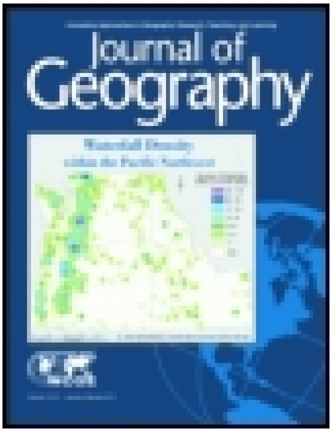


Journal of Geography
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rjog20

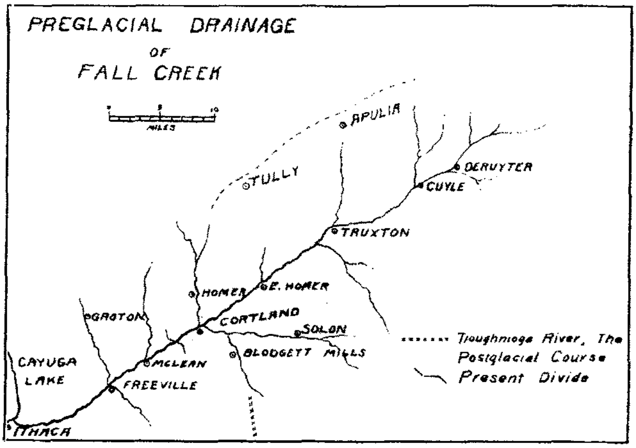
The Chinook Winds

Alvin T. Burrows [a]
[a] Weather Bureau
Published online: 20 May 2008.

To cite this article: Alvin T. Burrows (1903) The Chinook Winds, Journal of Geography, 2:3, 124-136, DOI: 10.1080/00221340308985932

To link to this article: http://dx.doi.org/10.1080/00221340308985932

establishment of the Blodgett Mills outlet for the drainage that once belonged to Fall Creek would lead this paper beyond its initial purpose, *i. e.*, of describing a type case in river diversion, which might be an incentive to the study and recording of similar instances.



THE CHINOOK WINDS*

BY ALVIN T. BURROWS,
Observer, Weather Bureau

ORIGIN of the Application of the Name "Chinook" to Winds.—At the present time there are three different winds called Chinooks. Each of them is essentially a warm wind, whose effect is most noticeable in winter. Under their influence snow is melted with astonishing rapidity and the weather soon becomes balmy and spring-like. The name "Chinook" is that of an Indian tribe which formerly lived near the mouth of the Columbia River. It was first applied to a warm southwest wind which blew from "over Chinook camp" to the trading post established by the Hudson Bay Fur Company, at Astoria, Oregon. The name soon came into general use in that locality, and as the adjacent country was settled the usage extended, so that now "Chinook" is applied not only to the warm, moist southwest winds along the Oregon and Washington coast, but to the warm, dry, descending winds east of the

*Reprinted by special permission from the Department of Agriculture Year Book, 1901.

Cascade range in Washington and the Rocky Mountains in Montana and elsewhere. In 1895 Mr. B. S. Pague, the local forecast official at Portland, Oregon, began to call the descending southwest winds that visited western Oregon and Washington during the winter "Chinooks."

Wet and Dry Chinooks.—The warm, wet Chinook of the Pacific Coast was for many years supposed to owe its existence to the Japan Current, over which it was thought to blow. This is still the popular belief in many localities where the wind occurs. Scientific investigation has shown the fallacy of this view. The Japan Current is but a small fractional part of the Pacific Ocean and its influence is correspondingly small. Its effect, if any, on the wind would be lost, as this current does not approach within 1,000 miles of the Puget Sound country. The relative warmth of the ocean over which the winds must blow is itself a sufficient cause of any relatively high temperature accompanying the wind. The moisture of these winds is obtained from the same inexhaustible source, the ocean.

The warmth of the dry Chinook in Montana and the one described by Mr. Pague occurring west of the Cascades is derived in a different manner. It results from a compression of air descending from a mountain, the moisture of which has been abstracted on the other slope. These winds are of the same nature as the foehn wind of Europe, and by some writers these two terms are used synonymously. The dry Chinook wind is defined by Professor Harrington, formerly chief of the Weather Bureau, as follows: "A warm, dry, westerly or northerly wind occurring on the eastern slopes of the mountains of the northwest, beginning at any hour of the day and continuing from a few hours to several days." Others make the definition somewhat broader. According to them this wind is defined as a warm, dry wind from the southeast, west or northwest when east of the Rocky Mountains, beginning at any hour of the day or night, and continuing from a few hours to several days.

Distribution and Characteristics of Chinook Winds.—The distribution of the Chinook is rather wide. It occurs most frequently in Washington, Oregon, Montana, Idaho, Wyoming and the Dakotas in the United States, and in the region immediately north in the British possessions. There are authentic instances recorded of this wind in Nebraska, Iowa, Minnesota and even Wisconsin. These latter visitations are rare, and the fact of their being genuine Chinooks is questioned. Professor Abbe states that a wind similar to the Chinook makes its appearance east of the Appalachian range. The winds that bring fog, rain or snow to Buffalo, Pittsburg, Knoxville and Chattanooga frequently descend as clear, dry winds on the eastern slope. The increase of temperature in these cases is not great.

The dry Chinook is a peculiar one. In the dead of winter it blows down from the mountains and high plateaus, where ice and snow are supposed to predominate, as a hot, dry wind upon the foothills and valleys below. Its effects are striking. The snow at these lower elevations, at first blown hither and thither by the increasing wind velocity, soon becomes moist and heavy under the influence of the blasts of hot air, and in an incredibly short time may entirely disappear. The temperature rises with astonishing rapidity and the whole aspect of nature is transformed. The arrival of the Chinook bears no relation to the shining of the sun, as it comes as frequently in the coldness of the night as in the warmth of midday. It puts in check the boreal blasts of winter and affords a most welcome relief from the monotonous cold and snow characteristic of mountain winters in high latitudes.

Beneficial Influence of Chinook Winds.—The climatic influences of the dry Chinook are important. In the region of its occurrence east of the Rocky Mountains it has, more than any other single cause, a modifying effect on the severity of winter. Were it not for the visitations of this warm, dry wind the vast stock ranges of Montana, Wyoming and the Dakotas would have to be abandoned in the winter, as the cattle and other stock, prevented by the snow from securing access to the nutritious grasses on the plains, would not be able to secure nourishment sufficient to sustain life. According to the testimony of stockmen in this region, the advent of the Chinook at a critical period is often the means of saving their herds, not only from starvation but from freezing. Instinctively the cattle seem to anticipate its coming, and in times of cold and hunger may be seen standing knee-deep in the snow with their heads turned toward the mountains, anxiously awaiting the arrival of relief. Mr. A. B. Coe, voluntary observer of the Weather Bureau at Kipp, Mont., states that were it not for the Chinook wind the northern slope country of Montana would not be habitable, nor could domestic animals survive the winters.

Aside from its temperature, the Chinook bears an important relation to the amount of snow remaining on the ground in the mountains and on the plains at the time of the spring thaws. If the Chinook has been absent, or infrequent in occurrence, the accumulated snow, especially on the plains, is likely to be great. The conditions are then ripe for high spring floods. If frequent visitations of the Chinook have occurred, much of the snow on the plains will have either disappeared through evaporation or been converted into a hardened mass of snow and ice. As ice it remains a long time unmelted in the ravines and affords an abundant supply of water for the creeks and rivers during the succeeding spring and early summer. In either event the danger from floods from this source is practically eliminated. It might appear at first thought that these hot winds, which so suddenly denude the plains of snow, would themselves cause floods. Such is not generally the case. These winds are intensely dry, having lost their moisture on the other side of the divide. Accordingly, they reach the eastern slope bereft of their original dampness, but possessing a manifold capacity for absorbing moisture from any source available. The melting snow supplies this source, and so rapidly does the evaporation follow that floods caused by the Chinook alone are practically unknown. Mr. Pague states that the influence of the Chinook wind removes great quantities of snow from the foothills and lower mountains during the winter season, and an absence of the Chinook will cause much of the snow that falls in winter to remain unmelted until spring. Such snow packs, hardens, and becomes a greater mass, for each new fall of snow adds to that which has already fallen. He also states that the floods in the Columbia River do not depend so much on the total precipitation of winter as upon the amount of snow in the mountains when the spring thaw begins.

Changes in Temperature Caused by Chinook Winds.—In Montana the approach of the Chinook is marked by a falling barometer. The winds are light, the sky cloudless, and the air clear and cold. The first signs exhibit themselves on the mountain tops, where horizontal streamers of clouds unfurling along the summits afford a sure indication of the approach of the warm air from the region of high pressure beyond. The clouds thus appearing on the mountain tops are followed by cumuli, which, rolled up in huge billowy masses, soon hide the crests of the mountains from the observer in the foothills. The current of air, warming up by compression as it descends, quickly evaporates its own cloud particles, and from this stage downward it warms with great rapidity. As a rule, the Chinook reaches the lower levels with considerable velocity, depending apparently in a large measure on the steepness of the barometric gradient existing between the neighboring areas of high and low pressure. When the gradient is steep the Chinook comes with a rush and a roar, blowing the snow before it. Its velocity is frequently equal to that of a gale. On account of the heat the snow soon settles and melts, and in a few hours becomes compact ice in the ravines, but may entirely disappear in the open. At other times the advent of the Chinook is less violent. The breeze is a gentle one and comes in light puffs, blowing the snow about in a fantastic manner, as before. Eventually the wind increases in force, but rarely changes its initial direction. It is not an uncommon winter experience, in regions where the Chinook occurs, to retire at night with a temperature well below freezing and several inches of snow on the ground, only to awaken the next morning to discover the snow all gone and the thermometer 40° or higher.

The rate and amount of temperature change vary, the distribution of atmospheric pressure being the controlling factor. A rise of 20° to 40° in ten or fifteen minutes frequently occurs, although the change is not always so great. The table following shows the temperature of the stations named on the mornings of January 9 and 10, 1894, between which periods a Chinook wind prevailed over the territory represented by these stations. The data is taken from the Weather Bureau records.

Changes in Temperature at Weather Bureau Stations during a Chinook Wind.

STATIONS.	Temperature 8 a. m. January 9, 1894.	Temperature 8 a. m. January 10, 1894.	Change in 24 hours.
	Degrees Fahr.	Degrees Fahr.	Degrees Fahr.
Roseburg, Ore.	34	44	10
Portland, Ore.	34	42	8
Fort Canby, Wash.	38	42	4
Seattle, Wash.	32	40	8
Walla Walla, Wash.	28	46	18
Spokane, Wash.	14	34	20
Helena, Mont.	10	38	28
Miles City, Mont.	—6	40	46
Havre, Mont.	20	32	12
Bismarck, N. D.	—22	32	54

During this period a high pressure with a reading of 30.7 inches was central over Nevada, and a low pressure with a reading of 29.8 inches over northern Montana.

In his report for November, 1896, the section director of the Idaho climate and crop service states that during the latter part of the month the state was visited by a succession of Chinooks which raised the mean temperature above normal and gave everything a spring-like appearance. In many places plowing was begun. The average temperature for the last half of the month was 12° warmer than the first half. In Montana during the same month the temperature rose from 6° to 40° in two hours at Dillon on the 16th; at Red Lodge from 21° to 31° in one hour; at Kipp on the 17th from 11° to 21° in nine minutes, and at Lewiston on the same date from 10° to 30° in three hours. At Great Falls, Chinook winds blew continuously on the 13th and 14th and up to 12.25 p. m. of the 15th, when a sudden change in temperature, but not in direction of the wind, occurred. The temperature dropped in a few minutes from 44° to 23°, but a few hours later rose to 54°, after which it fell gradually to 19°. These rapid fluctuations, characteristic of the Chinook, are not well understood, but are supposed to be due to the surging back and forth of the currents of cold and warm air.

Conditions Accompanying Some Well-Defined Chinooks.—Following the warm weather of November, 1896, came a series of snowstorms and cold waves of great intensity for the season. The effect on grazing cattle in Montana was especially severe. Thousands of the helpless beasts wandered aimlessly over the hills searching in vain for food and shelter. As the days went by and no relief was afforded, their safety was a question of great moment. No food was obtainable, for the grasses upon which they were wont to subsist lay buried under thirty inches of snow. On the evening of December 1, 1896, the temperature at Kipp, Mont., was -13°. The air was scarcely moving and the sky was clear. Suddenly over the edge of the mountains in the southwest appeared a great bank of black clouds, their outer edges blown into tatters by the wind. In a few minutes a short puff of hot dry air had reached the plains and in the following seven minutes the temperature had risen 34°. The wind increased in velocity to twenty-five miles and the temperature rose to 38°. Within twelve hours every vestige of the thirty inches of snow had disappeared, leaving the hills bare and the plains covered with water.

Chinook winds with temperatures generally above freezing occurred over Washington, Oregon, Idaho, and Montana on December 2, 3 and 4, 1896. These winds were caused by the presence of a high pressure central over Utah and a low area moving along its northern edge. The winds in this instance are reported to have cleared the snow blockades which had closed the railroads and to have removed the snow from the stock ranges. On December 3, the Portland, Ore., forecast official predicted warm Chinook winds for Washington, Oregon and Idaho, a prediction verified by events.

These warm winds do not always closely follow the mountain slopes, but may take a gentler decline and reach the earth at a distance of a hundred or more miles from the base. When this happens, a well-defined Chinook with moderate temperature may be in existence high up on the mountain and farther away on the plains, while between them, near the foot of the mountain, the temperature may be at zero or below. The following is an example: At Kipp, Mont., elevation 4,400 feet, on February 13, 1897, at 8.15 p. m., the temperature was 6°, wind northwest, weather clear and seven inches of snow on the ground. Thirty-eight miles away, at Summit, Mont., altitude 5,500 feet, at the same time, the temperature was 39°, with southwest winds and dense clouds. Three feet of snow was on the ground, but melting rapidly. The Chinook had prevailed for thirteen hours, yet had not reached thirty-eight miles below. Two days later the temperature at Kipp rose to 40° in twelve minutes. In many instances on record the weather has been warm and spring-like near the summit of the mountains, while a cold wave has raged in the valleys below. Travelers who cross the Rocky Mountains in Montana in winter often meet with this phenomenon. Mr. E. J. Glass, section director of the Montana climate and crop service, in a paper on the "Chinook Wind" delivered before the convention of weather bureau officials, at Milwaukee, Wis., in August, 1901, cited an instance of an east-bound Northern Pacific passenger train leaving the summit of the pass with weather mild and the temperature above freezing. A half hour later the train had descended into a cold wave where the temperature was –13°. He states that conditions similar to this frequently exist between Helena and a voluntary station a few miles away and of slightly greater elevation. During the coldest weather of the winter of 1898 at Helena, the temperature at the mountain station was about 32°.

On December 4, 1897, an extensive Chinook was recorded. Its influence was felt as far east as Iowa, where the temperature rose suddenly in the night 12° to 14°. On this date the pressure was 30.7 inches over Utah and 29.7 inches over Manitoba, thus creating a strong indraft of air toward the latter place. In this instance the eastward flowing air probably remained close to the ground and did not rise until near the lakes. Similar conditions prevailed on December 29, 1897, temperatures in Minnesota, Iowa and Wisconsin being from 20° to 50° warmer than on the day preceding. At the same time Chinook winds were felt in Washington and Oregon, as well as in the immediate mountain country east of the Continental Divide.

The Weather Bureau records for Havre, Mont., furnish a number of instances of rapid variations in temperature. On December 18, 1898, in the afternoon the temperature was 45°; at 4 the next morning it was 18°. During the next two hours there was a gain in temperature of 6°, and in the following ten minutes a rise of 20°. Half an hour later the temperature fell to 30°, only to bound back to 44° at 7.30 a. m. On March 7, 1900, the temperature at this place rose 31° between midnight and 4 a. m.

It remained stationary until 10.30 a. m., when in three minutes it decreased from 44° to 18°, and twenty minutes later registered 11°. The variations until 3 a. m. the next day were slight, when a rapid rise in less than an hour carried the temperature back to 40°, only to fall again a few hours later to 9°. The wind during this entire period was from the south or southwest. Figures I and II, showing the automatic records taken by the thermographs and barographs at Havre, Mont., and Williston,

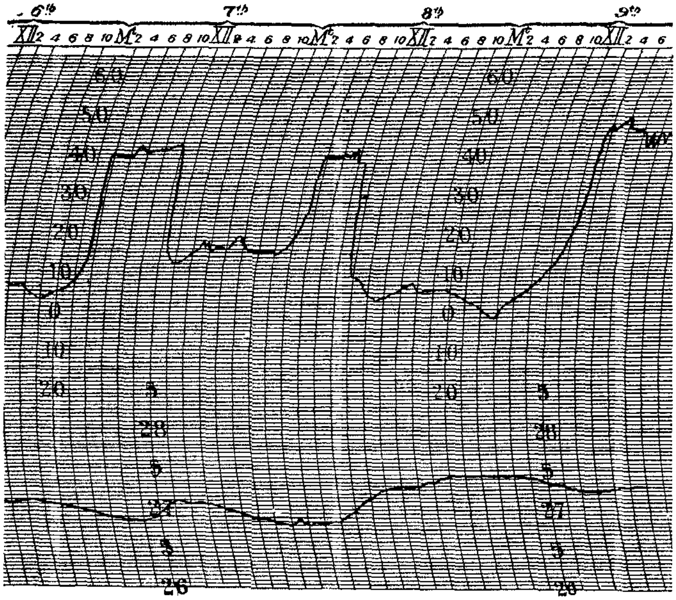


FIG. 1. *Automatic records taken by the thermographs and barographs at Havre, Mont.*

N. D., during this period may give a clearer conception of the facts. The upper lines are the thermograph traces and the lower lines the barograph traces.

Among other dates upon which well-defined Chinooks occurred may be mentioned January 14–18, 1899; December 21–25, 1899, and February 24–25, 1901. Perhaps the instances already given are sufficient to afford a general idea of conditions accompanying a Chinook. It is found by an examination of the weather maps of conditions prevalent at the time of Chinooks that certain barometric relations are usually present. Figure III, which is the weather map for the morning of December 4, 1897, may be taken as a fairly typical representation of the distribution of pressure

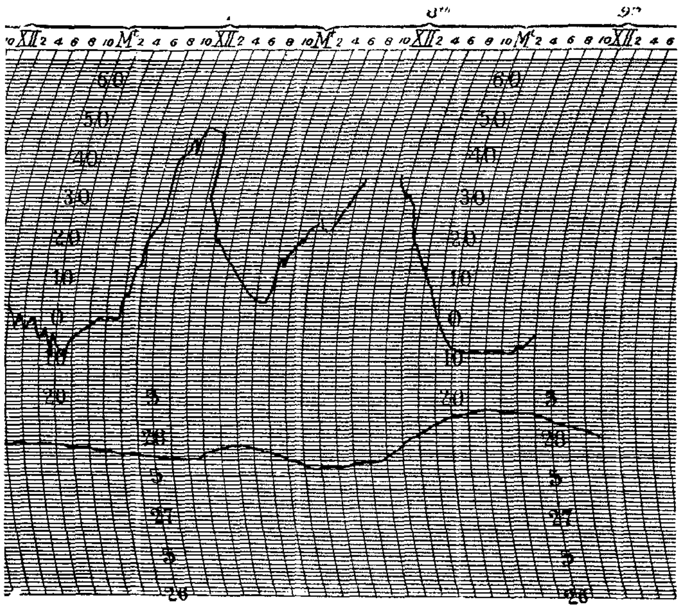


FIG. 2. *Automatic records taken by the thermographs and barographs at Williston, N. D.*

and the resultant winds at such a time. It will be observed that the high pressure, or anti-cyclone, is central over Utah, while the low pressure, or cyclone, is over Manitoba. The air, obeying natural laws, flows from the area of high pressure over the mountains to the low pressure. Emanating from the high plateau region of northern Nevada, Utah and southern Idaho, it flows up and over the ranges to the northward and down the other side. In Oregon and Washington the resultant winds are from the south or southeast, while east of the Rocky Mountains the direction is from the south or southwest. In each case the air reaches a lower elevation than it possessed on the plateau. In doing so it must undergo compression and its temperature is raised accordingly.

Discussion of Conditions Producing Chinooks.—It is a well-established principle of physics that air, if caused to ascend, expands as it rises. As the expansion proceeds heat is used in doing work against the outside pressure, and the temperature is accordingly lowered. This process, known as dynamic cooling, proceeds at a perfectly definite rate, being 1.6° for each 300 feet of ascent, provided no condensation takes place. It is found that the capacity of air to retain vapor diminishes as the temperature is reduced. Ascending air soon reaches a point where its capacity is taxed to the utmost, and if further ascent occurs condensation takes place and the air current becomes cloudy. This has an important effect on the rate of cooling, as the condensation of water vapor liberates latent heat. The decrease of temperature with ascent is then lowered at a rate depending upon the temperature of the air when condensation commenced and upon the pressure. At a pressure of thirty inches and a temperature of condensation of 10° the fall in temperature is at the rate of 1.2° for each 300 feet; at the same pressure and a temperature of condensation of 30° the rate is 1° for each 300 feet; at a pressure of twenty-two inches and a temperature of condensation of 10° the rate is 1.1° for each 300 feet, and at a temperature of condensation of 30° it is 1° for each 300 feet. At the freezing point, moist air ascends for a short distance without loss of temperature, the energy required to maintain the increased volume being supplied by the latent heat derived from the conversion of water particles into ice. Apply these facts to Chinook winds. Suppose an

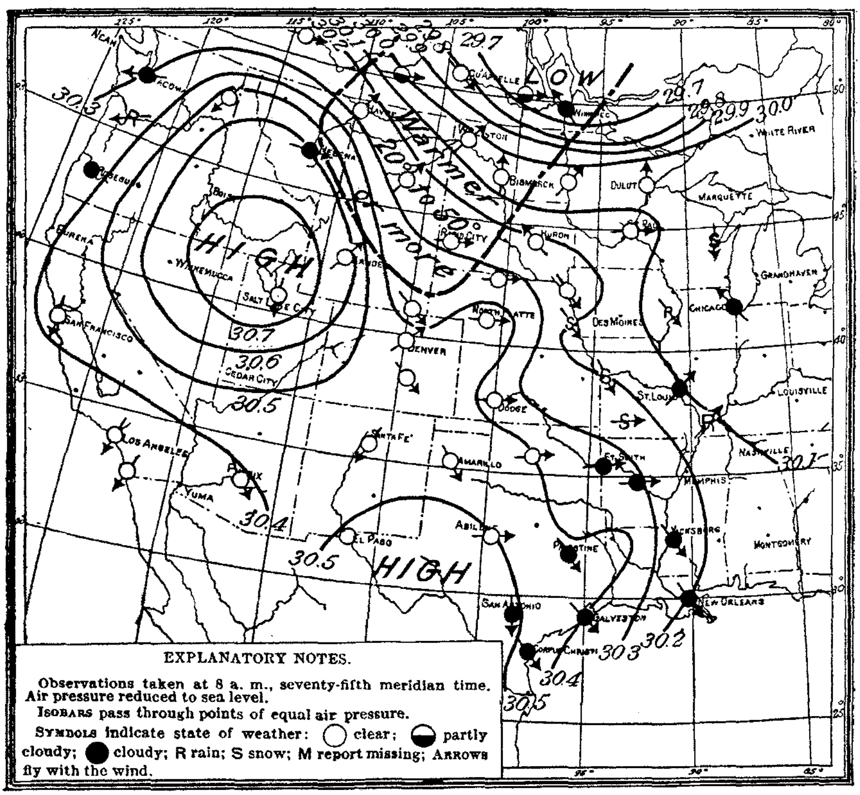


FIG. 3. *Weather map for December 4, 1897, showing the areas of high and low pressure and the direction of the winds.*

area of high pressure over Montana and the Dakotas, with the temperatures ranging below zero. Let a low area appear off the British Columbia coast and at the same time a second high area move in from the upper California coast. The Dakota storm will move eastward, as will also the low in British Columbia and the high in California, the latter tending to assume a stationary position over Utah, while the low skirts its northern periphery. It is while this movement is in progress that Chinook conditions prevail. Warm, dry air is fed into the low from the high, and this process continues until stronger atmospheric forces break up the combination. This period is not likely to extend, however, beyond two or three days, and may be much less.

The temperature changes that occur in this system are worthy of note. The average temperature of the January highs entering the United States from upper California is about 44°. In passing over the mountains into the region of northern Utah the moisture is precipitated as rain or snow, and the temperature suffers a decrease to about 5° or 10°. The elevation of the plateau country is from 4,000 to 7,000 feet. The Willamette Valley and the Puget Sound region have elevations but slightly above sea level. In the valley of the Columbia the elevation nowhere exceeds 1,000 feet, while east of the Rocky Mountains the elevation gradually decreases from 4,000 to 2,000 feet. The summits of the mountains vary from 5,000 to 8,000 feet. In view of these topographical conditions, the reason for the warm wind down the mountain slopes is apparent. As the air is pushed out of the anti-cyclone toward the low it finds its way blocked on every side. It is literally hemmed in. The downward movement of the air over the center of the anti-cyclone pushes the air out below and compels it to flow up over the mountains, cooling as it goes. The dew point is soon reached, and clouds are formed, followed by snow. As a consequence, when the air reaches the summit of the mountains its temperature is lower, and the absolute amount of moisture it contains is less than before, but it has retained most of the heat evolved by the condensation. In descending the other slope the clouds which were formed on the windward side rapidly dissolve as the temperature rises, and the capacity of the air for moisture consequently increases. In the ascent, on account of the latent heat liberated by condensation, the rate of decrease of temperature is less than the normal rate. In the descent on the other side the dew point of the almost dry air is soon reached and passed. From this point downward the increase is at the normal rate, there being a net gain of about 0.5° for each 300 feet. Thus it will be seen that stations having the same elevation on different sides of a mountain range will have different temperatures, where the air blows from one over the range to the other. When it is remembered that the eastern half of Montana and the Dakotas is several thousand feet lower than the plateau region where the high pressure is centered, the reason for the warm, dry southwest wind over these states becomes apparent. The contrast is made the greater because of the low temperature existing east of the mountains before the advent of the Chinook.

These Chinooks, therefore, need for their production an area of high pressure and an area of low pressure so located that the winds in being drawn out of the high into the low will be compelled to pass over an intervening mountain range. Owing to the location of the path of the storm tracks, the winter season is the time of the greatest number of Chinooks. During this period the daily chart of reduced pressures shows a tendency of high pressure to pile up over the plateau region. This is known as the continental high of midwinter. Anti-cyclones drifting eastward from the Pacific Ocean along the forty-first parallel become stationary over Utah, where they persist until borne away by a superior high over Montana, or under some circumstances until disintegrated. In summer the storm tracks are different and few high areas pass over Utah. The Chinook winds in the northwestern states are accordingly rare at such a time.

The Southeasterly Chinook Winds.—Two of the winds known as Chinooks have already been described. The third, a southerly or southeasterly wind, west of the Cascade Mountains, is not so generally recognized as a Chinook, and it is only in the last decade that this appellation has been applied to it. It has several of the characteristics of the wet Chinook from the ocean and the dry Chinook farther east. It is described by Mr. Pague in his pamphlet on "Weather Forecasting on the Pacific Coast," and also by Mr. S. M. Blanford in an appendix to that pamphlet. Mr. Pague holds that this wind is originally a dry descending wind, due to the outflow from a high area in Utah. He attributes its high temperature to compression after the moisture has been lost in the plateau regions. The fact that near the ocean it is a wet wind and frequently followed by rain, has led to the assumption that the descending current becomes mixed with the humid air from the ocean. This is hypothetical, and further investigation may yield a different explanation.

The temperature changes accompanying this wind are neither so strong nor so sudden as in the case of the dry Chinook. One reason for this is found in the fact that the winter temperature west of the Cascade Mountains is relatively high and long periods of severely cold weather are rare. However, its effect is not inconsiderable. Mr. Pague, in "The Mild Temperature of the Pacific Northwest and the Influence of the Kuro Shiwo," claims that the influence of this southeasterly Chinook wind has a greater effect on the winter climate of the Pacific Northwest than does the adjacent ocean. This view may, perhaps, give undue weight to dynamic heating, as the ocean is thought to be the predominating factor in determining the winter climate of this region. A better understanding of the effect of the Chinook wind on winter weather can be had by considering it divorced from oceanic influences. This is the case east of the Cascade Mountains and in Idaho, Montana and Wyoming. Here the winters are generally severe, broken intermittently by visitations of the Chinook wind.

Conclusion.—As stated in the beginning of this paper, all three Chinook winds possess high temperatures. One is moist and may be followed by rain. It occurs only near the ocean. Another is a dry wind, and rain seldom follows for some time after its occurrence. The third wind occupies an intermediate stage, and, from the present knowledge of it, seems a combination of the two. From November to March these Chinooks play an important part in determining the character of the weather in the northwestern states. They are active agents in tempering the severity of the winter. When they arrive cold waves vanish, the snow disappears, and a short period of bright, balmy spring-like weather ensues. The Chinook aids the railroads in keeping their tracks clear of snow, enables the stockmen to bring their cattle safely through the winter, and stores up water in the form of ice for future use, making irrigation in the summer possible. It is an ever-welcome guest, whose coming is indicative of good, and whose absence would be a momentous evil.

THE EDUCATIONAL VALUE OF GEOGRAPHICAL EXHIBITIONS

BY ALICIA DE RIEMER,
Of the State Normal School, Stevens Point, Wis.

THE expenditure and waste of physical energies peculiar to the individual from infancy are indicative of an innate, compelling desire to "do something." It is the purpose of modern education to present conditions which will make possible some expression of that desire and thus develop power through purposeful self-effort. If that indefinite desire *to do* be directed along lines of least resistance and concentrated interest without crushing or curbing the fresh individuality of the child, a love for a subject will be stimulated that will be abiding and of permanent value.