Wind and Storm

Our subject, Wind and Storm, is entirely too large for us to think of presenting more than its principal features in a single lecture.

We will only attempt to give the most important facts in as nearly their natural order as possible, leaving out for the want of time very much, which is of importance to a complete understanding of the subject in its more minute detail. Very few, if I mistake not, are keeping up with the rapid developement of our knowledge of the subject, or have any idea of the vast amount of labor that is being bestowed upon it. I will therefore take time to give you a hasty historical sketch of the work done in recent times and some account of what is being done at present. Before beginning this, however, we have a few words to say of weather prophets.

In all ages of the world men have exhibited the greatest desire to know today, what the weather will be tomorrow. Every age has had its weather prophets, and the sayings of these predictors have been more or less sought by all classes of men; from the lowest to the highest, wise and unwise. In all ages of the world the wise have finally found that the predictions of the prophets have been utterly unprofitable, if the forecast was for a greater period than twenty four hours in advance of present time. Most weather prophets of the past have depended, or pretended to depend, upon the position of certain stars for their information. We wish to say now, in order that we need not again allude to the matter, that all such weather prediction is utterly worthless. And as there is at the present time so much of this going on by our friends, Venor, Tice and others I should perhaps give some reasons for making so broad a statement;

In recent times scientific men have been eager to obtain all kinds of practical information upon this subject, and have investigated all of these theories of the influence of the moon, the conjunction of the planets, positions of the stars &c, upon the weather, All of these popular notions, which have found place among the people, have been subjected to the closest scrutiny, by men who were capable to deal with the subject, and had the data by which they could arrive at correct conclusions. The principal Astronomical Observatories of the world have for years kept the most complete records of the weather in their localities, and the observation of the positions of the heavenly bodies is their business. Now in order to test any theory of the influence of the moon in its different phases, positions of the planets &c, is to lay the records of the weather alongside the chart of the positions of the heavenly bodies said to influence it, and read off the results for twenty-five or fifty years. For instance if the change of the moon is said to bring rain, the weather at each change is examined for fifty years back and compared with the weather in the intervals. If the conjunction of certain planets is said to bring bad weather, the condition of the weather at each such conjunction is examined and compared with the weather in the intervals for a great many years. When examined in this way all these theories have proven utterly worthless; the weather has continued to do as it liked notwithstanding the protests of the stars and the star gazers. I think every one will understand how easy it is for those who have these records at hand to settle all such questions and settle them in a way that leaves no room for doubt. Having said this much upon this phase of weather prediction, we need not allude to it again during the evening.

By the 1st we ascertain the facts
By the 2nd we ascertain the laws of winds and storms
By the 3rd we utilize these laws

Divisions of the subject.

The study of the weather presents three departments; namely,

1st The observation and recording of the present weather.

2nd The study of the records of past weather.

3rd The foretelling of future weather.

The first is necessary to the second; and the first and second are necessary to the third, which is the principal object of the study.

Weather prediction presents two departments which are perhaps equally desirable,

1st The foretelling of the weather of the immediate future, as, for one, two or three days in advance, as is now being done by our government signal service. This enables us to avoid, or at least gives us time to prepare for the dangers of sudden and violent changes.

2nd The foretelling of the general character of the next succeeding season. In this department the forecast of the general character of the weather in its effects upon the principal crops, is the most important in all agricultural districts.

We wish now to call your attention for the most part, to the prediction of the weather which will prevail in the immediate future, and the discovery of the laws which have enabled us to do this with tolerable accuracy. This comes mostly under the head of the observation and recording of present weather.

Historical Sketch.

We will first trace the history of the discovery of the laws of winds and storm, and then try to explain, as far as we may, their cause. Standing first, both in importance and in time, is the discovery of storm motion. By the term storm motion is meant something entirely different from the apparent motion of storms. A cloud comes up with a wind from the south or the southeast, and we have rain. The storm appears to us to come from that quarter. This is not what is meant by storm motion. We have no reference to the direction of the wind, or the visible movement of clouds, but refer to the motion of the storm as a whole, which is independent of the direction of the winds accompanying it. This was first noticed by Benj. Franklin and Louis Evans each separately, between 1740 & 1750.

Franklin was caused to notice it by the fact that he was prevented by a storm from observing an eclipse at Philadelphia and afterward found that it had been observed at Boston before the storm came on. An examination of local reports showed that the storm had progressed regularly northeastward, although, at most points it had come up with an easterly wind. This is the first simultaneous observation at different points recorded, and slept unnoticed for many years.

In 1833, nearly one hundred years later, Kantz made an attempt to set down on charts a week or so after date, as soon as he could then ascertain the facts, the actual condition of the weather prevailing at a given hour over a considerable area of country. His charts soon gave him the idea of the regular motion of storms, confirming Franklin's observations.

In 1847 Wm. C. Redfield suggested, (in the American Journal of Science for that year,) the idea of employing the telegraph in the study of the weather. Kantz's observations alluded to above, and similar observations that were being made by Mr. Redfield, and others, were developing the following notions;

1st Storms move in a regular and definite direction.

2nd Storms are circular in form.

3rd Storm winds blow in a circular direction around a center which moves forward with the storm.:

These ideas were vigorously opposed by the late Admiral Fitz Roy and others, and much discussion resulted, much of which will be found in the journal above referred to. Mr. Redfield's idea was, that by the use of the telegraph, the facts might be traced as they occurred. His great ability and the zeal with which he pushed these studies, have won for him such distinction that he has been accredited with the discovery of storm motion; in this however, he was anticipated by others.

In 1848 the same proposition was made to a British scientific association by John Ball, but nothing was done.

In 1850 the Smithsonian report suggested the idea of wall maps exhibiting simultaneous weather observations over a large area of country. This institution was already collecting and collating weather reports upon an extended scale; but the observations upon which they were based were not simultaneous. In 1855 Leverrier exhibited to the Paris Academy of Science maps exhibiting the condition of the weather at the same instant in different parts of France.

The idea of wall maps was first carried into effect by the English Telegraph Co., which caused maps to be set up at their several stations with hands affixed at principal points. These were set at certain hours each day to show the

I would not be able to give any clear explanation of the cause of the Tornado unless the causes of winds and the forces operating be understood

I will therefore give some history of the progress of the exact study of the winds as showing the manner in which information of the facts have finaly and are now being obtained - The theory of winds and storms - And then speak of Tornados direction of the wind for each locality, thus presenting to the eye the existing current of wind over a considerable scope of country. No records were kept however, and the results were lost—

In 1858 Buys Ballot Law was propounded, which was this; "In the northern hemisphere the wind always flows so as to keep the lowest bar, on its left-hand." In making this announcement the Dutch Professor told much more than he knew, he had discovered a fact and he announced it without knowing its value. His statement was not exactly correct, but very nearly so, for if we stand with our back to the wind the left-hand must be thrown forward from twenty to thirty-degrees to point to the lowest Barometer, We will speak of this again.

In 1860 Leverier asked the cooperation of England in a system of weather Telegraphy, but failed to obtain it. Three year later Leverier issued his first chart with his bulletin international.

In the same year Galton published his Meteorographica in which by different colored symbols he brought into prominence the idea of the different kinds of weather, associated with winds from different directions. In 1862 the first attempt was made to publish a daily weather chart in England. It was to be furnished to subscribers at two shillings per month. The project was still born, only one issue being published. In 1863 the late Admiral Fitz Roy made an extended practical test of weather telegraphy in England with marked success. It seems that the Admiral undertook this test believing that the circular theory of storms would be disproved; the theory was confirmed.

In 1871 Charles Chapman of the Shipping and Mercantile Gazette, England, made the next attempt to publish a daily weather chart. This has been continued regularly ever since. In 1875 the London Times began the same thing, which is also continued. Previous to this time Maury had made his wonderful chart of the prevailing winds of the world, especially of the oceans. I suppose all know what is meant by a ship's log book, a book in which the vessel's position, direction and rate of sailing, and the incidents of the voyage are noted. In these books the condition of the weather and direction of the wind each day, often each hour, is noted. Now Maury gathered up the old log books from all parts of the world. He spent many years in gathering together all that could be obtained. Records from observers on the land were also gathered together. From these he found the average number of days on which the wind blows from certain directions in each month in the year for all parts of the world, but especially of the ocean.

This was for the time the most perfect wind map that had been made, and was of vast importance to sailors; for by it they could so direct their course as to obtain the best winds. This resulted in shortening the time of all long voyages. It also gave a vast amount of practical information from which to deduce the laws of wind and storm. It is a curious fact that in the making up of this valuable chart by Maury, no idea of the circular motion of storms was developed. He seems to have worked with a single thought, which was to find, and chart the prevailing winds for each month in the year, for every locality for the benefit of sailing vessels.

During the session of the congress of the U.S. of 1869-70 a bill was passed establishing the U.S. weather signal service, as a portion of the war department. This result was brought about, mostly I think, by the fine results obtained by the Smithsonian Institute, which had for many years been obtaining daily reports from various parts of the U.S. These reports were for the most part from persons who made the observations, and reported them without pay, the Smithsonian Institute furnishing the instruments.

Nov. 1st 1870 at 7-35 A.M. Washington meantime, the first systematized syncronous meteoric observation ever made in the U.S., was taken by the observing sargent at 23 stations. This began our present signal service. The observations were taken three times per day, and all at the same instant of time, that is by Washington time; not by the local time at the stations. The results of these observations are recorded in tridaily maps; and with these are noted every thing of any importance connected with the weather; as the height of barometer, the degree of temperature, the humidity of the air, whether the weather was fair or cloudy, and if cloudy, the degree of cloudiness and the character of the clouds, the direction and force of the wind, the amount of rainfall, the amount of snow; every storm is traced from its beginning to its end or until it has passed the boundaries of the U.S. This record is bound in monthly volumes and forwarded to each person regularly engaged in meteorological observations. The stations of this service reporting by telegraph now number about three hundred in the U.S., besides several stations in Alaska from which records are received as often as opportunity offers. Canada also has a number of similar stations which coöperate with ours.

In 1873 the International Meteorological Congress convened at Vienna, composed of official representatives from the principal governments of the world. It was there proposed by Gen. Myer, the representative from the U.S. that "It is desirable with a view to their exchange, that at least one uniform observation, of such character as to be suited to the preparation of synoptic charts, be taken and recorded daily and simultaneously, at as many stations as practicable throughout the world." This was concurred in and led to the establishment of the international weather service which is now in full operation. Map No. 9. shows the storms of one month throughout the civilized world, as charted from the international daily bulletins. In this service we have at the present time, cooprating with the U.S. and exchanging observations, the following countries, covering their territorial extent more or less perfectly; Algiers, Australasia, Austria, Belgium, Central America, China, Denmark, France, Germany, Great Britain, Greece, Greenland, Iceland, India, Italy, Japan, Mexico, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Tunis, Turkey, British North America, the Azores, Malta, Mauritius, Sandwich Islands, South Africa, South America and West Indies. The results of these observations have been charted and published daily by the U.S. since July 1st 1875.

In addition to these, all the principal astronomical observations of the world and a great number of scientific men, in their private capacity, are furnishing their observations regularly and receiving in return, the national and international report; By order of the war department all U.S. vessels, in whatever seas they may happen to be, are required to give their position and make the observations at the same hour of Washington time, as they are made by the government stations on land, and report the same to our signal office at the earliest practicable moment. All the principal lines of ocean steamers plying between the U.S. and other countries, are voluntarily cooperating, and furnishing their reports regularly. Each ship thus becomes an observing station, and but for the fact that their reports cannot be instantly telegraph to the chief office, as upon the land, these would be as valuable as any. They answer the purposes of after study just as well, and they are now sufficiently numerous on the Atlantic, between us and Europe, to furnish us very perfect charts of the winds and storm of that region. The vessels of the Pacific ocean give us less perfect charts of the regio between our western coast and China, but they are sufficient to define the storm tracks with tolerable accuracy.

We have now given you a hasty recital of what has been and is now being done under the first head or department of this study, the observation and recording of present weather. We have done this for the purpose of showing the regular and systematized manner in which the subject has been, and is now being studied. The facts which have been gathered have not been the work of any one man, but of a great many men working separately, but interchanging their notes. The theories deduced have been the result of the comparison of the facts gathered by all, and have borne the scrutiny of the intelligence of the world. They have, as far as possible, been subjected to practical tests. Today, and every day, the seaman upon our coasts, consults our government signals before putting out to sea, for he has learned from many tests, that the signal officer with his tridaily reports from observers scattered throughout the U.S., can tell better than he, what weather he will meet on the morrow, notwithstanding all his sailor experience,

Results of the study of the records of past weather.

We pass now to the 2nd department of our subject, the study of the records of past weather. Under this head we shall attempt only to give you a brief summary of what has been arrived at by this study. This department has been prosecuted with all the diligence of the first. Every new fact has been closely scanned and assigned to its true place, as nearly as possible, with the collection already made with which to associate it. From the facts so gathered, theories have been deduced which have been corrected and recorrected, as time and additional knowledge suggested. We will give an outline of these as we understand them. For the purpose of explaining them more easily I have had a number of maps drawn, which I have converted into wind and storm charts. (No. 1

(maps →

is a map of the western hemisphere upon which I have made a purely theoretic chart of the prevailing winds from the equator to the north and south poles. No. 2 is a map of the northern hemisphere upon which I have so placed arrows, as to make a theoretic chart of the prevailing winds of the northern hemisphere. No. 3 is an enlarged copy of an international storm chart, in which the storm tracks for one month are shown. No. 4 is one of the U.S. storm charts which records the storm tracks of our country, for the month of December 1881. No. 5 is a chart of abnormal storms. No. 6 is an illustration of the cyclone and anticyclone.

The Cause of Winds.

In entering upon this study it is necessary that you get the idea of a ball surrounded by an atmosphere, and keep the whole volume in your mind, as a whole, and not by parts or localities, for we must now deal with the whole mass of the at-

V

mosphere.

(The cause of winds may be deduced into two principal and two modifying causes.

1st The difference in temperature between the equatorial and polar regions, produces north and south currents; Modified by the reduced diameter of the earth toward the poles, which will not allow of a continuous, unbroken current from the equator to the poles.

2nd The rotation of the earth which causes east and west currents; Modified by the formation of eddies or whirls, which produce variable winds. Besides these, there subcauses or local modifying causes might be mentioned as;

1st. Mountain ranges.

2nd. Ocean currents of warm or cold water,

3rd. Local differences in the temperature of the land or sea, or land and sea.

The 1st cause, The difference in temperature between the equatorial and polar regions, produces north and south currents of air. Under this cause we may construct the following law, Cold air is inclined to move toward a warmer region and warm air is inclined to move toward a colder region, or warm air is inclined to move toward the north and cold air is inclined to move toward the south, and will do so unless hindered by counteracting influences. If this cause met with no hindrance, we should have only north and south currents, the warm air moving northward and the cold air moving southward. The air of the equatorial regions would rise up and roll away to the north, forming an upper current to the poles, and having become cold would fall and return southward to the equator, ~~again~~ forming a distinct lower current, as shown by the lines drawn above map 1. The shape of the earth prevents such currents from becoming continuous. The largest diameter, following the parallels of latitude, is at the equator, and it rapidly diminishes toward the poles. For this reason a continuous current north from the equator, forming a belt around the globe, cannot pass to the north pole. The diameter of the earth very soon becomes too small to accomodate it, and a portion of it must turn back again toward the south. This we find it actually does, varying somewhat with the seasons, at about twenty-five or thirty degrees from the equator, as shown by the curved arrows in black on maps Nos, 1 and 2. Now as the diameter of the earth diminishes rapidly from this point northward, it follows that a portion of the north bound current must be continually turning back, through all the distance to the pole. From about parallel thirty, to the equator there is no northward

habits of an animal in their
completeness upon a few ~~[illegible]~~
square miles of teratory but
to study the phenomena of a storm
in its completeness he must he
must be able scan the continent
almost at a glance

This could only be done since
we have had the telegraph and
this is sufficient reason for the
fact that this subject has not
been successfully studied until
very recent times ~~Therefore~~
~~because knowledge of this subject is so little diffused~~
~~In a lecture of this kind it seems~~
~~necessary~~ ~~Therefore~~ Because of this
and the little diffusion of this
knowledge as yet It seems necessary
in any such Lecture as ~~this~~ is proposed
this evening to begin forth the
primary facts in order to
be understood

current of air at the surface of the earth. There must therefore be a compensating northward current in the upper regions of the atmosphere. These we have marked in the long curved arrows in red. The reason for this curve will be found in the cause of east and west winds. From this point about 30° north, to the poles, the north and south currents are continually changing places, so that a part of the time there is a north wind and part of the time a south wind on the surface. The prevalence of these currents vary at different times and places. In this region upon the average throughout the year, the south wind blows about ~~four~~ five days, for ~~one~~ 2 day of north wind.

Line

South to North

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Direction of wind as observed in 3 daily observations for the year 1880 (1095 observations) by the Signal service observers at the following stations extending from Key West Fla. to Marquette Michigan

	Northerly.	Southerly.	Easterly	Westerly.
Key West	302.	388.	890.	93.
New Orleans	352.	446.	672.	226.
St Louis	345.	491.	272.	293.
Springfield (Illes)	336.	544.	266.	401.
Chicago Ill.	268.	547.	277.	516
Marquette Mich	451.	379.	230.	635

Pacific Slope

	N	S	E	W
Olympia Wash	378.	590.	123.	312.
Portland Oregon	397.	525.	270.	540
Sacramento Cal.	361.	574.	121.	359
Average	478.	543	171	403

Line east to west

New England

	North	South	East	West
New port R.I.	578.	446.	188	627
East Port Mass	463.	468.	273	438
Philadelphia Pa	454.	411.	240.	597
Average	498.	441.	233	554

Lake Region

	N	S	E	W
Toledo Ohio	272	523	279	592
Detroit Mich	288	495	241	652
Chicago Ills	268	574	277	516
Milwaukee Wis	234	510	284	490
~~Keokuk Iowa~~ Average	265.	525.	270	562

The Northwest

	N.	S.	E.	W.
Duluth Minn	690.	269.	484	587
Pembina D.K.	426.	390.	168.	474.
Pikes Peak	323.	552.	155.	749
Average	479.	403.	269.	603.

Please remember that in speaking now of north and south winds, we have reference to winds inclined north, or south, no matter how much they may move eastward or westward. (Line North & South)

The 2nd. cause of winds is the rotation of the earth, which causes east and west winds. This cause of winds acts upon the whole body of the atmosphere, already thrown into currents, moving northward and southward by the first cause, and modified by its special modifying influence.

The rotation of the earth toward the east carries its surface at the equator, eastward a little over one thousand miles per hour. This rapid motion constantly decreases as we pass from the equator toward the poles; at 60 degrees north its motion is diminished one half ~~by~~. Therefore if we start with the southward current, arrows in black on maps 1 and 2, at about parallel 30 or 32, we will find it making a great curve to the westward, laying loosely upon the earth and floating southward it has not acquired the greater momentum of the earth near the equator, and it does not keep up, the result of these combined movements, is the north-east or trade winds of the north tropics. As it presses on southward however, it gradually acquires the momentum of the earth, hence at the equator we have a zone of calms in which the heated air rises up into the colder regions above, and lets fall its moisture in copious showers, which are alternated with sunshine, known to sailors as the Doldrums. Having risen up it rolls away toward the north, as stated under the first cause, but carrying with it the eastward momentum of the equatorial regions. Hence when it begins to fall to the surface north of parallel 32, as described under the 1st. cause, its motion eastward is greater than that of the earth in its diminished diameter, and it presses the whole volume of the atmosphere to the east. This eastward impulse is kept up through the temperate and frigid zones, in both the north and southward currents; that is to say, in the northern regions the atmosphere, partaking of the motion of the equatorial region, moves east faster than the earths surface, producing our westerly winds; In the equatorial regions it fails to keep up with the increased rapidity of the earth's surface, and produces our easterly or trade winds.

East and west current on Line

One of the difficulties heretofore experienced in constructing theories of the cause of winds, has been the supposed necessity of counter currents east and west. The supposition that if there be a westerly current at the surface, there must be an easterly current above, to compensate for it. The more extended observations of recent years dispels this idea. The east or west movement is around the earth. There is no compensating current.

From the equator to parallel 28 or 30 the currents are all westward except a periodic reversal in the longitude of India, known as the monsoon. Then we have a narrow zone, in which the currents are nearly north and south, almost no east or west winds. North of this the prevailing currents are all eastward. When we speak of prevailing currents we mean the wind that blows the greatest number of days in the year.

North and south currents do not pass around the globe, but from the equator toward the poles and back again. Therefore in this direction we must have compensating currents. The winds of the northern and southern hemispheres are counterparts of each other, as the left side of a man is the counterpart of his right side; therefore a description of the one, suffices for the other, until we reach local modifying influences. Thus far we have spoken only of the prevailing currents, a current north, a current south, a current west, south of parallel 30, a current east, north of this. The combination of these for the temperate and cold regions gives us winds from the northwest, and from the southwest, but from no other quarter, leaving the cause of our variable winds, blowing from every point of the compass unexplained.

Show winds on line

We will find the explanation of the variable winds in the cause modifying the east and west currents. This is the most intricate and difficult part of our subject, and to gain a clear understanding of these variable winds we must keep the propositions already laid down clearly in view. As already stated this modifying cause is the formation of eddies or whirls of wind.

These are two in number, known

Tornado - "From the latin - Tornare to turn; that is a turning wind" Webster
Webster also includes Huracan as practically synonimous -
Hurricane. From the Spanish Hurrican, a violent storm - is now more generally used to indicate a violent straight wind rather than a whirling wind
Cyclone - The tendency - started by Gen Myer I believe - is now to confine the word to the large gentler whirl of the ordinary warm rotary winds which accompany the low Barometer
Anticyclone - accompanies the high Barometer

as the Cyclone and Anticyclone. In our study of these we will find the cause of storms. (Explain the words Cyclone and tornado)

Cyclone and Anticyclone.

The causes of the cyclone and anticyclone are;

1st. The warming of the strata of air at and near the surface of the earth.

2nd. The rotation of the earth.

3rd. The form of the earth.

Each of these must be considered as standing in intimate relation to the causes of winds already explained.

The cyclone is a column of warm air ascending from the earth with a gyratory motion, in a direction against the hand of the watch, and inward toward its center, in the northern hemisphere and with the movement of the watch in the southern.

The anticyclone is a column of cold air descending to the earth with a giratory motion, in a direction with the hands of the watch, and outward from its center. In the southern hemisphere the direction of the giration is reversed. The first and principal cause of the cyclone and anticyclone is, evidently the difference of temperature between the upper and lower regions of the atmosphere. Here the atmosphere obeys the 1st. law; warm air has a tendency to move toward a colder region, cold air has a tendency to move toward a warmer region. This law holds good whether the direction be up, down, north or south. Our atmosphere evidently loses heat fastest at the top, its heat is carried off into space by radiation and the upper strata become very cold, while the lower strata, lying upon the earth become comparatively warm. Then a change occurs, the warm air ascends and the cold air descends; in each case, evidently in the form of a column with a broad base on the earth. While doing so, it obeys the forces which cause the prevailing currents already discussed; hence in the latitude of the eastward current, the ascending column or cyclone, while ascending, moves also to the east and north. The descending column or anticyclone, while descending moves also to the east and south. In the latitude of 30 to 35, where we have only north and south currents, with oscillations east or west, the cyclone moves north and the anticyclone south, but may oscillate eastward or westward.

South of latitude 30 to the equator they both move westward. (Explain from chart)

A cyclone formed in latitude 20° would move nearly westward, but tending to the north, and through the degrees from twenty to forty it describes a great curve to the north, and finally to the northeast, and possibly to the east. Between the latitudes of 40 and 60° the course of the cyclone varies somewhat in different parts of the world, as may be seen by a glance at map 3. Beginning at the Mississippi river, the movement is northeast, until the west coast of Europe is reached. In parts of Europe and Asia the course is inclined to the south of east. From the eastern coast of Asia to the middle of the Pacific ocean, the course is again north east. Then from that point to the Mississippi, the course is south of east.

The rate of motion of cyclones varies greatly. They travel much slower while making the curve to the north than after their motion becomes more eastward. A few cyclones have been traced almost around the earth, and if they had continued at the same speed, would have made the entire circuit of the globe in about one month. See storm track no. on map no. 3.

The cause of the definite giratory motion of the cyclone and anticyclone is to be found mostly we think in the rotation of the earth.

When that part of the atmosphere forming the trade winds, reaches within a few degrees of the equator, it rises ~~up~~ high above the earth and rolls away toward the north, in the direction marked by the curved arrows in red. In performing this circuit it is thrown into eddies and whirls which move in the direction of the anticyclone; these flow northward increasing in diameter and losing intensity, and having passed over the trade winds, and having cooled they begin to fall to the earth, turning back southward, and still retaining the giratory impulse, and consequently descend in that form. We mention this as a probable mode of of their formation.

Another reason for the definite giratory motion of the anticyclone, is the influence of the near proximity of a cyclone, Table showing the pressure per square inch and square foot of different heights of the Mercurial Collum taking 15 lbs per sq inch ~~to~~ instead of 14.7 to avoid fractions

Inches of Mercury	lbs per in	lbs per ft	400 ft 20 x 20	Miles per hour
1/10	1/20	7.2	2.880	50 — 10.
2/10	1/10	14.4	5.760	60 — 18
3/10	3/20	21.6	8.640	
4/10	1/5	28.8	11.520	80 — 30
5/10	1/4	36	14.400	
6/10	6/20	46.2	18.480	
7/10	7/20	50.4	21.060	100. — 50
8/10	8/20	57.6	23.040	
9/10	9/20	64.8	25.920	
1	1/2	72.	28.800	
1 1/10		79.2	31.600 x	
1 2/10		86.4	34.560	
1 3/10 ~~[illegible]~~		93.6	37.440	
1 4/10		100.8	40.320	
1 5/10		108.	43.200	
1 6/10		128.2	47.280	
1 7/10		122.4	48.960	
1 8/10		129.6	51.840	

1 9/10		136.8	53120	
2		144	57.600	
2 1/4		152	60,800	
2 1/2		180	72.000	
2 3/4		198	79.200	
3		216	86.400	

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000

If we can find a definite cause for the motion of the one, that will also be sufficient to account for the motion of the other. For the anticyclone is usually bordered by cyclones and the cyclone by anticyclones. They move together and are continually wedging past each other, the cyclone slipping northward and the anticyclone southward in their eastward progress. The winds of the anticyclone flow out from its center so as to fit into the winds of the cyclone, which blow into its center. See illustrations map No. 6,

The cause of the definite direction of the gyratory motion of the cyclone is the rotation of the earth upon its axis.

Let us suppose a column of air to begin to rise from the surface of the earth, midway between the parallels 40 & 45° and that the air

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Table representing the eastward motion of the earths surface at different distances from the Equator

Degree	Rate of Motion in miles per hour	Less than last succeeding	Less that at the Equator
0° =	1036		
15° =	1,000	= 36 =	36
30° =	897	= 103 =	139
45° =	732	= 165 =	304
60° =	518	= 214 =	518
75° =	268	= 250 =	758

J. Lamar

flows in toward its center for a distance of 150 miles on either side, making a diameter of 300 miles, which is a very common size in this latitude.

Now the difference in the eastward motion of the earth on its northern and southern borders, will be 53 miles per hour. The air at the surface of the earth, has acquired very nearly the easterly motion of the earth, or if not the difference is likely to be about equal on both its sides. Hence the air arriving near the center from the south, will have a motion eastward, if we allow nothing for loss of motion in transit, 53 miles greater per hour than that, arriving from the northern border. It will be seen that this difference in the eastward motion, is sufficient to determine the direction of the spiral motion, not only in latitude 40 to 45; but in any latitude in which cyclones are found. If we suppose the southern edge, upon the equator and the northern edge, 300 miles north the difference in the eastward motion will be 3.3 miles per hour, which is quite sufficient to determine the direction of the giration. Over to Page 58 >

The <u>force of the wind</u>, however, is determined, not so much by the difference of eastward motion of the earth's surface, as by the difference in the weight of the ascending column and that of the surrounding atmosphere. This difference in weight we ~~determine~~ find by the barometer. If the rising column is but little warmer than the surrounding air, the motion will be only a very gentle breeze. If this difference be greater, the force of the wind will be greater in proportion, and if the difference be very great, if the ascending column be very warm and the air about it very cold, we will have winds of great force - a hurricane. Hence the greater prevalence of severe winds farther south. It is also a matter of fact that the smaller the circuit of a cyclone, the greater the force of the wind.

The terrible hurricanes of the Bahama Islands, are seldom more than 30 or 40 miles in diameter and generally much smaller, while in this latitude, cyclones range from 200 to 1000 miles in diameter and the winds are proportionally gentle. Sometimes, however, we have cyclones of very small diameter in this latitude, sometimes less than a mile; and it is these that do the great damage. We think the reason small cyclones are more violent than large ones may be explained.

If we could sink a pine log 100 feet high and one foot in diameter, to the bottom of the sea, and then let it go, with one end pointing upward, it would ascend like an arrow. If we could do the same thing with a block of pine 100 feet high and 300 feet in diameter, it would ascend with less speed, on account of the greater difficulty of displacing so much greater bulk of water. Any one may try this experiment on a small scale in a tub of water. Our atmosphere is supposed to be about 50 miles in height. A column of air three hundred miles in diameter, cannot ascend with very great force, on account of the combined difficulty and slowness with which the ascended column will roll away at the top and its place be supplied at the bottom. If, however, it be but-

but half a mile in diameter, it will
shoot up like a pine log from the sea.
The suck of air at the bottom will be
like that of a great chimney 40 miles
in height. The ~~very small cyclones~~ Tornados of
the temperate zones seem to be formed
about ~~large~~ cyclones of mild intensity.
The conditions leading to their formation
seem to be, loss of the circular form in
the ~~principal~~ cyclone, the near approach
or joining together of two cyclones, or a
change of direction in the motion of a
cyclone from interference with an anti-
cyclone, or other cause. A fragment,
so to speak, seems to separate from
the ascending column, and thus forms

a narrow column which shook up-ward with great fury, and the whirl of the inrushing air at the bottom becomes a terrible whirlwind. [Stop]

Tornado here

> In this latitude the number of ordinary cyclones passing over us varies greatly with the seasons. The number observed in the U.S. is about 15 per month. They are at all times sufficiently numerous to account for our changeable winds.

We will not take time now to speak at any length of the subcauses of winds,

1st. Mountain ranges, running north & south, break the continuous motion of the air around the globe by their projection above the general level and cause it to be deflected more or less from its course, while they favor currents setting southward by the greater cold of altitude. Hence along the Rocky Mountain range of the U.S., there is a greater prevalence of north winds, than in the Mississippi Valley, and eastward, and they carry the cyclones with them as is clearly seen by a glance at map No. X.

The difference is also seen in Europe and Asia. There are differences of this kind, however, that are not determined by this cause.

Ocean currents of warm or cold water seem to cause a divergence of wind, notably the gulf stream, which seems to be followed by a warm south-west wind, making the winds of the Atlantic less variable as to their general direction, but favoring storms by the sharper differences in the temperature of the air in its different parts.

Local differences of temperature, when they are very great, causes local winds flowing from the colder to the warmer regions. These are familiar as land and sea breezes, and are sufficiently well-known. They are all in obedience to the first law of the winds. The most notable of these is the monsoon of India, in which during the hot weather the trade wind is reversed; that is the southward current, instead of being on the Earth is above and passing on south of the equator, descends to the earth, gains its momentum eastward and thence passes north as a southwest wind.

The cyclone as we have seen is not necessarily a destructive wind, but may be a gentle summer breeze. Neither does the cyclone necessarily bring rain, though in this locality we never or at least very rarely have rain without it.

Warm air is capable of holding a great deal more of the vapor of water than cold air. Hence when a warm humid atmosphere passes from a warm to a cold region a portion of its moisture is precipitated first in the form of cloud and then in the form of rain, snow or hail. Now in the cyclone the warm air is gathered up from the surface of the earth and is transported to the cold regions above the earth and if it contains a greater amount of the vapor of water than it can contain after becoming cold that excess falls as rain, no matter how violent the cyclone. A cyclone may rage with the utmost fury from one end of the great Sahara desert to the other, carrying up clouds of sand, but no rain will fall because the warm air carried up is dry. Therefore a cyclone to yield rain must be formed over, or pass over land that is moist or over the sea when the air is humid, and even when formed at sea it cannot pass far into a desert region before its moisture is lost, for it must be remembered that to continue to yield rain the cyclone must be constantly fed by humid air from near the earth. For this reason a heavy rain penetrating to a great distance into a dry and parched country is next to impossible.

The anticyclone always yields dry winds. The cold air from the upper regions of the atmosphere, descends to the earth in a state capable of receiving more watery vapor, therefore we have sunshine and comparative cold with the anticyclone.

We are now ready to discuss weather prediction. The chief of the weather bureau at Washington receives three times per day reports by telegraph from different points in the U.S. In these reports the direction of the wind and its force, the height of the barometer, the temperature, the humidity of the atmosphere, the amount of snow, the degree of cloudiness and the character of the clouds, indeed every feature of the weather is noted. All these features are spread in symbols, which are familiar ~~to have~~ on a map prepared for the purpose. Each cyclone and anticyclone with its comparative intensity stands out like a picture. He sees the entire character of the weather at a glance. This map is then compared with those of the three previous observations and the changes noted. The direction and rate of the movement of each cyclone and anticyclone and the changes in their relative positions are noted. The increasing or diminishing intensity of each is a subject of study. From this review of the present weather he arrives at the probabilities for the morrow in the different districts of the U. S. and his report is delivered to the telegraph office for distribution.

If reports show a cyclone with a very low barometer central near Florida, with a movement north or north east, it is known from the observation of storms in this region, that it will almost certainly sweep over the entire eastern coast of the U.S., and at every port, signals are displayed announcing its approach and about the time it may be expected; and along the sea-coast, some idea is usually given as to the force of wind that may be expected.

If a severe storm is approaching the lakes, the same thing is done, and if the storm is very severe it is watched hour by hour and special warnings telegraphed. The direction of the wind so important to sailors, is usually told. For the inland districts the reports, or predictions, are not so full and complete. If a heavy rain is approaching during the day, we generally find the announcement of it in the mornings paper, of the day on which it will occur. If the day is to grow colder or warmer, to clear off or cloud up with showers here and there it is told us; and if we form the habit of looking up these dispatches every morning, we will soon find that the predictions are very reliable. The per cent is not yet sufficient to enable us to grasp them with certainty. Any storm which moves out of the usual course of storms in its locality is considered abnormal.

We have spoken of the discovery of Buys Ballots law. We will now try to explain it and its uses. The law as announced by the Dutch professor is this - "In the northern hemisphere the wind always flows so as to keep the lowest barometer on its left hand." You will see by this map of the cyclone that if you stand with your back to the wind at any point; and stretch out your left hand a few degrees to the front; you will point to the center of the storm. Now if you know the habitual storm tracks of the region in which you happen to be you are able at once to tell by the direction of the wind in your locality just about the direction from you of the storm center and can at once know with tolerable certainty whether you are near the center of the track of the comeing storm or upon one of its margins. To us here upon the land this is not of so much importance, but to the sailor on the southern seas, when violent cyclones are often met with, it becomes of great importance.

Let us suppose him to experience a change of wind. He consults the ship's barometer and finds it is falling. These two facts tell him plainly that he is within the limits of a cyclone and he knows from previous study of the weather the probable direction of the movement of this cyclone, and it is of the utmost importance to him to know whether he is in the center of the storm track or upon one of its margins. The direction of wind at once tells him where the storm center is, and the rapidity of the fall of his barometer, tells him whether or not the storm is of such violence as to endanger his ship. If he be near the coast and the direction of the approaching storm is such, as to favor him he may run for a harbor or he may run to the right or left of the storm track so as to escape its violence, using the wind which threatens to engulf him, in making his escape.

We may now spend a few minutes discussing the character of the storms of our country. We have here, two distinct classes of rain storms differing essentially in character. We may distinguish them as the northern and the southern, or the normal and the abnormal, as they were sometimes termed by General Myer. Any storm moving much out of the usual course of the storms of its locality, is termed abnormal. We may here state two propositions. 1st Any storm moving much to the north of the usual course for the locality, is apt to be of unusual intensity. 2nd. Any storm moving much to the south of the usual course for the locality, is apt to be very weak and soon die out. The storms of the U. S. are formed our own territory, come to us from the Pacific ocean across the Rocky mountains, come from the north across the region of the Saskatchawan river and Manitoba, from the Gulf of Mexico and the Bahama Islands. The storms from the Gulf and the Bahama Islands differ immensely from the others in the relative amount of rainfall. I noticed this some years ago and sought for the reason of the difference. I found, however, that the difference had been noted by others, and two years ago Prof. Loomis made an analysis of the southern rain-storms as compared with the northern for a period of eight years taking those storms if I understand him rightly, in which there was general rain along their line of progress, excluding those of low intensity which only gave occasional showers.

The average rain-fall from the northern storms he found to be 1.99 inches. The average rain-fall from the southern storms, he found to be 7.94 inches. The southern storms therefore yield upon an average per storm four times as much rainfall as the northern storms.

These southern storms, however, are very few in number, so few that they are regarded as abnormal.

It was one of these or rather two, one following right in the wake of the other (plotted on map 5), that flooded the whole Mississippi Valley, in February 1881 and caused our high waters. In this whole region about as it fell upon frozen ground and was lost so far as wetting the ground is concerned.

The storms that come to us across the Rocky mountains bring almost no water into the Mississippi valley from the sea. In crossing the Rocky mountains they are forced up to a great height and their moisture is mostly precipitated upon the mountains by the cold of those high regions. Therefore when they begin to descend the eastern slope, they come as dry or comparatively dry cyclones, until they have crossed the dry plains. This is the reason of the comparative dryness of this region. As they begin to reach the regions traversed by the storms, coming across the valley of the Saskatchawan and the lakes of Manitoba where the moisture of the earth is greater, their rain-fall increases until the Mississippi river is reached from thence northeast; There is no great difference in the amount of the rainfall from the individual storms. There is, however, a very great difference in the amount of the rain, and especially of snow East and here, on account of the concentration of the storm paths over New England which may be seen in map 4. For one foot of snow at Chicago there is about five feet in Maine. The increase is gradual and continuous for the whole distance.

Those storms coming to us across the line from British America have either crossed the mountain range far north, or have developed in or near the valley of the Saskatchawan rivers and do not differ essentially in their rainfall from those, which have crossed the mountains below or have developed upon our own soil. We may say that these storms receive the moisture which they precipitate exclusively from the soil over which they pass, by gathering up the air which has been in near contact with the earth and hurling it into the cold regions above, thus causing it to yield again to the earth, that which it has lost by evaporation.

The storms from the Gulf of Mexico come out from a warm sea over which the air is very warm and capable of holding a great amount of watery vapor. This warm vapor-filled southern atmosphere is taken up and hurled upward and northward over the land which rises gently north from the Gulf and is litterally spilled down upon the earth from the Gulf to the lakes. This does not last however. They are usually about exhausted on reaching the lakes. They then turn east-ward following the usual storm-tracks of that region and lose their special characters. (Trace out on map 5.

Storms from the Bahama Islands sweep the eastern coast and possess the same characteristics as those from the Gulf.

It may be of interest to examine for a moment the comparative amount of the rainfall that is poured back into the sea from the great river. We can say with confidence that all the water that flows into the Gulf of Mexico from the Mississippi river is brought into the Mississippi. Water shed from the sea by the clouds and no more. If the clouds lifted from the sea and let fall more water in this great valley, than is discharged again into the sea, the country would become flooded, unless indeed we could account for the difference by the evaporation. But in a calculation like this we must regard the rainfall from this evaporation to be about equal to the evaporation, and that it is only the excess of rain-fall over ~~and above~~ the evaporation that is delivered again to the sea.

The average total rainfall of the Mississippi Valley is estimated at 55 inches per year. The evaporation of this region is estimated at one eighth inch per day or 45 5/8 inches per year, leaving 9 3/8 inches of the rainfall to be discharged by the Mississippi river into the Gulf. But we can come at this more accurately by inquiring the amount of water actually delivered into the Gulf by the great river, for here we can measure its width, average depth and its current and find the amount to be equal to 9¾ inches over the entire watershed, a difference of only ⅛ inch per year, between the two modes of calculation.

These facts seem to argue strongly that our excess of water comes from the southern rains. I therefore took southern storms as represented by Prof. Loomis, and getting their average rain-fall for the series of years which he gives. I find that the excess of their precipitation above those of the northern storms is almost exactly represented by the amount of the rain-fall actually delivered back to the sea by the Missis-sippi.

Stop Back to Page 5-8 84.

We had hoped to say something upon the 2nd. department of weather prediction. Namely the forecast of the general features of the next succeeding season in the effects upon the principal crops, but for want of time we can only mention it; There is no doubt in my mind but that in the course of years we will be able to do this with tolerable certainly. Some facts are already known, but they are too few as yet for us to build them into such a connected chain as to serve well our purpose. From what has been said you will see that rains do not readily penetrate deeply into a dry and parched country. A few moments' thought will also show you that here, during the summer months, the evaporation and outflow of water ~~of water~~ by way of our streams is much greater than the rainfall, hence the drying up of our water courses. Therefore the surface of the earth becomes very dry, evaporation becomes almost nothing, the cyclones gather up air that is comparatively dry and the rains fail. Now it will be seen at once that if the spring comes on with the earth already dry, ~~the water courses~~ . We cannot have a wet season, unless, indeed, we should have a <u>very</u> <u>unusual</u> series of rain from the south.

Again we may have a very unusual water-fall and yet have a very dry summer, as was the case the last year. Some here will perhaps remember, that one year ago I urged the building of additions to our water-works on the plea, that we would necessarily have a very dry summer. I think most persons will say that I was right as regards the effect upon the crops and yet I was wrong, in regard to the actual amount of rain for the year. We had the very unusual phenomena of an unusually dry crop year and at the same time, a year, as a whole, of heavy rains and unusually high waters.

Again it is now known that for some reasons as yet unexplained flood and drought moves in pretty definite cycles. We have a few years that are comparatively wet, running somewhere from five to nine years. In a period of two hundred years through which I have traced it the average was about 8½ years. This may be of some use in predicting the seasons, though the oscillations are too irregular to be very reliable.

Again we have still larger cycles of comparative flood and drought, running a period of from sixty to eighty

This cycle in the present century had its central point of drought for this region about the year 1818. There may be a few old men in J'ville who will remember, that in that year corn failed almost entirely and the settler who made seed was fortunate. The prairies burned off in June all through the years from 1810 to 1820 and men endeavored to obtain water by digging in dry creek beds. The immense gulch holes now to be seen in Nebraska, full of water the year round were then formed by the burning out of peat-boggs, which had formed along the hollows.

The central point of flood was

in the year 1844. There are many here that remember this who passed through it. I have lived long enough to see large lakes, where fish were plentiful, converted into cornfields.

We are not far from another central point of drought. But there are reasons why it should not be so severe as in former years.

Coming years will bring floods again. Our streams will be filled to the brim and the lakes be upon our flat prairies unless prevented by the arts of man.