopes of these mountains.

Certainly this is a very good illustration of the control over railroad construction and operation which results from a heavy rainfall on steep slopes. An old railroad line, the one first constructed and now replaced by the new one at a better grade, is kept open and ready for use in emergencies, in case the new line is washed out. Both the Paranaguá and Santos lines across the coast mountains of Brazil furnish excellent examples of sharp climatic contrasts between warmer, damper, and rainier seacoast lowlands, and cooler, drier uplands within a few miles of the sea but separated by mountains of moderate elevation.

THE RETURN VOYAGE.

The voyage back to New York from Rio de Janeiro (August 19–September 6) brought, in general, a repetition of most of the weather conditions recorded on the outward voyage. The southeast trade with glorious trade weather, trade cumuli, and occasional short rain squalls, was carried up to about latitude 2° north. The temperature rose from 75° to 81.5° as lower latitudes were reached. While at anchor off Bahia, the southeast trade seemed to blow stronger during the warmer hours of the day. The wind here blows away from the city, out over the bay, so that the boats which carry passengers to and from the steamers sail out without difficulty, but must tack or be rowed back to the quay. As the east-southeast and southeast winds weakened light variable winds, calms, and doldrum showers were experienced. The steamer crost the doldrum rain and cloud belt in about twelve hours, but the interval between the well-marked southeast and northeast trades was about twenty-four hours, or 250 to 300 miles. The northeast trade was picked up in about latitude 6° north.

The "green ray" was again observed on August 23. The western sky was clear, except for a few scattering fracto-cumulus clouds above the sun, but the sun itself set in a haze over the land.

After passing Cape San Roque, the ship's course was altered to nearly northwest. The southeast trade thus became a following wind, blowing in the same direction as that in which the vessel was steaming. The relative velocity of the wind felt on board thus became very light and the passengers began to complain of the heat. As a matter of fact, the temperature of the air was exactly the same as when the wind was on our beam; the difference in the "sensible temperature" was due solely to the difference in wind velocity. This is a good illustration of the importance of wind in controlling our feeling of heat or cold, for none of the other factors (temperature, humidity, state of sky, exposure, etc.) which control the "sensible temperature" had changed at all. It was noted that the trade showers, coming from the southeast and therefore moving in the same direction as the steamer, lasted perceptibly longer than when the course of the steamer and the direction of progression of the showers were nearly opposite to one another, as on the outward voyage. Few observations were made with the nephoscope, as practically no clouds except trade cumuli were seen. No cirrus was seen near or on the equator. About 6° north of the equator some cirrus and cirro-cumulus were observed coming from north 10° east and north 20° east.

On August 28, when about 50 to 75 miles offshore, the greenish color of the ocean showed the effect of the fresh water of the Amazon and served to remind the observer of the enormous amount of water which falls as rain over the Amazon Basin. The strong northwest set of the ocean current off the northeastern coast of South America here gave the steamer the largest daily runs logged during the entire voyage, out and back.

While at anchor in Carlisle Bay, Barbados, the effect of the land was noted in the high temperatures observed on board, 84.5° at 4 p. m. being the maximum. No readings as high as this were obtained at sea. While passing within sight of Guadaloupe, Deseada, Antigua, and Barbuda the heavier growth of cumulus clouds over the islands than over the sea was distinctly seen. The temperatures during this time averaged 1° to 2° higher than at a distance from land.

The northern limit of the northeast trade was reached at about latitude 22° north. The easterly wind gradually died out, and a day of very unsettled weather with squalls and thunder-showers followed, and then came the fine weather and light variable winds and calms of the Horse Latitudes. The day before reaching New York there was a northeast wind and cooler weather, followed by falling barometer on September 6, with southeast wind and rain. The change from the steady conditions of the trades had come; the barograph began its familiar irregular curve as it registered the approach and passage of a temperate-latitude cyclone; the general rain, heavy nimbus clouds, and changing wind—all were unmistakable signs that the traveler had again entered the familiar meteorological conditions of home.

The steamer anchored at 6 p. m., Sunday, September 6, off Bedloe's Island in New York Harbor, almost under the shadow of the Statue of Liberty. The closing meteorological scene was a magnificent thunder-storm which past over the city and harbor that night: a fitting ending to a summer spent, as this was, in search of weather.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Librarian.

A NEW EDITION OF HANN'S CLIMATOLOGY.[1]

The second edition of Hann's "Handbuch der Klimatologie" was published in 1897, and an English translation of the first volume, dealing with general climatology, was published by R. DeC. Ward in 1903. Volume II and III, which constitute the most extensive climatography of the world that has yet been written, and are the great basis of reference to the literature of the subject down to 1897, have unfortunately not been translated into English.

All meteorologists will welcome with the greatest satisfaction the publication of the third edition of this work, of which the first volume, "General Climatology," has just appeared. The pages are much larger than in the preceding edition; hence Volume I, with a slightly diminished number of pages, contains actually about half again as much reading matter. Nearly every page shows the incorporation of new material, and an entirely new chapter has been added, dealing with the climatic zones of the earth. In the second edition this subject was briefly treated in Volume II.

Even greater interest will attach to the appearance of the remaining volumes, as it is especially the climatographic portions of Hann's work that have fallen behind the present state of knowledge. Many regions that were *terræ incognitæ* in a climatological sense eleven years ago are now dotted over with meteorological stations; and the work of computing normals has everywhere gone ahead rapidly. Hence, the two volumes on special climatology, tho indispensable in the absence of any later authority, are in urgent need of revision.

METEOROLOGY IN THE TRANSVAAL.

The annual report of the Meteorological Department of the Transvaal for the year ended June 30, 1907, is at hand, and records a healthy growth in that service, and activity in many interesting lines of work. The number of meteorological stations reporting to the central office at Johannesburg is now 407, an increase of 31 since the last report. On July 1, 1907, the department was transferred from the colonial secretary's office to the lands department.

A daily forecast for the ensuing twenty-four hours is prepared at Johannesburg at 3 p. m. and wired to every postal

[1] Hann, Julius. Handbuch der Klimatologie. 3d ed. I. Band: Allgemeine Klimalehre. Stuttgart: J. Engelhorn. 1908. xiv, 394 p. 8°.