The Climate of the Arctic as Viewed by the Explorer and the Meteorologist

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THE CLIMATES OF ARCTIC REGIONS as seen by the explorer-geographer and by the professional meteorologist are in sharpest contrast. This is explained by their different methods of observation. The explorer has been obliged to learn the hard way, by making his observations upon the ground with comparatively small use of instruments for precise measurements; the meteorologist, by extrapolating the weather at any place from a few *fixed* weather stations, where the meteorological units are all measured with the greatest precision, at frequent intervals and over long periods of time.

Extrapolation is based on a fundamental assumption that the weather of any region is brought to it from outside by cyclonic low-pressure areas which migrate across it. The tracing of the paths of the cyclones and the construction of synoptic weather charts which set forth the meteorological units is all a work of extrapolation. Actual observations made between the stations do not come within the scope of the inquiry.

A president of the American Meteorological Society has said: "A forecast is made in accordance with past trends, as evidenced by previous maps and the pressure tendency field. . . . This is largely a subjective process. . . ." (*11*).

Where there are closely meshed weather stations, the inadequacy of this standard technique of the meteorologist may not be generally apparent; but in remote undeveloped regions, where weather stations can be set up only with the greatest difficulty and at very great distances from each other, its deficiencies are sufficiently obvious. Extrapolation across hundreds of miles, and based on theories derived in other regions, must lie within the realm of the imagination. To apply extrapolation at all in such regions, it is necessary to *assume* that low-pressure areas invade and cross over them; and, as we shall see, there are vast areas where the weather is self-contained and without transiting cyclones.

I propose to illustrate the working out of the contrasted explorer's and meteorologist's methods of inquiry within two great Arctic regions. These are: (1) the Central Arctic Basin, a vast expanse of sea which is covered over throughout by floating ice floes, and (2) the glacier-covered, high plateau-island of Greenland. These regions are of the same order of magnitude, each of 1,000,000 square miles or more. The Arctic Basin is nearly circular and about 1,400 geographical miles in diameter. Greenland is of obovate outline about 1,400 miles in length and 600 in average breadth. Except for one brief period, when two meteorological bases were precariously maintained in Central Greenland, weather stations have been set up only on the extreme fringes of these two great Arctic regions.

In the future, as in the past, it will not be possible to maintain fixed weather stations within the Arctic Basin, for the reason that its cover of floating ice is constantly drifting. Since it has been impossible to make fixed stations in the interior of the Arctic Basin, meteorological theories based on a supposed planetary air circulation have taken their place.

The climate of the Central Arctic Basin as seen by the meteorologist. As far back as the middle of the 19th Century two American meteorologists, Matthew Fontaine Maury and William Ferrel, conceived the Arctic Polar Basin to be a low-pressure area with barometric reading at the Pole itself (by extrapolation from far outside) 29.63″ of mercury. To cite Ferrel: "Near the poles the tendency to flow towards the equator seems to be greater and causes a current *from* the poles. . . ." A year later (1857) the English meteorologist, James Thomson, independently expressed much the same idea in his "On the grand currents of atmospheric circulation."

Twenty years later a quite different theory was promulgated. The German physicist, Von Helmholtz, who had given much attention to meteorological theory, conceived the earth's polar regions to be areas of radiation, because of a supposed frigid surface, above which the cooled air must, he reasoned, be mounded up and flow off toward lower latitudes. In 1922 the Norwegian physicist and geophysicist, Vilhelm F. K. Bjerknes, gave to this idea a modern dress by his hypothesis of the "North Polar Front." It assumed, as Von Helmholtz' theory had done, that within the area surrounding the Poles there is a piling up of cold air, and that it is separated by either a surface of discontinuity or by a transitional layer from that outside. From this polar anticyclone, cold air was supposed to be moving out in all directions.

As we are to see, the hypothesis of the North Polar Front, or polar anticyclone, above the Arctic Basin was, at the time of its promulgation, contrary to all that had then been learned concerning its climate, and especially to what Bjerknes' great compatriot, Nansen, had shown a quarter-century earlier. The Bjerknes theory was, however, adopted by the meteorological profession throughout the world and was regularly made use of in constructing climatic charts of the Northern Hemisphere.

The climate of the Central Arctic as learned by the explorer. The first International Polar Year for concerted study of the polar regions (1882–83) saw almost the beginning of Arctic exploration bases, with others set up at intervals into the first decade of the 20th Century. A number of these were on the outer fringe of the Central Arctic Basin. Six of these widely separated stations showed the mean annual atmospheric pressure to indicate neither a polar cyclone nor an anticyclone, but an amazingly uniform normal pressure. In millimeters of mercury these annual pressure means were measured as: 758 at Cape Sheridan in latitude 82½°, 759 at Fort Conger (Greely, 1882–83) in latitude 81½°, 760 at Fort Conger (Peary, 1908–09), 758 at Point Barrow in latitude 71°, 760 at Cape Fligely in latitude 82° (Jackson, 1895–96), and 757 on Rudolf Island in latitude 82° (Nansen, 1895–96).

In the year 1894 the great explorer-scientist, Fridtjof Nansen, had set out on his polar ship *Fram* to drift in the pack across the Arctic Basin, making full scientific investigations throughout. For two and a half years (1894–96) this exploring expedition drifted slowly across the area along a chord about one-third of the way in to the Pole.

Nansen's meteorological observations showed the Arctic Basin to be the greatest area of uniformly normal atmospheric pressure anywhere known on our planet, and today found to be unique. In consequence, it was an almost windless region. For the first year of the *Fram's* drift the mean annual air pressure was registered as 758 mm of mercury, with but slight variation between winter and summer. During the second year the ship drifted throughout along the 85th parallel, only 5 latitude degrees from the Pole, and the mean annual pressure observed along it was 761 mm. For the 7 months of the third year, about equally divided between winter and summer, the corresponding pressure was found to be 758 mm. From these observations the Norwegian meteorologist, H. Mohn, calculated that the range of mean monthly atmospheric pressure at the Pole itself could not have exceeded 5 mm (*32*). Of the windlessness of the region through which he had drifted, Nansen had much to say when he visited the writer in 1929. This was to be the experience of Peary, also, when he crossed the region and achieved the North Pole in 1909.

The Soviet polar studies. Further proofs of the normal atmospheric pressure over the Arctic Basin and its absence of wind were to come in the years 1937 and 1938. In 1937 the Soviet S. S. *Sedov* had been caught in the Arctic pack to the north of Siberia near the 82nd parallel, and the ship had drifted across the basin during the next two years. For the *Sedov's* drift the mean annual atmospheric pressures for these years were 760 and 760 mm.

During these same years the Soviet North Pole Station had been in operation. Laid down by airplanes at the Pole itself, the station drifted slowly southward with the floes along the meridian of Greenwich for the first 5 latitude degrees, then south southwestward about parallel to, and 100–200 miles off, the Greenland east coast. This continued until it had reached the 76th parallel—a total drift of over 1,000 geographical miles.

Until the Arctic Basin had been left behind, the most uniform of meteorological conditions prevailed. The region was so nearly without wind that only rarely could a windmill be operated to charge the batteries. Atmospheric pressure was almost absolutely normal (*20*).

The drift of the S. S. *Sedov* had coincided with that of the North Pole station; so, combining the observations and bringing in those from the permanent Soviet weather stations on the fringe of the basin, Dzrdzeewski was able to construct synoptic pressure charts for the basin as a whole. To cite him: *"The usual hypothesis of a constant polar anticyclone breaks down in the light of the observations of the North Pole Station and Sedov. . . . The point of greatest interest . . . is that the chart to show mean annual air pressure the isobar of 1013 mb*[1] *surrounds the Central Polar basin with no other isobar within it"* (*4*; italics in the original).

As soon as the North Pole Station had drifted within about 200 miles of the Greenland coast, however, the conditions completely changed. It had now entered a region of almost incessant storms. The leader then wrote in his diary: "Greenland is letting us know where it stands." Much later, when near the end of the drift, he added: "The wind has been blowing constantly since we got into Greenland waters. The blizzard has made hermits of us. We stay inside the tent like badgers in their lair" (p. 236). But this has to do with the other Arctic region.

The climate of Greenland as learned by the explorers. The first important invasion of Greenland by an exploring party was that of Baron Adolf Erik Nor-

[1] Normal pressure.

denskiöld in 1883, who made his penetration from near Disko Bay on the west coast in latitude 68° N. Southeast winds of great force were faced for a distance estimated to be 100 km.

Complete transections of the island were first made by the great explorers, Nansen in South Greenland in 1888 and Peary in two double transections of far Northern Greenland in 1892 and 1895, after he had already made deep penetrations from the west coast.

Nansen's transection was made from the east coast, climbing in the face of fierce blizzards to an imperceptible divide at an elevation of 9,000′ and then, with a small sail raised on the sled, coasting down the west side. Of the winds encountered he wrote (*19*):

> The prevailing winds were therefore land winds which blew from the interior toward both coasts. This points to a maximum air pressure in the interior and to air currents toward it which flow off on both sides over the slope toward the sea.

This was the initial discovery of the glacial anticyclone of Greenland, which was, as we shall see, to be confirmed throughout the next half-century by all the great Greenland explorers, two of them, Alfred De Quervain and Alfred Wegener, meteorologists.

Peary's summary statement on the climate of Greenland. Next after Nansen to describe the climate of Greenland was Robert E. Peary, greatest of polar explorers. After more than 3,000 miles of sledge travel over Greenland, Peary summed up the pattern of its wind system in the following sentences (*21*):

> . . . the direction of the wind of the "Great Ice" of Greenland is invariably radial from the center outward, normal to the nearest part of the coastland ribbon. So steady is this wind, and so closely does it adhere to this normal course, that I can liken it only to the flow of a sheet of water descending the slopes from the central interior to the coast. The direction of the nearest land is always easily determinable in this way. The neighborhood of great fjords is always indicated by a change in the wind's direction; and the crossing of a divide, by an area of calm or variable winds, followed by wind in the opposite direction, independent of any indications of the barometer.

This wind-pattern above the inland ice of Greenland, which has the model of a gigantic cake of very thin batter, can be summed up by the single word *katabatic,* down-slope, except as the winds are deviated clockwise by as much as half a right angle, due to the earth's axial rotation.

Like other explorers, Peary had observed the winds of Greenland where they are, and not from permanent stations in fixed positions outside. For this reason they have not been taken into account by professional meteorologists. Moreover, the direction and force of the wind was as a rule, not measured on precision instruments with data which can be expressed in numerical figures.

The direction of the wind and its force were learned by him because he had had to face it while the sled-dogs toiled strenuously, not against a preceptible slope, but only against the wind; or, *per contra,* with sail raised for a tail wind, all his efforts given over to applying a brake to prevent the sled from over-running the dogs. Wind force was registered also in the daily runs as plotted on the chart of the course. Those on the downslope had been two to three times as long as those on the ascent. In camp the tent always had to be set up with the opening on the lee side, or it would have been blown away.

While in camp, wind force and direction had been noted by the bellying-in of tent walls, which pressed against the bodies of the men in their cramped quarters. Everywhere except within a cold interior area, the dominant wind direction is graven on the hard-packed snow in the furrows of its surface—the *sastrugi.* These are so constant in direction as to be used in laying the course.

Over the inland ice the wind direction and its force are also indicated by the motion of fine snow, which is continually drifting outward over its surface toward all coasts. To cite Peary again (*21,* p. 234):

> There is one thing of special interest to the glacialist—the transportation of snow on the ice-cap by the wind. No one who has not been there can have any conception of its magnitude. The wind is always blowing, and blowing always on lines which would be gravity lines from the interior. . . . I have walked for days in an incessant sibilant drift of flying snow, rising to the height of the knees, sometimes to the height of the head. If the wind becomes a gale, the air will be thick with the blinding drift to the height of 100 feet or more. . . . When it is remembered that this flow of the atmosphere from the cold heights of the interior ice-cap to the lower land of the coast is going on throughout the year with greater or less intensity, . . . it will be seen that the above assumption is not excessive.

Observations made by the Greenland exploring expedition of 1906–08. After Peary's North Greenland explorations, European expeditions, mainly from Denmark, followed during the early years of the 20th Century. The first of these was a Danish one to northeast Greenland in the years 1906–08, led by Mylius Erichsen. On his staff were three meteorologists: Alfred Wegener, W. Brand, and the then student, Peter Freuchen. Two meteorological stations were set up, one of them on the coast in latitude 77° N., where Wegener and Brand were located. Wegener at the base station had kite and captive-balloon equipment. With this he was able to establish the fact that the ground observations made in a station on the coast (where it was shielded by rock cliffs) gave no true picture of the local winds (*26*). These were by the aerological aids first encountered at an elevation of 1,000 m, the height of the rock walls. All strong winds were found to blow from the northwest, the down-slope direction of the inland-ice, with the 45° clockwise deviation. Up to that time the prevailing easterly winds everywhere encountered off the northwest Greenland coast had been supposed to have come across the island from the East Greenland Sea. These observations of Wegener, the first ever to be made in northeast Greenland, thus were the first from a meteorologist to confirm Peary's law of outblowing winds.

Wegener's observations were also significant in showing that meteorological ground observations made in a fjord bottom near the coast do not give reliable results with regard to the local winds. Hinrich Rink, long a keen observer while an inspector in West Greenland, had learned this as a result of his long residence there. On many occasions the overriding of the bottom currents by strong outward-blowing winds would be made known by the roaring of the blizzard overhead, which sometimes continued for days, but with no ripple to be seen on the water of the fjord below (*24*). At other times the wind would get down into the fjord, but with a quite different direction, since it always blew parallel to the local fjord walls.[2] The air pressure is the only meteorological ground unit which can be reliably observed at a fjord-bottom station.

Dating from this, his first of several Greenland expeditions, Alfred Wegener became a strong supporter of the Greenland anticyclone and continued to be to his tragic death on the ice cap in 1930.

Glacial anticyclones over both Greenland and the Antarctic. The only existing continental glaciers are those over Greenland and the Antarctic continent. The latter is of about the area of the entire United States; the former, of that part of it which is east of the Mississippi River. By assembling the wind observations made by all the sledging parties when traveling over the inland ice covering these great areas, the writer was in 1910 able to show that both areas were alike under a system of outblowing winds, and he gave to each of them the name *glacial anticyclone* (*8*).

Observations made on the Greenland expeditions of 1912–13. The years 1912 and 1913 were to see no less than four Greenland exploring expeditions, three of them complete transections and one of them a double cross-section. Three were Danish and one Swiss. All were able to confirm the everywhere-prevailing outblowing winds of the glacial anticyclone.

The Swiss expedition of 1912 was led by the distinguished explorer-meteorologist, Alfred De Quervain, who made a transection of the inland ice from Disko Bay on the west coast to Angmagssalik on the east coast, a south-central cross-section. He encountered the same pattern of winds that had been described by Peary, and since he passed through the central area of the island—something that Peary had not done—he found there a cold area sharply set off from that over the inland ice outside. This was shown both by its much lower air temperature and by the three-times-greater daily range of temperature, though the common border was marked by no topographical break in the surface (*2*). This central area is quite naturally assumed to be the interior area of downdraft which feeds the outblowing winds.

The second Danish northeast Greenland expedition was led by Capt. J. P. Koch. Its scientific reports were written jointly by him and his principal companion, Alfred Wegener (*13*). A winter was spent at station Borg, set up for meteorological and other scientific observations on the inland ice of northeast Greenland, and the following summer a great transection of the island was made to the west coast at Pröven (latitude 72½° N). The pattern of the winds encountered illustrated the glacial anticyclone in great perfection, and they confirmed the central downdraft area, as Dr. De Quervain had already done.

Knud Rasmussen, who with Peter Freuchen made a double crossing in north Greenland near, but farther south than, the southernmost of Peary's crossings, confirmed the pattern of outblowing winds (*22*).

Eynar Mikkelsen, in the years 1909–12, directed a Danish expedition in search of the remains of the lost Erichsen party and to find, if possible, their maps and diaries. He made an interior sledge journey from Danmarkshavn over the ice cap in a north-northwesterly direction to Independence Fjord. The winds encountered throughout were all from the westerly quarter down the slope of the inland ice (*16*).

Rasmussen's Second Thule Expedition of 1916–18, this time across the inland ice of northwest Greenland (*23*), and Lauge Koch's quite remarkable sledge journeys of 1920–23 on and about northeast Greenland (*14*), also revealed the same down-slope winds everywhere.

In 1926 this writer brought together all the scattered meteorological data derived from both Greenland and the Antarctic up to that time and issued them under the title, *The glacial anticyclones* (*9*). The Antarctic

[2] This vitally important knowledge the writer acquired the hard way when a Greenland tenderfoot a score of years ago. Alone in a small rowboat on a crooked fjord, the high waves threatened to upset his craft and precipitate him into the icy water. He rowed madly to double a point which was in sight ahead. When around the bend, the situation was still quite unchanged.

data of most significance had been those observed over the inland ice by sledging parties, and these clearly revealed the Antarctic anticyclone. These winds had not, however, been taken account of by the professional meteorologists, who had occupied the coastal weather stations; and, since the theory of polar cyclones was at the time the dominant one, the reaction of the meteorological profession was that, *if* such an anticyclone actually lay above the inland ice, it must be thin and overlaid by a cyclone (*7*).

The University of Michigan Greenland expeditions, 1926–33. It thus became an important inquiry to measure, if possible, the thickness of the layer of outblowing winds and fix the altitude of its ceiling. To pursue this inquiry in Greenland, this writer organized the Greenland expeditions of the University of Michigan and directed the four which were carried out between 1926 and 1931. The fifth was directed by his colleague, Dr. Ralph L. Belknap. During these years four aerological stations were set up close to the glacier front in West Greenland: at Ivigtut in latitude 61° N, at Mount Evans in latitude 67° 30′, at Camp Scott in latitude 73°, and at Peary Lodge in latitude 74° 15′. At each of these stations daily pilot balloons were sent up and their paths followed by theodolite to an average height of 7,000 m, but with many to much higher levels. Each of the four stations was maintained for at least a year, the main station of Mount Evans for two years, and at this station 776 pilot balloon ascents were carried out. By these investigations the ceiling of the outblowing winds was found, near the west border of the inland ice, to be at about 3,000 m, or roughly 2 miles (*33*).

Alfred Wegener's German expedition of 1929–31 to take measurements of the Greenland anticyclone. A preliminary expedition to fix the position of the stations for the main expedition was carried out in the summer of 1929. On this, Dr. Wegener was accompanied by three well-known meteorologists: Johannes Georgi, Fritz Löwe, and Ernst Sorge. All were destined to play important roles on the main expedition. This preliminary expedition made two deep penetrations over the inland ice to distances of 100 and 130 miles, respectively. They were made in the face of strong head winds during the inward journey, but with tail winds on the return (*28*).

The plan of the larger expedition, for the purpose of deriving measurements of the glacial anticyclone, was outlined by Alfred Wegener in an *avant propos* issued in 1928 (*27*). To cite:

> On the wind relationships in greater elevations we have up to the present those only from West Greenland (De Quervain, Hobbs). If one is to understand in toto the kinematics of the glacial anticyclone one must study the distribution of the wind and likewise the temperature distribution along a complete west-east cross-section, and, if possible, as far up as the stratosphere. It is still an open question whether the so astoundingly regular air distribution of the glacial anticyclone extends upward to the border of the stratosphere, or is earlier replaced by winds flowing in above. . . .
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> . . . The stations must be along a west-east cross-section of Greenland, thus, two in western and eastern coast regions, and one in the central névé region within the realm of the cold core of the anticyclone.

The main "Alfred Wegener Expedition" was carried out as planned, except that Dr. Georgi, who was in charge of the important central station of *Eismitte,* was, even as late as October, not yet supplied with his prefabricated winter house, adequate food or fuel supplies for the winter months, or all of his aerological equipment. At great risk to his life, Wegener set out with a great sledging caravan to take in these needed supplies, but he encountered such fierce head winds that most of the sleds had to be sent back. With Dr. Löwe and one heroic Eskimo, Willem Rasmussen, the leader pushed on with a single sled, but met with such violent surges of the outblowing winds that he was compelled to jettison most of his cargo and arrived at the station with Dr. Löwe's feet so badly frozen that he had to be left there and have his toes amputated. On November 1, his 50th birthday, Wegener and the faithful Rasmussen left *Eismitte* for the coast, but both perished on the way out.

With the extra mouth to feed, Georgi and his staff at *Eismitte* dug a cave snow-house, husbanded to the limit the scanty food and fuel, survived the winter, and performed the planned research—a really great accomplishment.

The cyclones which arrive at Greenland's west coast are switched north. While Wegener's expedition was in occupation of its three "profile" aerological stations, the British Arctic Air-Route Expedition, led by the youthful Gino Watkins, was maintaining for a period of 7 winter months an "Ice Cap station" in the Greenland interior near latitude 68° N. For the full year it maintained also a "base station" on the east coast, near Angmagssalik, in latitude 66° N. Neither station had aerological equipment (*17*). At the same time, also, the University of Michigan Greenland expeditions were maintaining two aerological stations, one at Ivigtut in extreme South Greenland (latitude 61½° N), the other on the west coast in latitude 73° N.

This unique situation, with 7 expedition stations operating, 2 in the interior and 5 carrying out upper-air studies, suggested to this writer that by combining in a post-mortem operation after the reports from the Danish coastal stations without radio had become available, it would be possible to trace the tracks of the cyclones which had arrived at the west coast during the year, for the *pressures* recorded at the coast stations could be relied upon. The suggestion was made to Dr. Georgi, who had been director of the *Eismitte* station. He gladly consented, the British, German, American, and Danish observation data were brought together, and the inquiry was carried out. This study revealed that those cyclones which had reached the west coast from a westerly quarter had been turned from their courses and diverted north up Davis Strait and Baffin Bay. Cyclones on tracks farther south which had passed Cape Farewell over the Atlantic had moved up the East Greenland Sea (*5*).

A somewhat similar inquiry, and with similar results, was conducted by R. L. Belknap for 1932–33 (Second International Polar Year), another favorable year for such a study (*1*). The Wegener expedition at its West Station also conducted such an inquiry, with the result that no cyclone was found to have made the transit of Greenland (*10*). Of the wind constancy Kurt Wegener says: "Along the route of the expedition from West Station to *Eismitte,* it blows from southeast to east southeast" (*29*).

At West Station, located between the Michigan stations, a closely agreeing value was obtained for the thickness of the layer of outblowing winds. From a locality 1,000 m higher and over the edge of the inland ice the ceiling was found at 4,000 m, to compare with 3,000 m measured at the four Michigan border stations (*29,* p. 31).

The downdraft area of central Greenland. At *Eismitte,* within the downdraft core of the anticyclone, Georgi found the thickness of this bottom layer of "heavy air" to be only 400 m, not 3,000 m, as at the margin of the inland ice in west Greenland. All his attempts to get kites above this ceiling were futile (*30*). Further evidence of the downdraft appears on his daily weather chart for the entire period of occupation (*6*). On this chart air pressure and temperature can generally be seen to vary together, not in reciprocal relation, as is common where air currents move laterally. With increased vigor of downdraft—higher air pressure—the adiabatic elevation of the temperature of the sinking air should increase and be registered in the near-surface layers.

Quite unexpectedly, a remarkable proof of the strong downdraft within the core of the anticyclone was furnished by a flight across Greenland in an effort to find the lost Wegener. The German Flight Captain Wolfgang von Gronau, in April 1931, flew direct from Scoresby Sound on the East Greenland coast in latitude 70° N southwestward to Sukkertoppen on the west coast in latitude 66°. This took him through the core of the anticyclone a little to the south of the *Eismitte* station. His plane, despite all his efforts to prevent it, was forced down by the downdraft, but when near the glacier surface he was able to level off and continue his flight so near to the surface that his radio antenna dragged behind in the surface snow. He had entered the 400-m-thick layer of the "heavy air" which flows outward along the surface (*New York Times,* August 19, 1931, p. 3, col. 8). One of the early plane crossings during World War II was less fortunate and crashed within the core area.

The core or "névé region" of the anticyclone was further proved to be an area of very heavy snow precipitation. Fine dry snow was separated out from the near-surface "heavy air" layer. On 213 days out of 365 (58%) snow was precipitated, and on 191 of these it was observed to be drifting out. At the other interior weather station within the core area, the British "Ice Cap station," snow was precipitated on 57 days of the 181 that it was occupied—some without observations—and on 23 of these it was observed to be drifting (*18*). Such heavy precipitation within the core of the anticyclone explains the origin of the stupendous quantities of snow which have been observed by all sledging parties to be almost constantly drifting outward over the flanks of the inland ice (*21*). Its only source is obviously the ice spicules of the cirrus and other closely related cloud forms, the dominant types observed above *Eismitte.* These would be adiabatically vaporized in the downdraft and be reprecipitated as they approached the glacier surface. At the end of the long winter season much of this snow is found piled up outside. That drifted during the summer months is largely melted within an intramarginal zone, where it produces the superglacial lakes and rivers always found there late in the season.

The observations made at all three profile stations of the Wegener expedition confirmed the presence of the glacial anticyclone. To cite Kurt Wegener's final conclusions (*31*):

> The observations of the wind at the profile stations show that the "heavy wind" already known for a long time is the characteristic wind of the inland ice which everywhere flows off the inland ice (p. 4). This phenomenon Hobbs has called the glacial anticyclone. As type examples of the "glacial anticyclone," which holds good for all seasons of the year, are the South Polar region and Greenland. . . . The statistical data show us that we have to do with a high pressure area at the level of the sea, from which on all sides air is streaming out. . . . The physical explanation of the glacial high pressure area . . . is obviously due to the outgoing heat irradiation of the ice surface (*Boden*). This has for a consequence that far up in the stratosphere the air-masses over Greenland sink down, stream out below, and from high outside a new instreaming develops (*31,* p. 28).

The Greenland climate according to the meteorological profession. The technique of the meteorological profession has stemmed from the assumption that the climate of any region is the result of weather that is brought into it from outside through the medium of migrating cyclones, which move into and over it. We have seen through the observations of explorers made now over half a century that the Greenland system of outblowing winds precludes any such transit of cyclones. Moreover, special studies carried out in 1930–31 by collaboration of three great expeditions showed that cyclones which arrived at the Greenland west coast had been diverted northward along the coast.

The first meteorological stations set up in Greenland date from the First International Polar Year (1882–83), when there were but few stations, and these located on the southern coasts. From them alone many tracks of cyclones were mapped crossing Greenland's thousand and more miles, and these tracks were marked out with the greatest precision (*25*). This is the origin of a myth which has persisted to the present day. Based on a few coastal stations in fjord mouths, from which reports now go out daily by radio, cyclones may be seen crossing Greenland on almost any daily synoptic chart issued by the Canadian Meteorological Office (Hobbs and Belknap, *1*).

But let us consider now two late memoirs by professional meteorologists on the climate of Greenland. The earlier of these to make its appearance dates from World War II, when in addition to coast stations, there was one located on the southeast flank of the inland ice about one-third of the way in to the divide. The author of this memoir is a professional meteorologist of the U. S. Weather Bureau who has now had experience in both the Arctic and the Antarctic (*3*). The following citation is from the abstract at the head of his paper:

> The published results of previous investigations reveal that meteorologists and glaciologists are not in agreement as to the role of the Ice Cap as a cold source in the general circulation, the importance of the Ice Cap as a barrier to air movements in the lower levels, and the principal sources of nourishment for the Ice Cap itself. . . .
> . . . This new survey of Ice Cap problems, *based upon a study of synoptic weather charts* and the author's experiences on the Ice Cap, leads to the following conclusions: The important outbreaks of Ice Cap air require a favorable stage in the general circulation and are not due to ''strokes'' of the glacial anticyclone; the transit of fronts and storms across the Ice Cap is governed by the general atmospheric circulation, fall and early winter being normally more favorable than summer, but crossings are possible at any time of the year; the principal nourishment of the Ice Cap is derived from normal cyclonic and orographic precipitation processes, and only little is obtained from sublimation deposits. (Italics not in the original.)

Dorsey's memoir, which is illustrated by 16 daily synoptic charts of Greenland (isobars only), shows cyclonic low-pressure areas crossing Greenland without modification of their courses either by the coast, by the outblowing winds, or by the rising dome of the two-mile-high glacier in their paths. He offers in the memoir itself not the slightest evidence that cyclones do cross Greenland. This would obviously be impossible, since there were at the time no observations from the interior to supply such evidence. No account had been taken by him of the earlier studies by Georgi (*5*) and Belknap (*1*) (made when interior observing stations were in operation), which indicated that those storms which arrived at the west coast had been switched up Davis Strait and Baffin Bay.

Dorsey's basis for tracing the transit of each cyclone would appear to have been finding a cyclone off the Greenland west coast on a certain date, and another, which was without identifiable thumbmarks, off the east coast enough later to have had an assumed sufficient time to have made the transit.

The other recent monograph on Greenland climate by a meteorologist is entitled, "Climate and weather over the coastland of northeast Greenland and the adjacent sea" (*12*). This title does not correctly describe the memoir, which includes nearly 100 daily synoptic charts of Greenland (isobars only). These are based wholly on observations made at 9 Danish coastal fjord-stations, all in the southern half of Greenland. Of these, three are on the west coast, three on the east coast, and three on the south coast. The author himself has had no experience of Greenland, but had written his memoir from outside. If the outblowing wind system of Greenland had been taken into account, the isobars over the inland ice in Hovmöller's charts should all have made angles not greater than 45° with the surface contours. As a matter of fact, they take any direction, often directly across or at any angle which was necessary in order to get the cyclones across. This sumptuous memoir is in the realm of the imagination.

Future technique for meteorologists who study the Arctic climates. It has been indicated in the above that the explorer and the meteorologist have reached quite different conclusions concerning the climates of two vast Arctic regions.

The explorers find the Central Arctic Basin to be an almost windless region of uniformly normal atmospheric pressure. No evidence was found that cyclones cross it. The professional meteorologists make it a vigorous fixed polar anticyclone area, but this is an hypothesis only.

The explorers have found Greenland to be covered over by a supervigorous glacial anticyclone fixed in position with outward-blowing winds everywhere. No cyclones cross it. The meteorological profession believes that Greenland is crossed by cyclones much as though it were an expanse of sea.[3] The great explorer-meteorologists, among others Alfred De Quervain and Alfred Wegener, and the explorer-scientist, Fridtjof Nansen, have taken their stand with the explorers.

An interesting consideration suggested by this discussion is whether in the future the technique of the meteorologist may change from one that has remained unchanged now for well-nigh a century. Will it give place to an objective one that makes observation of the weather *where it is,* not one theorized from somewhere else? If this is to happen, two factitious assumptions of the profession will certainly have to be abandoned. These are: (1) that the weather of a region must necessarily be determined by cyclones which invade it from outside; (2) that no weather observations can be used which have not been made at permanent stations fixed in position and with their observations repeated there over long periods of time.

This writer believes he can see the future meteorologist of the Arctic in a one- or two-man party lightly equipped and traveling rapidly across country. Several times each day he will halt, with a walky-talky report the geographical coordinates of his position, and send a weather report. Every few days he will acquire a fresh supply of food and fuel, delivered to him or cached for his use, either by submarine, aircraft, or truck, as may be most practicable. In his weather report essential accuracy will take the place of an unnecessary precision, for weather can vary so rapidly both in time and place that a refined precision seems to be superfluous. Location of the stations would in this system change frequently, but if the number of parties sufficed and their routes had been well laid out, there would be coverage for a daily weather chart.

[3] Glacial anticyclones like those now above the existing continental glaciers must also have overwhelmed the earlier ones which in Pleistocene time spread out over North America and Eurasia. Their deposits have heretofore been interpreted as though they had been like the little glaciers of the Swiss Alps but in a much expanded form. Extensive revision has in consequence already begun (Hobbs. The glacial anticyclone and the continental glaciers of North America. *Proc. Amer. phil. Soc.*, 1943, **86**, 368–402; The glacial anticyclone and the European continental glacier. *Amer. J. Sci.*, 1943, **241**, 333–336; American and Eurasian glaciers of the past: a picture based on existing ones. *Sci. Mon.*, 1948, **66**, 99–106; *Glacial Studies of the Pleistocene of North America.* Ann Arbor: Edwards Bros., 1947). Glacial geologists do not appear generally to have accepted the glacial anticyclones, and, supporting their position by that of the meteorological profession, they have published articles denying their existence. See *15*.

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NEWS and Notes

Gerhard Tintner, professor of economics, statistics, and mathematics at Iowa State College, has been granted a leave of absence to work with the research staff at the statistical laboratory at Cambridge, England. During the coming year Dr. Tintner will also give a series of lectures in economics and statistics to the Cambridge University undergraduate students.

James C. Warf was recently appointed assistant professor of chemistry at the University of Southern California. Dr. Warf, a Guggenheim Fellow now at the Chemisches Institut in Bern, Switzerland, was formerly associated with the Manhattan Project at Iowa State College.

Louis B. Howard, chief of the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, has resigned to become the first head of the year-old Department of Food Technology at the University of Illinois College of Agriculture. He will be succeeded by **G. E. Hilbert**, director of the Northern Regional Research Laboratory at Peoria, Illinois.

Horace N. Marvin, of the University of Arkansas School of Medicine, has been appointed head of the Department of Biology, M. D. Anderson Hospital for Cancer Research, Houston, Texas. At the Hospital, which is the state cancer hospital and a branch of the University of Texas, Dr. Marvin will be engaged in research on the relation of hormones to cancer and growth in general.

Irene Rosenfeld, research pathologist at the University of Wyoming, has been granted sabbatical leave from September 1 of this year to September 1, 1949, in order to accept an Atomic Energy Fellowship. She will conduct research at the Donner Laboratory, University of California, during that period.

H. A. Ireland, director of geologic research for the Standard Oil Company of Texas, and **A. G. Fischer**, of the staff of the University of Rochester, have been appointed professor of geology and instructor, respectively, at the University of Kansas. Dr. Ireland will teach courses in sedimentation and petrography, while Dr. Fischer will teach stratigraphy and elementary paleontology.

Grants and Awards

The $1,000 Paul-Lewis Laboratories Award in Enzyme Chemistry will be made to Albert L. Lehninger, assistant professor of biochemistry in the University of Chicago's Departments of Surgery and Biochemistry and a member of the University's Committee on Cancer, at the 114th national meeting of the American Chemical Society, which opens in Washington, D. C., on August 30. Dr. Lehninger's award address, on "Enzymatic Oxidation of Fatty Acids," will be delivered on September 2 at a symposium being conducted by the Society's Division of Biological Chemistry. The 31-year-old professor was cited, according to the ACS announcement, "for his research on the chemistry and metabolism of fatty acids, which has greatly increased man's understanding of the manufacture of body tissue and muscular energy."

The Biological Laboratories, 16 Clinton Street, Brooklyn, New York, has received from the Atomic Energy Commission, through the Office of Naval Research, a grant of $9,000 for a 6-month study of the effects of antisera on radiation damage. The work will be carried on under the direction of Norman Molomut, formerly of the Department of Medicine, College of Physicians and Surgeons, Columbia University, who organized the Laboratories in 1946 for the purpose of engaging in researches in physiology and microbiology.

Fellowships

Airborne Instruments Laboratory, Inc., Mineola, New York, has established two fellowships to aid worthy young men in obtaining advanced degrees in the field of communications and electronics, one valued at $1,000 plus tuition at Stanford University, the other in the amount of $1,200 plus tuition ($1,800 for a married man) at the Massachusetts Institute of Technology. Recipients are to be selected by the staffs of the Electrical Engineering Departments of the two schools.

The Socony-Vacuum Oil Company, Inc., has recently announced that it has appropriated $50,000 for a doubled program of fellowships in chemistry and physics at leading educational institutions. In addition to the 10 fellowships established last year and being continued for the 1948–49 academic year at California Institute of Technology, Harvard, Massachusetts Institute of Technology, Notre Dame, Ohio State, Princeton,