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in action; the whole perhaps constituting the least costly and the most durable and powerful steam boat.

But it remains to say, that although safety is thus provided for, the covered barge is capable of being the swiftest as well as the most convenient and elegant method of carrying *passengers;* because the proportion of power that may be placed on board the engine boat may be much greater than usual, while the buoyancy of the barge occasions, in a smooth *wake*, little resistance.

Hitherto the requisite timber and iron, in a hull where the engine works perpendicularly and the cabins are so long as to afford large accommodations, has been such that perhaps the *carpenter's bill* of no class of vessels has been so high.

If these suggestions should tend to promote the extension or profit of this branch of navigation, the appropriation of your pages to this subject thus liberally will not be without public benefit.

Respectfully yours, &c.

JOHN L. SULLIVAN.

New York, Feb. 19, 1831.

ART. IV.—*Remarks on the prevailing Storms of the Atlantic coast, of the North American States;* by WILLIAM C. REDFIELD, of the city of New York.

THE changes which usually occur in our atmosphere may be considered as of two kinds or classes. In the one class are recognized those effects which are the result of gradual variations in the temperature, humidity, and density of the atmosphere. In the other, we include all those active and more striking changes, which result from the agency of unusual or irregular movements of the atmospheric currents. These extraordinary movements we denominate storms, hurricanes, &c.; and they exhibit, or develope the most striking atmospheric phenomena with which we are acquainted.

The occurrence of storms is sometimes conjecturally ascribed to mere changes in electricity; but the natural tendency to equilibrium, in the more subtle, as well as the denser fluids, appears to forbid this supposition, and these electrical changes seem rather to occur in consequence of other disturbing causes, which operate to destroy the general equilibrium. It has been justly remarked, that to ascribe every phenomenon, with the cause of which we are unacquainted, to

electrical agency, serves rather to retard than to advance our knowledge of nature.

Rarefaction, occasioned by an increase of temperature, has also been adduced as the immediate agent in producing storms; but, to say nothing of the difficulty of proving an extraordinary increase of temperature before a storm, it has been justly remarked by Dr. Hare, that "the air, being a perfectly elastic fluid, its density is dependent on pressure as well as on heat, and it does not follow that air, which may be heated in consequence of its proximity to the earth, will give place to colder air from above. The pressure of the atmosphere varying with the elevation, one stratum of air may be as much rarer by the diminution of pressure consequent to its altitude, as denser by the cold consequent to its remoteness from the earth; and another may be as much denser by the increased pressure arising from its proximity to the earth, as rarer by being warmer. Hence, when unequally heated, different strata of the atmosphere do not always disturb each other."

It is, indeed, the prevailing opinion that change of temperature, is a principal cause of those extensive currents or revolutions of the earth's atmosphere which we distinguish as trade winds, monsoons, &c.; and it is to the operation and effect of these great and regular moving masses or currents, that we are disposed mainly to ascribe the more active and striking meteorological phenomena which occur in every latitude. But whether this be admitted or not, it must be evident, that to ascribe the occurrence of storms and hurricanes chiefly to change of temperature or rarefaction, in a *particular locality*, whether in the tropical or temperate latitudes, is falling into as great an error as if we were to ascribe the tides of the bay of Fundy, or the coast of Patagonia, to the specific attraction of the heavenly bodies on those localities. Indeed, the analogy between the tides and currents of the ocean, and of the atmosphere, is perhaps sufficient for our argument, for as the great semi-diurnal swell, or tide wave of the ocean, is brought to bear with concentrated effect upon its smaller portions, or tributaries, so do the massive currents or tides of the atmosphere often press with corresponding energy upon its more detached portions, while seeking to restore the general equilibrium. We have the full effects of heat and rarefaction exhibited on nature's grandest scale, between the tropics, acting jointly with other causes, and the aggregate and uniform result, is only that of a regular and moderate breeze or trade wind, and an equable state of the barometer. To

create in the midst of these equable winds or elsewhere, by the aid of rarefaction, a fanciful vacuum into which the atmosphere, from a distance of many miles, and even many hundreds of miles, is to rush with all the fury of a storm, is to do violence to the established principles of natural science. To ascribe such effects to such a cause, is no better warranted than to refer all storms to the direct influence of electricity and magnetism.

As connected with these remarks, the following explanations are given of some of the principal terms used in application to this subject.

WIND *is air in motion;* either progressively over the surface of the earth, or relatively, as regards the surrounding portions of the atmosphere.

A CALM, *is a cessation of motion in the air at the surface of the earth.* It is obvious however that a given portion, or current of the atmosphere may be stationary as regards this surface, and yet may be rapidly moving through, or penetrating other portions of the atmospheric fluid. A calm, therefore, affords no evidence of a state of quietude in the surrounding, or superincumbent portions of the atmosphere.

A STORM, *is a violent wind, passing over the earth's surface.* In popular language, a storm is supposed to mean a wind or tempest, accompanied by rain, or indications of rain. In the views to be submitted, the term will be used in its most general sense, but chiefly as applying to those winds or atmospheric changes, which are attended by a condensation or deposition of vapor.

A HURRICANE, *is a wind or tempest of the most extraordinary violence.* It has been stated as a distinguishing characteristic of hurricanes, that *the wind blows from different points of the compass*, during the same storm.

It is an obvious fact that most of the storms of the Atlantic coast of the United States, excepting thunder gusts, blow from an eastern quarter of the horizon. It has also, been often noticed, and the fact is recorded by Dr. Franklin, that north-east storms commence in the south-west and make progress from thence in a north-east direction, being experienced much sooner at Philadelphia than at Boston. Another leading fact, noticed by every observer, is, that in north-east storms, a return of fair weather *first appears to the leeward* or westward; or, in other words, that these storms first terminate as well as commence in the south-western quarter. Some attempts have been

made to explain the manner in which storms blowing from the north-east, should, at the same time, be found extending in that direction, without visible cause, and in apparent opposition to their own forces.

The unsatisfactory character of these explanatory theories has induced the writer to pay some attention to the foregoing facts, and to the other phenomena exhibited by the storms of our climate, which has resulted in an apprehension that the general causes and manner of operation of these storms are not beyond the reach of investigation.

The storms experienced in that portion of country bordering upon the sea coast, and on the adjacent parts of the Atlantic ocean, are commonly viewed as forming two varieties, one of which is distinguished as blowing from the north-eastern, and the other from the south-eastern quarter of the horizon. These do not greatly differ in their ordinary effects, although those from the north-east have usually a more prolonged duration, and exhibit a more sensible reduction of temperature. Some account of the phenomena and ascertained progress of a south-eastern storm, which occurred in September, of the year 1821, may, in its leading features, apply to many other storms, and will, it is believed, afford sufficient ground for the conclusions which we shall attempt to establish.

This storm, as experienced in the central parts of the state of Connecticut, commenced blowing violently from E. S. E. and S. E. about six o'clock on the evening of the 3d day of September, having been preceded by a fresh wind from the southern quarter, and flying clouds. It continued blowing in heavy gusts, and with increasing fury till about 10 o'clock, P. M. when the wind suddenly subsided. A calm or *lull*, of perhaps fifteen minutes duration ensued, which was terminated by a violent gust from the north-west, which continued till about 11, P. M. and then gradually abated. Much damage was sustained, and fruit trees, corn, &c. were uniformly prostrated towards the north-west.

It afterwards appeared that the same storm was experienced, with at least equal violence, at New York, about three hours *earlier* than at the point before mentioned, but blowing from a more eastern quarter, and terminating its ravages at about 8, P. M. having also been preceded by a fresh wind from the southward. That in the north-eastern parts of Massachusetts, it was experienced some hours later than in Connecticut. That at Providence, in the state of Rhode Island, where the memorable gale of 1815 had raged with such terrific fury, the storm was felt from the south-eastern quarter, but not se-

verely ; as was also the case in the south-eastern parts of Connecticut. In the north-western portions of the latter state, and the adjacent towns of Massachusetts, the gale blew with its chief violence from the north-western quarter, and the trees and corn, as the writer afterwards witnessed, were uniformly prostrated *towards the south-east*. At Worcester, in Massachusetts, the storm occurred some hours later than in Connecticut.

It appears, therefore, that the more violent effects of this storm were of limited extent from south-east to north-west, but were exhibited over a much greater range of country from south-west, progressively, to north-east; that in the central part of Connecticut, the mass of atmosphere upon the earth's surface, was moving for several hours, apparently towards the north-west, with a probable velocity of seventy five to one hundred miles per hour, while in the northern parts of Litchfield county, in the same state, at a distance of say forty miles, the wind, at about the same period, was blowing with nearly equal violence *towards* the south or south-east. Towards the sea coast of Rhode Island, from whence the gale at Middletown, in Connecticut, seemed to come with such surprising velocity, the gale was of no extraordinary character ; while at New York, the storm had ceased blowing from the eastward, soon after its commencement from the south-east in this part of Connecticut.

In reviewing these facts, we are led to inquire how, or in what manner it could happen, that the mass of atmosphere should be found passing over Middletown for some hours, with such exceeding swiftness, towards a point apparently within thirty minutes distance, and yet never reach it; but a portion of the same or a similar mass of air, be found returning from that point with equal velocity ? and how were all of the most violent portions of these atmospheric movements which occurred at the same point of time, confined within a circuit whose diameter does not appear to have greatly exceeded one hundred miles ? To the writer there appears but one satisfactory explication of these phenomena. *This storm was exhibited in the form of a great whirlwind.*

This position renders it proper to notice a class of winds which we have not previously considered.

Some idea of the existence and character of whirlwinds or tornadoes, as they are sometimes called, is common to most persons who are at all conversant with the subject of meteorology. One variety of whirlwind is often exhibited during the prevalence of dry westerly

winds, which, owing to partial obstructions or other causes, frequently form into eddies or whirls, the rotative motion of which increases with their progress as they are wafted along by the surrounding atmospheric current, raising clouds of dust and other light substances, till they finally become broken or dissipated. The writer has seen a whirlwind of this kind, operate with so much violence in passing over a river, as to raise a white cloud of spray to the height of some forty or fifty feet, which disappeared before reaching the opposite shore. Whirlwinds of a still severer character sometimes occur, and are, by seamen, denominated *white squalls*, from the white appearance of the spray thus raised into the atmosphere. Doctor Franklin, it is well known, maintained the identity of these smaller whirlwinds with water spouts.

Another class of whirlwinds, of more formidable character, are those which sometimes attend the thunder storms, or *gusts*, of the Atlantic states, and more frequently, ravage the fields and forests of the regions west of the Alleghany mountains, carrying desolation and death in their progress. Like the smaller class, they are carried along by the attendant wind of whose mass they form an integral portion. Their ravages are generally confined to a narrow track, often of but few yards in breadth. Rising at times, over objects in their path, and leaving them untouched, they again descend to the surface, and continue the work of destruction. The chief force of these winds evidently consists in the almost inconceivable rapidity with which the mass revolves about its own axis of rotation, a velocity which is, therefore, unopposed, except by the obstacles brushed upon at the earth's surface, and which is maintained in full activity by the concentric, or tangentical pressure, or action of the surrounding portions of the atmosphere.

It is believed that no valid reason can be shown, why much larger masses of the atmosphere may not acquire, and develope, rotative movements, similar to those which are exhibited by whirlwinds, and the demonstrated existence of the latter ought to free us from the charge of maintaining a mere hypothesis, when we ascribe the same character to such storms as that which we have already described, if we can show that they are attended with corresponding phenomena.

It is demonstrably evident, that at any point over which the center of a whirlwind may pass, the wind must, at the moment in which this center passes, suddenly change to a direction almost exactly op-

posite to that in which it has been felt during the preceding part of its progress, and that at the immediate center of the whirl, little or no violence of effect can at any time be experienced. It is further evident that, towards one side of the track of a whirlwind, it must blow in a direction which is *retrograde* from that of its progress, while, on the opposite portion of the track, the direction of the wind will be found in the contrary direction, and coinciding with the progressive motion of the body of the whirlwind. Now these known phenomena, or peculiarities of a whirlwind, appear to have been fully exhibited by the storm in question, though on a more extensive scale, and for aught that appears, may also be exhibited in some degree, by every other storm. We might expect, however, to find in the supposed revolutions of the great masses which compose our easterly storms, the violence of effect to be lessened in due proportion to the magnitude of the revolving mass, and the increase of surface affording resistance, except in cases where the amount and duration of the rotative forces should be adequate to the production of equal velocities. The duration of the storm, also, at each of the several points over which it passes, instead of being momentary, as in the lesser whirlwinds, must increase with the dimensions of the revolving mass.

If our position be conceded, then it is no longer difficult to explain the paradox, or mystery, which otherwise pertains to the phenomena exhibited by this storm, and all others of a similar character. We can now perceive why the wind may blow, even with excessive violence, at one point, and yet scarcely be felt in a position but a few miles distant from the regular track of the storm. We can trace the circumvolution which produces such a contrariety in the direction of the wind on the opposite sides, or portions, of the revolving mass, and we can appreciate the centrifugal tendency and other causes, which produce about the rotative axis of the storm, that suspension of effect which occurs on each successive portion of the track over which its center of rotation may pass. We can also perceive the cause of the sudden change of wind at this crisis of the storm, and we can satisfactorily explain the more gradual changing or veering of the wind, which takes place on the more eastern or western portions of the advancing storm. We can discern the reason why, in seamen's phrase, "a north-wester will never remain long in debt to a south-easter," and we may also appreciate some of the causes which render the last semi-diameter of the rotative mass a dry wind, in a short period after this change in its direction.

Nor do we any longer find difficulties in conceiving of the regular progress of the storm from south-west to north-east, as a component portion of the general mass of atmosphere which has previously been tending in that direction. This progress still continues while the stormy mass is revolving around its own moving axis, and we can readily comprehend the violent effects of its unresisted rotation, while this velocity becomes accelerated by nearly all the oblique forces, and perhaps resistance, of the circumjacent currents or masses of moving atmosphere.

In order to give a further history of the storm of 1821, and lest we should fall into the error of adopting a conclusion, which a more complete array of the facts might fail to warrant, we will give some further notice of the first appearance and entire progress of this storm, so far as we have been able to obtain accounts of it. This will enable us to identify its track, and exhibit further evidence of its character as a whirlwind, or, will afford us evidence with which to combat that conclusion, if it be erroneous.

The earliest supposed trace of this hurricane which has been obtained, is from off Turks-Island, in the West Indies, where it appeared on the first of September, two days previous to its reaching our coast. It was felt there severely, but at what hour in the day we are not informed.

The next account we have is from Lat. 23° 43′, where the storm was severe, Sept. 1st, from south-east to south-west. Whether these two accounts are considered as identifying the storm, or otherwise, will not, at this time, be deemed material.

Our next report is from Lat. 32° 30′, Lon. 77° west from Greenwich, on the night of Sept. 2d, a hurricane for three hours.

At 3, A. M. on the 3d of September, a severe gale was experienced thirty miles outside of the American coast, off Wilmington, North Carolina.

At Wilmington there was no gale.

At Ocracock bar, N. C. at day light on the morning of the 3d, a severe gale from east-south-east.

At Edenton, N. C. the gale was at north-east.

Off Roanoke, on the morning of the 3d, a dreadful gale at east, then south-west and north-west.

A vessel from Charleston, S. C. two days previous to arriving in the Chesapeake, experienced the gale at 4, A. M. on the 3d, from south-east to west-south-west.

A vessel from Bermuda, experienced the gale from the *westward*, on the inner edge of the gulf stream.

Another vessel, from Charleston, *did not experience the gale.*

In Lat. 37° 30′, on the inner edge of the gulf stream, gale from the *westward*, with squalls.

On James' river, Virginia, the gale was severe from north-west.

At Norfolk, Va. the gale raged, on the 3d, for five hours, from north-north-east to north-north-west, and terminated at the latter point; greatest violence from 10, A. M. to 1, P. M.

At sea, forty miles north of Cape Henry, severe from south-east, changing to north-west.

Off Chincoteague, coast of Maryland, on the 3d, gale from south-east.

At Snowhill, Maryland, gale commenced at 11, A. M.

In Lat. 38° 30′, Lon. 74° 30′ gale south by east.

Gale reported as slight in the gulf stream.

A ship from Boston, bound to Norfolk, *experienced nothing of the gale.* On the 3d, was in Lat. 40° 19′, weather foggy, and *light winds from south-east.*

At Morris' river, Delaware, the gale was from east-south-east.

No hurricane was felt at Baltimore.

At Cape Henlopen, Del. the gale or hurricane commenced at half past 11, A. M. from east-south-east, shifted in twenty minutes to east-north-east, and blew very heavy for nearly an hour. A calm of half an hour succeeded, and the wind then shifted to the west-north-west, and blew, if possible, with still greater violence.

At Cape May, (New Jersey) commenced at north-east, at 2, P. M. and veered to south-east, and blew with violence. After abating fifteen minutes, it again blew with increased violence for two hours, and then abated. *The sun set clear, with pleasant weather, at which time not a cloud was to be seen in the western horizon.*

At Bombay-Hook, near the mouth of the Delaware river, the gale blew from north-north-east, to west-north-west.

At sea, forty miles north-east of Cape May, the gale was at south-east, and lasted eight hours.

At Philadelphia, the storm commenced at 1, P. M. on the 3d, from north to east, and raged with great violence *from north-east to north-west*, during the greater part of the afternoon.

At Trenton, (New Jersey) the gale commenced at 3, P. M. with the wind *from north-east.*

In Lat. 39° 20′, Lon. 73° 30′, the gale blew from east-south-east to south-south-east, and continued eight hours.

At New York, the gale was from north-east to east, and commenced blowing with violence at 5, P. M.; continued with great fury for three hours, and then changed to west. More damage was sustained in two hours than was ever before witnessed in the city, the wind increasing during the afternoon, and *at sunset was a hurricane.* At the time of low water, the wharves were overflowed, the water having risen thirteen feet in one hour. Previous to the setting in of the gale, the wind was from *south* to *south-east*, but *changed to the north-east at the commencement of the storm*, and blew with great fury till evening, and then shifted to the westward.

At the quarantine, Staten-Island, the wind was reported as east-south-east. Other accounts fix it at east.

At Bridgeport, Conn. the gale commenced violent at south-east, at 6, P. M. and continued till 9, P. M.; then shifted to north-west, and blew till nearly 11, P. M.

At New London, the gale was felt from 7, P. M. to 12 at night.

On the coast of Rhode Island, between Point Judith and Watch-hill, gale from the south.

At Middletown, Connecticut, violent from south-east for five hours.

At Hartford, commenced heavy from south-east at 7, P. M.

At Springfield, Mass. violent from 9 to 12, P. M.; then changed to the westward.

At Northampton, from south-east on the same evening.

At Worcester, Mass. in the night, between the 3d and 4th of September.

At Boston, the gale commenced at 10, P. M., but does not appear to have been severe. At the time the storm was raging with its greatest fury at New York, the citizens of Boston were witnessing the ascent of a balloon, and the aeronaut met with little or no wind.

The general course of this storm, northward of Cape Hatteras, appears to have been from south-south-west to north-north-east, and of its further progress we are uninformed.

It appears from the foregoing statement of facts, that this storm, previous to its reaching Long Island, extended but a moderate distance inland, and that its influence seaward from the coast was almost equally limited;—that, between these boundaries, it maintained a regular progress along the coast, from a great distance towards the south, and probably even from the neighborhood of the West-India

islands ;—that this progress, though slower in the lower latitudes, was, after reaching the American coast, at a rate not greatly differing from thirty geographical or nautical miles per hour, which is presumed to have been nearly the velocity of the direct southerly current prevailing in the atmosphere at that time, at a medium height from the surface ; and this rate of progression appears to have governed the duration and termination of the storm at each place over which it passed ;—that on the western margin, or verge of the storm, or at those places most distant from the sea, the wind was north-easterly or northerly, while on the opposite verge, at sea, the wind was southerly and westerly ;—that along the central portion of the track, the storm was violent from the south-eastern quarter, *changing suddenly to an opposite direction ;*—and that there was previously and subsequently, no prevalence of an easterly wind, nor was there any other apparent cause for a direct movement of the atmosphere from that quarter ; all the existing tendencies being in another direction. The *center* of the storm or hurricane, appears to have been generally outside the coast, till, reaching Long Island, it crossed the same, and entered upon the State of Connecticut. It seems also to have passed westward of New Haven, and to have entered the valley of the Connecticut river near Middletown, and after partially following that valley for some distance, and crossing the State of Massachusetts, the storm must have disappeared towards the eastern coast, and its further progress does not appear to have been reported.

The general analogy or correspondence of the foregoing facts to the known phenomena of whirlwinds and tornadoes, will, it is believed, be sufficiently evident, at least so far as the difference in the magnitude and other circumstances of these rotative masses, will permit of the resemblance. As it will be assumed, in the progress of our remarks, that this peculiarity of motion is a general attribute of storms, it may therefore be proper to sum up these points of resemblance in a more concise manner.

1. The regular progress of both the storm and the whirlwind from the point where they first become appreciable in their effects, till their ultimate extinction, uninfluenced by any particular direction of wind which they may exhibit, deserves especial notice.

2. The limited diameter of the known smaller, and the supposed larger whirlwind, or storm, as compared with the extent over which they sweep in pursuing their several tracks, is an important resemblance, and is evidence of a similarity in the mode of operation.

3. The regular and obvious proportion which the several diameters of the storm and whirlwind, and their rate of progression, bear to their duration, at each point over which they pass.

4. The different and opposite, or nearly opposite directions in which the wind is found to blow upon the opposite sides of the track, and also upon the opposite marginal portions, of both the storm and the whirlwind.

The last consideration, if established, hardly falls short of demonstrative evidence of the supposed identity in the mode of action in these different masses of moving atmosphere. Every person, on examining the track of a destructive whirlwind, where it has passed through a forest, will, in crossing that track, often find the trees prostrated in exactly opposite directions, and it is obvious that this effect must necessarily follow, as the result of the acknowledged cause, a circular, or rotative force in the whirlwind. The same effect was equally apparent, only on a larger line of observation, after the storm or hurricane of 1821, as already described. The same general evidence of a sudden or a progressive change in the direction of the wind, runs through all the accounts which we have given, or which it is in our power to submit, in relation to other storms.

In relation to whirlwinds of the smaller class, we may here take occasion to remark, that it is not conceived to be essential to the character of a whirlwind, that its axis of rotation should occupy a vertical position, or one but slightly inclined to the plane of the horizon. On the contrary, the axis, or center of gyration, in whirlwinds of a limited character, may, and probably often does, occupy a horizontal position at a considerable height in the atmosphere. This variety of whirlwind is presumed to enter largely into the formation of thunder-storms and squalls, and particularly hail-storms.

Having attempted to establish the circumrotative character of the south-east storm which has been described, we are led to inquire whether other south-easterly storms possess the like character; and whether this be also an attribute of the north-eastern storms of our coast, and also what constitutes the specific difference of character in these storms.

If the foregoing views be sufficiently established, it must follow, that *the direction of the wind at a particular place, forms no part of the essential character of a storm, but is only incidental to that particular portion or parallel, of the rout or track of the storm which may chance to become the point of observation.* We have seen that

in order to blow from the south-east, the center of the storm, (if its progress be north-eastward) must pass near the point or parallel from which we observe it, *the direction of the wind being, in all cases, compounded of both the rotative and progressive velocities of the storm, in the mean ratio of these velocities ;* while towards the northern and western margin of the same storm the wind is north-easterly. Such south-east storms, their central portions being on, or near, the land, must necessarily be circumscribed in their influence by the obstructions and elevations of the interior, and particularly by the mountainous ranges. Being thus confined or limited in their dimensions, they of course extend only to a corresponding distance on the opposite semi-diameter to seaward, and this furnishes the reason why the south-east storms experienced on land, are never known to extend, at sea, to any great distance from the coast. The narrow dimensions of the south-east storm also favor its more rapid impulsion by the prevailing southerly current of atmosphere, and this sufficiently accounts for its comparatively short duration.

It results also from these views, that if a storm blow from the north-east along our coast, its central portion, or axis, will be found to range at a considerable distance from the coast, at sea. If such a storm be also felt over a considerable portion of the country adjacent to the coast, its dimensions must be far more considerable than those of the south-east storm, and if in addition to its increased dimensions, it be found to advance with less rapidity than the smaller storm, its increased duration will be sufficiently explained.

The generally admitted progress of our storms from south-west to north-east is confirmed by all the evidence which the writer has been able to obtain. It has been freely assumed also in these remarks, from what was deemed to be sufficient evidence, that most storms, if not all, exhibit in a greater or less degree a circumrotative character, or in other words, that they usually blow in the form of extensive eddies or whirlwinds, and the specific character of the north-east and south-east storms of our coast, and their points of difference has been explained upon these principles. Should the evidence produced be deemed insufficient to establish these views, further confirmation may be obtained for them by ascertaining the direction of the wind in an easterly storm, on a line drawn across its track from north-west to south-east. The farther inland such an enquiry is extended, the more northerly will have been the direction of the wind, till we get beyond the extreme verge of the storm. On the other hand, as we

approach the seaboard the wind will have blown in a more easterly direction, and veering further as we extend our enquiries in that direction. If we farther prosecute the enquiry among the records of our nautical friends we shall find a further veering of the wind to east, and ultimately to south-east and south; till towards the opposite or south-eastern margin of the storm its effects will have been felt from south to south-west, and generally to west or north-west, till the circle is completed.

If the position of a ship on our coast, be within the north-western half or semi-diameter of the storm, it will usually commence from a point to the northward of south-east, veering, ultimately, by way of north, to the westward. But if the position of the ship be within the opposite or south-eastern semi-diameter, the storm will commence between south-east and south, veering afterwards to south-west, west, and even north-west. Rain, or the deposition of vapor in any form, seems chiefly confined to the north-eastern or advancing semi-diameter of the revolving mass, though its external or marginal portions are often free of clouds; while most of the south-western semi-annular section or division, displays the appearance of clear weather. Near the frontier margin of the revolving mass, upon the land side, we may sometimes notice the clouds which form the upper stratum connected with the storm, disposed into corticular ranges or layers, of greater or less density, and with various degrees of frequency and harmony in the arrangement. North-eastern storms often blow but moderately, which is to be ascribed to a sluggish rotation, and comprising, usually, a more extensive surface than south-eastern; they bring to us, in their extensive revolution, the humid and chilly atmosphere of the north-eastern coast.

As the storms of the North American coast, may sometimes be traced, as we have seen, from a great distance in the general direction of that coast, it may not be unavailing to seek for the primary causes which bring them into operation.

Owing to the general prevalence of the trade winds in the tropical regions, and which, in the northern Atlantic, extend to about the thirtieth degree of latitude, the incumbent mass of atmosphere is in constant progress towards the American continent, and into the gulf of Mexico. Continents, and especially elevated and mountainous ranges, are well known barriers to the trade winds, which being thus obstructed by the isthmus of the two Americas, restore the equilibrium of the northern hemisphere by a general and regular efflux of

variable winds, tending back to the north-east in the temperate latitudes. This prevalence of these compensating winds is so uniform as to occasion an average difference of seventeen days in favor of the eastern passage of packet ships engaged in the European trade. Even in England they have two hundred and twenty five days of westerly wind to one hundred and forty days of an easterly direction, and if our view of the easterly storms be correct, this tendency is more general and uniform than has hitherto been supposed, most of the other winds being, in that case, but irregular modifications of the westerly or returning trade wind. The prevailing effect upon the North American coast, during most parts of the year is that of a south-westerly wind, but becoming more westerly as we advance northward.

This general current of atmosphere is often qualified in its direction, and acted upon obliquely by the more western and north-western land winds. These several winds or modifications of the same general current, often prevail in stratified currents overlaying each other, the most western of these currents forming generally the upper stratum. It is probable, as already suggested, that these winds are but the recoiling, or returning masses of the trades which penetrate to the bottom of the gulf of Mexico, the superior strata of which may be sent back from the most western points of the horizon from the highest barrier which is found in the great Mexican elevations, or even the Chippewayan range.*

There is a class of these variable returning winds, which appear to recoil in a comparatively short circuit from the gulf of Mexico by way of the North American coast, and from whence, in the autumnal and winter seasons, they often fall in upon the trades, from a northerly direction, at different points between the eastern limit of the gulf of Mexico and the meridian of the Bermudas, thus coinciding in effect with another obstacle to the regular progress of the northern portion of the trades which we shall now mention.

At these seasons the northern margin or parallels of the trade winds in sweeping towards the gulf, must necessarily come in collis-

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* It appears from a record of the prevailing winds at Little Rock, on the river Arkansaw, that during a period of five months ending with October last, the winds from south-east to south-west were in the proportion of nearly four-fifths of all those that blew from all points of the compass; and that in the same period there was only *two days* in which the wind prevailed from any point between west and north-east. This is but an item in the great mass of evidence by which this great circuit or revolution in the atmosphere is established.

ion with the great Archipelago of islands which skirt the northern limit of the Caribean sea. Of these islands, the three largest form an almost perfect and continuous barrier, opposed, obliquely, to the progress of these regular winds. Now as the mass of moving atmosphere presses down upon the islands in its south western progress, and sweeps along their northern coasts, the obstruction which they afford produces a constant tendency to circular evolution in the mass which constitutes the impending or passing current, and which, there is reason to believe, takes full effect upon large portions of the trade wind at successive periods, and especially after the parallel or portion of the trades sweeping north of the islands, becomes narrower by the approach of the autumnal equinox. These masses of atmosphere, thus set into active revolution, continue to sweep along the islands with increased rapidity of gyration till they impinge upon the American coast, or encounter the more regular returning efflux of the trades, or land wind of the North American continent. Gradually assuming a different direction as they recoil from these obstructions and receive new impulsive forces, the stormy masses continue to sweep over, or along the American coast, in a direction conforming, generally, to that coast, or to the direction of the Florida stream, and in conformity also with the prevailing atmospheric current, of which they become an integral part, till they finally become lost, or dissipated, at an unknown distance in the northern Atlantic, or perhaps even reach the coasts of Europe or its northern islands; the particular course of each storm being no doubt modified by the various oblique winds and other incidents which may attend its progress.

That the foregoing is a just account of the formation of the hurricanes and severe storms of the West Indies and the lower latitudes of the North American coast, is strongly confirmed by the fact, that beyond the 12th parallel of latitude, which is a little southward of Barbadoes, hurricanes are never known to occur. The more common origin or source of the autumnal hurricanes is believed to be about the north eastern angle of this great chain of islands; and if we rightly appreciate the operation of these causes, they uniformly tend to produce the rotative movement in the direction which has been recognized, that is, from *right* to *left*, or, in seamen's dialect, *against the sun*. This course of rotation is understood to be contrary to that which is exhibited in the trades which pass southward of the great islands, and which, on reaching the gulf of Mexico incline from left to right, *with the sun*, thus coinciding, or blending, with

the returning winds of the North American States and the northern Atlantic, or falling back again upon the trades by a circuitous route.

It appears not improbable that these *hurricane formations*, if this term may be applied to our idea of storms, may sometimes originate at various positions in the great curve between the windward islands of the West Indies, and the capes of North Carolina, and that the more southern and windward formations often diverge to the northward upon a track which, in the lower latitudes, lies eastward of the Floridian current, and producing those severe tempests on the Atlantic, of which we hear only by the occasional reports of our mariners; while those storms of a more leeward origin, or which pursue a more westerly direction, press upon our coast as they advance northward, and thus become more appreciable in their effects, or perhaps visit us with their violence.

The violent hurricanes of the West Indies* having been included in the range of these remarks, it will here be observed, that it is not deemed to be possible, considering the nature of the atmosphere and its constant tendency to an equal distribution, that the wind should blow with very great violence at hardly any place on the globe, unless by means of a circuitous, or revolving motion, in that portion of the atmosphere by which the effect is produced. The position of the axis of revolution may sometimes, however, be horizontal, or may be inclined in any degree from the plane of the horizon, as in the cases which have been alluded to, and as is probably

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* It has been supposed by some, that the hurricanes of the West Indies, are but thunderstorms of extraordinary violence, but an acquaintance with the usual phenomena of these hurricanes will lead to a different conclusion. The fact is well established that thunderstorms arise in the west and move in an earterly direction. Hurricanes, on the contrary, first appear in the eastern or southern quarter of the horizon, and advance in a westerly or north-western direction. Violent thunder and lightning is by no means a necessary and uniform attendant on hurricanes, and the gyration of these storms being, as has been shown, chiefly horizontal, is not calculated to produce that sudden and violent admixture of the higher and lower strata which, in the vertical gyration of a thunderstorm, produces such striking electrical effects. In the hurricane, the gradual and uniform depression and contact of the upper region with the lower produce, ordinarily, only those broad flashes of lightning which indicate electrical action upon an extensive surface, with but little energy of action. The passage of a hurricane over a hilly country, or mountainous island, will however, by a disturbance of the general equalibrium, doubtless produce violent thunder and lightning.

It may be added that in the season of hurricanes when the inhabitants of the Caribean Islands can discern *thunder clouds* in the horizon, all immediate apprehensions of a hurricane are at once removed.

the case sometimes with violent winds which blow from off mountains, or high table land. The motions of some parts of the atmosphere which may be immediately contiguous to a storm or a whirlwind, may also be in every intervening state of regularity or confusion. It is believed, however, that all hurricanes and tornadoes must be ascribed to causes analogous to those of which we have taken cognizance. Those which occur in the East Indian seas are well known to attend the changes of the monsoons, where winds moving in different directions, are brought to bear upon each other, or upon the opposing coasts, and the violent rotative effects naturally follow.

The desultory character of this essay, and the nature of the subject treated of, may seem to require some further detail of facts, or circumstances, tending to corroborate the foregoing views, and which will now be given, although the recollections of most persons, and particularly the observations of experienced and intelligent shipmasters, it is believed, will sufficiently establish the leading facts upon which these remarks are grounded. It is to the recorded observations, and careful reports of the members of the laborious and hazardous profession to which we now allude, that the cause of science must be chiefly indebted for an accurate and extensive knowledge of oceanic meteorology.

Some storms of recent occurrence have, from their peculiar violence, excited more than ordinary attention, and the following statements have been selected from the accounts which have been obtained of their locality and progress. The first of these storms which claims our notice, is that which passed the city of New York on the 17th of August last, (1830) being at New York, and along the whole coast north of Hatteras, a *north-east storm.*

This storm, or hurricane, was severe at the island of St. Thomas', on the night between the 12th and 13th of August.

On the afternoon of August 14th, it commenced at the Bahama Islands, and continued during the succeeding night, the wind veering almost round the compass during the existence of the storm.

On the 15th of August, the storm prevailed in the Florida channel, and was very disastrous in its effects.

In Lat. 26° 51′, Lon. 79° 40′, in the Florida stream, the gale was severe on the 15th, from north-north-east to south-west.

Late on the 15th, off St. Augustine, (Florida) in Lat. 29° 58′, Lon. 80° 20′, the gale was very severe.

At St. Andrews', twenty miles north of St. Mary's, (Geo.) from 8, P. M. on the 15th, to 2, A. M. on the 16th, the storm was from an eastern quarter, then changed to south-west, and blew till 8, A.M.

Off Tybee, and at Savannah, (Geo.) on the night of the 15th; changed to north-west at 9, A. M. on the 16th, and blew till 12, M.

At Charleston, (S. C.) on the 16th, the gale was from the south-east and east, till 4, P. M.; then north-east, and round to north-west.

At Wilmington, (N. C.) the storm was from the east, and veered subsequently to the west.

In the interior of North Carolina, the storm was felt at Fayetteville.

In the vicinity of Cape Hatteras, at sea, the storm was very heavy from the south-east, and shifted to north-west.

A vessel bound from New York to Hayti, in the middle or outer part of the gulf stream, about Lat. 33° Lon. 72°, experienced the gale, moderately, from south-west and south-south-west, but with a very heavy sea from a westerly direction, and is supposed to have been on the outer margin of the storm.

Another vessel, at about the same distance from the coast, experienced similar effects.

Early on the morning of the 17th, the gale was felt severely at Norfolk, and also in Chesapeake Bay; from the north-east.

Off the Capes of Virginia, on the 17th, in Lat. 36° 20′, Lon. 74° 2′, "a perfect hurricane" from south to south-south-east, from 5, A. M. to 2, P. M., then shifted to north-west.

On the 17th, in Lat. 37° 30′, Lon. 74° 30′, near the coast of Virginia, the gale was severe at east-north-east, and changed to west-north-west.

Off Chincoteague, (Md.) precise distance from the coast unknown, the gale was severe between south-south-east and north-north-east.

Off the coast of Delaware, in Lat. 38°, Lon. 72°, "tremendous gale," commencing at *south-east*, at 1, P. M. on the 17th, and blowing 6 hours, then changed to *north-west*.

At Cape May, (N. J.) the gale was north-east.

Off Cape May, in Lat. 39°, Lon. 74° 15′, heavy gale from east-north-east, on the afternoon of the 17th August.

Near Egg Harbor, coast of New Jersey, the gale was heavy at north-east on the same afternoon.

Off the same coast, in Lat. 39°, Lon. 73°, the gale was at east-north-east.

In the same latitude, Lon. 70° 30′, "tremendous gale," commencing at south-south-east, and veering to north.

At New York, and on Long Island Sound, the gale was at north-north-east and north-east, on the afternoon and evening of the 17th.

Off Nantucket shoals, at 8, P. M. the gale commenced severe at north-east by east.

In the gulf stream, off Nantucket, in Lat. 38° 15′, Lon. 67° 30′, on the night of the 17th, "tremendous hurricane," commencing at south, and veering, with increasing severity, to south-west, west, and north-west.

At Elizabeth island, Chatham, and Cape Cod, (Mass.) the gale was severe at north-east, on the night between the 17th and 18th.

On the 18th, heavy gale from north-east, at Salem and Newburyport, Mass.)

Early on the 18th, in Lat. 39° 51′, Lon. 69°, severe gale from *south-east*, suddenly shifting to *north*.

In Lat. 41° 20′, Lon. 66° 25′, "tremendous hurricane" from north-north-east on the 18th of August.

On the night of the 18th, off Sable island, and near the Porpoise bank, in Lat. 43°, Lon. 59° 30′, "tremendous heavy gale" from south and south-west to west, and north-west.

In Lat. 43°, Lon. 58°, severe gale from the south, the manner of change not reported.

This remarkable storm appears to have passed over the whole rout comprised in the foregoing sketch, in about six days, or at an average rate of about seventeen geographical miles per hour.

The duration of the most violent portion of the storm, at the several points over which it passed, may be stated at from seven to twelve hours.

The general width of the track influenced in a greater or less degree by the gale, on the American coast, is estimated to have been from five to six hundred miles.

Width of the hurricane portion of the track, or severe part of the gale, one hundred and fifty to two hundred and fifty miles.

Semi-diameter of the hurricane portion of the storm seventy five to one hundred and twenty five miles.

Rate of the storm's progress from the island of St. Thomas to Providence Island, Bahamas, fifteen nautical miles per hour.

Rate of progress from Providence to St. Johns, Florida, sixteen miles per hour.

From St. Johns to Cape Hatteras, North Carolina, sixteen and a half miles per hour.

From Cape Hatteras to Nantucket, on the south-eastern coast of Massachusetts, eighteen miles per hour.

From Nantucket to Sable Island, off the south-eastern coast of Nova Scotia, twenty miles an hour.

The general rout of this storm is delineated on the annexed map, so far as could be done by a careful collation of accounts from more than seventy different localities. The four dotted lines are supposed to include that portion of the rout on which the storm exhibited its greatest violence, but its entire influence was spread over a much wider range. The two central lines are believed to be an approximation to the rout pursued by the vortex, or moving axis, of the storm.

The storm appeared on this part of the coast simultaneously with the prevalence of a north-westerly wind, which maintained itself at a few miles distance, for some hours after the setting in of the north-east wind at New York; the latter gradually extending itself up the Hudson. During the whole period of the gale the extreme margin of the stratum of clouds pertaining to the storm, was visible from the city and elevated not less than ten or fifteen degrees in the north-western horizon. The sun set during the height of the gale, and by illumining the lower surface of the dense canopy at his departure, gave a most striking degree of splendor to the scene; an effect which was much noticed at New Haven, and other places.

On the western part of the Atlantic ocean, between the parallel of New York and the northern limit of the trades, the prevailing winds, for a considerable period both previously and subsequently to the occurrence of this storm, were south-westerly, or from the southern quarter; and over the whole breadth of the Atlantic on the rout frequented by ships in the European trade, fresh south-western or westerly winds also prevailed at the same period, for many weeks. These facts are well established by numerous marine journals which have been consulted in relation to this subject.

Striking evidence of the vorticular or rotative character of the storm, is afforded by the journals of two of our outward bound European ships, the Britannia and the Illinois. The former had sailed from New York on the 16th, with the wind in a southern quarter, and encountered the storm on the night of the 17th, between Block Island and the latitude of 39°. The storm was first felt from N. E. and E. N. E., and on the course steered by the ship veered by mid-

night to E. S. E., at which time it was a "perfect hurricane" and the "sea tremendous beyond description." At 4 A. M. of the 18th the wind had veered back to north, and at 8 A. M. to north by west. The Illinois was, on the same night, in the gulf stream, in a south-easterly direction from the Britannia, standing eastward with a fair wind and moonlight, when the *scuds* appeared flying with great swiftness, and the wind, changing to *south*, soon commenced blowing a full hurricane, veering successively, during the night, first to south-west, then to west and to north-west, raging with increased fury till 8 A. M. on the 18th when it abated. It appears evident that this vessel was in the outward or southern semi-diameter of the storm, and that its vortex or axis passed between the two ships. It is also worthy of remark that the Illinois, which was bound from New Orleans to Liverpool, had passed through the Florida channel just previous to the passage of this storm towards the continent, and experienced, from the south, its tremendous swell, while off the coast of South Carolina, but by favor of a fine south-west wind and the current of the gulf stream the ship escaped, for the time being, to be afterwards overtaken by the storm when it had assumed its north-eastwardly course.*

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* Since writing the above, the letter from which the following is an extract has been received from the commander of the Illinois.

I sailed from New Orleans on the 3d of August, bound to Liverpool; nothing worth notice occurred until the 15th, being then in the Gulf Stream, lat. 33° N. lon. 77° W.; winds light in the south-east; experienced a very heavy swell from the south, more than I had ever experienced before in this part, unless preceded by heavy gales. We had no indications of wind at this time, but a dull and heavy appearance in the south. During the night of the 15th the wind shifted round to south south-west, the weather still continuing fine.—By the commencement of the 16th we had a fresh, wholesale breeze, so that with the help of the Gulf Stream, we ran at a great rate, steering north-east; lat. at noon 36°, lon. 73°.—All the 17th the wind continued steady at south south-west, blowing a strong, wholesale breeze; appearance in the south dull and heavy; the sea quite smooth again, and to appearances we had outrun the heavy southerly swell. Lat. at noon 37° 58′, lon. 69° 23′; still continuing to run about the course of the Gulf Stream; temperature of the water 86°.—On the first part of the 18th, (*afternoon of the* 17*th, current time,*) the wind backed to south and began to *freshen-in* very fast; some heavy clouds arising in the south-west, and likewise observed some small flashes of lightning in that quarter. 8 P. M. the wind had increased to a strong gale; the weather at this time had an unusual appearance, but still it did not look bad; 10 o'clock, the wind still increasing, took in our sails and prepared for the worst; 11 o'clock, the sea ran high and cross, which induced me to heave the ship too under a close-reefed main top-sail. About half past 12, (midnight,) all was darkness; the heavy clouds that had been rising in the south-west had at this time overtaken us; the rain fell in torrents, and

The next storm on which we shall bestow a moment's attention, is that which occurred on the succeding week, which passed New York on the 26th and 27th of August, and which was also on this coast a north-east storm, of about three days duration. From the eastward of the Bahamas it appears to have passed northwardly, between the Florida stream and the Bermudas, and touching the American shore near Cape Hatteras, raged with great fury for about forty hours at each locality, as it swept the great central curve of our coast, and passing from thence, continued its course over George's Bank, in a north-easterly direction. It was evidently of greater compass and slower progress than the preceding storm, as is proved by a collation of the various reports of mariners and its long duration, and its effects were almost equally violent. A few notices only, will be given of the reports of this storm; and we here note the fact, that it is sometimes difficult to determine between current and nautical time, in the dates of marine reports.

August 22d, the gale was experienced off the Bahamas.
" 23d, in lat. 27° 30′, lon. 72°, heavy at E. N. E.
" " " 30° 30′, " 68°, do. do.
" 24th, " 33°, " 65°, tremendous gale at S. E.
" " " 35°, " 70°, heavy gale. [two hours.
" 24th and 25th, off Cape Hatteras, severe gale E. N. E. forty-
" 25th and 26th, lat. 37°, lon. 74°, severe gale N. E. [W.
" " " off Cape May, forty hours, changing to N. and
" " " lat. 38° 30′, lon. 71°, severe at N. E.
" 26th, at Boston and the east coast of Massachusetts, N. E.
" " lat. 41°, lon. 62°, severe at S.

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the lightning was uncommonly vivid; the wind had, in the space of one hour, increased from a moderate gale to a perfect hurricane. Half past 1 A. M. it began to veer to the westward; at 3 A. M. it was west, and rather increased in violence as it shifted. At day light the sky had cleared, but the gale, if any thing, rather increased in its fury; the sea was tremendous and ran in every direction. 7 A. M. the wind had got to the north-west, and at 9 o'clock it began to abate a little in violence. At noon it became moderate enough to steer off our course.—All the 19th, moderate gales at north-west and clear weather. Lat. at noon of the 18th 38° 33′, lon. 66° 30′; lat. on the 19th 39°, lon. 62° 22′; temperature of the water 81°—still continuing in the Gulf Stream.—From this period, (excepting one or two gales from the eastward,) until we arrived at Liverpool, on the 12th of September, we had moderate winds from south south-west to north north-west, with a very smooth sea.—I have only to add, that from an experience of twenty or thirty years, during which time I have been constantly navigating the Atlantic, my mind is fully made up, that heavy winds or hurricanes run in the form of whirlwinds.

Yours truly,

ROBERT WATERMAN.

This storm pursued, in the early part of its progress, a more northwardly rout, than is usual for those storms that reach the coast, and its rate of progress cannot have greatly exceeded ten miles per hour.*

It may be remembered, that Doctor Franklin has assigned one hundred miles per hour as the average rate of the advance made by north-east storms, *towards* the north-east. As the termination of these storms also follows on from the south-west to north-east, in the same ratio with their commencement, the *direct* effect of this rate of progress would, of itself, be equal to a violent hurricane from *south-west*. The facts which we have exhibited show a very different result, and the discrepancy can be accounted for, only by supposing that in the state of the country at that early period (1740) reports of meteorological facts were too unfrequently and loosely made, to furnish the necessary data for a correct estimate on this subject. The mistake might easily be fallen into in a case like that which we have last mentioned, where a storm of very great extent has fallen obliquely upon the coast; as even a correct report of the

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* The annexed extract from the New York Gazette, comprises some additional facts, and will assist us in forming some just conception of the scenes which are often occasioned by the severe storms of the Atlantic:—

Extracts from the log-book of the ship of war Kensington, W. W. Ramsay, Esq. commander.

Monday, August 23d, Cape Henlopen bearing west-south-west at 7, P. M.; discharged the pilot, and steered off east-south-east.—Tuesday, August 24th, commences with light and variable weather; from 4 to 6, P. M. light airs from the southward; from 6 to 8, nearly calm; from midnight to 4 A. M. moderate and clear—disagreeable head sea; from 4 to 8, A. M. wind fresh from east-north-east; from 8 to meridian freshening, took one reef in the fore and main, and two in the mizen-top-sails.—Wednesday, August 25th, wind high from the north-east—took two reefs in the fore and main-top-sails; from 4 to 6, P. M. fresh gales from the north and east; weather cloudy; sent down royal yards: from 6 to 8, wind increasing; at 7, 40, close reefed the top-sails, reefed the courses, and furled the main-sail; from 8 to midnight, very squally, with rain; at midnight under close-reefed topsails, reefed fore-sail and fore-stay-sail; the second gig washed from the larboard davits; from 4 to 8, A. M. wind not so strong, and hauling to the east.—Thursday, August 26th, fresh gales from north and east, with heavy head sea: attached an eight-inch hawser to the end of the bowsprit; brought both parts into the hawse holes, and set them well up; got a pull of the bobstays and bowsprit shrouds; from 4 to 6 P. M., gale increasing; in sending down topgallant yards lost fore-topgallant-mast and yard; furled the fore-sail, fore and mizen-top-sails; got preventer tackles from the fore-mast to the bowsprit; at 6, Andrew McCormick was washed from the jib-boom and drowned; from 6 to 8, P. M. gale very heavy, the sea increasing to an alarming height; from 8 to midnight, gale most violent; lying to, under close-reefed main-top-sail and fore-

time of its first appearance, might show an apparent progress at this high rate between certain points, on or near, the great central curve of our coast.

The two storms next reported to us, took effect on a more eastern portion of the Atlantic. One of these appeared on the 20th of September, pursuing a northerly course in Lat. 39°, Lon. 40°. The other appeared off the south-east border of the great bank of Newfoundland, on the 24th of September, pursuing a north-easterly direction. Both storms exhibited the essential character which we have described, with all the violence of hurricanes.

The next storm which we have occasion to notice, appears to have originated in the vicinity of the Windward Islands, near the close of September, and which, passing the Bermudas on a course somewhat west of north, on its approach to the Florida stream assumed a more easterly course, towards the eastern coast of Newfoundland, or the Grand Bank. Of this storm, which was very disastrous, we shall give a few reports.

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stay-sail. From midnight to 4 A. M. gale raging with great violence—a tremendous sea; at 1, A. M. the main and mizen-topgallant-masts were blown away close to the caps; at 2, A. M. a perfect hurricane from the north, taken aback; the ship in a very critical situation; pitched away the jib-boom, with it the sprit-sail-yard, sprung the bowsprit and fore and main-masts—attempted to relieve the ship of the main-top-sail, weather sheet parting, the sail was instantly thrashed to pieces; at 4, the situation of the ship was most critical, working violently, and much distressed from the weight of her battery; at 4, 30, foresail, fore-top-sail and main-sail burst from their gaskets and were blown into ribbons; from 4 to 8, A. M. gale raging with unabated fury—fore-stay-sail blown from the bolt-rope, and such the force of the storm, that not a rag of canvass could be shown; at 4, 40, main-top-mast went by the cap; at 5, fore and main-mast badly sprung, secured the partner wedges with heavy spikes; to save the fore-mast and bowsprit, cut away the fore-top-mast, carrying with it the head of the fore-mast, and part of the fore-top; cock-billed the fore-yard and secured the lee arm to the cable bitts; at 5, 30, carried away weather mainbrace bumpkins; to save the mast, cut away the main-yard, which no human effort could secure; the situation of the ship awful in the extreme; five feet water in the hold, and the crew perfectly paralyzed: the wind had now attained a furious height, and the sea increased to such an alarming degree, that with great difficulty men could be found to cut away the main yard.—Friday, August 27th, gale yet dreadful; at 4, 30, wind hauled to west; set the mizen-stay-sail to keep the ship too; from 4 to 8, gale somewhat abated, set the main-stay-sail; at 6, gale abating, all hands employed in clearing wreck—weather cloudy; from 8 to midnight, moderate, heavy sea, ship very uneasy; from midnight to 4, very heavy sea; from 4 to 8, A. M. gale again increasing. Spoke ship Norfolk, *from Norfolk*; received an offer of assistance. *The Norfolk was not in the gale.*

In Lat. 20° 30′, Lon. 63°, the storm commenced on the 29th of September, at 1, P. M., and continued till half past 6, P. M. from north-east and south-west alternately.

On the same day, in Lat. 22° 46′, Lon. 65°, a hurricane.

Sept. 30th, at night, Lat. 26° 7′, Lon. 66° 31′, "very heavy" five and a half hours.

Oct. 1st, Lat. 30° 38′, Lon. 63°, severe at south-east, shifted to north-west.
" " Lat. 33°, Lon. 66° 30′, severe gale or hurricane.
" " Lat. 34° 9′, Lon. 66° 12′, "hurricane" at east-south-east.
" " Lat. 35°, Lon. 68°, severe gale.
" " Lat. 38°, Lon. 63°, "a hurricane."
" " Lat. 38° 30′, Lon. 57°, severe gale.
" " Lat. 40°, Lon. 61°, hurricane from nearly south, at 2, P. M., sudden and violent from the north.
" " Lat. 40° 25′, Lon. 58° 24′, moderate gale, with heavy swell and cross sea.
" " Lat. 41°, Lon. 55°, very severe.

By an average estimate of dates and distances, it appears to have made progress at the rate of about twenty-seven miles per hour.

A north-east storm, of three days' duration, appeared on our central coast one week subsequent to the foregoing, the rainy, and more tempestuous portion of which continued about twenty-four hours, its progress and other features being analogous to those previously described.

It must not be supposed that the facts which are comprised in the foregoing recitals, are peculiar only to the most violent storms, or to the season of the equinoxes, but the same general features appear to have pertained to every storm which has prevailed in these regions. The extensive hurricane of 1804, which swept over most of the islands in the West Indies, commenced at Martinico on the 3d of September, reached Savannah on the 7th, Boston on the 9th, and became a *snow-storm* on its arrival in the interior of New Hampshire. The great gale of 1815, commenced at St. Bartholomews on the 18th of September, and reached Rhode Island on the morning of the 23d, where it was awfully destructive from the *south-east*, while in the south-eastern part of Massachusetts it was then blowing at *south*, at New London from *east* to south-east, and at New York from *north* to *north-north-west*. The violent north-east snow-storm of Decem-

ber 6th, 1830, swept along our whole coast in the same manner,* it being experienced from the southward and westward, by vessels which were at a certain distance from the coast. It would be easy to fill a volume with the record of facts of a like character, and it is believed that, of the storms of the last forty years, the route and corresponding character of all those which have been sufficiently violent to receive notice in the marine reports, can be traced in a similar manner; while not an instance of a contrary kind has come to our knowledge.

A remission of the south-westerly and westerly winds usually occurs towards the close of the autumnal season, or rather, perhaps, these winds exert their chief force, at this period, on more southern parallels. At this period we often experience a long succession of easterly storms, generally of a sluggish character, and attended with cold rains. This weather sometimes continues into the winter months, and generally occurs again, subsequently to the vernal equinox. Perhaps some of these storms, as well as those of other periods, originate to the northward or *leeward* of the great headlands of our coast, particularly those of North Carolina; but, however originating, the absence of the impulsive effect of a brisk westerly wind, causes them to linger on our shores, to the annoyance of hypochondriacs, and all admirers of a cloudless sky. In some rare instances, the circuit of these north-eastern storms is so great as to sweep, at one and the same time, up the gulf and lower valley of the St. Lawrence, and along our coast, almost to Cape Hatteras, while vessels which are approaching our shores from southern latitudes, encounter the same atmospheric current at west and north-west.

The prevalence of regular winds, generally tends to produce fair weather. By a regular wind is here understood, an atmospheric current of magnitude, which blows, uninterruptedly, in nearly a direct course, without any extraordinary agitation of its parts, or, which blows in a circuit of such extent, as to preserve a similar equability and placidity of movement. At a period subsequent to the vernal equinox, we are sometimes visited by an easterly wind of this character, of no inconsiderable duration. A remarkable instance of the kind occurred in the spring of 1830, when we experienced a regular

* The great snow-storm and gale of January 15, 1831, which occurred after this article was forwarded for publication, exhibited the same character, being a north-east storm on shore, while at a certain distance from the coast, its force was exerted in nearly an opposite direction.

east wind, from even the shores of Europe, and the passage of some returning ships was performed in fifteen or sixteen days, and in some instances, without taking in a top-gallant-sail.* After a little chilliness on the first day or two in which it prevailed, this wind became remarkably bland and agreeable in its effects, in a greater degree, perhaps, than any other winds which we experience at that season. North-easterly storms, of an extensive formation, and with a moderate gyration, are also supposed to blow, occasionally, with a clear sky, towards their marginal portions, for a considerable time, and over a large extent of country; constituting what are somtimes called *dry north easters*, and which, in some places, disappear without producing symptoms of rain.

The gyral axis of a storm in most cases, is probably inclined in the direction of its progress, for, being retarded by the increased resistance of the surface, the more elevated parts of the storm must necessarily be inclined forward and overrun to a very considerable distance the more quiet atmosphere, which lies near the surface. This will account for the first hazy appearance of the storm which is exhibted in the south west, usually on the evening previous to its *setting-in*, and often, some hours previous to any change of wind at the surface.† This overlaying of the higher portion of the storm will account for another premonitory indication which we shall yet have occasion to notice, and thus, also, vessels at sea sometimes encounter the sudden violence of these winds upon their more lofty sails and spars, while all is quiet upon deck. Thus also a balloon sent up in a moderate breeze, has, on ascending a considerable height, been carried off at the rate of seventy miles an hour. The two lateral margins of the advancing storm will also overlay the prevailing

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* On this occasion, London papers were read in New York on the sixteenth day after their publication.

† Dr. Mitchill has recorded as the result of the observation of laboring people in New York, that when the haze or *cirrous* which, appearing at sunset, indicates the approach of a storm, is seen over Staten Island at S. W. or more southerly, the storm of the succeeding day will blow from the *north-east;* but if it appears over the Jersey shore of the Hudson from W. S. W. to N. W. then the storm is expected to blow at *south-east.* These prognostics accord very closely with the views maintained in this article—for as in a S. E. storm, its most advanced and central portion must be over the land, its first appearance will necessarily be exhibited in the western quarter of the horizon—while a north-east storm, the main body of which passes over the ocean, and covers the land with only its north-western limb or margin, will accordingly exhibit its premonitory appearances in a more southerly direction.

current in the same manner, to a less extent, owing to the centrifugal action of the storm; the greatest velocity and force being unquestionably produced at a considerable elevation. These lateral effects or overlayings in the higher portions of the atmosphere often occur, it is believed, without producing any visible influence at the surface. A somewhat contrary effect is usually produced on the receding margin where the prevailing current, or impelling wind, presses heavily upon the advancing mass, and generally overlays it to some extent.

One of the most important deductions which may be drawn from the facts and explications which are now submitted, is an explanation of the causes which produce a fall in the barometer on the approach of a storm. This effect we ascribe to the centrifugal tendency, or action, which pertains to all revolving or rotatory movements, and which must operate with great energy and effect upon so extensive a mass of atmosphere as that which constitutes a storm. Let a cylindrical vessel of any considerable magnitude, be partially filled with water, and let the rotative motion be communicated to the fluid, by passing a rod repeatedly through its mass, in a circular course. In conducting this experiment we shall find that the surface of the fluid immediately becomes depressed by the centrifugal action, except on its exterior portions, where, owing merely to the resistance which is opposed by the sides of the vessel, it will rise above its natural level, the fluid exhibiting the character of a miniature vortex, or whirlpool. Let this experiment be carefully repeated by passing the propelling rod around the exterior of the fluid mass, in continued contact with the sides of the vessel, thus producing the whole rotative impulse by an external force, analogous to that which we suppose to influence the gyration of storms and hurricanes, and we shall still find a corresponding result, beautifully modified, however, by the quiescent properties of the fluid; for instead of the deep and rapid vortex before exhibited, we shall have a concave depression of the surface, of great regularity, and by the aid of a few supended particles, may discover the increased degree of rotation which becomes gradually imparted to the more central portions of the revolving fluid. The last mentioned result obviates the objection, which, at the first view might, perhaps, be considered as opposed to our main conclusion, grounded on the supposed equability of rotation in both the interior and exterior portions of the revolving body, like that which pertains to the rotation of a wheel, or other

solid. It is most obvious, however, that all fluid masses are in their gyrations subject to a different law, as is exemplified in the foregoing experiment; and this difference, or departure, from the law of solids is doubtless greater in aeriform fluids than in those of a denser character.

The whole experiment serves to demonstrate, that such an active gyration as we have ascribed to storms, and have proved, as we deem, to appertain to some, at least, of the more violent class, must necessarily expand and spread out, by its centrifugal action, the stratum of atmosphere subject to its influence, and which must consequently become flattened, or depressed, by this lateral movement, particularly towards the vortex or center of the storm, lessening thereby the weight of the incumbent fluid, and producing a consequent fall of the mercury in the barometrical tube. This effect must increase till the gravity of the circumjacent atmosphere, superadded to that of the storm itself, shall, by its counteracting effect, have produced an equilibrium in the two forces. Should there be no overlaying current, in the higher regions, moving in a direction, different from that which contains the storm, as in case of violent storms of great extent there probably is not, the rotative effect may, in these latitudes, be extended into the region of perpetual congelation, till the medium becomes too rare to receive its influence. But, wherever may be the limit of this gyration, its effect must be to depress the cold stratum of the upper atmosphere, particularly towards the more central portions of the storm, and, by thus bringing it in contact with the humid stratum of the surface, to produce a permanent and continuous stratum of clouds, together with a copious supply of rain, or a deposition of congelated vapor, according to the state of temperature prevailing in the lower region.

If the view which has before been taken of the forward inclination of the axis and advancing margin of the storm be well founded, it will result, that on its approach, the barometer will usually be affected previously to any sensible indications of its proximity, especially if the storm be a violent one, and that the sinking of the mercury will continue till the nearest approach of the center of the storm, as existing in the higher parts of the atmosphere. It will also ordinarily happen that, previous to the arrival or passage of the center of rotation, as exhibited at the surface, the mercury will commence rising, and continue its ascent during the approach and prevalence of

the last or receding semi-diameter of the storm, even though the violence of the wind, as sometimes happens, should be greater than on its advancing section; the rise of the barometer being accelerated by the impulsion of the general current which presses forward the storm, as well as by the forward inclination of the gyrating mass.

It sometimes happens, when the central portion of an extensive storm passes over or near the point of observation, that the comparative calm or *lull* which prevails about the apparent center of rotation, is preceded by a gradual, rather than sudden, abatement of the wind, and that the seemingly contrary wind of the opposite section of the storm, as gradually resumes its violence. This circumstance, among others, has led to the erroneous conclusion of the prevalence of two distinct and opposing storms, one rapidly succeeding the other, or, as a comparison of facts at different points on the central line of the storm's progress might seem to show, that these supposed separate storms were constantly blowing, each directly against the other. The tendency of such a movement, however, must be to produce an immediate calm, instead of a continued and violent gale, and would inevitably produce a rapid and unnatural rise in the barometer at the first setting in of the storm, a rise which must continue as long as these forces remained opposed to each other. Now as the barometer invariably falls, when under the influence of a violent gale, its testimony ought to be decisive against such a view of the subject, even were it possible to assign any natural cause which would be adequate to furnish the immense and inconceivable power which would be necessary to produce and sustain belligerent movements of such violence and duration. The application of a little physical arithmetic to subjects of this kind, it is conceived, would often prevent the adoption of erroneous or hasty conclusions.

The usual phenomena of these changes, on the central track of the more violent storms of the Atlantic, are however, often exhibited in a manner too sudden and striking, to permit of the illusion of two separate storms to take possession of the mind of the observer; with whatever solution he may attempt to reconcile the apparently opposing effects. Every experienced navigator will shrink with instinctive apprehension from the very idea of those moments of awful and treacherous stillness which place him in the central vortex of the hurricane, ready to be overwhelmed by the rapidly advancing and seemingly impenetrable line of spray which envelops the onset of the

last and most dreaded portion of the receding storm.* A spirited and graphic description of this remarkable and well known crisis of a hurricane, constitutes a leading feature in almost every well wrought description of a marine tempest.

We have assumed that the leading storms of the northern and western Atlantic, and the American coast, originate in detached and gyrating portions of the northern margin of the trade winds, occasioned by the oblique obstruction, which is opposed by the islands to the direct progress of this part of the trades, or to the falling in of the northerly and eddy wind from the American coast upon the trades, or to these causes combined. Were it not for the fear of ranging beyond the limits of established data, we might follow out this part of the subject so far as to enquire after the probable influences which indicate or govern the succession of periods in which these aerial masses thus fall into a state of gyration, and the probable effect of this gyration upon each successive portion of the trade wind which may follow in the same course. If we venture on this ground, we would say that the most probable indication of the separations which we suppose to occur from this parallel of the trade, would be found in the diurnal influences to which they are exposed, these being among the most powerful causes which mark the production of meteorological phenomena, or, in other words, that such a portion of the passing atmosphere would be likely to become detached in one body, as should arrive at, or pass a given meridian of the obstruction, in the course of an entire day. The extent of this influence on the atmosphere, if subject to a progressive rate of sixteen miles an hour, which is near the average advance of the storms in that region, would be something short of four hundred miles from east to west,

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* To the southward of Newfoundland, shifts of wind are very common, and it frequently happens that, after blowing a gale upon one point of the compass, the wind suddenly shifts to the opposite point and blows equally strong. It has been known, that while one vessel has been lying-to in a heavy gale of wind, another, not more than thirty leagues distant, has at the very same time been in another gale, equally heavy, and lying-to, with the wind in quite an opposite direction.———In the year 1782, at the time the Ville de Paris, Centaur, Ramilies, and several other ships of war, either foundered or were renderod unserviceable, in lat. 42° 15′, lon. 48° 55′, on or near the Banks, together with a whole fleet of West Indiamen, except five or six, they were all lying-to, with a hurricane from east south-east; the wind shifted, without any warning, to north north-west and blew equally heavy, and every ship lying-to under a square course foundered.—*Purdy's Memoir, 6th edition, London,* 1829, *corrected from Medical Repository.*

which corresponds sufficiently with the usual diameter of the lesser storms, and also with the probable breadth, in latitude, of that portion of the trade which, in the stormy season, is subject to this influence. Now the immediate effect of the rotative motion in this mass, will be to induce, in some degree, a counter gyration in the diurnal mass which next succeeds it, and which has not yet become subject to the original rotative influence. The previous tendency, thus imparted, will enable the second diurnal mass to pursue its course along the islands on the following day, in a comparatively quiescent state, which is induced by these contrary influences. But not so with the third diurnal succession of atmosphere, which, previous to its arrival, has perhaps already felt the influence of the counter movement of the second mass, somewhat in the manner in which toothed wheels, by their external contact, communicate motion to each other; and this diurnal mass, thus predisposed, may receive the gyrating impulse with more facility than either of the two which have preceded it. By parity of reasoning, the fourth day would witness the passage of a comparatively undisturbed atmospheric current, while on the fifth day an increased disposition to gyration would again occur, and so alternately, on the succeeding days. These successive diurnal influences, though subject to all the collateral influences which may chance to attend them, may notwithstanding, be supposed to produce some discernable effects, and, in the usually regular progress of these winds towards the continent, and afterwards in the general direction of the coast, these diurnal effects might be supposed distinguishable at a great distance from their original source.

It may happen at some seasons, that the causes which produce the revolving impulsion, operate upon a still larger portion of the atmosphere, equal, we will suppose, to the space occupied in the advance of two days, and some also of three days, as seems to be the case with some extensive storms or hurricanes. Now in most of these cases, whether in periods of one, two, or three days' duration, their termination will coincide at the end of the sixth day.* On the *seventh* day, therefore, a renewal of the original revolving influence, may again be expected to occur. Whatever may be thought

* At St. Augustine, in Florida, where the storms from the vicinity of the islands frequently appear, it is said that a storm which continues more than *one* day, will last *three* days; and this peculiarity, parhaps, continues to be observable till the storm has advanced a much greater distance along the coast, but with less exactitude in proportion to the distance from the place of its origin.

of this hypothesis, there are persons who suppose that in stormy seasons there is, in our climate, a constant tendency to the recurrence of bad weather on the third, fifth and seventh days from the date of a given storm, and this is more particularly noticed on the seventh days, especially when the storm may happen to fall on Sundays. The records of the weather for the more stormy part of the last three years, if carefully examined, will be thought to accord with this opinion, particularly as regards the seventh day storms. These have sometimes occurred for many weeks in succession, and in some cases of failure, have appeared within twelve hours, sooner or later, of the assumed period. If this idea of the subject be well founded, it may be interesting to inquire whether this peculiarity in the weather be not the origin of those diurnal indications, which prevail in some of the febrile diseases of our climate.

The foregoing view of the character of our easterly storms tends to show more clearly the general uniformity and extent of the great atmospheric current of westerly winds, which sweeps over a considerable portion of our continent, and of the Northern Atlantic. It also strengthens the opinion which we have entertained, that these westerly winds, together with the trades which originate them, form but a portion of a great circuit or system of winds, whose revolutions are constantly, though in some parts, irregularly, maintained, in the atmosphere which is incumbent upon the greater part of the Atlantic ocean and a large portion of the adjacent continents; and that this revolution, varying in its sphere with the change of seasons, is kept in constant activity by the causes which produce the trade winds. The same winds produce also in their turn, the great system or circuit, of oceanic currents, comprising the equatorial, the gulf stream, the arctic current, and also their numerous appendant currents, often of a gyrating and varying character, like that of the bay of Biscay. The center of this oceanic revolution is found in that great eddy of the Atlantic which is called the grassy sea, lying between the parallels of 20° and 35° of north latitude, and the 28th and 60th merdians of longitude west from Greenwich. We have the satisfaction to find, on referring to an able and interesting outline of our physical geography and climate, that this great and continued revolution in the atmosphere of the Atlantic basin is supported by irrefragable evidence drawn from a valuable collection of meteorological tables, which have been compiled from numerous observa-

tions, made at various points on both sides of the Atlantic.* The same able geographer has shown also in coincidence with the revolution, a general westerly wind or current in the temperate and higher latitudes, connecting the basins of the Pacific and Atlantic, and sweeping entirely across the continents of America, Europe, and part of Asia, and which we find is sustained by numerous authorities. These extensive revolutions, in the great aerial ocean which envelopes our earth, seem to be a benevolent provision of the great author of nature, tending to equalize the climate and temperature of our globe which would otherwise be attended with far greater inequalities.

It appears, also, if the severe storms of the Northern Atlantic pursue a general and somewhat uniform course, that, on receiving intelligence of the occurrence of such a storm, in a particular locality, a probable opinion may be formed of the hazard or exposure of any absent vessel, whose position on the ocean may be known with any good degree of certainty. This shows the importance of particular marine reports, specifying the *latitude and longitude*, *date*, *time of commencement*, *direction*, *duration*, and *subsequent changes* of such storms as may exhibit, either extraordinary violence, or indications of such violence in their immediate vicinity.

In the early stages, or indications of storms upon our coast, it would seem, also, that a pretty correct estimate may be formed of the bearing, and probable course of the *heart of a storm*, and of the course also which, if steered, will have the best tendency to lessen its violence, or duration; and that those navigators who find in any of the more moderate storms, an adverse wind, may, by pursuing a course transverse to that of the storm, often modify its direction in a manner favorable to their wishes.

These remarks are frankly submitted to the consideration of gentlemen of science and observation, who may have means and opportunity for a more accurate and extensive examination of the subject. Any person who may be able to furnish additional facts relating to any of the storms which have been noticed in this article, is respectfully requested to leave a memorandum of the same in the care of Messrs. E. & G. W. Blunt, Hydrographers, in the city of N. York.

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* View of the United States. By William Darby. Philadelphia, 1828. H. S. Tanner. 18mo. pp. 654.—If in addition to the usual tabular records of meteorology, a separate column should be appropriated for noting the course of the clouds, and particularly of those which form the upper stratum, we should obtain evidence, far more conclusive of the prevailing direction of the great atmospheric currents than can be derived from the direction of the winds at the earth's surface.