morning report in Ontario; Kingston barometer 0.32 below the normal; brisk SW. winds and cloudy weather in the Middle Atlantic States and New England, accompanied in the latter by heavy rains. In the afternoon central in Maine, brisk SW. winds were reported from Carolina to Massachusetts, with a maximum velocity of 28 SW. at Cape Lookout. The course of the area was northeast, and by midnight it had passed into the Gulf of St. Lawrence. No signals were displayed during the passage of this area.

No. VII.—This area, whose presence was first shown by the barometers in the Northwest on the 24th was central on the morning of the 25th in eastern Manitoba; Pembina barometer 0.33 below the normal generally cloudy weather, with southerly to westerly winds and light local rains, being reported from the Upper Lakes and Northwest; moving southeasterly, with increased pressure, it was central over Lake Superior, midnight of that date. During the day southerly to westerly winds and cloudy weather had prevailed, with moderate rain-fall over the Lake region and Northwest. On the 26th, in the morning, the depression was central over Lake Michigan; Escanaba, barometer 0.26 below the normal; in the afternoon in eastern Michigan. At midnight it reached southern Ontario. During the day, rainy weather, with brisk to high southerly winds, on the New Jersey and North Carolina coasts, and rainy weather, with fresh easterly winds, in New England, were reported, while clear weather and fresh southerly winds prevailed over the Lake region. Signals displayed in connection with high area No. IV on the 25th from Macon north to Sandy Hook inclusive were continued up, and during the afternoon of the 26th signals were displayed at New York. On the morning of the 27th, the pressure passed off the New England coast; Portland barometer 0.28 below the normal. At this time fresh to high northerly winds, 30 miles NE. at Eastport Me., with cloudy weather and heavy rain-falls, were reported from New England, and fresh to brisk west to southwest winds from the New Jersey and North Carolina Coasts. All the Signals on the Atlantic coast were then lowered, having been fully justified, as shown in connection with high area No. IV.

No. VIII.—This area appears to have sprung up from the remains of area No. VII, and at midnight of the 27th was central north of Lake Superior, at which time fresh westerly winds, with heavy rain-falls, were reported from that Lake. On the morning of the 28th the central pressure had reached the eastern part of Lake Superior; Marquette barometer 0.22 below the normal. Moving eastward through Ontario at midnight it was central at Quebec, and on the morning of the 29th passed into the Gulf of St. Lawrence. The passage of the area was marked by little energy, and no dangerous winds in connection therewith were reported.

No. IX.—This area was central in western Manitoba on the afternoon of the 30th, and by midnight had reached central Dakota; Bismarck and Pembina barometers, respectively, 0.29 and 0.31 below the normal. Its course during the 31st was a little east of south while its movement was sluggish, and its pressure increasing being 0.18 below the normal at Yankton on midnight of the 31st. No dangerous winds were reported in connection with this area.

INTERNATIONAL METEOROLOGY.

World Weather Charts—Meteorological Charts of the Northern Hemisphere.—It has been the plan of these charts that they should be based upon observations taken simultaneously by day and at night on land and at sea. The observations to be those of the barometer, thermometer, weather, etc., had everywhere on the globe at the same fixed instant of physical time—That is for example observations so arranged that those at Washington, St. Petersburg, Constantinople, etc., are taken not at the same hours of local or clock time at those cities—for they would not then be taken at the same moment, but so arranged that the readers or observers are actually at the instruments at once, all reading and recording at one and at the same moment the readings and records are being made at every other station, and so for all places. The atmosphere over any extent of the earth can thus be viewed as a whole, and at once before any movements in it are possible. The resulting charts give a true synopsis—in effect a photograph of the atmosphere and its conditions at the instant. Such observations are known as Simultaneous Observations. They are characteristic of the work of this officec. They were for the first time practically employed by it for purposes of prediction in 1870. Simultaneous observations as thus described are, upon the invitation of the United States, widely taken throughout the world. They are collated at this office, printed and issued daily, forming "The International Bulletin of Meteorological Observations taken simultaneously." The International co-operation, embraces observations taken by almost every civilized power north of the equator, and observations taken at sea.

Four charts, based upon International Meteorological Observations, taken simultaneously, are issued with this *Review*. These charts have been specially prepared. The subject of the preparation of such World Charts is referred to in the annual report of the Chief Signal Officer for the year 1878 and in preceding reports. They embrace within their limits the Northern Hemisphere.

Chart No. IV is based on the *Bulletin of International Meteorological Observations*, taken at 7:35 a. m., Washington mean time, under date of December 26, 1878, and exhibits in graphic form the barometric pressure and temperatures over the Northern Hemisphere so had for that date and hour. Lines of equal barometric pressure and equal temperature are charted and their values are expressed in French and English measures. Extended areas of high pressures and marked barometric depressions are respectively indicated as High, Higher, Highest and Low, Lower, Lowest. This map presents the data of the bulletin for the day charted for study. It is a map of the Northern Hemisphere and is charted daily.

Chart No. V, is based on the daily *International Weather Charts and Daily Bulletin of International Meteorological Observations* taken simultaneously for *December*, 1877, and shows the mean isobars, mean isotherms, mean velocity and prevailing direction of the wind at 7:35 a.m., Washington mean time, (0:43 p. m., Greenwich mean time,) for that month, as deduced from the simultaneous observations received at this office. The values of the lines are given in French and English measures. Isolated means, when barometric, are expressed in English inches, and when thermometric, in degrees Fahrenheit. The chart is one of the Northern Hemisphere.

Chart No. VI, is based on the *Daily International Weather Charts* and *Daily Bulletin of International Meteorological Observations for December*, 1877, and shows the movements of the *Centres of Low Barometer*, as charted from day to day, for that month, and also the lines of equal precipitation (rain and melted snow) as deduced from U. S. Signal Service observations and those of co-operating international observers. Arabic numerals show the location of the centre of Low Barometer at 7:35 a. m., Washington mean time, (0:43 p. m., Greenwich mean time,) on the day of the month having a similar number. Lines of equal rain-fall are given in both French and English measures. Isolated rain-falls, without the continuous lines, are expressed in English inches. The chart is one of the Northern Hemisphere.

Chart No. VII, is based on International Simultaneous Observations received to date, on United States Signal Service observations and on marine and other reports, received from voluntary observers. It shows the movements of the centres of the most definitely marked areas of Low Barometer of recent date. The tracks in black have been charted in previous Reviews in connection with the storms of the United States, and the tracks as subsequently determined are charted in red. The subject of Ocean Storm Tracks and the connection of them with storm-tracks on land is expressly considered in the preparation of these charts. A table of the wind velocities accompanying the storms, both on the European and American coasts, is printed upon the chart. The chart is one of the Northern Hemisphere.

In order to satisfy the many inquiries concerning the condition, scope and progress of the labor connected with the international simultaneous observations, there is herewith published an extract from the Annual Report of the Chief Signal Officer to the Secretary of War, dated Nov. 1st, 1878, wherein are sufficiently set forth the origin of the work, its plan, the co-operation it has received from distinguished co-laborateurs, its progress, scope, and purposes, as follows:

"The proposition adopted at the congress of persons charged with meteorological duties, assembled at Vienna in 1873, and to the effect that it is desirable, with a view to their exchange, that at least one uniform observation, of such character as to be suited for the preparation of synoptic charts, be taken and recorded daily and simultaneously at as many stations as practicable throughout the world, has continued to have practical effect.

By authority of the War Department, and with the courteous co-operation of scientific men and chiefs of meteorological services representing the different countries, a record of observations taken daily, simultaneously with the observations taken throughout the United States and the adjacent islands, is exchanged semi-monthly. These reports are to cover the territorial extent of Algiers, Australasia, Austria, Belgium, Central America, China, Denmark, France, Germany, Great Britain, Greece, Greenland, Iceland, India, Italy, Japan, Mexico, Morocco, The Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Tunis, Turkey, British North America, the United States, the Azores, Malta, Mauritius, Sandwich Islands, South Africa, South America and West Indies.

On July 1, 1875, the daily issue of a printed bulletin, exhibiting these international ssmultaneous reports, was commenced at this office and has been since maintained. A copy of this bulletin is furnished each co-operating observer. The results to be had from the reports thus collated are considered as to be of especial importance. The bulletin combines, for the first time of which there is record, the labors of the nations in a work of this kind for their mutual benefit. There is needed only the assistance to be had from the naval forces of the different powers (that of the navies of the United States and of Portugal being, as heretofore related, already given to extend the plan of report upon the seas) to bring more fully within the scope of study observations practically extending around the northern hemisphere. This end is to a great extent already attained.

In this connection the office has to acknowledge the cordial and valuable co-operation of the meteorological services of the different countries, represented as follows:

Algiers, by General Teissier, Commandant Supérieur du Génie; Austria, by Prof. Dr. Julius Hann, Director of the Imperial Royal and Central Meteorological Institute at Vienna; Belgium, by J. C. Houzeau, Directorof the Royal Observatory at Brussels; Costa Rica, by Señor Federico Maison, Director of the Central Office of Statistics and Meteorology; Denmark, by Captain N. Hoffmeyer, Director of the Royal Danish Meteorological Institute at Copenhagen; France, by U. J. LeVerrier, Director of the Paris Observatory, Prof. E. Mascart, Director of the Central Meteorological Bureau of France, and the respective observers; Germany, by Prof. Dr. Geo. Neumayer, Director of the German Naval Observatory, Hamburg; Great Britain, by Robert H. Scott, Esq., F. R. S., Secretary of the Meteorological Council, London, Alexander Buchan, M. A., F. R. S. E., Secretary of the Scottish Meteorological Society, Edinburgh, and the respective observers; Greece, by Prof. Dr. J. F. Julius Schmidt, Director of the Royal Observatory at Athens; India, by H. F. Blanford, Meteorological Reporter to the Government of India; Italy, by the Minister of Agriculture, Industry and Commerce, and the respective observers; Japan, by the Imperial Meteorological Observatory, and the Imperial University of Tokei, Japan; Mexico, by Señor Mariano Barcena, Director of the Central Meteorological Observatory in the City of Mexico, and the respective

observers; Netherlands, by Prof. Buys Ballot, Director of the Royal Meteorological Institute of the Netherlands at Utrecht; Norway, by Prof. H. Mohn, Director of the Royal Norwegian Meteorological Institute at Christiana; Portugal, by J. C. de Brito Capello, Director of the Meteorological Observatory of the Infante Don Luiz at Lisbon; Russia, by Prof. H. Wild, Director of the Imperial Central Physical Observatory of Russia at St. Petersburg; Spain, by Antonio Aguilar, Director of the Royal Observatory at Madrid, and the respective observers; Sweden, by Prof. R. Rubenson, Director of the Royal Swedish Meteorological Institute at Stockholm, and Dr. H. H. Hildebrandsson, Chief of the Meteorological Division of the Upsala Observatory; Switzerland, by Prof. R. Wolf, Director of the Observatory at Zurich, and Prof. E. Plantamour, Director of the Observatory at Geneva; Turkey, by A. Coumbary, Effendi, Director of the Central Observatory at Constantinople, and Prof. C. V. A. Van Dyck, Superintendent of the Lee Observatory at Beirut; Australasia, by Francis Abbott, Director of the Meteorological Observatory, Hobart Town, Tasmania, and R. L. J. Ellery, Director of the Meteorological Observatory at Melbourne, Victoria, Australia; Canada, by Prof. G. T. Kingston, Director of the Magnetic Observatory at Toronto, and Superintendent of the Meteorological Office of the Dominion of Canada, and the respective observers; United States Navy, by the Navy Department, through Rear-Admiral Daniel Ammen, and Commodore W. D. Whiting, U. S. N., Chiefs of the Bureau of Navigation; and by individual observers at other points.

The office has to regret the death, since the date of the last annual report, of four co-laborers in the work, Urbain Jean Joseph Le Verrier, Director of the Paris Observatory, Prof. Ernest Quetelet, Director of the Royal Observatory at Brussels, Prof. Edward Heis, of Münster, and Prof. Pietro Angelo Secchi, of Rome.

A number of observations taken on vessels at sea to complement the synchronous reports of the service, and at the request of the department, have been received on the form provided for the purpose. Their utility is evident in the study of storms approaching our coasts or which endanger vessels from our ports.

The cöoperation of the Navy of the United States in the taking of observations, simultaneously with the system adopted at this office, wherever naval vessels of the United States may be, as assured by the general order of the Secretary of the Navy, dated December 25th, 1876, has largely increased the data of this class. This cöoperation has been skillfully rendered by the Navy Department and the United States Navy, through the Chief of the Bureau of Navigation.

The people of the United States are thus the first nation whose Army and Navy co-operate, as all armies and navies should, under official orders, in the taking of simultaneous observations, wherever the forces may be.

In view of the existence of the system of simultaneous reports to be made at sea by the vessels of the naval and commercial marines of the United States and other nations, and to provide for its extension, carefully tested barometers of the best make have, since the date of the last annual report, been prepared and located, as standards, at the ports of New York and San Francisco.

These barometers have been publicly located to afford means for comparison of the ships' barometers of the shipping of all nations. The instruments, while carefully guarded, are easily accessible. Public notice is given of the location, and a Sergeant of the Signal Corps attends daily to give information and to take charge of any ship's barometer which may be brought for comparison.

The standard barometer for the use of shipping on the Atlantic Ocean is located at the Maritime Exchange, in New York City; the standard barometer for the use of shipping on the Pacific Ocean is located at the Merchants' Exchange, in the city of San Francisco.

The officers of the Signal Service at the different cities and ports of the United States and upon the sea-coast offer every facility and aid in their power to the vessels of any nation.

With the plans for charting now adopted at this office, and with the reports now received here, it appears that the meteoric changes occurring over a great portion of the continents north of the equator can be charted with an accuracy sufficient to permit careful and valuable study. This charting, to be of the best attainable value, must be supplemented from the records of observations had on the seas. A ship at sea becomes one of the best of stations for a simultaneous system. The value of the record is enhanced by the change of the ship's location occurring within each of the twenty-four hours. There is no sea-going vessel but which carries human life, and each ought to carry, by compulsion, if need be, meteorological instruments. The smallest craft, in caring for its own safety, may use them enough to add to the value of the most extensive record. There is no nation without interest in the work proposed to be based upon exchanged simultaneous reports, and none has hereto hesitated, when the subject has been properly presented, to aid in a duty which, so easily done as to require very little effort on the part of any one person, has for its object a good to mankind. The work cannot, from its nature, be for the selfish good of any section.

A number of the great steamship companies, foreign and domestic, operating the principal commercial sea-routes, have promised and will give their powerful influence and aid.

The office has the co-operation of the Pacific Mail Steamship Company, through its agents, Williams, Blanchard & Co.; the White Star Line, through its agents, Ismay Imrie & Co., Liverpool, and R. J. Curtis, New York; the Occidental and Oriental Steamship Company, through its president, George H. Bradbury; the North German Lloyd, through its agents, A. Schumacher & Co.; the American Steamship Co., through its president, H. D. Welsh; the Red Star Line, through its president, James A. Wright; and the Allan Line, through its agents, A. Schumacher & Co.

The United States bear, in the cases of all maritime observers co-operating in this system, all expenses for forms, postages, etc., when so desired, and not infrequently, and, when necessary, loan the required instruments.

The number of observations made daily on separate vessels at sea is one hundred.

Even if predictions are not directly practicable, research has already gone far enough to indicate the paths through which to learn what sequences will be found on our own western coasts, consequent on conditions reported as existing on or near the eastern coast of Asia or on the Pacific Ocean.

Similar studies will have reference to our own southern and eastern coasts and to the western coasts of the European Continent. The time cannot be far distant when vessels leaving any Atlantic port may be informed whether any notable disturbances exists at sea, and where it is likely to threaten the voyage.

The establishment of permanent ocean stations in lines traversing the oceans over or near the telephic cables; and in telegraphic communication with either continent, is not considered impracticable and has been referred to in a preceding report.

There is reason to hope that a progress has been made which will eliminate from the study of practical international meteorology some of the difficulties hitherto encountered.

There are grounds to hope also, that the atmospheric conditions and changes of cordition can be charted with sufficient accuracy over any extent of the earth's surface. If the hope has fruition meteorological barriers will, as against study, practically cease to exist.

While the stations are crowded in some localities, each is useful—each serving to check the work of the other, and each aiding to close the gaps the failure of other stations might sometimes cause. The work is not likely to be abandoned by those in the different countries who have taken part in establishing it, and who share its benefits. If it served no other purpose than to maintain, as it does, the pleasant co-operation of those charged with the meteorological duties of the different countries, it would be of value. It is hoped that by systems of observations thus extensive, generalizations may be had to permit the announcement of meteoric changes for periods longer in advance than have been hitherto practicable.

The average number of daily simultaneous observations now made in foreign countries is two hundred and ninety-three. The total number of stations on land and on vessels at sea from which reports are entered in the bulletin regularly is five hundred and fifty-seven. The co-operation of the different nations, secured by this plan of exchange, as above described, renders the additional cost to the United States, of the grand system of reports it makes possible, but little more than that of the cost of the preparation, paper, and binding of the International Bulletin and the accompanying charts, a cost which would have to be met in great part for the proper preservation of the records themselves, even if the bulletins were not distributed.

The Chief Signal Officer is gratified to announce in his report that the work of the collection of the reports of International Simultaneous Observations, carried on in foreign countries in cöoperation with the United States, as well as within the Territories of the United States and upon the seas, thus above referred to, has, in the year just passed, so far progressed as to have attained one principal result for which it was set on foot. On July 1st, 1878, it became possible, for the first time in the history of this office, to commence the issue, on that date, of a daily international weather map, charted daily and issued daily, each chart based upon the data appearing upon the International Bulletin of Simultaneous Reports of similar date. The charting extends around the world, and embraces for its area the whole Northern Hemisphere.

The daily issue of a chart of this kind, thus daily issued for the first time by the United States, is without a precedent in history. It exhibits the cöoperation, for a single purpose, of the civilized powers of the world north of the equator.

The studies of such charts make possible the improvement which will come as the work progresses, and the area of the chart is better filled with reports of observations carefully elaborated, are fully appreciated by scientific men.

The questions as to the translations of storms from continent to continent, and of the times and directions they may take in such movements; the movement of areas of high and of low barometer; the conditions of temperature, pressure and wind-direction existing around the earth at a fixed instant of time, permitting thus the effects of day and night to be contrasted; the distribution and amount of rainfall, and other studies, many and valuable, only suggested by this enumeration, may be by such studies settled. It seems not impossible that in the future questions of climatology, and perhaps others bearing upon the prediction of weather changes far in advance of the time at which these changes may happen, or questions of the character of coming seasons even, may be answered by the researches these charts will make practicable.

The very great aid and material furnished in this elaborated form gives to the search for generalization, or for data in the support of theories, was referred to in the last annual report. In frequent cases little more than collation is necessary.

As a means of better combining the work and the interests of the several nations; of certainly securing that co-operation at sea which will enable the lines of the charting to be drawn as fully and as well over oceans as over continents; and which will give the world ultimately a knowledge as practical of the movement of areas of disturbance in the midst of the seas as is now had of such movements on some continents, the undertaking is of much importance.

It is an advantage of the charting draughted from simultaneous reports that studies by normals, not possible in any other way, can be made. The normal pressure, temperature, &c., arrived at from observa-

tions taken at any one place, at the same and a fixed instant of time every day, become established as to that place and time with accuracy.

Many causes of error are eliminated.

The inter-comparison of these normals with the normals taken at other places simultaneously with the first and under the similar condition that the normals to be found by those places are to be from observations taken at those places at a fixed time and on every day, gives results reliable, and differing from those to be had by the use of normal readings arrived at in any other manner. Normals for the year, for the season, and for the month may be determined by such procedure. The comparison of such normals will show in the case of abnormal changes in any district or section, for any season, whether and how they are compensated by compensating variations elsewhere. There are interesting studies as to what sequences there may be to follow such atmospheric variations occurring over any region or country—either in that region or country or elsewhere—and how and where the compensating variations occur, and with what concomitants or sequences of meteoric changes.

There is the hope to gain in this way, or by investigations which such study will suggest, information to benefit the commercial and agricultural interests of the world.

There is the further hope that as it is more fully realized by the different peoples, how close in the future the practice of such investigations draws, each member of the family of nations will find its own interests in labors of this description, and draw more closely the bonds and join with energy in a work which has so begun to connect them. The undertaking, world-wide in extent, is capable of rendering a world-wide benefit."

Maps based upon a single simultaneous observation, taken daily, demonstrate what may be expected when more frequent observations are attainable, and the daily period of twenty-four hours may be exactly divided by the intervals at which such observations are taken.

It is by the study of charts of the character of those herewith described and referred to, the practical solutions of the gre t questions of Ocean and Continental Meteorology, and possibly some prevision of seasons, may be hoped to be arrived at.

On chart No. VII are shown the probable tracks of storm-centres over the oceans, deduced from data received at this office up to August 6th, and in the upper right-hand corner will be found an index to the same. In the upper left-hand corner is a table giving the approximate direction and probable maximum velocity of the wind (in miles per hour and meters per second) attending area No. III. Below is a brief notice of the areas, and also of some storms over the Southern Hemisphere:

North Atlantic Ocean.—No. I probably moved northeastward over the British Channel, during the night of June 2nd, thence to the North Sea and Gulf of Bothnia, and southward over Russia to the Black Sea. No. II may possibly be a continuation of area of low barometer No. XIV, shown on chart No. I, of the *May Review;* it passed southeastward over Newfoundland on June 1st, and on the 2nd and 3rd rainy weather and variable winds prevailed thence to 40° W.; on the 4th and 5th a depression probably existed about as shown on chart, although reports from the Azores are not yet to hand. No. III is a continuation of low area No. III, of chart I, *June Review;* it passed over Newfoundland (barometer at St. Johns about 29.04) on the 14th and crossed the ocean, attended by rainy weather and high seas and followed by westerly gales and high NW. sea swell; it passed northeastward over the British Isles on the 21st with very unsettled weather and moderate to fresh southerly gales. No. IV is a continuation of low area No. IV, of *June Review;* on the 18th it was south of Newfoundland, but cannot at present be traced farther eastward. No. V probably originated during June 11th off Newfoundland, after which it moved eastward. No. VI is a continuation of low area No. V, of the *June Review;* it probably passed eastward north of Newfoundland on the 23rd, developed increased energy about 50° N., 30° W. on the 26th, and northeastward at some distance to the northwestward of the British Isles on the 27th and 28th. No. VII probably followed a path somewhat as shown on chart from the 22nd to the 25th. *South Atlantic Ocean.*—Ship Altcar, at Queenstown, June 22nd, from San Francisco reports:—"From lat. 30° S., long. 123° to *Cape Horn*, which was passed April 16th, 1879, had continuous gales from NE. by E. to S. and heavy cross-seas; lost sails, stove boats, bulwarks, &c.; decks constantly flooded—from *April 22nd* constant gales, culminating on *May 1st* and *2nd* in a terrific gale and heavy sea, during which decks were constantly under water." At Montevideo, *May 23rd*, 1879, N. gale; 24th, SSE. strong gale; *June 24th* and *25th*, schooner Syra driven ashore and lost during storm. *North Pacific Ocean.*—Three tracks are shown on chart:—No. I produced strong SW. winds and moderate gales, with heavy rains, at Yokohama on *April 24th* and *25th*, and brisk to high winds at Unalaska on the 27th and 28th. No. II produced heavy rainfall (2.75 inches in one hour) at Yokohama from 7 to 8 p. m. of *May* 7th. No. III probably passed eastward at some distance north of Yokahama on *May* 12th and 13th, and produced SE. to W. gales at Unalaska on the 14th and 15th. *South Pacific Ocean.*—*April* 11th to 14th 1879, from 34° S., 166° E. to 34° S., 151 E., ESE. to SW. gales, heavy seas and bad weather; at Sydney, N. S. Wales, *May* 3rd, SSW. gale, squally; 25th, 34° S., 170° E., NE. gale, rough sea, rain; 26th, 36° S., 175 E., ENE., strong gale, squally. *Indian Oeean.*—*March* 8th, 1879, 12°41′ S., 113° 23′ E., heavy squall from WSW. 11th, 14° S., 112° E., "had tail of a hurricane from NW., hove to for five hours." *April* 20th, 31° S., 39° E., severe gale from NW. to SW. *May* 4th, 24° S., 54° E., hurricane. *Bay of Bengal.*—During the latter part of *May* the monsoon rains set in along the coast and the track of an area of low pressure which on *May* 20th was probably central over the bay is given on chart No. VII.