ORIGIN OF AMERICAN COLD WAVES.

By R. F. STUPART, Director Meteorological Service, Canada, dated Toronto, May 17, 1904.

As yet I am unable to add much to what I said in my letter of February 9. Without doubt, however, the question is so intimately connected with the movement of high and low areas, that I am having some maps printed, taking in all the northern territories almost to the Arctic Sea, as it appears to me this is the best way of arriving at results. With the barometer reading at Dawson, York Factory, Fort Chipewyan, Moose Factory, and Norway House, we shall be able to extend our isobars and get a better idea of the formation and subsequent movement of highs and the accompanying cold waves. From the further work I have done I think it is apparent that in some seasons pronounced cold waves developing in Yukon, or in the far North, never reach either Alberta or Manitoba. In other months, while there is nothing abnormal in the far Northwest, a cold wave may develop just north of Manitoba and Ontario, and the temperature in these provinces fall almost as low as near the Arctic Circle. I am satisfied, however, that it is true in a general way that a cold wave may be expected in Manitoba about five days after it sets in over the Klondike.

INCREASED FLOW OF SPRING WATER IN THE AUTUMN[1].

By G. A. LOVELAND, Section Director, dated Lincoln, Neb., May 28, 1904.

Many of the inhabitants of north-central and northwestern Nebraska have become convinced by casual observation that there is an increased flow of water from natural springs during the fall and winter months, and that at the same time water in the marshes and small lakes of the region increases in depth. So far as the writer is aware, no measurements have been made by which the times and amounts of fluctuation can be determined with any exactness. While lack of such measurements limits the discussion, some facts affecting water supply in this region can be presented. These facts relate to: 1. Geological structure. 2. Precipitation and temperature. 3. Evaporation. 4. Run-off in streams.

1. *Geological structure.*—The surface soil in Nebraska west of the ninety-eighth meridian and north of the Platte River is sandy in formation. In fact, about 24,000 square miles in the central portion of the region (65 per cent of the entire district) are occupied by wind-blown sands, constituting the great sandhill district. North and west of the sand hills are large areas of Arikaree and Ogalalla formation, both with a large proportion of sand in their composition. Outcropping near the Platte River, and underlying most of the western third of the territory under consideration, is the Brule clay. Beneath all these, and underlying all of Nebraska west of the ninety-eighth meridian, and extending considerably east of that meridian in some localities, is the Pierre clay. Its surface outcrops are in the lower portion of the Niobrara Valley, the Republican Valley, and the extreme northwestern portion of the State. It is a mass of nearly impervious Cretaceous clay and shale 1000 to 2000 feet thick in the central and western portions of Nebraska.

At some distance beneath this Pierre clay is the water-bearing Dakota sandstone formation, which outcrops in the eastern portion of Nebraska and carries the great artesian water supplies which are so extensively developed in South Dakota and northeastern Nebraska. This formation also furnishes water for springs and wells in southeastern Nebraska; but it does not affect the surface water supply in the northwestern portion of the State, for the Dakota sandstone is separated from the sandy surface soil by the thick and nearly impervious layer of Pierre clay.

The water supply for the springs and lakes of this district is a question of precipitation upon, evaporation from, and percolation through a sandy soil, varying from 100 to 400 feet in thickness.

2. *Precipitation and temperature.*—Nearly one-half the annual precipitation occurs during the three months of May, June, and July, while only about one-eighth of the annual amount falls during the four months of November, December, January, and February. The following table contains the monthly and annual average precipitation, in inches, for the district, computed from the records of the past twenty-eight years:

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
0.52	0.65	1.05	2.18	3.12	3.37	3.06	2.23	1.53	1.17	0.48	0.60	19.96

The following table contains the monthly and annual average temperatures for the district, computed from the records of the past eighteen years:

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
21.9	22.8	32.8	48.3	58.4	68.1	73.8	71.9	62.5	49.9	34.6	27.2	47.8

The water sinks readily into the sandy, permeable soil until it strikes the nearly impermeable clay layer beneath; then, as it can go no farther downward, it saturates the soil, raising the surface of the saturated zone (which is called the water table) toward the surface until it is high enough for the water to flow off laterally through the soil to a ravine or low spot. Here the water comes to the surface and either evaporates or passes along the ravines to the rivers that drain the district. These rivers carry the water across the eastern or lower outcropping areas of the Pierre clay.

3. *Evaporation.*—The evaporation is very large in summer from the surface of both water and soil. The latter, because of its sandy nature, becomes very hot under the rays of the summer sun. A relatively small proportion of the rainfall is absorbed by the vegetation. No satisfactory measurements of evaporation are available, but it is believed the following table[2] fairly presents the evaporation from a free water surface, in inches, and its variation throughout the year:

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1.92	2.73	3.20	4.83	5.06	5.33	6.68	5.81	4.80	3.36	1.86	2.66	48.24

4. *Run-off in streams.*—That the volume of water in rivers draining this region is remarkably uniform, is shown by the daily gagings. The surface run-off after heavy rains is very much less than from most soils, and the large body of saturated sand furnishes water to prevent a large decrease during dry periods.

The run-off from three rivers of the region has been measured for a period of from two to five years; the Niobrara at Valentine, and the North Loup and Middle Loup at St. Paul. The daily mean flow in cubic feet per second is given in the following table. Unfortunately there were no measurements in the winter months for the longer records:

[1] The present paper relates to the subject of the flow of spring water after the first killing frost mentioned in the Monthly Weather Review for January, 1904, p. 23.

[2] Computed from the data published in Climate and Crop Report for Nebraska, November, 1896.

Month.	Middle Loup.		North Loup.		Niobrara.	
	Flow in cubic feet per second.	Length of record.	Flow in cubic feet per second.	Length of record.	Flow in cubic feet per second.	Length of record.
		Years.		*Years.*		*Years.*
February	....	....	....	....	998	1
March	....	....	....	....	1,260	2
April	1,450	4	1,382	4	937	2
May	1,159	4	1,145	5	798	2
June	1,471	5	1,336	5	716	2
July	1,206	5	999	5	860	2
August	962	4	1,048	5	748	2
September	979	5	887	5	644	2
October	1,072	5	997	5	715	2
November	1,015	2	1,165	2	766	2
December	....	....	....	....	708	2

Conclusions.—An exceedingly large amount of the water in a heavy rain is absorbed by the sandy soil. This raises the water table, which conforms quite closely to the contour lines of the country for a time. A leveling process begins immediately by the water passing from the higher to the lower places along the slope of the water table. The rapidity of movement depends upon the "head" or steepness of the grade, and the texture of the soil.

The surface of the water in the marshes and lakes of the region indicates the elevation of the water table at that place. The rise and fall of the water in a lake will depend upon the relation which the supply of water, flowing to it down the slope of the water table from the higher elevations in the high lands bears to the loss, by evaporation from the surface of the lake and the flow on down the water table to the rivers. This flow from the lake may be in part on the surface at an outlet, or, as in this region, mainly, in some cases entirely, through the soil by slow percolation.

The movement of the ground water is slow, even in this permeable soil. The great sand-filled basin acts as a natural reservoir, more perfectly than a lake, because of the less evaporation from a surface of sand than of water and the slow flow toward the outlet.

In discussing the amount of ground water Mr. G. W. Rafter[3] divides the year into three periods; the storage period, including December to May; the growing period, June to August, when evaporation and absorption are most noticeable, and ground water tends to become lower; the replenishing period, September to November, when the demands on ground water are less, and it tends to return to normal height.

The record of water movement in the streams of this district seems to indicate that September is the month of least run-off, followed by an increase in October and November. The replenishing period may begin a little later than the time selected by Mr. Rafter, or it may become apparent in the springs and lakes in the interior earlier than it shows in the rivers.

In the article on "The disposition of rainfall in the basin of the Chagres" in the MONTHLY WEATHER REVIEW for February, 1904, p. 64, Table 7 shows that the heaviest rainfall occurs in July, while the greatest outflow due to ground water occurs in November, or four months later. This, with the slow movement of ground water through a sandy soil, as determined by Mr. C. S. Slichter,[4] seems to justify the suggestion that the heavy rainfall of early summer, absorbed on the hills, would percolate through the soil and reach the lower levels from four to six months later.

It would seem that the increased water reported might be explained by the slow percolation of the water from the heavy rainfall of May, June, and July, combined with the decreased evaporation due to lower temperature, and the smaller demands of vegetation; in fact, to the general law of increase in ground water in this the replenishing period. Local conditions of soil and climate emphasize this increase, making it more noticeable than in most places.

[3] Water Supply and Irrigation Papers of the United States Geological Survey, No. 80, p. 17. [4] Water Supply and Irrigation Papers, No. 67, United States Geological Survey, p. 27.

AUTHORITIES.

Geological structure.—Dr. G. E. Condra, associate professor of geology, University of Nebraska, and Professional Papers, No. 17. United States Geological Survey.

Evaporation.—Table from Monthy Report, Nebraska Section of Climate and Crop Service, United States Weather Bureau, for November, 1896.

Run-off.—Tables furnished by Prof. O. V. P. Stout, professor of civil engineering, University of Nebraska.

THE TEMPERATURE OF THE AIR ABOVE BERLIN.

FROM OCTOBER 1, 1902, TO DECEMBER 31, 1903, AS SHOWN BY THE DAILY ASCENTS EXECUTED AT THE AERONAUTICAL OBSERVATORY OF THE ROYAL METEOROLOGICAL INSTITUTE OF PRUSSIA.

By PROF. DR. RICHARD ASSMANN, Director of the Observatory.

There are four methods employed by modern aeronautics for scientific purposes:

1. *Ascents of free balloons*, carrying one or more observers. After the famous voyages of James Glaisher, in the years 1862–1866, free ascensions were seriously taken up again in 1891 at Berlin, and since then executed in large number with improved instruments (especially Assmann's aspirated psychrometer) up to the greatest height ever reached (10,800 meters, Berson and Süring on July 31, 1901).[1]

2. *Ascents of smaller balloons carrying self-registering instruments*, after the example of Hermite and Besançon at Paris, called "ballons-sondes," a method tested above all by Teisserenc de Bort at Paris by hundreds of ascents. Instead of balloons of 40 to 100 cubic meters of silk or paper, as employed elsewhere, the Aeronautical Observatory at Berlin makes use of small elastic rubber balloons holding but 2 or 3 cubic meters, which, increasing in volume with the height, ascend with increasing velocity and finally burst, without reaching an equilibrium, and a parachute brings the apparatus safely to the ground. An ascent up to 20,000 meters takes but an hour's time or little more, and so does the descent; thus the rubber balloon hardly ever covers a distance of more than 50 to 70 kilometers in its flight.

3. *Lifting of registering instruments by means of kites.*

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4. In case of the wind being too weak to lift kites (below 5 or 6 meters per second) the *kite-balloon of Sigsfeld-Parseval* (capacity 68 cubic meters of hydrogen) is used and enables us to reach heights up to 2500 meters.

The Aeronautical Observatory of the Royal Meteorological Institute of Prussia, established in the year 1899 near the shooting camp of Tegel in very modest dimensions, avails itself of all the four methods above mentioned. In spite of its unfavorable situation amid extensive forests, and the perils and hindrances resulting from the vicinity of Berlin with its electric street car lines, as well as the neighborhood of the military grounds (shooting camp and barracks of the balloon division) since August, 1902, there have been made daily ascents with kites or kite-balloons without any regard to the weather. The results thereof have been regularly published through the medium of the Berlin Weather Bureau, in the Official Gazette of the same day and in several of the more important evening papers of the metropolis, as well as in the daily weather charts of the Deutsche Seewarte at Hamburg and of the Berlin Weather Bureau.

The regular ascents are made in the mornings; the publica-

[1] The four ascensions made by Hammond in 1885 from Philadelphia also gave excellent results with the sling psychrometer.—ED.